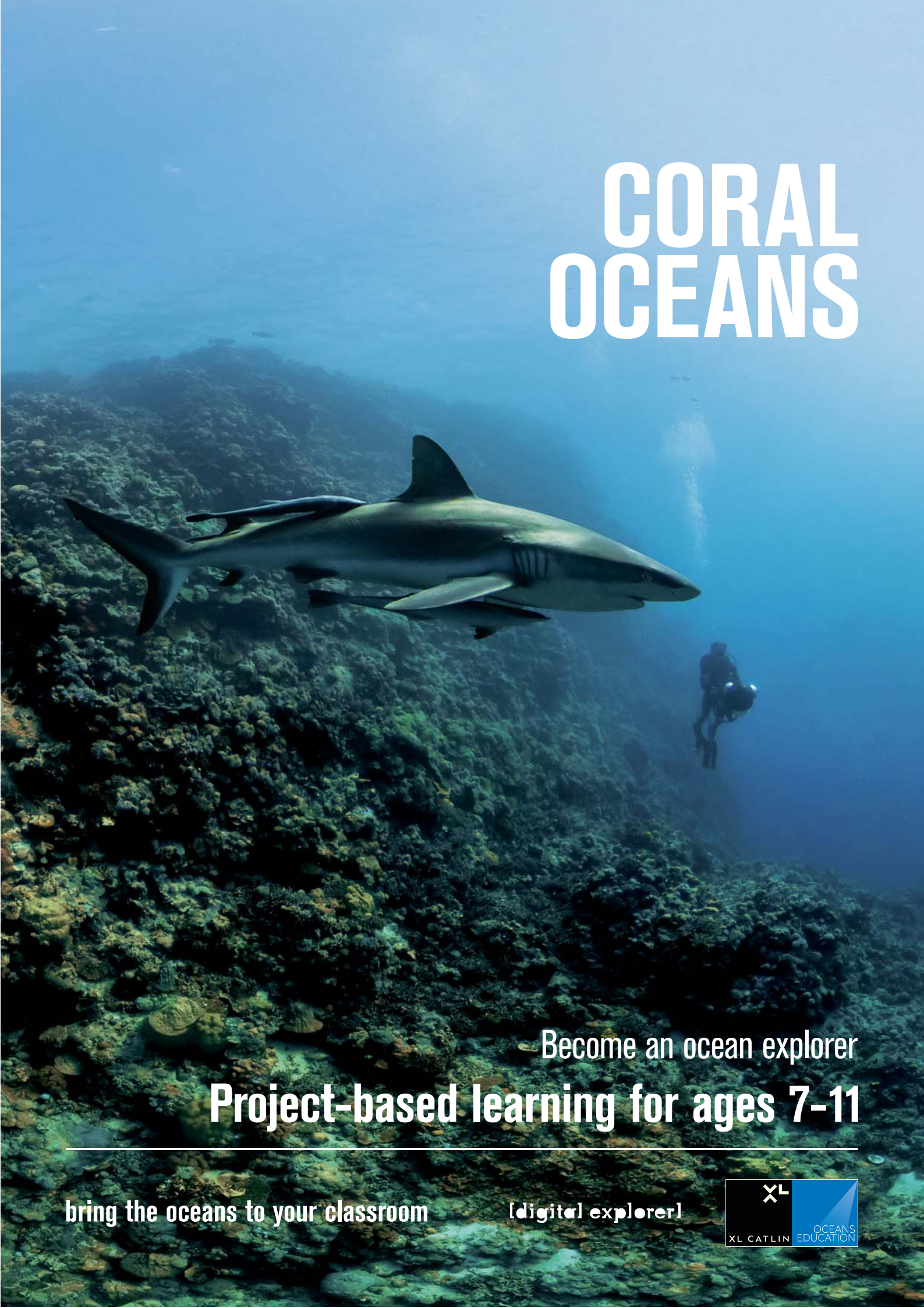
CORAL
OCEANS
Become an ocean explorer
Project-based learning for ages 7-11
bring the oceans to your classroom
[digital explorer]
XL CATLIN
OCEANS
EDUCATION

CONTENTS

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INTRODUCTION

Welcome to the Coral Oceans education pack for ages 7-11.

The Coral Oceans resources from Encounter Edu are based on the research and journeys by explorers and scientists taking part in the 2012 and 2013 Catlin Seaview Surveys.
www.catlinseaviewsurvey.com

This booklet for ages 7-11 forms part of a wider education programme to support oceans learning in schools.

OceansEucation.com is the online home for Encounter Edu Oceans and also provides:

- An Oceans Ambassador programme to link scientists and ocean experts with schools
- Multimedia resources and lesson ideas for primary and secondary schools
- Teacher training opportunities

The Encounter Edu Oceans programme will continue to develop, so keep in touch as we work to bring the oceans to your classroom.

Many thanks to the members of the Catlin Seaview Survey teams for their assistance in creating these resources, and to Catlin Group Limited for their continued support.

About XL Catlin

XL Catlin Oceans Education is a marine learning programme, created in 2011 to provide education outreach for sponsored science expeditions (Catlin Arctic Survey, XL Catlin Seaview Survey, XL Catlin Deep Ocean Survey). Nearly a decade later, it has become a full-fledge education programme, providing teachers with award winning resources and live education events to ignite student curiosity. By 2020, it has set the ambitious goal to reach 10 million children making XL Catlin a leader in ocean literacy and education community.

About Encounter Edu

Encounter Edu designs and runs STEM and Global Citizenship education programmes, which make use of virtual exchange, live broadcast and virtual reality. These technologies create classroom encounters that widen young people's world view. Learning is further underpinned by an online library of teacher resources and training. Combined, these provide children with the experience and knowledge to develop as engaged citizens and critical thinkers for the 21st Century.

About The Association for Science Education

The Association for Science Education (ASE) is the largest subject association in the UK. As the professional body for all those involved in science education from pre-school to higher education, the ASE provides a national network supported by a dedicated staff team.

About Global Change Institute (GCI) - University of Queensland

The GCI contributes to evidence-based, progressive solutions to the problems of a rapidly changing world within the existing and projected frameworks of those problems: political, environmental, social, economic, and technical.

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OVERVIEW

This resource will act as your guide to the world of coral, and in particular, to the Great Barrier Reef. Use it to connect your students with this natural wonder and the diversity of life that depends on it.

The Great Barrier Reef is one of the few biological structures visible from space. It is the iconic coral habitat of our planet, and stretches for over 2,300km along the eastern coast of Australia.

The coral reef has puzzled scientists for centuries. On his famous Beagle voyage, Charles Darwin was baffled as to how such richness of life was possible in the nutrient poor waters of the tropics. We now know that coral ecosystems cover less than 1% of the ocean's surface, but support an astounding 25% of marine life.

Diving beneath the surface, you may be lucky enough to spot turtles, sharks and rays. Swimming closer to the reef itself, a host of colours and movement comes into view. Life in all its forms swarms and flits, lurks and darts. Massive coral 'bommies'—some over 500 years old—provide a home for Christmas tree worms. Rainbow parrotfish scrape the rocks and coral, feeding on algae, and everywhere coral grows in myriad shapes and hues.

Revealing the ocean to everyone

Until now, this amazing world was the preserve of the few who had the opportunity to swim, snorkel and dive on the coral reef. The Catlin Seaview Survey has changed this. Using state-of-the-art underwater cameras, the team has produced an immersive virtual diving experience. Anyone with access to the internet can now explore the Great Barrier Reef, with further coral reef areas being added on an ongoing basis (see page 09 for further notes on virtual diving).

This new method of surveying the reef not only makes this natural wonder more accessible, it has a scientific purpose at its core. To create a global survey of the world's coral reefs would have taken decades using traditional methods. With coral ecosystems under threat from a variety of sources, the Catlin Seaview Survey is providing scientists globally with a rapid assessment record. The photographic baseline allows scientists to monitor the health of coral ecosystems more effectively.

Going deeper on the reef

The survey of the shallow reef, to create a baseline study, was carried out in conjunction with a deep reef expedition series. The deep reef, lying between 30 and 100 metres under the water's surface, is a little-explored habitat. Known as the 'twilight zone' because of the limited light available, researching the deep reef requires the use of specialist deep sea divers and Remotely Operated Vehicles (ROVs).

The deep reef team are undertaking a range of scientific research including: measuring the vulnerability of the deep reef to rising ocean temperature and acidity, and the genetic connections between deep and shallow reef corals.

Running out of time

The research is time critical. Some estimates state that the world's coral reefs will be in terminal decline by 2050. A 2012 report by the Australian Institute of Marine Science found that the Great Barrier Reef has lost half of its coral cover since 1985, due to a combination of storm damage (48%), crown-of-thorns starfish (42%) and bleaching caused by warming seas (10%). The future of the world's coral reefs is uncertain.

The decline is not only resulting in a loss of natural beauty and diversity, but could have far-reaching implications for human health and prosperity. Coral reefs provide food and income for over 500 million people across the planet, to the value of US$375 billion per annum. Beyond their direct economic value, reef systems provide essential protection for coastal areas from storms and waves.

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TEACHERS' NOTES

Lessons Overview

This series of lessons will introduce your students to the diverse and amazing life of the coral reef, and will enable you to cover core topics within the science curriculum.

Each lesson has a different focus, and together they form an expedition experience for your class. There are five different types of lessons:

- Information lesson providing background on the ocean and coral reef
- Creative lesson providing the opportunity to build a model coral reef in the classroom
- Dive mission lesson exploring core science topics through a 'virtual dive'
- Sustainability lesson examining the human impact on the coral reef
- Communications lesson for students to share their learning with a wider audience

Lesson 1 - Coral Explorer

Learning Objectives

- Identify the oceans on a map and locate the world's coral reefs
- Learn about a habitat different to your own local environment
- Use technology in the classroom to undertake virtual field trips

This lesson introduces young people to the wonders of the coral reef and the adventures of the Catlin Seaview Survey. Students will learn about where coral reefs are found in the world, and some of the living things that depend on them. In this first lesson, students will embark on their journey to become coral explorers, learning through the experiences of scientists and the expedition team, before going on a virtual dive to the Great Barrier Reef.

Lesson 2 - Reef Builders

Learning Objectives

- Learn about a less familiar habitat and the animals and plants that live there
- Identify species that live in habitats different to your local environment
- Use creativity to explore the habitat and living things

For teachers wishing to bring a hands-on and creative element to the unit, this lesson provides the template for building a reef in your classroom, and can act as the basis for future dive mission lessons. Rather than a traditional lesson plan, this lesson describes two possible ways of making your own reef in the classroom: reef-in-a-box and a reef mural. Depending on the time you have available, you can either use one or both of these approaches over the course of the unit.

Lesson 3 – Amazing Polyps

Learning Objectives

- Describe the anatomy of a coral polyp
- Understand the life cycle of coral, including the life process of reproduction (including sexual and asexual reproduction)
- Understand the different methods that coral polyps use to get energy

The Great Barrier Reef stretches for over 2,300km along the eastern coast of Australia, but the creatures that have created this amazing habitat measure just a few millimetres across. This lesson covers the basic anatomy of coral polyps, their life cycle and reproductive processes, and finishes with a game that shows how tropical coral polyps get their energy boost to create such incredible structures.

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TEACHERS' NOTES

Lessons Overview

Lesson 4 - Classification and Keys

Learning objectives

- Identify and name a variety of living things using classification keys to assign them to groups
- Know and use scientific language to describe groups of living things (e.g. invertebrates, vertebrates, etc.)
- Discuss why living things are placed in one group and not another

This dive mission introduces students to the range of life on the reef. Starting off by learning to name and identify different species, students will then sort them into different groups and start to use classification keys.

Lesson 5 - Food Chains

Learning Objectives

- Recognise and describe how animals obtain their food from plants (and algae) and other animals, using the idea of a food chain
- Construct and interpret a variety of food chains, identifying producers, predators, and prey
- Compare animals in familiar habitats with animals found in less familiar habitats, for example the ocean

This dive mission combines science and creativity to help young people learn more about life on the coral reef and the food chains that link them. The output for this activity is to create a mobile to hang at home or in the classroom that shows some of the main types of life on the coral reef, connected in food chains.

Lesson 6 - Adaptation

Learning Objectives

- Identify how animals and plants have adapted to suit their environment in different ways
- Introduce the idea that adaptation may lead to evolution
- Create the ultimate coral animal, demonstrating an understanding of adaptation

Different species have adapted to life on the coral reef in amazing and diverse ways. From sleeping in mucus bubbles, to snakelike skeletons, those living on the reef have had to develop ingenious methods for finding food and staying alive. In this lesson, students are challenged to create the ultimate coral animal.

Lesson 7 - Human Impact on the Reef

Learning Objectives

- Explore examples of human impact (both positive and negative) on environments
- Recognise that environments can change and that this can sometimes pose a danger to living things
- Suggest actions that can be taken on a global and local scale to reduce the negative human impact on environments

In this lesson students will consider the various impacts humans have had on the coral reef ecosystem, both positive and negative. These range from long-term environmental changes caused by increased atmospheric carbon dioxide, to changes in land use in coastal areas, to the impact of fertilisers on the ecosystem. Students will be prompted to consider what changes could be made to ensure that there are healthy coral reefs well into the future.

Lesson 8 - Expedition Press Conference

Learning Objectives

- Communicate their 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

At the end of the expedition, teams will create an expedition report to communicate their findings to a wider audience. The output from this lesson could be a formal written report, press release or video.

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NOTES FOR TEACHERS

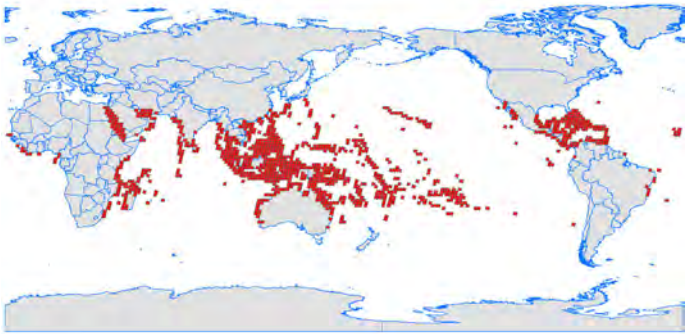
Coral Introduction

The wonderful ocean

The ocean is undeniably important. Life began in the ocean, and it covers over 70% of our planet. 95% of life is aquatic. 50% of the oxygen we breathe comes not from the rainforest, but from the ocean. The ocean is the primary source of protein for over a billion people. It absorbs up to 50% of the carbon dioxide we produce and regulates the global climate system.

