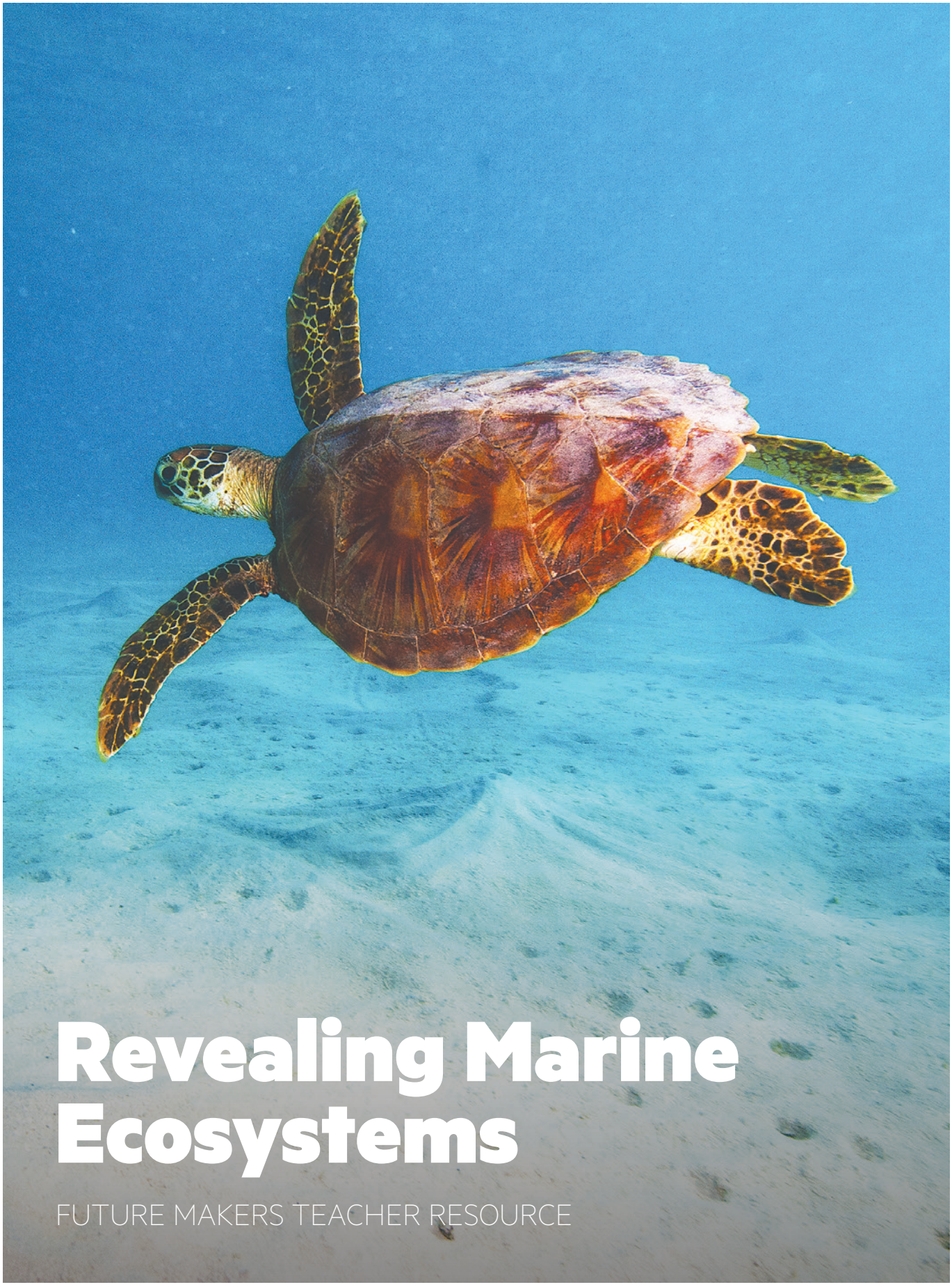

Revealing Marine Ecosystems

FUTURE MAKERS TEACHER RESOURCE

QGC | FUTUREMAKERS | QUEENSLAND MUSEUM NETWORK | Queensland Government

Future Makers

Future Makers is an innovative partnership between Queensland Museum Network and Shell's QGC business aiming to increase awareness and understanding of the value of science, technology, engineering and maths (STEM) education and skills in Queensland.

This partnership aims to engage and inspire people with the wonder of science, and increase the participation and performance of students in STEM-related subjects and careers — creating a highly capable workforce for the future.

Cover Image: Green Turtle, Chelonia mydas*. QM, Gary Cranitch*

QUEENSLAND MUSEUM NETWORK

Queensland Government

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

This teacher resource is produced by Future Makers, a partnership between Queensland Museum Network and Shell's QGC business, with support from the Australian Research Council and other parties to ARC Linkage Project LP160101374: The University of Queensland, Australian Catholic University Limited and Queensland Department of Education.

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Workshop Overview

The world around us is incredibly complex. Due to interactions between organisms and the environment, slight changes in the ecosystem can potentially have far-reaching impacts. This workshop explores the complexity of a marine habitat and the effects of human activity on these ecosystems. Students will also consider how scientists are working to increase our understanding of this watery world, before becoming scientists themselves, investigating ocean acidification through hands-on experimentation.

The workshop has been divided into three parts in order to scaffold learning and help students draw connections between content and activities. The following topics are explored in each aspect of the workshop:

Part 1

- What is an ecosystem?
- How we can represent interactions between organisms living in an ecosystem.
- How are organisms classified according to their position in a food web?

Part 2

- What is our place within a marine ecosystem?
- How do humans impact the marine ecosystem?
- What can we do to address human impacts on the marine ecosystem?

Part 3

- Introducing Dr Paul Muir: How scientists learn more about the world around us.
- We are scientists: Investigating ocean acidification.
- How does CO_2 affect water?
- How does acid affect organisms with calcium carbonate shells?
- Which shelled organisms will be most affected by a change in pH?
- Student investigation: The effect of ocean acidification on calcium carbonate.

This workshop has been structured using the 5E's instructional model.

The following topics and concepts are explored in each aspect of the workshop:

ENGAGE	**Investigation Station: Specimen Object Analysis** Observe and analyse a specimen to determine what we can learn from objects.
EXPLORE **EXPLAIN**	**Marine Food Web** Explore the interactions between organisms in a marine ecosystem.
EXPLORE	**Citizens of the Sea: Community of Inquiry** Participate in a community of inquiry to discuss our connections with the ocean.
ELABORATE	**Making Connections: Object and Article Analysis** Use objects and articles to explore how humans impact the marine environment.
EVALUATE	**Analysing Human Impact** Collaboratively investigate the effect of human activity on the marine ecosystem and how we can minimise our impact.
ENGAGE	**Introducing Dr Paul Muir** Learn about the marine environment from marine biologist, Dr Paul Muir.
ENGAGE **EXPLORE** **EXPLAIN** **ELABORATE** **EVALUATE**	**Investigating Ocean Acidification: We are Scientists** Conduct experiments to investigate the impacts of carbon dioxide on the marine environment.

ENGAGE

Investigation Station: Specimen Object Analysis

Teacher Resource

This activity is designed to explore and build on students' prior knowledge of marine organisms. Object-based learning is, 'a mode of education which involves the active integration of authentic or replica material objects into the learning environment'[1] and is used to prompt investigation and promote student inquiry.

