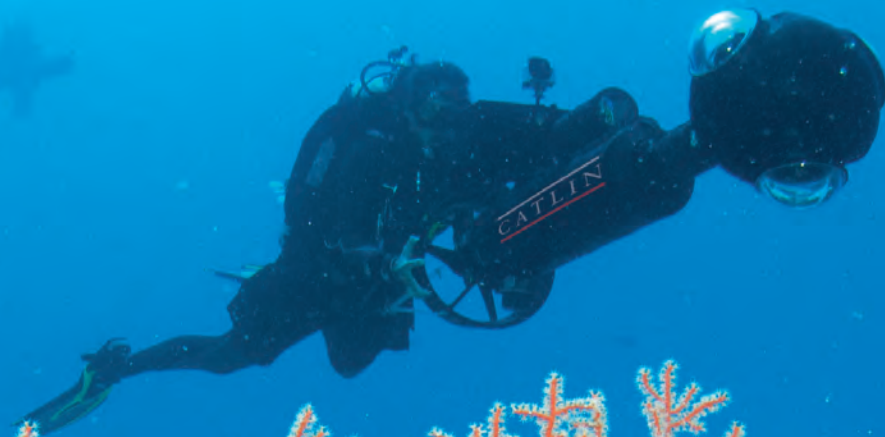


CORAL OCEANS



Become an ocean explorer
Science learning for ages 11-14

bring the oceans to your classroom

[de | oceans]

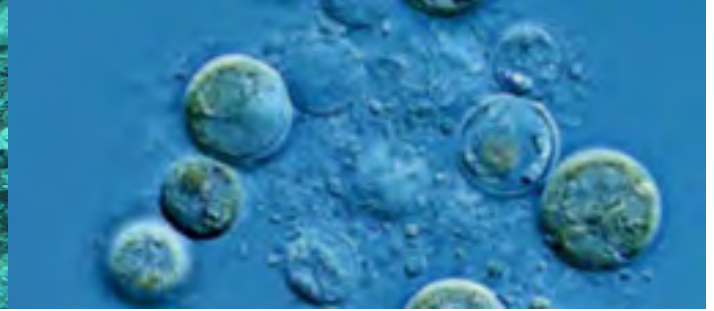
CATLIN
Underwriting Ambition

ACTIVITY SHEET 05

Coral reef scales



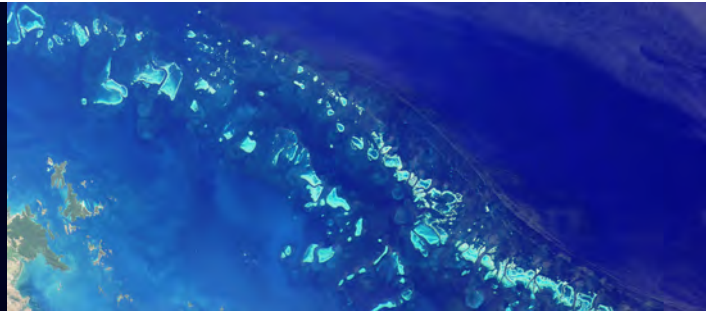
Coral colony



Zooxanthellae



Coral reef



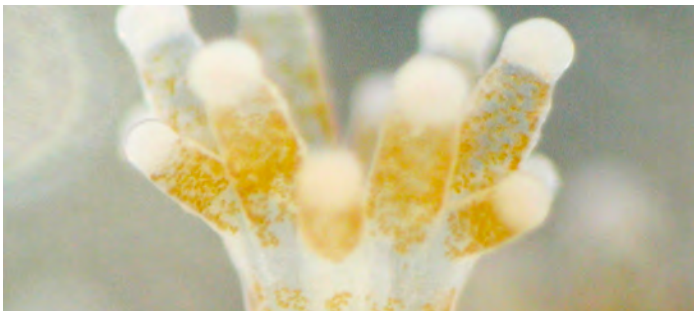
Reef mosaic



Habitat patch



Habitat zone



Coral polyp

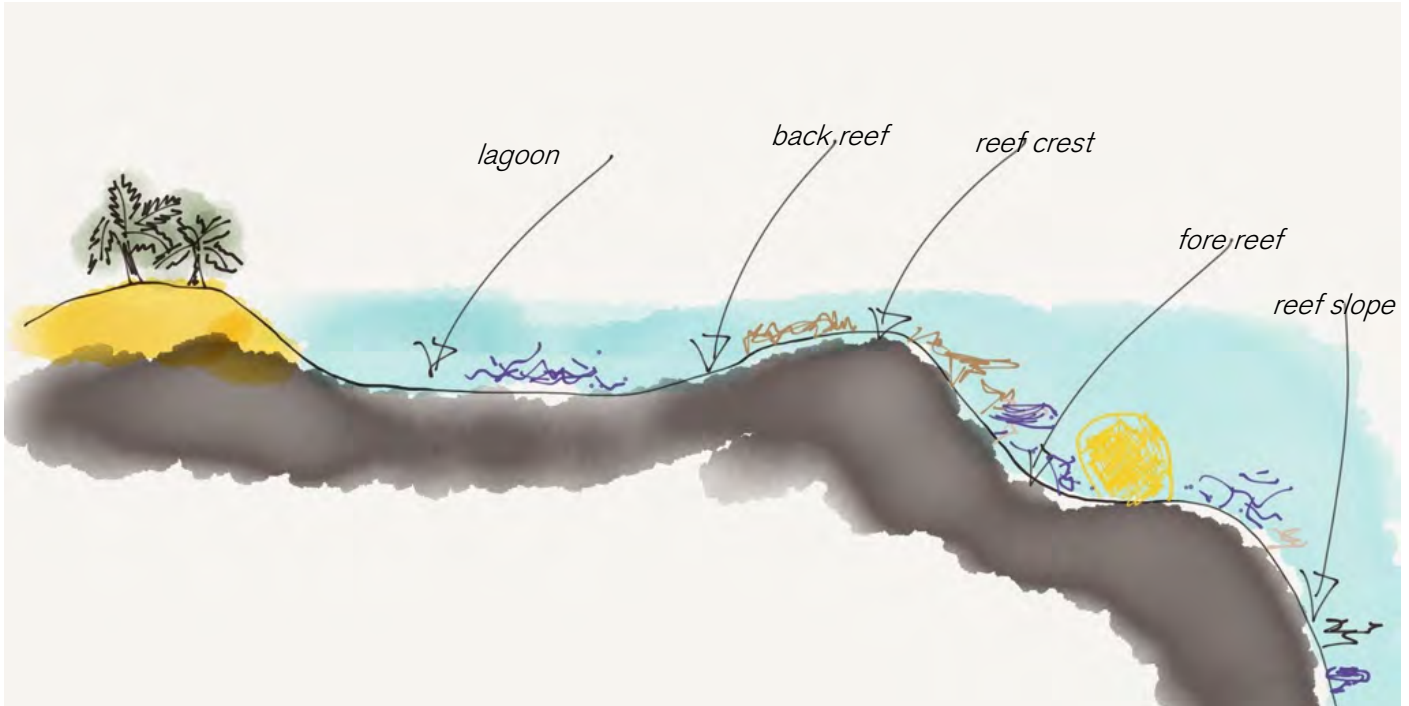


Coral branch



ACTIVITY SHEET 06

Coral reef sketch



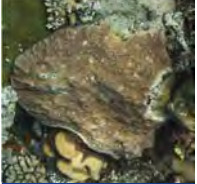
Branching coral

This coral resembles a plant in the way that it grows. Longer branches can be damaged by waves, but it can also be quite squat.



