

Healthy Reefs from Polyp to Policy



UNIT PLAN - MARINE SCIENCE YEAR 11 AND 12



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- Reid et al. (2012) Coral Reefs and Climate Change: The Guide for Education and Awareness. CoralWatch, the University of Queensland, Brisbane. ISBN: 9780646590851 (pbk.)
- Coral Reefs and Climate Change, Educational Video Series, Produced by Wildfury and CoralWatch at the University of Queensland, Brisbane. ISBN: 9780646579429

The views expressed in this work are those of the authors, and do not necessarily reflect those of The University of Queensland. They are based on the latest possible research.

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Preface

Coral reefs are the jewel of our oceans. They cover less than 1% of the Earth's surface, yet contain over 25% of marine biodiversity. Society values reefs for their natural beauty and their capacity to support livelihoods and communities. Yet, one third of reefs have been lost, and reefs that remain continue to be threatened.

Teachers can play a vital role in marine conservation - sharing the latest science about reef ecosystems and involving students in reef monitoring. CoralWatch provides the tools you need to engage students in marine science and reef monitoring.

CoralWatch has used the Coral Health Chart to promote active learning opportunities for citizen scientists of all ages since 2002. The content of this Unit Plan extends beyond monitoring, and provides the tools you need to bring reef science into the classroom. In addition to reef biology and ecology, these units provide an overview of threats to reefs and management strategies that can improve the future outlook of reefs. The diverse scientific elements covered in this Unit Plan also provide multiple entry points for students to engage with science and cultivate a scientific approach to understanding the world. This is vital for navigating complex issues such as climate change and the impacts these issues will have on society.

Getting your students out into the field is a wonderful way for them to experience reef ecosystems, and one that they will never forget. The field component of this Unit Plan provides activities to support your field trips. However, for those of you unable to take your class to the reef, this Unit Plan provides virtual tools and a suite of classroom activities for every area.

CoralWatch aims to promote healthy reefs by raising awareness about the current threats to reefs and galvanise action that supports reef conservation. We hope that you can inspire your students to understand reef ecosystems, and empower them to be active participants in ensuring a future for healthy reefs.

The CoralWatch team

Angela Dean, Diana Kleine, Justin Marshall



‘From Polyp to Policy’ is a brilliant unit that is quite flexible for teachers to use for a variety of time frames including a single term unit or an fully integrated semester unit. It is a detailed unit full of interesting activities for students to do, including all the resources you will need to deliver it. The diagrams and pictures that support the unit reflect the standard we see in the Coral Reefs and Climate Change textbook. The unit is very easy for teachers to pick and choose topics to cover and can be presented with or without a field trip. Congratulations to the team for making such a useful tool for teachers.”

*Kelly Kilah,
St. Teresa's Catholic College
& Marine Teachers Association of Queensland*

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How to Use this Unit Plan

This unit plan focuses on Grade 11 and 12 Marine Science. It is linked to the Marine Science Senior Syllabus 2013, produced by Queensland Studies Authority, Australia. It may also be suitable for use for other Australian teachers, as part of science or geography programs.

This Unit Plan is not only for Australian teachers - these lessons and activities can be used with any group of students or adult learners.

Some activities make use of the Coral Health Chart and other CoralWatch materials – these can be ordered from CoralWatch (www.coralwatch.org). The Virtual Reef tools provide an opportunity to learn about coral bleaching and reef monitoring in the classroom. They can be used to assist student preparations for a field trip, or can provide a valuable alternative to a field trip.

Please note: if you are not able to take your class on a fieldtrip you can still use these materials. You can utilise the majority of these activities in a classroom setting, using recommended DVDs, books, articles and websites.

Each lesson relates to the chapters in the education guide and video series, Coral Reefs and Climate Change – The Guide for Education and Awareness. These are available from CoralWatch – www.coralwatch.org

Each lesson has a clear structure

Elaboration

Identifies how the lesson is linked to key concepts from the Marine Science syllabus.

Learning objectives

The knowledge or skills that the student should acquire by the end of each lesson.

Key learning points

A summary of key messages of the lesson.

Resources

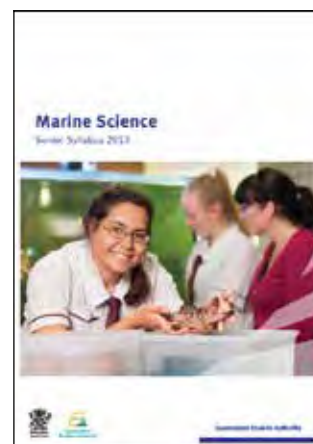
Relevant resources to support learning for each lesson topic. A key resource for this lesson plan is the book 'Coral Reefs and Climate Change – the Guide for Education and Awareness' (published by CoralWatch) and accompanying DVD series. Chapters or videos that specifically relate to each lesson will be listed. Links to other relevant resources are supplied, including websites, reports and articles. Several lessons also include resources such as ID sheets or handouts for students.

Background

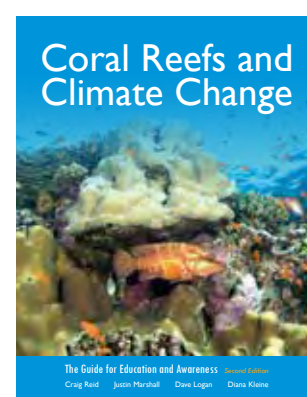
Information for the teacher that will support learning for each lesson.

Activities

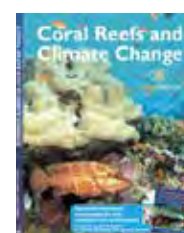
Activity outlines for use in the field or classroom. These are suggested activities only. Feel free to adapt these to suit the needs of your class, or develop your own activities.



Marine Science Senior Syllabus 2013



Coral Reefs and Climate Change – The Guide for Education and Awareness



Coral Reefs and Climate Change DVD

Course and Assessment Planning

This unit plan 'Healthy Reefs - from Polyp to Policy' contains lessons and activities that allow students to explore the definitions and determinants of reef health—from how the biology of corals is influenced by the environment, through to local and regional approaches to management of reef threats. It integrates all four areas of study and key concepts.

20 hours is the minimum time required to complete this unit. Please note that this unit plan can be extended across a full semester.

CoralWatch has developed four assignment options using different assessment techniques. The choice of assignments will depend on the needs of your classroom and the time assigned to this unit.

Unit/Inquiry	Time	Areas of Study Key concepts / elaborations			
		MB	OC	CS	MS
Overall Learning Objectives At the end of this unit plan, students will be able to: <ul style="list-style-type: none"> - Explain that coral reefs are home to amazing biodiversity. Beginning with a single polyp, reefs can grow so large that they can be seen from space. - Describe that healthy reefs need the right balance of sunlight, temperature, and water quality. Changing these conditions can damage coral health. If severe, entire reefs can be destroyed. - Understand that the way we manage our oceans influences all marine life. Even if reefs are damaged, our actions can help reefs to recover and maintain healthy oceans. - Use tools and methods in the field to measure reef health and contribute real data to a global monitoring program. 	minimum	1.1	1.4	1.1	1.4
	20 hours	1.2	3.3	1.3	2.4
		1.4	3.4	1.4	3.1
	maximum	3.2	3.5	1.7	3.5
	55 hours	3.3	3.6	2.1	
		3.6		2.2	
				2.3	
				2.4	
				2.5	
				2.6	
				2.7	
				3.4	
				3.5	

Areas of Study

MB - Marine Biology

OC - Oceanography

CS - Conservation and sustainability

MS - Marine Research Skills

No.	Assesment technique *	F S	Dimensions			Information
			KU	IA	EC	
1	ERR	*	X	X	X	Multimodal + Background research report Year 11: 3-5 minutes Year 12: 5-7 minutes Protect healthy reefs for the future 'Create a 'pitch' about the need for reef protection.
2	EAR	*	X	X	X	Written - Action research report and statement Year 11: 600-1000 words Year 12: 800-1200 words Health assesment Your job as an environmental consultant is to conduct an environmental assessment, collect and analyse field data and write an Environmental Impact Statement.
3	ERS	*	X	X	X	Written - Investigative report Year 11: 600-1000 words Year 12: 800-1200 words Reefs in decline Read the following scientific article: The 27-year decline of coral cover on the Great Barrier Reef and its causes and respond to questions.
4	ERR	*	X	X	X	Written - Argumentative essay Year 11: 600-1000 words Year 12: 800-1200 words Reef management Formulate an argument for or against the following statement 'An area where no one is allowed to visit is worth less than a place you are allowed to go'

Assesment technique

ERR - Extended research response

EAR - Extended response - action research

ERS - Extended response to stimulus

F - Formative**S** - Summative

* School based decision
depending whether the unit plan
is used for year 11 or 12.

Dimensions assessed

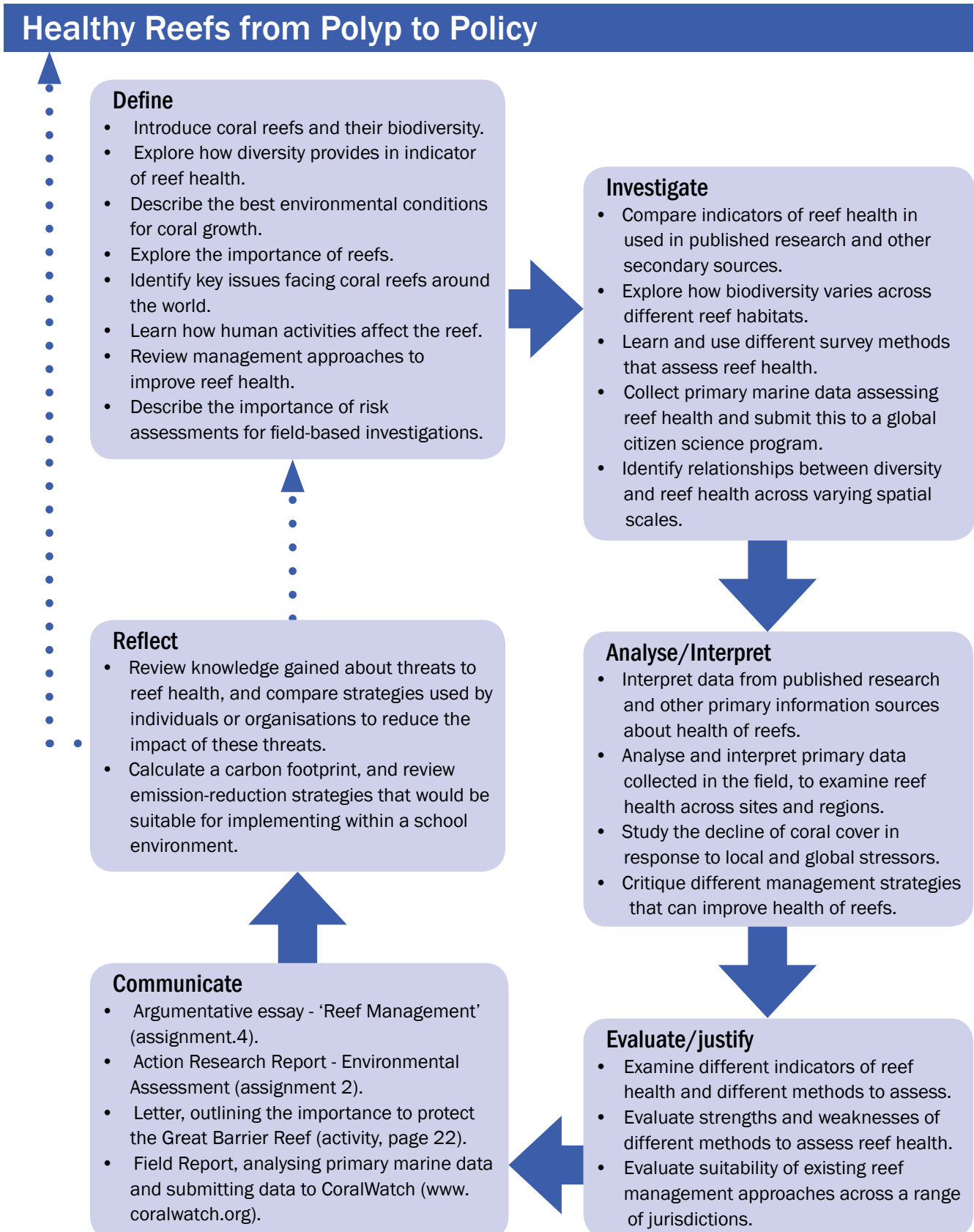
KU - Knowing and Understanding

IA - Investigating and Analysing

EC - Evaluating and Communicating

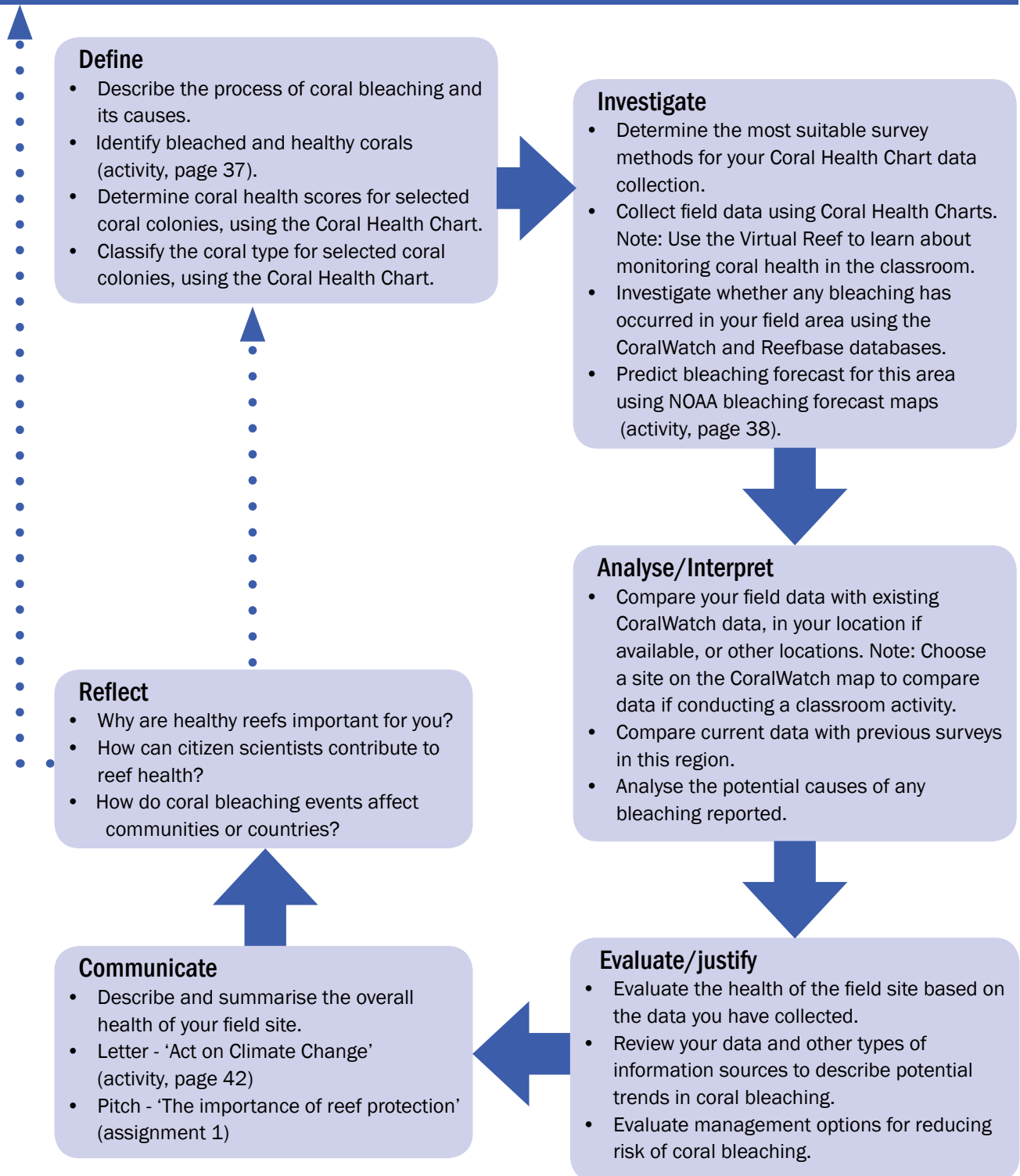
Learning Experiences

Healthy Reefs from Polyp to Policy follows an inquiry-based learning approach bringing all areas of study together in contexts. The inquiry-based learning method applies to the whole Unit plan as well as individual lessons. Each lesson contains background information needed to be able to investigate marine-related issues. The activities offered will challenge students to research and analyse marine information. Students will present their conclusions and recommendations, and review their approach.



The CoralWatch teaching approach fits well within the framework of inquiry-based learning. CoralWatch gets people actively involved in monitoring. It provides students the opportunity to collect real data and contribute to a global monitoring program.

CoralWatch - Acting on Coral Bleaching



Unit Overview*

Lesson		Content	Choice of activities
Week 1	1	Coral Biology	Explaining factors that influence coral distribution Describing coral symbiosis
	2	Marine Biodiversity	Comparing biodiversity between regions Comparing biodiversity between ecosystems Classifying invertebrates
Week 2	3	Reef Habitats <i>from the shore to the ocean</i>	Identifying reefs using photographs Identifying reefs introducing Google Earth
	4	Importance of Reefs <i>why care about reefs</i>	Comparing benefits of reefs between countries Writing a letter explaining the importance of reefs Exploring the cost of a bleaching event
Week 3	5	Health of Reefs Worldwide	Using the IUCN Red List to identify threatened coral species Using the IUCN Red List to compare organisms Using the IUCN Red List to examine threatened species across countries
	6	Local Threats to Reefs	Using ReefBase to identify local threats Reading the GBR Outlook Report to examine human impacts Researching the Crown of thorns sea star
Week 4	7	Global Threats to Reefs <i>Climate change & ocean acidification</i>	Identifying areas at risk of ocean acidification Identifying animals at risk from ocean acidification Lab activity showing acidification
	8	Global Threats to Reefs <i>Climate change & coral bleaching</i>	Recognising bleached corals Explaining change in sea surface temperatures Using predictive tools - NOAA Coral Reef Watch
Week 5	9	Marine Management <i>Managing local threats</i>	Improving water quality on the Great Barrier Reef Researching the effect of marine reserves Developing a code of practice
	10	Marine Management <i>Acting on climate change</i>	Comparing mitigation strategies Writing a letter to a politician Calculating carbon footprint
Week 6	11	Sustainability	Researching indicators of sustainability Designing a project for your school that will benefit reefs
	12	Citizen Science	Comparing citizen science groups Considering research questions
Week 7	15	Marine Research <i>Reef monitoring</i>	Describing ways to measure coral cover Practising transects
	16	CoralWatch <i>Coral Health Chart</i>	Collecting virtual data using Virtual Reef poster Analysing virtual data using Virtual Reef booklet Analysing real data using www.coralwatch.org
Week 8	17	Risk Assessment	Identifying dangerous animals Writing a risk assessment in preparation of Field Plan
	18	Preparation for Fieldtrip	
Week 9	19 20	Fieldtrip	Exploring and identifying invertebrates and fish Estimating coral cover Identifying local threats Identifying coral type Measuring coral health using various survey methods

* This 10-week unit plan contains 8 weeks of lectures. The extra 2 weeks allows time for the fieldtrip and assignments. 20 hours is the minimum time required to complete this unit, please note it can be extended across a full semester.

Key concepts and associated elaborations		
MB	MB 1.4 Organisms are classified according to levels (e.g. kingdom, phylum, class, order, family, genus and species). MB 3.6 Organisms populate areas following changes in habitats and environments (e.g. succession).	
MB	MB1.1 Biodiversity, the variety and abundance of life, is an indication of the health of marine environments. MB1.2 There are a number of different classification systems for marine organisms according to a range of characteristics. MB 3.3 Organisms in food webs interact via relationships and consumer levels as energy cycles through food webs.	
MB OC	MB 3.2 Marine environments consist of zones, classified according to features such as availability of light and substrate composition (e.g. intertidal zone, continental margin, abyssal plane, oceanic trenches and midocean ridges). MB 3.6 Organisms populate areas following changes in habitats and environments (e.g. succession). OC1.4 Marine organisms live in a variety of habitats, which may be classified according to biotic and abiotic factors.	
CS	CS 1.1 For many cultural groups, marine environments are central to meeting nutritional, recreational and ceremonial needs (e.g. Aboriginal and Torres Strait Islander peoples, international communities). CS 1.3 The marine tourism industry is important to Australia's economy and has potential impacts on marine health, water quality and biodiversity (e.g. habitat destruction, pollution, overuse).	
OC CS	OC3.3 Natural global processes and human activity lead to environmental and climatic change (e.g. increased concentrations of carbon dioxide in the atmosphere, increased temperatures). CS 2.4 Increases in population density of coastal areas impact on the health of coastal water and should be carefully managed for sustainable outcomes.	
CS	CS 1.4 Aquaculture and recreational and commercial fishing place demands on marine ecosystems which must be monitored to ensure sustainable futures (e.g. overfishing, ocean ranching). CS 2.5 Land management practices contribute to the health of marine ecosystems (e.g. siltation, algal blooms, agricultural practices). CS 1.7 Coastal engineering, including structures built to regulate water or sediment flow, affect currents and marine ecosystems.	
OC	OC 3.3 Natural global processes and human activity lead to environmental and climatic change (e.g. increased concentrations of carbon dioxide in the atmosphere, increased temperatures). OC3.4 Increases in average global temperatures impact on marine environments by altering thermal regimes and changing physical and chemical parameters of the ocean (e.g. rising sea levels and ocean acidification). OC 3.5 Ocean acidification and increased ocean temperatures have the potential to alter the primary productivity of the ocean.	
OC	OC 3.3 Natural global processes and human activity lead to environmental and climatic change (e.g. increased concentrations of carbon dioxide in the atmosphere, increased temperatures). OC3.4 Increases in average global temperatures impact on marine environments by altering thermal regimes and changing physical and chemical parameters of the ocean (e.g. rising sea levels and ocean acidification).	
CS	CS 1.4 Aquaculture and recreational and commercial fishing place demands on marine ecosystems which must be monitored to ensure sustainable futures. CS 2.1 Sustainable management practices, economic and ecological, are shaped by the environmental philosophies of stakeholders. CS 2.3 Recreational and commercial use of marine environments is managed through zoning, legislation, licensing and enforcement to protect the longevity of marine ecosystems. CS 2.4 Increases in population density of coastal areas impact on the health of coastal water and should be carefully managed for sustainable outcomes CS 2.6 Education of stakeholders is essential to encouraging sustainable management practices.	
OC CS	OC3.6 Reducing the effects of climate change is a complex issue requiring global agreements, national frameworks, industry participation, community decisions and individual action. CS 2.2 The Exclusive Economic Zone is internationally recognised by the United Nations with each nation being responsible for resource management. CS 3.6 Decision making involves the consideration of a range of stakeholders' views and a range of alternative path ways for action.	
CS	CS2 Sustainable management practices are essential for the protection of marine resources. CS 2.7 Consultation through stakeholder groups guides policies relating to sustainable marine practices (e.g. Local Marine Advisory Committees [LMACs], CoralWatch, Australian Marine Environment Protection Association [AUSMEPA]). CS 3.5 Marine scientists work in a variety of fields that contribute to the sustainability of marine environments (e.g. research, education, policies).	
CS OC	CS2.7 Consultation through stakeholder groups guides policies relating to sustainable marine practices. OC3.6 Reducing the effects of climate change is a complex issue requiring global agreements, national frameworks, industry participation, community decisions and individual action.	
CS MS	CS3.5 Marine scientists work in a variety of fields that contribute to the sustainability of marine environments (e.g. research, education, policies). CS3.4 Research into the effects of human activities and resource management practices should be conducted to evaluate long term impacts. CS3.5 Field guides and identification keys use scientific and common names to classify organisms according to distinct and observable features. MS2.4 Snorkelling equipment and practices are used to observe or survey underwater ecosystems, including conducting transect studies. MS3.1 Marine navigation and communication devices (e.g. GPS[global positioning system], radio, mobile phone) and procedures are used for coordination and safety	
CS MS	CS 3.5 Marine scientists work in a variety of fields that contribute to the sustainability of marine environments (e.g. research, education, policies). MS2.4 Snorkelling equipment and practices are used to observe or survey underwater ecosystems, including conducting transect studies. MS3.1 Marine navigation and communication devices (e.g. GPS[global positioning system], radio, mobile phone) and procedures are used for coordination and safety	
MS	MS1.4 Dangerous marine organisms are identified and first aid treatments administered if required. MS2.4 Risk assessments are carried out prior to conducting investigations in the laboratory and the field (e.g. sun protection, chemical MSDS, participant ability).	
MS	MS2.4 Snorkelling equipment and practices are used to observe or survey underwater ecosystems, including conducting transect studies. MS3.1 Marine navigation and communication devices (e.g. GPS [global positioning system], radio, mobile phone) and procedures are used for coordination and safety (e.g. EPIRB).	

