# Contents

# Applicable standards
## National Curriculum for England Key Stage 3

### KS3 Science

| Element of the Science Programme of Study | Lessons 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Biology** | | | | | | | |
| • Interactions and interdependencies (Relationships in an ecosystem) | ✓ | | ✓ | | | ✓ | |
| • The interdependence of organisms in an ecosystem | ✓ | | ✓ | | | | |
| • Genetics and evolution (Inheritance, chromosomes, DNA and genes) | | ✓ | | ✓ | ✓ | ✓ | |
| • Differences between species | | ✓ | | | | | |
| • Variation between species and between individuals of the same species meaning some organisms compete more successfully | | ✓ | | | | | |
| • Material cycles and energy (Photosynthesis) | | | ✓ | | | | |
| • Dependence of almost all life on Earth on the ability of photosynthetic organisms | | | ✓ | | | | |
| • Changes in the environment may leave individuals within a species less well adapted to compete successfully and reproduce, which in turn may lead to extinction | | | | ✓ | ✓ | ✓ | |
| • How organisms affect, and are affected by, their environment, including the accumulation of toxic materials | | | | | | ✓ | |
| **Physics** | | | | | | | |
| • Motion and forces (Pressure in fluids) | | | | | ✓ | | |
| • Pressure in liquids, increasing with depth | | | | | ✓ | | |
| **Working scientifically** | | | | | | | |
| • Use appropriate techniques, apparatus, and materials during fieldwork and laboratory work, paying attention to health and safety | ✓ | | | | ✓ | | |
| • Apply sampling techniques | | ✓ | | | | | |
| • Make predictions using scientific knowledge and understanding | | | | | ✓ | ✓ | |
| • Make and record observations and measurements | | | | | ✓ | | |
| • Select, plan and carry out the most appropriate types of scientific enquiries to test predictions | | | | | ✓ | | |
| • Pay attention to objectivity and concern for accuracy, precision, repeatability and reproducibility | | | | | | ✓ | |
| • Understand that scientific methods and theories develop as earlier explanations are modified to take account of new evidence and ideas, together with the importance of publishing results and peer review | | | | | | ✓ | |
| • Ask questions and develop a line of enquiry based on observations of the real world, alongside prior knowledge and experience | | | | | | ✓ | |
| • Present observations and data using appropriate methods and draw conclusions | | | | | | ✓ | |

# Applicable standards

## National Curriculum for England Key Stage 3

### KS3 Science (continued)

| Element of the Science Programme of Study | Lessons 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Working scientifically** | | | | | | | |
| • Present reasoned explanations | | | | | | ✓ | |
| • Evaluate data | | | | | | ✓ | |
| • Identify further questions arising from their results | | | | | | ✓ | |

# Applicable standards
## Next Generation Science Standards

### Grade 5-8 Science

| Element of the curriculum | Lessons 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Life Sciences** | | | | | | | |
| **MS-LS1-4.** Use argument based on empirical evidence and scientific reasoning to support an explanation for how characteristic animal behaviors and specialized plant structures affect the probability of successful reproduction of animals and plants respectively. | | ✓ | ✓ | | | | |
| **MS-LS1-5.** Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms. | | ✓ | ✓ | | | | |
| **MS-LS1-6.** Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms. | | | ✓ | | | | |
| **MS-LS1-7.** Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism. | | | ✓ | | | | |
| **MS-LS2-1.** Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. | ✓ | | ✓ | | | ✓ | |
| **MS-LS2-2.** Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems. | ✓ | | ✓ | | | ✓ | |
| **MS-LS2-3.** Develop a model to describe the cycling of matter and flow of energy among living and non-living parts of an ecosystem. | | | ✓ | | | | |
| **MS-LS2-4.** Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. | | | ✓ | | | | |
| **MS-LS2-5.** Evaluate competing design solutions for maintaining biodiversity and ecosystem services. | | | ✓ | | | | |
| **MS-LS3-1.** Develop and use a model to describe why structural changes to genes (mutations) located on chromosomes may affect proteins and may result in harmful, beneficial, or neutral effects to the structure and function of the organism. | | | | ✓ | ✓ | ✓ | |

# Applicable standards

## Next Generation Science Standards

| **Grade 5-8 Science**<br>**Element of the curriculum** | Lessons 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| **Life Sciences** | | | | | | | |
| **MS-LS4-2.**<br>Apply scientific ideas to construct an explanation for the anatomical similarities and differences among modern organisms and between modern and fossil organisms to infer evolutionary relationships. | | | | ✓ | ✓ | ✓ | |
| **MS-LS4-4.**<br>Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment. | | ✓ | | ✓ | ✓ | ✓ | |
| **MS-LS4-6.**<br>Use mathematical representations to support explanations of how natural selection may lead to increases and decreases of specific traits in populations over time. | | | | ✓ | ✓ | ✓ | |
| **Physical Science** | | | | | | | |
| **MS-PS1-4.**<br>Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed. | | | | | ✓ | | |
| **Science and Engineering Practices** | | | | | | | |
| • Asking questions | | | | | ✓ | ✓ | ✓ |
| • Developing and using models | | | | | ✓ | ✓ | ✓ |
| • Planning and carrying out investigations | | | | | ✓ | ✓ | ✓ |
| • Analyzing and interpreting data | | | | | ✓ | ✓ | ✓ |
| • Using mathematics | | | | | ✓ | ✓ | ✓ |
| • Constructing explanations | | | | | ✓ | ✓ | ✓ |
| • Engaging in argument from evidence | | | | | ✓ | ✓ | ✓ |
| • Obtaining, evaluating and communicating information | | | | | ✓ | ✓ | ✓ |

## Lesson 1: How do scientists explore underwater ecosystems?

### Overview

This lesson introduces students to the marine habitat and the wealth and diversity of life found in the ocean. Students will learn about how scientists explore underwater, going on their first classroom 'Dive' and learning some important dive skills.

### Learning outcomes

- Recognize the diversity and range of habitats and life in the ocean
- Use some of the dive skills needed to explore underwater
- Classify common species found on coral reefs

### Resources

**Slideshow 1:**
How do scientists explore underwater ecosystems?

**Student Sheet 1a:**
Video reflection

**Student Sheet 1b:**
Species card sort

**Student Sheet 1c:**
Dive log

**Video:**
Setting sail

**Video:**
Dive signs

**Google Map:**
Lady Elliot Island

**Subject Update:**
About: Catlin Seaview Survey

**Subject Update:**
How to: Quick start to 360VR in the classroom

**Subject Update:**
How to: Four ways to use 360VR in the classroom

## Lesson 2: How do scientists use classification in coral habitats?

### Overview

Coral reefs support 25% of all marine life on the planet. During this lesson, students will discover more about the coral ecosystem and about the different types of coral. They will then 'dive' on the Great Barrier Reef to undertake a coral survey, identifying the main coral types, distribution and abundance on two survey sites.

### Learning outcomes

- Identify the different habitat zones and describe differences in environmental conditions
- Use simple key to identify coral types
- Use survey techniques to compare coral distribution

### Resources

**Slideshow 2:**
How do scientists use classification in coral habitats?

**Student Sheet 2a:**
Coral reef scale

**Student Sheet 2b:**
Reef habitat zones

**Student Sheet 2c:**
Coral ID

**Student Sheet 2d:**
Dive log

**Video:**
Wonders of coral

**Gallery:**
Zones on the reef

**Gallery:**
Coral reef quadrat survey

## Lesson 3: How is energy transferred on the reef?

### Overview

In this lesson students will explore the interdependence of life on the reef and where different animals, plants and other organisms get their energy from through feeding and symbiosis. Students will learn about the different nature of primary production on the reef compared to terrestrial environments.

### Learning outcomes

- Describe the different techniques species use to get their energy
- Identify the range of primary producers in the ocean
- Create a food web describing interdependence of reef life

### Resources

**Slideshow 3:**
How is energy transferred on the reef?

**Activity Overview 3a:**
Coral feeding game

**Activity Overview 3b:**
Coral food web

**Student Sheet 3a:**
Coral species

**Student Sheet 3b:**
Dive log

**Video:**
Wall of mouths

**Video:**
Sea cucumbers

**Video:**
Reef shark

**Video:**
Coral feeding game

**Gallery:**
Coral life (advanced)

**Subject Update:**
About: Coral

## Lesson 4: How have reef specialists evolved and adapted?

### Overview

Different species have adapted to life on the coral reef in amazing and diverse ways. From sleeping in mucus bubbles, to flexible snakelike skeletons, life on the reef has had to find ingenious methods to find food and stay alive. The reef is also host to numerous examples of symbiosis and finding food and safety in the strangest of places, whether that be in a shark's mouth or 'vacuuming' the sandy seabed. In this lesson, students are challenged to create the ultimate reef organism.

### Learning outcomes

- Identify and describe different types of adaptation on the coral reef
- Create the ultimate coral animal, demonstrating an understanding of adaptation

### Resources

**Slideshow 4:**
How have reef specialists evolved?

**Student Sheet 4a:**
Ultimate coral animal

**Student Sheet 4b:**
Dive log

**Gallery:**
Coral life

**Gallery:**
Adaptation on the reef

**Subject Update:**
Learn more: Adaptation

## Lesson 5: How do forces affect deep coral exploration?

### Overview

The expedition also explored the deep reef down to 100 metres. Find out about water pressure, the use of special technology and how corals have adapted to life in this twilight zone.

### Learning outcomes

- Explain the relationship between water depth and pressure
- Describe the technology needed to explore the deep reef
- Investigate how corals adapt to lower light conditions

### Resources

**Slideshow 5:**
How do forces affect deep coral exploration?

**Activity Overview 5a:**
Under pressure

**Activity Overview 5b:**
Exploring deep coral

**Student Sheet 5a:**
Diving deeper

**Student Sheet 5b:**
Dive log

**Video:**
Monitoring the reef

**Video:**
Submarine science

**Video:**
Under pressure

**Subject Update:**
How to: Quick start to 360VR in the classroom

**Subject Update:**
How to: Four ways to use 360VR in the classroom

## Lesson 6: What is the effect of human impact on the reef?

### Overview

Students will consider the varied threats that the coral reef faces. These range from long-term environmental changes caused by increased atmospheric carbon dioxide, to changes in land use in coastal areas and the impact of fertilizer on a certain species of starfish. Students will be prompted to consider what changes could be made to ensure that there are healthy coral reefs well into the future.

### Learning outcomes

- Investigate the different factors affecting the coral reef
- Judge the impact of human activity on the coral reef
- Explain their own and others' views about environmental change

### Resources

**Slideshow 6:**
What is the effect of human impact on the reef?

**Activity Overview 6a:**
Cloudy waters

**Activity Overview 6b:**
Ocean acidification in a cup

**Activity Overview 6c:**
Dissolving 'coral' in vinegar

**Student Sheet 6a:**
Cloudy waters

**Student Sheet 6b:**
Ocean acidification in a cup

**Student Sheet 6c:**
Dissolving 'coral' in vinegar

**Student Sheet 6d:**
Threats overview

**Student Sheet 6e:**
Coral threats information sheets

**Video:**
Coral future

**Video:**
Sailing home

**Subject Update:**
Learn more: Coral threats overview

**Subject Update:**
Learn more: Coral and water quality

**Subject Update:**
Learn more: Human activity on the reef

**Subject Update:**
Learn more: Coral in a high $CO_2$ world

## Lesson 7: How do scientists share their findings?

### Overview

At the end of an expedition, teams create an expedition report to communicate their findings to a wider audience. This could take the form of a formal written report, a press release or a video. These outputs can be shared at an assembly, parents evening, with the local press or do send a selection through to Encounter Edu (info@encounteredu.com) so that we can post them on our website.