Boulder coral

This coral often looks like a rock or boulder on the sea bed. It needs deeper water so it does not become completely exposed at low tide.



Encrusting coral

Encrusting coral grows like a thin crust on the seafloor. It is resistant to waves but can be overgrown by other corals.



Branching plate coral

Sometimes branching coral is a type of coral that grows in shorter 'fingers' and forms a larger plate.



Plate coral

Plate coral can be found at different depths. Their shape can be more resistant to waves than other types of coral.

Summary

There are different habitat zones on the reef. These are areas that have different environmental conditions:

- Wave strength
- Depth and potential exposure at low tide
- Amount of sunlight

Activity

1. Cut and paste or copy the sketch above, labelling the different habitat zones found on the coral reef.
2. For each habitat zone choose the coral(s) that would be best suited to this environment.
3. Cut and paste the different corals to the correct zone on your diagram. You can use the corals in the sketch as a guide.

Review

- Can you give reasons for your choices?
- Why do you think that there are different varieties of coral?

ACTIVITY SHEET 07

Coral ID



Branching coral

This type of coral colony grows into branching shapes. This can resemble a tree. Branching coral can also form large flat areas or tables of small individual branches or branchlets.

A common type of branching coral is *Acropora cervicornis*, also known as staghorn coral, because it looks like the antlers on a male deer or stag.

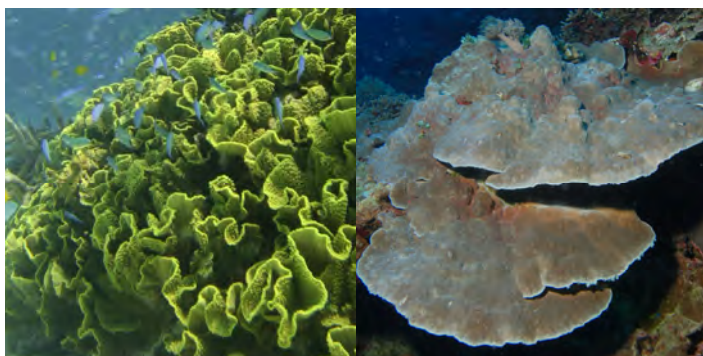


Plate coral

Plate corals come in a variety of shapes, but all of them are formed from flat plates. Sometimes these plates are flat like tables, other times they look more like vases.

Some types of plate coral have fronds like lettuce or fingers and tubes rising from their surface.



Boulder or massive coral

These coral often look like rocks or boulders on the seabed.

Massive corals can be small, the size of a golf ball, or very large, up to 5 metres high.



Ridge and valley coral

These corals come in different shapes and sizes, but are distinguished by the ridges and valleys over their surface.

Some patterns make the coral look like a brain (see left hand picture). These corals are referred to as brain corals.

ACTIVITY SHEET 08



Dive #2

Opal Reef

Coordinates: 16° 12' 16" S, 145° 54' 21" E

Name

Date

Time	Weather	Temp. air/sea	Max. depth	Bottom time
In _____		_____ °C	↓ _____ m	_____ min
Out _____	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	_____ °C		

Survey Site 1	Coral ID key		Coral coverage
Description of site	<input type="checkbox"/> Branching coral		Branching coral %
	<input type="checkbox"/> Plate coral		Plate coral %
	<input type="checkbox"/> Boulder coral		Boulder coral %
	<input type="checkbox"/> Ridge & valley coral		Ridge & valley coral %
	<input type="checkbox"/> Sandy bottom		Sandy bottom %
	<input type="checkbox"/> Other		Other %

Survey Site 2	Coral ID key		Coral coverage
Description of site	<input type="checkbox"/> Branching coral		Branching coral %
	<input type="checkbox"/> Plate coral		Plate coral %
	<input type="checkbox"/> Boulder coral		Boulder coral %
	<input type="checkbox"/> Ridge & valley coral		Ridge & valley coral %
	<input type="checkbox"/> Sandy bottom		Sandy bottom %
	<input type="checkbox"/> Other		Other %

Reasons for any difference in cover

Buddy signature

Dive master signature / stamp

ACTIVITY SHEET 09

Coral feeding



Summary

This activity demonstrates how corals get their energy. Students will model how most corals change from getting their energy from photosynthesis via the zooxanthellae to using their tentacles and nematocysts (stinging cells) to catch zooplankton (microscopic animals, larvae and eggs).

Preparation

Each student will need:

- Surgical or other latex or plastic glove
- Double-sided tape
- Green markers or green stickers
- Paper bag or strip of construction/sugar paper
- Cotton wool

Activity

1. Divide students into groups of 5-6.
2. Tell the class that they are going to model how a coral polyp gets its energy.
3. Pupils should put on the glove (just one per student).
4. Mark the gloved back of the hand with green dots using stickers or a green marker pen—these dots represent the zooxanthellae (algae) within the coral polyp.
5. Stick squares of double-sided sticky tape around each gloved finger—the stickiness represents the stinging cells (nematocysts) on each tentacle / finger.

6. Create a sleeve out of the paper bag or paper that fits over their hand. This represents the corallite or limestone cup that the polyp lives in.
7. During the day the gloved hands will all be closed into a fist. This protects the tentacles from predators and the zooxanthellae are still exposed to sunlight and provide the coral with between 70% and 90% of its energy via photosynthesis.
8. At night, the polyps open up and feed on zooplankton. Students in their groups should sit next to each other, representing a small coral colony.
9. All students should close their eyes ready to try to catch zooplankton, with their fingers. The teacher should go round each group and scatter cotton wool (representing zooplankton) over each coral colony.
10. Students can open their eyes to see how much they have caught.

Review

- Corals use two methods for getting food and nutrients.
- Corals do not 'eat' the zooxanthellae, but receive the products of photosynthesis, in exchange for protection and nutrients.
- Why do coral polyps need zooxanthellae?
- What would it be like to have a plant living inside you?

ACTIVITY SHEET 13

Under pressure



Dr Pim Bongaerts of the Global Change Institute explores the deep reef

Summary

At sea level the atmosphere exerts a pressure of 1 bar. This is the normal pressure that we feel. If you have ever been in an airplane, been up a mountain or dived in the ocean, you might have felt your ears pop. This is because of the air pressure changing.

Pressure underwater increases at 1 bar for every 10 metres (or 33 feet). This means that at 40 metres below the surface, where the deep reef team are working, the pressure is 5 bar, or five times greater than at sea level.

The deepest point in the ocean is the Challenger Deep, which is 10,994 metres (36,070 feet) deep. The pressure here is about 1,100 bar. This is the equivalent of taking the Eiffel Tower, turning it upside down and putting it on your big toe. Only three people have been to the bottom of the ocean in specially designed submarines.

This activity shows the relationship between water depth and pressure.

Preparation

Each student group will need:

- 1.5 – 2 litre plastic bottle
- Masking or duct tape
- Scissors or similar tool to create holes

Activity

1. Divide students into groups of 5-6
2. Tell the class that they are going to investigate the relationship between pressure and depth.
3. Students should make three holes, evenly spaced, in a vertical line, in the bottle.
4. Cover the holes with tape and fill the bottle with water, and put the lid on.
5. Stand the bottle in a sink or take it outside and ask students to guess how the water will behave coming out of the holes. Where will the pressure be greatest? How will you know?
6. Untape the holes and unscrew the lid. What do students observe?

