

Beautiful Oceans
Coral Reef Adventures



CORAL REEF
ECOSYSTEM & FOOD WEB



BEAUTIFUL OCEANS

Copyright © Beautiful Oceans Inc. 2006

All rights reserved.

No part of this publication may be reproduced or transmitted in any form or by any means, or stored in a data base or retrieval system, without the prior written permission of the publisher. Requests for permission or further information should be addressed to the Permission Department, Beautiful Oceans Inc.

Care has been taken to trace ownership of copyright material contained in this text; however, the publisher welcomes any information that enables them to rectify any reference for credit in subsequent editions.

This publication is designed to provide accurate and authoritative information on the subject matter covered. Scientific knowledge is constantly changing; this publication is therefore intended as a general guide only. The publisher welcomes any information that enables the rectification, enhancement or enrichment of knowledge provided in this publication for subsequent editions. This publication is sold with the understanding that the publisher is not engaged in rendering legal, scientific, or other professional service. If legal or scientific advice is required, the services of a competent professional should be sought.

Published by Beautiful Oceans, Inc.
P.O. Box 48088 - Bernard Branch
Montreal, Quebec
Canada. H2V 4S8

Product No20001 (Rev. 2/08) Version 1.1
86138 5698 RM 0001
Printed in Canada



BEAUTIFUL OCEANS

Image references

Figures 1.1, 1.7, 1.9, 1.13, 1.15, 2.1, 2.2, 2.3, 2.5, 2.6, 2.7, 2.8, 2.9, 2.10, 2.11, 2.12, 2.13, 2.14, 2.15, 2.16, 3.4, 3.6, 3.7b, 3.8, 3.9, 3.10, 3.11, 3.12, 3.13, 3.14, 3.15, 3.16, 3.17, 3.18, 3.19, 3.20, 3.22, 3.23, 3.24, 3.25, 3.26, 3.27, 3.28, 3.29, 3.30, 3.31, 3.32, 3.33, 3.34, 3.35, 3.36, 3.40, 3.41, 3.42, 3.43, 3.44, 3.45, 3.46, 3.47, 3.48, 3.49,
Copyright © 2006, Beautiful Oceans and its licensor. All rights reserved.

Figure 1.2
Publication of US Department of Interior; US Geological Survey (USGS)

Figure 1.3
Photographer: Alex Tewfik

Figure 1.4
Photographer: Paige Gill

Figures 1.5, 1.6
Photographer: Ronald C. Philips

Figure 1.10
Publication of Ocean Blue
www.oceanblue-web.com

Figure 1.11
Publication of Eurekalert

Figure 1.12a
Publication of University at Buffalo Reporter; Photographer: Ellen Goldbaum

Figures 1.12b, 1.8, 3.2
Publication of the National Oceans and Atmospheric Administration (NOAA) NOAA Central Library.

Figure 1.14
Photographer: Colin Ackerman

Figure 2.4
Publication of the National Oceans and Atmospheric Administration (NOAA) Center for Coastal Monitoring and Assessment, NOAA

Figures 3.1, 3.5b, 3.39
Publication: Wikipedia.org

Figure 3.3
Publication of NASA

Figure 3.5a
Publication of Museo Nazionale Dell'Antartide, Italy

Figure 3.7a
Photographer: Henri Valles

Figure 3.21a
Photographer: Denise Tackett

Figure 3.21b
Photographer: Joerg Adam

Figure 3.37
Photographer: Beth Pope and James Engman

Figure 3.38
Photographer: Huw Evans



ACKNOWLEDGMENTS

We are indebted to numerous individuals who contributed advice, knowledge, time and effort in making this program what it is today: a fun, scientifically validated, high quality publication that helps SCUBA divers and snorkelers to better understand and enjoy their coral reef experience, while supporting and protecting this invaluable ecosystem.

