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A Teaching Guide to the Biology and Geology of Bermuda

A field study guide to the past and present biology and geology of Bermuda with an identification manual illustrating over 750 common species

by Martin L. H. Thomas

Project Nature
Field Study Guides for Bermuda Habitats

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A Teaching Guide to the Biology and Geology of Bermuda

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Foreword

Bermuda is an isolated oceanic island with a unique environment. It is a world leader in marine conservation legislation, environmental research and education. With their sponsorship of the Bermuda Biodiversity project, world-class exhibits and innovative education programming, the Bermuda Aquarium, Museum and Zoo (BAMZ) and the Bermuda Zoological Society (BZS) are at the forefront of these endeavors.

Martin Thomas is Bermuda's most experienced ecologist and one of the most prolific writers on Bermuda's natural history. This Teaching Guide to the Biology and Geology of Bermuda is the latest publication from BZS and the final in the series. It follows his nine Project Nature Field Study Guides to Bermuda Habitats and is the ultimate tool for teachers and students at the middle and high school levels for exploring Bermuda's natural history from pre-colonial times to the present day.

I urge all teachers to use this book; it is an incredible resource! Don't let it just sit on your shelf, get out there, explore and learn about Bermuda along with your students. All our habitats are accessible and lend themselves to investigation. Start by visiting the Natural History Museum, Local Tails and the Aquarium at BAMZ. Taking the next step of engaging your students in practical investigation will lead them to a greater understanding of the relationships and greater sensitivity to the delicate balance within our habitats. As Bermuda becomes increasingly developed, we need citizens who have knowledge of our environment combined with a strong conservation ethic to ensure that informed decisions are made in the future.

We are grateful for Martin Thomas' love of Bermuda, his dedication and unmatched energy in bringing us his latest book. Our little island needs this!

Mary Winchell
Former Education Officer
BAMZ / BZS
July 2005

Acknowledgements

The help of the following people is gratefully acknowledged; without their encouragement and assistance this study and field guide could not have been produced.

Brian Lightbourn, Principal Curator of the Bermuda Aquarium, Museum and Zoo paved the way for the production of this volume and his support of the project is greatly appreciated. Mary Winchell, the former Educational Coordinator was largely responsible for the idea of the Project Nature series, now comprising ten field guides. Holly Mitchell, the present Educational Coordinator has taken over Mary Winchell's supportive role and this is the third field guide published under her leadership.

One thing has remained constant throughout the series and this is the very expert assistance of Liz Nash in getting the manuscripts ready for publication by designing the layout, arranging and inserting the illustrations, collating the contents, looking after printing and binding and giving very useful advice during the writing stage. The very marked improvements in the overall appearance of this series of publications, is largely the result of her efforts and advice. All those involved with this series are most grateful to her.

Many people have assisted in the background field, library, proof-reading, review and museum work essential to a task such as this. Without their help and encouragement the guide would be much less complete and practical than it is. Grateful thanks are extended to: Anne Glasspool, Heather De Silva, Joseph Furbert, Andy Fields, Jennifer Conklin-Gray, Lynn Thorne, Mark Outerbridge, Louise Lamphier, Roz Collins, Lisa Greene, Bobbii Cartwright, Judie Clee, Jean Hannant, Chris Flook, Sarah Manuel, Mary Lou Harley, Alan Logan, Sandra Rouja, Jeremy Madeiros, Richard Winchell, Wolfgang Sterrer, Margaret Emmott, and Penny Hill.

The illustrations of the species of plants and animals important in the natural history of Bermuda, were adapted, with permission, from a variety of sources including, "Marine Fauna and Flora of Bermuda" edited by W. Sterrer, "Bermuda's Marine Life" by W. Sterrer, "Bermuda's Seashore Plants and Seaweeds" by W. Sterrer and A. R. Cavaliere, and the "Identification Manual to the Pelagic Sargassum Fauna", Bermuda Biological Station for Research Special Publication No. 11, by B. Morris and D. D. Mogelberg. Line drawings have also been contributed by R. A. R. "Joe" Smith, Michelle Pasquin, Andrew Dobson, David Wingate, Tiana Harley-Thomas and Janet Percy. Others were prepared especially for this or previous volumes of Project Nature by the author. Full-page habitat illustrations are by Jo-Anne Stevens of the University of New Brunswick, Saint John, Canada, except for that of the cave mouth cliff which which is by the author, the Paget Marsh Bermuda Palmetto swamp by Michelle Pasquin and the early Bermuda Cedar forest by Janet Percy.

The very thorough work of N. L. Britton which appeared in 1918 as the book "Flora of Bermuda", is an inspiration to everyone working on the terrestrial and freshwater plants of these islands. Sadly, it is long out of print and the few surviving copies are kept locked away. The Bermuda Aquarium, Natural History Museum and Zoo has a photocopy that can be referred to by those especially interested in this subject.

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Part 1. Introduction

Chapter 1. Introduction to the Study, Field and Identification Guide

Content of the Book

This field and study guide is intended as a general introduction to Bermuda, its origins, general geology, biological history, present-day natural history and the conservation and pollution problems, which face the country. We will consider the geology and biology together as natural history, because, as we shall see, the interactions between biology and geology are better illustrated in Bermuda than almost anywhere else on earth. To understand the situation in present-day Bermuda, we have to go back for millions of years and trace events up until now.

The book starts in Part 1 with an introduction that explains how the book is set up, gives guidance on natural history terms and explains scientific names. This is followed by two chapters on the ancient history of Bermuda and the first life here. The introduction concludes with a chapter giving notes on field trips. The second part of the book is concerned with the natural history of Bermuda just before the islands were colonised. The third part deals with the present day natural history. The fourth part is a comprehensive identification guide to the common flora and fauna of Bermuda.

Summary

This field, study and identification guide describes the past and present geological and biological features of Bermuda. Field trips are outlined for all appropriate subjects in the guide.

In all parts of the book, observation and hands-on experience are emphasized in a wide variety of field trips, which cover both general topics, and details of natural history. Because these field trips will be more meaningful if participants can identify the geological features and animals and plants that they see, the fourth section of the book has illustrations of all common and important geological structures, animals and plants that can be seen. This book summarises information from the series Project Nature, a complete list of which appears inside the front title page. All are available from the Bermuda Zoological Society. To make the text suitable for a variety of ages, text boxes with non-technical summaries are included throughout.

Items in bold text, with the exception of headings, are defined in a glossary at the back of the book.

About Islands

Bermuda is a tiny collection of islands with vast expanses of open sea on all sides. There are two general types of island, **oceanic islands** and **continental islands**. Bermuda is a collection of oceanic islands because it is not situated on a **continental shelf** but rises up directly and steeply from the deep ocean floor. Examples of oceanic islands are the Hawaiian group, the Galapagos Islands, Iceland and Easter Island. Examples of continental islands are Newfoundland, Madagascar, Britain, Australia and Java. Continental islands may be very large and oceanic ones are usually smaller, although both types include lots of tiny islands. To live in Bermuda is almost to live on the ocean. The only thing lacking is the motion of a vessel; thank goodness for that! The main effects of the ocean are part of the way of life. As an example, the usually friendly climate of Bermuda depends almost totally on the ocean. At a similar latitude on the North American continent, the annual variation in climate would be very much greater. Bermuda's two seasons, summer and winter, are expanded on the mainland to include very definite spring and autumn but winter shows the greatest differences. On the continent, winter would be much more severe with frost and snow a regular, annual occurrence. This in turn affects the way of life for humans and determines what animals and plants live there. Rough weather at sea close to Bermuda affects everyone on the islands. In the case of a hurricane or other violent storm, there are no inland areas in which to seek shelter and salt spray affects everything. Life in Bermuda means being ready for anything the ocean can foster.

An Isolated Island

The one word, which sums up Bermuda's situation, is isolated. The closest points of land are Cape Hatteras, U.S.A. which lies 960 km or 600 miles northwest and Nova Scotia, Canada, which is 1,280 km or 800 miles due north. All other landmasses are much further away but, as we shall see, it is not merely distance, which gives isolation. Although the Caribbean islands are one and a half times further away than Canada, Bermuda has more in common with them. Bermuda has a land area of only 55 km^2 or 21 square miles whereas the Atlantic Ocean in which it lies comprises over 30 million square miles or 137 million square kilometres! In other words you could fit 2 1/2 million islands the size of Bermuda into the Atlantic Ocean! If you were a bird swept off the coast of West Africa in a violent gale, the chances of finding Bermuda before you died of exhaustion; starvation or thirst would seem to be infinitesimally small. However, it does happen now and again. So although Bermuda is small and isolated it does have some natural communication with far-away places. You will notice that I said natural communication; this is because this whole picture of isolation and communication has become drastically altered by man. Not only has man introduced new species to Bermuda from all over the world, but since the islands were colonised in the early 1600s has also managed to totally change the animals and plants on land so that any resemblance to a natural condition has to be carefully sought out and interpreted.

Summary

Bermuda is a very isolated group of small **oceanic islands** only 21 square miles in area. The closest land is Cape Hatteras, USA, 1,280 km or 600 miles to the west. Although the Caribbean islands are quite far away, Bermuda has more animals and plants in common with them than the closer USA and Canada. Very occasionally, however, birds from Europe and Africa far to the east do reach Bermuda. Since man arrived in the early 1600s he has **introduced** other animals and plants from all over the world and has changed Bermuda for ever.

When we look at the isolation of Bermuda in relation to its natural history, we find that it is not a simple picture but varies with the **habitat** or living space of the organism involved. For instance some marine creatures are not really isolated at all. A good example of this is the Spiny Lobster (*Panulirus argus*). Many of the Spiny Lobsters in Bermuda have come from eggs laid in the Caribbean islands. We know this by looking at the **DNA** profiles of Bermudian lobsters and comparing them to Caribbean ones. If these two groups or **populations** of lobsters were truly isolated from one another, their DNA profiles would differ, but they do not. But how can these two distant populations not be isolated from each other.

Things that Modify Isolation

This is where we have to consider other factors than just sheer distance and small size, as determining the degree of isolation. In this case the answer lies in ocean current patterns, which in turn result from general global wind systems. To explain what is happening here we have to go to the Northeast **Trade Wind** Belt. The Northeast trades are winds that blow constantly from the Northeast just north of the equator in the Atlantic Ocean. In the days of sail, ships used these winds to cross the Atlantic Ocean from east to west. Sailors quickly learned that these winds blew all year round and that they could rely on them. Well, of course, these winds also created waves, which in turn spawned currents moving from east to west. Now geography comes into the picture too; Figure 1.1 shows the situation. The current created north of the equator carries water to the west and most of it ends up in the Gulf of Mexico where it is confined. The result is quite predictable, the water level in the Gulf of Mexico is 1 m (3 ft) higher than outside the Gulf. This may not seem much, but the Gulf of Mexico is huge (Fig.1.1) and a 1 m (3 ft) layer of water this size is a huge volume. The water in the Gulf of Mexico has what is termed a **head**, which will tend to flow downhill. It can't go east because that is where the water is coming from, so instead it flows north

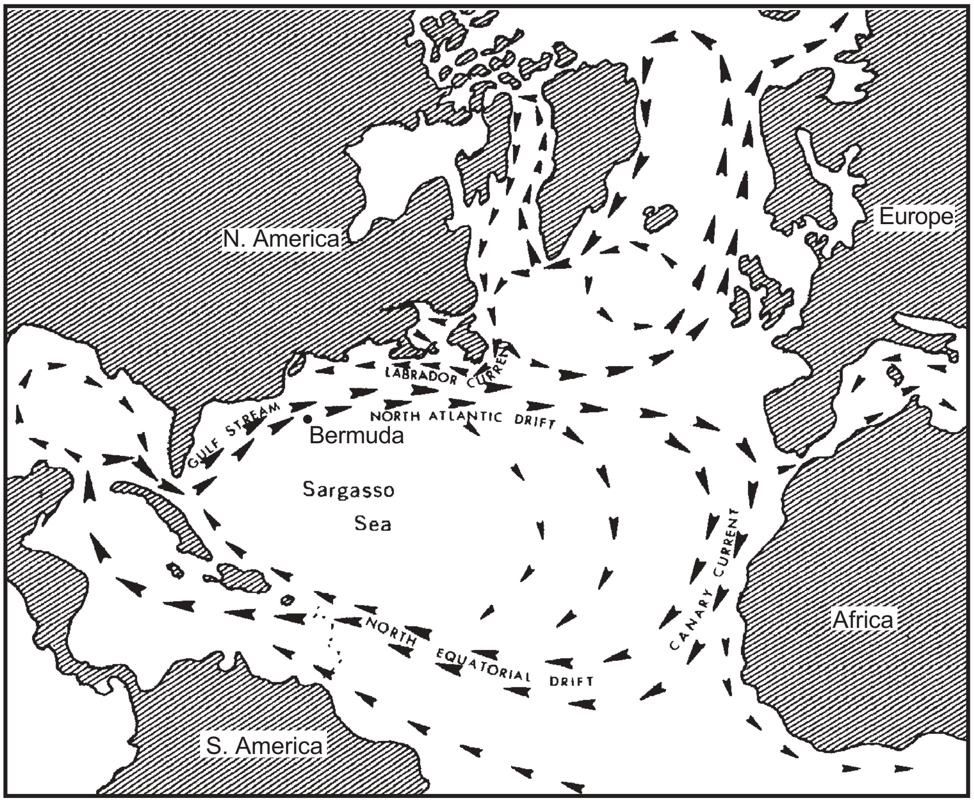


Figure 1.1. Surface oceanic currents in the North Atlantic

through the Straits of Florida, between the U.S.A. and Cuba. This northward flow is called the **Gulf Stream** and to give some impression of its size, it carries more water than all the rivers in the world put together and is virtually immune to wind until it gets up off the coast of Canada where it turns east across the Atlantic Ocean. Not all the water goes through the Straits of Florida but smaller portions flow between and around the Caribbean islands. At any rate this water comes from tropical areas and it is warm and flows just past the west coast of Bermuda. Side branches of the main current spin off and include Bermuda in their path. Now we can see how lobster eggs from the Caribbean could get carried to Bermuda. In actual fact the eggs hatch into larvae, with limited swimming power that travel on the Gulf Stream. It does not take much imagination to see that fishes and other marine creatures can come by the same route. The above example serves to show how some marine creatures get here and one may suppose that a few land animals and plants might also travel this way on logs or as floating debris. The topic of animal and plant transportation to Bermuda will be explored in more detail below in Chapter 8.

Summary

Although it may seem at first glance that all groups of animals and plants in Bermuda are equally isolated from others in the world, this is not so. Marine life is less isolated than the rest because of the huge **ocean current**, the **Gulf Stream**, flowing from the south past the west end of Bermuda. This current is constant and has been there for probably millions of years. The Gulf Stream brings with it lots of marine life as eggs, juvenile creatures, fish, turtles etc and objects floating at the surface can carry plants, terrapins, seeds and other things. A good example of this is the Spiny Lobster. Which regularly comes to Bermuda from eggs laid in the Caribbean

Island Generalisations

Studies of island natural history on a worldwide basis have shown that several important generalisations can be made. More isolated islands have a lower variety of different living organisms (a lower **biodiversity**), a higher proportion of animals and plants found nowhere else on earth, and a higher rate of **extinction**. Island size also affects the picture in that larger islands show these effects less than smaller ones. Another universal feature that emerges is that man has a high capacity to reduce the variety of life and to increase the rate of extinctions. Bermuda is an excellent example to study all these effects in practice.

Chapter 2. Some Natural History Terms

Words you Need to Know

In a guide of this nature some technical terms must be used. When words in the text are in bold, they are explained in the glossary at the end of this guide. However, a few more general ones are used very frequently and deserve a more detailed explanation. Most of these are ecological in nature. Ecology can be most simply defined as the study of nature or the examination of animals and plants, or **organisms**, and the surroundings that they occupy. On a large scale, a collection of organisms and their surroundings form an **ecosystem**. An ecosystem consists of a characteristic group of organisms in a particular type of surroundings. For example, the open ocean and its inhabitants can be considered as an ecosystem, as can forests, marshes, coral reefs, deserts etc. On a smaller scale, the surroundings of groups of organisms living under similar conditions are called **habitats** or **environments**. There are many habitats within an ecosystem. For example, on a coral reef, there may be steep-sided channels, cavities, shaded locations etc. In a forest there may be dense areas with virtually bare ground, or more open areas with a lot of undergrowth. We might even subdivide further to **micro-habitats**, which might be a small cavity under a coral colony or the space under a fallen leaf in the forest.

Another group of terms is used to describe the variety of life in an area. If there are a large number of different organisms (**species**) in an area it is said to have higher **biodiversity**. A location where biodiversity is low is often called **depaurporate**. The word **diversity** is often used instead of biodiversity but it can also be applied to the structure of habitats. Thus a complex habitat like a forest with its many layers can be called diverse while an uncolonised area of flat sand could be said to lack diversity.

There are several terms, concerning the origins of animals and plants that will be frequently used in this field guide that you should be familiar with. Animals or plants that have evolved in Bermuda to form new species are called **endemic**. Species called endemic must have evolved here and nowhere else, however, it is possible that they spread elsewhere after they evolved, or that they were introduced elsewhere by man. Endemic species form a very small and very important part of Bermuda's fauna and flora. Organisms that arrived in Bermuda by natural means and have persisted until today are termed **native**. Examples that have been added to the natural complement through the activities of man are known as **introduced**. Introduced species that have spread on the islands and that now reproduce naturally here, are called **naturalized**. If an endemic species that is still confined to Bermuda is eradicated it is **extinct**; an extinct organism has ceased to exist on earth. Several organisms endemic to Bermuda have been introduced to other locations. An example is the Bermudiana (*Sisyrinchium bermudiana*) a beautiful plant, which is grown in gardens throughout the world in suitable climates. If one of these 'exported' organisms dies out in Bermuda, it is

Summary

To use this guide you need to be familiar with a few technical terms. Animals and plants together are **organisms**. The place where groups of animals and plants, or **communities**, live is called a **habitat**. Very large habitats are **ecosystems**. If there are a great many different organisms or **species** in a habitat it has high **biodiversity**. Species which have evolved in Bermuda are **endemic**. They do not naturally live elsewhere. **Native species** arrived here by natural means and **introduced species** were brought by man. Introduced species which spread on their own are **naturalized**. Naturalized organisms which become a nuisance are **invasive**. If an endemic species completely disappears it is **extinct**. If native or introduced species disappear they are **extirpated**. Other terms are explained in the glossary at the end of the book.

extirpated not **extinct**. Any animal or plant that became native or naturalized and was subsequently lost from Bermuda is also termed **extirpated**, providing it still occurs elsewhere. If a species exists anywhere on earth it is not extinct. Naturalised species which reproduce rapidly and spread often become a nuisance as they compete for space, food etc. with native and endemic species, these are called **invasive species**. A good example of an invasive tree is the Brazil or Mexican Pepper (*Schinus terebinthifolia*) another is the Indian Laurel (*Ficus retusa*). An example of an invasive animal is the Pigeon or Rock Dove (*Columba livia).*

Chapter 3. Scientific Names

Use of Scientific Names

Summary
Scientific names consisting of two words written in italics, are given for the first mention of a species in any section of the text, together with the common name. This is done because common names vary from place to place. With a scientific name you absolutely are sure of the **species** you are referring to.

Scientific names of animals, plants and bacteria, written in italics, are given for the first mention of any species in any chapter but not for subsequent mentions in the same chapter. They are also given along with the common name with every description of a species in the identification section (Part 4). Scientific names are included because they provide a reference to that exact species in other writings. No two scientific names are ever identical. Common names can change from place to place; indeed quite a few of those used here apply only in Bermuda. For example the fish commonly called the Black Rockfish (*Mycteroperca bonaci*) in Bermuda, is also known here as the Runner Rockfish, elsewhere it is called the Black Grouper, or Poey! Scientific names can only change under very special circumstances and even then the old name is never re-used. Additionally, scientific names, once you get used to them, also give clues to family relationships of organisms and are often are quite descriptive of some noticeable feature. For example an anemone found only in the floating masses of the oceanic seaweed called Sargasso Weed (*Sargassum* species) has been given the scientific name of *Anemonia sargassensis*! And of course the seaweed itself (*Sargassum*) is named for the vast body of ocean water lying to the east of Bermuda called the Sargasso Sea. A really extreme example is the scientific name for the deepwater Vampire Squid, *Vampyroteuthis infernalis*, which might be roughly translated as the Infernal Vampire Squid! Sometimes scientific names are quite beautiful, for example *Annalisella bermudensis*, which has no common name, is a tiny flatworm living on seagrass! Scientific names always consist of two words, the first is known as the **generic name** and the second as the **specific name**. Specific names are usually descriptive of some feature or shows where the organism lives. Specific names such as *bemudensis*, *bermudana* etc., often but not always mean that the species is endemic. Such is the case with the Bermuda Palmetto, *Sabal bermudana* and the Bermudiana, *Sisyrinchium bermudiana.* However, the Red Anemone, *Actinia bermudensis*, is widely distributed in Gulf of Mexico but was only named *bemudensis* because it was first found here. Different species with the same generic name are always closely related and may be difficult to tell apart. For example, the Bermuda Killifish, *Fundulus bermudae*, is very closely related to the Killifish, *Fundulus heteroclitus*, found on the mainland, and they are virtually indistinguishable!

Chapter 4. The Beginning of Bermuda

Summary
Bermuda began 110 million years ago when an undersea volcano erupted on the **Mid Atlantic Ridge**. This ridge is where liquid rock rises from within the Earth to the sea bed forming a new sea bottom. This happens continuously, so the Atlantic Ocean is enlarging about 4 cm/yr (1 1/2 in). Because of this, the volcano "Mount Bermuda", which probably reached the surface, moved steadily west away from the ridge. About 40 million years ago when it was 1,200 km or 750 miles from the ridge it passed over a "**hot spot**" which added more liquid rock causing another eruption. This one resulted in a group of three volcanoes, one of which the "Bermuda Seamount" became the Bermuda we know today. It now is 2,000 km (1,250 miles) west of the ridge.

The Start of Bermuda

Bermuda is called a **ridge island** because it probably arose on the **Mid Atlantic Ridge** of the Atlantic Ocean about 110 million years ago. The Mid Atlantic Ridge is a largely underwater geological feature running down the centre of the Atlantic Ocean (**Figure 4.1**). The Mid Atlantic Ridge is a site of intense geological activity because it lies at the **spreading junction** or zone between the European and American **tectonic plates**, large plates of the Earth's crust riding on molten **magma** beneath. There are two types of these junctions. At spreading junctions, the surface of the Earth is enlarging as molten magma from within rises to the surface and solidifies. At the other type, **collision junctions**, one plate slides beneath another, causing earthquakes and building mountain ranges. The West coast of North America is an example of this second type. Another example is the area just off the west coast of Indonesia where an earthquake caused by one plate moving under the other, caused the very destructive Tsunami in southeast Asia, which resulted in such terrible loss of life in late 2004. Sometimes islands are produced in this type of situation too; these are called **island arcs** because they often occur in arc shaped groups. A third, less common, type of plate junction is where the two plates slide sideways against each other. This type is also characterized by earthquakes.

Bermuda's Volcanic Past

Along the Mid Atlantic Ridge new crust material is being added continuously and as a result the two plates move slowly apart at about 4 cm (1.5 in)/yr. Together with the spreading come frequent small tremors, some earthquakes and the creation of a variety of volcanoes. One of these erupting 110 million years ago later became the Bermuda islands. The volcano appeared just to the West of the ridge and produced a large cone termed a sea mount, which rose close-to or above the surface. This volcano, which has been called Mount Bermuda, then moved slowly away from the ridge, covering 1,200 km or 750 miles during 60-80 million years without volcanic activity. It then went through a second phase of eruption as it passed over a 'hot spot' in the crust, which added more magma. At this time Mount Bermuda was enlarged to form the Bermuda Seamount, consisting of three volcanic peaks now called the Bermuda Pedestal, the Challenger Bank and the Plantagenet or Argus Bank. If Bermuda had arisen solely as a result of a volcanic eruption away from the Mid Atlantic Ridge, as some geologists theorize, it would be a **hot spot island** rather than a ridge island. We may never know which type Bermuda really is. The volcanic rock which comprised all of early Bermuda is very hard, almost black and called **basalt**. **Figure 4.2** shows the basic features of the formation of Mount Bermuda.

The group of peaks rises sharply about 4,000 m or 13,000 ft from the seabed but the Bermuda Pedestal is the only one currently above sea level. The Bermuda Seamount has moved a further 800 km or 500 miles away from the Mid Atlantic Ridge in the last 30 million years or so to lie where it is today. Luckily, volcanic activity is a thing of the past for the Bermuda Seamount as it now lies in a stable area of the Earth's crust. However, occasional earthquakes still occur as weaknesses in the underlying rock give way under the stress of the spreading process. The last significant earthquake, centered 370 km southwest of Bermuda, occurred on March 24, 1978 and measured 5.8 on the Richter scale!

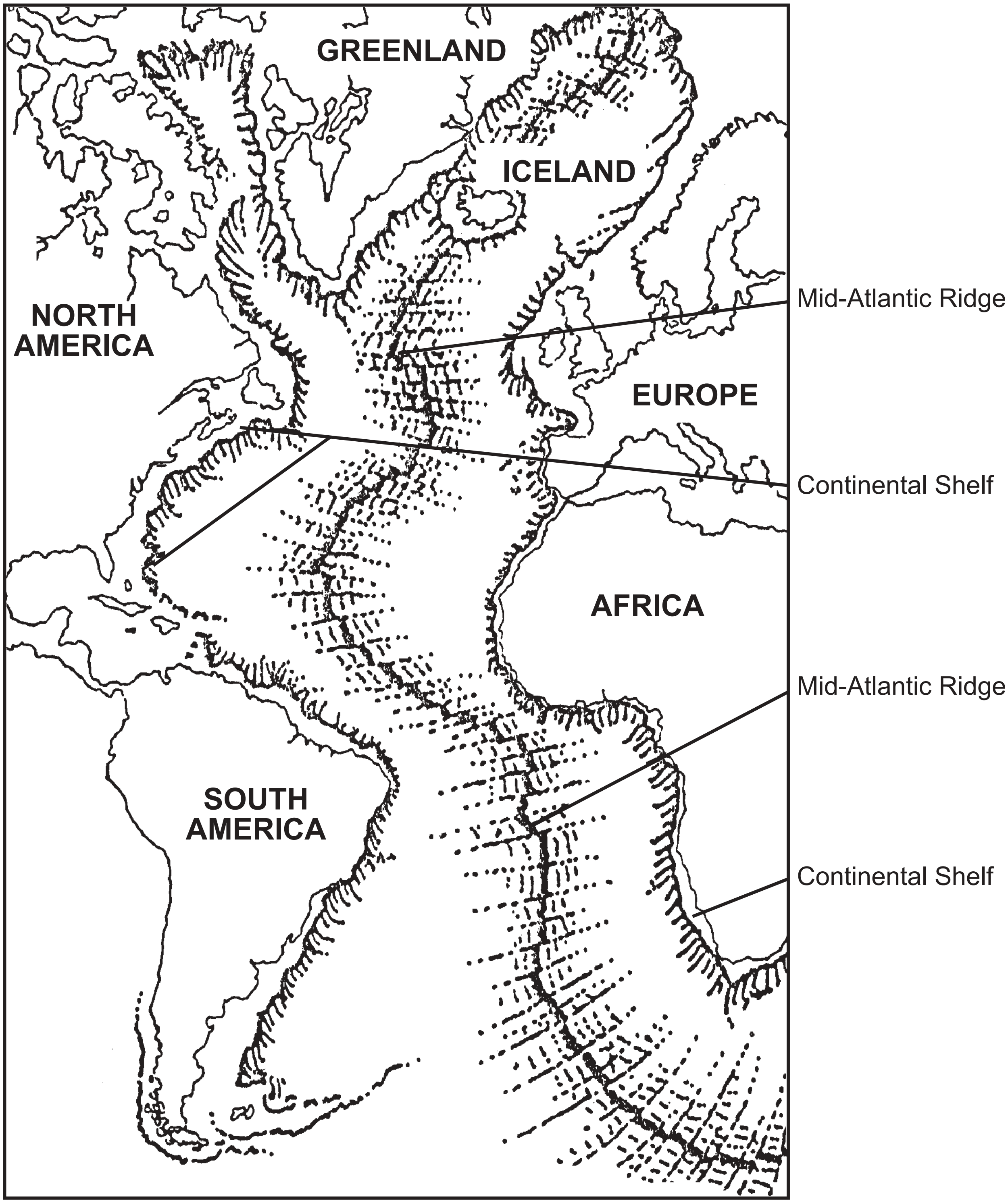
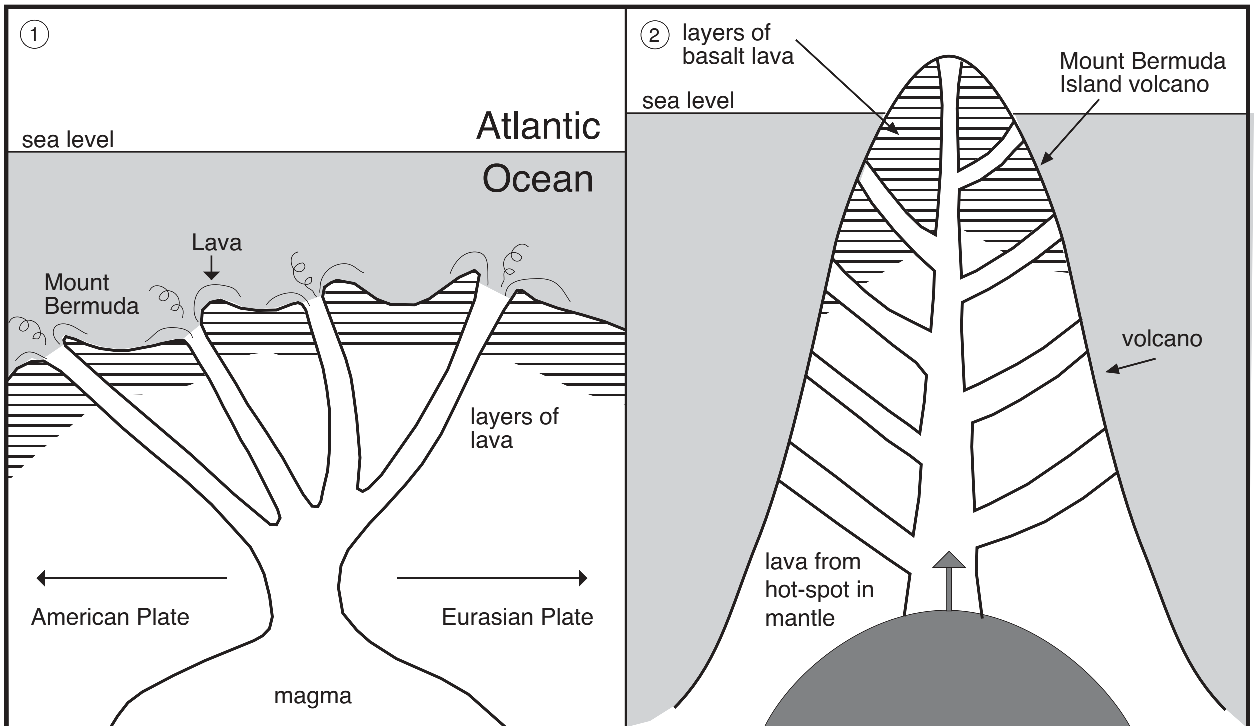


Figure 4.1. The Mid-Atlantic Ridge



110 Million Years Ago The Bermuda seamount formed from volcanic eruptions on the ocean floor	**35 Million Years Ago** A second phase of volcanic activity built Bermuda into a mountain which may have reached 3,000 feet above sea level.

Figure 4.2. An interpretation of the formation of Mount Bermuda.

Chapter 5. First Life Long-ago

Very Early Bermuda Life

There is no reason why the new Mount Bermuda, 110 million years ago, would not be colonised by marine organisms as soon as it cooled enough to support life. Organisms would have arrived as **spores**, **larvae** and even some adults carried on ocean currents. Even though 110 million years is a long time ago, it is but a fraction of the time that life has been present on Earth. Bacteria were present about 5 billion years in the past and many marine invertebrates, such as sponges starfish, sea squirts, anemones and worms appeared at least 600 million years ago. Early land plants and animals were present over 400 million years in the past. **Mammals**, warm-blooded animals that suckle their young, probably arose at about the same time that the volcano, that would become Bermuda, erupted in mid-Atlantic. However, if we consider man's place on earth, then human ancestors appeared only 6 million years ago and advanced man less than 1 million years before now. So, man's evolution has taken place during the last 5% of the existence of Mount Bermuda.

Summary

Life almost certainly appeared on Mount Bermuda as soon as it was cool enough for **organisms** to settle. Even if the volcano had risen above the surface, the first colonising organisms were marine because others would have no easy means of getting there. Additionally, variations in sea level probably drowned any terrestrial colonisers at intervals. Marine colonising organisms arrived on **ocean currents** but were probably different than we see today as water temperatures were probably lower. Nevertheless, seaweeds, corals and other creatures that produce limestone-like deposits or shells produced reefs and sediments that improved **habitat diversity** and paved the way for other organisms.

What Came First

The nature of the first biological colonists would have depended very much on whether the volcanic cone rose above the sea surface. There is no accurate information on this but it is believed that it at least rose close to the surface. Ancient sea levels were anything but constant, decreasing in glacial periods as water was locked up in the ice caps and rising in the warmer inter-glacial times as ice melted. Mount Bermuda may well have been an island at times and just submerged at others. So, even if terrestrial life was established it was probably wiped out by periodically rising sea levels. For this reason only marine organisms were permanent colonisers. Additionally, the marine climate around the dormant volcano may have varied considerably, and certainly at times was quite cool; because of this early marine communities may have had little in common with those of today.

Habitat Diversity

There was, however, at this stage, a very low **diversity** of habitats and because of this many organisms reaching the area in ocean currents could not find suitable living spaces and either did not settle, or settled and failed either to survive or to reproduce. Because of this problem, progress toward a more diverse island community was slow. However, some organisms such as **seaweeds** and **corals** undoubtedly appeared and produced early **reefs** composed of **limestone**. As **erosion** from ocean currents, waves and the action of some organisms took place, sediments began to be laid down and were augmented by shells and shell fragments of many organisms. The appearance of **sediments** improved matters, but it was only when marine sediment deposits were exposed to the air that a huge increase in habitat diversity on land paved the way for a more diverse natural community there. Emergence of the island into the air saw the addition of **intertidal** sedimentary and rocky habitats, a harsh **terrestrial** zone just above that subject to wave and spray action, and then as height increased, a variety of coastal habitats behind which true terrestrial and some primitive freshwater habitats were created.

Although many habitats were created long ago, it was only the truly marine ones that would be rapidly and permanently colonised by organisms. Organisms that did not have adults, larvae or spores that could live for an extended time in open-seawater, would not have a good chance of colonising the newly created habitats of Mount Bermuda.

Chapter 6. Notes on Field Trips

General Considerations
The field trip should always be thoroughly gone over with all participants well in advance. An introductory trip to the Bermuda Aquarium is a very good idea, and will help students to be able to identify some of the plants, invertebrates and fishes.

Although materials required are detailed for each field trip, the main thing that students of any age should be encouraged to do, is to make careful observations at each location and to make notes and sketches or diagrams of what they see. This is best done in pencil on a clipboard, which has several sheets of good, fairly heavy paper. Pencil work on good paper can withstand dampness or even rain, quite well and can be dried out later.

A good first aid kit is essential on any field trip. The first aid kit should include a bottle of rubbing alcohol as it is a good treatment of stings and for cleaning skin that might have come in contact with poisonous plants such as Poison Ivy (*Rhus radicans*). It is also a good general cleanser and antiseptic. Someone in authority in the group should also have a cellular telephone in case help is needed.

No collecting of any material alive or dead should be permitted on field trips. Dead material is part of the environment and in many cases forms an important **micro-habitat**. Dead material is also an important food source for many animals. Try to identify everything that is seen from this guide, other identification books or prior knowledge; if identification can't be done, make careful notes that will allow identification at a later time. If rocks are turned over they must be carefully replaced as they were. It is suggested that no digging be permitted, as this is likely to kill buried animals rather than retrieving them. If any shallow excavations are made by hand, fill them in. Try to leave the study area as undisturbed as possible, never leave trash and try to clean up any that is there.

Although field trips are designed to look at a particular location, always be ready to point out other aspects of natural history that may present themselves. A few pairs of binoculars for each group are a good idea for looking at birds and objects in the background.

Open Water Locations
Field Trips to open water locations such as the open sea or one of the sounds, should be very thoroughly planned in advance, preferably with the advice of the Bermuda Aquarium. A suitable boat is an absolute necessity. If possible the teacher in charge should visit the chosen boat and make sure that it is suitable. Ship-to-shore radio is essential as is good emergency and lifesaving equipment and some protection from the weather is certainly desirable. The person in charge of the students should carry a cell telephone with a fully charged battery. Once the students are on board, the captain should be asked to go over all emergency procedures and lifesaving equipment locations, before you leave the dock.

The weather is also critical and mid-winter is best avoided. At any season, good waterproof and wind-proof clothing is a good idea and a good healthy snack and drink should be carried. If any students are prone to seasickness, appropriate medication should be taken before the start of the field trip.

When looking at the open ocean it does not really matter where you go around Bermuda. Just head a km (1/2 mile) or more beyond the reefs and you are there. It often pays to cruise around for a while as some of the things you would like to see may be quite scattered. For example patches of sargassum may be everywhere or quite sparse. At any rate, try to find sargassum and stop among it. In the open sea, one does not normally anchor as it is too deep, just drifting in the chosen locality is best. Note that a drifting boat will show much more motion than when underway and this may bring on sea-sickness quite quickly.

At certain times of the year, whales or seabirds may be commoner in specific locations. The group leader can enquire at the aquarium ahead of time to see what and at what locations sightings would be most likely. For example Humpback Whales are usually seen in March or April on their migration north. Shearwaters may be seen off the island from time to time or in migration. However, they will probably not approach the boat and good binoculars are needed to get a good view. Wilson's Storm Petrels may come close to the boat and can sometimes be attracted by throwing food overboard. Never throw trash into the ocean.

Coral Reef Locations
Field Trips to the coral reefs with young students must be very carefully planned and safety must always be at the forefront of preparations. Since a boat must be used it should be chosen carefully. Critical factors are its capacity in terms of passengers, its seaworthiness, radio communication, its safety features and the experience and knowledge of the captain or operator. With this in mind, vessels run by the Bermuda Biological Station for Research or by the Bermuda Aquarium, Museum and Zoo offer advantages as they are used to this type of work and have knowledgeable employees as a back up.

Very little of the detail of the reef can be seen from the sides of a boat but if the students are not strong swimmers this will have to suffice. In this case it would be wise to look at larger features rather than detail. For example several different reef types could be visited with only short stops at each. An alternative would be the use of a glass-bottomed tourist boat but it would have to be made clear in advance, that you wish to go to a natural undisturbed reef location, rather than where these boats normally take tourists. Their regular spots are far from natural since the fish have congregated for artificial feeding.

Certainly any reef field trip will be most rewarding if students can swim strongly and use a mask and snorkel. It is also essential either that the teachers swim or that the group is accompanied by strong adult swimmers familiar with the reefs and their animals and plants. Again in this regard, the Biological Station and the Aquarium have such qualified people on staff. It is a wise precaution to check out the swimming abilities of students in advance, during a visit to a safe, shallow, bay. If the group is going to swim over reefs, students should be in no smaller groups than pairs. Weaker swimmers should be grouped with stronger ones. Enough staff or helpers should be present that all students can be observed at all times. Additionally, a safety person, familiar with all the participants should remain on the boat, check all swimmers in and out of the water and scan all the people in the water constantly. Students should be called back if any problem occurs. There must also be an agreed signal, such as a blast on the ship's horn, to bring all the participants back to the boat, at once, if needed. An example could be a shark sighting (unlikely but possible) or deterioration in the weather. Thin wet suits or wind surfing suits are a terrific advantage as they give some extra flotation and keep participants warm. It is surprising how many people get cold even in mid summer. If the water is below body temperature, and it always is, the body will lose heat.

Bear in mind that a visit to a coral reef can be a terrifically rewarding experience and that the best insurance against disappointment is very thorough preparation.

There are some plastic field guides to reef animals available that can be taken into the water and do help with the identification of common fauna.

Shallow Water Locations
It is an advantage to go to shallow water locations at low tide as more material will be exposed in shallower water. Tide times are given in the daily newspaper. However, at any state of the tide, it will help in observing animals and plants to actually wade in the water. In doing this it is advisable for everyone to wear a pair of old running shoes, mud shoes etc., to guard against sharp objects on the bottom. Even while just wading, a face mask can help in seeing things clearly in the water. All that people need to do is to bend forward so that the glass is immersed in the water. In deeper locations of about a metre (3 ft) it may be better to actually swim or drift slowly through the water using a mask and snorkel. This is particularly effective in observing seagrass beds and muddy bottoms, since it prevents sediment and **detritus** being stirred up into the water. If students are to swim, a light wet suit top or body surfing jacket is a good idea.

There are some plastic field guides to marine animals available that can be taken into the water and do help with the identification of some common fauna.

There are few hazards in these shallow water environments, but accidents are always possible so be ready for them.

Seashore Locations
Seashore locations should always be visited as closely as possible to low tide as this ensures that a maximum amount of the habitat is exposed. Tide times are given in the daily newspaper. In practice any time within two hours of low tide is usually fine. The weather too is important, as it is virtually useless and dangerous, to go to a seashore location being pounded by heavy waves. There are good rocky and sandy shores on all sides of Bermuda so it is sensible to have several possible locations in mind for a field trip and then on the day of the trip pick the one in the most sheltered situation for the present wind conditions.

Sturdy water-resistant footwear with a good tread is essential and students should wear easily washable clothing. A wind-proof jacket is a good idea unless the weather is very calm and hot. Some rocky shores are quite slippery and care should be taken to avoid smooth slopes. Additionally, the top of rocky shores is often rough with sharp points and cutting edges, care is needed when walking there.

If possible the field trip leader should visit the area before the class trip and decide on the best study location and approach route.

Wetland Locations
As their name suggests, many of these locations will be damp at all times and downright wet at others. Rubber boots are obviously the best footwear, they are waterproof and also protect the lower legs against sharp objects and plant stems. A water and wind-proof washable jacket is also a good idea but in excellent weather any sturdy washable outerwear is fine.

Locations suggested for wetland field trips are apt to change very considerably with time. Storms can spoil coastal examples and inland ones may become too overgrown to be useful. Because of this, it is essential that field trip leaders visit possible locations in advance to check their suitability.

In the case of freshwater wetlands remember that these systems are under great stress and rapidly disappearing. Because of this, it is best to keep field trip participants down to a small number that can be very thoroughly supervised. Trampling and other disturbance must be kept to a minimum. Additionally, some of these sites are polluted; in these cases keep contact with water or organisms to a bare minimum, and/or wear protective gloves.

Terrestrial Locations
These locations are typically quite dry and because of this any sturdy footwear and outerwear will

be fine. However, be aware that trash is an ever-present problem and can be a hazard. Be especially careful of pieces of corroded metal and broken glass. It is a good idea to take along a trash bag and to clean up obvious hazards before any detailed study.

Part 2. Natural History of Pre-colonial Bermuda

Chapter 7. How the Land Features of Bermuda Developed

Volcanic Rocks

The hard, dark, volcanic rocks or **basalt** deposits of Bermuda are now nowhere visible at the surface above sea level, although small fragments are sometimes found. They were formed during the two probable periods of volcanic activity in the island's distant past. The first 110 million years ago on the Mid Atlantic Ridge and the second 30-40 million years ago in the Atlantic sea floor. All the basalt is therefore very old. Samples of the basalt have been obtained by drilling down from the present land surface and from deep-diving submersible vehicles at over 75 m (250 ft) depth down the side of the volcanic cone. The basalt from the top layers of the volcanic seamount that has been dated, has proved to be 30-40 million years old and therefore comes from the second volcanic eruption when the original Mount Bermuda passed over a **hot spot** in the Earth's crust. It is probable, but unproved, that basalt 110 million years old lies at the centre of the volcanic cone. If no 110 million year old rocks exist, then Bermuda is a **hot spot island**. The closest that volcanic rock comes to the present surface of Bermuda is at 30 m (100 ft) below sea level in the Castle Harbour area. Mostly, the top of the basalt lies at about an average depth of 75 m (250 ft) below sea level. No crater of the original volcano has been found in various coring projects, rather it seems that the shape of the underlying volcano is a cone with the top as a relatively flat surface. This probably resulted from wave erosion of the original volcanic peak at times in the distant past when the volcanic cone rose above sea level. Deep diving submersible observers have seen shore-like features on the sides of the volcanic cone at depths of 100 m (300 ft) or so, that are evidence that a good part of the old volcano has been exposed to the air at times. **Figure 7.1** summarises this stage of Bermuda's development.

Summary
The rock produced by volcanoes is hard and dark and called **basalt**. It can only be found by drilling 75 m (250 ft) below the surface or by diving down the side of the Bermuda Seamount in a submersible vehicle. The basalt at the top of the old volcano is 30-40 million years old and was produced in the second round of volcanic activity when the Bermuda Seamount passed over a 'hot spot'.

Summary
The top of the old volcano is now covered in a layer of limestone about 80 m (250 ft) thick produced by living organisms, mainly calcareous seaweeds and corals, both of which can form hard, rock reefs. The production of limestone started long ago.

Early Limestone Rocks

<u>Limestone Production</u>

All the limestone rock and sediment which now makes up the land surface and shallow-water features of Bermuda has been produced by animals and plants, a process called **bio- deposition**. This layer of limestone rock and sediment now caps the volcanic rock in a layer averaging over 80 m (250 ft) thick. The production of this limestone layer has taken place in well lighted, shallow seawater and probably started as soon as the top of the submarine volcano rose close to the surface. The two main groups of organisms that have laid down this huge cap of limestone are **crustose calcareous algae** (often called **crustose coralline algae**) and **corals** which together form reefs, however, fragments of the skeletons and shells of a wide variety of marine animals are also important. Crustose calcareous algae are sheet-like seaweeds, resembling pink rock, that deposit calcium carbonate (limestone) within their tissues so becoming rock hard. Just when limestones started to form in ancient Bermuda is unclear and depended on the temperature of the surrounding seawater. Bermuda lies somewhat further north than where seawater warm enough to support corals can generally be found. At present, warmer water is transported here from further south by the **Gulf Stream**, (**Figure 1.1**) a huge ocean current. However, it is likely that warm ocean currents have bathed the shores of Bermuda for millions of years and therefore the reefs would have been among the early ecosystems developed around Bermuda. Rocks formed in this way are called **marine deposits**.

Summary
The process by which **limestone** rock is turned into sediment is called erosion. Wave action can break rock into chunks which then grind against each other to produce finer material. Animals and plants are also very important in the erosion of rock, this is called **bio-erosion**. Bio-erosion can result from feeding or burrowing activities as animals scrape away rock to get food, or burrow into it for protection. Sediment production also results from the bio-chemical products of life and many **blue-green cyanobacteria** live in cavities produced in this way. Sediments also result from the breakdown of shells, supporting structures and skeletons of many marine animals and plants.

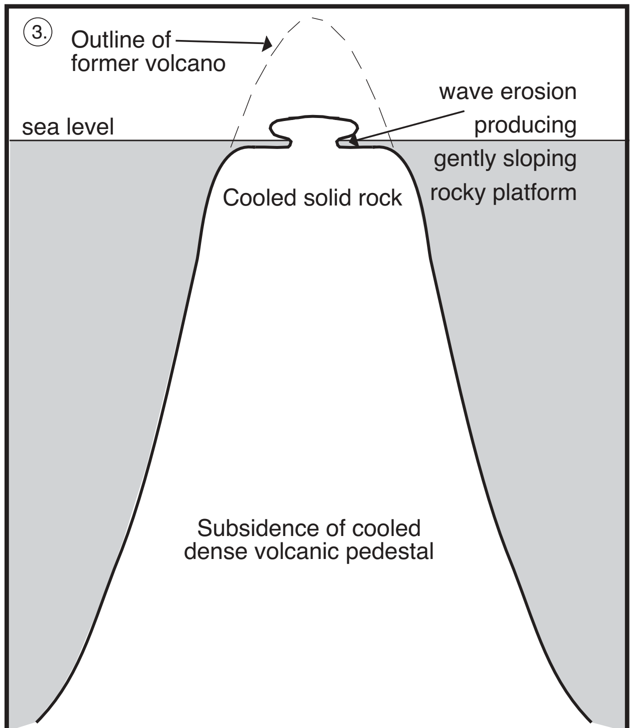
Erosion and the Formation of Limestone Sediments

Physical Erosion

The creation of sand and finer sediments from both the erosion of reef rock, and from the hard parts of organisms deserves somewhat more explanation. Erosion is a quite diverse process with both physical and biological components. **Physical erosion** (**mechanical erosion**) of rock in seawater results mostly from the pounding or hydraulic action of wind generated waves along reefs and shorelines. Waves created in other ways, for example underwater earthquakes, add to the erosive power of water. This primary erosion process produces material of very varied size, from huge blocks of rock down to tiny particles of mud. Subsequently, the larger material is moved around by the waves and in the process grinds against other broken-away material; a process known as **attrition**. This secondary erosion results in progressively smaller material. Only when particles are quite small will they be transported in suspension by waves and in water currents and re-deposited elsewhere.