In this activity, students firstly observe a specimen. They may want to use a magnifying glass to scan for finer details. They then identify what the specimen is, determine if it is real or a model/ representation and make an annotated scientific drawing to communicate ideas about the specimen. Following this, students examine the features of their specimen to make and record inferences about its habitat, movement, diet and predators.

Curriculum Links

Science

YEAR 5

Science Understanding

Living things have structural features and adaptations that help them to survive in their environment (ACSSU043)

Science Inquiry Skills

Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS093)

General Capabilities

Literacy

Composing texts through speaking, writing and creating

Numeracy

Using measurement

Critical and Creative Thinking

Inquiring: Identifying, exploring and organising information and ideas

Analysing, synthesising and evaluating reasoning and procedures

[1] *Jamieson, A. (2016). Object-based learning: A new mode in Arts West. Retrieved from https://arts.unimelb.edu.au/articulation/editions/2016-editions/december-2016/object-based-learning-a-new-mode-in-arts-west*

Investigation Station: Specimen Object Analysis

Student Activity

What am I/what do I represent? *(if known)*	
Is this specimen 'real' of a model/representation?	

Draw your specimen and label the physical features

- Size
- Shape
- Colour and pattern
- Skin covering
- Limb type
- Mouthparts
- Other notable features

Investigation Station: Evidence and Adaptations

Living things have features and behaviours that help them survive in their environment. We call these adaptations.

Look at the features of your specimen to answer the following questions:

Specimen:		**Prediction:**	**Evidence:**
Habitat:	What type of environment does your animal live in?		
Movement:	How does your animal move?		
Diet:	What does your animal eat and how does it catch its food?		
Predators:	How does your animal stop and/or avoid predators?		

List 2 questions you have about your specimen.

1.
2.

EXPLORE - EXPLAIN

Marine Food Web

Teacher Resource

In this activity, students model the interactions between organisms living in the marine ecosystem. Pairs of students may select an image of an organism and stand in a circle with the whole class group. A ball of string is provided to one pair of students who start the activity. These students identify how their organism is connected to another in the circle (i.e. if their organism eats or is eaten by another organism), before passing the ball of string to the pair of students representing that specimen. The ball of string is secured in some way to that specimen (for example, the string could be tied to a chair in front of the students) and the process is repeated until all organisms are connected to each other.

Following this, the food web can be recreated on a chart or wall. Language associated with food chains and webs can be introduced during this whole group activity. Labels have been provided to classify organisms according to their position in the food web; however you may ask students to identify more interrelationships such as predator/prey, competitors and decomposers.

Students could also start to consider how living things and/or human activity can influence the health and population of other living things.

Curriculum Links

Science

YEAR 7

Science Understanding

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

Science Inquiry Skills

Communicate ideas, findings and evidence-based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS133)

YEAR 9

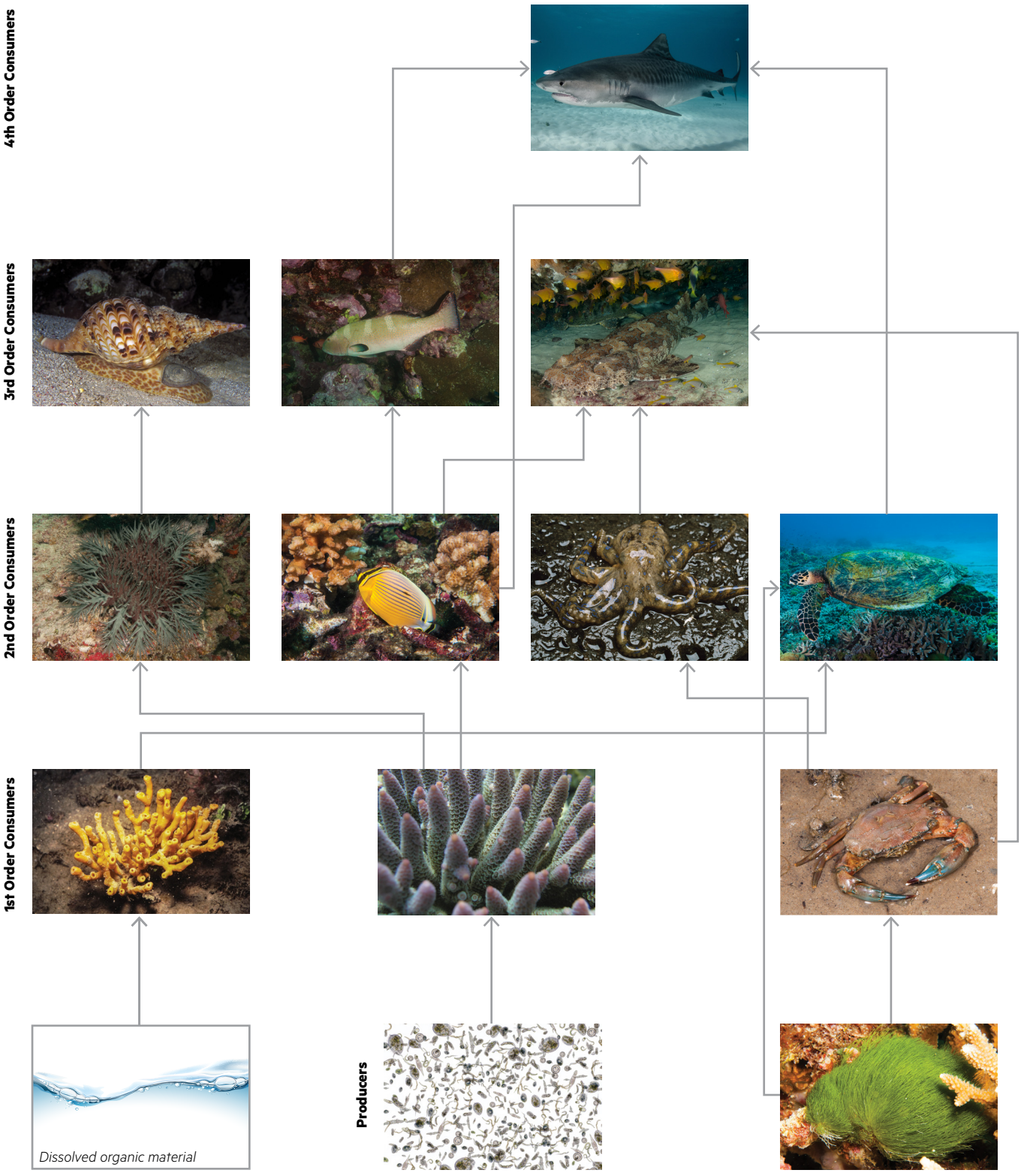
Science Understanding

Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (ACSSU176)

Science Inquiry Skills

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)

