Marine Ecosystems

CORALWATCH

SCIENCE YEAR 7 LESSONS AND RESOURCES

Classification - Food Webs - Rhythm and Flow - Water Cycles

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

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This lessons set accompanies the book and DVD:
- 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, The University of Queensland, Brisbane. ISBN: 9780646579429

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CORALWATCH

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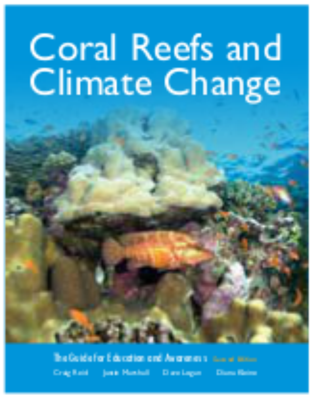
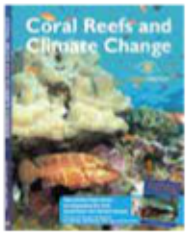
How to use

These lessons and resources are developed by CoralWatch at The University of Queensland for Grade 7 Science. All lessons and activities are linked to the Australian Curriculum v8.3. Apart from the science understanding for chemical science - this workbook could cover most of year 7 Science (see page 6-7).

CoralWatch has used the Coral Health Chart to promote active learning opportunities for citizen scientists of all ages since 2002. The content of this lesson plan extends beyond monitoring, and provides worksheets to bring reef science into the classroom. Each lesson relates to chapters in the education guide and DVD series, *'Coral Reefs and Climate Change – The Guide for Education and Awareness'* published by CoralWatch. The Virtual Reef tools provide a real opportunity to learn about coral reefs, 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. However, we encourage you to take students in the field since this is be the most valuable and intense experience learning about our beautiful coral reefs.



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



Coral Reefs and Climate Change DVD.

This lessons are not only for Australian teachers - they can be used with any group of students or adult learners. All CoralWatch materials can be ordered from CoralWatch (www.coralwatch.org).

Structure

This booklet contains 4 sections:

Classification, Food Web, Rhythm and Flow, and The Water Cycle.

Coral Health Chart.

Each section contains:

Content descriptions

Include the curriculum links to the three strands of science understanding, science inquiry skills and science as a human endeavour.

Key to general and cross-curriculum capabilities

Each lesson and worksheet identifies which capabilities are incorporated within learning area content.

Learning objectives

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

Succes criteria

The succes criteria help teachers to decide whether their students have achieved the learning objectives.

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.

Worksheets

The worksheets can be printed and used in the field or classroom.

Answer keys

Answer keys for the teachers are provided for all worksheets.

Assignment

Students will be reporting on environmental health, using coral as an indicator species in the assignment task provided at the end.

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. 2006. Monitoring coral bleaching using a colour reference card. Coral Reefs 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 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.

Why we need your help?
Very little is known about coral bleaching trends on a global scale. Monitoring is most effective when conducted regularly. There are not enough scientists to monitor all the world's reefs and 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 and recovery, and the severity and extend of coral bleaching. All data is publicly available and forms a great resource for education and student projects.

CoralWatch has developed various education materials aiming to create a better understanding of coral reefs and how we can help to save them. Teaching about coral reef ecosystems in the classroom will create curiosity and wonder under students. Getting a better understanding of coral reefs helps changing behavioural attitudes and move towards a more sustainable world.

To find out more, visit [WWW.CORALWATCH.ORG.](http://www.coralwatch.org)

Contents

	content descriptions	CLASSIFICATION			FOODWEBS							RHYTHM AND FLOW				
		C1	C2	C3	FW1	FW2	FW3	FW4	FW5	FW6	FW7	RF1	RF2	RF3	RF4	RF5
SCIENCE UNDERSTANDING	ACSSU111	X	X	X												
	ACSSU112				X	X	X	X	X	X	X					
	ACSSU115												X	X	X	X
	ACSSU116															
	ACSSU117											X		X		
SCIENCE INQUIRY SKILLS	ACSIS124	X	X	X	X	X	X	X	X	X	X		X		X	
	ACSIS125	X	X		X	X	X	X	X	X						
	ACSIS126		X					X	X	X			X			
	ACSIS127															
	ACSIS128															
	ACSIS129	X	X		X	X	X	X	X	X	X		X			
	ACSIS130	X	X		X	X	X	X	X	X	X		X			
	ACSIS131	X	X		X	X	X	X	X	X						
	ACSIS132	X	X		X	X	X	X	X	X	X				X	
	ACSIS133	X	X		X	X	X	X	X	X	X		X			
SCIENCE AS HUMAN ENDEAVOUR	ACSHE119	X	X		X	X	X	X	X	X		X	X	X	X	
	ACSHE120															
	ACSHE121															
	ACSHE122															
	ACSHE223	X	X		X	X	X	X	X	X	X				X	
GENERAL CAPABILITIES	Literacy	X	X	X	X	X	X	X	X	X	X		X	X	X	X
	Numeracy									X			X		X	
	ICT capability									X		X	X	X	X	
	Critical and creative thinking	X	X		X	X	X	X	X	X	X	X	X	X	X	
	Personal and social capability	X	X		X	X	X	X	X		X					
	Ethical understanding			X				X	X							
	Intercultural understanding	X	X		X	X	X	X			X					
CROSS-CURRICULUM	Aboriginal and Torres Strait Islander histories										X					
	Asia and Australia's engagement with Asia															
	Sustainability	X	X	X	X	X	X	X	X		X					

WATER CYCLE							FIELDCOMPONENT											ASSIGN-MENT
WC1	WC2	WC3	WC4	WC5	WC6	WC7	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	
		x					x	x	x	x	x							
x	x		x	x	x							x	x	x	x	x	x	x
						x			x	x		x	x	x	x	x	x	x
							x	x	x	x	x	x	x	x	x	x	x	x
				x					x	x	x	x	x	x	x	x	x	x
									x	x					x	x	x	x
				x					x	x					x	x	x	x
				x					x	x				x	x	x	x	x
									x	x					x	x	x	x
				x					x	x								x
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					x				x	x	x	x	x	x	x	x	x	x
x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
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			x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
									x	x								
			x		x	x		x	x	x	x	x	x	x	x	x	x	x

General capabilities

General capabilities are a key dimension of the Australian Curriculum. They encompass knowledge, skills, behaviours and dispositions that, together with curriculum content in each learning area and the cross-curriculum priorities, will assist students to live and work successfully in the twenty-first century. They play a significant role in realising the goals set out in the Melbourne Declaration on Educational Goals for Young Australians (MCEETYA) 2008 that all young people in Australia should be supported to become successful learners, confident and creative individuals, and active and informed citizens.

The Australian Curriculum includes seven general capabilities. These are:

- Literacy
- Numeracy
- Information and communication technology capability
- Critical and creative thinking
- Personal and social capability
- Ethical understanding
- Intercultural understanding.

Cross-curriculum priorities

The Australian Curriculum is designed to meet the needs of students by delivering a relevant, contemporary and engaging curriculum that builds on the educational goals of the Melbourne Declaration. The Melbourne Declaration identified three key areas that need to be addressed for the benefit of both individuals and Australia as a whole. In the Australian Curriculum these have become priorities that provide students with the tools and language to engage with and better understand their world at a range of levels. The priorities provide dimensions which will enrich the curriculum through development of considered and focused content that fits naturally within learning areas. They enable the delivery of learning area content at the same time as developing knowledge, understanding and skills relating to Aboriginal and Torres Strait Islander histories and cultures, Asia and Australia's engagement with Asia or Sustainability. Incorporation of the priorities will encourage conversations between learning areas and between students, teachers and the wider community.

Cross-curriculum priorities are addressed through learning areas and are identified wherever they are developed or applied in content descriptions. They are also identified where they offer opportunities to add depth and richness to student learning in content elaborations. They will have a strong but varying presence depending on their relevance to the learning area.

- Aboriginal and Torres Strait Islander histories and cultures
- Asia and Australia's engagement with Asia
- Sustainability

Source: http://www.acara.edu.au

Classification

Identification of marine organisms (ACSSU111)

The following lessons developed by CoralWatch focus on classification within the marine environment. There are 3 classroom worksheets and 5 recommended CoralWatch field activities. All of them can be used as stand-alone lessons or as a sequence. Curriculum links are provided for all lessons as well as extra resources, background information and answer key to all acitivities.

Classification classroom worksheets

C1 Observable features of organisms and dichotomous keys
C2 Classifying corals using a dichotomous key
C3 Identifying coral types

Recommended CoralWatch field activities

1. Dangerous marine animals
2. Exploring and identifying invertebrates
3. Food webs – Intertidal rocky shores
4. Food webs – Intertidal coral reefs
5. Identifying coral type using the Coral Health Chart

CONTENT DESCRIPTIONS

Science understanding

Classification helps organise the diverse group of organisms (ACSSU111)

Science inquiry skills

- Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS124)
- Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS125)
- Measure and control variables, select equipment appropriate to the task and collect data with accuracy (ACSIS126)
- Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate (ACSIS129)
- Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence (ACSIS130)
- Reflect on scientific investigations including evaluating the quality of the data collected, and identifying improvements (ACSIS131)
- Use scientific knowledge and findings from investigations to evaluate claims based on evidence (ACSIS132)
- Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS133)

Science as a human endeavour

- Scientific knowledge has changed peoples' understanding of the world and is refined as new evidence becomes available (ACSHE119)
- Science knowledge can develop through collaboration across the disciplines of science and contributions of people from a range of cultures (ACSHE223)

Key

General capabilities & Cross-curriculum priorities addressed within these worksheets include:

- Literacy
- Critical and creative thinking
- Personal and social capabilities
- Ethical understanding
- Intercultural understanding
- Sustainability

Learning Objectives

Students are learning to:

- Identify observable features of an organism.
- Classify organisms into groups based on observable features.
- Explain why organisms are classified into groups to identify relationships.
- Successfully use a dichotomous key to identify an organism based on observable features.
- Construct a dichotomous key based on observable features.

Success Criteria

- Students understand the reasons for classifying such as identification and communication.
- Students can group a variety of organisms on the basis of similarities and differences in particular features.
- Students understand that as scientific knowledge has grown, biological classifications have changed over time.
- Students are able to classify using hierarchical systems such as Kingdom, Phylum, Class, Order, Family, Genus and Species.
- Students understand and are able to use scientific conventions for naming species - binomial.
- Students can use provided keys to identify organisms surveyed in a local habitat.

Background

There are more than 5 million different species of plants and animals on earth. For scientists to communicate effectively and avoid confusion when studying them, they use an universally accepted naming system called the '**Linnaean Classification System**' developed by Carolus Linnaeus in the 18th century. The Linnaean Classification System is a hierarchical system of classification of organisms based on observable features and behaviours. Today, this system includes eight taxa: domain, kingdom, phylum, class, order, family, genus and species. With the advancement in technology, scientists are using DNA discoveries to re-examine the relationships between organisms to refine the classification system. **Taxonomy** is the study of 'taxons' or names and groupings of organisms into a systematic classification reflecting evolutionary relationships. A **dichotomous key** is a simple tool that can be a used to identify unknown organisms based on mostly observable characteristic features. Dichotomous means 'divided in two parts' and the key is made up of a series of choices that leads a person to the correct identity of an unknown thing or organism.

Resources

- *Coral Reefs and Climate Change: the Guide for Education and Awareness* - recommended sections: Coral reefs - Reef-building corals, Coral growth, Fish tales, Hungry fish, Fish shapes, A crowd of invertebrates.
- *Coral Reefs and Climate Change* video series - recommended video: Coral reefs, Importance of reefs (5 min).
- Coral Finder waterproof guide and website: www.byoguides.com/coralfinder/
- Veron JEN (2000) Corals of the World. Australian Institute of Marine Science and CRR QLD Pty Ltd, Townsville.

Coral Finder.

Curriculum links - Answer key for worksheets

WORKSHEET C1

OBSERVABLE FEATURES OF ORGANISMS AND DICHOTOMOUS KEYS

ACARA curriculum links

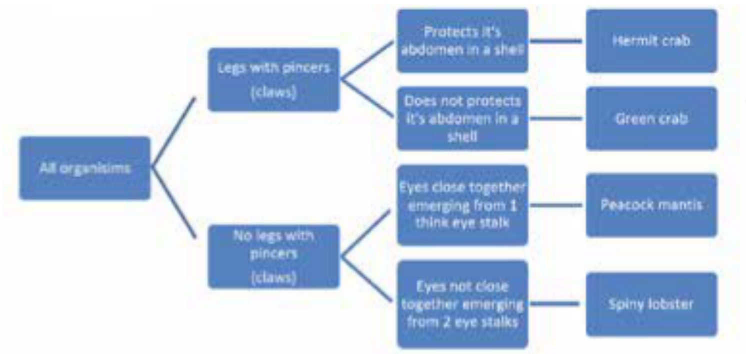
Science understanding (ACSSU111)
Science inquiry skills (ACSIS124, ACSIS125, ACSIS129, ACSIS130, ACSIS131, ACSIS132, ACSIS133)
Science as a human endeavour (ACSHE119 & ACSHE223)

Answers

1 - 5

Feature	Peacock mantis	Hermit crab	Spiny lobster	Green crab
Exoskeleton	*	*	*	*
Legs with pincers (claws)		*		*
Long abdomen	*		*	
Antennae longer than body	*		*	
Eyes close together emerging from 1 thick eyestalk	*			
Colourful	*	*	*	
Protects its abdomen in a shell		*		
Total	5	4	4	2

6 - 7



8. Dichotomous keys can be developed and used to identify all organisms on earth because each species has distinctive features that separate it from all other species.

WORKSHEET C2

CLASSIFYING CORALS USING A DICHOTOMOUS KEY

ACARA curriculum links

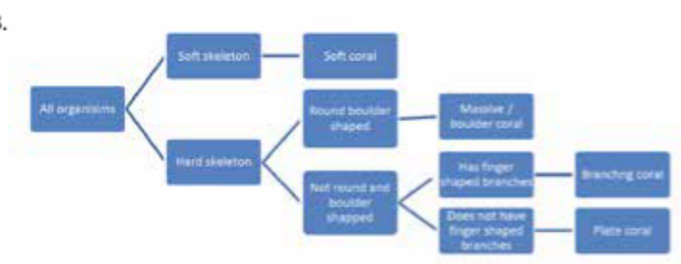
Science understanding (ACSSU111)
Science inquiry skills (ACSIS124, ACSIS125, ACSIS126, ACSIS129, ACSIS130, ACSIS131, ACSIS132, ACSIS133)
Science as a human endeavour (ACSHE119 & ACSHE223)

Answers

1 - 2

Feature	Massive / Boulder	Plate	Branching	Soft
Hard skeleton	*	*	*	
Round and boulder shaped	*			
Flat shaped		*		
Finger shaped branches			*	*
Total	2	2	2	1

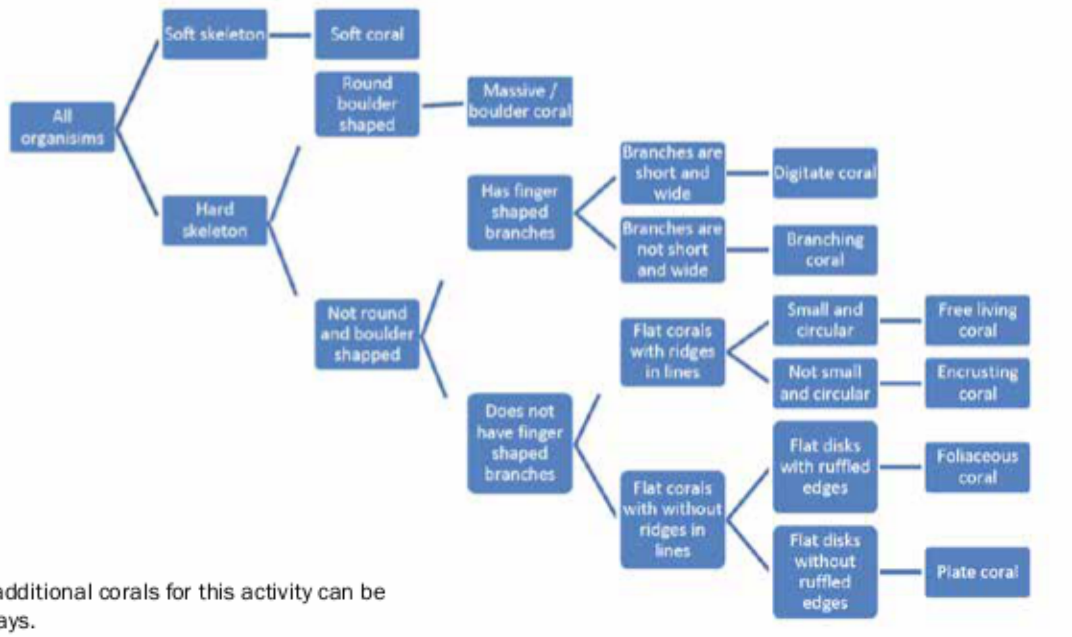
3.



4. The dichotomous key can be applied to the corals in group B but the corals are slightly different and are different species. Characters that could be added are: a. line shaped ridges on the coral, b. many flat disks with ruffled edges, c. small and circular corals, and d. short and wide branches compared to long and thin branches.

Curriculum links - Answer key for worksheets

5.



5. **Teacher note**
Access to alternate or additional corals for this activity can be achieved a variety of ways.
- Your local marine environment on a field excursion.
- Conduct a field excursion utilising an external facility e.g. Heron Island Research Station, Moreton Bay Research Station, Moreton Bay Environmental Education Centre, etc.
- Use a Virtual Reef in your classroom. Printed versions can be ordered from www.coralwatch.org
- You can find more pictures of the same families online.

6. There are many reasons why a dichotomous key can change after they are made. Dichotomous keys are subject to change when new species are included in the key. Species of plants and animals new to science are continually discovered and cause changes to various keys. Dichotomous keys written for use in a particular location require changes when a species from a different location moves into the location that the key was written for. Many organisms' features change from juvenile to adult forms (caterpillars and butterflies) or male to female forms (many species of birds have brown females and colourful males). Therefore, if a key is written for a particular organism's features, other forms of the same organism with different features may not fit the same key and produce different results.

WORKSHEET C3
IDENTIFYING CORAL TYPES

ACARA curriculum links
Science understanding (ACSSU111)
Science inquiry skills (ACSIS124)

Answers


PLATE


BRANCHING


BOULDER


PLATE


BRANCHING


BRANCHING


BOULDER


BRANCHING


SOFT


PLATE (LIKE)


SOFT


BOULDER

Observable features of organisms and dichotomous keys

Dichotomous key

In order to classify organisms, it is important to identify features that they share with other organisms and also which are unique. Scientists use a tool called a dichotomous key to help identify organisms. A dichotomous key is a branching diagram that uses the presence or absence of characters to make a simple decision of 'yes' an organism has this feature, or 'no' it does not have this feature. This makes finding the name and description of an organism much easier.

Peacock mantis.

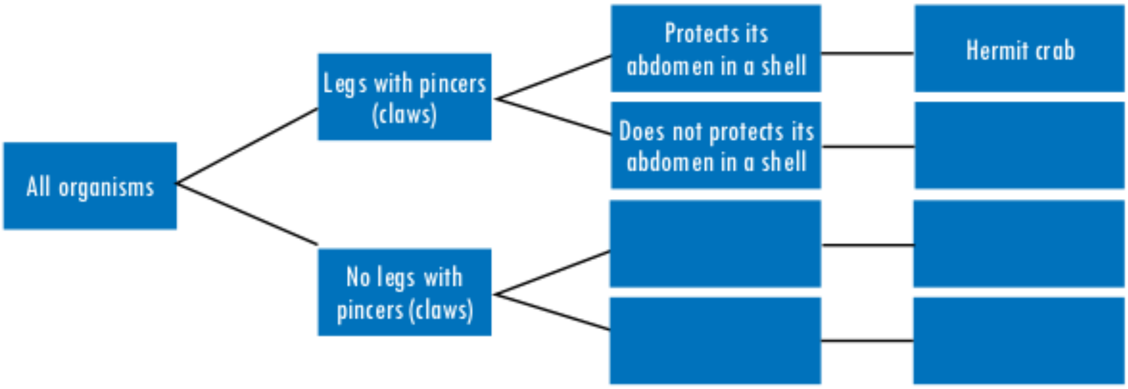
Hermit crab.

Spiny lobster.

Green crab.

Using the pictures

1. Draw a table listing all four species as column headings.
2. In groups of three, look at the first picture carefully and identify features of that organism. List all these in row headings and place a dot in each box in that row. Example headings may be 'Exoskeleton' or 'Antennae' if you see these features.
3. Once the group has listed all the features that are visible, they should look at the second picture. If the second organism has one of the characters listed, then a dot can be placed in the column of the second picture in the row of this feature. If a character is observed that wasn't on the first organism, a new row heading should be made for that feature and a dot placed in the row for the second organism.
4. Complete this for all four pictures.
5. Look at the completed table and rank the columns from highest number of dots to the lowest.
6. The numbered columns will now be used to produce a tree diagram or dichotomous key. Draw a circle on a page with the words 'all organisms' in the centre. Now go to the column where all but one organism have the same feature and use this to draw two branches from the centre circle. For example:



7. Write the name of the single organism that is identified in a new circle. Move to the column with the next highest rank and continue with the branching until all organisms species names are written in circles.
8. Discuss in a group whether this method could be used to identify all organisms on earth? Run each of the organisms through the key that you have just developed as a group to see if this system works.

Classifying corals using a dichotomous key

Group A

Massive / Boulder	Plate	Branching	Soft

Platygyra daedalea.

Acropora.

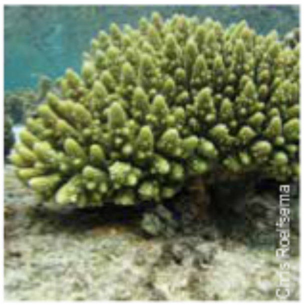
Acropora.

Gorgoniidae.

