MARVELLOUS MANGROVES OF QUEENSLAND

A curriculum-based teachers' resource guide for Australia

Marvellous Mangroves Australia

A Wetlands Education Resource Book for Australia

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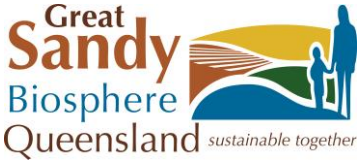

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CONTENTS

INTRODUCTION
MARVELLOUS MANGROVES OF QUEENSLAND

Welcome to the Marvellous Mangroves of Queensland – a guide for teachers that will provide a complete understanding of mangrove ecology, and support the conservation of the vitally important ecosystems provided by these remarkable trees.

This workbook is aimed mostly at students aged 8 to 13 (Grade 4-8), although the materials can be made more sophisticated for older grades. It has been designed for use outside the school with, for example environmental clubs or youth groups. The book is designed primarily to provide schoolteachers with a complete resource for conducting a Mangrove Education Unit in the classroom and the field. The book contains background on the types of mangroves found in Queensland, their ecology, and the many functions that they perform. The workbook also describes what's happening to the mangroves – how and why they are being degraded and lost, and the consequences of this loss for ecosystems and, ultimately, people. Finally, the workbook addresses mangrove conservation issues that are relevant to the islands, and provides students with ideas for projects to help conserve mangroves that they themselves can undertake in their own schools and communities. These activities should help the children to become more self-confident in their knowledge of mangrove ecosystems, and committed to taking part in actions that will help to conserve the world's diminishing mangroves.

Each section of the workbook contains a number of hands-on activities and exercises to illustrate and reinforce concepts that are described, and for experiential learning. Also included is information on the most common mangrove invertebrates, plants, birds and mammals, as well as a "how-to" section for conducting a field trip to a local mangrove swamp. It is important that classwork is followed by taking students into the field, as there is no substitute for experiencing the wonders of mangroves first hand.

In order to incorporate the information and activities in this workbook into the Australian science curriculum, just check the charts on page vii for learning objective tie-ins. Other parts of the workbook/curriculum cover knowledge and skills in geography, civics and citizenship, English and the arts.

HOW THIS BOOK CAME INTO BEING

Work began on this book in 1998 when writer/teacher Martin Keeley moved permanently to Cayman Brac. During the previous eight years, Mr. Keeley was intensively involved in the development and implementation of curriculum and teaching resources in British Columbia, Canada. The focus of these educational activities was wetlands – their importance as vital, yet little understood, ecosystems. Many of the resource materials in this workbook were adapted from hands-on activities that were included in two teachers' resource guides: Discover Boundary Bay (1993) and Exploring Estuaries and Wondrous Wetlands. The development and implementation of these workbooks was carried out by a team of educators under Mr. Keeley's direction in his position as executive director of the Friends of Boundary Bay.

Mr. Keeley, with initial funding from the Canadian International Development Research Centre and the Mangrove Action Project, began to adapt these resources for use in Cayman Islands schools. An initial month of teaching at Spot Bay Primary School on Cayman Brac was followed by summer school. The following fall, more of the materials were adapted for an ecology course that he developed for Year 7 through 10 at Cayman Brac High School. In the fall of 1999, he began working full-time with the Cayman Islands Department of Education to teach hands-on ecology to the three primary and one high school on Cayman Brac, with trips to Grand Cayman to work with primary school teachers there. This work has continued through to 2007, with annual trips to each of Grand Cayman primary schools sponsored since 2002 by the Caribbean Utilities Company Ltd. (CUC).
The final result of these teaching programmes is this workbook which was first published in 2000.

During the development and implementation of these resources, Mr. Keeley also worked on a similar, region-wide workbook, Wondrous Wetlands of the West Indies. This book was published by the West Indian Whistling Duck Working Group of the Society of Caribbean Ornithology in 2001 with a second edition in 2004. Through the international NGO, the Mangrove Action Project (MAP) – of which Mr. Keeley is Education Director – the book has been adapted and translated for use in Colombia (the San Andres/Old Providence Archipelago and Cartagena), Honduras, Guatemala, Sri Lanka, Brazil, China, Belize and Indonesia. This work was carried out in conjunction local non-governmental agencies, teachers, educators and scientists in each of these countries so that the contents could relate to specific flora and fauna as well as social and teaching conditions in each country.

The long-term goal of MAP is to introduce this mangrove curriculum to every country in the world that has mangroves. Many people helped in the production of this resource guide. They are all listed in the credits. They all believe, as does the author, that exploring the world around us is FUN–and that schools should incorporate hands-on learning as much as possible to reinforce what is learned from books.

HOW T0 USE THIS BOOK

This workbook is designed with Year 4 to 8 children in mind, but most of the activities can be modified for use with upper and lower years as well. The book is divided into five sections. Supplemental resources for areas such as species identification in the field are recommended throughout the book and in the Resources Section at the end, which contains a complete bibliography listing further resources as well as where to obtain them. Each section deals with a major topic relevant to Queensland mangroves and contains three kinds of material: one or more informational sections, activities and worksheets ready for students to use.

It is important to incorporate environmental studies with disciplines other than science (scientific topics are obviously comprehensively covered in this book) and the chart on page vii outlines the specific tie-ins with primary and lower secondary science curriculum. However, other disciplines are also included: Humanities and Social Sciences (Geography, History and Civics and Citizenship), Language Arts (English) including Drama and Written Arts) as well as Mathematics and Visual Arts.

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

Marvellous Mangroves of Queensland follows the same set of criteria by integrating several curriculum strands in each learning experience.

As an educator, you are the best judge of the abilities and interests of your students. Activities within this guide can be adapted or used in part to suit the needs of students at any age level. (To help with this, options for activities based on age level are offered throughout the book.) You can also choose activities from anywhere in the guide to meet your needs. These activities can be integrated into themes or topics that you are studying in class. The duration of each activity is show, but, again, this can be adapted to suit your own classroom needs and the learning skills of your students.

In the book, students are taken from the discovery of mangroves to awareness of environmental issues relevant to mangroves, and are encouraged to take individual or class action to positively affect the environment. To maximize comprehension of topic, it is recommended that the book be used as a unit, but activities can be used separately or to enhance other sections. The first two sections provide an in-depth look at what wetlands are, what lives in them, and how they work. Section 3 deals with what is happening to mangroves – primarily their destruction – and the final

two sections give students an understanding of how they can help change this situation by taking action and exploring mangroves in the field.

Because the book is based on the concept of implementing classroom learning in the field, a field trip is a must. This book gives teachers a complete guide to the “dos and don’ts” of running a field trip. It also supplies detailed instructions and the data collection work sheets that will be needed. Good luck, and please let us know if you have any suggestions for changing or adding to the material found in the book.

Martin A. Keeley, Cayman Brac, 1 August 2014.

CONTENTS SECTION 2

WHAT LIVES IN MANGROVES?

From a distance, mangroves don't look very interesting, and they often have a strong and unpleasant smell. Large areas seem to be covered by uniform vegetation, composed of just a few tree species and a few larger plants. What a contrast to tropical forests where a small patch of woodland contains hundreds of species of trees! Take a closer look and you will see that the wetlands are teeming with life—full of living things that are different in unexpected ways. In the mangrove world, trees have roots that breathe and look like legs, jellyfish swim upside down, barnacles feed with their feet, and crabs live in trees.

How Are Mangroves and Other Plants Adapted to Live in Wetland Conditions?

Growing in waterlogged soil poses special problems for plants.

- **Standing up:** The roots of wetland plants do not have much to hold onto because wetland soils are sloppy, so staying upright can be a problem. Mangroves have developed prop roots to help spread the load of the trunk over a broader area. Other trees, like the Yellow Mangrove, have buttresses. Some places are too wet to support trees and only grasses and herbs grow there.
- **Breathing:** Wetland soils are often black and smelly. This is because they are low in oxygen (or anoxic). Waterlogged soils are often anoxic because oxygen spreads more slowly through water than through air. This slows the decomposition of plant materials. The bacteria that live in anoxic conditions produce sulphur-rich compounds—and bad smells. To compensate for the lack of oxygen, wetland plants often have roots that grow above the sediment out into the air—called aerial roots or breathing roots, also called **pneumatophores.**

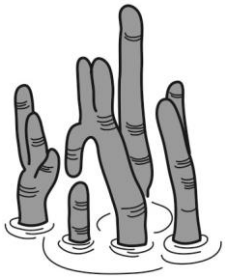


Figure 12: Aerial roots or pneumatophores

- **Getting rid of salt:** Some wetlands, like saltwater ponds, are even saltier than the sea. This occurs when water evaporates from the surface, leaving salt behind. Water or soil that is saltier than the sea is hyper-saline. Plant cells cannot function properly if they contain too much salt. Some plants, like Red Mangroves, try to prevent salt getting into their tissues. Others, like Grey Mangroves, can tolerate more salt than usual in their sap, and control the salt in their tissues by excreting it through specialized salt glands in their leaves.
- **Getting enough water**: It seems odd that plants growing in the sea should be short of water; but where the water is salty, fresh water can be hard to get. Plants that grow in salty water often have thick, waxy leaves (like Red Mangrove) that help to reduce water loss, or fleshy leaves (like Grey Mangroves) that can store water. These adaptations are also found in plants that live in dry places.

How Are Animals Adapted to Live in Mangroves?

Mangrove animals have to live, feed, and reproduce in a world dominated by mud and water, where the amount of water and mud is constantly changing. When the tide is high, tidal wetlands are flooded. When it goes out, water levels fall. Pools may be cool at night and close to boiling in the heat of the day. Pools that are governed primarily by rainfall may get very salty in times of drought, and then are suddenly flushed by fresh water after rain. Food is abundant, but it may be salty, indigestible, or in the form of small particles.

Animals need special **adaptations** to live and feed in this changeable world. For example, Fiddler Crabs have lots of legs to spread their weight over a larger surface area and keep them from sinking in, so they can move over the surface of the mud, gobbling up tasty morsels like Red Mangrove leaves that have washed up. When animals are not feeding, they need a safe place to hide—or they may become prey themselves. Fiddler Crabs, for instance, burrow into the mud.

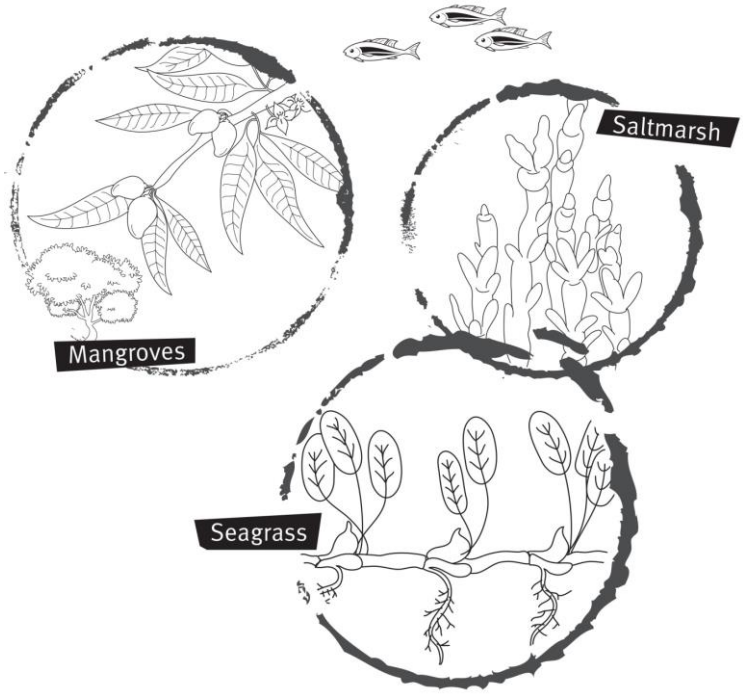
Using birds as an example, here are some mangrove wetland plant habitats and what they provide for various species.

- **Red Mangrove** roots provide perches for small herons to stand on and hunt from.
- **Salt marsh** provides cover for birds to hide in, and soft ground on which to nest.
- **Grey Mangrove** canopy provides roosting habitat for Terek Sandpipers and nesting habitat for Little Egrets and Lesser Noddys.
- **Samphire plants such as the succulent shrubs** provide low cover offering nesting habitats for terns and sandpipers.
- **Holes in trunks** of Grey Mangrove trees provide nesting habitat for Collared Kingfishers

Birds are adapted by their shapes to the areas in which they feed and nest. Long-legged herons, with their long, heavy bills, wade in deep water and hunt larger fish and occasionally crabs. Small herons like the Striated Heron have short legs but move very fast. These herons stand in the mangrove roots above the surface of the water and lean down to stab fish. The Little Egret, an intermediate-sized heron, wades in mid-level water. With its fine, sharp beak, it spears fish that are not hunted by the larger and smaller herons.

The Black-necked Stilt is adapted to wade in water and has a long, stiletto-like stabbing bill that can take insects like water boatmen off the surface of the water, or probe the soft mud. Different waders or shorebirds have different lengths of bill and leg, ensuring that they use different areas of the pond or foreshore, from the edge to mid-level, and different depths of mud. In this way, they do not compete with each other for the same food. The Ruddy Turnstone takes prey from under small stones and off the surface. Diving birds like the Collared Kingfisher and Whiskered Tern take their prey from the deeper parts of the water**.**

Adaptation allows many species to share the same wetland.



Roots and Root Dwellers

Roots are very useful to Red Mangrove trees, but they are equally useful to the hundreds of species of other plants and animals that make their homes on or near them. Once the Red Mangroves have started to grow in the mud, plants and animals settle on them. Red Mangrove roots host a fairyland of fantastic creatures and plants. Multi-coloured sponges (bright red, orange, yellow, or sky-blue), algae, corals of many shapes and colours, sea squirts (tunicates), fan worms, oysters, and sea anemones are just a few of the living things that crowd onto the roots. These creatures take advantage of the mangrove root surfaces to settle in places where there is nothing else to hold onto. Once there, they can feast on the detritus carried in by the tides, the decomposing leaves of the mangrove trees, and the other animals that seek shelter among the roots.

A mangrove root looks simple—but it is not. It is made up of several zones, the highest of which is almost always dry. The animals that live there (like monitors, crabs, and snails) do not like to be wet too often. The next zone is wet during high tides. Animals in this zone—barnacles and oysters, for example—have to feed when the tide is high and shut down tight when the tide is out. Below them, animals and plants are usually wet, but have plenty of light. Look for sea squirts in this zone. At the bottom, conditions are more stable. There is less light, but more food falling from the surface. Animals that feed by filtering food from the water, such as fan worms and sponges, are common in this zone. Some animals, like upside-down jellyfish (*Cassiopea andromeda*), just lie on the bottom of a pool with their feet up, waiting for food to fall on them.

The dense growth of roots protects animals and plants from waves and currents, and stops large predators from getting in. The currents carry the fry of many fish, prawns and crabs into the mangrove root ecosystem. There they hide, feed, and grow among the roots. These include the young of many favourite commercial species—Sea Mullet, Barramundi, Mud Crabs and many others.

Some creatures spend their whole lives in the water, while others move freely between the air and the water. Crabs and snails often live on the edge.

Figure 13: The mangroves are habitat for many different species

Table 2: How intertidal and saltwater animals meet their needs through adaptation

Need	Adaptation
To prevent themselves from drying out	Ability to hide under rocks or mud **(crab)** Ability to burrow in mud **(crabs and prawns)** Ability to hide in plant cover **(amphipods)** Ability to find tidal pools to stay in **(small fish)**
To prevent themselves getting washed away	Foot that acts like a suction cup to hold the animal in place **(gastropod snail)** Strong byssal threads to attach themselves to surfaces **(oyster)** Tube feet with suction cup that hold the surface **(sea stars)** Cement that attaches them permanently to a surface **(barnacles)**
To protect themselves from severe temperature changes	Hard outer shell to retreat into **(crab, hermit crab, oyster)** Ability to find tidal pools to stay in, shaded areas in the roots of the mangroves **(small fish)** Ability to hide beneath rocks, roots and leaf litter **(crabs)** Ability to stay buried in the sand or mud **(prawns)**
To protect themselves from predators	Ability to change colour to blend into its surroundings **(mangrove snapper)** Ability to retreat under rocks, branches or roots or into burrows **(fiddler crab and mud crabs)** Strong hard shell **(oyster)**
To obtain food	Ability to scrape or graze algae and detritus from mud and rocks **(snail)** Claws to rip flesh, leaves and detritus **(crabs)** Ability to sweep through water with their legs and filter plankton and other food materials from water **(barnacles)** Tongue (radula) that acts like a file to drill a hole through the shell of an oyster so the oyster can be digested **(carnivorous snails like whelks).**

What Eats What?

All the energy in the world comes from the sun. Mangrove leaves and the algae that grow on mangrove roots capture this energy by **photosynthesis**, converting it into leaves, trunks, and branches. This is called **primary production**. With plenty of sunshine, water and mineral resources, the mangroves can produce very efficiently; in fact, they are among the most productive ecosystems in the world. A healthy mangrove system produces one kilogram of litter per square meter per year. This litter consists of leaves, bark, twigs, flowers and seeds. What happens to this litter?

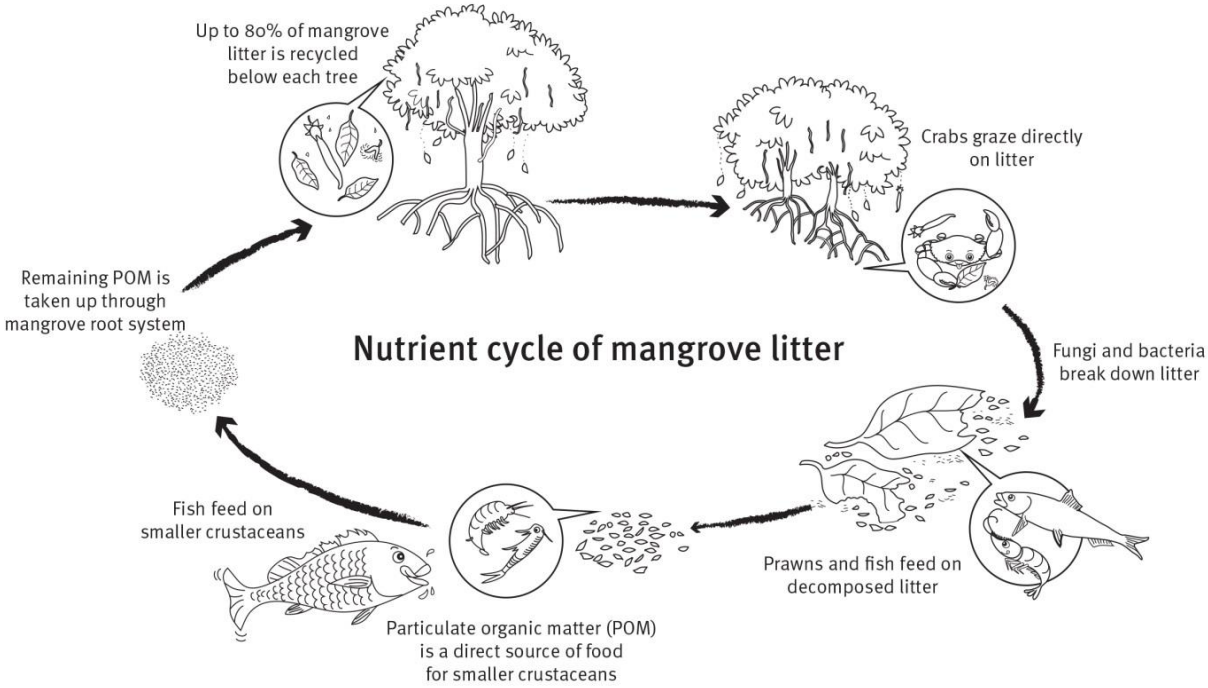


Figure 14: Nutrient cycling of mangrove leaf litter

Mangrove leaves are tough and few things eat them, but some crabs have developed a taste for them. Examine the leaves on a mangrove tree closely and you will probably see where they have been nibbled. The crabs are called **primary consumers**. Unlucky crabs are eaten by herons. The herons are **secondary consumers**, which eat primary consumers.

Take a look at a shallow pool in the Red Mangroves. It is likely to be lined with yellowing leaves—those that are not eaten on the tree fall into the water. They may look as if they are being wasted, but appearances are deceptive. As soon as a leaf enters the water, it is attacked by micro-organisms: bacteria and fungi. These are called **decomposers**. Look closer. Some leaves may have patches of bright pink. This is a fungus, busily breaking down the leaves. Take a leaf out of the water. It will probably feel slimy. This is due to the bacteria and fungi on its surface. Decomposers convert the cellulose of the leaves into proteins and simple sugars. When a leaf hits the water, it is about 3% protein. Microbial action converts a further 19% into protein—excellent food for the young fish, lobsters, and prawn that are growing up in the area.

As the fish and prawn feed and grow, they get too large for the narrow spaces between the roots. Soon they must venture out. There they may be eaten by bigger fish, such as Barramundi, that feed

in the channels and lagoons. These bigger fish, along with other animals and birds that eat primary and secondary consumers, are predators. Predators lurk in the canopy of the Red Mangrove trees or out in open water, ready to swoop down and feed on the unwary. Herons often skulk on roots near the water, ready to spear a fishy victim. Spiders, lizards and Mangrove Kingfisher's feast on the mosquitoes that breed in the water. Other birds like Pelicans roost and nest in the canopy, close to their open-water feeding grounds.

Much of the food produced in mangroves is washed away (or exported) by tides and currents, and provides food and nutrients for animals and plants along the coast.

Food Chains and Food Webs

Plants and animals in any given ecosystem or habitat are linked by their feeding relationships. Just like the mangrove swamp, every habitat creates decomposers: bacteria, fungi, and some insects that break down dead plant and animal matter (called **detritus**) into minerals and humus. The fertile soil that results enables producers—green plants—to grow, providing a food source for primary consumers—animals that eat plants and grasses, which are also called **herbivores**. (**Carnivores** eat other animals, and **omnivores**, like humans, eat both plants and animals.) These animals in turn provide a food source for predators—animals that eat consumers. **Predators** can be either secondary consumers, which eat only primary consumers, or tertiary consumers, which eat secondary consumers, or both. For example, the Heron eats crabs (primary consumers) as well as fish (secondary consumers), so the Heron is both a secondary and a tertiary consumer. This is called a food chain.

A food chain is one feeding cycle within a larger or more complex food chain called a food web. A food web begins with the process by which the sun's energy is captured and shared among living organisms. A simple mangrove food chain is shown in Figure 15 and a food pyramid in Figure 16.

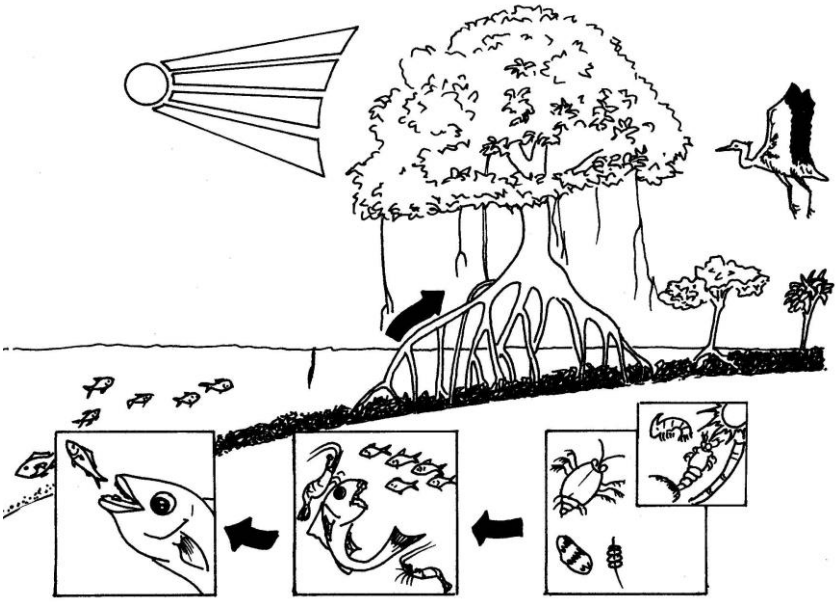


Figure 15: Mangrove Food Chain

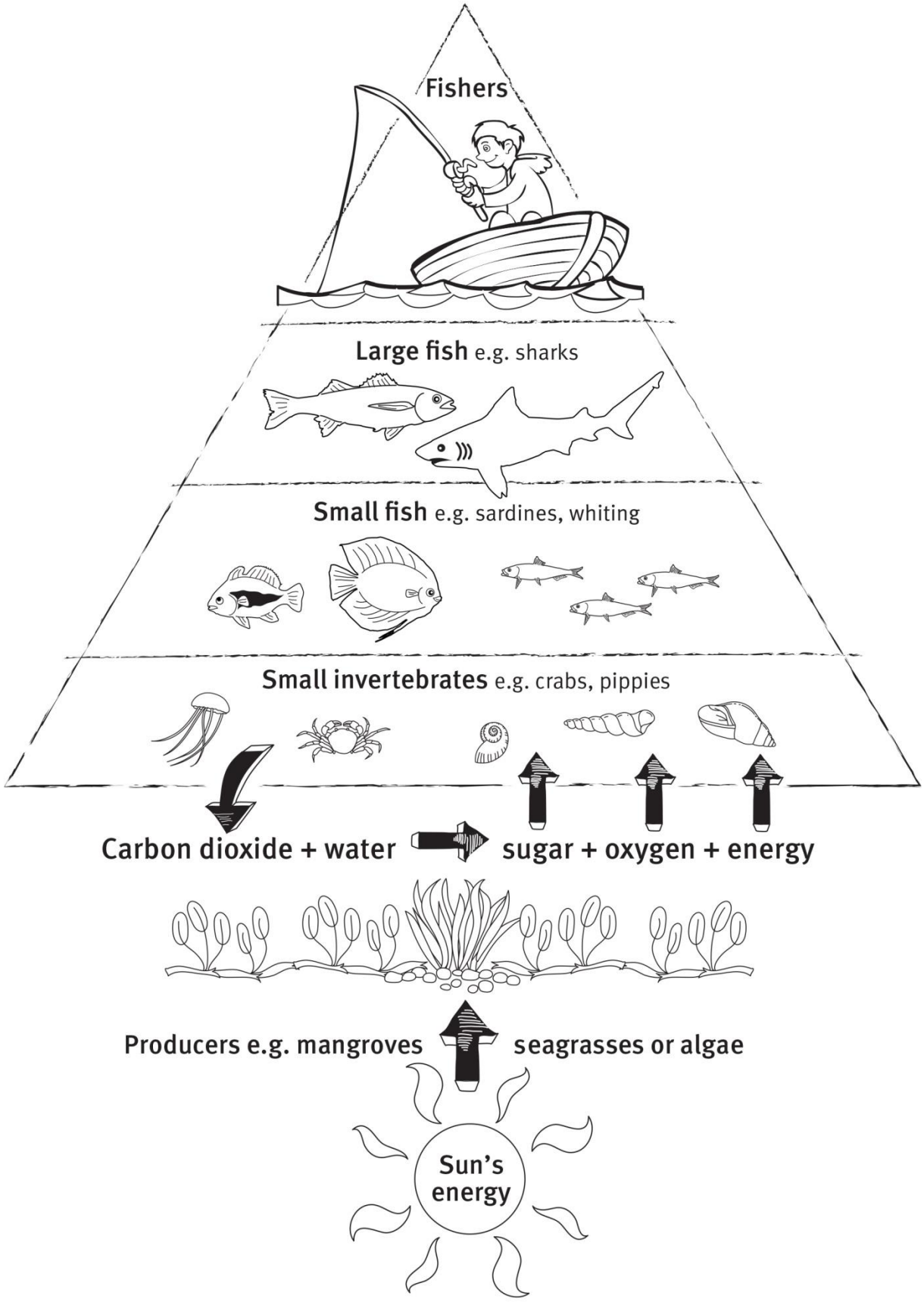


Figure 16: Mangrove Food Pyramid

Mangrove Habitat Study

• Name the plant and animal species.
• Create a food chain (simple) or food web (more complex)
• Is there a niche? Explain it.
• Does this habitat contain the four basic elements – food, water, shelter and space? (Explain and give examples.)
• What could harm this habitat?

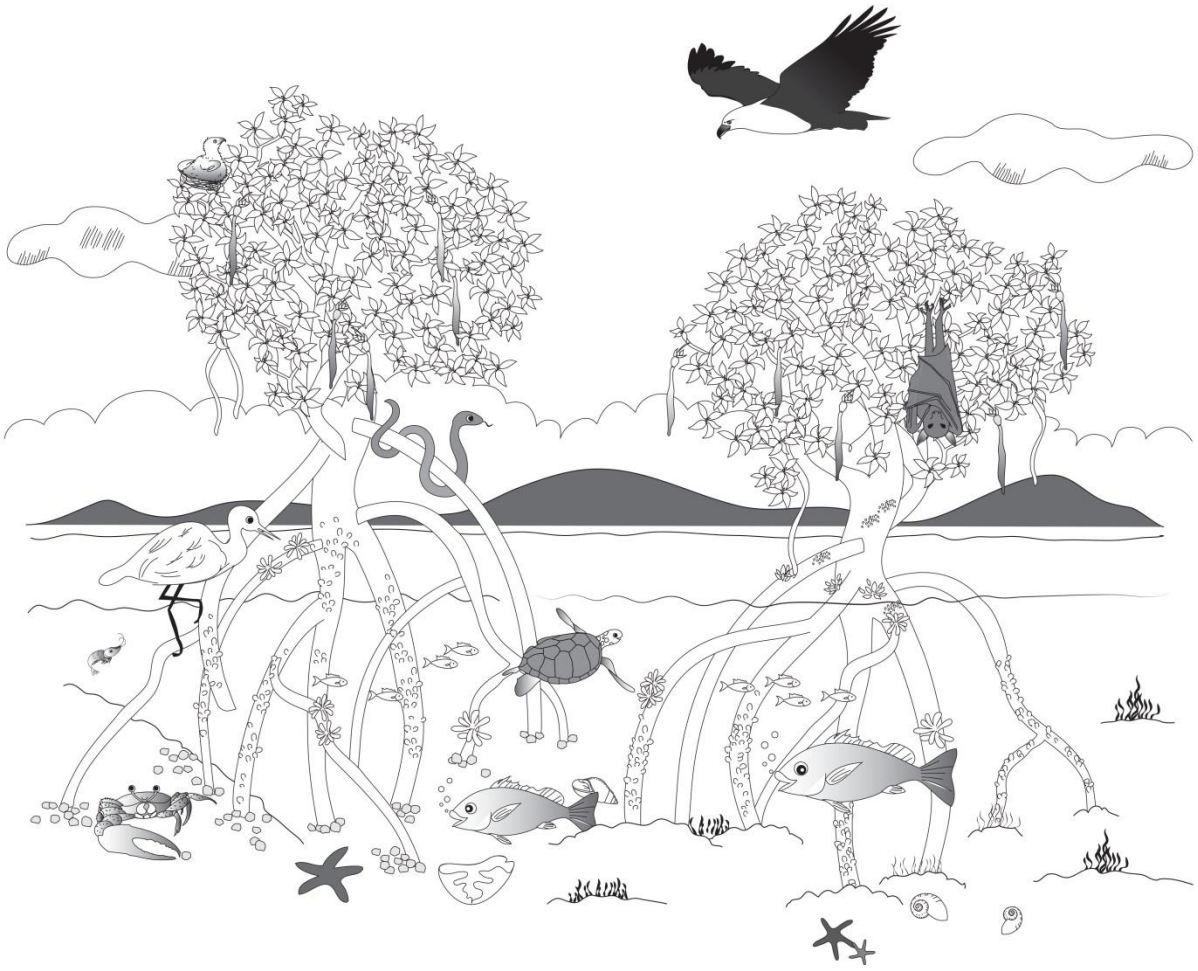


Figure 17: The mangroves as habitat for other species

Activity 2-A: Spot the Difference - Mangroves

Summary Students will learn that the three species of mangroves (grey, red and yellow) have very different seeds, roots, and leaves. These adaptations to their particular environment help to identify the different species.

Learning Objectives
Students will be able to:
(a) Identify three species of mangroves;
(b) List adaptations of each species; and
(c) Explain the reproduction of the Red Mangrove.
Age Levels
10 and up
Subject Area
Science
Time
1 hour
Materials
Red Mangrove seed (propagule) with top attached, and leaf *
Grey Mangrove leaves and seed*
Picture of Grey Mangrove root (pneumatophore)
Yellow Mangrove leaf and seed*
Sketch pad or drawing paper
Mangrove plant illustrations from page 2-21 to 2-39

*Note due to the Fisheries Act 1994 (Qld) it is not possible to remove marine plant material (plants or seeds) without a permit.

To obtain a research permit, you will need to complete the *Code for self-assessable development - Works for educational, research or monitoring purposes in a declared fish habitat area or involving removal, destruction or damage of marine plants – Code MP05* (http://www.daff.qld.gov.au/__data/assets/pdf_file/0007/59632/MP05-Research-2011.pdf).

Under the code, you are limited to collecting no more than two buckets each having a capacity of 10 litres of marine plants in one day. Once completed you fax or email the form to the District Officer of the nearest Queensland and Boating Fisheries Patrol and the Manager (Planning and Assessment) of the relevant regional Fisheries Facility at least 5 business days but not more than 20 business days before you need to collect your samples.

Otherwise, it is suggested that examine the plants in situ or use resource materials for this activity.

Background Mangroves are virtually the only trees that have learned to adapt to growing in salt water or conditions heavily influenced by salt. To do this, they have developed special features that enable them to process the salt. These are described in greater detail on page 2-2.

Preparation Examine the seeds and leaves from each of the three different species of mangroves

Procedure

1. Examine the Red Mangrove seed (propagule).
    a. Drop the seed into water. Which end falls first?
    b. Separate the top (attachment) from the seed. How are they attached?
2. Examine the Red Mangrove leaf.
    a. Is there a difference between the top and bottom sides?
    b. What is the shape of the leaf?
    c. With a fingernail, scrape the top and what do you see?
3. Examine the Red Mangrove root illustration.
    a. Is there a main trunk?
    b. How do you think the roots function?
4. Examine the Grey Mangrove leaf.
    a. What is the difference between the top and bottom of the leaf? [The bottom has salt pores.]
5. Examine the illustration of the Grey Mangrove root system.
    a. Estimate the extent of the root system and the tree cover (canopy). Is it larger, smaller, or the same? (Check this during field investigation or homework.)
    b. Predict the function of the roots. (With older students, try to design an experiment to test your predictions. For example, try breathing through a snorkel while under water. Explain that this is how Grey Mangroves get their carbon dioxide.)
6. Examine the Yellow Mangrove leaf and stem.
    a. How does the leaf function? What do you think the little bumps are on the stem just below the leaf?
7. Examine the illustration of the Yellow Mangrove root system.
    a. How are the roots similar to those of the Grey Mangrove?
    b. Predict the function of the roots. (With older students, try to design an experiment to test your predictions.)
8. Have students draw pictures of each set of leaves, roots, and stems.

Discussion/Reflection

Which of these three species would grow closest to water? What are your reasons for this answer? How do these three differ in the way they get rid of the salt in their systems?

Activity 2-B: Mangrove Food Web

Summary Mangrove ecosystems have a complex food web.

Learning Objectives
Students will be able to:
(a) Describe the elements of the food chain: producers; primary, secondary, and tertiary consumers; and decomposers;
(b) Understand the distinction between herbivores, carnivores, and omnivores;
(c) Gain a basic understanding of how pollutants work in the food chain; and
(d) Build a mangrove food web.

Age Levels
8 and up

Subject Area
Science

Time
1 hour

Materials
Reading background (page 2-6 to 2-8 and below)
Mangrove Food Web Clues (page 2-14)
One worksheet (page 2-15) per student

Background Plants and animals in any ecosystem or habitat are linked by their feeding relationships. Every habitat creates **decomposers**: bacteria, fungi, and some insects that break down dead plant and animal matter (called **detritus**) into minerals and humus. The fertile soil that results enables producers—green plants—to grow, providing a food source for **primary consumers**—animals that eat plants and grasses, which are also called **herbivores**. (**Carnivores** eat other animals, and **omnivores**, like humans, eat both plants and animals.) These animals in turn provide a food source for **predators**—animals that eat consumers. Predators can be either **secondary consumers**, which eat only primary consumers, or tertiary consumers, which eat secondary consumers, or both. For example, the Heron eats crabs (primary consumers) as well as fish (secondary consumers). So the Heron is both a secondary and a tertiary consumer. This is called a food chain. A food chain is one feeding cycle within a larger or more complex food chain called a food web. A food web begins with the process by which the sun's energy is captured and shared among living organisms.
When certain chemicals enter water, they can affect the entire food chain. Chemicals, such as the herbicide diuron and heavy metals, get into the water through run-off from the land. They are ingested over time by microscopic organisms called plankton. Tiny invertebrates eat the plankton and store the chemicals in their own bodies, where they are more concentrated than in the plankton. Fish eat the invertebrates and also store the chemicals in their bodies, becoming more polluted than the invertebrates. Birds, mammals, and humans then eat the fish containing high levels of pollutants, and the chemicals get into our bodies. This is called bioaccumulation. (See the "Deadly Links" activity on page 3-13).

Procedure

1. See worksheet on pages 2-15.

2. Use the clues (page 2-14) to fill in the worksheet.

3. Check answers (see handout on page 2-16).

Discussion/Reflection

What other plants and animals that you know about could fit into the charts?

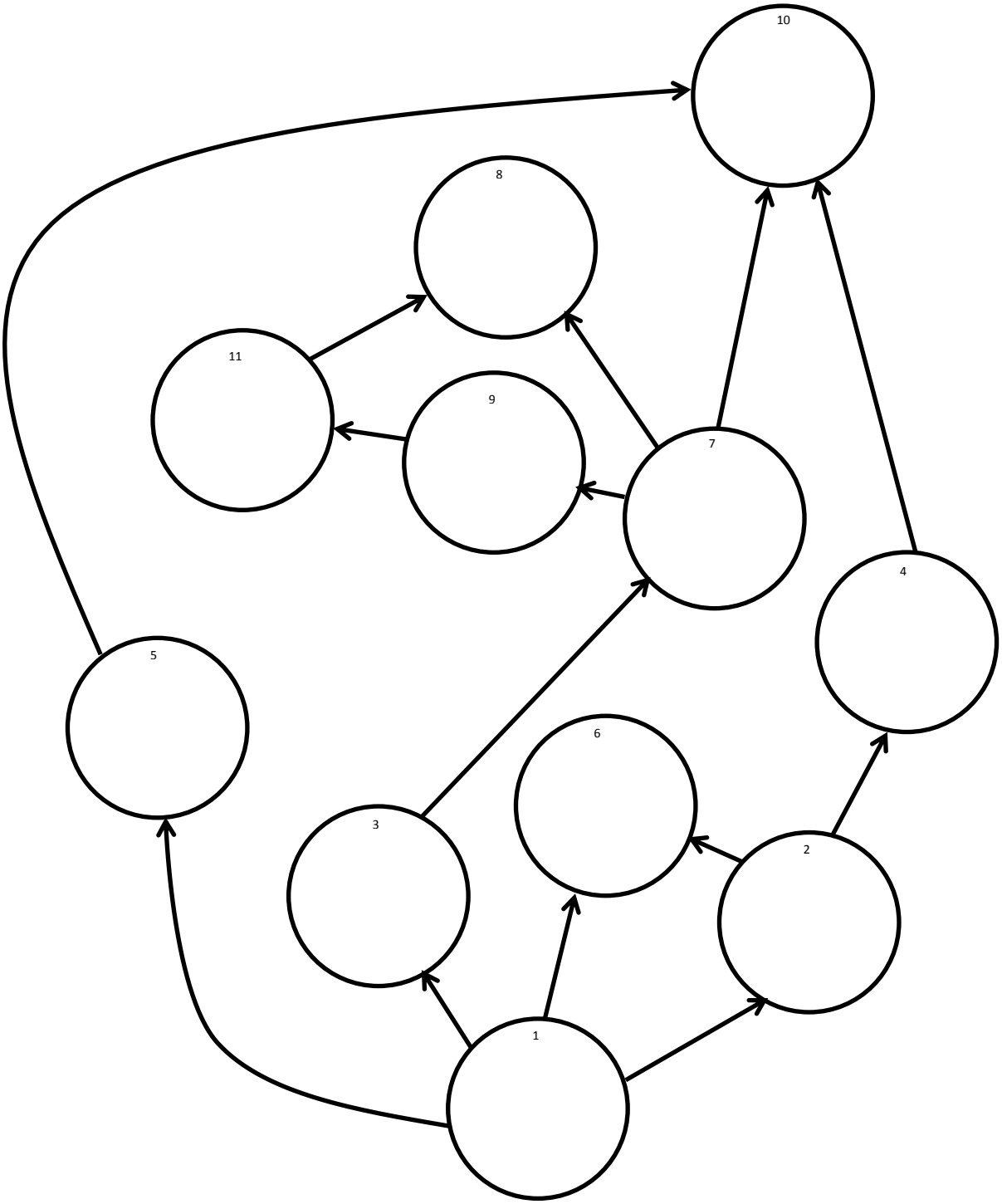
Mangrove Food Web: Clues

Complete the simplified food web for a mangrove habitat, using the following words to fill in the correct numbered circles: oyster, heron, amphipod, white-bellied sea eagle, human, plants, snake, green turtle, mangrove jack, detritus and fiddler crab.

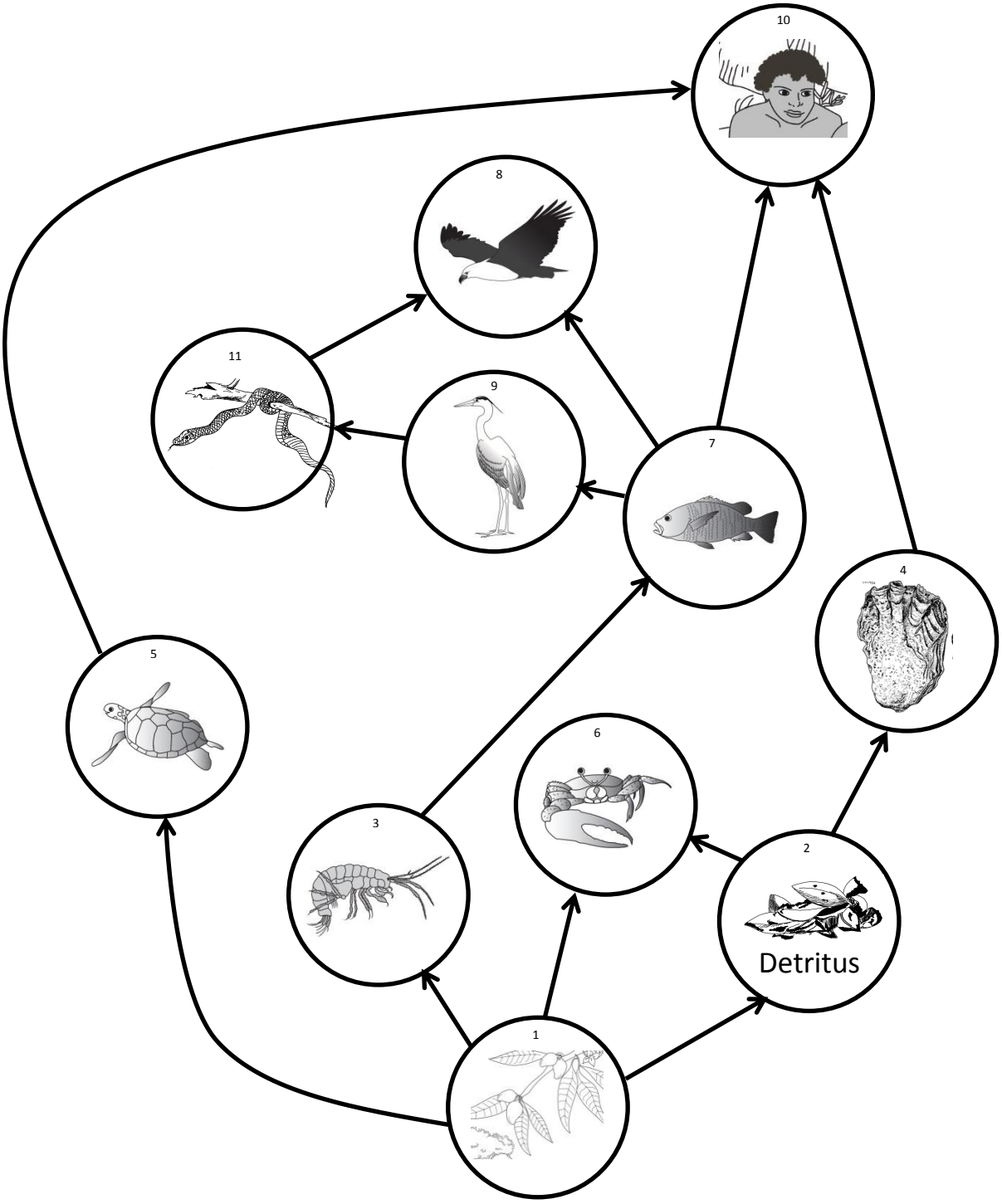
Clues for Numbered Circles

- These organisms use energy from the sun to make food (1).
- This is dead plant material enriched with bacteria and fungi. It returns plant nutrients to the mangrove (2).
- This tiny invertebrate feeds on organic matter (3).
- These shelled animals live beneath Red Mangroves and filter-feed, concentrating on small particles of organic matter (4).
- This reptile feeds on algae, seagrass, mangrove fruit and jellyfish (5).
- This crustacean is the ultimate recycler; it will eat algae, microbes, fungus, or other decaying detritus (6).
- This vertebrate with fins lives underwater and feeds on prawns and small fish, their young will also eat amphipods (7).
- This bird of prey mainly eats reptiles and fish (8).
- This long-legged animal can be seen patiently standing in shallow water looking for small aquatic creatures including fish, frogs, and crabs (9).
- If it wants to, this creature can find and eat almost anything in the mangroves. Nothing in the mangroves can kill and eat this animal (10).
- This animal slithers around to hunt for frogs, birds and small mammals (11).

Mangrove Food Web Worksheet



Mangrove Food Web: Answers



Activity 2-C: Mangrove Story Board

Summary This activity focuses on the mangrove's importance to juvenile fish and other animals by having students participate in creating a felt story board while listening to a story about Mr Lates Calcarifer, the Great Barramundi.

Learning Objectives

Students will be able to:

(a) Describe the different relationships that occur in a mangrove ecosystem—water cycle, food chains;

(b) Define the words habitat, mangroves, salinity, detritus; and

(c) List the basic requirements all living things need to survive.

Age Levels

4–11

Subject Areas

Science, language arts, art

Time

30–60 minutes

Materials

A felt board divided as follows, from the top down:

blue sky in the upper section

an area of high land (ridge), coloured grey or black

an area of grasslands, coloured green

soil, coloured brown

shallow water, coloured light tan

shallower ocean, coloured blue-green

deeper ocean, coloured darker blue

Cut-outs in felt, or drawings (use enlarged copies of illustrations in unit handouts or field guide) that have been laminated, with Velcro attached to the back, or cut-outs of coloured construction paper with tape attached to the back. Have students prepare these as they would for a class mural. Cut-outs should include:

- a sun (to represent energy source)
- a cloud or two (for discussing the water cycle)
- mangroves—red, grey, yellow
- samphire plants and sea grass
- animals that fly and live in the trees—lorikeets, Little Red Flying Fox , herons, pelicans, Ospreys
- reptiles that live in the trees—such as lizards
- amphibians that live in the trees like frogs
- spiders and insects— such as mosquitoes, dragonflies, butterflies, ants and bees—that live in the trees and fly in the air
- animals that live in the mud and dead mangrove leaves, such as clams, oysters, sponges, sea squirts, snails, crabs (fiddler and mangrove), worms and amphipods and copepods

- animals that live in the water (young, getting older towards the deeper water) such as turtles, barramundi, mangrove jack, mullet, prawn, upside-down jellyfish; birds such as herons, stilts, snipes, and other shorebirds

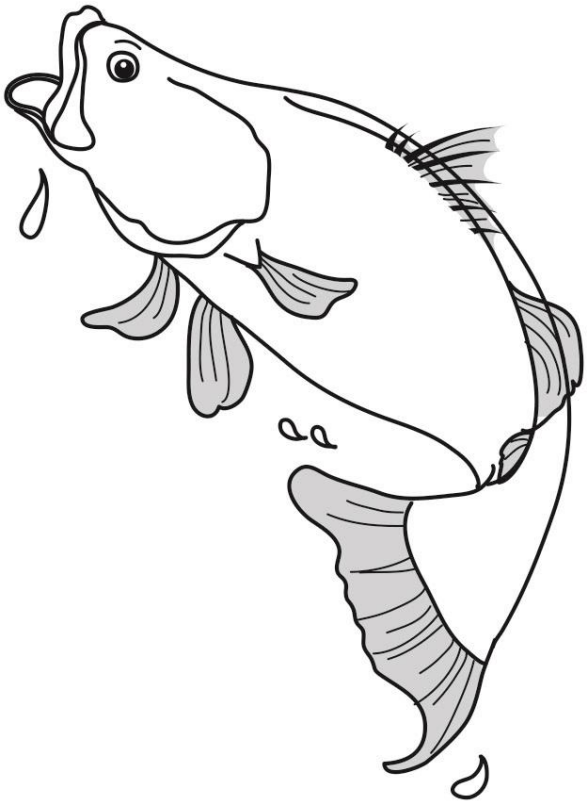
Note: If felt is unavailable for cut-outs, use coloured construction paper or colour part of each section to indicate its composition. A poster depicting a typical mangrove ecosystem is just as effective if a felt board cannot be obtained.

Background The mangrove wetland is a unique setting that provides habitat, or home, for a variety of animals that are all completely dependent on the mangroves for the food, water, and shelter that they provide. You can also include the following concepts during your presentation, leading into further discussions on life cycles, food chains, and predator/prey relationships.
productivity—The flow of energy that starts with the sun and is captured by photosynthesis, which enables plants to grow and thus the rest of the ecosystem to develop. With plenty of sunshine, water, and mineral resources, the mangroves are among the most productive ecosystems in the world.
abiotic—Non-living elements that are present in the mangroves—water, clouds, mud, sun, and climate—that determine what will live here.
producers—Plants that harvest energy from the sun in the process known as photosynthesis.
primary consumers—Organisms that eat plants, such as grazing animals, birds, and insects.
secondary and tertiary consumers—Predators that eat animals.
decomposers—Micro-organisms responsible for decay.
detritus—The term used to describe dead and decaying plants and animals.

Procedure When all the materials have been assembled, have students place appropriate items on the board as you lead a discussion on what can be found in the mangroves. They may come up and select items from an assortment at the front of the class, or provide ones they have made. You might want to cover what lives where in the mangroves so students will focus on what to look for and where. On visits to mangroves, students and teachers are often amazed at what they find in the mud, so this is a good part to emphasize in your discussion.

Discussion/Reflection
Tell the following story, using the felt board and cut-outs to illustrate what you are saying. Involve the students by encouraging them to answer your questions. (Correct answers, along with suggestions to the teacher, are in italic type, in square brackets– see following page.)

Mr Lates Calcarifer – the Great Barramundi



DOES ANYONE KNOW what saltmarshes and mangroves are? Mangroves are amazing plants—they're trees, really—that grow in salt water on the edge of the ocean. In a few moments we will see how important the mangroves are as habitat. Mr Lates Calcarifer, the Great Barramundi, was born from an egg tucked away safely in the saltmarsh behind the mangroves.

Soon after hatching, as the tide rises, little Lates moved into the mangrove behind a cluster of mangrove roots. For the first few days of his life he feeds on small plankton, like amphipods and copepods. As he grows, before he migrates upstream to freshwater where he will establish his territory and spend the rest of his life, he lives among those same mangrove roots. What a strange world to grow up in, but what an exciting place to explore!

And there's so much to eat—hundreds of juvenile fish and prawns in silvery schools. Still and silent, Lates waits in more open water for a small fish to stray from the school; then, suddenly, he snaps it up for a tasty meal.

But Lates the Barrumundi is only a few centimetres long, and there are others who would like to make a meal of him. From the surface of the water, he catches a glimpse of a slow-moving shadow.

What do you think it is? *[A white-faced heron.]*
Where would be a good place to hide? *[Among the roots of the mangroves].*
Briefly describe life in the mangrove roots and why it is so productive. What other animals might we see here that would use the shelter of the Red Mangrove roots? *[Prawn, mud crabs, fiddler crabs, other young fish like mullet and crustaceans like amphipods and copepods.]*

"Hmmm . . . looks like there are some interesting things to eat here," says Lates, as he spies a tasty prawn. The amphipod and the prawn use the mangrove roots for shelter, but they also find lots of food to eat in the muddy layer of ooze underneath the dead mangrove leaves, called detritus.

Where did this rich stuff come from? *[It is made up of dead and decaying plants and animal material that have fallen from the mangrove trees and flowed down from the land when it rained.]* There is a good supply of invertebrates here in this rich habitat, and the barramundi's survival depends on this healthy aquatic habitat.

Let's review what the young barramundi needs in order to survive.

• Food—the barramundi eats tiny fish, fry, and some plankton like copepods and amphipods.

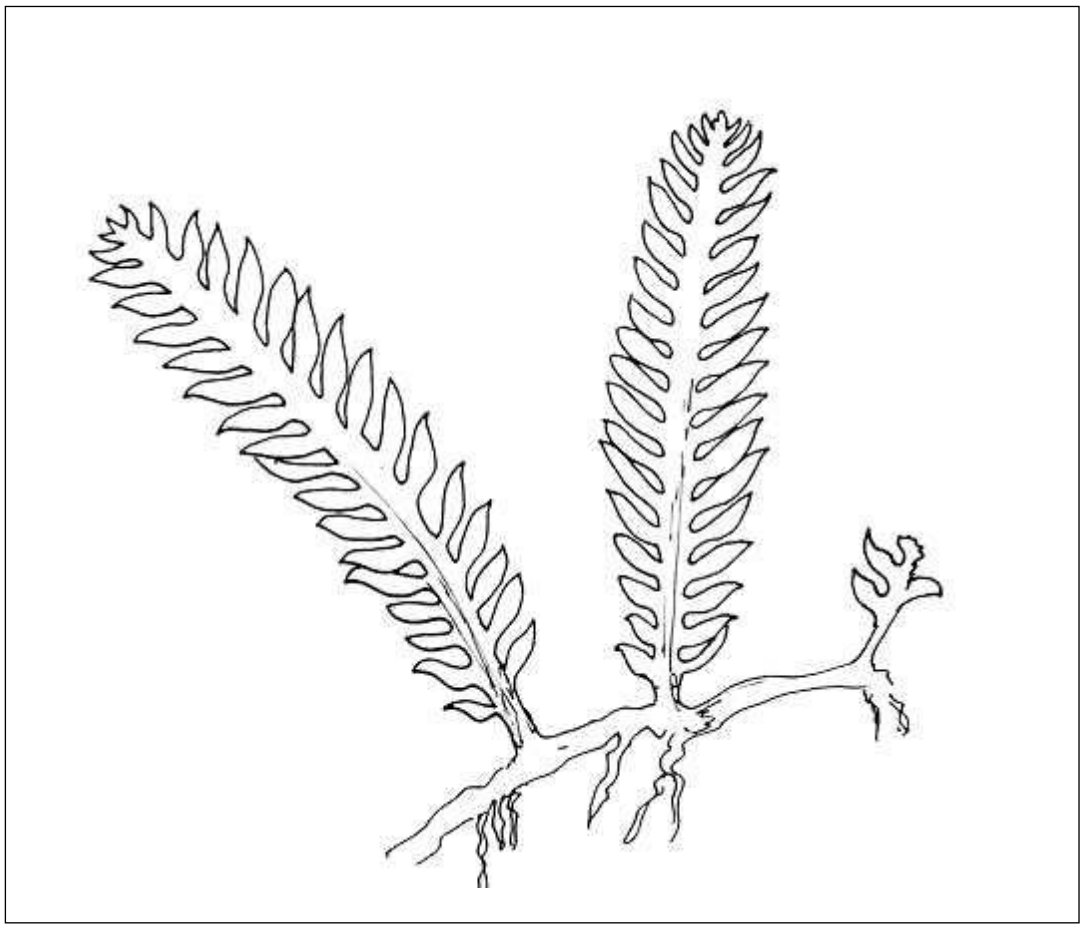
• Shelter—the mangrove roots give the barramundi a place to hide and find food, and also shelter the food the barramundi needs.

• Water—all animals need a good supply of water. In the years when there is drought, barramundi sometimes find it hard to make it back into the saltmarsh to lay their eggs. Also, the water flow into the mangroves carries much of the rich sediment we call detritus, which is necessary for a healthy ecosystem.

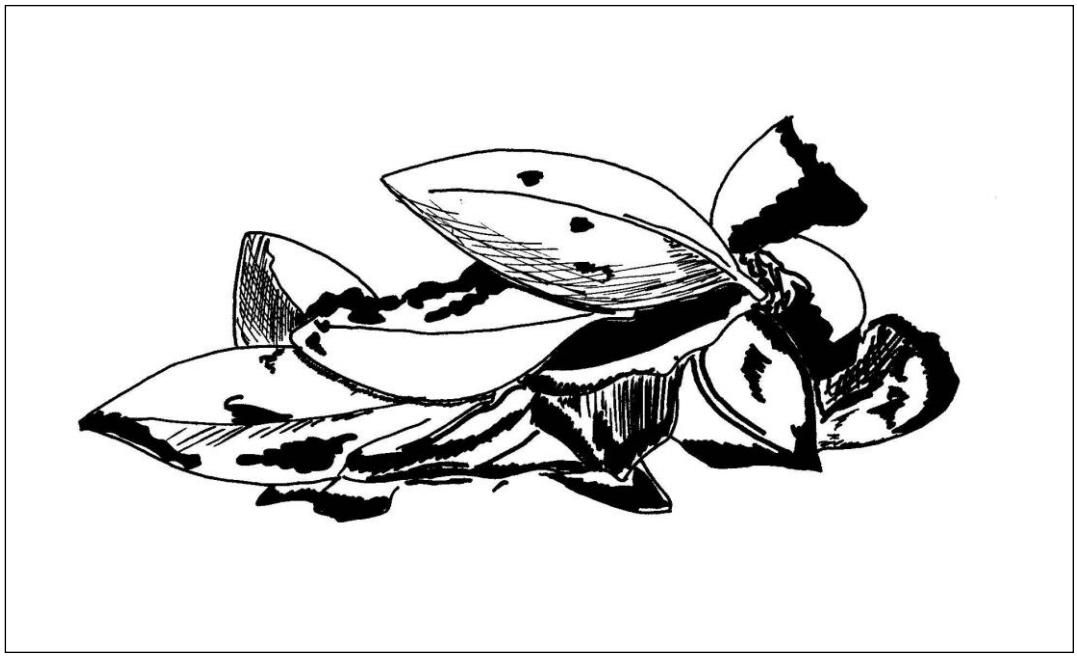
• Space—the barramundi needs adequate space. If a species is overcrowded, there is too much competition for food, and the animals become stressed. All these factors make up habitat.

Later, when we explore the mangroves, you'll meet some of these animals and look at some of their adaptations—like how they move, breathe, and feed in this ever-changing environment called the mangrove swamp.