Biological Erosion

Another process of great importance is **biological erosion** or **bio-erosion** as it is commonly called. This is erosion that results from the action of a very diverse group of marine animals and plants. **Feeding bio-erosion** is certainly a major component of sediment production in Bermuda. One of the main contributors to this process is the Parrotfishes. Parrotfishes feed mainly by scraping small seaweeds off the surface of reefs and other rocky bottoms. They have heavy, powerful, jaws that remove a surface layer of rock along with their food. The digestive process removes food but passes on ground rock as body waste. Very large quantities of sediment are produced in this way. A variety of marine invertebrates, including snails, sea urchins and crabs produce sediment in a similar fashion. **Burrowing bio-erosion** is also very important and is carried out by a very wide variety of marine animals. Burrows may be created in either rock or sediment, but it is the former, which is most important in the creation of new sediment. Even simple marine animals burrow into rock. A good example are boring or burrowing sponges, several species of which are common in Bermuda. These sponges create a habitat within rock or molluscan shells by bio-chemically cutting out tiny, very regularly shaped pieces of limestone, which they eject out into the surrounding water. Another very interesting burrower into rock is the Black Date Mussel (*Lithophaga nigra*). This is an example of a creature whose scientific name is very descriptive. Lithophaga means ‘rock eater’ and nigra means ‘black’. The Black Date Mussel is a jet-black rock burrower. This 2.5 cm (one inch) long mussel can be found in extraordinarily large numbers in some locations, and they are capable of removing a huge volume of rock. The deep cleft, just below low tide level, in the vertical, rocky shores of Harrington Sound, called the Harrington Sound Notch, results from the boring activities of this species. In this example, tiny larvae settle out from the water onto the rock and burrow into it by a combined chemical and mechanical method. The mussel softens the rock with acid and then scrapes it away using the teeth-like structures on the end of the shell. The sediment produced is ejected into the water from a small hole maintained to the outside. It feeds on plankton in the water, drawn in through this same hole. As it grows the mussel enlarges the hole. Huge numbers of holes weaken the rock surface causing it to break away. The cavity produced by this activity may extend at least 3 m (9 ft) back into the cliff and makes the cliff face unstable. Thus in this case, bio-erosion promotes physical erosion. The combined process produces huge amounts of sediment. A third very important type of bio-erosion can be called **biochemical bio-erosion** or physiological bio-erosion. The natural life-processes of animals and plants result in the production of acids that can erode limestone rock. By night plants, and animals constantly, produce carbon dioxide which reacts with water to produce carbonic acid. This in turn can be used together with other organic acid products, to dissolve rock thereby creating a protected living space within it. A very good example of this is the black-coloured, **blue-green cyanobacterium**, which is virtually universal at the top of the seashore in limestone rock. The body of the organism is partly buried in tiny cavities eroded into the surface of the limestone. This erosion results in a very jagged surface to the upper shore which is called **phytokarst**. This term needs explanation. **Karst topography** occurs in terrestrial limestone regions as a result of solution or chemical weathering and is characterised by numerous sharp-pointed hills of very variable size. The prefix 'phyto' is used to mean plants. Blue-green cyanobacteria were previously considered as plants and share with them the presence of photosynthetic pigments. Phyto-karst is on a much smaller scale than true karst topography. A second common blue-green cyanobacterium, this time pale pink in colour, may be found as a layer 1 cm (1/2 in) or so entirely within the limestone rock. In this case the habitat of the plant is totally produced by erosion or enlarging of cavities in the rock. These examples result mainly in dissolved calcium carbonate in the water, rather than in actual sediment production. However, they also weaken the rock making it more prone to physical erosion, which results in sediment. In animals, biochemical bio-erosion is often combined with mechanical burrowing to soften rock. In this case, quite strong acids are produced by special cells or glands. Two such examples, the boring sponges and the Black Date Mussel, have been cited above.



After the volcanic phase finished, erosion by wind, rain and waves gradually reduced the mountain top to black sand and a flat platform at sea level.

Figure 7.1. Bermuda as a volcanic island.

Shell Fragments

Sediments are also produced from the calcareous shells of many marine creatures including snails and **clams** and from parts of the skeletons of crabs, lobsters, fish etc. Particularly important are fragments of seaweeds that lay down lime or calcium carbonate to strengthen their structures and to make themselves less attractive as food. As with sedimentary particles produced by other means, these fragments are further reduced in size by physical attrition as they rub together or roll over the bottom. Shell fragments and particles of marine algae are often readily identifiable in samples of Bermudian marine sediment.

Sand Dune Formation

Glaciation

Fascinating as the very early geological history is, it is only the last 1.5 million years or so that has been really important in determining the present surface character of Bermuda. This period mainly falls in the middle and late part of the **Pleistocene epoch**. The Pleistocene was the time of the last great glaciation or Ice Age on earth when huge ice caps built up at the poles. The water tied up in these ice caps lowered sea levels world wide by up to 125 m (350 ft). However, during the Pleistocene epoch the climate was not uniformly cold, but rather slowly changing from warm to cold, and back again producing glacial and inter-glacial periods. There were at least four such climatic changes in the last 900,000 years. This lowering of sea level in the cooler periods was important because it brought previously submerged features close-to or above the surface of the ocean, and this is when the activity which produced the present Bermuda land mass got underway.

Summary

Sand dunes started to form during the last ice age when sea level fell exposing marine sand to the wind. Bermuda was then much larger and became covered with sand dunes. The main ones were along the coasts but **mobile dunes** travelled downwind into the interior. There were also large low areas within the island where sand had been blown away. **Coastal dunes** quickly became covered in vegetation, those further inland were poorly vegetated.

Dune Formation

The last 12,000 years, are the most important from the point of view of the determination of the topography of the islands and shallow waters of Bermuda. By this time a cap of limestone and calcareous sediments up to at least 24 m (75 ft) thick, had developed on top of the old volcano, and because sea levels were 30 m or 100 ft lower than at present, much of this was exposed to the air and formed an island at least ten times the size of present day Bermuda. From east to west, Bermuda was probably 60 km (42 miles) in length! We know from the geological record, that Bermuda at this time consisted of a vast tract of sand dunes. There were two main types of dune, **coastal dunes** and **mobile dunes**. Coastal dunes formed along shorelines as winds moved dry sand from beaches inland. They formed series of dune ridges parallel to the shore and stretching a variable distance inland. These dunes tended to be fairly quickly colonised by dune plants which stabilised the dunes stopping inland movement. Mobile dunes on the other hand did not become vegetated and continued to move downwind across the inland part of the island. This resulted in an undulating sandy interior region with some quite large ridges of dunes and many low areas of varying size where sand had been blown away. These were the **inter-dunal lows**.

Present-day Limestone Rocks

Dunes to Rocky Hills

Details of the old dunes are known because although they were somewhat unstable and tended to move slowly about with the wind, they were subject to rain action. Rain water is slightly acidic and therefore dissolves limestone until the water becomes saturated with **calcium carbonate**, the chemical that makes up limestone. Thus at the surface of dunes, every rain fall resulted in sand grains losing a little of their substance, and the percolation of lime-saturated water to deeper layers. In dry periods, this water slowly evaporated from between the grains and its cargo of calcium carbonate was deposited cementing the grains together. The resulting rock, called **aeolianite**, was often still quite porous, but this same process was repeated many times, forming ever-denser limestone, a process

Summary

Sand dunes were changed into rock called **aeolianite** when acidic rain water fell on them. Then further dunes formed on the old ones and in turn became aeolianite. Along the coasts the dune masses were very large probably reaching 300 ft above sea level. Aeolianite made up 95% of the surface rock, the rest was marine in origin, the remains of subtidal sand deposits and reefs.

called **lithification** or **diagenesis**. In this way entire sand dune formations were **fossilised** exactly as they had been laid down. We know that the old dune tracts were very large since their fossilised remains, which are the hills of Bermuda, now rise up to 60 m or 200 ft above present sea level. These are not, however, the remains of single monster dunes, but rather dunes formed on top of other dunes. Since sea level then was 30m or 100 ft lower than now, dune systems rising to at least 90m (300ft) in elevation were probable. These were huge dunes for limestone sand situations, which usually produce quite small dunes. We also know that these hardened dunes were subject to erosion back to sand, and that there were many periods of active dune building, followed by periods when dunes were converted to aeolianite. Many places along the shores of Bermuda and in road cuttings clearly show old dune surfaces, as well as eroded dunes with others on top of them.

Thus, the rock on top of the volcanic seamount came to be composed of two types of limestone, aeolianite and the marine deposits, mentioned above, which are called reef rock. Reef rock makes up only a very small fraction of the rocks exposed at the surface of Bermuda.

The process of lithification changes sand to aeolianite rock but does not destroy the evidence left in the dunes of how they were formed. If we look carefully at a sand dune and dig a hole into it, it quickly becomes obvious that the sand has been deposited in layers or **strata**. These layers represent times when sand was deposited. If the wind died down or changed direction this would be reflected in the layering. Often winds die down at dusk and re-appear in the morning, producing a daily pattern of strata. However, the layering does not only show the addition of new sand, but the removal of previously deposited sand by erosion. Thus layers may be removed as well as added. The record of all this is perfectly preserved in the rock as is evidence of the prevailing wind direction.

Mobile Dune Features and Bedding

The simplest example is that of a single mobile dune which became fixed in place and then lithified. This will show some basic features of dune formation and structure as shown in **Figure 7.2.** The most striking feature is that the side of the dune facing the wind is gently sloping whereas the downwind side is steeply sloped. The side towards the wind is called the windward side and the downwind side, the leeward side. If sections are cut out of the aeolianite of the lithified dune, then its structure of sand layers or strata is clearly shown. This is termed the **bedding** of the dune. The leeward side is shown to be composed of many steeply sloping layers and these form the **foreset beds** (F in **Figure 7.2**). Lying over the foreset beds and extending on to the windward face are **surface beds** of layers parallel to the surface (S in **Figure 7.2**). Sections of the windward side of the dune show a much less regular pattern of layers reflecting the more dynamic wind action there. The gently sloping **backset** or **windward beds** (W in **Figure 7.2**) are there but often interrupted where portions have been scooped out by the wind and then re-filled. Thus the bedding is often very irregular showing many old surfaces and layers deposited at different angles. This is called **cross bedding** (C in **Figure 7.2**).

Summary
Aeolianite dune remains have preserved all the features of the ancient dunes. The layers of sand are perfectly preserved and called bedding. The windward side of the dune has gently sloping beds whereas the leeward side has steeply sloping ones. Where different types of bedding are found it is called **cross bedding**. Beach remains also show bedding on a finer scale that slopes very gently. Subtidal marine beds are often rippled.

Shoreline Deposits

Another set of layers is formed if the aeolianite results from old beach deposits. **Figure 7.3** shows a section of a typical beach with the parts labelled. Just below the water is the **subtidal zone**, while the middle portion of the beach is the **foreshore**. Above high tide level is the **backshore** and

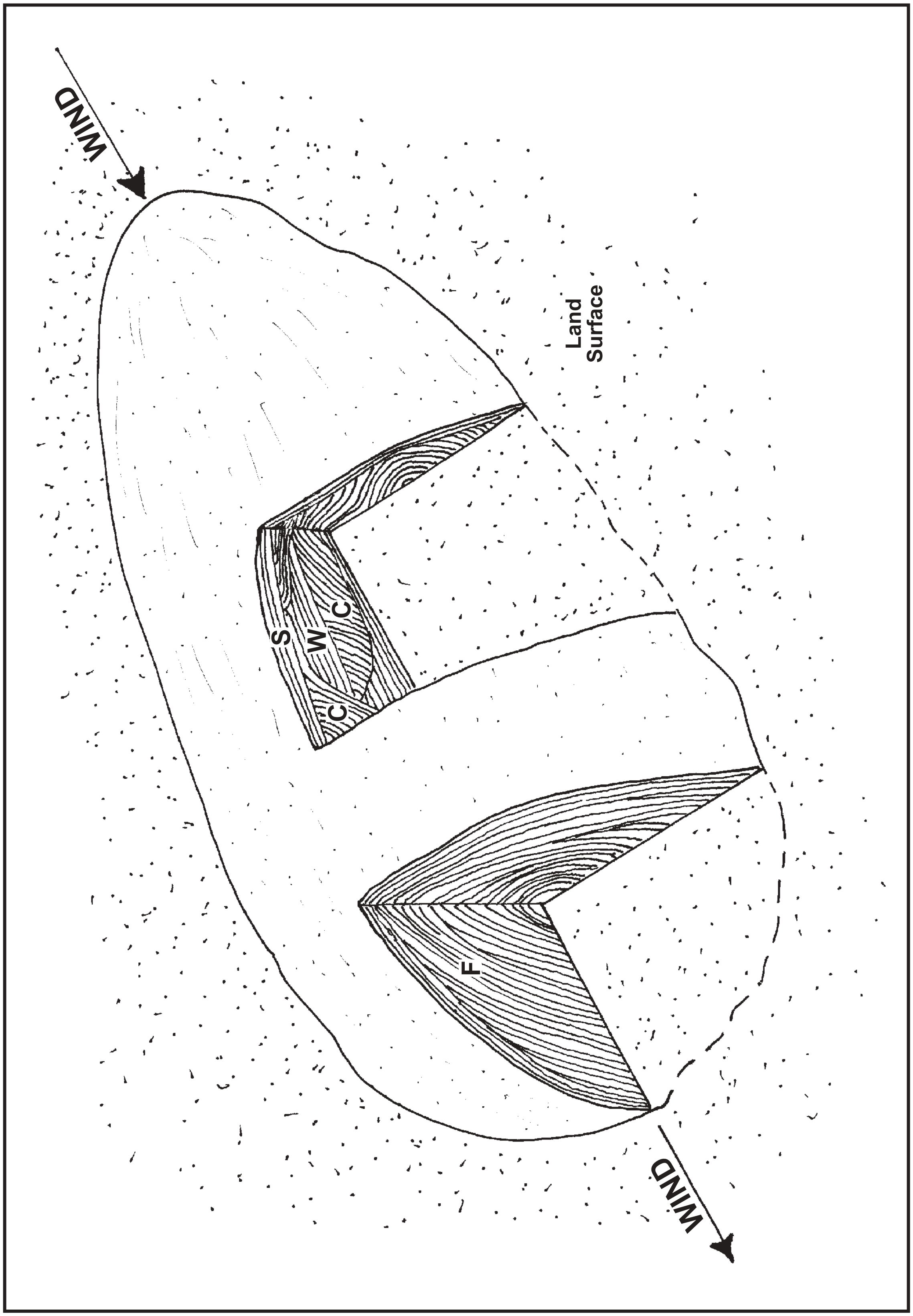


Figure 7.2. Diagram of a lithified mobile dune showing interior bedding features

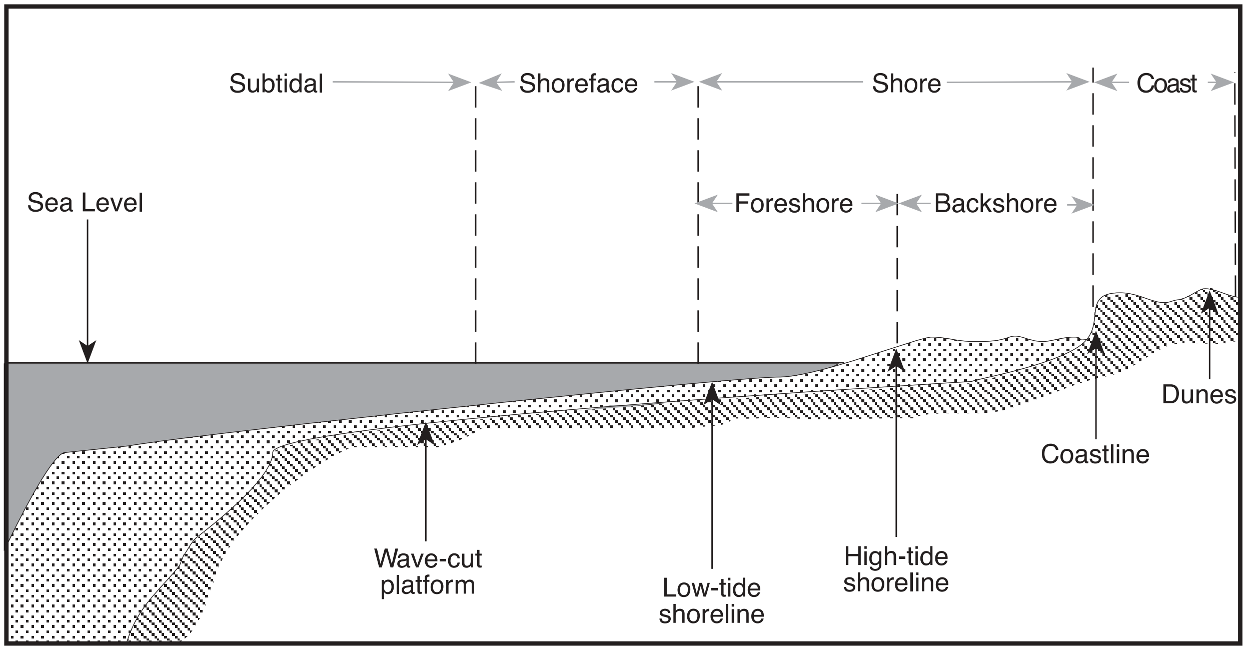


Figure 7.3. Physical features of a typical sandy beach

behind that the dunes. The foreshore and backshore beds are typically gently sloping towards the sea but the foreshore slopes more than the backshore which is often almost level. Both of these deposits can be mistaken for windward dune beds. They may also show some minor cross bedding. Below the wave washed area, the subtidal beds are very characteristically rippled in shape. Where such deposits lie above present sea level they are evidence of a previous higher sea level. There is one other type of limestone deposit associated with shorelines, this is **conglomerate**, formed of broken pieces of aeolianite rubble, later cemented together and very characteristic in structure. Conglomerates were formed where wave action broke up aeolianite at the back of the shore. When you see conglomerate you know you are looking at an old shoreline.

Cliffs frequently show a whole sequence of beds from subtidal lower down changing through beach deposits, and sometimes conglomerates to typical dunes above. Such a situation is shown in **Figure 7.4**.

Soils, Sediments and Formations on Land

You might think that all the sediments on land have been formed in some way from the calcareous sands and the weathering of aeolianite. However, this is not the whole story. Dune formation and lithification were very slow processes. There were several inter-glacial periods thousands of years long with no significant new dune formation. These allowed the development of a carpet of vegetation on the land and also the accumulation of soil from the fallout of atmospheric dust to which was added some limestone sand. These deposits formed almost horizontal layers up to 1 m (3 ft) in thickness of a characteristic red brown colour and clayey consistency, and are called **red beds**, **red geosols** or '**terra rossa**'. In addition shorter pauses in dune formation but still characterised by vegetation growth produced fine, white soils derived from sand, these are **white geosols**. Red and white geosols are both examples of **palaeosols**, which can be roughly translated as old or fossil soils. As with the sand, palaeosols became lithified into fairly hard rock.

Summary

In past periods when dune formation was slow, plants spread over the land and soils derived from atmospheric fallout developed up to1 m (3ft) thick. These were reddish in colour and are called **red beds**. Red beds separate formations laid down in different periods of dune building.

These palaeosols are useful as they mark the boundaries between historic stages of dune formation. The aeolianite between palaeosol layers is called a **formation** and in Bermuda there are five main formations each of which are given a name. At any one location it is unusual for more than two formations to be visible. A typical situation is shown in **Figure 7.5**. The oldest formation is the Walsingham Formation, above which in sequence lie the Town Hill, Belmont, Rocky Bay and Southampton Formations. This is illustrated in **Figure 7.6**.

At present good deep red soils are present in low areas on the islands and are used for agriculture. Poorer, shallower soils are characteristic of other areas.

Sediments in the Water

Just as sediments on land respond to wind and gravity, those in water respond to water movement from waves, tides and currents and gravity.

<u>Sediment Classification</u>
Sediments in water are characterised on the basis of the general size of particles that make them up. For those found in the systems described in this field guide, the coarser sediments are termed sands and the finer ones muds and silts.

<u>Sedimentation</u>
Once sediment is produced it tends to fall to the seabed. This is called **sedimentation**. The rate of sedimentation is directly proportional to particle size and density. Since all limestone particles are similar in density, size is the overriding factor here. Thus sedimentation is rapid with sand and slow with mud and silt particles. If water-carrying sediment is in motion, then **sediment sorting** will take place with coarse sediments being deposited at relatively fast current velocity and fine muds and silts only in comparatively still conditions. Places with frequent wave action (high energy environments), such as South shore, or of constant high current velocity, such as Flatts Inlet, are characterised by coarse sands. Locations with negligible wave action and very slow currents, for example Coot Pond on North Shore, or Sinky Bay on South Shore, are characterised by muddy sediments. If the particle sizes of grains within a sediment are fairly constant it is referred to as a **well sorted sediment**. If, on the other hand, a wide variety of particles sizes are present it is termed **poorly sorted sediment**. Well-sorted sediments would be found where a water current, carrying sediment, fans out and slows down. In this case a sequence of sediments starting with coarse sand and progressing through finer particle sizes to mud would be deposited as the current flows. Such a situation has been created in Harrington Sound by the strong current flowing under Flatts bridge. Well sorted sediments are also found on exposed South Shore beaches. Poorly sorted sediments are likely to be found where current velocity and direction are very variable. Many bays have poorly sorted sediments in them.

Summary

Coarser sediments are sands, finer ones mud and silts. Finer particles are readily moved long distances by water and only settle to the bottom in calm conditions. Coarse particles stay closer to where they were formed. Sediments with mostly one size of particle are called **well sorted**, those with mixed sizes are **poorly sorted**. Well sorted fine sediments allow little water to percolate through them and tend to be low in oxygen. Coarser well sorted sediments are permeable, well oxygenated and support tiny interstitial organisms between the grains.

<u>Sediment Consolidation</u>
Another factor that affects sediment mobility is **sediment consolidation**. In places of very varying current velocity, sediments may be constantly deposited and then re-suspended. Fine sediments when first deposited trap large amounts of water among their particles. As they sit and settle, this water is slowly expelled, consolidating the sediment. Consolidated sediment is firmer and denser

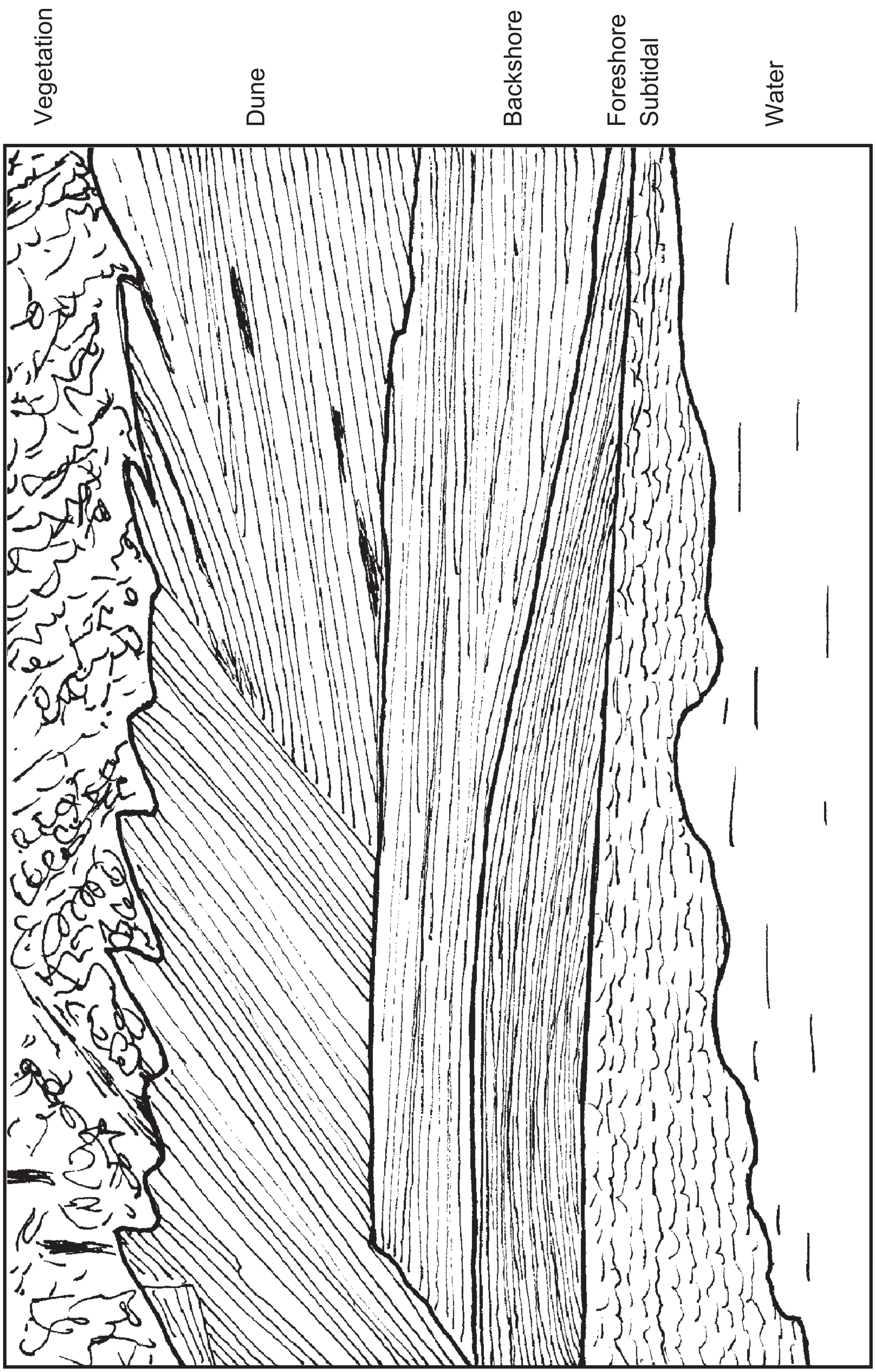


Figure 7.4. Geological strata shown in a cliff face.

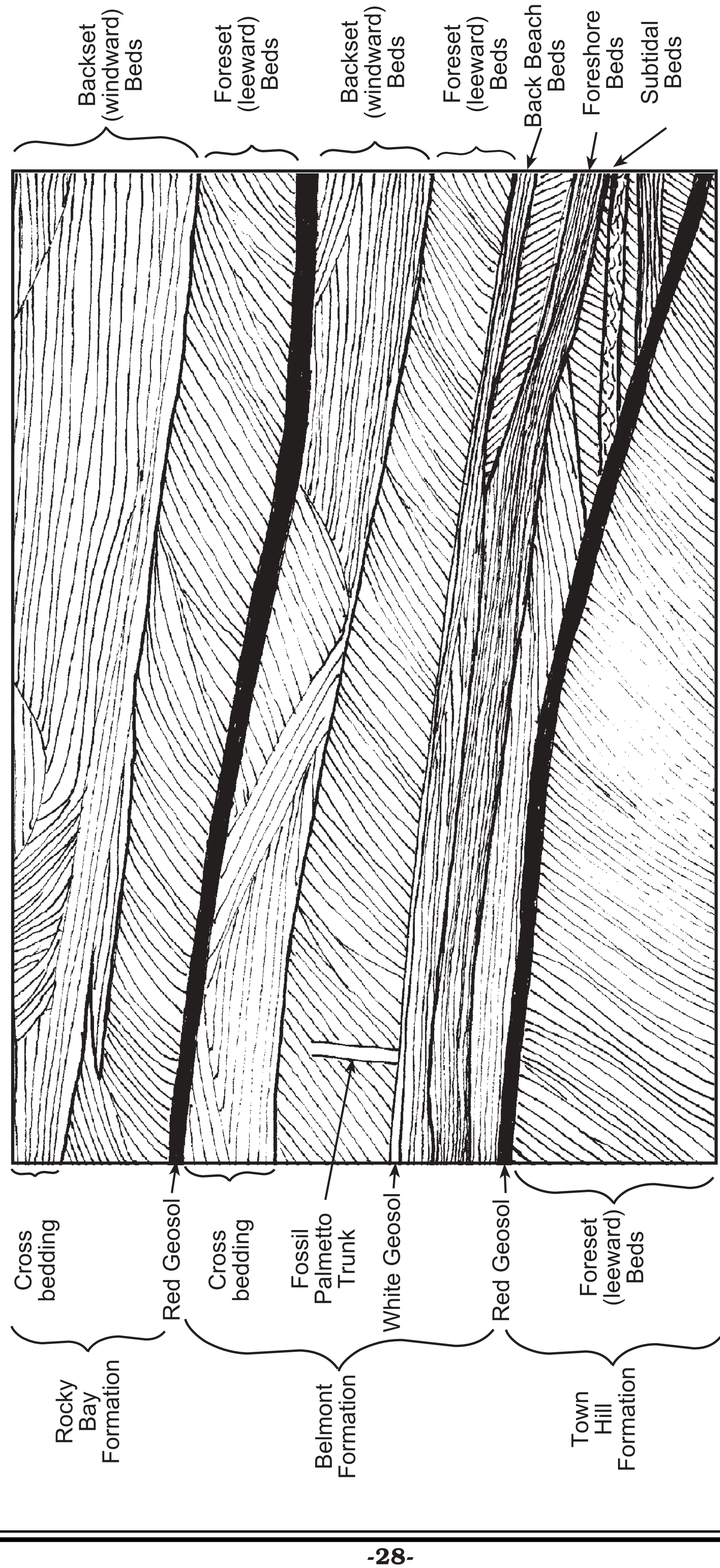


Figure 7.5. Palaeosols separating aeolianite formations shown in a rock cutting.

than that which was deposited but the grain size does not change. Consolidated sediments can only be moved by a much higher current velocity than that at which they were deposited. As a result they become more and more stable with time and tend to stay put.

Sediment Permeability

Another physical attribute of sediments that is of great importance to life therein is **sediment permeability**. Permeability refers to the amount of open, water-filled spaces among sediment grains. It can also be measured by the rate at which water can move through the sediment. This property can be made clearer with examples. Consider a coarse sand deposited in constant high water velocity; it will lack smaller sediment particles, be very permeable and have lots of water-filled voids. In a second example, varying current velocity has resulted in a sediment of very mixed particle size. In this sediment the voids between large particles are filled with small particles, permeability is poor and spaces are few and far between. Permeability is also low in sediments of constant, tiny particle size. Well sorted sediments have greater permeability than poorly sorted sediments. The water-filled spaces within permeable sediments are often colonised by communities of tiny animals called the **interstitial fauna**.

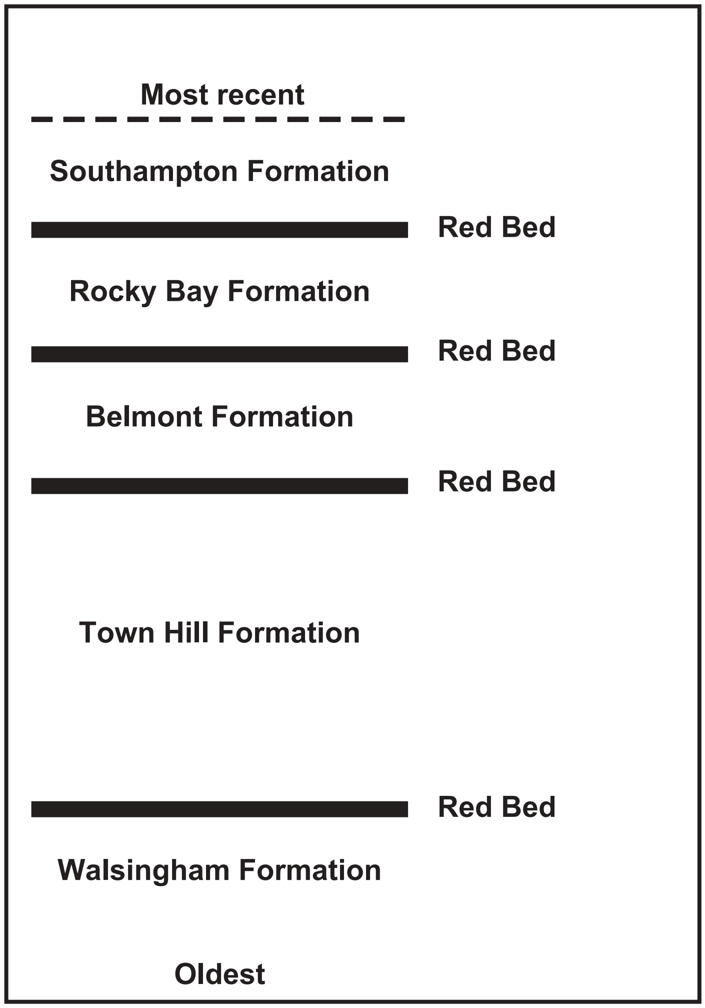


Figure 7.6 The sequence of aeolianite formations in Bermuda

An important aspect of sediment permeability is the amount of oxygen present within the sediment. Shallow waters are normally rich or even saturated with oxygen, especially by day when photosynthesis adds oxygen to the water. However, oxygen is also readily absorbed by water directly from the air. Permeable sediments through which water is moving will normally be well oxygenated. Such sediments are light in colour and have no offensive smell. Sediments that do not have water moving through them will normally have no or very little oxygen present. Such sediments are usually dark in colour and if oxygen is absent often have an unpleasant smell. Poorly oxygenated sediments are more difficult for burrowing animals to colonise. However, animals adapt to such conditions by pumping surface, oxygen rich water through their burrows.

The Formation of Major Land and Coastal Features

On land the areas dominated by large masses of fossil dunes became the ranges of hills or upland areas and the lower areas between dunes the upland valleys. Smaller ranges of dunes and their lower areas became lowland hills and valleys.

Erosion not only produced the sand which characterises these systems, but also produced low spots among the coastal dunes that were later to become bays. Solution weathering and erosion also created caverns and caves. The origins of the many sheltered bays around the coastlines of the Bermuda Islands are certainly quite varied. Probably many of them arose as low areas among dune tracts. Rainwater ran into these depressions causing erosion and dissolving limestone both of which processes further deepened these locations. When sea level rose at the end of the glacial period, such low areas of land were flooded to produce many bays: others not connected to the sea, except by underground passages, became saltwater ponds. All these drowned dune depressions had gently sloping shores. Another process that gave rise to bays was the creation of underground caverns at the time of low sea level. Some of these became very large, and the weak limestone roofs collapsed creating steep sided depressions. Again with a rise of sea level these could become bays. In contrast to those described above such bays tended to have steep, rocky shorelines. Probably most bays arose in these ways, but some smaller ones may have been created by fairly recent erosion of shorelines by wave action. Some of the surface aeolianite is very weak and crumbly and is readily broken down by waves.

Summary

Coarser sediments are sands, finer ones mud and silts. Finer particles are readily moved long distances by water and only settle to the bottom in calm conditions. Coarse particles stay closer to where they were formed. Sediments with mostly one size of particle are called **well sorted**, those with mixed sizes are **poorly sorted**. Well sorted fine sediments allow little water to percolate through them and tend to be low in oxygen. Coarser well sorted sediments are permeable, well oxygenated and support tiny interstitial organisms between the grains.

The interior part of the old Bermuda landmass, when it was at its greatest extent, had some extensive areas of low land. This was a result of erosion combined with the predominant dune formation along the coastlines. A number of large basins of varying size existed and when sea level rose they filled with water. The largest depression formed North Lagoon and the others the various sounds such as Great Sound, Little Sound, Castle Harbour and St. George's Harbour. Harrington Sound was also one of these and its formation is detailed in the example below.

Cave Formation

The low areas within the landmass of Bermuda were also very important in the formation of the many caves that exist in the aeolianite rock. Rain, at times heavy, was always a feature of the Bermuda climate and although the rock and sand were very porous it did run downhill both on the surface and within the sand and rock. Naturally it channelled where flow was easiest dissolving the rock and causing erosion there. These places became enlarged as the flow continued and the sub-surface ones eventually became caves. Some of these were very large and long. Some caves starting in Harrington Sound go out under North Lagoon and are kms (mi) long! Only very specialised and highly trained cave divers can explore these caves. In places, underground ponds, some quite large, were formed by this process. Later some of these collapsed to form steep sided depressions called **sinks** or sink holes. Others that filled with seawater as sea level rose formed marine ponds. Walsingham Pond is a good example, and cave features such as **stalactites** can still be seen around the edges. Caves only formed through the action of freshwater as seawater cannot dissolve limestone to any extent. The presence of a cave containing seawater is absolute proof that sea level was once below where the cave now lies. Many of the caves now start in air and descend into seawater, which is percolating in via submerged caves or fissures.

Processes of solution and evaporation as freshwater percolates down from above into caves also gives rise to many beautiful cave formations, known as **speleothems**, which are as well developed here as anywhere in the world. Freshwater is usually seen dripping from the roof, the ends of stalactites etc. Examples of speleothems are **stalactites**, which hang from the roof, and **stalagmites**, which ascend from the floor; both are shaped like very elongated cones. Stalactites and stalagmites often unite to form **pillars**. Other common speleothems include **curtains** which are undulating thin sheets, **flow-stones** which form where water cascades down a slope and **soda straws** which are delicate, thin, hollow parallel-sided tubes hanging from the roof. These speleothems are only created very slowly, to add 1 mm (1/25 in) takes many years. They are also easily damaged if touched, as the oil from fingers alters the way the water flows down them. **Figure 7.7** shows common speleothems.

A Special Example: Harrington Sound

Harrington Sound History

> **Summary**
> Harrington Sound was formed from a large depression among the dunes that had a smaller ridge of dunes down the centre. At first, when sea level was low, Harrington Sound became a freshwater habitat with ponds and marshes. Fossils from this time are preserved in the mud at the bottom. Caves and tunnels drained some of the water out to sea. When the sea rose the water flooded into the sound through the caves creating what you see today.

To look at the origin of Harrington sound we must go back about 15,000 years. At this time the Bermuda landmass was much larger than at present because sea level was greatly reduced as a result of the water tied up in the ice caps to the north and south. The islands at this time extended from North Rock or beyond to the north, and to just beyond the present south shore as well as to the east and west of the present landmass. The land was not a level plain but rather a large tract of sand dunes that were higher around the edge particularly along the south shore. Within the land area the dunes were lower and among them were several large **depressions** and many small ones. These large depressions would over time form the sounds. Rainfall bringing somewhat acidic rain tended to run into all these depressions where it further deepened them due to solution weathering and erosion. However, water did not collect at first as the underlying aeolianite limestone was very porous. Fissures through which water flowed, enlarged with time to produce caves which ran out to lower areas, some to the coast. The rain water also helped to lithify the dunes to limestone as freshwater saturated with lime evaporated from between the grains leaving a limestone cement. Approximately 15,000 years ago it was probable that Harrington Sound was a large depression among the dunes with a ridge of smaller dunes running in an east-west axis down the centre of this depression. These dunes divided the depression into two areas, which eventually became the north and south **basins** of Harrington

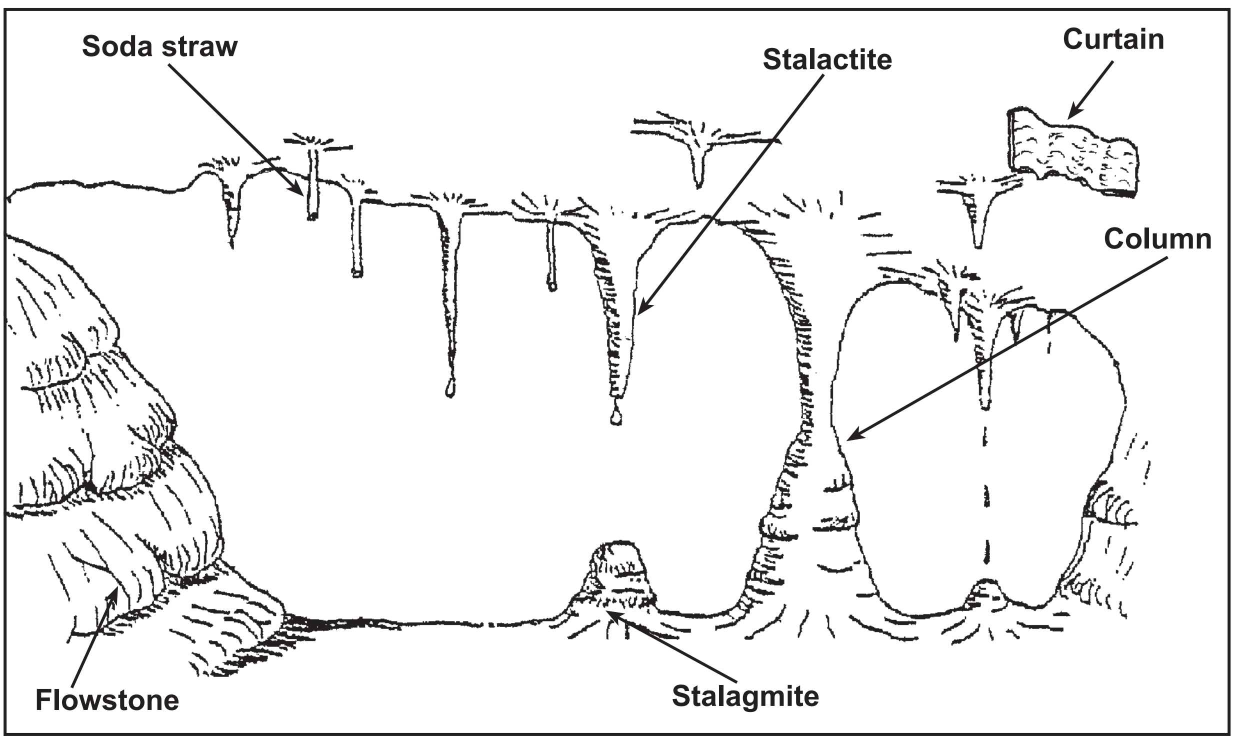


Figure 7.7. Common speleothems found in Bermuda caves.

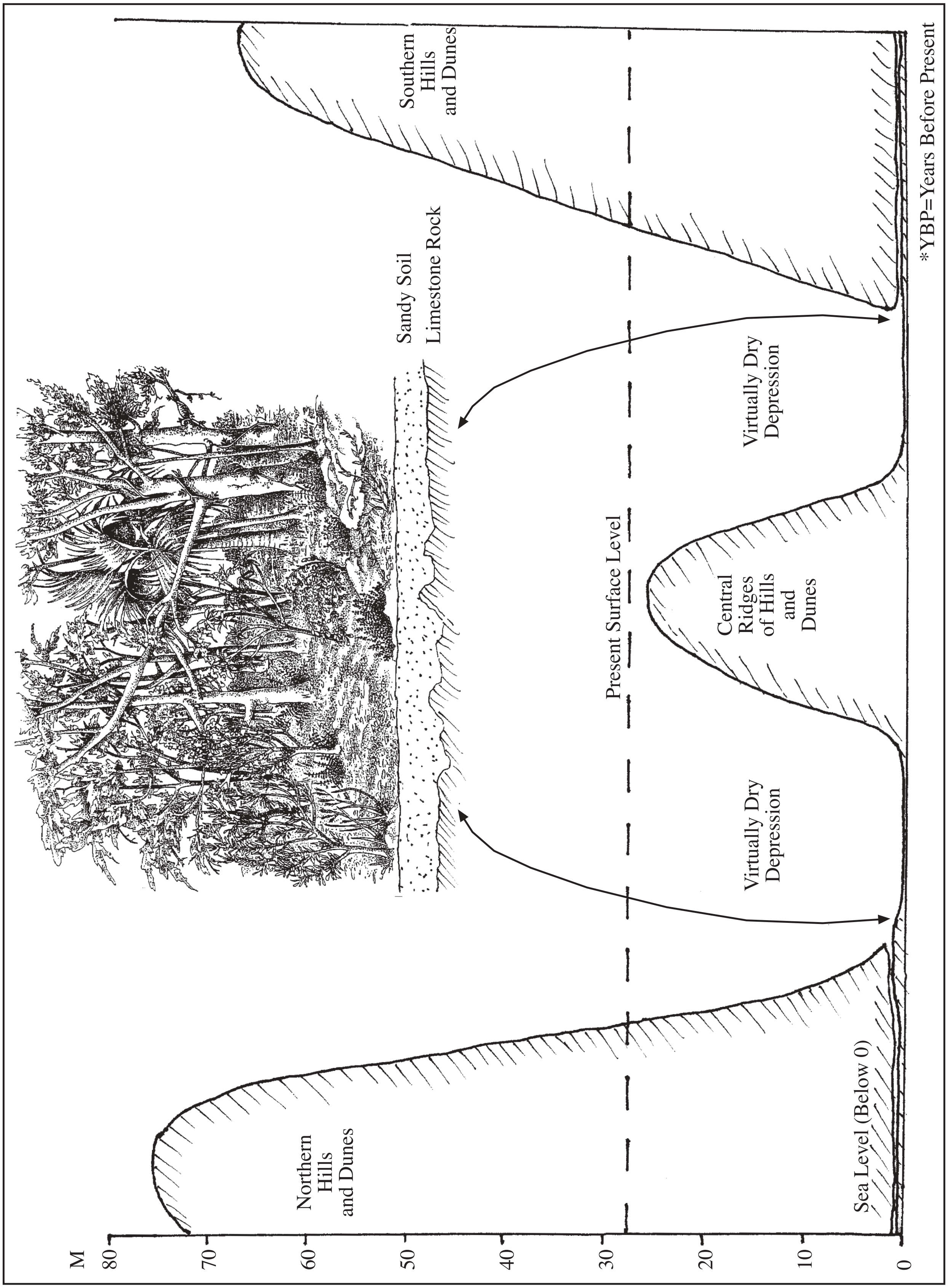


Figure 7.8. Harrington Sound Depression 15,000 YBP*

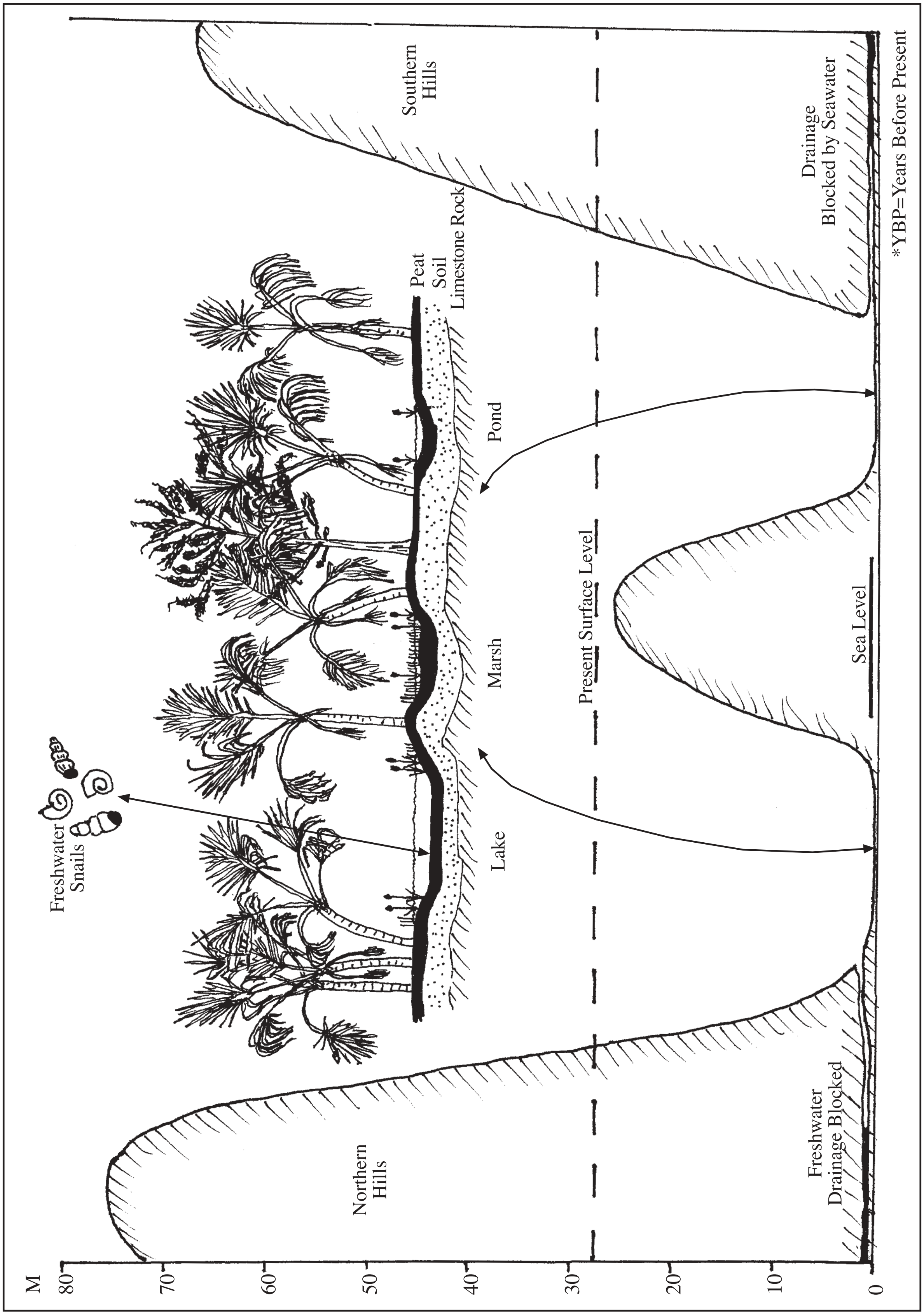


Figure 7.9. Harrington Sound Depression 11,000 YBP

Sound. The deeper areas to the north and south of the ridge had within them wet areas as well as caves and passages beneath the surface. Collapse of these structures further deepened the depressions. The probable nature of Harrington Sound 15,000 years ago is shown diagrammatically in **Figure 7.8** which shows a cross section along a north-south axis.

Although the details are not known, it can be assumed that the deeper depressions, including those within the future Harrington Sound, would have damp areas at the bottom which, even in the absence of standing water, would support a range of freshwater marsh species. As these plants grew and then died they started to leave behind dead remains which became **peat**. Peat was essential to the further development of the depressions as it slowly formed a layer relatively impermeable to freshwater. In other words, peat sealed the surface of the sand and aeolianite and allowed freshwater **ponds** and **marshes** to develop. Another important characteristic of peat is that it decays only very slowly and preserves within its structure recognisable remains of plants and animals of the ponds and marshes. By 11,000 years ago ponds and marshes were well developed in the Harrington Sound depression as shown by remains preserved in the peat still present below the mud in the two deep basins of the sound. At this time sea level had risen to about the same level as the bottom of the depressions and served to block any remaining freshwater drainage to the ocean. This situation is shown in **Figure 7.9** Peaty soil above water level supported extensive swamp-forest dominated by Bermuda Palmetto (*Sabal bermudana*). At water level, the forests gave way to marshes characterised by grasses such as the Saw Grass (*Cladium jamaicense*) and various rushes and Reeds (Details of freshwater marsh vegetation are given in Project Nature, Wetlands of Bermuda and in Chapter 24). These marshes in turn gave way to extensive ponds. Freshwater snail shells from the ponds are well preserved as fossils in the mud from the pond bottoms. With time the ponds filled with peat and mud and the whole basin bottom became very flat. This is reflected today in the very flat muddy bottoms of the two deep basins lying at about 20 m (65 ft) below present sea level.

<u>8,000 Years Ago</u>

About 8,000 years ago the climatic warming trend that was resulting in rising sea levels was temporarily reversed and caused sea levels to fall again. This resulted in a return of the drainage from the depressions to the sea. But this time, the peat layer was well developed and the freshwater drained over its edges at the depression margins. Peat water is quite acid and it dissolved the limestone at the edges of the basins resulting in the formation of a **moat**-like depression there. This depression persists to this day as a discontinuous slightly deeper trough (24 m, 70 ft deep) around the very flat mud bottoms of the two basins. This situation is shown in **Figure 7.10**.