Review

- How did what you observe compare with what you predicted?
- Why do you think the water is flowing with greater force at the bottom compared with the top?

ACTIVITY SHEET 14

Diving deeper



Marine Biologist Norbert Englebert of the Global Change Institute working at a depth of 40m

Deep Reef team member Norbert Englebert describes what it is like to work on the deep reef

Working on the deep reef side of the survey is a real privilege. I suppose as a scientist you always want to see something that no one has ever seen before, and the deep reef is such an unexplored habitat.

When I was growing up I was drawn by these amazing photos of the reef and underwater exploration in magazines like National Geographic. I started diving more and more and now find myself studying for my doctorate at the University of Queensland and diving on the Great Barrier Reef.

When you dive on the deep reef, it's really, really relaxing. You only hear yourself and your bubbles. It's so calm. It's so different from the hectic situation before you dive in.

But when you work down there you have to have a good plan. It's five times harder doing things underwater and when you are working at 40 metres you only have 8 minutes. If you have an hour's worth of air in your tanks, then you spend 2 minutes swimming down, 8 minutes working and 50 minutes coming back up.

We spend a lot of time perfecting our plan. If anyone has an idea that can save 30 seconds doing a certain task, then that's amazing. It may mean we can get twice as much done on each dive. Everything just takes time. Say you left your pencil on another desk, you can just take a couple of steps and reach and get it. On the deep reef it's different. If you wanted to go and get

that pencil, it feels like a massive effort.

On the way down, you have to clear your ears because of the pressure all the time. You really notice that you're breathing harder. The pressure is five times more than it is at the surface.

There are other changes too. Sometimes at 40 metres it's really dark, so dark that you cannot see the surface and that feels odd and a bit scary. Red light disappears first, and if you don't have a torch, then everything is dark blue. It's also pretty cold down there. And then there is nitrogen narcosis when you are below about 30 metres, which gives you a little drunken feeling.

Below 40 metres, we need to use ROVs (Remotely Operated Vehicles). They are really important. If we didn't have them, then we'd never know what was down there.

To study the deep reef, you don't just have to be a good scientist, you also have to be technically minded and have the right equipment. It's a very specialised area of science, and I love it.

Questions

1. What inspired Norbert to become a marine scientist?
2. What does Norbert enjoy about the job?
3. What changes might you experience diving to 40 metres?
4. Choose three words to communicate what it would be like to work as part of the deep reef team, and justify your choices.

ACTIVITY SHEET 15

Exploring deep coral



Exploring deep reef coral on Osprey Reef in the Coral Sea

Summary

Corals have adapted in several ways to life on the deep reef. One of the ways that they have adapted is colour. Corals on the deep reef tend to be darker.

This experiment is designed to test the hypothesis that deep reef corals are darker, because they need to absorb more of the available light.

Preparation

Each buddy pair will need:

- 3 pieces of material of varying shades (these could match coral colours - 2 from the shallow reef, e.g. yellow and light brown and 1 from the deep reef, e.g. very dark brown)
- 3 thermometers
- A light source, e.g. a lamp (using an incandescent bulb rather than an energy-saving one, as these emit more waste heat)

Activity

1. Make sure that all thermometers are at the (same) room temperature.
2. Note the temperature of each thermometer.
3. Place one thermometer under each of the pieces of material.
4. Put the thermometers covered by the material under the light source, making sure they are the same distance away (approx. 20cm).
5. Keep the thermometers there for 15 minutes.
6. Note the new temperature for each thermometer.

Review

- Which colour absorbed the most energy?
- Why do deep corals need to absorb more of the available light?
- How else might a coral adapt to lower light conditions?

ACTIVITY SHEET 16



Dive #5	Osprey Reef	Coordinates: 13° 54' 15" S, 146° 38' 59" E
Name		Date

Time	Weather	Temp. air/sea	Max. depth	Bottom time
In _____	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	_____ °C _____ °C	_____ m	_____ min
Out _____	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>			

What would be the best shape for deep reef coral and why? Design an experiment to show this.

Buddy signature

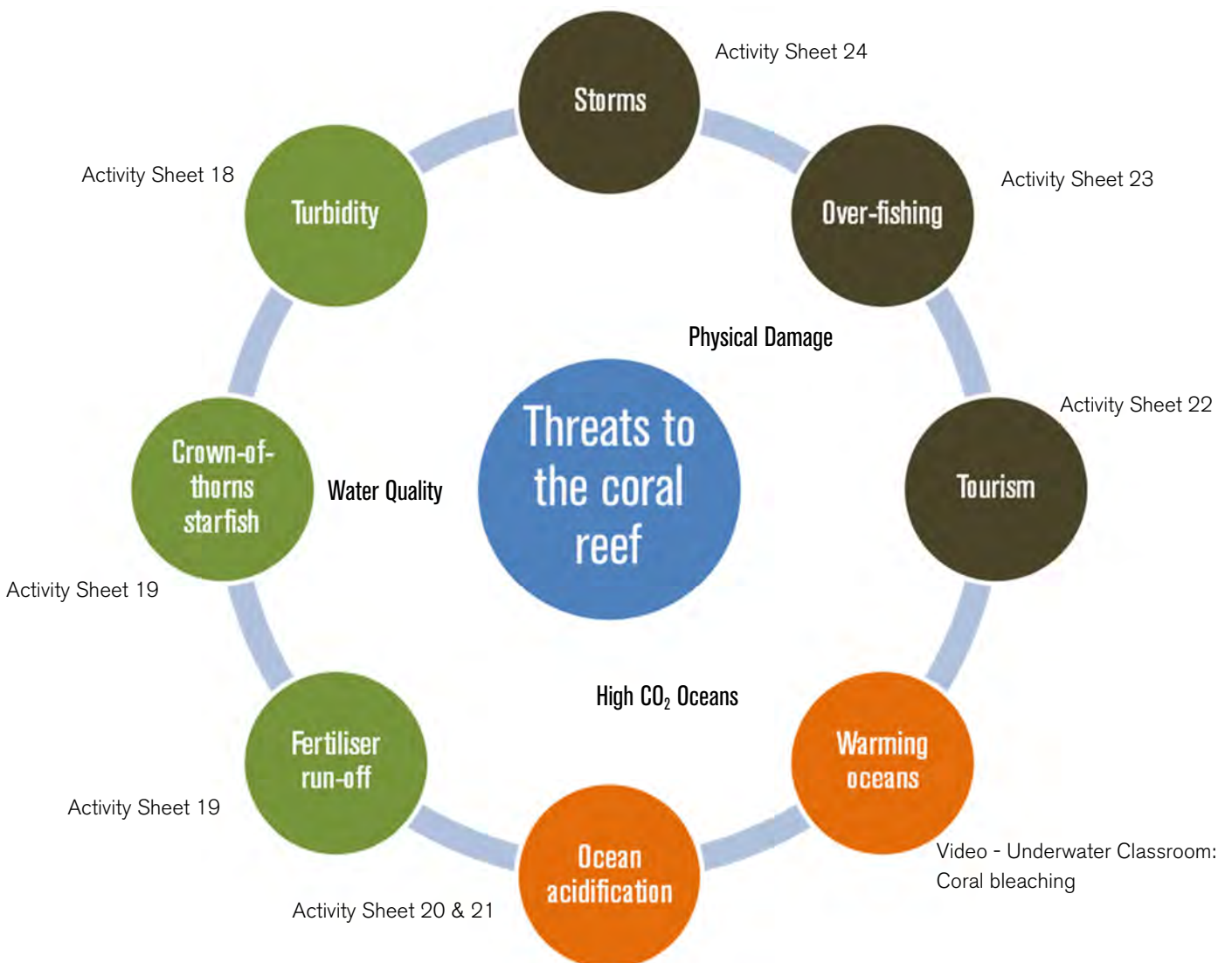
Dive master signature / stamp

ACTIVITY SHEET 17

Coral threats overview

Use the diagram below to select activities to learn about the different threats that coral ecosystems face. The threats have been grouped into three main areas:

- Effects of high CO₂, i.e. warming oceans and ocean acidification (see Fact Sheet 3)
- Water quality from land, i.e. turbidity and fertilizer / nutrient run-off (see Fact Sheet 4)
- Physical damage, i.e. from shipping, storms, over-fishing and tourism (see Fact Sheet 5)



ACTIVITY SHEET 18a

Cloudy waters

Summary

The Secchi disk was created in 1865 by an Italian priest and scientist, Pietro Angelo Secchi, to measure water transparency in oceans, lakes and ponds.

In this experiment, students will make and use a Secchi disk to test the transparency of two water samples, and will be asked to consider how transparency could affect corals.

Traditionally, plain white Secchi disks are used for ocean work, and black and white for inland waters and there are guidelines for the size and method of taking measurements (see these FAQs from the University of Plymouth for more details www1.plymouth.ac.uk/marine/secchidisk/Pages/FAQ.aspx)

Preparation

To make a Secchi disk for classroom use, you will need:

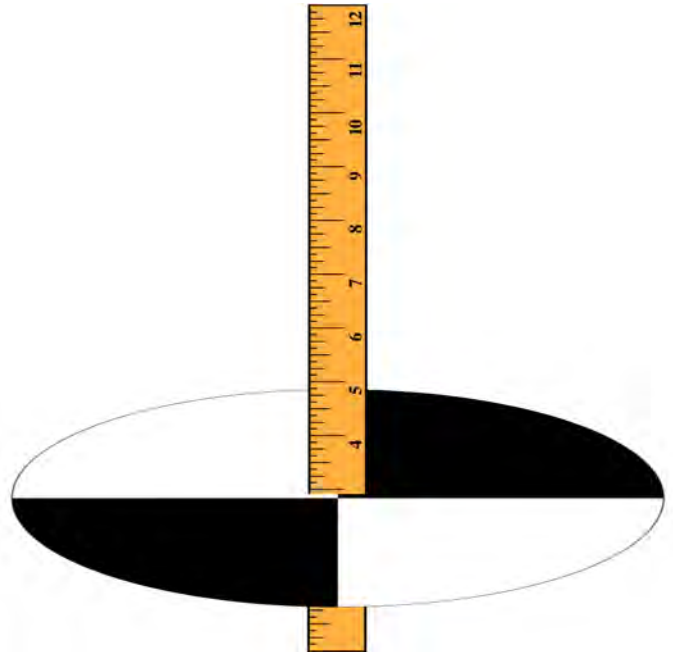
- Piece of white plastic (e.g. the lid of margarine or ice cream tub)
- Scissors
- Waterproof tape
- Marker pen
- Ruler

For the experiment you will need:

- 1 large container (e.g. buckets)
- Some sediment (e.g. soil)

Making the Secchi disk

1. Draw a circle (10cm-15cm) on the plastic lid and cut around the line, so that you have a plain disk.
2. Draw a cross on the topside of your disk and fill in two quarters, to match the pattern in the diagram.
3. Cut a slot in the middle of the disk and push the ruler through it, taping or sticking it in place.



Experiment

1. Fill the bucket with water.
2. Add one spoonful of soil to the bucket and stir in, making sure that the soil is suspended in the water, rather than sitting at the bottom.
3. Place the Secchi disk in the bucket and measure the depth at which you can no longer see the disk. It may be that you can touch the bottom of the bucket and still see the disk.
4. Make a note of this depth (write 'bottom' if you can still see the disk if the disk touches the bottom and you can still see the disk).
5. Repeat this process, adding a total of 10 spoonfuls of soil, making a note of the visible depth of the disk for each spoonful added.

Review

- How does the amount of soil/sediment affect turbidity?
- How might increased turbidity affect coral? Why is this the case?

ACTIVITY SHEET 18b

Turbidity alarm



Plume of sediment from a river moving towards the reef (Photo credit: NASA)

Summary

Turbidity is the name given to the cloudiness of water. In this experiment, students are going to design, make and test a turbidity alarm for coral reefs.

Equipment needed:

- Buzzer
- Cell
- Light dependent resistor
- Wiring
- Clear container
- Soil
- Measuring cylinder

Overview

Increased turbidity in the water can harm corals in two ways. More turbid water can prevent light from reaching the coral. This reduces the amount of energy that corals can receive from photosynthesis. The second is that the sediment can settle over coral reefs, smothering the coral.

The mission here is to create an electronic 'turbidity alarm' that will sound when the water becomes too cloudy and may harm corals.

Activity

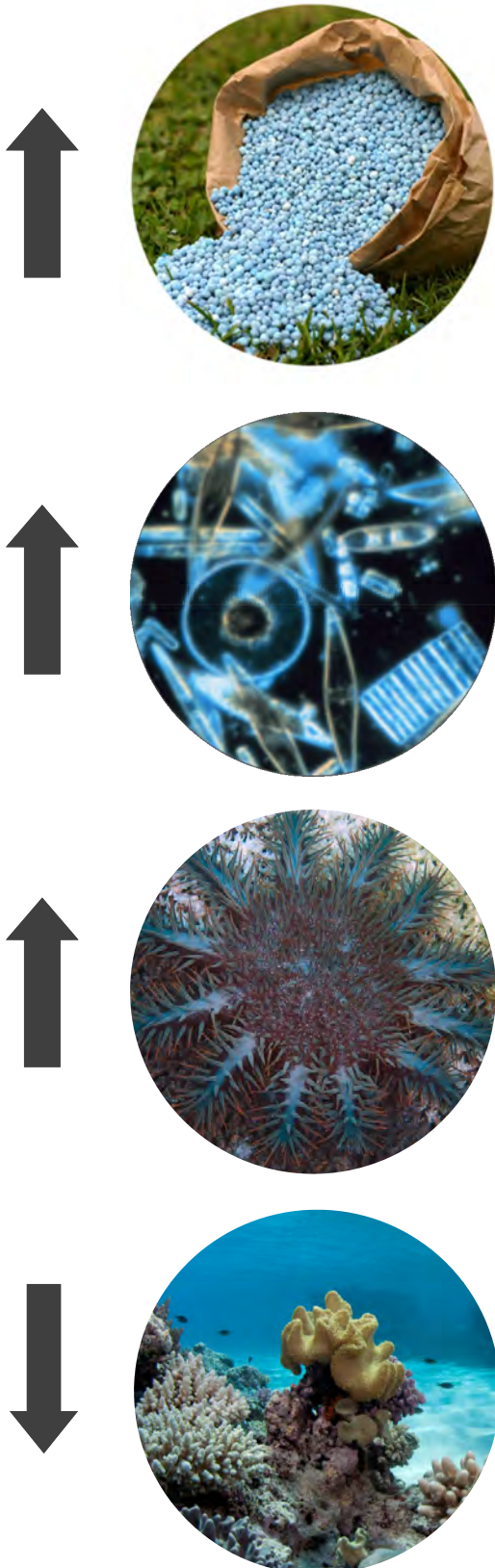
1. Design a circuit for the alarm system using the components that you have.
2. Test the sensitivity of your new alarm system by placing your sensor underneath the clear container filled with water (you may need to prop it up on blocks).
3. Add small measured amounts of soil to the water and stir it in. Continue this process gradually until the alarm sounds.