### Learning outcomes

- Communicate findings using primary and secondary sources
- Choose an appropriate format and style for a real purpose and audience
- Explain their own and others' views about environmental change

### Resources

**Slideshow 7:**
How do scientists share their finding?

**Subject Update:**
Learn more: Coral threats overview

**Subject Update:**
Learn more: Coral in a high $CO_2$ world

**Subject Update:**
Learn more: Coral and water quality

**Subject Update:**
Learn more: Human activity on the reef

# Teacher guidance

## Lesson activities

**Explain**
teacher exposition using slides or script to support

**Demonstration/watch**
students watch a demonstration or video

**Student activity**
activity for students to complete individually such as questions on a Student Sheet

**Group work**
activity for students to complete in pairs or small groups

**Whole class discussion**
teacher conducts a whole class discussion on a topic or as a plenary review

## Teacher ideas and guidance

**Assesment and feedback**
guidance to get the most from AfL (Assesment for Learning)

**Guidance**
further information on how to run an activity or learning step

**Idea**
optional idea to extend or differentiate an activity or learning step

**Information**
background or further information to guide an activity or explanation

**Technical**
specific ICT or practical hints and tips

## Health and safety

**Health and safety**
health and safety information on a specific activity

# How do scientists explore underwater ecosystems?

Age 11-14

60 minutes

## Curriculum links

- Understand the scale of coral reefs and the purpose of the XL Catlin Seaview Survey
- Identify the challenges scientist working underwater face
- Sort and classify species

## Resources

**Slideshow 1:** Underwater explorer

**Student Sheet 1a:** Video reflection

**Student Sheet 1b:** Species card sort

**Student Sheet 1c:** Dive log

**Video:** Setting sail

**Video:** Dive signs

**Google Map:** Lady Elliot Island

**Subject Update:** How to: Quick start to 360 VR in the classroom

**Subject Update:** How to: Four ways to use 360 VR in the classroom

## Lesson overview

Throughout this lesson students explore underwater habitats and begin to understand the importance of the XL Catlin Seaview Survey. Students consider why exploration of this kind can be challenging for humans and learn dive signs so they can communicate on their virtual dive. During the virtual dive students use 360 virtual reality to explore this dynamic environment, identifying some of the species that live there. Students go on to classify these species and record the findings of their first dive.

| Lesson steps | Learning outcomes |
|---|---|
| **1. What is the ocean habitat like? (10 mins)** Students are introduced to the coral ocean through a quiz to understand the scale and complexity of this ecosystem. | • Know that we live on a 'blue planet'<br>• Name a variety of ocean habitats and species that live there |
| **2. How is the baseline survey being created? (10 mins)** Students become familiar with the XL Catlin Seaview Survey and the scientific rational behind the exploration. | • Describe the XL Catlin Seaview Survey and its scientific aims |
| **3. How do scientists work underwater? (15 mins)** Students consider some of the challenges scientists face working in this environment and practice using dive signs to communicate. | • Understand the different techniques scientists use to work underwater |
| **4. What types of things are found on the reef? (15 mins)** Students go on a virtual dive and identify the species they encounter. These species are then classified. | • Carry out a virtual dive on the reef<br>• Identify common species found in the coral reef habitat |
| **5. Why is the Great Barrier Reef so important? (10mins)** Students complete a dive log, specifying the species they encountered on their virtual dive and summarising what the ocean habitat is like. | • Reflect on the importance of the Great Barrier Reef |

# TEACHER GUIDANCE 1 (page 1 of 2)

| Step | Guidance | Resources |
|---|---|---|
| **1**<br>10<br>mins | Step 1 introduces students to some basic ocean facts before embarking on a journey to understand the coral reef habitat.<br>· Use slide 2 to introduce learning outcomes.<br>· Ask students what they think the ocean habitat is like? Take some feedback.<br>· Use slides 2-14 to take students through the quiz.<br>· Use the quiz answers to emphasise the importance of the oceans and bring students to the realisation that we live on a blue planet, with the ocean covering 71% of the surface.<br>· Explain that the ocean is not one habitat but a variety of different habitats, just like it is on land.<br>· Use slides 15-19 to introduce students to the diversity of life and habitats in the ocean. | **Slideshow 1:**<br>Slides 1-19 |
| **2**<br>10<br>mins | Step 2 introduces students to the XL Catlin Seaview Survey. This is the research expedition on which Coral Oceans is based.<br>· Use slides 20-25 and watch Video: Setting sail to explain the mission.<br>· Show students Student Sheet 1a and explain that they will be learning about scientists and their work exploring the coral reef over the next few lessons. Students do not have to take notes on first viewing.<br>· Hand out copies of Student Sheet 1a individually, in pairs or small groups depending on the set up of your class.<br>· Ask students to complete as much of the Student Sheet 1a as they can.<br>· Watch the video again, asking students to complete more of the video reflection questions.<br>· Conduct a review as a whole class discussion.<br>· If necessary go over terms such as 'baseline' and 'transect', so that students understand the scientific rationale for the survey.<br>· Introduce students to their dive mission for the lesson, to find out what species are found on the Great Barrier Reef. | **Slideshow 1:**<br>Slides 20-25<br>**Student Sheet 1a:**<br>Video reflection<br>**Video:**<br>Setting sail |

| Step | Guidance | Resources |
|---|---|---|
| **3**<br>15<br>mins | Step 3 asks students to consider the challenges for scientists working underwater.<br>· Discuss the challenges scientists face working under water, such as using scuba gear and communication. Emphasise how different this is from working in a lab and doing land-based fieldwork.<br>· Watch Video: Dive signs to introduce students to the dive signs used to communicate underwater and encourage students to join in.<br>· Use slide 28 for students to practice. | **Slideshow 1:**<br>Slide 26-28<br>**Video:**<br>Dive signs |
| **4**<br>15<br>mins | Step 4 takes students on a virtual dive to identify different species.<br>· Using slides 29-40 point out some of the species students might see on their dive.<br>· Hand out Student Sheet 1b (which has been cut into cards), one set per group of six and allow students a few minutes to look through them and arrange them so they can reference them during their dive.<br>· See Subject Updates for options of how to run this part of the lesson. Demonstrate how to navigate the virtual dive using slide 41.<br>· Instruct students to begin and encourage them to identify some of living things that they see using the species cards.<br>· Students share what they have spotted on their virtual dive.<br>· Next ask students to sort the species cards to learn about the variety of species found on the reef and classify them. Students can choose their own classifications, or you may wish to specify certain criteria. Use sticky-notes to organise categories.<br>· Differentiate this activity depending on the ability of the class using an appropriate level of taxonomy. | **Slideshow 1:**<br>Slides 29-41<br>**Student Sheet 1b:**<br>Species card sort<br>**Google Map:**<br>Lady Elliot Island<br>**Subject Update:**<br>How to: Quick start to 360 VR in the classroom<br>**Subject Update:**<br>How to: Four ways to use 360 VR in the classroom |
| **5**<br>10<br>mins | In step 5 students complete their dive logs to include the range of species identified (with appropriate classification).<br>· Instruct students to record what life they saw on their first dive.<br>· Ask students to demonstrate their understanding of classification by grouping these species.<br>· Discuss the answer to the opening question, i.e. the Great Barrier Reef is an important habitat because it is home to such a large and varied array of life. | **Slideshow 1:**<br>Slide 42<br>**Student Sheet 1c:**<br>Dive log |

# Video reflection

Reflect on the video you have just watched and make notes in the four boxes below. When you watch the video a second time, see if you can answer some of the questions you have listed in the 'I still want to know' section.

| | |
|---|---|
| I learnt... | I still want to know... |
| I felt... | This changed my view of science... |

# Species card sort

## Maori Wrasse
### *Cheilinus undulatus*

| | |
|---|---|
| **Kingdom** | Animal (Animalia) |
| **Phylum** | Chordate (Chordata) |
| **Class** | Bony fish (Osteichthyes) |

The Maori wrasse is one of the largest reef fish and the largest of the wrasse family. They are voracious predators, eating anything from molluscs to echinoderms and crustaceans, as well as small fish. They are one of the few species to eat the Crown-of-thorns starfish.

**Size**
They can grow up to 2m in length

**Feeding**
They feed on molluscs, crustaceans and echinoderms. They have few natural predators.

**Habitat**
Reefs throughout the Indian and Pacific oceans, from the shallows to a depth of 100m.

**Threats**
They are vulnerable to overfishing and pollution from e.g. cyanide fishing.

**Did you know?**
They get their name from the markings on their face which resemble traditional Maori tattoos!

## Cleaner wrasse
## Genus *Labroides*

| | |
|---|---|
| **Kingdom** | Animal (Animalia) |
| **Phylum** | Chordate (Chordata) |
| **Class** | Bony fish (Osteichthyes) |

Cleaner wrasses are fish which specialise in cleaning other, larger fish. This symbiotic relationship allows larger fish to stay clean, and provides a food source for the wrasse. The cleaner wrasses congregate in 'cleaning' areas, where bigger fish visit to be groomed by the wrasses, which swim into their mouths and gills to ensure everything is clean.

**Size**
Most species of cleaner wrasse are small, no bigger than 20cm long

**Feeding**
They feed off the dead tissue and parasites of fish they clean and have few predators, as larger fish prefer the benefits of cleaning to a quick snack!

**Habitat**
They live mainly around coral reefs of the Indian and Pacific oceans.

**Threats**
They face no specific threats except those that threaten the coral reef ecosystem as a whole.

**Did you know?**
Some wrasses, instead of waiting for customers in the cleaning areas, make 'house visits' for shy fish!

## Nudibranch
## Order *Nudibranchia*

| | |
|---|---|
| **Kingdom** | Animal (Animalia) |
| **Phylum** | Mollusc (Mollusca) |
| **Class** | Gastropod (Gastropoda) |

Nudibranchs are a type of mollusc and some of the most colourful animals on the Great Barrier Reef. Often referred to as 'sea slugs', these animals have a variety of different defence mechanisms to avoid being eaten, from storing poisonous cells from anemones they eat, to appearing as bright and colourful as possible to scare of would-be predators.

**Size**
Nudibranchs range from 2cm to 60cm long.

**Feeding**
Nudibranchs eat sea anemones and jellyfish. Some species are also cannibalistic. They are eaten by large fish such as wrasse.

**Habitat**
They live in the warm shallows of coral reefs.

**Threats**
They can be threatened by eutrophication caused by run-off from coastal areas, as well as fishing techniques such as dredging and bottom trawling.

**Did you know?**
Nudibranchs are simultaneous hermaphrodites, meaning that they have both male and female sex organs!

## Brown algae
## Genus *Sargassum*

| | |
|---|---|
| **Kingdom** | Protist (Protista) |
| **Phylum** | Brown algae (Phaeophyta) |
| **Class** | Phaeophyceae |

Sargassum includes some of almost 2,000 species of brown algae. It is a type of seaweed which grows thickly, attached to rocks in shallow waters as well as floating with the ocean currents. Its fronds have small globe-shaped compartments filled with gas. This helps it float near the sea's surface to enable photosynthesis. It plays a dual role by helping to form habitats as well as providing a food source.

**Size**
A few centimetres to up to 12 metres in warmer waters.

**Feeding**
It absorbs sunlight through photosynthesis and is eaten by smaller, herbivorous fish and sea urchins.

**Habitat**
Temperate and tropical waters.

**Threats**
Pollution can affect their ability to build proteins.

**Did you know?**
It is edible and tastes slightly bitter... but it must be cooked first!

## Christmas tree worm
## *Spirobranchus corniculatus*

| | |
|---|---|
| **Kingdom** | Animal (Animalia) |
| **Phylum** | Annelid (Annelida) |
| **Class** | Polychaete (Polychaeta) |

Christmas tree worms are a type of worm known as polychaetes. This refers to the little 'chaeta' or feet they have along their sides. The distinctive feature of the Christmas tree worm is the two crowns shaped like Christmas trees. These are used to strain the water for small particles of food, which are then transported in mucus to the mouth at the base of the crown.

**Size**
Christmas tree worms have a huge range of size from a few millimetres up to 3 metres.

**Feeding**
Christmas tree worms filter the seawater for plankton. They are eaten by fish.

**Habitat**
The Christmas tree worm larvae settle on damaged coral polyps and create a burrow. Preference is shown for large coral 'bommies' or mounds.

**Threats**
Because of their dependence on live coral, anything that threatens the coral, impacts Christmas tree worms.

**Did you know?**
If a fish bites off the crown, it quickly grows back!

## Crown-of-thorns starfish
### *Acanthaster planci*

| | |
|---|---|
| **Kingdom** | Animal (Animalia) |
| **Phylum** | Echinoderm (Echinodermata) |
| **Class** | Sea start (Asteroidea) |

The crown-of-thorns starfish is one of the most studied echinoderms on the Great Barrier Reef, because of the effects that periodic population outbreaks have on coral reefs. It is an unusual species in that it is a specialist corallivore. They have been responsible for 42% of the decline in coral cover on the Great Barrier Reef since 1985.

**Size**
Adults are usually 20cm to 40cm in diameter.

**Feeding**
Crown-of-thorns starfish feed on hard corals and occasionally soft corals and anemones. They are eaten by few species, such as the trigger fish and a marine snail, Triton's trumpet.

**Habitat**
On coral reefs.

**Threats**
There are no known threats to the crown-of-thorns starfish, but populations die out when they run out of food.

**Did you know?**
Divers have killed up to 120 crown-of-thorns starfish an hour to control outbreaks!

## Triton's trumpet
### *Charonia tritonis*

| | |
|---|---|
| **Kingdom** | Animal (Animalia) |
| **Phylum** | Mollusc (Mollusca) |
| **Class** | Gastropod (Gastropoda) |

Triton's trumpet is a large predatory sea snail. This mollusc is one of the few species that eats the crown-of-thorns starfish, as it has become immune to its toxins. One of the largest sea snails, they also feed on other starfish and sea urchins. They immobilise their prey by injecting them with a paralysing agent in their saliva.