Snapshot of Marine Ecosystem



Marine Food Web

Student Activity

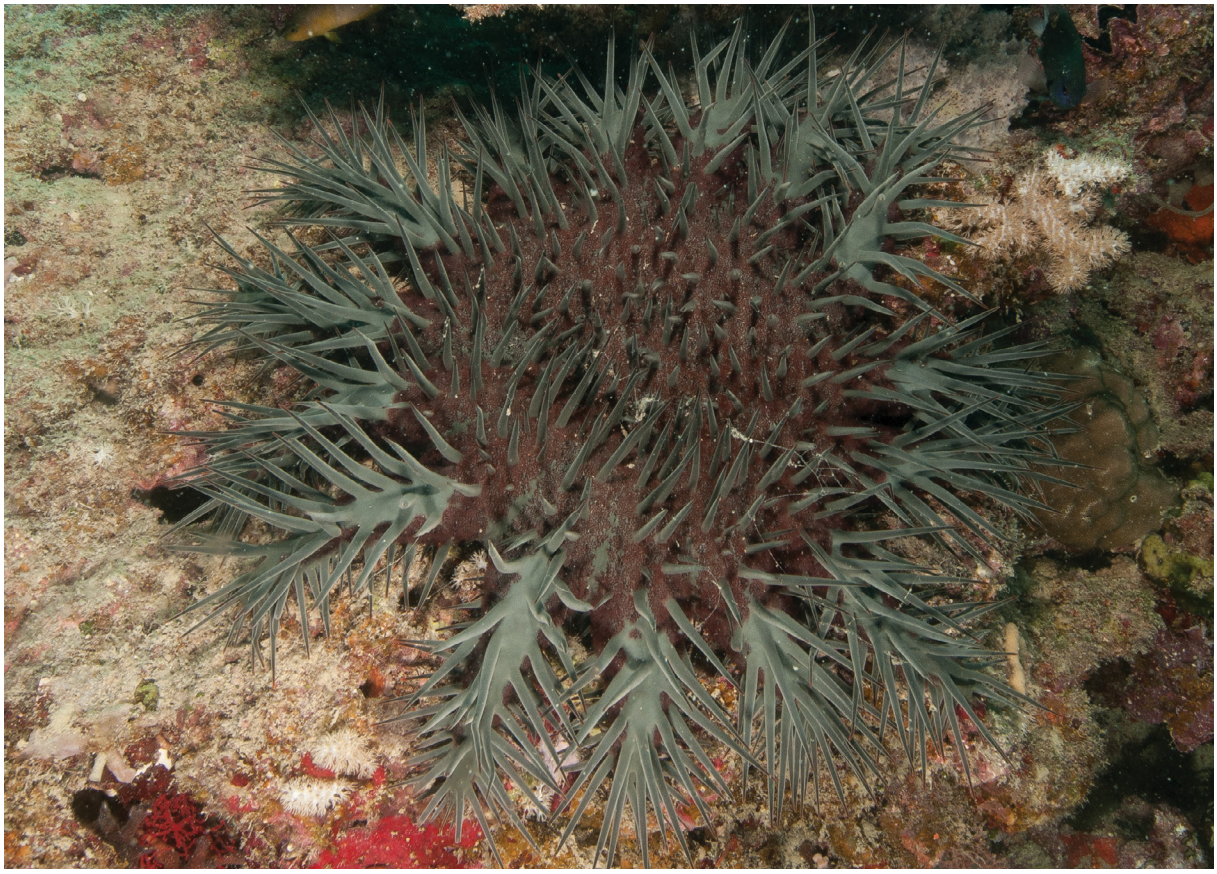
Use images of the marine ecosystem and the food web labels to create your own food web, and show the interactions between organisms in a marine ecosystem.

Labels for the Marine Food Web

Producers
1st Order Consumers
2nd Order Consumers
3rd Order Consumers
3rd Order Consumers
4th Order Consumers

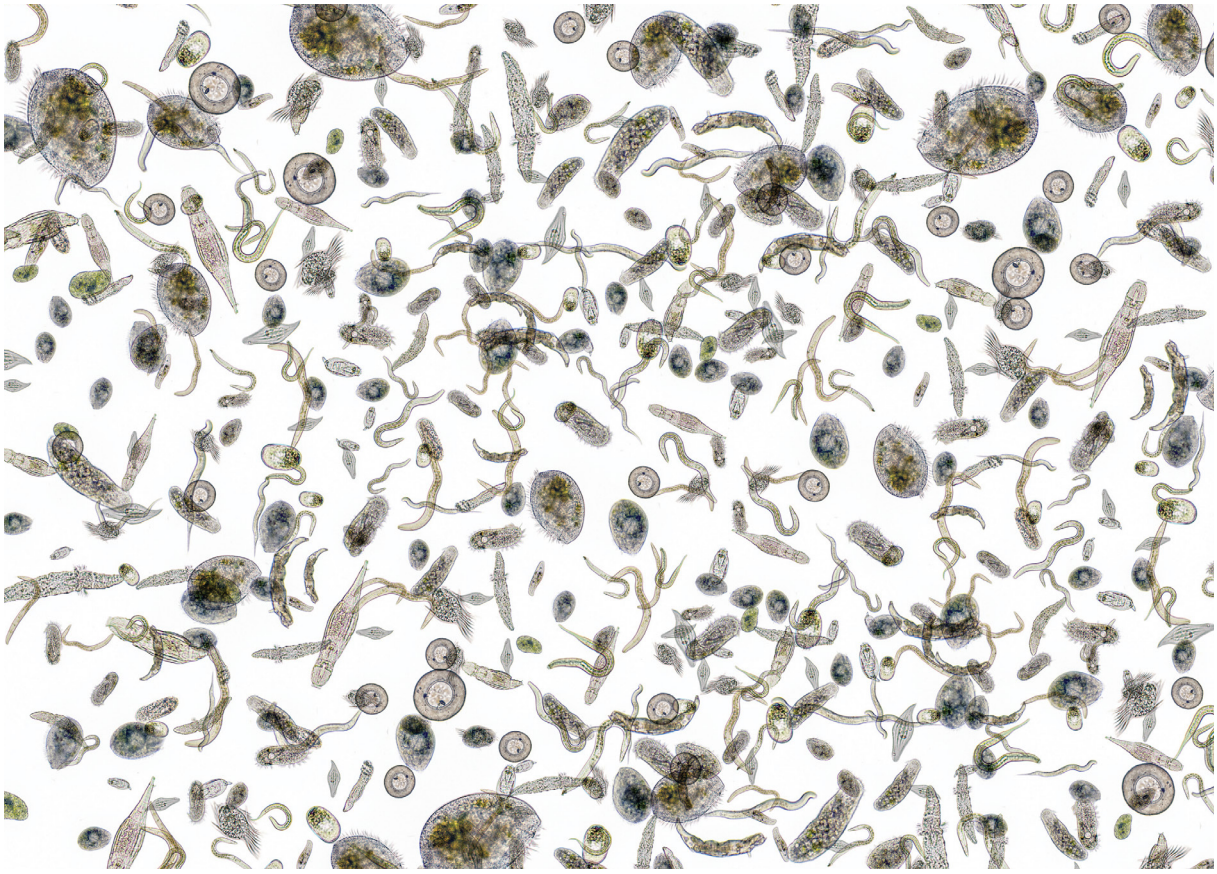
Pinstripe Butterflyfish, Chaetodon lunalatus. QM, Gary Cranitch

Bluespotted Coral Trout, Plectropomus laevis. QM, Gary Cranitch



Crown-of-thorns Sea Star, Acanthaster planci. QM, Gary Cranitch

Hawksbill Turtle, Eretmochelys imbricata. QM, Gary Cranitch



Phytoplankton.

