A TEACHER'S GUIDE TO MARINE ENVIRONMENTAL EDUCATION IN SAINT LUCIA

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Note:

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CONTENTS

Introduction

As a small island developing state, the coastal resources of Saint Lucia serve many diverse interests, supporting environmental, economic, social and cultural development, and aesthetic functions. It is therefore necessary to protect and conserve the natural resource base within the coastal zone, to ensure that the benefits being derived are maintained. Increasingly, Marine Protected Areas (MPAs) are proving to be successful tools for the protection of natural resources, while providing numerous opportunities for the people who depend on the exploitation of these resources, to benefit through the provision of sustainable livelihoods.

In order to effect change in the mindset of Saint Lucians on the significance of marine protected areas and coastal resources in general, it is important to target the education sector. This will ensure the sustainability of the message by educating the youth, who may respond with a positive change in attitude towards marine resources. With more knowledge, these stakeholders may become motivated to support policies and make more informed decisions.

Successful implementation and sustainability of awareness activities targeting the youth will be based on the training of teachers in order that they educate their students on the marine environment. This Guide to Marine Environmental Education is aimed at providing some direction to teachers in communicating the importance of marine resources management in the classroom. The Guide is designed to offer flexibility in lesson planning, and highlights a number of resources available to enhance lessons and learning. Linkages between content and the situation in the Caribbean Region, and more specifically in Saint Lucia, help to provide avenues for more active involvement in resource conservation through practical examples and exercises.

It is envisioned that this Guide will be used in creating and implementing an annual teacher training course on marine resources. Workshops will be held to equip teachers with tools which can be used to educate students and other teachers on the environmental value of coastal resources, and to stimulate their active involvement in resource conservation.

The programme will be a joint initiative of the Saint Lucia National Trust and the Department of Fisheries.

MODULE 1: The Marine Environment – An Introduction

INTRODUCTION

The ocean is comprised of water and other dissolved elements, which support marine life and influences the movement of the ocean water. The ocean water is in constant motion connecting the oceans. These movements influence weather and climate, as well as living conditions for marine organisms in the oceans. Understanding the ocean water movements sheds light on the distribution of marine life, and as such assists marine managers in management of the marine environment.

OVERALL OBJECTIVES

1. To know the general characteristics of the marine environment and the coastal ecosystems in the wider Caribbean and how it influences ocean currents.

2. To understand how ocean water and currents influence marine life and how this is important to their management.

THEMES

This module is divided into three themes:

Theme 1.1:	What's seawater made of? The Physical and Chemical Characteristics of Seawater
Theme 1.2:	Movement of the Ocean and Seas Ocean Currents Circulation Patterns
Theme 1.3:	Treasures of the Sea Fisheries Resources in Saint Lucia

DELIVERY TIME

Expected time to deliver the module: Five (5) hours

THEME 1.1:

What's Seawater made of?

Chemical Properties of Seawater

Objectives

- To know the main chemical attributes of seawater and how it influences the environmental and habitat conditions of the Caribbean.

Materials/ equipment

- Overhead Projector
- Flipchart paper
- Markers

Strategies

- **Activity 1.1a and 1.1b**: Climate change and our Oceans

Students carry out two experiments to investigate ocean acidification.

Delivery Time

- 1 ½ hours

What's Seawater made of?

The Physical and Chemical Properties of Seawater

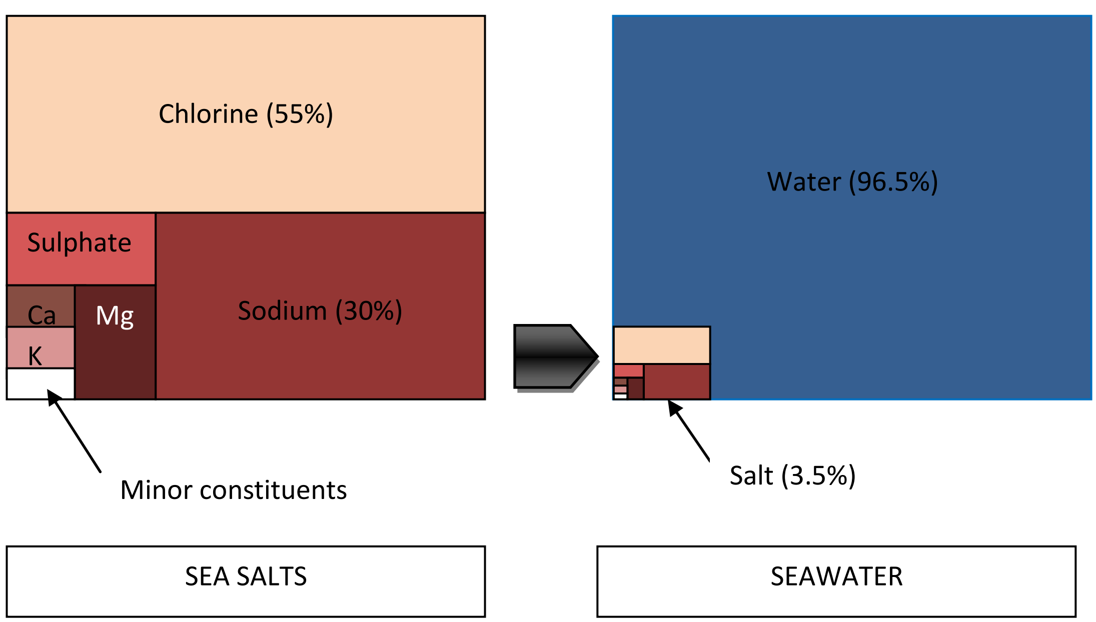
BACKGROUND INFORMATION

COMPOSITION OF SEA WATER

The most important components of seawater that influence life forms are salinity, dissolved gases (mostly oxygen and carbon dioxide), nutrients, pH, and temperature.

a. Salinity

Seawater is a complex mixture of dissolved inorganic material and dissolved gases (ignoring the many inorganic and organic materials and organisms that are merely in suspension). The amount of dissolved inorganic materials is what gives seawater its salinity. Most parts of the ocean have a salinity of typically 3.5% or 35ppt. However, factors such as low or high rainfall regimes, high or low evaporation, melting of glaciers, high surface drainage from landmasses, etc., influence salinity levels in localized situations. The major dissolved constituents of seawater occur in constant relative ratios in seawater. The diagram below illustrates abundance of salt in seawater:



The two most abundant constituents in seawater are sodium and chloride (the components of table salt).

Variations occur in ocean salinity due to several factors. The most common factor is the relative amount of evaporation and precipitation in an area. If there is more evaporation than precipitation then the salinity increases. If there is more precipitation (rain) than evaporation then the salinity decreases. Another factor that can change the salinity in the ocean is due to a very large river emptying into the ocean. The runoff from most small streams and rivers is quickly mixed with ocean water by the currents, and has little effect on salinity. But large rivers (like the Amazon River in South America) may make the ocean have little or no salt content for over a mile or more out to sea. The freezing and thawing of ice also affects salinity. The thawing of large icebergs (made of frozen fresh water and lacking any salt) will decrease the salinity.

Many marine organisms are highly affected by changes in salinity. This is because of a process called osmosis which is the ability of water to move in and out of living cells, in response to a concentration of a dissolved material, until equilibrium is reached. Marine organisms respond to this as either being osmotic conformers (also called poikilosmotic) or osmotic regulators (or homeosmotic). Osmotic conformers have no mechanism to control osmosis and their cells are the same salt content as the liquid environment in which they are found (in the ocean this would be 3.5% salt). If a marine osmotic conformer were put in fresh water (no salt), osmosis would cause water to enter its cells (to form an equilibrium), eventually causing the cells to pop (lysis). Osmotic regulators have a variety of mechanisms to control osmosis and the salt content of their cells varies. Their mechanisms will prevent any drastic changes to the living cells. Marine osmotic regulators include most of the fish, reptiles, birds and mammals. These are the organisms that are most likely to migrate long distances where they may encounter changes in salinity. An excellent example of this is the salmon fish. The fish is about 1.8% salts, so in seawater it tends to dehydrate and as such it constantly drinks the seawater. Special cells on the gills (called chloride cells) excrete the salt so the fish can replace its lost water. When a salmon migrates to fresh water its cells start to take on water so the salmon stops drinking and its kidneys start working to produce large amounts of urine to expel the water.

b. Nutrients

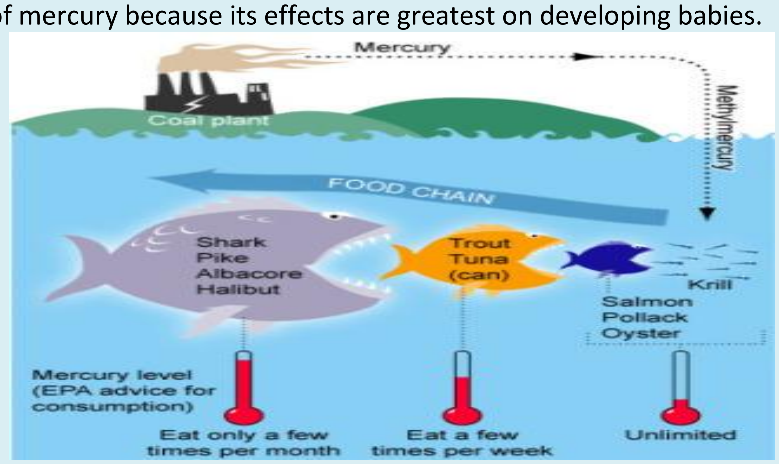
There are other elements in seawater that are necessary for life processes; however, these are usually not common in seawater because it is quickly consumed in biological activities. The nutrients include nitrogen (as nitrate), phosphorus (as phosphate), silicon (as silicate), iron, and manganese. Of these, nitrate and phosphate are considered the limiting nutrients, due to the fact that these minor elements are essential for plant growth. As such, inputs of nutrients to the marine environment stimulate rapid growth of plant species. Some elements found in seawater are toxic in high concentrations; these include mercury (Hg).

BOX 1.1a - Bioaccumulation of Mercury in Fish

Mercury is a toxic metal that is released into the environment through natural and human sources. It has been well known as an environmental pollutant for several decades. Each year power plants and other sources create tons of mercury pollution, which makes its way into our homes and bodies. Some of the sources of mercury pollution include metal smelting (facilities that recycle auto scrap), chlorine chemical plants, cement plants, and coal-fired power plants. Power plants are the largest source of mercury air emissions worldwide. As the price of oil rises, coal becomes a more economically attractive source of energy in countries where it is abundant and inexpensive. Other sources of mercury are also on the rise. High demand for polyvinyl chloride (PVC) from China's booming construction industry has fuelled growing demand for the mercury catalyst used in PVC production.

Most commonly, the gaseous form is released to the atmosphere, which it is then deposited onto land and water in rain and/or snow. Once in the ocean, the mercury can be converted to its most toxic form, methylmercury. Mercury and methylmercury is present in only small concentrations in seawater. However, it is absorbed, usually as methylmercury, by tiny aquatic plants and animals at the start of the food chain. Methylmercury is fat soluble, it cannot be destroyed, it cannot be combusted, and it does not degrade. As such it gets stored in the fat of these organisms and the fish that eat them build up methylmercury in the fatty tissue of their bodies. As ever-bigger fish eat smaller ones, the methylmercury is concentrated further up the food chain and bioaccmulates in the larger species.

Fish products have been shown to contain varying amounts of heavy metals, particularly mercury and fat-soluble pollutants from water pollution. Species of fish that are long-lived and high on the food chain, such as marlin, tuna, shark, swordfish and king mackerel contain higher concentrations of mercury than others. Methylmercury is highly toxic to mammals, including people, and causes a number of adverse effects. Pregnant women, in particular, are advised against eating fish that may have high levels of mercury because its effects are greatest on developing babies.



Picture: Carr, C. (2010). The Cove and the Self-righteousness of Activists. The Inductive. Retrieved December 3, 2011 from: http://www.theinductive.com/blog/the-cove-and-the-self-righteousness-of-activists.html

U.S. Geological Survey
http://water.usgs.gov/wid/FS_216-95/FS_216-95.html

BOX 1.1b – Persistant Organic Pollutants (POPs) in the Caribbean

Most Caribbean nations are signatories to the Stockholm Convention, which aims to reduce and mitigate contamination from selected persistent organic pollutants (POPs). Studies of POPs contamination in the Caribbean coastal environment have been limited to a few projects that have detected localized sources of contamination. In addition to contamination from localized point sources of POPs, the Caribbean basin may be influenced by inputs of POPs at a regional scale from large continental rivers, such as the Orinoco River to the southeast and the three major rivers that enter the Gulf of Honduras to the southwest.

In 2009/2010, through the Caribbean Coastal Pollution Project (CCPP) of the United Nations University Institute for Water Environment and Health (UNU-INWEH), white grunt (Haemulon plumieri) samples were collected within the Wider Caribbean Region to monitor the levels of POPs in fish tissues from the Wider Caribbean Region. Four countries were sampled in the Caribbean basin: to the north (Jamaica), west (Mexico) and east (St. Lucia, Trinidad and Tobago)

The dorsal muscle of the fish was analysed to determine the risk for the consumption of POPs. A variety of different POPs where analysed including hexachlorobenzene a by-product during the manufacture of chemicals used as solvents (substances used to dissolve other substances), other chlorine-containing compounds, and pesticides and DDT, a commonly used pesticide prior to 1972 when it was banned.

Overall the concentrations of the target POPs were low relative to consumption guidelines used to protect the health of humans consuming contaminated seafood. There were variations in the levels and types of contaminations in the different countries. The differences in contamination observed in white grunt from the countries sampled may reflect: i) geographical differences in the use of pesticides, ii) differences in overland or subsurface transport pathways from the source to the coastal zone, iii) marine circulation patterns and currents, and/or iv) patterns of atmospheric deposition of POPs in the Caribbean.

Van Lavieren et al. (2001)

c. Dissolved gases

All the atmospheric gases are present in solution in seawater. However, there are three main gases in seawater: nitrogen, oxygen and carbon. Nitrogen has the highest concentration in seawater compared to oxygen and carbon dioxide; yet, very few organisms can use it as a nutrient. The percentage of carbon dioxide in the ocean is higher than that of atmospheric carbon dioxide because carbon dioxide is a very soluble gas. Carbon dioxide is present primarily as bicarbonate ions, and is the major factor controlling the pH of seawater (which is normally within the range 7.5-8.4).

$CO_2 + H_2$	$\longleftrightarrow$	H_2CO_3	$\longleftrightarrow$	$H + HCO_3^-$	$\longleftrightarrow$	$2H^+ + CO_3^{2+}$
		Carbonic Acid		Bicarbonate ion		Carbonate ion

Oxygen is not constant in seawater. Oxygen typically varies, with the higher values close to the surface of the water column. Below 100m the abundance of oxygen begins to drop and oxygen is lost.

BOX 1.1c – Ocean Acidification

The ocean absorbs approximately 1/3rd of the carbon dioxide (CO_2) emitted to the atmosphere from the burning of fossil fuels. However, this valuable service comes at a steep ecological cost - the acidification of the ocean. As CO_2 dissolves in seawater, the pH of the water decreases, which is called "acidification". Since the beginning of the industrial revolution, ocean pH has dropped globally by approximately 0.1 pH units.

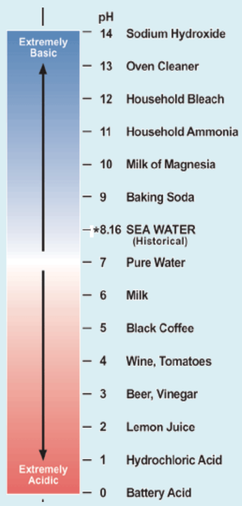
The pH level is not alarming itself but it is the rate of change that is cause for concern. The ocean has never experienced such a rapid acidification. By the end of this century, if concentrations of CO_2 continue to rise exponentially, we may expect to see large changes in pH. Such large changes in ocean pH have probably not been experienced on the planet for the past 21 million years.

How is atmospheric CO_2 responsible for ocean acidification?
When CO_2 dissolves in seawater, it forms carbonic acid, which releases hydrogen ions into solution. Acidity is a measure of the hydrogen ion concentration in the water, where an increase in hydrogen leads to an increase in acidity (and a *decrease* in the pH scale used to quantify acidity). These hydrogen ions then combine with carbonate ions in the water to form bicarbonate. Carbonate ions are the basic building blocks for the shells of many marine organisms.

Thus the formation of bicarbonate through this chemical reaction removes carbonate ions from the water, making them less available for use by organisms. The combination of increased acidity and decreased carbonate concentration has implications for many functions of marine organisms, many of which we do not yet fully understand.

BOX 1.1b – Ocean Acidification (Cont'd)

How acidic are the oceans?



The oceans are not, in fact, acidic, but slightly basic.
Acidity is measured using the pH scale, where 7.0 is defined as neutral, with higher levels called "basic" and lower levels called "acidic". Historical global mean seawater values are approximately 8.16 on this scale, making them slightly basic. To put this in perspective, pure water has a pH of 7.0 (neutral), whereas household bleach has a pH of 12 (highly basic) and battery acid has a pH of zero (highly acidic).

However, even a small change in pH may lead to large changes in ocean chemistry and ecosystem functioning. Over the past 300 million years, global mean ocean pH values have probably never been more than 0.6 units lower than today. Ocean ecosystems have thus evolved over time in a very stable pH environment, and it is unknown if they can adapt to such large and rapid changes.

What can we expect in the future?
Today, the surface ocean is saturated with respect to calcium carbonate (including its several mineral forms, i.e., high-magnesium calcite, aragonite, and calcite), meaning that under present surface conditions these minerals have no tendency to dissolve and that there is still enough calcium and carbonate ions available for marine organisms to build their shells or skeletons. However, based on the emissions scenarios of the Intergovernmental Panel on Climate Change (IPCC) and general circulation models, we may expect a drop in ocean pH of about 0.4 pH units by the end of this century, and a 60% decrease in the concentration of calcium carbonate, the basic building block for the shells of many marine organisms.

The Ocean Acidification Network. (n.d).Retrieved December 3, 2011 from:
http://ioc3.unesco.org/oanet/FAQacidity.html)

d. *Temperature*

If you want to know about the temperature of the ocean, you have to learn about the parts of the ocean first. The ocean can be divided into three layers based on their densities. The top part of the ocean is called the surface layer. Then there is a boundary layer called the transition zone. The transition zone or thermocline separates the surface layers and the deep water of the ocean. The deep ocean is the third part of the ocean.

The surface layer is heated by the sun. Wind and waves mix this layer up from the bottom, so the heat gets mixed downward too. The average temperature of the ocean surface waters is about 17^0C (62.6^0F).

Ninety percent (90 %) of the total volume of ocean is found below the transition zone in the deep ocean. The deep ocean is not well mixed. Much of this deep ocean water is between 0-3^0C (32-37.5^0F), lacks oxygen and is pitch dark. In the low latitudes, the transition zone temperature changes more rapidly with depth than it does in the layers above or below. As such, this thin warm layer is found between 100-500m.

DID YOU KNOW?

Fish that live in the deep sea have adaptations to help them locate prey or attract mates in the pitch black of the deep ocean. For example, the deep sea angler fish has a long fishing-rod-like adaptation protruding from its face, on the end of which is a bioluminescent piece of skin that wriggles like a worm to lure its prey.

Deep sea angler fish

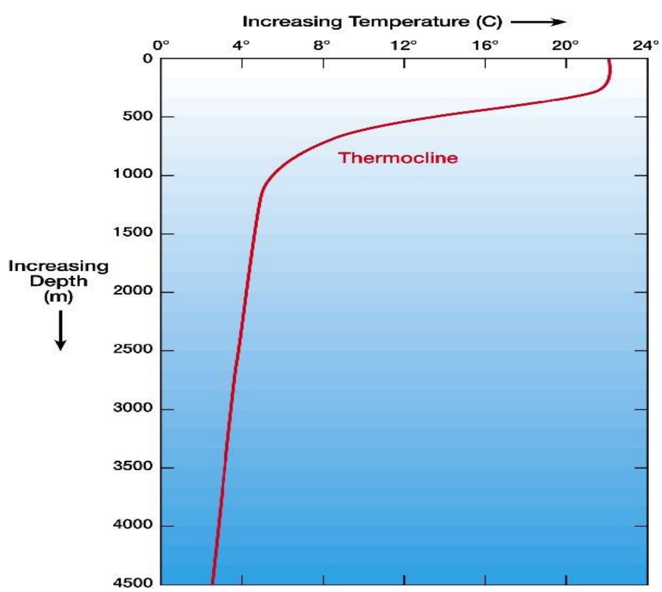


Figure 1.1a A simple temperature-depth ocean water profile in low latitudes. (http://marinebio.org/oceans/temperature.asp)

In high latitudes there is little difference between the temperatures of the surface and deep layers. Within the whole depth of the water the temperature limits are between -1.8 to 1.8^0C. However, in the middle latitudes there is a seasonal transitional zone due to warming in the summer months. In the winter, the surface water cools and there is mixing of the water which extends to a depth of several hundred meters, and usually produces a slight transitional zone at 500 to 1500m.

Temperature is one of the most important oceanographic variables and it influences the ecological processes in the ocean in two main ways:

- ✓ By affecting photosynthesis and
- ✓ By affecting the mixing of the water column.

Temperature is a limiting factor in photosynthesis. The rate of photosynthesis increases as temperature increases up to a maximum. If temperature increases past this maximum, it results in a rapid reduction in the photosynthetic rate. Deep water coral in contrast to tropical coral are found in waters about 300 to 500m, and do not have symbiotic photosynthetic plants called zooxanthallae in their cells (See more on zooxanthallae in theme 2.2). Instead, they feed solely on zooplankton and rely on ocean currents to bring their food.

The mixing of the water column is caused by temperature-generated density gradient that facilitates the movement of nutrients. We will learn more about temperature –generation density gradients in Theme 1.2.

Water temperature exerts a powerful control over the distribution and behavior of marine organisms. Temperature tolerances vary widely between marine organisms, with each being restricted to distribution within its particular temperature tolerance range.

BOX 1.1c - Temperature tolerance of yellowfin tuna

Tropical tunas such as the yellowfin tuna are characterised as r-selected species due to early age of sexual maturity, long spawning duration and short-life span. Tunas are multiple broadcast spawners; shedding their eggs and sperm directly into the sea for fertilisation. The Atlantic yellowfin tuna is believed to spawn daily and year round over vast areas in the Atlantic Ocean.

Temperature has an effect on the growth of yellowfin tuna larvae. The mean water temperature tolerance and preferences for tuna larvae (0 – 1 year) spans 25 – 30^{0}C with an optimum temperature between 29 – 29.5^{0}C, which results in the best hatching results for yellowfin tuna eggs in an *ex situ* experiment. This temperature tolerance of the larvae results in spawning activity taking place in waters that will increase the chances of survival of the larvae. Hence, spawning activity of tunas takes place in sea surface temperatures of about 24^{0}C and higher, with 85.3% of the spawning taking place between 26 – 30^{0}C. As such, the production of yellowfin tuna as with other Caribbean finfish can be expected to be fairly much concentrated in a thin upper layer of the Caribbean Sea where the temperatures are warmer.

Williams-Peter, S. (unpublished, 2010). Too hot to handle: Exploring the effects of increased sea surface temperature on the Atlantic yellowfin tuna. Halifax, N.S., Dalhousie University.

SAMPLE TEACHING AND LEARNING STRATEGIES

The strategies proposed here include:

Activity 1.1a and 1.1b:

Climate change and our Oceans

Students carry out two experiments to investigate ocean acidification.

THEME 1.2:

Movement of the Ocean and Seas

Ocean Currents Circulation Patterns

Objectives

- To appreciate the influence of ocean currents circulation pattern in the dispersal of eggs, larvae, sediments, contaminants, and migratory species across the Caribbean region.

Materials/ equipment

- Overhead Projector
- Flipchart paper
- Markers

Strategies

- **Activity 1.2** Salinity and Deep Ocean Currents

Deep ocean currents are caused by differences in water temperature and salinity. In this experiment, develop a model to explain the role of salinity and density in deep ocean currents.

Delivery Time

- 2 ½ hours

Movement of the Ocean and Seas

Ocean Circulation Patterns

BACKGROUND INFORMATION

Ocean Circulation Patterns

The ocean is always in motion, mainly through three different mechanisms: Tides, Waves, and Currents.

a. Tides

Tides are usually the largest source of short-term sea-level fluctuations at the seashore. Tides create a current in the oceans, near the shore, and in bays and estuaries along the coast. These are called "tidal currents". Tidal currents are the only type of currents that change in a very regular pattern and can be predicted for future dates. Tides are caused by the combined effects of the gravitational forces exerted by the moon and the sun and the rotation of the Earth. These result in pulling on large areas of water, setting them swinging in a regular motion. Most places in the ocean usually experience two high tides and two low tides each day (semi-diurnal tide), but some locations experience only one high and one low tide each day (diurnal tide). Saint Lucia experiences diurnal tides with a maximum tidal range of 0.55m.

DID YOU KNOW?

The Bay of Fundy between the Canadian provinces of New Brunswick and Nova Scotia is known for having the highest tidal range in the world - 11.7 m.

Tide changes proceed via the following stages:

- Sea level rises over several hours, covering the intertidal zone; flood tide.
- The water rises to its highest level, reaching high tide.
- Sea level falls over several hours, revealing the intertidal zone; ebb tide.
- The water stops falling, reaching low tide.

b. Waves

Waves are the most obvious processes on the ocean surface. Waves are the movement of energy through the top layer of water, caused by winds. Waves in the oceans can travel thousands of miles before reaching land. Wind waves range in size from small ripples to huge waves over 30 meters high.

c. Ocean Currents

An ocean current is a continuous, directed movement of ocean water. Ocean currents are import to the dispersal of organisms (in both larval and adult stages), as well as the spreading out of terrestrial freshwater, sediments and pollutants drainage. There are two types of ocean currents: surface and deep. Surface ocean currents are generally wind-driven whereas deep ocean currents are driven by density and temperature gradient.

i. Surface Ocean Currents

The water at the ocean surface is moved primarily by winds that blow in certain patterns because of the Earth's spin and the Coriolis Effect. Winds are able to move the top 400 meters of the ocean creating surface ocean currents. Surface ocean currents form large circular patterns called gyres. Gyres flow clockwise in Northern Hemisphere oceans and counterclockwise in Southern Hemisphere oceans because of the Coriolis Effect. There are five major ocean gyres.

DID YOU KNOW?

The North Pacific gyre is home to an area called the Great Pacific Garbage Patch. It is estimated to cover an area roughly 2250 times the size of St. Lucia and contains approximately 3 million tons of plastic litter, though much of this plastic is broken up into pieces too small to see with the naked eye.

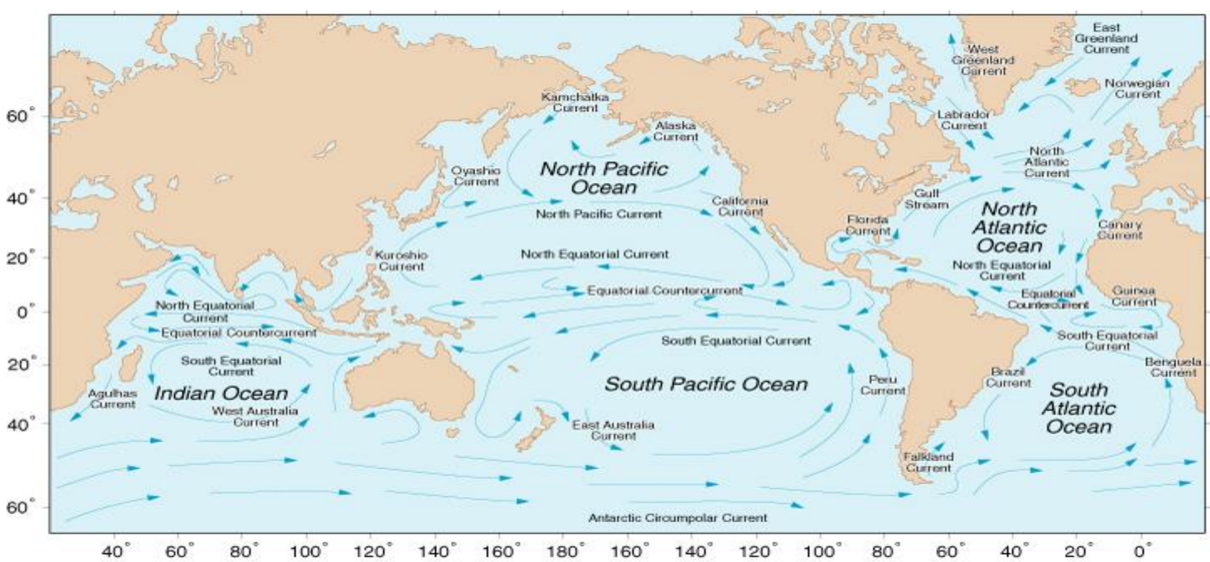


Figure 1.2a Major ocean surface currents including the five major gyres: Indian Ocean, North and South Atlantic, and North and South Pacific.

Ocean surface currents push water into the Caribbean Sea mostly through passages in the southeast between the islands of Grenada, St. Vincent, and St. Lucia in the Lesser Antilles. The water then continues westward as the Caribbean Current, the main surface ocean current in the Caribbean Sea. The current then turns north to pass the Gulf of Mexico through the Yucatán Channel. This water finally passes out into the Atlantic again to form the Gulf Stream.

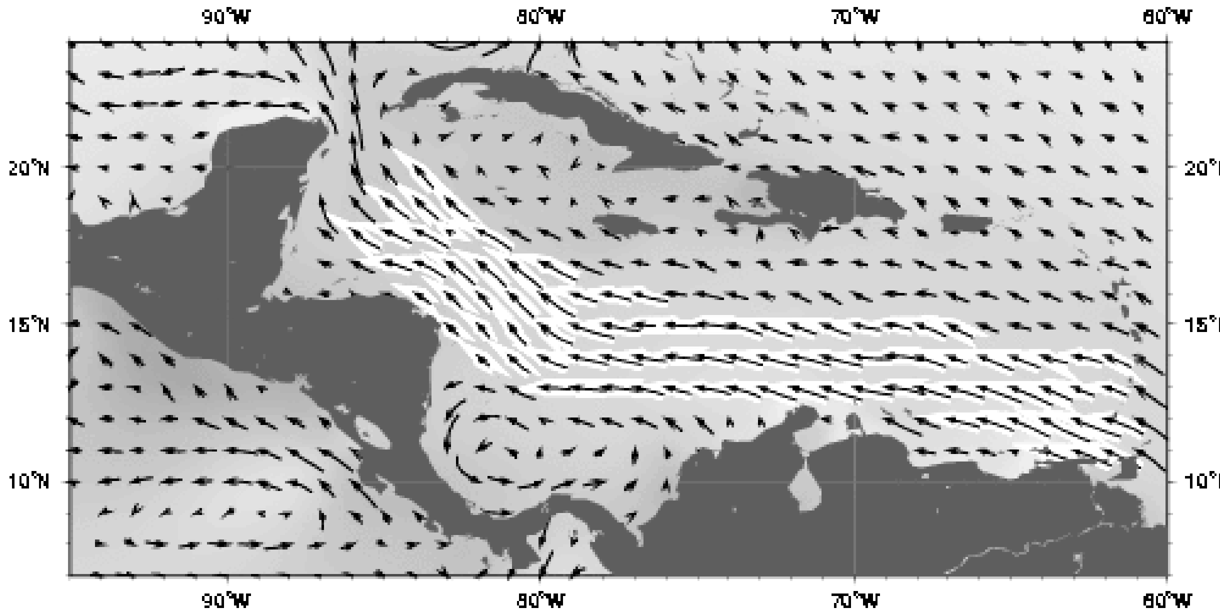


Figure 1.2b Surface Currents in the Caribbean Sea (http://oceancurrents.rsmas.miami.edu/caribbean/caribbean.html)

By the time the water moves across the Atlantic into the Caribbean the floating animals and plants have removed most the nutrients. Many of these creatures are eaten or die and sink to the ocean floor. This means that the Caribbean waters are poor in nutrients, unproductive and contain relatively few living organisms.

ii. Deep Ocean Currents (Thermohaline Circulation)

The sinking of water masses at the two poles produce outflows that are manifested as “deep” currents, which act to take nutrients and oxygen to the deeper layers of the oceans. These deep currents form part of the thermohaline circulation, which is also called the global ocean conveyor belt. Density differences in different parts of the sea are responsible for deep ocean currents. These density differences in the ocean are a function of temperature and salinity; however, the effect of temperature variation has the greatest effect on the ocean current

To start surface currents moves surface water at the equator to the poles, as it cools it gets denser and sinks to the deep ocean taking life sustaining nutrients and dissolved gases such as oxygen with it. Also when ice forms in colder waters it leaves behind its salt, which increases the salinity of surrounding waters. The higher salt content makes the cold polar water create the thermohaline circulation (See Figure 4). The cold salty water masses at the poles sink down several kilometres and spread out horizontally moving along the bottom of the Atlantic Ocean.

After rising to the surface in the Pacific Ocean through the process of upwelling, the surface waters flow through the many passages into the Indian Ocean. Eventually they flow into the Agulhas Current, the Indian Ocean boundary current that flows around southern Africa. After entering the Atlantic Ocean once again, the surface waters join the wind-driven currents in the Atlantic, becoming saltier by evaporation under the intense tropical sun. Trade winds transport some of this water vapour out of the Atlantic Ocean basin, across the Isthmus of Panama, and into the Pacific Ocean basin. Atlantic surface waters eventually return northward to the Labrador and Greenland seas in the North Atlantic.