**Size**
Adults grow to between 10cm and 35cm long.

**Feeding**
Triton's trumpet feeds on sea urchins and starfish.

**Habitat**
On coral reefs.

**Threats**
Like all organisms with a carbonate structure or shell, Triton's trumpet can be affected by ocean acidification. In some areas, the collection of shells for ornaments can be a threat.

**Did you know?**
The name Triton's trumpet comes from the ancient practice of cutting off the tip of the shell and using it as a trumpet!

## Clown Anemonefish
### *Amphiprion ocellaris*

| | |
|---|---|
| **Kingdom** | Animal (Animalia) |
| **Phylum** | Chordate (Chordata) |
| **Class** | Bony fish (Osteichthyes) |

There are 30 different species of anemonefish, so called as they have a symbiotic relationship with anemones. The anemone provides shelter from predators and provides the fish with a food source. The fish eat invertebrates which could otherwise harm the anemone and protect the anemone from other predators.

**Size**
Typically between 10cm-20cm long.

**Feeding**
They eat zooplankton such as copepods, and are hunted by larger fish.

**Habitat**
Shallow reefs and lagoons of the Indian and Pacific oceans, including the Great Barrier Reef and Red Sea.

**Threats**
Anemonefish are popular aquarium fish. The release of the Disney film 'Finding Nemo' in 2003 saw a sharp increase in demand which saw clown anemonefish populations decline.

**Did you know?**
Anemonefish (as well as some types of damselfish) are the only fish to be unaffected by the very strong poison of the anemone!

## Pearlfish
### *Carapidae*

| | |
|---|---|
| **Kingdom** | Animal (Animalia) |
| **Phylum** | Chordate (Chordata) |
| **Class** | Bony fish (Osteichthyes) |

Pearlfish are tiny fish which live inside invertebrates, including starfish, clams and sea cucumbers. They enter their host's body cavity via their anus and live there, protected from predators and with a ready source of nutrients. Most species of pearlfish live at peace with their host, but others are parasitic.

**Size**
From a few centimetres long to 20cm.

**Feeding**
Small invertebrates and crustaceans, or some feed off the organs of their host. They are eaten by larger fish.

**Habitat**
They live in tropical waters of the Atlantic, Indian and Pacific oceans, to a depth of 2,000m but more usually in shallow waters of less than 30m.

**Threats**
They face no specific threats other than those that face the coral reef ecosystem in general.

**Did you know?**
Their anus is close to their head, enabling quick and easy defecation by popping their heads out of their host's bottom!

## Bumphead parrotfish
### *Bolbometopon muricatum*

| | |
|---|---|
| **Kingdom** | Animal (Animalia) |
| **Phylum** | Chordate (Chordata) |
| **Class** | Bony fish (Osteichthyes) |

This distinctive fish has a vertical forehead and huge teeth for ramming into and then eating corals. They grow slowly and can live for up to 40 years. They are found in groups, and sleep as groups too, often in the shelter of caves or shipwrecks.

**Size**
They grow to over 1m in length.

**Feeding**
They live off algae and live corals, eating over 5 tonnes a year, and are primarily hunted by sharks, as well as humans.

**Habitat**
Bumphead parrotfish live around reefs and lagoons of the Indian and Pacific oceans, to a depth of around 30m.

**Threats**
They face no specific threats other than those that face the coral reef ecosystem in general, but can suffer from over-fishing.

**Did you know?**
They are hermaphrodites – they begin life as females and turn into males as they mature!

## Staghorn coral
### *Acropora cerviciornis*

| | |
|---|---|
| **Kingdom** | Animal (Animalia) |
| **Phylum** | Cnidaria |
| **Class** | Anthozoa |

Staghorn coral is a branching stony coral. Such hard corals are actually colonies of tiny polyps, a small animal much like the sea anemone. The polyps form a carbonate shelter and as the polyps reproduce, these carbonate structures grow as long branches. Hard corals are essential in creating the 3D reef habitat that supports so many different species.

**Size**
Branches range from a few centimetres to over 2m.

**Feeding**
Hard corals receive energy from their symbiotic relationship with zooxanthellae. The polyps also catch plankton such as copepods.

**Habitat**
Back and fore reef habitats at a depth of 0-30m.

**Threats**
Damage from changes in salinity, pH level and especially from increases in sea temperature which can cause bleaching. Locally, threats include storm damage and being eaten by the crown-of-thorns starfish.

**Did you know?**
Polyps reproduce both sexually and asexually and the polyps are both individual animals and linked within a colony!

## Sea anemone
## Order *Actiniaria*

| | |
|---|---|
| **Kingdom** | Animal (Animalia) |
| **Phylum** | Cnidaria |
| **Class** | Anthozoa |

Anemones are a type of polyp, the same animal that forms corals. They are usually found as single polyps, but can also form colonies. They have tentacles formed around an oval body which have stinging capsules at their ends, to immobilise their prey. They have a symbiotic relationship with some species of fish, which use the anemones as a refuge and are not stung. In return, these fish protect the anemone from predators.

**Size**
Anemones range from 1cm across to over 1m in diameter.

**Feeding**
Sea anemones eat small fish and shrimp. They are eaten by nudibranchs, some sea stars and fish.

**Habitat**
They usually live on the hard bottom of the sea and are found in most tropical and temperate coastal areas.

**Threats**
There are no known threats to sea anemones other than the general threats to the coral ecosystem. It can be affected by outbreaks of the crown-of-thorns starfish.

**Did you know?**
Some species of sea anemone can live for over 50 years!

## Blue green algae
## Phylum *Cyanbacteria*

| | |
|---|---|
| **Kingdom** | Bacteria (Monera) |
| **Phylum** | Cyanobacteria |
| **Class** | - |

Cyanobacteria are microorganisms, bacteria which fix nitrogen and carbon. They also produce oxygen through photosynthesis, enabling other species to live in the surrounding environment. Some live within protists (e.g. algae) or sponges, providing energy to the host, or form part of lichens in the splash zone of rocky shore environments.

**Size**
Microscopic, although in aquatic environments occasionally create ‘blooms’ which can be seen from space!

**Feeding**
They obtain energy from the sun through photosynthesis. They supply nutrients to other forms of algae and form an important part of the marine food web.

**Habitat**
All land and aquatic environments across the entire planet.

**Threats**
Pollution can affect their ability to build proteins.

**Did you know?**
The oldest known fossils are made from cyanobacteria and are 3.5 billion years old!

## Tiger shark
### *Galeocerdo cuvier*

| | |
|---|---|
| **Kingdom** | Animal (Animalia) |
| **Phylum** | Chordate (chordata) |
| **Class** | Sharks & rays (Chondrichthyes) |

One of the largest sharks in the world, the tiger shark is one of the apex predators on the Great Barrier Reef. It gets its name from the dark vertical stripes along its sides that resemble a tiger's stripes. It is a solitary creature, mainly hunting at night.

**Size**
Adult tiger sharks commonly grow to between 3m and 4.2m long, and can grow over 5m in length.

**Feeding**
They are voracious predators and not very picky, eating anything from fish to turtles, squid, marine mammals, human rubbish and car number plates.

**Habitat**
Mainly throughout tropical and subtropical waters worldwide, and are often found close to the coast.

**Threats**
They are vulnerable to fishing due to their slow growth and long lifespan.

**Did you know?**
About 10 people a year die from shark attacks, but humans kill 100 million sharks every year!

## Manta ray
### *Manta alfredi*

| | |
|---|---|
| **Kingdom** | Animal (Animalia) |
| **Phylum** | Chordate (Chordata |
| **Class** | Sharks & rays (Chondrichthyes) |

Mantas are large graceful fish, that often look like they are flying through the water with their large pectoral fins. They are filter feeders, using lobes either side of their mouth to funnel plankton towards them. Mantas are often found visiting cleaning stations, where fish such as the cleaner wrasse nibble parasites and their dead skin.

**Size**
Reef mantas reach 5.5 metres wide.

**Feeding**
Mantas are filter feeders, eating plankton and fish larvae. The mantas main predators are large sharks and orcas (killer whales).

**Habitat**
Typically found throughout tropical and subtropical waters.

**Threats**
They are slow swimmers near the surface and often become entangled in fishing gear.

**Did you know?**
They have the largest brain of all fish and we still have much to learn about their social behaviour!

## Green turtle
### *Chelonis mydas*

| | |
|---|---|
| **Kingdom** | Animal (Animalia) |
| **Phylum** | Chordate (chordata) |
| **Class** | Reptile (Reptilia) |

Green turtles are one of the six species of sea turtle that are found on the Great Barrier Reef. In the non-breeding season, turtles from the Great Barrier Reef travel as far as Fiji and Indonesia. Green turtles lay their eggs in pits they dig on beaches on islands and bays.

**Size**
Green turtles usually have a carapace (shell) between 80cm and 120cm long.

**Feeding**
Green turtles feed mainly on algae and seagrass. They are eaten by humans and larger sharks.

**Habitat**
Green turtles are found throughout tropical and subtropical oceans, returning to beaches to nest and they feed on coral reefs and seagrass meadows.

**Threats**
Destruction of seagrass meadows is the main threat. They also risk being caught in fishing nets and having their nesting sites destroyed by coastal developments.

**Did you know?**
Green turtles are reptiles and cold-blooded and they have been known to sunbathe to warm themselves up!

## Copepod
### Subclass *Copepoda*

| | |
|---|---|
| **Kingdom** | Animal (Animalia) |
| **Phylum** | Arthropod (arthropoda) |
| **Class** | Crustacean (Crustacea) |

A copepod is a small marine animal. It is a crustacean, and is related to lobsters, shrimps and crabs. Copepods are zooplankton, small animals that are carried by ocean currents rather than making their own way in the world. The word copepod comes from two Greek words kope- oar and pod- foot. They are the most abundant animal on this planet.

**Size**
Copepods are typically 1mm to 2mm long.

**Feeding**
Copepods are secondary producers, eating algae and turning this into the more complex building blocks needed for larger marine life, such as filter feeders.

**Habitat**
Throughout the oceans from pole to pole.

**Threats**
Copepods are susceptible to a decrease in the pH of the ocean from the process of ocean acidification.

**Did you know?**
There are an estimated 1,347,000,000,000,000,000,000 copepods in the world's oceans!

## Boulder coral
## Family *Portidae*

| | |
|---|---|
| Kingdom | Animal (Animalia) |
| Phylum | Cnidaria |
| Class | Anthozoa |

Poritidae is a family of hard corals that can form large coral mounds, known as 'bommies'. Such hard corals are actually colonies of tiny polyps, a small animal much like the sea anemone. Hard corals are essential in creating the 3D reef habitat that supports so many different species. They grow very slowly at a rate of 1-2cm a year.

**Size**
These mounds can range up to 8m high and 5m across.

**Feeding**
Hard corals receive energy from their symbiotic relationship with zooxanthellae. The polyps also catch plankton such as copepods with their stinging tentacles.

**Habitat**
The 'bommies' favour lagoons and proximity to the reef slope.

**Threats**
Hard corals are susceptible to damage from changes in pH level and especially from increases in sea temperature which can cause bleaching. Locally threats include pollution from runoff and being eaten by the crown-of-thorns starfish.

**Did you know?**
Some of these coral colonies are over 700 year olds and they can be dated by counting their annual growth bands!

## Red coralline algae
## Genus *Porolithon*

| | |
|---|---|
| Kingdom | Protist (Protista) |
| Phylum | Red algae (Rhodophyta) |
| Class | Rhodophyceae |

Porolithon are pinkish algae which build and strengthen coral reefs. They live on rock, binding materials together and forming a calcified layer beneath them to protect the reef crest from the impact of waves and storms, and are known as 'reef cement.' They also convert nutrients into food for other species and generate oxygen.

**Size**
From microscopic up to 25cm.

**Feeding**
They absorb sunlight through photosynthesis and provide a food source for smaller, herbivorous fish.

**Habitat**
Primarily reef crests, as well as the inner and outer reef, in warm and tropical waters.

**Threats**
They are under threat from ocean acidification which makes it harder for the formation of their carbonate structures. Pollution and higher water temperatures also have an impact.

**Did you know?**
Although they appear red or pink in colour they also contain green chlorophyll!

## Mantis shrimp
## Order *Stomatopoda*

| | |
|---|---|
| **Kingdom** | Animal (Animalia) |
| **Phylum** | Arthropod (Arthropoda) |
| **Class** | Crustacean (Crustacea) |

Mantis shrimps are aggressive and typically solitary creatures. They kill their prey in two different ways, by spearing or smashing with their large front claws. Some species are 'spearers' impaling their prey and other are 'smashers', striking their victims and stunning or killing them.

**Size**
Mantis shrimps grow to between 1cm and 40cm long.

**Feeding**
'Spearers' prefer animals without a hard shell such as small fish. 'Smashers' prey on crabs, snails and other molluscs. They are preyed upon by larger fish.

