Marvellous Mangroves

in the

Cayman Islands

A Curriculum-Based
Teachers' Resource Guide

Marvellous Mangroves in the Cayman Islands

A Wetlands Education Resource Book for the West Indies

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CONTENTS

INTRODUCTION

MARVELLOUS MANGROVES IN THE CAYMAN ISLANDS

Welcome to *Marvellous Mangroves in the Cayman Islands* – 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 6 to 11, 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 Scouts. The book is designed primarily to provide schoolteachers in the Cayman Islands 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 Cayman, 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 Cayman'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 local science curriculum, just check the charts on page vii for learning objective tie-ins. The primary focus is on the Life Processes and Living Things strand. Other parts of the workbook/curriculum cover knowledge and skills in social studies, art, mathematics and language 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), Honduras, Guatemala, Sri Lanka and Brazil. 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.

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HOW T0 USE THIS BOOK

This workbook is designed with grade 3–7 children in mind, but most of the activities can be modified for use with upper and lower grades 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 mangroves in the Cayman Islands 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 the primary school science curriculum. These tend to focus on the Life Processes and Living Things strand)). Other disciplines include social studies, language arts, art, physical education and mathematics. This workbook indicates where activities are cross-curricular with parts of the curriculum other than science.

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.

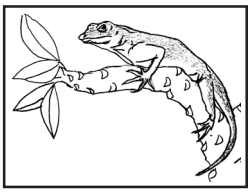
Because the book is based on the concept of implementing classroom learning in the field, a field trip is a must. This book gives teachers a complete guide to the “dos and don’ts” of running a field trip. It also supplies detailed instructions and the data collection work sheets that will be needed.

Good luck, and please let us know if you have any suggestions for changing or adding to the material found in the book.

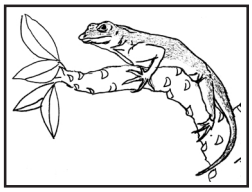
Martin A. Keeley, Cayman Brac, 10 January, 2007.

Mangrove Resource Guide Interface with "Science Anytime" Curriculum Years 1 to 6

Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
UNIT B Plants and the Seasons. Animals and the Seasons.	**UNIT A** Animal Hall of Fame: Section 2: Birds. Section 3. Fish. Section 4: Amphibians. Section 5: Reptiles. Section 6: Insects.	**UNIT E** Endangered Species. Entire Unit	**UNIT A** Sections A & B: Why Do Animals Differ? Entire Unit. Section C: Animals! Animals! Which Group? Entire Unit Section D: Animals Grow and Change. Entire Unit.	**UNIT A** Section A: Food Needs. Energy from the Sun. Farming. Section D: Dyes.	**UNIT A** Section A: Water in the Air.
UNIT C Waterworks. Water Can Change. Sink or Float. Water and Other Materials.	**UNIT D** Section 1: Looking at Roots, Stems, Leaves. Leaves at Work. Seeds. Seeds Sprout. From Seed to Plant Section 3: Animals and Their Needs; All Together Now!	**UNIT F** Wonderful Water. Going, Going, Gone. Now You Don't. See It, Now You Do.	**UNIT D** Lakes, Ponds, Rivers, and Streams. .Section A: Entire Section. Section C: Changes in Saltwater Ecosystems. Entire Section. Section D: Water Pollution.	**UNIT B** Currents & Coastlines: Entire Unit including Section B: What Lives in Coastal Waters. Section C: Oil Spills.	**UNIT B** Section A: Through the Looking Glass (using microscopes).
UNIT D Animals are Living Things. Birds Hatch. Frogs Change, Too!		**UNIT G** Habitat: Looking at My World. Up Close. Making a Home. Here or There? Cayman Wetlands: Living Through Changes. Plants and Animals of the Wetlands. Importance of the Wetlands. Reef & Ocean: A Salty World. Pollution Solutions: Trouble in the Great Outdoors. Packing It Up.		**UNIT D** Section D: National Treasures. Entire section.	**UNIT C** Section A: What Time is It?
UNIT E Seeds and Plants. Entire Unit					**SOCIAL STUDIES** **Environmental Concerns:** Pollution and Conservation



Contents Section 1



Types of Mangroves

Throughout the tropics and subtropics, wherever coasts are gently sloping and temperatures average 24°C (80°F), coastal wetlands are inhabited by extraordinary trees called mangroves (Figure 1). They are found at river mouths, fringing sheltered bays, around lagoons and ponds, and on islets and cays. There are nearly three-quarters of a million hectares of mangroves in the insular Caribbean basin. This is more than 5% of all the mangroves left in the world. The Cayman Islands have more than 7,000 hectares, or almost 20,000 acres, of mangrove habitat.

Where are the mangroves?

Mangroves can be found along the coastlines of most islands, wherever the coastal shelf is shallow. They tend to be more extensive on sheltered shorelines and inlets. Nearly 70% of the wetlands of the Caribbean are found in Cuba. A further 19% are in the Bahamas. This does not mean that the wetlands of other countries are not important. Even the smallest mangrove can be very important to the ecology of an area. In the Cayman islands, the Central Mangrove Wetland in Grand Cayman, of some 3,400 hectares (8,000 acres), represents almost half of the total mangroves found on all three of the Cayman Islands.

Which species of mangroves occur in the Caribbean?

Worldwide, there are more than 50 species of mangroves, only seven of which are found in the insular Caribbean. Some species are closely related to each other, while others look similar or have similar adaptations but are not related at all. All share an amazing ability to grow in places shunned by other plants. Mangroves flourish only in the narrow, inhospitable zone where the tropical sea meets the land, and salt water and fresh water mix. They alone love the tropical places that are too hot, too salty, too wet, and too exposed to wind, rain, tides, and storms for other plants.

The various species of mangroves have things in common, such as the ability to deal with excess salt in their surroundings, and spreading root systems that allow trees to grow in mud. But every species grows in a slightly different part of the wetland and has its own special adaptations. Most Caribbean wetlands, including those found in the Cayman Islands are dominated by just four species of mangroves. They are Red Mangrove *Rhizophora mangle*, Black Mangrove *Avicennia germinans*, White Mangrove *Laguncularia racemosa*, and Buttonwood, or Button Mangrove *Conocarpus erectus* [Chart 1].

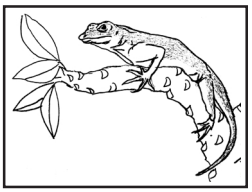
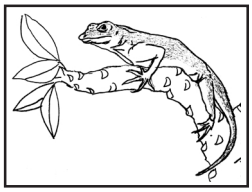


Chart 1. Identification Guide to the Four Most Common Species of Cayman Islands Mangroves

Characteristic	Red Mangrove	Black Mangrove	White Mangrove	Buttonwood
Habitat	Along the shoreline, and in rivers and lagoons, in salty water	Usually to landward of Red Mangroves in shallower, salty water	Usually to landward of Black Mangroves, in brackish water	On landward side of mangrove swamps, also near the sea on rocks, beaches, and berms (not usually in water)
Roots	Thick stilt or prop roots and long, slender aerial roots	No prop roots; surrounded by thin breathing roots, which stick out above water	Thick, knobby breathing roots; no prop roots	No prop or breathing roots
Leaves				
Appearance	Large, rounded, and leathery	Long and thin, salt crystals on back	Rounded, sometimes with pinkish stems, 2 small bumps at base of leaf	Long and thin, 2 small bumps at base of leaf
Placement	Opposite	Opposite	Opposite	Alternate
Flowers	Yellow-cream with 4 pointed petals	White with 5 petals	Very small, white	Very small, in clusters, yellowish
Fruits	Form torpedo-like plantlets on the tree	About 1 inch long, flattened	Green and ribbed, in clusters	In clusters with rounded heads

Imagine that you are approaching a Caribbean island from the sea. As the island shelf gets shallower and the land gets nearer, the first species of plant that you are likely to see is a Red Mangrove. They grow mostly in places that are permanently wet and salty—on the shores of cays and islets, along the edge of the sea, beside rivers close to the sea, and around salty ponds and lagoons. In the Caymans, North Sound is the most obvious example of this, although the south side of Little Cayman is also dominated by mangrove.

With their stout, curved **prop roots**, which arch down into the water from their trunks, and their long, slender aerial roots, which are like thin fingers reaching into the water, Red Mangroves cannot be mistaken for any other tree. Like other roots, theirs have two main functions—support and breathing. Extraordinary conditions require special **adaptations** (changes in structure and function that

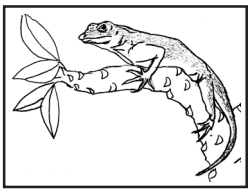


make a plant or animal more suited to its environment), and the prop roots are very different from normal roots. Arching around the main trunk like tangled legs, they support and spread the weight of the trunk, branches, and leaves, and thus enable the tree to stay upright in muddy, tidal, and windy conditions. Like the aerial roots, the parts above the water are covered with tiny pores or **lenticels** (which look like small knobs), through which the tree can breathe. This is necessary because the mud on which Red Mangroves grow is so low in oxygen that no ordinary roots could breathe there. If the lenticels are covered with water for too long, the mangroves will die. This often happens as a result of a hurricane.

Clinging to the edge of the land, the Red Mangrove roots trap sediments and build up the land behind them. When the coastal shelf is shallow, they grow out into the sea, extending the land and protecting it from storm damage and erosion. The reproductive cycle of the Red Mangrove is adapted to help this process.

It all begins when the Red Mangrove bursts into flower. This usually occurs in spring or summer, and Caribbean mangroves can flower all year round. The waxy bright-yellow star-shaped blossoms attract bees and are quickly fertilized. The mature fruits stay attached to the tree while they develop into little plantlets (called **propagules)**. The roots of the propagules begin to grow while they are still attached to the parent tree. When they are 20–30 cm (7–12 in) long, the dart-shaped, heavy propagules fall from the tree and plunge deep into the mud below. Some are washed away by waves

Figure 1: Parts of a Red Mangrove Tree



and currents and float for many months before they wash up in a nice muddy place. As soon as they get to a suitable spot, the propagules are ready to grow. In the right conditions, they spring up densely, growing more than 60 cm (23–24 in) a year, reaching out into the sea over shallow reefs or mud banks or filling in shallow ponds and channels.

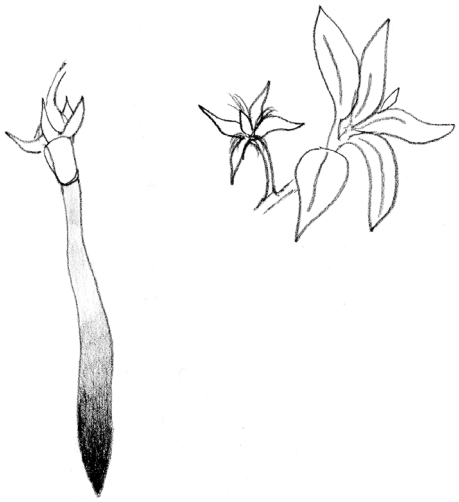
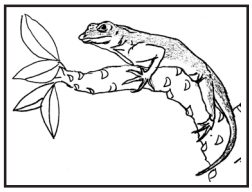


Figure 2: Mangrove Propagule and Mangrove Flower

Forming food for other living things makes Red Mangrove ecosystems among the most productive in the world. An average-sized Red Mangrove tree can drop more than *two tons* of leaves a year. Red Mangroves provide a sheltered nursery that nurtures young fish, shellfish, and turtles before they move out into the open ocean to make it on their own. Many thousands of other creatures make their homes in and under the roots of Red Mangroves, all completely dependent on the food, water, and shelter that the mangroves provide. Above the water, many species of birds and insects live, nest, or hunt in the trees' branches and among the leaves. Red Mangroves also provide a protective barrier that filters sediments and pollutants that wash toward the sea from the land, keeping them from working their way onto the reefs and destroying the coral. In addition, mangroves provide us humans with food, and with shelter from hurricanes and other storms, and filter our groundwater, keeping it clean. Throughout the tropics, wherever coastal mangroves have been cleared away, coastal fisheries have collapsed.

Red Mangroves grow on the seaward edges of the shore. Their roots trap sediments, and the level of the mud rises. Over time, conditions become drier and less suitable for Red Mangrove seedlings and more suitable for other species. This process is called **succession**.

The roots of Black Mangroves have found a different solution to the problems of growing in mud—which is black and smelly because of the large amount of rotting plant material it contains. Horizontal roots spread out from the main trunk, with vertical roots sticking up from them. They form a carpet of thin, knobby fingers called **pneumatophores** around the base of the tree. The pneumatophores are generally long enough to stick out above the water at high tide so they can breathe. The above-ground parts trap sediments and pollutants washed toward the sea by rivers and streams from the land, and help to protect the coral reefs and seagrass beds. Below ground there are fine roots



sticking out sideways, which absorb nutrients from the mud (Figure 3).

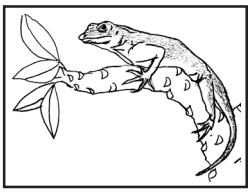
Black Mangroves can grow on the edges of ponds that are much saltier than sea water (water that is saltier than sea water is called **hypersaline**). They can tolerate tidal areas, in which the mud is sometimes exposed for part of the day or year and evaporation increases the salt level, or **salinity**, of the soil. They can have high levels of salt in their sap, and they control the amount of salt in their tissues by excreting salt through their leaves. Look closely at a leaf and you will see the crystals of salt. Lick or wash them off, and a few minutes later more will form.

Often, thousands of Fiddler Crabs forage among the mangrove roots, taking advantage of fallen leaves and washed-up pieces of food.

White Mangroves prefer more fresh water than Red or Black Mangroves. They can often be found further inland than the other species. Like Black Mangroves, they have pneumatophores. However, these are wider and often more knobby (sometimes flattened like small toadstools), and grow less densely, than those of Black Mangroves. Like Black Mangroves, they excrete some salt from small glands on their leaves.

Buttonwoods, also called Button Mangroves, are often found growing among the Black and White Mangroves, often on the landward edge of a wetland. They are found on rocks beside the sea, or among other trees on the berm. The presence of Buttonwood is a good indication of drier, better-drained soil conditions.

Figure 3: Young Sea Creatures Growing in the Red Mangrove Roots



Activity 1-A: Habitat is Home

Summary Pictures or posters of different ecosystems will be used to introduce mangrove wetlands. Pictures of wetland species will be used to introduce the concept of **habitat**. This will be followed by an exercise.

Learning Objectives

Students will be able to:
(a) differentiate between the various types of wetland; and
(b) define **habitat**.

Age Levels 4–16

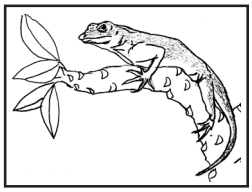
Subject Areas Sciences, language arts, arts and crafts

Time 30–60 minutes

Materials Pictures of mangrove swamps
Copies of page 2-5, 2-6, 2-9, and 2-17, showing connections
Chalkboard or easel paper
Crayons or markers (optional)
Drawing paper

Background All living things need food, water, shelter, and space to survive. Areas that provide these basic requirements for an organism are referred to as **habitat**.

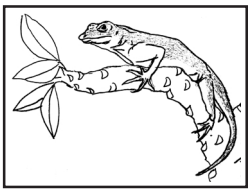
Procedure **1.** Start by introducing the term *habitat* to the students. Explain that the places where plants and animals live are called their homes or habitats. Show the students pictures of mangrove swamps. Then tell them that within their habitats, plants and animals find everything they need to survive.
2. Ask the students what animals and plants need to survive. List their answers on a chalkboard or a sheet of easel paper. They should be able to conclude that all living things need food, water, space, and shelter, as well as sunlight, air, and other physical features.
3(a) (ages 4-11). Pass out drawing paper and crayons or markers, and have the class draw a habitat scene featuring a wetland or mangrove in your area. Explain that they should draw some of the plants and animals that live in the wetland or mangrove habitat, as well as some of the important things the plants and animals get from the habitat. For example, they could draw a mangrove swamp scene showing the trees themselves, as well as other plants; mangrove tree animals as well as the ones that live in the water; the sun, soil, and other features.
3(b) (ages 11-16). Have the students write an essay on a wetland or mangrove in your



area. They should include some of the plants and animals that live in the wetland/ mangrove habitat, as well as some of the important things plants and animals get from the habitat.

Discussion/Reflection

Several of the essays may be used as the basis of a classroom discussion.

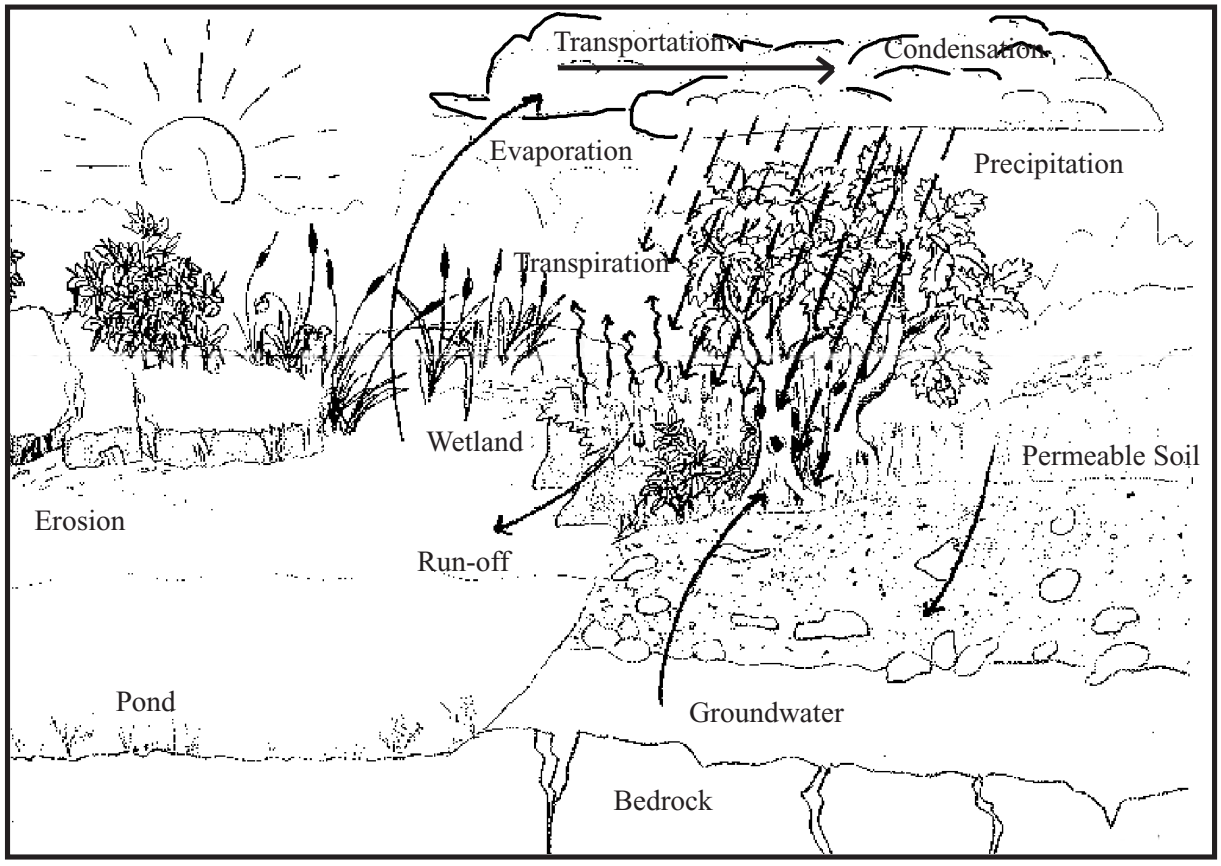


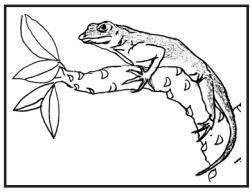
Mangroves and the Water Cycle

The amount of the water in the world never changes—but water is constantly changing form, from liquid to gas or solid, and back again. The movement of water from the Earth to the sea to the air and back to the Earth is called the **water cycle** (Figure 4). The water cycle is driven by the heat of the sun.

Three things can happen to water that falls as rain. Some is absorbed by plants. More hits the ground and flows away, forming rivers and streams and filling lakes and wetlands. In the Cayman Islands there are no rivers or streams as there are no mountains, and so the majority of the rain filters into the ground, filling underground reservoirs or lenses that sit above brackish water, which in turn sits above sea water that has permeated the limestone rock that makes up the islands. This is the **groundwater**. Every river, stream, and underground reservoir is supplied with water by its own area of land. This area is called a **watershed**.

Figure 4: The Water Cycle





All the water in a watershed is connected. Any activity in a watershed that affects the water will affect the other water bodies. For example, if the rivers in the mountains become clogged with silt because too many trees are cut down, less water will evaporate from the rivers, less rain will fall in the mountains, and less water will enter the rivers and streams. The wetlands by the sea will dry up. In order to protect a coastal wetland, it is necessary to protect the whole watershed.

With the flow of water to the mangrove wetlands comes a steady supply of nutrients from the surrounding land. The organic silts and sediments settle and, warmed by the sun, provide ideal conditions for the growth of microscopic plants and animals—the base of aquatic food chains. The abundance of food materials leads to some mangrove wetlands' being called the most productive systems (in terms of gross plant material) on Earth. A well-established marsh is estimated to be as much as 50 times as productive as a similar area of grassland, and about eight times as productive as cultivated land. The contribution of plant material to climate is one reason it is so important to protect mangrove wetlands.

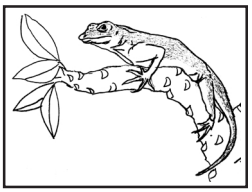
Mangrove wetlands and climate

On mountainous islands, the climate is often very predictable, with hot, sunny mornings followed by heavy afternoon showers. Wetlands play an important role in maintaining this pattern. In the Caymans, especially in Grand Cayman, the Central Mangrove Wetlands perform a function similar to that of mountains, with prevailing winds moving more than 40 million gallons of water a day from east to west, where the water falls as heavy rain. Cayman Brac is much drier because it has few wetlands, whereas Little Cayman, which has extensive mangroves, has more rainfall than the Brac but not nearly as much as Grand Cayman.

Most Caribbean wetlands are densely covered by plants. A plant, because of its spreading leaves, has much greater surface area than the area of soil it covers. Plants, like the mangroves that cover the Central Mangrove Wetland, lose water through their leaves by a process called **transpiration**. Therefore, a wetland contributes much more water to the water cycle than the same area of land would if the wetland were not there.

Here is how the climatic pattern works in mountainous islands. After sunrise, the land heats up and water evaporates from the sea and from coastal and wetland plants. Prevailing winds carry this moist air inland, toward the mountains. The mountains force the warm, moist air to rise; as it reaches colder air at higher altitudes, it condenses and falls as rain, filling up both upland and lowland wetlands.

In this way, wetlands help to maintain local climates.



Water

Activity 1-B: Mystery Object

Summary Students are given a list of clues to try to guess what topic they will be discussing.

Learning Objective

Students will be introduced to the importance of water.

Age Levels 4–7

Subject Areas Science, geography

Time 10–30 minutes

Materials A jar containing water
A covering such as a cloth or paper bag

Background Water plays many essential roles in our lives.

Procedure **1**. Hold the jar of water hidden in a cloth or paper bag or some other container. Explain to the students that they are not to guess out loud what is in the container, but should raise their hands at the end of each clue when they think they know what the item is. The clues can be given in any order you like, adjusting them to the sophistication level of the students.

2. Say: "I'm going to give you some clues about our outdoor classroom activity . Inside this bag is a mystery object, and you have to guess what it is."

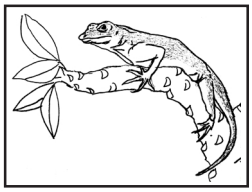
3. Give the clues one at a time, in any order you wish.

*Most of the Earth is covered with this.
*Every plant and animal needs this to survive.
*This takes up more room if you freeze it.
*This can float in the air.
*This can run down a hill.
*This can drop from the sky.
*This can support a giant ship at sea, like a cruise ship.
*Because it is recycled, this might have been drunk by the dinosaurs 150 million years ago.
*You should drink eight glasses of this a day.
*This comes in three different forms.

"The answer is: WATER!"

Discussion/Reflection

Discuss the importance of water to our lives, where it comes from and where it goes, and why we must protect it and ensure that it is always clean.



Activity 1-C: Water Cycle Rap

Summary Students will learn the process of the water cycle through doing a rap.

Learning Objective

Students will understand the process of the water cycle.

Age Levels 4–13

Subject Areas Science, music

Time 10–30 minutes

Materials None needed

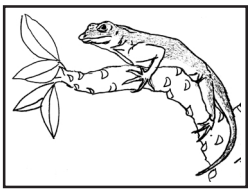
Handout Water cycle process

Background Most of the Earth is covered with water, and every living thing needs it to survive. That's why we need to keep it clean. The water that exists today is the same water that the dinosaurs drank—because of the process of the water cycle. Many different types of rain or moisture come from the atmosphere—snow, hail, mist, fog, rain—in the process known as **precipitation**. When rain falls, it soaks into the ground, filling up lakes, rivers, and wetlands. This process is called **saturation**. Water then returns to the atmosphere as an invisible vapour. When it is emitted from plant leaves, the process is called **transpiration**. Water vapour rises from the Earth's surface when heated by the sun in the process known as **evaporation**. As the water vapour cools it condenses, usually on tiny particles of dust in the air, and collects to form clouds. We call this process **condensation**.

Procedure **1.** Review the water cycle with the students.
2. Have the students stand up and reach high above their heads, then bring their arms down as they say "precipitation". They should then touch the ground, saying "saturation". Next have them raise their arms partway up as they say "transpiration" and the rest of the way up as they say "evaporation". Finally, they should form a circle with both arms raised overhead, saying "condensation". Do this slowly at first, then have them continue to do the cycle, gradually speeding up.

Discussion/Reflection

Refer to the handout, and lead the students into a discussion of the process.



The Water Cycle

Activity 1-D: Water Cycle Relay

Summary Use this activity as a game to demonstrate the process of the water cycle.

Learning Objective
Students will be able to understand the process of the water cycle.

Age Levels 4–11

Subject Area Science

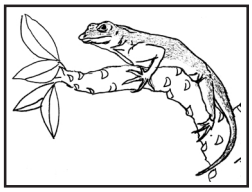
Time 30–45 minutes

Materials Four or more buckets
Two cups
Handout: Water cycle process

Background Same as for Water Cycle Rap on page 1-12

Procedure **1.** Divide the students into two or more teams.
2. For each team, set up two sets of buckets (two buckets per team), with one set approximately one-third full of water. Place the ones containing water about 10 m (30 ft) away from the empty ones. Line the two teams up behind the buckets containing water.
3. Students must fill a cup with water and "precipitate" by running the water (without spilling) to the other (empty) bucket, which represents a wetland or stream. When the race begins, the first student from each team runs with his or her cup of water and empties it into the bucket at the other end. When they return to the other side, they hand off the cup to the next person in line on their team. The first team that empties its bucket and spills the least is the winner.
4. Play the game again, this time having the students "evaporate" the water from the wetland or stream back to the clouds.

Discussion/Reflection
Use the water cycle chart on pages 1 through 9 to go through the water cycle process with the students, and then lead them into a discussion of the importance of water.



Activity 1-E: Salty Currents

Summary This activity demonstrates the mixing of fresh and salt waters.

Learning Objectives

Students will be able to:

(a) observe what happens when fresh and salt waters meet and mix; and
(b) observe how water temperature influences plant and animal habitat.

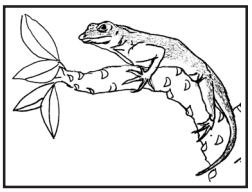
Age Levels 10 and up

Subject Area Science

Time 30–60 minutes

Materials Two 5- or 10-gallon aquariums or clear plastic containers of similar size and shape (if using aquariums, make sure the one that contains salt water will **not** be used later for freshwater fish)
Two small (6 or 8 oz) glass bottles, such as soda or mineral-water bottles, with caps
Salt (coarse or table salt)
Food colouring
Paper and pencil for recording results
Easel paper or flip chart
Labels, or permanent marker for labelling bottles

Background Many kinds of wetlands (including mangroves) are located where fresh water from the land meets salt water from the ocean. The most obvious characteristic of sea water is its saltiness, or **salinity**. But most kinds of wetlands, from salt ponds to estuaries, are less salty than the ocean, and organisms face a constant fluctuation in salinity as both tides and freshwater flow interact. A good example of this is where the water from the Central Mangrove flows into the North Sound of Grand Cayman. Salt water is denser than fresh water and tends to sink to the bottom, so the organisms often have to deal with "layers" of different salinities. Fresh water, being lighter than salt water, floats to the top of ocean water. Wind, waves, and tides can stir up the layers, so wetlands animals must be prepared for quick changes in salinity. On a secondary-school level, this activity works with Chemistry and Physics classes as it demonstrates density through the movement of saltwater and freshwater currents.



Procedure

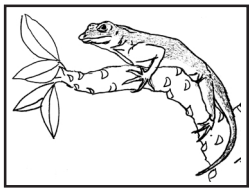
1. Ask two students to half-fill both aquariums with cold fresh water. Also fill the two small bottles with water. Cap and label one of the bottles "fresh water". To the other one, have a student add enough salt to make a very salty mix (approximately two teaspoons, which is much saltier than sea water). Cap the second bottle and have a student shake it up until the salt is completely dissolved. Label the bottle "salt water".
2. Lead the class in a discussion to predict what will happen when the two bottles are placed at the bottom of the aquarium or basin and uncapped to let the water escape. Record students' predictions on easel paper or a chalkboard, and encourage them to give reasons for their predictions.
3. Ask students to suggest how we might observe what the water in each bottle will do when it comes into contact with the water in the aquarium or basin, if the waters all look the same. Teacher direction may be required to lead the students to think of adding food colouring to the water in the bottles as a solution to the problem.
4. Add food colouring to both small bottles of water. Have a student shake up each of the bottles to make sure the food colouring is completely dissolved.
5. *(Note: If you do the saltwater demonstration first, the results are more surprising to the students, and usually give a clue to whether their predictions are correct for the second demonstration.)* Have a student lay one bottle on its side on the bottom of one of the aquariums and then uncap it. Observe what happens as the bottled water leaks into the basin. Discuss the reasons for what happened. Compare the predictions to the actual event. Leave the basin undisturbed to see what will happen to the water over time. Follow the same procedure with the second bottle of water.
6 (alternative). If you have only one aquarium or container, follow the same procedure, but use two different colours to distinguish the saltwater mix from the fresh water.

Discussion/Reflection

Culminate the activity with a discussion of wetlands and estuarine areas. Deep ocean water is always colder than the water in a shallow estuary. Water entering both the estuary and wetlands as run-off from streams and rivers is usually colder than the water already in the estuary and wetland areas, which has been warmed by the sun. How do differences in water temperature influence the plants and animals that live there? Plant growth is faster in warm temperatures, and this is one reason that wetlands and estuaries are so productive.

Extensions

Students may draw or write about the experiments on paper or in a science log as a follow-up.



Activity 1-F: Evaporation Demonstration

Summary Students observe under what conditions water evaporates fastest, and how salts are left behind in the process of evaporation.

Learning Objectives

Students will be able to:

(a) define evaporation;
(b) explain how seasonal wetlands dry up and how tidal pools become smaller; and
(c) describe how salt is extracted from sea water.

Age Levels 7–14

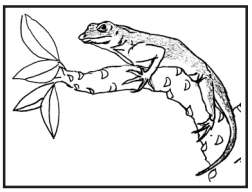
Subject Areas Science, language arts

Time Long (2–3 lessons)

Materials Four same-size glass containers with tops (such as jars formerly containing pickles, mayonnaise, etc.)
Salt (coarse or table salt)
Food colouring
Labels
Handout: Water cycle chart (page 1-19)

Background Heat from the sun and air causes water to evaporate. Water that evaporates turns into a gas called **water vapour** and rises into the air. This is how puddles dry up and disappear after the rain, how seasonal wetlands dry up, and how tidal pools become smaller (hotter and saltier) very quickly. When it evaporates quickly and in large amounts, as it does in tropical and sub-tropical areas, water leaves behind salts that have previously been absorbed from the rock and soils that surround the wetland.

Procedure **1.** Ask two students to fill all four glass containers with fresh water. To two of them, have a student add enough salt to make a very salty mix (approximately two teaspoons, which is much saltier than the ocean). Cap and label the containers “salt water”.
2. Select four places in the school grounds or classroom and place each container in one of them; leave the tops off. Label each container with a description of where it has been placed. The locations will be:
(a) a cool, shady place
(b) a hot, sunny place

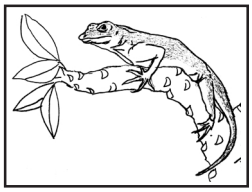


(c) a hot, sunny, but drafty (windy) place
(d) a drafty, cool, and shady place
Leave the containers in their locations for a week.
3. Discuss where water vapour comes from. Most of it comes from the oceans, including the Caribbean Sea. It also comes from the surfaces of lakes, ponds, and wetlands; from the transpiration of breathing plants; the perspiration, or sweating, of humans and animals; and the respiration, or breathing, of humans and animals. Ask the students to predict what will happen in the various containers.
4. Collect the containers and observe each one, noting its condition in science logbooks or on an observation sheet.

Discussion/Reflection

Culminate the activity with a discussion of why the container that was in a hot place has little or no water left, and has salt crystals around its edges. Ask if any students have ever tasted water from the ocean or an inland salt pond, and if they know why it is salty. Discuss why water in cool, shady places evaporates more slowly and is therefore better habitat for wildlife.

Extension Following a field trip to a local wetland, students can bring back small containers of water and place them in the same locations for a week, and observe what happens to the water samples.



Activity 1-G: Condensation Demonstration

Summary By creating condensation in a glass jar, students observe how water condenses to form precipitation.

Learning Objectives

Students will be able to:

(a) define condensation; and
(b) explain how clouds are formed.

Age Levels 7–14

Subject Areas Science, language arts

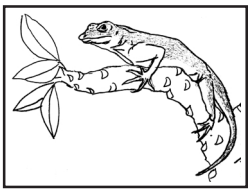
Time 30–60 minutes

Materials A large Pyrex glass jar
An extra-large jar lid
A small tin can containing ice cubes
Salt (coarse or table salt)

Background When water vapour rises, it meets cool air and begins to change form into tiny droplets of liquid water, forming clouds. If the air around a cloud becomes cooler, water vapour condenses further and the tiny droplets join up, forming larger droplets. This process is called **condensation**. When the droplets can no longer float in the air, they fall to Earth as rain or, in northern climes, snow, sleet, or hail.

Sometimes condensation happens close to the surface of the ground or water. Then the water droplets create a low cloud called mist, fog, or steam. When this happens, water purifies itself of salts or pollutants. The purpose of this activity is to show how water condenses to form precipitation.

Procedure **1.** Pour half a cup of very hot water into the large Pyrex glass jar.
2. Cover the jar with an extra-large jar lid turned upside down.
3. Place a small tin can containing ice cubes on top of the jar lid. Water vapour will form a cloud of steam in the air. Large water droplets will form on the inside of the glass jar as the steam cloud meets the lid, which has been cooled by the ice. Condensed water drops will roll down the side of the lid or just drop.
4. Repeat the experiment, only this time have a student add enough salt to make a very salty mix in the Pyrex jar. This represents a saltwater pond or the ocean.
5. After several minutes, ask the students if the water in the drops is different from the hot salt water. Have them taste the drops.



Discussion/Reflection

Culminate the activity with a discussion of what happened to the salt in the water. Ask if any students have ever tasted water from the ocean or an inland salt pond, and if they know why it is salty. Discuss why rainwater does not contain salt.

Extension Learn all the words of the water cycle (see next page).

WATER CYCLE WORDS

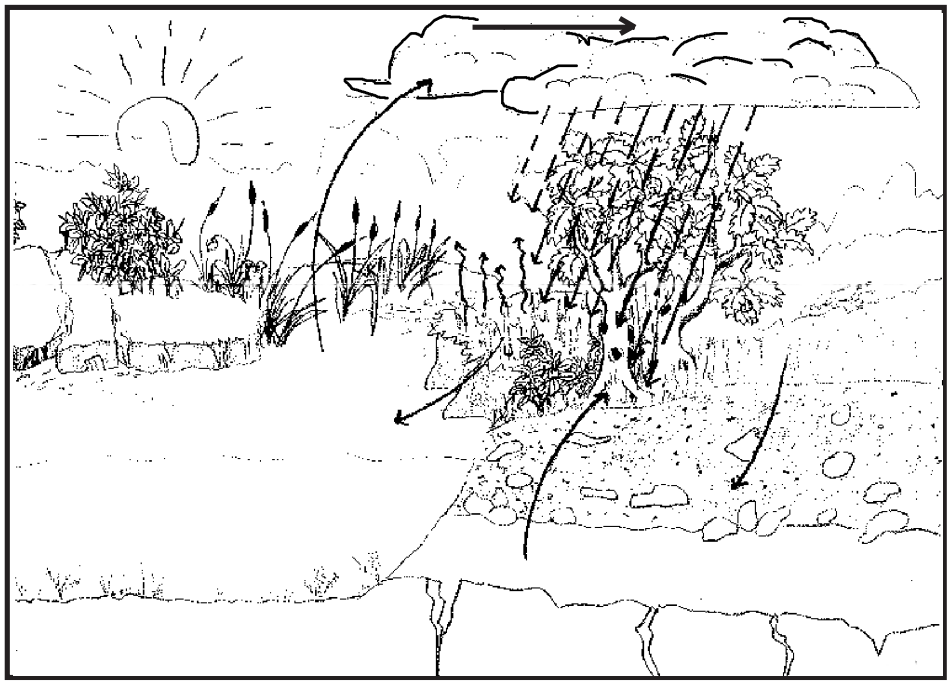
Match each word in column 1 with its definition in column 2 by writing the appropriate letter in each blank. Using your answers, label the diagram below.

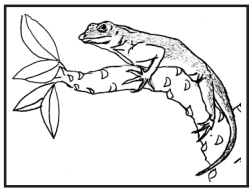
Column 1

a) precipitation
b) evaporation
c) condensation
d) run-off
e) groundwater
f) transpiration
g) the water cycle
h) transportation

Column 2

___ the change of water vapour to liquid
___ the process whereby water travels from the Earth to the air and back to the Earth
___ the release of moisture by living things
___ water collected below the soil on the bedrock
___ the change of water from liquid to gas
___ any type of moisture that falls to Earth
___ the flow of water from land into lake, river, wetland, or ocean
___ the phase in which clouds carry water from the point of evaporation to the point of precipitation





Mangrove Functions and Benefits

Introduction

Wetlands throughout the Caribbean provide a great variety of benefits and functions both to the natural world and to people. The description of these functions that follows this introduction will give you more details, and the activities provide a way to demonstrate to your students exactly what these benefits and functions are.

For small islands prone to hurricanes and all the damage they inflict, perhaps one of the biggest benefits of mangrove wetlands is that they protect our islands from severe storm damage—as long as we leave them alone! Wetlands also help clean, through natural filtration, the very water that we rely on for our lives—and at the other end of the human food-processing cycle, they can also help in the treatment of human waste.

Mangrove wetlands represent habitat at the base of the food chain that provides us with much of our food, whether it's the fish we catch and eat that began their lives in the wetlands, or the crops we eat that rely for their health and survival on the nutrients provided by wetlands soil.

Useful Products Provided by Wetlands

Forest Resources

Mangroves and swamp forests provide timber, fuelwood, roundwood for house construction, and sticks for yams and fish pots. Red Mangrove timber is highly valued for building docks because it remains strong when wet. Sustainable harvesting is possible, and a model for it has been developed in St. Lucia.

In some parts of the world (for example, Eastern Europe) swamp plants have been grown and harvested as biomass to be burned in power stations. This has never been tried in the Caribbean.

Agricultural Resources

Aquaculture

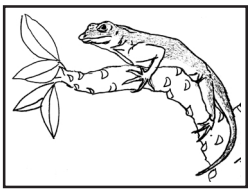
Mangroves are sometimes cleared, ponds excavated, and surface water flows redirected to create fish and shrimp ponds. These ponds are seldom as productive as the natural ecosystems they replace. Many rapidly become too salty for aquaculture and are abandoned.

Honey

Beehives in Black Mangroves produce very high-quality honey.

Forage

Cattle and goats graze on mangrove seedlings and other wetland plants. Farmers often set fire to salt marshes and freshwater marshes to encourage the growth of soft new shoots for forage. This dam-



ages the wetland and prevents regeneration of mangroves.

Fisheries

Many fishermen around the Caribbean depend on mangrove wetlands because they provide nurseries and feeding grounds for many commercially important species of fish, including jacks and snappers.

Typically, fish spawn on reefs some distance from shore. Currents and tides sweep the young fish toward the land and into the mangrove roots, where they find abundant food and protection from predators.

Similarly, commercial species of crabs migrate to the shore in the mating season, there to release their eggs. Only 50 years ago, these crab migrations were huge and dramatic, involving thousands of crabs, which would crawl over houses on their way to the sea and make roads dangerous for driving. Today, in many places the numbers of crabs are so much reduced that the crab migration is barely noticed.

Commercial shrimps do things the other way round. They lay their eggs in the rivers. The young migrate to the sea to grow, returning to the wetlands to breed.

Other commercially important species that depend on wetlands include lobsters, conch, and oysters. When wetlands are filled, destroyed, or polluted, the fisheries collapse. The effects can be felt hundreds of miles away, because healthy wetlands are often sources for young fish, conch, and lobsters down-current.

Miscellaneous resources

In the past, much more use was made of wetland resources than is the case today. Mangrove bark was used to make floor polish, and vines and leaves were harvested as craft materials. Synthetic materials have replaced many of these products, although thatch-palm leaves are still used for making baskets and for roofing, especially in tourist areas.

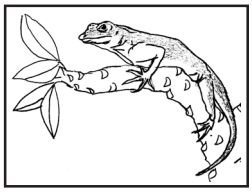
Useful Services Provided by Coastal Wetlands

Water Supply

Some coastal wetlands catch fresh water, helping to maintain the balance between the salty water of the sea and the fresh groundwater under the land. When wetlands are drained, there is less fresh water in the ground, and coastal wells may be polluted by seawater draining in to take its place.

Springs and blue holes

In some wetlands, there are beautiful springs or blue holes, where fresh water bubbles out of vertical caves in the limestone. These supply water for many coastal communities. There may also be underwater springs in the beds of rivers or even under the sea. Underwater springs help to maintain the conditions that fish and shrimp need to grow and reproduce.



Coastal Protection and Maintenance of Water and Air Quality

Control of floods

Wetlands catch storm water, soaking it up like sponges, and releasing it slowly after the peak has passed. In this way, they help to prevent floods. They also protect coral reefs and seagrass beds, which can be damaged by sudden flooding with fresh water.

Protection of shorelines

The roots of wetland plants help to bind and stabilize the soils along the coast, while their leaves, branches, or trunks break the force of hurricane and storm winds. They help to protect property by reducing coastal erosion and storm damage. They also trap sediments that are washed to the coast by rivers, and so protect the reefs and seagrass beds. Often these sediments include large amounts of dangerous substances, including excess nutrients from fertilizers, pesticides washed from agricultural land in the upper watersheds, or heavy metals from mining. The wetlands stop these environmental contaminants from getting to the sea, and can often transform them through biological, chemical, and physical processes into harmless substances.

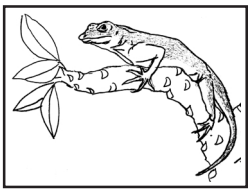
The wetlands of the Cayman Islands are likely to be able to grow fast enough to keep up with the rise in sea level due to global warming. This means that their importance for coastal protection will increase.

Contribution to coastal productivity

Coastal wetlands in the Cayman Islands are among the most productive ecosystems in the world. Wetlands cover only 6.4% of the Earth's surface, yet they account for 24% of global productivity. Wetlands plants trap large amounts of carbon, turning it into food for other plants and animals.

Contribution to air quality

Wetland plants produce oxygen through the process of photosynthesis. Excess nitrogen, like that contained in fertilizers, is broken down in wetlands through a process called **denitrification**. Atmospheric levels of carbon and sulphur, both of which have increased dramatically as a result of the burning of fossil fuels and peat, are lowered by wetlands' ability to act as sinks (natural catchment basins) and to reduce these elements to harmless forms.



Other Important Qualities of Wetlands

Many of the most important qualities of mangrove wetlands are hard to value in terms of money or usefulness, but they are very important.

Biological Diversity and Endangered Species

Because wetlands are so productive, many species of plants and animals use them for food, shelter, spawning, nesting, or hunting. Eighty percent of all breeding bird populations in the West Indies, together with more than half the protected migratory bird species, rely on wetlands at some point in their life cycles. Virtually all the Caribbean commercial fish and shellfish species depend to some extent on wetlands.

The wetlands of the Caribbean are also extremely important for biological diversity—the richness of living things. Many species of plants and animals are found only in Caribbean wetlands—nowhere else in the world. One example is the West Indian Whistling-Duck. Some species, like the Swamp Bloodwood, are found only on a few islands. Others are found only on one island, or even in only one wetland. The Royal Palms of Cuba, Jamaica, and Hispaniola are examples of species that are endemic to the wetlands of those islands.

Some species that live in Caribbean wetlands have never been studied. Much remains to be discovered.

Destruction of wetlands throughout the region means that many species that were once common have become rare. They include the magnificent but widely feared American Crocodile (now extirpated in the Cayman Islands) and several species of birds, including the West Indian Whistling-Duck.

Educational Value

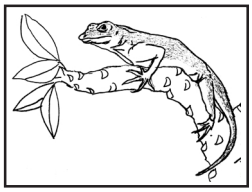
Wetlands make excellent living laboratories for studying ecology, geography, history, and many other subjects. They are attractive sites for research because they tend to be compact in area and diverse and complex in nature.

Heritage Value

Some wetlands have probably changed very little since the native peoples of the Caribbean knew them. They are a living part of the natural heritage of the region.

Natural Beauty and Recreation

Increasingly people are seeking natural beauty and quiet places to get away from city life. In the wetlands, they find beautiful landscapes, quite different from the ones they left. Besides hunting and fishing, activities such as canoeing, walking, and bird-watching attract millions of people to wetlands every year. Artists and photographers also are drawn to wetlands because of the many species of plants and animals that can be seen there.



Mangrove Functions

Activity 1-H: Mangrove Metaphors

Summary Students will learn the functions of mangrove wetlands including flood control, coastal protection, wildlife nursery, and resting place though the use of metaphors.

Learning Objectives

Students will be able to:
(a) describe wetland functions; and
(b) create and use metaphors to help them understand the basic conditions and processes in a wetland.

Age Levels 9 and up

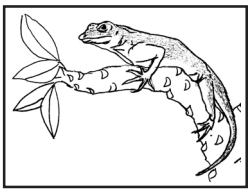
Subject Area Science

Time 30–60 minutes

Materials A large bag or pillowcase containing the following items (see Procedure)

Write out a list with a brief explanation of how each item's function compares to the mangrove's function (see below)

Object	**Mangrove Wetland Function**
Pillow	is a resting place (for migrating birds)
Cradle	holds and protects (provides a nursery that shelters and protects young)
Antacid	neutralizes (a natural system that can trap and treat sewage wastes and environmental pollutants)
Cereal	food (provides nutrient-rich food)
Sieve or strainer	strains (silt and debris from the water)
Eggbeater	mixes (fresh and salt water in all coastal wetlands, and oxygen in all wetlands)
Sponge	absorbs water (run-off from floods)
Soap	cleans (helps to purify the environment)
French fries box	food source, or represents young fish (fry)
Toy boat	recreation (place where humans go boating)
Fishing hook/line	commercial fishery (provides young fish that grow into fish stocks)
Soother	nursery for young creatures (fish, crabs, etc.)
Toy bird or fish	protected habitat for wildlife, including fish and birds

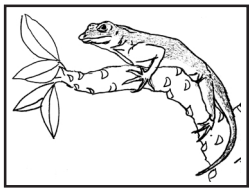


Coffee filter	filters out sediment and other forms of silt, prevents erosion
Band-Aid	protects (against storms)

Background The mangrove wetland has many functions, which can be explored through the use of metaphors. A metaphor is a figure of speech in which something is spoken of in terms of something else; it gives a vivid image through direct comparison. “Love is a rose” and “The eyes are windows to the soul” are two examples.

Migratory birds use the mangrove branches as a resting place. The tangled roots provide a nursery that shelters and protects (cradles) young fish, many of which are important to the commercial fishery. Some of the other functions of a mangrove include: the sponge effect—absorbs run-off; the filter effect—takes out silt and debris; nutrient control—wetlands absorb nutrients from fertilizers and other sources that may cause contamination; protection—wetlands are a natural nursery, providing protection and nourishment for newborn life, and also protect coastlines against storms by anchoring the land to prevent erosion.

Procedure **1.** Prepare a “Mystery Metaphor Container”, filling the pillowcase or bag with the items in the Materials list or any other item that you think could represent a mangrove wetland function. Set aside the container and items.
2. Ask the students to sit quietly, perhaps closing their eyes. Ask them to imagine a mangrove wetland near where they live. What plants do they see? What birds, animals, and other small creatures? What does the air feel like? How does it smell? If they were in bare feet, what would it feel like? (If you think students cannot visualize a mangrove wetland, you may want to show them a slide show or a short video before trying this activity.)
3. Invite the students to tell what they imagined. List their ideas. Encourage discussion and sharing.
4. With their ideas as a point of reference, help students identify which plants and animals are most likely to be found in a wetland near where they live.
5. Provide the students with background information about the basic ecological activities occurring in mangrove wetlands. Suggest that these activities are taking place in mangroves all the time—as are other activities that the students can probably think of.
6. Now bring out the “Mystery Metaphor Container”. Tell the students that everything in the container has something to do with a wetland. Have the students divide into groups of two or three, depending on class size—the number of groups should match up with the number of objects.) In turn, have a representative of each group draw out an object from the container.
7. Then, as a group, students must figure out how the object could represent the various functions of a mangrove wetland—what it is or what it does. Have the students discuss their ideas about the relationship. Encourage the students to build on



each other's ideas.

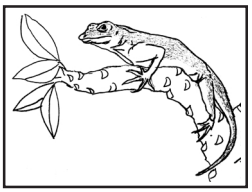
8. Ask each group to report to the class.

Discussion/Reflection

Summarize the major roles of mangrove wetlands in contributing to a healthy habitat for wildlife.

Ask the students if their own attitudes about wetlands are different now as a result of doing this activity. If yes, how?

How is our own well-being connected to that of a wetland ecosystem?



Activity 1-I: Wetland Models

Summary Students will learn that wetlands have waterlogged soil or are covered with a relatively shallow layer of water.

Learning Objectives

Students will be able to:
(a) construct a model of a wetland;
(b) flood the model to show how wetlands hold water; and
(c) answer questions about how wetland water retention helps people.

Age Levels 9 and up

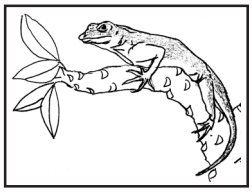
Subject Areas Science, art

Time 1–2 hours

Materials Large, shallow pans (e.g., aluminum pans, greenhouse germination flats, or plastic trays), one for every five students
Modeling clay **or** Styrofoam **or** cornstarch cooked with water and allowed to harden
Florist's green Styrofoam, large sponges, or indoor/outdoor carpeting
Variety of model-building materials: toothpicks, cheesecloth, cleaners, cotton swabs, glue, poster paint
Natural materials including pine (casuarina) needles, twigs, grass, weeds, and soil
Glass container of muddy water

Background Review the material on pages 1-20 through 1-23 and the Water Soakers and Wetland Metaphors activities regarding the functions and benefits of wetlands.