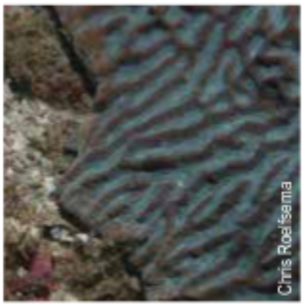
Group B

Free living	Digitate	Encrusting	Foliaceous

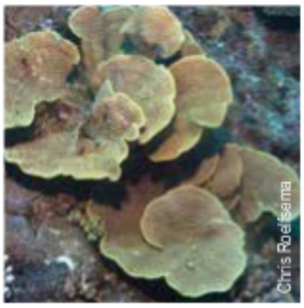
Fungiidae.



Acropora.



Goniastrea.



Turbinaria.

Questions

1. Develop a table of observable features for the corals in Group A.
2. Look at the completed table and rank the columns from highest number of dots to the lowest.
3. Now produce a tree diagram or dichotomous key as was undertaken in Worksheet C1.
4. Now apply the dichotomous key to the corals in Group B. Does this system work for all of these corals? List the characters that might also need to be added to your key to help distinguish between coral species visually?
5. In the classroom, discuss and explore any differences about the observable characters of the corals in group B or while in the field compared to when you initially developed the key in the classroom. With a greater understanding of the coral shapes and forms, would you produce a different key? As a group consolidate these ideas to produce a more accurate key based on your greater knowledge.
6. Write five to seven sentences outlining the reason why dichotomous keys might change and also whether an organism you are keying out is always going to fit into the key you have. If you think it will not, explain why?

Identifying coral types

Instructions

Corals can appear in different shapes. For each coral pictured, identify the coral type and write this underneath. Choose between boulder, branching, plate and soft - as on the CoralWatch Coral Health Chart.

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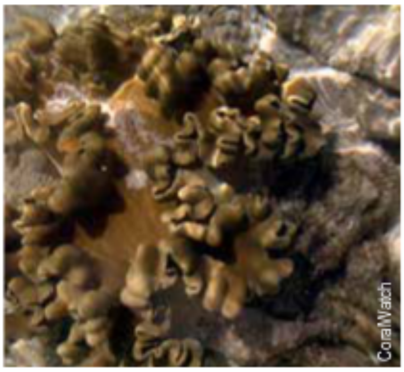

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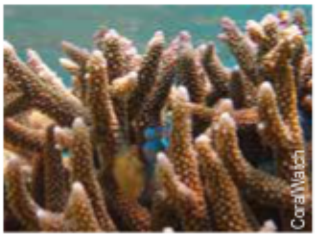
CORALWATCH MONITORING

CoralWatch uses the Coral Health Chart as a cheap, simple, non-invasive method for the monitoring of coral bleaching and the assessment of coral health.
In the field, users simply compare colours of corals with colours on the chart and record matching codes. In addition, we ask you to record the coral type.

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

Corals can exist in many shapes, and some corals may not clearly match any of these categories. Our aim is to keep the chart and survey as simple as possible, so if you're experiencing difficulties when classifying your corals, please simply choose the closest coral type.

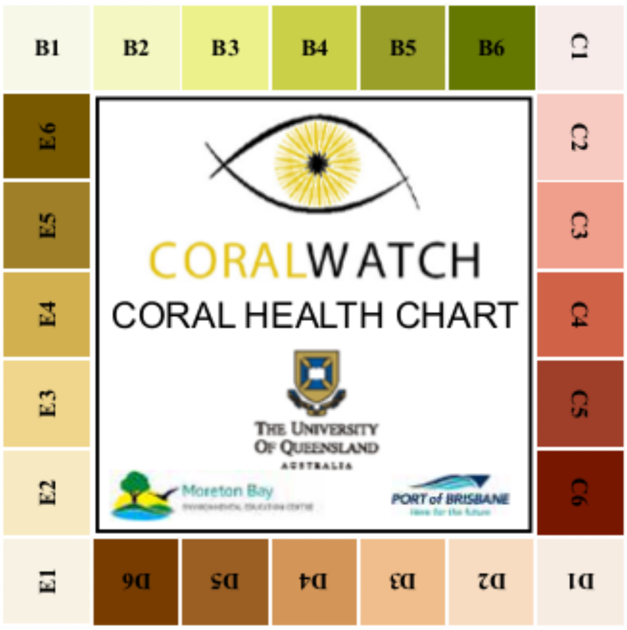


Boulder (BO)
Any massive or rounded coral, such as some Porites species.

Branching (BR)
Any branching coral, such as some Acropora species.

Plate (PL)
Any plate-like shape coral, such as tabular Acropora species.

Soft (SO)
Any corals lacking a hard skeleton, such as Sarcophyton species.



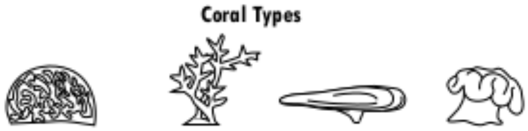
How to Use the Coral Health Chart

1. Choose a random coral and select the lightest area.
2. Rotate the chart to find the closest colour match.
3. Record the colour code on a data slate.
4. Select the darkest area of the coral and record the matching colour code.
5. Record the coral type.
6. Continue your survey with other corals. Record at least 20 corals.
7. Submit your data using the CoralWatch Data Entry Apps or enter online at www.coralwatch.org.

Survey Methods include (depending on experience and location):
- **Random Survey** – Select corals randomly, such as the closest coral after every second fin kick.
- **Transect Survey** – Select corals by following a line (transect) and record every few meters.
- **Easily Identified Corals** – Select corals you can recognise and return to (permanent transect).

Tips
- Corals are fragile animals, make sure your survey has no affect on marine life.
- Due to colour loss at depth, use a torch when diving below 5 metres/15 feet.
- Avoid measuring growing tips of branching and plate corals since they are naturally white.
- Do not monitor blue or purple corals because they have a different bleaching response.
- Some corals are naturally lighter than others. Regular surveys are needed to look at coral health over time or pick up trends of bleaching and recovery.

Coral Types



Boulder (BO) Branching (BR) Plate (PL) Soft (SO)

Instructions on how to use the Coral Health Chart can be found on the back of the chart.

Food Webs

Connections on coral reefs (ACSSU112)

The following lessons developed by CoralWatch focus on food webs and connections within the coral reef ecosystem. There are 7 classroom worksheets and 8 recommended CoralWatch field activities. All of them can be used as stand-alone lessons or as a sequence. Curriculum links are provided for all lessons as well as extra resources, background information and answer key to all acitivities.

Food web classroom worksheets

FW1 Introduction to food webs
FW2 Marine food webs
FW3 Corals: producer or consumer?
FW4 Measuring coral health using virtual reef booklets
FW5 Measuring coral health using virtual reef poster
FW6 Measuring Coral Health – Interpreting real data
FW7 Altered food webs: farming and sediment runoff

Recommended CoralWatch field activities

2. Exploring and identifying invertebrates
3. Food webs – Intertidal rocky shores
4. Food webs – Intertidal coral reefs
5. Identifying coral type using the Coral Health Chart
6. Measuring coral health using random surveys
9. Entering and analysing data using Excel
10. Entering data using www.coralwatch.org
11. Entering data using CoralWatch data entry apps

CONTENT DESCRIPTIONS

Science understanding

Interactions between organisms, including the effects of human activities can be represented by food chains and food webs (ACSSU112)

Science inquiry skills

- Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS124)
- Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS125)
- Measure and control variables, select equipment appropriate to the task and collect data with accuracy (ACSIS126)
- Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate (ACSIS129)
- Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence (ACSIS130)
- Reflect on scientific investigations including evaluating the quality of the data collected, and identifying improvements (ACSIS131)
- Use scientific knowledge and findings from investigations to evaluate claims based on evidence (CSIS132)
- Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS133)

Science as a human endeavour

- Scientific knowledge has changed peoples' understanding of the world and is refined as new evidence becomes available (ACSHE119)

Key
General capabilities & Cross-curriculum priorities addressed within these worksheets include:

Literacy	Critical and creative thinking	Intercultural understanding
Numeracy	Personal and social capabilities	Aboriginal and Torres Strait Islander histories
ICT capability	Ethical understanding	Sustainability

Learning objectives
Students are learning to understand, interpret and construct food webs in order to understand the interactions between organisms in any ecosystem.

Success criteria
- Students can use and interpret food chains to show feeding relationships in a habitat.
- Students can construct and interpret food webs to show relationships between organisms in an environment.
- Students can classify the organisms of an environment according to their position in a food chain.
- Students are able to recognise the role of microorganisms within food chains and food webs.
- Students know how to investigate the effect of human activity on local habitats, such as deforestation, agriculture or the introduction of new species.
- Students are able to explore how living things can cause changes to their environment and impact other living things, such as the effect of cane toads.
- Students can show evidence of researching human activity and how it may affect a food web.

Background
Food chains are a way that scientists use to show how food moves in an ecosystem. They show the link between one organism and the organism that eats it. This is shown in a food chain by using arrows. The head of the arrow always points to the animal doing the eating. At the start of every food chain is a **producer**. Producers are organisms that use energy from the sun and convert it into sugars that can be used as food. These sugars can be stored by the producer. Plants and algae are producers. Animals are not able to convert sunlight into sugars. However, if they eat or consume the parts of a producer that contain stored sugars, the animal is able to use this as a source of energy to sustain life. We call animals **consumers** because they need to consume a producer or another consumer in order to obtain food. Humans do not eat just one type of food (life would be very boring if we did). Instead, we eat a range of foods. Many animals are the same. To draw a food chain for animals that are food for more than one animal we sometimes need to use more than one arrow. When we do this for an **ecosystem** we are able to see many food chains link together. We call the resulting diagram a **food web.** For an example of a large food web see p119 in the book *'Coral Reefs and Climate Change'*. An important component of all food webs is that when consumers or producers die, there are organisms that break them down so that they can be recycled into the food web once again. These are known as **decomposers**. On land one decomposer we know very well is from a group of organisms known as fungi (mushrooms are a type of fungi). In the ocean, bacteria play a big role in the decomposition of dead organisms. Every living thing is eaten by something in marine ecosystems. Smaller prey are consumed by larger predators, until they, in turn, succumb to injury or disease, and are then recycled on the sea floor. Overconsumption or removal of any link in these chains will affect the pattern of the entire food web.

Resources
- *Coral Reefs and Climate Change: the Guide for Education and Awareness* - recommended sections: Coral reefs - Food webs, Coral bleaching, Reef-building corals, Coral growth.
- *Coral Reefs and Climate Change* video series - recommended video: Coral reefs, Coral bleaching (5 min), CoralWatch (5 min).

Curriculum links - Answer key for worksheets

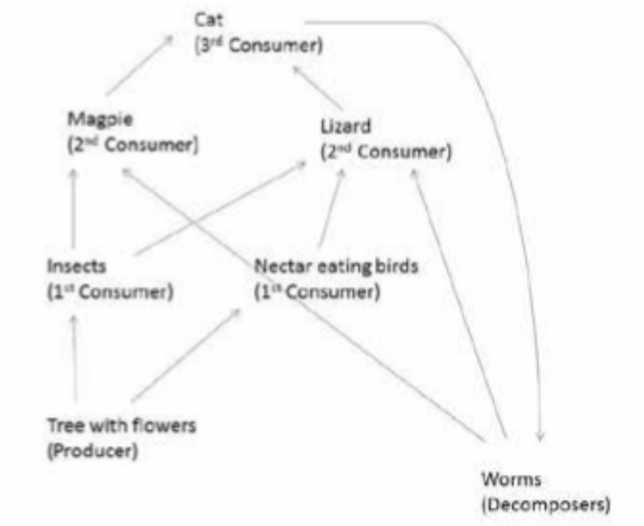
WORKSHEET FW1
INTRODUCTION TO FOOD WEBS

ACARA curriculum links

Science understanding (ACSSU112)
Science inquiry skills (ACSIS124, ACSIS125, ACSIS129, ACSIS130, ACSIS131, ACSIS132, ACSIS133)
Science as a human endeavour (ACSHE119 & ACSHE223)

Answers

1. Terrestrial and saltmarsh plants & Aquatic plants and algae
2. Insects, small fish & snail
3. Snake, crane, duck & sea eagle
4. Bacteria
5. Sun
6. A food chain shows food energy moving in one linear direction from producer to consumers where as a food web shows the complex movement of food energy from many producers interacting with many consumers in a variety of ways. A food web is a better representative of the predator/prey interactions in real-life ecosystems.
7. Sea eagle:
   Tertiary = Aquatic plants and algae – Small fish – Large fish – Sea eagle
   Quarternary = Aquatic plants and algae – Small fish – Large fish – Crane/Duck – Sea eagle
8. Crane & duck:
   Secondary = Aquatic plants and algae – Large fish – Duck
   Tertiary= Aquatic plants and algae – Small fish – Frog – Crane
9. An example only



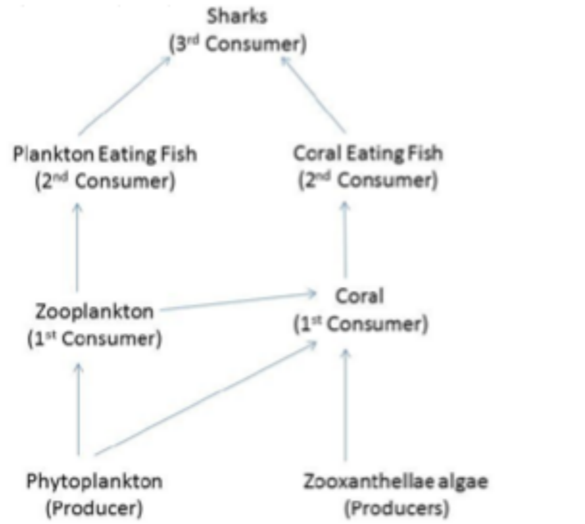
WORKSHEET FW2
MARINE FOOD WEBS

ACARA curriculum links

Science understanding (ACSSU112)
Science inquiry skills (ACSIS124, ACSIS125, ACSIS129, ACSIS130, ACSIS131, ACSIS132, ACSIS133)
Science as a human endeavour (ACSHE119 & ACSHE223)

Answers

1. Seagrass & algae
2. Turtle, damselfish & crab
3. Shark, triggerfish, octopus & damselfish
4. Bacteria
5. Seagrass – Turtle – Shark
   Algae – Damselfish – Triggerfish – Shark
   Algae – Crab – Octopus – Triggerfish – Shark
   Algae – Crab – Octopus – Shark
   Algae – Crab – Damselfish – Triggerfish – Shark
6. There would be more turtles, triggerfish and octopus. As a result of the increased numbers of turtles, triggerfish and octopus, there would be less jellyfish, seagrass, damselfish and crabs.



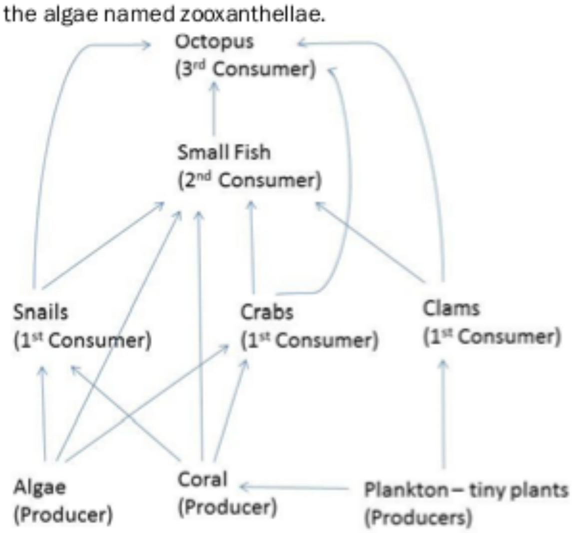
WORKSHEET FW3
CORALS: PRODUCER OR CONSUMER?

ACARA curriculum links

Science understanding (ACSSU112)
Science inquiry skills (ACSIS124, ACSIS125, ACSIS129, ACSIS130, ACSIS131, ACSIS132, ACSIS133)
Science as a human endeavour (ACSHE119 & ACSHE223)

Answers

1. The primary producer in the coral-algae relationship is the algae named zooxanthellae.
2.
3.



Curriculum links - Answer key for worksheets

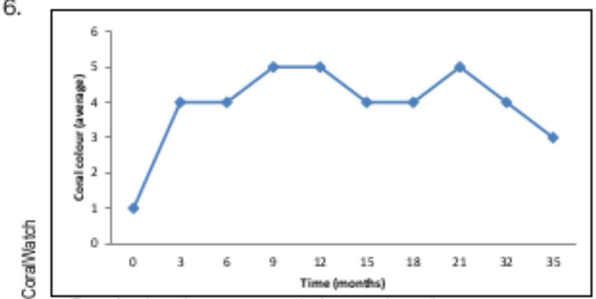
WORKSHEET FW4

MEASURING CORAL HEALTH USING VIRTUAL REEF BOOKLETS - INTERPRETING REAL DATA

ACARA curriculum links

Science understanding (ACSSU112)
Science inquiry skills (ACSIS124, ACSIS125, ACSIS126, ACSIS129, ACSIS130, ACSIS131, ACSIS132, ACSIS133)
Science as a human endeavour (ACSHE119 & ACSHE223)

Answers

1. a. three recovered no. 4, 5 and 7
   b. anytime between 4 months to years
   c. two died completely, no. 2 and 6
2. No. 1 recovered most but it took 4 months
   No.2 still not recovered after 22 months
3. No. 5
   No. 6 = Soft coral. When a soft coral dies, nothing is left behind as soft corals do not have a skeleton.
4. It took 10 months to recover.
5. Blue corals have pigments - no zooxanthellae. Colours of the chart are based on number of zooxanthellae left behind when corals stress.
6. 

Graph showing seasonal change in colour over time - coral No.7 of virtual reef booklet.

WORKSHEET FW5

MEASURING CORAL HEALTH - INTERPRETING REAL DATA USING VIRTUAL REEF POSTER

ACARA curriculum links

Science understanding (ACSSU112)
Science inquiry skills (ACSIS124, ACSIS125, ACSIS126, ACSIS129, ACSIS130, ACSIS131, ACSIS132, ACSIS133)
Science as a human endeavour (ACSHE119 & ACSHE223)

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.
Discuss in class the results which may vary slightly due to the use of photos with some shading.

WORKSHEET FW6

MEASURING CORAL HEALTH - INTERPRETING REAL DATA USING CORALWATCH DATABASE

ACARA curriculum links

Science understanding (ACSSU112)
Science inquiry skills (ACSIS124, ACSIS125, ACSIS126, ACSIS129, ACSIS130, ACSIS131, ACSIS132, ACSIS133)
Science as a human endeavour (ACSHE119 & ACSHE223)

Answers will vary, depending on the reef of choice.

WORKSHEET FW7

ALTERED FOOD WEBS: FARMING AND SEDIMENT RUNOFF

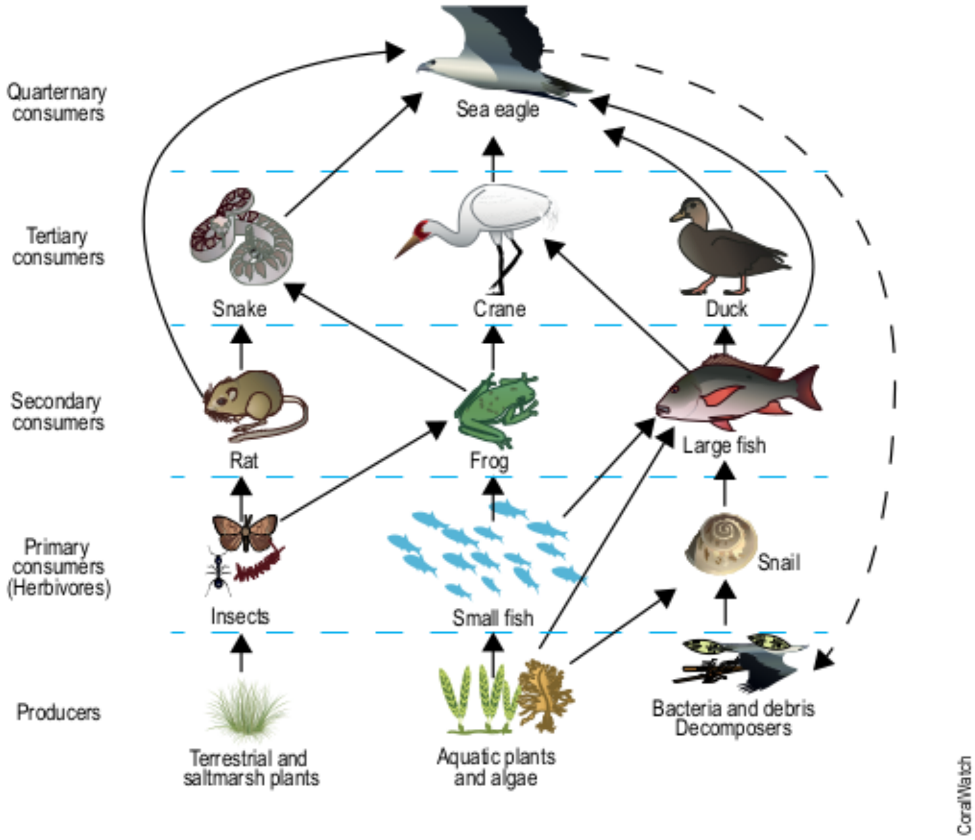
ACARA curriculum links

Science understanding (ACSSU112)
Science inquiry skills (ACSIS124, ACSIS129, ACSIS130, ACSIS132, ACSIS133)
Science as a human endeavour (ACSHE223)

Answers

1. Answer will vary per student.
2. The number of turtles, dugongs and fish would reduce because they don't have enough food to eat if the algae and coral die from the sediment. The sharks would have less food to eat due to the reduced numbers of turtles, dugongs and fish. The sharks would eat more clams than before to make up its diet. Therefore the number of plankton-eating fish would also reduce.
3. The sediment influx caused by the heavy rain and exposed soil from farming and construction has reduced the biodiversity from 8 different types of organisms to 3 types of organisms.
4. The amount of sediment entering the waterways can be reduced by various means including the following:
   a) Planting vegetation along river banks to stabilise the banks and stop the soil washing down stream in heavy rainfall. See channel erosion http://hlw.org.au/report-card/focusareas/channel-erosion and water management: https://portbris.com.au/environment/water-management
   b) Building a rain garden, see http://hlw.org.au/getinvolved/help/raingarden
   c) Construction sites stop exposed sediment from washing into drains by implementing 'Erosion & sediment control' (ESC) practices. These practices include covering exposed soil and putting sediment barriers in drains at the construction site. See http://hlw.org.au/initiatives/esc/principles
   Preventing sediment from entering waterways by any or all of the above methods will improve the water clarity and quality. The clearer water will allow more sunlight to penetrate to the bottom and increase the numbers of aquatic plants and corals. With an increase of aquatic plants and corals available for animals to eat, more snails, crabs, fish, turtles and dugongs will be able to survive and thus increasing the biodiversity of the associated marine environment.
5. Prior to European settlement, coral bleaching may have occurred from high sediment runoff resulting from extreme floods. Extreme floods would have occurred as a result of tropical cyclones. Unlike now, the thick vegetation around the waterways would have filtered the sediment saving coastal areas from severe sediment loads. Also, there was less exposed soil available for washing into waterways because aboriginal farming and construction practices did not produce wide scale destruction of natural vegetation.