The ocean is not just one habitat. It has the same level of diversity as better-known land-based habitats. There are seagrass meadows and kelp forests, undersea mountains and canyons deeper than Mount Everest is high. There are rocky shores and muddy bottoms. And then there are the coral reefs.

Coral reefs exist in warm, tropical, shallow waters around the world. Well-known areas of reef are South East Asia (the Coral Triangle), the Great Barrier Reef along the eastern coast of Australia, the Caribbean, and the Red Sea.



Map showing the world's coral reefs

What is coral?

A coral reef is not a plant or a rock, although it can resemble both. A coral reef is a living structure made up of tiny animals called polyps.

The coral polyp is an animal from the same group, or phylum, as jellyfish and sea anemones, called Cnidaria. The majority of coral polyps are sessile, which means that they are fixed in one place.

Like other animals, such as crabs, lobsters and shellfish, they grow their own structures from calcium carbonate dissolved in the ocean.

Corals reproduce both sexually and asexually. There is one day a year when corals release their eggs and sperm into the water, so that the fertilised eggs will develop into larvae and settle on a part of the reef to grow into a new coral.

Close-up of coral polyps

Corals get their energy both through photosynthesis and by capturing prey with their small tentacles. The energy from photosynthesis comes from a symbiotic relationship with a type of algae, zooxanthellae. The zooxanthellae live in the tissue of the coral and passes energy to the polyp, receiving certain nutrients in return.

Most corals are colonial. This means that the individual polyps are connected together in a single system, sharing nutrients, as well as being individual animals at the same time.

The biology of the coral ecosystem can be confusing if compared with terrestrial examples. They:

– are an animal that looks like a rock or a plant

– reproduce sexually and asexually

– receive their energy both from the sun and from catching plankton

– are both a large colony and made up of individual polyps

Life in the sea is different: other animals grow in colonial structures such as sponges; some jellyfish also have algae living in their tissue to supply extra energy through photosynthesis; and some sea stars (commonly called starfish) reproduce both sexually and asexually.

Why are reefs important?

Coral is not just important because it is amazing in itself, but also because it is a habitat-forming animal. The beautiful structures created by the coral polyp support over 25% of life in the ocean. Without the reef, thousands of species would be in jeopardy. Coastal fisheries would be badly affected and livelihoods would be lost. Polyps may only measure a few millimetres across, but they play a crucial role in the global ecosystem.

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NOTES FOR TEACHERS

Ocean Literacy

Traditional examples, processes and case studies in the science curriculum have been drawn from land-based knowledge. The rainforests are often referred to as the lungs of the planet, while in fact more primary production takes place in the ocean, and the bulk of this activity is by algae and bacteria rather than flowering plants.

A number of initiatives are seeking to rebalance our understanding of the ocean, and to develop a more representative science curriculum. These include:

- National Marine Educators Association (USA) - marine-ed.org
- Marine Education Society of Australia (Aus) - mesa.edu.au
- Ocean Literacy UK (UK) - oceanliteracy.org.uk

The table below shows how this resource can help meet elements of the Ocean Literacy Framework for your students. See oceanliteracy.wp2.coexploration.org for further details.

Elements from the Ocean Literacy Framework	Lessons
1a The ocean is the dominant feature on planet Earth, covering ~70% of the surface.	01
3e The ocean dominates the Earth's carbon cycle. Half the primary production on Earth takes place in the sunlit layers of the ocean, and the ocean absorbs up to half of all CO_2 added to the atmosphere.	04, 07
5a Ocean life ranges in size from the smallest virus to the largest animal that has ever lived on Earth – the blue whale.	01, 02, 03, 04
5b Most life in the ocean are microbes – the most important primary producers in the ocean.	05
5c Some major groups of life are found exclusively in the ocean. The diversity of major groups of organisms is greater in the ocean than on land.	02, 03, 04
5d Ocean biology provides many unique examples of life cycles, adaptations, and important relationships among organisms (symbiosis, predator-prey dynamics, and energy transfer) that do not occur on land.	03, 04, 05, 06
5e The ocean is 3D, offering vast living space and diverse habitats from the surface, through to the water column, and down to the seafloor. Most of the living space on Earth is in the ocean.	01, 06
5f Ocean habitats are defined by environmental factors such as salinity, temperature, oxygen, pH, light, nutrients, substrate, pressure, and circulation. Some regions of the ocean support life more diverse and abundant than anywhere on Earth, while much of the ocean is considered devoid of life.	01, 03, 06, 07
6e Humans affect the ocean in a variety of ways. Human development and activity leads to pollution and physical modifications.	07
6g The ocean sustains life on Earth, and humans must live in ways that sustain the ocean. Individual and collective actions are needed to effectively manage ocean resources for all.	07
7a The ocean is the last and largest unexplored place on Earth – less than 5% of it has been explored.	01
7c Over the last 40 years, the use of ocean resources has increased significantly, and their sustainability depends on our understanding their potential and limitations.	07
7d New technologies, sensors, and tools are expanding our ability to explore the oceans like never before.	01

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NOTES FOR TEACHERS

'Dive Feel'

The lessons and dive missions in this education pack are designed to give students a feel for what it is like to be a marine scientist and to explore and work underwater. Alongside the science and marine literacy in each lesson, different elements have been included to bring the world of coral expeditions to life.

Classroom ideas

We invite teachers to adopt the following ideas and formats to bring a 'dive feel' to their classroom.

Teachers as the 'dive master'

Throughout the series of lessons, the teacher can pose as the dive master, briefing their divers at the beginning of each lesson and signing or stamping their log book sheets at the end.

Dive signs

One of the problems divers encounter working underwater is communication. Divers cannot talk to each other and so they use a range of dive signs (like sign language). A selection of these are included on Activity Sheet 01. Teachers may want certain portions of lessons to be conducted using only dive signs to communicate.

Buddy system

Divers rarely dive alone, instead they dive with a buddy. Consider putting students into pairs for the series of lessons.

Dive logs

Every diver and underwater expedition keep dive logs, sometimes purely for safety, and at other times for a record of what has been explored and discovered. Log books are also used as proof that a diver can handle advanced and difficult conditions. Students can use the dive log pro forma (Activity Sheet 03) and complete it as a learning review. Students will be able to use these as the basis for the end of unit assessment, when they will have the chance to create an expedition report.

Expedition media

All the lessons are based on an actual expedition. Research shows that using case studies involving real people (scientists with first names!) and real world scenarios creates greater learner engagement and attainment.

Examples of blog posts, videos, and photos from the expeditions are referenced throughout the lessons, to bring this very different environment to life in the classroom.

[de] Student Media Player

The videos and photos from the Catlin Seaview Survey expeditions are presented using the [de] Student Media Player online. References to content on the Media Player are made throughout the lesson plans. The online platform has an intuitive interface, and has been designed for use on desktops, laptops, and tablets.

Teachers can create sequences of photos, videos, and graphics from the resources, bringing an easy-to-use multimedia element to their lessons.

Students can browse and learn from the photo and video captions in their own time, supporting independent learning.

You can access the [de] Student Media Player at:
media.digitalexplorer.com

Follow the team live

During the expedition phases of the Catlin Seaview Survey, the team will be posting regular updates on catlinseaviewsurvey.com. A number of social media sites are also used and can be shared with students (NB: please follow related guidance for social media use both from your school and from the service providers).

Google+	plus.google.com/+CatlinSeaviewSurvey/
YouTube	youtube.com/user/CatlinSeaviewSurvey/
Twitter	twitter.com/SeaviewSurvey
Facebook	facebook.com/CatlinSeaviewSurvey

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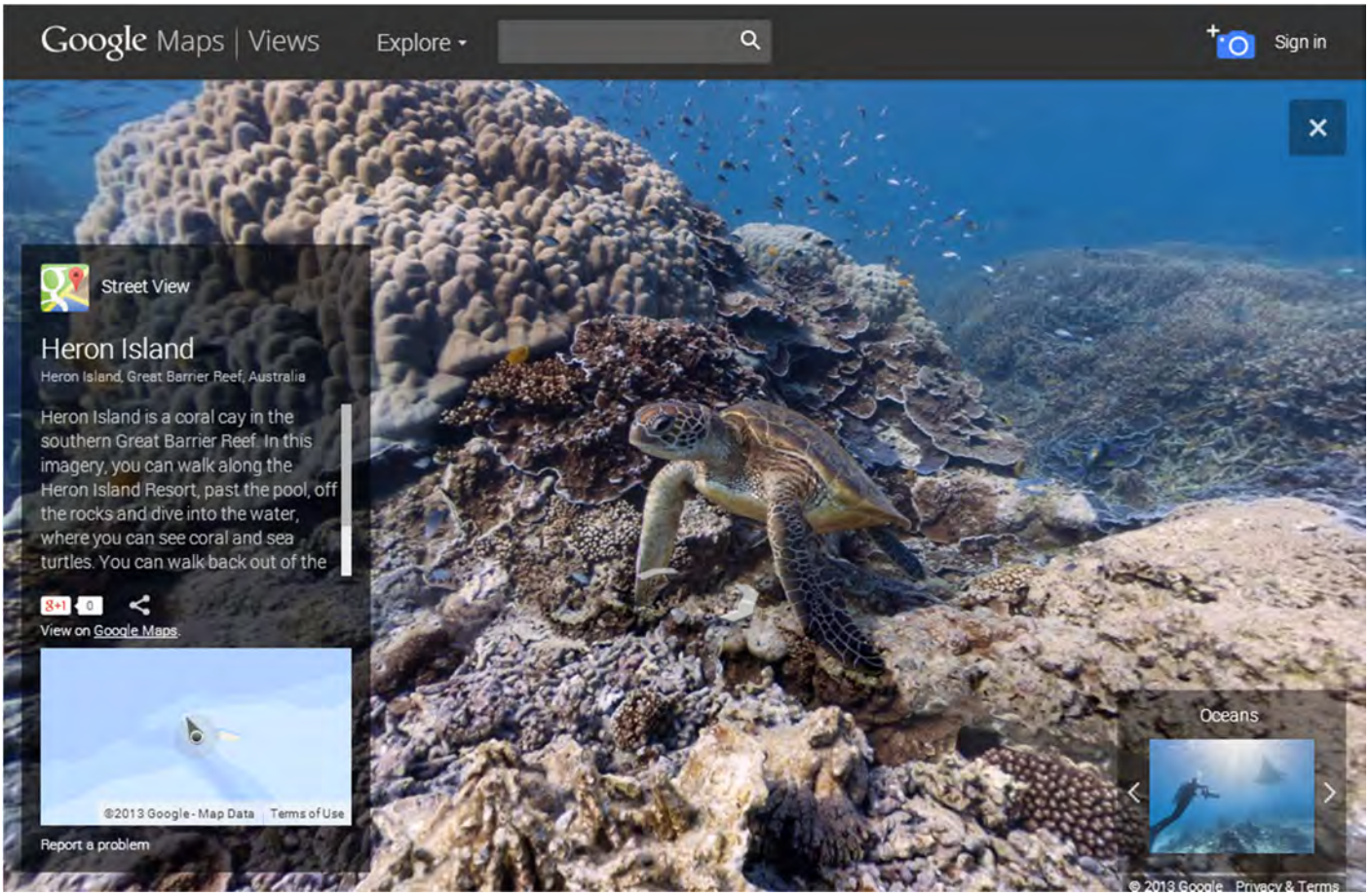
NOTES FOR TEACHERS

Virtual Diving



The underwater SVII cameras developed by the Catlin Seaview Survey team have changed the ways we can explore the ocean. The images collected by the camera not only provide scientists with baseline data on the health and coverage of the reef, but also open up this incredible and unique world to a global audience.

Since the Catlin Seaview Survey launched in September 2012, it has surveyed over 250km of reef. The images have been stitched together to create astonishing 'virtual dives', which can be viewed via Google Maps.

According to the project director, Richard Vevers, these virtual dives have opened up the ocean to millions of people. "This is as close as you can get to a dive experience without getting wet," he says.

Virtual diving can be accessed in the classroom via Google Maps (maps.google.com/ocean) or via the Catlin Seaview Survey website (is.gd/virtualdive).

In addition, a number of resources have been created by Digital Explorer to make use of the underwater imagery available on Google, and to use the Google Earth platform to teach more about coral ecosystems.

These can be downloaded from oceans.digitalexplorer.com/resources/googleocean and comprise four activities:

- Classification
- Food chains
- Symbiosis
- Threats

A Google Earth (kml) file has also been created containing information about the different species that live on the Great Barrier Reef (also available from the link above).

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LESSON 01: CORAL EXPLORER

Summary

This lesson introduces young people to the wonders of the coral reef and the adventures of the Catlin Seaview Survey. They will learn about where coral reefs are found in the world, and some of the living things that depend on them. In this first lesson, students will embark on their journey to become coral explorers, learning through the experiences of scientists and the expedition team, before going on a virtual dive on the Great Barrier Reef. The lesson provides the platform for further discovery through a series of science curriculum linked dive missions.

