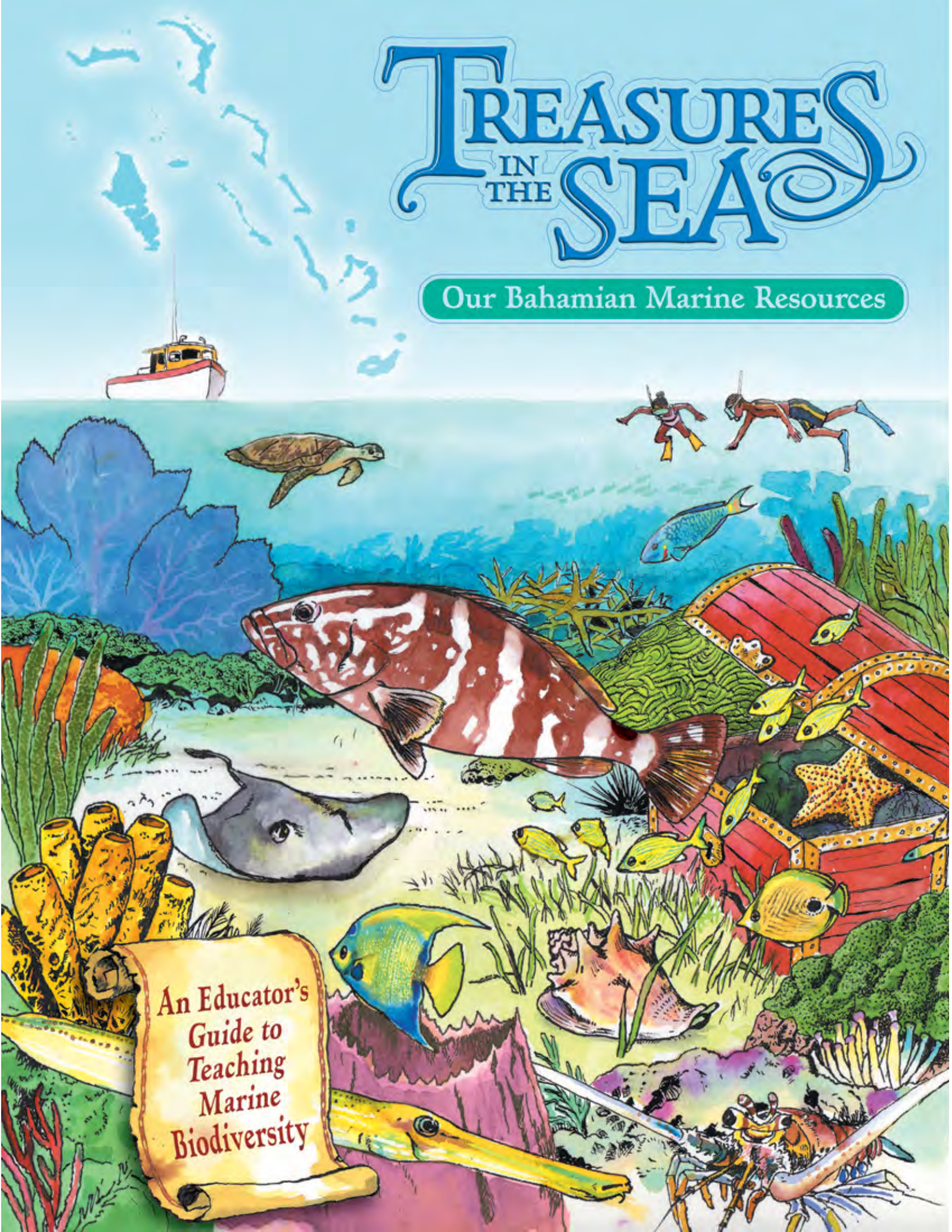
Treasures in the Sea

Our Bahamian Marine Resources



An Educator's Guide to Teaching Marine Biodiversity

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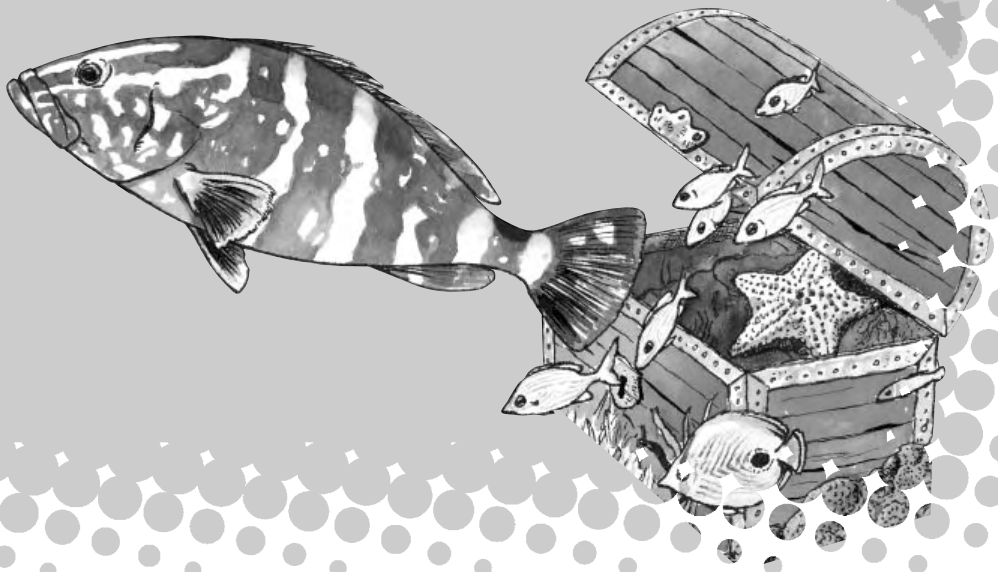

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YOUTH, SPORTS & CULTURE
P. O. BOX N-3913/14
NASSAU, THE BAHAMAS

FORWARD

We are privileged in The Bahamas, to live in one of the most beautiful countries in the world! Cognizant of this fact, it is realized that education of ALL members of our society is vital in order to keep it this way. The conservation and enhancement of the environment are critically important to the protection of our biodiversity (variety of life), the health of our nation and to the sustainability of the economy of The Bahamas and other Caribbean Small Island Developing States. Therefore, emphasis must always be placed on Environmental Education and on raising the awareness of the need for Environmental Stewardship throughout all sectors of our society.

Realizing that the environment and our national resources are assets which must be preserved through initiatives and strategies geared toward sustainable development, The Ministry of Education, Youth, Sports and Culture is pleased to note the partnership that has been established with The Bahamas National Trust (BNT) for almost four decades. This relationship has assisted us in working toward the achievement of the goal of our Bahamas Environment Education Programme (BEEP) an initiative of our Department of Education's Science and Technology Unit that envisions "**a school populace of environmentally knowledgeable, skilled and dedicated citizens who are willing to work individually and collectively toward affecting dynamic changes in the management of the environment.**"

It is pleasing therefore, that the Bahamas National Trust has extended its partnership to assist us "across the waters" with support from The American Museum of Natural History's Center for Biodiversity and Conservation in producing an Educator's Guide to Teaching Marine Biodiversity entitled **Treasures in the Sea - Our Bahamian Marine Resources!**

The production of such a resource designed for our teachers will enhance our efforts to integrate marine biodiversity via an interdisciplinary classroom approach in our schools for the health of our marine and coastal environment has direct and crucial impacts on the social and economic well being of every citizen in our archipelagic Bahamian society. Therefore, it is vital that we teach our students and by extension, their parents and community members "to discover, cherish, and protect their sea and all of its treasures!"

"A sustainable future is one in which protection of the natural environment, economic prosperity and social justice are pursued simultaneously to ensure the quality of life of present generations and to secure the well-being of generations to come: education is crucial to attaining that future." *Learning for a Sustainable Future – Annual Report 1999.*

Carl W. Bethel, M.P.
Minister of Education, Youth, Sports and Culture
June 2007

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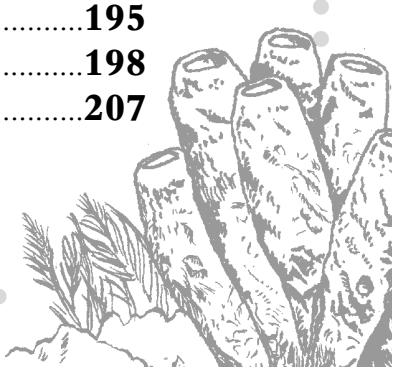


An Overview of *Treasures in the Sea*

Treasures in the Sea: Our Bahamian Marine Resources is designed to provide ideas to integrate marine biodiversity into your teaching. Marine biodiversity is the variety of life — genes, species, and ecosystems — found in oceans, coastal waters, and estuaries. This is an ideal topic for interdisciplinary studies, touching on science, social studies, language arts, mathematics, and the creative arts. This resource book is intended to serve as a complement to the curriculum guidelines of the Ministry of Education, Youth, Sports and Culture. *Treasures* is designed for primary grades three to six, though many of the activities may be adapted for younger or older students in formal and nonformal settings.

One of the most important things we can do is educate young people about the amazing diversity of marine life, building their skills and knowledge to help protect and conserve it. To encourage students to discover, cherish, and protect their sea and all of its treasures, *Treasures* introduces marine conservation concepts by focusing on some of The Bahamas' more important marine species, such as the Nassau grouper, queen conch, and spiny lobster (which we call crawfish). These species, familiar to all of us, will help students understand life cycles, critical habitats, cultural and economic connections, and the urgency of conservation and management. We hope you will find this a useful approach for building a unit or course. We encourage you to supplement the materials with a range of sources that offer diverse viewpoints, such as newspaper and magazine articles, local stories, and books listed in "Suggested Resources" on page 198.

This book includes background information on marine biodiversity, highlighting the unique characteristics of The Bahamas' marine treasures and outlining some of the threats to these resources, as well as conservation measures to protect them. Fact sheets provide the basic information on the queen conch, crawfish, and Nassau grouper, including a description; range and habitat; diet; reproduction and life cycle; ecological, social, and economic value; threats; and conservation.

Introductory activities help students learn about connections that characterise marine biodiversity in their own area and hone their observation and investigation skills, setting the stage for exploring the following concepts through a variety of hands-on activities:

Form and Function – the physical characteristics of organisms that are the foundation for exploring how they function and survive

Life Cycles – the successive stages an organism passes through during its lifetime and its requirements in the course of this cycle

Habitats – where animals and plants live and find the food, water, shelter, and space necessary for survival

Interdependence – the links among species through relationships based on food, protection, or other needs

Economic and Cultural Values – the many ways people value marine biodiversity, including the role marine resources play in the economy and culture

Conservation – actions to stem the tide of biodiversity loss, including fisheries regulations, marine protected areas, and measures to prevent pollution and encourage restoration

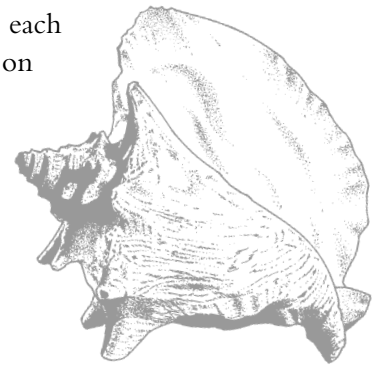
In addition to the activities, this book contains a variety of resources to help you teach about marine biodiversity, including an introduction to assessing student learning, assessment suggestions in each activity, appendices offering guidelines for outdoor and cooperative activities, a framework for skills related to marine biodiversity, a glossary of terms, and a list of suggested resources to consult for additional information.

On the Internet, check treasures.amnh.org for additional activity components and updates. You can also give us your feedback on *Treasures* there and share your experiences and teaching ideas.

An Introduction to The Bahamas' Marine Treasures

The ocean covers nearly three-quarters of the planet. While it is really just one immense body of salt water, we have named the interconnected parts of it as various "seas" and "oceans." Home to a multitude of diverse living things, this one vast ocean essentially sustains all life on Earth. The ocean's systems are key to regulating our climate, and provide us with oxygen and water. We depend on the ocean for food, transportation, recreation, and in many other ways both obvious and subtle.

Located in the Atlantic Ocean, and sharing many characteristics of islands in the wider Caribbean region, The Bahamas constitutes one of the most extensive archipelagos in the world, comprising a chain of 700 islands and cays. The rich Bahamian underwater world supports a variety of species that make their homes in the extensive coral reefs, seagrass meadows, mangrove wetlands, and ocean waters surrounding our islands. Our economy and way of life depend on these marine ecosystems and the resources they provide. Fishers harvest conch, crawfish (spiny lobster), grouper, and other fish to provide food and income for their families. White sand beaches, clear water, coral reefs, and abundant marine life attracts millions of tourists each year. All of us enjoy eating delicious and nutritious fish and take pleasure in playing on our beaches and snorkelling or diving on our reefs.



However, the ocean's resources are not unlimited. We risk losing them if we use too much, or if we damage marine environments through harmful fishing, boating, and diving practices, uncontrolled coastal development, and pollution. Caring for The Bahamas' marine treasures today is essential to ensure that what we leave for future generations is more than just a treasure map.

What Is Marine Biodiversity?

Biological diversity, or **biodiversity**, refers to the variety of life in all its forms and the interactions among them. It encompasses all life on the planet at all levels, from genes to species to entire ecosystems. **Marine biodiversity** is the variety of life in and around the world's saltwater ecosystems, including oceans, seas, bays, sounds, and all the areas where fresh and salt water meet.[1] The extraordinary wealth of marine biodiversity is illustrated by the fact that of the approximately 33 or more major groups (phyla) of animals that are currently recognised, all but one are found in marine ecosystems. In contrast, many animal phyla are absent from terrestrial ecosystems.[2] The number of marine species that have been identified and described is in the range of 230,000 – 275,000. This may sound like a lot, but it represents only 15% of the total (terrestrial and marine) described biodiversity.[3] Most marine biologists believe there are many more marine species — likely millions in coral reefs and in the vast, little-explored deep ocean.[4] The more we learn about life in the ocean, the more we can appreciate how much we depend upon it and how important it is to conserve marine biodiversity.

The high diversity of marine species is likely due to the fact that early life first diversified in the ocean billions of years before various forms started transitioning to land. The complexity and vastness of the ocean creates a diversity of habitats, which in turn has led to the evolution of a high diversity of species. Considering the ocean floor alone, with its huge open plains, chains of volcanic mountains, deep trenches, and rich coastal zones, there are a wide variety of places to live.[5] In addition, while life on land is primarily limited to areas near the ground, marine species inhabit the ocean bottom, the entire water column, and the sea surface, as well as the air above it. Variations in currents, light availability, and water chemistry add to the factors that generate a complex seascape capable of supporting diverse life forms.

An **ecosystem** is a community of living things that are linked by energy and nutrient flow, and that interact

with each other and the physical environment. An ecosystem can be as big as the ocean and as small as a tide pool, or even a coral polyp. The major marine ecosystems found in The Bahamas are rocky shores, sandy shores, mangrove wetlands, seagrass meadows, hard bottom, coral reefs, and the pelagic zone (or open ocean). Globally, marine ecosystems also include the deep ocean and polar oceans. Portions of these ecosystems provide habitats for various species. A **habitat** is a place where an animal or plant finds the nutrients, water, sunlight, shelter, living space, and other essentials it needs to survive. In this resource book, activities help students explore the diversity of ecosystems in The Bahamas' marine environment, and learn about the habitats these ecosystems provide — particularly for queen conch, crawfish, and Nassau grouper. More information on these focal species is found in the fact sheets on pages 16 – 21.

Rocky Shores

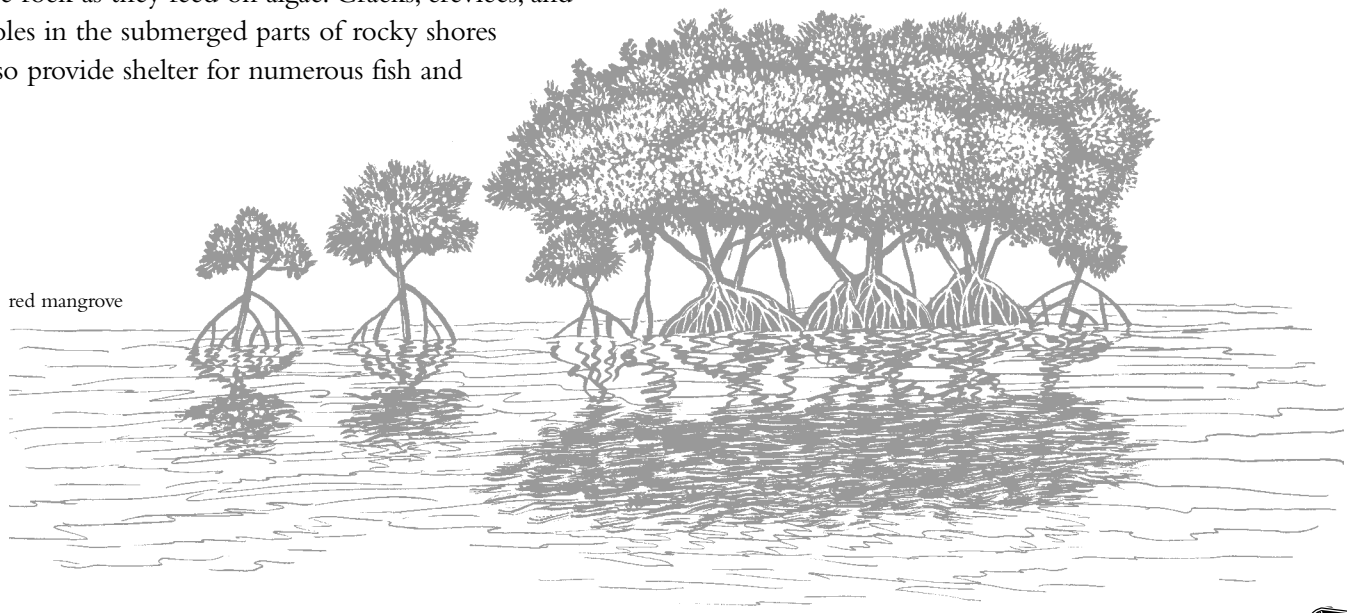
The rocky shores of The Bahamas reflect the formation of the islands themselves, thought to have occurred when the sea level was lower during repeated Pleistocene "ice ages." During these periods, sand was blown into dunes, which then hardened into limestone when the sea level rose again. Today, limestone shorelines typically have a deep notch at sea level (called the intertidal nip) formed by erosion from wave action, as well as by organisms such as mollusks that constantly scrape away and dissolve the rock as they feed on algae. Cracks, crevices, and holes in the submerged parts of rocky shores also provide shelter for numerous fish and invertebrates (animals without backbones) such as crawfish. Shallow, submerged rocky areas can also have sparse coral colonies that may eventually proliferate and form an extensive living reef.

Sandy Shores

Most sandy beaches of the wider Caribbean are made of calcareous (lime-based) sands that are the remains of the skeletons of plants and animals. If you examine a handful of sand, you may be able to see fragments of mollusk shells, corals, and algae. Animals such as sea turtles and some shorebirds lay their eggs and build nests on the beaches. Offshore from sandy beaches the bottom is also usually sandy. These shallow sand flats, interspersed with beds of turtle grass and other seagrasses, along with small patch reefs, may be underwater at high tide and exposed at low tide. These areas are important habitats for sand-dwelling species such as conchs. As juveniles, conchs bury themselves under the sand for almost a year to feed and grow. Other species commonly found resting on or cruising over sandy flats include rays, bonefish, barracudas, and small sharks.

Mangrove Wetlands

Mangrove wetlands are found where salt-tolerant trees grow in shallow, brackish waters along coasts and in the creeks of Bahamian islands. This habitat provides a nursery for many important fish species as well as living space for other creatures such as crawfish, snappers, land



red mangrove

crabs, bats, and birds. Mangroves in and around estuaries also trap sediments that might otherwise flow onto reefs and suffocate corals. With its distinctive prop roots, the red mangrove tree is the most salt-tolerant species, and grows at the shoreline or in shallow water, often forming extensive areas of mangrove wetlands. By shedding leaves into tidal creeks, mangrove trees also provide important nutrients for estuarine nursery areas.

Seagrass Meadows

Seagrass meadows, or beds, are areas of submerged grasses that provide primary habitat and nursery and feeding grounds for many fish and other mobile animals, including groupers, turtles, crawfish, conch, and ballyhoo. These areas are usually shallow with warm water, a sandy bottom, and an abundance of seagrasses (marine flowering plants) such as turtle grass *(Thalassia testudinum)* and manatee grass *(Syringodium filiforme)*. Among the seagrass there may also be some small corals, sponges, other invertebrates, and various species of algae. In addition to contributing to primary productivity, seagrass meadows provide important ecological services in coastal areas by helping to trap sediments from the land, filter coastal waters, and stabilise the sea floor.[6]

Hard Bottom

The Bahamian marine environment includes many areas of flat seafloor with exposed rock or consolidated sediment on which a variety of plants and animals grow. This hard bottom habitat supports abundant patches of the short, club-like algae of the genus *Batophora* (2 – 6 cm or 1 – 2.5 in. tall), often seen growing on conch shells. Tall plants (over 1 m or 3 ft.) known as *Sargassum* also grow here. These plants have air-filled floats that help keep them upright in the water when they are attached to the bottom, or enable them to float after they become detached. Also common in this habitat are a group of soft corals, known as gorgonians. Gorgonians can be mistaken for plants because their skeletal structure frequently has a flexible "trunk" that branches upward. Gorgonians include sea fans, sea plumes, sea whips, and sea rods.

Coral Reefs

Although coral reefs cover less than 1% of the Earth's surface, they have the highest biodiversity of any of the marine ecosystems. Reefs are sometimes called "rainforests of the sea" because of their diversity, or even "cities in the sea" because of the way various organisms that inhabit reef ecosystems carry out different ecological functions. In The Bahamas, coral reefs border most of the north and east coasts and bank edges of the archipelago. On Andros Island, the bank-barrier reef is quite extensive, forming a 229-km (143-mile) stretch of corals.[7] A spectacular abundance of life is drawn to coral reefs, which teem with activity as their inhabitants compete for food and living space. Coral reefs provide shelter and food for crawfish, groupers, and countless marine animals. One of the reasons coral reefs are so diverse is because corals create many different structures, such as caves and holes, which serve as spaces for a variety of species to live (see box on facing page). Warm water, abundance of light, and presence of vegetation also contribute to an ideal habitat for many different species. Coral reef ecosystems are extremely important to Bahamians as a source of food, recreation, and tourism.

Pelagic Zone

The pelagic zone, or open ocean, encompasses all waters above the ocean bottom and is where larvae and other tiny floating organisms (plankton) are found. The open ocean is a major "roadway" for migratory species like turtles, whales, dolphins, tuna, and seabirds. Of course, it is also the area where there are major shipping lanes for movement of people and goods.

Coral Reefs: Spaces for Many Species

Corals, relatives of sea anemones and jellies (jellyfish), are made up of structural units called polyps that secrete calcium carbonate "skeletons." While some coral species grow as a single polyp (known as solitary corals), other species form large colonies of interconnected polyps. Over many years — hundreds to thousands — these colonial corals, along with other calcareous invertebrates and algae, can become reefs.

There are several types of reef habitats, such as patch reefs, reef crests, and reef fronts, which in combination may form various types of reef complexes.

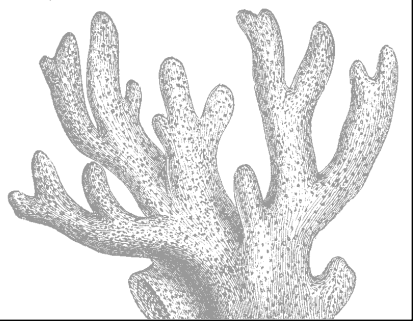
Patch reefs are small, isolated coral reefs often found in lagoons where they may be surrounded by seagrass beds or hard bottom habitat. Patch reefs provide shelter during the day for fish that venture into the adjacent seagrass at night to feed. Such reef habitats commonly have a small "halo" of relatively clear sand around them that has been cleaned by grazing fish and invertebrates.

The *reef crest* begins where deep reefs rise up close to the surface, breaking incoming waves. In The Bahamas and throughout the Caribbean the dominant species of the crest zone used to be the elkhorn coral. Now, in some areas of the Caribbean, disease, storms, predation, elevated water temperatures, and pollution have caused a 90 – 95% decline in elkhorn coral populations.

Both elkhorn *(Acropora palmata)* and staghorn *(Acropora cervicornis)* corals were listed as threatened under the U.S. Endangered Species Act in 2006.[8] These are the first species of corals to be listed under the Act, an important milestone in conservation of coral reef habitats.

Just below the reef crest, the *reef front* (also known as fore reef) forms where the waves of the open sea approach the shallow waters off an island or bank. The reef front may slope down gradually to deeper outer waters, or slope steeply, sometimes reaching a sharp drop-off and forming an outer wall that plunges to depths of hundreds of feet. The shallow parts of this reef habitat, where the most sunlight penetrates, also support the most coral growth, like elkhorn coral and boulder-star coral *(Montastraea annularis)* in The Bahamas. This benthic (bottom-dwelling) community is diverse, and includes corals, sponges, gorgonians, algae, and many other types of organisms.

Towards the outer, seaward edges of the reef front there may be a *rubble zone*, a band of sandy patches littered with fragments of broken coral skeletons, conch shells, and other reef debris that has washed down from the reef. The rubble zone provides habitat for a variety of fish including the jewfish (also known as goliath grouper) and the sand tilefish, which builds a nest from the rubble.



Why Is Marine Biodiversity Important?

Life as we know it depends on a healthy ocean and the biodiversity it contains. Most of the rain, snow, and other precipitation that falls to the Earth originally evaporated from the ocean. The ocean helps control weather, temperature, and the balance of gases in the atmosphere, and also provides the land with the fresh water it needs to maintain healthy plant and animal communities.[9] Global temperatures and weather are highly affected by ocean currents that carry warm tropical waters to the poles and bring cooler waters to the equator. The Gulf Stream is a major current that moves large quantities of water from the Gulf of Mexico and the Caribbean across the Atlantic into northern Europe. Currents such as this contribute to a mild climate on land. And where these currents converge, they bring together a concentration of living things, which in turn creates a feeding ground that attracts other species. The biodiversity that the ocean supports plays an essential role in the air we breathe, the food we eat, the medicine we take, and our quality of life.

Atmosphere

Numerous marine phytoplankton photosynthesise to produce much of the oxygen needed for life on Earth. Phytoplankton (plants and plantlike organisms, many of which are microscopic) drift in large quantities in the surface waters of the ocean where there is abundant sunlight and where carbon dioxide is being absorbed from the air. Through the process of photosynthesis, phytoplankton convert sunlight and carbon dioxide into the sugars they need for energy and release oxygen as a byproduct. Scientists estimate that 50 – 75% of the oxygen in the Earth's atmosphere comes from ocean photosynthesis.[10]

Food

About 75% of the world's fish catch is used for human consumption. Seafood is an important source of animal protein for people, and some small island nations depend on fish almost exclusively.[11] Demand for seafood has been rising globally due to increased awareness of seafood's healthy properties — it is low in saturated fat and high in protein, vitamins, minerals, and healthful oils. Bahamians have long relied on the sea as a source of food.

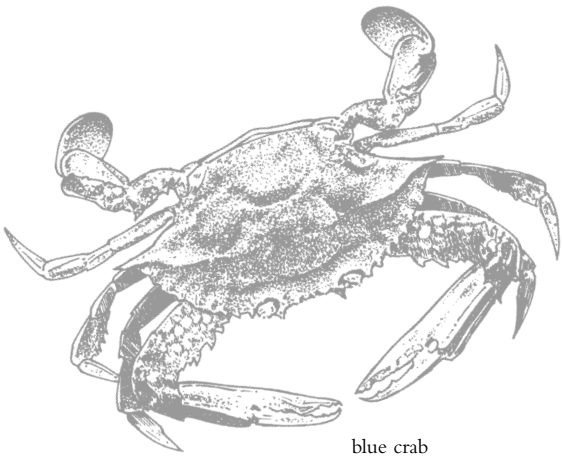
Medicines

Many medicines contain compounds derived from complex chemicals found in marine plants, animals, and fungi. For example, chemicals extracted from a Caribbean sea squirt *(Ecteinascidia turbinata)* may play a role in treating cancer, and can be harvested sustainably if pruned and allowed to regrow. Another example is a species of sea whip *(Pseudopterogorgia elisabethae)* that lives in coral reefs in The Bahamas and elsewhere in the Caribbean, which generates an anti-inflammatory substance used in skin creams.[12] Research on coral reefs may also lead to new forms of pain relievers. Scientists have even developed a technique using the calcium matrix from corals to help repair damaged bones.[13]

Economy

Marine biodiversity affects the world economy both directly and indirectly. The ocean provides goods, services, and employment to millions of people around the world. Globally, the marine-based segment of the tourism industry is one of the fastest growing, with increasing popularity of recreation such as snorkelling, diving, and sportfishing.[14] The tourism industry in The Bahamas provides an estimated 50 – 60% of the gross domestic product (GDP) and employs about half of the nation's work force.[15]

Many Bahamians have employment directly tied to the sea, as fishers, or indirectly in the sale and distribution of related products and services. Over 9,000 people work in the Bahamian fishing industry — 95% as fishers — contributing on average 2.5% to the GDP.[16] The principal commercial fisheries in The Bahamas are crawfish, conch, shallow water scalefish (groupers, jacks, snappers, and grunts), and deep water scalefish (red snapper). In 2004, total landings (the recorded commercial catch) were valued at $95.3 million. In that same year crawfish landings in The Bahamas accounted for 88% of the country's total fisheries production and represented the fourth largest landings of crawfish in the world. In



blue crab

addition to commercial fishing, fisheries categories include artisanal fishing (capture of small quantities of scalefish, crawfish, and conch for subsistence) and recreational fishing, which is also small-scale and includes sportfishing (targeting large pelagic fish like blue and white marlin and dolphinfish in open water, or bonefish in sandy flats, generally for catch and release).[17]

Sponges and shells are among the valuable non-edible marine resources. Sponging was a major Bahamian industry from the 1840s until the 1940s, but declined after disease killed most of the sponges and synthetic sponges were developed as an alternative. The local industry has seen a resurgence in exports since the 1990s, mainly due to a demand for natural products in conjunction with a disease that damaged the Mediterranean sponging industry. Shells are collected in small quantities for sale to tourists and are used in the handicraft industry, however many shells for sale in Bahamian markets have been imported.[18]

Ecosystem Services

Marine biodiversity also plays an important role in providing critical ecosystem services beyond supporting fisheries. **Ecosystem services** are the benefits humans derive from the functions or processes of ecosystems. For example, healthy reefs and mangroves protect coastlines from the effects of waves and storms. Mangroves also filter pollutants by trapping sediments washed from the land. In fact, a high level of biodiversity enhances stability of ecosystems and their capacity to provide services. And marine ecosystems with more biodiversity tend to be more resistant to disruptions to services (such as water quality) and are able to recover more quickly afterward compared with less diverse systems.[19] While scientists have only recently begun to try to translate ecosystem services into monetary units, initial estimates of the value of coastal ecosystem services are in the trillions of dollars, making it abundantly clear that they make a significant contribution to human well-being at a global scale. [20]

How Are The Bahamas' Marine Resources Threatened?

From coastal ecosystems to the deepest depths of the ocean, there is hardly a place on Earth that has not been affected by human activities. A growing human population can directly impact marine biodiversity through the accompanying acceleration in habitat loss, overexploitation of resources, pollution, and introduction of invasive species, and indirectly through climate change. This is accentuated by the fact that more than half of the current world population lives close to the coast, and coastal populations are growing at a much faster rate relative to those in the interior.[21] In The Bahamas, the entire population lives within the coastal zone. Many coastal and marine environments have been considered "commons," or accessible to all, and therefore are vulnerable to overexploitation. Destructive practices are increasingly threatening the survival of marine life and the future of fisheries in The Bahamas and the surrounding region. Tourism, while it brings great economic benefit, can also take a heavy toll on the environment if it is not carried out sustainably.

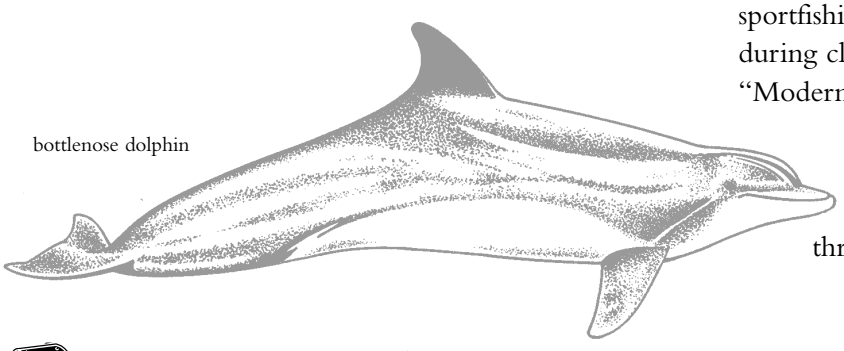
Habitat Loss

Over the last 100 years, half of the world's coastal wetlands have been lost, and almost 70% of the world's beaches are eroding at above natural rates because of human impact.[22] While natural, seasonal occurrences such as storms, hurricanes, surges, and changes in tides impact coastal ecosystems, human activities also pose direct threats. In The Bahamas mangrove wetlands continue to be cleared to meet the demand for coastal development, and beaches are negatively impacted by channeling to make marina entrances, constructing

seawalls or jettys, building in the active beach zone, sand mining, and removing beach vegetation.

Heavily inhabited coastal areas can contribute to loss of adjacent habitats. Large-scale seagrass losses reported worldwide are due to increased nutrient and sediment runoff, physical disturbance, invasive species, disease, commercial fishing practices, aquaculture (farming of fish and shellfish), and global climate change.[23]

More than half of the world's coral reefs are potentially threatened by human activity, with some 20% already damaged beyond recovery.[24] Large-scale impacts to reefs include physical destruction (from dredging, boat groundings, and hurricanes), depletion of large animals such as sea turtles and some fishes, reduced water quality, and "bleaching" (warming surface waters, such as occurred during El Niño events in the late 1990s, cause corals to "bleach" due to loss of their algae, called zooxanthellae).[25] At the local level, reefs are susceptible to pollution, sedimentation, anchoring of boats, excessive use by recreational divers, and adjacent coastal development.[26] Coral reefs have declined in the waters of the more developed and populated islands of The Bahamas, such as New Providence, but are generally healthier in more isolated areas. Other countries in the Caribbean region are experiencing similar or more dramatic declines in coral cover.[27] Scientists estimate that since the 1970s, 80% of coral cover on Caribbean reefs has disappeared.[28] Across The Bahamas, degradation of coral reef ecosystems decreases their attraction for tourists, reduces habitat quality for commercially important fish species, and exposes adjacent islands to the erosive effects of wind and waves.



bottlenose dolphin

Overfishing

The degradation of critical coastal ecosystems combined with a rising demand for fish worldwide is leading to increased pressure on commercial and artisanal fisheries in many places. Globally, fish harvests showed rapid growth ever since the Food and Agriculture Organization (FAO) of the United Nations began collecting data in 1950. While increased fishing efficiency, facilitated by the availability of better equipment and technology (see below), contributed to this trend, some estimates indicate a leveling off of global fish harvest during the late 1980s and early 1990s.[29] To meet demand, aquaculture is booming, accounting for one third of fish consumed globally.[30] However, the growth of aquaculture is generally not sustainable because it requires coastal space, relies on wild fish stocks, and is highly vulnerable to pollution and disease.[31]

Fishing fleets continue to grow and use increasingly sophisticated technology to track and capture fish. Hi-tech fleets use radio and satellite communications, echosounders (apparatus used to detect and identify fish and determine depth of water and nature of the seabed), sonar, and even airplanes to track schools of fish.[32] Studies have suggested that the increased effectiveness of these methods has contributed to a global decrease in the number of large fish in the ocean by 90%.[33] Many populations cannot withstand the heavy fishing pressure and some, such as the queen conch in Florida, and the Atlantic cod, have suffered collapses.

Serious threats to the health of The Bahamas' fisheries include the use of "unselective" gear (such as dredges and driftnets that have a high incidence of bycatch), improper fishing practices (such as use of fish traps and household bleach), exceeding legal catch limits (for sportfishing), and poaching (which can involve fishing during closed seasons or in marine protected areas).[34] "Modern" fishing methods used in The Bahamas include breathing apparatus; long lines with chemical lights to attract fish at night; global positioning systems (GPS) to guide boats through the shoals of a favourite fishing site, and

to record and relocate crawfish condominiums (shelters made with sheets of aluminum on blocks, enclosed on all but one side that offer attractive "habitats" for crawfish); and larger boats equipped with refrigeration.[35]

The high value of crawfish has led to intensified efforts in that fishery. The size of the individuals caught has been declining, an indication that the species is being overfished.[36] The average individual size of queen conch landed has also been decreasing while the overall quantity taken has been increasing due to the demand for this staple food. Taking of undersized, juvenile conch is a problem.[37] Decline in spawning aggregations of Nassau grouper has also raised concern, as aggregations that have disappeared elsewhere in the region have not returned.[38]

Pollution

Pollution can come in many forms, from poorly managed waste and marine debris to oil spills. In The Bahamas, municipal waste has generally been disposed of in dumps, from which it can be carried to the ocean by wind or seep into the ground. Improper disposal of hazardous wastes, such as automobile tires and batteries, motor oil, medical waste, dry cleaning solvents, pesticides, paints and other chemical waste can all have serious consequences as they can make their way into the marine environment. These substances can poison fish, destroy coral reefs, threaten marine life and contaminate food chains. Facilities in The Bahamas are not yet adequate to address these issues, and the dispersed nature of the population among Bahamian islands is a management challenge. Dumping along roadsides or on abandoned land is also common.[39]

Wind, rain, and creeks can carry debris into the sea, posing a threat to many organisms. Each year millions of seabirds, sea turtles, fish, and marine mammals become entangled in marine debris or swallow plastics, which they may mistake for food. Unsightly trash can also discourage tourists and result in lost revenues.

Oil spills are harmful to marine life and are also very difficult and expensive to clean up. The Caribbean region is vulnerable to marine oil pollution due to the fact that 50,000 ships and 14.5 million tourists — many of whom travel on cruise ships — pass through the region each year, resulting in an enormous amount of maritime traffic.[40] Because large tankers cannot travel over the shallow banks of the Bahamian archipelago, there is also a risk of spills when transferring fuel to smaller boats for deliveries to many of the Family Islands.[41] In the main ports of Nassau and Freeport, accidental spills from cruise liners and other ships can cause contamination of the local environment and its fisheries. Bilge water released from ships is another major source of oil pollution in the Caribbean, because the concentration of oil in bilge water is often quite high.[42]

Introduced Species

Another major threat to marine biodiversity is the introduction of non-native, or exotic, species. These species are carried in some way from their native habitat to a new environment where they can become invasive, taking over habitat from native species. In the ocean, non-native species are often introduced by ships delivering products around the globe.[43] For stability these ships usually carry ballast water, which they discharge as they arrive at a port, often releasing many new organisms in the process. Organisms can also arrive on ship hulls or anchor chains. Species may be introduced in many other ways: through aquaculture, biological control (the use of living organisms to control pest populations), intentional or unintentional release into the wild from aquariums, in shipments of live seafood, and even on the soles of visitors' shoes.

While introduced species do not always cause problems in their new habitats, there can be great ecological and economic costs when they do. Species can become invasive and displace native plants and animals if they are able to grow and reproduce quickly, have a large number of offspring, disperse to a large area, adapt to new food and habitat, and if they lack predators in the new location.[44] Native species on islands like those of The Bahamas are generally not well equipped to protect themselves from new predators, parasites, and competitors. For example, the Bahama parrot, a native species in

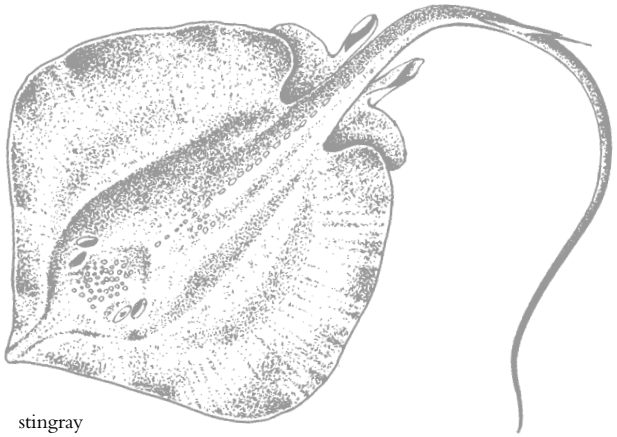
Abaco, nests on the ground, a behaviour developed in the absence of native predators. But when raccoons, pigs, and cats were introduced to the island, the parrot's young became very vulnerable to predation.

An invasive fish species now appearing in Bahamian waters is the red lionfish *(Pterois volitans)*, a native to the Indo-Pacific.[45] Lionfish were likely introduced through accidental or intentional release from aquaria. They feed on a wide variety of smaller fish, shrimp, and crabs, which are abundant in the western Atlantic and inexperienced with the predatory style of the lionfish. Moreover, few predators have been reported in the native habitat of the lionfish, and potential predators in their new habitat have no experience with the fish's venomous spines.[46] These spines can kill potential predators and are harmful to divers and fishers. Juvenile Nassau groupers and other species of reef fish have been found in the guts of lionfish.[47]

Climate Change

Actual and predicted climate change adds still another layer of stress on marine biodiversity. Scientists are increasingly in agreement that human activity is contributing to global climate change, which includes temperature increases, sea level rise, changes in precipitation patterns, and increased frequencies of extreme weather events.[48] In particular, greenhouse gases (emissions such as those from electricity generation and transportation) that trap heat energy in the atmosphere are leading to rising sea surface temperatures. In The Bahamas greenhouse gases that contribute to this global issue primarily originate in New Providence where two-thirds of the population resides.[49]

The low-lying islands of The Bahamas are especially vulnerable to inundation and the predicted increase in seasonal storms and hurricanes. Extensive damage to landscapes, particularly shoreline erosion, is expected to occur, in addition to flooding and structural damage. Even a minor sea level rise could significantly impact many islands and cays by causing beach loss and increasing vulnerability to storm surge, beach erosion,



stingray

flooding, and salinisation of soil and groundwater.[50] The impacts of global climate change make it all the more important to conserve mangroves, which are coastal buffers. Warming ocean water temperatures may also increase the incidence of coral bleaching. Finally, the continued uptake of atmospheric carbon dioxide (a greenhouse gas) by oceans is expected to dramatically increase the acidity of the ocean.[51]

How Can We Conserve The Bahamas' Marine Treasures?

Protection and management of The Bahamas' marine resources will help ensure that future generations can benefit from these treasures. Education, fostering a conservation ethic, scientific research, habitat protection and restoration, and regulations and enforcement are all important for the conservation of marine biodiversity.

Education and Fostering a Marine Conservation Ethic

Educating our students about the importance of marine biodiversity helps them acquire the knowledge, awareness, attitudes, and skills for effective environmental stewardship. When people get involved through their own actions and by supporting conservation policies, it can make a big difference. For example, over 1,000 schoolchildren in The Bahamas wrote letters to our government asking for protection of the habitat of the Bahama parrot in Abaco. As a result of this major educational campaign (coordinated by the Bahamas National Trust), Abaco National Park was established in 1994 to protect 83 km^2 (32 sq mi.) of the northern-most range of the endangered Bahama parrot.

The marine environment plays a central role in Bahamian culture, figuring prominently in festivals, traditions, and stories. Many festivals in The Bahamas revolve around seasonal and environmentally related events. Heritage festivals are held on the Family Islands, often celebrating the main attribute of the island, such as CrabFest in Andros, the Pineapple Festival in Eleuthera, and Rake n' Scrape Festival on Cat Island. Regattas occur regularly in various boating communities, such as the national regatta in Georgetown, bringing numerous visitors. There are also conch cracking contests and sportfishing tournaments. Bahamian dishes — delicacies unique to The Bahamas or prepared in a Bahamian way — are a highlight of these events.

The Bahamas has a strong oral tradition through storytelling, songs, and news brought by travelers passing through. The wisdom of elders, particularly on the Family Islands, is respected and passed on to younger generations.[52] Traditional and local knowledge are significant components in conservation decision-making. In addition, consultation with local resource users is an important part of the process of designating new marine protected areas and determining other management practices.

Habitat Protection and Restoration

Marine protected areas are one of the main mechanisms for protecting marine ecosystems and species that depend upon them. **Marine protected area** (MPA) is a general term for an area associated with the ocean that receives any sort of protection. Currently MPAs account for approximately 1% of the world's oceans,[53] though many nations, including The Bahamas, are increasingly recognising the importance of MPAs.[54] Marine protected areas in The Bahamas include marine parks or sanctuaries, no-take reserves, and fully protected marine reserves. These protected areas are designed for a variety of purposes and may have different levels of restrictions on various activities. For example, no-take reserves emphasise the limitations on the extraction of resources from an area. Some reserves protect specific sea turtle nesting sites or coral reefs, which provide habitat for a variety of marine species; others are designed to keep fish stocks thriving; and still others serve primarily as recreational and educational areas. This type of protection allows some activities and restricts others, while still offering substantial benefits to biodiversity conservation and fisheries management.

In 2000 the Government of The Bahamas initiated a process to create one of the world's first networks of MPAs by proposing the protection of 20% of The Bahamas' marine environment, including the parks and reserves already established.[55] The aim of the process is to ensure healthy populations of queen conch, crawfish, and Nassau groupers, and other marine resources into the future. Studies such as those of the Exuma Cays Land and Sea Park indicate that fisheries benefit through the movement of conch larvae across reserve boundaries into adjacent areas.[56] Other studies have shown how MPAs benefit coral reefs.[57] The Bahamas Department of Marine Resources has been working with local communities, non-governmental organisations, and scientists to determine the best sites and conditions for the establishment of several new MPAs.

While protecting habitats before they are degraded is the best conservation scenario, it is often necessary to restore damaged habitats in order to bring back biodiversity and ecological function. This may involve filling in and planting to re-establish and better stabilise beaches and dunes. Coral reef restoration projects, using artificial "reef balls" on which corals can propagate or be transplanted, have been implemented around the world, including numerous locations in The Bahamas. There are also projects under way to restore estuary and creek systems, especially where roads have been constructed across the mouths of estuaries, limiting natural water exchange (which prevents the flushing of sediments and nutrients) and preventing movement of fish and invertebrates.

Marine Protected Areas in The Bahamas

In recent years the number of areas set aside to protect marine habitats and species in The Bahamas has increased. Following are some of the long-established parks and some that have been newly designated.

Black Sound Cay National Reserve
This two-acre (.008 km^2 or .003 sq mi.) mangrove reserve was established in 1988 to protect a vital coastal ecosystem and the wildlife of Abaco's Green Turtle Cay.

Central Andros National Parks
Established in 2002, these 1,158 km^2 (447 sq mi.) of parks in Andros protect portions of one of the world's longest barrier reefs, a high concentration of blue holes (underwater caves and sinkholes), as well as valuable mangrove wetlands. Marine life that seeks habitat across these areas includes crabs, conch, bonefish, and West Indian flamingos.

Exuma Cays Land and Sea Park
Established in 1958 and designated a no-take marine reserve in 1986, this is one of the oldest land and sea parks in the world, and the first marine fishery reserve in the wider Caribbean, protecting more than 456 km^2 (176 sq mi.) of pristine marine environment. Studies have indicated that this park plays an important role as a replenishment area for species that are exploited in surrounding waters.

Little Inagua National Park
Located on the largest uninhabited island in the wider Caribbean, this 127-km^2 (49 sq mi.) park, established in 2002, is important for fisheries replenishment. Eggs, larvae, and sub-adults are carried to other parts of The Bahamas by currents flowing northeast. It is also a documented nesting location for sea turtles.

Lucayan National Park
This park, east of Freeport on Grand Bahama, encompasses the world's longest known underwater cave system with over 9.5 km (six mi.) charted. Above ground, all of the vegetative zones of The Bahamas are represented. The park was established in 1977 and covers 40 acres (.16 km^2 or .06 sq mi.).

Pelican Cays Land and Sea Park
This 8.5-km^2 (3.3 sq mi.) park is located north of Cherokee Sound in Great Abaco. Visitors can experience impressive undersea caves, and enjoy its coral reefs and rich wildlife.

Union Creek National Reserve
Twenty km^2 (7.7 sq mi.) of enclosed tidal creeks on the northwest shore of Great Inagua offer an important research site for sea turtles, especially the green turtle. Established in 1965, the reserve is not open to the public in order to protect the habitat where turtles lay their eggs.

Walker's Cay National Park
Located on the northern-most island of The Bahamas and fringed by its own barrier reef, this park was established in 2002 and encompasses 15.5 km^2 (six sq mi.). This area is renowned for stunning underwater coral cathedrals teeming with high concentrations of fish and a wide variety of other marine life, making it a big attraction for divers.

For more information, visit www.thebahamasnationaltrust.org/parks.php

Scientists Investigate Marine Reserves in The Bahamas

Where should the boundaries lie for new reserves? How many reserves are necessary to both protect marine life and replenish economically critical fisheries? The answers require an understanding of how biological, social, and geophysical components play a role in the marine environment. This type of system-level thinking has its own term: biocomplexity.

In 2001 an international team of ecologists, geneticists, anthropologists, oceanographers, economists, and mathematicians was formed to investigate marine reserves in The Bahamas. The study, called the Bahamas Biocomplexity Project, was initiated by the American Museum of Natural History's Center for Biodiversity and Conservation. Project scientists have studied biological, sociological, and "connectivity" (how the system "flows" hydrographically and genetically) aspects of The Bahamas. The data gathered contribute to computer models that describe The Bahamas' complex ocean system and predict how changes will affect it. Studies of the 20-year no-take performance record of the Exuma Cays Land and Sea Park provide important pieces of the puzzle. Scientists expect that the data from this "experimental control" of a marine wilderness can be applied to marine reserves across The Bahamas, and even worldwide.[58]

For more information, visit bbp.amnh.org.

Regulations and Enforcement

The Government of The Bahamas has enacted various regulations to protect the marine environment and resources.

- The *Bahamas National Trust Act* of 1959 established the Bahamas National Trust and gave it the power to acquire lands to conserve communities of plants and animals and natural environmental features, developing a national park system.[59]
- The *Coast Protection Act* (1968) declares the preservation and maintenance of the coast against erosion and encroachment by the sea.[60] According to this act, the government has the power to carry out works for the protection of the coast as well as to charge the owner of the land for any resulting expenses. However, this act does not enforce any fees for the degradation of coastal areas, despite many new environmental concerns.[61]
- The *Fisheries Resources Jurisdiction and Conservation Regulations* (1986) provide for the sustainable harvesting of specific marine resources; prohibit the removal of coral; forbid the use of destructive fishing methods, such as firearms or explosives and poisonous chemicals like bleach; and only allow Bahamian-owned vessels to fish commercially in Bahamian waters (with some exceptions due to observance of international treaties).[62]

Additional rules and regulations have also been established for species threatened with overfishing, including queen conch, crawfish, and Nassau grouper — species that are the focus of many activities in this resource book. These include closing areas to fishing and instituting closed seasons, and regulations pertaining to the size of fish that can be taken and the methods that can be used to catch them. **For more information on regulations pertaining to conch, crawfish, and grouper, see the species fact sheets on pages 16 – 21.**

Enforcing regulations poses a number of challenges. In The Bahamas, there are a small number of fisheries officers to cover a large area dispersed across an archipelago. Agencies such as the Royal Bahamas Defence Force and the Royal Bahamas Police Force have other responsibilities in addition to assisting with protection of the marine environment. Coordination among agencies, with non-governmental organisations (the Bahamas National Trust and others) and community groups offers additional support for management.[63]

Recognising that marine life generally does not stay within political boundaries, and is impacted by factors for which one country alone cannot be responsible, The Bahamas is a signatory or participant in a number of international agreements, including the following:

- The *Convention on the Law of the Sea and Agreement on Straddling and Highly Migratory Fish Stocks* declares the right of countries to govern the water and protect species within 200 nautical miles of their coasts, and encourages international cooperation to ensure protection and to promote optimal utilisation of fisheries resources.[64]
- The *Convention on International Trade in Endangered Species of Wild Flora and Fauna* (CITES) protects certain endangered species from overexploitation. For example, an export permit is necessary for trading queen conch, a species listed in Appendix II of CITES.
- The *Convention on Biological Diversity* states the need for nations to develop national strategies for the conservation and sustainable use of biological diversity. The Bahamas was among the first nations to sign the 1992 Convention on Biological Diversity, and hosted the first Conference of Parties to the Convention in Nassau in 1994.[65]
- The *International Queen Conch Initiative* was adopted in 1996 by the countries within the conch's range to promote a common international management strategy in the Caribbean region. Minimum shell size limits and harvest quantities, as well as other measures, are intended to aid the recovery of the species from past overexploitation.[66]

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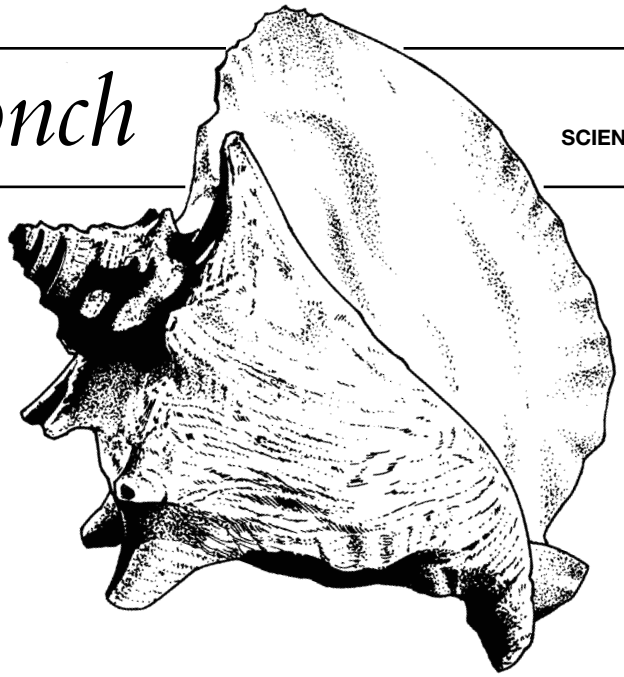
Queen Conch

SCIENTIFIC NAME: *Strombus gigas*



Kingdom	Animalia
Phylum	Mollusca
Class	Gastropoda
Order	Sorbeoconcha
Family	Strombidae
Genus	*Strombus*
Species	*gigas*

Description

The queen conch is one of the largest marine snails. It is a soft-bodied mollusk in a large, flared shell. Its scientific name *Strombus gigas* means "giant spiral shell." This shell, covered with protective blunt spikes, has an orange hue on the exterior (though not always apparent because of algal growth), while the interior is a shiny, pink colour. The shell can grow to 30 cm (12 in.) in length.

The conch's body consists of a black speckled "foot"; two sensitive tentacles; a "head" with two protruding stalks, each with an eye on the end; and a snout-like mouth (proboscis) with a rough, tongue-like radula that has thousands of tiny denticles (tooth-like protrusions). (See diagram on page 48.) The head and foot are covered by a thin layer of tissue called the mantle, which secretes the shell and also shelters the feathery gills that allow the conch to take in oxygen from the sea water.

The conch's single foot ends with a "claw" called an operculum. It plants the operculum on the sandy seafloor to propel itself forward slowly, in a hopping motion. Like many other snails, the conch can pull its operculum tightly into the shell opening to defend against attacking predators. The foot is also useful as a lever for regaining an upright position if the shell is tipped, and it is the source of the meat used in many popular dishes.

Range and Habitat

The queen conch's range includes the warm, shallow waters off south Florida, Bermuda, The Bahamas, areas throughout the Caribbean, Central America, and south to Brazil. Queen conchs are rarely found at depths greater than 21 m (70 ft.). Adults live around coral rubble, in the hard-bottom communities of soft corals and sponges, or on sandy bottoms and seagrass beds.

Diet

The conch is a slow moving herbivore (plant eater) that is most active at night when it feeds on algae found on sand, seaweed, seagrass blades, and on floating organic debris.

Reproduction and Life Cycle

Conchs breed throughout the year, except from November to January. During mating, the male sits directly behind the female and uses the sexual organ (the "verge") on its right side to deposit sperm into the groove that runs down the right side of the female's foot. Up to several weeks following internal fertilisation, the female releases an egg mass, which, although only five to 15 cm (two to six in.) long, can contain up to half a million fertilised eggs! This mass is actually a tightly folded egg-filled tube. From 21 to more than 36 m (70 – 120 ft.) of tube strands may be produced at a rate of about 1.5 m (five ft.) per hour. Sand grains soon adhere to the sticky mucus on the tube, hiding the eggs from predators.

After four to five days, the eggs hatch into tiny free-floating larvae, called "veligers." These veligers are so small that 10 can fit into one drop of water. They do not look like conch at all. Their bodies have two round lobes rimmed with fine hairs that beat back and forth very fast, and help the conch swim and move food into its

mouth. Veligers drift in the sea feeding on tiny, one-celled organisms (phytoplankton).

After approximately four to six weeks, the conch settles to the seafloor and undergoes a metamorphosis. Its lobes disappear, and the foot and snout-like mouth develop. It develops a very fragile shell and finally begins to look like the conch that we know. For about a year, the juvenile conch buries itself in the sand and becomes nocturnal, only coming out to feed at night.

At a few months old the conch's shell is white, but by the time it is five or six months old the shell shows streaks of dark brown. Young conchs are called "rollers" because their shells do not yet have the stable, flared lip of the adults. When the juvenile is three to four years old, the shell stops growing in size and length, becomes thicker and heavier, the spiral gets bigger, and the flared lip develops. It is only when the lip is fully flared that the conch reaches sexual maturity. Few conchs survive to adulthood, instead becoming food for many ocean organisms. Those that do survive may live up to 25 years.

Value

The conch is a source of food for many animals besides people. Juvenile conch are eaten by crawfish, crabs, hermit crabs, sea snails, hogfish, and queen triggerfish. Few animals can prey on an adult conch, but those that are able to crack its shell include loggerhead turtles, horse conchs, stingrays, and leopard rays. When abandoned, conch shells provide shelter for many sea creatures, such as hermit crabs and juvenile groupers.

The queen conch also has an important cultural and economic role in The Bahamas. It has been a staple food in the diet of Bahamians for hundreds of years, as well as an important fishery resource. The conch is a "cultural symbol" and popular food dishes include cracked conch, conch fritters, conch chowder, conch salad, and scorched conch. Shells have long been popular souvenirs, however current regulations prohibit their export without the proper permit.

Threats

The queen conch is vulnerable to overfishing because it matures slowly and populations are not replenished quickly. It is also slow-moving and easy to capture; the use of snorkelling gear has made harvesting even easier, considerably increasing the quantity caught (scuba is prohibited for fishing in The Bahamas). Reproduction may fail if conch populations fall below certain density thresholds. The queen conch has been a staple meat source throughout the Caribbean region for centuries, which has contributed to population declines of the queen conch in much of the wider Caribbean.

Conservation

The queen conch is listed in Appendix II of the Convention on the International Trade in Endangered Species (CITES). This listing categorises the species as threatened and at risk of becoming endangered. All international trade of queen conch is strictly controlled among CITES signatory nations.

Conch populations in some areas of The Bahamas show evidence of overfishing. Where numbers are reduced, populations are at risk of collapse. Due to concern about the status of conch fisheries, the Bahamas Department of Marine Resources has prohibited the harvesting and possession of conch with a shell that does not have a well-formed lip and has limited the export of conch.

Researchers have observed that juvenile queen conchs typically live in aggregations, probably for protection against predation. Protection of key nursery areas would increase the chances of maintaining a sustainable conch fishery.

Queen conchs have been bred in captivity, but attempted reintroduction programmes have so far been unsuccessful.

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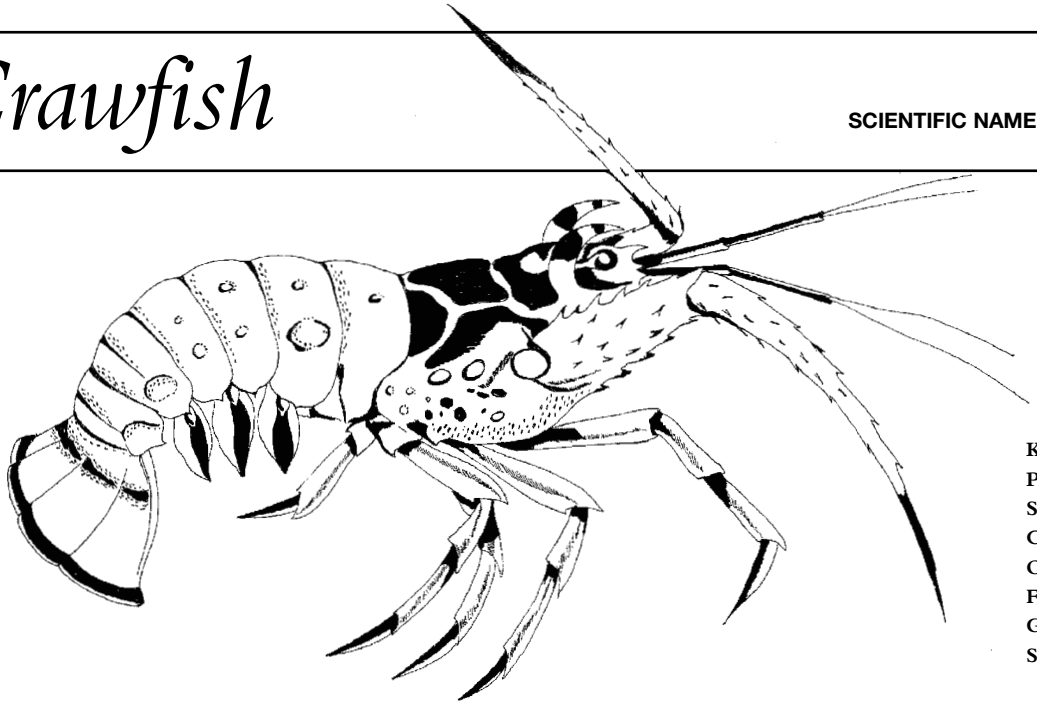
Crawfish

SCIENTIFIC NAME: *Panulirus argus*



Kingdom	Animalia
Phylum	Arthropoda
Subphylum	Crustacea
Class	Malacostraca
Order	Decapoda
Family	Palinuridae
Genus	*Panulirus*
Species	*argus*

Description

The crawfish, also known as the Caribbean spiny lobster, has a body comprised of a cephalothorax (the fused head and thorax) and an abdomen, which is segmented and flexible. The crawfish has a hard outer shell, or exoskeleton. The shell covering the cephalothorax is called the carapace. (See diagram on page 51.) The colour of the carapace varies from mottled greenish purple to reddish brown with a few dark spots, while the shell covering the abdomen is brown and tan with a few light spots on each segment.

Rows of spines on its carapace earn the crawfish the common name spiny lobster. These spines as well as two sharp horns over its eyes, and a pair of long, conical antennae, often called whips, are used for defense against predators. A second pair of antennae, called antennules, are used for sensory perception and are folded alongside the body when not in use. The stalked eyes of the crawfish are compound (or multi-faceted), providing a mosaic of images that enable the crawfish to detect movement well. Male crawfish have an opening at the base of each of the fifth pair of walking legs. The fifth pair of a female's walking legs has hook-like "spurs" at the tips. While the male has a single set of four pairs of leaf-like swimmerets (or pleopods) under the tail, each of the female's swimmerets has two lobes (one flat and one like a small pincers). The end of the tail is fan-like, with two lobes on each side of a centre lobe. When disturbed, a crawfish flips this fan to make a hasty backwards retreat.

Range and Habitat

Crawfish are found throughout the tropical and subtropical waters of the Atlantic Ocean, Caribbean Sea, and Gulf of Mexico, occurring from South Florida, The Bahamas, and Bermuda to the West Indies. They require several types of habitats over the course of their life cycle. As larvae, crawfish drift in the open ocean. In the post-larval stage, they settle in the vegetation of nearshore benthic (bottom) habitats. As they develop, juveniles seek shelter in crevices of rocks, sponges, and corals. Maturing crawfish move to deeper reef habitats. Adults live in small groups in protective recesses in reefs during the day and forage in the open at night.

Diet

Examination of the contents of crawfish stomachs has revealed that they feed on sea urchins, hermit crabs, sea stars, small mollusks (such as young conch and clams), and worms. Crawfish are scavengers and will feed on almost any animal matter that they come across while foraging. They are able to detect food at some distance using special sensors on their antennae.

Reproduction and Life Cycle

Crawfish reach sexual maturity at about three years old, when the carapace measures nearly eight cm (over three inches). They spawn when the ocean is warm during the spring and summer. The male places a sticky fluid on the underside of the female. This hardens into a black patch (called a "tar spot"), containing thousands of sperm. The female scratches the spot with the hook on her leg to release the sperm as she discharges eggs. The fertilised eggs attach to hairs on the pincer-like lobes of the swimmerets under her tail for two to three weeks, until they turn from orange to dark brown and are ready to hatch. A female with an eight-cm carapace can produce about 250,000 eggs, while a female with a carapace greater than 10 cm (four in.) can produce over a million eggs, though as few as one individual may survive to become an adult. Large crawfish may spawn two or three times during the mating season; smaller crawfish spawn only once.

A female carrying eggs (in "berry") usually stays on the deeper edges of a reef, so when the eggs hatch the larvae are released into the open sea. The transparent, flat, spider-like larva, called a phyllosome, looks nothing like its parents. It drifts in the ocean feeding on other plankton, moulting 11 times over six – 12 months. At approximately nine months, the phyllosome undergoes a metamorphosis in which its body takes on the shape of a small crawfish. The still transparent post-larval crawfish swims towards shore to settle in nursery areas like mangroves, algal and grass beds, or shallow reefs. Juveniles also hide on boat bottoms, anchor ropes, and dock pilings. Soon after they settle, juveniles take on striped and banded yellow and dark brown patterns that help them hide in the vegetation. Sub-adults move to coral reefs and crevices. Crawfish continue to grow larger throughout their lives, with some reaching nearly a meter (more than three feet) long from head to tail. Because they frequently moult and grow a new shell, it is difficult to accurately determine an adult lobster's age, so scientists do not yet know the maximum age a wild crawfish can reach.

Value

Crawfish is an important food source for large groupers, loggerhead turtles, octopus, sharks, and people. Crawfish are "reef cleaners" and play a vital role in keeping our coral reefs healthy. They also have significant economic value. Fishing of crawfish is a multimillion-dollar industry in The Bahamas. On average, crawfish represent 60% of total fishery product landings and more than 85% of the value of landings annually.

Threats

Crawfish are heavily fished throughout their range. In The Bahamas, crawfish are considered generally abundant, with localised depletions near major population centres. The continued success of the commercial fishery depends upon use of responsible fishing methods and respect for fishing regulations.