Procedure **1.** Explain that wetlands are very complicated natural systems, and scientists are still learning more about how they work. One important thing that we do know about wetlands is that they help to reduce flood damage by soaking up excess water and then releasing it slowly into lakes, rivers, and the ocean.
2. This can be a class project, or you can divide the class into groups of five and give each group a pan, some florist's Styrofoam or sponge or indoor/outdoor carpeting, modeling clay, and other building materials.
3. Instruct each group to build a wetland model according to the following instructions:
a. Spread a layer of modeling clay in half the pan to represent land. Leave the other half of the pan empty to represent a lake or other body of water such as a river or the



ocean.

b. Shape the clay so it gradually slopes down to the body of water (see diagram).

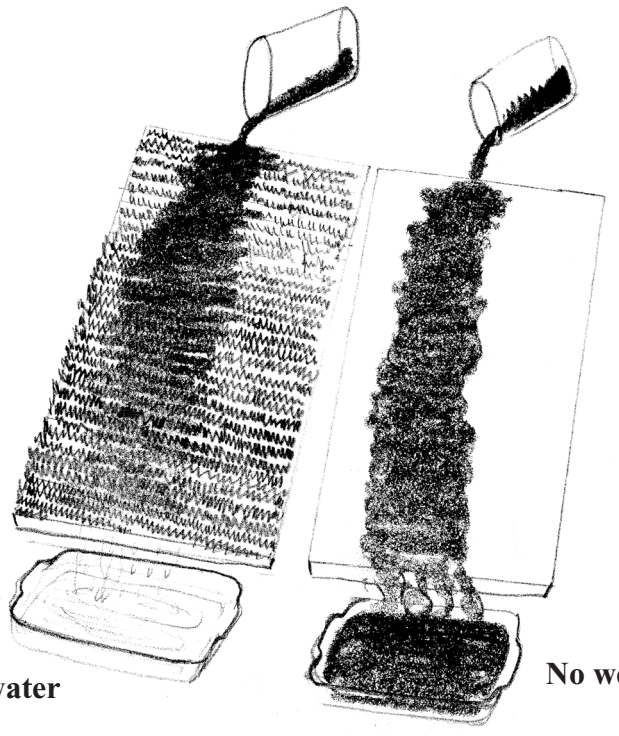
c. Smooth the clay along the sides of the pan to seal the edges. You can also form meandering streams in the clay that lead to the body of water.

d. Cut a piece of the florist's Styrofoam, sponge, or indoor/outdoor carpeting to completely fill the space across the edge of the clay (see diagram). The Styrofoam represents the wetland buffer between dry land and open water.

e. Have students add the final touches to their models by attaching plants (natural materials) and animals (moulded from additional clay) with toothpicks. Show students pictures of different wetlands as a guide. Here are some ideas: for cattails, use cotton swabs painted brown, pieces of grass, or toothpicks painted green with bits of brown clay stuck on the tops. Use long pine needles for reeds. Make trees by gluing pieces of green sponge onto twigs. For mangroves, use upside-down twigs with green sponge glued onto the main stem.

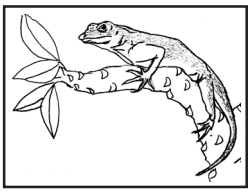
4. Tell the students they are going to simulate a rainstorm by slowly pouring water onto a model (use the one you made). Pour the container of muddy water on the land as shown. Have students describe what happens. (The water should soak into the "wetland" and slowly drain into the body of water.) Have students pour water on their models.

5. Now look at the water in the water body of the model. Is it still dirty? Discuss the



Wetland model filters water

No wetlands—dirty water



value of the marsh in water filtration and pollution reduction. (Through a variety of processes, wetlands help to purify water (see page 1-22).

6. Ask students what would happen if the wetland weren't there. Remove the wetland from one of the models and pour the same amount of water on it. Have the students note any difference. (The water should fill the body of water much more quickly, and it should be dirtier because the water body is no longer buffered by a wetland.) Explain that most wetlands are shallow basins that collect water and slow its rate of flow. This slowing helps reduce flooding and allows sediments to settle.

7. Change the size of the wetlands in the model. Repeat the experiment. Have the students note any changes.

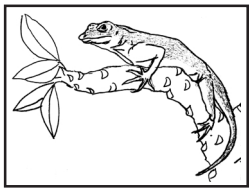
Discussion/Reflection

Ask the students the following questions:

What would happen if the marsh were paved over? *[The water wouldn't soak in.]*

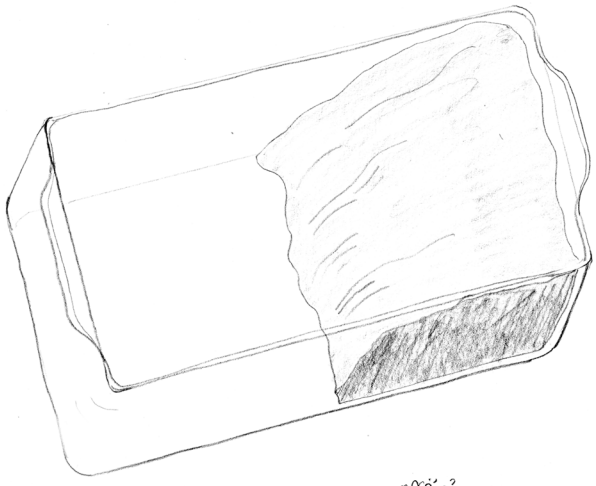
What would happen to areas downstream? *[Could result in flooding.]*

Why are wetlands important to people? *[They can reduce flooding, prevent erosion, and help to clean our water.]*



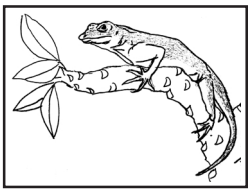
Wetland Model

Step 1—Build wetland



Step 2—Add plants and wildlife

Step 3—Add water



Activity 1-J: Settle Down

Summary Students will construct a model to show how wetland plants slow down flowing water and enable potentially harmful suspended sediments to settle.

Learning Objectives

Students will learn how mangrove wetlands plants trap sediments, which prevents them from being deposited in streams, rivers, lakes, and the ocean.

Age Levels 7–14

Subject Area Science

Time 30–60 minutes

Materials

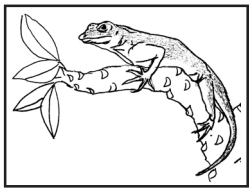
One 1-litre (2-quart) jar with a tight-fitting lid
A variety of sediments, including small rocks, smaller rocks, sand, sandy dirt, and clay
Clock or stopwatch
Piece of artificial grass or piece of a fibre doormat
Flat sheet of wood or plastic similar in size to the artificial grass or doormat
Two shallow pans (sheet-cake pans work well)

Background When floodwaters are slowed by mangrove, the silt and other sediments they carry settle out among the roots and stems of wetland plants like mangroves. This helps to protect the ocean downstream from a build-up of sediment that could otherwise clog the gills of aquatic animals and bury their eggs. It also helps protect water supplies from pollutants and other impurities, because other wetland plants can take up and use nutrients and other chemicals that the silt may contain. If it weren't for wetlands, these impurities might eventually contaminate rivers, lakes, groundwater (including an island's freshwater lens), and other water supplies, some of which may be used as sources of drinking water.

Procedure

1. Explain that flowing water carries sediment of different sizes. The faster the water flow, the larger the sediment particles that can be transported in suspension. As the water is slowed, the larger particles settle out first. In still water, the finer sediments (clay and silt) will settle to the bottom.

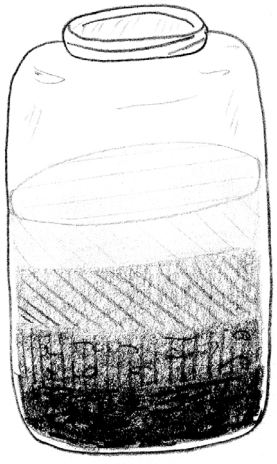
2. Mix the different sediments (sand, dirt, etc.) together in the jar, filling it one-half to three-quarters full. Top off the jar with water, and put the lid on. Have a student shake the jar until the contents are thoroughly mixed, then set the jar on the table in front of the class. Begin timing.



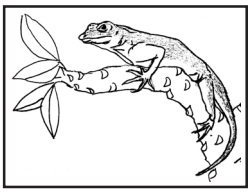
3. As the sediments begin to settle, explain that muddy water loaded with sediments can be harmful to wildlife. Ask the students to think of reasons why. *[For example, it clogs filter feeders like clams and oysters, smothers fish eggs, impairs plant and coral growth by blocking light, "blinds" sight-feeding animals, and clogs fishes' gills so they cannot breathe.]* Would more sediments settle to the bottom if the water were flowing quickly or slowly? *[The slower the flow, the smaller the particles that will settle out.]*
4. Check the sediment jar (it will take a while to settle). How long did it take to settle out completely? Did the sediments settle in layers—that is, by particle size?
5. Next, describe how wetlands can slow the flow of water in a system by simply "being in the way" of the water.
6. Set up the wetlands models (the doormat or artificial grass and the flat piece of wood) so they are both on a slight tilt. Explain that the doormat or artificial grass is a healthy wetland filled with plants, and that the piece of wood is a damaged wetland where the plants have all died or been removed. In both wetlands, water enters through a stream, flows through the wetland, and eventually ends up in a lake or the ocean.
7. Place the pan at the low end of each "wetland" and pour water simultaneously onto the high end of each.

Discussion Which "wetland" does the water flow through faster?
In which "wetland" would more sediments settle out?
Which "wetland" would have cleaner water flowing from it?
How would channeling (dredging a ditch through) a wetland affect water quality downstream, where the wetland meets the sea?
How would this affect people?

Mix water and sediment



Allow to settle down



Activity 1-K: Water Soakers

Summary Students will learn how mangrove wetlands absorb water, thereby controlling floods.

Learning Objectives

Students will be able to:
(a) observe the way different natural materials soak up water; and
(b) describe one way in which mangroves and other wetlands control floods, and release water slowly during a drier time.

Age Levels 9 and up

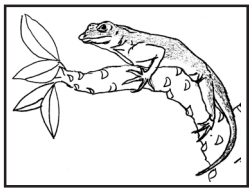
Subject Areas Science, math

Time 30–60 minutes

Materials

Kitchen sieve
Cheesecloth **or** nylon stocking **or** mosquito netting (enough to cover the sieve)
Bowl (large enough to hold the sieve)
Scale
Sphagnum moss (any moss will do) **or** peat moss (found in plant stores or nurseries) **or** leaf litter **or** a sponge
Sand (from your yard or beach)
Sod (a small piece from your yard)
Rock (a small piece from almost anywhere)
Copies of data sheet

Background One of the primary functions of intact mangrove wetlands in the Cayman Islands and throughout the Caribbean is to prevent flooding. This is because wetlands act like giant shallow bowls. Water flowing into these bowls naturally loses speed as it collects and spreads out. Wetland vegetation helps to slow down fast-moving water, too. As a result, flood damage to developed areas near wetlands is often much less than damage to areas located near wetlands that have been drained and filled. This is never more apparent than during hurricanes, when wetland vegetation such as mangroves always breaks the force of the storm, and wetland areas soak up the run-off that results from the heavy rain that usually accompanies hurricanes.

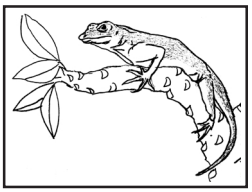


Procedure

1. Weigh out a sample of each material. Each of the four samples should weigh about the same.
2. Put the cheesecloth (or stocking or mosquito netting), sieve, and bowl together to make your Soaker Tester (see diagram, Figure 1).
3. Put the sample of sphagnum or other moss (or leaf litter or a sponge) in your Soaker Tester. Carefully weigh the whole thing (Soaker Tester with moss). Write down the weight in space 1-A of the Data Sheet.
4. Add water to the bowl until it is nearly full. Let the Soaker Tester and moss sit for five minutes.
5. Take the sieve out of the bowl. Pour the water out of the bowl (see diagram, Figure 2). Some water may drop out of the sieve for a few seconds. Do NOT squeeze any water from the moss or the sieve.
6. Put the sieve back in the bowl. Weigh the Soaker Tester and moss again (see diagram, Figure 3). Write the answer down in space 1-B of the Data Sheet.
7. Repeat steps 3 through 6 using the other materials listed in the materials list. Write down the weights you find in the proper places in the Data Sheet.
8. What is the weight of water each material soaked up? Find out by subtracting the number in column A from the number in column B. Write the results in column C.

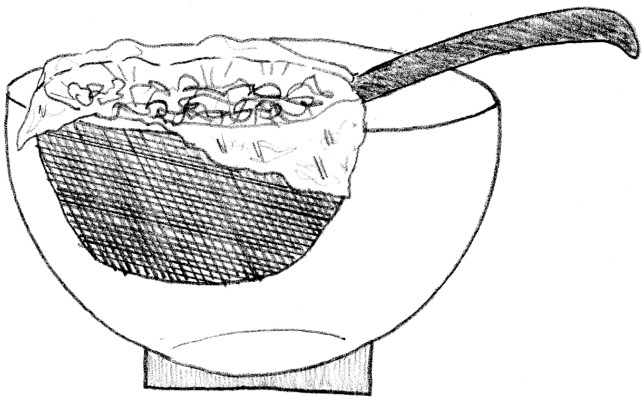
Discussion

Which material tested holds water best?
Which of the materials you tested would you most likely find in a wetland? *[Mosses and sod. You may find sand and rock below; however, their role in water storage is less important.]*

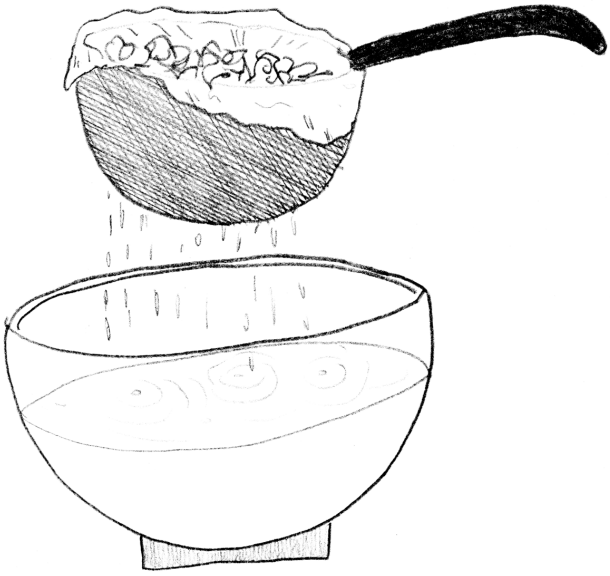


Water Soakers

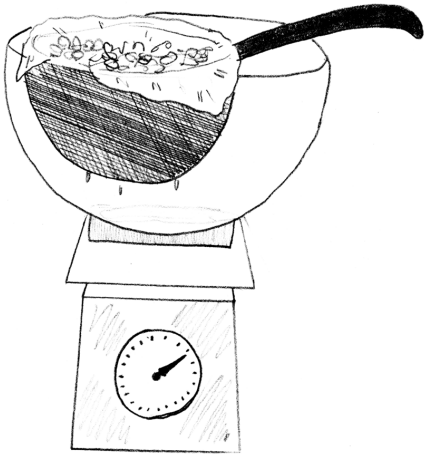
Add sample of moss to sieve

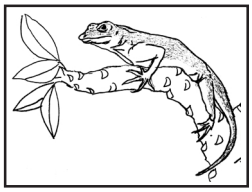


Soak sieve in water



Weigh water-soaked moss





Water Soakers Data Sheet

Material	A Weight of Soaker Tester (dry)	B Weight of Soaker Tester (wet)	C Weight of Water (B – A = C)
Sphagnum moss, peat moss, or other moss or leaf litter (or sponge)			
Sod			
Sand			
Rock			

Results

Which materials hold water best?

Which of the materials would you most likely find in a wetland?

From your experience in this activity, what is one way wetlands help to control floods?

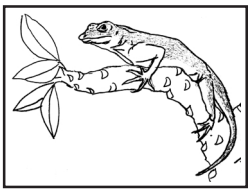
Conclusion

_____

_____

_____

_____



Activity 1-L: Nutrient Trap

Summary By playing a game, students will be able to demonstrate the way that nutrients are trapped by wetlands.

Learning Objectives

Students will learn that mangrove wetlands trap nutrients through the process of filtration and help keep them out of the water.

Age Levels 4–11

Subject Area Science

Time 30–60 minutes

Materials Cards (optional: marked with an "N" or a "P")—enough for half the class

Background Where do nutrients come from? Nutrients are a natural part of plants and animals—when they die and decompose, nutrients are returned to the soil and water where they can be "recycled", or reused by other things.

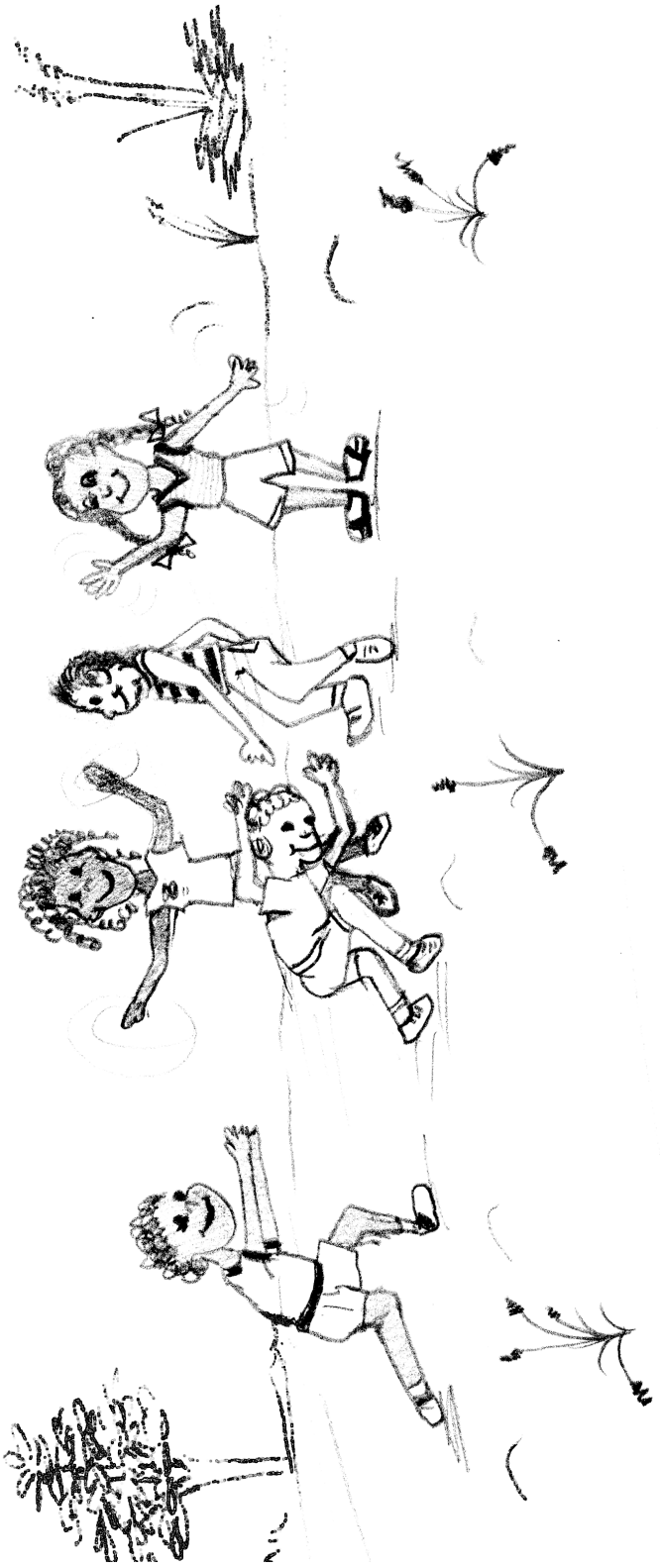
People also put nutrients on the land, in the soil, and in the water. Ask the students: "Who has ever walked their dog? Gone to the bathroom? Fertilized their yard or parent's ground?" Human and animal wastes contain nutrients like nitrogen and phosphorus, and they often get washed or flushed into the water.

Too many nutrients make the water unhealthy. Remind students that nutrients combine with particles of soil. When the soil washes away and ends up in the water, two forms of pollution result: muddy and cloudy water from too much sediment or soil, and "pea soup", or excess algae growing on the excessive amounts of nutrients! Ask the students: "What are some ways that fertilizers and soil wash off the land?" *[Rain picks up loose soil from construction and from bare spots under downspouts and roofs, and rivers and streams carve and carry away soil from their banks.]*

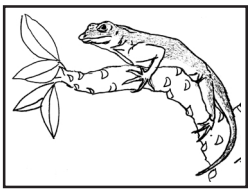
Wetlands trap soil and nutrients and help to keep them out of the water. Run-off is filtered as it passes through wetlands on its way to water bodies. Therefore, water in streams and rivers and from direct run-off is cleaned as it passes through mangrove wetlands. This activity will demonstrate this function to students.

Procedure **1.** Discuss the basic ideas about mangroves being a way to trap sediment and nutrients that are described in the Background.

2. Take the class outside to a large play area. Divide the class into two teams. **Team 1** will be "mangrove trees" growing in a wetland. **Team 2** will be "soil particles with



The Nutrient Trap



nutrients attached". This team will wear the nutrient card or tag to indicate that they are soil particles that carry or contain nutrients. You may mark these cards with an "N" for nitrates and a "P" for phosphates if you like. **Explain the rules** on the following pages and play a few rounds.

3. Repeat the game several times, using students' suggestions for modifying the plant spacing to change the rules. Keep count of the number of rounds required to complete each game with the modified spacing. Give each student a chance to play both roles.

4. After the game, discuss the roles played and relate the results of the rounds to what actually happens when it rains or when water flows through a wetland.

Rules of the Game

1. The "mangroves" form an irregular line at one end of the outside area, spaced so that their outstretched arms do not touch. The mangroves must try to "trap" soil particles containing nutrients by tagging them.
2. The area behind the mangroves is designated the waterway (river, ocean, etc.). This can be a rope laid out to make a line, the edge of a playing field, or stones.
3. The "soil particles" line up facing the plants and, on signal, must make their way to the waterway without being touched by a mangrove. The soil particles must drag one foot as they run, or hop on one foot, so they don't move too quickly.
4. The mangroves may bend, stretch, and stoop, but they may not move their feet (roots) to tag the soil particles. Soil particles may not go around the end of the plant line.
5. When a soil particle is tagged, the student must remove the nutrient tag that he or she is wearing and give it to a mangrove (mangroves use up nutrients). The soil particle now becomes a mangrove and joins the line of mangroves at the exact spot tagged.
6. Any particles of soil that escaped to the waterway will then go back to the starting line and, on signal, will try again to safely pass through the mangrove wetland. The game continues until all the particles have been caught.

Discussion/Reflection

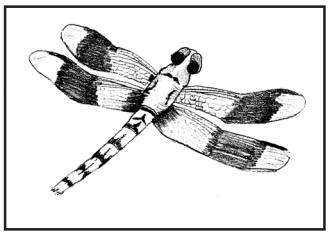
Were the mangroves able to trap more particles in areas where they grew closer together?

What happened when there were gaps or bare spots in the line of mangroves?

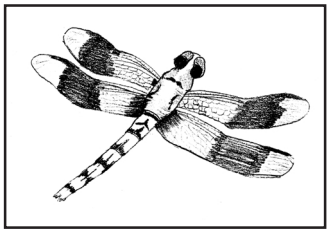
Would it have helped if you had had more mangroves?

Why are shoreline plants or mangroves important to the water they border?

Why is it important to plant and maintain plants anywhere, even in yards and areas near pavement?



Contents Section 2



What Lives in Mangroves?

From a distance, mangrove wetlands 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 four 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.

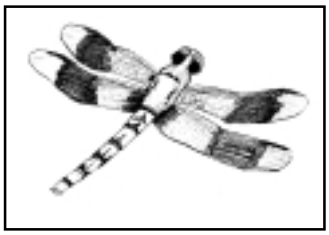
How Are Mangroves and Other Plants Adapted to Live in Wetland Conditions?

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 Swamp Bloodwood, have buttresses. Some places are too wet to support trees, and only grasses and herbs grow there. Some plants, like Phragmites, spread by falling down across the water. In open water, plants like water lilies float on the surface.
- **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 out into the air—aerial roots or breathing roots, also called **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 **hypersaline**. 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 Black 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 Black Mangroves) that can store water. These adaptations are also found in plants that live in dry places.

How Are Animals Adapted to Live in Mangrove Wetlands?

Mangrove wetland 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, then be 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.
- **Sedge marsh** provides cover for birds to hide in, and soft ground on which to nest.
- **Black Mangrove canopy** provides nesting habitat for herons and warblers, and warblers and vireos can hunt for insects among the leaves.
- ***Sesuvium* mats** provide low cover around ponds, offering nesting habitats for terns, nighthawks, and sandpipers.
- **Holes in trunks** of Black Mangrove trees provide nesting habitat for parrots and woodpeckers.

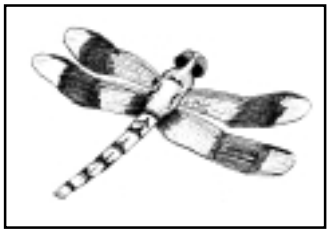
Birds are adapted by their shapes to the areas in which they feed and nest. Long-legged herons, with their long, heavy bills, wade in deep water and hunt larger fish and frogs, and occasionally crabs. Small herons like the Green Heron have short legs but move very fast. These herons stand in the mangrove roots above the surface of the water and lean down to stab fish. The Snowy Egret, an intermediate-sized heron, flies near the surface and dips its feet in the water to attract fish or 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 sandpipers 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 Kingfisher and Least Tern take their prey from the deeper parts of the water.

Adaptation allows many species to share the same wetland.

Roots and Root Dwellers

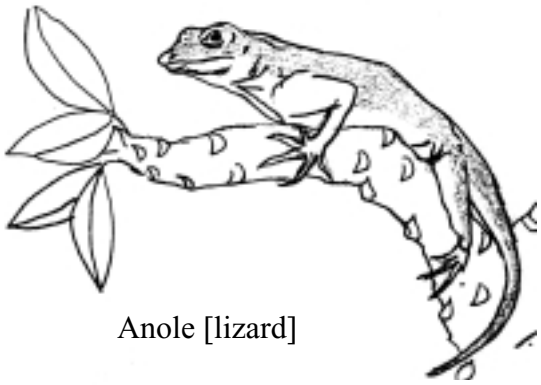
Roots are very useful to Red Mangrove trees, but they are equally useful to the hundreds of species of other plants and animals that make their homes on or near them. Once the Red Mangroves have started to grow in the mud, plants and animals settle on them. Red Mangrove roots host a fairyland of fantastic creatures and plants. Multi-coloured sponges (bright red, orange, yellow, or sky-blue),



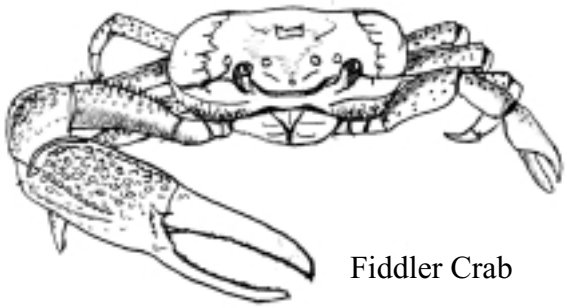
algae, corals of many shapes and colours, sea squirts (tunicates), fan worms, oysters, and sea anemones are just a few of the living things that crowd onto the roots. These creatures take advantage of the mangrove root surfaces to settle in places where there is nothing else to hold onto. Once there, 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 lizards, 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, 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, shrimp, lobsters, and crabs into the mangrove root ecosystem. There they hide, feed, and grow among the roots. These include the young of many favourite commercial varieties—snappers, parrotfish, lobsters, 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.

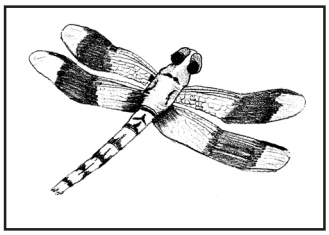


Anole [lizard]

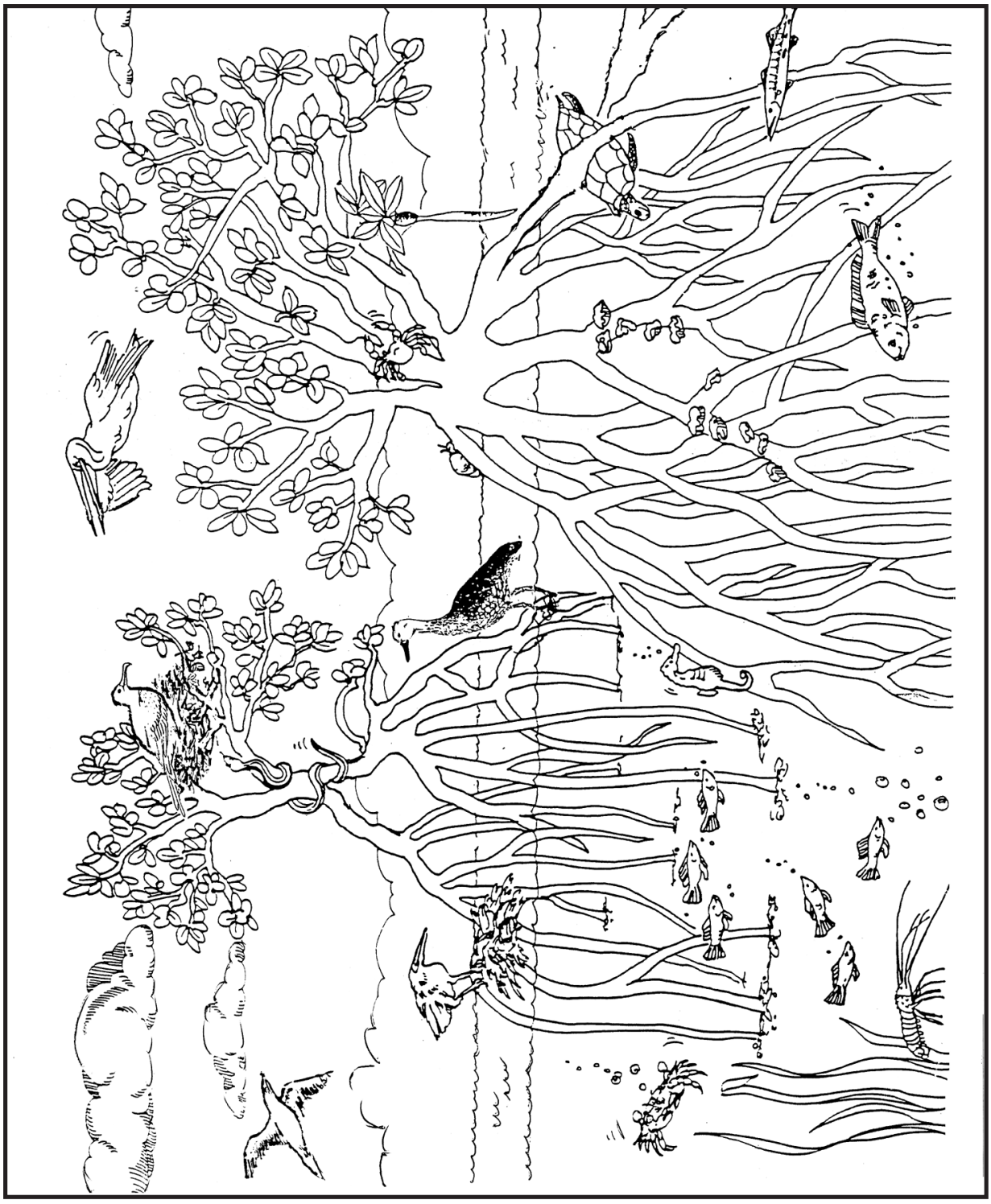


Fiddler Crab

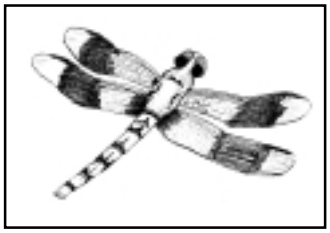
Mangrove Oyster



Marvellous Mangroves

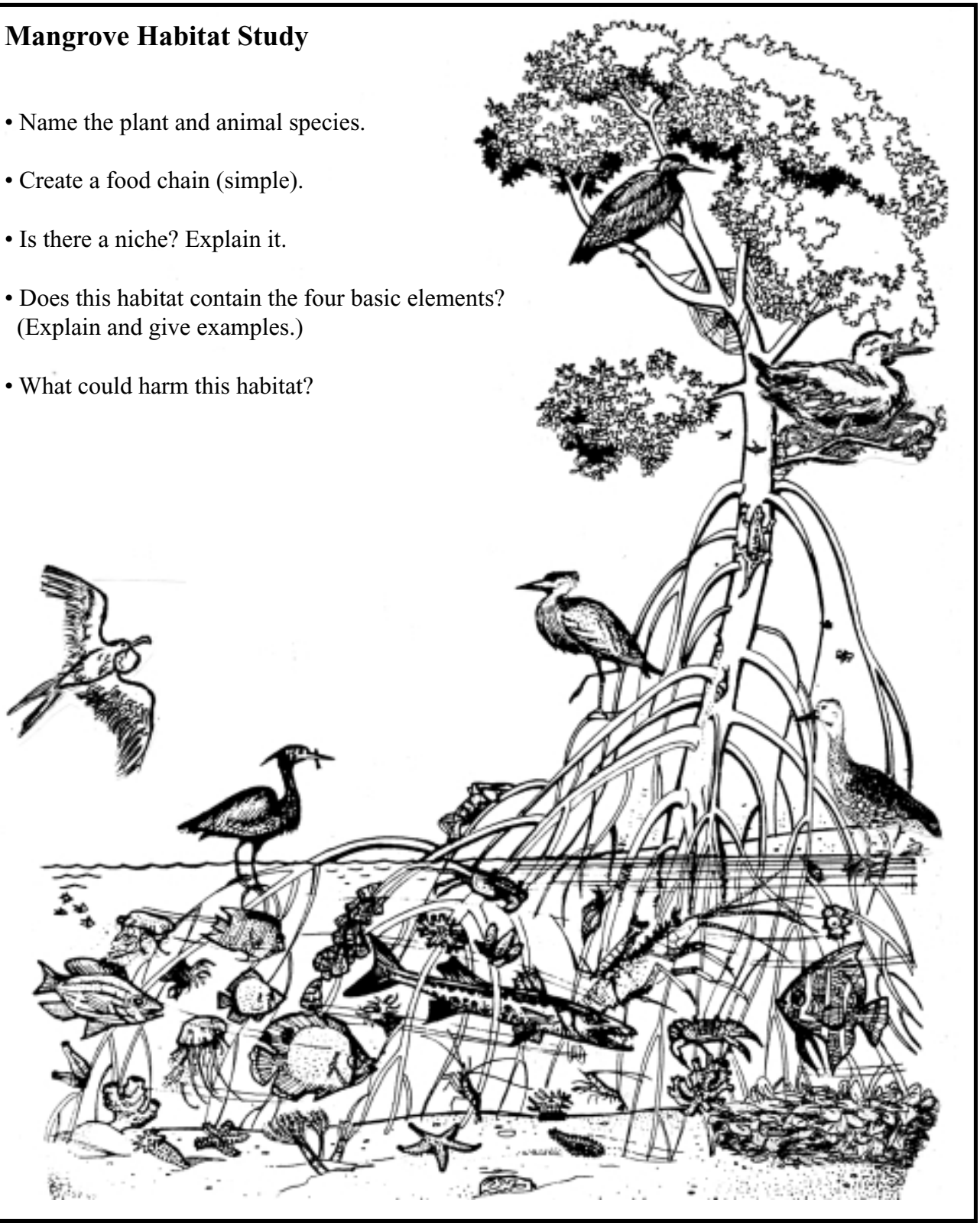


MANGROVES AS HABITAT



Mangrove Habitat Study

- Name the plant and animal species.
- Create a food chain (simple).
- Is there a niche? Explain it.
- Does this habitat contain the four basic elements? (Explain and give examples.)
- What could harm this habitat?



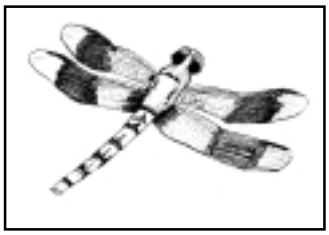
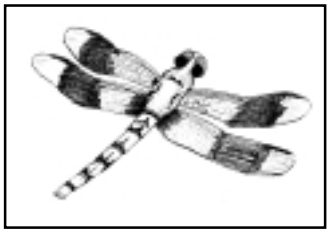


Chart 4. How Intertidal and Saltwater Pond Animals Meet Their Needs Through Adaptations

Need	Adaptation
To prevent themselves from drying out	Ability to hide under rocks (**crab**) Ability to burrow in mud (**shrimp**) Ability to hide in plant cover (**amphipods**) Ability to find tidal pools to stay in (**small fish**)
To prevent getting washed away	Foot that acts like a suction cup to hold animal in place (**snail**) Strong "byssal threads" that **oyster** spins to attach itself to surfaces Tube feet with suction-cup ends that hold the surface (**mud brittle star**) Glue that attaches it to surfaces (**barnacle**)
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 (**small fish**) Trapdoors, or armoured plates, that close around them (**snail**) Ability to hide beneath rocks, roots, and seaweed (**crab**) Ability to stay buried in sand or mud (**shrimp**)
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 holes (**fiddler crab, shore crab**) 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 (**shore crab**) Ability to sweep through water with their legs and filter plankton 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 (**West Indian murex snail**)



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 in the Cayman Islands drops between 7 and 15 tonnes of leaves per hectare. What happens to these leaves?

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**. The unlucky ones are eaten by night-herons. The night-herons are **secondary consumers**, which eat primary consumers.

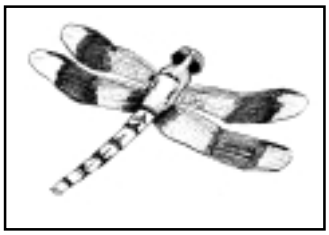
Take a look at a shallow pool in the Red Mangroves. It is likely to be lined with yellowing leaves—those that are not eaten on the tree fall into the water. They may look as if they are being wasted, but appearances are deceptive. As soon as a leaf enters the water, it is attacked by micro-organisms: 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 shrimp that are growing up in the area.

As the fish and shrimp 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 barracuda, 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. Green Herons often skulk on roots near the water, ready to spear a fishy victim. Spiders, geckos, anole lizards, and Yellow Warblers feast on the mosquitoes that breed in the water. Other birds like Brown 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

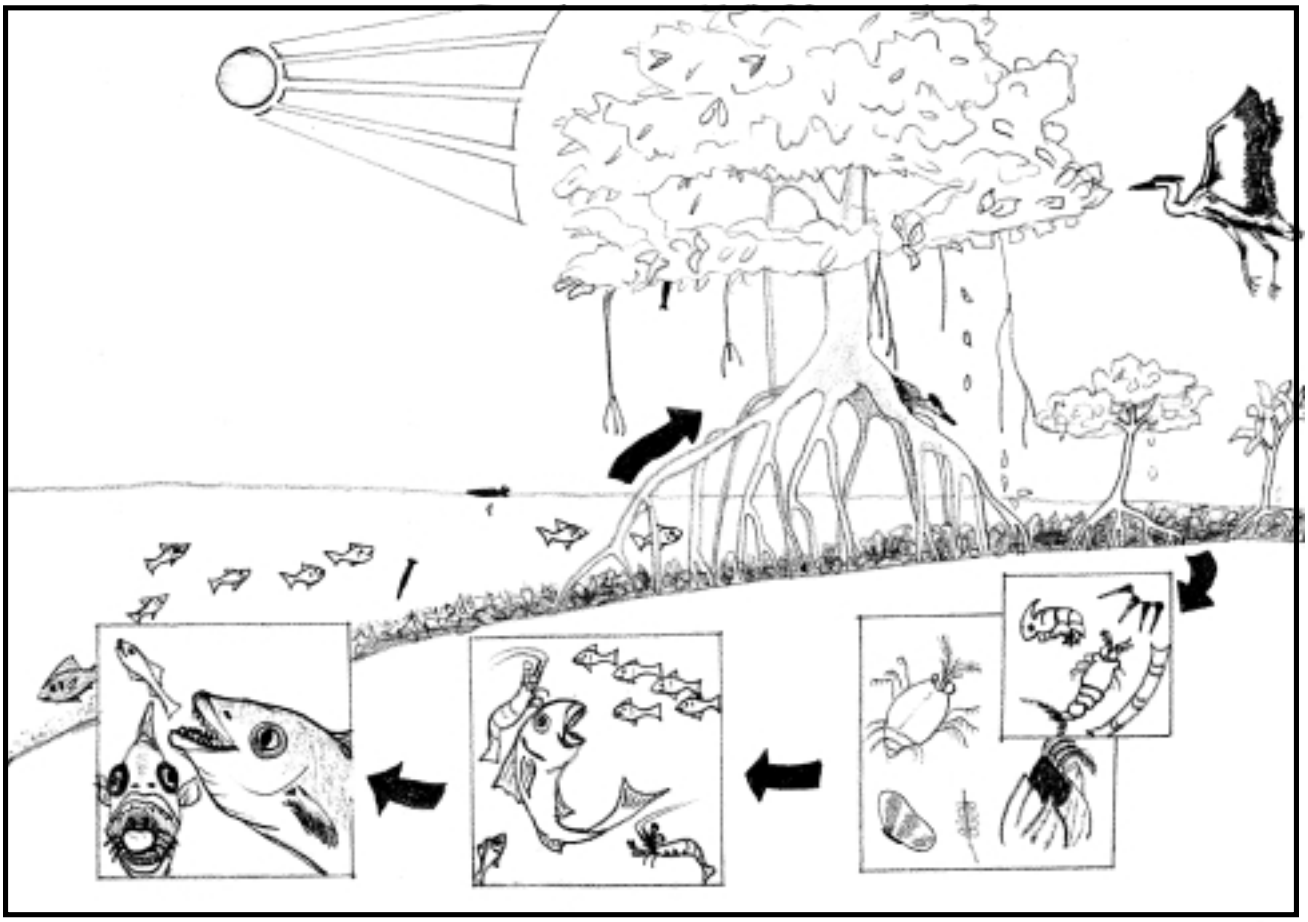
Plants and animals in any given ecosystem or habitat are linked by their feeding relationships. Just like the mangrove swamp, every habitat creates **decomposers**: bacteria, fungi, and some insects that break down dead plant and animal matter (called **detritus**) into minerals and humus. The fertile 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

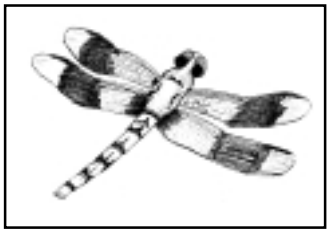


provide a food source for **predators**—animals that eat consumers. Predators can be either **secondary consumers**, which eat only primary consumers, or **tertiary consumers**, which eat secondary consumers, or both. For example, the Ching Ching (Greater Antillean Grackle) eats insects (primary consumers) as well as lizards and fish (secondary consumers). So the Ching Ching 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 web is shown in Figure 5.

Figure 5: Mangrove Food Web





Activity 2-A: Spot the Difference: Mangroves

Summary Students will learn that the three species of mangroves (red, black, and white) 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 8 and up

Subject Area Science

Time 1 hour

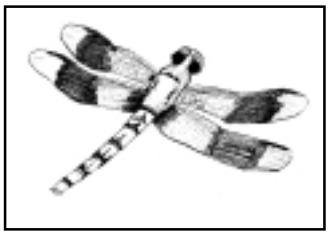
Materials Red Mangrove seed (propagule) with top attached, and leaf
Black Mangrove leaves and seed
Picture of Black Mangrove root (pneumatophore)
White Mangrove leaf and seed
Sketch pad or drawing paper
Mangrove plant illustrations from page 2-11

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.

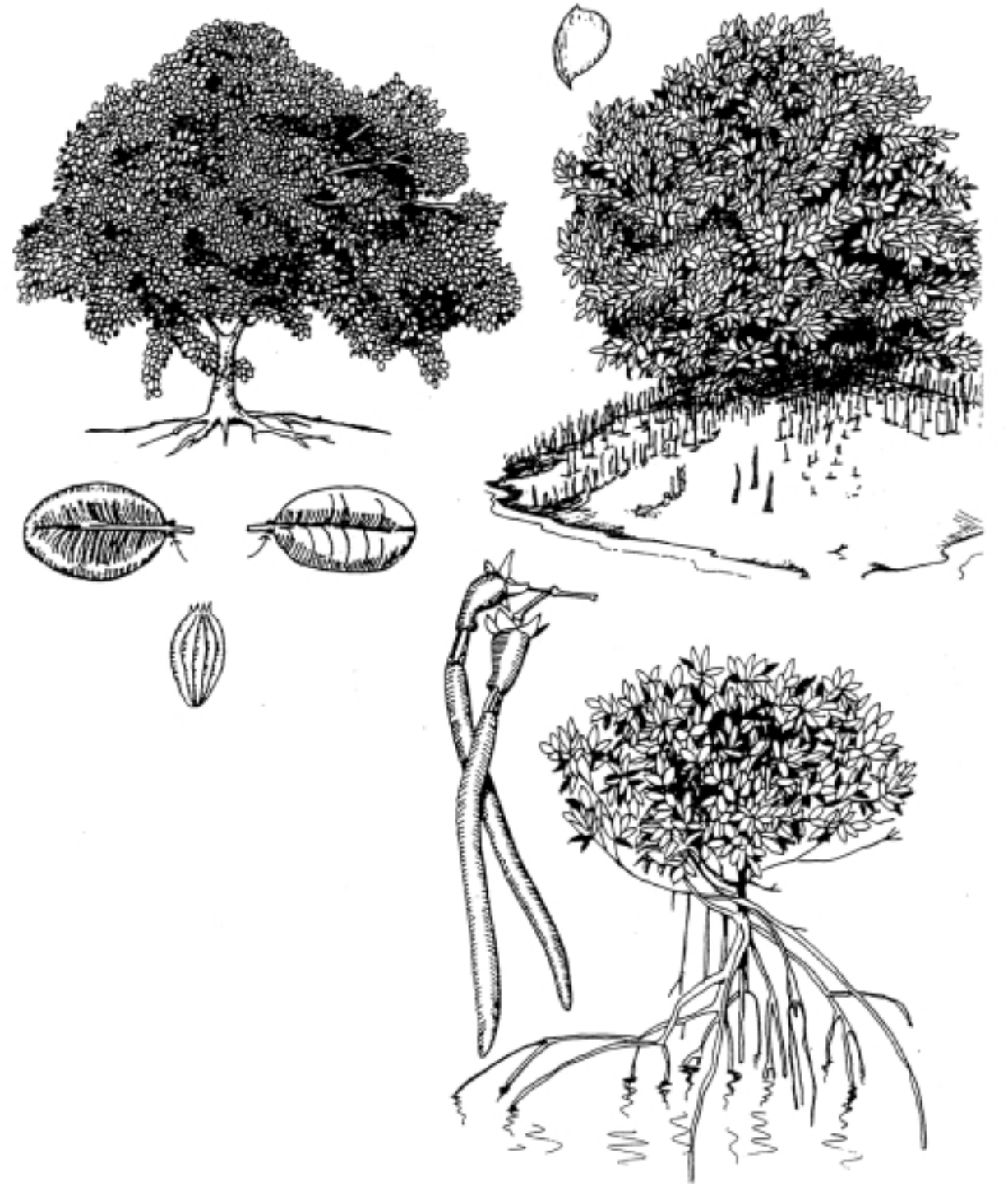
Preparation Collect seeds and leaves from each of the three different species of mangroves and lay them out on a table.

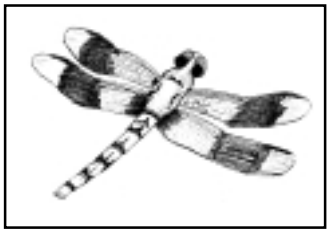
Procedure

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?
3. Examine the Red Mangrove root illustration.
  a. Is there a main trunk?



Spot the Difference





b. How do you think the roots function?

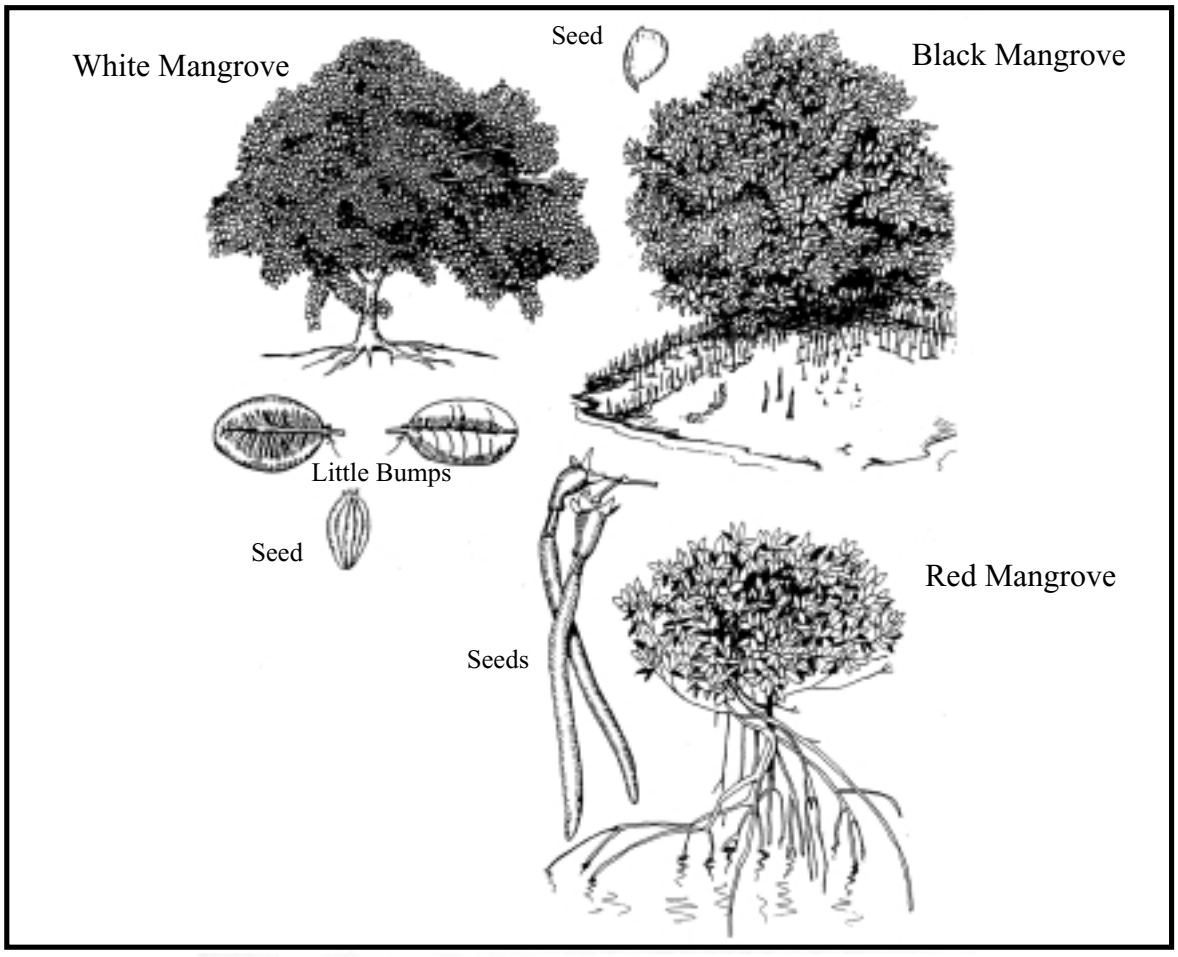
4. Examine the Black Mangrove leaf.
What is the difference between the top and bottom of the leaf? *[The bottom has salt pores.]*

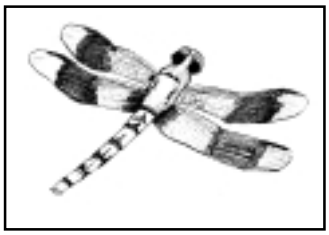
5. Examine the illustration of the Black Mangrove root system.
a. Estimate the extent of the root system and the tree cover (canopy). Is it larger, smaller, or the same? (Check this during field investigation or homework.)
b. Predict the function of the roots. (With older students, try to design an experiment to test your predictions. For example, try breathing through a snorkel while under water. Explain that this is how Black Mangroves get their carbon dioxide.)