Learning Objectives

- Identify the oceans on a map and locate the world's coral reefs
- Learn about a habitat different to your own local environment
- Use technology in the classroom to undertake virtual field trips

Preparation

- Download and familiarise yourself with Slideshow 01 - Coral Explorer from oceans.digitalexplorer.com/resources
- Use Fact Sheet 01 - About the Great Barrier Reef and Fact Sheet 02 - Catlin Seaview Survey for background information
- View videos and photos at media.digitalexplorer.com, and either browse the videos in the Coral Oceans (Primary) Theme or search using keywords
- Print out copies for your class of:
  - Activity Sheet 01 - Dive Signs
  - Activity Sheet 02 - Dive Equipment (optional or homework)
  - Activity Sheet 03 - Dive Log
- Ensure you are familiar with how to use 'virtual diving' resources, either the underwater panoramas on the Catlin Seaview Survey website (is.gd/virtualdive), or via Google Maps (maps.google.com/oceans). More information about these resources can be found on page 9

Notes

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LESSON 01: CORAL EXPLORER

Aims / Objectives	Activities	Resources	Outcomes
STARTER: WHAT IS THE OCEAN HABITAT LIKE?	Introduce students to some basic ocean facts leading to a realisation that we live on a blue planet with the ocean covering over 70% of the surface. The ocean sustains not just one habitat, but a variety of different habitats, just as we have on land. Use the slideshow to introduce students to the diversity of life and habitats in the ocean.	Slideshow 01 - Underwater Explorer	Know that we live on a 'blue planet' Locate and name the five oceans
WHAT IS THE CATLIN SEAVIEW SURVEY?	Introduce students to the Catlin Seaview Survey using the slideshow and appropriate videos for your class from suggestions in the Resources column. Tell students that they are going to go on a virtual dive in the classroom, but first they need to learn a little about coral reefs and working underwater.	Slideshow 01 Video - Catlin Seaview Survey: Introduction Video - Ep 01: Setting Sail Video - Ep 05: Sharing the Science	Locate the world's tropical coral reefs and identify the environmental factors that coral reefs need Describe the Catlin Seaview Survey and its science aims
WORKING UNDERWATER - DIVE SIGNS	Discuss the challenges for scientists working underwater, from the limited time they can spend using scuba gear, to the problems of communication. Use Activity Sheet 01 to introduce students to the dive signs used to communicate underwater. With your class, create a song with relevant actions to help remember the different dive signs. You will then put them into practice for your first virtual dive.	Slideshow 01 Activity Sheet 01 - Dive Signs Video - Ep 07: Dive Signs	Use song (and dance) to remember the common dive signs used by scientists working underwater
WORKING UNDERWATER - DIVE EQUIPMENT (OPTIONAL OR FOR HOMEWORK)	*The expedition scientists need to use a range of diving equipment to work underwater. For deep dives (down to 40m), equipment can weigh up to 40kg in total.* *Use Activity Sheet 02 as an individual research task during the lesson if students have access to computers or tablets, or set as a homework task to find out how different kit works.*	*Slideshow 01* *Activity Sheet 02 - Dive Equipment* *Video - Ep 8: Dive Kit*	*Know about the technological advances that allow scientists to work underwater*
LET'S GO DIVING	Show the virtual diving on a digital projector to the class. Set a 10 minute time limit and tell the class that after this time they will run out of air. They will need to signal 'Time to go back' using dive signs when they have 1 minute left of air. With the class silent and only using dive signs to navigate, steer them through the wonders of the reef.	Virtual diving using either: maps.google.com/ocean or is.gd/virtualdive	Enjoy the wonders of the reef and practice common dive signs
PLENARY SHARING LEARNING ABOUT THE CORAL REEF	Students complete their dive logs to record what they have learnt during the lesson. Dive logs can be kept in individual folders and form the basis of the end of unit expedition report.	Activity Sheet 03 - Dive Log Whole Class Discussion	Reflect on the wonders of the coral reef and record thoughts and discoveries

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LESSON 02: REEF BUILDERS

Summary

For teachers wishing to bring a hands-on and creative element to the unit, this lesson provides the template for building a reef in your classroom and can act as the basis for future dive missions. Rather than a traditional lesson plan, this lesson describes two possible ways of making your own reef in the classroom: reef-in-a-box and a reef mural. Depending on the time you have available, you can either use one or both of these approaches over the course of the unit, or adapt these ideas to make your own reef.

Learning Objectives

- Learn about a less familiar habitat and the animals and plants that live there
- Identify species that live in habitats different to your local environment
- Use creativity to explore the habitat and living things

Preparation

- Download and familiarise yourself with Slideshow 02 – Reef builders from oceans.digitalexplorer.com/resources
- Print out copies for the class of:
  - Activity Sheet 04 - Reef-in-a-box
  - Activity Sheet 05 - Reef mural
- Each activity sheet option lists the creative materials needed
- Print out copies for the class of reef life templates (download from oceans.digitalexplorer.com/resources)
- View videos and photos at media.digitalexplorer.com, and either browse the videos in the Coral Oceans (Primary) Theme or search using keywords

Notes

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LESSON 02: REEF BUILDERS

Aims / Objectives	Activities	Resources	Outcomes
STARTER: HOW DO CORAL REEFS FORM?	Use the slideshow to introduce students to the process by which corals grow and form the 3D habitat of the coral reef, providing opportunities and living space for a range of other life. Comparisons can be made to the way a local woodland grows and provides a habitat for a range of different plants and animals.	Slideshow 02 - Reef builders Video - Ep 3: Wonders of coral	Understand how corals create the 3D habitat of the coral reef and provide living space for other species
REEF-IN-A-BOX OPTION	Split your class into groups of 2-6 depending on class size and the space you have for completed reef boxes. Use the list on Activity Sheet 04 to prepare the creative materials and reef life templates for each group. Use the slideshow or model the activity to support students to create their reef-in-a-box. Students then create their reef habitats, making the background design. The coral, plants, and algae, invertebrates, and vertebrate species can be added as part of Lessons 03 and 04.	Slideshow 02 Activity Sheet 04 - Reef-in-a-box	Learn about a less familiar habitat and use creativity to model this in the classroom
REEF MURAL OPTION	Split your class into groups of 2-6 depending on class size and the wall space you have available. Use the list on Activity Sheet 05 to prepare the creative materials and reef life templates for each group. Use the slideshow or model the activity to support students to create their reef murals. Students then create their reef habitats, making the background design. The coral, plants and algae, invertebrates. and vertebrate species can be added as part of Lessons 03 and 04.	Slideshow 02 Activity Sheet 05 - Reef mural	Learn about a less familiar habitat and use creativity to model this in the classroom
REVIEW: COMPARE THE CORAL REEF TO THE LOCAL ENVIRONMENT	Students can record what they have learnt in their dive log, and use this as the basis for a discussion on the similarities and differences between the coral reef and their local environment. The discussion can be developed over future lessons, as students learn more about the reef habitat through dive missions.	Activity Sheet 03 - Dive Log Whole class discussion	Compare a less familiar habitat with the local environment

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LESSON 03: AMAZING POLYPS

Summary

The Great Barrier Reef stretches for over 2,300km along the eastern coast of Australia, but the creatures that have created this habitat measure just a few millimetres across. This lesson covers the basic anatomy of the coral polyp, their life cycle and reproductive processes, and finishes with a game that shows how tropical coral polyps get their energy boost to create such amazing structures.

Learning Objectives

- Describe the anatomy of a coral polyp
- Understand the life cycle of coral, including the life process of reproduction
- Understand the different methods that coral polyps use to get energy

Preparation

- Download and familiarise yourself with Slideshow 03 - Amazing Polyps from oceans.digitalexplorer.com/resources
- Print out copies for the class of:
  - Activity Sheet 06 - Coral reef scales
  - Activity Sheet 07 - Incredible edible polyp
  - Activity Sheet 08 - Coral life cycle
  - Activity Sheet 09 - Coral feeding game
- View videos and photos at media.digitalexplorer.com, and either browse the videos in the Coral Oceans (Primary) Theme or search using keywords
- There are some extra materials that will be needed for the incredible edible polyp and coral feeding game activities. These are listed on the respective activity sheets.

Notes

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DIVE MISSION: AMAZING POLYPS

Aims / Objectives	Activities	Resources	Outcomes
STARTER: HOW BIG IS THE REEF AND HOW SMALL IS A POLYP?	Use the cut-out card activity on Activity Sheet 06 to show students the different scales that exist on coral reefs. Students should cut out the different photos of coral and coral reefs and order them according to size.	Slideshow 03 - Dive Mission: Amazing polyps Activity Sheet 06 - Coral reef scales	Understand that one of the few living structures visible from space is made up of tiny animals
MAKING A CORAL POLYP MODEL	Activity Sheet 07 describes how to make a model of a coral polyp using different foods and sweets. This is a fun way for students to learn more about the different aspects of coral anatomy as they make (and eat!) their incredible edible polyps.	Slideshow 03 Activity Sheet 07 - Incredible Edible Polyp Video - Incredible Edible Polyp	Describe the anatomy of a coral polyp
HOW DO CORAL POLYPS REPRODUCE AND GROW THEIR COLONIES?	Coral polyps reproduce both sexually and asexually. The life cycle of a coral polyp is similar to life cycles that students may be familiar with, such as frogs and toads, i.e. sperm fertilise the eggs in water. Students can sketch and label the reproduction and life cycle of a coral polyp and that of a more familiar animal such as a frog or toad, using Activity Sheet 08 as a guide. Hold a class discussion to examine the similarities and differences between the life cycle of a coral polyp and a more familiar animal.	Slideshow 03 Activity Sheet 08 - Coral Life Cycle	Explain the life cycle of coral, including the life process of reproduction (sexual and asexual reproduction) in animals
HOW DO POLYPS GET THEIR ENERGY BOOST?	Use Activity Sheet 09 to show how coral polyps get an energy boost, using a clever method to harness energy from the sun, as well as feeding on tiny animals.	Slideshow 03 Activity Sheet 09 - Coral Feeding Game Video - Coral Feeding Game	Understand the different methods that coral polyps use to get energy
PLENARY WHAT DO I KNOW ABOUT POLYPS?	Students can now add their corals to their reef mural or reef-in-a-box if they have not done so already. Use the dive log template for students to record all the new facts that they have learned about polyps.	Reef life templates Activity Sheet 03 - Dive Log Whole class discussion	Review the new learning about coral polyps and their role on the reef

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LESSON 04: CLASSIFICATION AND KEYS

Summary

This dive mission introduces students to the range of life on the reef. Starting off by learning to name and identify different species, students will then sort these into different groups and start to use classification keys. More advanced classes may want to devise their own keys. As different living things are identified and classified, they can be added to the reef display.

Learning Objectives

- Identify and name a variety of living things using classification keys to assign them to groups
- Know and use scientific language to describe groups of living things (e.g. invertebrates, vertebrates, molluscs, plants, etc.)
- Discuss why living things are placed in one group and not another

Preparation

- Download and familiarise yourself with Slideshow 4 - Classification and Keys from oceans.digitalexplorer.com/resources
- Print out copies for the class of:
  - Activity Sheet 10 - Grouping Coral Life
  - Activity Sheet 11 - Coral Life Photo Sheet
  - Activity Sheet 12 - Key for Coral Life
  - Activity Sheet 13 - Scientific Groups
  - Activity Sheet 14 - Coral Invertebrate ID
  - Activity Sheet 15 - Animal Dive Signs
- View videos and photos at media.digitalexplorer.com, and either browse the videos in the Coral Oceans (Primary) Theme or search using keywords

Notes

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LESSON 04: CLASSIFICATION AND KEYS

Aims / Objectives	Activities	Resources	Outcomes
STARTER: HOW CAN WE GROUP LIVING THINGS?	Use the slideshow to introduce students to the idea of classification, the method used by scientists to group living things. Using either the living things from the reef mural or reef-in-a-box, or the examples of coral life on Activity Sheet 11, ask students to work through Activity Sheet 10. There are no right answers to the main classification exercise.	Slideshow 04 - Dive Mission: Classification and Keys Activity Sheet 10 - Grouping coral life Activity Sheet 11 - Coral life photo sheet or Examples from reef mural or reef-in-a-box	Understand that living things can be grouped based on observable characteristics
HOW DO SCIENTISTS GROUP LIVING THINGS?	Scientists develop key questions to classify (group) and identify different species. Use the slideshow to identify the shared characteristics of some examples of coral life. Students can then use the key on Activity Sheet 12 to classify coral life (using either the reef mural, reef -in-a-box, or photo sheet examples) according to scientific principles. Results can be recorded on Activity Sheet 13.	Slideshow 04 Activity Sheet 11 - Coral Life Photo Sheet, or examples from reef mural or reef-in-a-box Activity Sheet 12 - Key for Coral Life Activity Sheet 13 - Scientific Groups	Use scientific language to describe groups of living things
HOW CAN KEYS BE USED TO IDENTIFY CORAL LIFE?	Keys are not only used to classify different living things, but also to help identify individual species. Students are challenged to create their own key for invertebrate life on the coral reef. Once completed the key can be trialed on some of the coral life in classroom displays, on the [de] Student Media Player, or the invertebrate species on the photo sheet.	Activity Sheet 14 - Coral Invertebrate ID	Identify and name a variety of living things using classification keys to assign them to groups
PLENARY	Divers use a series of dive signs to point out different types of animals underwater. You can see some examples in the video or on Activity Sheet 15. Students should think up some more animal dive signs based on their new knowledge of life on the coral reef. Students can then share their new dive signs and decide which are best suited to each animal.	Video - Ep 07: Dive Signs Activity Sheet 15 - Animal Dive Signs Whole class discussion	Review classification and identification and demonstrate new learning in the context of underwater exploration

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LESSON 05: FOOD CHAINS

Summary

This dive mission combines science and creativity to help young people learn more about life on the coral reef and the food chains that link them together. The output for this activity is to create a mobile to hang at home or in the classroom, showing some of the main types of life that can be found on the coral reef, and how they are related through predator-prey relationships.