<u>Rising Sea Level</u>

This lowering of sea level lasted only a thousand years or so and then the level rose steadily again as the climate warmed and the polar ice caps melted. As sea level rose higher than the bottoms of the basins, it flooded into the sound through the caves, cracks and fissures created earlier. At this point, there was a mixture of salt and fresh-water in the ponds and fresh-water organisms were replaced by those of **brackish** conditions. Brackish is a term that describes diluted seawater. This period is reflected in the sediments by the presence of the shells of brackish water snails and is shown diagrammatically in **Figure 7.11,** which depicts conditions at about 6,000 years ago. No doubt there were also brackish water plants such as Widgeon Grass (*Ruppia maritima*), but **biodiversity** would have been quite low in this changeover period from a fresh to a salt environment.

Sea level rose quite steadily for the next several thousand years and Harrington Sound and other sounds became seawater environments. By 3,000 years ago, this process was well underway and the situation was as shown in **Figure 7.12.** The sound was shallower than at present but fully saline and supported a diverse marine community, which would have entered through caves and fissures. There is no reason to suppose that the fauna and flora would have been much different than it is today. However, large fish such as the Spotted Eagle Ray (*Aetobatus narinari*) which frequent shallow waters, would probably not have been present. At this time the other sounds were probably completely landlocked and ecologically very similar to Harrington Sound.

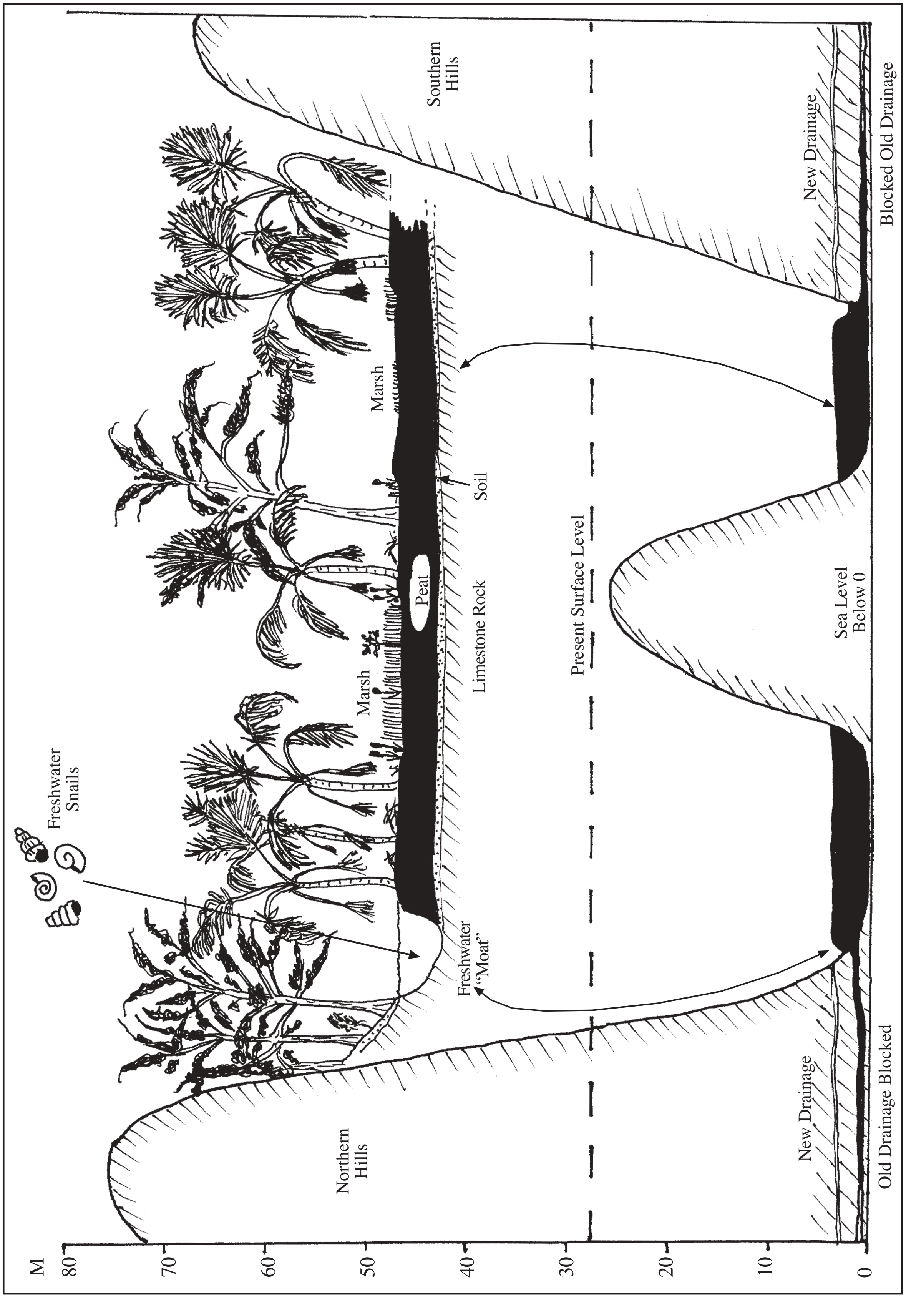


Figure 7.10. Harrington Sound Depression 8,000 YBP

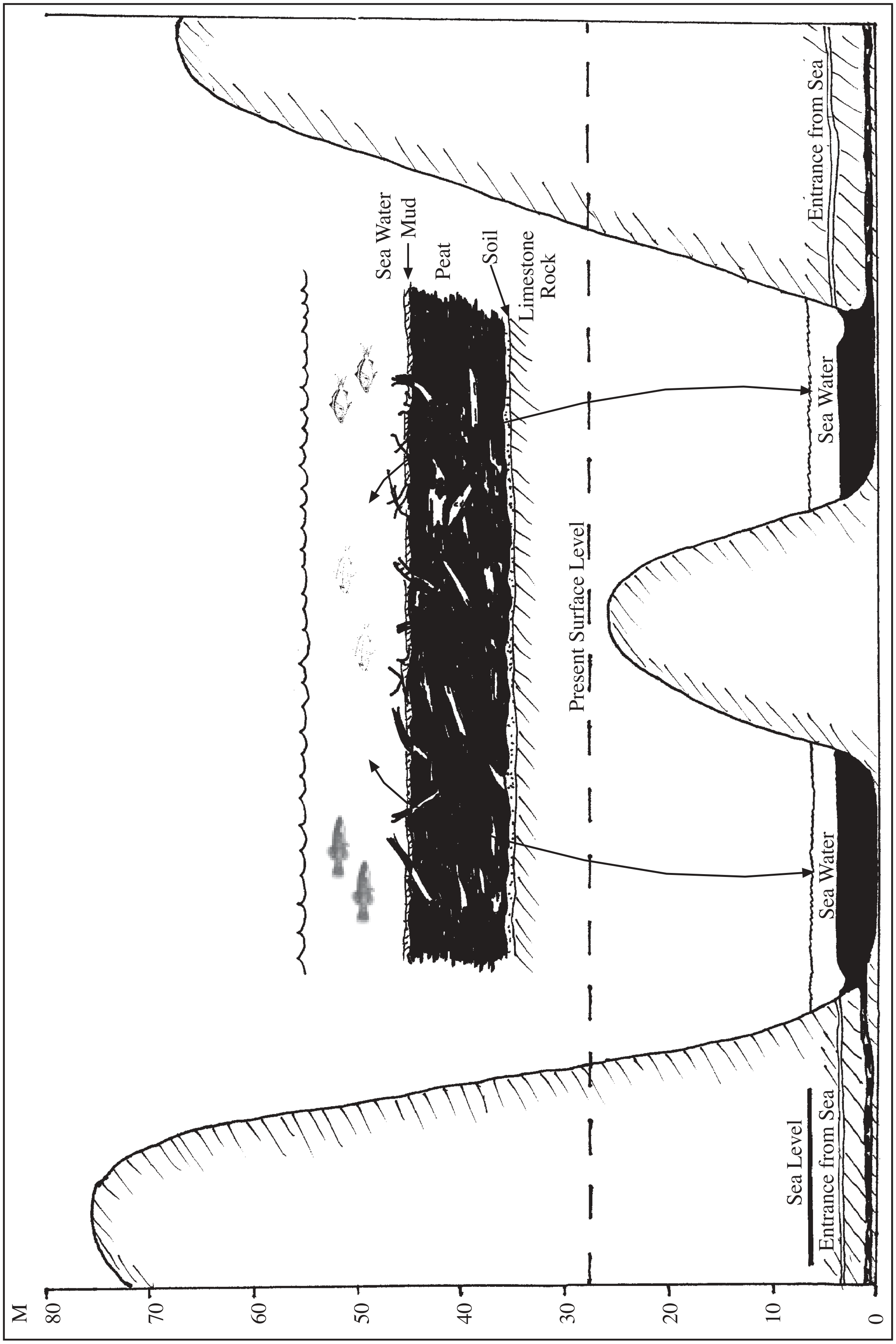


Figure 7.11. Harrington Sound Depression 6,000 YBP

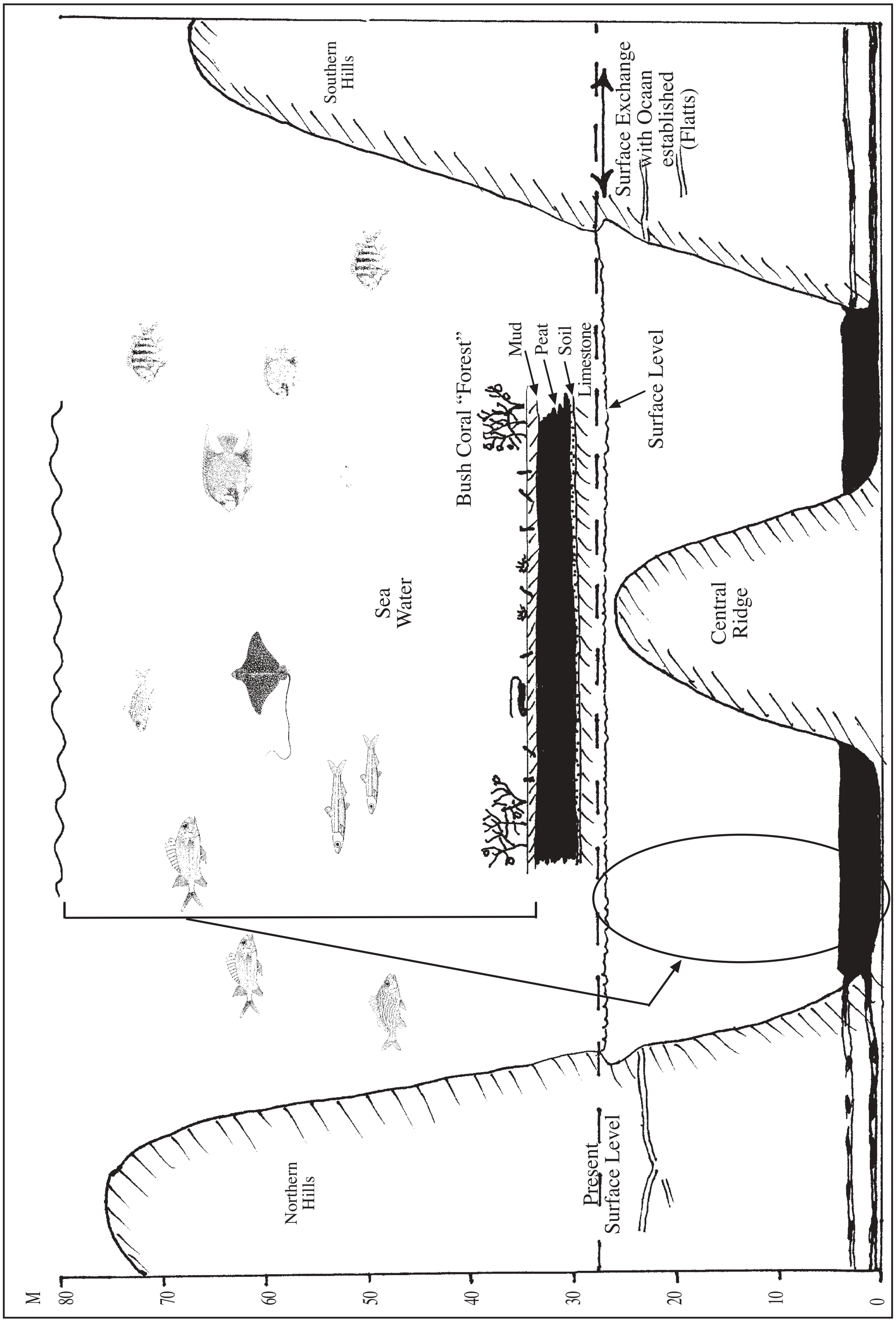


Figure 7.12. Harrington Sound Depression 3,000 YBP

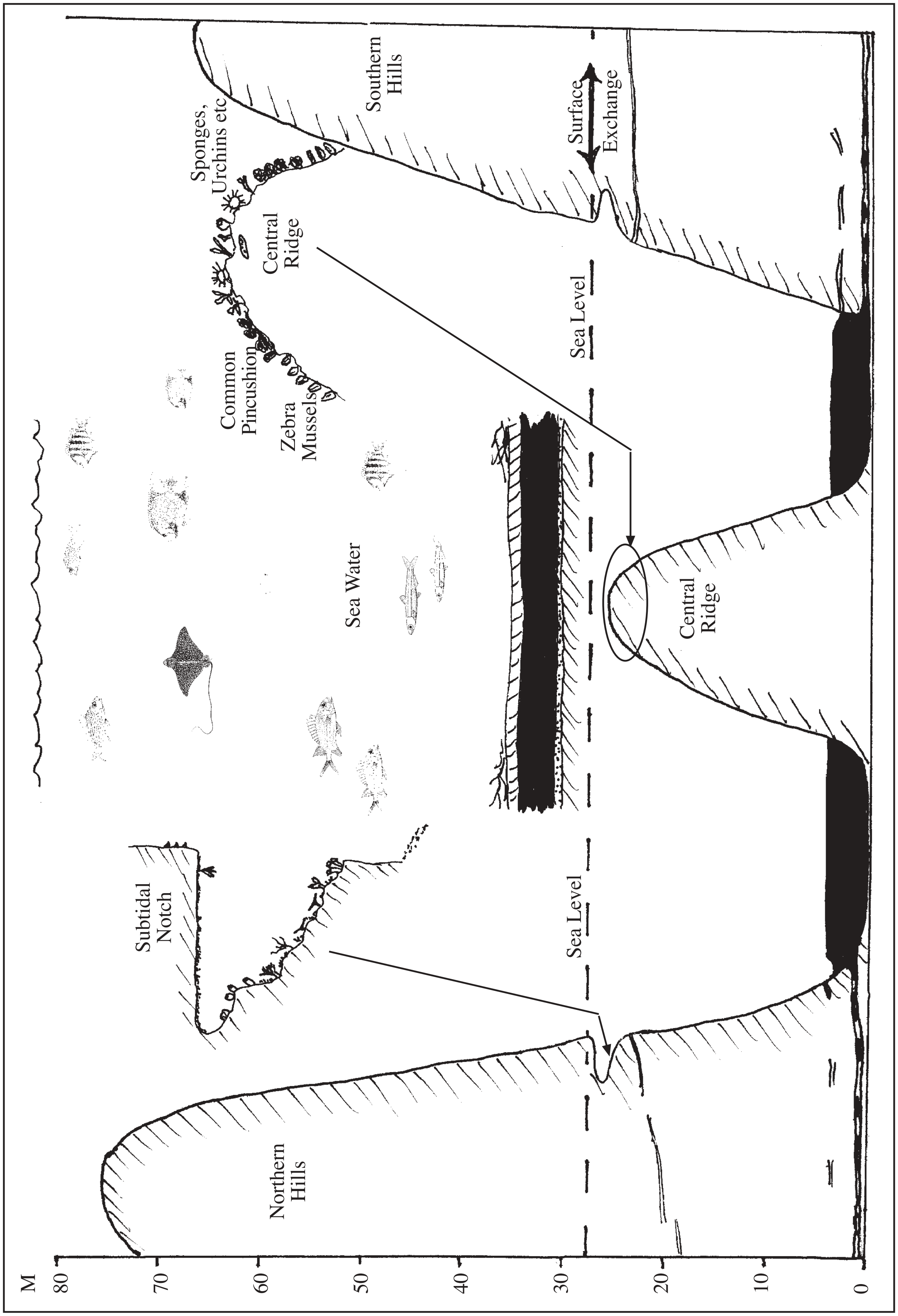


Figure 7.13. Harrington Sound at present

Present Conditions

As sea level approached present conditions and stabilised, surface connections between the sounds and the sea were established in lower spots around the rims. In all but Harrington Sound, these formed large connections and tidal regimes similar to those of the coastal sea were established increasing flushing rates and allowing the free access of marine creatures. In the case of Harrington Sound the land around the rim was high enough that this did not happen and only one or two small connections developed. The present one through Flatts Inlet may once have been augmented by one through the present Major's Bay to Shelly Bay on the north shore. As a result Harrington Sound has only a very small tide and a low flushing rate. The present situation is summarised in **Figure 7.13**.

Questions

1) What is the name of the dark, hard rock produced by volcanoes? ____________________

2) About how deep would you have to drill into the limestone in Bermuda to reach volcanic rock? ____________________

3) Limestone was laid down by living organisms. What do we call this process? ____________________

4) Name two organisms important in the production of limestone.
____

5) Limestone produced by marine organisms eventually became sand. What are two ways that this would have been carried out? ____________________
____

6) Why is the lowering of sea level critical in the formation of the large tracts of sand dunes that once covered Bermuda? ____________________
____

7) What is aeolianite? ____________________

8) Are the most steeply inclined beds found on the leeward or windward end of a mobile dune?
____

9) What is a poorly sorted sediment? ____________________

10) Sediment is moved by water. What do we call this process? ____________________

11) Where would we expect to find rippled sediments? ____________________

12) Under what conditions were caves formed in Bermuda? ____________________
____

13) How are speleothems formed inside caves? ____________________
____

14) How does sand get changed into aeolianite rock? ____________________
____

15) What is a bio-erosional notch? ____________________
____

Field Trip # 7.1 to Observe the Main Surface Geological Features of Bermuda

General

There are a wide variety of locations in Bermuda at which the geological features of the islands are well displayed. Many of the best ones are man-made, as a result of road, railway or other construction. Others such as cliffs are natural. However, only a few locations can show it all and transportation between several locations is needed to see the full range of conditions..

Preparation

Read the geological section of this field guide (Chapter 7). Make sure you know the main bedding features shown in aeolianite as well as the appearance of red beds.

Dress

Sturdy footwear with non-slip tread and readily washable outerwear are all that are needed. In very bright weather, sunglasses help in seeing the main features in the rock.

Equipment

Clipboard, pencil and several sheets of good paper. A ruler with a metric scale. A few pairs of binoculars for the group. Vehicle(s).

Suggested Locations

Do either (1) and (2) or just (3)

1) A road or Railway Trail cutting. This should be at least 5m (15ft) in vertical height and it is best if it is not much colonised by bushes, weeds etc. There are some excellent ones on main roads but the traffic situation is such that such locations are only suitable for very small groups. The Railway Trail has good cuttings at various locations.

2) An open hilly, coastal area. The best is probably Ferry Reach Park, but others such as Hog Bay Park or Spanish Point Park would work.

3) A combination area. The Railway Trail in Ferry Reach Park is probably the best location for a one stop field trip. Walking the Railway Trail from Whalebone Bay to Lover's Lake would show most features and has the advantage that it is traffic free.

Another possible site that has only natural features is Spittal Pond Nature Reserve. In that case go to the east parking lot and follow the footpath towards the west. Good views of the hilly terrain are available right at the start and a nice cliff exposure is present in the first bay at the very east end of the pond as well as further along.

Observation

1) Aeolianite Cutting or Cliff Face.

A) Stand where you can see all of the face of the cutting or cliff. You don't have to be close as the features you are looking for are quite large. Look for and tick off those you find:

a) Foreset (Leeward) Beds. ❐
b) Hindset (Windward) Beds. ❐
c) Cross Bedding. ❐
d) Red Beds (Palaeosols). ❐
e) Formations if Present. ❐
f) Marine Beds if Present. ❐
g) Conglomerate if Present. ❐
h) Any Fossils that are present. ❐

B) Draw a half page diagram of the exposed face labelling all the geological features you can find among those listed above.

C) Go up close to the vertical rock face or if you cannot get close look at any piece of broken off rock that is lying around.

a) Look carefully at the rock. Can you identify the sand grains from which it was formed? Is it porous?

____

____

b) Go to another place close by that looks different. How does it differ from the first location? Are the grains in the rock smaller or larger? ____________________

Is it more ❒ or less porous ❒.

D) If you see any other features in the rock such as red layers or pockets, fissures or fossils, look at them closely, describe them in words and make a drawing of one of those you see.

E) Look for any evidence of erosion. Do any layers weather/erode more than others? What has caused this weathering/erosion? Think of gravity, wind and water.

Observation

2) Rolling or Hilly Terrain

A) Stand where you can see a good stretch of countryside; if there is a pond in it so much the better.

a) Think about what the hills that you see represent. Write your observations down.

b) In your imagination go back a few thousand years and decide what it would have looked like before the sand became lithified into rock. Describe how it might have looked then.

c) Look for an old dune peak and an inter-dunal low area.
Tick off those seen. Old Dune Peak ❐ Inter-dunal Low ❐

d) If a pond is present think about how it was formed. If it is circled by Mangrove Trees it is marine. If it is rimmed by mostly grasses it is brackish or fresh.
Which is the case here? Marine ❐ Fresh ❐

If it is marine, how is it connected to the sea?______________________________

____

If it is fresh or brackish, what keeps the water from draining out through the limestone?

____

2) Coastline if Present.

A) Look along a stretch of coastline, the more varied the better.

a) Try to interpret what you see considering marine erosion and the rock that is exposed. ____

____

b) Look for cross sections of old dunes. Present ❐ Absent ❐

c) If a bay is present try to explain how it came into being.____________________

d) On a marine shore look for phyto-karst. What is the origin of this phyto-karst?

____

<u>Observation</u>

3) <u>Combination Locality</u>

A) Tick off those present.

a) Foreset (Leeward) Beds. ❐
b) Hindset (Windward) Beds. ❐
c) Cross Bedding. ❐
d) Red Beds (Palaeosols). ❐
e) Formations if Present. ❐
f) Marine Beds if Present. ❐
g) Conglomerate if Present. ❐
h) Fossils. ❐

B) Look carefully at the surface of the rock in two different places.
Observations on grains. Site 1. ____

____

____

____ Porous? ❐

Observations on grains. Site 2. ______________________________

____

____

______________________________ More porous? ❒ Less porous? ❒

C) Other features observed in the rock face ______________________________

____

____

D) Evidence of weathering/erosion ______________________________

____

Place of most weathering/erosion ______________________________

Cause of weathering/erosion ______________________________

E) a) What do the surrounding hills represent? ______________________________

b) How would this have looked before the sand became aeolianite? ______________

____

c) Features in the surrounding area.

Dune peak present? ❒ Inter-dunal Low present? ❒

d) Pond Present? ❒ Fresh? ❒ or Marine? ❒

Mangrove rimmed? ❒ or Grass edged? ❒

If Marine how is it connected to the sea? ______________________________

____

If Fresh or Brackish what keeps the water from draining out? ______________

____

F) a) What are your ideas on how the coastline formed? ______________________

____

____

b) Are cross sections of old dunes present? ❒

c) Is a bay present? ❒ How did it arise?

____

____

d) Is Phyto-karst present? ❒ How is Phyto-karst formed? ______________

____

____

Field Trip # 7.2. Field Trip to Harrington Sound (Geology)

General

Harrington Sound is a very interesting location both from a biological and geological point of view. It is the site of the Bermuda Aquarium, Natural History Museum and Zoo and that is the best location to start a field trip from. There are very few places around the shore of Harrington Sound that are good for viewing the main features of the sound, as it is ringed almost continuously with private homes. For this reason field trips to the sound are best conducted from a boat.

Suggested Itinerary

If a field trip must be conducted from shore, the aquarium property does provide good viewing of the sound as a whole, some of the islands and a fair amount of the rocky shore and cliffs. If the sound is viewed from the aquarium it makes sense to also visit the museum and to view the geological exhibits there.

If using a boat, cruise around to see the general features. Look at bare cliffs, rock-falls and islands especially Hall's Island. Look at the mostly vegetated face of Abbott's Cliff, which has many endemic and native plants. If the boat has a recording depth sounder, get the captain to sail in a straight line from just off the east end of Trunk Island towards the Harrington Sound Post Office on the Harrington Sound Road between Devil's Hole and Shark's Hole, with the sounder on all the way until you are 100 m (100 yd) from shore. If only a non-recording depth sounder is available just watch the way the depth changes. You should see the deep flat-bottomed basins separated by a rocky ridge of drowned, lithified sand dunes.

Preparation

Read the geological section of this field guide. For extra information on Harrington Sound, the Project Nature Field Guide "The Ecology of Harrington Sound" would also be useful especially for ecological background. The aquarium also has available a scientific report called "Marine Ecology of Harrington Sound, Bermuda" which contains more information and maps of the sound, its depths, bottom deposits and biological communities.

Dress

For a land-based trip no special clothing is required. For a boat trip, good non-slip footwear and a wind-proof jacket are fine.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group.

Observations from a boat

Note: These observations can be done in any order while you are in the sound.

A) With the boat stopped off a cliff at least 6 m (20 ft) high. (You don't have to be close, as the features you are looking for are quite large). Look for and tick off.

- a) Foreset (Leeward) Beds ❐
- b) Hindset (Windward) Beds ❐
- c) Cross Bedding ❐
- d) Red Beds (Palaeosols) ❐
- e) Formations if Present ❐
- f) Marine Beds if Present ❐
- g) Conglomerate if Present ❐
- h) Any Fossils that are present ❐

B) Draw a diagram of the exposed face labelling all the geological features you can find among those listed above.

C) Circle Hall's Island. Realise that this island is the only place where the ridge of lithified sand dunes running roughly towards the aquarium from here, rises above the surface. Between Hall's Island and the aquarium, at least three more large dunes rise to within 5 m (15 ft) of the surface. If the water is very clear, they are visible from the surface. Hall's Island itself shows the effects of erosion at the shoreline and just below. The cliffs resulting from erosion are mostly quite low but in several spots are impressive. Remember that in Harrington Sound, wave action is low due to the sheltered nature of the sound. Here another kind of erosion, **bio-erosion**, is more important and has created a deep notch just below the surface that cuts well back into the rock. If it is calm, you should be able to see this notch from the boat. This is a **bio-erosional notch** that is better developed here than anywhere else in the world. At the west end of Hall's Island, the erosion has resulted in the collapse of large chunks of rock into the water. Look at all these things and fill in the answers on the field trip question section below.

1) What does Hall's Island represent? ________________________________

____

____

What is the evidence of erosion around Hall's Island? ________________________

____

____

The main form of erosion along the shore of Harrington sound is:

1) wave erosion ☐ or 2) bio-erosion ☐

D) For boats with a depth sounder. Get the captain to sail in a straight line from just off the east end of Trunk Island towards the Harrington Sound Post Office on the Harrington Sound Road between Devil's Hole and Shark's Hole, with the sounder on all the way until you are 100 m (100 yd) from shore. The speed of the boat should be about half speed and constant. Ask if you can have the trace. If only a non-recording depth sounder is available just watch the way the depth changes. You should see the deep flat-bottomed basins separated by a rocky ridge of drowned, lithified sand dunes. More senior students should make a table of the depth at 30 second intervals. These can be graphed later to produce a depth profile of Harrington Sound. Put time (an index of distance) along the bottom of the graph and depth on the side with zero at the top. If you wish a more realistic profile with distance along the bottom of the graph, use a map to get the distance along the line you travelled and then convert your times to distance. Note in this type of profile the depth and distance scales will differ. Try to fill both axes of the graph.

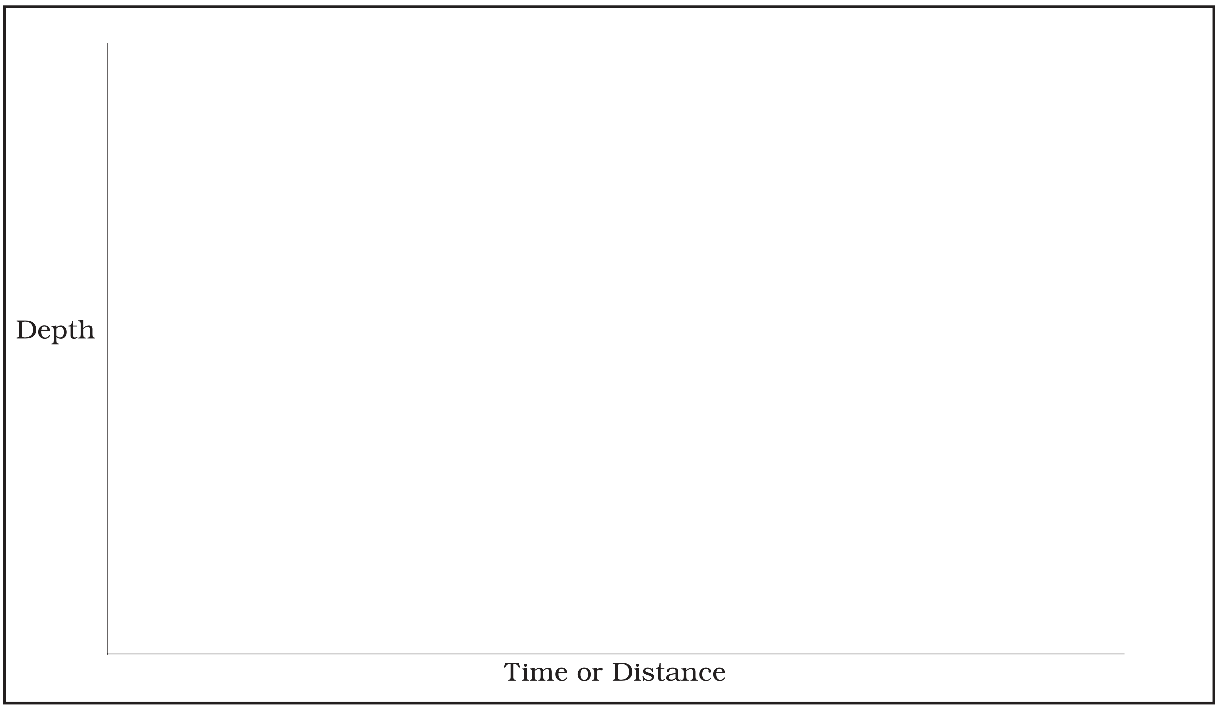
How deep are the flat-bottomed basins in Harrington Sound? ______________________________

What does the shallower ridge in the middle of the sound represent? ______________________

____

____

Depth Profile of Harrington Sound



E) Abbott's Cliff. Look at the cliff, which is not vertical but rather a very steep slope. Notice the several large chunks of rock that have fallen from the cliff into the sound. The largest of these is Cockroach Island. Look at the cliff face and realise that much of the vegetation there is endemic and native species; however, introduced species are now displacing them. In the future it is hoped that this area will be restored to its pre-colonial state.

Abbott's Cliff is an important Natural History site. Give one reason for this. ______________

____

____

Observations for a Shore-based Field Trip

A) Go to the aquarium dock that is in the sound and look out at the sound and to the shores. The shore on the far side of Flatts Bridge has moderate cliffs whereas round the aquarium, the cliffs are quite low. Out in the sound, off the aquarium, are Trunk and Rabbit Island, the latter being a nesting sanctuary for Longtails (*Phaeton lepturus*). Look in the water on the sound side of the dock. You should be able to see that the rock recedes just below the water surface. This is a **bio-erosional notch** caused by the eroding action of living organisms, principally the Black Date Mussel (*Lithophaga nigra*).

Name one Harrington Sound island that can be seen from the aquarium ____________________

Where does one see the bio-erosional notch in Harrington Sound? ____________________

____

What is the name of the clam that forms the notch? ____________________

B) Go around on to the bridge. Notice the current and which way it is flowing. Look carefully into the water and see if you can see orange coloured patches on the bottom. These are colonies of the Boring Sponge (*Cliona lampa*), which also causes bio-erosion at this location. The sponge burrows into the rock removing grains of aeolianite as it goes.

Where can you see the Boring Sponge?____________________

____

The water is flowing 1) Into the sound ❒ 2) Out of the sound ❒ ?

C) Proceed to the museum. Look at the two big maps at either end of the curved central structure, which show Bermuda as it is today and Bermuda in pre-colonial times. Find ten differences between the maps and describe them. Look also at the cast of a rock cutting in Black Watch Pass and see what bedding features are shown there. Make a drawing of this exhibit and label the features in the rock that it shows. Look for other exhibits that show geological features and how Bermuda was formed. Look particularly at the exhibit showing the effect of changing sea level. Describe what it shows. A few cave features are also shown in another exhibit.

Ten differences between the maps

1) ____
2) ____
3) ____
4) ____
5) ____
6) ____
7) ____
8) ____
9) ____
10) ____

What do you find most striking when you compare these two maps? ____________________

____

Rock Cutting Drawing

What is the main thing shown by the exhibit on changing sea level? ______________________

____

Which museum exhibit told you the most about Bermuda in the past, give details?

____

____

____

Field Trip # 7.3 to a Cave

General

A field trip to a cave does present some practical problems. The only practical option is to visit one of the commercial caves, namely Crystal Cave or Fantasy Cave. A guide is provided by the operators, but what is described is aimed at tourists rather than students. The field trip leader should try to make a special arrangement with the operators so that real cave features are emphasised and that time is made available just to look carefully around at the speleothems and other features.

Preparation

Read this field guide and anything else you can find on caves in Bermuda.

Dress

No special clothing is needed but sturdy non-slip shoes are an advantage.

Equipment

Clipboard, pencil and several sheets of good paper.

Observations

Features to look for in the cave are:

1) The following speleothems; tick off those that you see and add their location (e.g. deep within the cave, on the floor within the cave.)

   Stalactites ❒ Location ______________________________

   Stalagmites ❒ Location ______________________________

   Soda Straws ❒ Location ______________________________

   Flow Stones ❒ Location ______________________________

   Pillars ❒ Location ______________________________

   Curtains ❒ Location ______________________________

2) Look for the following other features or objects. Tick off those that you see and add their location.

   Freshwater ❒ Location ______________________________

   Salt Water ❒ Location ______________________________

   Fossils ❒ Locations ________________ Type ________________

3) Make notes on anything else of interest. ______________________________

   ____

4) Either in the cave or later, from memory, make a drawing showing the main speleothems.

Drawing of the Main Speleothems in a Cave

5) Stalactites and stalagmites are formed as freshwater laden with dissolved limestone evaporates and the lime in the form of calcite is deposited. This is quite easy to imagine, but try to explain the origin of soda straws. ____

____

____

____

When you look at soda straws on the roof of the cave, notice that some of them have needle-like extensions coming off the sides. Most of these are straight but others are twisted. Could you venture to make an explanation of these? ____________________________

____

____

____

Chapter 8. The Establishment of Habitats and their main Inhabitants

How Living Animals and Plants got here

Ocean Currents

The transportation of marine animals and plants to Bermuda has already been mentioned above. In summary many marine organisms have larval stages, eggs or spores, which can be transported long distances in the ocean on ocean currents. Adult animals that can swim can also move long distances. Additionally, floating material propelled by winds and currents also transports marine organisms. In the case of Bermuda transportation in ocean currents is very efficient, because the huge ocean current the **Gulf Stream** passes just to the west of the islands. This surface current brings water from all parts of the Atlantic Ocean, but especially the Caribbean and Gulf of Mexico areas, and is a constant source of living organisms.

Summary
Marine organisms could reach ancient Bermuda by transportation on **ocean currents**. Currents also brought floating material that contained living organisms or seeds of intertidal and coastal animals and plants.

Terrestrial Organisms on the Sea

When we look at mechanisms by which non-marine organisms could be transported to Bermuda, we have already covered one very important, but seemingly unlikely one, this is transport by ocean currents. Ocean currents such as the **Gulf Stream** which flows just to the west of Bermuda, can transport more than marine organisms, because floating logs, debris etc. would almost certainly occasionally carry intertidal organisms and shoreline inhabitants. This method of transportation is augmented for floating things, by the fact that Bermuda lies in a zone of prevailing westerly winds. Such winds would tend to push floating things eastward where they would be more likely to strike Bermuda. In fact many coastal plants have large, salt-tolerant seeds that float readily in seawater. Others have parts of the plant, such as rhizomes, bulbs, corms etc. that can break away and perform a similar role to seeds. No doubt quite a variety of salt-tolerant animals also arrived clinging to logs or riding on top of them. It is easy to imagine that the Diamondback Terrapin(*Malaclemys terrapin*), an estuarine turtle of Eastern North America, could have arrived in this way. However, for the fully terrestrial and freshwater species that got here, other methods were probably more, or at least as important as floating.

Summary
Terrestrial and freshwater organisms could not reach Bermuda as easily as marine ones. However, birds, bats and many insects can fly and the prevailing westerly winds would help them to come from the west. Storms could bring them from other directions, but the chances of finding Bermuda would be small. The wind also carries many seeds, spores and even spiders. For freshwater organisms, mud on the feet of waterfowl could bring a wide variety of species. Others that resist digestion have travelled in the guts of flying creatures.

Wind Transport

A major one of these other methods is certainly the wind. Many plant seeds and spores can be carried long distances on the wind. Indeed many plant seeds are adapted especially for transport in this way being either very tiny, and light, or having wind-catching feathery or parachute-like seeds. Examples of these among the native plants of Bermuda are Jamaica Dogwood (*Dodonaea viscosa*), and many members of the daisy family (*Compositae*) such as Shrubby Fleabane (*Pluchea odorata*) and Low Cudweed (*Gnaphalium viliginosum*). Although most freshwater and marsh plants are poor candidates for wind transport, there are those such as the Narrow-leaved Cattail (*Typha angustifolia*) that can move in this way. Many animals too are adapted for wind transport. Winged insects are an obvious example, as are birds and bats. But non-flying creatures such as spiders, clinging to a long thread of web material, may also arrive on the wind. Many tiny animals, such as protozoa, have small spores or resting stages that can be wind-borne. A great help in wind transport is the position of Bermuda in the westerly wind belt, which flows over the North American continent before going out over the Atlantic Ocean. Storms from other directions would also bring things from other locations, particularly those to the North and South. Wind transport from the East is also possible in storms but the distance is huge and the chances of success small; nevertheless, European birds are seen here from time to time, and if they can be blown that far, no doubt other things have also made this journey. It is difficult to look back and make assumptions about how much of the flora and fauna arrived on the wind; however, there are a great many native species that are poor candidates for this mode of travel. For example, we can rule out those that are large and/or heavy at all stages of their life-history.

<u>Transportation on Feet and in Guts</u>
For those other terrestrial and particularly the freshwater living things, transport on the bodies of, or in the intestines of, migrating or wind born flying creatures also certainly played a part. Many seeds are highly resistant to digestive processes and some only germinate rapidly when the protective seed-coat has been thinned and softened in this way. Mud clinging to a bird's feet is also a very probable means of seed, spore and snail transport. Migrating waterfowl probably brought most of the original freshwater creatures and plants.

<u>Problems</u>
Compared to dispersal on continents, however, the chances of any terrestrial organism reaching a distant oceanic island are very low indeed. We must never forget that Bermuda is a small group of islands far from any other coast; these factors more than any others limited the **colonisation** by new organisms and kept the biotic diversity relatively low. If one looks at islands around the world, biotic diversity is lowest on small islands far from the nearest shore. We can safely assume then that terrestrial and fresh-water diversity were always very low, and increased only slowly over a very long time period.

Survival, Reproduction and Spread

An important facet of this whole process of natural colonisation, is that because physical or habitat diversity was low, the ecological conditions required for most arriving species to grow and reproduce would quite likely have been very poor, or not have existed at all. Because of this, many potential colonising species probably died out before they became established. This process of continual **extirpation** also helped to keep **biodiversity** at a low level.

<u>Succession</u>
The development of new biological communities in a newly created environment follows a very predictable pattern. The first stage, **primary succession**, is assumed to be exceedingly slow and takes place with only bare rock and water present. Examples of primary succession in nature are rare, and hard to study because events take place so slowly. However, events such as the creation of the new volcanic island Surtsey off the Icelandic coast do show this process in operation.

Summary
Land and freshwater organisms reaching Bermuda did not survive in many cases because their natural habitats were poorly developed or absent. Those that did survive and reproduced, helped to increase habitat diversity paving the way for later arrivals. Early plant colonisers helped to develop rich soil and provided shade. Coastal communities of organisms appeared first, followed by inland terrestrial organisms. Freshwater biological systems were the slowest to develop.

Secondary succession, which starts when sediment starts to accumulate, is a much faster process that is more frequently observed in nature. In secondary succession, the first stages or **seres**, are typified by a small number of readily dispersed plants. As succession proceeds, animal and plant diversity increases, organic content of the sediment rises and the overall complexity of habitats increases. In theory, secondary succession proceeds until as diverse and stable a community and environment as possible are achieved, and then remains this way as the climax.

Marine Succession

In the case of Bermuda we can assume that the marine communities followed the classical course from primary through secondary succession, to some semblance of climax. It probably began on the volcanic peak long before limestone started to be laid down, and progressed over thousands of years, probably accelerating as the limestone cap was laid down to finally become the relatively stable and diverse community we see today.

Terrestrial Succession

If we consider the land, however, the course of succession was probably different from this classical form. It obviously commenced later than that in the sea, but probably also progressed much faster. This is because sediments produced previously in the sea, were available for transfer to the land by wave action and during sea level changes. These sediments were undoubtedly then dispersed over the available land surface principally by wind, but also by gravity and water movement. Probably, a completely bare limestone rock island never existed. As soon as sea bed was exposed, both rock and sediment would be present. Thus primary land succession may have occurred only in small pockets, and secondary succession on the sand proceeded at the same time. Secondary succession producing a fairly diverse land community may have been a fairly rapid process.

Coastal Plant Communities

Most coastal flowering plants found along both rocky and sedimentary shores, are adapted to dispersion by floating on the sea as described above. Even though Bermuda is far from the nearest shore, we can safely assume that these colonising plants appeared as soon as land was available. This is because many cross entire oceans all the time and are exceedingly widely distributed! Plants such as Seaside Goldenrod (*Solidago sempervirens*), Seaside Purslane (*Sesuvium portulacastrum*), Sea Oxeye (*Borrichia arborescens*) and Seashore Rush Grass (*Sporobolus virginicus*), probably quickly established themselves on rocky coastlines. The first tree may well have been Buttonwood (*Conocarpus erectus*), which can exist as a stunted form in very exposed locations. At the same time sand dune inhabitants would start to grow along windswept sandy shores. Closest to the sea, at the strand-line, Scurvy Grass (*Cakile lanceolata*) would act as a sand stabiliser, while behind this area, plants such as Seaside Evening Primrose (*Oenothera humifusa*), Seaside Morning Glory (*Ipomoea pes-caprae*), Bay Bean (*Canavali lineata*), and others, would quickly become established, further stabilising blowing sand. In more sheltered sedimentary, coastal areas, where mud would gather, the Red Mangrove (*Rhizophora mangle*) probably soon became established, trapping further water borne sediment and quickly creating more sheltered areas in its **lee**. There, the Black Mangrove (*Avicennia germinans*) would grow, and behind that, salt-marsh plants such as Woody Glasswort or Marsh Samphire, (*Salicornia perennis*), Sea Lavender (*Limonium carolinianum*), Sea Rush (*Juncus maritimus*) and Saltmarsh Oxeye (*Borrichia frutescens*), among others, probably thrived.

All these newcomers helped to stabilise coastlines and their fallen leaves transported inland, enriched the primitive sandy soil. At first the inland areas consisted of large tracts of mobile sand dunes. These dune fields would have been difficult for plants to colonise because the sand shifted with every wind, and despite generally significant rainfall, the rapid drainage of water through the sand kept the surface dry and somewhat salty. Nevertheless, some plants probably formed patchy communities among the dunes. Even though these patches may have often been short-lived, their remains would improve soil structure, and over time they would pave the way for true inland plants.

Colonising Freshwater

We can say with reasonable confidence that the freshwater habitats and communities would be very slow to develop. This is due to several factors. Firstly, the sediments derived from limestone, are very porous to water. Even today, torrential rain just disappears into the ground in most locations. Because of this, there would have been no permanent streams or Ponds. In limestone soils, freshwater only gathers where a considerable layer of organic plant remains, forming a **peat deposit**, compresses into an **impermeable** layer, sealing the sediment surface. The accumulation of peat is a very slow process and consequently, freshwater ponds were certainly slow to develop. Once there, however, they would pave the way for succession to freshwater marshes and swamps which themselves would accelerate peat production.

Questions

1) Name the ocean current that is most important in transporting marine life to Bermuda. ______

2) How big is this current? ______

3) Where does this current flow from? ______

4) Why is the water carried by this current so warm? ______

5) How did non-flying land creatures get to Bermuda? Give two probable mechanisms. ______

6) How does a prevailing west wind help organisms from the mainland to get here? ______

7) What organisms other than birds or bats be carried to Bermuda on the wind? ______

8) Can ocean currents transport land organisms to Bermuda? If so how? ______

9) Why would some organisms get here successfully and then die out? ______

10) Why are remnants of the past such as Butterfield Park so important today? ______

11) Why is peat so vital in the formation of freshwater habitats? ______

12) Give four examples of native coastal plants that probably arrived by transportation on ocean currents. ______

13) Why would some organisms reaching Bermuda fail to survive? Give two or more reasons. ______

14) What are the two main phases of succession? ______

15) Why are migrating waterfowl so important to the establishment of freshwater communities in Bermuda? ______

Field Trip # 8.1 to Demonstrate some Early Natural Habitats and Communities

General

On land, almost no early natural communities are left and at the other end of the scale most fully marine habitats are pretty well as they were. Shallow-water and coastal communities form a middle ground.

Preparation

Read this and the following section of this field guide.

Dress

No special clothing is needed.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group. Vehicles. Suggested Route. Start at Point Shares proceed to Paget Marsh boardwalk finish off at Astwood Park.

Observations

1) On Point Shares Road stop at Fairyland Creek. From the road look at the mangrove swamp in the end of the bay. Mangrove swamps like this were common prior to colonisation but have been cut down and removed in many locations. Also in the shallow water of the bay seagrasses grow. They are still common but are also reduced in extent by man.

   A) Name two natural habitats seen here that were common prior to colonisation.

   a) ________________________ b) ________________________

   B) Look around and list a few things that man has added. ____________________
   ____
   ____
   ____

2) Proceed on to Butterfield Park. This is a very rare example of an old upland Palmetto Forest that is little changed. Proceed into the park but stay on the path as some very rare and endangered species live on the forest floor and must not be disturbed.

   A) Look at the old Bermuda Palmetto trees. Some have very irregular trunks others show V-shaped notches cut by early settlers for collecting the sap to make bibby. Draw one of the old trees showing its shape.

Drawing of an Old Bermuda Palmetto Tree in Butterfield Park

B) On the forest floor look for the endemic Bermuda Sedge, but do not touch it. It is now very rare. How many of this plant can you see? ______________________________

3) Go to the boardwalk in Paget Marsh. Look at the exhibit, which shows how the marsh formed and then proceed along the boardwalk. After the pond, the plant communities around you are in a reasonably original shape. Identify the following as you proceed:

a) Mangrove Swamp. Red mangrove trees in this example. Note all the native ferns at the back of the swamp. Tick off any of the following that you see. (Look for illustrations at the back of this guide).

Giant Fern ❐ Sword Fern ❐

Cinnamon Fern ❐ Royal Fern ❐

Southern Bracken ❐

b) Saw Grass Marsh. Home of the Sora, a bird in the Rail family. This marsh also has numerous native Narrow-leaved Cattail and Wax Myrtle shrubs. Tick off those you identify.

Saw Grass ❐ Wax Myrtle ❐

Narrow-leaved Cattail ❐ Others ______________________________

____

c) Palmetto Forest. Note the difference from the Butterfield park examples. These are lowland Palmettos. Look for two native vines climbing up the trunks. Tick them off when you identify them.

West Indian Cissus ❐ Virginia Creeper ❐

Look for any birds or other animals that are about; this is a good birding location. List any birds or other animals that you see.

1) ______________________________
2) ______________________________
3) ______________________________
4) ______________________________
5) ______________________________

4) Proceed to Astwood Park on the south shore. In the park go to the open grassy area close to the cliff top. Look at four main areas The Ocean, The Boiler Reef Tract, The Shoreline, the Inland Area.

a) Look out to sea; of all the ecosystems around Bermuda this is the least affected by man. The animals and plants are almost all native and very rich in biodiversity.
Although the ocean is little affected, how is man altering it? ______________________________

____

b) Look at the boiler reef tract marked by boiling patches of white water just offshore. Sometimes you can see a second tract further out and ancient tracts are well below the surface beyond that. Those furthest out formed in the past when sea level was lower. How many lines of boilers can you see?

1 ❐ 2 ❐ 3 ❐

Note that boilers are not coral reefs but formed by crustose coralline algae and worm shells. They are very solid reefs. Both these organisms were here in the distant past and undoubtedly contributed to very early reefs.

Boilers do occur elsewhere in the world but are uncommon. It is interesting that at least two endemic species have evolved on these reefs, these are Verrill's Hermit Crab and Martin's Barnacle. Do you think the fact that boiler reefs are a relatively isolated environment, is important in explaining why evolution to new species took place there?

____

Why?______________________________

c) Look at the rock shore at the base of the cliffs. This area too contains mostly native animals and plants but several species of sea shell found there have been seriously reduced by shell collectors. Therefore it serves as an intermediate example of the effects of man.

d) Turn around and look generally inland and to the coastal areas to the east and west. In contrast to the ocean, reefs and shore, the vast majority of what you see are introduced species. Apart from the general terrain almost everything is changed by man. Look for the following introduced species and tick those that you can see.

Whispering Pine ❐	Pigeons [Rock Doves] ❐
Oleander ❐	Norfolk Island Pine ❐
Hibiscus ❐	Fiddlewood ❐
Banana ❐	Allspice ❐
Dogs ❐	Palms other than Bermuda Palmetto ❐

If you do see any endemic plants list them here:

1) ____
2) ____
3) ____
4) ____

Chapter 9. Changes among Animals and Plants after their Establishment here

The Appearance of New Organisms: Evolution and Endemic Species

Early Competition and Evolution

To help us look back at the colonisation process, it is useful to consider some general aspects of the **evolution** of new species (the **endemics**) on Bermuda. Evolution is normally very slow, and so it is reasonable to assume that species unique to these islands arrived a long time ago, as closely related species from elsewhere. Additionally, early survivors would have a very wide variety of habitats available to them, if they could adapt to the island conditions. In pioneering communities competition for such essential resources for life, as light, space, water and plant nutrients, would also be at a low level. So, perhaps we can fairly safely say that species that evolved here in Bermuda and came to occupy a very wide range of habitats, compared to their forebears elsewhere, probably arrived while **biodiversity** was still comparatively low. We do know that when Bermuda was first discovered by man, it was almost totally forested and it is reasonable to assume that trees were the characteristic species of inland areas, practically from the start. Additionally, tree fragments are common in old peat deposits and some fossil tree remains such as Bermuda Palmetto (*Sabal bermudana*) roots are common.