Editorial concept

Stephan Becker

Writer

Ian Popple

Editing

Julia Asselstine

Henri Valles

Scientific guidance

Henri Valles

Layout and production

Catherine Marion

Illustrations

David Devaux

Photographs

Alex Tewfik, Caroline Rogers,
Brian Helmuth, Paige Gill,
Ronald C. Philips, Colin Ackerman,
Denise Tackett, Joerg Adam,
Beth Pope, James Engman,
Neil Sullivan, Huw Evans,
Henri Valles, Ocean Blue,
COREL, NOAA, NASA, USGS,
Wikipedia, Eurekalert,
Museo Nazionale Dell'Antartide

FOREWORD

Welcome to your Beautiful Oceans Coral Reef Adventure

Beautiful Oceans Coral Reef Adventures have been carefully designed to help snorkelers and scuba divers broaden their tropical island vacation. Each Coral Reef Adventure includes a state-of-the-art manual covering selected topics in marine biology. This manual is supplemented by Creature Discovery Kits that provide more in-depth knowledge about specific species. Written in an appealing, easy-to-understand format, Beautiful Oceans materials draw upon rigorously researched and scientifically validated information from the fields of marine biology, behavioural ecology and oceanography. The knowledge you will discover will interest all coral reef enthusiasts, from the occasional snorkeler to the passionate scuba diver.

Beautiful Oceans Coral Reef Adventures also combine exciting in-water activities that allow people of all ages to explore, understand and enjoy the coral reef ecosystem. Although our programs can be applied independently by anyone, you may wish to visit a Beautiful Oceans Science Dive & Snorkel Center where a certified Beautiful Oceans Science Instructor will provide direction, and take you on an unforgettable guided tour of a local coral reef.

The possibilities do not end here however. At selected resorts and dive centers, Beautiful Oceans takes coral reef exploration to new heights (or perhaps depths!). Detailed three-dimensional coral reef maps allow you to explore each site as if it were their own backyard. An island overview graphic indicates a reef's position on the island, detailed site descriptions explain architectural features, suggested routes make it easy to navigate and find points of special interest, such as the location of a lobster shelter or an area where sting rays are common, which in turn link to your Creature Discovery Kits. Submersible pocket dive slates remind you of key-features, species and their behaviours. Finally, the official *Beautiful Oceans Coral Reef Guardian* recognition and membership card completes the experience.

At Beautiful Oceans we understand and value the strong bonds that connect living organisms and their environment. We have a responsibility to safeguard the cycles, processes and systems on which the web of life has relied for millions of years. Beautiful Oceans' is committed to protecting the environment through both education and charitable donation. For each Coral Reef Adventure sold, Beautiful Oceans provides financial support for conservation projects, including scientific assessments, marine protected areas and local education programs. The *Beautiful Oceans Coral Reef Guardian* recognition and membership card is your proof of this contribution to coral reef protection.

As *Beautiful Oceans Coral Reef Guardian* you have demonstrated a desire for knowledge, a devotion to the natural world and its diverse and interconnected life, while taking an important step toward preventing further degradation of a unique and magnificent ecosystem—the coral reef. Pass your knowledge on to others. You may even want to consider becoming a Beautiful Oceans Science Instructor. Remember:

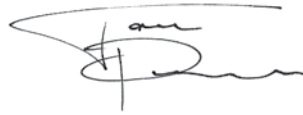
In the end, we will conserve only what we love, we will love only what we understand, we will understand only what we are taught.

(Baba Dioum, Senegal, 1968)

Thank you for your support.



Stephan Becker
Président Directeur Général



Ian Popple
Vice-président, Science Marine



INTRODUCTION

The Earth—our blue planet

The Beautiful Oceans experience takes you on a journey through the world's oceans—a vast world that covers nearly three-quarters of our planet's surface to an average depth of 4 km (2.5 miles).

Approximately 97 percent of the water on Earth is contained within the three oceans—Atlantic, Pacific and Indian. These oceans are home to millions of organisms, amounting to over 90 percent of the world's living biomass. All life evolved from this environment, and to this day, all life owes its continued existence to it.

The oceans maintain Earth's habitable temperature by trapping heat from the sun and distributing it around the globe via their network of currents—a circulation that takes centuries to complete. Fresh water evaporates from the surface of the oceans and falls on the land as life-giving rain, quenching the thirst of both plants and animals alike. Microscopic organisms, called phytoplankton, drift in the surface waters, adding oxygen to our atmosphere in the same way as plants do on land. This vital process allows every one of us to breathe. Without the oceans, life on Earth would simply cease to exist.

Countless people around the world are drawn to the ocean, and many of the more adventurous among us are drawn to explore what lies beneath. Recreational SCUBA diving and snorkeling have provided the means for us to explore the underwater realm, and each year millions take this opportunity to discover coral reefs—one of the most beautiful and unique ecosystems in the world.