Introduction to food webs



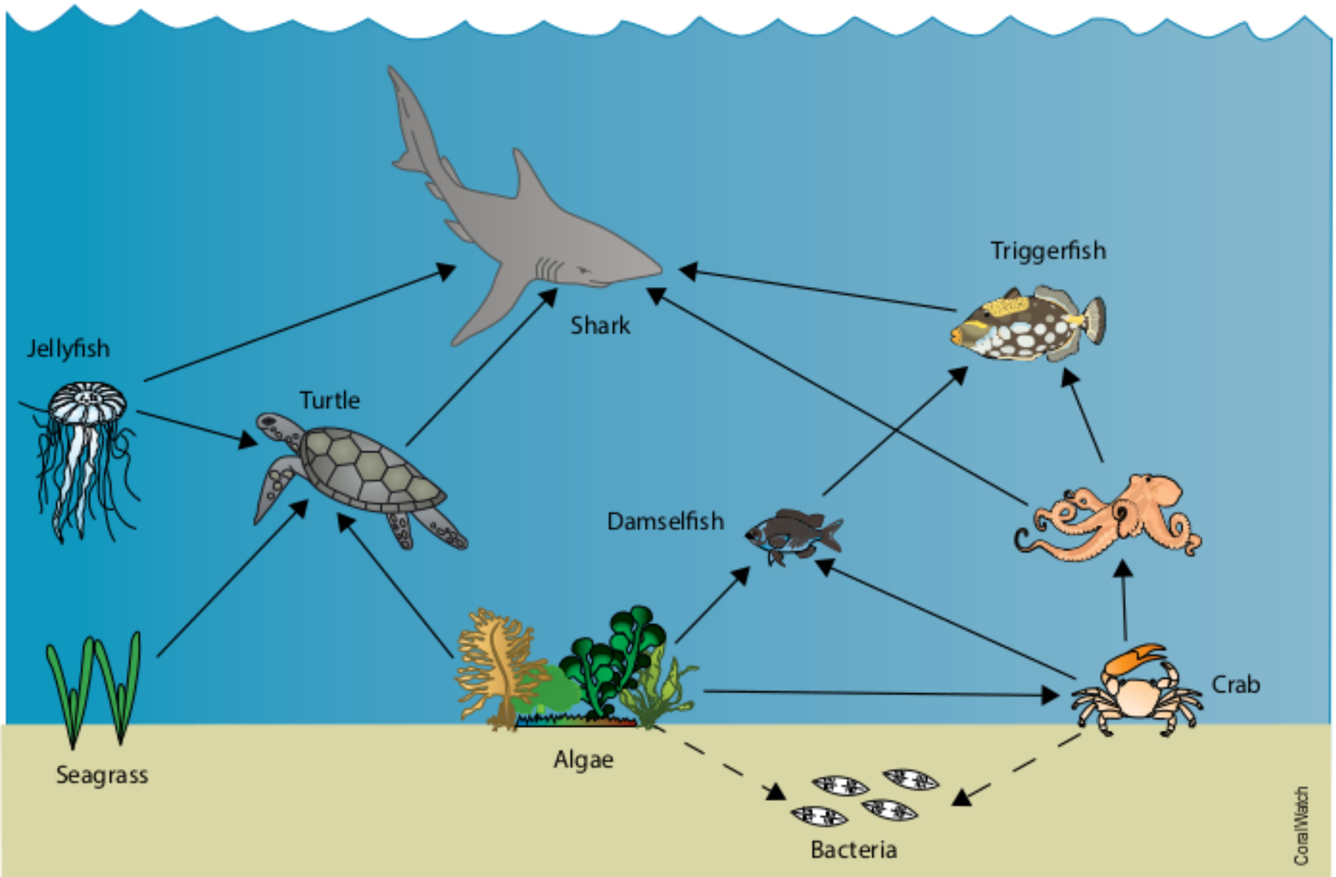
Instructions

Every living thing is eaten by something in all ecosystems. Producers are eaten by first order consumers. Smaller prey is consumed by larger predators, until they, in turn succumb to injury or disease, and are recycled by decomposers. Removal of any link in these chains will affect the pattern of the entire food web. As we move up a particular food chain, the first organism to eat a producer is called a first order or primary consumer. The animal that eats the primary consumer is the secondary consumer and so on. In a food web, some animals can be more than one level of consumption at the same time.

Using the food web and the legend:

1. Identify and list the producers.
2. Identify and list the primary consumers.
3. Identify and list the the tertiary consumers.
4. Identify and list the decomposers.
5. If grass is a producer in this ecosystem, where does it get its energy from?
6. Describe the difference between a food chain and a food web.
7. Looking at the food web, is there an animal that is both a tertiary and quarternary consumer?
8. Looking at the food web, is there an animal that is both a secondary and tertiary consumer?
9. In pairs, think about one of the gardens in your school. Construct your own food web of all the organisms that live there. Make sure you identify a producer and consider what might be the decomposer of this ecosystem.
10. As a class, discuss three of the food webs produced by students and encourage peers to evaluate the ideas about the organisms and suggest improvements.

Marine food webs



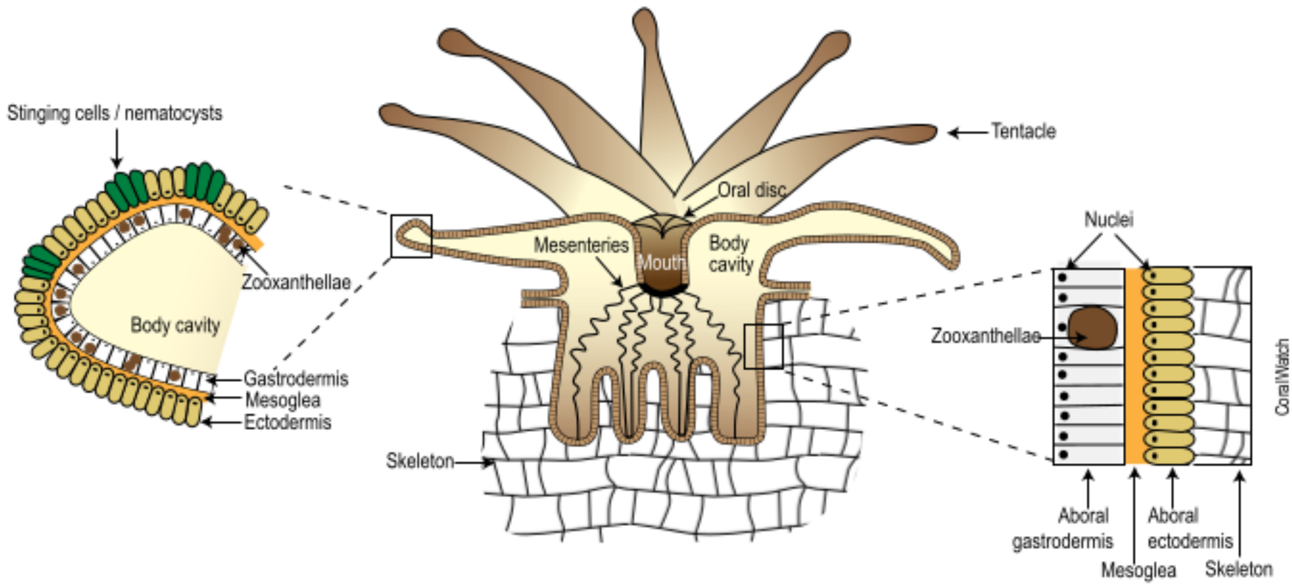
Every living thing is eaten by something in marine ecosystems. Smaller prey is consumed by larger predators, until they, in turn succumb to injury or disease, and are the recycled on the sea floor. Removal of any link in these chains will affect the pattern of the entire food web.

Instructions

Using the food web and the legend:

1. Identify and list the producers.
2. Identify and list the primary consumers.
3. Identify and list the secondary consumers.
4. Identify the decomposer.
5. Draw 2 food chains from the food web.
6. How would the organisms be affected if the sharks were completely removed from the system due to fishing?
7. List organisms that you might see when walking along at low tide on a coral reef. See if you can produce a food web based on this list. What is the producer? What is the highest level consumer?

Corals: producer or consumer?



Corals build hard structures that can be seen from the air and even from space. Corals are animals. They build reefs by secreting a skeleton which the animal uses to hold itself in place. When viewed close up, **tentacles** and a **mouth** are visible. Corals use these structures at night to capture **plankton** and feed. However, during the day something very different occurs. Corals often have a relationship with a special type of algae called **zooxanthellae** (pronounced 'zoo-zan-thel-ay'). The algae actually live inside cells in the inner cell layer of the coral. When exposed to sunlight, just like other algae, the zooxanthellae are able to produce their own food through photosynthesis. In fact, they are so good at producing their food that they have enough left over to share with the coral. In turn, the coral shares nutrients with the algae. This type of relationship is called **symbiosis**. In a symbiotic relationship, the organisms live together with one another to the benefit of both. This relationship has happened over such a long period that many corals now cannot survive very long without their algal partners. When coral becomes stressed, it can kick out the algae living inside it. This process is known as **coral bleaching**. Bleaching is the term used, because the algae are often what give the coral their brown or green appearance and when gone the white skeleton is visible underneath. If corals cannot recover and get the algae back into their cells in time, they can die.

Some fish eat coral such as angelfish, butterflyfish and blennies. Some fish that eat plankton include damselfish and fusiliers. Plankton is made up of both phytoplankton (tiny plants) and zooplankton (tiny animals).

Corals: producer or consumer?

Instructions

1. Identify the primary producer in the coral-algae relationship.

2. Draw a food web on the worksheet with coral, plankton, zooxanthellae, coral-eating fish, plankton-eating fish and sharks.

3. Identify the:

   a) Tertiary consumers

   b) Secondary consumers

   c) Primary consumers

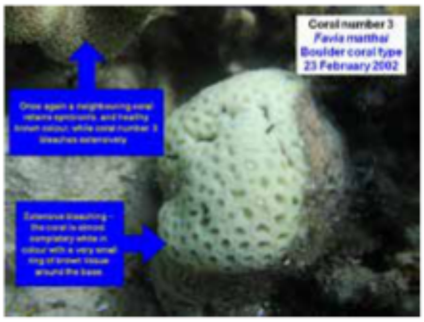
   d) Primary producers

   e) Decomposers

Measuring coral health using virtual reef booklets

Instructions

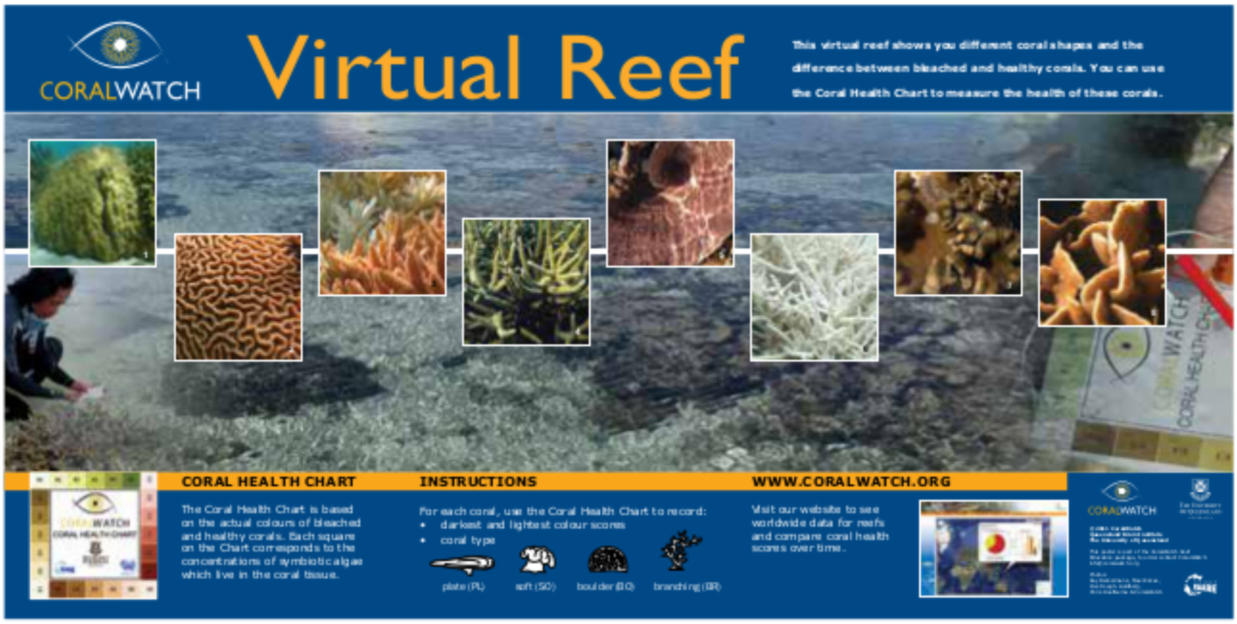
Use the virtual reef booklets to investigate the consequences and frequency of coral bleaching and determine if these events seem to be increasing.



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 can recovery 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.

Before - During - After Bleaching Lizard Island 2016
In 2016 and 2017 Lizard Island was affected by another serious bleaching event. Download the Lizard island booklet from www.coralwatch.org/web/guest/education-products and write a summary of your findings.

Measuring coral health using virtual reef poster

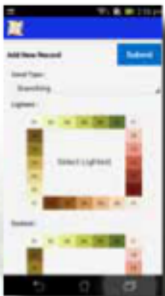


Food Webs

Instructions

1. Following the instructions on the back of the Coral Health Chart, match the coral colours on the virtual reef poster with the colour scores on the chart.
2. Record your colour scores and coral types on a data sheet that you can download from www.coralwatch.org.

You can also download the CoralWatch 'data entry' mobile phone app and enter your data in **demo mode**.



Google play
App Store

CORALWATCH

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

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

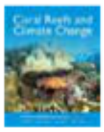
Date of survey: ____/____/____ (Day / Month / Year) Time collected: (ie. 14:00 or 2pm) ____________

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 L=Lightest D=Darkest		Coral Type Br=Branching Bo=Boulder Pl=Plate 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

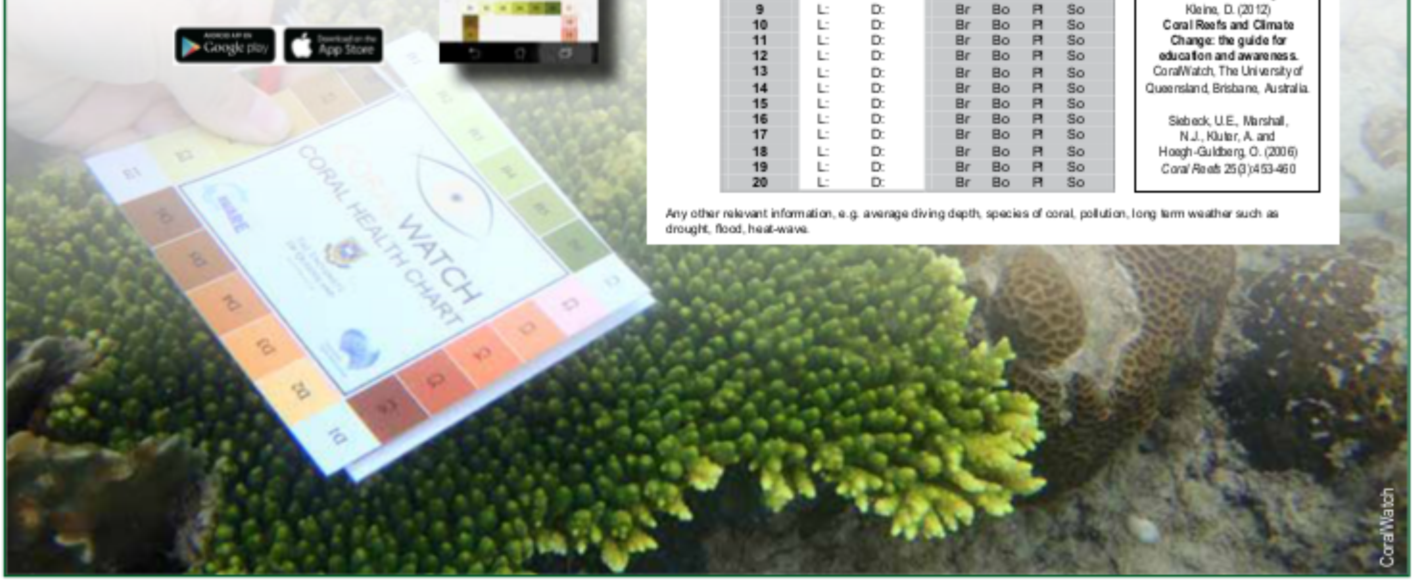
Check out these resources...



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.

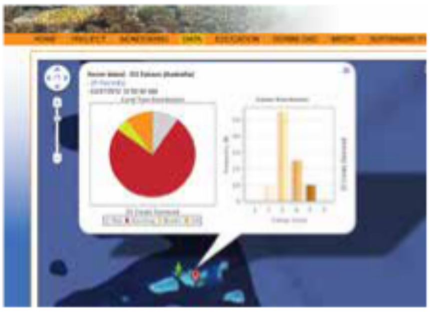


CoralWatch

Measuring coral health - Interpreting 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 and coral type distribution comparing all surveys for one reef.

Altered food webs: farming and sediment runoff

Coastal areas are often famous for their extensive seagrass meadows which provide food for large populations of green sea turtles and dugongs. Unknown to most people, these areas are important habitats for corals. Corals are important because they provide food and shelter for fish and other marine creatures. A coral's health is extremely susceptible to changes in the environment. This makes coral an important species to monitor and use to indicate environmental conditions. Coastal areas are part of a precious environment which needs to be protected from environmental damage caused by humans and their activities.

High levels of sediment entering waterways are a major environmental concern. The main cause of high sediment levels is from soil erosion from creeks and rivers, farming land and building construction sites. Sediment is composed of soil particles that are washed off the land into creeks and rivers. Sediment can be a range of different sizes including large sand particles and smaller fine mud particles. The increased amount of soils particles suspended in the water causes the water to become cloudy which is called water turbidity. High water turbidity can have impact to species inhabiting the water by blocking sunlight and smothering seagrasses and corals that require light to grow, consequently reducing the amount of food available for turtles, dugongs and fish.

Using the food web produced in Worksheet FW2 examine the effects on a food web when the community structure and biodiversity in the ecosystem is altered.

Questions

1. Using the food web constructed previously for Worksheet FW2, consider what would happen to the food web in the event of large amounts of rain. Choose a coastal area near you and focus on sediment and how it may affect the system. Look at the food web you have constructed and place a cross through plants and animals that may be affected directly by this event.
2. Describe what effect this would have to other organisms that consume this organism in the same food web? What about organisms at higher orders of consumption? Would anything happen to those organisms?
3. Draw a new food web for the ecosystem based on the alterations you have described for the first food web. How has the large amount of rain falling on the city effected biodiversity?
4. In groups of three, consider some ways to help reduce the sediment running into the area. Describe what this may do in the short, medium and long term and report this back to the class.
5. Consider what your area may have looked like prior to European settlement. Especially think about any coral skeletons observed in Worksheet FW5. Can you think of any events that may have caused coral bleaching and or smothering with sediment that may have been observed by indigenous groups in the area at the time? Are these events still a possibility today?

CoralWatch

Altered food webs: farming and sediment runoff

Altered food web template

Tertiary consumers

Secondary consumers

Primary consumers

Primary producers

Decomposers

Rhythm and Flow

Tides and coral spawning (ACSSU115 & ACSSU117)

The following lessons developed by CoralWatch focus on rhythm and flow, tides and coral spawning. There are 5 classroom worksheets and 8 recommended CoralWatch field activities. All of them can be used as stand-alone lessons or as a sequence. Curriculum links are provided for all lessons as well as extra resources, background information and answer key to all acitivities.

Worksheet overview

RF1 Bryan Cox gravity video activity
RF2 The moon and tides
RF3 Tidal effects on organisms
RF4 The moonlit phenomenon of coral spawning
RF5 Astronomy word search

Recommended field activities

2. Exploring and identifying invertebrates
3. Food webs – Intertidal rocky shores
4. Food webs – Intertidal coral reefs
5. Identifying coral type using the Coral Health Chart
6. Measuring coral health using random surveys
9. Entering and analysing data using Excel
10. Entering data using www.coralwatch.org
11. Entering data using CoralWatch data entry apps

CONTENT DESCRIPTIONS

Science understanding

- Predictable phenomena on earth, including season and eclipses, are caused by the relative positions of the sun, earth and the moon (ACSSU115)
- Change to an object's motion is caused by unbalanced forces, including earth's gravitational attraction, acting on the object (ACSSU117)

Science inquiry skills

- Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS124)
- Measure and control variables, select equipment appropriate to the task and collect data with accuracy (ACSIS126)
- Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate (ACSIS129)
- Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence (ACSIS130)
- Use scientific knowledge and findings from investigations to evaluate claims based on evidence (ACSIS132)
- Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS133)

Science as a human endeavour

- Scientific knowledge has changed peoples' understanding of the world and is refined as new evidence becomes available (ACSHE119)
- Science knowledge can develop through collaboration across the disciplines of science and contributions of people from a range of cultures (ACSHE223)

Key

General capabilities & Cross-curriculum priorities addressed within these worksheets include:

- Literacy
- Numeracy
- ICT capability
- Critical and creative thinking

Learning objectives

- Students will be able to describe the effects of the moons gravity on the marine environment on earth.
- Students will be able to explain the occurrence of natural phenomena caused by the relative movements of the earth, sun and moon.