6. Examine the White Mangrove leaf and stem.
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 White Mangrove root system.
a. How are the roots similar to those of the Black Mangrove?
b. Predict the function of the roots. (With older students, try to design an experiment to test your predictions.)

Key to Identifications



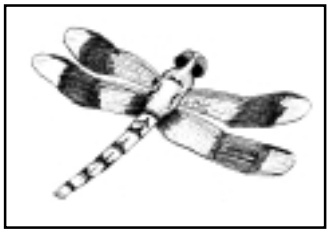


8. Have students draw pictures of each set of leaves, roots, and stems.

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?

Extensions If you can find Black, Red or White Mangrove seeds, especially ones that have already begun to grow roots, bring them back to the classroom together with water and samples of mud and detritus from a nearby pond or mangrove swamp. Put the water and mud and detritus that you have brought back into a container (preferably one like an aquarium) and plant the seeds in the mud and detritus. Every few days, add water obtained from the same location where the seeds were found. Initially, the water will stink, but if the seeds take root, they will ultimately remove the smell.



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

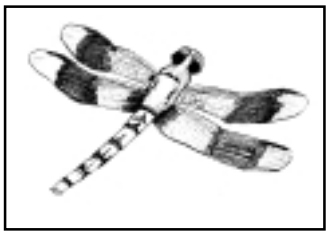
Subject Area Science

Time 1 hour

Materials One worksheet (page 2-18) per student
Mangrove Food Web Clues (page 2-16)
Reading background (page 2-2 to 2-6 and below)

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 Ching Ching (Greater Antillean Grackle) eats insects (primary consumers) as well as lizards and fish (secondary consumers). So the Ching Ching 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. Here is how that happens. The chemicals, such as DDT 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 chemi-



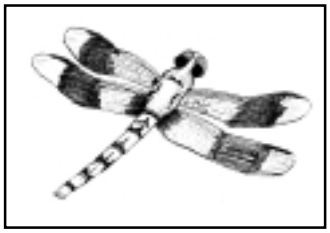
cals in their own bodies, where they are more concentrated than in the plankton. Fish eat the invertebrates and also store the chemicals in their bodies, becoming more polluted than the invertebrates. Birds, mammals, and humans then eat the fish containing high levels of pollutants, and the chemicals get into our bodies. *(See the "Deadly Links" activity on page 3-14).*

Procedure

1. See worksheet on pages 2-18.
2. Use the clues (page 2-16) to fill in the worksheet.
3. Check answers (see handout on page 2-17).

Discussion/Reflection

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

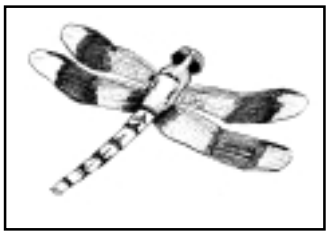


Mangrove Food Web: Clues

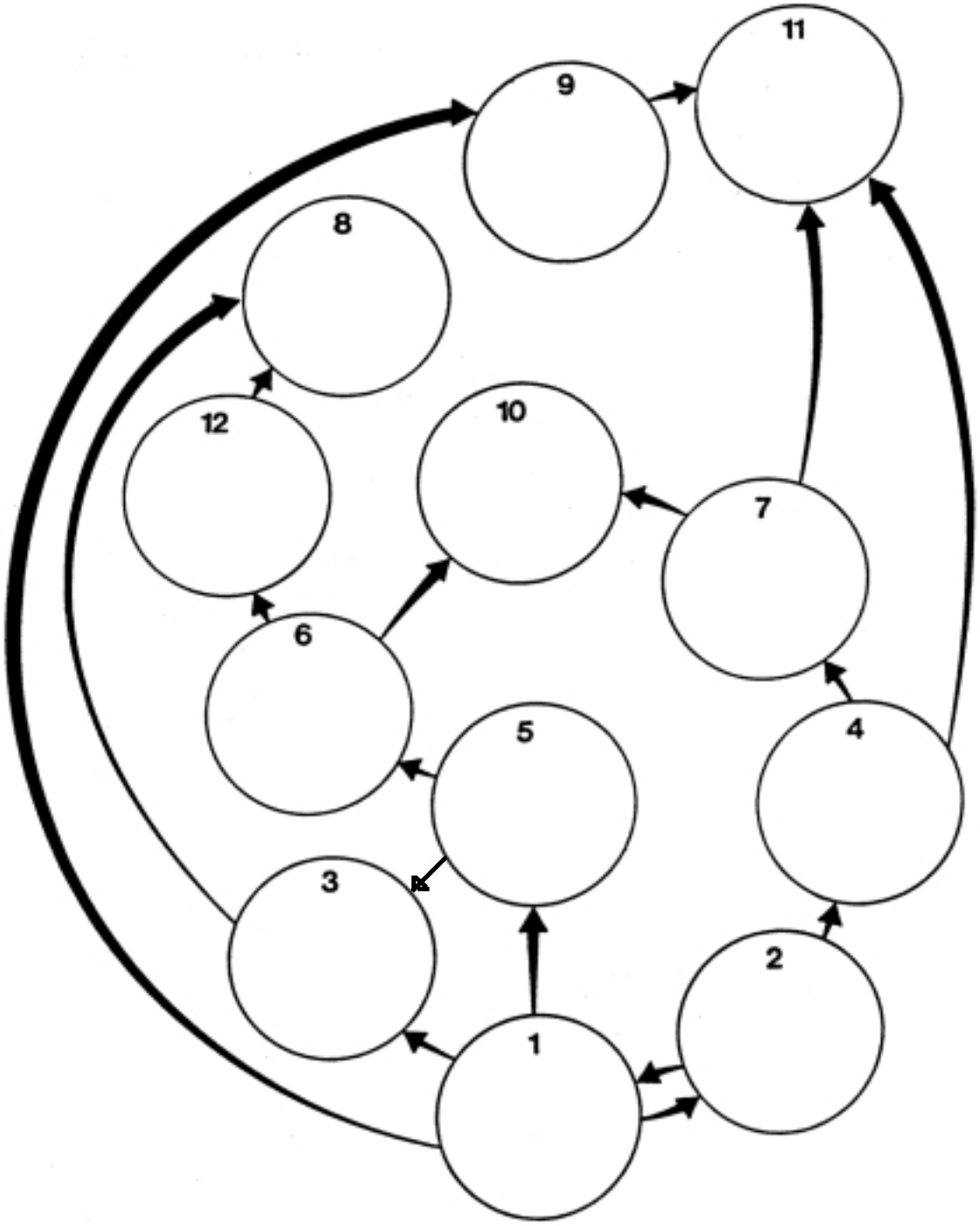
Complete the simplified food web for a mangrove habitat, using the following words to fill in the correct numbered circles: oyster, heron, amphipod, merlin (osprey or fish-hawk), human, plants, snake, frog, mangrove snapper, detritus, Black-Necked Stilt, crab.

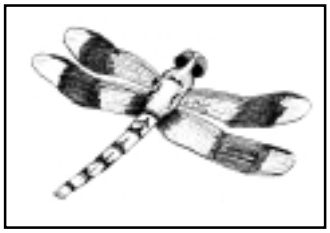
Clues for Numbered Circles

- These organisms use energy from the sun to make food.
- This is dead plant material enriched with bacteria and fungi. It returns plant nutrients to the mangrove.
- This black bird eats mainly insects and shrimp.
- These shelled animals live beneath Red Mangroves and filter-feed, concentrating on small particles of organic matter.
- This tiny invertebrate feeds on organic matter.
- This amphibian eats any small moving invertebrate.
- This vertebrate with fins lives underwater and feeds on bottom-dwelling invertebrates.
- This animal hunts for snakes, lizards, frogs, and small birds.
- This animal lives on the land and lays its eggs in the sea; it eats mostly plants.
- This long-legged animal can be seen patiently standing in shallow water looking for fish, frogs, snakes, and crabs to eat.
- 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.
- This animal slithers around to hunt for frogs and rats.

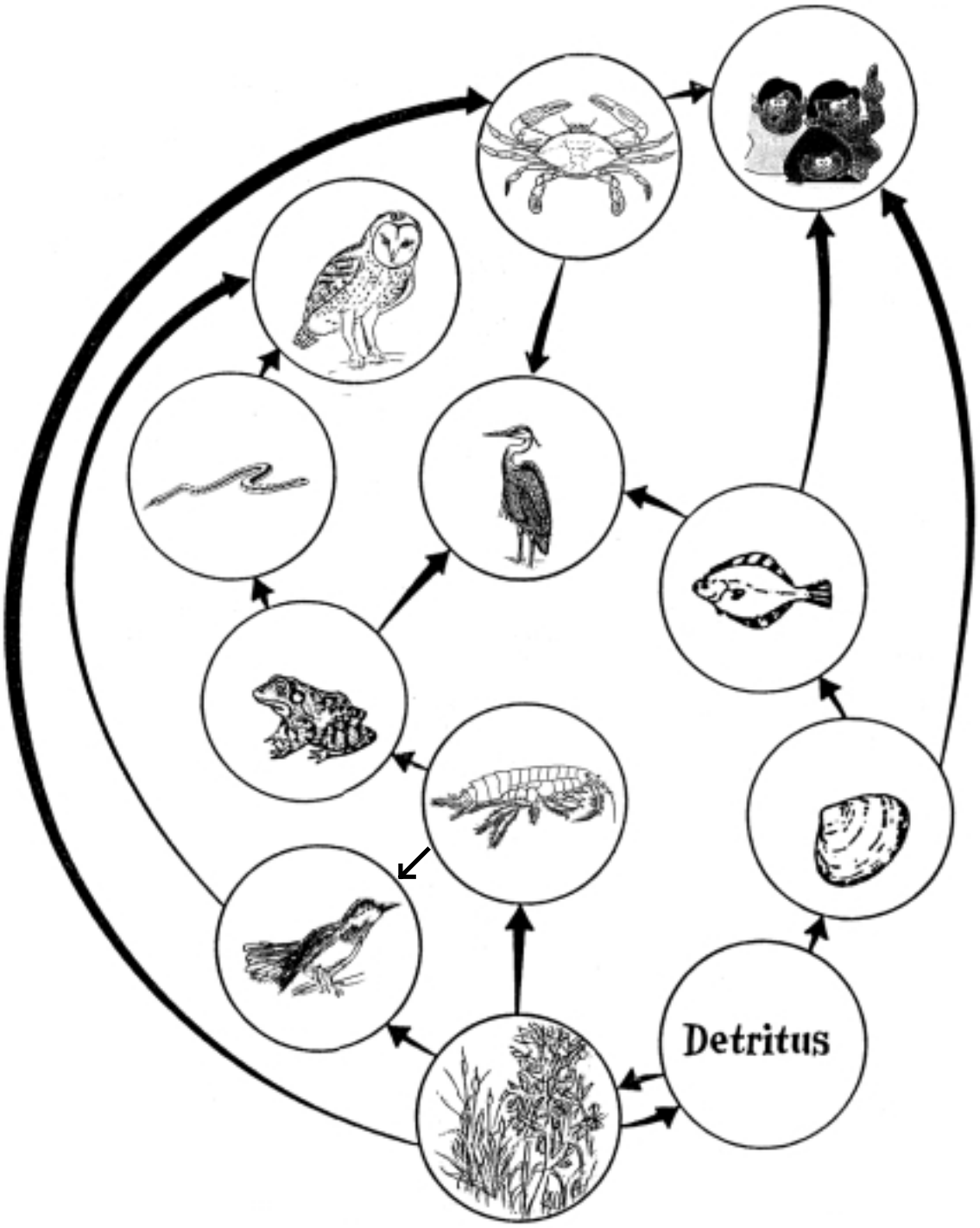


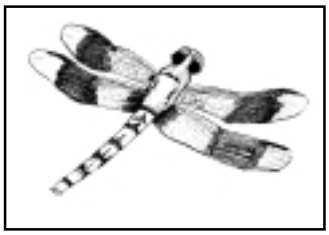
Mangrove Food Web





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 Sphyraena, the Great Barracuda.

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

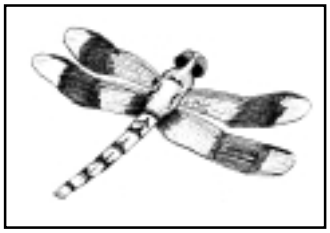
Time 30–60 minutes

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

blue sky in the upper section
an area of high land (bluff), coloured grey or black
an area of savanna, 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)
- mangrove trees—red, black, white, and buttonwood
- saltwort and sea grass
- animals that fly and live in the trees—boobies, frigatebirds, Yellow-throated Warblers, herons, pelicans, Ospreys (merlin or fish-hawk)
- reptiles that live in the trees—anole lizards and frogs
- spiders and insects— such as mosquitoes, dragonflies, 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, oys-



ters, sponges, sea squirts, snails, crabs (fiddler and mangrove), worms, amphipods, and water striders

- animals that live in the water (young, getting older towards the deeper water) such as turtles, barracuda, snapper, flounder, shrimp, upside-down jellyfish; birds such as West Indian Whistling-Ducks, 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.

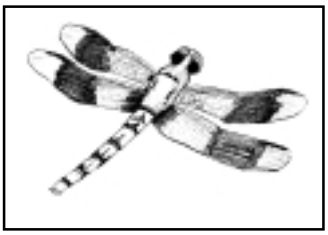
detritus—The term used to describe dead and decaying plants and animals.

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.)

MANGROVES AS HABITAT



DOES ANYONE KNOW what 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.

Sphyraena Barracuda, the Great Barracuda, was born from an egg tucked away safely behind a cluster of Red Mangrove roots. As he grows, before he moves to the reef 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 pinfish and mojarras in silvery schools. Still and silent, Sphyraena Barracuda 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 Sphyraena Barracuda is only six inches 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 great blue heron.]* Where would be a good place to hide? *[Among the roots of the Red Mangrove. 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? *[Ghost shrimp, mangrove crabs, fiddler crabs, young lobsters, amphipods, and isopods.]*

"Hmmm . . . looks like there are some interesting things to eat here," says Sphyraena Barracuda, as he spies a tasty ghost shrimp. The amphipod and the ghost shrimp 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**.

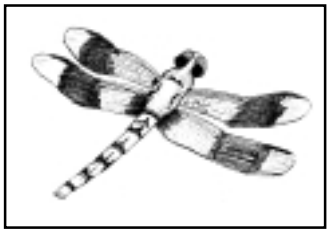
Where did this rich stuff come from? It is made up of dead and decaying plants and animal material that have fallen from the mangrove trees and flowed down from the land when it rained. There is a good supply of invertebrates here in this rich habitat, and the barracuda's survival depends on this healthy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

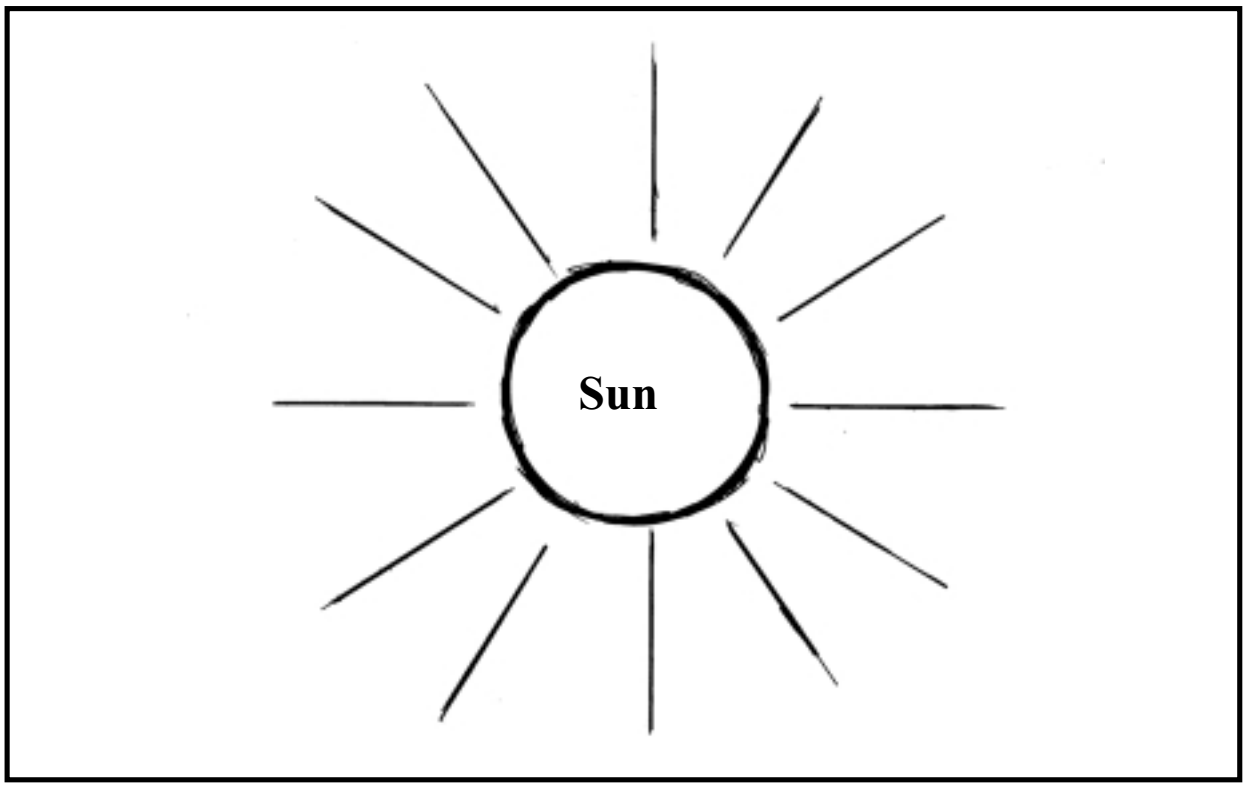
Let's review what the young barracuda needs in order to survive.

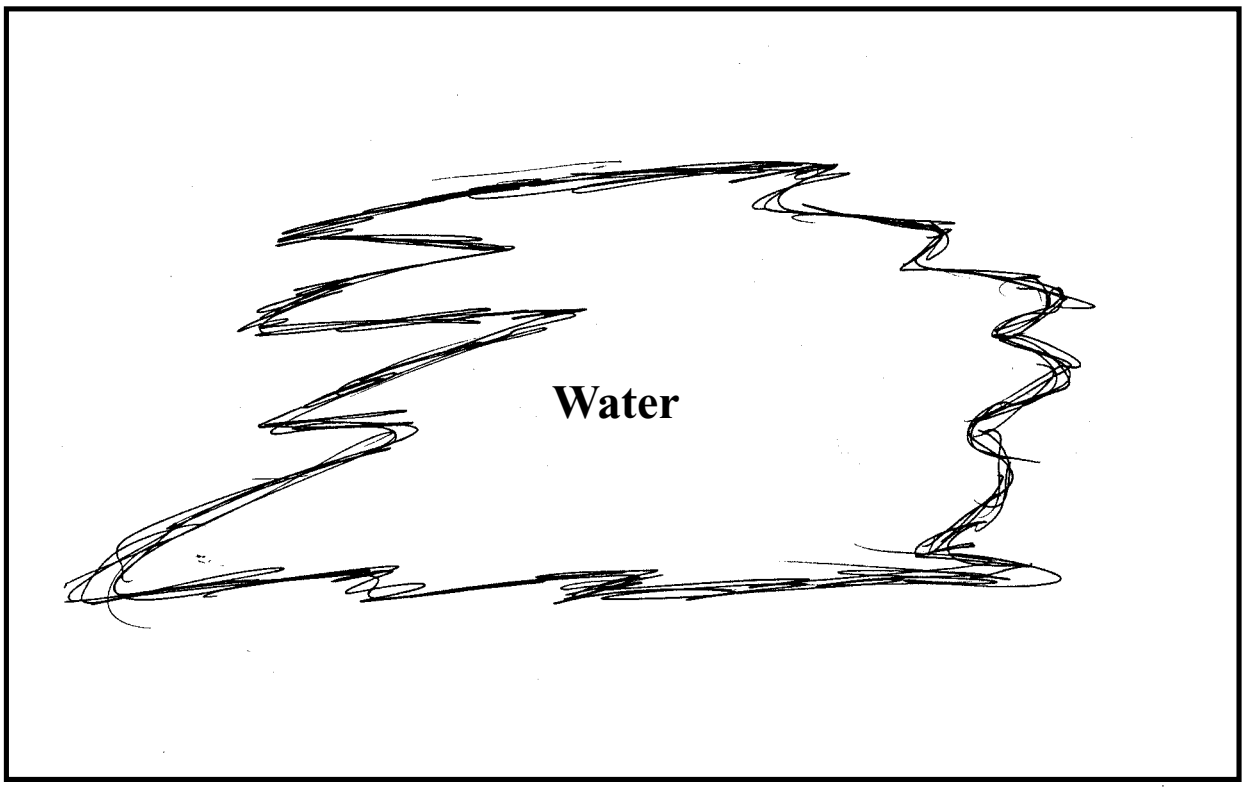
- *Food*—The barracuda eats tiny fish, fry, and some aquatic insects like isopods and amphipods.
- *Shelter*—The Red Mangrove roots give the barracuda a place to hide and find food, and also shelter the food the barracuda needs.
- *Water*—All animals need a good supply of water. In the years when there is drought, barracuda sometimes find it hard to make it back into the mangroves 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 barracuda needs adequate space. If a species is overcrowded, there is too much competition for food, and the animals become stressed.

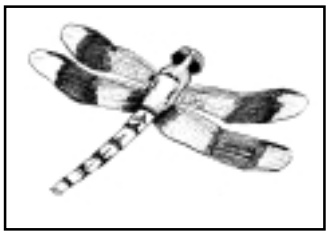
All these factors make up habitat.

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.

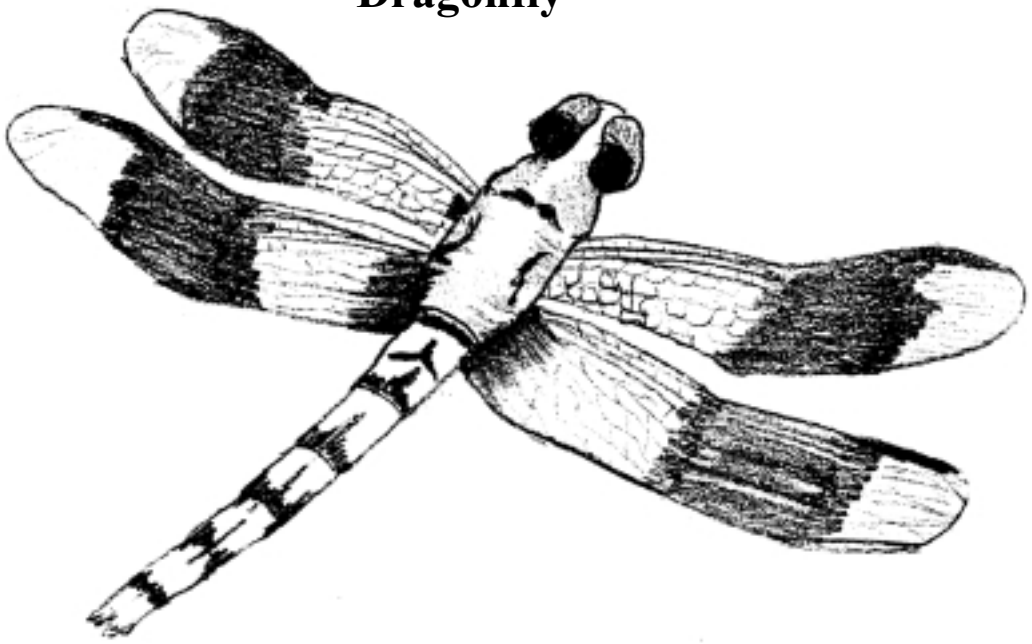



Sun

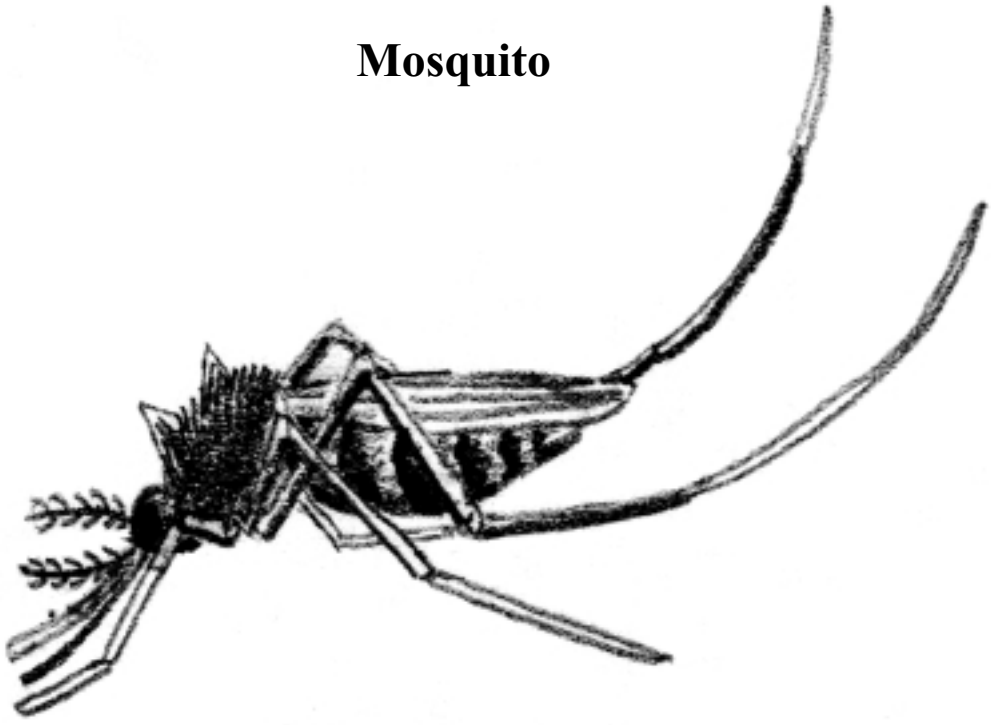

Water

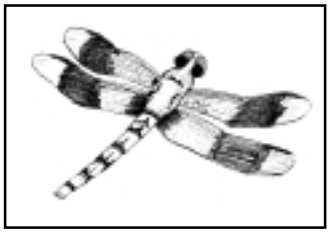


Dragonfly

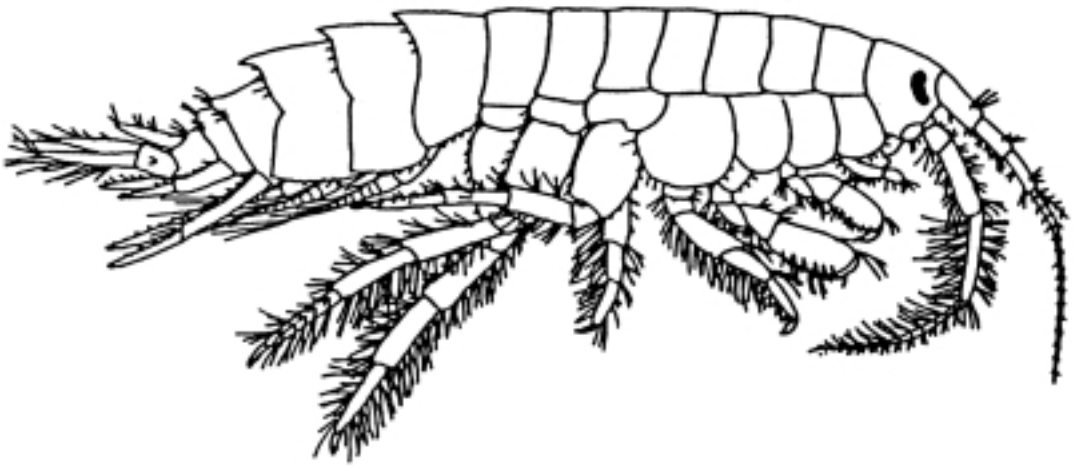


Mosquito

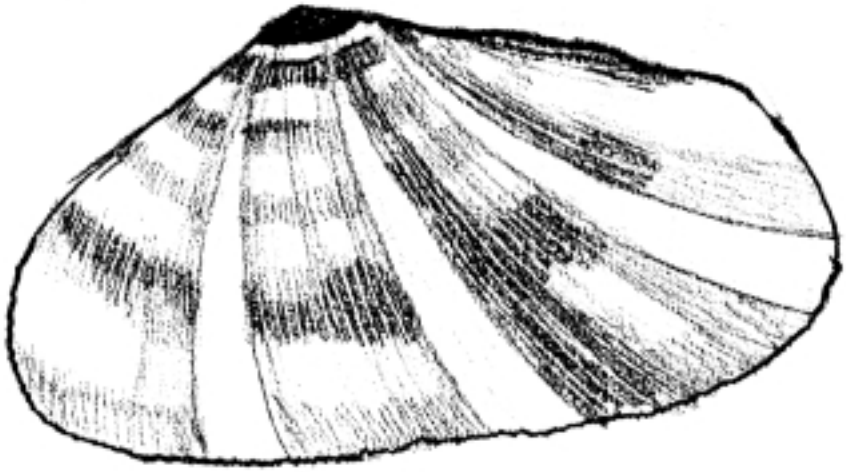


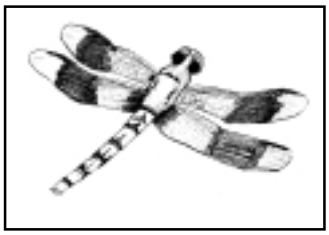


Amphipod

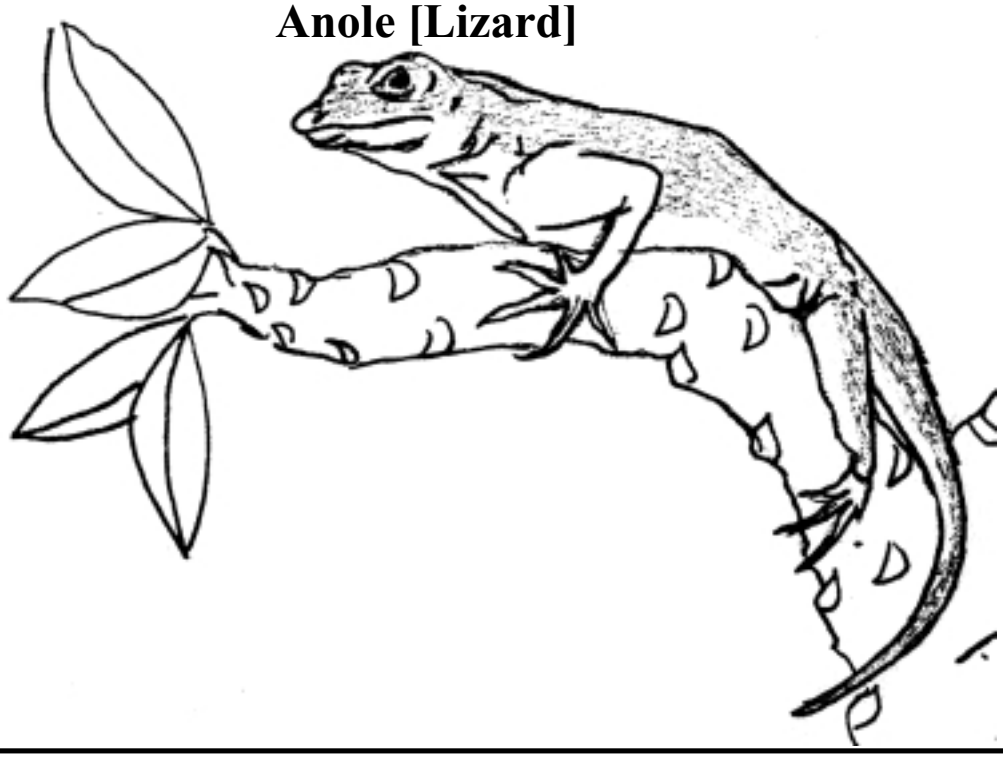


Mangrove Oyster

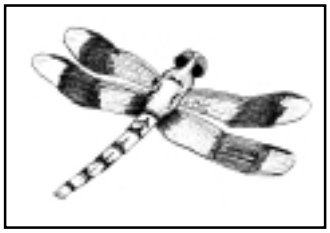




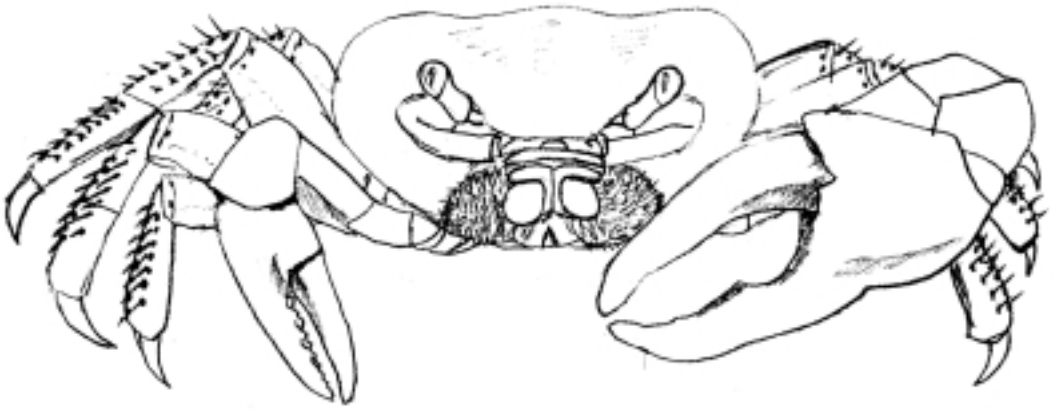
Anole [Lizard]