Discussion

- Why does the buzzer sound?
- What is the relation between turbidity and coral health?
- How could this system be used to prevent further harm to coral reefs?

ACTIVITY SHEET 19

Fertiliser and Starfish



An increase in the use of chemical fertilisers for crops means that more of these chemicals are being washed into the sea from farms near the coast. This increase in fertilisers in the sea causes an increase in the amount of algae.

The crown-of-thorns starfish depends on algae when it is in its larval stage. The more algae, the more crown-of-thorns larvae will survive. Scientists are showing clear links between outbreaks of crown-of-thorns starfish and the amount of algae available.

The crown-of-thorns starfish is a specialist coral predator. So the more there are, the less coral coverage there will be. The Australian Institute of Marine Science estimate that 42% of the loss of the coral cover between 1985 and 2012 is because of the crown-of-thorns starfish.

ACTIVITY SHEET 20

Ocean acidification in a cup



Dr Pim Bongaerts studies an ocean acidification experiment at the Heron Island Research Station

Summary

This experiment shows how water becomes more acidic when carbon dioxide is bubbled through it. It also references respiration. It is best to use distilled water rather than tap water, as tap water can be quite hard (i.e. containing a lot of dissolved calcium carbonate). This hardness can slow down the acidification process as the carbonate ions attempt to buffer it.

You can create a seawater substitute by dissolving 32g of table salt in 1 litre of water. This represents the average salinity of the oceans.

Equipment needed per group of 2:

- Boiling tube or beaker containing 100ml distilled water – labeled 'fresh water'
- Boiling tube or beaker containing 100ml 'sea water' – labeled 'sea water'
- 2 straws
- pH indicator (either Universal Indicator or Hydrogen Carbonate Indicator) or pH meter
- Watch or timer

Overview

Students will start by estimating the pH of the two types of water and creating a hypothesis about what will happen when they blow through the solutions.

Students will record how the pH of the two types of water changes as they blow through the straw into the waters for 3 minutes at 30 second intervals.

A plenary activity can be based around what changes they have observed and why they think that this has happened.

Video

A video demonstration of this activity can be found online. Go to media.digitalexplorer.com and search for 'Ocean acidification in a cup'.

ACTIVITY SHEET 21

Dissolving 'coral' in vinegar



Healthy fire coral compared with bleached coral. This photo was taken by the Shallow Reef Survey team in Bermuda.

Summary

This activity demonstrates the ability of an acidic substance (in this case vinegar) to dissolve coral reefs

Equipment needed per group:

- 200 ml of clear vinegar (such as malt vinegar or other pickling vinegar)
- Chalk (i.e. CaCO_3)
- Appropriate container or beaker

Instructions

1. Pour the vinegar into the container.
2. Add the chalk to the container and observe what takes place.
3. Discuss with pupils what is happening to the chalk as it reacts with the vinegar.

The science

Malt vinegar contains acetic acid.

The acid reacts with the calcium carbonate in the chalk to form calcium ions, water and carbon dioxide.



Discussion questions

1. What is produced from the dissolution of coral in the vinegar?
2. Which compounds cause this reaction?
3. How might a more acidic ocean affect organisms that rely on calcium carbonate for protection?
4. How might it affect organisms that depend on these animals for food?

Notes

The current problem that ocean acidification poses to hard corals and other organisms is that it makes it more difficult to create their carbonate structures. If more energy is being used to make these structures, then less is available for other processes such as reproduction and growth. Polyps may also become more susceptible to other threats such as disease.

Video

A video demonstration of this activity can be found online. Go to media.digitalexplorer.com and search for 'Ocean acidification in a cup'. The 'Coral in vinegar' demonstration starts at time marker 3:56.

ACTIVITY SHEET 22

Tourism poster



Lady Elliot Island - a tourist resort on the Great Barrier Reef

Below are a selection of rules for tourists on the Great Barrier Reef:

- Select the most important ones and create a poster for display at a resort
- Give reasons for your selection

Don't touch anything

Watch your fins

No souvenirs

No litter

Maintain buoyancy

Don't feed fish

Strap down your gauges and spare regulator

Don't ride sea turtles and manta rays

ACTIVITY SHEET 23

Overfishing

Overfishing has two impacts on the reef. Various fish species from large sharks to smaller and tasty coral trout are directly affected by fishing. However, overfishing also affects the balance of the whole coral reef ecosystem.

When there are enough fish (1,000kg - 1,500kg in an area measuring 100 metres x 100 metres), the coral reef is healthy. When this number decreases because of overfishing, the health of the reef is affected. This is because there are no longer enough fish to eat the algae and sea urchins.



Discussion questions

1. How does overfishing affect the reef?
2. What weight of fish per hectare (an area measuring 100 metres x 100 metres) is best for a healthy reef?
3. How can the reef be protected from overfishing?

Scientists found that every hectare (an area measuring 100 metres x 100 metres) has between 1,000kg and 1,500kg of fish. This amount of fish was most often found in reef areas where there were fishing rules, such as protected reefs with no-fishing zones.

When the amount of fish fell to 850kg per hectare, there was an increase in the amount of algae and a decrease in the amount of coral.

When the amount of fish fell to 300kg per hectare, there was a large drop in biodiversity. There is also a large decline in the number of herbivorous fish, meaning that less algae is eaten. The algae starts to take over the coral.

Below 150kg of fish per hectare, there was a collapse of the coral reef and coral growth and cover rapidly descend to zero.

These figures are based on research by the ARC Centre of Excellence for Coral Reef Studies at James Cook University compiled surveys of over 300 reef sites

ACTIVITY SHEET 24

Storm damage



Storms can cause widespread physical damage on the reef and are a natural occurrence. One of the most powerful cyclones on record was Cyclone Yasi in the summer of 2010-11. It was responsible for huge damage to the reef as can be seen in the photograph above.

Coral reefs do recover from such events and regrow naturally to their previous condition. However, climate scientists predict that there will be an increased frequency of these extreme weather events because of climate change.

This means that the coral reef will have less time to recover in between powerful cyclones.

Discussion questions

1. How do storms affect the reef?
2. Why does the frequency of storms matter to a healthy reef?
3. What changes could be made to decrease the chance of more frequent and powerful storms affecting the reef?