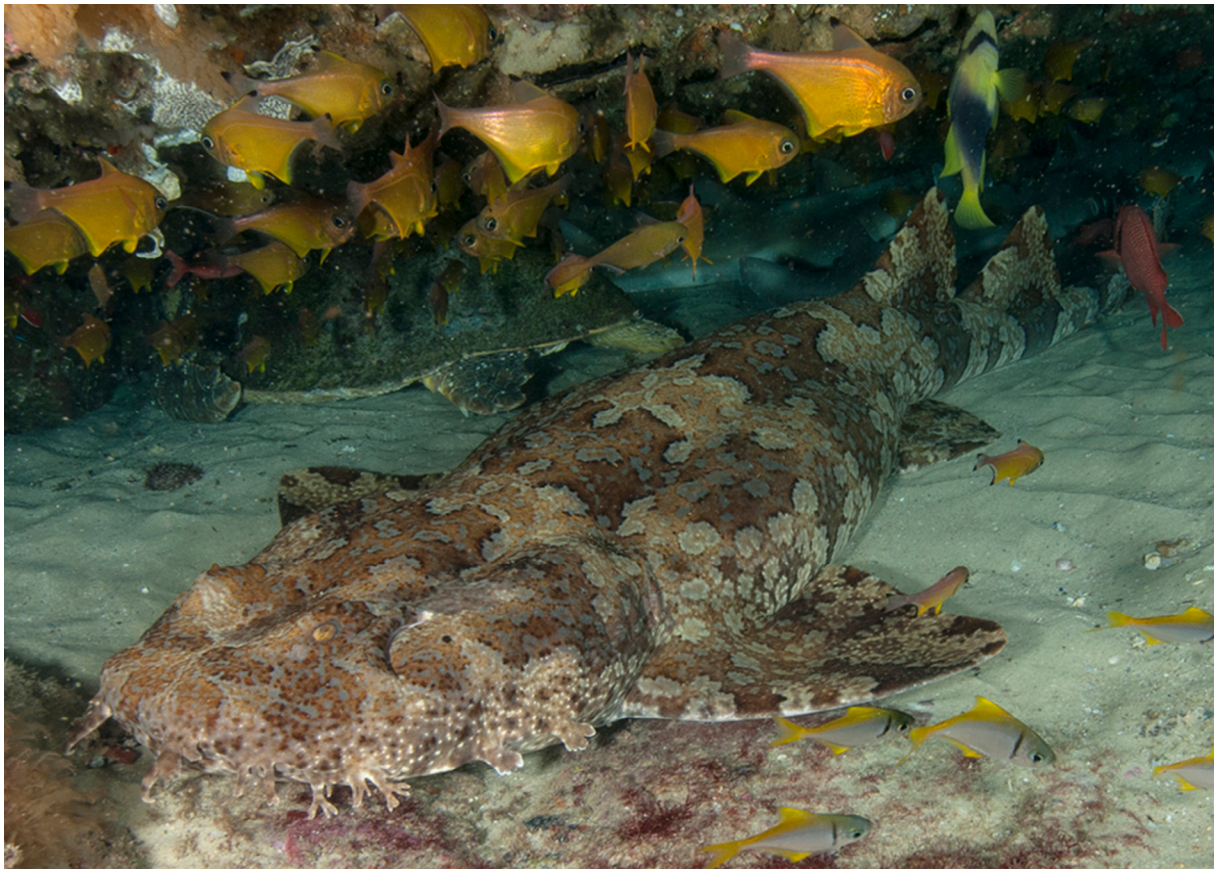
Blue-lined Octopus, Hapalochlaena fasciata. QM, Gary Cranitch

Bob Marley Sponge, Pipestela candelabra. QM, John Hooper

Crenate Swimmer Crab, Thalamita crenata. QM, Gary Cranitch

Tiger Shark, Galeocerdo cuvier.

Turtle Weed, Chlorodesmis major. QM, Gary Cranitch



Spotted Wobbegong, Orectolobus maculatus. QM, Gary Cranitch

Giant Triton, Charonia tritonis.

Healthy Coral, QM.

Dissolved organic material.

EXPLORE

Citizens of the Sea: Community of Inquiry

Teacher Resource

In this activity, students participate in a community of inquiry to discuss their connection to the marine environment. The community of inquiry provides students with an opportunity to reach a deep, shared understanding of the concepts and issues underpinning the inquiry topic. The community of inquiry may be used as an introduction to the *Making Connections: Object and Article Analysis* activity or anywhere throughout the unit.

The community of inquiry is a process of discussion where participants pose open-ended questions, listen to the viewpoints of others and share their own ideas. Disputed or contestable issues and concepts are considered collaboratively within a supportive and respectful learning environment. It is important that all participants reflect on their thinking.

The following ways of working are used during the community of inquiry process. These should be put up on a wall for all students to refer to throughout the process:

- Listen attentively to others
- Build upon and connect ideas
- Have respect for others, yourself and place
- Disagree reasonably and respectfully
- Many responses and opinions may be considered to be correct

Detailed step-by-step instructions for this activity can be seen below.

1. Show students the quote from Dr Ian Poiner, Chairperson of the Great Barrier Reef Marine Park Authority, **'We are all citizens of the sea'**.
2. In small groups, ask students to discuss the overarching question: **What could this quote mean?** Remind students to give reasons for their answers.
3. Ask students to share their responses to these questions which can be recorded on a whiteboard or butchers paper.
4. Define the word 'citizen' with your students, then pose the following question: **Being a citizen implies rights and responsibilities, whether you are a citizen of the world, your country, your state, your community or your family. If we are citizens of the sea, what rights and responsibilities might we owe this place?** Students should again discuss in small groups.
5. Ask students to share their responses to this question, and record their answers on a whiteboard or butchers paper. Record any questions posed by students on a separate page. These can be addressed in the future.
6. Keep a record of students' responses to display around the room. These can be referred and added to throughout the unit.

Curriculum Links

Science

YEAR 5

Science as a Human Endeavour

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE083)

Science Inquiry Skills

Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS093)

YEAR 6

Science as a Human Endeavour

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

Science Inquiry Skills

Communicate ideas, explanations and processes using scientific representations in a variety of ways, including multi-modal texts (ACSIS110)

YEAR 7

Science as a Human Endeavour

Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE120)

Science Inquiry Skills

Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS133)

YEAR 8

Science as a Human Endeavour

Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE135)

Science Inquiry Skills

Communicate ideas, findings and evidence based solutions to problems using scientific language, and representations, using digital technologies as appropriate (ACSIS148)

YEAR 9

Science as a Human Endeavour

Values and needs of contemporary society can influence the focus of scientific research (ACSHE228)

Science Inquiry Skills

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)

Humanities and Social Sciences

YEAR 5

Knowledge and Understanding: Geography

The influence of people, including Aboriginal and Torres Strait Islander Peoples, on the environmental characteristics of Australian places (ACHASSK112)

The environmental and human influences on the location and characteristics of a place and the management of spaces within them (ACHASSK113)

Geography

YEAR 10

Geographical Knowledge and Understanding

Human-induced environmental changes that challenge sustainability (ACHGK070)

Environmental world views of people and their implications for environmental management (ACHGK071)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Critical and Creative Thinking

Inquiring: Identifying, exploring and organising information and ideas

Reflecting on thinking and processes

Personal and Social Capability

Self-management

Social awareness

Ethical Understanding

Understanding ethical concepts and issues

Reasoning in decision making and actions

Exploring values, rights and responsibilities

Intercultural Understanding

Interacting and empathising with others

Cross-Curriculum Priorities

Sustainability

Sustainable patterns of living rely on the interdependence of healthy social, economic and ecological systems. (OI.3)

World views are formed by experiences at personal, local, national and global levels, and are linked to individual and community actions for sustainability. (OI.5)

Actions for a more sustainable future reflect values of care, respect and responsibility, and require us to explore and understand environments. (OI.7)

Designing action for sustainability requires an evaluation of past practices, the assessment of scientific and technological developments, and balanced judgements based on projected future economic, social and environmental impacts. (OI.8)

ELABORATE

Making Connections: Object and Article Analysis

Teacher Resource

Students explore how humans impact the marine ecosystem by completing an object analysis. The objects have all been found in and around the marine ecosystem. Question cards are supplied to prompt student discussion.