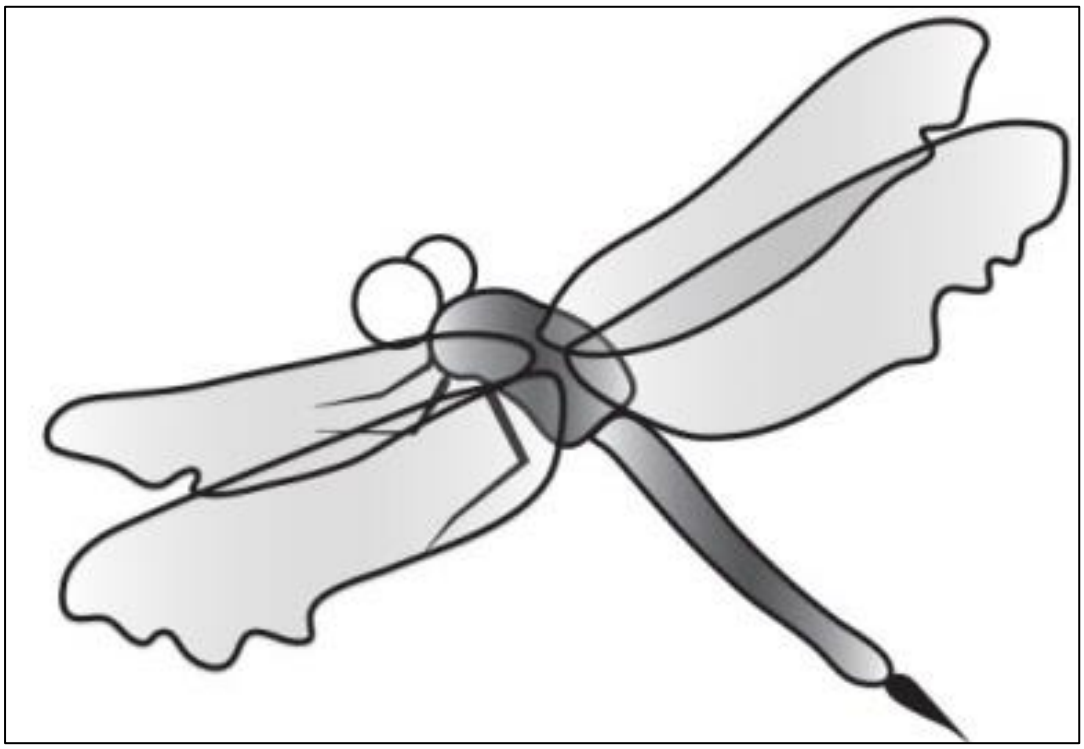
Figures to use in story board



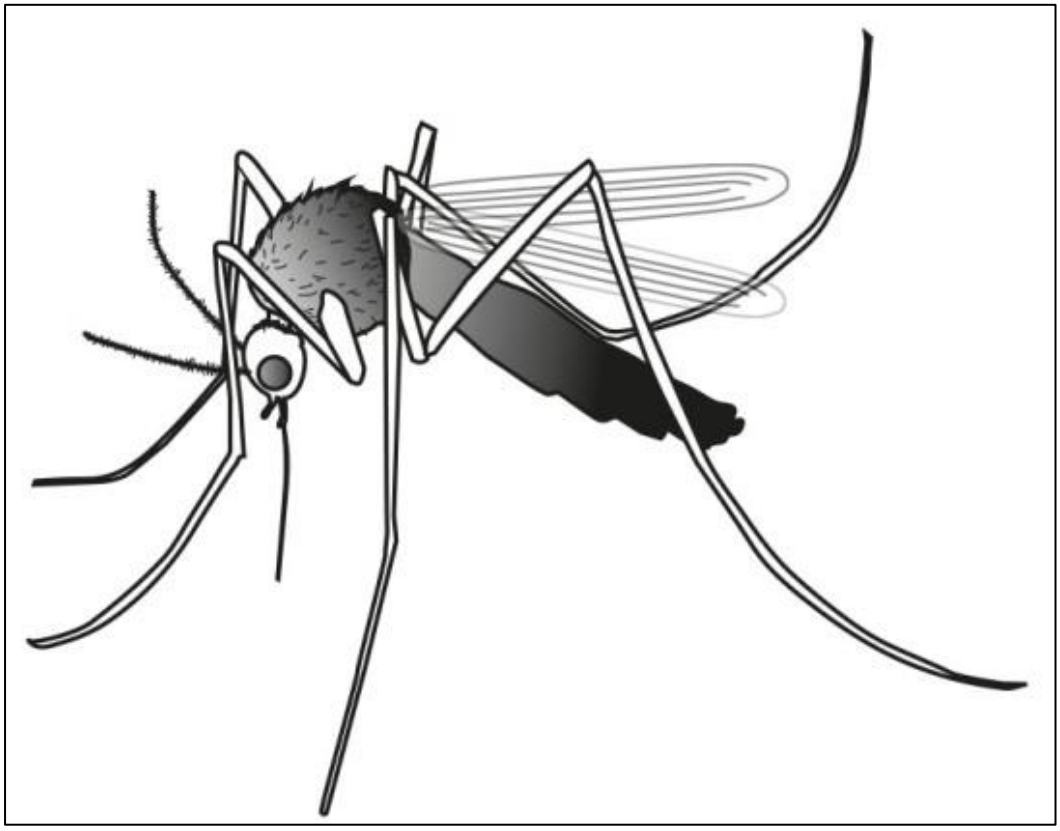
Algae



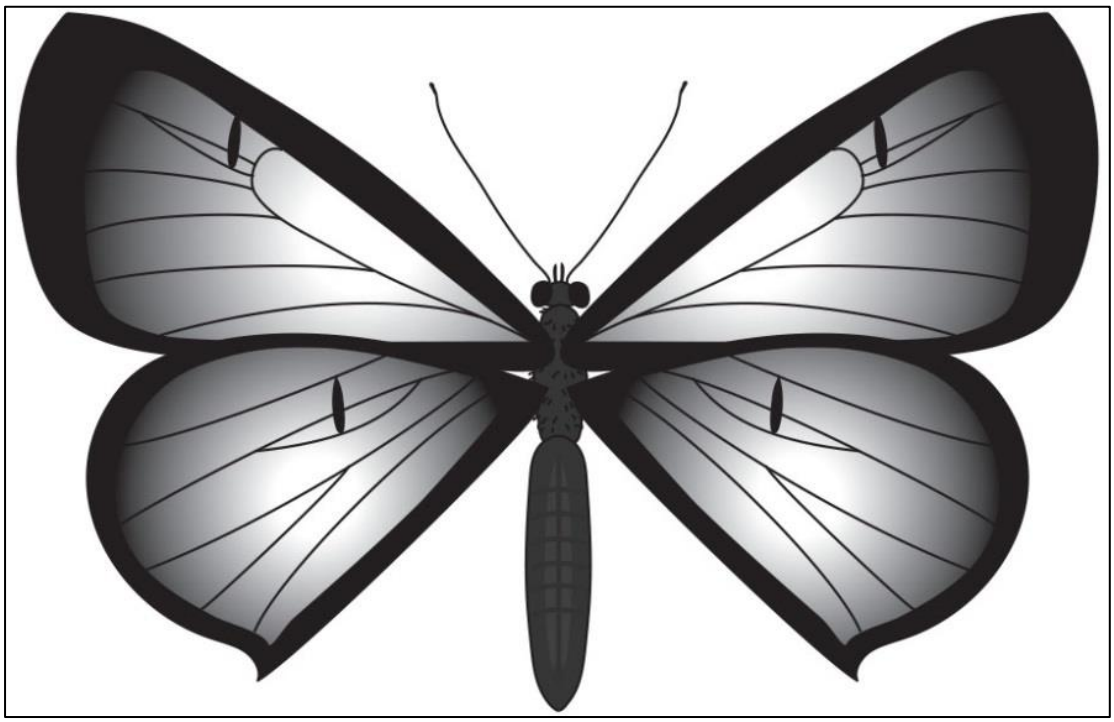
Detritus



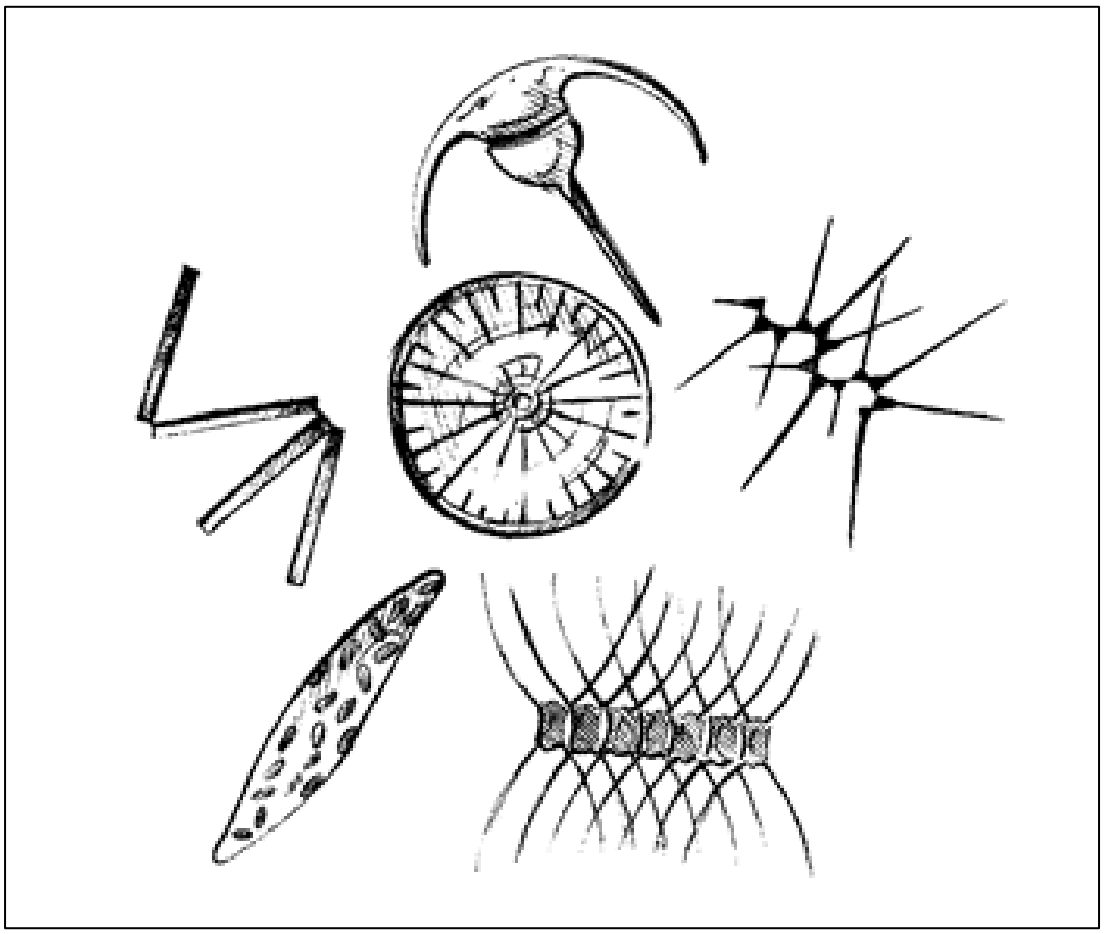
Dragonfly



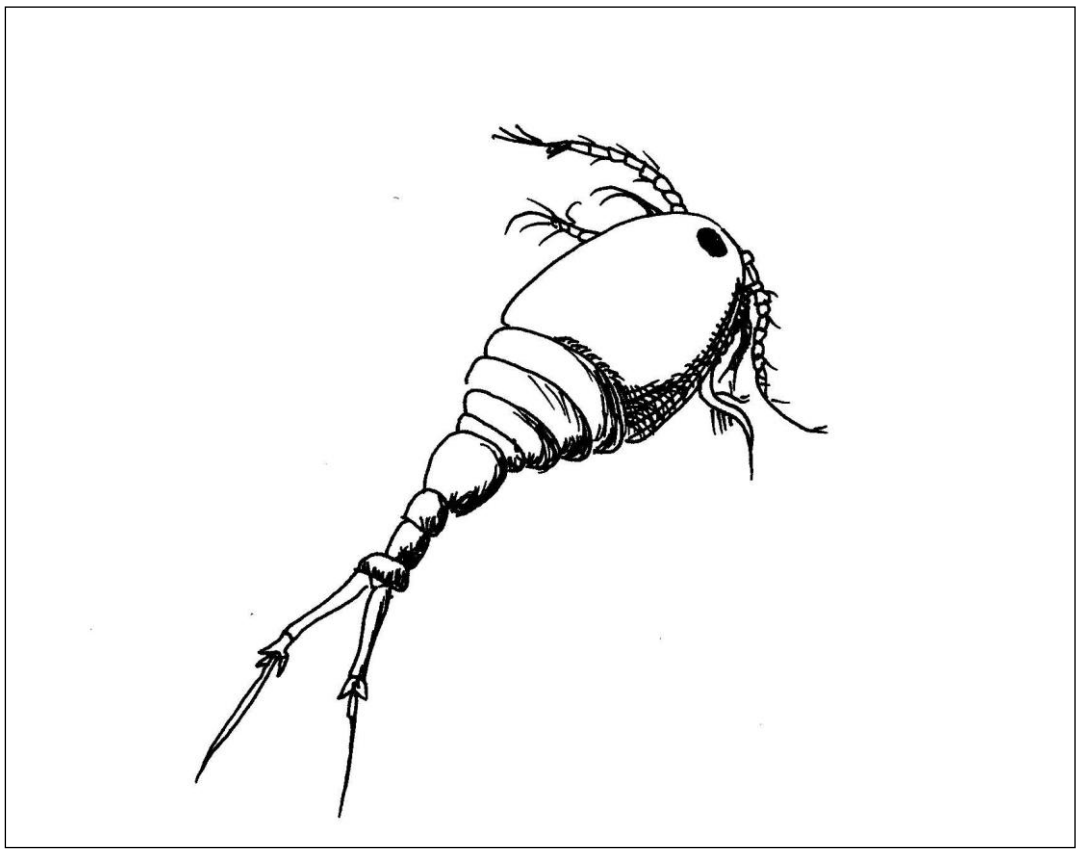
Mosquito



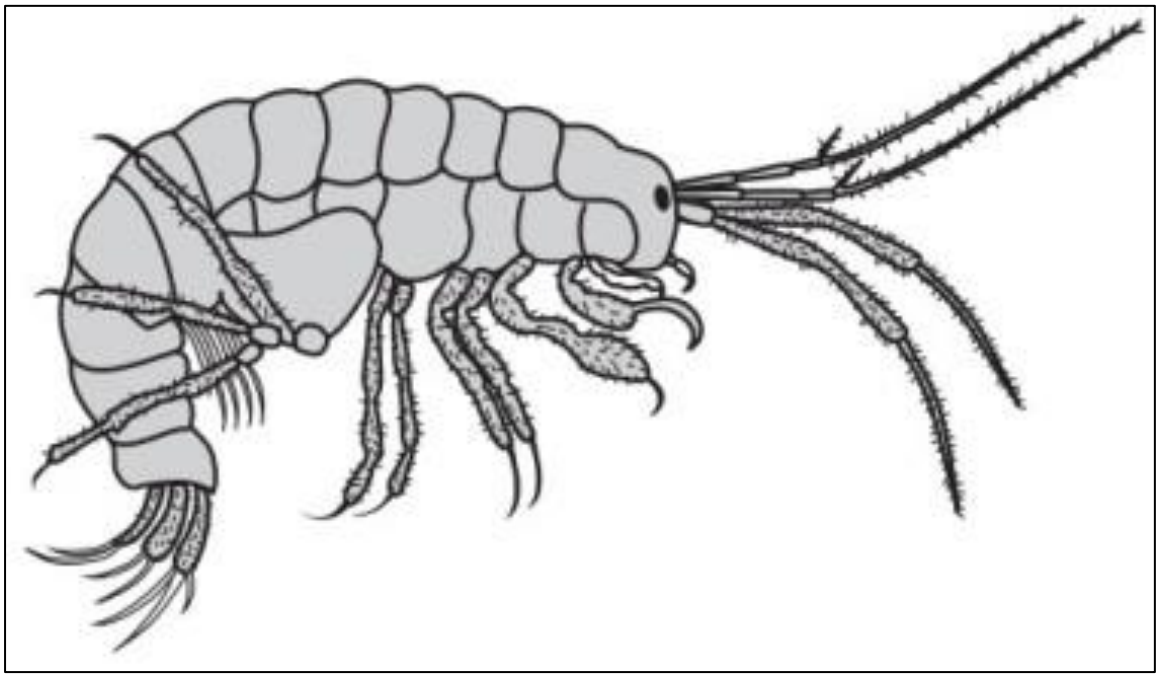
Illidge's Ant Blue Butterfly



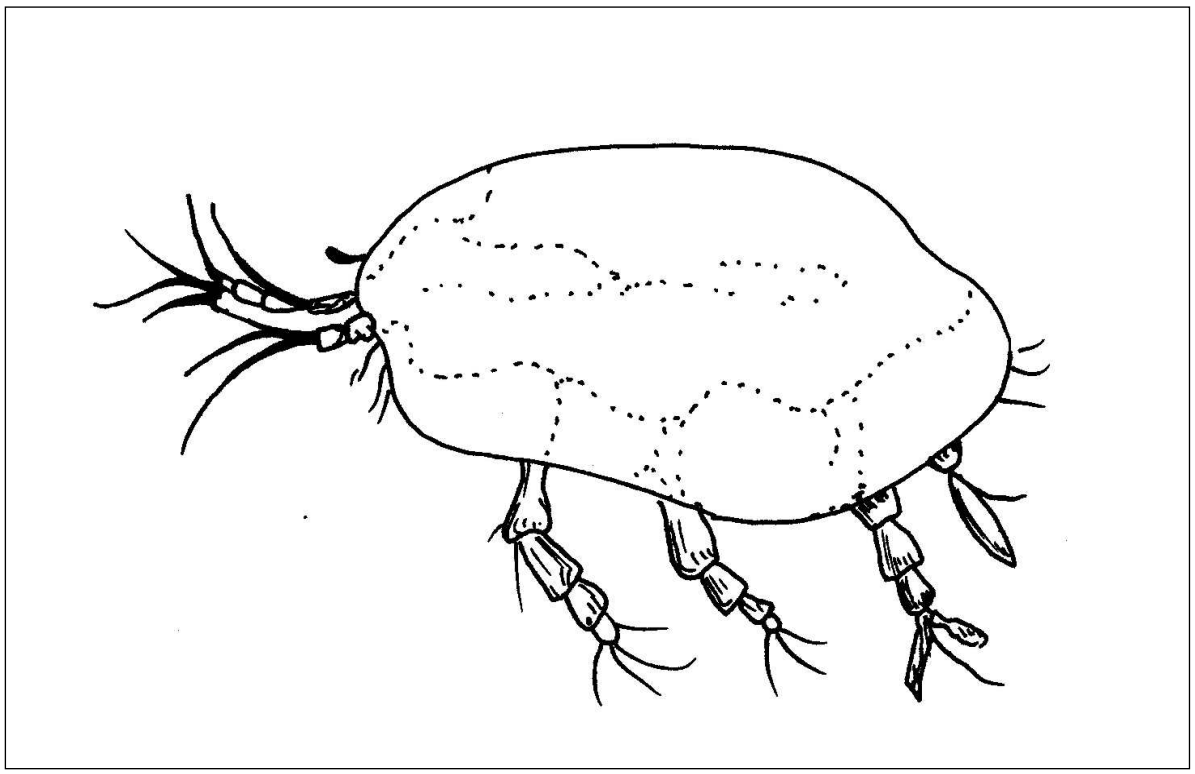
Phytoplankton



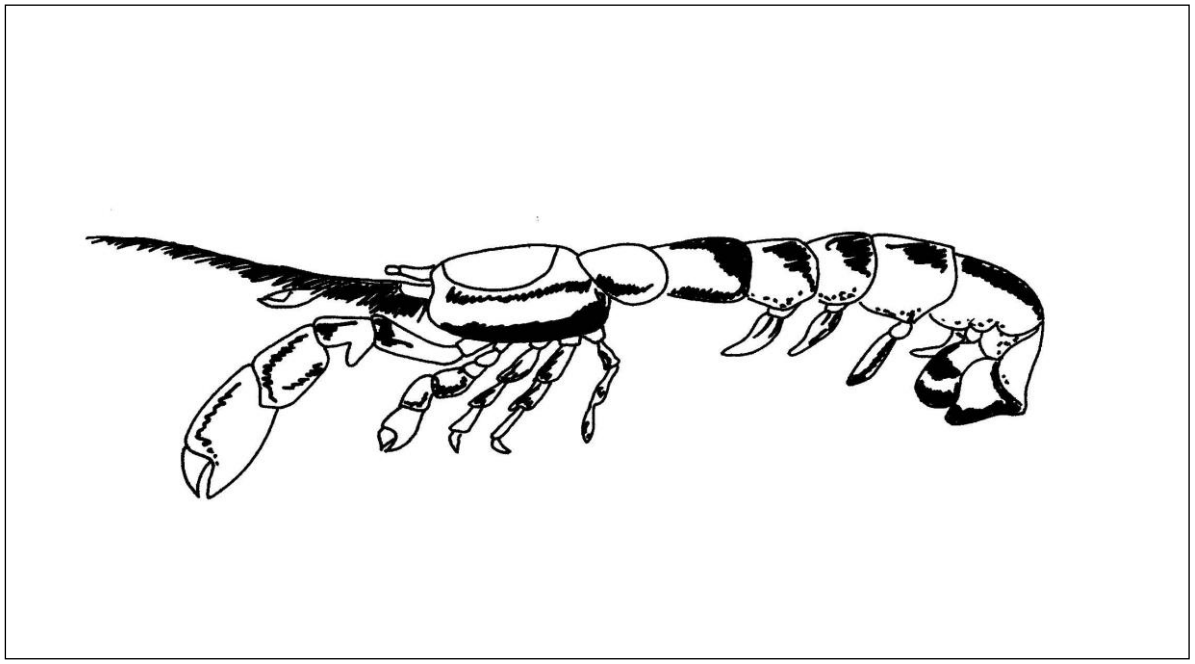
Copepod



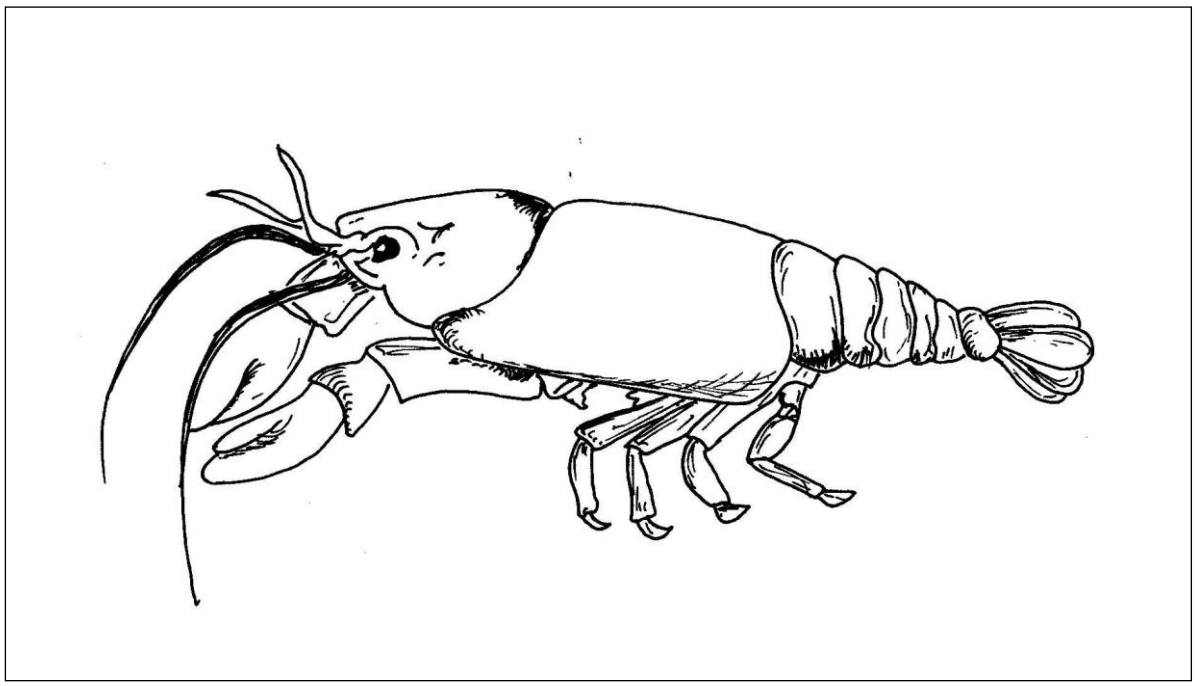
Amphipod



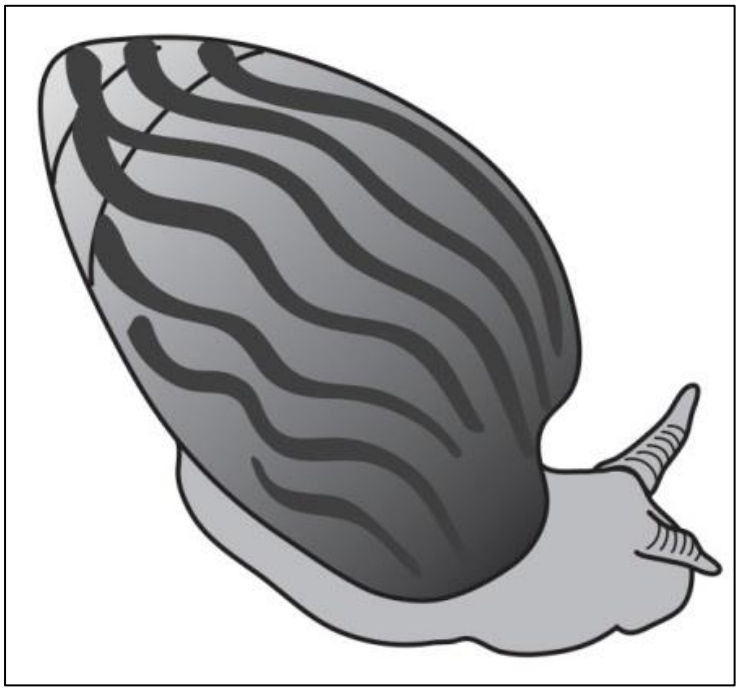
Seed Shrimp



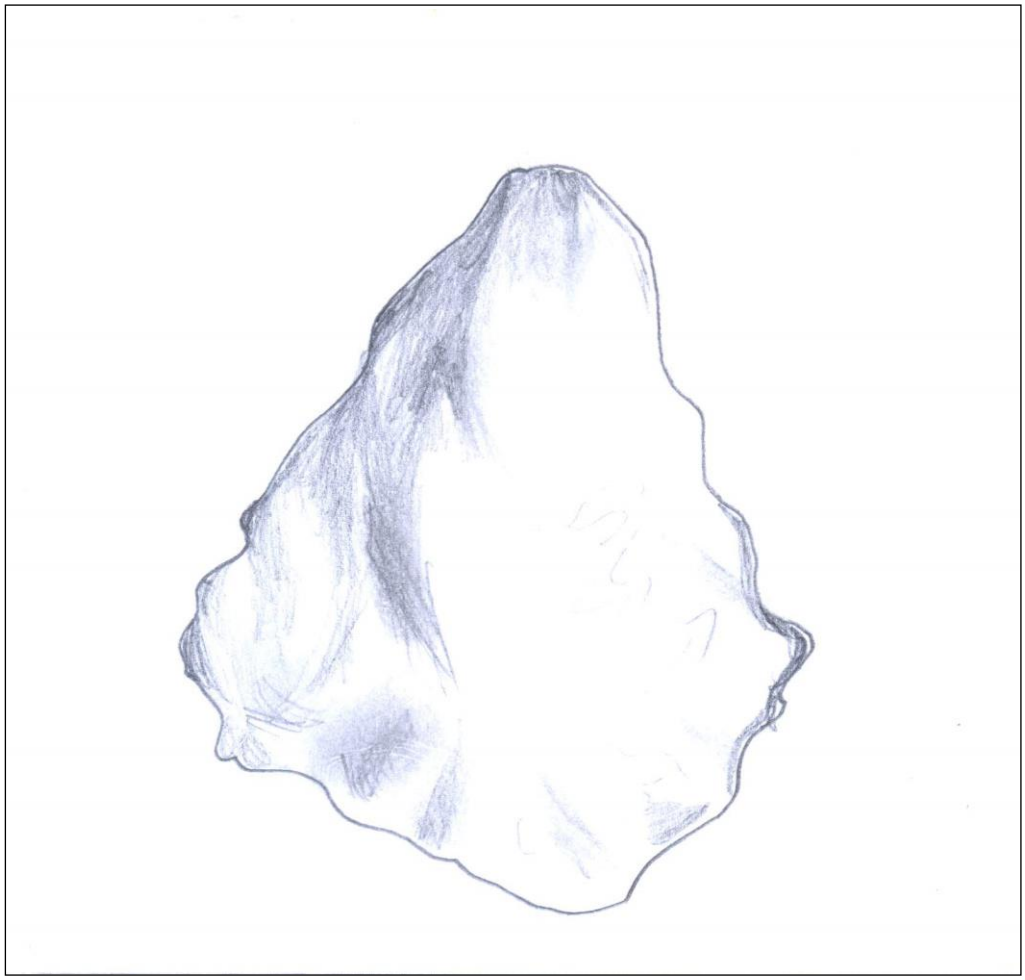
Ghost Shrimp



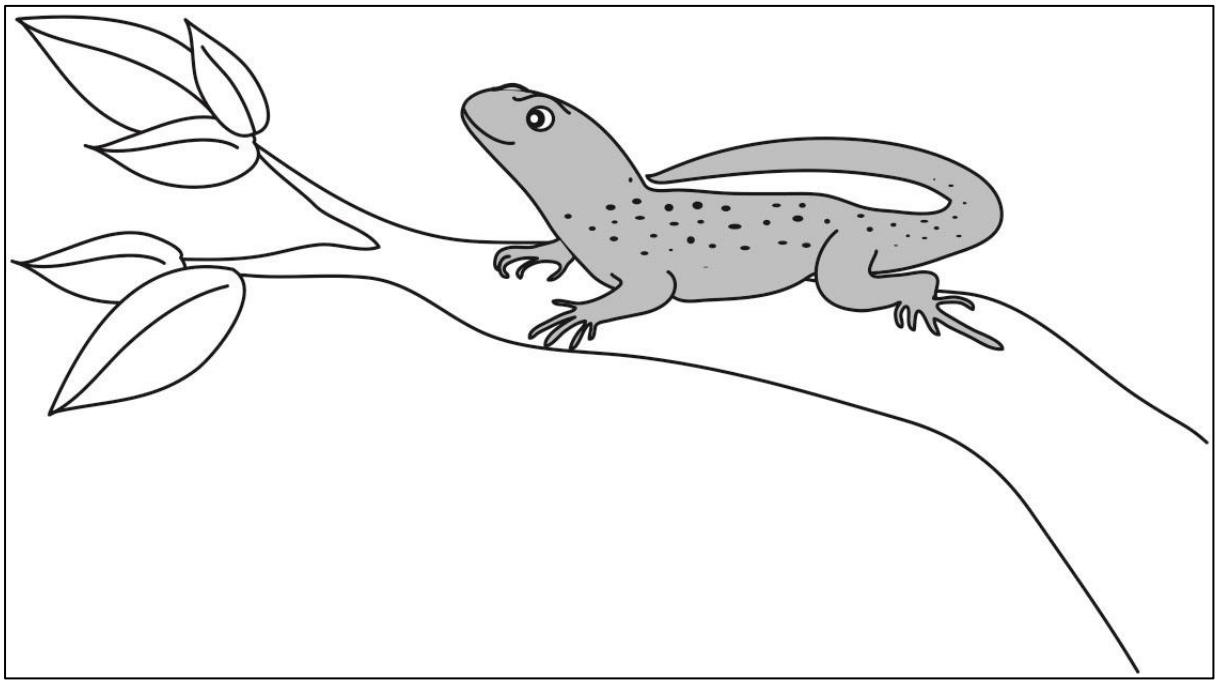
Crayfish



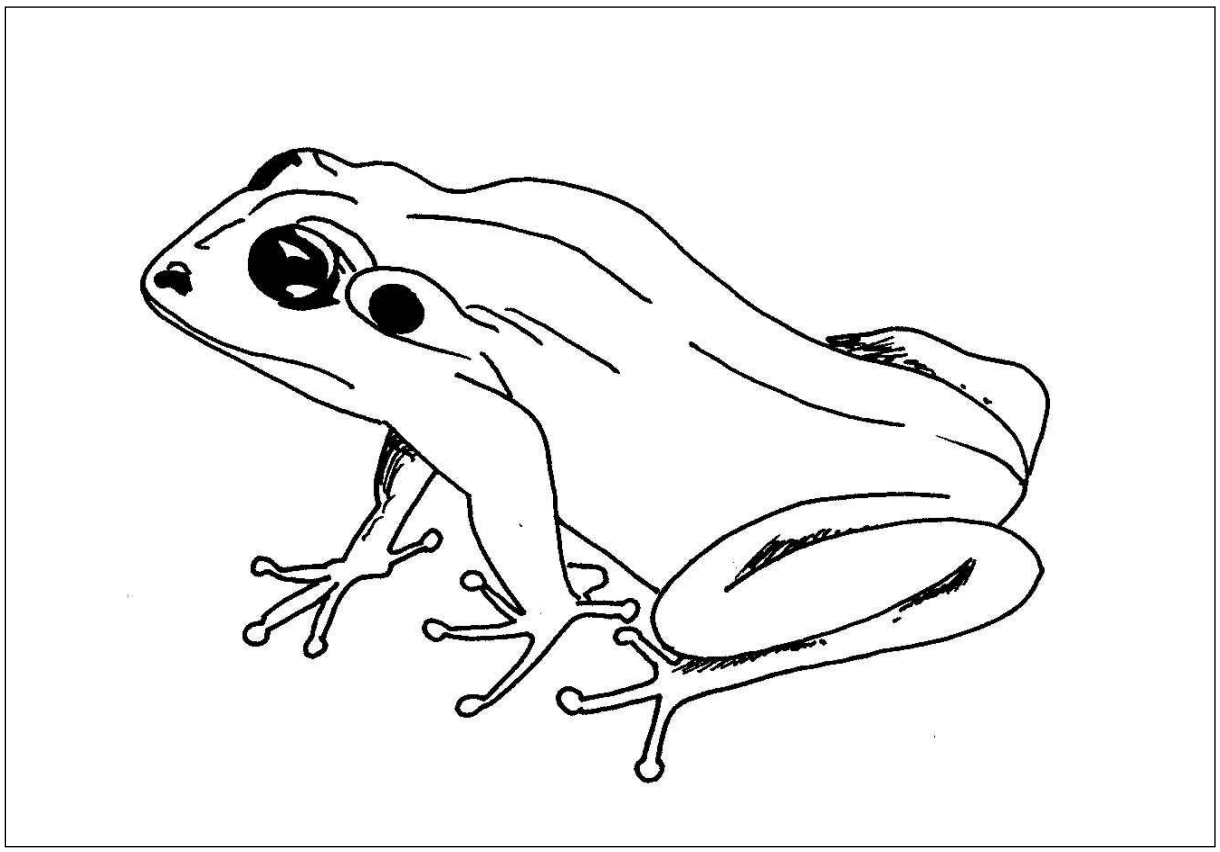
Grazing Snail (Gastropod)