Lessons

Coral Biology

Elaboration

MB 1.4 Organisms are classified according to levels (e.g. kingdom, phylum, class, order, family, genus and species).

MB 3.6 Organisms populate areas following changes in habitats and environments (e.g. succession).

Learning objectives

At the end of this session, students will be able to:

- Describe simple biology of corals.
- Identify different growth forms of corals.
- Describe coral growth and calcification.
- Explain how corals obtain their energy.
- Apply this knowledge to identify how energy requirements for corals influences distribution of reefs.

Key learning points

- Corals are animals, related to jellyfish
- Corals build calcium carbonate skeletons that create reef structures
- Corals need energy to build reefs. Corals obtain most of their energy via small symbiotic algae that live inside the coral tissue. These algae generate energy via photosynthesis.
- Because corals require sunlight for energy, they are mainly found in shallow tropical and subtropical oceans.
- Most corals live within a narrow temperature range. Some corals have adapted to different temperatures. Corals in the Red Sea have adapted to higher temperatures, whereas corals in Moreton Bay (Queensland) have adapted to lower temperatures.

Resources

- *Coral Reefs and Climate Change: the Guide for Education and Awareness* - recommended sections:
 - Coral Reefs – Reef-building Corals
 - Coral Reefs – Reef Growth
 - Coral Reefs – Patterns of Distribution
 - Ocean Environment – Energy from the Sun
 - Ocean Environment – Natural Lighting
- AIMS Coral Fact Sheets – Environments: [//coral.aims.gov.au/info/environments.jsp#](http://coral.aims.gov.au/info/environments.jsp#)

Background

Corals - from polyp to reef

Corals are living animals, and are part of the same invertebrate phylum as jellyfish, known as Cnidaria. Reef-building corals are part of the class Anthozoa, and order Scleractinia.

A single animal is called a coral polyp. Polyps can range in size from less than 1mm to more than 15cm. Most corals form colonies, where thousands of polyps share the same physical skeleton. Some corals are solitary and live as a single polyp. Corals use calcium and carbonate molecules from the seawater to construct a skeleton. Tiny algae, called zooxanthellae (or symbiotic algae), live within the coral. Zooxanthellae provide the coral with colour and the energy they need to grow.

Using the sun for energy

Zooxanthellae are located within the inner cells of the coral tissue. Zooxanthellae use energy from sunlight to convert the coral's waste products into energy that the coral needs to grow. This process is called photosynthesis. This is why healthy corals need sunlight and clean water. Most reef-building corals grow most effectively when the ocean temperature is between 18°C and 29°C

Coral growth forms

There are more than 800 different species of hard corals. The skeleton of each species is unique. Corals come in many different shapes and sizes - these are called coral growth forms. Branching corals are fast-growing and provide a home for many different types of reef fish. Large boulder corals grow more slowly and some may be more than 100 years old.

Corals - hard versus soft

Soft corals are also commonly found on reefs. They are related to hard corals, but there are some key differences.

Characteristics - hard corals

- Hard calcium carbonate skeleton
- Symbiotic relationship with zooxanthellae
- Each polyp has 6 tentacles or multiples of 6
- Lots of research
- Rigid structure

Characteristics - soft corals

- No calcium carbonate skeleton – may appear soft or leathery
- Only some have symbiotic zooxanthellae
- Each polyp has 8 tentacles or multiples of 8
- Not much research
- Soft structure that can move



Close-up hard corals.



Close-up soft corals.

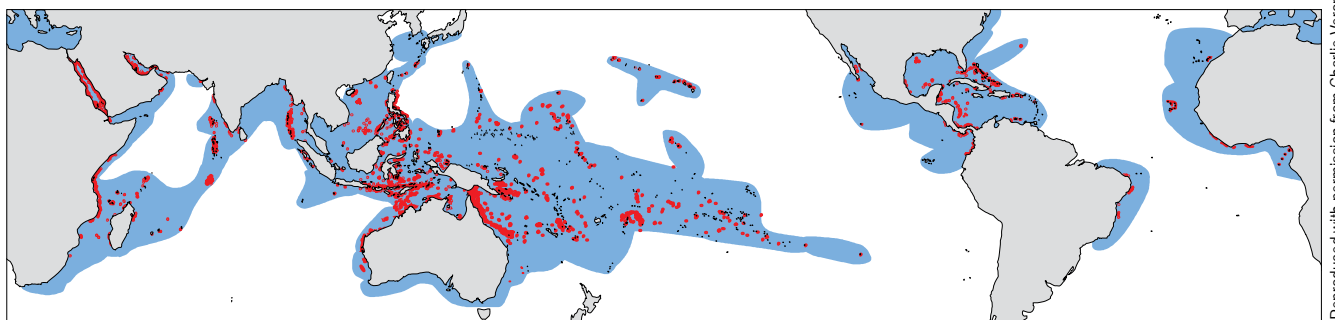


Activities

Classroom activity 1 – Coral distribution

Look at the map showing where corals are found around the world.

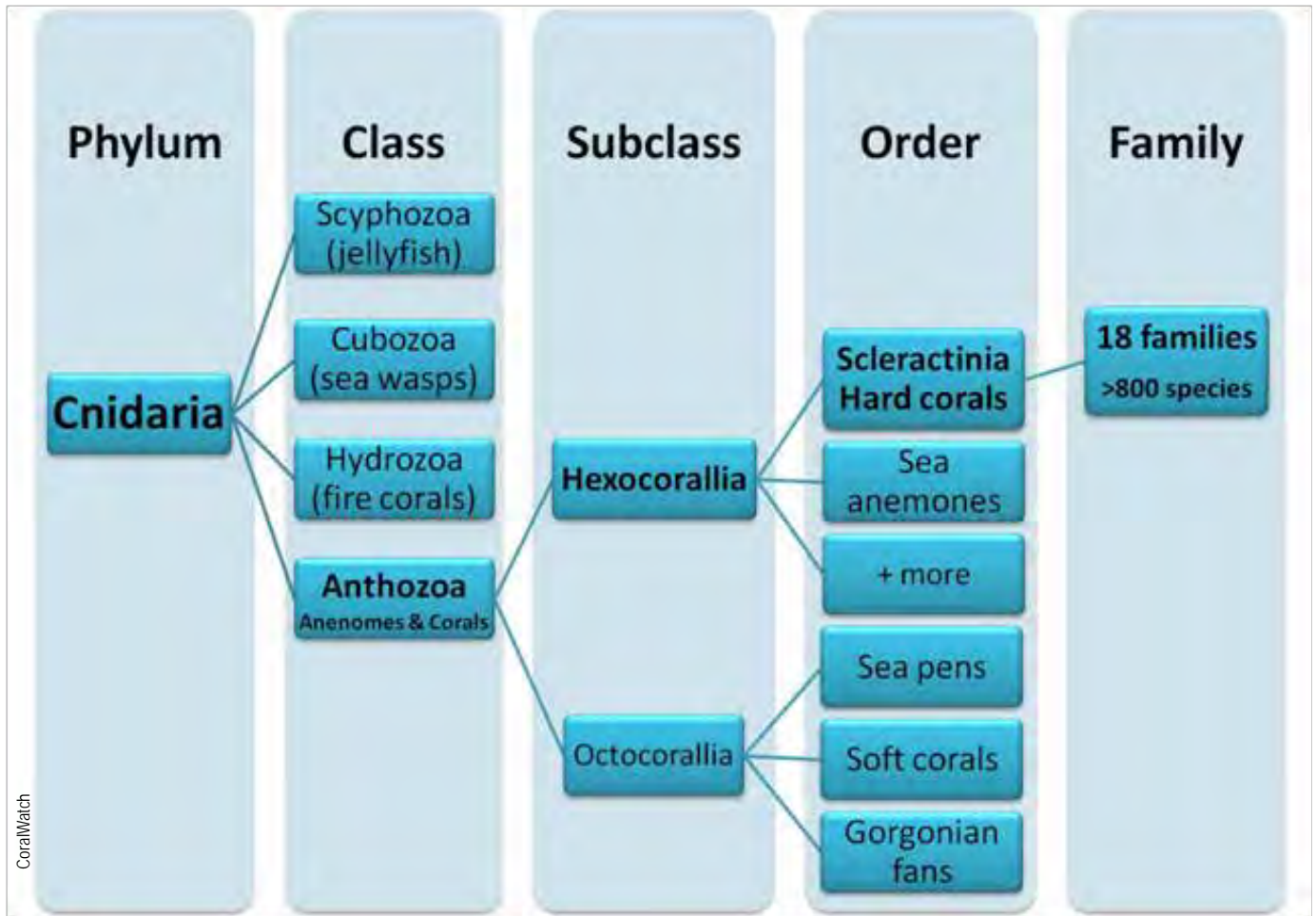
- List 4 factors that influence where reef-building corals grow and describe how they are important for coral growth.
- On the Great Barrier Reef, the diversity of coral species declines as you travel from north to south - explain why.



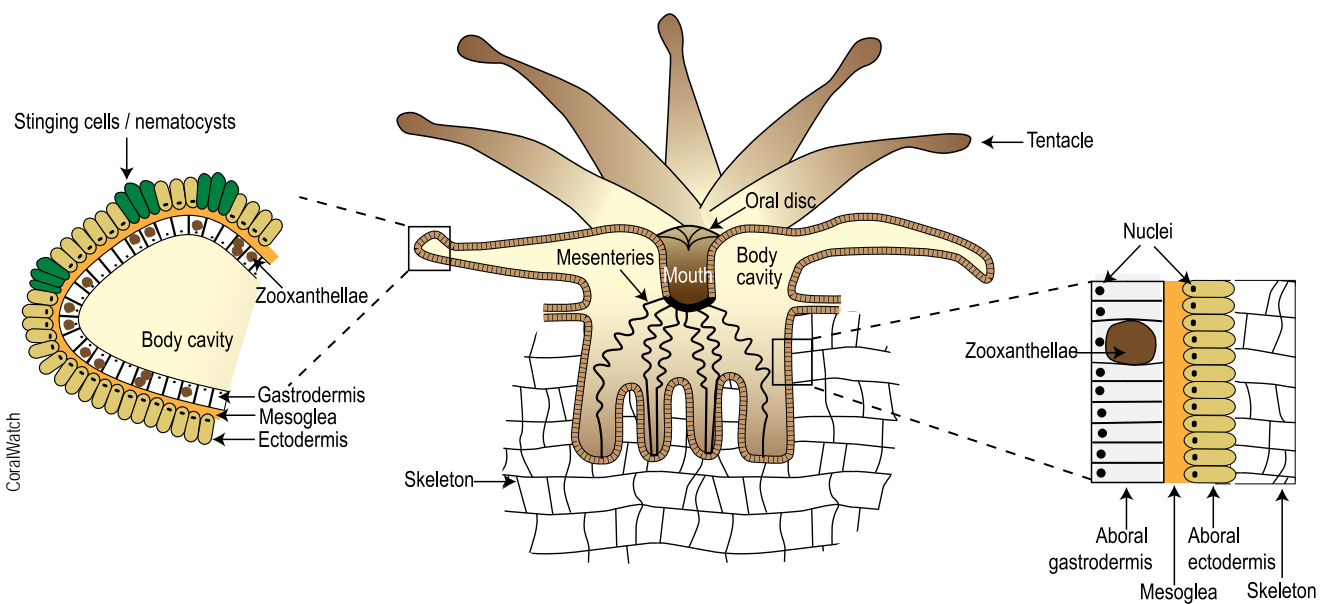
The global distribution of coral reefs (red) and reef-building corals (blue). The Coral Triangle contains the greatest genetic diversity, with numbers of species decreasing as you move away from this region.

Classroom activity 2 - Coral symbiosis

Describe the symbiosis between corals and algae. Describe 3 other examples of symbiosis found on coral reefs.



Classification of reef-building corals.



Anatomy of a coral polyp

In a coral polyp, zooxanthellae are located within the inner cells of the gastrodermis, which are separated from the outer cells of the ectodermis (epidermis) by the mesoglea. Microcrystals of aragonite are excreted where the ectodermis is in contact with the skeleton (aboral ectodermis, or calicoblastic layer), increasing the size of the calcium carbonate skeleton.

Marine Biodiversity

Elaboration

- MB1.1 Biodiversity, the variety and abundance of life, is an indication of the health of marine environments.
- MB1.2 There are a number of different classification systems for marine organisms according to a range of characteristics (e.g. benthic layer, mode of locomotion, coral shape, trophic level, life cycle).
- MB 3.3 Organisms in food webs interact via relationships and consumer levels as energy cycles through food webs (e.g. primary producers, consumers).

Learning objectives

At the end of this session, students will be able to:

- Identify examples from each of the key taxonomic groups found in coral reef environments.
- Identify geographical areas of higher and lower reef diversity.
- Compare how diversity of coral reefs compares with diversity of other marine and terrestrial ecosystems.
- Describe how different types of reef animals contribute to the health of reefs.

Key learning points

- Biodiversity is the variety of living organisms in a particular environment. The greater the number of different types of organisms present, the higher the biodiversity. Areas of very high biodiversity are called biodiversity hotspots.
- Healthy reefs are home to hundreds or thousands of species of corals, invertebrates, fish and even reptiles.
- The key invertebrate phyla found in reefs include crustaceans, molluscs, echinoderms and marine worms.
- Corals, jellyfish and anemones are part of the phylum Cnidaria.

Resources

- *Coral Reefs and Climate Change: the Guide for Education and Awareness* - recommended sections:
 - Coral Reefs - Patterns of Distribution
 - Coral Reefs - A Crowd of Invertebrates
 - Coral Reefs - Hungry Fish
 - Coral Reefs - Connectivity
 - Coral Reefs - Foodweb
 - Coral Reefs - Reef-building Corals
- *Coral Reefs and Climate Change* video series - recommended video:
 - Coral Reefs - Coral Reefs Introduction (5min)
- AIMS Coral Fact Sheets - *Patterns of Diversity*: [//coral.aims.gov.au/info/diversity-patterns.jsp](http://coral.aims.gov.au/info/diversity-patterns.jsp)
- AIMS Coral Fact Sheets - *Hotspots of biodiversity and endemism*: [//coral.aims.gov.au/info/diversity-hotspots.jsp](http://coral.aims.gov.au/info/diversity-hotspots.jsp)

Background

Millions of animal species make up the biodiversity that supports coral reefs. Reef invertebrates (animals without backbones) include corals, sponges, sea squirts, sea stars, shrimp, crabs, anemones, cuttlefish, clams, worms, jellyfish, sea cucumbers, and cone snails. Invertebrates perform a range of important functions on the reef - they move nutrients through the reef ecosystem and help keep many reef animals clean and free from parasites.

Reef vertebrates include thousands of species of colourful reef fish, larger ocean fish, rays, sharks, and reptiles such as sea snakes and sea turtles.

So many organisms live on coral reefs because reefs provide shelter and food. To escape predators, animals can hide within cracks and crevices in the reef created by corals. Nearly every living thing on a reef is food for another organism, and together they make up a complex food web. Scientists are still discovering new species on coral reefs, which means that nobody knows exactly how many creatures live on coral reefs!

The Coral Triangle - centre of biodiversity

The Coral Triangle is the geographical region incorporating the marine waters and reefs around Indonesia, Malaysia, Papua New Guinea, Philippines, Solomon Islands and Timor-Leste. The Coral Triangle is home to the world's richest diversity of corals and marine life, with more than 550 species of corals found in this region.

The Great Barrier Reef

As you travel away from the Coral Triangle, the diversity of corals becomes lower. The Great Barrier Reef is home to about 400 species of reef-building corals.

Moreton Bay – South East Queensland

Moreton Bay in South East Queensland is considered a site of international importance (under the Ramsar Convention) and is home to more than 120 species of corals. That is a larger number of species than found in the Caribbean! On land, South East Queensland and the Wet Tropics are the biodiversity hotspots in Queensland.

Activities

Classroom activity 1 - Biodiversity within regions

Research the internet, creating lists highlighting biodiversity in different regions.

You can work in groups and research the following areas:

- Moreton Bay
- Great Barrier Reef
- Caribbean

Use the lists below as a start, make them consistent and plot the final results - using Excel - in a graph. Compare the end results with other students.



Map of the Coral Triangle

Department of Environment, Water, Heritage and Arts, 2009

Diversity in the Coral Triangle

- Covers an area of 6.8 million square kilometres
- Includes 18,500 islands
- Contains four of the world's 25 'biodiversity hotspots'
- Contains more than 100,000 square kilometres of coral reefs
- Contains 605 species of hard corals, 76% of known coral species
- 45 mangrove species
- 13 seagrass species
- 2228 species of reef fish
- Highest diversity of reef invertebrates in the world

Diversity of the Great Barrier Reef

- 1500+ species of fish
- 400 species of hard coral
- One third of the world's soft corals
- 5000-8000 species of molluscs
- 400-500 species of marine algae
- 600 species of echinoderms
- 17 species of sea snakes
- 22 species of seabirds and 32 species of shorebirds
- 13,000 dugong
- 6 of the 7 species of sea turtle, all listed as threatened
- 30 species of cetaceans (whales and dolphins)

Classroom activity 2 – Biodiversity within ecosystems

Research the internet and compare the biodiversity between coral reefs to other environments.

In a group of three choose one of the following biomes:

- Tundra
- Polar region
- Rainforest
- Desert
- Temperate forest
- Grass and rangelands
- Freshwater ecosystems

Classroom activity 3 - Classification of invertebrates

For each picture, identify the type of invertebrate, write down its common or scientific name.



Chris Roelfsema - all photos

Reef Habitats from the shore to the ocean

Elaboration

- MB 3.2 Marine environments consist of zones, classified according to features such as availability of light and substrate composition (e.g. intertidal zone, continental margin, abyssal plane, oceanic trenches and mid-ocean ridges).
- MB 3.6 Organisms populate areas following changes in habitats and environments (e.g. succession).
- OC1.4 Marine organisms live in a variety of habitats, which may be classified according to biotic and abiotic factors (e.g. rocky shore, pelagic zone, bioregion).

Learning objectives

At the end of this session, students will be able to:

- Identify different habitats within a reef.
- Identify different types of reefs.
- Identify how environmental factors such as sunlight and wave action affect corals and marine life.
- Describe how coral growth forms change across different zones of the reef.
- Describe how marine diversity changes across different zones of the reef.

Key learning points

- There are many different habitat zones on reefs – the reef flat, reef crest and reef slope. Each will have a different pattern of diversity, with differences in coral cover, and types of coral species or growth forms.
- Coral growth will vary with their exposure to wave action – corals growing in areas of high wave action will be thicker and shorter, whereas corals growing in water with minimal wave disturbance will take on more delicate growth forms.
- Corals in very shallow water are exposed to high levels of sunlight. Corals contain sunscreen-like molecules to protect them from the sun. Corals in shallow areas tend to be paler in colour than similar corals found in deeper areas.
- Coral reefs are influenced by proximity to land. Coral reefs in areas close to shore usually have different levels of coral cover and types of coral species compared to offshore reefs.

Resources

- *Coral Reefs and Climate Change: the Guide for Education and Awareness* - recommended sections:
 - Ocean Environment – Seafloor Structure
 - Coral Reefs – Zones across the Reef
 - Coral Reefs – Reef-building corals

Background

Different types of reefs

Reefs occur in a range of geological settings. This creates different types of reefs:

- Coral cays are small islands composed entirely of sand. They have low elevation and are formed at the surface of coral reefs.
- Barrier reefs are separated from the shore by a lagoon or deep sea water zone.
- Atolls are a series of coral islands that form a circular shape surrounding a central lagoon.
- Fringing reefs are found close to the shore, separated only by a shallow lagoon.

Reef habitats from beach to ocean

As you walk or snorkel across a reef, you will come across different habitats. Each habitat contains plants and animals that have adapted to the particular conditions. Closest to the shore is the reef flat and lagoon. The lagoon and reef flat are usually shallow, with high levels of sunlight and high temperatures. Here, corals will be protected from waves, but they have to tolerate high temperatures. Reef flats include sandy areas and small patches of coral. Common reef invertebrates include sea stars and sea cucumbers.

Beyond the lagoon, there is a ridge where corals may be exposed at low tide - this is called the reef crest. The reef crest is exposed to strong waves and currents. Here, corals tend to have 'short and stubby' (digitate) or encrusting growth forms to protect themselves from waves. Corals on the reef crest produce mucus to protect them from sunlight

exposure at low tide. Coralline algae are common on reef crests, where they cement reef rubble together. Many invertebrates are also found in this area.

Moving out, the reef then descends down what is called the reef slope. On the reef slope, large and diverse coral colonies can be seen, along with a large range of fish species, especially pelagic (ocean) species.

Great Barrier Reef

The Great Barrier Reef stretches down the coast of Queensland. There is a latitudinal gradient in diversity of marine organisms – those which prefer higher temperatures are more likely to be found in the northern areas of the Great Barrier Reef, while organisms found in the southern areas are more likely to tolerate cooler sea temperatures. The Great Barrier Reef also varies longitudinally, across the continental shelf. Diversity of fish or coral communities found in the inner-shelf are different from those found in the outer shelf areas. This diversity of habitats contributes to the ecological importance of the Great Barrier Reef.

Moreton Bay (South East Queensland)

Close to the mainland and the mouth of the Brisbane river, the water has lots of soil and sediment run-off. Much of this comes from inland areas via our catchment and river systems. Too much soil in the water can limit the sunlight that corals need for energy. Because of this, only some species of coral can live in these inshore areas. Corals that tolerate murky water tend to be small, round corals. You can see these corals off Wellington Point and underneath Raby Bay marina.

As you travel away from the mainland, you can see changes in water quality and types of corals. As the water becomes clearer and cleaner, you will see more branching corals. You can find many branching corals off North Stradbroke Island (Myora, Shag Rock) and Moreton Island (Flinders Reef).



Activities

Classroom activity 1 - Types of reefs

Identify the type of reefs for the images below. Use the internet to find some additional information.



Lady Elliot Island



Lizard Island

Classroom activity 2 - Google Earth

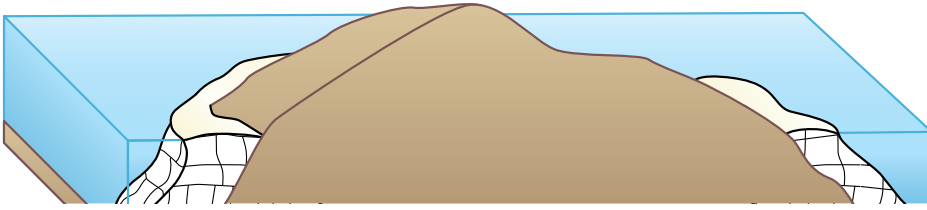
Use Google Earth to view the satellite image of various reefs. Identify whether these are fringing, barrier, atoll reef or coral cay. Zoom in and grab a screenshot. Print this and label your picture with the reef types and single reef zones.

Questions

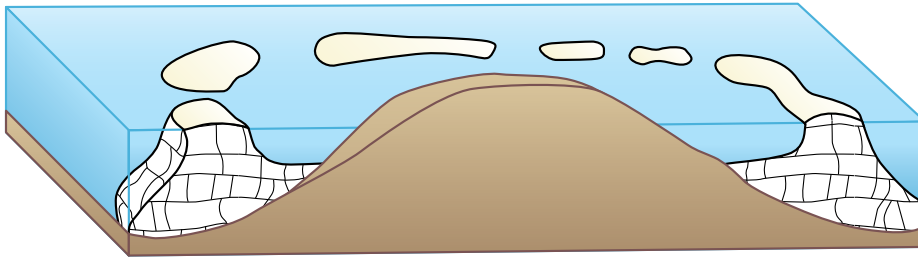
1. Are there many cities or villages close by that could impact this reef via pollution runoff?
2. What type of reefs will be most influenced by activities on land and why?
3. What type of reefs do you find in Moreton Bay area?