Once students have completed their object analysis, they analyse a media article. During their analysis, students are encouraged to identify how the article connects to their object and previously explored specimen. They are also encouraged to explain how all articles are connected and build on the marine ecosystems narrative explored in the workshop.

Articles could be chosen to challenge student assumptions, and/or to show the positive changes science and technology can have on the environment. To build on this activity the class could also investigate media bias, and how to source credible, accurate and reliable information.

Some articles you could choose from include:

- Why is land clearing bad news for the Great Barrier Reef?
- This sixth-grade inventor built a robot to hunt ocean plastic
- Most plastic on our beaches could have come from anywhere. But not the Durban nurdle
- Losing Nemo? Wider effects of mass Great Barrier Reef bleaching emerge
- Australian beaches covered with rubbish from lost sea cargo
- This Irish teenager may have a solution for a plastic-free ocean

This activity could follow on from the *Citizens of the Sea: Community of Inquiry*. If students have completed the community of inquiry, you may wish to add an additional final question related to the quote, 'We are all citizens of the sea' by Dr Ian Poiner. Questions include:

- *Object Analysis*: How is this object connected to Dr Ian Poiner's quote?
- *Object and Article Connections*: What story does the article, object and quote tell together?

Curriculum Links

Science

YEAR 5

Science as a Human Endeavour

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE083)

YEAR 6

Science as a Human Endeavour

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

YEAR 7

Science Understanding

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

Science as a Human Endeavour

Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE120)

People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity (ACSHE121)

YEAR 8

Science as a Human Endeavour

Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE135)

People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity (ACSHE136)

YEAR 9

Science Understanding

Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (ACSSU176)

Science as a Human Endeavour

People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities (ACSHE160)

Values and needs of contemporary society can influence the focus of scientific research (ACSHE228)

Humanities and Social Sciences

YEAR 5

Knowledge and Understanding: Geography

The influence of people, including Aboriginal and Torres Strait Islander Peoples, on the environmental characteristics of Australian places (ACHASSK112)

The environmental and human influences on the location and characteristics of a place and the management of spaces within them (ACHASSK113)

Geography

YEAR 10

Geographical Knowledge and Understanding

Human-induced environmental changes that challenge sustainability (ACHGK070)

Environmental world views of people and their implications for environmental management (ACHGK071)

General Capabilities

Literacy

Comprehending texts through listening, reading and viewing

Text knowledge

Word knowledge

Critical and Creative Thinking

Inquiring: Identifying, exploring and organising information and ideas

Reflecting on thinking and processes

Making Connections: Object and Article Analysis

Student Activity

Object Analysis: Question Cards

1. Look at the object. What do you think it is?
2. What story could this object tell us?
3. How is this object connected to the marine environment?
4. How is this object connected to you?

Article Analysis

Prediction

Examine the source, date, headline and images. Write three questions you expect to be answered in the article.

First Reading

Underline any words you are unsure about. Use content clues, a dictionary or a group discussion to identify the meaning of these words. Write in replacement words for your underlined words.

Second Reading

Answer the following questions about the article:

1. Summarise the article in the 66 word grid below.

2. Why was the article written?

3. How does this article make you feel?

4. Return to your original three questions. Were they answered in the article?
   If not, how come? How could you find the answers to these questions?

Making Connections: Relationship between an Object and Article

1. How does your object connect to the article?
2. Has the article changed the story of your object?
3. What story do the article and object tell together?
4. What actions could be taken to change this story?

EVALUATE

Analysing Human Impacts

Teacher Resource

Students investigate the effect of human activity on the marine ecosystem in more detail. Topics could include the effect of litter, deforestation, sea level rise, tourism, climate change or ocean acidification.

Students choose a topic and then analyse the impact of the human activity on individual organisms and the whole ecosystem. They then discuss what is being done to minimise the impact on the ecosystem, and what more could be done. It can be valuable to pass the placemats around so that all groups can contribute to building a comprehensive summary. Groups can then share their results with the class.

Curriculum Links

Science

YEAR 5

Science as a Human Endeavour

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE083)

YEAR 6

Science as a Human Endeavour

Scientific knowledge is used to solve problems and inform personal and community decisions (ACSHE100)

YEAR 7

Science Understanding

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

Science as a Human Endeavour

Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE120)

People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity (ACSHE121)

YEAR 8

Science as a Human Endeavour

Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE135)

People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity (ACSHE136)

YEAR 9

Science Understanding

Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (ACSSU176)

Science as a Human Endeavour

People use scientific knowledge to evaluate whether they accept claims, explanations or predictions, and advances in science can affect people's lives, including generating new career opportunities (ACSHE160)

Values and needs of contemporary society can influence the focus of scientific research (ACSHE228)

General Capabilities

Literacy

Composing texts through speaking, writing and creating

Critical and Creative Thinking

Inquiring: Identifying, exploring and organising information and ideas

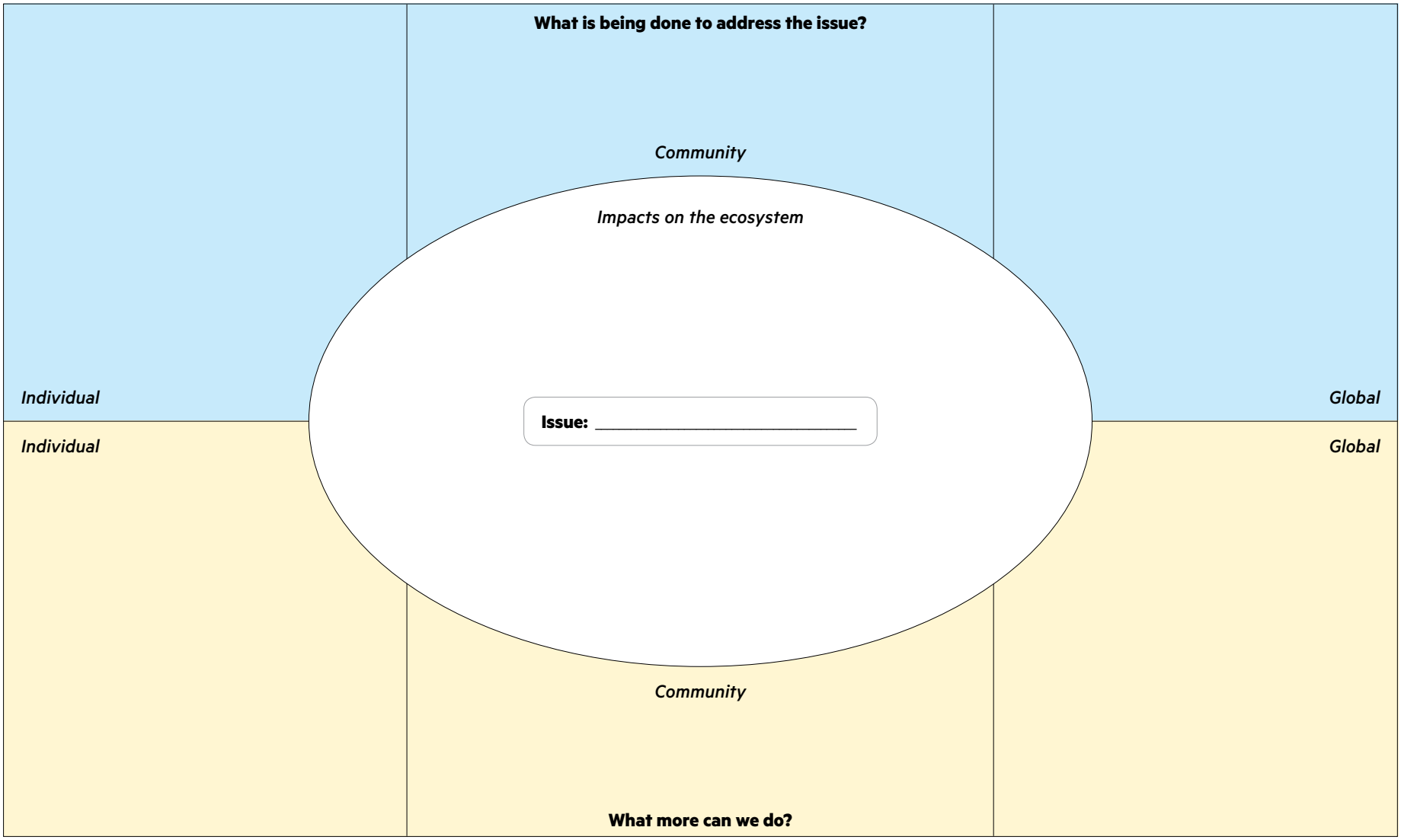
Generating ideas, possibilities and actions

