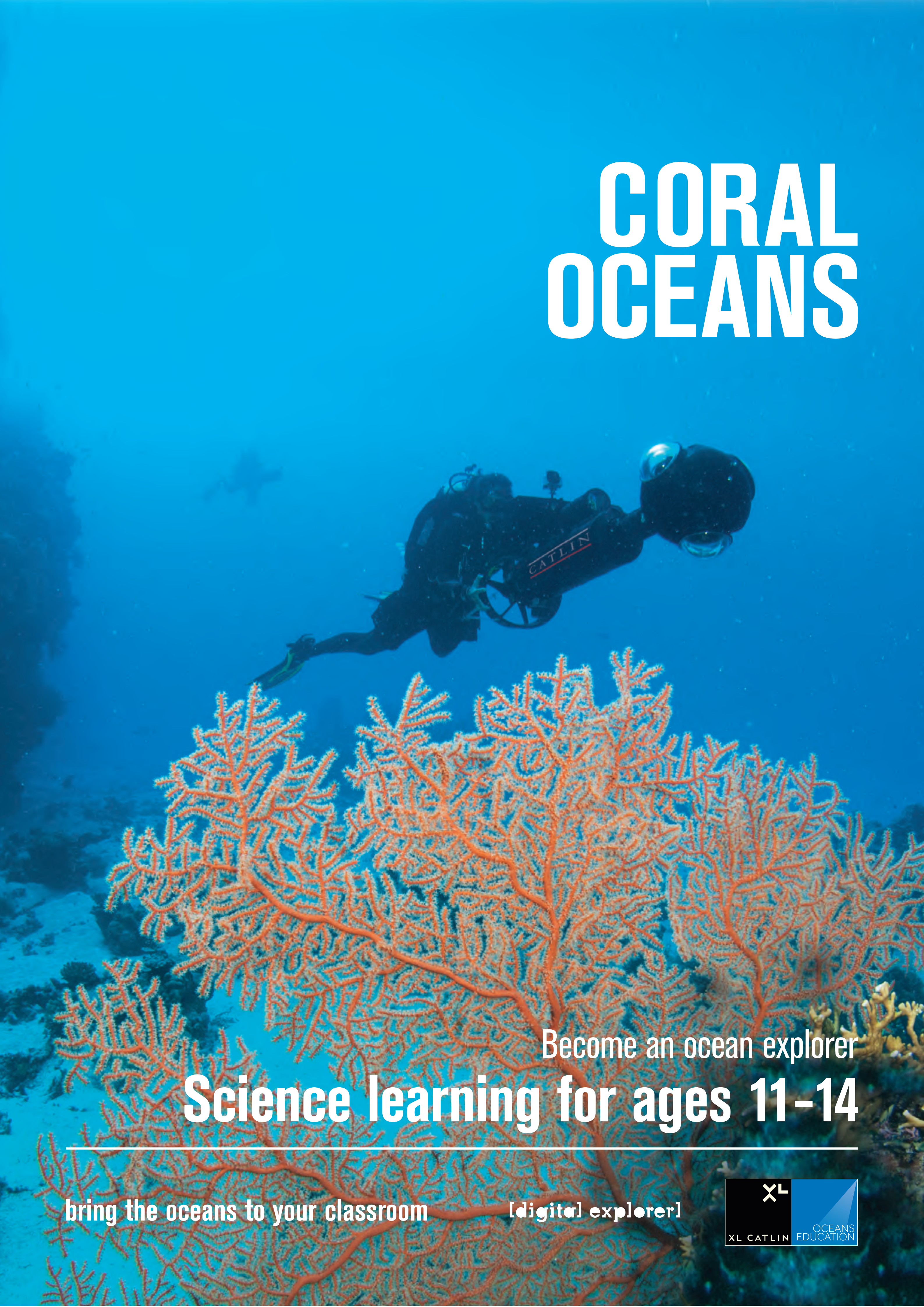


CORAL OCEANS

Become an ocean explorer

Science learning for ages 11-14

bring the oceans to your classroom

[digital explorer]

XL CATLIN OCEANS EDUCATION

CONTENTS

INTRODUCTION

Welcome to the Coral Oceans education pack for ages 11-14!

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

This booklet for ages 11-14 forms part of a wider education programme aimed at supporting oceans learning in schools.

OceansEducation.com is the online home for [de] 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 programme will continue to develop, so do keep in touch as we work to 'Bring the oceans to your classroom'.

Thank you 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 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 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 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, technical.

OVERVIEW

This resource will act as your guide to the world of coral and in particular to the Great Barrier Reef. 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 on our planet and stretches for over 2,300km along the eastern coast of Australia.

The science of the coral reef has puzzled scientists for centuries. Charles Darwin, on the famous Beagle voyage, was baffled as to how such richness of life was possible in the nutrient poor waters of the tropics. We know now that coral ecosystems cover less that 0.1% 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 7 for further notes on virtual diving).

This new method of surveying the reef is not only to make this natural wonder more accessible but has a scientific purpose at its core. To create a global survey of the world's coral reefs would have taken over 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. This photographic baseline allows scientists to monitor the health of coral ecosystems more effectively.

Going deeper on the reef

This shallow reef survey, creating 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 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: vulnerability of the deep reef to rising ocean temperature and acidity and genetic connections between deep and shallow reef corals.

Running out of time

This 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 and fragile.

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

TEACHERS' NOTES

Lessons Overview

1. Underwater Explorer

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

Learning Objectives

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

2. Wonders of coral

Coral reefs support 25% of all marine life. During this lesson, students will discover more about the coral ecosystem, modeling the different coral habitat zones. They will then 'dive' on the Great Barrier Reef to undertake a coral survey.

Learning Objectives

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

3. Energy on the reef

In this lesson students will investigate the interdependence of life on the reef and where different animals, plants and other life get their energy from through feeding and symbiosis.

Learning Objectives

- Describe the feeding techniques of different species
- Identify the range of primary producers in the ocean
- Create a food web using species found on the coral reef

4. Ultimate adaptation

Different species have adapted to life on the coral reef in amazing and diverse ways. In this lesson, students are challenged to create the ultimate coral animal.

Learning Objectives

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

5. Diving deeper

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

Learning Objectives

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

6. Coral future?

Students will consider the threats that coral reefs face. Threats range from long-term environmental change caused by increased atmospheric CO_2 to changes in coastal land use.

Learning Objectives

- Investigate the different factors affecting the coral reef
- Judge the impact of human activity on the coral reef
- Debate how changes in human behaviour can help to preserve the reef for future generations

7. Expedition report

At the end of the expedition, teams 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.

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

TEACHERS' NOTES

Ocean literacy

The ocean is undeniably important, covering over 70% of the world's surface and containing 98% of the living space on the planet. Its processes are critical to the current balance of life, providing 50% of the oxygen we breathe, absorbing up to 50% of manmade CO_2 and regulating the climate.

Traditionally, examples, processes and case studies in the science curriculum have been drawn from land-based knowledge. The rainforests are touted as the lungs of the planet, when 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 seek to change this imbalance and create a more representative science curriculum.

– 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 develop ocean literacy for your students, using the Ocean Literacy Framework (oceanliteracy.wp2.coexploration.org).

Lessons	1	2	3	4	5	6
1a The ocean is the dominant feature on our planet Earth – covering ~70% of the surface. There is one ocean with many ocean basins.	●					
3e The ocean dominates the Earth's carbon cycle. Half the primary productivity 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.			●	●		
5a Ocean life ranges in size from the smallest virus to the largest animal that has lived on Earth, the blue whale.		●				
5b Most life in the ocean exists as microbes. Microbes are the most important primary producers in the ocean.			●			
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.	●		●			
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.			●	●	●	
5e The ocean is 3D, offering vast living space and diverse habitats from the surface, through the water column to the seafloor. Most of the living space on Earth is in the ocean.		●			●	
5f Ocean habitats are defined by environmental factors such as salinity, temperature, oxygen, pH, light, nutrients, substrate, pressure and circulation, ocean life is not distributed temporally or spatially, i.e. it is patchy. Some regions of the ocean support life more diverse and abundant than anywhere on Earth, while much of the ocean is considered a desert.		●			●	
6e Humans affect the ocean in a variety of ways. Human development and activity leads to pollution and physical modifications.						●
6g Everyone is responsible for caring for the ocean. 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.						●
7a The ocean is the last and largest unexplored place on Earth – less than 5% of it has been explored.	●				●	
7c Over the last 40 years, use of ocean resources has increased significantly, therefore the future sustainability of the ocean resources depends on our understanding of those resources and their potential and limitations.						●
7d New technologies, sensors and tools are expanding our ability to explore the oceans.	●				●	

'DIVE FEEL'

These lessons 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 used 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 dives or lessons, the teacher should pose as the dive master, briefing divers at the beginning of each lesson and signing or stamping their log book sheets at the end.