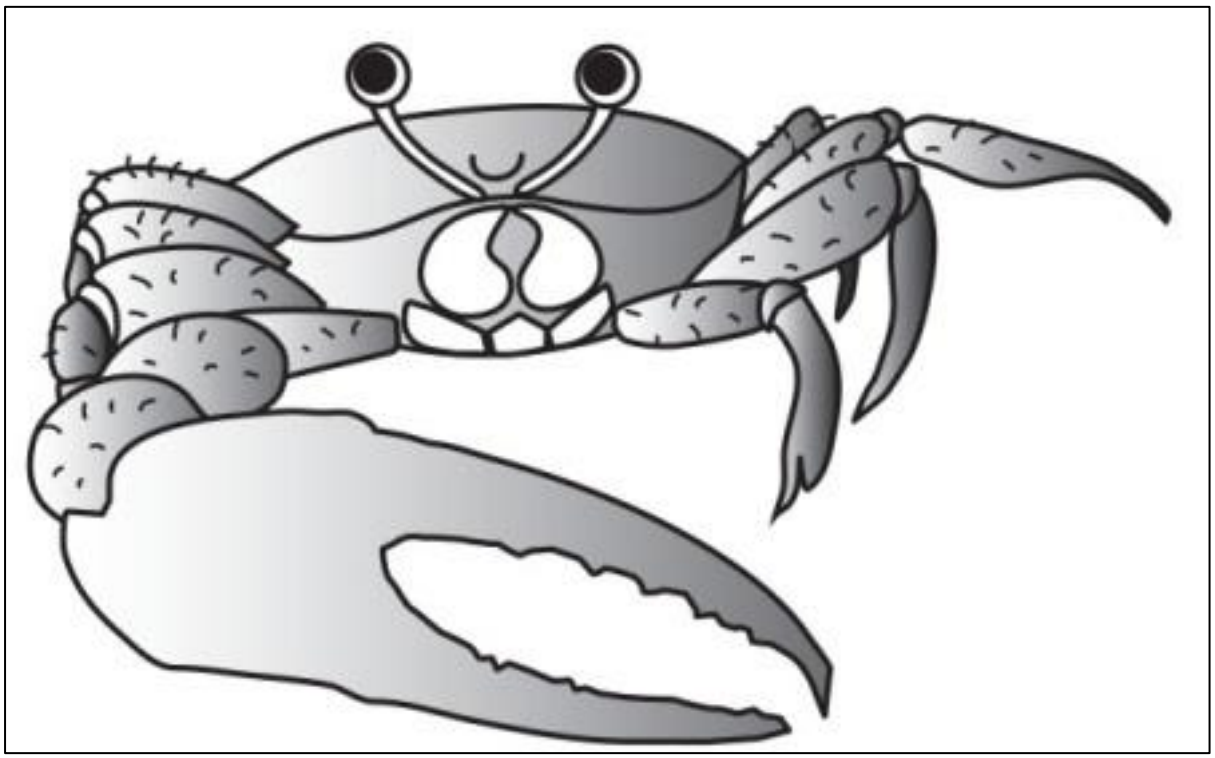
Oyster



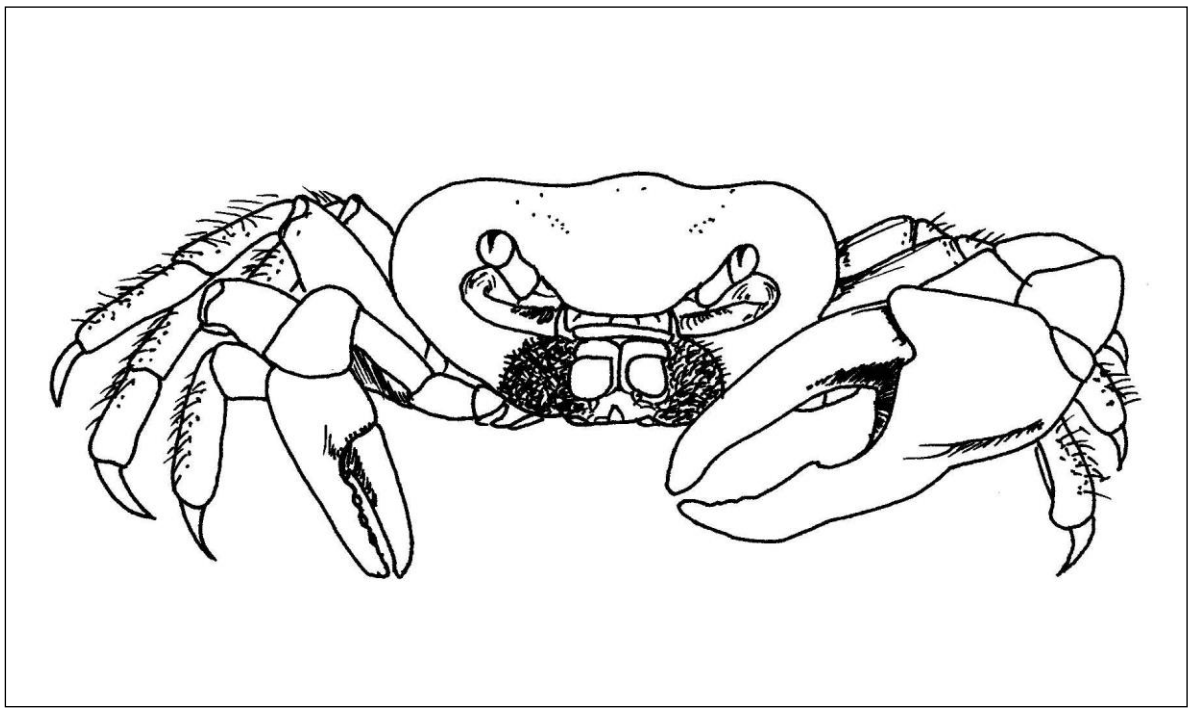
Lizard



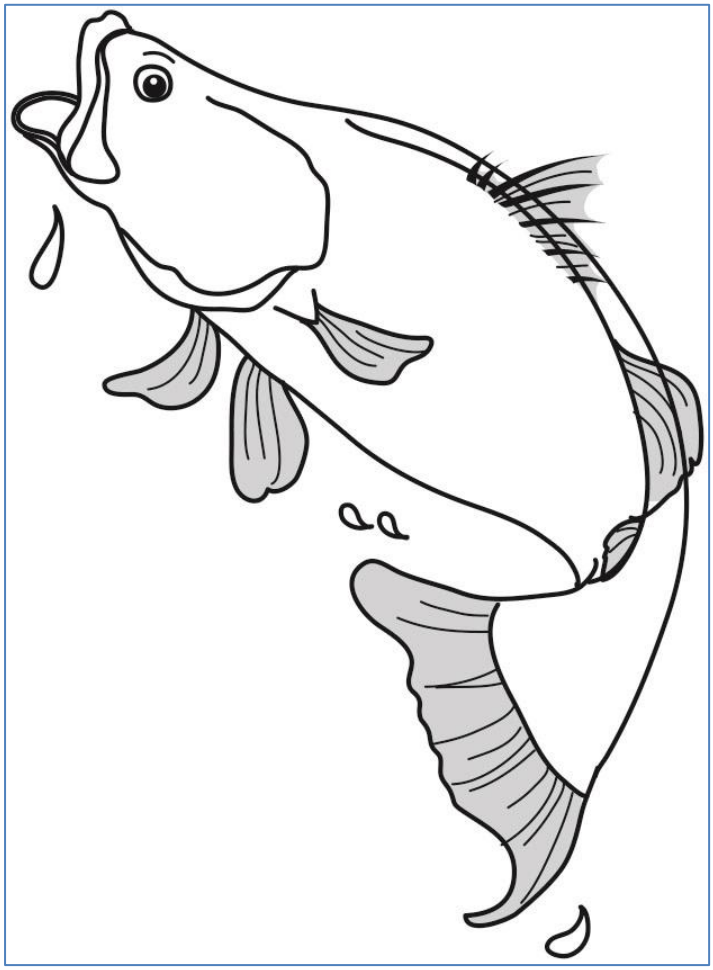
Frog



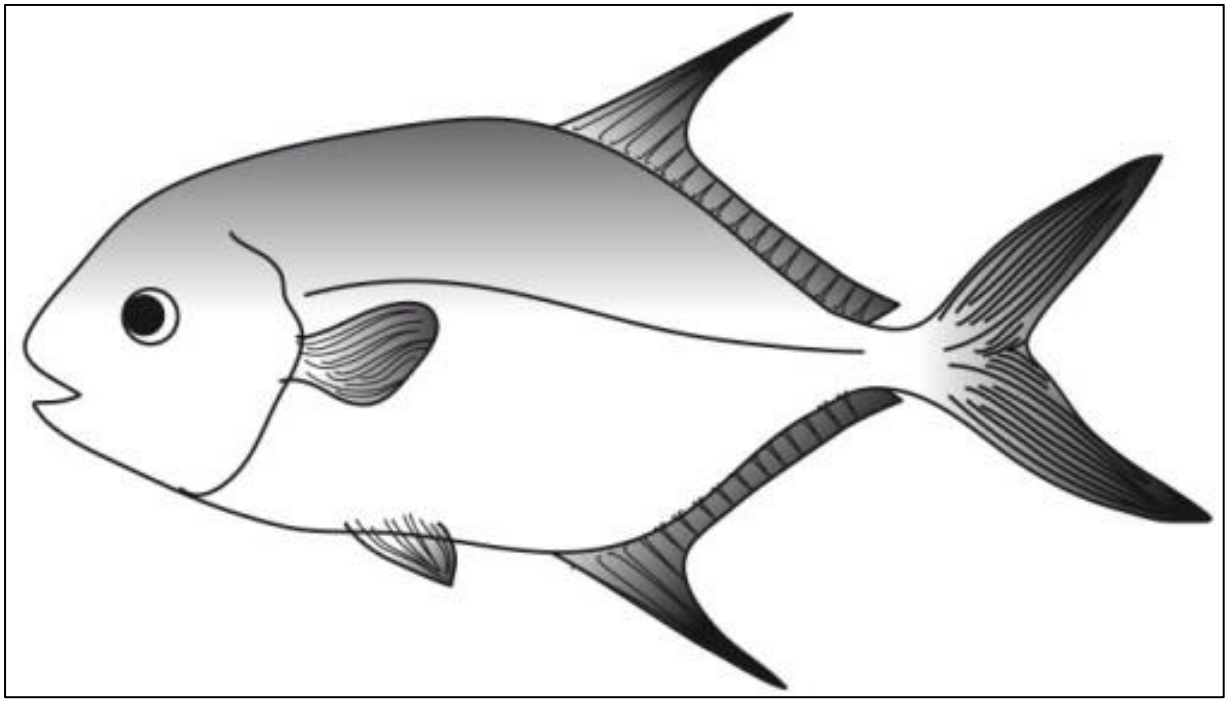
Fiddler Crab



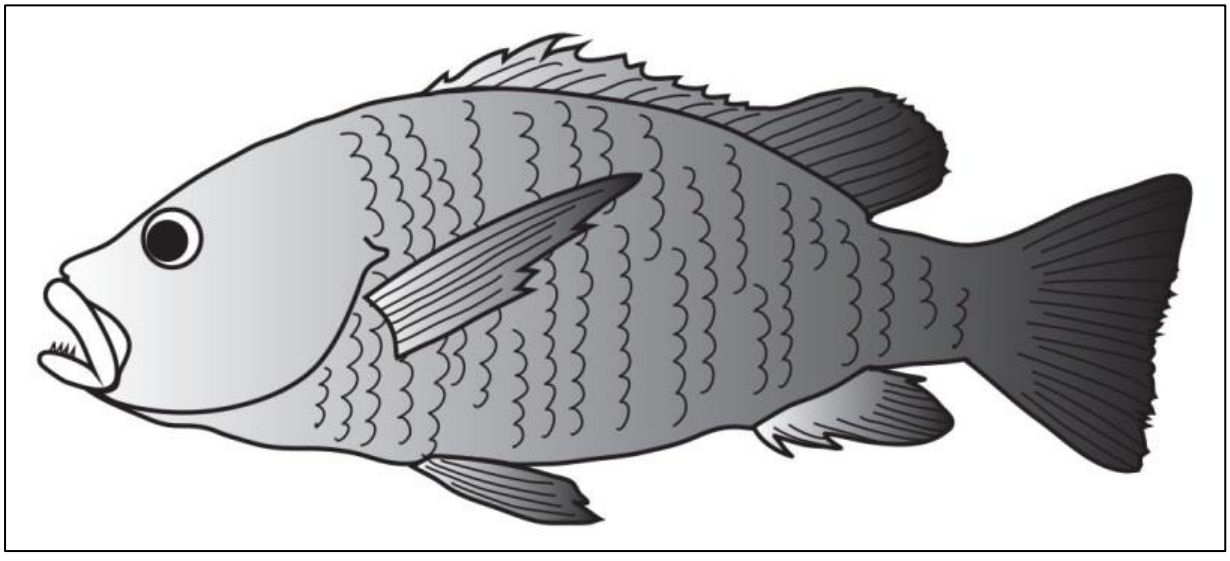
Mud Crab



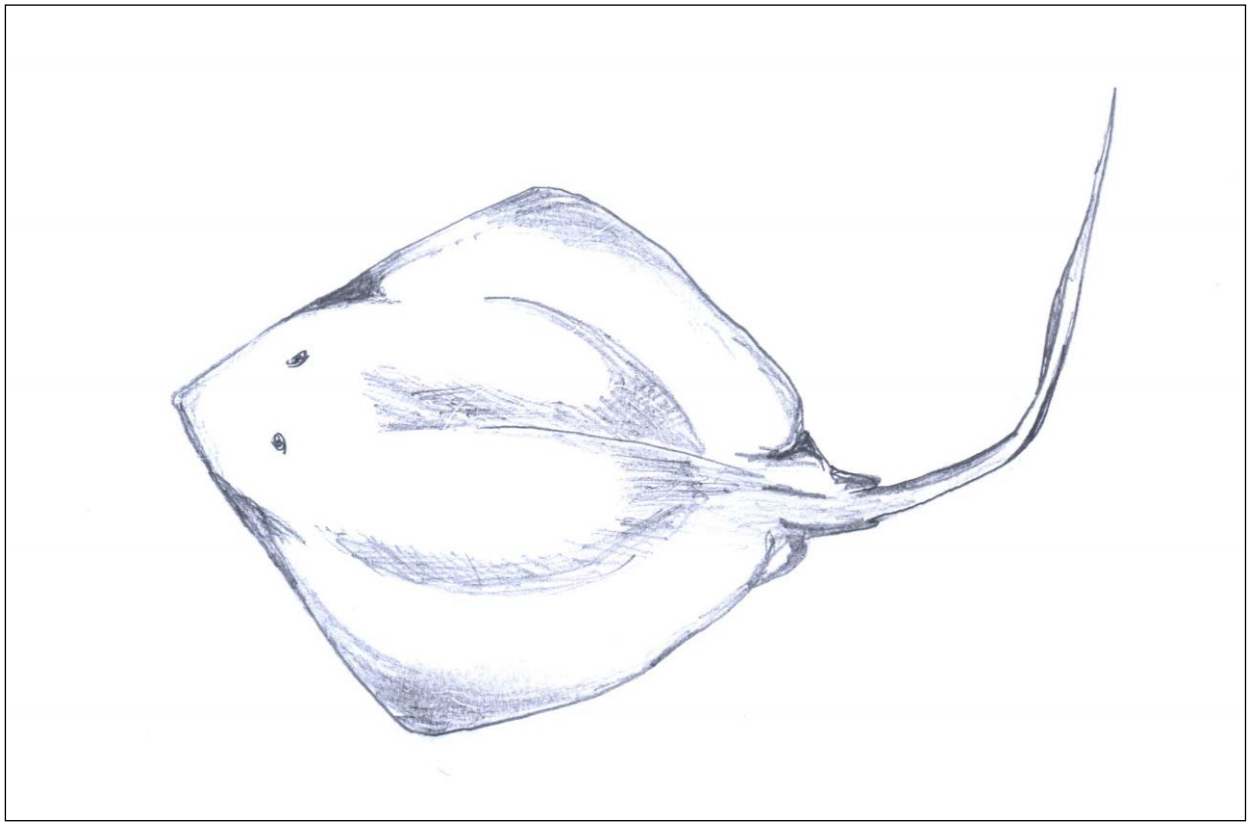
Barramundi



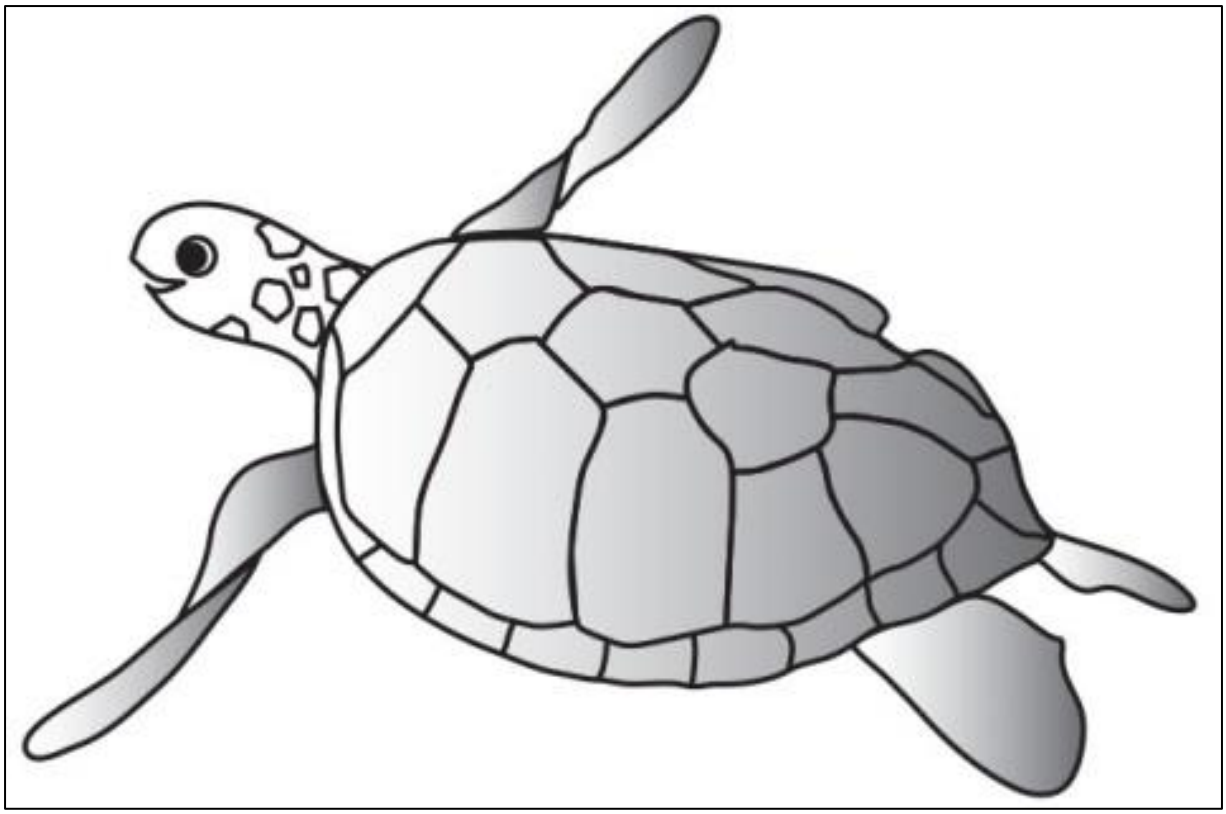
Permit



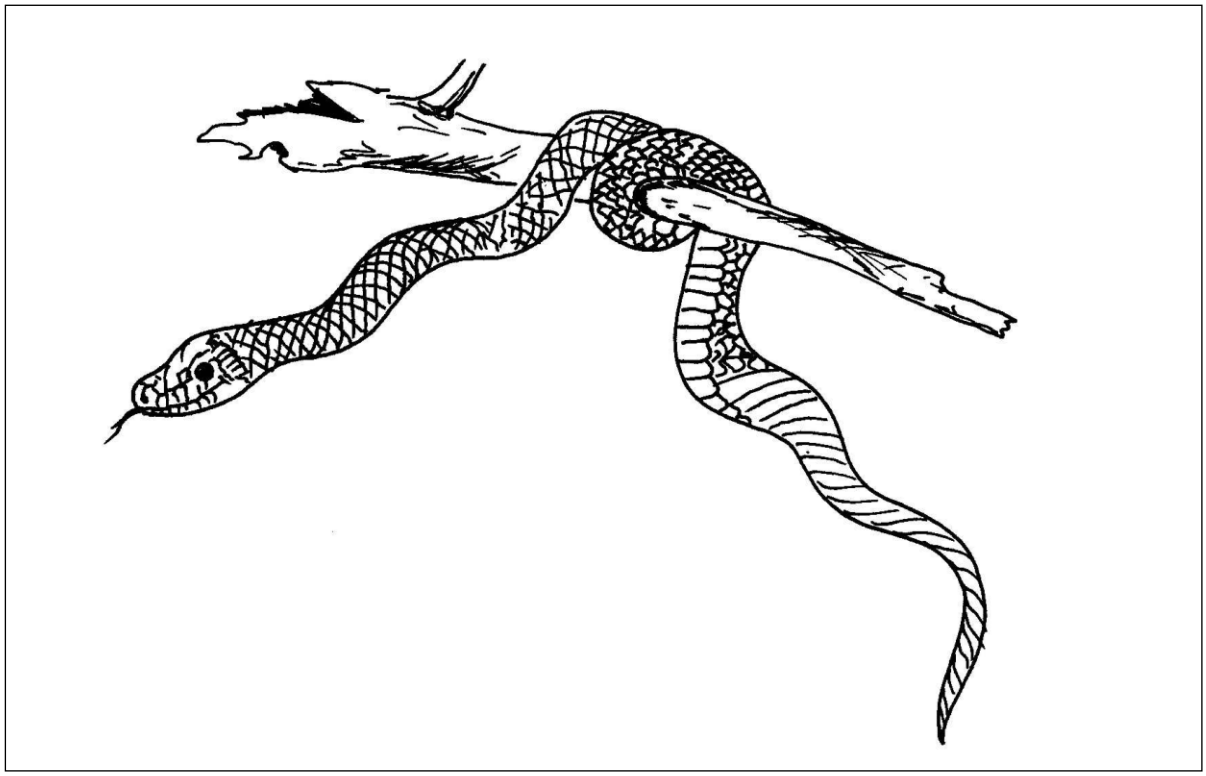
Mangrove Jack



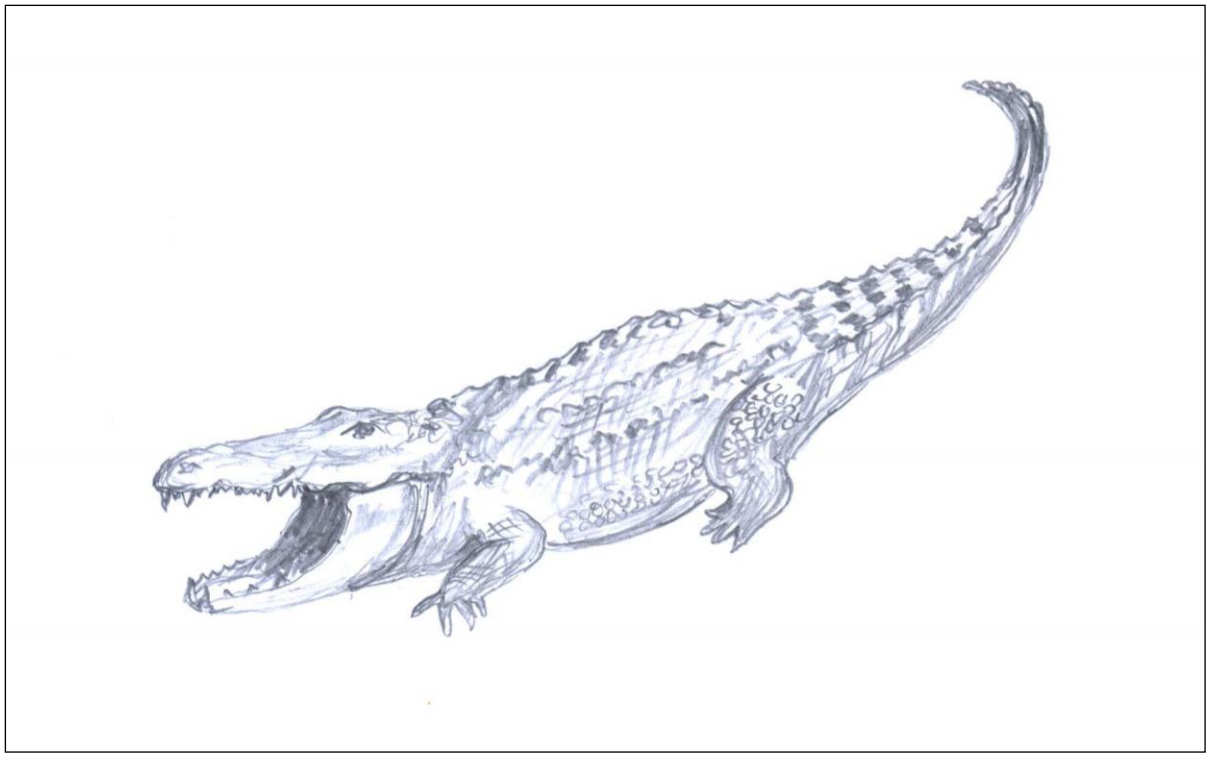
Stingray



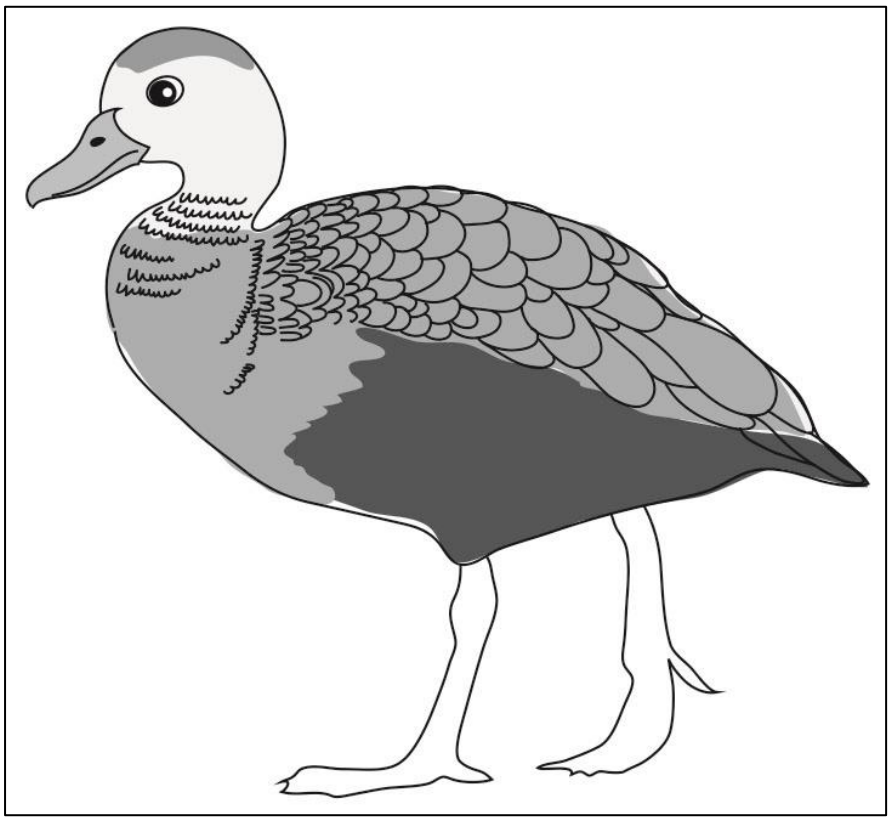
Green Turtle



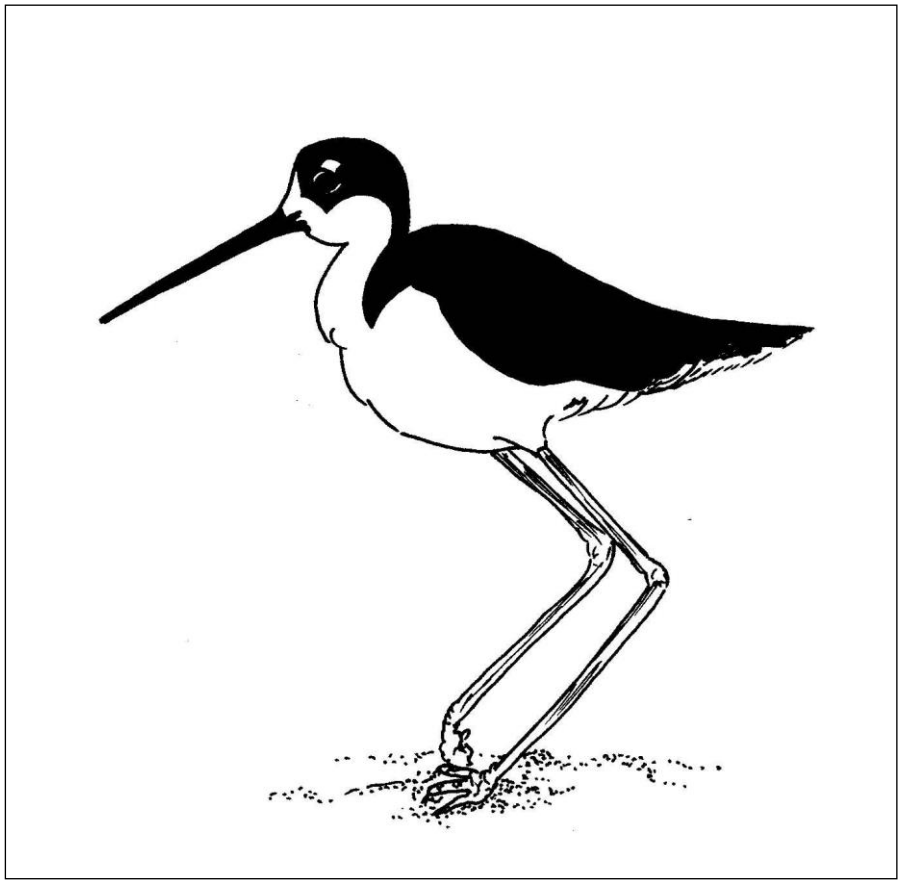
Snake



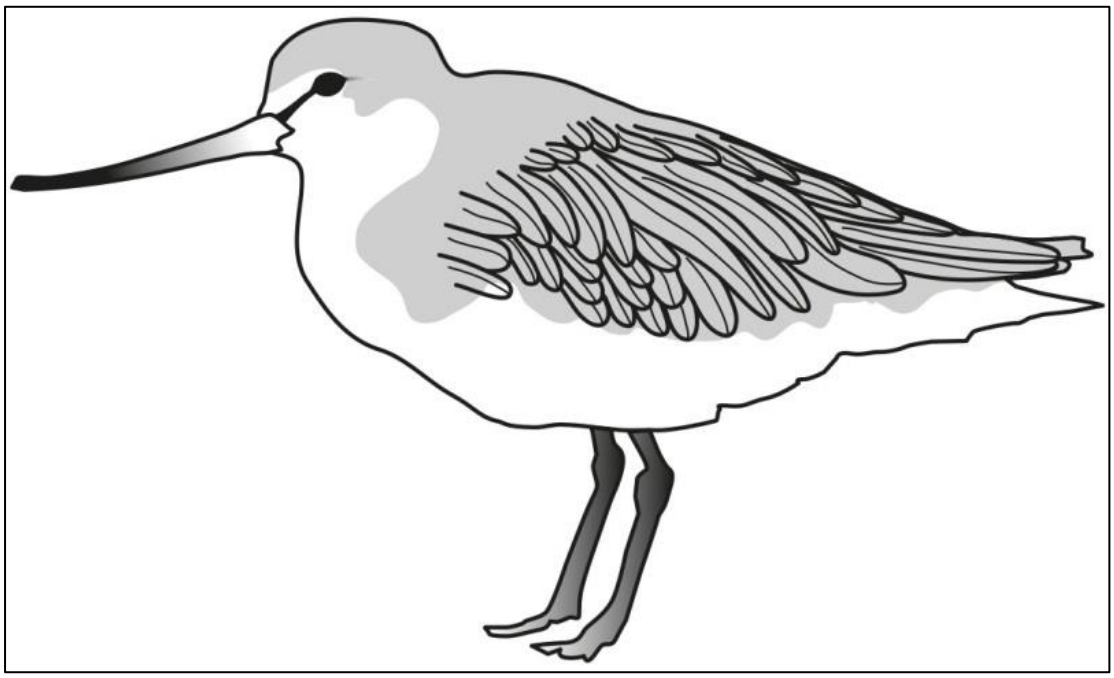
Crocodile



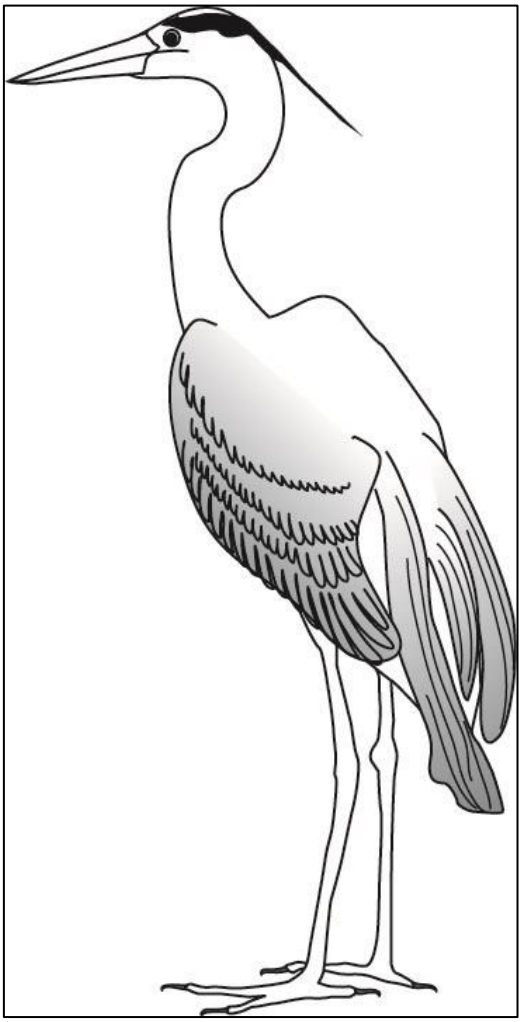
Duck



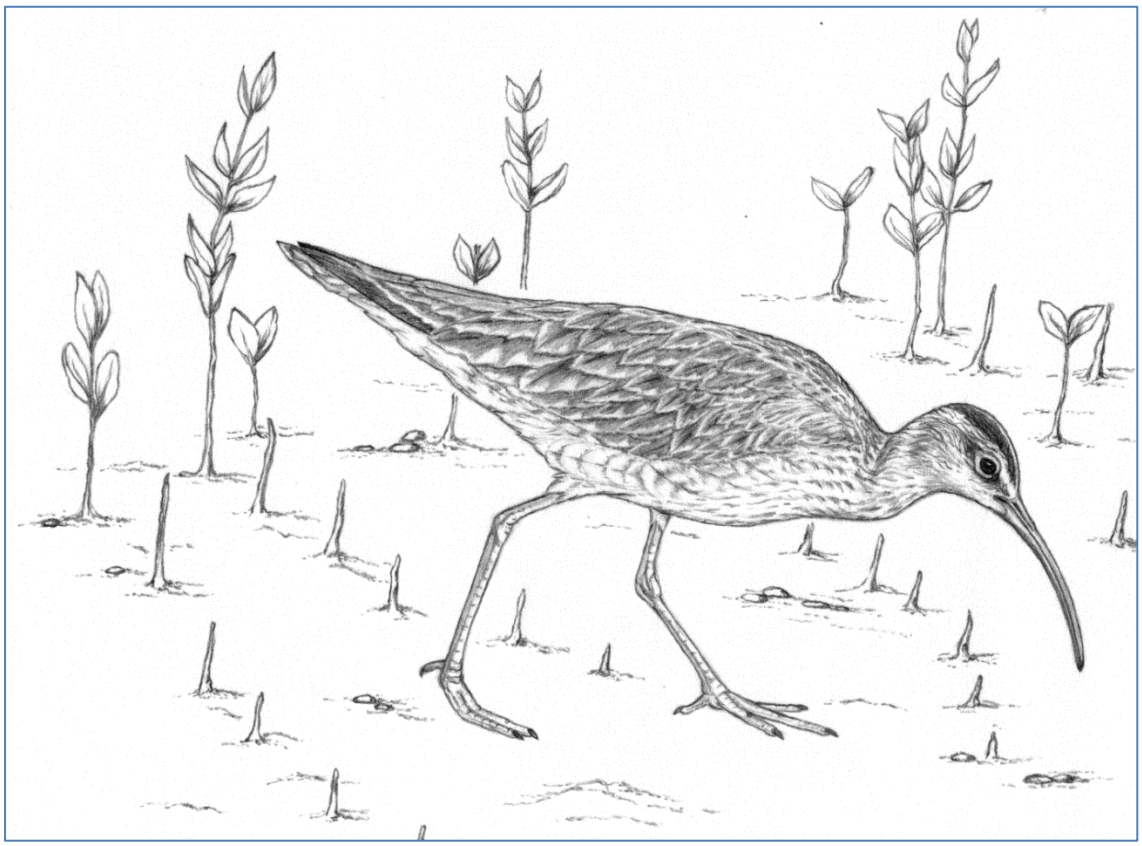
Black-winged Stilt



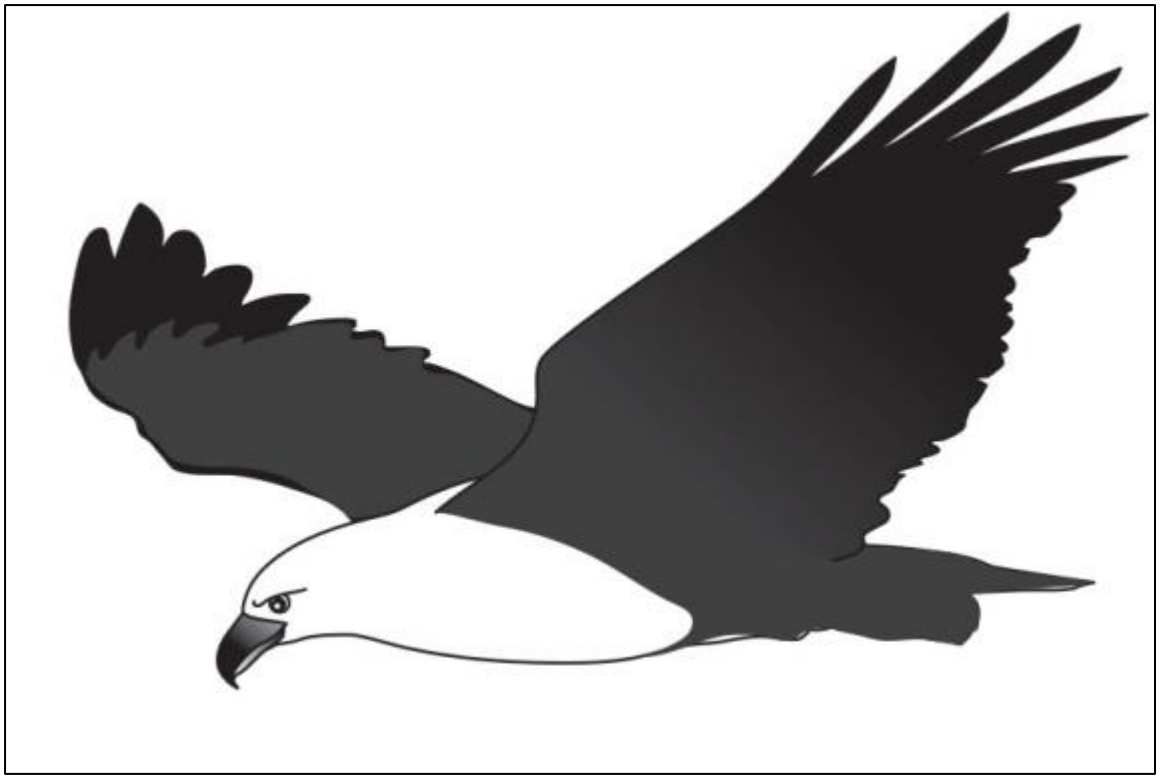
Terek Sandpiper



Heron



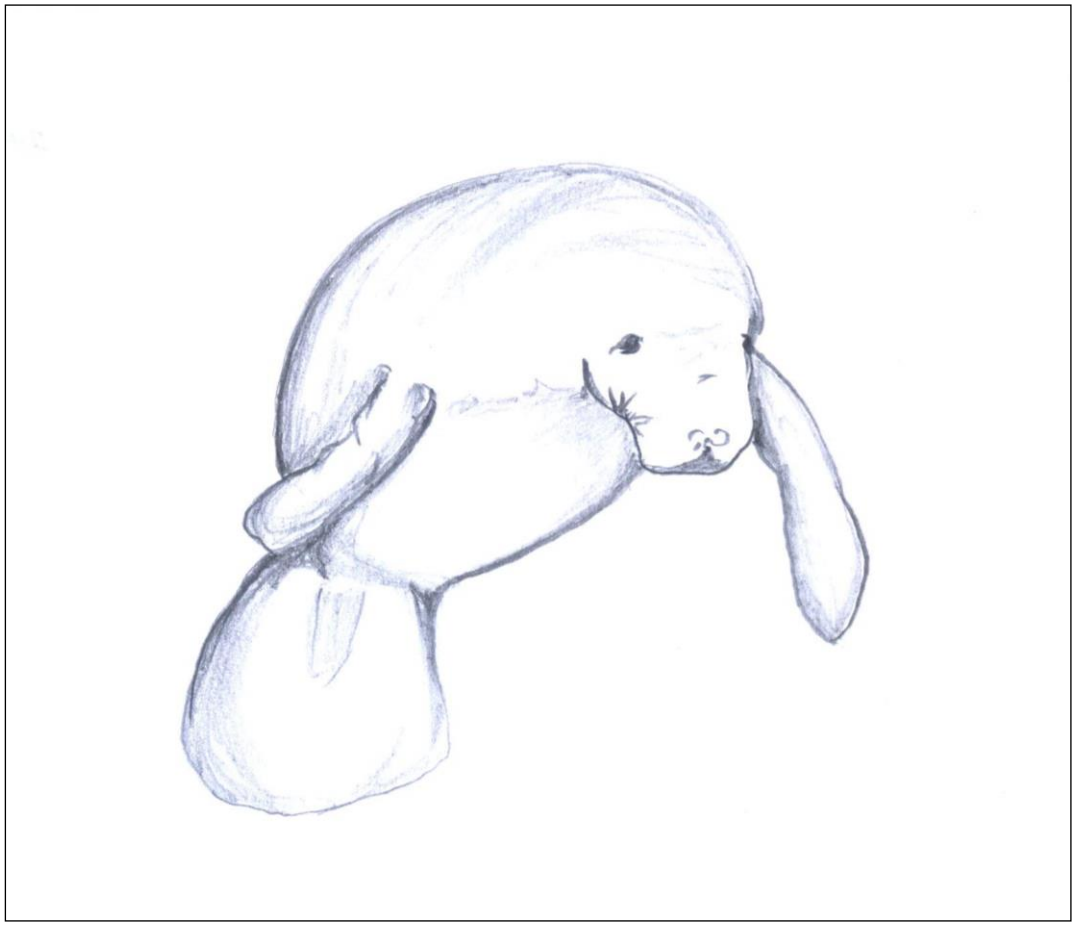
Whimbrel



White-bellied Sea Eagle

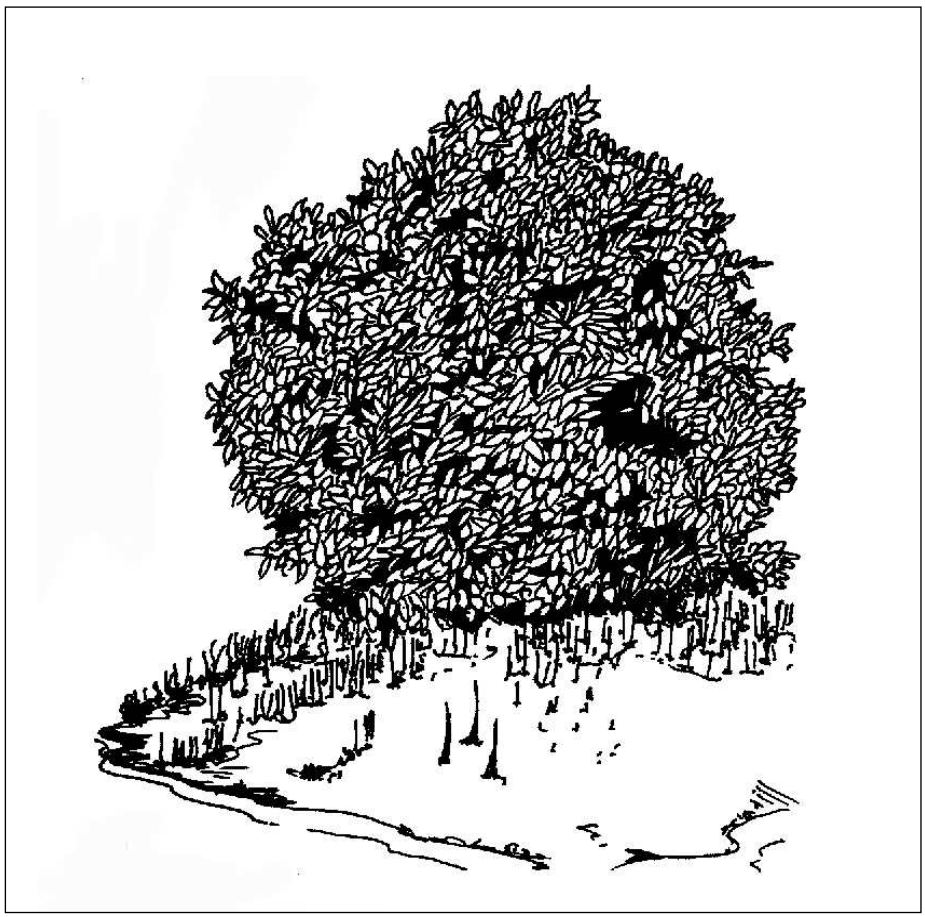
Flying Fox

Water Mouse



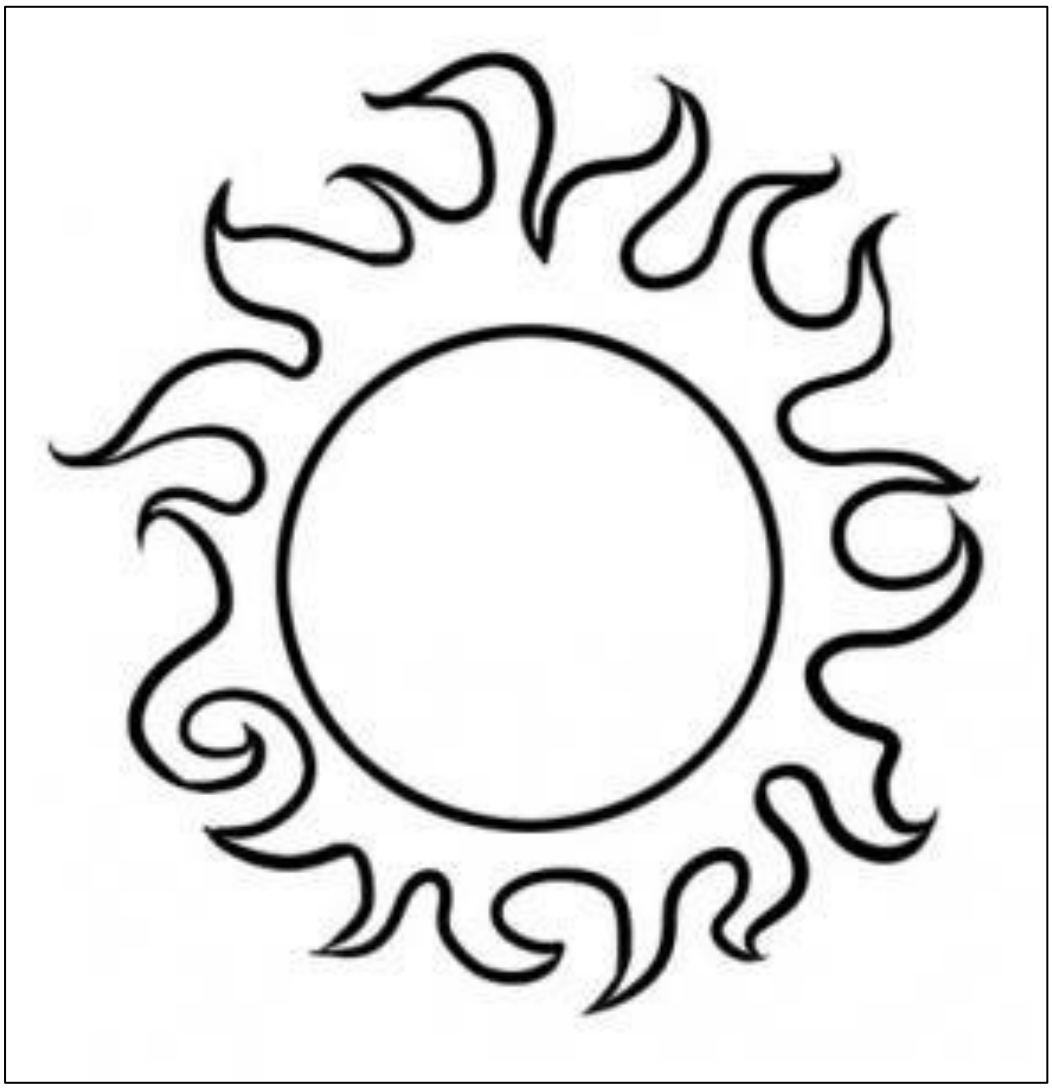
Dugong

Water



Grey Mangrove

Red Mangrove



Sun

Activity 2-D: Touchy-Feely Bag

Summary Mangrove ecosystems have a complex food web. Students will select an object and say whether it is found in the mangrove ecosystem.

Learning Objective
Students will be able to understand the basic functions of mangroves from the plants and animals that live there.
Age Levels
4–11
Subject Area
Science
Time
30–60 minutes

Materials
Large black bag that looks mysterious, although a cloth shopping bag will also work well.
Mature Red Mangrove seed (the entire seed)*
Feather
Shell (mangrove clam or any shell from a mangrove swamp)
Crab claw (preferably fiddler crab) or shell
Mangrove swamp mud (in a small plastic bag; smells like rotten eggs)
Leaves (Grey Mangrove if possible) *
Toy frog, fish, insect, duck, etc.
Bird's nest (only one that has fallen out of a tree)
Water in a small, squeezable container
Fish bones (remnants of a bird's lunch)
Grey Mangrove root
Samphire and saltmarsh plants*

*Note due to the Fisheries Act 1994 (Qld) it is not possible to remove marine plant material (plants or seeds) without a permit.

To obtain a research permit, you will need to complete the *Code for self-assessable development - Works for educational, research or monitoring purposes in a declared fish habitat area or involving removal, destruction or damage of marine plants – Code MP05* (http://www.daff.qld.gov.au/__data/assets/pdf_file/0007/59632/MP05-Research-2011.pdf).

Under the code, you are limited to collecting no more than two buckets each having a capacity of 10 litres of marine plants in one day. Once completed you fax or email the form to the District Officer of the nearest Queensland and Boating Fisheries Patrol and the Manager (Planning and Assessment) of the relevant regional Fisheries Facility at least 5 business days but not more than 20 business days before you need to collect your samples. Otherwise, please substitute resource materials such as photos for this activity.

Background Copy of mangrove ecosystem description from page 2-2 to 2-5, or illustrations in this section.

Procedure

1. The materials list offers a sample of mangrove wetland artefacts that you could put into the bag. Add other items or substitute when necessary. Keep these items in a safe place for future use, to lessen the impact on our environment of collecting natural items.

2. Introduce mangroves to your class if you haven't already done so. Call upon a volunteer to come to the front of the room.

3. Blindfold the student and have him or her reach into the bag and pull out one item. Or you may prefer to put an item in the student's hands. (This causes less disturbance to your collected items.) Have the volunteer hold the item up for the class to see. Remind the other students not to call out the name of the item.

4. While feeling the item and smelling it (if appropriate), the student describes how it feels and smells, then tries to guess what it is. If necessary, the class may help with clues.

5. Remove the blindfold so the student can see the object.

6. Repeat for several items and volunteers.

Discussion/Reflection
How are the different items in the mangrove ecosystem related to each other?
Can you think of other items you might find that would be related to each other.

Activity 2-E: Living Web

Summary Students will learn that mangrove ecosystems have a complex food web with many different kinds of wildlife and plants dependent on each other for food and shelter.

Learning Objectives
Students will be able to:
(a) describe a mangrove system food web; and
(b) predict changes in a mangrove system that will occur if one or more parts is removed.
Age Levels
6 and up
Subject Area
Science
Time
30 minutes
Materials
A ball of string or thick wool at least 20–30 m long
Picture cards from pages 2-21 to 2-42 (see following list) sun, water, phytoplankton, algae, mangrove trees (red and grey), detritus, dragonfly, Illidge's ant-blue butterfly, mosquito, copepod, amphipod, seed shrimp, ghost shrimp, crayfish, oyster, snail, fiddler crab, mud crab, lizard, frog, barramundi, permit, mangrove jack, sting ray, green turtle, crocodile, snake, duck, black-winged stilt, terek sandpiper, heron, whimbrel, white-bellied sea eagle, flying fox, water mouse and dugong,
Pictures of items can be photocopied from the drawings on pages 2-21 through 2-42.
If necessary, punch a hole in each and attach string or flagging tape long enough to hang the cards around the students' necks.
Master list for teacher.

Background Everything in a mangrove ecosystem is dependent on everything else—the baby fish that need the invertebrates as food and the mangrove tree roots as shelter; the fiddler crab that needs the mud as shelter and the leaves as food; the Heron that eats fish and invertebrates in the mud and water. And, of course, almost everything needs the sun and water for its survival. The removal or damage of any part of this ecosystem by pollution or any other form of destruction will have a profound effect on the rest of the creatures that live within it. The mangrove ecology description from page 2-2 to 2-5 shows these links in more detail.

Procedure

1. Attach a card representing a member of the mangrove ecosystem (including sun, water, sediment, phytoplankton, algae, detritus etc.) to each student.

2. Have the students stand in a small circle; the teacher stays outside the circle.

3. As the teacher calls out an item, the student holding the ball passes it to the student wearing the appropriate card. The teacher first call out "Sun" and passes the ball of string to the student wearing

the sun card. From then on, depending on age level and the particular class, either the teacher or the students can call out the names of the items in turn.

4. Someone who needs sun (all qualify) calls: “I’m Red Mangrove, and I need Sun.” Sun passes the ball of string to Red Mangrove, but still holds onto the end of it. Fiddler Crab might say “I need Red Mangrove leaves for food” and is passed the string while Red Mangrove and Sun still hold onto it . . . and so on. The reverse relationship might also be used; for example, Water might say, “I’m Water and Fiddler Crab needs me.”

5. Continue game, connecting all the correct items. (Try not to cross the centre of the circle too often, as it uses a lot of string.) The string should join all the students in a web.

6. Remove an item (a student drops the string and backs out of the circle) because of pollution or other harmful impact on the ecosystem. Remove other items that might be affected by the particular impact. Ask students to explain what is happening to a healthy food web. What is the result if an item within this web is removed—say Red Mangrove dies (Red Mangrove lets go the string)? How does it affect the species connected to it?

Discussion/Reflection

Ask students which items are producers (plants) and which are consumers.
Ask students to describe one food chain in the student-made web.
There are simple (a few items) and complex webs. Which webs are more able to handle losses of individual species?
Discuss why some items might be removed (for example, pollution, and development).

Activity 2-F: Mr. Frog's Dream

Summary Traditional story of a frog wanting to fly like a duck

Learning Objective
Students will learn about the role of animals in wetlands.
Age Levels
7–11
Subject Areas
English and Science
Time
30–60 minutes
Materials
Story

Background Not needed

Procedure
1. Read the story to the class. You can tell them the tale or have them participate by role-playing the different creatures in the tale.
2. List key science words (what students remember).

MR. FROG'S DREAM
(This story has been adapted from a Central American tale told by the Nicarao people of Nicaragua, and depicts what happens one spring time to the talkative, self-centred Mr. Frog. You can set it in any mangrove or other wetland near your own school. If you give Mr. Frog a strong local or regional accent, the story works even better!)

JUST DOWN THE ROAD, in a pond at the edge of Baldwin Swamp, lived a handsome young frog that had many talents. His name was Mr. Frog. Now, Mr. Frog wasn't just any old frog; he could jump further [have the students practise jumping], swim faster [have the students practise swimming], and sing louder [have the students practise "ribbetting"] than any other frog in the whole wetland. He was so highly admired that all the other frogs and the creatures that inhabited the pond called him MISTER Frog.

Now, Mr. Frog could also talk. Well, all frogs can talk a little, of course, but Mr. Frog talked all the time, loudly and unceasingly. And do you know what he talked about? Himself, and, of course, his own accomplishments, which he considered most spectacular. "I am such an incredible creature," he boasted. "I can jump higher, swim faster, and sing louder than any other frog in the whole world." Pretty soon all the rest of the creatures in the pond got pretty bored with Mr. Frog's constant boasting, and whenever they saw him coming, they would pretend they had something very important to do. They would dive to the bottom of the pond to look for something to eat, or hide behind a mangrove tree. They would do everything they could to avoid him. But Mr. Frog didn't care, because he had the birds to talk to. Every spring and fall, when the migrating shorebirds stopped off at the mangrove pond for refreshments, they would be entertained with Mr. Frog's

stories of his marvellous prowess and general brilliance. In fact, they encouraged his noisy boastings. Of course, they didn't have to listen for very long—just for a few days, while they ate lots of food to get them ready for the next portion of their flight. They thought Mr. Frog was a very amusing fellow.

Summer ended, and the coolness of winter began. The birds had all made it to their warm wintering grounds—some even stayed in Baldwin Swamp for the season. Mr. Frog, however, had slowed down, and was spending a lot of time dozing in the shade of the mangroves. He'd wake now and then for an occasional nibble when it rained, but most of the time he just snoozed. And as he snoozed, he had a wonderful dream: he dreamed that he could fly!

One morning in early springtime, Mr. Frog finally emerged from his winter lassitude and swam over to his favourite lily pad. There, he basked in the sunshine and thought about his dream. Normally, he would have been very chatty, and would have leaped around enthusiastically. But this morning he just sat quietly contemplating. And every so often he would examine himself in a very peculiar manner. He twisted and turned and tried to look at his feet, his legs, his back . . . but he just couldn't figure out how he was going to fly. He knew he wanted to go with the birds, flying to faraway lands and seeing strange and wonderful things, but how was he going to do it? However, he wasn't so deep in thought that he forgot to eat, and every so often his long, sticky tongue would dart out and zap a nice juicy insect.

Figure 18: Mr Frog dreams

Mr. Frog was so quiet that all the other creatures in the mangrove pond thought there was something wrong with him. So they gathered around and said, "Mr. Frog, Mr. Frog, what is the matter with you? You haven't said a word since you woke up. Are you sick or what?"

Well, now Mr. Frog had an audience, and he never could resist an audience. He drew himself up regally and said, "Well, you creatures of the pond, I have to tell you that I had the most amazing dream." "A dream, Mr. Frog?" said the creatures. "What kind of dream?"

"I dreamed," he said, "I dreamed . . . that I could FLY. Like a bird."

“Yeah, right,” said the creatures in the pond, “How?”

Mr. Frog hadn’t quite figured that out. So, he thought long and very, very hard, and then suddenly he knew. “Ah yes, of course, what a genius I am! Sometimes I astound myself with my own intelligence. Such a brilliant idea, so simple, yet absolutely brilliant. Ah, I have the brainpower of a million, zillion other creatures to have come up with such an incredible scheme!”

“Tell us how, Mr. Frog! How?” all the creatures chorused.

“No, no, no,” said Mr. Frog, “That’s for me to know, and you to find out.”

And with that he hopped over to the edge of the pond where Mrs. Swallow was resting in the mangrove trees. “Hey, Mrs. Swallow, good morning. Have you seen the ducks?”

“Sorry, Mr. Frog, I haven’t seen the ducks on this trip. Why don’t you try the sandpipers over on the edge of the pond? They just flew all the way down from Northern Siberia. Maybe they saw the ducks on their way here.”

“Okay,” said Mr. Frog, and swam over to where the sandpipers were busy pecking in the mud, looking for yummy bugs to eat. “Hey, Sandpipers, have you seen the ducks?” he asked. “Nope—sorry, Mr. Frog,” replied all the sandpipers in unison. “Haven’t seen the ducks. And we can’t talk to you right now—too hungry. Gotta eat, eat, eat before we head north. Try some of the other pond creatures; maybe they saw the ducks.”

So Mr. Frog tried some of the creatures he hadn’t asked before. But nobody had seen the ducks. And so, very disappointed, he made his way sadly back to his favourite lily pad and sat staring miserably into the water—when, all of a sudden: “Quack, quack, quack.” Down came two wild ducks and landed on the pond.

“Oh boy, oh boy,” exclaimed Mr. Frog, as he swam hurriedly over to where the ducks were quenching their thirst. “Ducks, am I ever glad to see you!”

“Mr. Frog,” said the ducks, “how nice to see you again. Did you have a good winter?”

“It was a wonderful winter,” burbled Mr. Frog. “I had the most incredible dream.” And he was so rude that he forgot to ask the ducks how their winter had been. But they didn’t mind, because they were used to Mr. Frog’s ways.

“A dream, Mr. Frog?” they asked. “What kind of dream?”

“I dreamed . . . ,” said Mr. Frog, “I dreamed that, with your help . . . I could fly.”

“Oh, I don’t think so, Mr. Frog,” said the ducks. “No, no, no. This sounds like another crazy Mr. Frog scheme to us. But, even if we could help you fly, where would you want us to fly you to?”

“I would love to fly with you to your summer home, where you make your nests.”

“Oh, I don’t think so, Mr. Frog,” said the ducks. “No, no, no. That would be much too far to fly—even if you do have some crazy scheme that works. The best we could do is fly you around the pond. Okay?”

Well, Mr. Frog was really disappointed, as he'd wanted to fly to faraway lands. But he didn't dare say anything, just in case the ducks changed their minds. "Oh, no, that would be wonderful," he chattered excitedly. "That would be absolutely marvellous. I would love to fly round the pond."

"Okay, then, Mr. Frog, tell us about this idea of yours," said the ducks.

"Well," said Mr. Frog, nervously, "I will go to the edge of the pond, break off a reed, and bring it back to you. You will hold one end in each of your beaks. I will hold the middle in my mouth. Together we will flap across the pond . . . and FLY!"

"Oh, I don't think so, Mr. Frog," said the ducks. "No, no. no. Really, where do you get these crazy ideas? A reed in our beaks? Whatever next? But, you know, we don't have anything else to do right now, so, what the heck, why don't we give it a try? Off you go and get your reed."

So Mr. Frog swam happily to the edge of the pond, found the perfect reed, and swam back with it in his mouth. He gave one end to each of the ducks to carry in their beaks, and was about to grab the middle in his mouth when the oldest and wisest duck said, "Now, Mr. Frog, a word of warning, and a word of advice. And we know this next bit will be very hard for you. Even supposing this crazy scheme of yours works—and we're not convinced it will—under no circumstances must you open…your…mouth."

"Moi? Open my mouth? Oh, you make a silly joke, yes? I would never do anything so stupid," protested Mr. Frog.

"Okay, Mr. Frog," said the ducks, "Don't say we didn't warn you."

With that, the ducks grabbed the two ends of the reed in their beaks, and Mr. Frog took the middle in his mouth. Together they splashed across the pond, and pretty soon they were airborne. This was incredible. Mr. Frog had never been so happy. His dream had come true—he was actually flying. He looked down at the pond, and all the creatures there were looking up at him with admiration. Even the butterflies flitting by said, "Mr. Frog, Mr. Frog! You're flying, just like us. Oooh!" And Mr. Frog began to think that maybe the ducks would change their minds, and fly him north. But then he looked at the ducks—and, being Mr. Frog, he got a wee bit jealous because they were so pleased with their performance. But he didn't dare do anything about it.

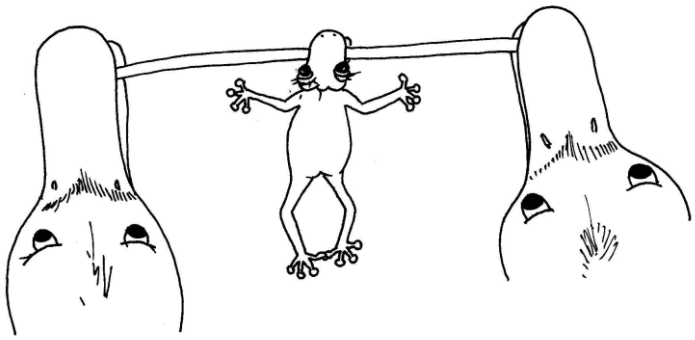


Figure 19: Mr Frog flying

The ducks started to really get into the whole project. They flew around the pond faster and faster. They boldly swooped lower, then higher, and then down they went. Round and round. Up and down. Faster and faster, until they were going so fast that Mr. Frog began to get dizzy—so dizzy that he couldn't think.

"Stop!" he yelled. "Stop!"

And with that, he let go the reed and fell from the sky.

A gasp of horror came from the crowd below him, and they scattered in every direction to take cover.

With a mighty splash, Mr. Frog hit the water, and sank, stunned, to the bottom.

After a little while, he made his way woozily to the surface. His ego was totally deflated. So he found his favourite lily pad and sat there, staring miserably into the water. When the pond grew calm again, all the creatures gathered round him. His youngest cousin, who was the bravest frog of all (after Mr. Frog) timidly asked, "Mr. Frog, Mr. Frog, what happened? Tell us what happened."

"I do not wish to speak of it," said Mr. Frog. "Never again shall words of my dream or this event pass my lips. And I don't want any of you," he yelled angrily at the pond creatures, "to ever, ever, ever, speak of this again. Okay?"

"Okay," they said.

And from that day 'til this, nobody ever spoke of Mr. Frog's dream again.

Activity 2-G: The Story of the Rainbow Serpent

Summary Indigenous perspectives

Learning Objectives
Students will be able to:
(a) Identify some of the mangrove animals they have been learning about;
(b) Identify at least one of the Indigenous methods of capturing fish
(c) The importance of sharing a resource in Aboriginal societies; and
(c) Enjoy the story.
Age Levels
4–11
Subject Areas
English, Sustainability and Aboriginal and Torres Strait Islander histories and cultures
Time
30–60 minutes
Materials
Story

Background Find out some more about the Rainbow Serpent and its significance in Aboriginal society.

Aboriginal people believe that the Rainbow Serpent created the Earth during the Dreamtime. It is named for the connection between the shape of a rainbow and the shape of a snake. When the rainbow is seen in the sky, it is said to be the Rainbow Serpent moving from one waterhole to another, and this concept was used to explain why some waterholes never dried up when drought struck. There are many names and stories associated with the serpent, all of which communicate the significance and power of this being within Aboriginal societies. It is viewed as a giver of life, through its association with water, but can be a destructive force if angry. The Rainbow Serpent is one of the oldest continuing beliefs in the world and continues to be a cultural influence today.

Procedure
1. Read the story.
2. Have students illustrate the story.
3. Discuss in the class some of the lessons contained in the story and why they might have been important in Aboriginal society, why those lessons are still important today and introduce the concept of sustainability.

The Story of the Rainbow Serpent

There were once two young fellas who were heading down to their local waterhole with a big bundle of bark under their arm. As they headed down to the waterhole, they passed an old man sitting under a tree.

“Where are you going?’ asked the man.

"We're going to poison the river and get some fish," replied the two young men. The old man asked the two younger men if they could bring just enough back for him and his family.

When the young men got to the river, they prepared the bark to make the sap run. They jumped in the water, making sure there were no crocodiles around and began to distribute the sap around the river.

A couple of hours later the men began to notice the first ripples in the river and saw the fish floating to the top of the water. They slipped into the water and took enough fish for themselves and the old man, however instead of stopping there and leaving the rest of the fish for others, they continued to take the fish and throw them on the bank to rot.

Figure 20: Two young men go fishing and learn an invaluable lesson from Yamini

The Rainbow Serpent, Yamini, was watching the men from the far side of the waterhole and became very angry about their actions, as they killed and discarded of the fish for no reason. Yamini decided to set a big barramundi in the middle of the river and when the men went to get the barramundi Yamini grabbed them, swallowed them, and disappeared back into the waterhole.

It was getting late and the old man sitting under the tree had still not heard from the two young men. When he got down to the river, he saw all of the dead fish on the banks and the water was boiling over. The old man began to dance around the water and as he danced, he noticed a tunnel where the Rainbow Serpent had left the waterhole.

The old man followed the tunnel until he came to a large area of anthill plains where he caught up with the Rainbow Serpent. Using his spear, he jabbed Yamini who reared up out of the ground and spat the two men's bodies out, covered in slime. The old man covered the two young men in sand and propped them up against an anthill. As the ants crawled up the men's bodies and started to bite them, they began to move and the breath of life was put back into them.

By this time, the rest of the tribe had seen what happened at the riverbank and they too followed the Rainbow Serpent's trail. They arrived just in time to hear the old man telling the two younger men about how wrong it was to be so greedy and throw all of the fish on the bank to rot. "Your greediness is what upset the Rainbow Serpent," the old man said.

From that day on, and still today, when an Indigenous Australian who is familiar with the story of Yamini goes near a waterhole, they make sure they only take enough fish to feed themselves and their family, as they know the Rainbow Serpent is watching.

The lessons learnt by the two young men in the Rainbow Serpent story have helped today's Indigenous Australians to understand the values of wetlands and they respect the waterhole for the precious food, resources and cultural significance that it offers.

Discussion / reflection:

1. Why do you think the old man asked the young men to bring back some fish for him and his family? *[Respect for elders is very important in Aboriginal society].*
2. How did the young men kill the fish in the river? *[They used a plant sap that stunned the fish. The Australian Indigo bush Indigofera australis is one of several bushes or trees used by Aboriginals to stun fish. The poison, obtained by crushing the roots of the plant affects the fish but not the people eating the fish.]*
3. Why do you think it would be important not to kill all the fish in the river? *[If all the fish were killed there would be no food for next time. The Aboriginal people collected all their food from the environment around them, if there was no more food, they would have to move to a new area. They carefully managed their food supplies and even burned the grasslands to encourage the growth of grass and young plants to bring in food like kangaroos and wallabies. The Aboriginal people knew it was important to live within the food that they had available…They couldn't just nip down to the local supermarket because they'd run out of cereal in the morning.]*
4. What lessons did Yamini teach the young men? *[Sharing, take only what you need and respect for their natural environment and the food that it provides].*

Activity 2-H: Crusty the Fiddler Crab

Summary Story of a fictional Fiddler Crab's adventure.

Learning Objectives
Students will be able to:
(a) Identify some mangrove animals and learn about moulting;
(b) Build a food web; and
(c) Enjoy the story.
Age Levels
4–11
Subject Areas
Science, English and The Arts
Time
30–60 minutes
Materials
Story
Handout: illustration of Fiddler Crab on page 2-55

Background Fiddler crab data from the introduction to this section.

Procedure
1. Preparation: Ask students to sketch a Fiddler Crab (or show them an illustration of a fiddler crab from page 2-55).
2. Read the story.
3. Have students illustrate the story.

Discussion/Reflection
Create a food web for the story.
What sort of animals moult? *[Those with external skeletons.]*
What is the difference between the way crabs grow bigger and the way you grow bigger?
Extension: After the story, have students label on the drawing the various parts of a fiddler crab.
Ask students what other adventures Crusty might have.

THE ADVENTURES OF CRUSTY
(Begin by explaining that the students will be involved in an adventure. Introduce the main character of this adventure by displaying a picture of a fiddler crab, and tell the students that the main character of the story is a fiddler crab called Crusty. Ask the students, "Can you guess where this story will take place?" *[Answer: The mangroves and seashore.]*
Students could also role-play how crabs move, simulating how and what parts are used to feed and protect themselves. They could also "become" moulting crabs, escaping their too-small outer covering.

Have students assume various roles: Crusty, the gull, the waves, etc. When you reach the sounds, have the students give the sound effects and also role-play where called for—pinching, scrambling sideways, tumbling, shedding shell of crab; screeching and flapping of gull; whoosh and thundering of ocean waves.

CRUSTY IS A FIDDLER CRAB who lives in a burrow in the mangroves on the edge of the ocean. Can you guess why his name is Crusty? *[He has a hard, crusty outer covering.]* Crusty also has a pair of large pincers, one much bigger than the other. How do the pincers of a crab work? *[The powerful pincers open and close like a pair of pliers, and are often used for gripping and crunching.]*

Crusty awoke one morning to the cries of a gull overhead: "SCREEETCH, SCREEETCH." He stuck his eyes out from underneath his favourite mangrove root. Crusty's eyes, like those of all fiddler crabs, are on stalks and move like a computer-game joystick so he can see all around. Crusty waved his big claw around, but the gull was too busy to notice him. Crusty watched the gull drop a clam from the sky onto the rocky beach nearby. The gull cried out louder "SCREEETCH, SCREEETCH!" The clam was now out of the seagull's reach.

Moving sideways, Crusty scrambled out of the shelter of the mangroves and along the sandy beach towards the clam. He was curious to see what had happened to it. Crusty seldom went far from his mangrove home, where all his crab cousins lived. Before he reached the clam, he found himself travelling over a pile of dead seaweed. Feeling hungry, he cut up the tasty seaweed with his pincers and moved it to the six pairs of movable mouth parts on the underside of his shell. Crusty sat enjoying a most delicious breakfast. As Crusty munched, he noticed a rumble and began to feel vibrations on the sand. The waves came closer and closer. He had not paid much attention to how far down the beach he had travelled, and now, as the tide came in . . . WHOOSH!

A large wave rolled in and picked up Crusty. It tumbled him over and over in the foamy water and then dropped him far down the shore, past the sand and in the rocks where the clam had fallen.

As Crusty picked himself up to begin his walk back up the beach, he discovered that one of his walking legs was missing. Do you know how many walking legs a crab has? *[Eight.]* Crusty was not worried because he could still walk, and he knew he would eventually grow another leg. When a crab's tough outer covering becomes too small, the back splits open. The back end of the crab's body pops out first. Then the crab pulls and tugs each of its walking legs and pincers out of the old covering like a person taking off a coat and gloves. The crab still has a covering on its body, but its new covering is soft. The crab pumps it full of water to enlarge it so the crab can continue to grow. The soft carapace absorbs chemicals from the sea and gets hard in a couple of days. The shedding of the covering is called moulting. Can you name other animals that moult their outer covering? *[Grasshoppers, cockroaches, some other insects, and snakes.]* Crusty knew that with each moult to follow, he would grow some more of the new leg to replace the one he lost when the big wave hit. Eventually, he would have a complete new walking leg.

Crusty wondered where the big wave had dumped him. Looking up, he realized he was at the bottom of a deep pool. He saw the steep sides lined with shiny green and brown seaweed—alive,

not like the dead seaweed he had just eaten. Can you guess where Crusty had landed on the beach? *[A tide pool.]*

Crusty had never ventured this far from home. When he saw two large eyes staring at him, he knew why! The eyes belonged to a creature with a big head and bigger mouth, and it was swimming up fast and very fiercely. Can you guess what creature was eyeing Crusty? *[A large eel.]*

Crusty crawled up and out of the tide pool and scurried sideways up the beach as fast as his little legs could carry him. Finally he was greeted by his crab cousins, waving their pincers from their burrows under the mangrove trees. He was home at last.

CRUSTY THE FIDDLER CRAB

WHY BIRD-WATCHING?

Bird-watching, or birding, is an ideal way for young people to gain an understanding about wildlife and the world of nature. Many activities can begin in the classroom, and field trips using natural mangroves (because there are so many different species to be found in wetlands) are excellent places for students to learn about birds, habitats, ecosystems, and how to care for the environment.

In the following activities, students will sharpen their observation skills as they learn the basics of bird identification. They learn to use size, shape, sound, behaviour, and field marks to tell the difference between ducks, herons, shorebirds, songbirds, and others.

We have included activities on bird identification that need to be supplemented with information about the birds found in your area. PowerPoint presentations (such as those available through the Queensland Wader Study Group Shorebird Identification Kit for Children), the Shorebirds 2020 Oz Shorebirds app (for iPhone, iPod and Android) and colour photographs are effective tools to help students learn about the birds they might see on the field trip. Local Coastcare group, Natural Resource management groups and local birding clubs in your area will almost certainly be willing to give a presentation on local species of birds. Ask your students if they can identify any birds, and if so, what the local names for them are.

Taking students birding may also help to build a new generation of stewards for our environment. If you instil in children a basic understanding of nature, they will grow up to be more environmentally sensitive and responsible adults.

Activity 2-I: Feather Features

Summary Students will learn how birds' feathers enable them to fly and keep warm.

Learning Objectives
Students will be able to:
(a) Describe two types of feathers
(b) Describe parts of feathers and how birds keep them clean
Age Levels
6 and up
Subject Area
Science
Time
60 minutes
Materials
Collection of contour and down feathers
Paper and pencils
Small amount of salad oil
An overhead projector (if available)
Magnifying lenses (if available)
Handout: copy of page 2-59 illustrating feathers

Background What makes birds different from all other animals is that they have feathers. Other animals— bats /flying foxes, and many kinds of insects—can fly; reptiles, fish, insects, and some mammals (platypus) lay eggs; but only birds have feathers.

Feathers have many functions: they enable a bird to fly, keep warm and dry, hide from predators, and communicate with other birds.

There are two main types of feathers: **contour feathers** and **down feathers**. Contour feathers are the most common feathers. They cover the body, wings, and tail. They are smooth and firm, give a bird its smooth, sleek shape, and protect the bird from heat and cold. They are waterproof, serving as a bird's raincoat. Flight feathers are special contour feathers on the wings that are shaped to help in flight. Down feathers are fluffy and soft. They lie under the contour feathers, close to the bird's skin, and help to keep the bird warm by trapping a layer of air next to its body. They act like a bird's down jacket. The softest, fluffiest feathers, the ones used by humans to stuff warm jackets and quilts, grow most thickly on birds that live in cold climates, especially waterbirds such as ducks, geese, and penguins.

Birds spend a lot of time every day preening—cleaning, arranging, and oiling their feathers with their bill. Preening is essential for birds. If feathers are not kept in shape, they lose their ability to keep the bird warm and dry. Most birds have a "preen gland" on the rump at the base of the upper tail feathers. Using its bill, the bird squeezes oil from this gland and then works it into the feathers,

drawing one feather after another through the clamped bill. The oil cleans and conditions the feathers and makes them waterproof. It is also thought to inhibit the growth of fungi and bacteria.

Procedure

1. Several days before the class, have students collect and bring in feathers. It doesn't matter if these come from wild birds or from chickens—feathers are feathers!

2. Let students explore how they can "ziplock" the feathers together by running their fingers along them. Compare flight/contour feathers with down feathers.

3. Sketch the features of the feathers and label the shaft (the hard centre tube that is hollow at the base) and the vane. (If the feather has one vane wider than the other, it is a flight feather from the bird's wing or tail. The vanes of regular contour feathers, which cover the body, are the same width on each side of the shaft).

4. Observe a feather projected to illustrate the fine structuring and barbs. Have the students draw a picture of each projected feather.

5. Flap the down and contour feathers up and down. Describe how each feels.

6. Dip the contour feathers into the salad oil. Run water over them.

Discussion/Reflection

How do barbs help a messed-up feather?

What is the difference between the flight/contour and down feathers?

Which feather holds up better in the wind?

Which feather makes a better pillow?

How do the feathers protect against water (rain, snow, etc.)?

Figure 21: Down Feather

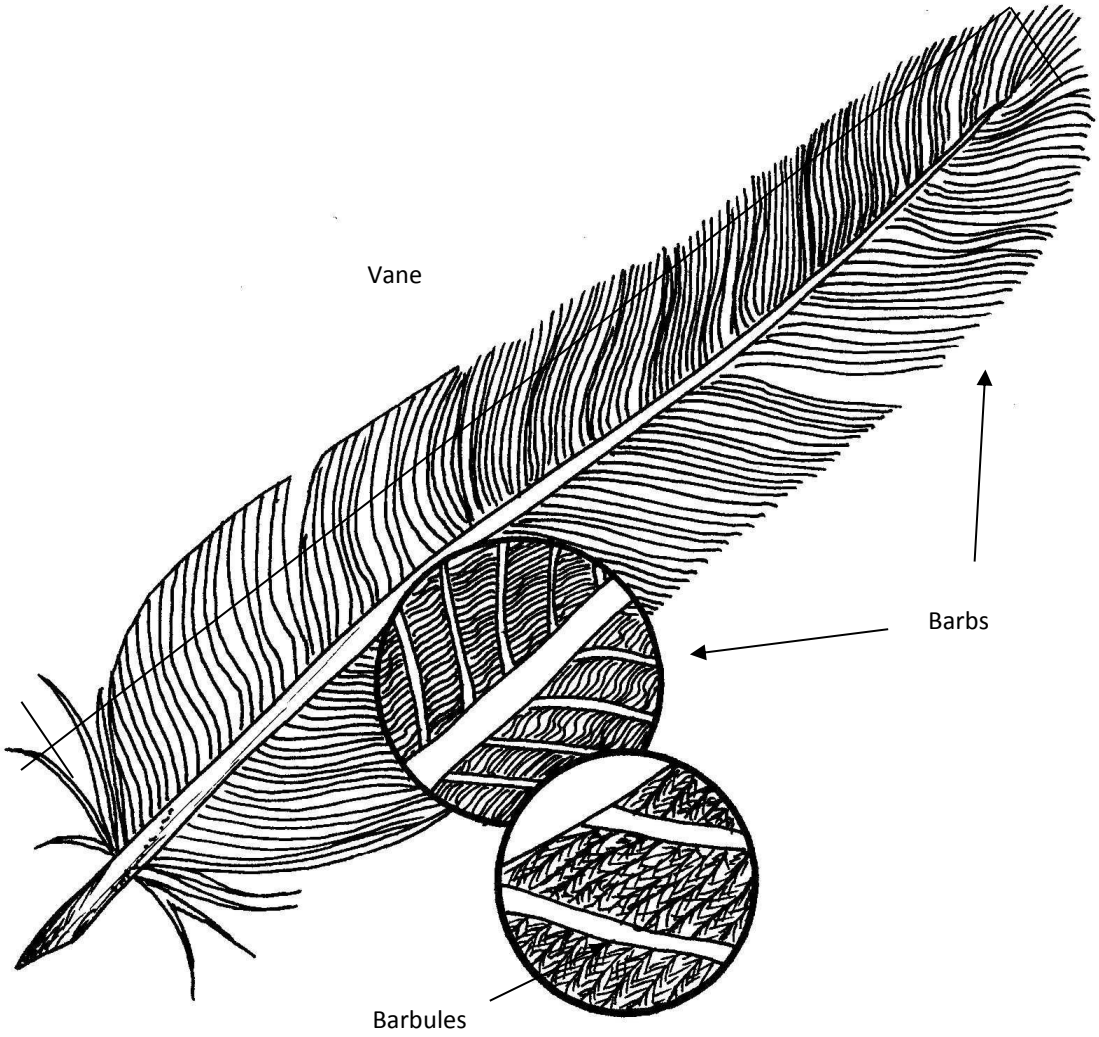


Figure 22: Feather features

Activity 2-J: Birds in Flight

Summary Students will learn how birds' unique bone structure enables them to fly.

Learning Objectives
Students will be able to:
(a) Describe the differences and similarities between the human arm and the bird wing; and
(b) Simulate bird flight patterns.
Age Levels
6 and up (terminology is for older students)
Subject Areas
Science, art
Time
60 minutes
Materials
Handouts: copies of page 2-61 illustrating wing and arm structure
Copies of "Flappers" from page 2-62
Eight index cards (5x10cm) per person
Scissors
Glue
Staplers
One large sheet of paper for each student

Background A bird's wing is similar to our arm. Both birds and humans have an upper arm connected to the shoulder, an elbow that connects the upper arm to the forearm, and a wrist that connects the forearm to the hand. The upper arm and forearm make up the bird's inner wing, and the rest of the wing is the hand section. Gliding birds such as gulls, frigatebirds and raptors like eagles have long inner wings compared to their small hand sections. The large inner wing provides the lift they need to soar. But flapping birds, such as finches, have smaller inner wings and long hand sections.

In flying, the wings perform two different functions. The arching inner wing stays steady, like the wing of a plane, while the "hand" feathers rotate, pushing ahead with every down-and-back stroke, much like swimmer's hands stroking through water. This pulls the bird forward and draws air over the "arm" section of the wing. The feathers of the arm section form a curved arch. As the air moves over the arch, it creates lift over the upper section of the wing, and the bird rises. Sustained flight is the result of rowing forward to achieve lift on the arched feathers.

Procedure
1. Working in teams, students will extend their arms and locate the following bones and structures shown on the handout: humerous, radius, ulna, wrist, and fingers.
2. Study the handout and have students orally identify the comparable parts on a bird wing and their own arms.
3. Give each student a copy of the "Flappers" page and a set of index cards.

4. Have the students cut each index card exactly in half so each has 16 smaller cards. (All cards should be exactly the same size.)
5. Have the students cut out the pictures from “Flappers” and glue one on the bottom right-hand corner of each card. Be sure to keep the pictures in the same order in which they appear on the sheet.
6. Arrange the cards one on top of the other, starting with picture #16 on the bottom and ending with picture #1 on top.
7. Staple them across the side, as shown.
8. Flip through the cards and make the bird fly.

Discussion/Reflection
Ask each student to move his or her arms like a bird. Discuss how a real flight pattern is different from “Flappers”.

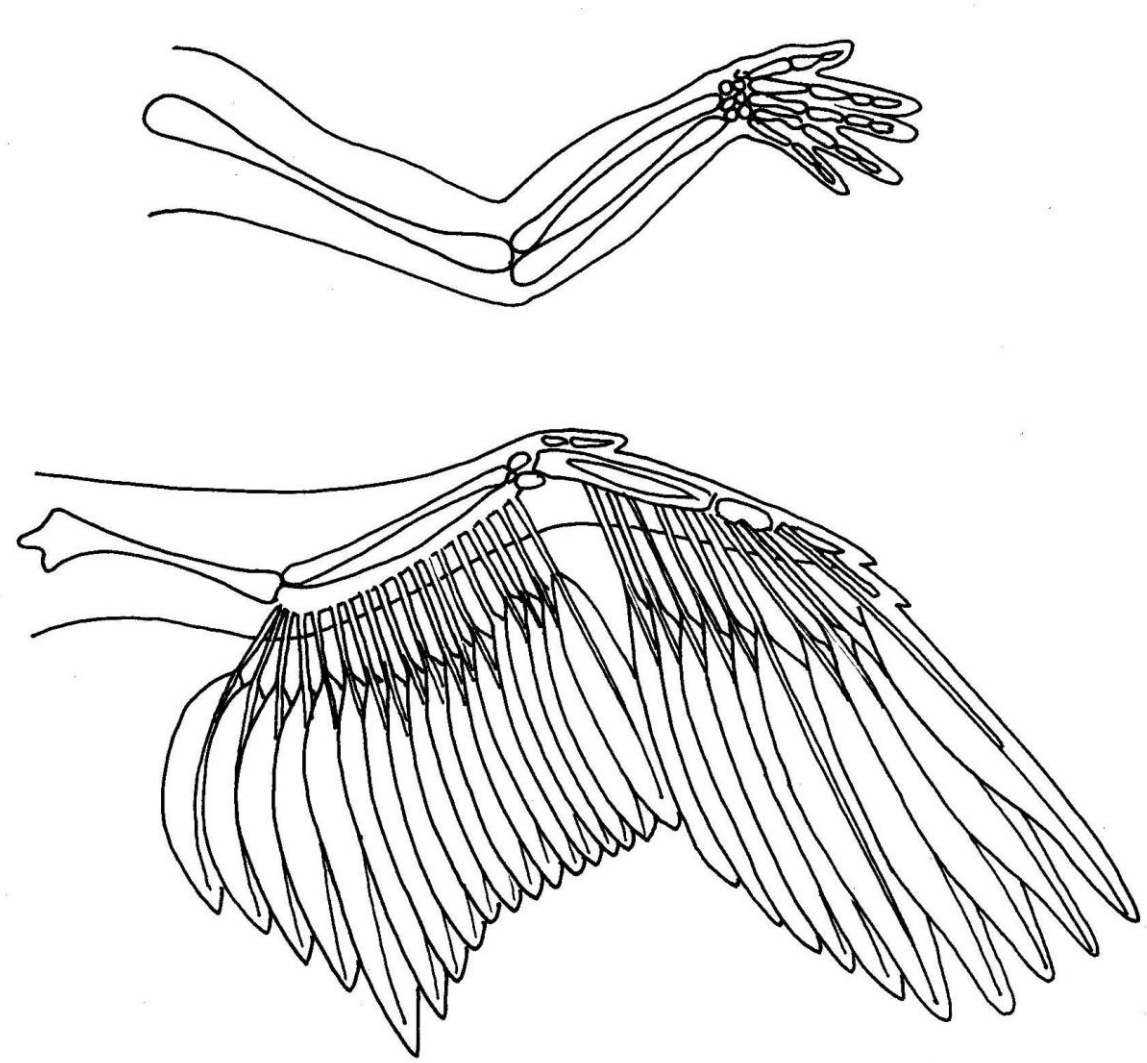


Figure 23: Bones and feathers - Human arm and bird wing

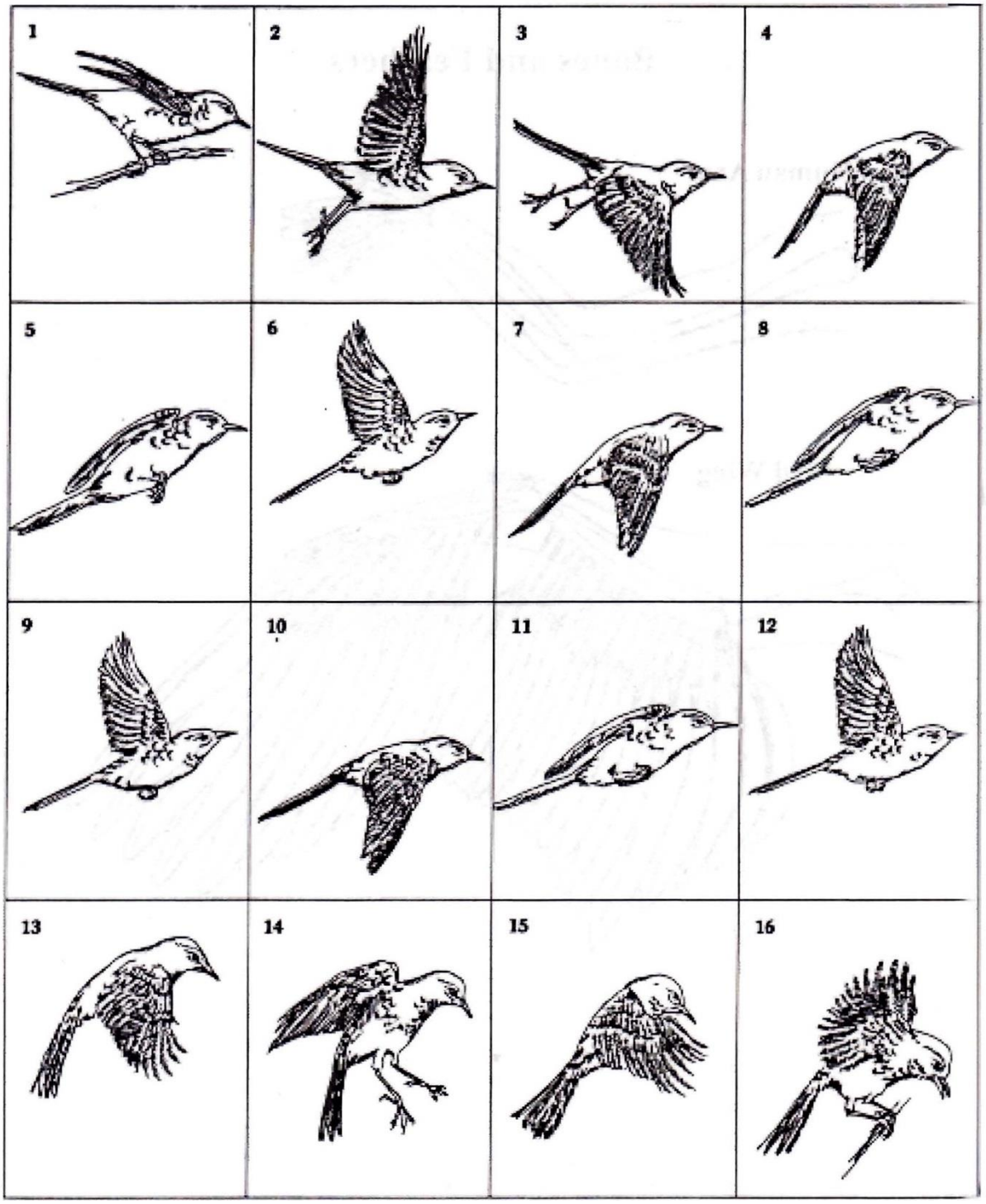


Figure 24: Flappers

Activity 2-K: Fill the Bill

Summary Each type of bird has a special beak and tongue adapted to eating a certain kind of food. In this demonstration, students can find out which beaks are best for tearing, scooping, stabbing, sucking, cracking, and picking up by going to different food stations that you have set up and deciding which tools go with which type of food.

Learning Objectives
Students will be able to:
(a) Describe eight different kinds of beak and how each is adapted to feed on different kinds of food; and
(b) Relate this adaptation to the birds' survival in wetlands.
Age Levels
7 and up
Subject Area
Science (Adaptations)
Time
2 hours

Materials
Copies of "Fill the Bill Matching Game" from page 2-67
Two aquariums or other large clear containers
Large saucepan
Tall, narrow vase, bottle, or glass jar
Small log or large tree branch
Bowl
Long piece of string
Foods
• Raw rice
• Rice cereal (like Rice Bubbles)
• Plastic fishing worms or 7cm pieces of string
• Popcorn or tiny marshmallows
• Styrofoam chunks or pieces
• Oatmeal (oats/porridge)
• Walnuts (whole) or other nuts
• Grapes or stemmed cherries hanging from a string
Beaks (tools)
• Chopsticks, toothpicks, or small twigs (in pairs)
• Pliers or nutcrackers
• Tweezers
• Strainers
• Small fishnets or envelopes
• Bamboo skewers
• Eyedroppers or straws

• Slotted spoons or large scoops
• Straw

Background Different kinds of birds have specially adapted beaks and tongues designed for eating certain types of food. This adaptation enables each species of bird to survive in its habitat, eating the food provided there. The following birds are found in the Queensland and live in a variety of habitats.

Ibis, oystercatchers, sandpipers, godwits, Eastern Curlews and stilts have long beaks that they use to probe for worms, crustaceans, and other small creatures in mud and water.

Pelicans and spoonbills have long flattened and pouch-like beaks that they use to scoop up fish and other aquatic creatures.

Cormorants have a long bone coloured hooked bill for diving down and feeding on fish and crustaceans.

Egrets and herons have long, thin beaks for spearing frogs or fish in the water.

Beach-stone Curlews have thick bills for foraging on the exposed intertidal mudflats

Ducks have bills that act like strainers, which they use to filter tiny plants and animals.

Raptors like Ospreys, sea eagles and kites use their talons to capture fish from the surface of the water and have a raptorial beak

Terns and gulls have sharp heavy bills that are useful for diving into shallow water and feeding on small fish.

Cockatoos have short, powerful conical beaks that are very strong, with which they can break open tough seeds and get the fruit from around a seed.

Kingfishers have large strong beaks which is uses to eat insects and lizards. In wetland areas it also uses its bill to take fish and crustaceans.

Finches and mistletoebirds have short, conical beaks that are very strong and can break open seeds.

Plovers and stints have small, sharp, pointed beaks for crustaceans, worms and molluscs.

Honeyeaters and sunbirds have long, needle like beaks that they use to probe deep into flowers to feed on nectar.

Bee-eaters, swallows, flycatchers and fantails have large, gaping mouths that act like nets to trap insects. These birds catch insects on the wing.

Procedure

1. Set up eight different stations, each with a special type of food. At each station you will need three different tools, one that represents the beak that best fits the food (in one case, two) and two that don't fit so well. Have a sign at each station that tells what type of food is represented (for example, a sign that says Nectar at station 1, a sign that says Worms at station 2 and so on).

The following is a list of food and tools for each station. The correct tool is indicated by an asterisk (*). In one case (station 4), there are two correct tools, for two different types of fish-eating birds; the second correct choice of bird and tool is indicated by a double asterisk (**).

Station 1: Large saucepan filled with dry oatmeal, with pieces of string or plastic fishing worms on the bottom to represent worms buried in the mud (Ibis, oystercatchers, sandpipers, godwits, Eastern Curlews and stilts)
Tools:
chopsticks, toothpicks, or twigs*
pliers or nutcrackers
strainer

Station 2: Whole walnuts or other nuts to represent seeds with hard coverings, such as sunflower seeds and pine seeds (finches, and parrots)
Tools:
pliers or nutcrackers*
tweezers
chopsticks, toothpicks, or small twigs

Station 3: Styrofoam chunks floating in an aquarium or other large container filled with water, to represent fish and other aquatic animals. (Spoonbills, pelicans,* herons, and egrets**)
Tools:
large scoop or slotted spoon*
bamboo skewer**
eyedropper or straw
chopsticks, toothpicks, or twigs

Station 4: Puffed rice in an aquarium or other large container filled with water, to represent tiny aquatic plants and animals. (Ducks)
Tools:
strainer*
tweezers
pliers or nutcrackers

Station 5: Popcorn or tiny marshmallows, which must be tossed in the air and caught in the air, to represent flying insects. (Bee-eaters, swallows, flycatchers, fantails and kingfishers)
Tools:
envelope or small fishnet*
tweezers
chopsticks, toothpicks, or twigs

Station 6: Rice spread on a log, surrounded by leaves (put rice under leaves as well), to represent caterpillars and other insects. (Bee-eaters)
Tools:
tweezers*
chopsticks
strainer

Station 7: Bowl with water or juice representing nectar. (Honeyeater or sunbird)
Tools:
Straw

Station 8: Cherries or grapes hanging from a string to represent fruit hanging from a branch (Parrot)
Tools:
eye dropper or straw
strainer
nutcracker or pliers*

2. Pass out the copycat page on page 2-67.
3. Divide your group into eight teams. (i.e., if you have 40 students, each team will be made up of five students). Each team will start at a different station. Explain that there are three different tools at each station, each of which represents the beak of a different type of bird. Each group must decide which tool would most efficiently get the food at each station. (To decide, they must try each tool.) Also explain that one station will have two tools that work for the food provided.
4. Once they pick the best tool, they should match it with the appropriate food, using the "Fill the Bill Matching Game". (You may want to set a time limit at each station to keep things moving).
5. Below the matching game on page 2-67 are pictures of different birds and their beaks. On the line underneath each picture, students should write the number of the tool that represents the correct beak. For example, they should write 1 on the line under the parrot.
6. Using the illustrations on page 2-68, students should describe how each bird uses its feet and bill to catch and eat food.

Discussion/Reflection
Discuss beak adaptations in general; explaining how, after millions of years, many birds have evolved very specialized beaks.

FILL THE BILL MATCHING GAME

Match the food in column 1 with the best tool for the job in column 2. Write the number of the correct tool on the blank next to the name of the food.