**Habitat**
Mantis shrimps live in crevices in the coral or rock in lagoons and also burrow in the sand.

**Threats**
They face no known threats, except those that threaten the coral reef ecosystem as a whole.

**Did you know?**
Their smash is so powerful and fast it can create a sonic boom and there are reports of mantis shrimps kept in aquaria breaking the glass.

## Sea cucumber
## Class *Holothuroidea*

| | |
|---|---|
| **Kingdom** | Animal (Animalia) |
| **Phylum** | Echinoderm (Echinodermata) |
| **Class** | Sea cucumber (Holothuroidea) |

Sea cucumbers are a diverse and common type of echinoderm, found all along the Great Barrier Reef. Within sea cucumbers, a number of species have some quite surprising habits. Some sea cucumbers reproduce asexually, splitting in half to form two complete individuals. A favourite defence mechanism to avoid being eaten by fish, is to shoot their guts and internal organs out of their anus.

**Size**
Adults typically range from 10cm to 30cm in length.

**Feeding**
Most sea cucumbers sift through the sediment for plankton and decaying organic matter. They are eaten by a range of fish.

**Habitat**
Found on coral reefs, the intertidal zone and in deep water.

**Threats**
Edible species of sea cucumber (yes - they are widely considered delicious!), known as bêche-de-mer are under threat from overfishing.

**Did you know?**
Some species have also developed a symbiotic relationship with species such as the pearl fish, which shelters in the sea cucumber's anus to avoid predation!

## Sea Urchin
## Class *Echinoidea*

| | |
|---|---|
| **Kingdom** | Animal (Animalia) |
| **Phylum** | Echinoderm (Echinodermata) |
| **Class** | Sea Urchin (Echinoidea) |

Sea urchins are related to starfish and sea cucumbers. Most sea urchins hide during the day to avoid predators. They also have poisonous spines to protect them. Sea urchins are mainly herbivorous eating the algae that grows on the coral reef. They play an important role in making sure that the coral reef is not overrun by seaweed.

**Size**
Adults typically range from 6cm to 12cm in diameter, not including the spines.

**Feeding**
Most sea urchins eat algae. They are preyed upon by snails such as Triton's trumpet and also by some crabs, rays and sharks.

**Habitat**
Found on coral reefs, sand flats and seagrass beds.

**Threats**
Sea urchin larvae are extremely sensitive to ocean acidification as well as threats to the coral ecosystem.

**Did you know?**
Most sea urchins only have mild venom, and although not fatal to humans, can be very painful if stepped on!

STUDENT SHEET 1c

# Dive log

Dive Mission

Name

Date

| Time | Weather | Temp air/sea | Max. depth | Dive time |
|---|---|---|---|---|
| In ............ | ☐ ☐ ☐ ☐ | .................... °C | ................. m | ............... min |
| Out............ | | .................... °C | | |

What life did you spot on your first dive? Can you put the different species into groups?

Dive buddy signature

Dive master signature / stamp

# How do scientists use classification in coral habitats?

Age 11-14

60 minutes

## Curriculum links

- Identify the different habitat zones and describe differences in environmental conditions
- Use a simple key to identify coral types
- Use survey techniques to compare coral distribution

## Resources

**Slideshow 2:**
Wonders of coral

**Student Sheet 2a:**
Coral reef scale

**Student Sheet 2b:**
Reef habitat zones

**Student Sheet 2c:**
Coral ID

**Student Sheet 2c:**
Dive log

**Video:**
Wonders of coral

**Gallery:**
Coral reef quadrat survey

**Gallery:**
Zones on the reef

## Lesson overview

This lesson helps students identify the different habitat zones on the coral reef and describe the differences in the environmental conditions. During their second dive students develop their identification skills through surveying the reef and identifying different coral types. Students draw conclusions about the reasons for the variety and abundance of coral species across the reef.

| Lesson steps | Learning outcomes |
| --- | --- |
| 1. **How big is the reef and how small is a polyp? (10 mins)** Students explore the different scales within the coral reef ecosystem and sort different corals from smallest to largest. | • Recall the scale of the Great Barrier Reef compared with the smallest part of the living coral |
| 2. **What smaller habitats exist within a coral ecosystem? (10 mins)** Students discuss and compare coral types with the conditions experienced on different parts of the reef. | • Identify different habitat zones and describe the differences in conditions |
| 3. **How can coral types be identified? (10 mins)** Students identify corals using a simple coral key and understand that for exact species recognition genetic testing is required. | • Use a key to identify coral types |
| 4. **How are coral types distributed on different parts of the reef? (20 mins)** Students complete a coral survey using actual images taken using the SVII camera. | • Use survey techniques to compare coral distribution in two different habitat zones |
| 5. **How are coral ecosystems varied? (10mins)** Students complete their dive log to reflect on how and why coral ecosystems are so varied. | • Understand how coral affects and is affected by its environment |

# TEACHER GUIDANCE 2 (page 1 of 2)

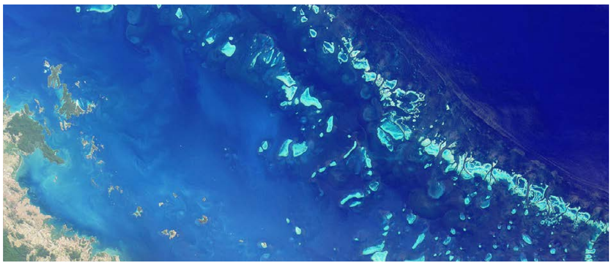
| Step | Guidance | Resources |
|---|---|---|
| **1**<br>10<br>mins | Step 1 encourages students to explore the scale of the coral reef ecosystem and sort different corals from largest to smallest.<br>· Use slide 2 to introduce learning outcomes.<br>· Watch Video: Wonders of coral.<br>· Use slide 4 to explain the scale of the coral reef.<br>· Students should cut out the images and arrange them from largest to smallest. Show slide 5 for students to check their results and amend. | **Slideshow 2:**<br>Slide 1-5<br>**Video:**<br>Wonders of coral<br>**Student Sheet 2a:**<br>Coral reef scale |
| **2**<br>10<br>mins | Step 2 allows students to discuss the different habitat zones and describe the differences in conditions.<br>· Look at Gallery: Zones on the reef and Coral reef quadrat survey.<br>· Hand out Student Sheet 2b. Students label and annotate the zones on the reef.<br>· Students check their work using slides 6-9. | **Slideshow 2:**<br>Slides 6-9<br>**Gallery:**<br>Coral reef quadrat survey<br>**Gallery:**<br>Zones on the reef<br>**Student Sheet 2b:**<br>Reef habitat zones |
| **3**<br>10<br>mins | In step 3 students are introduced to their dive mission, to survey different parts of the reef to find out about the distribution and abundance of coral types. Explain that scientists use two main methods to identify species; genetics and keys. For this dive mission students will be using a simple coral key to identify different coral types. For exact species recognition, scientists rely on genetic testing alongside other methods.<br>· Use slide 10 to introduce the dive mission.<br>· Hand out Student Sheet 2c.<br>· Show slides 11-14 and ask students to practice identifying the types of coral that can be seen in each image, using Student Sheet 2c. | **Slideshow 2:**<br>Slides 10-14<br>**Student Sheet 2c:**<br>Coral ID |
| **4**<br>20<br>mins | Step 4 involves students identifying different coral at the survey sites.<br>· Display slides 15-18 and ask students what they can identify straight away.<br>· Remind students that they will be using actual images taken using the SVII camera.<br>· Students complete the survey on Student Sheet 2d.<br>· If students are finding the % column tricky to complete, give them the hint that because the grid is 10 x 10 squares, i.e. 100 squares, each square represents 1%. | **Slideshow 2:**<br>Slides 15-18<br>**Student Sheet 2d:**<br>Dive log |

| Step | Guidance | Resources |
|---|---|---|
| **5**<br>10 mins | Step 5 sees students complete their dive log and reflect on the variety of coral ecosystems.<br>· Explain that once they have completed their survey they should describe why there could be differences in coverage.<br>· Remind students to get their dive logs signed off. | **Slideshow 2:** Slide 19<br>**Student Sheet 2d:** Dive log |

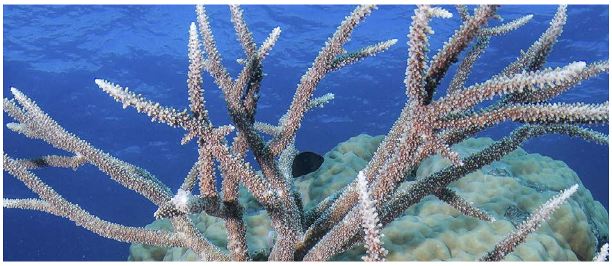
STUDENT SHEET 2a

# Coral reef scales

Coral reef

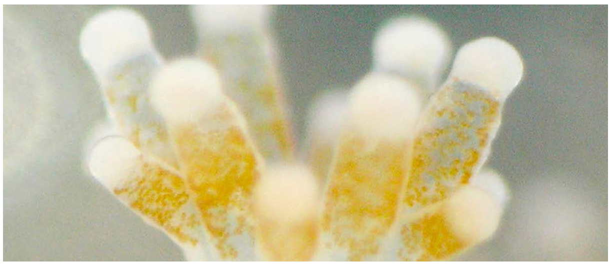


Reef mosaic



Coral colony

Habitat patch



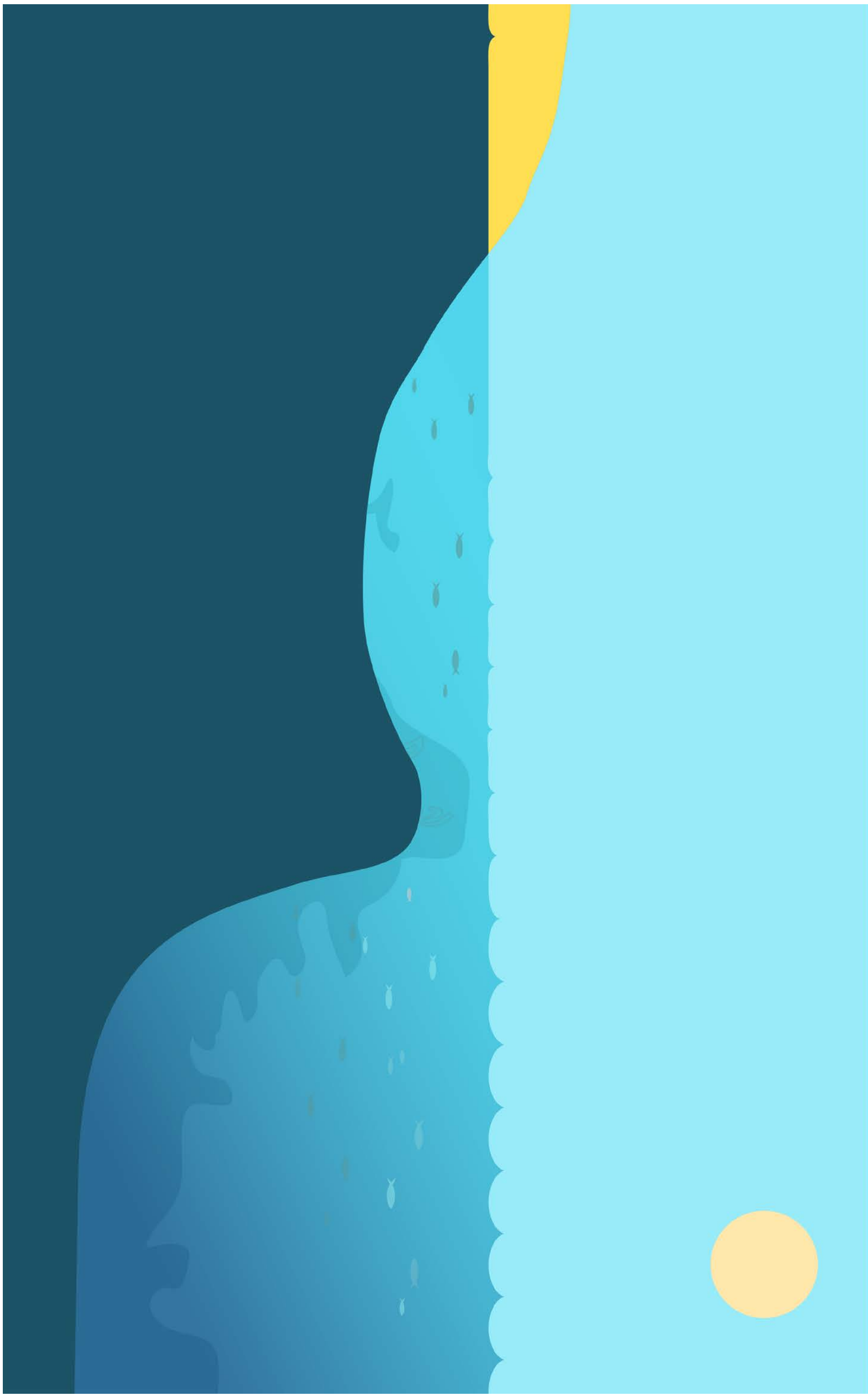
Coral polyp

Coral branch

Algae (zooxanthallae)

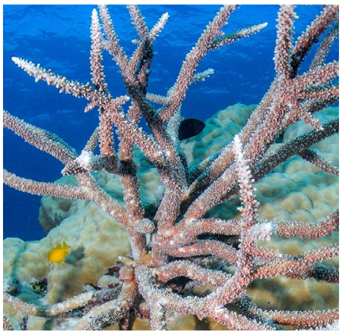
Habitat zone

# Reef habitat zones



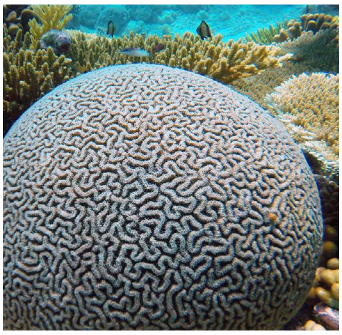
## Branching Coral

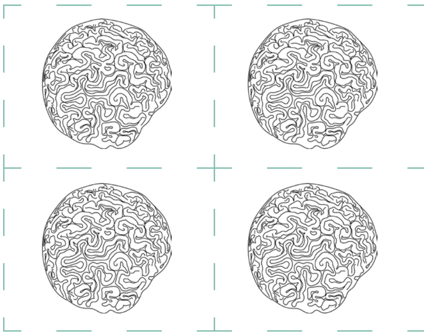
These corals are some of the fastest growing corals on the reef, potentially growing up to 2 meters tall. Found in a variety of areas up to 30m deep.