Success criteria

- Students understand natural phenomena such as lunar and solar eclipses, seasons and phases of the moon.
- Students are able to model the relative movements of the earth, sun and moon and how natural phenomena such as solar and lunar eclipses and phases of the moon occur.
- Students can explain why different regions of the earth experience different seasonal conditions.
- Students will understand how gravity affects objects on the surface of earth.

Background

The rise and fall of the sea is the result of the gravitational attraction of both the **sun** and **moon**. As the moon moves around the earth in an elliptical orbit, its gravitational attraction causes the ocean surface to bulge. As the **earth** spins, it moves through this tidal bulge with its own centrifugal force, resulting in a second bulge appearing on the opposite side of the world. These are the **high tides**, with the **low tides** occurring between the two tidal bulges.

The height of the tides varies with the position of the moon's orbit relative to the sun. When the moon is in line with the sun, **Spring tides** occur, with the largest variation between the highs and lows. **Neap tides** have the smallest difference between high and low tide. Neap tides happen when the moon is in a position 90° to the sun, their opposing forces reducing the difference in the tidal heights of the ocean's surface.

Because of the tilt in the earth's axis and the variations in the shape of ocean basins, tides vary across the planet. In places such as Antarctica, the Mediterranean Sea and the Black Sea, tides are determined not only by the moon's influence, but also by the **wind**. Tides may also vary in their size. On the Great Barrier Reef and Ningaloo Reef, 6-8 m tides are common. The Bay of Fundy in Canada has some of the world's largest tides, reaching up to 18 m. Some of the smallest tides are found in the Caribbean – these can be less than 1 m. Some locations experience only one high and low each day (diurnal tides).

Resources

- *Coral Reefs and Climate Change: the Guide for Education and Awareness* - recommended sections: Rhythm and Flow, Current connections, Patterns of distribution.
- *Coral Reefs and Climate Change* video series - recommended video: Productive seas (5 min), Rising sea (5 min).
- Bryan Cox gravity video www.youtube.com/watch?v=E43-CfukEgs
- WillyWeather tide data http://tides.willyweather.com.au/ (preferred) or
- The Bureau of Meteorology tide data http://www.bom.gov.au/australia/tides/
- Blue Planet clip www.youtube.com/watch?v=wsaZ8-I7akg
- Natural History Museum clip https://www.youtube.com/watch?v=zuHzNRynSLc

Curriculum links - Answer key for worksheets

WORKSHEET RF1
BRYAN COX GRAVITY VIDEO ACTIVITY

ACARA curriculum links

Science understanding (ACSSU117)
Science as a human endeavour (ACSHE119)

Answers

1. Light feathers.
2. The feathers fell to the ground at a slower rate than the bowling ball because of air resistance*. *Air resistance is an opposing force acting on the motion of any moving object created by friction between air and the object.
3. Gravity.
4. Air.
5. Both the bowling ball and the light feathers fell to the ground at the same time.
6. There was no air to create air resistance. Therefore the force of gravity affected both objects equally.

WORKSHEET RF2
MOON AND TIDES

ACARA curriculum links

Science understanding (ACSSU115)
Science inquiry skills (ACSIS124, ACSIS126, ACSIS129, ACSIS130, ACSIS133)
Science as a human endeavour (ACSHE119)

Answers

1-4. See your local tide data that you present to the class for the answers.

5. Spring tides.
6.

7. A neap tide is the tide, or group of tides, with the smallest change in tide height between the low and high tide levels.
8. See your local data provided to your students. Neap tides have the smallest change in tide height between the low and high tide levels.
9.

10. Neap tides are best to visit an intertidal flat as there is less water on the flat and you can spend more time out on the flat.

WORKSHEET RF3
TIDAL EFFECTS ON ORGANISMS

ACARA curriculum links

Science understanding (ACSSU115 & ACSSU117)
Science as a human endeavour (ACSHE119)

Answers

1.

2.

	Positive effects	Negative effects
Wave action	Brings food & oxygen and removes wastes	Tearing animals off the rocks
Effects of exposure at low tide	Increased photosynthesis	High temperatures, reduced oxygen, extremely high or low salinity and vulnerable to predation

3.

Animal adaptations to intertidal conditions					
Animal	Picture	Location	Forces of wave action	Increased temperature	Exposure to predators
Limpet		Rocks	Very strong foot to hold onto rocks	Hides in shaded cracks in the rocks	Strong hard shell covering body
Soldier Crab		Sand	Buries in the sand	Buries in the sand to avoid long exposure to high heat	Burrows in the sediment to avoid predators

WORKSHEET RF4
THE MOONLIT PHENOMENON OF CORAL SPAWNING

ACARA curriculum links

Science understanding (ACSSU115)
Science inquiry skills (ACSIS124 & ACSIS132)
Science as a human endeavour (ACSHE119 & ACSHE223)

Answers

1. Scientists believe there is an interplay between the sun intensity and the lunar cycle which triggers the coral to spawn after the full moon. An event that can take hours or obnly a few minutes each year.
2. Spawning at the same time allows the maximum numbers of coral sperm and egg to come in contact and then develop into an embryo, thus maximising cross-fertilisation. Also releasing large quantities of spawn on the same night means that the large amount of spawn is too much to eat all at once for predators. Secondly, many predators can't see very well at night.
3. Scientists use a programmable system of LED lighting to replicate the lunar cycle and sun intensity to match the area from where the corals were collected from (in this case south-west Fiji) to stimulate them to spawn at the same time.
4. Scientists have discovered that corals have blue sensitive photoreceptors in their skin to see the moonlight with. Photoreceptors are similar to very simple eyes that can only detect light or dark and cannot detect any shapes or pictures. The blue photoreceptors in the coral's skin can 'see' when there is moonlight (which is pale blue) and when there isn't moonlight thus helping them to identify the correct time to spawn. See reference below for more technical detail. Gorbunov MY & Falkowski PG (2002) Photoreceptors in the cnidarian hosts allow symbiotic corals to sense blue moonlight. Limnol. Oceanogr. 47(1): 309–315.

WORKSHEET RF5
ASTRONOMY WORD SEARCH

ACARA curriculum links
Science understanding (ACSSU115)

Bryan Cox gravity video activity

Brian Cox visits the world's biggest vacuum chamber - Human Universe: Episode 4 Preview - BBC Two.

Brian Cox visits the world's biggest vacuum chamber - Human Universe: Episode 4 Preview - BBC Two.

Instructions

View Bryan Cox gravity video

See https://www.youtube.com/watch?v=E43-CfukEgs

Questions

1. In first experiment, the chamber was at normal air conditions, what fell to the ground slowest, the heavy bowling ball or the light feathers?

2. What was the reason one fell slower than the other?

3. What force is acting on both the falling objects?

4. In the second experiment, what did they pump out of the vacuum chamber to make it the same conditions as outer space?

5. In the second experiment, which object fell to the ground slowest, the heavy bowling ball or the light feathers?

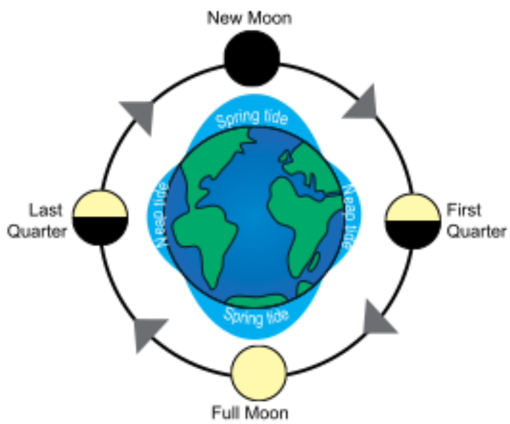
6. Why did this happen?

Moon and tides

The rise and fall of the sea is the result of the gravitational attraction of both the **sun** and **moon**. As the moon moves around the earth in an elliptical orbit, its gravitational attraction causes the ocean surface to bulge. As the **earth** spins, it moves through this tidal bulge with its own centrifugal force, resulting in a second bulge appearing on the opposite side of the world. These are the **high tides**, with the **low tides** occurring between the two tidal bulges.

The height of the tides varies with the position of the moon's orbit relative to the sun. When the moon is in line with the sun, **Spring tides** occur, with the largest variation between the highs and lows. **Neap tides** have the smallest difference between high and low tide. Neap tides happen when the moon is in a position 90° to the sun, their opposing forces reducing the difference in the tidal heights of the ocean's surface.

Because of the tilt in the earth's axis and the variations in the shape of ocean basins, tides vary across the planet. In places such as Antarctica, the Mediterranean Sea and the Black Sea, tides are determined not only by the moon's influence, but also by the **wind**. Tides may also vary in their size. On the Great Barrier Reef and Ningaloo Reef, 6-8 m tides are common. The Bay of Fundy in Canada has some of the world's largest tides, reaching up to 18 m. Some of the smallest tides are found in the Caribbean – these can be less than 1 m. Some locations experience only one high and low each day (diurnal tides).



Look up your local tides using WillyWeather (http://tides.willyweather.com.au/) for graphical representation or The Bureau of Meteorology website (http://www.bom.gov.au/australia/tides/) for tabular information.

Questions

From the data for your closest location, answer the following questions.

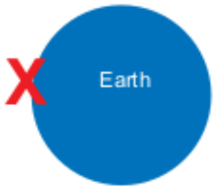
1. What time and height in metres is the highest tide today?
2. What time and height in metres is the lowest tide today?
3. How many high tides are there in 1 day (24 hours)?
4. What date and time is the highest tide for the month?
5. What is the name given to the highest tides of the month?
6. Draw a diagram of the location of the sun, moon and earth relative to each other on this day with the highest tide of the month.
7. Explain what a neap tide is?
8. What date is neap tides in your data? Explain why it is neap tide.
9. Draw a diagram of the location of the sun, moon and earth relative to each other on this day with the most neap tides of the month.
10. Your class are planning an excursion to walk around an intertidal zone next month. What days and times are most suitable for your class?

Tidal effects on organisms

The intertidal zone is the area of shoreline that is underwater during high tides, and exposed during low tides. For the plants and organisms that live in this zone, the changing tides create challenges for survival. At low tide, marine organisms are exposed to changing environmental conditions. As the water level drops, waves smash against the rocks, tearing away those that do not have a strong hold on the substrate. The wave action brings food and oxygen and removes the wastes from the tidal areas.

At low tide the sunlight is no longer diffused and weakened by seawater and the rate of photosynthesis increases significantly. The temperature can vary as much as 20°C between the water and the air which is difficult for organisms to deal with. Evaporation from tidal pools removes water surrounding marine organisms and plants. This reduces oxygen levels and the surroundings become extra salty. When heavy rainfall occurs during extreme low tides, the fresh water runoff leads to rapid salinity changes causing marine organisms to become stressed. Organisms are also exposed to predation by land and air animals. When you walk along the shore at low tide, you can see how marine organisms have adapted to these regular tidal rhythms.

Instructions



1. Draw the possible positions of the moon relative to the earth at low tide at the location marked with an X.

2. Positive and negative effects of life in the intertidal zone

Fill in the empty boxes of the table from information provided in the text above.

	Positive effects	Negative effects
Wave action		
Effects of Exposure at Low Tide		

3. Think pair share

Have you ever seen a Chinese hat snail (limpet) on the rocks around the intertidal rock pools? Or a cast (group) of soldier crabs marching across the mudflats?

From your experiences and knowledge, what adaptations do they have to cope with in the intertidal zone? Fill in the table below.

Animal adaptations to intertidal conditions					
Animal	Picture	Location	Forces of wave action	Increased temperature	Exposure to predators
Limpet					
Soldier Crab					

The moonlit phenomenon of coral spawning

Every year, between late spring and early summer (November to December), corals on the Great Barrier Reef spawn over a three to five day period, triggered by the full moon and strong summer sunlight. The timing of this event is synchronised across species, and over distances of up to 1200 km. The eggs and sperm are released, and rise up to the ocean surface, forming huge slicks that extend for kilometres. Eggs are fertilised by sperm to make an embryo.

Embryos rapidly develop into coral larvae that drift with water currents and tidal systems. Coral larvae may drift for just a few hours or for several weeks. They can travel long distances before settling. The larvae will gradually move down the water column until they touch the reef surface. If the conditions are right and the ocean floor is clean, they will settle and lay down the base of their skeleton.

A single polyp, only 1-2 mm across, will form the basis of a new colony as it grows. Its lifespan may be as long as 1000 years!

Instructions

View the following Blue Planet video www.youtube.com/watch?v=wsaZ8-I7akg
and the Natural History Museum clip www.youtube.com/watch?v=zuHzNRynSLc

Think pair share: answer the following questions and write down your answers.

1. What triggers corals to spawn at the same time?
2. Why is it advantageous for corals to spawn at the same time?
3. How does the scientist get the coral to spawn inside the laboratory?

The big question to brainstorm and further research as a class:

4. How do corals detect when it is full Moon and summer time?

Astronomy word search

H	P	O	Z	D	I	S	T	K	T	U	L	S	N	N
L	T	D	M	G	W	C	C	F	W	U	T	E	T	O
Q	J	R	I	U	H	F	N	O	N	A	I	D	B	I
X	X	Z	A	N	P	O	T	A	N	Z	B	I	N	T
F	Y	X	F	E	I	T	R	O	Z	A	R	T	E	A
G	Q	H	J	T	V	E	N	F	B	Y	O	G	A	T
E	S	P	I	L	C	E	R	A	L	O	S	N	P	O
Q	N	S	A	L	M	O	R	B	Y	N	O	I	T	R
B	O	Z	I	O	Y	T	I	V	A	R	G	R	I	J
P	K	P	N	S	V	U	P	A	I	Z	C	P	D	L
K	S	E	L	L	I	P	T	I	C	A	L	S	E	D
E	H	Y	S	N	I	Y	M	O	N	O	R	T	S	A
P	Y	F	O	U	T	X	S	E	A	S	O	N	S	I
Y	Y	O	K	Y	N	D	S	L	X	B	Q	T	H	M
G	M	W	I	H	C	M	C	E	Y	A	X	I	S	T

Find and circle the words below.

ASTRONOMY

AXIS

EARTH

ELLIPTICAL

GRAVITY

LUNARECLIPSE

MOON

NEAPTIDES

ORBIT

PHENOMENON

POSITION

ROTATION

SEASONS

SOLARECLIPSE

SPRINGTIDES

SUN

The Water Cycle

Human impacts (ACSSU116)

The following lessons developed by CoralWatch focus on the water cycle and human impacts on the marine environment. There are 7 classroom worksheets and 8 recommended CoralWatch field activities. All of them can be used as stand-alone lessons or as a sequence. Curriculum links are provided for all lessons as well as extra resources, background information and answer key to all activities.

Worksheet overview

WC1 The water cycle
WC2 Water cycle crossword
WC3 Coastal waters and bay inhabitants
WC4 The water cycle of coastal regions
WC5 Sediment runoff – Human impact
WC6 Monitoring corals
WC7 Coral bleaching – Sign of stress

Recommended field activities

2. Exploring and identifying invertebrates
3. Food webs – Intertidal rocky shores
4. Food webs – Intertidal coral reefs
5. Identifying coral type using the Coral Health Chart
6. Measuring coral health using random surveys
9. Entering and analysing data using Excel
10. Entering data using www.coralwatch.org
11. Entering data using CoralWatch data entry apps

CONTENT DESCRIPTIONS

Science understanding

- Classification helps organise the diverse group of organisms (ACSSU111)
- Some of earth's resources are renewable, including water that cycles through the environment, but others are non-renewable (ACSSU116)

Science inquiry skills

- Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS124)
- Measure and control variables, select equipment appropriate to the task and collect data with accuracy (ACSIS126)
- Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence (ACSIS130)
- Reflect on scientific investigations including evaluating the quality of the data collected, and identifying improvements (ACSIS131)
- Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS133)

Science as a human endeavour

- Scientific knowledge has changed peoples' understanding of the world and is refined as new evidence becomes available (ACSHE119)
- Science knowledge can develop through collaboration across the disciplines of science and contributions of people from a range of cultures (ACSHE223)

Key

General capabilities & Cross-curriculum priorities addressed within these worksheets include:

Literacy
ICT capability
Critical and creative thinking
Personal and social capabilities
Ethical understanding
Sustainability

Learning objectives

- Students will be able to describe the water cycle including describing changes of states and locations.
- Students will be able to identify how humans impact the water cycle and the environmental consequences of these impacts.

Success criteria

- Students can consider the water cycle in terms of changes of state of water.
- Students know who to investigate factors that influence the water cycle in nature.
- Students can show evidence of exploring how human management of water impacts on the water cycle.

Background

There is a fixed amount of water on earth. Different forms of water move around the planet in what is called the **water cylce**. Water from the oceans **evaporates** and enters the atmosphere in the form of **water vapour**. When water vapour cools down, it becomes **liquid** again, **condensing** into small droplets, which form **clouds**. When clouds become too heavy, the water vapour returns to earth as **rain**. Rain enters groundwater, rivers and oceans, and the cycle begins again.

It is estimated that the volume of water stored on earth is 1.39 billion km^3. Almost all of this (96.5%) is contained within our oceans. Less than 1% of all water on earth is fresh drinking water, stored within groundwater, lakes and rivers. The polar ice caps, glaciers and snow store a further 1.7%. Water vapour in our atmosphere represents only 0.001% of the water total present. While these percentages vary over geological time, the total amount will always remain the same.

Humans impact the water cycle by changing the way land is used. Increased land clearing for agricultural use has exposed soil and removed the water filtration efforts of vegetation especially along creeks and rivers. This has led to increased **sediment loads** entering rivers and consequently the oceans. Inshore marine habitats are smothered by incoming sediment and light is blocked to organisms that rely on photosynthesis for energy. Researchers use coral as an indicator species of environmental health because they are susceptible to bleaching when stressed in such conditions. CoralWatch researchers encourage citizens including school groups, to help monitor the health of their local marine waterway by utilising their simple to use Coral Health Chart and entering data. CoralWatch's monitoring data is available to anyone to analyse which makes it a perfect school project.

Resources

- *Coral Reefs and Climate Change: the Guide for Education and Awareness* - recommended sections: Inside water, Just add salt, Coral bleaching.
- *Coral Reefs and Climate Change* video series - recommended video: Coral bleaching (5 min).

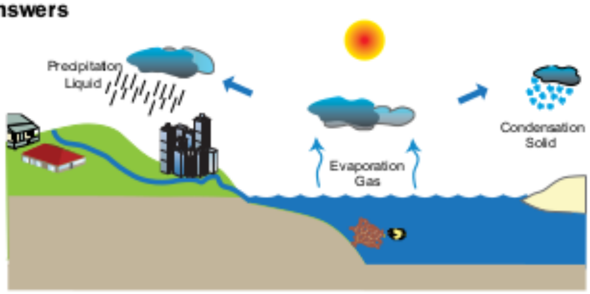
WORKSHEET WC1
THE WATER CYCLE

ACARA curriculum links

Science understanding (ACSSU116)

Answers

1.



2. Water from the oceans _*evaporates*__ and enters the atmosphere in the form of water vapour.
When water vapour cools down, it becomes liquid again, _*condensing*_ into small droplets, which form clouds. When clouds become too heavy, the water vapour returns to earth as _*precipitation*_.

3. 1. Gas 2. Liquid 3. Solid

WORKSHEET WC2
WATER CYCLE CROSSWORD

ACARA curriculum links

Science understanding (ACSSU116)

Answers

WORKSHEET WC3
COASTAL WATERS AND BAY INHABITANTS

ACARA curriculum links

Science understanding (ACSSU111)

Answers

Seagrass, fish, dolphins, shark, stingray, corals, moray eel, crabs, turtles.

WORKSHEET WC4
THE WATER CYCLE OF COASTAL REGIONS

ACARA curriculum links

Science understanding (ACSSU116)

Answers

1. **Liquid** - a runny substance composed of molecules that move freely among themselves but do not tend to separate like those of gases; neither gaseous nor solid.
Precipitation - falling products of condensation in the atmosphere, as rain, snow or hail.
Condense - to reduce to another and denser form, as a gas or vapor to a liquid or solid state.
Evaporating - to change from a liquid or solid state into vapor.
River - a natural stream of water of fairly large size flowing in a definite course or channel or series of diverging and converging channels.
Catchment area - a drainage basin composed of the area drained by a river and all its tributaries/creeks.
Water cycle - the natural sequence through which water passes into the atmosphere as water vapor, precipitates to earth in liquid or solid form, and ultimately returns to the atmosphere through evaporation.
Gas - any such fluid or mixture of fluids.
Please note that Dictionary.com was used to obtain these definitions.

2.

Location	Ocean	Atmos-phere	Atmos-phere	Atmos-phere	Catchment area	River	Ocean

WORKSHEET WC5
SEDIMENT RUNOFF - HUMAN IMPACT

ACARA curriculum links

Science understanding (ACSSU116)
Science inquiry skills (ACSIS126, ACSIS130, ACSIS131, ACSIS133)

Answers

a. The course sediment size should settle to the bottom first.
b. The fine sediment size should settle to the bottom last.
c. Course sediment will settle at the mouth of rivers but fine sediment will stay suspended blocking sunlight and eventually settle further out to sea smothering the inhabitants on reefs.
d. Aquatic plants, seagrass, algae and coral need sunlight to photosynthesise and produce the food and energy they need to survive, grow and reproduce.
e. Aquatic plants, seagrass, algae and coral will die if they are consistently smothered with sediment or have the sunlight blocked from reaching their photosynthetic cells.