_____Worms	1.Pliers or nutcrackers
_____Seeds	2. Slotted spoon or scoop
_____Fish and frogs	3. Strainer
_____Tiny water plants and animals	4. Bamboo skewer
_____Flying insects	5. Tweezers
_____Caterpillars and crawling insects	6. Fishnet or envelope
_____Fruit	7. Chopsticks, toothpicks, or twigs

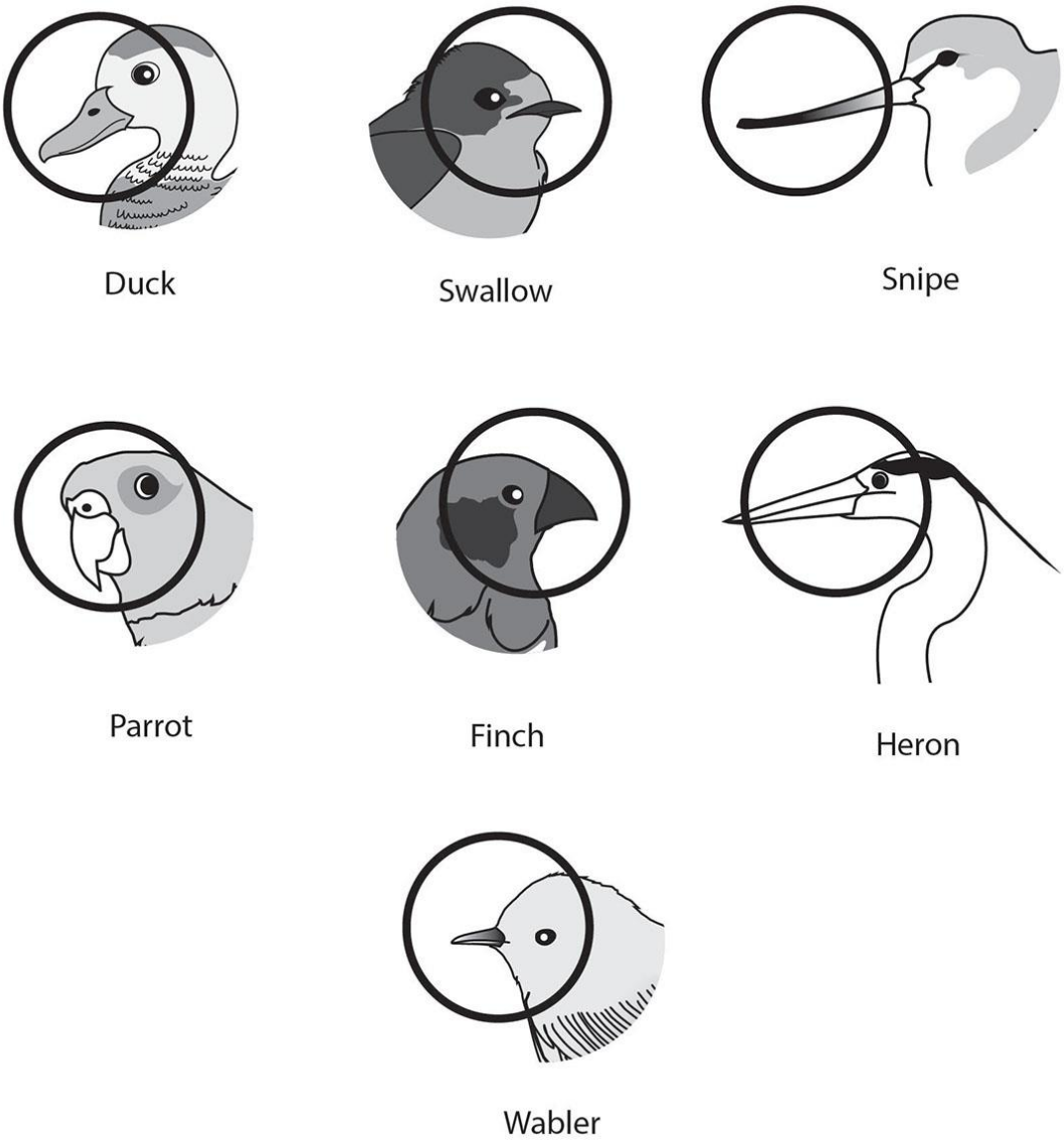


Figure 25: Match that bill!

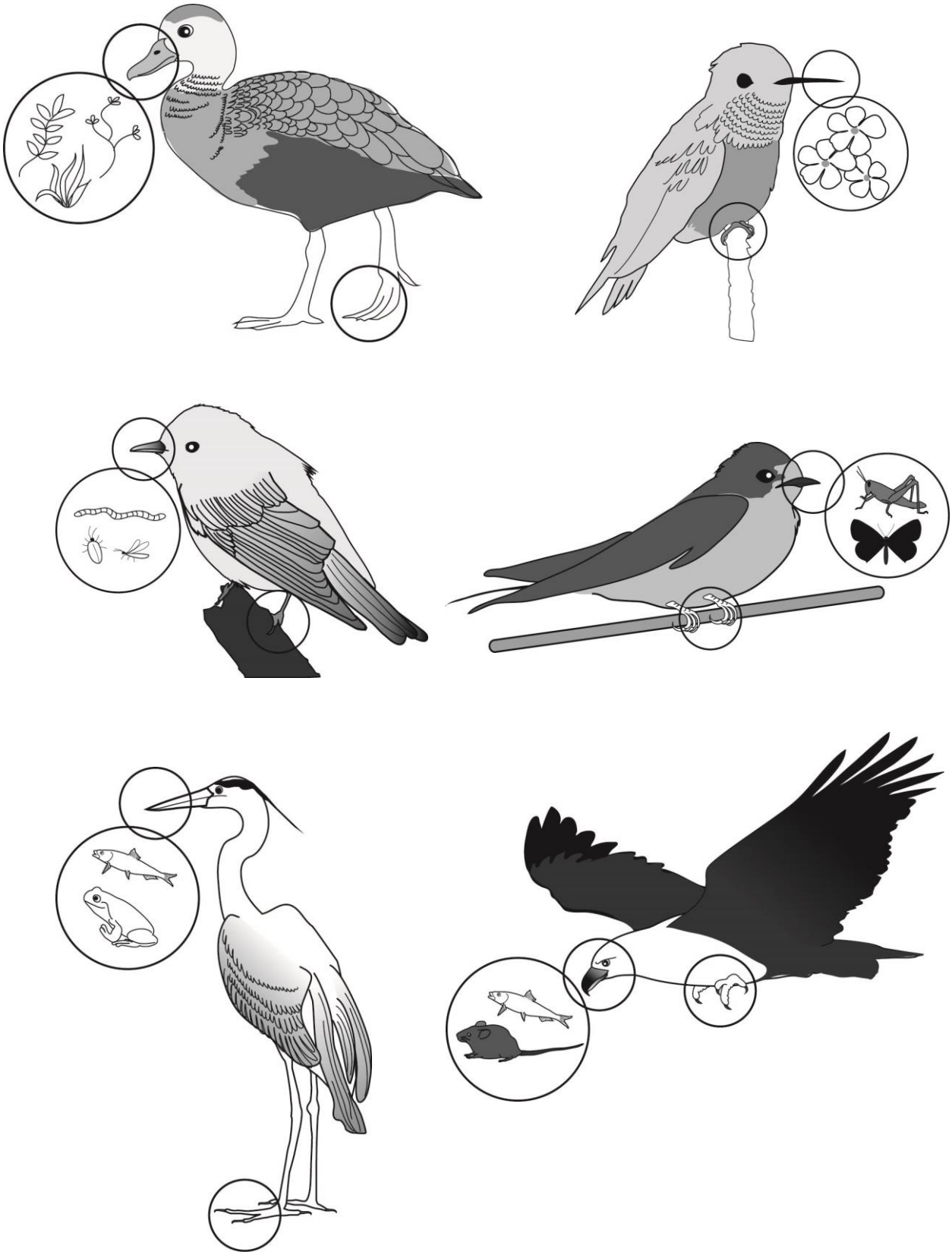


Figure 26: Birds' Bills, Food and Feet

Activity 2-L: Bird Silhouettes

Summary Birds are found in many shapes and sizes.

Learning Objectives
Students will be able to:
(a) Use shape to identify familiar birds by matching silhouettes to the names of common birds; and
(b) Learn to distinguish between different shapes of beaks, feet, legs, etc.
Age levels
7 and up
Subject Areas
Science
Time
1 or 2 lessons or homework
Materials
Copies of Bird Silhouettes on page 2-70
Pencils

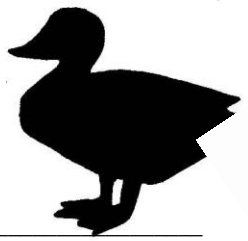
Background Over 230 species of birds have been documented in Australian mangroves. Some of these birds can be seen every day, and some are quite rare. The silhouettes are of commonly seen birds that are easily identifiable. Each has distinguishing features that are easy to spot if you look closely at the birds themselves. For more details about birds, their habitats and lifestyles please see bird identification books such as *Birds of Australia* by Jim Flegg and/or *What Bird is That?* By Neville Cayley.

Procedure
This is another activity to introduce the idea of identifying birds. In this activity, shape is used to identify some common birds.
1. The Bird Silhouettes on page 2-70 to 2-71 show the shape of some birds commonly found in the mangroves and wetland areas. Give each student a copy and see how many bird shapes they can identify. General names like “duck” are as specific as you need to get here, although with older grades, you can be more specific. You can also compare local names with “official” names.
2. Identify which birds are residents and which migrate to the mangroves. If the group is having trouble, you can write on the board the list on names they have to choose from. This can also be made a homework assignment together with the bird identification charts. The names are:

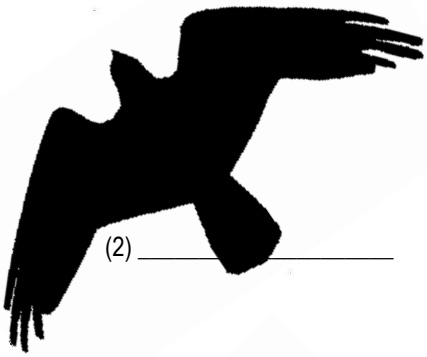
(1) Duck, (2) Sea Eagle, (3) Sandpiper, (4) Heron, (5) Lorikeet, (6) Welcome Swallow, (7) Beach Stone Curlew, (8) Australian White Ibis, (9) Pelican, (10) Frigate Bird, (11) Crested Tern, (12) Osprey

Discussion Discuss with the students what characteristics they used to identify the birds. Ask if they see these birds all year round or only in the winter. This is a good way to lead into the topic of migration. If a student has an “almost correct” answer (e.g., #3 Plover instead of Sandpiper), discuss the similarities of the species and how easy it is to mistake one for the other, but also point out that there are subtle differences and draw these to the students’ attention.)

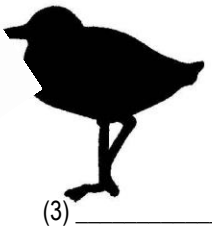
Bird Silhouettes



(1) _____

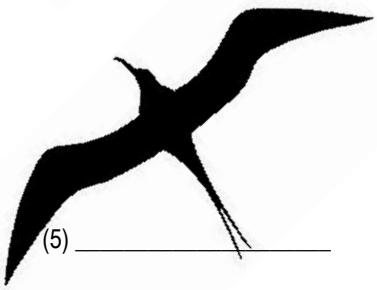


(2) _____

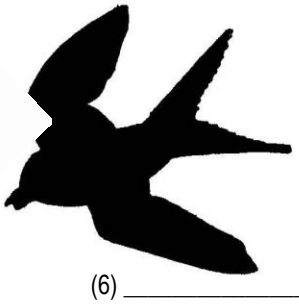


(3) _____

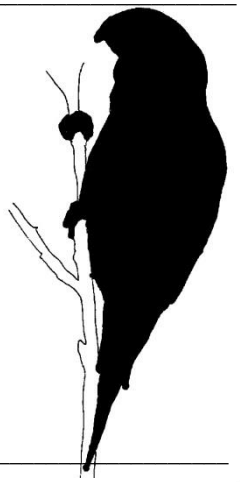
(4) _____



(5) _____



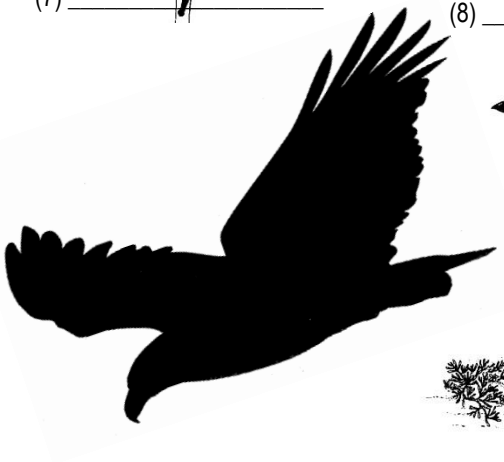
(6) _____



(7) _____

(8) _____

(9) _____

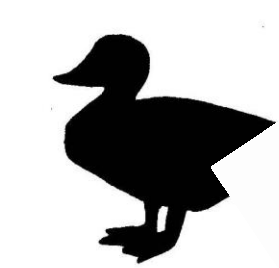


(10) _____

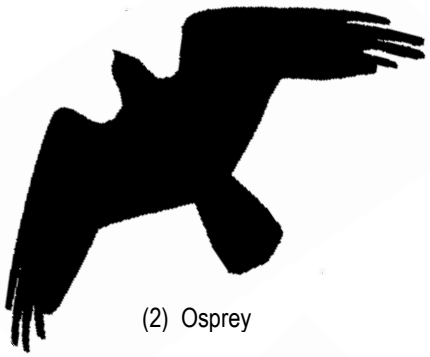
(11) _____

(12) _____

Bird Silhouettes (Answers)



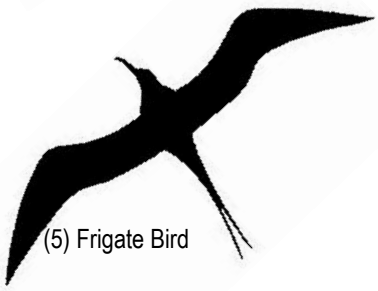
(1) Duck



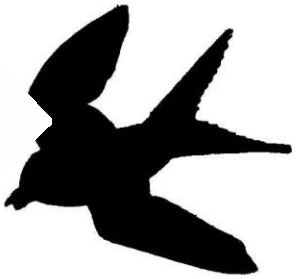
(2) Osprey

(3) Sandpiper

(4) Heron



(5) Frigate Bird

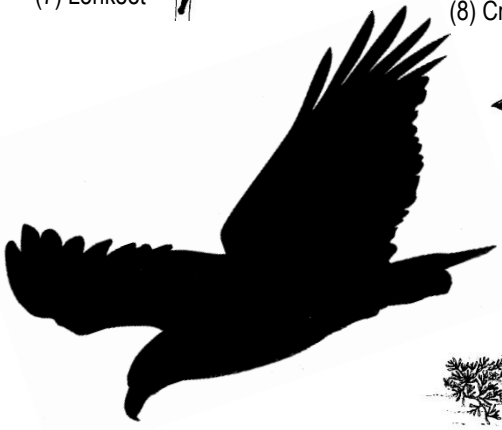


(6) Welcome Swallow

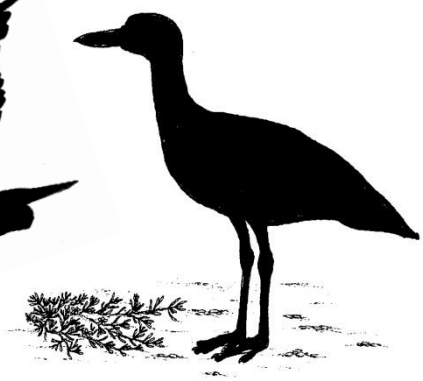
(7) Lorikeet

(8) Crested Tern

(9) Australian White Ibis



(10) White-bellied Sea Eagle



(11) Beach-Stone Curllew

(12) Pelican

Activity 2-M: Spot the Difference: Birds

Summary Students will look for subtle differences among birds by listing the differences between drawings of two almost identical birds.

Learning Objective
By comparing two illustrations, students will learn:
(a) That birds have different plumage at different times of year; and
(b) How to spot characteristics of different birds in the field.
Age Levels
8 and up
Subject Area
Science
Time
10–20 minutes
Materials
Copies of "Spot the Difference" from page 2-73
Pencils

Background Review this section of this book, "Mangroves as Habitat", concentrating on the parts about birds. Access additional resources (see resources section at the end of this guide) or field guides to your local bird species. At different times of year, birds change their plumage. They do this for many different reasons, including mating and breeding, as well as for migration.

Procedure Have the students list as many differences as they can find between the two bird drawings.

Discussion/Reflection
Discuss what differences were found.
What features do you think bird watchers use to identify birds [Shape, size, beak shape, wing shape, tail shape, colour and call].

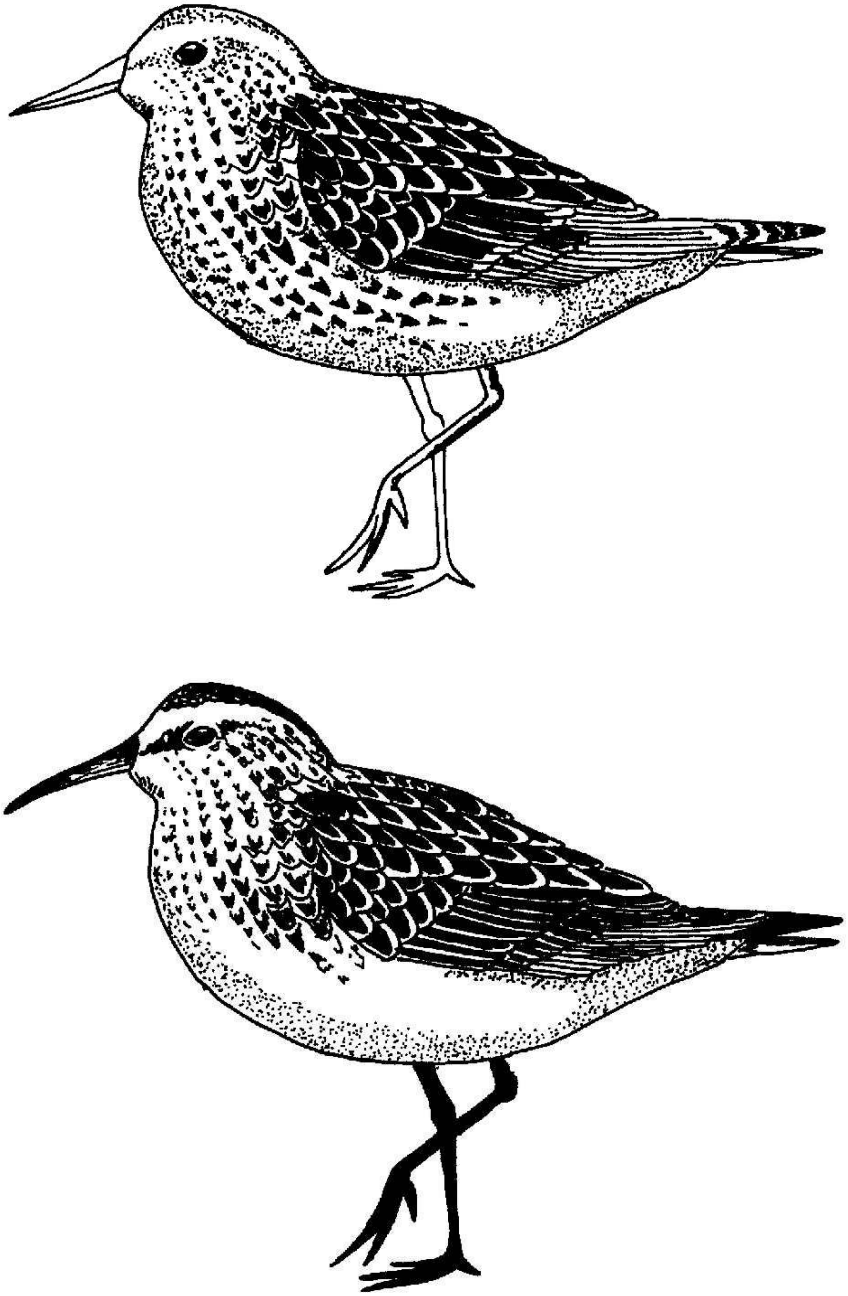


Figure 27: Shorebirds - spot the difference

ALL ABOUT MIGRATION

Migration is the seasonal movement of birds or any other animal. Many birds have a summer home and a winter home, and each year they make the same round trip from one home to another. Some birds migrate only a short distance, but the majority fly thousands of kilometres every year.

More than one-third of the world's bird species migrate with the seasons. Where do birds go? How do they know where to go and how to get there? Migration is complex, and science is still searching for many of the answers.

Why do birds migrate?
In order to survive, every animal needs a place to **feed**, **rest**, and **reproduce** in safety. Often these activities require different habitats, so the animal must move from one to another.

Many birds cannot live all year round in the place in which they were born and in which they breed. They are forced to leave when conditions become inhospitable, and return later when they improve.

Several species of migratory shorebirds breed within Russia, North Eastern China, Siberia and Alaska. These birds than migrate large distances to the Australian coast and associated mangrove areas to "winter" here (in our summer) and avoid the extremely cold climates of their nesting areas. The birds migrate south to find more abundant food sources to prepare for their next breeding seasons and what better place to do it, than in the well-stocked areas of coastal mangroves and tidal wetlands of Australia?

The incredible journey
Night or day: Some species migrate at night, others during the day. Ducks and wading birds are more likely to migrate during the night. Many small birds also fly under protection of darkness.

Speed: Migrating birds fly at a more or less constant rate. Ducks can do up to 80 km/h (and sandpipers fly up to 90 km/h. How long it takes a bird to migrate depends on how favourable the weather is, and how abundant the food along the way. A regular migratory visitor, the Bar-tailed Godwit is documented to complete the longest non-stop migration ever recorded completing a journey of just over 11 000km in approximately 9 days!

Rest stops: During migration, most birds don't usually fly non-stop. They make a few stopovers for one or two days or even longer. These rest stops are usually after long stretches of sustained flight, and they are made in large wetland or estuarine areas—like mangroves—places particularly rich in food. These sites are called staging areas and include places like the Yellow Sea in China. The staging areas make up a chain of wetlands between Australia and Siberia called the East Asian Australasian Flyway.

Weather: Sometimes bad weather forces birds to stop and wait for several days. Heavy rain can delay migration, and a rainy front may cause migrating birds to turn back. Wind can slow migration

and even blow birds completely off course, especially if they are migrating over the ocean. Thick fog often confuses the birds' sense of direction.
Dangers: Half of migrating birds never reach their destination. Birds face hazards such as storms with rain, ice, snow, and lightning; predators, predators like hawks and human hunters; tall buildings with glass windows; towers and power lines; airplanes and jets; and pollution, such as oil spills. Birds must pass through areas where their particular kind of food is scarce, through unfamiliar landscapes with unknown predators. Many must fly long distances over the open ocean with no place to land. Sometimes, after flying thousands of kilometres, birds arrive to find that their marsh, mudflat, or mangrove home has been filled in, paved over, or dredged while they were gone.

How do birds find their way?
How birds find their way from one home to another is a mystery. Scientists are still studying how birds navigate. They are thought to use several different methods, and different species seem to use different combinations of these methods.

Birds that migrate by day are thought to use their eyes, looking for landmarks such as rivers, mountain ranges, and coastlines. Some birds may also use the position of the sun in addition to landmarks.

Birds that migrate at night seem to orient themselves to the position of the stars. Small land birds migrating at night fly with the airflow. In spring, they fly northward on warm air masses coming from the south, and in the fall, they fly on cool winds flowing down from the north.

Birds are thought to use bands of polarized light, and the Earth's magnetic directions. Some birds find their way by recognizing odours, by long-distance hearing, or by following other migrating birds. Other birds also learn the migratory route from their parents and once learned younger birds can travel these routes by themselves.

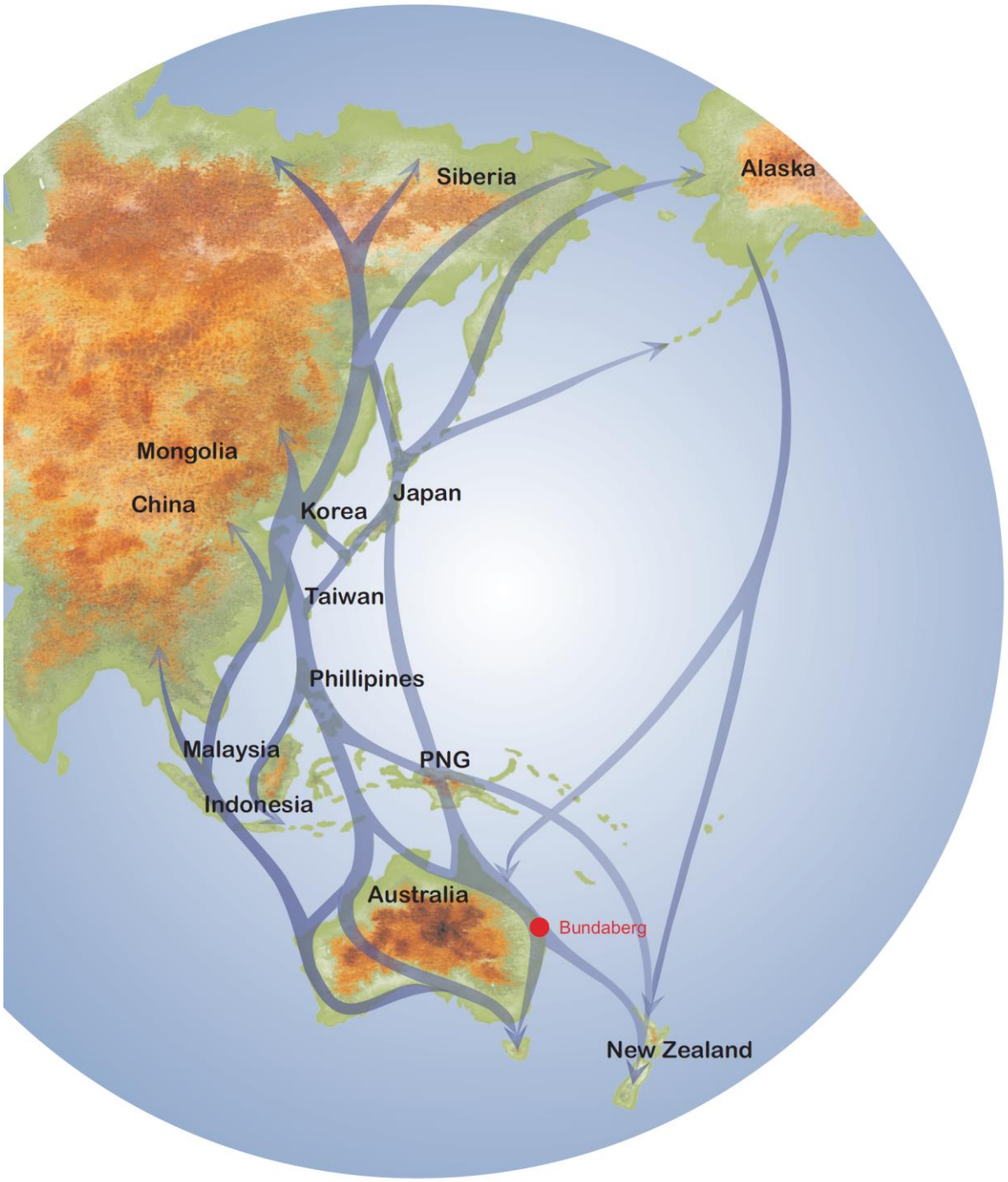


Figure 28: East Asian Australasian Flyway

Activity 2-N: Migration Homework

Summary Mangroves are home to many species of migrating birds.

Learning Objective
Students will be able to write a story or poem about bird migration.
Age Levels
6 and up
Subject Areas
Science and social studies
Time
30 to 60 minutes
Materials
pencil
paper
copies of pages 2-74 to 2-76 on migration
copy of local Field guide to Bird Identification

Background There are two types of birds found in Queensland: residents, which live here year-round, and visitors, which are migrants that usually spend the summer here. Many of these birds are found in people's gardens, and, of course, are seen frequently in the wild. Birds found in mangroves range from Beach Stone Curlew (residents) to Bar-tailed Godwit (migrants). Determining whether they are residents or migrants is a simple task: consult your local Field Guide to Bird Identification, and it will describe all of the commonly seen birds of your local area. For more information about migration, see pages 2-74 to 2-76, and the background to the Migration Headache activity on page 2-80.

Procedure
1. Write a story or poem like October Birds on Page 2-78 about a bird that migrates to your local beach or wetland for the summer. Describe the problems it faces when it flies here. Describe where it lives and what it does when it gets here, and what it does when it leaves in the autumn and arrives at its winter home (which will be summer in the northern hemisphere).
2. Students can draw pictures if they wish to illustrate their stories.
3. Read the stories or poems aloud in class.

Discussion/Reflection
Have students compare notes in class about the birds they saw as well as where and when they saw them.

Extension Have students discuss with their parents and grandparents any differences they have noticed in the number and type of birds that they have seen. Brainstorm about why there is a difference (if any) between the numbers of birds seen now compared with earlier times.

Example:

The October Birds (Swallows)*

By Crystal Scott
Year 7, Cayman Brac High School

The leaves are beginning to turn
red, yellow, orange and brown.
Winter, you always bring me down,
making me frown, all over town.
Before I go I must eat
three times my weight. Will I
ever get off my feet?
I will fly two days straight,
looking for a handsome mate.
I can't wait to fill my mouth
when I reach far down south.
On Cayman Brac I'll make my home for
several months, I'll not roam.
When flowers bud way up north,
that is when I'll venture forth.

*On bird migration

Activity 2-O: Migration Stories

Summary Students will be asked to write about a bird that migrates to their area.

Learning Objectives
Students will be able to:
(a) Describe a local migratory bird;
(b) Describe its winter habitat; and
(c) Describe any migratory problems it may face.
Age Levels
6 and up
Subject Areas
Science, language arts
Time
1–3 hours
Materials
Local Field Guide to the Identification of Birds
Or web-based resources such as the Shorebird 2020 website
Paper and pencil
Local people

Background (See “Migration Headache” activity on page 2-80)

Procedure
1. Find out what migratory birds come to your area.
2. Write a real or fictional story about the migratory route, populations, and habitat problems of one of these species.
3. Describe where you might find this bird in your country—what area and what kind of habitat it needs.

Discussion/Reflection
Have you seen this bird?
Where would you go, and in what seasons, if you were this bird?

Activity 2-P: Migration Headache

Summary Migrating birds face many hazards in their travels between wintering and breeding grounds.

Learning Objectives
Students will be able to:
(a) Describe the role of Queensland mangroves and tidal wetlands for migrating birds;
(b) List three factors that favour their migration success;
(c) List three factors that reduce migratory success; and
(d) Describe one action that will improve migration success.

Age Levels
7 and up

Subject Areas
Science, social studies

Time
1 or 2 lessons

Materials
One paper plate for every student or every two students, depending on class size (Clearly mark the plates to differentiate bottom from top.)
In this activity, each student represents thousands if not tens of thousands of migratory birds. The game takes up to 45 minutes (maybe more), and requires a large outdoor area such as a playing field, gymnasium, or basketball court.
Copy of Migration Maze on Page 2-83.

Background Explain to the students that many factors limit the survival of populations of migrating birds. Some involve changes in wintering and nesting habitats. Sometimes there will be abundant food, water, shelter, and space suitably arranged to meet the habitat requirements of the birds. At other times, when the habitat is stressed, many factors limit the potential for survival (see chart on page 2-83). Sometimes the area of available habitat is reduced.
Some limiting factors are a natural and dynamic part of any environment. This is also true of factors favouring survival. However, the significant difference to the survival of populations of migrating shorebirds and aquatic birds seems to be the loss or degradation of huge areas of suitable habitat, much of it as a result of human intervention—such as draining of wetlands, destruction of nesting cover, and pollution of water supplies. And not only does this occur in wintering and nesting areas, it also takes place on the flyways, where the birds are dependent on wetlands for “refuelling” and resting stops.
Be sure to create one or more “disaster” years to illustrate catastrophic loss of large areas of available habitat. Remember that, overall, the availability of suitable habitats for migrating birds is diminishing; the activity should end with fewer areas of available habitat than can accommodate the birds. There is general agreement that the greatest long-term threats to the survival of populations of migratory shorebirds and waterfowl are the loss and degradation of habitat.

Rules of the Game

1. Students move only on command
2. Referees judge which students arrive first to the plate. (Remember how many students are assigned to each plate: no more are allowed).
3. Referees remove and replace the plates as told by the teacher.

Game Players

1. Move (migrate) from one end of the field to a plate.
2. Any student not reaching a plate is removed from the game.
3. The winners are those students left when the game ends.

Representation

1. Students are playing birds going to summer in wetlands in Australia or to summer wetlands in Siberia for breeding.
2. Removing plates represents wetland losses.

Procedure

1. Select a large playing area about 20m long. Place the paper plates in two patches, one at each end of the playing field.

2. There should be one plate for each student or every two students at each end of the field. Designate one of these areas “nesting habitat” (Siberia, Russia, China and Alaska) and the other “over-wintering habitat” (Australia). Choose one or two students to remain at each end (over-wintering and nesting habitat). Explain that they are the referees and in charge of the paper plates. When you ask, they must remove or replace the paper plates. In the event of a fight between migrating birds as to who got to the plate first, these students are the judge.

3. Explain to the students that they are birds that are commonly found in Australia in spring, summer, and autumn, and they will migrate between the two areas at your signal. Tell them that the plates represent wetlands. These wetlands provide suitable habitat for migrating birds (shorebirds, etc.) At the end of each journey, the students will have to have one foot on a paper plate in order to continue. If they cannot get their foot on a plate, that means they have not found any suitable habitat. They “die” and have to move, at least temporarily, to the sidelines and watch. During migration, the birds may want to “flap their wings”, moving their arms like birds in flight.

4. Round One Begin the activity with all the students at the over-wintering habitat in Australia. Announce the start of the first migration. Have the students migrate in slow motion until they become familiar with the process; then they can speed up. On the first try, all the birds will successfully migrate to the nesting habitat in Siberia. Explain that there has been no loss of available habitat. Thus, a successful nesting season is at hand.

5. Round Two Before the students migrate toward the wintering habitat, have the student referees remove or turn over one plate from the over-wintering region. Explain that a large wetland has been drained and used for condominiums and a golf course. Repeat the instruction to migrate, and send the birds to the wintering habitat. Have the one or two students that didn’t make it stand on the sideline. Tell the students that these birds have died as a result of loss of habitat. Remind any “dead

birds" that they will have a chance to get back into the activity. They can come back as new, young birds born in their Siberian and Arctic tundra breeding grounds.
Note: The next round will result in a large number of students waiting on the sidelines to re-enter the nesting habitat. Allow two to four young birds to join in Round Three.
6. **Round Three** Before the next migration to the nesting region, turn over or remove four plates in the nesting habitat. This represents a catastrophic loss. Tell the students that this is the result of an oil spill in the local river that severely damaged the wetland habitat. Instruct the students to migrate.
7. **Round Four** *(optional)* Repeat the process for eight or 10 migration cycles to illustrate the changes in habitat conditions with resulting effects on the birds. Give examples of the factors that might influence the birds' survival.

Discussion/Reflection
What factors encourage migration success?
What factors reduce migration success?
What happens to migrating bird populations when there are wetland losses?
What can you do to improve migratory success?
Extension: When back in the classroom, ask students to do Migration Maze (page 2-80) to reinforce problems encountered by migrating birds.

Migration Maze

Both the Sharp-tailed sandpiper and the Red-necked Stint migrate from the Arctic to Australia for the summer. Both face deadly hazards on the way here.

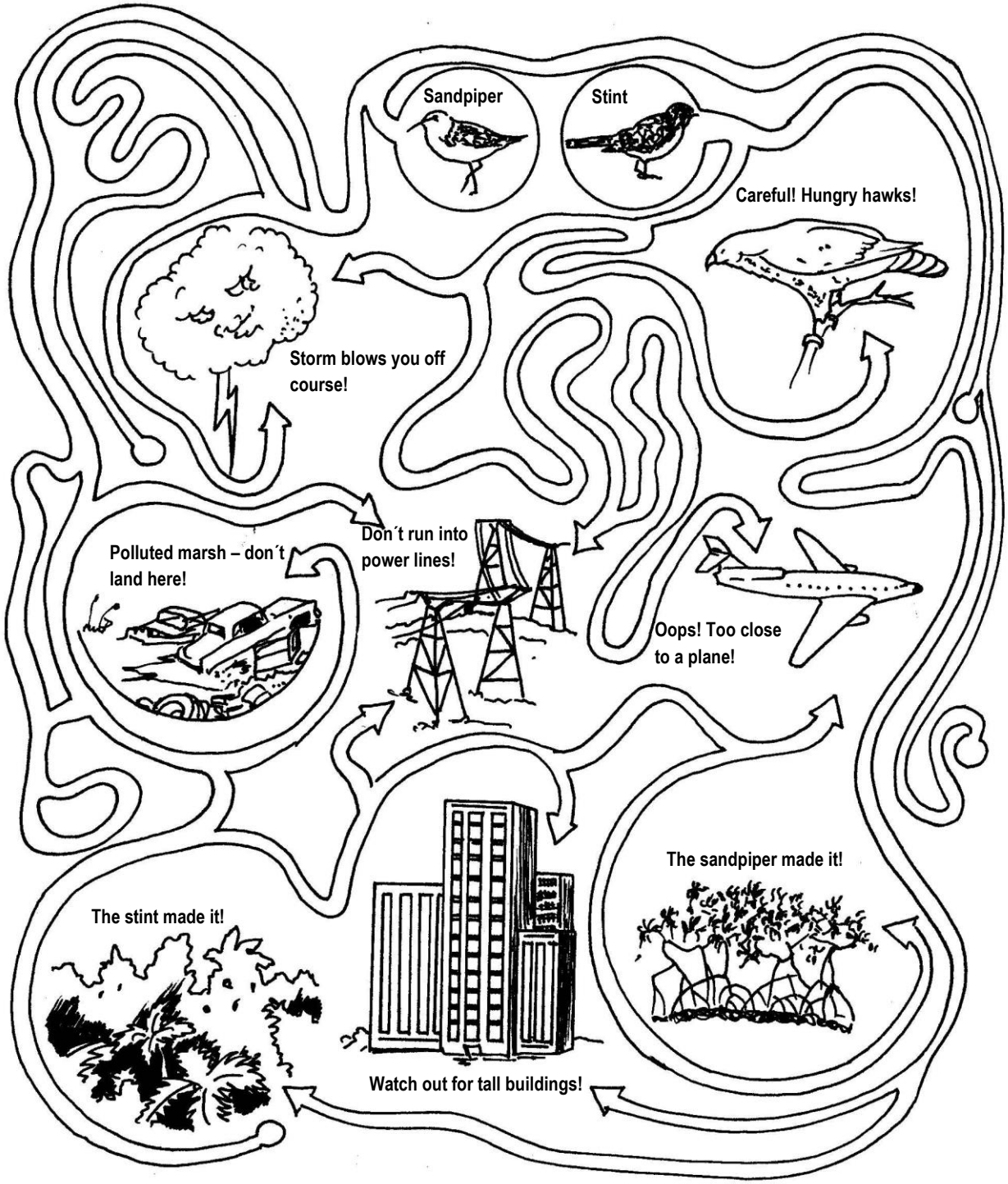


Figure 29: Migration Maze

Migration Headache Plates Chart

Factors REDUCING survival	No. of plates lost*	Factors FAVOURING survival	No. of plates gained*
Urban development and land reclamation	5	Preservation of wetlands	4
Wetland drainage	5	Dynamic balance with predators	4
Conversion of wetlands to farmland	3	Restoration of habitat	3
Pollution and contamination of groundwater e.g. oil spill	3	Education about wetlands and the importance of wetland habitat	3
Drought	3	Normal rainfall (neither drought nor flood)	2
Conversion of natural waterways to canals and stormwater systems	2	Installation of Water Sensitive Urban Design in new housing developments introducing wetlands	2
Lead shot in food supply	2	Education about hunting	1
Illegal hunting (poaching)	1	Arrest of poachers	1
Domestic dogs allowed to run free in wetland areas	1	Responsible pet owners keep their dogs on a lead near shorebird habitat	1

*Number of plates lost and gained: These numbers are only suggestions, and are not necessarily in accurate or direct proportion to the size of the threat, percentage change in survival rates, etc., which will vary between particular places and incidents. You may choose to alter the numbers, particularly in relation to class size.

CONTENTS SECTION 3

HUMAN IMPACTS ON MANGROVES

Although mangroves contribute to the economy in many ways, these benefits are not obvious like the benefits from the same area of a commercial crop such as sugar cane or bananas. Mangroves are essential to maintain coastal fisheries, protect property and coastlines from the effects of cyclones and storms and protect coral reefs from sediments and pollutants. However mangroves are frequently seen as expendable and little care is taken of them. Often mangroves areas are just seen as an area for mosquito breeding and a place to unlawfully dump rubbish. Thankfully, this view is started to change as education improves about the benefits of these wetland areas.

Throughout the World, mangroves are being destroyed or degraded. Everywhere— including Australia—the pressures are the same. Most of the population and economic activity takes place on the coast, and there is an ever-increasing demand for coastal land. Over 80% of Australia's population lives within 50Km of the coast. Most of the more accessible land is already taken up, so pressures on mangroves are increasing.

Mangroves Destruction

Wetlands are being destroyed in many ways. Some examples of this are:

- Filling for ports, tourist resorts, housing, airports, and industrial sites
- Drainage for agriculture and aquaculture
- Excavation for fish and prawn farms
- Dumping of garbage
- Dredging of channels for navigation and drainage
- Drowning as a result of cyclones and rising sea levels

Mangroves Degradation

The quality and productivity of mangroves are being reduced by human activities. They include:

- Changes in water levels as a result of blocking of channels to sea, reduction of inflows from land, sink holes (the centre sinking theory), changes to water channels
- Reduction of natural regeneration as a result of fires, and grazing animals
- Pollution from sewage, garbage dumps, fogging for mosquitoes
- Construction of groins, docks, piers, causeways, runways, and roads
- 4WD access
- Increased boat access and potential damage from increased boat wash

Long-term Effects of Mangrove Destruction

When mangroves are lost or degraded, their economic and ecological functions are disrupted or destroyed. Some of the most obvious results are loss of fisheries, increased flooding, increased coastal damage from cyclones, and increased salinity of coastal soils and water supplies. The people who feel the costs of wetland destruction are the fishermen and other people who make their living on the coast. The people who reap the benefits from the developments usually live far away, in cities and towns.

Human Activities That Affect Wetlands

Approximately 17% of Australia's mangroves have been destroyed since European settlement, with mangroves near developing centres being removed and destroyed for land reclamation. For example in Moreton Bay, close to Brisbane, an estimated 20% of pre-European mangrove area has been reclaimed for landfill. As the population increases along the coastline, this has a corresponding increase in the usage and development of the wetland areas. This degradation of the mangrove habitat has a direct effect on the capacity for the area to function effectively as a viable ecosystem.

The chief threats to the mangrove areas are the conversion and land use change and the indirect effects of sediments and chemical runoff from catchments degraded by clearing of upland vegetation and associated agriculture.

Perhaps because people see mangroves as wastelands, they rarely hesitate before adding their own rubbish to them. Throughout the region, people who want to dispose of unwanted household or building wastes just dump them in wetlands. The effects on wildlife are severe. The rubbish prevents natural regeneration of wetland vegetation, pollutes water, and is dangerous to health.

Mangroves can also be destroyed by seemingly unconnected activities in the water cycle. Water extraction from rivers can reduce the amount of water getting to a wetland. Silt washed down from deforested hills can fill wetlands. These activities can cause the wetlands to dry out. As they dry out, they can become more vulnerable to fires. Occasional fires are a natural part of the cycle of wetland ecosystems, but when they happen too frequently, they prevent the natural regeneration of swamp forests and mangroves. Not all damage to wetlands is deliberate. Accidents, such as oil spills at sea, can cause serious damage to wetlands. Oil smothers mangrove roots and the trees die. The mangrove can take more than 20 years to recover.

Natural Processes That Affect Wetlands

Mangroves can also be destroyed by natural processes, including cyclones and storms, diseases, and pests. Cyclones are the most serious of these. Cyclones can uproot trees and remove branches and leaves. Most mangroves can recover from moderate cyclone damage—but global climate change means that the number and severity of cyclones will probably increase. More and more severe, cyclones could make it harder for mangroves to survive the other stresses they face.

Global warming will also cause a rise in sea levels. If they are healthy, recent studies show mangroves may be able to grow fast enough to keep up with the rise, and go on protecting our shorelines. Cyclones such as Yasi and Larry caused over 5 billion dollars' worth of damage to buildings, farms and the fishing industries in the Northern Queensland areas. In areas (Trinity Bay Inlet) where good mangrove protection existed, the damage to boats and associated marinas was limited through the presence of mangroves. In areas such as Cardwell, where mangroves had been removed for large marina developments, the damage bill was excessive.

In Australia, mangroves and wetlands are also affected by extreme weather events including floods and long periods of drought. During the Brisbane floods of 1974, the existing mangroves suffered very little damage due to the mangroves only being located at the mouth of the River. However the

floods of January 2011 have had a much more damaging effect to the local mangrove populations. As a result of the 1974 floods, Wivenhoe Dam was erected allowing for an increase in the quantity of salt water within the Brisbane river system and in turn increase the amount of mangroves growing on the river banks. Surveys completed by the Queensland Department of Environment and Heritage Protection has documented an increase in siltation and resulting in the death of the majority of Grey Mangroves. However the Milky mangroves have already shown signs of regrowth and re-establishment. It is estimated that it will take 10 years for the mangrove ecosystem to recover.

Impact of Wetlands Loss

When wetlands are lost or damaged, the wildlife they support is lost or damaged too. The impacts spread far beyond the wetlands. For example, the endangered Illidge's Blue Ant Butterfly lays its eggs only on the stubs of the Grey Mangrove in the presence of specific ant colonies, the *Crematogaster*. The larvae are then "adopted" by the ant and thought of as their own and taken back to the colony where they are cared for. The larvae can mask it's presence through the use of pheromones and mimics the smell of the ant larvae within the nest. However as soon as it becomes a butterfly it loses this masking behaviour and must exit the nest quickly before the ants realise their mistake. The survival of the Illidge's Blue Ant Butterfly is dependent wholly on the Grey Mangrove population. If the increase of chemical run off is not stemmed the Grey mangroves with continue to recede causing the loss of habitat for this butterfly.

Unfortunately, human beings often do not realize the consequences of wetland loss until it is too late. Once they are gone, we begin to notice increased lowland flooding, the dying out of species, and pollution of streams. The groundwater will also begin to disappear.

While it is true that the Earth is an interconnected and dynamic whole, this "big picture" point of view is difficult to convey on local and individual levels. Unfortunately, changes in one corner of an environment can begin a chain of events with the power to affect everything from microscopic organisms to the earth's atmosphere. Wetlands are an interconnected system that contribute to flood control, pollution control, and habitat for many plants and animals, including humans.

Management of Mangroves in Australia

All three levels of government in Australia (local, state and federal) have a role in the protection of mangroves. They are managed through general legislation relating to the environment, fisheries, coasts and wetlands. Currently no mangrove species is considered threatened in Australia and it appears that the total mangrove area may in fact be increasing. In total approximately 8% of Australia's mangrove communities occur in protected areas and the clearing of mangroves is currently prohibited in Queensland and New South Wales. All mangroves are protected plants and require a permit or notification before they can be damaged or removed. Since 1993 there has been an increase in the National awareness of the importance of mangrove systems and the need to maintain the unique biodiversity of this valuable habitat.

Factsheet #1: Surface Water and Groundwater

Surface water is easy to see: it's the water that flows in rivers and streams, that fills lakes, bays, oceans, and wetlands everywhere.

Groundwater, on the other hand, is hidden from view. It fills the spaces between soil particles and rocks underground—a bit like the way water fills a sponge. Most groundwater is precipitation that has soaked into the ground, and sometimes it feeds lakes, springs, wetlands, and other surface water. Groundwater is what prevents the salinity of the water around the roots of mangroves from reaching lethal levels. Tidal groundwater can move through mangroves in two ways. It can flow into the mud due to tidal differences of the water table and it can be flushed from animal burrows through tide change. Unfortunately, groundwater is an easy way for mangroves to be polluted by heavy metals and pesticides as they travel from affected areas upstream.

Factsheet #2: Classifying Water Pollutants

Chemical Pollutants

Chemical water pollutants are water-soluble substances. Chemical substances can enter water sources through natural processes such as the leaching of minerals from soil, rocks, and mineral deposits. Chemical substances can also enter water sources as a by-product of manufacturing processes and power generation, through excess use or run-off in agriculture, or home use of chemicals and household products.

Organic: oil and dyes, synthetic detergents, chlorinated hydrocarbons (DDT, PCBs), refined hydrocarbons, phenols and carboxylic acids, carbohydrates, sugars

Inorganic: acids, bicarbonates (acid salts), alkalis, chlorine, metallic salts, nitrates, phosphates, sulphates, hydrogen sulphide, radioactive isotopes

Biological Pollutants

It is not easy to classify biological pollutants as either natural or manufactured. For example, algae may be present naturally, but nutrients added by people can cause abundant algae growth, with serious results for the quality of the water. Excessive algae growth greatly increases the water's biological oxygen demand.

Pathogenic forms: bacteria, viruses, protozoans, fungi, algae, disease-producing parasitic worms

Algae: excess growth caused by an excess of nutrients (decay uses up oxygen)

Aquatic weeds: use oxygen as they grow; can choke waterways

Physical Pollution

Physical water pollution refers to material that is either suspended or floating in the water. Physical pollutants may be added naturally to the waterway or placed there as the result of human activities, often in larger quantities than nature can easily handle and purify.

Floating matter: foam and scum, wood and leaves

Suspended matter: silt, sand, gravel, metal pieces, cinders, rubber, plastic, wood chips, paper, pulp, solid sewage material, animal carcasses

Thermal Effects

Heated water may be discharged into streams, lagoons, reservoirs, or the ocean by electric power plants or desalination plants. Heat reduces the ability of water to dissolve oxygen, and the loss of oxygen in the water harms fish and other aquatic life.

Factsheet #3: Effects of Pollutants on Water

Sediments

Particles of soil, sand, silt, clay, and minerals wash from land and paved areas into streams, wetlands, and oceans. In large, unnatural quantities these natural materials can be considered a pollutant. Construction projects often contribute large amounts of sediment. Sediments may fill stream channels and harbours that later require dredging—and the dredging itself will stir up or re-suspend the same sediments. These sediments suffocate fish and shellfish populations by covering fish spawning areas and clogging the gills of bottom fish and shellfish. They also cloud the water and prevent sunlight from reaching seagrass and corals, causing their death.

Hydrocarbons and Petroleum Products

Oil and other petroleum products like gasoline, kerosene and methane, can find their way into water from mining activities, oil refineries, power plants, gas stations, streets and ships. Oil spills kill aquatic life (fish, birds, shellfish and vegetation). Weathered oil becomes tarry and may make sand so hard that worms, molluscs, and the like can no longer live there. Birds are unable to fly when oil loads their feathers. Shellfish, crabs, and small fish are poisoned. Fuel oil, gasoline, and kerosene may leak into groundwater through damaged underground storage tanks, while methane can leak into groundwater through the process of natural gas fracking.

Human and Animal Wastes

Human wastes that are not properly treated at a waste treatment plant or in domestic septic systems, and are then released into water, may contain harmful bacteria and viruses. Diarrhoea, hepatitis, flu, and the common cold are examples of diseases that can be caused by bacteria and viruses in contaminated water. The main source of the problem is sewage getting into the water—which sometimes happens as a result of breakdown of waste treatment systems caused by cyclones and floods. People can come into contact with these microorganisms by drinking the polluted water. Unexpected flooding of barnyards or stock pens can increase the toxic effects of animal waste in water. Animal waste can also act as a fertilizer and create damage by increasing nutrients (see “Fertilizers” below).

Organic Wastes

Domestic sewage-treatment plants, food-processing plants, paper mills, and leather-tanning factories release organic wastes that bacteria consume. If too much waste is released, the bacterial populations increase and use up the oxygen in the water. Aquatic creatures, especially fish, die if too much oxygen is consumed by decomposing organic matter.

Inorganic Chemicals

Detergents, pesticides, and many synthetic industrial chemicals are released to waterways. Many of these substances are toxic to fish and harmful to humans. They cause taste and smell problems and are difficult to treat effectively. Some are very poisonous at low concentrations. Inorganic chemicals and mineral substances, solid matter, and metal salts commonly dissolve in water. They often come from mining and manufacturing industries, oilfield operations, agriculture, and natural sources.

These chemicals interfere with natural stream and wetland purification; they may also corrode expensive water-treatment equipment.

Fertilizers

The major source of agricultural and aquaculture pollution is surplus fertilizers in the run-off. Fertilizers contain nitrogen and phosphorus that can cause large amounts of algae to grow. The large algal blooms cover the water's surface and the algae die after they have used up all the nutrients. Once dead, they sink to the bottom, where bacteria feed on them. The bacterial populations increase and use up most of the oxygen in the water, and once the free oxygen is gone, many aquatic animals die. This process is called **eutrophication**.

Heated Water

Heat reduces the ability of water to dissolve oxygen. Electric power plants use up large quantities of water in their steam turbines. The heated water is often returned to streams, lagoons, reservoirs, or the ocean. The loss of oxygen in the water harms fish and other aquatic life. The same impact occurs with desalination plants, which heat up the water during the reverse-osmosis process and then discharge it into the ocean. Desalination plants also produce large quantities of very saline water, or salt which can damage the areas where it is discharged.

Acid Precipitation

The pH is the measure of acidity in a solution. Aquatic animals and plants are adjusted to a rather narrow range of pH levels in water. When water becomes too acid because of the presence of inorganic chemical pollution, exposed acid sulphate soils or acid rain, fish and other organisms die.

Pesticides (Insecticides, Herbicides, Fungicides)

Agricultural chemicals designed to kill or limit the growth of certain life forms are a common source of pollution. Farmers use them to limit the negative effects of "undesirable" species on crop production and golf courses. Irrigation, groundwater flow, and natural run-off bring these toxic substances to mangroves, and oceans.

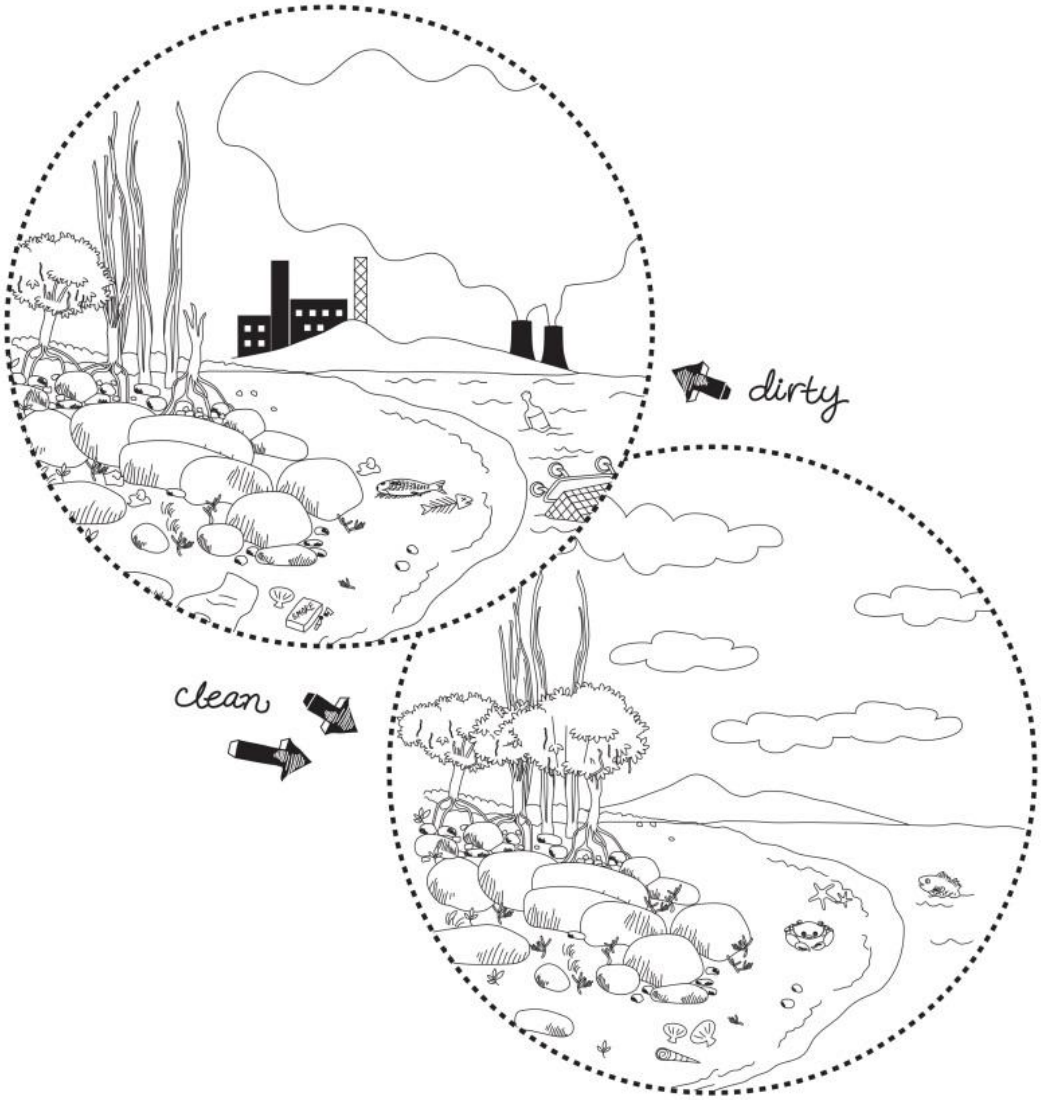


Figure 30: What impacts does pollution have on your waterway?

Factsheet #4: Pollution Sources

Down the Drain

When most people rinse something down their drain, flush their toilet, or do a load of wash, the wastewater either goes to a sewage treatment plant to be purified or runs through a septic system, which operates like a tiny sewage-treatment plant. The big plants remove dirt, biodegradable materials such as food waste, and many other pollutants from the water before the water is dumped into the waterways—usually the ocean. They also treat the water to kill harmful bacteria and viruses. Your septic tank does much the same. But neither the plants nor your own septic system can remove all the chemical pollutants. For example, chemicals that are used in paint thinners and phosphates that are used in many detergents pass right through some sewage treatment plants.

Off the Streets

Oil, litter, dirt, and anything else that's on the streets washes into stormwater drains. In some areas the stormwater is diverted to sewerage treatment plants where it is used to dilute the sewerage and becomes secondary or tertiary treated in the process. This is quite an expensive process and is not used widely in Australia. Otherwise stormwater drains drain directly into rivers and coastal areas. There are some mitigation techniques being currently used and these include Gross Pollutant Traps which work using a centrifugal design to remove litter and oil. Some places use coastal nets to prevent the larger litter from entering the rivers and wetlands however these fail to address the problem of oil and heavy metal pollutants. With stormwater consisting of freshwater, the direct impact of dumping this straight into a coastal area is an increase of siltation due to the mixing effect of salt and freshwater.

Industrial Waste

Factories that make chemicals, paper, medicines, steel, and many other products create a lot of waste. There are a lot of laws in place governing the disposal of this commercial waste with many companies able to treat these chemicals safely. However on some sites this waste may enter the stormwater system inadvertently, and as storm water is not treated. There are ways that responsible companies can reduce their impact. They can control the work site and ensure that it is tidy. They can contain the waste and isolate it from drainage areas. They can clean it up once they are done by sweeping or vacuuming and disposing of chemicals in line with manufacturers specifications.

Trashing the Water

When trash gets thrown overboard, it can create an ugly mess—both in the water and on the shore where it washes up. Trash can also harm or even kill wildlife. For example, thousands of seabirds and marine mammals die each year after eating or becoming entangled in plastic debris and ghost nets floating in the ocean or in mangroves.

Factsheet #5: Auto Awareness

The automobile is one of the biggest contributors to pollution problems throughout the world. The car seems to have an impact on every aspect of our lives (mostly because we all seem to want one, or two, or more!). Here are some of the ways the car and its operation cause pollution—and some solutions that we can each incorporate into our lives.

Direct impacts to Mangroves

Increasingly mangrove and wetland areas are becoming more available through the increased use of 4WD vehicles and other recreational vehicles. Driving through sensitive mangrove areas creates:

- Visible depressions changing the way water moves in the mangrove
- Breaks in the continuity of species such as salt marshes and mangrove communities
- Increases the surface compaction
- Causes physical damage to invertebrate species and mangroves
- Distresses migrating species such as shorebirds

Car Manufacturing

- Mining for raw materials such as bauxite (to make aluminium) or iron ore (to make steel) creates waste that can pollute land and water. It also creates dust that pollutes the air, and causes soil erosion that pollutes water when the soil washes into surface water.
- Processing raw materials into car parts causes pollution. Steel factories and other manufacturing plants, for example, create waste products that pollute air, land, and water.
- Many car parts are made of plastic—a product made from petroleum that takes hundreds of years to biodegrade.
- Auto assembly plants create waste such as toxic paints and lubricants, which pollute air, land, and water.

Junked Cars and Tyres

- Each year, millions of cars end up in junkyards. Car junkyards are ugly and take up much land.
- When reusable materials aren't recovered after cars are junked, resources are wasted, and new materials must be made from scratch.
- Batteries, air conditioners, and other parts of junked cars can leak. The toxic materials they release can pollute water supplies or air.
- Tire dumps can sometimes catch on fire, releasing toxic fumes that pollute the air and toxic residues that leach into water supplies. Tyres dumped in landfills take up a lot of space.

Fossil Fuels

- Most cars run on petrol, a product made from oil. Drilling, processing, and transporting oil creates air, water, and land pollution.
- When engines burn petrol they release toxic gases and other waste products into the air. These substances can cause respiratory diseases, cancer, and other health problems. They also contribute to acid rain and global climate change.
- Car engines require motor oil. Just one litre of oil can contaminate thousands of litres of water, polluting drinking water supplies and poisoning wildlife.

• Driving at excessive speeds cuts down fuel efficiency.

Roads

• Building roads creates dust and waste and causes soil erosion and habitat destruction.
• Asphalt, a main ingredient in road surfaces, is made from oil.
• Increased traffic on roads creates noise pollution and increases air pollution from exhaust fumes.
• Fluids that drip from cars into roads will wash off those roads, damaging roadside vegetation and polluting water supplies.

Auto Air Conditioners

• Using car air conditioners can cause a car to burn more fuel.
• When junked or improperly maintained, car air conditioners can leak damaging hydrocarbons into the atmosphere. Following information on the impacts chlorofluorocarbons (CFCs) had on the ozone layer, R134a refrigerant was moved in as a replacement. We now know that R134a is a 'super greenhouse gas' having over 1500 times more greenhouse potential (GHP) than CO_2 (carbon dioxide).

Car Care

• Washing cars can pollute waterways, when detergent and road grime run into storm drains and then into surface water.
• Improperly inflated tyres reduce fuel efficiency.
• Motor oil, brake and transmission fluids, window-washer fluid, coolant, and lubricants that leak or are disposed of improperly can pollute land and water.
• An improperly maintained engine doesn't burn fuel efficiently and increases air pollution.

Some Solutions

• Alternative power sources such as sunlight, electricity, ethanol (fuel from grains or the sugar industry), and methane can eliminate many of the pollution problems associated with burning fossil fuels.
• Recycling car parts can cut down on pollution caused by mining and processing of new materials.
• Recycling car air-conditioning refrigerants and oil can prevent air and water pollution.
• Developing safe refrigerants can reduce the greenhouse effect.
• Engine and exhaust systems can be redesigned to burn fuel more efficiently and to reduce the emissions of air pollutants.
• Individuals can reduce auto-caused pollution by walking, biking, sharing cars, or using buses or taxis; by driving at reasonable speeds on highways; by keeping cars well maintained; by patronizing service stations that support recycling and reuse of materials; by supporting laws that require tighter pollution-control measures; and by buying fuel-efficient cars.
• Limiting 4WD access to sensitive mangrove and wetland areas.

Activity 3-A: Deadly Links

Summary Students play a game that illustrates how pollutants that enter the food chain at the bottom work their way up until they finally affect predators at the top of the chain.

Learning Objective
Students will be able to give examples of ways in which pollutants—such as pesticides used in gardening, aquaculture, and agricultural practices as well as mosquito control—enter the food chain.
Age Levels
9 and up
Subject Area
Science
Time
30–60 minutes
Materials
A package of multi-coloured drinking straws, green, yellow, red, and blue, cut in lengths of approximately 6 cm so you have a total of about 100, roughly 25 of each colour (or in a ratio of 30 per student).
Eighteen stationery envelopes (or one-third the number of students in the class)
Copy of page 3-14 showing bioaccumulation
Eight coloured bibs or hats (optional)

Background During the past century, people have developed pesticides (including herbicides, fungicides, insecticides, and rodenticides) to control unwanted organisms such as weeds, insects, fungus, and rats. These pesticides contain poisons, toxic chemicals that settle into the soil or stay on crops until they are washed off by rain or irrigation. Through run-off or groundwater, they eventually reach a wetland or the ocean. Testing the ocean water after this has occurred typically does not show a particularly high concentration of these chemicals—but testing the fish does!
The natural recycling processes of mangroves do not work very well with toxic chemicals. Rather than being decomposed and broken into harmless products that can be used by plants and animals, toxins enter the estuaries. They are taken up and concentrated in aquatic plants and animals in a process known as **bioaccumulation**. Bottom-dwelling organisms such as amphipods siphon the detritus (dead or decaying plant or animal material) from the water and can easily take up pollutants that have settled. These toxins, when ingested, remain inside the bodies of the amphipods and are passed along at each step of the food chain.
This is how bioaccumulation works: If an amphipod ingests one piece of detritus containing 10 units of toxin, then it will retain 10 units of toxin: 1 x 10 = 10). If a Mangrove Jack eats 10 amphipods, each containing 10 units of toxin, then the Mangrove Jack will retain 100 units of toxin (10 x 10 = 100). If an Osprey eats 10 Mangrove Jack, each containing 100 units of toxin, and then the Osprey will retain 1000 units of toxin (10 x 100 = 1000), and so on.