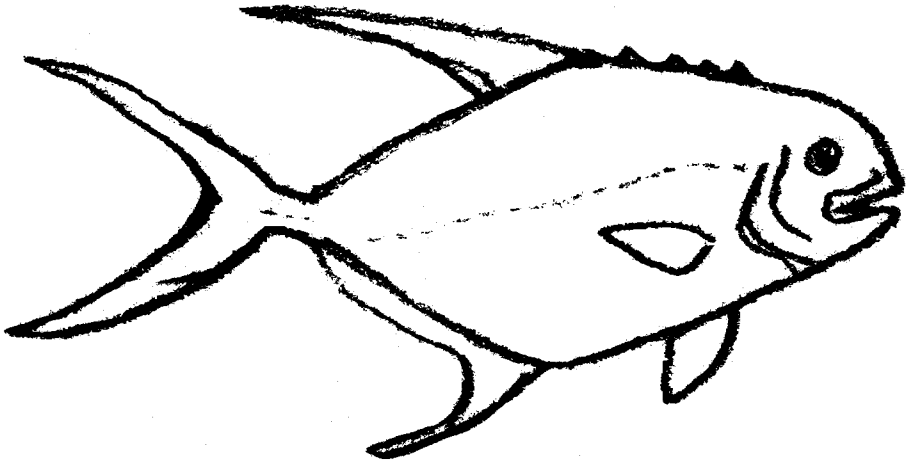
West Indian Whistling-Duck

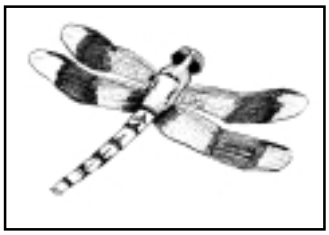


Great Land Crab

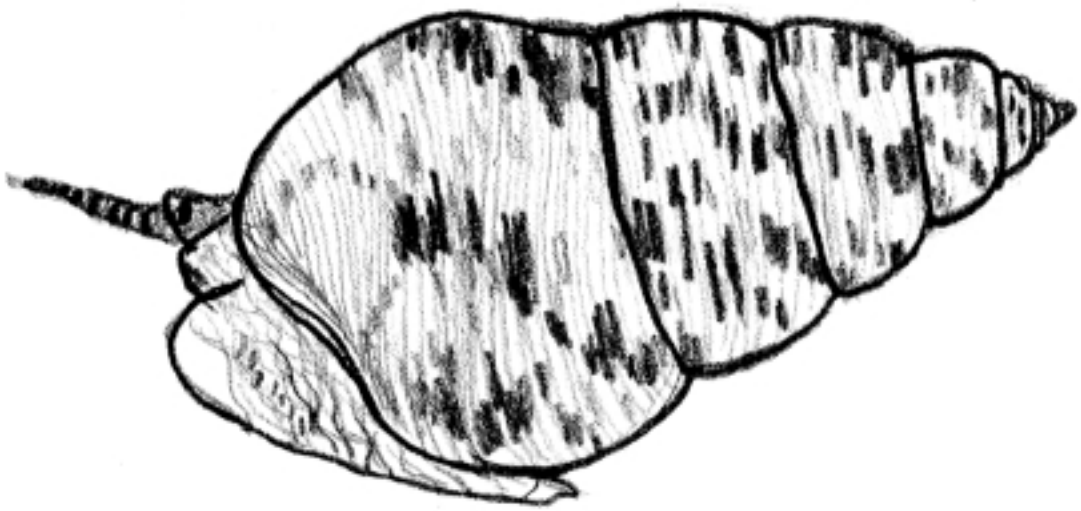


Permit

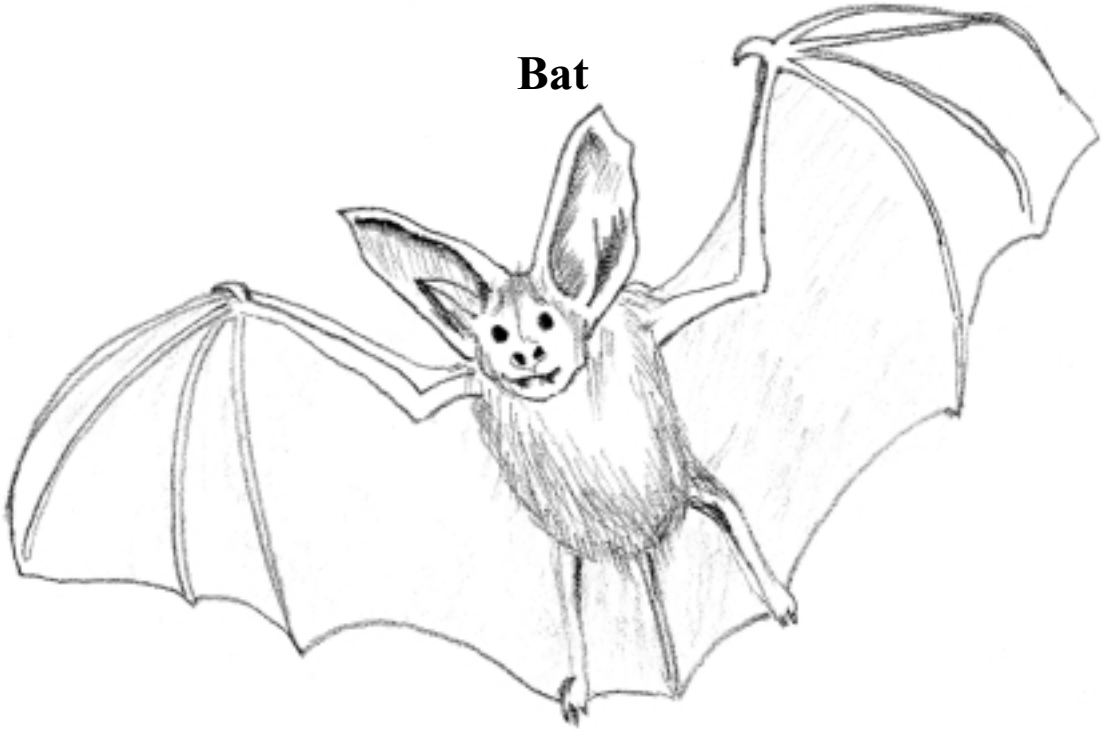


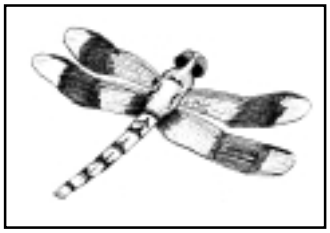


Mangrove Snail

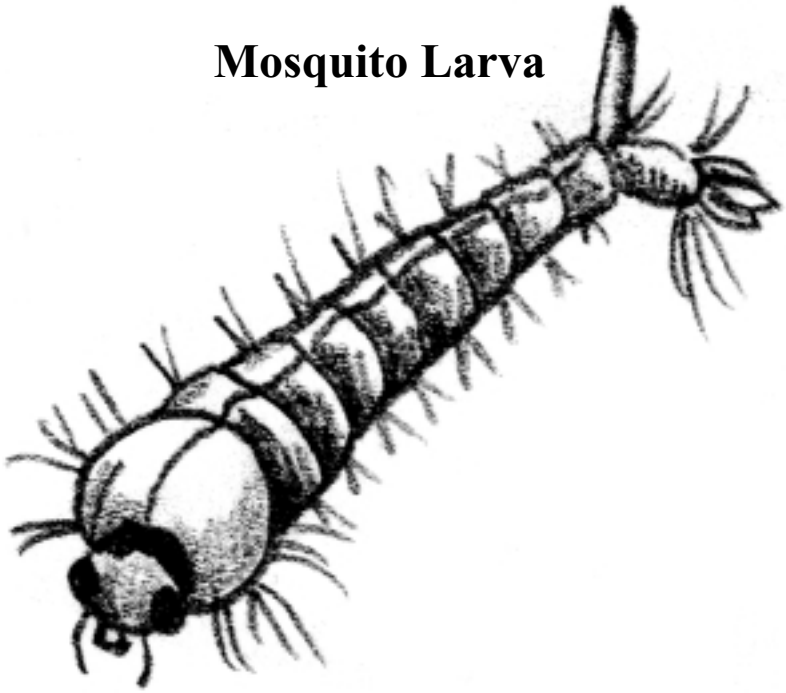


Bat

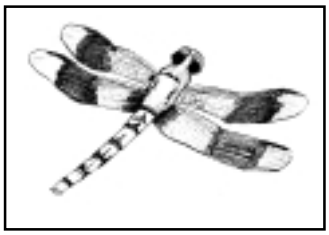




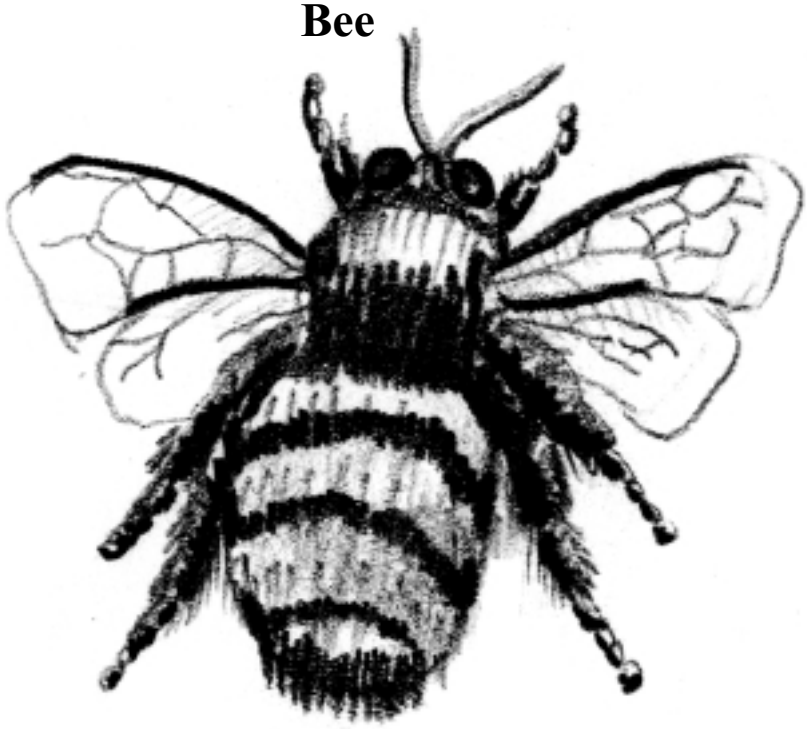
Mosquito Larva



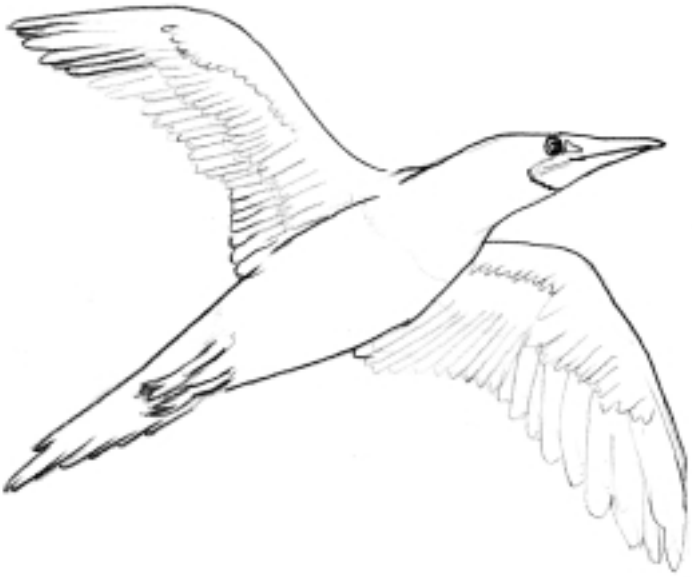
Detritus

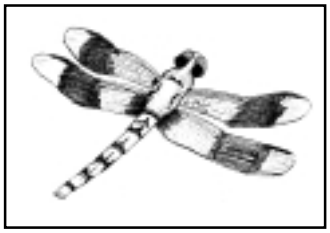


Bee



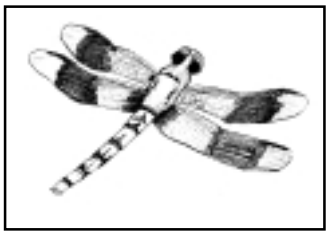
Red-footed Booby





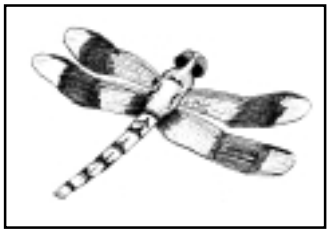
Black Mangrove

Ching Ching

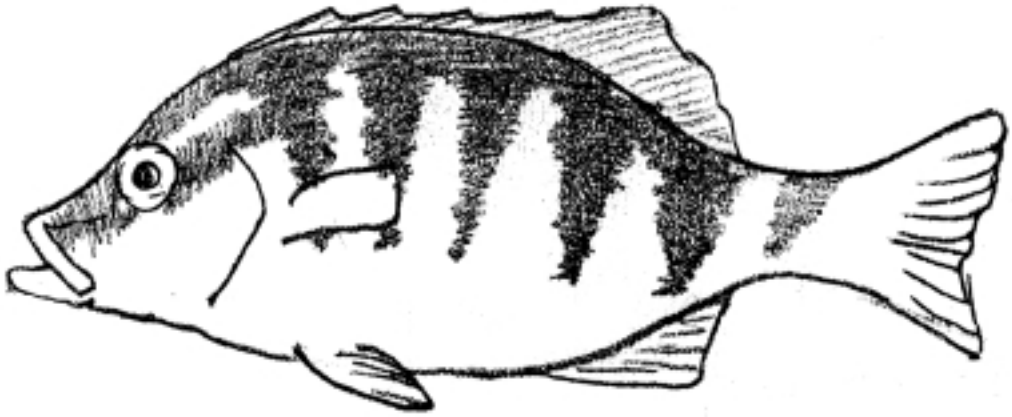


Red Mangrove

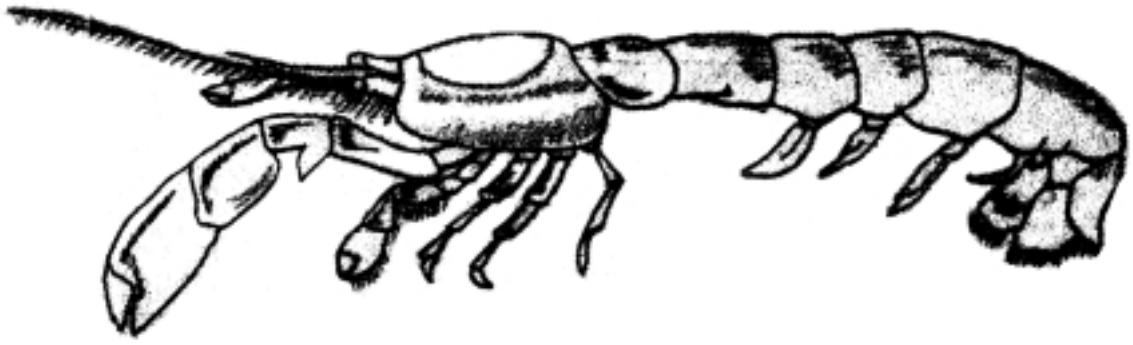
Great Blue Heron

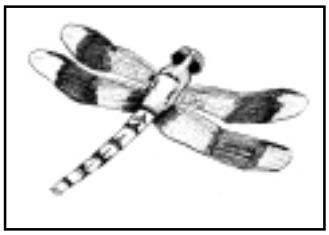


Mangrove Snapper

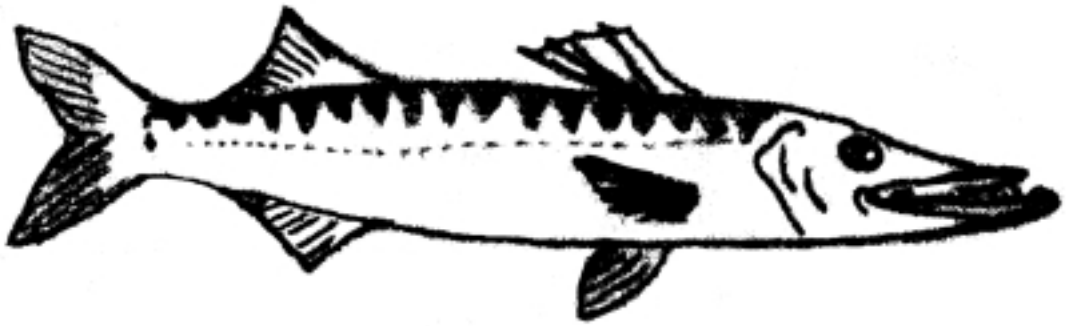


Ghost Shrimp

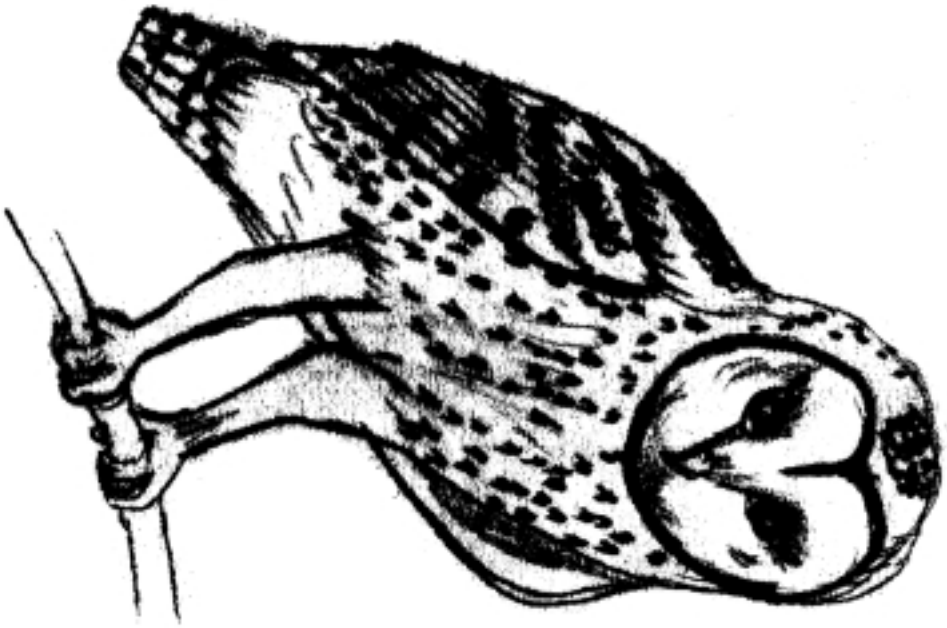


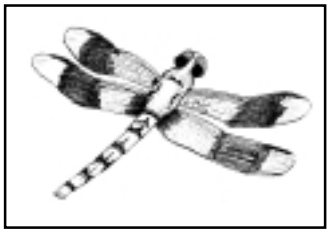


Barracuda



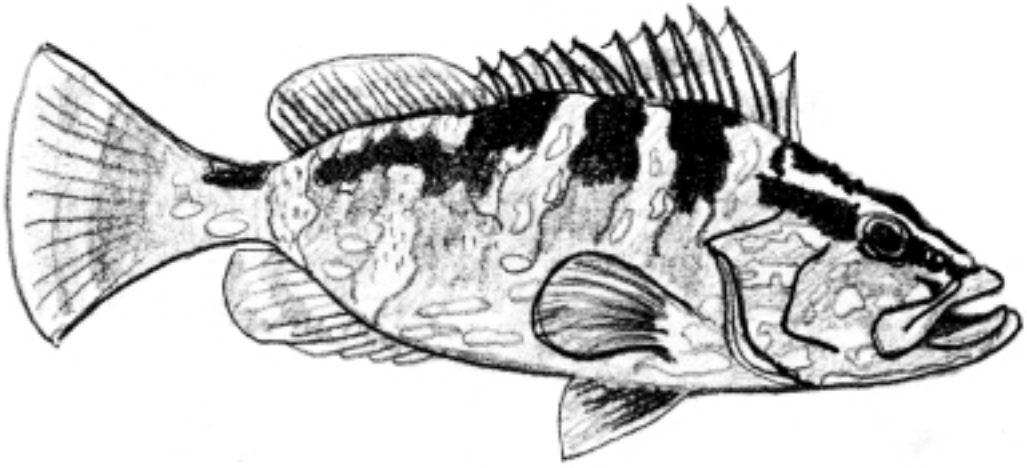
Barn Owl

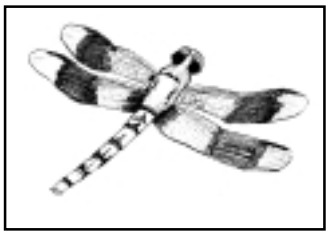




Land Crab

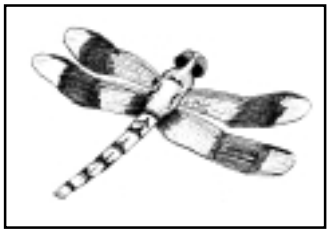
Nassau Grouper



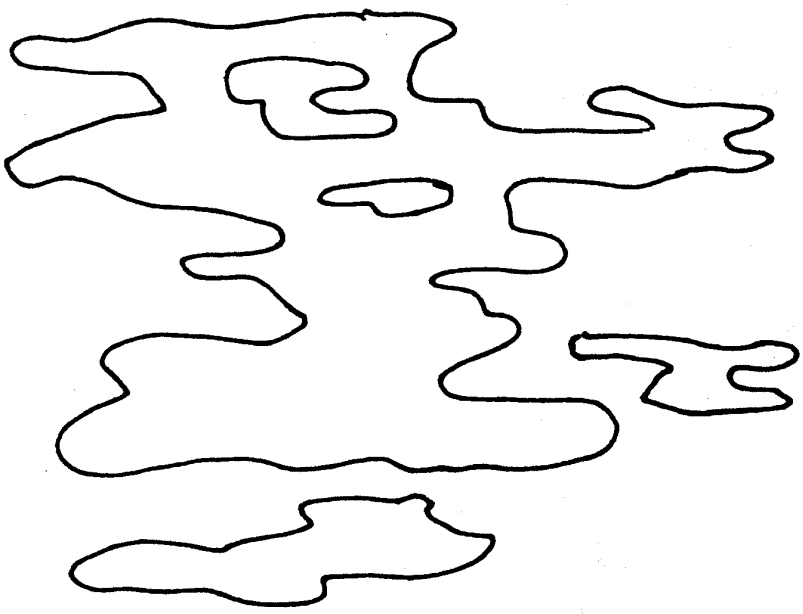


Turkey Vulture

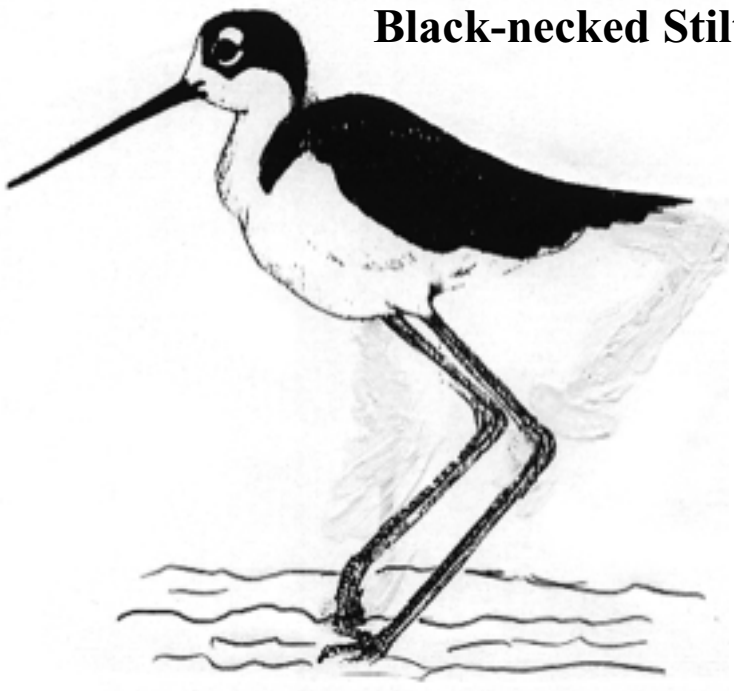
Nesting Red-footed Booby

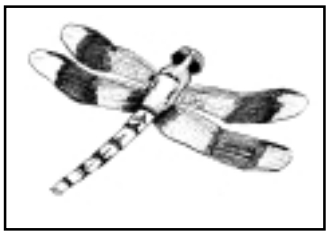


Algae



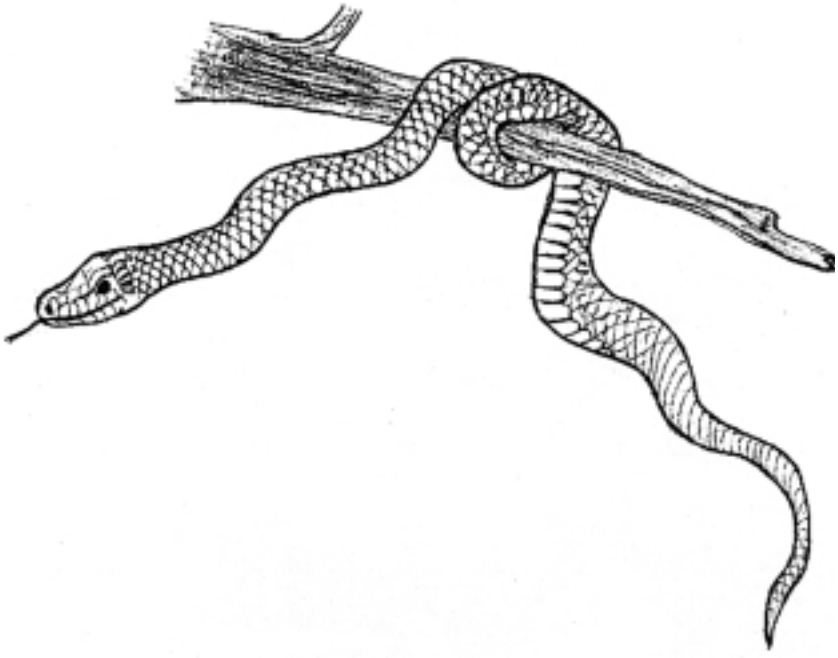
Black-necked Stilt

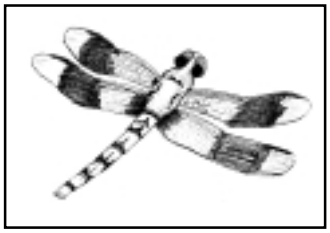




Warbler

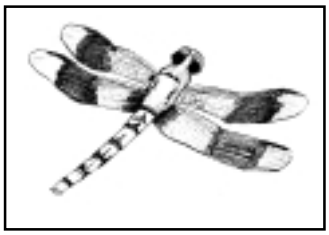
Snake



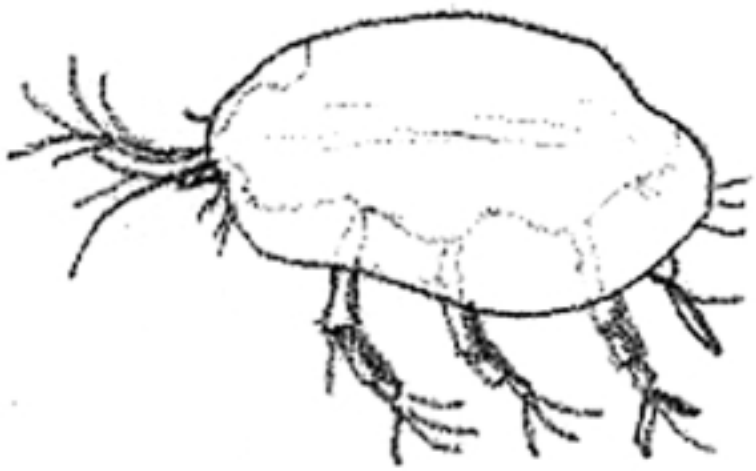


Frigate nesting

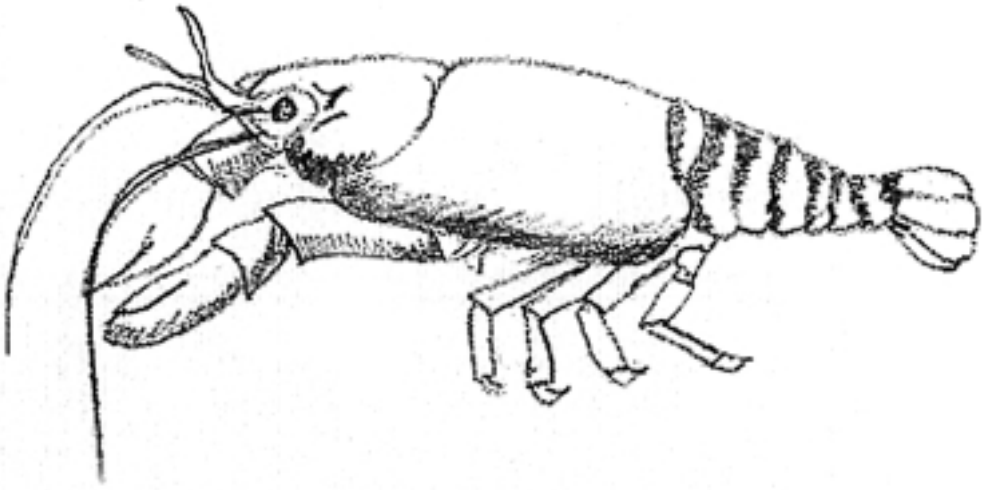
Osprey

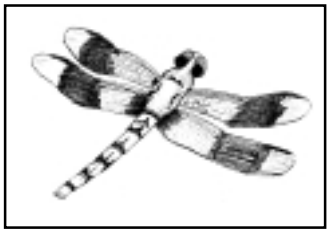


Seed Shrimp



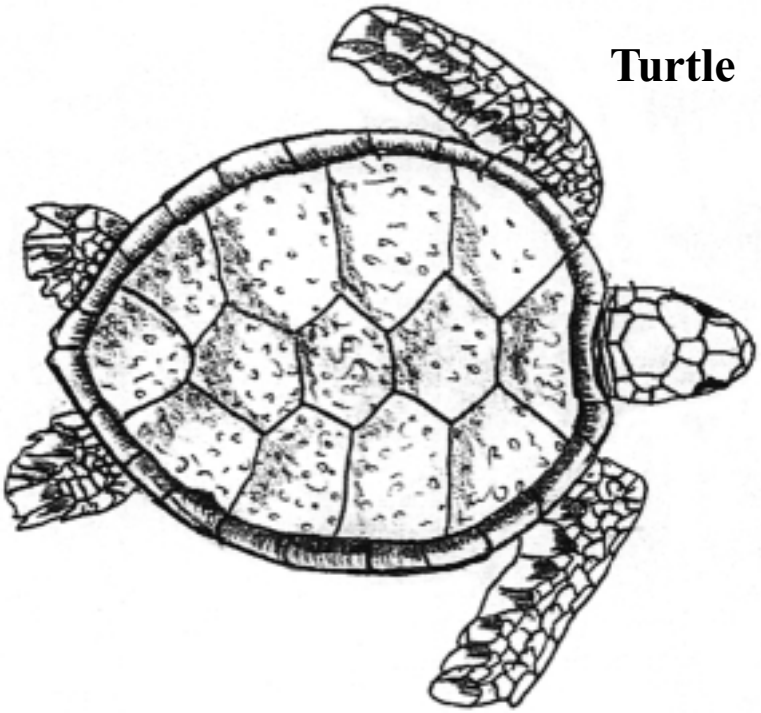
Crayfish

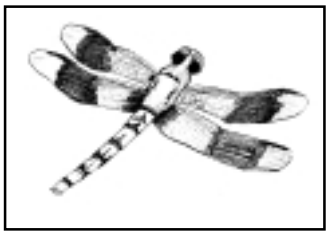




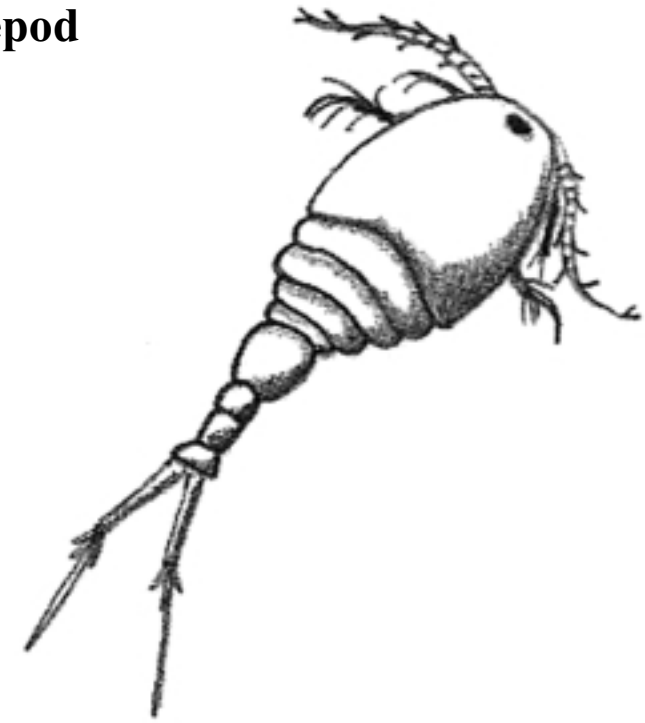
Frog

Turtle

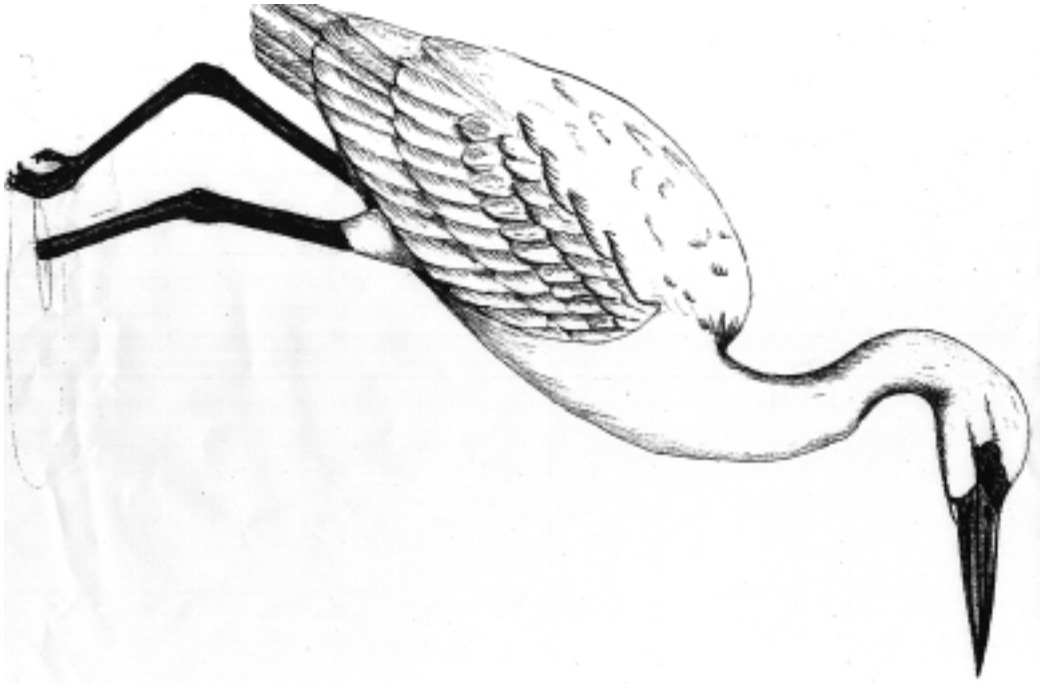


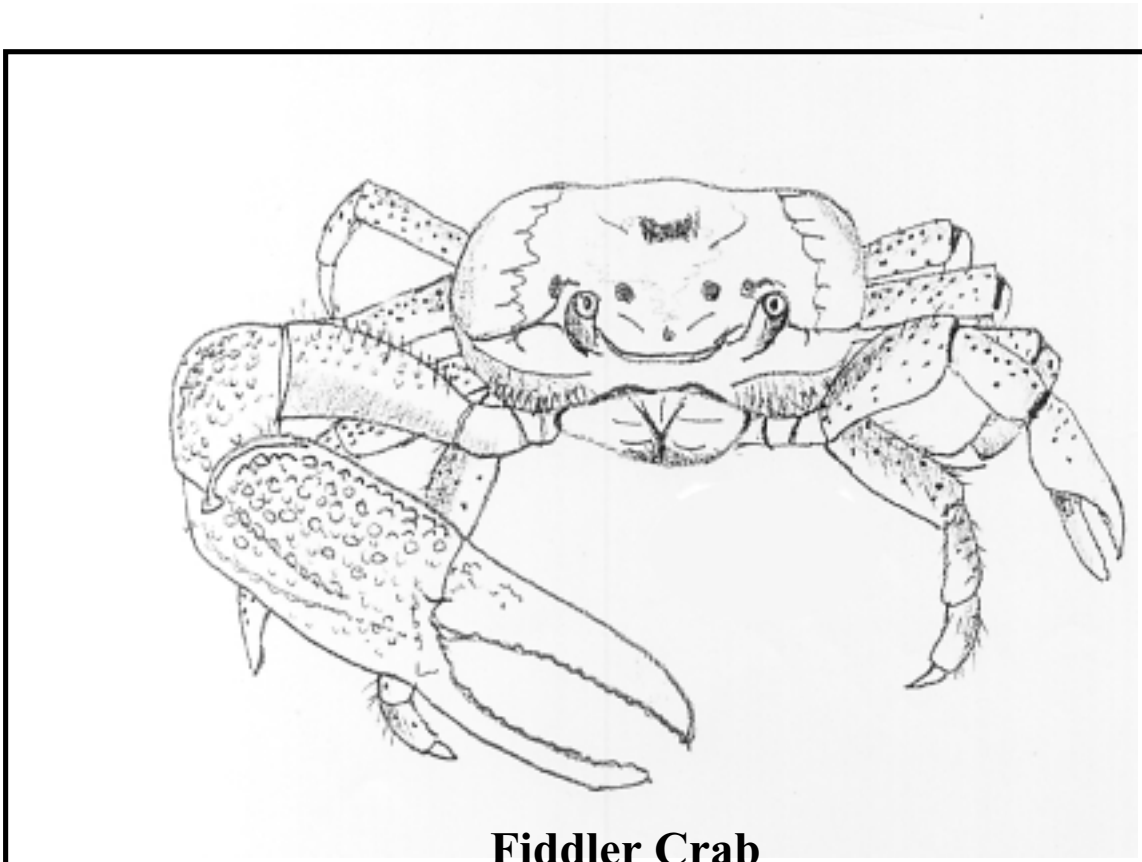


Copepod

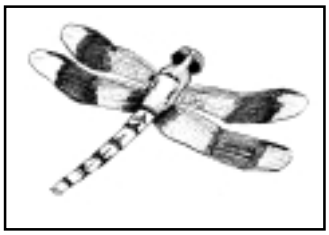


Egret





Fiddler Crab



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 mangrove wetlands from the plants and animals that live there.

Age Levels 4–11

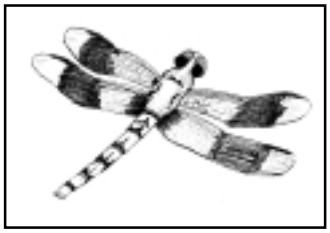
Subject Area Science

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 (Black 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)
Black Mangrove root
Saltwort or other mangrove plant

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 artifacts 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 mangrove wetlands 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.

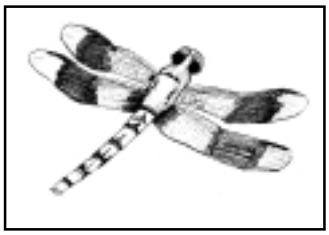
4. While feeling the item and smelling it (if appropriate), the student describes how it feels and smells, then tries to guess what it is. If necessary, the class may help with clues.

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

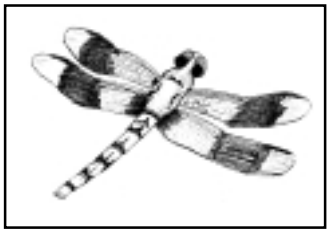
Materials A ball of string or thick wool at least 20–30 m (65–100 ft) long
Picture cards from pages 2-22 to 2-42 (see following list)

sun, water, Phytoplankton, copepod, algae, detritus, crab larvae, mangrove trees (red, black, and white), amphipod, brittle star, mangrove oyster, fiddler crab, mangrove crab, land crab, mangrove snapper, green turtle, frog, West Indian Whistling-Duck, anole (lizard), Osprey, Great Egret, parrot, Yellow Warbler, flamingo, dragonfly, mosquito, crayfish

Pictures of items can be photocopied from the drawings on pages 2-22 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 Black-necked Stilt that eats tiny fish and invertebrates in the mud and nests on the ground at the edges of ponds; and the Great Egret that wades in the water hunting for fish. 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 2-6 shows these links in more detail.

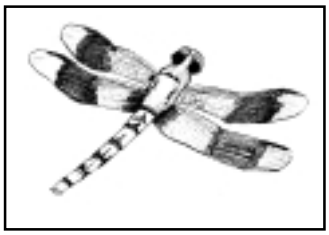
Procedure **1.** Attach a card representing a member of the mangrove ecosystem (including sun, water, sediment, Phytoplankton, algae, detritus, leaves) to each student.



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 calls 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 life (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, overhunting, 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 Language arts, 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

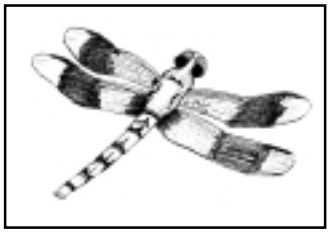
(This story has been adapted from a Central American tale told by the Nicarao people of Nicaragua, and depicts what happens one springtime to the talkative, self-centred Mr. Frog. You can set it in any mangrove or other wetland near your own school. If you give Mr. Frog a strong local or regional accent,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

JUST DOWN THE ROAD, in a pond at the edge of the Central Mangrove swamp, lived a handsome young frog who 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 who 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 impor-



Mr. Frog Dreamin'

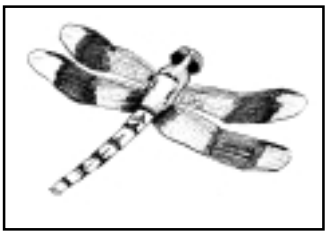
tant to do. They would dive to the bottom of the pond to look for something to eat, or hide behind a mangrove tree. They would do everything they could to avoid him.

But Mr. Frog didn't care, because he had the birds to talk to. Every spring and fall, when the migrating birds 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 the Central Mangrove 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.



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 up from Colombia. 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 to Canada. 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.

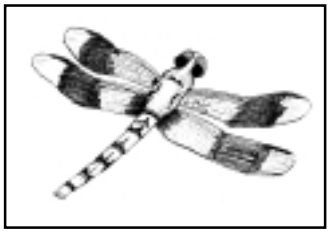
"A dream, Mr. Frog?" they asked. "What kind of dream?"

"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."

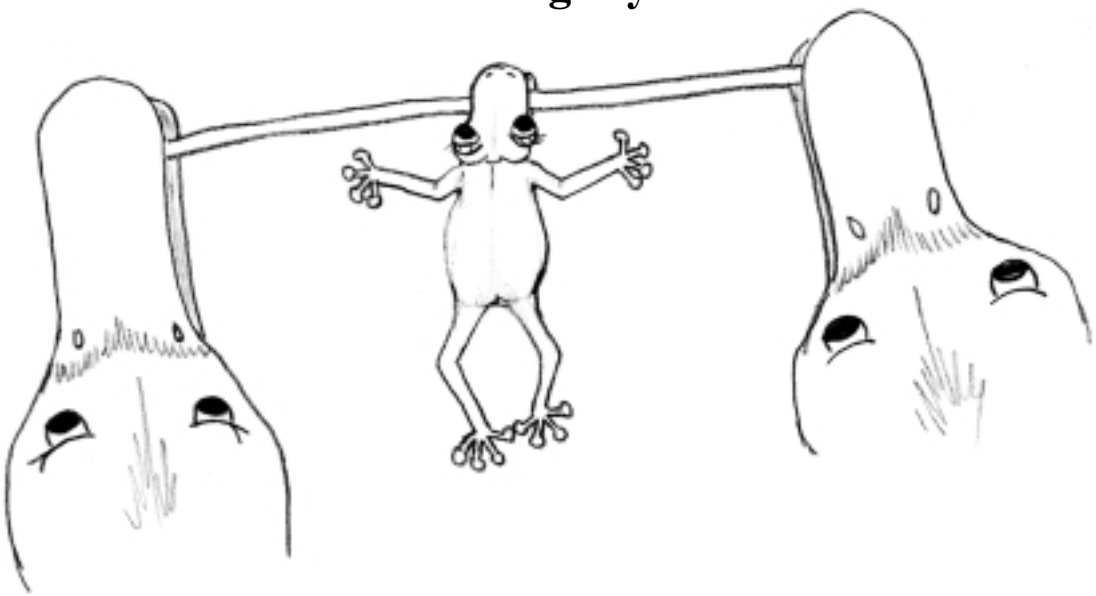
So Mr. Frog swam happily to the edge of the pond, found the perfect reed, and swam back with it in his mouth. He gave one end to each of the ducks to carry in their beaks, and was about to grab the middle in his mouth when the oldest and wisest duck said, "Now, Mr. Frog, a word of warning, and a word 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**."

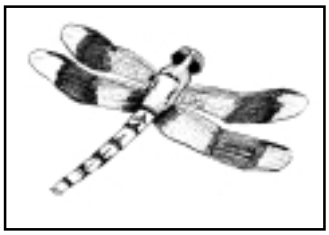
"Moi? Open my mouth? Oh, you make a silly joke, yes? I would never do anything so stupid," protested Mr. Frog.

"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

Mr. Frog Flyin'





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 to Canada. 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.

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.

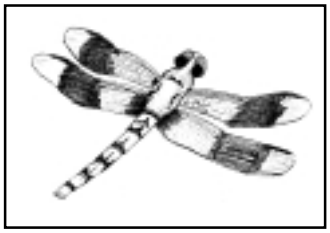
After a little while, he made his way woozily to the surface. His ego was totally deflated. So he found his favourite lily pad and sat there, staring miserably into the water.

When the pond grew calm again, all the creatures gathered round him. And 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: 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 Language arts, art

Time 30–60 minutes

Materials Story
Handout: illustration of Fiddler Crab on page 2-53

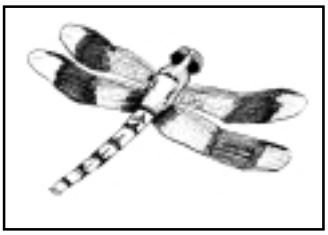
Background Fiddler crab data from the introduction to this section.

Procedure **1.** Preparation: Ask students to sketch a Fiddler Crab (or show them an illustration of a fiddler crab from page 2-53).
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.]*

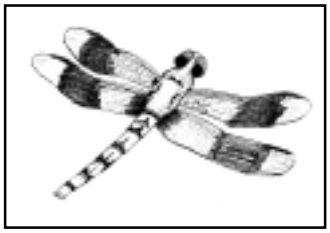
Crusty awoke one morning to the cries of a gull overhead: "SCREEETCH, SCREEETCH." He stuck his eyes out from underneath his favourite mangrove root. Crusty's eyes, like those of all fiddler crabs, are on stalks and move like a computer-game joystick so he can see all around. Crusty waved his big claw 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.

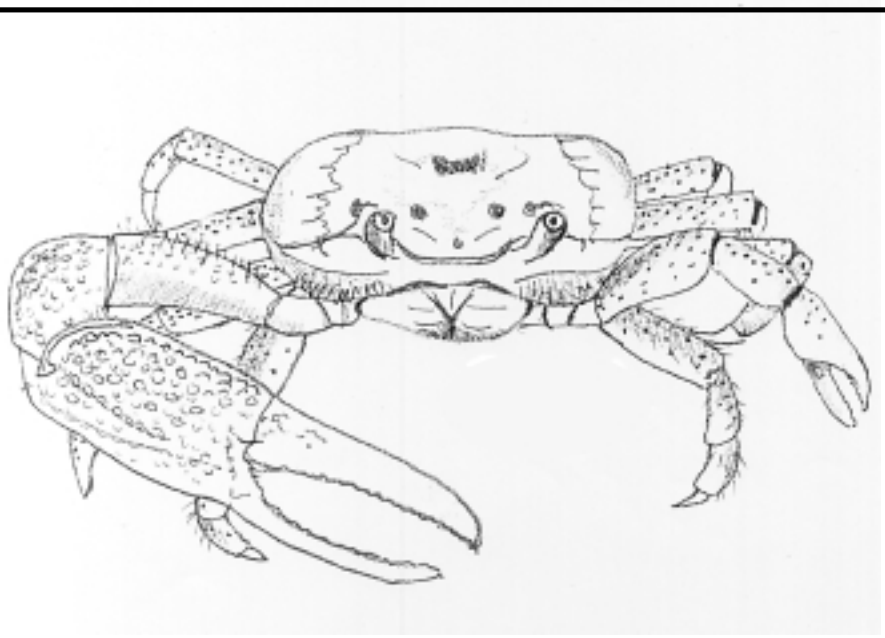
When a crab's tough outer covering becomes too small, the back splits open. The back end of the crab's body pops out first. Then the crab pulls and tugs each of its walking legs and pincers out of the old covering like a person taking off a coat and gloves. The crab still has a covering on its body, 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



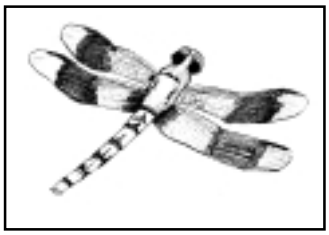
shedding of the covering is called **moulting**. Can you name other animals that moult their outer covering? *[Grasshoppers, cockroaches, some other insects, and snakes.]* Crusty knew that with each moult to follow, he would grow some more of the new leg to replace the one he lost when the big wave hit. 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 tidepool.]* 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 tidepool 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.



Fiddler Crab



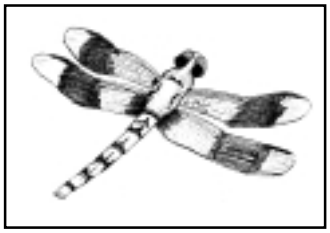
Why Bird-watching?

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 mangrove wetlands (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 on your island. Slide presentations and colour photographs are effective tools to help students learn about the birds they might see on the field trip. The West Indian Whistling-Duck slide show includes slides of many of the kinds of birds you are likely to find in your local wetland, and can be obtained by contacting the addresses listed in the Resource Section. The National Trust office or birding club 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 instill in children a basic understanding of nature, they will grow up to be more environmentally sensitive and responsible adults.



Activity 2-H: 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

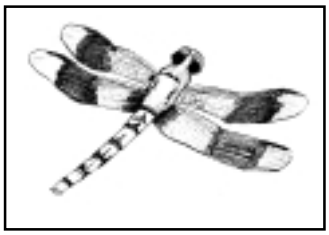
Materials Collection of contour and down feathers
Paper and pencils
Small amount of salad oil
An overhead projector (if available)
Handout: copy of page 2-58 illustrating feathers

Background What makes birds different from all other animals is that they have feathers. Other animals— bats, flying squirrels, and many kinds of insects—can fly; reptiles, fish, insects, and some mammals (duck-billed 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



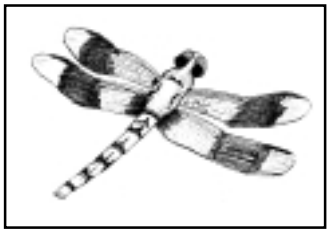
squeezes oil from this gland and then works it into the feathers, drawing one feather after another through the clamped bill. The oil cleans and conditions the feathers and makes them waterproof. It is also thought to inhibit the growth of fungi and bacteria.

Procedure

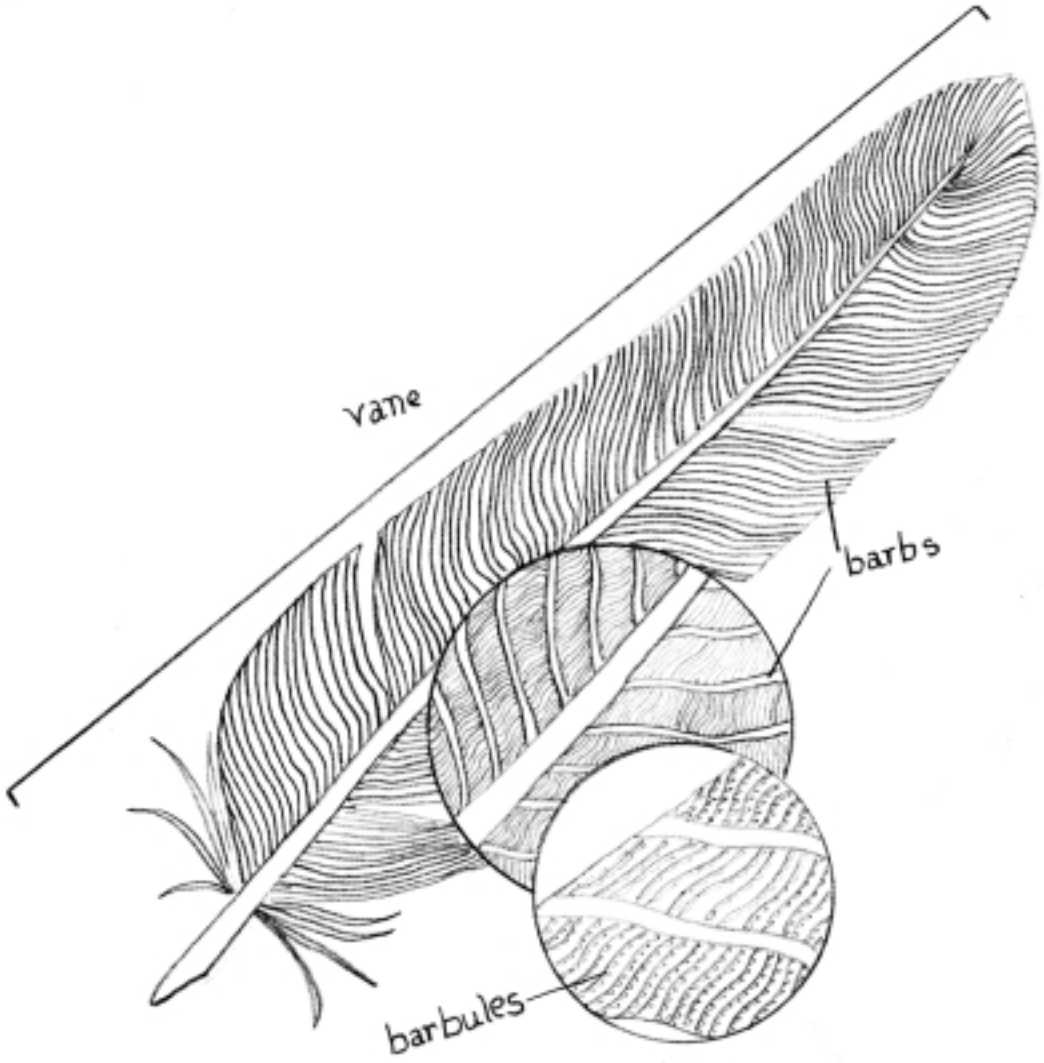
1. Several days before the class, have students collect and bring in feathers. It doesn't matter if these come from wild birds or from chickens—feathers are feathers!
2. Let students explore how they can "ziplock" the feathers together by running their fingers along them. Compare flight/contour feathers 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.

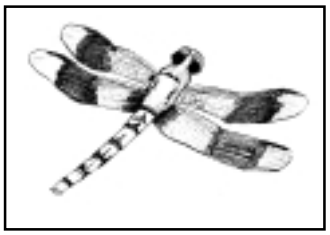
Discussion/Reflection

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.)?



Feather Features





Activity 2-I: 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

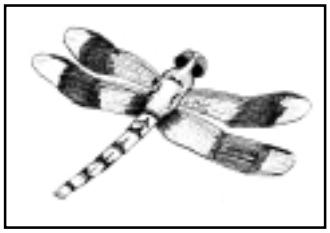
Time 60 minutes

Materials Handouts: copies of page 2-61 illustrating wing and arm structure
Copies of "Flappers" from page 2-62
Eight index cards (3 x 5 inches) 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, vultures, and frigatebirds 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 thrushes, 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.

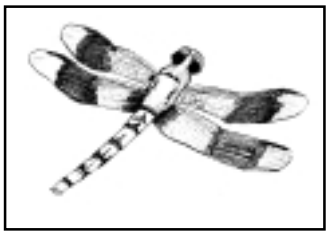
Procedure **1.** Working in teams, students will extend their arms and locate the following bones and structures shown on the handout: humerus, radius, ulna, wrist, and fingers.



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.

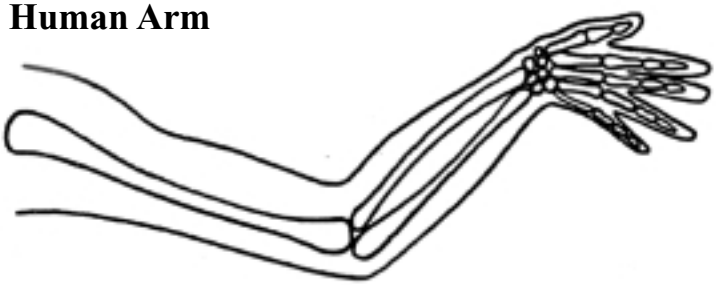
Discussion/Reflection

Ask each student to move his or her arms like a bird. Discuss how a real flight pattern is different from "Flappers".

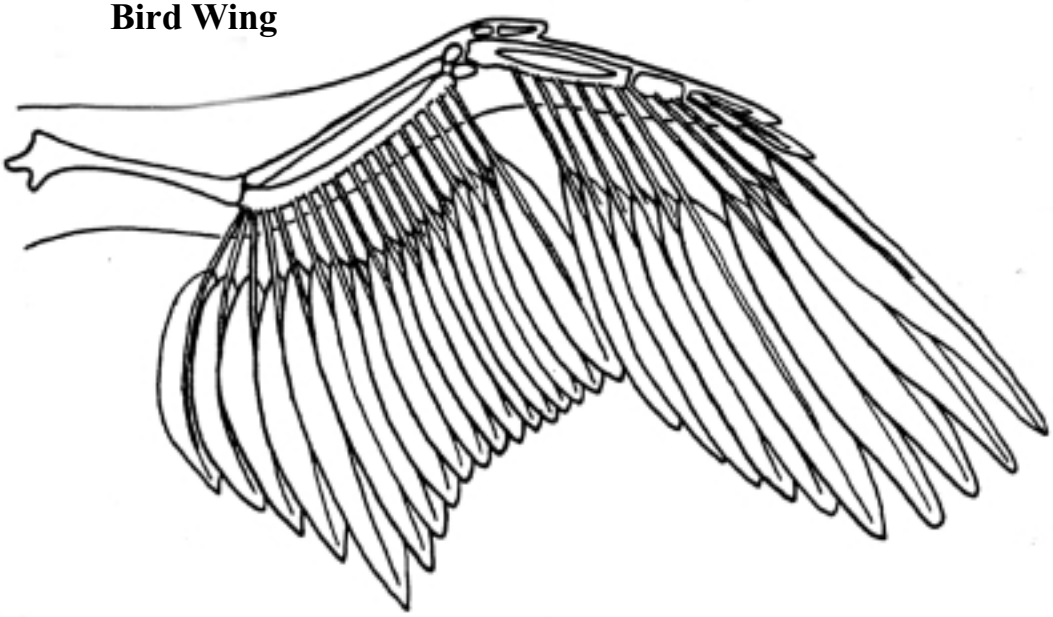


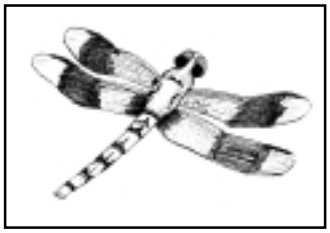
Bones and Feathers

Human Arm

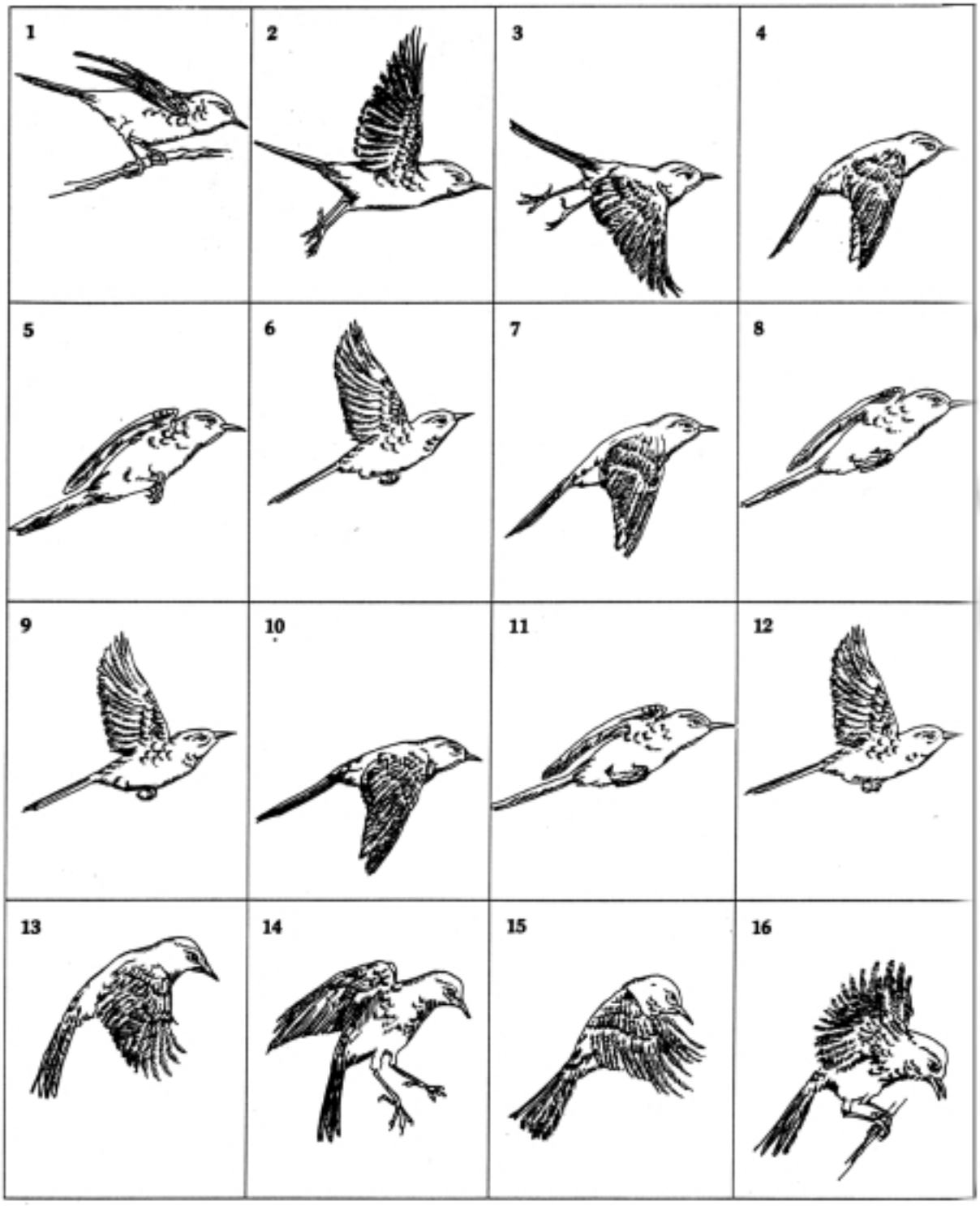


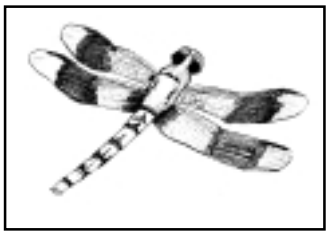
Bird Wing





Flappers





Activity 2-J: 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

Tim 2 hours

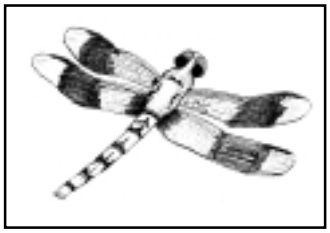
Materials Copies of "Fill the Bill Matching Game" from page 2-67
Two aquariums or other large clear containers
Large saucepan
Tall, narrow vase, bottle, or glass jar
Small log or large tree branch
Long piece of string

Foods

- Raw rice
- Rice cereal (like Puffed Rice or Rice Krispies)
- Plastic fishing worms or three-inch pieces of string
- Popcorn or tiny marshmallows
- Styrofoam chunks or pieces
- Oatmeal (oats porridge)
- Walnuts (whole) or other nuts
- Seagrapes 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

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 Caribbean and live in a variety of habitats.

Snipes, sandpipers, and **stilts** have long beaks that they use to probe for worms, crustaceans, and other small creatures in mud and water.

Roseate Spoonbills and **pelicans** have long flattened and pouch-like beaks that they use to scoop up fish and other aquatic creatures.

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

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

Parrots 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.

Bullfinches, grassquits, waxtails, and other **finches** have short, conical beaks that are very strong and can break open seeds.

Warblers have small, sharp, pointed beaks for picking insects from leaves, logs, and twigs.

Nighthawks, swifts, and **swallows** have large, gaping mouths that act like nets to trap insects. These birds catch insects on the wing.

Procedure **1.** Set up seven 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 (snipes, sandpipers, and stilts)

Tools:

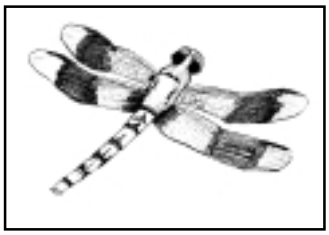
chopsticks, toothpicks, or twigs*

pliers or nutcrackers

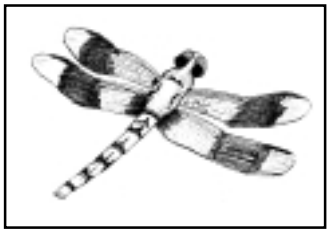
strainer

Station 2: Whole walnuts or other nuts to represent seeds with hard coverings, such as sunflower seeds and pine seeds (bullfinches, grassquits, buntings, and other finch-like birds, and also 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. (Roseate 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 (flamingos and 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 (nighthawks, swifts, and swallows)
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 (warblers)
Tools:
tweezers*
chopsticks
strainer
Station 7: Cherries or seagrapes hanging from a string to represent fruit hanging from a branch (parrots)
Tools:
eye dropper or straw
strainer
nutcracker or pliers*
2. Pass out the copycat page on page 2-68
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



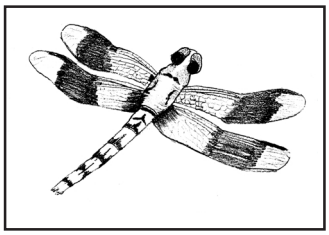
the “Fill the Bill Matching Game”. (You may want to set a time limit at each station to keep things moving).

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

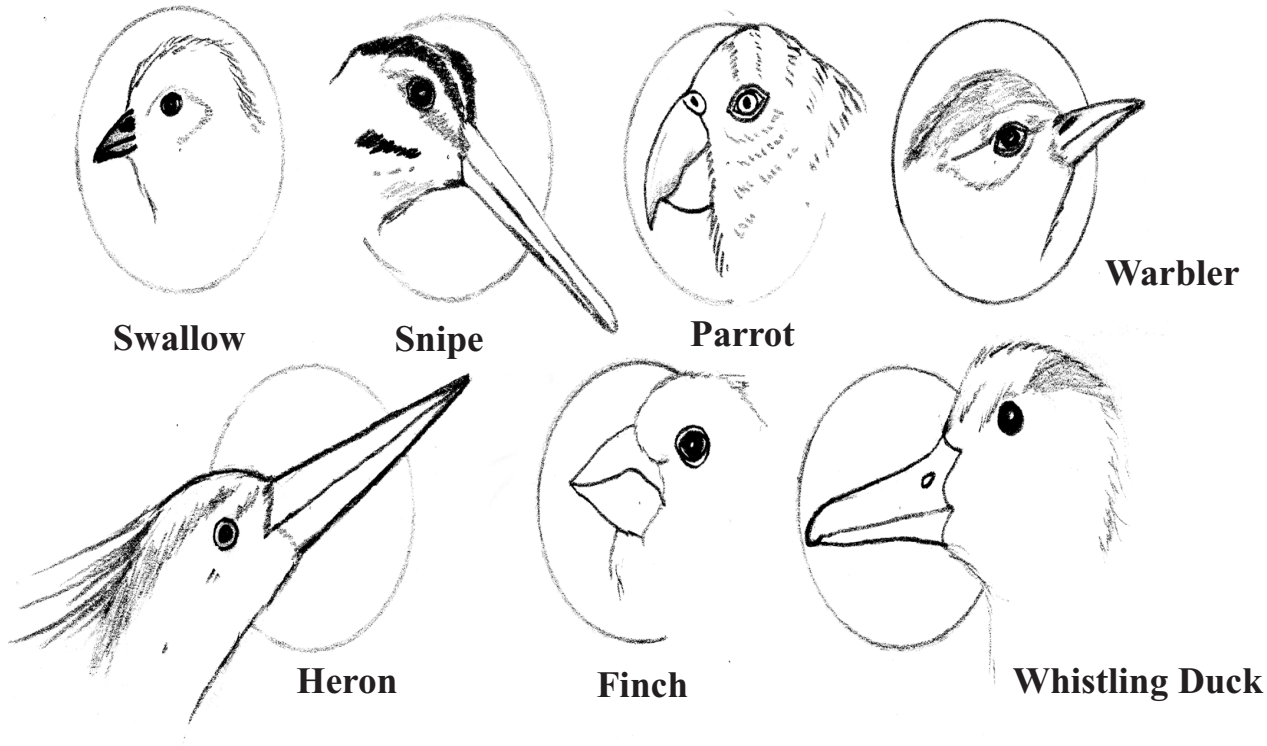
Discuss beak adaptations in general, explaining how, after millions of years, many birds have evolved very specialized beaks.