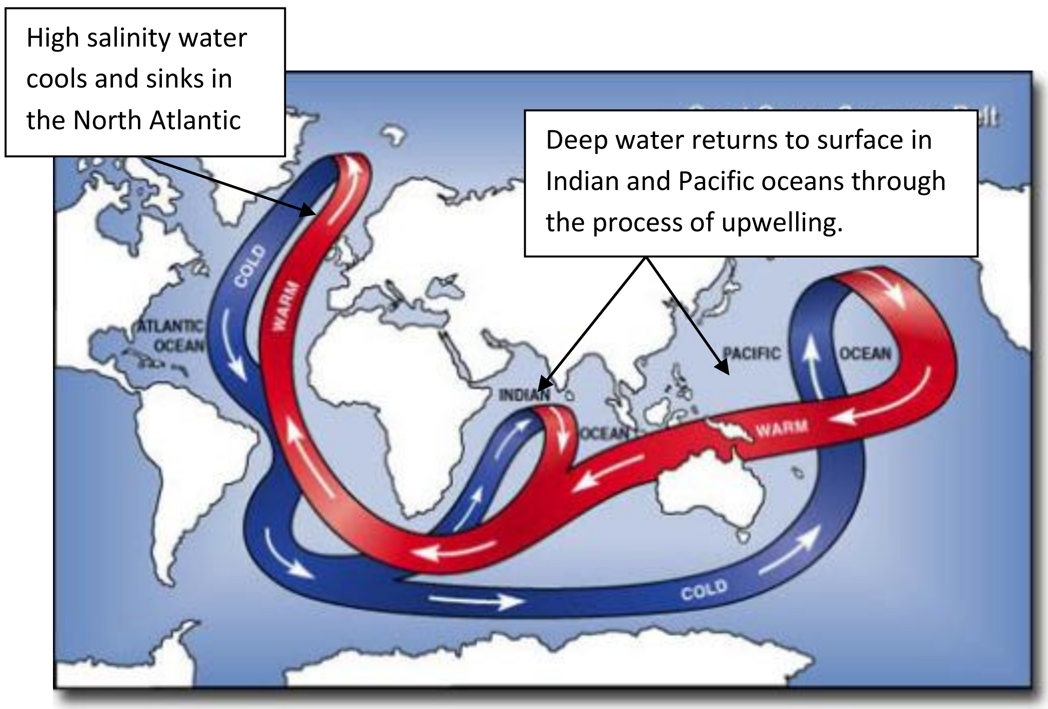


Figure 1.2c Global Ocean Conveyor Belt

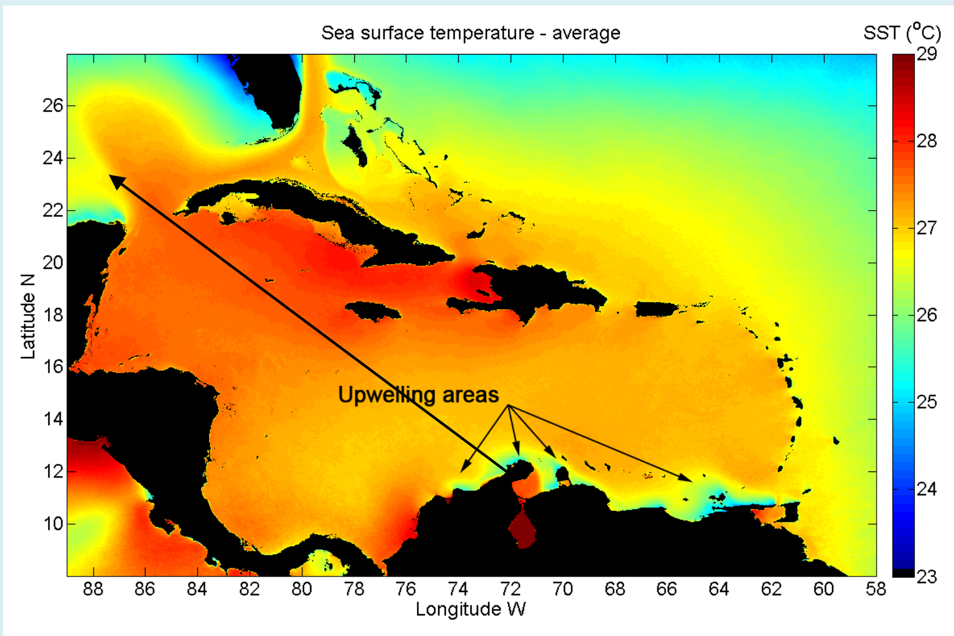
Impact of Ocean Circulation on Marine Ecology

Surface ocean currents affect upwelling in many places. Winds blowing across the ocean surface often push water away from an area. When this occurs, cold nutrient rich water rises up from beneath the surface to replace the diverging surface water. This process is known as “upwelling.” This ascending and recycling of nutrients to the upper photosynthetic layers of the surface layer controls the distribution of organisms and affects size, metabolism, growth, reproduction and survival of marine life.

The cold nutrient rich water is biologically productive and therefore, good fishing grounds are typically found were upwellings are common. When the deep water gets to the surface, these extra nutrients are snatched up by plankton that floats in the ocean. The number of plankton grows where there is an upwelling. Tiny animals gobble up the plankton including fish. This means that upwelling areas are full of marine life. About half the fish caught in the world comes from places where there is an upwelling.

BOX 1.2a - Upwellings promote spawning grounds

Within the Caribbean, there are two major spawning grounds for the yellowfin tuna. The spawning grounds are located near upwellings in the south eastern Caribbean Sea, north of Venezuela with peak spawning from July to November, and the Gulf of Mexico, peak spawning from May to August. The upwelling areas used for spawning by yellowfin tuna correspond to the areas of high production of phytoplankton and zooplankton.



The region for maximum production of phytoplankton is along the upwellings in north coast of Venezuela and high production of phytoplankton is present along the coasts of the Florida, Gulf of Mexico, Panama and extending southeast through to Guiana.

BOX 1.2a - Upwellings promote spawning grounds (cont'd)

In the Gulf of Mexico it was found that the dominant zooplankton classes are copepods. The larvae of yellowfin tuna have been reported to eat copepods. Larvae of other fish species also feed on the phytoplankton and zooplankton in the upwelling areas in the Wider Caribbean.

The intensity of upwelling areas are believed to be influenced by wind strength and sea surface temperatures among other variables. There is uncertainty of the magnitude of the effect of sea surface temperature on upwelling areas; however, sea surface temperature may affect the abundance of plankton by impacting plankton mortality, reproduction and development.

Williams-Peter, S. (unpublished, 2010). Too hot to handle: Exploring the effects of increased sea surface temperature on the Atlantic yellowfin tuna. Halifax, N.S., Dalhousie University.

SAMPLE TEACHING AND LEARNING STRATEGIES

The strategies proposed here include:

Activity 1.2

Salinity and Deep Ocean Currents

Deep ocean currents are caused by differences in water temperature and salinity. In this experiment, develop a model to explain the role of salinity and density in deep ocean currents.

THEME 1.3:

Treasures of the Sea

Fisheries Resources in Saint Lucia

Objectives

- To identify difference between coastal and offshore fisheries resources and list examples.
- To explain why it is important to understand the life cycle of fisheries resources.
- To describe the importance of these habitats to the productivity of fisheries.
- To describe why Fisheries Management is important for productive fisheries.

Materials/ equipment

- Overhead Projector
- Flipchart paper
- Markers

Strategies

- **Activity 1.3** Sea turtle Nesting Game

In this activity students build a board game and play it to observe how marine animals face many natural and human dangers. As such they learn that it is critical that we help protect their habitat to allow their population to thrive.

Delivery Time

- 1 hour

Treasures of the Sea

Fisheries Resources in Saint Lucia

BACKGROUND INFORMATION

Types of Fisheries Resources in Saint Lucia

A *fishery* refers to targeted marine species for human consumption. These marine species are usually referred to as fisheries resources. Fisheries resources can be harvested sustainably; this is called a sustainable fishery. A sustainable fishery is one in which fishing practices can be maintained indefinitely without reducing the targeted species' ability to maintain its population and without adversely impacting on other species within the ecosystem by removing their food source, accidentally killing them, or damaging their physical environment. Many governments develop plans and strategies to work towards sustainable fisheries based on the type of fishery. There are two main groups of fisheries resources in Saint Lucia: Coastal and Offshore.

a. Coastal

Although the productivity of the open Caribbean is low due to the influx of nutrient poor waters this is not the case for some of the coastal areas. Coastal habitats such as mangrove forests, coral reefs and seagrass beds are capable of producing anything up to 40 times as much living material as the barren sea (See Module 2). The sparse nutrients of the sea are supplemented by drainage from the land as well as by large quantities of rotting leaves from plants and trees, which supports vibrant coastal fisheries.

Coastal fisheries are characterized as fisheries with the target species being located close to shore. They are generally considered a national fisheries resource. However, due to the movement of currents transporting them at different life stages across the Caribbean and the close proximity of the Caribbean islands there are often regional efforts towards management. Examples of coastal fisheries resources in Saint Lucia are:

- Queen conch / Lanbi
- Spiny Lobster/ Houma
- White Sea Egg / Chadon
- Reef associated species or pot fish (e.g. Queen parrot fish/ Tèt wim)
- Coastal pelagic fishes (e.g. Jacks/ Kawang)

b. Offshore

Offshore fisheries resources are located far from shore are they are generally migratory species. As such they are considered a shared fishery resource. This means they are a group of commercially exploitable organisms, distributed over, or migrating across far distances, between two or more national jurisdictions, or a national jurisdiction and the adjacent open ocean. In this case these fisheries can only be sustainably managed through the cooperation with other countries concerned. Examples of offshore fisheries resources include:

- Flying fish (e.g. four-winged flying fish / volan)
- Ocean pelagic fishes (e.g. dolphinfish/ dowad)
- Marine mammals (e.g. short finned pilot whale/ mashween)

In some cases fisheries resources can be found in environments near the coast or offshore either at different stages in their life cycle or for feeding, breeding or nesting.

For example:

- Young jacks remain in open sea, when mature they move inshore and school.
- Hawksbill and green sea turtles feed within the coastal area and come up on beaches to nest.

Maintaining the Productivity of Fisheries

Ensuring sustainable fisheries are a top priority for many countries including Saint Lucia. Fisheries resources support many livelihoods; particularly, in rural communities where there is limited access to employment outside of the agriculture sector. Hence, fisheries can be considered a “treasure” for many communities. A sustainable fishery ensures that the fishery is productive. A productive fishery maintains, for generations to come, enough fish to support livelihoods while still maintaining a balanced ecosystem. An important component of sustainable fisheries is to ensure that the fishery species goes through their life cycle to reach breeding age adult and to allow as many of these adults to reproduce. Consequently, there are a number of strategies that are engaged to maintain sustainability. These can grouped as strategies to 1.**regulate fishing** in an effort to allow reproduction before removal and maintain the right number and size structure of the species population or 2.**habitat protection** in an effort to protect areas that are important to the species life cycle in Saint Lucia. In some cases the strategies can be effective for both purposes.

1. REGULATING FISHING

i. **Closed fishery periods or Close seasons:** These are stipulated times that no one is allowed to harvest the target fishery species. For example: The fishery laws of Saint Lucia make provisions for closing the lobster fishery. From March 1st to August 1st 2012 the lobster fishery will be declared closed. The period of closure of the fishery usually coincides with a point in the organisms life cycle where fishing it will cause the fishery to become unproductive. In the case of the lobster the fishery is closed around the point of peak reproduction.

ii. **Gear Restrictions:** These are rules set out on the type of gear that can be used to fish. In the fisheries laws of Saint Lucia there are a number of gear restrictions legally instituted and include a mesh size of 3.75cm for fish traps and various mesh sizes depending on the type of net. There is also a ban on certain types of nets. Gear restrictions work to prevent the capture of juvenile organisms so they can become breeding age adults or reduce the capture of non-target species.

iii. **Specific size limits:** A size limit stipulates the size of species that can be caught. This allows organisms to either grow to breeding age adults or allow adults to contribute young to the population before being caught. In Saint Lucia size limits are used for lobster, conch and sea eggs.

iv. **Moratoriums:** These are extended closed fishery periods. It is usually used to allow a fishery to recover from being unsustainably fished. In the 1980s, there was a moratorium on white sea eggs, which lasted for three (3) years.

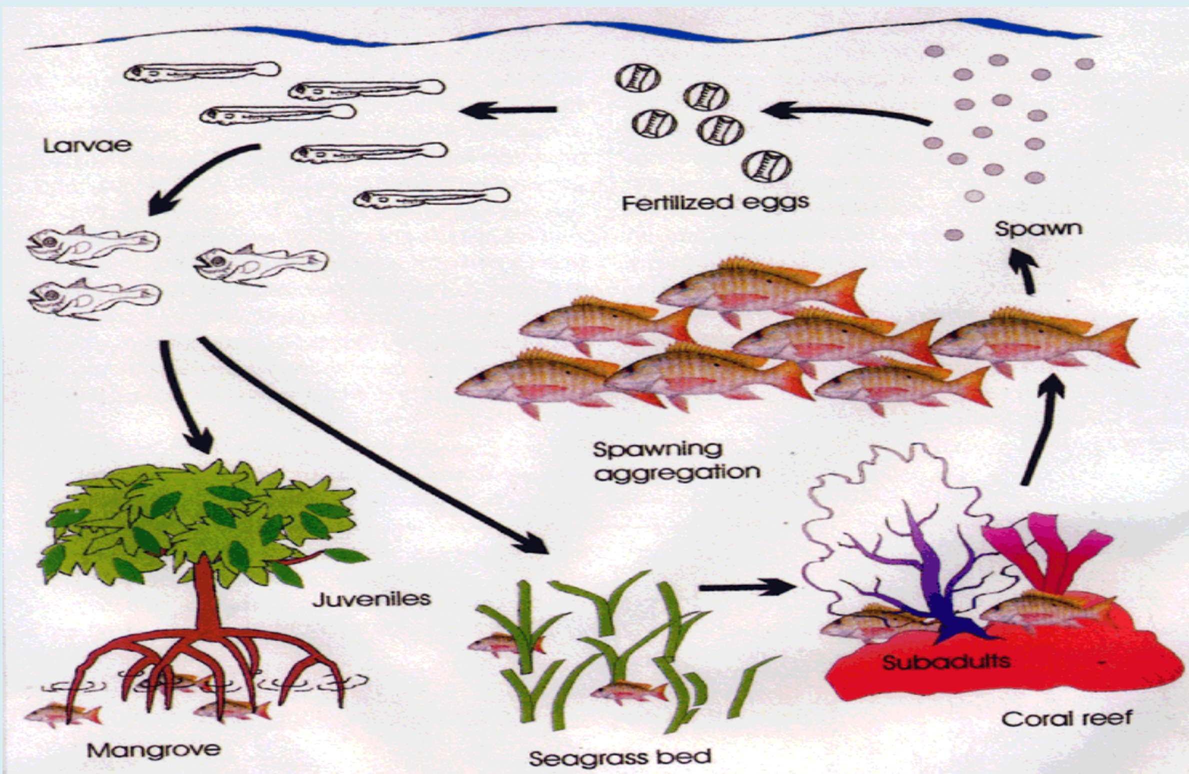
2. Habitat Protection

v. **Closed Areas:** Areas that are used as a habitat for breeding, nesting or nursery area for juvenile stages of fishery species are often closed to fishing. This means that no one is allowed to fish in these locations. Under the fisheries laws these closed areas are called marine reserves. There are twenty four (24) marine reserves in Saint Lucia, these include mangrove forests and coral reefs.

vi. **Gear restrictions:** Gear restrictions also work to protect certain habitats. For example, bottom trawling destroys benthic habitats and is not selective in its catch. As such there are international debates about its continued use as a fishing gear. Trawling is not a fishing method used in Saint Lucia.

BOX 1.3a - Importance of Habitat Protection

Most reef-associated fish species have a **complex life cycle,** exploiting a variety of habitats throughout their life cycle. Most often, the larvae of reef species are pelagic, inhabiting the open ocean, whereas the adults are sedentary reef inhabitants. Many species may also use reef-adjacent habitats, such as mangrove and seagrass beds, during juvenile stages. The mutton snapper or Sob as it is called in Kwéyol is an example of a reef-associated fish with such a complex life cycle. Module 2 provides further details on the importance of these coastal habitats.



The Nature Conservancy. (2011). Fish spawning aggregations: a reef resilience toolkit module. Retrieved December 6, 2011 from: http://www.reefresilience.org/Toolkit_FSA/F1a0_Problem.html

SAMPLE TEACHING AND LEARNING STRATEGIES

The strategies proposed here include:

Activity 1.2

Sea turtle Nesting Game

In this activity students build a board game and play it to observe how marine animals face many natural and human dangers. As such they learn that it is critical that we help protect their habitat to allow their population to thrive.

MODULE 2: Ecology of Marine Ecosystems

INTRODUCTION

In this module, four of the major coastal marine ecosystems found in Saint Lucia are described. These are mangrove forests, beaches, seagrass beds and coral reefs. Coastal marine ecosystems support the world economies and human life. Development priorities of countries have focused on how much humanity can take from marine ecosystems, and too little attention has been paid to understanding their critical ecological role in the environment. Hence, this section provides an overview of the biology of these ecosystems and their ecological functions.

OVERALL OBJECTIVES

- To know and identify the general characteristics of the marine ecosystems in Saint Lucia, and
- To appreciate the ecological importance of these systems.

THEMES

This module is divided into three themes:

Theme 2.1:	Dynamic Ecosystems The Ecology of Mangrove Forests and Beaches
Theme 2.2:	Under the Sea The Ecology of Seagrass Beds and Coral reefs
Theme 2.3:	The Circle of Life Connections between Marine Ecosystems

DELIVERY TIME

Expected time to deliver the module: Five (5) hours

THEME 2.1:

Dynamic Ecosystems

The Ecology of Mangrove Forests and Beaches

Objectives

- Understand what mangrove forests and beaches are,
- Be able to distinguish the different types of mangrove trees,
- Describe the natural processes taking place on beaches and in mangrove forests,
- Understand the importance of mangrove forests and beaches and the ecological role they play in marine ecosystems.

Materials/ equipment

- Overhead Projector
- Flipchart paper
- Markers

Strategies

- **Activity 2.1a : Mangrove Habitat**
  This activity focuses the importance of mangrove forests to juvenile fish and other animals by having students participate in creating a felt story board while listening to a story about Sphyraena, the Great Barracuda.
- **Activity 2.1b: Secret Mission**
  This activity provides students to investigate the mangrove forest and learn about the forest by discovery in a fun filled way.
- **Activity 2.1c: Beach zones and profile**
  In this activity students explore the beach. They design beach profiles, inspect marine life, and examine natural beach habitats.

Delivery Time

- Two (2) hours

Dynamic Ecosystems

The Ecology of Mangrove Forests and the Seashore

BACKGROUND INFORMATION

MANGROVE FORESTS

a. What and Where?

Mangroves are salt –tolerant plants that live between the sea and the land where they are flooded by tides. This is called the in the intertidal zone. They grow in pure seawater or water concentrated by evaporation to over twice the salinity of ocean seawater; however, they are capable of growing in estuarine and to a limited degree freshwater. Mangroves usually grow in coastal areas of tropical and subtropical regions - mainly between latitudes 25°N and 25°S in sheltered areas like estuaries, river banks, and marine shorelines. They occur in 124 countries and territories covering an estimated area of 15.6 to 19.8 million hectares.

DID YOU KNOW?

The term 'mangrove' is used to describe individual trees or shrubs and also the general habitat, although the habitat is often called a 'mangrove forest' or 'mangal'.

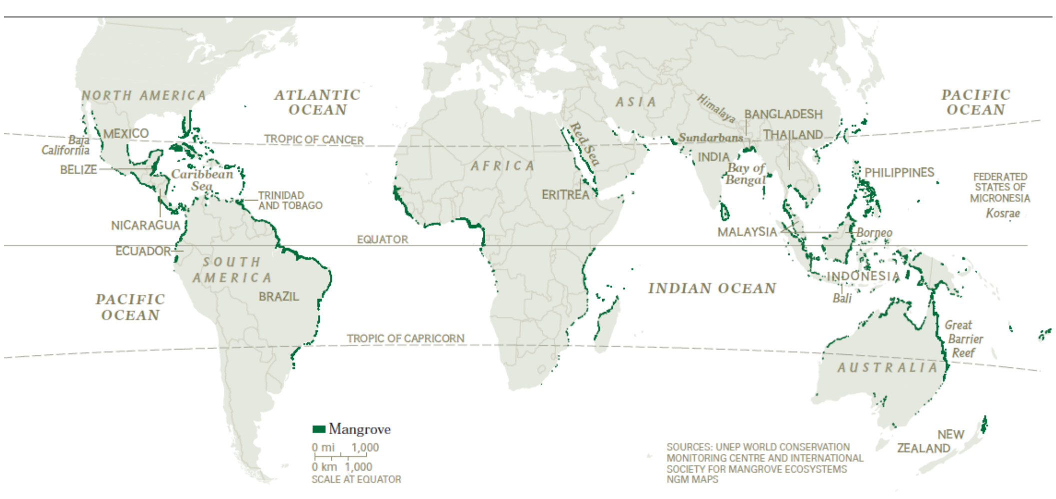


Figure 2.1a Worldwide Distribution of Mangroves

A study conducted in 1991 revealed that mangrove forests in Saint Lucia account for 179.30 hectares; however, these dynamic growing systems are continuing to decline due to severe stress from a variety of human activities. Compared to the east coast of Saint Lucia very few mangroves are presently found along the west coast.

> **DID YOU KNOW?**
>
> *The two largest mangrove forests in Saint Lucia are located in Vieux fort on the south eastern coast of the island. These are Mankote and Savannes Bay Mangrove Forests. They have also been recognized as wetlands of international importance under the RAMSAR convention*

b. Mangrove Species

Mangrove species originated in the Indo-Malayan region. The seeds of early mangroves spread westward, by ocean currents, to India, East Africa, and eastward to the Americas, arriving in Central and South America about 66 and 23 million years ago. Scientists believe that the earliest mangrove species originated in the Indo-Malayan region since there are many more mangrove species in this region than anywhere else in the world.

There are approximately 35 species of true mangroves and another 60 or more species that can be present in a mangrove forest as well as in adjacent plant communities. These are called mangrove associates. Mangrove associates are not restricted to the typical mangrove environment and are often found within drier, more terrestrial areas. Buttonwood (Conocarpus erectus) is commonly an associate of a mangrove forest. Three types of mangroves dominate Florida and the Caribbean. These three types are the red mangrove or *manng wouj* (Rhizophora mangle), two species of the black mangrove or *manng salé* (Avicennia germinans and A. schaueriana[1]), and white mangrove (Laguncularia racemosa). The table below highlights some important distinguishing physiological features.

Table 2.1a Characteristics of the Red, Black and White mangroves

	Mangrove Type		
Feature	**RED**	**BLACK (A. germinans)**	**WHITE**
ROOTS	"prop roots" derived from the trunk and "drop roots" from the branches.	pencil-like aerial roots known as pneumatophores born from underground horizontal cable roots.	May develop peg roots which are similar to pneumatophores except they are shorter and more stout in appearance
LEAVES	large broad elliptical leaves which terminate with a blunt point;	green, narrow elliptical leaves with pointy ends; often encrusted with salt	broad, flat oval rounded at both ends; Two glands are found at the base of each leaf
SEEDS/PROPAGULE	pencil-shaped; about 15 cm long	Oval, lima bean-shaped; 2-3cm long	very small; green pea shaped; usually less than 0.5cm
BARK	Gray to reddish-brown	dark brown or blackish	reddish-brown

[1] A. schaueriana is a rare species of black mangrove in Saint Lucia.

c. Zones and Community Types

Mangroves often exhibit a distinct pattern of species distribution. Explanations for distribution patterns are based on the differing responses of individual species to the character and pattern of environmental conditions such as soil physiochemistry, physical disturbances, predation and competition. Typically a mangrove forest can be described as having three zones: the outfacing edge which is exposed to high tides called the seaward zone, the middle zone, and the inland portion of mangrove forest, called the landward zone. The landward zone is less frequently covered by sea water and can receive freshwater from ground water or land runoff, this is where the mangrove associates can survive.

The red mangrove is often the most seaward-growing species of mangrove in the Caribbean and Atlantic mangrove forests, whereas, the black mangrove typically grows further inland than the red mangrove, often between zones of red and white mangroves. However, it is important to note their distributions may overlap.

Mangroves are found in a variety of tropical coastal settings creating normally three major functional types of mangrove forests namely riverine, fringe, and basin (Figure 2.1b). Mangrove forests in Saint Lucia range from a few scattered scrub patches to the more diverse riverine and or fringing mangrove communities.

The three types can be summarized as follows:

1. Riverine mangroves exist along tidal rivers and creeks, which get flooded daily by the tides and may be several miles inland from the coast. They receive nutrients from both upland and estuarine sources, and fresh water flushing lowers the salt stress. These favourable conditions make the riverine mangrove forest very productive with trees growing taller.

2. Growing conditions for fringe mangroves are less favourable and trees will seldom grow to half the height of those in a riverine environment. Fringe mangroves occur along the border of protected shorelines and are influenced by daily tidal range. Examples are the mangrove forests lining Marigot Bay in Saint Lucia. They receive little freshwater or nutrients from the land, and are vulnerable to erosion, turbulent waves, and tides high winds.

3. Basin mangroves are located inland from fringe and riverine mangroves along the interior side of swamps or in depression basins. They are only flushed by infrequent extreme tide events. The resulting stagnant, salty conditions may exclude red mangroves and stunt the growth of black and white mangroves.

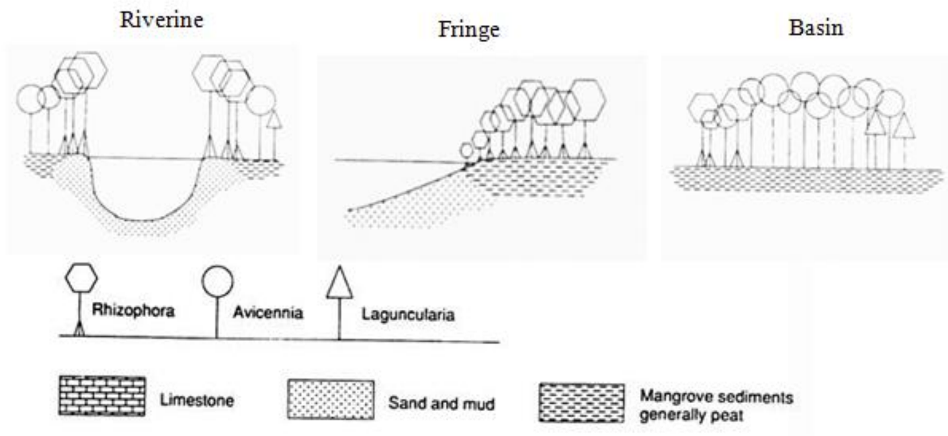


Figure 2.1b Types of Mangrove Forest Communities

d. Adaptation to Living Conditions

As a group of plants, mangroves share several highly specialized adaptations that have allowed them to colonize and thrive in their adverse environment. The mangrove environment has some special physiochemical characteristics such as salinity, tidal currents and muddy oxygen-poor soil. This section will discuss the adaptations to these environmental conditions.

1. Salinity

Plants experience many problems living in or near sea water, because most plant and animal tissues are more dilute than seawater. For osmosis to occur, water must move from a more dilute to a more concentrated compartment. When one waters a normal plant with sea water, the plant will wither and die as the salty soil now extracts water from the plant instead of replenishing it. So the high level of salinity in the mangrove environment will lead to high concentrations of salt in tissues, which will severely damage metabolic processes, leading to death.

DID YOU KNOW?

Dwarf mangroves may only grow to 5 feet tall in 50 years. The stunted growth can be the result of extremely salty conditions due to limited freshwater, and inundation by tides.

There is a diversity of strategies mangroves have developed for salt management in an effort to maintain osmotic and water potential. These include salt-secretion and salt-exclusion (ultrafiltration). The following discusses these adaptations in the red, black and white mangrove:

The black mangrove (A. germinans) and white mangrove (L. racemosa) are salt secretors; they have glands in their leaves through which excess salt can be secreted. To maintain water movement into their roots, the salt is partially excluded by the roots and the salt in their cells are excreted by salt glands located on the leaves. The water in the concentrated salt solution evaporates near the gland, leaving behind salt crystals, which are ultimately removed by wind or rain. Mangroves with salt glands have the highest tolerance to elevated salinity.

Other mangrove plants like the red mangrove (R. mangle) are non-secretors. It excludes salt from entering the roots but lacks salt excreting glands. The salt in the cells of the red mangrove is 100 times less concentrated than in seawater. It is generally agreed that this is accomplished by a process of ultrafiltration in the cell membranes of roots. At the root surface salt is prevented from entering while allowing the water to pass through. This is effective at removing the majority of salt from seawater.

All three species exhibit, to a small degree, a combination of both methods of salt regulation. The red mangrove stores and disposes of excess salt in the leaves and fruit, whereas the black and white mangroves are capable of limited salt exclusion in the roots.

Viviparity is also a characteristic that might be related to adaptation to high salinity. Mangroves produce seeds called propagules, which germinate on the trees before falling and start growing rapidly when they become anchored in the mud. It is suggested that when they are still attached to the mother trees, the propagules would be trained to tolerate high salinity by absorbing salinity from the mother trees.

2. **Tidal Currents and Muddy Oxygen-Poor Soil.**

Mangrove trees are adapted for survival in oxygen-poor or anaerobic soil through specialized root structures because they have multiple functions in absorption and plant stabilization. Due to the proximity to the sea, mangrove root systems are regularly flooded by seawater with the tides. The regular influx of water causes the soil in which the mangroves are rooted to become waterlogged. In waterlogged soils, the spaces between the soil particles fill with water resulting in lower oxygen levels than air. Plants require oxygen for respiration in all living tissues, including the underground roots. Waterlogged soil also provides challenges for the stability of the mangrove. However, the mangrove root system has developed uniquely due to its exposure to tides and the waterlogged soil condition.

Root adaptations make it possible for mangroves to remain firmly rooted when they are regularly inundated by high tides. The aerial roots in the black mangrove are connected underground by shallow wide- spreading dense mat of roots called cable roots, which surrounds the trunks of black mangroves, adding to the structural stability of the tree. And prop roots and drop roots in red mangroves provide a stable support system.

Roots in the mangroves have also adapted to maximise oxygen intake for respiration. The aerial roots in the black mangrove extend upward from the underground cable roots below the soil surface. During low tides, air is taken up through small pores on the roots called lenticels and is transported to living root tissues. Hence, these aerial roots allow for the transport of atmospheric gases to the underground roots. These aerial roots can grow to as much as 20 cm or more in height depending on the depth of flood tides. Similar to the aerial roots, the prop roots in the red mangrove also have lenticels. The above-ground areas of these roots are perforated by many lenticels that allow oxygen to diffuse into the underground roots. Water is prevented from entering the tree via lenticels due to its hydrophobic nature and therefore, water is excluded even during high tides.

The white mangrove (Laguncularia racemosa) has no visible aerial roots or prop roots. However, when it is found in oxygen-depleted soil or flooded for extended periods of time, it often develops peg roots. The peg roots function similarly to aerial roots.

Mangroves have also adapted to oxygen poor soil condition by evolving shallow root systems rather than deep taproots.

e. *Ecological Role of Mangroves*

Mangrove forests are among the world's most highly productive ecosystems. A valuable indicator of mangrove productivity is leaf litter. Leaf litter, including leaves, twigs, propagules, flowers, small braches and insect refuse is a major nutrient source to consumers in mangrove systems. As the litter decomposes it provides organic matter for food chains both within the mangroves and in neighbouring estuarine and coastal areas due to tidal flushing. In general, high levels of organic matter, or high productivity, means that a larger number and more diverse array of animals can be supported within a particular ecosystem contributing to the health and function of the marine food chain. When the leaves and branches of a mangrove fall to the ground they provide a wide variety of aquatic animals such as molluscs, crabs and worms with a primary source of food. These primary level consumers in turn support an array of secondary consumers, including small fish and juvenile predators, when mature, become third level consumers.

Mangrove forests are used periodically or as a permanent home by a wide variety of species. They serve as a fish breeding and nursery ground, and habitat for avifauna and other animals.

As such mangrove forests are considered to be vitally important as habitat areas for a wide array of organisms.

BEACHES

a. What are they?

The seashore is the area of land adjoining the sea. Saint Lucia's shoreline comprise of sandy and rocky shores, mangrove forests and cliff areas. There may or may not be a beach at the seashore. A beach is a gently sloping section of the shore area where unconsolidated sediment, or grains of worn-down rock, has collected. Unconsolidated sediment is sediment in which the individual grains are clearly separated and can move freely, like grains of rice. Most beaches are composed primarily of sand, although some are composed primarily of pebbles, gravel, fragments of seashells or larger rock pieces.

b. Saint Lucia's Beaches

There are over 100 beaches in Saint Lucia. Sixty percent (60%) of these beaches are located along the west coast and 40% are along the east coast. In total, beaches accounts for approximately 16.78% of the shoreline of Saint Lucia.

DID YOU KNOW?

The longest beach in Saint Lucia is Vigie beach along the west coast and the largest beach is Grande Anse beach located on the east coast.

c. How is a Beach Formed?

Beaches are formed by particles of material washed ashore by waves and currents. The particles of material are either eroded land material washed to sea by streams and rivers or eroded offshore material such as headlands or coral, which is washed up from the seabed. Particles comprising the beach are occasionally biological in origin, such as eroded coral, mollusc shells or coralline algae. The beaches in Saint Lucia get their sediments mainly from inland sources; this is particularly evident on beaches such as Anse Galet in Soufriere. Anse Galet beach has black sand due to deposits from volcanic rock that is washed into the sea by the Anse Galet River.

Beach formation begins as particles in the sea. Two separate processes result in the deposit of these particles of sand and sediment on the seashore. Most of the sediment is suspended in sea water and transported along the coast by longshore currents - a stream of water flowing parallel to the beach. Longshore transport can deliver up to a million cubic yards of sediment annually to a single beach. In the second process, sand deposited onshore by the longshore current is then oscillated by waves breaking onto and receding from the beach. This continual onshore-offshore movement gradually pushes the sand along the beach edge. Both the longshore transport of sediment along the coast and the movement of sand by waves along the foreshore are a part of the process called littoral drift. These two separate processes result in the deposit of sand and sediment on the shore forming a beach.

d. Changing Beaches

Beaches are profoundly influenced by the sea in terms of its appearance. Beaches are dynamic because they are altered by waves, tides and currents in a continual process of creation and erosion. Seasonal cycles of sand deposition and loss dramatically affect the appearance of beaches from summer to winter. Wave action in the summer months tends to bring up sand from deeper water and builds wider gently sloping beaches. Winter wave action generated by stormier weather erodes the sand, reducing the width of the beach and causing it to become steep-fronted. Most of the sediment is carried out to sea and deposited as an underwater sandbar, which is then eroded by the next summer's waves to rebuild the beach. Violent storm waves can even strip of the sand replacing it with coarser particles such stones.