Lesson structure

Each lesson starts with a dive briefing for that specific location (real locations from the Great Barrier Reef leg of the Catlin Seaview Survey are used). Some practice activities may follow, before students undertake their main dive activity (with a time limit being set dependent on how full their air tanks are). The last section of each lesson sees students fill in their dive logs, just like a professional diver, to review and record their learning.

Dive signs

One of the problems encountered working underwater is communications. Divers cannot talk to each other and so use a range of dive signs to communicate with each other. A selection of these are included on Activity Sheet 03. Teachers may want certain portions of lessons to be conducted in silence, using dive signs only to communicate.

Buddy system

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

Dive logs

Every diver and underwater expedition keeps 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. Each lesson has its own dive log pro forma for students to complete as a learning review. Students will be able to use these as the basis for the end of unit assessment, creating an expedition report.

Expedition Media

These resources are based on actual expeditions. 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.

Digital Explorer For Students Zone

A collection of multimedia resources from the expedition can be found in Digital Explorer's For Students Zone. Go to media.digitalexplorer.com and select the Coral Oceans theme to browse the videos and photos.

Follow the team live

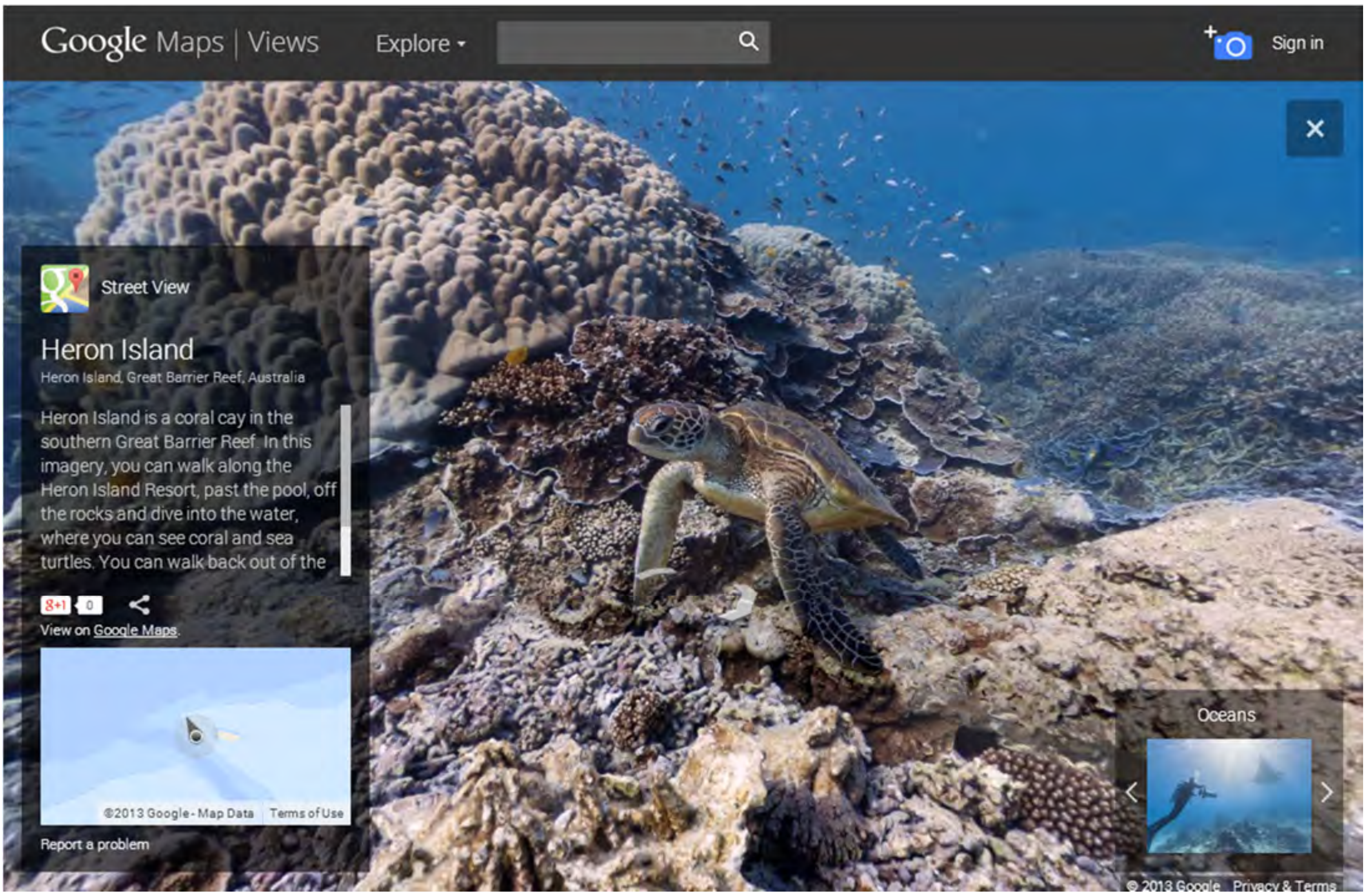
During the expedition phases of the Catlin Seaview Survey, the team will be posting regular updates on catlinseaviewsurvey.com. A number of social media sites are also used and can be shared with students (NB please follow related guidance for social media use both from your school and from the service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

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

Take part in a live chat

When the expedition is in the field, the team organize a number of Google Hangouts, multi-user video chats. For the launch of the Catlin Seaview Survey, the team organized the first ever Hangout from underwater (youtu.be/JwLud5QpfRs). Anyone can sign up to take part and future Hangouts will be advertised on the Catlin Seaview Survey Google+ page.

VIRTUAL DIVING



The underwater SVII cameras developed by the Catlin Seaview Survey team has changed the way that 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 can all be stitched together to create astonishing 'virtual dives', which can be viewed on Google Maps.

According to Richard Vevers, the project director, it has opened up the ocean to millions of people. "In a very real sense this is as close as you can get to a dive experience without getting wet."

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

In addition, a series of resources have been created to make use of the underwater imagery in 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 webs
- Symbiosis
- Threats

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

DIVE 1: UNDERWATER EXPLORER

Summary

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

Main Enquiry

- Why is the Great Barrier Reef such an important habitat?

Learning Objectives

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

Preparation

- Download and familiarise yourself with 'Slideshow 1 - Underwater Explorer' from oceans.digitalexplorer.com/resources
- Use 'Fact Sheet 1 - About the Great Barrier Reef' and 'Fact Sheet 2 - Catlin Seaview Survey' for background information
- View videos and photos at media.digitalexplorer.com and either browse the videos in the Coral Oceans (Secondary) theme or search using key words
- Print out enough copies of:
  - Activity Sheet 01 - Ocean habitats
  - Activity Sheet 02 - Creating a baseline
  - Activity Sheet 03 - Dive Signs
  - Activity Sheet 04 - Dive 1 log
  - Relevant species slides from the Slideshow