Conservation

To produce enough larvae to sustain harvest levels, crawfish must be allowed to reproduce undisturbed. Conservation of crawfish habitat is an important part of this. The Bahamas Department of Marine Resources has put in place the following regulations:

- An annual closed season from April 1 through July 31
- A minimum harvestable size of 8.25 cm (3.25 in.) carapace length or 14 cm (5.5 in.) tail length
- Possession of an egg-bearing female is prohibited as is removing the eggs from a berried (egg-bearing) female
- Use or possession of bleach or other noxious or poisonous substances is prohibited without a permit
- Crawfish traps are limited to wooden slat traps no more than .9 m (3 ft.) long and .6 m (2 ft.) wide, with slats at least 2.5 cm (1 in.) apart

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Nassau Grouper

SCIENTIFIC NAME: *Epinephelus striatus*

Kingdom	Animalia
Phylum	Chordata
Class	Actinopterygii
Order	Perciformes
Family	Serranidae
Genus	*Epinephelus*
Species	*striatus*

Description

The Nassau grouper is an important part of the coral reef community and a valuable fisheries resource. Nassau groupers often rest on the seafloor under ledges, around caves, and in crevices and cracks in the reef. The Nassau grouper belongs to the seabass family of fishes which tend to have strong, stout bodies and large mouths. Five dark brown bars (vertical markings), a dark band (diagonal marking) running from the snout through the eye to the forward side of the dorsal fin, and a dark saddle-like spot on the base of the tail fin are markings that distinguish the Nassau grouper from other groupers. Its broad, fan-shaped tail makes it a slow long-distance swimmer, but enables it to accelerate quickly and make short, quick movements to catch prey. (See diagram on page 59.) A Nassau grouper will change its colour and patterns when it is threatened or to hide from prey. Groupers are among the largest fish on the reef, reaching a maximum length of 1.2 m (4 ft.) and weight of more than 23 kg (50 lbs), but averaging 0.3 – 0.6 m (one to two ft.) long and 4.5 – 9 kg (10 – 20 lbs). They have an average life span of 16 years, but may live for more than 20 years in the wild.

Range and Habitat

Nassau groupers are found in the tropical western Atlantic Ocean and the Caribbean Sea from Bermuda, The Bahamas and southern Florida to Central America and northern South America. Adult Nassau groupers inhabit shallow waters to depths of approximately 100 m (328 ft.) and prefer areas associated with reefs or rocks where they can hide under ledges, in caves, crevices, and cracks. Young groupers are often seen in shallow water near the shore where they settle in algal and seagrass beds, mangroves, and patch reefs.

Diet

Nassau groupers, like most seabass, are predators. They sit camouflaged outside the openings of caves and wait to ambush prey such as crabs, crawfish, reef fish, and octopus. They see well without much light, and often hunt at dawn and dusk when other fish are looking for shelter or feeding. As groupers grow, their diet changes. Juveniles feed mainly on crustaceans, while adults will eat both invertebrates and fish.

Reproduction and Life Cycle

During the full moon from late November through February when water temperatures are cool, Nassau groupers migrate up to hundreds of kilometres to gather in large groups around certain bank locations to spawn (a form of reproduction in which eggs and sperm are released into the water). Groupers are one of only a few species that form these large spawning aggregations, now numbering in the hundreds, but were once commonly made up of thousands to tens of thousands fish. At these aggregation sites, returning fish undergo various colour phases as spawning approaches. Groupers will rise quickly to the surface in small groups, releasing eggs and sperm into the open sea. Males are often seen nudging the bellies of females to trigger the release of eggs. Spawning continues for several days following the occurrence of the full moon.

The clear, fertilised eggs, measuring less than one millimetre in diameter, are carried away from the reef

by the wind and tide. Larvae hatch from these tiny eggs within approximately 20 to 40 hours. After 35 – 50 days at sea, currents return the larvae to coastal areas where they settle in nursery areas such as algal beds. At about 10 – 12 months, juveniles move to patch reefs in shallow waters where they remain for several years. As they reach adulthood, Nassau groupers move to deeper reefs where they continue growing until they reach sexual maturity, between four to eight years of age. Of the million or so eggs released by each female, less than 1% survives to adulthood.

An interesting aspect of the life cycle of many species of grouper is that they can change sex from female to male, however evidence for this is weak in Nassau groupers, indicating that it is not typical for the species.

Value

Nassau groupers play a key role in reef communities. They are a food source for sharks, and small groupers are eaten by barracudas, lizard fish, and dolphins. They also participate in symbiotic relationships, for example visiting "cleaning stations" where small fish and shrimp remove parasites from their exterior and the inside of their mouths. Decreases in Nassau grouper populations have community-wide impacts.

Named after The Bahamas' capital, the Nassau grouper has high social value and is popular in traditional dishes such as boiled fish and grouper fingers. It has been The Bahamas' most economically valuable finfish in recent years. According to the Department of Marine Resources, in 2003 recorded landings of grouper totaled 421,880 kg (930,087 lbs) and were valued at over $2.7 million. The Nassau grouper is also a favourite of snorkellers for its size, inquisitiveness, and photogenic appearance.

Threats

Humans are the predators that have had the biggest impact on grouper populations. In addition to maturing slowly, Nassau groupers are exceptionally vulnerable to overexploitation because of their spawning aggregations, which form in predictable areas and at predictable times, and from which fish can be caught prior to reproduction. Where spawning aggregations have disappeared due to overfishing, they do not form again. Direct threats to groupers include uncontrolled fishing on spawning aggregations, spearfishing, and the capture of juveniles in small mesh traps. Other threats include habitat destruction, coral breakage by divers, siltation from construction, runoff, dredging, sewage, and other contaminants that harm both coral reefs where adult Nassau groupers live, as well as algal beds in nearshore nursery areas. The Nassau grouper occupies only a fraction of its previous range and is classified as endangered according to the World Conservation Union (IUCN). This classification signifies that the Nassau grouper has suffered a rapid population decline — it has declined by about 60% over the last three decades — and is at risk of extinction. It is commercially extinct in most of the Caribbean region. Since the 1990s, spawning aggregations have not occurred in Puerto Rico, Bermuda, or the United States Virgin Islands. The Bahamas is one of the few countries where stocks remain commercially viable, though they are much less abundant than in previous decades.

Conservation

Signs of decline in the Nassau grouper population have prompted the Bahamas Department of Marine Resources to establish an annual closed season from the beginning of December to the end of February. This closed season protects Nassau groupers when they gather in spawning aggregations and are the most vulnerable. Other management measures that would help protect the Nassau grouper include:

- Marine parks and reserves where the fishing of grouper is prohibited
- Enforcement of the minimum legal harvest size of three pounds

Sources

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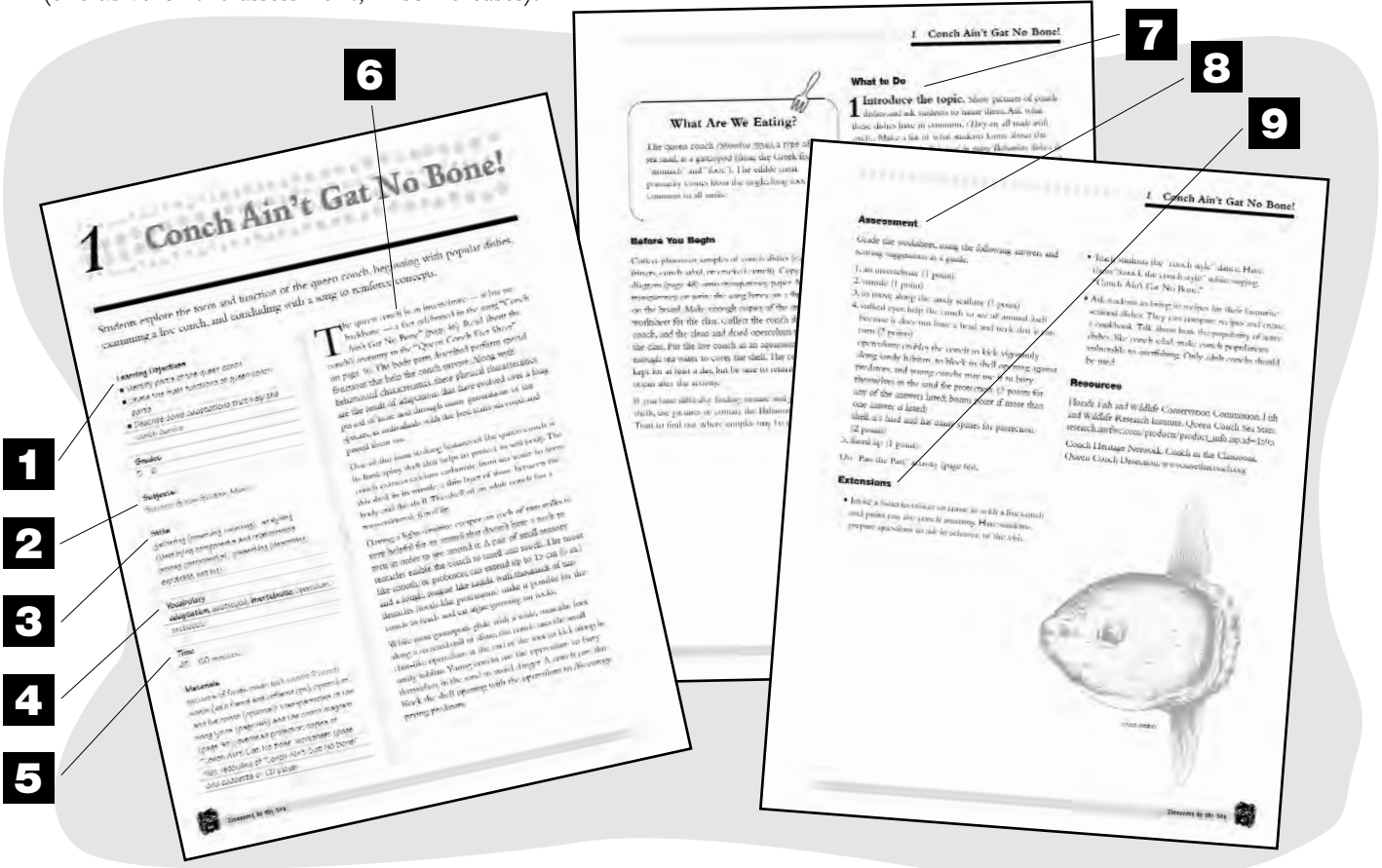
An Introduction to the Activities

The activities in *Treasures in the Sea* are geared for the Bahamian classroom through descriptions and illustrations of local species and habitats, references to local customs and stories, and suggestions of local sites to visit. Activities include background information, advice for guiding students in hands-on learning, and tips on how to connect students to the community and to the outdoors. We have identified skills and suggested approaches to assist you in planning, implementing, and evaluating activities.

Each activity follows the format in the sample below.

1. **Learning Objectives:** Objectives describe what students should know or be able to do after participating in the activity.
2. **Subjects:** Lists specific disciplines to which the activity connects.
3. **Skills:** Lists key skills students will use in the activity. You will find a complete list in the "Skills Framework" on page 191.
4. **Vocabulary:** Highlights important words in the activity that students might not know. Words in bold are defined in the "Glossary" on page 195.
5. **Time:** Gives an idea of the time an activity will take based on pilot testing and educator comments (exclusive of the assessment, in some cases).
6. **Introduction:** Starts off each activity and includes related background information.
7. **What to Do:** Includes step-by-step directions to conduct the activity.
8. **Assessment:** Suggests ways to assess the extent to which learning objectives have been met. "Assessing Student Learning" on the next page explains the approach used in this resource and offers ideas for assessment strategies. For activities with worksheets, this is where you will find the answer key.
9. **Extensions:** Suggests additional activities or projects to encourage more in-depth investigation. Some can also be used as assessment strategies.



Assessing Student Learning

There are a variety of ways to assess student progress. Many teachers are seeking ways to show that their students can go beyond the recitation of facts. They are asking their students to demonstrate a mastery of higher order thinking skills in the context of their classroom activities. To do this, they incorporate authentic assessment methods that demonstrate and promote further learning, along with traditional assessment methods that tend to rely on recall, such as homework, quizzes, and book reports.

The practice of doing regular classroom assessments is important to determine whether or not your students have acquired specific knowledge or skills, and to diagnose student strengths and weaknesses to plan appropriate instruction. Classroom assessment is also a means to provide feedback to students, parents, policymakers, and others about the effectiveness of educational services. Classroom assessments have the potential to enhance instruction and learning, and thus should be used to their fullest potential.

Treasures in the Sea is designed to assist you as you assess student learning. Each activity suggests at least one way to assess student learning in relation to the activity's learning objectives. Some of the suggested methods assess student understanding of factual information. Many of the assessments ask students to demonstrate a theoretical or applied conceptual understanding.

These methods include: guided discussion; worksheets; writing a paragraph, essay, or position statement; diagramming relationships among concepts; and observation of the learning process that takes place in the course of the activity. When grading student performance, rubrics may be used. These can be created, with student participation, to outline expectations for the activity and assign points to each criterion in a way that everyone agrees on and understands from the outset.

Sample Rubric

For an activity in which students create a poster of a marine habitat and what lives there (see "Home Sweet Habitat," page 94), their work can be assessed with a rubric such as this:

	Bull's Eye (4 points)	Right on Target (3 points)	Getting Close (2 points)	Missed the Mark (1 point)	Points
Poster Elements	Students identify the unique habitat features and make connections with the animals and plants living there. Extra elements are included (e.g., size and scale of organisms).	Students identify the unique habitat features and make connections with the animals and plants living there.	Students misidentify a couple of elements required, either the unique habitat features and/or examples of plants and animals that live there.	Poster is incomplete and does not identify any unique features and/or plants and animals in the habitat.	
Poster Mechanics	Information on the labels is accurate.	There are minor inaccuracies on the labels.	There are major inaccuracies on the labels.	Most information on the labels is inaccurate.	
Knowledge of the Subject	Students demonstrate full knowledge related to the habitat and answer questions with explanations and elaborations.	Students answer questions related to the habitat, but do not elaborate.	Students are uncomfortable and can only answer basic questions regarding the habitat.	Students cannot answer questions about the habitat.	
				TOTAL POINTS	

Other types of criteria can be added if you have objectives that you would like to meet in addition to those specified in the activity. For example, you can assess process skills such as group participation or problem solving. Or you can establish standards for visual presentation such as neatness, organisation, and creativity; and for verbal presentation such as clear introduction and summary, clear speech and appropriate volume, and eye contact with the audience. Discuss these with students to make sure that expectations are clearly defined.

In addition to the assessment methods suggested in the activities, consider using some of the general techniques listed here.

Dramatisation	Students role-play or act out an activity's key concepts. This can also be done using finger or hand puppets.
News Reporting	Students pretend they are news reporters and give a 30-second report about what took place during an activity and what was significant about it.
Signaling	A class is asked a series of questions. All students signal their own response by holding their thumbs either pointed up for "yes" or down for "no."
Journal Writing	Students write and illustrate their own personal version of what they learn and do throughout the activity, or over the course of a series of activities.
Visual Representation	Students draw, paint, or otherwise create an image that conveys an activity's central ideas. They can expand this into a comic strip, a photographic essay, a picture book, a diorama, or three-dimensional model.
Teaching	Students teach the activity's concepts to peers or younger students.
Position Statements	Students write from a specific point of view. (For example: What a grouper's point of view might be regarding camouflage, or a fisher's perspective on quotas.)
Self-Described Outcomes	Students are asked open-ended questions that allow them to describe, either in written or verbal form, what they learned. (For example: "Describe three things you learned while doing this activity.")
Real World Examples	Students find examples of an activity's concepts in their community or in the media, and then report those examples to the rest of the class. They can conduct interviews to discover what other people think about a concept or issue.
Game Making	Students make games that involve the activity's facts and concepts. (For example: Students make and play a trivia-style board game where players move around a gameboard by correctly answering questions.)
Peer Testing	Students write assessment questions for each other, then evaluate their peer's responses.

Adapted from:

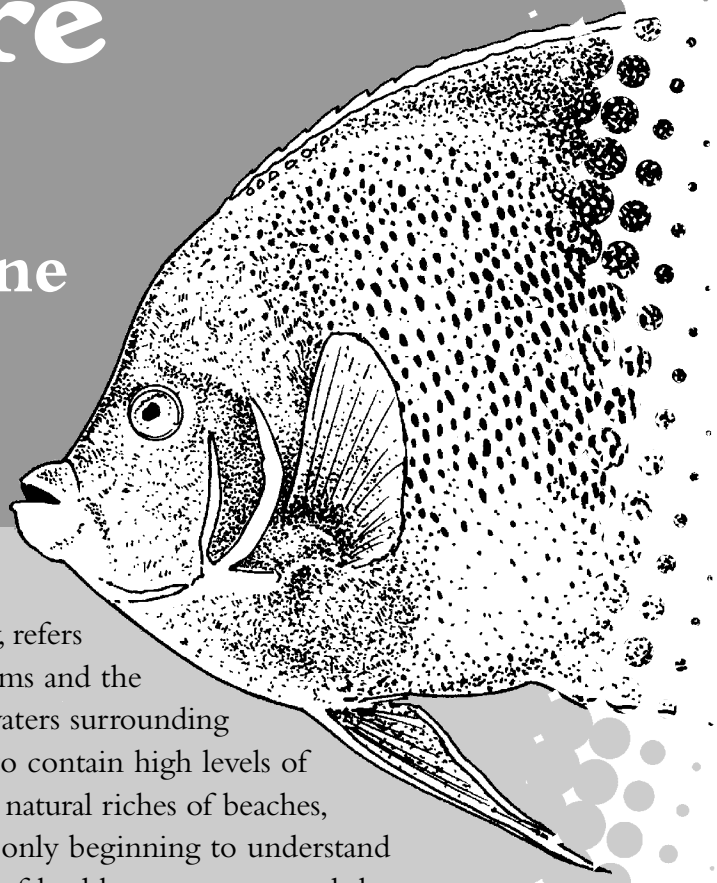
Aquatic Project WILD: Aquatic Education Activity Guide. 1992. 2nd edition. Bethesda, MD: Western Regional Environmental Education Council, Inc., p. 221.

Project WET Curriculum and Activity Guide. 1995. Bozeman, MT: The Watercourse and Western Regional Environmental Education Council, p. 494.

SECTION 1

Treasure Trove

Bahamian Marine Environment and Resources



Biological diversity, or biodiversity, refers to the variety of life in all its forms and the interactions among them. The waters surrounding the islands of The Bahamas are known to contain high levels of biodiversity. Beyond some of the familiar natural riches of beaches, seagrass beds, and coral reefs, people are only beginning to understand the value of maintaining a wide variety of healthy ecosystems and the plants and animals in them. We are also only beginning to understand the threats to biodiversity and the urgency of protecting it. Activities in this section help students learn about the interactions that characterise marine biodiversity in their own area, and hone their observation and investigation skills, setting the stage for exploring the other concepts found further on in this resource book.

1 All the World's a Web

By making "word webs," students identify the components of marine biodiversity and interpret the relationships among the various components.

Learning Objectives

- Define marine biodiversity
- Create a word web that illustrates some of the complex connections in the web of life
- State at least one way that marine biodiversity affects people's lives

Grades

3 – 6

Subjects

Science, Social Studies, Language Arts

Skills

organising (arranging), analysing (identifying components and relationships among components), interpreting (relating), applying (creating)

Vocabulary

biodiversity, ecosystem, marine biodiversity; plus any unfamiliar words in "Web Words" list

Time

45 – 60 minutes

Materials

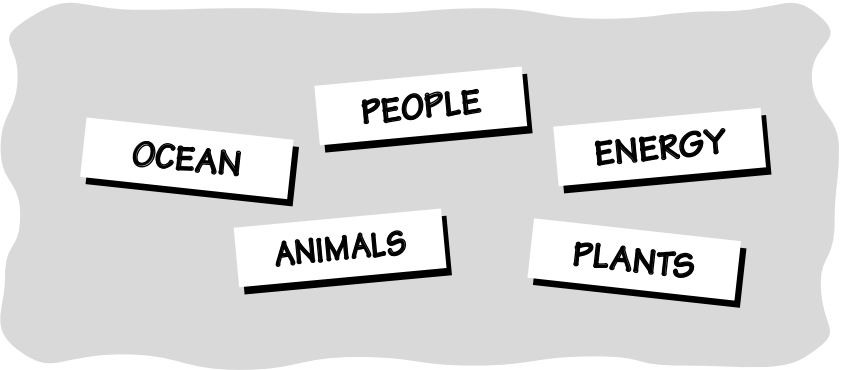
chalkboard, pencils, container for key words, and key words on separate pieces of paper

Biodiversity is the variety of life around us — and much more. It covers all life on the planet at all levels, from genes to species to entire ecosystems. It is also everything that living things do — the grand total of interactions of living things among themselves and with their environment. These interactions can be as simple as a leatherback sea turtle's dependence on jellyfish for food or a grouper's dependence on a coral reef for protection. At another level, the sea turtle, the jellyfish, the grouper, and coral polyps also depend on all of the elements that make up their ecosystem — from clean water to the right climate. At still another level, this ecosystem interacts with other ecosystems to form a huge, global system of interacting parts.

This activity is a great way to begin a marine biodiversity unit because it focuses on connections, which are at the heart of understanding biodiversity. The activity can also give you an idea of how your students are thinking about biodiversity before you start a unit on the topic.

Before You Begin

Write each of the key words below on a separate piece of paper and put all five key words in a container. Write the web words (page 29) on a chalkboard. Alternatively, you can download and print the web words from treasures.amnh.org.

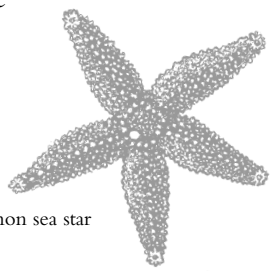


What to Do

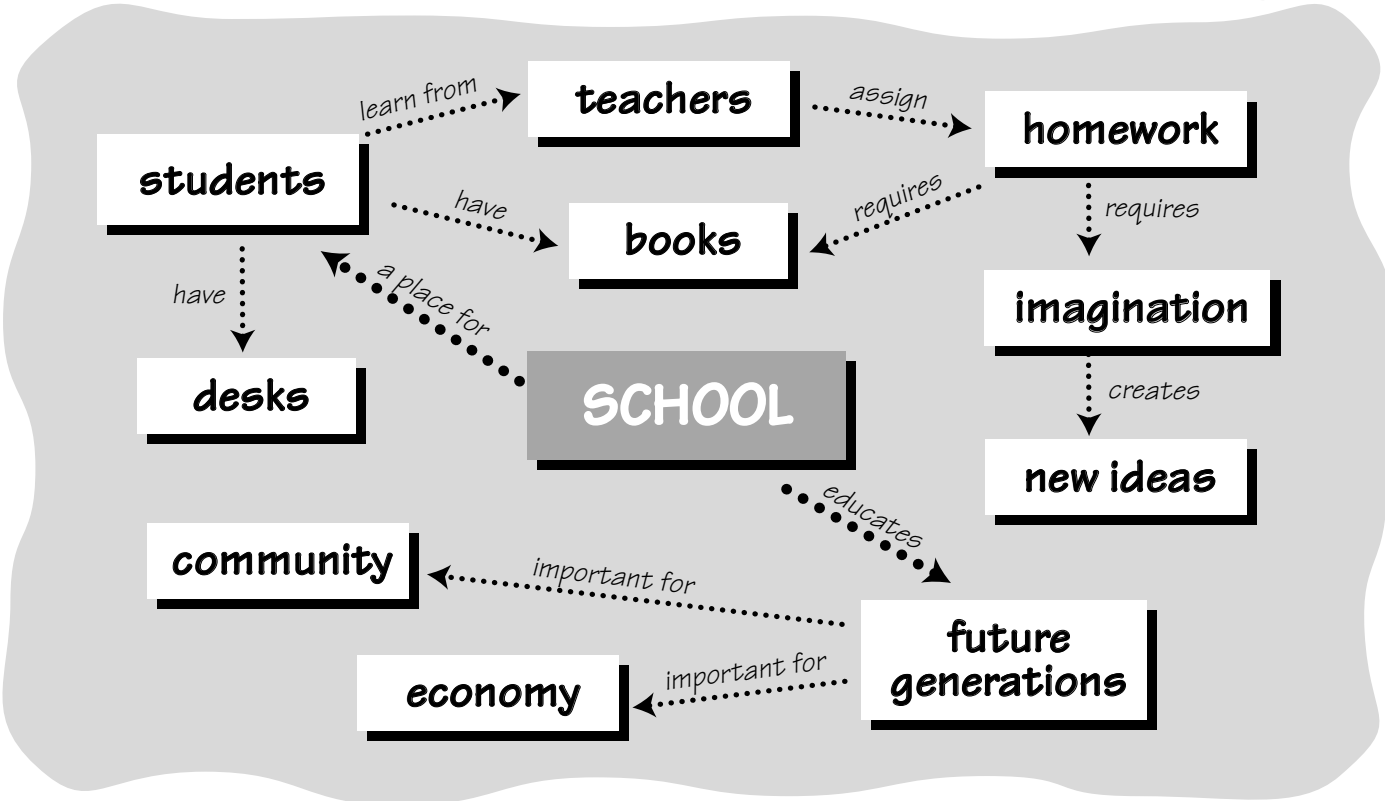
1 Create a sample word web. Use the word "school" as a key word to create a word web on the chalkboard. Ask the students what other words they think of when they think of their school. Some examples might be teacher, student, books, desks, and homework. Draw arrows and write the connections between words. For example: Students *learn from* teachers. Teachers *give out* homework, and so on.

2 Introduce marine biodiversity. Write the term "biodiversity" where everyone can see it and ask the students for their ideas on its meaning. Use the glossary and background information to familiarise the students with the word. You can also break the word "biodiversity" into its two parts — *bio* means "life" (as in "biology," the study of living things) and *diversity* means "variety." Explain that biodiversity is the ultimate web because it includes all life on Earth. Marine biodiversity refers to all life forms in the oceans, coastal waters, and estuaries (areas where fresh water and salt water meet). Marine biodiversity is often intricately connected to life on the land.

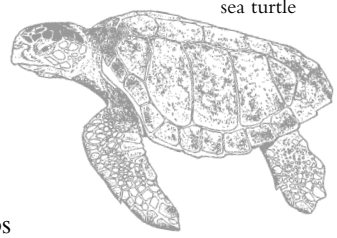
3 Review the vocabulary and divide the class into groups. Go over any key words and web words that the students aren't familiar with. Then divide the class into groups of four to five students and have someone from each group pick a key word from the container. Tell the groups to write that key word in the centre of a piece of a paper. Next, give them time to create a web in which the key word forms the hub, and web words connect to the key word or to other web words. Ask them to draw arrows and write in words that describe the connections they're creating. Examples include verbs and phrases such as "produces," "affects," "benefits," "is helped by," "can lead to," and "can cause." For example: People *eat* fish, fish *live on* coral reefs, human population growth *can cause loss of* natural habitats, pollution *can harm* marine mammals, and so on.



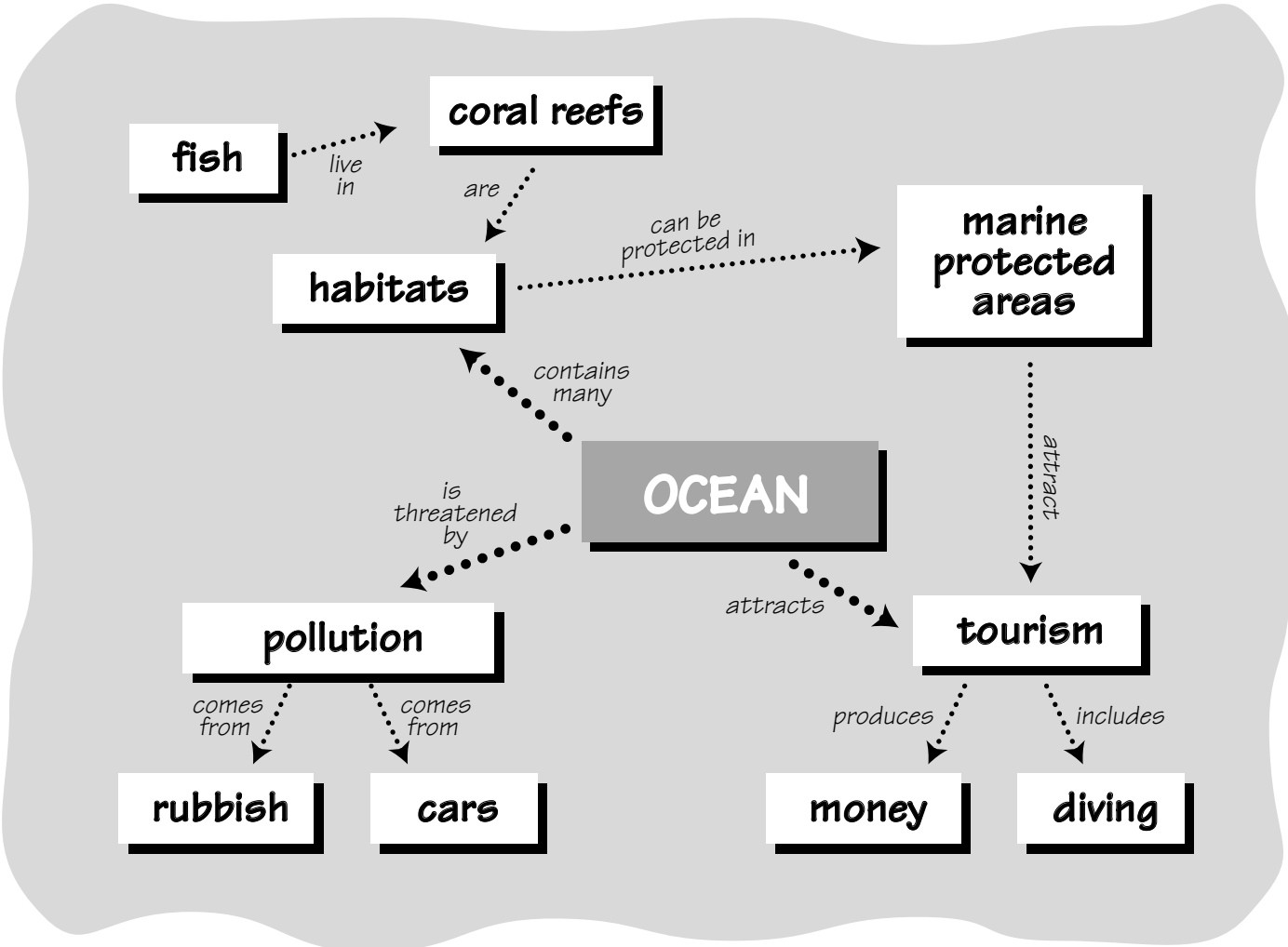
common sea star

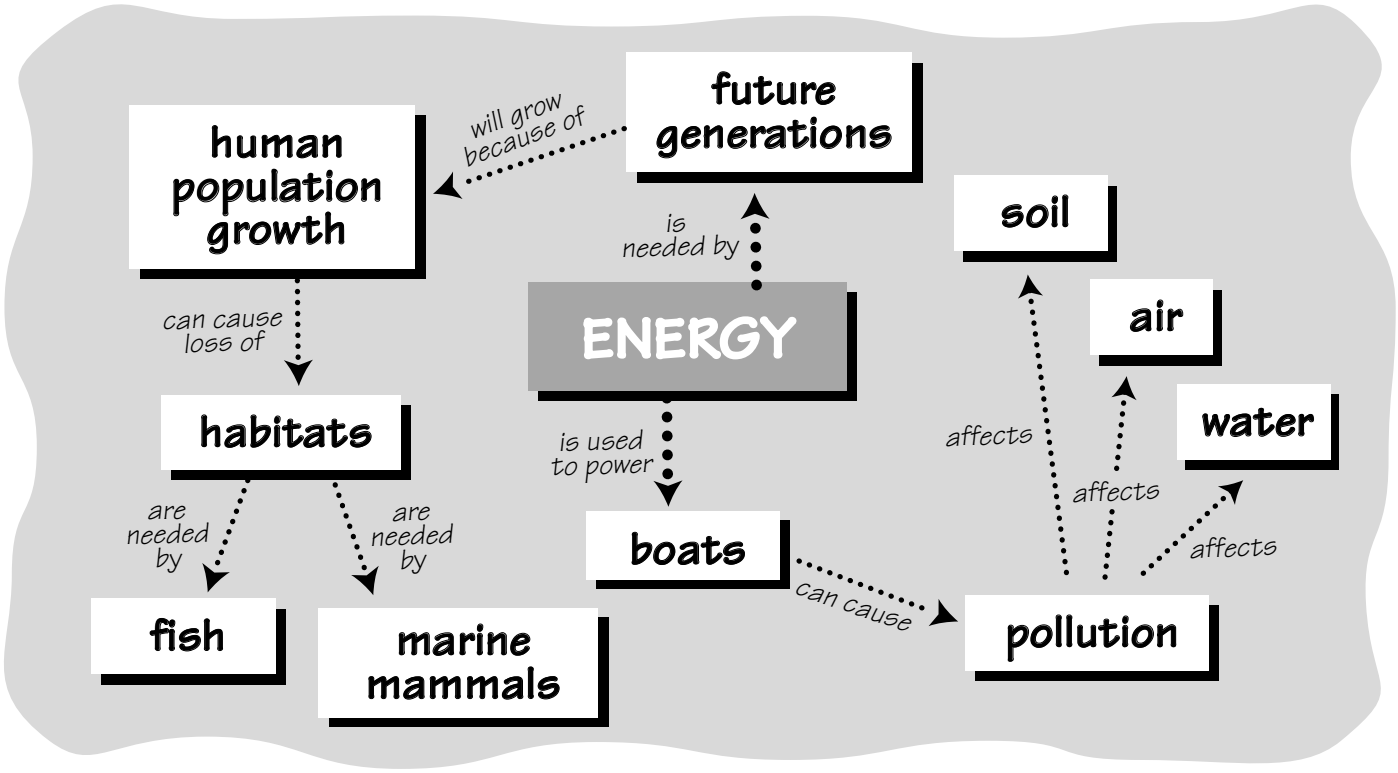


4 Discuss the webs. Each group should be able to explain the connections that they drew between the key word and the web words, as well as between the different web words. Ask the students if they notice any similarities among different groups' webs and have them work within their groups to identify and write down two or more of these similarities, such as the same web word connections. You might also want to have them write down any differences they notice. If students didn't use some terms, ask why. Can they think of ways these terms could be included in the webs?


loggerhead sea turtle

5 Create new webs. Have the groups create webs as before, but this time use the term "marine biodiversity" as the key word. They can add any new web words they might think of. Again, have students share their ideas.





Assessment

This activity can be used as an assessment for other activities. You can have your students create webs after they complete activities or units in this resource book to see if they understand the basic concept of marine biodiversity and how it is linked to other issues. For example, they can create webs around a key word such as "habitat" after completing a unit on marine habitats.

Key Words	Web Words				
ocean	soil	boats	food	mangroves	tourism
animals	money	habitats	human population growth	cars	diving
people	water	coral reefs	air	rubbish	fishing
plants	future generations	marine mammals	medicine	school	marine protected areas
energy	ocean	pollution		trees	
				fish	

You may wish to add terms for more advanced students or when doing the activity at the culmination of a unit. Some possibilities: sustainable harvesting, overharvesting, traditional fishing methods, modern fishing methods, endangered species, pesticides, crops, organic farming, atmosphere, research, technology, household rubbish, beach rubbish. Students can also come up with their own lists and trade with each other.

2 Sea for Yourself

Take a trip to the seashore, an aquarium, or other site to get more closely acquainted with marine life.

Learning Objectives

Identify the variety of local marine life to reinforce understanding of marine biodiversity

Grades

3 – 6

Subjects

Science, Art, Language Arts

Skills

gathering (collecting, recording, observing, measuring), organising (sorting, arranging, categorising, drawing)

Vocabulary

biodiversity, ecosystem diversity, marine biodiversity, species diversity, symbiosis, tentacle

Time

30 minutes classroom, 1 hour minimum for field trip plus travel time

Materials

Option 1 (seashore field trip): field notebooks for each student (these can be actual notebooks or several pieces of paper that have been folded over and stapled to make a booklet), buckets, nets, rulers, field guides

Option 2 (aquarium or nature centre field trip): copies of "Scavenger Hunt Clues" (page 36), clipboards (optional)

Even though they live near the ocean, marine biodiversity might be a new idea to your students. Before diving into the concepts covered in other activities in this resource book, you can use this activity to inform your students and inspire them to learn more about the topic by taking a closer look at the diversity of life that can be found in the ocean. Two options for investigating marine life are suggested in this activity.

Option 1 — A trip to the seashore is a great way to introduce your students to the wonders of marine biodiversity. An experience like this is exciting for students and will give you a chance to reinforce some key concepts about life in the sea.

Option 2 — A trip to an aquarium or nature centre that features examples of marine life can also expose students to some fascinating life forms and the environments they inhabit.

If you are unable to take students on a field trip, you can develop a virtual tour using the "Scavenger Hunt Clues" (page 36). Write possible answers for each clue on the board or a handout sheet. Students can then use field guides or Internet searches to find pictures and information on these. See the extension on page 35 and refer to "Suggested Resources" on page 198 for videos, Web sites, and images.

Option 1: Seashore Field Trip

Before You Begin

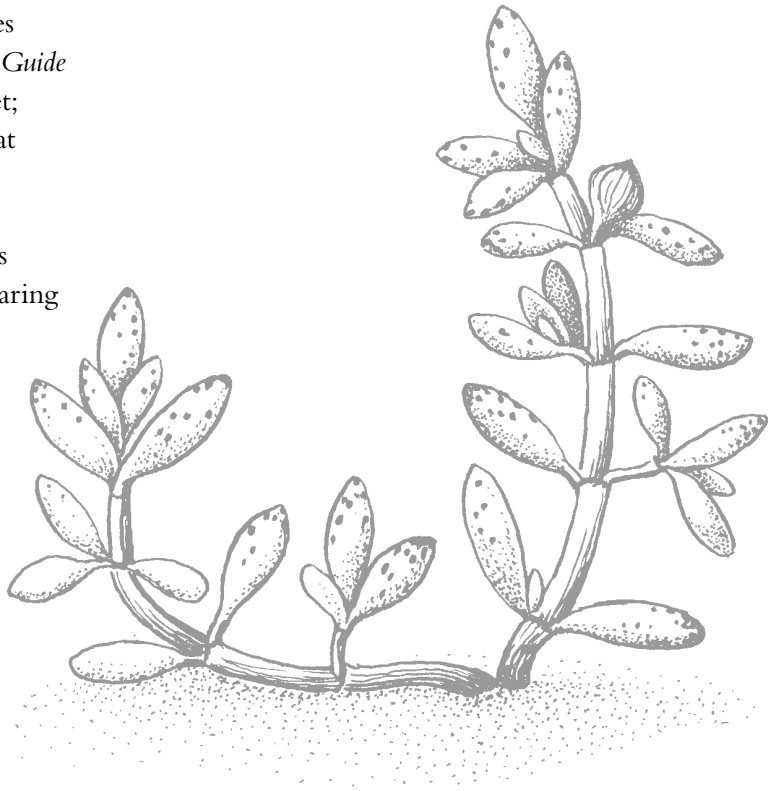
If you're planning to take your students to the seashore, you might want to invite an expert along to help. (See "Suggested Resources," page 198, for a listing of organisations or agencies.) An expert can give you ideas (or materials) to help in your exploration of the shore. Be sure to bring field guides, if available.

When choosing a site to visit, you'll want to take into account a variety of factors, including travel time, accessibility, and facilities. Once you've identified a few possibilities, you might consult with local experts about which sites are the least disturbed and offer the greatest opportunities to find diversity of life. Be aware that usually you are not allowed to collect or move live animals or plants, or even shells. Observe them and then leave them in their natural setting.

Once you've selected a site, check the tide tables for low tide when more of the shoreline is exposed and can be explored; marinas, guidebooks, and Web sites can provide this information. (For example: *Cruising Guide to Abaco and Northern Bahamas,* www.abacoguide.net; or enter your location and select Marine Reports at www.myforecast.com.) Make any necessary travel arrangements (such as transportation, chaperones, permission slips, and so on). See "Taking Your Class Outside," page 192, for some practical tips on preparing for outdoor trips with your students.

Make it a Scavenger Hunt

This activity is designed to offer students a relatively unstructured introduction to marine biodiversity, giving them time to explore the seashore on their own. The emphasis is on observing and recording information. If you'd like to provide more structure for the activity you can make it a scavenger hunt. Scavenger hunts can be a great tool to help sharpen students' observation skills, and they are also helpful if there are particular things you want students to look for on the seashore. You can put together a scavenger hunt that is specific to your region. It can be similar to the one in Option 2 (page 34), but you may wish to have your students sketch the species they observe, especially if they can't name them.



seaside purslane

What to Do

In the Classroom

1 Review the term "marine biodiversity." If you've already discussed marine biodiversity with your students, ask them if they remember what it means. *(Biodiversity is the variety of life at all levels — from genes to species to entire ecosystems. It's also everything that living things do — all of the interactions of living things among themselves and with their environment.)* If your students are unfamiliar with the idea of biodiversity, you can use the activity "All the World's a Web," page 26, to introduce this concept before taking your trip.

Ask the students if they can think of any examples of marine species that live nearby. Do they know of different marine ecosystems in their area? Explain that they'll be taking a trip to the seashore and learning firsthand about local marine biodiversity.

On-site

2 Give students pointers on locating samples. Once you're at your site, tell students that their job is to find as many organisms as they can that make up the local marine biodiversity. Distribute field notebooks and other materials students can use in their investigations. Make sure students have pencils (ink will run if it gets wet). Give them a set amount of time to explore (at least 30 minutes). They should search the shore and record their findings in the field notebooks. Encourage them to record plants that have washed ashore, such as seaweed and turtle grass, and animals (as well as any signs of animals, including seashells, egg cases, crab shells, animal bones, tracks, nests, and droppings). Caution students not to touch or pick up anything that may be hazardous, such as glass, needles, or nails.

Collect Information, Not Specimens

Many people who work in the marine field believe that students should not be allowed to collect specimens at any seashore. This way they minimise disturbance to the marine environment. If students are taught to observe and record their findings in field notebooks instead of collecting specimens, students' families may learn to do the same.

When scientists record what they observe in the field, they include information such as the date, habitat type, weather conditions, interesting behaviour, and they often sketch what they see.

Talk about what students should include in their field notebooks. Suggestions include: location, date, and time the item was found; conditions (weather and tidal height); a sketch of each item; the name of the organism if they know it (provide field guides, if possible); and a description (shape, colour, length, other characteristics). If they observe more than one individual of a species they can also record the number and any differences they see among individuals.

3 Find a central area to analyse students' findings. Gather students at a central (preferably shady) area to work in pairs to review their notes and discuss relationships among the specimens they observed. They may list species and then higher levels of classification, such as animals with shells, plants that grow on shore, plants that grow in the water, and so on. Ask each pair of students to share their categories with the rest of the class, as well as anything unusual they found.

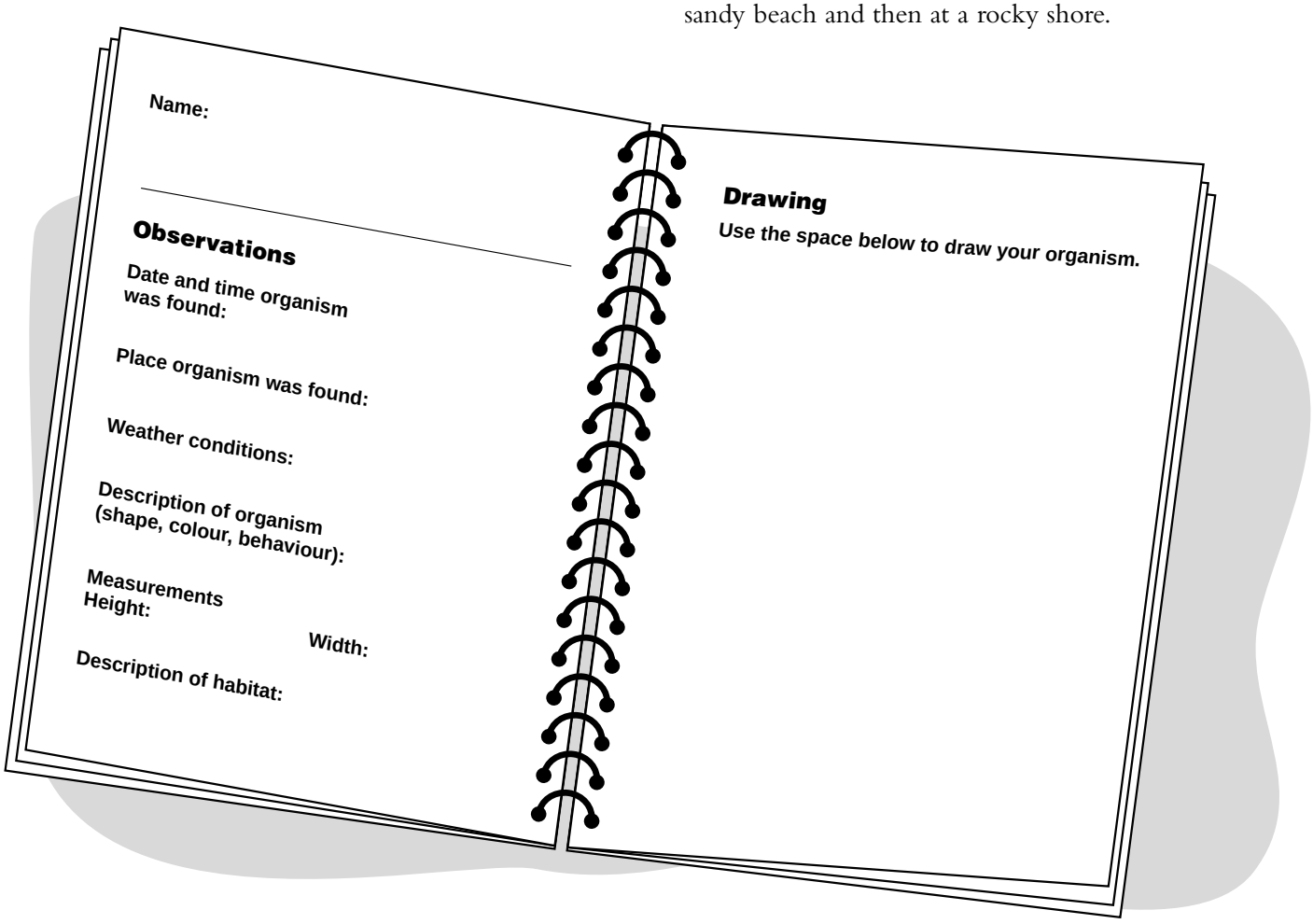
4 Discuss the marine biodiversity that students observed.

- What kinds of species did the students describe in their notebooks?
- Were there visible differences among individuals, or did all the members of the same species look identical?
- Was it sometimes difficult to tell if two individuals were from different species or the same species?

Some more advanced questions are:

- How many different species did your students find? Did they find more or fewer species than they thought they'd find? Were there some categories of plants and animals that had more species in them than others? (For instance, were there more animals with shells than animals without shells?) Why might this be the case?
- Were the students able to identify the ecosystem(s) in the area you explored? What is the major ecosystem type you are in? Are there any smaller-scale ecosystems found within the larger one (such as tidal pools along a rocky shore)?

If you have time to visit more than one site, students can make comparisons between the sites, for example noting major features and species they observe at a sandy beach and then at a rocky shore.



Option 2: Aquarium or Nature Centre Field Trip

Before You Begin

If you're taking a trip to an aquarium or nature centre, call ahead to schedule your visit and make any necessary arrangements (such as transportation, chaperones, permission slips, and so on).

Be sure to make an advance visit to the institution. Take along a copy of the "Scavenger Hunt Clues" (page 36) to get a feel for the variety of answers students may find. If you want to alter the clues to make them more appropriate to your group or to the institution you are visiting, retype them and make copies. Otherwise, make one copy of "Scavenger Hunt Clues" for each team of two students. Collect enough clipboards so that each team has one. (You can also make clipboards out of heavy cardboard and have students attach their papers with clothespins or large binder clips. See page 192.)

What to Do

In the Classroom

1 Review the term "marine biodiversity." Introduce or review the concept of marine biodiversity. (See "All the World's A Web," page 26, for ideas.) Tell students that the place they will be visiting includes examples of marine biodiversity. They'll be looking for answers to specific questions given to them as part of a marine biodiversity scavenger hunt. You might also have the students check the institution's Web site, if it has one, to find out more about it and to help with planning.

2 Organise your group for the field trip. Assign a partner to each student for the field trip. Each student should stay with the partner at all times and will work with this person to find examples for the clues listed on the scavenger hunt worksheet. Assign a clear role for the chaperones as they accompany your students throughout the exhibits. For example, you might provide them with some questions they can use to help guide the students in their discoveries.

On-site

3 Hand out copies of the scavenger hunt. Once you reach the site, give each pair of students a clipboard and copy of the "Scavenger Hunt Clues." Make sure every student has a pencil.

Explain to the students that they may not be able to find answers to all of the clues. Their goal should simply be to find as many of the items as possible. When they find an item, they should write its name beside the clue or sketch a picture of it. (Some plants or animals may be relevant to more than one clue.)

You should decide in advance which parts of the institution the students are allowed to explore and whether they will move through the area as a group or if pairs will work independently. If appropriate, select a meeting spot and set a time for regrouping there. Then let the pairs pursue their hunts.

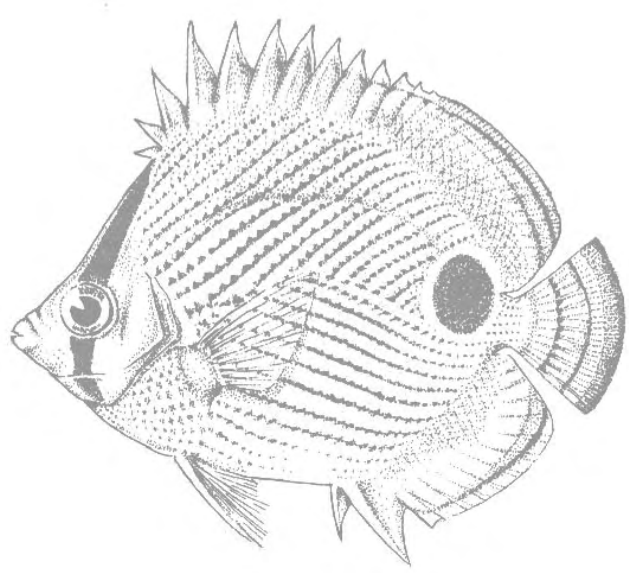
4 Review answers. When the students have completed their scavenger hunts, review their results. Which clues were easy to track down? Which ones were more difficult? Did they find many different species? Did they observe any differences among individuals of the same species? Did they identify different ecosystems at the site?

Assessment

Have each student write a paragraph describing local marine life. Students should give examples from the experience to identify the types of ecosystems and the kinds of species that can be found in them. (Alternatively, to assess student learning after the visit to a local institution, ask students to select one species they saw and write a paragraph about how it has adapted to its ecosystem.) You can develop a rubric with students based on criteria such as the number of local ecosystems named, the number of plants and animals named that live in these ecosytems, and identification of characteristics of species that make them well-suited for the ecosystem where they are found.

Extensions

If your school has Internet access, students may go on a "virtual tour" of oceans as an alternative to the field trip options described above, or in preparation for a field trip. If there is no Internet access, you can create a virtual tour using books and magazines. Students may select a Web site from the handout, "Virtual Ocean Explorations," (page 37) to visit. (Note: Web addresses change frequently so you may wish to test them before doing the activity.) Each student should create a page of a field guide or journal that describes his or her exploration of the marine Web site. Students should include notes telling what is special about the marine ecosystems they explored, and give examples of marine diversity encountered on this site. Have them make sketches for their pages, too. Have students share the results of their explorations.



foureye butterflyfish

SCAVENGER HUNT CLUES

Name: _____

Date: _____

As you walk around, try to find:

1. an animal that blends into its surroundings
2. a very flat fish
3. an animal that lives in a shell
4. an animal that's attached to something else
5. an animal that eats other animals
6. an animal that looks like a plant
7. an animal that spends most of its time on the bottom of the ocean
8. a type of seaweed
9. an animal that escapes its enemies by swimming very quickly
10. an animal or plant that drifts near the surface of the water
11. an animal with tentacles (long, flexible body parts with suckers at the tips)
12. an animal that spends part of its time in the water and part of its time on land
13. an animal or plant that lives on the shore
14. an animal that's smaller than an apple
15. an animal that escapes its enemies by hiding in the sand
16. an animal that escapes its enemies by hiding between rocks
17. a marine ecosystem that is sometimes submerged by water and sometimes not
18. a marine ecosystem where a lot of plants grow
19. a symbiotic relationship (two animals or plants that depend on each other)
20. an animal that produces light
21. an animal that's bigger than you are
22. an animal that must go up to the water surface to breathe air

VIRTUAL OCEAN EXPLORATIONS

These sites provide images and descriptions of life in the ocean, and many of them discuss what scientists know as well as what they do not yet understand about life in underwater environments.

1. www.discovery.com/exp/coralreef/coralreef.html

Explore the barrier reef off the coast of Andros from different perspectives — underwater and from space — and learn about some of the animals that live there.

2. www.ocean.washington.edu/people/grads/scottv/exploraquarium/vent/intro.htm

Part of the University of Washington's School of Oceanography Exploraquarium, "choose your own adventure" as you explore deep-sea vents — geysers on the ocean floor.

3. www.worldwildlife.org/expeditions/reef

Dive into depths of the largest Atlantic Ocean coral reef system and come face-to-face with 30-foot whale sharks and more than 500 other species of fish.

4. www.amnh.org/exhibitions/permanent/ocean

Explore marine ecosystems — coral reefs, the sea floor, kelp forests, mangrove forests, polar seas, estuaries, the continental shelf, and the deep sea — and the variety of life found in these ecosystems. The American Museum of Natural History's Milstein Hall of Ocean Life features a broad spectrum of marine life and ecosystems, and dioramas including the Andros Coral Reef.

5. www.coralfilm.com/edu.html

Click on *Learning about Reefs* and then *The Virtual Reef* to "dive" to different depths and see what lives there.

6. ology.amnh.org/marinebiology

Marine Biology: The Living Oceans is an interactive Web site where you can learn what marine biologists do and some of the fascinating aspects of marine biodiversity that they study.

7. www.pbs.org/wgbh/nova/abyss

Discover the odd landscape and strange life forms of the abyss — an ecosystem with deep-sea vents lying 2.4 km (1.5 mi.) below the surface of the water off the Pacific Northwest coast of the United States.

8. ali.apple.com/belize

Where Land and Sea Intertwine: Mangrove Forest and Sea Turtles of Belize

www.mangroves.si.edu/education

Mangal Cay Virtual Mangrove Trail

These two virtual field trips bring the sights and sounds of the mangrove forests to you. Note that the files are large and you may need assistance downloading and viewing them.

3 Services on Stage

Act out four short skits that demonstrate some of the many services marine biodiversity provides.

Learning Objectives

- Explain how marine biodiversity affects people's everyday lives
- Describe the role of marine biodiversity in providing ecosystem services

Grades

5 – 6

Subjects

Social Studies, Language Arts, Science, Art (drama)

Skills

applying (composing, creating), presenting (writing, acting), citizenship (working in a group)

Vocabulary

ecosystem services, marine biodiversity

Time

60 – 70 minutes

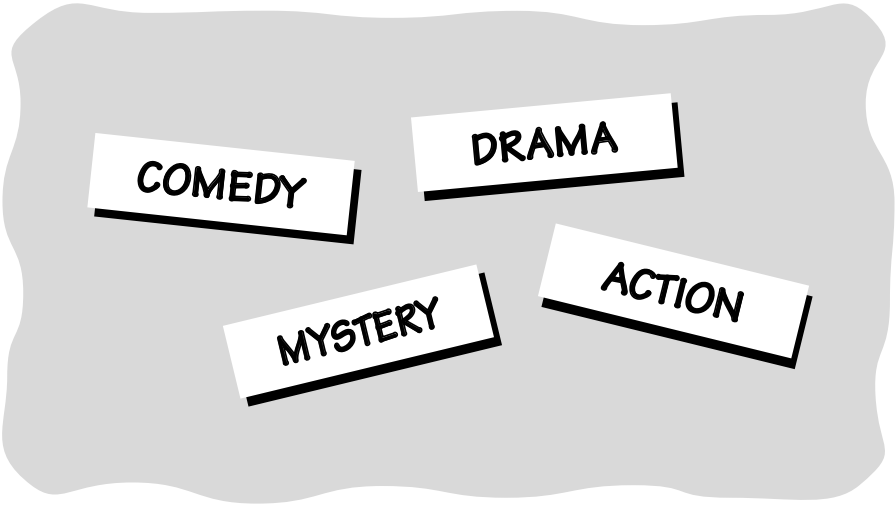
Materials

strips of poster board to make sets of biodiversity definition cards, envelopes or baggies for each set, copies of "Sea Services Cards" (pages 41 – 42), four slips of paper

How important is marine biodiversity? How would our lives be different if the ocean weren't home to such a wide variety of life? Among other things, we wouldn't have the kind of atmosphere that we need to survive. (Tiny ocean-dwelling plants, called phytoplankton, produce the majority of the Earth's oxygen.) We'd also be without a huge source of animal protein that comes from seafood, and we'd have to give up medicines from chemicals found in marine life. Marine biodiversity plays an important role in providing us with these services — and is a source of enjoyment for millions of people. Refer to page 7 for discussion of ecosystem services.

Before You Begin

Copy the four "Sea Service Cards" (pages 41 – 42). On four strips of paper, write "comedy," "mystery," "drama," and "action." Write the definition of biodiversity on strips of poster board *(Biodiversity is the variety of life forms and the interactions among them).* Write enough so that groups of four or five students will each have one. Cut the definition apart so there is one word on a card, and put each set of definition words in a baggie or envelope.



What to Do

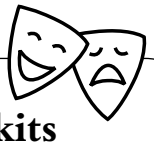
1 Review the definition of biodiversity. Write the definition of biodiversity on the board. Read the definition, then have the students read it together. Cover or erase the definition. Divide the class into groups of four or five students. Distribute a set of words that make up the definition to each group. Tell the students that they are going to play definition scramble: each group works together to arrange the words to create the definition. Discuss the definitions they assemble.

2 Ask students how marine biodiversity affects their everyday lives. Do your students think that marine biodiversity affects them? How? How do they think life would be different at home and at school without marine biodiversity? Have the students share some of their ideas. They may be surprised to know that marine biodiversity affects everyone, even those who do not live on the coast. Explain that they'll be putting on four short skits that will help demonstrate some of the reasons why marine biodiversity is important.

3 Assign students to four groups and give each group its subject and style. Divide the class into four groups. Explain that each group is going to get an explanation of a different service that marine biodiversity provides to people. Then they'll create a short skit that demonstrates that service for the rest of the class in one of four styles — comedy, drama, mystery, or action. Define the different styles and give examples. (*Sponge Bob* is a comedy, *Charlotte's Web* is a drama, *Scooby Doo* is a mystery, and *Danny Phantom* is an action programme.) Have one representative from each group choose a "Sea Services" card, which you've folded so they can't see the subject they're choosing. Once each group has its subject, have another representative choose the group's style. Again, fold these so students can't see which style they're picking.

4 Create and practise skits. Give the students a set amount of time to create and practise their skits. The amount of time you give them will depend on the amount of time you have for the activity. If time is short, the activity can be completed in one class session. Students should prepare skits of about two to three minutes in length and should have at least 15 minutes to create them. If you have more time, students can do more research on their subjects and can create longer skits.

5 Present the four skits. Once students are ready, have them present their skits. After each skit, you may want to give the group some time to make any additional comments that they think will help explain the service they demonstrated in their skit. Also, allow other students to ask questions. You may need to fill in some missing details to help clarify the marine service the group has portrayed in the skit.



Four Styles for Skits

Comedy	light, often humorous performance that usually ends happily
Drama	serious narrative programme, with a plot comprised of a succession of events; generally emotional elements
Mystery	a programme portraying the investigation of something unknown or unexplained, often a puzzling crime
Action	drama fueled by intense action such as fighting, stunts, car chase, or explosions, usually involving a hero

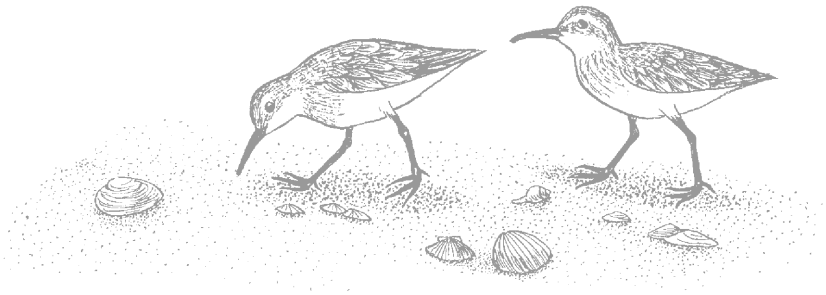
6 Discuss the importance of marine biodiversity. Once all of the groups have presented their skits, hold a discussion about the services marine biodiversity provides. Were students surprised by the many services that marine biodiversity provides? Can they think of other ways marine biodiversity is important?

Assessment

On the chalkboard, draw the trunk of a tree and label it "Marine Biodiversity." Then add four main limbs labeled "Food," "Medicines," "Air," and "Enjoyment." Have students expand their trees with branches growing from each of the main limbs. Each of the branches should provide examples that help explain the service that each main limb provides, such as antibiotics, sunscreens, painkillers, and cancer treatments on the "Medicine" limb, and grouper, conch, and crawfish on the "Food" limb. Only one branch (oxygen) will be needed for the "Air" limb. Students should provide three to four correct extensions per limb for food, medicine, and enjoyment.

Extensions

- Do your students think that members of the general public are aware of how important marine biodiversity is to them? Tell the students that they will be designing an ad campaign to help spread the word about marine diversity. Students can design a poster or make a video targeting a particular audience. See "Awareness Campaigns and Public Service Announcements," at treasures.amnh.org, for more information.
- Ask students to research how marine biodiversity provides employment to millions of people — a marine service that was not highlighted in the "Sea Services" cards. Once students have gathered information, have them write up short paragraphs modeled on the format of the "Sea Services" cards. When they are finished, make a list on the board of all of the marine-related occupations that they thought of. Then encourage the group to expand the list as other ideas occur to them. Be sure to include occupations that may be indirectly connected to the sea, such as a professor of marine biology, a server in a seafood restaurant, and a seafood seller in a supermarket. (See "Working in the Marine Environment" on page 150.)



western sandpipers

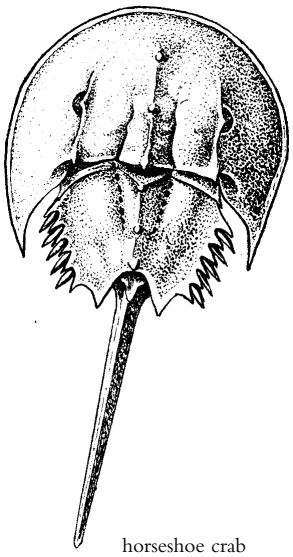
Sea Services Cards

Marine Biodiversity Is a Source of New Medicines

Have you ever been in pain? Had an infection? Got a sunburn? Then marine biodiversity may have come to the rescue. Drug companies are testing, and already using, drugs that have come from different kinds of sea life. Those in use include antibiotics and skincare products. Cancer treatments, pain relievers, and sunscreens are being researched.

The ocean is a great source of new medicines because the diversity of marine life contains a wide variety of chemicals. In places like coral reefs, many species have powerful chemicals that they use to discourage predators from eating them. And many of those same chemicals can be used in medicines.

Not only are the chemicals important to medicine, but other parts of organisms can be important too. For example, the blood of the horseshoe crab (commonly found along the east coast of the U.S.) can be used to test for bacterial infections in people, and some doctors are using corals to help repair damaged bones. So, the next time you're swimming in the ocean, just think of all the new cures that could be swimming around you!

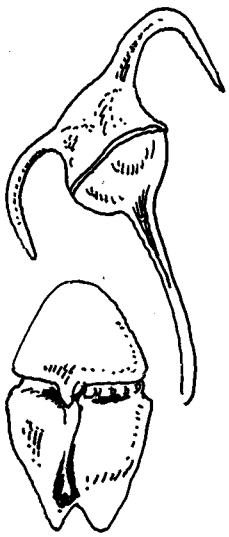


horseshoe crab

Marine Biodiversity Helps Balance the Gases in the Air

People and other animals take in oxygen and give off carbon dioxide. So, what helps keep the overall amount of oxygen from decreasing in the atmosphere and the amount of carbon dioxide from increasing? Plants perform this vital service — they take in carbon dioxide and give off oxygen, helping to balance the mix of gases in the air. And most of the plants responsible for doing this are found in the ocean. Tiny marine plants and plant-like organisms called phytoplankton (FIE-toe-plank-ton) float near the surface where sunlight can reach them, and they are responsible for making the majority of the oxygen in the air. Most kinds of phytoplankton are so small they can be seen only with a microscope.

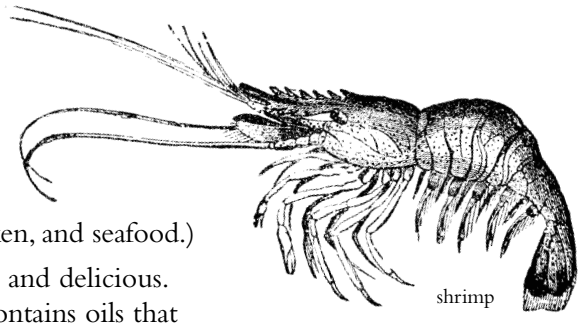
How can such tiny organisms do so much work? Even though they're much smaller than most plants on land, there are many more phytoplankton. In fact, billions can be found in just a gallon of sea water. So, the next time you take a breath of fresh air, thank those little ocean plants!



phytoplankton

Marine Biodiversity Is a Major Food Source

Have you ever eaten grouper fingers? Conch salad? Whelks? Shrimp? Tuna? Crawfish? There are lots of different kinds of seafood, and billions of people who eat it.



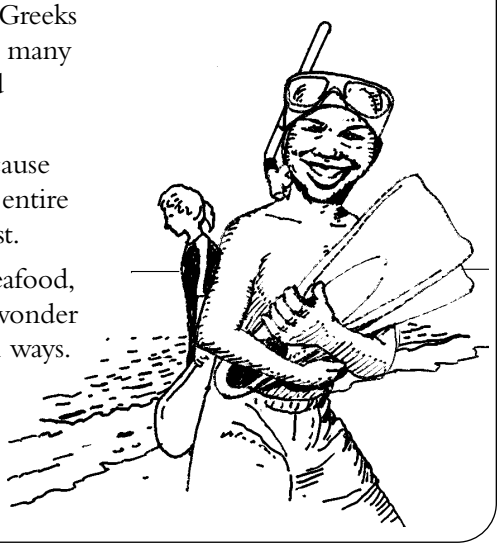
shrimp

Seafood provides an average of almost 20% of the animal protein that people eat worldwide. (Animal protein comes mostly from red meat, chicken, and seafood.)

Many Bahamians eat seafood because it's nutritious and delicious. It's high in protein, vitamins, and minerals, and it contains oils that help reduce the risk of heart attack. It's also low in fat. In some countries, seafood is the main source of animal protein, so it's a very important part of their diet. Even if seafood isn't your favourite thing to eat, remember that billions of people around the world depend on it for a healthy diet.

Marine Biodiversity Influences Our Culture

Whale watching. Deep-sea fishing. Snorkelling on coral reefs. Birding in mangroves. Exploring the wonders of tide pools. When you stop and think about it, people have found many ways to enjoy marine biodiversity, but this is nothing new: the Ancient Greeks decorated their pottery with images of marine creatures. And many tales have been told through the ages about the amazing and mysterious life of the sea.



People from all over the world gravitate to The Bahamas because of its beauty, resources, and biodiversity. In The Bahamas the entire population of 303,611 people (2000 census) lives near the coast.

With so much richness to offer — colourful creatures, tasty seafood, opportunities for adventure, and untold mysteries — it's no wonder the ocean has come to shape our lifestyles in such meaningful ways.

SECTION 2

More than Meets the Eye

Understanding Form and Function

The kind of body an organism has give clues to how it functions and survives. Physical characteristics make each species unique, and adaptations help it survive and thrive in the sea. Students investigate the special features and cool tools of marine animals like the queen conch, crawfish, and Nassau grouper through crafts, songs, and games.

1 Conch Ain't Gat No Bone!

Students explore the form and function of the queen conch, beginning with popular dishes, examining a live conch, and concluding with a song to reinforce concepts.