Learning Objectives

- Recognise and describe how animals obtain food from plants, algae and other animals, using the idea of a food chain
- Construct and interpret a variety of food chains, identifying producers, predators, and prey
- Compare animals in familiar habitats with animals found in less familiar habitats, for example in the ocean

Preparation

- Download and familiarise yourself with Slideshow 05 – Food Chains from oceans.digitalexplorer.com/resources
- View videos and photos at media.digitalexplorer.com, and either browse the videos in the Coral Oceans (Primary) Theme or search using keywords
- Print out copies for the class of:

  Activity Sheet 16 - Food chains
  Activity Sheet 17 - Coral Food Chain Mobile
  Activity Sheet 18 - Reef Mural Food Chain
  Relevant slides from the Slideshow to use as templates and for more information, or 'borrow' these from the reef in a box or reef mural activities
- Art and other materials needed to make the food chain mobiles are listed on Activity Sheet 17

Notes

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LESSON 05: FOOD CHAINS

Aims / Objectives	Activities	Resources	Outcomes
STARTER: WHAT LIFE IS FOUND ON CORAL REEFS?	Introduce the dive mission to find out what different reef species eat. Watch a clip of a dugong (sea cow) eating seagrass and link to a feeding pattern that students will recognise. Students should already be aware of plants being producers. Then watch the Underwater Classroom videos and discuss which species are carnivores, herbivores, producers, and consumers in each case, and how creatures depend on each other within a food chain.	Slideshow 05 - Food Chains Video - Dugong Feeding (bbc.co.uk/nature/life/Dugong#p00n0zl4) For more videos search for keyword 'Underwater Classroom' at media.digitalexplorer.com	Understand how different species get their energy through feeding
WHAT PRODUCERS LIVE ON THE REEF?	Most of the primary productivity in the ocean does not come from plants. Introduce students to the range of primary production on the reef. This is also an opportunity to introduce students to plankton and their place in the marine food chain.	Slideshow 05	Identify the range of primary producers in the ocean
HOW DO LIVING THINGS LINK IN FOOD CHAINS?	Before putting the food chain mobile together, introduce or revise basic information about how living things are connected using Activity Sheet 16. This will help to reinforce some of the key terms.	Activity Sheet 16 - Food chains Slideshow 05	Describe food chain relationships using scientific terms
CREATING CORAL LIFE CARDS (OPTION: USE REEF MURAL)	In groups, pupils should draw all the living things found on the coral reef on cards. All cards should be the same size. If needed, the reef life templates can be used, as these have outline templates of the different living things studied so far. An option to use string or wool to create food chains with the reef mural is described on Activity Sheet 18.	Slideshow 05 (OPTION: Activity Sheet 18 - Reef Mural Food Chain)	Prepare to create the food chain mobile or reef mural food chain
HOW DO LIVING THINGS ON THE CORAL REEF LINK TOGETHER?	Use the instructions on Activity Sheet 17 to guide pupils to create a food chain mobile, using the living things cards. These can then be hung in the classroom.	Activity 17 - Food Chain Mobile Slideshow 05	Demonstrate a scientific concept using art and creativity
PLENARY HOW MIGHT FOOD CHAINS BREAK?	Guide a plenary discussion about how food chain links can be broken and the importance of all living things on the coral reef.	Whole class discussion	Reflect on the importance of all parts of food chains

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LESSON 06: ADAPTATION

Summary

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 for finding food and staying alive. The reef is also host to numerous examples of symbiosis, and creatures finding food and safety in the strangest of places – whether in a shark's mouth or by 'vacuuming' the sandy seabed. In this lesson, students are challenged to create the ultimate reef animal.

Learning objectives

- Identify how animals and plants have adapted in different ways to suit their environment
- Introduce the idea that adaptation may lead to evolution
- Create the ultimate coral animal, demonstrating an understanding of adaptation

Preparation

- Download and familiarise yourself with Slideshow 6 – Adaptation from oceans.digitalexplorer.com/resources
- Prepare art materials and paper for each student to design their ultimate coral animal. These could be made the same size to fit the reef-in-a-box or reef mural that students created during Lesson 02
- View videos and photos at media.digitalexplorer.com, and either browse the videos in the Coral Oceans (Primary) Theme or search using keywords

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LESSON 06: ADAPTATION

Aims / Objectives	Activities	Resources	Outcomes
STARTER: WHY HAVE ANIMALS ADAPTED TO SURVIVE ON THE REEF?	Use the slideshow to ask students how many stonefish they can see. How has the stonefish adapted to survive on the coral reef? Further slides demonstrate the need for all species to compete for food in the nutrient-poor waters of the coral ecosystem. Connect this to students' prior learning about the need for corals to get extra energy from algae through photosynthesis, as well as their knowledge of the coral reef food chain.	Slideshow 06 - Adaptation	Identify specific adaptations used by coral reef species Explain the need for adaptation for survival
HOW HAVE DIFFERENT SPECIES ADAPTED TO LIFE ON THE REEF?	Introduce students to the dive mission for the lesson: to create the ultimate coral animal. They will learn from a number of different animals to discover the strategies used to survive. Using the slideshow, introduce students to the range of adaptations that animals have used to increase their chances of survival on the reef.	Slideshow 06	List a range of adaptation strategies used on the reef
WHAT WOULD MAKE THE ULTIMATE CORAL ANIMAL?	Get students to create the ultimate coral animal using what they have learnt so far as inspiration. Using art materials, students can draw their new animal and list the adaptations that will ensure its survival and success. Students may wish to research other coral animals online to gain further information. Suitable websites are listed at the back of the booklet. You can also use videos and photos at media.digitalexplorer.com.	Art materials Use hashtag #living things in the Coral Oceans (Primary) Theme for examples of adaptation	Create the ultimate coral animal using knowledge gained so far
PLENARY HOW ANIMALS ADAPTED TO LIVE ON THE CORAL REEF?	Students complete their dive log and explain what they have discovered about adaptation on the reef. You may wish to introduce the concept of evolution here. That as animals become more specialised and adapt to different opportunities and niches on the reef, they have evolved into different species over many generations. If students wish to have their ultimate coral animal displayed on the [de] Oceans website, they can spend time honing their work in their own time and then email it to: info@digitalexplorer.com The best examples will be displayed in an online gallery.	Activity Sheet 03 - Dive Log Whole class discussion	Review and consolidate understanding of adaptation on the reef

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LESSON 07: HUMAN IMPACT ON THE REEF

Summary

Students will consider the various impacts humans have had on the coral reef ecosystem, both positive and negative. These impacts range from long-term environmental changes caused by increased atmospheric carbon dioxide, to changes in land use in coastal areas and the impact of fertilisers on the ecosystem balance. Students will be prompted to consider what changes could be made to ensure that there are healthy coral reefs well into the future.

Learning Objectives

- Explore examples of human impact (both positive and negative) on environments
- Recognise that environments can change and that this can sometimes pose dangers to living things
- Suggest actions that can be taken on a global and local scale to reduce the negative human impact on environments

Preparation

- Download and familiarise yourself with Slideshow 7 – Human Impact on the Reef from oceans.digitalexplorer.com/resources
- View videos and photos at media.digitalexplorer.com, and either browse the videos in the Coral Oceans (Primary) Theme or search using keywords
- Use the following activity sheets as appropriate with your class, many are optional depending on the level of your class and the amount of time you wish to devote to this topic:

    Activity Sheet 17-22 - various activity ideas and information for students
    Activity Sheet 23 - Coral Threat Cards
    Activity Sheet 24 - Good Coral Living Cards
    Activity Sheet 25 - Coral Future Poster Template

- Background information for teachers on the threats facing the coral reef:

    Fact Sheet 3 - Threats Overview
    Fact Sheet 4 - Coral in a High $C0_2$ World
    Fact Sheet 5 - Coral and Water Quality
    Fact Sheet 6 - Human Activity on the Reef
    Fact Sheet 7 - Conservation on the Great Barrier Reef

Notes

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LESSON 07: HUMAN IMPACT ON THE REEF

Aims / Objectives	Activities	Resources	Outcomes
STARTER: WHY SHOULD WE CARE FOR THE REEF?	Start the lesson by reviewing previous learning about the reef and why it is important. Students may remember facts about the importance of the reef from Lesson 01, or about their favourite animals from subsequent lessons. This activity can be done on the board or by students in pairs or small groups. This starter reflects good environmental education practice by focusing on 'love before loss'.	Slideshow 07 - Human impact on the reef Whole class discussion Video - Ep 09: Sailing Home	Identify the reasons why the reef is important on a personal, local, and global level
HOW MIGHT THE REEF BE HARMED?	The reef is faced with multiple threats. Some of these are local and some are more global environmental trends. Fact Sheet 03 provides an overview of these threats. Use Activities 17-22 as appropriate for your class to learn about these threats. Review the activities using the coral threat cards on Activity Sheet 23. Cut out the cards and place them in a jar or container. Invite each pair or small group to choose a card and then explain how the coral reef might be affected by these threats.	Slideshow 07 - Human impact on the reef Fact Sheet 03 - Threats Overview Optional activities Activity Sheets 17-22 Activity Sheet 23 - Coral Threats Cards Video - Ocean Acidification in a Cup Video - Underwater Classroom: Coral bleaching	Explore examples of how human impact can have a negative effect on the environment
WHO CAN HELP CARE FOR THE REEF?	Replicate the threats card activity but with examples of actions that can have a positive impact on the reef.	Activity Sheet 24 - Good Coral Living Cards	Explore examples of how human impact can have a positive effect on the environment
TAKE ACTION FOR THE REEF	Students can use what they have learnt to produce a poster showing an action that can be taken to protect the reef for future generations.	Activity Sheet 25 - Coral Future Poster template	Suggest actions that can be taken on a personal, local, or global scale to protect the environment
PLENARY THE BIG QUESTION	This plenary session refers to 'intergenerational justice', the idea that adults are depleting the natural inheritance of the planet. What question would your students ask and who would they ask? For example, asking a parent why adults place the economy above the environment, or a politician why there is a new port being planned on the Great Barrier Reef.	Whole class discussion	Reflect on the nature of environmental change and who is responsible

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LESSON 08: CORAL PRESS CONFERENCE

Summary

This final lesson brings together all the previous learning as the classroom expedition returns to port, and the team delivers a press conference. The output from this lesson can be a written article, a blog post, audio report, press release, or video. These outputs can be shared at an assembly, parents' evening, with the local press, or you can send a selection through to Digital Explorer (info@digitalexplorer.com) so that we can post them on our website.

Learning Objectives

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

Preparation

- Download and familiarise yourself with Slideshow 08 – Coral Press Conference (from oceans.digitalexplorer.com/resources)
- Templates for some of the outputs are available:

  Activity Sheet 26 - Storyboard Template
  Activity Sheet 27 - Article Template
  Activity Sheet 28 - Sailing Home Blog

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LESSON 08: CORAL PRESS CONFERENCE

Aims / Objectives	Activities	Resources	Outcomes
STARTER: WHY DO WE NEED TO SHARE OUR FINDINGS?	Explain that expeditions have to share their research and findings with a wider audience. Not everyone can go to the Great Barrier Reef, so the team that does visit always share their discoveries once they return.	Slideshow 08 - Coral press conference	Identify the reasons for communicating the findings of an expedition
WHAT WERE YOUR MAIN FINDINGS?	The class teams should review their learning from the past lessons. They should choose their main findings and experiences, as well as selecting some secondary sources such as information from fact sheets or photos they have used. These will form the basis of the story that they are going to share. The teams should select five points in total.	Dive logs from lessons 01-07	Summarise previous learning and select appropriate secondary sources
COMMUNICATING YOUR DISCOVERY	Pupils are free to use the format that suits them and the resources available. Pupils could use ICT to create a video, or complete their article or press release. Sample templates are available as well as a blog post by a marine biologist on her experiences returning to port after an expedition.	Dive logs from lessons 01-07 Activity Sheet 26 - Storyboard Template Activity Sheet 27 - Article Template Activity Sheet 28 - Sailing Home Blog	Communicate findings using a range of formats
PLENARY CORAL PRESS CONFERENCE	Class teams share their articles, videos, etc. with the rest of the class. These can also be shared with local news and websites such as digitalexplorer.com, or presented to the whole school and/or parents at an event or assembly. Set this up as a press conference being held from the Great Barrier Reef. Some pupils may want to create a suitable backdrop in the classroom or use the reef mural or reef-in-a-box.	Whole class presentations	Present findings to peers and real audiences

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ACTIVITY SHEET 01

Dive Signs

Try to copy each of the dive signs. Scientists working underwater must remember them all.

When you are ready try out the dive signs on your partner. Can your partner work out what you are communicating to them? What does your partner reply?

Ascend (go up)

Descend (go down)

Turn around

Stop!

Which direction?

Take it easy, relax, slow down

Are you OK? I am OK.

Something is wrong

Time to head back

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ACTIVITY SHEET 02

Dive Kit

The divers on the Catlin Seaview Survey need about 24kg of equipment to work underwater. This rises to about 40kg for the deep reef team, who need to wear an extra air tank for the greater depth. Can you research to find out why the divers need so much equipment?

Watch Peter Dalton, the Shallow Reef Survey's field technical officer, explain the kit needed to be underwater explorers, on the [de] Student Media Player:
http://media.digitalexplorer.com/resource/446

air tank

mask

dive computer

wetsuit

BCD*

harness

torch

regulators x 2

fins

cutters

* Buoyancy Control Device

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ACTIVITY SHEET 03

Dive Mission

Name

Date

Time	Weather	Temp. air/sea	Max. depth	Dive time
In _____	☐ ☐ ☐ ☐	____ °C	_____ m	_____min
Out _____		____ °C		

Dive buddy signature

Dive master signature / stamp

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ACTIVITY SHEET 04

Reef-in-a-box

Summary

This activity is a fun way to learn about the coral reef, by making your very own reef-in-a-box. You can use your model reef as a reference point for future lessons.

Preparation

To make your reef-in-a-box you will need:

- A cardboard box measuring at least 60cm wide x 40cm high x 40cm deep (the bigger the better!)
- Coloured backing paper - blue for the sky and a yellow or sandy colour for the bottom
- Aluminium foil
- Glue
- Sticking tape
- Scissors
- Matchsticks or paper clips
- Cotton thread or fishing line
- Copies of the reef life templates if using
- A selection of art materials to colour your reef life - pens, pencils, paints, etc.
- Coloured pipe cleaners to add a 3D feel to some of the animals, such as the brain coral, sea anemone, and crown -of-thorns starfish

See over for further instructions

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ACTIVITY SHEET 04 (cont.)

Reef-in-a-box

Activity

To make your reef-in-a-box, get into teams of between two and six. If you have a lot of time, it may be fun to work for longer on your model reef as a pair. If you need to complete your reef-in-a-box a bit faster, then it will be better to have more people in your team.

Making the background

1. If your box still has flaps attached to it, cut these off.
2. Cut a piece of yellow or sandy-coloured backing paper to line the bottom of your box and stick it in place with glue.
3. Cut pieces of blue backing paper to line the top and sides of the box to represent the sky, and stick these in place with glue.
4. Now measure out a section of aluminium foil to go around the sides of your box. Cut a wave pattern along the top of the foil, and then stick it in place around the sides beneath the skyline.