Notes

DIVE 1: UNDERWATER 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 71% of the surface. The ocean is not one habitat but a variety of different habitats, just like it is on land. Use the slideshow and Activity 01 to introduce students to the diversity of life and habitats in the ocean.	Slideshow 1 - Underwater Explorer Activity Sheet 01 - Ocean habitats	Know that we live on a 'blue planet' Name a variety of ocean habitats and species that live there
HOW IS THE BASELINE SURVEY BEING CREATED?	Introduce students to the Catlin Seaview Survey using a selection of suggested videos and the slideshow. If necessary go over terms such as 'baseline' and 'transect', so that students understand the scientific rationale for the survey. Introduce students to their dive mission for the lesson, to find out what species are found on the Great Barrier Reef.	Slideshow 1 Video - Ep 1: Setting Sail Video – Ep 5: Sharing the Science Video - Catlin Seaview Survey: Introduction Video - Seaview Science: Shifting baselines Activity Sheet 02 - Creating a baseline	Describe the Catlin Seaview Survey and its science aims
HOW DO SCIENTISTS WORK UNDERWATER? (OPTIONAL)	Discuss the challenges for scientists working underwater, from the limited time due to using scuba gear to the problems of communication. Emphasise how different this is from working in a lab and doing land-based fieldwork. Use Activity Sheet 03 to introduce students to the dive signs used to communicate underwater.	Activity Sheet 03 - Dive signs Video - Ep 7: Dive Signs Video - Ep 8: Dive kit Slideshow 1	Understand the different techniques scientists use to work underwater
WHAT TYPES OF LIVING THINGS ARE FOUND ON THE REEF?	Students can start their virtual dive on the reef. They may be able to identify some of living things that they see using the species cards. Students share what they have spotted on their virtual dive. Because of the diversity of life on the reef, individual species recognition may be difficult. Students can use the websites listed at the back of this booklet to research species recognition for homework. Students then sort the species cards found on slides 16-26 to learn about the variety of species found on the reef and classify them according to the groups specified by the teacher.	Slideshow 1 Virtual diving using either: maps.google.com/oceans Or is.gd/virtualdive (selecting Heron Island from the drop down menu of 'Other locations') Differentiate this activity depending on the ability of the class using an appropriate level of taxonomy. Also use #living things in the Coral Oceans (Secondary) theme to find more information on species at media.digitalexplorer.com	Carry out a virtual dive on the reef Identify common species found in the coral reef habitat
PLENARY WHY IS THE GREAT BARRIER REEF SO IMPORTANT?	Students complete their dive logs to include the range of species identified (with appropriate classification). Discuss the answer to the opening question, i.e. the Great Barrier Reef is an important habitat because it is home to such a large and varied array of life.	Activity Sheet 04 - Dive 1 log Whole class discussion	Reflect on the importance of the Great Barrier Reef

DIVE 2: WONDERS OF CORAL

Summary

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

Main Enquiry

– How are coral ecosystems varied?

Learning Objectives

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

Preparation

– Download and familiarise yourself with 'Slideshow 2 – Wonders of coral' from oceans.digitalexplorer.com/resources
– View videos and photos at media.digitalexplorer.com and either browse the videos and photos in the Coral Oceans (Secondary) theme or search using key words
– Print out enough copies of:
    Activity Sheet 05 - Coral reef scales
    Activity Sheet 06 - Coral reef sketch
    Activity Sheet 07 - Coral ID
    Activity Sheet 08 - Dive 2 log

Notes

DIVE 2: WONDERS OF CORAL

Aims / Objectives	Activities	Resources	Outcomes
STARTER: HIOW BIG IS THE REEF AND HOW SMALL IS A POLYP?	Use the card sort activity set out in Activity Sheet 05 to demonstrate to students the different scales within the coral reef ecosystem. Students should cut out the different photos of coral and coral reefs and place them in size order from the largest to the smallest.	Slideshow 2 - The wonders of coral Activity Sheet 05 - Coral reef scales Video - Ep 3: Wonders of coral Use key word 'reef scales' in the Coral Oceans (Secondary) theme for photos at: media.digitalexplorer.com	Recall the scale of the Great Barrier Reef compared with the smallest part of the living coral
WHAT SMALLER HABITATS EXIST WITHIN A CORAL ECOSYSTEM?	Copy or cut out and paste a sketch of the different habitat zones on the reef. Discuss these habitat zones and compare coral types with the physical conditions experienced on different parts of the reef (water depth, exposure to waves, temperature and light). Introduce students to the dive mission for this lesson to survey different parts of the reef to find out if there is a difference between the distribution and abundance of different coral types.	Slideshow 2 Activity Sheet 06 - Coral reef sketch Video - Coral reef zones (optional)	Identify different habitat zones and describe the differences in conditions
HOW CAN CORAL TYPES BE IDENTIFIED?	Scientists use two main methods to identify species - genetics and keys. For this dive mission students will be using a simple coral key to identify different coral types. For exact species recognition, scientists have to rely on genetic testing alongside other methods. Practise identifying corals using slides 8-11.	Slideshow 2 Activity Sheet 07 - Coral ID Use key word 'Coral ID' in the Coral Oceans (Secondary) theme for more photos at: media.digitalexplorer.com	Use key to identify coral types
HOW ARE CORAL TYPES DISTRIBUTED ON DIFFERENT PARTS OF THE REEF?	Use slides 12-15 to show the two different survey areas and/or hand out print-outs. Remind students that they will be using actual images taken using the SVII camera. Students complete their coral survey using Activity Sheet 08. Students could also use online virtual diving to conduct their surveys.	Slideshow 2 Activity Sheet 07 - Coral ID Activity Sheet 08 - Dive 2 log Use key word 'survey site' in the Coral Oceans (Secondary) theme for photos at: media.digitalexplorer.com	Use survey techniques to compare coral distribution in two different habitat zones
REVIEW: HOW ARE CORAL ECOSYSTEMS VARIED?	Students complete their dive log using Activity Sheet 08 to reflect on the main enquiry for this lesson: 'How (and why) are coral ecosystems varied?'.	Activity Sheet 08 Whole class discussion	Understand how coral affects and is affected by its environment

DIVE 3: ENERGY ON THE REEF

Summary

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

Main Enquiry

– How do living things on the reef depend on each other?

Learning Objectives

– Describe the different techniques species use to get their energy
– Identify the range of primary producers in the ocean
– Create a food web using species found on the coral reef

Preparation

– Download and familiarise yourself with 'Slideshow 3 - Energy on the reef' from oceans.digitalexplorer.com/resources
– Download and familiarise yourself with Coral species Google Earth file or pdf from oceans.digitalexplorer.com/resources
– View videos and photos at media.digitalexplorer.com and either browse the videos and photos in the Coral Oceans (Secondary) theme or search using key words
– Print out enough copies of:
    Activity Sheet 09 - Coral feeding
    Activity Sheet 10 - Coral food web
    Activity Sheet 11 - Dive 3 log

Notes

DIVE 3: ENERGY ON THE REEF

Aims / Objectives	Activities	Resources	Outcomes
STARTER: WHAT CARNIVORES, HERBIVORES AND PRODUCERS LIVE ON THE REEF?	Introduce the dive mission to find out what different reef species eat. Watch a clip of a dugong (sea cow) eating sea grass to link a feeding pattern that students will recognise. Students should already be aware of plants being producers. Then watch the underwater classroom footage and discuss which species are carnivores, herbivores, producers and consumers in each case and how they depend on each other within a food chain. Students can start to sketch out some food chains found on the reef.	Slideshow 3 - Energy on the reef 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. Slides 05-08 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 web.	Slideshow 3	Identify the range of primary producers in the ocean
WHERE DOES CORAL GET ITS ENERGY FROM?	Use Activity Sheet 09 to set up the coral feeding activity. Students will behave like polyps to see if they can catch enough plankton to power their coral colonies. The activity will demonstrate that coral cannot get enough energy from plankton alone and needs another source of energy to build the reef. Use slides 09-10 to explain how coral receives the rest of its energy.	Activity Sheet 09 - Coral feeding Slideshow 3 For a video demonstration search for 'Coral feeding game' at media.digitalexplorer.com	Explain how coral gets enough energy in nutrient poor waters
HOW DO SPECIES DEPEND ON EACH OTHER ON THE REEF?	Students will now look at the food web on the reef, using the instructions on Activity Sheet 10 to create a food web. Background species information can be found on slides 13-15 (these could be printed out), online at oceans.digitalexplorer.com or as part of the Coral Species Google Earth file	Activity Sheet 10 - Coral food web Coral species kml Slideshow 3 Use hashtag #living things in the Coral Oceans (Secondary) theme for more photos at media.digitalexplorer.com	Create a food web using species found on the coral reef
PLENARY HOW DO LIVING THINGS ON THE REEF DEPEND ON EACH OTHER?	Use Activity Sheet 11 for students to reflect on their learning, identifying how different species are linked through the food web.	Activity Sheet 11 - Dive 3 log	Understand that different species are producers and consumers and note examples of symbiosis

DIVE 4: ULTIMATE 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 to find food and stay alive. The reef is also host to numerous examples of symbiosis, and finding food and safety in the strangest of places, whether that be in a shark's mouth or 'vacuuming' the sandy seabed. In this lesson, students are challenged to create the ultimate reef organism.

Main Enquiry

- How are animals adapted to live on the coral reef?