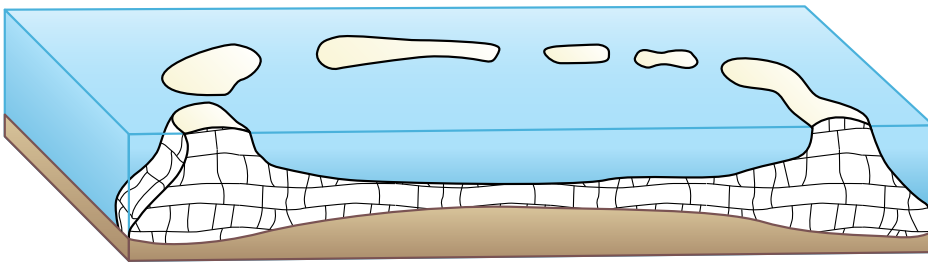
Different types of reefs



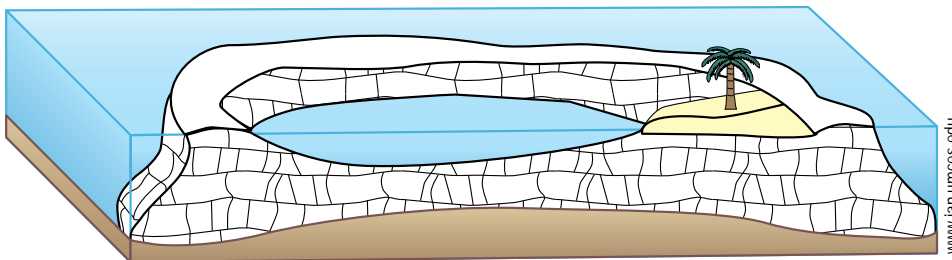
Fringing reef



Barrier reef

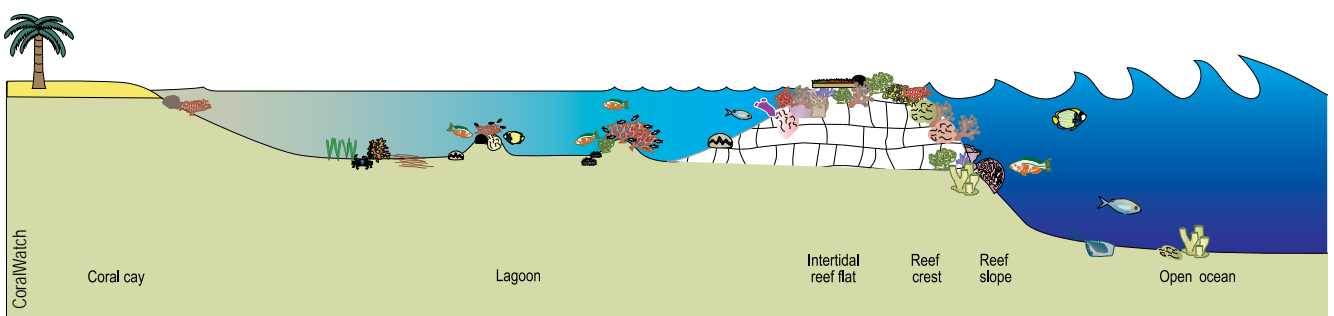


Atoll



Platform reef and Coral cay

Reef habitats from beach to ocean



Importance of Reefs - Why care about reefs?

Elaboration

CS 1.1 For many cultural groups, marine environments are central to meeting nutritional, recreational and ceremonial needs (e.g. Aboriginal and Torres Strait Islander peoples, international communities).

CS 1.3 The marine tourism industry is important to Australia's economy and has potential impacts on marine health, water quality and biodiversity (e.g. habitat destruction, pollution, overuse).

Learning objectives

At the end of this session, students will be able to:

- Describe the concept of ecosystem services.
- Describe the different benefits that reefs provide society.
- Apply this knowledge to explain how different societies may experience different benefits from coral reefs.

Key learning points

- Different ecosystems provide many types of benefits for human societies – these benefits are called ecosystem services.
- Reefs provide many ecosystem services: income from tourism, livelihoods and income from commercial fishing, food from recreational fishing, pharmaceutical or other commercial products, coastal protection from cyclones and storm surges, and the benefits of connecting with natural beauty.
- Healthy reefs make a significant contribution to the economies of Australia, and throughout the Coral Triangle.

Resources

- *Coral Reefs and Climate Change: the Guide for Education and Awareness* - recommended sections:
Coral Reefs - The Importance of Reefs
- *Coral Reefs and Climate Change* video series - recommended video:
Coral Reefs - Importance of reefs (5min)
- Report *Valuing the Effects of Great Barrier Reef Bleaching* download from www.barrierreef.org/GBRF/media/Our-Projects/Oxford/GBRF_OxfordReport_Final_WEB.pdf
- *Economic Values of Coral Reefs, Mangroves, and Seagrasses: A Global Compilation*. Conservation International. 2008. Center for Applied Biodiversity Science, Conservation International, Arlington, VA, USA: www.conservation.org/documents/CI_Marine_CI_Economic_Values_Coral_Reefs_Mangroves_Seagrasses_compilation_2008.pdf

Background

Ecosystem services

Nature provides a range of benefits for people and society. For example, bees pollinate crops that we need for food. Rivers provide clean water. The benefits that nature provides us are called ecosystem services.

Healthy reefs provide a range of ecosystem services. By creating a home of biodiversity, reefs support fish life and so create a source of food for many of the world's population. Healthy reefs support employment, income, and livelihoods, via jobs in tourism, local fishing, and commercial fishing. The physical shape of the reef creates a barrier that protects coastal communities from cyclones and storm surges. Many organisms found in reefs contain toxins or chemicals that can be used to develop new medicines and pharmaceutical products. Coral reefs help to remove carbon dioxide from the atmosphere, and can help reduce the effects of global warming.

Many individuals and communities also enjoy the beauty of reefs - this type of benefit is difficult to place a dollar value on. But research shows that nature may be good for our health and well-being.

Value of reefs

Considering all of the ecosystem services that reefs provide, scientists and economists work together to try and estimate how much reefs are worth. One study estimated that the world's coral reefs provide a net benefit of \$29.8 billion (US dollars) every year. This was related to tourism and recreation (\$9.6 billion), coastal protection (\$9.0 billion), fisheries (\$5.7 billion), and biodiversity (\$5.5 billion).

The Great Barrier Reef has been estimated to contribute \$3.7 billion per year to the Australian economy.

Studies of reefs in the Caribbean show that reefs provide annual net benefits of up to \$4.6 billion per year. The largest share of this was from dive tourism (\$2.1 billion), followed by coastal protection and fisheries.

Reefs in Indonesia contribute an estimated \$1.6 billion each year to the Indonesian economy, related to fisheries, coastal protection, tourism and aesthetic value.

Activities

Classroom activity 1 - Reef benefits





List at least 3 benefits that healthy reefs could bring to you and your family. List 3 benefits that healthy reefs could bring to a student and their family in Indonesia. What are the differences between Australian and Indonesian reefs and communities that could influence this?

Classroom activity 2 - Reef importance

Write a letter to the editor, outlining why it is important to protect the Great Barrier Reef.

Classroom activity 3 - Cost of a bleaching event

Read the report from the Great Barrier Reef Foundation ‘Valuing the Effects of Great Barrier Reef Bleaching’, from August 2009. Explain the difference between ‘direct use value’, ‘indirect use value’, ‘non-use value - national’, and ‘non-use value-international’, giving examples for each. (Tip - these are described in sections pp23-55).

<p>Natural heritage</p>  <p><i>Thousands of species make up the diversity of life on coral reefs.</i></p> <p><small>Craig Reid</small></p>	<p>Shoreline protection</p>  <p><i>Reefs act as natural breakwaters that protect people and homes from storm surges and waves.</i></p> <p><small>Chris Roelfsema</small></p>	<p>Fishing industry</p>  <p><i>Commercial fishing provides food, jobs and income as part of a global seafood market.</i></p> <p><small>Ove Hoegh Guldberg</small></p>	<p>Local fishing</p>  <p><i>Hundreds of millions of people rely on reef fish as their main source of protein.</i></p> <p><small>Chris Roelfsema</small></p>
<p>Tourism industry</p>  <p><i>More than 1 million people visit the Great Barrier Reef each year, supporting a large industry.</i></p> <p><small>Craig Reid</small></p>	<p>Cultural ties</p>  <p><i>Balinese people providing an offering to the sea.</i></p> <p><small>Chris Roelfsema</small></p>	<p>Pharmaceutical products</p>  <p><i>Toxins from the cone snail are used in new medicines to treat pain.</i></p> <p><small>Dave Logam</small></p>	<p>Product source</p>  <p><i>Bird poo (guano), deposited on islands over thousands of years, is a source of fertiliser.</i></p> <p><small>Dave Logam</small></p>

Health of Reefs Worldwide

Elaboration

- OC3.3 Natural global processes and human activity lead to environmental and climatic change (e.g. increased concentrations of carbon dioxide in the atmosphere, increased temperatures).
- CS 2.4 Increases in population density of coastal areas impact on the health of coastal water and should be carefully managed for sustainable outcomes (e.g. loss of mangroves, saltmarshes and seagrasses).

Learning objectives

At the end of this session, students will be able to:

- Describe the IUCN categories for threatened plants and animals.
- Describe different indicators of reef health.
- Identify current conservation status of corals and reefs worldwide.
- Compare conservation status of reefs in different regions.
- Compare conservation status of reefs with other ecosystems.

Key learning points

- The IUCN Red List of Threatened Species provides a way of identifying species at risk. One third of reef-building coral species are threatened with extinction.
- Another common way to measure the health of an individual reef or group of reefs is using 'coral cover' – this is the percentage of reef area that is covered by live coral. Around the world, about 25% of reef area has been lost. In the last 27 years, almost half of the coral cover of the Great Barrier Reef has been lost.

Resources

- *Coral Reefs and Climate Change: the Guide for Education and Awareness* - recommended sections:
 - Coral Reefs – State of the Reefs
 - Coral Reefs – Shifted Baseline
 - Climate Change – Tracking Change
 - Power of Us – Reefs, Our Biggest Concern
- *Coral Reefs and Climate Change* video series - recommended videos:
 - Coral Reefs - Shifted Baseline (5 min.)
 - Coral Reefs - Altered ecosystems (5 min.)
- Report: Reefs at Risk Revisited, 2011 Burke L, et al. World Resources Institute, Washington DC
www.wri.org/publication/reefs-at-risk-revisited
- Report: Great Barrier Reef Outlook Report 2009
www.gbrmpa.gov.au/__data/assets/pdf_file/0018/3843/OutlookReport_Full.pdf
- IUCN red list - www.iucnredlist.org/

Background

The IUCN Red List of Threatened Species

The International Union for the Conservation of Nature has developed the IUCN Red List of Threatened Species. This identifies species at risk of extinction and allows scientists and policy-makers to identify priority areas and monitor changes over time. The classification uses the following categories:

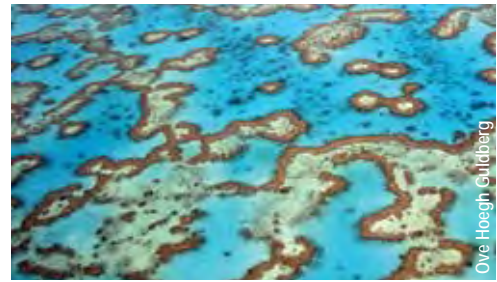
- Extinct: no doubt that the last individual organism has died.
- Extinct in the wild: the only known individual organisms are in captivity.
- Critically Endangered: extremely high risk of extinction in the wild.
- Endangered: very high risk of extinction in the wild.
- Vulnerable: high risk of extinction in the wild.
- Least Concern: evaluation indicates that it does not qualify for the above categories.
- Data deficient: inadequate information to assess risk.

The IUCN website (www.iucnredlist.org/) allows you to search for different species or different habitats. Find out more about how the IUCN measures each of these categories: [//jr.iucnredlist.org/documents/redlist_cats_crit_en.pdf](http://jr.iucnredlist.org/documents/redlist_cats_crit_en.pdf)



One third of corals are threatened with extinction

Assessment of 845 species of reef-building corals indicates that one third (32.8%) are at risk of extinction. The proportion of corals threatened with extinction has increased. (Carpenter et al, Science 2008;321:560-3)



Coral Cover

One important way to assess the health of coral reefs is to measure how much of an area is actually covered by hard corals. This measurement is called 'coral cover'. The amount of coral cover is influenced by rates of reproduction, growth and mortality. When corals reproduce less, grow more slowly or die more frequently, coral cover declines. Scientists around the world are identifying how coral cover is changing in response to local and global stressors.

In the Great Barrier Reef, long-term monitoring shows that average coral cover over more than 200 sites has declined from 28% to 14% over the last 27 years (almost 50% loss). In the Caribbean, coral cover has declined from approximately 50% to 10%. This is happening to many reefs around the world. Overall, it has been estimated that more than one quarter of all reef areas in the world have been lost.

Other indicators of reef health include the diversity of coral species, or the numbers of important organisms such as sharks or certain invertebrates. Many of these measures also indicate that reef health is declining.

Activities

Classroom activity 1 - Threatened corals

Look at the website for the IUCN Red List (www.iucnredlist.org). List 5 species of corals that are threatened (either vulnerable, endangered, or critically endangered), and 5 that are not (Least Concern). For those that are threatened, list the key threats for each species.



Tip: you can search for corals by typing 'coral' into the search window on the Red List website. This will list corals and other reef creatures. To limit your search to reef building corals, try typing 'scleractinia' into the search window (Scleractinia is the name of the Order that encompasses reef-building corals). Click on each species name to find out more information.

Classroom activity 2 - Threatened organisms

Look at the table that summarises the Red List categories for all animal classes and orders.
www.iucnredlist.org/documents/summarystatistics/2013_1_RL_Stats_Table_4a.pdf

1. How many species of reef building corals are listed, and how many are listed as threatened (vulnerable, endangered critically endangered)? (Tip: look for Class Anthozoa, Order Scleractinia). What percentage of corals are threatened?
2. Compare this with another group of organisms, e.g. try looking at Class Holothuroidea (sea cucumbers), one of the orders within Class Actinopterygii (bony fishes), or Class Amphibia (frogs).

Classroom activity 3 - Threatened species worldwide

Look at the IUCN table that summarises the total endemic and threatened endemic species in each country
www.iucnredlist.org/documents/summarystatistics/2013_1_RL_Stats_Table_6a.pdf

1. What is the total number of animal species in Australia? How many (and what proportion) are threatened (vulnerable, endangered or critically endangered)?
2. How many animal species are found in Indonesia? How many (and what proportion) are threatened (vulnerable, endangered or critically endangered)?
3. Choose another two countries in different parts of the world, and identify the number of animal species and the proportion of these that are threatened.

Local Threats to Reefs

Elaboration

- CS 1.4 Aquaculture and recreational and commercial fishing place demands on marine ecosystems which must be monitored to ensure sustainable futures (e.g. overfishing, ocean ranching).
- CS 2.5 Land management practices contribute to the health of marine ecosystems (e.g. siltation, algal blooms, agricultural practices).
- CS 1.7 Coastal engineering, including structures built to regulate water or sediment flow, affect currents and marine ecosystems (e.g. rock walls, canal estates).

Learning objectives

At the end of this session, students will be able to:

- Describe what ecosystem functions are provided by herbivorous fish.
- Explain how overfishing impacts reefs.
- Describe how poor water quality impacts on reefs.
- Describe how management of inland and coastal areas can impact water quality and reef health.

Key learning points

- Corals compete with macroalgae for space and light. Too much macroalgae can limit the growth of corals. Herbivorous fish provide an important function for reefs – eating macroalgae, creating the best conditions for corals to reproduce and grow.
- Overfishing, especially overfishing of herbivores such as parrotfish, can lead to an overgrowth of macroalgae. This can then lead to a decline in coral growth.
- Corals need clean, clear water to grow. Activities that disturb coastal or riparian areas can lead to soil, sediment or pollutants such as fertilizers to flow into reef ecosystems. Other activities that worsen turbidity, such as dredging, also damages health of coral ecosystems.

Resources

- *Coral Reefs and Climate Change: the Guide for Education and Awareness* - recommended sections:
Coral Reefs – State of the Reefs
- *Coral Reefs and Climate Change* video series - recommended video:
Coral Reefs - State of the Reefs (5min)
- Report: *Reefs at Risk Revisited*, 2011 Burke L, et al. World Resources Institute, Washington DC
www.wri.org/publication/reefs-at-risk-revisited
- Report: Great Barrier Reef Outlook Report 2009
www.gbrmpa.gov.au/__data/assets/pdf_file/0018/3843/OutlookReport_Full.pdf

Background

Healthy reefs need the right balance of sunlight, temperature, and water quality. Changing these conditions can damage coral health. If severe, entire reefs can be destroyed.

Reefs are affected by many human activities and natural events. 'Local threats' arise from activities occurring within a specific region, such as overfishing. Reefs affected are usually close to where the 'threat' is occurring. Local threats are able to be managed by local and regional actions. Local management is influenced by policies of specific regions or countries. 'Global threats', such as coral bleaching related to thermal stress and ocean acidification, are directly linked to increasing atmospheric carbon dioxide concentrations.

Destructive fishing practices and overfishing

Overfishing and use of destructive fishing methods is very damaging to reefs. Blast fishing and poison fishing kill more than just the targeted fish – these techniques kill other species including coral. In some regions, blast fishing has destroyed 80% of corals. Overfishing damages more than 55% of the world's reefs.

Sediment and pollution

Keeping reefs healthy does not just involve the ocean. What we do on the land is also important. Corals need clean, nutrient-free water to be healthy. High levels of coastal development can increase the levels of sediments and

nutrients washing from the land into the ocean. Development of inland regions also influences corals. Fertilisers from farms can enter rivers and flow to the ocean. Deforestation can increase sediment washing into the river and then into the ocean. Sediments cover corals - blocking their access to light. Nutrients such as fertilisers promote the growth of algae which compete with corals.

Coral Triangle

In the Coral Triangle, overfishing and destructive fishing are considered the most common and serious local threat to reefs.

The Great Barrier Reef

A major threat to the health of the Great Barrier Reef is poor water quality, especially in the inshore areas of the reef. A range of human activities contribute to poor water quality - land clearing, grazing, coastal development and dredging can increase sediment flowing onto the reef, worsening turbidity. Fertilizers used in agriculture can also run-off into reef areas. Research suggests that poor water quality also contributes to the impact of other threats, such as the crown of thorns sea star.

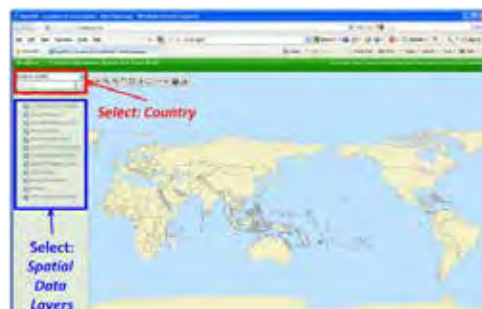
Corals in Moreton Bay - South East Queensland

Moreton Bay is also influenced by changing water quality. Branching corals used to be more common in Moreton Bay. Research shows that inshore branching corals began to disappear in the mid-1800s. At this time, European settlement changed land use in the Moreton Bay catchment. Land-clearing and farming led to increased soil and pollution run-off into the bay. This changed water quality, making conditions less suitable for branching corals. Now, only some types of corals can tolerate living in these inshore areas.

Activities

Classroom activity 1 – Reefbase

1. Go to the website: reefgis.reefbase.org
2. Click on “Reefs at Risk” on the left side bar.
3. Make sure that the ‘Global 2011’ section is selected. This uses the most recent data, from 2011
4. Click on the link to “Overfishing and Destructive Fishing” on the left hand side bar, and click ‘Refresh Map’ at the bottom of the left side bar. Which countries or regions are most at risk of overfishing? Zoom into some areas if you can’t identify the countries. Which countries are least affected by overfishing? What is the difference between these countries?
5. Now, click on ‘Watershed-based pollution on the sidebar, and click ‘Refresh Map’. (Tip: watershed is another term for catchment, that is used in the USA. This refers to pollution which enters the reef via flow from rivers and water catchments). In which countries are reefs most threatened by catchment pollution? Zoom in on the Great Barrier Reef - how are the areas near the shore (inshore reefs) different to offshore reefs?



Classroom activity 2 - Human impact

Read the Great Barrier Reef Outlook Report. There are many sections that discuss water quality and the health of the Great Barrier Reef (e.g. Section 9 - Long Term Outlook). List 5 human activities that can affect water quality on the reef. Describe 5 ways that poor water quality can affect the health of reef ecosystems.

Classroom activity 3 - Crown of thorns sea star

The crown of thorns sea star can cause high rates of coral mortality. Use the internet to research this creature, and answer the following questions:

1. What is the scientific name of this animal, and what Phyla does it belong to? What other marine organisms are in this phyla?
2. How does the crown of thorns sea star eat coral?
3. How much coral can a crown of thorns sea star eat in one day?
4. Why is it important not to touch these creatures?
5. What factors influence outbreaks of crown of thorns sea stars?
6. How do scientists and reef managers remove crown of thorns sea stars from the reef?



Global threats to reefs

Climate Change & Ocean Acidification

Elaboration

- OC 3.3 Natural global processes and human activity lead to environmental and climatic change (e.g. increased concentrations of carbon dioxide in the atmosphere, increased temperatures).
- OC3.4 Increases in average global temperatures impact on marine environments by altering thermal regimes and changing physical and chemical parameters of the ocean (e.g. rising sea levels and ocean acidification).
- OC 3.5 Ocean acidification and increased ocean temperatures have the potential to alter the primary productivity of the ocean.

Learning objectives

At the end of this session, students will be able to:

- Describe how human activities lead to greenhouse gas emissions.
- Identify important greenhouse gases.
- Identify how carbon dioxide is absorbed by oceans and the impact on ocean chemistry.
- Explain how changing ocean chemistry influences coral calcification.
- Analyse how other marine life will be affected by ocean acidification.

Key learning points

- CO₂ is a greenhouse gas that traps heat in the Earth's atmosphere.
- Human activities have increased the amount of CO₂ in the atmosphere. This leads to increased temperatures ('global warming') and changes in patterns of rainfall and weather events ('climate change').
- Approximately one third of CO₂ is absorbed by the oceans. As atmospheric CO₂ rises, so does the amount absorbed by oceans. This changes ocean chemistry and is called ocean acidification.
- Ocean acidification can reduce the rate that corals and shellfish produce calcium carbonate skeletons.

Resources

- *Coral Reefs and Climate Change: the Guide for Education and Awareness* - recommended sections:
 - Ocean environment – A Basis Ocean
 - Ocean environment – Ocean Acidification
 - Coral Reefs – State of the Reefs
 - Coral Reefs - Food Web
 - Climate Change - The Carbon Cycle
- *Coral Reefs and Climate Change* video series - recommended videos:
 - Ocean Environment - Ocean Acidification (5min)
 - Climate Change - Climate Change Introduction (5min)

Background

Greenhouse gases

A layer of gases surrounds the Earth, forming our atmosphere. Some of these gases are 'greenhouse gases' - they trap heat energy, regulating the Earth's temperature. This is 'the greenhouse effect' and is essential for life on earth.

Carbon dioxide (CO₂) is a greenhouse gas. Small amounts of CO₂ occur naturally. However, human activities such as burning fossil fuels (oil and coal) have led to a dramatic increase in the amount of CO₂ released into the atmosphere. In 200 years, atmospheric CO₂ has increased from 280 parts per million to more than 380 parts per million. This is higher than any other time humans have lived on this planet – and it is increasing.

Increased greenhouse gases results in higher temperatures. In the last 100 years, temperatures have increased by about 0.7°C. This is called Global Warming.

More CO₂ and higher temperatures will have a large effect on many aspects of our climate – earlier onset of seasons, reduced snow and glacial cover, sea level rise, and more intense cyclones or weather events. This is called Climate

Change. Climate change will have a significant effect on all ecosystems, especially coral reefs. Climate change has a significant effect on our environment.

Carbon sinks

When CO₂ is emitted into the atmosphere, some remains in the atmosphere, and some is absorbed into the soil, plants and oceans. We call these 'carbon sinks'. CO₂ easily dissolves in water, and the oceans are one of the most important carbon sinks, absorbing approximately one third of atmospheric CO₂.

The amount of CO₂ absorbed by the ocean is influenced by the amount of CO₂ in the atmosphere. This is described by Henry's Law, which states that, at a constant temperature, the amount of gas dissolved in a liquid is directly proportional to the partial pressure of that gas. So, as atmospheric concentrations of CO₂ rise, the partial pressure of CO₂ in the atmosphere also rises. This directly increases the amount of CO₂ absorbed by the oceans. This process is also dependent on temperature. Gases such as CO₂ become more soluble in water at lower temperatures.

