Marine Systems

Connections and Change

CORALWATCH

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

The reef and beyond & Changes on the reef

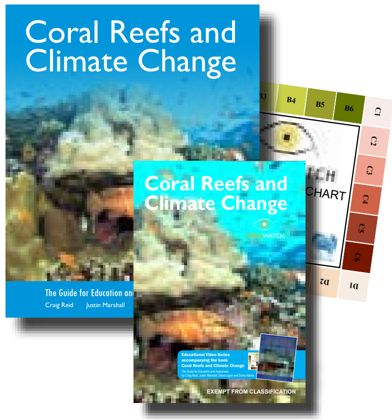
MARINE SCIENCE 2019 - UNIT 3 WORKSHEETS / RESOURCES

Contents

CoralWatch has developed various lessons for Unit 3, Marine Science, General Senior Syllabus. This booklet is a start, we will develop more lessons over time and post them on our website. You can download the lessons FOC from https://coralwatch.org/index.php/education-2/curriculum-materials/marine-science/

All lessons are linked to our 'Coral reefs and Climate Change' book and video series. Practical activities for field and classroom have been developed to practice content. For copies of the book, coral health charts, virtual reef and other materials visit our online shop https://coralwatch.org/index.php/shop/

If you take your students in the field to collect data, please don't forget to upload your data in our global database. All data is public available, students can travel the world and find data from currently 2015 reefs in 78 countries. CoralWatch data has been used in the example data test.



'Coral Reefs and Climate Change' book and video series

Lessons

UNIT 3 - TOPIC 1 - THE REEF AND BEYOND

Coral Reef Distribution

SUBJECT MATTER AND BACKGROUND INFO

- identify the distribution of coral reefs globally and in Australia
- identify abiotic factors that have affected the geographic distribution of corals over geological time including dissolved oxygen, light availability, salinity, temperature, substrate, aragonite and low levels of nitrates and phosphates
- recall that corals first appeared within the geological record over 250 million years ago but not in Australian waters until approximately 500 000 years ago
- recognise that the Great Barrier Reef of today has been shaped by changes in sea levels that began over 20 000 years before present (BP) and only stabilised 6500 years BP
- recall the different types of reef structure (e.g. fringing, platform, ribbon, atolls, coral cays)
- recognise the zonation within a reef cross-section (e.g. reef slope, reef crest/rim, lagoon/back reef).

GUIDANCE

- Notional time: 6 hours
- Snorkelling skills may be used to expand marine scientific inquiry skills in this unit.
- Opportunities exist to discuss sea level rise from Aboriginal perspectives and Torres Strait Islander perspectives. Sea level change in the Holocene resulted in an increase of approximately 125 metres in depth.
- Factors that could influence the distribution patterns of reefs include changes moving down latitudinal gradients and across, from inshore to outer shelf reefs.
- SHE: Analyse how the evidence from other disciplines, such as plate tectonics and shifts between glacial and interglacial periods, leads to improvements in the models used for the formation of reefs.

Coral Reef Distribution

Subject matter: Identify the distribution of coral reefs globally and in Australia.

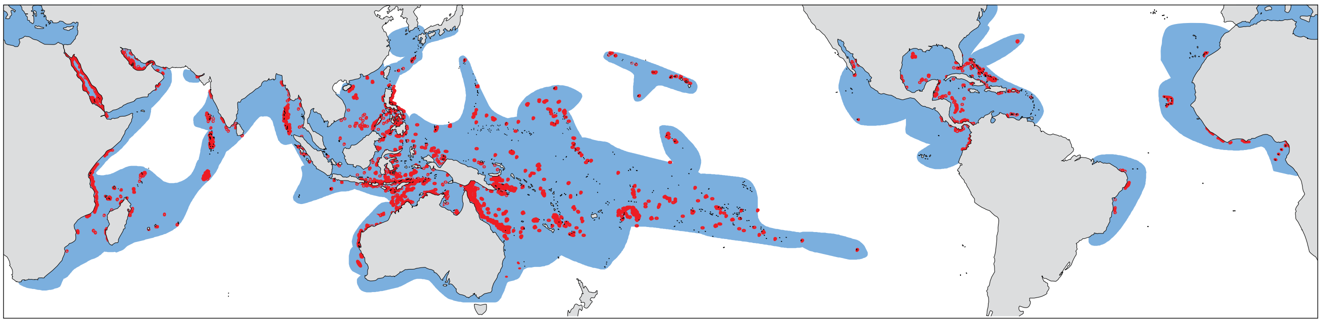
The distribution of coral reefs is determined by a combination of factors. These include the geology and geography of the region, ocean temperature, ocean chemistry, and surface currents. Corals adapt their physical structure to suit the environmental conditions in which they are found. Individual coral species can be found growing amongst mangrove roots and inshore areas, through to the edge of the continental shelf.

Recommended reading: Coral Reefs and Climate Change - Patterns of distribution (p.84-85)
View video: Coral Reefs and Climate Change DVD series - Coral reefs intro

Coral distribution - Classroom

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

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



Reproduced with permission from Charlie Veron

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

Biodiversity within regions - Classroom

Research biodiversity in different regions using the internet. Create a lists of each regions. You can work in groups and as an example, research the following areas:

- Moreton Bay
- Great Barrier Reef
- Caribbean

Use the list below as a start, find similar facts for your region and plot the final results - using Excel - in a graph. Compare the end results with other students.

Department of Environment, Water, Heritage and Arts, 2009

Map of the Coral Triangle

Diversity in the Coral Triangle

- Covers an area of 6.8 million square kilometres
- Includes 18,500 islands
- Contains four of the world's 25 'biodiversity hotspots'
- Contains more than 100.000 square kilometres of coral reefs
- Contains 605 species of hard corals, 76% of known coral species
- 45 mangrove species
- 13 seagrass species
- 2228 species of reef fish
- Highest diversity of reef invertebrates in the world

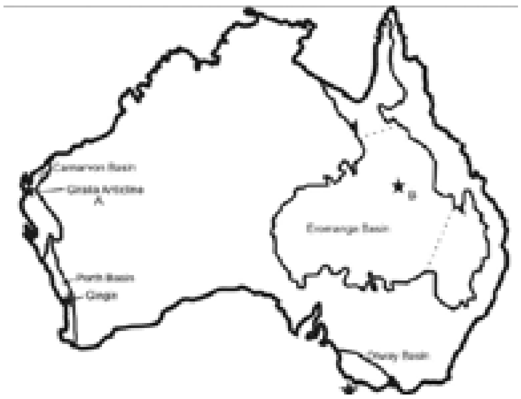
Tracking Change

Subject matter: Corals first appeared within the geological record over 250 million years ago but not in Australian waters until approximately 500 000 years ago.

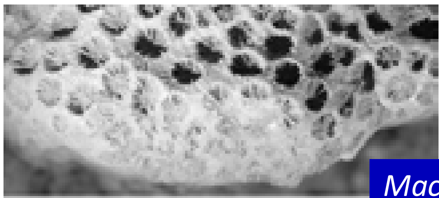
Recommended reading:
- Coral Reefs and Climate Change - The age of the Great Barrier Reef (p. 93), Tracking change (p.168-170), A paleo perspective (p. 225)
- View video: Coral Reefs and Climate Change DVD series - Tracking change and scientific finding.
- Kuznetsov V, The Evolution of Reef Structures through Time: Importance of Tectonic and Biological Controls, December 1990, Volume 22, Issue 1, pp 159–168 https://link.springer.com/article/10.1007/BF02536950
- Australian Cretaceous Cnidaria and Porifera, Jell P, et.al. An Australasian Journal of Palaeontology 35(2):241-284 June 2011, https://www.researchgate.net/publication/232901753_Australian_Cretaceous_Cnidaria_and_Porifera

Corals in Outback Queensland

During the Cretaceous period (144 to 65 million years ago) a great inland sea stretched over one quarter of the country, inhabited by large underwater creatures and brimming with sea life. Remains of marine reptiles, dinosaurs, pterosaurs, birds, fishes, crustaceans, cephalopods, gastropods, bivalves, echinoderms, plants and trace fossils are on display 'Kronosaurus Korner' Richmond and 'Age of Dinosaurs' in Winton. Major discoveries were done in 2016 (https://www.abc.net.au/news/2016-07-12/marine-fossils-found-in-outback-qld/7589792).

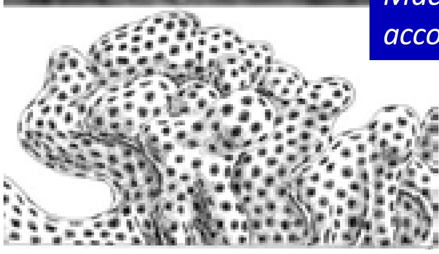


Only one coral species (*MacKenziephyllio accordensis*) from 140 million years ago was found near Longreach.



Peter Jell et.al

MacKenziephyllio accordensis



Ancient coral reefs - Classroom

1. Search in the library or on the internet for ancient reefs near you or in Australia. Think about locations such as Monto and Cania in QLD or Winjana Gorge in WA.
2. Write a little summary report of what you find. Think about for example:
   - Location of ancient reef
   - Distance to the coast
   - How did the reef get there
   - How old is the ancient reef
   - Is there a difference in the structure or coral size and shape/form
   - What other fossils did they find in ancient reefs
3. Discuss your or your groups findings with other people.

Fossil reef in Western Australia

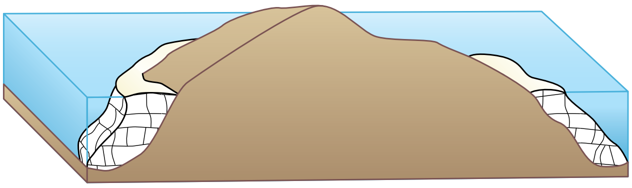
Reef Structures

Subject matter: Recall the different types of reef structure (e.g. fringing, platform, ribbon, barrier, atolls, coral cays).

Recommended reading: Coral Reefs and Climate Change - Patterns of distribution (p.84-85) Zones across the reef (p.92-94)

FRINGING REEF

Fringing reefs are reefs that grow directly from a shore, with no "true" lagoon (i.e., deep water channel) between the reef and the nearby land. Without an intervening lagoon to effectively buffer freshwater runoff, pollution, and sedimentation, fringing reefs tend to particularly sensitive to these forms of human impact.



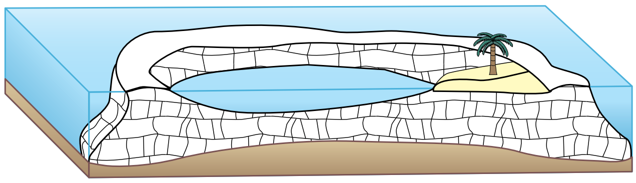
Fringing reef

Coral coast, Fiji

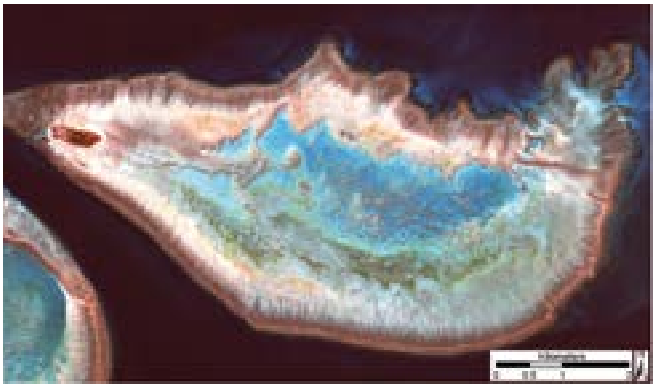
Fringing reef in Indonesia.

PLATFORM REEFS AND CORAL CAYS

Platform reefs begin to form on underwater mountains or other rock-hard outcrops between the shore and a barrier reef.
Coral cays begin to form when broken coral and sand wash onto these flats; cays can also form on shallow reefs around atolls. Coral cays are small islands, with typical length scales between 100 - 1000 m, that form on platform reefs,



Platform reef and Coral cay



Heron Island

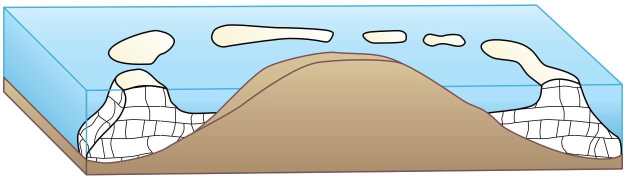
Lady Elliot Island

Reef Structures

BARRIER REEFS

BARRIER REEFS are coral reefs roughly parallel to a shore and separated from it by a lagoon or other body of water.The coral reef structure buffers shorelines against waves, storms, and floods, helping to prevent loss of life, property damage, and erosion.

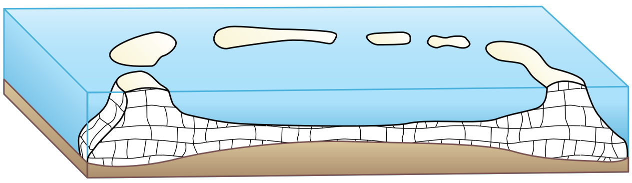
RIBBON REEFS are a type of barrier reef and are unique to Australia. The name relates to the elongated Reef bodies starting to the north of Cairns, and finishing to the east of Lizard Island. The Ribbon Reefs form a stunning chain of 10 individual reefs.



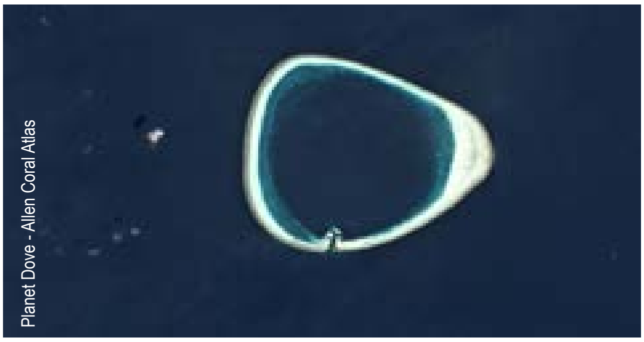
Outer Ribbon Reefs of the Northern GBR

ATOLLS

Atolls are a series of coral islands that form a circular shape surrounding a central lagoon.The formation of an atoll is a slow process that can take millions of years. It begins when an underwater volcano erupts, creating a buildup of lava on the seafloor. Fringing reefs develop around the volcanic island. As the reef expands, the interior island usually begins to subside and the fringing reef turns into a barrier reef. When the island completely subsides beneath the water leaving a ring of growing coral with an open lagoon in its center, it is called an atoll.



There are 5 atolls in Australia: Lihou Reef (Coral Sea), Mermaid Reef, Imperiesuse Reef, Clerke Reef (NW Coast), Ningaloo Reef (WA)



Maldives

Coral Sea

Reef Structures

Identifying reef distribution and types - Classroom

Use http://reefgis.reefbase.org to:

1. Recall where coral reefs are in the world by describing the main regions (e.g. Red Sea).
2. Identify which regions in the world were affected by a severe coral bleaching event during the period January to December 2002 by selecting the spatial data layer: Coral bleaching and SST and then select the dates and refresh the map.
3. Identify the regions which had the largest occurrence of coral disease in the period January to December 2002 by selecting the spatial data layer: Coral diseases, and then select the dates and refresh the map.
4. Locate in South East Asia which countries are mostly threatened in 2002 by: coastal development, overfishing, destructive fishing, or marine pollution by selecting the country and then select the spatial data layer: Reefs at Risk, and refresh the map.
5. Determine areas in South East Asia that are commonly monitored by Reef Check's volunteer monitoring program by selecting the country or zoom into South East Asia and then select the spatial data layer: Coral Reef Monitoring, and refresh the map.
6. For South East Asian countries find out which one's have: atoll reefs, fringing reefs or barrier reefs by selecting the country or zoom into South East Asia and then select the spatial data layer: Location of Coral Reefs, then select the reef and geomorphic type and refresh the map.