Learning objectives

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

Preparation

- Download and familiarise yourself with 'Slideshow 4 – Ultimate adaptation' from oceans.digitalexplorer.com/resources
- View videos and photos at media.digitalexplorer.com and either browse the videos and photos in the Coral Oceans (Secondary) theme or search using key words
- Print out enough copies of:
    - Activity Sheet 12 – Dive 4 log

Notes

DIVE 4: ULTIMATE ADAPTATION

Aims / Objectives	Activities	Resources	Outcomes
STARTER: WHY HAVE ANIMALS ADAPTED TO SURVIVE ON THE REEF?	Use slide 02 to ask students how many stonefish they can see. How has the stonefish adapted to survive on the coral reef? Slides 04-05 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 zooxanthellae through photosynthesis and how different types of corals occupy different habitat zones and niches on the reef.	Slideshow 4 - Ultimate Adaptation	Identify specific adaptations used by coral reef species Explain the need for adaptation for survival
HOW HAVE DIFFERENT SPECICES 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 find out the strategies used to survive. Using slides 08-17, show students the range of adaptations that animals have used to increase their chance of survival on the reef.	Slideshow 4 Additional photos and videos of adaptations can be found by using hashtag #living things in the Coral Oceans (Secondary) theme at media.digitalexplorer.com	List a range of adaptations on the reef
WHAT WOULD MAKE THE ULTI-MATE CORAL ANIMAL?	Students create the 'ultimate coral animal' using what they have learnt so far to inspire them. Using Activity Sheet 12, students draw their new animal and list the adaptations that will ensure its survival and success. Students may wish to research other coral animals online at media.digitalexplorer.com to gain further information. Suitable websites are listed at the back of the booklet.	Activity Sheet 12 - Dive 4 log	Create the 'ultimate coral animal' using prior knowledge
PLENARY HOW ANIMALS ADAPTED TO LIVE ON THE CORAL REEF?	Students complete their dive log and explain what they have found out about adaptation on the reef. 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.co.uk. The best examples will be displayed in an online gallery.	Whole class discussion	Consolidate understanding of adaptation on the reef

DIVE 5: DIVING DEEPER

Summary

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

Learning objectives

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

Preparation

- Download and familiarise yourself with 'Slideshow 5 – Diving Deeper' from oceans.digitalexplorer.com/resources
- View videos and photos at media.digitalexplorer.com and either browse the videos and photos in the Coral Oceans (Secondary) theme or search using key words, e.g. 'Deep reef'
- Print out enough copies of:
  - Activity Sheet 13 - Under pressure
  - Activity Sheet 14 - Diving deeper
  - Activity Sheet 15 - Exploring deep coral
  - Activity Sheet 16 - Dive 5 log

Notes

DIVE 5: DIVING DEEPER

Aims / Objectives	Activities	Resources	Outcomes
STARTER: USE OF TECHNOLOGY	The deep reef team are exploring the coral reef between the depths of 30 and 100 metres. Working at these depths requires different technologies and diving techniques. Very little is known about this area of the reef, known as the mesophotic zone or more colloquially the 'twilight zone'. Watch the video clip of the ROV (Remotely Operated Vehicle) placing a data logger on the deep reef. Ask pupils why an ROV is being used rather than a team of divers. Discuss the use of technology to explore extreme environments.	Slideshow 5 - Diving deeper Video - Deep Reef: Monitoring the reef Video - Deep Reef: Scientific transects	Describe the technology needed to work on the deep reef
UNDER PRESSURE	Water pressure is one of the limiting factors in underwater exploration. This experiment demonstrates the relationship between depth and water pressure. Use Activity Sheet 13 with students to investigate the relationship between depth and pressure.	Activity Sheet 13 - Under pressure Video - Under pressure	Understand the relationship between pressure and depth underwater
DEEP DIVING	Using the blog post written by Norbert Englebert (Activity Sheet 14), part of the deep reef team, put the learning so far in the lesson into a human context. Questions on the sheet can be answered individually or as a plenary discussion. Consider creating a word cloud of the words used to describe working at depth (Question 4), using a service such as tagxedo.com. This could form part of a classroom display.	Activity Sheet 14 - Diving deeper	Communicate what it is like to work at depth
CORALS AT DEPTH	The team are investigating deep corals. Refer to the coral feeding activity in the Dive 3 lesson and ask pupils why deep corals may have to adapt to get enough energy. Use the experiment on Activity Sheet 15 to show the relationship between colour and depth for corals.	Activity Sheet 15 - Exploring deep coral Video - Deep Reef: New coral species	Investigate the relationship between depth and coral colour
PLENARY: HOW IS CORAL DIFFERENT ON THE DEEP REEF?	Colour is not the only adaptation for deep reef corals. Students should note their thoughts about how corals might change in shape. Use slides 14-19 to show photographs of the deep and shallow reefs and consider differences between coral species as a prompt. Students should consider how corals might change shape with depth on their dive logs.	Activity Sheet 16 - Dive 5 log	Propose how scientists could explore the deep reef

DIVE 6: CORAL FUTURE?

Summary

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

Learning Objectives

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

Preparation

– Download and familiarise yourself with 'Slideshow 6 – Coral future?' from oceans.digitalexplorer.com/resources
– View videos and photos at media.digitalexplorer.com and either browse the videos and photos in the Coral Oceans (Secondary) theme or search using key words, e.g. 'threats'
– Use Factsheets 03-05 for background information on the threats facing coral reefs
– Use Activity Sheet 17 - Coral threats overview to design and choose the range of activities for this lesson
– Use Activity Sheets 18-24 to guide students' investigation of the threats facing coral reefs
– Print enough copies of:
  Activity Sheet 25 - Threats overview
  Activity Sheet 26 - Dive 6 log

Notes

DIVE 6: CORAL FUTURE?

Aims / Objectives	Activities	Resources	Outcomes
STARTER: WHAT'S THE STATE OF THE GREAT BARRIER REEF?	Use the slideshow to introduce students to the findings of the AIMS (Australian Institute for Marine Science) report. The report shows how 53% of the coral cover on the Great Barrier Reef has been lost between 1985 and 2012. How do students feel about this? Discuss their emotional reactions (e.g. anger, indifference, etc.) and prompt them to describe reasons behind these feelings.	Slideshow 6 - Coral future? Video - Ep 9: Sailing home	Describe the damage to the Great Barrier Reef since 1987 and share their reaction to it
HOW CAN HUMAN ACITIVITY AFFECT THE REEF?	Activity Sheet 17 lists a number of activities and sources of information that students can study to gain an understanding of how and why the reef is being damaged. These activities can be used in a variety of ways: a) Divide the class into 8 groups and assign each group with a threat. Groups will then work out how to explain the impact of their threat to the rest of the class. b) Select a representative range of threats and divide the class into the same number of groups. Set up a carousel of activities. Groups fill in Activity Sheet 26 to record their learning. c) Choose a small number of activities or sources of information for students to work through in their buddy pairs or small groups. NB feel free to select just some of the activities depending on time and the ability level of your class.	Activity Sheets 18 - 24 for threat activities and information Activity Sheet 25 - Threats overview	Investigate the range of impacts on the coral reef
CAN YOU LIVE A REEF-FRIENDLY LIFE?	Draw a diagram of reef friendly and reef unfriendly living based on Activity Sheet 25.	Activity Sheet 26 - Dive log 6	Identify and communicate examples of reef friendly living
PLENARY WILL YOUR CHILDREN SEE A CORAL REEF?	There is a possibility that coral reefs will be in terminal decline by 2050. This would mean that students' future children may never have the chance to see a coral reef. – How do students feel about this? – What do they think should change? – Whose responsibility is the future of the reef?	Whole class discussion	Debate the future of coral

DIVE 7: EXPEDITION REPORT

Summary

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

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

Preparation

- Download and familiarise yourself with 'Slideshow 7 – Expedition Report' from oceans.digitalexplorer.com/resources
- Have a look at an example blog post from the expedition, 'Fact Sheet 06 - Heading home'
- Templates for some of the outputs are available:
  - Activity Sheet 27 - Expedition report template
  - Activity Sheet 29 - Article template
  - Activity Sheet 29 - Video story-board template