Coral reefs—the rainforest of the ocean

Coral reefs are often referred to as the rainforests of the sea because the number of organisms they support is comparable to that of terrestrial rainforests. The number of different species that depend on coral reefs is estimated in the tens of thousands, including approximately 4,000 species of fish, and around 700 species of coral; incredibly this represents nearly 25 percent of all known marine life, yet coral reefs make up less than 1 percent of the world's oceans.

So many organisms packed into such a small space makes for exciting diving and snorkeling, as anyone who has explored a coral reef is quick to share. The sheer number of organisms encountered on a healthy coral reef produce a kaleidoscope of colours and shapes that literally take the breath away.

Tragically, however, coral reefs are under threat from a barrage of environmentally unsound practices, such as overfishing, unregulated

coastal development and pollution resulting in global warming. In the past decade, 25 percent of the world's coral reefs have been destroyed—an area greater than the size of Greece.

Unless we change our irresponsible behaviour, the first generation of divers and snorkelers to discover this unique world may, tragically, be the last. Understanding coral reefs is the first step toward protecting and conserving this precious ecosystem.

Marine biology and ecology—the science of ocean life

Marine biology is the study of sea life; marine ecology involves study of the relationships between these organisms and their environment. Both scientific disciplines intersect several other related fields including chemistry, physics and geology.

The thought of completing a scientific course may strike fear in the heart of many, but those who know Beautiful Oceans understand there is nothing to fear. With this Beautiful Oceans program, you will discover how incredibly simple and truly fascinating marine science can be.

Here are some important tips that will help you get the most from your Beautiful Oceans experience:

Beautiful Oceans uses both common and scientific names

Scientific names are both useful and fun to learn. The scientific name of an organism remains the same, whereas common names can vary from country to country. All scientific names consist of two words: a genus name with a capitalized first letter and a species name; both are written in italics.

In short, a species is a group of organisms that can reproduce, resulting in fertile offspring. Blue tangs represent an individual species, as do ocean surgeonfish, for example. A genus represents a group of similar species, which do not reproduce together. Blue tangs and ocean surgeonfish are in the same genus, but represent different species.

Scientific names are usually of Latin or Greek origin. Where possible, the route of each scientific name is explained: Gr. denotes Greek origin; L. denotes Latin origin; NL denotes New Latin origin. We also provide a pronunciation key.

Technical terms are defined in the glossary

Technical terms are written in bold blue text and link to the respective entry in the glossary. In the Beautiful Oceans course pack, the glossary is located at the back of each booklet. For web-based courses at the Beautiful Oceans eAcademy, simply click on these words for a full explanation.

Beautiful Oceans programs contain additional information

Beautiful Oceans programs include additional information in the form of **Did you know?**, **Science box**, **Diver & snorkeler tip**, **Diver & snorkeler best practices**, and **Quick quiz**, which complete your learning experience. **Did you know?** boxes provide 'wow' facts that are sure to amaze. The **Science box** contains interesting overviews of the latest research breakthroughs or additional scientific information related to a particular section of the course. **Diver & snorkeler tips** provide interesting advice and observations for your discovery dive or snorkel tour. **Diver & snorkeler best practices** provide advice to help you become an environmentally responsible 'eco-diver' or 'eco-snorkeler'. The **Quick quiz** contains "food for thought", allowing you to test your knowledge at the end of each section.

Program links help you find information that interests you

Beautiful Oceans offers programs on all aspects of coral reef biology and ecology. Subject matter that falls outside the realm of the particular course you are taking may be explained in more detail in another Beautiful Oceans program.

Practical application through diving and snorkeling

Our programs are designed with the recreational diver and snorkeler in mind. At Beautiful Oceans we believe that applying the knowledge learnt in our programs will vastly improve your learning experience. After the successful completion of the in-class component of your program, you will receive your official Beautiful Oceans Membership Card. Be sure to inquire about adventure dives and snorkel tours at your Beautiful Oceans Science Dive Center.





LEARNING OBJECTIVES

Program objectives:

This program will help you understand what constitutes a coral reef ecosystem and how food webs result in the movement of energy from organism to organism. You will also learn about seagrass and mangrove ecosystems, which are associated with coral reefs. This program will introduce you to some of the major groups of organisms that live on coral reefs, such as phytoplankton, zooplankton, algae, plants, corals, fishes, sponges, echinoderms, arthropods, worms and mollusks. You will also learn some of the basic interactions that occur between these groups, discover example species and learn some of their interesting behaviours. Finally, this program will introduce you to the Beautiful Oceans Coral Reef Organism Behaviour Tool and will provide you with an easy way to apply this tool to organisms you encounter on coral reefs. With the help of the tool, you will learn how to identify **what** your creature of interest does to gain the energy it needs to survive, **how** it gains energy, and **when** the best time to observe this creature is.