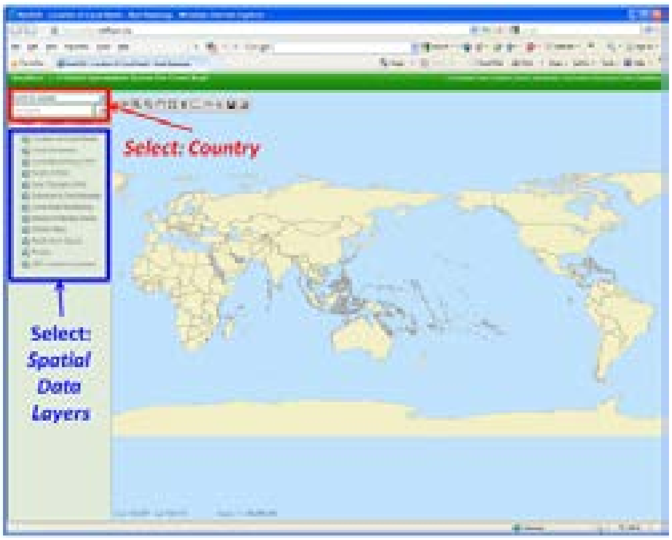


Figure 3: Screenshot of the Reef Base Geographical Information System Website which provides a user interface to assess, question and analyse geographic information related to the reefs of the world by selecting a spatial data layer and a region of interest.

Use Google Earth to*:*

7. View the satellite imagery of an atoll reef, fringing reef or barrier reef, previously found in Reef Base GIS (task 6) and then describe the location of the reef types in relation to the country by zooming into the area of interest using Google Earth tools and determine the neighbouring countries.
8. For the atoll reef, fringing reef or barrier reef of tasks 6 and 7, describe what you expect are the impacts using a visual assessment of the imagery in location to adjacent countries and oceans. Again, zoom into the area of interest and assess the land adjacent to the reefs on number. Determine the population density by assessing the number of cities or villages or the run of turbid water.

Questions

1. What type of reefs will be most influenced by activities on land and why?
2. What type of reefs do you find closest to your home or choose a reef you have visited.

Single Reef Zonation

Subject matter: The reef is build up in different zones (e.g. reef slope, reef crest/rim, lagoon/back reef).

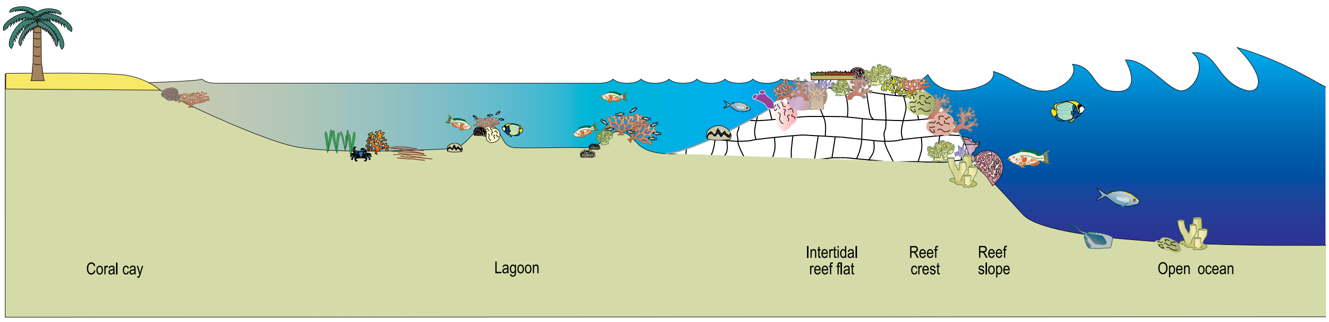
Recommended reading: Coral Reefs and Climate Change - Single reef zonation (p.95)

Reef habitats from beach to ocean

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

Beyond the lagoon, there is a ridge where corals may be exposed at low tide - this is called the reef crest. The reef crest is exposed to strong waves and currents. Here, corals tend to have 'short and stubby' (digitate) or encrusting growth forms to protect themselves from waves. Corals on the reef crest produce mucus to protect them from sunlight exposure at low tide. Coralline algae are common on reef crests, where they cement reef rubble together. Many invertebrates are also found in this area.

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



Reef profile- Field

1. Decide on a suitable location in which you will walk to conduct the survey (avoiding large areas of live coral and using sandy tracks if possible).
2. Position a staff upright on the edge of the water with one of end of a 20m string attached at its base (the length of string can be altered depending on your reef).
   Please note, for permanent structures on the reef you will need to apply for a permit. Temporary structures also need to be attended at all times and should not impact the marine environment.
3. From the shoreline, walk out 20m, hold the second staff upright and pull the string tight, raising and lowering it along the staff until it is level (when the bubble is in the centre of the window on the spirit level).
4. Stop and make the following observations of the area around you and record them in the 'Reef profile data' table:
   a. distance travelled
   b. height of string on the staff
   c. dominant coral type nearby (branching, boulder, plate or soft)
   d. substrate (sand, coral rubble, algae, live coral)
5. Leave the staff furthest from shore in place and carry the other staff from its current position out towards the reef crest, making sure the string is once again level before making your height measurements.
6. Repeat this procedure until you have reached the edge of the reef.
7. Use these observations to plot the reef profile in the area provided.

Reef profile data table - field activity

Observer(s):

Location: Date:

Weather conditions: windy / calm / cloudy / sunny

Distance (m)	Height difference	Coral type (Br, S, Bo, Pl)	Substrate (sand, coral, rubble, algae, live coral)

UNIT 3 - TOPIC 1 - THE REEF AND BEYOND

Coral Reef Development

SUBJECT MATTER

- recall the three main groups of coral (i.e. Alcyonacea: soft corals, sea fans and Scleractinia: stony/hard corals)
- classify a specific coral to genus level only, using a relevant identification key
- identify the anatomy of a typical reef-forming hard coral including skeleton, corallite, coelenteron, coral polyp, tentacles, nematocyst, mouth and zooxanthellae
- recall that the limestone skeleton of a coral is built when calcium ions [Ca2+] combine with carbonate ions [CO32–]
- describe the process of coral feeding (including night-feeding patterns and the function of nematocysts)
- identify and describe the symbiotic relationships in a coral colony (including polyp interconnections and zooxanthellae)

GUIDANCE

- Notional time: 9 hours
- In field investigations of reef communities, corals are often identified based on morphology (e.g. boulder, plate, branching, soft) rather than species or genus.
- Opportunities to use a variety of biological classification keys should be provided, including pictorial keys.
- It is recommended the genus species for the coral example is linked to a case study.
- Case studies may be virtual or conducted in the field.
- The process of building a coral skeleton is complex and influenced by a variety of factors notably the concentration of ions, temperature, light and pH changes

Hard and Soft Corals

Subject matter: recall the following groups of coral: Alcyonacea 'soft corals' and the two morphological groups within Scleractinia 'hard corals' — reef-forming/hermatypic and non-reef forming/ahermatypic.

Recommended reading: Coral Reefs and Climate Change - Reef building corals (p.86-88)

Alcyonacea / soft corals

Soft corals, sea fans and gorgonians are common names for a group with the scientific name Octocorallia or Alcyonacea. Octocorals are ecologically important components of the coral reef landscape, and being beautiful and colourful, are an attraction for divers.

Characteristics:

- Most soft corals lack a hard external skeleton, instead soft corals contain small calcareous sclerites in their body
- Soft structure that can move
- Do not always have symbiotic zooxanthellae
- Each polyp has 8 tentacles or multiples of 8
- About 100 genera in 23 families are known to occur in shallow Indo-Pacific coral reefs

Species: blue coral (*Heliopora*), red organ-pipe coral (*Tubipora*), *Sinularia, Dendronephthya, Sarcophyton* e.g.

Scleractinia / stony, hard corals

Characteristics:

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

Hard corals can be further separated into two sub-groups. The zooxanthellate (**reef-building or hermatypic**) corals are ones that depend on zooxanthellae algae for nutrients. These shallow water corals have a major reef-building function. They are generally found in clear water less than 50 metres deep as the algae need light for photosynthesis.

The azooxanthellate (**deep water or ahermatypic**) corals do not contain zooxanthellae and therefore gain their nutrition solely from filtering plankton from seawater. These isolated, solitary or colonial forms rarely build big constructions and many of these coral species are present in non-reef environments in coastal areas such as Moreton Bay in Queensland.

Tubastrea (azooxanthellae)

Answer key for next page: row 1 (hard, hard & no zooxanthellae, hard), row 2 (hard, hard, soft), row 3 (hard, hard, hard), row 4 (hard, soft, hard), row 5 (hard, soft, soft).

Hard and Soft Corals

Types of corals - Classroom

Identify the images below. Are these hard or soft corals? Are there any without zooxanthellae?

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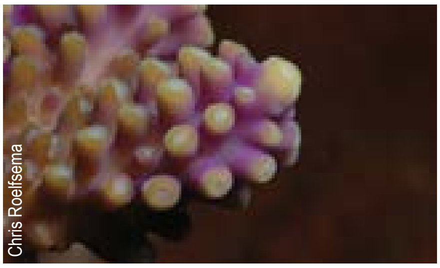

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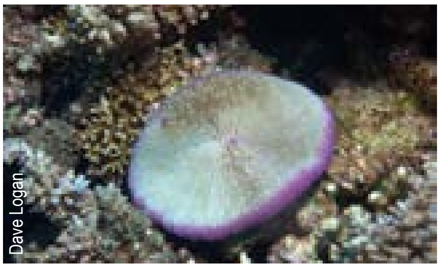

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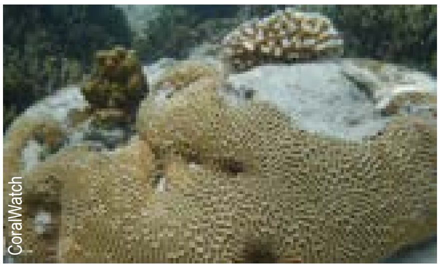

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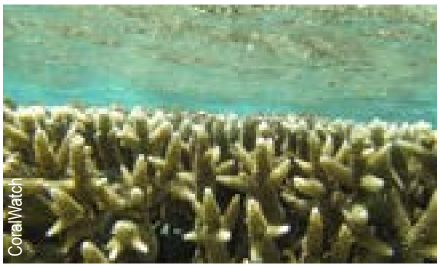

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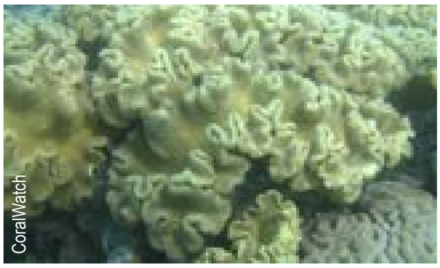

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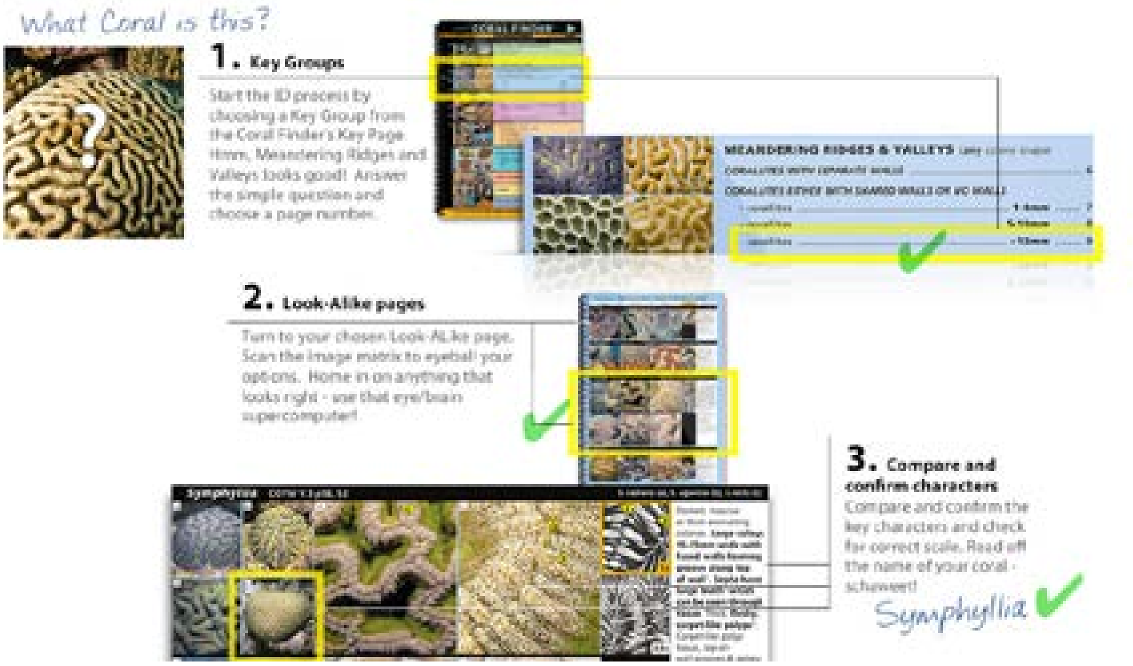
Coral Classification

Subject matter: Classify a specific coral to genus level only, using a relevant identification key.

Recommended reading: Coral Reefs and Climate Change - Reef building corals (p.86-88) Coral growth (p.90-91)
Coral Finder, Russel Kelley (www.byoguides.com/coralfinder/) + training videos
Online resources: Corals of the World, Veron 2000 (www.coralsoftheworld.org/page/home/)
Hard Coral Genus Identification Guide, Zoe Richards (http://museum.wa.gov.au/kimberley/sites/default/files/WA%20Coral%20CompactusV2_May2018.pdf)

Identify corals - Classroom

Classifying corals can be very difficult. There are 800 species of corals worldwide, 18 different families are described in Corals of the World and 67 genera can be identified using the Coral Finder.
Some genera appear in many different growth forms, is often to due to environmental conditions. This variation makes it sometimes difficult to identify the genus. The Coral Finder is an easy-to-use coral ID guide, which lets any user identify corals to genus level regardless of growth form.



How to use
1. Start by studying a bit of coral lingo in the coral finder.
Familiarise yourself with terms like septa, costa, septacostae, corallite, polys, walls.
2. Choose a coral you want to identify. This can be from a photo, skeleton or live coral in the field.
Choose the keygroup (branching, meandering, massive, thin, solitary, large polyps, columns, lace corals) on the front page of the coral finder that best describes your call.
3. Answer the text prompts (shared/seperate walls, size of corallites e.g.) and select a look-alike page.
4. On the look-a-like page compare the different options. If you can’t find your coral, try an alternative key group.
5. Find more information about your coral in Corals of the World, Veron 2000.

Tips
- The size of the corallite is used by the Coral Finder to compare and contrast coral genera. To measure this use the shortest distance between the inner edges of the corallite wall.
- Look for clear features, some corals are much easier to identify than others, such as the ones with large daytime extended polyps or solitary corals.
- Branching corals may have two different types of corallite - axial and radial. Axial corallites form the axis of growth at the tip of the branch. All *Acroporas* are defined by having axial corallites, an easy one!

Coral Classification

Classifying corals using photos - Classroom

Use the coral finder to identify corals to genus level.
Ask yourself the following questions:
- What is the most likely growth form?
- Are there shared walls or common walls?
- What size are the corallites?
- Are there any special features such as large daytime polyps? Paliform lobes?

Massive or thick
Corallites with separate walls, 8 – 20mm
Polygonal corallites very distinctive

Massive, meandering,
shared walls,
paliform lobes

Branching no axial corallite
Corallite >2mm, arranged in rows
Branch tips pointed

Classifying corals using coral skeletons - Classroom

Use the coral finder and a microscope to identify corals to genus level.
Ask yourself the following questions:
- What is the most likely growth form?
- Are there shared walls or common walls?
- What size are the corallites?
- Are there any special features such as large daytime polyps?

Use a microscope to look up close at special features

Coral type: branching
Are there axial corallites?

Coral type: massive
Shared walls
Paliform lobes?

Coral Classification

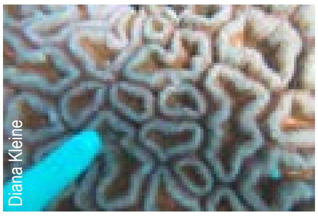
Classifying corals - Field

The Coral Finder is a water proof tool that you can take in the field and use on the spot. Make sure you don't touch the corals as they are fragile.

Another very effective way of coral identification is to take a camera in the field and take photos from different angles and ID them later. Try to take a sequence of images that includes a scale reference and location.

Wide- shot

Mid-shot



Scaled close-up

Close-up

Classifying coral types - Field

Examine coral diversity using a transect line

This exercise is an field investigation of reef communities. Corals are often identified based on morphology (e.g. boulder, plate, branching, soft) rather than species or genus.