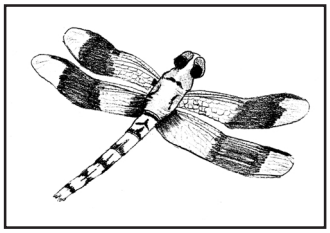


Fill The Bill Matching Game

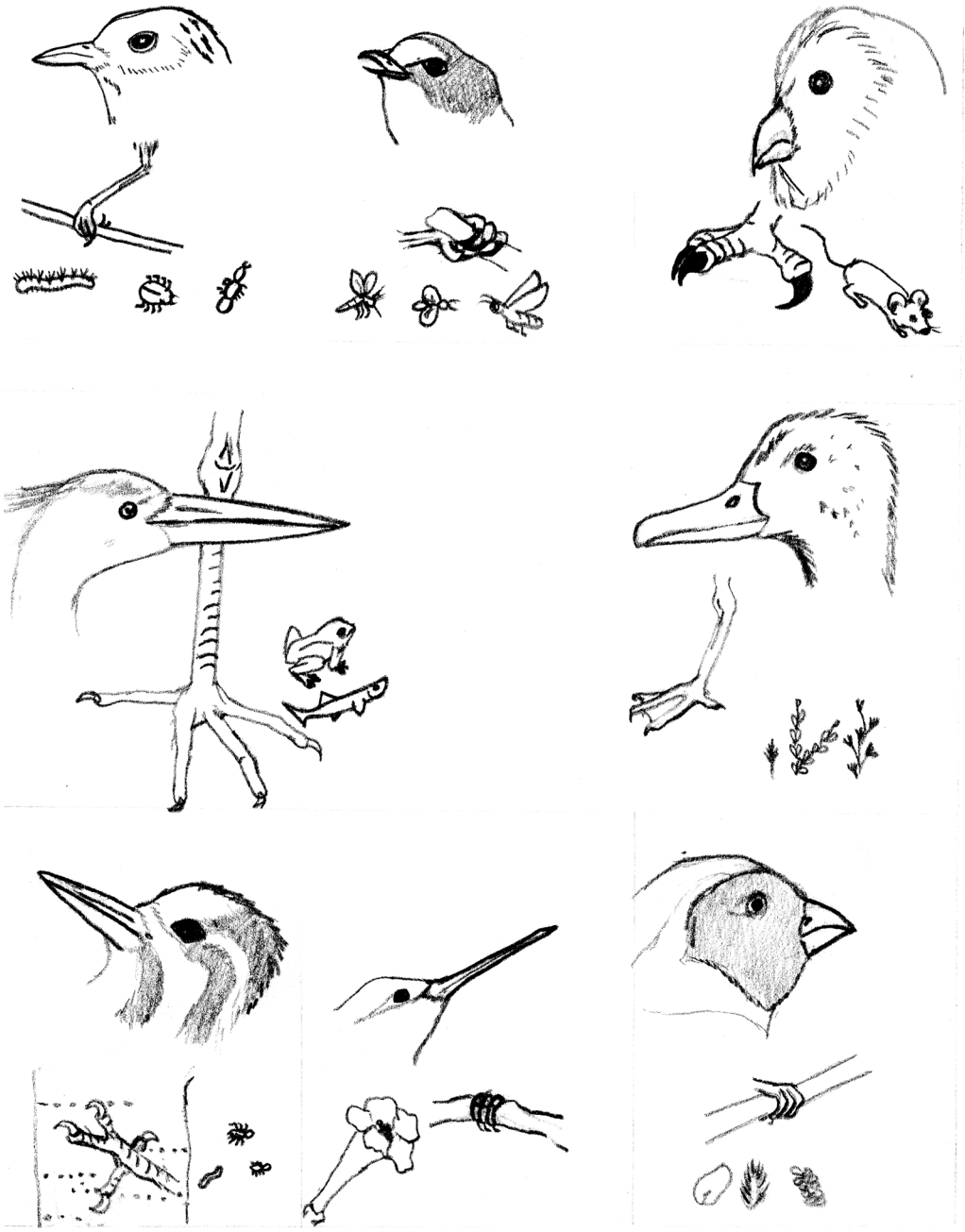
Match the food in column 1 with the best tool for the job in column 2. Write the number of the correct tool on the blank next to the name of the food.

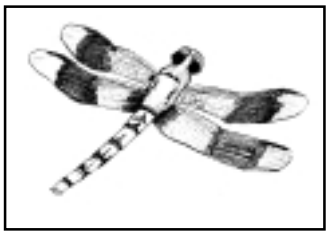
_____Worms	1. Pliers or nutcrackers
_____Seeds	2. Slotted spoon or scoop
_____Fish and frogs	3. Strainer
_____Tiny water plants and animals	4. Bamboo skewer
_____Flying insects	5. Tweezers
_____Caterpillars and crawling insects	6. Fishnet or envelope
_____Fruit	7. Chopsticks, toothpicks, or twigs





Birds' Bills and Feet





Activity 2-K: 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 found in the Cayman Islands; 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 2-71
Pencils

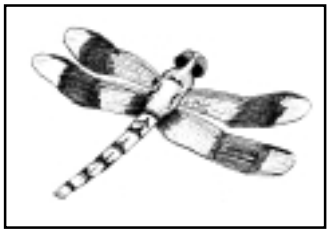
Background More than 180 species of birds either live in (are residents) or visit (migrate to and from) the Cayman Islands. Some of these birds can be seen every day, and some are quite rare. The silhouettes are of commonly seen birds that are easily identifiable. Each has distinguishing features that are easy to spot if you look closely at the birds themselves. For more details about birds, their habitats and lifestyles, please see *Birds of the Cayman Islands* by Patricia Bradley.

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 2-71 show the shape of some birds commonly found in the Cayman Islands. 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.

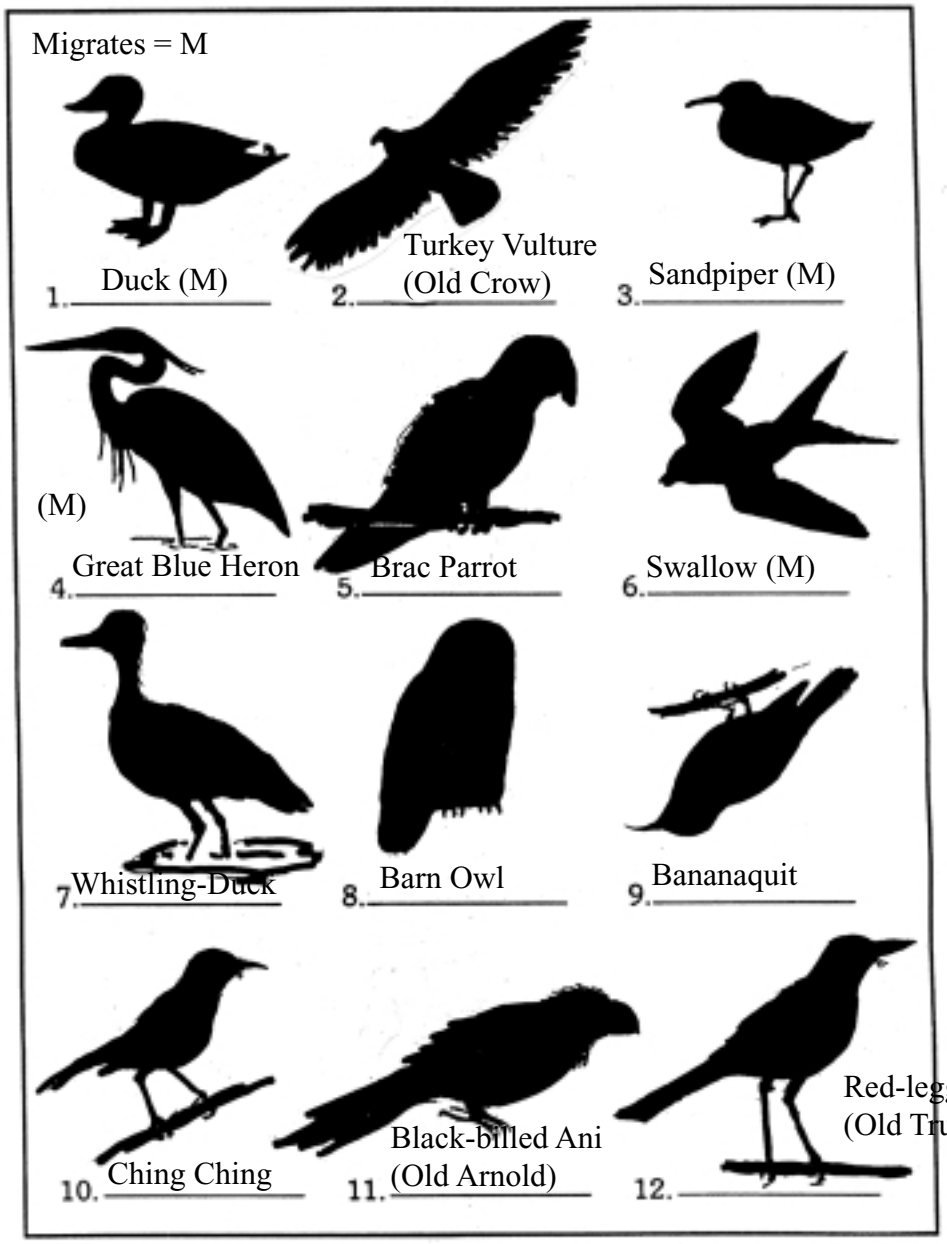
2. Identify which birds live in the Cayman Islands and which migrate here. If the group is having trouble, you can write on the board the list on names they have to choose from. This can also be made a homework assignment together with the bird identification charts. The names are:

(1) Mallard Duck, (2) Turkey Vulture (*Old Crow*), (3) Sandpiper, (4) Great Blue Heron, (5) Cayman Islands Parrot, (6) Swallow, (7) West Indian Whistling-Duck, (8) Barn Owl, (9) Bananaquit, (10) Ching Ching, (11) Black-billed Ani (*Old Arnold*),

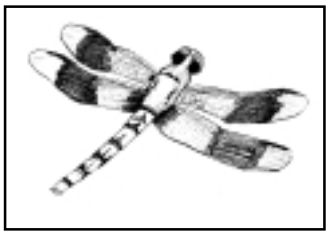


(12) Red-legged Thrush (*Old Truss*).

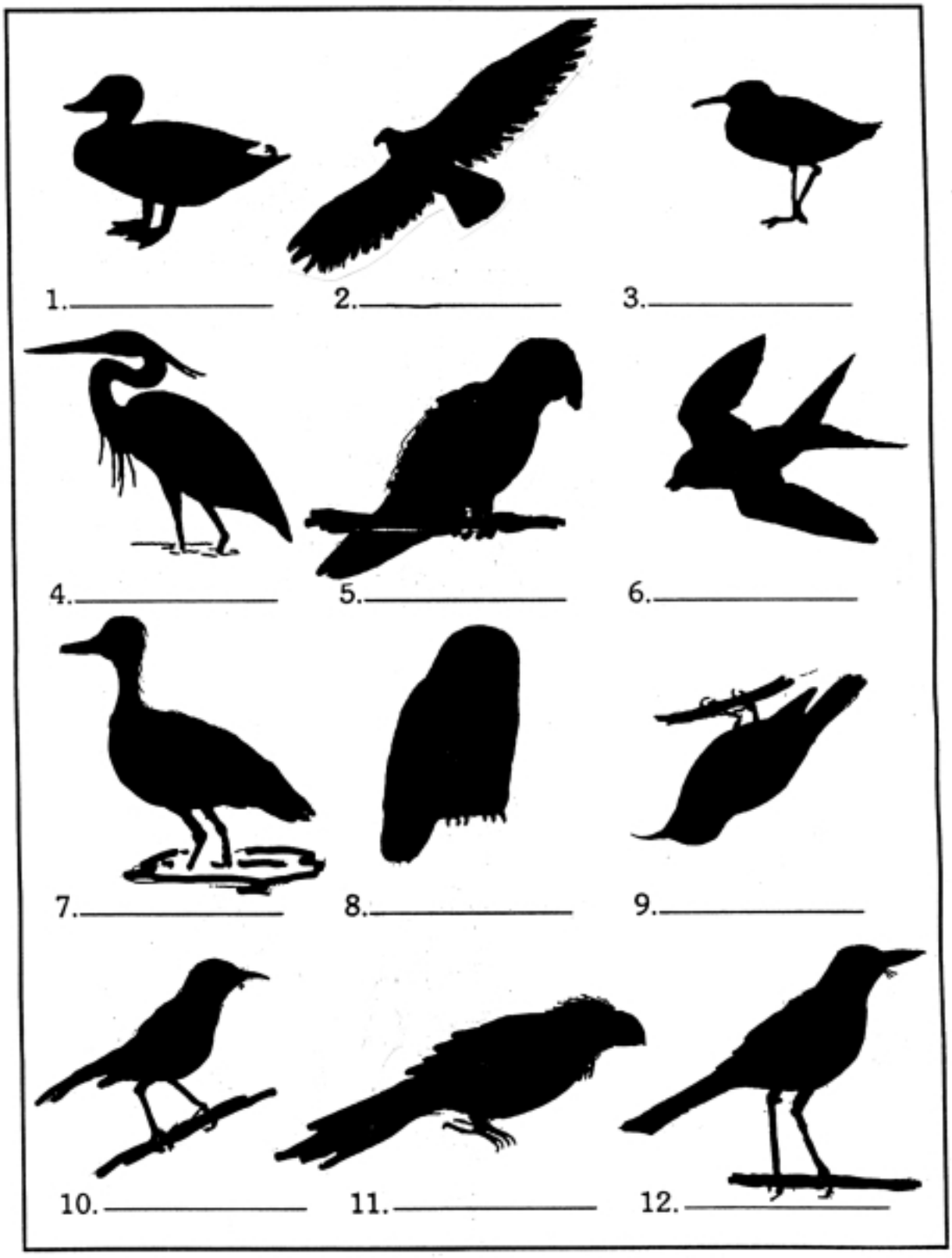
Discussion Discuss with the students what characteristics they used to identify the birds. Ask if they see these birds all year round or only in the winter. This is a good way to lead into the topic of migration. If a student has an "almost correct" answer (e.g., #3 Plover instead of Sandpiper), discuss 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.

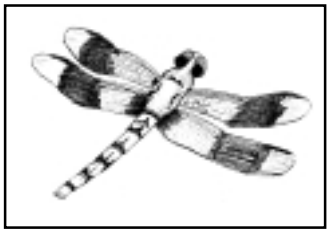


MANGROVES AS HABITAT



Bird Silhouettes





Activity 2-L: 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

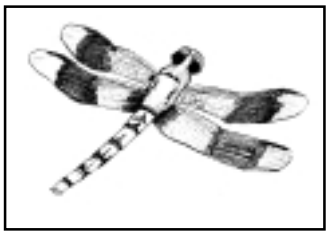
Materials Copies of "Spot the Difference" from page 2-73
Pencils

Background Review this section of this book, "Mangroves as Habitat", concentrating on the parts about birds. Also, study *Birds of the Cayman Islands* by Patricia Bradley. 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.

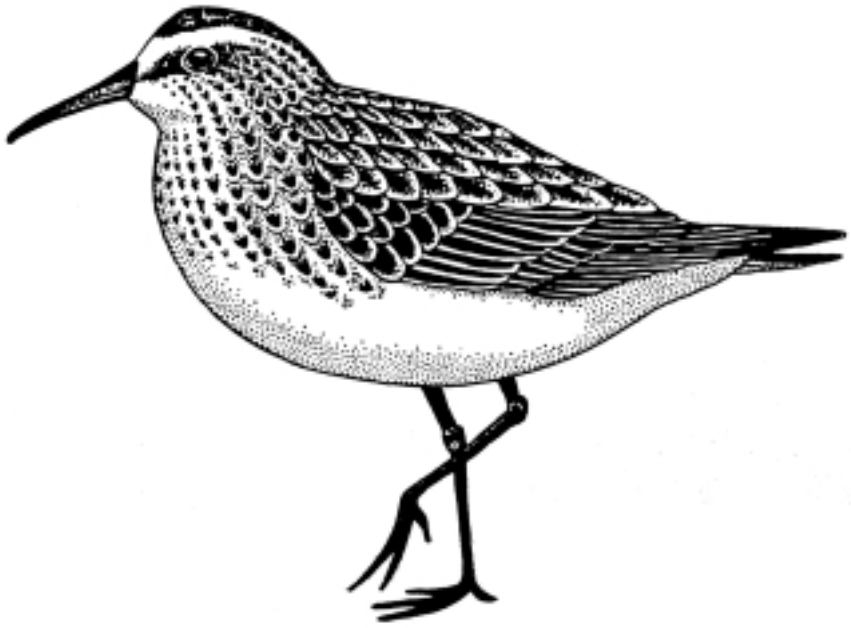
Procedure Have the students list as many differences as they can find between the two bird drawings.

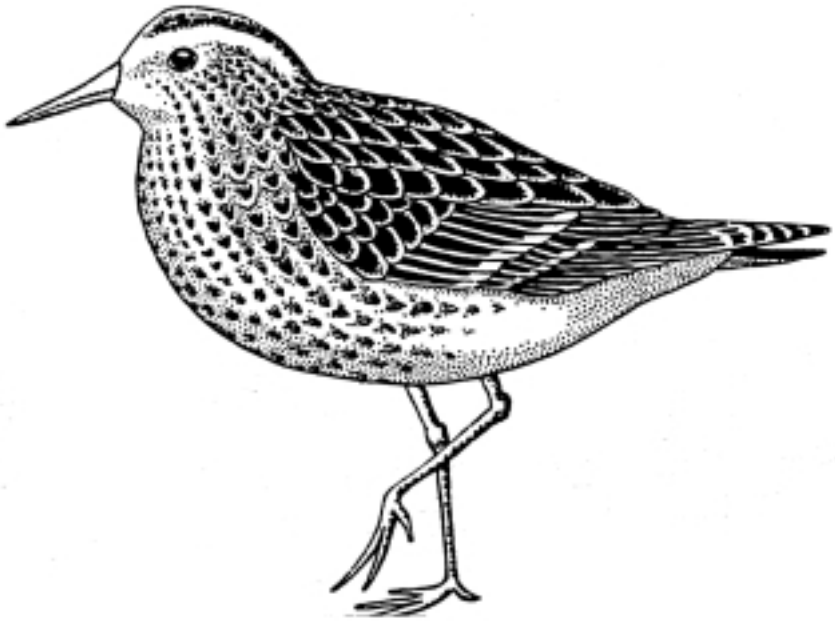
Discussion/Reflection

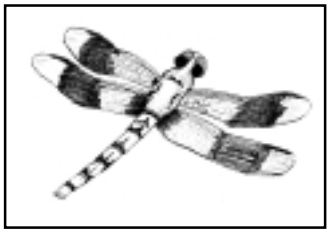
Discuss what differences were found.



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.

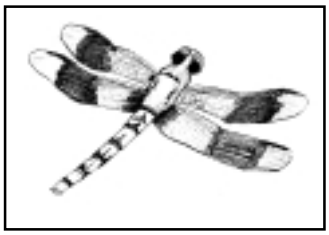
Waterfowl and shorebirds breed in the tundra of the far north because it is an ideal habitat in which to nest, raise young, and moult. The land is flat and waterlogged, laced with waterways, ponds, and sloughs in which there is abundant growth of aquatic plants, insects, and amphipods, the favourite foods of waterfowl and shorebirds. Sedge meadows and grassy marshes provide a safe breeding ground, inaccessible to many predators. Here birds can raise their young and moult without fear of predation.

But in winter the north is hard on birds. The tundra is covered by ice and snow. Aquatic plants and animals are buried under ice. The length of day, and therefore the time in which to hunt for food, is shortened, and more energy is needed to keep warm. Birds migrate south to find more food.

The incredible journey

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

Speed: Migrating birds fly at a more or less constant rate. Geese average about 75 km/h (45 mph). Ducks can do up to 80 km/h (50 mph) and sandpipers fly up to 90 km/h (55 mph). How long it takes a bird to migrate depends on how favourable the weather is, and how abundant the food along the way. One remarkable case was recorded of a Knot (a European shorebird) that covered more than 4,500 km (2,800 mi) in eight days—an average speed of almost 600 km (375 mi) a day!



Rest stops: During migration, 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.

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. Birds often find themselves in the Cayman Islands following a bad storm.

Dangers: Half of migrating birds never reach their destination. Birds face hazards such as storms with rain, ice, snow, and lightning; 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 open ocean with no place to land.

Sometimes, after flying thousands of miles, birds arrive to find that their marsh, mudflat, or mangrove home has been filled in, paved over, or dredged while they were gone.

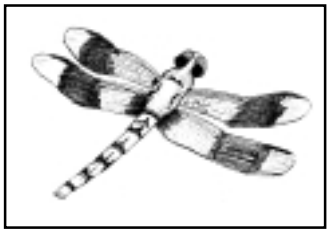
How do birds find their way?

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**.



Activity 2-M: Migration Homework

Summary The Cayman Islands are home to many species of migrating birds.

Learning Objective

Students will be able to write a story or poem about bird migration in the Cayman Islands.

Age Levels 6 and up

Subject Areas Science and social studies

Time 30 to 60 minutes

Materials pencil
paper
copies of pages 2-74 and 2-75 on migration
copy of *Birds of the Cayman Islands*

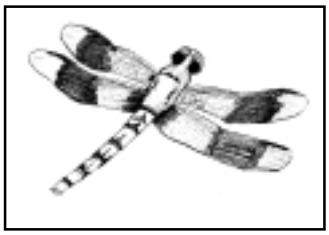
Background There are two types of birds found in the Cayman Islands: residents, which live here year-round, and visitors, which are migrants that usually spend the winter here. Many of these birds are found in people's yards, and, of course, are seen frequently in the wild. Birds found in mangrove swamps range from West Indian Whistling-Ducks (residents) to Great Blue Herons (migrants). Determining whether they are residents or migrants is a simple task: consult *Birds of the Cayman Islands* by Patricia Bradley, and it will describe all of the commonly seen birds in the Caymans.

For more information about migration, see pages 2-74 and 2-75, and the background to the Migration Headache activity on pages 2-79 and 2-80.

Procedure 1. Write a story or poem like *October Birds* on Page 2-77 about a bird that migrates to your island for the winter. 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 spring and arrives at its summer home.
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.

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?

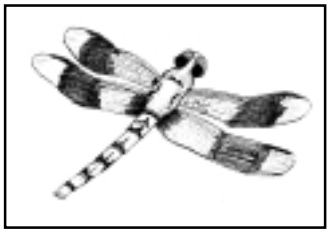
I will fly two days straight,
looking for a handsome mate.

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



Birds

Activity 2-N: Migration Stories

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

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

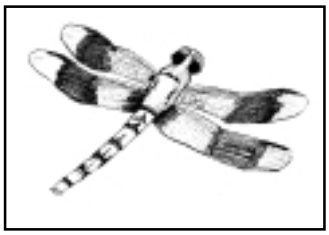
Materials *Birds of the Cayman Islands* by Patricia Bradley
Paper and pencil
Local people

Background (See "Migration Headache" activity on page 2-79)

Procedure **1.** Find out what migratory birds come to your island.
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-O: 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 the Cayman Islands 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.)

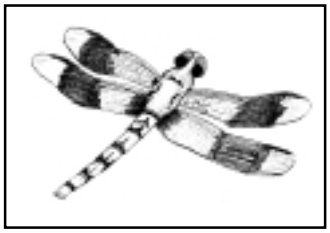
In this activity, each student represents thousands if not tens of thousands of migratory birds. The game takes up to 45 minutes (maybe more), and requires a large outdoor area such as a playing field, gymnasium, or basketball court.

Copy of Migration Maze on Page 2-80.

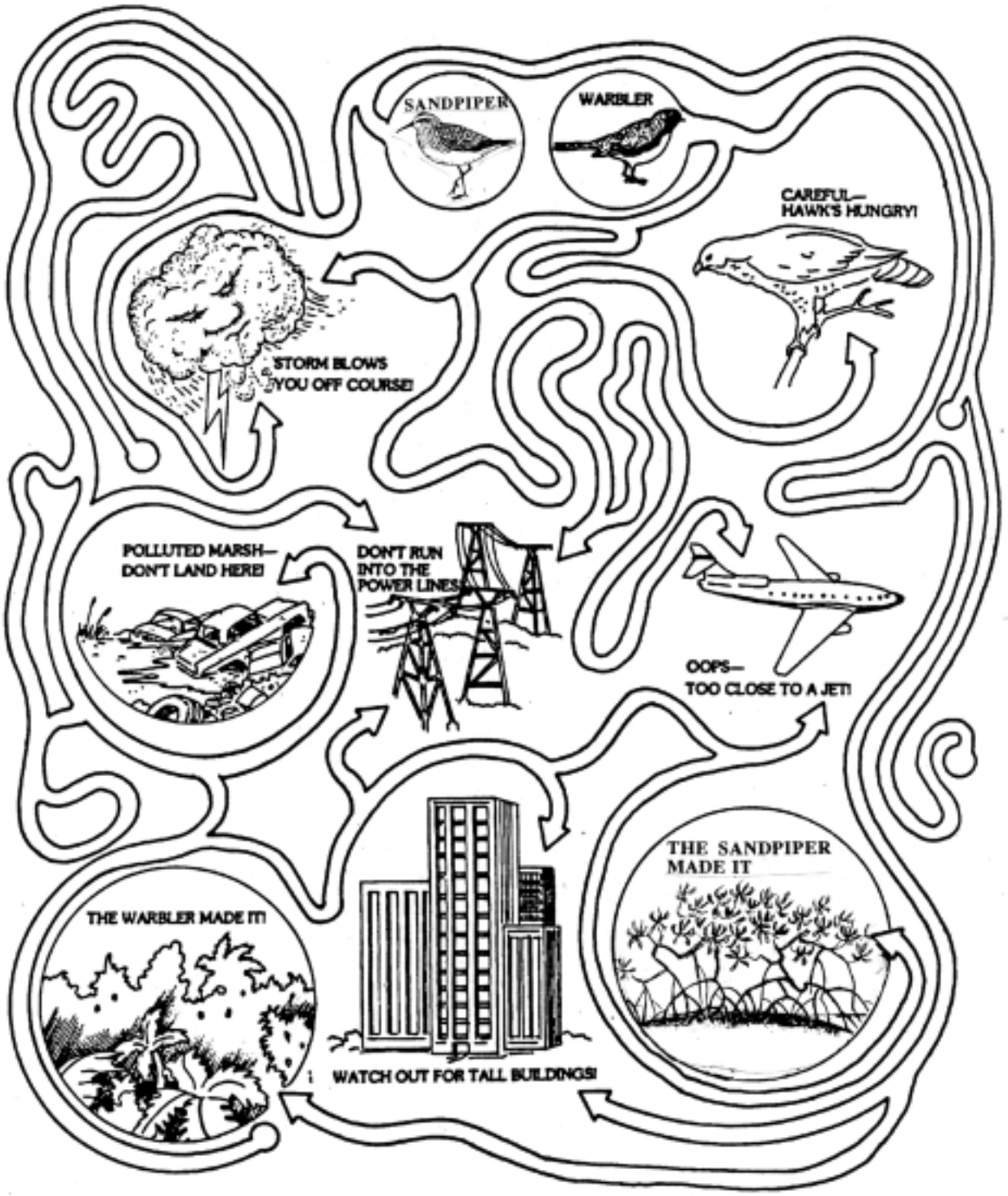
Background Explain to the students that many factors limit the survival of populations of migrating birds. Some involve changes in wintering and nesting habitats. Sometimes there will be abundant food, water, shelter, and space suitably arranged to meet the habitat requirements of the birds. At other 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.

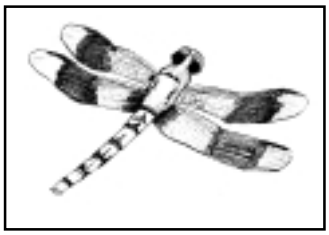
Be sure to create one or more "disaster" years to illustrate catastrophic loss of large areas of available habitat. Remember that, overall, the availability of suitable



Migration Maze



Both the sandpiper and the warbler migrate to the Cayman Islands for the winter. Both face deadly hazards on the way here.



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 winter in wetlands in the West Indies or to wetlands in North America for summer breeding.
2. Removing plates represents wetland losses.

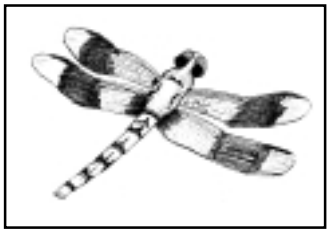
Procedure

1. Select a large playing area about 20 m (22 yards) 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" (northern United States and Canada) and the other "wintering habitat" (the Cayman Islands). Choose one or two students to remain at each end (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 the Cayman Islands in the fall, winter, and spring, 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 (waterfowl, 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 wintering habitat in the Cayman Islands. 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 North America. 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 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 the North American 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.

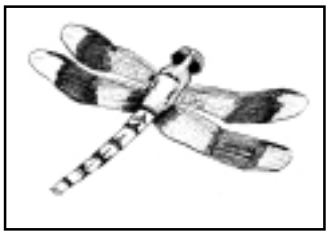
6. Round Three Before the next migration to the nesting region, turn over or remove four plates in the nesting habitat. This represents a catastrophic loss. Tell the students that this is the result of an oil spill in the local river that severely damaged the wetland habitat. Instruct the students to 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 on your island do to improve migratory success?

Extensions When back in the classroom, ask students to do Migration Maze (page 2-80) to reinforce problems encountered by migrating birds.



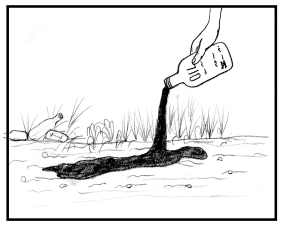
Migration Headache Plates Chart

Factors REDUCING survival	No. of plates lost *	Factors FAVOURING survival	No. of plates gained*
Urban expansion	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 ground water e.g. oil or chemical spill	3	Education about wetlands and habitat	3
Drought	3	Normal rainfall (neither drought nor flood)	2
Conversion of natural waterways to canals	2		
Lead shot in food supply	2	Education about hunting	1
Illegal hunting (poaching)	1	Arrest of poachers	1
Golf course/ condo/hotel construction	4		

**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.

HUMAN IMPACTS ON MANGROVES

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 hurricanes and storms, protect coral reefs from sediments and pollutants, and provide useful products, including timber. Unfortunately, these resources seem to belong to no one. The person who owns the land on which they are found rarely benefits from them, and their value is not reflected in the price of the land. Mangrove wetlands are frequently seen as expendable, and little care is taken of them.

Recently the courts in Puerto Rico ordered a company to pay more than US$50,000 per hectare to restore some mangroves that had been damaged by an oil spill. This reflected the importance of the mangroves to coastal ecosystems and fisheries. No one would pay such a high price to buy mangrove land. Indeed, mangrove land is often seen as being of very little value. Many communities think of it as a nuisance, a source of mosquitoes and the lair of crocodiles.

Throughout the Caribbean, mangrove wetlands are being destroyed or degraded. Everywhere—including the Cayman Islands—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. Most of the more accessible land is already taken up, so pressures on mangrove wetlands are increasing.

Mangrove Wetlands Destruction

Wetlands are being destroyed in many ways. Though not all of these apply to the Cayman Islands, some examples are:

- Filling for ports, tourist resorts, housing, airports, and industrial sites
- Drainage for agriculture (including rice)
- Excavation for fish and shrimp farms
- Dumping of garbage
- Dredging of channels for navigation and drainage
- Cutting of forests for timber and charcoal
- Drowning as a result of hurricanes and rising sea levels

Mangrove Wetlands Degradation

The quality and productivity of mangrove wetlands 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, extraction of water from blue holes, changes to water channels
- Reduction of natural regeneration as a result of fires, and grazing cows and goats
- Pollution from sewage, garbage dumps, fogging for mosquitoes
- Construction of groins, docks, piers, causeways, runways, and roads

HUMAN IMPACTS ON MANGROVES

Long-term Effects of Mangrove Destruction

When mangrove wetlands 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 hurricanes, 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

When settlements spread along the coastline, the mouths of coastal lagoons are often blocked by houses. If the lagoon is cut off from the sea, young fish can no longer get in to seek food and shelter, and coastal fisheries suffer. Without the normal flushing by the sea, the pond may become too salty, even for mangroves. The trees die, and bare salt flats are left behind. Without protection from coastal mangroves, houses, roads, hotels, and other structures are vulnerable to storm damage.

Wetlands are prime sites for fish and shrimp farms. Although the total amount of fish or shrimp produced in a farm is much less than the total production of a wetland in its natural state, the profits go to one person instead of many. Therefore, there is interest in cutting down mangroves to create ponds. Very often, the ponds quickly get too salty for aquaculture and are abandoned, leaving an unproductive mess.

A similar fate has befallen many schemes to create agricultural land for rice and other crops by draining mangrove wetlands. Large amounts of money have been spent, only to find that the swampland is too salty, or too expensive to maintain because of the high cost of pumping out water. The effect may be an overall loss in agricultural land, because when wetlands are destroyed a buffer is lost and sea water seeps into coastal groundwater, making wells salty.

Perhaps because people see mangrove wetlands as wastelands, they rarely hesitate before adding their own rubbish to them. The rubbish dumps for many coastal towns are in wetlands. Throughout the region, people who have to get rid 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. It destroys the visual quality of the wetland and encourages moves to fill wetlands.

Mangrove wetlands can actually be very useful places for disposing of sewage, as long as it is done in a controlled way. If properly managed, wetlands can soak up nutrients and purify water.

Many other uses of wetlands can be sustainable in the long term. Projects in St. Lucia have demonstrated how timber and charcoal can be sustainably harvested from mangrove wetlands. This usually involves removal of selected trees, leaving plenty to grow back. Too often, however, the mangroves are simply cut completely away.

Mangrove wetlands can also be destroyed by seemingly unconnected activities in the watershed. Water extraction from aquifers and 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. Fires are sometimes set on purpose by farmers who want to improve grazing, or fishermen who want to drive fish into traps. They are also started by lightning. 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 hurricanes and storms, diseases, and pests. Hurricanes are the most serious of these. Hurricanes can uproot trees and remove branches and leaves. Most mangroves can recover from moderate hurricane damage—but global climate change means that the number and severity of hurricanes will probably increase. More, and more severe, hurricanes 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, mangroves may be ableto grow fast enough to keep up with the rise, and go on protecting our shorelines. Recent hurricanes such as Lenny, Georges, Mitch, Gilbert, and Hugo caused billions of dollars' worth of destruction in the West Indies and Central America. Much of the damage occurred in coastal areas that were probably once protected by mangroves. It is only a matter of time before a similar storm makes landfall in the Cayman Islands.

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, White-crowned Pigeons are favourite game birds on many islands. They breed and roost in the mangroves. When mangroves are destroyed, or hunting is not properly managed, their populations are reduced. The White-crowned Pigeons feed on seeds and spread the seeds of forest trees. When pigeon populations are reduced, forests can no longer regenerate properly.

Unfortunately, human beings often do not realize the consequences of wetlands 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. To a farmer in need of more crop acreage, an island planning board desperate for housing sites, or a construction firm building a hotel that will

provide jobs for hundreds of people, the loss of a wetland or two in exchange for the benefits of their project seems like a reasonable trade-off. 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 contributes to flood control, pollution control, and habitat for many plants and animals, including humans.

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. Many Caribbean people rely on groundwater for their drinking water (others, of course, use cisterns to catch and store rainwater for drinking). Groundwater is one of the most important sources of irrigation water. Unfortunately, some of the groundwater on nearly every island has become tainted with pollutants. And some scientists fear that the percentage of contaminated groundwater may increase as toxic chemicals dumped on the ground during the past several decades make their way into the groundwater.

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, or through 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

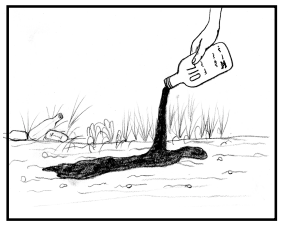
It is not easy to classify biological pollutants as either natural or manufactured. For example, algae may be present naturally, but nutrients added by people can cause abundant algae growth, with serious results for the quality of the water. Excessive algae growth greatly increases the water's biological 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. Certain wood-cutting practices affect sediments in run-off. Sediments may fill stream channels and harbours that later require dredging—and the dredging itself will stir up the same sediments. These sediments suffocate fish and shellfish populations by covering fish spawning areas and clogging the gills of bottomfish and shellfish. They also cloud the water and prevent sunlight from reaching seagrass and corals, causing their death.

Petroleum Products

Oil and other petroleum products like gasoline and kerosene can find their way into water from ships, oil refineries, power plants, gas stations, and streets. 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.

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. Typhoid fever, polio, cholera, dysentery, diarrhea, 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 hurricanes. People can come into contact with these microorganisms by drinking the polluted water. Often, unexpected flooding of barnyards or stock pens can suddenly 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

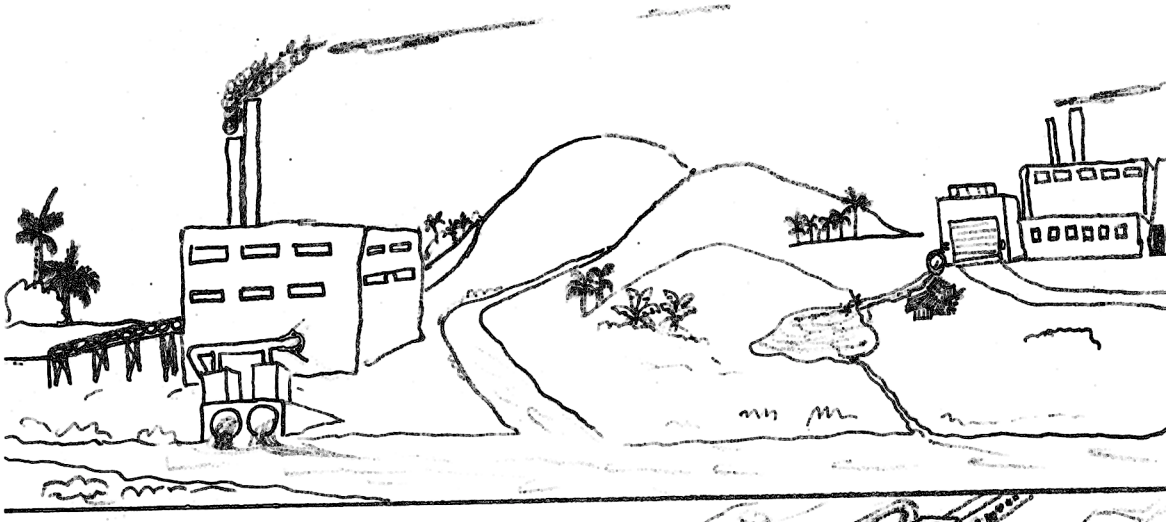
Domestic sewage-treatment plants, food-processing plants, paper mills, and leather-tanning factories release organic wastes that bacteria consume. If too much waste is released, the bacterial populations increase and use up the oxygen in the water. Aquatic creatures, especially fish, die if too much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

Inorganic Chemicals

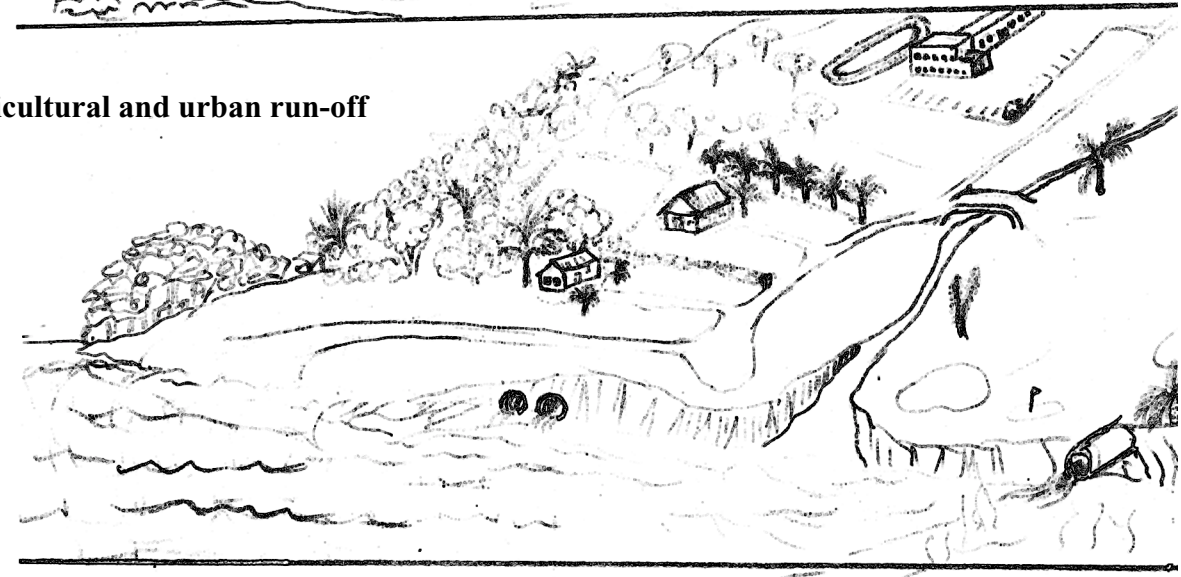
Detergents, pesticides, and many synthetic industrial chemicals are released to waterways. Many of these substances are toxic to fish and harmful to humans. They cause taste and smell problems and

Water Pollution Today

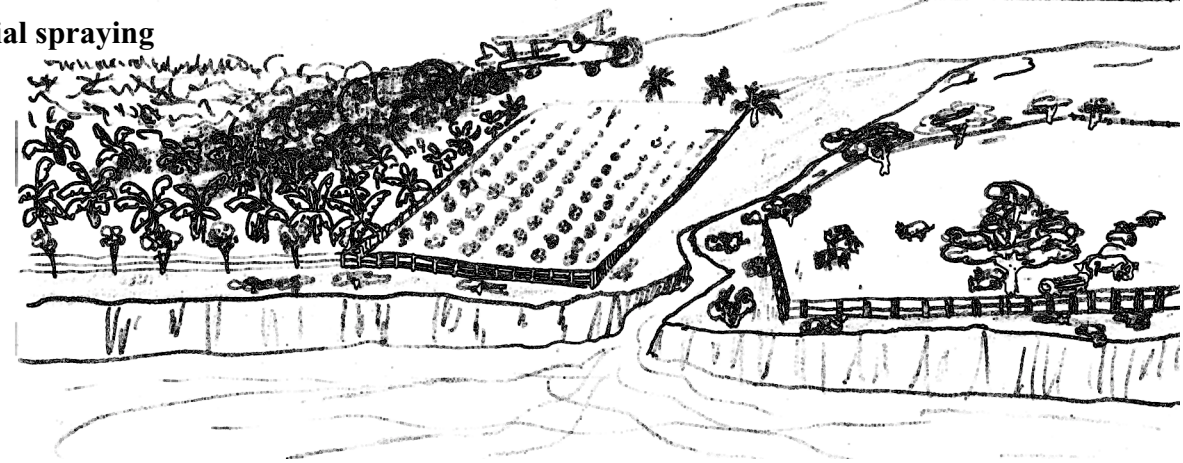
Industrial waste

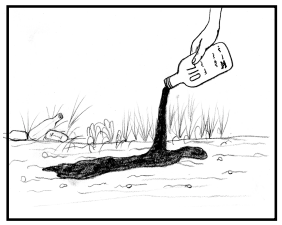


Agricultural and urban run-off



Aerial spraying





often cannot be treated 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 also corrode expensive water-treatment equipment and increase the cost of boat maintenance.

Fertilizers

The major source of agricultural and golf-course 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, 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 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 and golf-course developers 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 mangrove wetlands, and oceans.

Factsheet #4: Pollution Sources

Down the Drain

When most people in the Cayman Islands rinse something down their drain, flush their toilet, or do a load of wash, the wastewater either goes to a sewage treatment plant—such as the one serving the West Bay Road area—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 storm drains or ditches. In most islands in the Caribbean, including parts of the Cayman Islands, these drain into a series of underground pipes that eventually dump directly into waterways or the ocean.

Industrial Waste

Factories that make chemicals, paper, medicines, steel, and many other products create a lot of waste. At one time, industries could legally dump waste into waterways or the ocean. But on some islands, pollution-control laws now limit the waste that industries can dump into surface water. These laws have greatly reduced water pollution in countries where they are in effect. However, not all types of industrial waste are regulated, and in some places there are few if any controls. In addition, some experts feel that the controls are not strict enough to protect aquatic systems.

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 floating in the ocean or in mangrove swamps.

Factsheet #5: Auto Awareness

The automobile is one of the biggest contributors to pollution problems throughout the world, and the Caribbean and the Cayman Islands are no exception. 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.

Car Manufacturing

- Mining for raw materials such as bauxite (to make aluminum) 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 Tires

- 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. And tires dumped in landfills take up a lot of space.

Fossil Fuels

- Most cars run on gasoline, a product made from oil. Drilling, processing, and transporting oil creates air, water, and land pollution.
- When engines burn gasoline 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 quart of oil can contaminate thousands of gallons of water, polluting drinking water supplies and poisoning wildlife.
- Driving at excessive speeds cuts down fuel efficiency.

HUMAN IMPACTS ON MANGROVES

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

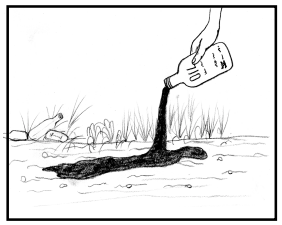
- Using car air conditioners can cause a car to burn more fuel.
- When junked or improperly maintained, car air conditioners can leak ozone-damaging CFCs into the atmosphere.

Car Care

- Washing cars can pollute waterways, when detergent and road grime run into storm drains and then into surface water.
- Improperly inflated tires 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), 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 CFCs and oil can prevent air and water pollution.
- Developing safe refrigerants can eliminate the use of ozone-destroying CFCs.
- 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.



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, golf-course management, and agricultural practices as well as mosquito control—enter the food chain.

Age Levels 9 and up

Subject Area Science

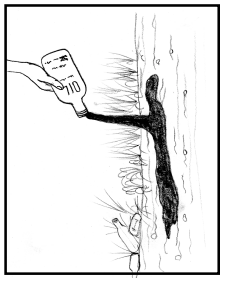
Time 30–60 minutes

Materials A package of multi-coloured drinking straws, green, yellow, red, and blue, cut in lengths of approximately 6 cm (2 in) 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 3-15 showing bioaccumulation
Eight coloured bibs or hats (optional)

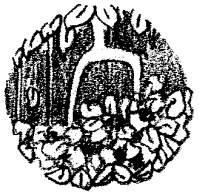
Background During the past century, people have developed pesticides (including herbicides, fungicides, insecticides, and rodenticides) to control unwanted organisms such as weeds, insects, fungus, and rats. These pesticides contain poisons, toxic chemicals that settle into the soil or stay on crops 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 mangrove wetlands 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 bays. 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.

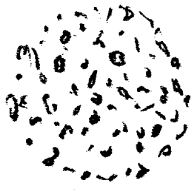
This is how bioaccumulation works: If an amphipod ingests one piece of detritus containing 10 units of toxin, then it will retain 10 units of toxin: 1 x 10 = 10). If a Mangrove Snapper eats 10 amphipods, each containing 10 units of toxin, then the Mangrove Snapper will retain 100 units of toxin (10 x 10 = 100). If an Osprey eats 10



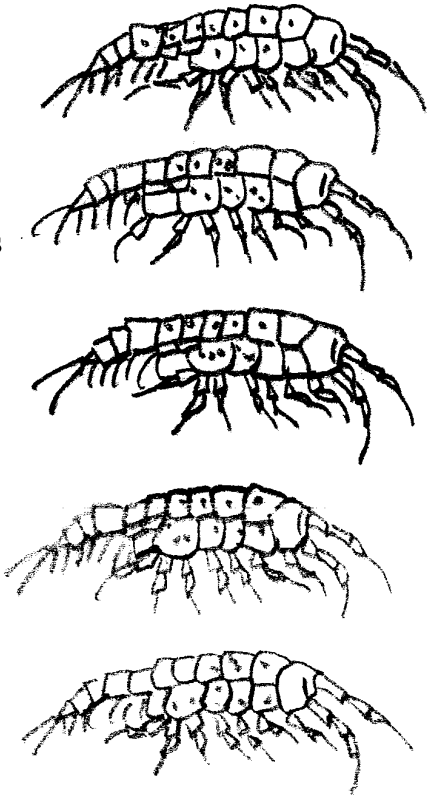
Bioconcentration Factor



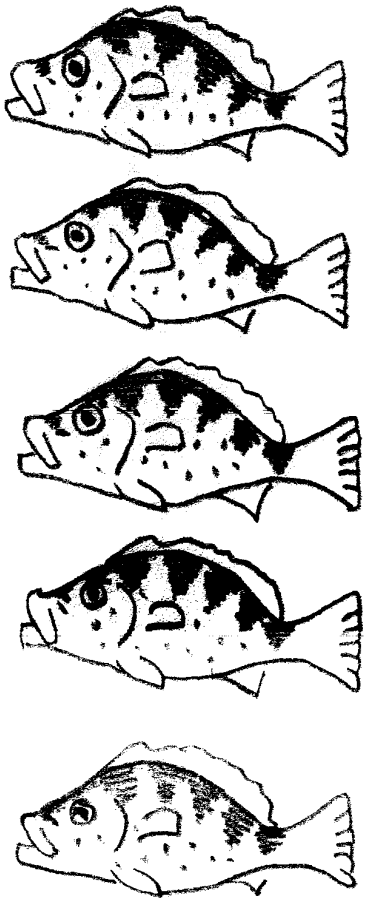
Decaying plants



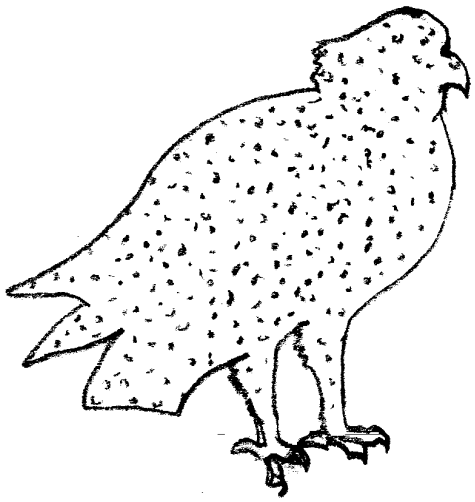
Detritus particle
with toxin attached



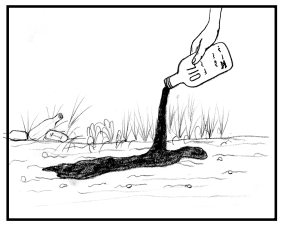
1X10=10
Amphipods ingest
sediments and
retain toxins



10X10=100
Mangrove Snappers
eat amphipods and
retain toxins



10X100=1000
Osprey eats
Mangrove Snappers
and retains toxins



Mangrove Snappers, each containing 100 units of toxin, then the Osprey will retain 1000 units of toxin (10 x 100 = 1000), and so on.