Adding the coral, algae and plants

1. Choose at least two types of plants or algae and two corals from the list opposite.
2. Use the reef life templates or search for images on the [de] Student Media Player (media.digitalexplorer.com). Select the Coral Oceans (Primary) Theme and select #living things from the hashtag list.
3. Stick these examples of reef life to the bottom of the sides of your box.

Adding a range of other life to the reef

1. Select a range of other coral creatures for your reef. Try to have a selection of different types of invertebrates, fish, and other vertebrates.
2. Use the coral life templates or search for images on the [de] Student Media Player (media.digitalexplorer.com). Select the Coral Oceans (Primary) Theme and select #living things from the hashtag list.
3. You can place the coral life on the coral, on the seafloor, or use thread to hang them from the top of the box (simply attach thread to for example a fish and make a hole through the top of the box and push the thread through. Use a matchstick or paper clip to keep it in place).

Reef life checklist

Plants and algae

- ☐ Seagrass
- ☐ Seaweed (macroalgae)
- ☐ Phytoplankton (microalgae)

Corals

- ☐ Boulder coral
- ☐ Staghorn coral
- ☐ Brain coral
- ☐ Plate coral

Invertebrates

- ☐ Sea anemone (cnidaria)
- ☐ Sea slug (mollusc)
- ☐ Triton's trumpet (mollusc)
- ☐ Copepod (crustacean)
- ☐ Mantis shrimp (crustacean)
- ☐ Crown-of-thorns starfish (echinoderm)
- ☐ Sea cucumber (echinoderm)
- ☐ Christmas tree worm (worm)

Vertebrates (fish)

- ☐ Manta ray
- ☐ Tiger shark
- ☐ Parrotfish
- ☐ Trevally
- ☐ Cleaner wrasse
- ☐ Clownfish

Vertebrates (other)

- ☐ Dolphin (mammal)
- ☐ Noddy (bird)
- ☐ Green turtle (reptile)

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ACTIVITY SHEET 05

Reef Mural

Summary

This activity is a fun way to learn about the coral reef, by making your very own reef mural. You can use your reef mural as a reference point for future lessons.

You could set aside one wall of the classroom and have the whole class work on the same mural, each adding an example of coral life. Alternatively, you could split the class into groups and have each group make their own mural.

Preparation

To make your reef mural, you will need:

- An area of wall (the mural pictured above measures 2m wide x 1m high)
- Coloured backing paper - two different blues (one for the sky and one for the sea), and a yellow or sandy colour for the bottom
- Glue
- Sticking tape
- Scissors
- A selection of art materials to colour your reef life - pens, pencils, paints, etc.
- Copies of the reef life templates if using
- Coloured pipe cleaners to add a 3D feel to some of the animals such as the brain coral, sea anemone, and crown-of-thorns starfish

See over for further instructions

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ACTIVITY SHEET 05 (cont.)

Reef Mural

Activity

Making the background

1. Cut a piece of yellow backing paper to make the seafloor. You can cut a pattern into the top to represent the shape of the reef.
2. Add a blue layer of paper for the sea, cutting a wave pattern into the top.
3. Add another layer of backing paper in a different shade of blue for the sky.

Adding the coral, algae and plants

1. Choose at least two types of plants or algae and two corals from the list opposite.
2. Use the reef life templates or search for images on the [de] Student Media Player (media.digitalexplorer.com). Select the Coral Oceans Primary Theme, and select #living things from the hashtag list.
3. Stick these examples around the bottom of your mural to form the reef habitat for the rest of your animals.

Adding a range of other life to the reef

1. Select a range of other coral animals for your reef. Try to have a selection of different types of invertebrates, fish, and other vertebrates.
2. Use the reef life templates or search for images on the [de] Student Media Player (media.digitalexplorer.com). Select the Coral Oceans (Primary) Theme and select #living things from the hashtag list.
3. Arrange the creatures around your reef mural. Different animals live on different parts of the reef, and you can find out more information about them on the [de] Student Media Player (media.digitalexplorer.com).
4. You may also be able to place animals near their favourite food!

Reef life checklist

Plants and algae

- ☐ Seagrass
- ☐ Seaweed (macroalgae)
- ☐ Phytoplankton (microalgae)

Corals

- ☐ Boulder coral
- ☐ Staghorn coral
- ☐ Brain coral
- ☐ Plate coral

Invertebrates

- ☐ Sea anemone (cnidaria)
- ☐ Sea slug (mollusc)
- ☐ Triton's trumpet (mollusc)
- ☐ Copepod (crustacean)
- ☐ Mantis shrimp (crustacean)
- ☐ Crown-of-thorns starfish (echinoderm)
- ☐ Sea cucumber (echinoderm)
- ☐ Christmas tree worm (worm)

Vertebrates (fish)

- ☐ Manta ray
- ☐ Tiger shark
- ☐ Parrotfish
- ☐ Trevally
- ☐ Cleaner wrasse
- ☐ Clownfish

Vertebrates (other)

- ☐ Dolphin (mammal)
- ☐ Noddy (bird)
- ☐ Green turtle (reptile)

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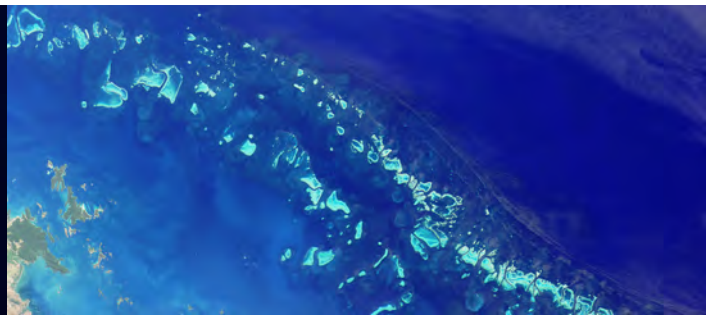
ACTIVITY SHEET 06

Coral Reef Scales

There are lots of different scales to discover on the reef, from the coral polyp, measuring just a few millimetres across, to the length of a reef mosaic, like the Great Barrier Reef, which is over 2,300 km long. Can you put these pictures in order of size?

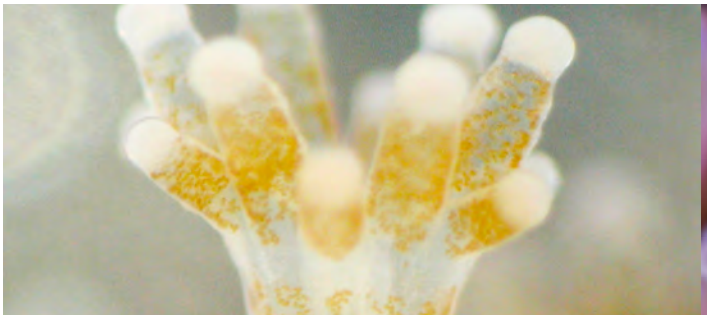
Coral reef



Reef mosaic

Coral colony

Reef patch



Coral polyp

Coral branch

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ACTIVITY SHEET 07

Incredible Edible Polyp

Summary

This activity is a fun way to learn about the basics of coral anatomy. Collect the ingredients below before making your incredible edible polyp.

Preparation

To make a polyp you will need:

- A plate
- A toothpick or skewer
- A section (approx. 3cm) of banana or a marshmallow
- Gummy straws/worms/Twizzlers (about 30cm worth in total)
- 2 round hard biscuits or crackers (about 4cm across)
- Hundreds and thousands / sugar sprinkles / freckles (preferably green)
- Jam (or jelly)

Video demo

See a demonstration at media.digitalexplorer.com/resource/448.

Activity

1. Pick up the section of banana or marshmallow. This is your polyp.
2. Place your polyp on the cracker or biscuit, using the jam as 'glue'. This represents the polyp sticking to the sea-floor.
3. Use the skewer or toothpick to make a hole in the top of the banana or marshmallow to represent the polyp's mouth.
4. Make six smaller holes around the outside of the banana or marshmallow. This is where the tentacles will go.
5. Cut the gummy straws into six equal sections and stick them in the holes you have just made.
6. Add the hundreds and thousands to the surface of the polyp to represent the algae (zooxanthellae).
7. You can also stick bits of cracker or biscuit to the outside of the marshmallow or banana with jam, to represent the corallite.
8. You can make a coral colony by building several polyps and putting them together on the same plate.
9. Once you have made your single polyp or colony, you can learn about parrotfish feeding habits so that you can replicate them.
10. Parrotfish have no hands and so as a true coral predator, you will now have to try to eat the coral without using your hands!

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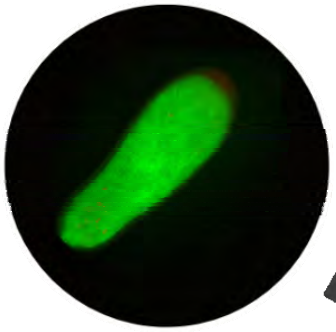
ACTIVITY SHEET 08

Coral Life Cycle

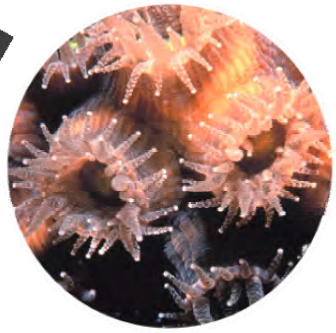
1. The fertilised egg develops into a coral larva that lives in the open water. A coral larva is known as a planula.



2. The planula develops into a small polyp and settles on the seafloor. It follows chemical signals to find the best spot.

3. Once it is attached to the sea-floor, the polyp develops into a full adult and begins to build a hard structure.

4. As the polyp grows, it divides into two smaller polyps, which are identical. These polyps grow and divide as well. This process is called 'budding'.



5. As the coral polyps bud and make their structures, each species forms a different shape. This staghorn coral grows like the horns of a deer.

6. Most corals spawn once a year, releasing eggs and sperm into the open water to fertilise.

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ACTIVITY SHEET 09

Coral Feeding Game

Summary

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

Preparation

Each student will need:

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

Video demo

See a demonstration at media.digitalexplorer.com/resource/444.

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 a 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 algae (zooxanthellae) within the coral polyp.
5. Stick squares of double-sided sticky tape around each gloved finger. The stickiness represents the stinging cells on each tentacle / finger.
6. Create a sleeve out of the paper bag or paper that fits over each student's hand. This represents the corallite or limestone cup that the polyp lives in.
7. The gloved hands will be closed into a fist during the day. This protects the tentacles from predators, and the algae (zooxanthellae) will still be exposed to sunlight, which provides 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. Students should close their eyes, ready to try to catch zooplankton with their fingers. The teacher can scatter cotton wool (representing zooplankton) over each coral colony.
10. Students then open their eyes to see how much zooplankton they have caught.

Review

- Corals use two methods for getting food and nutrients.
- Corals do not 'eat' the algae (zooxanthellae), but receive the benefits of photosynthesis, in exchange for protection and nutrients.

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ACTIVITY SHEET 10

Grouping Coral Life

Summary

The scientific word for grouping living things is 'classification'. Classify the living things on the coral reef by putting them in six different groups. Write the names in the boxes below.

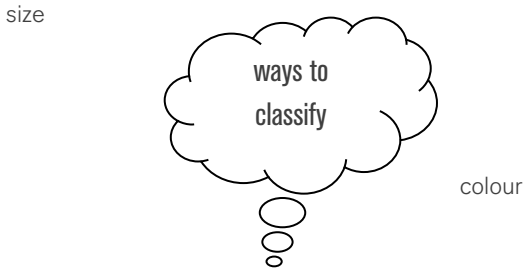
Group 1	Group 2	Group 3

Group 4	Group 5	Group 6

Questions

Now see if you can answer these questions in your group:.

1. Why did you choose to classify the living things in this way?
2. Can you think of all the different ways to classify different living things?
3. A useful way of classifying living things is by asking key questions. For example, in pairs, decide which of the living things on the coral reef has a backbone.
4. Now decide which of the living things on the coral reef can swim.



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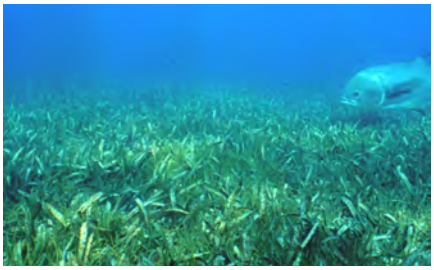
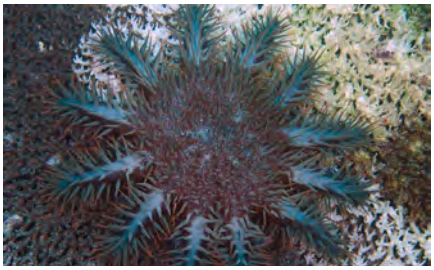
ACTIVITY SHEET 11