Learning Objectives

- Identify parts of the queen conch
- State the main functions of queen conch parts
- Describe some adaptations that help the conch survive

Grades

5 – 6

Subjects

Science, Social Studies, Music

Skills

gathering (observing, listening), analysing (identifying components and relationships among components), presenting (describing, explaining, writing)

Vocabulary

adaptation, gastropod, **invertebrate,** operculum, proboscis

Time

45 – 60 minutes

Materials

pictures of foods made with conch; 2 conch shells (with flared and unflared lips), operculum, and live conch (optional); transparencies of the song lyrics (page 46) and the conch diagram (page 48); overhead projector; copies of "Conch Ain't Gat No Bone" worksheet (page 49); recording of "Conch Ain't Gat No Bone!" and cassette or CD player

The queen conch is an invertebrate — it has no backbone — a fact celebrated in the song "Conch Ain't Gat No Bone" (page 46). Read about the conch's anatomy in the "Queen Conch Fact Sheet" on page 16. The body parts described perform special functions that help the conch survive. Along with behavioural characteristics, these physical characteristics are the result of adaptations that have evolved over a long period of time and through many generations of the species, as individuals with the best traits survived and passed them on.

One of the most striking features of the queen conch is its hard, spiny shell that helps to protect its soft body. The conch extracts calcium carbonate from sea water to form this shell in its mantle, a thin layer of tissue between the body and the shell. The shell of an adult conch has a rosy-coloured, flared lip.

Having a light-sensitive eyespot on each of two stalks is very helpful for an animal that doesn't have a neck to turn in order to see around it. A pair of small sensory tentacles enable the conch to smell and touch. The snout-like mouth, or proboscis, can extend up to 15 cm (6 in.) and a rough, tongue-like radula with thousands of tiny denticles (tooth-like protrusions) make it possible for the conch to reach and eat algae growing on rocks.

While most gastropods glide with a wide, muscular foot along a secreted trail of slime, the conch uses the small claw-like operculum at the end of the foot to kick along in sandy habitats. Young conchs use the operculum to bury themselves in the sand to avoid danger. A conch can also block the shell opening with the operculum to discourage prying predators.

What Are We Eating?

The queen conch *(Strombus gigas)*, a type of sea snail, is a gastropod (from the Greek for "stomach" and "foot"). The edible meat primarily comes from the single, long foot common to all snails.

Before You Begin

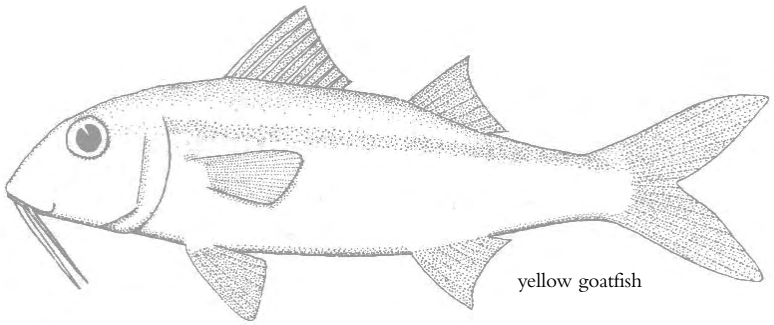
Collect photos or samples of conch dishes (e.g., conch fritters, conch salad, or cracked conch). Copy the conch diagram (page 48) onto transparency paper. Make a transparency or write the song lyrics on a flip chart or on the board. Make enough copies of the student worksheet for the class. Collect the conch shells, live conch, and the clean and dried operculum to show to the class. Put the live conch in an aquarium with enough sea water to cover the shell. The conch can be kept for at least a day, but be sure to return it to the ocean after the activity.

If you have difficulty finding mature and juvenile conch shells, use pictures or contact the Bahamas National Trust to find out where samples may be obtained.

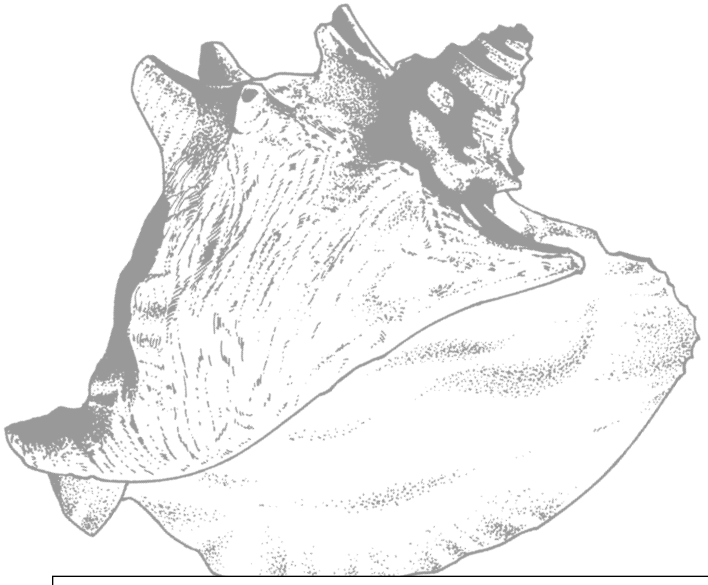
What to Do

1 Introduce the topic. Show pictures of conch dishes and ask students to name them. Ask what these dishes have in common. *(They are all made with conch.)* Make a list of what students know about the conch. *(For example: It is used in many Bahamian dishes. It is an invertebrate. It is a kind of sea snail. It matures slowly and lives a long time.)* Review the definition of "invertebrate." Inform students that they will be learning about special features — or physical adaptations — of the conch that help it to survive in its environment.

2 Discuss conch form and function. Use an overhead projector to show the conch transparency. A live conch can also be used for this purpose (if properly handled and kept in appropriate tank conditions). Point out the different parts of the conch and ask students what function they would predict based on the form of the part. *(See the activity introduction and the "Queen Conch Fact Sheet" on page 16 for information to guide discussion.)* For example, when passing around the conch shells, draw attention to the flared lip and spines on the mature conch shell. Ask what functions these shell characteristics have. Pass around the operculum and ask students if there is anything special about its shape that shows it is well suited for its function (locomotion and protection against predators).



yellow goatfish



3 Complete worksheets. Distribute the student worksheet and read the instructions together. If the worksheet is to be completed individually, leave enough time at the end of the lesson to discuss students' answers.

4 Sing "Conch Ain't Gat No Bone." Display the lyrics on the board or on a transparency. Explain that the song reminds us that the conch is an invertebrate. Sing the song together along with the recording or have students listen to the song.

Conch Ain't Gat No Bone

written by Alphonso Higgs (Blind Blake)

Chorus:

Acka, racka, bone n' shemima, conch ain't gat no bone
Acka, racka, bone n' shemima, conch ain't gat no bone
Acka, racka, bone n' shemima, conch ain't gat no bone
Acka, racka, bone n' shemima, conch ain't gat no bone

Mosquito had a party, sandfly gone to see
Polka stood behind the door and peep right out at me.

Chorus

I went down the road the other day to buy myself some souse.
I chew up the bone, spit out the spoon, forget me had a mouth.

Chorus

The Songs and Culture of Our Bahama Islands: An Illustrated Treasury of Bahamian Folk Songs and Traditions, vol.1, compiled and arranged by Esau McKenzie. (Nassau, The Bahamas, 1991).

Assessment

Grade the worksheet, using the following answers and scoring suggestions as a guide:

1. an invertebrate (1 point)
2. mantle (1 point)
3. to move along the sandy seafloor (1 point)
4. stalked eyes: help the conch to see all around itself because it does not have a head and neck that it can turn (2 points)
   operculum: enables the conch to kick vigorously along sandy habitats, to block its shell opening against predators, and young conchs may use it to bury themselves in the sand for protection. (2 points for any of the answers listed; bonus point if more than one answer is listed)
   shell: it's hard and has many spines for protection (2 points)
5. flared lip (1 point)

Do "Pass the Part" activity (page 66).

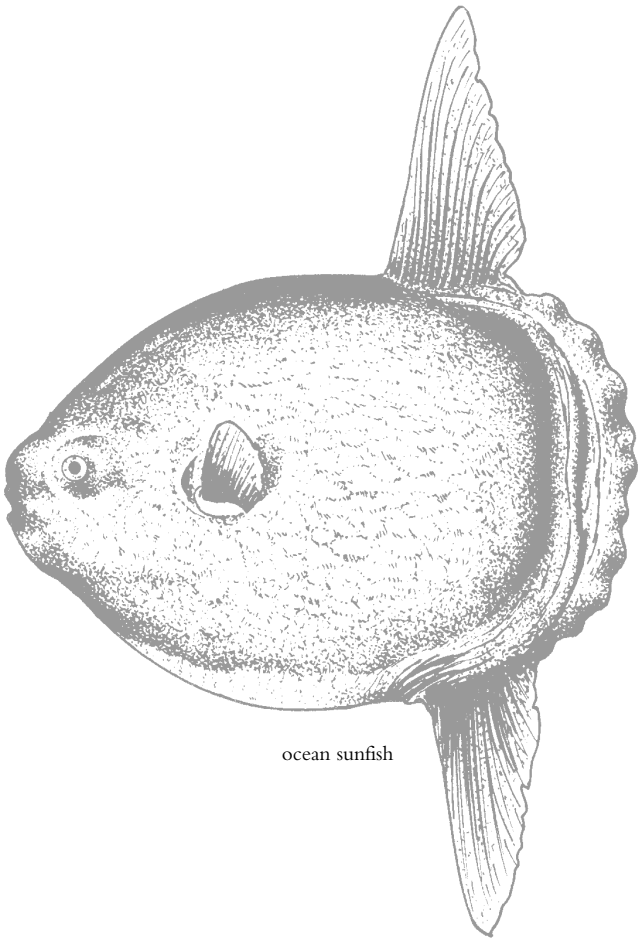
Extensions

- Invite a fisheries officer to come in with a live conch and point out the conch anatomy. Have students prepare questions to ask in advance of the visit.
- Teach students the "conch style" dance. Have them "knock the conch style" while singing "Conch Ain't Gat No Bone."
- Ask students to bring in recipes for their favourite seafood dishes. They can compare recipes and create a cookbook. Talk about how the popularity of some dishes, like conch salad, make conch populations vulnerable to overfishing. Only adult conchs should be used.

Resources

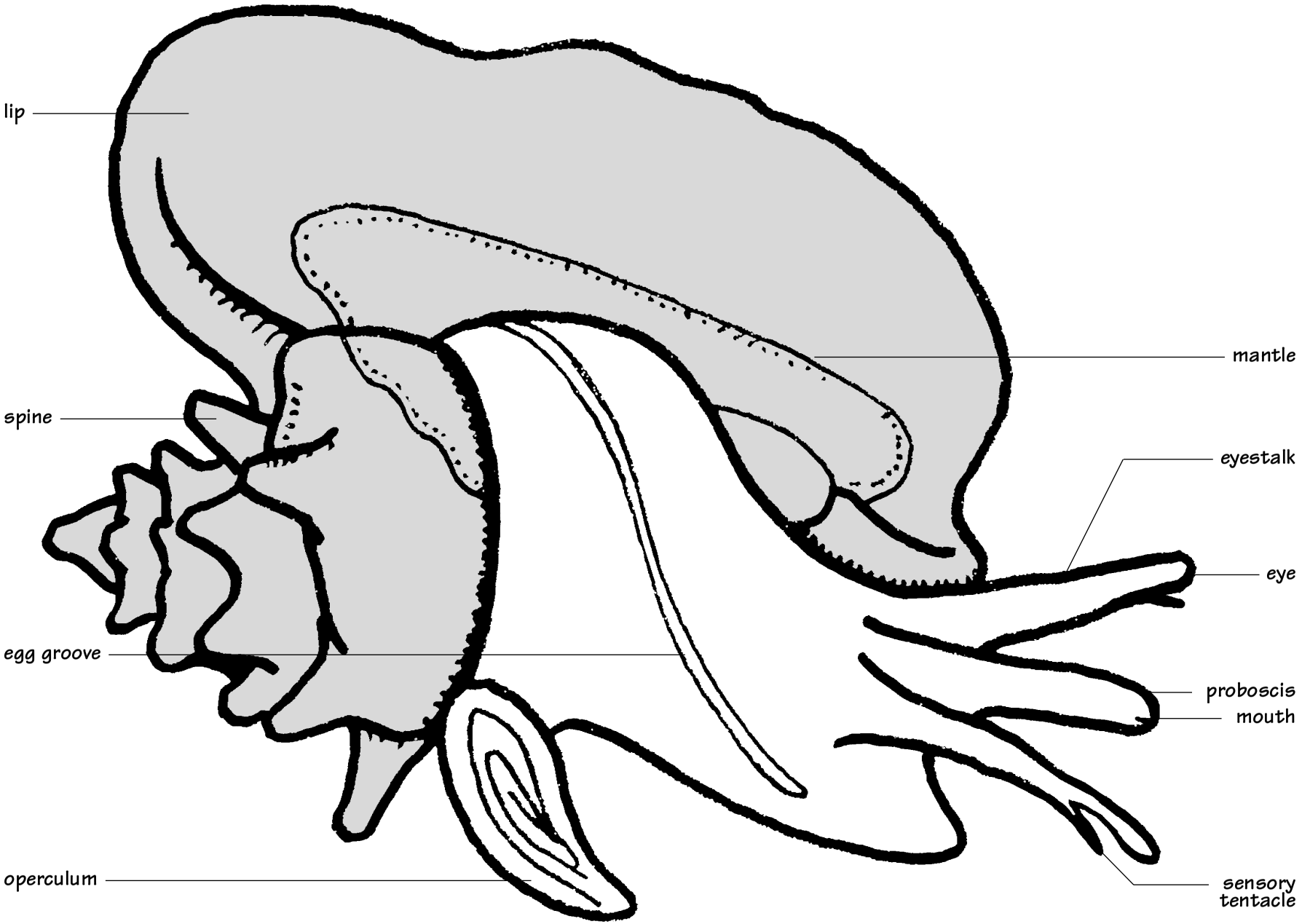
Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute. Queen Conch Sea Stats. research.myfwc.com/products/product_info.asp?id=1595

Conch Heritage Network. Conch in the Classroom, Queen Conch Dissection. www.savetheconch.org



ocean sunfish

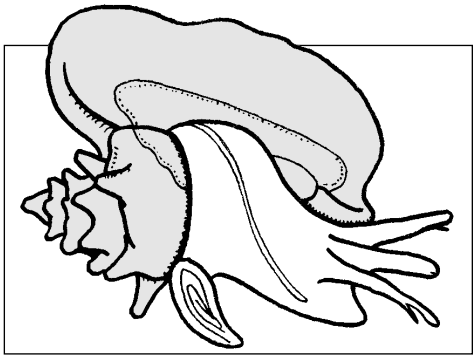
Queen Conch


lip
mantle
spine
eyestalk
eye
egg groove
proboscis
mouth
operculum
sensory tentacle

CONCH AIN'T GAT NO BONE

Name: _____

Date: _____



Study the conch diagram (or a live conch if available) and answer the questions.

1. Circle the correct answer. The conch has no backbone. It is

   an invertebrate a vertebrate

2. What is the layer of tissue called that the conch uses to secrete its shell?

   _____

3. Study the conch's foot. Circle the phrase that describes how this animal uses its foot.

   to swim to move along the sandy seafloor to catch food

4. State how these special tools or parts of the conch help the conch survive.

   stalked eyes _____

   _____

   _____

   operculum _____

   _____

   _____

   shell _____

   _____

   _____

5. How can you tell if a conch is mature? _____

2 Crawfish Critters

Students create models or colour a picture to learn about crawfish anatomy and functions.

Learning Objectives

- Identify parts of the crawfish
- State the main functions of crawfish parts

Grades

5 – 6

Subjects

Science, Language Arts, Art

Skills

gathering (observing, listening), analysing (discussing, identifying components and relationships among components), applying (designing, constructing)

Vocabulary

exoskeleton, carapace, cephalothorax, chemosensor

Time

Option 1: 1 hour, Option 2: 1½ hours

Materials

crawfish pictures; crawfish transparency (page 54); overhead projector; green, yellow, brown, and red crayons, markers, pastels, or paint and brushes; magazine pages torn into pieces (for paper mosaic); glitter; glue; hole punch

For each student:

colouring page (page 55), "Crawfish Form and Function" worksheet (page 57), model supplies: crawfish pattern (page 56); 8½-x-11 inch sheet of white card stock or construction paper; 10 5-inch green, yellow, or brown pipe cleaners (for legs); 2 8-inch pipe cleaners (for "whip" antennae); 2 6-inch pipe cleaners (for antennules); scissors; *optional:* 2 eyes cut from black felt, 3 muffin liners (for tail)

A crawfish is an invertebrate — it has no inner skeleton or bones. Instead it has an exoskeleton, which means it wears its skeleton on the outside of its body, much like a suit of armour. The body of the crawfish is divided into sections: the head, thorax, and abdomen. The head and thorax are fused into what is called the cephalothorax. The shell covering the cephalothorax is called the carapace. The rows of spines on its carapace earn the crawfish one of its common names — spiny lobster — and protect it from predators like the loggerhead turtle.

An Endangered Crawfish Predator

The loggerhead sea turtle *(Caretta caretta)*, so named because of its large head, preys on crawfish, queen conch, and other crustaceans and mollusks. This turtle uses its powerful jaws to crush the shells of its prey to get at the soft meat inside. Loggerhead populations are declining globally due to threats such as coastal development and fisheries bycatch. While the loggerhead is highly endangered in some areas, like the Mediterranean, it is more common in The Bahamas, where it can be harvested from August 1 – March 31. The taking of turtle eggs, however, is illegal.

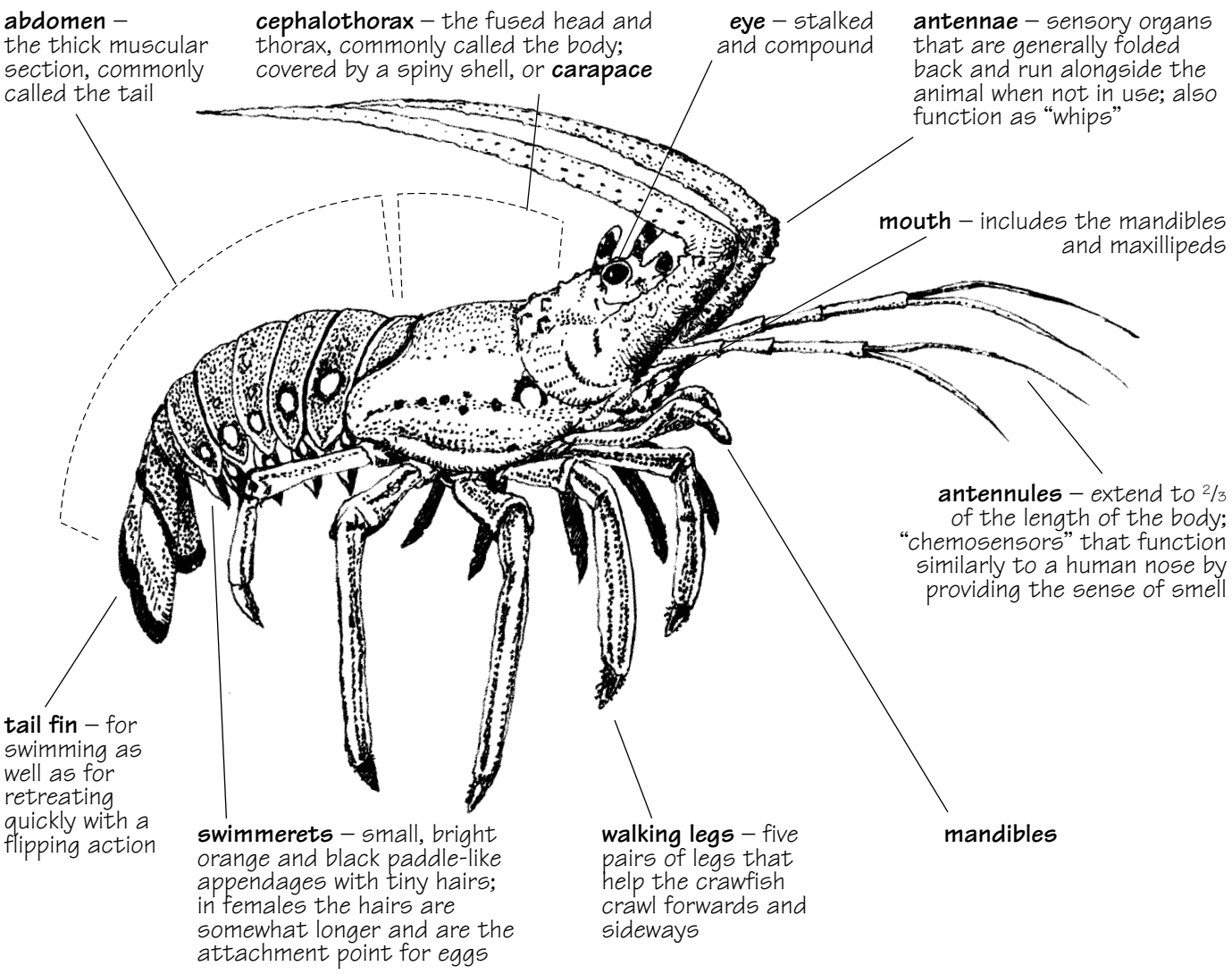
The "Crawfish Fact Sheet" on page 18 describes the anatomy of the crawfish, including its colourful shell in shades of greenish purple to reddish brown and tan. Its defenses include not only the spiny carapace, but two sharp horns over its eyes, and a pair of whip-like antennae that can inflict a tearing wound. Crawfish also make a rasping noise by rubbing the pads at the base of these antennae against ridges on their heads ("stridulation"), likely for the purpose of warning of danger or discouraging predators.

Crawfish eat hermit crabs, small mollusks, and any other animal matter they come across while foraging. The crawfish uses its legs to manipulate prey into position near its mouth. The mouth, on the underside and towards the front of the cephalothorax, is surrounded by the mandibles, or jaws, and by maxillipeds, or plate-like accessory jaws. These sets of jaws are used to bite and crush food, and direct it into the mouth.

Crawfish breathe with gills, as fish do. The gills are under the hard shell of the cephalothorax.

Before You Begin

Collect materials. Copy page 54 onto transparency paper. Make a crawfish pattern for each student by copying the pattern (page 56) onto cardstock. Photocopy the "Crawfish Form and Function" worksheet (page 57) and the colouring page (55), if you plan to use it.



What to Do

1 Discuss crawfish anatomy. Ask students to describe a crawfish. Show pictures of the crawfish and indicate body parts as students name them, or ask students about what they see. Show the transparency of the crawfish and describe the major parts. Ask students what function they would predict based on the form of the part. *(See the activity introduction and the "Crawfish Fact Sheet" on page 18 for information to guide discussion.)*

2 Activity Options

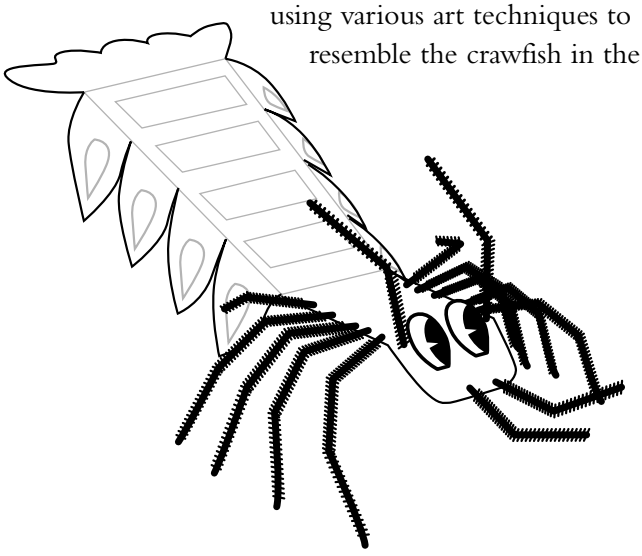
Option 1: Colour the crawfish.

Distribute copies of the colouring page. Ask the students to use the pictures and information as a guide to colour the crawfish realistically. Suggest using one of the art techniques in the box to the right. Students can personalise their pictures by drawing, cutting and pasting, or colouring a background for the crawfish. *(See habitat information on pages 2 – 4 for ideas.)* Have the students label the antennae, carapace, abdomen, swimmerets, and walking legs.

Option 2: Make a crawfish model.

a. Display the pictures of the crawfish and distribute the crawfish pattern and art materials.

b. **Body:** Have students decorate the crawfish pattern using various art techniques to resemble the crawfish in the pictures. When students are finished, they can cut out the crawfish and bend it along the dashed lines to position the head, swimmerets, and tail.



c. **Legs:** Punch five holes along the left and right side of the carapace. Insert a pipe cleaner into each hole and secure by twisting. Bend the legs so that the crawfish is in a standing position.

d. **Antennae:** Punch two holes for the whips and two for antennules in the head. Insert pipe cleaners and bend into position.

e. **Eyes:** Students can glue on the eyes (or use black felt circles).

f. An option for the tail is to fold three muffin liners in half, overlay them to make a fan, and staple them over the crawfish tail.

g. Call out the crawfish parts and have students locate them on their model.

Art Techniques

Stippling Use the tip of a marker to make a pattern of dots. Create a shading effect by filling in with many dots or combine dots of various colours to blend colours.

Bleeding Spritz water on a marker drawing (with a pump sprayer or a paint brush) to create soft, blurred effects.

Mosaic Decorate with small pieces of coloured paper, tile, or other material.

h. Let the paint and glue dry and display the models in the classroom.

3 Review and wrap-up. Distribute the "Crawfish Form and Function" worksheet and read the instructions together. Students should recall what they learned about crawfish form and function and refer to the crawfish transparency to complete the worksheet. Have students work either independently or in groups, or do the worksheet as a homework assignment.

Assessment

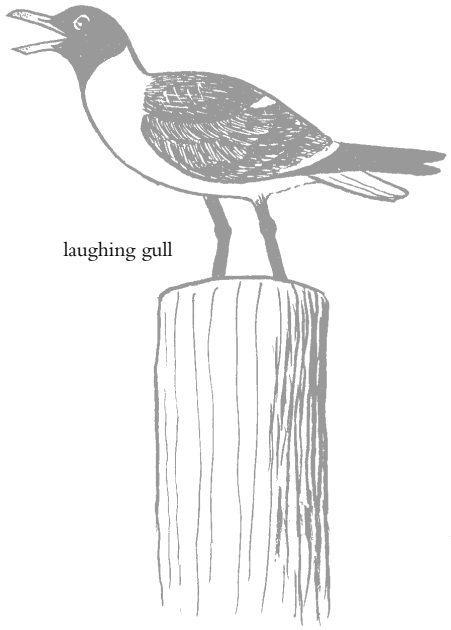
For Option 1: Colour the crawfish. Students should colour the picture as realistically as possible and label the antennae, carapace, swimmerets, and walking legs correctly.

For Option 2: Make a crawfish model. Students should decorate the model realistically, attach appendages appropriately, and be able to identify the body parts: antennae, carapace, swimmerets, and walking legs.

Grade the worksheet, using the following answers and scoring suggestions as a guide:

1. head, thorax, abdomen (3 points)
2. cephalothorax (1 point)
3. legs: to manipulate food (1 point)
4. 10 legs (1 point)
5. the eyes are stalked (1 point)
6. spiny (1 point)
7. mandibles (1 point)
8. antennae (1 point)

Do the "Pass the Part" activity, page 66.



laughing gull

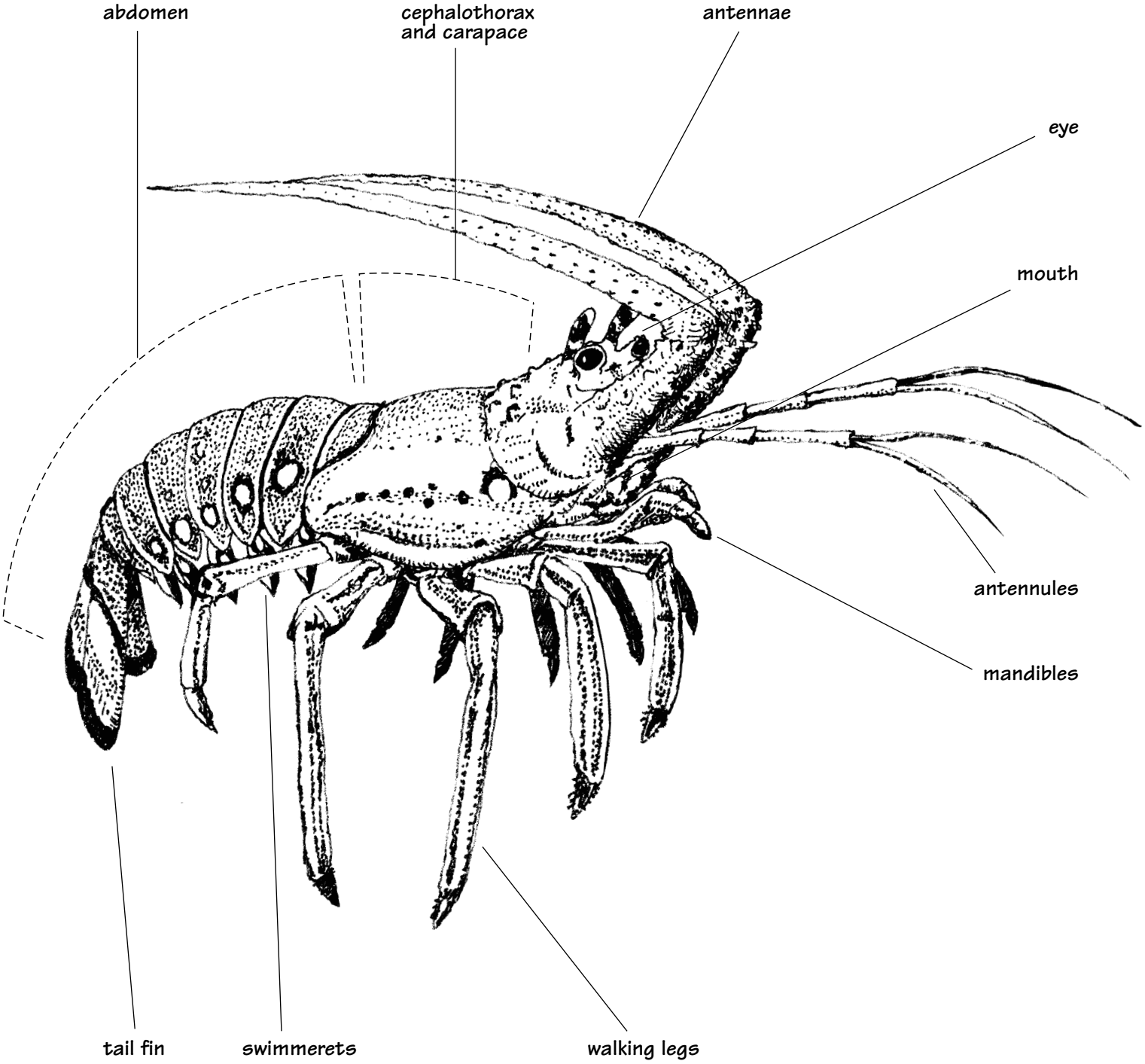
Extensions

- Invite other classes to an exhibit of the crawfish models.
- Go see real crawfish (Atlantis Aquarium on Paradise Island has lots!), show a video of the crawfish in its natural habitat, or bring in a live crawfish.
- Have a fisherman, fisheries officer, or another knowledgeable person point out the parts of a live crawfish to the students.

Resources

Perry Institute for Marine Science – Caribbean Marine Research Center. 2004. Poster series #2: Spiny Lobster. Jupiter, Florida. www.perryinstitute.org

Crawfish (Spiny Lobster)



CRAWFISH COLOURING PAGE

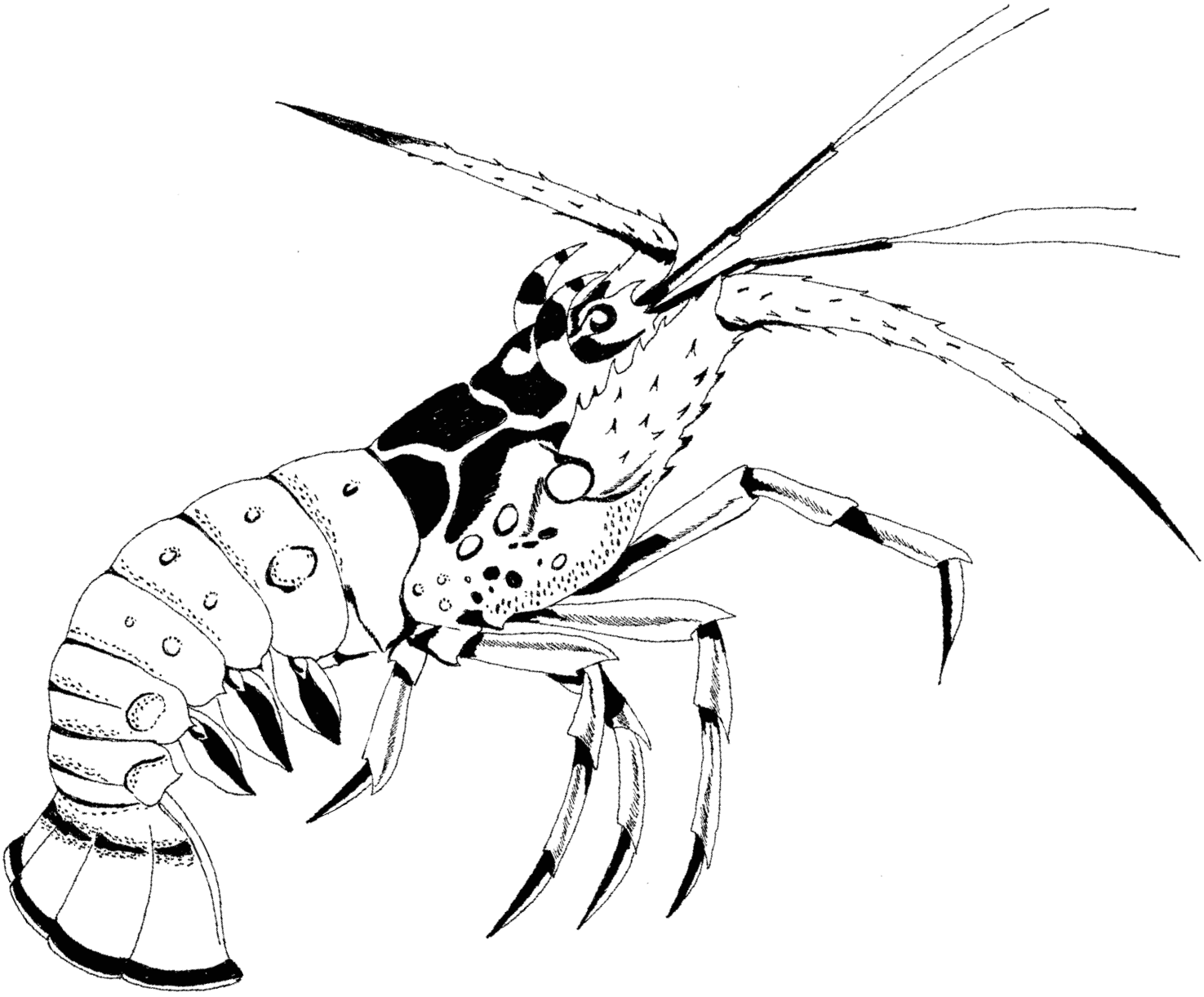
Name: _____

Date: _____

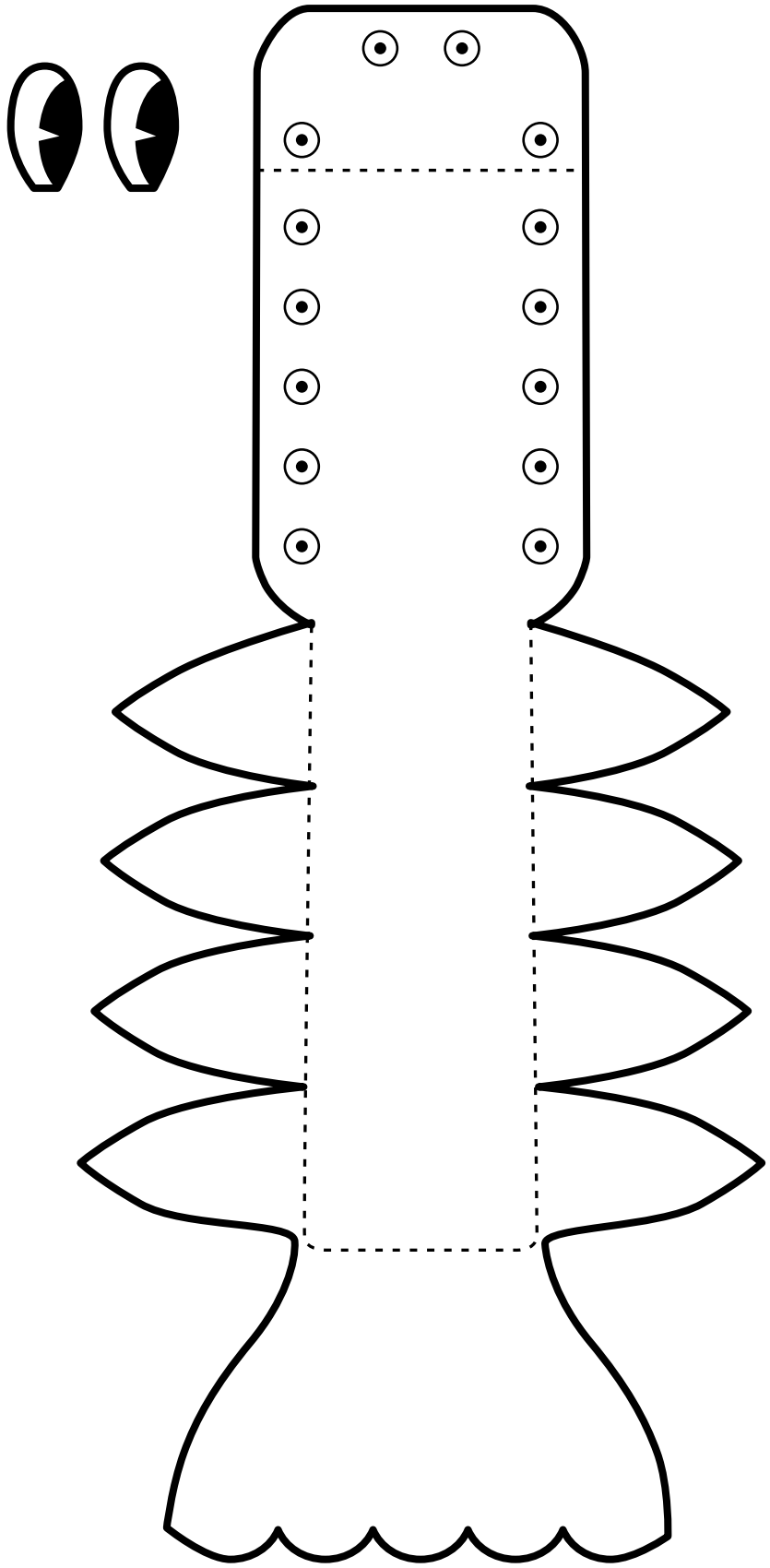
Colour the crawfish and label it with the words listed here.

antennae carapace abdomen

swimmerets walking legs



Crawfish Pattern

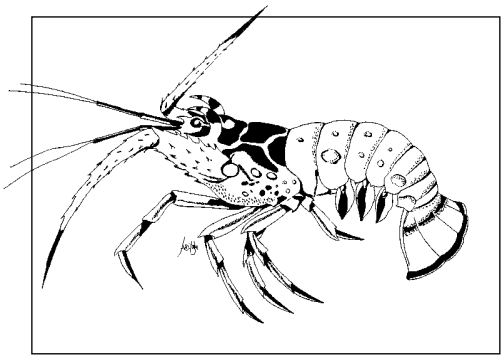


CRAWFISH FORM AND FUNCTION

Name: _____

Date: _____

Use the diagram or poster of the crawfish to answer the questions below.



1. What are the three main body parts of the crawfish?

   a. _____

   b. _____

   c. _____

2. The fused head and the thorax, commonly known as the "body" of the crawfish, is also called the _____.

3. Find the crawfish's mouth. What other parts would help the crawfish to eat?

4. The crawfish has no claws. How many legs does it have?

5. Can you find the crawfish's eyes? What is special about these eyes?

6. Fill in the blanks: The crawfish's protection is its hard, s__i__y shell.

7. What part of its mouth does the crawfish use for crushing and eating food?

8. What does the crawfish use to sense its surroundings?

3 Grouper MISSING

Students learn about Nassau grouper form and function by making "MISSING" posters and doing worksheet activities. The concept of adaptations is introduced with a poem.

Learning Objectives

- Identify the parts of the Nassau grouper
- State the main functions of Nassau grouper parts
- Describe some adaptations that enable fish to live in water

Grades

3 – 6

Subjects

Science, Language Arts, Art

Skills

gathering (observing, listening), organising (matching, drawing), analysing (discussing, identifying components and relationships among components, comparing and contrasting)

Vocabulary

raspers, **vertebrate**

Time

1½ hours

Materials

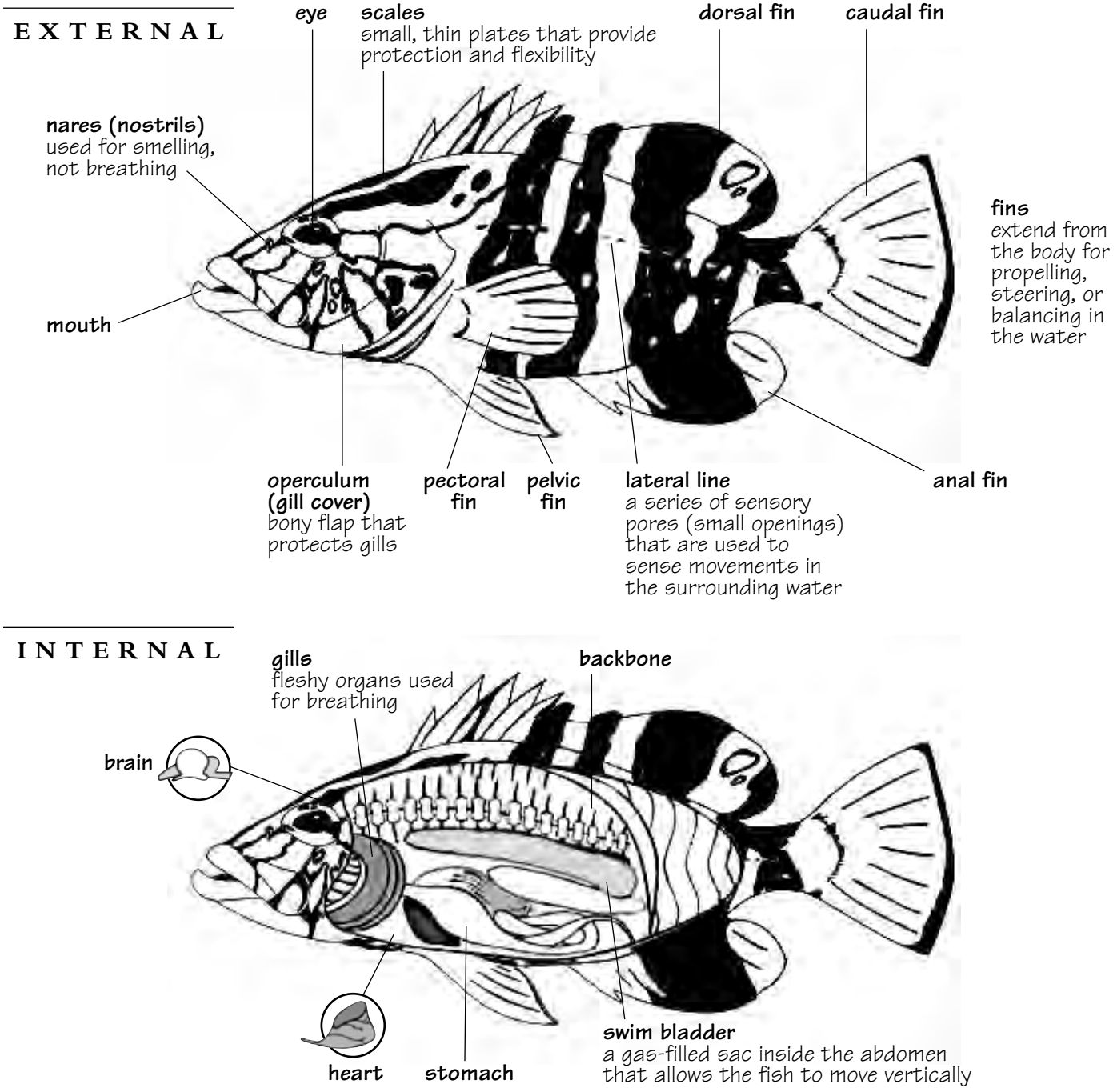
copies of "MISSING" (page 63), "Fish Body Parts and Functions" (page 64), "Grouper Adaptations" (page 65); cassette tape and tape player; fish backbone in a zippered baggie; Nassau Grouper transparency (page 62); overhead projector

The Nassau grouper is one of the largest fish on the reef, growing to a maximum of 1.2 m (4 ft.) and weighing over 22.7 kg (50 lbs). It's a heavy-bodied fish with a characteristically large mouth. Its markings distinguish it from other groupers: five dark brown bars (vertical markings) on the body, a dark band (diagonal marking) running from the snout through the eye to the forward side of the dorsal fin, and a dark saddle-like spot on the base of the tail fin.

While its broad, fan-shaped tail makes it a slow swimmer, it is able to accelerate quickly and make short, quick movements to catch prey. The Nassau grouper's colour and pattern go through various phases as it develops from a juvenile to an adult. It can also change colour and pattern when moving from one environment to another, and when it is surprised or afraid. This colour-changing ability helps it blend into its surroundings so it can ambush fish to eat. Groupers have several sets of strong, slender, rasper-like teeth. While these are similar to a shark's teeth, groupers do not use them to tear flesh, but to prevent small fish from escaping their mouths. Read more about the Nassau grouper's anatomy in the "Nassau Grouper Fact Sheet" on page 20.

What Makes a Fish a Fish?

Fish are vertebrates — they have backbones — like amphibians, reptiles, birds, and mammals. They have scales, fins, and gills that make them well-adapted to the marine environment. Most fish are cold-blooded, which means they cannot control their body temperature, but rely on the temperature of their surroundings. While they don't need hair or fur to insulate their bodies the way warm-blooded animals do, some fish are adapted to warm water and others are adapted to cold.



Before You Begin

Make the recording of the "Grouper News Bulletin" (on page 60) or have a student do it. Use music and a "reporter voice" to make the recording more realistic. Make a transparency of the Nassau grouper on page 62. Make copies of the worksheets on pages 63 – 65 for each student. Clean a fish backbone and put it in a zippered baggie.

What to Do

1 Play the recording of the news bulletin.

Ask the students whom they think the news bulletin is about. *(A grouper fish.)* Explain that when someone or something is missing, posters with a drawing and description are often posted around the community so people can be on the lookout.

2 Create the poster. Distribute copies of "MISSING." Explain to students that they are going to create their own MISSING poster of the grouper fish, first labeling some of its key features. Project the Nassau grouper transparency. As each part is identified, describe it and instruct students to label the grouper on their posters, using the appropriate part from the list provided. Point out the backbone on the transparency and show the fish backbone. *Warning – handle with care, these are very sharp bones!* Students can write a title or text on their posters to make it a MISSING poster, for example, "MISSING! Nassau grouper last seen at…"

3 Discuss grouper parts and functions. Distribute "Fish Body Parts and Functions" and have students do the activity in groups or individually. When they are finished, ask questions to reinforce what they have learned. What parts of the fish help it to breathe? *(gills)*, move in water? *(fins)*, or eat? *(mouth)*, and so forth.

4 Discuss adaptations. Explain that groupers and other fish have adaptations (special tools or characteristics) that enable them to survive, such as fins for swimming and gills for breathing. Ask a student to read the poem "The Fish Had a Wish." Have students complete the "Grouper Adaptations" worksheet and draw the parts identified onto the fish drawing. Alternatively, for younger students you can prepare "puzzle" pieces for them to paste onto the drawing by copying the illustration on page 63 and cutting out the parts that correspond to the statements on the worksheet.

Grouper News Bulletin

This just in! A very important fish is missing! The disappearance of this fish causes grave concern among humans and marine life alike. All citizens are asked to be on the lookout for an oblong, large fish with large eyes and coarse, spiny fins. It is average size for its kind, estimated to be about two feet long and weighing 20 pounds. It is a light, buff colour with five irregular dark brown vertical bars on each side. The third and fourth vertical bars form a W-shape above the lateral line. Black dots are located around its eyes. This fish can change colour patterns from light to dark brown very quickly, depending upon its mood and the surrounding environment. The public is advised to concentrate search efforts in areas where parrotfish, wrasses, damselfish, squirrelfish, snappers, and grunts reside. This fish should be hungry and will likely be seeking out these fish as prey. Report all sightings to the fisheries officer in your area. We are holding out hope that this fish will return to its home unharmed.

The Fish Had a Wish

by Lynn Gape

The fish had a wish
that he could walk on
the land
But his fins could not
get a grip in the sand.

The fish had a wish
that he could soar like
the birds
But he needed some
wings with feathers
he heard.

The fish had a wish
that he could leap
into trees
But out of the water he
just could not breathe.

The fish had a wish
that he could swim far
and wide
And he traveled the
oceans following the
tides.

Assessment

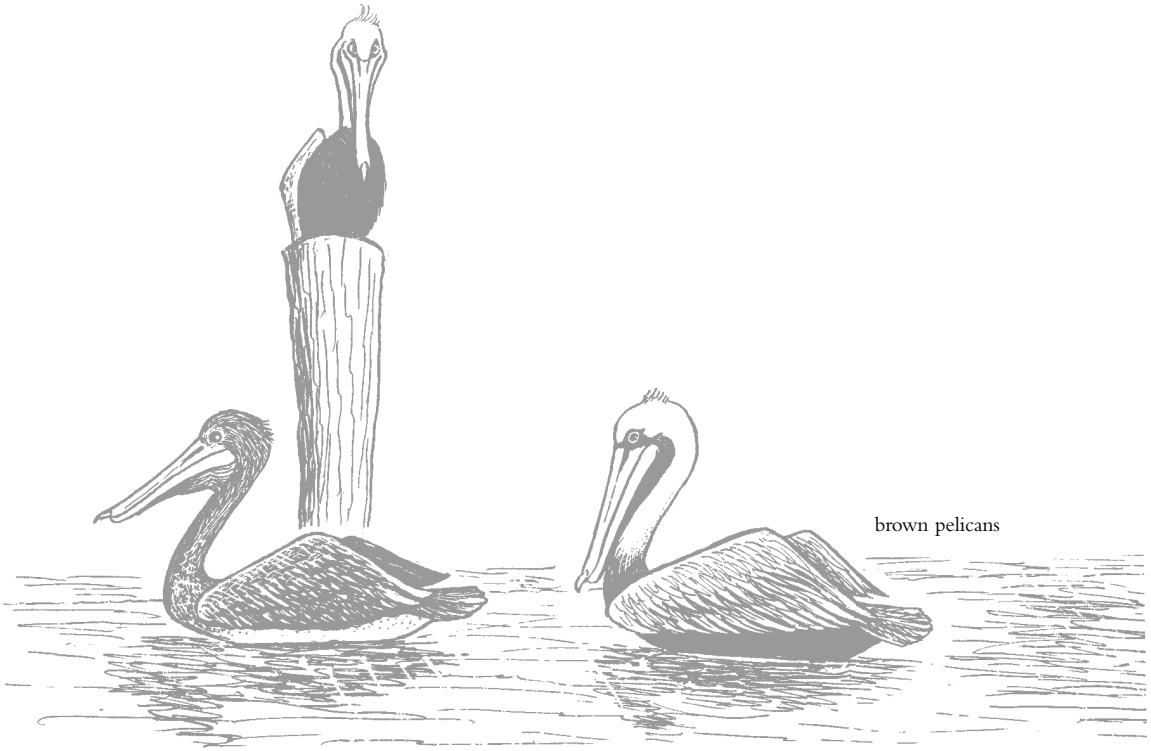
Have students work in pairs, acting as "detectives" to identify any differences between their posters and then discuss them. *(Did students interpret the facts from the news bulletin the same way? Did they label the fish features correctly?)* Discuss the conclusions of this peer review as a class.

Grade the worksheets, using the following answers as a guide:
Fish Body Parts and Functions 1 c, 2 d, 3 e, 4 f, 5 a, 6 g, 7 h, 8 b
Grouper Adaptations 1 fins, 2 mouth, 3 gills, 4 operculum, 5 scales, 6 nares, 7 lateral line, 8 caudal fin

The "Pass the Part" activity on page 66 is a great way to review grouper body parts and functions.

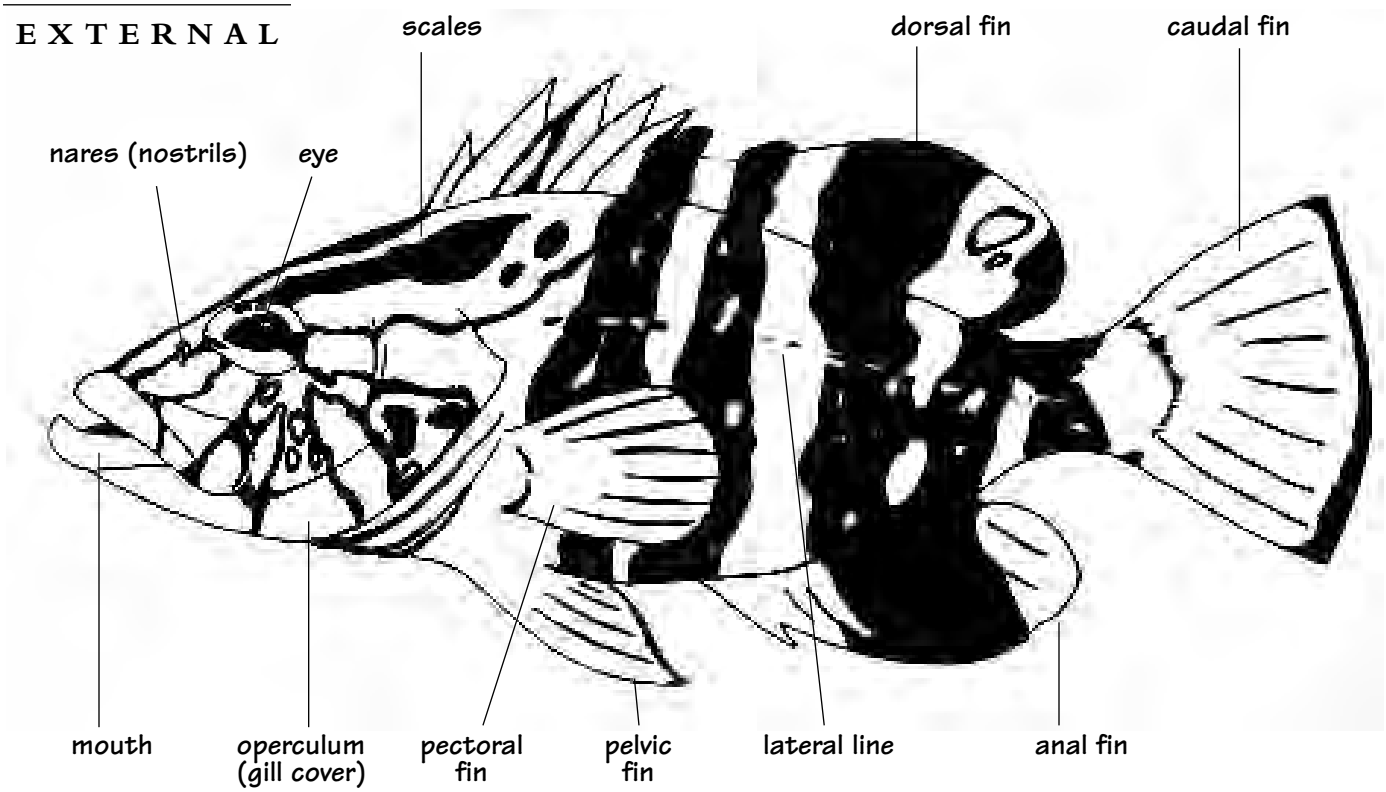
Extensions

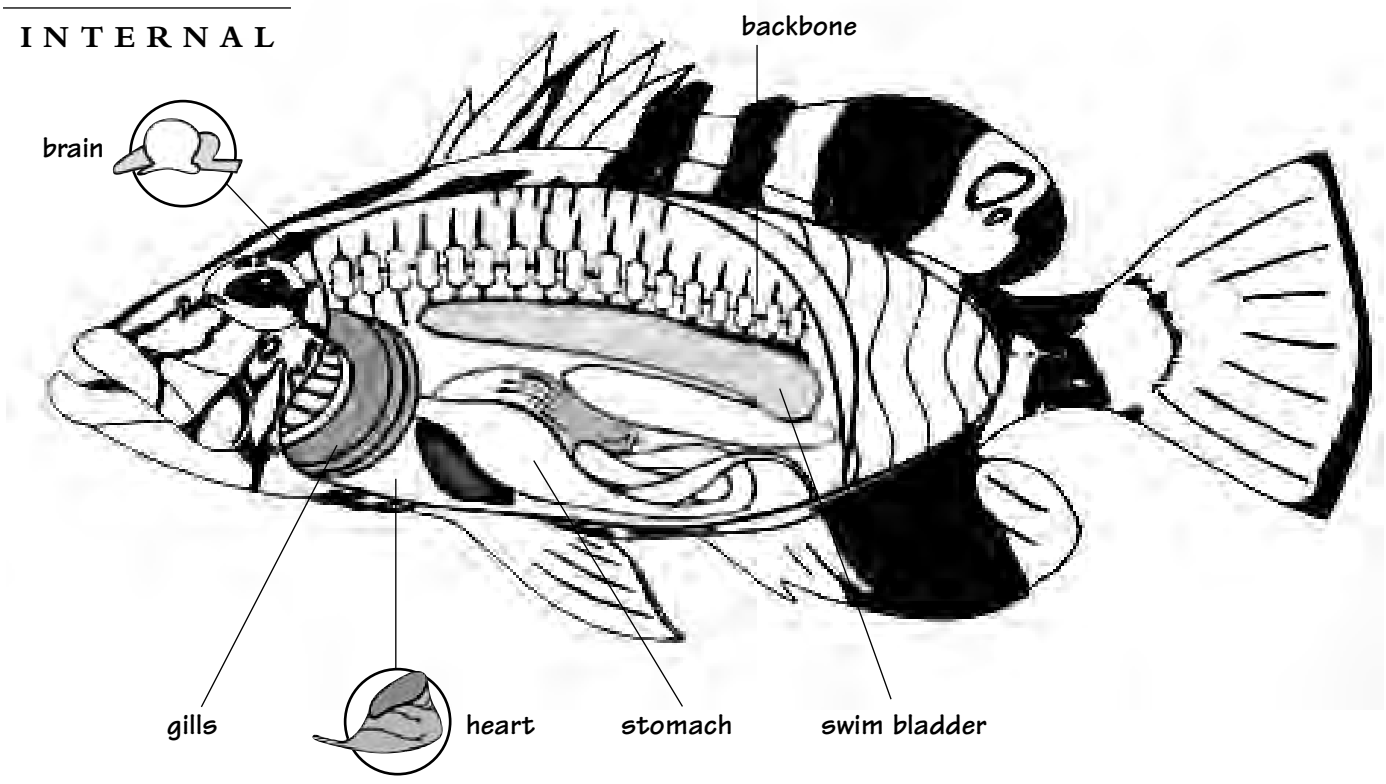
- Instead of a radio news bulletin, students can do a skit of a television news alert complete with a panel of "expert analysts" to talk about the Nassau grouper.
- Students can dissect a fish and compare what they find to the Nassau grouper illustration.
- Read the poem "The Nassau Grouper" by Telcine Turner-Rolle. Have the students write their own poems about the Nassau grouper.



brown pelicans

Nassau Grouper





Name: _____ Date: _____

MISSING

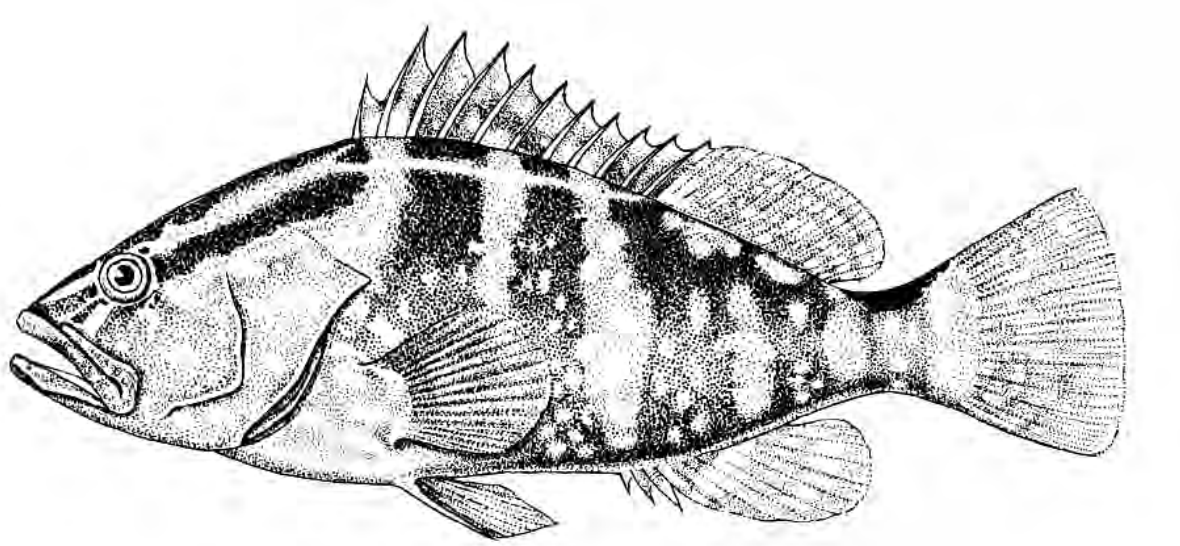
Use the words below to label the parts of the grouper.

anal fin	dorsal fin	gills	mouth	pelvic fin	
eye	lateral line	pectoral fin	caudal fin	nares	operculum

FISH BODY PARTS AND FUNCTIONS

Name: _____

Date: _____



Write the letter of the part that matches each function below.

Function	Part
_____ 1. the part of the body that the fish uses to catch food, located in the front of the body	a. fins
_____ 2. sight organs located on the head	b. scales
_____ 3. fleshy organs that are used for breathing and are located on the side of the head	c. mouth
_____ 4. a series of pores (small openings) that are located along the sides of fish to sense vibrations in the water	d. eyes
_____ 5. body parts used for propelling, steering, or balancing in the water	e. gills
_____ 6. the flap that protects and covers the gills	f. lateral line
_____ 7. a gas-filled sac inside the abdomen that allows the fish to move vertically	g. operculum
_____ 8. small, thin plates that provide fish with protection and flexibility	h. swim bladder

GROUPER ADAPTATIONS

Name: _____

Date: _____

Adaptations are the special features of an organism that help it to survive in its environment. In this activity we learned about the parts that fish have, and some that are specific to Nassau groupers that make them well-adapted to life in the sea. Fill in the answers below and identify the part by drawing it onto the fish.

1. Fish don't have any legs. What do they use to move around? They swim with _____.

2. The large, fleshy body part that groupers use to capture their prey is: _____.

3. People breathe by using their lungs to take in oxygen from the air. Fish need oxygen, too, but they do not have lungs. They breathe with _____.

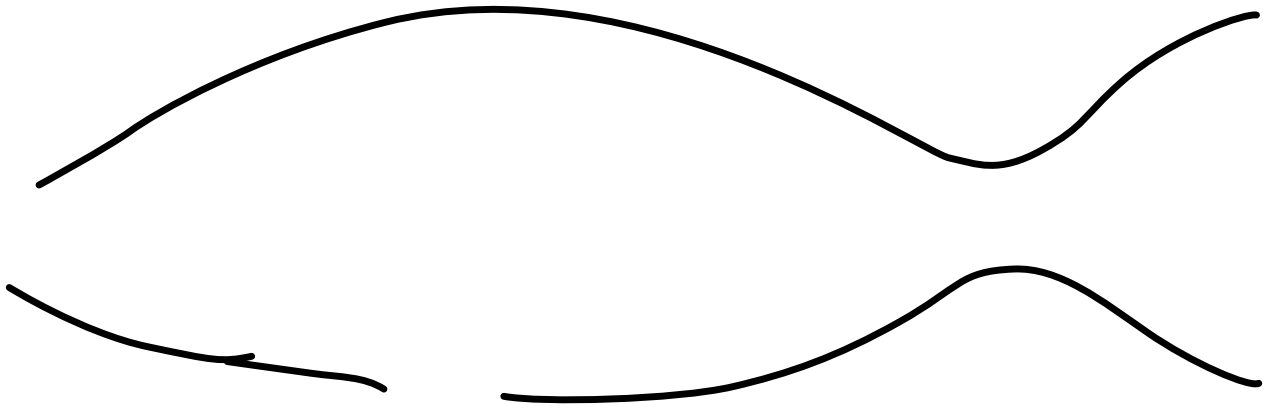
4. The _____ is a structure that protects the fish's gills from the environment.

5. A fish is covered in small plates called _____ that protect it and allow it to move freely.

6. We use our nostrils to breathe and to smell. A fish's nostrils are called _____, and they are only used for smelling.

7. A fish senses movements or disturbances in the water with its _____ _____.

8. The grouper's large tail, or _____ _____, is used for steering and accelerating quickly.



4 Pass the Part

Students play a straw relay game to review queen conch, crawfish, and Nassau grouper characteristics.

Learning Objectives

- Demonstrate knowledge of queen conch, crawfish, and Nassau grouper form and function by matching function clues with corresponding parts

Grades

3 – 6

Subjects

Science, Physical Education

Skills

organising (matching, manipulating materials), analysing (identifying components and relationships among components), citizenship (working in a group)

Vocabulary

adaptation, anatomy, relay

Time

1 hour

Materials

play chart(s) — large illustrations of conch, crawfish, and grouper (pages 70 – 72); paper to make circles about 7.5 cm (3 in.) in diameter; photocopy of "Pass the Part Clues" (page 69); 8½-x-11 inch sheet of card stock or poster board; scissors; glue; masking tape; one straw for each student

A relay game is a competition between teams in which all the team members work together. This straw relay not only requires knowledge of anatomy and adaptations, but also involves physical skill and competition. It is a good culminating activity to follow "Conch Ain't Gat No Bone," "Crawfish Critters," and "Grouper MISSING."

Before You Begin

Decide if you want to review the form and function of one, two, or all three of the animals on the game pages (70 – 72). Take these pages to a copy centre to enlarge them to about 90-x-60 cm (36-x-24 in.) or draw the outlines and title them to create play charts. Cut out paper circles to fit the circle outlines on the enlarged game page(s). Label the cut-out circles as follows:

Conch: mantle, eyestalk, operculum, foot, radula, denticles

Crawfish: abdomen, antennae, mandibles, spiny shell, cephalothorax, walking legs

Grouper: caudal fin, nares, scales, swim bladder, gills, lateral line

Cut out the clue boxes and mount them on poster board. The day before the activity, instruct students to review the parts and functions of the marine animals as homework.

What to Do

1 Review the parts and their functions. Review the parts of the conch, crawfish and/or grouper with students. Refer to the previous activities in this section and the species fact sheets on pages 16 – 21.