Reflecting on thinking and processes

Analysing, synthesising and evaluating reasoning and procedures

Analysing Human Impacts

Student Activity



ENGAGE

Introducing Dr Paul Muir

Teacher Resource

Scientists are regular people, like you and me, who have questions that they want to answer. Many of these scientists work at Queensland Museum. In this activity, students watch a video featuring Dr Paul Muir as he explains the coral reef ecosystem and what he loves about his job as a marine biologist with Queensland Museum.

This STEM Video: Marine Ecosystems, Dr Paul Muir can be accessed at Queensland Museum Network Learning Resources. You may then facilitate a discussion around what students found most interesting in the video, as well as what they learnt and what they would like to know more about. Students could also complete a literacy activity, where they write a journal entry based on a day in the life of a marine biologist.

Dr Paul Muir is a marine biologist investigating coral reef biology.

Curriculum Links

Science

YEAR 7

Science as a Human Endeavour

People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity (ACSHE121)

YEAR 8

Science as a Human Endeavour

People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity (ACSHE136)

YEAR 9

Science Understanding

Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (ACSSU176)

Science as a Human Endeavour

Values and needs of contemporary society can influence the focus of scientific research (ACSHE228)

Investigating Ocean Acidification: We Are Scientists

Teacher Resource

In these activities, students investigate the impacts of carbon dioxide on the marine environment. For any experiment, it is important to complete a thorough risk assessment and wear appropriate protective equipment.

How does CO_2 affect water?

The air we exhale is 4-5% carbon dioxide. In this experiment, students use universal indicator, water, a straw and their breath to investigate the effect of carbon dioxide on water.

Part 2 of this investigation is a teacher demonstration. During the demonstration, a piece of dry ice is dropped into water with universal indicator and everyone watches what happens! Throughout this experiment, students should make predictions and observations. The similarities and differences between this experiment and the acidification of our oceans can also be discussed.

Remember to follow your school policy on the use of dry ice and complete a risk assessment. Safety glasses and gloves should be worn at all times during the demonstration.

How does acid affect organisms with calcium carbonate shells?

Students compare the effect of water and acid on calcium carbonate. Marine molluscs such as bivalves and gastropods have shells made of calcium carbonate and coral has a calcium carbonate skeleton. How might ocean acidification affect these organisms?

Which shelled organisms will be most affected by a change in pH?

Marine molluscs range from tiny pteropods only a few millimetres in length, to giant clams which can weight hundreds of kilograms. Will ocean acidification have the same impact on molluscs of different sizes? Students discuss what the results of this experiment could mean for marine ecosystems.

Student investigation: Effect of ocean acidification on calcium carbonate

Many marine organisms have shells or exoskeletons made of calcium carbonate ($CaCO_3$), including oysters, clams, sea snails and coral. In this activity, students investigate how ocean acidification may affect these organisms. Students develop and conduct an experiment to test the effect of acid on calcium carbonate and then analyse the results in a scientific report. To increase similarities between the model and the real world, carbonic acid/carbonated water could be used for this investigation.

Curriculum Links

Science

YEAR 9

Science Understanding

Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (ACSSU176)

Chemical reactions involve rearranging atoms to form new substances; during a chemical reaction mass is not created or destroyed (ACSSU178)

Chemical reactions, including combustion and the reactions of acids, are important in both non-living and living systems and involve energy transfer (ACSSU179)

Science Inquiry Skills

Formulate questions or hypotheses that can be investigated scientifically (ACSIS164)

Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (ACSIS165)

Select and use appropriate equipment, including digital technologies, to collect and record data systematically and accurately (ACSIS166)

Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies (ACSIS169)

Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS170)

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data (ACSIS171)

Critically analyse the validity of information in primary and secondary sources and evaluate the approaches used to solve problems (ACSIS172)

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174))

YEAR 10

Science Understanding

Global systems, including the carbon cycle, rely on interactions involving the biosphere, lithosphere, hydrosphere and atmosphere (ACSSU189)

Different types of chemical reactions are used to produce a range of products and can occur at different rates (ACSSU187)

Science Inquiry Skills

Formulate questions or hypotheses that can be investigated scientifically (ACSIS198)

Plan, select and use appropriate investigation types, including field work and laboratory experimentation, to collect reliable data; assess risk and address ethical issues associated with these methods (ACSIS199)

Select and use appropriate equipment, including digital technologies, to collect and record data systematically and accurately (ACSIS200)

Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies (ACSIS203)

Use knowledge of scientific concepts to draw conclusions that are consistent with evidence (ACSIS204)

Evaluate conclusions, including identifying sources of uncertainty and possible alternative explanations, and describe specific ways to improve the quality of the data (ACSIS205)

Critically analyse the validity of information in primary and secondary sources and evaluate the approaches used to solve problems (ACSIS206)

Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS208))

Investigating Ocean Acidification: We Are Scientists

Student Activity

Have you ever encountered a problem you had to investigate or research to solve? Then you are a scientist! Scientists investigate the world around us to learn more. In these activities you are scientists investigating the impacts of carbon dioxide on the marine environment.

How does CO_2 affect water?

Aim

To investigate how carbon dioxide affects the pH of water.

PART 1: Student Investigation

Materials

Universal indicator

Water

500 mL conical flask

One-way straw

Method

1. Make a prediction: What will happen when you blow carbon dioxide into water?
2. Add 2 mL of indicator and 250 mL of water to the beaker.
3. Submerge the straw in the solution and blow air through the straw for 2 minutes. (When you need to take a breath, remove your mouth from the straw and breathe normally, do not inhale through the straw).
4. Describe your observations. Did anything change? Why?

Results

How did the pH of your solution change?

Approximately how many times more acidic did your solution become? Explain the results (remember pH is a logarithmic scale - see pH scale diagram).