Step to take

1. Lay out a tape measure or string with measurements marked on it.
2. Record data every 50 cm. What types of coral are found directly underneath the transect tape.
3. Swim or walk along the tape.
4. Enter your results in an excel sheet and create a piegraph.

You can repeat this exercise (or works in groups) and cover various areas of the reef. Start in the lagoon, towards the reef crest and reef slope. Compare findings.
Are there different growth forms found on the reef crest compare to the lagoon?

Tip: Create your own classroom resource by take a video along the transect line recording the different types of corals.
This can be used in class to practice reef monitoring.

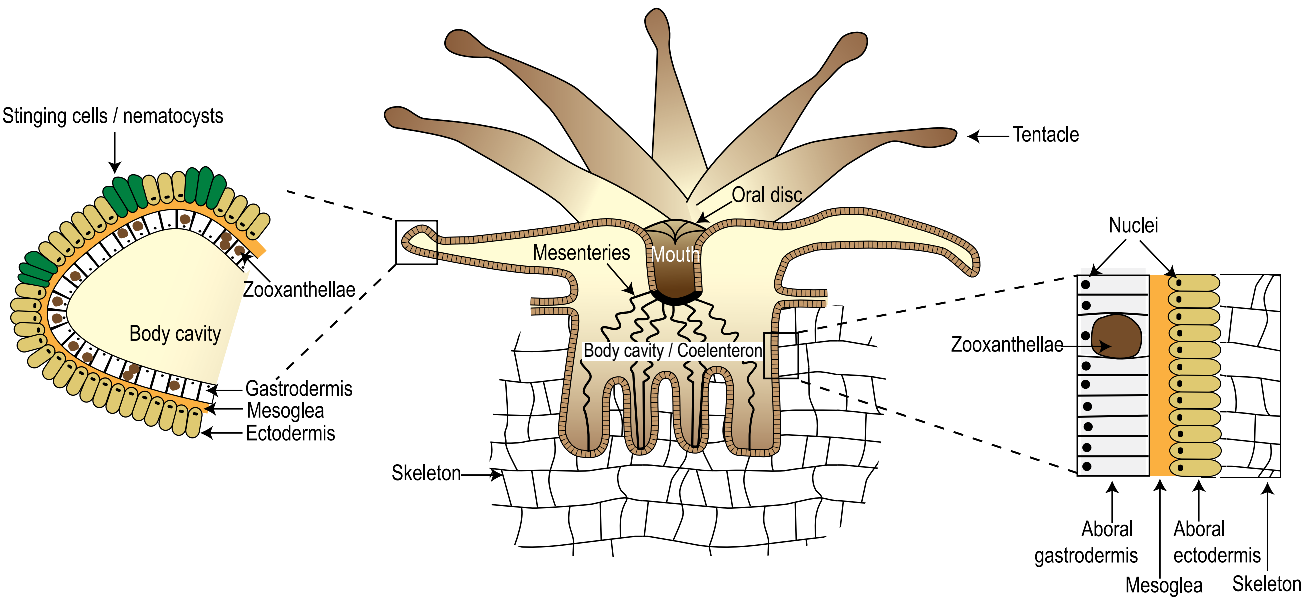
Note: A transect line in the field must be attended at all times. This is a strict Marine Park regulation.

Equipment
Transect tape
datasheet on waterproof paper or data slate
pencil
protective reef shoes

Coral Biology

Subject matter: identify the anatomy of a typical reef-forming hard coral including skeleton, corallite, coelenteron, coral polyp, tentacles, nematocyst, mouth and zooxanthellae.

Recommended reading: Coral Reefs and Climate Change - Reef-building corals (p.86-89), Coral growth (p.90-91)



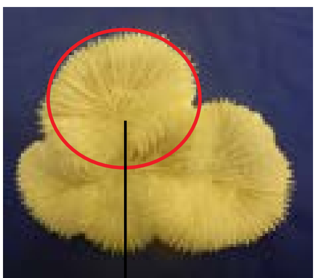
Anatomy of a coral polyp

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

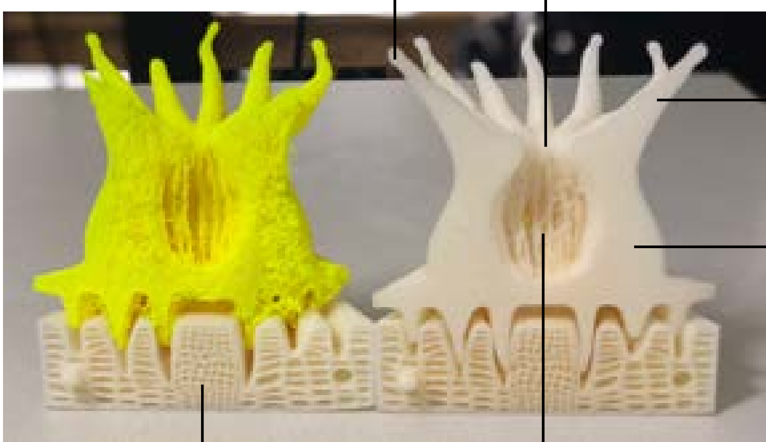
3-D models for classroom use

If you have access to a 3-D printer, print this fantastic resource provided by NOAA. This 3D generic coral polyp model shows a cross section of a single polyp, including its tentacles, gastrodermis, stomach cavity, and the complex skeletal structure underneath. If you use thermo-sensitive filament for the top polyp portion, the polyp can mimic coral bleaching when the 3-d model exposed to warm water.
See also the education video online.(https://coralreef.noaa.gov/education/polypmodel.html)

Coral skeleton



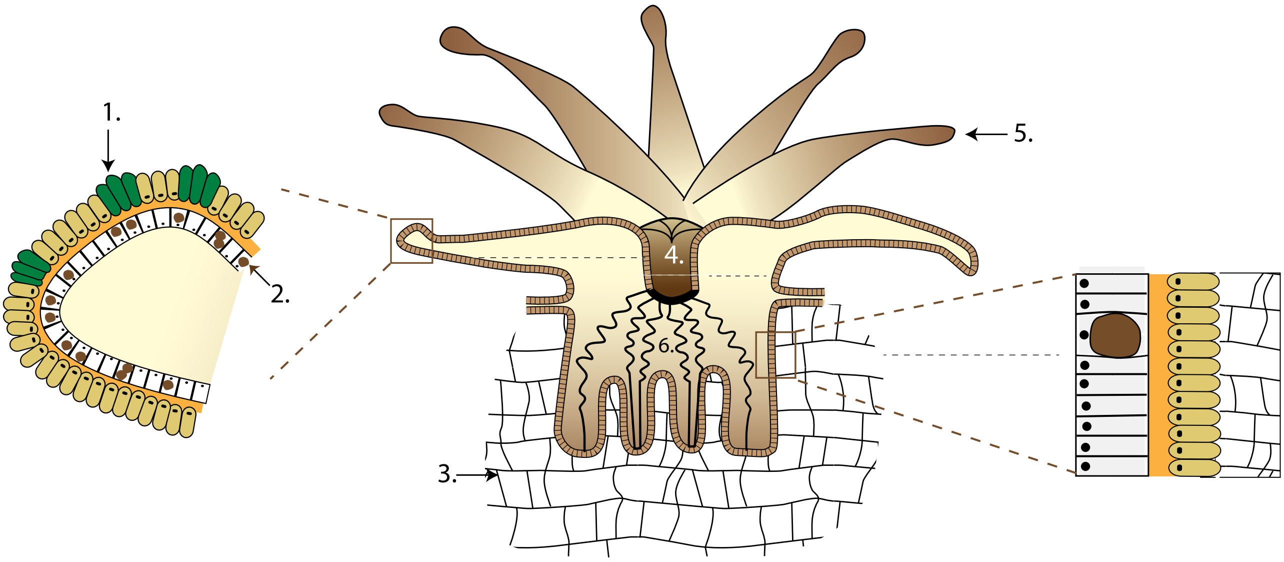
3-D Model

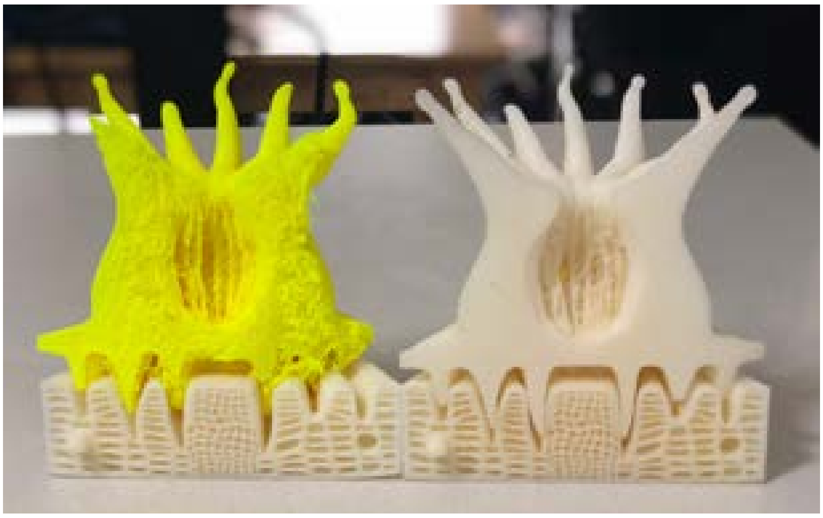


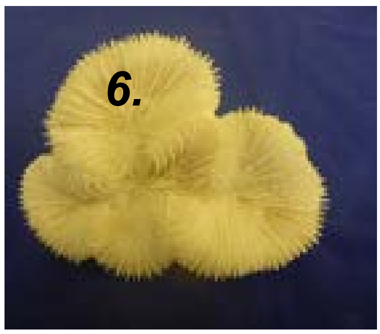
Coral Biology

Label a coral polyp - Classroom

Include: skeleton, corallite, coelenteron, coral polyp, tentacles, nematocyst, mouth and zooxanthellae







Describe

skeleton ....

corallite ....

coelenteron ....

coral polyp............

tentacles..............

nematocyst..........

mouth.........

zooxanthellae...............

Symbiosis

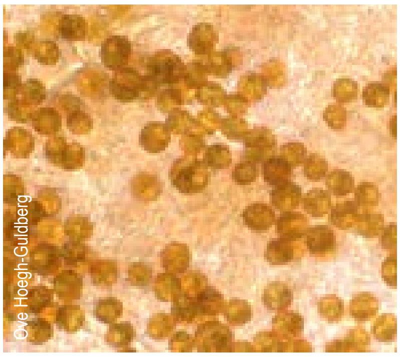
Subject matter: Identify and describe the symbiotic relationships in a coral colony (including polyp interconnections and zooxanthellae.

Recommended reading: Coral Reefs and Climate Change - Zooxanthellae (p.89)
View video: Coral Reefs and Climate Change DVD series - Coral Bleaching

Investigate zooxanthellae in corals - Lab

1) Remove small coral fragment or Anemone tentacle. Don't collect from the wild unless you have a permit.
2) Add 5ml of PBS or seawater into zip lock bag
3) Place coral fragment into the zip lock bag
4) Use the airpik/waterpik to clear a surface of the coral (aim for a circle or square so you can estimate the surface area).
5) Make sure you get all of the tissue off the area of coral
6) (If possible complete the following step) Centrifuge the solution to concentrate the algal pellet and remove the excess solution/supernatant from above the pellet. Then resuspend pellet in known volume of seawater /PBS
7) Measure (if step 6 is not completed) and Mix the pellet solution with a pipette to ensure its thoroughly mixed
8) Place a cover glass on the haemocytometer(counting chamber) and pipette a known volume at the edge of the cover slip/haemocytometer and allow surface tension and pressure to drawn solution across the measuring area.
9) View the sample under the microscope and count the cells between the double lines in square of 20 divisions (5 squares). Keep to regular square count between samples. For example use 3 or 5 square in your counting regime. Clean and repeat 3-5 times with fresh subsamples and take the average of the counts as a measure per volume. If there are cells that are on the double line borderline, and more than their half inside then include these in the count. NB: If there are too many cells in your solution or they are clumped together, then remix and dilute further. Like wise if there are very few cells then concentrate the main sample.

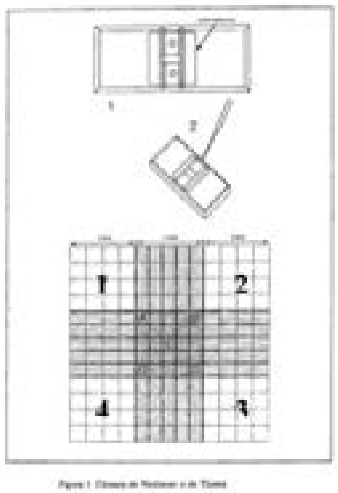
Safety precautions
Coral tissue contain nematocyst that may cause respiratory issues when tissue is released, therefore all work should be conducted outside in a well-ventilated area or in a fume hood.



Further activities
Describe the symbiotic relationship between the symbiotic algae and the coral.

Note: Counting zooxanthellae in coral tissue is a bit more difficult than it sounds. You need specialized equipment to get the tissue separated from the coral in a controlled system (fume hood) and after that you need to separate the zooxanthellae from the tissue by centrifuge/vortex, homogenizing, etc. This all needs to happen on ice and you need to know the size and surface area of the coral to calculate how much tissue you have and known very small amounts of homogenizer - this all to later calculate exactly how many zooxanthellae the coral has per cm^2. But before these calculations you need a special tool (haemocytometer) to calculate the number of zooxanthellae in your suspension. An easier solution is to use the tentacle of an anemone. See example next page.

Equipment
- Small coral fragment/ anemone tissue
- 1 pipette (1 ml) and disposable tips
- Cutters
- Airpik or Aaterpik
- Airpik tips
- Small zip lock
- 5ml of PBS or filtered seawater
- Calipers (to measure coral)
- Hemacytometer
- Hemacytometer cover slips
- Microscope
- Pipettes
- Tissues for cleaning



The hemocytometer is a counting-chamber device originally designed and usually used for counting blood cells.

Symbiosis

Investigate zooxanthellae in anemone - Lab

Explore what zooxanthellae look like and the large amount that is present.

You can use anemone that clownfish use (a variety of species, most common *Heteractis spp* or *Stichodactyla spp*) or another anemone species (*Aiptasia pulchella*). If you have an aquarium you can use the anemone in there or buy one from the shop. Don't collect from the wild unless you have a permit.

Steps to take

1) Depending on species available and amount of people involved in your experiment, decide if you just need one tentacle or several small animals. The photos of this experiment show Aiptasia pulchella species and individual animals were fairly small.
2) To relax the tentacles we used magnesium chloride (FC: 0.36 M).
3) Cut one tentacle and/or placed this together with one small animal in between cover slips.
3) Looking under the microscope zooxanthella and nematocyst should be able to be identified between 10x and 40x magnification.

NB: Makes sure no saltwater /PBS comes into contact with the microscope as this will cause corrosion and damage

Tips when using a tentacle from a bigger anemone

Place the tentacle on top of a coverslip and look under the microscope at the tentacle. If the tissue is clear and thin, you can already see the zooxanthellae. Cut the tentacle in half, look again. Squash tentacle a bit with flat object and add a drop of water, look again. Squash tentacle even further, add more water if needed. You can squash the tentacle more and add a cover slip carefully, try to avoid bubbles underneath it. Check the different amounts of zooxanthellae and the nematocysts (stinging cells) during your experiment.

Be careful with using the coverslips, squashing is difficult without breaking the cover slip. Make sure you don't cut yourself.

Further activities

- Describe the symbiotic relationship between the symbiotic algae and the sea anemones.
- Compare the amount of zooxanthellae and nematocysts at the tip of the tentacle with the base of the tentacle - what is the ratio between the two?
- Draw a nematocyst, find out more about their function.

Photos: CoralWatch

Aiptasia pulchella in aquarium.

Aiptasia pulchella in vial.

Cutting one tentacle.

Seperate tentacle and anemone between coverslips.

Viewing zooxanthellae with the microscope.

Photo: 2012 Waldo Nell

Symbiodinium are the golden-brown circles. The elongated light grey cells are stinging cells, nematocyst.