2 Divide the class into teams and practise. Divide the class into two or three teams (depending on the number of game charts). If this activity is used to review the parts and functions of only one species, you will need to make a copy of the materials for that species for each team. Instruct each team to choose a leader or appoint one for each team. Distribute straws and circles and have students practise picking up and passing the circles by sucking on the straw.

3 Set up the game. Clear the room and form relay lines, with students in each team lining up one behind the other. Place a desk or table in front of each team and lay out the six circles on the desk along with the corresponding clue sheet. On the wall or bulletin board behind each team hang the team's large conch, crawfish, or grouper picture. Roll a piece of tape and stick it in the centre of each circle on the large picture, being careful not to cover the number.

4 Explain the game and play.

a. The first student reads the first clue on the clue sheet, and picks up the circle with the answer with his or her straw by placing the end of the straw against the circle and sucking in the air so that the suction holds the circle on the end of the straw.

b. With the circle on his or her straw, the student turns to face the next student in line. This student takes the circle by placing the straw on the circle and sucking in air while the first student releases the suction on the circle.

c. In this way students pass the circle from straw to straw until it is sucked up by the last student on their team.

d. This student then carries the circle to the big conch, crawfish, or grouper play chart and tapes it onto the right number (for Clue 1 the circle should be taped to the circle marked #1 on the large picture).

e. The student then hurries to the front of the line, reads Clue 2, picks up the appropriate circle, and passes it down the line.

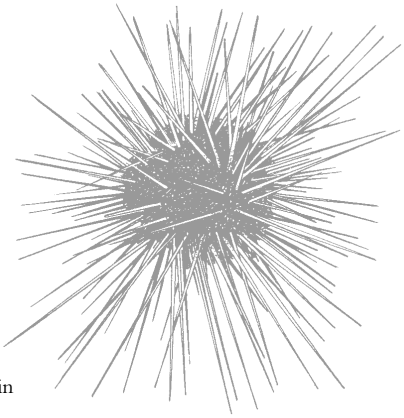
f. Again, the last student must tape the circle onto the conch, crawfish, or grouper in the correctly numbered circle and he or she goes to the front of the line for round three.

g. As soon as one team tapes all of its circles to its grouper, conch, or crawfish, the game is over.

Rules and Reminders

- Students should read the clues carefully because the answers in the circles do not necessarily correlate with the place on the body of the animal.
- No one is allowed to use his or her hands as the circle is being passed along. Only after the last person has sucked up the circle can he or she touch it.
- If the circle should drop before it gets to the end of the line, it must be placed back on the desk or table, and the team must start that round again. (If students keep dropping circles, don't make them start at the beginning. Just let them suck the circles off the ground and keep passing them along.)
- Teams should be far enough apart so that they cannot see which circles other team leaders are picking up.

5 Tally the scores. The team that finishes first gets ten points. Each team gets five points for every circle in the correct spot. If the fastest team has all the circles filled in correctly, it wins. But if it missed some, another team can still win. As you tally the scores, discuss each clue so that everyone understands the answers.



sea urchin

Assessment

Students should tape the circles to the charts as follows, earning points for correct answers as described in Step 5, with additional points possible for the team that works the most quickly together.

Clue	Conch	Crawfish	Grouper
1	mantle	abdomen	caudal fin
2	eyestalk	antennae	nares
3	operculum	mandibles	scales
4	foot	spiny shell	swim bladder
5	radula	cephalothorax	gills
6	denticles	walking legs	lateral line

Adapted from "Pass the Part," an activity in *Ranger Rick's NatureScope* (Birds, Birds, Birds),1989, with the permission of the publisher, the National Wildlife Federation®.

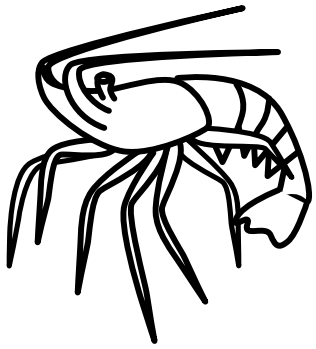
Pass the Part Clues

Conch Clues

1. The thin layer of tissue where the shell is created
2. This part makes it possible for the conch to see around it
3. The part that is like a trap door
4. The part snails use to move along the seafloor
5. Conchs eat using a _____
6. These are tiny, teeth-like parts

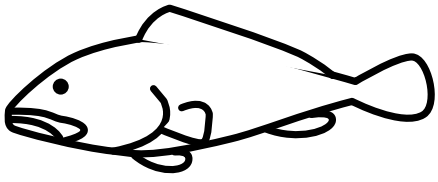
Crawfish Clues

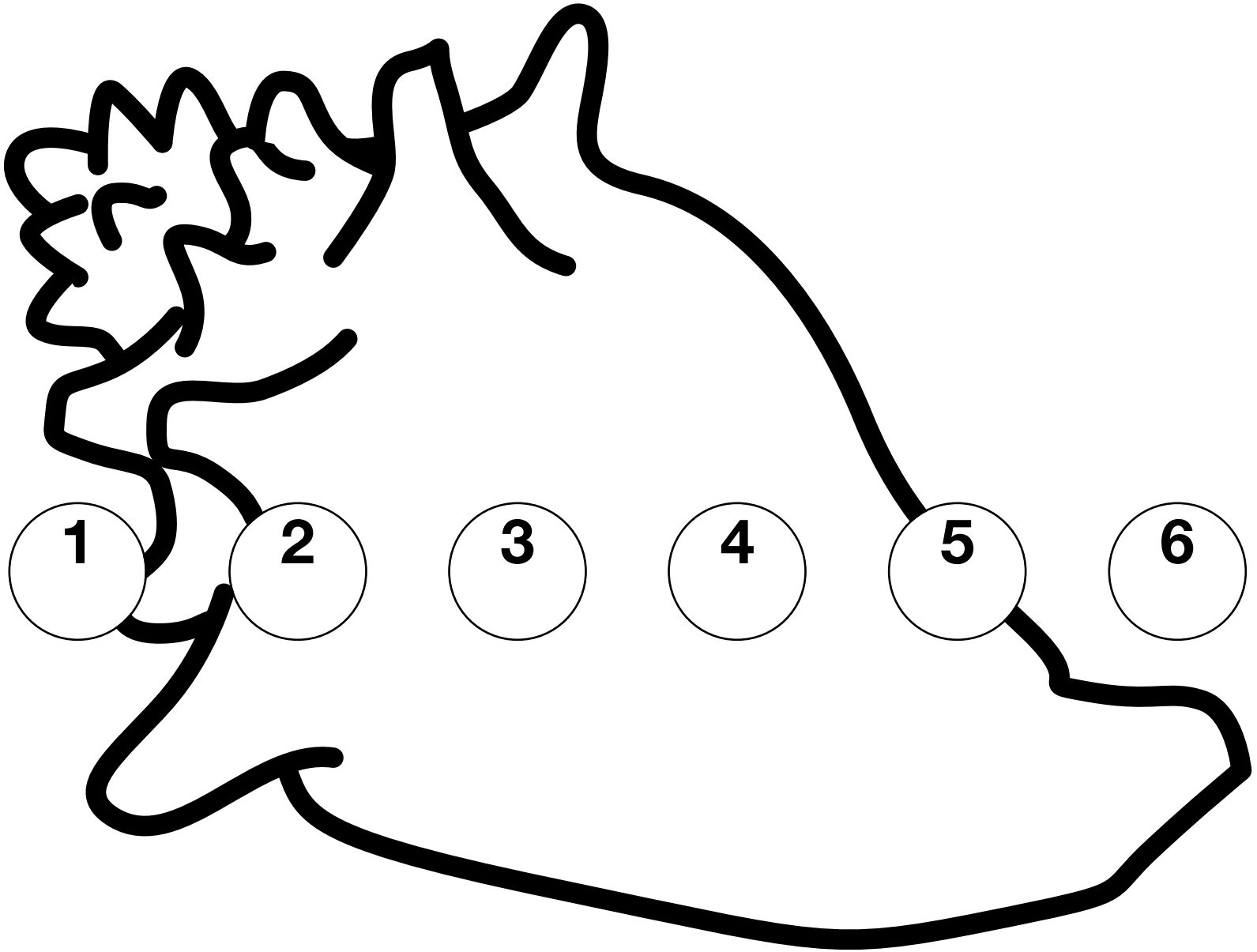
1. This section is commonly referred to as the "tail"
2. These provide the sense of touch
3. Jaw-like structure for crushing and eating food
4. This protects the crawfish from predators
5. Contains the head and thorax sections, together commonly called the "body"
6. What the crawfish uses to move around



Grouper Clues

1. The part that provides the main thrust for swimming
2. Nostril-like organs, used for smelling, not breathing
3. Small, thin plates that cover the body of the fish
4. A gas-filled sac inside the abdomen that helps the fish to move up and down
5. These help the fish take oxygen from water
6. This is used to sense vibrations in the water

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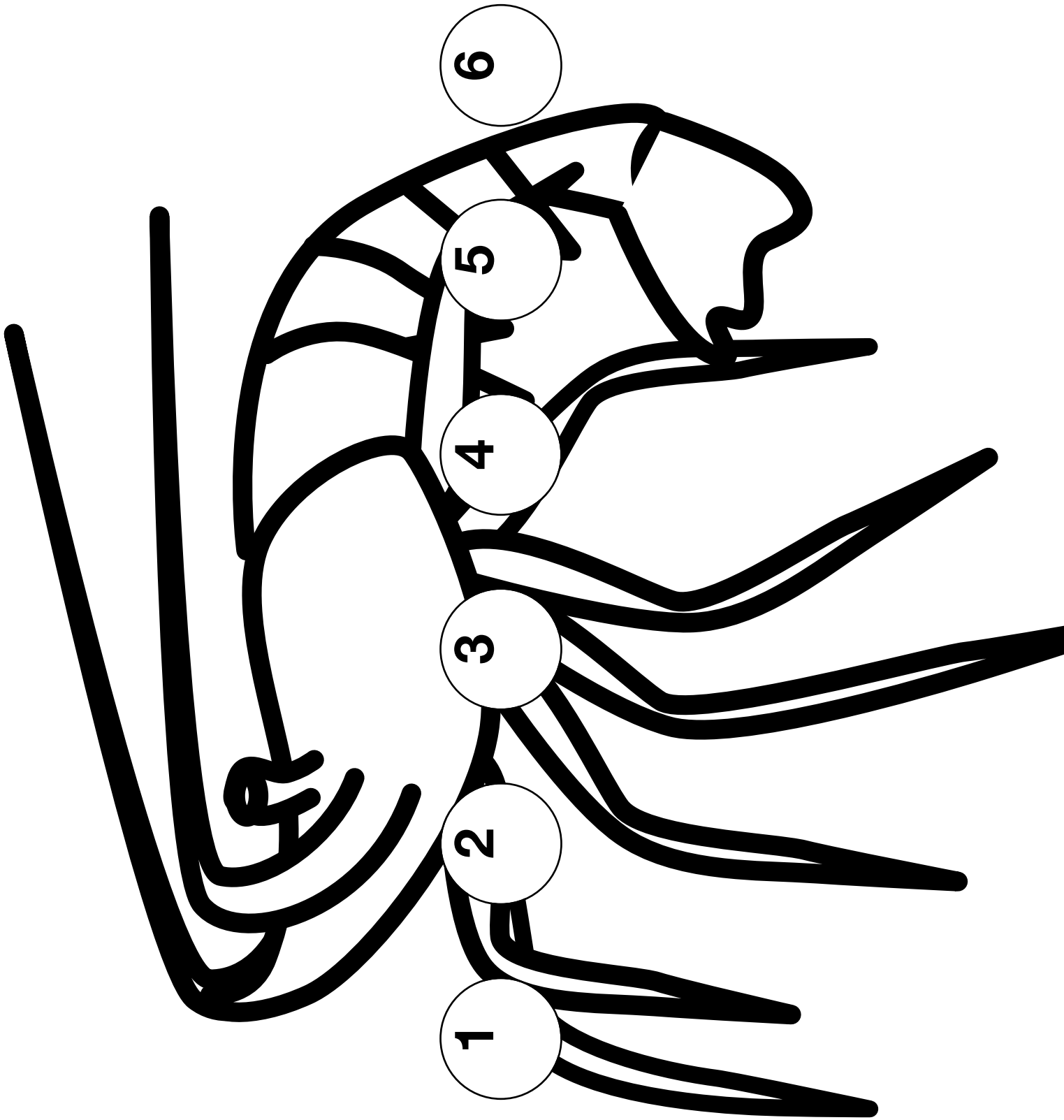
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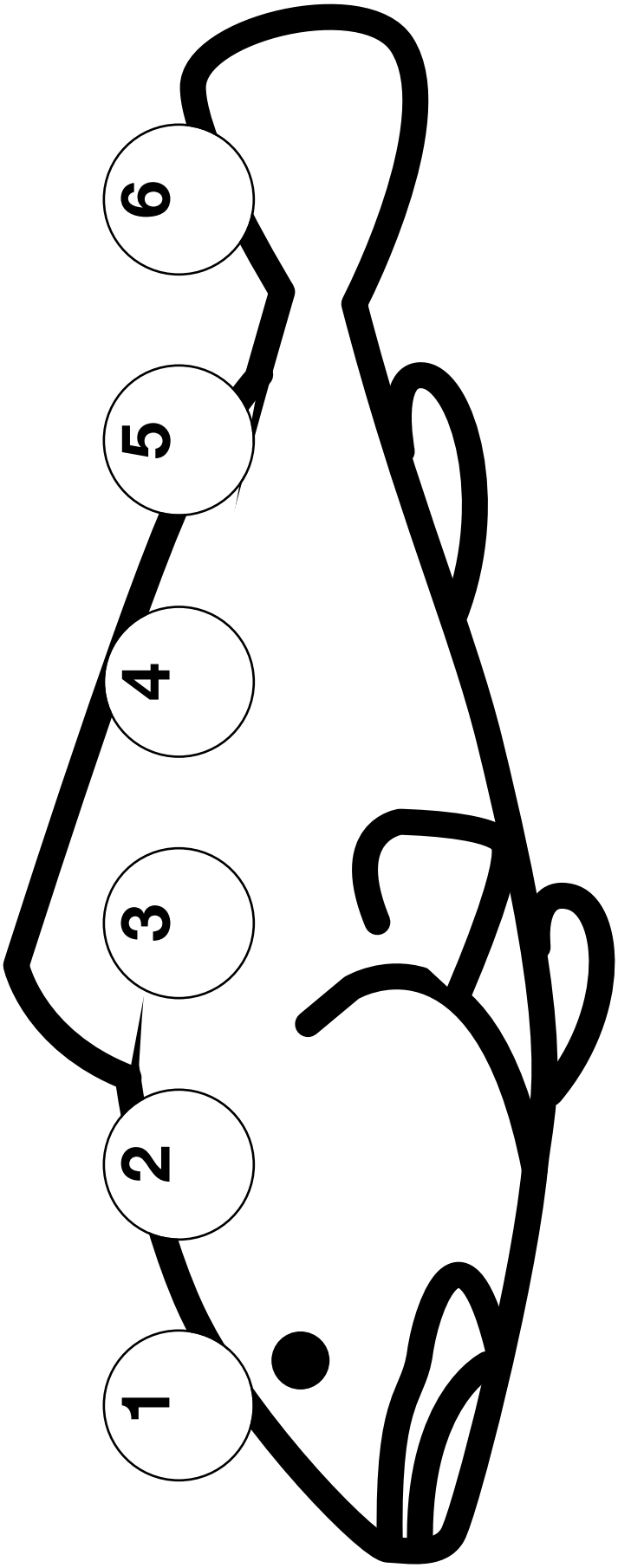
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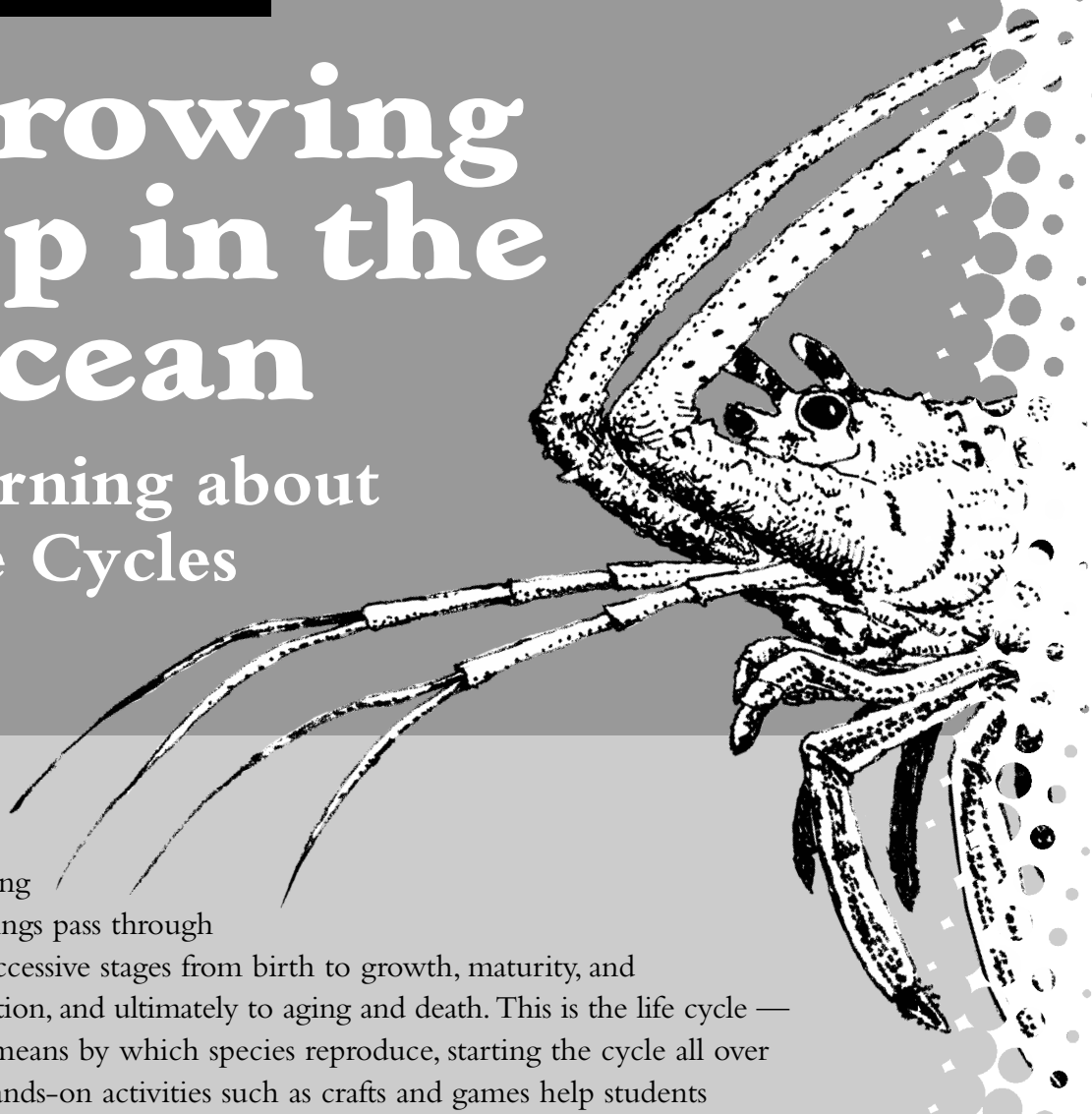
SECTION 3

Growing Up in the Ocean

Learning about Life Cycles



Living things pass through successive stages from birth to growth, maturity, and reproduction, and ultimately to aging and death. This is the life cycle — and the means by which species reproduce, starting the cycle all over again. Hands-on activities such as crafts and games help students understand the various stages in the life cycles of the queen conch, crawfish, and Nassau grouper. They also identify these species' needs for survival and learn about the threats impacting their populations.

1 Conch Life Cycle Wheel

Students make a wheel that illustrates and describes the stages in the life cycle of the queen conch.

Learning Objectives

- Describe the major stages in a queen conch's development
- Distinguish a mature adult conch from an immature, juvenile conch

Grades

5 – 6

Subjects

Science, Art, Music

Skills

organising (sequencing, manipulating materials), analysing (identifying components and relationships among components, comparing and contrasting), presenting (describing, writing)

Vocabulary

mature, **metamorphosis, spawning,** veliger

Time

45 minutes

Materials

For each student: 1 paper fastener, 3 sheets of letter size card stock, a copy of the conch life cycle descriptions and illustrations (pages 78 – 79), scissors

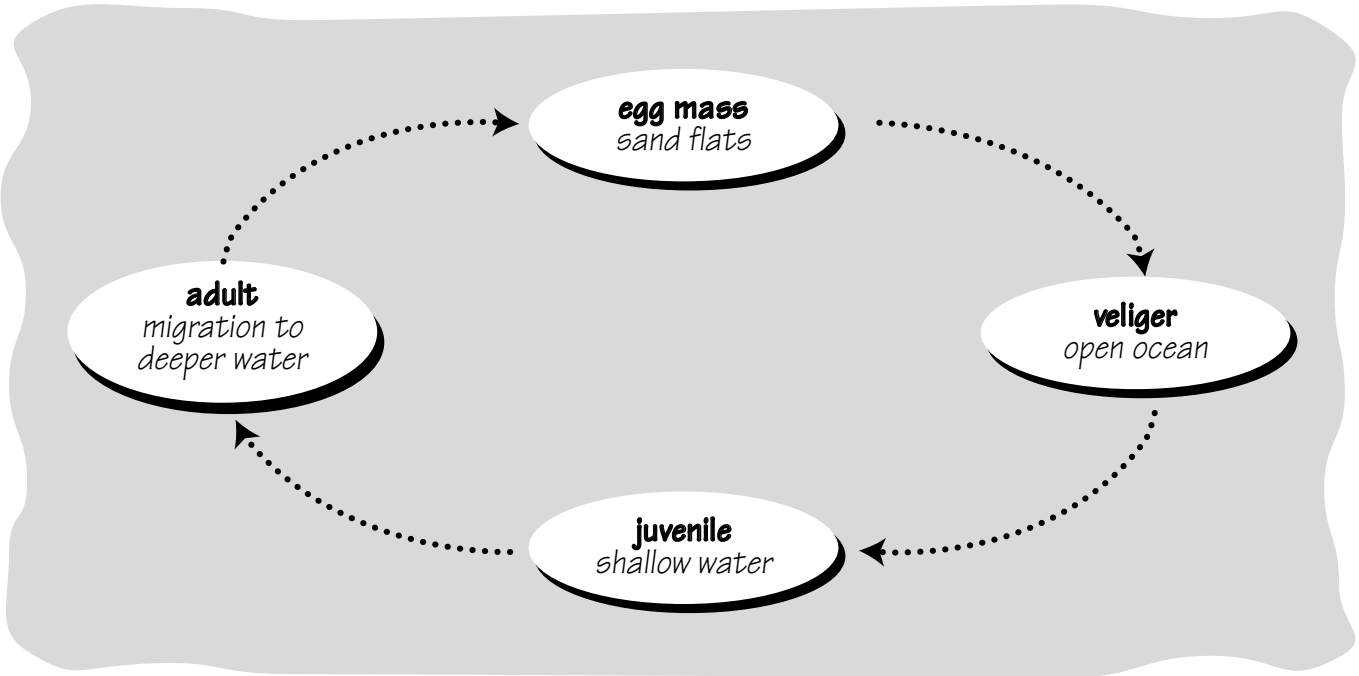
For the class: 2 conch shells (with flared and unflared lips), several patterns for the wheel cover (page 77), glue, art supplies (crayons, pencils, glitter), pushpin (to be handled by the teacher only), tape player and cassette recording of "We Love We Conch So" by Phil Stubbs, queen conch poster (Perry Institute for Marine Science – CMRC)

If you take a walk by the seaside, you might see a Bahamian fisherman in his dinghy knocking a conch shell to remove the meat. The conch went through various stages before reaching this point. A conch starts out as one of hundreds of thousands of eggs in an egg mass. It then takes on a larval form — called a veliger — which looks very different from what it will become. Over several weeks, the conch undergoes a metamorphosis, developing a conch body and shell and settling to the sea floor where it buries itself in the sand for about a year! Emerging at night to feed, the juvenile conch continues to grow. It's called a "roller" because the shell does not yet have a flared lip, but by three to four years of age, the shell reaches its full size and has the thick, fully flared lip that indicates it is mature.

The slow-moving conch is easy to pick up by hand or with simple fishing gear (such as a conch hook). And, because conchs mature relatively slowly, they do not quickly replenish their populations.

Before You Begin

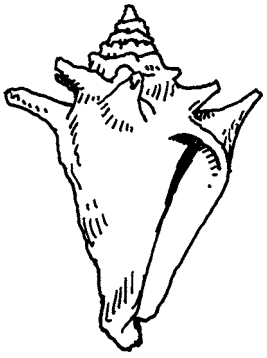
Collect the conch shells (see page 45). Review the description of the conch life cycle in the "Queen Conch Fact Sheet," page 16. Using the wheel cover pattern on page 77, make several patterns for the students to use. Make a copy of the conch life cycle illustrations and descriptions (on pages 78 and 79) for each student.

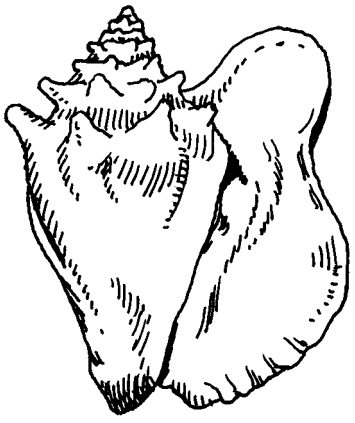


Old Enough to be Eaten?

It's illegal to catch a conch with a short lip because it still has growing to do. This is a juvenile conch that has not reached maturity. We must allow conch to mature and reproduce in order to have conch in the future.

An adult conch has a flared lip. It's legal to catch adults, but we shouldn't take more than we need. Overfishing of conch has led to their commercial extinction (an insufficient population for harvest) in some places in the Caribbean.





Adapted from Coastal Awareness Month supplement 2006.

What to Do

1 Introduction. Play the song "We Love We Conch So" by Phil Stubbs. Talk about the words of the song with your students. Use the "Queen Conch Fact Sheet" and poster to describe the life cycle of the conch. Pass around the conch shells and ask students to compare them. Which one is from a mature conch? How do students know?

2 Make conch life cycle wheels. Guide students through the following steps:

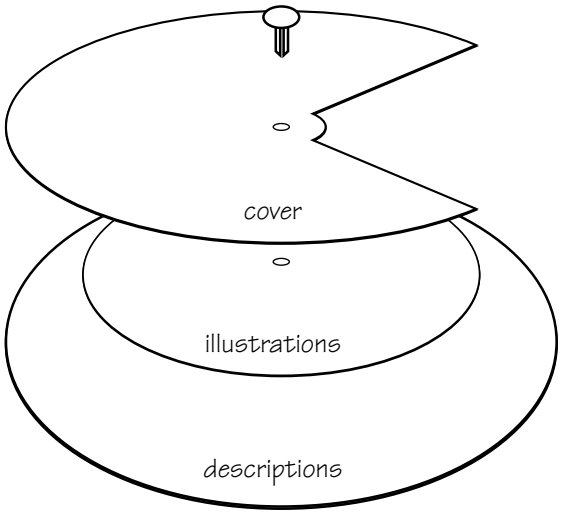
a. Cut out the life cycle descriptions circle and glue it on a sheet of card stock. Carefully trim the card to the size of the circle.

b. Cut out the illustrations circle, glue it on a sheet of card stock, and trim it to the size of the circle.

c. Trace the wheel cover pattern onto a sheet of card stock and cut it out so that it looks like a pie with a wedge missing.

d. Decorate the wheel cover with messages about the conch or information about its life cycle.

e. Place the illustrations circle on top of the descriptions circle. Place the wheel cover on top.



f. Teacher's step: poke a pushpin or scissors point through the centre to make a small hole through all plates.

g. Finish the wheel by inserting the fastener though the centre hole and securing it in the back.

3 Show and tell. Ask the students to show the different stages of the life cycle by adjusting their wheels.

Assessment

Have students use the descriptions to write a story about the life cycle of the conch titled "How I Grow." The story should include the four major stages in the development of the queen conch and where it lives at each stage.

Play the CYCLE game on page 88.

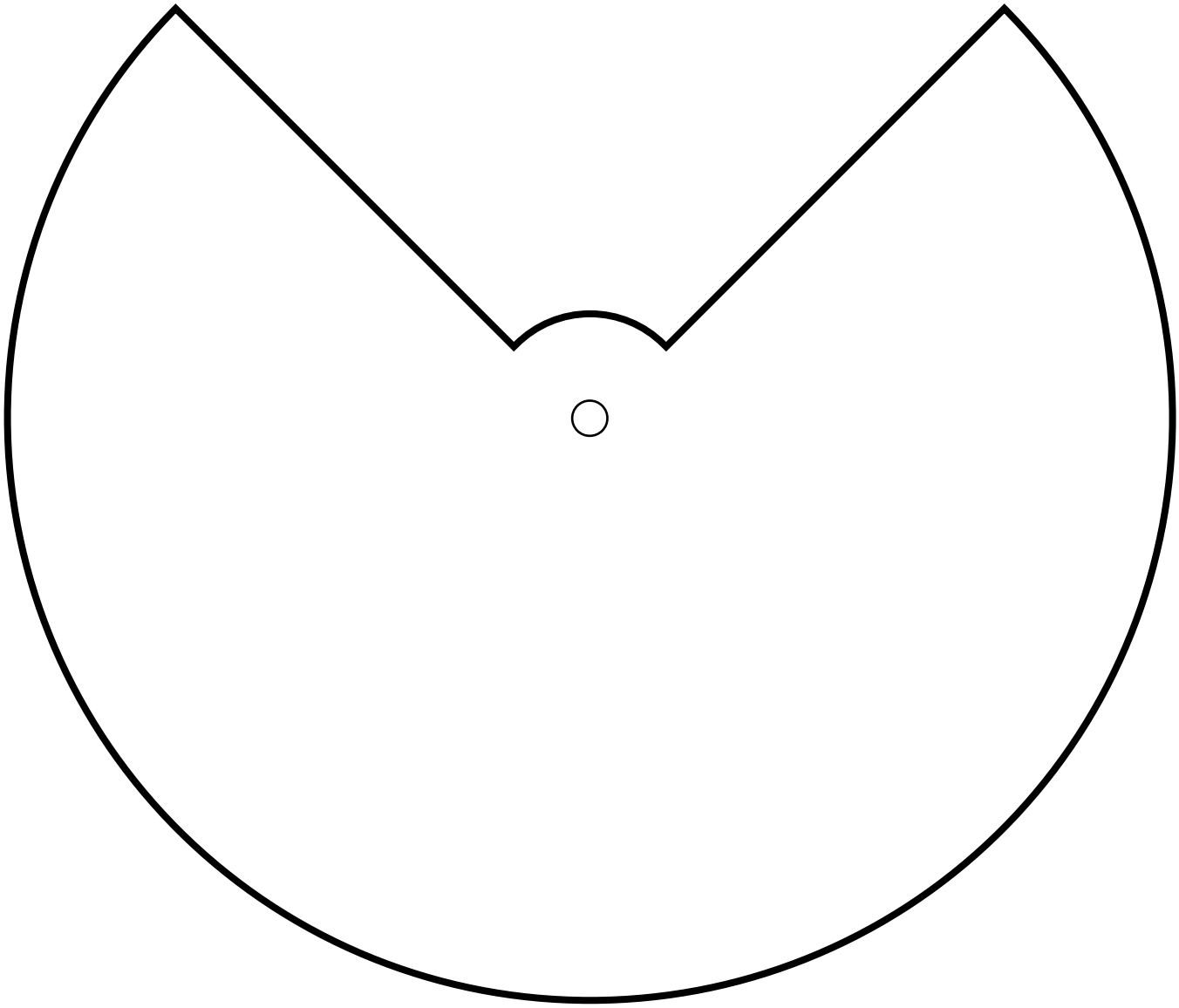
Extensions

- Use math concepts to construct the wheel. Students can measure the diameter of the circles, calculate the circumference of the circles, divide the circle into four equal parts, and measure the angles.
- Students can create a survey sheet and interview other students about their knowledge of the conch life cycle. They can create graphs to illustrate the results.
- Investigate a conch midden to collect data on the number of juvenile and adult conch shells. Discuss implications for conch conservation. (See treasures.amnh.org for complete activity.)

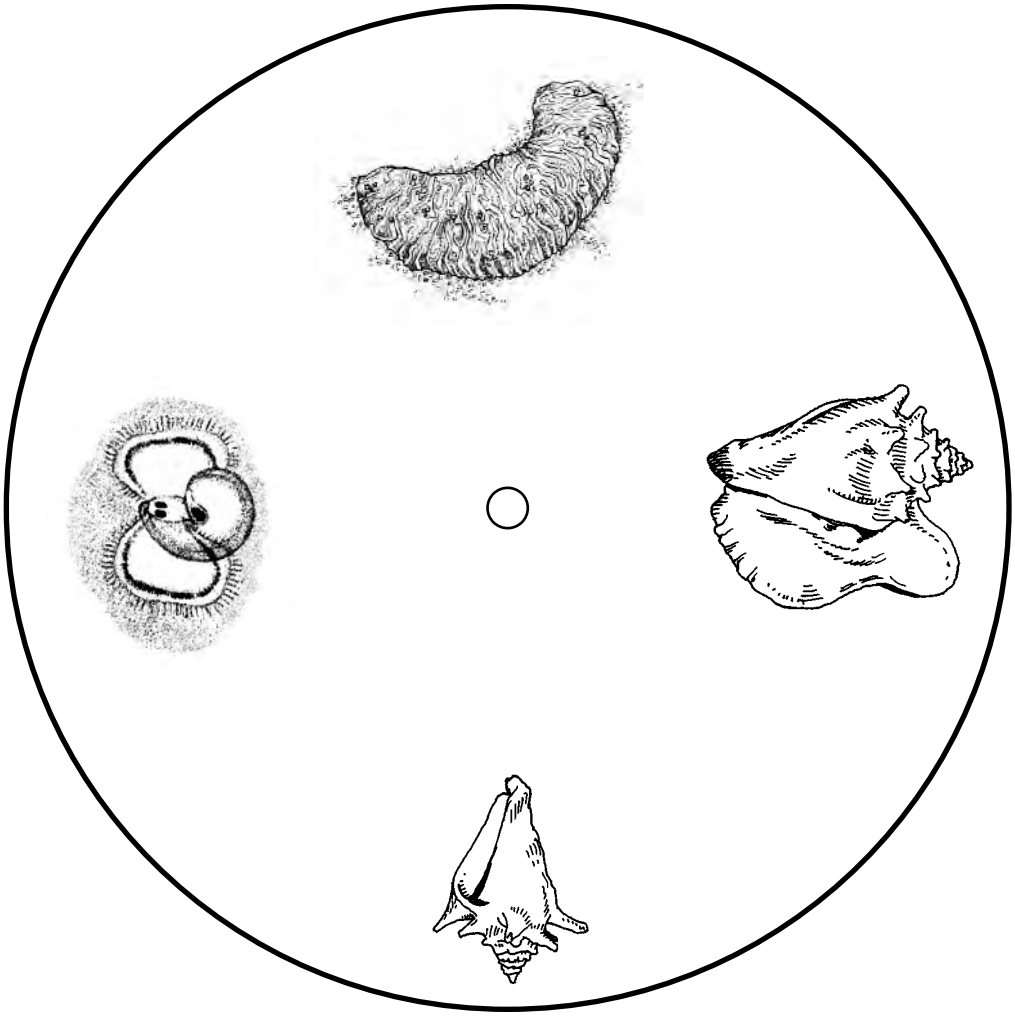
Resources

Perry Institute for Marine Science – Caribbean Marine Research Center. 2004. Poster series #1: Queen Conch. Jupiter, Florida. www.perryinstitute.org

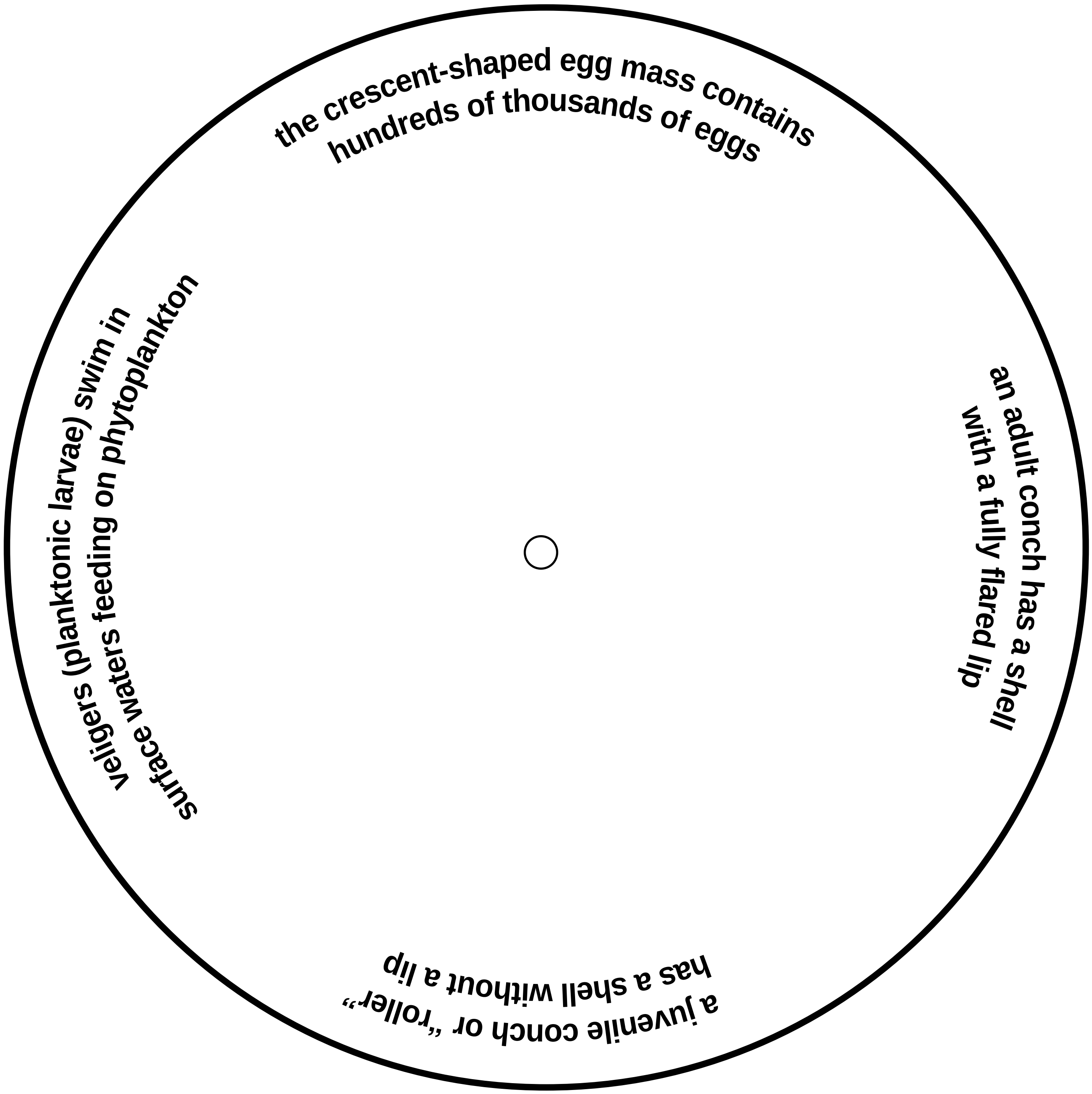
Wheel Cover Pattern



Conch Life Cycle Illustrations



Conch Life Cycle Descriptions



2 Crawfish Mobile

Students create a mobile of the crawfish life cycle that illustrates its development from egg to mature crawfish.

Learning Objectives

- Describe the major stages in the development of a crawfish
- Illustrate the habitats of the crawfish at different stages of its development

Grades

5 – 6

Subjects

Science, Art

Skills

organising (sequencing, drawing, manipulating materials), analysing (identifying components and relationships among components)

Vocabulary

juvenile, **metamorphosis, moult,** phyllosome

Time

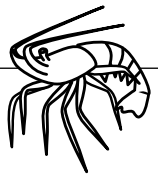
45 – 60 minutes

Materials

For each student: card stock (or construction paper), scissors, a wire hanger, 5 pieces of string, a copy of "Crawfish Life Cycle" (page 83)

For the class: glue, hole punch, spiny lobster poster (Perry Institute for Marine Science – CMRC), stapler or thumb tacks

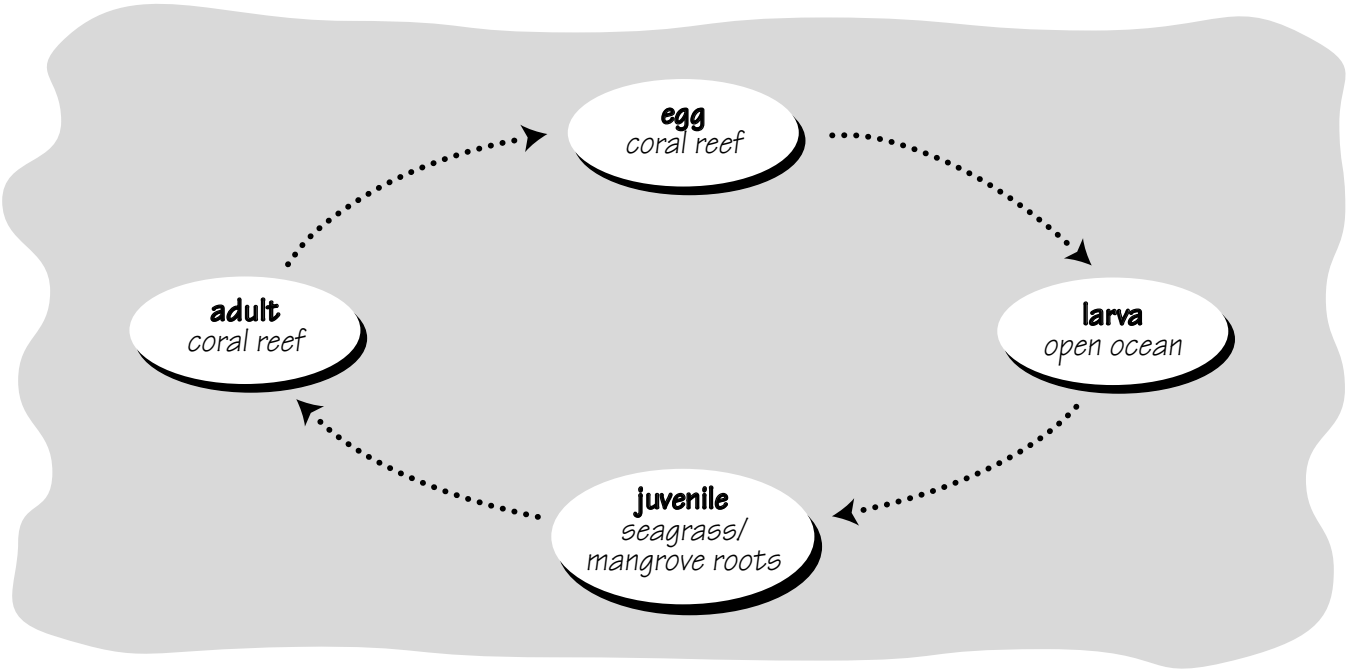
It takes about three years for a crawfish to go from egg to mature adult. From one of thousands of orange-coloured eggs (or millions, in the case of a large female), it becomes a transparent, spider-like larva, called a phyllosome, and drifts for several months in ocean currents. It moults several times before undergoing a metamorphosis, or complete change in appearance — now with the shape of a tiny, but still transparent crawfish. This juvenile crawfish swims towards shore to settle in nursery areas like mangroves, grass beds, or shallow reefs. Its body becomes coloured, marked with yellow and dark brown. As it matures, it moves to coral reefs and crevices. It will continue to grow throughout its life, moulting and growing a new shell. See the "Crawfish Fact Sheet" on page 18 for more information.



How do Crawfish Grow?

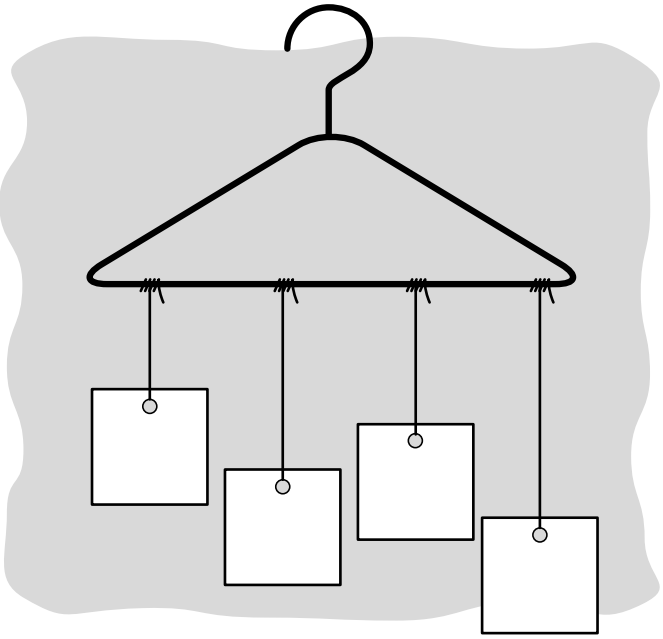
A crawfish moults, or sheds, its outer shell as it grows. Before moulting, a crawfish grows a soft shell — like a second skin — underneath its hard shell. Then it splits its hard shell open where the tail joins the body and backs out of the shell through this opening. The crawfish now has only its soft skin-like shell and is especially vulnerable to predators until the soft shell swells to a larger size and slowly hardens. The crawfish has room to grow in this new shell until it is time to moult again.

Spiny Lobster fact sheet (Bahamas National Trust, 2003).



Before You Begin

The day before, ask students to bring a wire hanger to school. Each child needs a wire hanger to do this craft. Make a copy of "Crawfish Life Cycle" (page 83) for each student. Cut five pieces of string for each student; these can be of equal length or of varied lengths for added interest.



What to Do

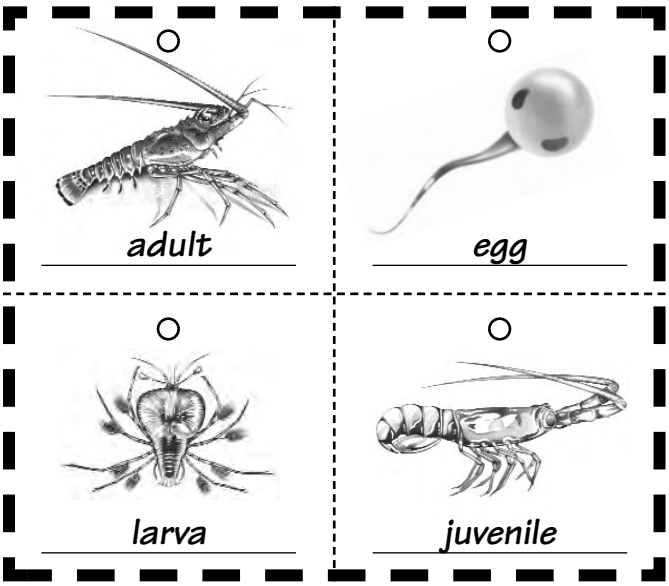
1 Introduce the crawfish life cyle. Begin the activity by showing the students the poster of the crawfish. Point out the different stages of its life cycle and discuss habitats it uses at each stage. Tell the students that they will be creating a life cycle mobile. Distribute a copy of the "Crawfish Life Cycle" to each student.

2 Make the mobile. Read the instructions on the "Crawfish Life Cycle" sheet with the students. Assist students in making the craft. Alternatives include: decorating hangers by wrapping them with yarn, ribbon, or raffia, or making a mobile without a hanger by linking pictures in a chain. When they are finished, a piece of string can be tied to the top of the hanger to hang it. A thumbtack or stapler can be used to hang the mobiles from the ceiling.

3 Wrap-up. Review the stages by pointing to each one of the pictures on the "Crawfish Life Cycle" mobiles and asking students to name each developmental stage.

Assessment

Exhibit the mobiles and have students vote on them based on categories such as most colourful, complete, or creative, as appropriate. All mobiles should have the correctly labelled stages of development and illustrate the habitat utilised by the crawfish at each stage.



Play the CYCLE game on page 88.

Extensions

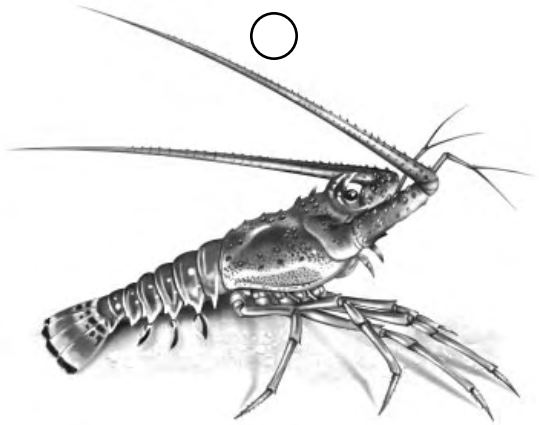
- Invite other students or members of the community to an exhibit of the mobiles.
- Investigate the food sources of the crawfish at the various stages.
- On the back of the squares in their mobiles, have students draw or write threats to the crawfish in each stage.

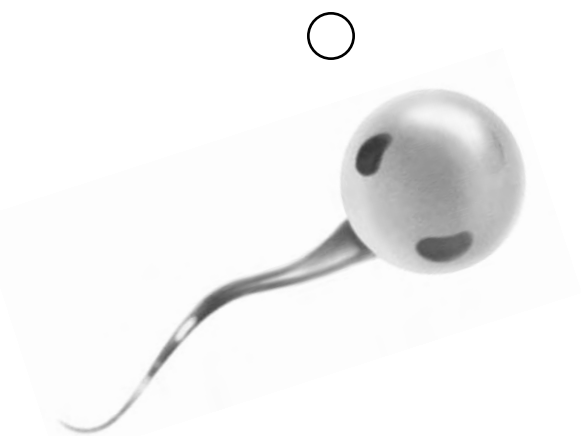
Resources

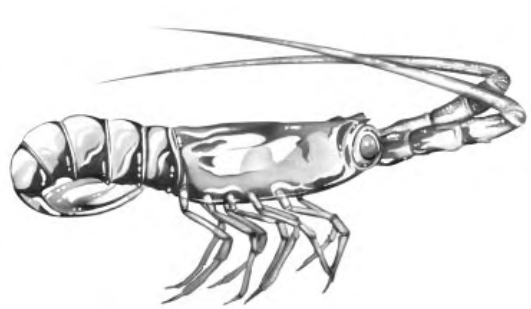
Perry Institute for Marine Science – Caribbean Marine Research Center. 2004. Poster series #2: Spiny Lobster. Jupiter, Florida. www.perryinstitute.org

CRAWFISH LIFE CYCLE

1. Label each of the four stages of the crawfish life cycle on the line under each picture.
2. Colour the pictures and draw the habitat where the crawfish lives during each of the stages.
3. Cut out the large square with all four pictures in it along the thick dashed line.
4. Glue this whole square with all the pictures onto heavy paper and trim it.
5. Cut along the remaining dashed lines to separate the pictures of the four stages in the crawfish's life cycle.
6. Punch a hole at the top of each picture as marked.
7. Thread string through the holes and secure the pictures to a hanger in the order of the stages of the crawfish life cycle.







3 Grouper Race for Survival

Students play a board game to learn about the life cycle of the grouper and its survival needs at various stages of the cycle.

Learning Objectives

- Describe the major stages in the life cycle of a Nassau grouper
- Name one challenge that the Nassau grouper faces at each stage in its development

Grades

3 – 6

Subjects

Science, Language Arts

Skills

organising (sequencing, manipulating materials), analysing (discussing), interpreting (identifying cause and effect), citizenship (working in a group)

Vocabulary

juvenile, **larva, overexploited, pelagic, predator, prey, spawning aggregation**

Time

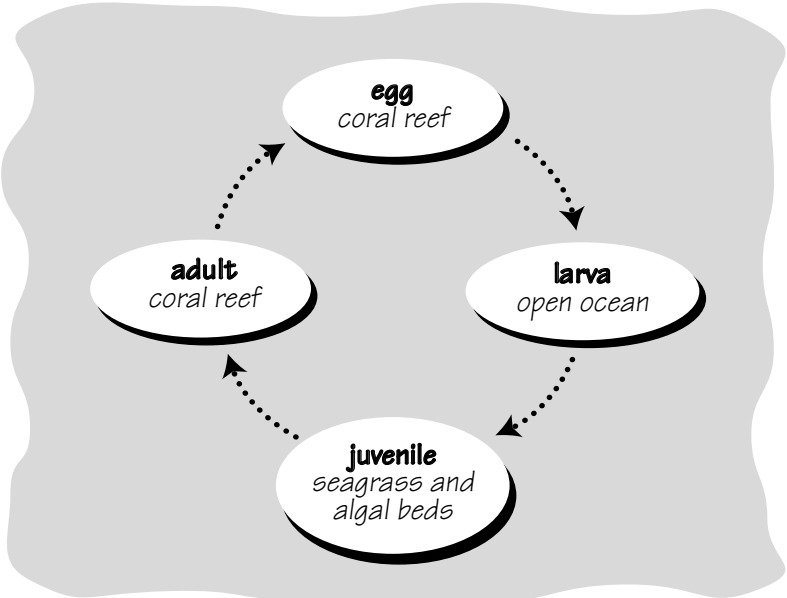
1 hour

Materials

For each pair of students: card stock to mount game board and a set of game cards (pages 86 – 87), 1 die, 2 playing pieces

For the class: Nassau grouper poster (Perry Institute for Marine Science – CMRC)

A life cycle is the series of stages an organism passes through during its lifetime. The Nassau grouper faces many challenges in completing the cycle from egg to adulthood. Most fish, including the Nassau grouper, develop from eggs outside the mother's body. The parents usually do not protect the soft eggs. Many eggs are produced so that enough young survive to continue the species — for the Nassau grouper that may mean a million or more eggs! Less than 1% of these eggs will survive through the life cycle. The tiny larvae that emerge may be eaten by big fish. Those that survive to the juvenile stage settle in seagrass or clumps of coral where they feed on crustaceans. Ten to 12 months later, these juveniles are carried by currents to the reef. It takes about seven years for a Nassau grouper to reach adulthood, the final stage in the life cycle. Adults live in caves and cracks in the reef. These are ideal places from which to ambush prey such as crawfish, parrotfish, red snapper, and other reef fish. The dark bars on Nassau grouper's body help it to blend into dark recesses. The adult Nassau grouper must avoid predators such as reef sharks, barracudas, and humans.



Top Predator with a Sixth Sense

The Caribbean reef shark *(Carcharhinus perezi)* is one of the top predators in the Bahamian marine environment. It spends most of its time on the edges of reefs and preys on reef-dwelling fish, including the Nassau grouper. Reef sharks are most active in the morning and evening hours when their prey is most likely to be feeding. They use six keen senses to locate prey: smell, sight, hearing, touch (including receptors which run along each side of the shark's body to detect water vibrations), taste, and electroreception (using small pores under the skin on its head and snout to detect weak electric fields).

When groupers gather to spawn they are especially vulnerable to overfishing. To protect them and ensure there will continue to be Nassau groupers in Bahamian waters, there is a closed season from December to February and Nassau groupers must be at least 1.36 kg (three lbs.) to be fished, purchased, or sold.

Bahamas Reef Environment Educational Foundation.

Before You Begin

Make one copy of the game board (page 87) and the game card sheet (page 86) for each pair of students, and cut the cards apart. For durability, mount the board and cards on card stock or copy them directly onto card stock, and laminate them. Make or collect playing pieces, such as fish-shaped erasers, or fish-shaped cardboard cut-outs — be creative! Remember, the playing pieces must be different so that each player can identify his or her playing piece.

What to Do

1 Introduce the life cycle of the Nassau grouper. Use the introductory information, the "Nassau Grouper Fact Sheet" (page 20), and the grouper poster to illustrate and explain its life cycle.

2 Play the "Grouper Race for Survival" game. Tell the students that they are going to play a game in which they pretend to be grouper eggs struggling to become adult groupers. Divide students into pairs or ask them to find partners. Pass out a game set to each pair of students. Explain the rules and play the game.

3 Discuss what students learned from playing the game. Ask questions like: Was it easy to go from an egg to becoming an adult fish? What were some of the dangers you encountered? What are some of the events that helped you to advance more quickly?

Assessment

Have students write sentences about what they experienced as "groupers." Students should name the stages in the grouper life cycle and one challenge groupers face at each stage.

Play the CYCLE game on page 88.

Extensions

- Have students write an essay (or a cartoon story) about a grouper's adventures throughout its life cycle, or how the life cycle could be easier if there were not so many dangerous situations.
- Students can make playing pieces for the board game by creating models of the grouper at various stages. Students can also add more cards to the game.
- Play a life-sized version of the game. Simply recreate the game board on pavement with sidewalk chalk. Use numbers to indicate the challenges and instructions that are written on the game board. Use a star or other symbol for the spaces where players must pick a card. The students can play in teams, with one student from each team assigned to be the "playing piece," another to roll the die, others to take turns selecting and reading the cards, and the whole group to work cooperatively and to cheer on the team. The same rules of the game apply.

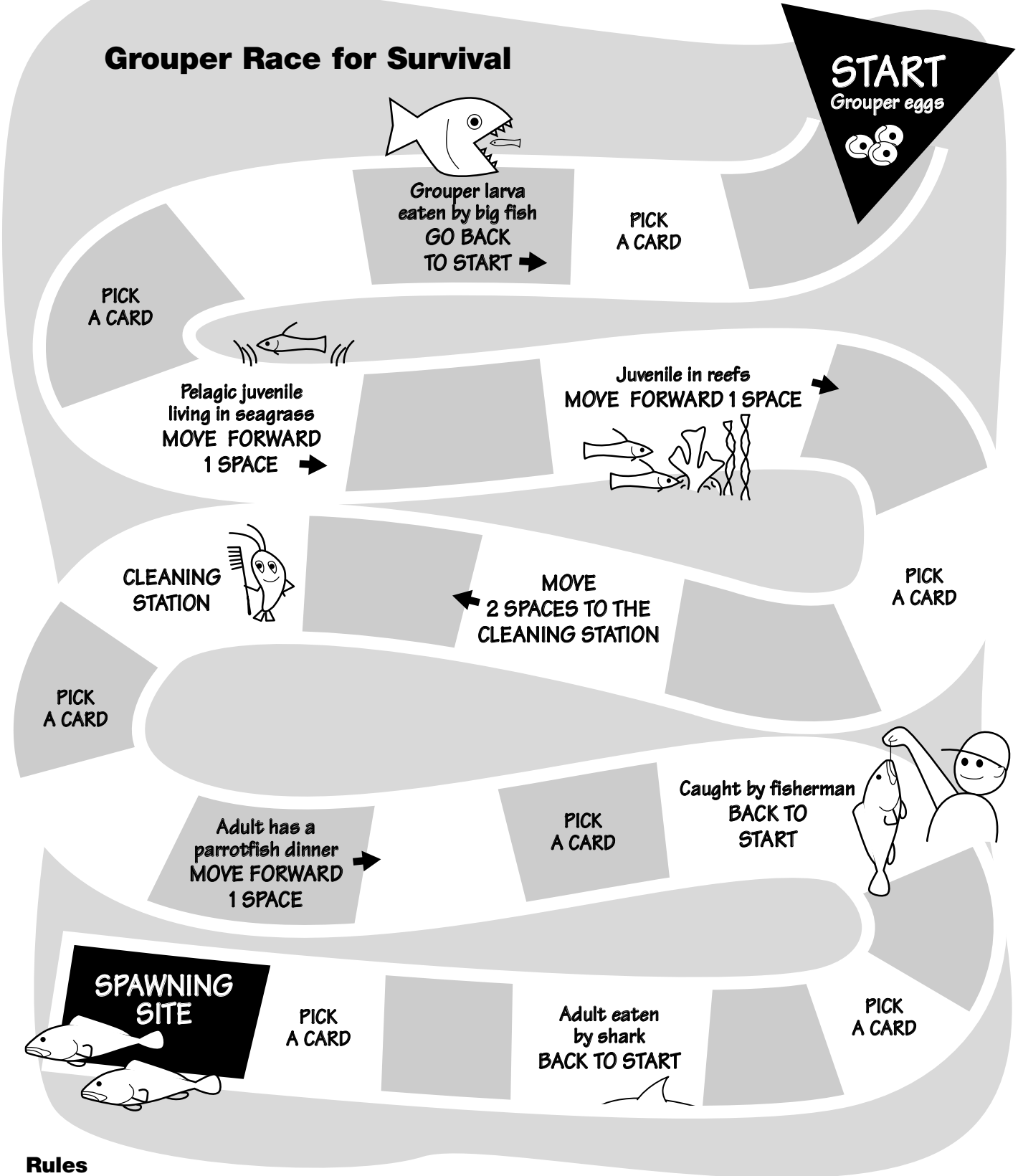
Resources

Perry Institute for Marine Science – Caribbean Marine Research Center. 2004. Poster series #3: Nassau Grouper. Jupiter, Florida. www.perryinstitute.org

Grouper Race for Survival Game Cards

Welcome to the fish buffet! Abundant food supply **move ahead 1 space**	*I'm starving!* Food shortage **move back 1 space**	*Whew! That was close!* Undersized grouper caught, but returned to the sea **move ahead 1 space**
Who wrecked my place? I'm moving! Reef damage **move back 2 spaces**	*Protection perfection!* Fishing laws enforced **move ahead 2 spaces**	*We had 452,000 girls and 563,000 boys!* Spawning sites protected **move ahead 2 spaces**
Eat beef! Overfishing of groupers **move back 2 spaces**	*I can't take this heat!* Increasing water temperature **move back 1 space**	*Swim for your life … !* Hurricane **move back 2 spaces**
Do you smell bleach? Illegal fishing practices **move back 1 space**	*The camera loves me!* Divers take pictures not fish **move ahead 1 space**	*A place to call my own!* National park created **move ahead 1 space**

Grouper Race for Survival



Rules

1. Shuffle the game cards and place them face down.
2. Each player rolls the die. The one who rolls the highest number plays first. (For additional rounds between the same players, the winner plays first.)
3. Place playing piece on the start space.
4. Roll the die and move the playing piece ahead the number of spaces indicated on the die.
5. If a player lands on a space with instructions, that player must move his or her playing piece accordingly. If the player lands on a PICK A CARD space, that player must take the top card, read it aloud and follow the instructions. Afterwards, the card should be placed face down at the bottom of the stack.
6. The first player to arrive at the spawning site is the winner!

4 Complete CYCLE

Play a BINGO-style game to review the life cycle of the queen conch, crawfish, and Nassau grouper.

Learning Objectives

- Name the major stages in the development of the queen conch, crawfish, and Nassau grouper
- Describe the characteristics of the different stages in the life cycles of the queen conch, crawfish, and Nassau grouper

Grades

5 – 6

Subjects

Science, Language Arts, Music

Skills

organising (matching), analysing (identifying components and relationships among components), interpreting (translating, summarising), presenting (explaining, writing)

Vocabulary

juvenile, **larva, metamorphosis, plankton, predator**

Time

1 hour

Materials

CYCLE game card for each student (page 91), game chips (300 or so), "CYCLE Clues" (page 90), scissors, glue, dry-erase marker, conch, crawfish and grouper posters (Perry Institute for Marine Science – CMRC)

Conch, crawfish, and grouper all begin life as eggs. Larvae emerge from these eggs that are so tiny that they can hardly be seen without the aid of a microscope. These tiny animals float in the plankton, carried by ocean currents. They undergo many changes as they become juveniles. There are many predators of these young animals, making it a challenge for them to survive to adulthood. When they are fully mature they are able to reproduce and have young of their own. This activity reviews what students have learned about life cycles in the "Conch Life Cycle Wheel," "Crawfish Mobile," and "Grouper Race for Survival" activities.

Before You Begin

Photocopy and laminate "CYCLE Clues" (page 90). Photocopy half as many game cards (page 91) as there are students. Randomly write answers from the clue sheet in the blank squares to complete the cards, making sure that each card is unique. Photocopy each card so that there are two of each — there will be two winners. Laminate cards for reuse and durability. (For subsequent use, you can keep originals and create more cards until you have a full set of unique cards.)

C – Y – C – L – E

by Monique Sweeting
(to the tune of BINGO)

Conch, crawfish, grouper need to grow
So we can have some more you know!

C – Y – C – L – E
C – Y – C – L – E
C – Y – C – L – E
Egg, larva, juvenile, adult

What To Do

1 Get ready to play. Begin by singing the song CYCLE to review the major stages of the life cycle. Use the posters to review the characteristics of these stages for conch, crawfish, and grouper. Pass out the game boards and chips. Tell the students that they will use what they have learned about the life cycles of the conch, crawfish, and grouper to play a game that is a lot like BINGO.

2 Explain and play the CYCLE game. The objective of the game is to find answers to the clues on the game board and be the first to complete a row horizontally, vertically, or diagonally.

a. Read each clue, allowing time for students to find what they believe is the correct answer and cover it with a chip. You can read the clues in any order, numbering each with the dry-erase marker as it is called.

b. Tell the students when a picture is the answer to a clue.

c. When a student has marked answers in a row horizontally, vertically, or diagonally, the student calls, "CYCLE complete."

d. Verify that the spaces the student marked on the game board correspond to the clues given.

Assessment

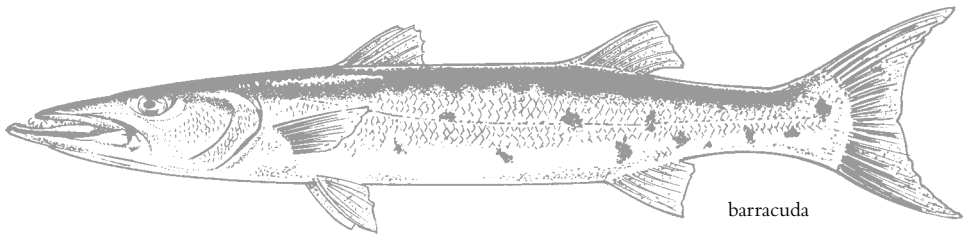
Have students choose the queen conch, crawfish, or Nassau grouper and write an essay describing the major stages in its life cycle including habitat, food sources, and predators at each stage, and major facts about reproduction: when it occurs, age at reproduction, and how many eggs are laid. Students who selected the same species can then compare their work and fill in a column in a table on the board summarising the information for all three.

Extensions

Use the "CYCLE Clues" to play a team trivia game. Divide the class into two to four groups. Flip a coin to determine which team goes first. Ask each team a question in turn. Make sure to ask all teams the same number of questions. Teams can huddle and work together to come up with the correct answer. *(Indicate when a clue refers to a picture and have the students come up and point out the correct image among those you have displayed at the front of the room.)* Score 10 points for a correct response.