BOX 2.1a – Effect of wind on Caribbean beaches

Waves are a function of wind. The Northeast Trade Winds create periods of high wave energy on the east coast beaches of islands in the Caribbean during the months from December through March and from June to July when they are strongest. The west coasts of the islands are sheltered from the Trade Wind waves. During the fall and winter months, October to March, the Eastern Caribbean Islands often experience high waves (swells) due to very intense low pressure systems in the North Atlantic Ocean. These waves approach from a northerly direction and are therefore felt on north, west and east coasts. Their effects are most severe on the west coasts since these coasts experience only low wave energy for most of the year.

e. Beach Zones

The beach can be divided into three main zones depending on its exposure to seawater. These zones are the inshore or subtidal zone, the foreshore or intertidal zone and the backshore or supratidal zone. The inshore is continuously submerged by water even during low tides. Sediment motion in this zone is dominated by wave activity. The foreshore is the area that inundated by the tides. Part of the day is spent in open air due to low tide and the rest of the day is spent covered in ocean water due to high tide. Beginning at the edge of the foreshore where there is dry sand, even with a high tide, extends the backshore upwards to the back of sand dunes. This area is dry as it is constantly exposed to the air and wind.

Sand dunes are mounds of sand that often lie behind the active part of a beach. In the Caribbean, they range from very low formations 0.3–0.6 m (1–2 ft) high to large hills of sand up to 6 m (20 ft) high. Dunes form when sand is carried by the wind from the beach towards the land. When the wind encounters an obstacle, like a clump of vegetation, the wind slows down and the sand is deposited. Dunes may best be regarded as reservoirs of sand.

f. Ecological Role of Beaches

DID YOU KNOW?

Grande Anse beach in Saint Lucia is one of the most important nesting locations for the endangered leatherback sea turtle.

Each of the zones on the beach provides a habitat to a variety of animals and plants that have adapted themselves to survive well in this unstable environment. To the casual observer, beaches may simply appear largely devoid of life because most organisms living there are quite small (a centimetre long or less) and live buried in the sand. This diversity of organisms are supported by the tides, which brings with it nutrients and food. When it goes out, the tide takes with it waste products and disperses eggs and larvae. Some of the animals feed on materials that wash ashore. Others filter food from the water. Still others feed on tiny algae and bacteria among the sand grains.

Because of the shifting sands, organisms living in the foreshore on a beach have adapted to these changing conditions. Without the cover of water, many animals simply shut down during low tide. Some of the animals spend most of their life buried under the sand. Others burrow into the sand when the tide is low or when the crashing waves hit the shore.

Beaches also serve as important breeding grounds for animals which are not permanent residents of the system. For example, sea turtles and the Saint Lucian iguana nest on the beaches of Saint Lucia, however, in the case of the sea turtle it spends most of its life history in the open ocean and the iguana in vegetated areas on land.

SAMPLE TEACHING AND LEARNING STRATEGIES

The strategies proposed here include:

Activity 2.1a:
Mangrove Habitat

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

Activity 2.1b:
Secret Mission

In this activity students use a guide for mangrove species identification including information on the physical features of a mangrove forest to determine whether a wetland is a mangrove forest. They then present their finding to a Secret Society that will provide protection to the mangrove forest.

Activity 2.1c:
Beach zones and profile

In this activity students explore the beach. They design beach profiles, inspect marine life, and examine natural beach habitats.

THEME 2.2:

Under the Sea

The Ecology of Seagrass beds and Coral reefs

Objectives

- Understand what seagrass, corals and coral reefs are,
- Be able to identify the different species of seagrass found in Saint Lucia,
- Understand that there are different types of corals,
- Be able to describe the ecological role coral reefs and seagrass beds play in marine ecosystems.

Materials/ equipment

- Overhead Projector
- Flipchart paper
- Markers

Strategies

- **Activity 2.2a : Seagrass Community**
  In this activity students inspect seagrass species found in Saint Lucia, learn how to monitor seagrass beds and see how seagrass beds are important in food webs.

- **Activity 2.2b: Visiting a Fish Landing Site or Market**
  In this activity, students visit a local fish landing site or market to help demonstrate the fish diversity existing on coral reefs and learn socio-economic importance of this diversity.

Delivery Time

- Two (2) hours

Under the Sea

The Ecology of Seagrass beds and Coral reefs

BACKGROUND INFORMATION

SEAGRASS BEDS

a. *What and where are they?*

Seagrass they are the only flowering plants that can live underwater. They look like lawn grass with roots, leaves, and rhizomes (horizontal underground stems that form extensive networks below the surface). Like terrestrial plants, seagrasses have leaves, roots, conducting tissues, flowers and seeds, and manufacture their own food via photosynthesis. Unlike terrestrial plants; however, seagrasses do not possess the strong, supportive stems and trunks required to overcome the force of gravity on land. Rather, the natural buoyancy of water supports seagrass blades causing them to remain flexible when exposed to waves and currents.

Seagrasses are found in tropical (hot), temperate (cool) and near the edge of the arctic (freezing) regions (Figure 2.2a). They are mainly found in bays, estuaries and coastal waters from shallow regions down to depths of 50 – 60 metres. The depth range of seagrass is dependent on the availability of light for photosynthesis. They inhabit all types of substrates, from mud to rock but the most extensive seagrass beds occur on soft substrates like sand and mud. Several factors, such as temperature, salinity, water depth, turbidity and wave action can potentially limit the distribution of seagrasses and seagrass species.

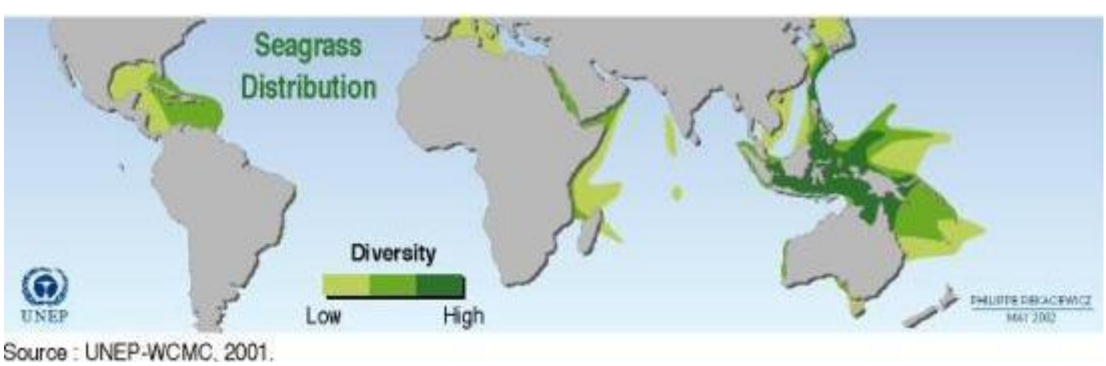


Figure 2.2a Global seagrass distribution and diversity

b. Seagrass Species

There are only about 60 species of seagrass around the world, and three of these are found in Saint Lucia. These are turtle grass (Thalassia testudinum), Manatee grass (Syringodium filiforme) and Shoal grass (Halodule beaudettei). Shoal grass tends to colonizes disturbed areas where conditions are too harsh for turtle and manatee seagrasses to occur.

Leaf shape, the pattern of veins on the leaves, and how the leaves attach to the rhizome usually identifies species of seagrass. Table 2.2a identifies the distinguishing features of these grasses.

DID YOU KNOW?

Turtle grass is the most common of seagrasses throughout the Caribbean. However, there is concern that an alien invasive species of seagrass - Halophila stipulacea, which came from the Indian Ocean, could out-compete our native seagrasses.

Table 1.2a Distinguishing Features of Seagrass Species

	Type of Seagrass		
Features	**Turtle**	**Manatee**	**Shoal**
Leaf colour and shape	Green; Flat broad, strap - shaped with rounded tips	Green; cylindrical, stem-like and thin with blunt tips	Green; Flat, narrow leaves, tip with two or three points.
Leaf attachment	Stems bear 3 to 7 leaves	Stems bear 2 to 3 leaves	Stems bear 1 to 4 leaves.

Due to their morphology and growth habit, seagrasses are also sometimes confused with marine macroalgae commonly called seaweed; however, closer examination reveals significant differences. The differences are outlined in Table 2.2b:

Table 2.2b Differences between Seagrass and Seaweed

Seagrass	Seaweed
Complex root structure to anchor plant in the sediment, and extract nutrients and minerals	Simple holdfast to anchor to hard substrate such as rocks or shells
Photosynthesis restricted to cells in leaves	Photosynthesis undertaken by all cells
Transport minerals and nutrients in specialized veins	Uptake of minerals and nutrients from water column via diffusion
Reproduction via flowers, fruits and seeds	Reproduction via spores

c. How do they grow and reproduce?

Seagrass can reproduce through sexual or asexual methods. In sexual reproduction, the plants produce flowers and transfer pollen from the male flower to the ovary of the female flower. Seagrasses can also grow by asexual (or vegetative) reproduction. Seagrasses grow vegetatively by extending and branching their rhizomes. This allows significant areas of seagrass beds to form from only a few shoots. In this way, seagrasses can recover after being 'cut' by animal grazers or disturbed by storms.

d. Ecological role of seagrasses

Seagrass beds provide habitats and nursery grounds for many marine animals. The complexity of seagrass habitat increases when several species of seagrasses grow together. Their importance for associated species is due to provision of shelter, food due to high productivity like mangrove forests, and nursery area to fish and invertebrates. The leaves of seagrasses conceal juvenile fish and smaller finfish, benthic invertebrates such as crustaceans, bivalves, echinoderms, and other groups. Fishes, particularly parrotfishes or tèt wim (Scaridae) and surgeonfishes or siwijen (Acanthuridae) and sea urchins or chadon (Echinoidea) are abundant, conspicuous, and in some areas commercially important consumers of algae and seagrasses in the Caribbean. Juvenile stages of many fish species spend their early days in the relative safety and protection of seagrasses.

DID YOU KNOW?

About 40 times more animals occur in seagrass beds than on bare sand.

Seagrass rhizomes provide shelter and protection to organisms living in the bottom substrate. The rhizomes intermingle to form dense networks of underground runners that deter predators from digging prey from the bottom substrate. Seagrass beds also help dampen the effects of strong currents, providing protection to fish and invertebrates, while also preventing the scouring of bottom areas.

Finally, seagrasses provide attachment sites to small macroalgae and epiphytic organisms such as sponges. These epiphytes use the seagrass as a platform for its growth. Epiphytes in some seagrass beds account for up to 30% of ecosystem productivity; they also contribute to food webs, either directly via organisms grazing on seagrasses, or indirectly following the deaths of epiphytes, which then enter the food web as a carbon source.

CORAL REEFS

a. What are they?

A coral reef is one of the most complex communities of plants and animals in the world. Coral reefs are limestone (calcium carbonate) formations mostly found in warm and tropical seas. However, there are deep-water corals, also known as cold-water corals, which extend to deeper, darker parts of the oceans than tropical corals where water temperatures may be as cold as 4°C. Millions of tiny animals called corals form coral reefs. The most important creatures on the reefs are the corals themselves. They form an outer limestone skeleton that protect their delicate body and when the coral dies these are left behind to form the foundation of coral reefs.

There are two types of coral - hard and soft. The soft corals do not produce the hard outer skeleton like hard corals. Instead, their skeleton comprise of tiny limestone spiny structures that do not fuse together allowing soft corals to be flexible. Both the soft and hard corals provide food and shelter for many marine organisms.

Corals are tiny polyps with a ring of tentacles surrounding a central mouth. The tentacles of the corals have tiny stinging cells called nematocyst that capture various animals and plants that float in the water. The tentacles move the captured prey towards the mouth. Some corals are composed of a single simple polyp while others are clearly colonies of many polyps. Yet other species are comprised of deformed polyps, which differ from the typical shape (e.g. brain corals).

Lining the central cavity of corals are single-celled plants called zooxanthallae. These plants photosynthesize and the coral polyp takes up their waste products to aid in the formation of their outer limestone skeleton. In turn, the coral provides the zooxanthallae with shelter, raw materials for photosynthesis, and ammonia for making proteins. Hence, the relationship is of mutual advantage. Because tropical corals can only form their skeletons with the help of zooxanthallae it means that, they cannot form skeletons in dark places.

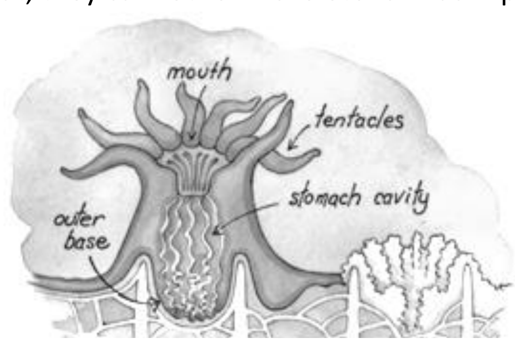


Figure 2.2b Illustration of the cross section of a typical coral polyp (AUSMEPA)

b. Growth and Reproduction

The process of coral growth is a relatively slow taking about one million years to create a reef. On particular days of the year, each coral polyp can produce either an egg or sperm and in some cases, the coral are hermaphroditic releasing packages that contain both egg and sperm into the surrounding water. The eggs and sperms float towards the surface where they fertilise. It is in the moment of fertilisation that results in the formation of larvae called planula. Some planulas free float 100 miles until they find a patch of seafloor to call home. There, they morph into their adult form: a polyp. As the polyp starts to feed it begins to create a colony of new polyps through the process of asexual reproduction called budding. The colony is therefore clones. Hundreds of generations of polyps each build tiny cup shaped homes by secreting their skeleton increasing the size of the colony. A layer of tissue that spreads over the skeleton connects the polyps in the colony to each other. After the polyps die, others land on top and form new skeletons. Slowly and gradually, a huge coral reef is built beneath.

DID YOU KNOW?

The branches of the staghorn coral Acropora cervicornis may grow centimetres each year. This is rapid compared with other corals such as the brain coral.

c. Coral Types

The polyps of different coral species form different structures. Many species can be identified by observing the overall structure. Other species require closer inspection of the individual polyps or other parts. The table below highlights some major groups of hard corals in the Caribbean.

Table 2.2c Description of the Major Groups of Coral in the Caribbean

Type	Groups	Description
HARD	*Brain*	There are several varieties of brain corals found throughout the world. The all get their name from the brain-like ridges that cross their surface.
	Star	Small, oval stubs rise from the yellowish-tan central core, each containing a delicate white star-shaped polyp
	Flower	Flower corals have solitary, encrusting or clumping growth forms and often have polyps on elongated stalks.
	Branching	Branching or pillar corals have colonies composed of branches or elongated projections. Example includes staghorn (Acropora cervicornis).
	Plate and fleshy	Plate corals include plate, leaf, and sheet coral and grow in a flattened plate, saucer-like or thin sheet fashion. They usually have thin disc-shaped colonies with polyps growing only on one side. Fleshy corals are distinguished by their large “fleshy” looking polyps.
SOFT	*Sea whips*	Colonies with few or no branches
	Sea plumes	Colonies with branches that are somewhat feather-like
	Sea fan	Colonies thickly branched, generally in single planes. Branching is somewhat flattened and stiff.

d. Type of Coral reefs

There are generally three recognised types of reef: fringing, barrier and patch reefs. Fringing reefs are the most common type of reef found in the Caribbean. They are found close to shore, building up on shallow parts of the underwater shelf. In Saint Lucia, fringing reefs are located mainly along the south east (Anse des Sables), central west (off the districts of Anse la Raye, Soufriere and Laborie), and north west coasts (Choc Bay). Patch reefs are isolated areas of reef surrounded by sandy plains or seagrass beds. Many of the reefs on the east coasts of St. Lucia are patch reefs. Barrier reefs are generally found many miles offshore, separated from land by a deep-water channel or a lagoon.

> **DID YOU KNOW?**
>
> *The Belize Barrier Reef is one of the largest barrier reefs in the world after the Great Barrier Reef in Australia and the New Caledonia Barrier reef in the South Pacific.*

e. Ecological Role of Coral reefs

Coral reefs play a critical role as habitat and nursery grounds for 10 to 20% of the world's fisheries. Their large, massive, branching, or encrusting carbonate skeletons provide habitat and food resources to support other reef organisms, such as finfish, lobsters and sea urchins.

> **DID YOU KNOW?**
>
> *Coral reefs occupy less than 1% of the ocean floor but are inhabited by more than 25% of all marine species*

Reefs maintain a network of intimate ecological relationships and delicate food webs. Juvenile reef associated fish are more likely to recruit to areas that have high coral cover and healthy coral communities. The change in habitat and structural complexity of coral reefs have shown to cause dramatic impacts on reef associated fish assemblages, particularly decline in specific species. Disruption of coral reef communities can break up vital ecological linkages.

SAMPLE TEACHING AND LEARNING STRATEGIES

The strategies proposed here are:

Activity 2.2a:
Seagrass Community

In this activity students inspect seagrass species found in Saint Lucia, learn how to monitor seagrass beds and see how seagrass beds are important in food webs.

Activity 2.2b:
Visiting a Fish Landing Site or Market

In this activity, students visit a local fish landing site or market to help demonstrate the fish diversity existing on coral reefs and learn socio-economic importance of this diversity.

THEME 2.3:

The Circle of Life

Connections between Marine Ecosystems

Objectives

- Be able to explain the links between key marine habitats.
- Be more sensitive of the need to protect coastal marine ecosystems.
- Know that there are functions that link different types of habitats.

Materials/ equipment

- Overhead Projector
- Flipchart paper
- Markers

Strategies

- **Activity 2.3: Where are the richest places?**
  This activity demonstrates the links between coastal marine ecosystems and highlights the need to protect marine ecosystems.

Delivery Time

- One (1) hour

The Circle of Life

Connections between Marine Ecosystems

BACKGROUND INFORMATION

LINKED HABITATS

Mangrove forests, beaches, seagrass beds and coral reefs are all linked. These ecosystems are also linked to the wider ocean, which provides a habitat to many organisms in the water column. The linkages provide benefits to the ecosystems in a variety of ways. The major ways these ecosystems are connected are discussed: these are the sediment relationship; water regulation; feeding, life stages, and food source. These are important factors to consider because linked habitats need to be managed as part of a single functional unit. An integrated approach to coastal management can address these complex ecological linkages between distant habitats. This integrated approach is discussed in Module 4.

a. Sediment Relationship

Soil from land enters the coastal waters and cause damage to the marine environment depending on the exposure and duration of high sediment loads. Sediment loads are reduced in coastal waters due to the network of mangrove roots that hold back the sediment and reduce the amount entering the water. The roots and rhizomes of seagrasses also trap and stabilise sediment. Sediment stabilisation is important because it reduces the turbidity of the water allowing seagrass and coral to obtain sunlight for photosynthesis and it reduces the amount of silt in the water that can cause abrasion or burial of the reefs during storm conditions.

Large amounts of skeletal material are constantly produced in the front of reefs due to wave action. These materials are broken up by abrasion and ground into smaller fragments. Biological activity by fishes and urchins also play a role in the breakdown of these calcium carbonate materials to lead to the formation of gravel, sand and silt. Some of these sediments are deposited onto beaches by ocean currents or accumulate on the seafloor where eventually may be colonised by seagrass and mangroves. Alteration of the natural cycle of accumulation and erosion of sand along the shore can cause increased turbidity of inshore waters or smother living reefs with excessive sediment.

b. Water regulation

Lower energy environments are favourable to seagrass and mangrove colonisation. As such, seagrasses and mangroves are dependent on coral reefs, which dissipate wave energy and create low energy (calm) environments. Seagrass and mangroves are enhanced in structure where these barriers are present. Fringing and basin mangroves forests regulate freshwater flow from land into coastal seawater thereby maintaining the optimal salinity for growth and productivity of coral reefs and seagrass beds.

c. Feeding and life stages

Many animals move either for short-term feeding or during their life stages, between the marine habitats that shelters the adult. Most fish will alter their activity and patterns of movement following the day –night cycle. Nocturnal fish families such as snappers, grunts, and squirrelfishes shelter in or near reefs by day and migrate to adjacent seagrass beds at night to feed. Diurnal reef associated fish families such as surgeonfishes, damselfishes, butterfly fishes, and wrasses migrate from daytime foraging sites to nighttime shelter in crevices and cavities of rocks and coral reefs, seagrass and sediment. Table 2.3a highlights a few fish species that display regular diel movement between tropical marine habitats for feeding.

Table 2.3a Fish species that display regular diel movements between tropical marine ecosystems for feeding. Underlined habitats indicate the time of day feeding occurs. (Adapted from: Nagelkerken, 2009)

			Residence at	
Fish family	**English Common Name**	**Creole name *(varies depending on community)***	**Day**	**Night**
Shark	Bull shark	Wétjen bwa	Offshore/ Open ocean	Reef
Grunt	Tomtate	Chaponn	Patch Reef, Mangrove, soft Corals	Seagrass, Sand
	French grunt	Si; Si jon		
Snappers	Schoolmaster snapper	Sadenchyen; Pag	Reef, Mangrove	Seagrass, Sand, Rubble
	Gray snapper	Ti pag		
	Lane snapper	Waliwakou; Sad mol		
Squirrel fishes	Long jaw squirrel fish	Mawiyan	Reef	Seagrass, Sand, Rubble rock
Drumfish	Highhat drumfish	Kaptèn; Labè	Reef	Sand
Jacks	Crevalle jack	Kamad; Kwang go tèt	Seagrass, Reef, Mangrove	Seagrass, Reef, Mangrove
Barracuda	Great Barracuda	Bétjin	Seagrass, Reef	Seagrass, Reef

In addition to moving between marine habitats for feeding, organisms may also use other marine habits for their juvenile life stages. Some reef organisms such as snappers, parrotfishes and the spiny lobster use mangroves and seagrasses as nursery grounds. The attractiveness of mangrove areas by juvenile-fish nurseries may be attributed to less predation. The turbid mangrove waters reduce the ability of large fish predators to see prey, also the shallow waters near a mangrove exclude large fishes, which prey on juvenile fish. Additionally, the structure of seagrass and mangroves enables small fishes to hide from predators.

For some species of fish, high abundance may not necessarily be derived only from the protection of juveniles from one habitat. Evidence exists, for example, that fish abundance and species richness are higher when mangroves and seagrass beds occur together rather than in isolation.

d. Food Source

Food and nutrients are essential to organisms of all ecosystems because it supports food chains and webs. Nutrients are transported between marine habitats via water currents and movement of organisms. Mangrove forests and seagrass beds tend to "leak" or export nutrients into the marine environment providing an important food source for secondary consumers and thereby supporting adjacent fisheries. Coral reefs also produce nutrients to a lesser extent.

Organisms transport nutrients between systems. The open ocean, which is an important marine habitat, inputs a major food source for inshore marine habitats - plankton. Planktivorous fish such as sardines and herrings use areas such as fringing reefs for diurnal shelter and undergo nocturnal migrations to feed on oceanic plankton. Some organisms inhabiting mangrove roots and seagrass beds such as molluscs also produce planktonic larvae. The larvae are carried by the water currents to other systems and serve as a potential food source. Reef fish contribute nitrogen into the food chain of marine habitats via their faeces. Nocturnal fishes that feed on one marine habitat takes shelter on other adjacent habitats and deposit nutrients in the form of faeces to the food web.

Sample Teaching and Learning Strategies

The strategy proposed here includes:

Activity 2.3:
Where are the richest places?

This activity demonstrates the links between coastal marine ecosystems and highlights the need to protect marine ecosystems on coral reefs and learn socio-economic importance of this diversity.

MODULE 3: Benefits of and Threats to Marine Ecosystems

INTRODUCTION

This module introduces the uses of the coastal and marine environment, and the threats posed to their use and sustainability. These are explored in the context of national development planning and general environmental management.

OVERALL OBJECTIVES

1. To identify the benefits provided by the coastal and marine environment, and the threats that pose overuse and destruction.
2. To identify the efforts of resource management agencies in Saint Lucia to reduce the threats to the coastal environment.
3. To identify some of the basic reasons why the threats to the coastal environment are difficult to control.

THEMES

The module is divided into the following themes:

Theme 3.1:	*Value Added* Ecosystem and Socio-economic Services
Theme 3.2:	*A Scary Situation* Natural and Anthropogenic Threats
Theme 3.3:	*National Interventions* Minimizing the Threats, Maximizing the Services

DELIVERY TIME

Expected time to deliver the module – Six (6) hours

THEME 3.1

Value Added

Ecosystem and Socio-economic Services

Objectives

- To explore the value of the many services and products that the marine environment provides.
- To discuss and understand the contribution of these resources to human well-being.

Materials/ equipment

- Overhead Projector
- Flipchart paper
- Markers
- Coloured paper cards

Strategies

- **Activity 3.1a: Marine Site Assessment**
  This activity enables students to observe in the field, the uses of the marine environment, and the provision of associated goods and services.
- **Activity 3.1b: Marine Product and Service Analysis**
  This activity allows students to appreciate the benefits of the marine environment to human well-being.

Delivery Time

- One (1) hour

Value Added

Ecosystem and Socio-economic Services

Background

The coastal zone contains some of the world's most biologically productive habitat and as such, is used extensively and increasingly for a large number of activities. As a small island state, Saint Lucia's economy has historically depended heavily on its coastal resources, especially for human settlements, trade, communications, fisheries, recreation, and more recently for tourism and commerce. Given the topography of the island, with its rugged, mountainous interior, most of Saint Lucia's population lives in close proximity to the coastline and continues to depend intimately on the coast and the resources it provides, for survival and well-being.

DID YOU KNOW?

More than one third of the world's population lives in coastal areas. Between 1990 and 2000, the estimated population living within 10km of the Caribbean coast grew from 36 million to 41 million.

BOX 3.1a – Uses of the Coastal Zone

"*Maritime commerce, oil and gas production, aquaculture, pharmaceutical and industrial biotechnology, tourism and recreation are but a few of the manifold human uses of the coastal zone whose values are not easily quantified. Add to these the myriad of free ecological services – storm surge protection, water filtration, waste discharge and dispersal, and industrial and power plant cooling, to name but a few – as well as the socioeconomic benefits, and one can see that the ecological importance of the coastal zone is virtually unparalleled*".

United States Agency for International Development (USAID)

The benefits derived from the marine environment are numerous and widely recognised. Different users place different values on these resources and the services they provide, resulting in multiple uses of the coastal area which are not always compatible with each other. This often leads to conflicts among resource users, degradation of the natural resource base, and other problems with effective management and sustainability of the marine environment.

In order to understand and reduce the threats to the marine environment, it is first necessary to develop an appreciation of the contribution of marine resources to human well being.

USES OF THE MARINE ENVIRONMENT

Humans use the goods and services provided by the natural environment at the levels of both single resources, and of larger-scale ecosystem functions or services. These goods and services can be grouped into various categories:

1. **Provision of goods** for direct consumption and for use as raw materials
    a. Primary consumption - air, water, food, drinks, etc.
    b. Raw materials - jewellery, timber, ores, construction materials, fuel, medicine, etc.

2. **Provision of services** - Transportation, recreation, education, waste treatment and disposal.
    a. Cultural – recreational, spiritual, aesthetic
    b. Economic – tourism, transportation, trade

3. **Maintenance of life-support systems** - Pest control, disaster reduction, production of oxygen, maintenance of atmospheric balance, nutrient cycling, etc.

BOX 3.1b – Resources of Significant Value

*"Coastal ecosystems are valuable in terms of the goods and services they provide (**direct use values**); the ecological functions which indirectly support economic activity (**indirect use values**); and the options for direct or indirect use of these ecosystems in the future (**option use values**). Coastal ecosystems also have **non-use values**; for example, individuals derive satisfaction from the aesthetic value of ecosystems and the knowledge that they will continue to exist for future generations (existence and **bequest values**)".*

Philippines Environment Monitor 2005

The marine environment, covering 71% of the earth's surface, provides a great abundance and diversity of raw materials and ecosystem services, which facilitate many different uses. Goods and services from coastal and marine resources can include seafood products, medicinal treatments and products, raw materials such as seaweed, minerals, oil and gas, live specimens for aquariums, transportation, aesthetics and recreation.

- **Fisheries**

The harvesting of fisheries resources is an important use of the marine environment. Saint Lucia has a rich biological diversity of marine and coastal resources, like coral reefs, which are important contributors to the fisheries sector. Many of the island's coastal communities are heavily dependent on near shore fisheries, as fisheries provides livelihoods for fishermen and their families, and others involved in the fishing industry (boat builders, fish pot makers, packers, distributors, retailers, etc).

DID YOU KNOW?

More than 3.5 billion people depend on the ocean for their primary source of food. Coral reef fisheries in the Caribbean region provide net annual revenues valued at an estimated US$310 million.

While a substantial amount of processed fish products (canned, smoked, salted fish, shrimp, crab, lobster) are imported into the country, Saint Lucia has a vibrant fishery for conch, tuna, dolphinfish, snapper and potfish, to name a few. Figure 3.1a illustrates the annual volume of aquatic species caught in Saint Lucia over the past 50 years.

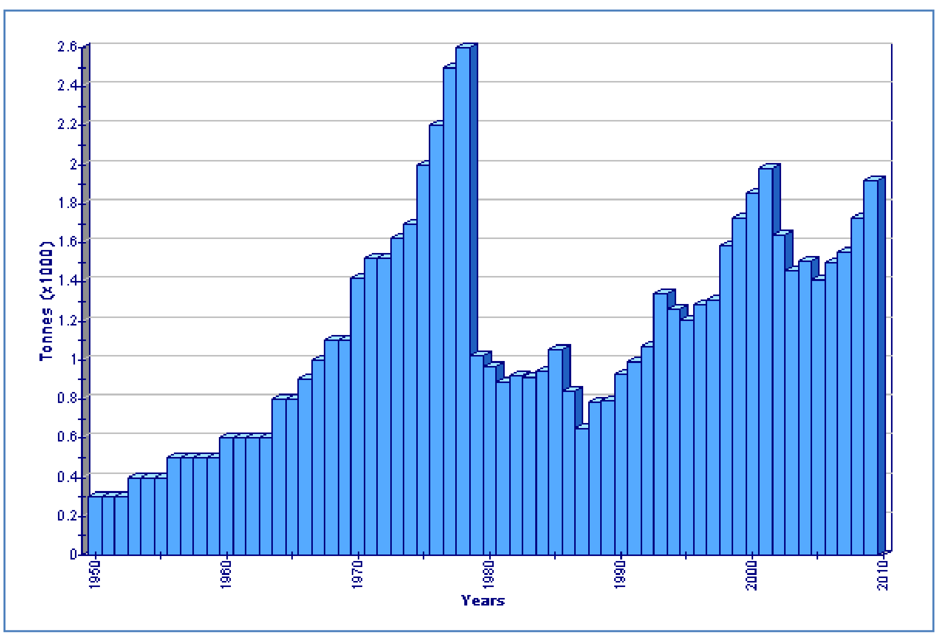


Figure 3.1a Saint Lucia Capture Production (FAO Fishery Statistic)

With an expanding local population, increased tourism and a shift towards healthy living, it is anticipated that the demand for fish and fish products will continue to rise over the coming years. This demand will only be met locally through expansion of the fishery and maintenance of the fish supply, both dependent on effective marine resources management.

As the fisheries become over-exploited, mariculture continues to be explored as a means of maintaining marine fisheries production levels. Additionally, there has been a significant increase in the collection (from natural stocks) and cultivation of seaweeds. In the Caribbean, seamoss cultivation is being pursued primarily as a means of maintaining the incomes of fisherfolk.

- **Medicine**

Though medicines from plants and animals have historically been derived primarily from land sources, the sea continues to be explored as a rich source of materials for use in medicinal research, because of the diversity of organisms in terms of form, function and biochemical makeup. Marine scientists are scouring the ocean for microorganisms and plants that naturally produce chemical compounds used for biological defence and health enhancement. These compounds are then analysed for potential human use and application in producing antibiotics, painkillers and other drug treatments. With the advances in diving technology and biological research, compounds from marine sources are now being tested as treatments for chronic pain, asthma and various malignancies, including breast cancer.

Over the past 30 years, scientists have extracted at least 20,000 new biochemical substances from marine creatures. With literally billions of undersea life forms and habitats still untapped, scientists are finding that the oceans could become the key to deriving 21st century medicines.

- **Raw Materials**

In addition to the foods (that are directly consumed) and medicines, the marine environment provides a number of products that are used as raw materials for a variety of purposes. These include seaweed for use in food and medical applications, animal feed and fertilizer, coral for jewellery making, sand for construction, and other materials for construction, such as wood from mangrove forests.

- **Services from the Sea**

In spite of the provision of a wide range of goods for consumption and as raw materials, the most significant contribution of the marine environment is in the form of ecosystem services.

These are the benefits that are obtained from the marine ecosystems and the resources they provide.

Such services include:

- **Tourism and Recreation**

Tourism is considered the mainstay of the region's economy, accounting for a large amount of the Caribbean's wealth and workforce. The island population of the Caribbean is more dependent on income from tourism than that of any other part of the world. For these countries, tourism is a main contributor to Gross Domestic Product (GDP) and a lead export and foreign exchange earner.

DID YOU KNOW?

Tourism contributes an estimated US$105 billion annually to the Caribbean economy.

The amenity value of the ocean forms the basis for the tourism industry in the Caribbean, as the product is still based on the "sand, sea, and sun" model. Although this perception of the product is slowly changing, anecdotal information suggests that tourists still spend a significant portion of their time on the beaches.