Summary
New species **evolved** very early in Bermuda: these are the endemic species. Newly arrived species had little competition at first and were able to colonise a wide variety of habitats, in doing so they changed to new species. On land trees quickly became the **dominant** plant form.

The Forest as an Example

The establishment of the Bermudian forest by the evolution of two new tree species, is a very good example of one possible course of events. There is a lot of evidence that the two trees that were to dominate the forests, Bermuda Cedar (*Juniperus bermudiana*) and Bermuda Palmetto, arrived very early when there was a lot of space available, and very little competition for natural resources. Natural competition between species often limits their distribution in diverse communities where space is limited. For example, mangrove trees, which are confined to coastlines, are perfectly capable of living in inland freshwater localities, but cannot compete with species that naturally evolved there. In Bermuda, the Cedar and Palmetto became established and spread rapidly. In each new generation of trees there would be considerable **natural variation,** and some of the new trees would be better adapted to the island conditions than their parents. **Natural selection** of the new, better adapted, trees would result in their increasing importance, until the original trees were gone. The new trees would differ genetically from their ancestors. In the case of the Cedar and Palmetto in Bermuda, both new species were able to colonise a very wide range of habitats, from freshwater swamps to dry uplands.

Summary
Two new trees, the Bermuda Cedar and the Bermuda Palmetto, dominated the forests from the start. They colonised areas from the highest hills down to lowland swamps. In doing so they created a new forest habitat that paved the way for the establishment of other forest species.

As the forest became established, a unique new habitat was created under the trees, and other new species evolved in this damp, stable environment. In these cases, evolution was made possible by the creation of a new forest habitat that suited their ecological needs. Examples of these other new species are the Bermuda Sedge (*Carex bermudiana*), the moss Bermuda Trichostoma (*Trichostomum bermudanum*), the Bermuda Maidenhair Fern (*Adiantum bellum*) and the shrub Bermuda Snowberry (*Chiococca bermudiana*).

The Disappearance of Animals and Plants: Competition, Survival and Extinction

Competition

Of particular importance in the early stages would be competition between individuals of the same species, a process called **intra-specific competition**. Individuals of the same or very similar species compete very vigorously and the result is **competitive exclusion**, where one competitor persists and the other dies out. We can safely assume this happened in these two cases because the colonising species completely disappeared.

Adaptive Radiation

In other situations this did not happen; instead, the colonising species persisted in some habitats and new species arising from it occupied other habitats or **niches**. A niche is simply the unique habitat of one species. A famous example of this second evolutionary path is the case of Darwin's Finches in the Galapagos Islands where one finch gave rise to a whole group of related species; this is termed **adaptive radiation**. In Bermuda the best example of adaptive radiation is that of the Poecilozonites land snails where many species developed from a single ancestor.

> **Summary**
> New species competed for resources among themselves and with their ancestors. This resulted in **competitive exclusion** where only the best adapted species survived. Some new species formed a group of new species whereas others stayed as a single species. During this process adaptations to their former life were often lost. For example resistance to disease. This caused problems later when diseases arrived.

Loss of Useful Traits

However, the cases of both the Bermuda Cedar and the Bermuda Palmetto, serve to show not only how evolution can enable a species to better survive in a new habitat, but also how other potentially useful features or **traits** may be lost. Consider the ancestor of the Cedar on the mainland co-existing with the disease Cedar Blight, because it had developed an **inherited** resistance to it. Any individuals lacking the genetic trait of disease resistance, would be eliminated in **natural selection**. However, in a new location where the disease was absent this would not occur, and those lacking disease resistance would persist if they were better fitted to succeed in other ways! This is what happened in Bermuda, and later, when man accidentally introduced the disease on introduced junipers, the Bermuda Cedar was almost wiped out. Bermuda Palmettos were also attacked by introduced pests and diseases but were not so severely affected; perhaps they retained partial resistance.

Failure to Colonise Widely

Returning to the development of the forests, one other naturally arriving tree, the Bermuda Olivewood, a beautiful, very compact tree up to 15 m or 45 ft high, evolved into a new species the Bermuda Olivewood (*Cassine laneana*) However, in this case it did not evolve to occupy diverse habitats but was restricted to reasonably sheltered, but well drained forest situations. It might be reasonably assumed that it arrived after the Cedars and Palmettos became dominant and could only compete with them in a specific habitat.

Native Species

Native species are those that arrived in Bermuda by natural means but remain essentially identical with their forebears elsewhere. Thus they arrived by the same means, as the **endemics** but did not evolve into new species. The reasons for this may never be clear, perhaps they arrived later than those which formed the endemics but had characteristics which adapted them to the structure of the already created upland forest. Alternatively, they may have arrived very early but were not well adapted to Bermudian conditions and only flourished after the

> **Summary**
> **Native species** are those which have arrived here by natural means but have not evolved into new species. Some of these species never became common; some are now endangered.

endemics evolved to dominate the forest. Several of these formerly quite common trees are now very rare and endangered. Perhaps the best known of these is the Yellow-wood (*Zanthoxylum flavum*) now existing as only a few specimens in the Walsingham limestone formation. The Southern Hackberry , (*Celtis laevigata*) was also probably widely distributed on sheltered hillsides. This tree, up to 15 m (45 ft) high, is native of the southeast United States. Like the Yellow-wood it was probably scattered or in small clumps among the Cedars and Palmettos. Another interesting native tree is Lamarck's Trema (*Trema lamarckiana*), a small shrubby tree of untidy growth form. Now quite rare, this tree was probably much more common before the arrival of man.

Endemic Species

Above we have used the early forest, with particular emphasis on the trees, as an example of one habitat in which the evolution of new species took place. However, it occurred in all living things, and many groups have been studied in enough detail, to be able to list both the endemic and native components with considerable confidence.

Summary
Endemic species are those which have evolved in Bermuda to produce new species not initially found elsewhere.

Endemic Species in Bermuda

The situation among the plants and plant-like cyanobacteria was roughly as follows. In the case of the **vascular plants** there were 156 species of native plants exclusive of the 11 species which have proved to be endemic. Among the **liverworts** there were 25 native, and the **fungi** and **lichens** numbered 747 non-endemic natives to which can be added the 50 endemic species. The seaweeds or **algae** including the **blue-green cyanobacteria** plants, which resemble seaweeds, were quite diverse with 833 non-endemic native species plus 9 endemics. The **protozoa** numbered about 200 native species, none of which are proven endemics.

The marine **invertebrate** animals were, as expected, the most diverse group with 2,915 native species identified to date, to which we can add 94 endemic animals. By contrast, the freshwater invertebrates had only 8 natives plus 2 endemics (insects not included). **Terrestrial invertebrates,** exclusive of the insects are another group of moderate diversity with 175 natives plus 13 endemics. The terrestrial and freshwater insects were the most diverse non marine group, with 1,116 native plus 41 endemic species described to date. The group of invertebrate animals including the **spiders**, **ticks** and **mites** were of intermediate diversity, containing 32 non-endemic native species plus 9 considered to be endemic. So far 79 parasitic invertebrate animals have been described, none of which were certain endemics.

Turning to the vertebrate animals, the marine fishes were the most diverse group, with 423 species, which were non-endemic natives, to which we can add the 7 known endemics. In freshwater, on the other hand, there were no native species, but 3 are considered to be endemic species. There were no native or endemic amphibians and only 4 native, marine reptilian species and a single brackish-water species to which we can add 1 endemic, terrestrial species. The birds, on the other hand, were a quite diverse group, with 334 probable non-endemic natives to which can be added 2 endemics. There were no terrestrial mammals, but the marine species number 36 natives.

The Overall Endemic Situation

When we look at the totals, the numbers are quite illuminating; for the marine environment the total number of non-endemic native species is 4,499, to which can be added 111 endemics, for a total of 4,610 species. The terrestrial group numbers 2,448 non-endemic native species, and 126 endemics, for a total of 2574 species. The smallest group as expected is from freshwater habitats, with 59 non-endemic natives and 5 endemics to total 54 species. Seventy-nine parasitic species have not been assigned to the above groups because they form a special case. The grand totals are 7,085 natives and 242 endemic species, for 7,327 species in total. Thus the percentage of endemics or **endemism** as it is often called, is 3.4% overall, 2.5% for marine organisms, 5.1% for terrestrial organisms and 8.5% for the freshwater environment.

Thus the percentage of endemic species, or the amount of island evolution, is highest in the least diverse freshwater group and lowest in the most diverse marine group. This may seem peculiar, but it makes sense if you consider the three main environments in terms of isolation. The sea is obviously the least isolated as it has a direct connection through water to other localities, and it continuously receives new individuals of a host of species. Indeed for a few species, such as the Spiny Lobster (*Panulirus argus*) most individuals found here may have come from the Caribbean as larvae. The terrestrial or land environment is much more isolated than the sea, and new individuals can only arrive by more tenuous transportation routes such as on the wind, or in association with flying creatures. The freshwater environment is certainly the most isolated of all, and the high percentage of endemic species is more striking when we consider that the freshwater community has certainly developed over a shorter time period than the others. We know that evolution of new species is generally a very slow process.

Summary
A large number of new species evolved in Bermuda. There are examples in most groups of animals and plants. However, comparatively few of them have become abundant and a large number have become extinct or very rare. Comparatively more new species evolved on the land than they did in the sea.

Comparison with other Islands

Compared with other oceanic island situations at similar latitudes, such as Hawaii, there is a much smaller total number of species here, and the proportion of endemic species here is very much lower. Of course Hawaii is a larger and more physically complex series of islands, which probably offers more habitat diversity than Bermuda. It also lacks a real counterpart to the Gulf Stream, which as pointed out above acts as a sort of conveyor belt bringing organisms to Bermuda and reducing its apparent isolation.

Examples of Endemic Species

Scientific Names of Endemic Species

You should have noticed that in the examples of species that evolved in Bermuda given above, that the second part of the scientific name, given in italics, was some variation of the name Bermuda. This **specific epithet** as it is called, normally gives some descriptive information about the organism, in this case its Bermudian origin. This happens in the case of most but not all Bermudian endemic species, as you will see below. Curiously, finding a specific epithet with some derivation of Bermuda does not necessarily mean that it is endemic to Bermuda. For example, in the case of a beautiful red seaweed called the Heartweed (*Halymenia bermudensis*), it merely signifies that it was first found in Bermuda, even though it also lives elsewhere.

Endemic Seaweeds

The seaweeds or marine algae have several very interesting endemic species. One of the most spectacular ones of these is the Bermuda Sargasso Weed (*Sargassum bermudense*). Sargasso Weeds are best known for the floating mats that come ashore from time to time, particularly in winter. However, some species of Sargasso Weed are attached to the bottom, as are most seaweeds, and one of these is the Bermuda Sargasso Weed, which is occasionally found on near-shore rocks. It is, however, sometimes seen in some of the Bermudian saltwater ponds where it forms impressive large bunches of brown fronds up to 3 m (10 ft) high!

Summary
The Bermuda Sargasso Weed is an example of an **endemic** seaweed. There are two endemic mosses, the Bermuda Trichostoma being common. The Bermuda Maidenhair Fern is endemic and widespread. Living on the forest floor the Wild Bermuda Pepper needs protection as does the Bermuda Sedge.

Endemic Mosses and Ferns

The mosses are not a very diverse group in Bermuda, but they do boast two endemic species. The Bermuda Trichostoma or Bermuda Moss (*Trichostomum bermudanum*) is a tiny dark green moss that is exceedingly common on damp rock or soil. By contrast the other endemic moss, the Bermuda Campylopus (*Campylopus bermudiana*) is very rare and confined to a specific **microhabitat** in Paget Marsh.

Ferns are another group that show a surprising amount of endemism, in that there are only19 species including the four endemic ones. Only one of these endemic species, the Bermuda Maidenhair Fern (*Adiantum bellum*), is at all common, occurring on shaded rock faces, walls etc. The other three are now exceedingly rare. The Bermuda Cave Fern (*Ctenitis sloanei*) is now confined to a couple of sites. The Bermuda Shield Fern (*Dryopteris bermudiana*) was once abundant in the Walsingham area, but is now on the verge of extinction. Perhaps even more threatened is Governor Laffan's Fern (*Diplazium laffanianum*), now absent from the wild, and perpetuated only by a few specimens in cultivation. Note that only one of these endemic ferns bears a specific epithet signifying Bermuda, the others have other descriptive words, for example signifying who they were named after.

Forest Floor Endemics

Smaller endemic plants of the forest floor include the Bermuda Sedge (*Carex bermudiana*), a small grass-like plant of fairly open forests, now uncommon. However, it has been re-introduced in restored habitats (Chapter 12), and Wild Bermuda Pepper (*Peperomia septentrionalis*), which lives on rock rubble and rock ledges in wooded areas, and is now rare except in the Walsingham area. Among the forest shrubs, Bermuda Snowberry (*Chiococca bermudiana*) is now found in the wild only in the Walsingham area, but is also frequently cultivated as a garden plant because of its showy white berries. Another forest endemic, formerly abundant but now also almost confined to the Walsingham area, is the Bermuda Bean (*Phaseolus lignosus*), a small vine with yellow, pea-like flowers.

Endemic Herbs

Three endemic flowering **herbs** of more open areas are St. Andrew's Cross (*Hypericum macrosepalum*) which has 4 petalled yellow flowers, Darrell's Fleabane (*Erigeron darrellianus*) a member of the daisy family occasionally found on banks and in wasteland, and Bermudiana (*Sisyrinchium bermudiana*) which is looked upon as the national flower. Once so common as to be a pest it is still widespread in many habitats and has lovely purple flowers in spring.

Summary

The best known of the **endemic** herbaceous plants is the Bermudiana, treated as Bermuda's national flower. Less well known examples are Darrell's Fleabane and St. Andrew's Cross. In the marshes, the small, endemic Bermuda Spike Rush is now very rare.

The one endemic marsh herb, the Bermuda Spike Rush (*Eleocharis bermudiana*), a small rush with grass-like leaves, is now an **endangered species**. Hopefully surviving only as scattered individuals in Paget and Devonshire marshes it has not been seen for several years.

Endemic Insects

The insects boast a large number of endemic species but few that can be said to be common; in fact many endemic insects are now extinct. Two recent extinctions that were formerly quite common are the Cicada or Bermuda Singer (*Tibicen bermudiana*) known from its nocturnal singing in trees, and the Bermuda Flightless Grasshopper (*Paroxya bermudensis*).

Interesting Examples among the Land Snails

The **land snails** too have some examples of recent extinctions; these include at least two species of endemic Poecilozonites (*Poecilozonites* spp.), which were eaten to extinction by a predatory snail, the Rosy Euglandina or Predaceous Snail, (*Euglandina rosea*), which was introduced by man hoping to control the Edible Snail (*Otala lactea*) which had become a pest.

Summary
The Bermuda Singer, an **endemic** cicada is very rare or **extinct** as are most of the species of the Poecilozonites Land Snails that evolved here. One species was re-discovered in 2002.

The Poecilozonites land snails were of great interest because they were Bermuda's best example of **adaptive radiation**; the better known example of Darwin's Finches in the Galapagos Islands was mentioned earlier. These snails originating from a single ancestor evolved, at first to produce six new species in Bermuda (*Poecilozonites bermudensis*, *Poecilozonites cupula*, *Poecilozonites nelsoni, Poecilozonites reinianus, Poecilozonites circumfirmatus* and *Poecilozonites superior*). Some of these species then continued evolving until there was a total of 15 species and sub-species varying in size from 5-45 mm (3/8 to 2 in). Probably all but one of these are now extinct, although three species *(Poecilozonites bermudensis*, *Poecilozonites reinianus* and *Poecilozonites circumfirmatus)* were found alive in 1969, and *Poecilozonities circumfermatus* was rediscovered in 2002. However, fossil specimens of many species are common, as are dead shells of others can be found quite easily in some cases. **Figure 9.1** shows a simplified diagram of adaptive radiation in *Poecilozonities* species.

<u>Endemic Fishes</u>

There are not many endemic species among the fishes but a few are well known. One of the most interesting is the Bermuda Killifish (*Fundulus bermudae*), a small but tough fish of Bermuda's saltwater ponds. It can live in water that is very low in oxygen, and is quite common. A second *Fundulus* species (*Fundulus relicta*) is recorded from a single pond. This is another small example of adaptive radiation and it is significant that it happened in the relatively isolated saltwater ponds. Another well known endemic fish is the Bermuda Bream (*Diplodus bermudensis*), very common in bays and coastal waters and reaching a size of 40 cm (16 in).

Summary
The Bermuda Bream is a common **endemic** fish. Less common are the Killifishes, found in marine ponds, which have developed at least two endemic species.

<u>The Bermuda Skink</u>

The once very common endemic lizard, the Bermuda Skink (*Eumeces longirostris*), is declining in numbers and now only common on islands in Castle Harbour, including Nonsuch Island and a few other places. It has been preyed upon by man's introductions, cats, rats and the Great Kiskadee (*Pitangus sulphuratus*). Reaching a length of 15-18 cm (6-7 in), the young ones have a bright blue tail, mature specimens being a greyish-tan with orange chin patches.

Summary
The only endemic lizard of four found here is the Bermuda Skink now only found at a few localities in Bermuda.

<u>Bermuda's Endemic Birds</u>

Of the two endemic birds, the Bermuda White-eyed Vireo or Chick-of-the-village (*Vireo griseus*), and the Cahow or Bermuda Petrel *(Pterodroma cahow*), the Cahow is by far the most famous; indeed it is probably the best known example of Bermuda's endemic species. This species was thought to be extinct, but was re-discovered in 1951 when 8 pairs were found breeding on small islands in the Castle Harbour area. With careful husbandry, particularly by Dr. David Wingate the former Conservation Officer, the numbers of this bird are rising steadily, but it is still an endangered species. The Cahow is an oceanic bird that

Summary
The White-eyed Vireo or Chick-of-the-village is an endemic vireo, but the most famous endemic bird is the Cahow or Bermuda Petrel. Once very common this bird now only breeds on a few islets. The Cahow is oceanic coming ashore only to nest.

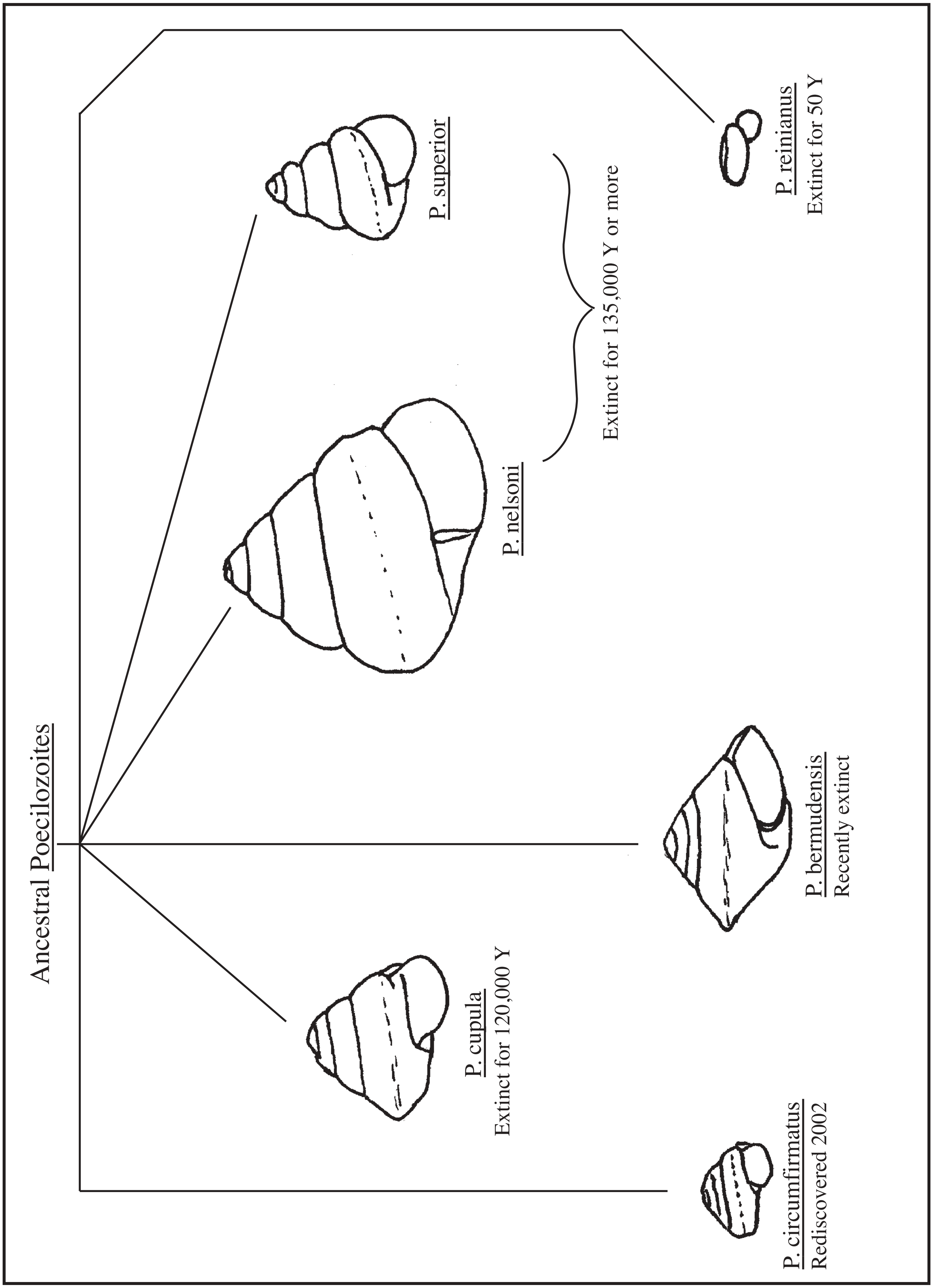


Figure 9.1. Probable adaptive radiation in *Peocilozonites* species

only comes ashore to breed. It is rarely seen as it only approaches the breeding areas at night. The Cahow was abundant when Bermuda was settled, but was easily caught by man and dogs and rapidly declined. In these early days it bred in tunnels under fallen cedars in the forest, a habitat that now scarcely exists, and if present is far from safe. Breeding now takes place in artificial tunnels on islands where predators are absent. The Bermuda White-eyed Vireo is a distinct endemic **race** of the White-eyed Vireo. A race is not distinct enough from the parent species to be given the status of a new species. However, in time it may become more distinct and its status may be changed.

Questions

1) What is an endemic species? ____________________
2) How did endemic species arise in Bermuda? ____________________
____
3) How does a native species differ from a naturalised one? ____________________
____
4) What do we call the species brought here by man? ____________________
5) Where in Bermuda do we find that most of the present plants are introduced? ____________________
____
6) Animals in the sea are mostly introduced. What is wrong with this statement? ____________________
____
7) Describe the difference between extinction and extirpation. ____________________
____
8) Name two important endemic trees. ____________________
9) What is the name of the endemic lizard? ____________________
10) Name one introduced lizard. ____________________
11) Which endemic species do you think is most important in Bermuda? Give several reasons for your choice.____________________
____
____
12) Name two environments dominated by native organisms. ____________________
____
13) Why do you think that there are no endemic amphibians in Bermuda? ____________________
____
14) Why do you think that some organisms that arrived early in Bermuda evolved to new species and others did not? ____________________
____
15) Why do you think that there are no native or endemic freshwater fish in Bermuda?
____
____

Field Trip # 9.1 to Look at Endemic and other Species

General
The best environment to look at endemic species is the terrestrial one. Those found in marshes and ponds are mostly rare or very difficult to find.

Preparation
Read this section and the previous one of this field guide.
Dress. No special clothing is needed.

Equipment
Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group. Vehicles.

Suggested Itinerary
Fortunately, many of the endemic species of terrestrial environments are large and easy to identify. Once you know which they are you can see them almost anywhere. This field trip could be carried out at any of the following locations; the best are listed first. Nonsuch Island, Paget Marsh, Blue Hole Park, Hog Bay Park, Spittal Pond Nature Reserve, Botanical Gardens, Butterfield Park, the Arboretum. Two of some of these sites could be visited in one field trip.

To get the most out of this field trip it is important to be able to distinguish between at least the common Endemic, Native and Introduced species. In the identification section at the end of this book, the status of each species and its habitat are clearly marked and the identification features are explained and illustrated.

Observations
1) At the location you have chosen decide what type of habitat that you are in. If two locations are to be visited, choose two in different habitats. Fill in the details below.

   Location ______________________ Habitat ______________________

2) This field trip requires some careful observation, so take time to have a good look around and see what is there in terms of endemic, native and introduced species. Then list your conclusions below. Use common names and for example tree, vine, shrub, herb, bird, mammal etc. as the type of organism.

   Endemic Species.
   a) Name ____________________ Type of Organism ____________________
   b) Name ____________________ Type of Organism ____________________
   c) Name ____________________ Type of Organism ____________________
   d) Name ____________________ Type of Organism ____________________
   e) Name ____________________ Type of Organism ____________________

   Native Species
   a) Name ____________________ Type of Organism ____________________
   b) Name ____________________ Type of Organism ____________________
   c) Name ____________________ Type of Organism ____________________
   d) Name ____________________ Type of Organism ____________________
   e) Name ____________________ Type of Organism ____________________
   f) Name ____________________ Type of Organism ____________________
   g) Name ____________________ Type of Organism ____________________

Introduced Species

a) Name ______________________ Type of Organism ______________________

b) Name ______________________ Type of Organism ______________________

c) Name ______________________ Type of Organism ______________________

d) Name ______________________ Type of Organism ______________________

e) Name ______________________ Type of Organism ______________________

f) Name ______________________ Type of Organism ______________________

g) Name ______________________ Type of Organism ______________________

h) Name ______________________ Type of Organism ______________________

3) Pick one endemic species and describe it in detail. ______________________

____

____

____

____

4) Make a drawing of another endemic species.

Chapter 10. The History of Early Organisms shown by Fossils

How Fossils came to be

How Fossils are Formed

Fossils are the identifiable remains of long-dead animals or plants that are found in rocks or old sediments. Very few organisms become fossils, soft, delicate ones were never fossilised in Bermuda only those that either had a very tough structure or had hard shells became fossils. In many cases, particularly for land plants, there is virtually nothing left of the original organism and what we see is an impression it left in sediment. In many cases the sediment later became hardened or lithified. Some fossils are merely the burrows of long dead organisms. In Bermuda, Ghost Crab (*Ocypode quadrata*) burrows are well fossilised. In other cases, the fossils are actually the shells or skeletons of creatures, little changed from when they were alive. This is true of the fossils found in mud at the bottom of Harrington Sound and in some of the ponds as well as many marine fossils. There are tests that can be used to determine the age of fossils and they are therefore very valuable in reconstructing the past.

> **Summary**
> **Fossils** were formed both in rock and sediment deposits. In **aeolianite** the fossils are really just impressions of shells, burrows or tough parts that got buried in sand. In sediment actual shells and vegetation remains were preserved.

Fossils in Bermuda

You may wonder why there is not more reference to fossils in Bermuda and what they might tell us. The sad truth is that the fossil record is quite poor and quite confusing in some respects, especially for terrestrial organisms. Marine animals are quite well represented as fossils, and good examples can be seen on the south shore of Bermuda at Ariel Sands. There are also some magnificent fossil exposures on Verrill and Lefroy Islands in Great Sound containing shells and the skeletons of sand dollars. On land, the situation is really unclear, and fossils give very little help. For example, the first verifiable Bermuda Palmetto remains, consisting of trunks and fronds, are about 300,000 years old; there are no verifiable Bermuda Cedar fossils. Although many of the tree trunks that were fossilised could have been Cedars, they are assumed to be Palmettos because readily identifiable Palmetto fronds are present close-by, in many, but not all, places. The trunks have lost all exterior detail. The oldest herbivorous land animal preserved as a fossil, the tortoise *Hesperotestudo bermudae*, is about the same age. However, there are earlier, poorly preserved fossils that seem to be vegetation, and the oldest limestone is around 800,000 years old. Land snails are also found as fossils, the best example being that of the Poecilozonites Land Snails, which was discussed above in Chapter 9, in relation to evolution. The oldest fossil of a land animal dated so far from Bermuda was about 400,000 years old; this was of a now extinct land tortoise. Tortoises are herbivorous therefore plants must have been present at that time.

> **Summary**
> Only a very few organisms living in early Bermuda were fossilised. On land the commonest **fossils** are Palmetto stumps, trunks and fronds. Marine and freshwater fossils contained many more species and gave more information on past **communities**.

Habitat Reconstruction from Fossils

Most of the fossils in the aeolianite limestone are in a life-like position but details of their environment were not preserved with them. However, groups of fossilised Bermuda Palmetto

(*Sabal bermudana*) stumps do show how common the species was. The case is different for fossils preserved in mud where a whole array of shells and plant material is preserved very well.

What is not shown in the Fossils found?

As we have seen, land fossils show almost nothing of the habitat or associated species but such details are preserved in the case of marine and freshwater fossil deposits. In all cases very tiny or soft animals and plants did not make fossils. Only a fraction of 1% of organisms that previously lived in Bermuda was fossilised. The fossil record in Bermuda is therefore very incomplete and only of very limited use in reconstructing the past.

Questions

1) Are fossils well represented in Bermuda? ______________________

2) What types of organisms have been fossilised in Bermuda? ______________________

____

3) About how old are the oldest Palmetto fossils? ______________________

4) What are the Poecilozonites snails and why are they important in Bermuda? ______________________

____

____

5) Why might Bermuda Palmetto remains be better fossilised than Bermuda Cedar Remains?

____

____

6) Do any of the fossils tell us much about the environment where the living organisms lived?

____

____

7) Why do you think that many marine animals were better fossilised than terrestrial or freshwater ones? ______________________

____

8) Do you think fossils are still being formed in Bermuda today? If so where? ______________________

____

____

Field Trip #10.1 To Observe the Variety of Fossils found in Bermuda

General
There is no one location that shows all the types of fossil found in Bermuda and an additional problem is that some of the best fossils are exposed in cliffs that are very difficult and/or dangerous to get to. This field trip is therefore far from a complete introduction to the fossils of Bermuda.

Preparation
Read this section of this field guide.

Dress
For walking around on the rocks, footwear should be sturdy with a good non-slip sole.

Equipment
Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group.

Suggested Locations
Fossils are best exposed along the coastlines and particularly along the south shore but also in some north shore and island rocks. Unfortunately many of these locations are difficult for school groups due to poor access or the requirement for a boat. Two places with good access are the north shore at Lover's Lake in the Ferry Point Park and Ariel Sands on the south shore.

At Lover's Lake, the best spot is a gully in from the shore that almost reaches the Railway Trail about opposite to the east end of Lover's Lake. At the top of the gully is an excellent exposure of Poecilozonites snail fossils in a bed of coarse aeolianite. Lower down the gully, careful searching should reveal marine fossils including the West Indian Top Shell.

The Ariel Sands site is private and can only be used with special advance permission from the management. However, it is an excellent site that has both terrestrial fossils and marine ones.

Another alternative might be to arrange a visit to the Natural History Museum at the Bermuda Aquarium asking in advance that a range of fossils, including *Poecilozonites* be put out for observation.

Observations
For the location visited.

1) Look for as many different fossils as you can find and name as many as possible. List them below and note whether they are marine terrestrial or freshwater.

   a ____________________ Marine ❐ Terrestrial ❐ Freshwater ❐
   b) ____________________ Marine ❐ Terrestrial ❐ Freshwater ❐
   c) ____________________ Marine ❐ Terrestrial ❐ Freshwater ❐
   d) ____________________ Marine ❐ Terrestrial ❐ Freshwater ❐
   e) ____________________ Marine ❐ Terrestrial ❐ Freshwater ❐

2) Do the terrestrial fossils occur at higher levels than the marine ones? If so why?

   Yes ❐ No ❐ ______________________________

   ____

3) Look at the rock in which the fossils appear. Is it coarse or fine-grained, does it show layers or any other clues as to its origin? ____

____

4) Look especially for the fossil land snail *Poecilozonites.* From what you see, what you have been taught and what you have read, say why this is an especially important group of fossils in Bermuda. ____

____

____

When and why did the last specimens of *Poecilozonites bermudensis* become extinct?

____

In what way do the Poecilozonites land snails resemble Darwin's Finches from the Galapagos?

____

5) Look at the types of animals and/or plants that occur as fossils. Why have these species been preserved in this way while other species never appear as fossils here? ____________________

____

____

6) Look around at this location in general and decide how it has changed since Bermuda was colonised. Some of the changes may be natural, others because of man. List the changes that you can deduce and state their cause. ____

____

____

____

Chapter 11. How Man Changed Bermuda

Early visits by man

Before man visited or colonised Bermuda, it must have been an idyllic location. The climate was excellent; the soil easily workable, there was an abundance of plants useful to man, as well as plenty of seabirds and turtles. The forests offered a wealth of trees suitable for firewood, shipbuilding, furniture making, house construction, clothes and rope as well as other things. Indeed the Bermuda Cedar (*Juniperus bermudiana*) is one of the toughest and most rot resistant woods in the world. Additionally the surface rock was relatively soft and easily worked for building, or readily smoothed off for roads.

Human Visits Before Colonisation

Before colonisation in the 17th century, Bermuda was certainly visited by a variety of seafarers, including buccaneers and pirates during at least the previous century. However, they did not seem to appreciate much of what the islands had to offer. They did use some Bermuda Cedar and no-doubt took turtles and seabirds for food. However, they dubbed the islands "Devil's Islands", supposedly because they mistook the sounds of numerous sea birds, for the utterances of supernatural beings. The area also had a bad reputation for serious storms. These early visitors must have thought they might return, however, because they released hogs to serve as future food. Rats may well have been accidentally introduced at this time. There is also a record of early settlers finding patches of tobacco. The islands were named in 1510 when a Spanish ship commanded by Juan de Bermudez visited the area. Captain Bermudez evidently thought enough of the location to name it after himself! However he did not stay. These early visitors set in motion a severe destructive influence on the natural history of Bermuda, which continues today. The area most affected was certainly the inland forest where the pigs and rats disturbed the forest floor and ate plants and seeds. This pre-colonisation disturbance undoubtedly started the decline of the endemic petrel, the Cahow (*Pterodroma cahow*). Cahows nested in holes in the forest floor, such as under the root-mass of blown-down Bermuda Cedars. Such locations would be highly vulnerable to the depredations of both hogs and rats. Since the nature of the early forest was changed for all time before man became resident, details of the character of the early forest were never recorded.

Summary

Early visitors included Juan de Bermudez who named the islands. The decline of Bermudian natural history began at this time when trees were exploited, Cahows and turtles used for food, and pests such as rats and hogs were introduced. Patches of tobacco were also grown.

Colonisation and its impact on Natural History

First Settlement

When colonisation came, it was more by accident than design. In 1609, the Virginia, U.S.A. bound British ship, the "Sea Venture", under the command of Sir George Somers, was wrecked on the eastern reefs. The survivors, living in what is now St. George's Island, used local timber to build two ships, the "Patience" and "Deliverance", and continued their voyage to Virginia in 1610. However, their experiences showed that the islands were excellent locations for colonisation; word of this re-crossed the Atlantic Ocean and the first boatload of British colonists arrived in 1612.

Summary

Colonization started in 1609 with the shipwreck of the British "Sea Venture", the first true colonists arrived in 1612. Human population growth was slow at first but really increased in the 1900s and now stands at 63,000 a very high figure for a small country.

By 1650, further immigration and local births had raised the population to about 5,000. However, these early years saw settlers severely plagued with disease, especially yellow fever and typhoid fever, and the resultant mortality resulted in a reduction in population in the last half of the 17^{th} century. In 1693, the population stood at about 4,000. Continued immigration and better control of disease resulted in a steady increase in population during the 1700s and the 10,000 mark was reached in 1770. By 1920, there were 20,000 inhabitants.

After the relatively slow growth in these early years, there was a very rapid increase in population. By 1981 the total had risen to 54,000 and, at the turn of the century, stood at 63,000. This is a very high population for a land area of only 55 km^2 (21 square miles) and Bermuda ranks as one of the most densely populated countries in the world.

The deleterious influence of man, can be looked at under two main categories, first exploitation of island natural resources and second the introduction, either accidentally or on purpose, of **exotic** animals, plants and diseases. Another factor now emerging as one of great importance has been the widespread use of **herbicides** and **pesticides**. The recent appearance of gross deformities in the introduced frog and toad populations, is attributed to pesticides and heavy metals in the environment. Another example was the softening of Cahow eggs by DDT, when it was in common use and for some time afterward.

> **Summary**
> Man has harmed the natural history of Bermuda by exploitation of natural resources, the introduction of pest species and the use of poisonous chemicals.

Exploitation of Natural Resources

On first colonisation, emphasis was on exploitation. At first exploitation was concentrated on readily usable species. Cedars were felled for building and shipbuilding, as well as for firewood and furniture. Palmettos (*Sabal bermudana*) were used for thatch, rope and hats. Additionally, their cabbage-like heart was used as a vegetable. So the two most important endemic tree species were used immediately. Marine turtles, particularly the Green Turtle (*Chelonia mydas*), were readily caught while feeding in seagrass beds, or at breeding time on the beaches. Also used were the Cahows during their winter breeding season. Like many island birds, cahows were docile and easily caught; huge numbers were eaten. Very early on, the easily accessible and flatter sections of the coastal and valley forest were cleared for agriculture and housing, as well as for roads.

Bermuda had been an isolated island for many thousands of years, and during this time competition among the limited number of native species was at a very low level. Additionally, there were no large **predatory** mammals, amphibians or reptiles on land, and the resident birds were mainly small land birds or marine species. Bermuda was really too small to support populations of large predatory birds such as eagles. This lack of predatory pressure had led to either native species that had no fear of man and his associated animals, or to endemic species with similar traits. Thus most things worth eating were simple to capture, and this exploitation was increased by a poor supply of imported food. So native and endemic species were decimated, as were the introduced hogs. All these effects were much worse on land than in the sea, and less severe in coastal areas than inland. For instance, although many mangrove swamps were removed in the course of coastal development, the great majority were left virtually untouched. The intertidal area too was not really hard-hit, although large marine snails such as the West Indian Top Shell (*Cittarium pica*) were no doubt collected in large numbers for food.

> **Summary**
> At first exploitation concentrated on animals and plants useful for construction of housing, furniture making and food. Birds such as the Cahow and animals like the turtles had no fear of man and were readily caught; numbers declined rapidly. Some trees such as the Yellow-wood were decimated.

Forest Exploitation

As time progressed, the very useful tree species were severely reduced in numbers. Bermuda Cedar was certainly the most heavily exploited, since its wood could be put to so many uses and the berries were also used for flavouring alcoholic drinks. It was also such an attractive wood that a great deal was exported; this export was passively increased by the use of cedar for packing crates. So severe was the exploitation of Cedar that restrictions on its use were put in place in the early 1600's and its export as wood was banned in 1657; much however, still left as packing crates. Yellow-wood (*Zanthoxylum flavum*), a native species, never very abundant but common among the Cedars and Palmettos, was so heavily used for furniture that the population fell to such a low level that natural reproduction ceased. This was almost certainly aggravated by habitat destruction first from foraging pigs, and later by other domestic animals. Palmettos were also heavily exploited. Leaves were used intact as thatch, and split for hats, rope and 'plait'. The growing heart of this fan palm was used as a vegetable, somewhat like cabbage, and the sap was tapped to make the alcoholic beverage called 'bibby'. However, Palmettos were not so severely decimated as Bermuda Cedars and Yellow-wood. For at least the Cedar and Palmetto, these population reductions were further complicated by introductions.

Summary
Even before colonisation **introduced pest species** began to take a deadly toll of land species. The original forests were rapidly destroyed and we will never know the details of their natural history. The main culprits were rats, hogs, cows, goats, dogs and cats. Introduced species also carried diseases and parasites that had more harmful efffects.

Introduction of New Animals and Plants

Very soon after first colonisation the introduced species began to take their deadly toll. The settlers brought seeds, pests such as rats and mice, pets such as dogs and cats, and domestic animals such as cows and goats; unseen on all these things were diseases, parasites and pests. All were destructive influences but some were much worse than others.

How Introduced Species Destroy Nature's Balance

Introduced species are a potentially serious problem particularly on islands, not only because ones suited to this environment can spread rapidly in the absence of serious competition, but also because endemic island species have not developed mechanisms that would allow them to compete successfully with the introductions. In the case of introduced pests and diseases, their effects are usually much more severe on endemic species than they were on closely related parent species from the mainland. This is attributed to a lack of resistance mechanisms that on the mainland evolved from a very long association between host and pest or disease. It is also true that a species from elsewhere may change its dietary or habitat preferences radically on introduction to a new environment. This makes the potential effect of planned introductions difficult to predict.

Introduced Pests and Diseases

Accidentally introduced pests and diseases have produced some of the most catastrophic results, particularly in relation to endemic trees. In 1940-42, two species of scale insects, the Oystershell Scale (*Insulaspis pallida*) and the Cedar Scale (*Carulaspis minima*) were accidentally brought in to Bermuda on ornamental species of Juniper. These insects carried and spread Cedar Blight. These tiny insects are covered by a hard impervious shell-like covering, and are difficult to control. Ladybirds introduced to control the scale had little effect. By 1949 over 15,000 dead Cedars had been cut down, by 1953 90% of Cedars were dead and by 1971, 99%. Fortunately, there were some cedars that had some resistance and Barry Phillips, a government horticulturist, made it a special project to propagate from these and re-plant the cedars. Many thousands of cedars have been re-planted, and the species is making a slow comeback. Another accidentally

Summary
One catastrophic introduction was that of Cedar Scale whose effects resulted in the death of over 99% of all Bermuda Cedars. The restoration of cedars through resistant specimens is still underway.

introduced scale insect, the Palmetto Scale, (*Comstockiella sabalis*) attacked the endemic Bermuda Palmetto but fortunately the tree had retained some resistance to this pest.

Intentional Introductions

Some of the introductions have achieved almost ludicrous status. The Jamaican Anole (*Anolis grahami*) was brought in 1905 to control another pestilential insect, the Mediterranean Fruit Fly (*Ceratitis capitata*). Once here it made little if any inroads on the Fruit Fly, but instead ate a wide variety of insects, including the ladybirds introduced to combat Cedar Scale, and became a pest itself. To control the anole, the large yellow tropical flycatcher the Great Kiskadee (*Pitangus sulphuratus*), was introduced to Bermuda in 1957. It too failed to live up to its lizard-eating reputation and instead, ate all manner of things including the eggs of the endemic Bermuda White-eyed Vireo (*Vireo griseus*), as well as those of a variety of native birds! While not all intentional introductions for the purpose of biological control of introduced pest species have resulted in unforeseen problems, many of them have.

Summary
Introduced species can have unforeseen effects. The Jamaican Anole, a lizard, was introduced to control Fruit Flies, but it ate Ladybirds introduced to control Cedar Scale. The Great Kiskadee brought in to control the anole, instead ate other things including Chick-of-the-village eggs!

An example of an apparently harmless introduction was that of the Mosquito Fish (*Gambusia holbrooki*) to control mosquitoes, which in the past carried malaria. Locally called 'guppies' these fish were introduced in the 1940s into drainage ditches and freshwater ponds. They controlled mosquitoes well and do not seem to have displaced any native or endemic species. This is probably because no other fish occupied that habitat. The endemic Bermuda Killifish (*Fundulus bermudae*) is typical of brackish waters and while some Mosquito Fish can be seen in the same general habitat as the Killifish, they appear to occupy different **niches**. Another fairly innocuous introduction was that of the Giant Toad (*Bufo marinus*), to control cockroaches. These very large toads do eat large numbers of cockroaches but also other insects; cockroaches are still very plentiful.

The Balance Between Introduced, Native and Endemic Species

In total, introduced species have done a huge amount of damage, and have changed the face of Bermuda for all time. As an example of the scale of these introductions, there is but a single native or endemic palm, the Bermuda Palmetto, while there are at least 40 introduced species. All the amphibians, two species of frog and the toad, are introduced. Among the land reptiles all lizards except the Bermuda Skink (*Eumeces longirostris*) are introduced. In the case of introduced species, it is the terrestrial environment which has suffered the greatest, while freshwater communities are moderately affected, and marine ones hardly at all. If we take the most extreme example of the higher land plants, there are 11 endemic species, 142 native species and about 2,900 introduced species! Only 5% of these plant species are native or endemic. At the opposite extreme, in marine environments there are about 5,402 native species, 740 endemics and 103 introduced. There 99.3% of the fauna and flora is native or endemic.

Summary
On land, **introduced species** make up the bulk of the plant populations. There are 11 **endemic species**, 142 natives and about 2,900 introductions! Only one of about 40 palms is endemic or native. In the sea, however, the situation is reversed, with 740 endemics, 5,400 **natives** and 103 introductions.

As an example of how introduced species can out-compete similar endemic ones, consider the Chinese Fan Palm (*Livistonia chinensis*) which is remarkably similar to the Bermuda Palmetto. Almost every small fan palm that you will find in Bermuda now is the Chinese Fan Palm. Additionally, the introduced species reproduces much more successfully under today's conditions.

Almost every seedling palm you will find will be of the introduced species. Adult palms can be distinguished by the toothed leaf-stalk on the Chinese Fan Palm, as compared to the smooth one on the Bermuda Palmetto. Additionally, in the Bermuda Palmetto, the leaf stalk or petiole extends through the leaf as an elongated point whereas in the Chinese Fan Palm it ends more abruptly as a blunt point. This latter feature is most useful in small specimens which may lack the spines on the leaf stalk in the Chinese Fan Palm.

The Decline of Land Habitats

Land at well-drained, lower levels was cleared rapidly and large areas of marsh-land were drained or filled, to produce building areas or farmland. Higher elevations followed more slowly, but the only areas remaining relatively undisturbed today are very rough, upland areas that were difficult to work without power equipment. Typical of this latter category was the tract of land between Harrington Sound and Castle Harbour. This area has the oldest limestone in Bermuda, called the 'Walsingham Formation', the surface of which is eroded into rough, small hills, deep sink holes and many caves. The limestone surface has a very jagged texture, known as **Karst topography**, which requires care to negotiate. Now, about 75% of the land area is developed in some way and over 10% is covered by buildings, roads and concrete. Only about 9 1/2 % of the land is made up of parks and protected areas.

Natural Systems that Survived Colonisation by Man

Of all the ecosystems in Bermuda, the open sea is least affected by man although even there, there are problems with pollution of various kinds. Near-shore shallow waters also retain most of their original characteristics except that many shallow bays, for example Whalebone Bay and Tobacco Bay, are severely degraded. Coastal ecosystems such as rocky shores are only seriously affected where man has built structures. Sandy shores are severely affected by tourist pressure. Many mangrove swamps have been removed, for example those around Mangrove Bay in Somerset, but those that remain have retained their original character well. The saltwater ponds also appear to have persisted in good condition despite the effects of man, this is surprising as they all receive polluted run-off from the land. All the other systems, principally those on land and those characterised by freshwater are so changed that little of their original character remains.

Questions

1) What harmful introductions were made by man before Bermuda was settled? ______________
2) Name one Bermuda ecosystem that has been virtually destroyed by man. ______________
3) Name two harmful things that came in accidentally on planned introductions. ______________
4) What introduced organism killed the majority of the Bermuda Cedars? ______________
5) Name two common introduced trees. ______________
6) Among introduced animals, name 2 that have done a great deal of harm. ______________
7) Which is the single endemic palm? ______________
8) Name some native or introduced species that has suffered greatly from habitat loss. ______________
9) Name one native tree now very rare in Bermuda. ______________
10) Do you think it is possible to save any of the remnants of the original forest that have survived to this day? ______________.
11) Why might cedars on Bermuda be less tolerant here than their ancestors on the mainland? ______________
12) Why is the effect of man most noticeable in terrestrial areas? ______________
13) What endemic marine bird was almost exterminated by man? ______________
14) What was man's effect on Green Turtle populations in Bermuda? ______________
15) Some plants were purposely introduced because they were useful to man. Give two examples of species and their uses. ______________

Chapter 12. The Restored Habitats

The Restoration Process

The Start of Restoration

David Wingate, the Bermuda Conservation Officer from 1966 until the year 2000, has worked tirelessly to restore some situations in Bermuda where sufficient control was available to do this. This work is now being continued under the direction of Jeremy Madeiros the present Bermuda Conservation Officer. The main site is Nonsuch Island in the Castle Roads area of Castle Harbour and a second one is Paget Marsh. Additionally some parts of the Walsingham Nature Reserve and the Spittal Pond Nature Reserve have been started in this direction, and Abbott's Cliff in Harrington Sound will be tackled in the future. Both locations tackled extensively so far are nature reserves and access to Nonsuch Island in particular, is quite restricted. At these locations introduced plants and some animals have been slowly removed. Rapid removal would have created an unstable ecological condition with unpredictable results. Now after years, the original Bermudian upland forest is taking shape on Nonsuch while a Palmetto swamp-forest is reappearing at Paget Marsh. This approach is remarkably successful in that the removal of invasive species over time restores a delicate ecological balance that favours the re-appearance of species thought to be extinct or on the verge of extinction.

Summary

Habitat restoration is aimed at returning some terrestrial areas to pre-colonial status. This is a long, difficult and costly process that is best done in reasonably isolated areas so that re-invasion by invasive species is minimised. The two main restored areas are Nonsuch Island and Paget Marsh.

You may wonder why this process is not carried out on a broader scale**.** Restoration is very labour intensive and this is expensive. Additionally, restoration can only be successful where there can be some degree of control over the re-invasion of undesirable species. An island like Nonsuch affords this control and Paget Marsh is in a deep depression that is somewhat isolated from surrounding land. However, great vigilance at both locations is needed to maintain the state of restoration needed.

Nonsuch Island

The restoration of Nonsuch Island has been called the "Living Museum" project. The island consists of 5.9 ha (14.5 acres) of land: although this is quite small it contains most of the land habitats available in Bermuda, and also has a coastline with rocky shores and sandy beaches. For this type of restoration the small size has an advantage in that the entire island can be monitored with minimal personnel and new introductions can be eliminated promptly. Nonsuch Island did retain many native and endemic species before the project began and so the start was not quite from scratch. Unfortunately before restoration began in 1963 the heavy cedar stand on the island was decimated by Cedar Blight, and as on the larger islands almost all the cedars died. This was a particular problem on Nonsuch as the island has an open southerly exposure, and is also receiving large ocean swells which may arise in the southern hemisphere but reach the south shore with little impediment. Because of this combination of factors, there was considerable concern that erosion would degrade island soils and that

Summary

Nonsuch Island at the southern boundary of Castle Harbour has had a varied history including being a base for the historic deep descents into the ocean by the Bathysphere (1928-31). It is also famous as the site from which the recovery program for the endemic petrel, the Cahow, thought to be extinct, has been carried out.

reintroduced plants would not have a suitable habitat in which to grow. To get around this, the decision was made to plant Casuarina (*Casuarina equisetifolia*) as a temporary windbreak.