Resources

Perry Institute for Marine Science – Caribbean Marine Research Center. 2004. Poster series #1: Queen Conch, Poster series #2: Spiny Lobster, Poster series #3: Nassau Grouper. Jupiter, Florida. www.perryinstitute.org

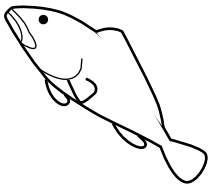
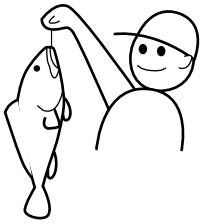
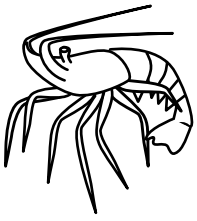


barracuda

CYCLE Clues

#	Clues	Answers
	Shedding the exoskeleton in order to grow a new one	moulting
	The physical changes that make the larva a juvenile	metamorphosis
	The stage after the egg	larva
	The gathering of grouper in large numbers to mate	spawning aggregation
	The part of the conch that is flared when it is an adult	lip
	A predator of adult conch, crawfish, and grouper	humans
	Picture clue: This is a grouper	grouper (picture)
	Picture clue: This is a conch	conch (picture)
	Picture clue: This is a crawfish	crawfish (picture)
	The colour of crawfish eggs	orange
	The female crawfish carries eggs under this part	tail
	This is observed in the night sky during grouper spawning	full moon
	All the tiny organisms that float in the sea	plankton
	What a baby conch is called	veliger
	Where juvenile conch bury themselves	sand
	Picture clue: This is where adult crawfish live	reef (picture)
	The number of eggs a crawfish has	millions
	This is the first stage of development	eggs
	This is the stage after larva(e)	juvenile
	A fully developed grouper, crawfish, or conch	adult
	To have young	reproduce
	The stages a creature goes through in its lifetime	life cycle
	To come out of the egg	hatch
	Picture clue: Removing fish from the sea	fishing (picture)

CYCLE Game Card

C	Y	C	L	E
				
				
		FREE		
				

SECTION 4

The "X" Marks the Spot

Marine Habitats

A habitat is a place where an animal or plant lives, and where it gets the nutrients, water, shelter, and space it needs to survive. In this section, students explore the diversity of marine habitats in The Bahamas, including rocky and sandy shores, mangrove wetlands, seagrass meadows, hard bottom, coral reefs, and the pelagic zone. Students identify components that make these habitats home for the conch, crawfish, and grouper — and many other marine organisms. The activities challenge students to creatively illustrate, describe, and present what they learn.

1 Home Sweet Habitat

Students research the characteristics of habitats of different marine creatures. They then use their findings as the basis for creating a classroom mural.

Learning Objectives

- Define habitat
- Identify the links among marine habitats
- Describe how organisms relate to one another and to their physical environment

Grades

3 – 6

Subjects

Science, Art, Language Arts

Skills

gathering (researching), organising (arranging, drawing), analysing (identifying components and relationships among components, discussing), applying (planning), presenting (writing, illustrating, reporting), citizenship (working in a group)

Vocabulary

brackish, community, **ecology, habitat, plankton** (zooplankton, phytoplankton)**, mangrove, pelagic, benthic**

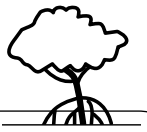
Time

1 hour to introduce the subject and to prepare the posters
1 hour for poster presentation and mural construction

Materials

For each student: 1 copy of the "Marine Habitats Diagram" (page 97)
For each group: 1 habitat card from "Marine Habitat Descriptions" and the corresponding list of organisms (pages 98 – 99), 6 sheets of poster paper, art supplies (markers, coloured pencils, crayons, construction paper, blue cellophane paper or plastic wrap for "water," scissors, paste), index cards (optional), Bahamas National Trust habitat fact sheets (optional), masking tape or putty adhesive

It may not be apparent from the surface, but the underwater world is as diverse as the world above. And depending where you look in the ocean, you will find different quantities and types of organisms, each suited to a type of habitat and its specific features. For example, the animals and plants that live close to the surface of the ocean require more light and warmer temperatures than those found down below. And some animals require open spaces while others seek small caves and crevices.



Most of the fish living primarily in the pelagic zone use coral reefs, mangroves, and other coastal regions for reproduction and for nurseries for their young.

Before You Begin

Refer to the background information (page 2) for descriptions of marine ecosystems and habitats common in The Bahamas. Make a copy of the "Marine Habitats Diagram" (page 97) for each student. Copy and cut out each marine habitat description (page 98) and a sample list of organisms for a specific habitat (page 99). Collect books, magazines, and pictures that illustrate the habitats in the diagram and the sample organisms (see "Suggested Resources" on page 198 or visit treasures.amnh.org).

What to Do

1 Discuss marine habitats. Distribute a copy of the "Marine Habitats Diagram" to each student. Explain that these are some of the many habitats in Bahamian marine environment. Ask students to define "habitat." If students need prompts, ask them about where they live (home, neighbourhood, street) and what resources they need in order to survive, such as water, food, air, and shelter. They can find all of these things in their "habitat" (their home or neighbourhood) and, just like in their own neighbourhoods, each habitat has a distinct "community" of inhabitants, or the living things that interact in an area.

Ask students what plants and animals they have seen when walking along the coast or swimming, snorkelling, or diving in the ocean. List these on the board and talk about the habitats where they may be found.

2 Introduce the mural-making activity. Explain that students will create an ocean mural to exhibit in the classroom or elsewhere in the school. Working in groups, they will illustrate unique features and organisms that compose and use a specific marine habitat. The illustrations will then be connected in a mural.

Divide the class into six groups and give each a habitat description (or let them pick from a hat) and the list of corresponding organisms. *(With older students, you can further divide coral reef habitat into patch reef, reef crest, and reef front. See background information on page 5.)* Distribute art supplies listed in "Materials." Students can reference relevant habitat fact sheets available from the Bahamas National Trust, and the books, magazines, or pictures you collected.

3 Create habitats. In their habitat groups, students should discuss the important features to include in their illustrations. They may wish to start with certain habitat elements such as the reefs or mangroves, then think about the community of organisms that live in or around them. Which organisms can be found in the sand or among the rocks? Which are attached to something else? Which are swimming?

Encourage students to represent their habitats with as much detail as possible, using colours and textures for drawing organisms, cutting out pictures from magazines, or folding paper to create three-dimensional forms. Ask them to consider size differences among organisms. For example, some plankton are half a centimetre (1/8 in.) long while a shark can be 3.5 – 6 m (12 – 20 ft.) long. Students can magnify or reduce the size of organisms in order to make them appear closer or more distant. Students may create labels — like those in a museum or aquarium — on index cards, describing the main features of their habitat and identifying each of the organisms included.

Hurray for Plankton!

Plankton are a diverse group of animals (zooplankton) and plants (phytoplankton) that drift with currents and tides because they have limited or no swimming ability. They range in size from microscopic bacteria and plants to larger organisms, such as jellyfish. Plankton communities form the base of many ocean food chains.

4 Link the habitat posters to make an ocean mural. Place the habitat illustrations in a series to create a mural based on the "Marine Habitats Diagram." Have each habitat group prepare a brief presentation (five minutes) and designate a representative to describe:

- Which species are in the habitat
- How these species meet their basic needs in this particular habitat

5 Discuss linkages among the habitats. Based on what they see in the mural and what they heard in the presentations, ask students how they think the habitats may be linked. Explain how animals will use various habitats for different purposes. For example, young crawfish can be found in areas near the shore, such as mangrove wetlands and seagrass meadows, but once they reach maturity they move out to deeper reef habitats. Ask students to identify other animals that appear in more than one habitat in the mural. Are there any others that they think would use additional habitats, perhaps at various stages in their life cycles or during different seasons?

Assessment

Based on the learning objectives of this activity, develop a rubric (see page 23) with students to assess how well they make connections between organisms and their habitat, and the accuracy of information they present. Use this rubric to assess posters and presentations, or have students do a peer review in which one group evaluates the work of another.

Students can also write a description of their habitats, giving examples of organisms that form the communities that live there. Have them define "habitat" in their own words. Create a rubric to assess written pieces.

Extensions

- Take a field trip to an aquarium, beach, or rocky shoreline (see "Sea for Yourself," page 30).
- Invite other classes, parents, or community members to look at the mural. Help students create invitations describing the mural exhibit.
- As homework, have students select an animal from their poster to research how it uses its habitat and what other habitats it may need to survive. Students can report their findings in writing or orally to teach their classmates.
- Have students come up with at least one animal or plant from the marine environment that is important in Bahamian culture or to the economy. Students can write reports to explain why the species is important and present them to the class.

Resources

Bahamas National Trust habitat fact sheets.

The Magic School Bus on the Ocean Floor by Joanna Cole (New York: Scholastic, 1992) Ms. Frizzle's class takes an underwater field trip and makes a classroom mural.

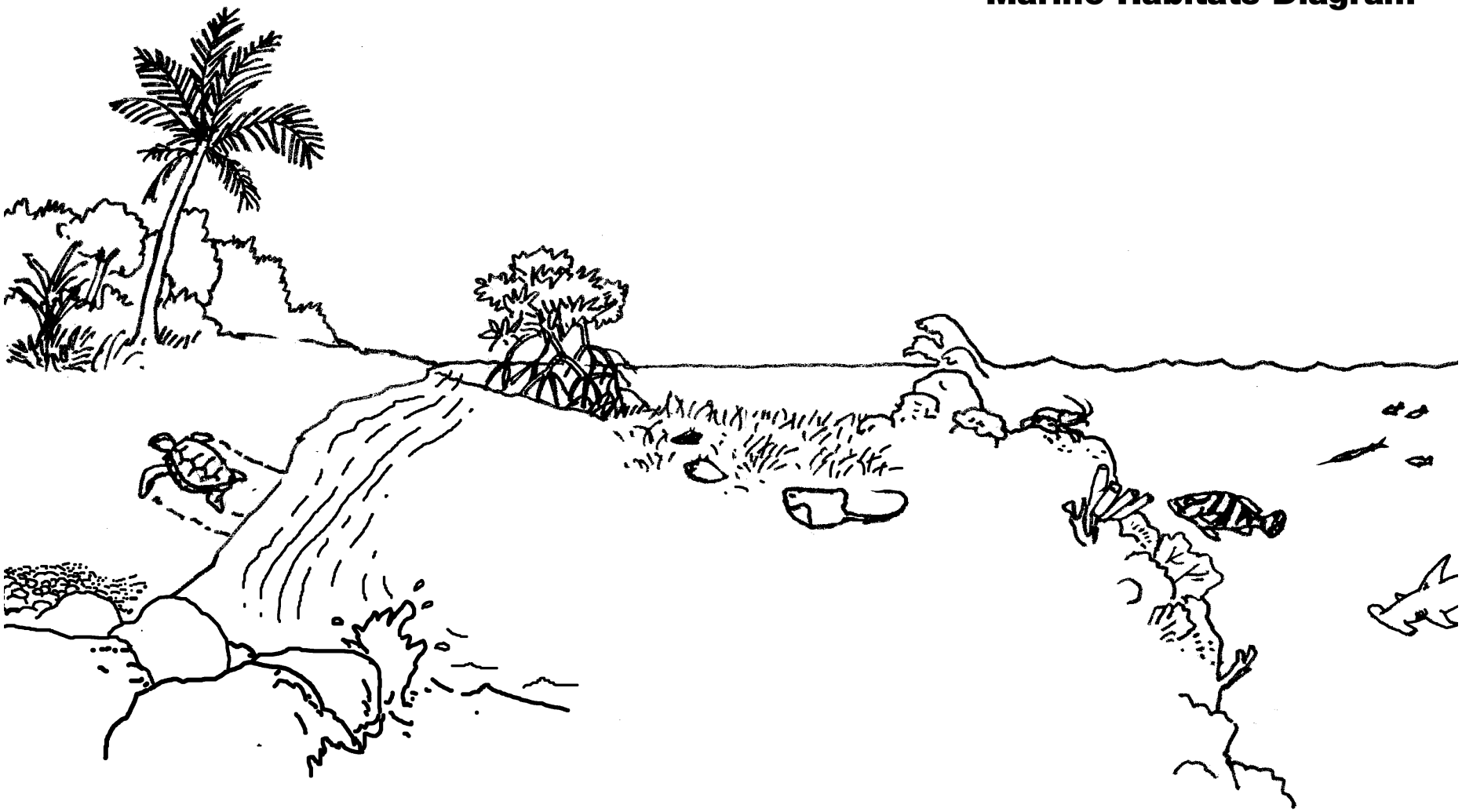
Adapted with permission from "Habitat is a Home," an activity in *Fishing for the Future: Marine Conservation and Resource Management* © 2005, published by Conservation International in collaboration with the National Department of Education and Milne Bay Provincial Government.

Additional ideas from:

"Coral Reef Zones Color Page and 3-D Mural" in *Coral Reef Teacher's Guide*. 2004. Reef Relief. www.reefrelief.org/publications/print/pdf/Teachers_Guide.pdf

"Sea No Evil: Investigating Marine Life at Various Ocean Depths" by Jackie Glasthal, The New York Times Learning Network, www.nytimes.com/learning. Developed in Partnership with the Bank Street College of Education in NYC.

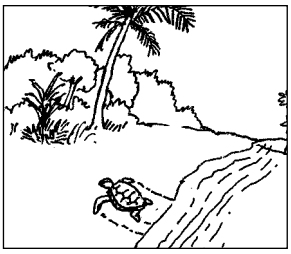
Marine Habitats Diagram



Beach **Rocky shore** **Mangrove wetland** **Seagrass meadow** **Coral reef** **Pelagic zone**

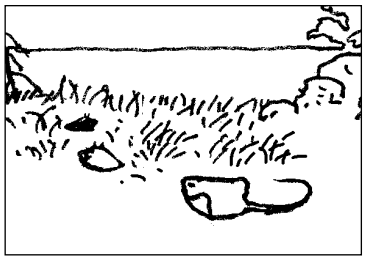
Marine Habitat Descriptions

Beach (sandy shore)



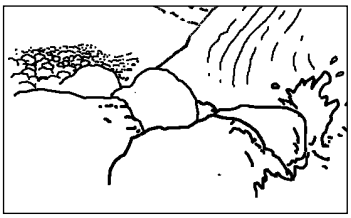
Most sandy beaches of the Caribbean are made of calcareous (lime-based) sands that are the remains of the skeletons of the animals and plants that built the banks and the coral reefs. By examining a handful of sand, you may be able to distinguish fragments of mollusk shells, corals, and algae. Animals such as sea turtles and some shore birds use the beaches to lay their eggs and build nests.

Seagrass meadow



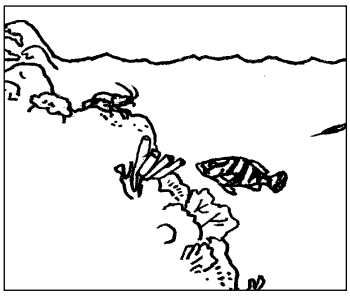
These are areas of submerged grasses that provide important habitats for feeding and nursery areas. Many fishes, including seahorses and razorfish, and also other animals such as turtles, conch, and ballyhoo live here.

Rocky shore



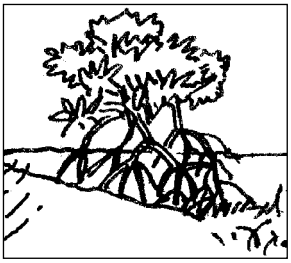
A variety of plants and animals live along rocky shores despite the challenges they face with the rise and fall of tides and the constant beating of the waves. At low tide, animals such as barnacles and limpets are exposed to predators like birds, mollusks, and crabs. At high tide they can become the prey of fish, such as snappers. Submerged shores provide nursery areas and shelter in cracks and crevices for invertebrates, such as crawfish, and for fish like blennies and gobies.

Coral reef



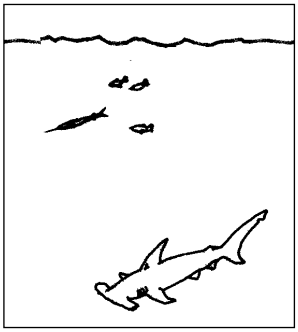
Reefs provide shelter and food for groupers, parrotfish, and thousands of other marine animals. This benthic community is diverse, including corals, sponges, gorgonians, and algae. These "rainforests of the sea" are extremely important to Bahamians as a source of food, recreation, and tourism.

Mangrove wetland



In the shallow, brackish waters along coasts and in creeks of Bahamian islands, mangrove tree roots provide nursery habitat for many important fish species, such as the Nassau grouper and the gray snapper. Mangroves in and around estuaries also provide living space for other animals, such as crawfish, land crabs, bats, and birds.

Pelagic zone



Also called the open ocean, this zone encompasses all waters above the bottom of the ocean and it is where millions of larvae and other drifting organisms (plankton) are usually distributed. The open ocean is a major "roadway" for migratory species like turtles, whales, and dolphins.

Sample List of Organisms

Beach (Sandy shore)

- Sea oats
- Bay geranium
- Sea grape
- Bay cedar
- Green turtle (nesting)
- Laughing gull
- Ruddy turnstone
- Wilson's plover
- Yellow legs (shore bird)
- Hermit crab
- Common sea star
- Sand dollar
- Plankton

Seagrass meadow

- Turtle grass
- Queen conch
- Crawfish
- Stovepipe sponge
- Rosy razorfish
- Longsnout seahorse
- Southern stingray
- Cushion sea star
- Stone crab
- Plankton

Rocky shore

- Red and green algae
- Chiton (curb)
- West Indian top snail
- West Indian top shell (whelk)
- Keyhole limpet
- Bleeding tooth snail
- Domingo mussel
- Mat anemone
- Juvenile sea star
- Common hermit crab
- Black sea urchin
- Blenny (fish)
- Fairy basslet
- Sergeant major
- Plankton

Coral reef

- Stoplight parrotfish
- Nassau grouper
- Porcupinefish
- Spotted moray eel
- Damselfish
- Crawfish
- Reef sharks
- Southern stingray
- Bluehead wrasse
- Barracuda
- Sea fan
- Sea anemone
- Sea urchin
- Brain coral
- Elkhorn coral
- Plankton

Mangrove wetland

- Red, black, white, buttonwood mangroves
- Red and green algae
- Flagfin mojarra (scad)
- Great barracuda (juvenile)
- Mangrove gambusia (mosquito fish)
- Mangrove /gray snapper
- Great blue heron
- Snowy egret
- West Indian whistling-duck
- Mangrove oyster
- Queen conch (juvenile)
- Nassau grouper (juvenile)
- Crawfish (juvenile)
- Green turtle
- Plankton

Pelagic zone

- Spotted eagle ray
- Hammerhead shark
- Flat needlefish
- Wahoo
- Yellow jack
- Frigate bird
- Royal tern
- Black jack
- Dolphinfish (mahi mahi)
- Marlin
- Bottlenose dolphin
- Beaked whale
- Green turtle
- Whale shark
- Plankton

2 Real Estate for Royalty

Students learn about the habitat requirements of queen conch by creating a "real estate brochure" highlighting food, shelter, and other features.

Learning Objectives

- Describe the habitat requirements of a queen conch
- Describe stresses to conch and threats to its habitat

Grades

4 – 6

Subjects

Science, Language Arts

Skills

gathering (reading comprehension, researching), analysing (discussing), presenting (writing, illustrating), citizenship (working in a group)

Vocabulary

habitat, herbivore, migration, predator, seagrass

Time

1½ – 2 hours

Materials

a copy of "Conch Client Profile" (page 103) for each student; books and fact sheets with information and illustrations of conch, or queen conch poster (Perry Institute for Marine Science – CMRC); drawing paper and coloured pencils; real estate ads or brochures (see example on page 101 or ask students to find an example to bring to class for analysis)

A habitat is a place where an animal or plant finds the nutrients, water, sunlight, shelter, living space, and other essentials it needs to survive. "Home Sweet Habitat" (page 94) introduces students to the marine habitats of The Bahamas and the types of creatures that live in them. In this activity, students focus on the features of queen conch habitat.

Seagrass beds provide important habitat for queen conch. Here they can find algae to eat on the glass blades. This habitat is characterised by shallow warm water with a sandy substrate or bottom, where there is an abundance of seagrasses, such as turtle and manatee grass (see "Conch Client Profile" on page 103). Seagrasses perform important ecological and economic functions in coastal areas worldwide. They provide habitat for fish and shellfish and serve as nursery areas for many marine species. They also help filter coastal waters, dissipate wave energy, and anchor sediments.

Before You Begin

Photocopy the "Conch Client Profile" and collect reference materials.

What to Do

1 Review the term "habitat." If you haven't already introduced the habitat concept, you can use the "Home Sweet Habitat" activity (page 94) to do this.

2 Analyse real estate brochures or advertisements. (See example on the facing page.) Real estate literature shows the kind of "habitat" someone might be interested in buying or renting. Ask students what type of information is included in the ad *(location, size, access to restaurants and water, access to shopping, type of neighbourhood, attractive views, safety, recreation).*

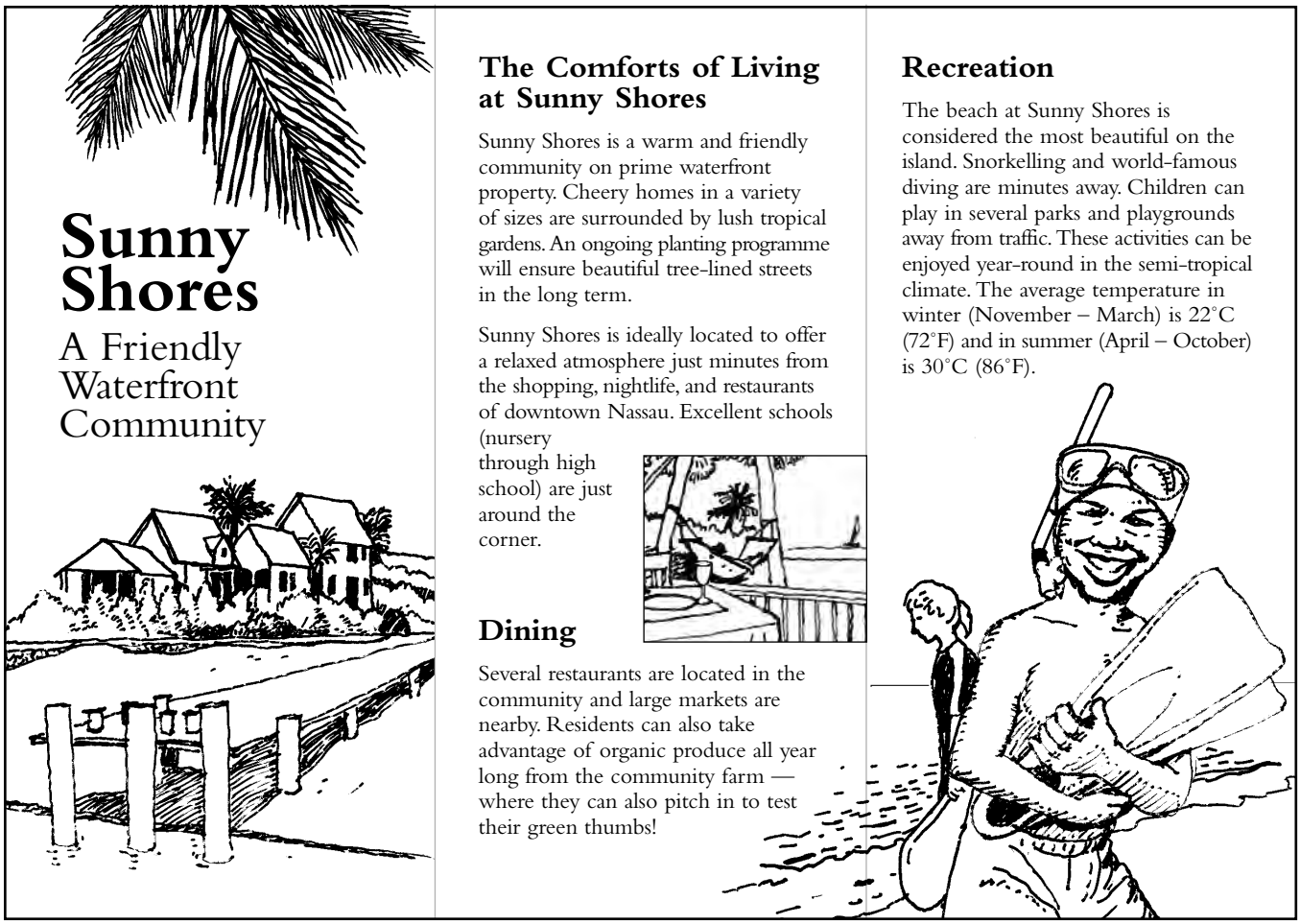
This type of information is similar in some ways to what the conch needs in a habitat — shelter, food, and protection from predators or other dangers. Ask students to look for descriptive words (adjectives like unique, charming, exclusive) and phrases in the ads that help make the property sound attractive. Can students identify any examples?

3 Divide students into pairs or teams and explain the activity. Each pair or team of students represents a real estate agency that has a habitat to offer that would be appealing to a conch at some point in its life cycle. They will make a brochure to highlight important features. Provide each group with copies of the "Conch Client Profile" and have other reference materials available.

4 Students research and create a real estate brochure about a conch habitat.

Guiding questions:

- What makes the habitat a good home? Describe conditions such as light and temperature (is the water warm or cold?).
- What shelter does the habitat offer (from predators or other dangers)?
- What food is found there for a conch? Students can describe "local restaurants" (like the Seagrass Café) and the dishes they serve.
- Are there any other features of the habitat that are important for conch? For example, is there access to



breeding areas or nursery areas for the young? Is it a good place for long term or short term conch residency? (The latter might best be marketed as a seasonal rental, perhaps a romantic mating spot.)

- Can students identify an actual location around their island or elsewhere in The Bahamas where the habitat is located?

Once students have collected all of the information they need, they should think about how to present it in a brochure using descriptions and illustrations to entice a conch to buy or rent. Encourage them to be creative! Students can think of names for the property they are selling and for their agencies, if they like.

The last page of the brochure can be used to describe current or potential problems with the habitats students describe. For example, students should mention things such as fishing pressures and land-based activities that impact conch and their habitat.

Assessment

Explain the scoring rubric, or criteria, by which students' brochures will be evaluated, for example:

- Provides a clear description of the conch's major habitat (1 point)
- Describes at least two of the habitat requirements of the conch (1 point)
- Describes at least one of the food requirements of the conch (1 point)
- Describes at least one stressor (such as predators or impact on habitat) that may affect the survival of the conch (1 point)

Total of 4 points

Extensions

Ask each student to write down four things they can do at home to protect the habitats of the queen conch. Students can make posters to exhibit at school or in the community illustrating these actions and why they are important.

Resources

American Museum of Natural History. 1996. Queen Conch: One in a (Half) Million. In *Endangered!: Exploring a World at Risk*. New York: AMNH. www.amnh.org/nationalcenter/Endangered/conch/conch.html

Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute. Queen Conch Sea Stats. research.myfwc.com/products/product_info.asp?id=1595

Perry Institute for Marine Science – Caribbean Marine Research Center. 2004. Poster series #1: Queen Conch. Jupiter, Florida. www.perryinstitute.org

UNEP World Conservation Monitoring Centre, Marine Programme. 2003. *World Atlas of Seagrasses.* www.unep-wcmc.org/marine/seagrassatlas/introduction.htm

Inspired by: "Reef Real Estate in the South Atlantic Bight," an activity developed by Stacia Fletcher in *Islands in the Stream 2002: Exploring Underwater Oases*, published by the National Oceanic and Atmospheric Administration's Ocean Explorer Program, oceanexplorer.noaa.gov/explorations/02sab/background/edu/media/sab_lessons.html; and by the South Carolina Aquarium's Sixth-Eighth Grade Online Curriculum, www.scaquarium.org/curriculum/iexplore/sixth_eighth/units/reefs/reefs_main.htm

Conch Client Profile

To find the best home, or habitat, for your client, the queen conch *(Strombus gigas)*, it is important to understand its needs.

Queen conch live in shallow, warm waters of the Caribbean region, usually where there is a lot of seagrass, like turtle and manatee grass. The conch is a herbivore, or plant eater. Juvenile and adult conch eat a variety of algae, including tiny algae that are found on sand, seaweed, and seagrass blades, and on floating organic debris. The queen conch moves slowly, but may wander in order to graze — up to 1.5 km (1 mile) in 2 months and more than 640 m (700 yards) in a week.

As they grow, conch move to increasingly deeper waters, though they are rarely found at depths greater than 21 m (70 feet). Conch may also shift habitats seasonally, moving from nearshore seagrass beds to deeper offshore feeding areas in winter. They seek open sand areas when it's time to mate in summer and early fall.

At about 3 to 4 years of age, conchs reach their full length. Their shells continue to thicken until they have a fully developed lip. At this point conchs are able to reproduce. To mate, conchs gather in large groups, or aggregations, in shallow, sandy habitats. Four to 5 days after fertilised eggs are laid, the larvae emerge. They travel great distances with the currents for the first few weeks of their lives. As juveniles they settle to the ocean floor, where they spend much of their first year buried in sand or sediment — a good way to avoid danger! Few conchs survive to adulthood, instead becoming food for many ocean organisms. Those that do survive may live up to 25 years.

Adult queen conch are eaten by loggerhead sea turtles, horse conchs, stingrays, leopard rays, and humans. The beautiful shell is also collected by people and used for jewellery and for conch trumpets. To avoid predators, queen conch often hide in the sand during the day and eat at night. The queen conch is a relatively slow-growing animal, so populations cannot be replaced quickly.

The conch's seagrass habitat is often close to, and ecologically linked with, reefs, mangroves, salt marshes, and other marine habitats. Runoff from human activities on land has major impacts in the coastal regions where seagrasses grow. Direct harm to seagrass beds occurs from boating, construction in the coastal zone, and destructive fishing practices. Global climate change — driven by human activities — may also impact seagrass distribution as sea level rises and severe storms occur more frequently.

3 Where the Wild Fish Are

Students learn about various marine habitats as they meet a variety of fish species and determine where each one lives.

Learning Objectives

- Identify some of the major marine habitats in The Bahamas
- Learn about the habitat requirements of a Caribbean fish species
- Identify links among habitats

Grades

3 – 6

Subjects

Science, Language Arts, Mathematics

Skills

organising (categorising, arranging), analysing (identifying patterns, discussing), interpreting (relating)

Vocabulary

benthic, brackish, habitat, mollusk, pelagic, trawl

Time

1 hour

Materials

For each student: 1 species card from "Caribbean Fish Cards" (pages 107 – 112), a short piece of string (optional)

For the class: 1 copy of the "Habitat Clues" (page 114); enlarged drawing of "Marine Fish Habitats" (page 113) or use the class mural if students have completed the "Home Sweet Habitat" activity (page 94), concealing the habitat names for this activity; scissors; tape; crayons, coloured pencils, or markers (optional)

Students may be surprised to learn that vast expanses of water in the ocean that seemingly look alike actually include many different habitats. Each of these habitats supports different species and plays a different role in ocean ecology. Many fish spend the majority of their time in a particular habitat, but depend on other habitats as well during various stages of their lives or different seasons. Refer to the background information (page 2) for more information on the common marine habitats in The Bahamas. This activity can be used as a reinforcement or assessment of the "Home Sweet Habitat" activity (page 94).

Why are Coral Reefs Important?

Coral reefs are formed by a variety of corals and numerous other animals and plants. Though reefs cover less than 1% of the Earth's surface, they have the highest biodiversity of any marine ecosystem. Coral reefs provide shelter and food for thousands of marine animals including species that are a primary food source for many people around the world. Reefs also protect coastlines from storms and wave erosion. However, they are also one of the most threatened marine ecosystems in the world because they are vulnerable to pollution, destructive fishing practices, and other problems caused by people.

Before You Begin

Copy and cut out the "Caribbean Fish Cards" on pages 107 – 112 and fold them along the dotted lines. Enlarge the "Marine Fish Habitats" drawing (page 113) on a large piece of paper or use the mural created in "Home Sweet Habitat" (page 94). Copy and cut out the "Habitat Clues" on page 114. Fold the clues and place them in a hat or bucket.

Find a guide book on the fish of the Caribbean (e.g., Paul Humann's *Reef Fish Identification: Florida, Caribbean, Bahamas*).

What to Do

1 Discuss what students know about marine fish. Ask students to name fish they have seen in an aquarium or while walking along the shore, or snorkelling or fishing. Write these on the board, listing only fish (queen conch, for example, is a mollusk and a sea star is an echinoderm — list these in a column with non-fish organisms). Ask students to name the marine habitats where they think these fish live and write these next to the names. *(Use a field guide to the fish of the Caribbean to identify any on the list — such as aquarium fish — that may be exotic.)* Explain that the next part of the activity will help students identify habitats of fish in the waters of the Caribbean region.

2 Learn about a fish species. Ask students if they know what the term "species" means. *(A species is a group of organisms that has a unique set of characteristics — such as body shape and behaviour — that distinguishes it from other organisms. If they reproduce, individuals within the same species can produce fertile offspring.)* Give each student a species description card or have them pick a card from a hat. Depending on the class size, students may need to work in pairs or groups, or conversely, work on two types of fish. Tell students that their job is to read the information about the fish and determine the habitat in which it lives. They may also colour the fish. *(You may wish to mention that while some fish, such as the Bahama gambusia — also popularly known as mosquito fish — is found only in The Bahamas, other species such as the dolphinfish or mahi-mahi are found throughout the Caribbean and in the Pacific Ocean as well.)*

3 Discuss marine habitats. While the students are preparing their fish, hang up the "Marine Fish Habitats" drawing. Ask students to imagine they are walking into the water right off the beach. What is the ocean like? *(Shallow, cooler in winter but warmer in the summer.)* If they were able to keep walking into deeper water, how would their surroundings change? *(There may be only sand, or algae, then corals — then it may get darker and colder. Fewer or no plants would be growing on the ocean floor, there would be fewer or no coral reefs, and so on.)* Conditions such as these — sunlight, temperature, and the presence of other marine organisms — influence where their fish may live. While many fish spend most of their time in one particular habitat, other habitats may be important for reproduction, or during juvenile and adult stages of their life cycles.

4 Identify the habitats on the drawing. To label the habitats in the drawing, have one student pick a habitat clue out of a hat and read it to the rest of the class. *(Note that there are two clues for each habitat. For younger students you can let them read both clues, but to make it more challenging for older students, have them read only one clue at a time.)* Ask the class to guess which habitat the clue describes. When they answer correctly, you or a student can write the name of the habitat on the drawing. Have another student pick and read the next clue and so on until all of the habitats in the drawing are labelled.

5 Affix fish to the "Marine Fish Habitats" drawing. Invite students to come forward and place their fish in the habitat on the drawing where they think their fish lives. Ask them to read their fish descriptions aloud and explain what information led them to select this habitat. Students can either tape the fish in its habitat, or tape it nearby and connect it to the habitat using a piece of string. *(Some fish descriptions mention more than one habitat type, so students can choose the one where they think the fish spends most of its time.)*

6 Discuss results. After students have matched fish species with their habitats, use the following points to guide discussion.

a. "Biodiversity" is a word that means the variety of life, including genes, species, and habitats. What type of biodiversity does the drawing illustrate? *(It includes a variety of fish species and the marine habitats where they live.)*

b. What are some reasons why a species of fish would favour a particular marine habitat? *(Preferred food sources, water temperature or depth, shelter from predators, etc.)*

c. Ask students to count the number of fish species in each habitat and rank the habitats from most to least. Which habitat has the most fish in it? What are some possible reasons for this? *(Corals create many different structures, such as caves and holes, which serve as spaces for a variety of species to live. Warm water, abundance of light, and the presence of vegetation also contribute to an ideal habitat for many different species.)* While the coral reef provides the primary habitat for many of the fish species in the activity, discuss how links among the habitats are important. Many fish spend a planktonic phase in the pelagic zone and use mangroves wetlands and seagrass meadows as nurseries. The health of any one habitat type is very much dependent upon that of adjacent habitats.

Assessment

Ask students to draw a cross-section (side view) of the marine habitats — or you can make a copy of the drawing for them to complete. They should label the habitats and name a fish that would live in each habitat.

Marine Fish Habitats Answer Key

Sandy shore [5,10, 11, 12, 13, 23]; Rocky shore [24], Mangrove wetland [3, 5, 6,7, 23, 24]; Seagrass meadow [1, 2, 5, 6, 8, 9]; Coral reef [1, 2, 3, 4, 6, 8, 9, 10, 18, 19, 20, 21, 22, 24]; Pelagic zone [14, 15, 16, 17]

Good cross-sections should identify at least four to six habitats with at least one fish assigned correctly to each.

Extensions

- Students can create field guide entries for each of the species highlighted in the "Caribbean Fish Cards." A field guide is used to identify animals or plants. Each entry should include information on the species such as its common and scientific names, size, colouration, habitat, range, and preferred diet.
- Have each student choose one species of fish and write a short report on it. The report should describe its preferred food, geographic distribution, method of reproduction, and other interesting aspects of its life and behaviour. They can also try to explain why they think their fish has a particular name (some names describe physical characteristics of the fish).
- Take a field trip to an aquarium or a beach to observe fish species and/or habitats. (See "Sea for Yourself," page 30.)

Resources

FishBase. A database searchable by common or scientific name, location, topic, or many other criteria. www.fishbase.org

National Audubon Society Field Guide to Tropical Marine Fishes of the Caribbean, the Gulf of Mexico, Florida, the Bahamas, and Bermuda by C. Lavett Smith and National Audubon Society. (New York: Knopf, 1997)

Reef Fish Identification: Florida, Caribbean, Bahamas, 3rd Edition by Paul Humann, edited by Ned Deloach. (Jacksonville, FL: New World Publications, 2002)

Caribbean Fish Cards

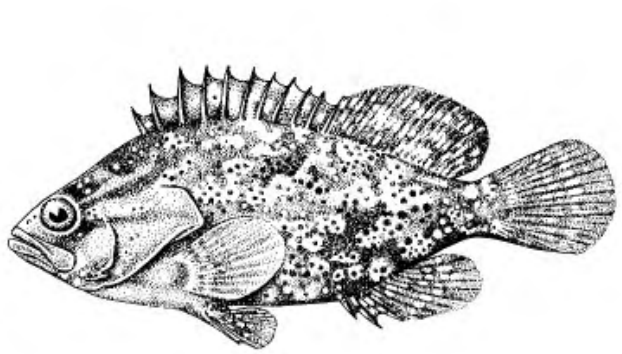
You may wish to enlarge illustrations for classroom use. Note that they are not to scale.

1

Mutton hamlet

(Alphestes afer)

This is a small colourful grouper with brownish or orange scales, orange spots, and darker brown spots forming vertical lines. It may let you come close to observe — if you are able to find it. It camouflages well in the colourful reef rubble and grassy beds that it prefers.

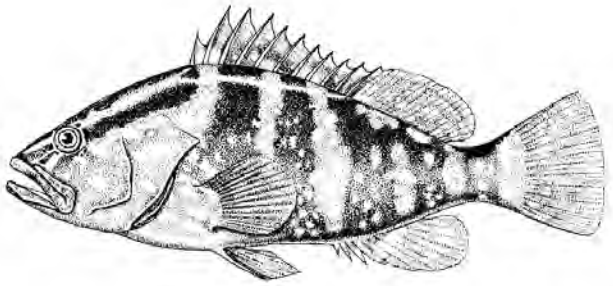


2

Nassau grouper

(Epinephelus striatus)

This fish has a black saddle spot on the base of its tail and five irregular, olive-brown bars over a light background. But a grouper can change to almost black when it needs to blend with its surroundings. It stays in shallow areas, resting on the bottom near rocks, corals, and grasses.

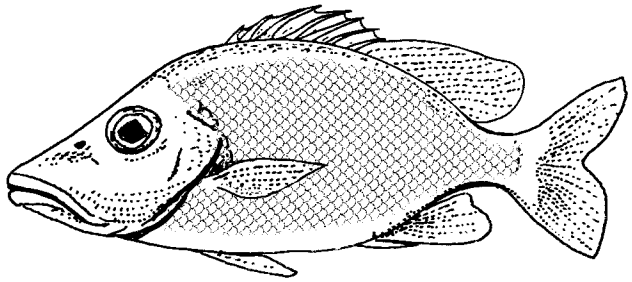


3

Schoolmaster

(Lutjanus apodus)

This is a common fish throughout the Caribbean. Schoolmasters like to drift (in schools) in shallow waters near coral reefs feeding on smaller fish and invertebrates. Younger fish usually grow in the lagoons, hiding in the roots of trees.

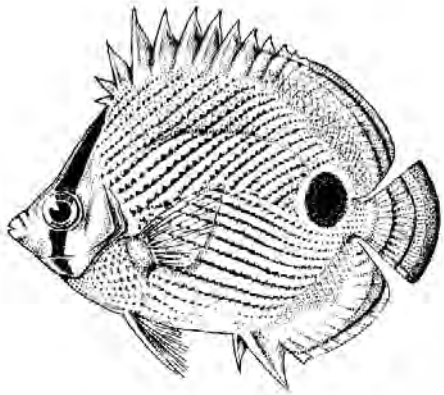


4

Foureye butterflyfish

(Chaetodon capistratus)

This is a round fish with a large spot on each side near its tail. These are called false eye spots and they fool bigger fish, like the barracudas, into thinking the tail is the head so they attack from the wrong end, giving the butterflyfish a better chance of escape. The butterflyfish feeds on zooplankton, soft coral polyps, and various worms.



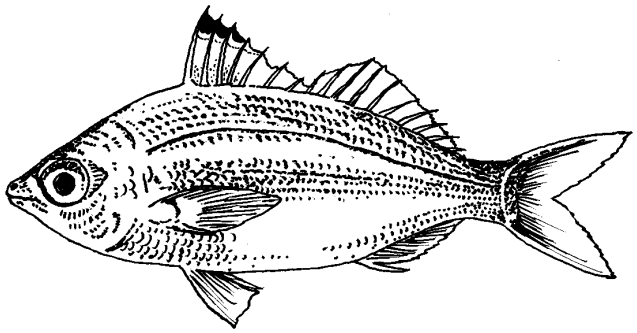
Caribbean Fish Cards

5

Flagfin mojarra

(Eucinostomus melanopterus)

This is a slender, bright, silvery fish, locally known as pilcher. It hovers over sand and grass beds, moves quickly from place to place, stopping to feed, occasionally raising its fins for a split second. It also moves through tree roots in brackish waters (where fresh water and salt water meet).

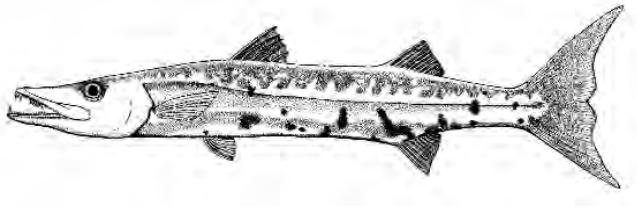


6

Great barracuda

(Sphyraena barracuda)

This is a quick swimmer, with a long smooth body and very sharp teeth that may look scary, but are harmless to humans. It spends all of its growing years among tree roots searching for small fish. When it becomes an adult, the barracuda moves to waters with grassy vegetation or corals to feed on small fish such as foureye butterflyfish and parrotfish.

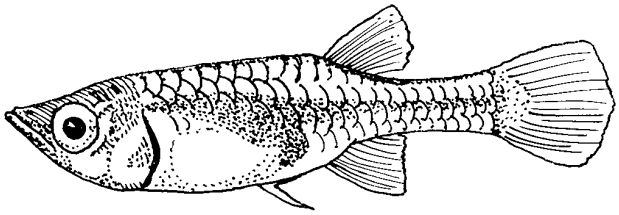


7

Bahama gambusia

(Gambusia manni)

A small fish with a translucent grayish body that lives in brackish waters (where fresh water and salt water meet), looking for food among tree roots and in lagoons. It is popularly known as the mosquito fish because it feeds on mosquito larvae.

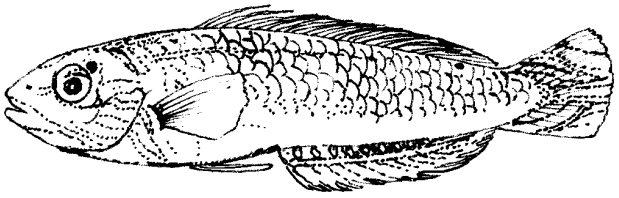


8

Blackear wrasse

(Halichoeres poeyi)

This is a colourful fish that ranges from shades of green to a brown that can quickly pale or darken to blend with the background. It can also display or conceal a black spot between the eye and the gill cover. It is common throughout the Caribbean where it can be found constantly swimming among turtle grass and sometimes on reefs.



Caribbean Fish Cards

9

Longsnout seahorse

(Hippocampus reidi)

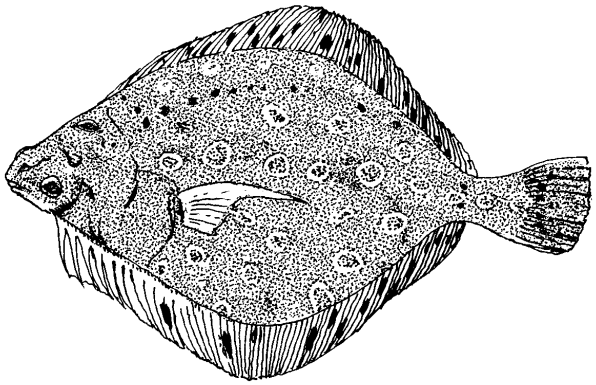
Seahorses are fish, too. Though not common in The Bahamas, the longsnout seahorse is occasionally seen here. It varies greatly in colour, from yellow to reddish orange, brown, or even black, and may even display two tones. It is usually found with its tail curled around branches of corals or grasses. The males protect the eggs in a brood pouch.

10

Eyed flounder

(Bothus ocellatus)

This is a flat fish that lies on the sandy bottom near grassy areas or coral rubble. To find it you have to look very carefully because it usually rests motionless on the bottom, blending with the background. When moving, it glides over the bottom in a wave-like motion.

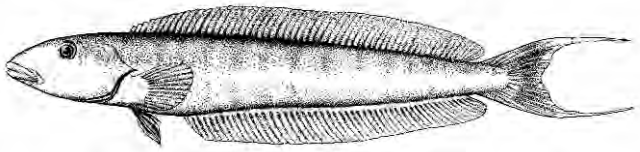


11

Sand tilefish

(Malacanthus plumieri)

This is a small fish that builds a burrow in sand and rubble and hovers near its entrance, undulating its fins and searching for food. When threatened it will quickly go back into its burrow.

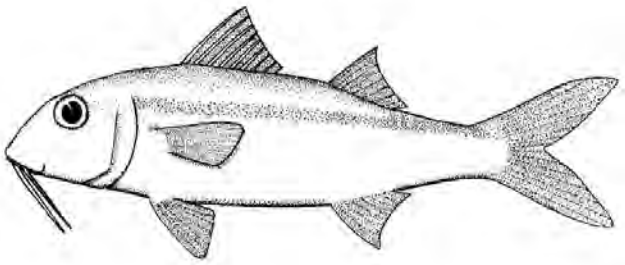


12

Yellow goatfish

(Mulloidichthys martinicus)

This fish is mainly white, but has a yellow tail and midbody stripe. It also has two barbels under the tip of its chin that it uses to dig in the sand to look for food. Yellow goatfish are abundant in the Caribbean, often swimming in large schools.



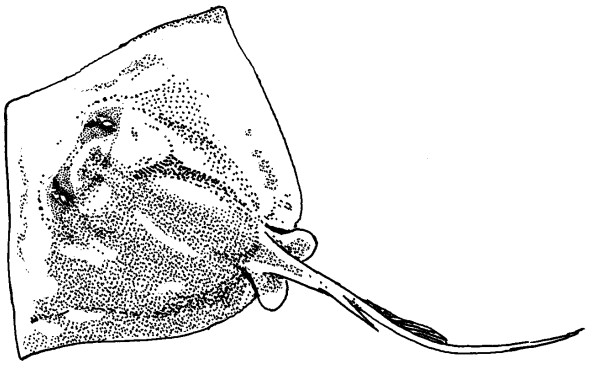
Caribbean Fish Cards

13

Southern stingray

(Dasyatis americana)

Only found in the Caribbean, this fish spends most of its time buried in the sandy ocean floor, leaving only its eyes and tail visible. When not buried, it will look for snails, crabs, and clams to eat. This ray has a flat body with a whip-like tail that has one or two venomous spines. Be careful where you step in the sand so you won't get a painful sting!

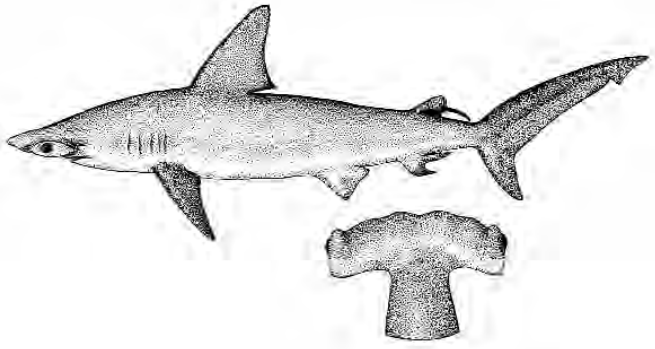


14

Hammerhead shark

(Sphyrna lewini)

You won't have any trouble identifying a hammerhead — its head is shaped like a wide rectangle or hammer, with eyes at either end. It is a voracious eater, making a meal of rays, smaller sharks, and other fish that it finds around deep waters.

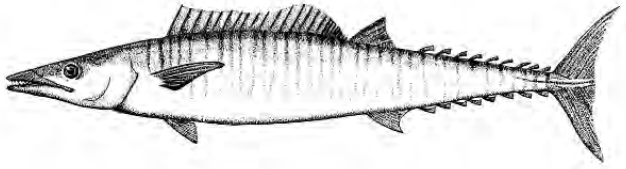


15

Wahoo

(Acanthocybium solandri)

You may have seen this fish on your plate. This is a large fish, appreciated for its delicious taste. Its bluish-green colour shades to silvery white towards its belly. It is commonly fished in deep waters, but may also swim over deep reefs.

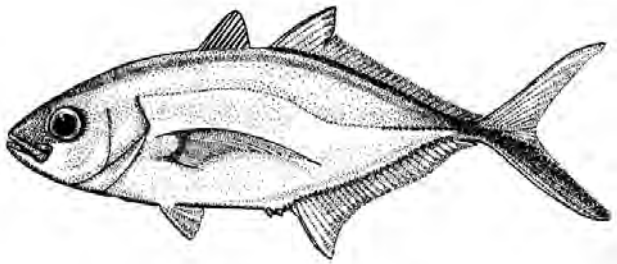


16

Bar jack

(Caranx ruber)

This silvery fish can darken almost to black, especially when feeding near the bottom. It prefers swimming in open waters in small to large schools. It will often follow goatfish and stingrays as they dig in the sand for prey and snatch their food away.



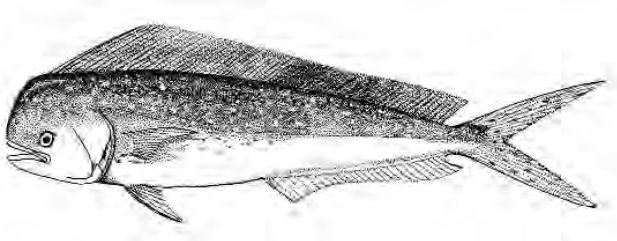
Caribbean Fish Cards

17

Dolphinfish

(Coryphaena hippurus)

This is a brilliant silver fish, common throughout the Caribbean, where it is sought after for its taste. Dolphinfish, also known as mahi-mahi, are rapid swimmers in the open waters and are often seen in small groups of one or two males with several females.



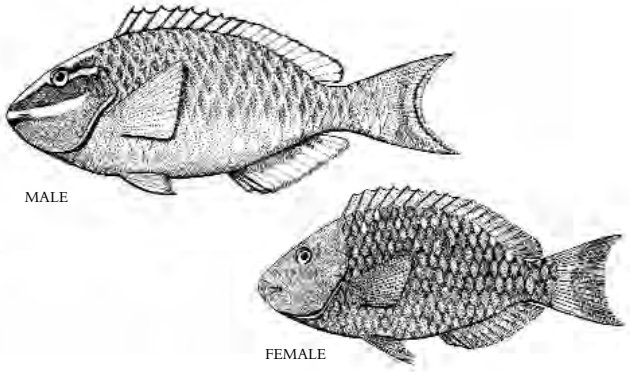
18

Stoplight parrotfish

(Sparisoma viride)

Male (blue/green, yellow, pink); Female (red belly and tail, brown body, white spots)

One of the largest fish in its habitat, this brightly coloured fish shows dramatically different colours between sexes and in different stages of development. Its mouth looks like the beak of a bird, pecking at the algae that grow on dead coral and inside coral polyps.



19

Trumpetfish

(Aulostomus maculatus)

A fish that is an expert in disguise — it can change colour and position its body to blend with the background. Its long, thin, trumpet-like body can mimic the colours of nearby corals, from brown to reddish, or blue to gray and even bright yellow.

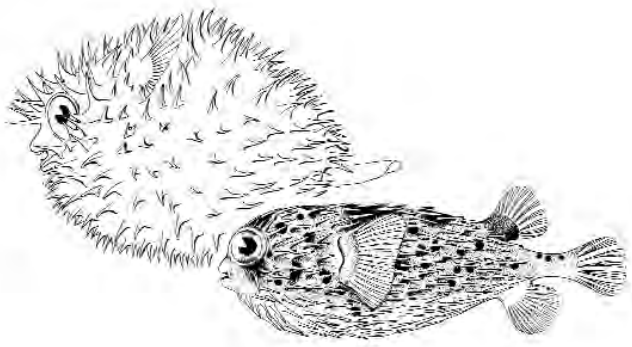
20

Balloonfish

also popularly known as spotted spiny puffer

(Diodon holocanthus)

This olive- to brown-coloured fish has small, dark spots and spines over its entire body. It is a shy fish that lurks in or near openings in the reef or in the roots of trees and will retreat into them if approached. If bothered, this fish inflates so predators cannot eat it. The swelling is a response to stress and usually the fish has difficulty deflating.



Caribbean Fish Cards

21

Spotted moray eel

(Gymnothorax moringa)

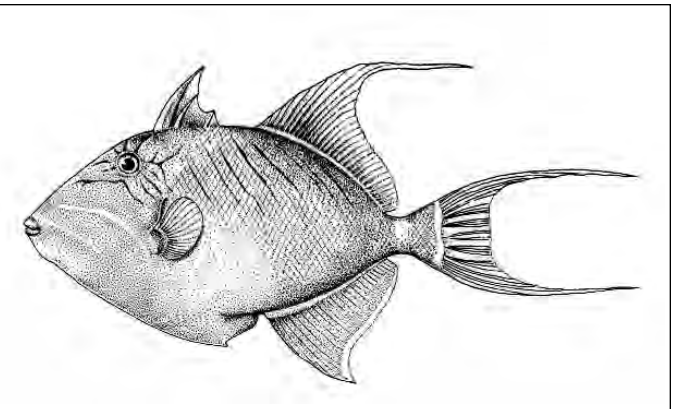
Long and snakelike, the eel likes to hide during the day in crevices on the reef. Its mouth is constantly moving, which makes the eel look like it may want to bite you. In truth, it needs to move its mouth all the time to push water across its gills to extract the oxygen it needs to breathe.

22

Queen triggerfish

(Balistes vetula)

Commonly called "Old Wife," this is one of the most spectacular fish on the reef. It can change colour at will from brilliant to pale in just seconds. Queen triggerfish eat many invertebrates, such as sea urchins.

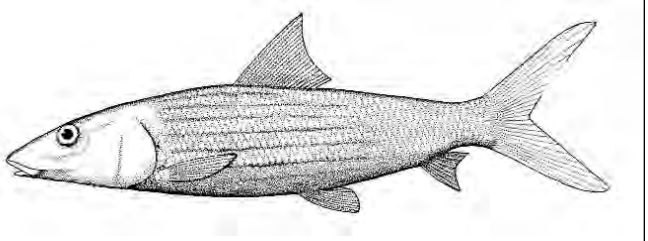


23

Bonefish

(Albula vulpes)

This elongated and silvery fish is one of the most important sportfish in warm waters worldwide, and particularly in The Bahamas and the rest of the Caribbean. Sportfishermen find bonefish on sandy flats near creeks or mangrove areas where these fish hunt for worms, crustaceans, and mollusks.

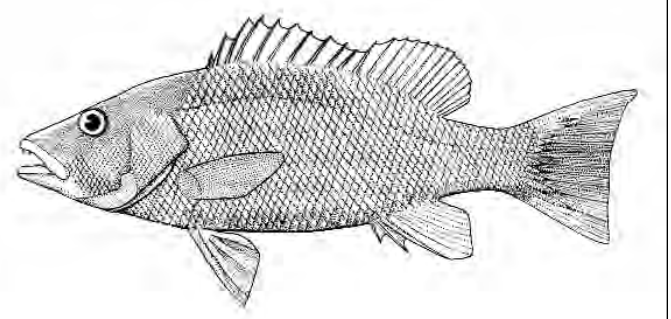


24

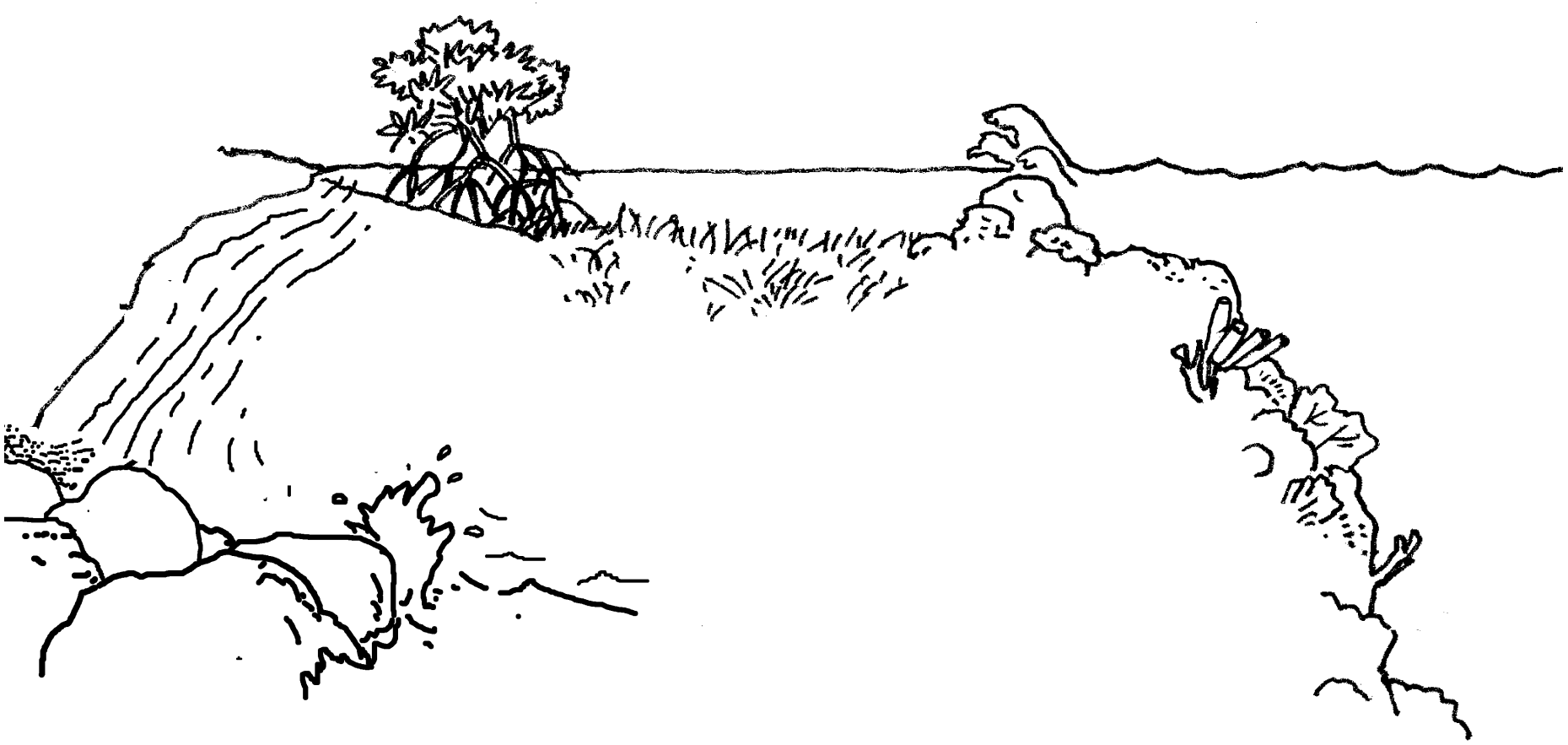
Gray snapper

(Lutjanus griseus)

Found throughout The Bahamas, the gray snapper has a mouth with thick lips, similar to a grouper. Its body is grayish with tints of red throughout. Young snappers may be found around trees in brackish waters (where fresh water and salt water meet). As an adult the gray snapper likes to frequent areas around ledges and rocks, but also around reefs, where it hunts for other fish, shrimp, and crabs.



Marine Fish Habitats



Habitat Clues

For each clue have students name the habitat that it describes from the following options: sandy shore (beach), mangrove wetland, rocky shore, seagrass meadow, coral reef, pelagic zone (listed here in the same order as the habitat clues below).

clue 1

- People like to swim in this shallow habitat.
- This habitat is made of many elements, such as sand, mollusk shells, corals, and algae.

clue 2

- When young, many species of fish prefer to live in the shallow waters of this coastal habitat.
- Plants in this habitat are adapted to the brackish and somewhat salty water, and their roots are perfect places for fish and other organisms to hide.

clue 3

- Animals that live in this habitat have to deal with high and low tides and the constant beating of the waves.
- Many invertebrates and fish use this habitat as a nursery and to shelter themselves in crevices, caves, and cracks.

clue 4

- This habitat provides camouflage for species that can blend into the vegetation.
- This type of habitat has plants that help trap sediments from the land and stabilise the sea floor.

clue 5

- Snorkellers often visit this colourful area of the sea.
- This habitat provides shelter and food for crawfish, groupers, and thousands of other marine animals.

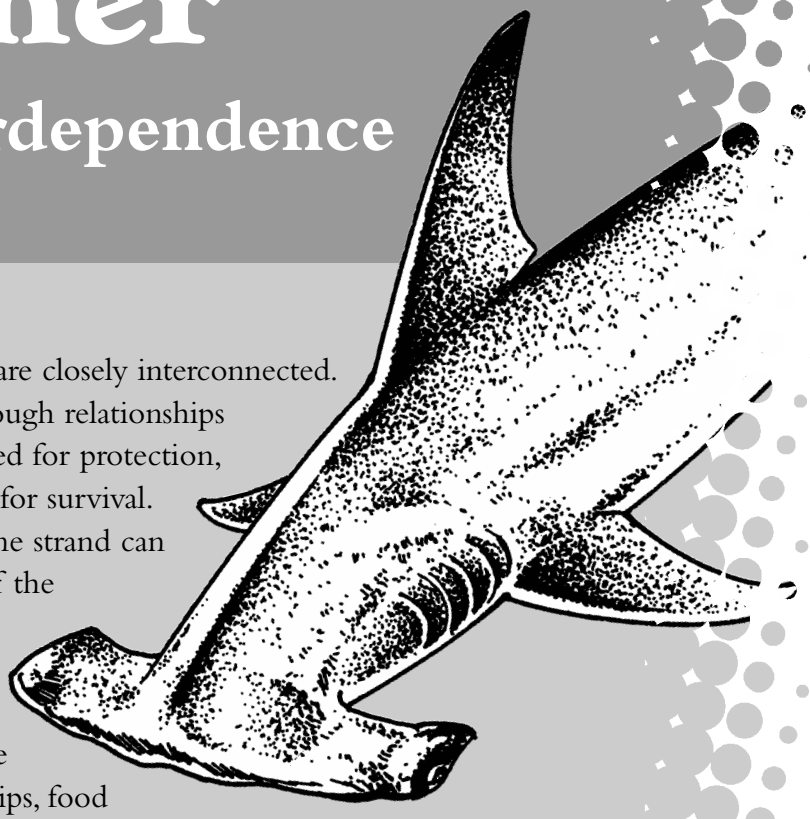
clue 6

- Fishing boats use large nets and trawls to catch fish and squid swimming in this habitat.
- You will find many large fish living in this habitat.

SECTION 5

We're All in this Together

Marine Interdependence



Almost all living things are closely interconnected. Species are linked through relationships based on food, the need for protection, or to meet other requirements for survival. Like a web, what happens in one strand can have an effect on other parts of the system. Remove any one species, and there could be serious repercussions. Activities in this section involve games to learn about partnerships, food chains, and food webs in the marine environment.

1 Friend or Anemone?

Students discover how species depend on each other to increase their chances for survival on coral reefs.

Learning Objectives

- Understand symbiotic relationships on a Caribbean coral reef
- Explain relationships among organisms and their physical environment
- Be able to present information learned to the class

Grades

5 – 6

Subjects

Science, Language Arts, Social Studies

Skills

analysing (questioning, discussing), applying (planning, creating), presenting (describing, public speaking, acting), citizenship (working in a group)

Vocabulary

algae, commensalism, invertebrate, mutualism, parasite, parasitism, photosynthesis, polyp, symbiosis

Time

70 minutes

Materials

For each student: "Symbiotic Shuffle" game card (pages 119 – 120), scissors, safety pin

For each group: a copy of "Symbiotic Shuffle Partners" (page 121)

In response to the almost constant danger and predation that are prevalent on the coral reef, many different species of plants and animals have developed ways in which they can cooperate with each other in order to increase their chances of survival. Symbiosis, which means "to live together," refers to situations where two species live in close contact with each other and interact in various ways. These partnerships have developed on reefs over thousands and thousands of years and support the diverse life of the ocean. By developing patterns of cooperation with another organism, many marine plants and animals have improved their chances of survival. Symbiotic relationships can help organisms acquire the food, protection, cleaning, or mobility that they need. This activity focuses on mutualistic symbiosis, in which both partners benefit from the association.

Before You Begin

Familiarise yourself with the organisms described in "Symbiotic Shuffle Game Cards" (pages 119 – 120) and "Symbiotic Shuffle Partners" (page 121). Photocopy and cut out the game cards so there is one card per student. *(There are eight organisms in total, so there will be several of each.)* Make one copy of "Symbiotic Shuffle Partners" and cut out the descriptions.

What to Do

1 Introduce the concept of symbiosis. Give an example of a symbiotic relationship such as that of people and houseplants. People care for houseplants by providing the conditions they need to survive — temperature, light, water — and in return can enjoy the plants' growth and beauty. Explain that many such relationships exist in the marine environment and students will be learning about some of them by playing the "Symbiotic Shuffle Game."

2 Play the game. Give each student a game card and instruct them to cut out the picture of their animal, and pin it to their clothes. (If your class needs more of a challenge, students should conceal their cards.) Give students time to read the description of their organism carefully, and to think of "yes" or "no" questions they can ask to find their symbiotic partners. Then students can go around the room asking questions until they find their "match." (Note: There will be several possibilities for matches since there is more than one of each organism.) For instance they can ask: Are you a plant? Are you an animal? Do you live in a hole? Once all the students have found their symbiotic partners, have them group together with the other organisms representing the same partnership. For example, all of the cleaner wrasses and groupers should be in one group.

3 Students learn about and present partnerships. Provide each group with the "Symbiotic Shuffle Partners" description corresponding to their partnership. Explain that their next task is to decide in their groups how to "teach" the class about their symbiotic partnership. They can use a short skit, creative writing, or illustrations. Give the students time to create and practise their presentations. For five-minute presentations, students should have at least 20 minutes to prepare. If you have more time, they may do more research on the partnerships and create longer presentations. Once students are ready, have them present their work. After each presentation, allow other students to ask questions and the group may make additional comments to help explain the relationship they demonstrated. You may need to fill in some missing details to help clarify.

4 Explain symbiotic relationships further. After the presentations, explain how symbiotic relationships like these are common in tropical waters around the world and that all of these partnerships can be found in the Caribbean region. Describe how these associations are examples of mutualism — a symbiotic relationship in which both organisms benefit. You can also explain that other types of symbiotic associations are called commensalism and parasitism (see box below). Ask students if they can think of any other symbiotic relationships. *(These may be marine or terrestrial. For example: Bees make it possible for some flowers to get the pollen they need to reproduce. Conversely, flowers provide bees with nectar to eat.)*

You Scratch My Back… or Else!

Besides mutualism, two other types of symbiotic relationships are commensalism and parasitism.