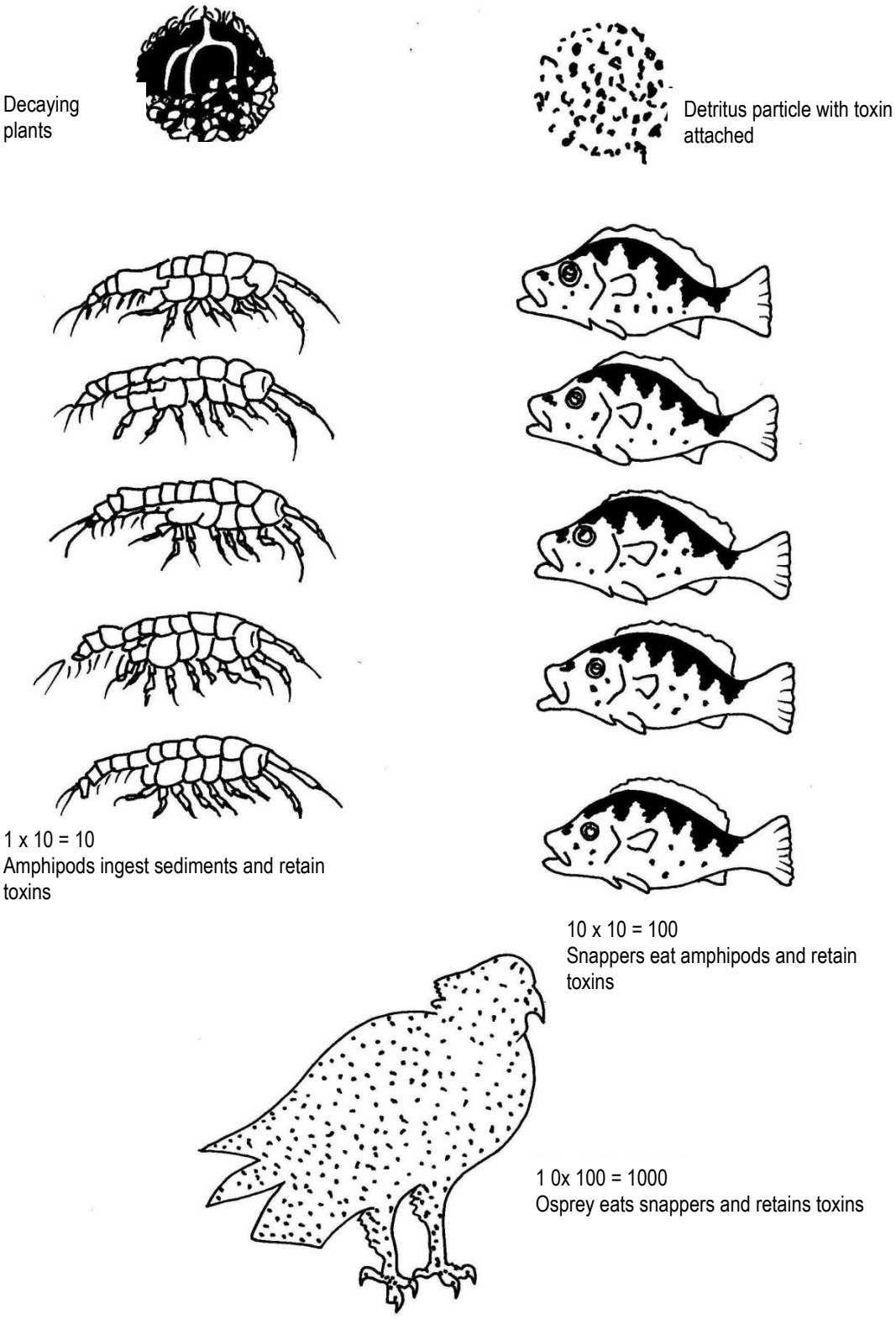


Figure 31: Bioaccumulation in the food chain

Procedure

Students become “Detritus”, primary and secondary consumers like “Amphipods” and “Mangrove Jacks”, and predators like “Ospreys” in a highly involving physical activity of a predator-prey relationship illustrating the food chain.

1. Tell the students this activity is about food chains: for example, Amphipods eat by filtering detritus, Mangrove Jacks eat Amphipods, and Ospreys eat Mangrove Jacks.

2. Divide the students as follows: three times as many Mangrove Jacks as Ospreys, and three times as many Amphipods as Ospreys. (In a class of 26, this would give two Ospreys, six Mangrove Jacks, and 18 Amphipods).

3. Each Amphipod is given an envelope, to represent the Amphipod’s “stomach” in which to collect its food (detritus/straws). The Mangrove Jacks and the Ospreys are given different-coloured bibs or hats so they can be easily identified.

4. Have the students close their eyes while you spread the food (detritus, represented by the straws) around a playing field, an open area, or a large floor area in the classroom.

5. Give instructions (times indicated are for classroom space; make it a little longer if played outside):

a. The amphipods will go out looking for food, which they each place in their stomach (envelope). The Osprey and Mangrove Jacks remain quietly on the sidelines, acting as predators do when watching their prey. After 20 seconds, signal (or whistle) for the Amphipods to stop feeding.

b. The Mangrove Jacks are now allowed to hunt the Amphipods. Ospreys still remain on the sidelines. When a Mangrove Jack catches an Amphipod by tagging, the Amphipod must give up its food envelope to the Mangrove Jack and move to “Amphipod heaven” at the side. Allow 15 to 20 seconds, enough time for each Mangrove Jack to catch one or more Amphipods. Give another signal (two whistles).

c. The Osprey are now introduced and given 15 to 20 seconds to hunt the Mangrove Jacks. When the Osprey tag the Mangrove Jack and retrieve the food envelopes, the Mangrove Jacks go to “Mangrove Jack heaven” at the side.

Note: Any Mangrove Jacks still alive may continue to hunt Amphipods, and Amphipods still alive may continue to eat detritus.

6. Give a signal (three whistles) to end all the action. Have the remaining “live” Ospreys, Mangrove Jacks, and Amphipods stand in view, with the “consumed” wildlife sitting on the floor a few feet away. Ask the “consumed” students who they were and who consumed them. Have the “live” Osprey, Mangrove Jacks, and Amphipods count the number of food pieces (straws) in their envelopes, putting them on the floor as they do (don’t let the students mix their straws with those of other students).

7. Inform the students that the following contaminants have been introduced into the food chain by farmers and gardeners to improve their crop, or by government agencies to destroy pests like mosquitoes.

Insecticides—red straws

Herbicides—yellow straws

All of the Amphipods who were not eaten by the Mangrove Jacks may now be considered dead if they have any yellow or red straws in their food supply. Any Mangrove Jacks that have more than half their food supply contaminated—yellow or red straws—are now dead. The Osprey with the highest quantity of yellow and red straws will not die at this time; however, it has accumulated so

many pesticides in its body that the eggs produced by it and its mate during the next season will not hatch successfully. The other Osprey is not visibly affected at this time.
8. Try the activity again, choosing other colours of straws and different toxins—e.g., blue straws for fungicides and green straws for rodenticides.

Discussion/Reflection
What are the advantages and disadvantages to the farmer, and gardener of using pesticides?
What are some real or imaginative alternatives to the use of toxins? (For example, some farmers successfully use organic or non-toxic substances along with crop rotation, companion planting, biological controls, and genetic approaches in efforts to minimize damage to their crops).
What other species that you know of were or are affected by the use of pesticides?
What are other possible sources of toxic chemicals that could enter the food chain?

Extensions Below are two case studies, one documented, one anecdotal, of declines in bird populations due to the ingestion of toxins that have gotten into the food chain. Interview family members, particularly grandparents, and document similar declines. Ask them, for example, if they remember more of a particular species when they were children than they see now.

Case Study #1
The Osprey is a predatory bird which primarily feeds on fish. When the fish it feeds on lives in waters polluted with pesticides, the pesticides accumulate within the body of the bird. DDT was introduced in Australia in the 1950's to help control insects that damaged crops. The pesticide residue makes the bird's egg shell extremely fragile and subsequently reduced the birth rate. This unfortunately reduced the population of birds like the Osprey. The use of DDT in Australia has been fully banned since 1987.

Case Study #2
Bioaccumulation of pesticides in various fish species has led to decreased viability of sperm, eggs and larvae. There can also be an increase in growth abnormalities and reduced life expectancy of the affected fish. Certain levels of pesticide exposure to fish eggs can also cause skeletal defects and growth reduction of the developing fish. As the smaller fish in the food web are affected they become easily targeted prey for larger predatory fish, subsequently affecting more and more fish species within the mangrove habitat.

Activity 3-B: Pollution Soup

Summary This activity illustrates how many of the items we use every day in the home and yard can create hazardous waste when mixed with water and disposed of carelessly.

Learning Objectives
Students will be able to:
(a) Identify household items that are harmful to the environment and those that are benign; and
(b) Learn how long-term disposal of household products can end up polluting our water supplies, and how to avoid such pollution.
Age Levels
7 and up
Subject Area
Science
Time
30–60 minutes

Materials
A large container—goldfish bowl, glass jar, aquarium or clear plastic container
An improvised filter system to represent what primary sewage treatment does, made of a plastic bottle (cut off the top section of the bottle to make a funnel, turn it upside down and set it in the bottom section of the bottle) and a plastic vegetable strainer
Cardboard cups labelled with felt pen and containing small amounts of the items listed under "Procedure"
Factsheets #2, #3, and #4 on pages 3-5 through 3-10

Background As outlined in the factsheets on pages 3-5 through 3-10, every day we use chemicals in and around our homes that will have a long-term, serious impact on the environment. If we are going to cut down on the pollution of our water supplies and the destruction of waterways and wetlands habitats, we need to change our household habits. For example, many people like to use bleach in large amounts as a general-purpose cleaner, because it kills bacteria. However, bleach contains chemicals, like dioxins, that are a known cause of cancer if absorbed over an extended period of time. Baking soda works just as well as a scouring agent and is a harmless alternative.

Procedure
1. Have a student fill the container half-full with cold tap water. Ask students if we can assume this water is safe to drink. "Who would drink this water?"
2. Pass out the prepared film canisters to students.
3. Have the students add the contents of the cardboard cups to the large container of water (approximately in order of listing); one at a time or in groups as follows:
• Natural items
• Manmade items used in the home
• Manmade items used in the home that are quite toxic—these go down the drain, for the most part, and then to a treatment plant (in urban areas) or a septic system (in rural areas)

• items used in the yard or community that often get washed down storm drains or go untreated into ditches and streams and end up in the ocean

4. Discuss what effects they have on humans and on the animal and plant life in places where the water will end up.

Natural items

- **Milk** left over after a meal.
  Would you drink this water?
- **Vegetable water**, from the draining of hot cooked vegetables.
  Is the water still okay to drink? Does the temperature of the water make a difference to you? Does it make a difference to fish?
- **Salad oil** from leftovers remaining in the salad bowl.
  Would you feed this water to your pets (dog/cat/bird)?
- **Food scraps**—potato or banana peels
  Would you drink this water or let your pets drink it?
- **Potting soil, mud or sand, leaves** from rinsed-off muddy shoes or hands after planting in the home or yard.

What does sediment do to aquatic life? What if this water accidentally ended up in your bath or shower? How would you feel? Would you be mad? Would you want to know who put it in your water?

5. Continue the discussion by pointing out that excessive nutrients increase the level of nitrates and decrease the level of dissolved oxygen in water. Explain that the items so far have been natural things and, while they have not contaminated the water, it becomes unpleasant to us. Adding a lot of foodstuffs will cause algae to grow. When these producers of oxygen die and decompose, they use up much of the dissolved oxygen in the water, so there will not be enough for the fish and other animals. Discuss the difference between natural and manmade items.

Manmade items #1

- **Shampoo**, after washing hair.
- **Laundry detergent**, after washing clothes.
  What would happen to you if you unknowingly drank some of this water? Would you be fine? Would you be ill? Do you think you might have to see a doctor?
- **Bleach mixed with water**, after washing and cleaning.

What kind of effect do you think this will have on the plant life in the area? In turn, how will this affect fish and wildlife that use the plant life for food and protection?

Manmade Items #2

Note: Items in (parentheses) indicate a harmless substance to use in the demonstration rather than a toxic one.

- **Household cleaner (baking soda),** used for scrubbing sinks and tubs.
- **Drano (rock salt),** used for clearing drains.
- **Motor oil (molasses)—**washes down storm drains and into ditches from driveways and roads

- **Coolant/antifreeze** (**milk with a drop of green or blue food colouring**)—washes down storm drains and into ditches from driveways.

If this water accidentally ended up in your shower, what might it do to your body? So imagine what these things must do to fish and wildlife, which have no choice about whether they consume these toxic substances. What would you want to say to someone responsible for putting these things in your water supply that would make them realize they could harm you and the plants and animals?

- **Styrofoam litter**—is washed down storm drains and ditches, left on beaches, or thrown from boats.
- **Plastic bags**—are washed down storm drains and ditches, left on beaches, or thrown from boats.
- **Aluminium cans**—are washed down storm drains and ditches, left on beaches, or thrown from boats.

Litter is quite obvious, and we can easily recognize it as pollution. Many of our fast food and take-out items are packaged in Styrofoam containers, plastic bags, and cans or bottles that get tossed away. What effect does garbage have on plants and animals? Murkiness of the water will prevent sunlight from getting through to the plants—so what happens then? Also, creatures often mistake garbage for food or become entangled in it. As the litter breaks down with the elements, tide, wind and waves, the particles become smaller and more included in the natural surroundings increasing the chance of mistaken ingestion by species such as marine turtles and fish.

Discussion/Reflection

Some of the discussions are included in the procedure (such as items 4 and 5). As the teacher goes through the activity, it is best to discuss the items at that time. The discussions can also be geared to different age levels, depending on how much information you wish to use.

When all the items have been added, discuss what primary treatment does (mostly in a sewage plant or in a septic tank). We often think that treatment plants are going to fix up this mess. Demonstrate by using the improvised filter. With primary filtration, solids are removed from the water, but not much of anything else. All of the pollutants dissolved in the water will, unfortunately, remain in the water afterwards. The same is true of septic tanks and grease, or grey-water, pits. We must be conscious not only of the big stuff going down the drains, but everything else as well. What goes in will inevitably end up poisoning the water and the creatures dependent on it for life. We, too, are among those creatures.

Also discuss the water cycle. Whatever goes into the water will somehow find its way back to us—in the food we eat, the water we drink, the clothes we wash.

Ask where the water that we use goes—"down the drain" in our homes and "down the storm drains or into the ditch" from our yards and streets. Because wetlands and estuaries are where many pollutants end up, we have to be concerned about what we do with our water. Floating bits attached to pollutants end up settling on the bottom. Saltmarshes and mangroves help to keep the ocean's water clean and healthy by filtering and removing harmful pollutants before they reach the sea.

Therefore, the water flowing out of the marsh is cleaner and purer. Some of these pollutants can actually be turned into harmless products through processes that take place inside the plants or below the soil in the plant roots.

There is, of course, a limit! Plants can store and get rid of only so much before these toxins are released back into the aquatic environment. As the plants die and decompose, these toxins will be harmful—in some cases, deadly—to the estuary and ocean. The effect of bioaccumulation on the food chain is an example of this (see page 3-14). The best solution is to reduce pollution or, better yet, eliminate it.

ALTERNATIVES TO HOUSEHOLD HAZARDOUS CHEMICALS

Cleaning Agents

Before the "chemical revolution," householders used creative non-toxic remedies for everyday cleaning problems. These alternatives are also usually much cheaper than the products you will purchase in a store! Can you find a non-toxic alternative in your home?

- Baking soda is a non-abrasive scouring powder.
- Use vinegar for windows and smooth surfaces.
- For gleaming wood furniture, use one tablespoon melted carnauba wax mixed with two cups mineral oil, or dissolve one teaspoon lemon oil in two cups mineral oil, or use pure beeswax.
- Rub toothpaste on wood to remove water stains.
- Avoid aerosol products; mist particles can enter the bloodstream. Use pump or spray bottles.
- Boil cinnamon and cloves in water on the stove for air freshener.
- Clean upholstery or carpet stains immediately with cold water or club soda.
- Open drain with metal snake or plunger, or pour baking soda followed by white vinegar down the drain (it will bubble—stand back!). Keep drains clear with rinses of boiling water and baking soda twice a week.

Paint and Solvents

- Use latex- or water-based paints wherever possible; latex- and water-based paints don't require thinners or solvents.
- Before disposing of oil-based or enamel paint cans, take them outdoors, remove the lid, and allow the contents to air-dry and harden.
- Re-use cleaning solvent as much as possible.

Yard and Garden

Chemical fertilizers are fast-acting, short-term boosters that may deplete the growth capacity of the soil with extended use. Try these simple alternatives:

- Use peat moss, manure, or fish meal for fertilizer.
- Start a compost pile and use the compost to enrich the soil.
- When cutting the grass, try mulching it instead of using a collection bag.

Herbicides are toxic remedies for weed control. Try these solutions:

- Use organic gardening techniques
- Pull weeds instead of using chemical control.
- Cover weeds with a tarp or black plastic sheet.

Pest Control

Caterpillars

- Use a mixture of one cup linseed oil and two tablespoons melted paraffin. Paint around tree trunks.
- Keep your garden clean. Plant debris attracts pests, and infected plants will breed them.

Snails

- Fill a shallow pan with stale beer and place in the garden. Collect and destroy!

Aphids

- Spray plants with a "bubble bath" of dish suds or soapy water. Rinse off when insects are dead.

Ants

• Mix equal parts of powdered sugar and powdered borax; sprinkle on the opening to the anthill or burrow. Or pour a line of cream of tartar, paprika, red chili powder, or dried peppermint leaves at the point of entry. Boiling water is also effective when poured on the nest.

Activity 3-C: Dumpity Dump

Summary Many pollutants enter wetlands and the ocean through careless daily actions.

Learning Objectives
Students will be able to understand the impact of pollutants on water and wetlands, and to recognize how they get there through our everyday actions.
Age levels
8 and up
Subject Areas
Science, Civics and Citizenship
Time
1 or 2 lessons
Materials
Empty or half-empty paint cans
Two wrenches and/or a hammer
Plastic bottle of transmission fluid or oil (can be empty or full)
Pitchfork or garden fork
Can of weed killer
Bottle of paint stripper
Old chemistry set
Old photography chemicals
Factsheet #4 on page 3-10

Background Many people have developed the habit of getting rid of things by just throwing them away, or pouring them onto the ground. All of these actions have serious environmental impacts, with the liquids often ending up in the mangroves or the ocean. See Factsheet #4 on page 3-11 for more details.

Procedure
This song can be used as a radio or TV commercial. One member of the class speaks the monologue and the others sing out the verse. Different kinds of props such as paint cans, pitchforks, and a wrench can be used for the monologues—it makes the song more visually interesting. Each time one of the items is referred to, the speaker can wave it about.

Discussion/Reflection
Have students talk about their observations of themselves and their friends and relatives, and how certain actions might cause serious water pollution.

Extension Students could research ways to recycle oil waste and hazardous products, or find alternative means of disposal, and prepare community posters to point out these concerns to family and friends.

Monologue:
I learned how to change the oil in my car several years ago. I change it every 10,000 kilometres without fail. The used oil is a nuisance, but I figured out that if I sprinkled it on the road I could keep the dust down.

Chorus:
Dumpity dumpity dumpity dump
They dump it on the ground—
Dumpity dumpity dumpity dump
Now that's not very sound.
Dumpity dumpity dumpity dump
Where do they think it goes?
Dumpity dumpity dumpity dump
Nobody seems to know.
Dumpity dumpity dumpity dump
It cycles right around.
Dumpity dumpity dumpity dump
They dump it on the ground.

Monologue: I had to rebuild my transmission and now I have all this transmission fluid to get rid of. Oh, it won't hurt anything if I dump it down the storm drain. First good rain will wash it into the ocean.

Chorus:
Dumpity dumpity dumpity dump
They dump it down the drain—
Dumpity dumpity dumpity dump
I think it's quite insane!
Dumpity dumpity dumpity dump
Where do they think it goes?
Dumpity dumpity dumpity dump
Nobody seems to know.
Dumpity dumpity dumpity dump
It makes it 'round again
Dumpity dumpity dumpity dump
They dump it down the drain.

Monologue: I've been helping my Dad with the cattle since I was four years old. My least favourite job is cleaning up the manure after them. Mum doesn't want it near the house, so I just dump it into the stream and the water takes it away.

Chorus:
Dumpity dumpity dumpity dump
They dump it in the stream—

Dumpity dumpity dumpity dump
It makes me want to scream!
Dumpity dumpity dumpity dump
Where do they think it goes?
Dumpity dumpity dumpity dump
Nobody seems to know.
Dumpity dumpity dumpity dump
The damage can be seen
Dumpity dumpity dumpity dump
Further down the stream.

Monologue: I've been meaning to clean out the storage shed for weeks. Today's the day. I'm going to get rid of everything I haven't used in a year. Gosh, there must be at least 25 different paint cans here—most of them from years ago. This is the blue enamel we used on the outside of the house 10 years ago. I had almost forgotten it. I'll just bag them up and dump them in the trash.

Chorus:
Dumpity dumpity dumpity dump
They put it in the trash—
Dumpity dumpity dumpity dump
I think that's rather rash.
Dumpity dumpity dumpity dump
Where do they think it goes?
Dumpity dumpity dumpity dump
Nobody wants to know.
Dumpity dumpity dumpity dump
The leachate cycles back.
Dumpity dumpity dumpity dump
They dump it in the trash.

Monologue: This paint stripper is from that dresser I fixed up three years ago. Here's some weed killer—I heard the other day that this one was banned because it caused cancer. Here are all those old photographic chemicals from when Christopher took the photography class. And here's some chemicals left from Chris's old chemistry set. Well, this is a good boxful—I think I'll just pour these down the sink before I get too many.

Chorus:
Dumpity dumpity dumpity dump
They dump it down the sink—
Dumpity dumpity dumpity dump
That's crazy, don't you think?
Dumpity dumpity dumpity dump
Where do they think it goes?
Dumpity dumpity dumpity dump

Nobody wants to know.
Dumpity dumpity dumpity dump
I hope they stop to think
Dumpity dumpity dumpity dump
Next time they take a drink.

Monologue: All this hard work really makes me thirsty. I'll just go have a nice cool glass of water.

Activity 3-D: Away with Waste

Summary Students will learn that the waste we "wash away" can have harmful effects later.

Learning Objectives
Students will:
(a) Discover how pollution can affect waterways, including wetlands; and
(b) Discover that the waste we "wash away" can have harmful effects later.
Age
7 and up
Subject Area
Science, English, The Arts
Time
30–60 minutes
Materials
Story-poem beginning on page 3-29, "Away on the Bay"
Drawing paper
Crayons or markers
Construction paper (optional)
Stapler (optional)
Glue (optional)
Copies of Factsheet #3 on page 3-7

Background In our everyday lives, we have developed various ways of getting rid of household items ranging from shampoo to laundry detergent, from car oil to drain cleaners. Very few people actually think about what ultimately happens to these domestically used pollutants that we dump down the sink or into the road. Factsheet #3 on page 3-7 and the poem "Away on the Bay" beginning on page 3-29 clearly shows what happens to this waste, and what we can do to help prevent it.

Procedure
1. Before reading the story, ask the students to name some of the ways they use water (for drinking, bathing, brushing teeth, cleaning clothes and dishes, and so on). Then ask them what happens to the water that drains out of their washing machines or washes down the sinks. (Don't worry about whether the students know the answer at this point. You'll be discussing what happens to household waste with them after the story). Explain that many people never think about what happens to the water they use in their households each day. They also don't think about what happens to the water that runs off their streets and yards.
2. Now tell the students that you are going to read them a story about a town called "Away", where people polluted the water in the nearby bay without realizing what was happening. Ask the students to listen carefully to the story to find out just how the water in the bay became polluted. Also tell them to listen for the word "away". Each time they hear it they should gesture with their thumb over their shoulder to represent something going away.
3. After you've read the story, discuss it with the students. Ask them if the waste from Away simply disappeared.*[No.]* What happened to the waste? *[It ended up in the bay.]* Then go over the verses in

the first half of the story to be sure the students understood what was happening in each one. Use the information in Factsheet #5, Pollution Sources, on page 3-11 to 3-12 to help with the discussion.
4. Pass out crayons or markers and have the students draw pictures of the story. They might draw the people in the town, the bay when it was polluted, or the bay when it was cleaned up again.
5. If you are working with older students, you might want them to create their own picture book or reference file of the story. Pass out copies of pages 3-29 through 3-30 and have the students draw a picture to go along with each verse of the story. Then have them glue their pictures on sheets of construction paper, copy the words of each verse onto the pages, and staple the pages together.

Extension Have the students do their own "Home Enquiry" research project. Students take home the questionnaire on page 5-20 and ask their parents to help them fill in the blanks. At the next class, use the answers to generate a discussion on where the water goes in their houses.

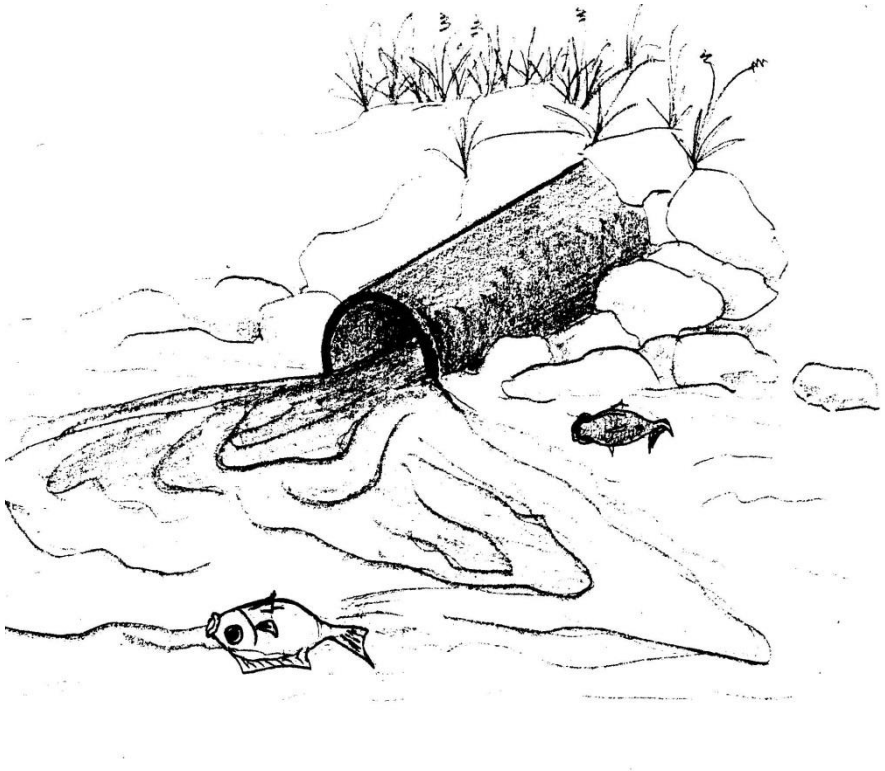


Figure 32: Where does your water go when it goes down a drain?

AWAY ON THE BAY

This is the tale of a town called **Away**
A town that was built on the shore of a bay.
A town where the folks didn't think much about
What they dumped in their water, day in and day out.

For one thing, a sink was an excellent place
To get rid of messes and leave not a trace.
Cleansers and cleaners and yesterday's lunch
Went **away** down the drain with a gurgly crunch.

At everyone's house there was laundry to do.
Day after day, how those laundry piles grew!
Load after load was washed, rinsed, and spun
And **away** went the water when each load was done.

On the High Street each day there were sidewalks to sweep.
The litter and dirt were swept into the street.
And then when it rained, everything washed **away**
Into drains in the road that dumped into the bay.

A mill there made "stuff" for the townfolk to use,
But a pipe from the mill churned out oodles of ooze.
And the ooze, well, it goozed from a pipe to the bay
Where it bubbled and glubbed as it drifted **away**.

Because the weather was warm, it was always a treat
To sail on the bay and bring picnics to eat.
But when folks were finished, they'd toss all their trash
Overboard and **away** with a plop and a splash.

Then folks started seeing that things weren't quite right;
The bay had become an unbearable sight.
Beaches and mangroves covered with garbage and glop
That rolled in with the waves—and the waves didn't stop.

The fish in the bay seemed all sluggish and sick,
The algae were everywhere—slimy and thick.
The birds near **Away** were all suffering too,
'Cause the fish they were eating were covered with goo.

The reefs where the coral was once pretty and bright
Began to turn white—a horrible sight.

And the tourists and divers who came all the time,
Went **away** somewhere else, where things were just fine.

So a meeting was called to discuss the sick bay,
And townspeople came from all parts of **Away**.
And during the meeting one person proclaimed,
"I know who's at fault: We all should be blamed.

"For years we've washed chemicals, dirt, and debris
Down our sinks, off our streets, and out pipes—so you see,
Although we all thought that our waste went **away**,
It all ended up going down into the bay.

"Now the bay is a mess—full of trash, soap, and goop,
The water's turned green, like a bowl of pea soup.
And our wildlife is sick from the garbage and grime;
The bay needs our help, right now while there's time."

The folks were all silent—they knew it was true.
And they realized now what they all had to do.
It was time to get busy, the bay couldn't wait.
If they didn't act now, it might soon be too late.

So they signed an agreement that very same minute
To care for the bay and to stop putting in it
The stuff that had made the bay icky and ill,
Like soaps that pollute and the ooze from the mill.

They also agreed to stop dumping their trash
Overboard and **away** with a plop and a splash.
And all of the efforts have been a success;
Today the bay's clean and no longer a mess.

And that is the tale of the town called **Away**
A town where the people, to this very day,
Remember a saying that's simple and plain:
Nothing just goes **away** ….when it's washed down the drain.

Activity 3-E: Garbage Shuffle

Summary By performing a trash rap, students learn about the history of how people have dealt with trash.

Learning Objective
Students will be able to describe how people have disposed of solid waste throughout history.
Age Levels
8 and up
Subject Areas:
Language arts, music
Time
60–90 minutes
Materials
Copies of pages 3-33 through 3-34, "A History of Rubbish"
Copies of pages 3-35 and 3-36, "The Rubbish Shuffle Rap"
Materials to make costumes and props (optional)

Background If you were an archaeologist, you could sift through the dusty remains of every human population since prehistoric times and discover something common to all of them: trash…rubbish…litter. See "A History of Trash" on pages 3-33 through 3-34.

Procedure
1. Begin by asking the class how people get rid of their rubbish (by dumping it, burying it, or burning it). Explain that the task of getting rid of rubbish has been around as long as people have existed.
2. Pass out copies of pages 3-35 and 3-36, "Rubbish Shuffle Rap", and have the students read through the rap.
3. Then use the information under "A History of Rubbish" (pages 3-33 through 3-34) to discuss the disposal method common to the time period depicted in each of the verses.

Discussion/Reflection
While discussing waste disposal through the ages, ask the students the following questions:
What kinds of trash have people thrown out during different periods?
How did they dispose of it?
Why could prehistoric hunters throw trash on the ground without any problems? How did trash cause problems in ancient Rome, medieval London, and 19th-century cities?
What kinds of pollution can trash create?
What are some of the problems with dumping trash at sea that aren't mentioned in the rap?
Some people think we should launch trash into outer space. What do you think?

Do the Garbage Shuffle Rap
1. Now tell the students that they can perform the rap. Have a volunteer who can demonstrate the rap rhythm read the first verse out loud so the group can get an idea of how the rap will sound.

2. Assign each of the verses to a different child or small group of students. Everyone can join in the chorus. Be sure to give the students plenty of time to practise their verses, and have them coordinate some moves to accompany the chorus, such as shuffling from side to side and clapping. Encourage them to make up appropriate actions for the verses too, such as pointing their fingers or shaking their heads.

3. You could also have the group make costumes and props to fit the different rap roles. The students may want to perform the rap for other groups to teach them about how people have disposed of trash through time.

4. When the students are ready to perform, have them stand in a semicircle. Start out with everyone doing the chorus, while the first "soloist" or small group moves out to do the first verse. At the end of the first verse, repeat the chorus while the first performer(s) returns to the semicircle and the second performer steps up front.

Continue alternating the verses with the chorus until the end of the rap.

Extension Have the students create a trash timeline, using drawings and short summaries to describe the various periods depicted in the rap. You could also have the group make up a new rap verse to describe the kinds of trash people might generate in the future and the ways they might dispose of it.

A History of Rubbish

1. Australia, 60,000 years ago

Many Aboriginal hunter-gatherers simply threw their rubbish on the ground around their camps. Others had special places to dump their refuse – for example shell middens where the debris from eating shellfish and other food have accumulated over time. They can contain:
shellfish remains, bones of fish, birds, and land and sea mammals used for food, charcoal from campfires and tools made from stone, shell, and bone. Made mostly of biodegradable items, the rubbish generally decomposed. Even non-biodegradable objects, such as old stone tools, never accumulated to any significant amount because people lived in small groups and moved from place to place.

2. Ancient Greece, 500 BC

For a time, city residents in ancient Greece and Rome threw their rubbish out into the streets. Human scavengers regularly picked through the waste for reusable items, a practice that continues even today in many parts of the world. Road levels grew higher and higher from the onslaught of trash. Old, torn-down homes were used as foundations on which to build new homes level with the roads.
People in Greece finally organized a system of municipal rubbish collection, carrying waste to dumps at least a mile outside town.

3. Medieval London, AD 1350

People in the Middle Ages threw trash, food, and human waste out into the streets, where it caused a problem in densely populated cities such as London. The mess contributed to the spread of various diseases. (The bubonic plague was one disease that became epidemic. It was spread by fleas from infected rats, which swarmed through the crowded, dirty cities).

4. Atlantic Ocean, 1500

People throughout most of history have considered the ocean limitless and have dumped rubbish into it without hesitation. The rubbish and food waste dumped during the age of ocean exploration usually disintegrated in the salt water. But today, the plastic, sewage, hazardous waste, and other materials we dump are harming marine life and washing up onto beaches, where they are dangerous to people and coastal wildlife. The Caribbean is particularly plagued with such marine debris because it is so close to the main shipping lanes, but there no beaches in Australia (not even ones that are uninhabited) where marine debris and plastics cannot be found . It's estimated that people around the world dump some 6.5 billion (6,500,000,000) Kg of waste into the oceans every year.

5. New York City, 1860

During the Industrial Revolution, large industrial cities in the U.S. became filthier than other cities in previous periods. Dead horses, coal and wood ash from furnaces, and kitchen and animal waste filled the streets and alleys. Pigs roamed the streets, eating much of the food waste. Rats and roaches also invaded the rotting mess, and there were epidemics of disease. Eventually, concerns

about public health led to city street clearing and better-regulated municipal garbage collection and disposal.

6. Melbourne, 1880

Many of Melbourne's parks were originally garbage dumping sites until the mid-1880's when large incinerators were used for garbage disposal. Melbourne City Council employed street cleaners and rubbish collectors in 1901 to dispose of the rubbish.

7. Melbourne, 1950's

Council rubbish collections were subsidized by other recycling facilities. People could return their glass bottles to be washed and refilled. Organisations such as the Salvation Army and Boy Scouts would recycle and reuse newspapers, and fish and chip shops and greengrocers would buy old newspapers to use for wrapping produce. Council were still allowing the use of backyard incinerators for the disposal of leaves and other combustible materials.

8. Australia, 1970's

Waste generation was not a major problem for the 1970's Australia. Food scraps were often fed to the backyard chooks or composted on the garden, and most glass bottles were recycled and reused. There was very little unnecessary packaging and what little waste there was burnt in backyard incinerators. Clothes were handed down to younger children or shared within the community and broken toys etc. were fixed.

9. Australia, 1997

As the population has increased and the average household wage increased so too did the amount of rubbish. The majority of Australia's rubbish is processed using large landfill sites which are getting harder to find as our waste generation increases. In 1996-97 approximately 22.7 million tonnes of waste was generated, that's the equivalent to 1,200Kg per person! Increased packaging from the fast food and the convenience food industry and a decrease in the recycling techniques of many households led to this increase.

10. Australia, 2006-07

As the population has increased to over 22 million people in Australia so too has the amount of rubbish generated. In 2006/07 approximately 43.8 million tonnes was generated in Australia, that's approximately 2,100kg of waste per person per year! Recycling initiatives, such as Clean-up Australia Day has created more of an awareness of our waste and is hopefully instigating a decrease of household waste in the future.

The Rubbish Shuffle Rap

Chorus
Do the rubbish shuffle; it's an age-old thrill—
'Cause we all make rubbish, and we always will!

Now I bet you're askin', bet you're dyin' to see
What an Aboriginal hunter from history
Does with his rubbish! (clap) . . . like old tools of stone—
All that rubbish! (clap) . . . like those shells and animal bones.
Well, I throw 'em, I drop 'em I toss 'em in the midden.
Then I move my camp and we go fishin'.

I'm a wise orator, I'm an ancient Greek.
I was born to talk, and I love to speak.
About rubbish! (clap) . . . it used to fill our roads—
All that garbage! (clap) . . . now we take it in loads
'Bout a mile beyond our city's limit.
Now our homes and streets aren't buried in it.

Now you might be askin' why a British maid
From the Middle Ages would be afraid
Of rubbish! (clap) . . . out the window we throw
All our rubbish! (clap) . . . to the street below.
Well, our city's so crowded that all of that rubbish is
Making us sick and givin' us rashes.

I'm a Spanish explorer and here's what I love:
It's a sailing ship that isn't full of
rubbish! (clap) . . . who wants a messy boat?
All that garbage! (clap) . . . it's tough to stay afloat.
So I toss my trash out into the sea,
Where it disappears and never bothers me.

It's the 1860s. I'm a germ detector.
I'm a New York City health inspector.
I hate rubbish! (clap) . . . the alleys flow with trash—
All that rubbish! (clap) . . . the water's full of ash.
Now those rubbish fumes—they can make you ill,
So it's time we cleaned up what we spill.

In the 1880's you would be a grump
If you lived, like me, near an open dump.
It's all rubbish! (clap) . . . full of bugs and flies—
In the rubbish! (clap) . . . the rats are monster-size.
The trash is so high that people say
We'll have rubbish mountains 'round here someday.

But there's a quick solution, as some folks feel
That incinerators are the way to deal
With rubbish! (clap) . . . it all goes up in smoke—
All that rubbish! (clap) . . . but I cough and choke
On the cloudy fumes that fill the air.
I just wish that I could move away somewhere.

It's the age of plastics; it's the age of ease.
I'm a '60s chemist, and I'm very pleased
With rubbish! (clap) . . . plastic cups, paper plates
In the rubbish! (clap) . . . disposables are great.
We've got landfills now to store this waste,
What we throw away can just be replaced.

There's an oil crisis, and I have to brag,
'Cause I think I've fixed the biggest snag
With rubbish! (clap) . . . 'cause the rubbish can burn—
All that rubbish! (clap) . . . can make a turbine turn.
We'll make energy from our piles of trash.
The only problem will be the toxic ash.

Now that's all very well in the Europe and the USA
But I'm on an island continent, and I live by the bay
With rubbish! (clap) . . . on my foreshore
That rubbish! (clap) . . . .washes up more an' more.
And people say the recyclin' cost too vast
But we gotta find a way that block to pass.

I'm your average kid, and I have to say
That I've found an awesome, cleaner way
With rubbish! (clap) . . . I try to make much less—
All that rubbish! (clap) . . . I'm tired of all this mess.
Now I reuse, recycle, make a compost pile—
It's the rubbish shuffle, 2014-style!

Activity 3-F: Oil Spill Clean-up

Summary Students will learn about the impact that oil spills, large or small, have on our waterways and wetlands.

Learning Objectives
Students will be able to:
(a) Understand the interaction of oil, water, and floating objects;
(b) Test the different methods of oil-spill clean-up on land and water; and
(c) Observe the effects of oil on bird feathers.
Age Levels
7 and up
Subject Area
Science
Time
60–90 minutes
Materials
Glass bottle or jar with cap
Water tinted blue with food colouring
Cooking oil coloured with black tempera paint
Cork or toy boat that fits inside the bottle
Large pan
Sand
Clean-up materials: cotton balls or swabs, cut-up pantyhose or stockings, paper towels, popcorn, sponges, sawdust, gauze pads, rope or string, turkey baster or eye dropper, popsicle sticks
Bird feathers
Clean water in small pan
Liquid detergent
Toothbrush
Factsheets #2, #3, and #5 on pages 3-6, 3-7, and 3-11

Background On the 11th March 2009, the 185m vessel the Pacific Adventurer lost 31 containers from its deck in rough seas. Some of these containers pierced the ship's hull resulting in the loss of 270 tonnes of heavy fuel oil. Due to weather and tidal conditions this oil was deposited on large sections of Moreton Island and in smaller quantities on the beaches of the Sunshine Coast and Bribie Island to the north of Brisbane. Approximately 2500 people were involved in the clean-up of the oil from state, local and federal government agencies and local community groups. Thankfully due to the time of year and the effects of Cyclone Hamish the wildlife damage was minimised and only 36 animals were affected. These included pelicans, petrels, turtles and sea snakes. Overall the cost of the clean-up operation was well over $100 million dollars!
To understand the impacts of oil spills on wildlife, three activities have been devised that will also help students understand what to do during an oil spill.

Part A: What Happens in an Oil Spill?

Procedure

1. Have the students fill a glass bottle or jar two-thirds full of water and add food colouring.

2. Put 1cm or more of black-tinted cooking oil into the bottle to represent the oil spill. Where does the oil congregate? *[On the surface.]*

3. Drop the cork or toy boat into the bottle. What happens to it? *[It becomes coated with oil.]*

4. Put on the cap and have the students shake the bottle vigorously to simulate a storm or wave action. What happens to the oil? *[Some mixes with the water.]*

Figure 33: What does happen in an oil spill?

Discussion What would happen to organisms that float on the surface, such as seabirds, ducks, seaweed, or plankton, or those that need to come to the surface to breathe, such as sea turtles, whales, or seals? *[They'd be coated with oil.]* Explain that over time, water and oil mix somewhat, and that some of the oil will sink to the bottom of the ocean. (Crude oil is heavier than cooking oil.) What would happen to the lobsters, crabs, sea urchins, and bottom-dwelling fish?

Part B: Cleaning up an Oil Spill

Procedure

1. In one end of the large pan, add a mound of sand to represent a sandy shoreline. Pour blue-tinted water into the rest of the pan.

2. Add black cooking oil to the water to simulate a spill.

3. Divide the class into teams of three or four students, and let each team choose two or three different clean-up materials to test.

4. Have the students make a plan for how they will use each material and then test them.

Discussion Talk about why the efforts worked or didn't work. Was all the oil removed? How well might their efforts work on an actual oil spill? What conditions might be different? Discuss what

kinds of equipment actual oil-spill clean-up personnel use, such as containment booms, skimmers, and absorbent materials, and how similar they are to items the students used.

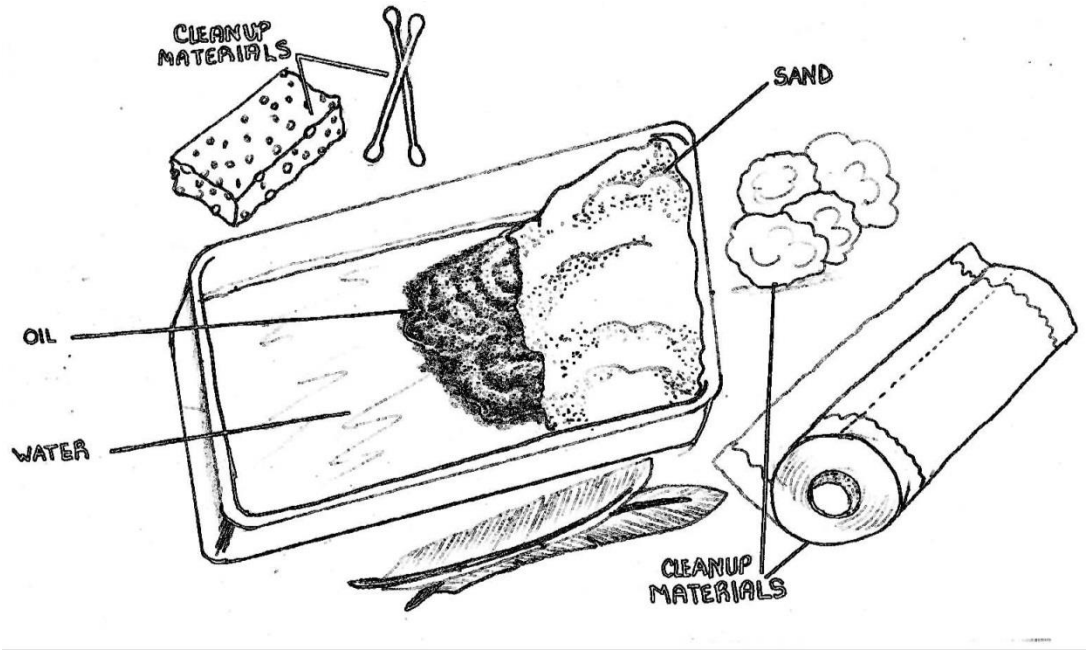


Figure 34: Clean up that oil spill

Extension: For homework, have the students research the concept of **bio-remediation** and how it works. What happens to the oil that is recovered after an oil spill? *[It is usually burned.]* Is bio-remediation a better alternative? Have the students make a diagram or list of the life in a marine environment (including mangroves and other shorelines) near them. How would each organism be affected by an oil spill? What animals are most vulnerable to an oil spill? *[Those that can't move; filter feeders like oysters, barnacles, and clams; those that surface often; those that depend exclusively on marine life for their food supply.]*

Part C: Oil and Feathers Don't Mix

Procedure

1. Examine a feather (see page 2-59, What Lives in Mangroves?). Natural oiliness on the feather keeps it from becoming waterlogged. Notice how it can fluff up after it's been handled.

2. Drop the feather into a pan of clean water. Does it float? Shake it off and dry it completely on a paper towel in the sun. Does it still fluff up after being wet?

3. Drop the feather into a pan of blue water and black oil. What happens to it?

4. Use more than one feather, and have the student groups try to clean them up. Some students may use liquid detergent; others may just scrub with a toothbrush. Dry the feathers on a paper towel in the sun. Do they fluff up?

5. Now drop them into a pan of clean water. Do they still float as before? These tests will indicate that the feathers have lost their ability to insulate and to resist waterlogging.

Activity 3-G: Wheel of Trouble

Summary Students will make a wheel that shows the reasons why the Beach Stone Curlew is becoming endangered.

Learning Objective
Students will understand why the Beach Stone Curlew is listed as vulnerable on the IUCN red list.
Age Levels
8–14
Subject Areas
Science, social studies
Time
40–60 minutes
Materials
Pictures of Beach Stone Curlew
Copies of page 3-42 showing "Wheel of Trouble"
Lightweight paper plates at least 23 cm in diameter
Crayons or markers
Scissors
Glue
Tape
Paper fasteners
Construction paper (optional)

Background The Beach Stone Curlew is endangered for the same reason that many other species are in trouble, including habitat loss, habitat degradation and pollution. Using the Curlew as an example, students can learn about the variety of problems that affect many endangered species.

Pre-procedure
Before you begin, make eight triangular patterns, following the directions under "Getting Ready" below. Then start the activity by showing the class pictures of Beach Stone Curlew and talking about their natural history. (For general information about Curlews, see *Shorebirds of Australia by Geering et.al.)*

Getting Ready
1. Cut out the circle on page 3-42 and tape it to the back of a paper plate. (Don't use too much tape because you will eventually be removing the circle.)
2. Cut out each segment, making sure you don't cut through the centre circle or along the outer edge of the circle (see diagram on page 3-42). After cutting out each segment, remove the paper pieces. (You will end up with four separate segments.)
Repeat until you have enough segments so each student can have one.

Procedure

1. Now tell the students that the Beach Stone Curlews are endangered. Explain to the class that they will be learning why these birds are in trouble by making a "Wheel of Trouble".

2. Give each child a copy of page 3-42, two paper plates, scissors, glue, a paper fastener, and crayons or markers. Also hand out the triangular segments you made earlier, one to each student.

3. Have students colour the pictures on page 3-42, then cut out the circle along the solid outer line.

4. Glue the circle onto the back of a paper plate. (Tell the students to use a thin layer of glue). Set this plate aside.

5. Lay the triangular pattern on the back of the other paper plate so that the edge of the pattern meets the edge of the plate. Trace it and cut out the shape.

6. Place the cut-out plate on top of the plate with the pictures and push a paper fastener through the centre of both plates. (If you are using thick paper plates, you may have to first poke a hole through the plates with scissors or a pen.)

Discussion/Reflection

As the students turn the top or bottom plate, each of the four pictures will appear in the cut-out space. Explain that these pictures illustrate the four major problems the Beach Stone Curlew face. Have the students turn their wheels to picture A, then B, and so on, and use the information under "Trouble for Beach Stone Curlews" on page 3-43 to talk about each of the problems.

After your discussion, have the students draw a picture of a Beach Stone Curlew on their top plate and write the title "Why Beach Stone Curlews are in Trouble."

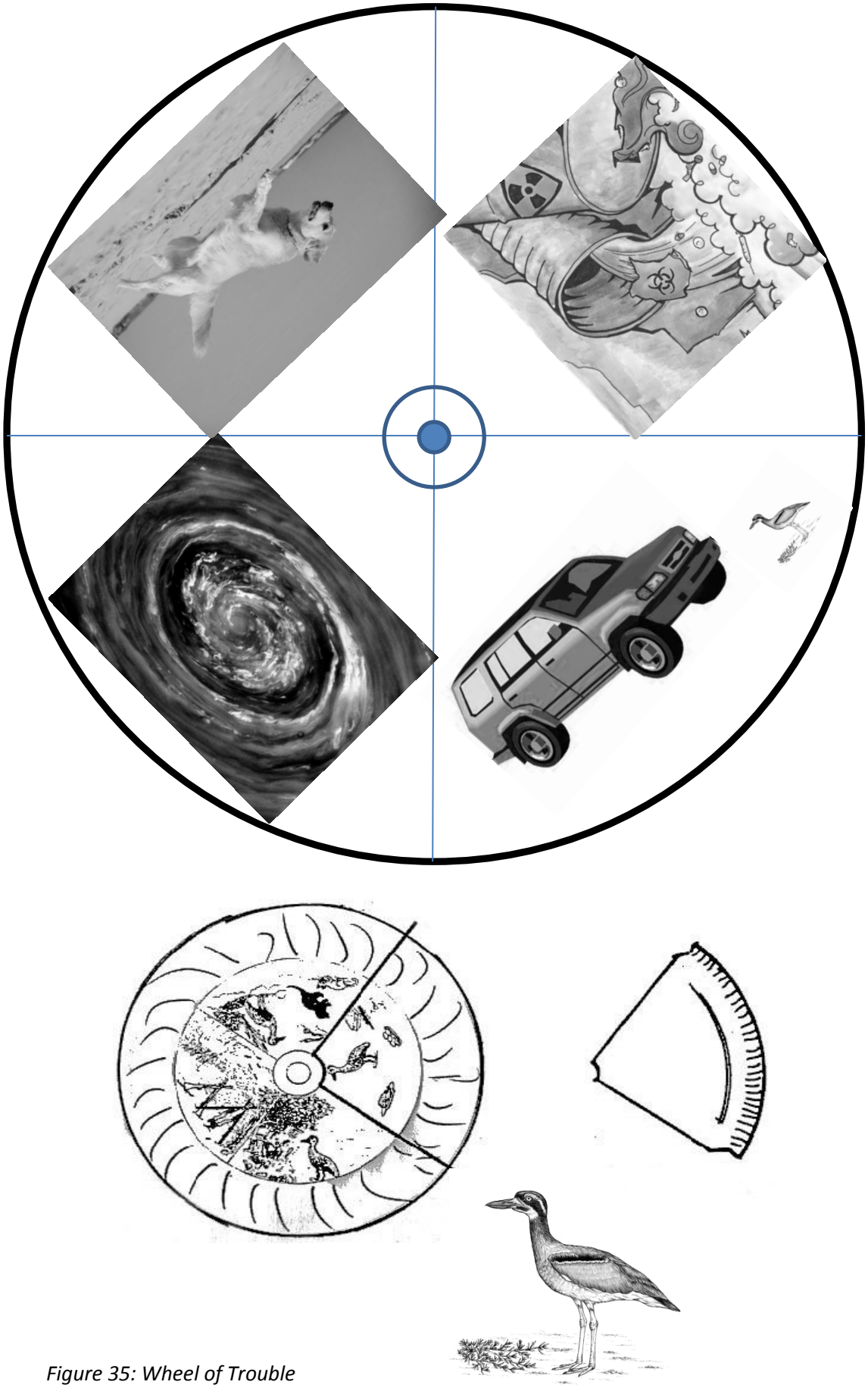


Figure 35: Wheel of Trouble

Trouble for Beach Stone Curlews

A. Recreational pressures.

Beach Stone Curlews are large birds that feed when the tide is low on exposed mudflats chasing small crustaceans and other invertebrates. They do not have a traditional "nest", however they generally lay one egg on the ground generally below a tree. This ground dwelling life can lead to lots of problems for this bird from humans. We like to fish from the beach at low tide often disturbing the birds from their nests. A lot of beaches are also easily accessed by 4WD vehicles and other recreational vehicles such as quad bikes and motorbikes. These are loud and noisy and often disturb the birds and compact their feeding grounds.

B. Habitat destruction and degradation.

Natural processes such as storms, cyclones, droughts and floods can cause a loss of habitat for the Beach Stone Curlew. With the loss of the protective mangroves the shore is opened to more predators and their eggs are exposed. Changes in the transport of sand through ocean currents by the construction of groynes and marinas have also led to the destruction of some historical mangrove sites which the birds have been migrating to for generations.

C. Water Quality and Pollution.

Poor water quality in coastal areas leads to a reduction in available food for the Curlews to eat. Curlews primarily feed on crabs and other invertebrates, poor water quality and excess siltation from upstream developments could lead to reduction of these food sources being available. Excessive siltation can also cause the loss of essential mangrove habitat by not allowing the mangroves to "breathe" through their pneumatophores being covered with mud. This can lead to fragmentation of the wetland areas providing less shade for the Curlews to nest around.

D. Introduced species.

Feral pigs, cats, dogs and foxes all have an impact on every aspect of the Beach Stone Curlew's lifecycles. Adults are predated by cats and foxes and are often exhausted by unrestrained dogs on the beach and in their wetland homes. Pigs and foxes are responsible for the devouring of their eggs. Beach Stone Curlews generally only lay one egg per season directly on the ground with only grass to camouflage them. The chicks are dependent on mum and dad until they are between 7-12 months old; this also makes them easy prey for the likes of cats and foxes.

Activity 3-H: The Rare Scare—the Road to Extinction

Summary Compare several imaginary animals to determine which has the characteristics of a "typical" endangered species.

Learning Objectives
Students will be able to:
(a) Define vulnerable, endangered, and extinct; and
(b) Describe several characteristics that make an animal extremely susceptible to extinction.
Age Levels
7–12
Subject Area
Science
Time
30–60 minutes
Materials
Copies of pages 3-47 and 3-48, "Imaginary Animals"
Index cards
Markers
Easel paper or chalkboard

Background Beach stone curlews, Rusty monitor, the water mouse, green turtles, loggerhead turtles, dugongs and many other endangered species have more in common than just their endangered status. Many share characteristics that make them extremely susceptible to becoming extinct. They are more prone to extinction if they:
• Interfere in some way with people's activities. Compete with people for food or area usage eg. crocodiles and fruit bats.
• Migrate. Animals that have to travel long distances between their feeding grounds and breeding grounds tend to encounter more problems that those that are resident to the area. Migration involves travels across oceans and continents either in the air where they are susceptible to storms, planes and tall buildings; or in the ocean where there are nets, boats and rubbish to threaten they travels. Good examples of migrating animals are the Bar-tailed Godwit, Beach Stone Curlew, Loggerhead turtle and the green turtle.
• Have very specific food or nesting requirements. Some animals specialise in what they eat and where they live. These specializations allow the animal to become endangered if their food source of habitat is damaged. A global example of this is the Giant Panda in China and local examples include the Illidge's ant-blue butterfly which relies on a certain species of ant and mangrove for its development and the water mouse which feeds lives on a mound built in the mangroves.
• Are very sensitive to changes. Many animals have a difficult time adapting to changes in their environment. Some animals struggle to deal with the introduction of a competing species. For example in Far North Queensland and the Northern Territory the freshwater crocodile is under threat from the movement of Cane toads into their areas. The cane toads have overrun populations of the natural food source of the crocodile; frogs, lizards and snakes; and in turn made themselves

the only food source for the crocodile. Unfortunately the Freshwater crocs cannot handle the cane toad's poison and they are now dying in record numbers.

• Are naturally rare. Some animals are rare throughout their range, and others have a very limited range. In both cases, the animals are often vulnerable to habitat destruction and other people-caused problems. A good example of this is the Rusty Monitor lizard. It primarily lives in hollows in mangroves and feeds on crabs, lizards and fish. Clearing of coastal habitat and fragmentation of the mangrove forest due to pollution has limited the quantity of trees with hollows for this lizard. Threats from introduced predators such as pigs, cats, foxes and cane toads have also had a big impact.

• Have small broods and long gestation periods. Ask the students if they can think of some animals that give birth to only one or two young a year or every two or three years (bats, elephants, beach stone curlews, grey nurse sharks). Explain that when the populations of these animals drop, it takes much more time for them to recover and sometimes become extinct before they have a chance to make a comeback.

• Animals with a low birth rate have another problem, too. They don't reproduce fast enough to produce offspring that can adapt to changing conditions. Have the class compare the capabilities of an elephant with those of a cockroach. Explain that, on the average, an elephant has about three young every 10 years, and that a cockroach has 80 young every six months. Copy the following figures onto the board and explain that if all the individual animals lived and mated, this would be the number of young produced in each generation:

	Elephant	Cockroach
1st generation	3	80
2nd generation	6	3,362
3rd generation	13	137,842
4th generation	28	5,651,522
5th generation	61	231,712,403
6th generation	132	9,500,208,482

Have the students compare the number of years it takes for an elephant and a cockroach to produce a sixth generation. (Since an elephant has an average of three young every 10 years, and a cockroach has an average of 80 young every half year, it would take elephants 60 years to produce six generations, and only three years for cockroaches to do the same). Emphasize that, because of their high birth rate, cockroaches have more opportunity to adapt to changes in their environment.

Preparation Paste each of the different characteristics that make animals prone to extinction (as outlined in the Background) onto index cards.

Procedure

1. Pass out copies of pages 3-47and 3-48, "Imaginary Animals".

2. Explain that each animal on these pages is imaginary but has the same characteristics as real animals living today.

3. Pass out index cards explaining reasons that animals become extinct.

4. Have students read the information on page 3-47 and on the index cards, and then decide what animals would be the first to become extinct as more and more people move into their area.
5. Tally on the blackboard how many students voted for each animal. Ask students why they picked each animal. Then explain that many animals that are threatened or endangered share one or more characteristics that make them more prone to extinction. Discuss some of these characteristics using information provided in the Background.
6. After the discussion, have the students look at pages 3-47 and 3-48 again to see if they agree with their original choices. Then take another tally and compare the results to those of the first one.
7. Explain that the Crested Crabbit is the animal that will probably become extinct first, because it has so many of the characteristics that make an animal susceptible to extinction. For example, it has a limited range, has a low birth rate, has a specialized diet, migrates, and nests only in one type of tree. Explain that the animals that have one or more of these characteristics usually survive well until people-related problems, such as habitat loss and pollution, start to affect them.

Extension Older students could research some of the costs of coastal developments that have been built on former mangroves. They could talk with people at both banks and insurance companies about such things as risk analysis and insurance premium costs. How much does cyclone insurance go up after claims caused by cyclone damage? The students could write a report on their findings. Students could research a “before and after” cyclone-damage scenario to determine what a storm actually costs a local community, and then write a report on their findings.

Scaly Mangrove Muncher

- Lives in mangrove forests.
- Feeds on insects, small mammals, and Grey Mangrove seeds, very fond of mangrove roots.
- Has one brood per year (average three young per brood).
- Lives in social groups called grandals.
- Some groups migrate, others stay year round.

Crested Crabber

- Is noted for its shiny mauve feathers.
- Lays three eggs every two years.
- Feeds on purple-shelled mud crabs.
- Nests on mud banks near gum trees.
- Migrates each year to Queensland.

Zobrun

- Lives in burrows.
- Often found in sandy dunes near the Equator.
- Feeds on rare shiny black cactus.
- Mates for life.
- Can have two broods a year, but usually has one; often gives birth to triplets, but two usually die.
- Is noted for its beautiful red fur.

Purple Ploon

- Lives in seagrass beds and Red Mangrove roots.
- Feeds on small fish and aquatic insects, very fond of mosquito larvae.
- Sleeps in mud 18 hours per day.
- Lays an average of four eggs per year; eggs very sensitive to pesticide poisoning.
- Has been introduced into other areas to control mosquitoes.

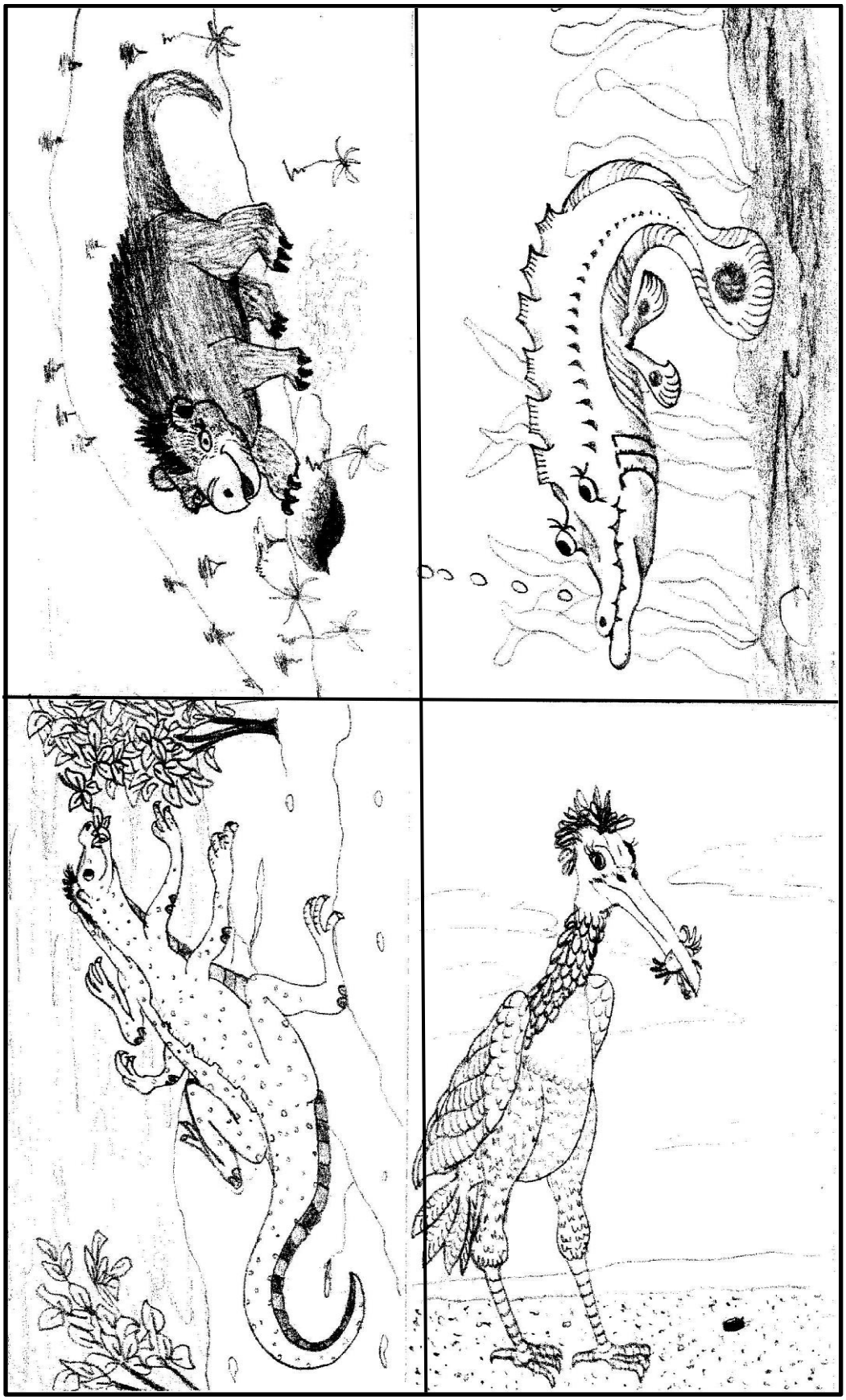


Figure 36: Imaginary Animals

Activity 3-I: Queensland Endangered Species Poster

Summary Many species of animals throughout Australia are either threatened or endangered. This activity will make students aware of what factors cause animals to become threatened and endangered.