Program key words:

coral reef ecosystem, seagrass ecosystem, mangrove ecosystem, nutrient, species richness, biodiversity, competition, symbiosis, food web, organism, energy, producer, consumer, herbivore, carnivore, top predator, omnivore, detritivore, decomposer, coral reef food web indicator, nocturnal, diurnal, active feeding, passive feeding, photosynthesis, sunlight, predation, algae, phytoplankton, zooplankton, stalked lettuce leaf algae, plants, turtle grass, manatee grass, shoal grass, cnidaria, coral, great star coral, fishes, blue chromis, Queen triggerfish, banded butterflyfish, barracuda, Nassau grouper, Caribbean reef shark, porifera, sponge, giant barrel sponge, echinoderm, cushion sea star, long-spined sea urchin, arthropod, crustacean, Caribbean spiny lobster, annelid, Christmas tree worm, mollusk, Caribbean reef octopus.

This program will answer the following questions:

- What is an ecosystem?
- What are the main components of an ecosystem?
- How does the coral reef ecosystem function?
- What other ecosystems are associated with corals reefs?
- What organism interactions occur within an ecosystem?
- What is a food web?
- What are the major levels of a food web?
- How is energy passed from one level to the next?
- Why is the Sun so important to the coral reef ecosystem?
- What are the major groups of organisms found on coral reefs?
- How does each group fit into the coral reef ecosystem?
- What are detritivores and decomposers and why are they important?
- Organisms can gain their energy passively or actively—what's the difference?
- How might you tell the difference between carnivores and herbivores?
- Why are phytoplankton so important to life on Earth?
- What are the differences between plants and algae?
- Are corals producers, herbivores or carnivores?
- How do fishes hear if they don't have ears?
- How do sponges feed if they don't have mouths?
- What coral reef creatures are related to insects?
- How is the Caribbean reef octopus a 'master of disguise'?
- How do I apply Beautiful Oceans' Coral Reef Organism Behaviour Tool in the water to easily answer the what – how – when related to virtually all feeding behaviours observed on the reef?

Benefits of the program:

- Understanding how coral reefs function as an ecosystem allows you observe the big picture of life on the reef and appreciate the importance of each individual organism
- Recognizing the major organisms that exist on coral reefs and their position in the food web helps you familiarize yourself with the entire ecosystem
- Knowing how one organism interacts with another can tell us a great deal about its role in the ecosystem—what scientists refer to as its ecological niche. Knowing an organism's niche can help us understand and even predict some of the behaviours and interactions we witness during our exploration of coral reefs through both scuba diving and snorkeling
- Understanding the morphology of an organism tell divers and snorkelers a lot about the lifestyle and behaviour of an organism
- To help us learn more about the coral reef food web and some of Caribbean's most common reef organisms, we have created the Beautiful Oceans Coral Reef Organism Behaviour Tool—Food Web. This tool will help you understand more about each organism you encounter on your discovery dives and snorkel tours—**WHAT** is the position of a particular organism in the food web, **HOW** does it gain energy, and **WHEN** does it gain energy—allowing to you find creatures, and observe and predict behaviours that you may otherwise miss

By the end of this program:

- You will be able to **describe** the characteristics of a coral reef ecosystem
- You will **understand** the connection between coral reefs, mangroves and seagrass ecosystems
- You will **understand** how predation, competition and symbiosis are part of a healthy functioning ecosystem
- You be able to **describe** the process of photosynthesis
- You will be able to **explain** the difference between a herbivore, omnivore and carnivore
- You will be able to **name** the major groups of organisms on coral reefs
- You will able to **identify** and name example species in each of these groups
- You will be able to **understand** and even **predict** some of the common behaviours of coral reef organisms
- You will **discover** what, when and how certain example species eat
- You will learn to **appreciate** all life on coral reefs from the tiniest phytoplankton to the shark