ACTIVITY SHEET 25

Threats overview

Threat	Effect on the reef	Reef unfriendly activity	Reef friendly activity
Fertiliser run off	Increased growth of crown of thorns star fish which damage reef	Continued use of fertilisers near shore	Decrease use of fertilisers Clean the river water before it reaches the ocean

ACTIVITY SHEET 26



Dive #6	Various sites	Coordinates: ° ' " S, ° ' " E
Name		Date

Time	Weather	Temp. air/sea	Max. depth	Bottom time
In _____ Out _____	☀ ☁ ☁ ☔ <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>	🌡 _____ °C 🌡 _____ °C	↓ _____ m	⌚ _____ min

Buddy signature

Dive master signature / stamp

ACTIVITY SHEET 27

Storyboard template



CAPTION:



CAPTION:



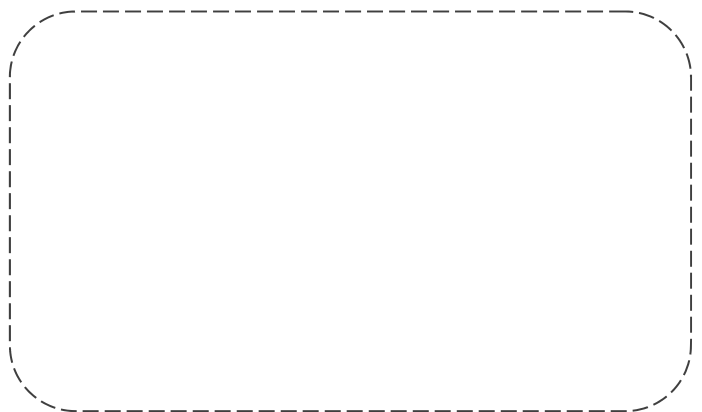
CAPTION:



CAPTION:



CAPTION:



CAPTION:

ACTIVITY SHEET 28

Article template

Coral Reef News

Headline

By:

Picture or photo

ACTIVITY SHEET 29

Report template

Create a detailed A2 poster to show what life is like on the reef now and how it could be in the future. Use this sheet to help you plan your poster.

Now:

What life can be found on the reef?

Coral reef food web & information about the interdependence on the reef

Threats:

The future:

Possible

Probable

Preferable

FACT SHEET 01

The Great Barrier Reef



An underwater panorama taken as part of the test dives during the 2012 Catlin Seaview Survey.

This panorama was taken at Lady Elliot Island and features on Google Maps - google.com/help/maps/streetview/gallery/ocean/lady-elliott-island.html

- One of the few biological structures visible from space, the Great Barrier Reef stretches over 2,300 km (1,430 miles) and began life about 600,000 years ago.
- It is home to more than 400 types of coral and 2,000 species of fish.
- Corals reefs globally occupy less than 1% of the ocean, but support 25% of all marine life.
- 30% of all reefs are estimated to be severely damaged, and close to 60% may be lost by 2030.
- Taking into account tourism, food and jobs, tropical coral reefs are also very valuable economically, yielding more than US\$30 billion annually according to the World Meteorological Society. According to the US National Oceanic Atmospheric Administration (NOAA) they are worth even more - US\$375 billion.
- Hard corals and other organisms which secrete calcium carbonate contribute most to reef building. The reef needs to be structurally strong to cope with differing light and sediment conditions as well as wave and storm power.
- Both hard and soft reef-building corals can only exist within a limited range of conditions, needing light and an optimum temperature and salinity range. The ideal conditions for coral reef growth are water temperatures of 26°C to 27°C, and salinity of 36 parts per thousand. If the water is clear, corals can grow to a depth of over 100m. This is reduced to 8m if the water is turbid or cloudy.
- Other species living on the reef, such as clams and parrotfish eat corals, contributing to bioerosion, so there is a natural reef cycle of production and destruction.
- This cycle can be disturbed by upsetting the ecological balance. The threats to coral reefs include:
 - increasing storm frequency and intensity
 - increased frequency and duration of coral bleaching, brought about by sustained and sudden rises in sea temperature
 - increased acidity - the pH is dropping due to the amount of CO₂ absorbed from the atmosphere into the ocean
 - changes in nutrient input (increase or decrease) which favour some species over others
 - overfishing or damage to habitats by the fishing industry
 - increased sedimentation and eutrophication due to human industrial activity including agricultural and commercial pollution and deforestation
 - littering, pollution and habitat destruction from tourism
- Most of the threats above are caused directly or indirectly

FACT SHEET 02

Catlin Seaview Survey



The SVII camera being used to create a photographic survey of the Great Barrier Reef.

This technological breakthrough will make over 75,000 images of the coral reef available to scientists globally through the Global Reef Record.

See immersive panoramas of the coral reef at is.gd/virtualdive

Our oceans are the primary source of protein for over 1 billion people. They produce 50% of the oxygen we breathe. They regulate the climate and make our planet habitable. They are integral to our very survival, yet for all of our reliance, they largely remain as they have always done, out of sight and out of mind - 95% hasn't even been seen by human eyes.

Understanding our oceans has never been more critical. Scientists are telling us they are in a rapid state of decline. However, monitoring change in ocean ecosystems has always been a challenge as there simply hasn't been the technology to conduct much research on a meaningful scale.

This is changing. The Catlin Seaview Survey is a series of scientific expeditions around the globe using specially designed technology such as underwater tablets and 360° cameras, to record and reveal the world's oceans and reefs like never before. It aims to be an independent, baseline, scientific study to enable everyone to see change over time and plan for the future.

Working with scientists from the University of Queensland, the Survey began in 2012 with an icon of the ocean, the Great Barrier Reef, off Australia. Two expedition teams visited 30 representative reefs along the Great Barrier Reef and Coral Sea, to research and record the shallow reef (0-12m) as well as the relatively unknown deep reef (from 30-125m).

More than 105,000 stitched images were taken and analysed to produce an important 'state of the reef' benchmark. This data is published in the Global Reef Record, and will be made freely available to scientists around the world to monitor changes in marine environments. It also provides valuable insights for more

than 50 nations worldwide that have significant coral reefs along their coastlines.

The survey is also being undertaken in close collaboration with the Great Barrier Reef Marine Park Authority to ensure that scientific data from both deep and shallow reef ecosystems can feed directly back into marine park management.

The deep reef is a little-explored environment. With poor light and issues of accessibility, there is little scientific knowledge relating to the reefs that lie between 30m and 100m depth. Yet this mesophotic or 'twilight zone' could well prove a critical element in the survival of coral reefs under rapid environmental change.

A combination of specialist deep sea divers and remotely operated vehicles (ROVs) will undertake a comprehensive survey of the coral communities at depth. Scientists utilise the same automated image recognition techniques as the shallow reef team. Accurate geo-positioning systems on the ROVs allow the photographic surveys to be repeated to monitor change over time. Temperature data loggers will be deployed to provide better insight into the ability for the deep reef to act as a refuge from increased temperatures experienced by coral species on the shallow reef.

For the general public and education audiences, the Catlin Seaview Survey brings unprecedented accessibility to our oceans through 'virtual diving.' A partnership with Google is helping to share this experience with millions across the world.

For more information, visit: www.catlinseaviewsurvey.com

FACT SHEET 03

Coral in a high CO₂ world

Increased atmospheric carbon dioxide has two impacts on coral ecosystems. Climate change caused by increased greenhouse gases including carbon dioxide contributes to ocean warming. Over 25% of the carbon dioxide emitted through human activity is absorbed into the ocean, undergoing the chemical reaction outlined above. This process is known as ocean acidification.

Warming oceans

Coral reef species live within a relatively small temperature margin. Although they are found through a sea temperature range of 18°C to 36°C, most are found in waters at about 26°C to 27°C.