The diverse marine and coastal assets have supported a growth in regional tourism, with substantial economic, environmental and social benefits including:

- Direct and indirect contributions to government revenues, through income taxes from tourism and tourism employment, and taxes and duties on goods and services provided to tourists
- Foreign exchange earnings, through tourism-related expenditure, and the export and import of related goods and services
- Employment and creation of business opportunities for groups and individuals (hotels, restaurants, taxis, tour operators and guides, farmers, local merchants and vendors, etc)
- Improved infrastructure (roads, electricity, transport networks, air and sea port facilities, water and sewage systems, and telephone networks) to facilitate tourism and improve the standard of living of the country
- Contribution to environmental conservation through revenue from park and protected area entrance fees, tours, user contributions, environmental taxes, equipment rental, etc.

- Fostering of a sense of national pride, which translates into low crime levels, effective solid waste disposal and management, reputation as a destination for events, etc.

- **Waste Disposal**

DID YOU KNOW?

Dredging accounts for about 80-90% of all material dumped at sea and amounts to hundreds of millions of tons a year.

As land became limiting for the disposal of hazardous wastes and sewage effluent, attention turned to the ocean. As a result, the seas have over the years been used as a sink to dispose of wastes resulting from human activity. This includes sludge from dredging of ports and rivers, hazardous and toxic industrial waste, and sewage effluent. Common solid waste matter (plastic materials, household refuse, old appliances and vehicles) are also disposed of at sea, as the ability of the oceans to cope with waste has been taken for granted.

In more recent times, more attention is being given as a result of the environmental and health problems associated with unregulated disposal of waste at sea (diseases, eutrophication, fish kills, resource contamination, habitat degradation, etc), with international multilateral agreements and treaties being adopted to deal with this issue (e.g. MARPOL 73/78).

Other services provided by the marine and coastal environment include:

- Coastal protection - mangroves, seagrass beds, coral reefs
- Shipping and transportation
- Stabilisation of global climate (control of carbon dioxide concentration in the atmosphere by phytoplankton at the oceans' surface)
- Energy production – coastal wind farms
- Shoreline maintenance
- Storm surge and flood protection
- Nutrient cycling
- Maintenance of biodiversity; and
- Cultural, aesthetic and spiritual value.

Saint Lucia's coastal area is critical to its cultural, environmental, social and economic development, and it is therefore necessary to protect and conserve the natural resource base within the coastal zone, to ensure that the benefits being derived are maintained.

SAMPLE TEACHING AND LEARNING STRATEGIES

Activity 3.1a

Marine Site Assessment

This activity enables students to observe in the field, the uses of the marine environment, and the provision of associated goods and services.

Activity 3.1b

Marine Product and Service Analysis

This activity allows students to appreciate the benefits of the marine environment to human well-being.

THEME 3.2

A Scary Situation

Natural and Anthropogenic Threats

Objectives

- To provide an overview of the threats (both human-induced and natural) to the marine environment
- To know the impact of overexploitation and misuse of marine resources and their environment

Materials/ equipment

- Overhead Projector
- Flipchart paper
- Markers

Strategies

- **Activity 3.2a: Visit to Degraded Marine Site**
  This activity enables students to observe in the field, the impact of natural and anthropogenic threats on marine resources, and to relate these to impacts on associated goods and services.
- **Activity 3.2b: Alien Invasion**
  This activity allows students to be able to define, compare and contrast invasive species, alien species and native species, and to learn how invasive species are introduced and controlled.

Delivery Time

- One (1) hour

A Scary Situation

Natural and Anthropogenic Threats

Background

There are multiple threats to coastal ecosystems globally and, in turn, the ecological goods and services they offer. According to Duffy (2006), "*Unsustainable use of marine resources poses serious threats to the food security of many coastal nations, particularly in the developing world. Destruction and degradation of coastal habitats such as coral reefs, seagrass beds, and mangroves, increases risks to coastal communities from natural and human-induced hazards such as hurricanes. Coastal pollution and habitat degradation also endanger economies of coastal areas that depend on tourism*."

While some of these impacts result from natural sources (like tropical storms and hurricanes), many of these threats come under pressure from humans, as we increasingly seek to benefit from the goods and services offered by the marine environment. The inadequate use of marine resources (through excessive extraction, inappropriate coastal development, land-based sources of pollution and maritime activities), has led to such issues as the degradation, loss and fragmentation of habitats, the overexploitation of biological resources, and the invasion of alien species and the displacement of natural residents, which themselves all place added stress on the marine environment.

The major sources of threat to the marine environment in the Caribbean region may include:

- Natural events, like climate change
- Over-exploitation of resources
- Coastal development
- Pollution derived from land-based sources
- Habitat destruction and alteration
- Maritime activities; and
- Invasive species.

NATURAL EVENTS AS A SOURCE OF THREAT

Climate Change

Climate change is now regarded as a real and serious threat to marine ecosystems. Levels of greenhouse gases (like carbon dioxide and methane) are rising unnaturally in the atmosphere because of emissions from burning fossil fuels. This increased air pollution is having a significant impact on global climates by raising average temperatures and by increasing the severity of events such as droughts and storms.

DID YOU KNOW?

The main environmental components of the coastal zone under threat from climate change impacts are beaches, coral reefs, mangals and the diverse species which occupy these coastal habitats.

While already impacting upon the marine environment, other changes, including increased ocean acidity, increasing sea levels, warming sea-surface temperatures (leading to shifts in circulation patterns), and altered rainfall patterns are expected, having significant consequences for the small island developing states like those of the Caribbean region.

Global warming is one phenomenon that is projected to increase precipitation in some areas, increase the frequency and intensity of some natural events, and may eventually change the weather patterns over large areas of the planet.

DID YOU KNOW?

The marine environment is already registering the impacts of climate change. The current increase in global temperature of 0.7°C since pre-industrial times is disrupting life in the oceans, from the tropics to the poles.

The destruction of the (stratospheric) ozone layer may create a much larger problem. As the ozone layer is depleted, increased ultraviolet radiation at the sea surface has major implications for marine life. Climate change has already altered the temperature and salinity of nursery habitats and is expected to cause more dramatic changes in the future.

Caribbean countries are particularly vulnerable to sea level rise, given the concentration of infrastructure, urban areas, livelihoods, and commercial activities in coastal areas. "*Global sea levels may rise by as much as 69cm during the next 100 years due to melting of glaciers and polar ice, and thermal expansion of warmer water. Rising water levels will have serious impacts on marine ecosystems. The amount of light reaching offshore plants and algae dependent on photosynthesis could be reduced, while coastal habitats are already being flooded. Rapid sea* *level rise will likely be the greatest climate change challenge to* mangrove *ecosystems, which require stable sea levels for long-term survival.*" (Retrieved from www.worldwildlife.org)

One of the most visually dramatic effects of climate change is coral bleaching. Coral bleaching in Caribbean countries, in response to increased seawater temperatures, became apparent in 1987, and has occurred several years since. Though the majority of coral colonies recover, some do not, with coral mortality reaching 70% in some regions of the world. This widespread phenomenon is expected to continue, creating additional stresses for shallow-water coral reefs, already seen as the marine resource most at risk from natural events.

Sources of threat to the coral reef ecosystem include:

- High temperature (coral bleaching)
- Flood events (transport large volumes of fresh water and sediments from land to the marine environment)
- Storms (structural damage)
- Sea level rise and
- Disease (may also be induced by some human activities, such as pollution).

DID YOU KNOW?

Multiple human activities – including poorly planned or sited coastal development, destructive fishing, overharvesting, and the runoff of sediments and nutrients – have caused the loss of over 25% of the world's coral reefs, and severely threaten close to 60% of the remaining reefs.

USAID

Some events, such as hurricanes and storms, also cause damage to other coastal and marine resources, including beaches, seagrass beds, and mangrove stands. Additionally, the impact of one event can increase the vulnerability of the resource to a different threat, or even act as the trigger for the other. For example, the damage caused to corals by disease (White Band, Black Band, Yellow Band, and White Plague diseases) may increase the susceptibility of the coral reefs to hurricane damage, as well as contributing to post-hurricane mortality.

Additionally, further saline intrusion into valuable coastal resources (aquifers, wetlands, agricultural lands, etc.) would have a profound impact on the development opportunities and quality of life for significant proportions of the peoples of the Caribbean.

OVER-EXPLOITATION AS A SOURCE OF THREAT

The overexploitation of marine resources (including sand for construction and coral for ornaments and jewellery) has been well documented, with overfishing for food severely impacting almost all fisheries in the world. **Overfishing** occurs when fish or other marine animals are harvested faster than they can reproduce, resulting in reduced fish stocks, and loss of jobs and income for fishers.

> **DID YOU KNOW?**
>
> *Overfishing is the most persistent danger to reefs, threatening over 60% of them.*

Overexploitation has several effects among which are shifts in the ecosystem balance, decline in reef population, reduction of average fish size in most commercial stocks, and shifting to less economically valuable fishes. In some areas, overfishing has also resulted in the local extinction of valued species.

In the Caribbean region, snapper and grouper fishing has significantly dropped and in many islands, they are "commercially extinct" and have been replaced in the catches by species with less economic value and lower trophic level such as grunts (Haemulidae), parrotfishes (Scaridae) and other species.

In some islands, such as the Lesser Antilles, with narrow shelves and centuries of intense exploitation, changes in fish fauna composition are so severe that fishermen and experts fail to recognize the existence of overfishing due to the lack of anecdotic records on past snapper and grouper abundance. This phenomenon, known as **shifting baselines**, occurs all over the world and has led to inadequate assessment of fisheries resources.

While complete fisheries statistics are lacking in most Caribbean countries, anecdotal information provided by patriarch fishers (who have seen their livelihood reduced over the last decades), alongside a wealth of research data on the Caribbean fish populations have demonstrated that overfishing is chronic in many areas, causing a dramatic decline in coastal resources in continental and insular shelves in the Caribbean.

> **DID YOU KNOW?**
>
> *Consumption of fish in the Caribbean is higher than local production and has to be satisfied by high levels of imports. Total imports of fish are valued at US$410 million annually in the Caribbean.*

Related factors that exacerbated the problem include:

- Significantly high levels of by-catch, which was subsequently dumped
- Destruction of habitats during the harvesting process (trawling for shrimp, dynamiting and chemicals for reef fish, etc.)
- Management of fisheries on a single-species basis
- Inadequate enforcement capability
- Inadequate protection of critical breeding and nursery sites

In addition to overfishing which disrupts the ecological food chain, **destructive fishing** methods (bottom trawling, dynamite fishing, and poison (cyanide) fishing) often destroy fish habitats, like coral reefs, and reduce fish stocks. Alteration of ecosystems from indiscriminate fishing also prevents quick recovery after mass coral bleaching and other widespread diseases.

DID YOU KNOW?

Destructive fishing practices are killing hundreds of thousands of marine species each year, and helping to destroy important undersea habitats.

The use of improved fishery-management techniques in recent years (less destructive fishing practices and gear, closed seasons, etc.) has apparently slowed the rate of exploitation, but recovery of stocks does not appear to be likely in the near future. Impacts of overfishing are widespread, going beyond the decline of a few economically valuable species to loss of livelihoods and income.

Overexploitation of resources is not limited to fisheries, sea urchins, turtles and other live resources of the coastal zone. Sand mining, whether legally permitted by the relevant local agency, or done illegally, leads to considerable destruction and degradation of coastal habitats. Harvesting of mangrove trees for construction or charcoal production is also an activity which may be allowed, once controlled and sustainable.

COASTAL DEVELOPMENT AS A SOURCE OF THREAT

"*The shoreline is in increasingly strong demand for human settlements, agriculture, trade, industry, amenity and marine transport activities such as shipping, fishing boats and recreational marinas*" (Clark (1994)).

Coastal development for tourism is particularly popular in many islands of the Caribbean region, as they attempt to capitalise on sought-after environmental features (sandy beaches, coral reefs, calm seas) for economic benefit. Beaches are the focal point for coastal recreation and tourism, and a major source of revenue for many countries, like Saint Lucia, with adjacent lands being the site of choice for hotel and resort development. At present, a number of hotels occupy beachfront property in Saint Lucia, with even more approved for development in the coming years.

While tourism has the potential to contribute substantial socio-economic benefits to Small Island Developing States (SIDS) like those of the Eastern Caribbean, its fast and uncontrolled growth often results in degradation of the marine environment, alongside loss of traditional cultures and loss of identity.

In addition to coastal development for tourism, an increasing part of the global population inhabits coastal regions, with major cities traditionally being built near the shoreline.

Figure 3.3b - Caribbean Reefs threatened by Coastal Development (Source: www.wri.org)

Coastal development is considered to rank among the most significant human threats to the marine environment, with impacts including:

- destruction or loss of critical habitats, like coral reefs and wetlands
- suspension of sediments in sensitive marine ecosystems
- disruption of ecosystem functioning
- reduced productivity and loss of organisms, including important (endemic and endangered) species
- alteration of ocean current patterns
- alteration of sand budget/movement resulting in erosion, and
- species disturbance from water-based activities (diving, snorkelling, boating, etc)

While people have lived in coastal areas for thousands of years, the enormous cities and megacities that have grown over the past 100 years have, unsurprisingly, quickly destroyed natural marine and coastal habitats. Despite efforts by the Government of Saint Lucia to curtail negative impacts of coastal development on the marine environment, the lack of established Environmental Impact Assessment (EIA) regulations may make it difficult to monitor and regulate environmental impacts during and after construction of coastal developments (Walker, 2007).

LAND-BASED SOURCES OF POLLUTION AS A SOURCE OF THREAT

It is generally agreed that within the Wider Caribbean Region, land-based sources of pollution form the most significant threat to the marine environment. The situation is no different for Saint Lucia, with land-based sources of marine pollution being identified as one of the biggest threats to the integrity of Saint Lucia's coastal zone.

DID YOU KNOW?

Land-based sources of pollution are estimated to account for 80 to 85% of marine pollution in the Wider Caribbean Region.

The main sources are categorized as **point sources** (which stem from one single source and can be traced back to a contamination event, e.g. oil spill) and **non-point (diffuse) sources** (which result from many sources over extended periods of time). Examples of point and non-point sources of pollution include:

- Point sources (industrial, sewage, and solid waste)
- Urban non-point runoff (stormwater runoff and combined overflow discharges)

- Non-urban non-point runoff (cropland, pastureland, and forestland runoff)
- Upstream sources (pollutants carried into the coastal zone as part of a river's streamflow)
- Irrigation return flows (irrigation water return to lake, stream, or canal)

Though the pollution inputs from land-based sources have not been fully quantified, the impacts on the near shore and marine environment are well known, encompassing degradation and destruction of the near shore habitats, reduction in bathing water quality (sometimes resulting in the temporary or permanent closure of bathing beaches), and generally creating public health hazards (United Nations Environment Programme (UNEP), 1987).

Programmes to deal with point sources of pollution concentrate primarily on pollution reduction through the development of effluent limitations (including permit and licence systems). This is particularly common when dealing with industrial pollution.

Even more problematic than the point sources of pollution are the non-point sources (Table 3.2a and Figure 3.2a). Mounting volumes of solid waste overwhelm the collection and disposal systems, and landfills and dumps produce leachate that contaminates the coastal ground water and the marine environment. The urban inputs through the drainage system are also significant, and difficult to address. Further, activities taking place in the watersheds produce negative impacts on the marine environment, as generated inputs are transported to the marine environment via large river systems.

Table 3.2a: Non-Point Sources of Pollution

Medium Impacted	Sources	Factors	Impacts
Soil	1. Industry 2. Agriculture 3. Atmospheric fallout	1. Toxic compounds 2. Pesticides 3. "Acid" rain	1. Decreased productivity 2. Health problems
Water (ground/ surface/ marine)	1. Sewage disposal 2. Agricultural run-off 3. Atmospheric fallout 4. Urban surface run-off 5. Commercial and residential	1. Sediments 2. Sewage effluent 3. Oils/hydrocarbons 4. Pesticides 5. Fertilisers 6. Marine debris 7. Solid waste 8. Toxic compounds 9. Wastewater	1. Health problems 2. Contamination of water supply systems 3. Decreased amenity value 4. Ecological disruptions 5. Decreased fisheries

	activities 6. Shipping and other marine activities	10. "Acid" rain	production
Air	1. Agriculture 2. Commercial activities 3. Residential activities 4. Waste disposal 5. Industry 6. Motor vehicle exhaust 7. Recreational activities 8. Construction activities	1. Noise 2. Particulates 3. Gases (oxides of sulphur, carbon, nitrogen, etc)	1. Property damage 2. Health problems 3. Crop damage
Source: Gardner, 1999			

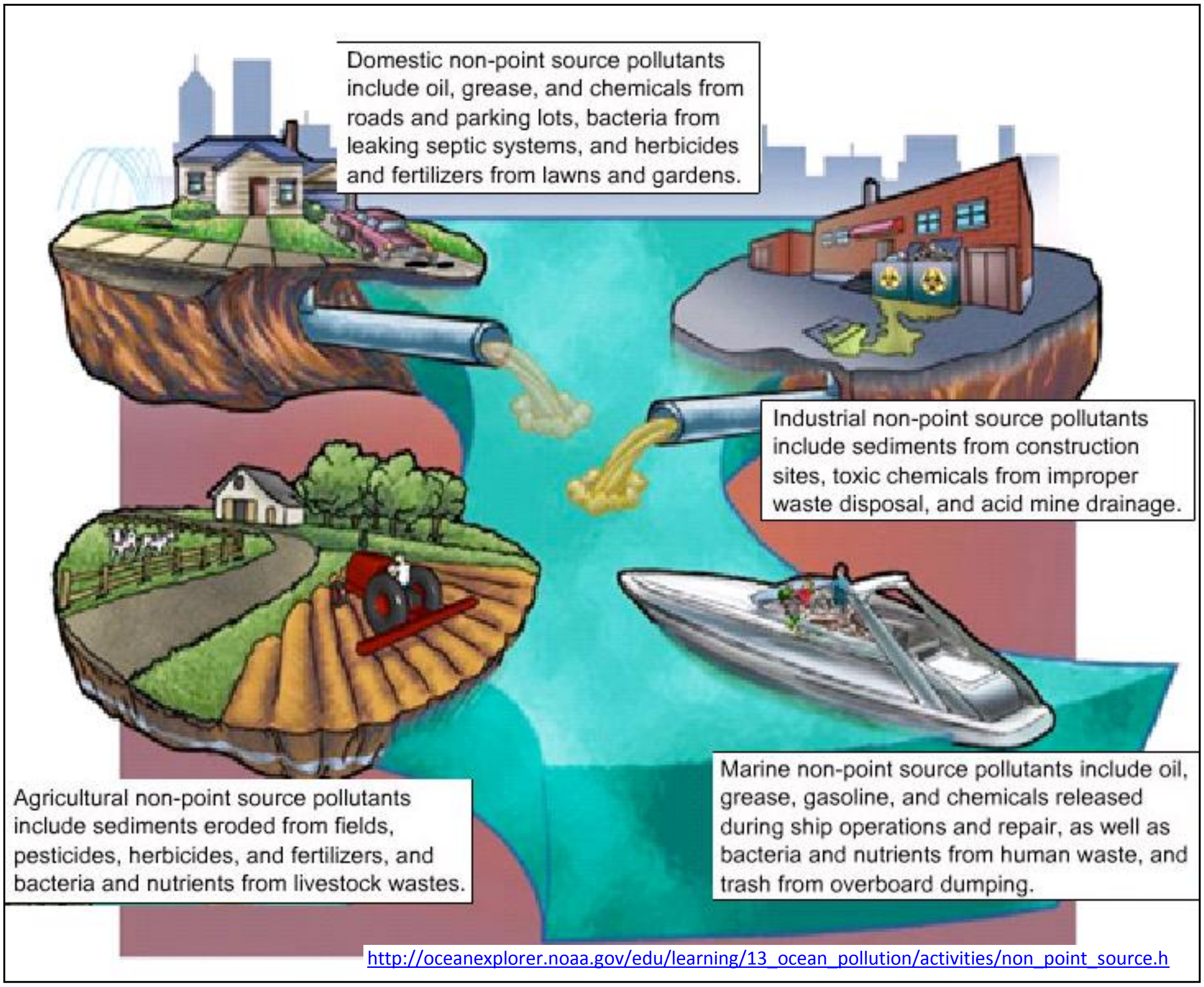


Figure 3.2a Non-point sources of marine pollution

While limited, data on coastal water quality in both densely populated areas and small coastal communities in Saint Lucia reveal signs of pollution. Pollution from non-point sources, in the form of untreated or partially treated sewage, sediments, agrochemicals and industrial by-products, are contributing to the deterioration of riverine and coastal water quality.

Sedimentation from inappropriate dumping, poor agricultural and coastal development practices, or other poorly managed land-based activities, can smother habitats, decrease water clarity and reduce photosynthesis by blocking off contact with light. Excess nutrients resulting from sewage or fertilizers and pesticides, result in excess algal growth, changes to aquatic community structure and fish kills. Inappropriate solid waste disposal results in the accumulation of plastic bottles and other wastes in many of the island's harbours and bays during periods of heavy rains. Further, solid waste generated from the expanding cruise tourism industry has increased in the last few years and it is necessary that port reception facilities are established to collect and dispose of such waste. To date, Saint Lucia lacks formal recycling plants for plastics or other such materials.

Notably, the continued pollution of these coastal waters has negative implications for near shore fishery resources, river systems, the water based tourism sector, and ultimately human health.

HABITAT DESTRUCTION AND ALTERATION

Habitat is lost in the marine environment when coastal development and marine use are inappropriate, destructive or unsustainable. Habitat destruction has been described in earlier sections as a major impact of other threats to the marine environment, like coastal development, climate change and pollution. Conversion of wetlands, like mangrove forests, for coastal development and construction, inappropriate aquaculture and mariculture practices, destructive fishing methods, and waste disposal degrade the marine environment, rendering the resources useless in providing their many goods and services.

Other potential consequences of threats that can lead to habitat degradation include increasing visitor-use pressure, introduced species of flora and fauna, human settlements and unsustainable extractive practices.

MARITIME ACTIVITIES AS A SOURCE OF THREAT

Many countries with a large marine expanse rely on port development and coastal support facilities for operation of the shipping industry, oil and gas exploration, fisheries, military operations, coastal trade, tourism, and other commercial and industrial uses.

Shipping and maritime activities can contribute to the degradation of the marine environment through dry-docking operations, ballasting and tank washing, harbour operations, and oil spills from exploration, production, and shipping. Ports and harbours may also be situated close to, or in direct contact with important marine and coastal ecosystems. Heavy industrial operations in these areas (in the form of oil processing, vessel servicing and maintenance) can result in destruction of both the coastal environment and of the economic and social well-being of local communities dependent upon coastal resources. UNEP (1989)

DID YOU KNOW?

The Caribbean region, with about 50,000 ships visiting annually and 14.5 million tourists a year, has some of the most intensive maritime traffic in the world.

indicates that many beaches in the Caribbean have experienced tar concentrations in excess of 100 g/m of shore, making them unfit for recreational uses.

Cruise tourism, one of the beneficiaries of a pristine environment, also contributes to the problem, through the disposal of solid and sewage wastes. Ship-generated waste (oils from cargos and engines, hazardous chemicals, solid waste and sewage) must be handled and treated appropriately, though adequate disposal facilities are often non-existent.

INVASIVE SPECIES AS A SOURCE OF THREAT

The ecosystems of the Wider Caribbean Region (WCR) contain diverse and valuable flora and fauna which provide food security and support for such industries as fisheries, agriculture and tourism. These resources also have significant ecological, economic, aesthetic and amenity value, resulting in the labelling of the region as one of the five most important of the world's 25 biodiversity hotspots, supporting 7,779 endemic species in only 263,500km^2 . The biggest threat to Caribbean biodiversity is invasive species, with more than 25% of the region's endemic species either being threatened, or having gone totally extinct. (Retrieved from www.islandconservation.org)

Defined as species which have established or spread (or have the potential to do so) outside of their natural distribution range, and which then threaten ecosystems, habitats or other species, economies, and environments, **invasive species** have become one of the greatest threats to biodiversity on a global scale.

In the past, aquatic species have dispersed freely throughout the world's oceans by natural means such as ocean currents, climatic conditions, by attaching to floating logs, and so on, with the only barriers to their spread being natural and environmental factors like temperature, salinity, land masses and natural predators. Today, human activities enable species to cross these barriers, establish new populations outside their native range and potentially threaten native species, humans and national economies in their new habitats.

Invasive or introduced marine species may enter the marine environment in different ways, including personal travel, aquarium imports, ballast water discharged by commercial shipping, inside internal seawater pipes on commercial and recreational vessels, through marine debris and oceanic currents.

DID YOU KNOW?

Invasive species are brought in from other countries via the four 'T's – trade, transport, travel and tourism.

www.cabi.org

While species may be introduced by humans to new locations for food, social or economic purposes (**intentional introduction**), many more species have been accidentally transported by human activities such as trade, transport and travel (**unintentional introduction**).

Whatever their means of introduction to a new environment, invasive species are increasingly seen as a major threat to indigenous biodiversity, through their impacts on habitats and ecosystems. The impacts may be economic, environmental or health-related, with invasive species potentially crowding out native species, altering habitats and imposing economic burdens on coastal communities, and on a country or region's overall development. The absence of clear borders in the marine environment limits management options, and more research and capacity-building are needed before the management of marine invasive species can be successfully undertaken (CABI (2006), Wittenberg and Cock (2001)).

BOX 3.2a – Invasion of the Lionfish

The invasion of the Indo-Pacific lionfish in Saint Lucian waters has triggered a swift response from the country's Fisheries Department aimed at halting its spread in order to protect the local ecosystem. The fish is said to have invaded the Western Atlantic and Caribbean Sea, and is a voracious predator with the potential to reduce native fish populations hereby adversely affecting local fisheries and ecosystems.

A spokesperson from the Fisheries Department yesterday told The VOICE that the sighting of the lionfish on the Ciceron reef has been confirmed and although there has been no damage to the local marine environment since, and that the situation in Saint Lucian waters is not alarming, action has to be taken to stop the lionfish from becoming a threat to marine life. The Department of Fisheries has been urging members of the public, fishing and diving communities to assist in identifying and destroying this threat to the island's marine wildlife. The Department called for extreme caution to be exercised when encountering or handling the lionfish as they contain venomous spines.

"Should you or someone else become stung by a lionfish follow these guidelines till professional medical treatment is available. Please report all sightings and encounters with the lionfish using this form. Members of the public, fishing and diving communities are also encouraged to familiarize themselves with the Saint Lucia lionfish Response and Action Plan for more detailed information," a release from the Department noted.

To prevent lionfish from negatively impacting local fisheries, marine ecosystems, and endangering public safety the Fisheries Department has prepared a response and action plan, the objectives of which are to ensure a sustained reduction of the lionfish throughout Saint Lucia.

The Department hopes to attain this through education (outreach and training), opportunistic and targeted detection and removal of the fish, monitoring and data gathering and data analysis and reporting. Through outreach and education the Department is hoping to raise awareness of the potential impacts of the lionfish invasion by describing the biology and ecology of the lionfish, especially as it relates to its rapid spread and impact on local fisheries and marine ecosystems. The Department is hoping to educate the public, including school children, on human health issues related to the lionfish as well as the fact that lionfish can be eaten as long as it is cleaned properly and its spines removed. Further, the Department wants to increase awareness of the points of contact for reporting lionfish sightings, increase participation of fishers, divers, and snorkelers in reporting sightings of the fish and train fishers and divers in safe handling and cleaning of the lionfish.

To provide support for outreach and education, through the GEF-UNEP project, "Mitigating the Threat of Invasive Alien Species in the Insular Caribbean", a variety of materials are made available on the lionfish threat such as fact cards (available in print and on websites), posters (available in print and on websites), 30 seconds Public Service Announcements (aired on major television stations) and radio and television interviews. … (cont'd)

BOX 3.2a – Invasion of the Lionfish (cont'd)

…The Department noted that several government agencies and non-profit organizations have education programmes targeting school children and relevant stakeholders and are either currently including information about lionfish in their education programmes or are willing to include the information in their programmes. The Fisheries Department Response and Action Plan, the draft of which came out last month noted that once the invasive species become established in an ecosystem, they are virtually impossible to eliminate, which has been particularly true for marine invasive species, because of their rapid growth in population in the western Atlantic and the Caribbean Sea. The goal is to remove lionfish once sighted.

It is anticipated that the opportunistic and targeted removal of lionfish will suppress lionfish populations so that they do not negatively impact local fisheries and marine ecosystems and do not endanger the public. The Department warned that care must be taken when capturing lionfish because of their venomous spines, adding that once the lionfish is sighted or removed, the sight should be marked or the GPS location or general description of the area should be reported by calling or visiting one of the following:

The Department of Fisheries (telephone number: (758) 468- 4143 or (758) 468- 4140) or the Soufriere Marine Management Association (telephone number: (758) 459-5500) or the Saint Lucia Marine Police (telephone number: (758) 456- 3870).

The lionfish, a native of the Indian and Pacific Oceans, is a member of the scorpion fish family Scorpaenidae. Unlike scorpion fish, which are well camouflaged and generally found lying motionless on the bottom, lionfish are often brightly coloured and, during the day, will often be found tucked under ledges or coral heads with their long, flagged dorsal and pectoral fins out-stretched. Similar to the native scorpion fish, lionfish can often be closely approached by a diver.

Two closely related species of lionfish, Pterois volitans, known as the common, turkey, or red lionfish and, P. miles, the cleartail or devil lionfish are rapidly invading the waters of the Caribbean (Snyder & Burgess 2007, Schofield 2009). Some 50 different species of fish have been found in the stomachs of lionfish in the Bahamas, including sea basses, wrasses, cardinal fishes, gobies and juvenile groupers (Green & Cote, Morris & Akins in press). These small fishes are also the prey of many species of Caribbean snapper and grouper.

There is concern that the lionfish could out compete native fish, especially commercially and recreationally important species by drastically reducing the populations of the fish that they feed on and directly preying on the juveniles of these species. Lionfish have only a couple known predators in the Atlantic Ocean. Known predators to date are limited to two grouper species (Nassau and tiger) that have been found with lionfish in their stomachs in the Bahamas.

Micah G. George (printed in the Saint Lucia Voice newspaper)

http://www.thevoiceslu.com/let_and_op/2011/november/05_11_11/Invasion.htm

BOX 3.2b – Alien Invasions

Colourful tropical fish are fun to watch in an aquarium or a home fish tank. But what happens when exotic fish are released into the wild? Most often these fish survive and start taking over the environment. One such example is the Lionfish – an invasive alien species that may soon threaten our Saint Lucian waters, as it comes down to our seas in ocean currents.

The ***lionfish****, known scientifically as Pterois volitans, is hard to miss with its red and white stripes and long venomous spines. This fish is native to the tropical Indian and Pacific region from Japan to Australia. Officials and scientists believe that the lionfish was introduced into the Atlantic Ocean in 1992 after escaping from an aquarium in Florida in the wake of Hurricane Andrew. Since then the lionfish have made our Caribbean waters their home and confirmed sightings have been on the rise since 2004.*

The lionfish travelled to the Bahamas over ten years ago, but it was not until 2004 that reports of sighting were confirmed. The number of lionfish sighted has increased significantly as the populations spreads across the Caribbean region. Lionfish have been observed all over the Bahamian archipelago, including the Turks and Caicos Islands. These alien fish have found their way to as far south as Bonaire where the first confirmed report was on October 26, 2009. Since then, approximately 60 lionfish sightings have been reported in Bonaire. Also, increasing numbers of lionfish have been sighted in neighbouring Dominica, St. Kitts, Antigua and more recently, Martinique!

Lionfish are a threat to our already stressed marine ecosystem. They have a BIG appetite and feed on all fish found on our coral reefs. Lionfish are able to grow and reproduce faster than native species like our snapper or pot fish. There are few fish that can eat the lionfish; therefore their population keeps growing much faster than that of other fish. Because of this, they pose a serious threat to native fish, their habitat, coral reefs and overall ecosystem function. They feed on many of our important fish species. They eat young snapper, grunt and grouper species, leaving none behind to reproduce to support the fishery that is important for food here in Saint Lucia.

Lionfish are also harmful to humans with its venomous spines and pose a threat to sea bathers, divers and fishers. The lionfish spines release a venomous sting that is fatal to its prey and can be very painful and dangerous to humans. A lionfish sting is very unpleasant and can make a person quite sick. Its painful sting can cause a wide range of symptoms from bellyache and swelling, to chest pain and seizures. If you or someone you know is stung by a lionfish there are steps you can take to reduce the effects of the sting.

Once the lionfish invades the marine environment they are there to stay. There is no way to completely get rid of them from our waters. However, every Saint Lucian can play a part to control this invasion by staying informed and following proper guidelines. Together we can protect our fisheries from the harmful effects of the lionfish. Let us all do our part! And be prepared for the invasion.

One could say that it was only a matter of time till the invasive Pacific Lionfish was spotted in Saint Lucia's waters. It was spotted at the Honeymoon Reef by a visitor on a dive with Sandals Dive Centre at the end of October, and an official response on this serious matter has been made by the Department of Fisheries [See Box 3.2c].

Allena Joseph, Department of Fisheries

BOX 3.2c – Invasive Lionfish Confirmed in Saint Lucia's Waters

PRESS RELEASE

Friday Oct 21, 2011

The invasion of the Indo-Pacific Lionfish within the Northeastern Atlantic and Caribbean has been progressively affecting the region over past years. The lionfish has a voracious appetite for eating juvenile reef fishes and it reproduces rapidly in new areas once it settles in. Based on a sighting and photographic record submitted through one of the Sandals dive centers, the Department of Fisheries this week has now verified the presence of lionfish in the waters of Saint Lucia, as sighted on a reef off the Ciceron area. This early notification of the presence of the Lionfish comes out of the swift response of the local dive company, having been part of the Lionfish Task Force set up earlier this year to facilitate St Lucia's preparedness for the likely invasion of the Lionfish. The fish was confirmed in waters off Martinique earlier this year, having made its way steadily southwards following a gradual wave of invasion throughout the islands of the Greater and now the Lesser Antilles.