Equipment

Tentacle of anemone
1 pipette (1 ml)
Cutters
1 Vial
5ml of PBS or filtered seawater
Magnesium chloride (0.36M)
2 cover slips
Seawater/PBS for rinse before and after MgCL2
Microscope
Tissues for clean up

UNIT 3 - TOPIC 1 - THE REEF AND BEYOND

Reef, Habitats and Connectivity

Subject matter

- recognise that corals are habitat formers or ecosystem engineers
- explain that habitat complexity (rugosity), established by corals, influences diversity of other species
- explain connectivity between ecosystems and the role this plays in species replenishment
- understand that fish life cycles are integrated within a variety habitats including reef and estuarine systems
- describe how fish, particularly herbivore populations, benefit coral reefs
- identify ecological tipping points and how this applies to coral reefs
- describe hysteresis and how this applies to the concept of reef resilience
- assess the diversity of a reef system using a measure that could include (but is not limited to) line intercept transects, quadrats and fish counts using underwater video survey techniques, benthic surveys, invertebrate counts and rugosity measurements
- analyse reef diversity data, using an index, to determine rank abundance
- interpret, with reference to regional trends, how coral cover has changed on a reef over time
- recognise that some of the factors that reduce coral cover (e.g. crown-of-thorns) are directly linked to water quality
- understand that the processes in this sub-topic interact to have an overall net effect, i.e. they do not occur in isolation.
- Mandatory practical: Examine the concept of connectivity in a habitat by investigating the impact of water quality on reef health.

Guidance Notional time: 12 hours

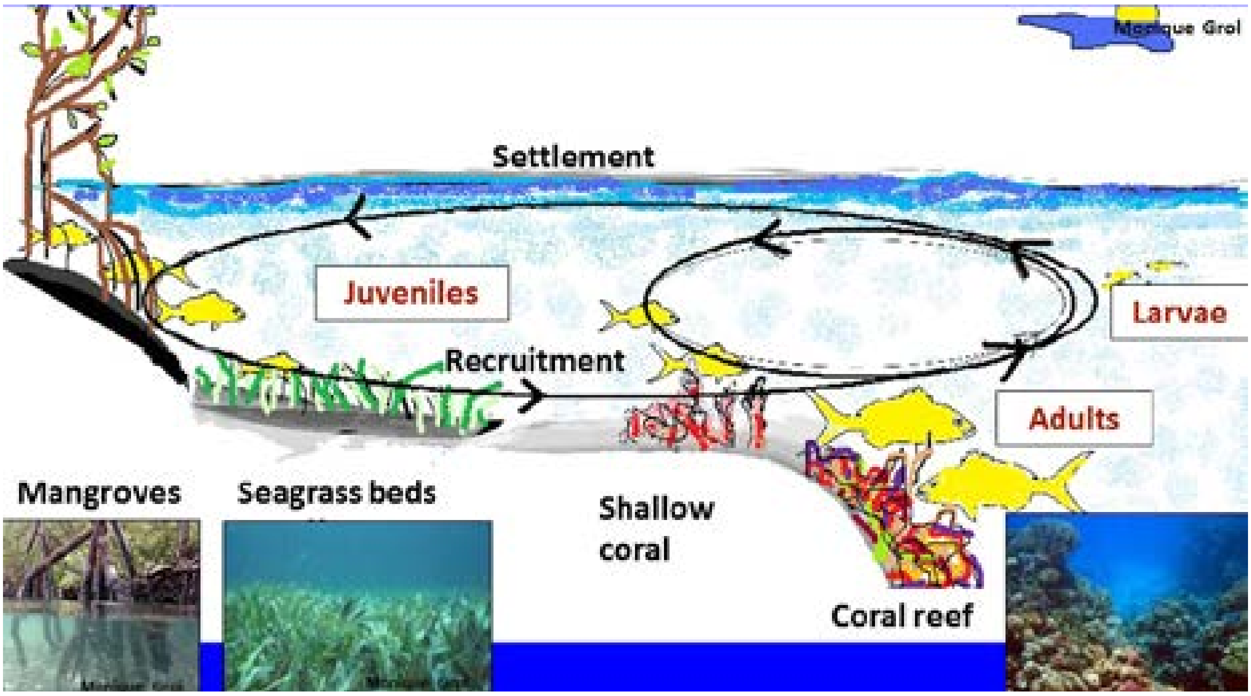
- Refer to the glossary for definitions of habitat former and ecosystem engineer.
- The process of building a coral skeleton is complex and influenced by a variety of factors, notably the concentration of ions, temperature, light and pH changes.
- Habitat complexity should include not only species diversity but also rugosity and percentage coral cover.
- Refer to the glossary for definitions of rugosity and (for reef resilience) ecosystem resilience.
- Data can be primary or secondary (fieldwork, collected or virtual).
- Diversity indices used to rank abundance could include Shannon–Wiener, Simpson's, or similarity indices
- When interpreting coral cover change, recognise that reefs can and do recover from pulse events but this may take decades.
- Examples of habitats for water quality testing could include estuarine, seagrass, inshore reefs.
- Suggested practical: Examine coral diversity using a transect technique (using online or field data).
- SHE: Investigate how complex models of marine ecosystems can be developed based on a wide range of evidence from multiple individuals and across disciplines.
- Water quality data for the mandatory practical can be either online, virtual or field data.
- Impacts on reef health should be considered as both qualitative and quantitative.
- Evaluation of water quality data in the mandatory practical should be supported with data analysis (descriptive and inferential statistics). Examples of inferential statistical tests include student t-tests, standard error, Mann–Whitney U and confidence intervals. Examples of correlation tests include Pearson correlation coefficient, Spearman's rank and Cohen's d effect size.

Connectivity

Subject matter: understand that fish life cycles are integrated within a variety habitats including reef and estuarine systems.

Recommended reading: Coral Reefs and Climate Change - Connectivity (p.116-117), Foodweb (p.118-119), Hungry fish (p.100-101)

A coral reef ecosystem includes shallow water habitats such as mangroves and seagrasses. They often act as nurseries for fishes and invertebrates and are vital for long term health of coral reefs. Some animals migrate in different life stages into different habitats, or part of habitat. This is called ontogenetic migration.



Ontogenetic migration - Classroom

Migration of animals beteeen habitats is often driven by food/growth, survival or reproduction.
Check the images below and research the barracuda living at various stages in different habitats.
Describe the importance of the different habitats.
Find examples of other animals that migrate.

Connectivity

Citizen science projects - classroom

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

Hungry Fish

Subject matter: describe how fish, particularly herbivore populations, benefit coral reefs.

Recommended reading: Coral Reefs and Climate Change - Fish tales (p.96-99), Hungry fish (p.100-101), Fish shapes (p.102-103)

Hungry fish - Classroom

There are estimated to be between 1,200 and 2,000 species of Great Barrier Reef fish, from 130 different families. The most common reef fish families are **damselfish, wrasses, butterflyfish, angelfish, rabbitfish, sweetlips, parrotfish, surgeonfish, trumpetfish, blennies, snappers, anthias.**
Identify the following fish families and find out what they eat. Are they herbivores, carnivores or omnivores?

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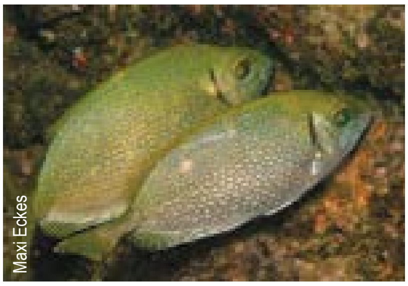

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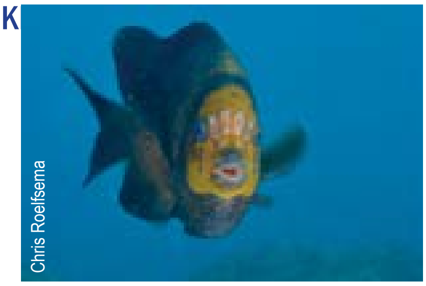
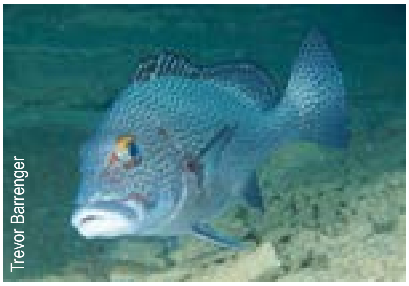
Hungry Fish

Answer key

Omnivore: angelfish
Emperor angelfish - *Pomacanthus imperator*

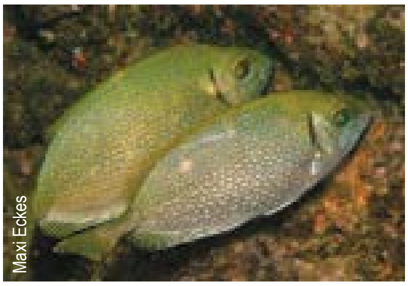


Herbivore: damselfish
Buffalo damselfish - *Parma microlepis*



Carnivore: sweetlips
Dotted sweetlip - *Plectorhinchus picus*

Herbivore: wrasses
Green moon wrasse - *Thalassoma lutescens*



Herbivore: rabbitfish

Carnivore: sharks
Grey nurse shark - *Carcharias taurus*

Carnivores: moray eels
Lyretail anthias female - *Pseudanthias squamipinnis*

Herbivore: butterflyfish
Goldbarred butterflyfish - *Chaetodon rainfordi*

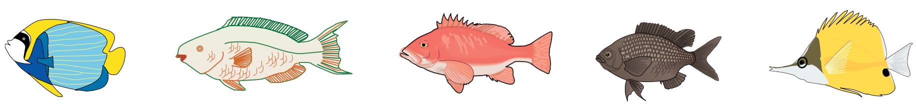
Herbivore: surgeonfish
Palette surgeonfish - *Paracanthurus hepatus*

Carnivore: trumpetfish
Yellow trumpetfish - *Aulostomus chinensis*

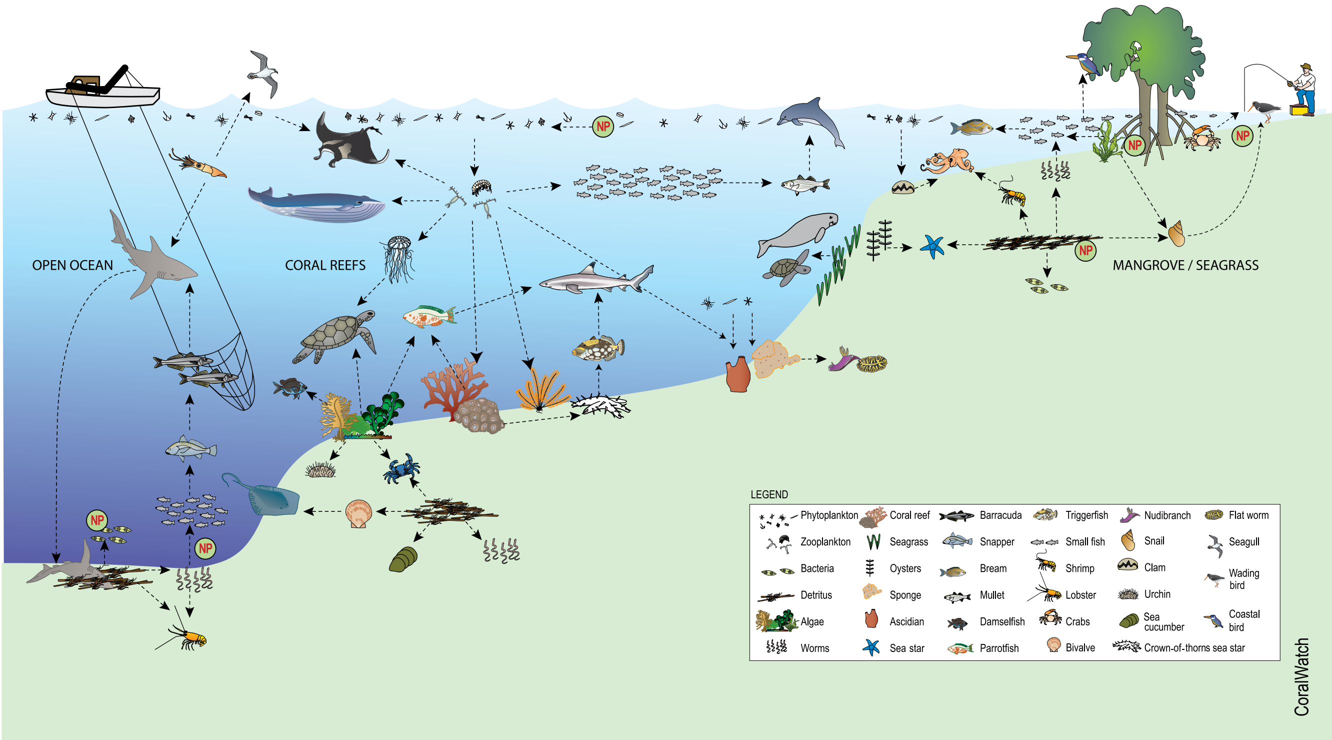
Herbivore: blennies
Piano fangblenny - *Plagiotremus tapeinosoma*

Herbivore: parrotfish
Sixband parrotfish - *Scarus frenatus*

And check out the drawings of common reef families on page 102 Coral Reefs and Climate Change



Hungry Fish



Foodwebs - Classroom

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 recycled on the sea floor. Removal of any link in these chains will affect the pattern of the entire food web.

Describe what would happen if the parrotfish, the damselfish, the crab and urchin would disappear from the reef.

Spot the differences - Classroom

Decribe what you can see in the the two photos.
If these photos were taken in the same location, what could have caused the change?
Include the likelyhood of the effects of 1. overfishing 2. reduced sunlight 3. temperature.

Hungry Fish

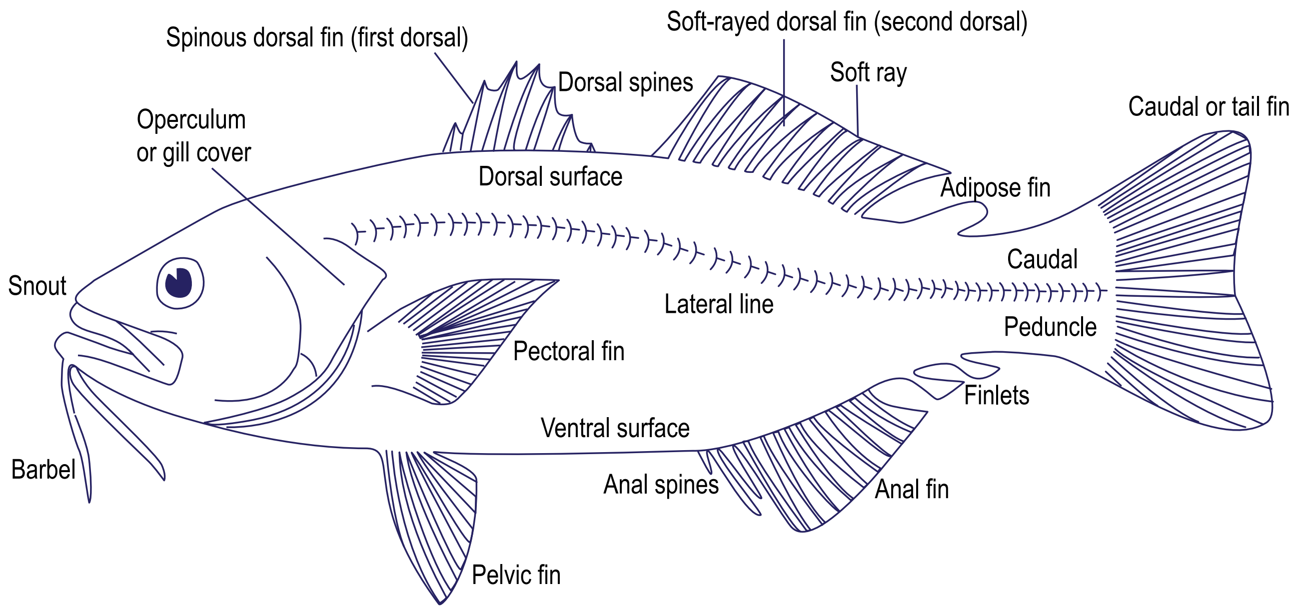
Hungry fish - Field

During this activity you will estimate the amount of plant material being eaten by select grazers on the reef.

1. Choose an herbivorous fish, such as a parrotfish or rabbitfish, or a crab to observe (it is easy to find crabs feeding on top of coral colonies on a reef flat at low tide if you stand still and it is not too windy).
2. Wait until the animal is no longer disturbed by your presence and tally the number of bites or claw scrapes it takes in the space of one minute.
3. Repeat this three more times to calculate average bites per minute.
4. Assuming it eats at the same rate for the whole day, calculate the total number of bites the organism would take in 12 hours.