Nonsuch Island History

Nonsuch Island has an interesting history. Privately owned from 1700-1860, it was leased out for livestock rearing. The Bermuda Government acquired the land in 1865, and in subsequent years it was put to various uses. From 1865 to 1914 Nonsuch Island served as a yellow fever quarantine station and hospital. During this time, docks, various buildings, a mortuary and cemetery were built. In the years from 1928-1931 the island was on loan to the New York Zoological Society as a marine research station. During this period it was occupied by Dr. William Beebe and Dr. John Tee Van and it was from this base that the historic deep descents by the "bathysphere" were organised. The Admiralty water barge 'HMS Supply' was also moved to Nonsuch Island during this period, and sunk touching the north shore to serve as a breakwater and fish holding tanks. Once in place it was re-christened the 'Sea Fern'. Following its scientific debut the island became a Junior Training School for Delinquent Boys; this was run from 1934-1948, and finally abandoned due to the isolation and difficulties with a safe anchorage. By 1948 Bermuda Cedar was already in decline and the ecosystem of Nonsuch began to deteriorate. What really got Nonsuch Island biological recognition, was the discovery of 7 breeding pairs of Cahows by Robert Cushman Murphy, of the American Museum of Natural History, and Louis Mowbray, Curator of the Bermuda Aquarium. These endemic birds had been considered to be extinct for over 300 years, and their re-discovery was a really astounding event. Although they were not on Nonsuch Island itself but on adjacent small islands, Nonsuch was an obvious base for conservation and study of this highly endangered species, especially after the breeding islands gained sanctuary status in 1951.

Nonsuch Island and the Cahow

It was in relation to the Cahow that David Wingate's career in biology and his association with Nonsuch began. He was vitally interested in the preservation of this species and bringing the Cahow population back to a viable level was to be a lifetime passion. The project began in earnest in the late 1960s with the installation of artificial burrows. As mentioned earlier, Cahows almost certainly nested in the forests of early Bermuda. They very likely used cavities under storm-felled Bermuda Cedar tree root masses. Pigs, rats and forest exploitation rapidly spoiled this breeding habitat, and at the same time adults were slaughtered wholesale when they came ashore to breed. The small islands were a good refuge from predators, including man, but did not naturally have good breeding habitat. The addition of artificial burrows was to break this barrier and were successful, except that other seabirds that nest in burrows, such as the Longtail (*Phaethon lepturus*), competed for this space. By 1961 the breeding population had risen to 11 pairs and a baffle in the nest tunnel solved the competition problem.

Green Turtle Nesting

In1962 David Wingate was installed as Warden of Nonsuch and in 1963 began, the "Living Museum" project; in 1966 he became Bermuda's first Conservation Officer. With Nonsuch being the centre of conservation work in Bermuda, it was natural that a project attempting to restore a breeding population of the Green Turtle (*Chelonia mydas*), should be centred there, especially as the South Beach on Nonsuch was a former nesting site. During the period 1967-1978 16,000 Green Turtles were hatched there and released to sea. If they have survived as a viable population, they should begin returning early in the new Millennium.

New Habitats on Nonsuch Island

By 1975 the restoration of the native flora of Nonsuch Island was well underway, but the natural habitats did not include **wetlands**. Other wetlands in Bermuda had been drastically reduced, and to provide examples that could be managed, two ponds were planned for Nonsuch. The freshwater pond was dug in a central location but leaking problems necessitated its re-excavation and the addition of a permanent liner in 1993. The saltwater pond was excavated behind the south beach, creating a small dune habitat between it and the sea. Red Mangroves (*Rhizophora* *mangle*) and the Bermuda Killifish (*Fundulus bermudae*) were introduced in 1976. In 1992, it was enlarged and Black Mangroves (*Avicennia germinans*) were added to the flora. Unfortunately, in 2003, Hurricane Fabian destroyed the saltwater pond.

Summary

The restoration of Nonsuch Island began in 1963 but was hampered by the death of the cedar forest in the Cedar Blight epidemic. Cedars were the main windbreak and to replace them Casuarinas were planted and are still being slowly removed as cedars grow back. **Introduced species** have mostly been removed and the island now has a good cedar forest with many other native and **endemic** species.

Re-introductions on Nonsuch

Nonsuch was also the site of two notable re-introductions of species that had been extirpated from Bermuda. During the period between 1976 and 1978, forty-four Yellow-crowned Night Herons (*Nyctanassa violacea*), hand -reared on a diet of Land Crabs (*Gecarcinus lateralis*) or Red Land Crabs, were released. This heron had previously been common in Bermuda but had been extirpated; its natural prey were Land Crabs and the two lived in balance. With the herons gone, the Land Crab population exploded, and attempted control with DDT had disastrous side effects. About 8 years after their re-introduction, Yellow-crowned Night Herons were breeding naturally in the Walsingham area, and now the success of the re-introduction is assured. Land crab populations have dropped to a very low level indicating that a full ecological balance may be some years away. A second re-introduction, that of the West Indian Top Shell,(*Cittarium pica*) which had been collected to extirpation for food, was carried out on Nonsuch in 1982, when a quantity of these large gastropods became available fortuitously. By 1986, they were breeding successfully and have spread widely since. However, although they are a protected species they are again being decimated by use as human food.

The End-result

By 1990, the new forest on Nonsuch had progressed to the state where successful self-propagation of many species had begun, and the Casuarinas installed as a windbreak could be started to be cut back or removed. The area has survived Hurricanes Fabian, Emily, Dean, Felix and Gert without really severe damage! Much remains to be done, but the Nonsuch experiment has been an unprecedented success, which serves an example to the rest of the world. Dr Wingate has said "The 'Living Museum' has succeeded beyond my wildest dreams and I believe this is because I took a holistic approach to the restoration, i.e., by reintroducing everything within its original context the native heritage has restored itself. You can turn the clock back by understanding nature and working with it, rather than against it".

Paget Marsh

Freshwater systems are described in the Project Nature Field Guide, "Bermuda's Wetlands". Here I will just briefly outline why Paget Marsh is important and how restoration has worked. Paget Marsh lies in a big sink hole in the central part of present-day Bermuda. Disturbance at this site was much less severe than in other peat marshes, and in about 1965 the Bermuda National Trust and the Bermuda Audubon Society together obtained most of the marsh to protect it for all time. This was principally a Bermuda Palmetto **swamp-forest** but also contained stands of Saw Grass (*Cladium jamaicense*), and impressive communities dominated by the Giant Fern (*Acrostichum danaeifolium*). The site was also rich in other fern species and contained two endemic mosses and a few specimens of the very rare leafless, primitive plant Psilotum (*Psilotum nudum*). Quite a number of very large Bermuda Cedars

Summary

Paget Marsh, a large sink in central Bermuda, has a wide variety of wetland habitats, some freshwater others **brackish**. There, invasive species have slowly been culled and wonderful pre-colonial conditions have returned. A boardwalk gives access to mangrove stands, sawgrass marsh and a Bermuda Palmetto swamp-forest. Giant Ferns may be seen from the boardwalk.

were also present. The marsh had been drained for mosquito control and the large ditches created were colonised by the Water Fern (*Salvinia olfersiana*). Also present in the central part of the marsh was a Red Mangrove stand, around an almost fresh pond. Although this basis of a natural peat marsh-palmetto swamp was there, the location had been extensively invaded by introduced shrubs, mainly Guava (*Psidium guajava*) and Ardisia (*Ardisia polycephala*). Much of the marsh has been carefully cleared of these and other **invasive species**, and the area has returned to a condition closely resembling a pre-colonisation peat marsh. To walk in the Palmetto forest of Paget Marsh is a wondrous and uplifting experience, truly stepping back into the past. In 1999, a boardwalk was constructed to allow public access without undue disturbance it passes through most of the natural habitats found in this lowland area.

Other Locations with Restored Areas and those for which Restoration is Planned

The principles employed at Nonsuch and Paget to entire natural systems have also been applied to parts of other reserves. While re-invasion is faster in such places than in more isolated ones, their unique biological character makes the process worthwhile.

One of the major secondary areas is in the Walsingham Tract. This area on the oldest limestone **formation** in Bermuda had eroded over 800,000 years to produce a very rugged topography, which held back development. The area is riddled with caves, sink holes, marine ponds and other fascinating features. Several rare, native and endemic species have survived there including, Lamarck's Trema, Yellow-wood, Southern Hackberry, Bermuda Olivewood, Wild Bermuda Pepper (*Peperomia septentrionalis*), Wild Coffee (*Psychotria ligustrifolia*) and Bermuda Bean (*Phaseolus lignosus*). There are also rare and endemic ferns such as the Bermuda Shield Fern (*Dryopteris bermudiana*), the Bermuda Cave Fern (*Ctenitis sloanei*) and the Bermuda Maidenhair Fern (*Adiantum bellum*). It was also the habitat of Governor Laffan's Fern (*Diplazium laffanianum*) now existing as only 4 or 5 specimens at the Bermuda Botanical Gardens. Two areas selected in 1978 have been partially cleared of invasives but much remains to be accomplished there.

The Spittal Pond Nature Reserve has also had areas partially cleared, and it is hoped that an early start can be made on the face of Abbott's Cliff in Harrington Sound, where up until recently the majority of the flora was either native or endemic

It must be appreciated that restoration of these areas is very labour-intensive and not without hazard. It is amazing that so much has been done so far. Without the dedication of David Wingate, Jeremy Madeiros and their assistants, we would certainly have lost all that remained of natural land areas.

Questions

1) Name one animal rescued from the brink of extinction in Bermuda. ____________________
2) What is David Wingate best known for? ____________________
3) Why are restored habitats so important? ____________________
4) Name the two main restored areas in Bermuda. ____________________
5) What tree was grown to replace the role of Bermuda Cedars as a wind break? ____________________
6) What are two of the main restoration experiments carried out on Nonsuch Island? ____________________
7) What area of rugged topography has been spared from building construction in Bermuda? ____________________
8) Name three endemic organisms that now occur on Nonsuch Island. ____________________
9) Why must restoration be carried out slowly? ____________________
10) Why is the Walsingham area important in relation to rare, endemic and native species in Bermuda? ____________________

Field Trip #12.1 to Nonsuch Island

Preparation

Read the restored areas section of this field guide and if possible look at two other Project Nature Field Guides, Bermuda's Wetlands and The Bermuda Forests. The Bermuda Zoological Society also has available a useful booklet "Guide to the Nonsuch Island 'Living Museum' Nature Reserve". There are no particular hazards if the trip is carefully planned. However, sometimes freshwater is unavailable on the island so have some with you. Keep away from the tops of sheer cliffs.

Equipment

As many copies of this field guide as possible. Copies of the Project Nature Field Guides "The Bermuda Forests" and "Bermuda's Wetlands" Clipboard, paper and pencil per student. At least one pair of binoculars for each four students would be good, more are a definite advantage. Vehicles and boat transport.

Dress

Wear long pants and sturdy footwear.

Location

Nonsuch Island Nature Reserve. Note that this is a restricted area and the trip must be planned in advance either through the Bermuda Biological Station for Research or the Education Department of the Bermuda Zoological Society and the Aquarium. Some charges may be applied! A qualified guide is required.

Observations

1) On approaching the island note that it is isolated from the land by water and that it has significant elevation. Both of these are important since a wide variety of habitats have been restored and created. Think about how the isolation both mimics the original isolation of Bermuda as a whole and makes the restoration easier to manage. However, the isolation in this case is but a narrow stretch of shallow water, what difference does that make?

2) When on the island look for the types of introduced species that you see and speculate how they got there. Are there some introduced species that it is totally pointless to control on Nonsuch?

   Introduced species a) Identity ____________________ How does it spread? ________________
   ____

   Introduced species b) Identity ____________________ How does it spread? ________________
   ____

   Introduced species c) Identity ____________________ How does it spread? ________________
   ____

   Introduced species d) Identity ____________________ How does it spread? ________________
   ____

   Introduced species e) Identity ____________________ How does it spread? ________________
   ____
   ____

3) On your guided tour of Nonsuch Island make a list of the different habitats that are pointed out to you. Describe each in general terms and state whether they are natural, restored or man made.

Habitat a) Type of habitat ________________ ___ Natural ❐, restored ❐ or man-made ❐?

Habitat b) Type of habitat ________________ ___ Natural ❐, restored ❐ or man-made ❐?

Habitat c) Type of habitat ________________ ___ Natural ❐, restored ❐ or man-made ❐?

Habitat d) Type of habitat ________________ ___ Natural ❐, restored ❐ or man-made ❐?

Habitat e) Type of habitat ________________ ___ Natural ❐, restored ❐ or man-made ❐?

Habitat f) Type of habitat ________________ ___ Natural ❐, restored ❐ or man-made ❐?

4) List all the endemic species that you see and give a habitat for each. Add to the list further endemic animals or plants that are on Nonsuch Island but that you did not see. In each of these cases state reasons that you may not have seen them.

Endemic Species a) ____________________ Habitat ____________________
Endemic Species b) ____________________ Habitat ____________________
Endemic Species c) ____________________ Habitat ____________________
Endemic Species d) ____________________ Habitat ____________________
Endemic Species e) ____________________ Habitat ____________________
Endemic Species f) ____________________ Habitat ____________________
Unseen Endemic a) ____________________ Habitat ____________________
Reason not seen ____
Unseen Endemic b) ____________________ Habitat ____________________
Reason not seen ____

5) What reptile is it hoped to restore as a breeding population to Nonsuch? ________________

Is it native ❐ or endemic ❐?

When might it re-appear? ________________________________
What problems are related to its return (or failure to)? ____________________

____

6) Sometimes animals and plants are so close to extinction that they appear to be gone forever. There is a particularly famous example of this for the Nonsuch area. What creature is involved?

____

Give a brief description of the creature and the history concerning it. Speculate on the success of the restoration of this population. ____________________

____

____

7) One person deserves the bulk of the credit for the restoration projects in Bermuda, without him we would have lost habitats and species for all time.

Who is it? ____________________

Say what you know about this person ____________________

____

____

____

Field Trip #12.2 to the Paget Marsh Boardwalk

Preparation

Read this section of this field guide and if possible look at two other Project Nature Field Guides, Bermuda's Wetlands and The Bermuda Forests. There are no great hazards if the trip is carefully planned. Don't leave the boardwalk and don't interfere with the natural fauna and flora of the location. Poison ivy does occur here so do not lean out from the boardwalk and touch any plant.

Equipment

As many copies of this field guide as possible. Copies of the Project Nature Field Guides "The Bermuda Forests" and "Bermuda's Wetlands" Clipboard and pencil per student. At least one pair of binoculars for each four students would be good, more are a definite advantage. Vehicles.

Dress

Wear long pants and sturdy footwear.

Location

Paget Marsh boardwalk.

Observations

1) As you descend to the marsh and before you go on the causeway look around. This location is in a deep depression in the old aeolianite limestone and is consequently damp and sheltered. There are some excellent explanatory panels just before you go on to the boardwalk, read them.

2) Note that in the past, the middle of the swamp was once a marine environment connected to the sea by fissures in the aeolianite rock. Succession to a freshwater swamp from a marine mangrove swamp is still underway look for evidence of this. In doing so look under the mangrove trees at the beginning of the boardwalk for species that occur in freshwater swamps or marshes. Write your observations.

3) On the start of the boardwalk note that the ditch and ponds around the edge are man made. The ditches were dug both for drainage and to control mosquitoes that carried diseases. The ponds were added to increase the diversity of habitats so that more wildlife would use the area. The boardwalk was put in place so that the area could be observed without trampling the undergrowth. Several rare and endangered species persist in this marsh including the Bermuda Campylopus a moss growing in the habitat created at the base of Bermuda Palmetto trees. Also present are Psilotum (*Psilotum nudum*) an ancient primitive plant, related to the clubmosses, without leaves and also found at Palmetto bases, Wild Bermuda Pepper, Bermuda Sedge and Bermuda Spike Rush. These, although present are still very rare and you may not see them. If you think that you have found one of these species, compare it to the picture and description at the end of this book. And list it here.

   Species a) Identity ________________________ How does it spread? ________________________

   ____

   Species b) Identity ________________________ How does it spread? ________________________

   ____

4) The forest on the slopes around the edge of the depression is dominated by introduced trees notably the Allspice (*Pimenta dioica*) and it has not been restored. Within the marsh, however, invading species particularly the shrubs Guava and Ardisia have been carefully removed. Why was this done? ____

   ____

5) Before you proceed further on to the boardwalk look back at the open area, list all the animals and plants that you can identify and place them as the left column of a table. In other columns state type of organism (e.g. tree, shrub, invertebrate etc); habitat; whether they are endemic, native, introduced or naturalised (status); their abundance (abundant, common, uncommon, rare) and add any general comments on their condition, whether they attract birds etc. Note that the Project Nature guide to Wetlands would be a big help in this! Use the binoculars to add species to your list.

Paget Marsh Open Area at the Boardwalk Start

Species	Type of Organism	Habitat	Status	Abundance	Comments

6) Then proceed slowly along the Boardwalk through a series of natural communities dominated by native and endemic plants. Name them in order as you go. You will find or see Saw Grass (*Cladium jamaicense*) marsh, Bermuda Palmetto swamp, Giant Fern beds, Red Mangrove swamp etc. Look for plants typical of each community and list them. For example the vines Virginia Creeper (*Parthenocissus qinquefolia*) and the West Indian Cissus (*Cissus sicyoides*) are characteristic of the Palmetto Forest while Wax Myrtle (*Myrica cerifera*) is scattered among the Saw Grass. The following table should be filled in with your observations. Use terms as in the table above.

Paget Marsh Boardwalk

Community	Species	Type of Organism	Habitat	Status	Abundance
Red Mangrove Swamp					
Giant Fern					
Saw Grass Marssh					
Bermuda Palmetto Swamp					

7) Comment on the main differences between the open area before the pond and the area through which the boardwalk is situated. ____

8) Note particularly that Bermuda Palmettos and Bermuda Cedars both occur in the swamp-forest and speculate on how this may have come to pass given that the ancestor of the cedars was a dry upland, tree. ____

9) At the inner end of the boardwalk look around and imagine the presence of thick growths of invasive shrubs such as Ardisia and Guava that are now removed. This removal was carried out very slowly, over many years, for good reasons. Why was it done this way? What were the hidden benefits of this approach? ____

Field Trip #12.3 to the Walsingham Forest

General.

The Walsingham area is quite large and varied; only a small part with poor access has been restored. For this field trip it is best to go to the part that is least altered by man or by introduced species. The best place is the Idwal Hughes Nature Reserve lying on the left of the road to Tom Moore's Tavern. There is a small parking place beside the road. Wherever you go at this location it is a more a demonstration of a forest altered by introduced species rather than of an original forest. This area, in parts, has a very irregular jagged limestone surface called Karst Topography. This leaves sharp points and edges which can cut or pierce. For this reason and on basic conservation principles do not wander off from the paths.

Preparation.

Read this section of this field guide.

Dress

Sturdy, non-slip footwear is needed and the paths are slippery after rain. Wear long sturdy pants to give some protection from twigs etc along the paths.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group. Vehicles.

Suggested Alternative Locations

This field trip could be started at the Blue Hole Park parking lot. However in this case you would have to go through the park to the footpath that leads into the Walsingham forest. The forest here is dominated by introduced species, particularly Surinam Cherry. It would also be possible to start at Tom Moore's Tavern and proceed around the side of Walsingham Pond following the path closest to the pond edge to a clearing. A path from there goes into the forest but it is uneven and hilly.

Observations

1) Proceed until you are in a true forested area. Stop at a suitable place to make observations. The forest has a definite layered (stratified) structure. The top layer where most of the leaves are, is the canopy. The open area below this is called the sub-canopy. The shrub layer, if present, is around head height and below that the ground layer contains the smaller plants and animals of the forest bottom. Identify the layers at your study location and decide which plant is most important (dominant) in each layer.

   Dominant canopy plant ______________________________

   Dominant sub-canopy plant ______________________________

   Dominant shrub layer plant ______________________________

   Dominant ground layer plant ______________________________

2) Vines are climbing, woody plants that go between the layers of the forest. If you can see vines, identify and name them. List them here.

   Vine a) Identity ______________________ Climbing on ______________________

   Vine b) Identity ______________________ Climbing on ______________________

3) This forest is extensively invaded by introduced trees, shrubs and herbs, but some endemic and native species are still present. In an area say 20 m (60 ft) wide around your study spot try to list eight of the species of plant present and note whether they are endemic, native or introduced. Put the most important species first in the list below.

a) Plant Identity ______________ Endemic ❒ Native ❒ Introduced ❒

b) Plant Identity ______________ Endemic ❒ Native ❒ Introduced ❒

c) Plant Identity ______________ Endemic ❒ Native ❒ Introduced ❒

d) Plant Identity ______________ Endemic ❒ Native ❒ Introduced ❒

e) Plant Identity ______________ Endemic ❒ Native ❒ Introduced ❒

f) Plant Identity ______________ Endemic ❒ Native ❒ Introduced ❒

g) Plant Identity ______________ Endemic ❒ Native ❒ Introduced ❒

h) Plant Identity ______________ Endemic ❒ Native ❒ Introduced ❒

As an indication of change realise that the most important species in the past was Bermuda Cedar with Bermuda Palmetto second.

4) Walk on into the forest for quite a distance but <u>don't get lost,</u> stay on the paths. See what other features of this area that you can see. Possible ones are cave mouths, sink holes, aeolianite cliffs and spikes of aeolianite sticking out of the ground (This is Karst Topography). <u>Do not leave the trail to do this</u>. If you do see a cave mouth or a cliff look at the plants growing on it. You may see rare ferns or the endemic Wild Bermuda Pepper but at any rate you will probably see native ferns or the common endemic fern, Bermuda Maidenhair Fern. Write observations below.

Cave mouth seen ❒ Observations ______________________________

____

Sink hole seen ❒ Observations ______________________________

____

Aeolianite Cliff seen ❒ Observations ______________________________

____

Limestone spikes seen ❒ Observations ______________________________

____

Part 3. Natural History of Modern Bermuda

Chapter 13. The Variety of Habitats and Ecosystems

Bermuda; small but varied

There are few places on earth that have the variety of ecosystems and habitats enjoyed by Bermuda in such a compact package. As discussed in detail earlier in the introductory section of this book, Bermuda is an extinct volcano that rises abruptly about 4,000 m or 13,000 ft from the oceanic sea floor. Because of this open ocean and deep sea ecosystems are available very close to Bermuda, a fact which has led to its use as an important centre for oceanic research based at the Bermuda Biological Station for Research. Another ocean feature which contributes to the great biological diversity is the vast ocean current called the Gulf Stream which passes northeast just to the west of Bermuda. As described earlier in this book the Gulf Stream is like a conveyor belt constantly transporting animals and plants, particularly marine ones, from the Gulf of Mexico area. The Gulf Stream is also responsible for Bermuda's sub-tropical climate, which fosters its high biodiversity and has promoted the development of very extensive tracts of coral and other biologically formed reefs.

Major factors in creating natural variety

Bermuda weather is not only very pleasant on the whole, but is another factor leading to the very high diversity of organisms and habitats found here. Bermuda lies within the range of latitudes in which the prevailing wind is westerly in direction. Thus much of the time the wind reaches Bermuda after traversing parts of North America. Although the mainland seems quite distant, it is close enough that many animals such as birds, insects and spiders are at least aided in getting here by the wind. The same is true of many plant seeds that have structures that help them to stay aloft for extended periods. The wind too helps in the transport of floating material at the surface of the sea. Additionally, we must not forget the role of storms and hurricanes, which are not infrequent in Bermuda. This type of violent weather may transport living things to Bermuda from almost anywhere but particularly Europe and North Africa.

Summary

Bermuda is a very small group of islands but it has an extraordinary variety of **ecosystems** and **habitats** in and around it. Factors leading to this include the **Gulf Stream**, the prevailing westerly winds and its geological structure. Additionally, its past history involving great lowerings of sea level have been important.

Bermuda is only a small group of isolated islands, which lessens the chance that living creatures carried in storms or ocean currents will find it, but at the same time increases the chance that new species will evolve here. Bermuda has close to 250 endemic species that evolved on the islands.

Another big factor in the development of the huge number of habitats in Bermuda is its geological nature. This has been explored in detail in the previous section of this book but in summary Bermuda is basically composed of a limestone cap on an extinct volcano. Limestone is reasonably easily eroded by wind, slightly acid rain, waves, living organisms and other factors. This basic structure combined with the surface erosion has led to a complex land mass much more varied for example, than a coral island to which it is often compared. For instance although Bermuda has no mountains it does have high hills never found on true coral islands. Erosion combined with the climate in the past which has lowered sea levels repeatedly, has given Bermuda its complex structure with over 120 islands, large semi-landlocked sounds such as Harrington Sound and The Great Sound, good harbours such as St. George's Harbour and Castle Harbour and countless bays and lagoons of various sizes and depths. The geological structure and past climate

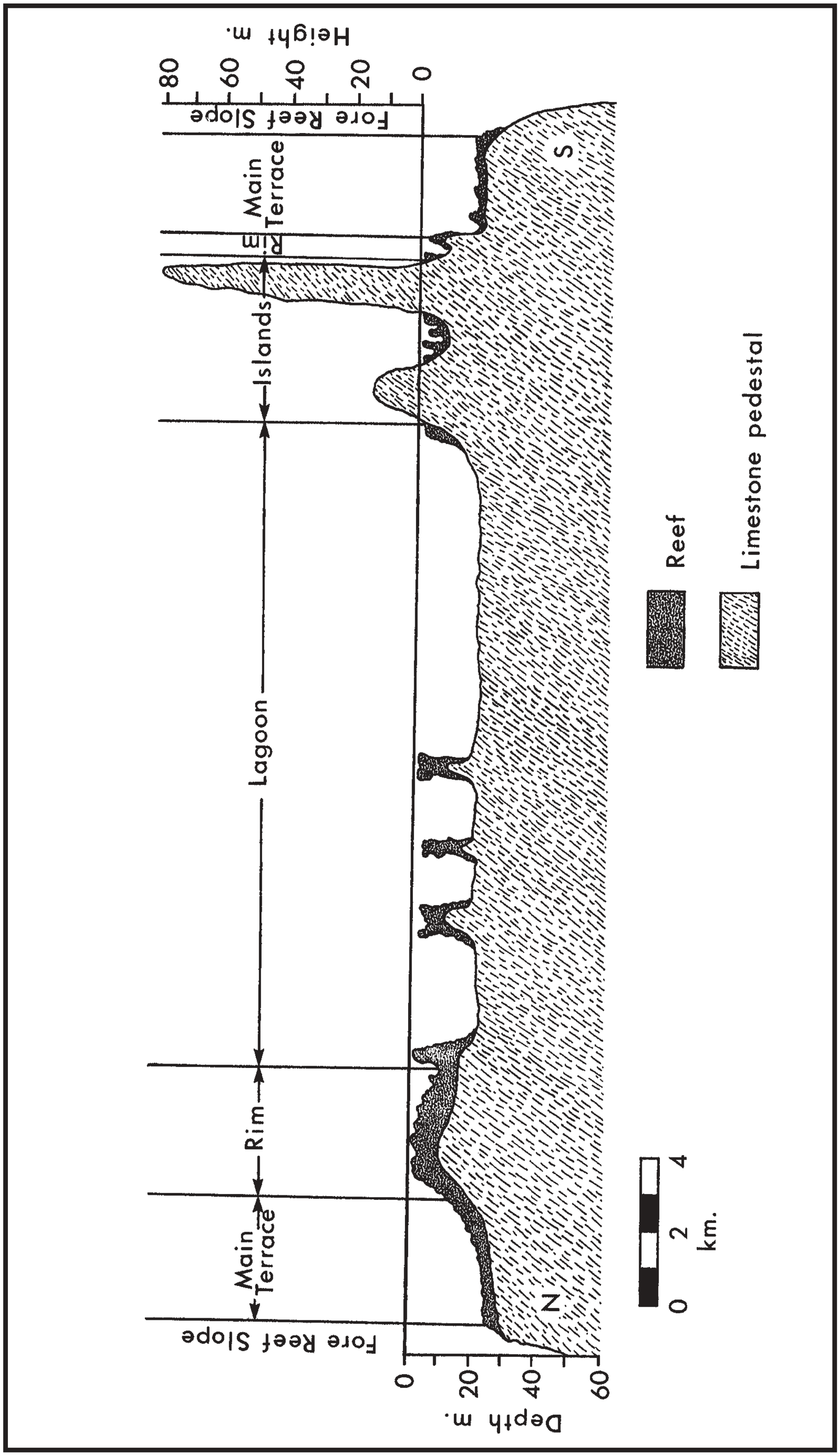


Figure 13.1. A cross-section of Bermuda showing the main physiographic regions.

have also given the islands their large number of caves, some very extensive, and its series of marine ponds. Both the caves and ponds are unique habitats, which harbour a very large number of rare and interesting species. Walsingham Pond for example has been called "The Sponge Metropolis of the World". The limestone soils of the islands, augmented by atmospheric dust, have also given very fertile conditions for plant growth.

The range of ecosystems and habitats

Figure 13.1 shows a cross section of Bermuda, detailing the main physiographic regions that have developed here. **Figure 13.2** is a cross section and panoramic view of the western portion of Bermuda showing the main marine and coastal ecosystems and habitats together with some important geological features. This figure also highlights typical organisms from a range of marine ecosystems.

Summary
The wide range of marine **ecosystems** and habitats includes the open sea, coral reefs, **lagoons,** sounds, sandy bays, seagrass beds, rocky and sandy shores, marine ponds and caves and **mangrove swamps**.

Beginning with the vast open ocean ecosystem and moving inshore we first encounter the coral reef ecosystem which includes a wide variety of habitats. The first is the fore reef slope in deeper water which merges into the rim reef at about 10m (30ft) depth. Towards the land from the rim reef lies the lagoon habitat within which are several types of lagoonal reefs, for example patch reefs. Along the south shore are the unique boiler reefs. The marine water habitats along the edge or within the land mass include bays, sounds, lagoons and harbours. Some of these also have inshore reef habitats such as pinnacle and fringing reefs. Coral reefs also have a large number of small habitats within them; examples of these are reef cavities and shaded reef-side locations. Seagrass beds are a special habitat that can be found in many sandy, coastal shallow water situations. The saltwater ponds are a marine habitat that is completely landlocked as are many of the saltwater caves. Both the sandy and rocky shore ecosystems are basically marine but have a few terrestrial components so they form a sort of transition zone to the land, as do the mangrove swamp ecosystem and the salt marsh habitat.

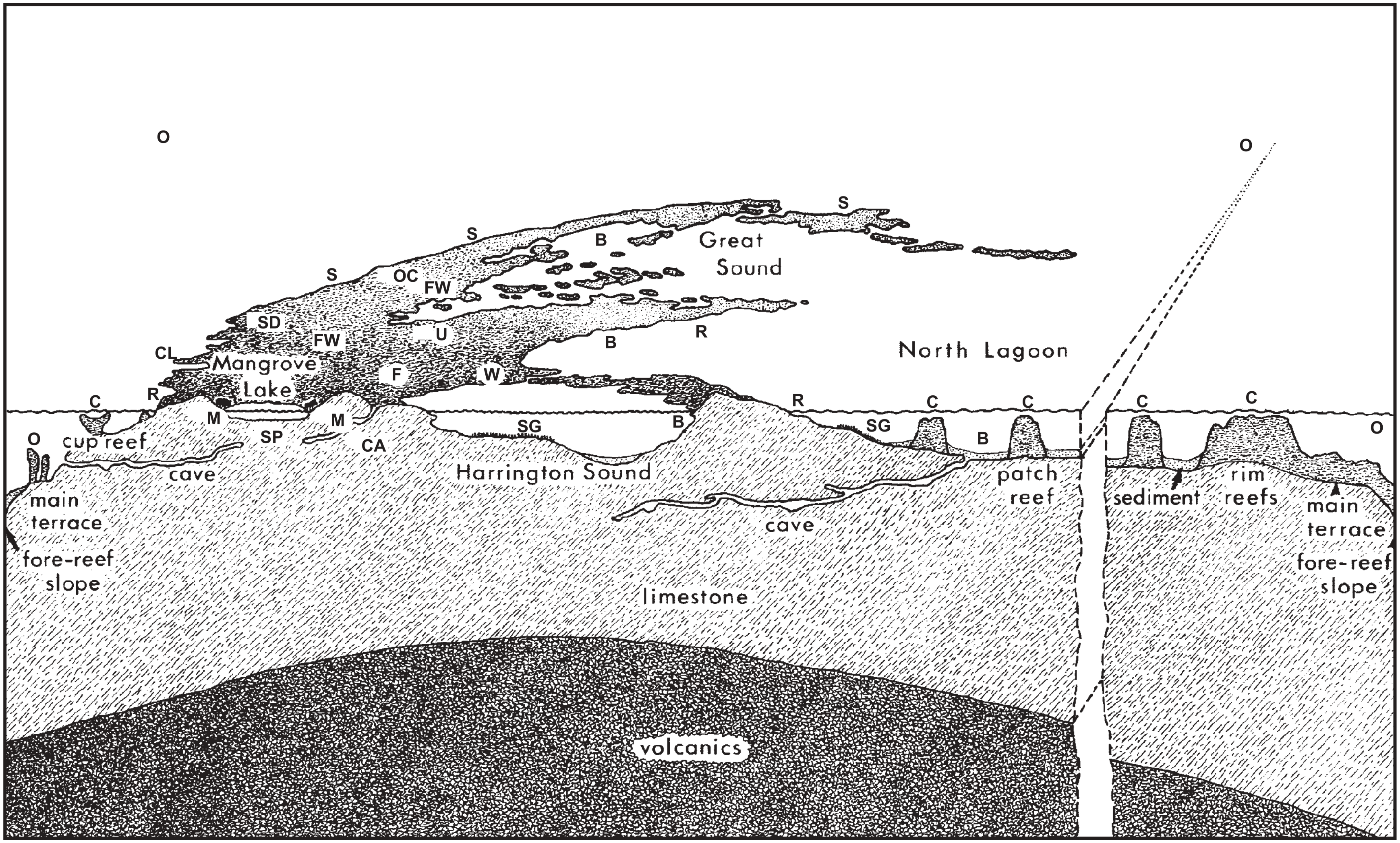
A unique transitional habitat between salt and freshwater ones is the brackish pond habitat characterised by low variable salinity and likewise tidepools along the rocky coast.

The terrestrial and freshwater systems in Bermuda are equally as complex as the marine ones but as has been emphasised in Chapter 11 these systems have been radically altered and degraded by man's activities. In these ecosystems and habitats the biodiversity and habitat diversity have both been greatly reduced and this trend continues. Nevertheless, there are still a great number of habitat types and this situation is highlighted in **Figure 13.3** Another almost transitional ecosystem are the sand dunes, however unlike the sandy shore it is much more terrestrial than marine in nature. In the same situation above rocky shores is the rocky coastal habitat devoid of soil except in pockets, here where the habitat is nearly vertical in nature the cliff habitat occurs. Above these lies the upland coastal hillside habitat which gives way further inland to the upland hillside/upland valley habitats which formerly, together were the forest ecosystem. In this area also are the low lying sinks with good soil and shelter as well as other unique habitats such as cave mouths and inland cliffs. In the lowest areas among the hills are the freshwater wetland areas, which contain the marsh, freshwater swamp and freshwater pond habitats.

Summary
Terrestrial and freshwater natural systems include upland hills and valleys, upland coastal areas, sand dunes, sinks, cliffs, cave mouths, freshwater **ponds**, **swamps** and **marshes**. Man has added several **habitats.**

<u>Man-made habitats</u>

Also within the hills are a multitude of man-made habitats including urban areas, farmland, parkland, sports fields, houses, gardens, stone walls, rock gardens, roadsides, ditches, wasteland etc.



Key:

B = Lagoons, Bays and Coastal Waters	FW = Freshwater Habitats	SD = Sand Dunes
C = Coral Reef	M = Mangrove Swamps and Salt Marshes	SG = Seagrass Beds
CA = Caves and Cave Mouths	O = Open Sea	SP = Saltwater Ponds
CL = Cliff and Steep Rocky Coasts	OC = Open Coastal	U = Urban Environments
F = Forest	R = Rocky Shores	W = Wasteland, Open Spaces and Wayside

Figure 13.2. A cross-section and panoramic view of western Bermuda showing the main ecosystems and habitats.

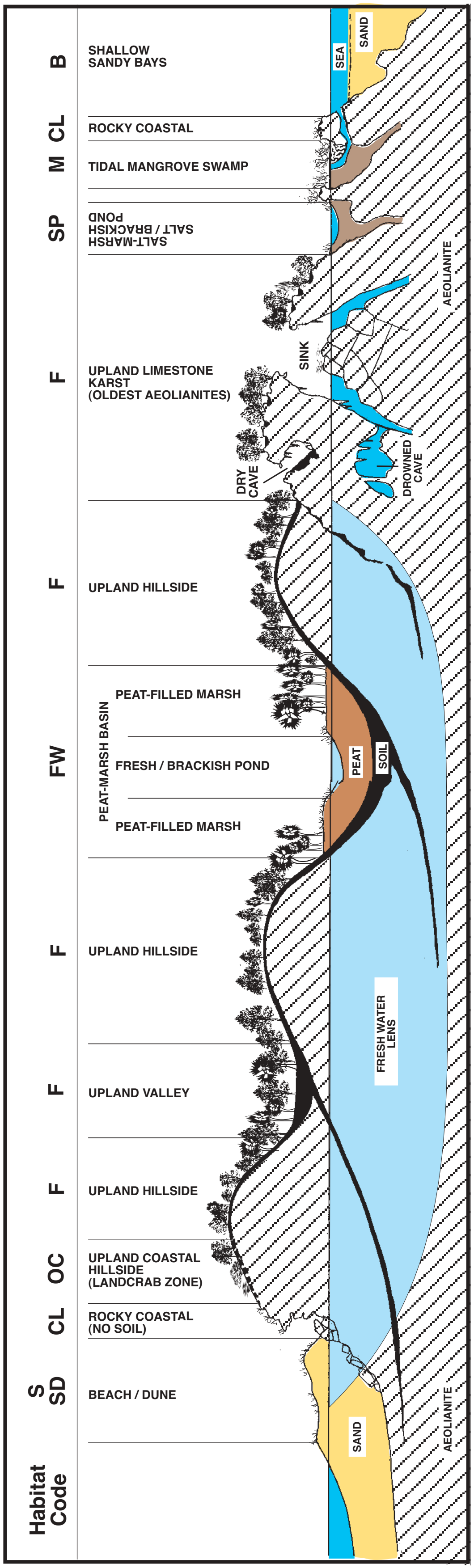


Figure 13.3. Cross-section of Bermuda showing the main plant habitat types together with the underlying geology.

Questions

1) Give two reasons why Bermuda has such a varied ecological makeup.

2) The Gulf Stream and prevailing westerly winds have helped in the development of high biodiversity in Bermuda. Why is this so?

3) Which is the largest ecosystem in the Bermuda area?

4) Name two habitats within the coral reef ecosystem.

5) What habitats or ecosystems might be considered as transitional between land and sea?

6) What former ecosystem existed in the area now occupied by upland hills and valleys?

7) Name three habitats created by man.

8) What shallow-water marine ecosystem is characterised by an expanse of grass-like plants?

9) Why do marine ponds and saltwater caves have much in common?

10) Why are freshwater habitats decreasing in extent in Bermuda?

Field Trip #13.1. An Overall Field Trip to see the Variety of Ecosystems and Habitats of Bermuda

General

To be successful, this field trip needs careful planning and the availability of both land and sea transportation. The actual route can vary somewhat according to a convenient starting point. But try to include as many terrestrial, freshwater, transitional and marine habitats as possible. If most of a day or two half-days are available the route can be extended but in a single half a day many habitats and ecosystems are available for observation.

Preparation

Read this section of this field guide.

Dress

This is a mainly observational rather than hands-on field trip, so no special clothing is needed. Comfortable walking shoes and sun protection are always a wise choice. For the boat portion a wind-proof jacket and sturdy non-slip footwear is suggested.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group.

Suggested Route

The order in which habitats and ecosystems are visited is not critical so the route can be varied quite a bit. The following is a suggested plan only. Depending on the time available the trip may be curtailed or extended. Alternatively the trip can be split into two portions, the terrestrial/ freshwater and the marine.

First look at the urban area around the school and pick out as many man-made habitats as possible, the students should fill in the table below so that a complete record is kept. For example roadsides, gardens, playing fields etc. can be the first examples.

A good second focus would be a freshwater wetland area and Paget Marsh at the boardwalk site would be excellent, as there are freshwater ponds, swamps, mangroves and marshes right there as well as upland hills and valleys and some farmland as well as more urban areas.

A very good third stop might be Blue Hole park which, close to the parking lot, has mangrove swamps, a brackish pond, a very nice cave mouth (Causeway Cave) with a cliff above it and several small safe caves on the shore. It also demonstrates parkland and Castle Harbour as well as some rocky and sandy shore.

From there go to the Aquarium to start the boat portion of the trip. The boat could be either at the T dock in Flatts inlet or the dock in Harrington Sound and it should be capable of going through Flatts bridge. Go just into Harrington Sound and have a good look around the aquarium's coast where you should see lots of coastal cliff and rocky shore. Go close to a cliff and pick out bedding features and rock-falls.

Green Bay, near to the aquarium is a nice shallow, sandy bay to visit with the added attraction of a marine cave mouth and a seagrass bed. Also look around at the upland hillsides and upland valleys and note the density of housing in this rural area.

Go through the bridge and Flatts Inlet into North Lagoon. Here again are bays, seagrass beds, rocky shores and views of the land. There are some near-shore reefs close by, for example close to Gibbet's Island and Stag Rock, so visit one and realise that further out are the other reefs and the open sea. Notice the channel markers that are necessary to keep large vessels from grounding on the many reefs in the area.

A variation on the aquarium boat trip could be a start from Tucker's Town dock after having a brief look at Trott's Pond, a marine pond, from the road. Tucker's Town dock is just within a nice bay with a sandy beach and rocky shores are all around. Castle Harbour is a nice inland saltwater sound. From the dock proceed towards the Castle Harbour Islands noting Nonsuch Island and seagrass beds in shallow water on its north side, and then proceed out off the south shore. There are platform reefs on the bottom and lots of boiler reefs. Here the open sea is close to shore and 5 minutes beyond the boilers puts you there.

Observations Fill in the following table.

Habitat or Ecosystem	Location Visited	Observations and Features	Man-made or Natural
Roadside			
Park or Playing Field			
Garden			
Town or Village			
Wasteland			
Upland Hillside			
Upland Valley			
Sink			
Cave Mouth			
Marsh			
Wooded Swamp			
Freshwater Pond			
Ditch			

Habitat or Ecosystem	Location Visited	Observations and Features	Man-made or Natural
Inland Cliff			
Upland Coastal			
Coastal Cliff			
Brackish Pond			
Marine Pond			
Rocky Shore			
Sandy Shore			
Sand Dune			
Coastal Bay			
Seagrass Bed			
Sound or Harbour			
Lagoon			
Coral Reef			
Boiler Reef			
Open Sea			
Marine Cave Mouth			
Other			

Chapter 14. The Open Ocean around Bermuda

The Ocean System

From an oceanic island such as Bermuda, the overwhelming magnitude of the ocean is more obvious than from a mainland shore; however few people are aware of how much of our planet is ocean. The interconnected parts of the oceans comprising open ocean areas, bays, gulfs, estuaries etc., together make up seven tenths of the surface of the Earth! Not only are the salt-water bodies wide, they are also very deep. The deepest places in **trenches** exceed 10,000 m (32,800 ft) while the average depth of the oceans is 3,800 m or 12,400 ft (3.8 km, 2.35 miles). The volume of water in the oceans is about 1,400 million cubic kilometres. A single cubic kilometre of water is a huge amount, enough to cover Bermuda in a layer 18 m or 59 ft deep! In the ocean life is more three-dimensional than on land, extending from the surface to the deepest locations of over 10,000 m. There are 300 times as much living space in the oceans as on land!

All ocean areas are interconnected and so anything introduced into the ocean can spread to anywhere else. This interconnection also means that seawater can move very long distances. Surface and deep **currents** are characteristic of the oceans. These currents and the property of water known as **heat capacity,** means that seawater can absorb a great deal of energy from sunlight and move that heat around. Thus water may be heated in warm climates, and then be transported in currents to cold areas. There the contained heat is slowly released, resulting in a milder climate. Thus the ocean extends the areas on earth that support abundant life. Bermuda is an excellent example of a place where the climate is greatly improved by the ocean. Also of importance in terrestrial climate is the fact that water vapour evaporates into the air from the surface of the sea. This humid air is the source of most of the rainfall on land areas that is essential to life.

Summary

Ocean systems cover 7/10 of the Earth and are up to 10,000 m deep. The average depth is 3,800 m or over two miles. The oceans are all inter-connected and huge **surface currents** move water to all parts. Ocean water absorbs heat in the tropics, releasing it in cooler climates, thereby warming them. Evaporation from the oceans makes up most of the rain.

Life originated in the oceans; at first it was simple but with time became more complex; some bacteria and most plants developed the ability to photosynthesise. **Photosynthesis** is the process by which the light energy of the sun is used, within organisms, to combine carbon dioxide from the air with water to produce organic material which is the food for the animal kingdom. A by-product of photosynthesis is oxygen and the oxygen produced in the oceans has provided the bulk of that on Earth. It was the availability of oxygen from the oceans that paved the way for the evolution of higher life forms.

Summary

Life began in the oceans and **photosynthetic** plants in the plankton have produced most of the oxygen in the atmosphere. Ocean pollution is now a problem worldwide.

Despite the huge size and volume of the oceans, they can become polluted. All material released into rivers ends up in the sea and to this burden is added that coming from densely populated coastal areas and shipping.

Ocean Characteristics; the Water, Waves, Tides and Currents

Water in General

Water is essential to life but is rare in the **solar system**. For water to remain on a planet there must be an **atmosphere**; in the absence of an atmosphere water is lost into space. The water on

Earth has originated from rocks and most was released during the cooling of the Earth's crust. Water has many unique properties which are important to life on Earth. The range between melting and boiling points means that most water on Earth is in a liquid state. The **specific heat capacity** of water is very high which results in its ability to store large amounts of heat. This property also means that water changes temperature only slowly. Another unusual property of water is that it expands on freezing. Were it the other way around, ice would form at the bottom of water bodies. Ice protects the water and organisms beneath. As with most liquids, the **density** of water depends on temperature. Density falls as temperature rises. The only exception to this is that the density of freshwater rises between 4ºC and 0ºC (39º-32ºF).

Summary
Water came from rocks cooling to form the Earth's crust. A peculiarity of water is that it expands on freezing to form floating ice. Seawater has a great variety of dissolved salts, the main one of which is common salt. 1 kg of seawater contains about 36 g of salts, this is called its **salinity**. Large bodies of seawater that differ in their characteristics are called **water masses.**

Seawater

The most obvious difference between freshwater and seawater is the salt. Although the most obvious component of seawater is common salt (Sodium chloride) there are also a large number of other salts present. Also present are most of the elements on Earth, many in very tiny quantities. All the salts and elements naturally present in seawater have come from the **weathering** of rocks and volcanic activity.

The total of the dissolved salts in seawater is termed its **salinity**. Salinity could be determined directly by evaporating a known quantity of water to dryness and weighing the resultant salts. If one litre (1,000 ml) of seawater from around Bermuda were evaporated, we would be left with about 36.5 grams of salt. The salinity of seawater is expressed in 'parts per thousand', which is abbreviated as ‰. Thus the surface salinity in the ocean around Bermuda is 36.5 ‰.

Water Masses

In such a huge volume of water as the world's oceans, it is inevitable that water in different locations will show different properties. On this basis the water in the oceans can be divided into **water masses**. The properties used to define a water mass are temperature, salinity and density. Coastal water masses are generally lower in salinity and density than offshore ones. Tropical surface waters have higher temperatures than temperate and polar ones.

Water Temperature

The main factor increasing temperature in seawater is **infra-red solar radiation**. Water absorbs infra-red light rapidly and because of this heating is confined to a very thin layer of about 1 m (3 ft) at the surface. One might think that this heated surface water would be mixed to greater depths very readily but this is not so. As water is heated it expands and its density falls. Thus, surface water in an area where it is gaining heat is lighter than the water beneath it. When large volumes of warm water overlay cooler water they tend to stay on the surface. Literally the surface water floats on that underneath. At the surface of the ocean, wind and wave action mix the surface water with that immediately below. Not even violent storms however can mix more than the top 30-50 m (100-160 ft) of water. At the junction between surface and deeper water temperature tends to fall quite sharply. This zone of rapid temperature change is called a **thermocline**. Density increases as temperature decreases going down through the thermocline. Ocean seawater loses temperature by conduction into colder air as well as in the process of

Summary
Seawater is heated by solar radiation in warm regions and cools in colder regions. Surface water is usually warmer than deep water and has a lower density. Warm surface and cold deeper water do not mix much and are separated by a **thermocline**. **Water masses** with horizontal layers that differ in characteristics are called **stratified**.

evaporation. Cooled water increases in density and if its density becomes higher than that underneath, it will tend to sink mixing with just sub-surface water as it does so. This happens routinely during winter. Around Bermuda this winter water does not sink to the bottom because deep waters are always colder and denser than surface ones. However in winter, a deeper surface layer extending down to about 600 m (2,000 ft) is quite well mixed. At its junction with deeper waters, a **permanent thermocline** has formed which is present the year round. When a water mass becomes divided into layers of differing characteristics it is called **stratified**. Stratification can occur on vastly different scales; in saltwater ponds it can occur in just a few metres of water. At sea where the temperature distribution from the surface to the bottom needs to be measured, an instrument called a **bathythermograph** is used to provide a graph of temperature against depth.

Density

Density is determined by the combination of temperature and salinity. Density is almost never measured directly it is given as Sigma-t values (st). (Sigma-t = [density-1] x 1000). Open ocean waters have a sigma-t in the range of 24-30.

Salinity

Salinity is reduced by dilution with freshwater either from freshwater run-off from land or in the form of rainfall. Because of the effect of rivers along shorelines, coastal water is often reduced in salinity. Whereas oceanic waters usually have salinities of around 35‰, coastal waters of 28‰ are quite frequent and in **estuaries** where rivers meet the sea, salinities decline to close to zero. The most common cause of an increase in the salinity of seawater is evaporation of water. In the sub-tropics evaporation usually exceeds rainfall and surface ocean water increases in salinity. This is the reason that ocean water around Bermuda has a higher salinity than the average. It would be reasonable to ask why this increase in salinity would not increase density so that surface waters could sink. In reality the effect of temperature in lowering density is much greater than the effect of salinity in increasing it!