Learning Objectives
Students will be able to:
(a) Understand which species are threatened or endangered regionally and locally; and
(b) Design a poster drawing attention to one particular endangered animal that contains information about why the animal became endangered, its habitat, and what can be done to protect both animal and habitat.

Age Levels
8–14

Subject Areas
Science, arts

Materials
Copy of Species at Risk list on page 3-51
Copy of example of endangered species poster on page 3-52
Drawing or art paper
Crayons or paints
Camera (optional)
List of suitable websites
Postcards and/or photographs

Background Endangered animals are specific animals whose populations are steadily becoming smaller or decreasing. These animals are in danger of dying out, or becoming extinct.
Animals become endangered for many reasons. Some are collected for the pet trade (eg. Rusty Monitor). Hunting is another threat, as is taking animals because they or their parts can be sold for profit. For instance, Hawksbill Turtles are killed for their shells. Some endangered species eat agricultural crops or prey on livestock, and farmers resort to shooting or poisoning animals that threaten their livelihood. As humans have needed more and more land for homes, recreational facilities, shopping centres, and agriculture, much habitat has been lost. In fact, habitat loss through alteration or destruction is the leading cause of species decline throughout the world.
Some species live in very specialized areas, thus limiting their ability to survive if their habitat is lost. Introduced predators—such as pigs, rats, cats, dogs, foxes, cane toads—create problems for endangered species, especially birds that are killed or lose their eggs through predation, and egg laying reptiles.

Procedure
1. Have each student select an endangered animal from the list provided on page 3- 51.
2. Have the students carry out research in the school or public library or on the Internet or through a local conservation organization to learn more about the way in which the existence of this animal is threatened.

3. Then have the students design a poster, featuring the animal they have chosen. See example on page 52.
4. Using what the students have learned about "their" creature, they can draw, use photographs, or write an answer to each question below to create an informative poster on their endangered species.

Discussion/Reflection
Have students share their knowledge by giving a presentation to the class on their chosen endangered species, using their poster as a visual aid.

Extension
Make a display of the posters in a central area of the school to create awareness in the school of endangered species in their region. Make a display of the posters in a local community area such as a library or sports complex to draw the community's attention to the problems of endangered species in their region.
Ask the students to generate their own endangered species list for their local area using the above-mentioned websites.

All about My Endangered Species
1. What does my endangered species look like?
2. What is its primary habitat?
3. Where does it have its young?
4. What does it eat?
5. What are the major threats to its survival?
6. How can we help to protect it?

Table 3: Examples of Threatened Fauna Species of Queensland

Regent Honeyeater (*Anthochaera phrygia*)	Eastern Curlew (*Numenius madagascariensis*)*
Blue Whale (*Balaenoptera musculus*)	Little Tern (*Sternula albifrons*)*
Grey Nurse Shark (*Carcharias taurus)*	Rusty Monitor Lizard (*Varanus semiremex*)*
Great White Shark (*Carcharodon carcharias*)	False Water Rat (*Xeromys myoides*)*
Loggerhead Turtle (*Caretta caretta*)	Illidge's Ant Blue Butterfly (*Acrodipsas illidgei*)*
Southern Cassowary (*Casuarius casuarius johnsonii*)	Koala (*Phascolarctos cinereus*)
Green Turtle (*Chelonia mydas*)*	Freshwater Sawfish (*Pristis microdon*)
Coxen's Fig Parrot (*Cyclopsitta diophthalma coxeni*)	Saltwater Crocodile (*Crocodylus porosus*)*
Leatherback Turtle (*Dermochelys coriacea*)	Spectacled Flying Fox (*Pteropus conspicillatus*)*
Mary River Turtle (*Elusor macrurus*)	Grey-Headed Flying Fox (*Pteropus poliocephalus*)*
Black Rock Cod (*Epinephelus daemelii*)	Fitzroy River Turtle (*Rheodytes leukops*)
Hawksbill turtle (*Eretmochelys imbricata*)	Whale Shark (*Rhincodon typus*)
Speartooth Shark (*Glyphis glyphis*)	Bridled Nail-Tail Wallaby (*Onychogalea fraenata*)
Swift Parrot (*Lathamus discolor*)	Greater Bilby (*Macrotis lagotis*)
Olive Ridley Turtle (*Lepidochelys olivacea*)	Giant Barred Frog (*Mixophyes iteratus*)
Wallum Sedge Frog (*Litoria olongburensis*)	Southern Marsupial Mole (*Notoryctes typhlops*)
Mary River Cod (*Maccullochella mariensis*)	Mahogany Glider (*Petaurus gracilis*)
Southern Giant Petrel (*Macronectes giganteus*)	Opal Cling Goby (*Stiphodon semoni*)
Humpback Whale (*Megaptera novaeangliae*)	Tinkling Frog (*Taudactylus rheophilus*)
Flatback Turtle (*Natator depressus*)	Campbell Albatross (*Thalassarche melanophris impavida*)
Australian Lungfish (*Neoceratodus forsteri*)	Grassland Earless Dragon (*Tympanocryptis pinguicolla*)
Beach Stone-Curlew (*Esacus magnirostris*)*	Northern Hairy Nosed Wombat (*Lasiorhinus krefftii*)
Australian Painted Snipe (*Rostratula australis*)	Ornamental Snake (*Denisonia maculata*)

And many, many more…… refer to http://www.environment.gov.au/cgi-bin/sprat/public/publicreports.pl?proc=species and generate your own list!

*Animals found in or adjacent to mangroves

Example: My Endangered Species Poster

Illidge's Ant Blue Butterfly
Acrodipsas illidgei

What does my endangered species look like?

The Illidge's Ant Blue butterfly has small white eggs with a diameter of ~0.7 mm. In its caterpillar stage it is white. The pupa of the butterfly is approximately 1 cm lengthwise and is brown.

Adults are brown and females have blue coloured regions on the upper surface of their wings that change colour depending on the angle from which the surface is being viewed. The underside of the wing of both male and females are fawn and contain small dark spots. The butterfly's wingspan is ~2 cm.

What is its primary habitat?

Illidge's Ant Blue lives in mangrove forests in SE Queensland. The species can be found at six confirmed sites: Mary River Heads, Beaver Rock and Maaroom in the Mary River Region; Redland Bay and Point Halloran in the Moreton Bay region; Brunswick Heads in New South Wales.

Where does it have its young?

The eggs are laid by the females in stumps on Grey Mangrove trees where there is a presence of Crematogaster ant colonies.

What does it eat?

The larvae are transported to the ants' nests by the ants where they feed on excretions from the butterfly larvae, while a larva on the other hand feeds on developing ants.

What are the major threats to its survival?

1. Destruction of mangrove habitats – particularly old mangrove trees which house the ant colonies in hollow stems and branches that are essential to their survival.
2. Spraying mangroves to control mosquitoes (fogging) using toxic substances such as malathion.

How can we help to protect it?

1. By protecting mangrove habitat.
2. By educating other people about the importance of the mangroves for the species.
3. Prevent the use of insecticides in mangroves that are known habitat for the butterfly.

Letter Soup

Find among the letters in the box the words that are part of mangroves as an important ecosystem:

Mangroves	Coastal	Importance	Seed
Propagule	Marine	Mud	Sustainable
Exchange	Economic	Resources	Management
Gases	Recover	Land	

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

EXPLORING MANGROVES
4 - 1

CONTENTS SECTION 4

FIELD EXPLORATION—GETTING READY

No study of mangroves is complete without a field trip to experience all kinds of wetlands at first hand. It is important that the lessons learned in the classroom be put into practice in the field. Nothing can replace the value of the children's hands-on experience with the sights, sounds, smells, and excitement of a true wetland.

While it is very important for students to visit an actual wetland, they also need to make connections with the natural resources available in their own "backyards". The following are activities that you can use to introduce your students to the environment around them. First, have the students discuss the word **environment**. It may mean different things to different students—a neighbourhood, the yard at home, the world, or even the school building. Let individuals choose a definition, and then ask a few to report what they have written.

Take the class outside for 10 minutes. For the first five minutes, have them write down the first five things that they see that they like and that they dislike. Spend the last five minutes hearing responses. There are no right or wrong answers. Return to the classroom and have students write a poem or a short story about the thing they'd like to change about their environment, telling how they would go about making the change. Display their work on a bulletin board.

Children need to experience the sights and sounds of wetlands to really appreciate them. Take them out in old clothes to a place where there is some mud. Have them scoop up a handful of mud. What does it feel like? How does it smell? Bring along some paper for mud finger paintings, or let the students draw mud designs. If mud is not readily available, make a few buckets of your own! And have fun.

This is also a time when you can introduce Sound Mapping (see page 4-34). This is another way to get the students to use their senses before a wetland visit. The next step is to read carefully the following pages on how to prepare for a field exploration. Then build or acquire the tools you will need, find your wetland, and book a date to go.

Now you are ready for the real thing—good luck!

FIELD INVESTIGATION
Mangrove Etiquette

Promote conservation!
Conservation is the protection and wise, sustainable use of natural resources. A visit to any natural area can be a stimulating and exciting experience for students of any age. However, all of us must be careful to remember that natural areas are habitats for wild plants and animals, so we should behave as visitors who have been invited to share someone's home.

Many people who go to mangrove areas are not aware that they are the home of thousands of creatures—especially when they visit intertidal areas associated with the beach! The diverse organisms living in mangroves and other kinds of wetlands have to contend with fluctuating water levels, drying sun, waves, and land predators (including humans) in order to survive. Use the following guidelines to encourage appropriate behaviour so the mangrove and marine life can survive your visit and be there for others to enjoy and for students when they return.

Teach important field skills.
A field trip is an excellent opportunity to teach students outdoor etiquette skills that they can use all of their lives and pass on to their own families and children. How can you help take care of animals, plants, and other organisms that you encounter in your field and classroom studies? How can you keep from disturbing their wetland homes? How can you learn more about your environment by observing it in its natural state? What can you do to ensure that enjoyable camping and other outdoor recreational activities do not harm wildlife or habitats?

We will see more if we are quiet. The site should be left as close to natural as possible, so that future visitors will be able to enjoy the area's plants, wildlife, and beauty.

Leave only footprints. Take only photos.

Some rules are necessary when visiting a natural site. Here are some suggestions:

1. **Step softly and quietly while observing animals.**
Stay quiet. Yelling, shouting, and running around will scare animals away, and may cause some to abandon their nests or young, or avoid the area in the future.

2. **Leave animals and plants where you see them.**
To help preserve the balance of the wetlands and intertidal areas, leave the creatures in their natural habitat. As tempting as it may be to take home or back to school a bucket of crabs or fish to observe, these organisms will have a much better chance of surviving if left in their own environment. If you are digging for mussels or worms, refill your holes. It is not the hole that is injurious, but the sand and mud piled up around the hole. All bivalves require a connection to the surface in order to survive. Their siphon can stretch only so far, and piles of mud or sand create a

suffocating blanket. Even empty shells are part of the mangroves ecosystem: limpets, periwinkle, barnacles, and mussels often grow on them, and they are, of course, often homes for hermit crabs.

3. **Replace rocks and logs in their original position after looking under them.**
Animals living under the rocks and logs may die if exposed to the sun, the air, and changes in temperature. Try to keep people from stepping into depressions left by the rocks or logs.

4. **Handle animals gently.**
They have different anatomies from our own, and we may be unaware of ways they can be hurt. Any animals that students handle will probably be much smaller than we are, so treat them tenderly.

5. **Do not move animals from one area of the wetland or intertidal zone to another.**
A tide pool in the low-tide zone has different temperatures and salinity from those higher up. A low tide animal such as a sea urchin or sea star would not survive in the high-tide pool. One type of wetland immediately adjacent to another may have much higher or lower salinity content. Thus, an animal adapted to fresher water might not survive if the water were more saline.

6. **When walking along the edge of the wetland or the low-tide area, avoid stepping on barnacles, mussels, and limpets.**
These intertidal creatures are closed, but still alive and waiting for the next tide to cover them and bring them food. This is a protective adaptation that helps them to survive in the intertidal zone.

7. **Leave the wetland or intertidal zone cleaner than you found it.**
Plastics make up the major portion of garbage in wetlands and the intertidal areas, and they can kill wildlife that become entangled in it or eat it. Clear plastic bags may be mistaken for jellyfish, while fishing line, six-pack rings, lost crab pots and plastic bands contribute to entanglement.

8. **Minimize trampling of plants and fungi.**
If trails are designated, stay on them as much as possible.

9. **Be aware that many birds nest on the ground.**
Different birds nest in mangroves, on beaches, and on the ground. Remember that such nests and the chicks are camouflaged from predators, and are therefore difficult to see before one's foot is right over them. Always watch where you are walking, and keep pets leashed during the breeding season. This is another reason to stay on trails.

10. **Never chase, flush, or harass animals.**
This includes being on foot, in a car, boat, personal watercraft, or all-terrain vehicles. Harassing endangered, threatened or migratory animals is against the law in Queensland.

11. **Move slowly, allowing the animal to keep you in view.**
Avoid sneaking up on animals. The following are the signs that you may be too close to birds:
• Head raised, looking at observers

- Skittishness
- Excessive preening or pecking at dirt or foot/bill wiping
- Alarm calls; repeated chirping or chipping
- Distraction play: broken wing, tail spread, etc.

12. **Teach students to stay away from an active nest.**
If an active nest is ever encountered (i.e., one with eggs or chicks, or one that looks new or under construction), it should never be touched. When moving away from the nest, do so by continuing to walk in the direction you were originally going. In other words, do not leave a one-way or V-shaped scent trail to a nest. This is because predators are smart; they not only sometimes watch people (have you ever been watched by a hawk?) but mammalian predators can smell your trail and follow it to a nest.

13. **Plan bathroom stops.**
These should be made just before leaving on the trip, and afterwards. However, teach children that if it is necessary to "use the bushes", never to leave toilet paper behind. Used toilet paper should always be carried in a plastic bag, and everyone should carry their own toilet paper and plastic bag when a long trip away from facilities is anticipated.

14. **Before leaving**
Take time to assess the impact of your visit. Have students ask themselves: "Is this area as beautiful now as before my visit?"

MANGROVE PLEDGE
To help students remember these guidelines, they could learn the following pledge or make up their own. Before you leave school, or when you arrive at the area of exploration, have them raise their right hands in the air as if they were swearing in a court of law to tell the truth, and repeat the pledge after you.

- When I visit the mangroves, I will remember that I am a guest.
- I will move silently and speak quietly.
- If I turn over rocks or logs to look at what lives beneath them, I will carefully put them back where I found them.
- I will have fun and take home memories, and leave behind only footprints in the mud or sand.
- I will not chase or scare birds away from their nests.
- I will take actions in my daily life to reduce pollutants that may enter the water, thereby protecting the communities of plants and animals that live here.

FIELD TRIP CHECKLIST

1. **Objectives**. Decide what the objectives of your field trip are and how you will integrate the field trip with your study of wetlands.

2. **Contact a resource person**. To locate a person in your area who is knowledgeable about mangroves, try contacting government agencies, your local Natural Resource Management group, the local council or your local Coastcare, bird watching or MangroveWatch group. These people may be able to visit your classroom, suggest possible sites, dates, and times for your field trip, or even accompany your class in the field.

3. **Select a date**.

4. **Select a site for your trip (with alternatives).** If you are hoping to include migrating birds that use wetlands as part of your trip, then you will need to find out dates when migrants are passing through the area. Often a successful field trip includes seeing plenty of birds, and migrating ones are important if you have covered migration in your classroom studies.

- ☐ **Obtain permission** for your field trip if the site is on private property.
- ☐ **Familiarize yourself with the site** by visiting it ahead of time, as well as obtaining any background information related to the site.
- ☐ If you will be visiting an intertidal area, **check a tide table**. One hour after high tide is often a good time to see shorebirds, but consult local experts to be sure.

5. **Arrange transportation**.

6. **Select activities** for use before, during, and after the field trip. This resource guide is full of ideas. Use these, gather ideas from other activity source books, or develop your own activities with the help of resource persons.

7. **Prepare the schedule** for the field trip. In scheduling, consider small-group divisions, distribution and use of equipment, travel time, timing of activities, and rainy-day alternative activities.

8. **Recruit assistants** among teacher aides and parents (grandparents are also good) for help during your field trip. We suggest a 1:5 ratio of adults to students. If possible, all adults should visit the site before the field trip. Be sure that the helpers understand their duties, and if possible, give them copies of the schedule, trip rules, etc., before the trip. Emphasize that their preparation and commitment will create a fun-filled learning experience.

9. **Give instructions to the class**. Let the class know where they are going and the behaviour that is expected of them (Mangroves Etiquette on page 4-3).

- ☐ Discuss etiquette and safety with the students. Stress not only safety for each other, but safety for the wetland.

- ☐ Give the students a list of what they need to bring along, including proper dress for the location and conditions.

10. **Send home permission slips**. Be sure to get emergency medical information for all students.

11. **Gather, make, and practise using field equipment.** Directions for making and using some suggested field equipment are included in this resource guide on page pages 4-15 through 4-18. Some students will be able to bring binoculars and bird and plant field guides from home. Make sure before you leave the school that all the binoculars have straps, and that books are marked with the children's names.

12. **Research and discuss wetlands and wetland wildlife with your class,** including identification, natural history, habitat, and bird migration.

- ☐ Plan and complete pre-trip activities.

13. **Assign responsibilities and tasks**. Assign all students (individuals, small groups, or the class as a whole) particular responsibilities for the field trip. You may have all the groups conduct the same activity, or have each group conduct a different activity. Assigning tasks helps ensure participation by all students.

14. **Copy data forms and make field journals**. Make sure students understand how they are to be used in the field. Create a field journal that students can use to record field observations and data. You can make copies of the data collection sheet on page 4-9. Use waterproof paper if available. A stack of five blank sheets can also be stapled in the middle and folded to form a 10-page journal. Clipboards are handy to hold journals and data sheets. Mount a pencil to each board with string or tape. If clipboards are not available, try attaching the data sheets with rubber bands to cardboard cut to fit.

15. **Practise the field trip**. The day before the trip, have students bring appropriate clothes and gear. On the playground, simulate the field trip to familiarize students with the equipment and tasks.

What to Wear and Bring

Usually, an old pair of sneakers and old pair of shorts and a tee shirt—clothing that doesn't matter if it gets wet and muddy—will be all students need to wear. If you plan your trip in the midday hours, it is also advisable to wear a hat and sunscreen to protect from the sun, and also to bring along an insect repellent if you expect the mosquitoes to be hungry. You'll need something to record your findings on (especially if you are going to use a Scavenger Hunt sheet of the kind found on page 4-29). If you are planning to take back a water sample to the classroom for analysis, you'll also need a few extra items.

Your list should read:

Clothing and Equipment

1. old pair of sneakers.
2. old tee shirt
3. old pair of shorts
4. extra pair of socks
5. hat or cap for protection against sun
6. sunscreen
7. insect repellent
8. pencil, paper, and clipboard (or equivalent substitute, like a sheet of cardboard)
9. sunglasses
10. pair of binoculars for bird study
11. old towel to dry off
12. water bottles
13. packed lunch if necessary
14. rubbish bag

For Water Studies

1. plastic containers
2. fishing nets (see page 4-17 for how to make one)
3. magnifying glasses
4. view glass (instructions for making one are on pages 4-15)
5. field guides (from the front of this workbook)
6. something to dig with
7. turkey basters, pipettes or small brushes for transferring organisms from one container to another
8. plastic buckets

Data Collection Sheet

Date	Observations: What, where, how many, under what conditions?

Activity 4-A: Using a Microscope

Understanding the fertility of mangroves depends on understanding the high levels of activity that take place on and in detritus, as well as in the surrounding waters. It is because the bottom of the food web is so rich that mangroves and other wetlands provide such an important place for many millions of creatures to feed, grow, and live. Examining through a microscope or hand lens the myriad of macro and micro invertebrates that live in wetlands gives children a clear understanding of the wealth of life they will find in wetlands, and why.

To some extent, our ability to understand the world we live in is dependent on our learning about things that our own senses cannot reveal to us. This is where resources such as the microscope become vital in our understanding of the microscopic world. The microscope is one of the essential tools of the biologist. Because microscopes are very expensive and fragile, please take the greatest care when using them. The following principles should be observed at all times.

Care of the microscope

1. When lifting the microscope, keep one hand firmly below the base while you grasp the arm with the other hand.
2. Never force the movement of any part of the microscope.
3. Use sparing amounts of water sample to reduce spillage onto the microscope
4. Do not use corrosive liquids (acids) when around the microscope.
5. Clean the eyepiece and objective lenses with lens paper, not paper towels or tissue paper, which will scratch the lens.
6. Keep all electrical cords in a secure position to prevent someone from accidentally pulling your microscope off the lab bench or table.
7. Always clean the microscope after use.
8. Always cover the microscope after use.

Viewing samples on slides

1. Place the microscope slide on a paper towel.
2. Use an eyedropper to add one or two drops of water from your water sample to the centre of the slide or to the specimen if it's already on the slide.
3. Put the slide on the stage after first moving the clips out of the way. This way you can move the slide around to follow the movements of your specimen.
4. Make sure your lens is on the lowest magnification. Gently focus on the slide by looking through the eyepiece and moving the table up or down slowly with the coarse adjustment wheel until your specimen becomes clear.
5. When you have the microscope focused under low power, you should not have to use the coarse adjustment wheel again.
6. Carefully turn the nosepiece to move the next objective lens into place. Even under 40x the lens will clear the slide (as long as the specimen is not too thick)
7. Use the fine adjustment wheel to focus the microscope on the specimen. Never use the coarse adjustment wheel when focusing under the high-power objective.

8. Use the diaphragm to adjust the amount of light passing through the specimen. You can often see many more details by adjusting the amount of light.
9. If you are using a light-source microscope, do not leave the light on when you are not looking at your specimen. The heat will kill the creature you are observing.
10. Always keep the microscope upright to keep water from running off the slide and into the microscope.

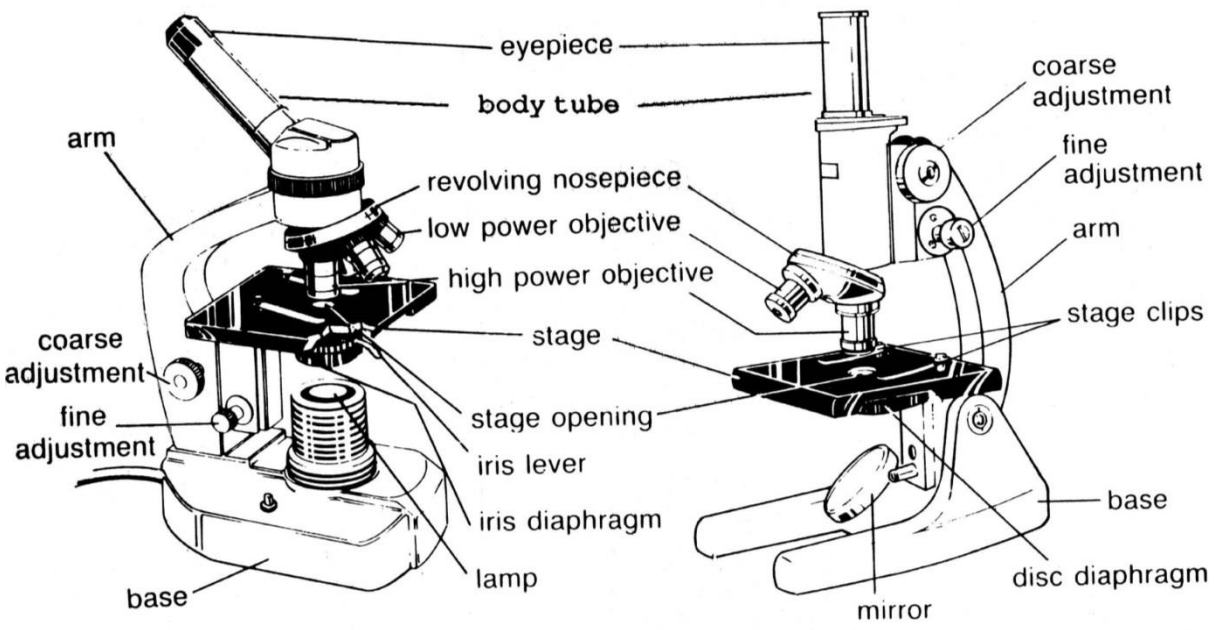


Figure 37: Parts of a microscope

Activity 4-B: How to Use a Hand Lens

There are many different types of hand lens available, but probably the best kind is the small plastic version that gives up to about 10 times magnification. It's a good idea to stay away from glass and metal hand lenses in the field, as they can break, and are expensive if lost—especially in a couple of metres of mud! To ensure that your plastic hand lens does not get lost, tie a piece of bright-coloured ribbon around it (surveyor's tape works well) and make sure the students hang it around their necks.

In the field there are two ways to look at objects with a lens.

Figure 38: Hand Lens

(a) The first is with a fixed object, such as a mangrove root, that you do not want to destroy. Hold the lens near to the object between your eye and the object until you can see that the object is magnified and in focus. This will probably require bending down, crouching, or standing on tiptoe.

(b) The second is with a movable object. Pick the object up and hold it in your hand. Then move your hand with the object in it up close to your eye, and, holding the hand lens in your other hand, move the lens up and down until it is focused on the object in your hand.

Activity 4-C: How to Use Binoculars

Everyone's eyes are different, so usually we need to account for a difference in eye strength when focusing. Centre-focusing binoculars have an adjustment to compensate for eyes of unequal strength or vision. You will notice that only one eyepiece is independently adjustable, and it has a scale marked off in *dioptres*, the optical measuring unit for spherical power. Note that the individual eyepiece setting, once adjusted, can be considered permanent. The scale reading should be noted and checked occasionally as it may be accidentally moved by handling or in moments of excitement.

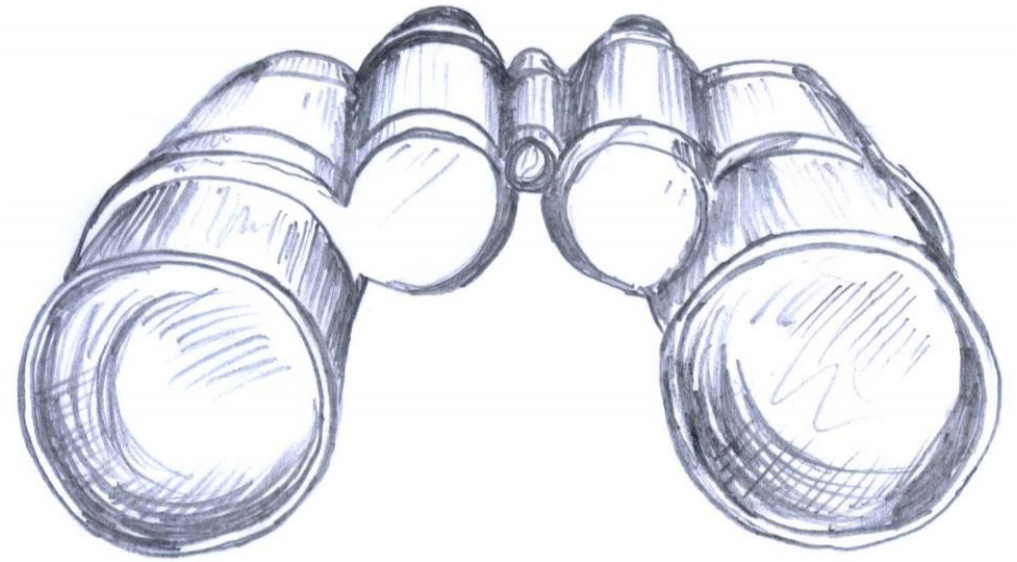


Figure 39: Binoculars

To adjust your binoculars for any difference in the strength of your eyes, first, using the lens cover or your hand, cover the objective lens (the outer, big lens that is on the same side as the adjustable eyepiece). With both eyes open to avoid distortion, look through the binoculars, and, using the central focusing mechanism, focus on a distant object until it is sharp and clear. Now transfer the cover to the other objective lens. Again keeping both eyes open, but this time using the adjustable eyepiece, focus on the same object until it is clear.

Your binoculars are now properly focused for your use. All you have to do is use the central focusing mechanism to focus on objects at various distances from you.

Focusing on moving objects and focusing quickly on something that is about to fly or move out of view is a real challenge. If you practise, over time you will be surprised to find how your coordinated use of eyes and binoculars improves. Be patient and practise, practise, practise!

Another challenge is finding and focusing on objects in the sky. Because the sky has depth, and because it has no background of objects (such as trees and the horizon line) that we can use as reference points both to find an object and to figure out how far away it is, it takes a lot of practice to be able to find an object quickly in the sky.

Note that many binoculars have rubber eye cups that can fold down for use with glasses or sunglasses.

Activity 4-D: Making a View Glass

Summary Students make view glasses to look below the surface of mangroves. It's a great way to see what's going on beneath the water without getting wet!

Learning Objective
Students will be able to make their own view glass for seeing beneath the water when they are on their field exploration.
Age Levels
8 and up
Subject Areas
Science, social studies, industrial arts
Time
1–2 lessons, or more
Materials
Plastic version (for younger students)
Large plastic containers (ice cream containers or bulk yoghurt containers are great) or large round cans
Heavy-duty clear plastic kitchen wrap
Several pairs of scissors
Large rubber bands
Wooden version (for older students)
1m length of 1 x 30cm board
28 x 35cm sheet of clear (picture) glass
Caulk
2.5cm panel pins

Background Fisherman have long used viewing glasses to look at the availability of fish in a certain area. Much like a mask, the viewing glass allows you to see the bottom clearly without getting wet! These days there are many vessels on the market with a viewing glass built into them, such as canoes, kayaks and body boards or spy boards.

Procedure
Plastic version
1. Cut out the top and bottom of the large plastic containers or cans, making sure there are no sharp edges.
2. Stretch a sheet of clear plastic kitchen wrap across the bottom and hold tightly in place with one or more large rubber bands, and/or secure with duct tape.
Wooden version
1. Cut the length of 1 x 30cm lumber into four sections. Two will be 27cms long and two will be 38cm long.
2. Using a router, cut a groove 5mm deep, the same width as the glass, around the bottom of all four pieces, about 2.5cm from one end of the pieces (this will be the bottom).

3. Using the panel pins, nail together three of the pieces, two of the 38cm pieces and one of the 28cm pieces.
4. Carefully slide into the grooves the 28x35cm sheet of clear picture glass until it is as tight fit as you can make it.
5. Fit the last piece of 27cm 1 x 30, and nail it tight. Make sure you don't break the glass.
6. Caulk around all the joints and the glass to make sure it doesn't leak.
7. Leave for 24 hours for the caulk to set.

Activity 4-E: Making a Plankton Net

Summary Wetlands are home to many micro and macro invertebrates, and making a plankton net enables students to catch these invertebrates for further study.

Learning Objective
Students will be able to make their own nets for catching plankton and invertebrates.
Age Levels
8 and up
Subject Areas
Science, social studies
Time
30–60 minutes
Materials
Metal coat hanger
Old pairs of tights or pantyhose (one pair per two students)
Several pairs of scissors
Needle and thread (one per student)
Wooden broom handle (optional)
Duct tape or string (optional)

Background Students will have learned about wetlands food chains in "Mangroves as Habitat" (Section 2). Many of the invertebrates that are the basis of the food chain in wetlands are very small, and students will not be able to see them without the use of a microscope after they have collected them. The plankton net enables them to do this. It can be used in conjunction with containers (plastic yogurt or margarine containers work well). Students catch the invertebrates and keep them in the plastic containers until it is time to either take them back to the classroom for further examination or return them to the mangroves.

Procedure
1. Bend the coat hanger so that one end makes a circle about 20-30cms in diameter, and the other end makes a handle.
2. Cut off one leg of the pantyhose or tights so that about 30-45cms is left with the foot part.
3. Wrap the open top part of the pantyhose around the circle part of the coat hanger.
4. Sew the top part of the pantyhose to the round part of the coat hanger. You may need to make this a two-student operation, with one holding the pantyhose in place while the other does the sewing.
5. Bind the broom handle to the handle part of the coat hanger using duct tape or string (optional).

Activity 4-F: Making a Sieve Box

Summary Mangroves are home to many micro and macro invertebrates, and making a sieve box enables students to catch these invertebrates for further study through “trawling” and sieving.

Learning Objective
Students will be able to make their own sieve boxes for catching plankton and invertebrates.
Age Levels
8 and up
Subject Areas
Science, social studies
Time
30 minutes
Materials
Large plastic containers or large round cans
Several pairs of scissors
Length of string or rope 1 m long

Background Students will have learned about mangroves food chains in “Mangroves as Habitat” (Section 2). Many of the invertebrates that are the basis of the food chain in wetlands are very small, and students are unable to see them unless they can use a microscope after they have collected them. The sieve box enables them to do this. It can be used in conjunction with containers (plastic yogurt or margarine containers work well). Students catch the invertebrates by dragging the sieve box through the mangrove wetland and then sieving through the mud and water, and keep what they find in the plastic containers until it is time to either take them back to the classroom for further examination or return them to the mangroves.

Procedure
1. Using the scissors, cut away the top of the large plastic containers, making sure you leave the handle.
2. Punch small holes (about 5cm across) into the bottom of the plastic container.
3. Attach the string or rope to the handle.

Activity 4-G: Water Column

Summary Students will use a microscope to observe the microscopic organisms in water that form the base of the food chain.

Learning Objectives
Students will:
(a) Observe microscopic organisms by using a microscope or hand lens;
(b) Learn to identify these organisms and place them in a food chain; and
(c) Build a food chain incorporating these organisms.
Age Levels
9 and up
Subject Area
Science
Time
2–3 lesson periods
Materials
Microscopes (one per two or three students if possible)
Plastic containers containing wetland water samples
Eye dropper
Glass slides
Pencils
Hand lens (magnifying glass)
Copies of "Invertebrates of Mangroves", pages 4-22 through 4-26
Copies of pages 4-10 and 4-11, “Using a Microscope”
Copies of page 4-27, “Microscopic Study—Sketch and Identify”

Background During your field trip, you will have gathered water samples from the mangroves (or wetland) and brought them back to the classroom for closer study. This process reinforces many of the concepts and activities that have appeared in previous sections. By looking at macro and micro invertebrates under the microscope, as well as describing, identifying, and drawing them, students will see for themselves the basis of the food chain.
In aquatic ecosystems (including all wetlands, of course), microscopic organisms, both plants and animals, are vital in the food supplies of fish, aquatic birds, reptiles, amphibians, crustaceans, and mammals—including humans. Bacteria measure less than two one-thousandths (0.002) of a centimetre, or 20 microns, across, but are extremely important. Because they are neither plants nor animals, they are described in a special group called microbes. They decompose, or break down, dead plants and animals into nutrients and are an important source of food for other microscopic animals. In this way nutrients are constantly being recycled.
Primary food production is provided by microscopic algae floating in the sunlit surface waters, called phytoplankton (plants). Filaments of algae that form the familiar pond scums usually harbour many microscopic animals. These tiny aquatic animals are called zooplankton. They range from microscopic one-celled animals (protozoans) to large, many-celled animals (metazoans) such as

worms, insects, fishes, and crocodiles. Some spend their entire life in water—hence are wholly aquatic. Others are aquatic only in some of their life stages. Many feed on phytoplankton, while others feed on other zooplankton that feed on phytoplankton. Thus the process continues throughout the food chain. Following are the descriptions of some common zooplankton.

• **Protozoa** are one-celled animals—the simplest of all animals. The more than 30,000 species live in a wide range of aquatic habitats. They are abundant in pond and lake waters, especially those enriched with organic matter. They occur in a great variety of body forms and have different methods of movement.

• **Hydras** have a saclike body of two layers of cells and a fringe of tentacles around a single body opening, which serves for both taking in food and eliminating wastes. Hydras can move by inching along slowly on their “foot”, or may turn end over end in a somersaulting motion.

• **Rotifers**, found only in fresh water, are commonly mistaken for one-celled animals. Their name refers to the wheel-like rotating movement of the hairlike projections (cilia) on the front of the body, which draws in food and water. At the rear is a base or foot that secretes “glue” by which the rotifer attaches to objects.

• **Worms** are never conspicuous, but they may be abundant under stones or in debris or mud. The segmented worms include aquatic bloodsucking leeches and earthworms. Most flatworms are parasites; a few are free-living.

• **Arthropods** are the most numerous of all animals. They are joint-legged, with a segmented skeleton. Crayfish, insects, and spiders are the large conspicuous types. Others are minute but equally important as food for fish or other animals.

• **Molluscs** have a soft body enclosed in a limey shell—a single-coiled structure (like snails) or two-hinged valves (like clams).

Procedure

1. Students will be divided into the groups they had during the field exploration.

2. Explain in detail how to use a microscope. See pages 4-10 and 4-11 for details.

3. Pass out microscopes, copies of pages 4-10 and 4-11, “Using a Microscope”, and copies of pages 4-22 through 4-26, "Invertebrates of Mangroves". Also pass out slides and eyedroppers, explaining that they are glass and will break if dropped.

4. Demonstrate how to take a water sample from the containers and put it onto the slide using the eyedropper. Explain that too much water will mean that the creatures in the water will have too much space to swim around in, and the water will also go all over everywhere! Explain how to use the eyedropper: do not tilt it so the creature can go into the rubber “bulb” or it will stick there and not come out. Also explain that the creatures they will be looking at are alive and will be returned to whence they came, so students should try to avoid killing them.

5. Have each group collect their water samples that have been brought back in the bucket.

6. Let the students try to search and find creatures in their water samples. Tell them they will have to identify and draw their creatures.

7. After about half an hour, pass out copies of page 4-27, “Microscopic Study—Sketch and Identify”, and have students fill them in. Explain that if they cannot identify their creature, they should give it a name that reflects its appearance, like “Fuzzylegs” or “Rodney”.

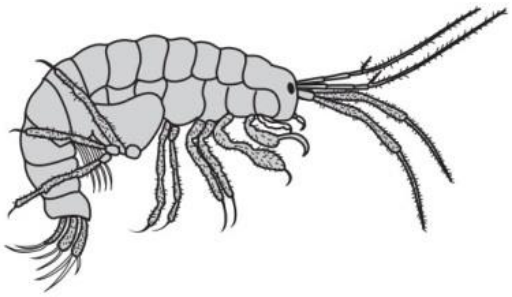
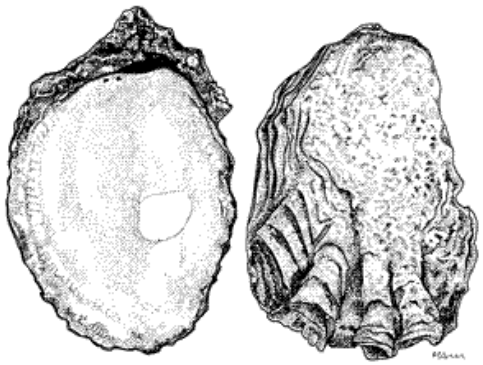
6. When time is up, have the students return all their water samples, including those on slides, to the bucket, again explaining that they will all go back to the pond.

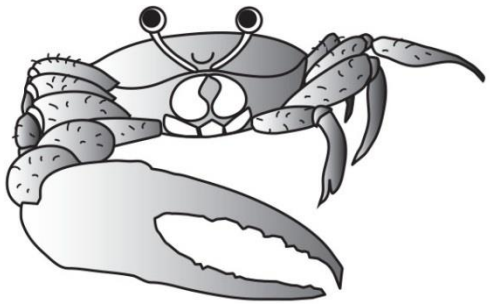
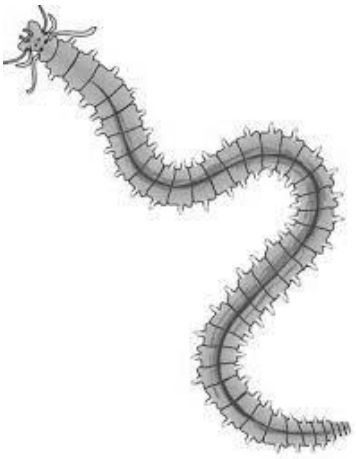
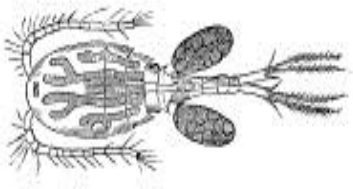
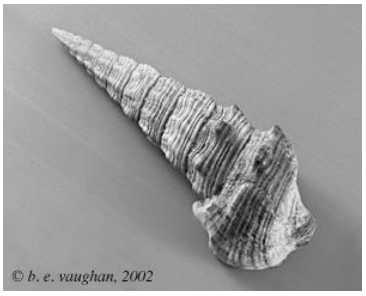
Extensions This is another opportunity for students to familiarize themselves with the enormous spectrum of invertebrates while practising research and careful comparison skills. Some of the creatures may not be easily identifiable from the invertebrate charts, so students will have to look in textbooks or go to the local library or university to try and find out what they have found. Have them check similarities with samples of which they have pictures by looking carefully at the shape of the animal, number of segments, legs, wings, etc.

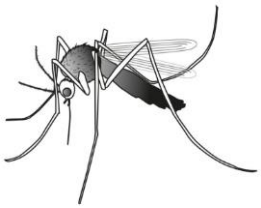
Visit another wetlands site. Compare the different invertebrates found at each site, and try to develop a theory as to why they are different (older students only). Return to the same site on a regular basis, and take water samples each time. Compare what you find in different seasons. Build up a data bank at school on specific sites.

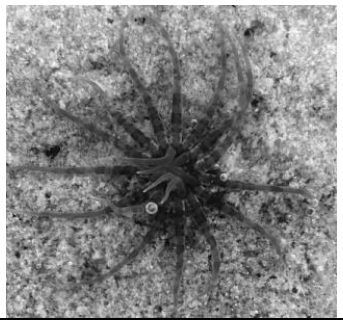
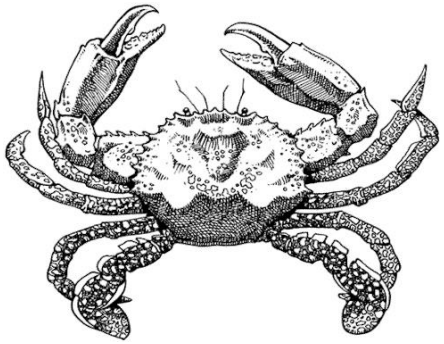
INVERTEBRATES OF MANGROVES

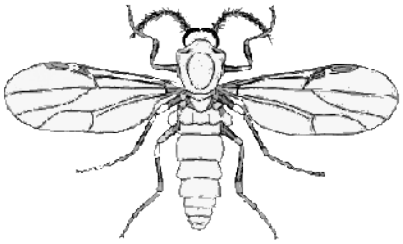
There are many thousands of species of invertebrates living in and around mangrove areas, and it would be impossible to provide illustrations of every one that you might find. Instead, we have concentrated on those that are most common in the water, in the mud, and on the mangroves.

Amphipod (Order Amphipoda) **Description** Microscopic to 2 cm. A small crustacean that looks like a prawn or a large flea. They have flat, convex bodies, and different species appear in different habitats. They are quite distinctive, with segmented bodies, long antennae, and hairs on their legs. Best identified through a microscope. **Habitat** Many species occur locally in shallow water habitat— from saltwater and freshwater ponds to the intertidal zone, tidal pools, and seagrass beds. **Food** Detritus.	
Mangrove Oyster (*Saccostrea glomerata*) **Description** The oyster possesses a smooth, thick shell with small teeth on the internal rim of the shell generally near the hinge. The mantel edges and adductor muscle scar are pale in colour. They reach approximately 60g in 3 years and can live up to 10 years. **Habitat** Endemic to Australia and are located in sheltered bays and estuaries. **Food** Plankton - Filter feeders	
Mud Lobster (*Thalassina anomala*) **Description** Is a lobster like animal that grows to up to 30cm long. Its colour ranges from pale to dark brown and brownish green. The carapace is tall and ovoid; the tail is long and thin and does not form into a proper tail fan. They can burrow up to 2m and are most active at night. They create large mud mounds up to 3m high and this aids in the generation of tidal pools and help in the growth of some mangrove species. **Habitat** Mud around mangrove roots **Food** Detritus	 FAO

Orange clawed Fiddler Crab (*Uca coarctata*) **Description** The male has an enlarged claw that is roughened and orange in colour. This colour fades to white as it reaches the tips of the claw. The males also have a white spot on the last walking leg. They reach approximately 40mm across. **Habitat** Sheltered mudflats near mangroves, flat banks close to mouth of streams. Lives in burrows close to other fiddler crabs. **Food** Detritus	
Polychaete worms (Class Annelida) **Description** Segmented worms generally less than 10cm in length. They are often brightly coloured and can be iridescent or even luminescent. Each segment has a pair of paddle like parapodia which are used for movement and respiration. There are generalised polychaetes which crawl along the mud and then there are specialist species which can burrow or swim or bore. **Habitat** Can live in all forms of habitat eg. Mud, pelagic (in the water column as plankton), on and in rocks, on and in mangroves. **Food** Some feed on detritus and others are filter feeders.	
Copepod (Order Isopoda) **Description** Microscopic to 0.5 mm. Often called a "cyclops", this zooplankton has one eye in the middle of its head. It has feathery antenna and a two-pronged tail. It tends to swim around very quickly. **Habitat** Mangroves, shallow water, often in the mud at the bottom of the pond. **Food** Detritus.	
Mud Whelks (*Pyrazus ebeninus*) **Description** Large turreted shell which grows to approximately 100mm. It has rounded whorls and a flared rounded aperture. The exterior of the shell is dark brown to grey and the operculum is brown. **Habitat** Lives in large colonies on the intertidal mudflats. **Food** Detritus	
Australian Paste Shrimp (*Acetes australis*) **Description** Small almost transparent shrimp with a tiny rostrum and long reddish-orange antennae. **Habitat** In brackish estuaries in shallow, sheltered coastal waters	

Food Plankton and detritus	
Estuarine Mussel (*Xenostrobus securis)* **Description** Brown to dark brown bivalve that grow to approximately 38mm **Habitat** It is gregarious and usually attached by byssal threads to timber, rocks or dead shells in brackish water **Food** Plankton	
Lined Nerite (*Nerita articulata)* **Description** Top of shell is usually slightly eroded and there are close set purple-black ridges on a pale pink background, however the shell colour varies with the density of ridges. **Habitat** Common on and around mangrove roots and trunks **Food** Algal grazer	
Ridged Periwinkle (*Littoraria luteola)* **Description** Thin with a high spire, top whorls have fine spiral grooves with delineate flat ridges that become stronger and further apart on body whorl. **Habitat** On mangroves, in particular the Grey Mangrove. They can climb to more than 2m **Food** Algal grazer	
Mangrove Peanut Worm (*Phascolosoma arcuatum)* **Description** Large and stout bodied worm shaped like a peanut. They feed by everting a long proboscis bearing a crown of tentacles. Can grow to approximately 65mm long and 10mm thick. **Habitat** Buries in muddy creek banks around mangroves and in the intertidal zones **Food** Detritus	
Leopard Flatworm (*Myoramyxa pardalota)* **Description** Thick fleshy oval shaped flatworm with dark spots resembling a leopard. Favourite food of the endangered Water Mouse. **Habitat** Under rocks and logs in the intertidal zone. **Food** Detritus	
Mosquito (Family Culicidae) **Description** Slender, delicate flies less than 6 mm long. Easily recognized by their long, sharp proboscis. Male has feathery antennae, unlike female's sparsely hairy antennae. Brown wings coated with delicate scales that fold over the abdomen. Larvae are called wrigglers or wigglers and grow up to 18 mm long. They look like tiny	

segmented worms with small heads and big eyes, pairs of hairs on their sides, and a tiny proboscis on the rear. **Habitat** Stagnant water in ponds, lakes, and puddles. **Food** Females need blood to incubate eggs, while males generally feed on plant juices.	
Muddy Shore Anemone (*Boloceroides mcmurrichii)* **Description** Brown body with cream and brown banded tentacles. Can grow to 10mm across **Habitat** Can attach to a variety of surfaces including mangroves, they are easily detached and can swim quite well by rhythmically pulsating its tentacles **Food** Plankton and large zooplankton feeders	
Estuarine Slug (*Onchidina australis)* **Description** Elongated oval with short tentacles. It has a finely granular surface which has olive and dark green blotches. Can grow to 30mm long. **Habitat** Mud in the high intertidal zone **Food** Detritus	
Mud Crab (*Scylla serrata)* **Description** Large olive-green swimming crab. Commercially important species. Has a sharp serrated carapace with large front pinchers. Can grow to more than 200mm across. Male and females are differentiated by their abdominal flaps. Females have broader abdominal flaps that males and are more pigmented as they mature. **Habitat** They make characteristic large oval burrows in banks of estuarine and mangrove areas **Food** Omnivores. Will eat just about anything including each other!	
Broad-fronted Mangrove Crab (*Metopograpsus frontalis)* **Description** Smooth mottled crab with a wide colour variation, however they are generally black-grey with purple pincers. There are rows of sine on the outer edge of major segment of walking legs. They can grow to 30mm, however they are usually smaller. **Habitat** Sheltered muddy intertidal zones around mangroves and rocky shores. **Food** Active predator and scavenger	

Biting midges or Sandflies (Family Ceratopogonidae) **Description** Small robust flying insects with piercing and sucking mouthparts. Only female midges feed on blood and both male and females also feed on nectar and vegetable fluids. They are most active at dawn and dusk and only disperse a short distance from their breeding sites. **Habitat** Eggs are laid in mud or leaf litter where the larvae have access to a nutrient rich environment. **Food** Blood, vegetable fluids and nectar.	
Mangrove Butterfly or Illidge's Ant-blue Butterfly **(*Acroclipsas illidgei)*** **Description** Adult butterflies are brown and the females have patches of blue on the wings. They are relatively small butterflies only reaching approximately 2cm across. The eggs and caterpillar stage are white, however the pupae is brown and resembles the pupae of its host ant the *Crematogaster.* The female butterfly lays its eggs on the Grey Mangrove in the presence of *Crematogaster* ant colonies. The larvae are then transported to the colony where the ants feed on its excretions and the larva feeds on the developing ants. The emerging butterfly is covered with fluffy scales to protect itself from hostile ant attacks as it leaves the colony. **Habitat** Grey Mangrove hollows **Food** Associated with Grey Mangroves.	

Microscopic Study – Sketch and Identify

Working in the same groups in class as were formed on the site, use the classroom microscopes to get a close-up look at the plant and animal life brought back in the water samples.

Salt pond water check list

Plants (including phytoplankton)

- ☐ Pond weed
- ☐ Blue-green algae
- ☐ Green Algae
- ☐ Diatoms
- ☐ Dinoflagellates
- ☐ Euglenoids
- ☐ Mangroves
- ☐ Reeds
- ☐ Sedges

Animals (including zooplankton)

- ☐ Protozoans
- ☐ Hydras
- ☐ Molluscs (snails)
- ☐ Worms
- ☐ Crustaceans
- ☐ Arthropods (aquatic insects)

Choose one of the living creatures you have observed under the microscope and in the space provided, make a detailed sketch of it.

List any interesting characteristics you observe (legs, wings, eyes, shells etc).

_____

_____

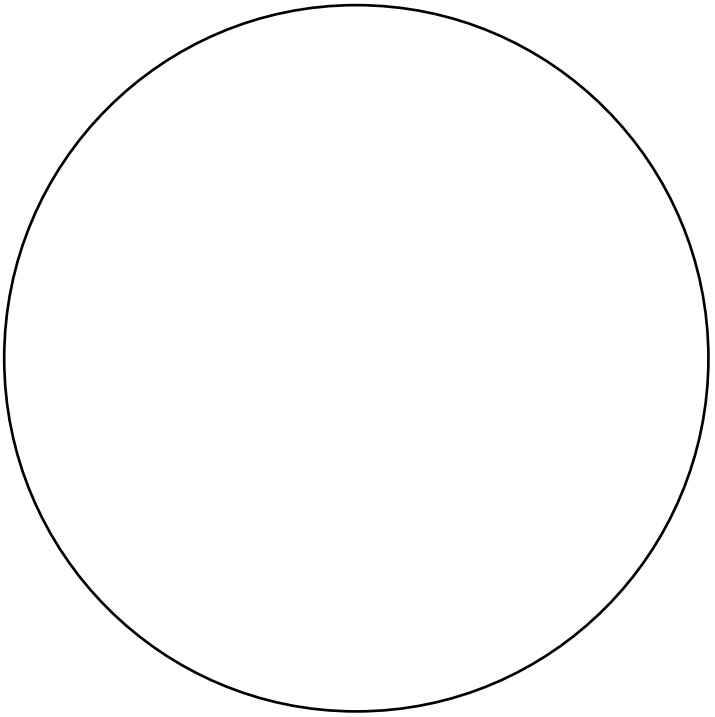
_____

_____

_____

_____

_____



Name your creature: _____

Activity 4-H: Mangrove Scavenger Hunt

Summary Students will use observation skills to find organisms and objects in mangroves.

Learning Objective
Students will learn to use all their senses—observation skills—to find and identify wetlands and their inhabitants.
Age Levels
6 and up
Subject Area
Science
Time
15–30 minutes
Materials
Copy of page 4-29, "Mangrove Scavenger Hunt"
Pencils
Clipboards

Background Read and learn the information in Sections 1 and 2, "All About Mangroves" and "Mangroves as Habitat".

Procedure
1. Pass out to each student a copy of page 4-29, "Mangrove Scavenger Hunt."
2. Explain that they have 15 minutes (it will usually stretch longer, and the time needed depends on the age of the students—be flexible) to gather information outlined in the sheet.
3. Lead them in finding and identify things.
4. When you are sure everyone has had enough time, gather the students together and compare results. Ask each student to report on what he or she found. See how many different items they have discovered.

Discussion/Reflection
Talk about where each item fits into the food chain.
Have the students design (draw and write) a food chain based on the evidence they have found.
Have the students draw different items, describe the various parts of, say, a fiddler crab and explain what these parts are for.
Discuss the signs of human influence and how they might have affected the mangrove ecosystem.

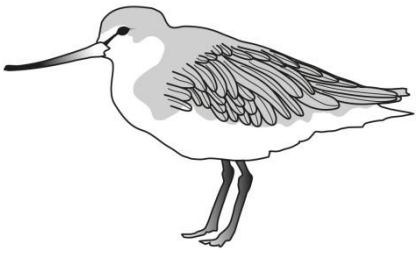
Extensions This activity can be easily adapted for any environment, such as a freshwater wetland ecosystem.
Note: This activity and accompanying worksheet can be adapted for freshwater, salt ponds, and marine aquatic habitats.

Mangrove Scavenger Hunt data sheet

It is your task to discover each of these items during your exploration. Remember to use all of your senses and put things back **exactly** where they were found. If you don't know the name of what you find, write down some observations to help you look it up when you get back to class.

Three different types of birds

1) _____
2) _____
3) _____



Three different types of aquatic creatures

1) _____
2) _____
3) _____

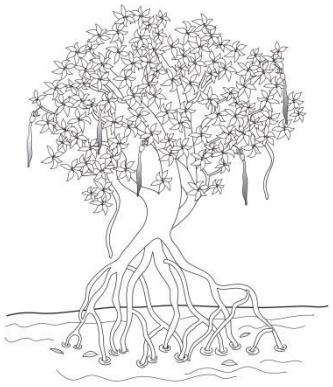
Three different type of terrestrial or land creatures (or animal signs such as tracks, scats or bones).

1) _____
2) _____
3) _____

What have you seen that might be food for a Heron? _____

Crab? _____

Turtle? _____



Three different kinds of plants.

1) _____
2) _____
3) _____

Two signs of human influence

1) _____
2) _____
3)

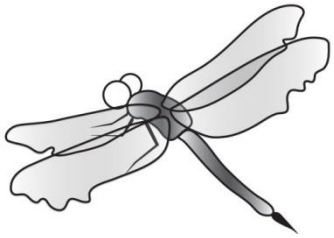
What did you touch that was smooth? _____

Rough? _____

Sharp? _____

Wet? _____

Dry? _____



Something you didn't like the smell of: _____

Something that you notice smells pleasant: _____

Activity 4-I: Mangrove Survivors

Summary Students will observe and record adaptations of mangroves and organisms associated with mangroves.

Learning Objective
Students will learn through observation the kinds of adaptations that allow mangroves to survive in salt water.
Age Levels
7 and up
Subject Area
Science
Time
30–60 minutes
Materials
Pages 2-10 and 2-11 from Activity 2-A, "Spot the Difference: Mangroves"
Pencils
Clipboards

Background Read and learn the information in Sections 1 and 2, “All About Mangroves” and “Mangroves as Habitat””.

Procedure
1. Explain to the students that mangroves have to get all four elements that they need in the right proportions. Ask them which elements there might be too much of here: salt water (high tides sometimes bring in too much); fresh water (cyclones and heavy rains can bring in enough fresh water to drown mangroves); air (storms often bring too much, in the form of wind); and sun (in tropical climates there is frequently too much sun). Fortunately, mangrove trees, especially Red and Grey Mangroves, have adaptations that allow them to survive these difficulties. Briefly review the ways in which these trees have “figured out” how to deal with this difficult environment.
2. Divide the class into groups of three or four. Give each group copies of pages 2-10 and 2-11, showing several adaptations that mangroves have for survival in warm, salty tropical water and hot climates. For each adaptation on the sheet, have the groups find a mangrove that has that adaptation.
3. When everyone has found examples of all the adaptations, gather the group together and take them on a tour of the mangroves. At each plant, stop and discuss the ways in which it is adapted to surviving the harsh tropical shoreline environment.

Activity 4-J: Mangrove Habitat Study

Summary Mangroves are a habitat for diverse organisms.

Learning Objective
Students will be able to name the plant and animal species in the mangroves.
Age Levels
8 and up
Subject Area
Science
Time
30 minutes
Materials
Copies of page 2-9, " Mangrove Habitat Study"
Pencils
Crayons (optional)

Background Read and learn the information in Sections 1 and 2, "All About Mangroves" and "Mangroves as Habitat".

Procedure
1. Pass out to each student a copy of page 2-9, "Mangrove Habitat Study".
2. Explain that mangroves are home to many different species. They should study the "Mangrove Habitat Study" page and identify as many species as they can.
3. Students should then create a food chain and a food web from the plants and organisms they find in the picture.
4. Have students explain how this ecosystem functions.
5. Younger students can conclude by colouring the picture.

Activity 4-K: Giant Footprint

Summary Many tiny organisms live underfoot that often go unnoticed.

Learning Objective
Students will learn that we must be careful where we walk in a mangrove area.
Age Levels
8 and up
Subject Area
Science
Time
30 minutes
Materials
Large wire footprints made from old coat hangers, or light wire - one for each group
Magnifying glasses (one per student if possible)
Giant footprint handout on page 4-33 (one per group)
Pencils (one per group)
Field guide on invertebrates at the front of this book

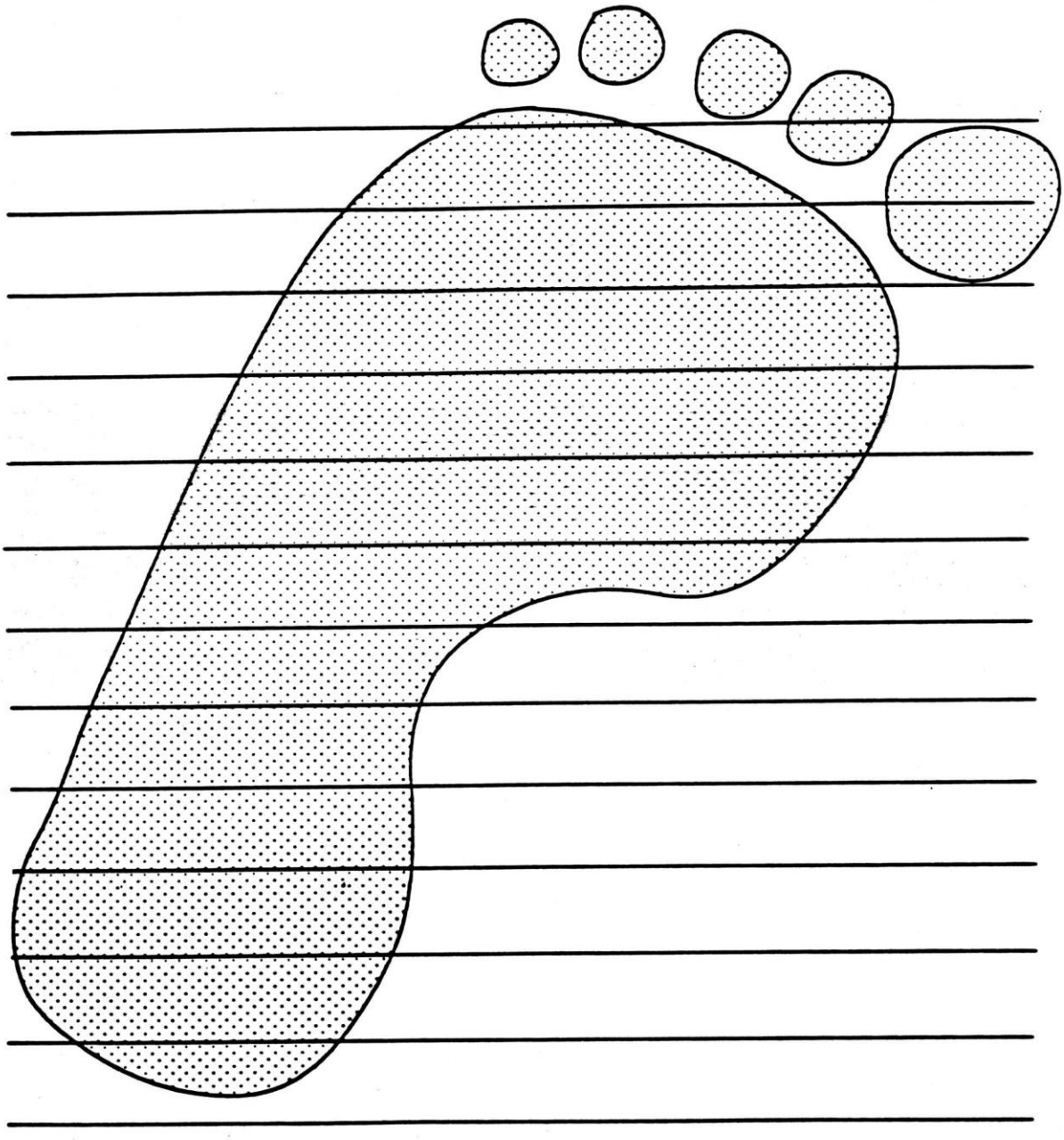
Background Read and learn the information in Sections 1 and 2 “All About Mangroves” and “Mangroves as Habitat”. For invertebrates, look at pages 4-22 through 4-26 in this section.

Procedure
1. Divide the class into an even number of groups of three or four students. Give one student from each group a wire “footprint”.
2. Have the students who are holding the footprints stand in a circle facing outwards. Tell them to take three giant steps away from the circle and stop.
3. Have them put the footprint down on the place where their next step would have fallen.
4. The rest of the group may now join them.
5. Have each group make a detailed list of all the different kinds of things that they find inside their footprint (sand, shells, mud, stones, plants, sticks, insects, feathers, crabs, etc.), using the Giant Footprint sheet.

Discussion/Reflection
Give the groups 10 to 15 minutes to list everything they can find inside the footprint.
Then call the students all together, and have each group compare what they have found in their footprints with what another group has found. Encourage them to discuss anything that they found that they weren’t expecting.

Figure of Giant Footprint

Describe all of the things that you can find inside the giant footprint.



Activity 4-L: Sound Mapping

Summary Students will listen for and describe sounds that they hear in the mangroves, and make a sound map.

Learning Objective
Students will learn:
(a) To use all their senses while outdoors; and
(b) That hearing is an important observational tool.
Age Levels
8 and up
Subject Area
Science
Time
10–20 minutes
Materials
One 7.5 x12cm index card and one crayon per person
Copy of a sonogram, or simplified example on page 4-35

Background Most of us have forgotten how to use our senses because of the daily bruising we get living in an urban environment. In particular, the everyday decibel level around us often drowns out simple sounds. This is a very quiet, focused activity, and the length of time will depend on the age, energy level, and other dynamics of each particular class. The longer the students spend on this activity, the more they will hear. Monitor the class, and call them in at the point where restlessness starts to interfere with concentration.

Procedure
1. Show the group a 7.5 x 12cm card with an X drawn in the centre. Tell the students that the card is a map and the X shows where they are sitting.
2. When they hear a sound, they should make a mark on the card that represents the sound—for example; wavy lines might mean the wind. The mark's location should indicate as exactly as possible the direction and distance of the sound. Tell them to keep their eyes closed while they listen. You may wish to show students a copy of the completed sound map at the bottom of the page.
3. Have everyone spread out and find their "listening place" quickly. Stress that once they find it, they are to remain seated and be as quiet as possible so as not to disturb the others. How long you play depends on your group.
4. Call the group back with a natural sound such as a bird call.

Discussion/Reflection
When they are back, have the students share their maps with a partner.
How many different sounds did they hear?
Which sounds did they like best?
Which sounds did they like least?
Were there sounds they had never heard before?