As a consequence of this sighting, the Department of Fisheries requests that all licensed dive operators and fishers now move to a higher level of surveillance in monitoring coastal waters for the lionfish. Any lionfish found should be carefully captured and, preferably frozen and brought to the Department of Fisheries where they can be examined and used in demonstrating and promoting the use of lionfish as a valuable food source. The Department has also called for a meeting of the National Lionfish Task Force to take place at its Castries office on Wednesday October 28th. At the meeting, the Task Force will seek to activate various components of the response plan. Persons are reminded that, although the Lionfish has venomous spines and must be handled very carefully using an appropriate protective barrier such as PVC gloves, it has been successfully used in many Caribbean countries and elsewhere in the world as a tasty and nutritious food fish. Developing a viable Lionfish fishery is often a key component of an effective national response.

DEPARTMENT OF FISHERIES
MINISTRY OF AGRICULTURE, LANDS, FORESTRY AND FISHERIES

SAMPLE TEACHING AND LEARNING STRATEGIES

Activity 3.2a

Visit to Degraded Marine Site

This activity enables students to observe in the field, the impact of natural and anthropogenic threats on marine resources, and to relate these to impacts on associated goods and services.

Activity 3.2b

Alien Invasion

This activity allows students to be able to define, compare and contrast invasive species, alien species and native species, and to learn how invasive species are introduced and controlled.

THEME 3.3

National Interventions

Minimizing the Threats, Maximizing the Services

Objectives

- To introduce measures taken nationally to minimize threats to the marine environment

Materials/ equipment

- Overhead Projector
- Flipchart paper
- Markers

Strategies

- **Activity 3.2a: Parts to Play**
  This activity will allow students to learn about the different pieces of legislation in place, and actors working to protect Saint Lucia's coastal resources

- **Activity 3.2b: It Wasn't Me! – Scenario Analysis**
  This activity allows students to apply knowledge of marine resources management legislation to different scenarios.

Delivery Time

- One (1) hour

National Interventions

Minimizing the Threats, Maximizing the Services

Background

Management of the coastal and marine resources is complex and can only occur through an inter-agency collaborative approach that integrates the management of the coastal zone into all other sector-based management programmes. As a result, many different agencies and organisations (governmental, non-governmental and community-based) share the responsibility for coastal resources management in Saint Lucia.

The Government of Saint Lucia has over the years put in place a number of policy, legislative and institutional arrangements to safeguard the environmental resources of the country, and to support sustainable development. While no harmonised legislation for Coastal Zone Management exists in Saint Lucia, the various agencies involved in marine resources management undertake different activities in accordance with their roles and mandates.

One such initiative is the declaration of marine reserves (including beaches, mangroves and coral reef systems) and enforcement of fisheries legislation to control destructive actions and practices, and thereby protect valuable fisheries resources. Establishment of marine management areas and controls on activities within critical marine sites also help to reduce the negative impacts from human activities on marine resources.

Other national agencies, on their own impetus, have engaged in public awareness and outreach activities in a bid to curb the human stresses on the marine environment. The Department of Fisheries, for example, continues to engage in sensitisation activities on different coastal management issues focusing on the fishery, mangrove and coral reef conservation, invasive species and good fishing practices, to name a few. The Saint Lucia Solid Waste Management Authority plays its part in educating the general populace on the consequences of indiscriminate waste disposal, and the Saint Lucia National Trust advocates on conservation, resources protection, protected areas management and related subjects.

These agencies form a small part of the network working to protect valuable marine resources, and the environment, in general (Box 3.3a). In order for coastal zone management initiatives to function effectively, a more integrated approach is required, clarifying the roles of involved agencies, and creating formal linkages among them.

BOX 3.3a – Key players in coastal zone management in Saint Lucia include:

Agency	Responsibility
Ministry responsible for agriculture, forestry and fisheries	*Responsible for the development and management of agricultural, forestry and fishery resources*
Ministry responsible for communications, works, transport and public utilities (including meteorological office)	*Responsible for maintaining a functional network of roads and other related infrastructure and systems*
Saint Lucia Air and Sea Ports Authority (SLASPA)	*Responsible for the operation of air and sea ports on the island*
Ministry responsible for environmental health	*Responsible for maintaining overall health as it relates to public safety, including monitoring of coastal/marine water quality*
Ministry responsible for planning and environment	*Responsible for ensuring sustainable use of all publicly and privately owned land in the interest of the public; maintaining and improving the quality of the physical environment; and protecting and conserving the natural and cultural heritage of the island*
Ministry responsible for tourism	*Responsible for development and management of the tourism industry*
National Emergency Management Office (NEMO)	*Responsible for mitigation of, preparedness for, coordinating responses to, and recovery from emergencies and disasters*
Saint Lucia National Trust	*Responsible for conservation and preservation of natural and cultural heritage of Saint Lucia*
Saint Lucia Solid Waste Management Authority	*Responsible for systems relating to collection and disposal of solid waste*

Source: Coastal Zone Management in Saint Lucia: Issues Paper (2002)

Noting the fragmented roles of agencies in coastal resources management, the Government of Saint Lucia undertook a **Coastal Zone Management Project** which aimed at establishing institutional arrangements that would facilitate the future development and management of the island's coastal zone. The project was overseen by a Coastal Zone Management Working Group comprising several agencies with an interest in, or responsibility for marine resources management. One output of the project is the **Coastal Zone Management Policy**, which was approved and adopted by the Cabinet of Ministers in 2004, and aims to guide coastal zone management in Saint Lucia. The project also supported the establishment of a **Coastal Zone Management Unit (CZMU)**, which has as some of its major roles the provision of technical input to development planning on issues related to coastal development and management, and the enhancement of public awareness of coastal zone management issues and programmes.

While efforts are being made at the national level, support from regional and international avenues is also explored. As such, Saint Lucia is party to different conventions and treaties geared towards safeguarding the marine environment and associated resources. Although these agreements are not incorporated into national law to promote enforcement at the national level, Saint Lucia, by participating in these treaties, has accepted certain obligations in return for specific benefits for resource management. These may take the form of access to technical assistance and resources, financial support and assistance with enforcement of management authority.

Some of the key treaties and conventions relating to coastal zone management to which Saint Lucia is party include (Retrieved from www.cep.unep.org):

- **Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (The Cartagena Convention) and its Protocols**

  The Cartagena Convention entered into force in 1986 for the purposes of the protection and management of the marine and coastal areas of the Wider Caribbean Region. The Cartagena Convention and its Protocols constitutes an important legal instrument for regional cooperation in the Wider Caribbean. The UNEP Regional Co-ordinating Unit is administering the convention. The convention has three associated protocols:

  - The Oil Spills Protocol, which provides for regional co-operation when an oil spill threatens the coast of a participating state, and for the preparation and updating of contingency plans. This protocol is in force.
  - The Protocol Concerning Specially Protected Areas and Wildlife (SPAW), which provides for the protection and management of marine areas and associated terrestrial areas, as well as wildlife. This protocol is supported by a special subprogramme of the Caribbean Environment Programme called the SPAW Programme. The protocol is in force.
  - The Land-Based Sources of Marine Pollution (LBS) Protocol is a legal instrument for dealing with environmental pollution reaching the marine environment from land-based sources. The Protocol is in force and is supported by a special subprogramme of the Caribbean Environment Programme called the Marine Pollution and Integrated Environmental Management Subprogramme (AMEP).

- **United Nations Convention on the Law of the Sea (UNCLOS)**

The 1983 convention came into force on 16 November 1994, and provides the basic framework for establishing maritime zones, and for regulating fishing, marine scientific research, and marine pollution within these zones.

- **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)**

This convention operates by a means of a system of import and export permits, designed to protect certain threatened species from over-exploitation. It prohibits international commercial trade in species considered endangered and listed in Appendix I, but permits such trade in a regulated manner in species listed in Appendix II, that could become endangered through international trade.

- **Convention for the Prevention of Pollution from Ships (MARPOL, 73/78)**

This convention is administered by the International Maritime Organization (IMO), and requires the contracting parties to impose a variety of controls on pollution from ships. The convention has five annexes covering oil, noxious liquids in bulk, harmful substances in packaged form, sewage and garbage.

- **Convention on Wetlands of International Importance (Ramsar)**

The Ramsar convention provides for increased protection of wetlands, including shallow coastal and marine areas. A state acceding to the convention is required to designate at least one significant wetlands site, which is subject to some form of sustainable management.

- **United Nations Framework Convention on Climate Change**

The Climate Change Convention was concluded at the 1992 UN Conference on Environment and Development (UNCED) in Rio de Janeiro. It concentrates on controlling the emission of greenhouse gases, such as carbon dioxide and methane. The developed countries will provide provisions of funding and technology to the developing countries to reduce such emissions.

- **Convention on Biological Diversity**

The Convention on Biological Diversity (CBD) was also concluded at UNCED. It requires states to adopt and carry out conservation policies to maintain biological diversity. For the Caribbean region, it has been recognized that the implementation of the SPAW Protocol of the Cartagena Convention would support the implementation of the majority of the obligations of the Convention on Biological Diversity. There is a special agreement between the CBD Secretariat and UNEP-Caribbean Regional Coordinating Unit (UNEP-CAR/RCU) on implementing the CBD at a regional level.

- **Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention)**

This treaty, established through the United Nations Educational, Scientific and Cultural Organization (UNESCO), allows contracting states to nominate sites within their territory to the World Heritage Committee for consideration for designation as natural and cultural sites of "outstanding universal value". Such designation entitles the country where the site is located to seek assistance from the World Heritage Fund for its protection.

- **International Convention on Civil Liability for Oil Pollution Damage**

This convention makes provision for coastal states to allow actions to be brought in their national courts against the owners of vessels which spill oil at sea, resulting in damage to fishing or related interests, such as tourism.

Projects

Projects have also been undertaken with some focus on the coastal resources in Saint Lucia. In some cases, Saint Lucia was a participating member of a wider, regional project, while in others total focus was on the national marine environment.

BOX 3.3b – North West Coastal Conservation Project

In 1994, in an effort to begin to address the issue of the continuous deterioration of the island's coastal and marine resources, the Government of Saint Lucia initiated the development of a coastal zone management framework for the island, through a two year project entitled the North West Coastal Conservation Project (NWCCP). The NWCCP sought to develop an integrated planning and management programme to address environmental and development pressures within the project area, as well as facilitate the long term restoration, protection, maintenance and sustainable use of coastal resources. Due to the success of the NWCCP, the Government of Saint Lucia sought to extend the project. In 1997 the project was extended to assess the contaminant inputs and loadings in riverine and coastal systems, so as to develop recommendations and an action plan for the study area and its related watersheds.

One of the major recommendations of the NWCCP to the Government of Saint Lucia included the establishment of a national Coastal Zone Management Unit (CZMU) within the public sector, along with a multi-sectoral advisory committee to address coastal zone management related issues.

Source: Coastal Zone Management in Saint Lucia: Issues Paper (2002)

SAMPLE TEACHING AND LEARNING STRATEGIES

Activity 3.3a

Parts to play

This activity will allow students to learn about the different pieces of legislation in place, and actors working to protect Saint Lucia's coastal resources

Activity 3.3b

It Wasn't Me! - Scenario Analysis

This activity allows students to apply knowledge of marine resources management legislation to different scenarios.

MODULE 4: Marine Resource Management

INTRODUCTION

This module presents an overview of Marine Protected Areas (MPA), with consideration of MPA establishment and management in the Caribbean, and more specifically in Saint Lucia.

OVERALL OBJECTIVES

1. To introduce the different methods and measures used for marine resource conservation, and the problems associated with effective management.

THEMES

The module is divided into the following themes:

Theme 4.1:	*Managing People* Community Based Co-Management
Theme 4.2:	*From Ridge to Reef* Coastal Zone and Watershed Management
Theme 4.3:	*Extra Protection* Marine Protected Areas

DELIVERY TIME

Expected time to deliver the module in hours: Six (6) hours

THEME 4.1

Managing People

Community Based Co-Management

Objectives

- To provide an overview of the co-management approach to resource management and conservation

Materials/ equipment

- Overhead Projector
- Flipchart paper
- Markers

Strategies

- **Activity 4.1a: Who's Who? – Stakeholder Analysis**
  This activity will introduce the importance of identifying and involving all stakeholders in decision-making for coastal resources management.

- **Activity 4.1b: Conflict Management - Soufriere Marine Management Area (Case Study and Site Visit)**
  This activity will help reinforce knowledge on how to effectively deal with conflicts.

Delivery Time

- One (1) hour

Managing People

Community Based Co-Management

Background

As you know, human beings have previously and continue to depend on the resources of the marine environment for economic, social, aesthetic, and other functions, often placing unwarranted stresses on coastal resources, and ultimately leading to their degradation and destruction. Today, human interaction with the various ecosystems is perhaps the most influential factor affecting the coastal environment and the vital natural processes occurring there. Management of the marine resources is above all else managing people and human activities so that their negative impacts on the coastal environment are minimized to the extent that would promote the natural productivity and sustainability of coastal and marine resources.

Maintaining healthy coastal and marine ecosystems is fundamental for sustaining livelihoods, and requires coordinated management techniques and interventions. The people of the Caribbean region, especially the poor and other disadvantaged groups, should be able and allowed to effectively engage in partnerships with government to sustain livelihoods that are dependent upon coastal resources. The combined effort of governments and groups of interested people (the stakeholders), often called **co-management**, is increasingly seen as essential for effective and sustainable management of natural resources, like the marine environment (McConney et al, 2003).

Co-management is broadly defined as management by two or more partners. This partnership may be applied under a detailed plan of action for resource conservation, management, benefit-sharing and sustainability, negotiated and agreed to by all concerned stakeholders. Implementation of co-management mechanisms for resource management is based on the premise that empowerment, participation and involvement in decision-making are required to allow resource users to take responsibility and management actions which will benefit resources conservation and sustainability.

> **DID YOU KNOW?**
>
> *Co-management is also called participatory, joint, stakeholder, multi-party, or collaborative management.*

In so doing, resources users must be provided with the necessary information and resources to guide decision-making, alongside the support provided by governments, non-governmental organizations, research institutions and other external parties, the private sector, technocrats and other stakeholders.

Other reasons behind the demand for successful and sustainable coastal resource co-management include (McConney et al, 2003):

- Increasing conflicts among coastal and marine resource users not being managed
- Many resources being fully or [partly] overexploited under management by government alone
- Coastal habitats being increasingly degraded by marine and land-based pollution
- Public sector reform and down-sizing of state agencies changing the nature of governance
- Trend towards empowering non-governmental organisations, communities and civil society
- Citizens' demands for greater legitimacy and transparency in management decision-making
- Donor agencies often have establishing co-management as a condition for receiving funds
- Where there are significant populations of indigenous people, it is seen a traditional right
- Multilateral environmental agreements contain provisions for cooperation in management

In small island states like those of the Caribbean region, the co-management approach tends to be most successful when community-based, i.e. resource users and communities become the primary implementers of the management plans, assisted and monitored by technical and other public sector services. Local communities often have traditional relationships with and a deep understanding of the natural resources and in some cases have made significant contributions to its conservation and maintenance through sustainable use practices and cultural respect.

A blueprint for community-based co-management does not exist, but this approach to natural resource management can help encourage both economic and local (community) development by fostering partnerships among various stakeholders, and encouraging community and user participation in overall resource management.

Participation and involvement in a co-management process are guided by some key factors which should be applied by site management to gain satisfactory results. First, all parties, independent of gender, race, political or religious affiliation, language, class and education, must be allowed to contribute to the process, and must be **empowered** to do so. Facilitators of any process must also ensure that all participants are encouraged to contribute to discussions and consultations, and must ensure that they are provided with the environment and tools to adequately achieve this.

Additionally, stakeholders must be provided with all **information** (in a useful form) which would allow them to make guided decisions on the management of the natural resource.

Stakeholder Analysis and Involvement

In order for any co-management intervention to be successful, it is important to identify all stakeholders and assess their interests at the start of the planning process, and as conditions change. To determine who should participate in management and how, distinctions must be made among the broad collection of individuals, groups and institutions, i.e., stakeholders, who are, in one way or another, and either positively or negatively, interested, involved, influenced or affected by the management intervention. The interests or stakes of the various actors (Box 4.1a) or stakeholders differ because of such things as tenure, ownership, history of use, and pattern or type of use.

A well-done stakeholder analysis will also identify roles and responsibilities, potential sources of conflict among stakeholders, and concerns to be addressed during management initiatives. On the other hand, a process that fails to identify and involve some of the stakeholders is likely to encounter difficulties being implemented, as those who have been excluded could easily be opposed to its outcome.

In the process of stakeholder identification, a number of important principles must be taken into consideration (UNEP-CEP, 2010):

- **Differences exist among stakeholder groups**. Even when all stakeholders share a common goal, such as the long-term sustainability of a natural resource, objectives, needs and priorities may differ. It is essential to identify, with precision, the often competing interests among stakeholders and ascertain who holds these interests.

- **Stakeholder groups are not homogenous**. Within a single group, sub-groups with varying perspectives and interests may exist. Similarly, the leadership of the group may not adequately represent the interests of all members.

- **All stakeholders are not necessarily organized in formal groups**. Stakeholders could, for example, include disparate individuals or households who use the resource for a similar recreational purpose or income generating activity.

- **Even when stakeholders are organized in a group, they may not have the capacity to effectively articulate and represent their interests.**

BOX 4.1a – Categories of social actors possibly relevant in natural resource management

***Local actors**, including the communities, organisations, groups and individuals who live and work close to the resources, the ones who possess knowledge, capacities and aspirations that are relevant for their management, and the ones who recognise in the area a unique cultural, religious or recreational value. (This is an ample category, including several sub-categories.)*

***Natural resource users**, including local and non-local, direct and indirect, organised and non-organised, actual and potential users, as well as users for subsistence and income purposes.*

***National authorities and agencies** with explicit mandate over the territory or resource sectors (e.g. ministries or departments of forests, freshwater, fisheries, hunting, tourism, agriculture, protected areas and, in some cases, the military).*

***Sub-national administrative authorities** (e.g., district or municipal councils) dealing with natural resources as part of their broader governance and development mandate.*

***Non-governmental organizations and research institutions** (e.g., local, national or international bodies devoted to environment and/ or development objectives) which find the relevant territories and resources at the heart of their professional concerns.*

***Businesses and industries** local, national or international (e.g., tourism operators, water users, international corporations) which may significantly benefit from natural resources in the area.*

***Non-local actors** national and international, indirectly affected by local environmental management practices (e.g., absentee landlords, down-stream water users, environmental advocates or animal rights groups).*

***Individual professions** employed in environment and development projects and agencies dealing with the management of natural resources in the area.*

Sharing Power: Learning by Doing in Co-management of Natural Resources throughout the World
by Grazia Borrini-Feyerabend, Michel Pimbert,M.Taghi Farvar, Ashish Kothari and Yves Renard

To ensure identification of all stakeholders in a natural resources management context, the process will benefit from using a list of all the current and potential functions of the resources and the sectors which are the object of management. Once the resources and sectors are examined, the relevant individuals, groups and organisations involved in or potentially affected by

DID YOU KNOW?

Special care must be taken to ensure that voiceless and disadvantaged groups that may include women, youth, the elderly and poor people, are not excluded from the analysis.

management interventions, can more easily be drawn up, using a list of questions similar to the following:

- Who is directly affected by the problem or situation being addressed?
- What are the interests of various groups in relation to the problem?
- How do groups perceive the management problem to affect them?
- What resources do groups bring to bear (for good or bad) on the problem?
- What organizational or institutional responsibilities do the groups have?
- Who should benefit, or be protected from, management interventions?
- What conflicts may groups have with each other and management strategies?
- What management activities may satisfy the interests of the various groups?

While there is no single best method for conducting a stakeholder analysis, the process should be as participatory as possible in order to fill gaps and highlight points that may be otherwise overlooked. Whatever method is selected, it should be guided by the specific intent and purpose of the planning exercise and the management issue being addressed. This will help to ensure that as many needs, concerns, roles and responsibilities are identified and adequately represented in the co-management process.

Community Mobilisation

Community-based co-management will require participation of community groups and members as key stakeholders, to ensure success in resource management and conservation. The overall underlying concept behind this approach is to encourage the communities to manage natural resources in a sustainable way by transferring some management responsibility, decision-making processes and the user benefits from areas designated for local community use. Community-based co-management requires a formal understanding of the existing social dynamics of the community (known leaders, role of government, NGOs and other institutions in the community, past experiences and ongoing activities), and is most effective when communities themselves take the lead. In order to gain the support and participation of all relevant parties, some level of mobilisation may be undertaken.

Community mobilisation engages all sectors of the population in a community-wide effort to address a given issue using a co-management approach, bringing together individual community members and resource users, policy makers and government agencies, professional groups, religious groups, the private sector, and other key players. Community mobilisation empowers individuals and groups to take some kind of action to facilitate change, and requires mobilisation of necessary resources, dissemination of information, and generation of critical support for the process and desired outcome. Such action leads to buy-in and ownership from the wider community, as well as promotion of effective decision-making through collaboration between individuals and organizations, and can create public presence and pressure to change laws, policies, and practices – progress that could not be made by just one individual or organization.

The most significant benefit for communities of community-based co-management is the opportunity to help address an issue impacting the community members, and to conserve valuable natural resources upon which their livelihoods are based.

Conflict Management

Conflict is an inevitable by-product of co-management, occurring when competing or opposing interests fail to find common ground. Particularly in the case of natural resource management, like those of the coastal environment, conflicts may arise between different users, because of different users, and between users and implementers of management interventions, the latter usually arising from perceived loss of benefits to users without compensation. An understanding of the proper management of conflicts can help contribute positively to a process like co-management.

While they are usually perceived to be negative, conflicts can present opportunities for assessment and evaluation, and for influencing change. If not managed properly, however, conflict can be counterproductive and can undermine the resource management arrangement. The issue therefore, is to ensure that enough information is provided to manage conflicts in such a manner as to arrive at even a temporary resolution in a non-disruptive manner.

DID YOU KNOW?

Effective communication is an essential tool for conflict management.

BOX 4.1b – Characteristics of Conservation Area Conflicts	
They involve several stakeholders.	*Conflicts often revolve around the loss of benefits of access or use. One or more stakeholder group is usually perceived as gaining at the expense of other groups.*
They are often influenced by factors and conditions external to the management area.	*This requires managers to look beyond the physical boundaries of the protected area to fully understand the roots of conflicts and address them effectively. These external factors can be: political, such as a change in government; legislative, such as the introduction of new laws and regulations that affect practices inside or outside of the management area; economic, such as a local recession; or environmental, resulting from the degradation of resources in areas connected to the ecosystem of the management area.*
They involve scientific and socio-cultural phenomena.	*Scientific data collected over time are not always available to support management decisions, particularly at the start of interventions; there may also be clashes between scientific knowledge and local knowledge, particularly when those who possess the former ignore or undervalue the latter.*
The process of identifying solutions to conflicts is often constrained by a lack of financial resources.	*The universe of solutions available for addressing conflicts is sometimes limited by financial resources, which can make it difficult to obtain goods and services that might aid in the resolution process.*
Adapted from Lewis, 1997.	

Guidelines for Participatory Planning: A Manual for Caribbean Natural Resource Managers and Planners
CANARI Guidelines Series

Guidelines for Conflict Management (UNEP-CEP, 2010) include:

1. **Understand the nature of the conflict and its underlying causes**. It is important to understand the various manifestations of the conflict (symptoms) and why the problem occurs (causes). This may require research and external contributions and services. A conflict in a MPA may manifest itself in the non-compliance of a user group with area regulations, for example. In such an instance, it would be important to understand such things as whether or not all or some of the group members are non-compliant, if the non-compliant members were a part of the original consultation and negotiation process, if

social and economic conditions have changed outside of the area and affected behaviour and decision-making among group members, etc.

2. **Analyse issues (including power dynamics among stakeholders) at the start of the process and clearly define interests**.

3. **Make sure the process for reaching a solution is legitimate and acceptable to all**. Ensure, for example, that all relevant stakeholders are a part of the process and that all positions and stakes are represented by the designated spokespersons. The process used should be culturally, socially, and politically appropriate.

4. **Ensure that the process is transparent**, i.e., all relevant parties are aware of all steps in the process and involved in decision-making as appropriate.

5. **Arrive at consensus on the method of addressing the conflict and define objectives for each stage of negotiation**.

6. **Design negotiation processes in stages** and reach results for each step before advancing the process to the next phase.

7. **Begin with the resolution of simple issues before attempting to resolve more complex issues**. This makes it possible for the negotiating parties to focus on the issues which can be relatively easily resolved and demonstrates that it is actually possible to reach agreements.

8. **Conclude with the formulation of a formal agreement** that clearly stipulates conditions and responsibilities for implementation

SAMPLE TEACHING AND LEARNING STRATEGIES

Activity 4.1a

Who's Who? – Stakeholder Analysis for Marine Resources Management

This activity will introduce the importance of identifying and involving all stakeholders in decision-making for coastal resources management.

Activity 4.1b

Conflict Management - Soufriere Marine Management Area

- **Case Study**
- **Site Visit**

This activity will help reinforce knowledge on how to effectively deal with conflicts.

THEME 4.2

From Ridge to Reef

Watershed and Coastal Zone Management

Objectives

- To explore the linkages between activities occurring within the watershed and impacts on coastal resources.

Materials/ equipment

- Overhead Projector
- Assorted craft materials – paint, Bristol board, cardboard, matchboxes, etc
- Flipchart paper and markers

Strategies

- **Activity 4.2a: Adopt-a-Watershed**
  This activity provides experience in watershed management, by encouraging students to assess activities, issues and threats, and propose appropriate solutions.

- **Activity 4.2b: Where's the Point?**
  This activity will enable students to learn about the source and impacts of contaminated runoff on coastal ecosystems and resources, and actions to reduce or eliminate the problem.

Delivery Time

- One (1) hour

From Ridge to Reef

Watershed and Coastal Zone Management

Background

What is a watershed?

A **watershed** is an area of land that is drained (both surface and groundwater) by a river and its tributaries into another body of water which, in small islands like Saint Lucia, may ultimately be the ocean. Watersheds come in all sizes, and contain a mix of habitats and features that influence each other. These include forests, wetlands, cities and towns, and a host of others. Watersheds include both streams and rivers that convey water as well as land surfaces from which water drains into those channels.

Watershed boundaries are defined by nature, and can be separated from adjacent basins by a geographical barrier such as a ridge, hill or mountain. The watershed boundaries on volcanic islands like Saint Lucia are clearly identified because of the island's rugged topography, mountain peaks and deep river channels.

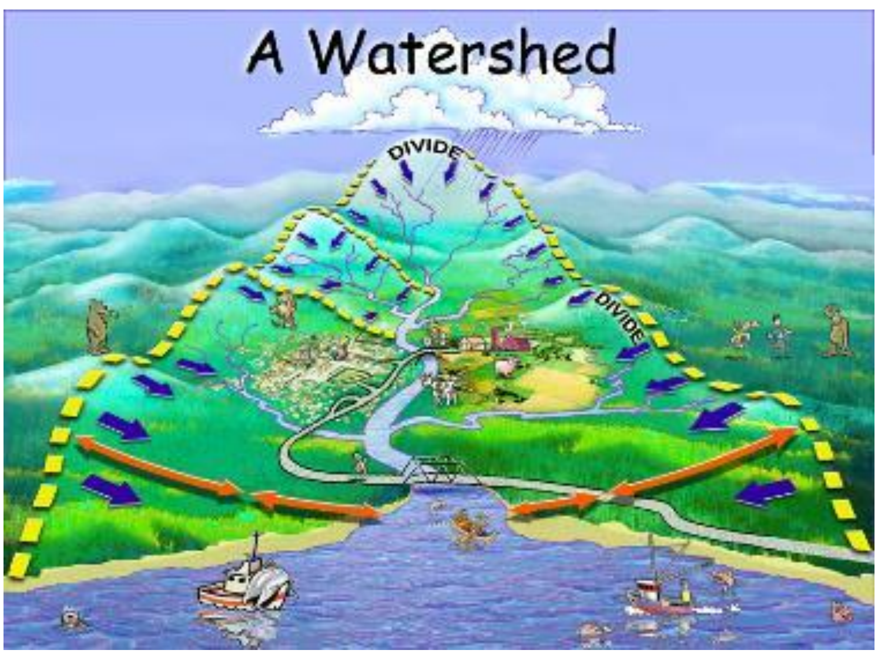


Figure 4.2a Pictorial view of a watershed **(Source: http://www.desalresponsegroup.org/alt_watershedmgmt.html)**

There are 37 main watersheds in Saint Lucia, all stemming from the island's interior mountain ranges and extending towards the coast (See Figure 4.2b).

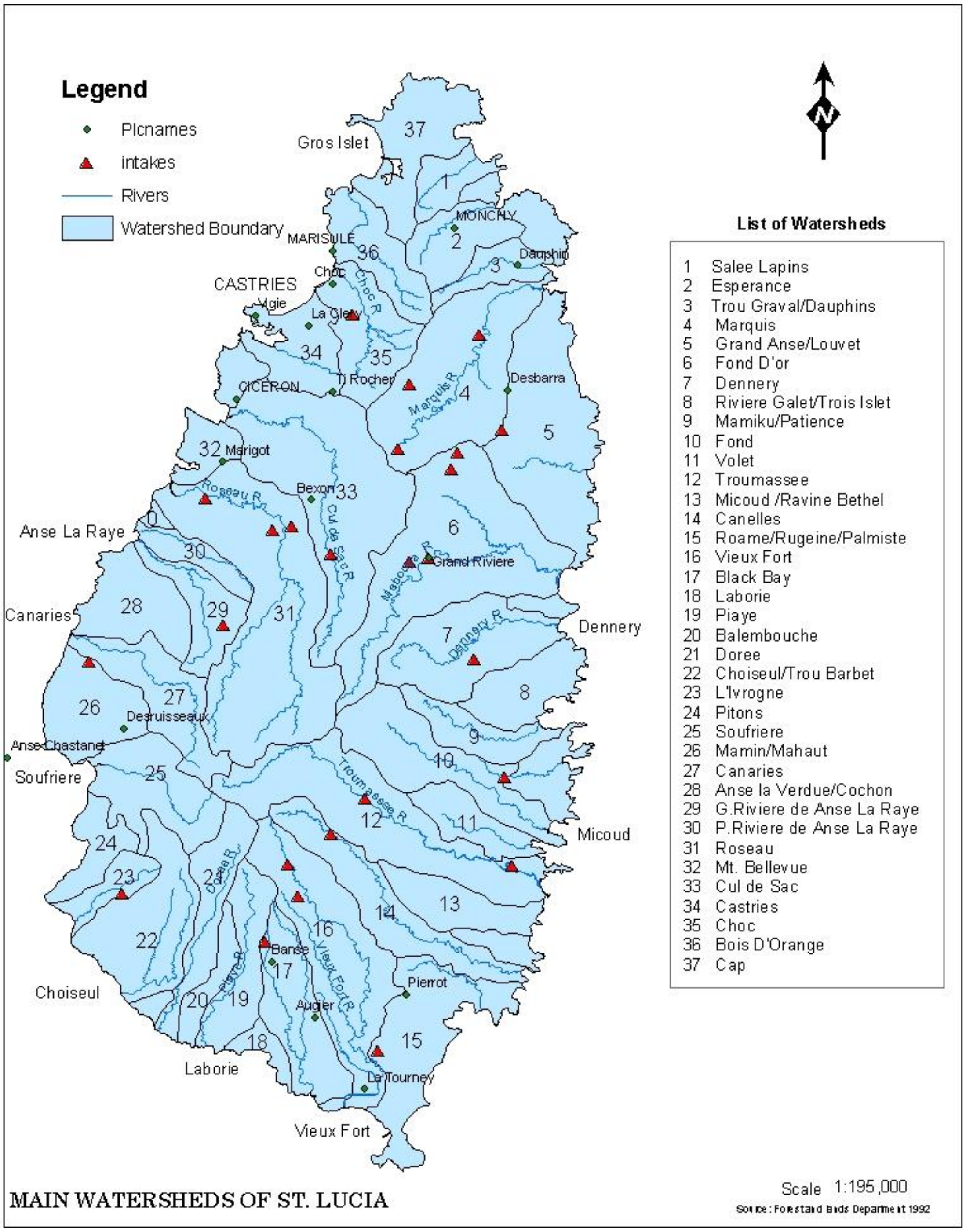


Figure 4.2b Watersheds in Saint Lucia

Seven (7) of these watershed are important for supplying the country with water. They are:

- Marquis
- Roseau
- Cul-de-Sac
- Fond d'Or
- Troumasee
- Canelles
- Vieux Fort

Because of the geographical nature of watersheds, land within the watershed boundaries is used in many different ways, by many different users. This can vary from diverse agricultural lands, to pristine forested regions, to major urban cities and sprawling suburbs. The way we live and use the land greatly influences the health of the watersheds, their networks of streams and rivers, and their ability to maintain vital ecosystem functions and services. The major concerns with respect to management of watersheds in Saint Lucia are poor agricultural practices, inappropriate land use, and improper disposal of waste (solid and liquid; domestic, industrial and agricultural) into waterways, all potentially jeopardising water quality and human health.

Population growth and demands for land and water resources for use and income generation have also led to intrusion of sensitive water catchment areas, and in some cases to unlicensed freshwater abstraction. These issues can result in severe environmental impacts on key economic sectors such as agriculture, health, water and tourism. It has been postulated that problems encountered within local watersheds stem mainly from inadequate public education and participation in ecosystem conservation efforts.

Watershed management is a proactive approach that harmonises land use and water management decisions in order to protect water resources and help communities within watershed boundaries to define and prioritise local needs, coordinate efforts and be mindful of the impact their actions have upstream and downstream. Watershed management plans are used as tools to support effective watershed management. These instruments provide direction and target resources for better management and restoration of watersheds, and serve as blueprints for improving water quality, reducing flood damage, and protecting natural resources within watershed boundaries. Effective watershed management also helps to prevent existing watershed problems from worsening, and moves countries like Saint Lucia closer to ensuring sustainable, healthy environments for human and natural prosperity.

BOX 4.2a – Land use and Watersheds

A watershed is all the land that drains into a river, stream, lake, or estuary, or flows into a groundwater basin. All land is within a watershed. The water resources within a watershed are connected, both above and below ground. Watersheds are critical to the health and welfare of our communities – they are the source of local water supplies for homes, industry and natural habitats.