Commensalism is a type of symbiosis where one organism benefits and the other is unaffected. One example is the 2.5 cm (1 in.)-long conch fish, *Astraopogon stellatus*, which hides from predators in the shell of a queen conch during the day and comes out at night to feed. The queen conch apparently does not mind the presence of the tiny fish.

Parasitism is another type of symbiotic association; in this case, one species benefits but causes harm to the other. In the same way that a fungus can eventually bring down a mighty tree, a boring sponge that digs into the hard structure of a coral to find refuge can gradually weaken and kill the coral.

Countless symbiotic associations such as these occur in the oceans and play important roles in the complexity and diversity of life.

Assessment

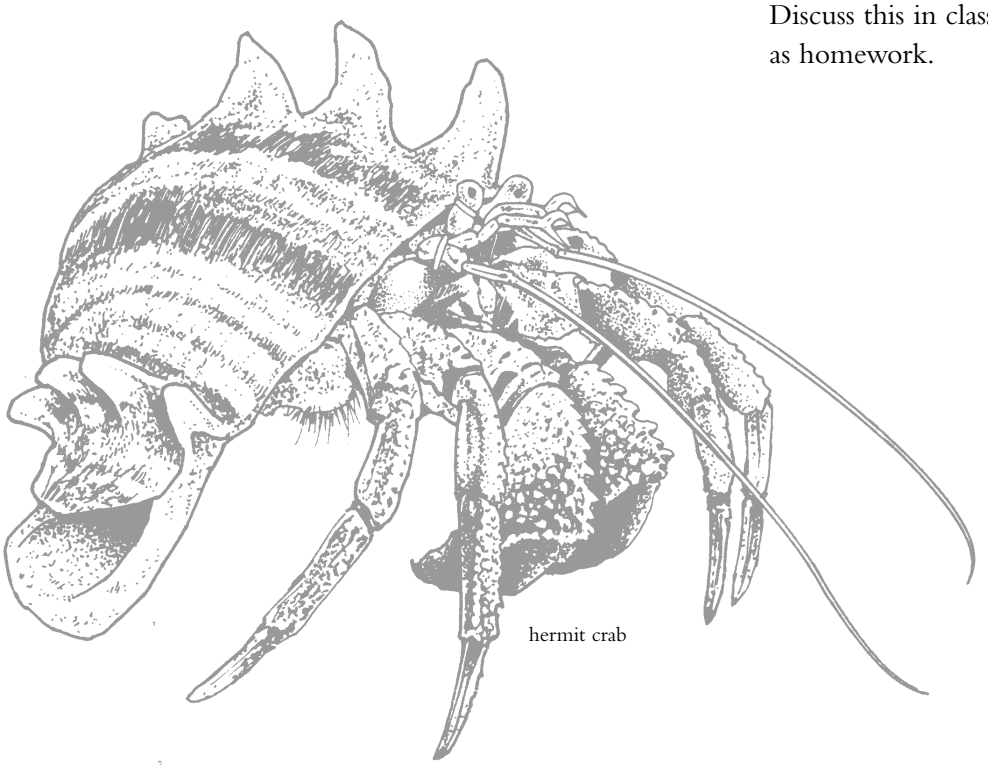
Assess student presentations by creating a rubric based on questions such as:

- Is the presentation well organised and logical? Is the arrangement of information clear?
- Does the group efficiently describe each species?
- How clear are the descriptions of the symbiotic relationship?
- Did the group add enough information? Is there anything important missing?

You may want to include any elements from language arts that your students are learning in class. Share the rubric with your students before they present, so they know on what basis they will be evaluated.

Extensions

- Have students research symbiotic relationships in familiar species and write a report on their research. They can also compare and contrast mutualism with other symbiotic relationships such as commensalism and parasitism.
- Have students choose one of the symbiotic relationships from the game and make a comic strip about a typical day in the life of these organisms. Encourage students to have fun, exaggerating characteristics for effect, making the scenes very active and exciting, and so on.
- Ask students if they can think of any symbiotic relationships that exist in their communities, schools, or families. *(For example: People provide food and care to dogs, which in turn give protection and companionship.)* Discuss this in class or ask students to write an essay as homework.

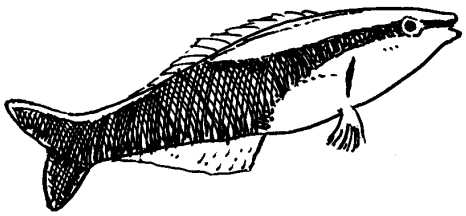


hermit crab

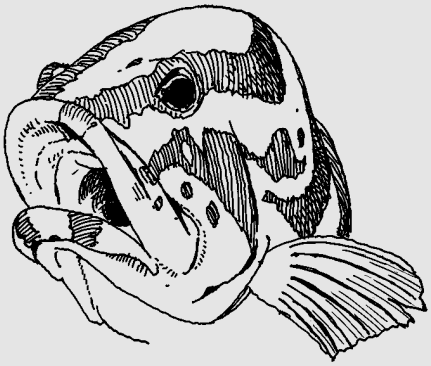
Adapted with permission from Shedd Aquarium. "Friend or Anemone," an activity in *Coral Reefs: Activity Guide for Grades 3 – 5* © 2000, published by Shedd Aquarium Society.

Symbiotic Shuffle Game Cards

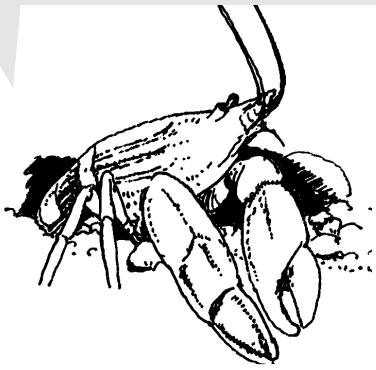
I am a small fish who loves to eat the tiny parasites that drive big fish crazy. Normally, big fish would like to eat me for a snack, but when I work at the cleaning station they leave me alone.



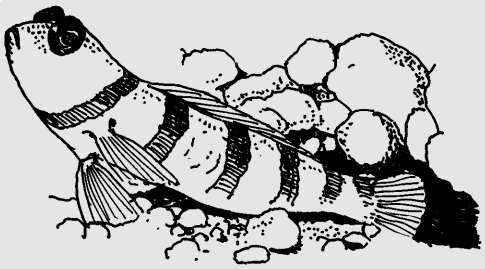
I am a large fish and fierce hunter, but there is one little fish that I will never eat. This little friend does me the favour of picking parasites off of me and cleaning between my teeth.



I am a small invertebrate and I can barely see, so I need to get help from a friend for protection. That's why I invite a small fish friend to live with me. This fish helps me by patrolling the neighbourhood and letting me know if there is any danger nearby.

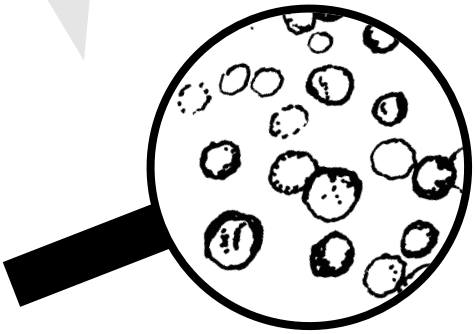


I share a hole built by a friendly animal and in exchange I act like a "seeing-eye fish." My friend is almost blind, so I keep an eye on danger and will sound the alarm if there are any threats to our safety.



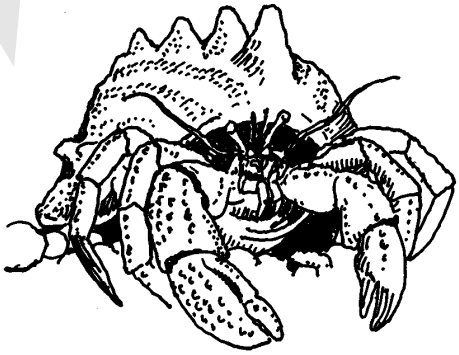
Symbiotic Shuffle Game Cards

We are tiny single-celled plants that live within the skin of an animal. Because we are plants, we need to live in a sunny spot to grow so we can supply our host with food that will provide the energy it needs to build us a safe home.

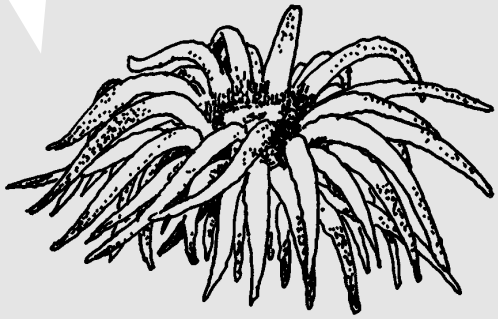


I look like a plant, but I am actually an animal that likes to live in warm, clear water where the sun is always shining. I enjoy the companionship of a partner that can produce energy to help me build a solid home.

I have a tough shell around me, but not hard enough to protect me against some animals with strong beaks, like the octopus. My defense against these harmful killers is to let another animal with stinging tentacles hang onto me.

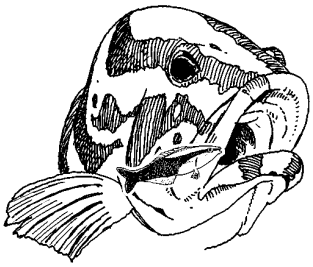


I am a plant-like animal with a stinging attitude. Since I can't move on my own, I look for free rides to other neighbourhoods where I can search for food. The threat of my sting keeps unwanted company away.



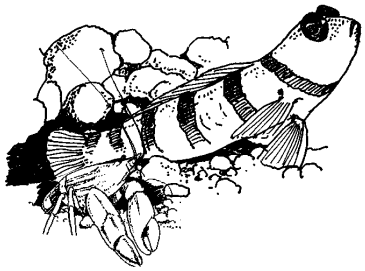
Symbiotic Shuffle Partners

Cleaner Wrasse and Grouper



Cleaning stations on the reef can look like a Saturday morning at the local car wash. Groupers and other big fish wait patiently in line while tiny cleaner wrasses groom them one by one. These brightly coloured wrasses advertise their occupation by twisting their bodies and waving their fins. Even though they are usually fierce predators, groupers never attack the cleaners. They let the tiny fish pick parasites from their bodies and even let them safely enter into their mouths to clean their teeth. If there is a threat while a wrasse is in the grouper's mouth, the grouper closes its mouth and swims away but leaves a small opening to allow the wrasse to escape. Without cleaners, groupers could get sick or even die from the parasites and debris caught in their bodies. Without groupers and other large fish, the wrasse would lose a steady food supply.

Goby and Snapping Shrimp



Because of its poor eyesight, the shrimp happily shares its burrow with the goby, which acts as its home alarm system. Perched in front of the burrow, the goby hunts for passing prey. The shrimp spends most of its time digging and cleaning out its burrow or looking for food near the entrance. When there is any sign of danger, the goby will sound the alarm by flicking its tail, and both the nearly blind shrimp and the goby retreat to the safety of the burrow. In exchange for the goby's services, the shrimp shares its protective burrow and keeps it clean for the goby.

Zooxanthellae *(zo-zan-THELL-ee)* and Coral

Zooxanthellae are tiny single-celled plants (or algae) that live inside the tissue of a coral polyp (an individual coral animal whose form resembles an inverted jellyfish). These plants, like all plants, carry out photosynthesis, using sunlight to convert carbon dioxide and water into food and oxygen, which the coral uses to grow and build a hard, limestone cup under its body. Without the nutrients the algae provides, corals could not build reefs. Housed within the coral polyp, the algae have a protected environment and receive food from the waste nutrients (nitrogen and carbon dioxide) the polyp generates. In this way, each species benefits from the other — the coral gains a food source, and algae receive nutrients and inhabit a sunny and safe home.

Hermit Crab and Sea Anemone

Some species of hermit crabs (crabs that live in the empty shells of other mollusks, such as the queen conch) frequently have sea anemones attached to their shells. These crabs will put up with the additional weight because many predators, especially the octopus, will avoid the poisonous sting of the anemone's tentacles. The sea anemone can move by itself from one spot to another on its suction-cup foot, but this is a very slow process. In return for protecting its host, an anemone gets a free and faster ride around the reef on the back of a crab, and may even get scraps of food left over from the crab's meals.

2 What Eats What

By exploring food chains and food webs that include important marine species in The Bahamas, students learn about the interdependence among species.

Learning Objectives

- Name marine species that are herbivores, carnivores, and omnivores
- Describe food chains and food webs
- Demonstrate and explain the interdependence of species

Grades

4 – 6

Subjects

Science, Language Arts, Social Studies

Skills

analysing (identifying components and relationships among components, questioning, discussing), interpreting (inferring, drawing conclusions, defining problems, identifying cause and effect), citizenship (working in a group)

Vocabulary

carnivore, consumer, decomposer, food chain, food web, herbivore, omnivore, predator, prey, producer

Time

1½ hours

Materials

yarn, cards (with pins or tape) or stickers with species names and illustrations

Marine plants and animals are part of an incredibly complex system that has evolved over millions of years. Each of the many and diverse living things in this system has an important role to play. For example, without grazing fish, such as the parrotfish, algae could grow out of control and deprive corals of light and oxygen.

A food chain shows how each living thing gets its food (or energy). For example, a simple food chain links algae, the sea urchin that eats them, the crawfish (that eats the sea urchin), and the shark (that eats the crawfish).

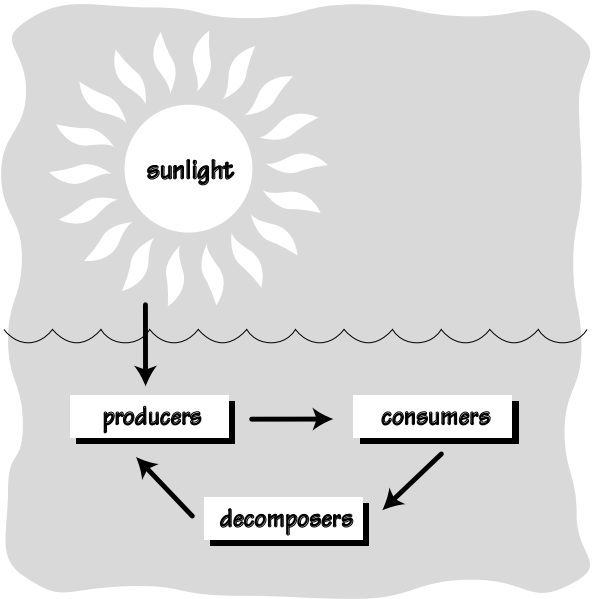
- Plants are called **producers** because they are able to use energy from the sun to produce their own energy (sugar) from carbon dioxide and water.
- Animals cannot produce their own food so they eat plants or other animals. They are **consumers**.
  - Animals that eat only plants are called **herbivores**.
  - Animals that eat other animals are called **carnivores**.
  - Animals that eat both plants and animals are called **omnivores**.
- **Decomposers** (fungi and bacteria) feed on decaying matter.

Most animals are part of more than one food chain and eat more than one kind of organism to meet their energy requirements. These interconnected food chains form a food web.

In this activity, students will identify herbivores, carnivores, and omnivores and connect them in predator and prey relationships to create a food web.

Producers, Consumers, and Decomposers — Let's Recycle!

In most ecosystems, plants are the primary producers. They generate energy through photosynthesis. (In the deep sea, where there is no sunlight for photosynthesis, bacteria make their own food from chemicals escaping the Earth's crust in a process called chemosynthesis. They form the primary producers in these food chains.) The energy from plants then fuels the rest of the food chain. Herbivorous consumers, who cannot synthesise food themselves, eat plants and in turn are eaten by carnivorous consumers. After a producer or consumer dies, decomposer organisms such as fungi and bacteria break down their nutrients and return them as fertilisers to primary producers. Without decomposers, nutrients would remain locked up within the dead organisms.



Before You Begin

Make cards for all the species in "Food Web Connections" (page 126), writing the name and including an illustration, if possible. Include the sun and the decomposers. You may wish to add species students are familiar with and laminate the cards for durability.

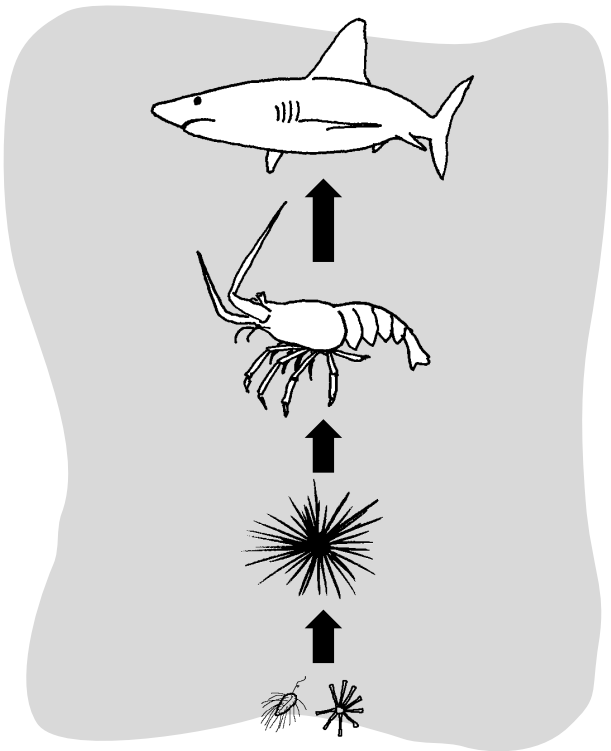
What to Do

1 Create food chains. Give each student a species card. Form a food chain, like the one illustrated below, having those students with the algae, sea urchin, crawfish, and shark cards line up.

Talk about how these species are connected *(when the sea urchin eats the algae it receives energy and so on up the chain)*. Can students identify the producer? *(algae)* Consumers? *(The sea urchin, crawfish, and shark are all consumers.)* Are there any herbivores in this food chain? *(the sea urchin)* Are there any carnivores? *(the crawfish and shark)* You can do this exercise again with other examples, such as:

algae ➤ conch ➤ loggerhead sea turtle ➤ shark

plankton ➤ shrimp ➤ Nassau grouper ➤ human



To reinforce understanding of the terms herbivore, carnivore, and omnivore, and to involve all the students, you can play a "What am I?" game. Ask students to think about what the species on their cards eat. Do they eat plants, animals, or both? Then say, "I eat only plants. What am I?" *(a herbivore)* All students with herbivore cards should go to a corner of the room that you indicate. Continue with "I eat only animals. What am I?" and "I eat both plants and animals. What am I?" When all students have selected their categories, have them discuss among their groups to see if they all agree. If they think a student should be in another category, that student can relocate. Then talk about the results as a class. There may be some species that students are unsure about and can research afterwards.

2 Play a Food Chain Game. Once students understand the components of a food chain, explain that they are going to play a game in which they form a food web. Because most animals eat, or are eaten by, more than one thing they are usually part of more than one food chain. These connecting food chains form a food web. Have students pin or tape species cards to their clothing. Find a place to play where students can spread out in a circle, but are close enough to be able to toss the ball of yarn to each other. The name of the game is "What Eats What," so start with one of the largest species *(human or shark)*. This player then has to "catch" one of its most likely food sources by holding on to the end of the yarn and tossing the ball to his or her prey. You can use "Food Web Connections" as a guide *(note that the arrows indicate the direction of energy flow, from producer to consumer or from prey to predator)*. For example, a shark might catch the crawfish, so the "shark" tosses the ball of yarn to the "crawfish." The crawfish then has to "catch" a squirrel fish or a sea urchin, while staying linked to the shark. Each student holds onto the yarn as s/he throws the ball, creating a connection to the next student in the food web.

When a player tosses the yarn, s/he can state that s/he is a predator of the one receiving the yarn. The receiving player can say that s/he is the prey of that animal, but in turn is the predator of another animal who is the next to be connected. If the player is a marine plant s/he can state that s/he is a producer.

Once the yarn has reached the students holding the producer organisms, have them connect to the "sun." If there are any students who are not yet connected, discuss where they could join the web until the whole class is connected. *(A juvenile grouper is included in "Food Web Connections," but you can also consider larval and juvenile forms of other animals if it helps to add them into the web. For example, crawfish and young green turtles could eat juvenile conch.)* There are many ways that this web could be formed, but this is an example that illustrates the interdependence of living things in the ocean.

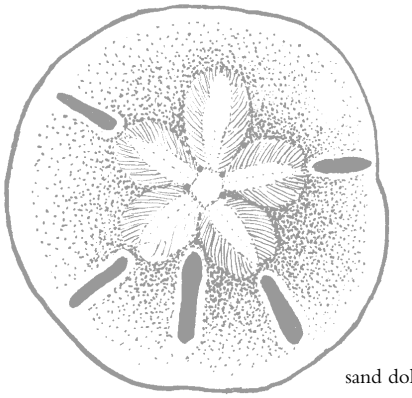
3 Illustrate what happens when links are broken. Many things can happen to disrupt the connections in a marine food web. With students still linked in a web, introduce scenario 1: *Overfishing is a common problem in the Caribbean — grouper, conch, and crawfish are heavily fished in The Bahamas. What would happen if all of these animals were gone?*

Students wearing the grouper, conch, and crawfish cards let go of the yarn and sit down. Discuss the "chain reaction" that could result. What would happen to the predators of these animals? *(They would have to substitute other prey, move elsewhere, or if neither of these are possible, they may not get enough to eat.)* What about their prey? *(The prey population could increase to a point where it negatively affects other links in the web. For example, if there aren't sufficient organisms feeding on algae, algae can overwhelm the coral reef, preventing the zooxanthellae in the coral polyps from photosynthesising.)*

Continue with scenario 2:
A resort with a golf course, roads, and houses is built right on the shore. Trees and plants are removed so that when heavy rains come, mud and sand are washed into the water, covering seagrass meadows and blocking the sun from the turtle grass. How would the loss of the turtle grass impact the food web?

Students wearing producer cards release the yarn and sit down. Discuss the consequences. Encourage students to think about the interdependence of species. Is turtle grass important to the survival of sharks? Do sharks eat turtle grass? *(Sharks don't eat turtle grass, but they eat sea turtles that eat seagrass.)*

4 What is our role in the web? The game illustrated that each species has an important role to play in the food web. What happens if we take too many grouper, conch, and crawfish? *(We may not find some of our favourite dishes to eat. The disappearance of these species would be a huge social and cultural loss to Bahamians, and it would also impact our economy. Loss of these species would also be an ecological loss — species that depend on conch, grouper, and crawfish for food would be affected, and populations of species that they eat may become disproportionately large.)* What can we do to help keep the food web intact? *(We need to obey regulations about closed seasons and minimum size and to reduce consumption of threatened or stressed species such as conch, grouper, and crawfish, especially during reproduction.)*



sand dollar

Assessment

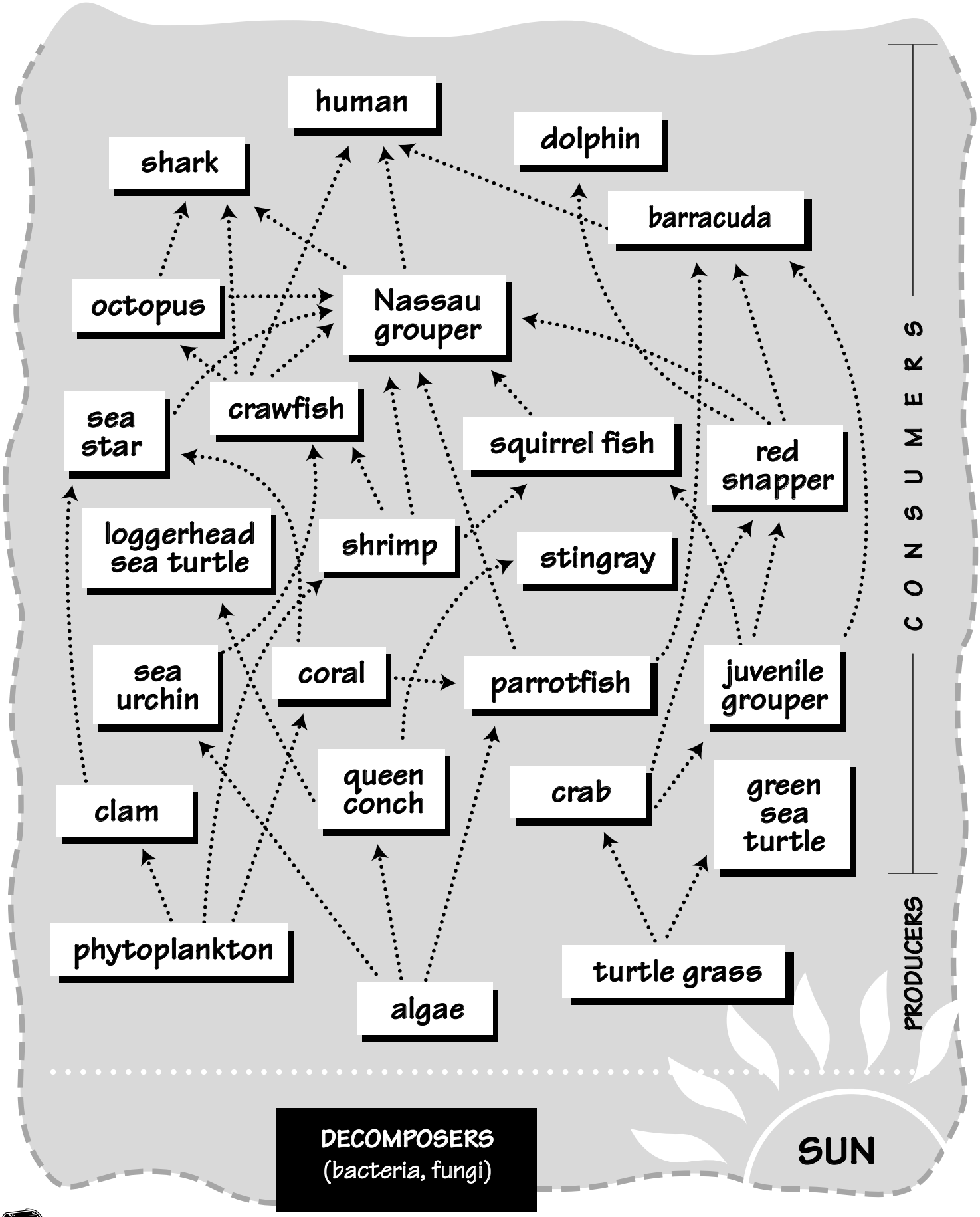
Have students write sentences answering the following questions:

- What did you learn today about the relationships between species in food chains or webs? *(They depend on each other for survival; energy passes from one species to another; every species has a function in its habitat, such as decomposing, consuming, producing.)*
- How is a food chain or web formed? *(Organisms are linked according to what eats what. Food chains begin with microscopic organisms that are preyed upon or consumed, and usually end with an organism nothing else will prey upon, such as a large shark. A web is formed by connecting food chains.)*
- What are the components of a food chain or web? *(producers, consumers, decomposers; or predators and prey)*
- Give an example of a herbivore, carnivore, and omnivore and something it eats.
- Why should people care if food chains are broken? Use an example to explain your answer. *(Whether it's a direct loss of a food source, or an indirect loss — such as the disappearance of turtle grass and the resulting disappearance of animals that eat grass that are eaten by people — students should give examples that illustrate the importance of interconnections.)*

Extensions

- Have students write a story or a comic strip from the perspective of a conch, grouper, or crawfish. What problems does it have finding food? How does it escape predators?
- Have students write a dialogue between two species that illustrates the relationship between them and how their lives are interconnected.
- Create a spelling list for the week based on the vocabulary used in the lesson such as: producer, consumer, decomposer, food chain, food web, herbivore, carnivore, omnivore.

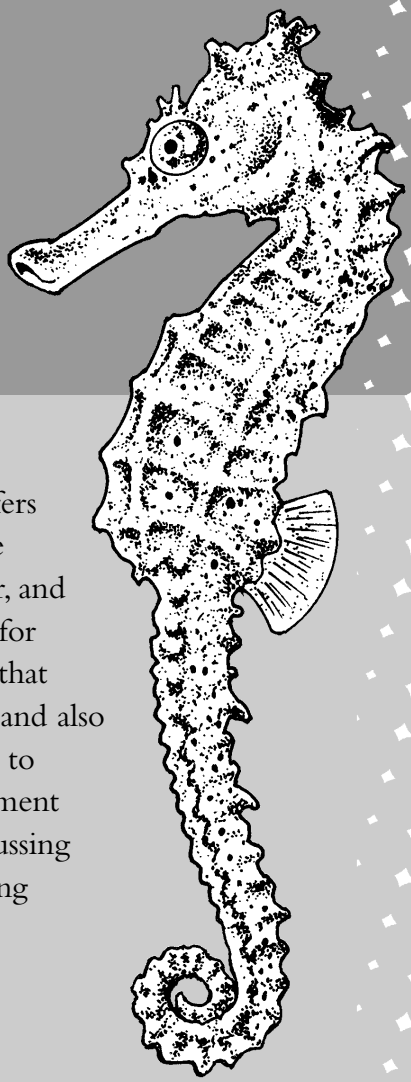
Food Web Connections



SECTION 6

What Is Our Treasure Worth?

Exploring Economic and Cultural Values



The marine environment and the resources it offers are integral to the economy and culture of The Bahamas. Fishing for and eating conch, grouper, and crawfish have been part of the Bahamian way of life for centuries. And tourism is a rapidly growing industry that depends on a healthy environment to attract visitors, and also provides employment for many Bahamians. Activities to explore the many ways we value the marine environment include: graphing and interpreting fisheries data, discussing stories about traditions tied to the sea, and investigating marine-related careers.

1 What Is Marine Biodiversity Worth to You?

Explore beliefs and values about why marine biodiversity is important and why it should be protected. This activity works best once students have become familiar with biodiversity issues. It is a good culminating activity for a biodiversity unit.

Learning Objectives

- Explain personal beliefs and values about protecting biodiversity
- List several reasons why people believe it is important to protect biodiversity

Grades

4 – 6

Subjects

Science, Social Studies, Language Arts

Skills

organising (arranging, listing), presenting (describing, public speaking, explaining), citizenship (working in a group, debating)

Vocabulary

ecological processes, economics, **marine protected area,** values

Time

1 hour

Materials

chalkboard, chalk, large pieces of paper, markers

People's feelings about marine issues depend on many things. The importance people place on marine resources and their habitats, and whether they think these resources should be conserved, do not depend only on their knowledge of these issues and the sciences that relate to them (such as ecology, biology, sociology, political science, economics, and so on). People's feelings also depend on personal beliefs and values (beliefs in which they have an emotional investment).

The most common way that people value marine resources is for their nutritional qualities or for their economic worth. However, marine resources can also be valued for their link to traditional cultures and for the role they play in local ecosystems. All of these values should be considered when making decisions about the conservation or management of a particular resource.

This activity is designed to give your students a chance to examine their values and to sharpen their own thinking by sharing their opinions and feelings with their peers. The students first discuss their points of view in small groups and then talk about biodiversity conservation as a class. You can use or adapt the series of numbered questions provided to get the students thinking about the range of biodiversity-related concerns, as well as additional guiding questions to help direct the discussions.

Before You Begin

Select some or all of the statements from "Why Care about Marine Biodiversity?" (page 131), depending on the level of your students, and write them on large pieces of paper so all students can see. Be sure to read through and familiarise yourself with the "Guiding Questions" on pages 132 – 133.

What to Do

1 Discuss whether conserving marine biodiversity is important. Explain that many people feel that it's important to conserve marine biodiversity and that they have diverse reasons for thinking so. Ask students to write down three to five reasons why it's important to conserve marine biodiversity (or assign this as homework in preparation for the session). Talk about students' ideas and write them on a chalkboard.

2 Display the statements and read each one aloud. Tape each of the statements you copied earlier in different places around the room so that they are high enough for everyone to see. (Or you can put up the papers before class, folding each bottom half up and taping it in place so the students can't read the words until you uncover them.) Explain that the statements represent many of the key reasons people have given for why it is important to conserve marine biodiversity. As a group, review each of the statements. Compare the ideas represented in the statements with the lists that the students generated.

3 Students choose a statement to stand near. Ask your students to carefully consider all of the statements. Have each student pick one statement and stand near it. Explain that the statement the students choose should be one that they feel strongly about because they think it is an important reason to conserve marine biodiversity. If they don't see a sign that reflects their viewpoint, they can stand at the sign marked "Other." Explain that there is no correct answer and it's OK to stand either alone or with a group.

4 Discuss the choices students made. After everyone has made a selection, have the students at each statement discuss among themselves why they chose that particular statement. After about five minutes of discussion, ask one person from each group to summarise the discussion. You might want to record the main points from each group on the chalkboard. (If any student is by him or herself, consider grouping statements or you can discuss the statement with the student.)

5 Open up the discussion to the entire class. After all the groups have given their summaries, use the questions on pages 132 – 133 to spur a group discussion on some of the arguments that local communities, biologists, conservationists, ecologists, economists, and others have put forth for conserving marine biodiversity. Read one of the numbered questions and have the students react to it. You can use the bulleted questions to challenge the students' thinking and to help direct their discussion as needed. Refer to the background information (page 2) and "Services on Stage" (page 38) for more help in leading the discussion.

You do not need to ask the class all the bulleted questions, and the students do not need to discuss each of the numbered questions in turn. However, during the course of the discussion, make sure that the students confront the issues highlighted by each numbered question and that they explain why they feel the way they do. Have them give examples whenever they can. Allow enough time for the students to fully discuss their points of view.

Assessment

Have students write a personal statement about the importance of conserving marine biodiversity. Explain that there are no right or wrong answers to this assignment — and that they don't even have to think conserving marine biodiversity is important at all. However, they should carefully consider everything they've learned as well as all of the points made during their discussion to make a well-reasoned and well-supported statement. Encourage the students to use examples to illustrate their points. Rubric criteria may include:

- The student uses examples to support personal beliefs.
- The student makes connections between the concepts discussed in class and personal beliefs.
- The student clarifies or challenges concepts from class using his or her individual belief system.

Extensions

- Students can research issues that came up in discussion.
- Each student or small group of students can choose one of the statements to use as a theme for a collage. Afterwards have the students make a display of the collages under a title they've created. Students can invite other classes, their families, or other community members to view their work.

moray eel

Adapted with permission from "The Spice of Life," an activity in *Biodiversity Basics: An Educator's Guide to Exploring the Web of Life* ©1999, published by World Wildlife Fund as part of *Windows on the Wild*, an international biodiversity education program.

Additional ideas from "Valuing Marine Resources," an activity in *Fishing for the Future: Marine Conservation and Resource Management* ©2005, published by Conservation International in collaboration with the National Department of Education and Milne Bay Provincial Government.

Why Care about Marine Biodiversity?

It is important to conserve marine biodiversity for economic reasons. Many people in The Bahamas sell fish and non-fish resources to make money for their families. Income from fisheries contributes to development.

It is important to conserve marine biodiversity because fish and other species are a primary source of food for many families in The Bahamas.

It is important to conserve marine biodiversity for medical reasons. Marine resources could provide us with new medicines that will save lives and benefit society.

It is important to conserve marine biodiversity because it helps maintain important ecological processes such as oxygen production and flood control that, in turn, help support all life on Earth.

Our lives would not be as rich if we lost species such as conch, grouper, or crawfish and the habitats where they live.

The rich diversity of marine life allows for important recreational activities such as diving, snorkelling, or fishing. Tourism generated by these activities can be an important source of income.

It is important to protect marine biodiversity because no generation has the right to destroy the environment and resources on which future generations will depend. It is our responsibility to take care of the diversity of life.

It is important to protect marine biodiversity because it provides inspiration and sparks curiosity and imagination. Many cultural traditions in The Bahamas are inspired by the diversity of marine life including art, music, and dance.

It is important to conserve marine biodiversity because all species have a right to exist.

Guiding Questions — Valuing Marine Biodiversity

1. Is it important to conserve marine biodiversity for medical reasons?

- Do people actually need marine resources for medicinal reasons?
- Can't scientists produce the medicines we need in a laboratory? *(Natural resources continue to be important in medical research; for example deep sea animals and sponges are being used in research to develop cancer drugs.)*
- If a plant or animal species is not known to have any medical benefit to people, is it then OK to let the species die out?

Hundreds of marine organisms — fish, snails, algae, and sponges, to name just a few — have medicinal properties. Drugs that have been derived, or are being developed, from marine resources include: antibiotics, tumor inhibitors, pain suppressants, anti-inflammatory treatments, skin care products, sunscreens, and medicines for heart and nerve conditions.

2. Does marine biodiversity help maintain important ecological processes that help support life on Earth?

- What sorts of ecological processes does marine biodiversity help maintain?
- People have developed an amazing array of technologies to deal with particular problems — everything from water treatment plants that purify sewage water to scrubbers that can take pollutants out of the air from factory smokestacks. Isn't it reasonable to assume that people will be able to develop technologies that can perform essential ecological processes in place of marine biodiversity?
- Are there any negative effects of technological solutions?

There are many services that nature provides us. Mangroves protect coastal communities from waves and storms, and help control erosion and siltation. Reefs are also important for protecting shorelines. Plankton — tiny drifting organisms — produce half of the world's oxygen through photosynthesis.

3. Would your life be affected in any way if we lost species such as conch, grouper, or crawfish?

- Is there anything about these species that makes them special?
- Would you feel the same way if we lost stone fish, sea urchins, stingrays, sharks, sea snakes, jellyfish, and other species that can be harmful to people?
- Are there species that you think are more important to protect than others? Which ones? Why?

4. Do all species have a right to exist?

- Do people have the right to use any of the ocean's resources however they want? Why or why not?
- Does the right to exist apply to ugly species that are of no use to people?
- Some species have been around for millions of years — and have survived incredible periods of destruction and change on the planet. Should that influence whether we decide to protect a species?

5. Some people argue that no generation has the right to destroy the environment and resources that future generations will depend on. Do you agree or disagree with this idea?

- Why should people today do without things they want when we don't even know what future generations will need or want?
- Do you feel that past generations have left you with the environment and resources you need to live?
- Many species have already become extinct. Has your life been affected in any way by the absence of these species? Why? Will future generations really care about species that disappeared before they were born?

The Caribbean monk seal, the dodo, and Steller's sea cow are some of the many species that are extinct as a direct result of human actions.

6. Is the diversity of life important for inspiring inventors and artists and for spurring curiosity and imagination?

- What human activities are inspired by nature?
- What inventions, stories, or works of art can you think of that were inspired by living things from the sea? Could these have been produced without the inspiration of nature?
- Would photographs and films on wild plants and animals be sufficient to provide inspiration to future writers and artists?

7. Is the diversity of life important for recreational activities?

- What kinds of recreational activities rely on marine biodiversity?
- Is it right to save an area so people can dive and snorkel if it means that other people lose their jobs? What types of jobs could be affected by a marine protected area?
- Does the fact that someone has done a particular job all his or her life — and perhaps one or more of his or her parents or grandparents also did the same job — give the person a right to keep doing that job even if it harms the environment? What kind of jobs could this relate to?
- Should people be allowed to take part in any recreational activity even if it harms the environment? How do we balance the rights of individuals and the rights of society as a whole?

2 How Many Fish Are We Catching?

Students graph data, identify trends in commercial landings of conch, crawfish, and grouper, and interpret graphs to propose reasons for increases or decreases.

Learning Objectives

- Use bar graphs to organise and present data on landings of conch, crawfish, and grouper
- Interpret information in bar graphs to identify increases or decreases in landings from one year to the next
- Discuss possible reasons for decreases in landings
- Name the administrative authority for the fishing industry

Grades

3 – 6

Subjects

Mathematics, Social Studies, Science, Language Arts, Music

Skills

organising (graphing), analysing (identifying patterns, comparing and contrasting, discussing), interpreting (generalising)

Vocabulary

biodiversity, closed season, commercial, fisheries resource**, landings, marine, overfishing, season,** trends

Time

1½ hours

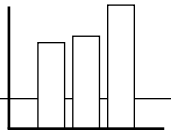
Materials

transparency of "Interpreting Bar Graphs" (page 138), overhead projector, masking tape, flipchart marked off as a bar graph (this can also be done on the blackboard), broad felt-tip marker, copies of the worksheets for each student (pages 139 – 141), crayons

Crawfish, grouper, and conch are important fisheries resources in The Bahamas. Crawfish is one of our chief exports, and though Nassau grouper and queen conch fisheries have collapsed elsewhere in the Caribbean, they remain an important part of the Bahamian economy. Thousands of Bahamians work in the fishing industry as fishers or in sales and distribution of related products and services. Communities where fishing is still the major source of income can be found on islands all over our country. The sea is also an important food source for Bahamians and many of our traditional dishes are made with seafood.

The Department of Marine Resources has administrative responsibility for fisheries in The Bahamas. It shares responsibility for enforcing fisheries regulations with the Royal Bahamas Defence Force and police and customs officers. The department also records landings — the commercial catch — for various fisheries products in order to document increases or decreases. Data including the weight and value of each type of marine resource harvested within a year are organised in tables and graphs. Fisheries officers use these diagrams to identify trends and develop strategies for each fishery.

A number of factors can affect landings in any given year. Sometimes poachers take fish from Bahamian waters, leaving fewer fish for authorised fishermen. Natural disasters, such as hurricanes, impact fish populations. Coastal development can also destroy critical habitats causing population declines. Furthermore, fishers who use illegal gear may damage habitat or overfish an area. Fishing during closed seasons that correspond with spawning can result in lower reproduction rates and this, in turn, leads to population declines.



Building Bar Graphs

Graphs quantify and communicate information visually. Bar graphs can be used to show how something changes over time (increase or decrease in the the weight of grouper landings) or to compare different times (the quantity of conch landings this year versus last year). A bar graph is a quick way to show differences and similarities among data sets.

The graph title describes the graph. The x (horizontal) and y (vertical) axes are labelled to indicate the unit of measure or value represented.

Good Mornin' Mr. Fisherman

Traditional Bahamian Song

Good mornin' Mr. Fisherman,
Good mornin' farmer Brown.
Have you any conch slop
Gimme a hand or two.
Bonefish bitin' I ain gat bait to catch them
Every married man gat he own bonefish.

The Songs and Culture of Our Bahama Islands: An Illustrated Treasury of Bahamian Folk Songs and Traditions, vol. 1, compiled and arranged by Essau McKenzie. (Nassau, The Bahamas, 1991).

Before You Begin

Find a large, clear floor space and use tape to create the x-axis, marking intervals and writing each year from 1998 to 2002 with the marker. Leave enough space so that students can comfortably form lines for each year. Mark off the y-axis with intervals of 100,000 up to 1,200,000. Draw the graph axes on the flipchart or blackboard and label them in the same way as on the floor. Make copies of the student worksheets.

What to Do

1 Discuss fishing in The Bahamas. Begin the lesson by having students sing "Good Mornin' Mr. Fisherman." Ask students what kind of fish the fisherman in the song wants to catch. Bonefishing is an example of small-scale fishing for personal consumption — bonefish cannot be bought or sold in The Bahamas. However, it is generally for "catch and release" and it is a target for sportsfishermen. Other types of fisheries may be large-scale, for commercial purposes. People who live in fishing communities on the islands of Eleuthera, Exuma, Andros, and Long Island depend heavily on fishing to earn money. Ask students to think of examples of fish that are caught to be eaten at home and fish that are sold in the market or exported. Explain that in this activity they will look at data from The Bahamas' commercial queen conch, crawfish, and Nassau grouper fisheries.

2 Introduce and interpret graphs. Show students the "Interpreting Bar Graphs" transparency with recorded conch landings (the commercial catch). Talk about how graphs are a visual way of presenting data and comparing it. Point out the parts of the graph such as the title, the x and y axes, the labels on the axes, the units used, and the bars. Ask the following questions to guide interpretation: What does this graph show? *(Students should read the title.)* What period of time is shown on this graph? *(This graph shows landings of conch from 1996 through 2003.)* In which years were landings greater than 1,400,000 pounds? (*1997, 1998, 2000, and 2001.*) When was the lowest landing of conch? *(1999)* What landing increases or decreases occurred during this period? *(Between 1996 and 1998 conch landings increased; a decline was experienced in 1999. The landings rebounded in 2000, but fell off slightly in 2001. Further decline was experienced in 2002, while 2003 saw an increase in landings.)*

3 Create a living graph. Use the table (above, right) based on actual figures (rounded to the nearest 100,000) from the Department of Marine Resources. Each student will represent 100,000 groupers. Have students form queues to represent the landings for a particular year. For example, 11 students would be needed in a line to represent 1,100,000 groupers landed in 1998. Transfer this information onto the chart or blackboard to create a bar graph. Explain that each bar you draw represents one of the lines students have formed. Demonstrate how the numbers on the y-axis are used to determine the height of each bar. Continue until students have formed lines for each of the years from 1998 to 2002 and you have recorded the data on a bar graph. Then have students use the graph to compare the lengths of the bars on the graph and discuss trends as they did for conch in step 2 above.

Recorded Grouper Landings

Year	Weight (lbs)
1998	1,100,000
1999	800,000
2000	500,000
2001	700,000
2002	900,000

4 Practise creating and interpreting graphs. Pass out the worksheets and explain the instructions for each exercise. Students will need crayons of six different colours to fill in the bar graph. For the Fisheries Report, you may wish to provide students with some "reporting terminology," such as synonyms to help them write descriptions of trends. For example:

instead of . . .	use . . .
increase	growth
decrease or drop	decline
same	unchanged, identical
fish that were caught	fish that were landed

Or have students use a thesaurus to find synonyms themselves. When students have completed the worksheets, bring the class back together to discuss their work.

Assessment

The following are suggestions for reviewing students' completed worksheets:

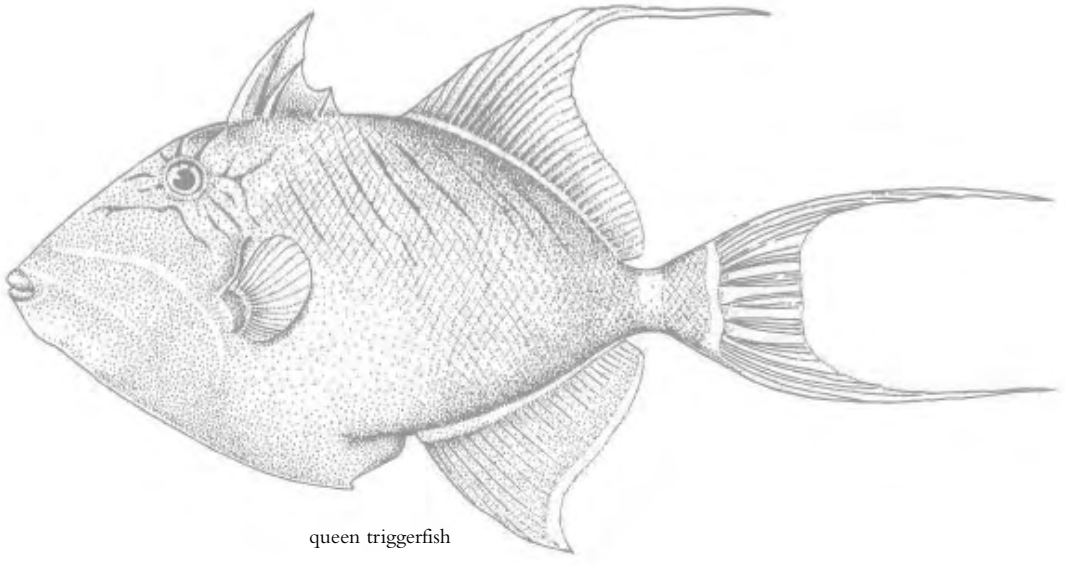
Build a Bar Graph: Have students compare graphs with one another to ensure that they accurately graphed the landing figures for crawfish.

Interpret a Bar Graph: Discuss students' responses to the questions.

Write a Fisheries Report: Ask students which government minister they addressed their reports to. What recommendations did they make for managing the crawfish fishery? What data did they use to support these recommendations?

Extensions

- The traditional Bahamian dance called the Quadrille is usually done to the song "Good Mornin' Mr. Fisherman." Teach the students this dance. Students can make their own rake and scrape band (with a saw, shakers, and drums) to accompany the song.
- Invite a fisheries officer, marine biologist, or environmentalist to speak to the class about fisheries in The Bahamas.
- Students can write a newspaper article about how many fish are being taken, using the figures to support an argument for management of a fishery (should management remain the same or should there be a change?).
- Create a "fishing ground" by scattering a box of different coloured toothpicks in an area outdoors where they can be recovered. Each colour represents a different kind of marine resource. For example, orange = crawfish, blue = grouper, yellow = conch, and so on. Assign a monetary value to each "fishery resource." Send the students "fishing" by having them collect as many toothpicks as they can. Students can graph their catch according to "species" (colour of toothpick) or value, and calculate the quantity or monetary value. (Add to the challenge by using a multi-coloured blanket or tablecloth. If green toothpicks are in a green or grassy area, were fewer "caught" than others?)



queen triggerfish

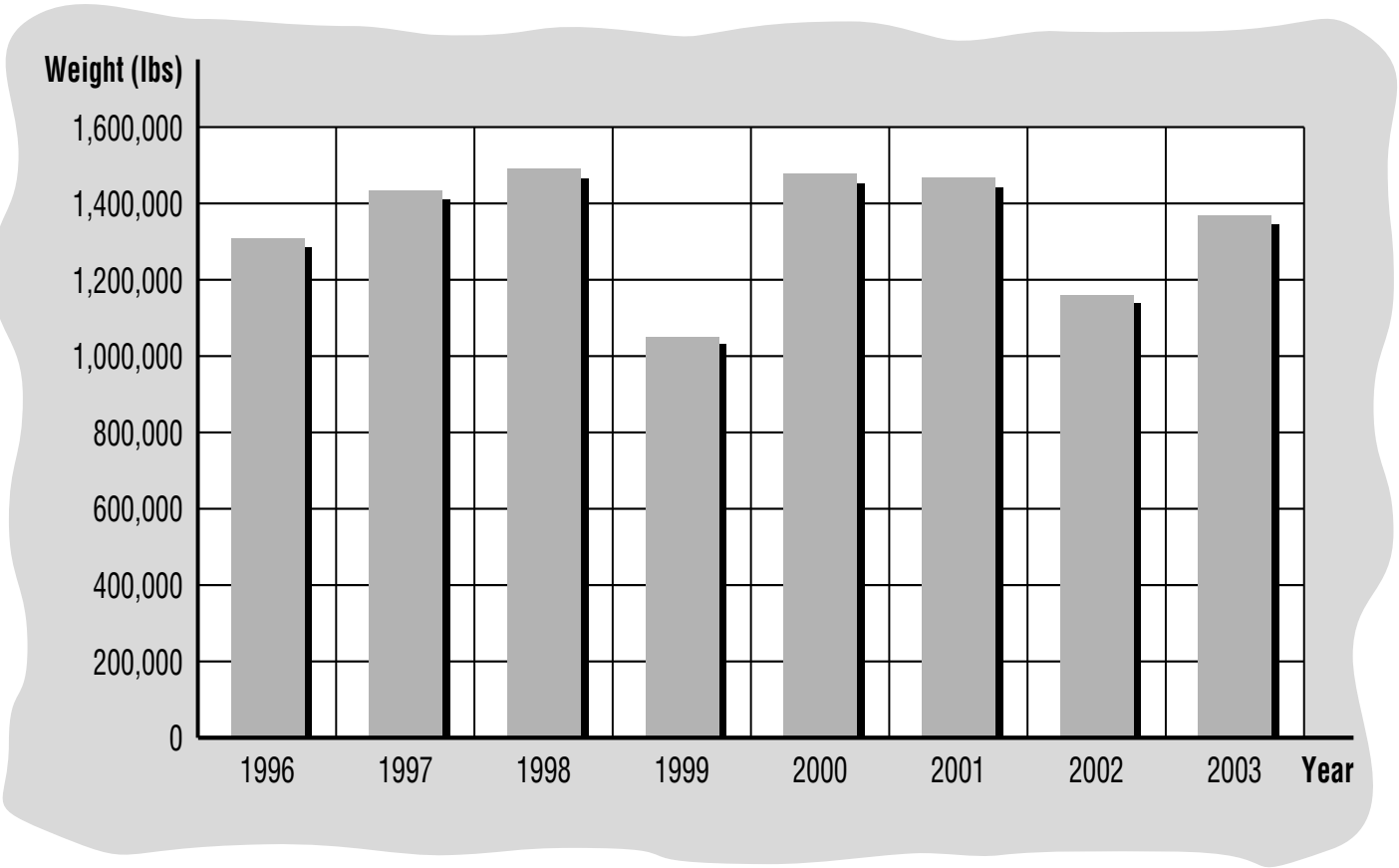
Data in this activity courtesy of Lester Gittens, Department of Marine Resources, 2005.
Activity idea based on "Make a Living Graph," www.proteacher.com.

Interpreting Bar Graphs

Recorded Conch Landings Data

Year	Weight (lbs)
1996	1,298,336
1997	1,428,745
1998	1,477,374
1999	1,040,307
2000	1,471,828
2001	1,456,583
2002	1,152,951
2003	1,365,844

Recorded Conch Landings



BUILD A BAR GRAPH

Name: _____

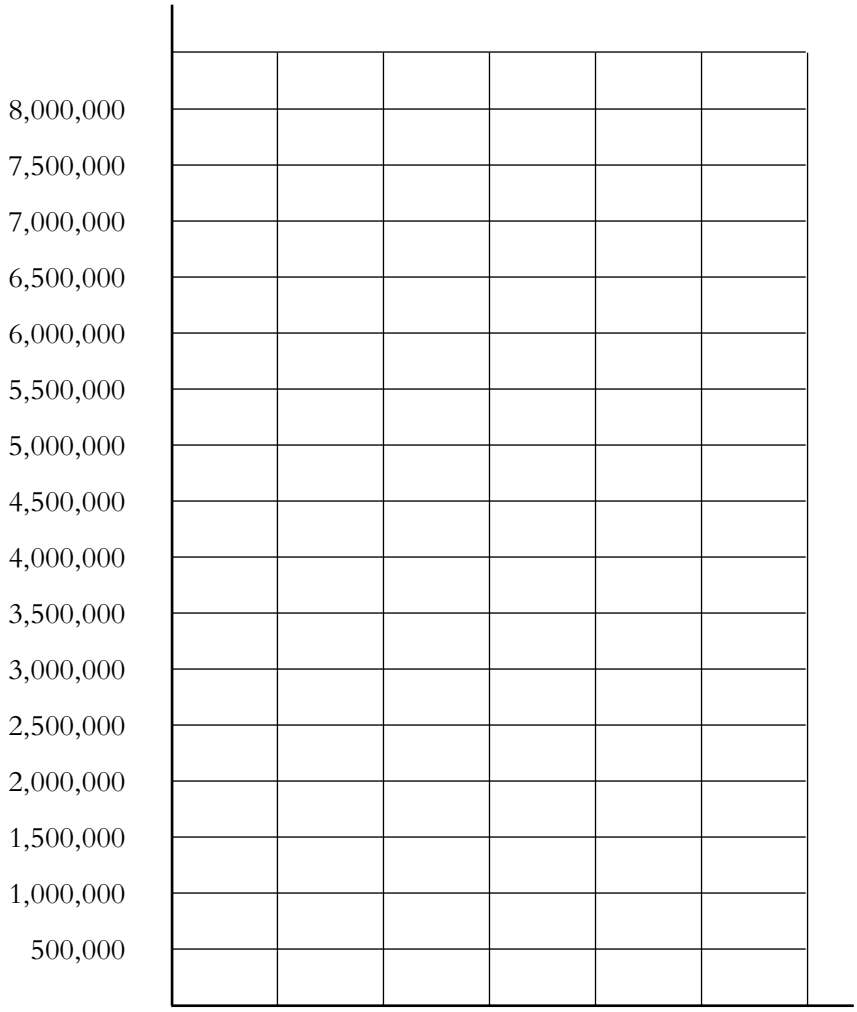
Date: _____

Use the data in the table to create a bar graph. Write a title for the graph and label the x and y axes. Colour the correct number of spaces in each column.

Recorded Crawfish Landings

Year	Weight (lbs)
1998	5,500,000
1999	6,000,000
2000	6,500,000
2001	5,000,000
2002	7,000,000
2003	7,500,000

Title: _____



INTERPRET A BAR GRAPH

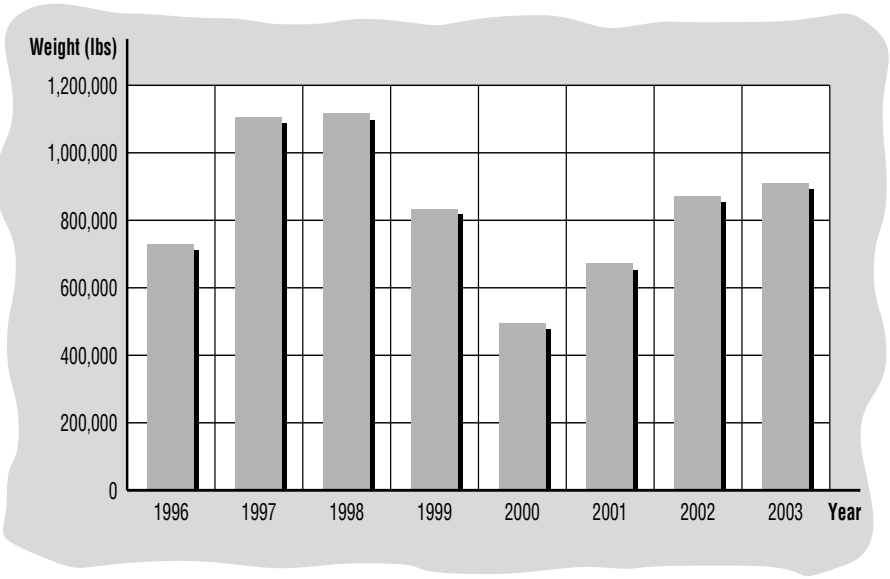
Name: _____

Date: _____

Use the graph to answer the questions.

Recorded Grouper Landings

Year	Weight (lbs)
1996	729,719
1997	1,132,264
1998	1,125,817
1999	841,044
2000	497,810
2001	681,151
2002	884,324
2003	930,087



1. In which two years was the greatest quantity of grouper landed? Suggest reasons for this increase.

2. In which year was the smallest quantity of grouper landed? Suggest a possible reason for this decline.

WRITE A FISHERIES REPORT

Name: _____

Date: _____

Imagine that you are a fisheries officer. Use the bar graph on crawfish landings that you created to write a report to the Minister (state which Minister) responsible for marine resources. Compare the landings of crawfish for different years. Give possible reasons for increases (growth) or decreases (decline). Do you think the trend shown in the graph will continue? Why or why not? Make recommendations for managing this fishery.

3 Ezra Goes Fishing

Students read a story about traditional fishing techniques and the reliance of local people on the sea. It emphasises conservation methods and shows why it is important to abide by fisheries regulations.

Learning Objectives

- Describe traditional fishing methods used in The Bahamas
- State how conservation and regulations are important for fishing

Grades

3 – 6

Subjects

Social Studies, Language Arts

Skills

gathering (reading comprehension, identifying main ideas, listening), interpreting (drawing conclusions), presenting (describing, illustrating)

Vocabulary

extracted, **mollusk,** momentum, pungent, skiff, sufficiently

Time

1 hour

Materials

a copy of the story "Ezra Goes Fishing" (pages 144 – 145) for each student; water glass, conch hook, and Hawaiian sling if available; map of The Bahamas

Fishing is an important economic and cultural activity in The Bahamas. Many Bahamians fish frequently, for personal consumption or enjoyment, or for economic gain. In recent years modern fishing methods have become prevalent, though many independent fishermen still prefer to use the older, more traditional techniques. These techniques are labour-intensive and small-scale, and therefore they are not widely used for commercial-scale fishing. The story in this activity describes some traditional fishing methods — handline fishing, and conching with a water glass and conch hook. Diving and spearing result in a much higher take than these methods do, and can be used in combination with modern fishing equipment.

Modern lobster fishers, for example, place artificial lobster habitats — known as "condos" — in the ocean, use breathing apparatus and compressors to stay underwater longer, and locate the condos with a global positioning system (GPS). Technology has also resulted in larger boats that can travel farther out to sea, increasing their yields. Modern fishing boats are equipped with radio communications, facilities for freezing the catch, and can accommodate a large crew. Scalefish are caught using traps, nets, and long-line methods in addition to spears. Long lines with baited circular hooks every 6 – 18 m (20 – 60 ft.), hung at the desired depth, can be up to 95 km (60 mi.) long.

While many of these new technological developments can be very expensive, they offer increased yields and can be financially lucrative for Bahamian commercial fishermen. In order to control the level of harvest, the government has issued regulations including size limits, designated seasons, and fishing method specifications, and also manages marine protected areas where wildlife is protected and fishing is not allowed.

Before You Begin

Make copies of the story (pages 144 – 145); locate a map; collect a water glass, conch hook, and Hawaiian sling, if possible.

What to Do

1 Read the story. Have students read the story to themselves or read the story together as a class, having each student read a paragraph.

2 Discuss. Ask students to locate Cat Island and Bennett's Harbour on a map of The Bahamas. Talk about the water glass, conch hook, and Hawaiian sling and ask students if they remember how these were used in the story.

Other questions for discussion:

- Bahamians traditionally use a conch hook to gather conchs. Ezra experienced trouble in bringing the conchs to the surface and only captured five. However, when his cousin Eric dove for conchs he was able to bring up 10. Could modern fishing methods be a cause of certain types of fish becoming scarce?
- How were Ezra, his cousin, and grandfather able to move the heavy boat to the water?
- How did they get the conch out of the shell? What did they use to do it?
- How did Ezra's grandfather clean the fish?
- According to Ezra's grandfather, why were there still conch around Cat Island?

Assessment

Have students write a paragraph on one of the traditional fishing methods used in the story. They should describe the equipment required, name the fish it is used to catch, and identify the advantages and disadvantages of the method in relation to a modern alternative.

Extensions

- Students can research and write a report on a fishing method not described in the story (for example, trawling, long-lining, lobster condos), with similar requirements as those in the assessment suggestion.
- Students can design a poster illustrating the fisheries regulations and why they should be obeyed. To research the information for the poster, they can interview a representative from the Department of Marine Resources or do an Internet search.
- Invite a fisherman to show the students how to clean a fish and to extract a conch from the shell.

Resources

"Primary Industries," Chapter 2 in *The Bahamas Today*, 2nd edition by Neil E. Sealey. (Oxford: Macmillan Education, 2005)

EZRA GOES FISHING

Ezra was 10 years old and it was his first trip to Cat Island to visit his grandparents. He finished school in June and it was now July. As a special treat for making the honor roll his mother was letting him make this trip. The plane landed in Arthur's Town and as Ezra walked down the steps from the plane he heard his grandmother call out, "Ezra, here we are, over here, hurry and come this way, son!"

His grandmother and grandfather both had on straw hats to protect their heads from the bright summer sun. His grandmother had on a flowered dress and his grandfather wore a white shirt with his blue jeans. They hugged and kissed him and helped get his bag and they all three got in the truck to travel to their home in Bennett's Harbour.

Once they were home Ezra's grandfather asked him if he would like to go fishing later that afternoon. He wanted to go before it got dark, but according to him after five o'clock "the smaller ones go away and we will catch the bigger fish." He also told Ezra that the tide would be high and that was the best time to catch fish.

Ezra and his grandfather walked from the house to the nearby seashore, where his grandfather had his fishing gear stashed in old milk crate. His grandfather took out a cutlass, or machete, nylon line, and several hooks. He had taken some conch out of the refrigerator before they left. It was weeks old and had a very strong smell. Standing at the water's edge, he hooked a thumb-sized piece of bait, and spun his lead around and around, gaining enough momentum to cast the line out to the reefs. As he gave the line some slack, they sat down on the beach, staring at the evening sky. He carefully pulled the line taut so he would be able to feel the bite.

"Granddad," asked Ezra, "Why are you using that old smelly conch? Couldn't you get some fresh conch?" His grandfather grinned and told Ezra that the old conch was the best if you wanted to catch fish as they were attracted by the pungent odor.

It wasn't long before the line jerked and Ezra's grandfather pulled in a nice-sized goggle-eye. He put the line out again and got another. They kept fishing until he had six medium-sized goggle-eyes and then he said, "OK, that's enough for dinner. Let's go home." They stopped to put the fishing line in the milk crate and walked home.

Ezra and his grandfather sat on the front porch after dinner and looked at the stars in the clear Cat Island sky. "Ezra, have you ever gone conching?" asked his grandfather. "No, sir," Ezra said. "I don't think we have any conch around Nassau." His grandfather smiled and told him that if he would like they could go in his cousin Eric's boat the next day and perhaps they would get some conch. Ezra went to bed that night dreaming of beautiful conchs carpeting the ocean floor.

"Ezra, wake up," called his grandfather the next morning. Ezra jumped out of bed and quickly dressed. His grandmother had packed them sandwiches and lots of water to take in the boat. "You be sure and keep your hat on your head," his grandmother said as they went out the door. They got in the truck and drove to his cousin Eric's house, which was right on the beach.

Eric was up and waiting for them and they walked down to the beach together. They had to help heave the skiff onto four very smooth logs each of which was about 12 feet long. The logs were lying with the boat where the thick brush met the white sand of the beach. The boat looked heavy. Ezra guessed that the craft weighed about 400 pounds. Once they got the boat on the rollers, it coasted the 20 yards down the incline to the water without too much trouble.

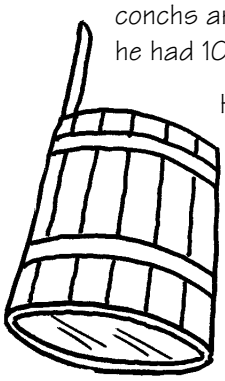
The boat had a small outboard engine and the three were soon far off the shore. The boat's flat bottom enabled it to skim over the surface without ever touching the sharp corals that were scattered on the ocean floor. Ezra was amazed at the beautiful sea fans and brightly coloured fish that darted between the antler coral as they traveled to the conch area. Finally, Eric stopped the boat and dropped the anchor. They were over a conch bed, where groups of this mollusk had buried

themselves in up to 10 inches of sand. Only the tips of their shells were visible.

Ezra watched with interest as Eric brought out a water glass and the conch hook. Eric explained to Ezra that it was possible to snag the conch without even going into the water. The **water glass** was a wooden bucket with sides that were three-quarters of an inch thick. Ezra guessed that it could hold nearly one half bushel, but he wondered why the bottom of the bucket was glass. Eric rested the glass on the surface and peered down into the crystalline water, searching for conch. Ezra was amazed that he could see right to the bottom and could see the tips of the conch shells. His cousin gave him the **conch hook**. It was a 12-foot-long wooden pole that had two three-inch grappling hooks protruding from one end. The pole itself had a two-inch diameter. Ezra tried to lift the conchs one at a time by hooking the upper part of the shell. He got very frustrated because the conchs kept sliding off. However his grandfather was very patient, coaching him on how to hook and raise the conchs until he had brought five to the surface and gotten them into the boat.

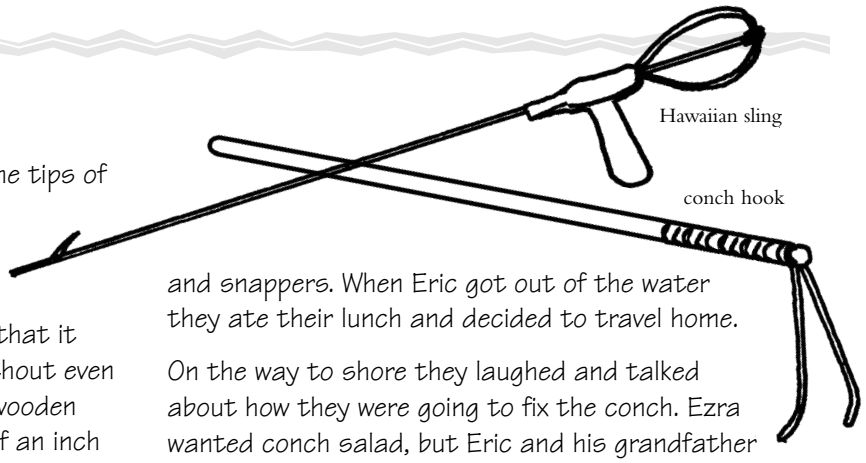
Ezra's grandfather told him that he did not like diving in the water to catch fish. He said, "The sea is another man's world and we shouldn't be botherin' another's home. Everyone has their own place on this God-given Earth."