Procedure Students become "Detritus", primary and secondary consumers like "Amphipods" and "Mangrove Snappers", 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 Snappers eat Amphipods, and Ospreys eat Mangrove Snappers.

2. Divide the students as follows: three times as many Mangrove Snappers as Ospreys, and three times as many Amphipods as Ospreys. (In a class of 26, this would give two Ospreys, six Mangrove Snappers, 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 Snappers 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 Snappers 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 Snappers are now allowed to hunt the Amphipods. Osprey still remain on the sidelines. When a Mangrove Snapper catches an Amphipod by tagging, the Amphipod must give up its food envelope to the Mangrove Snapper and move to "Amphipod heaven" at the side. Allow 15 to 20 seconds, enough time for each Mangrove Snapper 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 Snappers. When the Osprey tag the Mangrove Snappers and retrieve the food envelopes, the Mangrove Snappers go to "Mangrove Snapper heaven" at the side.

Note: Any Mangrove Snappers 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 Snappers, 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 Snappers, 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 Snappers may now be considered dead if they have any yellow or red straws in their food supply. Any Mangrove Snappers 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, golf-course manager, and gardener of using pesticides?

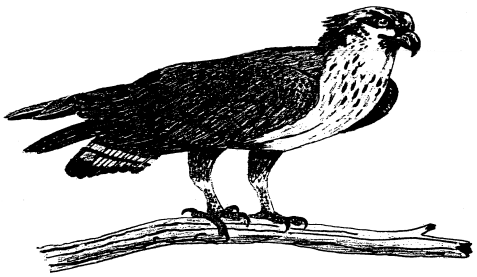
What are some real or imaginative alternatives to the use of toxins? (For example, some farmers successfully use organic or non-toxic substances along with crop rotation, companion planting, biological controls, and genetic approaches in efforts to minimize damage to their crops).

What other species that you know of were or are affected by the use of pesticides?

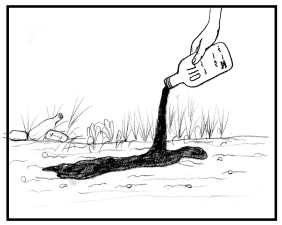
What are other possible sources of toxic chemicals that could enter the food chain?

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 (also known as the Fish Hawk) is a common winter visiting bird throughout the Caribbean including the Cayman Islands. It can often be seen hunting throughout the region. Its prey is mostly fish, though it occasionally hunts egrets at local airports. Not too many years ago (the 1950s and 1960s), the Osprey was almost extinct because its prey had absorbed DDT from agricultural run-off. The Osprey also absorbed the DDT, and this affected its ability to reproduce—the eggs often had thin shells that cracked before the baby bird was ready to hatch. Osprey also suffered from illegal shooting (because people thought it caught



too many fish) and habitat loss. However, the 1972 ban on the use of DDT, plus other factors, have enabled this magnificent bird to make a comeback.

Case Study #2

There has been a drastic decline in the number of Barn Owls in the Cayman Islands. While there is no accurate count of the number of Barn Owls, there are many reports of a significant decline in numbers in recent years. The owls' primary food is rats and mice, which in turn feed on plants, fruits, and nuts. The owls also eat lizards, bats, and other, smaller bird species like bananaquits. The decline in numbers is being attributed to the increase in the number of multi-dose poisons that are being used to bait and kill rats and mice. These poisons are then absorbed by the owls, and a build-up of the toxins eventually kills the birds.

Barn Owl

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

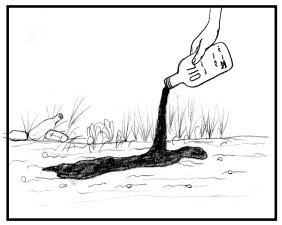
Subject Area Science

Time 30–60 minutes

Materials A large container—goldfish bowl, glass jar, or aquarium
An improvised filter system to represent what primary sewage treatment does, made of a plastic pop 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
Film canisters, labeled (masking tape works well) and containing small amounts of the items listed under "Procedure"
Factsheets #2, #3, and #4 on pages 3-7 through 3-11

Background As outlined in the factsheets on pages 3-7 through 3-11, 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 throughout the Cayman Islands 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 film canisters 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**—yam 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
- **Aluminum cans**—arewashed 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.

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. Marshes 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 3-15). 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. On some smaller islands, this is still true. 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.

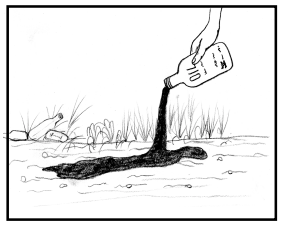
Herbicides are toxic remedies for weed control. Try these solutions:

- 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.



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 every day actions.

Age levels 8 and up

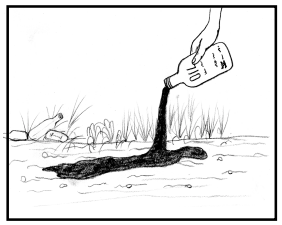
Subject Areas Science, social studies

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 3-11

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.

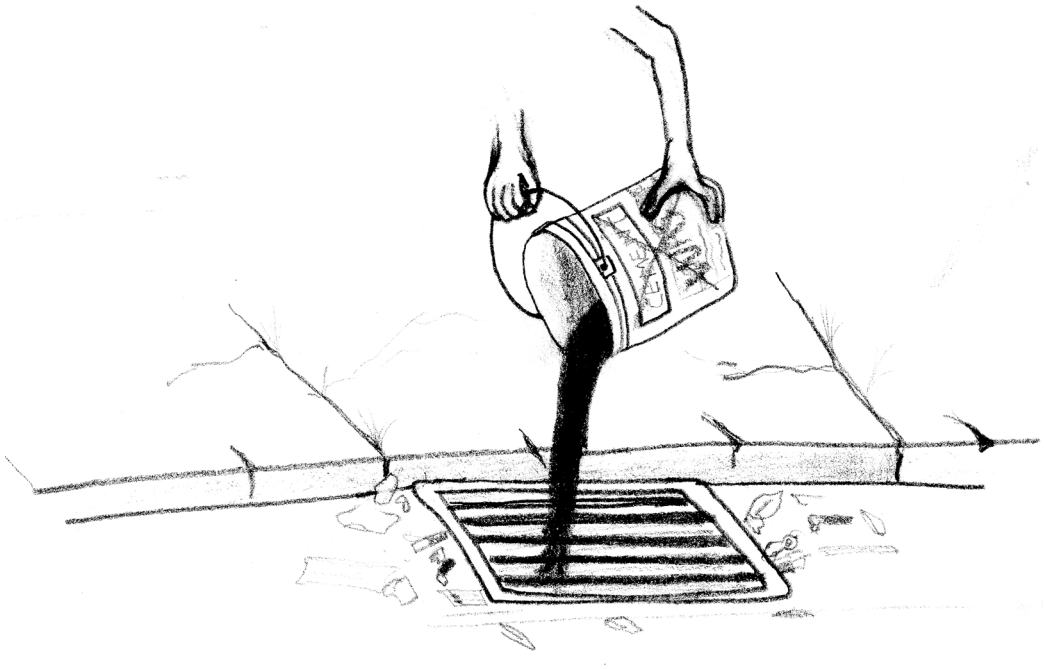
Procedure This song can be used as a radio or TV commercial. One member of the class speaks the monologue and the others sing out the verse. Different kinds of props such as paint cans, pitchforks, and a wrench can be used for the monologues—it makes the song more visually interesting. Each time one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



Monologue:
I learned how to change the oil in my car several years ago. I change it every 10,000 kilometres (6,000 miles) 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.

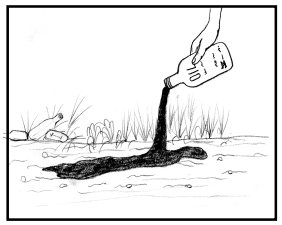


Monologue: I had to rebuild my transmission and now I have all this transmission fluid to get rid of. Oh, it won't hurt anything if I dump it down the storm drain. First good rain will wash it into the bay.

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.

HUMAN IMPACTS ON MANGROVES



Monologue: I've been helping my Pa with the cows since I was four years old. My least favourite job is cleaning up the manure after them. Ma 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.

HUMAN IMPACTS ON MANGROVES

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. Man, 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:

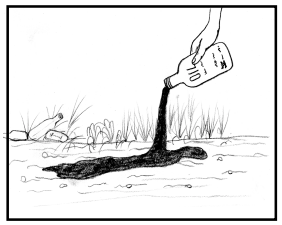
Dumpity dumpity dumpity dump
They put it in the trash—
Dumpity dumpity dumpity dump
I think that's rather rash.
Dumpity dumpity dumpity dump
Where do they think it goes?
Dumpity dumpity dumpity dump
Nobody wants to know.
Dumpity dumpity dumpity dump
The leachate cycles back.
Dumpity dumpity dumpity dump
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: Gee, all this hard work really makes me thirsty, mon. I'll just go have a nice cool glass of water.



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.

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 Language arts

Time 30–60 minutes

Materials Story-poem beginning on page 3-33, "Away on the Bay"
Drawing paper
Crayons or markers
Construction paper (optional)
Stapler (optional)
Glue (optional)
Copies of Factsheet #3 on page 3-8

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 3-8 and the poem "Away on the Bay" beginning on page 3-33 clearly show 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.

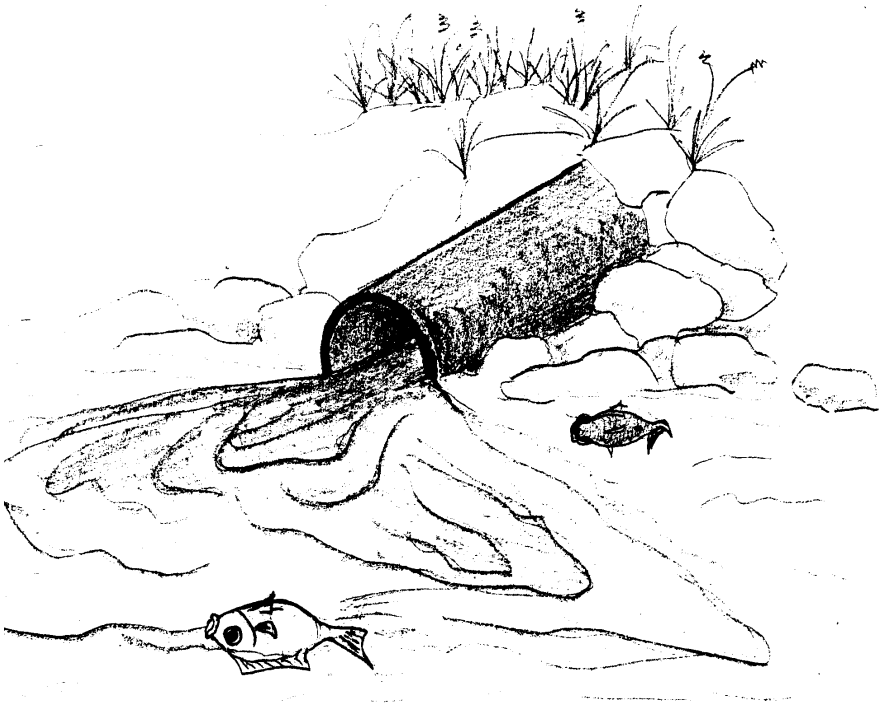
3. After you've read the story, discuss it with the students. Ask them if the waste from Away simply disappeared.[*No.*] What happened to the waste? [*It ended up in the bay.*] Then go over the verses in the first half of the story to be sure the students understood what was happening in each one. Use the information in Factsheet #5, Pollution Sources, on page 3-11 to 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 of the story. Pass out copies of pages 3-33 through 3-36 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 5-26 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.

Away on the Bay



AWAY ON THE BAY

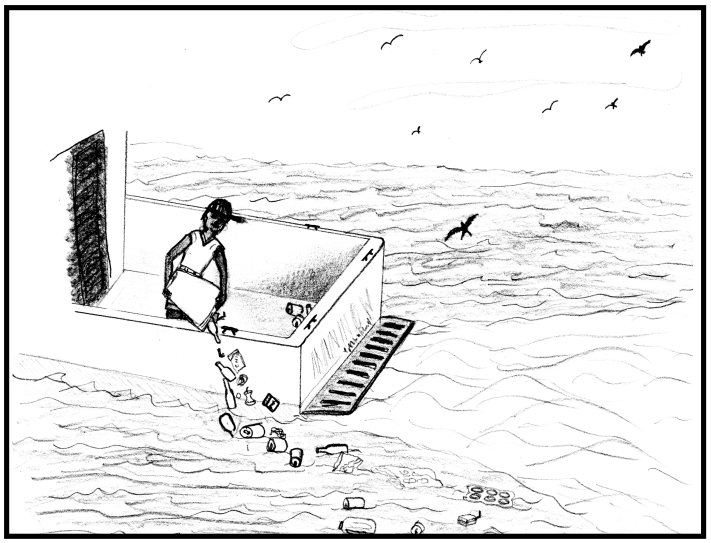
This is the tale of a town called **Away—**
A town that was built on the shore of a bay.
A town where the folks didn't think much about
What they dumped in their water, day in and day out.

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 Main 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.

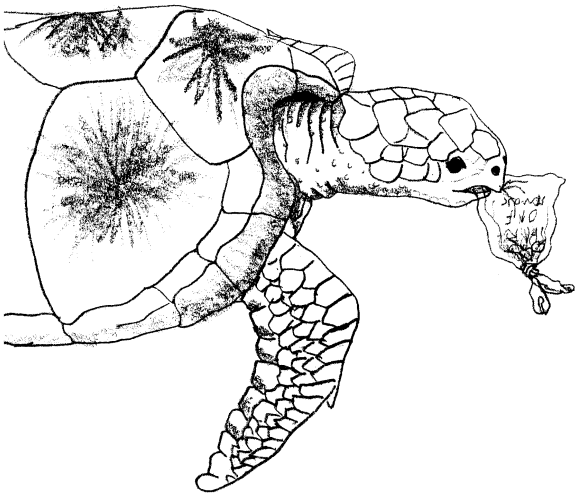
A mill there made "stuff" for the townfolk to use,
But a pipe from the mill churned out oodles of ooze.
And the ooze, well, it goozed from a pipe to the bay
Where it bubbled and glubbed as it drifted **away**.



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.



Turtles might eat plastic thinking it's jellyfish

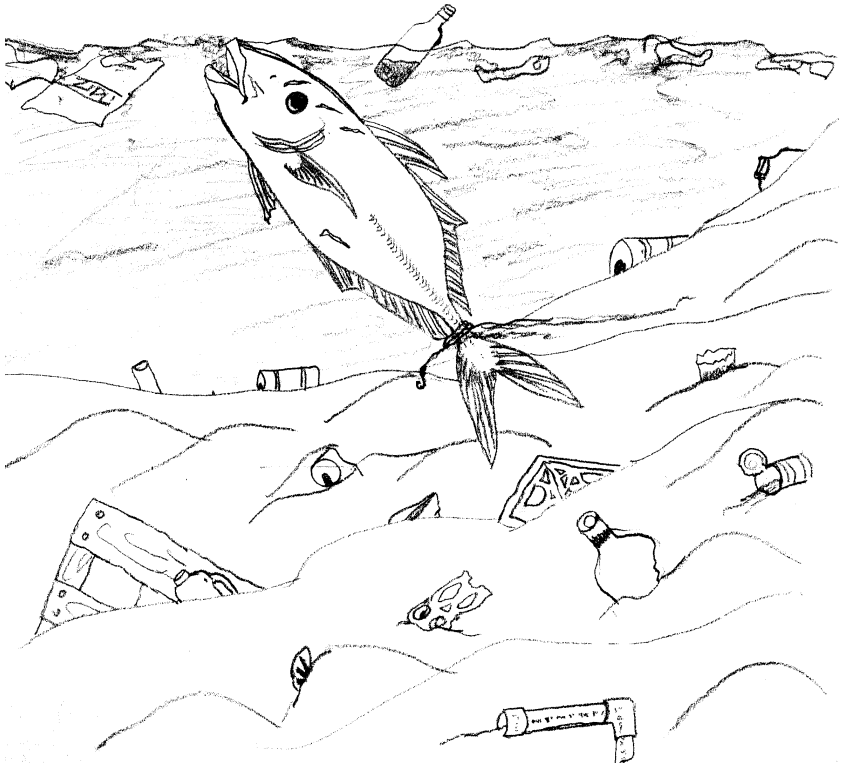
Birds get entangled in six-pack rings

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.

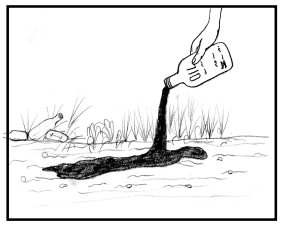
So a meeting was called to discuss the sick bay,
And townspeople came from all parts of **Away**.
And during the meeting one person proclaimed,
"I know who's at fault: We *all* should be blamed.

"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."



Trash in the bay



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

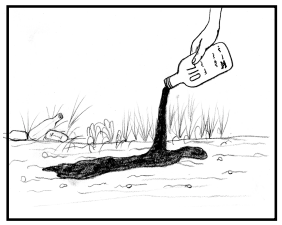
Materials Copies of pages 3-39 through 3-41, "A History of Trash"
Copies of pages 3-42 and 3-43, "The Garbage Shuffle Rap"
Materials to make costumes and props (optional)

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 . . . garbage. See "A History of Trash" on pages 3-39 through 3-41.

Procedure **1.** Begin by asking the class how people get rid of their trash (by dumping it, burying it, or burning it). Explain that the task of getting rid of garbage has been around as long as people have existed.
2. Pass out copies of pages 3-42 and 3-43, "Garbage Shuffle Rap", and have the students read through the rap.
3. Then use the information under "A History of Trash" (pages 3-39 through 3-41) 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(s) 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 Trash

1. Africa, 1.5 million years ago
Many prehistoric hunter-gatherers simply threw their trash on the ground around their camps. Others had special places to dump their refuse. Made mostly of biodegradable items, the trash 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.

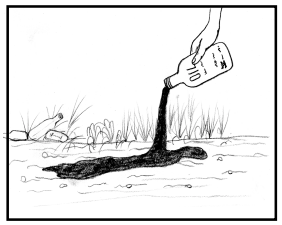
2. Ancient Greece, 500 BC
For a time, city residents in ancient Greece and Rome threw their trash out into the streets. Human scavengers regularly picked through the waste for reusable items, a practice that continues even today in many parts of the world. Road levels grew higher and higher from the 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 trash 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 trash into it without hesitation. The trash 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 garbage because it is so close to the main shipping lanes. It's estimated that people around the world dump some 14 billion (14,000,000,000) pounds of waste into 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. Los Angeles, 1930
The large-scale burning of trash in incineration plants had been used on and off as a waste-disposal method since the 1870s. Although incinerators significantly reduced the volume of trash, citizens complained about the smoke and smells from these plants. Many of the incinerators that were common during the 1930s were later closed down.



7. North America and Europe, 1960

The period after World War II marked the rise of the throwaway lifestyle and the development of synthetic materials. Households no longer burned much wood or coal, but they generated more waste from disposable products and packaging materials, including a lot of paper and plastic trash. They also began throwing out more toxic substances that ended up in dumps and landfills. These hazardous materials leached through the soil into water supplies. And when dumps caught fire and smouldered, toxic fumes were released into the air. It later became clear that, as landfills filled up, siting new "safe" ones would become more and more difficult.

8. North America and Europe, 1973
A movement to control the increasing volume of garbage going into landfills led to a revived interest in incineration. New technology focused on converting waste to energy through incineration. Incinerators became known as "resource recovery" plants, such as the one described in the rap. Not only do these plants reduce the volume of trash, they also produce usable energy. This was seen as an added benefit after an oil crisis raised concern about the West's limited energy sources. But the plants still emit noxious fumes, are expensive to build and run, and produce a highly toxic ash. Because of these problems, these plants have yet to gain widespread acceptance.

9. North America and Europe, 1990
Citizens of North America and Europe and throughout many parts of the world have begun to reduce, reuse, and recycle to cut down on the total amount of materials entering the solid-waste stream and to save natural resources.

10. The Caribbean, 2000
Many of the problems of solid-waste disposal still face most islands in the Caribbean, including the Cayman Islands where the Grand Cayman disposal site is full. Space is very limited for landfills, and yet most governments plead poverty when it comes to setting up successful recycling programs. Local people in many places still throw trash into the sea, and an increasing number of ships dump trash overboard. Incineration is becoming one of the methods of disposal, but more effort needs to be put into finding ways to encourage recycling, reusing, and reducing the use of disposable items. One example to follow is that of the Commonwealth Brewery on New Providence Island in the Bahamas, which has started a very successful cottage industry of recycling bottles.

The Garbage Shuffle Rap

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

Now I bet you're askin', bet you're dyin' to see
What a hip hippo hunter from prehistory
Does with his garbage! (clap) . . . like old tools of stone—
All that garbage! (clap) . . . like those animal bones.
Well, I throw 'em, I toss 'em, I drop 'em at my feet.
Then I move my camp and go hunt more meat.

I'm a wise orator, I'm an ancient Greek.
I was born to talk, and I love to speak.
About garbage! (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 garbage! (clap) . . . out the window we throw
All our garbage! (clap) . . . to the street below.
Well, our city's so crowded that all of that trash 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
Garbage! (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 garbage! (clap) . . . the alleys flow with trash—
All that garbage! (clap) . . . the water's full of ash.
Now those garbage fumes—they can make you ill,
So it's time we cleaned up what we spill.

HUMAN IMPACTS ON MANGROVES

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

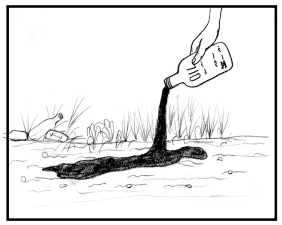
Now we're in the Depression, and some folks feel
That incinerators are the way to deal
With garbage! (clap) . . . it all goes up in smoke—
All that garbage! (clap) . . . but I cough and choke
On the cloudy fumes that fill the air.
I just wish that I could move away somewhere.

It's the age of plastics; it's the age of ease.
I'm a '60s chemist, and I'm very pleased
With garbage! (clap) . . . plastic cups, paper plates
In the garbage! (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 garbage! (clap) . . . 'cause the trash can burn—
All that garbage! (clap) . . . can make a turbine turn.
We'll make energy from our piles of trash.
The only problem will be the toxic ash.

I'm your average kid, and I have to say
That I've found an awesome, cleaner way
With garbage! (clap) . . . I try to make much less—
All that garbage! (clap) . . . I'm tired of all this mess.
Now I reuse, recycle, make a compost pile—
It's the garbage shuffle, 1990s-style!

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



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 cleanup 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

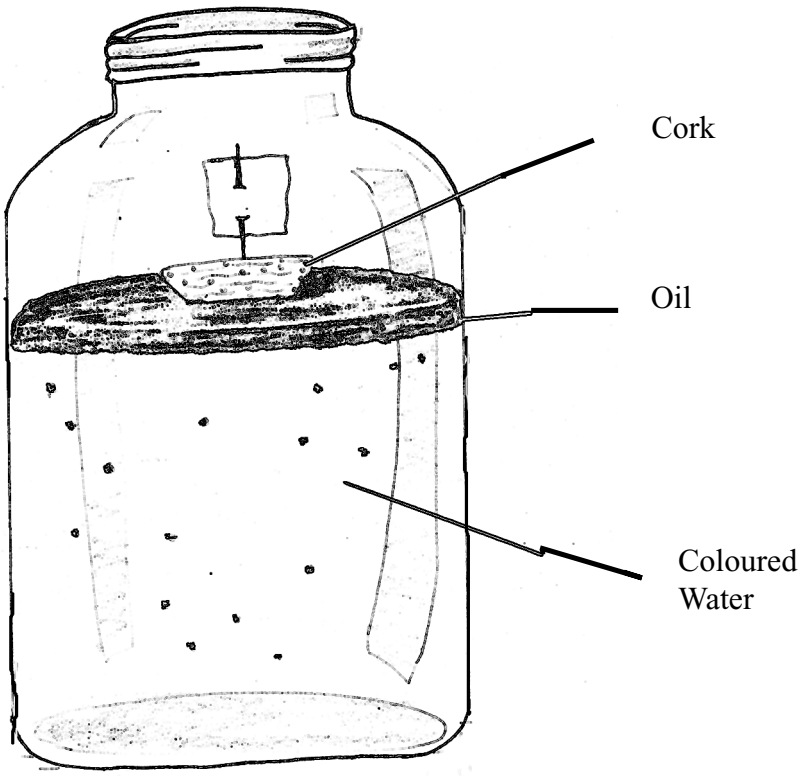
Glass bottle or jar with cap
Water tinted blue with food colouring
Cooking oil coloured with black tempera paint
Cork or toy boat that fits inside the bottle
Large pan
Sand
Cleanup materials: cotton balls or swabs, cut-up pantyhose or stockings, paper towels, popcorn, sponges, sawdust, gauze pads, rope 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 3-7, 3-8, and 3-11

Background Every year, throughout the West Indies, there are small oil spills. The islands are on the major oil shipment routes to and from South America and oil-producing nations like Venezuela and Trinidad. Thousands of supertankers criss-cross the Caribbean every year. One serious accident—a collision or a sinking in a tropical storm—could do irreparable damage to the mainstay of the West Indies' and Cayman Islands' economy—tourism. The sandy beaches and coral reefs would be wiped out overnight if a vessel half the size of the Exxon *Valdez* went down. This oil supertanker ran aground in Prince William Sound, Alaska, in 1990, carrying millions of tons of crude oil from Alaska's North Slope oilfields, destined for California. Despite millions of dollars spent on clean-up and restoration, the sound's ecosystem has still not yet fully

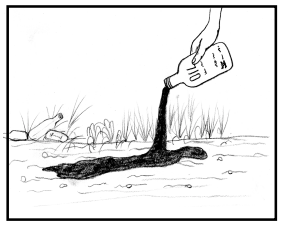
recovered. Fortunately, this has not yet happened here—but it is always a distinct possibility.

In the meantime, many other vessels ply the Caribbean Sea—from huge cruise ships to freighters carrying every cargo imaginable. These vessels are often the cause of small spills, or, worse, illegally pump their bilges while afloat. The oil from small spills and illegal dumping ends up in the same place—on our beaches and reefs. During the loading and unloading of tankers, whether it is to pump oil into refineries or storage tanks or to ship the refined products, there are often spills caused by carelessness or accidents.

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.



HUMAN IMPACTS ON MANGROVES



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 half an inch 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*.]

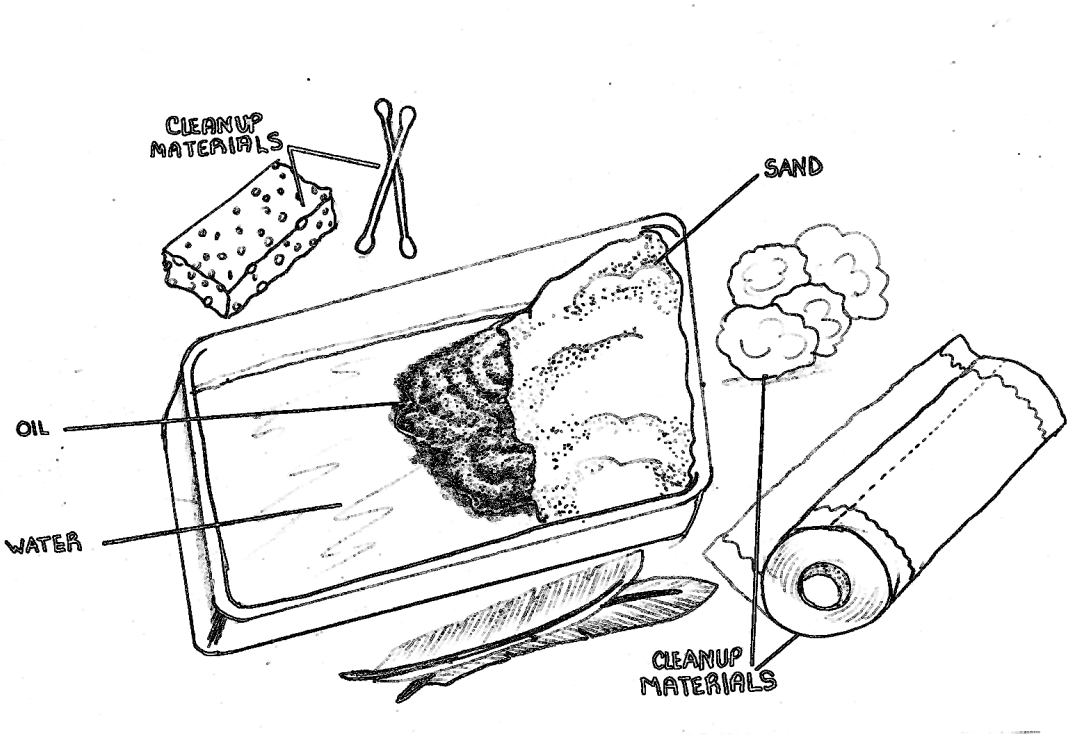
Discussion What would happen to organisms that float on the surface, such as seabirds, ducks, seaweed, or plankton, or those that need to come to the surface to breathe, such as sea turtles, whales, or seals? [*They'd be coated with oil.*]
Explain that over time, water and oil mix somewhat, and that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

Extensions 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

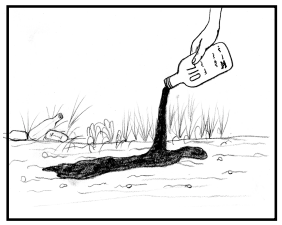
1. Examine a feather (see page 2-59, What Lives in Mangroves?). Natural oiliness on the feather keeps it from becoming waterlogged. Notice how it can fluff up after it's been handled.

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 West Indian Whistling-Duck is becoming endangered.

Learning Objective

Students will understand why the West Indian Whistling-Duck is endangered.

Age Levels 8–14

Subject Areas Science, social studies

Time 40–60 minutes

Materials Pictures of West Indian Whistling-Ducks (pages 2-25)
Copies of page 3-49 showing "Wheel of Trouble"
Lightweight paper plates at least nine inches (23 cm) in diameter
Crayons or markers
Scissors
Glue
Tape
Paper fasteners
Construction paper (optional)

Background The West Indian Whistling-Duck is endangered for the same reason that many other species are in trouble, including habitat loss, unregulated hunting (poaching), and pollution. Using the Whistling-Duck as an example, students can learn about the variety of problems that affect many endangered species.

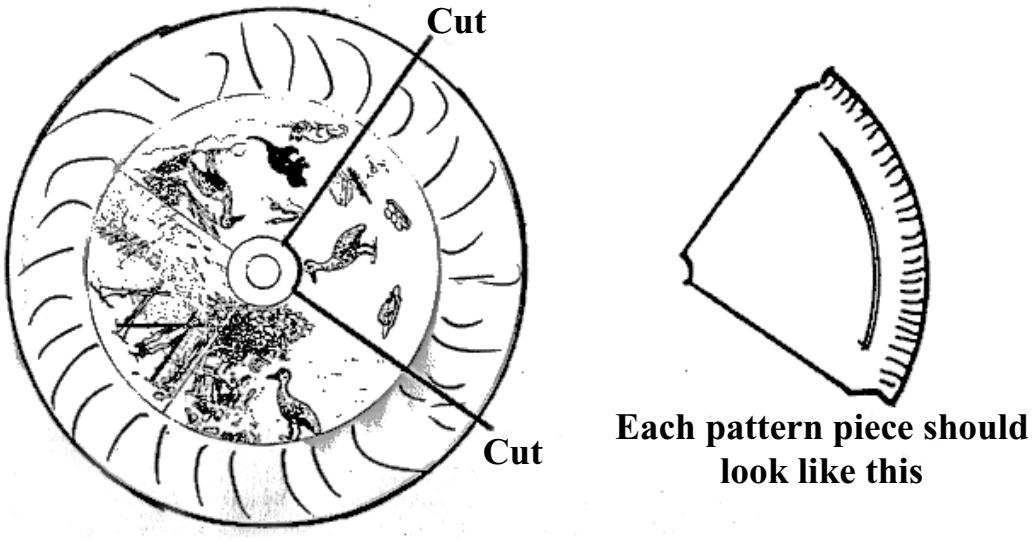
Pre-procedure

Before you begin, make eight triangular patterns, following the directions under "Getting Ready" below. Then start the activity by showing the class pictures of Whistling-Ducks and talking about their natural history. (For general information about Whistling-Ducks, see *Birds of the Cayman Islands.*)

Getting Ready

1. Cut out the circle on page 3-49 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 3-50). After cutting out each segment, remove the paper pieces. (You will end up with four separate segments.)

Wheel of Trouble



Repeat until you have enough segments so each student can have one.

Procedure

1. Now tell the students that Whistling-Ducks 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 3-49, 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.

4. Have students colour the pictures on page 3-49, then cut out the circle along the solid outer line.

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

6. 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.

7. 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 West Indian Whistling-Ducks face. Have the students turn their wheels to picture A, then B, and so on, and use the information under "Trouble for Whistlers" on page 3-51 to talk about each of the problems.

After your discussion, have the students draw a picture of a West Indian Whistling-Duck on their top plate and write the title "Why West Indian Whistling-Ducks are in Trouble."

Trouble for Whistlers

A. Meat and eggs. Unregulated hunting and poaching is a major problem for West Indian Whistling-Ducks. They are shot—often mistaken for other ducks—for food, and their eggs are also sometimes taken for food. Overhunting has caused the West Indian Whistling-Duck to be eliminated from many islands where it was once plentiful.

B. Wetland destruction. Development is another major problem for Whistling-Ducks. In many places around the Caribbean, including the Cayman Islands, people have built homes, condos, marinas, hotels, roads, ports, power stations, tourist resorts, and many other types of development where Whistlers nest and live. Mangrove wetlands are cut down and filled, as well as being rechanneled for mosquito control, thus completely destroying the duck's habitat.

C. Pollution. Many mangrove wetlands were once used as garbage dumps (and in many places still are). Pollutants from garbage like old transformers, oil barrels, and other toxic products make their way into the food chain and ultimately kill the ducks. Similar problems occur from sewage, industrial waste, and pesticide run-off. Oil and chemical spills coat the feathers of the birds and will ultimately kill them—especially in estuarine areas where they often feed on tidal flats.

D. Introduced species. For many hundreds of years, the Whistler had no known predators, and therefore thrived. However, the Indian mongoose, raccoons, rats, cats, and dogs have been introduced into the islands over the years, and these animals hunt and kill the birds and eat their eggs and young.

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 endangered, threatened, 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 3-54 and 3-55, "Imaginary Animals"
Index cards
Markers
Easel paper or chalkboard

Background West Indian Whistling-Ducks, green turtles, parrots, pandas, elephants, 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—for instance, by killing livestock, eating or ruining crops, or feeding on animals that people like to eat. Because of such "nuisance behaviour", these animals are often shot, poisoned, or harmed. For example, many parrots and bats in the West Indies like to eat fruits and vegetables, and are killed to stop this damage. And although the killing of parrots is now illegal in the Cayman Islands, people still kill bats.
- Migrate. Animals that migrate usually depend on several different habitat areas, so are very vulnerable to habitat destruction. For example, many songbirds that migrate to the Cayman Islands in winter are in trouble because thousands of acres of their forested wetlands habitat have been developed into farms, pastures, homes, resorts, marinas, and roads.
- Have very specific food or nesting requirements. Some animals are very "picky" about what they eat or where they live, or both. These specialized animals, which are often adapted to eating only one type of food or living in only one type of area, can become endangered if their food source or nesting site disappears. The

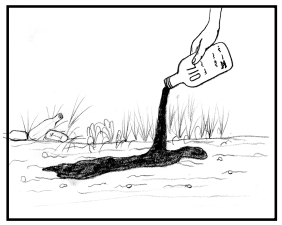
panda eats only the stems, twigs, leaves, and fresh young shoots of particular types of bamboo. The Cayman Brac Parrot nests only in cavities in dead and hollow trees, while the Bahamian Parrot in Abaco nests only in underground limestone cavities.

- Are very sensitive to changes. Many animals have a difficult time adapting to changes in their environment. For example, birds of prey and many other animals are very sensitive to chemical changes in their environment, such as the introduction of pesticides. Other animals have a hard time competing with introduced species that have the same nesting or food requirements. Introduced finches in Puerto Rico compete with the Puerto Rican Parrot for food and nesting sites.
- 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. This is particularly true of many of the plants and animals that live on small islands, with the Whistling-Duck a classic case in point. As more and more people move into small islands, many already rare plants and animals face habitat loss, competition from introduced species, new diseases, and other problems.
- 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, condors). Explain that when the populations of these animals drop, it takes much more time for them to recover because of the low birth rate. And the animals sometimes become extinct before they have time to make a comeback.

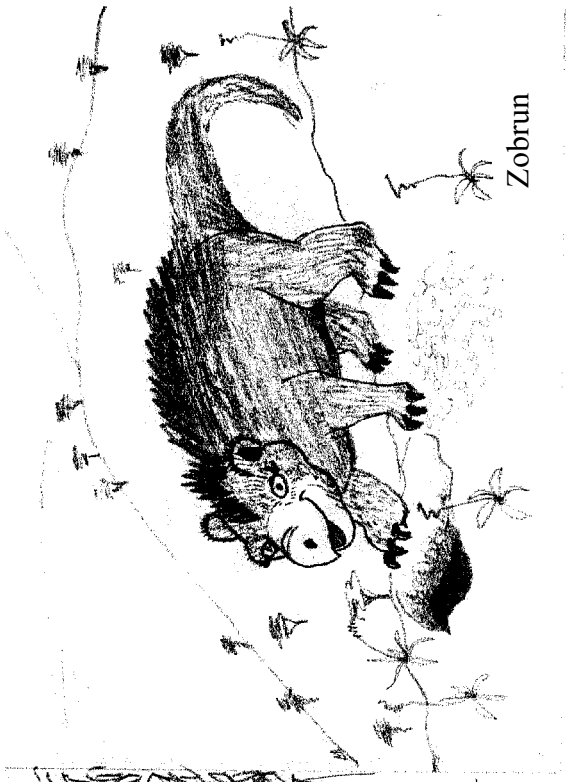
  Animals with a low birth rate have another problem, too. They don't reproduce fast enough to produce offspring that can adapt to changing conditions. Have the class compare the capabilities of an elephant with those of a cockroach. Explain that, on the average, an elephant has about three young every 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:

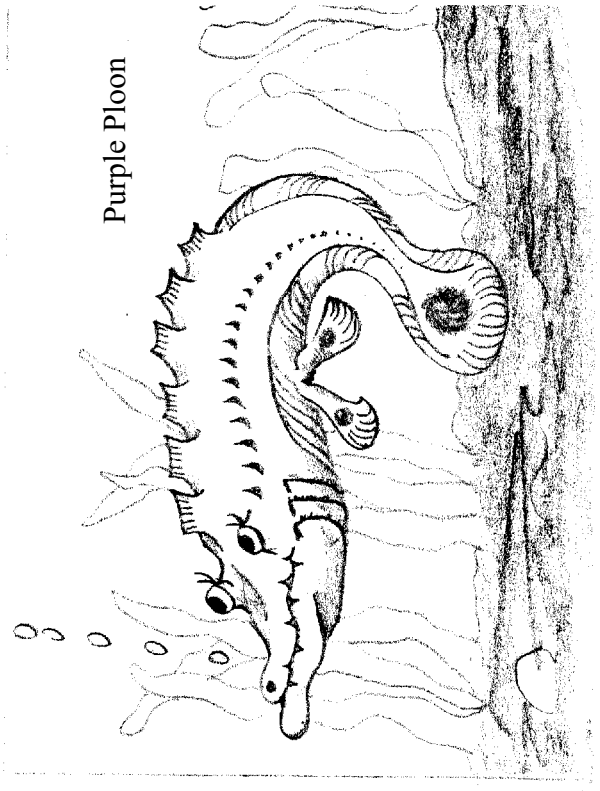
	Elephant	**Cockroach**
1st generation	3	80
2nd generation	6	3,362
3rd generation	13	137,842
4th generation	28	5,651,522
5th generation	61	231,712,403
6th generation	132	9,500,208,482

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 cock-



Imaginary Animals





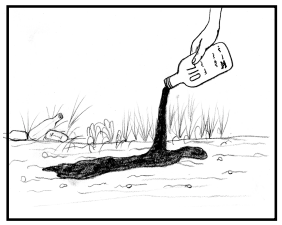
Imaginary Animals

Scaly Mangrove Muncher
- Lives in mangrove forests.
- Feeds on insects, small mammals, and Black Mangrove seeds, very fond of munra 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 mudbank of small island in gum trees.
- Migrates each year to a tropical island in the Caribbean.

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.



roaches 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 3-54 and 3-55, "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 3-55 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 3-54 and 3-55 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 birthrate, 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 wetlands. They could talk with people at both banks and insurance companies about such things as risk analysis and insurance premium costs. How much does hurricane insurance go up after claims caused by hurricane damage? The students could write a report on their findings.
Students could research a "before and after" hurricane-damage scenario to determine what a storm actually costs a local community, then write a report on their findings.

Activity 3-I: Caribbean & Cayman Islands Endangered Species Poster

Summary Many species of animals throughout the Caribbean and in the Cayman Islands are either threatened or endangered. This activity will make students aware of what factors cause animals to become threatened and endangered in the West Indies.

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

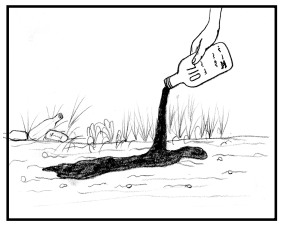
Materials

Copy of Species at Risk list on page 3-58
Copy of example of endangered species poster on page 3-59
Drawing or art paper
Crayons or paints
Camera (optional)
Copies of *Endangered Species of the Cayman Islands* (National Trust)
Postcards and/or photographs from magazines

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. 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 (e.g., corn) or prey on livestock, and farmers and ranchers resort to poisoning these animals that threaten their livelihood. As humans have needed more and more land for homes, recreational facilities, malls, 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 rats, cats, dogs, raccoons, and mongoose (especially on islands)—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 3-58.
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. Also, obtain copies of *Endangered Species of the Cayman Islands* from the National Trust.
3. Then have the students design a poster similar to the one on page 3-59, featuring the animal they have chosen.
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.

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?

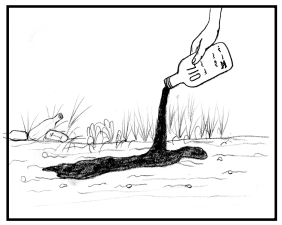
4. What does it eat?

5. What are the major threats to its survival?

6. How can we help to protect it?

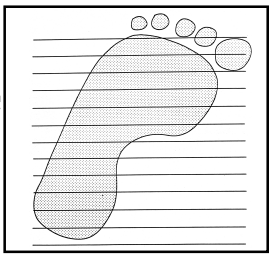
Species at Risk in the West Indies

Bahamas Parrot (Bahamas)
Cayman Brac Parrot (Cayman Brac)
Cayman Parrot (Grand Cayman)
St. Lucia Amazon (St. Lucia)
West Indian Flamingo (Caribbean)
West Indian Whistling-Duck (Caribbean)
Bahamian Hutia (Bahamas)
Jamaican Hutia (Jamaica)
Hispaniolan Hutia (Hispaniola)
Hawksbill Turtle (tropical seas)
Leatherback Turtle (tropical seas)
Green Turtle (tropical seas)
Loggerhead Turtle (tropical seas)
West Indian Manatee (Caribbean)
Caribbean Monk Seal (Caribbean)
Black-capped Petrel (Cuba, Hispaniola)
Gundlach's Hawk (Cuba)
Zapata Rail (Cuba)
Cuban Conure (Cuba)
Red-necked Amazon (Dominica)
Imperial Amazon (Dominica)
Puerto Rican Nightjar (Puerto Rico)
Jamaican Least Pauraque (Jamaica)
White-breasted Thrasher (Martinique, St. Lucia)
White-winged Ground Warbler (Hispaniola)
American Crocodile (Caribbean)
Turks & Caicos Rock Iguana (Turks & Caicos, Bahamas)
Jamaican Iguana (Jamaica)
White Key Iguana (Bahamas)
Exuma Iguana (Bahamas)
Anegada Iguana (U.S. Virgin Islands)
Rhino Iguana (Haiti)
Ricord's Iguana (Dominican Republic)
Mona Island Iguana (Dominican Republic)
Lesser Antilles Iguana (Lesser Antilles)
Little Cayman Iguana (Cayman Islands)
San Salvador Iguana (Bahamas)
White Key Iguana (Bahamas)
Andros Ground Iguana (Bahamas)
Cuban Ground Iguana (Cayman Islands, Cuba)
Cuban Tree Boa (Cuba)
Jamaican Boa (Jamaica)
Queen Conch (Caribbean)
Mona Cave Shrimp (Puerto Rico)
Hercules Beetle (Caribbean, different sub-species)
Eight-spotted Skipper (Jamaica, D.R.)
Scarce Haitian Swallowtail (Hispaniola)

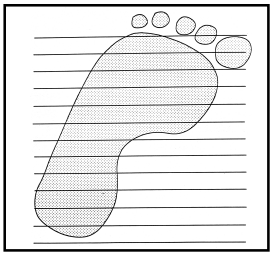


Endangered Species Poster

The West Indian Whistling-Duck is the largest and rarest of the eight species of whistling ducks. They roost in mangroves during the day.



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. Whether it be to a mangrove swamp or a saltwater pond, 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". 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 neighborhood, the yard at home, the world, or even the school building. Let individuals choose a definition, then ask a few to report what they have written.

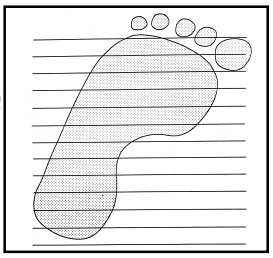
Take the class outside for 10 minutes. For the first five minutes, have them write down the first five things that they see that they like and that they dislike. Spend the last five minutes hearing responses. There are no right or wrong answers. Return to the classroom and have students write a poem 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 4-38). 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 Wetlands 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 wetland 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, crashing waves (at seashore wetlands), 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?

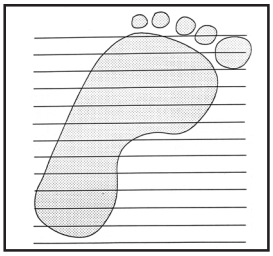
We will see more if we are quiet. The site should be left as close to natural as possible, so that future visitors will be able to enjoy the area's plants, wildlife, and beauty.

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 roughhousing will scare animals away, and may cause some to abandon their nests or young, or to avoid the area in 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 pond fry to observe, these organisms will have a much better chance of surviving if left in their own environment. If you are digging for clams or worms, refill your holes. It is not the hole that is injurious, but the sand and mud piled up around the hole. All clams require a connection to the surface in order to survive. Their syphon can stretch only so far, and piles of mud or sand create a suffocating blanket.



Even empty shells are part of the mangrove wetlands ecosystem: limpets, chitons, 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 tidepool in the low-tide zone has different temperatures and salinity from those higher up. A low-tide animal such as a sea urchin or sunflower star would not survive in the high-tide pool. One type of wetland immediately adjacent to another may have a 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.

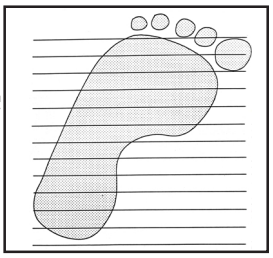
7. Leave the wetland or intertidal zone cleaner than you found it.
Plastics make up the major portion of garbage in wetlands and the intertidal areas, and they can kill wildlife that become entangled in it or eat it. Clear plastic bags may be mistaken for jellyfish, while fishing line, six-pack rings, 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 marshes, 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, plane, personal watercraft, or all-terrain vehicle. Harassing animals is against the law on some islands.

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

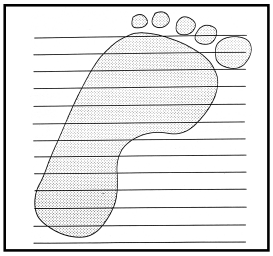


- Skittishness
- Excessive preening or pecking at dirt or foot/bill wiping
- Alarm calls; repeated chirping or chipping
- Distraction play: broken wing, tail spread, etc.

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.

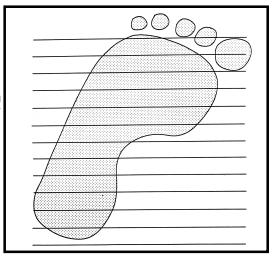
14. Before leaving
Take time to assess the impact of your visit. Have students ask themselves: "Is this area as beautiful now as before my visit?"



Mangrove Wetlands 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 or your local National Trust or botanical gardens. This person 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 island. Often a successful field trip includes seeing plenty of birds, and migrating ones are important if you have covered migration in your classroom studies.

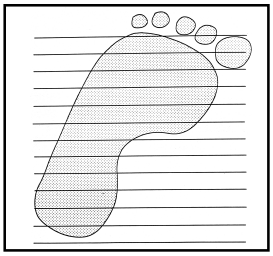
- ❑ **Obtain permission** for your field trip if the site is on private property.
- ❑ **Familiarize yourself with the site** by visiting it ahead of time, as well as obtaining any background information related to the site.
- ❑ If you will be visiting an intertidal area, **check a tide table**. One hour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

❑ **5. Arrange transportation.**

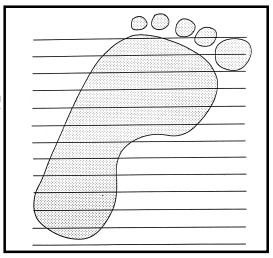
❑ **6. Select activities** for use before, during, and after the field trip. This resource guide is full of ideas. Use these, gather ideas from other activity source books, or develop your own activities with the help of resource persons.

❑ **7. Prepare the schedule** for the field trip (see sample schedule on page 4-9). 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 (Mangrove Wetlands 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. See sample on page 4-10.
- ❑ **10. Send home permission slips** (see sample on page 4-11). 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. Check with your local Society of Caribbean Ornithology representative, as the Whistling-Duck Working Group has some pairs of binoculars available for teachers. 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 4-12. 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.



Sample Field Trip Schedule

CAYMAN BRAC HIGH SCHOOL

P.O. Box 251
Stake Bay
Cayman Islands
British West Indies

Tel: (345) 948-2500
Fax: 345) 948-2254

Memo to: Melanie Bryan, George Hicks High School
From: Martin Keeley, Cayman Brac
Date: 1 May 2000
Subject: Schedule for Heritage/Ecology Trip to Cayman Brac:

The following is the timetable for your field trip to Cayman Brac on Thursday, May 4.

8.30 am Bus will pick up students and teachers at airport. Drive to Bight Road (old trail across the Bluff). Your chief guide for the day will be T.J. Sevik, a young Bracker whose job directly involves heritage/nature tourism.

8.45 am Walk the Bight Road to the Brac Parrot Reserve. Study flora and fauna enroute. The walk is scheduled for one hour.

9.45 am Bus picks up everyone at Parrot Reserve and takes them to the Museum at Stake Bay.

10.00 am Visit Brac Museum, approximately 40 minutes.

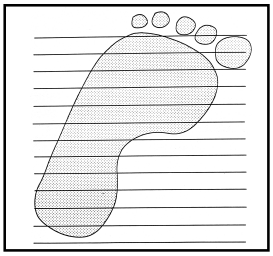
10.40 am Bus takes everyone to the family home of Sylvia Rich at the Creek, currently rented out. The tenants will give a home tour—the house is from early part of the century, survived the ’32 Storm, and has been beautifully restored. About one hour.