Covering a watershed with buildings and pavement has multiple, negative consequences. Hard, impervious surfaces allow less water to infiltrate the soil. This increases urban runoff and can lead to flooding and the pollution of our existing water supplies. Impervious surfaces prevent the replenishment of underground aquifers, the source of much of our drinking water.

We need to identify watersheds that are undeveloped, determine their value, and maintain the most important ones in an undeveloped state. They are our critical sources of water.

We have been taking our watersheds for granted. Today, we recognize that additional imported water supplies can be costly, and that the most reliable water resources are the locally controlled supplies that can be protected by sustainable watershed management. Watersheds maintain the health of forests, fisheries, wetlands, coastal resources, agricultural landscapes, habitat and water supplies. They are the foundation for a sustainable environment that supports recreational activities and healthy local economies. Also, where land is completely paved over, treatment costs are about five times greater than in areas where less than 40% of the land in a watershed is paved.

Local governments for communities in the same watershed need to make their land-use decisions in concert with one another because each action can potentially protect or weaken the water system shared by all.

Communities should develop strategies with other stakeholders in the watershed to assure the preservation of undeveloped watershed areas, protect current water supplies, and reduce flooding. The benefits for working together to preserve the common watersheds are many, including:

- *The preservation of local water quality*
- *The preservation of adequate water supplies to support the regional economy..*
- *A reduced risk of floods.*
- *The preservation of natural habitats and the recreational resources that residents value.*

Adapted from "Land Use and Watersheds: How to Reduce Costs While Improving the Reliability and Quality of Water Resources"
(Source: http://www.lgc.org/freepub/docs/water/water_watershed.pdf)

It is important to recognise the linkages between the watersheds and the coastal areas as they impact on each other. Inadequate management of activities within the watershed can impact greatly on the coastal resources of small islands like Saint Lucia. The sustainability of the health and economic development of the country relies largely on the adoption of an integrated approach to watershed and coastal areas management.

Integrated Coastal Zone Management

While there is not one definition for Integrated Coastal Zone Management (ICZM), this management approach is broadly defined as a process for the management of the marine environment by "attempting to balance the benefits from the economic development and human uses of the coastal space while sustaining over the long-term, the ecological, socio-cultural, and historical values of a particular given area" (Source: www.coastalwiki.org).

ICZM regards the coastal environment as a unique resource system, requiring specific management approaches and collaboration of all sectors and groups to ensure the sustainable use of marine and coastal resources. Elements for effective ICZM are many, and are considered essential in reaching a successful outcome (See Box 4.2b).

Because of the many activities occurring in and impacting on the coastal zone, and to the nature of the linkages between terrestrial and marine systems, ICZM is no easy feat. In small islands like Saint Lucia, with limited barriers between the marine and terrestrial environments, the need for interventions to protect coastal resources becomes even more critical.

In aiming to reduce the impact of the threats to the coastal environment, a Strategy and Action Plan to guide interventions in coastal zone management was developed for Saint Lucia. The purpose of the strategy is to "facilitate improved management of the coastal and marine resources of Saint Lucia, and to ensure that economic growth is balanced with sound management of the use of coastal and marine resources".

BOX 4.2b – Elements of Integrated Coastal Zone Management

Integrated coastal zone management programmes must be informed by all the parameters of human habitation, industrial development, commerce and recreational activities in development zones. For ICZM to be effective, the programme must have the capacity to inform the:

- *Preparation and implementation of land and water use, activity zoning and siting policies;*
- *Preparation of coastal profiles identifying critical areas (hot spots), including eroded segments, physical processes, development patterns, user conflicts and setting priorities for action and management. This becomes particularly important for informing design parameters of regions development plans;*
- *Development of contingency plans for human induced and natural disasters including effects of potential climate change and sea level rise;*
- *Development of contingency plans for degradation and pollution due to human activities;*
- *Determination of improvements to housing, drinking water, sanitation, solid waste management and industrial management;*
- *Development of conservation and restoration plans for critical habitats;*
- *Development of assessment regimes for coastal and marine development including changes in land use (coastal zone) and water quality (coastal and marine waters) incorporating monitoring and enforcement strategies;*
- *Designing of architectural elements that are informed by cultural, aesthetic, or geographic impositions;*
- *Development of environmental quality criteria;*
- *Development of capacities to empower the participation of people;*
- *Development of public education, awareness, and information programmes; and*
- *The involvement of all key stakeholder institutions, community and non-governmental organisations in the execution of actions pertinent to all the above.*

Source: Integrated Coastal Zone Management Strategy and Action Plan for Saint Lucia (2008)

In preparing the ICZM Strategy and Action Plan, a number of issues requiring priority attention were raised by communities and resource management agencies during a series of consultations. The issues identified are manifested in social, economic and ecological stresses that impact the overall quality of life of all communities on the island, and include:

- **Social**

- Poorly coordinated management of the use of coastal resources
- Inefficient planning
- Resource-use conflicts
- Improper solid and liquid waste disposal
- Low level of awareness and expertise about management of coastal resources
- Inadequate institutional structures

- Weak monitoring and enforcement
- Eroding access to beaches
- Inadequate attention to sanitation and other community health issues
- Poor quality potable water supplies
- Weak development/management of protected areas

▪ **Economic**

- Flooding due to: improper drainage; anthropogenic activities; obstructions created by debris or infrastructural works
- Unsustainable economic enterprises that degrade coastal resources, for example harvesting of limited natural resources for sale (e.g. Corals, beach sand)
- Lack of understanding of the contribution of coastal resources to society and economic growth
- Lack of incorporation of the value of natural capital into national accounting systems
- Over- and destructive fishing
- Poor agricultural practices

▪ **Ecological**

- Beach sand mining, harvesting of limited fragile or endemic resources
- Degradation of mangals (mangrove forests) seagrasses, coral reefs, forests, and other critical biodiversity, (e.g. turtles, other terrestrial or marine fauna and flora)
- Destructive fishing practices
- Destruction of critical sensitive habitats and other non-living resources
- Degradation of water quality by contamination from solid and liquid wastes, agrochemicals, sewage, etc.
- Encroachment on beaches (interference with beach stability)

▪ **Natural**

- Sea level rise due to global warming
- Changes in: coastal processes, shore profiles from storms
- Earth movements (landslides due to earthquakes)
- Flooding
- Impacts of hurricanes and storms
- Tsunamis
- Volcanic events

This list highlights the need for an integrated approach to coastal zone management in Saint Lucia, taking to account the myriad activities occurring in the marine environment, the impact of land-based activities, and the importance of collaboration and participation of all relevant stakeholders in decision-making and active management.

BOX 4.2c – Integrated Watershed and Coastal Area Management (IWCAM) Project

*The Project **Integrating Watershed and Coastal Area Management (IWCAM) in the Small Island Development** States (SIDS) of the Caribbean, with a value of USD 22 Million, was approved by the Global Environment Facility (GEF) in May 2004. Implementing agencies were the United Nations Environment Programme (UNEP) and the United Nations Development Programme (UNDP). Executing agencies were the Secretariat of the Cartagena Convention (UNEP-CAR/RCU) and the Caribbean Environmental Health Institute (CEHI).*

The thirteen participating SIDS were Antigua & Barbuda, The Bahamas, Barbados, Cuba, Grenada, Dominica, Dominican Republic, Haiti, Jamaica, Saint Kitts and Nevis, Saint Lucia, Saint Vincent & the Grenadines, and Trinidad & Tobago. The Project commenced in the second quarter of 2005, and hosted its Final Project Conference in Kingston, Jamaica, 16 – 18 November 2011.

The overall objective of this Project was to strengthen the commitment and capacity of the participating countries to implement an integrated approach to the management of watersheds and coastal areas. The long-term goal is to enhance the capacity of the countries to plan and manage their aquatic resources and ecosystems on a sustainable basis. In particular, project activities focused on improvements in integrated freshwater basin-coastal area management on each island of the regional groupings of Caribbean SIDS.

The demonstration projects provided a wealth of experience and lessons learned in terms of practical approaches to integrated watershed and coastal areas management, and notably, tangible evidence of benefits of the approach. Many examples of the following can be cited: improved access to water for human well-being, for agriculture and basic sanitation; communities being cleaned; children being educated on environmental issues; and professionals across the region developing and applying new skills.

In Saint Lucia, the Watershed Management Committee, responsible for motivating and mobilizing the wider community to participate in several activities, took the initiative to transform itself into an NGO, the Trust for the Management of Rivers, to promote, implement, and ensure sustainability of the IWCAM approach after the project was finished.

Source: www.iwcam.org

SAMPLE TEACHING AND LEARNING STRATEGIES

Activity 4.2a

Adopt-a-Watershed

This activity provides experience in watershed management, by encouraging students to assess activities, issues and threats, and propose appropriate solutions.

Activity 4.2b

Where's the Point?

This activity will enable students to learn about the source and impacts of contaminated runoff on coastal ecosystems and resources, and actions to reduce or eliminate the problem.

THEME 4.3

Extra Protection

Marine Protected Areas

Objectives

- To know the importance, functions and locations of Marine Protected Areas at the national, regional and global levels.
- To understand the nature of Marine Protected Areas in Saint Lucia

Materials/ equipment

- Overhead Projector
- Flipchart paper
- Markers

Strategies

- **Activity 4.3a: Water Parks**
  This activity will help reinforce knowledge of marine and coastal resources, their uses and threats, and options for management and protection.
- **Activity 4.3b: The MPA Debate**
  Have an appreciation for the role and benefits of establishing marine protected areas (MPAs), and reinforce knowledge of stakeholder analysis and involvement in MPA management

Delivery Time

- One (1) hour

Extra Protection

Marine Protected Areas

Background

For centuries, protected areas (PAs) have been used worldwide to encourage the sustainable use of, and equitable distribution of benefits derived from natural resource conservation. Defined by the World Conservation Union (IUCN, 1994) as **"*areas of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and natural and associated cultural resources, and managed through legal or other effective means*"**, the number of protected areas is ever increasing as the means to achieve conservation objectives.

The main purposes for establishment and management of protected areas are identified as:

- Scientific research
- Wilderness protection
- Preservation of species and genetic diversity
- Maintenance of environmental services
- Protection of specific natural and cultural features
- Tourism and recreation
- Education
- Sustainable use of resources from natural ecosystems and
- Maintenance of cultural and traditional attributes.

Based on the possible mix of priorities that can be generated by the management objectives stated above, protected areas have been grouped by the IUCN into the following six (6) categories:

- **Category I: Strict Nature Reserve/Wilderness Area**
    - area managed mainly for science or wilderness protection (includes two sub-categories; Strict Nature Reserve - Ia, and Wilderness Area - Ib).

- **Category II: National Park**
    - area managed for ecosystem protection and recreation

- **Category III: Natural Monument**
    - area managed mainly for conservation of specific natural features

- **Category IV: Habitat/Species Management Area**
    - area managed mainly for conservation through management intervention

- **Category V: Protected Landscape/Seascape**
    - area managed mainly for landscape/seascape conservation and recreation

- **Category VI: Managed Resource Protected Area**
    - area managed mainly for the sustainable use of natural systems

Globally, the protection of marine areas has been a relatively recent initiative, as compared to the use of protected areas for terrestrial conservation and resource management. As such, considerable efforts are being directed worldwide to establishing marine protected areas (MPAs) for management of the coastal and marine environment. Marine protected areas can be developed under several of the categories, hence the familiar terms of fisheries management area, fish sanctuary, marine reserve, marine park, and so on, that protect reefs, mangroves, shipwrecks, archaeological sites, the seabed and other features of the coastal environment.

What is a Marine Protected Area (MPA)?

Marine protected areas (MPAs) are defined by the IUCN as "***any intertidal or subtidal terrain, along with the waters that covers it, and the flora and fauna and historical and cultural attributes that it contains, set aside by law or any other effective means in order to protect part of the entire environment***". In other words, MPAs are especially dedicated to the protection and maintenance of biodiversity and other natural and cultural coastal resources, through legal or other management methods.

DID YOU KNOW?

Within 5 years of the creation of a network of sanctuary zones around the Caribbean island of St. Lucia, catch by fishers increased between 46 and 90%, depending on the gear they used (Roberts CM, Bohnsack JA, Gell F, Hawkins JP, Goodridge R (2001) Effects of marine reserves on adjacent fisheries. Science 294: 1920-1923).

Benefits of MPAs

Effectively managed marine protected areas can provide many benefits for the marine environment, by helping maintain ecosystem structure and functions, protecting habitats and species, and enabling sustainable use of coastal resources, thereby assisting in restoring productivity of the oceans and avoiding further degradation. They are also sites for research and scientific study, and can generate income through tourism and sustainable fishing practices.

Benefits provided by properly designed and managed MPAs are increasing in number, and can provide a strong case for MPA establishment and effective management (Box 4.3a). However, despite their documented and proven success in managing marine resources, MPAs remain few in number, and cases of effective management are minimal.

BOX 4.3a – Summary of the benefits of MPAs

- *Conservation of biodiversity, especially critical habitats of threatened species;*
- *Protection of attractive habitats and species on which sustainable tourism can be based;*
- *Increased productivity of fisheries by: insurance against stock collapse; buffer against recruitment failure; increase in densities and average sizes of individuals; increase in reproductive output; provide centres for dispersal of propagules and adults (spillover); contain more natural species composition, age structure, spawning potential and genetic variability;*
- *Contribute to increased knowledge of marine science through information on functional linkages, implementation of the precautionary principle, provision of control sites for research and ecological benchmarks against which to measure human-induced change; potential as nodes in monitoring networks; more "natural" systems where natural mortality can be compared with fishing mortality;*
- *A refuge for intensely exploited species;*
- *Protection of genetic diversity of heavily exploited populations;*
- *Protection of cultural diversity, e.g. sacred places, wrecks and lighthouses.*

Adapted from a list developed by Kathy Walls, Dept of Conservation, New Zealand.

Marine Protected Areas in the Caribbean

The Caribbean has a long history of designating protected areas, with the first terrestrial protected area (the Main Ridge Reserve of Tobago) established in 1765, and the first marine protected area (Pedro and Morant Banks in Jamaica) established in 1907 (Putney, 1994).

DID YOU KNOW?

In 2008, more than 700 MPAs and marine reserves had been established in Latin America and the Caribbean

The initiatives to establish protected areas in the Caribbean involved the effort of individuals, national organisations (public sector and civil society), regional non-governmental organisations, regional inter-governmental institutions, international non-governmental organisations, and the international multi-lateral institutions.

BOX 4.3b – The Caribbean Challenge

*In May of 2008, leaders from the Bahamas, Jamaica, Grenada, the Dominican Republic, and St. Vincent and the Grenadines launched the **Caribbean Challenge**, a region-wide campaign to protect the health of the Caribbean's lands and waters. To date, participating governments in the Caribbean Challenge include: Antigua and Barbuda, The Bahamas, Cayman Islands, the Dominican Republic, Grenada, Jamaica, St. Kitts and Nevis, St. Lucia, and St. Vincent and the Grenadines. These Caribbean nations have committed to protecting nearly 20 percent of their marine and coastal habitat by 2020. The Cayman Islands intends to exceed the Challenge's goal by protecting 30% of its shelf by the 2020 deadline. Now, these countries have come together to develop sustainable financing for protected areas through the establishment of the Caribbean Biodiversity fund, which currently has funding commitments of over USD $40 million.*

The Caribbean Challenge will result in a wholesale transformation of countries' national park systems and will nearly triple the amount of marine and coastal habitat currently under protection, setting aside almost 21 million acres of coral reefs, mangroves, sea grass beds and other important habitat for sea turtles, whales, sharks and other wildlife. The three core components of the Challenge include:

- *creating networks of marine protected areas expanding across 21 million acres of territorial coasts and waters*
- *establishing protected area trust funds to generate permanent, dedicated and sustainable funding sources for the effective management, expansion and scientific monitoring of all parks and protected areas*
- *developing national level demonstrations projects for climate change adaptation.*

*Modeled on other large-scale conservation financing efforts, including the **Micronesia Challenge** and the **Great Bear Rainforest** in British Columbia, the Caribbean Challenge goes far beyond piecemeal, incremental conservation. The campaign to meet the Caribbean Challenge is a campaign to end paper parks in the Caribbean forever.*

To support the Challenge, the Conservancy has pledged $20 million in cash and in-kind resources to endow national protected area trusts and provide technical support.

Source: The Nature Conservancy (www.nature.org)

Marine Protected Areas in Saint Lucia

In 1986, 1990 and 2000 a total of twenty-six (26) marine reserves were declared under the Fisheries Act to conserve and protect critical habitats like mangroves, turtle nesting sites and breeding and nursery grounds for fish, coral reefs and artificial reefs (sunken ships, planes, etc).

Nineteen (19) marine reserves were declared in Saint Lucia in 1986 and a further six (6) in 1990. A revised list of twenty-four (24) marine reserves (including the reserves from the two previous listings) was declared in 2000. These are located around the island. All marine reserves, as declared in Saint Lucia, are no take areas, where human activity is limited, and resource exploitation is prohibited.

Management of these reserves for the most part is weak, with sub-active to active management existing in some of the marine reserves. As such, infringements do occur in some marine reserves, particularly in the more remote areas. Fishing in Saint Lucia is artisanal in nature and with regard to the Fishing Priority Areas located within Marine Protected Areas, fishing intensity is low.

A. **The Soufriere Marine Management Area (SMMA)** is a marine protected area, officially declared in 1995. It was declared a **Local Fisheries Management Area (LFMA)** in 2001 under the Fisheries Act No. 10 of 1984. It comprises several zones including Marine Reserves (no take areas), Fishing Priority Areas, Yacht Mooring Areas, Recreational Areas and Multiple Use Areas. The marine reserves in the SMMA are:

    - Reefs from Anse Chastanet Bay, including Turtle Reef, to the Western most point of Trou au Diable Beach (includes Grande Caille Reef);
    - Reefs from just west of Rachette Point to and including Bat Cave;
    - Reefs from southern end of Malgretoute Beach to northern end of Jalousie Beach (i.e. reefs around Petit Piton);
    - Reefs from northern extent of Gros Piton to the western most point of Gros Piton.

    The Soufriere Marine Management Association, which manages the area, was declared a not-for-profit Organisation under the Companies Act of Saint Lucia in 2003.

    Marine Reserves therein were first declared in small reef sections in **1986** as: Anse Mamin Reef; Reef between Grande Caille and Rachette Point; Anse I'Lvrogne; Reef at Malgretoute; Reef at Anse des Piton.

In **1990**, one large portion comprising Turtle Reef and the portion of the reef extending seawards from the southernmost point of Anse Chastanet Beach to Grand Caille Point was declared as ‘Reefs at Anse Chastanet’.

In **2000**, most of the reefs in Soufriere were declared as in the revised list above, encompassing the areas declared in 1986 and 1990.

A **Pitons Management Area (PMA),** which includes part of the SMMA, has been declared as an **Environmental Protection Area (EPA)** under the Physical Development Plan Act of 2001. In addition, the PMA, including its terrestrial and marine components, was declared a **World Heritage Site (WHS)** in 2004.

B. The Canaries/Anse la Raye Marine Management Area (CAMMA) is a marine protected area officially declared in 1998. It comprises several zones: Marine Reserves (no take areas), Fishing Priority Areas, Yacht Mooring Areas, Recreational Areas and Multiple Use Areas. The marine reserves in the CAMMA are:

- Marigot Bay Mangrove (First declared in 1986)
- Artificial Reef at Anse Cochon (Lesleen M) (First declared in 1990)
- Reefs extending from Rocky Shore South of Anse Cochon to the northern most point of Beach Anse Galet (First declared in 1990)
- Artificial Reef at Anse la Verdure (Daini-Koyomaru Dredger) (First declared in 2000)

All of the above areas were re-declared marine reserves in 2000.

C. Other Marine Reserves

Marine Reserves first declared in 1986

- Grande Anse Beach and Mangrove
- Cas En Bas Mangrove
- Maria Islet Reef
- Marquis Mangrove
- Rodney Bay Artificial Reefs
- Savannes Bay Mangrove
- Anse Pointe Sable- Man Koté Mangrove
- Esperance Habour Mangrove
- Praslin Mangrove

- Fond d’Or Beach and Mangrove
- Louvette Mangrove
- Bois d’Orange Mangrove
- Choc Bay Mangrove

Marine Reserves first declared in 1990

- Vigie Bay Artificial Reef
- Artificial Reef at Moule a Chique
- Reefs extending from Caesar Point to Mathurin Point

All of the above areas were re-declared marine reserves in 2000.

The Savannes Bay and Man Koté Mangroves were declared **RAMSAR sites** in 2002, and form part of the **Pointe Sable Environmental Protection Area (PSEPA)**, so declared in 2007, under the Physical Development and Planning Act of 2001. This initiative formed part of an OECS Protected Areas and Associated Livelihoods (OPAAL) Project, the national component of which was spearheaded by the Saint Lucia National Trust (SLNT).

The revised Systems Plan for Protected Areas in Saint Lucia lists all previously declared marine reserves as Marine Protected Areas, and proposes the establishment of Marine Management Areas (MMAs) for protecting those marine areas that are considered to be of a high quality (ecological, recreational, economical) and are, or maybe threatened by coastal development.

The key objectives of the proposed Marine Management Areas are:

- promoting the conservation and sustainable use of marine resources
- safeguarding the biodiversity, quality and productivity of marine ecosystems
- facilitating public enjoyment of the area’s special qualities, provided this does not
- conflict with the above objectives and
- raising understanding and awareness of marine ecosystems.

Marine Protected Areas (MPAs) are proving to be successful tools for the protection of natural resources, while providing numerous opportunities for the people who depend on the exploitation of these resources to benefit through the provision of sustainable livelihoods. While some of these areas have not yet been legally established, the designation of specific areas as MPAs, Marine Management Areas, and the active management of already declared Marine Reserves will contribute greatly to protecting the vital coastal and marine resources of Saint Lucia.

SAMPLE TEACHING AND LEARNING STRATEGIES

Activity 4.3a

Water Parks

This activity will help reinforce knowledge of marine and coastal resources, their uses and threats, and options for management and protection.

Activity 4.3b

The MPA Debate

Have an appreciation for the role and benefits of establishing marine protected areas (MPAs), and reinforce knowledge of stakeholder analysis and involvement in MPA management

MODULE 5: Sample School Based Assessments

by Motielall Singh, Curriculum Officer, Ministry of Education, Human Resource Development and Labour, Saint Lucia

INTRODUCTION

School Based Assessment (SBA) has been an integral part of the Caribbean Examination Council (CXC) programme in all the sciences except Human and Social Biology at the Secondary School level. This follows on the decision to discontinue the practical examinations. At the Primary level, it is a new initiative that has been introduced as part of the Minimum Standards Tests (MST) in Grades 2 and 4 in Saint Lucia.

This module is designed to highlight the importance of School Based Assessment (SBA) and to assist teachers in selecting appropriate activities for teaching and assessing the various practical skills required by each science syllabus. It contains simple activities related to one or more of the objectives set out by the previous modules or the Primary and Secondary schools` science curriculum. It also focuses on the need for consistent and objective assessment with general criteria laid out for moderating each skill.

Included are examples of how a given activity can be broken down into a number of discrete steps from which criteria for assessment can be selected. Mark schemes are also provided but the weighting given to specific criteria or sub skills being marked for any exercise are merely suggestions. Teachers may vary them to reflect particular emphases which suit the focus of their own work plans.

OVERALL OBJECTIVES

1. To understand the importance of School based assessment

2. To recognize that School Based assessment is an alternative form of assessment

3. To appreciate that School Based Assessment is a learning experience

THEMES

The module is divided into the following themes:

Theme 5.1: *Importance of School Based Assessment (SBA)*

Theme 5.2: *School Based Assessment as a form of Evaluation*

Theme 5.3: *School Based Assessment activities*

DELIVERY TIME

Expected time to deliver the module – Five (5) hours

THEME 5.1

Importance of School Based Assessment (SBA)

Objectives

- Understand the importance of School Based Assessment
- Recognize the advantages of School Based Assessment to teachers and students

Materials/ equipment

- Overhead Projector

Strategies

- **Activity 5.1a: SBA Importance**
  This discussion focuses on the general importance of School Based Assessment, highlighting its origin
- **Activity 5.1b: Advantages to students and teachers**
  This activity will outline the various advantages of doing School Based Assessment, pinpointing the benefits to both teachers and students

Delivery Time

- One (1) hour

THEME 5.1

Importance of School Based Assessment (SBA)

SBA Importance

School Based Assessment (SBA) has become an important component of many examining bodies because they have opted for continuous teacher assessment of practical and related skills. School Based Assessment (SBA) provides an alternate means of assessing student development and achievement. Students now have a chance to master the requisite skills before being assessed. Since assessment is based on class performance over a period of time candidates tend to get better grades.

School Based Assessment represents a set of strategies, which promote evaluation for learning through the performance of meaning practical task or experiments. Students should be encouraged to take an active part in assessment. When students are exposed to assessment criteria and procedures and take ownership for assessing the quality, quantity and processes of their own work, they develop self-assessing skills.

The School Based Assessment (SBA) should form part of the classroom teaching and learning and therefore not necessary **increase the workload of teachers**. It should be integrated with curriculum and instruction so that teaching, learning and assessing form a continuous process.

The School Based Assessment (SBA) for Grades 2 and 4 students, in the St Lucian context, refers to common tasks based from content area mainly in Science and Technology and Social Studies done at the Primary school level, supervised and marked by the classroom teachers. The weighting of this SBA component of the Minimum Standard Test (MST) examination will contribute 20% of the total assessment for each subject. Similarly, for the CXC sciences a set of between sixteen (16) to twenty (20) practicals must be done and assessed over a two year period, which will contribute to 20 % of the final examination.

SBA advantages to students and teachers

1. Teaches now have an opportunity they would not normally have, that is, they can assist in evaluating their students using practical activities and criteria of their own choice.

2. By providing students with regular practice and discussing corrections with the class, teachers can determine when their students have mastered a particular skill and are ready to be assessed.

3. Students know in advance the criteria by which each skill will be assessed.

4. Students are **not** evaluated on a single occasion when they might not perform at their best. Those students who do not perform well under the **stressful conditions of an examination** can improve their grades by the SBA.

5. Some skills which cannot be assessed under examination conditions, such as the ability to use simple pieces of apparatus and measuring devices (Manipulation and Measurement), can now contribute to candidates grades.

6. The careful preparation and execution of practical activities helps students to better understand and remember certain concepts reducing the time spent trying to explain them from a book or chalkboard

With the discontinuation of the practical examinations at the CSEC level, the SBA has assumed heightened significance as it is now the major means of assessing practical work. If the advantages outlined above are to be realized, practical work must be a regular component of teaching and learning in the sciences at all levels.

- **Points for the teacher**

The following ‘guidelines’ apply to maximize use of the SBA:

1. All practical work should be marked and feedback given to students.

2. Students must be familiar with the general criteria or guidelines for assessing each skill.

3. Students should be given adequate opportunity to practice a particular skill before being assessed for SBA.

4. Students should not be tested **under examination conditions** as this defeats the purpose of SBA.

5. Students need not be told which exercise will be used for SBA. All practical should be treated as equally important.

6. Simple tasks with clearly defined criteria should be used when a skill is being assessed.

THEME 5.2

School Based Assessment (SBA) as a form of Evaluation

Objectives	• To identify appropriate task for SBA practical • To recognize the importance of field trips • To appreciate basic guidelines for a field trip • To assess practical work
Materials/ equipment	• Overhead Projector
Strategies	• **Activity 5.2 a: Appropriate task for SBA practical** This activity will introduce and highlight some basic guidelines in selecting tasks for SBA practical • **Activity 5.2 b: Importance of field trips** This activity allows students to appreciate the benefits of field trips • **Activity 5.2 c: Preparation and Guidelines for field trips** This activity will help to reinforce some general guidelines for the execution of field trips • **Activity 5.2 d: Assessing SBA practical** This activity will assist teachers in selecting appropriate criteria for assessing students' practical
Delivery Time	• Two (2) hours

Appropriate task for SBA practical

To produce marks which accurately assess the syllabus objectives, appropriate activities must be selected which test the practical objectives as stated in the module or syllabus. This ensures that assessment is consistent with practicals chosen and valid. If the marks are to be reliable, then marking must be consistent and to the standard expected for performance at that level. In other words marking must be fair and in this case, to the expected standard. The teacher must be able to justify all the marks. This can only be achieved if, before the practical is assessed, the teacher carefully.

(i) analyses and plan the tasks to be performed,

(ii) develops detailed criteria for assessing selected tasks,

(iii) design a mark scheme which can be used accurately and consistently.

The task selected should not require elaborate preparation or **expensive apparatus and materials**. However, if they are to be used, like any other practicals, they can be varied to suit the objectives of a particular lesson, the abilities of a particular class or the physical conditions of a particular school. It must be emphasized that they should not be catering only for the **top students.**

Teachers are encouraged to experiment and not only sticking to known practicals or practicals with known results. There is little to be gained when students work towards getting the 'right' answers. In addition some skills can only be properly taught and learned by investigating genuine problems or situations.

Task selected should be interesting, worthwhile that relates to your instructional outcomes and allows your students to demonstrate what they know and can do. Appropriate tasks selected have to do with how successful the practicals are as outline below:

SUCCESSFUL PRACTICALS

Successful practicals are achieved if teachers are well prepared and the students know what is expected of them.

1. Check that all the necessary materials and apparatus are in place and accessible.

   There should be at least one set of apparatus for every four (4) to six (6) students in an ideal situation. Chemicals can be shared, one set for each workbench.

2. Group work is good but at least some of the time, each student should be able to work alone.

   Groups with large numbers tend to be taken over by some students while others are spectators. Monitor students working in groups so that the same students do not dominate all the interesting activities.

   <u>It is important that students each be given the opportunity to observe the results of all the experiments and to handle all materials even if they do not themselves perform all the activities.</u>

3. The aim of the investigation and the procedures to be followed should be clearly understood by all students.

   Copies of instructions can be prepared (one set per group) or the aim and method written on the chalkboard. If the class is not skilful in the procedures to be used this can be demonstrated before they begin to work.

4. Get students to collect and assemble their reagents and apparatus.

   If this is done according to the sequence of the instructions it will increase their efficiency and save time.

5. Practicals chosen should be simple but interesting.

   Try to arouse students` interest by giving them a genuine question to answer. This is necessary because the general practical found in many texts are so well known and the answers so obvious that they generate little interest in most students. They can be varied in a number of ways.

   For example, students already know that exercise increases the heart and breathing rate so have them find the percentage difference instead. They can them make accurate comparisons between different groups in the class, for example boys versus girls, different weights of students or active versus sedentary students.

Investigating whether it is valid to refer to beans as a 'perfect substitute for protein' is more interesting than just doing food tests on beans for no obvious reason. Ask them to comment on the relative make up of different compounds and not only on whether they are absent or present. This can be followed by a discussion on how the same tests could be used to make a more accurate or quantitative estimate, that is, a follow-up exercise in planning and design.

6. Students should be encouraged to record results directly into their practical books.

   The aim, method and apparatus can be written while they wait for results and tables drawn to receive results. If time does not allow the whole exercise to be done in class, the discussion can be completed for homework.

7. Observations should be recorded faithfully.

   The terms 'no change' or 'a positive/negative' result are unacceptable. Students should write down what they actually saw. For example 'the solution remained green'.

   Under no circumstances should students be encouraged or allowed to write up practicals they have not done or invent results. They learn little from this exercise and will be at a grave disadvantage in answering data-based questions which mainly set from practical activities.

8. Students should be encouraged to refer to the aim in writing up the discussion.

   The aim is the question set out for which they are seeking an answer. The discussion should state clearly what they found out and how they know their results are acceptable. This will include a clear explanation of the role of the control. For example,

   > "There was no starch present in the leaves of the plant which was not receiving sunlight. The plant which received sunlight (the control) made starch. This show that without sunlight plants cannot photosynthesize and make starch."

9. Students' practical books should be corrected regularly and marked as soon as possible.

    If students do not get feedback after a practical, they will make the same mistakes over and over again. If you are tight for time, mark a random sample of about a third of the books and discuss common errors with the class before the next session. The rest of the books can be marked when time allows.

Importance of field trips

Field trips can provide students with excellent learning experiences and opportunities at little cost to the student and the school. Field trips are of various kinds. Any trip which takes students away from the classroom and has a specific learning objective is a field trip.

1. Field trips need not be complex or costly and anywhere that learning can take place is worth a visit. This includes:
    - trips to beaches, rivers and rain forest
    - a farm
    - hospitals or health centres
    - agricultural or environmental agencies

    A journey to a hospital to see a dialysis machine or to a polyclinic to see basic laboratory techniques can focus student learning and give meaning to the teaching activities which normally takes place in school.

2. The spin off from a field trip may introduce students to new vocational opportunities or careers and studies related to the new technologies which now dominate these fields.

3. Field trips extend the classroom into the community and may permit teachers to innovate equipment their school cannot afford, for example making of a quadrat.

    Field work by its very nature cannot be taught within the classroom. Some field work is a must. A number of simple activities can be organized initially around the school yard. The overall benefits of a full fledged field trip cannot be over estimated.

    Field trips are means of observing and experiencing the real or living environment in action. Like all other teaching strategies, it should be firmly attached to a set of teaching objectives.

A properly conducted field trip:

1. Allows students to demonstrate a wide range of practical and enquiry skills.

2. Encourages appropriate attitudes towards the conduct of biological work and a demonstration of concern for the environment and respect for life.

3. Allows for participation of all students by using a wide range of the abilities and talents present in the group.

4. Provides examples of the different components of an environment and increases understanding of the interactions and relationships between the components.

A field trip arranged to study a plot of land experiencing stunted growth of plants, for example, one should be able to successfully examine the following:

- distribution of the plants
- the pH of soil
- animals present and their relationship to plants
- predator-prey relationships and food chains
- effect of soil and climatic conditions on organisms
- effect of man's activity

Follow-up activities should stress:

- the recognition of inter-relationships
- trends
- predictions of patterns of development and growth
- the consequences of varying activities to the particular environment

Organizing the class for this outing can be very challenging. This depends on the quality of the plan, arrangement and preparedness of all parties involved. It calls for the co-operation of enough teaching staff and/or parents/adults of the community to assist with supervision.