Coral Life Photo Sheet


Mantis shrimp

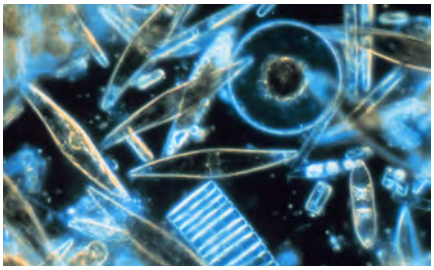

Sea slug


Seagrass


Crown-of-thorns starfish


Staghorn coral


Clownfish


Phytoplankton


Parrotfish


Tiger shark


Dolphin


Triton's trumpet


Manta ray


Boulder coral


Noddy


Green turtle

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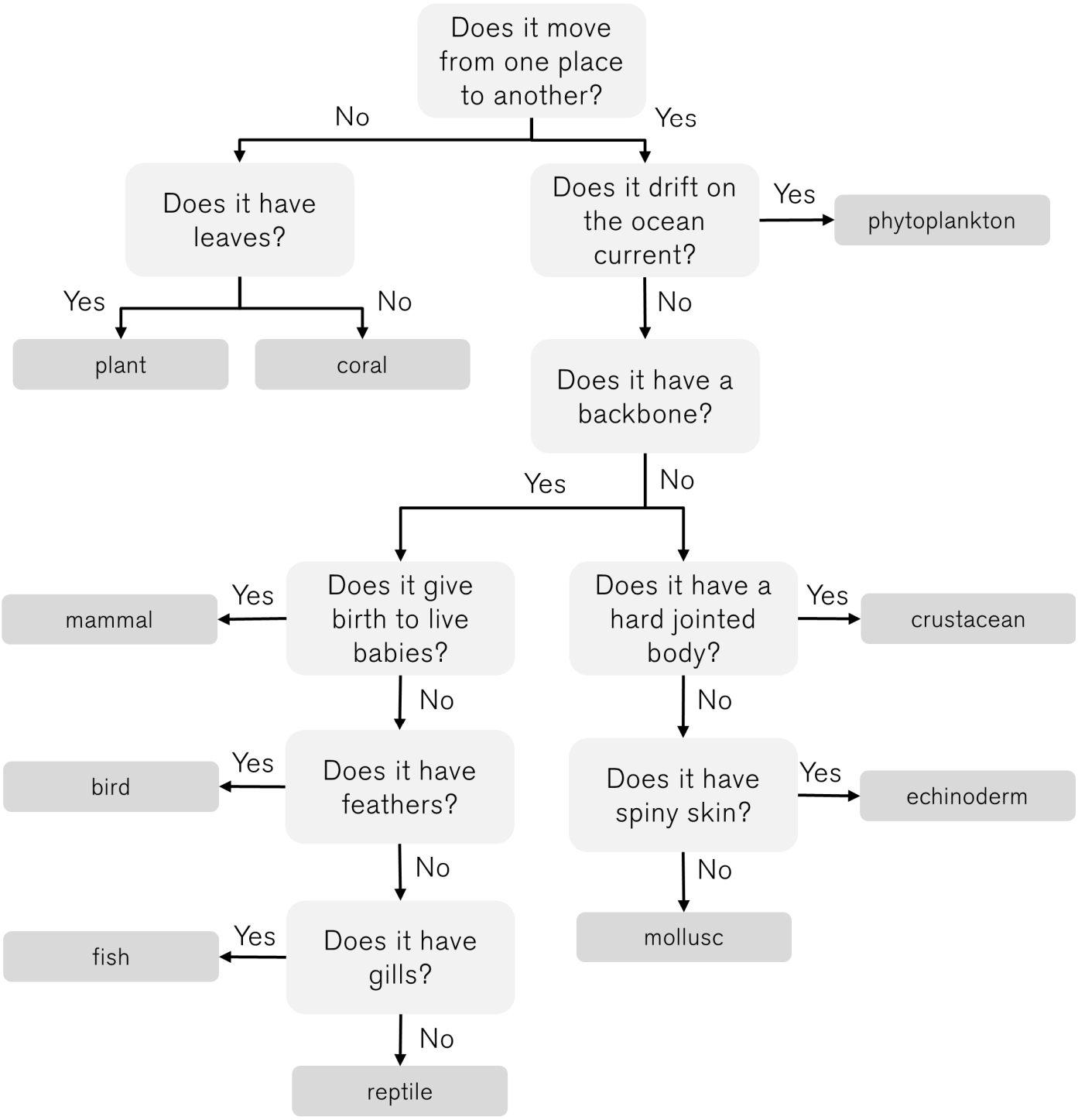
ACTIVITY SHEET 12

Coral Life Classification



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ACTIVITY SHEET 13

Scientific Groups

A key is a series of questions that scientists use to sort and group life. Keys use the fact that similar types of life share characteristics.

For each example, for coral life, decide how it should be classified and write the name of each plant, algae or animal in the correct group below.

Plant	Coral
Phytoplankton	Mammal
Fish	Bird
Reptile	Echinoderm
Mollusc	Crustacean

Can you complete the following sentences using the information from the key?

1. A tiger shark is a fish, because...
2. A crown-of-thorns-starfish is a echinoderm, because...
3. A dolphin is a mammal, because...
4. A green turtle is a reptile, because...

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ACTIVITY SHEET 14

Coral Life Classification

Your challenge now is to make your own key. In your groups decide on the key questions that will help anyone identify the coral reef invertebrates below.

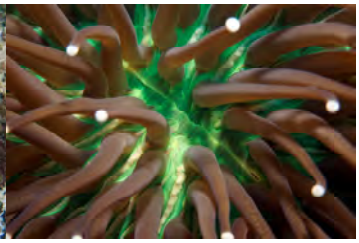
Remember that your key questions need to be about observable characteristics and have 'yes' or 'no' answers.

Hint: you may need to practise on some spare paper first.

Christmas tree worm

Copepod

Crown-of-thorns starfish



Sea anemone

Mantis shrimp

Sea cucumber

Sea slug

Triton's trumpet

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ACTIVITY SHEET 15

Animal Dive Signs

Divers use animal dive signs to point out different species underwater. Below are two examples: the green turtle and the lionfish. Can you come up with dive signs for the shark and clownfish as well? Draw the signs in the space below. You can also think about dive signs for all the different examples of coral life that you have learnt about.

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ACTIVITY SHEET 16

Food Chains

Information

Plants and animals are called different things depending on what they eat to survive.
Carnivores are animals and plants that eat animals.
Herbivores are animals that eat plants.
Omnivores are animals that eat both plants and animals.

Question 1

Complete the sentences using the words below.

Plants are _ _ _ _ _ _ _ _ _ because they make their own food using _ _ _ _ _ _ _ _ _.
_ _ _ _ _ _ _ _ _ are animals that _ _ _ other animals. Animals that are _ _ _ _ _ _
and _ _ _ _ _ by other animals are called _ _ _ _ .

prey	sunlight	eat
predators	moonlight	producers
plants	animals	farmed
hunted	eaten	lunch

Question 2

In pairs, decide whether the animals on the coral reef are carnivores, herbivores, or omnivores, and whether they are predators or prey or both.

About food chains

Living things in their environments are dependent on each other for food. Food chains show which animals eat other animals or plants. A food chain starts with what gets eaten and the arrows point towards the animal or plant that is doing the eating.

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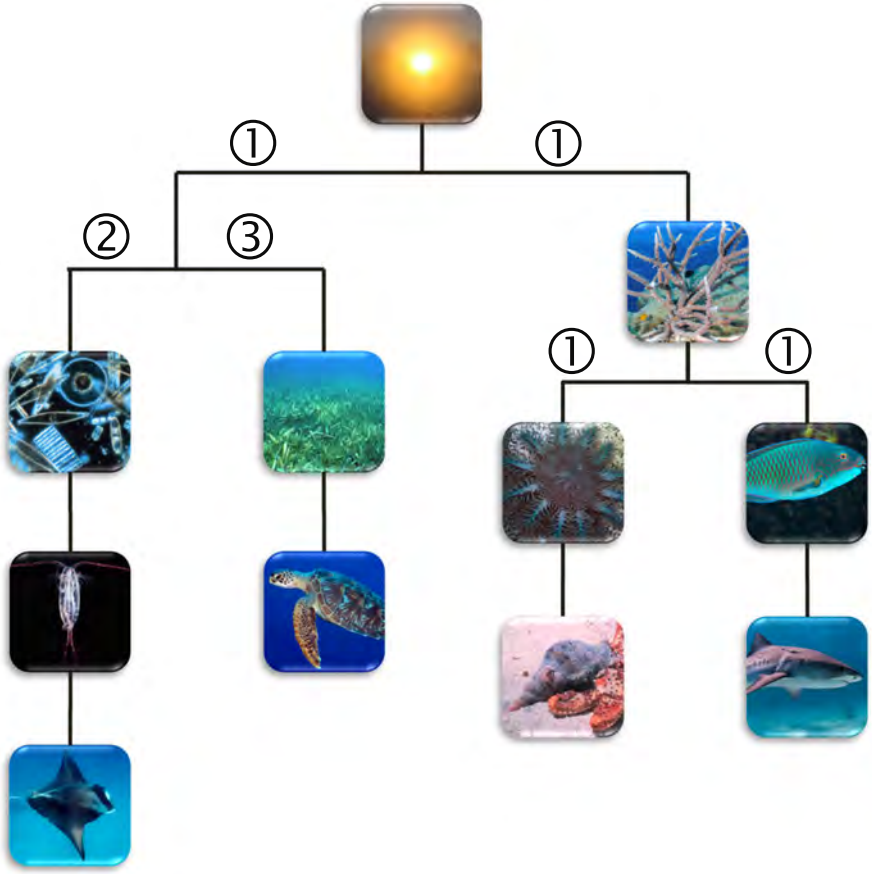
ACTIVITY SHEET 17

Coral Food Chain Mobile



Summary

In this activity, pupils use the reef life cards to create a food chain mobile.

Preparation

Each group will need:

- Dowelling, twigs or old wire coat hangers (make sure sharp ends are taped or covered)
- String or fishing line
- Glue or sticking tape
- Scissors

You may also want to make a demonstration food chain mobile beforehand.

Activity

Pupils should start by trying to lay the living things cards in order to show the predator–prey relationships between them.

Once pupils have laid the cards out in the right order, they can start to hang them together using string, tape, and sticks. Each group will need three twigs / sections of dowelling / a wire hanger / or similar.

Design extension notes

The numbers on the diagram above show the relative distance along the sticks to hang the cards, so that the mobile balances. You may wish to let pupils work out how best to balance the varying numbers of cards as a Design & Technology extension activity.

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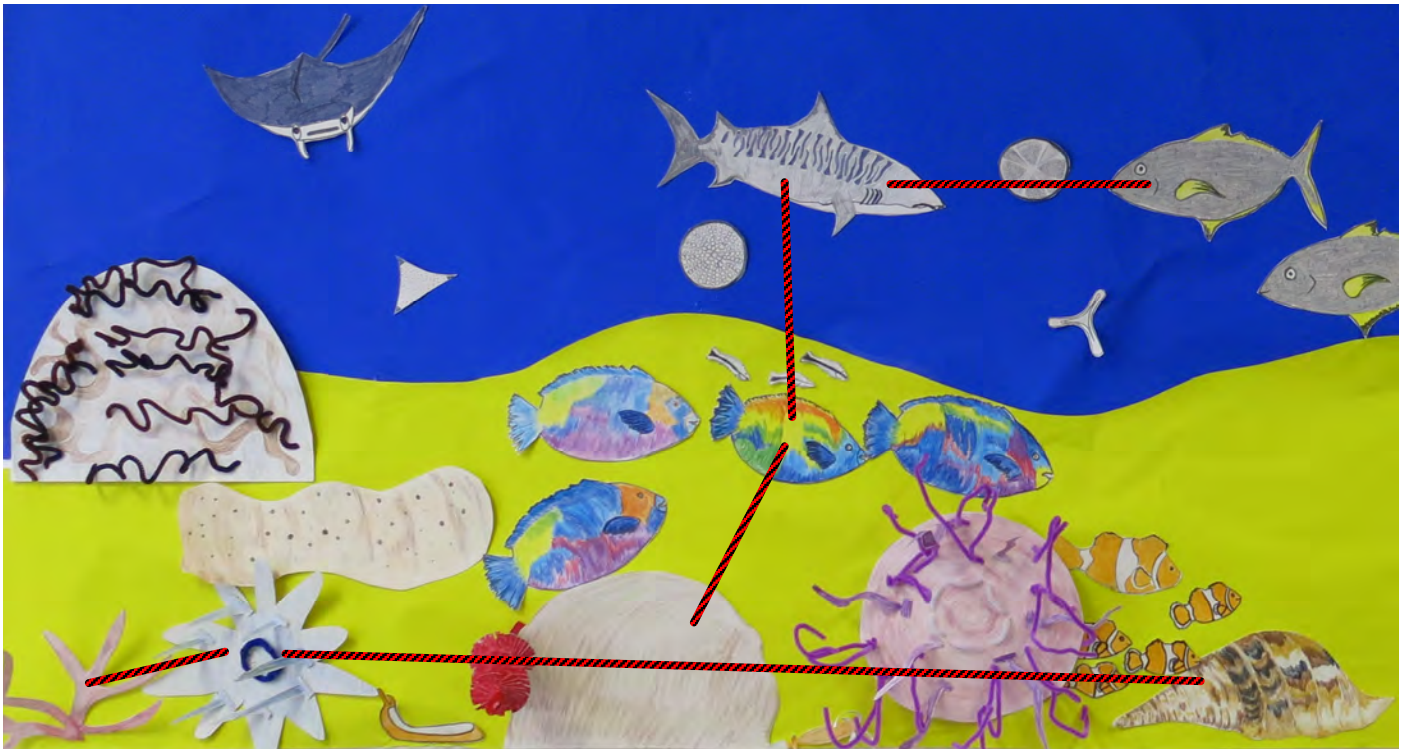
ACTIVITY SHEET 18

Reef Mural Food Chain



Summary

Instead of creating a coral food chain mobile, students could use the coral reef mural to show the feeding links between different living things.

Preparation

Each group will need:

– Wool

– Drawing pins / thumb tacks

– Scissors

Activity

Using the information on the [de] Student Media Player or from the slideshow, students can start to connect the different living things using lengths of wool.

Stick a drawing pin / thumbtack in an animal and then connect it either to a predator or prey.

See what the longest food chain on the reef might be.

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ACTIVITY SHEET 19

Ocean Acidification in a Cup

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

Summary

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

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

Equipment needed per group of 2:

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

Overview

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

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

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

Video demo

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

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ACTIVITY SHEET 20

Dissolving 'Coral' in Vinegar

Example of bleached coral in an ocean acidification experiment at the Heron Island Research Station

Summary

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

Equipment needed per group:

– 200ml of clear vinegar (such as malt vinegar or other pickling vinegar)

– Chalk (i.e. $CaCO_3$)

– Appropriate container or beaker

Instructions

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

The science

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 can you see when you put the chalk or shell in the vinegar?
2. How might a more acidic ocean affect coral?
3. How might a more acidic ocean affect other life on the coral reef?

Notes

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

Video demo

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

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ACTIVITY SHEET 21

Overfishing

When too many fish are caught, it affects life on the reef in two ways. Overfishing has had a direct impact on lots of different species from sharks to smaller fish like snappers.