## Boulder Brain Coral

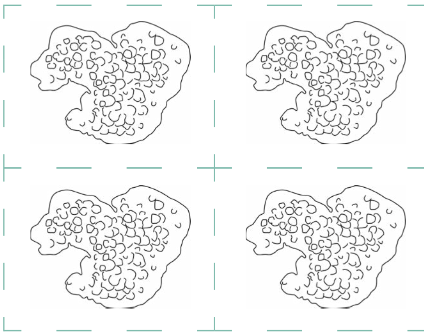
The most common coral found in the Carribbean Sea, predominantly in the shallower areas of the reef habitat.





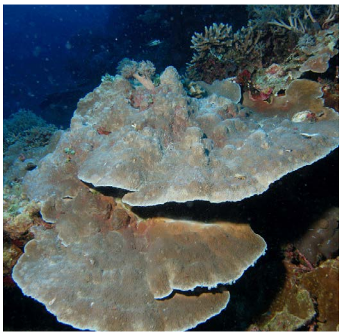
## Encrusting Coral

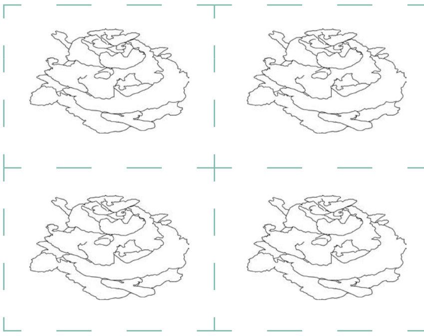
They have a low spreading growth, usually along hard rock surfaces. Unlike other corals they grow in width not upwards.



## Plate Coral

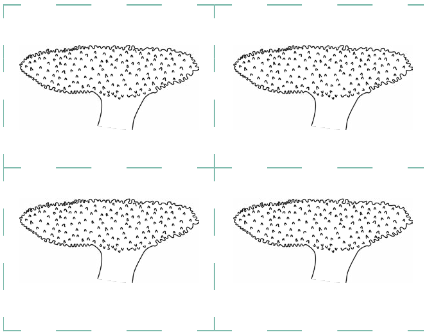
These corals usually live in deeper rocky areas on the reef. It is a very common coral found in the Indian and Pacific oceans.



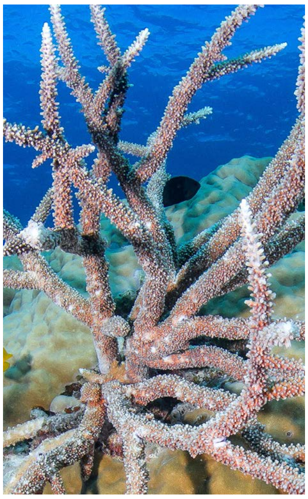


## Branching Plate Coral

These corals are found in the reef slopes and lagoons, protected from strong wave action and usually in areas of between 0-30m depth.

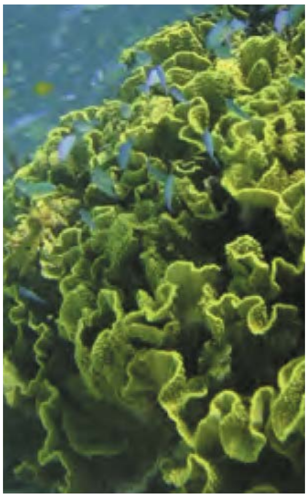


# Coral ID



**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.



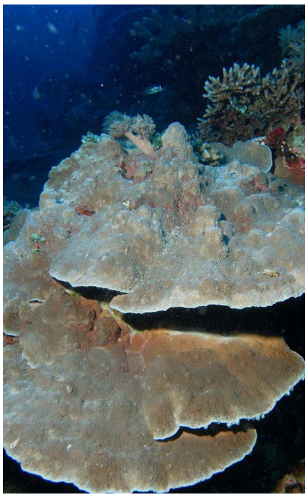


**Plate coral**
Plate corals come in a variety of shapes, but all of them are formed from flat plates. Sometimes these plates are flat like tables, other times they look more like vases.

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. These corals are referred to as brain corals.

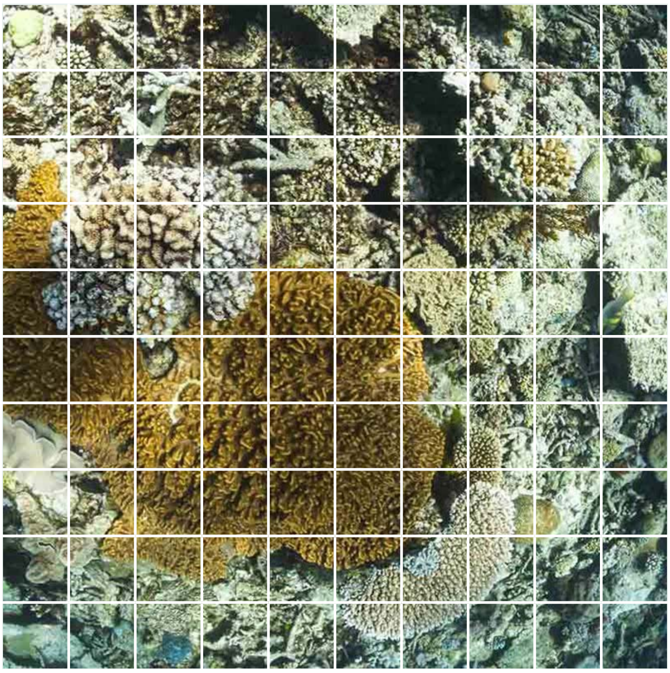
STUDENT SHEET 2d

# Dive log

XL CATLIN SEAVIEW SURVEY

| Dive Mission | |
|---|---|
| Name | Date |

| Time | Weather | Temp air/sea | Max. depth | Dive time |
|---|---|---|---|---|
| In ............ | ☐ ☐ ☐ ☐ | .................... °C | ................. m | ............... min |
| Out............ | | .................... °C | | |



Survey site 1 - Opal reef

Survey site 2 - Opal reef

# STUDENT SHEET 2d

## Survey site 1 - description of site

### Coral ID key

- ☐ Branching coral
- ☐ Plate coral
- ☐ Boulder coral
- ☐ Ridge & valley coral
- ☐ Sandy bottom
- ☐ Other

### Coral coverage

| | |
|---|---|
| Branching coral | % |
| Plate coral | % |
| Boulder coral | % |
| Ridge & valley coral | % |
| Sandy bottom | % |
| Other | % |

## Survey site 2 - description of site

### Coral ID key

- ☐ Branching coral
- ☐ Plate coral
- ☐ Boulder coral
- ☐ Ridge & valley coral
- ☐ Sandy bottom
- ☐ Other

### Coral coverage

| | |
|---|---|
| Branching coral | % |
| Plate coral | % |
| Boulder coral | % |
| Ridge & valley coral | % |
| Sandy bottom | % |
| Other | % |

Dive buddy signature

Dive master signature / stamp

LESSON 3

# How is energy transferred on the reef?

Age 11-14

60 minutes

## Curriculum links

- Describe the different techniques species use to get their energy
- Identify the range of primary producers in the ocean
- Create a food web describing interdependence of reef life

## Resources

**Slideshow 3:** Energy on the reef

**Activity Overview 3a:** Coral feeding game

**Activity Overview 3b:** Coral food web

**Student Sheet 3a:** Coral species

**Student Sheet 3b:** Dive log

**Video:** Wall of mouths

**Video:** Sea cucumbers

**Video:** Reef shark

**Video:** Coral feeding game

**Gallery:** Coral life (advanced)

## Lesson overview

In this lesson students will explore the interdependence of life on the reef and where different animals, plants and other organisms get their energy from through feeding and symbiosis. Students will learn about the different nature of primary production on the reef compared to terrestrial environments.

| Lesson steps | Learning outcomes |
| --- | --- |
| 1. **What consumers and producers live on the reef? (10 mins)** Students watch videos which explore feeding patterns and discuss which species are carnivores, herbivores, producers and consumers. | • Understand how different species get their energy through feeding |
| 2. **What producers live on the reef? (5 mins)** Students find out that most primary productivity in the ocean does not comes from plants and are introduced to plankton and its place in the food web. | • Identify the range of primary producers in the ocean |
| 3. **Where does coral get its energy from? (15 mins)** Students take part in an activity which demonstrates how coral sources it energy to build the reef. | • Explain how coral gets enough energy in nutrient poor waters |
| 4. **How do species depend on each other on the reef? (20 mins)** Students look at the food web on the reef and create their own food web. | • Create a food web using species found on the coral reef |
| 5. **How do living things on the reef depend on each other? (10mins)** Students reflect on how different species are linked through the food web. | • Understand that different species are producers and consumers and note examples of symbiosis |

# TEACHER GUIDANCE 3 (page 1 of 2)

| Step | Guidance | Resources |
|---|---|---|
| **1**<br>10<br>mins | In step 1 students watch videos and explore feeding patterns to identify which species are carnivores, herbivores, producers and consumers.<br>· Use slide 2 to introduce learning outcomes.<br>· Explain students will be watching three videos and that during the films they should identify herbivores, carnivores, consumers, producers, predators and prey.<br>· Watch Videos: Wall of mouths, Sea cucumbers and Reef shark.<br>· Discuss which species are carnivores, herbivores, producers and consumers in each case and how they depend on each other within a food web.<br>· Ask students in pairs to sketch out some food webs found on the reef on mini-whiteboards. | **Slideshow 3:**<br>Slides 1-6<br>**Video:**<br>Wall of mouths<br>**Video:**<br>Sea cucumbers<br>**Video:**<br>Reef shark |
| **2**<br>5<br>mins | Step 2 is a teacher led explanation about productivity in the ocean, introducing plankton and their place in the food web.<br>· Display and read from slides 7-9.<br>· Encourage students to ask questions and share their prior knowledge.<br>· Explain any misconceptions. | **Slideshow 2:**<br>Slides 7-9 |
| **3**<br>15<br>mins | Step 3 is a coral feeding activity where students behave like polyps to see if they can catch enough plankton to power their coral colonies.<br>· You can either watch Video: Coral feeding game on slide 10 with the students to demonstrate the activity or you may wish to watch the video beforehand and demonstrate the activity to the students yourself.<br>· Hand out the materials for students to play the coral feeding game.<br>· You may wish students to work in pairs to support one another with the construction.<br>· Students complete Activity Overview 3a: Coral feeding game.<br>· This activity demonstrates that coral cannot get enough energy from plankton alone and needs other sources of energy to build the reef.<br>· Use slides 10-15 to explain how coral receives the rest of its energy. | **Slideshow 3:**<br>Slides 10-15<br>**Video:**<br>Coral feeding game<br>**Activity Overview 3a:**<br>Coral feeding game |

| Step | Guidance | Resources |
|---|---|---|
| **4**<br>20<br>mins | In step 4 students look at the food web on the reef and create their own food web.<br>· Use slides 16-17 to demonstrate what a food web looks like.<br>· Explain that students will be creating their own food webs using the species in Gallery: Coral life (advanced). The background information on each species is also displayed on slides 18-20.<br>· Hand out Student Sheet 3a which provides background information about each species.<br>· Follow guidance in Activity Overview 3b on how to complete a food web. | **Slideshow 3:**<br>Slides 16-20<br>**Gallery:**<br>Coral life (advanced)<br>**Student Sheet 3a:**<br>Species on the coral reef<br>**Activity Overview 3b:**<br>Coral food web |
| **5**<br>10<br>mins | Step 5 asks students to reflect on their learning, identifying how different species are linked through the food web.<br>· Hand out Student Sheet 3b.<br>· Explain that students should draw a food web using the information from the previous activity.<br>· Student's should shade predators in green, primary consumers in yellow, secondary consumers in orange and tertiary consumers in red.<br>· They should then label the top predators.<br>· Remind students to get their dive log signed off. | **Student Sheet 3b:**<br>Dive log |

# Coral feeding game

Age 11-14
(adult supervision)

15 minutes

## Details

**Each student will need**

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

## Safety and Guidance

**Health and Safety**

Check for any students with an allergy to latex and provide an alternative.