Preparations and Guidelines for field trips

Proper preparation is essential if students are to benefit from a field trip. The larger the number involved the more critical coordination becomes. Successful planning is the key. An appropriate plan should provide students with experiences which expand and reinforce their understanding of the environment.

Generally, there are four stages in planning a field trip:

Starfish washed ashore

(a) Student preparation
(b) Administration
(c) On-site visit and activities
(d) Follow up

Field trips are not just an outing but must focus on clear guidelines. Students must be prepared for the field trip, motivated and their input into the planning of the trip is important. The ideas from them should form an integral part of your plan.

1. Emergency Plan

   An outline of what you will do in case of an emergency is necessary. Your plan will depend on the nature of the activity but it is important to work out what you would do in advance. For example,

   - Note the nearest hospital or health centre, and police station to the site being visited.

   - Prepare a list of phone numbers to call if you need assistance.

   - Check alternate routes.

   - Have a phone number for contacting the principal, vice principal or teacher in-charge after school hours. In case of a delay, parents can be informed.

2. Supervision and control

   Set out clear guidelines for students concerning their conduct and dress code during the visit. Consider involving parents as well as other teachers. There should be at least one (1) adult for every 15 students. The Ministry of Education may have other regulations which should be followed.

3. Communication

   Good communication is essential. This includes a meeting point and time for those who ‘stray’ and a database of all phone numbers of persons on the trip.

4. Contact on arrival

   A brief orientation period will enhance communication and flow of activities. Remind students of the rules and the objectives.

5. Site Schedule

   Write up and circulate the activities and timing at the site. Ensure departure time is understood.

6. Returning Time

   Be on time. A late departure from the site can cause problems and concern at the parent level. If departure is delayed more than 15 minutes, contact the school and explain the problem. Check your register before departure.

The following important steps have been identified in terms of where the activities take place.

STEP1. IN THE CLASSROOM/LABORATORY: PREPARATION FOR THE TRIP

Discuss the objectives of the trip:

- Decisions on what to visit and investigate should be made with both teacher and students making input. Discussion should cover background material on factors pertaining to the whole area such as climate.

- Out of this discussion should come a series of questions which students might seek to answer as a result of observations made on a field trip.

- Include the locations to be visited, and what to look for. Provide stimulus materials such as pictures or video of the chosen site or similar habitats.

Outline the procedure to be followed on the trip

Students will need to be constantly reminded of this, but should know from the outset how they will set about getting answers to the questions identified on the trip.

Introduce students to useful apparatus and equipment:

- Long trip, rope or plastic coated clothes line
- Quadrat (1 or ½ metre square)
- Metre ruler/tape measure
- Hand lens and thermometer (optional)
- Suitable equipment for collecting specimens – nets, knives, plastic buckets, plastic bags and screw-top jars
- Ruled sheets for recording data

A quadrat

Students might need to make their own metre rulers, using strips of wood. They should also be encouraged to make their own quadrats. These can be made from string, wire or wood, depending on what is available. If a wooden frame is used, it can be held in place by four nuts, so that it is collapsible and easy to carry.

If a wooded area is to be investigated, then a larger quardrat, about $5m^2$ will be needed. This is best made of rope, knotted, or marked with coloured material at the required distances. A length of rope marked like this, is also useful for quick measurements of longer distances.

Give instructions on how to collect specimens:

This is absolutely essential, as one danger of this kind of activity, especially if the location chosen is heavily used, is that animals and plants are disturbed. This could lead to their eventual loss from the area. Use the opportunity to reinforce caring attitudes for the environment.

As far as possible containers carried on the trip should be of unbreakable material. Jars should have screw caps. Plastic bags suitable 'ties' are excellent for keeping plant material fresh for a day or two. Specimen jars and bags should include labels on which to note the exact site (quadrat/zone) where found.

It is useful to provide students with some help in identifying organisms in the field. This might be in the form of simple diagrams and keys.

STEP2. IN THE FIELD

Your first consideration, when taking students on a field trip, should be their safety. For example, if a trip is to the beach, river or a pond, there should be a sufficient number of strong swimmers in the group. Under no circumstances should swimming be allowed on any field trip.

Before work begins review any relevant safety regulations and emergency procedures with the class. Put one or more adults in charge of each group. Remind students to look out for each other.

Initial group discussion

At any chosen site, an initial discussion should focus the attention of the class on the overall picture. This discussion should arise out of general class observations if outstanding characteristics of the site.

Task assignment

Groups should be assigned to specific tasks for the collection of data:

- making physical counts of plants and animals
- looking for evidence of interrelationships like food webs
- drawing a 'map' of the site
- making temperature measurement of soil and air
- collection of soil samples and determining soil pH
- noting the effects of pollution.

In the field

Each group must have at least one person who records the information. Without this, information tends either to be lost and challenges in compiling an accurate report for the field trip.

This is only one example of how group work may be assigned. Teachers are encouraged to use whatever format is appropriate for their situation.

STEP3. IN THE CLASSROOM/LABORATORY

Follow-up work after the trip

This phase of the work is one in which students usually need much guidance and encouragement. The motivating excitement of the trip itself will have passed and the work can be detailed.

(a) Living specimens should be sorted, further examined and discussed.

(b) Plants and animals should be classified and adaptations to their respective environments noted.

(c) Soil should be examined for animal life, and investigations done to determine some of its characteristics, for example, estimation of its humus content, drainage or water holding capacity.

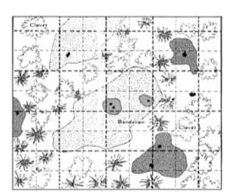
Exercises should challenge the students and the purpose of these activities is to enable them, through a closer look at the soil and living things in an area, to form some conclusions as to why the area studied supported the particular relationships which they observed.

Preparation of a Permanent Report

This helps to improve students' communication skills, and to fix what they have seen in their minds.

The record might include:

(a) a written outline of steps or procedure in the investigation
(b) charts and/or histograms to illustrate the relative numbers of species
(c) recordings from transects to show the zonation or distribution of vegetation
(d) pressed plant specimens and preserved animal specimens
(e) diagram to illustrate interrelationships of organisms
(f) a sketch of the area to pinpoint the chief physical aspects of the site
(g) An analysis of the effects of man's presence in the area



Sketch of a quadrat

Display/Exhibition

A display of the material produced at step 3 (b) might be arranged. Other members of the school community or other educational institutions might be invited. Class members can take turns to explain the exercise any visitors. This builds their confidence and interest in what they have done. The questions asked would generate ideas for future work.

Other ideas
Variations on this type of field activity include:

(a) Comparing two sites
(b) A long-term study of a nearby plot over a period of six months or a year, as might be feasible.

The basic approach would be the same as outline above. These types of studies make it easier to isolate patterns, especially those related to man's interference.

Studying an environment over time will help students to appreciate how the numbers and species present respond to changes in order to maintain a balance.

A display of findings to which the community is invited is an effective way of increasing their understanding of the local environment and helps to inform them of preservation practices.

Assessing SBA practical

Practical investigations are an integral part of any sciences. Students doing the sciences are required to master certain practical skills laid out in the curriculum. Each of these must be assessed on a regular basis for submission to the examining body. This means that students must be given practice in acquiring these skills before they are formally assessed.

Assessing SBA task, there are certain practical skills that must be considered as outlined below:

1. **OBSERVATIONS/RECORDING/REPORTING (ORR)**
   In assessing this group of skills the teacher is evaluating the students` ability to make and record observations and then report them faithfully. The report should be clear and accurate enough that someone who did not see the original observation or investigation

can understand what took place. It is important to focus on the accuracy of the report. Allowing or teaching students to report on work they have not done, or make observations which they have not seen themselves is counter-productive.

2. **MEASUREMENT AND MANIPULATION (MM)**

This is the ability to use apparatus and handle organisms, chemicals and other materials in class, laboratory or the environment. If these skills are not mastered investigations cannot succeed and to be efficient in the practicals, students need practice and training. Manipulation and measurement are best assessed using observation checklists which must be prepared prior to the investigation. It is advisable not to assess more than 10-15 students at anyone time, for example, a class of 30 students, while one half is being assessed the rest can be given another task, like drawing of specimen.

3. **DRAWING (DR)**

Drawings are useful in recording observations made on biological specimens and also help to increase students` ability to see details and accurate relationships between the parts of the specimens. Assessing drawing is an easy way to teach structure because students remember what they actually seen and investigated themselves much more than what is illustrated or described in a text. Additionally, it`s advantageous to the teacher because drawing lessons are usually easy to plan, students are engrossed and the classroom is fairly quiet.

4. **ANALYSIS AND INTERPRETATION (AI)**

This skill is achieved by the students analyzing or discussing the results of the practical carefully, comparing experimental data with that from the control and interpreting the results to what is already known. For students to master this skill they should be given practicals for which the results are not known before, so they can have enough practice in drawing conclusion based from results obtained.

5. **PLANNING AND DESIGN (PD)**

This skill is generally easy to assess but very challenging to teach. Students can only become proficient in this skill when they can recognize a problem, formulate a hypothesis, come up with a possible plan, choosing appropriate materials, and appropriate controls to test hypothesis. Students should also able to explain what results are expected and discuss the limitations of the plan.

THEME 5.3:

School Based Assessment activities

Objectives

- Provide samples of SBA activities
- Plan and design SBA activities from the previous four (4) modules

Materials/ equipment

- Flipchart paper
- Markers

Strategies

- **Activity 5.3 a: Sample SBA activities**
  This is an outline of some sample practical activities based from students` work
- **Activity 5.3 b: Designing and Planning SBA activities**
  This activity allows students to work in groups designing and planning practical activities from the modules.

Delivery Time

- Two (2) hours

Sample SBA activities

Sample 1: Making Observations

Aim of activity:

- To identify and classify the organisms found in one metre area of the school yard.

Apparatus/materials:

- Hand lens
- Forceps
- Petri dishes
- Note book
- Pencil

PLACE:	NAME OF SITE	
DATE:		
TIME:	QUADRAT 1	QUADRAT 2
Number of different kinds of flowering plants		
Names of flowering plants		
Number of different types of grasses		
Names of grasses		
Number of different kinds of minibeasts		
Names of minibeasts		

Tabulation of results

Task analysis/procedure:

- Find and examine the specimens collected
- List the external features of each organism
- Group them according to similarities
- Make a key to distinguish between organisms

Criteria for assessment:

- Accurate list of features of organisms found
- Accurate groupings using observed features
- Presentation and accuracy of key designed
- Identification of distinguishing features

Mark scheme:

- All 4 criteria properly done - 5 marks
- 3 criteria well done - 4 marks
- 2 criteria well done - 3 marks
- 1 criteria well done - 2 marks
- No criterion well done - o mark

Maximum – 5 marks

The mark scheme can be adjusted to suit a particular purpose or situation. Also any one of the criteria can be used on its own for detail assessing.

Sample 2: Assessing Measurement and Manipulation (MM)

Aim of activity:

- To investigate the distribution of different variety of weeds in a lawn

Apparatus/materials:

- One quadrat per group
- Twine/string/rope
- Notebook/pencil
- Short sticks/flags as markers

Task analysis/procedure:

1. Mark off area to be studied using string and flags
2. Draw a sketch of the marked area
3. Examine and note any particular features of the area
4. Locate starting point from which quadrat will be thrown
5. Throw quadrat over shoulder or with eyes closed
6. Mark relative position of quadrat on sketch map
7. Examine area within quadrat carefully
8. Identify different weeds and count numbers present
9. Record species and numbers in a table
10. Repeat steps 5-9 at least five (5) times
11. Calculate the density of each species.

Criteria for assessment

Using of apparatus – the quadrat

- Appropriate system used to ensure randomness for each throw
- Quadrat thrown horizontally
- Quadrat used safely, that is, no harm to other students
- Number of throws adjusted to accommodate characteristic of site
- Located area closely examine

Mark scheme:

- Quadrat thrown randomly - 1 mark
- Quadrat thrown horizontally - 1 mark
- Quadrat used safely - 1 mark
- Adequate number of throws - 1 mark
- Counting carefully - 1 mark

Total – 5 marks

At least two (2) throws should be observed and marked for an accurate assessment.

Sample 3: Assessing Planning and Design (PD)

Aim of activity:

- To plan and design an investigation into the factors affecting the distribution of small animals under a tree.

Observation:

- From an investigation under a tree, it was observed that the number and variety of invertebrates were greater under the tree than away from the tree.

Task analysis/plan:

- List all the factors which might contribute to the distribution of the invertebrates
- Choose one of the variables listed and formulate a hypothesis which might support the observation
- Design an appropriate plan to test the hypothesis. The design should include:
- Aim consistent with hypothesis
- Apparatus/materials are suitable

- Plan with an appropriate and logical sequence of steps
- Suitable control
- Describe the results expected
- State the limitations of the method

Criteria for assessment:

1. Contributing variables listed – for example, differences in light and temperature.
2. Hypothesis clearly stated so it is testable – for example, invertebrates prefer shaded area because of its lower light intensity.
3. Aim appropriate to hypothesis – for example, to investigate the response of shaded invertebrates to different light intensity.
4. Appropriate apparatus/materials – for example, 3 different wattage bulbs (5, 20 and 40), four (4) cardboard boxes of equal sizes and shape, twenty (20) or more of each of the invertebrates found in the area, garbage bag, masking tape and four (4) covered dishes.
5. Reasonable and logical sequence of activities – for example, cut one small opening in the first three (3) boxes through which a light bulb can fit. Place the different wattage bulbs connected to a switch in the opening of the first 3 boxes. Leave undisturbed in the same place for the same time (15-20 minutes). After time elapses, compare the distribution of the invertebrates in each box.
6. Control described – for example, completely darkened 4th box.
7. Limitations stated – for example, temperature may change during the activity because of heat from the bulb. Temperature may rise due to the box being enclosed.
8. Expected results described – for example, organisms will huddle on corners away from the light.

Mark scheme:

- Criteria 1, 2, 3, 4, 6, 7 and 8	- 1 mark each	7 marks
- Criteria 5	- 3 marks	3 marks
	Total	10 marks

Designing and Planning SBA activities

1. Class break up in four (4) groups
2. Group will choose/select a leader
3. Each will be assigned a module (1-4) based on choice or preference
4. Each group will come up with ONE activity
5. Groups will plan activity to include the following:
    - Aim of activity
    - Apparatus/materials
    - Task analysis/procedure
    - criteria for assessment
    - mark scheme
6. Group leader present activity to class for discussion
7. Group make necessary changes
8. Activities added to Module five (5)

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BEACHES: http://www.unesco.org/csi/act/cosalc/hur5.htm

CORAL REEFS: http://www.reefresilience.org/

OCEANOGRAPHY: www.noaa.gov

SCIENCE TEACHER RESOURCES: www.nsta.org

INVASIVE SPECIES: http://www.cabi.org/

ORGANISATIONS:

Saint Lucia National Trust - http://www.slunatrust.org/

Department of Fisheries - http://malff.com/

The Nature Conservancy - http://www.nature.org/

Caribbean Marine Protected Area Network and Forum (CaMPAM) - http://campam.gcfi.org/CaribbeanMPA/CaribbeanMPA.php

UNEP-Caribbean Environment Programme - http://www.cep.unep.org/

APPENDICES

Sample Teaching and Learning Strategies

Activity 1.1a

Climate Change and the Ocean

In this activity students investigate the chemical properties of seawater and discover how these properties can be impacted by climate change.

By the end of the activity students will:

1. Know how to measure the pH of seawater
2. Understand that pH in water is lowered with the addition of Carbon dioxide
3. Appreciate the effect of climate change on select properties of seawater
4. Understand the effects of a lower pH on the calcium carbonate exoskeleton or shells of marine life
5. Be able to describe the impact of certain effects of climate change on marine life

Procedure:

The teacher can perform these demonstrations or give it to students to do in groups and evaluate their performance and answers.

Part 1.1a:

How can acids affect marine life?

Activity: Egg in Acetic Acid (a.k.a. Vinegar) Demonstration.

This demonstration shows the effects of an acid on organisms.

Materials: Large Jar, Egg, and Vinegar (Acetic Acid)

1. Observe what happens when an egg is placed in a jar of vinegar and record your observations

Close the jar and leave it overnight.

Next day: Remove the egg from the acid and place it in a dish.

2. What happened to the calcium carbonate shell of the egg in acid?

An egg contains all of the chemicals (proteins and other materials) needed to make a chicken.

3. What did the acid do to these materials after the eggshell has been broken down?

In a way, an egg is like many marine creatures. Its living material is covered with a carbonate shell.

4. List as many sea creatures as you can think of that have Calcium Carbonate (a.k.a.limestone) shells or exoskeletons?
5. What could happen to the exoskeletons of these animals if the pH of the ocean were to be lowered?
6. What does a lower pH do to the proteins and other materials that make up living things?

Part 1.1b:

How do the oceans become acidic?

Activity: Carbon Dioxide and pH in Water

Materials: Water beaker or clear plastic cup, drinking straw

Aquarium pH test kit solution crushed coral or seashells

Pour about 50 ml of water to a clear plastic cup or beaker

Next, add a few drops of pH indicator solution (from an aquarium pH test kit) to the water and mix it with a straw.

1. Record the colour and pH of the solution. colour:_______________ the pH is _____

Slowly!!! exhale through the straw into the water with pH indicator solution until you notice a colour change?

2. Describe the colour change of the solution
3. What is the new pH of the solution? ______
4. What gas are you adding to the solution as you exhale? __________
5. What does the addition of carbon dioxide gas do to the pH of water?
6. Describe how the addition of carbon dioxide can lower the pH of the seawater?

This is “acidification.”

When CO_2 is added to water it forms Carbonic Acid (H_2CO_3)… (do the math)

$$CO_2 + H_2O = H_2CO_3 \text{ Carbonic Acid}$$

Add some crushed coral or seashells to this solution and swirl it around slowly for several minutes. (Eventually you will notice a colour change).

7. What is happening to the pH of the solution as the coral or seashells are added?
8. What compound are these exoskeletons?
9. What process used by plants can remove carbon dioxide from water?

Discussion questions

1. What is ocean acidification?
2. What is causing our oceans to become more acidic?
3. What are the reasons for the increasing levels of CO_2 to our environment?

Subject Area:

Chemistry, **Geography**, Biology and Integrated Science.

Activity 1.2

Salinity and Deep Ocean Currents

Deep ocean currents are caused by differences in water temperature and salinity. In this experiment, students develop a model to explain the role of salinity and density in deep ocean currents.

This lesson plan was developed by NSTA master teacher Jerry D. Roth through NSTA's partnership with NOAA.

By the end of the activity students will be able to:

1. The student will carefully pour different solutions into a basin that shows how the different solutions can model layering in the ocean.

2. The student will observe that waters of different temperatures can layer according to their respective temperature, with hot water rising above colder water.

3. The student will observe that waters with different salinity will layer according to their respective salinity with more saline water being more dense than that of lower salinity.

4. The student will recognize that the effects of salinity and temperature are the root cause of thermohaline layering in the ocean.

5. The student will combine the results of the two separate exercises and predict which of the conditions might prevail.

Procedures/Instructional Strategy:

- Divide students to work in groups of two to complete the activity.

Materials and Equipment:

Materials and equipment shared by the entire class include triple–beam balances or other reasonably accurate scales, roughly a pound of table salt, and food dye in two colours. I recommend red or blue dye. Each pair of students should have a clear plastic shoebox. The plastic shoeboxes are readily available in most "Dollar Stores." They generally come with lids and I find them useful storage containers when not being used for this lab. Each pair of students also needs two 500 ml beakers for mixing and pouring their solutions. All students need a quantity of ice to chill their solutions and a source of hot water.

Step 1. Making the solutions:

Mix 2 litres of saltwater solution and pour into the shoebox for the temperature test. If your shoeboxes are smaller, use less solution. The saltwater solution is made by dissolving 35 grams of NaCl into a litre of room-temperature water. This roughly approximates the salinity of seawater at 3.5%. Additionally, each pair of students needs a minimum of one more litre of room–temperature solution for the experiment regarding water temperature.

Step 2. Temperature Test

(a): The first test involves having students create 500 ml of hot and 500 ml of cold seawater. The cold water can be made by chilling a beaker of the "seawater" in an ice bath for 10 to 15 minutes.

(b): The warm seawater can be made by warming the solution on a hot plate or using hot tap water to make the solution.

While the solutions are changing temperature, ask the students to predict which of the waters will rise or sink when gently poured into the room-temperature solution and record their prediction in their lab notebook. This test is fairly direct and most students may predict that the warm water will rise over the colder water.

(c): Once the solutions have reached temperature, add a few drops of different colored food colouring to each solution. I prefer red for hot and blue for cold.

(d): Have the students gently pour the contents of each of their beakers into the opposite ends of their shoebox. Allow time for the solutions to settle.

Caution: If the beakers are poured into the shoebox too quickly the solutions will mix. Otherwise, have the students note the layering that resulted and compare the layering results to their earlier predictions.

Once the students have finished observing the layering and made notations in their notebooks regarding their observations, have them discard the solutions in the drain and rinse their shoebox for the next test.

Ask the students to list where in the ocean sources of warm seawater and cold seawater arise.

Step 4. Salinity Test - The second test is a little more complicated to predict.

(a): Have all of the students make a litre of “regular” (35 grams NaCl per litre of water) seawater and pour it into their shoebox.

(b): Have half of your groups make seawater that is ¼ as salty as “normal” sea water by mixing 8.75 grams of salt per litre of water. I have students colour this solution blue.

(c): Have the other half of the groups make seawater that is 4 times as salty by dissolving 120 grams of salt in a litre of water. Colour this solution red.

(d): Ask the students to share half of their solutions with a group that has made the other solution. Make sure their solutions are clearly labelled.

Have the students record their predictions about which layer will rise to the top; the hypertonic (greater or more than) solution, the isotonic (same as) solution, or the hypotonic (under or less than) solution. Have the students record the reasoning for their prediction regarding their prior knowledge of density.

Step 5: Direct the students to carefully pour the contents of the beakers of hyper and hypotonic solutions into opposite ends of their isotonic shoebox and observe the layering.

Caution: If the beakers are poured into the shoebox too quickly the solutions will mix. Otherwise, have the students note the layering that resulted and compare the layering results to their earlier predictions.

Does the layering match the predictions? Have the students offer a reasonable explanation as to why their predictions where right or wrong.

Ask the students to record where in the ocean water that is more salty than seawater may exist and where water that is less salty than “regular” seawater may exist.

Step 6: Finally the students should predict which is more important to the layering: temperature or salinity. Ask the students to propose a test that might determine which is more important. My recommendation is simple: Have the students test the temperature solutions with the solutions of different salinity. Ask them to report their results in a summary of the lab on the accompanying sheet.

Outcome/Assessment:

A straightforward assessment of this activity involves students explaining what they observed during the lab. A formal write-up may be acceptable but the important factors in this lab are:

1. How does salinity affect ocean layering?
2. How does temperature affect ocean layering?
3. Which has a greater impact on the oceans, salinity or temperature?

If you would like the students to complete a follow up to the lab, they should look to the website listed in the extension section, which contains a tutorial regarding the concept.

Extension:

This lesson also directly applies to the theme regarding the sun and its effect on the ocean since it is primarily the sun that heats the oceans and not the Earth's internal temperature. Because warm water rises to the surface and currents are affected by wind and the Earth's rotation, the students should be able to see and perhaps understand the connection between deep ocean circulation and weather. Variations in a Salty Ocean contains an activity that allows the students to look at actual data and make their own predictions of the interactions of salinity and temperature.

Internet Resources:

Deep Ocean Currents, Surface Ocean Currents are the keywords and the URLs include:

- A CURRENT is a CURRENT by ANY OTHER NAME, BUT WHAT is a CURRENT?
- Thermohaline Circulation
- Variations in a Salty Ocean
- JHU/APL Ocean Currents Website

Classroom Resources:

Provide a list of materials, consumables, and any physical equipment, including the total number of computers if using an entire lab, single computer station, LCD, speakers, etc., that a teacher looking to replicate your lesson would need. If your lesson also includes a hands-on component, please include all equipment necessary.

At least 4 scales to measure salt
1 plastic shoebox for each pair of students
1 lb of salt (table salt is adequate)
2 colours of food colouring for comparing the different solutions
One 1L beaker and two 500 ml beakers per pair of students
Sufficient quantity of ice to cool solutions
Heat source to warm water or hot tap water.

Holt, Cold, Fresh, and Salty - Student Worksheet

Name:______________________ Date:_______

1. Write your predictions for the hot and cold water test:

2. Did your prediction match the observed results of the test?
3. Describe your results in terms of the density of the solutions.
4. Record your predictions for the salinity water test:
5. Did your prediction match the observed results of the test?
6. Describe your results in terms of the density of the solutions.
7. Plan and execute a simple experiment that attempts to show which of the factors, temperature or salinity, has more of an impact on ocean layering.

Subject Area:

Primarily aimed at the geosciences, this is also valid with physical science and/or introductory chemistry.

Activity 1.3

Sea Turtle Nesting Game

In this activity students build a board game and play it to observe how marine animals face many natural and human dangers. As such they learn that it is critical that we help protect their habitat to allow their population to thrive.

By the end of the activity students will:

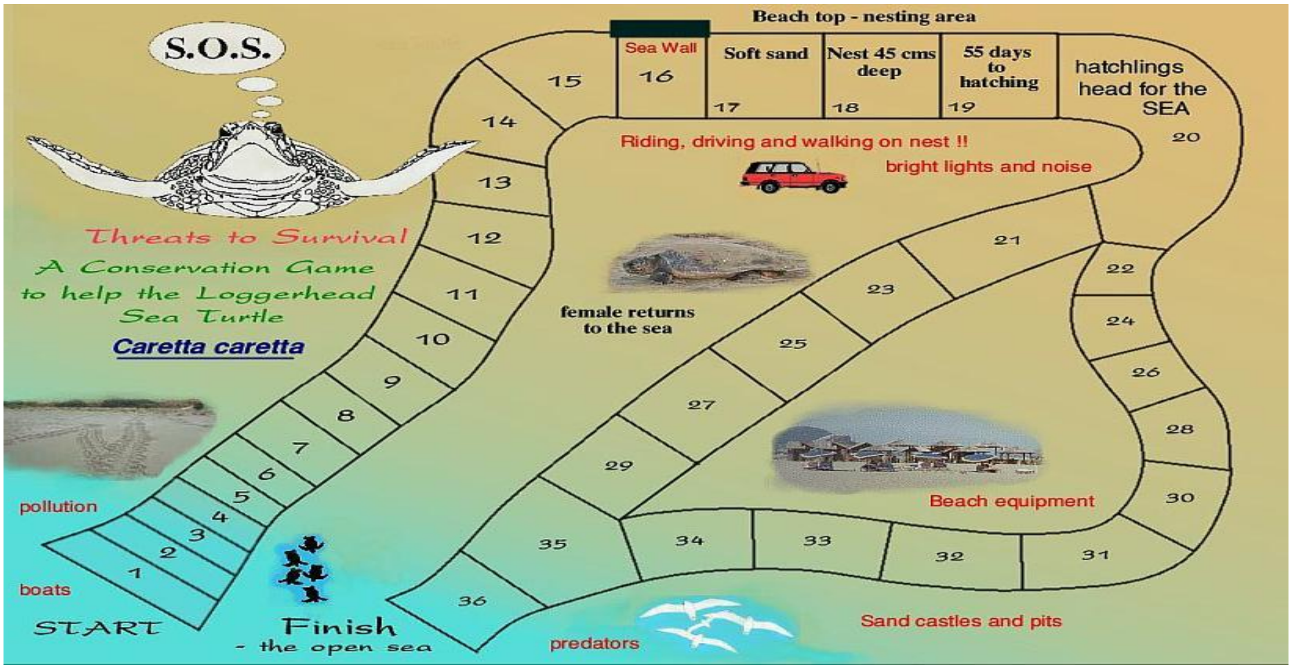
1. Know the threats to sea turtles
2. Be able to identify practises that may hinder the survival of sea turtles
3. Understand that the survival of a species depends on many factors

Procedure:

> Ask students to identify all the human practises that can harm sea turtles and their babies /hatchlings), for example: driving on the beach and putting plastics in the sea water. Then, ask the students to list the practises that can help sea turtles survive, for example, shielding it from artificial light and using fishing gear that allows them to escape. Also, discuss the natural factors that can harm sea turtles, for example, predators such as crabs on the beach and fishes in the sea. Based on all three lists ask students to create a game starting with baby turtles hatching and trying to survive to mature sea turtle that come back to lay on the beach. Or they can create the game so that the person with the sea turtle that hatches the most baby turtles and gets them back to the sea safely is the winner. If a draw, the turtle that does it most quickly will win.

You will miss a turn or step backwards or lose hatchlings if you encounter harm to the turtles. And you will step forward or gain an extra turn if you encounter something promoting the survival of the sea turtle.

Students can create small board game or really large games. They can even incorporate playing cards and mathematical equations for more interest. Let the students express their creativity. Here's an example of a game:



Subject Area:

Environmental Science, Biology, Craft, Mathematics and Language Arts.

Activity 2.1a

Mangrove Habitat

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

By the end of the activity students will be able to:

- describe the different relationships that occur in a mangrove ecosystem—water cycle, food chains;
- define the words **habitat**, **mangroves**, **salinity**, **detritus**; and
- list the basic requirements all living things need to survive.

Preparation:

Create a felt board divided as follows, from the top down:

- ✓ blue sky in the upper section
- ✓ an area of high land (bluff), coloured grey or black
- ✓ an area of savanna, coloured green
- ✓ soil, coloured brown
- ✓ shallow water, coloured light tan
- ✓ shallower ocean, coloured blue-green
- ✓ deeper ocean, coloured darker blue

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

- a sun (to represent energy source)
- a cloud or two (for discussing the water cycle)
- mangrove trees—red, black, white, and buttonwood
- saltwort and sea grass
- animals that fly and live in the trees—e.g. boobies, frigatebirds, Yellow-throated
- Warblers, herons, pelicans, Ospreys (merlin or fish-hawk)
- reptiles that live in the trees—anole lizards and frogs
- spiders and insects— such as mosquitoes, dragonflies, and bees—that live in the trees and fly in the air

- animals that live in the mud and dead mangrove leaves, such as clams, oysters, sponges, sea squirts, snails, crabs (fiddler and mangrove), worms, amphipods, and water striders.
- animals that live in the water (young, getting older towards the deeper water) such as turtles, barracuda, snapper, flounder, shrimp, upside-down jellyfish; birds such as West Indian Whistling-Ducks, herons, stilts, snipes, and other shorebirds

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

In the classroom:

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

Discussion/Reflection:

Tell the following story, using the felt board and cut-outs to illustrate what you are saying. Involve the students by encouraging them to answer your questions. (Correct answers, along with suggestions to the teacher, are in italic type, in square brackets.) Teachers can adjust to story to suit students age range or to increase the scope of information.

Mangrove Story

DOES ANYONE KNOW what mangroves are? Mangroves are amazing plants—they're trees, really—that grow in salt water on the edge of the ocean. In a few moments we will see how important the mangroves are as habitat.

Sphyraena Barracuda, the Great Barracuda, was born from an egg tucked away safely behind a cluster of Red Mangrove roots. As he grows, before he moves to the reef where he will establish his territory and spend the rest of his life, he lives among those same mangrove roots. What a strange world to grow up in, but what an exciting place to explore! And there's so much to eat—hundreds of pinfish and mojarras in silvery schools. Still and silent, Sphyraena Barracuda waits in more open water for a small fish to stray from the school; then, suddenly, he snaps it up for a tasty meal.

But Sphyraena Barracuda is only six inches long, and there are others who would like to make a meal of him. From the surface of the water, he catches a glimpse of a slow-moving shadow.

What do you think it is? *[A great blue heron.]* Where would be a good place to hide? *[Among the roots of the Red Mangrove. Briefly describe life in the mangrove roots and why it is so productive.]* What other animals might we see here that would use the shelter of the Red Mangrove roots? *[Ghost shrimp, mangrove crabs, fiddler crabs, young lobsters, amphipods, and isopods.]*

"Hmmm . . . looks like there are some interesting things to eat here," says Sphyraena Barracuda, as he spies a tasty ghost shrimp. The amphipod and the ghost shrimp use the mangrove roots for shelter, but they also find lots of food to eat in the muddy layer of ooze underneath the dead mangrove leaves, called **detritus**. Where did this rich stuff come from? It is made up of dead and decaying plants and animal material that have fallen from the mangrove trees and flowed down from the land when it rained. There is a good supply of invertebrates here in this rich habitat, and the barracuda's survival depends on this healthy aquatic habitat.

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

- ***Food***—The barracuda eats tiny fish, fry, and some aquatic insects like isopods and amphipods.
- ***Shelter***—The Red Mangrove roots give the barracuda a place to hide and find food, and also shelter the food the barracuda needs.
- ***Water***—All animals need a good supply of water. In the years when there is drought, barracuda sometimes find it hard to make it back into the mangroves to lay their eggs. Also, the water flow into the mangroves carries much of the rich sediment we call detritus, which is necessary for a healthy ecosystem.
- ***Space***—The barracuda needs adequate space. If a species is overcrowded, there is too much competition for food, and the animals become stressed.
- All these factors make up habitat.

Subject Areas: Science, language arts, art

Activity 2.1b

Secret Mission

This activity provides students to investigate the mangrove forest and learn about the forest by discovery in a fun filled way.

By the end of the activity students will be able to:

- Determine and identify the different types of mangrove species in Saint Lucia
- Identify the different distributions of mangrove species and the types of mangrove forests.
- Identify and describe the role of mangrove forests in the ecosystem.

Preparation:

Teachers can have another teacher get disguised as a secret agent. He/she will give the students the "secret mission". Print out the mission instructions and put it in a folder marked "TOP SECRET". You will make arrangements beforehand to conduct field visit to a mangrove forest.

In the classroom:

During a lesson on mangrove forests or a lesson right after the topic you will arrange to get a surprise visit from the secret agent when you discretely excuse yourself from class for an urgent matter. The secret agent will provide the students with the top secret folder and mission instructions. Then she/he will leave the class before your return.

SECRET MISSION:

Your mission is to investigate the mangrove forest – if you chose to accept.

The Indo-Malayan Council of Mangroves is made up of about 35 true mangroves and 60 or more mangrove-associated species. They have received reports that the mangrove is an imposter and are threatening to remove is designation as a marine reserve.