CONTENTS

Coral Reef Ecosystem & Food Web

| | | |
|--|--|-----------|
| CHAPTER 1 – THE CORAL REEF ECOSYSTEM | | 3 |
| Topic 1 | The coral reef ecosystem defined | 3 |
| Topic 2 | Associated ecosystems – seagrasses and mangroves | 6 |
| Topic 3 | Organism interactions – predation | 11 |
| Topic 4 | Organism interactions – competition | 13 |
| Topic 5 | Organism interactions – symbiosis | 14 |
| CHAPTER 2 – THE CORAL REEF FOOD WEB | | 19 |
| Topic 6 | The coral reef food web – what is it? | 19 |
| Topic 7 | The coral reef food web – producers | 23 |
| Topic 8 | The coral reef food web – consumers | 27 |
| Topic 9 | The coral reef food web – detritivores and decomposers | 31 |
| Topic 10 | Coral reef organism behaviour tool – food web | 33 |
| CHAPTER 3 – CORAL REEF FOOD WEB - EXAMPLE ORGANISMS | | 37 |
| Topic 11 | Coral reef organisms: phytoplankton | 37 |
| Topic 12 | Coral reef organisms: zooplankton | 41 |
| Topic 13 | Coral reef organisms: algae Example organism: stalked lettuce leaf algae – <i>Halimeda tuna</i> | 44 |
| Topic 14 | Coral reef organisms: plants – plantae Example organism: turtle grass – <i>Thalassia testudinum</i> | 47 |
| Topic 15 | Coral reef organisms: corals – cnidaria Example organism: great star coral – <i>Monstastrea cavernosa</i> | 50 |
| Topic 16 | Coral reef organisms: fishes – pisces | 54 |
| Topic 17 | Example organism: blue chromis – <i>Chromis cyan</i> | 58 |
| Topic 18 | Example organism: queen triggerfish – <i>Balistes vetula</i> | 61 |
| Topic 19 | Example organism: banded butterflyfish – <i>Chaetodon striatus</i> | 64 |
| Topic 20 | Example organism: barracuda – <i>Sphyraena barracuda</i> | 67 |
| Topic 21 | Example organism: Nassau grouper – <i>Epinephelus striatus</i> | 70 |
| Topic 22 | Example organism: Caribbean reef shark – <i>Carcharhinus perezii</i> | 73 |
| Topic 23 | Coral reef organisms: sponges – porifera Example organism: giant barrel sponge – <i>Xestospongia muta</i> | 77 |
| Topic 24 | Coral reef organisms: echinoderm – echinodermata Example organism: long-spined sea-urchin – <i>Diadema antillarum</i> | 82 |
| Topic 25 | Coral reef organisms: arthropod – arthropoda Example organism: Caribbean spiny lobster – <i>Panulirus argus</i> | 87 |
| Topic 26 | Coral reef organisms: worm – annelida Example organism: Christmas tree worm – <i>Spirobranchus giganteus</i> | 91 |
| Topic 27 | Coral reef organisms: mollusk – mollusca Example organism: Caribbean reef octopus – <i>Octopus briareus</i> | 96 |

CORAL REEF ECOSYSTEM & FOOD WEB

the who's who of the coral reef



CHAPTER 1

THE CORAL REEF ECOSYSTEM

Topic 1. Coral reef ecosystem defined

An ecosystem is a finely balanced community of **organisms** that interact with their **environment**. Ecosystems consist of **biotic** components, such as **plants**, **animals** and even microscopic **bacteria**; and **abiotic** components (the physical environment), such as waves, currents and **sediment**.



Figure 1.1: A healthy coral reef containing extensive biodiversity

The **environment** and its **resources** shape the lives of the **organisms** within an **ecosystem**. Although the physical environment of an ecosystem may seem relatively stable over a human lifetime, drastic events such as hurricanes can bring chaos in the blink of an eye—a not-so-gentle reminder that ecosystems are dynamic and organisms must adapt to survive.

Biodiversity is a common term used to describe a broad spectrum of types and levels of biological variation. The most basic measure of biodiversity is **species richness**, which provides information on the number of different species in a certain area, but does not take into consideration that some species may be more abundant than others. We will use the term biodiversity as a generic term to describe the number of **organisms** on a **coral reef**, but it should be noted that biodiversity is actually much more complex. Coral reef biodiversity is among the highest of any ecosystem on Earth.

Science Box

An **ecosystem** consists of a biological community and its physical **environment**. The scientific study of ecosystems, or the relationship between **organisms** and their environment, is known as **ecology**—a term coined by German biologist Ernest Heinrich Haeckel in 1866. Eco comes from the Greek word ‘home’, and ology comes from the Greek word ‘to study’. Ecology is therefore literally ‘study of the home’.