Notes

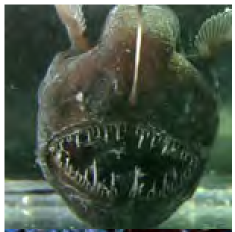
DIVE 7: EXPEDITION REPORT

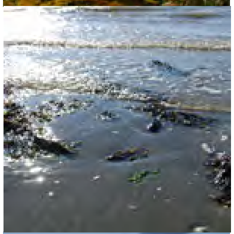
Aims / Objectives	Activities	Resources	Outcomes
STARTER: WHY DO WE NEED TO SHARE OUR FINDINGS?	Explain that expeditions need to share their findings for two main reasons. The science research needs to be shared with a wider audience. Not everyone can go to the coral reef and so the team needed to communicate what they found out. The other reason is that expeditions are often sponsored. The Catlin Seaview Surveys are sponsored by an insurance company, Catlin. It helps sponsorship to show support on TV and in the news.	Slideshow 7 - Expedition report	Identify reasons for communicating the findings of an expedition
WHAT WERE YOUR MAIN FINDINGS?	The class teams need to review their learning over 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 previous lessons	Summarise previous learning and select appropriate secondary sources
CORAL COMMUNICATIONS	Students are free to use the format that suits them and the resources at school. Students could use ICT to create a video or complete their report or press release.	Dive logs from previous lessons	Complete Expedition report
CORAL REPORT	Class teams share their reports, articles, videos, etc. with the class. These can also be shared with local news and websites such as digitalexplorer.com. Set this up as a press conference from the Great Barrier Reef. Some pupils may want to create a suitable backdrop in the classroom.	Completed reports (students may wish to finish these as homework)	Present findings to peers and real audiences

ACTIVITY SHEET 01

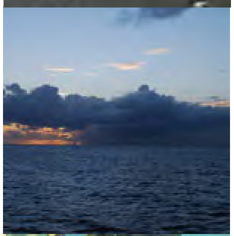
Ocean habitats (match the habitat with the animal)


Rocky shore

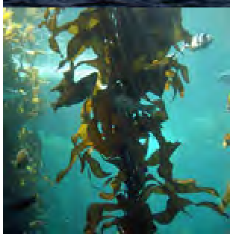
Anglerfish



Muddy shore

Sea otter



Open ocean

Lugworm



Kelp forest

Green turtle



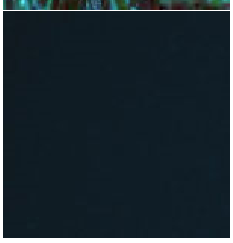
Coral reef

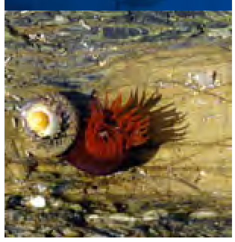
Clownfish



Seagrass meadow

Tuna



Deep ocean

Sea anemone


ACTIVITY SHEET 02

Creating a baseline

Our oceans provide the primary source of protein for over 1 billion people. The ocean provides half of the oxygen that we breathe and controls the climate. It is the ocean that makes our planet a living planet.

Understanding our ocean is critical. Scientists tell us that the condition of the ocean is getting worse but monitoring these changes is difficult. Advanced technology is essential.

The Catlin Seaview Survey has developed special underwater technology to make this type of research possible. Their new 360° cameras allow scientists to record the world's oceans and reefs like never before. The panoramic view created by these hi-tech cameras will create a survey of the oceans. Then scientists will be better able to monitor change. They will have a starting point or baseline to use as a comparison. Scientists will be able to monitor change over time and plan for the future.

Scientists from the University of Queensland surveyed the Great Barrier Reef and Coral Sea. At 34 different sites they recorded the shallow reef (1-12m) and at a smaller range of sites, the almost unknown deep reef (30-100m). They will need to take more than 100,000 images which will be stitched together and then analysed. This baseline survey will form a starting point for future studies of the reef.

Questions

1. Give 3 reasons why our oceans are essential to life.
2. Why has it been difficult to monitor the oceans previously?
3. Why are Catlin Seaview Survey now able to record the condition of the oceans?
4. What is a baseline survey?
5. How will a baseline survey help scientists better under-stand the oceans?

ACTIVITY SHEET 03

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

ACTIVITY SHEET 04

Dive #1	Heron Island	Coordinates: 23˚ 26' 30" S, 151˚ 54' 35" E

Name	Date

Time	Weather	Temp. air/sea	Max. depth	Bottom time
In ________ Out ________	☐ ☐ ☐ ☐	_____ ˚C _____ ˚C	_______ m	______min

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

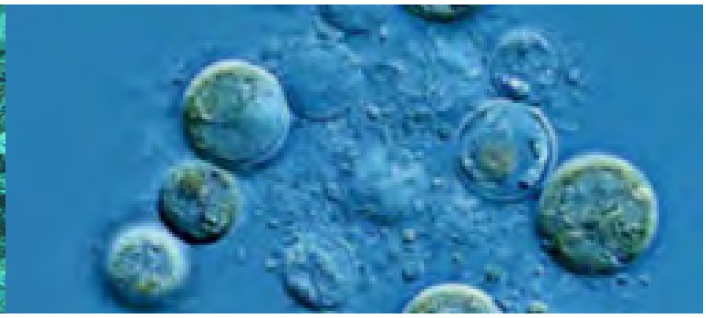
Buddy signature	Dive master signature / stamp