Figure 14.1 shows how temperature, salinity and density vary in relation to depth in ocean waters around Bermuda.

Light in Seawater

Light in seawater is very important because of its importance to life. As mentioned above the process of photosynthesis, which is dependent on light energy, is the basis of organic food upon which all organisms rely. Light is also important for visual behaviour, such as food gathering, recognition of enemies, identification of the opposite sex etc.

In general 65% of all light is lost in the first 1 m (3 ft) of water. Infra-red rays penetrate about 1 m (3 ft). At the other end of the spectrum ultra-violet frequencies are even more rapidly absorbed in the first few centimetres (inches) of water. Visible light penetrates much further, especially blue and green wavelengths, and its penetration depends on water clarity. In the very clearest waters only 0.1% of all light reaches 200 m (650 ft) but some highly adapted deep sea animals respond to very minute light levels down to a depth of 1,000 m (3,300 ft). The illuminated waters of the ocean are termed the **photic zone**. Nowhere is this deeper than 200 m (650 ft), in turbid coastal waters the photic zone is often only a few metres (yards) deep.

> **Summary**
> Light is rapidly absorbed in seawater and even in the clearest water almost all is gone by 200 m. Thus, all deep waters are totally dark. The surface layer where **photosynthesis** occurs, and food is produced is called the **photic zone**. Oxygen too must come from the surface layers and gets depleted lower down.

Since photosynthesis is so important, a name has been given to the depth where the production of organic material (food) by photosynthesis balances food energy usage by organisms. This is the **compensation depth** and it

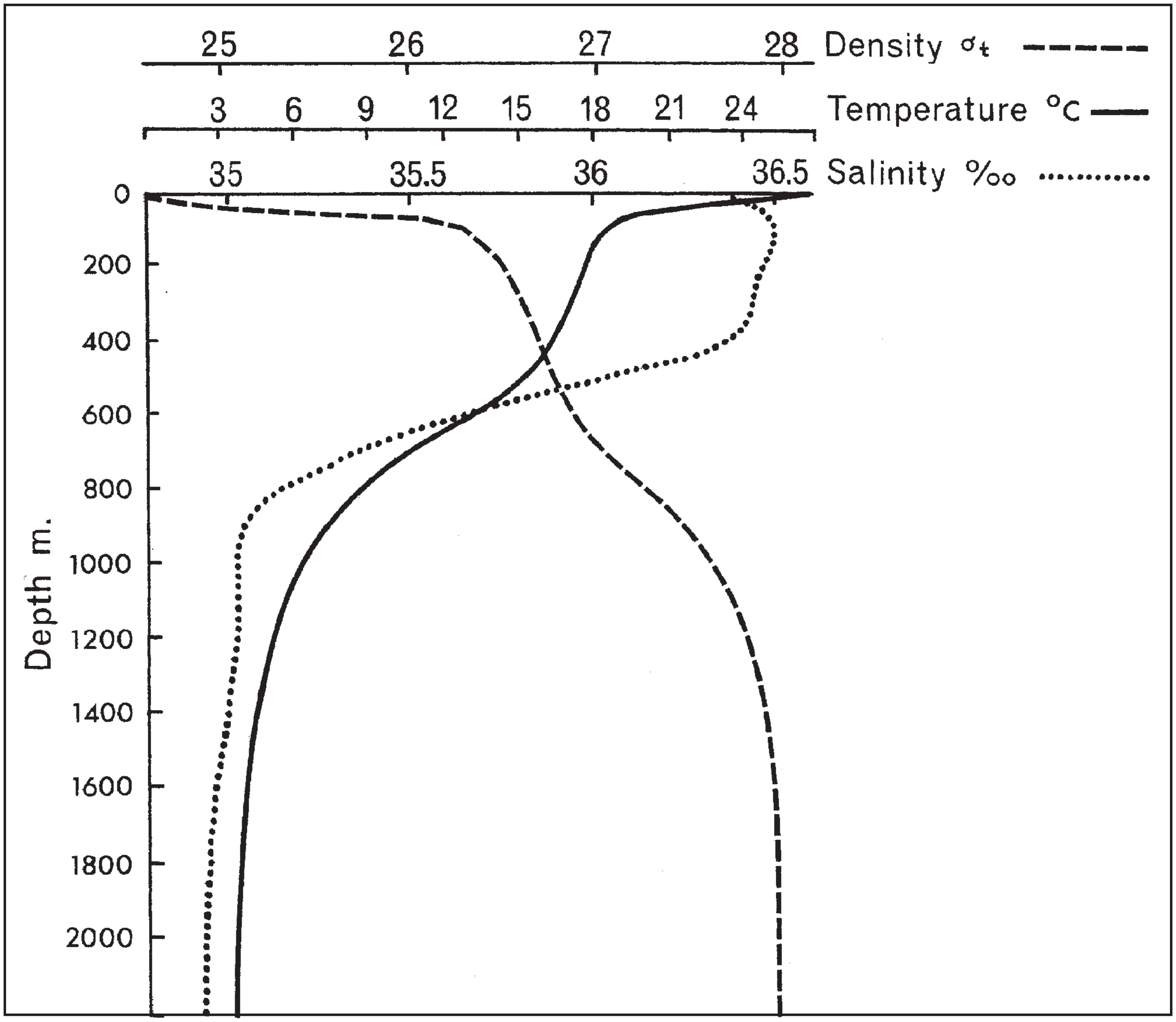


Figure 14.1. Variation of temperature, salinity and density with depth in oceanic water off Bermuda

coincides with the depth to which 1% of surface illumination penetrates. Above the compensation depth more food is produced than is consumed and below it the opposite is the case. In ocean waters around Bermuda the compensation depth lies at about 100 m (325 ft).

The measurement of light levels in seawater can only be done accurately with sophisticated electronic **photometers,** but a good index of light penetration can be made with a **Secchi Disc** which is a weighted, white disc about 30 cm (1 ft) in diameter painted with two black quadrants alternating with white ones. The Secchi Disc is dropped on a depth-graduated rope until it can no longer be seen. This depth will be somewhat shallower than the compensation depth, but can be used as an index. A Secchi Disc is particularly useful in comparing light penetration at a series of locations from the open sea in to coastal waters.

<u>Oxygen in Seawater</u>
Oxygen is one of the few elements found in seawater that varies greatly in quantity. This is because oxygen is closely linked to life processes. During the process of respiration most living organisms use oxygen and give off carbon dioxide. However photosynthetic plants in lighted waters give off oxygen and take up carbon dioxide. The result is that in the **photic zone**, above

the **compensation depth** dissolved oxygen levels rise during the day. At night, oxygen levels fall at all depths. In shallow water with lots of plant life, dissolved oxygen levels in the water frequently reach the **saturation point** and bubbles of oxygen rise to the surface.

Any oxygen in deep, dark waters must have come from the surface carried in water currents and water isolated there gradually declines in oxygen content. In water masses where intense **stratification** prevents any appreciable mixing of surface and deep waters, water at the bottom may run out of oxygen completely, this is called **anoxia**. This situation develops occasionally in Bermuda in Harrington Sound (See Project Nature, “The Ecology of Harrington Sound”). Anoxic conditions are lethal to most higher animal life.

Plant Nutrients in Seawater

All plants need nutrients in order to grow and reproduce. Plant nutrients are divided into macro-nutrients which are needed in appreciable quantity and micro-nutrients needed only in trace amounts. In the sea nitrates and phosphates are the two main macro-nutrients. Since plant life is confined to the shallow photic zone, these nutrients are only important there. Although nutrients are added in freshwater runoff and some nitrogen is fixed at sea, the bulk of the nutrient supply is recycled within the ocean. Phytoplankton and other plants take up both nitrogen and phosphorous compounds as they grow and they return to the water when these organisms die. In most of the open ocean, especially where there is a **permanent thermocline**, these nutrients are in very low supply; they are added only very slowly and completely lost when dead plant cells drop through the thermocline. Thus they tend to decline in surface water. In temperate climates where surface waters cool enough in winter to sink down, deeper waters rich in nutrients rise to replace them, this is called an **overturn**. In spring this new nutrient supply produces a rapid growth among the phytoplankton known as a **bloom**. However, in most tropical and sub-tropical waters, surface temperatures are always high and overturns do not occur. Because of this surface waters are constantly nutrient depleted and phytoplankton growth and reproduction are severely limited. This leads to the very clear waters found in such situations since there are very few organisms to impede light penetration.

Summary

All plants in the sea including phytoplankton need **nutrients** to grow. The main ones, of many, are nitrogen and phosphorus. Nutrients are taken up by plants in the **photic zone**, most are recycled when plants die but some sink through the **thermocline** and their nutrients are lost. Around Bermuda this results in a very unproductive surface layer.

Water Currents

There are two main types of currents in the sea these are 1) **Wind-driven Currents** and 2) **Density Currents**. Wind-driven currents, as the name suggests, are produced by the action of wind on the sea surface while density currents arise from the difference in densities of bodies of water.

Wind blowing across water sets it in motion. To a casual observer in one location, it might appear that the wind blows over the sea from almost random directions. This may be true in some places in the short-term, but in the long term the wind is fairly predictable, even in Bermuda where it is more variable than elsewhere. If we look at the whole globe, we find that in polar regions, the winds are easterly, in mid latitudes they are westerly and in the tropics they are either NE or SE. These tropical winds are

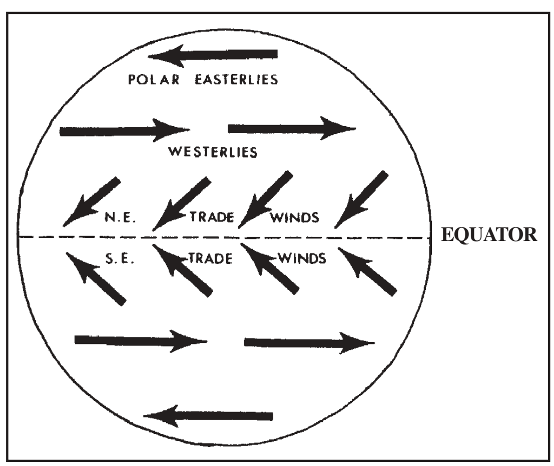


Figure 14.2. General wind patterns at the Earth’s surface.

called the **Trade Winds** and blow virtually constantly. This is shown diagrammatically in **Figure 14.2.** If there were no continents to interfere with current flow, currents would go around the world in bands like the winds. However the continents provide barriers and cause currents to flow in huge circles around the ocean basins. These circles are called **gyres** and are shown in simplified form in **Figure14.3.** Winds are named after the direction they come from. Currents, by contrast, are named for the direction they are going to!

Summary

Surface water currents are produced by winds and form vast circulating water patterns called **gyres** in the ocean. A very large surface current called the **Gulf Stream** passes to the west of Bermuda bringing life and warm water from the Gulf of Mexico. Deeper currents called **density currents** result mainly from polar cooling which causes water to sink and move along the bottom or at an intermediate depth.

<u>Currents around Bermuda</u>

In each ocean basin, the shapes and positions of the continents cause some complications in the flow of the gyres. The situation for the North Atlantic Ocean basin, in which Bermuda lies, is shown in **Figure 14.4.** The NE Trade Winds just to the north of the equator are among the most predictable winds on Earth, blowing constantly and strongly. Over the equator itself winds are generally calm and this region has been called the **Doldrums**. The trade winds produce the **North Equatorial Current**, which flows ever more strongly as it moves west. Much of this water enters the Gulf of Mexico where it is dammed by South America, Central America and the southern USA. The only exit is the comparatively narrow Straits of Florida. As a result the water mounds up in the Gulf of Mexico so that the surface is 1 m (3 ft) higher than in the ocean. This may seem slight, but an immense volume of water is involved and it flows out to the N under the influence of gravity to produce one of the largest and strongest currents in the world, the **Gulf Stream**. The Gulf Stream flows NE up the eastern seaboard of the USA passing to the west of Bermuda. As it goes it broadens, slows and curls of water peel off the sides mixing with other water. These curls are also called **gyres** and many of them impinge on Bermuda bringing warm water and organisms from the south.

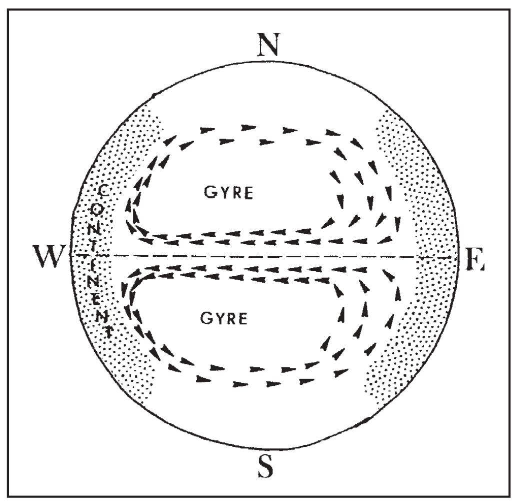


Figure 14.3. Generalised current patterns for ocean basins.

<u>Sub-surface Currents</u>

Density currents mainly arise when the density of a water mass increases due to cooling at the surface, which causes it to sink. This happens on a very large scale in both the Arctic and Antarctic. These deep density currents pass Bermuda but have no effect at the surface. They do however provide the explanation of why the deep water here is so cold as shown in **Figure 14.1.**

<u>Tides</u>

Tides are a universal feature of the oceans. Tides are really very long waves and result from the gravitational pull of the heavenly bodies on the envelope of seawater around the Earth. In effect the gravitational force of the moon pulls a bulge of seawater towards it and causes a second one on the other side of the earth. These bulges follow the moon around the Earth. Since the duration of the moon's orbit is 24 h 50 min, the crest of the waves, which is high tide, will pass each point at this interval. The only ocean on Earth that has tides exactly following the path of the moon is the Southern Ocean. This is because it is the only ocean that is continuous around the planet. In the other ocean basins, just as currents were modified by the land masses so are tides. Nevertheless most places have regular high tides at close to 12 hours and 25 minute intervals. Low tides occur halfway between highs.

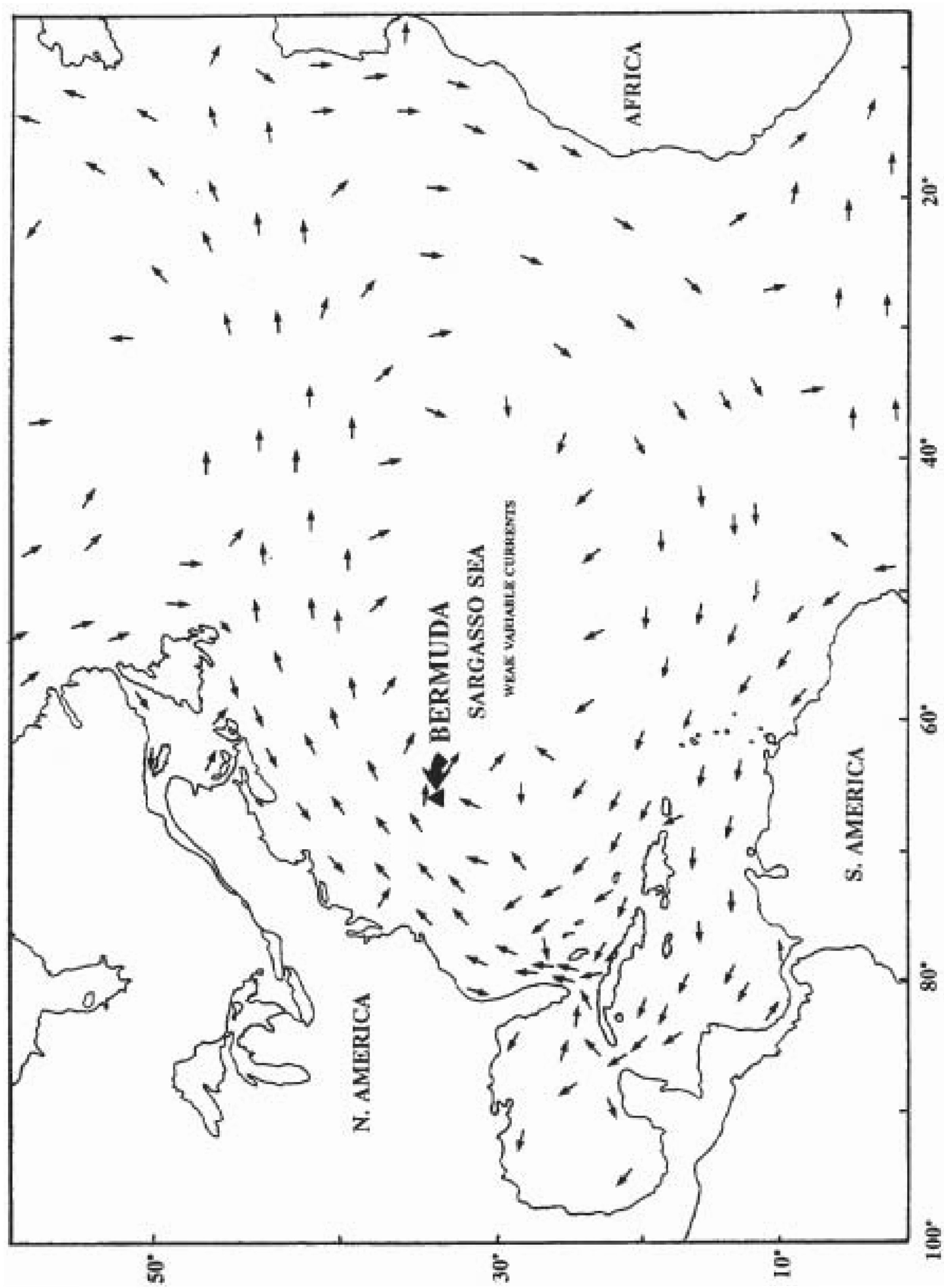


Figure 14.4. Surface currents in the North Atlantic Ocean

The only other heavenly body other than the moon that has an appreciable effect on the tides is the sun. At 14-day intervals, the sun and the moon are roughly in line and their gravitational forces combine to produce tides of a larger range. **Tidal range** is the height difference between high and low water levels. These higher tides at fortnightly intervals are called **Spring Tides**. Seven days after spring tides the tidal range is at its minimum and these smaller tides are called **Neap Tides**. Since the orbits of the heavenly bodies are highly predictable, so are tides. This allows the production of tide tables for any point on Earth that predict the time and height of each tide. Tide predictions in Bermuda are published in the newspaper and also available as yearly sets looking something like a calendar. The average tidal range in oceanic localities such as Bermuda is about 75 cm (2.5 ft); this increases to about a metre (3.2 ft) on spring tides and decreases to about 50 cm (1.6 ft) on neap tides. These tides are small compared to the average for continental shores and are easily altered by the weather both in timing and range.

> **Summary**
> Tides result from the gravitational pull of the moon and the sun. There is a high tide every 12 h 50 min. At 14-day intervals tides have a larger range; these are **spring tides** and small range tides called **neap tides** follow 7 days later. Tides can be predicted and their time and height is published in the newspaper.

Surface Waves

Like surface currents, most waves result from the force of the wind on the surface of the water. The higher the wind velocity the higher the waves. Small waves are closer together than large. The distance between wave crests is called the **wavelength** and the vertical height difference from trough to crest is the **wave height**. As height increases so does wavelength. Strong winds blowing over a large area of ocean for a considerable time can produce very large waves. These waves can travel over the surface of the ocean far beyond their point of origin. Such waves, produced by distant winds are called **swell**. Swell from storms far to the south is a frequent feature of Bermuda's south shore beaches.

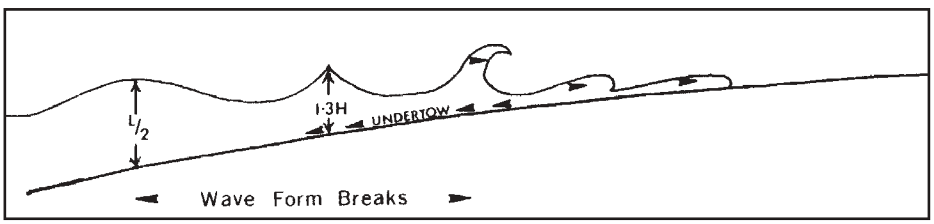


Figure 14.5. Stages in the breaking of waves over a sandy bottom.

When waves or swell move into shallow water their motion is affected. At a depth of half the wavelength, the waves steepen and shorten, and with further shallowing, the wave breaks. **Figure 14.5** shows the stages in breaking waves. Breaking waves strike the shore with great energy and can do considerable damage. When waves meet an irregular coastline they tend to straighten it by eroding headlands away and depositing sediment in bays. This process is very evident along Bermuda's south shore and is shown diagrammatically in **Figure 14.6. Figure 14. 7** shows the erosional effect of waves on rocky and sandy shores. The **wave cut notch** typical of rocky shores with soft rock is very well shown on south shore headlands in Bermuda. **Figure 14.7** also shows how sandy shores are affected by waves, these features too can be seen on the south shore, but they vary considerably with the intensity of wave action. Observation of the shore after a moderate

> **Summary**
> Most waves are caused by the wind and large ones can travel huge distances as **swell**. Waves are an important erosive factor along shorelines. Very large waves called **tsunamis** or **tidal waves** have nothing to do with wind or tide but result from earthquakes and similar occurrences.

storm will show these typical features. The position of the **berm** should coincide with high tide level. During local storms such as hurricanes, wave action can remove huge quantities of sand, break up rocks and damage wharves etc.

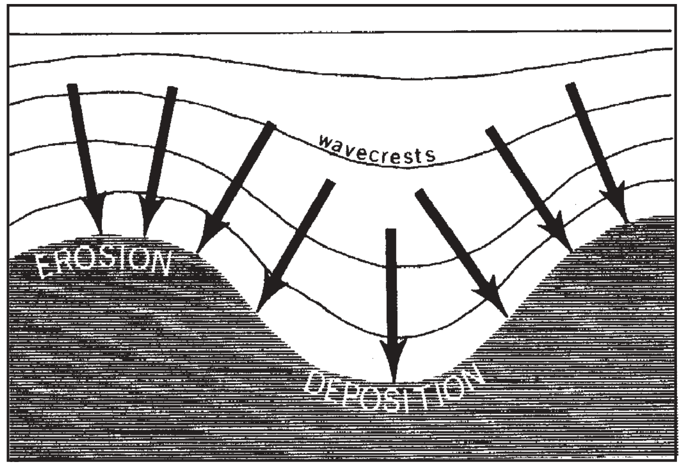


Figure 14.6. Shoreline wave action. The distance between the arrows shows wave intensity.

So-called Tidal Waves or Tsunamis

These are very large waves caused by earthquakes, underwater volcanoes and landslides. The term "tidal wave" is very confusing as they have nothing whatever to do with tides. Tsunami, the Japanese word for such waves is a better term. Tsunamis always have a long wavelength, often many kilometres (miles), but their height is very variable. At sea, because the wave is so long, these waves are scarcely noticeable to ships. However, when they impinge on shores, those with a large wave height often cause catastrophic damage. Some of the worst shoreline disasters, for example the December 2004 one in the Indian Ocean, have been the result of tsunamis.

Groups of Life in the Ocean

Life in the ocean has been classified into several main groups depending on their environment and mode of life. Organisms living up in the water off the bottom are called **pelagic** and those living on the bottom are referred to as **benthos**.

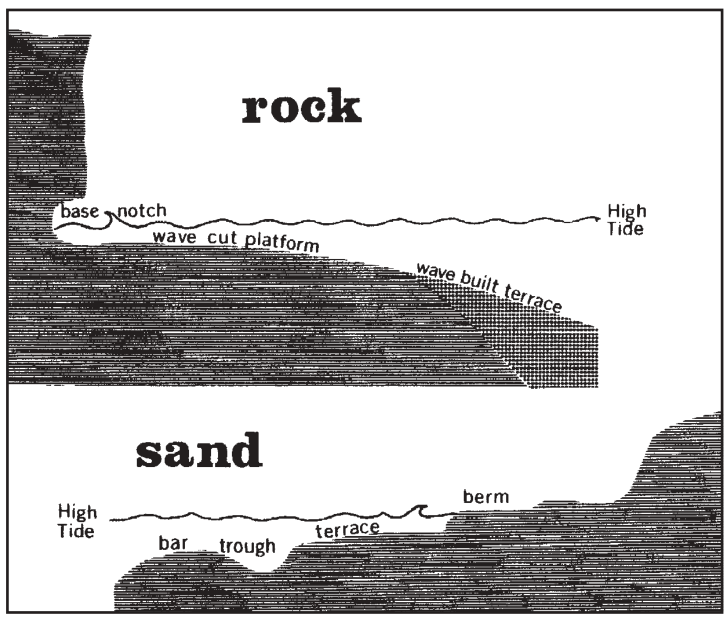


Figure 14.7. Wave-cut profiles of rocky and sandy shores.

The most abundant and widespread pelagic forms of life in the ocean are the **plankton.** They are divided into two sub-groups, the **phytoplankton** or plant plankton and the **zooplankton** or animal plankton. Plankton are generally small or minute and if they have any swimming ability it is weak. Most just float in the water. If they can swim, they cannot do it strongly enough to swim against ocean currents except for short bursts. A few larger, weakly swimming creatures, such as jellyfish, are still plankton.

A very special group of the plankton are the **neuston,** which drift right at the surface. We will return to this group as they are particularly important around Bermuda.

Pelagic animals that can swim strongly in the water above the bottom comprise the **nekton**. The nekton includes a huge diversity of organisms from great whales, through many fish, squids and others.

The benthos also includes a huge variety of organisms. Benthos are divided into those that live in burrows, the **infauna** and those that live on the surface of the sediment, the **epibiota**. In shallow water the epibiota includes both animals and plants. In deep water all the benthos are animals.

Plankton; the Drifting Life of the Ocean

Phytoplankton

The phytoplankton are the drifting plant life of the ocean. By far the majority are single-celled plants from a wide variety of plant groups. Several are from the **cyanobacteria** or **blue-green algae**, which were formerly classified as plants. A few are multicellular. The phytoplankton are the main photosynthesisers in the ocean and are at the base of many food chains. Virtually all phytoplankton live in the photic zone although a few can survive in deep waters for long periods.

The most abundant group of phytoplankton are the **diatoms**. These tiny, single celled plants have no means of movement and are suspended in the water. The characteristic feature of the diatoms is that they form a very thin perforated, capsule or **frustule** of silicon dioxide which is crystal clear. The frustule is composed of two halves one of which slides over the other forming a box-

Summary
Phytoplankton are mostly single-celled drifting plants in the photic zone of the ocean. They are the basis of the ocean food chain and are extremely diverse. The commonest of these are the **diatoms** which have a two-part silica **frustule** or shell. **Dinoflagellates** are also common and have some poisonous and also **bioluminescent** species.

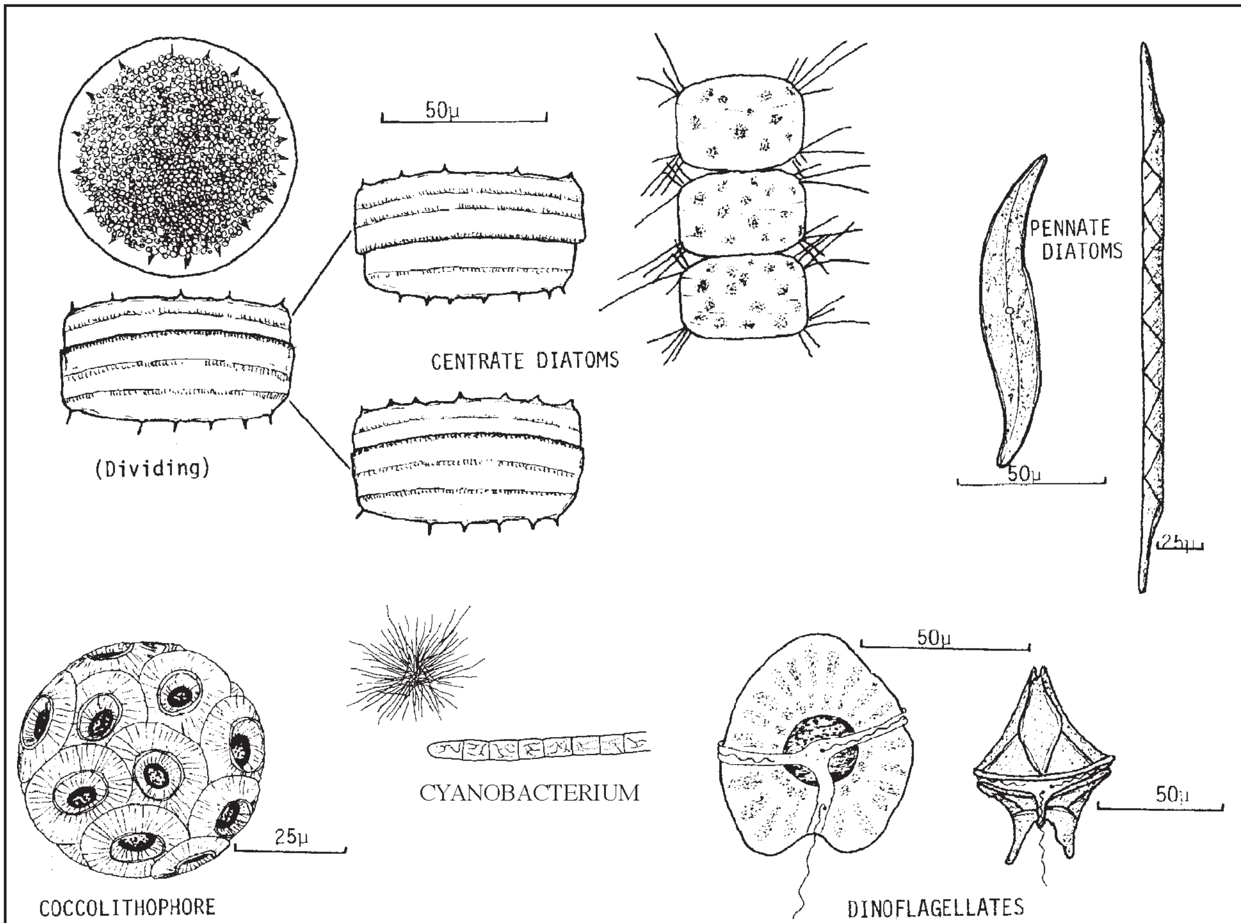


Figure 14.8. Examples of various phytoplankton. A micron (μ) is a thousandth of a millimetre.

like structure. Each species has a characteristic frustule shape. There are two basic shapes of diatom, one like a very shallow cylinder called **centrate** and the other elongate or **pennate**. **Figure 14.8** shows examples of both these types of diatom as well as the division of a centrate one. When they die, the frustules of diatoms which are delicate but resistant to fragmentation, slowly sink to the seabed. These remains form siliceous or **diatomaceous oozes**. These deposits are used commercially as abrasives and insecticides.

The second most important group among the phytoplankton are the **dinoflagellates**. Many of these are armoured by **chitin** plates, which form a characteristic skeleton. Others are naked. Whichever form they are in, there are usually two whip like **flagellae**, one in a groove around the body and one trailing. Both flagellae beat constantly, the one spinning the body and the other driving it forward. Thus these organisms can swim weakly and use this to maintain their place in the surface waters. An armoured and a naked one are illustrated in **Figure 14.8.** The dinoflagellates are a very diverse group and not all are pigmented. Some species are **bioluminescence**, meaning they can produce light, and may flash or glow in surface waters. If you are swimming at night and the water lights up as you disturb it, ten to one it is a caused by a dinoflagellate. Other dinoflagellates are quite poisonous and may cause fish kills and **paralytic shellfish poisoning**. Some are quite brightly coloured and may give the water a characteristic tint. One reddish one, also poisonous, is called '**red tide**'. Most members of this group are good food for a variety of organisms in the sea.

Another member of the phytoplankton that can contribute to deep sea oozes are the **coccolithophores**. These are small organisms the exterior of which is protected with a series of disc-like plates of calcium carbonate. They have a single flagellum. In places they are common enough to give the sea a milky appearance. Some of the deep sea calcareous oozes are composed entirely of coccolithophore plates and are termed **coccolithophore oozes**.

Phytoplankton belonging to the cyanobacteria group are worth a mention because they are able to fix dissolved nitrogen into nitrogen compounds. Nitrates are required by plankton, as discussed above, and are often in poor supply in the ocean. Some members of this group are quite common in the warmer ocean water around Bermuda and some use gas bubbles to buoy themselves up in the water. Cyanobacteria may be abundant enough to colour the water and some water bodies are named because of this. One example is the Red Sea and another the Azure Sea, also called the Gulf of California.

Zooplankton

Zooplankton are a very diverse group with almost all of the phyla in the animal kingdom represented. There are two main groups of the zooplankton, the **holoplankton** or permanent plankton and the **meroplankton**, the seasonal or temporary plankton. The latter are larval or juvenile stages of nekton and benthos. An example of the meroplankton would be the larva of the Bermuda Lobster (*Panulirus argus*). Most zooplankton are virtually colourless, which makes them very difficult to see in the water. This is an adaptation to avoid being eaten by predators.

Among the zooplankton is a wide range of protozoa some of which are very numerous. One of the best known groups are the **foraminifera**. The red sands of the south shore of Bermuda are coloured by the skeletons of a benthic member of this group. However, there are lots of pelagic examples too. Each individual consists of several chambers of calcium carbonate forming a **test**, pierced with holes from which protrude the **pseudopodia**, which collect phytoplankton and organic particles as food. In places

Summary

Zooplankton are the animal plankton that feed on the **phytoplankton**. Most are small crustaceans about the size of a grain of rice. Most can swim weakly but are swept along in ocean currents. Many other animal groups are present in the zooplankton from single celled **protozoa** to large jelly fish. Zooplankton form the main food supply for fish and other larger sea creatures.

the tests of foraminifera are numerous to form a calcareous ooze called **foraminiferan ooze**. An example is shown in **Figure 14.9.** A small but interesting group of zooplankton are the **acantharians**; these unique members of the zooplankton have a skeleton of strontium sulphate, which consists of 20 regularly arranged spines. Another large group of protozoa are the **radiolarians**; radiolaria have a skeleton of silica rods (**Figure 14.9**). Feeding in a similar way to the foraminifera they too are numerous enough that the skeletal material forms an ooze called **radiolarian ooze**. Many other small protozoa, such as the **ciliates** are also included in the zooplankton.

Examples of the jellyfish group (**Coelenterates**) that are common in the plankton are many; these range from the small larval **medusas** of benthic forms such as hydroids and anemones to large jellyfish which may have trailing tentacles 10 m (30 ft) long. A typical medusa is shown in **Figure 14. 9**. An interesting subgroup from this general group is the **siphonophores** which are really colonies of animals each individual having a specialised function. The Portuguese Man-of-War (*Physalia physalis*) is one of these but it is a member of the neuston. Other smaller species are common in the plankton. The **Comb Jellies** (**Ctenophores**), a totally marine group, closely resemble the jellyfish group but have a generally round body, which has bands of beating cillia to propel it. Its shape has given rise to the name of Sea Gooseberries; one is shown in **Figure 14.9**.

Another group of animals only found in the zooplankton are the **Arrow Worms** or **Chaetognaths**. This is a very widespread group with low **species diversity**. They resemble small, perfectly clear fish; they can dart rapidly to catch prey but are generally weak swimmers.

The most diverse and abundant group of animals in the zooplankton are the **crustaceans**: the planktonic crustacea are the single largest group of protein producers in the world. They are very important food for a wide variety of fish. Many benthic crustaceans such as crabs, lobsters and shrimps have meroplankton larvae, but the vast bulk of the planktonic crustaceans are holoplankton creatures called **Copepods,** a group with over 6,000 species. A typical copepod such as is shown in **Figure 14.9** looks like a small grain of rice with two long antennae and a number of shorter legs. Both legs and antennae are used in swimming but like other zooplankton they are relatively weak swimmers. Copepods are one group, which demonstrate the behaviour of **diurnal vertical migration**. This typically involves their feeding near the surface by night and descending to deeper water by day. Such behaviour has been shown to minimise predation and to diversify their diet. The second-most important group of planktonic crustacea are the **Euphausid Shrimps** or **Krill**, an example of which is depicted in **Figure 14.9.** As plankton go these are large creatures up to several cm (an inch or so) long; they are abundant in southern waters but widely distributed. They are very important food for many of the great whales and also for seabirds including penguins. An average Blue Whale consumes about three tons of krill per day!

There is a wide variety of other zooplankton such as the meroplankton larvae of starfish and sea urchins but one particularly interesting group are the **Salps**. As shown in **Figure 14.9** they resemble miniature, transparent barrels which move slowly through the water by a form of jet propulsion aided by a series of one-way valves in the body.

Life at the Surface of the Sea; Sargasso Weed and Special Animals

<u>Neuston</u>

The neuston are a very specialised group of animals and plants which live in association with the surface of the sea. Members of this group are not infrequently washed ashore in large numbers in Bermuda. One member of the is group is the Portuguese Man-of-War. It is a siphonophore colony in which one individual forms a sail at the top and others below form a group of feeding and defensive individuals. As all Bermudians know, this is a very poisonous creature. In the same group, but more benign,

Summary

The **neuston** are a special group of organisms that live just at the surface of the sea. They are highly adapted to a drifting life and include such creatures as the Portuguese Man-of-War the By-the-wind Sailor and the Common Purple Sea Snail.

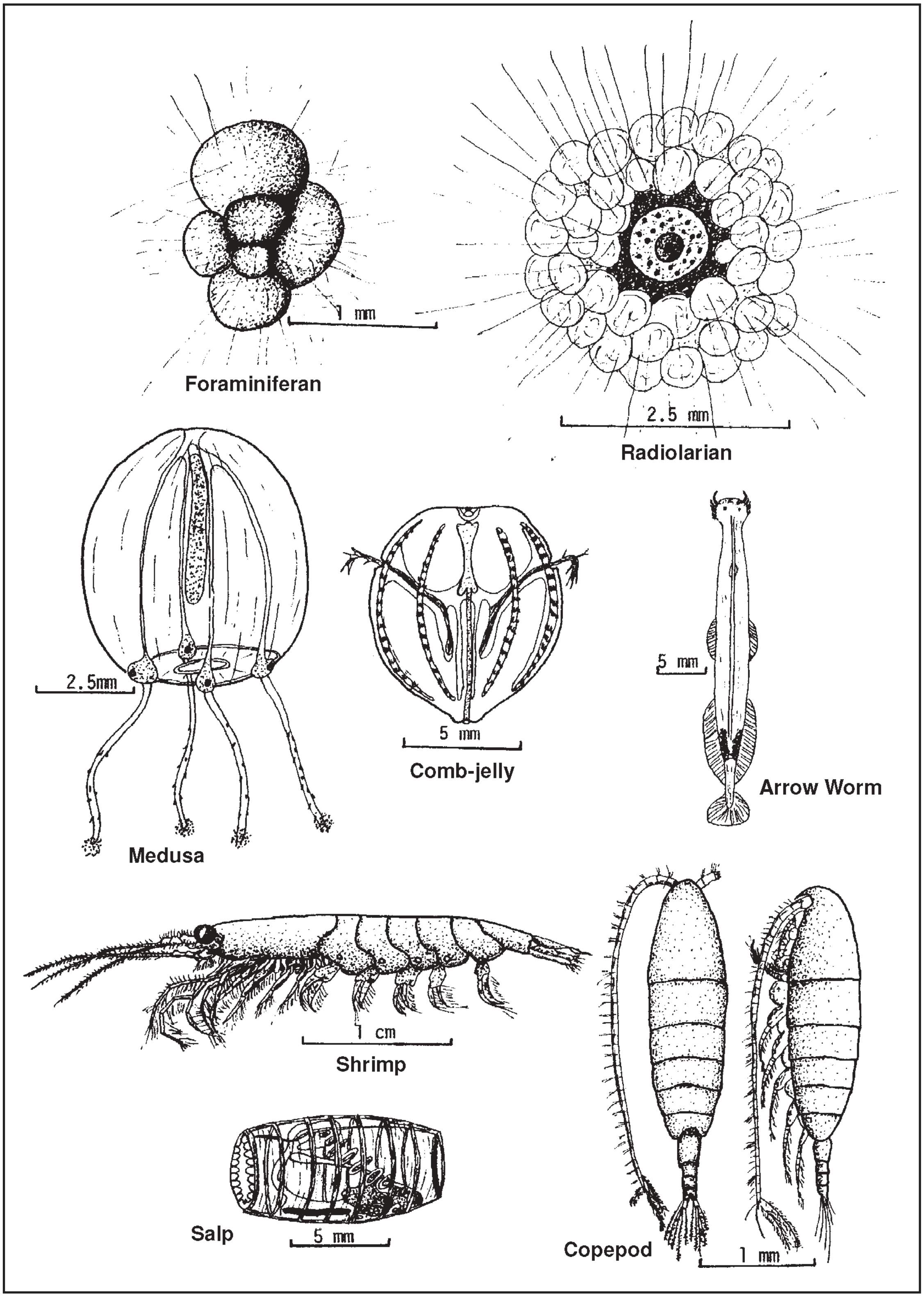


Figure 14.9. Examples of zooplankton.

is the By-the-wind Sailor (*Velella velella*) which also has a sail, but is much smaller than the Portuguese Man-of-War. In both these examples the sail enables them to feed over a very large area of water but does not consume the energy that swimming does. Also washed ashore with the By-the-wind Sailors is a snail, the Common Purple Sea Snail (*Janthina janthina*) that travels the sea surface on a raft of hardened bubbles that it produces. It is a predator on By-the-wind Sailors, which it intercepts by collision!

The Sargassum Weed Community

One very special group of neuston forms the **Sargassum weed patch** or sargasso weed community, very common in the oceans around Bermuda. The oceanic species of sargassum are brown seaweeds that unlike most members of that group, do not live attached to the bottom. Rather they drift at the surface of the ocean buoyed up by gas-filled bladders. Other sargassum species live attached to the bottom in shallow water and one, the Bermuda Sargasso Weed,*(Sargassum bermudense)*, is **endemic** to Bermuda. There are two common species of floating sargassum: these are *Sargassum fluitans* and *Sargassum natans*. Both are described and illustrated in the identification section of this guide. Each sargassum plant forms a roughly spherical mass about 15 cm (6 in) in diameter. However, plants become entangled and may form huge rafts hundreds of metres (yards) long. Sargassum rafts provide food for a wide variety of organisms but perhaps more important provide cover and shelter in an environment generally lacking these attributes. Some of the animals living in association with the sargassum are only found in that situation; in other words they are endemic to the sargassum community, and have evolved there. A larger group is found both in sargassum clumps and elsewhere, for instance in shallow coastal environments. Some of the sargassum fauna is very highly adapted to that environment, so much so that they are exceedingly difficult to spot as they have become camouflaged in both shape and colour to look like sargassum itself! Around Bermuda, sargassum can be readily collected with a dip net as clumps pass by a boat. For study purposes, sargassum collected in this way should be immediately placed in a pail of fresh seawater, as some of the inhabitants are very delicate. Many of the inhabitants are extremely difficult to see but non-attached ones may be brought into the open by shaking bunches of sargassum over a white pail of seawater. Many others are firmly attached to the weed and many are tiny. A good microscope is needed to study them. Sargasso Weed that is washed ashore is useless for study except to see the dried remains of some of the attached creatures.

Summary

Floating brown seaweeds called Sargasso Weed form floating clumps or rafts in the ocean around Bermuda. This is a very special environment which supports a huge variety of life, many of which are found nowhere else. Many Sargasso Weed inhabitants are tiny and must be observed under a microscope.

The most common animals found in association with the sargassum rafts are **hydroids**. At least 11 different species are common and many others are uncommon or rare. Hydroids are small, generally colonial animals related to the jellyfish. Colonies most commonly consist of a branching, stem-like structure from which arise numerous **polyps** consisting of a ring of tentacles around the mouth. They are commonly found attached to rocks and seaweeds in shallow water. Closely related to the hydroids and jellyfish are the **sea anemones**. One member of this group is characteristic of the sargassum clumps and commonly found there; this is the Dark Star Anemone, with the very appropriate and descriptive scientific name of *Pseudactinia melanaster*. Its colour matches the light brown of the sargasso weed.

Tiny white tubes on the surface of the Sargasso Weed harbour small **polychaete worms** called Coiled Tube Worms, (*Spirorbis formosus*), which can be recognised by the tiny (1.5 mm, 1/15 in) coiled, white tubes.

After the hydroids, the **crustacea** show the most species diversity among the sargassum clumps. A group of tiny crustaceans having much in common with the planktonic copepods described above, but adapted to live in association with the bottom or on seaweeds, or attached animals, are common among the sargasso weed fronds. The barnacles are also crustaceans but the adults are always attached and most have protective plates around the body. The Sargasso Barnacle (*Lepas pectinata*) is one of the 'goose barnacle' group found often attached to floating objects in the ocean. These barnacles have a fleshy stalk which attaches them. In the Sargasso Barnacle this stalk is short and the whole animal less than 2 cm (3/4 in) long. A third crustacean common on sargasso weed is the very small and aptly named *Carpias bermudensis* only 2 mm 1/10 in) long; it is flattened from top to bottom, whereas some other small relatives are flattened from side to side. The caprellids are very highly adapted crustaceans with very slender bodies and grasping legs. They typically live attached to seaweeds or bottom-dwelling animals and are usually well camouflaged; one called *Hemiaegina minuta* is common in the sargasso weed. Several shrimps are common; typical of these is *Leander tenuicornis* also found commonly in seagrass beds. Its yellowish-brown colour with darker brown patches is good camouflage. The most typical crab of the sargassum clumps is the Sargassum Crab (*Planes minutus*), which has also been found on oceanic turtles. Despite its scientific name it is not minute but may reach 2 cm (7/8 in) long! This is large compared to much of the weed clump fauna.

Summary
Many of the Sargasso Weed inhabitants are very well camouflaged so that they resemble the weed that they live in. This is true of the Sargassum Nudibranch and the Sargassum Fish which is a small angler fish that hunts its prey in the weed clumps.

The **sea-spiders** are a curious group of marine animals which bear a superficial resemblance to true spiders. They are generally small with tiny bodies and long clinging legs. The Sargassum Sea-spider (*Anoplodactylus petiolatus*) is very common and reaches about 4 mm (1/5 in) long.

The **mollusca**, which include the snails, slugs and clams as well as octopuses and squids, have a few representatives living in the weed rafts. The only common snail is the Brown Sargassum Snail (*Litiopa melanostoma*), growing to about 5 mm (1/5 in). The shell is very light in weight, thin and smooth and may sometimes be found in large numbers washed up on the beach. Two sea slugs (nudibranchs) are common among the weed tangles. The Sargassum Nudibranch (*Scyllaea pelagica*), grows to about 5 cm (2 in) long, the species is brown in colour and has flaps on the body which resemble the seaweed. A very tiny cousin is the Pygmy Doto (*Doto pygmaea*) only 3 mm (1/8 in) long, also well camouflaged.

Bryozoa or Moss Animals are often mistaken for plants. Like the hydroids they are mostly colonial and may grow as a sheet on rocks or seaweeds or have an upright plant-like form. The one found abundantly on sargassum plants (*Membranipora tuberculata*) forms lacy layers over the stems, bladders and fronds. Although typical of sargassum it is also found on other brown seaweeds.
To conclude this account of the animals associated with the sargassum rafts, two fascinating fish that live there must be mentioned. The first of these is a small angler fish, the Sargassum Fish (*Histrio histrio*) which may attain 15 cm (6 in) long, but is commonly much smaller. It is well camouflaged in colour and in that the fins resemble sargassum fronds. Although many of the angler fish use an artificial fishing lure on a rod attached to the top of the head, to attract their prey, this one stalks fish and crustaceans among the weed clumps. The second fish resident in the sargassum is the Pugnose Pipefish (*Syngnathus pelagicus*) a very slender, eel-like fish, closely related to the seahorses, reaching 12 cm (4 3/4 in) long. Like the Sargassum Fish this one hunts among the weed clumps.

Sargasso Weed animals are illustrated in a special section of the identification part of this book.

The Active Swimmers; Fishes, Squids, Dolphins, Turtles and Whales
Although this group of organisms is widespread and diverse they are scattered over a wide area and only seen infrequently at the surface.

Fish

Common oceanic bony fish around Bermuda would include the Wahoo (*Acanthocybium solandri*), the Yellowfin Tuna (*Thunnus albacares*) and the Blue Marlin (*Makaira nigricans*). Local examples among the cartilaginous fishes are the Dusky Shark (*Carcharhinus galapagensis*), the Whale Shark (*Rhincodon typus*) and the Spotted Eagle Ray (*Aetobatus narinari*).

Squid

Some of the more interesting and bizarre of the nekton are the giant deep-sea squids. These huge creatures are rarely seen by humans but are the normal food of Sperm Whales. Sperm Whales can dive to great depths and find their prey in almost total darkness. The imprints of squid suckers are often clear on Sperm Whale skins and the beak-like feeding mechanisms of giant squids have been found in Sperm Whale stomachs. There are several other species of squid occasionally seen at sea such as the Orange-back Squid (*Ommastrephes pteropus*); little is known about their habits and ecology.

Summary

There are many different large, actively swimming animals in the open ocean but few of them are frequently seen. Wahoo, Tuna and Marlin are reasonably common fish. Among the whales, the Humpback and Fin are regularly observed. The most oceanic turtle, the Leatherback is very rarely observed. The most famous oceanic bird is the endemic Cahow but Shearwaters and other Petrels are seen more regularly.

Turtles

The one turtle that is truly oceanic except at breeding season is the Leatherback Turtle (*Dermochelys coriacea*), a huge turtle reaching 1.8 m (6 ft) in length and a weight of 600 kg (1300 lb)! Unlike the other turtles it does not have a bony shell, but rather is covered in a thick, leathery skin with five prominent longitudinal ridges. Specimens are occasionally brought ashore in Bermuda, but it is rarely seen. Its diet consists almost solely of jellyfish but they also consume floating plastic, which may kill them.

Whales and Dolphins

The Whales are certainly one of the best known groups within the nekton even though they are neither numerous or common. Some of the whales are plankton eaters especially where krill abound, but others include smaller fish in their diet. An example of a whale seen close to Bermuda is the Humpback Whale (*Megaptera novaeangliae*). Whales in this general group are called baleen whales and they capture their small prey by filtering huge volumes of water through a set of whalebone (baleen) plates in their mouths. Another whale in this same group seen in this area is the Minke Whale (*Balaenoptera acutorostrata*). These huge whales therefore feed just like the smaller plankton feeding fishes such as the Herring. The Sperm Whale (*Physeter macrocephalus*) on the other hand is a hunting predator that feeds on large deepwater squid. Other marine mammals include the Dolphins and Seals none of which are commonly seen.