11.40 am Bus takes everyone to Public Beach for lunch and relaxation (two hours).

2.00 pm Visits to Bat Cave, Rebecca’s Cave, and West End Ponds (two and a half hours).

4.30 pm Bus takes students to Brac Reef Hotel for sandwiches, shopping, and R&R before trip back.

6.00 pm Return to airport for plane back to Grand Cayman (flight leaves at 7.00 pm).



What to Wear and Bring

Fortunately for those of us planning to explore wetlands in the Cayman Islands, we don't have to load ourselves down with cold- or wet-weather gear of the kind usually worn by students "up north" for their field trips.

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 4-34). If you are planning to take back a water sample to the classroom for analysis, you'll also need a few extra items.

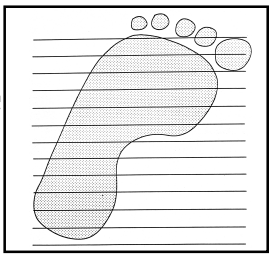
Your list should read:

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. insect repellent for mosquitoes
7. pencil, paper, and clipboard (or equivalent substitute, like a sheet of cardboard)
8. sunglasses
9. pair of binoculars for bird study
10. old towel to dry off
11. water bottles
12. packed lunch if necessary
13. trash bag

For Water Studies

1. plastic containers
2. fishing nets (see page 4-19 for how to make one)
3. magnifying glasses
4. view glass (instructions for making one are on pages 4-17 and 4-18)
5. field guides (from the front of this workbook)
6. something to dig with
7. turkey basters or small brushes for transferring organisms from one container to another
8. plastic pails



Sample Permission Slip/Letter

CAYMAN BRAC HIGH SCHOOL

P.O. Box 251
Stake Bay
Cayman Islands
British West Indies

Tel: (345) 948-2500
Fax: (345) 948-2254

24 September 2000

Dear Parent/Guardian

As you are probably aware, we have been studying the ecology of mangrove wetlands in the classroom this term.

Next Wednesday, we are planning a field trip to the West End Ponds to examine mangroves first-hand. As usual with all field trips, we need your permission to allow students to do this. I would be grateful if you would sign the slip below and return it to me as soon as possible. I'm afraid that students who do not return the slip will not be able to take part in this exciting program. To avoid unnecessary work, this slip will cover permission for both fall field trips.

Transport will be provided, and there will be no charge for this curriculum-based activity. If you wish to discuss this, please do not hesitate to contact the Principal or myself to arrange an appointment.

Yours sincerely,
Martin A. Keeley
Ecology Teacher

CAYMAN BRAC HIGH SCHOOL

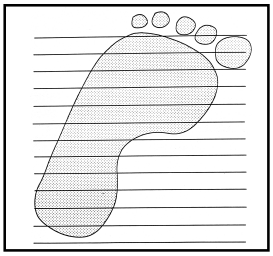
Permission slip for Mangrove Field Trip, September 27, 2000

NAME OF STUDENT_____HOMEROOM_____

I give permission for my son/daughter to take part in the Mangrove Field Trip.
Yes No (Circle one)

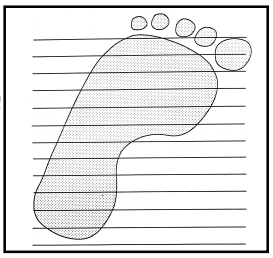
PARENT/GUARDIAN SIGNATURE_____DATE_____

If your child has any medical problems, please give details.



Data Collection Sheet

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



Activity 4-A: Using a Microscope

Understanding the fertility of mangrove wetlands 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.

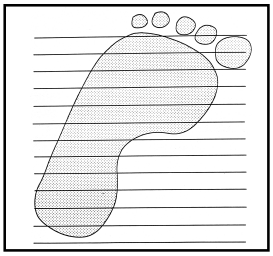
To some extent, our ability to understand the world we live in is dependent on our learning about things that our own senses cannot reveal to us. This is where resources such as the microscope become vital in our understanding of the microscopic world. The microscope is one of the essential tools of 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.

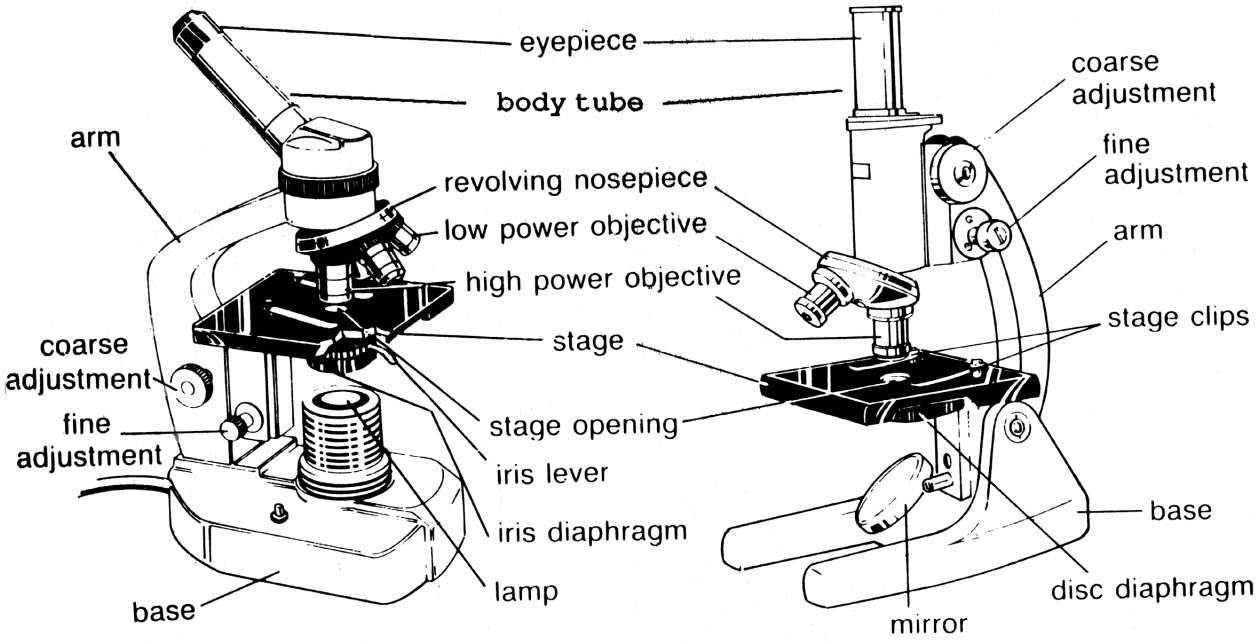
Viewing samples on slides

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

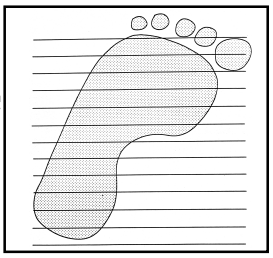


lens will clear the slide (as long as the specimen is not too thick)

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.



Parts of a Microscope



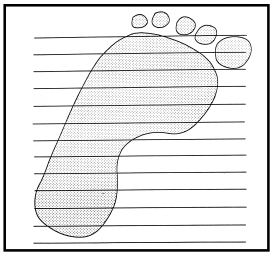
Activity 4-B: How to Use a Hand Lens

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 10 feet 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.

(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 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 *diopters*, 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.

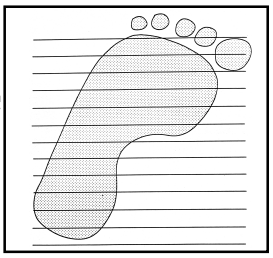
To adjust your binoculars for any difference in the strength of your eyes, first, using the lens cover or your hand, cover the objective lens (the outer, big lens that is on the same side as the adjustable eyepiece). With both eyes open to avoid distortion, look through the binoculars, and, using the 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

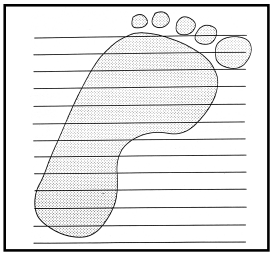
Subject Areas Science, social studies, industrial arts

Time 1–2 lessons, or more

Materials **Plastic version** (for younger students)
Large plastic containers or large round cans
Heavy-duty clear plastic kitchen wrap
Several pairs of scissors
Large rubber bands
Wooden version (for older students)
41-inch length of 1 x 12-inch board
11 x 14-inch sheet of clear (picture) glass
Caulk
One-inch panel pins

Background Hundreds of years ago, fishermen in the Cayman Islands developed a way to see if there were any fish to catch. It's called a view glass and is an integral part of fishing culture on many Caribbean islands. In the olden days, caulking was used the same way as it was with boats—usually a form of pitch and rope. Now, however, modern caulking methods and materials are used to seal up the glass. It makes an ideal field tool, especially for younger children who cannot swim.

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 12-inch lumber into four sections. Two will be 10.5 inches long and two will be 15 inches long.

2. Using a router, cut a groove one-quarter inch deep, the same width as the glass, around the bottom of all four pieces, about one inch from one end of the pieces (this will be the bottom).

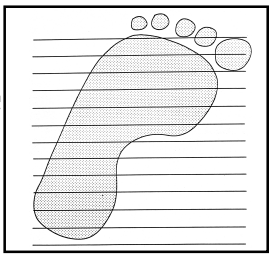
3. Using the panel pins, nail together three of the pieces, two of the 15-inch pieces and one of the 10.5-inch pieces.

4. Carefully slide into the grooves the 11 x 14 sheet of clear picture glass until it is as tight a fit as you can make it.

5. Fit the last piece of 10.5-inch 1 x 12, 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

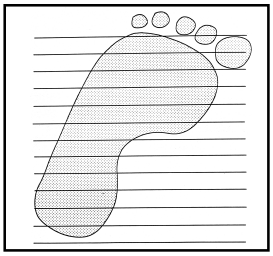
Subject Areas Science, social studies

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 8–12 inches in diameter, and the other end makes a handle.
2. Cut off one leg of the pantyhose or tights so that about 12–18 inches 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).



Tools for Collecting

Activity 4-F: Making a Sieve Box

Summary Mangrove wetlands 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

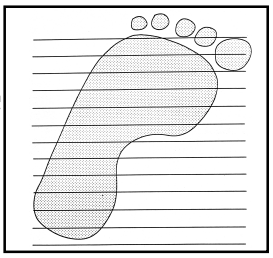
Subject Areas Science, social studies

Time 30 minutes

Materials Large plastic containers or large round cans
Several pairs of scissors
Length of string or rope 1 m (3–4 ft) long

Background Students will have learned about mangrove 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 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 one-quarter of an inch 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

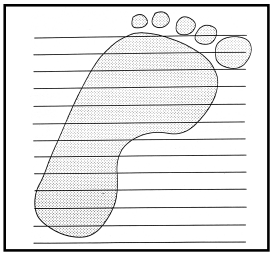
Time 2–3 lesson periods

Materials

Microscopes (one per two or three students if possible)
Plastic containers containing wetland water samples
Eye dropper
Glass slides
Copies of page 4-31, “Microscopic Study—Sketch and Identify”
Pencils
Hand lens (magnifying glass)
Copies of "Invertebrates of Mangrove Wetlands", pages 4-24 through 4-30
Copies of pages 4-13 and 4-14, “Using a Microscope”

Background During your field trip, you will have gathered water samples from the mangroves 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.

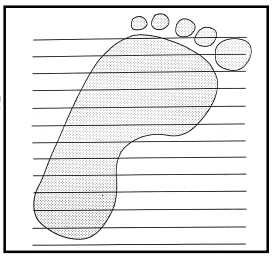


Primary food production is provided by microscopic algae floating in the sunlit surface waters, called **phytoplankton** (plants). Filaments of algae that form the familiar pond scums usually harbour many microscopic animals. These tiny aquatic animals are called **zooplankton**. They range from microscopic one-celled animals (protozoans) to large, many-celled animals (metazoans) such as worms, insects, fishes, and alligators. 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).

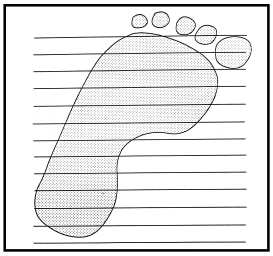
Procedure

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 4-13 and 4-14 for details.
3. Pass out microscopes, copies of pages 4-13 and 4-14, "Using a Microscope", and copies of pages 4-24 through 4-30, "Invertebrates of Mangrove Wetlands". 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 4-31, "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.

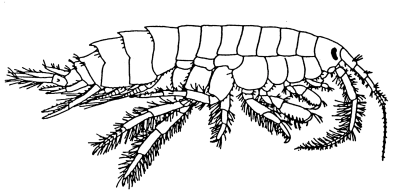
Extensions This is another opportunity for students to familiarize themselves with the enormous spectrum of invertebrates while practising research and careful comparison skills. Some of the creatures may not be easily identifiable from the invertebrate charts, so students will have to look in textbooks 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 Mangrove Wetlands

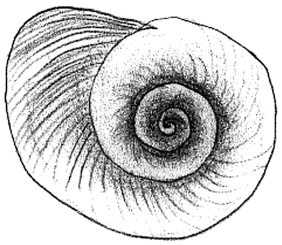
There are many thousands of species of invertebrates living in and around wetland areas, and it would be impossible to provide illustrations of every one that you might find. Intead, we have concentrated on those that are most common in the water, in the mud, and on the mangrove trees that grow in the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

Amphipod or Scud (Order Amphipoda)



Description Microscopic to 2 cm (1 in). A small crustacean that looks like a shrimp 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.

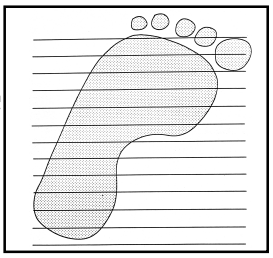
Atlantic Moon Snail or Shark Eye *Polinices duplicatus*



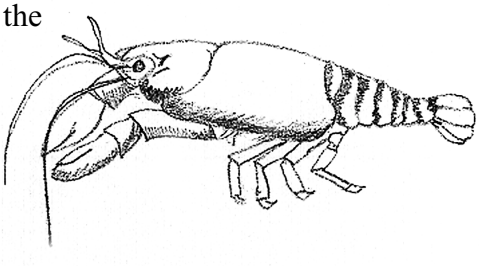
Description 2.5 to 6 cm (1–2.5 in). Generally flattened and wider than high, the shell is glossy and smooth. It is a tan or bluish-gray, whitish at the base. A heavy purplish-brown skin almost covers the central cavity around which the whorls coil, leaving a narrow, curved slit along the outer edge.
Habitat Intertidal zone in sand and mud. They can often be detected by the sand collars in which they lay their eggs.
Food Other molluscs, usually bivalves; by drilling a neat round hole through the shell of the prey.

Barnacle (Class Cirripedia)

Description There are four main species, and size depends on species, which can range from 6 mm (0.25 in) for the Fragile Star Barnacle to 2.5 cm (1 in) for the Ivory Barnacle. Grayish in colour, these encrustations look like miniature volcanic cones that stay closed when the tide is out. When covered with water, the tops of the cones open to allow feather-like appendages to emerge to catch food.
Habitat Usually attached to rocks, pilings, oyster shells, bottoms of boats, etc.
Food Plankton, which they filter-feed from the water.

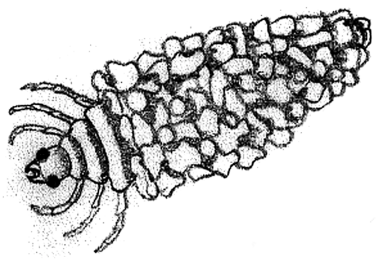


Beach Crayfish *Callianassa* sp.



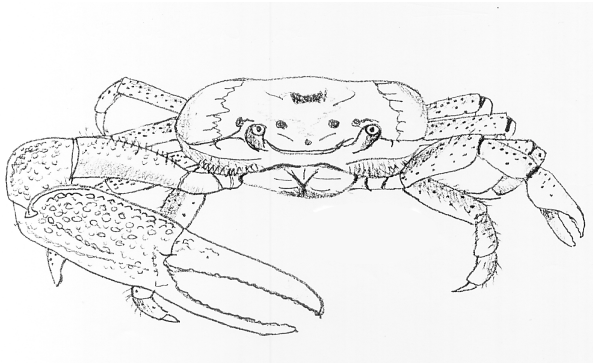
Description To 8 cm (3.25 in) long. Carapace about 1/4 of the animal's length (shorter than the mud shrimp). Skin covering its body is smooth, white, and glossy. It lacks a flattened hairy area in front. Its claws are unequal and its movable fingers hairy.
Habitat Extensive burrows in mud and sand, beneath rocks in the intertidal and shallow subtidal zones.
Food Plankton and other tiny organic particles, which they filter-feed from the water.

Caddisfly larva (Order Tricheroptera)



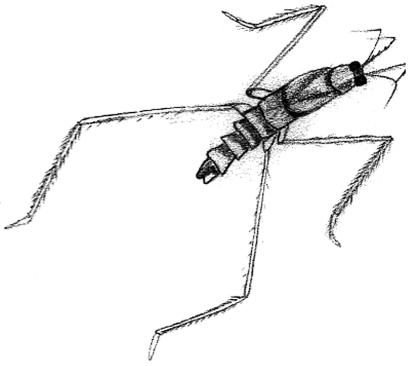
Description Microscopic—up to 1 cm (0.5 in), these larvae can be free-living in water or may live in cases made from sticks, gravel, and sand. The free-living larvae seldom have gills along their abdomens, and have a narrower head than thorax. Abdomen ends in pairs of prolegs which may be hidden by hairs. Each proleg has a single hook on the end, and these are sometimes fused together.
Habitat Creates its own case (except free-living ones) and are found in freshwater ponds and marshes, mangroves, shallow water, often in the mud at the bottom of the pond, and under rocks.
Food Algae, detritus, some very small insects.

Caribbean Fiddler Crab *Una rapax*

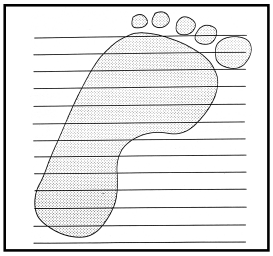


Description The most common of many species of fiddler crabs found in the West Indies. Length 2.1 cm (0.8 in). Light-tan colour, claw light tan, lower palm and finger darker but never red. Centre of palm almost smooth, covered with fine granules. The large claw, found in the male only, is used primarily for mating and territorial displays rather than feeding or defense.
Habitat Sheltered mudflats near mangroves, flat banks close to mouth of streams. Lives in burrows close to other fiddler crabs.
Food Detritus, especially dead Red Mangrove leaves.

Common Water Strider (Skater) *Gerris remigis*



Description 12–16 mm (0.5–0.6 in) long and slightly flat. Dark-brown to black, some with silvery markings. Short forelegs. Long, slender middle and hind legs. Mostly wingless. These creatures have many local names because they appear to walk on water.

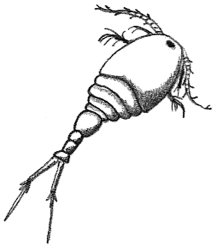


Habitat Surfaces of ponds, slow streams, marshes, mangroves, and other slow-moving waters.
Food Aquatic insects, including mosquito larvae that rise to the surface and terrestrial insects that drop into water.

Coon Oyster *Lopha frons*

Description To 5 cm (2 in) long with red or brown shell, white inside, often with violet margin. Thin with folds and ridges.
Habitat Red Mangrove prop roots.
Food Filter-feeds plankton and other micro-organisms.

Copepod (Order Isopoda)

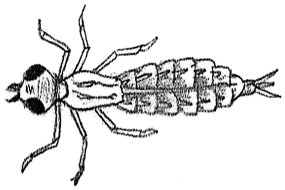


Description Microscopic to 0.5 mm (0.05 in). Often called a "cyclops", this zooplankton has one eye in the middle of its head. It has feathery antenna and a two-pronged tail. It tends to swim around very quickly.
Habitat Salt ponds and marshes, mangroves, shallow water, often in the mud at the bottom of the pond.
Food Detritus.

Crab Larvae *Zoea larva*

Description Up to 2 cm (0.5 in). A crab in the larval stage may moult three or four times before reaching full size, each time becoming more like the adult in appearance. In one stage it has a long proboscis, with two short legs and a segmented tail. It usually dark-brown or grey.
Habitat Salt ponds and marshes, mangroves, and intertidal zone.
Food Often smaller versions of the larval stage called Nauplius.

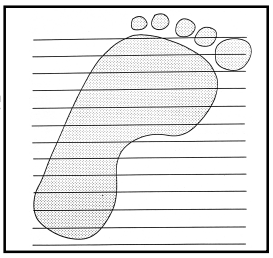
Dragonfly Nymph (Order Odonata, Suborder Anisoptera)



Description Microscopic up to 1 mm (1/16 in) long. Dragonfly nymphs have no tails, but there are three prongs on the end of their bodies. The body itself is squat and stout, and they have large mouthparts. They have large eyes, and a mask-like lower lip.
Habitat Salt ponds and marshes, mangroves, shallow water, often in the mud at the bottom of the pond.
Food Small aquatic insects.

False Cerith *Batillaria* sp.

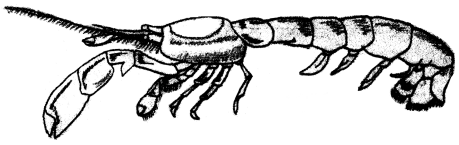
Description Small shell 1–2 cm (0.25–0.75 in) high; strong and rough. Colour varies from black to white, often with narrow or broad light-coloured spiral bands. The aperture is narrow and toothless. The shell spirals to a point at one end.
Habitat Usually found in great numbers in mud at the edges of salt and mangrove ponds and intertidal areas.
Food Detritus.



Ghost Shrimp *Callianassa atlantica*

Description Up to 8 cm long (3.25 in). Translucent white, smooth, and glossy. Claws are unequal in size, movable fingers are hairy. Males lack large tooth on inner margin of upper finger of large claw. Often buried in sand with only eyes exposed.

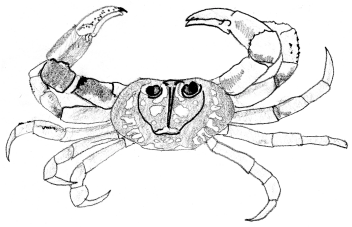
Habitat Several individuals are usually found in a single burrow system, which often has several branches. Burrows in silty sand in mangrove, intertidal, and estuarine areas. Also found beneath rocks in same areas.



Food Filter-feeders, trapping tiny organic particles from water pumped into their burrow by their flattened abdominal appendages (pleopods).

Great Land Crab *Cardisoma guanhumi*

Description Huge carapace (shell) up to 9.5 cm (3.75 in) long. Males have vastly unequal claws; larger claw with slender gaping fingers may be longer than carapace. Adults pale-grey or bluish; young usually blue to violet.



Habitat Coconut groves, irrigation ditches, and marshes, especially close to the sea. Constructs large, deep burrows extending to water levels.

Food Nocturnal, sometimes foraging during the day on fruit and leaves.

Lister's Tree Oyster *Isognomon radiatus*

Description To 5 cm (2 in) long. Longer than Mangrove (Flat Tree) Oyster but related species. Bivalve is yellowish with reddish radial markings; 4–8 widely spaced grooves on hinge. Often have barnacles growing on their shells.

Habitat In colonies on Red Mangrove prop roots and rocks, mostly in the intertidal zone.

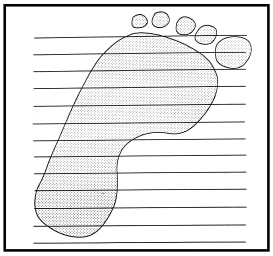
Food Filter-feeds plankton and other micro-organisms.

Mangrove Crab *Aratus pisonii*

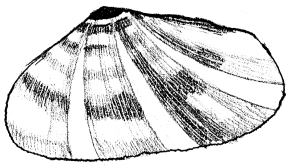
Description Up to 2.5 cm (1 in) long. Fast-moving little crabs have a carapace that is usually dark-green in colour, though the colour can vary. On the back half of the carapace are what appear to be a series of faint crease lines extending from each edge towards the midline. Outer surface of the claws has clusters of black hairs.

Habitat Trunk or limbs of Red Mangroves, occasionally entering the water to escape predators or moisten their gill chambers.

Food Red Mangrove leaves.

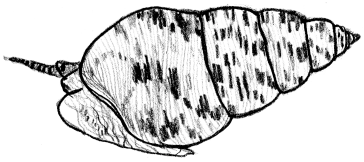


Mangrove (Flat Tree) Oyster *Isognomon alatus*



Description To 7.5 cm (3 in) long. Bivalve is grey or purplish and very flat. Hinge has 8–12 parallel grooves. Often have barnacles growing on their shells.
Habitat In colonies on Red Mangrove prop roots and rocks, mostly in the intertidal zone.
Food Filter-feeds plankton and other micro-organisms.

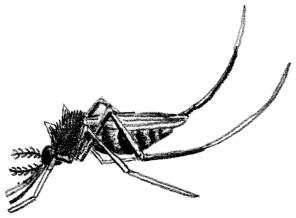
Mangrove Snail *Littorina anguilifera*



Description Up to 2.5 cm (1 in) high. The shell is thin with numerous fine spiral grooves. The colour varies from orange to reddish-brown with darker wavy bands. The aperture is whitish and the columella is purple.
Habitat Usually found clinging to branches of mangrove trees and on pilings and sea walls.
Food Microscopic algae and diatoms it scrapes from the sub-strate.

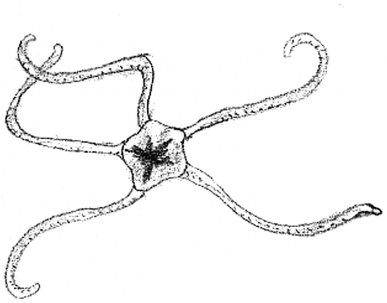
Mosquito (Family Culicidae)

Description Slender, delicate flies less than 6 mm (0.25 in) 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 (3.4 in) 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.

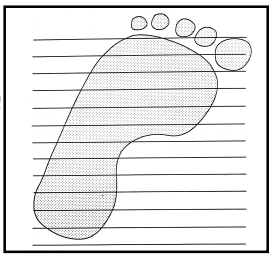


Habitat Stagnant water in ponds, lakes, marshes, and puddles.
Food Females need blood to incubate eggs, while males generally feed on plant juices.

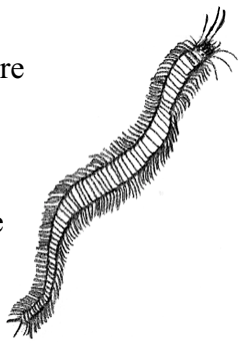
Mud Brittlestar *Ophiophragmous filograneus*



Description One of several species of brittlestar to be found in the intertidal zone**.** Centre disc can be up to 1 cm (0.5 in) across, arms up to 15 cm (6 in) long. Brittlestars superficially resemble starfish, except they are generally smaller and have slender, serpentine arms that are sharply demarcated around the central disc. Colour is a dingy grey except for indistinct banding on the arms.
Habitat In the sand and mud of the intertidal zone, often in shoal grass roots.
Food Detritus, algae, micro-organisms, and small fishes.



Polychaete Worms (Class Polychaeta)

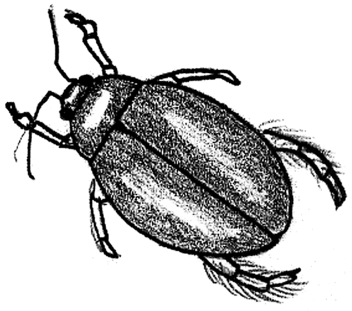


Description There are many different species of polychaete worm, but they are generally divided into two groups: free-swimming or sedentary (living in burrows). They are variable in body shape and size, depending on their lifestyles. The clam worm, for example, can grow up to 1 m (3 ft) long. Each segment of the worm bears a pair of fleshy, bristly appendages called parapodia, which are used in respiration, filter-feeding, and locomotion.

Habitat Free-swimming worms are found in salt ponds and marshes, mangroves, shallow water, and the intertidal zone. Sedentary worms are often in the mud where they have made burrows that they rarely leave.

Food: Varies depending on species: sedentary worms eat mostly detritus and plankton, free-swimming worms eat small crustaceans and molluscs.

Predacious Diving Beetles (Family Dystiscidae)

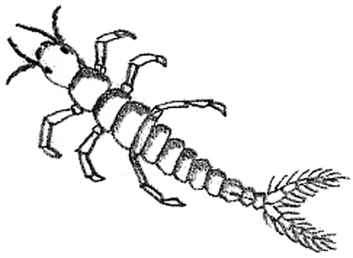


Description 2.5–3.8 cm (1–1.6 in). Oval shape; dark brown or black, often with a greenish tinge, sometimes with yellow along sides. Legs are yellow or brownish. Carry air supply with them when diving, in the form of a bubble of air.

Habitat Salt and freshwater ponds and marshes, mangroves, and pools and lakes.

Food Detritus and less vigorous aquatic animals like tadpoles and small fish.

Predacious Diving Beetle Larvae (Family Dystiscidae)

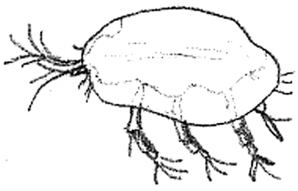


Description Microscopic—called water tigers, these larvae are 5–70 mm (0.24—2.75 in) long. They have strong, sickle-shaped jaws, six legs, and a dual tail with hairs on it.

Habitat Salt and freshwater ponds and marshes, mangroves, and pools and lakes. Larvae crawl out of the water to pupate in moist earth.

Food Small aquatic insects.

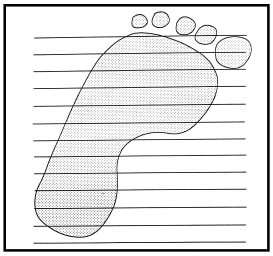
Seed Shrimp (Order Decopoda)



Description Microscopic to 0.5 mm (1/25 in). A tiny crustacean that looks like a bean seed when it is closed. When the seed shrimp is swimming, legs with hairs appear from inside the shell.

Habitat Salt ponds and marshes, mangroves, shallow water, often in the mud at the bottom of the pond.

Food Detritus.

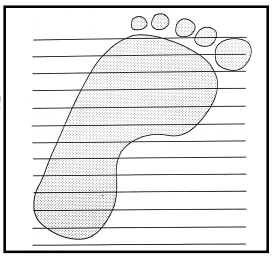


Water Boatman (Family Corixidae)

Description 5–13 mm (0.25–0.5 in). Elongated oval shape. Gray to brown, upper surface, usually with fine crossbands. Head concave, concealing forward portion of prothorax and making forewings appear to arise immediately behind head. Forelegs short, tarsi scooplike. Middle and hind legs are flattened, paddle-like. Hind parts fringed with hair.
Habitat Salt ponds and marshes, mangroves, shallow water.
Food Minute algae.

West Indian Murex *Chicoreus brevifron*s

Description Large—to 15 cm (6 in) long, with brown, thorny, long-spined shell with large aperture.
Habitat Red Mangrove roots and intertidal zone.
Food Barnacles, oysters, and mussels.



Microscopic Study – Sketch and Identify

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

Salt Pond Water Life Checklist

Check the plants and animals you found at the site or in your water sample.

Plants (including Phytoplankton)

- Pond weed ❑
- Blue–green Algae ❑
- Green Algae ❑
- Diatoms ❑
- Dinoflagellates ❑
- Euglenoids ❑
- Mangroves ❑
- Reeds ❑
- Sedges ❑

Animals (including Zooplankton)

- Protozoans ❑
- Hydras ❑
- Mollusks (snails) ❑
- Worms ❑
- Crustacea ❑
- 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.)

_____

_____

_____

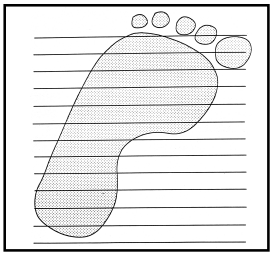
_____

_____

_____

_____

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

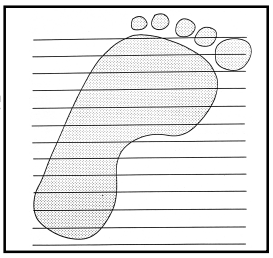
Materials Copy of page 4-34, " Mangrove Scavenger Hunt"
Pencils
Clipboards

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 4-34, "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.

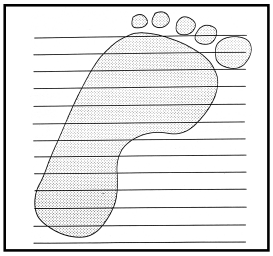
Discussion/Reflection

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 pond, and marine aquatic habitats.



Mangrove Scavenger Hunt

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, tell what you observed about it to the class.

Three different kinds of birds:

Three different kinds of aquatic creatures

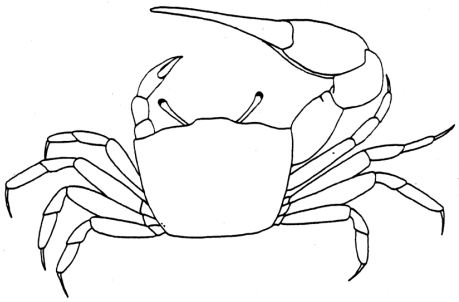
Three different kinds of animals (or animal signs such as tracks, scat or animal bones)

What have you seen that might be food for a

Heron?

Crab?

Stilt?



Three different kinds of plants:

Two signs of human influence:

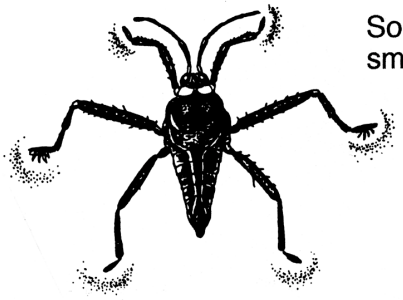
What did you touch that was smooth?

rough?

sharp

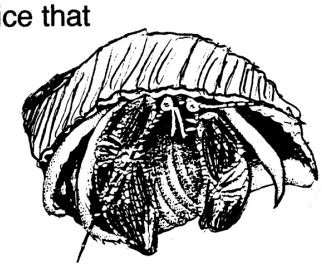
wet?

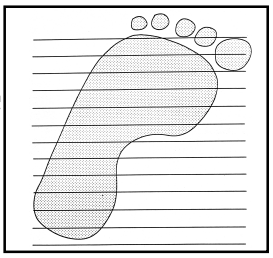
dry?



Something you don't like the smell of:

Something you notice that smells pleasant:





Activity 4-I: Mangrove Survivors

Summary Students will observe and record adaptations of mangroves and organisms in the mangroves.

Learning Objective
Students will learn through observation the kinds of adaptations that allow mangrove trees to survive in salt water.

Age Levels 7 and up

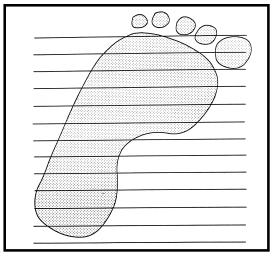
Subject Area Science

Time 30–60 minutes

Materials Pages 2-11 and 2-12 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 (hurricanes 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 Black 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 2-11 and 2-12, 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 tree 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

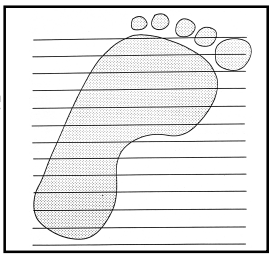
Subject Area Science

Time 30 minutes

Materials Copies of page 2-6, " 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 2-6, "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 wetland area.

Age Levels 8 and up

Subject Area Science

Time 30 minutes

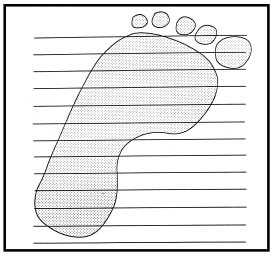
Materials Large wire footprints made from old coat hangers, one for each group
Magnifying glasses (one per student if possible)
Giant footprint handout on page 4-38 (one per group)
Pencils (one per group)
Field guide on invertebrates at the front of this book

Background Read and learn the information in Sections 1 and 2 "All About Mangroves" and "Mangroves as Habitat". For invertebrates, look at pages 4-24 through 4-30 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.

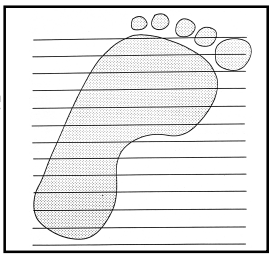
Discussion/Reflection

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.



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

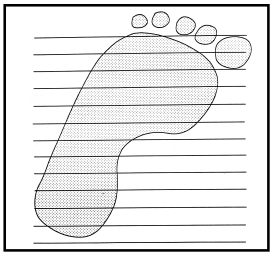
Time 10–20 minutes

Materials One 3 x 5-inch index card and one crayon per person
Copy of a sonogram, or simplified example on page 4-40

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.

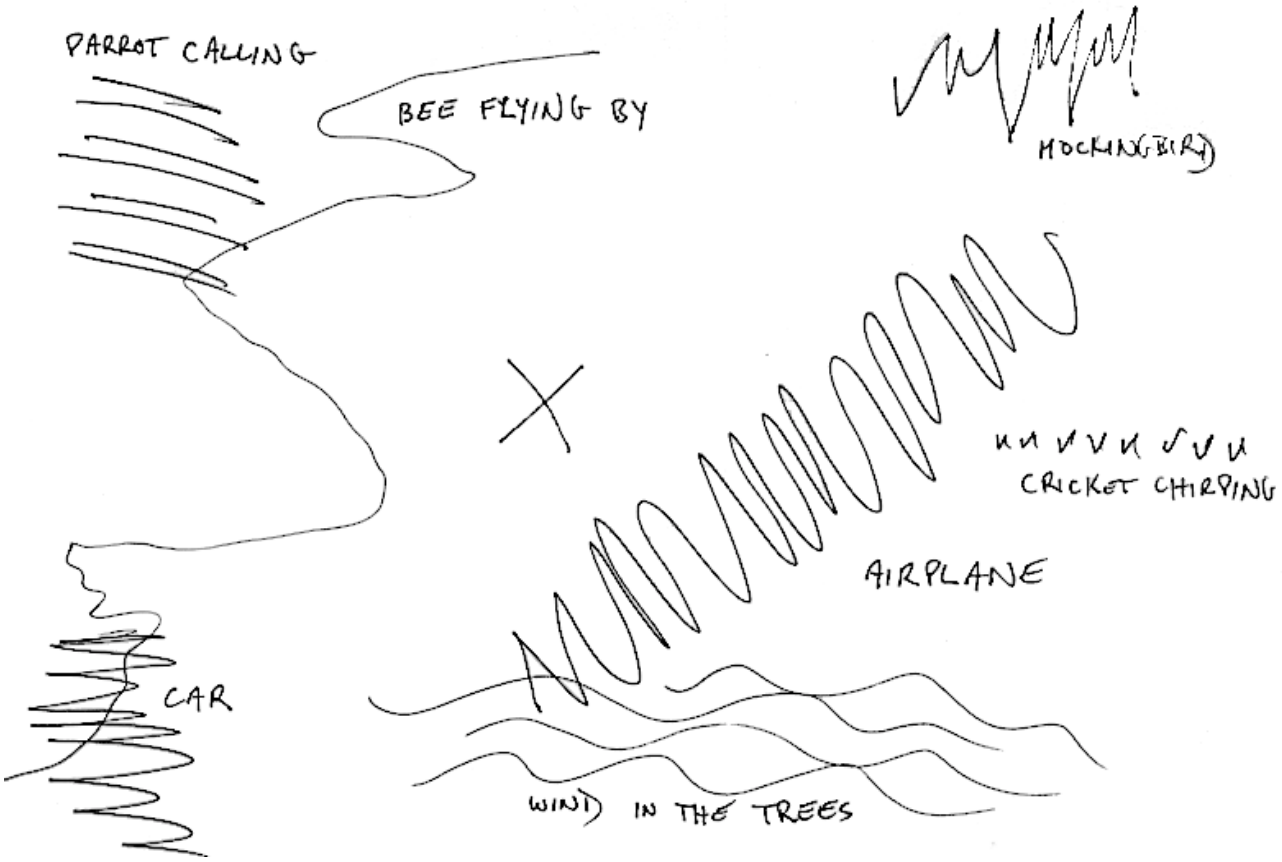
Procedure

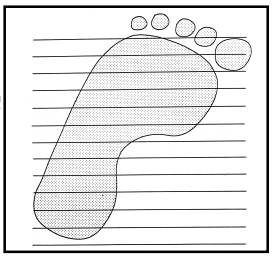
1. Show the group a 3 x 5-inch card with an X drawn in the centre. Tell the students that the card is a map, and the X shows where they are sitting.
2. When they hear a sound, they should make a mark on the card that represents the sound—for example, wavy lines might mean the wind. The mark's location 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?





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 4-42), one per pair of students
Pencil or crayon (one per pair)

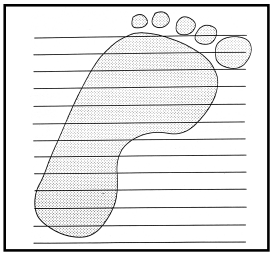
Background Read and learn the information in Sections 1 and 2, "All About Mangroves" and "Mangroves as Habitat", particularly the parts about birds. Birds use wetlands for everything from nesting to feeding, and, of course, obtaining water for survival. During each of the different times in a bird's 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 Killdeer, 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 wetlands**.**

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

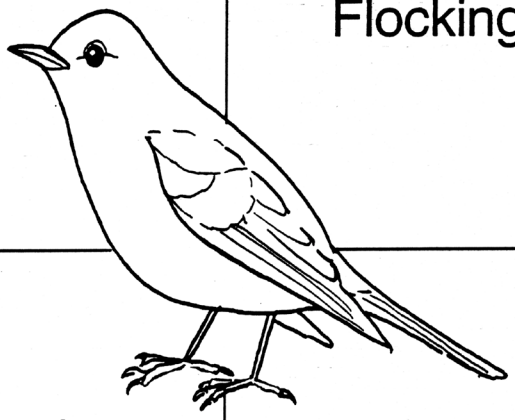
When everyone has finished, or when you are close to your destination, gather the group together and discuss what they saw.
What was the most interesting bird behaviour?

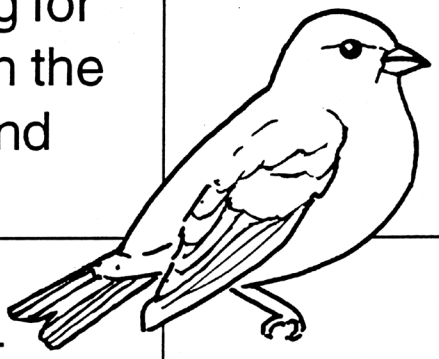


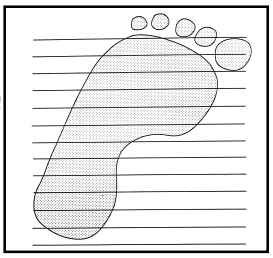
BIRD BEHAVIOR BINGO

check off the ones you observe

Hunting for Food in Branches	Resting	Flocking
Hunting for Food While Flying	Preening	Camouflaged
Hunting for Food on the Ground	Alarm Call	Aggressive Behavior
Not Camouflaged	Singing	Approaching or Leaving a Nest







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 *The Birds of the Cayman Islands*; and
(b) the importance of keeping records of different bird species observed.

Age Levels 8 and up

Subject Area Science

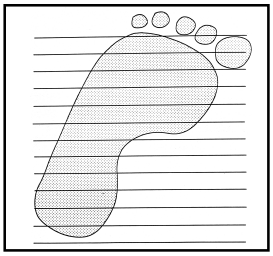
Time 10–20 minutes

Materiasl Pencils
Field guides, one per team (use copies of *The Birds of the Cayman Islands*)
Copies of "Field Record of Birds" form on page 4-45
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. Also study copies of *The Birds of the Cayman Islands*. Mangrove wetlands are vital as bird habitat, for both endemic and migrating species of birds that live on and use your island. Understanding this, and learning how to identify different species, enables students to learn how different kinds of birds (ducks, wading birds, shorebirds, passerines, etc.) have adapted to different niches in wetlands. Many students who start with simple bird identification like this activity eventually become life-long birders who develop their own Life Lists of birds.

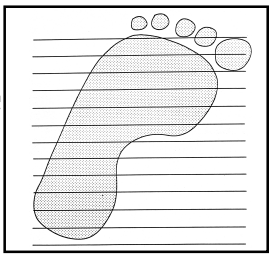
Procedure **1.** At the beginning of a term in which birds will be studied, hand out to each student a copy of the sheet "Field Record of Birds" on page 4-45. Explain that they are to keep a record of the birds seen on field trip as well as at home.

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



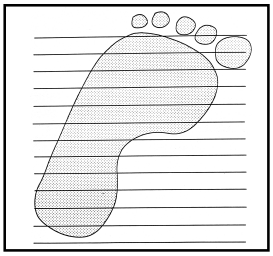
the binoculars identifies field marks such as colour ("I see a red spot on its chest") and size ("it has longer legs than other birds"). The other person looks in the field guide, sharing ideas with his or her partner. Students usually work out a suitable way to share the work; just make sure they share 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 Birds

	Bird Species	Date	Habitat	No. Seen
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				



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

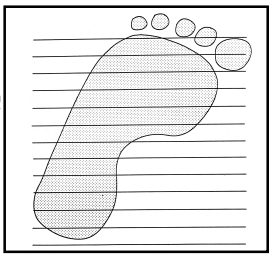
Subject Area Science

Time 30–60 minutes

Materials A blank sheet of paper with the title "Transect"
Copies of pages 1-2 through 1-6 with descriptions of different kinds of mangroves
150 m (400 ft) of heavy string
Four heavy wooden stakes or lengths of PVC pipe, each 3 m (8 ft) long, with waterproof marks every 2 ft (or 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
An inventory of plants found in the wetland (if available) from your country's Department of Resources or Environment, a local university, or the National Trust
Clipboards
A camera (optional)
Waders and/or rubber boots, or 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 4-49). 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 upland vegetation is present. The distance will vary depending on the nature of the mangrove wetland. (In large wetlands, 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 (9 ft) along the transect line toward the upland area. At this point insert a third stake (stake C).

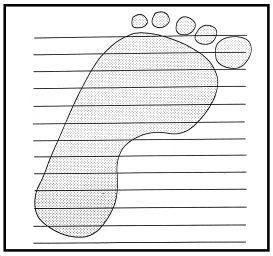


3. The transect line and stakes A and C form a "window" that will assist you in drawing a profile of the wetland vegetation. The markings on the stakes will assist you in showing the different plant species to (approximate) scale.
4. Students will sketch the vegetation in this first window on their transect 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 (9 ft), 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 wetland, and describe how each appears to be changing the wetland.
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 wetland.
Speak to people who live nearby and ask if they have seen any recent changes to plant life in the wetland.
Look for evidence that indicates that the wetland 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.

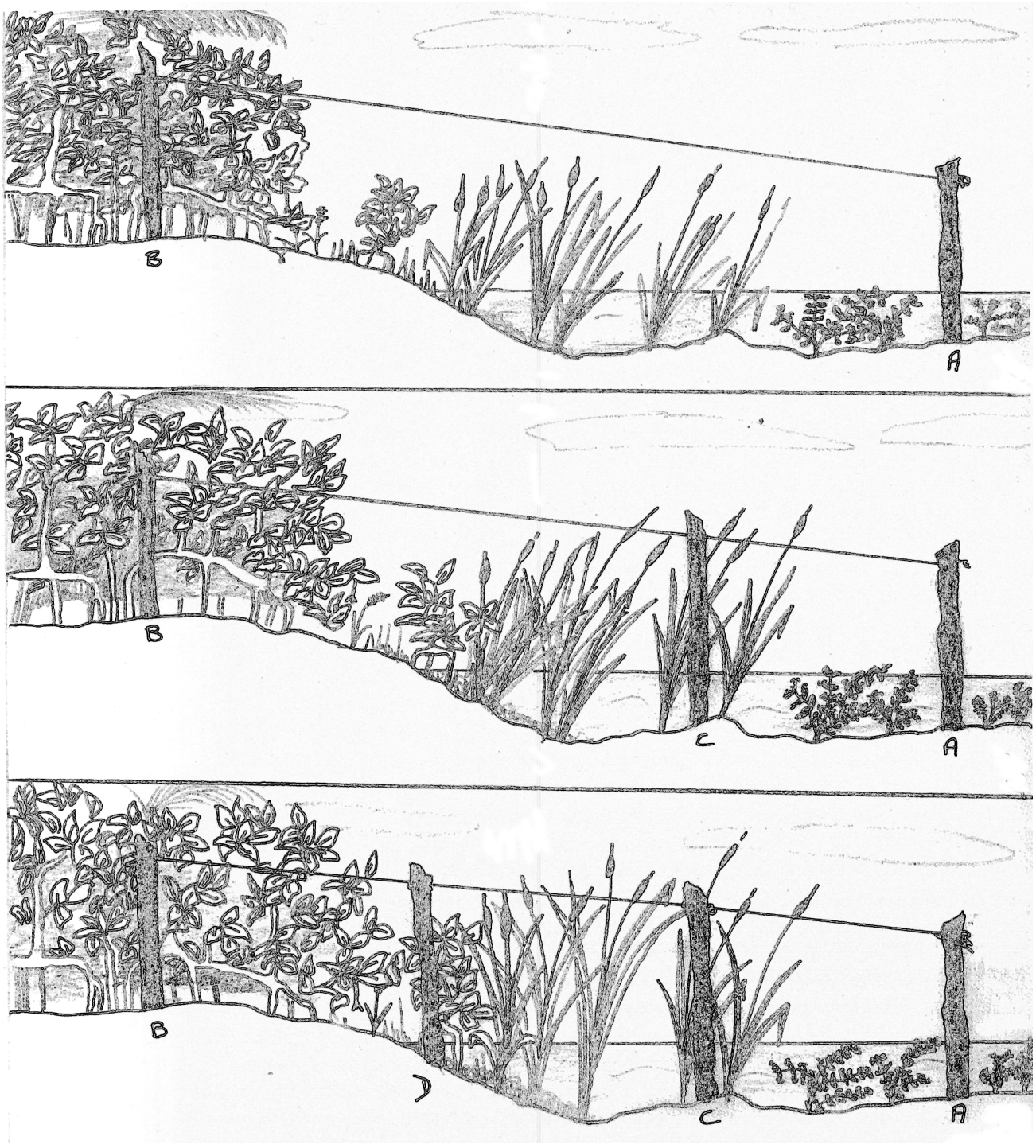


Students could prepare a report on the plant life in this wetland: description, kinds, diversity, presence of exotic plants. Are there rare, threatened, or endangered species? Why is plant life important, and what wildlife uses specific plants? Use drawings and photographs, as well as the transect work, 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 wetland—the Cayman Islands Department of Environment.

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.


B
A
B
C
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B
D
C
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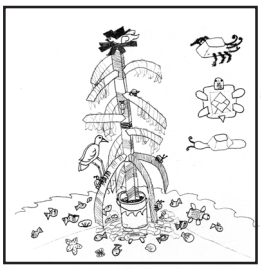
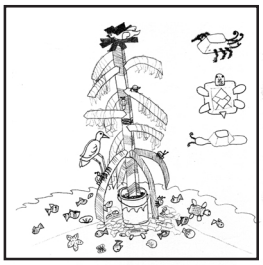


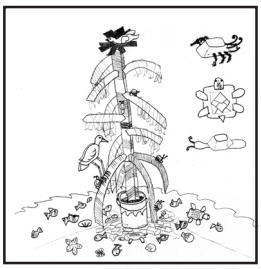
CONTENTS SECTION 5



Making Change

Sometimes it seems that the environmental issues and problems facing our islands and mangrove wetlands 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 island 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 consciousness in this way will we be able to protect our valuable island resources—whether they be wetlands or the creatures that inhabit them. Contact the National Trust or a local environmental organization to see how you can help. You can start by carrying out some of the activities in this section.