Fish identification - Field

1. Go snorkelling and look for as many fish as you can.
2. Draw the basic shape of the fish on a waterproof slate and make notes about colour, size and specific features.
3. Take note of where they occur - near a particular coral type, on the sand, in the water column, etc.
4. Estimate the approximate numbers of fish of each species you observed (e.g. 1, 2-10, 50+).
5. Use field guides and your field notes when you are back on shore and write down the scientific and common name of each species you have identified.



Source: Cailliet G, Love M, Ebeling A (1986) Fishes: A field and laboratory manual on their structure, identification and natural history. Waveland Press

Common groups of reef fish

Disk-shaped/colourful Butterflyfish, Angelfish, Spadefish

Pygoplites diacanthus (Regal Angelfish)

Chaetodon mertensii (Merten's Butterflyfish)

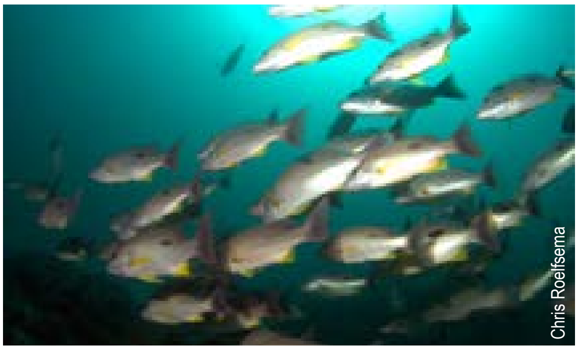
Ovals Butterflyfish, Angelfish, Spadefish

Acanthurus nigricans (Goldrim Surgeonfish)

Chromis flavapicis (Yellowtipped Damselfish)

Sloping heads/Tapered bodies Snappers, Coral Breams, Emperors

Lethrinus miniatus (Redthroat or trumpet Emperor)



Lutjanus russellii (Russell's Snapper)

Silvery Jacks, Barracudas, Tunas, Needlefish, Mullets, Flagtails, Grunters

Sphyraena jello (Pickhandle Barracuda)

Haemulon sciurus (Bluestriped Grunt)

Common groups of reef fish

Slender schools/Colourful Fusiliers, Anthias

Caesio Teres (Blue and Yellow Fusilier)

Pseudanthias dispar (Peach Fairy Basslet)

Heavy Bodies, large lips Groupers, Soapfish, Hawkfish, Sweetlips

Plectorhinchus lineatus (Diagonal Banded Sweetlip)

Parupeneus crassilabris (Thicklipped Goatfish)

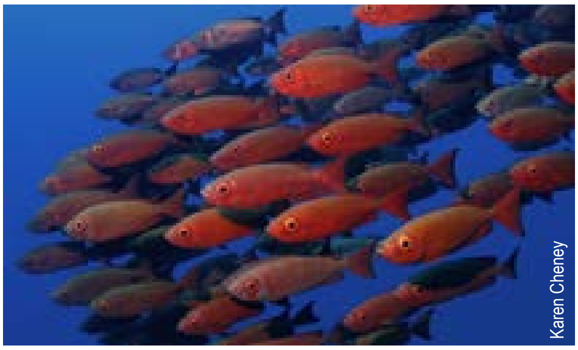
Swim with pectoral fins Parrotfish, Wrasses

Scarus ghobban (Blue Barred Parrotfish)

Thalassoma quinquevittatum (Fivestripe Wrasse)

Reddish/Big Eyes Soldierfish, Squirrelfish, Bigeyes

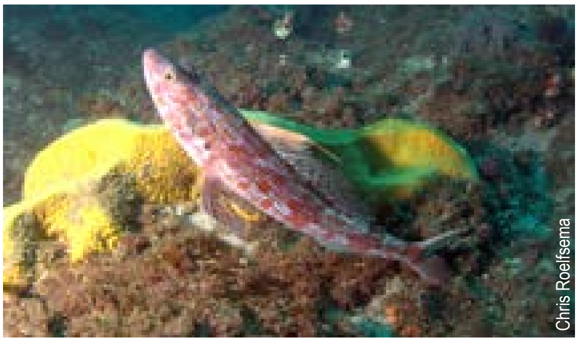
Myripristis kuntee (Blackbar Soldierfish)



Priacanthus hamrur (Moontail Bigeye)

Common groups of reef fish

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



Synodus variegatus (Reef Lizardfish)

Nemateleotris magnifica (Fire Dartfish)

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

Pterois volitans (Common Lionfish)

Scorpaenopsis venosa (Raggy Scorpionfish)

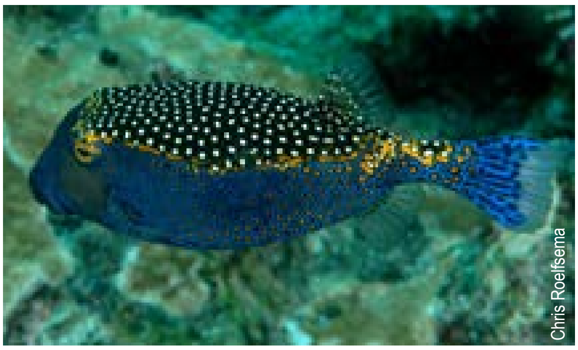
Small, elongate bottom dwellers Gobies, Blennies

Ecsenius fourmanoiri (Fourmanoir's Blenny)

Salarias fasciatus (Jewelled Blenny)

Odd shaped swimmers Boxfish, Goatfish, Trumpetfish, Sweepers, Puffers, Molas, Filefish, Remoras

Aulostomus chinensis (Trumpetfish)



Ostracion meleagris (Spotted Boxfish)

Common groups of reef fish

Eels
Morays, Snake Eels, Conger eels, Garden Eels

Rhinomuraena quaesita (Ribbon Moray)

Gymnothorax fimbriatus (Darkspotted Moray)

Pipefish and Seahorses
Ghost Pipefish, Seahorse, Pipefish

Hippocampus bargibanti (Pygmy Seahorse)

Doryrhamphus pessuliferus (Orange-banded Pipefish)

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

Manta birostris (Manta Ray)

Triaenodon obesus (White Tip Reef Shark)

Pastinachus sephen (Cowtail Stingray)

Orectolobus maculatus (Spotted Wobbegong)

photos Chris Roelfsema

Coral Cover

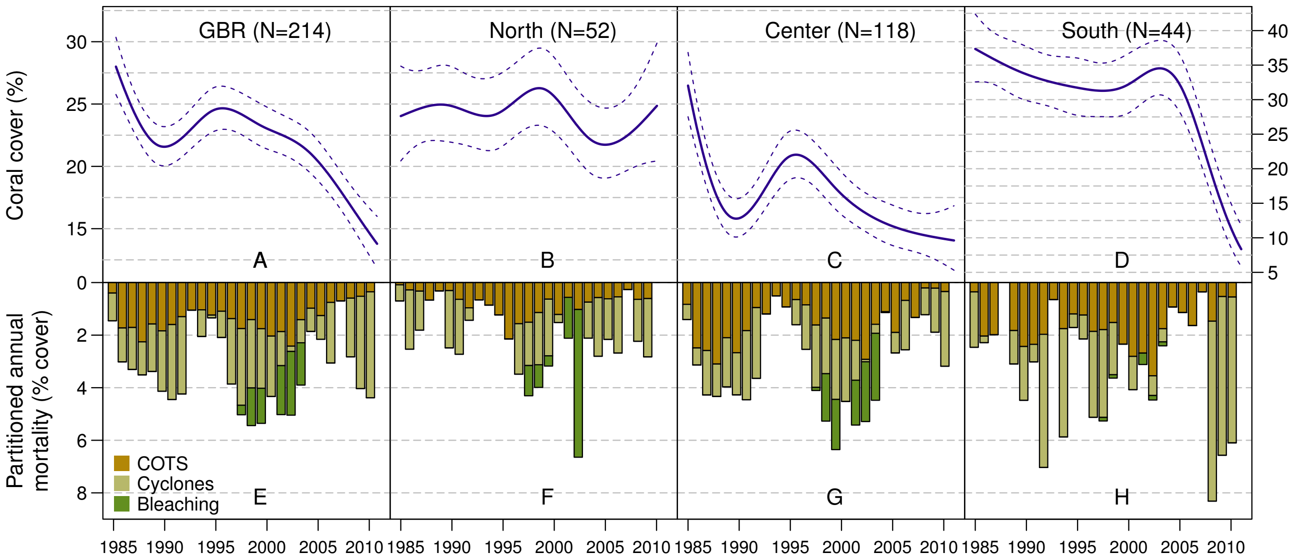
Subject matter: interpret, with reference to regional trends, how coral cover has changed on a reef over time.

Recommended reading: Coral Reefs and Climate Change - State of the reefs (p.124), Reefs in decline (p.125)
View video: Coral Reefs and Climate Change - Reefs our biggest concern
Scientific article: The 27–year decline of coral cover on the Great Barrier Reef and its causes.
De'ath G, Fabricius KE, Sweatman H, Puotinen M (2012). The 27–year decline of coral cover on the Great Barrier Reef and its causes. (www.scienceinpublic.com.au/wp-content/uploads/Full-PNAS-paper-for-publication.pdf)
Ecological Monitoring of Coral Reefs, Jos Hill and Clive Wilkinson (https://portals.iucn.org/library/efiles/documents/2004-023.pdf)

Coral cover - Classroom

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

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



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

Explain the findings of the study (*De'ath G, Fabricius KE, Sweatman H, Puotinen M (2012)* and address the following questions:

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

Coral Cover

Crown-of-thorns sea star - Classroom

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

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

Coral Cover - Classroom

Read Methods for Ecological Monitoring of Coral Reefs, Jos Hill and Clive Wilkinson.
Describe at least 3 different ways to measure coral cover in reef monitoring research. How is each of these conducted? List any specific advantages or disadvantages of each method.

Estimating coral cover using quadrats - Field

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

Equipment

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

Teacher notes

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

Estimating coral cover using transects - Field

1. Lay out a tape measure or string with measurements marked on it.
2. Record data every 50 cm. Is there coral found directly underneath the transect tape.
3. You can swim or walk along the tape.
4. Calculate the percentage coral cover. Number of times coral recorded divided by the total of points along the transect assessed (e.g if there are 40 points assessed and only 20 have coral then percentage coral is 50%).

TEACHER GUIDE

UNIT 3 - TOPIC 2 - CHANGES ON THE REEF

Anthropogenic Change

SUBJECT MATTER AND BACKGROUND INFO

- analyse results from models to determine potential reef futures under various scenarios
- recall the global anthropogenic factors affecting the distribution of coral (i.e. coral mining, pollution: organic and non-organic, fishing practices, dredging, climate change, ocean acidification and shipping)
- describe the specific pressures affecting coral reefs (i.e. surface run-off, salinity fluctuations, climate change, cyclic crown-of-thorns outbreaks, overfishing, spills and improper ballast)
- recognise that during the Holocene no evidence of coral bleaching or ocean acidification can be found within coral cores dating back 6000 years
- explain the concept of coral bleaching in terms of Shelford's law of tolerance
- interpret thermal threshold data for reefs in the northern, central and southern sections of the Great Barrier Reef in relation to the likelihood of a bleaching event
- use a specific case study to evaluate the ecological effects on other organisms (e.g. fish) after a bleaching event has occurred
- describe the conditions necessary for recovery from bleaching events
- compare the responses to bleaching events between two regions, while recognising that coral cover increases on resilient reefs once pressures are reduced or removed
- interpret data, including qualitative graphical data of coral cores, that demonstrates that coral cores can act as a proxy for the climate record (i.e. they provide information on the changes in weather patterns and events affecting the composition of coral communities).

GUIDANCE Notional time: 7 hours

- Models to determine potential reef futures could include those produced from the Australian Institute of Marine Science (AIMS).
- Syllabus link: Shelford's law of tolerance is covered in Unit 2 Topic 1: Marine ecology and biodiversity.
- When interpreting thermal thresholds, students should recognise the differences moving from the northern to central to southern Great Barrier Reef and the relationship between degree heating weeks (DHW).
- Case studies of ecological effects could include the:- rate of recovery of reefs following bleaching events relationship between depth and rugosity following bleaching events or- response rates of reefs in different areas/ depths.
- SHE: International collaboration is often required when addressing global issues. The Intergovernmental Panel on Climate Change (IPCC) is an objective, scientific, intergovernmental body that adopted the Representative Concentration Pathways (RCPs) in its 2014 Fifth Assessment Report. Recognise the ecological consequences of climate change for reefs with reference to each of the four RCPs (2.6–8.5).
- SHE: Examine how decisions made on reef management and conservation are based on scientific knowledge, which relies on clear communication of findings, peer review and reproducibility.
- An understanding of the technique of coral coring is not required.

An Altered Ecosystem

Subject matter: analyse results from models to determine potential reef futures under various scenarios.

Recommended reading: Coral Reefs and Climate Change - A shifted baseline (p.138-140), An altered ecosystem (p.142-143), State of the reefs (p.125), A safer target (p.152-153)
View video: Coral Reefs and Climate Change - Altered ecosystem
Check AIMS - Models to determine potential reef futures could include those produced from the Australian Institute of Marine Science (AIMS). https://www.aims.gov.au/docs/research/climate-change/position-paper.html

Global outlook - Classroom

The aim of this activity is to explore the costs and benefits of climate change in different ecosystems across the world. You will investigate and create a poster presentation on the changes that will occur in human communities and natural systems if global temperatures increase above two degrees Celsius.

The consensus that is derived from the data is that, if we wish to avoid the harsher effects of climate change, the average global temperature increase must remain below 2°C, with CO_2 emissions remaining at a 450ppm CO_2 equivalent. The long term projections by the IPCC suggest we are already dancing on this critical edge.

It is suggested that beyond 2°C the ecological fabric begins to tear, causing shifts in species range and transforming entire landscapes over time. Impediments such as farms, roads and cities lie directly in the path of the most favourable migration routes. This is why we see the projected increase in the rate of extinction occurring with the increases in global temperatures into the future. Redistribution of rainfall will impact natural and agricultural systems. The temperatures for the germination of some plants will be surpassed, with the extension in the ranges of pest and weed species contributing to a decrease in land productivity of staple cereal crops.

Vector borne diseases such as malaria, dengue and yellow fever will breach their equatorial confines as the range of their mosquito carriers is expanded with the increases in temperature. These alone will place a substantial additional burden on health systems, even in developed countries such as Australia. The further we move away from this threshold, the greater the magnification of the health effects. Malnutrition, diarrhoea, and mortalities due to heat waves and flooding become part of an expanding array of health issues that must be addressed as terrestrial and marine ecosystems tend towards carbon sources rather than sinks, accelerating changes.

Every country, regardless of their geographic location and economic status, will be affected by climate change to some degree. Developing countries will be the most vulnerable but developed nations will also be overwhelmed. America watched, first in fascination, then in horror, as one of its states descended into chaos and anarchy when Hurricane Katrina caused the death of 1800 people as 80% of New Orleans was submerged in flood waters.

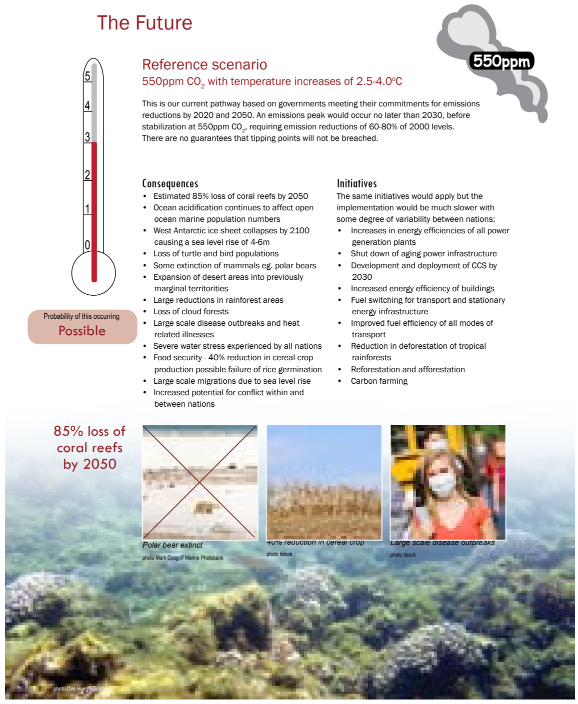
The science informs us that to avoid the dangerous impacts of climate change, CO_2 levels should be no greater than 450ppm, a situation expected to arrive in the next six years. The economists, while conceding that this is the case, point to the economic realities, which show why it is not achievable in the near term, resulting in setting a limit of 550ppm CO_2. Beyond this is unknown territory. The International Energy Agency has suggested that on current trends we are moving to an emissions scenario where 1000ppm by the end of this century is a very real possibility. Inherent within all these conclusions is a level of risk.