Birds

The Cahow is certainly the most famous of Bermuda birds and at the same time the least observed! Like all the Gadfly Petrels, the Cahow is a truly oceanic bird. It remains on the open ocean except for the breeding season, which extends from late October to early June. Even during this breeding period a great deal of time is spent at sea. The first breeding individuals arrive in Bermuda in late October to early November. Since their approach to, and activities on, land is totally nocturnal, they are rarely seen except by their human custodians.

Breeding is confined to several small islands off Castle Harbour and Coopers Island. All these islands are protected refuges. Visitors to the breeding sites are discouraged as the population is still very small and fragile! Courtship is aerial and a noisy affair: it was perhaps these sounds that gave Bermuda its early reputation as the "Island of Devils". The nests, which are merely a scrape in the ground, are now all situated in artificial burrows about 1.3 m (4 ft) in length, constructed of concrete with a wooden baffle part-way down the tunnel to exclude White-tailed Tropic Birds or

Longtails (*Phaethon lepturus*), as they are locally known. Formerly, the birds probably nested all over the Bermuda Islands in burrows in the forest. The first eggs are laid in early January, one per female, and are incubated by the female parent for 51-53 days. The young are fed in the burrow by the female, for about another 12 weeks, until they are full grown by late May or early June.

The feeding in itself, is a marvel of nature. The food does not consist of local species but rather, small squid found in the Gulf Stream hundreds of kilometres (miles) to the west of Bermuda. Because of this, it takes a parent a full day to get a meal for the single chick. The squid, swallowed at capture, is regurgitated when the parent returns. When the chicks are fully grown, they are abandoned by their parents. They emerge from the burrow, have a few practice wing stretchings and take-offs for a few nights and then fly off, not to return for many years when they are sexually mature. Long-term plans for the Cahow include a return to breeding on Nonsuch Island, and perhaps carefully protected main-island sites. The Cahow is still one of the rarest birds in the world and is even more rarely seen!

There are also a number of oceanic birds, which tend to stay off-shore. Some of these can be seen with powerful binoculars, or a telescope, as they fly by on migration or while feeding. This group includes, Cory's Shearwater (*Calonectris diomedea*), the Greater Shearwater (*Puffinus gravis*), the Sooty Shearwater (*Puffinus griseus*), the Manx Shearwater (*Puffinus puffinus*) and the two Petrels, Wilson's Storm Petrel (*Oceanites oceanicus*) and Leach's Storm Petrel (*Oceanodroma leucorhoa*). Petrels will sometimes approach a boat if food is thrown overboard.

Life in the Deep Sea

The ecosystem of the deep sea is a difficult one to study; life there is very sparse but also very diverse. Studies of the fauna of the deep sea starting with those off Bermuda by William Beebe have shown several interesting features, which differentiate deep sea life from that closer to the surface. The effect of diminishing light levels with depth is clearly shown at depths where light is dim, the so-called twilight zone. Their adaptations such as very large eyes and deep, flat silvery bodies are seen, as is the appearance of light producing organs. Often the eyes point up whereas the light producing organs point down. The Hatchet Fishes typified by *Sternoptyx diaphana* show these features clearly, whereas the Lantern Fish, which may ascend to the surface at night, are less adapted but still have large eyes and light producing organs. **Figure 14.10** shows a typical Hatchet fish and a fairly common Lantern Fish (*Myctophum nitidulum*). The adaptations shown in these small fishes enable them both to catch prey and avoid detection by predators; the light organs are probably used to attract mates at breeding times.

As depth increases and light is totally gone, the trend is to black or dark-red colouration, combined with tiny eyes and very large mouths. These abyssal creatures hunt by senses other than sight and need to be able to consume prey almost as big as themselves. This is because life is so sparse that meals become very infrequent. Another radical adaptation found in the Angler Fishes is the presence of tiny males, parasitic on females. This eliminates searching for a mate in total darkness where the next individual of the species may be kilometres (miles) away. Three highly-adapted nektonic fish from mid-depth dark waters are shown in **Figure 14.11**.

The life on the bottom of the deep sea (benthos) is difficult to study and rarely seen. Just a few examples are highlighted here. The corals of deeper waters are generally the **soft corals**, these lack the limestone skeleton of the

Summary

Life in the deep sea is difficult to study but very interesting. Light fades rapidly with depth and as it does so eyes get larger and **bio-luminescent** organs appear. This is shown in the Hatchet and Lantern fishes. Deeper where darkness is total, organisms are usually black or red and eyes are reduced. Fish from great depths often have large mouths and leg-like fins, and crabs and lobsters have very long, thin legs and slender antennae. Snails and clams are very diverse.

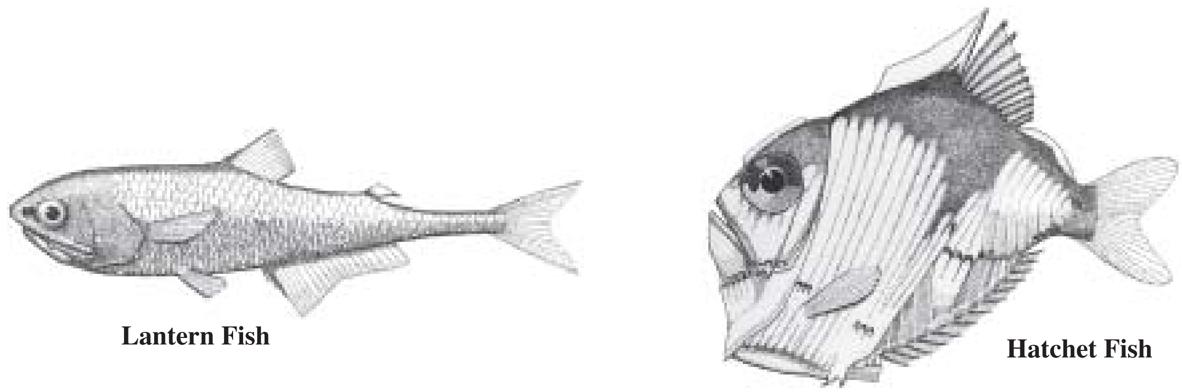


Figure 14.10. A typical Lantern Fish and Hatchet Fish

reef corals and have very long **polyps**. One of these, the Dandelion Coral (*Nidalia occidentalis*) is shown in **Figure 14.12.** Lobsters and crabs from deeper waters tend to have long slender legs and antennae. The Rosy Nephropsis *(Nephropsis rosea)* from the deep ocean bed and the Galatheoid Crab *(Munida simplex)* which inhabits deep, soft bottoms are shown in **Figure 14.12.** There are a wide variety of deep sea snails, one of those found at mid depths around Bermuda, Lightbourn's Murex (*Pterynotus lightbourni*) is named after the Bermudian collector Jack Lightbourn. It is illustrated in **Figure 14.12.** Also shown in **Figure 14.12** is the Oval Corbula (*Varicorbula operculata*), a clam, from sand at moderate depths. An example of a fish from quite deep locations is the Longsnout Scorpion Fish (*Pontinus castor*) (**Fig. 14.12**). Fishes from even deeper often have very elongated fins, almost like legs, to keep them above the very soft mud.

Pollution at Sea

Although the ocean is huge it is still noticeably polluted. Pollution from the land enters the ocean in rivers and runs off from the land. Additionally, in some places, wastes from land are dumped at sea and quite a lot originates from ships. Oil is a common oceanic pollutant and may come from either damaged tankers or be discharged from other ships. Although great efforts are made to stop this practice of discharging waste oil at sea, it still occurs. Oil floats on the water and is often driven ashore. Oil and tar-balls from oil, commonly wash up on Bermuda beaches. Plastic in the sea is proving to be very harmful to a variety of sea life. Plastic bags may be eaten by turtles or whales and may clog their digestive systems. Plastic rings from the tops of cans get stuck on ocean fish, birds and mammals and can kill them. Because of the inter-connected nature of the oceans and the huge currents of the ocean basins, floating and dissolved pollutants are spread over wide distances. A good example is DDT, an insecticide, which has been scarcely used for years, which has turned up in Antarctic wildlife, even though it has never been used there. A tin-based anti-fouling treatment for boats has caused reproductive problems in marine snails on a very wide basis. Radioactive materials from man's activities also pollute the oceans.

Summary

Pollution at sea is a real problem, ranging from floating oil through all kinds of plastic to dissolved toxic substances. Many of these pollutants are hazardous to marine life and very hard to clean up.

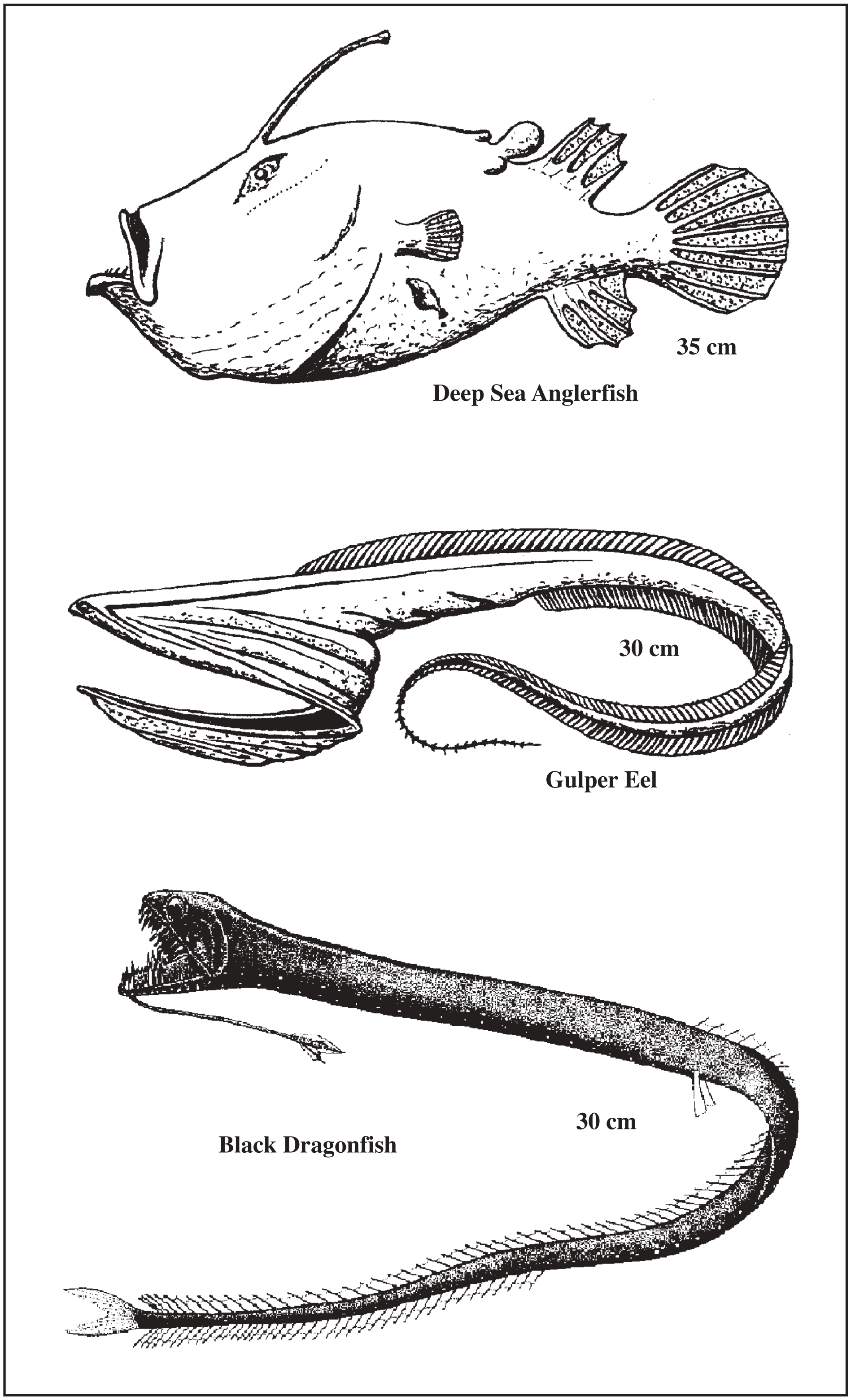


Figure 14.11. A deep-sea Anglerfish with attached, tiny male, a Gulper Eel and a Black Dragonfish.

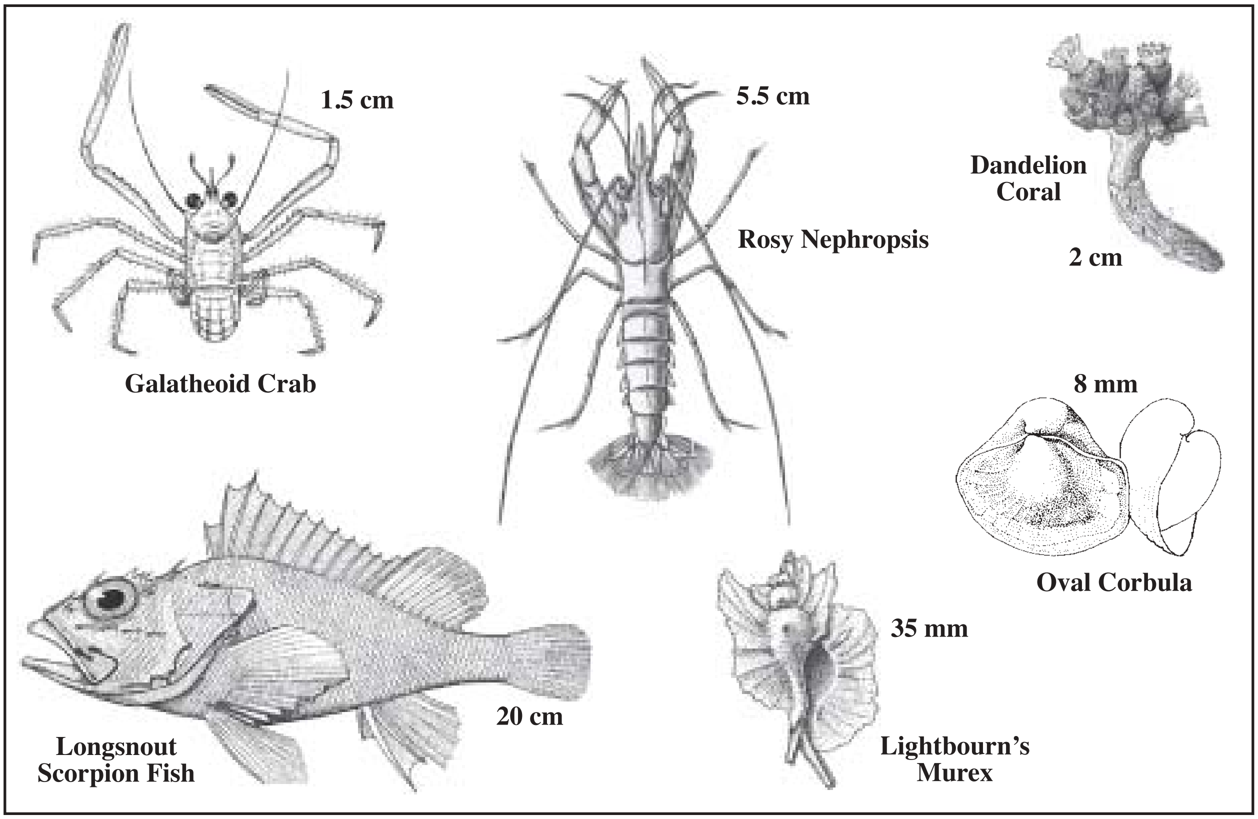


Figure 14.12. Examples of benthos from the deep sea.

Questions

1) About how much of the surface of the earth is covered by the oceans? ____________
2) Why are the oceans so important in regulating climate on land? ____________
3) Name two important differences between fresh and saltwater. ____________
4) Waves may be created in a variety of ways. What are two of these? ____________
5) What is a thermocline? ____________
6) Why is the deep water off Bermuda so cold? ____________
7) Which group of phytoplankton is characterised by a two-part silicon frustule (shell)? ____________
8) Which group of animals makes up the majority of the zooplankton? ____________
9) What are three inhabitants of the Sargasso Weed clumps? ____________
10) What is a Portuguese-Man-of-War? ____________
11) Where would you find the Common Purple Sea Snail? ____________
12) Name one oceanic fish found off Bermuda. ____________
13) Which of the whales is most often seen off Bermuda? ____________
14) What is the name of the oceanic turtle that is rarely seen close to shore? ____________
15) Which oceanic bird is endemic to Bermuda? ____________
16) What is one oceanic bird that is not a petrel that may be seen off Bermuda? ____________
17) What are two of the peculiar features seen in deep sea organisms? ____________
18) What are two sources of oceanic oil pollution? ____________
19) What harm do plastic bags do in the ocean? ____________

Field Trip # 14.1 to the Open Sea

Introduction

In Project Nature Field Guides we usually give specific locations for several field trips. When looking at the open ocean it does not really matter where you go around Bermuda. Just head a km (1/2 mile) or more beyond the reefs and you are there. It often pays to cruise around for a while as some of the things you would like to see may be quite scattered. For example patches of sargassum may be everywhere or quite sparse. At any rate try to find sargassum and stop among it. In the open sea, one does not normally anchor as it is too deep, just drifting in the chosen locality is best. Note that a drifting boat will show much more motion than when underway and this may bring on seasickness quite quickly. If any students are prone to seasickness, appropriate medication should be taken before the start of the field trip.

At certain times of the year, whales or seabirds may be commoner in specific locations. The group leader can enquire at the aquarium ahead of time to see what and at what locations sightings would be most likely. For example Humpback Whales are usually seen in March or April on their migration north. Shearwaters may be seen off the island from time to time or in migration. However, they will probably not approach the boat and good binoculars are needed to get a good view. Wilson's Storm Petrels may come close to the boat and can sometimes be attracted by throwing food overboard.

The Boat

Field Trips to the open ocean with young students must be very carefully planned and safety must always be at the forefront of preparations. Since a boat must be used it should be chosen carefully. Critical factors are its capacity in terms of passengers, its seaworthiness, its safety features and the experience and knowledge of the captain or operator. Although any good boat will be equipped with ship-to-shore radio, a cell phone should be carried in case a call to shore is needed. With this in mind, vessels run by the Bermuda Biological Station for Research or by the Bermuda Aquarium, Museum and Zoo offer advantages as they are used to this type of work and have knowledgeable employees as a back up. They also have some specialised equipment such as dip nets, plankton nets, depth sounders and secchi discs, which are almost essential to get the most out of a field trip

The weather is also critical and winter is best avoided.

If it is possible it is a good idea to take along an assistant who is familiar with shipboard practices and the equipment and techniques that are to be used. The vessel may supply such a person in some cases. Whoever the assistant is, make sure they go over the field trip in advance.

Clothing

At any season good waterproof and wind-proof clothing is a good idea; footwear should be selected that will get a good grip on the wet deck of a boat. A good healthy snack and plenty to drink should be carried.

Preparation

Before the field trip the material presented in this field guide should be gone over in as much detail as suits the age group of the students involved. This material is certainly more suited to more senior students, but all ages can get something out of it.

Equipment

The equipment needs can be divided into two groups: firstly the items the group should take and secondly those items that should be on the boat.

A) Group material.
   1) A notebook or clip-board and good, heavy paper and a HB pencil. Pencils are better in damp situations than pens.

2) Several wide-mouthed plastic jars are essential, the bigger the better.

3) A plastic ruler graduated in cm.

4) The largest, long-handled, fine mesh dip net that you have or can borrow. Two if possible.

5) Some plastic bags of various sizes.

6) A pair of tweezers.

7) Binoculars. One pair each is ideal otherwise one pair per every two students.

8) An unbreakable water thermometer.

9) A metre stick.

10) Several plastic pails.

11) Some waterproof card for labels. (Some card is laminated and will come apart, try a sample in water before the trip). (Labels are always placed inside bottles or bags)

12) At least one copy of the Project Nature guide to The Open Ocean around Bermuda.

13) If you have, or can borrow a refractometer type of salinometer, take it along.

B) Boat material.

1) A secchi disc. (This can be either white or in black and white quadrants). If it is not weighted, a good heavy weight such as a SCUBA divers belt weight is needed to help it drop straight and quickly. The line tied to the disc should be marked in m and be 50m or more in length. Alternatively a 50 m surveying tape can be used.

2) A phytoplankton net, preferably 1m in diameter at the mouth, but 50 cm would do. Phytoplankton nets are of very fine mesh, somewhere around 60-100μ mesh opening. The end of the net should be a plastic bottle which can be unscrewed and poured into a plastic bottle.

3) A zooplankton net, 50-100 cm at the mouth. These nets are coarser than the phytoplankton nets and designed to let the phytoplankton through while retaining the zooplankton. A 0.5 mm mesh size is satisfactory. If such a net is unavailable some zooplankton can be collected in a finer net.

4) A depth sounder to determine the depth at the sampling location(s).

5) A gaff-hook to retrieve floating objects.

6) Long-handled fine-mesh dip nets if not brought by the group.

Procedure.

A) Departure and along the way.

Note: The group leader should brief the captain on the objectives of the trip, preferred sampling location, equipment to be used etc. However, remember that the captain has the right to use another location if it is safer or to abort the trip in the case of bad weather or medical problems.

1) Check with the captain and board the vessel when he is ready for you.

2) Get the captain to go over safety and behaviour rules and point out all the safety equipment.

3) Sail to a chosen sampling location. This may take an hour or more, depending on starting location and chosen sampling site.

4) Some time en-route can be taken to go over what will be done, and who will do it, at the sampling location.

5) On the way look out for a) birds, b) whales or dolphins, c) sargassum rafts, d) floating garbage or oil., e) Portuguese Man-of-War, By-the-wind Sailors or other neuston. f) anything else of interest. Students should fill in the table below to record observations.

Organism or Object seen	Quantity	Location	Notes

6) Watch for changes in the weather or sea state. Get the wind direction and speed from the captain.

Wind direction ________________________ Speed ______________________________

B) On site (station)

1) Make sure everyone knows what is being done and who is doing it.

2) Estimate wave height and direction and wave length. These parameters can be difficult to measure. Wave height can be done with a metre stick if you are careful and thoughtful. Remember that the boat is going up and down too! Get the captain to give you the boat length and use it for wavelength (crest to crest). Make sure you do not mix imperial and metric measures. Things to think about here are;

   i) Are there just one set of waves coming from one direction?
   ii) If so are the waves coming down wind (wind driven).
   iii) If the wave situation is complex try to sort out at least two kinds. One should be wind-driven and smaller, the other swell and larger. If there is swell, where does it seem to be coming from? Think about the possible origin of the swell. Note your findings and ideas.

Wave height cm ____________________Wave Length m______________________

Number of sets of waves 1 ❒, 2 ❒, 3 ❒, more ❒.

Observations on the sea state ____

____

3) Take the water temperature in a bucket filled from the sea. Compare it to air temperature taken in the shade. Try to explain the difference. Think about the heat capacity of water and the season.

Water Temperature ____________C Air Temperature ________________C

Explanation for difference ____

____

4) Keep a look out for oceanic birds and whales. Note your observations.

Bird or Whale	Number	Distance Away	Notes

5) Scoop up a dip net full of sargassum and tip it into a bucket of fresh seawater. See what you can observe of the seaweed itself, things attached to it and things living among it.

Organism Seen	Where Observed	Quantity	Notes

6) Scoop up another batch of weed and holding it in your hands, shake it vigorously over a second bucket. This should dislodge some of the inhabitants, some of which can be quite surprising! These things were probably in the other lot of weed too, but probably were not seen. Why is this so? Think about camouflage and behaviour. Check the bottom of the net.

7) Repeat steps 5 and 6 to make sure you have a good sample

8) Identify all that you can. Students might like to sketch some of the organisms that you found.

Organism Seen	Where Observed	Quantity	Notes

9) Drop the secchi disc and note the depth at which it can no longer be seen. What living or non-living things in the water column will limit the depth at which the disc can be seen.

Secchi Disc Disappearance Depth ____________________m
Why does it disappear? ____

____

10) Note the water depth from the depth sounder. The captain will be able to show you how it works and how to read the depth.

Water Depth ________________________________ m ❐ or ft ❐

11) Note your position with relation to Bermuda. The captain can help with this too.

Position with relation to Bermuda ________________________________

12) If you are going to have a laboratory to follow the field trip take a good large bottle of clean seawater and cap it.

13) If you are going to have a laboratory to follow the field trip, put covers on the buckets if you have them. If the buckets have no covers get rid of half the water by straining it out through a dip net.

14) If you have a salinometer, check the salinity of the water, demonstrate the instrument and note the result. (Note: The best source for salinometers at a reasonable price are aquaculture supply companies.)

Salinity ______________________________ parts per thousand.

C) In the general location of the sampling location.

1) Get the captain to go as slowly as possible and get he or some knowledgeable person to use the phytoplankton net. It will be streamed 20 m or so astern while tied to the vessel. It is imperative that the vessel goes very slowly and this will probably entail putting the vessel in and out of gear to keep the speed down. 5 minutes is a good tow time. At the end of the sampling period haul back the net and wash the material stuck to the mesh down into the bottle. A seawater hose at low pressure, directed on to the outside of the net will help in this. Transfer the catch into a plastic jar. Label it, cap it and pass it round for inspection.

2) Repeat the procedure outlined above with the zooplankton net. This net can be towed considerably faster as the water passes through it more easily. Remember at this point that a sample taken at night would be richer. It would also be better to drag the net at a greater depth than the phytoplankton one. Weights or a special hydroplane, called a depressor, can be used to accomplish this.

3) If the samples are to be taken back for laboratory examination, put the bottles in a cool shady place, or the 'fridge, if there is one. On return to school or laboratory, either examine the catch immediately or refrigerate it overnight and look at it as soon as possible on the next day. If you are just going to look at the catch on the boat, do so carefully, noting what you can see, and then return it to the sea. Note that phytoplankton is mostly invisible to the naked eye and will show up as cloudiness in the bottle.

4) Cruise around for half an hour or so keeping a good lookout. Note sightings of any organisms or pollution.

5) Head home.

D) When fairly close to shore.

1) Have the boat stop.

2) Repeat the secchi disc observation.

   Secchi Disc Disappearance Depth ____________________m

3) Repeat wave height and length readings.

   Wave height cm ____________________Wave Length m ________________________

   Number of sets of waves 1 ❒, 2 ❒, 3 ❒, more ❒.

   Observations on the sea state ____
   ____

4) Try to explain differences in results. ____
   ____
   ____

Laboratory Work

Plankton

A) Equipment.

1) Eye droppers.
2) Microscope slides.
3) Cover glasses.
4) Mounted needles.
5) Petri dishes.
6) Compound microscopes.
7) Stereo microscopes.
8) As many copies of Project Nature, The Open Sea around Bermuda as possible.

B) Procedure

1) Put out the samples.

2) Students can get samples of either zooplankton or phytoplankton with the eye droppers.

3) For <u>phytoplankton</u> put a few drops of water on a slide and apply a cover glass, examine under a compound microscope. Adjusting the lighting will help to make the organisms visible. Identify from the illustrations in Project Nature The Open Sea around Bermuda. List those identified and draw several.

4) For <u>zooplankton</u> put a dropper-full in a petri dish of clean seawater. Examine under a stereo-microscope. Remember the animals are clear or nearly so. Careful observation is needed. Additionally they may still be alive and swimming. Identify from the illustrations in Project Nature, The Open Ocean around Bermuda. List those identified and draw several.

Sargassum Organisms

A) Equipment

1) Forceps.
2) Eye droppers.
3) Petri dishes.
4) Stereo microscopes.
5) As many copies of Project Nature, The Open Sea around Bermuda as possible.

B) Procedure Record results in a notebook.

1) Using the eye or a stereo-microscope as appropriate identify as many swimming or free-living organisms as possible. For the microscope use an eye dropper to get a sample. Some organisms may be quite small so suck up a sample from the bottom of the bucket. Identify from the illustrations in Project Nature The Open Sea around Bermuda. List those identified and draw several.

2) Break off a piece of sargassum and examine it using the stereo microscope. Look for attached organisms as well as those that crawl about clinging to the plant.

3) Look carefully at all the sargassum. Can you find both species? Sketch a piece of each pointing out the distinguishing characteristic.

Chapter 15. The Coral Reefs

Reef Forming Animals and Plants

Summary
The two main groups of organisms producing the coral reefs are corals and **crustose coralline algae**. The crustose coralline algae form sheet-like, pink layers on the surface of the reef. In Bermuda the algae are somewhat more important than the corals. Both of these organisms lay down huge amounts of limestone and produce very hard rock. **Boiler reefs** are made by crustose coralline algae and worm shells.

In warmer ocean waters than Bermuda's corals are the main coral reef building organisms, and they and their remains make up the vast majority of the reef structure. In Bermuda, however, hard corals although very important on the reef, are not the main living things that contribute to their structure. Perhaps more important than the corals are the **Crustose Coralline Algae**. These are really red seaweeds that grow in a sheet-like form on the rock surface. The one very important characteristic that they share with the corals is that they incorporate calcium carbonate into their tissues thereby forming solid limestone. Although they are red seaweeds, the large amount of white calcium carbonate in the tissues makes them a lovely pink colour. They may be hard to spot on the surface of the reef, as there is often a thin overgrowth of other tiny algae that mask the pink colour. Although corals are animals and algae are plants they both obtain their food energy by the same basic process, as we shall explore below. The surface texture of crustose coralline algae is not as pronounced as that of the corals, but the species diversity in this group of seaweeds is reflected in different growth patterns and colours. Some species form very smooth sheets, others are ornamented with bumps or ridges and yet others grow as a series of overlapping scales. Unlike the corals, they are exceedingly difficult to identify to species and we will just treat them as a group. Neither corals nor crustose coralline algae grow rapidly, but over time they lay down the massive limestone structure of the coral reefs. At times of rising sea level they can grow steadily upward to keep their position in bright light and thereby lay down hundreds of metres (ft) of solid limestone rock.

In addition to crustose coralline algae and corals, worm shells (Vermetid Snails) are also an important reef-building group. The role of reef construction in the boiler reefs of the south shore is principally taken by **worm shells** and Crustose Coralline Algae. The bulk of the limestone rock deposited in these reefs is made up of tiny worm shells in a matrix of crustose coralline algae. This type of reef is as hard or harder than the true coral reef and tends to occur in areas of very high wave action. Worm shells may also form reefs without the aid of crustose coralline algae, but these are usually in locations where wave action is low but currents rapid. Such reefs are rare in Bermuda, but do occur off Spanish Point at the entrance to Great Sound.

Reef Habitats

The corals and crustose coralline algae create the massive structure of the reefs, but they are patchy in their distribution, and grow at different rates, and into a wide variety of shapes. Because of this the reef is never a smooth structure, but very undulating and dissected by channels. There are many crevices, voids, caves and chambers on and within the reef. These create a structure of great physical diversity, which in turn gives a very large number of varied habitats. This physical diversity is very important in supporting the huge biological diversity of life on the reefs which will be described below.

While reefs are important in their own right it must be pointed out that they are important in creating other environments, habitats and ecosystems. Reefs are usually surrounded by

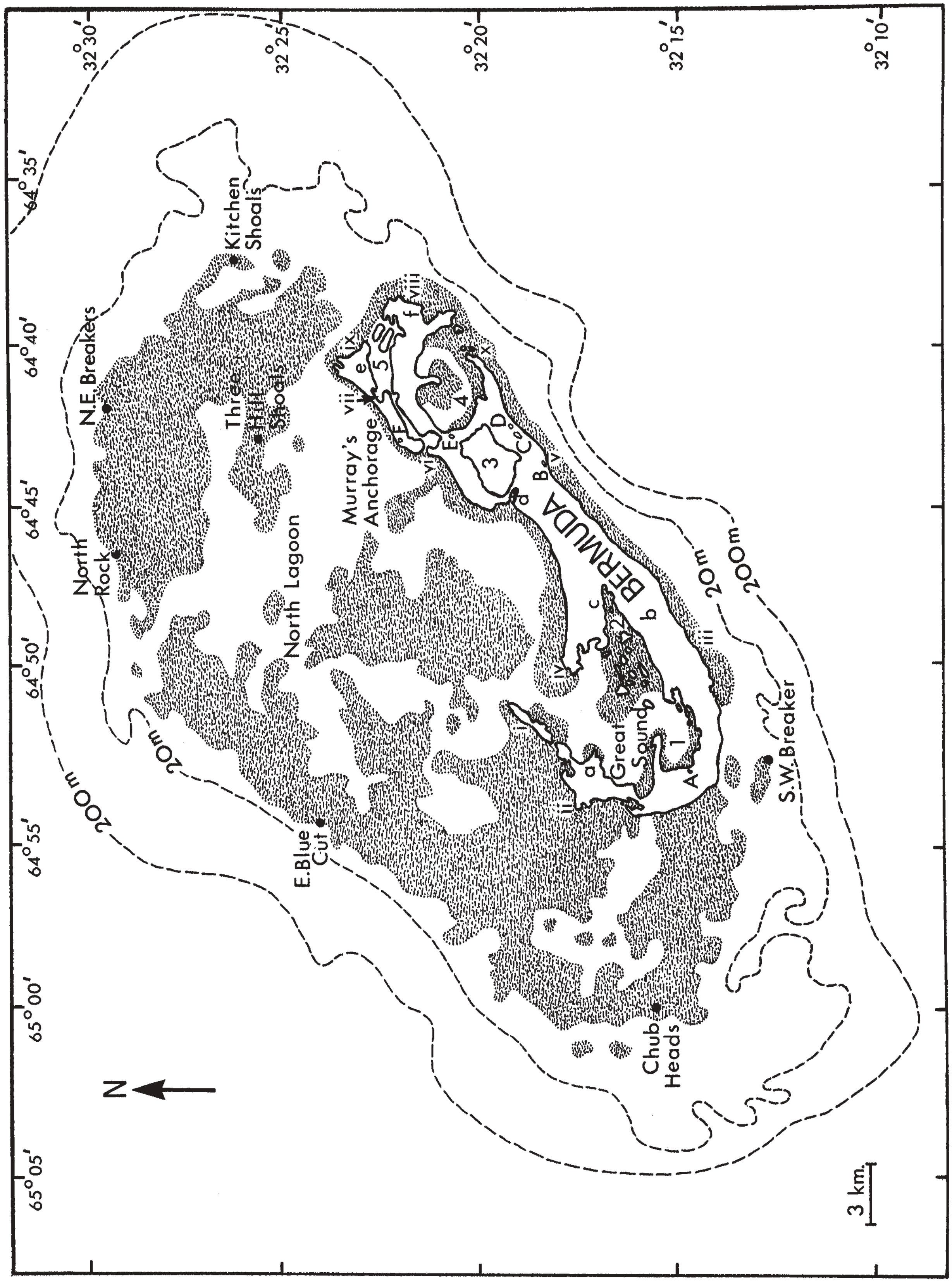

32°30'
32°25'
32°20'
32°15'
32°10'
64°35'
64°40'
64°45'
64°50'
64°55'
65°00'
65°05'
N.E. Breakers
Kitchen Shoals
Three Hill Shoals
North Rock
North Lagoon
Murray's Anchorage
BERMUDA
Great Sound
E. Blue Cut
Chub Heads
S.W. Breaker
20m
200m
N
3 km.

Figure 15.1. The distribution of the main reefs around Bermuda.

Key to Figure 15.1

PLACES

a. Somerset Village
b. Paget
c. City of Hamilton
d. Flatts Village
e. Town of St. George's
f. St. David's Village

SOUNDS AND HARBOURS

1. Little Sound
2. Hamilton Harbour
3. Harrington Sound
4. Castle Harbour
5. St. George's Harbour

SHORELINE LOCATIONS

i. Ireland Island
ii. Daniel's Head
iii. Stonehole Head and Bay
iv. Long Point
v. Spittal Pond
vi. Coney Island
vii. Mullet Bay
viii Great Head (St. David's Head)
ix. Alexandra Battery
x. Natural Arches

MARINE PONDS

A. Evans Pond
B. Spittal Pond (in Spittal Pond bird sanctuary)
C. Mangrove lake
D. Trotts Pond
E. Walsingham Pond (In Walsingham Trust)
F. Lovers Lake (In Ferry Point Park)

sedimentary areas that support their own community of organisms. Examination of these sediments shows that they are derived from reefs. Parrotfish grazing alone, supplies an enormous amount of sediment and this is augmented by other calcareous particles such as molluscan shells, sea urchin spines, foraminiferan tests, coralline algal fragments etc. Within the reefs, cavities, in a variety of sizes, support their own community of organisms and provide shelter for fish, lobsters, octopuses, etc.

Summary
Within the reef structure there are a great number of smaller **habitats** such as cavities, overhangs, shady areas etc. These provide living space for a wide variety of creatures.

The Corals

About 17 species of hard coral, the main reef building corals, are found on the reefs of Bermuda and to this array we must add one species of coral-like hydroid, The Fire Coral (*Millepora alcicornis*) which is remarkably similar to the true corals in most respects. All the corals are illustrated in the identification section of this book and just the main ones will be described here. The Brain Corals (*Diploria* spp), of which there are two species, are probably found in more reef habitats than any other. They are easily recognised by their hemispherical ridged surface. Some colonies are quite large. Also very common in a wide variety of coral reef habitats is the Mustard Coral (*Porites astreoides*) characterised by bumpy-surfaced colonies of a mustard-yellow colour. Another very widespread and important group of coral are the Star Corals, comprising the Small Star Coral (*Montastrea annularis*), the Great Star Coral (*Montastrea cavernosa*) and the Ten-ray Star Coral (*Madracis decactis*). The Small Star Coral is common on all the outer reefs as is the Ten-ray Star Coral. The Great Star Coral peaks in abundance on the rim reefs. The Small and Great Star Corals tend to form sheet-like colonies whereas the Ten Ray Star Coral forms a mass of brownish knobs. Proceeding in to the more sheltered lagoonal areas the Mustard Coral becomes most common followed by the Brain and Small Star Corals. In the even more sheltered inshore reefs and in Harrington Sound, we see the more delicate corals such as the Chinese Hat Coral (*Agaricia fragilis*) the Bush Corals (*Oculina* spp) and the Yellow Pencil Coral (*Madracis mirabilis*).

Summary
Two species of Brain Coral live on a wide variety of reefs together with the Fire Coral (a hydroid). Very important on all the outer reefs are the Star Corals of which there are three species. On reefs in more sheltered, near-shore areas, are found the more delicate Chinese Hat Coral, the Ivory Bush Coral and Pencil Coral.

The remaining corals illustrated in the identification part of this book, are less common but should be looked for. The Rose Coral (*Isophyllia sinuosa*) is a small widespread coral that is easily recognised by its bright colour which may be grey, green, white, yellow or brown to which may be added iridescent highlights!

The so called Fire Coral, which can sting if touched, is also very common and important in almost all coral reef habitats and is the main reef builder in a few highly wave beaten areas. It can be of almost any form and is a pale dusky ochre in colour, with a smooth texture.

The Variety of Coral Reefs in Bermuda

Introduction

The main distribution of reefs around Bermuda is shown by the dark areas on the map in **Figure 15.1**. A cross section of the Bermuda Platform shown in **Figure 15.2**, indicates where the reefs occur in relation to the land mass and to the lagoon.

Deep-water Reefs

The outermost reefs are on the **fore reef slope** situated in depths from 25-75 m (75-230 ft) around the outer edge of the Bermuda Platform. To the landward of this are the **main terrace**

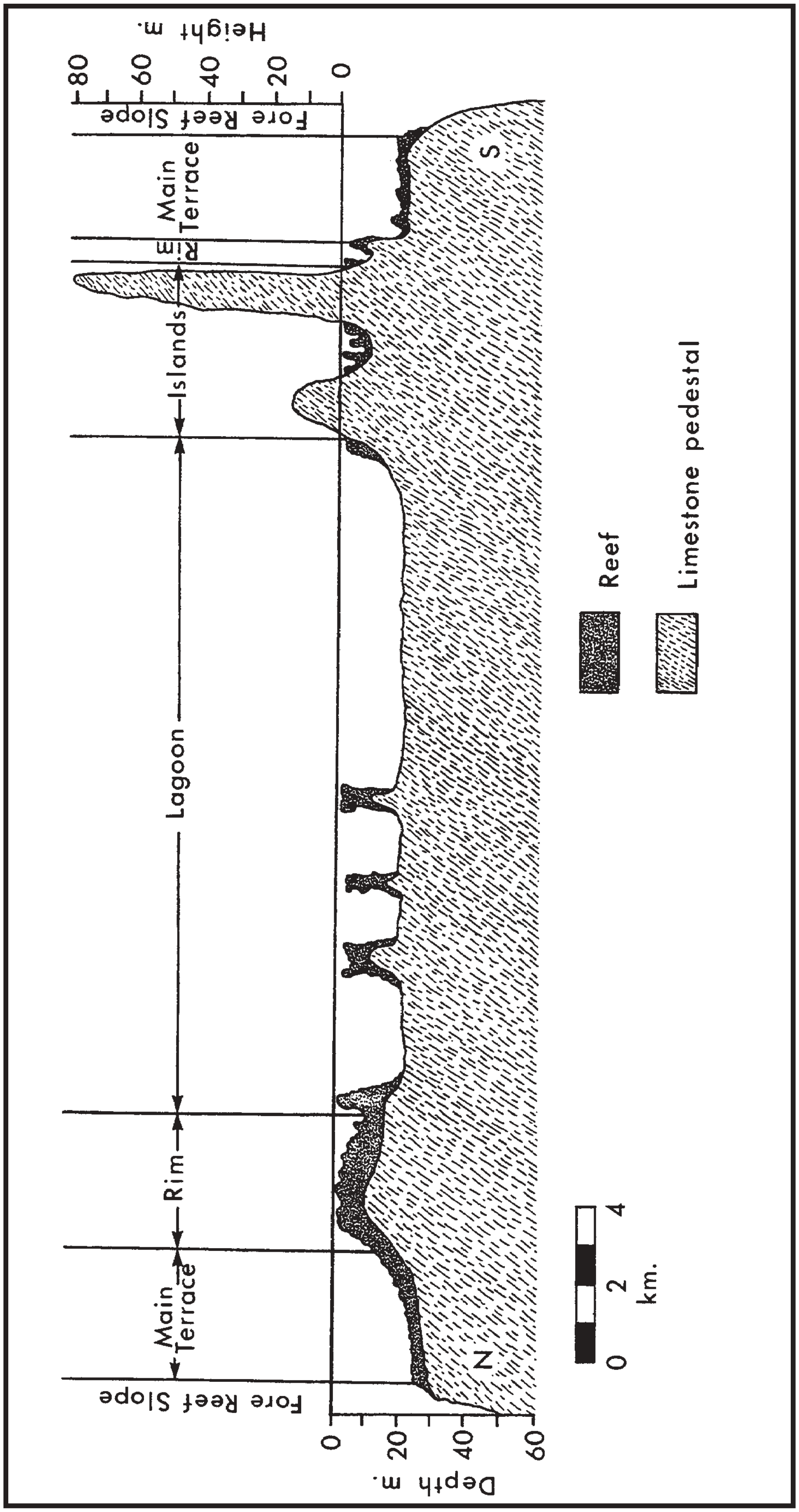


Figure 15.2. Cross section of the top of the Bermuda Platform showing the location of the main reefs in relation to the land mass.

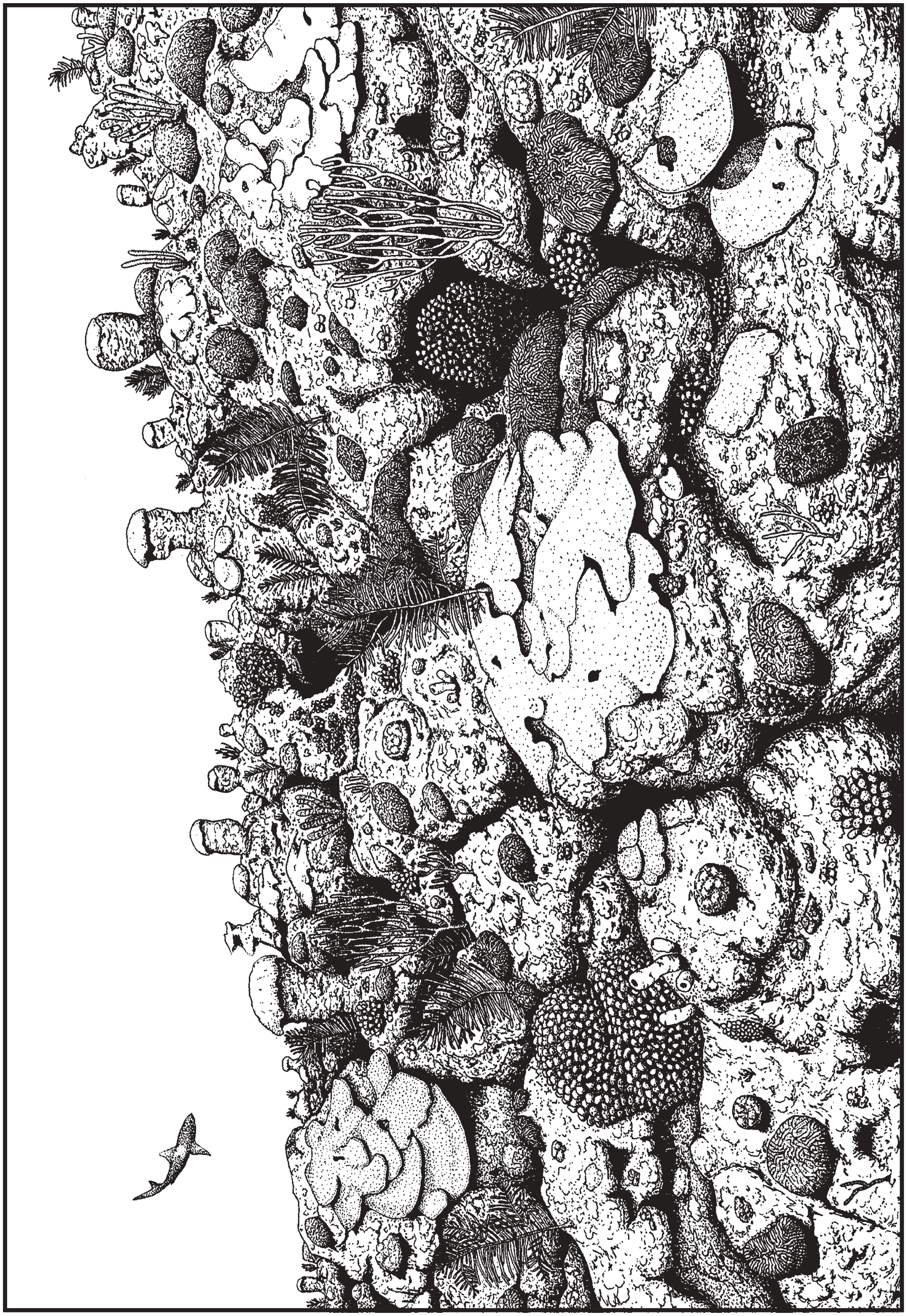
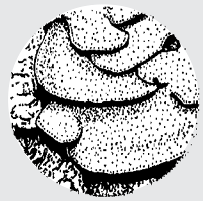


Figure 15.3. The Fore reef Slope reef at a depth of
30 m (100 ft) to the north of North Rock

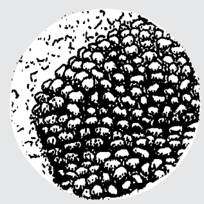
Key to Figure 15.3

Small Star Coral
Montastrea annularis

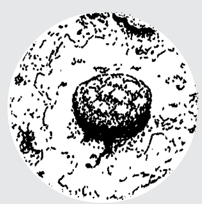


Common Brain Coral
Diploria strigosa

Ten-ray Star Coral
Madracis decactis



Mustard Coral
Porites astreoides



Sea Plume
Pseudopterogorgia americana

Porous Sea Rod
Pseudoplexaura porosa

Vase Sponge
Callysponga vaginalis

reefs at depths from 15-25 m (45-75 ft). Both of these areas are too deep for anyone but highly trained SCUBA divers to observe. Because of this limitation, details of the biology and structure of these reefs will not be given. However, it is important to appreciate their general characteristics.

Fore Reefs Slope Reefs

The deepest reefs of the fore reef slope have not been well studied, but it is known that the reef rock is laid down mainly by crustose coralline algae rather than corals. Hard corals are not abundant (only covering about 25% of the surface) but some soft corals are common. This reef type differs from more shallow ones in that fleshy brown seaweeds are common, showing that grazing is not as thorough as at shallower depths. In the shallower fore reef slope habitat the coral cover is greater with the Small Star Coral (*Montastrea annularis*) and the Ten Ray Star Coral (*Madracis decactis*) being most common followed by the Common Brain Coral (*Diploria strigosa*) and the Mustard Coral (*Porites astreoides*). **Figure 15.3** shows the shallow main terrace reef at a depth of 30 m (100 ft) to the north of North Rock.

Summary

The reefs of the **fore reef slope** are the deepest and **crustose coralline algae** predominate. Brain and Star Corals get commoner as the depth decreases.

Main Terrace Reefs

On the considerably shallower main terrace reefs the situation is markedly different. In terms of the quantity of coral present these reefs are the richest in Bermuda (as much as 50% coverage). Only on these reefs is the majority of deposition of limestone carried out by corals rather than crustose coralline algae. The main hard corals are the Common Brain Coral, the Small Star Coral, the Ten-ray Star Coral and the Mustard Coral. Soft corals are common as is the Vase Sponge (*Callyspongia vaginalis*).

Summary

The **main terrace reefs** are the richest in corals in Bermuda. Here the corals are more important than the **crustose coralline algae**. Brain Corals are the commonest here.

Shallow-water Reefs

Inside the main terrace, the following reef types are shallow enough to be explored using a mask and snorkel.

Rim Reefs

The **rim reefs** in 1 to 15 m (3-45 ft) of water around the rim of the Bermuda Platform are the best known and most often visited of all the coral reefs in Bermuda. These are the reefs which protect the land mass to the north, east and west from storm waves. They are readily visible from the air as one approaches or leaves Bermuda, and also easy to observe from a boat or when using mask and snorkel. The water over these reefs is usually quite clear, sometimes amazingly so, but there is often a strong current and/or wave surge that moves swimmers around. Once used to the conditions, they present no problems to good swimmers.

Summary

The **rim reefs** form the shallow reef tract around the N W and E side of Bermuda. Details of these reefs can be seen from the surface through the clear water. Brain Corals and the Great Star Coral are most common.

A drawing of rim reefs at the locality we suggest for a visit appears in **Figure 15.4**. Conditions for coral growth on these reefs are not as good as further offshore and only about 22% of the bottom is coral covered. As shown in the drawing, Brain Corals (*Diploria* species) are commonest followed by the Great Star Corals (*Montastrea cavernosa*) and the Mustard Coral. Sea whips and sea fans are very common members of the soft coral community. The sea fans are aligned so that the wave surge over the reef hits them broad side. This is an adaptation to filter feeding since it exposes the sea fan to the most water.