Activity 5-A: Writing Skills

Summary Field trips to mangroves and wetlands 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

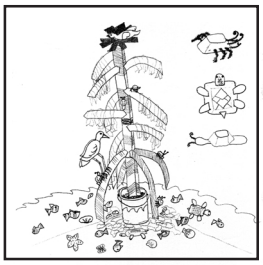
Time 30–60 minutes

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 tree, 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.

MAKING CHANGE



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:

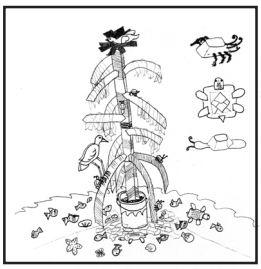
In the mangrove swamp
Fish swim, crabs crawl, heron stalk,
The roots are their home.

Try writing a haiku about your own exploration experience.

_____

_____

_____



Activity 5-B: Mangrove Controversy: Town Hall Meeting

Summary Mangroves throughout the West Indies and the Cayman Islands are being 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

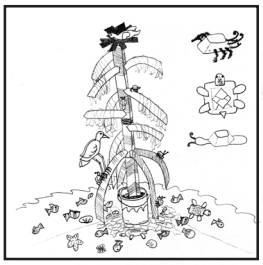
Time 2–4 lessons, or more

Material Costume materials (props) hats, ties, glasses, binoculars, etc.
Paper and pencils
Copies of page 5-10, "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 Cayman Islands. Usually the Central Planning Authority makes such decisions, and the CPA sometimes gives the public an opportunity to comment on the issues. The exercise, however, 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 wetland. It may be that you know of a mangrove wetland in your area that is in jeopardy, and you can base your exercise on that specific wetland. Otherwise, use a real wetland in your area as the topic, pretending that it is under development pressure. It is obvious that the Central Mangrove in Grand Cayman faces such pressures, as do mangroves on the West Bay peninsula. In Little Cayman there are pressures from development and the new airport, and on the Brac the West End Ponds and southwest marshes are the only extensive mangroves on the island.

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 wetland. They call themselves Citizens Opposed to Mangroves (COM) and



argue that the wetland 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 city council meeting during which concerned people of the island 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 wetland.
The characters and a brief description are listed below:

Characters

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

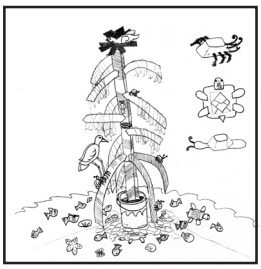
City Council Members (6)

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

All council members are elected officials who most likely also have other jobs. They must weigh the evidence on this issue and decide the fate of the local wetland, for the good of the city and the island.

Guest Speakers (12)

1. Phil Swamp: Phil is a carpenter who builds homes. He knows that if the mangrove wetland were filled in, homes could be built in the area, providing more jobs for carpenters.
2. Wanda Drejanbuild: Wanda has already built a small marina on a neighbouring island, and sees this mangrove swamp 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 mangrove wetlands are in reducing floods and is concerned about her home.
4. Duane DeMarsh: Duane is a farmer who has filled in a marsh on his property and thinks all marshes should be filled in for better uses.
5. Ima Heron: Ima is a long-time resident of the city and grew up near the wetland. She thinks the mangroves are beautiful and wants her grandchildren to be able to enjoy them too.
6. Will Huntmore: Will loves to hunt, and helps to feed his family through hunting. He realizes how important mangrove wetlands are for ducks and other animals.



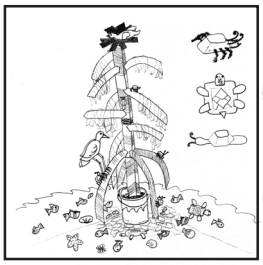
7. Candy Velop: Candy is another developer who would like to build condominiums around Wanda's marina, and provide them all with "ocean views".
8. Amos Keetow: Amos detests pests. He lives near the mangroves and feels they are the sources of the insects that ruin his life in his expensive new home.
9. Crystal Clearwater: Crystal is the director of the water authority that provides water for the city and the island. She is concerned because she knows that mangrove wetlands are important areas for water purification.
10. Dr. Peat Bog: Dr. Bog is a scientist with a Ph.D. in wetlands science from the University of Away. He has studied mangrove wetlands and knows how valuable they are to people.
11. Fly Fish: Fly is a local fisherman who knows the importance of mangrove wetlands as a nursery for many of the fish and conch from which he makes a living. He is concerned that dredging the mangroves will destroy the fishery.
12. 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 condos.

Procedure

1. Students will be enacting a town council meeting or its local equivalent by role-playing the characters with different viewpoints. The task will be to decide the fate of the local mangrove wetlands. Should the council preserve it, convert it 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 5-10)— 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. Peat Bog, you know I was raised on this island, and I went away to study biology. When I was away, I looked at wetlands all over the place, and after many years I became an expert. So, I met this gal, Betty Buttonwood, and she 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 condos somewhere else, or, alternatively, why Marsha needs to live near a tidal floodplain

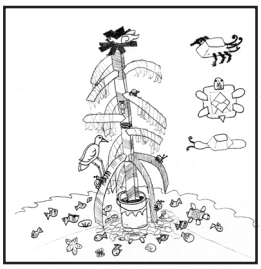
Note: If time allows, assign a committee of students to study the problem and report back to the council at a later date. Prepare a report that (a) describes the value of wetlands, (b) analyses the potential effects of other activities on the wetlands, and (c) proposes several alternatives for how the 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 wetland, and the meeting is adjourned.

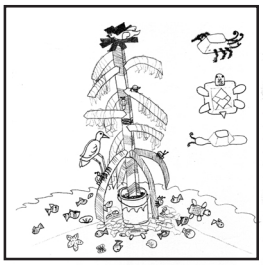
MAKING CHANGE



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 wetland 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?

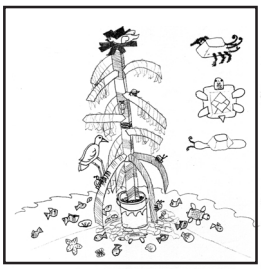
Circle one: Preserve it Destroy it Compromise

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.

_____

_____

_____

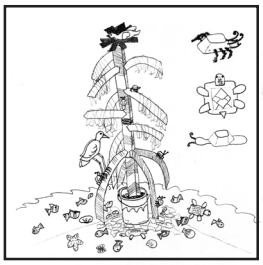
Write down reasons that people would want to destroy mangroves.

_____

_____

_____

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 Throughout the West Indies—including the Cayman Islands—many species have been in decline. However, 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

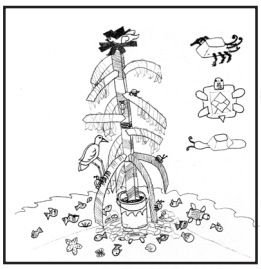
Subject Areas Science, social studies

Time 30–60 minutes

Materials "Success Stories" (page 5-13) and pictures of Flamingo, Osprey, Alligator, and Grand Cayman Parrot (pages 5-15 through 5-18)

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 raptors like Ospreys and Bald Eagles are much healthier than they were a few years ago. So are Bahamian Flamingos and Alligators. The two subspecies of Cayman Parrots are also better off than they once were.

Procedure **1.** Discuss each of the four species listed under "Success Stories" on page 5-13. 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 5-15 through 5-18) 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 5-14, 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 on your island that you know are making a comeback.



Success stories

Alligator

These wetland reptiles—found especially in Florida's Everglades—weren't doing too well in the 1960s, when there was a high demand for alligator shoes, belts, purses, and other products made from alligator leather. But in the U.S.A. the Endangered Species Act of 1973 made it illegal to sell alligator skins, and the animals recovered quickly. Now, throughout much of their range, alligators are no longer considered endangered.

Osprey

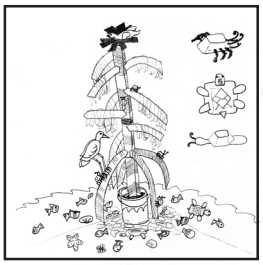
Once a common sight in the Caribbean, these birds, locally called fish hawks, went into a serious decline during the middle of the 20th century because of DDT. This pesticide accumulated in the birds' bodies, poisoning some outright, and causing many Osprey to lay eggs with very thin shells. Most of these thin-shelled eggs broke under the weight of the incubating parent birds. DDT was banned from most uses in the U.S.A. in 1972, and in the Cayman Islands later in the 1970s. Since then, many populations of these birds have been steadily increasing with the protection of some habitat, although this is still not considered enough for long-term continuation of the Osprey's comeback.

Flamingo

During most of the first half of the 20th century, the West Indian Flamingo was in serious trouble, and many colonies in the Caribbean were simply abandoned. The Bahamas is a case in point: the flamingo population had dropped to near extinction because of overhunting for feathers and food and habitat destruction from human population expansion. Even the Royal Air Force added to the problem by buzzing them during World War II. A combination of industry (the Morton Salt Company), the government, and non-profit groups created the Inagua National Park on Great Inagua, and now the flamingo population is over 50,000 birds.

Cayman Brac Parrot and Grand Cayman Parrot

On both islands, until the late 1980s these subspecies were both in danger. In 1985 there were only about 40 parrots on the Brac, and the population was in danger of extinction. On Grand Cayman at that time the population was somewhat more secure, with between 900 and 1700 birds. Both populations had declined because people captured parrots for pets and hunted them to prevent crop damage on the Brac, with habitat loss as an additional factor on Grand Cayman. Public education programs conducted by the National Trust in conjunction with RARE, together with the acquisition and protection of habitat, have enabled the Brac population to grow to 400 birds; some 2000 now live on Grand Cayman. Further habitat will need to be protected in the future for the parrots' long-term survival.



THEY'RE BOUNCING BACK

Words

They're bouncing back,
They're bouncing back,
The Bahamian Flamingos are bouncing back!
Tall and graceful birds that dance,
Now they have another chance!

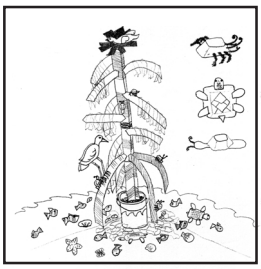
They're bouncing back,
They're bouncing back,
The alligators now are bouncing back!
Sharp-toothed beasts with scaly skin,
They're swimming in the swamps again!

They're bouncing back,
They're bouncing back,
The Ospreys now are bouncing back!
Soaring over lake and bay,
Doing better every day.

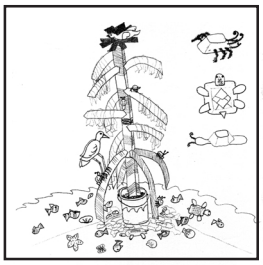
They're bouncing back,
They're bouncing back,
The Cayman Parrots are bouncing back!
Green and red with heads of white,
Their numbers now are out of sight.

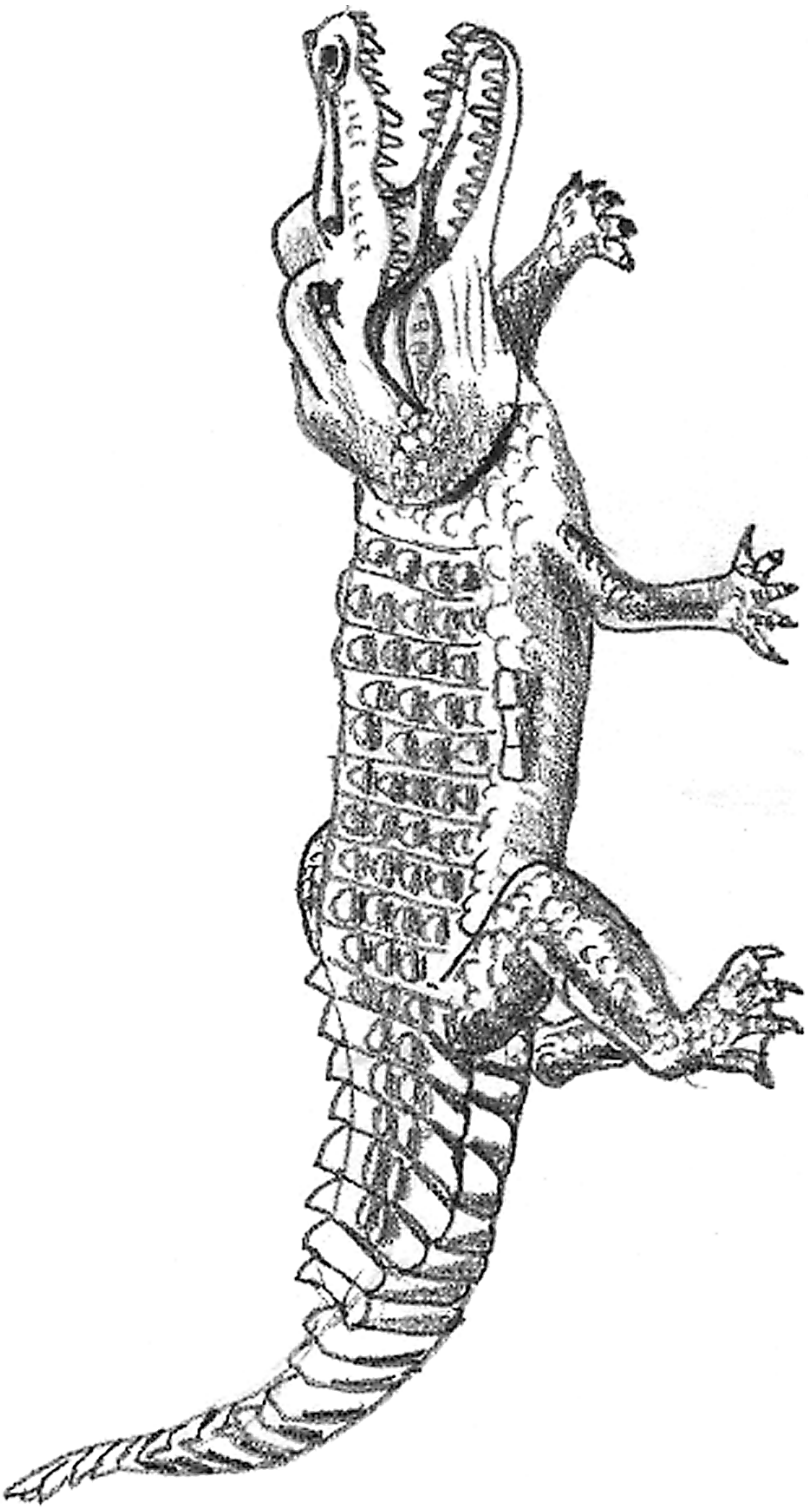
Motions

- Flamingo: Slowly flap arms up and down and lift legs high with each step.
- Alligator: Stretch arms out in front and move them apart and together to imitate jaws opening and closing
- Osprey: Hold arms straight out to side to lean this way and that as though soaring.
- Parrot: Hold arms straight out to side and move up and down very quickly. Squawk loudly.

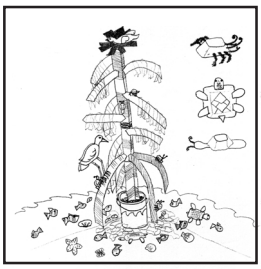


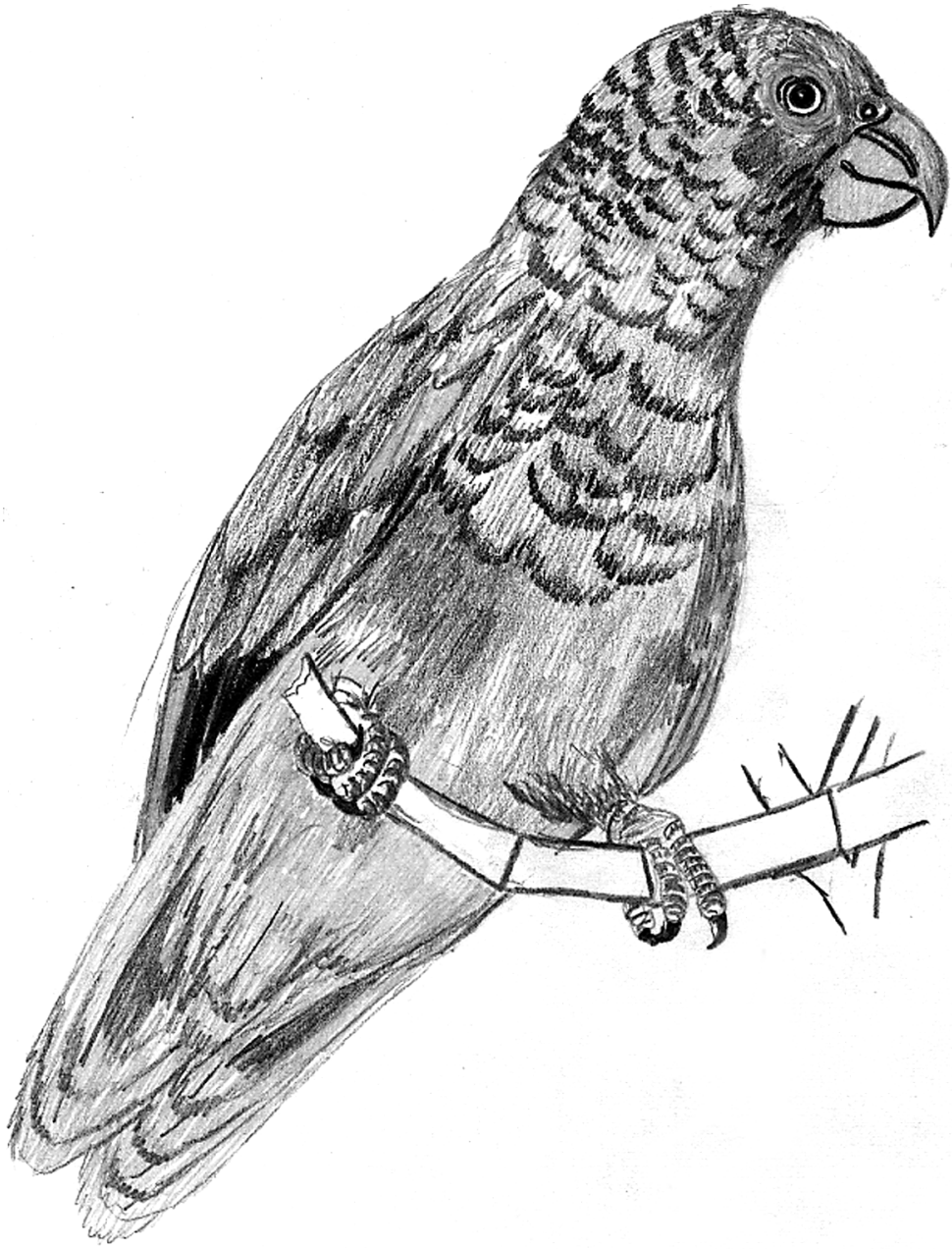
Flamingo



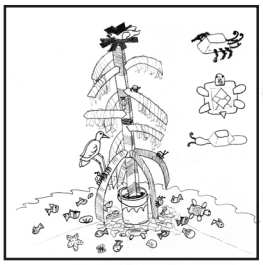


Alligator

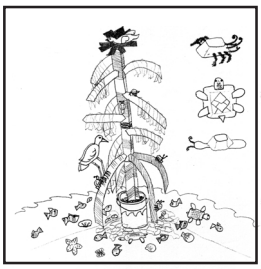




Cayman Parrot



Osprey



Activity 5-D: Marine Debris: Collection and Impact

Summary A great deal of garbage washes up on the shores the Cayman Islands. 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

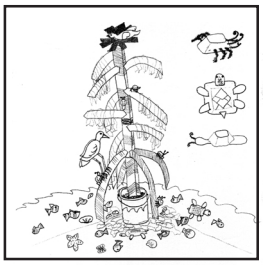
Time 2–4 lessons, or more

Materials

Marine debris recording sheets (pages 5-21 and 5-22)
Copies of page 5-23 showing marine debris biodegradation timeline
Trash bags (if your island 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 Masses of solid wastes, including hypodermic syringes and other medical debris, are washed ashore on the beaches and mangroves of the Cayman Islands every day. Much of this garbage comes from ships that dump their waste overboard. However, much trash may be transported via rivers from landlocked countries in Central and South America to the ocean (for more details see Section 3, “Human Impacts on Mangroves”, Factsheets on pages 3-7 through 3-11). 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, sea turtles consume large numbers of jellyfish, and often mistake plastic bags for jellyfish. These bags may lodge in the turtle’s esophagus, stomach, or intestine and cause the turtle to die of starvation or other complications from the blockage.

MAKING CHANGE



Procedure

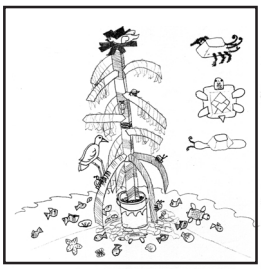
1. Divide the class into small groups. To each group give garbage bags, marine debris recording sheets and marine debris timeline sheets, pencils, clipboards, and gloves.
2. Explain to students that while they are gathering up the marine debris, they will also be analyzing it for its type, location, 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 glass (**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 island. 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 analyze 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 Trash Monster by assembling all the pieces of garbage into “Mr. Trashman”.
Access the Marine Debris World Wide Web home page through the following address: <http://www.ncsu.edu/unity/lockers/marinedebris/index.html>.
to learn about other debris-collecting programs.



INTERNATIONAL UNDERWATER CLEANUP DATA CARD

Thank you for participating in the International Coastal Cleanup and completing this data card. This form is designed for international use, therefore, not all listings may apply to your area. Data collected since 1986 by the Center for Marine Conservation (CMC) has been used in CMC's International Marine Debris Database and annual Cleanup Reports to help develop solutions and stop the dumping of trash into marine/aquatic areas. It is important to complete the following information and return this card to your area coordinator or mail it to CMC at the address at the bottom of this card.

Type of cleanup: ☐ Shoreline/Beach or ☐ Underwater

Zone Name/Location Cleaned _____ Nearest City/County_____

Today's Date: Month_____ Day_____ Year_____ Name of Coordinator _____

Name_____ Affiliation _____

Address _____

City _____ State _____ Country_____ Zip Code _____

Phone (____)_____ Email Address _____ Age_____

Do you currently receive the International Coastal Cleanup newsletter, *Coastal Connection?* ___ Yes ___ No
If not, would you like to be placed on the mailing list? ___ Yes (please list address above) ___ No

Would you like to receive information on the Center for Marine Conservation(CMC)? ___ Yes ___ No

Use your voice to defend the marine environment by joining CMC's free "Ocean Action Network". You will receive Action Alerts (by mail or Email) on critical issues letting you know how and when to help protect our oceans. I want to join ___ Yes ___ No

Number of people working together on this card _____ Estimated distance of area cleaned_____
Number of trash bags filled _____ Total estimated weight_____

CLEANUP SAFETY TIPS FOR DIVERS

1. Adhere to the buddy system and follow all safe diving procedures.
2. Use complete, well-maintained, reliable equipment.
3. Maintain proper buoyancy & avoid contact with bottom.
4. Breath properly for diving & never hold your breath.
5. Know & obey local diving laws & regulations.
6. Do not try to salvage heavy or dangerous items.
7. Do not use your BC as a lifting device.
8. Carry clippers or a knife to cut away line, rope or netting.
9. Wear gloves to protect your hands from debris.
10. Avoid hazardous areas & dive within your limits.

ENTANGLED ANIMALS (Dead or Alive) *Be as specific as you can.*

Type of Animal	Form of Entangling Debris	Comments

FOREIGN LABELS: Please list all items with foreign labels or other markings to help us identify the item's origin such as cruiseline names, military identification or debris with names and/or address of shipping, fishing, or oil/gas exploration companies. Please do not list items that are common to your local area, i.e. imported water or beer.

	Label or other markings	Type of item
Example:	ABC Shipping Company	plastic strapping band

What was the most peculiar item you collected? _____

Comments/Observations during the cleanup_____

The following national and international organizations endorse and/or support the International Coastal Cleanup:

U.S. Environmental Protection Agency

IUCN — The World Conservation Union

Intergovernmental Oceanographic Commission (IOC) of the United Nations' Educational, Scientific, and Cultural Organization (UNESCO)

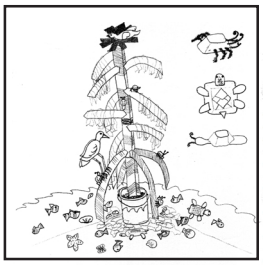
Please return this card to your area coordinator or mail it to:

CENTER FOR MARINE CONSERVATION
Atlantic Regional Office
1432 N. Great Neck Road, Suite 103
Virginia Beach, VA 23454 USA
Phone (757) 496-0920 Fax (757) 496-3207

CENTER FOR MARINE CONSERVATION

Printed on recycled paper, using soy-based ink.

MAKING CHANGE



ITEMS COLLECTED

You may find it helpful to work with a buddy as you clean the area, one of you picking up trash and the other taking notes. An easy way to keep track of the items you find is by making tick marks. The box is for total items; see sample below.

Example:
egg cartons ||||-||||-||||-| TOTAL 16 cups ||||-||||-||||-||||-|| TOTAL 22

PLASTIC

	Total number of items		Total number of items
bags:		fishing nets	
food bags/wrappers		hard hats	
salt		light sticks	
trash		pieces	
other bags		pipe thread protector	
bottles:		rope	
beverage, 2 liter or less		sheeting	
beverage, gallon jugs		longer than 2 feet	
bleach, cleaner		2 feet or shorter	
oil, lube		6-pack holders	
other bottles		strapping bands	
buckets		straws/stirrers	
caps, lids		syringes	
cigarette butts		tampon applicators	
cigarette lighters (disposable)		toys	
cups, utensils		vegetable sacks	
diapers (disposable)		"write protection" rings	
fishing line		other plastic (specify)	
fishing lures, floats			

FOAMED PLASTIC

buoys, floats		packaging material	
cups		pieces	
egg cartons		plates	
fast food containers		other foamed plastic (specify)	
meat trays			

FOLD ALONG THIS LINE

GLASS

bottles/jars:		fluorescent light tubes	
beverage bottles		light bulbs	
food jars		pieces	
other bottles/jars		other glass (specify)	

RUBBER

balloons		tires	
condoms		other rubber (specify)	
gloves			

METAL

bottle caps		55-gallon drums:	
cans:		rusty	
aerosol		new	
beverage		pieces	
food		pull tabs	
other		wire	
crab/lobster traps		other metal (specify)	

PAPER

bags		newspapers/magazines	
cardboard (packing material)		pieces	
cartons (including boxes)		plates	
cups		other paper (specify)	

WOOD

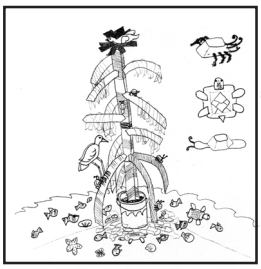
(leave driftwood on the beach)

crab/lobster traps		pallets	
crates		other woods (specify)	
lumber pieces			

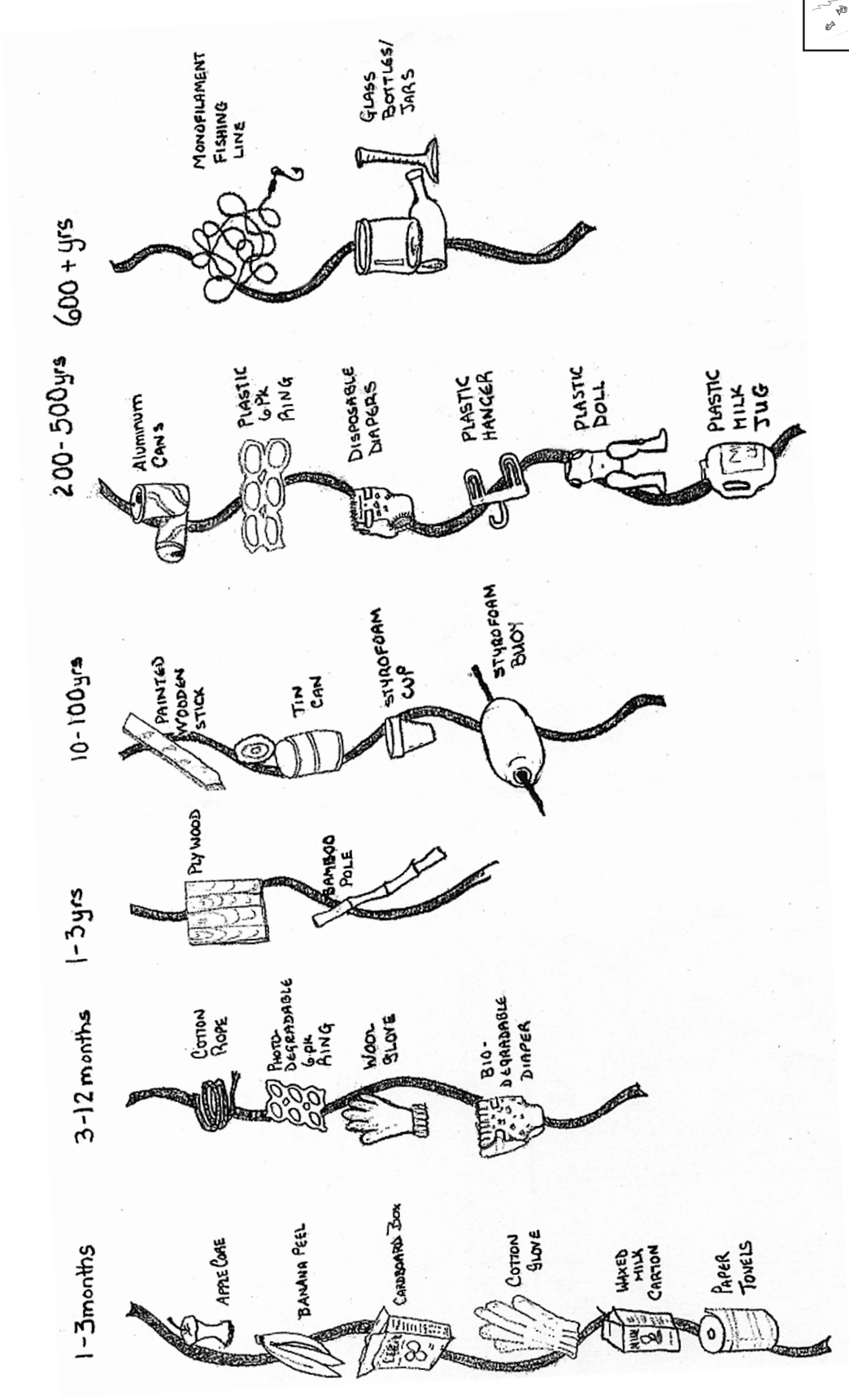
CLOTH

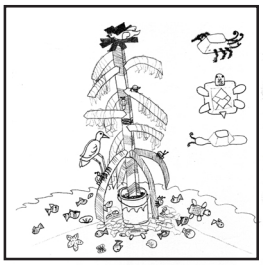
clothing/pieces

Remember to turn the card over and fill out your name and address and to record sources and entangled wildlife!



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 wetlands habitat 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 homes and on their islands.

Age Levels 9 and up

Subject Areas Science, social studies

Time 1–2 lessons, or more

Materials Copies of factsheets on pages 3-7 through 3-11 showing water/wetland pollutants
Copies of questionnaire on page 5-26
Chalkboard or paper and easel
Pencils

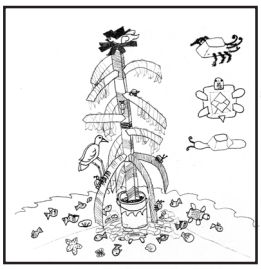
Background Begin by reviewing the factsheets on pollution in Section 3, "Human Impacts on Mangroves". Many problems caused by water contamination have occurred in the past and continue to happen now that affect our lives and those of the animals we share our islands with. Take a look at water on your island and how it is used and disposed of. For example, review the following information:

Home supplies: Look at wells, cisterns, and trucked or piped water from a central processing plant. How is water used in your home?

Sewage: Not too many years ago, most people used outhouses. These have been replaced, in most places, by septic systems and modern sewage collection and treatment systems. Find a way to study how these systems function.

Contamination: After major hurricane damage, there are often problems with the spread of gastrointestinal diseases through contaminated water. Diseases like typhoid and cholera frequently occur because of water contamination. Discover how this happens.

A newer method of septic and sewage disposal is the use of deep wells.



However, this can cause contamination because the pollutants enter the salt water lying under the island and eventually seep through to the ocean. This is because limestone is very porous and allows water to pass through it, which enables the pollutants to reach the ocean. Many homes are close to the shoreline, meaning pollutants can enter the ocean more quickly.

Wells: Many islands get their water from wells that tap down into the freshwater lens that lies under the islands, sitting on top of the salt water.

Seawater: Many people in the olden days used to drink a glass of seawater regularly for its therapeutic values.

Birds and the water supply: Wetland birds require fresh water just as humans do, and they obtain it from wetlands. Other birds not always found in wetland areas also need water, and they, too, often use wetlands to find it. However, in times of drought, when wetlands dry up, the birds become more inventive—for instance, getting water from heavy early-morning dew.

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 on your island: where it comes from, where it goes, and how it gets polluted.

3. Point out that birds and animals have to drink fresh water daily, and most of them get this from wetland areas.

4. Give students copies of the questionnaire on page 5-26, and have them take the questionnaires home and ask parents or other older people to give them answers.

Discussion/Reflection

When students have returned with their completed questionnaires, discuss the following concerns with them.

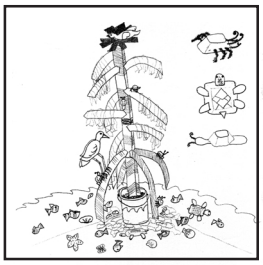
Do you think there is a water problem on this island?

If there were a water problem for humans and birds, how would you resolve it?

How do birds adapt to lack of water?

Extensions

Students can extrapolate what would happen to birds (and humans) during drought conditions when fresh water is in short supply.



WATER QUESTIONNAIRE

Wells, Septic Systems, and Other Needs

1. Describe the well at your house. How deep is it? Is the water sweet and pure?

2. If you don't have a well, where does the water you drink come from?

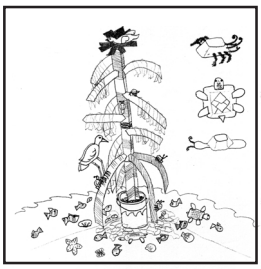
3. How does the septic system work at your house?

4. Ask your grandfather or grandmother (or another older person) if they used to drink a glass of seawater regularly.

5. If they did, why did they?

6. Where do birds get their fresh water?

7. Have you seen birds drinking? How do they do it?



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 swamp and where in the swamp they live; and
(b) understand the basic functions of a Red Mangrove tree.

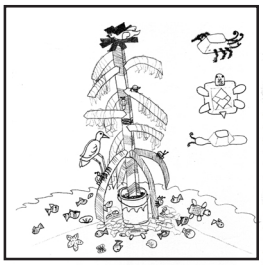
Age Levels 8 and up

Note: This could also be part of a community outreach project.

Subject Area Science

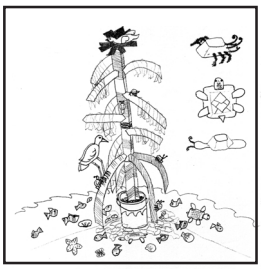
Time 2–4 lessons, or more

Materials Copies of page 2-5 (Marvelous Mangroves colouring sheet) and 2-6 (Mangrove Habitat Study
Copies of page 5-28 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
Cellophane tape
Stapler
Thin cardboard
Styrofoam trays
Large brown paper bag
Small brown paper bag
Old newspapers
Crayons or felt-tip markers, or both



Build a Mangrove

MAKING CHANGE



Several old brush or broom handles or an old hat stand
Two pieces of 2 x 4, each about 1.2 m (4 ft) 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 , "All About Mangroves", and Section 2, "Mangroves as Habitat".

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 2-5 and 2-6, or a photograph of a mangrove swamp. Explain that this is a mangrove swamp, 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.

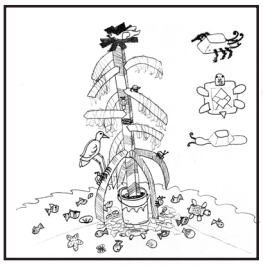
Trunk

Option A (stationery)

- Tape or staple several sheets of brown construction paper together to form a trunk about 30 cm (1 ft) wide and 90 cm (3 ft) 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 60 cm (2 ft) 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 (7 ft) tall. Drop one end into the hole in the middle of the crossed 2 x 4s (each about 120 cm—4 ft—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

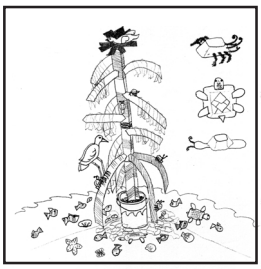
- Cut black or brown construction paper, or cardboard boxes, into strips about 2.5 cm (1 in) wide and 60–90 cm (2–3 ft) long. Also cut shorter strips to make "accessory" roots that branch off the longer ones.
- Beginning at the bottom of the trunk, either tape the strips end to end to form roots reaching 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 West Indian Whistling-Ducks, 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 (the kind produce and meat is packaged on), 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 (0.5 in) 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

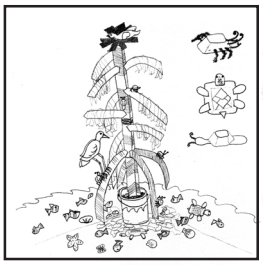
Snail

- 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 (8–18 in). You will need to cut 30 or more pieces for each jellyfish. **OR** use two or three bags of pastel-coloured Christmas tree "icicles".
- 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 (6–12-in) 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 wetlands
- as a class project for a science fair
- for community outreach, to show functions and benefits of mangroves
- for peer teaching of other students

RESOURCES

Books

Eyewitness Books
Plants, *Tree*, *Fish*, *Seashore*, *Rocks and Minerals*, *Bird*, *Pond and River*, *Ocean*, *Fossil*, *Amphibian*, *Mammal*. London: Dorling Kindersley Ltd.; New York: Alfred A. Knopf. Website: <http://www.dk.com>.

*Flora & Fauna of the Caribbean: An introduction to the Ecology of the West Indies.*By Peter R. Bacon. Key Caribbean Publications Ltd. (P.O. Box 21, Port of Spain, Trinidad), 1978.

The Nature of Florida's Beaches. Written and illustrated by Cathie Katz. ISBN 1-888025-07-7. Atlantic Press (P.O. Box 510366, Melbourne Beach, FL 32951, USA), 1995.

Marine Life of the Caribbean. By Alick Jones and Nancy Sefton. ISBN 0-333-25839-8. London and Basingstoke, UK: MacMillan Educational Ltd., 1979.

The Seashore Naturalist: A Guide to Study at the Seashore. Written and illustrated by Deborah A. Coulombe. ISBN 0-671-76503-5. Simon & Schuster (Rockefeller Centre, 1230 Avenue of the Americas, New York, NY 10020, USA), 1992.

The Ephemeral Islands—A Natural History of the Bahamas. By David G. Campbell. London and Basingstoke, UK: MacMillan Educational Ltd., 1978.

Threatened Birds of the Americas. The ICBP/IUCN Red Data Book. By N.J. Collar, L.P. Gonzaga, N. Krabbe, A. Madrono Nieto, L.G. Naranjo, T.A. Parker III, and D.C. Wege. ISBN 1-56098-267-5. Cambridge: Smithsonian Institution Press/International Council for Bird Preservation, 1992. ICBP, 32 Cambridge Road, Girton, Cambridge CB3 OPJ, England.

IUCN Red List of Threatened Animals. Compiled and edited by Jonathan Baillie and Brian Groombridge. ISBN 2-8317-0335-2. Cambridge: International Union for Conservation of Nature and Natural Resources, 1996. IUCN Publications Services Unit, 219c, Huntingdon Road, Cambridge CN3 ODL, England. E-mail: <iucn-psu@wcmc.org.uk>.

Natural History of the Cayman Islands. Edited by Nancy Sefton. George Town: Cayman Islands Conservation Association, Cayman Free Press, 1976 (out of print).

Southeastern and Caribbean Seashores. Peterson Field Guide. By Eugene H. Kaplan. ISBN 0-395-31321-X. Houghton Mifflin Company (215 Park Avenue South, New York, NY 10003, USA), 1988. Website: <http://www.hmco.com/trade/>.

RESOURCES

Coral Reefs. Peterson Field Guide. By Eugene H. Kaplan. ISBN 0-395-31661-8. Houghton Mifflin Company (215 Park Avenue South, New York, NY 10003, USA), 1982. Website: <http://www.hmco.com/trade/>.

A Directory of Neotropical Wetlands. Compiled by Derek A. Scott and Montserrat Carbonnel. ISBN 2-88032-504-8. International Union for Conservation of Nature and Natural Resources, 1985. IUCN Publications Services Unit, 219c, Huntingdon Road, Cambridge CN3 ODL, England. E-mail: <iucn-psu@wcmc.org.uk>.

West Indian Whistling-Duck Colouring Book and Poster. Colouring book produced by the Bahamas National Trust for the Society of Caribbean Ornithology, West Indian Whistling-Duck Working Group. Copies from Martin Keeley, General Delivery, Watering Place, Cayman Brac, Cayman Islands. Tel: 345-948-0319. E-mail: <mangrove@candw.ky>.

Wild Trees in the Cayman Islands. By Fred Burton. National Trust for the Cayman Islands (P.O. Box 31116 SMB, Grand Cayman, Cayman Islands), 1997. Tel: 345-949-0121. Fax: 345-949-7494. E-mail: ntrust@candw.ky>.

Resource Guides and Other Print Resources

Animal Tracks Wetlands Action Pack. By Maria Hagedorn. National Wildlife Federation (8925 Leesburg Pike, Vienna, VA 22184, USA), 1998. Tel: 703-790-4100. Website: <http://www.nwf.org>.

Discover Boundary Bay. A Teacher's Resource Guide. Coordinated by Martin A. Keeley. Friends of Boundary Bay (P.O. Box 1441, Station A, Delta, BC V4M 3Y8, Canada), 1993. Tel: 604-940-9810. Fax: 604-940-9833. E-mail: <bcwetnet@direct.ca>. Website: <www.bcwetlands.com>.

Discover Wetlands. By Karen Lippy, Judy Friesen, Susan Vanderburg, Laurie E. Usher, and Brian Lynn. Washington State Department of Ecology (P.O. Box 47600, Olympia, WA 98504-7600, USA), 1995. Tel: (360) 407-6000. E-mail: <tgat461@ecy.wa.gov>.

Ecoscope for Sustaining Wetlands. By Gordon Harrison. The Demeter Foundation (RR#2, Almonte, Ontario KOA IAO, Canada), 1994. Tel: 613-256-1487. Fax: 613-256-0744. E-mail: <gharriso@achilles.net>.

Saltwater EcoScope. Coordinated by Toby Rowe. Friends of Boundary Bay and BC Wetlands Society (P.O. Box 1441, Station A, Delta, BC V4M 3Y8, Canada), 1999. Tel: 604-940-9010. Fax: 604-940-9833. E-mail: <bcwetnet@direct.ca>.

RESOURCES

Exploring Estuaries and Wondrous Wetlands. A Teacher's Resource Guide. Coordinated by Martin A. Keeley. Friends of Boundary Bay (P.O. Box 1441, Station A, Delta, BC V4M 3Y8, Canada), 1993. Tel: 604-940-9810. Fax: 604-940-9833. E-mail: <bcwetnet@direct.ca>. Website: <www.bcwetlands.com>.

Everglades National Park—An Activity Guide for Teachers. Coordinated by Neil De Jong. Everglades National Park, P.O. Box 279, Homestead, FL 33030, USA. Tel: 305-242-7753. Or Florida Advisory Council on Environmental Education, Room 237, Holland Building, Tallahassee, FL 32399-1400, USA.

Oceanography and Coastal Processes. A Teacher's Resource Guide. Project Director, Sharon H. Walker. Biloxi, MS: Institute of Marine Sciences, 1998. J.L. Scott Marine Education Center and Aquarium, P.O. Box 7000, Ocean Springs, MS 39566-7000, USA. Tel: 228-374-5550: Fax: 228-374-5559 E-mail: <shwalker@seahorse.ims.usm.edu>.

Project WET: Curriculum and Activity Guide. Project Director, Dennis Nelson. Bozeman, MT: Project WET, 1995. The Watercourse, 201 Culbertson Hall, Montana State University, Bozeman, MT 59717-0570, USA. Tel: 406-994-5392. Fax: 406-994-1919. E-mail: <rwwet@msu.oscs.montana.edu>.

Brochures and colourful posters (FREE):
Our Coastal Heritage
Mangroves—An Endangered Ecosystem
Salt Ponds
Coral Reefs
Seagrasses
Department of Planning and Natural Resources, Division of Fish and Wildlife, 101 Estate Nazareth, St. Thomas, US Virgin Islands 00802.

Birds, Birds, Birds!
Endangered Species: Wild & Rare
Pollution: Problems and Solutions
Wading Into Wetlands
Diving Into Oceans
Amazing Mammals
Ranger Rick's NatureScope
National Wildlife Federation, P.O. Box 777, Mount Morris, IL 61054-8276, USA. Tel: 800-588-1650. Or McGraw Hill Books, 11 West 19th, New York, NY 10011, USA.
Website: <www.books.mcgraw-hill.com>.

RESOURCES

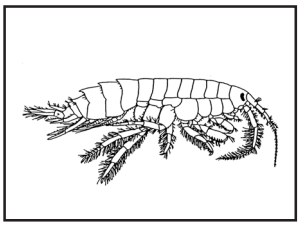
A Field Guide to Shells Coloring Book. By Roger Tory Peterson. National Wildlife Federation and National Audubon Society. Houghton Mifflin Company, 2 Park Street, Boston, MA 02108, USA.

The Coral Forest: Diversity of Life on the Coral Reef. A Teacher's Guide. Developed by Ruth Brown, Jana Gentry-Gruber, Joanne Hardesty, Mary Meyer, Jo Thompson, and Wendy Weir. San Francisco: Coral Forest, 1996. Coral Forest, Suite 1040, 400 Montgomery Street, San Francisco, CA 94104, USA. Tel: 415-788-REEF. Fax: 415-398-0385. E-mail: <coral@igc.apc.org>.

Videos

Eyewitness Videos
Plants, *Tree*, *Fish*, *Seashore*, *Rocks and Minerals*, *Bird*, *Pond and River*, *Ocean*, *Fossil*, *Amphibian*, *Mammal*. Narrated by Martin Sheen. Produced by BBC Worldwide Americas for Dorling Kindersley Ltd., London. Website: <http://www.dk.com>.

Our Coastal Heritage
Mangroves—An Endangered Ecosystem
Salt Ponds
Coral Reefs
Department of Planning and Natural Resources, Division of Fish and Wildlife, 101 Estate Nazareth, St. Thomas, US Virgin Islands 00802.



Glossary

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. For example, ducks have webbed feet that help them to swim.

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 Amphipodos that includes scuds or sideswimmers that are found in most pond or mangrove water.

arthropod—an invertebrate animal characterized by jointed legs, a segmented body, and an exoskeleton of chitin; includes lobsters, crabs, shrimp, and insects.

bacteria (singular: bacterium)—minute single-celled organisms, most of which are parasitic; bacteria are the primary organisms responsible for decay and fermentation.

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.

bloom—sporadic occurrence of huge populations of algae.

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.

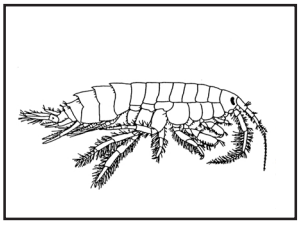
calls—bird vocalizations that are not songs; made during courtship, feeding, and migration, as well as to warn.

camouflage—protective colouration or shape that helps to hide an animal from its predators or prey.

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.

GLOSSARY



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 esophagus 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.

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 H_2O.)

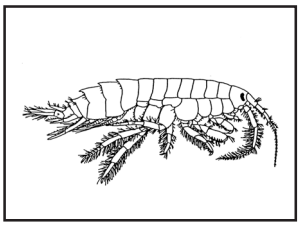
down—soft feathers next to a bird's body that provide insulation.

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. Many species of birds, turtles, and iguanas are endangered in the West Indies.

GLOSSARY



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.

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.

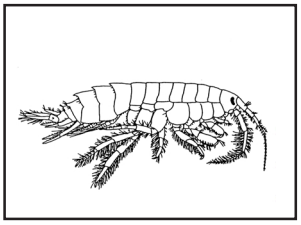
gizzard—the muscular part of a bird's stomach that grinds hard-to-digest food.

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.

GLOSSARY



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.

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 mongoose was brought into parts of the West Indies to kill rats. 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.

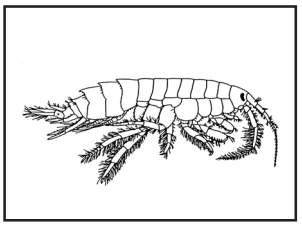
mangrove—a general term applied to several tropical and subtropical salt-tolerant trees.

mature—fully developed, adult.

megaplankton—very large plankton such as jellyfish and sunfish.

metabolism—energy changes that sustain life within an organism.

GLOSSARY



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, a warbler might migrate from the U.S. to the West Indies for the winter.

moult—to shed and regrow an exoskeleton or other outer body coverings; for example, when a bird sheds and replaces old feathers.

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". For example, the niche of a Whistling-Duck could be described as: nighttime feeder in ponds, plant eater, daytime rooster in trees, ground-nester, non-migrator.

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. In the Black Mangrove it is a vertical extension of the root that contains air; in a Man-o-War (frigatebird) it is an air-filled bladder inflated to attract a mate.

poach—to hunt, kill, or collect a plant or animal illegally.

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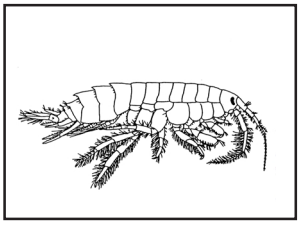

point pollution—pollution that comes from a particular source, such as from a factory or a sewage treatment plant. Nonpoint pollution, which doesn't come from a single identifiable source, includes materials that wash off streets, yards, farms, and other surfaces.

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; in animals (coral), a horizontal outgrowth that gives rise to new individuals.

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.

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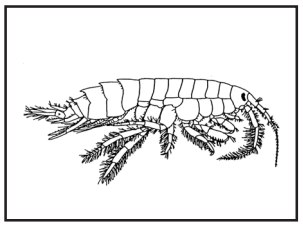


salinity—the saltiness of water, measured in parts per thousand.

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.

spray zone—zone above the high tide line that is regularly wet by the salt spray of the surf.

spring tide—tide of maximum range occurring at the new and full moon.

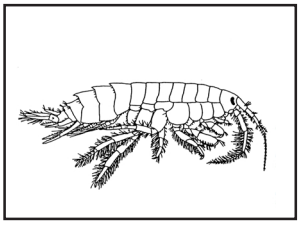
stinging cell—in coelenterates (such as coral or jellyfish), cells that contain stinging structures.

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; for example, a saltwater pond filling in and becoming a land-based 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. The Nassau Grouper is a threatened species, as is the West Indian Whistling-Duck.

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. Along the coasts of the West Indies there are two high tides and two low tides each day (24 hours).

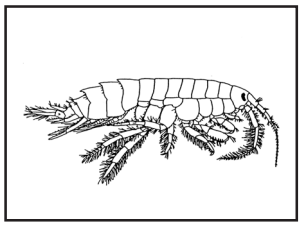
tidepool—depression in a rock (or created by rocks)within the intertidal zone that traps water as the tide recedes.

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. For example, all birds are warm-blooded.

waste—material eliminated from the body.

zooplankton—animal plankton.