WORKSHEET WC6
MONITORING CORALS

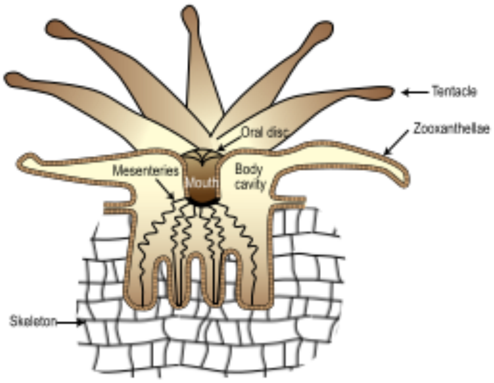
ACARA curriculum links

Science understanding (ACSSU116)

Science as a human endeavour (ACSHE119 & ACSHE223)

Answers

1.



2. Healthy reefs produce food for millions of people and help to protect coastal land from cyclones and storm surges. Reefs support local economies, providing employment from tourism and fishing industries.
3. In healthy coral, symbiotic algae (zooxanthellae) live within the coral tissue. Algae provide the coral with food and energy and give the corals their characteristic brown colour. In return the coral provides a home for the algae. Both parties benefit from living together.
4. Stressful environmental conditions can cause the coral to expel the algae, changing the coral colour to white. This whitening of coral is called 'coral bleaching'.
5. Coral health can be measured with the CoralWatch Coral Health Chart. CoralWatch uses colour as an indicator of coral health. However, coral colour is just one indicator of coral health. Other indicators could be % coral cover, species diversity & richness, the amount of macroalgae and fish present.

WORKSHEET WC7
CORAL BLEACHING - SIGN OF STRESS

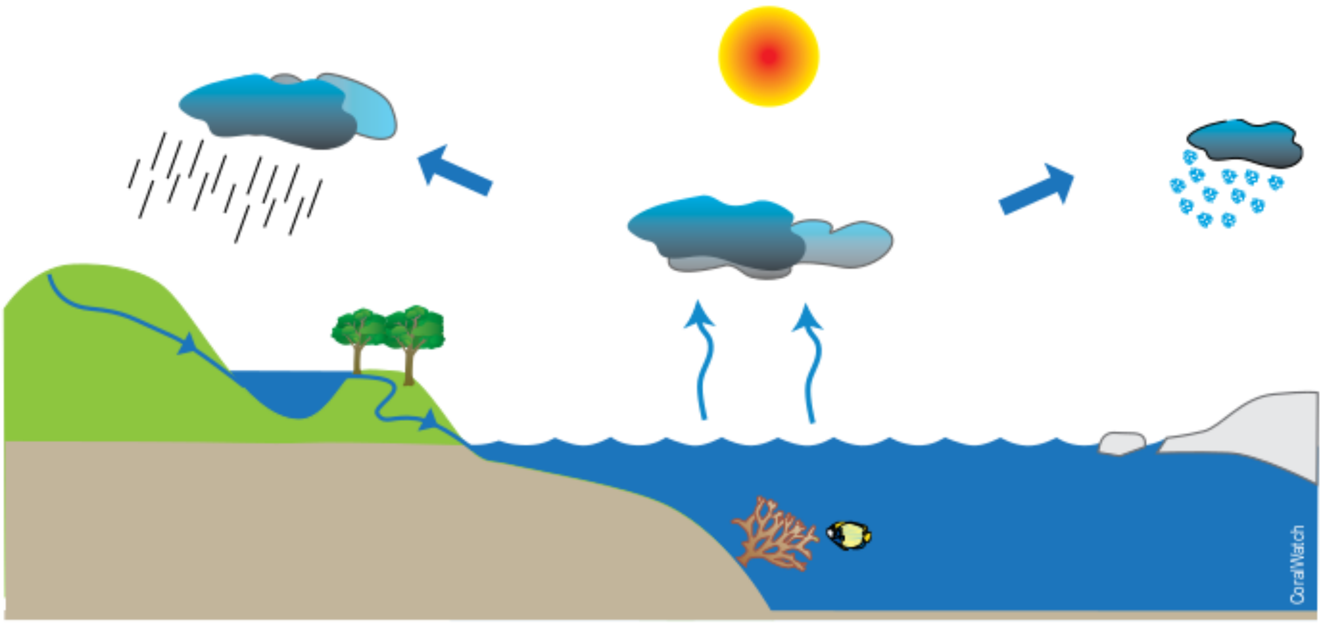
ACARA curriculum links

Science inquiry skills (ACSIS124)

Answers

Note that the top right coral is very light in colour which can be caused by bleaching, but can also be normal. For example, corals in Moreton Bay are in general lighter in colour.

The water cycle



Instructions

1. Label the diagram above with the following words:

Liquid	Gas	Solid
Evaporation	Precipitation	Condensation

2. Fill in the blanks using: Condensation, Evaporates & Preciptation

Water from the oceans ________________________ and enters the atmosphere in the form of water vapour.

When water vapour cools down, it becomes liquid again, _______________________ into small droplets, which form clouds.

When clouds become too heavy, the water vapour returns to earth as ________________.

3. Label the three physical states of water with: Liquid, Solid & Gas

Water vapour	Precipitation	Iceberg
1.__________	2.__________	3. _________

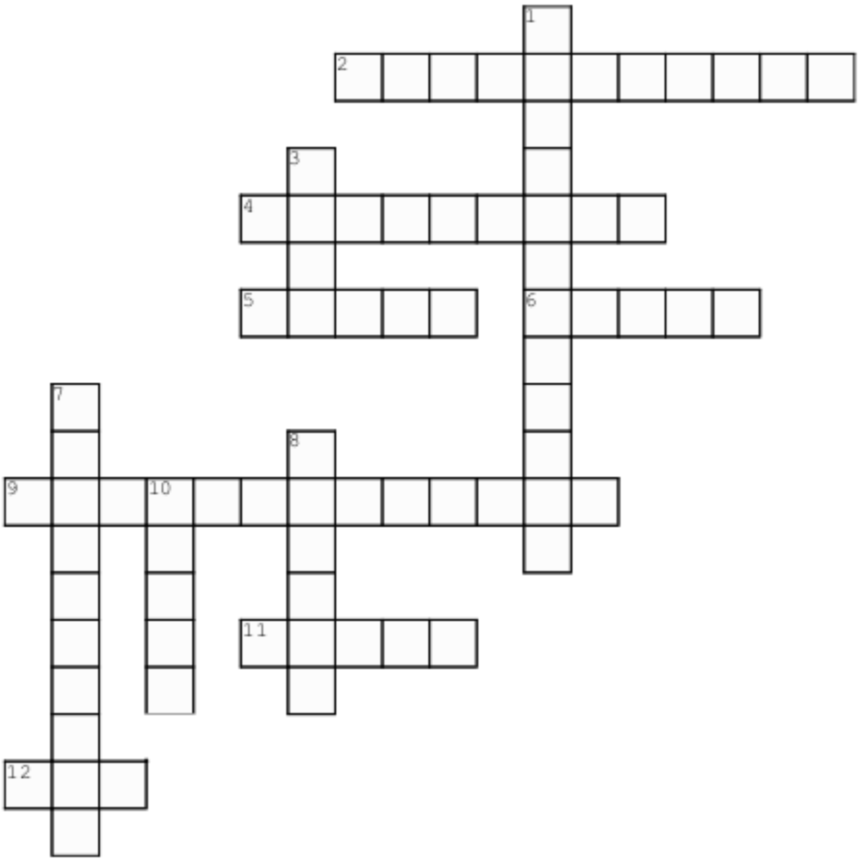
←→ ←→

Water cycle crossword

Name: ______________________________

The Water Cycle Crossword

Complete the crossword below



Across

2. When water molecules in a liquid changes to a gas.

4. The land area where excess water drains into creeks

5. When rivers and creeks are unable to carry all the excess water this causes?

6. The physical state of water when it gets very cold.

9. When water vapour in the sky forms water droplets and falls to the ground.

11. Large drainage channel where all water in a catchment eventually goes through before entering the ocean.

12. The physical state of water when it moves into the atmosphere

Down

1. The process which leads to clouds forming.

3. Sometimes thunderstorms lead to precipitation of water in a solid state.

7. A large body of water off the coast of Brisbane.

8. The physical state of water in rivers, creeks and the ocean is?

10. Small channel where water drains and feeds into larger bodies of water.

Coastal waters and bay inhabitants

Coastal waters and shallow bays frequently occur along Australia's coastline. These ecologically important and productive regions support abundant and diverse animal and plant species. The shallow waters allow light to penetrate to the ocean floor, increasing photosynthesis and producing large areas of rapid plant and algal growth. This high productivity increases food supplies and supports large populations of invertebrates and juvenile fish. In order to examine these areas in detail, we will conduct a case study on Moreton Bay.

Moreton Bay is a large and shallow bay off the coast of Brisbane city in Queensland, Australia. It is internationally recognised for having areas of mangroves and seagrasses, some corals, and large fish populations.

Satelite image of Moreton Bay.

Moreton Bay corals.

Moreton Bay seagrass, Halophila ovalis.

Moreton Bay dugongs.

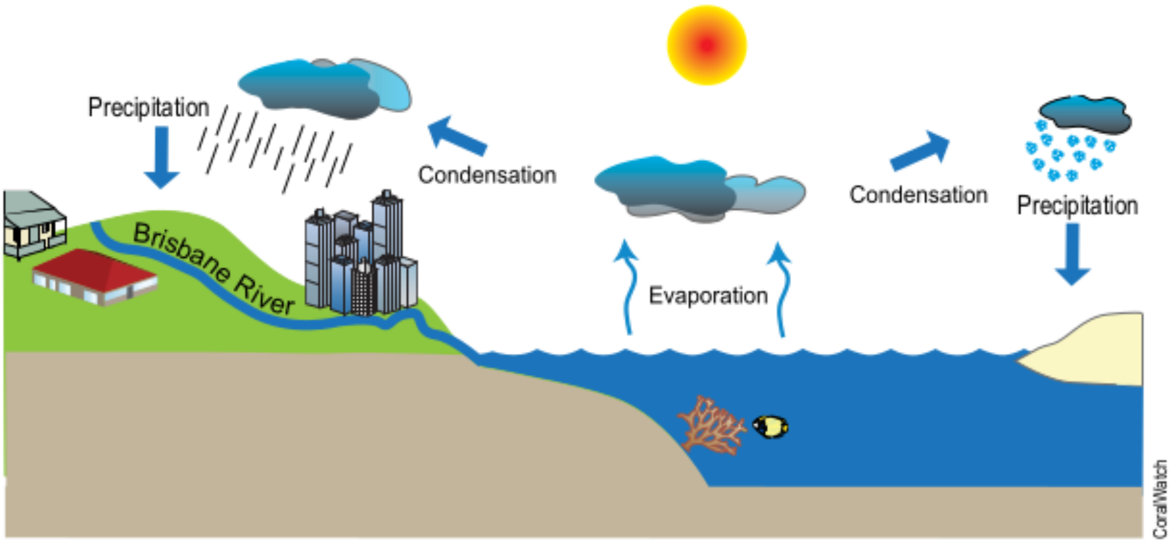
Water Cycle

Instructions

View 'Healthy Waterways FinCam' video at https://youtu.be/znctrwVdCck

Question: What are some plants and animals of Moreton Bay filmed in this footage?

The water cycle of coastal regions



The water cycle of coastal regions begins with **liquid** water molecules on the surface of the land and the ocean that heat up from the sun and **evaporating** into the air as **gas** molecules called **water vapour**. The gas rises up and enters the cool air high in the atmosphere. Once cool, the gaseous water molecules **condense** to form small liquid water droplets creating clouds. When the water droplets in clouds get too heavy, they fall to the ground as **precipitation** (rain or snow for example). Some liquid water is absorbed into the ground and the excess surface water drains into local creeks. Other water runs off from the land into rivers and creeks. This process is the same for coastal regions and on land hundreds of kilometres away. Eventually, rivers reach the coast. The '**catchment area'** of a river is the land area surrounding it, from where excess water drains into it. River catchment areas are usually extensive covering hundreds of square kilometers. Rivers drain their collection of fresh water into the salty and shallow coastal waters and oceans. This completes the cycle of the **water cycle** in coastal regions.

Questions

1. Look in a dictionary and write the definition for the words below.

Liquid | Precipitation | Condense | Evaporating
River | Catchment area | Water cycle | Gas

2. **Complete the table below listing water cycle stages. Fill in the physical states of water molecules and the location it can be found.**

Location	Ocean		Atmosphere			River	

Water Cycle

Sediment runoff – Human impact

What is sediment?

Sediment is soil particles that are washed off the land into creeks and rivers. Sediment can be a range of different sizes including large sand particles and smaller fine mud or clay particles.

Brisbane flood 2011.

Think, Pair and Share activity

Pair up with a friend and discuss the following. Make sure you write down your ideas!

Fast moving water carries sediment with it. Imagine running the hose with the tap fully opened in a sand pit.
- What happens to the sand?
- Where does it move to?

What do you think happens when there is heavy precipitation and flooding into a river catchment?
Where does the sediment end up?
How does this sediment affect the inhabitants living in the shallow, coastal ocean waters?

Sediment runoff

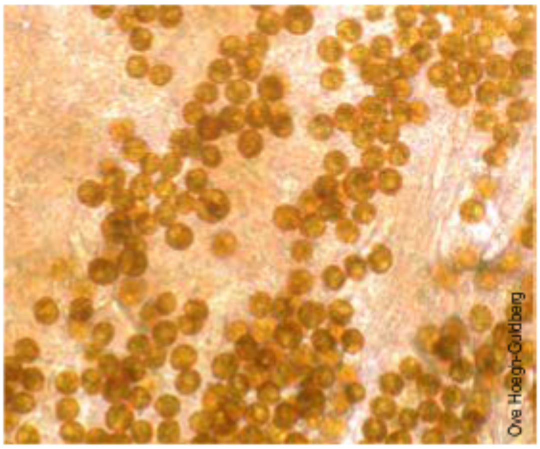
High levels of sediment entering waterways are a major environmental concern. The main cause of high sediment levels is a result of soil erosion along creeks and rivers, but also on farming land and building construction sites. Many coastal bays are vulnerable to high sediment loads entering through their local rivers. The increased amount of soil particles suspended in the water causes the water to become cloudy which is called water turbidity. High water turbidity in coastal areas is harmful to its marine inhabitants by blocking sunlight and smothering algae, seagrasses and corals that require light to grow, consequently reducing the amount of food available for other animals such as turtles, dugongs and fish.

Instructions turbidity activity

1. Label 3 identical bottles with lids with 'fine', 'medium' and 'course'.
2. Fill all bottles with equal amounts of water up to 3 cm from the top.
3. Collect equal volumes of 3 types of sediment (fine, medium and course). Use course sand for course type sediment, fine sand for medium type sediment and super fine dust-like soil for fine type sediment. If you cannot find super fine sediment, use talcum powder.
4. Add a different sediment type to each of the 3 bottles corresponding to your sediment lables.
5. Shake vigorously for 30 seconds and place in a location where they will not be moved.
6. Observe the water turbidity and record the time it takes for the water to become clear.
7. Discuss your results.
   a. Which sediment size settled to the bottom first? How long did it take?
   b. Which sediment size settled to the bottom last? How long did it take?
   c. What implications does sediment particle size have on coastal marine inhabitants?
   d. What inhabitants of coastal marine environments need light to survive? Why?
   e. How are these inhabitants affected by increased turbidity?

CORAL BLEACHING - SIGN OF STRESS

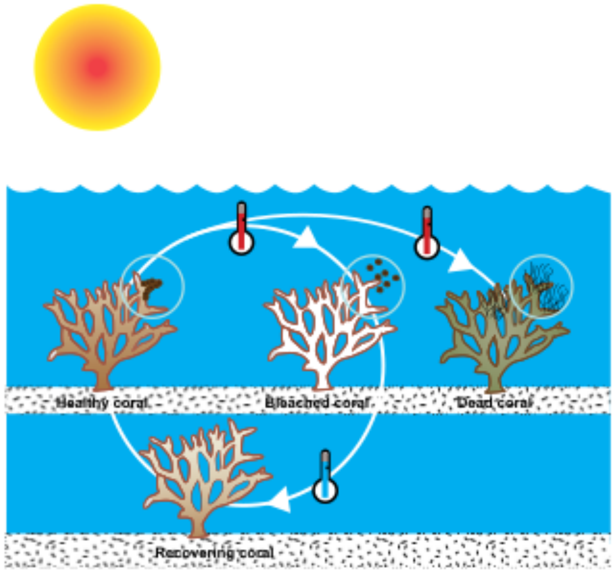
Corals are animals that build hard structures that can be seen from the air and even from space. They build reefs by secreting a calcium carbonate skeleton which the animal uses to hold itself in place. When viewed close up, polyps with tentacles and a mouth are visible. Corals use these polyps at night to capture plankton and feed. However, during the day something very different occurs. Corals often have a relationship with a special type of algae called zooxanthellae (pronounced 'zoo-zan-thel-ay'). The algae actually live inside cells in the inner cell layer of the coral. When exposed to sunlight, just like other algae, the zooxanthellae are able to produce their own food through photosynthesis. This is why corals and their zooxanthellae need sunlight and clean water. In fact, they are so good at producing food that they have enough to share with the coral. In turn, the coral shares nutrients with the algae. This relationship betwee coral and zooxanthellae is called symbiosis.



Zooxanthellae - macro photo.

Coral bleaching

In a symbiotic relationship, the organisms live together with one another to the benefit of both. This relationship has evolved over such a long period that many corals now cannot survive for long periods of time without their algal partners. When coral becomes stressed from high sediment loads and high water temperatures, it can kick out the algae living inside it. This process is known as coral bleaching. Bleaching is the term used because the algae are often what give the coral their brown or green appearance and when gone the white skeleton is visible underneath.
If environmental conditions don't change back to normal quickly enough, corals cannot recover and let algae back into their cells in time, they will starve and can die.



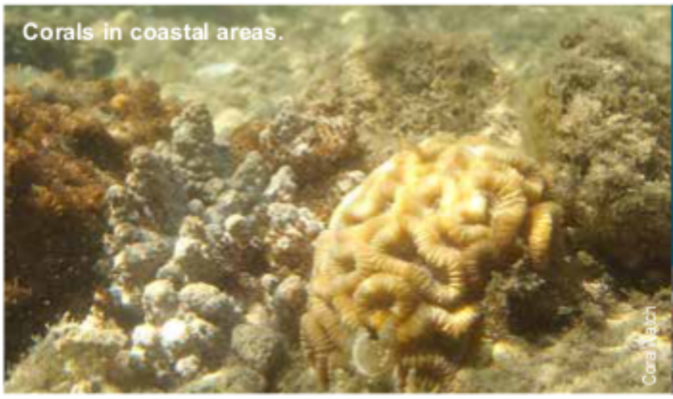
Healthy coral.

Unhealthy/Bleached coral.

Monitoring corals

Corals in coastal areas

In coastal areas water has lots of soil and sediment runoff. The main cause of high sediment levels is soil erosion from creeks and rivers, farming land and building construction sites via our catchment and river systems. Too much sediment in the water can limit the sunlight that corals and their zooxanthellae need for energy. Because of this, only some species of coral can live in these inshore areas. Corals that can tolerate murky water tend to be small, round corals. As you travel away from the mainland to more offshore areas, you can see changes in water quality and types of coral.



Corals in coastal areas.

Corals offshore.

Monitoring coral health

Scientists monitor the health of corals to determine the health of the marine environment they are in. The health of a coral is determined by the number of symbiotic algae inside the coral cells. The brown/green zooxanthellae give the coral its brown/green colour. When corals are stressed they have less zooxanthellae and become pale or even white in colour, this is called coral bleaching. You can measure the level of coral bleaching by using the CoralWatch Coral Health Chart to identify coral colour.

Citizen science

CoralWatch scientists need your help! Citizens like you can help scientists collect valuable coral health data. Simply, use a CoralWatch Coral Health Chart to colour match a coral with the chart's colours and write down the matching code. Make sure you measure at least 20 corals each time and record the lightest and darkest colour codes for each coral colony. Also record the coral type, date, water temperature, weather condition, time of day, and your location (preferably GPS coordinates). Don't forget to enter your data into the global CoralWatch database. Visit www.coralwatch.org for more information.

Saving our corals

One way to reduce stress to corals is to reduce the amount of sediment in the water. Look at the website: http://healthywaterways.org/report-card/focusareas to see how south-east Queensland is reducing sediment loads entering Moreton Bay.

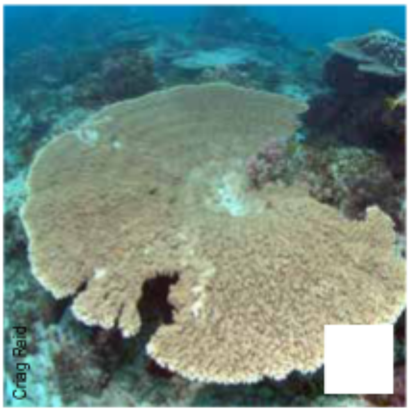
Questions

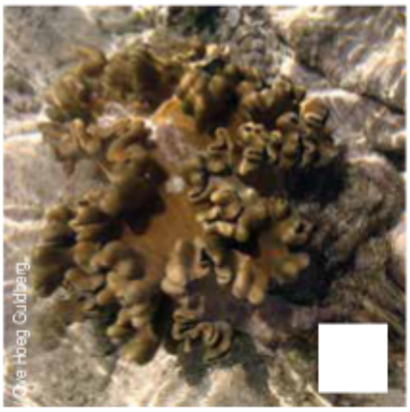
1. Draw and label a coral including the following labels: mouth, tentacles & zooxanthellae.
2. Why are corals important?
3. What is a symbiotic relationship? Explain the relationship associated with corals.
4. What is coral bleaching?
5. How can scientists measure coral health?