Research shows that an **ecosystem** with high **biodiversity** is generally more productive and more resistant to disturbances—like the aforementioned hurricanes—than an ecosystem with lower biodiversity. In periods of upheaval, healthy and diverse ecosystems are better able to recover because changes can be balanced by adjustments within the community; it's like nature's safety-net for hard times. For example, black-band disease is an increasingly common **coral** disease caused by **bacteria**. Although these bacteria are capable of 'eating' through a range of different coral **species**, they are particularly partial to **massive corals** (also known as **dome-shaped** corals). **Branching corals**, such as *Acropora palmata* (elkhorn coral) and *Acropora cervicornis* (staghorn coral), seem largely resistant to black-band disease.



Figure 1.2: A coral under attack from black-band disease (photo by Caroline Rogers. Courtesy of USGS)

Imagine a **coral reef** with high coral **biodiversity**, containing **branching-form**, **plate-form**, **massive**, pillar and finger corals as well as seafans and other soft corals. If black-band disease were to descend upon this reef, chances are high that enough corals would survive to provide food and shelter for the other reef creatures. Now imagine a reef with low coral diversity, perhaps consisting of only a few **species** of **massive coral** and no branching-forms at all. In this situation, black-band disease might literally spell disaster for the entire **ecosystem**.

Did you know?

Ecosystems can vary in size—a single pond can be considered an ecosystem as can an entire planet.

The **organisms** within an **ecosystem** usually live in harmony with their **environment** and its **resources**, but occasionally this system is thrown out of whack when one **species** becomes too abundant. For example, under certain conditions, **locusts**, which are capable of eating their own weight in food each day, can appear in swarms so large that they leave entire areas uninhabitable as a result of their feeding.

Humans may not be the most numerous **species** on the planet, but we are certainly the most destructive. Over the centuries our actions have profoundly damaged countless **ecosystems** and placed stress on other **organisms**. By damaging the **environment**, destroying **resources**, and reducing **biodiversity**, we weaken the ability of ecosystems to recover from natural and **anthropogenic** (human-caused) disturbances.

All the different components of an **ecosystem**, which includes both **organisms** and their **environment**, are intimately connected. What this means is that even a tiny disturbance to one aspect of the ecosystem can have repercussions on the system as a whole. Sometimes, all it takes is the loss of one **species**, to bring the whole ecosystem crashing down like a house of cards.

Diver & snorkeler best practices

Never remove living **organisms** from the **reef**. A beautiful **shell** or piece of **coral** may make a tempting gift for a friend and family member, but needless to say, removing organisms from the coral reef is incredibly damaging and often illegal. Shells are often home to living creatures, whether it is the original inhabitant or a sheltering hermit crab. Certain shellfish play a vital role in the health of the reef, such as the large, horn shaped 'triton trumpet', the only natural **predator** of the coral consuming crown of thorns starfish. Remember the maxim: "Take only pictures and memories; leave only bubbles."

Quick Quiz

1. What are the two main components of an ecosystem?
2. Can you name an abiotic ecosystem component?
3. Can you name a biotic ecosystem component?
4. Why is biodiversity important to ecosystems?
5. Why is the word 'interconnected' so important for ecosystems?

Answers: 1. biotic and abiotic components; 2. Abiotic example: any non-living factor, such as wind, water and sediment; 3. Biotic example: any living organism, such as fish, coral, sponge, crustacean, etc.; 4. Ecosystems that have high biodiversity are often more productive, more resilient to disturbances, and are better able to recover from disturbances; 5. All ecosystem components are interconnected, so even a tiny disturbance may have repercussions on the entire system.

Topic 2. Associated ecosystems – seagrasses and mangroves

The **Coral reef** is the **ecosystem** that divers and snorkelers most commonly explore. As explained in the introduction to this program, coral reefs are often known as the rain forests of the sea because the wealth of life (**biodiversity**) they contain is comparable to that of tropical rainforests. Literally tens of thousands of different **species** rely on coral reefs for their existence—approximately 25 percent of all marine life! Many coral reef **organisms** will be explored later in this manual.

Coral reefs are closely associated with several other marine **ecosystems** in the **tropics**, such as **mangroves** and **seagrasses**. Many of the **organisms** found on coral reefs move between these ecosystems to feed and reproduce. As a result the boundaries between these ecosystems often become blurred.