The two strategies available to us are mitigation (taking steps to reduce our carbon emissions) and adaptation (coping with those effects that cannot be avoided). It will be the level of engagement on local and international scales that will

An Altered Ecosystem

determine the risks of the adverse affects of climate change. While each nation will have its own individual approach, tailored to their social and economic circumstances, it will only be through an international agreement on the accepted levels of carbon dioxide in the atmosphere that the scope of response by each nation state will be determined.
To achieve a level of stabilisation for carbon emissions at 450ppm will require nothing short of an energy revolution. Following a global agreement, all countries would need to reduce their 2000 level carbon emissions by 80-90% by 2050. The sheer scale of the challenge that would confront all nations makes meeting this target unlikely in the short to medium term. To keep our reefs intact, 350ppm is suggested as the target level for a safe climate, which we have already surpassed.

1. During this activity you will research and create a poster on the effects a 2°C temperature increase will have on a chosen biome.
2. In a group of three choose one of the following biomes:
   Tundra
   Polar region
   Rainforest
   Deserts
   Temperate forests
   Grass and rangelands
   Marine ecosystems
   Freshwater ecosystems
3. Research the following question: What are the costs and benefits of a 2oC rise in temperature to the biome, the people who use it and the economy it helps to support?
4. Create a poster to display along side other biomes on the planet that other groups will research.
5. As a class, discuss each biome briefly and the kinds of costs and benefits climate change means.



Questions

1. State the biome you investigated and how you would be personally affected by the changes predicted there from a 2oC global temperature rise.
2. What is the relationship between developed and developing countries and the geography of the biomes?
3. List some ways of improving the resilience of biomes and the communities that they support.
4. Which regions are most likely to benefit from climate change and why?
5. Describe what tipping points are.
6. What are the factors that influence any ecosystem surpassing these points?
7. Explain ways that temperature increase magnifies and exacerbates the existing pressures within an ecosystem.
8. What are some tipping points that may be triggered within your biome?
9. How are changes within an ecosystem linked to the overall stability of an economy?
10. Discuss some of the key changes within our society that will ensure that we stay below the 550ppm CO^2 limit.

Further research questions

1. Investigate the issues of food and water security.
2. Using a diagram and labels, draw what an ‘energy revolution’ would look like.
3. What are the social and ecological impacts resulting from the loss of one of these biomes?
4. What are the security implications of climate change?
5. How would you manage some of the situations given in the example of the future?

Human Impact

Subject matter: recall the global anthropogenic factors affecting the distribution of coral.

Recommended reading: Coral Reefs and Climate Change - Recent scientific findings (p.172-174)
Great Barrier Reef Outlook Report (*http://www.gbrmpa.gov.au/our-work/reef-strategies/great-barrier-reef-outlook-report*)

Human impact - Classroom

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

Identifying threats - Field

Instructions

1. Copy the 'Local Impact Table' onto a waterproof slate.
2. While snorkelling, identify threats. Tally each time you see evidence of that threat affecting the reef. Take photos if you can. Some threats might not be visible but you know they exist. You may observe indirect evidence of their effects (e.g. damaged coral from a cyclone).
3. Compare your results with rest of the class.
3. Answer the following questions:

a. Which threats did you observe affecting this reef?
b. Do you observe indirect evidence of any threats? Provide details.
c. Suggest strategies that individuals or organisations can implement to reduce the impact of these threats.
d. Is your area part of a marine park?
e. If so, are there regulations in place to minimise impact?

Equipment

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

Teacher notes

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

Human Impact

LOCAL IMPACTS TABLE

Observer(s):

Location: Date:

Weather conditions: windy / calm / cloudy / sunny

Threat		**Tally** *(every time noticed)*
	**Pollution**	
	**Invasive species: Crown of Thorns**	
	**Coral Bleaching**	
	**Algal overgrowth**	
	**Damaged coral**	
	other	
	other	

Coral Bleaching

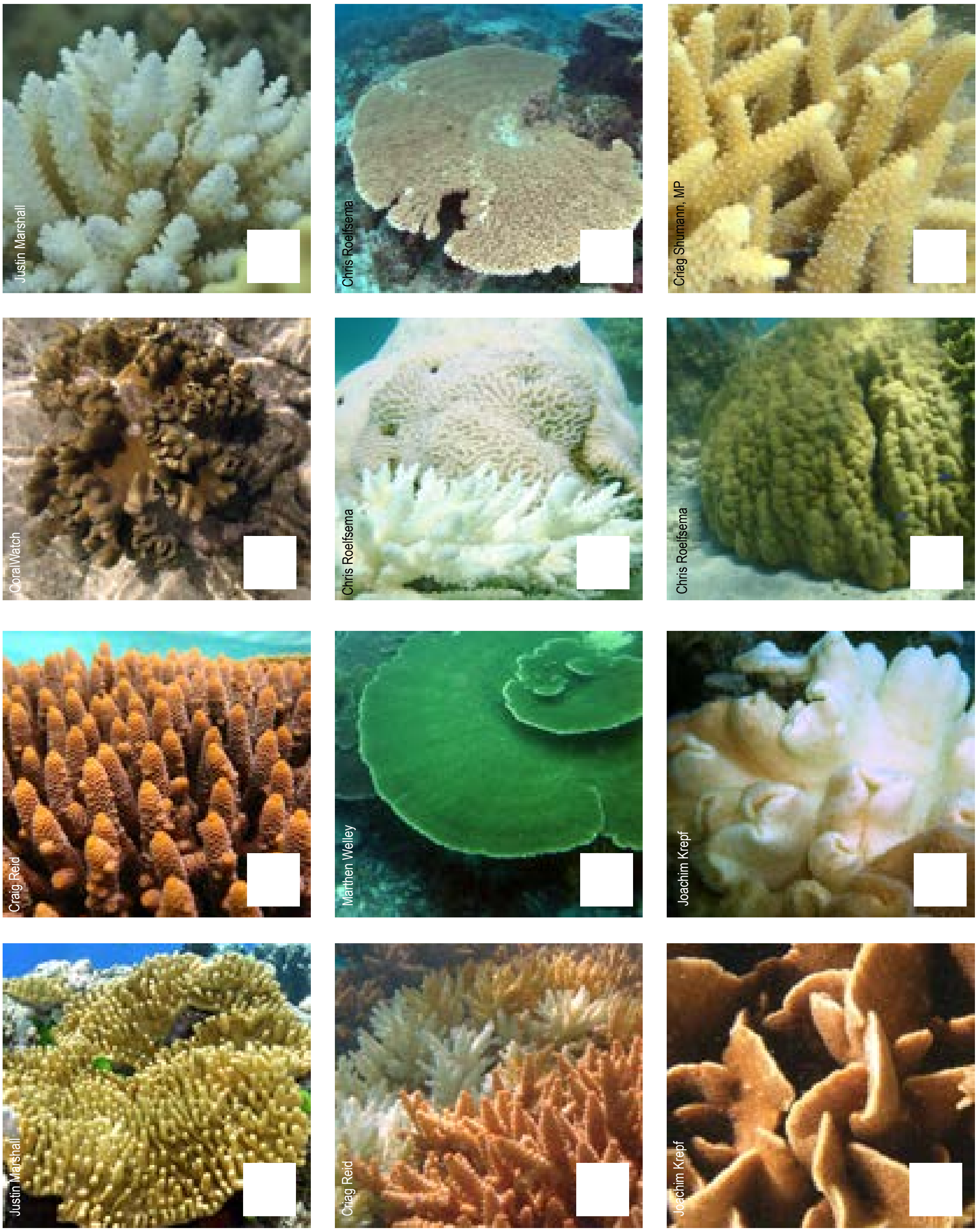
Subject matter: explain the concept of coral bleaching in terms of Shelford's law of tolerance.

Recommended reading: Coral Reefs and Climate Change - Coral bleaching (p.126-129), Ecosystem resilience (p.130-133)
View video: Coral Reefs and Climate Change - Coral bleaching

Shelford's law of tolerance: A law stating that the abundance or distribution of an organism can be controlled by certain factors (e.g. the climatic, topographic, and biological requirements of plants and animals) where levels of these exceed the maximum or minimum limits of tolerance of that organism.

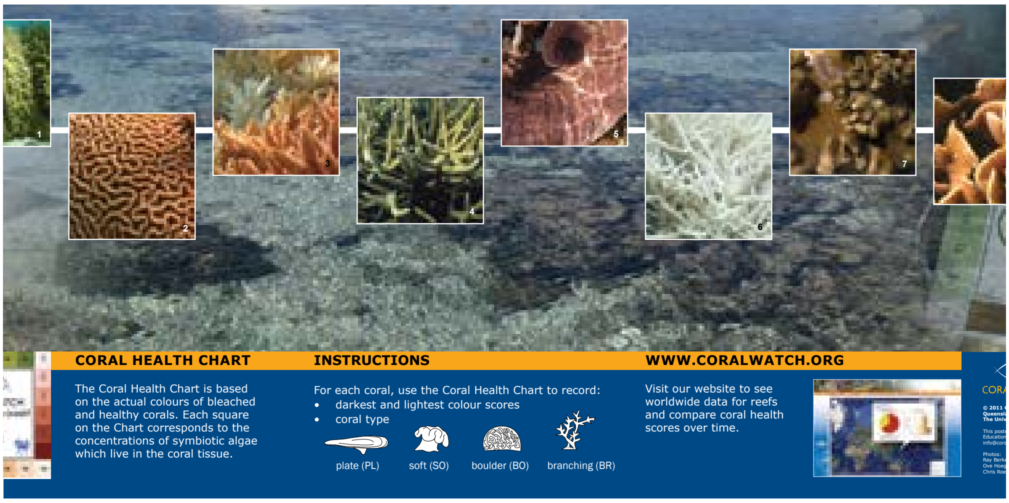
Coral bleaching - Classroom

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



Coral Bleaching

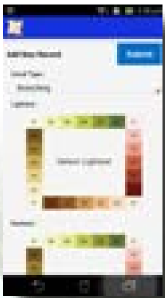
Measuring coral health using virtual reef poster - Classroom

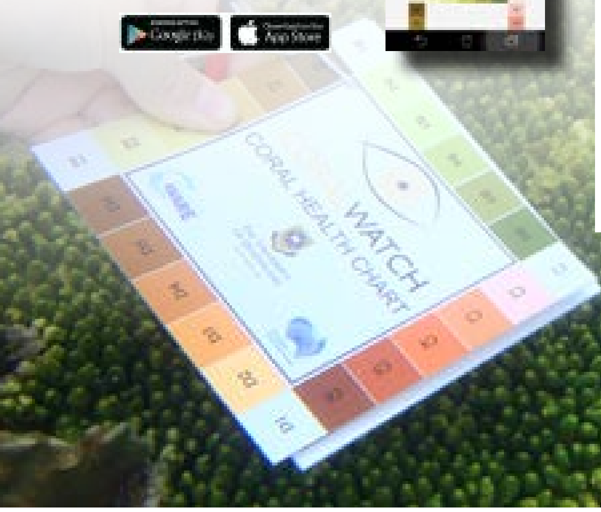


Instructions

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**.





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

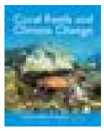
Date of survey: ____/____/____ (Day / Month / Year) Time collected: (ie.14:00 or 2pm) ______________

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

Coral Bleaching

Recommended reading: Coral Reefs and Climate Change - Acting on coral bleaching (p.212-214), [CoralWatch Do-It-Yourself Instructions]
View video: Coral Reefs and Climate Change - CoralWatch Intro/How to

Measuring Coral Health using transects - Field

Instructions

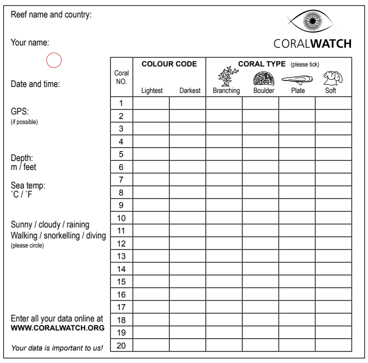
1. Read the instructions on the back of the Coral Health Chart.
2. Make sure you have all your equipment as listed above.
3. Start with recording survey details on your data slate: name, date, time, GPS (if possible), water temperature, depth, activity and conditions.
4. Follow the instructions on the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

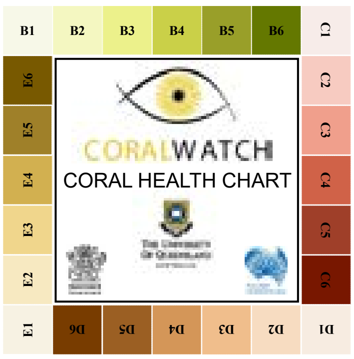
Teacher notes

- You can do this acitivity as a random survey. But make sure it is done randomly, don't get students to choose corals they like or the ones that are bleached. Use a set number of steps / fin kicks to determine the next coral you will measure.
- The CoralWatch Virtual Reef Activity is useful preparation for using the Coral Health Chart in the field.
- The CoralWatch data slates contains all required survey details.
- The distance along the transect line between measurements can vary depending on coral cover. If there is no coral underneath the assigned reading, students can pick the closest coral colony.
- Ensure students don't damage the coral as they lay out the tape.
- For future reference, students could mark the start and end of your transect using GPS coordinates.

Equipment

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





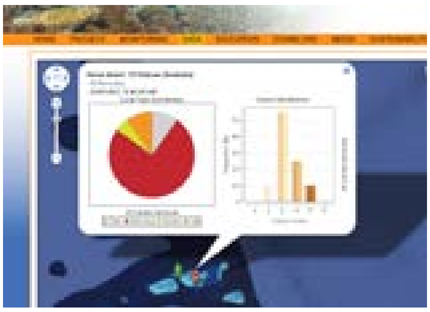
Example of CoralWatch data slate and Coral Health Chart.

Coral Bleaching

Interpreting live coral bleaching data - Classroom

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.

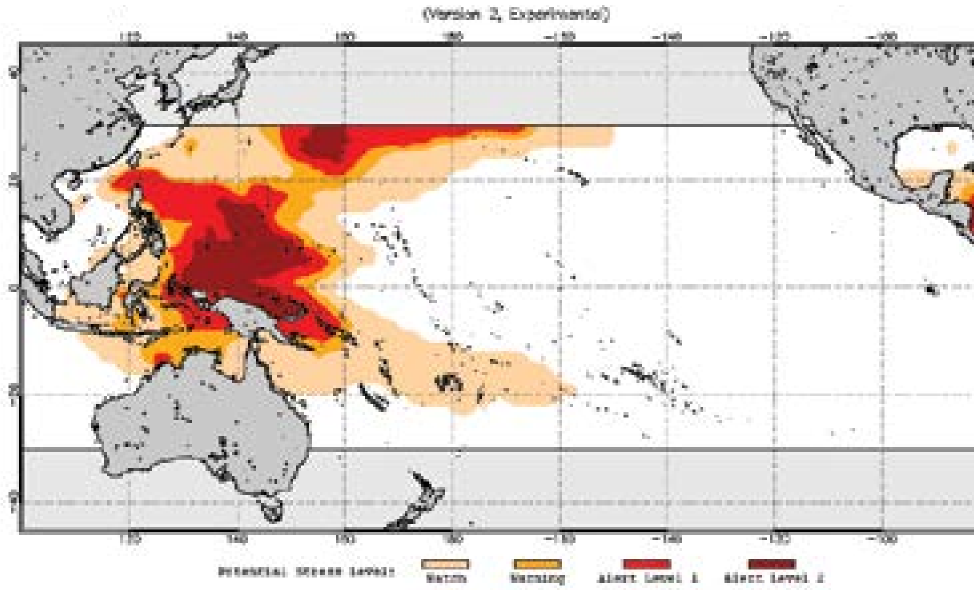
Predicting Coral Bleaching

Subject matter: interpret thermal threshold data for reefs in the northern, central and southern sections of the Great Barrier Reef in relation to the likelihood of a bleaching event.