Sound Mapping

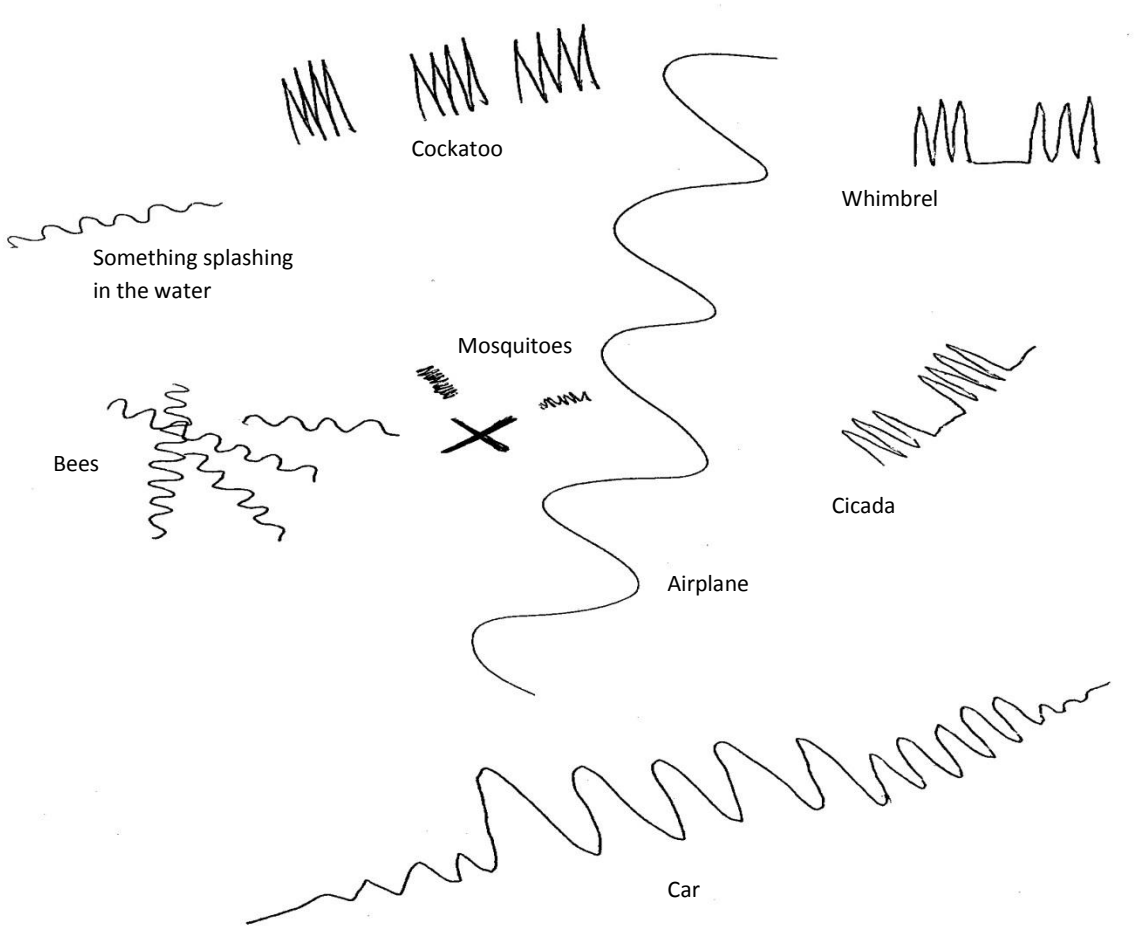


Figure 40: Example of a sound map

Activity 4-M: Bird Behaviour Bingo

Summary Students will practise bird observation and record bird behaviours.

Learning Objective
Students will learn to observe birds and the way they behave in different locations.
Age Levels
8 and up
Subject Area
Science
Time
15–30 minutes
Materials
Bird Behaviour Bingo Sheet (page 4-37), one per pair of students
Pencil or crayon (one per pair)

Background Read and learn the information in Sections 1 and 2, "All About Mangroves" and "Mangroves as Habitat", particularly the parts about birds. Birds use mangroves for everything from nesting to feeding. During each of the different times in a bird's life, it has different behaviours. When it is courting, it uses colourful displays; and when it is trying to protect its young, some birds, like the Plover, will pretend they have a broken wing to lure the predator away from the nest. Learning about the behaviour birds display teaches students the way birds have adapted to survive in mangroves.

Procedure
1. Have the students form pairs and give each pair a Bird Behaviour Bingo sheet and a crayon.
2. Review the behaviours on the sheet and make sure all the students know what they are looking for and how to record what they see.
3. Before setting out, set the rule that there will be absolutely no talking during the walk except on those occasions when the whole group stops to look at something and discuss it. The quieter you are as a group, the more you will see. Decide on some silent signals to be used if somebody wants to get the attention of the group to point out something interesting. Stress that even if a pair finds all the behaviours on the sheet, they are to stay with the whole group and remain quiet until everyone reaches the destination.

Discussion/Reflection
When everyone has finished, or when you are close to your destination, gather the group together and discuss what they saw.
What was the most interesting bird behaviour?

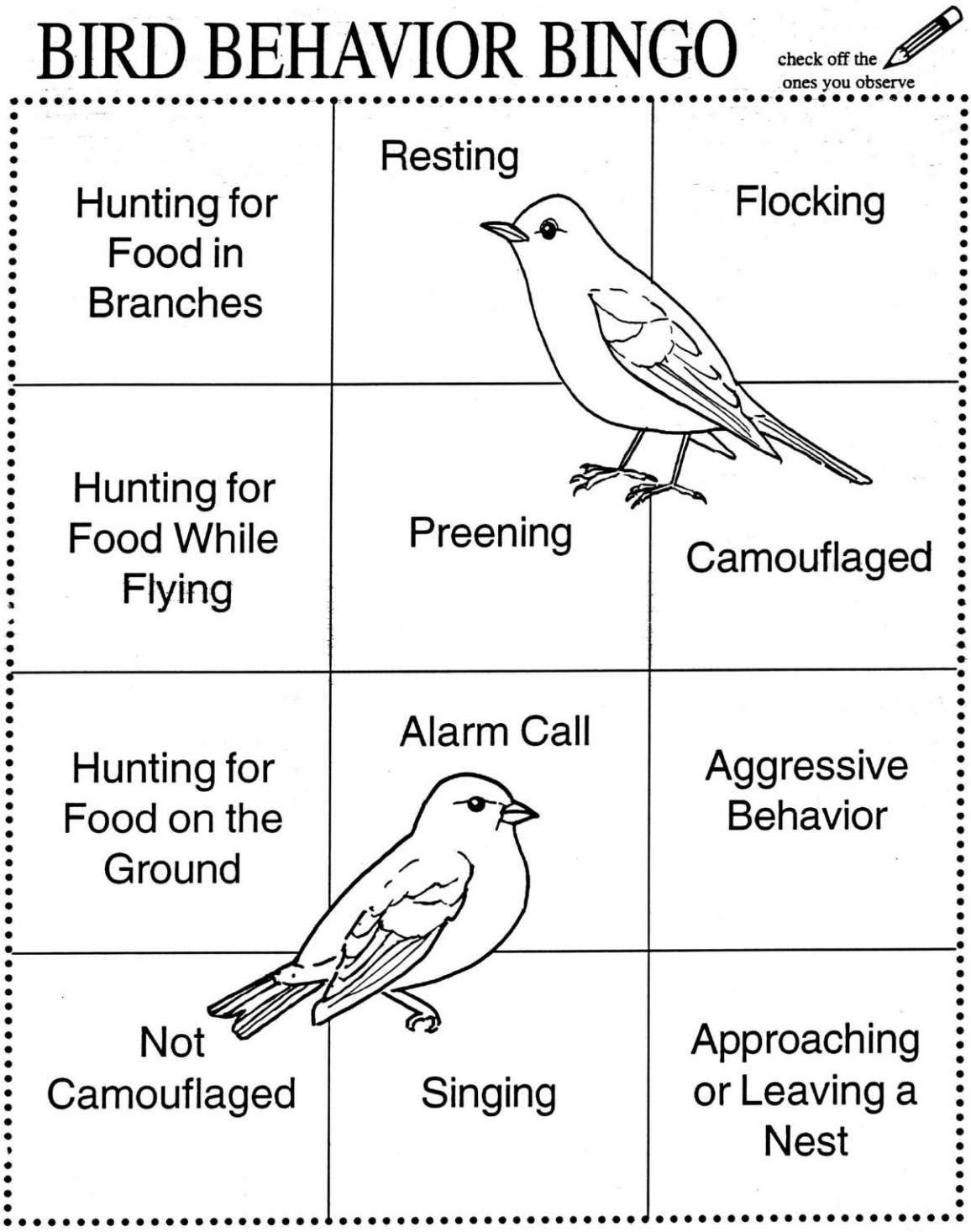


Figure 41: Sound Bingo

Activity 4-N: Field Record of Birds

Summary Students will work in teams and use charts or field guides to identify a number of birds commonly found in wetlands, identify the birds at the field-trip site, and keep a record of birds seen throughout the year.

Learning Objectives
Students will learn:
(a) To identify birds with the aid of shorebird identification guides; and
(b) The importance of keeping records of different bird species observed.
Age Levels
8 and up
Subject Area
Science
Time
10–20 minutes
Materials
Pencils
Field guides, one per team (such as the *Shorebirds Identification Booklet*)
Copies of "*Field Record of Birds*" form on page 4-40
At least one pair of binoculars or spotting scope, if available

Background Review Section 2 of this book, "*Mangroves as Habitat,*" concentrating on the parts about birds. Mangroves are vital as bird habitat, for both endemic and migrating species of birds that live on and use your area. Understanding this, and learning how to identify different species, enables students to learn how different kinds of birds (ducks, wading birds, shorebirds, etc.) have adapted to different niches in the mangroves. Many students who start with simple bird identification like this activity may become life-long bird watchers.

Procedure
1. At the beginning of a term in which birds will be studied, hand out to each student a copy of the sheet "*Field Record of Birds*" on page 4-40. Explain that they are to keep a record of the birds seen on field trip as well as at home.

Preparation

2. You may want to introduce the idea of keeping a "Life List" of birds seen. Many bird-watchers "collect" all the birds they have seen in their life, and compare their lists with the lists of other bird-watchers to find out who has seen the most rare birds.

3. Before the field trip, teach students how to use binoculars and "stalk" birds by being very quiet and moving silently. They should take turns with the binoculars, learning how to focus them and how to spot specific bird features. The person with the binoculars identifies field marks such as colour ("I see a red spot on its chest") and size ("it has longer legs than other birds"). The other

person looks in the field guide, sharing ideas with his or her partner. Students usually work out a suitable way to share the work; just make sure they share the glasses.

The Trip

In the field, use the same techniques that you practised ahead of time. Another way to see a lot of birds is to remain in one place quietly, preferably hidden by a bush or tree.
Then the birds will assume you are part of the neighbourhood and will often come close enough that you can see them better.

Field Record of Bird Species Sheet

	Species	Date	Habitat	No. seen
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				

Activity 4-O: Conducting a Transect

Summary Students will create a profile of wetland vegetation based on using a transect.

Learning Objective
Students will learn through observation that plant types change in response to different water levels.
Age Levels
10 and up
Subject Area
Science
Time
30–60 minutes
Materials
A blank sheet of paper with the title "Transect"
Copies of pages 1-2 through 1-7 with descriptions of different kinds of mangroves
150 m of heavy string
Four heavy wooden stakes or lengths of PVC pipe, each 3 m long, with waterproof marks at 40 cm, 120 cm, and 240 cm; leave enough room below the mark at ground level for the stake to be inserted into the ground
Several hand lenses (at least one for every two students)
A notebook or science journal to record various observations and diagrams of plants
Field resource guides such as: Norm Duke's *Australia's Mangroves* or Catherine Lovelock's *Field Guide to the Mangroves of Queensland* and Louise John's *Field guide to Common Saltmarsh Plants of Queensland.*
Clipboards
A camera (optional)
Gumboots or an old pairs of sneakers

Background Review Section 2 of this book, "Mangroves as habitat," concentrating on the parts about the different species of plants that can be found in mangrove wetland areas.

Procedure
1. Using the stakes and string, the students should lay out a transect line perpendicular to the shoreline (see diagram on page 4-43). The transect line should extend from a point in the water (stake A) where underwater plants can be seen to another point (stake B) where inshore vegetation is present. The distance will vary depending on the nature of the mangroves. (In large mangroves, it may not be practical to lay out string because of the distance involved.) Make sure that the students push the stakes or plastic pipe deep into the ground to prevent them from being pulled over.
2. Starting from the first stake, or stake A, have one student walk approximately 3 m along the transect line toward the upland area. At this point insert a third stake (stake C).

3. The transect line and stakes A and C form a "window" that will assist you in drawing a profile of the mangrove vegetation. The markings on the stakes will assist you in showing the different plant species to (approximate) scale.
4. Students will sketch the vegetation in this first window on their transect form or in their science journals. Identify and label the different plant forms. For each plant form, have them count the number of different species present, and identify and label as many plant species as they can. Students will also observe evidence of wildlife using the plants—for instance, insects eating leaves, crabs burrowing in roots, and birds nesting in bushes.
5. Describe the conditions along the transect line for this "window": wet soils or dry? Sunny or shaded?
6. When students have finished studying and drawing in this first window, start from stake C, walk another 3 m, and insert the fourth stake, or stake D. Stakes C and D form a second window.
7. Sketch the vegetation found in this second window. Identify and label the different plant forms. For each plant form, count the number of different species present and label as many plant species as you possibly can. Describe the conditions along the transect line for this "window": wet soils or dry? Sunny or shaded?
8. Repeat the procedure until you come to the end of the transect line. (You will need to "leapfrog" stakes C and D until you complete the transect.)
9. Identify any exotic (introduced) species observed in the mangroves, and describe how each appears to be changing the environment.
10. Speak to field-naturalists or biologists about the plant life found here, and ask them if it is vulnerable/rare, threatened, or endangered. Why is it important? Is it changing or threatened?
11. Look for evidence of disease, insect damage, etc., by examining leaves, stems, trunks, and roots of the various plants.

Discussion/Reflection
Ask students what role vegetation plays in this mangrove.
Speak to people who live nearby and ask if they have seen any recent changes to plant life in the mangrove.
Look for evidence that indicates that the area might be changing or threatened. For example, the chemical balance of the water might be changing, siltation might be taking place, and the water level might be changing. How will this affect the wetland, the surrounding area, and the local community? Record all your observations and deductions for later class analysis.

Extensions
Students should make a good copy of their plant species profiles for their science journals or later science displays.
Students could research and describe how one plant species they have identified has adapted to life in a wetland.
Students could prepare a report on the plant life in this wetland: description, kinds, diversity, and presence of exotic plants. Are there rare, threatened, or endangered species?

Why is plant life important and what wildlife uses specific plants? Use drawings and photographs, as well as the transect work, to substantiate the report. The report should also look at any threats or changes to the wetland plants: what are the causes and consequences?
The report should be presented to the government agency responsible for the health of the mangrove.
Brainstorm possible solutions to any threats to the wetland.
Take measurements of all plants, and plan to visit the same location and conduct the same measurements (with the same or different classes) at a later date. This way you will build up a bank of information on the mangrove wetland area you have selected.

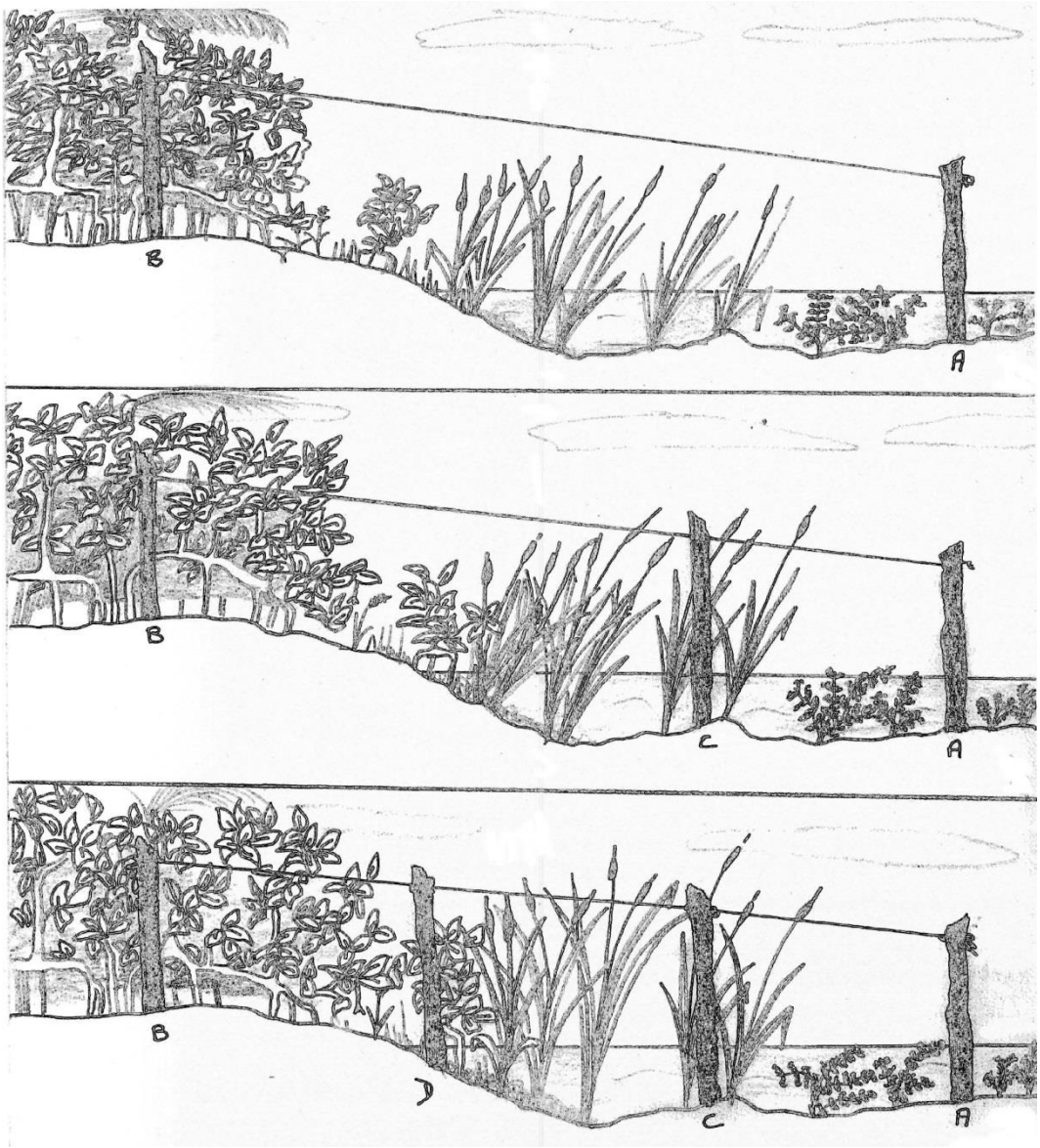


Figure 42: Setting up a vegetation transect

WATER QUALITY IN MANGROVE ECOSYSTEMS

Mangroves are able to adapt themselves to practically all types of adverse conditions with the exception of very low temperatures and are therefore distributed mostly in the tropical regions in low-lying, broad coastal plains where the topographic gradients are small and the tidal amplitude large. Mangrove trees therefore grow in soil that is more or less permanently water-logged, and in water whose salinity fluctuates and may be as high as that of the open sea. The environment in which mangroves are found is influenced by salinity, tidal currents, high temperatures and muddy anaerobic soil. See Fact Sheets #1 to #5 on pages 3-5 to 3-12.

Any ecosystem consists of living (biotic) components and non-living (abiotic) components. The abiotic component is the mixture of nutrients, minerals and other elements found in soil and water, and it is this "soup" that supports life. Since mangrove ecosystems contain water, examining water quality (the abiotic component) is key to understanding the conditions suitable for life in this habitat. In addition, identifying changes in water quality can warn of changes or threats to the plant and animal life found in the ecosystem. Various factors can alter water quality and impact mangrove ecosystems. These are described in the following pages.

Mangrove forests are varied ecosystems with water quality changing with tides and fresh water inputs from rivers. There are five parameters examined in water quality monitoring, these are:

1. **Temperature**

Mangroves grow in tropical regions, in temperatures ranging from 20^{o}C and the seasonal fluctuation does not exceed 5^{o}C. Mangroves have been reported to grow in latitudes where the average sea surface temperature is 24^{o}C. Any further rise in temperature may lead to spreading of only some species.

Temperature varies with the season, from day to night, within a water body and from surface to deep layers. In water bodies, temperature determines the amount of oxygen dissolved in the water: as the temperature of water increases, its ability to hold oxygen decreases. Therefore, cold water holds more dissolved oxygen than warm water.

The temperature of a body of water changes more slowly and is more stable than the temperature of land or air. This protects aquatic life as it allows sufficient time for them to adjust to natural and seasonal changes in temperatures. Sudden and dramatic changes in water temperatures will stress the organisms that live there.

2. **pH**

The pH measurement is the scale used to describe the amount of hydrogen ions present in a water solution. pH is measured on a scale of 0 to 14, where 0 is highly acidic, 7 is neutral, and 14 is highly basic (alkaline). A solution is more acidic when it contains more hydrogen ions. The pH of some common household substance is shown below:

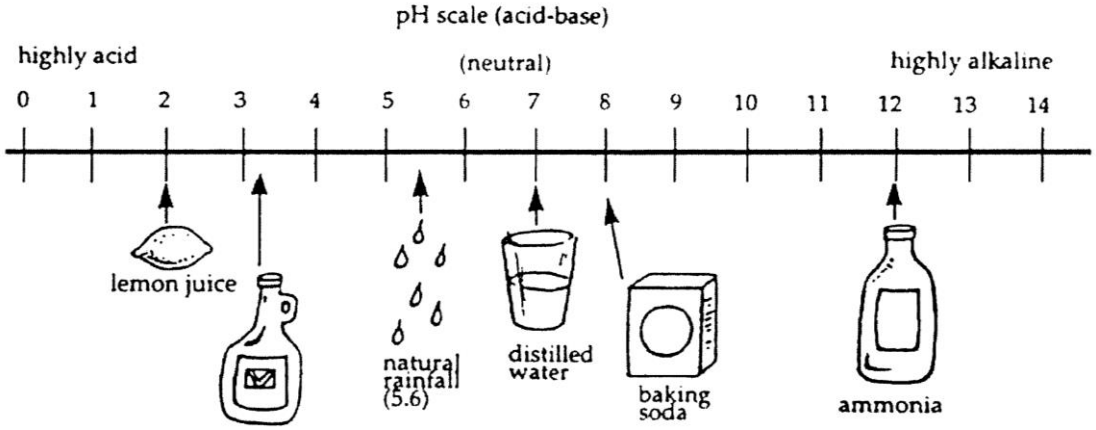


Figure 43: pH of commonly found household items

The pH of most natural waters ranges from 6.5 to 8.5. The salty waters of the ocean contain strong basic ions such as sodium, potassium, and calcium. These particles attach readily to the free hydrogen ions, leaving a basic solution. Ocean water has a resulting pH on the basic side, with a pH range of between 7.5 to 8.4. Freshwater influences, especially in an estuary, will result in lower pH characteristic of freshwater. The mixing of fresh and saltwater produces varying levels of pH to which organisms must adapt.

pH affects aquatic organisms. Most organisms cannot survive in water where the pH is greater than 9.6 or less than 4.5. Acidic conditions are stressful on larvae and young fish. In acidic waters, heavy metals, such as aluminium and copper, leach in to the water. Heavy metals can accumulate in shellfish and on the gills of fish. Increases in **Greenhouse Gases** – especially carbon dioxide (CO_2) – in the atmosphere in turn lead to more CO_2 being absorbed in the oceans. The subsequent result of this is a lowering of the level of PH in ocean water.

3. **Salinity**

Sea water contains nearly all known elements in a dissolved form including our common table salt known as sodium chloride. These salts are important for the growth and reproduction of plants and animals.

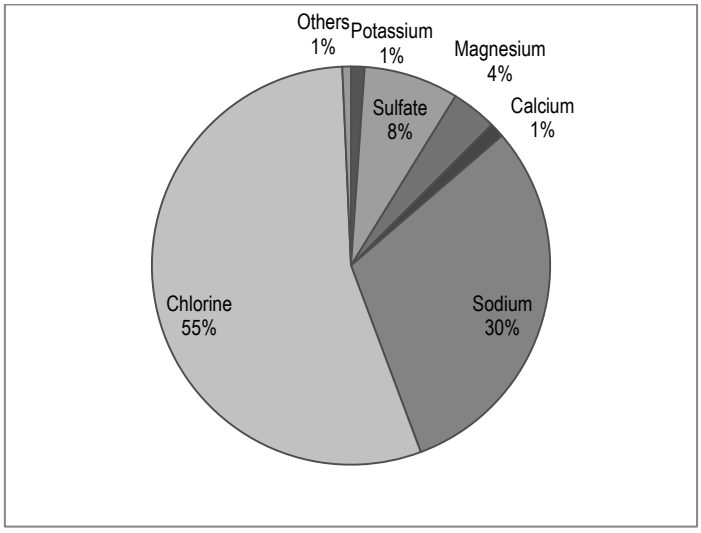


Figure 44: What makes the sea salty?

Salinity plays a vital role in the distribution of mangrove species, their productivity and growth as a forest. Changes in salinity are normally controlled by climate, hydrology, rainfall, landscape and tidal flooding. Different mangrove types have different levels of salinity tolerance. Generally, mangrove vegetation is lusher in lower salinities. Mangroves are poor competitors under non-saline areas where freshwater marsh plants easily out-class them.

Salinity levels in saltwater wetlands will fluctuate depending on amounts of fresh water mixing and inputs. Mixing can be caused by tides and waves, as well as fresh water inputs which can increase with period of heavy rains. Mangroves and organisms of the saltwater wetlands have adapted to these fluctuating salinity levels.

Salinity is most commonly measured in parts per thousand (ppt). This means that ocean water, with about 35ppt has 35 grams of salt for every 1000g of water. The symbol 0/00 means parts per thousand.

4. Dissolved oxygen

Oxygen, or O_2, is a clear, odourless, colourless and tasteless gas. Oxygen is an atmospheric gas and when dissolved in water, it is available to aquatic organisms. Dissolved oxygen is an important element of all wetland ecosystems, including saltwater wetlands.

Conditions are considered to be "anoxic" or lacking oxygen if there is less than 1 part per million (ppm) of dissolved oxygen. Many species cannot survive under anoxic conditions.

Climate, daily temperature changes, and salinity affect the level of dissolved oxygen (DO) found in any aquatic ecosystem. Cold fresh water holds more oxygen than warm or salty water.

The large size of saltwater bodies results in few problems with low DO levels. Consistently low water temperatures together with wave action and tides give ocean water suitable DO levels. However in saltwater wetlands, tidal pools can experience reduced DO levels with the combined effects of temperatures increases, lack of water movement, and decomposition of organic material. Organisms of saltwater wetlands have adapted to these conditions and developed unique strategies to deal with the variable DO levels when the tide rises and falls.

Table 4: Factors and causes that affect dissolved oxygen levels

Factors that affect dissolved oxygen levels	Causes
Respiration	Wetland plants and animals consume oxygen for respiration needs Algae and other plants release oxygen during the day (Photosynthesis)
Decomposition (bacteria and other decomposer organisms consume oxygen to decompose decaying plant matter and animals)	Excess nutrients from waste water treatment plants, agricultural or urban runoff can cause algae blooms; as algae die, they decompose Large amounts of organic matter from river runoff can cause increase in decomposition
Temperature (cold water holds more dissolved oxygen than warm water)	Thermal pollution Loss of vegetation increases water temperature Impoundments, tidal pools, channelization increase water temperature Turbidity can increase water temperature from sediment absorption of heat
Salinity	Fresh water holds more oxygen than salt water
Weather	Cool, windy days decrease evaporation and increase the amount of air mixing into water Hot, dry calm water increases evaporation, and decreases the amount of mixing with water

5. Turbidity

Turbidity measurers water clarity - how much the suspended material in water decreases the passage of light through the water. Suspended materials include soil particles (clay, silt, and sand), algae, plankton, microbes, and other substances. Turbidity can affect the color of the water.

Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO.

Water clarity can be affected by the following factors:

- Soil erosion
- Waste discharge
- Urban runoff

- Eroding stream banks
- Large numbers of bottom feeders (such as carp), which stir up bottom sediments
- Excessive algal growth.

Turbidity can be useful as an indicator of the effects of runoff from construction, agricultural practices, logging activity, discharges, and other sources.

Turbidity can be measured using a Secchi disc. The Secchi disc is best used in deep, slow moving water bodies (Figure 45).

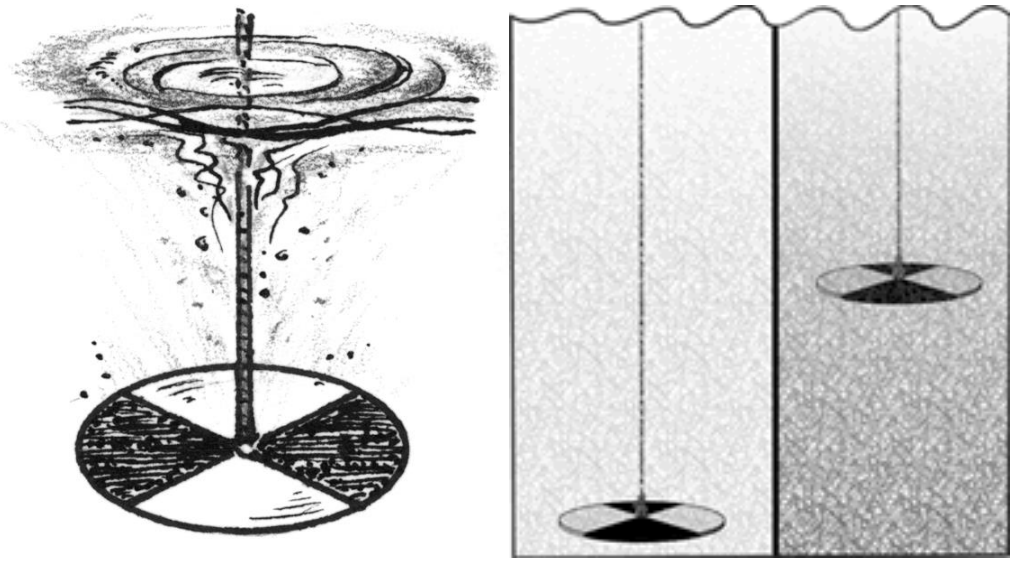


Figure 45: Using a Secchi disc.

Importance of water quality

All living organisms depend on water for survival. When the quality of the water is compromised, they may have problems surviving. Maintaining water quality, therefore, is essential to maintaining life on Earth.

Factors affecting water quality

Chemicals – such as fertilizers, insecticides and herbicides can run off into storm drains and local waterways during storms. Also, solvents, paints, waste oils and other chemicals flushed down the drain or poured into storm drains quickly make their way to local waterways.

Industrial pollution threatens waterways, adding a variety of contaminants, often in high concentrations, in the water of immediate regions. The salinities of shoreline areas can be affected by human construction and development.

Human factors, such as thermal pollution and the runoff of excessive nutrients affect the level of DO; thermal pollution causes a temperature increase, which in turn, reduces the level of DO, and

excessive nutrients stimulate algae blooms. When these algae die, their decomposition consumes oxygen. This can result in severe oxygen depletion.

Large amounts of organic matter are flushed into estuaries from rivers. Once in the estuary, organic matter is decomposed by organisms such as bacteria and fungi, which it turn use oxygen. In most cases decomposers break down organic matter at a reasonable rate and the system can replenish the oxygen supply. When large amounts of organic material are added, however, oxygen levels can be depleted and organisms can be affected leading to excessive die-off or aquatic organisms.

See Fact Sheets #1 to #5 on pages 3-5 to 3-12.

Activity 4-P: Water Quality

Summary

Learning Objectives

Students will be able to:

a) Learn about the conditions that support life in a wetland by testing and analysing water quality, and

b) Determine if water quality has deteriorated or is threatened.

Age levels

8 and up

Subject Areas

Science; Social studies

Time

45 minutes

Materials

Hat or cap
Sunscreen
Water bottle
Thermometer
Rubber gloves
DO test kit or meter
Data sheet
Appropriate clothing
Water testing kit for pH or pH paper
Data collection sheet
Bottle labels
Glass or plastic jars to use as sampling bottles
Eyedropper
Salinity meter
Secchi Disc
Hydrometer method

Procedure

Temperature

1. Measure the air temperature by holding the thermometer in the shade for about two minutes. Do not let the thermometer rest on surfaces that might transmit their own heat.
2. Record the air temperature on the data recording form.
3. Wash off the thermometer with tap water and wipe it dry before returning it to the kit.
4. Measure the water temperature by submerging the thermometer into the body of water (or a container of sample water) and holding it there for two minutes. Place the thermometer at least four inches beneath the surface and make sure it does not touch the bottom.

Note: You may hold the thermometer directly in the body of water itself or in a container of sample water. If you test water from a container, you should measure its temperature before the water has time to warm up or cool down.

5. Record data on data sheets.

Notice significant changes in temperature readings between sampling locations, look for possible reasons. Start with natural causes, such as a shallow tidal pool versus the sea.

Temperature change	Effects on wetlands organisms
a change of no more than 4°C	is ideal
an increase or decrease of between 5° and 8°C	is somewhat stressful
a change of more than 8°C	is very stressful

pH

1. Collect water samples using an eyedropper.
2. Approximations of acidity can be easily obtained through using pH paper.
    a) Tear off about 5 cm of pH paper.
    b) Place 3-4 drops of your sample on the paper.
    c) Compare colour to the standard chart.

Note: Measure the pH immediately after sampling, since temperature change can affect pH.

Salinity

There are two basic ways to measure salinity:

A. Through the use of a salinity meter, which will measure most accurately. With the dissolved salt in saltwater, the higher the salinity the higher conductivity it will have. Conductivity is the amount of electric current which can pass through something. The higher the salt content, the more electricity will travel through, increasing conductivity. The salinity meter converts conductivity into salinity. These meters can be expensive, but they are reliable and easy to use.

B. Salinity can also be calculated using a hydrometer. A hydrometer is a hollow glass tube with a scale printed on top. It works on the principle that increased salinity results in increased density. When objects float in saltier water they are more buoyant. The hydrometer will float higher in saltier water and the water surface will be lower on the printed scale. Cold water is also more dense than warm water, so the temperature affects the buoyancy at the same time. Correction tables have to be used to obtain a corrected density calculated at 15°C in order for salinity to be determined.

Procedure

Salinity meter

Material needed for this procedure is a salinity meter

1. Observe and record possible factors that might affect salinity levels (i.e. inflow of fresh water), and mark observations on your map.
2. Determine the salinity content of the water samples as instructed in the kit or meter manual.
3. Record the salinity on the water quality data sheet.

Hydrometer method

Materials needed for this methodology are a hydrometer, temperature and density correction tables, sampling bottle and a container large enough to allow the hydrometer of float (i.e. 500 ml graduated cylinder)

1. Observe and record possible factors that might affect salinity levels (i.e. inflow of fresh water), and mark observations on your map.
2. Collect water samples from several depths at each of your sampling locations.
3. Pour about 450 ml of your sample into a container (i.e. 500 ml graduated cylinder)
4. Measure and record temperature (°C)
5. Measure density with hydrometer (Look at the point where the water line crosses the scale.)
6. Correct the density using chart 1, the Density-Water Temperature Chart. (For example: Your sample was 5°C with a density of 1.0100. Find the 5° column. Go down the column to the 1.0100 line. The chart reads -9. Subtract 0.0009 from 1.0100 to get your corrected density of 1.0091)
7. Use this new, corrected density to determine salinity on Chart 2, Salinity/Corrected Density Chart.
8. Determine the salinity content of the water samples.

Dissolved Oxygen (DO)

In the field:

1. Students will observe and record possible factors that might affect dissolved oxygen. Mark observations on your map.
2. As directed in the dissolved oxygen kit or meter's instructional manual, collect wetland samples from your sampling locations.
3. Determine the dissolved oxygen content of the water samples as instructed in the kit or meter manual.

Oxygen levels	Effect on organisms
8 to 14 ppm (parts per million)	Ideal
5to 7ppm	somewhat stressful/stressful for very active organisms
3 to 5ppm	stressful for all aerobic organisms
1 ppm or less	anoxic conditions

Turbidity:

Turbidity is measured by using a Secchi disk that is an 8-inch diameter disk with alternating black and white quadrants (view diagram on page 4-50). The disk is lowered into the water using a rope-marked every meter-until it can no longer be seen from the surface. It is lowered some more and then raised while observing the depth at which it reappears. The point at which the disk disappears is a function of the water's turbidity.

Note: For very turbid water, it may be preferable to use a turbidity tube.

Discussion/Reflection

Aquatic temperatures vary and the temperature range that is ideal for one species may not be ideal for another. Dramatic and sudden changes in water temperature stress plant and animal life in the wetland.

Determine temperature changes between different sampling locations and use the following table to determine how stressful any temperature change is that you noted.

Due to saltwater's high pH, the aquatic life is more tolerant of fluctuations in high pH ranges. For example snails, clams, and mussels can tolerate a pH range of between 6.8 and 9.7.
Since living organisms are able to survive within a certain pH range, dramatic changes in pH can result in the death of plants and wildlife, reproductive failure, deformation of adult and young, and starvation for some species because their food sources have died out.

Organisms of saltwater wetlands have adapted to the variable salinity levels of their environment. As salinity levels change through the estuary, different organism communities will predominate.

Salinity	Water type
25-40 ppt	saltwater
17-25 ppt	freshwater influence minimal
5-l7ppt	brackish water
1-5 ppt	fresh water

Water Quality Data Collection Sheet

Name: _____

Location: _____

Date: _____

Weather: _____

Site	pH	Turbidity (m)	Water Temperature (°C)			Salinity (0/000)			Dissolved Oxygen ppm		
			1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd

MAKING CHANGE
5 - 1

CONTENTS SECTION 5

MAKING CHANGE

Sometimes it seems that the environmental issues and problems facing the mangroves are overwhelming. Never let it be said, however, that individuals and groups cannot make a difference. All over the world, students and their communities are working to help protect and enhance our environment. In this section, you will read about four examples of people who have made a difference in bringing back different species from the brink of extinction.

There are many ways to raise the awareness of the people you live with and those who visit your island, from a Science Fair to a public project aimed at tourists. Only by raising people's awareness in this way will we be able to protect our valuable island resources—whether they be wetlands or the creatures that inhabit them. Contact a local environmental organization to see how you can help. You can start by carrying out some of the activities in this section.

Developing an Ecotourism program can also help raise awareness in your community and wider, it can also create an additional and sustainable economic base for the community.

Activity 5-A: Writing Skills

Summary Field trips to mangroves are often inspirational and always fun! Students will write poems about these experiences.

Learning Objectives
Students will be able to write a poem or haiku about their field-trip experiences.
Age Levels
8 and up
Subject Area
Language arts
Time
30–60 minutes
Materials
Copies of vertical-poem and haiku forms on page 5-4

Background Notes on observations from field trip and study of previous sections.

Procedure
1. After visiting a site for a program and a field trip exploration, ask students what lessons they have learned and what feelings or impressions they have been left with.
2. Have them choose one item—concept or object—that particularly stands out, and write about it. It could be a mangrove plant, a pond, a mudflat, a season, or a specific creature, bird, fish, or invertebrate. The following handout can be used for writing poems about mangroves, and can be adapted for other observed items.

VERTICAL POEM

Choose a word that reflects some aspect of what you have learned, and use each letter of the word to begin a line of your poem.

M _____

A _____

N _____

G_____

R_____

O_____

V_____

E _____

S _____

HAIKU

Japanese haiku is a form of poetry with only three lines. The first line contains five syllables, the second has seven, and the third has five. For example:

In the mangroves
Fish swim, crabs crawl, heron stalk,
The roots are their home.

Try writing a haiku about your own exploration experience.

_____

_____

_____

_____

Activity 5-B: Mangrove Controversy: Town Hall Meeting

Summary Mangroves throughout the Australia have the potential to be destroyed by development and ill-advised land-use decisions. Students get a chance to participate in the decision-making process by creating a local council or other organization that makes planning decisions and a cast of characters both for and against the proposal.

Learning Objectives
Students will be able to:
(a) Recognize the many viewpoints in land-use issues; and
(b) Understand the process of land-use decision-making.
Age Levels
10 and up
Subject Areas
Social studies, language arts
Time
2–4 lessons, or more
Material
Costume materials (props) hats, ties, glasses, binoculars, etc.
Paper and pencils
Copies of page 5-9 and 5-10, “Character Worksheet”
Name cards for city council members

Background In this exercise, students will role-play the characters listed below to enact a town hall, city council, planning board, or similar meeting. Admittedly, this type of forum may not be the way land-use decisions are made in the Australia, but there are usually public consultation meetings to allow local residents to express their concerns in regards to new development applications. The exercise, will give students exposure to the variety of viewpoints held by the public.
To begin this activity, first think of a name for your mangrove. It may be that you know of a mangrove in your area that is in jeopardy, and you can base your exercise on that specific area. Otherwise, use a real mangrove in your area as the topic, pretending that it is under development pressure.

The scenario is this: Some (fictitious) people in your town have been meeting surreptitiously to express their dismay about the “stink pond” in the community—the local mangroves. They call themselves Citizens Opposed to Mangroves (COM) and argue that the mangrove is of no real value and should be converted to other uses. In particular, a developer thinks it would make a wonderful marina. Another faction (also fictitious) has heard about COM and has joined together to defend this natural area. Using the motto “Save Our Mangroves” (SOM), these citizens feel the wetland is valuable for a variety of reasons and should be preserved at all costs. The mayor, upon hearing of the growing dispute between COM and SOM—not to mention the $50 million marina proposal—has called a special council meeting during which concerned people of the community will offer their

opinions on the subject, as guest speakers. A decision will be made at the end of the meeting to determine the fate of the mangroves.

Characters

Mayor Justus B. Faire: Mayor Faire is a wise and fair person who wants to make the best possible decision for the town—especially because this year is an election year.

City Council Members (6)

1. Simon Sense
2. Bertha Broadmind
3. Harry Reason
4. Iris Wise
5. Phil Osopher
6. Kitty Prettycity

All council members are elected officials. They must weigh the evidence on this issue and decide the fate of the local mangrove, for the good of the town.

Guest Speakers (12)

1. **Phil Swamp**: Phil is a carpenter who builds homes. He knows that if the mangroves were filled in, homes could be built in the area, providing more jobs.
2. **Wanda Drejanbuild**: Wanda has already built a small marina in a neighbouring area, and sees this mangrove as the perfect opportunity to enter the big leagues of developers.
3. **Marsha Plenty**: Marsha lives in a house near the tidal floodplain. She knows how important mangroves are in reducing floods and is concerned about her home.
4. **Duane DeMarsh**: Duane is a farmer who has drained a mangrove area on his property and thinks all mangroves should be drained for better uses.
5. **Ima Heron**: Ima is a long-time resident of the town and grew up near the mangrove. She thinks the mangroves are beautiful and wants her grandchildren to be able to enjoy them too.
6. **Wes DeCrabpot**: Wes loves to fish, and helps to feed his family through fishing and crabbing. He realizes how important mangroves are to the recreational fishing industry.
7. **Candy Velop**: Candy is another developer who would like to build beachside units around Wanda's marina, and provide them all with "ocean views".
8. **Amos Keetow**: Amos detests pests. He lives near the mangroves and feels they are the sources of the insects that ruin his life in his expensive new home.
9. **Crystal Clearwater**: Crystal is a member of the local Mangrove Watch and she has learnt how important mangroves are for nutrient uptake and carbon sequestration.
10. **Dr. Pete Bog**: Dr. Bog is a scientist with a Ph.D. in wetlands science from the University of Away. He has studied mangroves and knows how valuable they are to people.
11. **Luka Fish:** Luka is a keen recreational fisherman. He knows the importance of mangrove wetlands as a nursery for many of the fish from which he feeds his family. He also knows most of the bird names as well, not that he'd admit that to his mates. He's been worried about the decline of the wetlands over the last 30 years, but thinks the stormwater drain might have something to do with it.

12. **Sean Prawn**: Sean is a local commercial fisherman who knows the importance of mangroves as a nursery for many of the fish from which he makes a living. He is concerned that dredging the mangroves will destroy the fishery.
13. **Tee Ball**: Tee is an avid golfer who just won the lottery. He has plans for a new golf course right next to the marina and the beachside units.
14. **Anita Guide:** Runs the local dive shop and knows that the health of the reef also depends on the mangrove ecosystem. She is concerned that the destruction of the mangrove will lead to an unhealthy reef that no one will want to visit.

Procedure

1. Students will be enacting a town council meeting or its local equivalent by roleplaying the characters with different viewpoints. The task will be to decide the fate of the local mangroves. Should the council preserve them, convert them to use for something else, or make some sort of compromise? (Compromise: a method of reaching agreement in a dispute, by which each side gives up something that it wants.)
2. Remember that each and every citizen in a democracy has the responsibility to participate in the decision-making process by expressing their views to their elected representatives. You may express your views by voting, writing letters, speaking at town hall meetings, and so on.
3. Read carefully the background information for this exercise.
4. Assign students to the following roles.
   - Select one person as the Mayor. This person will be the facilitator of the meeting.
   - Appoint six city council members who will listen to the testimony and ask questions of the public.
   - Divide the remainder of the class into 12 groups (two or three students per group, depending on the size of the class). Each of these groups will be represented by one of the 12 guest speakers, with one person from the group being the spokesperson.
5. Each character should have a character worksheet (see page 5-9 and 5-10) — one for each city councillor and the Mayor, and one for each group represented by a guest speaker. Take time to answer the questions. The guest speakers each get a piece of paper with their character description, and members of the group should work together to answer the questions for their character.
   Important: Remind students that the characters they are playing may not necessarily think the way they do. They are to put themselves in the shoes of their characters and say what those persons might say, according to the character descriptions.
6. Arrange seven desks in the front of the classroom for the city council members. Put name cards on the desks for each member. Seat the Mayor in the middle.
7. After everyone has filled out a character worksheet, students may put on any costume or prop materials that are appropriate for their role, simply to add to the interest of the exercise (ties, glasses, straw hat, hunting vest, etc.).
8. Have the Mayor officially open the meeting and introduce himself or herself to the audience. Have the city council members introduce themselves. The Mayor should briefly introduce the situation and then invite public testimony from the guest speakers.
9. Each guest (spokesperson) is to stand up before the council to express his or her viewpoint, using the character worksheet for reference. When making their statements, guest speakers

should introduce themselves, describe what they do and anything else relevant about themselves, and say what they feel about wetlands and about this specific question.
Example: "I am Dr. Pete Bog, you know I was raised in this area, and I went away to study biology. When I was away, I looked at mangroves all over the place, and after many years I became an expert. So, I met this wonderful woman, Betty Buttonwood, who became my wife, and I thought I'd come back home and raise my family. Well, I spent years and years studying every tiny thing about mangroves, and I came to this big conclusion: they are so important for us that I think it is criminal to destroy them."

10. After all the guest speakers have had their say, it is time for the council to ask questions and challenge the viewpoints of the guest speakers in order to clarify the issue. This will ideally be a time of creative thinking. For example, someone might ask Candy why she cannot build her units somewhere else, or, alternatively, why Marsha needs to live near a tidal floodplain
Note: If time allows, assign a committee of students to study the problem and report back to the council at a later date. Prepare a report that (a) describes the value of mangroves, (b) analyses the potential effects of other activities on the mangroves, and (c) proposes several alternatives for how the site could be used. When the committee is ready to report to the council, reconvene the meeting. Allow the council to ask any further questions.
11. After all the questions have been asked, the Mayor will decide it is time to make a decision and will call for a vote:
    All in favour of preserving the mangroves?
    All in favour of converting the mangroves to _____?
    All in favour of some sort of compromise?
12. After the vote, the Mayor makes a declaration about the fate of the mangroves, and the meeting is adjourned.

Discussion

If you yourself were voting on this decision, how would you vote?
How should decisions like this be made?
Should all people be involved in making the decision?
Should laws be written to protect mangroves?
What kind of laws would you make to protect mangroves?

Extensions

Students visit a local town hall meeting and perhaps give testimony if an issue under discussion involves a mangrove with which the class is familiar.

CHARACTER WORKSHEET
GUEST SPEAKERS

Name_____

What do you do? _____

Describe yourself: _____

_____

_____

How do you feel about mangroves?

_____

_____

_____

_____

_____

What do you think should happen to this mangrove area?

Circle one: Preserve it Destroy it Compromise

Why?

_____

_____

_____

_____

CHARACTER WORKSHEET
MAYOR AND CITY COUNCIL MEMBERS

Name:_____

What do you do? _____

Describe yourself: _____

_____

How do you feel about mangroves? _____

_____

_____

Write down reasons that people would want to save mangroves.

_____

_____

_____

_____

Write down reasons that people would want to destroy mangroves.

_____

_____

_____

_____

You will be making an important decision about the mangroves in your community. Therefore, you will want to know everything you can about the situation so you can make the best decision. Keep an open mind. Think of questions to ask the guest speakers about why they feel the way they do.

Activity 5-C: They're Bouncing Back

Summary There are several success stories that illustrate how endangered species have been brought back from the brink of extinction.

Learning Objectives
Students will be able to:
(a) Learn the names of several species that are healthier now than they once were; and
(b) Discuss some of the problems these species have faced and the ways people have helped them.
Age Levels
5–10
Subject Areas
Science, social studies
Time
30–60 minutes
Materials
"Success Stories" (page 5-12) and pictures of Wollemi Pine, Muir's Corella, Humpback Whale, and Regent Honeyeater (pages 5-14 through 5-15)

Background There is so much bad news associated with endangered species and the increasing rate of extinction that it's easy to overlook the positive things that have happened. Many people don't realize, for example, that populations of Wollemi Pine, Muir's Corella, Humpback Whale and the Regent Honeyeater are on the improve.

Procedure
1. Discuss each of the four species listed under "Success Stories" on page 5-12. Use the information provided to briefly go over the problems each species has faced and how the animal has been helped. Also show students pictures of the animals (pages 5- 14 through 5-15) during your discussion.
2. Get the students up onto their feet and have them form a circle.
3. Go over the motions and words of the chant on page 5-13, and then have the students "perform" the chant a couple of times as they march around the circle.
4. You might want to add a few verses of your own, too, for any local species in your area that you know are making a comeback.

Wollemi Pine (*Wollemia nobilis)*
The Wollemi Pine was only discovered in 1994 and belongs to one of the most ancient genus and became a discovery of international significance. Only a small grove of mature plants and seedlings were found in the Wollemi National Park in 1994 and since then 2 other small groves have been located. The New South Wales National Parks and Wildlife Service have put in place regulations that only allow certain researchers access to the wild trees. Since 1999, Forestry Plantations Queensland has been propagating the plants for sale and to increase this endangered species distribution both locally and worldwide.

Muir's Corella (*Cacatua pastinator pastinator*)

Muir's Corella is a stocky white cockatoo which is endemic to Western Australia. In November of 2012 it was removed from WA's Threatened species list due to successful conservation efforts. The Corella was initially recorded as threatened due to its limited distribution in southern Western Australia and the almost 3000km^2 between populations and the actual area they were occupying was only 500km^2. A recovery plan was put in place in 2005 and annual corella counts were conducted. An education program was launched to educate the neighboring public on the advantages of living with the birds instead of shooting them. Land reclamation occurred providing a larger habitat for the corella's and the population has increased to the point where it has been removed from the threatened species list. There are still plans in place to monitor the population and continue the education programs.

Humpback Whale (*Megaptera novaeangliae*)

Whaling began in Australia in the late 18th Century. Early whaling involved the use of hand harpoons from small boats with the whale carcasses being dragged to shore. As the number of whale's dwindled it became harder to locate them resulting in the development of harpoon guns, explosive harpoons and steam driven whaling boats. In the late 19th Century large scale commercial whaling resulted in the over-exploitation of some whale species including the Humpback Whale. Whaling stations in Australia and New Zealand are estimated to have killed over 40 000 Humpback Whales until their protection in 1963. The whaling industry in Australia continued until 1978 when only Sperm Whales were being targeted. In 1979, Australia adopted an anti-whaling policy and since then these majestic creatures have had protection with our waters. Unfortunately this has not stopped the global take of Humpback Whales from their summer home of Antarctic waters by countries such as Japan. Despite this limited hunting effort the recovery in the Humpback Whale population is continuing with the population estimated to be up to 5000 individuals breeding each year in Australian waters. This is significant increase from 1962, when the east coast population was estimated to be only 100! The Humpback Whale is now listed as of Least Concern on the IUCN Threatened species list where until 2008 it was listed as Vulnerable.

Regent Honeyeater (*Xanthomyza phrygia*)

Fifteen years ago the Regent Honeyeater faced extinction as its habitat was cleared at an amazing rate. This tiny black and gold native Australian bird was once found abundantly through the great number of box ironbark forests of NSW and Victoria. These eucalypt forests have been under intense logging pressures in recent years, up to 85% of the forest has been removed since European settlement, and this has resulted in the reduction of numbers of the Regent Honeyeater to an estimated 800 individuals nationally. Through a captive breeding program with Taronga Zoo approximately 80 birds have been re-introduced into the wild. To supplement this breeding program over 385 000 box ironbark seedlings have been planted, bringing some areas back to their former beauty. It's hoped with continued captive breeding and subsequent release, combined with continual planting of trees this bird's population will gradually increase.

THEY'RE BOUNCING BACK

They're bouncing back,
They're bouncing back,
The Wollemi Pine is bouncing back!
Hidden away in Wollemi
Now protected and grown for all to see.

They're bouncing back,
They're bouncing back,
Muir's Corella is bouncing back!
Once poisoned and hunted, almost gone
My habitat is being restored and I'll live on.

They're bouncing back,
They're bouncing back,
The Humpback Whale is bouncing back!
Majestic marine giant, I sing and play
Returning soon to Hervey Bay

They're bouncing back,
They're bouncing back,
The Regent Honeyeater is bouncing back!
My brilliant flash of yellow, for all to see
Thousands of trees planted, more habitat for me

Motions

- Wollemi Pine: Stand with your hands pointed above your head and gently sway.
- Muir's Corella: Stretch arms out behind you interlocking fingers and strut from your left foot to your right foot. Squawk loudly.
- Humpback: Pretend to breach and spy hop – bend knees and hold arms straight out to and move up and down slowly.
- Regent Honeyeater: put your hands out in front of you with your fists gently clenched (gripping a branch), look left, look right then spread your arms (wings) and fly.

Figure 46: Wollemi Pine

Figure 47: Muir's Corella

Figure 48: Humpback Whale

Figure 49: Regent Honeyeater

Activity 5-D: Marine Debris: Collection and Impact

Summary A great deal of garbage washes up on beaches and in wetlands across Australia. What it is and where it comes from will be determined in a series of field trips, research, and classroom activities.

Learning Objectives
Students will be able to:
(a) Understand marine debris and its sources, and be able to describe its adverse effects on organisms;
(b) Determine the distribution and predominant types of marine debris in their island; and
(c) Understand how long it takes various types of debris to biodegrade, and list potential solutions to the problem.

Age Levels
8 and up

Subject Areas
Science, social studies

Time
2–4 lessons, or more

Materials
Marine debris recording sheets - downloaded at: http://www.tangaroablue.org/resources/data-sheet.html
Copies of page 5-18 showing marine debris biodegradation timeline
Trash bags (if your area has a recycling program, use two colours for separating recyclables from non-recyclables)
Clipboards and pencils for each group
Gloves
First aid kit
Map of beach location to be cleaned

Background Marine debris is the name given to waste that finds its way into our seas and oceans. Plastics, rubber, metal, wood and glass can be found floating in our oceans or washed up on our beaches and mangroves. Marine debris is not only a hazard to ships, divers and beach goers – it is also a threat to marine life. Some litter comes from ships that dump their waste overboard. However, between 60 and 80% is transported via rivers and stormwater from upstream areas. Most of this litter (more than 90%) consists of plastics, glass, metal, and wood. Not only is this litter aesthetically displeasing, it can pose a threat to many organisms. For instance, Leatherback turtles consume large numbers of jellyfish, and often mistake plastic bags and balloons for jellyfish. These bags may lodge in the turtle's oesophagus, stomach, or intestine and cause the turtle to die of starvation or other complications from the blockage.

Procedure

1. Divide the class into small groups. To each group give garbage bags, marine debris recording sheets and marine debris timeline sheets, pencils, clipboards, and gloves.

2. Explain to students that while they are gathering up the marine debris, they will also be analysing it for its type, location, time needed to decompose, and potential threat to wildlife and the ecosystem.

3. Explain the importance of wearing gloves, and what they should do in the event of finding a syringe or glasses (call the teacher and avoid picking it up themselves).

4. Assign to each group a specific shoreline area to be cleaned up, and indicate the location on a map of the beach. Tell them there will be a prize for the most unusual item found, as well as the most litter picked up. If items have labels on them, the students should write down the product type and name on the sheets.

5. Make sure that arrangements have been made with the local garbage-collection service for the bags of garbage to be picked up.

Discussion/Reflection

During the picking up, discuss the possible origin of the items of debris. For items with labels on them, have students discuss how long they might have been at sea, or whether they originated locally.

One group can analyse the data and create a report that would include the most common types of debris and assumed origins of debris. Another group could research ways in which the debris can affect animal and plant life on the shoreline and in the water.

Extensions

Students should make a display of the garbage they pick up for a school open day or science fair. For example, if they find an old fishing net, hang it between two or three poles and attach the debris to it in sections—each section representing 100 years— that illustrate how long it takes each type of debris to biodegrade.

Younger students can create a marine creature (turtle, whale etc.) to represent the damage debris can do to our marine wildlife.

Access the Australian Marine Debris Initiative, an initiative of the Tangaroa Blue Foundation on the World Wide Web at: http://www.tangaroablue.org/ . Tangaroa Blue is an Australian registered charity focused on the health of our marine environment.

The Australian Marine Debris Initiative's datasheet can be downloaded at:
http://www.tangaroablue.org/resources/data-sheet.html

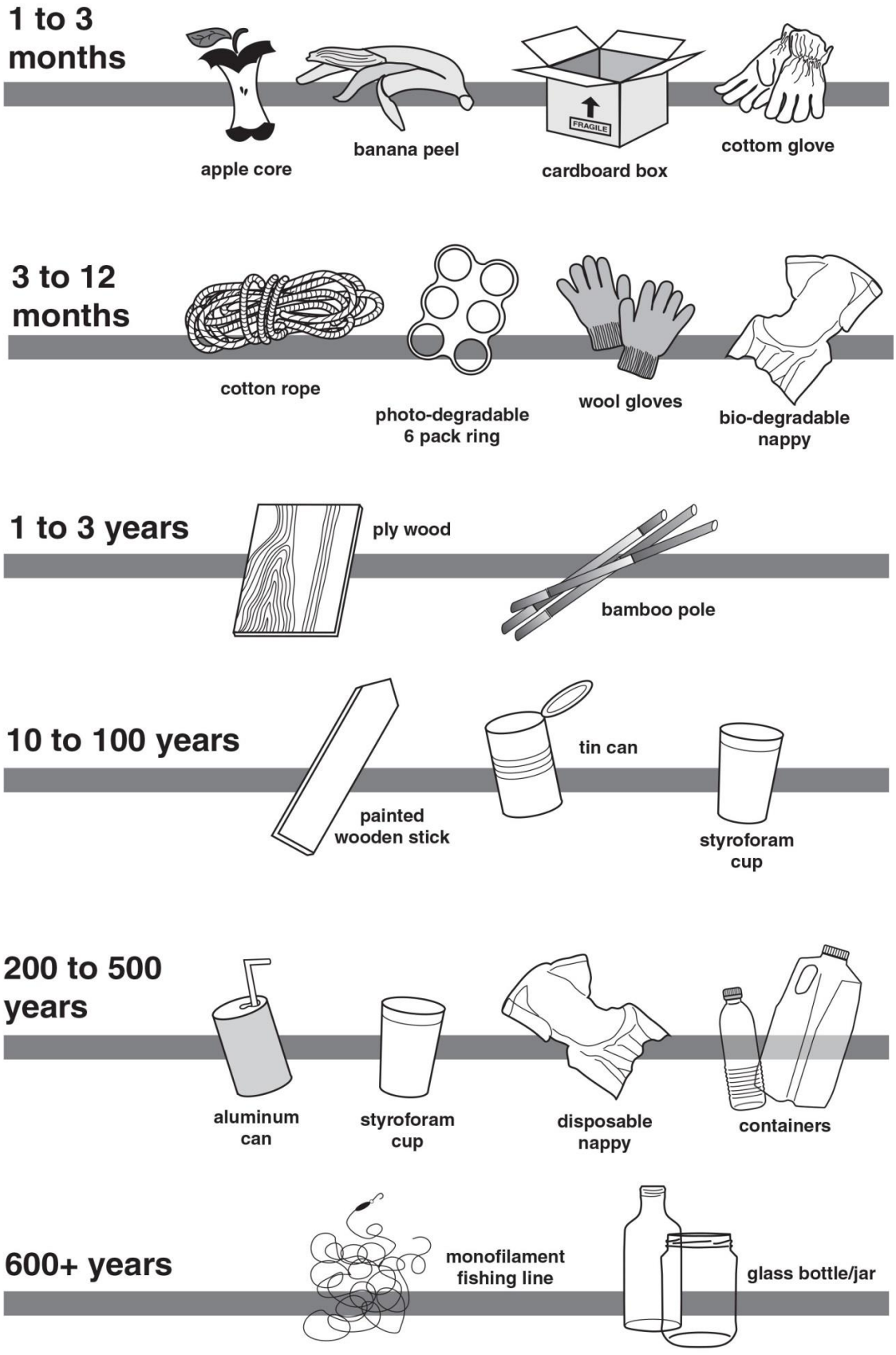


Figure 50: How Long It Takes Marine Debris to Biodegrade

Activity 5-E: What About Water? Home Analysis

Summary We all need water to survive, but we take it for granted that it will always be available. The same is true for the many species that rely on mangroves for their survival. With this home review, students can discover where their water comes from and where it goes, and find ways to protect and improve water quality.

Learning Objectives
Students will be able to:
(a) Understand where their water supply at home comes from;
(b) Determine where the waste water in their homes goes;
(c) Understand where wildlife gets the water it needs to survive; and
(d) Find ways to improve water quality in their local community and mangrove areas.
Age Levels
9 and up
Subject Areas
Science, social studies
Time
1–2 lessons, or more
Materials
Copies of factsheets on pages 3-5 through 3-12 showing water/wetland pollutants
Copies of questionnaire on page 5-20
Chalk or whiteboard or paper and easel
Pencils

Background
Begin by reviewing the factsheets on pollution in Section 3, "Human Impacts on Mangroves". Many problems caused by water contamination have occurred in the past and continue to happen now that affects our lives and those of the animals we share the mangroves with. Take a look at water on your area and how it is used and disposed of. For example, review the following information:
Home supplies: How is water used in your home? Do you have rainwater tanks?
Sewage: Most places have either septic systems or central sewage collection and treatment systems. Find a way to study how these systems function.
Contamination: After major cyclone damage, there are often problems with the spread of gastrointestinal diseases through contaminated water. Discover how this happens.
Bores: Many farms get their water from bores that tap down into the freshwater that lies under the earth.

Procedure
1. Review the material in the background and on pages the pollution factsheets from Section 3, "Human Impacts on Mangroves".
2. Discuss the way water is used in your area: where it comes from, where it goes, and how it gets polluted.

3. Give students copies of the questionnaire on page 5-20, and have them take the questionnaires home and ask parents or carers to give them answers.

Discussion/Reflection
When students have returned with their completed questionnaires, discuss the following concerns with them.
Do you think there is a water problem on your area?
If there were a water problem, how would you resolve it?

Extensions Students can extrapolate what would happen to mangroves during drought conditions when fresh water is in short supply. What mechanisms to the mangroves and sea birds have in place to excrete excess salt? (Answer: Salt excretion from leaves and salt glands in gulls and terns)

WATER QUESTIONNAIRE
Wells, Septic Systems, and Other Needs
1. Are you on town water or rainwater at your house?
2. Describe the rainwater tank at your house. How big is it? Is the water sweet and pure? Does your house use the rainwater as greywater?
3. Do you have a bore?
4. How does the septic system work at your house?

Activity 5-F: Build a Mangrove

Summary Students will build a life-size model of a Red Mangrove tree.

Learning Objectives
Students will be able to:
(a) Name some of the animals that live in a mangrove and where in the mangrove they live; and
(b) Understand the basic functions of a Red Mangrove tree.
Age Levels
8 and up
Note: This could also be part of a community outreach project.
Subject Area
Science
Time
2–4 lessons or more
Materials
Copies of 2-9 (Mangrove Habitat Study)
Copies of page 5-22 showing a mangrove model
Magazine pictures of Red Mangroves
Construction paper of different colours
Crepe paper of different colours
Glue (hot-glue gun works best)
Scissors or cutting knife
Small paper plates
Curling ribbon or pastel-coloured “icicles”
Egg cartons
Pipe cleaners
Old cardboard boxes
Brown tape
Sticky tape
Stapler
Thin cardboard
Styrofoam trays
Large brown paper bag
Small brown paper bag
Old newspapers
Crayons or felt-tip markers, or both
Several old brush or broom handles or an old hat stand
Two pieces of 2 x 4, each about 1.2 m long, joined together in a cross, with a hole drilled in the middle

Background Read the parts about mangroves and related habitat and the wildlife that lives there in Section 1, “All About Mangroves”, and Section 2, “Mangroves as Habitat”.