Encounter Edu

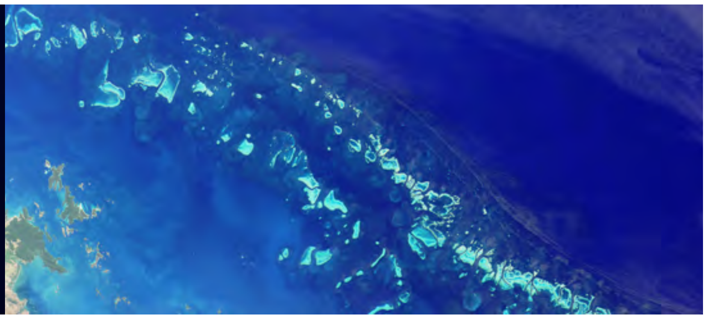
ACTIVITY SHEET 05

Coral reef scales


Coral colony

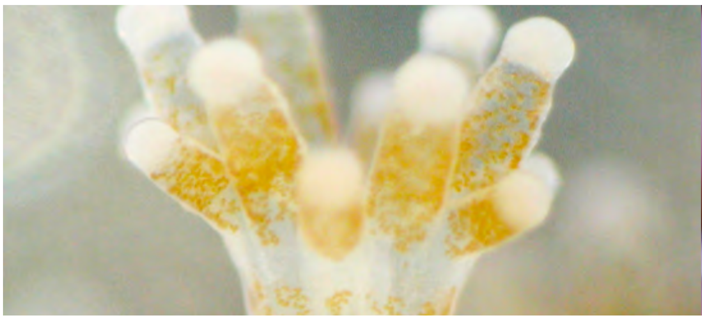

Zooxanthellae


Coral reef


Reef mosaic


Habitat patch

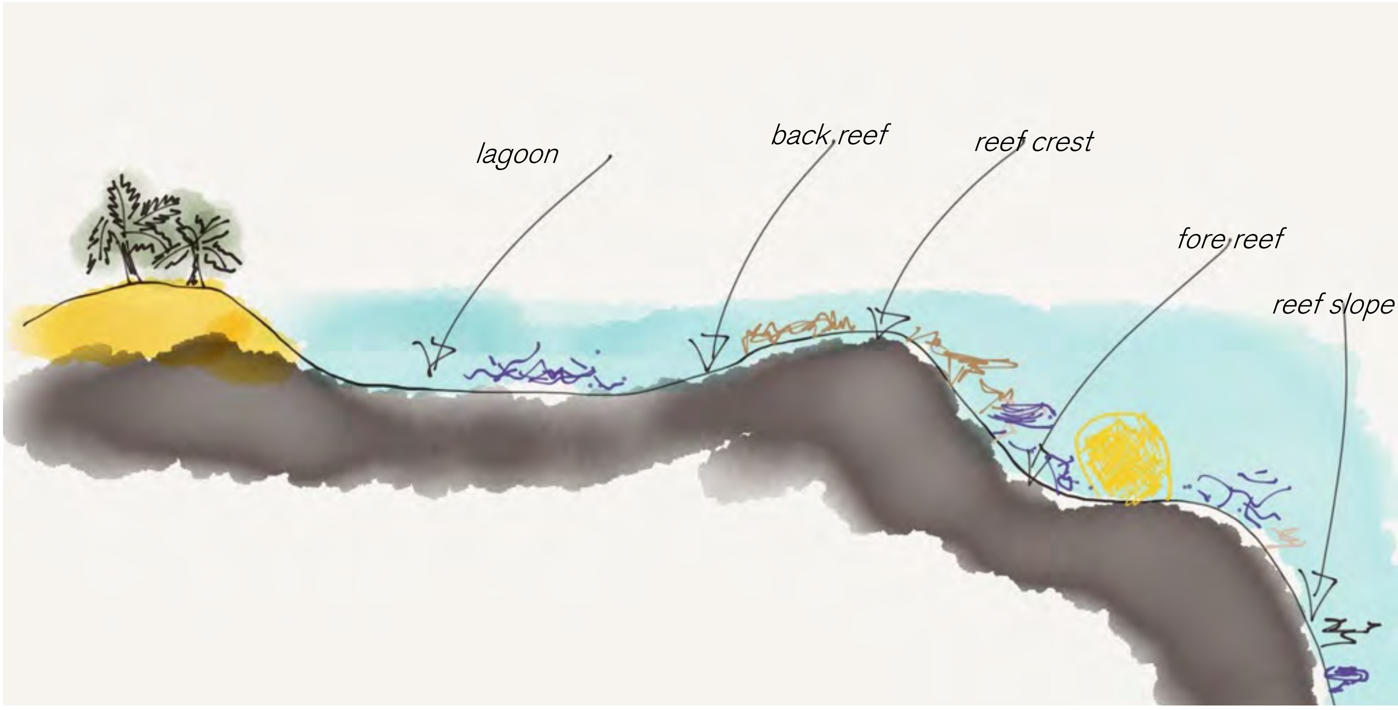

Habitat zone


Coral polyp


Coral branch

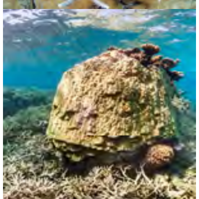
ACTIVITY SHEET 06

Coral reef sketch



Branching coral

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



Boulder coral

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

Encrusting coral

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

Branching plate coral

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

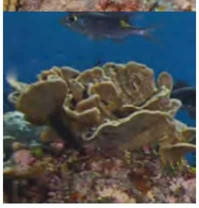


Plate coral

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

Summary

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

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

Activity

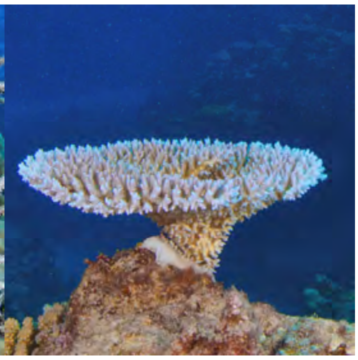
1. Cut and paste or copy the sketch above, labelling the different habitat zones found on the coral reef.
2. For each habitat zone choose the coral(s) that would be best suited to this environment.
3. Cut and paste the different corals to the correct zone on your diagram. You can use the corals in the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

Review

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

ACTIVITY SHEET 07

Coral ID

Branching coral

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

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

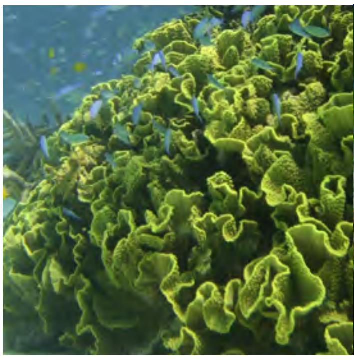



Plate coral

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

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


Boulder or massive coral

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

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


Ridge and valley coral

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

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

ACTIVITY SHEET 08

CATLIN SEAVIEW™ SURVEY

Dive #2

Opal Reef

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

Name

Date

Time

In ________

Out ________

Weather

☐ ☐ ☐ ☐

Temp. air/sea

____ ˚C

____ ˚C

Max. depth

______ m

Bottom time

_____min

Survey Site 1

Description of site

Coral ID key

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

Coral coverage

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

Survey Site 2

Description of site

Coral ID key

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

Coral coverage

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

Reasons for any difference in cover

Buddy signature

Dive master signature / stamp

ACTIVITY SHEET 09

Coral feeding

Summary

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

Preparation

Each student will need:

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

Activity

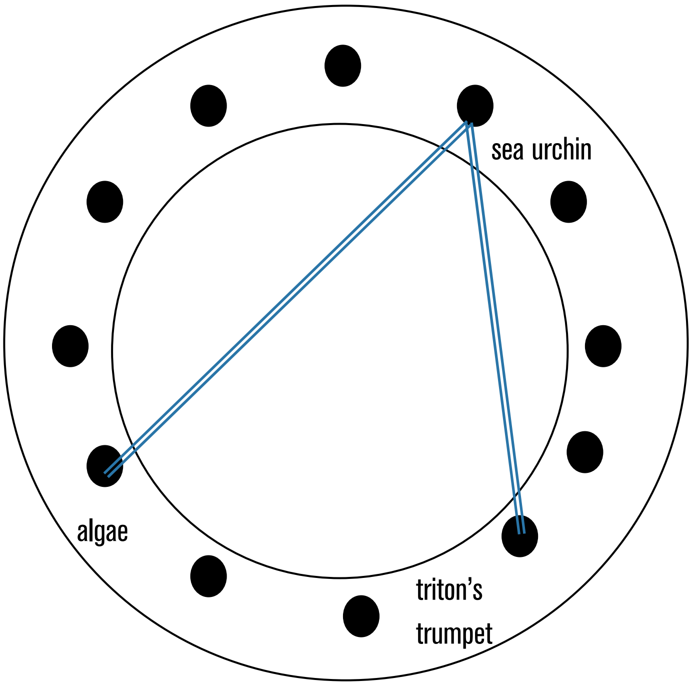
1. Divide students into groups of 5-6.
2. Tell the class that they are going to model how a coral polyp gets its energy.
3. Pupils should put on the glove (just one per student).
4. Mark the gloved back of the hand with green dots using stickers or a green marker pen—these dots represent the zooxanthellae (algae) within the coral polyp.
5. Stick squares of double-sided sticky tape around each gloved finger—the stickiness represents the stinging cells (nematocysts) on each tentacle / finger.
6. Create a sleeve out of the paper bag or paper that fits over their hand. This represents the corallite or limestone cup that the polyp lives in.
7. During the day the gloved hands will all be closed into a fist. This protects the tentacles from predators and the zooxanthellae are still exposed to sunlight and provide the coral with between 70% and 90% of its energy via photo-synthesis.
8. At night, the polyps open up and feed on zooplankton. Students in their groups should sit next to each other, representing a small coral colony.
9. All students should close their eyes ready to try to catch zooplankton, with their fingers. The teacher should go round each group and scatter cotton wool (representing zooplankton) over each coral colony.
10. Students can open their eyes to see how much they have caught.

Review

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

ACTIVITY SHEET 10

Coral food web



Summary

Students link different living things on the reef to demonstrate the interconnectedness of this habitat.

Preparation

Each pair will need:

- Cardboard
- Scissors
- Tape
- Wool or string

Activity

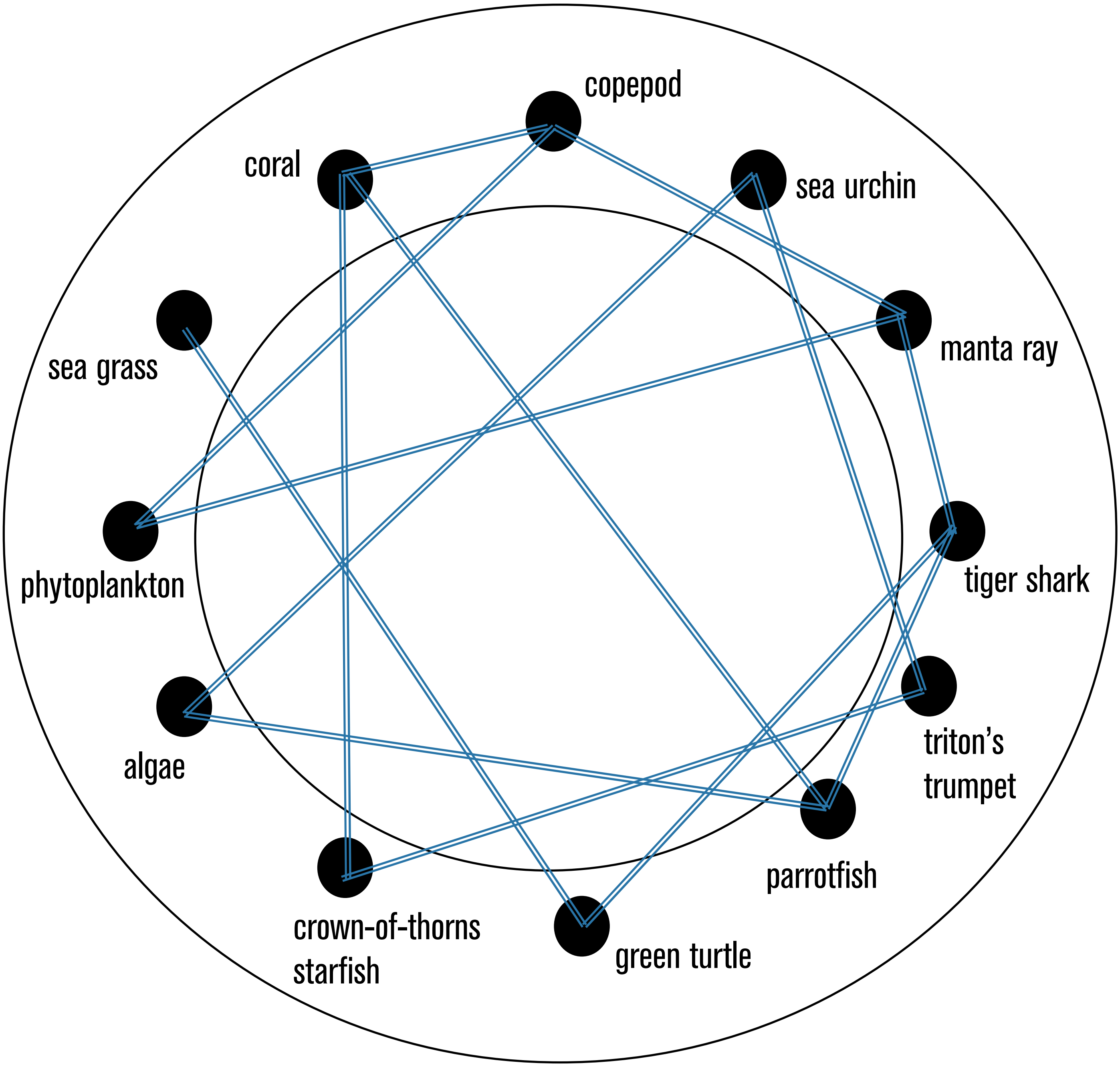
1. Cut out a ring of cardboard at least 20 cm in diameter (or two rings and stick together to make stronger).
2. Punch 12 holes around the ring at evenly spaced intervals like a clock face.
3. Write the names of the following species next to the holes: coral, sea grass, phytoplankton, algae, crown of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

Review

- What was the longest food chain that you created?
- How are different living things connected?
- What would happen if just one organism was threatened?

ACTIVITY SHEET 10 continued

Coral food web completed



ACTIVITY SHEET 11

CATLIN SEAVIEW SURVEY

Dive #3	Agincourt Reef	Coordinates: 16° 01' 15" S, 145° 51' 04" E

Name	Date

Time	Weather	Temp. air/sea	Max. depth	Bottom time
In ________ Out ________	☐ ☐ ☐ ☐	____ °C ____ °C	______ m	_____min

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

Buddy signature	Dive master signature / stamp

Encounter Edu

ACTIVITY SHEET 12

CATLIN SEAVIEW SURVEY

Dive #4	Mystery	Coordinates: ° ' " S, ° ' " E

Name	Date

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

Draw a picture of the 'ultimate' coral animal that you have 'found'. Make sure that you label the characteristics that make it so well adapted to life on the coral reef.

Buddy signature	Dive master signature / stamp

Encounter Edu

XL CATLIN OCEANS EDUCATION

ACTIVITY SHEET 13

Under pressure

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

Summary

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

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

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

This activity shows the relationship between water depth and pressure.

Preparation

Each student group will need:

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

Activity

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

Review

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

ACTIVITY SHEET 14

Diving deeper

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

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

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

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

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

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

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

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

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

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

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

Questions

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

ACTIVITY SHEET 15

Exploring deep coral

Exploring deep reef coral on Osprey Reef in the Coral Sea

Summary

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

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

Preparation

Each buddy pair will need:

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

Activity

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

Review

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

ACTIVITY SHEET 16

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

Name

Date

Time	Weather	Temp. air/sea	Max. depth	Bottom time
In ________ Out ________	☐ ☐ ☐ ☐	_____ °C / _____ °C	______ m	_____min

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

Buddy signature

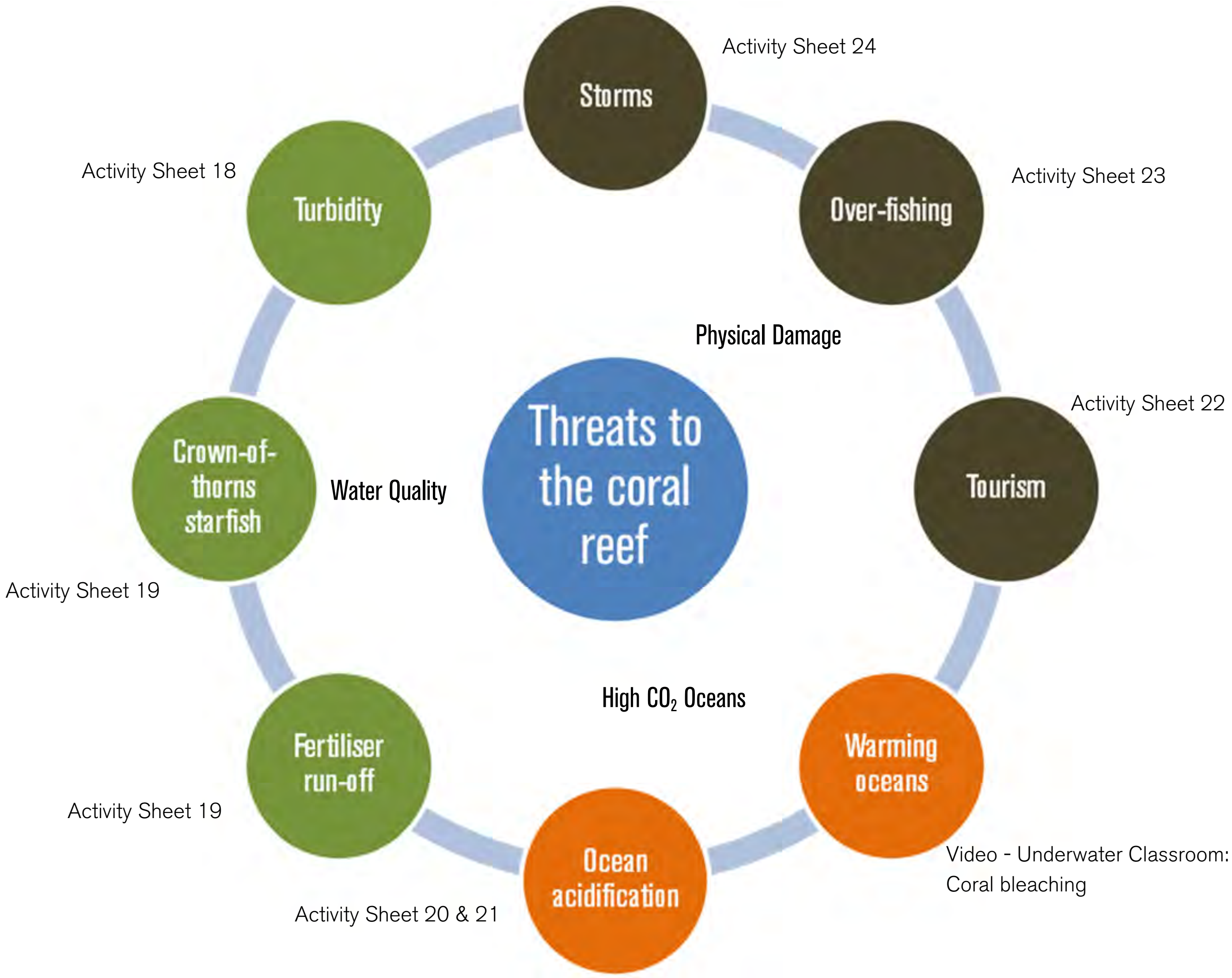
Dive master signature / stamp

ACTIVITY SHEET 17

Coral threats overview

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

- Effects of high CO_2, i.e. warming oceans and ocean acidification (see Fact Sheet 3)
- Water quality from land, i.e. turbidity and fertilizer / nutrient run-off (see Fact Sheet 4)
- Physical damage, i.e. from shipping, storms, over-fishing and tourism (see Fact Sheet 5)