Recommended reading: Coral Reefs and Climate Change - The bigger picture (p.234-235)
View video: Coral Reefs and Climate Change - Coral bleaching
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)

Sea surface temperatures - Classroom

Read the IPCC Fourth Assessment Report: Climate Change 2007 section on Sea Surface Temperature:
Answer the following questions:
1. In figure 3.4b, what do the different lines in the graph represent?
2. Explain why sea surface temperatures are usually described as an ‘anomaly’ rather than a mean.



NOAA

NOAA Coral Reef Watch - Classroom

Use https://coralreefwatch.noaa.gov/satellite/index.php and read more about Coral Reef Watch Satellite Bleaching Alert System. Familiarise yourself with the five status levels.

Go to outlook and click on the map that will show Indonesia, then click on “Pacific” to see Thermal Stress Outlook for the region.
1. Are there any areas on your map that show alert Level 2?
2. Are there any areas on your map that show warming?
3. Copy your map with the outlook of one month, 2 months and 3 months earlier. What are the differences? Has the bleaching forecast changed?

See also the exercises to calculate degree heating weeks on NOAA webpage
https://coralreefwatch.noaa.gov/satellite/education/tutorial/crw29_exercises.php

UNIT 3 - TOPIC 2 - CHANGES ON THE REEF

Implications for Marine Systems

SUBJECT MATTER AND BACKGROUND INFO

- recognise that the type of carbonate ions and concentration of ions have an implication for the development of shell-forming and skeletal-forming organisms including hard corals (Scleractinia), coralline algae, molluscs, plankton and crustaceans
- interpret trends in data in relation to the carbonate system and changes in pH
- distinguish between laboratory-scale and field-based experiments and what they demonstrate about ocean acidification
- describe the potential consequences of ocean acidification for coral reef ecosystems
- explain how resilience may partially offset ocean acidification responses in the short term.
- Mandatory practical: Investigate the effects an altered ocean pH has on marine carbonate structures.

GUIDANCE

- Notional time: 6 hours
- Calcium carbonate can be precipitated into two main forms: calcite and aragonite.
- Examples of data that could be interpreted include Bjerrum, hockey stick or Keeling curves.
- The precipitation of aragonite is dependent on the concentration of both calcium and carbonate ions. It can be described using the following equation:
- Suggested practical: Investigate how CO_2 lowers the pH of a solution.
- Suggested practical: Investigate how changes in temperature and salinity affect the solubility of CO_2 in aqueous saline solutions.
- Suggested practical: Investigate the effect of CO_2 on planktonic organisms.
- Resilience of coral reefs is improved by minimising other impacts including coastal run-off (nitrogen inputs), and habitat destruction and fishing. The reef and catchment management processes of the Great Barrier Reef aim to reduce nutrient load in run-off.

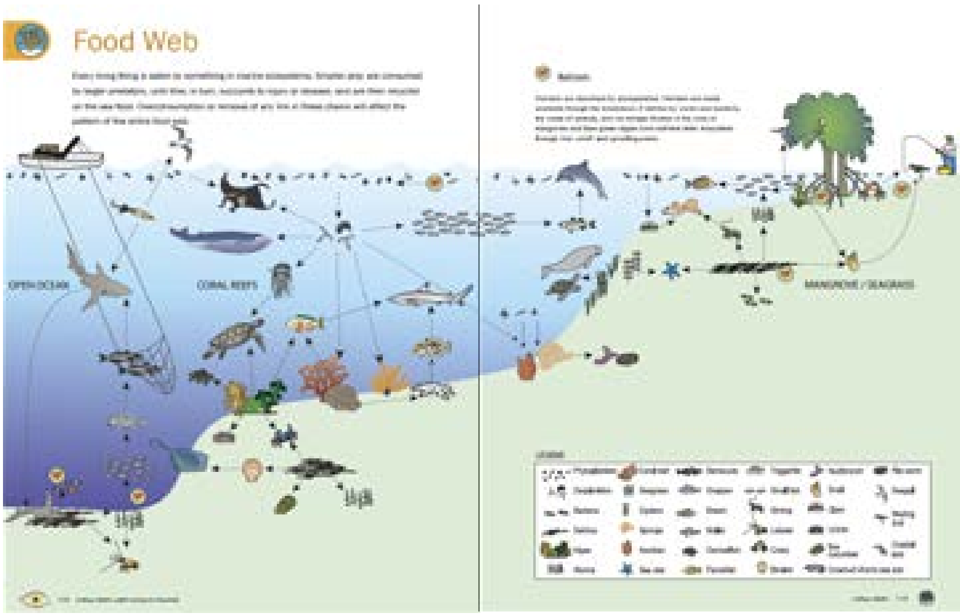
Effect of Ocean Acidification

Subject matter: describe the potential consequences of ocean acidification for coral reef ecosystems.

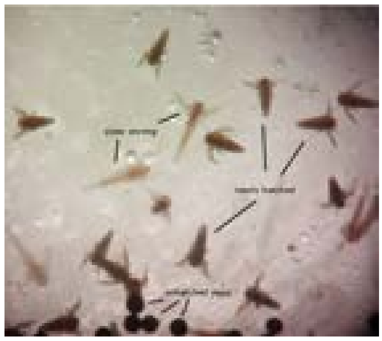
Recommended reading: Coral Reefs and Climate Change - Ocean acidification (p.68-71), Fish in trouble (p.72-73)
View video: Coral Reefs and Climate Change DVD series - Climate Change

Effect of pH acidification on animals - Classroom

Draw a simple marine food web or use the drawing below. Highlight which animals may be directly affected by ocean acidification? Describe how this will affect other marine organisms?



Effect of pH acidification on Arthemia's eggs - Lab



Prepare two days before:
Eggs of Arthemia (baby brine shrimp) in solutions with different pH or salinity. They will hatch in 18-30 hours. Using a binoccular, count the number of eggs and shrimps. Evaluate the best conditions and list other abiotic factors which influence the hatching. Describe different factors that influence the pH of waters and their effect on shrimps.
See also: http://mylabolog.blogspot.com/2015/02/diy-brine-shrimp-or-artemia-hatchery.html

Artemia eggs
Hatch rates are often touted as high as 95% on many non-decapsulated brands, but the tragic reality is that in many domestic cases only around 40% yield is actually attained. Several factors need to be considered when hatching Artemia eggs. Temperature plays a huge role, with 25°C/77°F consistently showing to be optimal for success. Salinity of water should be very high and a specific gravity of 1.030 should be aimed for at 25°C.
Water needs to be both hard and alkaline, with a pH of 9.0 favourable. Anything below 8.0 has a big impact on hatching and success rates. The most common flaw is failing to provide a light source. Inside the Artemia egg is a chemical called trehalose which is triggered by a light source to turn into glycerol. This is a hygroscopic chemical and draws water through the membrane and into the Artemia itself, starting the hatching process.
Some Artemia have been known to hatch in the dark, but these exceptions not fully understood, and do not represent successful hatches. Adding an artificial light source to San Francisco brine shrimp is known to increase hatches by 50% or more. To successfully produce Artemia from eggs, a volume of water needs to be vigorously aerated for movement with the eggs in it. These will hatch in the conditions as stated in around 18 hours, although a second smaller hatch can also occur afterwards.

Effect of Ocean Acidification

Ocean acidification - Lab

In preparation of this activity, you will need to collect plankton and calcareous algae. To collect plankton, use a plankton net, trawl through the water for 10 minutes and seal the collected plankton in a jar.

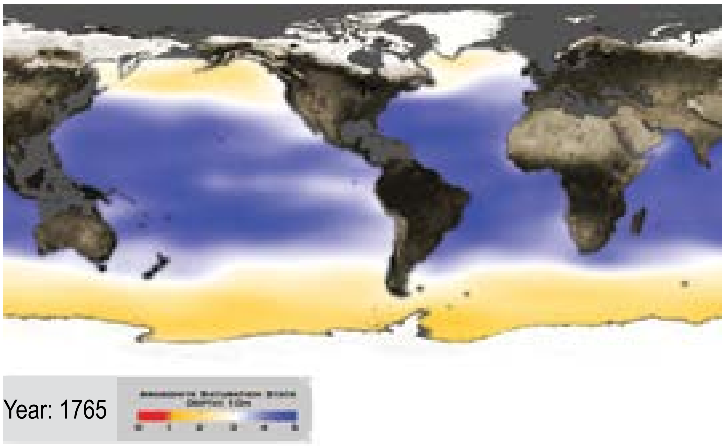
1. Look at the algae sample you collected in the field:
   a. Add filtered sea water to the algae, seal it and gently shake.
   b. Tip the water into a plastic beaker and repeat this process twice.
   c. Using a pipette, extract a small amount of the seawater, place on a microscope slide and view it under a microscope.
2. Looking in the water column sample you collected in the field:
   a. Wash the plankton net with filtered seawater to improve extraction of micro organisms.
   b. Tip the jar into a clean plastic beaker.
   c. Using a pipette, extract a small amount of the seawater, place on a microscope slide and view it under a microscope.
3. Use books and websites to identifying what you have found and note the abundance of plankton. Draw and identify two dominant plankton from each section, using identification charts. Also identify and draw your calcareous algae.
4. Take two equal sub samples of plankton-filled seawater from each substrate type. Add 10ml of filtered seawater to one sub sample, add 10ml of soda water, vinegar or another dilute acid in the other. Leave the samples to sit for half an hour. Now use the pipette to prepare a slide of normal plankton and acidified plankton. (This is an extreme case of acidification that does not reflect current realities).
5. Collect two samples of calcareous algae, place one in dilute acid and the other in filtered seawater overnight. Observe any visible changes in the two samples.

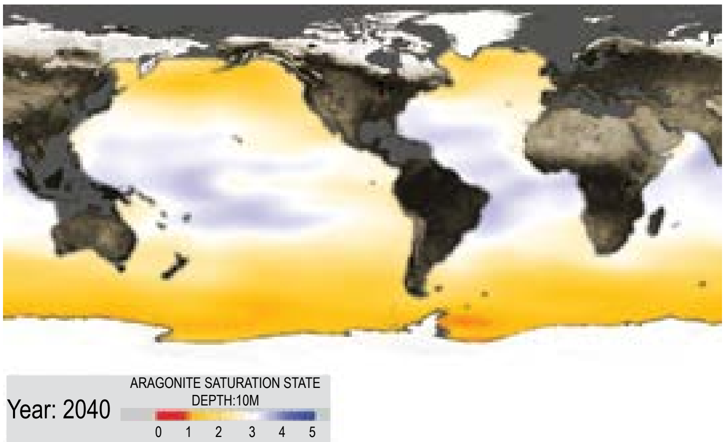
Plankton drawings	
Algae drawings	

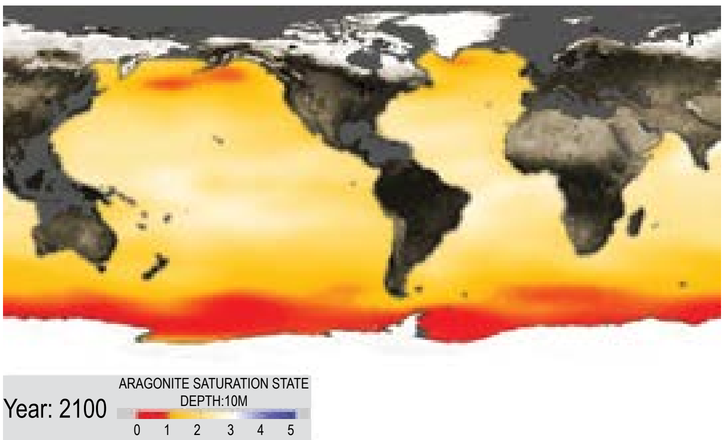
Effect of Ocean Acidification

Ocean pH - Classroom

Look at the maps highlighting ocean pH across the globe. Which areas of the oceans are most at risk of ocean acidification? Use your understanding of gas laws and gas solubility in fluids to explain why some oceans absorb more CO_2 than other areas. (Tip: You can search for this answer on the internet or in a textbook).
You can test this effect by looking at soda water. What happens to the carbon dioxide bubbles when soda water is heated?

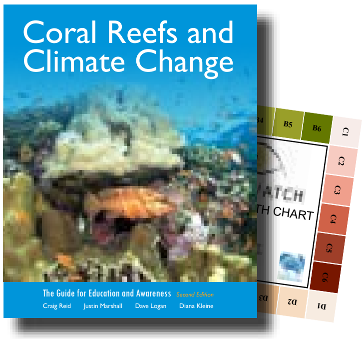






Aragonite saturation states

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

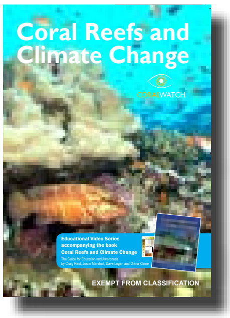


'Coral Reefs and Climate Change' book with free Coral Health Chart and monitoring instructions.

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

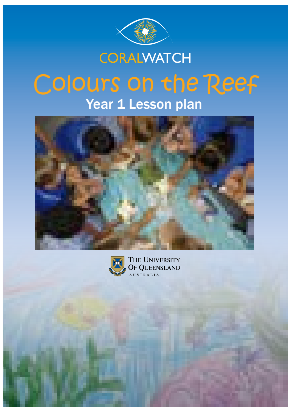
Available for primary or high school. Includes Moreton Bay (MB) virtual reef, MB Coral ID sheet, year 1 and/or year 7 lessons and resources, MB and GBR info flyers, Coral Health Chart with slate and DIY monitoring instructions.

Ultimate teaching package

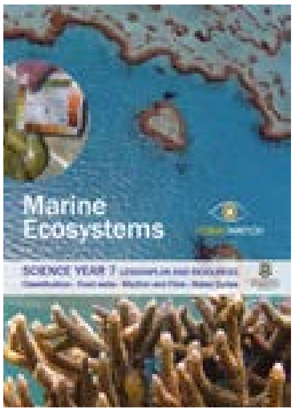
Includes Book and DVD, activity CD, workbook, class set of Coral Health Charts and slates, DIY monitoring instructions, virtual reef materials, posters and booklets. See orderform for full contents.

CORALWATCH RESOURCES

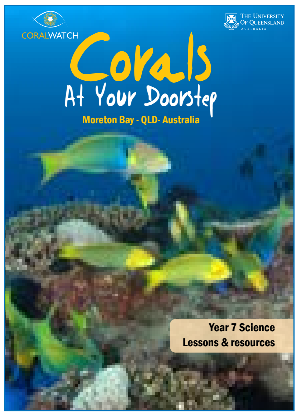
Australian curriculum linked lesson materials



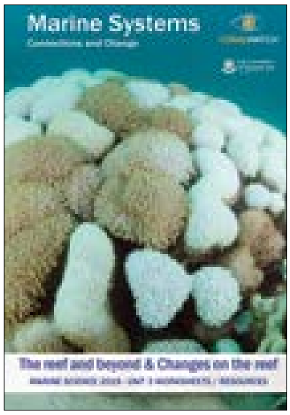
'Colours on the Reef'
Year 1 Science
Lesson plan.



'Marine Ecosystems'
Year 7 Science
Lessons and resources.

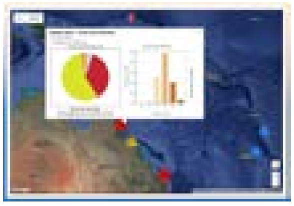


'Corals at Your Doorstep'
Moreton Bay QLD Australia
Year 7 Science
Lessons and resources.



'Marine Systems'
Marine Science 2019, Unit 3
worksheets / Resources

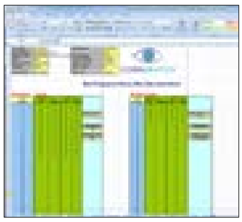
CoralWatch Data



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

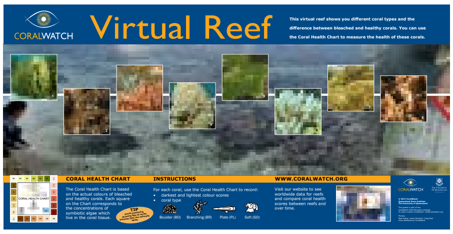
'Data entry'
Guide to entering CoralWatch
data online or by App.

'Data analysis'
Guide outlining applications of
CoralWatch data.



'Raw data input sheet'.

Virtual reef materials



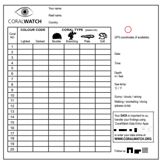
'Virtual Reef poster' - 2 versions
Moreton Bay or Tropical Reef.