However Ezra's cousin Eric had a pair of good flippers, a properly fitting mask that kept the water from his eyes and nostrils, and a snorkel. He put on his gear and hopped overboard. He dove down and picked up two conchs and brought them to the surface. Soon he had 10 conchs in the boat.



water glass

He then asked Ezra's grandfather to hand him a spear and a **Hawaiian sling**. This was simply a wooden handle with a hollow rubber tube attached. The stainless steel spear fit through a hole drilled down the middle of the wood and catches on the loop. Eric speared several medium-sized groupers and snappers. When Eric got out of the water they ate their lunch and decided to travel home.



Hawaiian sling

conch hook

On the way to shore they laughed and talked about how they were going to fix the conch. Ezra wanted conch salad, but Eric and his grandfather said they really wanted some nice spicy conch fritters. Ezra asked his grandfather why there were so many conch around Cat Island when they hardly saw any around Nassau. His grandfather explained that in Cat Island they were careful to only take legal-sized conch. He picked up a conch from the bottom of the boat and showed Ezra how the conch had a flared lip, which meant that the conch was at least five years old.

When they got back to the beach, they had to get the conchs out of the shell and clean the fish. Eric explained to Ezra that the conchs coil themselves throughout the inner cavity of their shell, and anchor their bodies in the shell's inner tip. He got a hammer from the house and using the claw end, made a sharp break near the top of the shell's outside surface. This loosened the conch sufficiently for the body to be extracted.

The fish had been placed on a wooden table that was under a sea grape tree on the beach. Using a knife with an eight-inch blade, Ezra's grandfather removed the scales, briskly shaving the fish. Ezra had to stand behind his grandfather so he would not be covered by a shower of scales. His grandfather cut off the back and side fins and then pried off the gills. He then split the fish down the ventral (under) side and scraped out the interior organs.

Ezra and his grandfather thanked Eric for taking them fishing and returned home to his grandmother. That night they had boiled fish, conch salad, and conch fritters. Ezra went to bed thinking about how lucky the people of Cat Island were to still be able to catch their dinner from the sea.

Fishing information from Eric Amrine, *Strangers No More: Anthropological Studies of Cat Island*.

4 Wish You Were Here!

Students make postcards of beach and coastal areas in The Bahamas and discuss what attracts tourists to such places and the importance of tourism to The Bahamas.

Learning Objectives

- Define tourism and ecotourism
- Illustrate and describe a beach or coastal area in The Bahamas
- Describe the role of tourism in The Bahamian economy
- Describe the role of conservation and management in sustaining tourism

Grades

3 – 6

Subjects

Science, Social Studies, Art, Language Arts

Skills

organising (drawing, mapping), analysing (comparing and contrasting, discussing), presenting (writing, describing)

Vocabulary

ecotourism, tourism

Time

1 hour

Materials

sample postcards (optional/suggested), map of The Bahamas, card stock, colouring materials

Globally, the marine-based segment of the tourism industry is one of the fastest growing, with increasing popularity of recreation such as snorkelling, diving, and sportfishing. The Bahamas' white sand beaches, clear water, coral reefs, and abundant marine life attract millions of tourists each year. Researchers who conducted a survey of divers in The Bahamas found that features divers look for are: a large number of fish, large reef fish, sharks and rays, small reef fish, and water quality and clarity. The tourism industry in The Bahamas provides an estimated 50 – 60% of the gross domestic product (GDP) and employs about half of the nation's work force. Bahamians work at airlines, hotels, restaurants, dive and tour operations, marinas, and in construction, craft production and sales, food supplies and equipment, and many, many other fields related to tourism.

While tourism can bring great economic benefit, it can also take a heavy toll on the environment if it is not carried out sustainably. Conservation is critical so that tourists will continue to enjoy their visits, while minimising their impact on the environment.

Before You Begin

Collect postcards to show as examples. Cut card stock in half or to the approximate size of a postcard.

What to Do

1 Define tourism. Ask students what tourism is and write their answers on the board. Explain that many of our visitors come to enjoy the coastal and marine areas of our islands. This is tourism — travel for recreational purposes. Many tourists send postcards to share the beautiful places and great experiences with their family and friends. Show students the postcard samples and talk about their components.

What is Ecotourism?

According to the International Ecotourism Society, ecotourism is:

"Responsible travel to natural areas that conserves the environment and improves the well-being of local people."

Principles for implementing and participating in responsible tourism activities include:

- minimise negative impacts
- build environmental and cultural awareness and respect
- provide positive experiences for both visitors and hosts
- provide direct financial benefits for conservation
- provide financial benefits and empowerment for local people
- raise sensitivity to host countries' political, environmental, and social climate

2 Make postcards. Ask students to think about a beach or coastal area where they like to go. On a postcard-sized piece of card stock, have them illustrate these places and write a message on the back to a friend or family member (or to another student whose name they pick out of a hat). If students do this activity after "Sea for Yourself" on page 30, they can draw on that experience to make their postcards.

3 Present and discuss postcards. Students can share their work with the class. (Alternatively, if students pick names, they can address the postcards accordingly, put them in a "mailbox" in the classroom, and the recipient can share his or her postcard when it is delivered.) Discuss the similarities and differences among the various places students have identified. What is it about these places that makes them special? List ideas on the board. Have students locate the places on the map.

4 Talk about tourism in The Bahamas.

Topics and questions to guide discussion:

- ***Understanding of and experiences with tourism***

  Why do students think people visit The Bahamas?

  Where do they go?

  What do they do?

- ***Tourism and the economy***

  How do we benefit from these visitors?

  Ask students to raise their hands if they know someone who works in tourism. What does this person do?

- ***Tourism and the environment***

  Ask students if they've heard the term, "ecotourism." Talk about responsibilities of tourists and hosts. *(Who is responsible for keeping the beach and sidewalks clean? Who benefits from a clean environment?)*

  What are some other ways we can be models for other Bahamians and for tourists? *(not touching or taking things from reefs, putting trash in its place)*

  Being "eco" isn't only for being outdoors. What we do inside can make a big difference. "Green" hotels take measures to use fewer resources and save money *(install efficient cooling systems and low flow showers and toilets; offer guests the opportunity to decline daily sheet and towel changes that require a lot of laundry)*.

  Ask students what they think restaurants can do *(offer foods that are in season, implement energy saving measures for dishwashing, lighting, and air-conditioning)*.

osprey

Assessment

A well-made postcard should include a picture on one side, and on the other the name of the place, a message, and address. Ask students to write a sentence about what attracts tourists to such places, and write a sentence about what would make it disappointing for a visitor: "Tourists wouldn't want to visit if…" *(For example, the reef has suffered bleaching and there are no fish, or the beach is full of litter)*. They can also draw pictures of these scenes and compare them with the attractive places they illustrated on their postcards.

Extensions

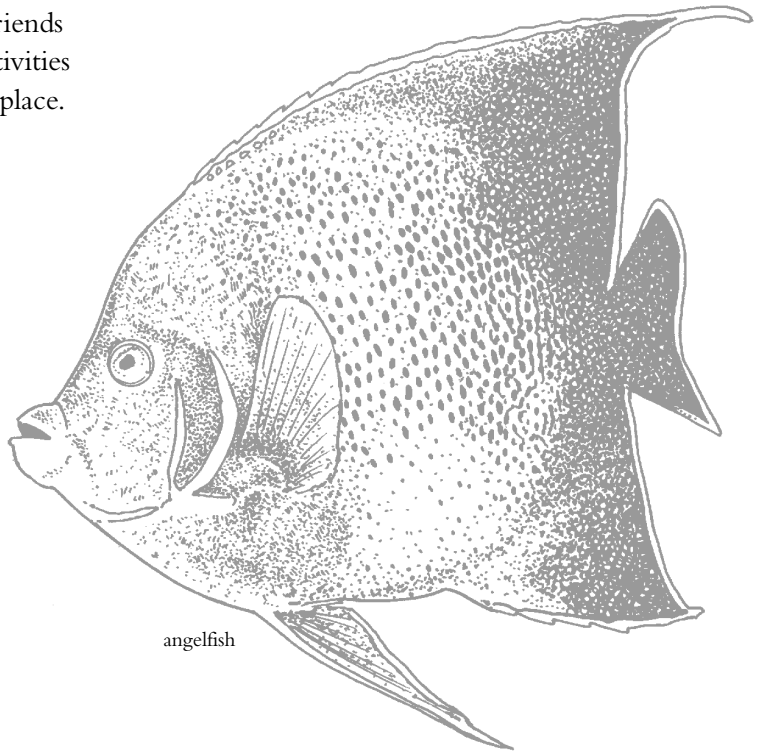
Students can do more research on the place they selected to find out what species live there. Based on this research, they can expand the postcard message into a longer email message that they would write to friends or family, describing the location, species, and activities that visitors can participate in while visiting this place.

Watch a video that features the beaches and coastal areas of The Bahamas such as those on the Exuma Cays National Park available from the Bahamas National Trust. Visit www.thebahamasnationaltrust.org/education_teach_video.php for a list of videos and information on borrowing them.

Visit the Bahamas Ministry of Tourism website, www.bahamas.com. What places and experiences are promoted for visitors to our country?

Resources

The International Ecotourism Society. Principles, facts, publications, and much more on ecotourism. www.ecotourism.org



angelfish

5 Working in the Marine Environment

This activity presents some of the marine-related career opportunities for young people in The Bahamas. Students choose careers to investigate and role-play interviews.

Learning Objectives

- Learn about careers in the marine environment, including academic training, skills, and time required for preparation
- List some of the ways that people's work can have an effect on marine issues and conservation

Grades

3 – 6

Subjects

Science, Social Studies, Language Arts

Skills

gathering (brainstorming, researching, interviewing), presenting (describing, public speaking), citizenship (working in a group)

Vocabulary

aquaculture, archaeologist, biotechnology, ecotourism, oceanographer

Time

1½ hours, plus research time outside of the classroom

Materials

For each student: "Marine Careers Table" (pages 152 – 153), "Career Research Guide" (page 154), "Career Interview Guide" (page 155)

There are many ways to work in the marine environment, from careers in marine biology and oceanography to fishing or tourism. This field may draw on the sciences, education, communication, economics, or business — or combine a number of these areas. Some marine-related jobs are highly specialised and require particular educational preparation, experiences, and skills. Some may even be unique to the people who do them, as is the case with someone who starts her own business or creates his own position because of a perceived need for his or her expertise.

Some characteristics shared by people in virtually all marine-related careers include a love of the marine environment, a respect for the way the ocean works, and a sense of curiosity. Many people in the various marine sciences describe a feeling of accomplishment or satisfaction about their work, knowing that what they are doing has or will make a difference for present and future generations. Others like the sense of pioneering discovery, given that much remains to be learned about the way the ocean works and the organisms that inhabit it.

Before You Begin

Make copies of the "Marine Careers Table," (pages 152 – 153) "Career Research Guide," (page 154) and "Career Interview Guide" (page 155).

What to Do

1 Discuss marine career opportunities. Ask students to brainstorm marine-related careers. Write them on the board as students name them. Encourage students to think broadly, to include careers that are indirectly related to the sea but still dependent upon it.

2 Explore a career. Distribute the "Marine Careers Table" and explain that students can select a career from the table that they would like to learn more about. They will research what it entails, including any academic and training requirements. Students can research the careers by: 1) interviewing persons employed in their selected career, 2) searching for information on the Internet, or 3) meeting with the school guidance counsellor to review resources on careers in the marine environment. Pass out the "Career Research Guide" as a guide for students' research.

3 Presentations and interviews. Once students have researched the marine career of their choice, they should prepare a presentation about it. They may make a poster and collect props (clothing or tools) to represent their career choice. Distribute the "Career Interview Guide" so that other students can ask each "qualified professional" questions about his or her career. Encourage the interviewers to add any other questions they have in addition to those in the interview guide. As an alternative, the presentations can be done in the form of a career fair in which half of the students set up display stations about the careers they have researched and the other half of the class rotates through these stations and asks questions. Then students reverse roles.

Assessment

Collect the "Career Worksheets" and evaluate the completeness of information provided. You can develop a rubric to assess presentations or written reports. (See the sample rubric on page 23.)

Extensions

Have students conduct research to find out what organisations deal with protecting the environment and list positions that are available at these organisations.

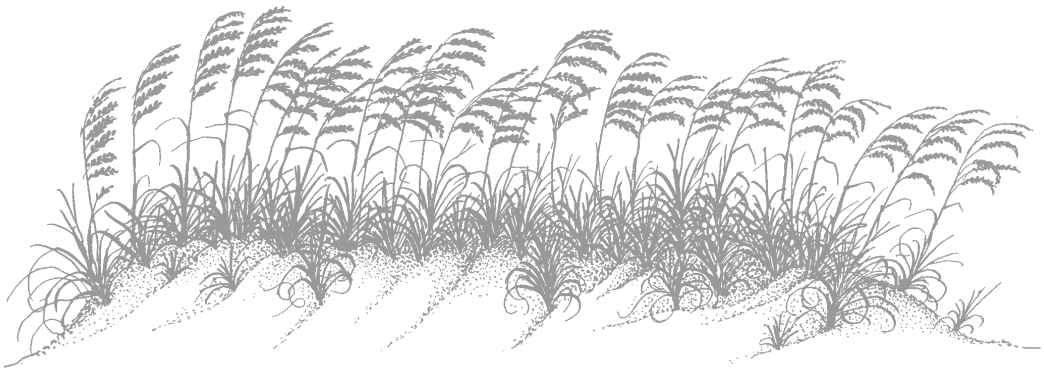
Students can write a proposed "career plan" by learning more about people who are involved in jobs of interest to them. Have students research the background of these people (for example, education, work experience, and memberships in professional organisations), and develop a career plan based on what they find.

Resources

www.marinecareers.net
An introduction to a wide range of marine career fields that features profiles of men and women working in those fields.

www.oceancareers.com
Explore more than 50 ocean-related careers to learn about job requirements, educational background, average annual salary, and employment trends. Includes profiles of people with these careers.

www.nmfs.noaa.gov/pr/education/careers.htm
Links to Web sites on marine-related careers.



sea oats

Marine Careers Table

Aquaculturist A farmer who raises fish or other aquatic animals or plants in a controlled environment.	**Aquarium Curator** A manager of public exhibits and specimen collections in an aquarium, who also maintains records and permits. An expert on aquatic environments and animals, and on water quality and filtration.
Aquatic Animal Veterinarian A veterinarian who specialises in the treatment and study of aquatic mammals, fish, or invertebrates.	**Director of a Marine Conservation Organisation** Leads a marine conservation organisation and secures funds; generally a person with several years of experience working in environmental conservation and advocacy.
Ecotourism Guide A guide who leads tours for visitors to foster an appreciation of natural and cultural resources and encourage conservation practices.	**Fisher** A fisher whose catch is sold and/or used to feed his or her family. Whether using traditional or modern techniques, a fisher must know the local waters "like the back of his or her hand."
Fisheries Biologist A scientist who studies fish and their habitats, and uses research results to manage and improve the quality of a fishery.	**Fisheries Officer** An officer who enforces fisheries regulations, conducts studies, prepares reports, and educates the public about issues related to fisheries.
Laboratory Technician An assistant to research scientists in the laboratory or in the field who sets up equipment, runs experiments, and collects data.	**Marine Archaeologist** A scientist who studies artefacts from the sea and coastlines, investigates shipwrecks, and helps preserve coastal areas that may have historical importance.
Marine Biologist A scientist who studies marine organisms, their behaviours, and their interactions with the environment.	**Marine Biotechnologist** A biomedical scientist working to develop new medicines from marine organisms.

Marine Careers Table

Marine Educator An educator who teaches about the workings and wonders of the marine world. Can work in a variety of settings from traditional classrooms to aquariums.	**Marine Mechanic** A mechanic who repairs and services the electrical, mechanical, and hydraulic equipment on boats. May work on propellers, steering systems, plumbing, fibreglass repair, and other boat components at docks or marinas.
Marine Park Warden A warden or park ranger who maintains marine park facilities, enforces regulations, and ensures the safety of visitors. Also monitors wildlife and works with fish and wildlife officers to implement conservation plans.	**Maritime Environmental Lawyer** A legal advisor who specialises in marine and environmental issues.
Oceanographer A scientist who studies physical (waves, currents, and tides) and chemical (salinity, oxygen, dissolved chemicals) properties, geology, and life forms in the ocean.	**Scuba Diving Instructor** A trainer who teaches the correct and safe way to scuba dive, an increasingly popular activity in coastal areas.
Seafood Importer/Exporter A businessman who distributes goods and services, exporting national seafood products and importing goods that cannot be obtained nationally.	**Seafood Restaurant Manager** Runs a restaurant that serves seafood — makes decisions about what goes on the menu, manages contracts for food and other supplies, and manages staff.
Ship's Captain In overall command of the ship, supervising safety, navigation, and crew. Usually has completed a course at a Merchant Marine Academy.	**Ship's Officer** The link between ship's captain and crew. An officer keeps the nautical log, coordinates cargo loading and unloading, and makes sure that all ship documentation is correct.
Ship's Pilot The navigator on a ship. With local boats, the pilot stays aboard and works as an employee of the boat's owner. With ocean-going ships, the pilot comes aboard as the ship approaches shore and guides the ship to its anchorage.	**Shipbuilder** A worker involved in the construction of ships, from pleasure craft to high-speed aluminium passenger- and vehicle-carrying vessels. May be a welder, fabricator, fitter (engineering assembler), electrician, or furniture maker.

CAREER RESEARCH GUIDE

Name: _____

Date: _____

1 What courses do you need to take in high school in order to pursue a career in _____ ?

2 Do you need to go to college/university or technical school?

3 What courses will you need to take?

4 How long will you need to be in college/university/technical school?

5 What special skills would you need to pursue a career in this area?

6 Describe a typical day of a person who works in this area.

7 Where would you find employment if you pursue this career? In or outside of The Bahamas?

8 What type of salary would you make in this career?

9 How does this career affect the marine environment?

10 How could this career help conserve the marine environment?

CAREER INTERVIEW GUIDE

Name: _____

Date: _____

1 What does a _____ do? _____

2 What is the most fun part of your job? _____

3 What do you like doing the least? _____

4 What subjects do I need to study in high school in order to pursue this career? _____

5 Would I need to go to college or technical school? _____

6 How long would my schooling or training take? _____

7 Where would I look for a job when I have completed my schooling or training? _____

8 Would I be able to work in The Bahamas? _____

9 How could I help the marine environment if I pursue this career? _____

SECTION 7

Taking Care of Our Treasures

Conservation in The Bahamas

While human actions are threatening marine species and their habitats, there are also a number of ways people are getting involved in conservation. Activities in this section examine some of the threats to marine biodiversity in The Bahamas, from overfishing to habitat destruction to marine debris and pollution. These activities introduce some alternatives to stem the tide of losses, including fisheries regulations, marine protected areas, and measures to prevent pollution and encourage restoration.

1 Fishing versus Overfishing

Students simulate studies conducted by scientists to estimate the population of a species of fish. Students learn about methods of promoting sustainable fisheries.

Learning Objectives

- Learn a method for estimating fish populations
- Identify various ways of managing fisheries in The Bahamas

Grades

5 – 6

Subjects

Science, Social Studies, Mathematics

Skills

gathering (simulating, recording), analysing (calculating, discussing, comparing and contrasting), applying (experimenting), interpreting (inferring), citizenship (working in a group)

Vocabulary

average, estimate, **overfishing, quota, sustainable fishery**

Time

1 hour

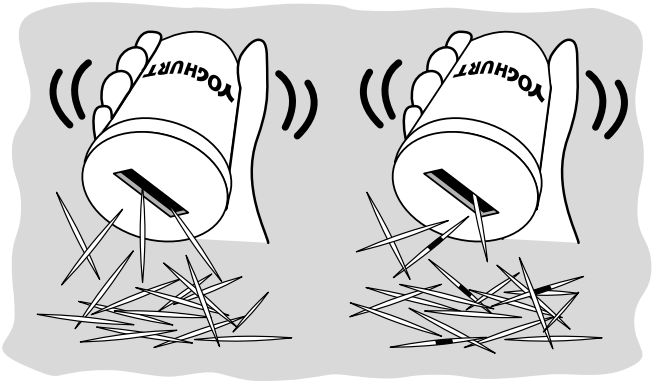
Materials

ruler, craft knife

For each group or pair of students: container with plastic lid — like a large (32-ounce) plastic yoghurt tub or a small coffee can; toothpicks, dry beans, or small straws cut in 6-cm (2½-inch) lengths (100 or so per group — exact quantities aren't necessary); coloured marker; worksheet (page 162); calculator

Every year, many millions of tons of fish are hauled from the ocean. How much is too much? The answer seems to vary depending on whom you ask. A scientist might say fishers should catch as many as would allow the maintenance of fish populations — this is a sustainable fishery. Fishers may be more inclined to catch as many fish as they can to earn a living, but many are also concerned about the future of the fishery for their children and grandchildren. Governments want to keep the fishing economy healthy and the environment healthy, too. A healthy environment is one in which fish can reproduce and the food web is unbroken.

To avoid overfishing it is important to strike the right balance between what we take and the number left behind to reproduce so the size of a fish population is maintained. But this is not a simple thing to agree on. While marine resources may have sustained entire human coastal and island populations in the past, demand has increased with population growth and tourism development, and technology has made it easier to harvest larger quantities. Traditional fishing methods such as hand-lines, baited lobster traps, and conch hooks have been replaced in many places with diving apparatus, spearguns, long lines, dredges, driftnets, and use of global positioning systems to place and relocate traps.



Before You Begin

Make copies of "Calculate the Population of Nassau Grouper" (page 162). Cut a slot in each of the container covers (1.5 cm x 7.5 cm, or about 1/2 in. x 3 in.). Read through the worksheet and the example in Step 2 below to familiarise yourself with the procedure for the experiment.

What to Do

1 Introduce the activity. Explain to students that they are going to conduct an experiment to find out how many Nassau groupers there are in an area adjacent to the Exuma Cays Land and Sea Park. Of course, counting every single grouper is impossible, so scientists have methods for estimating the total number of fish. One way they can do this is to: (1) catch and tag fish in a specific location, and then release them; (2) periodically return to the same place and catch additional batches; and (3) count the total number of fish caught in each batch as well as the number of tagged fish caught. Using these totals, scientists can estimate the total population. With this information, they can consider management strategies to help prevent grouper from being depleted in that area.

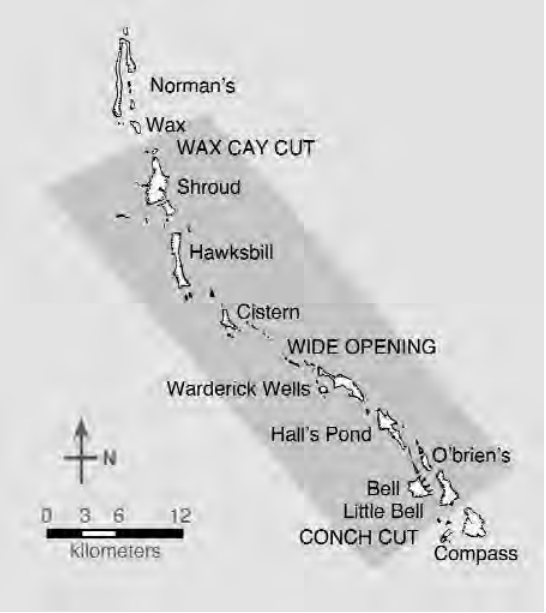
2 Go over an example of the method. Demonstrate the procedure to students and fill in numbers in a table on the board as you go along, using the example numbers and calculations provided here, or actual numbers from a demonstration.

Catch and tag the first batch of fish: Let's say the first time you give the container five shakes over a tabletop, 22 toothpicks ("fish") fall out. These should be tagged with a coloured mark, the number recorded, and the toothpicks returned to the container.

Go fishing: Now you are ready to conduct the experiment. With the cover on the container and a hand over the opening, shake it vigorously to mix up all the fish. Repeat the shaking process over the table as you did to mark the first batch of fish. Let's say this time 20 toothpick "fish" fall out. Count how many of them are

Exuma Cays Land and Sea Park — Benefits for Fish and People

The 456-km^2 (176 sq mi.) Exuma Park was established in 1958. It is one of the oldest land and sea parks in the world! It was designated a no-take marine reserve in 1986. Studies suggest that the Exuma Cays Land and Sea Park plays an important role as a replenishment area for species that are exploited in surrounding waters. Continued research comparing concentrations of conch, crawfish, and grouper within the park with those outside the park, and tracking their movements — as studies are doing by tagging groupers — will improve our understanding of the park's benefit to fisheries.



tagged (suppose there are four). The total number of fish "caught" and the number of tagged fish are recorded for Round 1 in the table below. (Remember that the first batch was to tag fish before starting the experimental rounds.)

To find out how many similar batches it would take to recover all of the tagged fish, divide the number of fish tagged in the first batch (22) by the number of tagged fish "caught" in Round 1 (4). The answer (5.5) multiplied by the total number of fish caught in this round (20) equals an estimated total of all the fish in the area (110). The calculations are recorded in the table.

Repeat: It is important to repeat the procedure several times to get to a closer estimate of the actual total. Starting again with all of the tagged and untagged fish in the container, repeat four more times the steps for mixing, shaking out, and recording the total number of fish and the number of tagged fish. Examples are filled in for Rounds 2 – 5 in the table.

Calculate: The total of the five estimates is 509, rounded to the nearest whole number (or "fish"). This is divided by five (the number of times fished once fish were tagged) to get the average.

3 Do the experiment. Divide students into small groups or pairs and give each the materials listed on page 158. Explain that they are going to do the experiment themselves. Make sure students understand the instructions on the worksheet. Depending on the level of your students, they can then work independently, or you can walk them through the activity, with each pair or group of students carrying out the steps simultaneously.

4 Discussion. Explain to students that once the number of fish is determined, this information and other important factors — such as the species' life span and the effects of changes in the environment — can be considered to develop strategies for fisheries management. There are a variety of regulations in place in The Bahamas *(see box on facing page)*, and others that could be implemented, such as setting quotas, or limits, on catches. The key is to make sure that with all the

If Tagged Fish = 22

	Total Fish in Catch/ Tagged Fish in Catch	Total Tagged Fish ÷ Tagged Fish in Catch = Number of Catches to Recover all Tagged Fish	Number of Catches x Total Fish in that Catch = Estimate of Total Fish in Area	Total Estimates of Fish ÷ 5 *(# of times you fished)* = Average Estimate of Total Population
1	20/4	22 ÷ 4 = 5.5	5.5 x 20 = 110	
2	9/2	22 ÷ 2 = 11	11 x 9 = 99	
3	30/7	22 ÷ 7 = 3.1	3.1 x 30 = 93	
4	25/5	22 ÷ 5 = 4.4	4.4 x 25 = 110	
5	22/5	22 ÷ 5 = 4.4	4.4 x 22 = 96.8	
			Total Estimates = 508.8	**509 ÷ 5 =101.8 or 102 fish**

fish caught by fishers plus those lost to pollution and other causes, there will still be enough left in the ocean to mature and reproduce at a rate that keeps the population from getting smaller.

Assessment

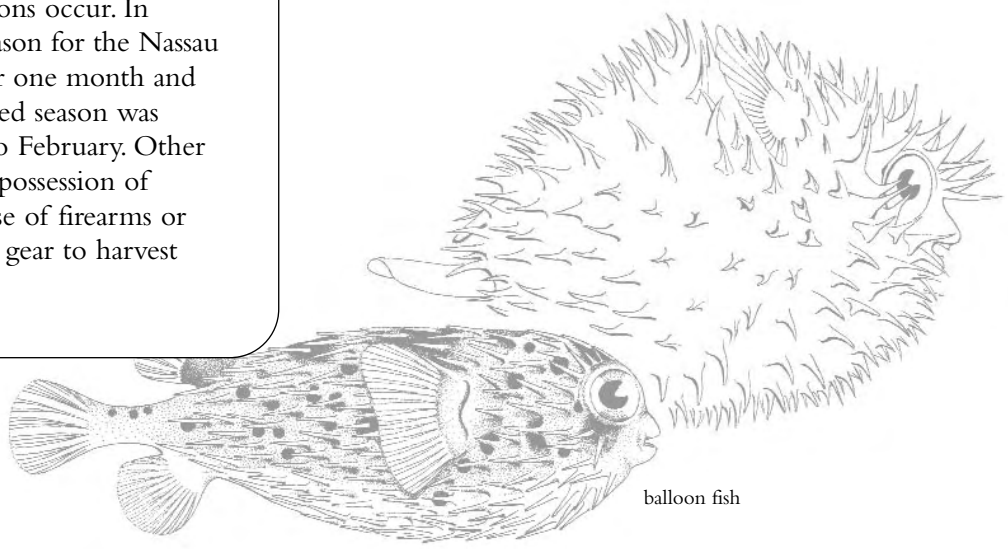
Have students write a paragraph explaining how estimating the population of fish in a particular area helps to make management decisions or set regulations. Ask them to think about: What kinds of regulations are there in the The Bahamas and why? What would happen in the future if there were no fishing regulations?

Do You Know the Fisheries Regulations?

In The Bahamas, different forms of fisheries management are used, including closing areas to fishing and instituting closed seasons. There are also regulations pertaining to fishing methods (e.g., mesh size for nets, use of scuba is prohibited). The Bahamas Department of Marine Resources has, since 1998, seasonally closed some specific areas where Nassau grouper spawning aggregations occur. In December 2003 a closed season for the Nassau grouper was put in place for one month and in subsequent years the closed season was extended from December to February. Other prohibitions include use or possession of bleach and other poisons, use of firearms or explosives, and use of scuba gear to harvest any marine products.

Extensions

- Students can play a game simulating a fishing community. They "fish" for peanuts or M&Ms according to different scenarios in which each player takes as many as possible or in which they communicate in order to cooperate to sustain the fishery. The game and variations are described at treasures.amnh.org.
- Have students research the different types of fisheries regulations in The Bahamas. What are some of the reasons for choosing closed seasons, closed areas (such as marine reserves), or quotes?
- Students can contact local restaurants and grocery stores to research which species of fish they sell. They can then research these to see if any populations are in decline because of overfishing. The class can consider the results and then write a letter to the business expressing their opinions about the fish they sell.



balloon fish

CALCULATE THE POPULATION OF NASSAU GROUPER

Name: _____

Date: _____

1. Catch and tag the first batch of fish.

Without counting your toothpicks ("groupers"), put them into the container ("ocean") and put on the cover. Hold your container upside down a few inches above a tabletop and give it five good shakes so that some of the toothpicks fall out. Tag each toothpick with a coloured mark. Count the toothpicks and write down the number of these "tagged groupers."

Tagged Fish = _____

This number should be entered in all rows of column c below.

2. Go fishing.

Put the tagged fish back in the container and replace the cover. Hold a hand over the opening, and shake it vigorously to mix up all the fish. Then give the container five shakes over the table to let the "groupers" fall out. Count the total number of toothpicks that fall out this time and how many of them are tagged. Enter these numbers in columns a and b below. Repeat until you have done a total of 5 rounds and filled in the table.

3. Calculate.

Fill in columns d and f. Do the calculations in columns e and g to estimate the total of all the groupers in the area. Then add up the five estimated totals and divide by 5 (the number of times fished) to get the average. Once you have the final estimate of the number of groupers in the area, count all of the toothpicks and see how close you are to the real total.

	a	b	c		d		e		f		g
Round	**Total fish in catch**	**Tagged fish in catch**	**Total tagged fish**		**Tagged fish in catch** (from column b)		**Number of catches to recover all tagged fish**		**Total fish in that catch** (column a)		**Estimate of total fish in area**
1				÷		=		x		=	
2				÷		=		x		=	
3				÷		=		x		=	
4				÷		=		x		=	
5				÷		=		x		=	
									Total Estimates		

Total estimates of fish ÷ **5** (number of times fished) **= Average Estimate of Total Population**
(from column g)

_____ ÷ **5 =** _____

2 To Protect or Not To Protect

Students role-play a community meeting in which the topic is whether or not to protect a coastal habitat.

Learning Objectives

- Evaluate the pros and cons of protecting a coastal habitat
- Present and defend a position on one of the related issues

Grades

5 – 6

Subjects

Science, Social Studies, Language Arts

Skills

analysing (questioning, discussing), interpreting (drawing conclusions, defining problems, identifying cause and effect, reasoning), applying (proposing solutions), presenting (persuading, debating, compromising), citizenship (taking a position)

Vocabulary

marine protected area (MPA), **no-take reserve,** stakeholders

Time

1 hour

Materials

A copy of the scenario for each student (page 168); a copy of the role descriptions (pages 169 – 170); props students can use to portray their roles; pictures of the habitat types and plants and animals found in protected areas in The Bahamas (optional)

Marine protected areas (MPAs) have the potential to provide a number of environmental, social, and economic benefits, such as:

- maintaining fisheries
- protecting plant and animal life
- protecting habitats, including breeding and nursery sites
- offering opportunities for visitors to observe marine plants and animals
- providing areas for scientific research
- providing areas for educational opportunities

However, there may be many stakeholders in a given area, some of whom stand to benefit from protection, while others may be required to make livelihood changes that may cost them — especially in the short term. Even if people agree that a protected area is a good thing, they may not agree on how the area should be managed. Some communities have established their own protected areas, managed through informal agreements — or have presented proposals to the government for official designation. The government of The Bahamas is also in the process of planning for a network of reserves to include both existing and new areas. The aim is to ensure healthy populations of queen conch, crawfish, Nassau groupers and other marine resources into the future, providing long-term support for the fishing industry and the tourism sector. Community meetings are part of the process to inform, gather opinions, and generate ideas for marine resource management.

Central Andros National Parks — A Community Process

The 1,158 km^2 (447 sq mi.) of parks in Andros protect one of the world's longest barrier reefs, a high concentration of blue holes (underwater caves or sinkholes), as well as valuable mangrove wetlands. Leading up to the establishment of the area in 2002, resort owners, bonefish guides, local government members, and community leaders joined together to create the Andros Conservancy and Trust, and worked with the Bahamas National Trust to prepare a proposal to the Government of The Bahamas for the creation of a national park.

Before You Begin

Create role description cards (page 169 – 170) to be distributed to each student (or team). Collect props and pictures, and photocopy the scenario on page 168. Refer to the background information (page 2) to read about marine protected areas (MPAs) in The Bahamas. Find out which MPAs or parks are in your area to give as examples. Further information can be found at the Web sites listed under "Resources" at the end of this activity.

What to Do

1 Discuss protected areas. Ask students if they have visited a park or reserve in The Bahamas and what they did there. Make a list on the board of the parks and reserves they name. Provide additional examples if necessary. Talk about each place and ask your students what visitors can do at these sites in terms of recreation, research, or tourism. Then, discuss why such areas are protected. *(To minimise impacts of development, to conserve breeding or nursery habitats, or to enable people to learn about and observe wildlife.)* You may wish to show pictures of some of the protected areas, illustrating the variety of habitats found there and the animals and plants that live in them.

Explain that the class will be focusing on marine protected areas in this activity. Marine protected area (MPA) is a general term for an area associated with the ocean that receives any sort of protection. MPAs may

What's in a Name?

Protected areas in The Bahamas include national parks, land and sea parks, reserves, and nature centers.

- National parks and land and sea parks are generally managed in order to protect their natural features, while allowing access for recreation, education, and research. Abaco National Park offers protection for the Bahama parrot and its northern nesting habitat. The Exuma Cays Land and Sea Park protects marine habitats and allows tourism while restricting fishing and other extractive or harmful uses.
- Reserves also protect significant natural features, including rare plants or animals — and usually do not allow public access. Union Creek National Reserve in Great Inagua is one such area where turtles can nest without being disturbed by people.
- Nature centers such as the Rand Nature Center (in Grand Bahama) and the Retreat Garden (in Nassau) are smaller, natural areas set aside for public recreation and enjoyment.

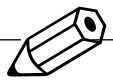
include marine parks or sanctuaries, no-take reserves, and fully protected marine reserves. Discuss the reasons for having marine protected areas (refer to the activity introduction).

2 Introduce the scenario, "To Protect or Not To Protect: That Is the Question!" Pass out a copy of the scenario to each student (or team). Read the scenario aloud (or have a student read it) and clarify any questions that students may have.

3 Assign roles. Tell your students they are going to play roles in a community meeting that has been convened to discuss the proposal to create a marine protected area on their island. Ask students to describe what a community meeting is like. Assign roles by distributing a description card to each student (or team) and have any other students act as reporters or townspeople. You may wish to assign some students to be town commissioners who vote at the end, or have the entire class vote. Either act as facilitator yourself, or choose a student who would be able to keep the meeting in reasonable order.

4 Prepare for the role play. Give students some time to prepare their roles and think about the information they will present individually or in teams. You may need to give more time to younger students or group the roles in teams so that students can help one another (e.g., group all tourism interests together; or form teams of pro, con, and compromisers). You might also want to have students create a prop that helps represent the role they are playing (such as binoculars, sunglasses, a dive mask or fishing pole), and the facilitator could use a gavel (or improvise one) and reporters carry notepads and pens (and take notes!).

5 Conduct the role play. Have the facilitator call the meeting to order, stating the purpose to discuss the proposed coastal conservation area. He or she can then use a list of speakers (or a copy of the "Role Descriptions" pages) and call on them one by one to tell his/her side of the story. After each one has presented his/her point of view, have the facilitator ask for comments and discussion from the audience. If you have more time you can encourage a debate among the participants. The facilitator then takes a vote on whether or not the community supports the creation of the protected area.



Suggestions for Running a Community Meeting

Community meetings allow for a group of people to be informed at one time and can provide a forum for a variety of perspectives to be presented and discussed, and differences accepted and resolved. A facilitator usually manages the meeting and encourages communication among all participants. Some pointers for community meetings:

- Make the purpose of the meeting clear from the beginning *(Why are we meeting?)* and explain the process or order in which the issues will be discussed. For example, have a representative from each side give a short overview of their opinions, then open the floor for discussion.
- Start with issues on which it is easy to get agreement or acceptance of differences.
- Allow conflicting opinions to emerge and try either to have these resolved or accepted by the group.
- At the end of the meeting, have someone (preferably a local leader) summarise the decisions made.

ring-billed gull

6 Discuss what students learned. Point out how the government and community groups organise meetings like this in real life to listen to various opinions on an issue. Sometimes it can be difficult to reach a consensus and compromise is necessary. Ask students to think about questions, such as: Why do we have to involve a variety of people in discussions about creating protecting areas? Why is it important to conserve areas? When are solutions driven by a sense of responsibility? When are people reluctant to take action? Why? Do students think their responses to the issues are realistic?

Assessment

In addition to the discussion, you can ask students to list pros and cons for protecting the coastal habitat. Ask for a minimum of three pros and three cons, or challenge students to list as many as they can think of.

Extensions

- Have students write an essay about what the life of one of the characters in the role play would be like if the area were set aside (or if it were not). The essay should explore how the character's personal and professional life would be affected.
- Have students investigate a local proposal to create a protected area. What are the pros and cons of this effort? If your students can find people who support it and others who oppose it, have them interview representatives of both perspectives.
- Invite a guest speaker to talk about the process of deciding where to create marine protected areas. Have students prepare questions and send these to the speaker beforehand.

Resources

National Parks Information
www.thebahamasnationaltrust.org/parks.php
www.bahamas.gov.bs/BahamasWeb/VisitingTheBahamas.nsf/Subjects/National+Parks

Fully-Protected Marine Reserves for the Future of Our Oceans: A Companion Guide to the Fully-Protected Marine Reserves Public Exhibition. (BREEF, TNC, and the Department of Fisheries, 2004)
cbc.amnh.org/center/pubs/pubscbc.html

Adapted with permission from "To Fence or Not to Fence," Texas Parks and Wildlife Department © 2006.
www.tpwd.state.tx.us/learning/resources/activities/coastal/fenceactivity.phtml

Additional ideas from "Design Your Own Marine Park!" by Roana O'Neill, in *Marine Education Activities Booklet: Diving Deeper and Exploring Further.* Marine Education Society of Australasia, Inc. (MESA) National Council, 2001.
www.mesa.edu.au/seaweek2002/booklet.htm

To Protect or Not To Protect: That Is the Question!

Community leaders have called a meeting to talk about how to manage an adjacent coastal area considering its importance to the community for fishing, tourism, and recreational activities. Developers, visitors, and other stakeholders (people who have a "stake" in what happens) make use of the area (or would like to) for a variety of purposes.

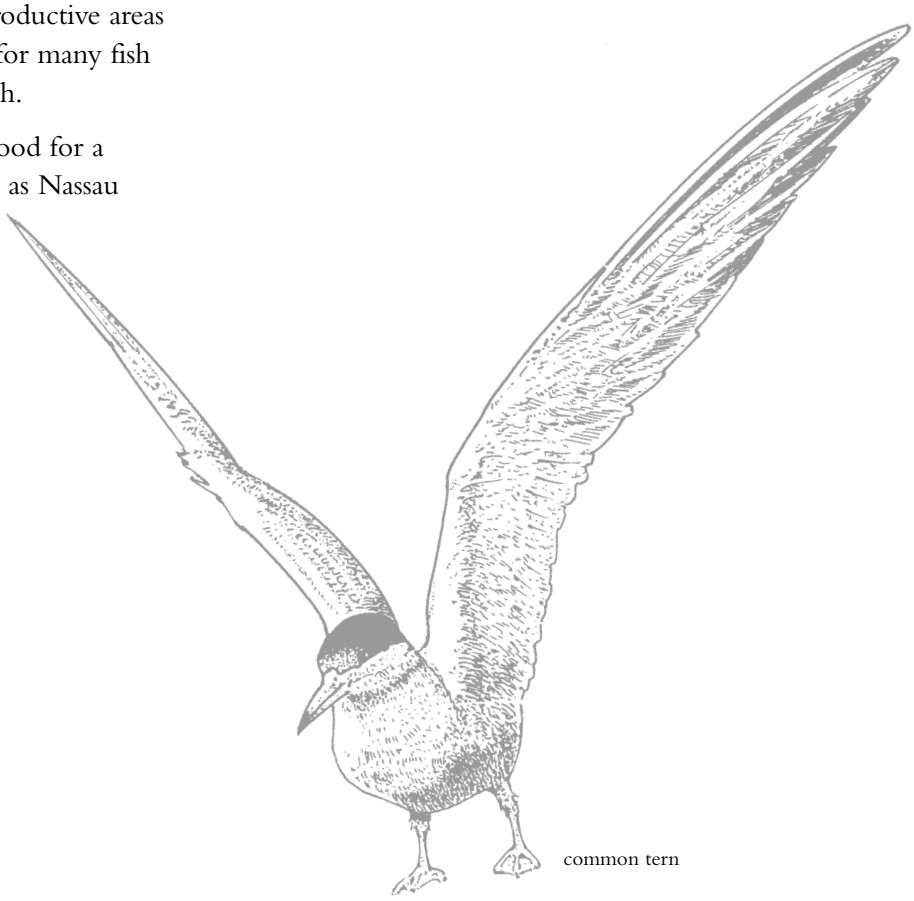
The area includes several habitat types, including beaches, mangroves, seagrass beds, and a nearby reef. These habitats and the diversity of life they support are important in ways that some people may not realise.

- Beaches act as buffers against high winds and absorb wave action during storms. They also trap soil particles coming from land that would cloud coastal waters where there are seagrass beds and coral reefs.
- Mangroves provide nesting and feeding habitats for many birds, some threatened and endangered. They also provide important nursery habitat for many reef fish.
- Seagrass beds are among the most productive areas on Earth, and serve as nursery areas for many fish and shellfish, such as the queen conch.
- The coral reef provides shelter and food for a multitude of marine organisms, such as Nassau grouper and crawfish.

Some activities that currently threaten the area are:

- Proposals have been submitted for housing and tourist developments close to the beach.
- Boaters anchor on the reefs and damage corals.
- Garbage is not well-maintained and pollutes mangroves and the ocean, threatening wildlife.
- Overfishing of certain marine species, such as queen conch, is reducing local populations.
- Jet skiing disturbs wildlife and creates wave action that contributes to beach erosion.

There has been talk about proposing a marine protected area (MPA) to include five square kilometres (about two square miles) of coastline in order to protect habitats and the species that depend on them. However, some people are opposed to this idea, and even among those in favour, there are differing opinions about what activities should or should not be allowed in the area.



common tern

Role Descriptions

Rosie Sandpiper

An elderly birdwatcher from Canada who enjoys keeping a life list of all the birds that she has seen. She is for conserving the area to protect the many birds who feed on the algal flats and use the salt marsh to nest and raise their chicks.

Dee Veloper

A wealthy developer who buys wetland areas because they are cheap and perfect for building marinas, winter residences, and tourist resorts. The construction of more homes and resorts in the area will create more jobs for local people in the construction and tourism industries.

Al G. Flat

A biologist who studies the rich diversity found in the various habitat types, including mangroves, seagrass beds, and coral reefs. His goal is to protect the area so that it can continue to serve as habitat for many animals and plants, and shelter the coast from negative human or natural impacts.

Wade Fisher

A sportfishing guide who argues that his clients bring a lot of money into the community. He feels that it is his right to run his business and that "catch and release" fishing has minimal impact on the environment.

Mac Diver

A dive operator who takes tourists from all over the world to snorkel and dive on the nearby coral reef. He is for protecting the area so he can continue making a living and people can enjoy the wonders of the reef.

Lillian Marina

She would like to see a marina built by her hotel located near the proposed protected area. A marina would attract guests who need to dock their boats, raising hotel occupancy to the level she needs to keep her business going.

Lupe Law Woman

The game warden who enforces fish and wildlife regulations that apply to the whole island. She keeps an eye out for poachers and people who destroy habitat.

Role Descriptions

Glory Morning

A local environmentalist who loves the beach morning glory flowers growing in the proposed protected area. She opposes unrestricted access by recreational vehicles that destroy the flowers.

Leila Reed

She harvests plants from the area for teas and food she sells in her nature shop, just like her mother and grandmother did. The recipe for her popular sea grape preserves is a well-guarded family secret. She is in favour of protection for the nutritional and medicinal plants found in the area, and wants to continue to have access to harvest them.

Kevin Angelfish

Works for a company that captures live fish for the aquarium business. Most of the valuable species are getting harder to find on other islands. He wants permission from the community and the local government to hire local fishermen to help him collect fish on the reef.

Pat Playtime

She loves to jet-ski through the area with her friends and family. Pat was born in the area and has always used it freely and she would like her children to have the same right. She is against imposing any regulations that would prohibit people from enjoying this wonderful area.

Fred Feather

He loves to hunt blue-wing teal (a migratory duck) in the area's wetlands. He is opposed to the proposal to designate a protected area because he would be prevented from hunting there. It's not the only place to hunt the duck, but it's his favourite.

Duke Dredger

He would like to see an access channel dredged from his residential canal adjacent to the proposed protected area. He believes that benefits of access for fishing boats will outweigh any potential erosion problems caused by the higher wave energy coming in.

Don Longline

He finds that he has to search longer and harder for fish that he used to find easily. He is for protecting some areas, especially important nursery areas for fish, so that the populations can be replenished and he can catch more to make more money. However, he wants certain areas open for fishing.

3 Pollution Solution

Students create and clean up a miniature oil spill while considering the environmental impacts of the spill.

Learning Objectives

- Describe effects of oil spills on the marine environment
- Identify methods of cleaning up oil spills
- Identify ways that businesses and individuals can help reduce pollution in the marine environment

Grades

3 – 6

Subjects

Science, Social Studies, Mathematics, Language Arts

Skills

gathering (simulating, recording), analysing (calculating, discussing), applying (experimenting, predicting), citizenship (working in a group, evaluating the need for citizen action)

Vocabulary

bilge water, emulsify, **pollution**

Time

1 – 1½ hours

Materials

clear bottle with lid, water, cooking oil, blue food colouring and paprika to tint the oil, cork or other floating object, "Oil Spill Cleanup" worksheet (page 177) for each student

For each group of students: a shallow oblong pan or tray, water, cooking oil, timer, cotton balls, teaspoon, medicine dropper, plastic container for wastewater, plastic bag for discarded cotton balls

Optional: photographs or articles about oil spills; liquid detergent, brush, bird feather, wire whisk, pebbles

If you have ever seen images of oil spills in the news, you have an idea of the problems they can cause and how difficult and expensive they are to clean up. Oil spills, especially from oil tankers, offshore platforms, and pipelines, are the most visible cause of oil pollution in the marine environment. However, oils enter the ocean in many ways, including from natural sources; large quantities enter through natural seeps from oil-bearing rock layers. While most of this oil is dispersed in the ocean, oil from land-based sources can cause problems. For example, when people pour their used motor oil onto the ground or into a septic system, it can seep into the groundwater, and eventually reach the ocean.

The Caribbean region is vulnerable to marine oil pollution due to the high volume of cruise ship traffic. Bilge water, released from the ships, can have a high concentration of oil.

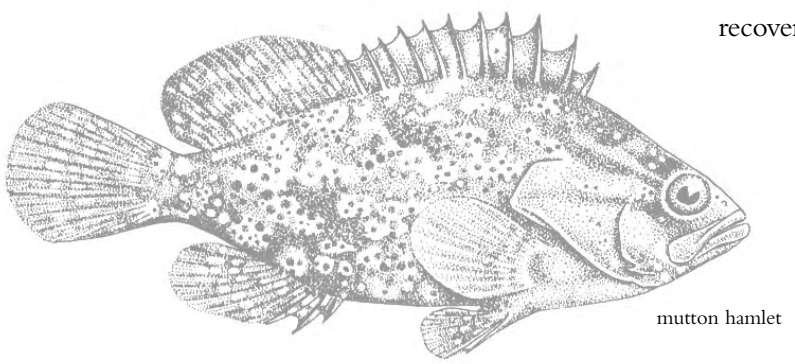
Oil Spills Near You

Notable oil spills in the Caribbean region include two spills that occurred in 1979, both involving the *Atlantic Empress*. On July 19, the *Atlantic Empress* collided with the *Aegean Captain* off the coast of Trinidad and Tobago, producing a combined spill of about 174 million litres (46 million gallons) of crude oil. On August 2, the *Atlantic Empress* spilled an additional 155 million litres (41 million gallons) off the coast of Barbados while being towed away, causing a fire in the process. Smaller-scale spills are a much more frequent occurrence and can be caused by a variety of factors. One such small-scale spill occurred in 2005 when 7,500 litres (2,000 gallons) of diesel fuel spilled into the sea from the *MV Legacy*. The oil reportedly escaped through holes punctured in a fuel tank when it struck a guardrail in Marsh Harbour, Abaco.[1]

[1] Caribbean Net News, 2005. Oil spill worries Bahamian officials, www.caribbeannetnews.com/2005/03/03/spill.shtml.

When an oil spill occurs in the ocean, oil may spread across miles of open water and onto beaches, littering them with tar balls. The intertidal zones — coastal areas that are habitat for fish, birds, and other wildlife — are often the most vulnerable. Animals may perish when the oil slicks their fur or downy feathers, decreasing the surface area so they are no longer insulated from the cold water. Or the animals may ingest the oil, then become sick or have problems reproducing. When an oil spill occurs along a coastline, it affects the human population as well; oil-covered beaches are a detriment to recreation and tourism. Emergency equipment and personnel must be rushed to the scene. The responsible party must be identified to determine who will pay for the cleanup. Usually the cleanup is a group effort by oil companies, government agencies, local groups, and volunteers.

Crews rescue and clean birds and animals, and painstakingly scrub the oil from the rocky shores with brushes and detergent. By sea and by air, other crews skim the spreading oil from the water's surface using special vacuuming equipment. Oil that cannot be skimmed is chemically emulsified — that is, the oil is broken up into tiny particles that will then float away and disperse out to sea. Sometimes microscopic helpers are put to work. Genetic engineers have developed oil-eating bacteria that can be used to ingest the oil, cleaning up long after the crews and volunteers have left. The experience gained from several well-publicised oil spills has ushered in an era of greater understanding and international cooperation with regard to containing spills and avoiding environmental disasters that affect our global ocean. One bright spot of news is that ecologists revisiting oil spill sites have found marine population recovery is better than they had originally predicted.



mutton hamlet

Before You Begin

Advise students of the activity the day before so they can wear clothing they don't mind getting dirty. Make a copy of the worksheet (page 177) for each student. Prepare materials for the demonstration and for the oil spill cleanup activity. For greater visibility in the demonstration, add a couple of drops of blue food colouring to the water. Put two teaspoons of paprika into a small container of the cooking oil and mix; after the paprika settles to the bottom the oil will be slightly tinted.

Investigate how to dispose of oil properly in your area (for step 4 in the activity).

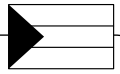
What to Do

1 Introduce the topic of oil pollution and how it affects the ocean. Use the background information to explain that oil spills are one of the sources of pollution in the marine environment. While they aren't the biggest culprit in terms of quantities of oil released into the ocean, when spills occur they can have a major impact on the marine environment and wildlife. Cleanup can be difficult and costly. The Caribbean is vulnerable due to the high volume of maritime traffic. Discuss oil spills with which students may be familiar, such as those mentioned in the box on the previous page.

2 Demonstrate the degree to which oil and water mix. Fill a clear bottle about two-thirds full with water (add blue food colouring, if desired). Pour 1½ cm (½ in.) of (tinted) cooking oil into the bottle. Ask students which is on top — oil or water — and why? *(In general, the molecules that make up oils and waxes adhere to one another and are less dense than water; thus, they float on the water's surface without mixing.)* What happens to an object (like a cork) that you drop into the bottle? *(It becomes coated with oil.)* Put the top on the bottle and shake it (like wave action). What happens to the oil? *(Some of the water mixes with the oil.)* Then let it stand and see what happens. Did the oil and water mix or separate? Ask students what they think will happen to the oil (or other petroleum product) as it spills out of a tanker into the ocean. *(The oil will probably spread out away from the spill site, staying on top of the water rather than sinking.)* If there is an oil spill, it generally does not go away by itself. In addition, currents and wind out on the open ocean cause the oil to spread and travel away from the spill site.

What would happen to organisms that float on the surface (sea birds, seaweeds, planktonic animals) or that need to come to the surface to breathe (whales, seals, sea turtles)? *(They will be coated with oil.)*

Explain that over time the water and oil will mix somewhat; some of the oil (which is heavier than cooking oil) will sink to the bottom, affecting bottom dwellers such as flounders, sea urchins, and crawfish.



Did you know that The Bahamas Maritime Authority Act and the National Oil Spill Contingency Plan of 1998 specify The Bahamas' plan for dealing with the potential disaster of an oil spill? Visit www.itopf.comcountry_profiles/profiles/bahamas.pdf to learn more.

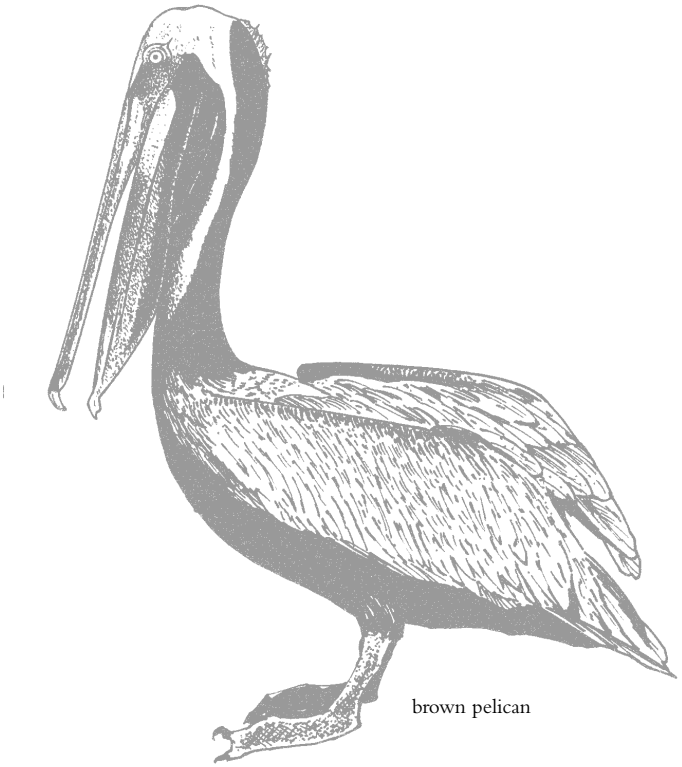
3 Divide students into oil spill cleanup crews of three to five. Explain that each group will cooperatively participate in an activity to carry out a simulated oil spill and cleanup. Arrange to have all the materials students need at each workstation. Have students suppose they are in the business of cleaning up oil spills. Their team has just received word of a tanker leaking oil in the harbour. How will they use their resources to effectively clean up the oil and prevent it from spreading? Guide students as they read through the directions on the "Oil Spill Cleanup" handout on how to make an oil spill and then clean it up. Advise them to use their resources wisely, as they will be "charged" for each piece of equipment and the disposal of the oil.

In carrying out the activity, limit the "disaster" to a portion of the classroom or lab where surfaces can be wiped dry. Use clear plastic bags to collect the oil-soaked cotton balls so that students can count them and be charged accordingly. Use quart-sized, wide-mouthed plastic containers for the wastewater, which can then be carried to a sink for disposal. (Students should only be using small amounts of oil that can be disposed of in this way.) Have paper towels on hand to clean up spilled water and warn students about slippery floors.

Options: One group of students can use a wire whisk to stir up the oil and water before beginning their spill cleanup. Another group can simulate an oil spill that hits a rocky coast by using pebbles at one end of the pan. Have students compare the amount of surface area for that cleanup with an oil spill on the open ocean. An interesting demonstration is to dip a bird feather in oily water and have students try to clean the feather using liquid detergent and a brush.

4 Evaluate the efficiency of oil spill cleanup methods. After the groups have worked on their oil spills for twenty minutes, have them tally the cost of their efforts and clean up their materials. Discuss the questions on the handout and compare group results. *(For question 4, a possible answer is that when an oil spill is contained and cleaned up quickly, the cleanup can be done more efficiently and economically.)*

Have students consider responsibilities for reducing oil pollution. Cars and boats are big contributors. What can individuals and businesses do? What can students and their families do at home? Do students know the proper way to dispose of used motor oil, empty oil containers (and those for oil additives for boats), household cleaning supplies, and other common toxic waste?



brown pelican

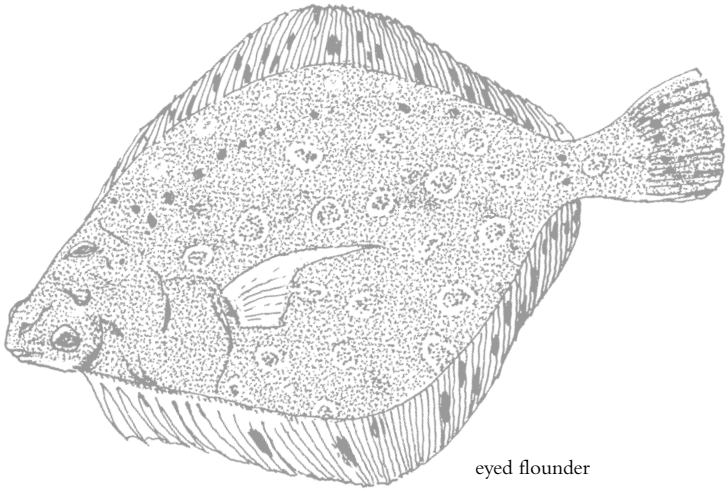
Assessment

Have students present and discuss their conclusions. Collect the "Oil Spill Cleanup" worksheet.

In addition, you can have students draw two beach scenes, before and after the spill. Ask them to label the scenes indicating at least three examples of how marine life is affected by the spill.

Extensions

- Have students collect newspaper or magazine articles about oil spills and create a map showing where and when the spills occurred. Discuss the damage to wildlife and local people, the way the oil was cleaned up, and the condition of the environment today.
- Students can role-play a press conference about what happened when an oil tanker ran aground and caused an oil spill along the coastline. Roles may include: reporters, ship captain, spokesperson for oil company, head of cleanup operations, representatives of the weather service, conservation agencies, the local fishing community, local government, local merchants' association, and local volunteers. Reporters can ask about the chain of events that led to the spill, how each group helped with cleanup, and how the spill has affected their lives. Students should be able to conclude from discussion that responsibility for cleanup must be shared and that local people are affected by the spill long after cleanup crews have left.
- Have students research and discuss green energy alternatives; list ways to reduce use of fossil fuel.



eyed flounder

Resources

Agencies that you may wish to consult for more information include:

- The Ministry of Transport and Aviation, responsible for oil pollution response in Bahamian waters
- The Ministry of Agriculture, for species of fish and wildlife that need protection

Adapted with permission from "Pollution Solution," *Ocean Planet*, Interdisciplinary Marine Science Activities, Smithsonian Center for Education and Museum Studies, smithsonianeducation.org/educators/lesson_plans/ocean/main.html.

Additional ideas from:

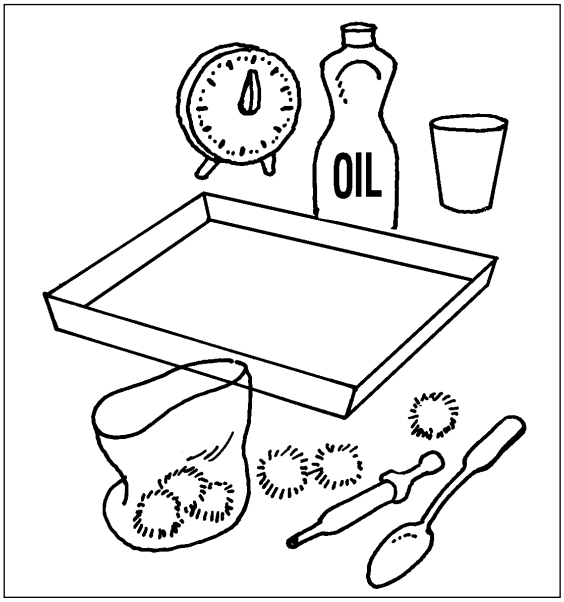
"Oil Spills: Trouble on the Water," an activity in *Oceans of Life: An Educator's Guide to Exploring Marine Biodiversity*, 2003, published by World Wildlife Fund as part of Windows on the Wild, an international biodiversity education program.

"Save the Bay," *Oil Spill Activities* 2000, Gulf of Maine Aquarium, octopus.gma.org/surfing/human/savethebay.html.

OIL SPILL CLEANUP

Name: _____

Date: _____



In this activity you will make your own "ocean" in a pan of water. You can simulate your own very limited environmental disaster — and then clean it up! Work with your group to set up the materials shown in the drawing.

1. Use the shallow pan filled halfway with water as your model ocean. Add a teaspoon of cooking oil to the middle of the pan to simulate a leaking oil tanker.
2. While one group member releases the oil in the centre of your ocean, another begins timing.
3. After one minute has passed, observe what happens to the oil. See how the oil is affected as another team member blows on the oil, simulating the wind.
4. Begin the cleanup of the oil using the available materials. You may take twenty minutes.
5. Try to do the cleanup efficiently because you will be "charged" for the use of each piece of equipment. No cleanup effort is free! Keep track of the time each technique is used. Use the chart below to calculate the cost of your efforts.

Equipment and Techniques	Cost	Minutes of Use or Number Used	Total Cost
Medicine dropper "skimmer"	$100/minute		
Cotton ball	$20/piece		
Waste disposal: Discarded cotton ball	$50/each		
Container for wastewater	$1,000/each		
Labor	$1,000/person/minute		
		Total Cost for Cleanup	

Use a separate sheet of paper to answer these discussion questions.

1. Did your group clean up the oil spill within 20 minutes? Did everyone agree on how clean the pan was?
2. Which technique seemed to work best?
3. Make a chart of the class results. Which group cleaned its ocean at the lowest price?
4. What importance does immediate response have in cleanup efforts?
5. Suppose class members used different kinds of oil. Would their results be the same? Do you think all petroleum spills behave the way vegetable oil does? Why or why not?

4 Take Action for Our Oceans!

Students participate in a beach cleanup and learn how much marine debris is washing up onto the coast, where this garbage comes from, and how long it takes for it to decompose naturally.

Learning Objectives

- Define marine debris and identify its sources
- Describe the adverse effects of marine debris on wildlife
- Compare how long it takes various types of debris to break down in the environment
- Participate in reducing the problem of marine debris

Grades

3 – 6

Subjects

Science, Social Studies, Language Arts, Mathematics

Skills

gathering (recording, observing), organising (classifying), analysing (calculating, comparing and contrasting), applying (hypothesising), citizenship (working in a group, planning and taking action)

Vocabulary

marine debris

Time

1 hour classroom, 2 hours minimum for cleanup plus travel time

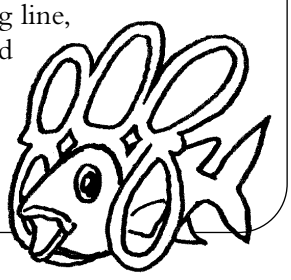
Materials

For each group: trash bags (if there is recycling on island, use 2 colours to separate recyclables from non-recyclables); clipboard, pencil, and "Marine Debris Collection Worksheet" (pages 183 – 184); 2 pairs of gloves; drinking water; first aid kit; small prizes, such as snacks or stickers (optional); a copy of the "Marine Debris Time Line" (page 185) for each student

Marine debris is trash found in the ocean or along the coast. From a potato chip wrapper tossed out of a car window to a cigarette butt left in the sand, trash ends up in the ocean environment. Sources of marine debris can be "land-based" or "ocean-based," depending on where it enters the water. Ocean-based debris is waste disposed of in the ocean from ships, recreational and fishing boats, and petroleum rigs and platforms. Land-based debris blows, washes, or is discharged into the water from land. There are estimates that up to 80% of marine debris enters the water from the land. Contributors include beach-goers, people who drop litter on sidewalks and streets, plastics manufacturers and transporters, inadequate sewage treatment operations, and poorly maintained garbage bins and dumps.

Almost 90% of Floating Marine Debris is Plastic

Due to its durability, buoyancy, and ability to absorb and concentrate toxins present in the ocean, plastic is especially harmful to marine life. In addition, animals often become entangled in fishing line, strapping bands and six-pack rings or mistake plastic for food.



Not only is marine debris ugly, it can pose a threat to many organisms. Each year millions of seabirds, sea turtles, fish, and marine mammals become entangled in marine debris or swallow plastics, which they tend to mistake for food. Marine debris isn't good for us either. Swimmers and divers can become entangled in abandoned netting and fishing lines, and beach users can be injured by stepping on broken glass, cans, needles, or other litter. Debris on our coasts can also result in lost tourism revenues.

We might assume that garbage would degrade quickly in the ocean, but it can persist for many years — even generations! It's important to prevent trash from getting into the ocean in the first place. Participating in a beach cleanup is one way to take action to reduce marine debris.

Before You Begin

Assemble materials and photocopy worksheets (pages 183 – 184). Select a site and date for the cleanup. Arrange transportation and chaperones. (See page 192 for field trip tips.) Make arrangements with the local garbage-collection service for the bags of garbage to be picked up. Or, if a local organisation sponsors cleanups (for example, Dolphin Encounters on New Providence, www.dolphinencounters.com), contact them for information.

What to Do

Field trip preparation

1 Define and discuss marine debris. Review the introductory information in this activity to guide discussion with students: What is marine debris? Where does it come from? What kind of impacts can it have on wildlife and marine ecosystems?