In each location that coral reefs are found, corals have adapted to the 'normal' temperature in that area and any dramatic and sudden changes in sea temperature can cause acute stress to coral polyps.

This stress affects the nutrient exchange between the polyps and zooxanthellae (or 'zoox' for short), the tiny algae that live within the coral polyps' tissue and supply it with energy.

In the worst cases, this can lead to the zooxanthellae leaving the polyps. As the 'zoox' are responsible for giving the coral their colour, when they leave the coral becomes white. This process is known as 'coral bleaching'.



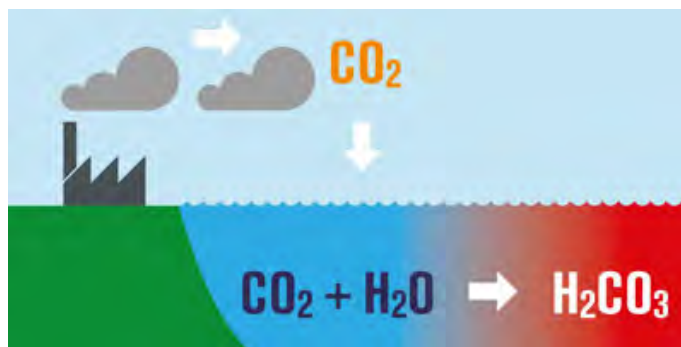
This bleaching can in turn lead to coral mortality as the 'zoox' provide between 70% and 90% of the energy for the coral polyps.

Coral bleaching occurs when the sea temperature rises by ~2°C, and this change is sustained for a period of 4-6 weeks.

This level of temperature change has become more frequent on the Great Barrier Reef and is associated with El Niño events. Particularly severe episodes occurred in 1998 and 2002 with over 50% of coral reefs on the Great Barrier Reef bleached to some extent in 2002.

Scientists are investigating the relationship between the current trends in climate change, El Niño events and the rate at which corals can adapt to temperature change to see what fate lies ahead for the world's coral reefs in the coming decades.

Ocean acidification



Ocean acidification is the process by which atmospheric carbon dioxide is dissolved in the oceans and through a chemical process becomes carbonic acid. This lowers the pH of the oceans, giving it the name 'ocean acidification'.

One of the problems associated with ocean acidification is that it affects the balance of carbonate ions in the oceans. These ions are the chemical building blocks used by a number of organisms to create shells and structures, including corals, which use carbonate ions to make their amazing structures.

The current problem that ocean acidification poses to hard corals and other organisms is that it makes life more difficult to make their carbonate structures. If more energy is being used to create these structures, then less is being used for other processes like reproduction and growth. Polyps may also become more susceptible to other threats such as disease.

FACT SHEET 04

Coral and water quality



Land run-off

Land run-off is the process where soil sediments, nutrients and chemicals are washed into the sea from the land. The amount of land run-off has increased because of changes in land use, including deforestation, land clearing for agriculture and urbanisation.

The change in the weather patterns in Australia have also contributed. Australia is experiencing periods of drought, followed by periods of intense rainfall.

An example of this is the increase of cattle farming in eastern Australia. Trees are cut down to make way for cattle. Their hooves break down the ground into dust, which is worsened by dry weather. All this dusty soil, is then washed away during periods of sudden rainfall.

There are several problems associated with land run-off that affect the Great Barrier Reef. The first is connected to the amount of soil in the water being washed out over the reef. This increases turbidity and sedimentation.

Turbidity is the measure of the cloudiness of the water and if the water is cloudy, less light can get through to organisms that need sunlight for energy. This includes the coral zooxanthellae, which give corals up to 90% of their energy. Sedimentation is when the soil settles on the bottom of the reef and can smother coral and other reef organisms.

Other nutrients in the run-off include phosphates and nitrates used as fertilisers. These help to increase algal growth on the reef, sometimes tipping the balance in favour of algae over coral. These nutrients have also been blamed for the destructive outbreaks of Crown-of-thorns starfish.

Lastly, pollutants such as herbicides used on farms can disrupt photosynthesis in seaweed, seagrass, red coralline algae, corals and others.

Crown-of-thorns starfish

The Crown-of-thorns starfish has been responsible for some of the worst damage to coral on the Great Barrier Reef in recent years. Research by the Australian Institute of Marine Science blames Crown-of-thorns starfish for 42% of the loss in coral cover between 1985 and 2012.

This starfish is unusual in that it is a specialist corallivore. The Crown-of-thorns starfish wraps itself around the coral structure and then throws up its stomach over the surface of the coral.



Digestive juices dissolve the polyps which are then absorbed as food.

Covered in poisonous spines, the Crown-of-thorns starfish has few natural predators. Some species of fish and the Triton's trumpet snail do eat this starfish, but their numbers are not sufficient to control outbreaks. Even the eggs contain a toxin, preventing them from being eaten by fish.

A number of reasons have been given for the increase in frequency and severity of Crown-of-thorns outbreaks:

- overfishing of natural predators such as Triton's trumpet
- that this is a natural phenomenon
- increased nutrients from land run-off has led to more food for the Crown-of-thorns larvae

Recent research gives strong support to the theory that run-off into lagoons contributes to these outbreaks.

FACT SHEET 05

Human activity on the reef



Overfishing

During the 19th and early 20th centuries, the Great Barrier Reef supported large commercial fisheries for export, including for sea cucumbers and turtles. Most of these fisheries have now collapsed or are no longer commercially viable.

Overfishing of large species in tropical waters has had an impact on their numbers. Whales, dugongs, turtles and sharks are now all severely depleted worldwide. The population of dugongs on the Great Barrier Reef has declined by more than 90% in the past 30 years and they are still the target of illegal fishing.

Larger carnivorous species such as groupers and snappers have also been affected on the Great Barrier Reef. The level of overfishing is fairly low compared to other reefs, but even so, the biomass (total weight) of larger species has been reduced by 4-5 times on fished reefs compared to nearby reefs protected by 'No-Take Areas' (NTAs).

Overfishing does not just affect those species directly targeted but also affects the balance of the ecosystem as a whole. The removal of carnivorous species has led to unsustainable levels of sea urchins in some areas.

Conservation methods such as NTAs help to maintain the balance of life on the coral reef, and healthy populations of herbivorous fish assist in preventing seaweed blooms, allowing corals to regrow after a disturbance.

Recreational impacts

The Great Barrier Reef contributes significantly to the Australian economy. In 2006-07, it was estimated that the value of Great Barrier Reef tourism was \$5.1 billion. The tourism industry generates 66,000 jobs and brings over 1.9 million visitors to the Great Barrier Reef each year.

In the 1950s and 1960s, tourism was largely unknown. There were only 12 tour operators on the Great Barrier Reef in 1968,

but this increased rapidly with 187 operators by 1980 and 742 in 1998.

This sudden growth has meant that tourism activity was unregulated and had a negative impact on the reef ecosystem, through:

- anchor damage to reefs
- boat collisions with large animals
- fin damage to coral from scuba divers
- trampling and littering
- sewage and pollution from hotels, boats and resorts

While these problems do still exist to an extent, they present far less of an impact now. The Great Barrier Reef Marine Park Authority has created zoning maps, showing what activities can take place in the different areas of the reef.

The reef tourism industry now plays a major role in promoting responsible activities by visitors and initiatives such as the use of public moorings at popular sites have sharply reduced anchor damage.