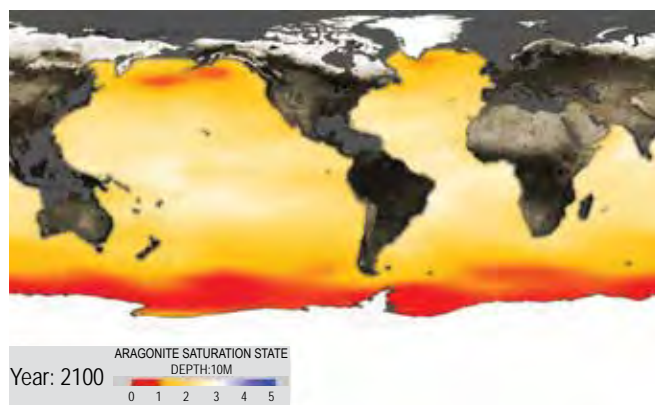
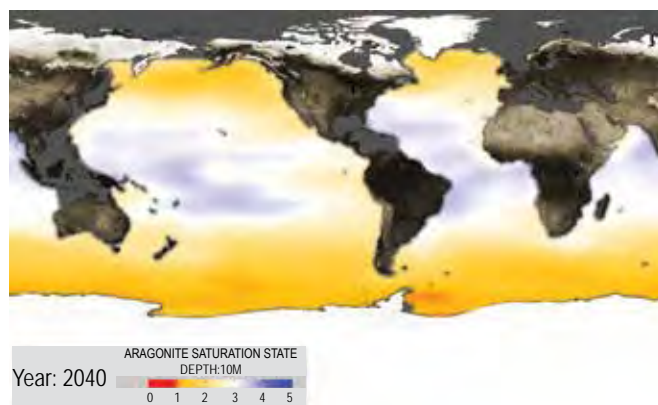
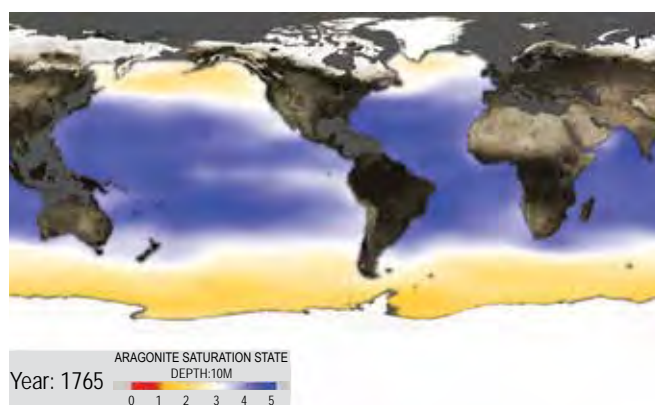
Ocean acidification

As the oceans absorb more CO₂, this changes the chemistry of the oceans. The CO₂ reacts with water to form carbonic acid and hydrogen ions. This has two important effects. Firstly, the hydrogen ions react with carbonate molecules in the oceans. This reduces the concentration of carbonate ions available for corals to make their calcium carbonate skeletons. Secondly, this process also lowers the pH of the oceans, making them more acidic. When ocean pH is lower, it is more difficult for many corals and shellfish to precipitate calcium carbonate necessary to build skeletons or shells. These changes to ocean chemistry are called ocean acidification.

Activities

Classroom activity 1 - Ocean pH

Look at the maps highlighting ocean pH across the globe. Which areas of the oceans are most at risk of ocean acidification? Use your understanding of gas laws and gas solubility in fluids to explain why some oceans absorb more CO₂ than other areas. (Tip: You can search for this answer on the internet or in a textbook). You can test this effect by looking at soda water. What happens to the carbon dioxide bubbles when soda water is heated?



Maps created by NOAA

Aragonite saturation states

Plankton, corals and shell-building organisms all depend upon an ocean that is saturated in aragonite. Its abundance reduces the amount of energy these organisms need to expend to build their calcified skeletons. Aragonite concentrations in the tropical oceans have already fallen from $\Omega=4.6$ to $\Omega=4.0$. This has resulted in reductions in the density of coral skeletons and changes in the structure of some phytoplankton species. As aragonite saturation levels fall, the capacity of corals and many other shell-building species to build their skeletons will be reduced.

Global Threats

CoralWatch



Global Threats

CoralWatch

- CoralWatch

Plankton drawings

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Algae drawings

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Global threats to reefs

Climate Change & Coral Bleaching

Elaboration

- OC 3.3 Natural global processes and human activity lead to environmental and climatic change (e.g. increased concentrations of carbon dioxide in the atmosphere, increased temperatures).
- OC3.4 Increases in average global temperatures impact on marine environments by altering thermal regimes and changing physical and chemical parameters of the ocean (e.g. rising sea levels and ocean acidification).

Learning objectives

At the end of this session, students will be able to:

- Identify how temperatures have changed over time.
- Explain how increased temperature influences corals and how coral bleaching occurs.

Key learning points

- Ocean temperatures are increasing over time.
- This increase in temperature affects the photosynthetic process in corals to increase risk of coral bleaching.
- Coral bleaching occurs when high temperatures, or other stressors, lead the coral to expel the symbiotic algae (zooxanthellae). These provide the coral with colour and nutrients, so when they have been expelled, the corals appear lighter in colour.
- Coral bleaching is a major threat to reefs worldwide, including the Great Barrier Reef.
- Coral bleaching can be predicted. Predictive tools are available online.
- Coral bleaching can be monitored using the Coral Health Chart.

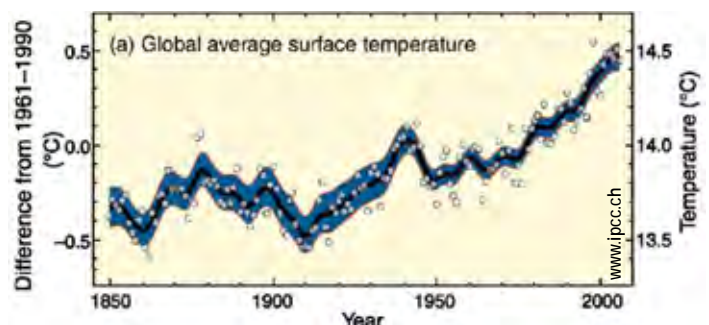
Resources

- *Coral Reefs and Climate Change: the Guide for Education and Awareness* - recommended sections:
 - Ocean Environment – Ocean Temperature
 - Coral Reefs – State of the Reefs
 - Coral Reefs – Coral Bleaching
 - Power of Us - The Bigger Picture
- *Coral Reefs and Climate Change* video series - recommended videos:
 - Coral Reefs - Coral Bleaching (5min)
 - Climate Change - Climate Change introduction (5min)
- Virtual Reef poster
- Virtual Reef booklet
- Virtual Lab
- Report: *IPCC Fourth Assessment Report: Climate Change 2007* section on Sea Surface Temperature:
www.ipcc.ch/publications_and_data/ar4/wg1/en/ch3s3-2-2-3.html

Background

Ocean temperatures

The Intergovernmental Panel on Climate Change (IPCC) collates data that assesses temperature changes over time. Research shows, that even taking into account natural variability, sea surface temperatures are steadily increasing.



Graph of changes in sea surface temperatures over time, taken from the IPCC Fourth Assessment Report: Change Change 2007

Coral bleaching

In healthy coral, tiny algae called zooxanthellae live within the coral tissue, providing it with nutrients and colour. When corals are stressed, they get rid of these algae, making the coral lighter in colour. This is called 'coral bleaching'. Without the zooxanthellae, corals do not get enough nutrients, and may die if the stressful conditions are severe. Many stressors can cause coral bleaching. The main cause of large bleaching events is increased water temperatures. Sea temperatures are predicted to rise, and bleaching events are expected to occur more frequently.

How do high temperatures affect corals?

In healthy corals, zooxanthellae generate energy via photosynthesis. Like other plants, this involves using carbon dioxide to generate energy products for the coral, and also oxygen. At temperatures that are higher than the coral is used to, this process changes - zooxanthellae can produce too many damaging oxidation products, such as reactive oxygen species or other free radicals. These can be toxic to the cells of the coral. To cope with this, the coral polyps expel the zooxanthellae, resulting in what we call coral bleaching. Higher than usual sun intensity can also interact with high temperatures to increase risk of bleaching.

Predictive tools - NOAA

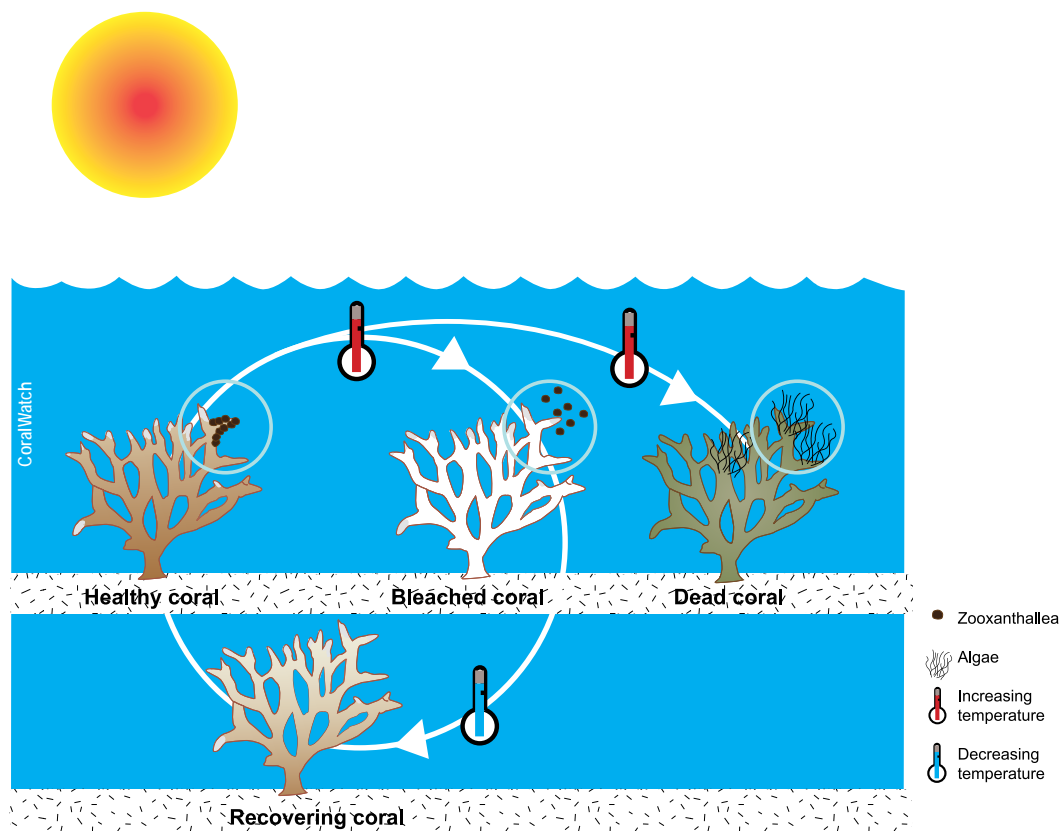
In the summer of 1997/1998 the National Oceanic and Atmospheric Administration (NOAA) began using near- real time satellite data to track global sea surface temperatures and anomalies as part of a predictive tool package for coral bleaching events. Since that time, NOAA has continued the development and refinement of a series of products as part of its Coral Reef Watch (CRW) program with data available through its website and Google Earth. This enables government agencies, NGO's and researchers, sufficient time to respond to a bleaching event.

Can bleached corals recover?

Serious bleaching events can lead to coral mortality. The most important factor influencing whether a coral survives a bleaching event is the amount of time that it is exposed to elevated temperatures under high light conditions. The longer the coral is exposed, the greater the chances of mortality. Bleaching events also increase the risk of coral diseases. If the bleaching stress is only brief, corals can recover quite quickly from bleaching events, in some cases regaining their colour in a matter of days. However, each bleaching event weakens the overall health of the coral over time.

Bleached corals can appear in various colours

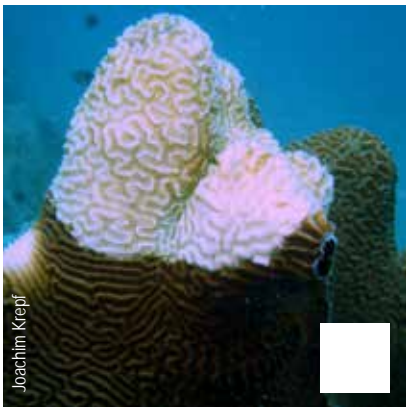
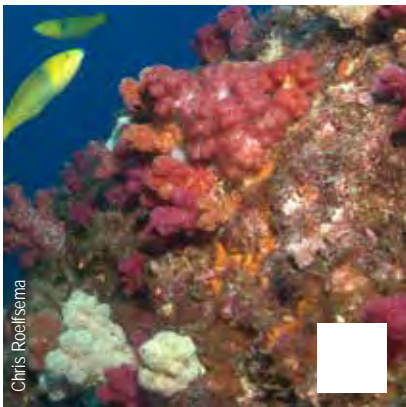
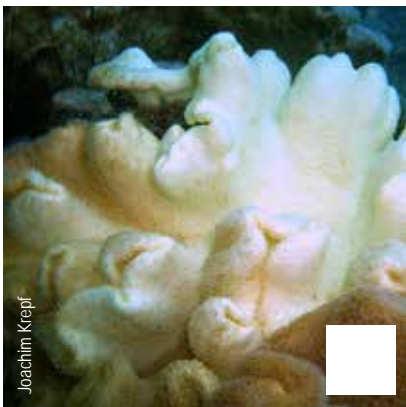
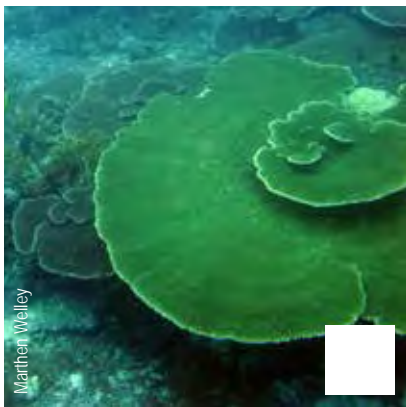
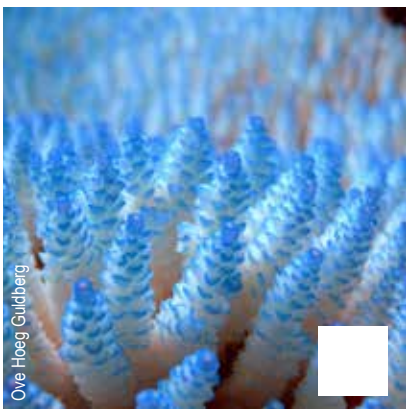
Without the brown zooxanthellae present in healthy coral, bleached coral will display the bright white calcium carbonate skeleton and any fluorescing pigments.



Activities

Classroom activity 1 - Coral bleaching

For each picture, decide if the coral is healthy or bleached. Tick the boxes if the coral is bleached or unhealthy.



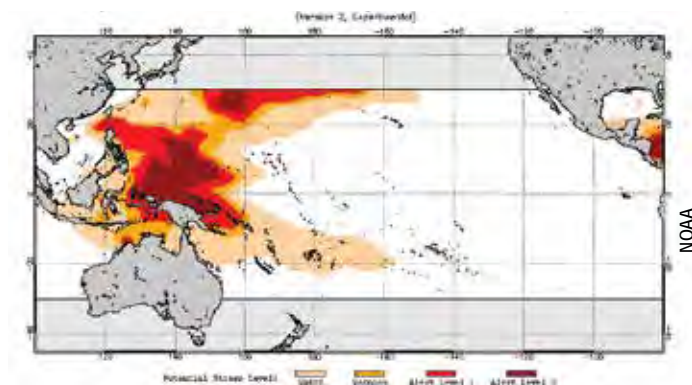
Classroom activity 2 - Sea surface temperatures

Read the IPCC Fourth Assessment Report: Climate Change 2007 section on Sea Surface Temperature: www.ipcc.ch/publications_and_data/ar4/wg1/en/ch3s3-2-2-3.html

Answer the following questions:

1. In Figure 3.4b, what do the different lines in the graph represent?
2. Explain why sea surface temperatures are usually described as an 'anomaly' rather than a mean.

Classroom activity 3 - NOAA Coral Reef Watch



Use www.coralreefwatch.noaa.gov and read more about Coral Reef Watch Satellite Bleaching Alert System. Familiarise yourself with the five status levels.

Go to outlook and click on the map that will show Indonesia, then click on "Pacific" to see Thermal Stress Outlook for the region.

1. Are there any areas on your map that show alert Level 2?
2. Are there any areas on your map that show warming?
3. Copy your map with the outlook of one month, 2 months and 3 months earlier. What are the differences? Has the bleaching forecast changed?

Marine Management - Managing local threats

Elaboration

- CS 1.4 Aquaculture and recreational and commercial fishing place demands on marine ecosystems which must be monitored to ensure sustainable futures (e.g. overfishing, ocean ranching).
- CS 2.1 Sustainable management practices, economic and ecological, are shaped by the environmental philosophies of stakeholders (e.g. local communities, Aboriginal and Torres Strait Islander peoples).
- CS 2.3 Recreational and commercial use of marine environments is managed through zoning, legislation, licensing and enforcement to protect the longevity of marine ecosystems.
- CS 2.4 Increases in population density of coastal areas impact on the health of coastal water and should be carefully managed for sustainable outcomes (e.g. loss of mangroves, saltmarshes and seagrasses).
- CS 2.6 Education of stakeholders is essential to encouraging sustainable management practices (e.g. consumers, recreational and commercial fishers).

Learning objectives

At the end of this session, students will be able to:

- Describe different strategies for improving reef health via reducing overfishing.
- Describe different strategies for improving reef health via coastal management.
- Analyse current management approaches for the Great Barrier Reef / Moreton Bay.
- Analyse effectiveness of different strategies to manage fishing and water quality.
- Compare how reef management strategies differ between Australia and reefs in The Coral Triangle.

Key learning points

- Research shows that managing human impacts at a local level can improve the health of reefs.
- Marine parks and marine protected areas can improve the growth of corals and support fish stocks in and out of marine reserves.
- The Water Quality Protection Plan for the Great Barrier Reef incorporates diverse strategies to improve water quality. Most of these strategies are focused on land-based activities.
- Tourism can be damaging to reefs, but also can be well managed to maximise economic and natural benefits of healthy reefs for local communities and visitors.

Resources

- *Coral Reefs and Climate Change: the Guide for Education and Awareness* - recommended sections:
 - Coral Reefs – Marine Management
 - Power of Us – Protecting World Heritage
- *Coral Reefs and Climate Change* video series - recommended video
 - Power of Us - Reefs our biggest concern (5m.)
- Report: *Reefs at Risk Revisited* - Chapter 7 Sustaining and Managing Coral Reefs for the Future
- Reef Water Quality Protection Plan 2013; www.reefplan.qld.gov.au/resources/assets/reef-plan-2013.pdf
- Great Barrier Reef Marine Park Zoning Plan 2003; www.gbrmpa.gov.au/__data/assets/pdf_file/0015/3390/GBRMPA-zoning-plan-2003.pdf

Background

The way we manage our oceans influences all marine life. Even if reefs are damaged, our actions can help reefs to recover and maintain healthy oceans.

Marine management

The ocean provides us with many essential resources – food, livelihoods and even energy. It is important to make sure the oceans are healthy. Although many marine ecosystems are threatened, there are things we can do to improve the health of our reefs and marine environment. Things we do as individuals are useful. However, it is also important for larger areas to be managed at a community or national level. This is marine management. Marine management can involve many organisations such as government agencies or local community organisations. Effective marine management is the only way to ensure our reefs are healthy for the future.

Marine managers use many different strategies to ensure that reefs remain healthy into the future. Many of these activities fall into 3 main categories:

1. Protecting fish and habitats

Creating marine parks is an important way to protect fish stocks and habitats such as mangroves and seagrass beds. Marine parks are most effective when they include important ecological zones and activities within the park are monitored. Because overfishing is a serious threat to reefs, protecting fish can also improve the health of corals. Establishing 'no take' zones in important breeding areas or restricting size of fishing catches can protect fish. Some policies focus on specific fish – such as banning sale of shark fins.

The Great Barrier Reef is an internationally important example marine zoning.

2. Reducing the impact of fishing

Blast fishing and cyanide fishing destroy reef habitats. Marine managers can help to enforce policies which ban destructive fishing techniques, educate communities, and provide support to improve fishing techniques.

Improving fishing practices can protect reefs. Nets with small mesh size are often banned because they catch juvenile fish. Many regions apply a quota, restricting the size or number of fish that can be caught. Some jurisdictions protect specific types of fish such as sharks.

3. Managing human activities

Human activities on land and in coastal areas can affect the water quality of reefs. The Great Barrier Reef has a Water Quality Protection Plan to ensure optimal water quality. Marine managers can support coastal developments that minimise damage to reefs and connected ecosystems. For example, preventing sewage run-off and erosion will reduce damage to reefs. Tourism is one of the ways that reefs can provide benefits to society. But tourism can be damaging if it is not well managed. Sustainable tourism initiatives can ensure that reefs bring economic benefits for local communities. Income from sustainable tourism can provide local support for reef protection.

Activities

Classroom activity 1 - Water quality

Read the Reef Water Quality Protection Plan (website in resources). This describes a range of approaches used to improve water quality on the Great Barrier Reef.

1. How is water quality measured?
2. How has water quality changed on the Great Barrier Reef over the last 30 years?
3. List 4 strategies that aim to improve water quality. For each of these, describe how these actions would influence water quality, and list examples of the key professional or community groups that need to be involved in the process (stakeholders).

Classroom activity 2 - Marine reserves

Choose one of the following scientific articles and answer the questions below:

1. Marine Reserves Enhance the Recovery of Corals on Caribbean Reefs (www.plosone.org/article/?uri=info%3Adoi%2F10.1371%2Fjournal.pone.0008657&representation=PDF) **OR**
2. Larval Export from Marine Reserves and the Recruitment Benefit for Fish and Fisheries
www.protectourcoralsea.org.au/media/transfer/doc/harrison_et_al_2012_-_current_biology_in_press.pdf
 - a. Describe the question that the study was trying to address?
 - b. Describe the study location.
 - c. What types of activities were not allowed in the main study sites?
 - d. What was the primary finding of this study?
 - e. If you were writing a news story about the study, what would be the main message to share with your readers?

Classroom activity 3 - Code of practice

1. Choose a reef that you have visited or would like to visit.
2. Identify the main activities reef visitors are likely to be involved in.
3. For each activity list 3-5 things people should do to keep themselves and the reef safe. Remember to think about how reefs may change throughout a year (e.g. breeding seasons or evacuations during cyclones).
4. In your project you should also include:
 - a. A brief description of the reef (location, size, access, accommodation).
 - b. Points of interest and importance (special wildlife or events, why this reef is important).
 - c. Local threats to the reef.
 - d. Current protection status (is it a marine park, who owns or looks after it?).
 - e. Who is responsible for enforcing these practices and penalties that apply.
5. Think carefully about the length, order and layout to best communicate the code of practice you have developed. Devise a communication strategy of where you would provide details of the code of practice to reef visitors.

Marine Management Acting on climate change

Elaboration

- OC3.6 Reducing the effects of climate change is a complex issue requiring global agreements, national frameworks, industry participation, community decisions and individual action.
- CS 2.2 The Exclusive Economic Zone is internationally recognised by the United Nations with each nation being responsible for resource management.
- CS 3.6 Decision making involves the consideration of a range of stakeholders' views and a range of alternative paths for action

Learning objectives

At the end of this session, students will be able to:

- Identify rationale for reducing greenhouse gas emissions.
- Describe the concept of mitigation, and identify key mitigation strategies.
- Describe the concept of adaptation, and identify examples of adaptation strategies.
- Analyse how different countries approach mitigation policies.
- Analyse effectiveness of different mitigation approaches.

Key learning points

- Human activities are one of the major contributors to increased emissions of greenhouse gases and global warming. So, modifying human activities and reducing greenhouse gas emissions (mitigation) can improve the health of reefs into the future.
- Acting on climate change can be done at an international level, national level, within schools or communities, or as individuals. It will take action on all these levels to reduce the effect of global warming and climate change on reefs.

Resources

- *Coral Reefs and Climate Change: the Guide for Education and Awareness* - recommended sections:
 - Coral Reefs – Marine management
 - Climate Change – Political and Economic Response
 - Climate Change – Mitigation
 - Climate Change - Climate Dynamics
 - Power of Us – Community Input
 - Power of Us – Collaborative effort

Background

The concentration of greenhouse gases in the atmosphere is higher than any other time in human history. There have been unprecedented increases in temperature around the world, with many of the 'hottest year' or 'hottest day' records occurring in the last decade. Many factors influence our climate - but research shows that human activities, especially burning fossil fuels, has increased atmospheric CO₂ and is changing our climate.

Greenhouse gas emissions are likely to increase, unless specific action is taken to reduce emissions. Strategies that aim to reduce atmospheric concentrations of CO₂ and other greenhouse gases are called mitigation strategies. These could include:

- Supporting alternative energy sources, such as those from wind or solar power.
- Costing CO₂ via a market mechanism to create incentives to reduce emissions, such as a carbon trading scheme or carbon price.
- Reducing emissions that come from deforestation by regulating or restricting deforestation and implementing tree planting and reforestation policies.

Many countries now meet to discuss setting global or national targets for reducing greenhouse gas emissions (or 'carbon emissions'). Some scientists are researching ways to capture and store greenhouse gases safely, usually in the ground - this is called 'carbon sequestration' or 'carbon capture and storage'.

Reducing greenhouse gas emissions is one of the most important ways to protect reefs from bleaching events and ocean acidification.

Community input - example

The Climate Project (TCP) Indonesia supports a group of diverse and dedicated volunteers who have been personally trained by former US Vice-President Gore. These Climate Presenters work to educate the public about the reality of climate change and promote both local and global solutions. TCP operates independently as a non-profit organisation with assistance from the Indonesian National Council on Climate Change, supports the work of more than 215 Presenters in Indonesia. Presenters come from diverse backgrounds and include business leaders, professionals, educators, athletes, musicians, scientists, actors, students and religious leaders.