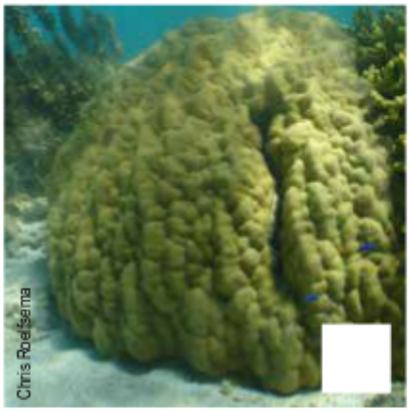
Coral bleaching – Sign of stress

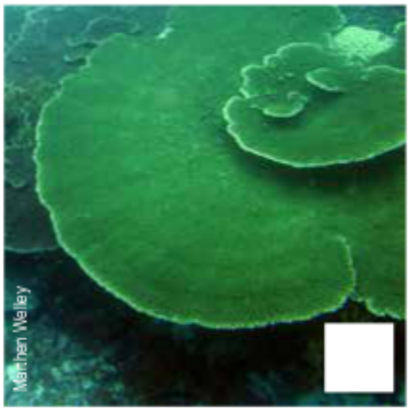
Instructions

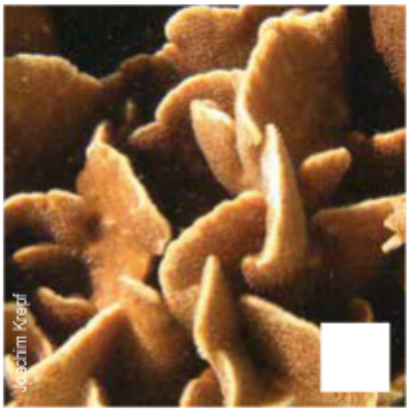
For each picture, decide if the coral is healthy or bleached. Tick the boxes if the coral is bleached or unhealthy.











Marine Ecosystems

Field Component

Planning your fieldtrip

Thorough planning is required to make your fieldtrip succesful.

Create a fieldplan including

- Risk assesment
- Safety and Code of Conduct
- Emergency procedures and contact details
- 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
- Tides and currents

Check the following

- Permits needed allowing you to do research
- Medical records from students
- Timing low-tide, especially for reef-walking

List of equipment that you may want to bring

- CoralWatch Coral Health Charts
- Waterproof slates with pencils to record data
- Quadrate
- Transect tape
- Clipboards
- Waterproof paper
- String
- Underwater camera
- Waterproof ID guide
- Mask, snorkel and fins, or reef-walking shoes
- Book and video 'Coral Reefs and Climate Change'
- Identification guides
- Personal items for each student
- Hat, sunscreen, sunglasses, water bottle

Teacher instructions, worksheets and infosheets are provided further for each activity seperately.

Field component

The following lessons developed by CoralWatch are field activities. All of them can be used as stand-alone lessons or as a sequence. Curriculum links are provided for all lessons as well as extra resources, background information and answer key to all activities.

Worksheet overview

1. Dangerous marine animals
2. Exploring and identifying invertebrates
3. Food webs – Intertidal rocky shores
4. Food webs – Intertidal coral reefs
5. Identifying coral type using the Coral Health Chart
6. Measuring coral health using random surveys
7. Measuring coral health using transect surveys
8. Establishing a permanent transect
9. Entering and analysing data using Excel
10. Entering data using www.coralwatch.org
11. Entering data using CoralWatch data entry apps

CONTENT DESCRIPTIONS

Science understanding

- Classification helps organise the diverse group of organisms (ACSSU111)
- Some of earth's resources are renewable, including water that cycles through the environment, but others are non-renewable (ACSSU116)

Science inquiry skills

- Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge (ACSIS124)
- Collaboratively and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed (ACSIS125)
- Measure and control variables, select equipment appropriate to the task and collect data with accuracy (ACSIS126)
- Construct and use a range of representations, including graphs, keys and models to represent and analyse patterns or relationships in data using digital technologies as appropriate (ACSIS129)
- Summarise data, from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions based on evidence (ACSIS130)
- Reflect on scientific investigations including evaluating the quality of the data collected, and identifying improvements (ACSIS131)
- Use scientific knowledge and findings from investigations to evaluate claims based on evidence (ACSIS132)
- Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS133)

Science as a human endeavour

- Scientific knowledge has changed peoples' understanding of the world and is refined as new evidence becomes available (ACSHE119)
- Science knowledge can develop through collaboration across the disciplines of science and contributions of people from a range of cultures (ACSHE223)

Key

General capabilities & Cross-curriculum priorities addressed within these worksheets include:

Literacy	Critical and creative thinking	Intercultural understanding
Numeracy	Personal and social capabilities	Sustainability
ICT capability	Ethical understanding	

Success criteria

- Students can identify risks that may occur in the field (1).
- Students identify characteristic features of different invertebrate groups and their associated habitats and learn about the biodiversity of the reef (2).
- Students observe and consider feeding relationships between species living in the intertidal zone of intertidal rocky shores (3) and/or intertidal coral reefs (4).
- Students identify coral types using the Coral Health Chart (5).
- Students monitor the health of corals using the Coral Health Chart in a random survey (6).
- Students monitor the health of corals using the Coral Health Chart along a transect line (7).
- Students monitor the health of corals using the Coral Health Chart establishing a permanent transect (8).
- Students enter CoralWatch field data into Excel and are able to discuss findings (9).
- Students enter CoralWatch field data into CoralWatch global database and are able to compare own data with other data (10).
- Students enter CoralWatch field data using CoralWatch phone Apps, and are able to view and compare results (11).

Resources

- CoralWatch monitoring materials; Coral Health Charts, DIY kits, Waterproof data slates

Answer key

Since all findings in the field will vary there is no answer key provided for this section. If you have any questions, feel free to contact CoralWatch at info@coralwatch.org

Dangerous marine animals

The **aim** of this activity is to identify risks that may occur in the field. Students will learn to evaluate the severity and likelihood of different risks and identify strategies to reduce impact of potential risks.

ACARA curriculum links
Science understanding (ACSSU111)
Science inquiry skills (ACSIS125)

Background
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 of hazards, 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.

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) 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 Code of Conduct.

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)
- http://www.rgs.org/OurWork/Schools/Fieldwork+and+local+learning/Fieldwork+safety/Risk+assessments
- Fieldguides for your local area

Instructions

- This activity should be conducted at low tide. Check tides timetable and plan this activity accordingly.
- Split the group into smaller groups and walk over the reef flat in search for dangerous marine animals.
- It can help to laminate ID sheets and provide groups with this.

Equipment if going in the field

- Booties or reef-walking/old shoes
- Hat, sunscreen, sunglasses
- Water bottle
- Waterproof slate with pencil
- Underwater camera (if available)
- Viewing tube (if available)
- Waterproof ID guide (if available)
- ID reference books

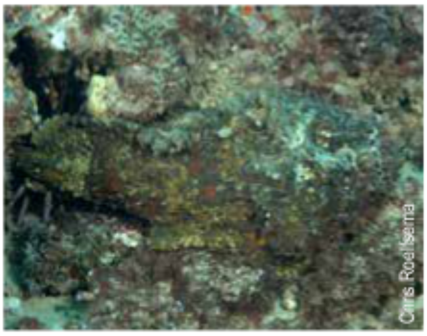
VENOMOUS MARINE ANIMALS

Tips for avoiding marine injuries

- Don't touch any marine organism
- 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.

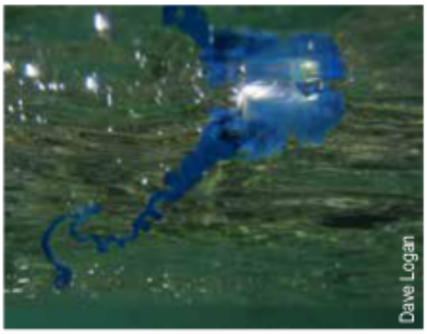
Stingrays - When stepped upon, spine can cause immediate pain.



Stonefish - Dorsal spines capable of piercing through shoes.

Scorpionfish - Tips of fins carry poisonous venom and can affect body part in minutes.

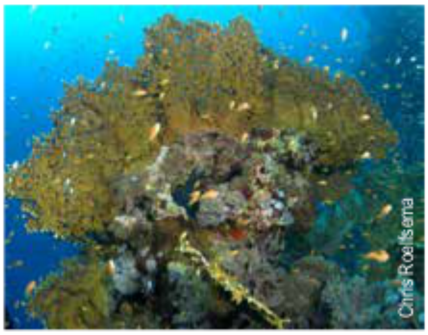
Lionfish - Spines have venom and can cause severe pain after a sting.



Blue bottle jellyfish - Discharge nematocysts and can present complications.

Sea urchin - Sharp and brittle spines which can inject poison. Painfull.

Cone shell - Shoots tiny harpoon (venomous). Painless to excruciating.



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

Hydroids - Nematocysts. Stinging sensation to extreme pain.

Blue ringed octopus - Serious bite. Painfull, can be fatal and needs treatment.

Box jellyfish - Nematocysts. Serious sting which is painful and can be fatal.

Fire urchin - Stinging sensation to extreme pain.

Dangerous marine animals

Instructions

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

Exploring and identifying invertebrates

The **aim** of this activity is to identify characteristic features of different invertebrate groups and their associated habitats and learn about the biodiversity of the reef.

ACARA curriculum links
Science understanding (ACSSU111)
Science inquiry Skills (ACSIS125)

Instructions

- This activity should be conducted on the reef flat/lagoon at low tide. Check tides timetable and plan this activity accordingly.
- 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 waterproof slate.
- It can be useful to laminate the ID-sheets with common groups of invertebrates, and take them into the field.

Equipment

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

Resources

- Invertebrate identification books
- Waterproof ID sheets / Common invertebrate cheat sheet in this curriculum

Recommended classroom activities

- Worksheet C2 - Observable features of organisms and dichotomous keys.

COMMON INVERTEBRATES

Porifera and Ascidians: Sponges, Seasquirts, Salps

Polycarpa aurata (Sea squirt).

Didemnum vexillum (Ascidian).

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

Carcinus maenas (Green crab).

Cnidarians: Jellyfish, Hydroids, Corals, Anemones

Stomolophus meleagris (Cannonball jellyfish).

Heteractis magnifica (Magnificent anemone).

Reef-building corals.

Echinoderms: Sea stars, Sea cucumbers, Sea urchins

Holothuria atra (Black sea cucumber).

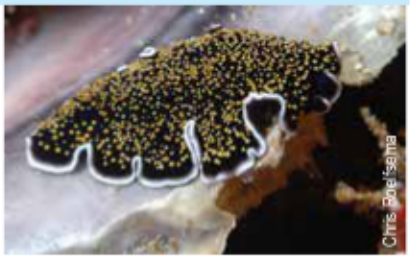
Stenopus hispidus (Banded coral shrimp).

Archaster typicus (Common sea star).

Worms: Bristleworms, Nematodes, Flatworms, Lace animals

Eupolymnia crassicornis (Spaghetti worms).

Spirobranchus spinosus (Christmas tree worm).



Thysanozoon nigropapillosum (Yellow-spotted flatworm).

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

Acanthopleura granulata (Fuzzy chiton)

Tridacna gigas (Giant clam).

Cypraea tigris (Tiger cowrie).

Exploring and identifying invertebrates

Instructions

Species ID - Reefwalk

1. Make simple drawings of the invertebrates you find. Work as a group and let everyone draw a different invertebrate to maximise the number of species found.
2. Use the invertebrates result table and make notes about colour, shape and other characteristics.
3. Take a photograph and use this as reference to look up in books once back on shore.
4. Back on shore, identify the invertebrates drawn/photographed 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.

INVERTEBRATES RESULTS TABLE

Observer(s):

Location: Date:

Weather conditions: windy / calm / cloudy / sunny

Drawing	Description List any characteristic features that assist identification

Food webs - Intertidal rocky shores

The **aim** of this activity is to observe and consider feeding relationships between species living in the intertidal zone of a coastal region, i.e. identify producers and first, second and third order consumers. Students will record and dentify characteristic features of different plant and invertebrate groups.

ACARA curriculum links

Science understanding (ACSSU111)

Science inquiry skills (ACSIS124, ACSIS125, ACSIS126, ACSIS129, ACSIS130, ACSIS131, ACSIS132, ACSIS133)

Science as a human endeavour (ACSHE119 & ACSHE223)

Instructions

- This activity should be conducted on the intertidal zone at low tide. Check tides timetable and plan this activity accordingly.
- To increase the amount of data collection, split the group into smaller groups.
- Features of the plant and invertebrate species found should be described.
- Waterproof invertebrate and plant ID sheets can help in the field to identify specimens found.

Equipment

- Sturdy reef walking shoes
- Hat, sunscreen and water bottle
- Waterproof paper to make notes and pencil
- Digital photo camera (if available)
- Identification guide or water proof ID sheets for invertebrates in the intertidal zone
- Coralwatch Coral Health Chart and datasheet (optional)

Resources

- Field guides such as plant and Invertebrate identification books
- Waterproof sheets of common invertebrates and plants or the the cheat sheets in this curriculum laminated

Recommended classroom activities

- Worksheet C2 - Observable features of organisms and dichotomous keys.

COMMON FLORA AND FAUNA – INTERTIDAL COASTAL REGIONS

Caulerpa taxifolia (Killer algae)

ALGAE grows on mud and sand flats. Requires large amounts of sunlight to produce its food.

Halophila ovalis (Dugong grass)

SEAGRASS grows in shallow water near the low tide mark. Needs sunlight to produce food.

Avicennia marina (Grey mangrove)

MANGROVE PLANTS are trees that grow on mud and sand flats. Roots poke through the sand into the air.

Pink sandy sponge

SPONGES may grow in the open or underneath rocks. They are filter feeders, commonly found in dirty waters.

Stichodactyla haddoni (Haddon's anemone)

ANEMONES bury their foot into muddy sand and use their sticky oral disc to catch food. Anemones also have symbiotic algae that live within their bodies that use sunlight to generate food.

Phyllodoce novaehollandia (Green paddle worm)

WORMS can live in the sand or mud and move about the intertidal zone at low tide. They can feed on small shrimp and crabs, other worms, and also scavenge on dead animals that are in the vicinity.

Tapas dorsatus (Tapestry venus clam)

BIVALVES are shells with two parts protecting the soft body of the animal inside. Bivalves filter food (phytoplankton & zooplankton) from the water. Many were important foods for local indigenous people for thousands of years.

Pyrazus ebeninus (Hercules club mud whelk)

GASTROPODS are sea snails and slugs. They live on rocks and in seagrass beds. They often eat seagrasses and algae in the marine environment.

COMMON FLORA AND FAUNA – INTERTIDAL COASTAL REGIONS

Aplysia sowerbyi (Sowerby's sea hare)

SEA SLUGS live in and around seagrasses and rocky shores. They feed on sponges, green and red algae. Some can be up to 15 cm long.

Hymenocera elegansi (Harlequin shrimp)

SHRIMP live in seagrass areas and around rocky areas. They feed on algae. Some shrimp make a loud clicking noise. They are called pistol shrimps.

Superfamily *Paguroidea* (Hermit crab)

CRABS eat many things including shrimp, gastropods, molluscs and even dead fish. Hermit crabs live inside shells made by other animals.

Class *Holothuroidea (Sea cucumber)*

SEA CUCUMBERS burry in sand and inhabit rocky shores. They feed on detritus and algae. When disturbed some species can eject masses of sticky white tendrils.

Acropora sp. (Hard coral)

CORALS can be found in rocky shores. They can have a stony skeleton or may be soft. Corals have symbiotic algae that live within their bodies that use sunlight to generate food. Corals also filter food from the water.

Haplochlaena fasciata (Blue-lined octopus)

OCTOPUS feed on crabs, crustaceans and small fish. No octopus should be touched as it may be a Blue-lined octopus. These have a highly venomous bite which can cause paralysis and death.

Plotosus lineatus (Striped eel catfish)

FISH move through the intertidal zone at high tide. They eat shrimp, crabs, octopus, worms and many other things.

Rhynchobatus australiae (Guitarfish)

SHARKS and **RAYS** move through the intertidal zone at high tide. They eat fish, bivalves, crabs and shrimp. You may also see Shovelnose rays in the shallow water.

Food webs - Intertidal rocky shores

Instructions

Field activity

1. Find a buddy or work in small groups.
2. Find an area that your teacher determines is safe to walk through.
3. Record any animals and plants observed at this location in the table.
4. Refer to the field guide to help with species identification.

Questions

1. Use the information provided in the field guide to determine what animals eat the plants, and identify any other animals you can observe in the area. Record this in the table (worksheet 3).
2. Predict which species are producers, first order consumers, second order consumers and third order consumers based on the information you have learned.

Back in the classroom activity

1. Construct a food web using all the plants and animals recorded in the field. Try to draw representative pictures of each animal or plant in the food web.
2. What types of corals did you observe in your field study? How do they fit into the food web of the intertidal zone?
3. Suggest what may happen if one of the first order consumers is removed from the system?

Food webs - Intertidal rocky shores

Food webs field activity results table

Group member names:

Location: **Date:**

Time:

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Food webs - Intertidal coral reefs

The **aim** of this activity is to observe and consider feeding relationships between species living in the intertidal zone and the shallow coral reef. Students will record and identify characteristic features of different invertebrate groups.

ACARA curriculum links
Science understanding (ACSSU111)
Science inquiry skills (ACSIS124, ACSIS125, ACSIS126, ACSIS129, ACSIS130, ACSIS131, ACSIS132, ACSIS133)
Science as a human endeavour (ACSHE119 & ACSHE223)

Instructions

- This activity should be conducted on the intertidal zone at low tide. Check tides timetable and plan this activity accordingly
- To increase the amount of data collection, split the group into smaller groups.
- Features of the plant and invertebrate species found should be described.
- Waterproof invertebrate and plant ID sheets can help in the field to identify specimens found.

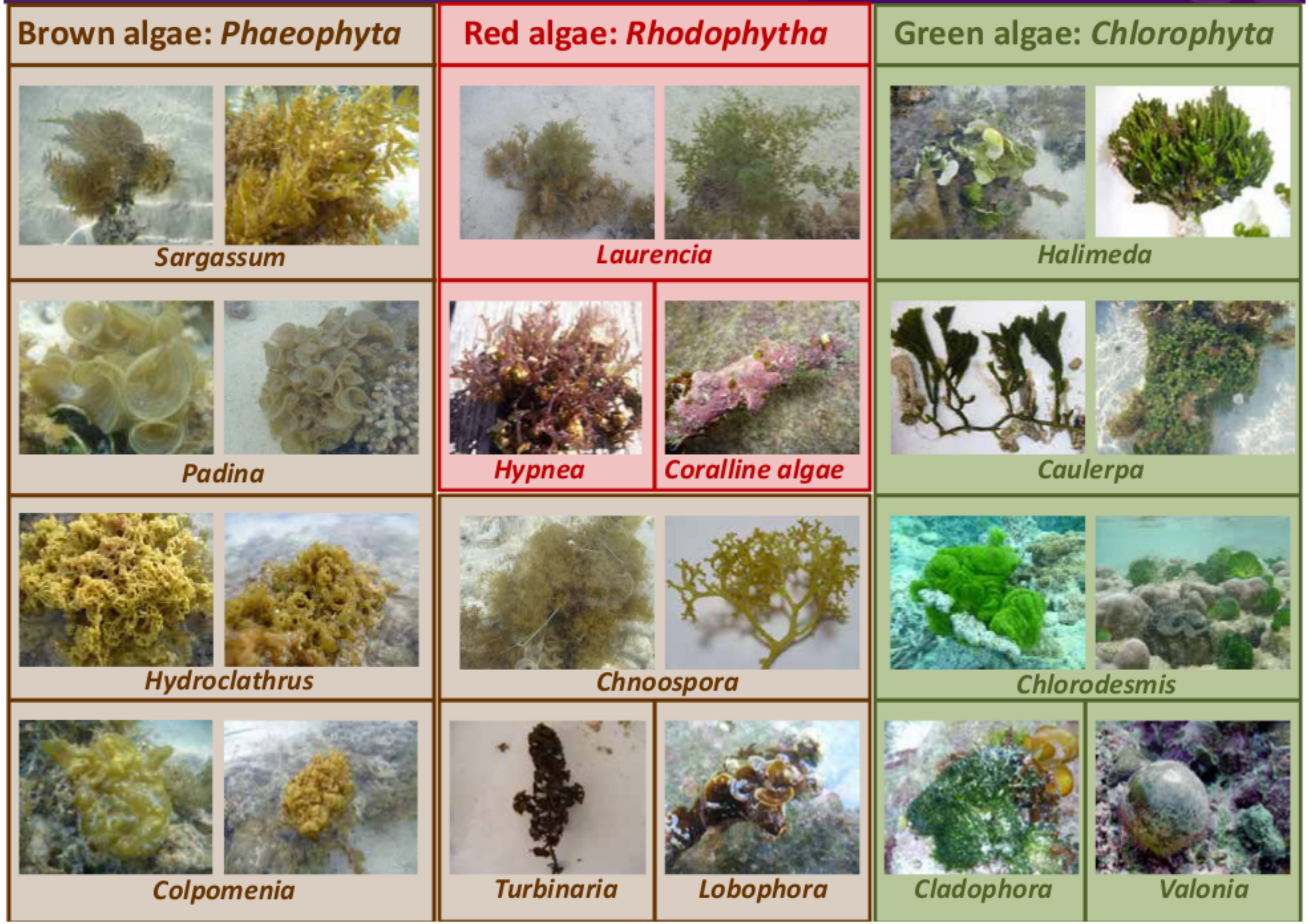
Equipment

- Sturdy reef walking shoes
- Hat, sunscreen and water bottle
- Waterproof paper and pencil
- Identification guide for animals and plants in the intertidal zone
- Digital camera
- Coralwatch Coral Health Chart and datasheet (optional)

Resources

- Common flora and fauna ID sheets
- Field guides

Common algal genera of Heron Island Reef Flat



Heron Island Research Station - Kyra Hay

Common critters of Heron Island Reef Flat

Echinoderms

Blue Star
Linckia laevigata

Pincushion star
Culcita novaeguineae

New Caledonian Star
Nardoa novaecaledoniae

Echinoderms

Tuberculate Star
Nardoa tuberculata

Greenish Sea Cucumber
Stichopus chloronotus

Black Sea Cucumber
Holothuria atra

Echinoderms

Variegated Sea Cucumber
Stichopus variegatus

Stained Sea Cucumber
Holothuria leucospilota

Brunt Sausage Cucumber
Holothuria edulis

Crustaceans

Tropical shore crabs
Grapsus sp.