## Demonstration


**Video: Coral feeding game**
www.encounteredu.com/discover/activities/coral-feeding-game

## Overview

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). See Video: Coral feeding game for a demonstration of this activity.

## Running the 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 (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 construction paper that fits over the 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 open their eyes to see how much they have caught.

## Expected results

- Students will understand that corals use two methods for getting nutrients and that corals do not 'eat' the zooxanthellae, but receive the products of photosynthesis, in exchange for protection and nutrients.

# Coral food web

**Age 11-14**
(adult supervision)

**20 minutes**

## Details

**Each pair will need**

- Cardboard
- Scissors
- Tape
- Wool or string

## Safety and Guidance

**Health and Safety**

Care should be taken when using scissors.

## Extension

Ask students what would happen if just one organism was threatened?

## Overview

Students link different living things on the reef to demonstrate the interconnectedness of this habitat. This activity can be done individually or in pairs.

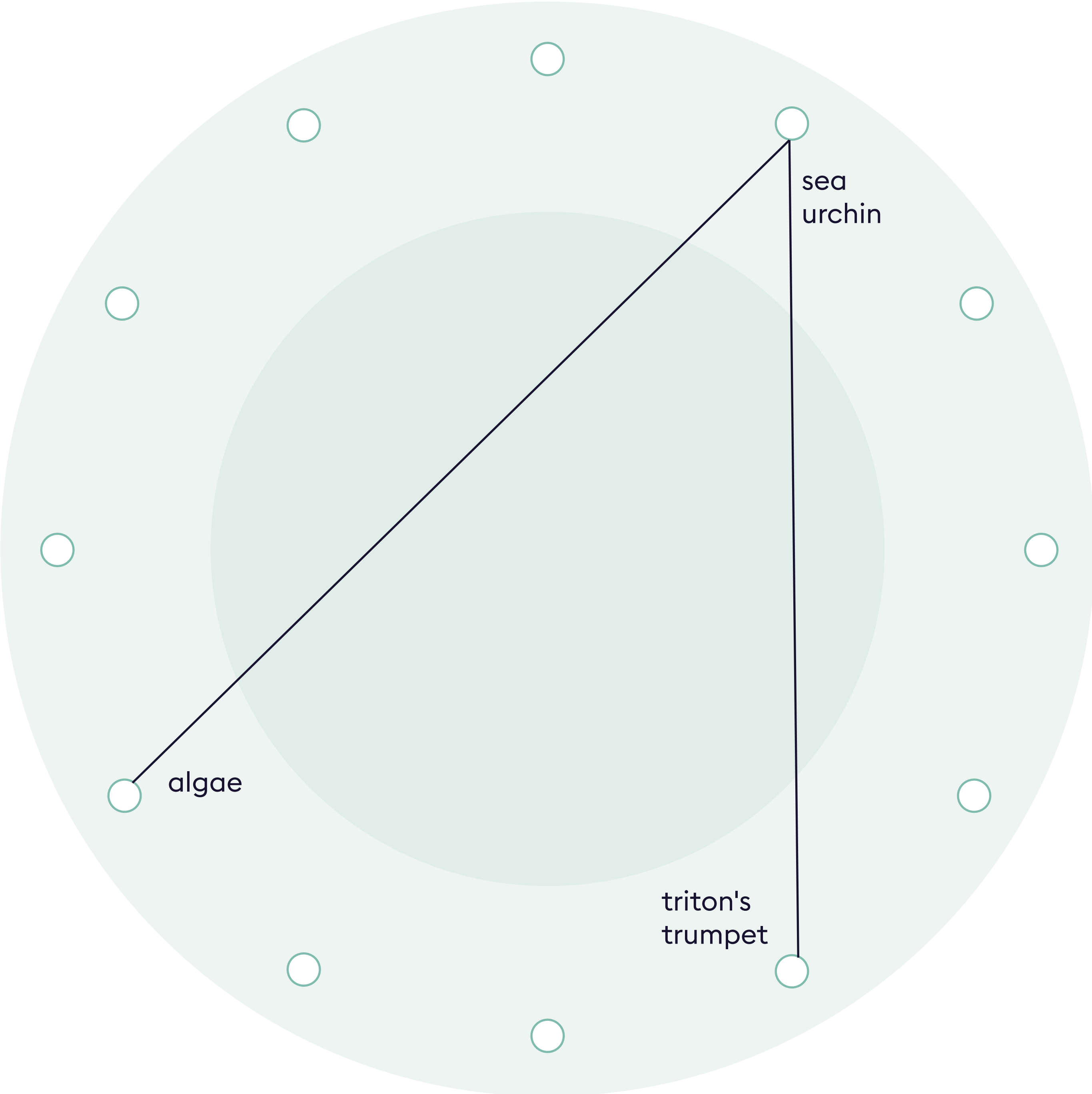
## Running the Activity

1. Cut out a ring of cardboard at least 20 cm in diameter (or two rings and stick together to make stronger).
2. Punch 12 holes around the ring at evenly spaced intervals like a clock face.
3. Write the names of the following species next to the holes: coral, sea grass, phytoplankton, algae, crown of thorns starfish, green turtle, parrot fish, triton's trumpet, tiger shark, manta ray, sea urchin, copepod.
4. Cut some wool or string.
5. Tie the wool to a producer.
6. Link this producer to the next organism along the food chain by passing the string through each hole, e.g. link algae to sea urchin and then to triton's trumpet or crown-of-thorns starfish.
7. When you have reached the top predator, tie the wool or string again, to end the chain.
8. Repeat this process for all the producers, until you have created a food web.
9. Use the species cards to help you.

## Expected results

- Students should identify the longest food chain they created and consider how different living things are connected.

## ACTIVITY OVERVIEW 3b



STUDENT SHEET 3a

# Species on the coral reef

**Parrotfish**

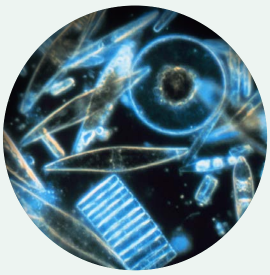
The parrotfish eats coral and some types of algae. It is eaten by large predators like the tiger shark.

**Sea grass**

Sea grass receives its energy from the sun. It is the favourite food of the green turtle.

**Tiger shark**

The tiger shark is an apex predator meaning that it is at the top of the food chain. It feeds on fish such as the parrotfish and manta ray as well as turtles.



**Phytoplankton**

Phytoplankton is the scientific name for the tiny algae in the ocean. It provides food for small animals such as copepods and large filter feeders such as the manta ray.

**Green turtle**
The green turtle eats sea grass. It can be eaten by large predators such as the tiger shark.

**Sea urchin**
Sea urchins feed on algae and are prey for shellfish like the triton's trumpet.

**Coral**
Coral gets its energy from small animals such as copepods as well as the algae inside its polyps. It is eaten by parrotfish and the crown of thorns starfish.

**Algae**
Algae receives energy via photosynthesis. It provides food for herbivores such as parrotfish and sea urchins.

**Triton's trumpet**
One of the most poisonous animals on the reef, the triton's trumpet feeds on starfish and sea urchins.

**Crown of thorns starfish**
This starfish is a specialist corallivore. It has few natural predators except for the triton's trumpet.

**Manta ray**
The manta ray is a filter feeder, sieving tiny algae and animals from the sea water. It is sometimes eaten by larger sharks.

**Copepod**
The copepod is a small marine animal related to crabs and lobsters. It eats phytoplankton and is eaten by a range of animals, like manta rays and coral.

# Dive log

XL CATLIN SEAVIEW SURVEY

| Dive Mission | |
|---|---|
| Name | Date |

| Time | Weather | Temp air/sea | Max. depth | Dive time |
|---|---|---|---|---|
| In ………… | ☐ ☐ ☐ ☐ | ……………… °C | ……………… m | …………… min |
| Out………… | | ……………… °C | | |

Draw a food web using the information from the last activity. Shade in producers (green), primary consumers (yellow) and secondary consumers (orange) and tertiary (and higher) consumers (red). Label the 'top predators'.

| Dive buddy signature | Dive master signature / stamp |
|---|---|
| | |

# How have reef specialists evolved and adapted?

Age 11-14

60 minutes

## Curriculum links

- Identify and describe different types of adaptation on the coral reef
- Create the Ultimate coral animal, demonstrating an understanding of adaptation

## Resources

**Slideshow 4:**
Ultimate adaptation

**Student Sheet 4a:**
Ultimate coral animal

**Student Sheet 4b:**
Dive log

**Gallery:**
Adaptation on the reef

**Gallery:**
Coral life

## Lesson overview

Different species have adapted to life on the coral reef in amazing and diverse ways. From sleeping in mucus bubbles, to flexible snakelike skeletons, life on the reef has had to find ingenious methods to find food and stay alive. The reef is also host to numerous examples of symbiosis and finding food and safety in the strangest of places, whether that be in a shark's mouth or 'vacuuming' the sandy seabed. In this lesson, students are challenged to create the ultimate reef organism.

| Lesson steps | Learning outcomes |
| --- | --- |
| **1. Why have animals adapted to survive on the reef? (10 mins)**<br>Students identify how different species have adapted to life on the coral reef and understand how survival involves competing for resources. | • Identify specific adaptions used by coral reef species<br>• Explain the need for adaption for survival |
| **2. How have different species adapted to life on the reef? (15 mins)**<br>Students learn from several different animals about the strategies they use to survive. | • List a range of adaption strategies used on the reef |
| **3. What would make the ultimate coral animal? (20 mins)**<br>Students create the ultimate coral animal. Using their prior knowledge they draw and label the adaptations their creature would have. | • Create the 'ultimate coral animal' using prior knowledge |
| **4. How have animals adapted to live on the coral reef? (15 mins)**<br>Students reflect on three of the animals they have discussed today and comment on the adaptations that make them effective reef dwellers. | • Consolidate understanding of adaption on the reef |

# TEACHER GUIDANCE 4 (page 1 of 1)

| Step | Guidance | Resources |
|---|---|---|
| **1**<br>10 mins | In step 1 students identify how certain species have adapted to survive on the coral reef.<br>· Show students slide 3 and ask how many stonefish they can see, reveal slide 4. Ask students to discuss in pairs how the stonefish is adapted to survive on the coral reef.<br>· Remind students about their prior learning using slide 5 about the need for corals to get extra energy from zooxanthellae through photosynthesis and how different types of corals occupy different habitat zones and niches on the reef.<br>· Go through slides 6-7 which demonstrate the need for all species to compete for food in the nutrient poor waters of the coral ecosystem. | **Slideshow 4:**<br>Slides 1-7 |
| **2**<br>15 mins | Step 2 introduces students to their mission for the lesson, to create the ultimate coral reef animal. They will examine several different animals to find out the strategies used to survive.<br>· Go through slides 8-18 to demonstrate a range of adaptations that animals have used to increase their chances of survival.<br>· For each animal ask students to talk in pairs about the adaptations they can see and why they are effective. Take feedback, encourage students to share prior knowledge. | **Slideshow 4:**<br>Slides 8-18 |
| **3**<br>20 mins | In step 3 students create their ultimate coral reef animal using what they have learnt so far to inspire them.<br>· Explain that students will be drawing and labelling their new animal and listing the adaptations that will ensure its survival and success.<br>· Hand out Student Sheet 4a for students to design their new animal.<br>· Students can research other coral animals using Gallery: Coral life and Adaptation on the reef to gain further information.<br>· Students may work in pairs to research and discuss ideas but should design their animals individually. | **Student Sheet 4a:**<br>Ultimate coral animal<br>**Gallery:**<br>Coral life<br>**Gallery:**<br>Adaptation on the reef |
| **4**<br>15 mins | Step 4 sees students complete their dive log and explain what they have found out about adaption on the reef using three species as examples.<br>· Hand out Student Sheet 4b and ask students to describe the adaptations of three animals on the reef.<br>· Remind students to get their Dive log signed off. | **Slideshow 4:**<br>Slide 19<br>**Student Sheet 4b**<br>Dive log |

# Ultimate coral animal

**Draw and label your ultimate coral animal.**

**Describe the characteristics that make it so well adapted to life on the coral reef.**

STUDENT SHEET 4b

# Dive log

Dive Mission

Name

Date

| Time | Weather | Temp air/sea | Max. depth | Dive time |
|---|---|---|---|---|
| In ............ | ☐ ☐ ☐ ☐ | .................... °C | ................ m | ............... min |
| Out............ | | .................... °C | | |

Choose three coral animals. Describe the adaptations that make them effective reef dwellers.