Catching too many fish also affects the health of the reef as a whole. The fish diagrams below shows what might happen to the reef if more and more fish are taken away.

The numbers on the fish show the weight of fish found in an area of reef measuring 100 metres by 100 metres.

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

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?

Healthy areas of reef contained 1,500kg of fish.

This amount of fish was most often found in reef areas where there were fishing rules, such as protected reefs with no-fishing zones.

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

When the amount of fish fell to 300kg per hectare, there was a large drop in the health of the reef.

There was also a large decline in the number of herbivorous fish, meaning that less algae is eaten, and the algae starts to overtake the coral.

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

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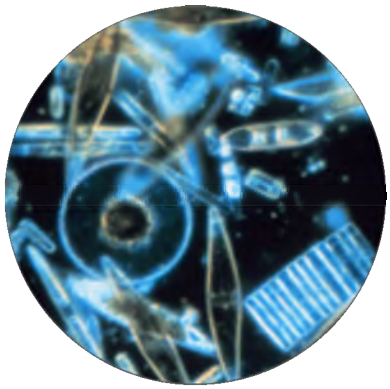
ACTIVITY SHEET 22

Too Much Poo

An increase in sewage, manure and chemical fertilisers for crops means that more 'fertiliser' is 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.

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ACTIVITY SHEET 23

Coral Threats Cards

The level of carbon dioxide in the atmosphere is predicted to continue to rise. This contributes to warming oceans which can harm corals.

Carbon dioxide absorbed by the ocean is affecting its acidity. This process, known as ocean acidification, can affect the ability of corals to grow their hard structures.

Species such as shark, snapper and grouper are being overfished. This is a problem not only for those species targeted directly, but also the coral ecosystem as a whole.

Some local fishermen are resorting to dynamite and cyanide fishing to catch enough fish to support their families. Such fishing practices damage the coral as well as kill the fish and lobsters.

More intensive farming methods mean that more soil is being washed out to sea. This soil can then smother the coral reef.

Increasing levels of development on the coast – housing, industry, ports and tourism – can add sewage to the ocean and also require areas of the reef to be destroyed.

Fertiliser from sewage and farming washes into the ocean. This can mean that more algae covers the reef, leaving slime and preventing coral from growing.

Some tourist practices can be harmful to the reef. Divers and boat anchors can break the coral.

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ACTIVITY SHEET 24

Good Coral Living Cards

Individuals, communities, and governments work to reduce carbon dioxide emissions.	Individuals choose to eat seafood in a responsible manner, only eating fish that are caught in a sustainable way.
Individuals and communities ask national governments and international bodies to make fishing practices more sustainable.	People learn how to dive, so that they can see the under-water world with their own eyes and become champions for these unique habitats.
Individuals and communities ask local and national governments to show more balance between economic development and the preservation of nature.	Governments set up marine protected areas, limiting the harmful practices of shipping, fishing, and tourism. Some of these areas are designated 'No Take Zones' which ban fishing of all kinds.
Scientists and local organisations (NGOs) work with communities to show them how to manage their local reef more sustainably.	Scientists and local groups work with farmers and communities to help them reduce the amount of harmful fertilisers and chemicals that end up in the ocean.

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ACTIVITY SHEET 25

Coral Future Poster Template

Use your knowledge about the coral ecosystem, threats to the coral reef and possible solutions to create a poster showing how the reef might be preserved for future generations, including your own.

The template below can be used to make an A4 poster about caring for the coral reef.

Love

What do you love about the coral reef?

Care

What threat to the coral reef would you like to tackle?

Act

What actions can be taken (and by whom) to help preserve the coral reef for future generations?

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ACTIVITY SHEET 26

Storyboard Template

CAPTION:

CAPTION:

CAPTION:

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ACTIVITY SHEET 27

Article Template

Coral Reef News

Headline

By:

Picture or photo

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ACTIVITY SHEET 28

'Heading Home'

Marine biologist Anjani Ganase, from the University of Queensland, describes how it feels to return from the shallow reef survey

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

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

The team becomes like a family, and although it's hard work, there's still time for laughter and fun – though I can't say I'm going to miss staying up to the early hours of the morning making sure that the data has been logged properly.

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

Each dive is like a mini-adventure. You never know what you are going to find. One day might be scary, being surrounded by sharks, and on another day you might see all kinds of different fish and other life on the reef.

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

When I'm back on land, I miss the closeness of the team – the friendships. On the first night in bed back on land, I can still feel the rocking motion of the sea!

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

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

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SUBJECT UPDATE

The Great Barrier Reef

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

This panorama was taken at Lady Elliot Island and features on Google Maps - maps.google.com/oceans

- One of the few biological structures visible from space, the Great Barrier Reef stretches over 2,300 km (1,430 miles) and began life about 600,000 years ago.
- It is home to more than 400 types of coral and 2,000 species of fish.
- Coral reefs globally occupy less than 1% of the ocean, but sustain 25% of all marine life.
- 30% of all reefs are estimated to be severely damaged, and close to 60% may be lost by 2030.
- Taking into account tourism, food, and jobs, tropical coral reefs are very valuable economically, yielding more than US$30 billion annually according to the World Meteorological Society. According to the US National Oceanic Atmospheric Administration (NOAA), they are worth even more - US$375 billion.
- Hard corals and other organisms which secrete calcium carbonate contribute most to reef building.
- Both hard and soft corals can only exist within a limited range of conditions, needing light, and an optimum temperature and salinity range. The ideal conditions for coral reef growth are water temperatures of 26-27°C, and salinity of 36 parts per thousand. If the water is clear, corals can grow to a depth of 100m. This is reduced to 8m if the water is turbid or cloudy.
- Other species living on the reef, such as clams and parrotfish, eat corals, contributing to bioerosion, so there is a natural reef cycle of production and destruction.
- This cycle can be disturbed by upsetting the ecological balance. The Great Barrier Reef has lost half its coral cover since 1985. The loss was due to storm damage (48%), crown-of-thorns starfish (42%), and bleaching (10%) according to a 2012 study by researchers from the Australian Institute of Marine Science (AIMS). Most of the threats listed below are caused directly or indirectly by human activity. These include:
  - increased frequency and duration of coral bleaching, brought about by sustained and sudden rises in sea temperature
  - increased acidity – the pH is dropping due to the amount of CO_2 absorbed from the atmosphere into the ocean
  - changes in nutrient input (increase or decrease) which favour some species over others
  - overfishing or damage to habitats by the fishing industry
  - increased sedimentation and eutrophication due to human industrial activity, including agricultural and commercial pollution and deforestation
  - littering, pollution and habitat destruction from tourism

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SUBJECT UPDATE

Catlin Seaview Survey

In this picture you can see the SVII camera being used to create a photographic survey of the Great Barrier Reef.

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

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

Our oceans feed one in four people on the planet every day. They produce 50% of the oxygen we breathe. They regulate the climate and make our planet habitable. They are integral to our very survival, yet despite this they largely remain as they have always done: out of sight and out of mind – with 95% of the oceans not even seen by human eyes.

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

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

Working with scientists from the University of Queensland, the Survey began in 2012 with an ocean icon, the Great Barrier Reef, off the coast of Australia. Two expedition teams visited 30 representative reefs along the Great Barrier Reef and Coral Sea, to research and record the shallow reef (0-12m) as well as the relatively unknown deep reef (from 30-100m).

More than 75,000 images were taken and analysed to produce an important 'state of the reef' benchmark. This data forms the Global Reef Record, and is made freely available to scientists around the world to monitor changes in marine environments. It will also provide valuable insights for more than 50 nations worldwide that have significant coral reefs along their coastlines.

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

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

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

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

For more information, visit: www.catlinseaviewsurvey.com

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FACT SHEET 03

Threats Overview

Coral reefs, like most habitats, go through a natural cycle of growth and destruction. Storms have battered coastal areas throughout the centuries. Species such as parrotfish nip and scrape at the reef, contributing to bioerosion. The reef regrows and rebounds from these incidents in a system of dynamic balance.

Storm damage on the Great Barrier Reef caused by Cyclone Hamish

What concerns scientists now is that human impacts are threatening this system of balance, resulting in an overall decline in coral coverage and health.

These threats to the coral reef around the world can be divided into two types: long-term changes to the ocean environment and more localised impacts.

Increased atmospheric carbon dioxide is causing two changes to the ocean. Heat trapped by greenhouse gases is causing warming. Coral is sensitive to changes in ocean temperature, and research has shown that this continuing warming trend can cause coral bleaching and mortality.

Another impact of increased atmospheric carbon dioxide is ocean acidification. This change in ocean chemistry places increased stress on the coral reef, and predicted pH levels in the future could even lead to the hard structure of the reef being corroded.

These long-term changes have not yet reached catastrophic levels. Currently, they can be viewed as stresses, which make recovery from more localised impacts more difficult. These local impacts are a combination of fishing, land use, and shipping practices.

But these all add up. A little bit of ocean acidification, a new coal terminal and shipping lanes, a little overfishing, an invasive species, a little too much fertiliser – all these combine to create serious threats to the coral ecosystem and the livelihoods of those who rely on them.

Fishing practices affect the reef in several ways. The most obvious impacts are from dynamite and poisons being used to eke out the remaining edible species. A loss of traditional herbivores such as parrotfish can lead to areas becoming overgrown with algae. Research has also shown that a general decline in fish abundance can harm the reef ecosystem as a whole, and overfishing of large predators such as sharks can cause a catastrophic cascade, which ripples down through the entire food chain.

Counter-intuitively, other stresses that affect coral reefs are not through practices at sea, but on land. The Great Barrier Reef has been threatened by changes in farming and land use in areas along the eastern areas of Australia. The increased use of fertilisers, shifts to more cattle farming, and a mining boom have all contributed to a decrease in coral health and coverage.

Fertilisers washed into the sea both from sewage and farming cause algal growth that benefits coral predators such as the crown-of-thorns starfish, and can cause areas of reef to become overgrown with slime, preventing young polyps from finding a suitable site to settle and grow.

Sediment from farms is carried out to sea during periods of intense rainfall. Previously forested areas have been converted to cattle farming and the loose soil washes into rivers.

Collectively, these threats mean that the outlook for reefs looks quite bleak. But the future for coral is still in our hands. Positive changes in farming practices are happening. NGOs and communities are working together to develop more sustainable fishing practices. The world is beginning to realise the potential threats of increased carbon dioxide emissions and putting agreements in place for future limits. Scientists from projects like the Catlin Seaview Survey and the Global Reef Record are empowering communities and governments alike with the data needed for effective management plans.

'Crisis' is the Greek word for opportunity, not disaster. Coral reefs are in crisis, and the opportunity exists to preserve these important and unique ecosystems for future generations.

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FACT SHEET 04

Coral in a High CO_2 World

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

Warming oceans

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

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

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

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

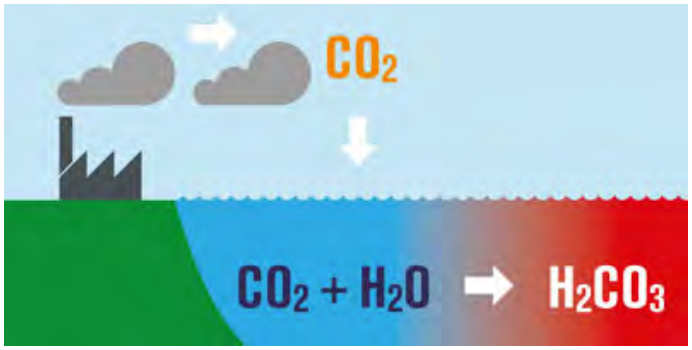
This bleaching can in turn lead to coral mortality, as the zoox provide between 70% and 90% of the energy for the coral polyps.

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

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

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

Ocean acidification



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

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

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

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FACT SHEET 05

Coral and Water Quality

Land run-off

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

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

The change in the weather patterns in Australia have also contributed to land run-off. Australia is experiencing periods of drought, followed by periods of intense rain.

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

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

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

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

Crown-of-thorns starfish

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

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

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

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

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

- overfishing of natural predators such as Triton's trumpet
- increased nutrients from land run-off have provided more food for the crown-of-thorns larvae
- it is a natural phenomenon

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

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SUBJECT UPDATE

Human Activity on the Reef

Overfishing

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

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

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

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

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

Recreational impacts

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

In the 1950s and 1960s, tourism was not as popular as it is today. There were only 12 tour operators for the Great Barrier Reef in 1968, but this increased rapidly, with 187 operators established by 1980, and 742 by 1998.

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

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

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

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

Habitat loss

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

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

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

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

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

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

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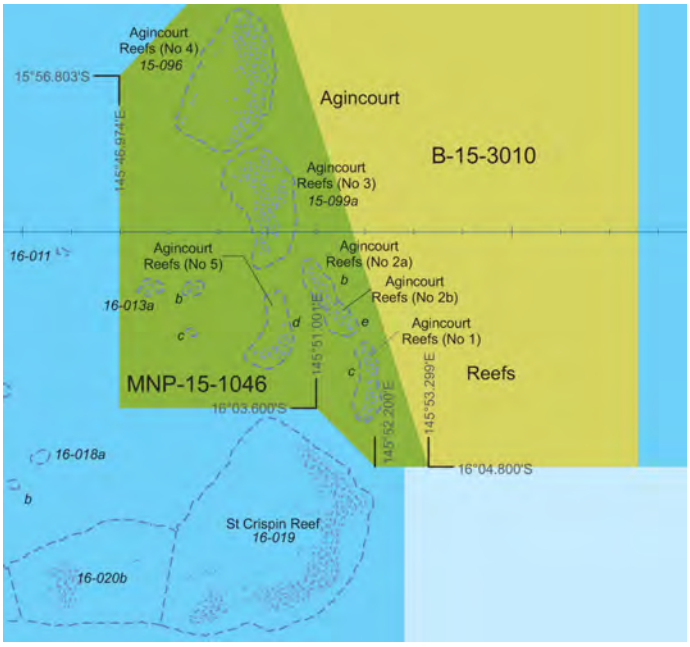
SUBJECT UPDATE

Conservation on the Great Barrier Reef

The Great Barrier Reef is contained within the Great Barrier Reef Marine Park, established in 1975 by the Australian government. It covers 344,400 km^2 in area and includes some 3,000 coral reefs, 600 continental islands, 300 coral bays, and about 150 inshore mangrove islands.