PART 2: Teacher Demonstration (optional)

Materials

Universal indicator

Water

1 L measuring cylinder

Dry ice

Gloves

Method

1. Make a prediction: What will happen when dry ice is added to water?
2. Add 9 mL of universal indicator to the measuring cylinder and pour in 600 mL of warm water.
3. Using gloves, drop a small handful of dry ice into the measuring cylinder.
4. Describe your observations. Did anything change? Why?

Results

Explain the results and describe the change in pH of your solution.

Approximately how many times more acidic did your solution become?

Questions

1. How does CO_2 affect water?

2. Why are our oceans becoming more acidic?

3. Explain the similarities and differences between this experiment and the real world.

4. How could this model be improved to better represent the ocean acidification in the natural environment?

Further Investigations

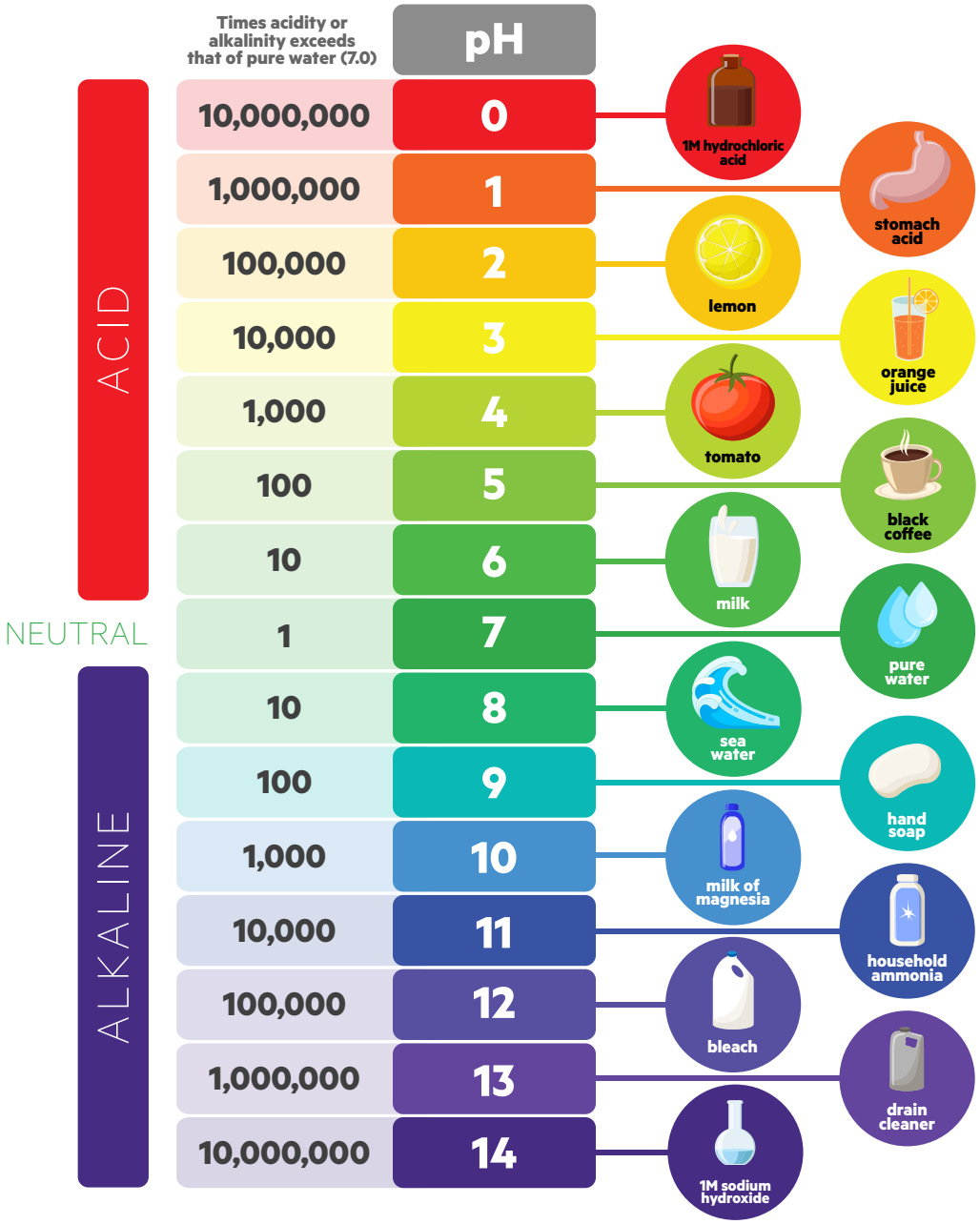
- Try comparing fresh water with sea water. Fill one beaker with 100 mL of fresh water and one with 100 mL of sea water. Add 5 drops of universal indicator and gently blow bubbles into each beaker for 2 minutes. Observe differences in pH and explain your results. (If sea water is not available, a substitute can be made by dissolving 30 g of common salt (sodium chloride) in 1 L of water.)
- Design an experiment to investigate the pH change in exhaled breath before and after exercise. Remember to keep your experiment fair by controlling the variables. You should write a justified hypothesis before you conduct the experiment. This activity links to the human body and homeostasis.

Identifying the pH of a solution

The pH of a solution tells us how acidic or alkaline (basic) a substance is. The acidity depends on the concentration of hydrogen ions, written as [H+]. The greater the hydrogen ion concentration, the more acidic the solution (and the lower the pH).

The pH scale is a 'logarithmic' scale (similar to the Richter scale for earthquakes). This means that every drop in pH value is 10 times more acidic than the value above: a pH of 6 is TEN TIMES more acidic than a pH of 7 (if this is converted to a percentage it would be 1000% more acidic)!

Since the industrial revolution, the pH of the oceans is estimated to have decreased from 8.2 to 8.11. This may not seem like much, but because pH is logarithmic this accounts for a 25 to 30% increase in acidity!



How does acid affect organisms with calcium carbonate shells?

Aim

To investigate the effect of acid concentration on calcium carbonate.

Materials

3 x 50 mL beakers

Calcium carbonate chips

Water

0.1 M hydrochloric acid

0.5 M hydrochloric acid

Method

1. Make a prediction: How will different acid concentrations affect the calcium carbonate?
2. Pour 40 mL of water into beaker A, 40 mL of 0.1 M hydrochloric acid into beaker B, and 40 mL of 0.5 M of hydrochloric acid into beaker C.
3. Pour approximately ¼ tsp of calcium carbonate chips to each beaker at the same time.
4. Describe your observations.

Results

Describe and explain the results.

When an acid and carbonate are combined they react to form a salt, carbon dioxide and water. This can be written as: **acid + carbonate → salt + carbon dioxide + water**

More specifically, hydrochloric acid and calcium carbonate form calcium chloride, carbon dioxide and water: **hydrochloric acid + calcium carbonate → calcium chloride + carbon dioxide + water**

Questions

1. Complete the balanced chemical equation for this reaction.

$2HCl + CaCO_3 \rightarrow$ [ ] + [ ] + [ ]

2. What could this mean for marine organisms with calcium carbonate shells and corals with calcium carbonate skeletons?

3. How might this affect the marine ecosystem?

4. How could this experiment be modified to collect quantitative data? Write a method for this experiment.

5. How could this experiment be improved to better model the real world?

Which shelled organisms will be most affected by a change in pH?

Aim

To investigate how surface area of calcium carbonate affects the rate of reaction with hydrochloric acid.