Activities

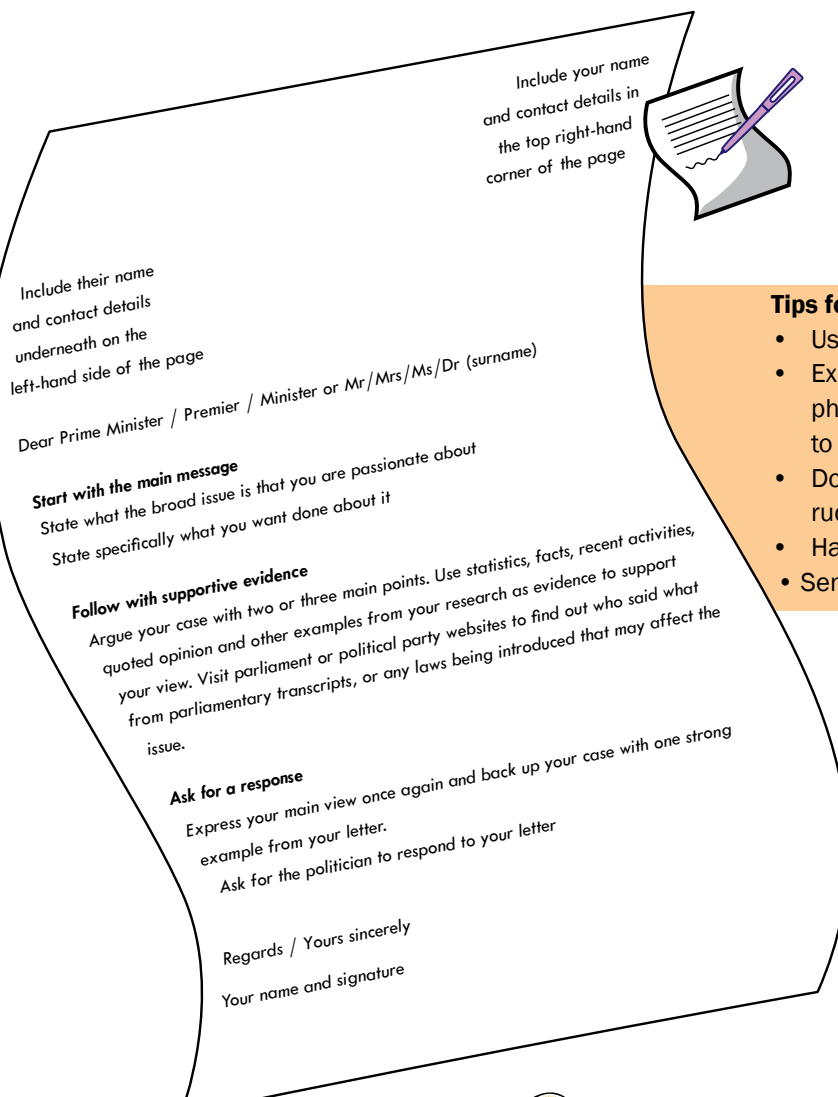
Classroom activity 1 - Mitigation strategies

Choose two countries in different parts of the world - use the internet to research their policies on reducing CO₂, and answer the following questions:

1. Do they have a target for reduction of CO₂ emissions? If so, what it is?
2. How are their policies similar?
3. How are their policies different?
4. Do these policies mention any research that supports the policy?

Classroom activity 2 - Letter of concern

1. Write a letter regarding a reef-related issue and suggested solutions. Address your letter to your local state or federal politician, or local councillor. Research their role, and make sure you have their correct title and address.
2. In your letter, choose a threat to reefs and what action you would like to see taken to protect reefs. Make sure you include:
 - The main issue, what is the problem and why is it important?
 - Your proposed solution - what action would you like to see taken?
 - What is the reason behind your suggestion? Is there research or other information to support it?
3. Decide whether you actually want to send the letter you have written (only you can make that choice).



Include your name and contact details in the top right-hand corner of the page

Include their name and contact details underneath on the left-hand side of the page

Dear Prime Minister / Premier / Minister or Mr/Mrs/Ms/Dr (surname)

Start with the main message
State what the broad issue is that you are passionate about
State specifically what you want done about it

Follow with supportive evidence
Argue your case with two or three main points. Use statistics, facts, recent activities, quoted opinion and other examples from your research as evidence to support your view. Visit parliament or political party websites to find out who said what from parliamentary transcripts, or any laws being introduced that may affect the issue.

Ask for a response
Express your main view once again and back up your case with one strong example from your letter.
Ask for the politician to respond to your letter

Regards / Yours sincerely
Your name and signature

Tips for writing the letter

- Use formal language
- Express your point of view with phrases like 'I feel' and 'I want to see'
- Don't expect a reply if you are rude, abusive or offensive
- Handwrite your letter
- Send your letter in the mail



Australian Coral Reef Society Inc.

A society promoting scientific study of Australian Coral Reefs

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c/- Centre for Marine Studies
The University of Queensland
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Fax: (07) 3365 4522

Email: Justin.marshall@uq.edu.au

9th September 2009

The Honourable Mr Peter Garrett
Minister for the Environment, Heritage and the Arts
Parliament House
Canberra
ACT

Dear Minister Garrett

Australian Coral Reef Society Comment on recent oil spills in the vicinity of Australian coral reefs and coastline.

Australia is a world leader in the call for the conservation of coral reefs and demonstrates role model management of The Great Barrier Reef (GBR). The GBR is one of the largest protected areas in the world, and was protected in its first instance when faced with the potentially high environmental risks of oil and gas exploration. With worldwide reef systems 40% destroyed or degraded to unrecognizable, Australia must continue as a world leader in protecting our less degraded reef systems and coastlines from threats such as this.

Despite the high standard of Health Safety and Environment policies promoted in the oil and gas industry, 2009 has witnessed two recent oil spills of significant threat to the marine environment.

The first in March when the Pacific Adventurer lost containers of ammonium nitrate and 270 tones of fuel oil offshore of Cape Moreton where as detailed by the Australian Marine Safety Authority (AMSA) : *“The oil impacted significant portions of the south-east Queensland coast, in particular the eastern and northern beaches and headlands of Moreton Island (a National Park), the eastern beaches of Bribie Island (north of Brisbane), the beaches and foreshores of the Sunshine Coast (north of Brisbane) and small areas of the Brisbane River.”*

(AMSA:www.amsa.gov.au/Marine_Environment_Protection/Major_Oil_Spills_in_Australia/Pacific_Adventurer/index.asp)

The second spill started on the 21st of August 2009, when a leak developed in an oil well of the Montara oil field in the Timor Sea, close to world significant biodiversity hotspots (<http://www.environment.gov.au/coasts/mpa/ashmore/index.html>): Cartier Reef (a National Marine Reserve), 150km from the Ashmore complex a National Nature

President:	Prof Justin Marshall; Tel: 07 3365 1397; Fax: 07 3365 4522	Email: justin.marshall@uq.edu.au
Hon Secretary:	Dr. Ulrike Siebeck; Tel: 07 3365 4070; Fax: 07 3365 4522	Email: u.siebeck@uq.edu.au
Hon Treasurer:	Dr Anna Scott; Tel: 02 6648 3923; Fax: 02 6651 6580	Email: ascott@nmsc.edu.au

Classroom Activity 3 - Carbon footprint

1. Make a list of 10 activities you enjoy doing every day.
2. Next to each, identify if you believe it releases none, few or lots of carbon emissions.
Hint: If you don't know the answer to this, it helps to think about the bigger picture. For each item on the list, think about how it was manufactured, what are the raw materials needed to make it, what is the energy used in the process.
3. Write one way you could reduce the emissions from the activity.

Before Class

Find out the following facts:

- How far is it from your home to school?
- What type of fuel does your car use?
- What do you use to heat water at home? (gas, electricity, solar)
- How much electricity did you use on your last electricity bill? Over what amount of time?

Reducing daily emissions		
Activities I enjoy doing every day	Carbon emissions (none, few, lots)	Way I could reduce emissions

Classroom Activity 4 - Carbon calculator

1. Complete a carbon calculator online to determine your carbon emissions.
2. Compare this to the rest of your group and find the average carbon footprint of your group.



Sustainability

Elaboration

- CS2 Sustainable management practices are essential for the protection of marine resources.
- CS 2.7 Consultation through stakeholder groups guides policies relating to sustainable marine practices (e.g. Local Marine Advisory Committees [LMACs], CoralWatch, Australian Marine Environment Protection Association [AUSMEPA]).
- CS 3.5 Marine scientists work in a variety of fields that contribute to the sustainability of marine environments (e.g. research, education, policies).

Learning objectives

At the end of this session, students will be able to:

- Describe the concept of sustainability.
- Describe the concept how the behaviours of individuals living away from the reef can influence marine life.
- Identify examples of sustainable behaviours suitable for individuals, schools, communities or businesses.
- Analyse a popular sustainability program.

Key learning points

- Sustainability aims to ensure that the lives of individuals, communities and nations contribute to the future health of reefs and natural resources, rather than their degradation.
- Individuals can choose to make sustainable decisions in every part of their lives.
- Communities, organisations such as your school, and countries can implement policies and programs that improve sustainability.

Resources

- *Coral Reefs and Climate Change: the Guide for Education and Awareness* - recommended sections:
 - Power of Us - Daily Life
 - Power of Us - Professional Life
 - Power of Us - Liveable Neighbourhood
 - Power of Us - Bridging the Gap
 - Power of Us - Collaborative Effort
- Coral Reefs and Climate Change video series - recommended video
 - Power of Us - You are the Market (5min)
- www.savemoretonbay.org.au
- Sustainable Australia Report 2013 - www.environment.gov.au/sustainability/measuring/publications/sustainable-australia-report-2013.html

Background

Sustainability can mean many different things. It can refer to communities living in a way that ensures their well-being can continue into the future. It can refer to a way of using natural resources that ensures these resources are not depleted and remain available for future generations. It can influence how we live, and cities, how we manage our natural resources, how we support food production, and how society create jobs and livelihoods. It can influence all parts of our lives, from what we choose to eat for lunch, through to designing cities and reducing carbon emissions.

With regards to reefs, sustainability refers to ensuring that the way we live minimises any negative impact on reefs, and ensures that reefs remain healthy for future generations.

Sustainability at school

Schools and students are often enthusiastic supporters of sustainable living. School sustainability projects that could help the reef include:

- Activities that increase environmental awareness and stewardship in all school units,
- Learning about local surroundings and their relationship with reefs (and other ecosystems) as well as different community members and groups,
- Working together to plant trees, collect rubbish, reduce plastic use, look after catchments, monitor water, waste and energy use.

Community members could be invited to participate via newsletters, brochures, fetes and fun days, presentations and documentaries or direct visits with farm, home or business owners or government representatives in your area.

Activities

Classroom activity 1 - Sustainability

Read the Sustainable Australia Report 2013 and answer the questions below

You can download it from this website: www.environment.gov.au/sustainability/measuring/publications/sustainable-australia-report-2013.html

1. How does this document define sustainability?
2. There are many different 'indicators' that are considered when deciding how sustainable Australia is, such as life expectancy, air quality or housing affordability. Choose one indicator where Australia is performing well. Describe our achievements for this particular indicator. Should we aim to improve this? Can you think of reasons why Australia is effective for this indicator?
3. Choose an indicator where we are performing poorly. Describe our achievements (or lack of achievements) for this particular indicator. Can you think of reasons why we are performing poorly for this indicator? What should we be aiming to achieve? What strategies could be implemented to improve our performance on this indicator?

Classroom activity 2 - Future guardian

The aim of this activity is to design, and hopefully implement, a change in your school or organisation that will benefit reefs. You will select a specific service, facility or activity (or develop a new one) in the school community that you believe could be made more sustainable. By doing this you can gain an appreciation of how change takes place and is influenced by people and the system it occurs in.

1. Research and audit one aspect of your school. You can choose from the following list:
Transport, Biodiversity, Electricity, Food, Waste, Water, Curriculum, Administration.
2. Design a project plan including:
 - A specific project goal (e.g. reduce the amount of light spilling from the school onto a beach where turtles are nesting, or increase the number of people riding their bikes to school to reduce carbon emissions).
 - The steps you would take (in a logical order) of creating change.
3. In small groups formulate a single goal that is SMART:
 - Specific: Clear to anyone that has a basic knowledge of the project.
 - Measurable: Know if the goal is obtainable and when it will occur.
 - Agreed Upon: Agreement with all the stakeholders what the goals should be.
 - Realistic: Within the availability of resources, knowledge and time.
 - Time Based: Enough time to achieve the goal, but not too much to lose motivation.
4. Put your project goal in the middle of a blank sheet of paper and write down all the ways you can think of to make this happen (think outside the box). This is where you can get creative, use colours and pictures showing ideas.
5. Separate your ideas into the categories outlined in the Factors of Change table and next to each one write down who is responsible for making it happen. (Draw your own table similar to the one below).
6. Now complete your project plan, including a time line and list of resources you will need to make it happen.

Project plan

ACTION	WHO	DUE DATE	RESOURCES
Infrastructure			
Regulations			
Incentives			
Education			

Citizen Science

Elaboration

- CS2.7 Consultation through stakeholder groups guides policies relating to sustainable marine practices (e.g. Local marine advisory committees, Coralwatch, AUSMEPA).
- OC3.6 Reducing the effects of climate change is a complex issue requiring global agreements, national frameworks, industry participation, community decisions and individual action.

Learning objectives

At the end of this session, students will be able to:

- Describe the importance of scientific knowledge in understanding the natural world.
- Describe how science can contribute to conservation efforts.
- Identify a question about reefs that could be examined using a research project.
- Compare examples of citizen science programs.

Key learning points

- The scientific method involves asking questions about the natural world and collecting data systematically to address the question.
- Citizen science programs engage volunteers and the general public in scientific research programs. Citizen science is popular for reef monitoring programs - engaging volunteers allows scientists to examine the health of reefs over time, across larger geographic areas.

Resources

- *Coral Reefs and Climate Change: the Guide for Education and Awareness* - recommended sections:
Power of Us: Citizen Science
- Coral Reefs and Climate Change video series - recommended videos:
Community input (5min)
CoralWatch (5min)
Power of Us
- CoralWatch Do It Yourself Kit
- Great Barrier Reef Marine Park zonation plan
- Put it to the Test – Fun video about asking scientific questions, www.youtube.com/watch?v=9kf51FpBuXQ

Background

Why science?

Science provides a way to understand the world around us. It is not just a collection of facts or knowledge - it is a process of discovery. Science relies on scientists to develop a question which can be tested. They then design an experiment, or process of data collection, which can test this question objectively. The information gathered is then used to refine the question, or develop a new question. This process is called the 'scientific method'. The key component of this is based on the approach that we can understand the world by objective and systematic observation or measurement.

Science and conservation

There are many examples of how science can tell us more about the natural world and different strategies to manage natural resources and conserve our precious ecosystems. The many things we have learnt in this course have been discovered by science - from how a coral polyp gets energy, to whether marine parks can improve fish stocks.

Reef monitoring

Accurate information about the health of our reefs is an essential part of marine management. This information is obtained by reef monitoring programs. Reef monitoring measures a range of indicators of reef health - such as coral cover, the number of different types of species in a certain area, the mix of different types of species, the presence of certain important species, or the presence of particular reef threats, such as disease or bleaching. Reef monitoring allows us to identify the health of a reef over time - whether it is recovering after a crown of thorns outbreak, or whether coastal development is having a negative impact on reef health.

Citizen science

Reefs are found across many hectares of oceans - some are close to villages or even cities. But many reefs are remote. If we want to learn more about the health of reefs, across different oceans and different time periods, we need a lot of people to help monitoring. In recognition of this issue, many environmental science now invite volunteers ('citizen scientists') to contribute their observations or to participate in monitoring programs.

Activities

Classroom activity 1 - Citizen science projects

- Go online and look at the websites for:
 - CoralWatch
 - Seagrass Watch
 - Mangrove Watch
- For each program, answer the following questions:
 - What is the program trying to achieve?
 - What methods are used to monitor the environment (e.g. transects, satellite images)?
 - What kind of people are doing the monitoring (e.g. students, scientists, tourists)?
 - How long has this monitoring program been in place?
- Find a site near you for which data is available and answer the following questions:
 - What is the name of the site?
 - What does the data collected tell you about that site?
 - Are you able to see whether this site has changed over time?
- Can you list other environmental monitoring programs?



Classroom Activity 2 - Research topics

- Come up with an example of a research question that could not be done by a single group of researchers and would need to involve the community. Which citizens would you get to be involved and why?
- Sometimes, citizen scientists can establish their own research project. If you were setting up a marine research project, what question would you want to ask? How would to begin to answer it? Tip: you could consider a research method that involved observation, or setting up an experiment.

Marine Research – Reef Monitoring

Elaboration

- CS3.5 Marine scientists work in a variety of fields that contribute to the sustainability of marine environments (e.g. research, education, policies).
- CS3.4 Research into the effects of human activities and resource management practices should be conducted to evaluate long term impacts.
- CS3.5 Field guides and identification keys use scientific and common names to classify organisms according to distinct and observable features.
- MS2.4 Snorkelling equipment and practices are used to observe or survey underwater ecosystems, including conducting transect studies.
- MS3.1 Marine navigation and communication devices (e.g. GPS [global positioning system], radio, mobile phone) and procedures are used for coordination and safety (e.g. EPIRB).

Learning objectives

At the end of this session, students will be able to:

- Describe what types of scientists are involved in marine research.
- Identify different reef survey methods and indicators of reef health.
- Describe a research project that has examined reef health.
- Evaluate what research skills would be needed for different types of projects.

Key learning points

- Why research is an important technique to understand reefs.
- Different methods for measuring reef health are determining percentage coral cover, percentage algal cover, reef colour, diseases.

Resources

- *Coral Reefs and Climate Change: the Guide for Education and Awareness* - recommended sections: Climate Change – Tracking Change
- *Coral Reefs and Climate Change* video series - recommended videos: Tracking Change (5 min.)
- www.savemoretonbay.org.au/pages/project-partners.html
- Report: *Methods for ecological monitoring of coral reefs*, Joss Hill and Clive Wilkinson, Australian Institute of Marine Science, 2004

Background

Reef monitoring

There are many different parameters of reef health. The health of reefs is assessed by monitoring programs which measure these parameters over time.

Biological parameters

Biological parameters focus on the living organisms on coral reefs. Biological parameters may also be used to assess the extent of damage to reefs from natural or human disturbances. These parameters include:

- Percentage cover of corals (both live and dead).
- Percentage cover of other benthic organisms, such as sponges, coralline algae and macroalgae.
- The type of species of corals or other organisms present on the reef (species abundance, diversity, or the 'mix' of different species (which is called 'community composition')).
- Presence of newly settled corals and juveniles.
- Numbers, species composition, size (biomass) and structure of fish populations.
- Presence of juvenile fishes.
- Presence or numbers of target species or organisms of special interest such as giant clams, COTS, sea urchins etc.
- Extent and nature of coral bleaching.
- Extent and type of coral disease.

Physical parameters

Physical parameters measure the physical, or non-living, environment on and around reefs.

This provides a physical description of the reef habitats and the surrounding oceans. These parameters can assist in making maps, measuring changes in the environment, and assessing the impact of human activities on the conditions that reefs require to remain healthy. Parameters include:

- Water quality and turbidity
- Temperature
- Depth, bathymetry and reef profiles
- Currents
- Temperature
- Visibility
- Salinity.

Which parameter is best?

There is no single parameter that can capture the full picture of reef health. Changes in coral cover over time is one of the most common techniques used to assess reef health. Many research studies use more than one indicator. The most suitable parameters will depend on whether reef monitoring is part of a research or reef management program, and the particular question being asked.

Adapted from: Methods for ecological monitoring of coral reefs, Joss Hill and Clive Wilkinson, Australian Institute of Marine Science, 2004.

Activities

Classroom activity 1- Coral cover

Read *Methods for Ecological Monitoring of Coral Reefs*, or do your own research on the internet.

Describe at least 3 different ways to measure coral cover in reef monitoring research. How is each of these conducted? List any specific advantages or disadvantages of each method.

School activity 2- Transects

This activity requires an outdoor area with diverse features.

1. Choose a safe area and lay out a measuring tape for a set distance (say, 20m). Different groups of students can conduct this activity in different areas.
2. Using a clipboard, walk along the length of the tape and record everything that is under the tape every metre.
3. Each group should report on their findings: what was the most common 'cover' reported? (e.g. grass, concrete, playground equipment). For each transect, report all the different items recorded, and the percentage that each contributed to the total number of measurements.
4. Discuss the differences between groups. What might have led to the differences? Can you think of whether your results would be different if you had placed your transect somewhere else?



CoralWatch – Coral Health Chart

Elaboration

- CS 3.5 Marine scientists work in a variety of fields that contribute to the sustainability of marine environments (e.g. research, education, policies).
- MS2.4 Snorkelling equipment and practices are used to observe or survey underwater ecosystems, including conducting transect studies.
- MS3.1 Marine navigation and communication devices (e.g. GPS [global positioning system], radio, mobile phone) and procedures are used for coordination and safety (e.g. EPIRB).

Learning objectives

At the end of this session, students will be able to:

- Understand how to use the coral health chart in the field.
- Describe the different coral types.
- Enter virtual data in Excell and analyse the results.

Key learning points

- The Coral Health Chart is a simple, non-invasive tool that can be used for 'reef walking', snorkelling or diving.
- The colour chart standardises changes in coral colour, providing a simple way to quantify bleaching and monitor coral health.
- The colour charts are based on the actual colours of bleached and healthy corals. Each colour square corresponds to a concentration of symbionts contained in the coral tissue. The concentration of symbionts is directly linked to the health of the coral.
- The Coral Health Chart can be used in different survey methods, including random surveys, transects, and monitoring easy to identify corals.

Resources

- *Coral Reefs and Climate Change: the Guide for Education and Awareness* - recommended sections:
Power of Us - Acting on Coral Bleaching
- *Coral Reefs and Climate Change*, video series - recommended video:
CoralWatch
- www.coralwatch.org
- CoralWatch Do It Yourself Kit
- Siebeck et al. Monitoring coral bleaching using a colour reference card. *Coral Reefs* 2006;25:453-460

Background

What is CoralWatch?

CoralWatch is based at The University of Queensland in Brisbane, Australia. CoralWatch integrates global monitoring of coral bleaching with education about coral reef conservation. In 2002, CoralWatch developed and validated the Coral Health Chart (Siebeck et al. Monitoring coral bleaching using a colour reference card. *Coral Reefs* 2006;25:453-460). The chart standardises changes in coral colour, providing a simple way to quantify bleaching and monitor coral health. The Coral Health Chart is used by dive centres, scientists, school groups, and tourists. Anyone can contribute to our global database! Collecting data is easy - you just compare colours of corals with colours on the chart and record matching codes. You don't need to wait until coral bleaching occurs - monitoring healthy reefs is also important. You can monitor any reef, any time, while diving, snorkelling or reef walking. Get involved in CoralWatch to monitor and protect reefs around the world.

CoralWatch produces books, DVDs and Reef Education Packages for schools. Find out more visit www.coralwatch.org.

Why we need your help?

Very little is known about coral bleaching trends on a global scale. Monitoring is most effective when conducted regularly. But, there are not enough scientists to monitor all the world's reefs. This is where you can help! If many people around the world, like you, contribute to our global database, we will be able to answer questions about patterns of coral bleaching, severity of coral bleaching, and patterns of recovery.

How to use the Coral Health Chart

1. Choose a random coral and select the lightest area.
2. Rotate the chart to find the closest colour match.
3. Record this colour on a slate or data sheet.
4. Select the darkest area of the coral and record the matching code.
5. Record the coral type.
6. Continue survey with other corals. Assess at least 20 corals.
8. Submit your data online at www.coralwatch.org. If you don't have access to the web, contact us.

Avoid measuring growing tips of branching corals because they are naturally white. Do not monitor blue or purple corals because they have a different bleaching response.

Coral type

Because identifying coral species is very difficult, CoralWatch classifies coral types according to easily identified groups. For this purpose, coral types are described by the overall shape ('growth form') of coral colonies.

The Coral Health Chart uses four coral types to classify corals.

Branching refers to any branching coral, such as *Acropora* species.

Boulder refers to any massive or rounded corals, such as some *Platygyra* and *Porites* species. **Plate** refers to any coral that forms a plate-like shape, such as tabular *Acropora* species, and the **soft** category refers to corals lacking a hard skeleton.

There are hundreds of different coral species, each with unique shapes and colours. Sometimes the colour or shape may not clearly match the options on the Coral Health Chart. If it is difficult to select a colour or coral type, simply record the closest. If a particular coral is too difficult to classify, just skip this coral and move on to the next one.

Colour scores

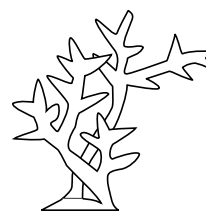
The colours on the Coral Health Chart are based on actual colours of bleached and healthy corals. Each colour corresponds to the concentration of symbiotic algae living in the coral tissue, which is directly linked to coral health. The lightest and darkest scores are recorded to allow for natural colour variation across the coral.