2 Prepare students for the field trip. Explain to students that they will be going to a beach to gather marine debris, analyse it for its type and source, and compare quantities of debris types. Then they will talk about the time it takes for different types of debris to decompose, and the potential threat of debris to wildlife and the ecosystem.

3 Discuss the steps of scientific methodology. The scientific method is the process scientists use, collectively and over time, to construct an accurate representation of the world. The method includes observing and describing a phenomenon, asking a question about it, and forming a hypothesis to explain it, and then performing experimental tests of the hypothesis. Have students come up with a purpose for their study and a hypothesis that they can test.

For example:

Scientific Question	Hypothesis
What materials make up most of the marine debris at the collection site?	Most marine debris is plastic.
Where is most marine debris found along the coast?	Most marine debris is found along the high tide line.

Explain the method for the study: Students will break into teams to clean up two different sections of the beach. For example, one group collects debris near the shoreline and the other on the upland portion of the shore; or you can have groups work on leeward versus windward sections of the beach. You can designate the area on a map for each group to clean up.

4 Brief the students on safety precautions for the field trip.
Some suggestions are:

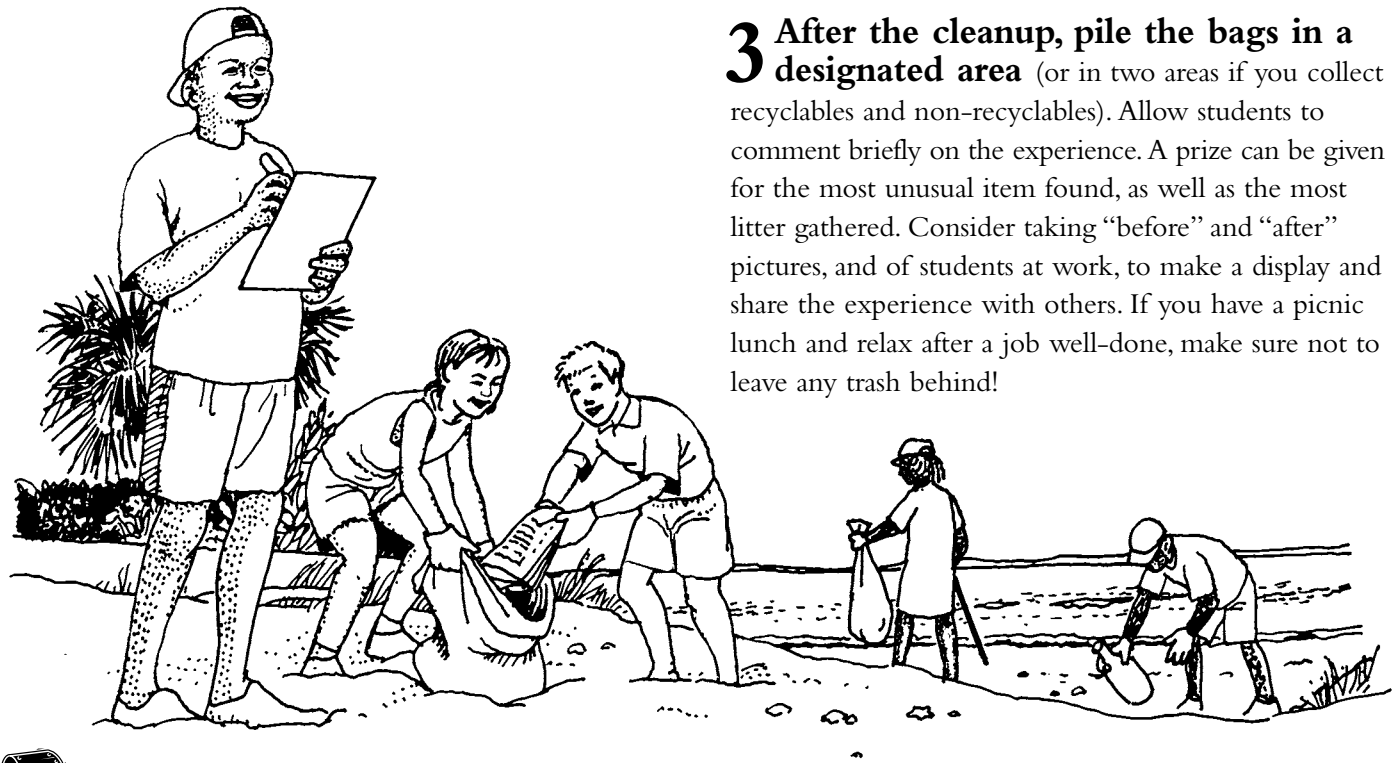
- Do not go near any large metal drums.
- Do not pick up any sharp objects or syringes — inform an adult where the sharp object is located.
- Debris collectors should wear gloves.
- Stay out of dunes and any protected areas.
- Watch out for wildlife and do not approach any animals you encounter.
- Don't lift anything too heavy.
- If you begin to feel very hot, dizzy, or tired, drink some water and notify an adult.

At the Beach

1 Go over the worksheet with students. Make sure students understand all of the terms and how to record the numbers, types, and sources (if known) of items collected. If items have labels on them, the students should write down the product type and name in the designated place on their debris collection worksheets. Remind students of the safety rules.

2 Conduct the cleanup. Divide the class into two teams, one for the waterline and one for the upper shore. Within the teams, break up into groups of four to cover the following roles: data recorder, debris bag holder, two debris collectors. Each group should have garbage bags, a "Marine Debris Collection Worksheet," a clipboard and pencil, and gloves. Students can switch jobs halfway through so that all have an opportunity to pick up trash. As they collect debris the groups should discuss and agree to which category each piece of debris belongs. Students should also look for possible clues as to debris sources (e.g., are there adequate trash cans, is there a nearby storm outfall, does the site get heavy use, do people fish in the area?). Define the boundaries for students and adult volunteers. Set a time for completion of the cleanup and a meeting place, and identify a way to signal the students when it is time to return (e.g., a whistle).

3 After the cleanup, pile the bags in a designated area (or in two areas if you collect recyclables and non-recyclables). Allow students to comment briefly on the experience. A prize can be given for the most unusual item found, as well as the most litter gathered. Consider taking "before" and "after" pictures, and of students at work, to make a display and share the experience with others. If you have a picnic lunch and relax after a job well-done, make sure not to leave any trash behind!



Back in the Classroom

1 Total results and present them. Each group should tally how many of each type of debris they collected and record it in a summary table of class results. For example:

Material	Shoreline totals	Upper shore totals
Plastic		
Styrofoam		
Glass		
Rubber		
Metal		
Paper		
Wood		
Cloth		

The groups should then choose a method for presenting the data such as a pie chart, line graph, or bar graph.

2 Discuss the results of the cleanup. Do results confirm hypotheses that were made before the cleanup? Which types of debris were most common? Where do students think most debris came from? How did it get into the ocean? How might it affect plant and animal life on the shore or in the water? Distribute the "Marine Debris Time Line" (page 185) and discuss how long various items can take to decompose in the ocean. What types of marine debris take the most time to decompose? Which take the least? What are possible reasons for this? *(Organic matter, made from things that were once alive, such as food or wood products, decomposes more quickly than inorganic matter, like glass, plastics, and metals. In addition, decomposition rates may be increased with exposure to warm temperatures and light.)*

Nearly 80% of Marine Pollution Derives from Land-Based Activities

Pollution Source	Consequences
discharge of untreated or partially treated sewage	pollute the sea seagrass dies abnormal algal bloom
oil spills	seabirds poisoned or smothered by oil oil slicks form coral reefs and tidal wetlands become polluted
industrial wastes	build up of pollutants in plants, shellfish, and food chains
litter	seabirds, fish, and mammals affected and can become entangled
dredging and disposal of material from dredging	damage to fish breeding grounds loss of seabed plants and animals affects balance of food chain
runoff from streets, construction sites, and farms	damage to coral reefs, fisheries, seagrass beds contaminated water

Assessment

Have students write a one-page summary of the sources and effects of marine debris, and what they can do to help reduce the problem. Some suggestions: *They can buy products with minimal packaging; reduce, reuse, and recycle. After enjoying the beach or boating, make sure trash is placed in proper receptacles. If there is trash left behind by someone else, pick it up, too. Instead of throwing out old toys, give them to friends, relatives, or others who will appreciate them. Buy paper and plastic containers made from recycled products. When packing a lunch, take re-useable containers rather than plastic bags or disposable cups.*

A rubric could include components such as:

- Describes sources and effects of marine debris
- Provides thoughtful examples of actions to reduce problems with marine debris

Extensions

- Make a display to illustrate how long it takes each type of debris to biodegrade, using the "Marine Debris Time Line" as a guide. For example, if students found an old fishing net, hang it between two poles and attach the debris to it in sections — each section representing 100 years.
- Students can create a trash sculpture by assembling the pieces of garbage, and/or make a poster using photos taken at the cleanup.
- Do additional beach cleanups to compare the quantity of debris in different locations or at the same location during different seasons.
- Students can conduct an experiment to see how trash degrades in the marine environment by filling two dishpans half way with water, putting identical assortments of debris in each (e.g., a plastic bag, piece of newspaper, glass bottle, and apple core), and covering one pan securely with screen and placing it outdoors in a sunny place while the other is placed in an out-of-the-way place inside. Record observations for at least two months. (See "A Degrading Experience" www.epa.gov/OWOW/OCPD/Marine/colunit1.pdf)

Resources

International Coastal Cleanup is a yearly event in September in which thousands of participants from around the world volunteer to clean up debris from oceans, lakes, and rivers.
www.oceanconservancy.org

Marine Debris Abatement. Trash in our Oceans:You Can Be Part of the Solution. US EPA. 2005.
www.epa.gov/owow/oceans/debris

Marine Debris Coloring Book, National Oceanic and Atmospheric Administration.
www.education.noaa.gov/books/debris/debris3.htm
Pages to print out and colour with slogans about marine debris.

Marine Debris Timeline, US Environmental Protection Agency, Gulf of Mexico Program.
www.epa.gov/gmpo/edresources/debris_t.html
Includes suggestions about which products can be reused, recycled, or composted to keep them out of the ocean.

North Carolina Big Sweep.
www.ncbigsweep.org/or.html
Literature, posters, videos, and slide shows on marine debris.

Adapted with permission from "Marine Debris: It's Everywhere!" and "Clean Shorelines, Clean Oceans: Shoreline Cleanup" activities in *Waves, Wetlands, and Watersheds*. California Coastal Commission Science Activity Guide (The California Coastal Commission, 2003). www.coastal.ca.gov/publiced/waves/waves1.html

Additional ideas from:

"Marine Debris: Collection and Impact" (Activity 5-F) in *Wondrous West Indian Wetlands Teacher's Resource Book* (West Indian Whistling-Duck Working Group of the Society of Caribbean Ornithology, 2001).

"Exploring Reef Biodiversity: Ideas for Studies of Society and Environment," ReefED, Great Barrier Reef Marine Park Authority. www.reefed.edu.au/activities/sose/index.html

MARINE DEBRIS COLLECTION WORKSHEET

Names: _____

_____

Date: _____

Loacation: _____

Safety Tips

- Do not go near any large metal drums.
- Do not pick up any sharp objects.
- Wear gloves.
- Stay out of dunes areas.
- Do not approach any animals you encounter.
- Don't lift anything too heavy.

Sources of Debris

Please list all items with foreign labels or other markings that indicate an item's origin (such as cruise line names, military identification, or names and addresses of shipping or fishing companies).

SOURCE	ITEM FOUND
Example ABC Shipping Company	Plastic strapping band

Number of bags filled: _____

What was the most unusual item you found? _____

_____

Work with your group or partner to clean the beach. Designate someone to take notes. Use the "Items Collected" checklist to record the types and quantities of items you collect. An easy way to keep track of the items you find is by making tally marks. The box is for total items; see sample below.

Example:

cups 𝍸 𝍸 𝍸 | TOTAL 16 flip-flops |||| TOTAL 4

Adapted from Ocean Conservancy's Beach Cleanup Data Card, www.epa.gov/owow/oceans/debris/floatingdebris/append-d2.pdf

ITEMS COLLECTED

Plastic

- bags _____ ☐
- bottles _____ ☐
- buckets _____ ☐
- caps, lids _____ ☐
- fishing line _____ ☐
- fishing lure, floats _____ ☐
- fishing nets _____ ☐
- flip-flops _____ ☐
- pieces _____ ☐
- rope _____ ☐
- 6-pack holders _____ ☐
- strapping bands _____ ☐
- straws _____ ☐
- toys _____ ☐
- other plastic (specify) _____ ☐

Styrofoam® (or other plastic foam)

- buoys _____ ☐
- cups _____ ☐
- food containers _____ ☐
- packaging material _____ ☐
- pieces _____ ☐
- other Styrofoam® (specify) _____ ☐

Glass

- bottles/jars _____ ☐
- pieces _____ ☐
- other glass (specify) _____ ☐

Rubber

- balloons _____ ☐
- tires _____ ☐
- other rubber (specify) _____ ☐

Metal

- bottle caps _____ ☐
- cans _____ ☐
- crab/fish traps _____ ☐
- pieces _____ ☐
- wire _____ ☐
- other metal (specify) _____ ☐

Paper

- bags _____ ☐
- cardboard _____ ☐
- cartons _____ ☐
- cups _____ ☐
- newspaper/magazines _____ ☐
- pieces _____ ☐
- plates _____ ☐
- other paper (specify) _____ ☐

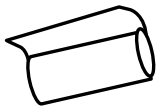
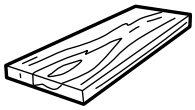
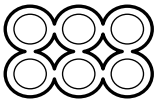
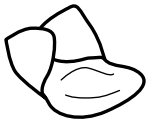
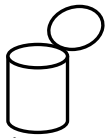
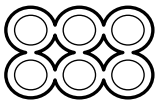
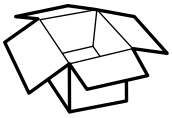
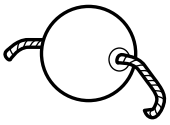
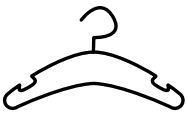
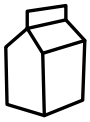
Wood (leave driftwood on the beach)

- crab/lobster traps _____ ☐
- crates _____ ☐
- lumber pieces _____ ☐
- other wood (specify) _____ ☐

Cloth

- clothing/pieces _____ ☐

Marine Debris Time Line

1 – 3 months	3 – 12 months	1 – 5 years	10 – 100 years	200 – 500 years	600+ years
 paper towel (2 – 4 weeks)	 cotton rope (3 – 14 months)	 plywood (1 – 3 years)	 painted wooden stick (13 years)	 aluminum can (200 years)	 monofilament fishing line (600 years)
 newspaper (6 weeks)	 photo-degradable 6 pk ring (6 months)	 cloth diaper (1 – 5 years)	 tin can (50 years)	 plastic 6 pk ring (400 years)	 glass bottle/jar (undetermined)
 apple core (2 months)	 wool glove (1 year)		 styrofoam cup (50 years)	 disposable diaper (450 years)	
 cardboard box (2 months)	 bio-degradable diaper (1 year)		 styrofoam buoy (80 years)	 plastic hanger (450 years)	
 banana peel (3 months)				 plastic milk jug (450 years)	
 cotton glove (1 – 5 months)					
 waxed milk carton (3 months)					

Page	Activity	Summary	Learning Objectives	Grades	Subjects	Skills	Related Activities
Treasure Trove: Bahamian Marine Environment and Resources							
26	1. All the World's a Web	By making "word webs," students identify the components of marine biodiversity and interpret the relationships among the various components.	• Define marine biodiversity • Create a word web that illustrates some of the complex connections in the web of life • State at least one way that marine biodiversity affects people's lives	3 – 6	Science, Social Studies, Language Arts	organising (arranging), analysing (identifying components and relationships among components), interpreting (relating), applying (creating)	Sea for Yourself, What Eats What?
30	2. Sea for Yourself	Take a trip to the seashore, an aquarium, or other site to get more closely acquainted with marine life.	• Identify the variety of local marine life to reinforce understanding of marine biodiversity	3 – 6	Science, Art, Language Arts	gathering (collecting, recording, observing, measuring), organising (sorting, arranging, categorising, drawing)	All the World's a Web
38	3. Services on Stage	Act out four short skits that demonstrate some of the many services marine biodiversity provides.	• Explain how marine biodiversity affects people's everyday lives • Describe the role of marine biodiversity in providing ecosystem services	5 – 6	Social Studies, Language Arts, Science, Art (drama)	applying (composing, creating), presenting (writing, acting), citizenship (working in a group)	All the World's a Web, What is Marine Biodiversity Worth to You?, Working in the Marine Environment
More than Meets the Eye: Learning about Form and Function							
44	1. Conch Ain't Gat No Bone!	Students explore the form and function of the queen conch, beginning with popular dishes, examining a live conch, and concluding with a song to reinforce concepts.	• Identify parts of the queen conch • State the main functions of queen conch parts • Describe some adaptations that help the conch survive	5 – 6	Science, Social Studies, Music	gathering (observing, listening), analysing (identifying components and relationships among components), presenting (describing, explaining, writing)	Pass the Part, Conch Life Cycle Wheel, Real Estate for Royalty
50	2. Crawfish Critters	Students create models or colour a picture to learn about crawfish anatomy and functions.	• Identify parts of the crawfish • State the main functions of crawfish parts	5 – 6	Science, Language Arts, Art	gathering (observing, listening), analysing (discussing, identifying components and relationships among components), applying (designing, constructing)	Pass the Part, Crawfish Mobile
58	3. Grouper MISSING	Students learn about Nassau grouper form and function by making "Missing" posters and doing worksheet activities. The concept of adaptations is introduced with a poem.	• Identify the parts of the Nassau grouper • State the main functions of Nassau grouper parts • Describe some adaptations that enable fish to live in water	3 – 6	Science, Language Arts, Art	gathering (observing, listening), organising (matching, drawing), analysing (discussing, identifying components and relationships among components, comparing and contrasting)	Pass the Part, Grouper Race for Survival

Page	Activity	Summary	Learning Objectives	Grades	Subjects	Skills	Related Activities
More than Meets the Eye: Learning about Form and Function							
66	4. Pass the Part	Students play a straw relay game to review queen conch, crawfish, and Nassau grouper characteristics.	• Demonstrate knowledge of queen conch, crawfish, and Nassau grouper form and function by matching function clues with corresponding parts	3 – 6	Science, Physical Education	organising (matching, manipulating materials), analysing (identifying components and relationships among components), citizenship (working in a group)	Conch Ain't Gat No Bone!, Crawfish Critters, Grouper MISSING
Growing Up in the Ocean: Learning about Life Cycles							
74	1. Conch Life Cycle Wheel	Students make a wheel that illustrates and describes the stages in the life cycle of the queen conch.	• Describe the major stages in a queen conch's development • Distinguish a mature adult conch from an immature, juvenile conch	5 – 6	Science, Art, Music	organising (sequencing, manipulating materials), analysing (identifying components and relationships among components, comparing and contrasting), presenting (describing, writing)	Conch Ain't Gat No Bone!, Complete CYCLE, Real Estate for Royalty
80	2. Crawfish Mobile	Students create a mobile of the crawfish life cycle that illustrates its development from egg to mature crawfish.	• Describe the major stages in the development of a crawfish • Illustrate the habitats of the crawfish at different stages of its development	5 – 6	Science, Art	organising (sequencing, drawing, manipulating materials), analysing (identifying components and relationships among components)	Crawfish Critters, Complete CYCLE
84	3. Grouper Race for Survival	Students play a board game to learn about the life cycle of the grouper and its survival needs at various stages of the cycle.	• Describe the major stages in the life cycle of a Nassau grouper • Name one challenge that the Nassau grouper faces at each stage in its development	3 – 6	Science, Language Arts	organising (sequencing, manipulating materials), analysing (discussing), interpreting (identifying cause and effect), citizenship (working in a group)	Grouper MISSING, Complete CYCLE
88	4. Complete CYCLE	Play a BINGO-style game to review the life cycle of the queen conch, crawfish, and Nassau grouper.	• Name the major stages in the development of the queen conch, crawfish, and Nassau grouper • Describe the characteristics of the different stages in the life cycles of the queen conch, crawfish, and Nassau grouper	5 – 6	Science, Language Arts, Music	organising (matching), analysing (identifying components and relationships among components), interpreting (translating, summarising), presenting (explaining, writing)	Conch Life Cycle Wheel, Crawfish Mobile, Grouper Race for Survival

Page	Activity	Summary	Learning Objectives	Grades	Subjects	Skills	Related Activities
The "X" Marks the Spot: Marine Habitats							
94	1. Home Sweet Habitat	Students research the characteristics of habitats of different marine creatures. They then use their findings as the basis for creating a classroom mural.	• Define habitat • Identify the links among marine habitats • Describe how organisms relate to one another and to their physical environment	3 – 6	Science, Art, Language Arts	gathering (researching), organising (arranging, drawing), analysing (identifying components and relationships among components, discussing), applying (planning), presenting (writing, illustrating, reporting), citizenship (working in a group)	Sea for Yourself, Real Estate for Royalty, Where the Wild Fish Are
100	2. Real Estate for Royalty	Students learn about the habitat requirements of queen conch by creating a "real estate brochure" highlighting food, shelter, and other features.	• Describe the habitat requirements of a queen conch • Describe stresses to conch and threats to its habitat	4 – 6	Science, Language Arts	gathering (reading comprehension, researching), analysing (discussing), presenting (writing, illustrating), citizenship (working in a group)	Conch Life Cycle Wheel, Home Sweet Habitat
104	3. Where the Wild Fish Are	Students learn about various marine habitats as they meet a variety of fish species and determine where each one lives.	• Identify some of the major marine habitats in The Bahamas • Learn about the habitat requirements of a Caribbean fish species • Identify links among habitats	3 – 6	Science, Language Arts, Mathematics	organising (categorising, arranging), analysing (identifying patterns, discussing), interpreting (relating)	Sea for Yourself, Home Sweet Habitat
We're All in this Together: Marine Interdependence							
116	1. Friend or Anemone?	Students discover how species depend on each other to increase their chances for survival on coral reefs.	• Understand symbiotic relationships on a Caribbean coral reef • Explain relationships among organisms and their physical environment • Be able to present information learned to the class	5 – 6	Science, Language Arts, Social Studies	analysing (questioning, discussing), applying (planning, creating), presenting (describing, public speaking, acting), citizenship (working in a group)	Home Sweet Habitat
122	2. What Eats What	By exploring food chains and food webs that include important marine species in The Bahamas, students learn about the interdependence among species.	• Name marine species that are herbivores, carnivores, and omnivores • Describe food chains and food webs • Demonstrate and explain the interdependence of species	4 – 6	Science, Language Arts, Social Studies	analysing (identifying components and relationships among components, questioning, discussing), interpreting (inferring, drawing conclusions, defining problems, identifying cause and effect), citizenship (working in a group)	All the World's a Web, What is Marine Biodiversity Worth to You?

Page	Activity	Summary	Learning Objectives	Grades	Subjects	Skills	Related Activities
What Is Our Treasure Worth?: Exploring Economic and Cultural Values							
128	1. What Is Marine Biodiversity Worth to You?	Explore beliefs and values about why marine biodiversity is important and why it should be protected. This activity works best once students have become familiar with biodiversity issues. It is a good culminating activity for a biodiversity unit.	• Explain personal beliefs and values about protecting biodiversity • List several reasons why people believe it is important to protect biodiversity	4 – 6	Science, Social Studies, Language Arts	organising (arranging, listing), presenting (describing, public speaking, explaining), citizenship (working in a group, debating)	Services on Stage, What Eats What, Ezra Goes Fishing, How Many Fish Are We Catching?, Wish You Were Here!, Working in the Marine Environment
134	2. How Many Fish Are We Catching?	Students graph data, identify trends in commercial landings of conch, crawfish, and grouper, and interpret graphs to propose reasons for increases or decreases.	• Use bar graphs to organise and present data on landings of conch, crawfish, and grouper • Interpret information in bar graphs to identify increases or decreases in landings from one year to the next • Discuss possible reasons for decreases in landings • Name the administrative authority for the fishing industry	3 – 6	Mathematics, Social Studies, Science, Language Arts, Music	organising (graphing), analysing (identifying patterns, comparing and contrasting, discussing), interpreting (generalising)	What is Marine Biodiversity Worth to You?, Ezra Goes Fishing, Fishing versus Overfishing
142	3. Ezra Goes Fishing	Students read a story about traditional fishing techniques and the reliance of local people on the sea. It emphasises conservation methods and shows why it is important to abide by fisheries regulations.	• Describe traditional fishing methods used in The Bahamas • State how conservation and regulations are important for fishing	3 – 6	Social Studies, Language Arts	gathering (reading comprehension, identifying main ideas, listening), interpreting (drawing conclusions), presenting (describing, illustrating)	What is Marine Biodiversity Worth to You?, How Many Fish Are We Catching?, Fishing versus Overfishing
146	4. Wish You Were Here!	Students make postcards of beach and coastal areas in The Bahamas and discuss what attracts tourists to such places and the importance of tourism in The Bahamas.	• Define tourism and ecotourism • Illustrate and describe a beach or coastal area in The Bahamas • Describe the role of tourism in The Bahamian economy • Describe the role of conservation and management in sustaining tourism	3 – 6	Science, Social Studies, Art, Language Arts	organising (drawing, mapping), analysing (comparing and contrasting, discussing), presenting (writing, describing)	Sea for Yourself, Home Sweet Habitat, To Protect or Not To Protect
150	5. Working in the Marine Environment	This activity presents some of the marine-related career opportunities for young people in the Bahamas. Students choose careers to investigate and role-play interviews.	• Learn about careers in the marine environment, including academic training, skills, and time required for preparation • List some of the ways that people's work can have an effect on marine issues and conservation	3 – 6	Science, Social Studies, Language Arts	gathering (brainstorming, researching, interviewing), presenting (describing, public speaking), citizenship (working in a group)	Services on Stage, Wish You Were Here!, Fishing versus Overfishing, To Protect or Not To Protect

Page	Activity	Summary	Learning Objectives	Grades	Subjects	Skills	Related Activities
Taking Care of Our Treasures: Conservation in The Bahamas							
158	1. Fishing versus Overfishing	Students simulate studies conducted by scientists to estimate the population of a species of fish. Students learn about methods of promoting sustainable fisheries.	• Learn a method for estimating fish populations • Identify various ways of managing fisheries in The Bahamas	5 – 6	Science, Social Studies, Mathematics	gathering (simulating, recording), analysing (calculating, discussing, comparing and contrasting), applying (experimenting), interpreting (inferring), citizenship (working in a group)	How Many Fish Are We Catching?, Ezra Goes Fishing, Working in the Marine Environment
164	2. To Protect or Not To Protect	Students role-play a community meeting in which the topic is whether or not to protect a coastal habitat.	• Evaluate the pros and cons of protecting a coastal habitat • Present and defend a position on one of the related issues	5 – 6	Science, Social Studies, Language Arts	analysing (questioning, discussing), interpreting (drawing conclusions, defining problems, identifying cause and effect, reasoning), applying (proposing solutions), presenting (persuading, debating, compromising), citizenship (taking a position)	Wish You Were Here!, Working in the Marine Environment
172	3. Pollution Solution	Students create and clean up a miniature oil spill while considering the environmental impacts of the spill.	• Describe effects of oil spills on the marine environment • Identify methods of cleaning up oil spills • Identify ways that businesses and individuals can help reduce pollution in the marine environment	3 – 6	Science, Social Studies, Mathematics, Language Arts	gathering (simulating, recording), analysing (calculating, discussing), applying (experimenting, predicting), citizenship (working in a group, evaluating the need for citizen action)	Take Action for Our Oceans!
178	4. Take Action for Our Oceans!	Students participate in a beach cleanup and learn how much marine debris is washing up onto the coast, where this garbage comes from, and how long it takes for it to decompose naturally.	• Define marine debris and identify its sources • Describe the adverse effects of marine debris on wildlife • Compare how long it takes various types of debris to break down in the environment • Participate in reducing the problem of marine debris.	3 – 6	Science, Social Studies, Language Arts, Mathematics	gathering (recording, observing), organising (classifying), analysing (calculating, comparing and contrasting), applying (hypothesising), citizenship (working in a group, planning and taking action)	Working in the Marine Environment, Pollution Solution

Skills Framework

The activities in *Treasures in the Sea* build a variety of skills to help your students to think critically, independently, and creatively about marine biodiversity. The skills framework we have used was developed by the World Wildlife Fund as part of *Windows on the Wild*, an international biodiversity education program, and is based on skills categories advocated and outlined in exemplary curricular materials, and by scientific and educational professional organisations.[1] It emphasises the following eight general skill categories, and the specific skills they contain.

Note: Each activity lists the key skills in the introductory information.

Gathering Information

reading comprehension, observing, listening, simulating, collecting, researching, interviewing, measuring, recording, identifying main ideas, brainstorming

Organising Information

matching, plotting data, graphing, sorting, arranging, sequencing, prioritising, listing, classifying, categorising, mapping, drawing, charting, manipulating materials

Analysing Information

identifying components and relationships among components, identifying patterns, comparing and contrasting, questioning, calculating, discussing

Interpreting Information

generalising, summarising, translating, relating, inferring, making models, drawing conclusions, defining problems, identifying cause and effect, confirming, reasoning, elaborating

Applying Information

planning, designing, building, constructing, composing, experimenting, restructuring, inventing, estimating, predicting, hypothesising, proposing solutions, problem solving, decision making, developing and implementing investigations and action plans, synthesising, creating

Evaluating Information

establishing criteria, verifying, testing, assessing, critiquing, identifying bias

Presenting Information

demonstrating, writing, illustrating, describing, public speaking, acting, reporting, persuading, debating, articulating, explaining, clarifying, making analogies and metaphors

Developing Citizenship Skills

working in a group, debating, compromising, seeking consensus, evaluating a position, taking a position, defending a position, evaluating the need for citizen action, planning and taking action, evaluating the results of action, becoming involved in community decision making

[1] WWF referred to and adapted the skills categories from those advocated by the Association for Supervision and Curriculum Development (ASCD) and the American Association for the Advancement of Science (AAAS); the list of skills in *Project WET*, a national water curriculum that used the ASCD and AAAS skills in its materials; the civics standards of the Center for Civic Education; and NAAEE's *Environmental Education Guidelines for Excellence: What School-Age Learners Should Know and Be Able to Do.*

Based on "Biodiversity Education Frameworks: Key Concepts and Skills," Appendix D in *Oceans of Life: An Educator's Guide to Exploring Marine Biodiversity* ©2003, published by World Wildlife Fund as part of *Windows on the Wild*, an international biodiversity education program.

Taking Your Class Outside

The most powerful multi-media tool available to teachers doesn't even have a plug! The outdoors can provide a dynamic change of pace and place that enriches learning opportunities and also promotes a sense of stewardship for the natural world. To make the best use of your time outdoors, here are some practical "tips and tricks" for working with students in the outdoors.

Before you go outside...

- Survey the site before you go out. This is not a big concern when using the school grounds. It becomes very important, however, when using a location that is off site. Trails can be closed or overgrown, beach erosion may have changed an area significantly, or litter and pollution may have rendered a location unsuitable. It's always best to check the site just before you take your group on its trip. Be alert to any potential safety hazards and, if possible, get additional safety information from whoever oversees the property you are visiting. Be sure to brief your students on any potential risks before your group visits the site. For example, if you are visiting the seashore, warn the students about the dangers of walking on slippery rocks or becoming stranded by an incoming tide.
- While still in the classroom, describe in detail the tasks that students will be expected to do outdoors.
- Review the rules and behaviours that will be expected outside. Avoiding a "recess" mindset is critical. It may sound obvious, but behaviour expectations need to be emphasised, especially with students who are not used to outdoor instruction. Also, discuss ways to protect the wildlife they will be observing, such as avoiding walking on tidepool creatures at the seashore.
- Pre-arrange groups or pairs before going out. Don't spend valuable outdoor time doing things you could do inside.
- Give background information and define vocabulary in the classroom. Use your outdoor time for doing rather than telling.
- If students will need to write or record data, consider making simple clipboards. Cut white poster board into pieces measuring about 25 by 30 cm (10 by 12 in.). Laminate the cardboard rectangles twice to improve moisture resistance. Place sheets of paper on top of the boards and use clothespins or binder clips to hold them in place. You now have an inexpensive set of lightweight, flat, and very portable writing surfaces.
- Double check to make sure that you have all necessary materials and equipment. Huge amounts of time are wasted when runners have to dash back to the classroom to bring out forgotten items when you're on the school grounds. And forgotten items on a trip can make the experience less effective.
- Begin with very short treks outside (15 minutes or so). Gradually increase your time outside, always being sure to very clearly explain indoors what specific tasks will be accomplished outdoors.
- If you are going to a seashore, park, or nature reserve, you probably will not be allowed to collect or even move live animals or plants from where you find them. Instruct your students to observe these plants and animals, and leave them in their natural setting.
- Use a backpack for your materials rather than a box. And bring a camera to capture the experience.
- Take one large trash bag along for each student. Bags make great sit-upons when the ground is damp, and raincoats when an unexpected shower comes up. (Cut holes for arms and head.)
- For your materials, buy quart- or gallon-size plastic freezer bags that zip tightly closed. They save space, display the contents, and keep your materials dry.

When you are outside:

- Clearly indicate boundaries. Telling students, "Stay on this side of the sand dune" is much clearer than saying, "Don't go too far." It can be helpful to tie ribbons or colourful strings on trees or shrubs that you want to use as boundaries. Be sure to remove ribbons or strings before you leave. Without clear boundaries, groups will radiate in all directions, creating time-consuming (and potentially dangerous) situations.
- Always have students stand or sit in a circle while you give directions or debrief activities. Trying to talk to a mass of students standing three or four deep is not very effective.
- As the facilitator, circulate constantly. Because the outdoors is loaded with natural distractions, it is important that you frequently move around to all groups to monitor and refocus attention to the task.
- View the unexpected as a bonus, not as an annoyance. That fantastic shell a student noticed may not have been in your lesson plan, but it can be a great springboard for discussing protective colouration.
- Be patient. Teaching outdoors is a little more time-consuming, but it's well worth the effort.

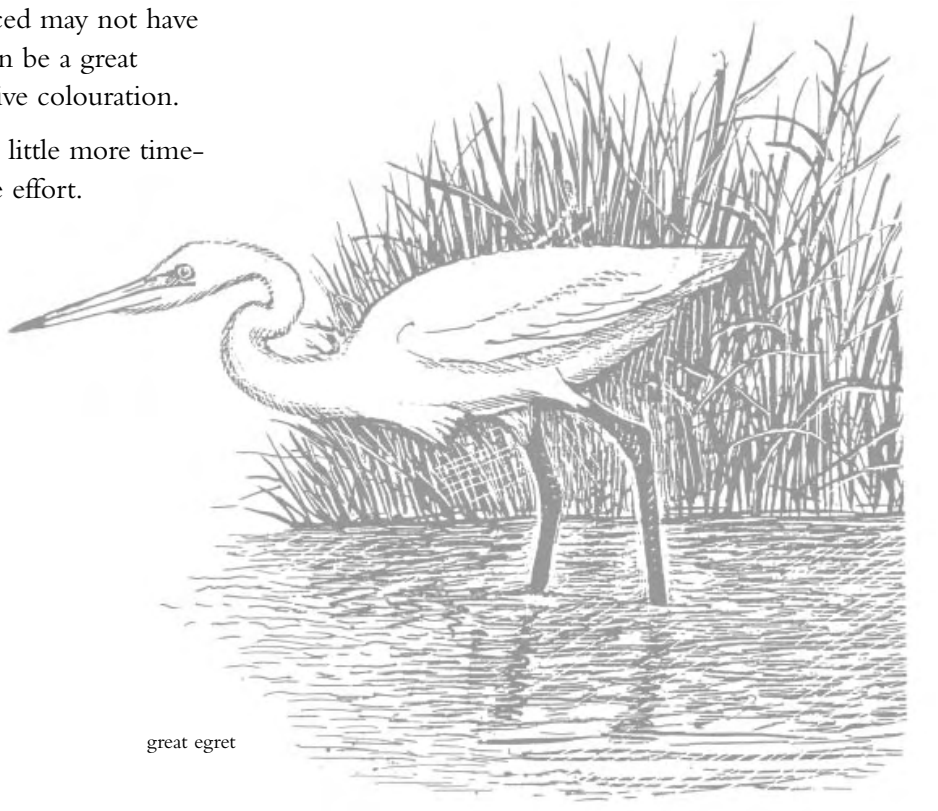
Back inside:

Use what you discovered outside — tabulate data, make charts, do creative writing, and encourage artistic expressions.

When possible, post or display something related to the outdoor experience. Pictures of species found on the beach, maps of the area, or student work related to the outing make a statement that the outdoor experience is directly related to the indoor classroom.

Have field guides and other interpretive resources readily available. Outdoor teaching often encourages students to ask, "What was that?"

If possible, have live plants and animals in the classroom. An aquarium, terrarium, or a classroom pet can go a long way in fostering a sense of wonder and the beginnings of stewardship.



great egret

APPENDIX D

Cooperative Learning Activities

Cooperative learning promotes interaction among students, encourages them to take responsibility for learning, and provides opportunities for them to apply concepts as they develop critical skills to make decisions and become stewards of the environment.

As the teacher, you function as a facilitator, while also setting goals for learning and then evaluating whether these are met through group activities.

It is sometimes challenging to have students work in groups if they have not had much experience doing so. One way to manage groups is to assign a specific role to each person in a group. Students may stay with one role over the course of several weeks and then rotate. This gives groups time to adjust to the composition of the team, but also ensures that students have the opportunity to take on different roles.

Leader or Investigator
Makes sure everyone in the group understands the assignment and consults with the teacher if necessary, conducts experiments and manipulates materials

Manager or Motivator
Encourages everyone to contribute, keeps the group on task and on time

Organiser
Distributes and collects materials, and makes sure the group cleans up when tasks are completed

Writer or Recorder
Records the ideas, questions, and answers of the group

Reporter
Presents the findings of the group to the class

Remind students that everyone in the group is responsible for achieving group goals. Give students some guidelines for working together. All group members should:

- Contribute ideas to the group.
- Listen carefully to ideas from others and take turns speaking.
- Help make good decisions and solve problems in a calm manner. If there is a disagreement, group members can vote to decide.
- Cooperate rather than compete.
- Ask for help from the teacher when in doubt.

Based on *Primary Science Curriculum Guidelines*, Grades 1 – 6, revised 2001, Science and Technology Section, Department of Education, Government of The Commonwealth of The Bahamas.

Glossary

Words in bold in the activity vocabulary lists are included here.

adaptation: a change in anatomy, physiology, or behaviour of an organism that improves its chances of survival and/or reproductive success

algae: one-celled or multi-celled photosynthetic organisms, typically aquatic; once considered to be plants, but now some are classified separately because they lack true stems, roots, and leaves; includes phytoplankton and seaweeds

anatomy: the bodily structure of a living thing

benthic: pertaining to the lowest level of a body of water, such as an ocean or a lake, inhabited primarily by organisms that tolerate cool temperatures and low oxygen levels, called benthos or benthic organisms

biodiversity: the variety of life at all levels — from genes to species to entire ecosystems — and the interactions among living things

brackish: describes water with a higher salt content than fresh water but not as salty as sea water, as occurs in estuaries where sea water mixes with fresh water

carnivore: an organism that eats animals

closed season: a ban on hunting or fishing pertaining to particular time, area, and/or species, frequently to protect spawners or young

commensalism: a symbiotic association in which one organism benefits and the other is unaffected

commercial: pertaining to business activity intended for profit

consumer: an organism that feeds on producers; e.g., a herbivore that eats green plants and their products

crustacean: an aquatic arthropod of the subphylum crustacea that includes crabs, shrimps, lobsters, woodlice, and barnacles

decomposer: an organism that breaks down organic matter into inorganic matter

ecological processes: activities resulting from the interaction of organisms with the environment and with other organisms, or interactions between ecosystems

ecology: the scientific study of the interactions between organisms and their environments

economics: the social science concerned with the production, distribution, and consumption of goods and services, and the management thereof

ecosystem: functional relationship defined by the interactions between living and non-living elements in an area

ecosystem diversity: encompasses the variety of habitats, communities, and ecological processes within the biosphere

ecosystem services: functions performed by ecosystems that perpetuate natural cycles (e.g., water, carbon, oxygen, and nitrogen), processes, and energy flows necessary to maintain an environment supportive of life

endangered species: a species of animal or plant threatened with extinction

estuary: a partially enclosed body of water where fresh water from a stream or creek meets salty water from the ocean; generally highly productive areas that serve as nurseries for marine animals

food chain: the linear relationship of organisms from producers to consumers, with each organism feeding on or getting nutrients from the previous organism

food web: the interlocking association of food chains that shows the more complex interactions among organisms

habitat: a place where an organism finds the nutrients, water, energy, shelter, and living space it needs to survive

herbivore: an organism that eats plants

interdependence: a relationship in which organisms depend on one another for survival

invertebrate: an animal that does not have a backbone

landings: the quantity of aquatic species caught and brought to shore by fishermen

larva: the immature form of an animal which changes structurally to become an adult; plural: larvae

mangrove: tree or shrub found in dense thickets in intertidal zones and estuaries; the most common in The Bahamas are of the genus *Rhizophora*, which have long stilt-like roots

marine: living or growing in the ocean, coastal waters, and estuaries; not terrestrial

marine biodiversity: the variety of life, including genetic and species variation, and ecosystems found in oceans, coastal waters, and estuaries

marine debris: trash found in the ocean or along the coast, often from land-based activities

marine protected area: an area of the ocean designated to protect and maintain biodiversity and natural and associated cultural resources, and managed through legal or other effective means

metamorphosis: a transformation in form or structure undergone by certain species of animals during their development

migration: the movement of animals from one region to another, often seasonal in response to changing conditions of climate or food supply

mollusk: a member of the invertebrate phylum Mollusca, having a muscular foot, soft unsegmented body enclosed in a mantle; most mollusks have a calcareous outer shell

moult: to shed the exoskeleton in crustaceans to allow for growth; or old feathers in birds, old skin in reptiles, or old hairs in mammals

mutualism: a symbiotic association in which both organisms benefit

no-take reserve: an area that is protected in order to emphasise the limitations on the extraction of resources

omnivore: an organism that eats both plants and animals

overexploited: pertaining to a resource that has been extracted excessively

overfishing: the harvesting of a particular species of fish at a rate that does not allow the population to be replaced by reproduction

parasite: an organism that exists by harming another organism

parasitism: a symbiotic association in which one organism benefits while the other is harmed

pelagic: pertaining to the open ocean rather than waters adjacent to land or inland waters

pelagic zone: encompasses all waters above the ocean bottom, also known as open ocean

photosynthesis: the process by which plants and certain other organisms synthesise carbohydrates from carbon dioxide and water using light as an energy source; in most cases oxygen is produced as a byproduct of this process

plankton: a diverse group of animals (zooplankton) and plants (phytoplankton) that drift freely in the water

pollution: contamination of the environment by chemical, physical, biological, or radioactive materials

polyp: the life phase of individuals in the phylum Cnidaria characterised by a cylindrical body, a mouth surrounded by tentacles, and a body anchored to the substrate

population: the number of individuals of a particular species in a defined area

predator: an organism that subsists by preying on other organisms

prey: an organism hunted or caught for consumption by a predator

producer: an organism that synthesises organic matter from inorganic matter; the lowest level in the food chain, part of the group including plants, phyto-plankton, and some bacteria

quota: a specified quantity or limit

season: a period of time characterised by a specific event or climatic characteristics

spawning: production or deposition of eggs by aquatic animals

spawning aggregation: a gathering of fish or other organisms for the purpose of mating

species diversity: the variety of species of organisms

sustainable: the characteristic of meeting the needs of the present without compromising the ability of people, species, or future generations to survive

sustainable fishery: management of a fish population and harvesting that does not diminish the ability of the population to survive

symbiosis: an interaction between two organisms living in close association or even the merging of two dissimilar organisms

threatened species: a species that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range; species of animal or plant listed as "threatened" pursuant to a specific act (e.g., Endangered Species Act, CITES)

trawl: a funnel shaped fishing net towed at various depths behind a motorised boat

vertebrate: an animal with a backbone; includes fishes, amphibians, reptiles, birds, and mammals

clapper rail

APPENDIX F

Suggested Resources

The following resources can help you design and enhance marine biodiversity lessons and units. We have included organisations, a variety of teaching resources, sources for general information and images, books for teachers and students, videos, Web interactives, and events. This list includes materials we have found or used, but it is not comprehensive. It is intended to give you a starting point for your exploration!

Please note that we accessed all Web sites in 2007, but Web addresses frequently change.

Organisations

Andros Conservancy and Trust (ANCAT)
Established in 1996, ANCAT works in the areas of marine conservation, protected areas, environmental education, resource conservation, wildlife conservation, and research/monitoring. The focus of their work is the island of Andros in particular and The Bahamas at large. (242) 368-2882

The Bahamas Environment Science and Technology Commission (BEST)
Established in 1994, the BEST Commission operates as project manager for international environmental initiatives on behalf of The Bahamas government. (242) 322-4546, E-mail: bestnbs@hotmail.com, www.best.bs

Bahamas Marine Mammal Survey (BMMS)
Since 1991 the BMMS has been conducting field research, responding, and assisting with marine mammal strandings and helping to educate the community about the marine environment generally and marine mammals specifically. E-mail: info@bahamaswhales.org, www.bahamaswhales.org

Bahamas National Trust (BNT)
The Bahamas National Trust, established in 1959, manages the national parks and protected areas of The Bahamas. The Trust also works in the area of environmental education and maintains libraries where educators can find resource materials on environmental issues, endangered species and Bahamian ecosystems. (242) 393-1317, E-mail: bnt@bahamasnationaltrust.org, www.thebahamasnationaltrust.org

Bahamas Reef Environment Educational Foundation (BREEF)
BREEF, established in 1993, promotes a sustainable relationship between Bahamians, visitors, and our marine environment through educational programmes for teachers, school groups, and fishermen. (242) 327-9000, E-mail: breef@breef.org, www.breef.org

Bahamas Sportfishing Conservation Association
Dedicated to the preservation of marine and coastal systems in the Caribbean, the protection of the sportfish in this remarkable fishery, and the economic benefits the sportfishing industry provides to the Bahamian people. (242) 368-6050, E-mail: BSCA@bahamasconservation.org, www.bahamasconservation.org

Department of Marine Resources
Fisheries officers enforce regulations, conduct studies and prepare reports, and can serve as guest speakers on matters relating to the marine environment and marine resources. (242) 393-1777

Dolphin Encounters
Dolphin Encounters and its non-profit affiliate Project BEACH offer professional development seminars for teachers, on-site marine education programmes, and web-based resources for both teachers and students to explore the local marine environment. (242) 394-2200 ext 102/103, E-mail: education@dolphinencounters.com, www.dolphinencounters.com/edu.htm

Exuma Resource Centre
This educational resource centre on Exuma not only makes available environmental education resources but also has a dormitory, two buses, auditorium, and computers to accommodate groups of students visiting the island. (242) 336-2790/2, E-mail: cjkettel@batelnet.bs

Friends of the Environment
Established in 1988, Friends works on Abaco in the areas of marine conservation, environmental education, resource conservation, wildlife conservation, research and monitoring, protected areas, and conservation of the Bahama Parrot. (242) 367-2721, E-mail: info@friendsoftheenvironment.org, www.friendsoftheenvironment.org

Gerace Research Centre (GRC)
Founded in 1971, the GRC is located on the island of San Salvador. The Centre has facilities to house and support scientists for research and educational programmes with labs, a library, vehicles, and boats. They host an annual conference on the natural history or geology of The Bahamas. (242) 331-2520, E-mail: grcss@juno.com, www.geraceresearchcenter.com

The Nature Conservancy (TNC)
Established in The Bahamas in 2002, TNC-Bahamas works in the areas of advocacy and policy, marine conservation, resource conservation, wildlife conservation, research and monitoring, and protected areas. (242) 327-2414, E-mail: Bahamas@tnc.org, www.nature.org

Teaching Resources

American Museum of Natural History – Resources for Learning
A collection of activities, articles, evidence and analysis, and more for educators, families, students, and anyone interested in teaching or learning about science. Resources related to the ocean can be found under the Earth Science theme. www.amnh.org/education/resources

Bridge
A clearinghouse of marine education resources available online, including a collection of lesson plans for K – 12. A source of information on global, national, and regional marine science topics for educators, and a contact point for researchers offering educational outreach. Search "recreation" for links to tips for field trips or other marine-related activities. www.vims.edu/bridge

Jean-Michel Cousteau's Ocean Futures Society, Ambassadors of the Environment (AOTE) Teacher's Corner
A database of links to science-related lesson plans, organised by topics, including: Catalina Island, Hawaii, Point Bonita, and outreach programmes on kelp forests, coral reefs, and marine mammals. www.aote.org/menu/teach/pre/tools_curideas.htm

Marine Activities, Resources, and Education (MARE)
Lists K – 6 guides on marine and coastal habitats and publications for teaching about ocean currents, oceanography, and conservation. www.lawrencehallofscience.org/MARE/resources

National Oceanic and Atmospheric Administration (NOAA)
A portal to a variety of lesson plans, activities, and materials for students and teachers developed through NOAA's many programs, including Coral Reef Conservation, Discovery Center, Marine Sanctuaries, and Ocean Exploration. Also lists professional development opportunities and links to information on responsible marine wildlife viewing. www.education.noaa.gov
See also NOAA's library, www.lib.noaa.gov

National Science Teachers Association – SciGuides and Teachers' Grab Bag
SciGuides contains a free guide on organisms and environments, including lesson plans, teaching tips, and examples of effective student assessments. Other SciGuides can be previewed and purchased. The Teachers' Grab Bag is a collection of links to science-related activities, Web sites, and educational products searchable by type of product (CD-ROM, publication, video/DVD, kit) and price (free, under $20, or over $20). sciguides.nsta.org and www.nsta.org/resourcesgrabbag

Ocean World
Educational site with links for educators and students providing information and photos on a variety of marine topics, and including activities, Web lessons, and book lists. oceanworld.tamu.edu

Office of Naval Research – Science & Technology Focus
Provides information about ocean habitats, marine mammals, ocean water, characteristic ocean zones, and research vessels. Experiments demonstrate such things as how boats float and how submarines dive. The Teachers' Corner offers guidelines for using the site and targeting various grade levels. www.onr.navy.mil/focus/ocean

Reef ED
Provides information on the origins of reefs, reef types, life cycles, and threats to reefs, and features concepts including the physical ocean, energy cycles, interdependence among species, and reproduction in the water. Also offers a curriculum for all grade levels and a searchable database of reef-related images and short video clips. www.reef.edu.au

TeAch-nology
Online lesson plans, worksheets, and teaching tools to support educators in effectively incorporating technology in teaching and learning. Organised by subject, theme, and searchable by key words. www.teach-nology.com

Information and Images

American Museum of Natural History – Bahamas Biocomplexity Project (BBP)
Find out about research on how to efficiently design marine protected areas that can best protect biodiversity while still addressing socioeconomic concerns. Download the BBP newsletter, as well as educational materials, publications, and habitat maps. bbp.amnh.org

Animal Diversity Web
An online database of animal natural history, distribution, and classification sponsored by the University of Michigan. Species accounts include descriptions, photos, sound recordings, and short movies. Sharks, echinoderms, bony fishes, amphibians, and many more are represented. animaldiversity.ummz.umich.edu/site/index.html

Bermuda's Coral Reefs
Web cam, photographs, and information on the coral reefs of Bermuda. A good resource for photographs and information on the coral and fishes of the region. coexploration.org/bbsr/coral/html/coral_camera.html and coexploration.org/bbsr/coral/assets/images

Conch Heritage Network
Provides information on queen conch biology, history of the fishery, conservation, and research; as well as conch classroom activities; an interactive map indicating conch status, research, and outreach activities by country; and links to the sites of relevant organisations. www.savetheconch.org

FishBase
A database including practically all fish species known to science, searchable by common or scientific name, location, topic, and many other criteria. www.fishbase.org

Sea Stats
This series of brochures from the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute covers conch, grouper, and crawfish, as well as other fishes, turtles, manatees, coral reefs, and more. Each is approximately four pages with information on age and growth, distribution, migration, and feeding habits. research.myfwc.com/products/products.asp

United Nations Environmental Program – Caribbean Environmental Program – Marine Issues
Definitions, descriptions, discussions, and links to marine issues relevant to Caribbean nations: coastal zone management, maintenance of biological diversity, land-based sources of marine pollution, coral reef management, sustainable tourism initiatives, and environmental education and awareness. www.cep.unep.org/marine-issues

Books for Teachers

Baha Mar: An Underwater Guide to The Bahamas by Rob Palmer. A guide to the aquatic environments of The Bahamas, with chapters devoted to the banks, lagoons and creeks, blue holes, reefs, and open sea. It contains descriptions of species inhabiting these areas, information on The Bahamas' natural and cultural history, and advice for divers. Indexed, with colour photographs. (London: Immel Publishing Ltd., 1995)

The Ephemeral Islands by David G. Campbell. A comprehensive natural history account considering the geological, evolutionary, historical, and social processes and conditions that led to the modern day Bahamas. Habitats and species unique to The Bahamas or in danger of disappearing are emphasised. (Oxford: Macmillan Caribbean, 1978)

Fully-Protected Marine Reserves for the Future of Our Oceans. Describes marine reserves, illustrates some of their benefits, features work of key players involved in the effort to create a marine reserve network in The Bahamas, and offers suggestions for supporting marine conservation. Designed as a companion guide to an exhibition by the same name in The Bahamas. (Department of Fisheries, BREEF, The Nature Conservancy, Bahamas National Trust, American Museum of Natural History, 2004) cbc.amnh.org/center/pubs/pubscbc.html#bahamas

Guide to Marine Life: Caribbean, Bahamas, Florida by Marty Snyderman and Clay Wiseman. A comprehensive, colour illustrated guide to the identification and habits of many marine animals of the Caribbean — from sponges to the great whales. (Locust Valley, NY: Aqua Quest Publications, 1996)

Handguide to the Coral Reef Fishes of the Caribbean and Adjacent Tropical Waters Including Florida, Bermuda, and The Bahamas by Joseph F. Stokes. A guide to identification of 460 fishes that a snorkeler or diver would be likely to see in the tropical inshore waters and coral reefs of the Western Atlantic, with colour illustrations. (New York: Lipincott and Crowell, 1980)

Marine Life of the Caribbean by Alick Jones and Nancy Sefton. An introduction to the region's fauna and flora with descriptions and illustrations of habitats, including mangroves, coral reefs, and the shore. The importance of conservation is emphasised throughout the text. (Northampton, MA: Interlink Publishing, 2003)

Marine Plants of the Caribbean: A Field Guide from Florida to Brazil by Diane Scullion Littler, Mark M. Littler, Katina E. Bucher, and James N. Norris. Colourful photographs and biological information about the marine algae and seagrass species found from Florida to Brazil, including The Bahamas. (Washington, DC: Smithsonian, 1989)

Marine Reserves: A Guide to Science, Design, and Use by Jack A. Sobel and Craig P. Dahlgren. A comprehensive look at the growing field of marine reserve science, as well as marine reserve management and policy. Contains case studies on marine reserves, including a description of The Bahamas' relatively long history with marine protected areas, the creation of the Exuma Cays Land and Sea Park, and past and present research on the ecological effects and benefits of the park. (Washington DC: Island Press, 2004)

National Audubon Society Field Guide to Tropical Marine Fishes of the Caribbean, the Gulf of Mexico, Florida, the Bahamas, and Bermuda by C. Lavett Smith. This comprehensive field guide covers the tropical marine fish in the region with colour photographs and full-text descriptions for more than 400 species, each with its own range map. (New York: Knopf, 1997)

The Nature of the Islands: Plants and Animals of the Eastern Caribbean by Virginia Barlow. Describes flora, fauna, and sea life with colour illustrations of typical nature scenes of the Caribbean islands. There are sections describing beach, coral reef, and mangrove habitats as well as different species of coral commonly found in the region. (Dunedin, FL: Cruising Guide Publications, 1993)

Reef Coral Identification: Florida, Caribbean, Bahamas, 2nd Edition (2001); Reef Creature Identification: Florida, Caribbean, Bahamas, 2nd Edition (2001); and ***Reef Fish Identification: Florida, Caribbean, Bahamas, 3rd Edition*** (2002) by Paul Humann, edited by Ned Deloach. This series of reference guides provides thorough information, full colour photographs, and line drawings pointing to the defining characteristics of a particular species. (Jacksonville, FL: New World Publications)

Books for Students

The Conch Book by Dee Carstarphen. Provides kid-friendly information and illustrations about the queen conch, from gestation to gastronomy. (Wicomico Church, VA: Pen and Ink Press, 1982)

Coral Reef, Look Closer Series. A reference book on the creatures inhabiting coral reefs. A coral reef scene is followed by a description of each of the animals and plants illustrated. Includes photographs of the creatures and a drawing of a child for size reference. (New York: Dorling Kindersley Publishing, Inc., 1992)

The Coral Reef by Jerry, Idaz, and Michael Greenberg. Beautiful photographs of inhabitants of the coral reef, organised by major groups with brief descriptions and scientific names. (Miami: Seahawk Press, 2002)

Coral Reefs: Earth's Undersea Treasures by Laurence Pringle. An introduction to coral reef systems, how they are formed, the relationships among creatures that live there, and threats coral reefs face. Illustrated with colour photographs. Written for ages 9 – 12. (New York: Simon & Schuster, Books for Young Readers, 1995)

Eyewitness Books feature photographs and texts examining a wide variety of natural history topics. Titles include *Fish, Ocean, Seashore, Shark,* and *Shell*. For ages 8 – 12. (New York: Dorling Kindersley Publishing, Inc.)

Grouper Moon by Cynthia Shawn. This is a story appropriate for younger children about an island boy and his friendship with a Nassau grouper. The book explores issues related to Nassau grouper, coral reefs, fisheries management, island development, and endangered species conservation. (Richland, WA: Aurelia Press, 1999)

The Kingfisher Young People's Book of the Oceans by David Lambert. Information about the world's oceans and how they were formed, geology, tides, waves, sea life, coasts, marine resources, and ocean myths and legends. (Boston: Kingfisher, 2001)

Leroy the Lobster by Kathleen Orr. The life story of a crawfish written with young children in mind, with colourful artwork and a simply written narrative that will appeal to all age levels. (Oxford: Macmillan Caribbean, 1985)

The Magic School Bus on the Ocean Floor by Joanna Cole. On a special field trip on the magic school bus, Ms. Frizzle's class learns about the ocean and the different creatures that live there. (New York: Scholastic, 1992)

The Magic School Bus Takes a Dive: A Book about Coral Reefs by Joanna Cole. Ms. Frizzle's class investigates a treasure chest on the ocean floor, and learns about the amazing creatures of the coral reef and the importance of partnerships. (New York: Scholastic, 1998)

My Grandpa and the Sea by Kathleen Orr. A story about a traditional fisherman who, when faced with competition from newer, bigger boats, learns about conservation and alternate methods of sea farming. (Minneapolis, MN: Lerner Publishing Group, 2004)

One Small Square: Seashore by Donald M. Silver, illustrated by Patricia J. Wynne. An introduction to exploring sandy and rocky shores, describing where and when to look for their inhabitants, and providing tools for finding and analysing signs of life. (New York: W.H. Freeman and Company, Scientific American Books for Young Readers, 1993)

Outside and Inside Sharks by Sandra Markle. Describes the inner and outer workings of sharks, including their diet, anatomy, and reproduction. Includes photos. Written for ages 4 – 8. (New York: Simon and Shuster, Atheneum Books for Young Readers, 1996)

The Secret Life of Fishes: From Angels to Zebras on the Coral Reef by Helen Buttfield. A voyage to coral reefs around the world, from the Caribbean to the Great Barrier Reef of Australia, from the Galapagos to the Hawaiian Islands. The book introduces more than 250 fishes in alphabetical order, with interesting facts about their appearance and behaviour. Watercolours by the author. (New York: Harry N. Abrams, 2000)

Shelly by Kathleen Orr. The life story of a conch, the largest snail in the Caribbean. Written with young children in mind, but with colourful artwork and a simply written narrative to appeal to all age levels. (Oxford: Macmillan Caribbean, 1991)

Videos

At Home in the Coral Reef. 12 min. Grades K – 3. An introduction to life in the coral reef. Comes with a 10-page teacher's guide. (Katherine Muzik, Spoken Arts, 1995)

Atlantic Realm, No. 1: Island Arks. Part 1: 29 min. Part 2: 28 min. Explores the origins of various ocean islands — including The Bahamas — and the wildlife they nurture. (Public Media, Inc., 1989) Available through the BNT video library, www.thebahamasnationaltrust.org/education_teach_video.php

Hanging In The Balance: The Future of Fishing in The Bahamas. 42 min. Grades 5 – 12. Presents the efforts of Bahamian fishers, scientists, government officials, and conservationists to conserve The Bahamas' marine environment and the fisher's way of life. (Friday's Films, 2004) Available from BREEF, (242) 327-9000, E-mail: breef@breef.org or contact info@fridaysfilms.com.

The Magic School Bus Gets Eaten. 30 min. Grades K – 4. The bus with Ms. Frizzle's class shrinks and travels through the ocean food chain. (Scholastic, 1995) www.scholastic.com/magicschoolbus/tv

Ocean Life. 26 min. Grades K – 12. Bill Nye, the Science Guy, goes underwater to explain ocean ecosystems and the importance of small organisms such as coral, plankton, and kelp as part of the complex system that supports life. (Bill Nye, 1995) www.billnye.com

Our Oceans, Ourselves. 8 min. Researchers describe studies of social, economic, and biological interactions in marine ecosystems and their implications for the development of a network of marine protected areas in The Bahamas. (American Museum of Natural History, 2005) sciencebulletins.amnh.org/bio/f/bahamas.20050814

Really Wild Animals: Deep Sea Dive. 45 min. Grades K – 4. Features the Great Barrier Reef and deep-sea creatures such as whales, sharks, and dolphins, and other ocean fauna in an exploration of the world's oceans from surface to seafloor. (National Geographic, 1994) shop.nationalgeographic.com

Web Interactives

American Museum of Natural History – Marine Biology: The Living Oceans
Interactive activities for learning about what marine biologists do and how they help the marine environment. ology.amnh.org/marinebiology

American Museum of Natural History – Milstein Hall of Ocean Life
Explore marine ecosystems — coral reefs, the sea floor, kelp forests, mangrove forests, polar seas, estuaries, the continental shelf, and the deep sea — and the variety of life found in these ecosystems. The American Museum of Natural History's Milstein Hall of Ocean Life features a wide spectrum of marine life and ecosystems, and dioramas including the Andros Coral Reef. www.amnh.org/exhibitions/permanent/ocean

Beachcomber's Companion
Go on a virtual beachcombing expedition with information on several different kinds of marine habitats and short videos describing a variety of marine and coastal life, as well as an activity that explores the diversity of coastal species and how these organisms are classified. www.beachcomberscompanion.net

Discovery "Life on the Reef" Expedition
Explore the barrier reef off the coast of Andros from different perspectives — underwater and from space — and learn about some of the animals that live there. This online journal describes an expedition in 2000 with scientists from the American Museum of Natural History. www.discovery.com/exp/coralreef/coralreef.html

Mangal Cay Virtual Mangrove Trail
A virtual field trip to a mangrove forest that describes the different types of mangroves, threats to their survival, and their importance to marine and coastal ecosystems. Requires high speed internet connection. www.serc.si.edu/education

Marine Activities, Resources, and Education (MARE) – Build a Fish
In an activity designed to teach about adaptations, students "build" their own fish using several different variables. They can then test their fish to see if it would survive in a variety of different habitats. scienceview.berkeley.edu/showcase/flash/fish.html

Marine Conservation Biology Institute – From Sea To Shining Sea
Students can use this interactive programme to see the effects of many different variables, including climate change, overfishing, and pollution, on the ocean ecosystem. Contains information on marine biology themes including: endangered species, exploration, and conservation in ecological regions all over the world. www.mcbi.org/shining_sea/s2ss_globe.htm

Tramline Virtual Field Trips
This site provides general ocean information, free resources for teaching, and virtual fieldtrips. www.field-guides.com/trips.htm

Where Land and Sea Intertwine: Mangrove Forest and Sea Turtles of Belize
This virtual field trip brings the sights and sounds of the mangrove forest to you in two video segments. Learning activities about wetlands are also available. ali.apple.com/belize

World Wildlife Fund – Expeditions in Conservation: Mesoamerican Reef
Dive into the depths of the largest Atlantic Ocean coral reef system and come face-to-face with 30-foot whale sharks and more than 500 other species of fish. www.worldwildlife.org/expeditions/reef

Programmes and Events

Coastal Awareness Month (April). For an entire month focus is placed on our coastal environment, how coastal degradation affects all Bahamians and visitors, and what we can do about it. Educational programmes, field trips, restoration projects, and cleanups are conducted. www.breef.org/

International Coastal Cleanup (usually held in The Bahamas in September). Each year, thousands of volunteers from around the globe participate, clearing tons of trash from coastlines, rivers, and lakes and recording every piece of trash collected. www.oceanconservancy.org

Wetland Education Week. Special education programmes aimed at increasing awareness of the importance of wetlands include puppet shows, slide shows, field trips, and the dissemination of educational resources on wetlands. Contact the Bahamas National Trust, (242) 393-1317, E-mail: bnt@bahamasnationaltrust.org, www.thebahamasnationaltrust.org

World Ocean Day (June 8). The Ocean Project helps to coordinate events and activities worldwide with aquariums, zoos, museums, and the World Ocean Network. Look for ideas to celebrate our world ocean and our personal connection to the sea. www.theoceanproject.org/wod

World Wide Biome Project. A global programme for students to investigate ecosystems in their locale using standard methods and submitting data to be posted and shared with students around the world. www2.kpr.edu.on.ca/cdciw/biomes

Youth Venture. Youth ages 12 – 20 who want to start a new environmental club or organisation can obtain guidance on how to plan, organise, and launch their venture, along with funds for start-up expenses. www.genv.net

Youth Visioning for Island Living – Caribbean, Atlantic, Pacific and Indian Oceans. Launched in January 2002, this inter-regional United Nations Educational, Scientific and Cultural Organization (UNESCO) initiative in the Caribbean, Indian Ocean, and Pacific regions seeks to ensure that the voices of the general public, including youth, are heard and become a driving force for island development. "Communities in Action" encourages island-based sustainable development activities supported by media and inter-regional Internet-based discussions. www.unesco.org/csi/YV/index.htm

FEEDBACK FORM

WHAT DO YOU THINK?

We're interested in your comments on the *Treasures in the Sea* resource book. Thank you for taking the time to share your ideas!

Please use the numbers below to rate the components of *Treasures in the Sea*. Feel free to add any specific comments on content, design, and usefulness.

Ratings: 4 = Great! 3= Good 2= Average 1=Poor

- ☐ Background Information
- ☐ Treasure Trove
- ☐ Growing Up in the Ocean
- ☐ We're All in this Together
- ☐ Taking Care of Our Treasures
- ☐ Glossary & Resources
- ☐ Assessing Student Learning
- ☐ More than Meets the Eye
- ☐ The "X" Marks the Spot
- ☐ What Is Our Treasure Worth?
- ☐ Overview of Activities (Appendix A)
- ☐ Overall Design

General Comments:

What do you like best about *Treasures in the Sea*?

What suggestions do you have to improve *Treasures in the Sea*? If you have comments about specific activities, please list the activity title(s) along with your recommendations.

If you found any errors, please describe them and include the page numbers. *(Use the back for additional space.)*

Anything else you want us to know? *(Use the back for additional space.)*

Please send this form to: Bahamas National Trust, The Retreat, Village Road, P.O. Box N-4105, Nassau, The Bahamas; 242-393-4978 (fax); bnt@bahamasnationaltrust.org

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