Seagrass ecosystems

Seagrasses are underwater **plants** common in the shallow, sunlit waters of the **tropics**. They are found in every sea in the world and there are approximately 60 known **species** worldwide. Seagrasses differ from **algae** in several ways. For a start, seagrasses have special kinds of roots called **rhizomes** (pronounced: righ-zomes), which help move **nutrients** throughout the plant. Most seagrasses also produce flowers, seeds and fruit, just like their **terrestrial** cousins.



Figure 1.3: Caribbean seagrass ecosystems are home to many organisms, some of which are also found on coral reefs (photo by Alex Tewfik)

Seagrasses, along with other **plants** and **algae**, are **producers**, which means they are capable of producing energy from **sunlight** through a process known as **photosynthesis**. Because of their dependence on sunlight to make energy, seagrasses are often found in shallow water, where enough sunlight penetrates for photosynthesis to occur. In the Caribbean, seagrasses are commonly found in protected coastal areas such as **fringing reef lagoons**, where **wave action** is low (see Beautiful Oceans program 'Coral Reef Architecture & Organisms' for more information).

Seagrasses perform a number of important **environmental** functions. The **ecosystem** as a whole represents important **nursery habitat** for many **coral reef organisms**. Seagrasses provide protection for these young organisms from the larger open water **predators**, like barracuda and grouper, commonly found on nearby coral reefs.

Diver & snorkeler tip

There are nine species of seagrass found in the Caribbean, but only three are common. When you find a patch of seagrass during a dive or snorkel, chances are it is either turtle grass (*Thalassia testudinum*), manatee grass (*Syringodium filiforme*) or shoal grass (*Halodule wrightii*).

Here are some tips to help you tell the difference between the three main species:

Turtle grass (*Thalassia testudinum*) has relatively wide, green flat leaves with rounded tips, ranging from 5-20-cm (2-8-in) in length. Turtle grass leaves are much wider and flatter than the two other species of seagrass described here. Turtle grass usually occurs in water less than 12 m (40 ft) deep.



Figure 1.4: Turtle grass (*Thalassia testudinum*) (photo by Paige Gill)

Manatee grass (*Syringodium filiforme*) has thin, green, hair-like (cylindrical) leaves that range from 5-20-cm (2-8-in) in length. Manatee grass usually occurs in water less than 12-m (40-ft) deep and rarely by itself. Other species of seagrass are commonly found next to this species.



Figure 1.5: Manatee grass (*Syringodium filiforme*) (photo by Ronald C. Philips)

Shoal grass (*Halodule wrightii*) leaves range from dark red or brown to green, are approximately 5-20-cm (2-8-in) in length, and have a flat or jagged tip. Shoal grass is a tough species—it can survive temperatures and salinities that may kill other species of seagrass. As a result shoal grass is often found in particularly deep or shallow areas. Sometimes shoal grass may even be exposed at low tide.



Figure 1.6: Shoal grass (*Halodule wrightii*) (photo by Ronald C. Philips)

Seagrasses also provide an important source of food for many **species** of **fish**, **crustacean**, **mollusk** and even **marine mammal**, like the rare West Indian manatee found in Florida and the Greater Antilles (e.g. Jamaica and Puerto Rico).

Science Box

Scientists actually divide the West Indian **manatee** into two separate species—the Antillean manatee (*Trichechus manatus manatus*) and the Florida manatee (*Trichechus manatus latirostris*). Although these **species** are very similar, they are not thought to reproduce together in the wild, which technically makes them separate species.

Did you know?

The West Indian **manatee** is part of the scientific order Sirenia, which contains other manatee **species** from Africa and South America, and the dugong, found in the **Indo-West Pacific**. The name Sirenia comes from the word siren. In ancient Greece sirens were mythological creatures—half woman—that inhabited the oceans, and whose songs would lure sailors to their death. To this day, the term “siren song” still refers to an appeal that is hard to resist but that may lead to danger.



Figure 1.7: The West Indian manatee (*Trichechus manatus*) is one of the oceans' largest vegetarians

Finally, through their network of **rhizomes**, **seagrasses** help trap **sediments** that might otherwise drift onto the adjacent **coral reefs** and smother corals and **sponges**. Thanks to **seagrass** beds, coral reefs often have a clear water environment.

Mangrove ecosystems

Mangroves are special trees and shrubs that have developed an ability to survive the inhospitable boundary between land and ocean. **Organisms** that live here must meet the challenges of fluctuating **tides** and **salinity** and low **dissolved oxygen** in the water (see Beautiful Oceans program: Coral Reef Architecture & Organisms). A total of 54 **species** of mangrove are known to science.