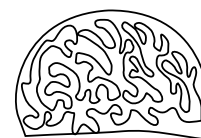
Bleached branching coral
Colour code: E1
Coral type: BR



Healthy branching coral
Colour code: D4
Coral type: BR



branching



boulder



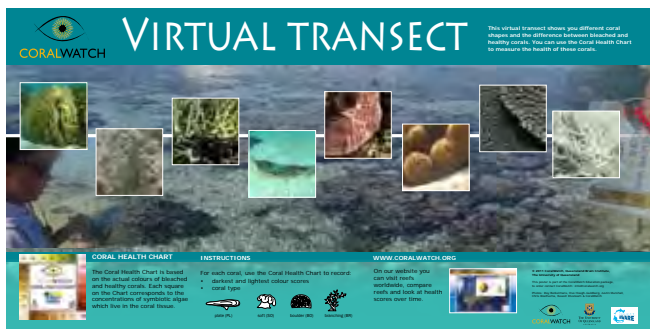
plate



soft



The Coral Health Chart can be used while reefwalking, snorkelling and scuba diving.



Activities

Classroom activity 1 – Virtual reef

1. Following the instructions on the back of Coral Health Chart, match the colours of the virtual reef poster with the colour scores on the chart.
2. Record your colour scores on a data sheet.
3. Record the coral types on a excel data sheet.



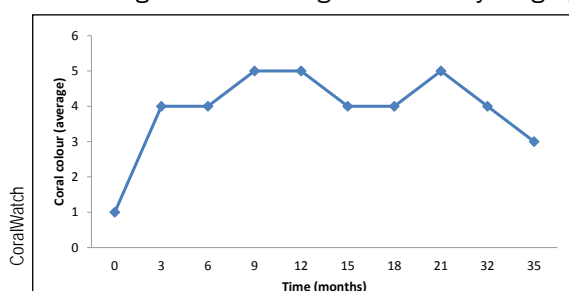
Classroom activity 2 – Virtual data

In this activity you will investigate the consequences and frequency of coral bleaching and determine if these events seem to be increasing.

What is the Virtual Reef?

The Virtual Reef provides an opportunity to learn about coral bleaching and collect scientific data without visiting the reef - it can be used to prepare for a reef field trip or as a valuable alternative. The Virtual Reef includes photos of seven different corals from Lizard Island, northern Great Barrier Reef. The photos were taken during and after the 2002 mass bleaching event.

1. Using the CoralWatch Virtual Reef booklet, review the process and progression of bleached corals in the field. Take note of:
 - a. How many recover?
 - b. How long recovery can take?
 - c. How many died as a result of bleaching?
2. Compare coral No.1 and 2. Which species has recovered most in what time frame?
3. Compare coral No.5 and 6. Which one has mostly recovered?
Compare coral No.6 with No. 2 (hard coral). What can happen to soft corals once the living tissue has died?
4. How many months did it take for coral No.4 to recover?
5. Why can the Coral Health Chart not be used for the monitoring of blue corals?
6. Go to coral No.7 and track the seasonal changes in colour and create a graph showing coral colour over time. Take the average colour readings as data for your graph.



Graph showing seasonal change in colour over time - coral No.7 of Virtual Reef booklet.



Classroom activity 3 – Real data

In this activity you will analyse and compare data results from the CoralWatch website.

1. Go to **www.coralwatch.org** and find the map under the data tab showing field data.

Visit a site along the Great Barrier Reef and choose one survey.

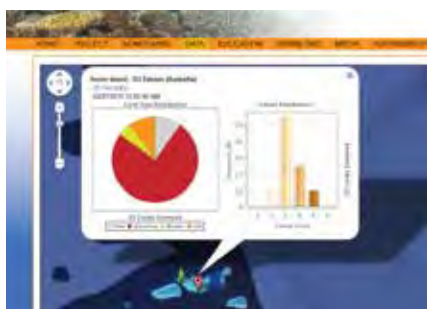
- a. What is the name of your reef?
- b. Which coral type was most abundant?
- c. Which coral type was the least abundant?
- d. Which colour score had the highest frequency?
- e. Who collected this data? Circle the answer.

dive centre / scientist / conservation group / school or university / tourist / other

2. Compare all surveys conducted on this reef by various people.

Go to data/reefs and find the name of your previous reef and view the graphs.

- a. What is the average colour over time?
- b. Which coral type was the most abundant at this reef?
- c. Which colour score has the highest frequency?
- d. How many corals have been surveyed?
- e. When was the last survey?



Data results single survey.



Average colour score over time comparing all surveys for one reef.



Average colour distribution and coral type comparing all surveys for one reef.

Risk Assessment

Elaboration

MS1.4 Dangerous marine organisms are identified and first aid treatments administered if required.

MS2.4 Risk assessments are carried out prior to conducting investigations in the laboratory and the field (e.g. sun protection, chemical MSDS, participant ability).

Learning objectives

At the end of this session, students will be able to:

- Identify risks that may occur in the field.
- Evaluate the severity and likelihood of different risks.
- Identify strategies to reduce impact of potential risks.

Key learning points

Risk assessment is the process where you:

- Identify hazards.
- Analyze or evaluate the risk associated with that hazard.
- Determine appropriate ways to eliminate or control the hazard.

In practical terms, a risk assessment is a thorough look at your workplace to identify those things, situations, processes, etc, that may cause harm, particularly to people. After identification is made, you evaluate how likely and severe the risk is, and then decide what measures should be in place to effectively prevent or control the harm from happening.

Resources

- Department of education and training - Curriculum activity risk assessment - Snorkelling, Open Water <http://education.qld.gov.au/schools/eppr/health/hlspr012/resources/snorkelopenwater.pdf>
- First aid manual - First Aid for Hazardous Marine Life Injuries, DAN Asia Pacific www.danasiapacific.org/main/proddetail.php?prod=INTER
- www.rgs.org/OurWork/Schools/Fieldwork+and+local+learning/Fieldwork+safety/Risk+assessments.htm

Background

It makes sense to follow advice that will keep us safe and to look after the things we value. Look out for strong currents before swimming, wear a helmet when riding your bike, don't text while driving, don't feed the birds, apply immediate pressure to a bleeding wound. These are tested ideas (some enforced by law and some not) recommended to protect people, assets and the environment. When several ideas are written around a theme, such as tourism, they form a code of practice, or best practice. We can call this a safety and conduct code.

Activities

Classroom activity 1 - Dangerous marine animals

Identify what creatures you might see on your fieldtrip that could potentially be dangerous. Use the following table, you can either draw the animal or find a picture on the internet.

Picture	Description	First aid treatment

Classroom activity 2 - Risk assessment (in preparation of the fieldtrip)

Develop a risk assessment for specific reef related activities in the field and possibly in the lab.

Complete the risk assessment worksheet provided, or one your school / group already own.

1. List at least eight activities you would do during a field trip to a reef.
2. Identify the main hazard involved with each (any situation that poses a level of threat to life, health, property or the environment).
3. Calculate the risk involved using the risk assessment matrix.
4. List the specific control measures you could use to bring each risk to acceptable levels.

These can include:

- a. Getting rid of the hazard or risk (e.g. the activity should not be done).
- b. Replace with something less harmful (e.g. an alternate activity or method).
- c. Separate people from the harm (e.g. keep a distance or restrict access).
- d. Change behaviour or the physical environment, (eg re-designing equipment, change locations or timing, add warning signs).
- e. Apply administrative arrangements (e.g. limit entry or time spent in a hazardous area, ensure immediate access to first aid kit).
- f. Use personal protective equipment (e.g. foot protection or sun smart gear).

Risk assesment matrix				
Consequence Likelihood	One minor injury Negligible	One severe injury or multiple minor injuries Marginal	One death or multiple severe injuries Critical	Multiple deaths Catastrophic
Certain	High	High	Extreme	Extreme
Likely	Moderate	High	High	Extreme
Possible	Low	Moderate	High	Extreme
Unlikely	Low	Low	Moderate	Extreme
Rare	Low	Low	Moderate	High

Risk assesment table			
Fieldwork activity	Hazards	Risks	Control measures to bring risk to acceptable levels
Snorkelling	Drowning	Moderate	Boat support
Collecting samples			
Reef walking			
Lab work			

Healthy Reefs from Polyp to Policy

FIELDTRIP BOOKLET



Field Component

Field component

Learning Objectives and Planning

This field trip booklet contains activities that allow students to explore the definitions and determinants of reef health. If suitable for your classroom, students can use the data they collect in the field for Assignment 2 (Environmental Assessment Plan).

Elaboration

- MS1.2 Risk assessments are carried out before conducting investigations in the laboratory and the field (e.g. sun protection, chemical material safety data sheets [MSDS], participant ability).
- MS1.3 Water safety skills (e.g. survival and rescue techniques) and first aid procedures (e.g. basic first aid skills and resuscitation) are important when undertaking marine activities.
- MS1.4 Dangerous marine organisms are identified and administration of first aid treatment is conveyed.
- MS1.5 Weather forecasts and synoptic charts are interpreted prior to and during investigations with decisions being made according to changing weather conditions.
- MS2.1 Vessels, instruments and techniques are used to observe and record the abiotic and biotic features of marine
- MS2.4 Snorkelling equipment and practices are used to observe or survey underwater ecosystems, including conducting transect studies.
- MS3.1 Marine navigation and communication devices (e.g. GPS [global positioning system], radio, mobile phone) and procedures are used for coordination and safety (e.g. EPIRB).

Overall Learning Objectives

At the end of this fieldtrip, students will be able to:

- Collect data using marine research skills
- Compare and analyse marine information from primary and secondary sources
- Analyse and interpret marine information to identify and explain relationships, trends and patterns
- Compare the differences between monitoring methods and apply these methods to your local reefs.

Resources

- *Coral Reefs and Climate Change*, video series - recommended video: CoralWatch
- CoralWatch Do It Yourself Kit
- www.coralwatch.org
- ID guides - see reference list
- First Aid guide

Field Activities

This booklet provides a choice of field activities focusing on measuring reef health. Recommendations are provided for one, two or three day fieldtrips. Teachers can make their planning based on length of trip, resources available, capabilities and number of students. This guide provides instructions and resources for the following activities:

1. Exploring and Identifying Invertebrates
2. Identifying Fish
3. Estimating Coral Cover
4. Identifying Threats
5. Identifying Coral Type using the Coral Health Chart
6. Measuring Coral Health using transects
7. Measuring Coral Health using random surveys
8. Establishing a Permanent Transect
9. Entering Data using Excel
10. Entering Data using www.coralwatch.org

Details on each activity, instructions and extra resources are provided further in this booklet.

Planning your activities

Make sure you plan your fieldtrip well. Look at the tides and choose your times accordingly. Depending on resources, location, teacher expertise, time available, the following exercises can be conducted over 1, 2 or 3 days.

One day fieldplan - exercises 5, 6 or 7

- Students will learn to identify coral growth forms
- Students will collect Coral Health chart data

Two day fieldplan - exercises 1, 3, 4, 5, 6, 7

- Students will learn 2 monitoring methods
- Students will learn to identify invertebrates
- Students will collect Coral Health chart data

Three day fieldplan - all exercises - RECOMMENDED

- Students will learn 3 monitoring methods
- Students will learn to identify invertebrates
- Students will collect Coral Health chart data

Suggested fieldplanning for three day trip

- | | | |
|--------|-----------|---|
| Day 1: | Low tide | - Exploring and identifying invertebrates |
| | | - Estimating coral cover |
| | High tide | - Identify threats |
| Day 2: | Low tide | - Identify coral type using the coral health chart |
| | | - Measuring Coral Health using transects - reef-walking |
| | High tide | - Measuring Coral Health using random surveys |
| Day 3: | Low tide | - Establishing a permanent transect |
| | High tide | - Measuring Coral Health using transects - snorkelling |

Planning your fieldtrip

Thorough planning is required to make your fieldtrip successful.

Create a fieldplan including:

- Risk assessment
- Safety and Conduct Code
- Emergency procedures
- Snorkelling and reef-walking procedures
- A list of animals that are dangerous or venomous and an up-to-date first aid guide for venomous marine creatures.
- Checklist of items that students are required to bring

Check the following:

- Permits, allowing you to do research
- Medical records from students

Equipment to bring:

- Coral Health Charts
- Waterproof slates with pencils
- Quadrat
- Transect tape
- Clipboards
- Waterproof paper
- String
- Underwater camera
- Waterproof ID guide
- Mask, snorkel, fins
- Book and video 'Coral Reefs and Climate Change'
- Identification guides
- Personal items for each student

Equipment

Each activity has a different range of equipment listed to complete the activity. Some of the exercises require the use of a quadrat. A quadrat is a square or rectangular sampling unit in which organisms are counted or measured. If you don't have access to a quadrat, you can make one using PVC pipe (electrical conduit). Cut 4 pieces that are 1m long, and join them at the corners. If you want to create a 'foldable' one, thread a rope through the pipes to connect them (instead of using the corners pieces).

VENOMOUS MARINE ANIMALS

Tips for avoiding marine injuries:

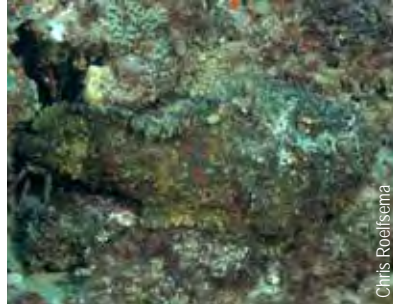
- Don't touch any marine organisms
- Avoid picking up shells
- When in the water, always be aware of your surroundings
- Shuffle your feet when walking into the water in sandy areas
- Always take a first aid kit and manual for marine stings

Before you go out into the field, make sure you have access to up-to-date first aid advice. When in doubt, seek medical care.



Chris Roelfsema

Stingrays - When stepped upon, spine can cause immediate pain.



Chris Roelfsema

Stonefish - dorsal spines capable of piercing through shoes.



Chris Roelfsema

Scorpionfish



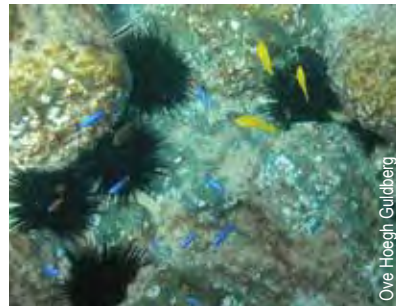
Chris Roelfsema

Lionfish: spines can cause severe pain.



Dave Logan

Jellyfish (Blue bottle): Discharge nematocysts.



Ove Hoegh Guldberg

Urchin: sharp and brittle spines.



Dave Logan

Cone shell - can shoot tiny harpoon. painless to excruciating.



Chris Roelfsema

Fire coral: Tentacles with nematocysts. Prickling sensation to extreme pain.



Chris Roelfsema

Hydroids; nematocysts. stinging sensation to extreme pain.



Chris Roelfsema

Blue ringed octopus - serious bite



www

Box jelly fish - serious sting

Exploring and Identifying Invertebrates

Learning Objectives

At the end of this field activity, students will be able to:

- Identify a number of invertebrates and their associated habitats.
- Identify characteristic features of different invertebrate groups.
- Have basic understanding of the site.
- Describe the biodiversity of the reef.

Equipment

- If snorkelling - mask snorkel, fins
- If reef-walking - booties, hat and sunscreen
- Waterproof slate with pencil
- Underwater camera (if available)
- Viewing tube (if available)
- Waterproof ID guide (if available)
- ID reference books



CoralWatch

Instructions

Species ID- reefwalk or snorkel

1. Make simple drawings of the invertebrates you can find. Work as a group and choose different ones to maximise the number of species found.
2. Use the invertebrates result table to identify which area of the reef you found your creature and to make notes about colour, shape and other characteristic features.
3. Take a digital photograph for referencing the invertebrate's identification back on shore.
4. Back on shore - identify the inverts and count the number of species.
5. Compare your data results with other students.
6. Answer the following questions:
 - a. What kind of animals do you find on the reef?
 - b. How many species did you find? Can you give them common and scientific names?
 - c. Are there certain groups of invertebrates quite common in your area?
 - d. How biodiverse is your area?
 - e. Does the biodiversity change between zones?
 - f. List some of the different functions of reef invertebrates.

Teacher notes

- The reefwalk activity should be conducted on the reef flat/lagoon at low tide. To increase the amount of data collection, split the group into smaller groups. Walk from shore to the reef crest and let students make notes on any changes in habitat.
- The invertebrates result table can be printed onto waterproof paper or copied onto a slate.
- It can be useful to laminate the ID-sheets with common groups of invertebrates, and take them into the field.
- The snorkel activity should be conducted close to the reef crest/reef slope.
- If possible, do both surveys (reef-walking and snorkelling) and compare the following:
 - a. Number of different species in the lagoon found during the reef-walk versus number of species along the reef crest or reef slope during the snorkel.
 - b. Total number of a specific species (for example sea-urchin) between close to shore versus close to reefcrest.



INVERTEBRATES RESULTS TABLE

[illegible]

COMMON GROUPS OF INVERTEBRATES

Porifera and Ascidians: Sponges, Seasquirts, Salps



Chris Roelfsema

Polycarpa aurata (Sea squirt)



Chris Roelfsema

Pegea confoederata (Salp)



Ove Hoegh-Guldberg

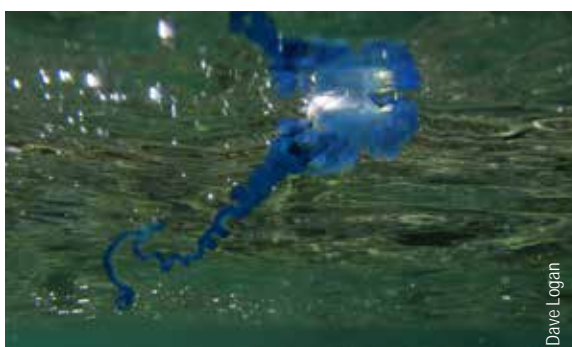
Clavelina huntsmani (Lightbulb tunicate)



Ove Hoegh-Guldberg

Didemnum vexillum (Ascidian)

Cnidarians: Jellies, Hydroids, Corals, Anemones



Dave Logan

Physalia utriculus (Blue bottle)



Craig Reid

Stomolophus meleagris (Cannonball jellyfish)



Eva McClure

Heteractis magnifica (Magnificent anemone)



Wen Sung

Reef-building corals

COMMON GROUPS OF INVERTEBRATES

Echinoderms: Sea stars, Cucumbers, Urchins



Holothuria leucospilota (Black sea cucumber)



Acanthaster planci (Crown-of-thorns sea star)



Archaster typicus (Common sea star)



Lamprometra palmata (Feather star)

Worms: Bristleworms, Nematodes, Flatworms, Lace animals



Spirobranchus spinosus (Christmas tree worm)



Phidolopora labiata (Lacy bryozoan)



Eupolymnia crassicornis (Spaghetti worms)



Thysanozoon nigropapillosum (Yellowspot flatworm)

COMMON GROUPS OF INVERTEBRATES

Molluscs: Chitons, Clams, Mussels, Oysters, Snails, Slugs, Nudibranch, Octopus, Squid, Cuttlefish



Eva McClure

Chromodoris elisabethina (Nudibranch)



Maxi Eckes

Tridacna gigas (Giant clam)



Diana Klaine

Acanthopleura granulata (Fuzzy chiton)



Chris Roelfsema

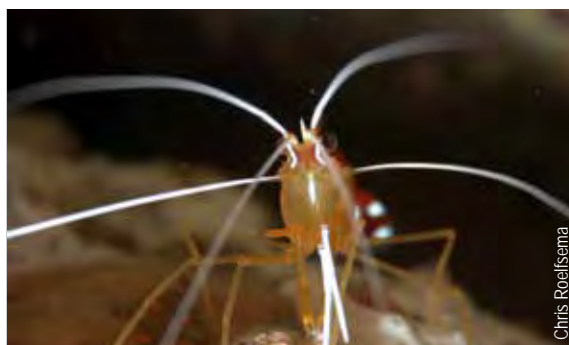
Cypraea tigris (Tiger cowrie)

Crustaceans: Copepods, Crabs, Shrimp, Lobster, Mantis shrimp, Amphipods, Isopods, Mysids, Barnacles



Roy Caldwell

Odontodactylus scyllarus (Peacock mantis shrimp)



Chris Roelfsema

Lysmata amboinensis (Cleaner shrimp)



Chris Roelfsema

Panulirus interruptus (Spiny lobster)



Chris Roelfsema

Carcinus maenas (Green crab)

Identifying Fish

Learning Objectives

At the end of this field activity, students will be able to:

- Identify a number of fish.
- Identify body parts of fish.
- Describe the biodiversity of fish on the reef.

Equipment

- Mask, snorkel, fins
- Waterproof slate with pencil
- Underwater camera (if available)
- Waterproof ID guide (if available)
- ID reference books

Instructions

1. Go snorkelling and look for fish that you are not familiar with.
2. Draw the basic shape of the animal on a waterproof slate and make notes about the colour, size and specific features.
3. If possible, take a photo.
4. Record where they occur - near a particular coral type, on the sand, in the water column, etc.
5. Estimate the approximate numbers of fish of each species you observed (e.g. 1, 2-10, 50+).
6. When you are back on shore, use fieldguides, your photos and field notes and try to identify the fish you have seen. Use the Observed Fish Table to record the scientific or common name.
7. Compare your results with the class.
8. Answer the following questions:
 - a. What fish species do you find on the reef and how can you identify them?
 - b. How many species did you find?
 - c. Are there certain groups of fish that were common in your area?
 - d. Did you observe a difference in the number of fish species (or types of fish) in each zone?
 - e. List 3 ways that fish help to keep reef ecosystems healthy.

Teacher notes

- It can be useful to laminate the ID-sheets with common groups of fish, and take them into the field.

Common reef fish families

Phylum	Chordata
Class	Osteichthyes
Order	Perciformes

Families



Pomacentridae (Damselfish)



Labridae (Wrasses)



Chaetodontidae (Butterflyfish)



Pomacanthidae (Angelfish)



Apogonidae (Cardinalfish)



Serranidae (Groupers, Basslets)



Scaridae (Parrotfish)



Acanthuridae (Surgeonfish)



Blenniidae (Blennies)



Gobiidae (Gobies)



Lutjanidae (Snappers)

CoralWatch

OBSERVED FISH TABLE

[illegible]

COMMON GROUPS OF REEF FISH

Disk-shaped/Colourful: Butterflyfish, Angelfish, Spadefish



Pygoplites diacanthus (Regal Angelfish)



Chaetodon mertensii (Merten's Butterflyfish)

Ovals: Butterflyfish, Angelfish, Spadefish



Acanthurus nigricans (Goldrim Surgeonfish)



Chromis flavapicis (Yellowtipped Damselfish)

Sloping heads/Tapered bodies: Snappers, Coral Breams, Emperors



Lethrinus miniatus (Redthroat or trumpet Emperor)



Scolopsis lineatus (Lined Bream)

Silvery: Jacks, Barracudas, Tunas, Needlefish, Mulletts, Flagtails, Grunters



Sphyaena jello (Pickhandle Barracuda)



Haemulon sciurus (Bluestriped Grunt)

COMMON GROUPS OF REEF FISH

Slender/colourful: Fusiliers, Anthias



Caesio Teres (Blue and Yellow Fusilier)



Pseudanthias dispar (Peach fairy basslet)

Heavy bodies/large lips: Groupers, Soapfish, Hawkfish, Sweetlips



Plectorhinchus lineatus (Diagonal Banded Sweetlip)

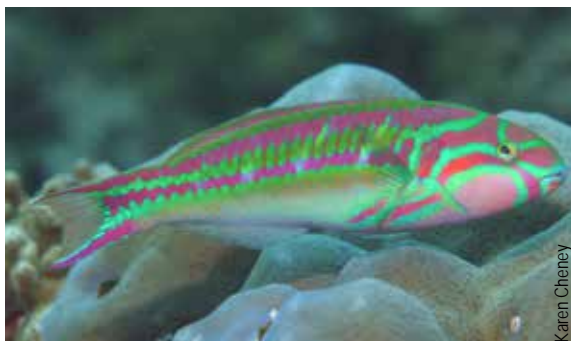


Parupeneus crassilabris (Thicklipped Goatfish)

Swim with pectoral fins: Parrotfish, Wrasses



Scarus ghobban (Blue Barred Parrotfish)



Thalassoma quinquevittatum (Fivestripe Wrasse)

Reddish/Big Eyes: Soldierfish, Squirrelfish, Bigeyes



Myripristis kuntzei (Blackbar Soldierfish)



Priacanthus hamrur (Moontail Bigeye)

COMMON GROUPS OF REEF FISH

Elongate sand and bottom dwellers: Dartfish, Lizardfish, Jawfish, Dragonets



Synodus variegatus (Reef Lizardfish)



Nemateleotris magnifica (Fire dartfish)

Odd-shaped bottom dwellers: Frogfish, Batfish, Gurnards, Scorpionfish, Stonefish, Flounders



Pterois volitans (Common Lionfish)



Scorpaenopsis venosa (Raggy Scorpionfish)

Small, elongate bottom dwellers: Gobies, Blennies



Ecsenius fourmanoiri (Fourmanoir's Blenny)



Salarias fasciatus (Jewelled Blenny)

Odd-shaped swimmers Boxfish, Goatfish,

Trumpetfish, Sweepers, Puffers, Molas, Filefish, Remoras



Aulostomus chinensis (Trumpetfish)



Ostracion meleagris (Spotted Boxfish)

COMMON GROUPS OF REEF FISH

Eels: Morays, Snake Eels, Conger eels, Garden Eels



Rhinomuraena quaesita (Ribbon Moray)



Gymnothorax fimbriatus (Darkspotted Moray)

Pipefish and Seahorses: Ghost Pipefish, Seahorse, Pipefish



Hippocampus bargibanti (Pygmy Seahorse)



Doryrhamphus pessuliferus (Orange-banded Pipefish)

Sharks, Rays:

Wobbegongs, Bamboo Sharks, Cat Sharks, Whale Sharks, Zebra Sharks, Hammerhead Sharks, Guitarfish, Coffin Rays, Stingrays, Eagle Rays, Cownose Rays, Manta Rays



Manta birostris (Manta Ray)



Triaenodon obesus (White Tip Reef Shark)



Pastinachus sephen (Cowtail Stingray)



Orectolobus maculatus (Spotted Wobbegong)

Estimating Coral Cover

Learning Objectives

At the end of this field activity, students will be able to:

- Estimate coral percentage cover within a transect.
- Estimate coral percentage cover for the reef.