Zoning



Detail from GBRMPA Zoning Map 5 - Cairns

The Great Barrier Reef Marine Park Authority (GBRMPA) has established a zoning plan. This plan provides maps of the entire marine park area and sets out the activities that are allowed to take place in each area. Examples of the maps can be downloaded from www.gbrmpa.gov.au/zoning-permits-and-plans/zoning/zoning-maps.

The example above shows the different zones around the Agincourt and St Crispin Reefs, which were surveyed by the Catlin Seaview Survey in 2012. The dark blue area denotes a Habitat Protection Zone, light blue for General Use, green for Marine National Park Zone, and brown for Buffer Zone.

There are varying levels of protection for these different zones on the reef, from a ban on all activities save for boating, diving, and photography in the Marine National Park Zone, to varying levels of permissions for fishing in other zones. For instance trawling is allowable in the General Use Zone but not the Habitat Protection Zone.

Engaging with communities

Alongside the wider management plan, GBRMPA engages with communities who can have a positive impact on the future of the reef. As part of their Reef Guardians programme (www.gbrmpa.gov.au/our-partners/reef-guardians), GBRMPA works with fishers, farmers, council, and schools, and also operates Onboard, a scheme to engage tourism operators in caring for the reef.

Is GBRMPA doing enough?

Some NGOs and community groups feel that GBRMPA needs to be doing more to help preserve the Great Barrier Reef. For instance, the Australian government announced further plans for the expansion of commercial ports, coal terminals, and shipping in late 2013.

Several NGOs are running campaigns to put pressure on GBRMPA and the Australian government to limit the amount of industrial development in the Great Barrier Reef Marine Park. An example is Fight for the Reef (www.fightforthereef.org.au) supported by the Australian Marine Conservation Society and WWF-Australia.

Moreover, the Great Barrier Reef could be placed on an international list of World Heritage Sites in Danger as early as 2014. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) maintains a list of World Heritage sites, those unique and irreplaceable places of cultural or natural value to humanity. And the World Heritage Committee of UNESCO has warned that without the urgent implementation of sustainable management improvements, the reef could land on their 'in danger' list.

A collective effort

Conservation on the Great Barrier Reef is a collective effort, involving regulatory bodies such as GBRMPA, individual farmers and fishers, teachers and pupils in schools, local communities and concerned individuals, scientists and researchers, tourism operators, and international bodies such as UNESCO.

We can all play a role in conserving the reef.

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GLOSSARY OF TERMS

Adaptation: the changes in an organism to become more suited to its environment. These can be changes in structure, behaviour, or how the organism functions.

Algae: plant-like life that lack the structures that plants have, such as leaves and roots. Algae includes small, single-celled examples known as micro-algae, and larger, often multi-celled examples such as seaweed, known as macro-algae.

Bleaching: results from the breakdown of the relationship between the coral polyp and the zooxanthellae that lives in its tissue. This is commonly caused by increased sea temperatures. The process is known as bleaching because the zooxanthellae give the coral its colour and so the coral appears white when the zooxanthellae have been ejected. Bleached coral is not dead, but can die if it stays bleached for periods of longer than 4 to 6 weeks.

Buddy system: the practice of diving in pairs for safety reasons, e.g. if there is an equipment failure for one of the divers.

Cnidaria: a phylum of animals, including jellyfish, sea anemones, and corals. Cnidarians are found exclusively in aquatic and mostly marine environments. They get their name from their use of cnidocytes (containing nematocysts) or stinging cells to capture prey.

Consumer: the term given to organisms that get their energy from other organisms rather than through photosynthesis.

Coral: a type of cnidarian that mostly forms large colonies made up of individual polyps, surrounded, in the case of hard corals, by a calcium carbonate structure.

Coral colony: the term used to refer to a collection of coral polyps in a single structure. All the coral polyps within a coral colony are connected and nutrients are shared between them.

Crustacean: a subphylum of arthropods that have hard-jointed shells, including lobsters, crabs, krill, and copepods.

Dive log: a form that divers fill in at the end of their dive. Dive logs are used for safety, to provide a record of underwater exploration and research, and for divers to provide evidence of their experience.

Dive master: a term both for a level of diving proficiency and the individual on an expedition who is in charge of the dive profiles (how deep and how long divers are in the water), as well as the equipment, including refilling air tanks.

Dive signs: a system of signs used by divers to communicate underwater.

Echinoderm: a phylum of marine animals characterised by their radial symmetry and spiny skin. The term echinoderm comes from the Latin for spiny skin. Echinoderms include sea urchins, sea stars (commonly called starfish), and sea cucumbers.

Ecosystem: an ecosystem is a complex set of relationships between animals, plants, and other life and their environment in a given area. An ecosystem can be as small as a section of coral reef, or as large as an entire ocean.

Eutrophication: the process where excess nutrients (often fertiliser from land) increases the amount of algae in the ocean. This results in algal levels that are too great for herbivorous animals to consume. When the excess algae dies, the bacteria feeding on it use increasing amounts of oxygen in their area of the ocean. This reduces the amount of oxygen available to other marine life and can lead to anoxic 'dead zones'.

Fore reef: the area immediately below the reef crest facing the ocean.

Habitat: the area or environment where a certain animal or other species normally lives. For example, shallow, warm tropical waters are the natural habitat for corals.

Habitat zone: a term used for varied habitats within an ecosystem, defined by environmental factors. Typical coral reef habitat zones include: lagoon, reef crest, fore reef, and reef slope.

Lagoon: the sheltered area between the reef and shore, also known as the reef flat.

Mollusc: a large and varied phylum of animals that contains creatures such as octopus, squid, slugs, snails, and shellfish.

Nematocyst: the sub-cellular stinging mechanism used by jellyfish, coral, and other cnidarians to capture their prey. It has been likened to a microscopic toxic harpoon.

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GLOSSARY OF TERMS

Nutrient: any nourishing substance used by living things for growth, repair and normal functioning. This can include food, as well as minerals such as nitrates and phosphates.

Ocean: the name for the connected body of salt water that covers over 70% of the Earth's surface. The ocean is divided into five basins: the Arctic Ocean, the Atlantic Ocean, the Indian Ocean, the Pacific Ocean and the Southern Ocean.

Ocean acidification: the process by which atmospheric carbon dioxide is absorbed by the ocean, and through a chemical reaction affects the ocean's chemistry, lowering the pH.

Photosynthesis: the process used by plants, algae, and some bacteria to make sugars (and thereby energy) from the sun.

Phytoplankton: microscopic plants and algae that drift on the ocean currents.

Plankton: small plants, algae and animals that drift on the ocean currents.

Planula: the name given to coral polyp larva.

Polyp: the animal that makes up the coral reef.

Primary producer: any living thing that receives its energy from the sun.

Primary production: another term for photosynthesis, and which can also refer to chemosynthesis.

Reef: traditionally a term for a navigational hazard, 'reef' now more commonly refers to the structures created by coral polyps.

Reef crest: the exposed top of the reef.

Reef mosaic: the patchwork of coral reefs that make up large areas of reef habitat. The best known example is the Great Barrier Reef, which stretches over 2,300km along the eastern coast of Australia.

Reef slope: the area sloping down from the reef towards the open ocean.

Salinity: the measure of the salt content of water. Typically, the ocean has a range of 31g to 38g of salt per litre.

Scuba diving: the use of 'self-contained underwater breathing apparatus' to breath underwater.

Sea: a contained area of ocean (e.g. Mediterranean Sea) or area of sea near to land (e.g. North Sea).

Sedimentation: when particles suspended in the ocean fall to the bottom. For example, soil that has washed out to sea which falls to cover the seafloor.

Substrate: the material that forms the seafloor, e.g. sandy substrate, rocky substrate, etc.

Turbidity: the scientific term for the cloudiness of water.

Zooplankton: small animals, larvae, and eggs that drift on the ocean current.

Zooxanthellae: a type of algae that lives inside the tissue of a coral polyp, typically supplying it with 70% to 90% of its energy.

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USEFUL WEBSITES

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

Catlin Seaview Survey

www.catlinseaviewsurvey.com

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

Global Change Institute, University of Queensland

www.globalchange.org.au/catlinseaviewsurvey/

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

BBC Nature Reef section

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

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

Catlin Explorers

www.catlinexplorers.com/

Family-friendly and child-focused website on coral reefs and Arctic expeditions

National Geographic Coral Collection

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

National Geographic Education's collection of resources on coral reefs

CNN's The wonderful World of Coral Reefs

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

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

ARKive Coral Reef Conservation

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

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

NOAA Ocean Service Education

oceanservice.noaa.gov/education/tutorial_corals/

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

reefED

www.reefed.edu.au

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

Reef Relief

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

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

Global Dimension

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

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

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PHOTO CREDITS

All photos courtesy of the Catlin Seaview Survey and Digital Explorer, unless stated otherwise below.

Page	Photo	Credit
6	Coral polyps	NOAA
6	Coral map	NASA
9	Google Oceans screenshot	Google
26	Dive signs	Peter Southwood
33	Coral reef	NASA
33	Reef mosaic	NASA
33	Coral polyp	OIST
35	Planula	OIST
35	Small polyp	OIST
35	Coral polyp	OIST
35	Group of polyps	NOAA
36	Group of polyps	NOAA
38	Diatoms	NOAA
38	Seagrass	NOAA
38	Triton's trumpet	NOAA
41	Copepod	Uwe Kils
44	Diatoms	NOAA
44	Copepod	Uwe Kils
44	Triton's trumpet	NOAA
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58	Storm damage	AIMS Long-term Monitoring Team
59	Bleached coral	Great Barrier Reef Marine Park Authority
60	Land run-off	NASA
62	Map section	Great Barrier Reef Marine Park Authority

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CATLIN
Underwriting Ambition

CATLIN EXPLORERS
A DEEPER UNDERSTANDING

Catlin Explorers

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

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

Case files

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

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

Fun Stuff

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

Explorer Missions*

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

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

* Explorer Missions should be supervised by a responsible adult.

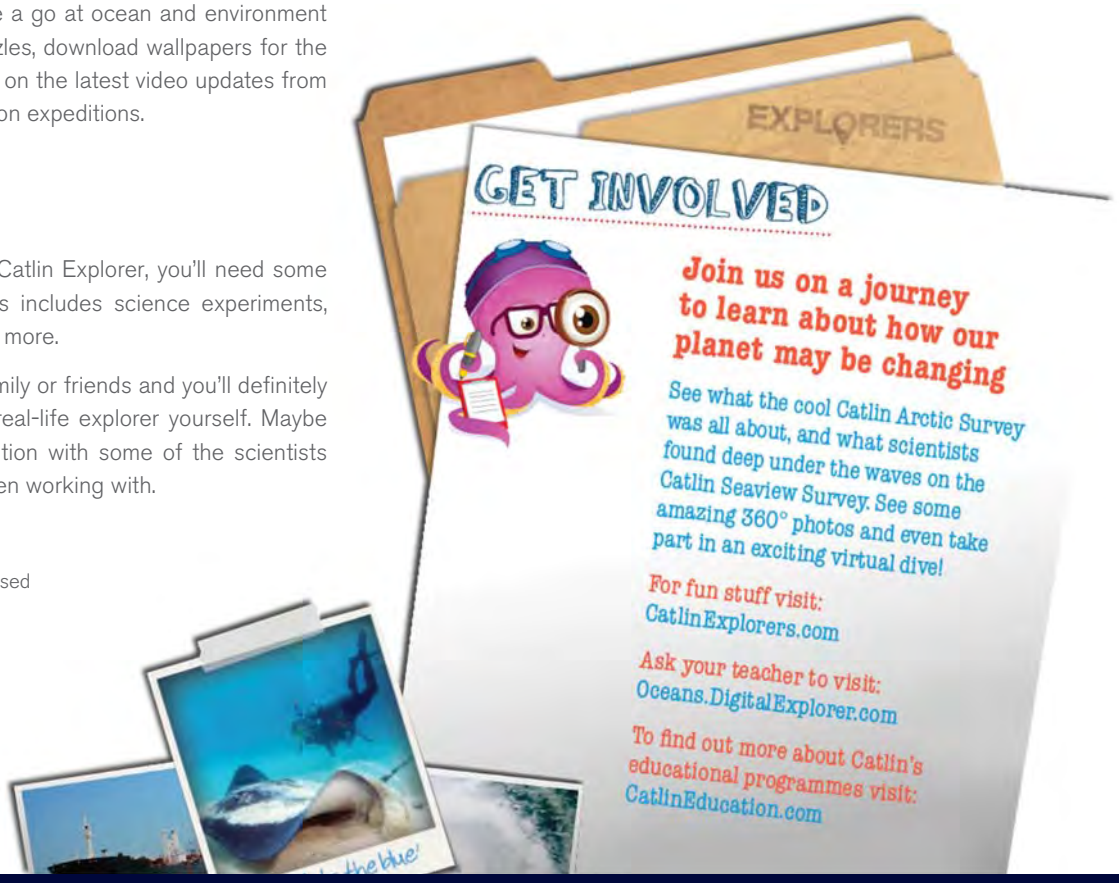
Link to insurance

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

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

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

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



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This booklet and further ideas about bringing the Coral Oceans to your classroom are downloadable from oceans.digitalexplorer.com

These resources for ages 7-11 are based on journeys undertaken by scientists and explorers as part of the Catlin Seaview Survey Expeditions (catlinseaviewsurvey.com). This complete unit of work covers important science curriculum topics, so that students can learn to:

- Describe how different habitats provide for the basic needs of animals and plants
- Identify and name a variety of plants and animals in their habitats, including micro-habitats
- Compare the life cycles, anatomy and the life process of reproduction of different animals
- Explore and use classification keys to help group and identify living things
- Describe how animals obtain their food, using the idea of a simple food chain
- Identify how animals and plants are adapted to suit their environment
- Explore examples of human impact on environments

The booklet also offers two creative project templates to use with your class:

- Create a coral reef mural
- Create a 3D model of a coral reef

These lessons and project ideas are designed to be used with further multimedia resources available online. A selection of videos and photos from the expeditions are available to view at media.digitalexplorer.com.

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