Habitat loss

The reef forming corals on the Great Barrier Reef form the habitat for much of the life found in this region, meaning that threats to the coral harm the ecosystem as a whole.

Coastal developments, urbanisation and other factors such as industrialisation and shipping in coastal areas pose a threat to life in the Great Barrier reef region.

Trawlers can damage patches of seagrass, used as food by animals such as sea turtles and dugongs. The nesting sites of a variety of turtle species are vulnerable. Turtles return to the same beach where they were born, meaning that any developments on these beaches will affect their reproductive capacity.

In some cases, lights on beaches from coastal resorts have disorientated hatchling turtles, which use the moon to guide them out to sea, leaving them stranded.

Industrialisation and increased shipping along the eastern coast of Australia also contribute to pollution and sedimentation on reefs close to the mainland.

Historical photographs of mainland reefs show vibrant strands of coral along the Queensland coast that are increasingly degraded today.

FACT SHEET 06

'Heading home'

Marine biologist, Anjani Ganase from the University of Queensland, describes what it is like returning from the Shallow Reef Survey



It's a strange feeling coming to the end of a trip out on the Shallow Reef Survey. Often the different legs of the survey run into one another, so it's off one boat and onto another, or just a few days in port to stock up on supplies.

When you're at sea, you don't meet any other people except for the small team and crew you're working with. The only sights are the sea and the coral reefs that we've been surveying. It might sound like it gets boring, but it's the complete opposite.

The team become like family, and although it's hard work, there's still time for laughter and some fun. I can't say that I am going to miss sitting up to the early hours of the morning making sure that the data has been properly logged and recorded.

The routine of the expedition makes sense because the work we are doing is important. It's an amazing privilege to be able to see so much of our underwater world. Some of the reefs that we have seen are absolutely breathtaking.

Each dive is like a mini-adventure. You never know what you are

going to find. One day might be scary being surrounded by sharks, and on another you see all kinds of different fish and other life on the reef.

There are dives when I feel sad. The condition of the reef in many areas is not what it was 50 years ago. You can be going along underwater with the SVII camera and all you see is the skeletons of the reef, these big dead structures. But there is hope, and that is why I do this job. There is a future for coral, but we all have to change to make that future happen.

When I am back on land, I do miss the closeness of the team, that camaraderie. On the first night in bed back on land, I still feel the rocking motion of the sea!

It's a simple life at sea, but one that I love. I wouldn't have it any other way.

You can follow the Anjani and the rest of the University of Queensland team at: globalchange.org.au/catlinseaviewsurvey/

USEFUL WEBSITES

The links below provide further background information and images on oceans topics.

Catlin Seaview Survey

www.catlinseaviewsurvey.com

Main website for the project, which includes links to multimedia content, virtual dives and the story of the survey so far

Global Change Institute, University of Queensland

www.globalchange.org.au/catlinseaviewsurvey/

Blog by the expedition science team from the Global Change Institute at the University of Queensland

BBC Nature Reef section

www.bbc.co.uk/nature/habitats/Reef

Short videos, photographs and more on coral reefs from the BBC Nature archive

Catlin Explorers

www.catlinexplorers.com/

Family-friendly and child-focused website on the coral reef and Arctic from expedition sponsor Catlin

National Geographic Coral Collection

education.nationalgeographic.co.uk/education/topics/coral-reefs/?ar_a=1

National Geographic Education's collection of resources on the coral reef

CNN's The wonderful world of coral reefs

edition.cnn.com/2013/03/27/asia/gallery/coral-reef-infographic

Useful range of coral reef infographics from CNN's Going Green team

ARKive Coral Reef Conservation

www.arkive.org/coral-reef-conservation/

Useful range of photos and species list from ARKive, also have a look at their education section

NOAA Ocean Service Education

oceanservice.noaa.gov/education/tutorial_corals/

A list of useful coral education resources from the US-based NOAA (National Oceanic and Atmospheric Administration)

reefED

www.reefed.edu.au

Lesson and resources for teachers and students developed by the Great Barrier Reef Marine Park Authority

Reef Relief

www.reefrelief.org/learn/educational-material/

Resources from teachers from coral reef protection NGO, Reef Relief, and some good ideas on reef friendly living

Global Dimension

www.globaldimension.org.uk/news/item/17247

A useful article on the Global Dimension website with a long list of resources on teaching about coral reefs

PHOTO CREDITS

All photos courtesy of Catlin Seaview Survey, unless stated below.

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22	Deep ocean	NOAA
22	Anglerfish	Javontaevious
22	Sea otter	NPS
22	Lugworm	Digital Explorer
22	Green turtle	Brocken Inaglory
22	Tuna	Ocean2012
22	Sea anemone	Fæ
24	Dive signs	Peter Southwood
26	Zooxanthellae	Emma Kennedy / University of Exeter
26	Coral reef	NASA
26	Reef mosaic	NASA
26	Coral polyp	OIST
30	Coral polyps	NOAA
42	Diatoms	NOAA
43	Mesocosms	Digital Explorer
44	Bleached coral	Digital Explorer
47	Storm damage	AIMS Long-term Monitoring Team
55	Ocean acidification diagram	Digital Explorer
55	Bleached coral	Great Barrier Reef Marine Park Authority
56	Land run-off	NASA
57	Shipping terminal	Digital Explorer

CATLIN EXPLORERS

A DEEPER UNDERSTANDING

CATLIN
Underwriting Ambition

Catlin Explorers

From the frozen Arctic to the tropical coral reefs, Catlin Explorers is a programme designed to inspire children and families to learn about the changing world around us and understand better the environment in which we all live and depend.

It follows the adventures of the explorers and scientists of the Catlin Arctic Survey and Catlin Seaview Survey and is designed so that learning can be done at home, in a relaxed and less formal environment.

Case files

Explore the science behind the headlines through a series of case files. Each case file introduces you to a new issue concerned with climate change.

These case files will make you an expert on issues such as sea level rise, rising temperatures and extreme weather. How might some of these issues affect your home and family?

Fun Stuff

You'll also get a chance to have a go at ocean and environment themed word searches and puzzles, download wallpapers for the computer at home and catch up on the latest video updates from the explorers and scientists out on expeditions.

Explorer Missions*

If you really want to become a Catlin Explorer, you'll need some practice. Our series of missions includes science experiments, explorer training techniques and more.

Have a go at these with your family or friends and you'll definitely be on the way to becoming a real-life explorer yourself. Maybe one day you will join an expedition with some of the scientists and explorers that Catlin has been working with.

* Explorer Missions should be supervised by a responsible adult.

Link to insurance

Perhaps not surprisingly, people wonder why a company like Catlin is sponsoring scientific research into the Arctic and coral reefs.

The simple answer is that as an insurance company, Catlin needs to understand the risks that may impact its business. Catlin insures things like wind farms, livestock, crops, satellites, space rockets and power stations (and more), all of which are susceptible to the impacts of a changing climate. Its sponsorship of ocean science is of particular relevance. For example, changes to the oceans may increase the number and intensity of weather events, sea level rise could flood low lying cities or areas of farmland and ocean acidification will affect the marine food chain. By undertaking scientific research into Arctic sea-ice loss and coral reef health, Catlin is focusing on two areas of the world that can be described as key indicators of climate change.

Catlin Explorers therefore uses the insurance focus to help explain the nature and impact of climate change.

All the case files, fun stuff and missions can be found online at CatlinExplorers.com