White spotted hermit crab
Dardanus megistos

Tiger Sea Cucumber
Holothuria hilla

Heron Island Research Station - Kyra Hay

Common critters of Heron Island Reef Flat

Mollucs	Mollucs	Mollucs	Elasmobranchs
 Chiton *Acanthopleura spinosa*	 Jimmie the Nudibranch *Gymnodoris* sp.	 Tigar Cowrie *Cypraea tigris*	 Epaulette shark *Hemiscyllium ocellatum*
			Annelids
 Common Sea Hare *Aplysia dactylomela*	 Phillip the Opisthobranch *Philinopsis gardineri*	 Gold Ringed Cowrie *Cypraea annulus*	 Christmas Tree Worm *Spirobranchus giganteus*
 Flat Bottomed Sea Hare *Dolabella auricularia*	 Ass's Ear Abalone *Haliotis asinina*	 Giant Clams *Tridacna spp.*	 Spaghetti Worm *Loimia medusa*

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Food webs - Intertidal coral reefs

Instructions

Field activity

1. Find an area that your teacher determines it is safe to walk through.
2. Record any animals and plants observed in this location in the table as a group.
3. Refer to field guides to help with species identification.
4. Any corals encountered should be assessed using the CoralWatch Coral Health Chart.

Questions

1. Use the information provided in the field guide to determine what animals eat the plants and other animals observed. Record this in the table (worksheet 4)
2. Predict which species are producers, first order consumers, second order consumers and third order consumers based on the information you have learned.

Back in the classroom activity

1. Construct a food web using all the plants and animals recorded in the field. Try to draw representative pictures of each animal or plant in the food web.
2. What types of corals did you observe in your field study? How did they fit into the food web of the intertidal zone?
3. Suggest what may happen if one of the first order consumers is removed from the system?
4. Did you find any difference in colour scores using the Coral Health Chart? Do you think the corals are healthy and why?

Food webs - Intertidal coral reefs

Food webs field activity results table

Group member names:

Location: **Date:**

Time:

1				
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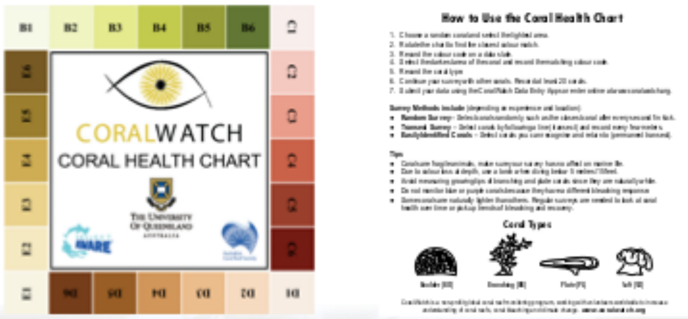
Identifying coral type using the Coral Health Chart

The **aim** of this activity is to identify coral types using the Coral Health Chart.

ACARA curriculum links
Science understanding (ACSSU111)
Science inquiry skills (ACSIS125 & ACSIS126)
Science as a human endeavour (ACSHE119 & ACSHE223)

Instructions
- This activity should be conducted at low tide. Check tides timetable and plan this activity accordingly.
- Because identifying coral species is very difficult, CoralWatch classifies coral types in easy identifiable 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 match. If a particular coral is too difficult to classify, just skip this coral and move on to the next one.
- CoralWatch classifies most free living, tabular, encrusting and foliaceous corals as plates.
- CoralWatch classifies most digitate, bushy and staghorn corals as branching.

Equipment
- Booties
- Hat, sunscreen and water bottle
- Coral Health Chart
- Waterproof slate or paper with pencil
- Underwater camera (if available)
- Viewing tube (if available)
- Waterproof ID guide (if available)
- ID reference books (if available)



BOULDER CORAL

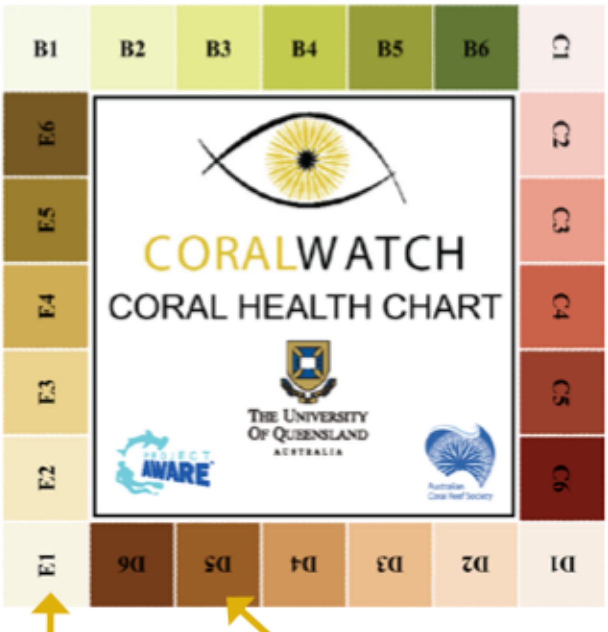
BRANCHING CORAL

PLATE CORAL

SOFT CORAL

CORALWATCH DO IT YOURSELF INSTRUCTIONS

Using the **CORAL HEALTH CHART** *is easy*



Bleached branching coral
Colour code: E1
Coral type: Branching (BR)

Healthy branching coral
Colour code: D5
Coral type: Branching (BR)

The Coral Health Chart records changes in coral colour, and provides a simple tool for people to monitor coral colour as an indicator of coral health.

Steps to take

1. Choose a random coral and select the lightest area.
2. Rotate the chart to find the closest colour match.
3. Record the colour code on a data slate.
4. Select the darkest area of the coral and record the matching colour code.
5. Record the coral type.
6. Continue your survey with other corals. Record at least 20 corals.
7. Submit your data using the CoralWatch Data Entry Apps or enter online at www.coralwatch.org.

Avoid measuring growing tips of branching and plate corals since they are naturally white. Do not monitor blue or purple corals because they have a different bleaching response. It's simple; only choose corals with colours that approximately match the chart.

CORAL TYPES - *just 4 to choose from*

Coral types are described by the overall shape (growth form) of coral colonies. Using the Coral Health Chart select the following four coral types or record what you think is the closest.

Boulder (BO)
Any massive or rounded coral, such as some Porites species.

Branching (BR)
Any branching coral, such as some Acropora species.

Plate (PL)
Any plate-like shape coral, such as tabular Acropora species.

Soft (SO)
Any corals lacking a hard skeleton, such as Sarcophyton species.

CORAL GROWTH FORMS

FREE LIVING

Fungiidae sp.

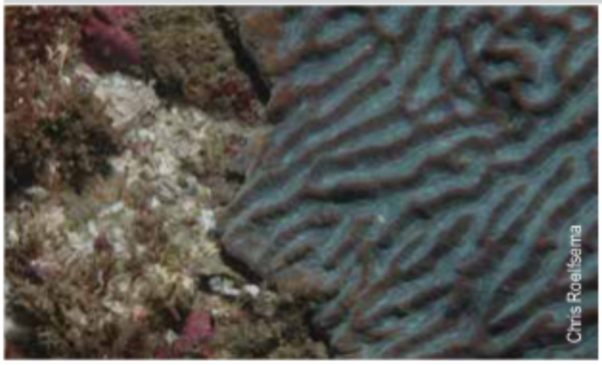
Fungiidae sp.

DIGITATE

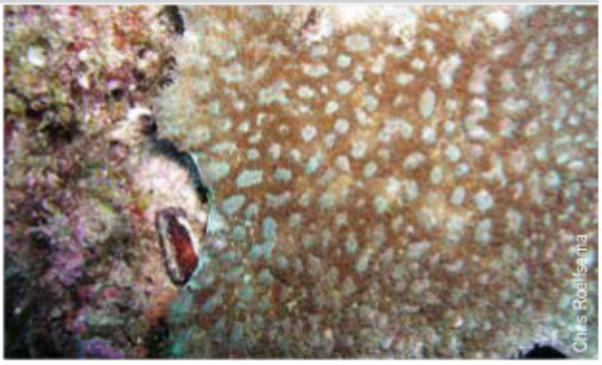
Acropora sp.

Pocillopora sp.

ENCRUSTING



Goniastrea sp.



Hydnophora sp.

SOFT

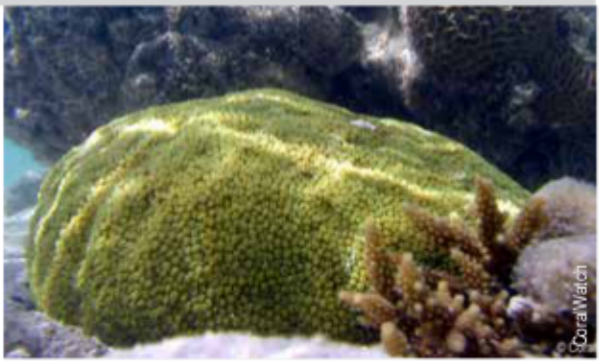
Lobophytum sp.

Sarcophyton sp.

CORAL GROWTH FORMS

BOULDER (MASSIVE)

Platygyra sp.



Porites sp.

PLATE

Acropora sp.

Acropora sp.

BRANCHING

Acropora sp.

Acropora sp.

FOLIACEOUS

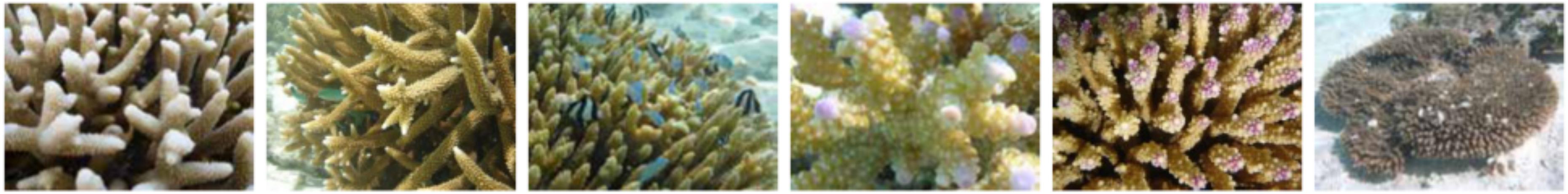
Turbinaria sp.

Pavona sp.

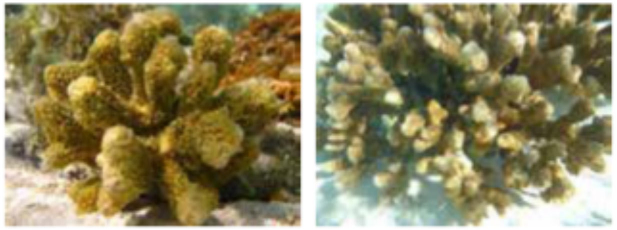
Common coral genera of Heron Island Reef Flat

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

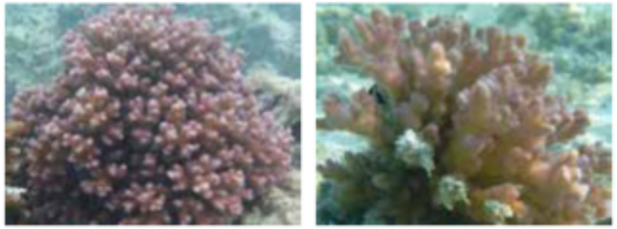
Acropora



Isopora

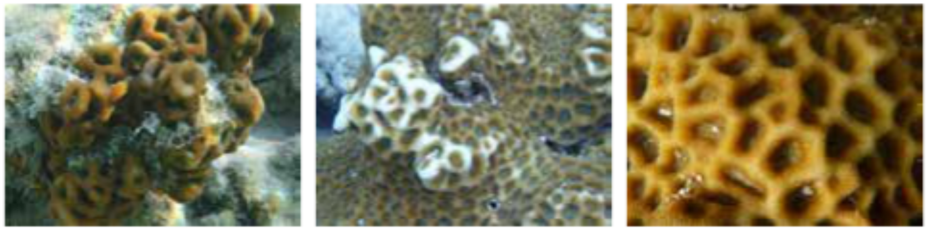


Pocillopora



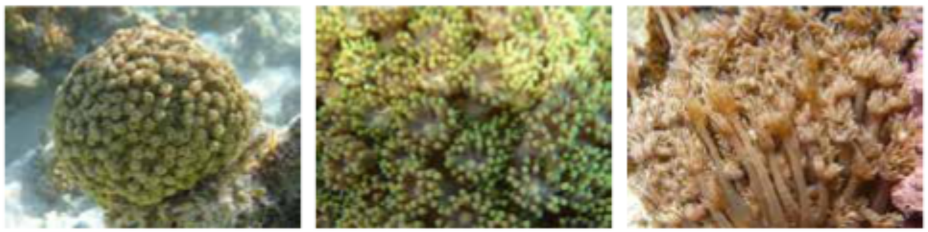
Stylophora

Favites



Porites

Goniopora



Montipora

Heron Island Research Station - Kyra Hay

Identifying coral type using the Coral Health Chart

CoralWatch


Branching (BR)


Boulder (BO)


Plate (PL)


Soft (SO)

The Coral Health Chart uses four coral types to classify corals. **Branching** refers to any branching coral, such as Acropora and Pocillopora species. **Boulder** refers to any massive or rounded corals, such as brain corals and 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, e.g. Sarcophytum species.

Instructions

1. Copy the coral type template on a waterproof slate.
2. Locate a coral colony, observe it and record the coral type. 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? Use your coral ID card.

CORAL TYPES	
Branching	**Boulder**
Plate	**Soft**

Field Component

Measuring coral health using random surveys

The **aim** of this activity is to monitor the health of corals using the Coral Health Chart in a random survey as research technique.

ACARA curriculum links
Science understanding (ACSSU116)
Science inquiry skills (ACSIS124, ACSIS125, ACSIS126)
Science as a human endeavour (ACSHE119 & ACSHE223)

Instructions

- The most important part of a random survey is that it is truly random: don't pick the corals you like or because they are bleached.
- This activity can be conducted snorkelling or reef walking. If reef walking, it should be conducted on a low tide.
- The CoralWatch Virtual Reef Activity is a useful preparation for using the Coral Health Chart in the field.
- The CoralWatch data slate contains all required survey details. You can also create your own data slates by transcribing all the information onto blank waterproof paper. Make sure you don't miss any details!

Steps to take for a random survey

1. Read the instructions on the back of the Coral Health Chart.
2. Make sure you have all your equipment as listed.
3. Start with recording survey details on your data slate: name, date, time, GPS coordinates (if possible), water temperature, depth, activity and conditions.
4. Choose how often you will measure a coral colony (e.g. every 6 steps or 2 fin-kicks).
5. Begin in a clear direction drawing an imaginary line in your direction of travel.
6. Every 2 fin-kicks, measure the colour scores and coral type of the coral colony closest to you.
7. Repeat this for at least 20 corals.

Equipment

- If snorkelling - mask, snorkel and fins
- If reef walking - booties, hat and sunscreen
- Coral Health Chart
- Waterproof data slate with pencil
- Thermometer (if available)
- Underwater camera (if available)
- Viewing tube (if available)
- GPS to record locaiton coordinates (if available)

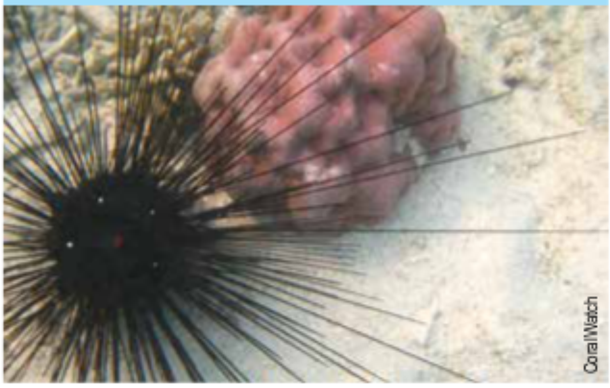
Example of CoralWatch data slate.

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.

TIPS FOR CORALWATCH MONITORING

Collect data from 20 different coral colonies

Be careful - avoid touching marine life



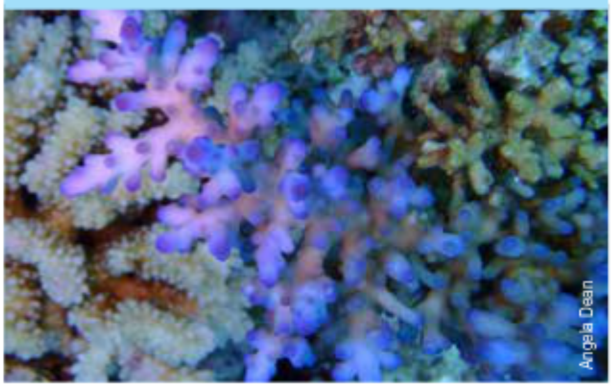
Stay together as a buddy team

Corals are fragile - please don't touch

Use a GPS for location accuracy

Use a torch when diving below 5 m/15 feet

Do not monitor blue corals



Blue corals bleach differently to other corals.

Don't measure the tips of corals

Growing tips of branching corals and the edges of plate corals are naturally pale.

Choose a **SURVEY METHOD** that suits you

The Coral Health Chart can be used while diving, snorkeling or reefwalking. You can choose a monitoring method that suits your skills, experience and location. Most people use the random survey method.

Random Survey – select corals randomly. Swim in an imaginary line and choose the closest coral after every second fin kick (or every second step when walking).

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

Easily Identified Corals – select corals you can easily recognise and return to. A permanent transect would give you the opportunity to monitor the same corals over time.

Colour scores

The colours on the Coral Health Chart are based on the actual colours of bleached and healthy corals. Each colour square 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.

Tips

- Due to colour loss at depth, use a torch when diving below 5m/15 feet.
- Monitor at least 20 corals per survey.
- Use a GPS if available and record co-ordinates OR select the location using our Data Entry Apps or online data entry form.
- Don't forget to record your name, country, name of reef, date and time of survey, depth, water temperature and weather.
- Corals are fragile animals, avoid touching or stepping on corals.
- When diving, secure your equipment and make sure you're properly weighted.

Convenient **DATA ENTRY** using Apps

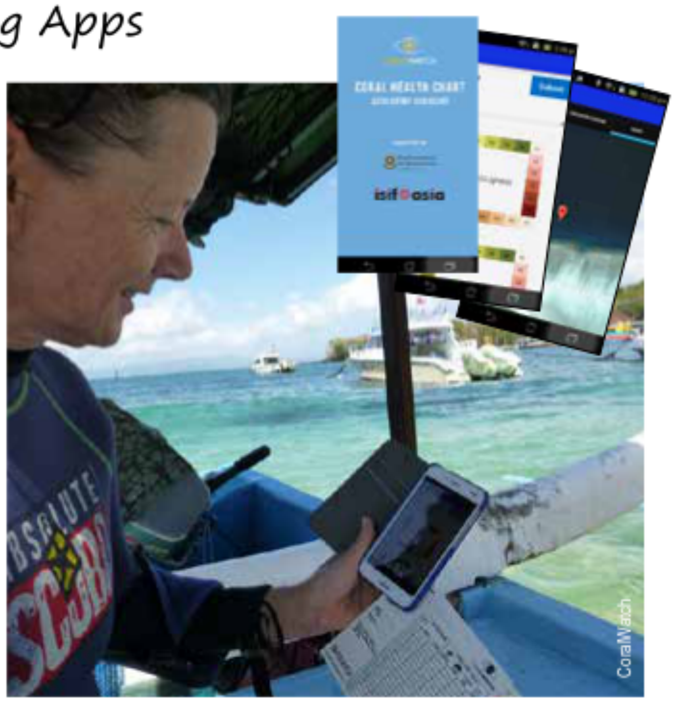
Transfer your findings to our global database by using the CoralWatch website or our 'CoralWatch Data Entry' Apps.

CoralWatch Data Entry Apps allows you to:

- Enter CoralWatch data results on your phone.
- Record the GPS co-ordinates on the spot.
- View your survey results.
- Store your survey data, work offline and upload at a later time.

ANDROID APP ON Google play | Download on the App Store

Available in English and Bahasa Indonesia.



Measuring coral health using transect surveys

The **aim** of this activity is to monitor the health of corals using the Coral Health Chart along a transect line as research technique.

ACARA curriculum links

Science understanding (ACSSU116)
Science inquiry skills (ACSIS124, ACSIS125, ACSIS126)
Science as a human endeavour (ACSHE119 & ACSHE223)

Instructions

- This activity can be conducted snorkelling or reef walking. If reef walking, it should be conducted on a low tide.
- The CoralWatch Virtual Reef Activity is a useful preparation for using the Coral Health Chart in the field.
- The CoralWatch data slates contain all required survey details. You can also create your own data slate by transcribing all the information onto blank waterproof paper. 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 or when taking measurements.
- For future reference, students could mark the start and end of your transect using GPS coordinates and re-survey the transect over time.

Steps to take for a transect survey

1. Read the instructions on the back of the Coral Health Chart.
2. Make sure you have all your equipment as listed.
3. Start with recording survey details on your data slate: name, date, time, GPS coordinates (if possible), water temperature, depth, activity and conditions.
4. 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 to 5 meter intervals.
5. Swim or walk along the tape, and record data every 50 cm (depending on coral cover). Aim to collect data for 20 different coral colonies.