Dive buddy signature

Dive master signature / stamp

# How do forces affect deep coral exploration?

Age 11-14

60 minutes

## Curriculum links

- Explain the relationship between water pressure and depth
- Describe the technology needed to explore the deep reef
- Investigate how corals adapt to lower light conditions

## Resources

**Slideshow 5:** Diving deeper

**Activity Overview 5a:** Under pressure

**Activity Overview 5b:** Exploring deep coral

**Student Sheet 5a:** Diving deeper

**Student Sheet 5b:** Dive log

**Video:** Monitoring the reef

**Video:** Under pressure

**360 Gallery:** Submarine science

**Subject Update:** How to: Quick start to 360 VR in the classroom

**Subject Update:** How to: Four ways to use 360 VR in the classroom

## Lesson overview

This lesson explores the technology required to explore deep reefs and considers how water pressure poses additional challenges to scientists exploring the 'twilight zone' through a teacher led demonstration. Students consider the human context of deep reef exploration through reading a blogpost written by Norbert Englebert a member of the deep reef team. Students conduct an experiment to test whether the colour of coral affects the amount of light it absorbs.

| Lesson steps | Learning outcomes |
|---|---|
| 1. **Use of technology (10 mins)** Students identify how different species have adapted to life on the coral reef and understand how survival involves competing for resources. | • Describe the technology needed to work on the deep reef |
| 2. **Under pressure (10 mins)** Students watch a teacher-led demonstration which illustrates the relationship between depth and water pressure. | • Understand the relationship between water pressure and depth |
| 3. **Deep diving (10 mins)** Students consider what it is like to be part of the dive team through reading about Norbert Engelbart's experiences and answering questions. | • Communicate what it is like to work at these depths |
| 4. **Corals at depth (20 mins)** Students conduct an experiment designed to test the hypothesis that deep reef corals are darker because they need to absorb more of the available light. | • Investigate the relationship between depth and coral colour |
| 5. **How is coral different on the deep reef? (10 mins)** Students consider the other adaptations of coral reefs and reflect on how corals might change shape at depth. | • Reflect on the best shape for deep reef corals |

# TEACHER GUIDANCE 5 (page 1 of 2)

| Step | Guidance | Resources |
| --- | --- | --- |
| **1**<br>10 mins | Step 1 introduces students to the technology required to explore reefs at depths of up to 100 meters.<br>· Explain that the dive team are exploring the coral reef between the depths of 30-100 meters and that working at these depths requires different technologies and diving techniques.<br>· Explain that very little is known about this area of the reef, known as the mesophotic zone, or more commonly the 'twilight zone'.<br>· Watch the video: Monitoring the reef and view the 360 Gallery: Submarine science.<br>· Ask pupils why an ROV is being used rather than a team of divers.<br>· Look at and read from slides 5-13.<br>· In pairs students discuss the use of technology to explore extreme environments, take feedback into a wider class discussion. | **Slideshow 5:**<br>Slides 1-13<br>**Video:**<br>Monitoring the reef<br>**360 Gallery:**<br>Submarine science |
| **2**<br>10 mins | Step 2 is a teacher demonstration of how water pressure can limit underwater exploration.<br>· You may wish to watch Video: Under pressure before the lesson and demonstrate yourself to the class or you may wish to watch the video with the class.<br>· Activity Overview 5a gives guidance on how to demonstrate to students the relationship between depth and water pressure. | **Slideshow 5:**<br>Slides 14<br>**Video:**<br>Under pressure<br>**Activity Overview 5a:**<br>Under pressure |
| **3**<br>10 mins | In step 3 students consider the human context of deep-sea exploration.<br>· Hand out Student Sheet 5a, a blog post written by Norbert Englebert, a member of the deep reef team.<br>· Ask students to read the blog post in pairs and discuss, then answer the questions on Student Sheet 5a.<br>· Consider creating a word cloud of the words used to describe working at depth (Question 4), using a service such as www.wordart.com, which could form part of a classroom display. | **Slideshow 5:**<br>Slide 15<br>**Student Sheet 5a:**<br>Diving deeper |

# TEACHER GUIDANCE 5 (page 2 of 2)

| Step | Guidance | Resources |
| --- | --- | --- |
| **4**<br>20 mins | Step 4 reminds students the team are investigating deep corals and refers them back to the coral feeding activity in lesson three. Explain that there are several differences between shallow and deep coral species.<br>· Ask students why deep corals may have to adapt to get enough energy.<br>· Show slides 16-22 to brief students on the differences between shallow and deep coral.<br>· Students complete Activity Overview 5b which demonstrates to students the relationship between colour and depth.<br>· Ask students to feedback on their results.<br>· Ask 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? | **Slideshow 5:**<br>Slides 16-22<br>**Activity Overview 5b:**<br>Exploring deep coral<br>**Subject Update:**<br>How to: Quick start to 360 VR in the classroom<br>**Subject Update:**<br>How to: Four ways to use 360 VR in the classroom |
| **5**<br>10 mins | In step 5 students recognise that colour is not the only adaptation for deep reef corals.<br>· Recap slides 17-22 to show photographs of the deep and shallow reefs.<br>· This time, ask students to consider the difference in shape between the coral species at this depth. Ask students to consider the differences between the coral species.<br>· Students note their ideas about how corals might change shape on Student Sheet 5b. | **Slideshow 5:**<br>Slide 17-23<br>**Student Sheet 5b:**<br>Dive log |

# Under pressure

Age 11-14
(adult supervision)

10 minutes

## Details

### What you need

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

## Safety and Guidance

### Precautions

Care with scissors should be taken.

## Overview

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. This activity shows the relationship between water depth and pressure. Watch Video: Under pressure for a demonstration of this activity.

## Running the Activity

1. Tell the class that you are going to demonstrate the relationship between pressure and depth.
2. Make three holes, evenly spaced, in a vertical line, in the bottle.
3. Cover the holes with tape and fill the bottle with water and put the lid on.
4. Stand the bottle in a sink or take it outside and ask students to predict how the water will behave coming out of the holes. Ask, where will the pressure be greatest? How do you know?
5. Un-tape the holes and unscrew the lid. Ask students, what do you observe? How did what you observed compare with what you predicted? Why do you think the water is flowing with greater force at the bottom compared with the top?

# Exploring deep coral

**Age 11-14**
(adult supervision)

**20 minutes**

## Details

**Each 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)

## Safety and Guidance

**Health and Safety**

If students are involved in creating the resources, care with scissors should be taken. Remind students not to touch the bulb as it will be hot.

## Ask

- 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?

## Overview

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

Organise materials into colour sets beforehand to save time during activity.

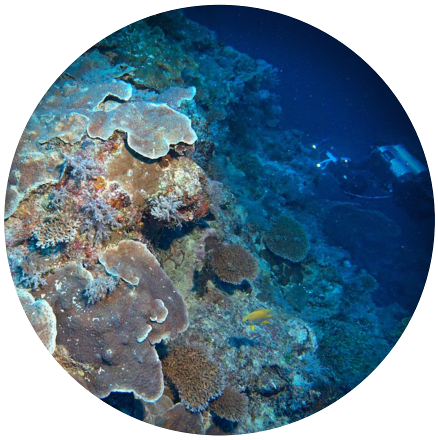
## Running the Activity

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.

## Expected results

- Students will understand the darker the coral the more light it will absorb.

# Diving deeper



**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.

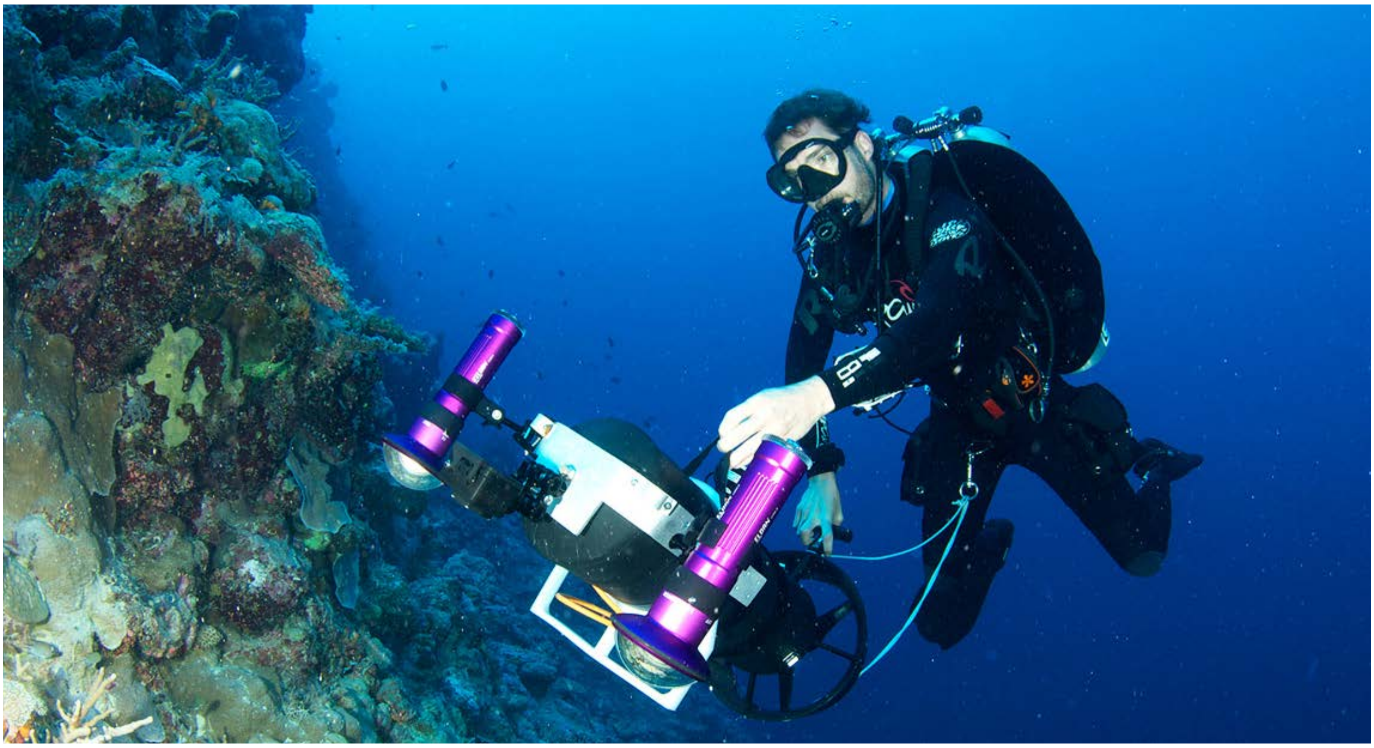
On the way down, you have to clear your ears because of the pressure all the time. You really notice that you're breathing harder. The pressure is five times more than it is at the surface.

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.

**Marine Biologist**
**Norbert Englebert**



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

## Question

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.

STUDENT SHEET 5b

# Dive log

Dive Mission

Name

Date

| Time | Weather | Temp air/sea | Max. depth | Dive time |
|---|---|---|---|---|
| In ............ | ☐ ☐ ☐ ☐ | .................. °C | ................ m | .............. min |
| Out............ | | .................. °C | | |

What would be the best shape for a deep reef coral and why?