ACTIVITY SHEET 18a

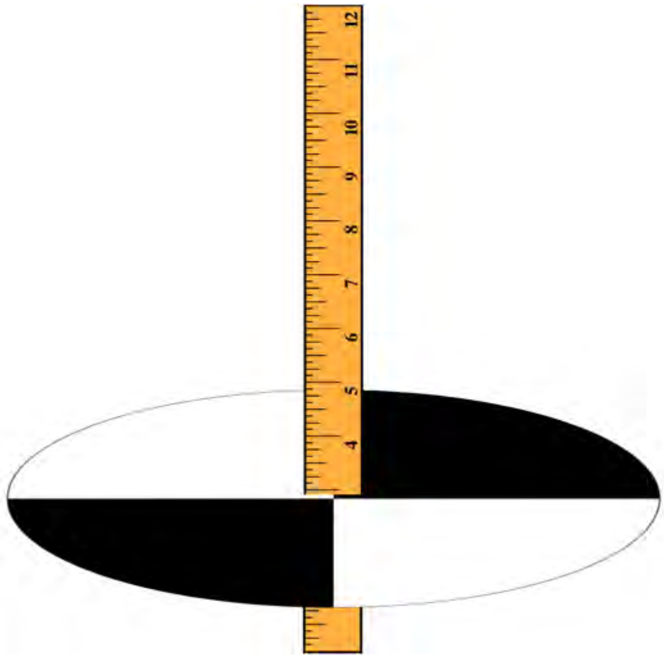
Cloudy waters

Summary

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

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

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



Preparation

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

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

For the experiment you will need:

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

Making the Secchi disk

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

Experiment

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

Review

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

ACTIVITY SHEET 18b

Turbidity alarm

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

Summary

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

Equipment needed:

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

Overview

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

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

Activity

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

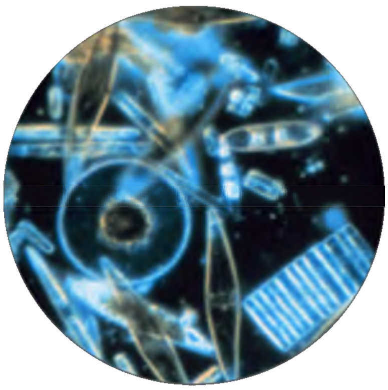
Discussion

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

ACTIVITY SHEET 19

Fertiliser and Starfish

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



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

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

ACTIVITY SHEET 20

Ocean acidification in a cup

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

Summary

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

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

Equipment needed per group of 2:

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

Overview

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

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

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

Video

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

ACTIVITY SHEET 21

Dissolving 'coral' in vinegar

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

Summary

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

Equipment needed per group:

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

Instructions

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

The science

Malt vinegar contains acetic acid.

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

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

Discussion questions

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

Notes

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

Video

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

ACTIVITY SHEET 22

Tourism poster

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

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

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

Don't touch anything

Watch your fins

No souvenirs

No litter

Maintain buoyancy

Don't feed fish

Strap down your gauges and spare regulator

Don't ride sea turtles and manta rays

ACTIVITY SHEET 23

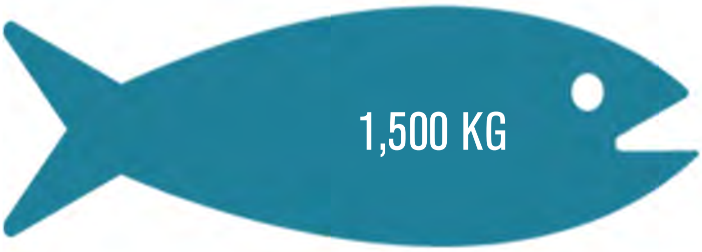
Overfishing

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

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

Discussion questions

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



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

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

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

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

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

ACTIVITY SHEET 24

Storm damage

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

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

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

Discussion questions

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

Encounter Edu

ACTIVITY SHEET 25

Threats overview

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

ACTIVITY SHEET 26

CATLIN SEAVIEW SURVEY

Dive #6

Various sites

Coordinates: ° ' " S, ° ' " E

Name

Date

Time

In ______

Out ______

Weather

☐ ☐ ☐ ☐

Temp. air/sea

_____ °C

_____ °C

Max. depth

______ m

Bottom time

_____min

Buddy signature

Dive master signature / stamp

ACTIVITY SHEET 27

Storyboard template

CAPTION:

CAPTION:

CAPTION:

CAPTION:

CAPTION:

CAPTION:

ACTIVITY SHEET 28

Article template

Coral Reef News

Headline

By:

Picture or photo

ACTIVITY SHEET 29

Report template

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

Now:

What life can be found on the reef?

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

Threats:

The future:

Possible

Probable

Preferable

FACT SHEET 01

The Great Barrier Reef

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

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

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

FACT SHEET 02

Catlin Seaview Survey

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

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

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

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

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

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

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

More than 105,000 stitched images were taken and analysed to produce an important 'state of the reef' benchmark. This data is published in the Global Reef Record, and will be made freely available to scientists around the world to monitor changes in marine environments. It also provides valuable insights for more than 50 nations worldwide that have significant coral reefs along their coastlines.

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

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

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

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

For more information, visit: www.catlinseaviewsurvey.com

FACT SHEET 03

Coral in a high 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 above. This process is known as ocean acidification.

Warming oceans

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

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

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

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

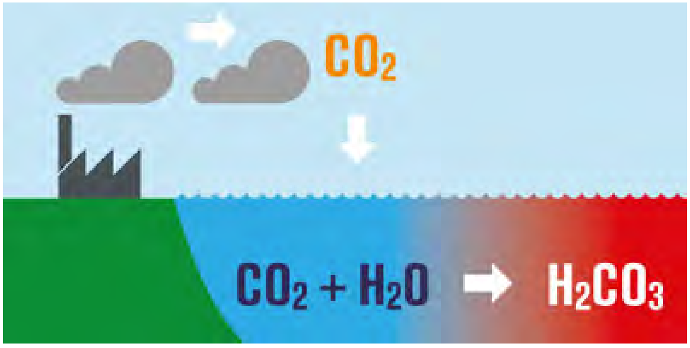
This bleaching can in turn lead to coral mortality as the 'zoox' provide between 70% and 90% of the energy for the coral polyps.

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

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

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

Ocean acidification



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

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

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

FACT SHEET 04

Coral and water quality

Land run-off

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

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

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

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

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

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

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

Crown-of-thorns starfish

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

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

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

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

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

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

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

FACT SHEET 05

Human activity on the reef

Overfishing

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

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

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

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

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

Recreational impacts

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

In the 1950s and 1960s, tourism was largely unknown. There were only 12 tour operators on the Great Barrier Reef in 1968, but this increased rapidly with 187 operators by 1980 and 742 in 1998.

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

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

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

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

Habitat loss

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

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

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

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

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

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

FACT SHEET 06

'Heading home'

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

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

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

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

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

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

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

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

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

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

USEFUL WEBSITES

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

Catlin Seaview Survey

www.catlinseaviewsurvey.com

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

Global Change Institute, University of Queensland

www.globalchange.org.au/catlinseaviewsurvey/

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

BBC Nature Reef section

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

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

Catlin Explorers

www.catlinexplorers.com/

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

National Geographic Coral Collection

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

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

CNN's The wonderful world of coral reefs

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

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

ARKive Coral Reef Conservation

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

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

NOAA Ocean Service Education

oceanservice.noaa.gov/education/tutorial_corals/

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

reefED

www.reefed.edu.au

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

Reef Relief

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

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

Global Dimension

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

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

PHOTO CREDITS

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

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

CATLIN EXPLORERS
A DEEPER UNDERSTANDING

CATLIN
Underwriting Ambition

Catlin Explorers

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

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

Case files

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

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

Fun Stuff

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

Explorer Missions*

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

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

* Explorer Missions should be supervised by a responsible adult.

Link to insurance

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

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

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

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