Equipment

- If snorkelling - mask, snorkel and fins
- If reef walking - booties, hat and sunscreen
- Coral Health Chart
- Waterproof data slate with pencil
- Tape measure or rope with distance measurements
- Thermometer (if available)
- Underwater camera (if available)
- Viewing tube (if available)
- GPS to record location coordinates (if available)

Establishing a permanent transect

The **aim** of this activity is to monitor the health of corals over time by using a **permanent transect** as a research technique. Students will learn to identify corals that are easy to recognise and suitable for future monitoring, taking photos, measurements and GPS coordinates for future reference.

ACARA curriculum links
Science understanding (ACSSU116)
Science inquiry skills (ACSIS124, ACSIS125, ACSIS126, ACSIS131)
Science as a human endeavour (ACSHE119 & ACSHE223)

Instructions

- This activity should be conducted on the reef flat at low tide. Check the tide tables for low tide.
- Allowing students to select their favourite coral colony and choose a name can make this an engaging activity for students.
- 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.
- Your school can set up its own permanent transect that you revisit each year providing your school with its own data to use for timeline comparisons!

Steps to take for a permanent transect

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.

Equipment

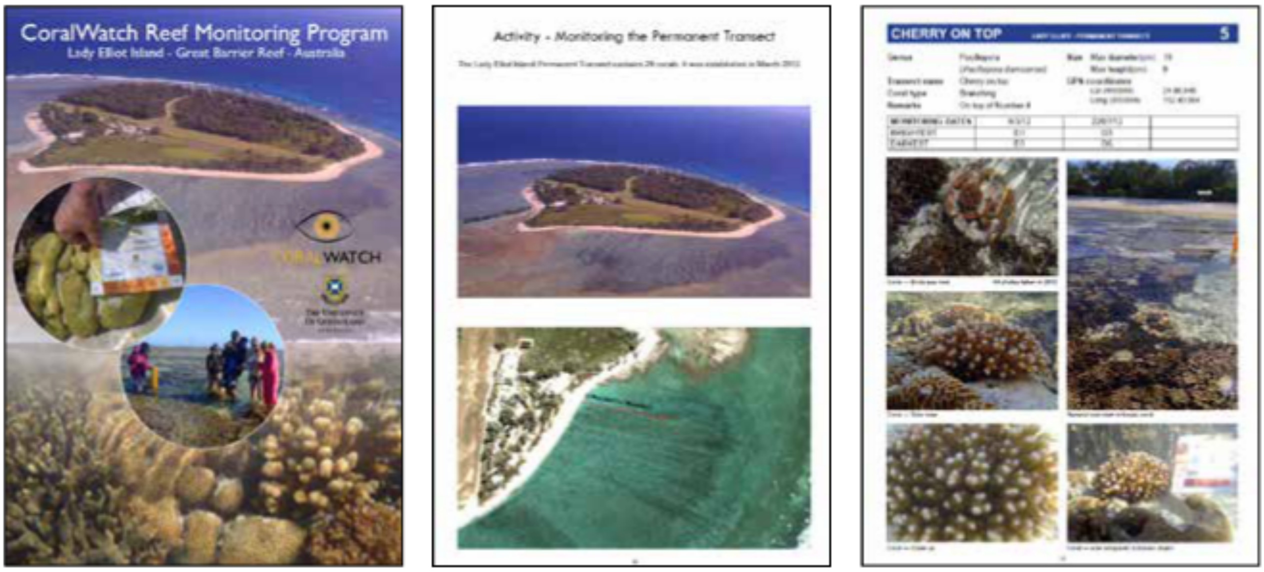
- Booties, hat and sunscreen
- Waterproof slate with pencil
- CoralWatch Coral Health Chart
- Waterproof data slate with pencil
- Underwater camera (if available)
- Viewing tube (if available)
- Waterproof ID guide (if available)
- GPS (if available)
- ID reference books and sheet cheat in the booklet
- Computer

Resources

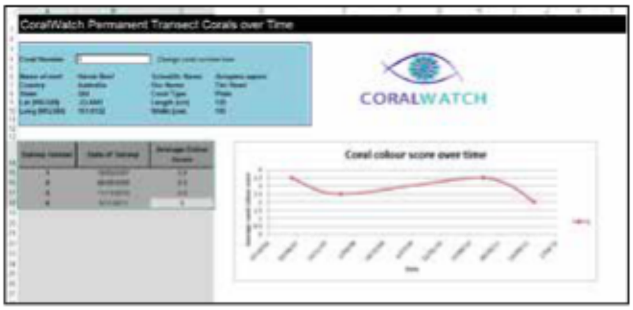
CoralWatch has established three permanent transects. Two located on Heron Island and one on Lady Elliot Island.
Help us to collect more data. Visit www.coralwatch.org/web/guest/education-materials to download:
- 'Heron Island Workbook' (PDF) and 'Permanent Transect data entry Heron Island individual 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.

Establishing a permanent transect



The booklets from Heron Island and Lady Elliot Island - available for downloading - will provide all existing survey details. We would like to invite you to visit these transects and add more data to our Excel sheets.



The Excel sheets allow you to add data and view coral colour score over time for each individual coral.

Entering and analysing data using Excel

The **aim** of this activity is to enter CoralWatch field data into an Excel spreadsheet and discuss findings.

ACARA curriculum links

Science understanding (ACSSU116)
Science inquiry skills (ACSIS124, ACSIS125, ACSIS126, ACSIS129, ACSIS130, ACSIS131, ACSIS132)
Science as a human endeavour (ACSHE119 & ACSHE223)

Instructions

1. Download and 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 reefs. Do your results indicate a healthy or more bleached reef?

Please note

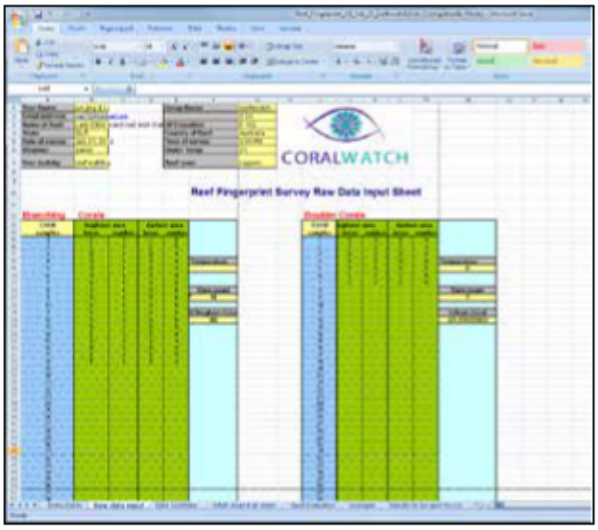
- This tool does not send the data to our online global database. If you have collected real data from the field, please enter it online, as described in the next activity.
- This tool is also suitable for entering practice data recorded as part of the Virtual Reef Activity. See also worksheet FW5, page 29.

Equipment

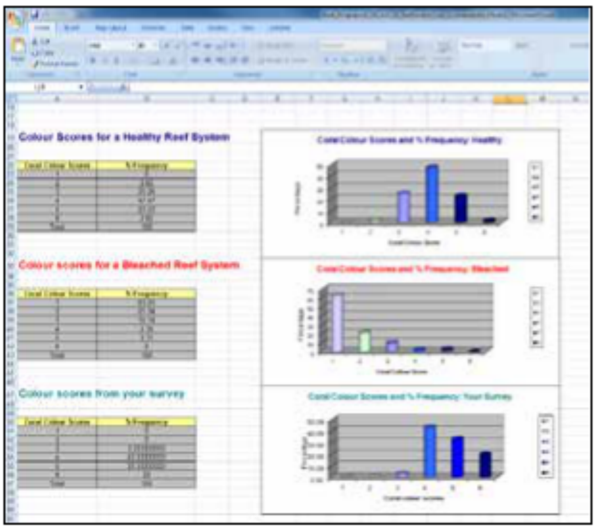
- Computer, with Microsoft Excel installed
- Your data collected in the field or using a Virtual Reef

Resources

- ‘Reef Fingerprint 100’ template - can be downloaded from the CoralWath website (www.coralwatch.org/web/guest/monitoring-materials).



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 the CoralWatch website

The **aim** of this activity is to enter CoralWatch field data into the CoralWatch online global database and compare and analyse your own data with existing data (if applicable).

ACARA curriculum links
Science understanding (ACSSU116)
Science inquiry skills (ACSIS124, ACSIS125, ACSIS126, ACSIS129, ACSIS130, ACSIS131, ACSIS132)
Science as a human endeavour (ACSHE119 & ACSHE223)

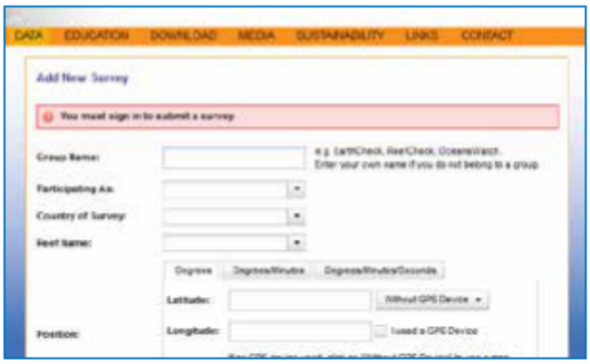
Instructions

1. Go to www.coralwatch.org
2. Go to the 'Download' tab and select 'Education Materials'.
3. Download the 'Data Entry' and 'Data Analysis' guidelines for step-by-step instructions.
4. Go to the 'Data' tab and select 'Enter data'.
5. You need to be signed in to submit a survey: you have to become a member to be able to enter data. Membership is free.
6. Enter all your details from your data slate and submit.
7. If you don't have GPS coordinates you can find your location on the map.
8. Enter all data records and look at your results.
9. Compare the data you collected to:
   a. Past data on the same reef (if available).
   b. A nearby reef.
   c. Fellow students.

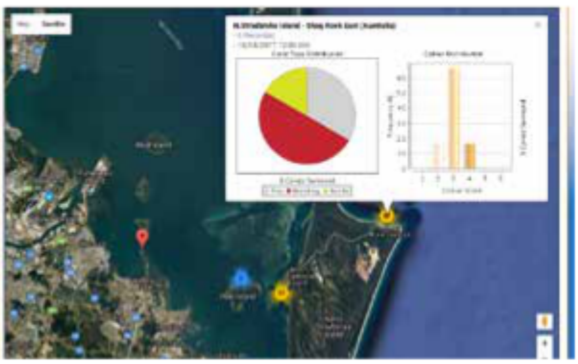
Point out the importance of entering real data. Entering survey data into the online CoralWatch global database ensures that the data can be used by reef managers and scientists studying coral bleaching.

Equipment

- Computer
- Internet access
- Your field data
- Data analysis pdf (download from CoralWatch)
- Data entry pdf (download from CoralWatch)



Example of the 'add new survey' page.



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

Entering data using the CoralWatch data entry Apps

The **aim** of this activity is to enter CoralWatch field data using CoralWatch phone Apps, view and analyse survey results, and upload the data to the CoralWatch global database.

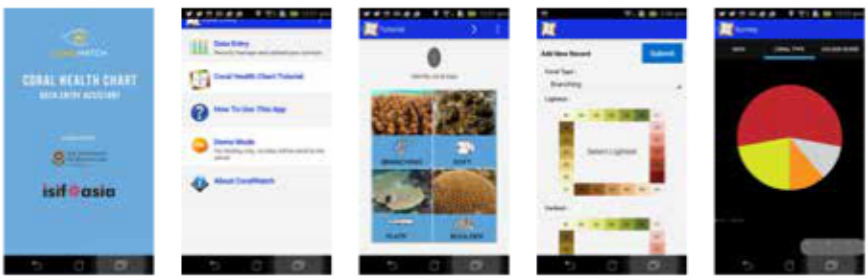
Students can practice entering data on the mobile App using demo mode with the virtual reef.

ACARA curriculum links
Science understanding (ACSSU116)
Science inquiry skills (ACSIS124, ACSIS125, ACSIS126, ACSIS129, ACSIS130, ACSIS131, ACSIS132)
Science as a human endeavour (ACSHE119 & ACSHE223)

Instructions
1. Download from the website the 'Data Entry' guideline for step-by-step instructions if needed (www.coralwatch.org,download - education materials).
2. Download the CoralWatch data entry App on a phone. Available for Android and Iphone.
3. Login/register as a member. Membership is required to enter data. Membership is free.
4. Set your phone preferences to online/offline use - you can store data and upload it later.
5. Add a new survey and enter all details as requested.
   Notes about GPS
   - Only select 'Use your current location' when you are at the actual field site. Don't use this option when you are back in the classroom.
   - If you revisit an existing field site - GPS coordinates will appear automatically and you can select 'Use above coordinates'.
   - Choose the 'Use map to choose location' to place a marker at your field site. This can be done in the field or classroom.
   - Or enter you coordinates manually.
6. After entering all your metadata, enter your survey data by selecting coral type, then the lightest and darkest colour for each coral.
7. Once finished, check results and upload data to the database. You have to manually upload data.

Please note
- To practice entering data use 'demo mode' - no data will be send to the global database.
- You will still need your Coral Health Chart and slate to collect your data in the field, but this App will make it quick and easy to upload your data to CoralWatch.

Equipment
- Android or Apple mobile phone
- Internet access
- Your field data



Different screen previews of the CoralWatch data entry App.

CoralWatch data entry Apps allow you to:
- Enter CoralWatch data on your phone.
- Record the GPS coordinates on the spot.
- View your survey results.
- Store your survey data, work offline and upload at a later time.

Assignment

Environmental Health: Using coral as an indicator species

ACARA curriculum links

Science understanding (ACSSU116)

Science inquiry skills (ACSIS124, ACSIS125, ACSIS126, ACSIS129, ACSIS130, ACSIS131, ACSIS132, ACSIS133)

Science as a human endeavour (ACSHE119 & ACSHE223)

Write up a scientific research report on your investigation on the health of the corals in your research area. Draw conclusions of coral health, making connections with environmental health, water quality and the water cycle.

Imagine that you are a scientist and you have been contracted to produce a report on the health of an inshore marine environment. Specifically you are to assess the sediment load entering the inshore environment using corals as an indicator species of environmental health. You are to conduct an environmental assessment, collect and analyse field data and write a report.

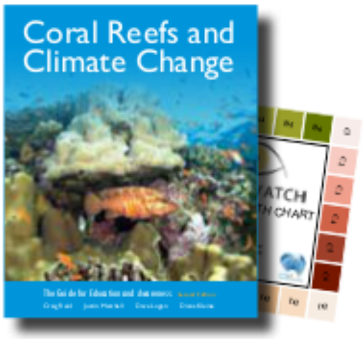
Assignment objectives students will learn to:

- Identify the importance of the marine environment.
- Discuss the issues associated with sediment – causes and affects.
- Develop a research question and a research plan for data collection.
- Collect research data.
- Analyse and interpret data.
- Present your conclusion of the health of the marine environment investigated, making connections with water quality and the water cycle.

Use the following outline to write your environmental report:

- **Title Page**
  - Include your name, class, title and subtitle. This needs to include the name of your location and indicator species.
- **Introduction** (1 paragraph)
  - Introduce your environmental issue and why you are concerned. Example 'Moreton Bay corals covered in sediment due to port expansion'.
  - Explain what coral bleaching is and why this is an indicator for water quality.
- **Method** (2 paragraphs)
  - Explain how you collected data.
  - Explain how you analysed the data.
- **Results** (1 or 2 paragraphs)
  - Present your data in graphical form and describe the findings.
- **Discussion** (1 or 2 paragraphs)
  - Evaluate the quality of your investigation. What when wrong, how could the results be more accurate?
  - Explain what the results mean making connections to water quality and environmental health.
  - Suggest solutions to high sediment load entering inshore areas.
- **Conclusion** (1 paragraph)
  - What was your final rating on the environmental health of the area you investigated?
- **Bibliography** (minimum 2 sources)
  - List where you found your supporting information used to write the report such as websites (e.g. www.coralwatch.org, articles, textbooks and other sources.

CORALWATCH AND OTHER RESOURCES



'Coral Reefs and Climate Change' book with free Coral Health Chart and monitoring instructions.

Coral Reefs and Climate Change
The Guide for Education and Awareness

CoralWatch has published the 2nd edition of the book 'Coral Reefs and Climate Change'. Beautifully illustrated, this book is targeted to students, reef enthusiasts and the general public. Chapters cover oceanography, coral reef ecology, climate change and conservation. This 2nd edition has been fully updated and includes the latest scientific findings. All books come with a Coral Health Chart and Do-It-Yourself kit. The book can be purchased alone or with our educational DVD series with short movies complementing the book.

Published by CoralWatch, The University of Queensland - 2012
ISBN: 978-0-646-59085-1. Paperback, 264 pages
Authors: Craig Reid, Justin Marshall, Dave Logan and Diana Kleine. Edited by Angela Dean.

'Coral Reefs and Climate Change' DVD.

Educational DVD Series

Illustrated through animated diagrams and photos, interviews with scientists, clear language, and footage from around the globe, this series brings concepts from the book to life. Each of these 22 stand-alone videos (3-8 min each) explore key topics in oceanography, coral reef ecology, climate change and reef conservation. Suited to use in a variety of settings, this series may be used independently or in conjunction with other CoralWatch education materials.

Published by CoralWatch, The University of Queensland - 2012
ISBN: 978-0-646-57942-9

'DIY Kit' with monitoring instructions.

Do It Yourself Coral Health Monitoring Kit

Includes Coral Health Chart, underwater data recording slate with pencil, instructions and information brochures, sticker and postcard. All packed in waterproof folder.

CoralWatch packages

Whether you are an individual or an educator, our education materials provide you with everything you need to get involved in protecting reefs.

Power of One package

Includes Book and DVD, Do It Yourself (DIY) monitoring instructions and reading materials packed in CoralWatch bag.

Moreton Bay education package

Available for primary or high school. Includes Moreton Bay (MB) virtual reef, MB Coral ID sheet, year 1 and/or year 7 lessons and resources, MB and GBR info flyers, Coral Health Chart with slate and DIY monitoring instructions.

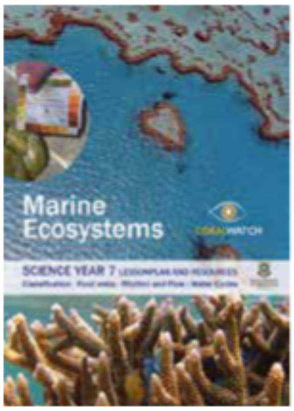
Ultimate teaching package

Includes Book and DVD, activity CD, workbook, class set of Coral Health Charts and slates, DIY monitoring instructions, virtual reef materials, posters and booklets. See orderform for full contents.

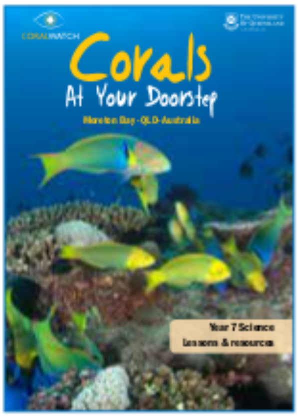
CORALWATCH AND OTHER RESOURCES

Australian curriculum linked lesson materials

'Colours on the Reef'
Year 1 Science
Lesson plan.



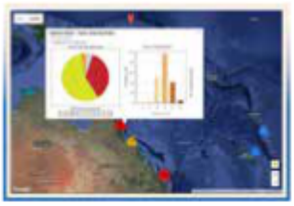
'Marine Ecosystems'
Year 7 Science
Lessons and resources.



'Corals at Your Doorstep'
Moreton Bay QLD Australia
Year 7 Science
Lessons and resources.

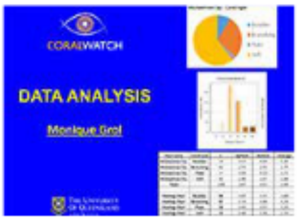
'Healthy reefs from polyp to policy'
Year 11/12 Marine Science
Unit plan.

CoralWatch Data

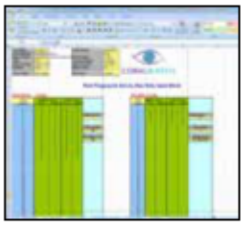


'CoralWatch global database'
Data freely available from 78 countries, 1667 reefs and 9565 surveys.

'Data entry'
Guide to entering CoralWatch data online or by App.



'Data analysis'
Guide outlining applications of CoralWatch data.



'Raw data input sheet'.

Virtual reef materials

'Virtual Reef poster' - 2 versions
Moreton Bay or Tropical Reef.

'Virtual lab booklet'.

'Virtual reef booklet'.

Monitoring

'CoralWatch DIY instructions'
Available in 12 languages.

Data slates

'Coral Health Charts'
Available in 5 languages.

Coral Bleaching

'GBR - 2016 Global Coral Bleaching'.

'Before - During - After Bleaching'
Photo series from bleaching event Lizard Island 2016.

CORALWATCH AND OTHER RESOURCES

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 NJ, 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
- Marshall NJ, Kleine DA, Dean AJ (2012) CoralWatch: education, monitoring, and sustainability through citizen science. Frontiers in Ecology and the Environment 10(6):332–334
- Leiper IA, Siebeck UE, Marshall NJ and Phinn SR (2009) Coral health monitoring: linking coral colour and remote sensing techniques. Canadian Journal of Remote Sensing 35:276-286

Articles and reports

- Burke L, Reytar K, Spalding M and Perry A (2011) Reefs at Risk Revisited, World Resources Institute, Washington DC. www.wri.org/publication/reefs-at-risk-revisited
- Burke L, Selig E and 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 and 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.mangrovewatch.org.au/
- 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
- ReefCheck Australia: https://www.reefcheckaustralia.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
- FishBase: www.fishbase.org
- Atlas of Living Australia: www.ala.org.au
- Australian Institute of Marine Science (AIMS): www.aims.gov.au
- ARC Centre of Excellence Coral Reef Studies: www.coralcoe.org.au
- Corals of the World: www.coralsoftheworld.org/page/home

Act Now

for the future of our reefs

www.coralwatch.org

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