'Virtual lab booklet'.

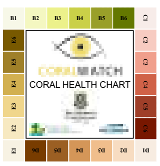
'Virtual reef booklet'.

Monitoring

'CoralWatch DIY instructions'
Available in 12 languages.

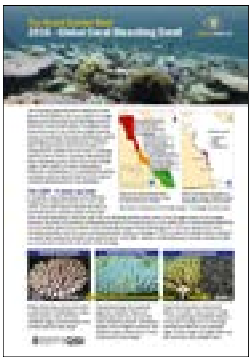


Data slates



'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.

Marine Science 2019 v1.1

IA1 sample assessment instrument

April 2018

Data test (10%)

This sample has been compiled by the QCAA to assist and support teachers in planning and developing assessment instruments for individual school settings.

Assessment objectives

This assessment instrument is used to determine student achievement in the following objectives:

2. apply understanding of the reef and beyond or changes on the reef to given algebraic, visual or graphical representations of scientific relationships and data to determine unknown scientific quantities
3. analyse evidence about the reef and beyond or changes on the reef to identify trends, patterns, relationships, limitations or uncertainty in datasets
4. interpret evidence about the reef and beyond or changes on the reef to draw conclusions based on analysis of datasets.

Note: Objectives 1, 5, 6 and 7 are not assessed in this instrument.

Subject	Marine Science	Instrument no.	IA1
Technique	Data test DRAFT		
Unit	Unit 3: Marine systems — connections and change		
Topic	Not Specific - DRAFT		

Conditions			
Response type	Short response Supervised exam conditions		
Time	60 minutes	**Perusal**	10 minutes
Other	• Length: up to 500 words in total, consisting of – short responses, i.e. sentence or short paragraphs – written paragraphs, 50–250 words per item – other types of item responses, e.g. interpreting and calculating, should allow students to complete the response in the set time • Queensland-approved graphics calculator permitted • Unseen stimulus		

Instructions		
Use the datasets to respond to the associated items in the spaces provided. Each item is associated with the dataset that immediately precedes it.		
Criterion	**Marks allocated**	**Result**
Data test Assessment objectives 2, 3, 4	10	
Total	**10**	

Data test summary

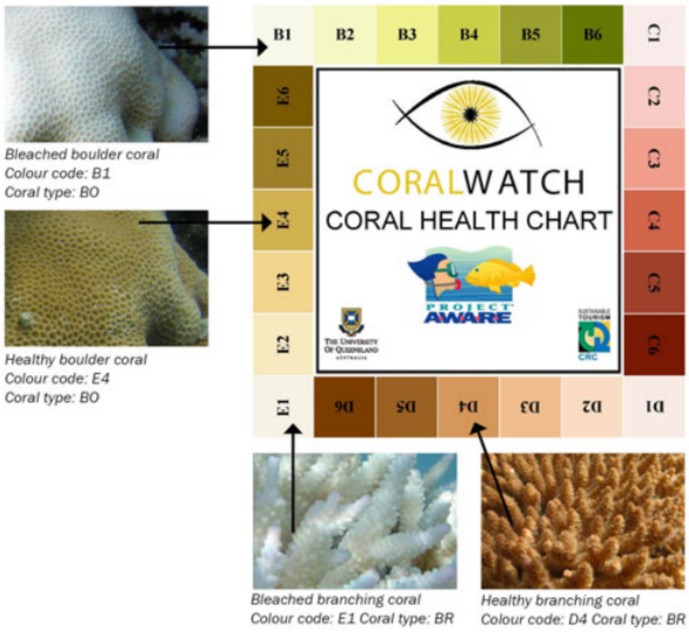
Dataset	Item	Objective			
		Apply understanding	Analyse evidence	Interpret evidence	
1	1	2			
	2		2		
	3			2	
2	4		2		
	5			2	
	6			2	
	7	2			
3	8	2			
	9		2		
	10			2	
Total		6	6	8	20
Percentage		30%	30%	40%	100%

Dataset 1

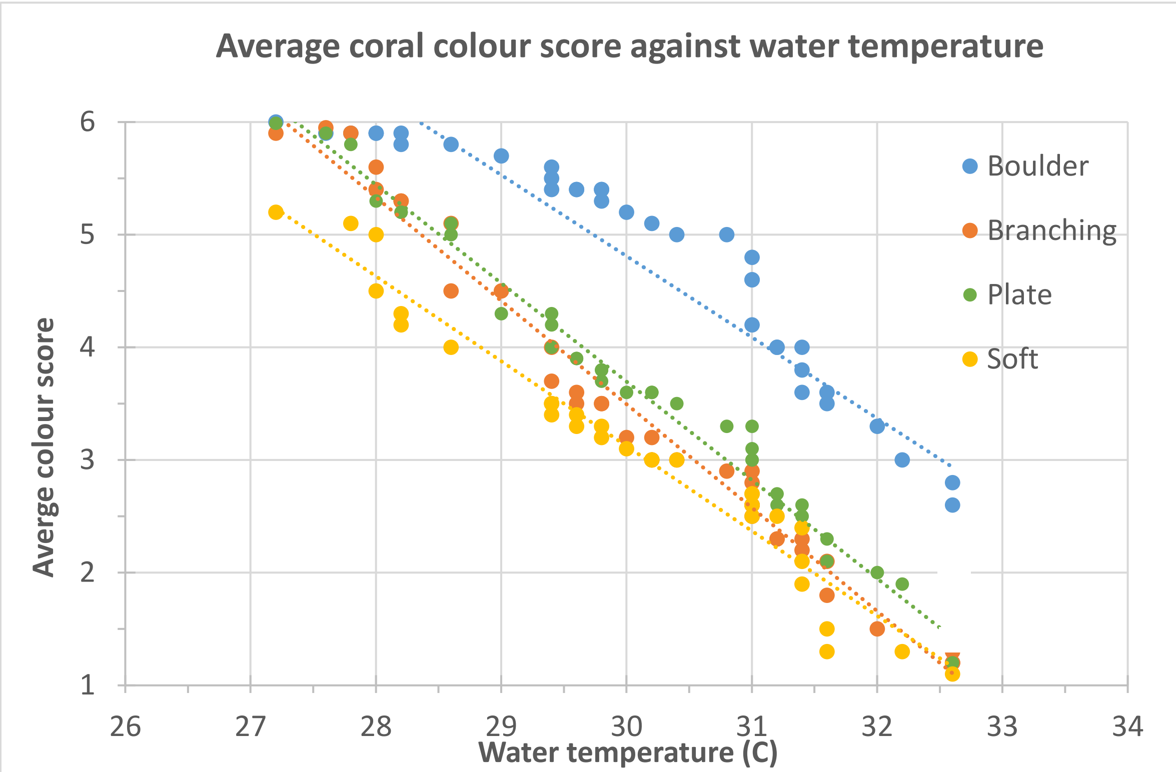
Figure 1

Coral Health Chart

Students used the colour chart in Figure 1 to record the health of different types of corals. On a scale of 1 (bleached) to 6 (healthy) the average coral colour score is plotted against temperature in Graph1.



Graph 1



Source: https://www.coralwatch.org/web/guest;jsessionid=BE64714E7EAA93A2FA3ECB9845DAE5BD

Item 1 (apply understanding)	2 marks

Determine the:

a. average colour score of a plate coral at 28.5 degrees celsius (to 1 decimal place).

Answer:

b. temperature at which soft coral has an average colour score of 2 (to 1 decimal place).

Answer: C

Item 2 (analyse evidence)	2 marks

Identify the relationship between coral colour and temperature:

____

____

Item 3 (interpret evidence)	2 marks

Predict the relative bleaching of plate coral and boulder coral at 33.5 degrees Celsius. Give reasons for your prediction.

____

____

____

____

____

Dataset 2

Acropora Sp.

The growth rate of 3 different species of *Acropora* coral was measured in centimetres per year at two reef locations. Reef A was 50 metres from a dredged channel, reef B was 5 km from a dredged channel.

The growth rates measured are presented in the table below along with the calculated P – Values for the data sets for each coral species.

Acrapora Sp.	Reef A Growth (cm per year)	Reef B Growth (cm per year)	P- Value
1	10	15	0.1
2	12	16	0.01
3	8	10	0.001

Source: University of Queensland

Item 4 (apply understanding) **2 marks**

Determine which *Acropora Sp.* shows the least difference in growth rate between reef A and reef B. Give reasons for your answer

Species Number _______

Determine which *Acropora Sp.* shows the greatest difference in growth rate between reef A and reef B. Give reasons for your answer.

Species Number________

Item 5 (analyse evidence)	**2 marks**

Derive the difference in the average annual growth rate for all corals on Reef A and Reef B. Show your working.

Answer:
cm

Derive the difference in the average growth rate for all corals on Reef A and Reef B as a %. Show your working.

Answer:
%

Item 6 (interpret evidence)	**2 marks**

Infer from the table above what affect dredging has on species 1 and species 3. Give reasons for your answer.

Species 1.

Species 3.

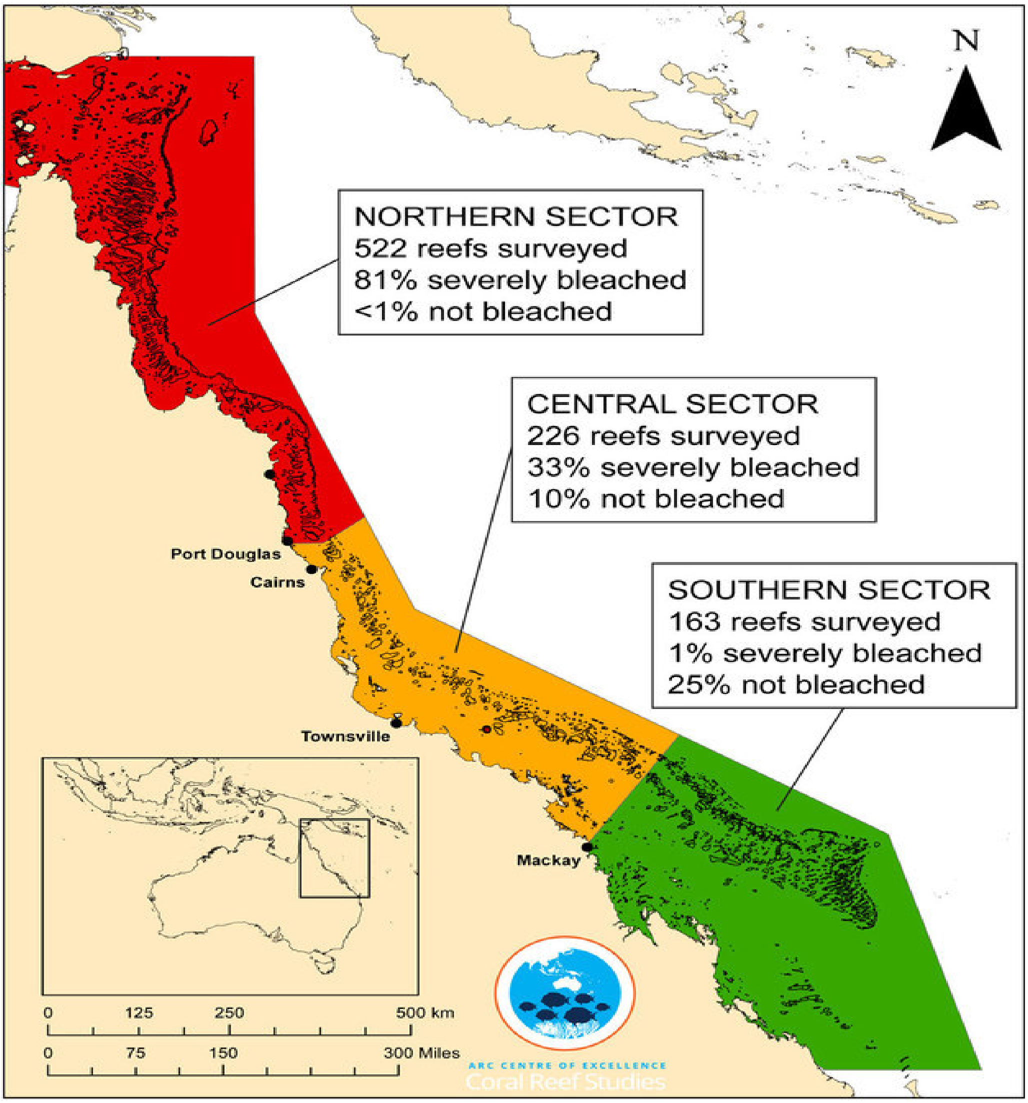
Item 7 (interpret evidence)	**2 marks**

Draw a conclusion about what the different p-values show with regard to the effects of dredging on Species 2 and Species 3. Give reasons for your conclusion.

Dataset 3

Figure 2.

Map of the Great Barrier Reef showing results of aerial surveys on reefs affected by the 2016 coral bleaching event- JCU



Item 8 (apply understanding)	**2 marks**

Calculate the following:

a. The % of all surveyed reefs that were severely bleached. Show your working.

Answer:
______________%

b. The number of reefs not bleached in the Southern and Central Sectors.

Answer:

Item 9 (analyse evidence) **2 marks**

Derive the length of the outer most limit of the Northern Sector in kilometres using the scale bar. Show your working.

Answer:
Km____________

Derive how far south Mackay is from Cairns using the scale bar. Show your working.

Answer:
Km____________

ITEM10 (interpret evidence) **2 marks**

Draw a conclusion about why the levels of severely bleached corals differ across the three survey regions. Give reasons for your conclusion**.**

____

____

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____

____

____

____

END OF PAPER

Instrument-specific marking guide (ISMG)

Criterion: Data test

Assessment objectives

2. apply understanding of the reef and beyond or changes on the reef to given algebraic, visual or graphical representations of scientific relationships and data to determine unknown scientific quantities
3. analyse evidence about the reef and beyond or changes on the reef to identify trends, patterns, relationships, limitations or uncertainty in datasets
4. interpret evidence about the reef and beyond or changes on the reef to draw conclusions based on analysis of datasets

The student work has the following characteristics:	Cut-off	Marks
• consistent demonstration, across a range of scenarios about the reef and beyond or changes on the reef, of – selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications – correct calculation of quantities through the use of algebraic, visual and graphical representations of scientific relationships and data – correct and appropriate use of analytical techniques to correctly identify trends, patterns, relationships, limitations and uncertainty – correct interpretation of evidence to draw valid conclusions.	> 90%	10
	> 80%	9
• consistent demonstration, in scenarios about the reef and beyond or changes on the reef, of – selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications – correct calculation of quantities through the use of algebraic, visual and graphical representations of scientific relationships and data – correct use of analytical techniques to correctly identify trends, patterns, relationships, limitations and uncertainty – correct interpretation of evidence to draw valid conclusions.	> 70%	8
	> 60%	7
• adequate demonstration, in the reef and beyond or changes on the reef, of – selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications – correct calculation of quantities through the use of algebraic, visual and graphical representations of scientific relationships and data – correct use of analytical techniques to correctly identify trends, patterns, relationships, limitations and uncertainty – correct interpretation of evidence to draw valid conclusions.	> 50%	6
	> 40%	5
• demonstration, in scenarios about the reef and beyond or changes on the reef, of elements of – selection and correct application of scientific concepts, theories, models and systems to predict outcomes, behaviours and implications – correct calculation of quantities through the use of algebraic, visual or graphical representations of scientific relationships or data – correct use of analytical techniques to correctly identify trends, patterns, relationships, limitations or uncertainty – correct interpretation of evidence to draw valid conclusions.	> 30%	4
	> 20%	3

<table>
<tr><th>The student work has the following characteristics:</th><th>Cut-off</th><th>Marks</th></tr>
<tr><td rowspan="2">• demonstration, in scenarios about the reef and beyond or changes on the reef, of elements of
– application of scientific concepts, theories, models or systems to predict outcomes, behaviours or implications
– calculation of quantities through the use of algebraic or graphical representations of scientific relationships and data
– use of analytical techniques to identify trends, patterns, relationships, limitations or uncertainty
– interpretation of evidence to draw conclusions.</td><td>> 10%</td><td>2</td></tr>
<tr><td>> 1%</td><td>1</td></tr>
<tr><td>• does not satisfy any of the descriptors above.</td><td>≤ 1%</td><td>0</td></tr>
</table>

Act Now

for the future of our reefs

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The University
Of Queensland
Australia

CORALWATCH