Equipment

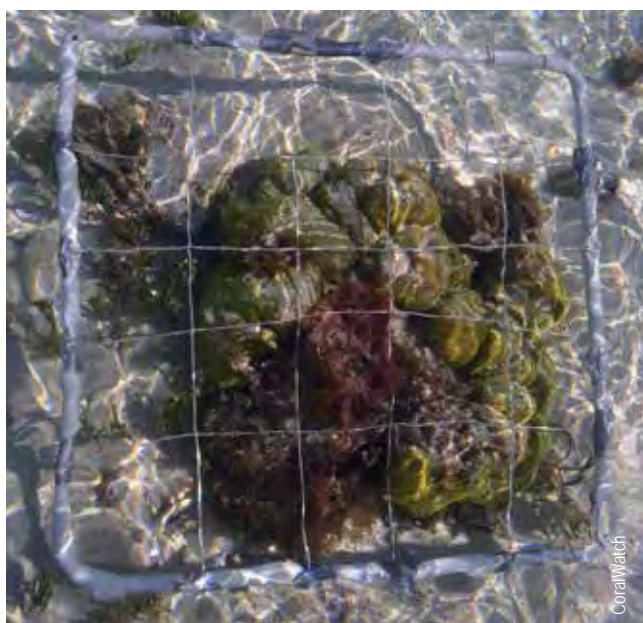
- Booties, hat and sunscreen
- Waterproof slate or paper with pencil
- Underwater camera (if available)
- Viewing tube (if available)
- Waterproof ID guide (if available)
- Quadrat

Instructions

1. Start from the shore and work towards the reef crest.
2. Place your quadrat randomly.
3. Calculate the percentage of coral, algae and sand/rock within the quadrat.
4. Plot your results in a bar graph. Don't forget to label each axes.
5. Discuss your results.
 - a. Is there more coral cover towards the reef crest?
 - b. What is the size of area you covered? (estimate if you don't have an exact figure)
 - c. Based on your results, estimate the coral cover of the lagoon. Was the area you measured similar to other areas of the lagoon? Or did your area have more (or less) coral than the rest of the lagoon?
6. Answer the following questions:
 - a. How can you estimate coral cover using a quadrat?
 - b. Does the coral cover change when you move from shore to reef crest?
 - c. How can you estimate the overall coral cover of your area?

Teacher notes

- *This activity should be conducted on the reef flat at low tide.*
- *The percentage cover of hard coral is one indicator of reef health.*
- *You can also use this exercise to practice recognising algae, invertebrates, hard corals and rock.*



Identifying Threats

Learning Objectives

At the end of this field activity, students will be able to:

- Identify different impacts that may be present on the reef.
- Identify threats that are not directly visible.
- Give an overview of the local regulations and level of protection.

Equipment

- Mask, snorkel, fins
- Waterproof slate with pencil
- Underwater camera (if available)
- Internet access



Instructions

1. Copy the Local Impact Table onto a waterproof slate.
2. While snorkelling, identify threats by ticking the box each time you see evidence of that threat affecting the reef. Take photos if you can.
Some threats might not be visible but you know they exist. You may observe indirect evidence of their effects (e.g. damaged coral from a cyclone).
3. Compare your results with rest of the class.
3. Answer the following questions:
 - a. Which threats did you observe affecting this reef?
 - b. Do you observe indirect evidence of any threats? Provide details.
 - c. Suggest strategies that individuals or organisations can implement to reduce the impact of these threats.
 - d. Is your area part of a marine park?
 - e. If so, are there regulations in place to minimise impact?

Teacher notes

- *Students should do additional research to find if the area is part of a marine park and if there are any regulations in place.*






LOCAL IMPACTS TABLE

Observer(s): _____

Location: _____

Date: _____

Weather conditions: windy / calm / cloudy / sunny _____

	Threat	Tick box (every time noticed)
 Chris Roelsetma	Pollution	
 Angela Dean	Invasive species: Crown of Thorns	
 Diana Kleine	Coral Bleaching	
 Ove Hoegh-Guldberg	Algal overgrowth	
 CoralWatch	Damaged coral	
	other	
	other	

Identifying Coral Type

using the Coral Health Chart

Learning Objectives

At the end of this field activity, students will be able to:

- Select coral types in the field.
- Identify coral types used by the Coral Health Chart.
- Identify invertebrates living around corals.

Equipment

- Booties, hat and sunscreen
- Waterproof slate or paper with pencil
- Underwater camera (if available)
- Viewing tube (if available)
- Waterproof ID guide (if available)
- ID reference books

Instructions

CoralWatch



soft (SO)



boulder (BO)



branching (BR)



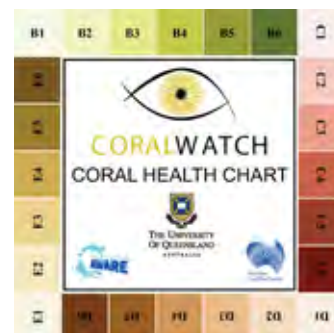
plate(PL)

The Coral Health Chart uses four coral types to classify corals. **Branching** refers to any branching coral, such as Acropora species. **Boulder** refers to any massive or rounded corals, such as some Platygyra and Porites species. **Plate** refers to any coral that forms a plate-like shape, such as tabular Acropora species, and the **soft** category refers to corals lacking a hard skeleton.

1. Copy the coral type template on a waterproof slate.
2. Locate a colony of coral, observe it and record what type it is.
Use the types described on the Coral Health Chart.
3. Sketch the coral.
4. List any marine organisms that you observe near the coral.
5. Answer the following questions:
 - a. Are there mainly soft or hard corals in your local area?
 - b. In which zone do most corals appear to be?
 - c. What is the most common coral growth form?
 - d. What is the most common species of coral?

Teacher notes

- This activity should be conducted in the lagoon at low tide.
- Because identifying coral species is very difficult, CoralWatch classifies coral types according to easily identified groups. For this purpose, coral types are described by the overall shape ('growth form') of coral colonies. There are hundreds of different coral species, each with unique shapes and colours. Sometimes the colour or shape may not clearly match the options on the Coral Health Chart. If it is difficult to select a colour or coral type, simply record the closest type. If a particular coral is too difficult to classify, just skip this coral and move on to the next one.
- CoralWatch would classify most free living, encrusting and foliaceous corals as plates.
- CoralWatch would classify most digitate corals as branching.



CORAL TYPES	
<div>Branching</div> <div>Marine life sighted</div>	<div>Boulder</div> <div>Marine life sighted</div>
<div>Plate</div> <div>Marine life sighted</div>	<div>Soft</div> <div>Marine life sighted</div>

CORAL GROWTH FORMS

Free living



Fungiidae sp.



Fungiidae sp.

Digitate



Pocillopora sp.

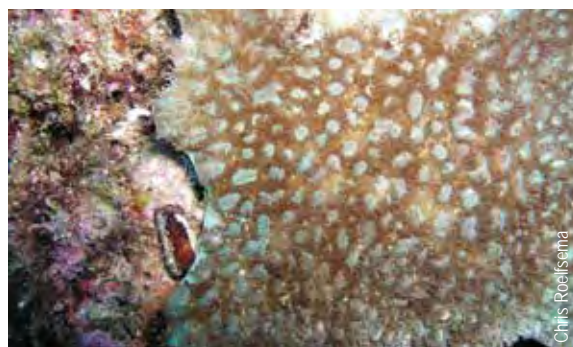


Stylophora sp.

Encrusting



Goniastrea sp.



Hydnophora sp.

Soft



Lobophytum sp.



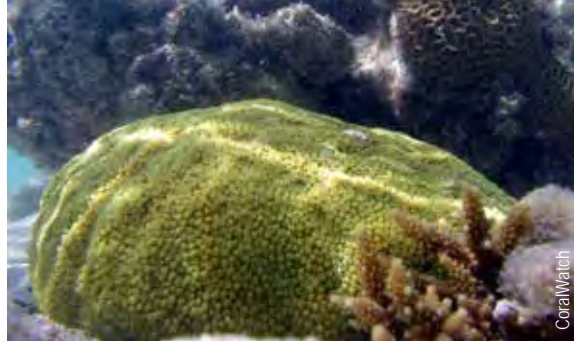
Sarcophyton sp.

CORAL GROWTH FORMS

Boulder (Massive)



Platygyra sp.



Porites sp.

Plate



Acropora sp.



Acropora sp.

Branching



Acropora sp.



Acropora sp.

Foliaceous



Turbinaria sp.



Pavona sp.

Measuring Coral Health using transects

Learning Objectives

At the end of this field activity, students will be able to:

- Monitor the health of corals using the Coral Health Chart.
- Use a transect line as research technique.

Equipment

- If snorkelling - mask snorkel, fins
- If reefwalking - booties, hat and sunscreen
- Waterproof DATA slate (see picture) with pencil
- Underwater camera (if available)
- Viewing tube (if available)
- Do It Yourself leaflet
- Coral Health Chart
- Thermometer
- GPS (if available)

Instructions

1. Read the instructions on the back of the Coral Health Chart.
2. Make sure you have all your equipment as listed above.
3. Start with recording survey details on your data slate: name, date, time, GPS (if possible), water temperature, depth, activity and conditions.
4. Follow the instructions on the chart and aim to collect data for 20 different colonies using a transect tape.
5. Lay out a tape measure or string with measurements marked on it. To decide what intervals to use on the transect tape you should consider the coral cover in your area. With high coral density you could collect data every half a meter, meter or with low density it might be best to take 2 meter intervals.
6. Swim or walk along the tape, and record data every 50 cm (depending on coral cover).



Teacher notes

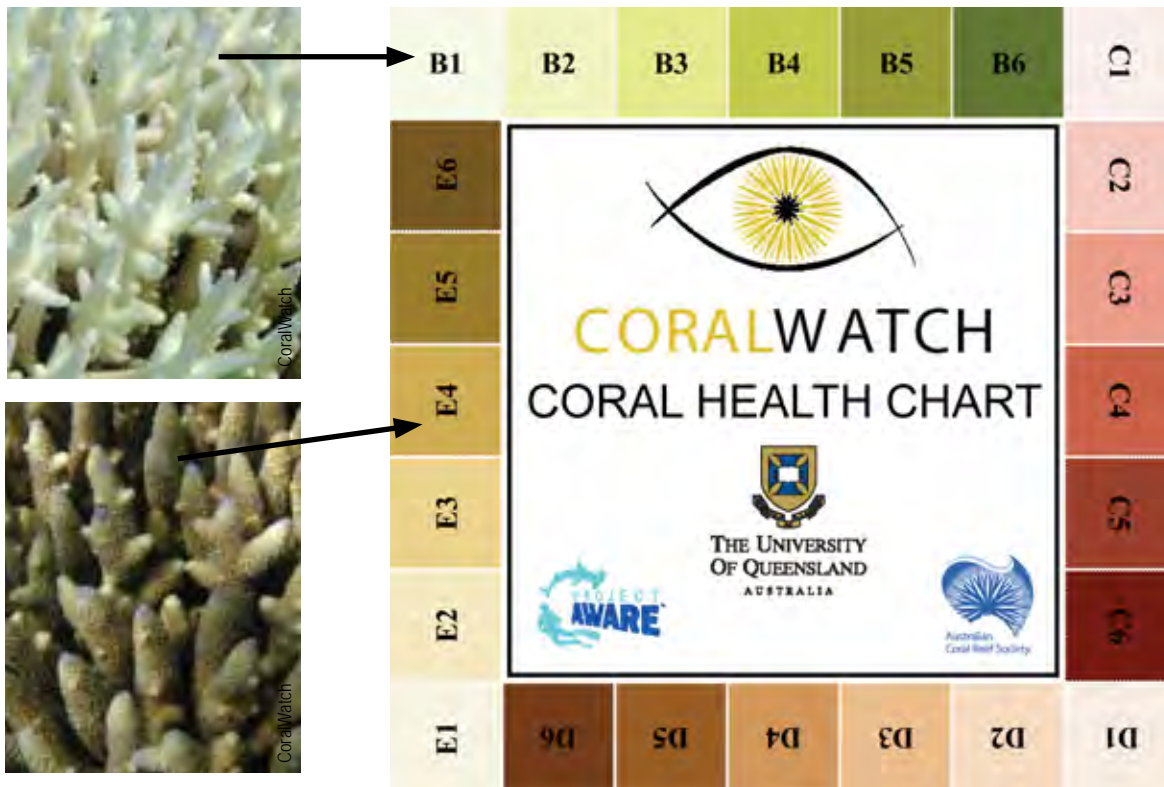
- The CoralWatch Virtual Reef Activity is useful preparation for using the Coral Health Chart in the field.
- The CoralWatch data slates contains all required survey details. You can also create your own data slates by transcribing all the information onto a blank slate. Make sure you don't miss any details!
- The distance along the transect line between measurements can vary depending on coral cover. If there is no coral underneath the assigned reading, students can pick the closest coral colony.
- Ensure students don't damage the coral as they lay out the tape.
- For future reference, students could mark the start and end of your transect using GPS coordinates.

Reef name and country:		CORALWATCH	
Your name:		CORAL TYPE (please tick)	
Date and time:		Branching	Boulder
GPS:		Plate	Soft
(if possible)			
Depth:			
m / feet			
Sea temp:			
°C / °F			
Sunny / cloudy / raining			
Walking / snorkelling / diving			
(please circle)			
Enter all your data online at			
WWW.CORALWATCH.ORG			
Your data is important to us!			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			

Example of CoralWatch data slate. You can create your own as long as you make note of all details.

The Coral Health Chart

The colour charts are based on the actual colours of bleached and healthy corals. Each colour square corresponds to a concentration of symbionts contained in the coral tissue. The concentration of symbionts is directly linked to the health of the coral.



Instructions - Using the Coral Health Chart

1. Choose a random coral.
2. Look down at the coral and select the lightest area, avoiding the tip of branching corals.
3. Hold the colour chart next to the selected area.
4. Rotate chart until you find the closest colour match.
5. Record the matching colour code along with coral type on the data sheet.
6. Repeat steps 2 to 5 for the darkest area of the coral.
7. Continue survey with other corals.
8. When you finish, transcribe your collected data to the website data sheet www.coralwatch.org and submit.

Survey Methods

The Coral Health Chart can be used while diving, snorkelling or reef-walking. You can choose one of three monitoring methods depending upon your skills, experience and location:

Random Survey – select corals randomly, such as choosing the coral closest to you every second fin kick or when you are reefwalking measure your steps.

Transect Survey – select your corals by following a line (transect) and record colour scores every few meters. Make sure that the transect has no affect on marine life.

Easily Identified Corals – select corals that you can easily identify and return to.

Coral types



soft (SO)



boulder (BO)



branching (BR)



plate(PL)

DATA SHEET

Group name: _____ Your name: _____

Email address: _____

Participation field: dive centre / scientist / environmental / school or university / tourist

Country of reef: _____ Reef name: _____

GPS if possible: _____ Depth _____ m / feet Sea temp: _____ °C

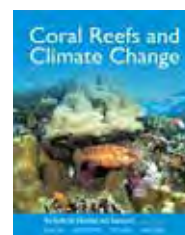
Date of survey: _____ / _____ / _____ Time collected: (ie. 14:00 or 2pm) _____
Day Month Year

Weather: sunny / cloudy / raining Your activity: reef walking / snorkelling / diving

***Please note: data will not be accepted on the website if any of these fields are left blank**

Coral Number	Colour Code		Coral Type			
	L=Lightest D=Darkest		Br=Branching Pl=Plate	Bo=Boulder	So=Soft	
example	L: D2	D: E5	Br	Bo	Pl	So
1	L:	D:	Br	Bo	Pl	So
2	L:	D:	Br	Bo	Pl	So
3	L:	D:	Br	Bo	Pl	So
4	L:	D:	Br	Bo	Pl	So
5	L:	D:	Br	Bo	Pl	So
6	L:	D:	Br	Bo	Pl	So
7	L:	D:	Br	Bo	Pl	So
8	L:	D:	Br	Bo	Pl	So
9	L:	D:	Br	Bo	Pl	So
10	L:	D:	Br	Bo	Pl	So
11	L:	D:	Br	Bo	Pl	So
12	L:	D:	Br	Bo	Pl	So
13	L:	D:	Br	Bo	Pl	So
14	L:	D:	Br	Bo	Pl	So
15	L:	D:	Br	Bo	Pl	So
16	L:	D:	Br	Bo	Pl	So
17	L:	D:	Br	Bo	Pl	So
18	L:	D:	Br	Bo	Pl	So
19	L:	D:	Br	Bo	Pl	So
20	L:	D:	Br	Bo	Pl	So

Check out these resources...



Reid, C., Marshall, J., Logan, D.,
Kleine, D. (2012)
**Coral Reefs and Climate
Change: the guide for
education and awareness.**
CoralWatch, The University of
Queensland, Brisbane, Australia.

Siebeck, U.E., Marshall,
N.J., Kluter, A. and
Hoegh-Guldberg, O. (2006)
Coral Reefs 25(3):453-460

Any other relevant information, e.g. average diving depth, species of coral, pollution, long term weather such as drought, flood, heat-wave.

Please enter your data directly onto the CoralWatch website www.coralwatch.org

Or use one of the following options if you don't have web access:

1. email: info@coralwatch.org
2. mail: CoralWatch, Queensland Brain Institute, The University of Queensland, Brisbane, QLD 4072 Australia

Thank you very much for participating! Check our website for survey results and global bleaching trends.

TIPS FOR MONITORING

For best data results and safe survey practices please use the following tips.

Collect data from 20 different coral colonies



CoralWatch

Be careful - avoid touching marine life



CoralWatch

Stay together as a buddy team



CoralWatch

Corals are fragile - please don't touch



CoralWatch

Use a GPS for accuracy



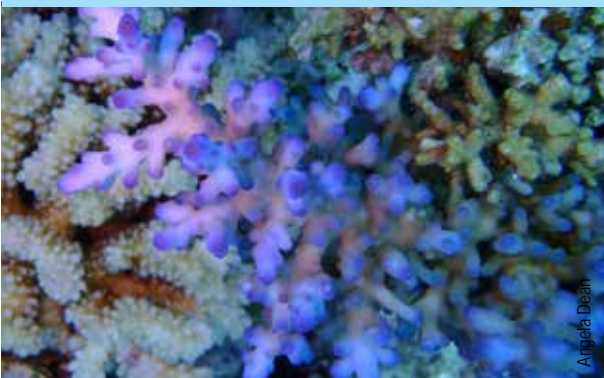
CoralWatch

Use a torch when diving below 5m/15 feet



Chris Roelfsema

Do not monitor blue corals



Angela Dean

Blue corals bleach differently to other corals.

Don't measure the tips of corals



Craig Reid

Growing tips are naturally pale.

Measuring Coral Health

using random surveys



Learning Objectives

At the end of this field activity, students will be able to:

- Monitor the health of corals using the Coral Health Chart while performing a random survey.

Equipment

- If snorkelling - mask snorkel, fins
- If reef-walking - booties, hat and sunscreen
- Waterproof DATA slate (see picture) with pencil
- Coral Health Chart
- Thermometer
- Underwater camera (if available)
- Viewing tube (if available)
- GPS (if available)

Reef name and country: _____

Your name: _____

Date and time: _____

GPS: _____

Depth: _____

Sea temp: _____

Sunny / cloudy / raining: _____

Walking / snorkelling / diving: _____

Enter all your data online at: WWW.CORALWATCH.ORG

Your data is important to us!

Coral No.	COLOUR CODE		CORAL TYPE (please tick)			
	Lightest	Darkest	Bleaching	Branch	Plate	Soft
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						

Example of CoralWatch data slate.

Instructions

The most important part of a random survey is that it is truly random - don't pick the corals you like or choose them because they are bleached.

1. Choose how often you will measure a coral colony (e.g. every 6 steps or 2 fin-kicks).
2. Begin in a clear direction drawing an imaginary line in your direction of travel.
3. Every 2 fin-kicks, measure the colour scores and coral type of the coral colony closest to you.
4. Repeat this for at least 20 corals.

Teacher notes

- This activity can be conducted snorkelling or reef-walking.
- The CoralWatch Virtual Reef Activity is useful preparation for using the Coral Health Chart in the field.
- The CoralWatch data slates contains all required survey details. You can also create your own data slates by transcribing all the information onto a blank slate. Make sure you don't miss any details!
- Use the same tips for monitoring and instructions for the use of the Coral Health Chart from Exercise 6.



This reef walker has chosen to survey a coral every 6 steps (or 2 metres). You can choose to survey your corals closer together or further apart - as long as the distance you choose is consistent throughout the survey.

Establishing a Permanent Transect

Learning Objectives

At the end of this field activity, students will be able to:

- To identify corals that are easy to recognise and suitable for future monitoring.
- Take GPS co-ordinates for future reference.
- Take photos and measurements for future reference.

Equipment

- Booties, hat and sunscreen
- Waterproof slate with pencil
- Waterproof DATA slate (see picture) with pencil
- Underwater camera (if available)
- Viewing tube (if available)
- Waterproof ID guide (if available)
- GPS (if available)
- ID reference books
- Computer

Instructions

Look for corals that you could recognise easily again when you revisit the site. They stand out from others because of their special features, such as their size, colour or shape. You can use them to set up a permanent transect, allowing you to monitor these specific corals over time.

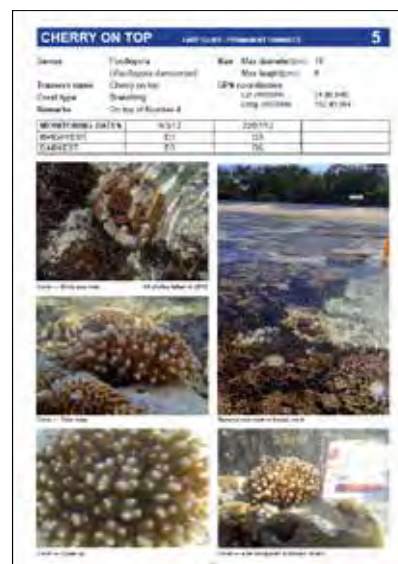
1. Find an easy to identify coral.
2. Take a GPS coordinate of the coral.
3. Identify the coral type.
4. Measure coral health score.
5. If possible, identify the coral genus or species, and list the scientific and common names.
6. Take photos: general overview to locate the coral, closeup, side view, top view, and one with the chart to give an indication of size.
7. Measure the size of the coral.
8. Record all information in an Excel sheet.

Teacher notes

- *This activity should be conducted on the reef flat at low tide.*
- *Allowing students to select their favourite coral colony and choose a name can make this a fun activity for students.*
- *CoralWatch has established two permanent transects, located on Heron and Lady Elliot Island.*
Help us to collect more data. Visit www.coralwatch.org/web/guest/education-materials to download:
 - 'Heron Island Workbook' (PDF) and 'Permanent Transect data entry Heron Island individual corals' (Excel)
 - 'Lady Elliot Kit' (PDF) and 'Permanent Transect data entry Lady Elliot Island individual corals' (Excel)*Excel sheets and individual coral ID pages can also be used as a template for your own transect, see next page.*



When you take photos take one with the chart to provide an easy reference to size.

[illegible]

Entering Data using Excel

Learning Objectives

At the end of this session, students will be able to:

- To enter their data into an Excel spreadsheet.
- To analyse their own data.
- To learn more about the excel program.