Dive buddy signature

Dive master signature / stamp

LESSON 6

# What is the effect of human impact on the reef?

Age 11-14

60 minutes

## Curriculum links

- Investigate the different factors affecting the coral reef
- Judge the impact of human activity on the coral reef
- Explain views about environmental change

## Resources

**Slideshow 6:** Coral future?

**Activity Overview 6a:** Cloudy waters

**Activity Overview 6b:** Ocean acidification in a cup

**Activity Overview 6c:** Dissolving 'coral' in vinegar

**Student Sheet 6a:** Cloudy waters

**Student Sheet 6b:** Ocean acidification in a cup

**Student Sheet 6c:** Dissolving 'coral' in vinegar

**Student Sheet 6d:** Threats overview

**Student Sheet 6e:** Coral threats information sheets

**Video:** Sailing home

## Lesson overview

Students will consider the varied threats faced by the coral reef. These range from long-term environmental changes caused by increased atmospheric carbon dioxide, to changes in land use in coastal areas. Through gathering information from a range of sources students will complete an overview of the threats faced by the reef. Students will be prompted to consider what changes could be made to ensure that there are healthy coral reefs well into the future.

| Lesson steps | Learning outcomes |
|---|---|
| **1. What's the state of the Great Barrier Reef? (15 mins)** Students explore the findings of the Australian Institute for Marine Science report which show that the Great Barrier Reef is being destroyed by storms, ocean warming (bleaching) and Crown of Thorns starfish and that since records began in 1986 this has resulted in coral coverage reducing by 30% (1/3 up to the beginning of 2017). | • Describe the damage to the Great Barrier Reef since 1987 and share reactions to it |
| **2. How can human activity affect the reef? (35 mins)** Students gather information from a range of sources through completing a carousel, to understand how and why the reef is being damaged. | • Investigate the range of impacts on the coral reef |
| **3. Will future generations see a coral reef? (10 mins)** Students reflect on the fact that by 2050 the coral reefs could be in terminal decline and describe how they feel about protecting corals now and in the future. | • Debate the future of coral |

| Step | Guidance | Resources |
|---|---|---|
| **1**<br>15<br>mins | Step 1 introduces students some of the threats facing the coral reefs.<br>· Explain that the findings of the Australian Institute for Marine Science report show that the Great Barrier Reef is being destroyed by storms, ocean warming (bleaching) and Crown of Thorns starfish and that since records began in 1986 this has resulted in coral coverage reducing by 30% (1/3 up to the beginning of 2017).<br>· Go through slides 3-7 to explain some of the reasons for the loss.<br>· Watch Video: Sailing home.<br>· In pairs ask students to discuss how they feel about this and share their emotional reactions (e.g. anger, indifference, etc.) ask them to explain the reasons behind these feelings. | **Slideshow 6:**<br>Slides 1-8<br>**Video:**<br>Sailing home |
| **2**<br>35<br>mins | Step 2 sees students complete a carousel activity where they gather information from a range of sources to gain an understanding of how and why the reef is being damaged.<br>· Use Activity Overviews 6a, 6b and 6c to set up the carousel.<br>· Group students into three or four groups.<br>· Explain that each group will start at a different station and will have approximately 10 minutes at each station to complete the activity.<br>· Use slide 9 to further demonstrate the carousel.<br>· Each activity has an Activity Overview to help you prepare in advance and a Student Sheet to instruct students how to complete the activity.<br>· Explain that there are also three different information sheets distributed around the classroom and that if they complete the carousel activity early, they should take an information sheet, read it and make additional notes on Student Sheet 6d. These can also be used if there is any remaining time at the end of the carousel activity.<br>· Hand out Student Sheet 6d and explain that students should use it to record their learning as they complete the activities. | **Slideshow 6:**<br>Slide 9-10<br>**Activity Overview 6a:**<br>Cloudy waters<br>**Student Sheet 6a:**<br>Cloudy waters<br>**Activity Overview 6b:**<br>Ocean acidification in a cup<br>**Student Sheet 6b:**<br>Ocean acidification in a cup<br>**Activity Overview 6c:**<br>Dissolving 'coral' in vinegar<br>**Student Sheet 6c:**<br>Dissolving 'Coral' in Vinegar<br>**Student Sheet 6d:**<br>Threats overview<br>**Student Sheet 6e:**<br>Coral threats information sheets |

| Step | Guidance | Resources |
|---|---|---|
| **3**<br>10<br>mins | In step 3 students discuss the future of the coral reefs.<br>· Explain that there is a possibility that by 2050 the coral reefs will be in terminal decline. This would mean that future generations may never have the chance to see a coral reef.<br>· Ask students how they feel about this and what they think should change.<br>· In pairs students discuss who is responsible for the future of the reef and feedback ideas. | **Slideshow 6**<br>Slides 10-14 |

# Cloudy waters

**Age 11-14**
(adult supervision)

**10 minutes**

## Details

**Each Secchi disk will require:**

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

**Each group will require:**

- Buckets or clear beakers
- Sediment (e.g. soil)
- Spoons

## Safety and Guidance

**Precautions**

Care should be taken to avoid spills.

## Overview

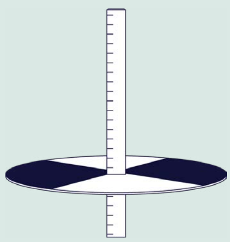
The Secchi disk was created in 1865 by an Italian priest and scientist, Pietro Angelo Secchi, to measure water transparency in oceans, lakes and ponds. In this experiment, students will make and use a Secchi disk to test the transparency of a water sample, and will be asked to consider how turbidity could affect corals. Traditionally, plain white Secchi disks are used for ocean work, and black and white for inland waters.

## Preparation

Make five or six Secchi disks before the lesson and have them ready at the work station for students to use prior to the carousel beginning. Place buckets and sediment on the work station.

### To make 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.



### Running the Activity

1. Students should 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. Make a note of this depth
4. Repeat this process, adding a total of 10 spoonful's of soil, making a note of the visible depth of the disk for each spoonful added.

## Expected results

- Students will understand how sediment affects turbidity and the impact this has on coral reefs.

# Ocean acidification in a cup

**Age 11-14**
(adult supervision)

**10 minutes**

## Details

**Equipment needed per pair:**

- **Student Sheet 6b**
- Boiling tube or beaker containing 100ml distilled water – labelled 'fresh water'
- Boiling tube or beaker containing 100ml 'sea water' – labelled 'sea water'
- 2 straws
- pH indicator (either Universal Indicator or Hydrogen Carbonate Indicator) or pH meter
- Watch or timer

## Safety and Guidance

**Precautions**

Care should be taken to avoid spills. Advise students to take turns blowing air through the water so they don't become light headed.

## Overview

This experiment shows how water becomes more acidic when carbon dioxide is bubbled through it.

## Preparation

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. Have all equipment at work station prior to starting the activity.

## Running the Activity

1. 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.
2. 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.
3. Students should discuss what changes they have observed and why they think that this has happened.

## Expected results

- Students will understand that water becomes more acidic as carbon dioxide flows through it.

# Dissolving 'coral' in vinegar

**Age 11-14**
(adult supervision)

**10 minutes**

## Details

**Equipment needed per pair:**

- **Student sheet 6b**
- 200 ml of clear vinegar (such as malt vinegar or other pickling vinegar)
- Chalk (i.e. $CaCO_3$)
- Appropriate container or beaker

## Safety and Guidance

**Precautions**

Care should be taken to avoid spills. Do not ingest vinegar.

## Overview

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

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

$$2H^{+} \text{ (the acid)} + CaCO_3 \text{ (the shell)} \leftrightarrow Ca^{2+} + H_2O + CO_2$$

## Preparation

Have all equipment at work station prior to starting the activity.

## Running the Activity

Students will:

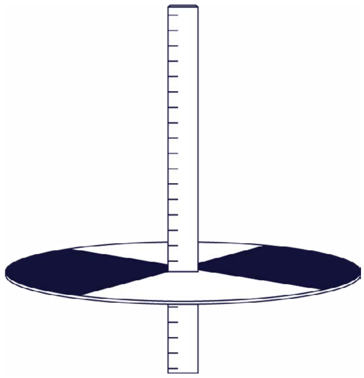
1. Pour the vinegar into the container.
2. Add the chalk to the container and observe what takes place.
3. Discuss with pupils what is happening to the chalk as it reacts with the vinegar.

## Expected results

- Students will understand the affect of acidic substances on coral reefs.

# Cloudy waters

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. Traditionally, plain white Secchi disks are used for ocean work, and black and white for inland waters. In this experiment, you will use a Secchi disk to test the transparency of a water sample and will consider how turbidity affects corals.



**Instructions**

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 the disk touches the bottom and you can still see it).
5. Repeat this process, adding a total of 10 spoonful's of soil, making a note of the visible depth of the disk for each spoonful added.

**Questions**

1. How does sediment affect turbidity?
2. What is the impact of turbidity on coral reefs?
3. Can you think of three events that could cause increased turbidity, natural and manmade?

# Ocean acidification in a cup

**This experiment shows the effect of carbon dioxide on water acidification.**

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

## Instructions

1. Start by estimating the pH of the two types of water and create a hypothesis about what will happen when you blow through the solutions.
2. Record how the pH of the two types of water changes as you blow through the straw into the waters for 3 minutes at 30 second intervals.
3. Think about what you have observed and why this has happened.
4. What are the implications of increased carbon dioxide for coral reefs?

STUDENT SHEET 6c

# Dissolving 'coral' in vinegar

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

## Instructions

1. Pour the vinegar into the container.
2. Add the chalk to the container and observe what takes place. Discuss 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.

$2H^+$ (the acid) + $CaCO_3$ (the shell) ↔ $Ca^2+$ + $H_2O$ + $CO_2$

## 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.

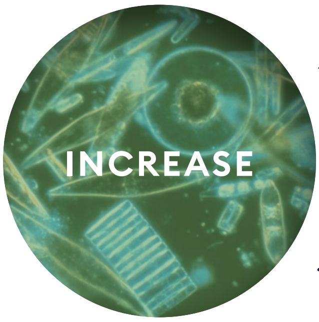
STUDENT SHEET 6d

# Threats overview

| Threat | Effect on the reef | Reef unfriendly activity | Reef friendly activity |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

# Coral threats information sheets


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.

## Overfishing

Overfishing has two impacts on the reef. Various fish species from large sharks to smaller 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.

**1500Kg**

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.

**850Kg**

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.

**300Kg**

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

**150Kg**

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

## 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?

## 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 below.

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?

# How do scientists share their findings?

Age 11-14

60 minutes

## Curriculum links

- Communicate findings using primary and secondary sources
- Choose an appropriate format and style for a real purpose and audience
- Explain their own and others' views about environmental change

## Resources

**Slideshow 7:** Expedition report

## Lesson overview

At the end of the expedition, teams create an expedition report to communicate their findings to a wider audience. This could take the form of a formal written report, a press release or a video. These outputs can be shared at an assembly, parents evening, with the local press and you can send a selection through to Encounter Edu (info@encounteredu.com) so that we can post them on our website.

| Lesson steps | Learning outcomes |
|---|---|
| **1. Why do we need to share our findings? (5 mins)** Students recognise the importance of sharing findings as firstly, not everyone can visit the coral reef and secondly the importance of raising awareness and revenue. | • Identify reasons for communicating the findings of an expedition |
| **2. What were your main findings? (10 mins)** Students review their learning through identifying their main findings and select five areas to report on. | • Summarise previous learning and select appropriate secondary sources |
| **3. Coral communications (30 mins)** Students use a variety of resources including ICT to create a report or press release. | • Complete an expedition report |
| **4. Coral report (15 mins)** Teams share their reports, articles, videos etc with a wider audience. | • Present findings to peers and real audiences |

# TEACHER GUIDANCE 7 (page 1 of 2)

| Step | Guidance | Resources |
|---|---|---|
| **1**<br>5<br>mins | Step 1 explains to students why scientific expeditions need to share their findings.<br>· Explain that there are two main reasons that scientists share their findings.<br>· Firstly, that science research needs to be shared with a wider audience as not everyone can go to the coral reef and so the team need to communicate what they found.<br>· Secondly, because expeditions are often sponsored. The XL Catlin Seaview Surveys were sponsored by an insurance company, XL Catlin. It helps sponsorship to show support on TV and in the news. | **Slideshow 7:**<br>Slides 1-4 |
| **2**<br>10<br>mins | Step 2 sees students review their learning from previous lessons.<br>· Explain that students will be planning and delivering a press conference or report to summarise what they have learnt about coral oceans.<br>· The press conference or report should last approximately ten minutes.<br>· Put students into groups of a size workable for your class.<br>· Explain that they should work together to decide the most important themes to report on. They can use their findings and experiences, as well as selecting some secondary sources such as information from fact sheets or websites.<br>· Ask students to focus on five main points which will form the basis of the story they will share. | **Slideshow 7:**<br>Slides 5-8 |
| **3**<br>30<br>mins | In step 3 students research and plan how to present their findings.<br>· Explain that students are free to use the format that suits them and the resources available at school.<br>· Students could use ICT to create a video or write a report or press release.<br>· You may wish to specify the media and resources used.<br>· Inform students how much time they have for this activity.<br>· Check in with groups while they are planning their press conference or report to ensure they are on track and remind them how much time they have left. | |

| Step | Guidance | Resources |
|---|---|---|
| **4**<br>15<br>mins | In step 4 students share their reports, articles, videos etc.<br>· Ask students to present their work and encourage the audience to be supportive.<br>· This can be set up as a press conference and some students may wish to create a suitable backdrop in the classroom.<br>· These can be shared with local news and websites such as www.encounteredu.com.<br>· You may wish to continue this into the next lesson to give groups adequate time to prepare and present. | **Slideshow 7:**<br>Slides 9 |