The report claims that there are no mangroves in this forest and as such the forest should no longer receive protection as a Marine Reserve. Can you help me prove that the mangrove forest is a mangrove forest, and protect is status as a Marine Reserve? I will be on another top secret mission and I need YOUR help to investigate!

I will divide you into two teams each team will be provided with some secret agent tools – a camera, binoculars and evidence bags. The BEST team will go on to present their findings to the Indo-Malayan Council. Be careful – your guides are suspected of being SPIES; they may sabotage your work if they know!

I will return on INSERT DATE AND TIME***. You will have 20 minutes to present your findings to me – the aim is try to convince the council to retain the mangrove as a marine reserve. Will you accept this mission? The future of the mangrove forest is on your shoulders – DO NOT LET US DOWN!***

Investigator Guidelines:

1. What species of mangroves are located in the Mangrove Forest?
   a. Provide physical evidence of these types of mangroves.

2. How are the species distributed? Are there any distinct zones?

3. What type of mangrove forest is the Mangrove Forest?

4. Mangroves have special adaptations to live in their environment

   a. Provide evidence that their environment is adverse.
   b. Provide evidence of adaptations to this adverse environment.

5. Does this mangrove have a role in supporting marine life? Provide evidence.

Discussion/Reflection

When the students go out to their planned field trip allow them to “investigate”, collecting evidence (e.g. mangrove leaves, pictures etc) to return to the classroom for their presentation to the Council. The presentation will allow students to show what they have learnt.

Subject Areas: Drama, Science, Literature

Activity 2.1c

Beach Zones and Profile

In this activity students explore the beach. They students design beach profiles, inspect marine life, and examine natural beach habitats.

By the end of the activity students will be able to:

1. Identify and separate the different zones of the beach by observation of various visual characteristics.
2. Understand that the zones of the beach respond to weather, waves and human actions.
3. Draw conclusions about how beaches work.

Procedure:

Preparation:

1. Organize a visit to nearby seashore with students to observe the different aspects of the shore, such as: shore type. Include a walk along the seashore with the students giving them a guide on what to do. The guide could include observing the following:
   a) Type of shoreline,
   b) Shape of the shoreline,
   c) Types of animals observed (alive or dead). Establish why?
   d) Types of plants observed (alive or destroyed). Why?
   e) List of observable human activities, including any harmful activities.
2. Establish teams of three students. Each team will have a "**seaward surveyor**", a "**landward surveyor**", and a "**data recorder**". The "seaward surveyor" is responsible for holding the seaward stake and ensuring that the rope is level between the two stakes (by sliding the loop up or down) when fully extended. The "landward surveyor" is responsible for holding the landward stake, sighting over the seaward stake to the horizon (as described in Appendix X), and shouting out the measurement (cm down from the top of the landward board) to the "data recorder". The "data recorder" should keep organized notes of each measurement including **horizontal distance (x), measurement of change in elevation, and (a), cumulative change in elevation of all measurements.** Students are encouraged to rotate positions within the team so everyone has experience with each task.

In the classroom:

3. Students are to develop data sheets to capture their information. Include names of people in the team profiling that day, the date, time, profile name and number, beach location, etc.
4. Students are to build a set of "Emery boards", the materials needed are two pieces of wood of equal length and a rope of known length. (Boards of 6-8 feet length will work well.) Tie a loop in each end of the rope, which can easily slide up and down the two boards. Measuring down from the top of each board, use a marker and a ruler to draw and label the "graduations" (marks of equal length). It is recommended that SI (system international) units are used for the exercise – an appropriate graduation interval is every two centimeters.
5. Explain to students the purpose of beach profiling:

   Beach profiling is a simple survey technique used to measure the contour of a beach. A beach profile or cross-section is an accurate measurement of the slope and width of the beach, which when repeated over time, shows how the beach is eroding or accreting. Long -term beach monitoring data is the first step to understanding complex beach processes. This information, combined with ocean current and wave data, helps scientists to better understand how fast and why our beaches are changing.

In the field:

1. Ask students to draw an aerial map of the beach, detailing the shape of the shoreline, the locations of the different zones (inshore, foreshore, backshore etc.) and other relevant information such as the presence of human activities that can interfere with the natural beach processes.
2. Set up a reference/control point at the back of the beach to be used to establish the beach profile. Each group will use the same reference point.
3. Students are to design the beach profile (See Appendix X for method).
4. Have students make observations of the types of organisms that live at the different zones. Ask them to draw conclusions as to the adaptations necessary for them to survive within each zone.

Data analysis:

1. Using the data of the beach profiles recorded by the class, the first step is to plot the cumulative vertical elevations (y-axis) as a function of horizontal position (x-axis). This will reveal the actual beach profile. It will also be valuable to plot slope against

horizontal position as a measure of steepness. Slope is calculated by dividing the difference in elevation between any two adjacent points by the difference in horizontal distance between those two points.

TIP: *At first, the beach profile data may not appear to be very exciting – about like a horizontal line, if the horizontal and vertical scales are equal. This provides an opportunity to employ a common technique of geologists, geographers, and cartographers (map makers) called "**vertical exaggeration**". To employ vertical exaggeration, simply alter the vertical scale by a chosen factor (for example, a factor of 10) to accentuate subtle topographic features.*

Recommended Resources:

Personnel: Coastal Zone Management Unit, Department of Fisheries

Subject Areas: Biology, Mathematics, Geography

Activity 2.2a

Seagrass Community **(adapted from Seagrass Watch Activity Book)**

In this activity students inspect seagrass species found in Saint Lucia, learn how to monitor seagrass beds and see how seagrass beds are important in food webs.

By the end of the activity students will:

1. Identify and distinguish the different species of seagrass in Saint Lucia.
2. Be able to appreciate the extensiveness of seagrass beds.
3. Understand the importance of seagrass beds in food webs.

Preparation:

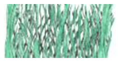
1. Working with a representative from the Department of Fisheries, obtain a sample of the seagrasses in Saint Lucia, this could also be incorporated a field trip with students.
2. Students are to be provided with the following information in addition to the sample of seagrass species. Seagrass plants have roots, stems and leaves. The roots can be simple or branching, and have fine hairs to help absorb nutrients. Rhizomes form in segments with leaves or vertical stems called shoots rising from the joins, which are called nodes or scars. Sometimes the leaves are on a stalk, called petiole. Seagrass have veins and air channels in their leaves and stems, so they can carry water, food and gases. Veins can be across the leaf blade or run parallel to the leaf edge.

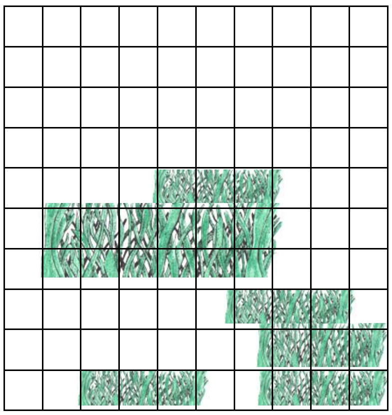
In classroom:

1. Ask students to draw each seagrass sample and to label the parts using the following words:

Rhizome, Leaf blade, longitudinal leaf vein, cross vein, leaf tip, branching roots, simple roots

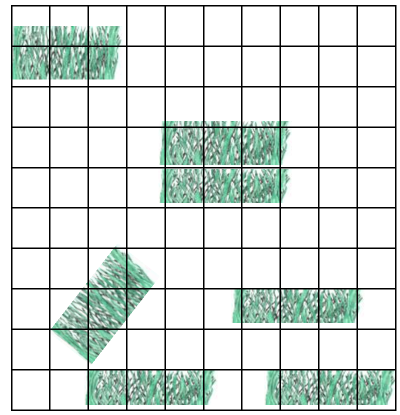
1. Using Table X in Theme 2.2 ask the students to identify each type of seagrass.
2. We can see if seagrass is healthy by monitoring them overtime – this is called monitoring. One way we can monitor is to measure the amount of seagrass in an area. In each of the quadrants below measure the percentage of turtle grass. These two randomly selected quadrants represent 50% of the total area monitored. Estimate the total % cover of seagrass in the entire monitored area. Each square in the quadrant is 1m each quadrant is 10m x 10m. This activity can be reproduced in the field.

 Turtle grass



Quadrant 1

% Turtle grass: ___________



Quadrant 2

% Turtle grass: __________

3. Create "who am I" clues for organisms associated with a seagrass for student to guess. The clues provide an indication of the organism as well as what it eats, pictures of the answers can be provided beforehand to assist in guessing depending on the students level.

   e.g.

   I am a soft-bodied invertebrate with a foot used in locomotion (substitute Mollusk). I grow a large single heavy shell that flares out as I grow into adulthood. The inside of my shell's lip is pink. I can be found in large herds in shallow water, grazing on algae growing on the seagrass leaves and rocky seafloor. **Answer: Queen Conch**

Place students in working groups. As they guess the answers they will connect the answers to build a seagrass food web. The food web construction can be evaluated.

Subject Areas: Biology, Integrated Science

Activity 2.2b

Visiting a Fish Landing Site (adapted from Tilling & Picard, 2001)

In this activity students visit a local fish landing site or market to help demonstrate the fish diversity existing on coral reefs and learn socio-economic importance of this diversity.

By the end of the activity students will:

1. Have observed reef-associated fish diversity and appreciate the role of coral reefs as a habitat.
2. Be able to make direct links between coral reef biodiversity and their own lives and communities.
3. Be aware that there are trends in fishing, some of which are due to impacts on coral reefs.

Introduction

Coral reefs are not accessible to most students. This means that their role in biodiversity remains a “distant” concept. A visit to a fish landing site where fishers primarily land reef associated fish will highlight the tremendous fish diversity that exists in our coastal water, and will help demonstrate the social and economic links with the coral reefs. Many of our fish stocks are dependent on health coral reefs, and nearby areas of mangroves and seagrass beds. As fish stock declines it affects the economic benefits. In this activity, students will look at the diversity of fish life on the reef,

Procedure:

Introduction:

1. In the classroom, have students brainstorm ideas to answer the following question:

“*Which of these seafoods do you think come from coral reefs and nearby areas?”*

- Sea urchin (Chadon)
- Pot fish
- Algae (sea moss)
- Lobsters
- Shark
- Conch

2. Review the answers. All of these foods can be caught on or near reefs.

Preparation:

1. Before conducting this out of the classroom activity contact Department of Fisheries to assist with informing interviewees at the fieldwork site of the visit and the type of questions and observations that are to be made.
2. Divide students into groups of at least four with each group including a leader and a recorder. Introduce the students to the reef fish identification guide. Agree through group discussion and consultation with the Department of Fisheries to a common set of questions and questionnaire format to answer these:

    a. Which types of coral reef fish have been caught?
    b. What proportions are they of the total fish catch.
    c. Have the types and sizes of the fish changed over the years?
    d. What do the fishermen think is the cause.

Fieldwork:

1. Using the reef fish identification guide to describe and count the variety of coral reef fish that are landed by a few fishing boats or being traded in the market.
2. Students are to pose their questionnaire to identified fishers. The teacher should circulate to make sure that the activity is being carried out and that the students are focused on their work. Reassemble when objectives have been met.

Follow-up

1. Students can obtain a time series graph of the in fish landed islandwide and the fishers registered to aid in assessing the trends in total fish catch over the years.
2. Ask students to interpret the results of their survey and present it to the class. A number of different graphical techniques can be encouraged here.
3. Students can use data on the fishermen registered at the landing site available at the Department of Fisheries to make connections between coral reef biodiversity and the economic and social links.

Recommended Resources:

- Personnel: Fisheries Officer, Department of Fisheries
- Books: Reef Fish Identification:

Subject Areas: Social Studies, Mathematics, Biology

Activity 2.3

Where are the Richest Places **(adapted from Tilling & Picard, 2001)**

This activity demonstrates the links between coastal marine ecosystems and highlights the need to protect marine ecosystems.

By the end of the activity students will:

1. Be able to interpret the links between key habitats and fishing.
2. Be aware of that communities can be dependent on the 'health' of natural areas.
3. Be more sensitive to the need to protect marine ecosystems.
4. Know that there are functions that link different types of habitats.

Procedure:

In the classroom:

1. Invite a staff member from the Department of Fisheries and other affiliated agencies to discuss Marine Reserves, Marine Reserve Networks and their importance. Provide students Appendix II showing the maps of marine ecosystems in Saint Lucia to review. The Background information in them 2.3 should also be introduced to students.

2. Then ask students to answer the following question:

   "*Why do you think that the fishermen and scientists are very worried about the health of coral reefs and nearby habitats in Saint Lucia? What does it mean for our communities and fishermen in the future?"*

   This can be presented in various formats such as an oral group poster presentation or as an essay.

In the field:

3. With the assistance of staff from the St. Lucia National Trust students can visit specific coastal areas in which marine ecosystems have been damaged. Students can be asked to also discuss the potential issues they observe.

Recommended Resources:

- Personnel: Fisheries Officer, Department of Fisheries
- Stationary: Bristol board, pictures, colour markers and picture cut outs.

Subject Areas: Social Studies, Geography, Biology, Language Arts.

Activity 3.1a

Marine Site Assessment

By the end of the activity, students will:

- Get familiar with the services and products provided by the marine environment in a chosen site, and compare and contrast with the uses of that area.
- Assess the effects of overexploitation and other threats (ongoing and potential) on the coastal resources of Saint Lucia and their uses (livelihoods, tourism, recreation, ecosystem services, etc)

Preparation:

1. As an introduction to the exercise, students will be exposed to material on uses of and threats to the marine environment, including videos, presentations, case studies and other reading material.
2. The south-east coast of Saint Lucia is recommended for this exercise, and general information on the area and its uses will be presented to students. In pairs or small groups, students will be allowed to review the material and discuss their approach to the activity. This can include specific points of observation, questions to be asked of resource users and site management staff, means for reporting back to plenary, and so on.

In the field:

1. The exercise will take the form of a bus tour to several points of interest on the south-east coast (Anse du Sable beach, Mankote Mangrove, Maria Islands Nature Reserve, Savannes Bay, etc, where students will observe ongoing activities, uses and users, conflicts and threats to the marine resources of the area. They will be offered a chance to meet with the area management staff, if applicable, and to interact with various stakeholder groups along the trip.

In the classroom:

1. Following the exercise, sufficient time will be allotted for group discussion and preparation for presenting findings to the class. This will be followed by general discussion on observations, and possible solutions to problems identified.
2. Presentations may take the form of a comprehensive list/matrix including all uses and threats observed, ranking them according to level of significance and impact:

- Resources and/or ecosystems ranked on the basis of perceived importance of the benefits provided; and

- Threats to coastal and marine resources, ranked on the basis of the importance of the resource and/or ecosystem threatened

This activity is best held after completion of both Themes 3.1 and 3.2.

Activity 3.1b

Marine Product and Service Analysis

By the end of the activity, students will:

1. Have an appreciation for the benefits of the marine environment to human well-being.

2. Rank goods and services identified according to perceived level of importance, based on observations.

Preparation:

1. As an introduction to the exercise, students will be exposed to material on various uses of the marine environment, using videos, presentations, case studies and other reading material.

2. Over the course of a specified time period (for example 2 days), students are to record observations of products and/or services from the marine environment used in the household, school, community, or otherwise.

In classroom:

1. Classroom activity will include the generation of a complete list of products and services observed over the specified time period.

2. Students will then rank and discuss the products and services based on recorded observances, and their importance to the local society.

Activity 3.2a

Visit to Degraded Marine Site

By the end of the activity, students will:

1. Have first-hand observation of a coastal site degraded by various activities (pollution, coastal development, overexploitation, etc), and the impacts on the associated products and services.
2. Be able to assess observed threats, sources and potential impacts on the marine environment

Preparation:

1. As an introduction to the exercise, students will be exposed to material on potential threats to the marine environment, using videos, presentations, case studies and other reading material.

In the field:

1. The exercise will take the form of a bus tour to a site possessing a degraded marine environment. At the site, students are to record observations of ongoing threat, assess causes of degradation, and determine the expected impacts of the marine resource conditions.
2. Students will be allowed to take photographs for use during their presentation to the class.

In the classroom:

1. Following the exercise, groups will be allowed to prepare for presenting findings to the class. This will be followed by general discussion on observations, and possible solutions to problems identified.

This activity is best held after completion of both Themes 3.1 and 3.2.

Activity 3.2b

Alien Invasion

(Adapted from the National Oceanic and Atmospheric Administration (NOAA))

By the end of the activity, students will:

- Be able to define, compare and contrast invasive species, alien species and native species.
- Be able to describe at least three problems that may be associated with invasive species.
- Be able to describe at least three invasive marine species, explain how they came to be invasive, and discuss what can be done to control them.

Preparation:

1. As an introduction to the exercise, students will be introduced to the concept of invasive species, their method of introduction into new ecosystems, impacts on habitats and other species, and measures of prevention, control and/or eradication. Information should be given on the conditions under which an organism typically becomes invasive and the differences between native species (species that are a natural part of an ecosystem), alien species (species that are not native) and invasive species (alien species that are harmful to native species or humans). This will be done using videos, presentations, case studies, factsheets and other reading material.

2. As an option, the lesson can focus on marine invasive species – what they are, why they are a problem and what can be done about them.

3. Sufficient time for research and small group discussion, if applicable, should be afforded before presentation of findings in a classroom setting.

In the classroom:

1. Students are to prepare a written case study on an invasive aquatic species. The reports should include the native location of the species, how it was introduced to an ecosystem where it became invasive, and what control measures are possible.

2. Students may also be required to present the findings to the class using electronic means, Bristol board, drama or any other suitable manner, for further discussion on mitigating the threat of invasive species to the marine environment.

ALTERNATIVE ACTIVITY

Invasive Species and Me

(Adapted from the National Oceanic and Atmospheric Administration (NOAA) – Alien Invasion – The "Me" Connection)

Although invasive species can cause serious problems for humans and other species, they are only doing what every other organism does – taking advantage of opportunities to survive and perpetuate their species.

Have students write a brief essay describing how the human species might be considered invasive by one or more other species, and what those species might do to deal with these "invaders".

Activity 3.3a

Parts to Play

By the end of the activity, students will:

1. Be familiar with the various pieces of legislation governing different aspects of coastal resources management
2. Learn about the actors in marine resources management (governmental, non-governmental, community-based, etc)

Preparation:

1. As an introduction to the exercise, students will be provided with relevant pieces of legislation, policies, and other papers on efforts to protect Saint Lucia's coastal resources.
2. Students will be given sufficient time to further research efforts by different agencies in implementing or enforcing legislation, and to engage in dialogue with representatives of Department of Fisheries, Physical Development, Coastal Zone Management Unit, Solid Waste Management, Saint Lucia National Trust, etc.

In the classroom:

1. Students, in pairs or small groups, will present findings of research activity.

Activity 3.3b

It Wasn't Me!
- **Case Study**
- **Role Play**

By the end of the activity, students will:

1. Have a good grasp of national efforts to protect the coastal resources
2. Understand the roles of key players in the coastal zone management process

Preparation:

1. As an introduction to the exercise, students will be exposed to material on the importance and threats to the marine environment, along with the various measures being taken nationally to promote coastal resources management and protection. This will be done using videos, presentations, case studies and other material.

In the classroom:

1. Students will be divided into groups, and presented with different scenarios requiring implementation of legislation or enforcement of regulations.
2. Each group will analyse each scenario in turn, presenting an analysis and solution or outcome to the problem presented.
3. Following the exercise groups will present on cases, following class discussion on chosen outcome.

Activity 4.1a

Who's Who? – Stakeholder Analysis

- **Case Study**
- **Role Play**

By the end of the activity, students will:

- Be able to conduct a stakeholder analysis to identify the individuals and groups that must be involved to benefit from a collaborative management process in the community
- Evaluate the roles and responsibilities of stakeholders in coastal resources management

Preparation:

1. As an introduction to the exercise, students will be provided with material on conducting a stakeholder analysis – methods, outputs, key players, etc through presentations, case studies and other reading material. A reporting tool will also be generated.
2. A local marine site will be selected for this exercise, and sufficient general baseline information will be presented to course participants to facilitate a stakeholder analysis.
3. Students will be divided into groups, and be given, or allowed to devise a management decision upon which the stakeholder analysis will be based.

In the classroom:

1. In small groups, trainees will be allowed to conduct a stakeholder analysis surrounding the selected management scenario and site, identifying as many stakeholders as possible.
2. Complete Stakeholder Analysis should be done for 2 selected stakeholders, using attached matrix.

Potential role in the issue or activity	Level of knowledge of the issue	Level of commitment	Available resources	Constraints
Vested interest in the activity	Specific areas of expertise	Support or oppose the activity, to what extent, and why?	Staff, volunteers, money, technology, information, influence	Limitations: need funds to participate, lack of personnel, political or other barriers

3. For one stakeholder, students must complete a stakeholder engagement plan, highlighting:

Potential role in the activity	Engagement strategy How will you engage this stakeholder in the activity?	Follow-up strategy Plans for feedback or continued involvement

4. Students will report the results of the activity to fellow classmates, sharing the management scenario, stakeholders identified, complete analysis for 2 primary stakeholders, and plan of engagement for chosen stakeholder.
5. Activity will be followed by general discussion.

As a follow-up to the activity, and to the discussion in the Module on Conflict Management, trainees may be allowed to further refine their stakeholder analysis, and in small groups, play the part of a particular stakeholder. The goal of the exercise is to note the differences among groups (in terms of priorities, interests and other stakes), and to work out ways to address conflicts arising in the site. (See Activity 4.3b.)

Activity 4.1b

Conflict Management - Soufriere Marine Management Area

- **Case Study**
- **Site Visit**

Preparation:

- As an introduction to the exercise, students will be provided with material on threats to conflict management and resolution, using videos, presentations, case studies and other material.

- Material on the Soufriere Marine Management Area (SMMA), including its history, conflicts in establishment, negotiations and resolution, will also be presented to students.

In the classroom:

1. Students will be divided into specific stakeholder groups, and be allowed to role play according to general stereotypes (for example, fishers are to assertively demand open access to the fishery, other resources users will demand access to particular resources for support of their livelihoods, and site managers are to balance the needs of both the site resources, and the various stakeholder groups).

2. Players will use assorted measures for conflict management to come to some resolution of the particular management issue.

3. The exercise will be followed by general discussion on the activity, and on conflict management and/or resolution in coastal resources management.

Activity 4.2a

Adopt-a-Watershed!

By the end of the activity, students will:

- Plan and design activities and strategies geared towards effective watershed and resources management, and reduction of land-based sources of marine resources pollution.
- Learn to work with corporate bodies, government agencies, and citizens to support watershed management at the community level.
- Develop a sense of stewardship towards local watersheds and the natural resources contained within them.

While this is intended as a long-term exercise whereby students adopt a watershed from early education, and follow its progress throughout school life, using the watershed to supplement different classroom learning points as they advance through the academic curriculum, this can be designed as an activity for school environmental clubs, as opposed to individual classrooms.

Preparation:

1. As an introduction to the exercise, students will be provided with material on watershed management and threats. Material will be tailored specifically to watersheds in Saint Lucia, and to the watershed within which the school is located. This activity can be designed as a collaborative effort among schools located within the same watershed.

In the classroom:

1. Students will research the various activities undertaken within the watershed, to determine threats to its resources, and the impact of activities on the marine environment.
2. Students will design initiatives geared towards watershed management and threat reduction, along with strategies for implementing these measures. These may include partnerships with other schools, environmental clubs, corporate citizens, community groups, etc.

Activity 4.2b

Where's the Point?

(Adapted from the National Oceanic and Atmospheric Administration (NOAA))

By the end of the activity, students will:

1. Be able to explain at least five sources of contaminated runoff.

2. Describe at least five impacts that contaminated runoff may have on coastal ecosystems and resources.

3. Describe and discuss at least five actions that can be taken to reduce or eliminate contaminated runoff.

4. Be able to construct a three-dimensional model of an actual watershed, and use this model to provide information on contaminated runoff to a specific audience that causes or is affected by a specific type of runoff pollution (OPTIONAL)

Preparation:

1. As an introduction to the exercise, students will be exposed to material on the concept of watersheds, contaminated runoff and its impacts. This will be done using videos, presentations, case studies and other material.
2. Students may be asked to brainstorm potential sources of runoff pollution in the watershed housing the school.
3. As an out-of-class activity or mid-term project, students may be asked to design a scale model of a local watershed and develop a plan for using the watershed model to provide information about causes and prevention of contaminated runoff.
4. Discuss the idea of "target audiences". Students should realise that because there are so many potential sources of contaminated runoff, there are also many different groups of people who need specific information about what they can do to reduce this problem. In addition, the most effective way to communicate this information depends upon the target audience. You may want to assign a target audience to each group of students, or allow them to make their own choice.

5. As part of their plan for reducing the contaminated runoff, each group can create a brochure or poster that can be distributed to their audience.
6. The internet can be used to research information about various sources of contaminated runoff, as well as success stories that have been achieved by nonpoint source programmes.

In the classroom:

1. Have each student group make a presentation on their watershed model design and planned information programme.
2. Have each group add to a running list of suggestions for preventing contaminated runoff on flipchart paper for later discussion.

ALTERNATIVE ACTIVITY

Did I do That?

(Adapted from the National Oceanic and Atmospheric Administration (NOAA) – Where's the Point? – The "Me" Connection)

Have students write brief essays describing how they contribute to the contaminated runoff problem in their own community, how their actions impact their own lives, and how they might act to reduce this problem.

Activity 4.3a

Water Parks

By the end of the activity, students will:

1. Reinforce understanding of the link between marine resources and external threats, and show an appreciation for how marine protected areas (MPAs) may be presented as possible solutions.

Preparation:

1. This Activity incorporates lessons learned in Modules 3 and 4, and assesses student knowledge of the concepts presented. As an introduction to the exercise, students will review Modules 3 and 4, paying attention as well to the outcomes of the various activities undertaken.

In the classroom:

1. Instruct students to write a brief essay on a coastal resource issue that affects them personally, including why the issue is important, and how the establishment of marine protected areas can help resolve it. Essays may also include references to at least three different stakeholder groups, the perspectives are held by each of these groups, and how MPAs can provide benefits.

2. This activity may be conducted as an in-class exercise, or given to students as a take-home essay or research paper which will be presented for grading.

3. Prizes may be awarded for top essays, and these can be used to generate further discussion among students.

Activity 4.3b

The MPA Debate

By the end of the activity, students will:

2. Have an appreciation for the role and benefits of establishing marine protected areas (MPAs)

3. Reinforce knowledge of stakeholder analysis and involvement in MPA management

This Activity can be conducted as a follow-up to Activity 4.1a: Who's Who – Stakeholder Analysis, allowing students to play the roles of different stakeholder groups in a decision-making process for the establishment of a marine protected area (MPA) in a site identified and defined.

Preparation:

2. As an introduction to the exercise, students will be exposed to material on marine protected areas and the benefits they provide to fisheries, livelihoods, aesthetics, etc. This will be done using videos, presentations, case studies and other reading material, and by liaising with the Department of Fisheries, Soufriere Marine Management Association and Pointe Sable Environmental Protection Area Management Office.

3. Consideration will also be given to the various stakeholder groups engaged in uses of the marine environment, and in resources management and conservation (Theme 4.1; Activity 4.1a).

4. Students will be divided into groups representing different stakeholders in the selected coastal environment – fishers, recreational users, tour guides, port operators, Environmental Department, Fisheries Department and Biodiversity Conservation advocates, hotel developers, legal representatives, etc. Each group will be provided with sufficient time to research their roles and prepare arguments to be presented at a multi-stakeholder meeting for consideration of establishing a marine protected area.

In classroom:

1. The scenario being studied will be presented, and groups will be allowed to present their cases and debate the establishment of a marine protected area in a zone currently used for multiple activities and my many different users and user groups.
2. Students will be allowed to come to a conclusion using conflict management and negotiating techniques, and environmental awareness instilled during the marine environmental education lessons and activities.

3. Representatives of MPAs and other relevant agencies may be invited to this presentation, in order to give their perspectives on the different arguments and the final decision taken.

Activity 5.1

Activity on Module 1 as presented during group exercise for Module 5

Name of teachers:

1. Ms Marie Charles (leader)
2. Mrs Valerie Constantine Regis
3. Ms Kimma Williams

Age Group: (Grade 5)

Aim: To compare some of the physical and chemical characteristics of sea water and river water

Apparatus and Materials:

Nine (9) Beakers, home-made turbidity tester, thermometers, digital turbidity tester, universal indicator paper, water samples, distilled water

Task Analysis:

1. Collect two (2) samples of water from each of the checkpoints designated by your teacher (mouth of river, a point along the beach/ away from the mouth of the river, higher up river course.
2. Test for pH using one of the samples collected at each of those three spots.
3. Keep the second sample to be tested later for turbidity.
4. Using the thermometer, record the temperature of the water at each the checkpoints.
5. Tabulate findings.

Criteria for assessment and Mark Scheme

Skill Assessed: *Manipulation and Measurement (M/M)*

- ✓ Temperature (use of thermometer) [4 marks]

  Reading done while bulb is completely immersed in the water **(1 mark)**

  Reading taken at eye level **(1 mark)**

  Accurate reading of thermometer **(1 mark)**

  Thermometer carefully handled **(1 mark)**

- ✓ Turbidity [2 marks]

  Box placed on flat surface **(1 mark)**

  Constant volume of water tested at each checkpoint **(1 mark)**

- ✓ pH [2 marks]

  pH paper immersed long enough in water sample to observe any changes **(1 mark)**

  pH scale accurately read based on the colour change noted. **(1 mark)**

Total – 8 marks

Activity 5.2

Activity on Module 2 as presented during group exercise for Module 5

Name of teachers:

1. Mr Sheraz Thomas (leader)
2. Mr Adrain Vaudroque
3. Ms Virgillia James
4. Mr Chade Desir

Age Group: Form 4 (Grade 10)

Aim: To investigate mangrove species succession in a mangrove swamp.

Apparatus: Mangrove identification chart

Line Transect
Meter Rule
Graph Paper
Pencil
Sample Bag
pH Metre
Thermometer

Tasks Analysis:

1. From the edge of the water at the seashore, run a line transect up to 50m inland.
2. Identify/Select and mark off 1 metre intervals.
3. Take note of the time of day and record the soil temperature and pH of the soil at every 5 metre intervals.
4. Making reference to the mangrove identification chart, identify and record the species of mangrove at every 1metre interval.
5. Draw a species profile (line transect) diagram of the area sampled.

Criteria for assessment: Analysis Interpretation (A/I)

- Background information:
  - Definition and types of mangroves (**2 marks)**
  - Special adaptations of mangroves (**1 mark)**

- Explanation of results:
  - Discussion on patter of succession based on temperature and pH findings. (**4 marks)**

- Limitations (**2 marks)**

- Conclusion (**1 mark)**

Total – 10 marks

Activity 5.3

Activity on Module 3 as presented during group exercise for Module 5

Name of teachers:

1. Mrs Lyrill Arthur Stanislaus (leader)
2. Mrs Jessica Chalon
3. Ms Elizabeth Soomer
4. Mr Chad Lafeuille

Age Group: Form 3 (Grade 9)

Aim: To investigate the impact of the coastal development on the destruction of species at the Ramp and Savannes Bay area.

Apparatus:

Cameras, science journals, pencils, marine and terrestrial guides.

Task Analysis/Procedures:

- Identify areas to be studied
- Examine each area
- Draw a sketch of each area
- Identify the species using guide books
- Listen and apply information derived from guides and stakeholders
- Determine the impact of coastal development on the distribution of species (marine and terrestrial) in the areas identified.
- Present data gathered in various ways e.g. Venn diagram, tables etc.

Criteria for Assessment:

- Group work – different tasks in groups
- Identifying key factors/species in the two areas
- Students are able to identify at least two (2) threats and benefits of each area.
- Show a correlation between the two areas studied using creative ways of presenting information

Marking Scheme:

(a) Observation Recording Reporting (ORR)

- Appropriateness of sketches: Are they a true representation of areas **(2 marks)**
- Correct identification of species in areas **(2 marks)**
- Identifying of 2 threats and benefits in area studied **(4 marks)**
- Appropriate representation of data **(2 marks)**

Total – 10 marks

(b) Measurement Manipulation (MM)

- Conduct in the field **(1 mark)**
- Collaboration with peers **(1 mark)**
- Completion of assigned task **(2 marks)**

Total – 4 marks

Activity 5.4

Activity on Module 4 as presented during group exercise for Module 5

Name of teachers:

1. Ms Giannetti George (leader)
2. Mr Alan Gabriel
3. Mr Jairaj Mangar
4. Ms Nikita Isaac

Age Group: Form 2 (Grade 8)

Aim: To investigate the water retention capacity of soils with and without vegetation.

Apparatus:

Measuring cylinders
Top loading/ triple beam balance
Beakers
2 Litre soda bottle
Wire mesh
Masking tape
Soil
Water
Stopwatches

Task Analysis/Procedures:

1. Cut off both ends of soda bottle
2. Cut soda bottle in half (longitudinal) to produce troughs.
3. Cut wire mesh of equal size and fasten to one end of each trough
4. Weigh 500g of bare soil using a balance and place in a trough labeled A.

5. To another soil sample labeled trough B (obtained from same source as in trough A) add and mix 50 g of vegetation.
6. Place troughs A and B at the same angle, 45 degrees, using a block of wood.
7. Place beaker underneath the lower end of each trough.
8. Measure 200ml of water using the measuring cylinder and pour this at the same rate from the same point above each trough.
9. Simultaneously start the stop clock and measure the volume of water collected in beakers after 5 minutes.

Criteria for Assessment: **Measurement Manipulation (MM)**

Marking Scheme:

- Building of troughs of equal size **(2 marks)**
- Reading the scale balance accurately **(1 mark)**
- Reading measuring cylinder at eye level **(1 mark)**
- Reading from the bottom of the meniscus **(1 mark)**
- Setting both troughs at same angle **(1 mark)**
- Synchronization of pouring water and stop watch **(2 marks)**
- Pouring water from same point **(1 mark)**
- Ensuring distribution of soil in troughs **(1 mark)**

Total – 10 marks