Materials

0.1 M hydrochloric acid

Calcium carbonate powder

Calcium carbonate chips

4 x 50 mL beakers

Electronic scale

Method

1. Make a prediction: How will surface area affect rate reaction?
2. Pour 40 mL of hydrochloric acid into a small beaker and place on a scale.
3. Place another empty, dry beaker on the same scale with the hydrochloric acid beaker and tare the scale.
4. Add 0.75 g of calcium carbonate power to the dry beaker.
5. Record the starting mass of the scale (this should be 0.75 g).
6. Pour calcium carbonate into the hydrochloric acid and place the empty beaker back on the scale.
7. Measure the mass every 30 seconds for 2 minutes and record in a table.
8. Repeat the experiment with calcium carbonate chips.
9. Graph the results (remember the dependent variable – mass – should be on the y-axis).

Results

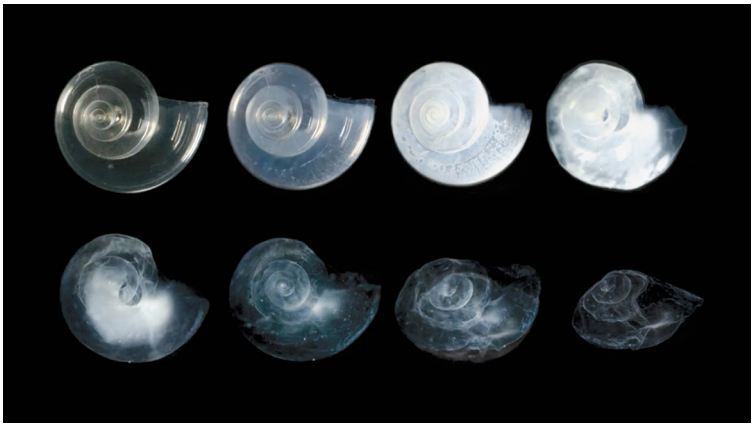
Explain the results.

Questions

1. Based on these results, are smaller shelled organisms or larger shelled organisms likely to be more affected by ocean acidification?

2. What could this mean for the marine ecosystem?

3. How could changes in the pH of the ocean affect people?



Student Investigation: Effect of ocean acidification on calcium carbonate

Today you are a scientist working at Queensland Museum. Your task is to investigate the effect of ocean acidity on shelled marine organisms by examining how an acid affects their calcium carbonate shells.

Aim

To investigate the effect of acid on calcium carbonate. Design and conduct an experiment, and present the findings as a scientific report.

Materials

Suggested materials for investigation:

- Calcium carbonate ($CaCO_3$)
- Digital scales
- Carbonated water
- Stopwatch
- 50 mL measuring cylinder
- Spatula
- Test tubes
- Test tube rack
- Deionised water
- Universal indicator or pH probe
- Acid

Method

1. Design an experiment to answer the research question 'How does acid affect calcium carbonate?'
2. Write a scientific report. Use the scaffold on the next page for guidance. The report should be written in third person, using past tense. Remember to change only one variable; this is the independent variable.

Structure of a Scientific Report

Today you are a scientist working at Queensland Museum. Your task is to investigate the effect of ocean acidity on shelled marine organisms by examining how an acid affects their calcium carbonate shells.

1. **Aim:** State the purpose of the investigation.
2. **Introduction:** Give background information on the topic being investigated, and explain the purpose of the experiment and how it will be conducted.
3. **Hypothesis:** Write an educated prediction as to the outcome of the experiment. This must incorporate the independent variable and the dependent variable. Remember to justify the hypothesis by giving reasons for why the particular prediction was made.
4. **Variables:** Include an independent variable (variable that is purposely changed), a dependent variable (variable that is measured), and at least five control variables (variables that are kept the same for a fair experiment).
5. **Materials:** List all equipment used in the experiment, include number and amounts e.g. 4 x 250 mL beakers.
6. **Method/Procedure:** List the steps taken to conduct the experiment. Remember, there should be enough detail for someone else to pick up the method and conduct the exact same experiment, and the method should be written in past tense.
7. **Risk Assessment:** What safety considerations must be made before, during and after this experiment? Include AT LEAST five hazards and how to minimise them.
8. **Results:** Include both qualitative observations and quantitative data. Record the results in a table. Use Microsoft Excel to graph the results, and briefly summarise the observations in a paragraph.
9. **Discussion:** Analysis of results and experimental design.
    - Describe what the results found. Include data in the analysis.
    - Explain if the results support or do not support (refute) the hypothesis.
    - How do the results compare with the information in the introduction?
    - Give possible reasons for why the results occurred. Include background knowledge, and an explanation for any inconsistent or unexpected results.
    - What problems were encountered and how could these be overcome in future investigations?
    - Evaluate the experiment and results:
        – Were the results fair? (Were all the control variables kept the same throughout the experiment?)
        – Were the results reliable? (Has the experiment been repeated many times with similar results?)
        – Were the results accurate? (Were the measurements precise?)
    - Suggest how the experiment could be improved in the future.
    - Explain future experiments that would be useful for collecting further information, and answering unknown questions.
    - Where is this experiment useful or important to real life?
10. **Conclusion:** Summarise the experiment and the results. Was the hypothesis supported or refuted?
11. **References:** List all sources in a consistent format and include in-text referencing in the introduction and discussion.

Appendix 1: Additional Resources

STEM Learning Resources

There are many more resources relevant to the marine environment that can be found online at Queensland Museum Network Learning Resources.

Coral Reef Ecosystems

Corals are the foundation of the coral reef ecosystem. These extraordinary animals acquire energy in two different ways: they can eat other organisms, and they can also capture energy from the sun. In this resource, students explore how surface area and volume affect the productivity of corals, and how energy flows through a coral reef ecosystem.

Introduction to Ocean Acidification

Atmospheric carbon dioxide levels are the highest they have been in human history, and possibly the last 20 million years. The continuing release of this gas into the atmosphere means that more carbon dioxide is being dissolved into the oceans. How does this affect ocean chemistry and marine ecosystems, and what can we do about it? In this resource, students conduct a simple experiment and complete a design challenge to learn more about carbon dioxide and the ocean.

Investigating Ocean Acidification

In this resource, students investigate how ocean acidification may affect shelled marine organisms. Using the materials listed, students develop and conduct an experiment to test the effect of carbonated water on calcium carbonate, and analyse the results in a scientific report.

Shell Classification

Learn about classification by taking a trip to the beach! In this resource, students use a dichotomous key to identify common Queensland seashells, and learn about the organisms that make shells.

Specialised Stinging Cells

Have you ever wondered why jellyfish have a powerful sting? In this resource, students learn about the amazing stinging cells of jellyfish. Students also view microscope images of a jellyfish tentacle, showing these cells magnified hundreds of times!

Queensland Museum Loans Kits

You can borrow kits and sets of museum specimens and artefacts from QM Loans to engage learners in your classroom. Examples of loans kits relevant to ecosystems include:

Coral Reef Habitat

Contains a variety of organisms that live within a coral reef ecosystem.

Great Barrier Reef

Investigate specimens and artefacts that live on and impact the Great Barrier Reef.

What's On the Menu

Explore the role of producers, consumers and decomposers in an ecosystem using a variety of specimens.

Wetlands

Investigate animals that live and survive within mangrove and swamp environments.

Queensland Museum Publications

The Great Barrier Reef: A Queensland Museum Discovery Guide

Investigate the complexity and beauty of the Great Barrier Reef, including its geology and geomorphology, biodiversity and human history.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