Equipment

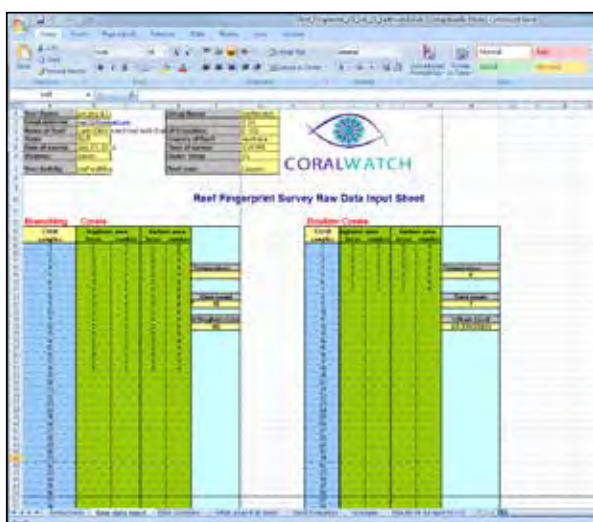
- Computer, with Microsoft Excel installed
- 'Reef Fingerprint 100' template (this can be downloaded at the CoralWath website: www.coralwatch.org/web/guest/monitoring-materials)
- Your field data

Instructions

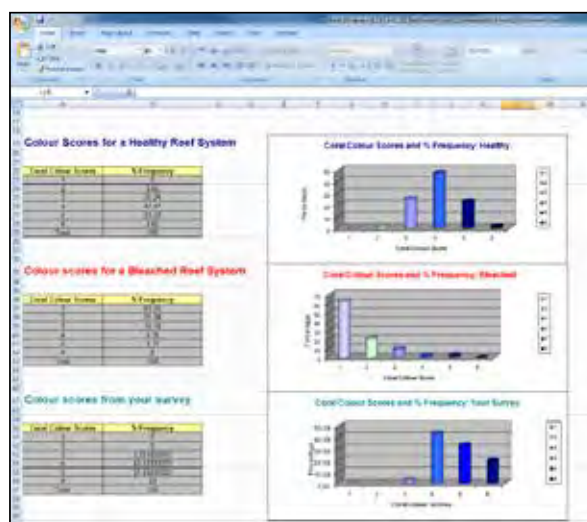
1. Open the 'Reef Fingerprint 100 Template'.
2. Go to 'Raw Data Input' tab:
 - Record name, email, date and time, water temp, reef zone, activity and weather conditions
 - Record brightest and darkest colour scores for each coral that you sampled.
3. Go to 'Data Summary' tab and look at the results from your survey.
4. Go to 'Reef Evaluation' tab and compare your results with the examples of healthy and bleached reef. Do your results indicate a healthy or more bleached reef?

Teacher notes

- *This tool does not send the data to our online bleaching database. If you have collected real data from the field, please enter it online, as described in the next activity.*
- *This tool is also suitable for entering practice data recorded as part of the Virtual Reef Activity.*



Example of the raw data input sheet.



The reef evaluation will enable you to compare your survey with a healthy versus bleached reef.

Entering Data using www.coralwatch.org

Learning Objectives

At the end of this session, students will be able to:

- Enter data into the CoralWatch online database.
- To compare their own data with existing data (if applicable).
- To analyse and understand what the results mean for the reef you surveyed or other sites nearby.

Equipment

- Computer
- Internet access
- Your field data

Instructions

1. Go to www.coralwatch.org
2. Go to enter data and sign in to submit a survey.
You have to become a member to be able to enter data. Membership is free.
3. Enter all your details from your datasheet and submit.
4. If you don't have GPS coordinates you can find your location on the map.
5. Enter all data records and look at your results.
6. Compare the data you collected to:
 - a. Past data on the same reef (if available)
 - b. A nearby reef.

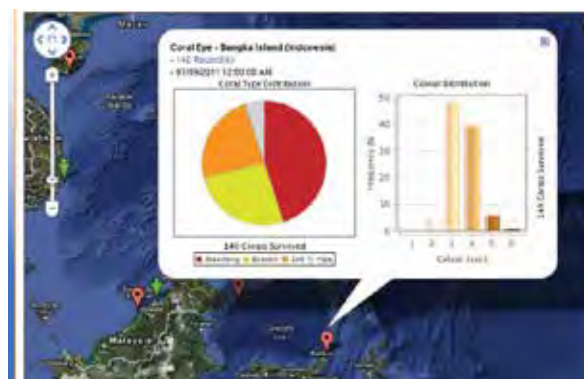
Teacher notes

- Point out the importance of entering real data.
Entering survey data into the online CoralWatch database ensures that the data can be used by scientists studying coral bleaching and reef managers.



CoralWatch website allows you to view all the data recorded for a particular reef.

Example of the 'add new survey' page.



Example of the survey result.

Assignments

Protect Healthy Reefs for the Future

Assignment 1 - Extended research response (multimodal)

For this assignment, create a 'pitch' about the need for reef protection. Your target audience could be a member of parliament, a local interest group, or a group of people who have never seen a reef. In your response consider the interests of your audience and how you can best address these. How can you convince your audience that reefs are important for their lives and for Australia. Your background research behind this presentation will need to be presented in an actual report.

Assignment objectives

Students will learn to:

- Explain why reef systems are vulnerable.
- To investigate issues and problems facing marine environments.
- Collect and evaluate primary data to support presentation.
- Justify recommendations about reef issues and problems.
- Communicate using language conventions to suit audiences and purposes.

Background

In many fields the task of bringing an idea to someone with the power to do something with it is called a pitch. In this case you want to convince a big group of people - most audiences will be living away from the reef - that they need to get involved with reef protection.

Tips

- Saying more in fewer words is the key to holding people's attention.
- Add photographs or illustrations to reinforce your words. What kind of images will best capture the audience?
- You can capture images (and sounds if possible) during your field trip that will best convey the key message.
- You could choose to focus on one particular amazing thing in the environment, maybe an endangered species.
- Practice speaking it out loud with another person.

Assignment instructions

- Step 1: Formulate and refine your idea. What is the issue, the key message?
- Step 2: Select an audience you would like to speak to (be creative, a bike club, students in another country, unemployed people, celebrities, the super wealthy). Identify the sort of language and images that will be appropriate for this audience.
- Step 3: Write a few sentences using language relevant to your audience. Begin with your most meaningful statement. Make sure it is something you truly believe and it is something the audience will care about. Think of what has shaped your views and make a locally relevant example. They could include natural events, visit to places, conversations, books eg. Include specific facts and end with a memorable concluding remark.
- Step 4: Research what your target group could do in their local environment, what sustainable activities could they undertake? Are there any citizen science project that they can get involved with?
- Step 5: Write a script with suggested images to accompany the words. Think of images you will be able to create or photos you could take in your local area.
- Step 6: What is the main outcome you wish to achieve?
- Step 7: Transfer your idea into a number of power point slides suitable for the length of your presentation. (Year 11: 3-5 minutes, Year 12: 5-7 minutes). A good rule of thumb is no more than 2 slides per minute. Remember that this is a multi-modal response, so use at least 2 modes (e.g. visual and spoken).

An example

- | | |
|---------|--|
| Slide 1 | Introduce the key message that you would like to share. Make a clear statement. |
| Slide 2 | Relevance to your audience (Importance of reefs). |
| Slide 3 | Facts and figures to back up your statement. |
| Slide 4 | Free slide for additional facts or information. |
| Slide 5 | Suggest actions that need to be taken. Use local examples where possible, and highlight ways your audience can contribute. |
| Slide 6 | Use a slogan to reinforce your key message. |

- Step 8 Present your pitch in class.

Health Assessment

Assignment 2 - Specialised extended research response: Action Research

Imagine that a development proposal has been submitted to conduct a development in the area of your field trip. This development proposal aims to construct one of the following:

- A harbour to expand on tourism or industry.
- A canal estate and remove all the mangroves.
- Another issue of your choice that will have impact on the environment (check topic with teacher).

Your job as an environmental consultant is to conduct an environmental assessment, collect and analyse field data and write an Environmental Impact Statement.

Assignment objectives

Students will learn to:

- Identify reef benefits for various stakeholders.
- Analyse issues and environmental problems relevant to marine environments.
- Develop a research question, and a research plan for data collection.
- Evaluate suitability of different research methods, such as use of transects or quadrats.
- Analyse and interpret data and other marine information.
- Apply research findings to the development proposal and make recommendations.

Background

An environmental assessment plan provides information about the assessment of the environment and its resilience to changes. There are various stages in how to conduct an environmental assessment.

1. Screening - Preliminary assessment of impacts to decide if a full report is needed. Many environmental scientists will not actually participate in the screening process, as scientists will often be approached after a developer has decided that they need an environmental assessment in order for development to proceed.

2. Public consultation and participation - Public involvement (public meetings; calls for submissions or surveys.)

3. Scoping - The process by which the key issues and concerns of interested parties (stakeholders) are identified

4. Collection and analysis of information - This includes carrying out baseline studies, identifying potential impacts of a development, proposing project alternatives and considering the views and concerns of the public. This is the most time consuming part.

5. Reporting the findings of the study - Your actual report, the Environmental Impact Statement

Assignment instructions

The screening process (No.1) and public consultation (No.2) has taken place and an environmental assessment is needed. Start with:

(no. 3) **The Scoping study.** Part of this can be done before visiting the fieldsite. Identify who benefits from this reef?

Does this reef provide income for people? Why are stakeholders concerned? What is the main issue?

Interviewing stakeholders can be done through roleplay in class.

(No. 4) **The collection and analysis of information.** This will be conducted during the fieldtrip. Marine research skills will be used to enter marine environments under study to gain an appreciation of or a perspective on the environment that will help the investigation. Students will investigate the biodiversity of the area, existing threats to the area, coral cover, coral health chart data. This also includes reading papers, reports and online information available about your fieldsite.

(No. 5) **Reporting the findings of the study.** Use your field data, research findings and knowledge to write your environmental impact statement.

See next page for outline

Use the following outline to write your Environmental Impact Statement.

Your name and class
Title and subtitle	This needs to include the name of your location, species that will be mostly impacted and the reason why. Example 'Moreton Bay, corals covered in sediment due to port expansion'.
Introduction	Introduce your environmental issue and why you are concerned
Chapter 1	Brief General Site description including <ul style="list-style-type: none">- a map of the area- stakeholders identified- existing beneficiaries of the reef
Chapter 2	Overall health of the area Describe indicators of reef health: e.g. coral cover, numbers of fish species found, numbers of invertebrate species
Chapter 3	Existing impacts on the reef Describe the presence of any observed impacts e.g. coral bleaching, pollution
Chapter 4	Proposed development Effects of development When this development is being constructed, what type of changes to the ecosystem would occur? When this development is finished, What types of effects would it have on the ecosystem?
Recommendations	Suggesting ways to minimise the impact Keep this brief.
Summary	Summarise your findings and clearly state why this development should not happen
Appendices	Field data
References	A list of references and sources of information used in the report should be included in this section. These may include (e.g. video evidence, photographs, blog entries, journals, written or spoken peer and teacher observations/checklists).

Reef in Decline

Assignment 3 - Extended response to stimulus

Read the following scientific article: *The 27-year decline of coral cover on the Great Barrier Reef and its causes*. De'ath G, Fabricius KE, Sweatman H, Puotinen M (2012). *The 27-year decline of coral cover on the Great Barrier Reef and its causes*. www.scienceinpublic.com.au/wp-content/uploads/Full-PNAS-paper-for-publication.pdf

Explain the findings of this study and address the following questions:

1. What does this research tell us about the health of reefs worldwide?
2. How have reefs changed over time?
3. Which areas of the Great Barrier Reef have exhibited the largest decline?
4. Which areas have exhibited the least decline?
5. Selecting one area of the reef, what factors have contributed to the observed decline?
6. How do these factors affect reef organisms?
7. What other factors are expected to influence health of the Great Barrier Reef in the future?

Assignment objectives

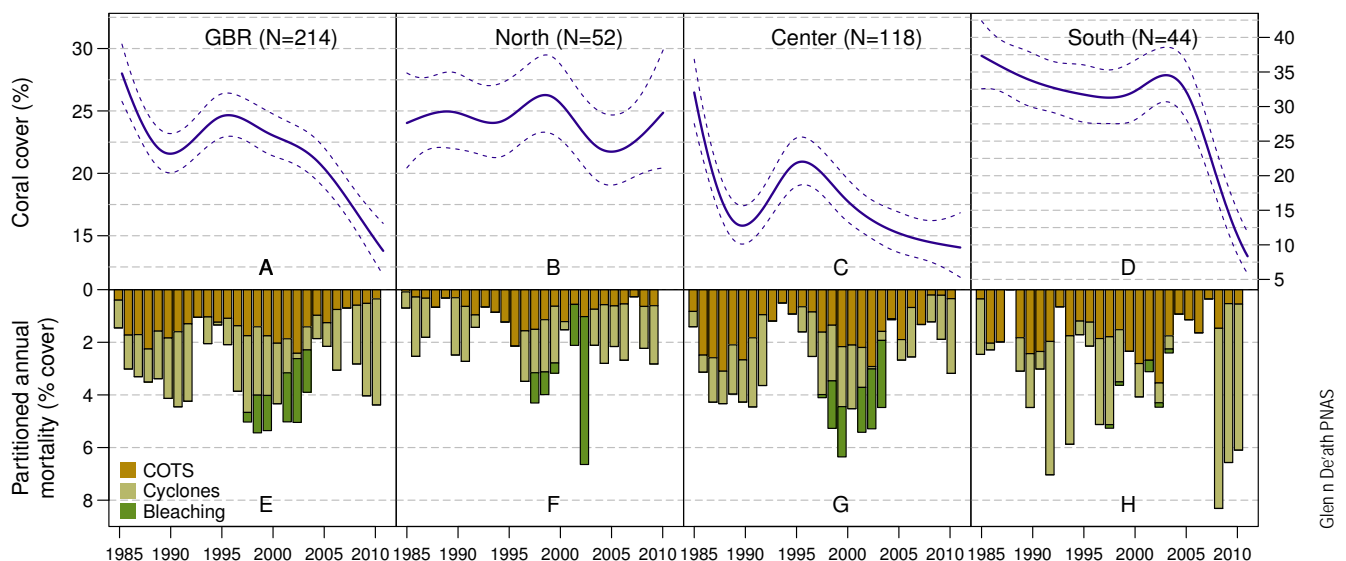
Students will learn to:

- Explain why reef systems are in decline.
- To investigate issues and problems facing the Great Barrier Reef.
- Understand coral cover and summarise the findings of the accompanying research paper.
- Report on the health of the Great Barrier Reef.

Background

One important way to assess the health of coral reefs is to measure how much of an area is actually covered by hard corals. This measurement is called 'coral cover'. The amount of coral cover is influenced by rates of reproduction, growth and mortality. When corals reproduce less, grow more slowly or die more frequently, coral cover declines. Scientists around the world are identifying how coral cover is changing in response to local and global stressors.

The Great Barrier Reef is one of the best-managed reefs in the world. However, long term monitoring by the Australian Institute of Marine Science shows that the Great Barrier Reef is also exhibiting significant loss of coral cover. Between 1985 and 2012, coral cover over 214 sites has reduced from 28% to 14%. Most of this decline has occurred since 1998. Like the decline in the Caribbean, some regions were more affected than others. Key contributors to coral mortality were cyclones (48%), outbreaks of crown-of-thorns sea star (42%) and coral bleaching (10%).



Glen n De'ath PNAS

Temporal trends in coral cover (A–D) and annual mortality due to COTS, cyclones, and bleaching (E–H) for the whole GBR and the northern, central, and southern regions over the period 1985–2012 (N, number of reefs). (A–D) Trends in coral cover, with blue lines indicating estimated means (± 2 SEs) of each trend. (E–H) Composite bars indicate the estimated mean coral mortality for each year, and the sub-bars indicate the relative mortality due to COTS, cyclones, and bleaching. The periods of decline of coral cover in A–D reflect the high losses shown in E–H.

Assignment Instructions

Use your previous findings and answers to the questions and follow this outline to complete your report.

Your name and class

Title: Reefs in Decline

Chapter 1: Introduce the issues related to declining reefs around the world
What does this research tell us about the health of reefs worldwide?
How have reefs changed over time?

Chapter 2: Health of the Great Barrier Reef
Summarise the findings of the accompanying research paper and copy the figures into your report
Which areas of the Great Barrier Reef have exhibited the largest decline?
Which areas have exhibited the least decline?

Chapter 3: Causes of declining reef health
Choose a section of the Great Barrier Reef that is described in this paper, and describe the main factors that have contributed to the observed decline.
Explain how these factors influence reef organisms
What other factors are expected to influence health of the Great Barrier Reef in the future?

Summary: Summary your findings and the key issues presented

References: Provide a list of references and information sources that you used to assist in writing your report.

Reef Management

Assignment 4 - Extended research response

Formulate an argument for or against the following statement

'An area where no one is allowed to visit is worth less than a place you are allowed to go'.

Assignment objectives

Students will learn to:

- Investigate management strategies to improve reef health.
- Evaluate the effect of human impacts on reef health.
- Evaluate economic and natural benefits of healthy reefs for local communities and visitors.
- Analyse the relative costs and benefits of human visitation to coral reefs.

Background

Reducing human impacts on the marine environment is an important part of marine conservation. Marine management involves making decisions and acting to reduce overfishing, protect coastal zones, improve land-use practices, and reduce pollution. These practices improve the health of our reefs and oceans. Marine managers have no control over global problems of increased temperatures and changing ocean chemistry. But they can suggest, influence and enforce the conditions necessary to ensure the long-term survival of the ecosystems they are assigned to protect. Marine management requires more than just science to identify solutions. A vital component of effective reef management is working with people and communities, promoting sustainable behaviours and attitudes.

Marine management can make a big difference to our reefs. However, there are some things that can improve management outcomes. Effective governance is essential – from the collection of marine park entry fees to enforcing fishing restrictions.

How we manage our marine resources into the future has implications that go far beyond the conservation of an ecosystem. Healthy reefs provide food, shelter, income, and social stability for hundreds of millions of people. The decline of these ecosystems compromises that stability.

Assignment instructions

Choose a reef close to you or of interest to you. You will need to research this reef in order to find data to support your position. When formulating your opinion, think about the diverse values of reefs - including those which are easy to place a monetary value on, and those that are difficult to place a monetary value on.

Consider the following questions. The answers will help you to write your argumentative essay.

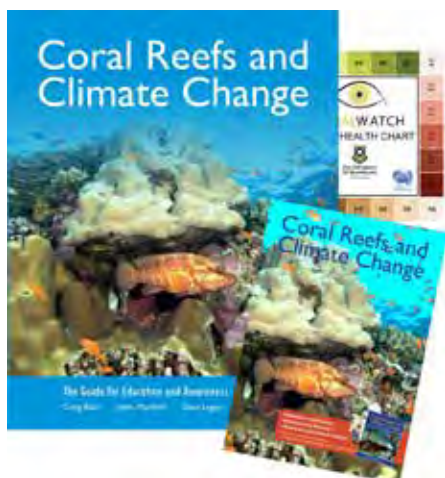
- Is your reef part of a marine park?
- Is your reef currently protected?
- Who are the stakeholders?
- What regulations are in place for users?
- What is the economic value of your area?
- If the area would be closed for all users, who would be disadvantaged?
- Is there much impact on your reef?
- Would your reef be better off without visitors?
- Would it help if reef visitors have to pay towards conservation and management (if any), each time they visit?

In your essay, introduce the key issues, and then describe each issue, providing evidence or arguments to support your position. After you have presented and argued each issue, provide a summary of your main argument, reinforcing your key messages.

References

CoralWatch Resources

Available from www.coralwatch.org



Coral Reefs and Climate Change Series Book and Educational Video

CoralWatch - Ultimate Teaching Package

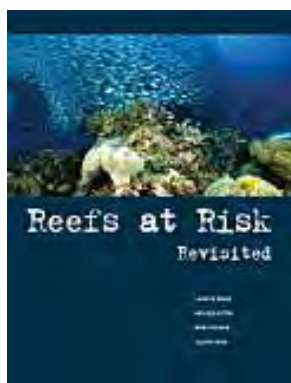


CoralWatch Do It Yourself Kit



CoralWatch - Virtual Reef materials

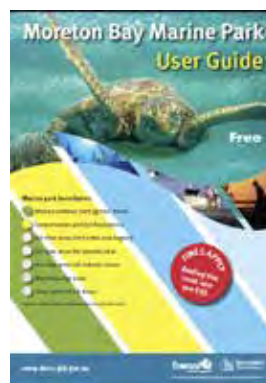
Reports - available for downloading



Reefs at Risk Revisited



Great Barrier Reef Outlook Report



Moreton Bay Marine Park User Guide



Valuing the Effects of Great Barrier Reef Bleaching

Books

- Allen GR and Steene R (1994) Indo-Pacific Coral Reef Field Guide. Tropical Reef Research, Singapore
- Allen et al. (2003) Reef Fish Identification - Tropical Pacific
- Duke N (2006) Australia's Mangroves. The University of Queensland, Brisbane
- Gosliner TM, Behrens DW and Williams GC (1996) Coral Reef Animals of the Indo-Pacific. Monterey, California: Sea Challengers
- Reid, C., Marshall, N. J., Logan, D. and Kleine D. (2012, 2nd edition) Coral Reefs and Climate Change; The guide for education and awareness. CoralWatch, The University of Queensland, Brisbane. 264 p.
- Veron JEN (2000) Corals of the World. Australian Institute of Marine Science and CRR QLD Pty Ltd, Townsville
- Waycott et al. (2004) A Guide to Tropical Seagrasses of the Indo-West Pacific. James Cook University, Townsville

Papers

- Siebeck UE, Marshall NJ, Kluter A, Hoegh-Guldberg O. (2006). Monitoring coral bleaching using a colour reference card. Coral Reefs. 25:453-460.

Articles and reports

- Burke L, Reynter K, Spalding M, Perry A. (2011) Reefs at Risk Revisited, World Resources Institute, Washington DC. www.wri.org/publication/reefs-at-risk-revisited
- Burke L, Selig E, Spalding M. (2002). Reefs at Risk in Southeast Asia. World Resources Institute, Washington DC. www.wri.org/publication/reefs-risk-southeast-asia
- Edwards AJ (2010). Reef Rehabilitation Manual. Coral Reef Targeted Research & Capacity Building for Management Program. Australia. www.gefcoral.org/LinkClick.aspx?fileticket=IR6CCRCqVtM%3d&tabid=3260
- Hill J, Wilkinson C (2004). Methods for Ecological Monitoring of Coral Reefs- A resource for managers. Australian Institute of Marine Science. www.icran.org/pdf/Methods_Ecological_Monitoring.pdf
- Hoegh-Guldberg O, et al. The Coral Triangle and Climate Change – Ecosystems, People and Societies at Risk. WWF Australia and The University of Queensland www.worldwildlife.org/what/wherewework/coraltriangle/WWFBinaryitem12250.pdf

Reports

- IPCC Fourth Assessment Report: Climate Change 2007 section on Sea Surface Temperature: www.ipcc.ch/publications_and_data/ar4/wg1/en/ch3s3-2-2-3.html
- Valuing the Effects of Great Barrier Reef Bleaching www.barrierreef.org/GBRF/media/Our-Projects/Oxford/GBRF_OxfordReport_Final_WEB.pdf
- Moreton Bay Marine Park User Guide www.nprsr.qld.gov.au/parks/moreton-bay/zoning/pdf/marine-park-user-guide.pdf
- Great Barrier Reef Outlook Report www.gbrmpa.gov.au/__data/assets/pdf_file/0018/3843/OutlookReport_Full.pdf

Websites

- Coral Triangle Initiative: www.cti-secretariat.net
- CoralWatch: www.coralwatch.org
- Great Barrier Reef Marine Park Authority: www.gbrmpa.gov.au
- FishBase: A Global Information System on Fishes: www.fishbase.org
- Mangrove Watch: www.marine.uq.edu.au/marbot/
- National Oceanic and Atmospheric Administration NOAA: www.noaa.gov
- Project AWARE: www.projectaware.org
- Reefball: www.reefball.org
- Reefbase: www.reefbase.org
- ReefCheck: www.reefcheck.org
- Seagrass Watch: www.seagrasswatch.org
- The Nature Conservancy: www.nature.org
- The University of Queensland: www.uq.edu.au
- World Wide Fund for Nature (WWF): www.panda.org/coraltriangle



What is CoralWatch?

CoralWatch integrates coral reef education and global reef monitoring. Using the Coral Health Chart volunteers from around the globe can monitor reefs and contribute to our global coral bleaching database.

CoralWatch promotes healthy reefs by:

- Raising public awareness about importance of reefs, conservation, sustainability, and climate change
- Developing and distributing education materials for diverse audiences
- Engaging the global community in monitoring coral health and coral bleaching



(Left to right) Justin Marshall (project leader), Diana Kleine (project manager), Angela Dean (project manager), Alex Coughlan (volunteer), Craig Reid (author) and Dave Logan (author).

Support CoralWatch

Did you know that corals are the second most endangered species group on the planet? There is a real need to protect reefs worldwide. Since 2002, volunteers in more than 70 countries have been using the Coral Health Chart to monitor reefs in their local area.

CoralWatch needs your support to engage people in reef conservation. Your gift will support our global network of volunteers and help distribute reef education materials to communities around the world. Help promote healthy reefs by supporting CoralWatch. You can make your tax-deductable donation online. Please visit www.coralwatch.org

Volunteers worldwide help collect valuable data. The majority of data is collected by schools and dive centres.



Act Now

for the future of our reefs



www.coralwatch.org



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