Did you know?

Some **organisms** that live in **mangrove ecosystems** have special adaptations that allow them to overcome the challenges of living in this ecosystem. The tarpon—*Megalops atlanticus* [meaning ‘Atlantic fish with large **scales**’—from (Gr.) mega=large, great + (Gr.) lops=scale, husk, peel + (Gr.) atlanticus=bear, carry, but also reference to the Atlantic Ocean] has a modified **swim bladder** that allows it to gulp air from the surface when **dissolved oxygen** becomes too low to breathe using their **gills**.

Mangrove plants are unique because of their ability to obtain **freshwater** from the **saltwater** within which they grow. Mangroves do this in two ways: by restricting salt absorption through their roots, and by secreting salt through their leaves. There are three common **species** of mangrove found in the Caribbean: red mangroves (*Rhizophora mangle*), which often grow straight out of the water; black mangroves (*Avicennia germinans*), which are usually located in slightly shallower water; and finally white mangroves (*Laguncularia racemosa*), the most landward of the three species.

Like **seagrass ecosystems**, **mangroves** provide numerous ecological services. The roots of mangroves trap **sediments**, acting like a filter that keeps coastal waters clear and unpolluted. The location of mangroves along the coast also provides coastal protection from **waves** and **currents**. Finally, mangroves provide **nursery habitat** and feeding grounds for many **coral reef organisms** like snook, tarpon and jacks, as well as **terrestrial organisms** like birds and **crabs**.



Figure 1.8: Caribbean mangrove ecosystems are home to many organisms, some of which are also found on coral reefs (photo by NOAA)

Science Box

A report issued in December 2005 by the World Conservation Union (IUCN) suggests that **mangroves** can help save lives by acting as natural barriers to **wave action**. The report compared the death toll in two Sri Lankan villages hit by the **tsunami** that devastated South-East Asia on December 26, 2004. Approximately 6,000 people died in the village without mangrove protection, while in a nearby village that was protected by a dense mangrove forest only two deaths were recorded. Previous research by the United Nations **Environment Program** (UNEP) has suggested that mangroves are capable of absorbing up to 90 percent of normal wave energy.

According to the United Nations **Environment Program** (UNEP) a square kilometer of **mangrove** can be worth nearly US\$1 million in terms of their benefit to local **fish** stocks and coastal protection. As such, many governments have now initiated replanting projects in areas where mangroves have been removed. Despite the value of mangroves, they are disappearing from our planet faster than tropical rainforests. Many countries have lost as much as 80 percent of their original mangroves.

Quick Quiz

1. Why are coral reefs often described as the rainforests of the sea?
2. What other tropical ecosystems are coral reefs often associated with?
3. Are seagrasses plants or algae?
4. Name three ecological services that mangrove ecosystems may provide?

Answers: 1. they contain a wealth of biodiversity comparable to that of tropical rain forests; 2. mangrove ecosystems and seagrass ecosystems; 3. seagrasses are plants; 4. mangrove ecosystems trap sediments, provide nutrients to organisms, and act as a nursery for some coral reef organisms.

Topic 3. Organism interactions – predation

As we have already mentioned, in a healthy **ecosystem**, **organisms** are often perfectly balanced with each other and their **environment**. This balance is achieved through various interactions, such as **predation**, **competition** and **symbiosis** (a broad term that describes the close and intimate relationships that occur between some **species**).

Predation is a term used to describe the hunting and consuming of another **organism** (known as the **prey**). Interactions between **predators** and their **prey** are particularly common on **coral reefs**. Predators have developed countless ways of launching their attack, while their prey, in-turn, have developed many ingenious ways of defending themselves.

Did you know?

Predators are either **carnivores** or **omnivores**. Other feeding interactions exist, such as those between **herbivores** and **producers**—**plants** and **algae**.

Some **predators**, like barracudas for example, opt for speed and strength to overcome their **prey**—sometimes referred to as “**active predation**”. Other predators, like lizardfishes and scorpionfishes, for example, choose to **ambush** their prey from a concealed position—sometimes referred to as “**passive predation**”. Active and passive predation are discussed in greater detail in relation to The **Coral Reef Organism Behaviour Tool—Food Web** (see topic 10).



Figure 1.9: Lizardfishes hide on the reef and ambush their prey as they swim by