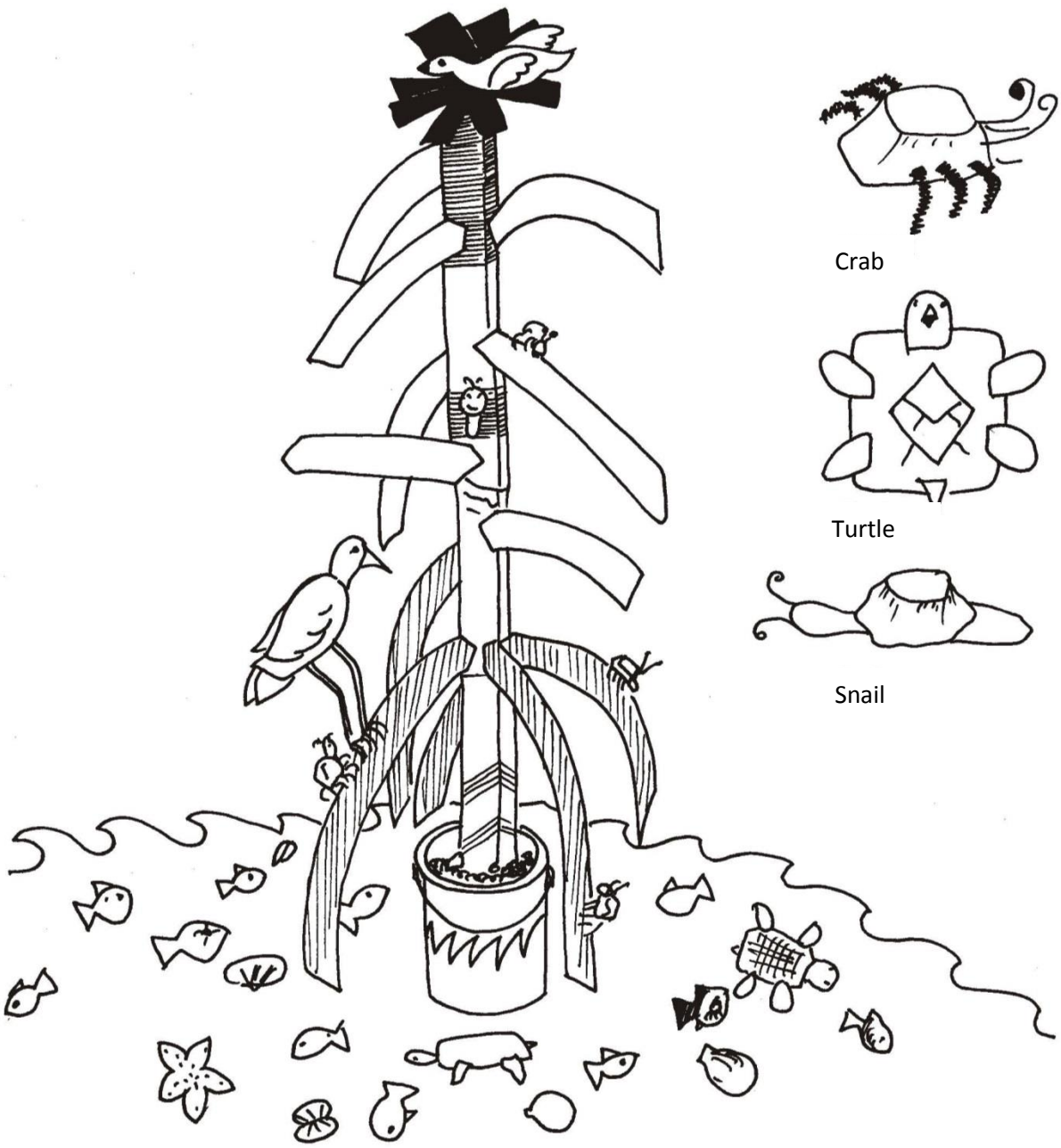


Figure 51: Building a mangrove in your classroom

Procedure

1. Clear a corner of your classroom, or a meeting area, and make way for a mangrove to take root! You can plan for a stationery structure, or something portable that can be taken out of the classroom.
2. First give each child a copy of pages 2-9, or photographs of mangroves. Explain that this is mangroves, and that it shows many of the creatures that live in the trees and among their roots in the water.

3. Tell the students that they will be working together in groups to build a Red Mangrove tree complete with roots, branches, leaves, and wildlife. Divide the students into several teams. The teams will depend on the abilities of the class. One or two teams will build the mangrove tree— its trunk, branches, and roots. One or two other teams will make the fish, birds, crabs, turtle, and other creatures that make their home in the mangrove.
4. Have the students research where the various creatures will live in the mangrove— where they will go in the model.
5. Bring out the construction materials, and watch the mangrove grow. Remember that you can improvise with materials—use what is readily available. For instance, you can build the trunk from thin cardboard, or wrap strips of old cardboard boxes around the "trunk" of old broomsticks. The leaves can be strips of construction paper, crepe paper, or old rags torn into strips. Before you build it, think about whether you would like the mangrove to be portable— for display outside the school (at a science fair, for example)—or stationery.

Trunk

Option A (stationery)

- Tape or staple several sheets of brown construction paper together to form a trunk about 30 cm wide and 90 cm long.
- Tape the trunk in the corner, attaching the sides of the trunk to the two walls. (This will give the effect of a three-dimensional tree.) The base of the trunk should be about 60cm above the floor (see diagram).

Option B (portable)

- Take the two or three old broom handles and tape them together so they are about 2 m tall. Drop one end into the hole in the middle of the crossed 2 x 4s (each about 120cm long). Glue it in place with hot glue. Or use an old hat stand.
- Tear up old cardboard boxes and wrap strips of cardboard around the broomsticks all the way to the floor. Tape in place with brown parcel tape. Glue to crossed 2 x 4s.

Water

- Create water around the mangrove by taping several sheets of blue tissue or crepe paper to the wall, or attach it to the base of the trunk and, later, the roots. The "sea" should reach from the floor to the base of the trunk.

Roots

- Cut black or brown construction paper, or cardboard boxes, into strips about 2.5 cm wide and 60–90 cm long. Also cut shorter strips to make "accessory" roots that branch off the longer ones.
- Beginning at the bottom of the trunk, either tape the strips end to end to form roots reaching along both walls, extending away from the corner, or cut a slit in the trunk and slide the end of the roots into the trunk, taping the slit closed around them. Anchor roots by taping them to the floor, or to the 2 x 4s. For the portable mangrove, they should not be taped to the floor.
- Tape more strips along the main roots to make a maze of roots. Keep attaching more strips until the tangle of roots reaches into the "water" a little higher than the base of the trunk.

Branches and leaves (canopy) and seeds

- Cut branches out of black or brown construction paper, or cardboard boxes, and tape them to the trunk, or cut a slit in the trunk and slide the ends of the branches into the trunk, taping the slit closed around the branches.
- Use sheets of green tissue or strips of green crepe paper to make layers of leaves, or make strips from old green rags. Tape a few sheets of the paper to the wall for the stationery model.
- Add a few more layers of tissue or crepe paper or rag strips, each one a little higher and a bit further from the corner and floor (see diagram and picture).
- If you want to get more students involved, have them cut out individual leaves from green construction paper and tape them to the branches.
- Draw and cut out Red Mangrove seeds (propagules) in bunches so they can be hung from the branches of the tree.

Mangrove animals

- For larger animals such as herons, pelicans, and other shorebirds, cut outlines out of thin cardboard. Colour them with crayons or markers and tape them in appropriate places on the tree.
- Build a bird's nest in the tree by cutting up strips of cardboard, gluing them together, and then gluing them to the tree branches.
- Cut smaller animals (fish, snakes, turtles, and so on) out of construction paper and tape them to the tree or water, or draw a template of a fish or turtle on a Styrofoam tray, cut it out and use it to make many different kinds of fish in many different colours.
- For a slightly larger turtle, stuff a large brown paper bag and a small brown paper bag with crumpled newspapers and staple the open ends shut. Use the glue gun to attach the smaller bag (the head) to one end of the larger bag (the body). Cut out flippers and tail from thin cardboard and glue them on underneath the body. Draw plates on the top shell with felt-tip markers.
- Bright-coloured sea squirts and sea anemones are frequently found on mangrove roots. These can be made by wrapping bright-coloured crepe paper around parts of the roots that are "underwater".
- By following the next set of directions, you can make crabs, snails, and spiders out of egg cartons.

Crab

- Cut out one cup from the egg carton and turn it upside down. On each side of the cup, poke four holes in a line about 1.3 cm from the bottom edge. Also poke two holes in the front section of the cup.
- Poke one pipe cleaner through a side hole and out the hole on the other side. Then bend the pipe cleaner ends downward to form the legs of the crab.
- Push the fifth pipe cleaner through the holes on the front of the crab and bend the ends forward. These will form the clawed legs.
- Cut claws and stalked eyes out of construction paper. Glue the eyes on the top of the cup and the claws on the end of the pipe cleaner. You can make a fiddler crab by making one claw much larger than the other.

Snail

- Cut out one cup from an egg carton and turn it upside down.
- Cut out a foot, head, and tentacles from construction paper and glue them to the cup.
- By following the next set of directions, you can make upside-down jellyfish out of paper plates and ribbon.

Upside-down Jellyfish

- Look at pictures of *Cassiopeia* (upside-down jellyfish common in mangroves). Discuss how jellyfish function.
- Make the tentacles by cutting paper curling ribbon into pieces varying from 20 to 45 cm. You will need to cut 30 or more pieces for each jellyfish.
- Use scissors to curl some of the ribbon "tentacles". Leave some of the pieces straight.
- Colour the paper plate "body" with crayons or markers in a symmetrical pattern; on top, colour the reproductive organs like a four-leaf clover. Then tape the ribbon or "icicle" tentacles to the inside of the plate (the side you eat from). Tape most of them around the plate's edge, but put a few in the middle.
- Cut a 15–30-cm length of crepe paper. Scrunch it up and glue or tape it to the centre of the plate, overlaying some of the tentacles. This is the jellyfish "body", which contains its mouth and anus. When you turn the plate over, the tentacles will hang down just like those of a real jellyfish.
- Attach them to the mangrove roots with tape so they look as if they are swimming.

Extensions

The mangrove model could be used for many other class or community education projects—for example:

- As a backdrop to a play about mangroves
- As a class project for a science fair
- For community outreach, to show functions and benefits of mangroves
- For peer teaching of other students

Activity 5-G: Mangrove Play

Summary Now you have built a mangrove (5-F), you have a backdrop for a play. Your students have started to research mangroves or may have visited a mangrove locally, so it may be a good time to review what they have learnt by bringing it all together in a class play. For younger students you may want to develop the basic plot yourself like a day in the life of the mangrove or how the animals work together to protect the baby fish from the predators? Then allow the children to develop their own script. For older students, you can set a more complex plot for example 'the day the fish disappeared' allowing the students to develop their own ideas for what happened to the fish [pollution, coastal development, cyclones, food web collapse] and how the community work together to restore the mangroves and bring back the fish. You can also use a selection of the costumes for a shorter more focussed activity to demonstrate food chains or food webs within the classroom.

Learning Objectives
Students will be able to write a play script and act out a performance (younger students) or in small teams develop the plot, script, props and deliver a performance (older students).

Age Levels
10-12

Subject Area
English - Language, Performing Arts

Time
30–60 minutes for a short focussed activity
10+ lessons for a longer activity (plot, research, script, practice and performance).

Materials
Research on mangroves from previous activities (or from this resource guide).
Loaned costume set (27 costumes) from the Burnett Mary Regional Group including:
2 White-bellied Sea Eagles
3 Sandpipers
1 White-faced Heron
1 Water Mouse
1 Turtle
2 Manta Rays
1 Shark
1 Mud Skipper
1 Sword fish
2 Jellyfish
1 Prawn
1 Crab

2 Gastropods (Snails)
4 Illidge's Ant Blue butterflies
1 Mosquito
3 Red Mangrove Trees
Mangrovia – inflatable dome.

Procedure

1. Decide on the target audience for the performance. A good choice would be younger students in your own school (Years 1 to 3), or a single class or year from a local primary school. Ideally, your students will need access to the group while researching their target audience, and again when it is time for performances.
2. Arrange internet and library access — for research and as the basis for the script.
3. Consider briefing parents/caregivers about the assessment and the value of it. It may be helpful to send a letter home so that they are aware of the commitment required.
4. Organise visits to the target audience so that students can research their audience.
5. Develop the main plot and with smaller groups of students and sub-plots and the script (if needed) a narrator will help pull the whole play together.
6. Plan for rehearsal and performance times early in the term so that students are well prepared.
7. Arrange performance space. This can be kept simple, or can involve professional lighting, sound, multimedia, etc.
8. Look at the resources provided in the appendixes, and decide which ones you will use with your students. You may like to present the materials as posters in the classroom.

Activity 5-H: Mangrove Ecotourism

Summary Ecotourism in the mangroves is an exciting and sometimes dramatic form of exploration. In recent years, a combination of exploratory techniques have evolved that highlight everything from bird-watching to kayaking. Many are non-invasive ways to explore the great biodiversity found in and around a mangrove forest.

Learning Students will be able to:

(a) Snorkel and explore the marine aspects of mangrove ecosystems;
(b) Observe and identify different species of birds – endemic and migrants to be found in mangroves;
(c) Observe and identify different species of mangroves and related plants
(d) Explore mangroves through kayaking;
(e) Demonstrate to tourists the ways in which mangroves function and the wildlife that is found in them – on land and in the water; and
(f) Learn the basic skills on nature interpretation including Aboriginal uses of mangrove resources.

Age levels

12 and up

Subject Areas

Science, Social Studies, Physical Education

Time

2-4 lessons or more

Materials

Kayaks
Binoculars
Wildlife identification books
Snorkel/mask and fins
Old clothing and shoes
Magnifying lenses

Background

Ecotourism: Definition and Concepts - Ecotourism has become a new tool to promote environmentally and culturally friendly tourism. The potential of ecotourism for assisting in resource conservation and community development has grown substantially in recent years. Ecotourism has unique characteristics that need special management methodology to enable tourists to enjoy their stay, while at the same time maintaining the natural environment. The principal ecosystems management concepts that need to be taken into consideration are as follows:

1. **Nature-based setting:** Ecotourism allows tourists to appreciate the surrounding nature while at the same time learning about a unique culture. Since ecotourism is based on natural biophysical attributes, conservation of natural resources is fundamental. Ecotourism sites like mangrove ecosystems should be rich in natural attractions; have diverse flora and fauna; be conducive to adventure and travel; have unique features and some historical and cultural values. Mangroves

are both interesting and educational; not be frequented by mass tourists and not threatened by destructive activities. They should have untouched native tradition; and be suitable for rehabilitation and conservation by tourism activity. The area should be ideal for walking, hiking, bird watching, swimming, kayaking, snorkelling and similar activities. Ecotourism involves travelling to relatively undisturbed natural areas to study or appreciate and enjoy the scenery and its flora and fauna. It is an environmentally sound tourism activity in a given ecosystem that yields socioeconomic benefits and enhances natural/cultural conservation. It is a means to generate income and employment for the local population, to help develop rural infrastructure, to raise funds and to build political support for nature conservation. Ecotourism can also alter norms, beliefs and the lifestyle of the host community.

2. **Educational Value:** Ecotourists normally seek educational experiences to learn more about the environment. Through interpretative programs such as high-quality guided tours, ecotourism can also promote environmental awareness and cultural understanding.
3. **Local Participation and Benefits:** The underlying concept is the reduction of local dependence on consumptive use of natural resources through benefits from tourism. By participating in ecotourism activities (such as guiding, kayaking and food services), local people can earn supplementary income while at the same time ensuring the conservation of biodiversity. Sustainable resources are essential for sustainable ecotourism. To achieve both resource conservation and sustainable economic use, ecotourism must ensure the engagement of a wide variety of groups who directly or indirectly determine the use of an ecotourism area and the involvement of different groups in the planning and management process along with a commitment to the ongoing education of operators.

Figure 52: Ecotourism can be an important part of the local economy

4. **Encouraging Conservation Awareness:** Ecotourists are normally willing to volunteer or contribute to conservation or development projects within the area. This can include identifying birds and wildlife, participating in ecosystem restoration projects and assisting in trash collection. In return, tourists receive a sense of satisfaction for conserving nature or assisting in the development of an area or community. Providing awards or certificates showing that they

have contributed to the protection of the environment or assisting in community development can enhance these initiatives.

5. **Low impacts and sensitivity to the environment:** Strategies to minimize the impacts of ecotourism activities include:
    a. Identifying appropriate locations for ecotourism development;
    b. Identifying proper ecotourism activities that do not harm the environment;
    c. Managing visitors;
    d. Controlling the number of visitors per trip;
    e. Controlling impacts by taking in all necessities needed as well as bringing out all trash to remote areas; and
    f. Designing the facilities, which emphasize blending with the natural surroundings

Procedure:

The potential of mangrove areas for ecotourism is high as long as the sites are accessible and located close to the existing resorts and hotels. The resort and hotel operators can be potential partners in promoting and developing these sites. The marketing, technical, financial, environmental and social aspect of promoting and developing mangrove areas for ecotourism should be closely explored before any actual development and operations are made. The technical viability, financial feasibility, environmental soundness and social acceptability of ecotourism development should be ascertained thoroughly and carefully. The strategy of promoting mangroves and the immediate surroundings for ecotourism should only be to provide amenities to visitors in a natural setting that offers low density, low intensity and non-intrusive facilities. This will maintain the integrity and stability to ensure the sustainability of the mangrove ecosystem and the link to the terrestrial and marine ecosystems. For example, Great Sandy Strait – Hervey Bay Whale Watching and bird watching.

Product, Place and Promotion

1. The attraction of mangroves is due more to the attractiveness of the ecosystem in general rather than interest in any particular species. Hence, what is required is skilled interpretation and education to attract and satisfy ecotourists, based on an assessment of the attributes of the area that are of potential interest to ecotourists. For a skilled interpreter, a mangrove and its nearby ecosystems can be the focal point around which a web of attributes and stories can be woven. For example, mangroves throughout the Great Sandy Strait haves a high abundance of flora and fauna from shorebirds to turtles, dugongs, whales and dolphins.
2. Information on the nature of tourists is likewise important. There are ‘hard core’ ecotourists as well as casual, less committed ecotourists. Ecotourists are heterogeneous, depending on their interest, intensity of interest and their willingness and ability to pay to satisfy their interest.
3. A social marketing survey is necessary to understand these different market segments and their relationship to the range of ecotourism opportunities available. The promotion of mangroves as ecotourism sites should focus on their high ecological value. Where possible this should be translated into a tangible monetary value to easily facilitate the understanding of the public, decision-makers, planners, managers, hotel and resort operators as well as tourists on the importance of mangroves.

The design and production of the information, education and communication (IEC) materials to promote mangroves as an ecological tourist attraction may not be sufficient for all those involved. An effective and sustained social marketing strategy should be carefully designed and implemented to specifically target audience such as tourists of different nationalities; the local people, and school children from the primary and secondary level.

4. In addition to the 4Ps of commercial marketing (product, place, price and promotion), social marketing considers people as the focal goal of the development strategy in changing the knowledge, attitude, skills and practices of the specific target audience. Hotel and resort operators, private organizations and individuals are already promoting ecotourism through magazines, brochures, ads and the Internet. The promotion is focused on the biophysical attraction and the unique scenery, particularly as guide for divers and snorkelers. Mangroves are included as an added benefit of the coastal ecosystem.

Figure 53: The mangroves are a great place for children to learn about the marine environment.

Discussion /reflection:

The tourism industry is the principal force in the development of ecotourism. There are, however, environmental costs and benefits and to ensure that the benefits exceed the costs, management structures should be in place. Students should examine how environmental benefits may be attained through the following, and explore how they might take place:

1. Enhances biodiversity conservation once local people commit to the changes in ways of utilizing the resource when they have benefited from ecotourism;
2. Raises the environmental awareness of visitors and locals;
3. Supports biodiversity knowledge and protection.

Extensions:

In order to realize the benefits outlined above, it is necessary to have a thorough understanding of the proposed sites to determine their attributes and ability to withstand the influx of visitors. There

is also a need to formulate a strategic ecotourism plan that considers the different perspectives of the ecotourism opportunity spectrum (EOS). Towards this end, inputs must be drawn, in a participatory manner, from various local, national and regional stakeholders, as well as the government. Based on the definition and concept of ecotourism, environmental and social values should be mutually inclusive. In other words, ecotourism development should result in net economic and social benefits for local communities as well as net environmental benefits to assure its sustainability. Early on, the potential cost and benefits of any proposed ecotourism development must be clearly identified. Ecotourism may provide the following benefits:

1. **Providing economic and conservation benefits.** Ecotourism may play a role in changing the way local communities benefit from their local environment. The major underlying cause of the destructive ways of utilizing resources is poverty. The desire to improve one's standard of living leads to the over-exploitation of commonly accessed resources such as mangroves. Ecotourism should link directly to the local people's needs. Conservation activities through ecotourism should provide long-term economic benefits to the local people. The accrued benefits from conservation have to be greater than the short-term, intermediate and personal benefits. It is necessary to provide alternative sources of income to reduce the dependency of the local people on the natural resources, which have greater potential to provide long-term community welfare. The immediate individual gains from consumptive exploitation of the resources such as over-development should also be set aside in favour of the accrued benefits that the resources could provide in a sustainable manner. For instance, the overgrazing in mangrove areas is not only an issue of what is more important, the cow or the mangrove, but the problem has deeper socioeconomic and socio-cultural implications. The local people can play a key role in restoring the mangroves. The establishment of a community-based nursery, involving the local people in rehabilitation, will augment their income and build up their commitment to conserve the resources.
2. **Raising environmental consciousness and changing behaviour**. Local people's involvement and participation in ecotourism development and management provide them the opportunity to have direct contact with their natural environments. "To care we must understand, to understand we must know, and to know we must have met." The consciousness-raising should be done not only for local people, but for tourists as well. Training local people as ecotourism guides can supplement their incomes and develop a local body of conservation advocates. Hands-on and on-the-job/field work increases the level of awareness and understanding and strengthens the capability to manage their resources sustainably.
3. **Support of research and conservation activities.** Ecotourists may contribute directly and indirectly to research and conservation activities in the area by donating their time, expertise or other resources. Some mangrove areas are ideal sites for ecosystem research as part of an R&D and for graduate studies (for example the Moreton Bay and the Great Sandy Strait Ramsar Wetlands). Interesting areas for research may start on unique adaptation of mangrove vegetation to its adverse environmental condition such as 1) the crown/foliage emerging from the buried bole or stems and root system; 2) the accumulation of sediments or silt in which mangroves are able to trap soil particles thereby hindering the siltation of sea grass beds and coral reefs.

Environmental Aspects of Ecotourism Planning. Determining the Limits of Acceptable Change (LAC). The focus of LAC analysis is to determine what the management objectives are in a particular area and the amount of change in the conditions of that area that is acceptable, and to select the indicators of change that can be monitored. Monitoring ensures that management prescriptions are successful in maintaining impacts below the LAC. For instance as people continually walk on the soil daily, soil compaction may inhibit the growth of roots near the pathways. Likewise, the daily disturbance on an adjacent lagoon may loosen up the soil, which may cause the transport of silt or sediments into nearby sea grass beds or coral reefs. This should be monitored closely and baseline data should be collected. The same is true for water quality where pollutants enter the ecosystem from "upstream." These might include agricultural run-off of fertilizers, insecticides, herbicides etc. or sewage outfalls into related river and shoreline systems. Water quality testing should be on-going and establish a clear base-line data of all contaminants.

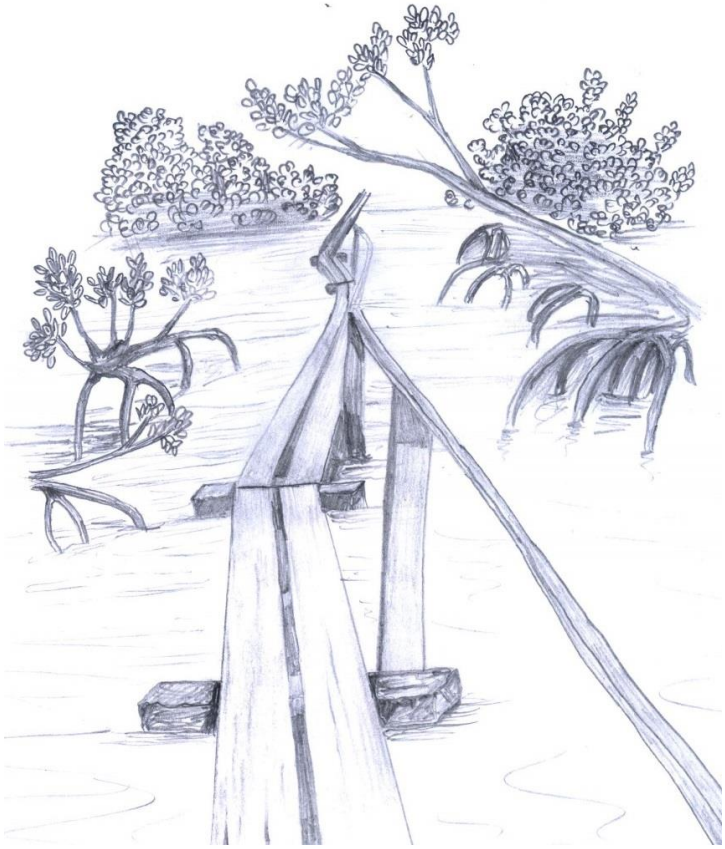


Figure 54: Boardwalks could also be provided around or into mangrove stands.

The management prescription of providing a boardwalk may lead to a change in the type of visitors. The 'hard core' ecotourists may no longer be able to see closely the ecosystem or species that they are interested in nor perhaps enjoy the limited number of visitors that made the site a satisfactory experience. It is important to maintain a range of ecotourism opportunities that will fulfil a wide array of visitors and conservation goals.
The environmental impact of ecotourism is not only that of the ecotourism activities but also that of the infrastructure and service facilities. The facilities should be non-intrusive, have low

impact waste disposal, be of low density but of high quality, eco-friendly, provide energy and be self-contained.

The different ecotourism resources that should be assessed are as follows:

- Natural resources (mangrove, lagoon, sea grasses, coral reef)
- Facilities (hiking trails, a visitor centre, sheds, cafeteria, tracks, signage, post, parking lot, entrance gate, etc.)
- Interpretation (visitor centre, information materials such as brochures, magazines, self-guided interpretative trails, local guides that lead interpretative hikes for organized or individual tours)
- Visitors (to provide statistics)
- Local participation to serve as guides, site (parks or reserves if possible) workers and labourers (provide catering services and garbage collection).

adaptation—structural or functional changes to an organism in response to a new condition or environment; evolutionarily speaking, the organism is better suited to reproduce and survive due to these changes.

algae (singular: alga)—simple unicellular or multicellular plants that have no vascular tissue and therefore no leaf, stem, or root systems.

amphipod—a crustacean of the order Amphipoda that includes scuds or sideswimmers that are found in most pond or mangrove water.

anoxic – depleted of dissolved oxygen

arthropod—an invertebrate animal characterized by jointed legs, a segmented body, and an exoskeleton of chitin; includes lobsters, crabs, prawn, and insects.

bacteria (singular: bacterium)—minute single-celled organisms, most of which are parasitic; bacteria are the primary organisms responsible for decay and fermentation.

bioaccumulation - Process by which certain toxic substances accumulate and keep on accumulating in living organisms, posing a threat to health, life, and to the environment.

biodegradable—having the ability to be broken down into simpler components by living organisms.

biological diversity—the diversity of life on Earth, reflected in the number and variety of species and populations, and the communities that they form.

bioremediation – the use of either naturally occurring or deliberately introduced microorganisms to consume and break down environmental pollutants, in order to clean a polluted site.

bloom—sporadic occurrence of huge populations of algae.

blue carbon – the amount of carbon captured and stored by mangroves and other tidal wetlands

brackish—salty water, but less salty than seawater.

breed—to produce young, to propagate.

burrow—a hole or passageway beneath the surface, or to make such a hole.

calls—bird vocalizations that are not songs; made during courtship, feeding, and migration, as well as to warn.

camouflage—protective colouration or shape that helps to hide an animal from its predators or prey.

carbon sequestration—the process of capturing carbon dioxide from the atmosphere, measured as a rate of carbon uptake per year

carbon storage—the long-term confinement of carbon in plant materials or sediment, measured as a total weight of carbon stored

carnivore—meat-eating animal.

cell—the basic unit of which all living organisms are composed, usually consisting of a nucleus and a mass of cytoplasm bound by a membrane.
chlorophyll—green pigment in plants that absorbs light energy needed in photosynthesis.

clutch—the number of eggs laid by a female during one nesting cycle.

cold-blooded—having a body temperature that varies with the temperature of the surroundings. For example, fish are cold-blooded.

community—a group of living organisms in a given area that interact with each other; the living component of an ecosystem.

competition—the struggle among organisms for food, space, and other requirements for existence.

conservation—the protection, management, and wise use of all living and non-living cultural and human resources.

crop—a sac at the bottom of the oesophagus in many birds used to store food for later digestion.

currents—movements of water created by winds, tides, or differences in salinity or temperature between water masses.

decomposers—organisms, primarily bacteria, that break down dead organic matter into simpler substances.

denitrification - reducing nitrates or nitrites to nitrogen-containing gases, usually by bacterial action.

detrivore—an animal that feeds on detritus.

detritus—material resulting from the decomposition of dead organic matter.

diatoms—microscopic algae with a two-part siliceous cell; important members of the phytoplankton.

dissolved oxygen—molecular oxygen present in water (not the O in H2O.)

down—soft feathers next to a bird's body that provide insulation.

dredge—to remove sand, sediments, mangroves, etc. from the bottom using a scoop or shovel-like device or large suction pipe.

ebb tide—the movement of the tidal current away from shore; a decrease in the height of the tide.

endangered species—a species that is immediate danger of becoming extinct.

endoskeleton—a skeleton that is produced within the body and remains embedded there.

environment—all the conditions or influences within a particular ecosystem that affect the organisms of that ecosystem.

estuary—brackish water influenced by the tides, where the mouth of the river meets the sea.

eutrophication - excessive richness of nutrients in a lake or other body of water, frequently due to run-off from the land, which causes a dense growth of plant life

excrete—to discharge.

exoskeleton—an external skeleton, like the shells of molluscs or arthropods.

extinct—no longer living. The Dodo is an extinct species.

fauna—all the animals living in a particular place.

filter-feed—a type of suspension feeding in which food particles are obtained by filtering them from a water current. For example, mangrove oysters filter-feed.

fledge—to take the first flight. Birds that have just fledged are often called fledglings.

flora—all the plants living in a particular place.

food chain—the passage of energy (food) from producers (plants) up to herbivores and carnivores.

food web—many interlocking and interdependent food chains.

fossil fuels—coal, oil, and other energy sources formed over millions of years from the remains of plants and animals. The burning of fossil fuel is a major source of pollution.

gastropod—a snail, limpet, nudibranch, or sea slug.

gizzard—the muscular part of a bird's stomach that grinds hard-to-digest food.

global climate change—the predicted change in the Earth's climate brought about by the accumulation of pollutants in the atmosphere. The effects of global climate change include altered weather patterns and rising sea levels.

greenhouse effect—the trapping of heat by gases, such as carbon dioxide, in the Earth's atmosphere.

groundwater—water that fills the spaces between rocks and soil particles underground. Groundwater is replenished when rainwater trickles through the soil. Surface water, such as lakes and rivers, is often replenished by groundwater.

habitat—the specific physical place where an animal or organism lives—e.g., in a hole, under a rock, on a mangrove root.

herbivore—a plant-eating animal.

host—an organism in which or on which another lives; in certain symbiotic relationships the host is the larger of the two partners.

hypothesis - a tentative statement (or educated guess) about the relationship between two or more variables. A hypothesis is a specific, testable prediction about what you expect to happen in your experiment.

immature—not fully developed.

ingest—to take into the body, especially solid substances.

insectivore—an animal that eats insects or other invertebrates.

intertidal zone—a coastal area between the high-tide and low-tide zones that is alternately covered with water and exposed to the air.

introduced species—an animal or plant that has been brought into areas where the species never lived before. For example, the cane toad introduced to control the cane beetle. Introduced species often compete with and cause problems for native species.

invertebrate—an animal without a backbone.

larva (plural: larvae)—the juvenile stage of many animals. The larva is usually different in appearance from the adult and may lead a very different way of life.

leaching—the process by which materials on or in soil are dissolved and carried by water seeping through the soil. Leaching may contaminate groundwater supplies.

macroplankton—zooplankton over 1 mm in size.

mandible—in birds, the two halves of the beak. In other vertebrates, the lower jaw.

mangrove—a general term applied to several tropical and subtropical salt-tolerant trees.

mature—fully developed, adult.

megaplankton—very large plankton such as jellyfish and sunfish.

metabolism—energy changes that sustain life within an organism.

metamorphosis—a change in form that an animal undergoes as it develops from egg to adult.

molluscs—invertebrates including gastropods (such as conch and snails), bivalves (clams and mussels), and cephalopods (squid and octopus).

migration—seasonal movement from one region to another. For example, loggerhead turtles from feeding grounds to nesting areas.

moult—to shed and regrow an exoskeleton or other outer body coverings; for example, when a crab sheds it's shells and replaces it with another.

mucus—a slimy secretion containing protein, which serves to moisten and lubricate membranes; is often used by filter- and suspension-feeders for trapping food particles.

native species—a species that occurs naturally in an area.

niche—the place where an organism lives and the activities it carries out; its address and "job".

ornithology—the study of birds. An ornithologist is a scientist who studies birds.

overgrazing—the process that occurs when cattle, sheep, goats, or other animals graze too much in too small an area for too long a period. Overgrazing often results in soil erosion, the destruction of vegetation, and other problems.

pectoral muscles—the breast muscles. In most birds, the pectoral muscles are very powerful. They raise and lower the wings during flight.

photosynthesis—the manufacture of complex chemicals from carbon dioxide and water using light as the source of energy. This is usually a property of plants, the green pigment chlorophyll being essential in the process.

plankton—the collective name for small, drifting plants (phytoplankton) and animals (zooplankton). These aquatic organisms are the basis of mangrove and ocean food webs.

plumage—a bird's feathers referred to collectively.

pneumatophore—an air-containing organ.

poach—to hunt, kill, or collect a plant or animal illegally.

point pollution—pollution that comes from a particular source, such as from a factory or a sewage treatment plant. Nonpoint pollution, which doesn't come from a single identifiable source, includes materials that wash off streets, yards, farms, and other surfaces.

pollution—a human-caused change in the physical, chemical, or biological conditions of the environment that creates an undesirable and harmful effect on living things.

population—members of the same species living in a community.

predator—a carnivorous animal. Its victim is called the prey.

preen—when a bird cleans, straightens, and fluffs its feathers.

prey—an animal that is killed for food.

producer—an organism that can produce organic substances from inorganic ones; plants.

propagule—seed of the Red Mangrove tree.

prop roots—roots growing out from stems, often tree trunks, at an angle that tends to support the plants. Red Mangrove trees have many prop roots.

radula—the file-like tongue of many snail-like molluscs, used for rasping their food.

raptorial—adapted for seizing prey.

rare species—a species that has a small number of individuals and/or has a limited distribution. A rare species may not be threatened or endangered.

reef—an offshore ridge of materials such as rocks or coral that lies close to the surface of the water.

regeneration—in invertebrates, the regrowth of a missing part or the restoration of a new individual from part of the original.

rhizome—in plants, a horizontal stem on or under the ground that produces stems and roots

rookery— breeding ground of gregarious birds or mammals. Gregarious means they live or nest in groups.

roost—a place where birds rest at night, often in large numbers.

salinity—the saltiness of water, measured in parts per thousand.

salt marsh—an area of soft, wet land periodically flooded by salt water.

scavenger—an animal that feeds on dead or dying organisms.

school—many similar aquatic organisms swimming together.

sea squirt—a tunicate attached to another object such as a Red Mangrove root.

sediment—the material that settles through the water column to the bottom.

seed—in flowering plants, an embryo covered by a seed coat.

sessile—attached to the bottom of rocks, pilings, Red Mangrove roots, and so on.

shell—hard exoskeleton of certain animals, especially molluscs and marine arthropods.
song—the notes repeated by a bird over and over in a regular pattern. Birds use song to help defend territories and sometimes to attract mates.

species—a basic taxonomic group consisting of individuals of common ancestry who strongly resemble each other physiologically and who interbreed, producing fertile offspring.

spring tide—tide of maximum range occurring at the new and full moon.

stinging cell—in coelenterates (such as coral or jellyfish), cells that contain stinging structures.

sublittoral—pertaining to the zone below the low-tide line.

subtropical—nearly tropical in location and climate.

subspecies—a subdivision of a species consisting of individuals different from the rest of the species but that can still interbreed with other members of the species.

substrate—the bottom, which may be muddy, rocky or sandy; called the substratum by specialists.

subtidal—pertaining to the zone below the low-tide mark.

succession—the evolutionary sequence whereby plant and animal communities replace one another until they reach a stable "climax" community

suspension feeding—feeding upon particles, either plankton or detritus, suspended in the water.

symbiosis—an association in which two dissimilar organisms live closely together.

tactile—pertaining to the sense of touch.

temperate zone—that part of the Earth's surface between the tropics and the poles.

territory—the space an animal or bird defends from other animals or birds (usually the same species) for mating or feeding.

thorax—in invertebrates, the region of the body between the head and abdomen.

threatened species—a species whose numbers are low or declining. A threatened species is not in immediate danger of extinction, but is likely to become endangered if it isn't protected.

tidal range—the difference in height between consecutive high and low tides.

tidal wave—tsunami, or a huge sea wave caused by an oceanic disturbance.

tide—the periodic ebb and flow of ocean waters caused by the gravitational pull between the Earth and the moon and the Earth and the sun. In Australia there are two high tides and two low tides each day (24 hours).

tidepool—depression in a rock (or created by rocks) within the intertidal zone that traps water as the tide recedes.

tissue—cells of similar structure that are grouped together and perform a specific function.

toxic—poisonous.

tropics—the region between the Tropic of Cancer and the Tropic of Capricorn.

tunicates—sedentary filter-feeding animals whose larvae superficially resemble tadpoles, and which have many features that link them to the vertebrates.

unicellular—composed of one cell.

univalve—a mollusc with a one-piece shell; a gastropod.

valve—in invertebrates, a distinct piece of a shell.

vertebrates—animals with backbones, including fish, birds, amphibians, reptiles, and mammals.

warm-blooded—being able to maintain a constant body temperature independent of the outside temperature.

waste—material eliminated from the body.

zooplankton—animal plankton.

		Year 4	Year 5	Year 6	Year 7	Year 8
Science Scope and Sequence	Science Understanding	**Biological Sciences:** Living things have life cycles. Living things including plants and animals depend on each other and the environment to survive. **Chemical science:** Natural and processed materials have a range of physical properties, these properties can influence their use. **Earth and space sciences:** Earth's surface changes over time as a result if natural processes and human activity.	**Biological sciences:** Living things have structural features that help them survive in their environment. **Chemical sciences:** Solids, liquids and gases have different observable properties and behave in different ways. **Earth and space sciences:** The Earth is part of a system of planets orbiting around a star (the sun).	**Biological Sciences:** The growth and survival of living things are affected by the physical conditions of their environment. **Chemical science:** Changes to materials can be reversible such as melting freezing, evaporating or irreversible such as burning and rusting. **Earth and space sciences:** Sudden geological changes of extreme weather conditions can affect Earth's surface.	**Biological sciences:** There are differences within and between groups of organisms; classifications helps organise this diversity. Interactions between organisms can be described in terms of food chains and food webs; human activity can affect these interactions. **Earth and space science:** Predictable phenomena on Earth, including seasons and eclipses are caused by the relative positions of the sun, Earth and the moon. Some of Earth's resources are renewable, but others are non-renewable. Water is an important resource that cycles through the environment. Physical sciences: Earth's gravity pulls objects toward the centre of the Earth.	**Biological sciences:** Cells are the basic units of living things and have specialised structures and functions. Multi-cellular organisms contain systems of organs that carry out specialised functions that enable them to survive and reproduce. **Earth and space sciences:** sedimentary, igneous and metamorphic rocks contain minerals and are formed by processes that occur within Earth over a variety of timescales.
	Science as a Human Endeavour	**Nature and development of science:** Science involves making predictions and describing patterns and relationships **Use and influence of science:** Science knowledge helps people to understand the effect of their actions.	**Nature and development of science:** Science involves testing predictions by gathering data and using evidence to develop explanations of events and phenomena. Important contributions to the advancement of science have been made by people from a range of cultures. **Use and influence of science:** Scientific understandings, discoveries and inventions are used to solve problems that directly affect peoples' lives. Scientific knowledge is used to inform personal and community decisions.		**Nature and development of science:** Scientific knowledge changes as new evidence becomes available, and some scientific discoveries have significantly changed people's understanding of the world. Science knowledge can develop through collaboration and connecting ideas across the disciplines of science. **Use and influence of science:** People use understanding and skills from across the disciplines of science in their occupations.	
	Science inquiry skills	**Planning and conducting:** Suggest ways to plan and conduct investigations to find answers to questions. Safely use appropriate materials, tools or equipment to make and record observations, using formal measurements and digital technologies as appropriate. **Processing and analysing data and information:** Compare results with predictions suggesting possible reasons for findings. Evaluating: Reflect on the investigation, including whether a test was fair or not. **Communicating:** Represent and communicate ideas and findings in a variety of ways such as diagrams, physical representations and simple reports.	**Questioning and predicting:** With guidance, pose questions to clarify practical problems or inform a scientific investigation, and predict what the findings of an investigation might be. **Processing and analysing data and information:** Compare data with predictions and use as evidence in developing explanations. **Communicating:** Communicate ideas, explanations and processes in a variety of ways, including multi-modal texts.		**Questioning and predicting:** Identify questions and problems that can be investigated scientifically and make predictions based on scientific knowledge. **Planning and conducting:** Collaborative and individually plan and conduct a range of investigation types, including fieldwork and experiments, ensuring safety and ethical guidelines are followed. In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task. **Processing and analysing data and information:** Summarise data from students' own investigations and secondary sources, and use scientific understanding to identify relationships and draw conclusions. **Evaluating:** Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of data collected, and identify improvements to the method. Use scientific knowledge and findings from investigations to evaluate claims. **Communicating:** Communicate ideas, findings and solutions to problems using scientific language and representations using digital technologies as appropriate.	
Geographical knowledge and understanding scope and sequence	Key inquiry questions	**The Earth's environment sustains all life:** How does the environment support the lives of people and other living things? How do different views about the environment influence approaches to sustainability. How can people use places and environments more sustainably?	**Factors that shape the human and environmental characteristics of places:** How do people and environments influence one another? How can the impact of bushfires or floods in people and places be reduced?	**A diverse and connected world:** What are Australia's global connections between people and places?	**Water in the world** or **Place and liveability:** How do people's reliance on places and environments influence their perception of them? What effect does the uneven distribution of resources and services have on the lives of people?	**Landforms and landscapes** or **Changing nations:** How do environmental and human processes affect the characteristics of places and environments? How do the interconnections between places, people and environments affect the lives of people? What are the consequences of changes to places and environments and how can these changes be managed?

	Key concepts	The F2 concepts continue to be a focus of study in years 3-6, but the scale of the places studied moves from the local to national, world regional and global scales. The concepts of sustainability and change are also introduced in these years.			In years 7-10, students further develop their understanding of place, space, environment, interconnection, sustainability and change and apply this understanding to a wide range of places and environments at the full range of scales, from local to global; and in a range of locations.	
	Content descriptions	The location of the major countries of Africa and South America in relation to Australia, and their main characteristics including the types of natural vegetation The types of natural vegetation and the significance of vegetation to the environment and to people. The importance of environments to animals and people, and different views on how they can be protected. The custodial responsibility that Aboriginal and Torres Strait Islander peoples have for country / place and how this influences their past and present views about the use of resources. The natural resources provided for the environment, and different views on how they could be used sustainably. The sustainable management of waste from production and consumption.	The influence of people, including Aboriginal and Torres Strait Islander peoples, on the environmental characteristics of Australian places. The influence of the environment on the human characteristics of a place. The influence people have on the human characteristics of places and the management of spaces within them. The impact of bushfires or floods on environments and communities, and how people can respond.	Significant events that connect people and places throughout the world. The effects that people's connections with, and proximity to, places throughout the world have on shaping their awareness and opinion of those places.	**Water in the world:** The classification of environmental resources and the forms that water takes as a resource. The way that flows of water connect places as it moves through the environment and the way this affects places. The quantity and variability of Australia's water resources compared with those on other continents. The nature of water scarcity and ways of overcoming it, including studies drawn from Australia, West Asia and/or North Africa. **Place and liveability:** The factors that influence the decisions people make about where to live and their perceptions of the liveability of places. The influence of environmental quality on the liveability of places.	**Landforms and landscapes:** The different types of landscapes and their distinctive landform features. The aesthetic, cultural and spiritual value of landscapes and landforms for people, including Aboriginal and Torres Strait Islander peoples. The human causes and effects of landscape degradation. The ways of protecting significant landscapes. **Changing nations:** The differences in urban concentration and urban settlement patterns between Australia and the United States of America, and their causes and consequences.
Geographical inquiry and skills scope and sequence	Observing, questioning & planning	Develop geographical questions to investigate	Develop geographical questions to investigate and plan an inquiry		Develop geographically significant questions and plan an inquiry using appropriate geographical methodologies and concepts	
	Collecting, recording, evaluating and representing	Collect and record relevant geographical data and information, for example by observing, by interviewing, conducting surveys, measuring, or from sources such as maps, photographs, satellite images, the media and the internet. Represent data by constructing tables and graphs. Represent the location of paces and their features by constructing large-scale maps that conform to cartographic conventions including scale, legend, title and north point, and describe their location using simple grid references, compass direction and distance.	Collect and record relevant geographical data and information using ethical protocols, from primary and secondary sources, for example people, maps, plans, photographs, satellite images, statistical sources and reports. Evaluate sources for their usefulness and represent data in different forms, for example, maps, plans, graphs, tables, sketches and diagrams.		Collect, select and record relevant geographical data and information, using ethical protocols, from appropriate primary and secondary sources. Evaluate sources for their reliability and usefulness, and represent data in a range of appropriate forms, for example, climate graphs, compound column graphs, population pyramids, tables, field sketches and annotated diagrams, with and without the use of digital and spatial technologies.	
	Interpreting, analysing and concluding	Interpret geographical data to identify distributions and patterns and draw conclusions.	Interpret geographical data and other information, using digital and spatial technologies as appropriate, and identify spatial distributions, patterns and trends, and infer relationships to draw conclusions.		Analyse geographical data and other information using qualitative and quantitative methods, and digital and spatial technologies as appropriate, to identify and propose explanations for spatial distributions, patterns and trends, and infer relationships.	

	Communicating	Present findings in a range of communication forms, for example, written, oral, digital, graphic, tabular and visual and use geographical terminology.	Present finding and ideas in a range of communication forms, for example, written, oral, digital, graphic, tabular, visual and maps, using geographical terminology and digital technologies as appropriate.		Present findings, arguments and ideas in a range of communication forms selected to suit a particular audience and purpose, using geographical terminology and digital technologies as appropriate.	
	Reflecting and responding	Reflect on their learning to propose individual action in response to a contemporary geographical challenge and identify the expected effects.	Reflect on their learning to propose individual and collective action in response to a contemporary geographical challenge and describe the expected effects if their proposal on different groups of people.		Reflect on their learning to propose individual and collective action in response to a contemporary geographical challenge, taking account of environmental, economic and social considerations, and predict the expected outcomes of their proposal.	
Civics and Citizenship Knowledge and Understanding Scope and Sequence	Key inquiry questions	How can local government contribute to community life?	What is democracy in Australia and why is voting in a democracy important? How and why do people participate in groups to achieve shared goals?			What are the freedoms and responsibilities of citizens in Australia's democracy? How are laws made and applied in Australia?
	Content descriptions	The purpose of government and some familiar services provided at the local level	The key values that underpin Australia's democratic system of government.	The roles and responsibilities of the three levels of government including shared roles and responsibility within Australia's federal system		The freedoms that enable active participation in Australia's democracy within the bounds of law, including freedom of speech, association, assembly and movement.
	Laws and Citizens					The types of law in Australia, including criminal law and civil law; and the place of Aboriginal and Torres Strait Islander customary law
	Citizenship, diversity and identity		Why people work in groups to achieve their aims, and how they can express their shared beliefs and values to exercise influence.			
	Questioning and Research		Develop questions and gather a range of information to investigate the society in which they live		Develop a range of questions to investigate Australia's political and legal systems. Identify, gather and sort information and ideas from a range of sources.	
	Analysis, synthesis and interpretation				Critically analyse information and ideas from a range of sources in relation to civics and citizenship topics and issues.	

	Problem-solving and decision making		Work in groups to identify issues and develop possible solutions and plan for action using decision-making processes.	Appreciate multiple perspectives and use strategies to mediate differences. Use democratic processes to reach consensus on a course of action relating to a civics or citizenship issue and plan for that action.
	Communication and Reflection		Present civics and citizenship ideas and viewpoints for a particular purpose using civics and citizenship terms and concepts. Reflect on personal roles and actions as a citizen in the school and in the community.	Present evidence-based civics and citizenship arguments using subject-specific language.
Historical Skills Scope and Sequence	Chronology terms and concepts	Sequence historical people and events. Use historical terms.	Sequence historical people and events. Use historical terms and concepts.	Sequence historical events, developments and periods. Use historical terms and concepts.
	Historical questions and research	Identify sources.	Identify and locate a range of relevant sources	Identify a range of questions about the past to inform an historical inquiry. Identify and locate relevant sources, using ICT and other methods.
	Analysis of sources	Locate relevant information from sources provided.	Locate information related to inquiry questions in a range of sources. Compare information from a range of sources.	Identify the origin and purpose of primary and secondary sources. Locate, compare, select and use information from a range of sources as evidence. Draw conclusions about the usefulness of sources.
	Perspectives and interpretations	Identify different points of view	Identify points of view in the past and present	Identify and describe points of view, attitudes and values in primary and secondary sources.
	Explanation & Communication	Develop texts, particularly narratives.	Develop texts, particularly narratives and descriptions, which incorporate source materials.	Develop texts, particularly descriptions and explanations that use evidence from a range of sources that are acknowledged.
	Key questions	What was life like for Aboriginal and/or Torres Strait Islander peoples before the arrival of the Europeans? What was the nature and consequences of contact between Aboriginal and/or Torres Strait Islander peoples and early traders explorers and settlers?	How did colonial settlement change the environment?	
	Key Concepts	The content provides opportunities to develop historical understanding through key concepts including sources, continuity and change, cause and effect, perspective, empathy and significance.		

	Knowledge and understanding	The diversity and longevity of Australia's first peoples and the ways Aboriginal and/or Torres Strait Islander peoples are connected to Country and Place (land, sea, waterways and skies) and the implications for their daily lives.				
English Scope and Sequence	Language Variation and Change			Understand different social and geographical dialects or accents are used in Australia un addition to Standard Australian English.	Understand the way language evolves to reflect a changing world, particularly in response to the use of new technology for presenting texts ands communicating.	
	Language for Interaction	**Language for social interactions:** Understand that social interactions influence the ways that people engage with ideas and respond to others for example exploring and clarifying the ideas of others, summarising their own views and reporting them to a larger group. **Evaluative language:** Understand differences between the language of opinion and feeling and the language of actual reporting or recording.	**Language for social interactions:** Understand that patterns of language interaction vary across social contexts and types of texts and that they help to signal social roles and relationships. **Evaluative language:** Understand how to move beyond making base assertions and take account of differing perspectives and points of view.	**Language for social interactions:** Understand that strategies for interaction become more complex and demanding as levels of formality and social distance increase. **Evaluative language:** Understand the use of objective and subjective language and bias.	**Language for social interactions:** Understand how accents, styles of speech and idioms express and create personal and social identities.	**Language for social interactions:** Understand how conventions of speech adopted by communities influence the identities of people in those communities. **Evaluative language:** Understand how rhetorical devices are used to persuade and how different layers of meaning are developed through the use if metaphor, irony and parody.
	Text structure and organisation	Understand how texts vary in complexity and technicality depending on the approach to the topic the purpose and the intended audience.	Understand how texts vary in purpose, structure and topic as well as the degree of formality.			
	Expressing and developing ideas	**Vocabulary:** Incorporate new vocabulary from a range of sources into students' own texts including vocabulary encountered in research.	**Vocabulary:** Understand the use of vocabulary to express greater precision of meaning, and know that words can have different meanings in different contexts.	**Visual language:** Identify and explain how analytical images like figures, tables, diagrams, maps and graphs contribute to our understanding of verbal information in factual and persuasive texts. **Vocabulary:** Investigate how vocabulary choices, including evaluative language, can express shades of meaning, feeling and opinion.	**Visual language:** Analyse how point of view is generated in visual texts by means of choices for example, gaze, angle and social distance. **Vocabulary:** Investigate vocabulary typical of extended and more academic texts and the role of abstract nouns, classification, description and generalisation in building specialised knowledge through language.	**Vocabulary:** Recognise that vocabulary choices contribute to the specificity, abstraction and style of texts.
	Interacting with others	**Listening and speaking interactions:** Interpret texts and information in spoken texts and listen for key points in order to carry out tasks and use information to share and extend ideas and information. Use interaction skills such as acknowledging another's point of view and linking students; response to the topic using familiar and new vocabulary and a range of vocal effects such as tone, pace, pitch, and volume to speak clearly and coherently. **Oral presentations:** Plan, rehearse and deliver presentations incorporating learned content and taking into account the particular purpose and audiences.	**Listening and speaking interactions:** Clarify understanding of content as it unfolds in formal and informal situations, connecting ideas to students' own experiences and present and justify a point of view. Using interaction skills, for example paraphrasing, questioning and interpreting non-verbal cues and choose vocabulary and vocal effects appropriate for different audiences and purposes. **Oral presentations:** Plan, rehearse and deliver presentations for defined audiences and purposes incorporating accurate and sequenced content and multimodal elements.	**Listening and speaking interactions:** Participate in and contribute to discussions clarifying and interrogating ideas, developing and supporting arguments, sharing and evaluating information, experiences and opinions. Use interaction skills, varying conventions if spoken interactions such as voice volume, tone, pitch and pace according to group size, formality of interactions and needs and expertise of the audience. **Oral presentations:** Plan, rehearse and deliver presentations selecting and sequencing appropriate content and multimodal elements for defined audiences and purposes, making appropriate choices for modality and emphasis.	**Listening and speaking interactions:** Identify and discuss main ideas, concepts and points of view in spoken texts to evaluate qualities, for example the strength of an argument or the lyrical power of a poetic rendition. Use interaction skills when discussing and presenting ideas and information, selecting body language, voice qualities and other elements, (for example music and sound) to add interest and meaning. **Oral presentations:** Plan, rehearse and deliver presentations, selecting and sequencing appropriate content and multimodal elements to promote a point of view or enable a new way of seeing.	**Listening and speaking interactions:** Interpret the stated and implied meanings in spoken texts and use evidence to support or challenge different perspectives. Use interaction skills for identified purposes, using voice and language conventions to suit different situations, selecting vocabulary, modulating voice and using elements such as music, images and sound for specific effects. **Oral presentations:** Plan, rehearse and deliver presentations, selecting and sequencing appropriate content, including multimodal elements, to reflect a diversity of viewpoints.

	Interpreting, analysing and evaluating	**Reading processes:** Read different types of texts by combining contextual, semantic, grammatical and phonic knowledge using text processing strategies, for example monitoring meaning, cross checking and reviewing. **Comprehension strategies:** Use comprehension strategies to build literal and inferred meaning to expand content knowledge, integrating and linking ideas and analysing and evaluating texts.	**Reading processes:** Navigate and read texts for specific purposes applying appropriate text processing strategies, for example predicting and confirming, monitoring meaning, skimming and scanning.	**Purpose and audience:** Analyse how text structures and language features work together to meet the purpose of the text. **Comprehension strategies:** Use comprehension strategies to interpret and analyse information and ideas, comparing content from a variety of textual sources including media and digital texts.	**Reading processes:** Use prior knowledge and text processing strategies to interpret a range of types of texts. **Comprehension strategies:** Use comprehension strategies to interpret, analyse and synthesise ideas and information, critiquing ideas and issues from a variety of textual sources. **Analysing and evaluating texts:** Compare the text structures and language features of multimodal texts, explaining how they combine to influence audiences.	**Reading processes:** Apply increasing knowledge of vocabulary, text structures and language features to understand the content of texts. **Comprehension strategies:** Use comprehension strategies to interpret and evaluate texts by reflecting on the validity of content and the credibility of sources, including finding evidence in the text for the author's point of view.
	Creating texts	**Creating texts:** Plan, draft and publish imaginative, informative and persuasive texts containing key information and supporting details for a widening range of audiences, demonstrating increasing control over text structures and language features. **Editing:** Reread and edit for meaning by adding, deleting or moving words or word groups to improve content and structure. **Handwriting:** Write using clearly formed, joined letters and develop increased fluency and automaticity. **Use of software:** Use a range of software including word processing programs to construct, edit and publish written text, and select, edit and place visual, print and audio elements.	**Creating texts:** Plan, draft and publish imaginative, informative and persuasive print and multimodal texts, choosing text structures, language features, images and sound appropriate to purpose and audience. **Editing:** Reread and edit student's own and others' work using agreed criteria for text structures and language features. **Use of software:** Use a range of software including word processing programs with fluency to construct, edit and publish written text, and select, edit and place visual, print and audio elements.	**Creating texts:** Plan, draft and publish imaginative, informative and persuasive texts, choosing and experimenting with text structures, language features, images and digital resources appropriate to purpose and audience. **Editing:** Reread and edit students' own and others' work using agreed criteria and explaining editing choices. **Use of software:** Use a range of software, including word processing programs, learning new functions as required to create texts.	**Creating texts:** Plan, draft and publish imaginative, informative and persuasive texts selecting aspects of subject matter and particular language, visual, and audio features to convey information and ideas. **Editing:** Edit for meaning by removing repetition, refining ideas, reordering sentences and adding or substituting words for impact. **Use of software:** Use a range of software, including word processing programs, to confidently create, edit and publish written and multimodal texts.	**Creating texts:** Create imaginative, informative and persuasive texts that raise issues, report events, and advance opinions, using deliberate language and textual choices, and including digital elements as appropriate. **Editing:** Experiment with text structures and language features to refine and clarify ideas to improve the effectiveness of students' own texts. **Use of software:** Use a range of software, including word processing programs to create, edit and publish texts imaginatively.
The Arts	Exploring ideas and improvising with ways to represent ideas	**Drama:** 4.1 Explore ideas and narrative structures through roles and situations and use empathy in their own improvisations and devised drama. General capabilities: Lit, CCT, PSC, EU, ICU. Cross-curriculum priorities: SUST **Media Arts:** 4.1 Investigate and devise representations of people in their community, including themselves, through settings, ideas and story structure in images, sounds and text General capabilities: Lit, Num, ICT, CCT, ICU. Cross-curriculum priorities: ATSIHC, AAEA. **Visual Arts:** 4.1 Explore ideas and artworks from different cultures and times, including artwork by Aboriginal and Torres Strait Islander artists, to use as inspiration for their own representations. General capabilities: Lit, Num, CCT, ICU Cross-curriculum priorities: ATSIHC, AAEA, SUST.	**Drama:** 6.1 Explore dramatic action, empathy and space in improvisations, playbuilding and scripted drama to develop characters and situations General capabilities: Lit, Num, ICT, CCT, PSC, EU, ICU. Cross-curriculum priorities: ATSIHC, AAEA **Visual arts:** 6.1 Explore ideas and practices used by artists, including practices of Aboriginal and Torres Strait Islander artists, to represent different views, beliefs and opinions. General capabilities: Lit, CCT, PSC, EU, ICU. Cross-curriculum priorities: SUST, ATSIHC, AAEA.		**Drama:** 8.1 Combine the elements of drama in devised and scripted drama to explore and develop issues, ideas and themes. General capabilities: Lit, CCT. Cross-curriculum priorities: SUST. **Visual arts:** 8.1 Experiment with visual arts conventions and techniques, including exploration of techniques used by Aboriginal and Torres Strait Islander artists, to represent a theme, concept or idea in their artwork. General capabilities: Lit, ICT, CCT,PSC, ICU. Cross-curriculum priorities: ATSIHC, SUST.	

	Developing understanding of practices (3-6)	**Drama:** 4.2 Use voice, body, movement and language to sustain role and relationships and create dramatic action with a sense of time and place General capabilities: Lit, Num, CCT, PSC, ICU. Cross-curriculum priorities: SUST, AAEA. **Visual arts:** 4.2 Use materials, techniques and processes to explore visual conventions when making artworks. General capabilities: Lit, ICT, CCT, ICU. Cross-curriculum priorities: SUST.	**Drama:** 6.2 Develop skills and techniques of voice and movement to create character, mood and atmosphere, and focus dramatic action. General capabilities: Lit, Num, CCT, PSC. Cross-curriculum priorities: NA. **Visual arts:** 6.2 Develop and apply techniques and processes when making their artworks. General capabilities: Lit, CCT, ICT, PSC, ICU. Cross-curriculum priorities: SUST.	
	Manipulating/applying the elements/ concepts with intent and Developing understanding of skills and techniques			**Drama:** 8.2 Develop roles and characters consistent with situation, dramatic forms and performance styles to convey status, relationships and intentions General capabilities: Lit, PSC, CCT, EU, ICU Cross-curriculum priorities: SUST 8.3 Plan, structure and rehearse drama, exploring ways to communicate and refine dramatic meaning for theatrical effect. General capabilities: Lit, ICT, CCT, PSC. Cross-curriculum priorities: NA. **Visual arts:** 8.3 Develop planning skills for art-making by exploring techniques and processes used by different artists. General capabilities Lit, Num, ICT, PSC, CCT. Cross-curriculum priorities: ATSIHC, AAEA, SUST.
	Structuring & organising ideas into form			**Visual arts:** Practice techniques and processes to enhance representation of ideas in their art-making. General capabilities: Lit, Num, ICT, PSC, CCT Cross-curriculum priorities: AAEA, SUST
	Sharing artworks through performances, presentation or display	**Drama:** 4.3 Shape and perform dramatic action using narrative structures and tension in devised and scripted drama, including exploration of Aboriginal and Torres Strait Islander drama. General capabilities: Lit, Num, ICT, CCT, PSC, ICU. Cross-curriculum priorities: ATSIHC, AAEA, SUST. **Visual arts:** 4.3 Present artworks and describe how they have used visual conventions to represent their ideas General capabilities: Lit, ICT, CCT, PCS, EU. Cross-curriculum priorities SUST**.**	**Drama:** 6.3 Rehearse and perform devised and scripted drama that develops narrative, drives dramatic tension, and uses dramatic symbol, performance styles and design elements to share community and cultural stories and engage an audience. General capabilities: Lit, Num, ICT, CCT, PSC, ICU. Cross-curriculum priorities: ATSIHC, AAEA, SUST. **Visual arts:** 6.3 Plan the display of artworks to enhance their meaning for an audience. General capabilities: Lit, ICT, CCT, PSC,EU,ICU. Cross-curriculum priorities: ATSIHC, AAEA, SUST.	**Drama:** 8.5 Perform devised and scripted drama maintaining commitment to role. General capabilities: Lit, CCT, PSC. Cross-curriculum priorities: NA. **Visual arts:** 8.5 Present artwork demonstrating consideration of how the artwork is displayed to enhance the artist's intention to an audience. General capabilities: Lit, ICT, PSC, CCT, EU, ICU. Cross-curriculum priorities: ATSIHC, AAEA, SUST.
	Responding to and interpreting artworks (3-6) Analysing and reflecting upon intentions (7-8)	**Drama:** 4.4 Identify intended purposes and meaning of drama, starting with Australian drama, including drama of Aboriginal and Torres Strait Islander Peoples, using the elements of drama to make comparisons. General capabilities: Lit, CCT, PSC, EU, ICU Cross-curriculum priorities: ATSIHC, AAEA, SUST.	**Drama:** 6.4 Explain how the elements of drama and production elements communicate meaning by comparing drama from different social, cultural and historical contexts, including Aboriginal and Torres Strait Islander drama General capabilities: Lit, CCT, PSC, EU, ICU. Cross-curriculum priorities: ATSIHC, AAEA, SUST. **Visual arts:** 6.4 Explain how visual arts conventions communicate meaning by comparing artworks from different social, cultural and historical contexts, including Aboriginal and Torres Strait Islander artworks. General capabilities: Lit, CCT, PSC, EU, ICU. Cross-curriculum priorities: ATSIHC, AAEA, SUST.	**Drama:** 8.6 Analyse how the elements of drama have been combined in devised and scripted drama to convey different forms, performance styles and dramatic meaning. General capabilities: Lit, ICT, CCT, PSC, ICU. Cross-curriculum priorities: SUST.