A very wide variety of fish is present with the Parrotfish being especially abundant.

Lagoonal Reefs

There is a wide variety of **lagoonal reef** types in North Lagoon; the main ones are listed below. The central and inner parts of the lagoon have mainly muddy bottoms and the reefs rise from the mud to the surface. Lagoonal reefs close to the Rim Reefs lie among sandy or sandy-mud bottoms. Often Lagoonal Reefs have very steep sides

Knob Reefs

These are the smallest reefs found in the lagoon. They are l-5 m (3-16 ft) wide and 1-3 m (3-9 ft) high. They consist of small groups of various corals rising out of the muddy lagoonal sediment.

Patch and Pinnacle Reefs

These are much larger than knob reefs and differ mainly in their heights, patch reefs being 3-6 m (9-20 ft) high and pinnacle reefs 6-20 m (20-65 ft) high above the sediment. Coral cover is generally quite low as only about 10-15% of the rock surface is coral covered. The main hard coral species are the same as on the rim reefs but their order of importance has changed with Mustard Coral being the most common followed in order by the Small Star Coral and the Brain Corals. Fire Coral is commoner here than further out to sea. Fish diversity and abundance is reduced in comparison with the Rim Reefs.

Summary

Shorewards of the **rim reefs**, and forming patches in the lagoon, are a wide variety of **lagoonal reefs.**. They range in size from small knob reefs through patch and pinnacle reefs to mini atoll reefs which have a circular shape.

Linear Reefs

These are elongated low reefs in shallow-water that follow ridges in the seabed. The corals are similar to those of the Patch Reefs.

Mini Atoll and Faro Reefs

These reefs form ring shaped structures in the outer part of North Lagoon. Small ones are Mini Atolls and larger ones Faros. They have a rim up to 20 m (65 ft) high around a sand-filled lagoon; in other aspects they resemble Patch Reefs.

Inshore Reefs

The best examples of **inshore reefs** can be found in Castle Harbour. Castle Harbour is a sheltered inland saltwater sound that can be visited even in quite windy weather. However, the disadvantage is that the visibility is quite poor because of sediment suspended in the water. Very little can be observed from the deck of a boat, but the use of mask and snorkel helps visibility, particularly if the swimmer can dive down a short distance

Fringing Reefs

These reefs lie parallel to the shore in 1-3 m (3-9 ft) of water. Good examples can be visited off the Blue Hole and Walsingham areas. These reefs are interesting in that they show the effect of increased sediment in the water. This was mentioned above when looking at coral ecology. The Fringing Reef of Castle Harbour shows the presence of many dead Brain Corals, some quite large. These died following the construction of the airport.

Knob and Pinnacle Reefs

These are similar in structure to reefs in N. Lagoon but support different types of coral. Ivory Bush Coral (*Oculina diffusa*) and Yellow Pencil and the Ten-ray Star Coral (*Madracis decactis*) are most common. The reason for this is connected with the high suspended sediment loads in Castle Harbour. Delicate branching corals like the Bush Finger, Pencil and Star corals are able to shed settled sediment more easily than their larger counterparts like the Brain Corals. Rose Corals are

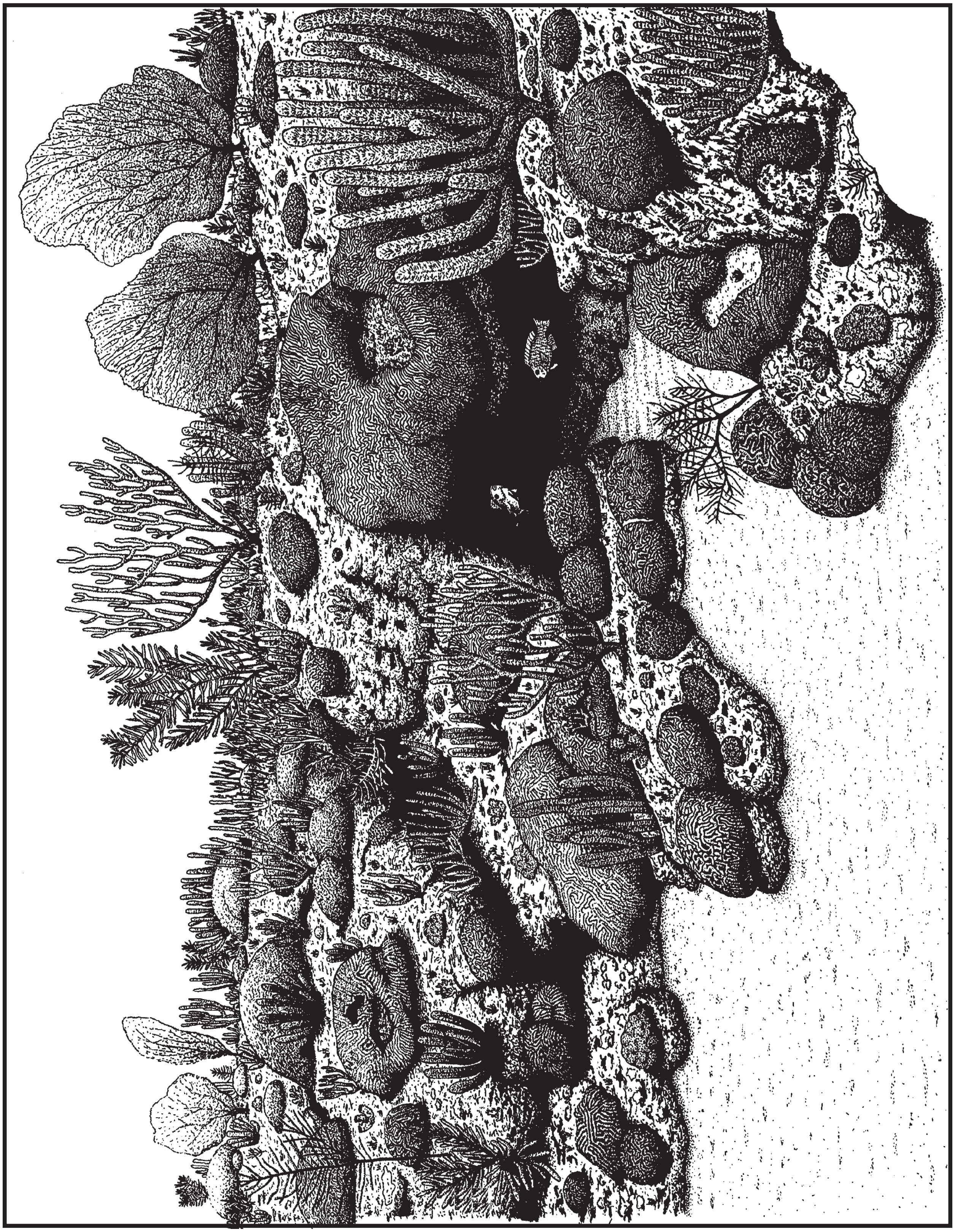


Figure 15.4. Underwater landscape of corals and soft corals on the rim reef at North Rock.

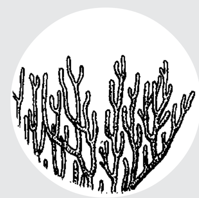
Key to Figure 15.4

Double-ridged Brain Coral
Diploria labyrinthiformis

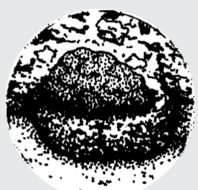
Purple Sea Fan
Gorgonia ventalina

Common Brain Coral
Diploria strigosa

Porous Sea Rod
Pseudoplexaura

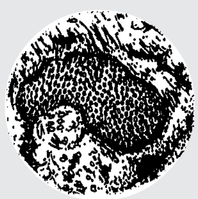


Mustard Coral
Porites astreoides



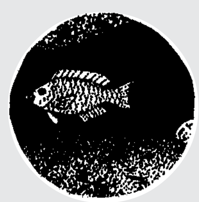
Dark Sea Rod
Eunicea tourneforti

Star Coral
Montastrea spp.



Sea Plume
Pseudopterogorgia americana

Parrotfish
Scariid



fairly common on the Knob and Pinnacle Reefs. Generally, corals are not abundant on these reefs and cover only about 12% of the rock surface. However there are a wide variety of red, green and brown seaweeds which are of considerable interest.

> **Summary**
> **Inshore reefs** occur in Castle Harbour and similar locations. They are not rich in corals, but support the more delicate species such as the Ivory Bush Coral and the Chinese Hat Coral. The Ten-ray Star Coral is also common here and Brain Corals persist but are smaller and less common.

Cup Reefs

The **cup reefs** are in the narrow band of reefs found along the south shore and are commonly called "**boilers**," because waves 'boil' over them almost continuously. They are quite hazardous to boats as they just reach the surface at low tide. Corals are not common on these reefs and they consist mainly of hard crustose coralline algae and the same kind of immobile worm shell (Vermetid snail) found commonly on the sea shores. Consequently these reefs are referred to as **Algal-Vermetid Reefs**. The worm shells found on the Cup Reefs and along wave-washed shores are the Corroding Worm Shell (*Dendropoma annulatus*). This is a tiny shell with an opening of only about 1 mm (1/20 in) but they occur in huge numbers of many thousand per m^2 (y^2). Together the algal mass and worm shells embedded in it form a very hard limestone. Cup Reefs are difficult to observe and are dangerous because of the constant wave action around them. They can only be safely observed in very calm conditions.

The cup reefs are a strange shape, rather like a wine glass (**Fig. 15.5**), being broadest at the top and narrowest at the bottom. Since the narrow bottom is further weakened by bioerosion and sand scouring, they very occasionally topple over in storms. Cup reefs vary greatly in diameter at the surface from about 1 m (3 ft) to at least 40 m (120 ft) and they often join together to form complex groups. A few very large, individual ones are found along the north shore beyond the Rim Reefs. **Figure 15.5** shows a typical cup reef as well as dead ones in deeper water that formed when sea level was lower. Structures on headlands along the south shore called **bio-constructional lips** are really like half a cup reef attached to the shore. Their structure is similar to the Cup Reefs further out as shown in **Figure 15.5.** There are also some **bio-constructional lips** scattered in the Rim Reefs where they show up as light coloured bands just below the surface at low tide.

> **Summary**
> The **cup reefs** of the south shore have few or no corals on them and are constructed by crustose coralline algae and small worm shells (Vermetid snails). These reefs, shaped like a wine glass are very hard.

Other Reefs

There are a few reefs off Spanish Point that are made up almost entirely of worm shells (vermetid snails). However, these Vermetid Reefs, or Worm Shell Reefs are constructed by the Large Tube Shell (*Serpulorbis decussatus*), a different species from the one responsible for building the boilers. The Large Tube Shell has a shell about 5 mm (3/8 in) in diameter that may be at least 10 cm (4 in) long. The reefs are very porous structures with the snail shells loosely cemented together. The reef structure is quite fragile in comparison with the coral and algal-vermetid reefs but its porous structure provides myriad habitats for small sea creatures.

> **Summary**
> Off Spanish Point there are a few unique reefs constructed of the shells of a large tube snail. These are **vermetid reefs**.

Coral Reef Ecology

Reef Dynamics

Although corals are animals, they really function more like plants in that they are able to use the energy of sunlight and carbon dioxide, to produce organic compounds which are their food. This is because of a **symbiotic** relationship, whereby brown algal cells from the phytoplankton (see

Chapter14) live within the corals. If you look at corals the brown colour of the algae is evident, even though the algal cells are too small to see individually. In essence, corals culture these algae, called **zooxanthellae** in their tissues. Light and some inorganic nutrients, particularly nitrogen, phosphorus and a range of trace elements are also needed by the algae. The corals supply carbon dioxide and these nutrients. This partnership is extremely efficient under most circumstances. The only time that it fails is under the stress of unusually warm seawater conditions, when corals may expel the zooxanthellae. This is known as **coral bleaching,** as corals become a lighter colour without their tiny plant associates. This bleaching does not necessarily kill corals, and when conditions improve they can get new zooxanthellae from the seawater. However, over extended periods of elevated water temperature, the corals may die.

Summary
Reefs are able to exist and grow rapidly because they have **symbiotic** algal cells in their tissues. These cells called **zooxanthellae**, create food for themselves and the corals by photosynthesis. In return the coral supplies shelter and plant **nutrients**. This relationship is efficient and makes the coral reefs one of the most **productive** ecosystems in the world.

Grazing

If you snorkel over the healthy rim reef at North Rock you will notice that there are few or no large seaweeds visible. If you fenced off a section of the reef so that no fish could get in, such seaweeds would very rapidly appear and grow. In time they would smother the corals and the crustose coralline algae, and the reef would cease to grow. The growth of seaweeds on coral reefs is normally kept in check by grazing animals. The most important of these are the parrotfish but other fish and various invertebrates also graze. In tropical countries where fisheries for reef fish, including parrotfish, have gone unchecked so that populations have been reduced to very low levels, the reefs have become virtually bare, just covered with seaweeds. Another aspect of grazing is that many of the crustose coralline algae need to be grazed to release their spores and enable these important plants to spread to new areas

Summary
Were it not for the constant grazing on the reef surface by Parrotfish and other **herbivores**, the reef would become overgrown with large seaweeds which would smother the corals.

Ecological Export from the Coral Reef

Although there are other symbiotic relationships among sea creatures, none are on the vast scale of the corals and the zooxanthellae. It is this relationship which has allowed the development of diverse, very productive communities in tropical shallow water. This enhanced productivity of the reefs extends well beyond them. Organisms and other products from the reefs spread into adjacent shallow waters providing food for other creatures. This phenomenon is called **ecological export**. The coral reef is the best example of an **export ecosystem**.

The Problem of Sediment in the Water

Since the presence of bright light is essential to hard coral growth, anything that reduces light will affect growth. Sediment in the water tends to reduce light by settling out on to the surface of the corals. Corals can remove this sediment by trapping it in mucus, and then moving it to the edge of the colony by ciliary action. Cilia are small hair-like projections on the coral surface that can beat in unison. Large flat or domed coral colonies, which are the most affected by sediment, are most common on the offshore reefs where sediment is less. As we move to inshore locations the most common corals are smaller species with knobby, finger-like or branching growth forms. These corals can shed sediment much more readily than the larger flatter ones.

Summary
Any sediment in the water over reefs reduces light penetration and settles on the surface of the corals. The corals can remove this, but in areas with high sediment loads, massive corals cannot grow.

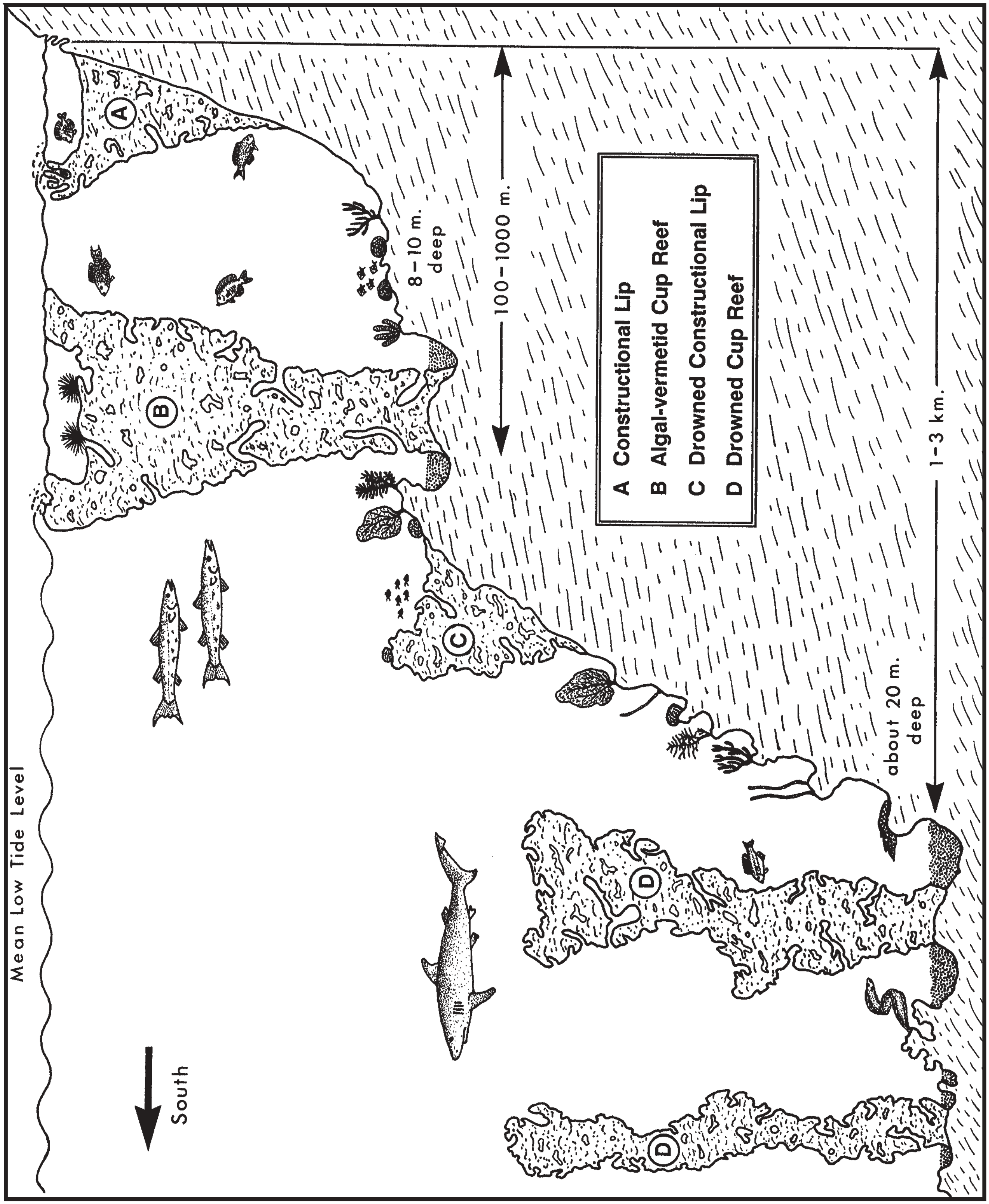

Mean Low Tide Level
South
8–10 m. deep
100–1000 m.
about 20 m. deep
1–3 km.
A Constructional Lip
B Algal-vermetid Cup Reef
C Drowned Constructional Lip
D Drowned Cup Reef
A
B
C
D
D

Figure 15.5. Idealised representation of present and former Cup or Boiler reefs off the south shore.

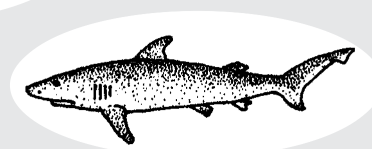
Key to Figure 15.5

Burrowing Urchin
Echinometra lucunter

Branching and fan gorgonaceans

Great Barracuda
Sphyraena barracuda

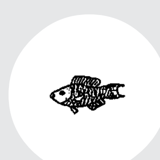
Bermuda Dusky Shark
Carcharhinus galapagensis



Moray Eel
Lycondontis sp.

Doctorfish
Acanthurus chirurgus

Parrotfish
Scariid



An interesting example of this is found in Castle Harbour, which once had very clear water for a coastal location and a good population of larger Brain Corals, before dredging was undertaken to build the airport during the Second World War. Dredging stirred up sediment and changed current patterns so that Castle Harbour has since remained murky. The large brain corals all died but a few smaller specimens survived and are now growing well.

Reproduction in Corals

Individual coral polyps can create new ones simply by dividing into two new individuals. This allows coral colonies to keep getting larger. However, this method would not allow the colonisation of new areas, which is accomplished by sexual reproduction. In this process eggs and sperm are released into the water where they unite to form a simple swimming larva. The process is made more efficient by synchronous spawning in which many individual colonies release eggs and sperm at the same time in response to a chemical stimulant released into the water. Coral larvae can be transported long distances in ocean currents and are stimulated to settle on the bottom when they encounter warm shallow water.

Summary
Corals grow when their **polyps** divide into two. New colonies are established through sexual reproduction, as swimming larvae can travel long distances.

Coral Aggression

Although corals are sessile creatures and would seem to be incapable of much direct interaction with one another, they often grow together and are then competing for space. Aggression occurs along the line of contact, where both corals produce filaments that can kill the tissues of the other. Some species of coral are more aggressive than others and normally succeed in stopping or even reversing growth of the other species. The more aggressive coral colony may overgrow the less aggressive one. Strangely, it is not the most abundant corals that are the strongest aggressors, so this process clearly does not determine coral dominance on the reef. Aggression has also been observed between anemones and corals.

Summary
Although corals cannot move around they can grow against each other. When they do, aggression takes place and the more vigorous aggressor can overgrow the other.

Coral Diseases

There are two principal diseases that attack corals in Bermuda. The most common of these is Black Band Disease which is typically seen on Brain Corals and Great and Small Star Corals. It can be recognised as a light coloured circular patch with a black edge. It is the black part that is the active disease site, the light area inside it is dead. This disease is caused by a Blue-green Cyanobacterium called *Phormidium corallyticum*. A second, less common disease is White Band Disease which appears as a white edged patch on Brain Corals. It is not known what causes this disease.

Summary
Several coral diseases attack corals in Bermuda; the commonest of these is black band disease caused by a **cyanobacterium.**

Soft Corals on the Coral Reef

Although the hard corals, along with the crustose coralline algae are the reef builders, there are also a wealth of soft corals, particularly on the outer reefs. These soft corals take the form of Sea whips, Sea Fans, Sea Rods and Sea Plumes, with their colonies taking the shapes suggested by the group names. They differ from hard corals in that the basic number of tentacles is eight rather than six. These soft corals are stiff but not hard, and form upright colonies that move in the surge of water across the reef.

Summary
Soft corals such as sea whips, sea fans and sea rods are very common on the reefs. They do not have **zooxanthellae** and feed by filtering particles from the water.

They have no zooxanthellae and feed by trapping tiny organisms or particles. They increase the structural diversity of the reef and act as a habitat for many other organisms.

Attached Animals on the Reefs

Although the hard and soft corals make up the bulk of attached animals on the reef there is a wide diversity of others including sponges, some of which bore into the rock, bivalve molluscs, anemones, hydroids, several worm shells, barnacles, moss animals, sea squirts etc. Common ones are illustrated in the identification section and have the habitat code of ‘C’.

Seaweeds and Blue-green Cyanobacteria of the Reefs

Although large seaweeds are uncommon on the reef as a result of grazing, it should not be assumed that there are none there. The non-living part of the reef is covered with a very short turf of algae, almost invisible to the naked eye. This turf grows rapidly and is important food for the grazing fish and invertebrates. Additionally, blue-green cyanobacteria can grow just within the surface of the rock. When parrotfish graze they actually remove the rock surface to get at this food source. They erode the reef and produce sand at the same time. **Figure 15.6** shows an enlarged drawing of part of the surface of a cup reef with the algal mat.

Summary
Although large seaweeds are rare on the reef, there is an almost continuous layer of tiny algae on surfaces not covered by corals. These algae are grazed by Parrotfish etc.

Crawling and Burrowing Life

A few crawling animals are seen on the reef including a variety of snails. The most spectacular of these is the Flamingo Tongue (*Cyphoma gibbosum*) sometimes seen on soft coral on which it preys. At night a variety of lobsters, crabs and shrimp wander over the reef. Sea urchins, sea cucumbers and starfish can be observed moving during the day, if one is patient.

The burrowing fauna of the reef is even more difficult to spot but is very diverse and important. Probably the easiest member of this group to spot is the Boring Barnacle (*Lithotrya dorsalis*); its presence is given away by a dark slit about 1cm (1/2 in) long frequently seen at the surface of corals. **Figure 10.6** shows some of the boring inhabitants of boiler reefs. A single coral head and the rock beneath it, if examined in detail could contain hundreds of individuals of many species.

Summary
Crawling animals are uncommon on the reef but there is a huge diversity of those that burrow and live in small cavities.

The biodiversity on the coral reef is among the highest for any ecosystem on Earth.

Coral Reef Fishes

There is no doubt that fishes play a prominent role on the reefs. They are diverse and quite abundant at nearly all sites. Additionally, they are easy and interesting to observe and not too difficult to identify. They are a vital part of the ecology of the reefs, important in recreational and commercial fisheries and have very interesting behaviour.

Generalist Fish found both on Coral Reefs and Elsewhere

There are a wide variety of fishes which you will see almost everywhere in Bermuda’s inshore waters.

Few will dispute that the Sergeant Major, affectionately known in Bermuda as the Cow Polly (*Abudefduf saxatilis*), is Bermuda’s most widespread fish. If there were a national fish, surely it would be this one! Whether you are looking in rock pools along the shore, gazing into the water

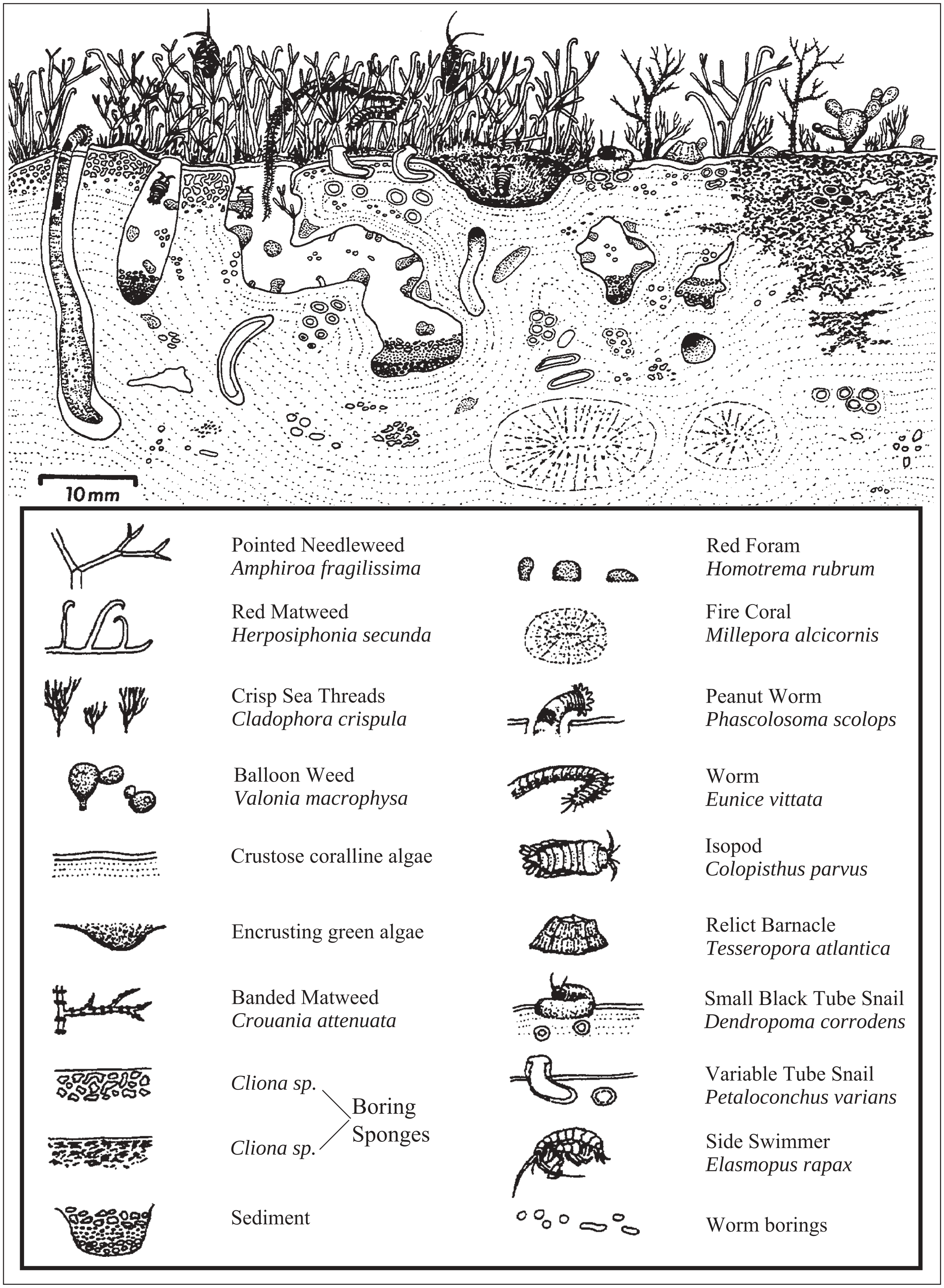


Figure 15.6. An enlarged drawing of a cross-section of part of the rim of a typical cup reef showing typical community species.

from a wharf, feeding the fish in Walsingham Pond, or snorkelling over the reefs, the Sergeant Major will be there in abundance. Additionally, they often nibble at swimmers, so their presence is hard to miss. The Sergeant Major is one of the damselfishes, and like others in this group, it has a very interesting breeding behaviour. First, the male carefully cleans an area, usually on a vertical rock surface or beneath an overhang, although a flat rock or even a sandy location may be used. The area cleaned may be up to 1 m (3 ft) across. When ready, the male attracts females by swimming in a loop up into the water. At this time, the male becomes a dark bluish-purple. Several females may be attracted but pair spawning is the rule. During spawning white blotches appear on both male and female. The eggs are laid in a mass on the sides of the cleaned rock, and then defended and ventilated by the male until they hatch and the young can go off alone. Sergeant Majors have a wide diet and often 'boil' at the surface around floating food.

Summary
A large group of fishes lives both on the coral reefs and elsewhere in coastal waters. These include such common fishes as the Sergeant Major, the Grunts, the Squirrelfish, Snappers, Butterfly Fish, Parrotfish, Wrasses and others. The Parrotfish are very important as grazers on the reefs. Many of these fish have interesting colour changes as they mature and others have very fascinating behaviour. There is a huge **diversity** of fish on the reef and they are easy to observe there.

Another exceedingly common group of fish found in a great many habitats and locations are the grunts. The French Grunt (*Haemulon flavolineatum*) is one of seven members of this family found in Bermuda. Wherever you go, on reefs, in bays, along the shore, or in some saltwater ponds, this species will be there, often in large numbers. The grunts get their name from a grinding sound made by teeth in the throat, that is amplified by the swim bladder. Grunts may form large schools, often with more than one species present. By day, they tend to be around reefs, rocks and other cover, but at night they disperse over sandy bottoms and grass beds to feed on small crustaceans.

Two of the eight species of squirrelfish found in Bermuda, also seem to be found almost everywhere, especially where there are cavities for hiding during the day. The squirrelfish are all nocturnal, but do appear during the day for short periods. All are reddish in colour and have large eyes. Both of these features are adaptations to feeding in dimly lighted water. The two commonest squirrelfish, the Longspine Squirrelfish (*Holocentrus rufus*) and the Squirrelfish (*Holocentrus ascensionis*), are frequent around wharves, along rocky coasts, in rocky areas of coastal bays, on reefs, in some saltwater ponds and often in caves some distance from the ocean. Another interesting habit of squirrelfish is that they can make a variety of sounds ranging through grunts, rattles and croaks.

The Grey Snapper (*Lutjanus griseus*) is another wide ranging fish. Large specimens of this grey-coloured fish are common under docks, on reefs and beyond. Whilst this fish is very common inshore during the summer they leave during the winter, presumably seeking the warmer offshore waters. Snappers are carnivorous, eating crustaceans and small fish, and they can make a tasty meal for humans too!

One of the most striking of the fishes, seen in a wide variety of habitats, is the Foureye Butterflyfish (*Chaetodon capistratus*). This small, very active fish cannot be mistaken for any other when looked at from the side. The body is flat from side to side and almost round in profile. There is a bold, black stripe through the eye and a large black spot at the base of the tail, hence the name foureye. It is thought that the black spot confuses predators, being mistaken for the real eye! It feeds on worm tentacles, coral polyps, etc. and is common around jetties, in larger tidal pools, along rocky shores and out to the reefs.

The parrotfish are a large, and very ecologically important group of fishes in all tropical waters. Parrotfish are typical of reef and rock bottom situations. Thirteen species have been recorded from Bermuda. Parrotfish in general are a tricky group to identify, as the colouration in juveniles and intermediate stages is frequently strikingly different from the fully mature adults. The species most likely to be encountered in many locations and habitats include the Striped Parrotfish (*Scarus croicensis*), the Stoplight Parrotfish (*Sparisoma viride*), the Queen Parrotfish (*Scarus vetula*), the Redband Parrotfish (*Sparisoma aurofrenatum*), the Redtail Parrotfish (*Sparisoma crysopterum*), and the Princess Parrotfish (*Scarus taeniopterus*). As a testament to their abundance, all these species are seen on 68% or more of all official fish surveys in Bermuda, at a wide variety of locations. The beak-like mouth, with which they scrape off algae, is the character that sets them apart. They vary widely in size; some, for example the Rainbow Parrotfish (*Scarus guacamaia*), reach 1 m (3 ft) long! Most of those seen commonly, 30 cm are (1 ft) or less in length.

Wrasses are a diverse group of marine fish that have evolved to occupy a very wide variety of habitats. Perhaps the most commonly observed is the Bluehead Wrasse (*Thalassoma bifasciatum*), which is discussed in more detail later. You will probably also notice the Spanish Hogfish (*Bodianus rufus*), but the fish just known as the Hogfish (*Lachnolaimus maximus*) is also frequently seen. Their food is varied but they are particularly fond of crustaceans, such as small crabs, which they can easily crush with their powerful jaws. Juvenile specimens often act as cleaners on larger fish. Like a variety of other fish, all hogfish start life as females, then when large, change sex to become males. A large male will have a harem of females, but pair spawning is the rule. The Spanish Hogfish spawns throughout the year, while the Hogfish spawns in winter, both species spawn at about an hour before sunset.

Another pair of fish of wide ranging habitat are the Bermuda Chub (*Kyphosus sectatrix*), and the Bermuda Bream (*Diplodus bermudensis*). Both of these fish are mid-water feeders. The Bermuda Bream is the smaller of the two, growing to 40 cm (16 in) while the Bermuda Chub can reach 76 cm (30 in) and a weight of up to 9 kg (20 lb). Both have relatively small heads and eyes, and are a dull silvery-grey in colour. They are sometimes seen in schools over reefs.

South shore bays, such as Church Bay, are excellent for looking at mixed schools of Ocean Surgeonfish (*Acanthurus bahianus*) and Doctorfish (*Acanthurus chirurgus*) along with their close relative in the doctorfish group, the Blue Tang (*Acanthurus coeruleus*). These fishes are deep in the body, and while the Surgeonfish and Doctorfish are a dull brown, the Blue Tang is a brilliant blue. They feed by nipping off tentacles and polyps of shoreline and reef creatures.

Some of the fishes ranging from bays to reefs have some interesting characteristics. One of these is the Sharpnose Puffer (*Canthigaster rostrata*), a charming little fish only about 12 cm (4 in) long, with a large head and tapering body. Dark mauve or brown above and white below, they are quite difficult to spot. Groups of these tiny puffers hang above the bottom, hovering and darting about like dragonflies. A close relative is the Bandtail Puffer (*Sphaeroides spengleri*). If disturbed, puffers gulp water and inflate like a balloon. The Porcupinefish (*Diodon hystrix*) lives in similar habitats to the puffers but is much larger. It, too, can inflate, but when it does so, numerous long spines appear! Another rotund fish that does not inflate is the Honeycomb Cowfish (*Acanthostracion polygonius*). It has two little horns between the eyes and a bulbous, very firm body, covered with blackish polygons on a cream background. The tail is large and set on a narrow stalk. Similar in shape and size but lacking the horns, the Smooth Trunkfish (*Lactophrys triqueter*) also has polygons on the body but less obviously displayed in a black background with light spots. The Porcupinefish, Cowfish and Smooth Trunkfish are solitary and feed along the bottom.

The prize for the most bizarre fish, might go to the Sharksucker or Remora (*Echeneis naucrates*), a very slim fish up to 1 m (3 ft) long, whose dorsal fin is modified to form an elaborate sucker on top of the head. As their name suggests, the Sharksucker uses its sucker to attach to sharks, rays or turtles, thereby hitching a free ride. Remoras can be seen swimming freely around, but they are usually in search of a host. They have been known to attach to many other things, including underwater cameras and even human swimmers! They are easily detached but an encounter can be quite surprising. They may act as cleaner fish on sharks but will also eat a wide variety of small fish and invertebrates.

Last, but not least, in this group of the most widespread fish, is the Blue Angelfish (*Holacanthus bermudensis*), one of the most beautiful of the Bermuda fishes. The Blue Angelfish is among only a very few fish whose diet consists primarily of sponges. Most sponges are packed with needle-sharp, silica spicules that resemble glass needles, but these apparently do no harm to the Angelfish. Another interesting feature is that they live in harems of one male and several females. If the male disappears, the largest female will change sex and take over the harem! This sort of sex change behaviour is quite common among the tropical marine fish. It may seem peculiar, but has great survival value in that it ensures that there are always plenty of females and that the less common males can be quickly replaced.

Specialist Fishes of the Reefs

Summary
A second, equally large and interesting group of fish are those that are uncommon except on the reefs. Some of these such as the Trumpet Fish are highly specialised and have unique behaviour. None of these reef fishes are really dangerous and sharks are very rare. Moray Eels sometimes bite if they are seriously disturbed but Barracuda's which have a bad reputation are harmless. Groupers have been important in reef fisheries but are now seriously reduced in abundance.

The widest variety of fishes is found on and around the reefs, and most locations have excellent examples. Outstanding sites for observing fish are Western Blue Cut and Eastern Blue Cut, both on the western reefs, and North Rock, on the northern reef. To the south, seas are usually rougher but on calm days a trip to the boiler reef tract can be most rewarding in terms of fish spotting.

People seem to expect that sharks will be a prominent part of the reef fish array, but the fact is that they are not. Many people who have spent countless hours watching fish on the reefs have never even seen a shark, so the chances of a visitor encountering one are extremely slight. Another interesting fish, totally characteristic of the reefs, is the Trumpet Fish (*Aulostomus maculatus*). This elongated fish, up to 1 m (3 ft) long but usually less, tends to hang motionless among the sea whips and fans where it is difficult to spot. When on the move, they swim horizontally. They can change colour with their surroundings, which makes seeing them an even more difficult task. While they normally feed by waiting out a holed-up fish, they also indulge in much more complex feeding behaviours. One of these is shadow feeding, whereby the Trumpet Fish 'shadows' another predator by lying very close to it and matching its colour. It may do this with morays, groupers, hogfish and others. A most interesting fact is that Trumpetfish also shadow stalks with herbivorous fishes, particularly the parrotfish. In this case, they are exploiting the fact that other fishes do not move away as parrotfish approach, since parrotfish would never attack. At any rate, Trumpetfish usually get their intended prey.

The moray eels are another group of characteristic reef fish. There are several species, among which the Green Moray (*Gymnothorax funebris*), Spotted Moray (*Gymnothorax moringa*) and Purplemouth Moray (*Gymnothorax vicinus*) are the most frequently seen. Actually, all the morays are nocturnal and difficult to find by day, as they hide in deep holes. These fish have a reputation for biting, but are actually very retiring and normally only bite if their lair is threatened. Moray Eels hunt mainly by smell but are very efficient predators; other fish have learned this, and groups of fish may shadow morays in the hope of getting a meal. Sometimes, a group of several other fish follow a single Moray Eel.

Adult Great Barracuda(*Sphyraena barracuda*) up to 2 m (6 ft) long are seen regularly around the reefs. They have a reputation for being aggressive, but there are no recorded attacks on humans, by Barracuda in Bermuda. Sometimes they do swim back and forth in front of swimmers as if barring the way. Perhaps in this case it is better to turn back, but probably the Barracuda would retreat if one went ahead.

The groupers are a diverse group of fishes, many of which live on reefs. The grouper most commonly observed on the reefs of Bermuda is the Coney (*Cephalopholis fulva*), a smaller member of the family. The Coney reaches about 25 cm (10 in) long. The Coney is a prized food fish now that larger groupers have been over-fished (See below). Several other members of the grouper family are reef inhabitants; these include the Yellowfin Grouper (*Mycteroperca venenosa*), Black Rockfish (*Mycteroperca bonaci*), Yellowmouth Grouper (*Mycteroperca interstitialis*) and the Graysby (*Cephalopholis cruentata*). All these groupers are bottom feeding carnivores. The name, grouper, comes from the fact that these fishes aggregate in specific areas for spawning. This has led to over fishing in the past, but now these spawning areas are mostly well known and are closed to fishing at spawning time. Nevertheless the groupers are a much less common group of fish in Bermuda than they once were.

The critical role of the grazing fish in maintaining reef health has already been mentioned. The key group of fish in this process are the parrotfish, although damselfishes also play a part. Parrotfish, as a group, occur in all the fish habitats, but are particularly prominent on the reef. Wherever you go, you will be able to observe these reef cleaners at work. Their beak-like mouth is ideally designed to scrape algae off the rock surface. Indeed, they are so thorough that they take a thin layer of rock with the seaweeds! The digestive process removes the plant material and the ground rock is eliminated as waste. Thus, at the same time, they clean the reef and maintain the sandy environment around it. The largest parrotfish on the reef is the Midnight Parrotfish (*Scarus coelestinus*); other common ones are the Stoplight Parrotfish, Blue Parrotfish (*Scarus coeruleus*) and the Rainbow Parrotfish. Parrotfish undergo a bewildering series of colour changes as they grow, making identification a difficult task. These fish generally swim either singly or in loose schools, consisting of a number of females, accompanied by one terminal male. All Parrotfish start off as females but some finish life as males. Despite the fact that these fish are abundant and well studied, their breeding biology is poorly understood. Parrotfish are diurnal feeders and at night they retire into reef cavities, where they sleep in a ‘cocoon’ of mucus.

The wrasses are another group of fish that have many colour phases. Bluehead Wrasse (*Thalassoma bifasciatum*) are small 15 cm (6 in), slender little fish that are very common in schools on the reefs. Spawning is a daily occurrence, in the early afternoon, that varies with the number of wrasse present. Where fewer individuals are present, Bluehead Wrasse spawn in pairs, but as numbers grow, group spawning becomes the normal method. In all situations, it is the terminal male that controls the situation. Another reasonably common wrasse is the Yellowhead Wrasse (*Halichoeres garnoti*), about the same size as the Bluehead, but much less gregarious. Another interesting small wrasse, common over the reefs, is the Creole Wrasse (*Clepticus parrae*). The Creole Wrasse, unlike the others, is not associated with the bottom but is always up in the water column, where it feeds on animal plankton. The juvenile Creole Wrasse are often confused with the Blue Chromis (*Chromis cyaneus*), which, although it is a damselfish, has the same slim shape as the Creole Wrasse and is bright blue. These two fish often swim and feed together. A fourth member of the wrasse family is the Puddingwife (*Halichoeres radiatus*). It is much larger than the Bluehead and Yellowhead and is a very curious fish, often following divers and snorkellers.

On the reef, several damselfish are quite common; one the Sergeant Major has already been mentioned. Others found on the reef include the Blue Chromis, the Beaugregory, (*Stegastes leucostictus*), Cocoa Damselfish (*Stegastes variabilis*) and the Three-spot Damselfish (*Stegastes planifrons*). In common with the Parrotfish and the wrasses, these energetic fish also exhibit colour changes. Damselfish are territorial and defend both feeding and breeding sites.

A favourite fish of many fish enthusiasts is the angelfish; there are two common ones on the reefs, the Blue Angelfish, already introduced above, and the Townsend Angelfish. The Townsend Angelfish is a hybrid between the Queen Angelfish (*Holacanthus ciliaris*) and the Blue Angelfish. Curiously, the Queen Angelfish is quite rare, so perhaps the Townsends breed true. The males of both species defend breeding territories.

The triggerfish are about the same size as the angelfish, but are much less deep in the body and have eyes set back on a long sloping forehead. Several species occur but the Queen Triggerfish

(*Balistes vetula*) is the most striking. Few fish eat sea urchins but the Triggerfish is an exception; they pick up the prey by the spines, flip it over and then attack the unprotected area around the mouth.

Reef Fisheries

Ever since Bermuda was settled, the reef fish have been exploited for food, and for most of this period, the main method of catching them was the 'fish pot'. Fish pots were large; mesh traps that were not at all selective, except that very small fish could escape through the mesh. The fish pots were often not checked daily and some fish died in them or were eaten by others. Other pots lost their marker buoys and could not be retrieved, but they nevertheless continued to trap fish! Because the traps were not selective, all species of fish were captured, but only some were used, the by-catch being sacrificed. As a consequence, fish stocks suffered. Fish pots were banned in 1990 and studies since suggest that some of the over-fished species may be recovering. Certainly, Bermuda has fared better than many Caribbean islands, where fish populations have been reduced to very low levels. There, coral reef health has declined because of the lack of grazing fishes, particularly the parrotfish. Under such circumstances, seaweeds smother the reef, resulting in the death of corals and other reef fauna. The entire reef diversity declines rapidly and reefs come to resemble algae-filled wastelands!

Summary
Commercial fishing for many reef fish has been greatly reduced in recent years. This has kept the numbers of fishes such as Parrotfishes from declining, but others, including many of the Grouper family have been seriously reduced and are not recovering as quickly as was hoped.

Groupers are a prized table fish and many species have been reduced to low numbers. In the past, Black and Nassau Groupers (*Epinephelus striatus*) were most prized and made up the bulk of the catch. As these declined, smaller species were sought, such as the Red Hind (*Epinephelus guttatus*). In 1983, Red Hind constituted over 50% of the grouper catch and subsequently, it too, declined. This led to higher catches of the small species, such as the Coney and the Creole fish or Barber (*Paranthias furcifer*), which in their turn, rose to be the majority of the catch. Despite a low bag limit on the most prized species of groupers, populations have not recovered significantly, although Black Rockfish are perhaps showing some signs of recovery. Some, such as the Mutton Hamlet (*Alphestes afer*), Gag Grouper (*Myctoperca microlepis*) and Tiger Grouper (*Myctoperca tigris*) are now locally extirpated.

Pollution and Conservation Concerns

Coral reefs all over the world are in a state of decline or under stress. There are many reasons for this, but the main ones are pollution, over fishing, mechanical disturbance, habitat change and global warming.

Pollution affects all parts of the world's oceans and pollution from far away impinges on Bermudas coral reefs. Chemical pollutants in the ocean get diluted and their effects are often quite subtle. Nevertheless over time, we see changes in diversity as species wax and wane as well as changes in indicators such as growth rate. Sewage pollution of reefs is a particular concern in Bermuda as huge volumes of raw sewage enter the sea off Hungry Bay on the south shore. An area around the outfall has seen changes in fish populations as well as diversity of other species.

Summary
Coral reef pollution and conservation are serious concerns as coral reefs throughout the world are generally declining. All types of pollution affect the reef, and wrecks and boat anchoring can destroy the surface. Global warming is also having harmful side effects.

Over-fishing of coral reef fishes has already been mentioned in relation to the importance of grazing. A high level of grazing by Parrotfish and other animals on the reef is essential for reef health. If these fishes are reduced in abundance by over fishing, seaweeds soon grow and smother the reef, killing corals and greatly reducing overall biodiversity and productivity. This has been observed in several Caribbean areas as well as elsewhere around the world. Over-fishing also leads to declines of other reef fish populations, as mentioned above.

Mechanical damage to reefs occurs when ships are wrecked, when anchor lines and mooring lines are dragged over the reef, when ship channels are created, when navigation aids are installed and in very intense storms. Most of these effects can be minimised by careful planning and common sense.

Habitat change or disturbance may be the result of any of the above factors, or from small but significant changes in the reef environment. Some of these merely result in a change but others lead to degradation of the reef ecosystem.

The matter of global warming or climate change is perhaps not a polluting factor. However man's activities have had a role in climate change and changing sea level temperatures certainly affect the coral reef ecosystem. As an example, warmer than normal water temperatures cause corals to expel their zooxanthellae. Although this is usually not a lethal effect, it does slow down coral growth and reduces total productivity of the reef.

Questions

1) What do corals and pigmented plants have in common? ______
2) Why is symbiosis so important on the coral reef? ______
3) Name two very important things that Parrotfish do. ______
4) What two group of organisms are mainly responsible for building the coral reefs at North Rock? ______
5) How do the Boiler Reefs of the South Shore differ from all the others? ______
6) Why is sediment in the water a problem for large, hard corals? ______
7) Name one carnivore and one herbivore found on the coral reefs. ______
8) What is the main cause of the dead Brain Corals on the Fringing Reef In Castle Harbour? ______
9) Why is sediment in the water only a small problem for small or branching corals? ______
10) Why are the waters of the south shore of Bermuda so much rougher than those of the other shores? ______
11) Describe the appearance and behaviour of one fish that is found only on coral reefs. ______
12) Name two species of fish that are found both on the coral reefs and in bays. ______
13) How do corals reproduce? ______
14) Name two species of coral found in Bermuda ______
15) What are two forms of pollution that stress coral reefs. ______
16) Name one coral disease. ______
17) Are sharks a threat to humans on the coral reefs around Bermuda?______
18) What is the name of one group of fish other than the Parrotfish which have been over-fished on reefs? ______
19) What is the name of the deepest reef tract around Bermuda? ______
20) What are the names of two smaller habitats that are found on the rim reef general habitat? ______

Field Trip # 15.1 to the North Rock Reef

General
North Rock is a Rim Reef location: other places on the Rim Reefs could be substituted, however North Rock is the best Rim Reef destination if setting off from the Aquarium or the Biological Station. Bear in mind that North Rock is 15 km (11 mi) away from the coast and that it will take a good hour to get there. There can also be heavy surge at North Rock, particularly in northerly winds. It is best to go in settled weather with light southerly winds.

Preparation
Read this field guide. If possible visit the Aquarium and practice identifying reef creatures especially corals and fish. Go over all organisational and safety features. Practice swimming with a mask, flippers and snorkel in a shallow water location.

Dress
Whatever the weather be prepared for cooler, wetter conditions. Windproof and waterproof outerwear is a good idea. If possible buy or borrow a thin wet suit jacket or body-surfing suit that fits well. Take mask, snorkel and flippers. Pack a good, large towel.

Equipment
No special equipment is required but students should have some way of making notes after they exit the water.

Observations
1) Try to list as many groups of living things that are seen. E.g. Hard Corals, Soft Corals, Fish, Red Seaweeds etc.

a) ____________________ b) ____________________
c) ____________________ d) ____________________
e) ____________________ f) ____________________
g) ____________________ h) ____________________

2) Try to identify and list as many hard corals as possible. Start with the most abundant.

a) ____________________ b) ____________________
c) ____________________ d) ____________________
e) ____________________ f) ____________________
g) ____________________ h) ____________________

3) Try to identify and list as many fish species as possible.

a) ____________________ b) ____________________
c) ____________________ d) ____________________
e) ____________________ f) ____________________
g) ____________________ h) ____________________

4) Look for and describe some examples of fish behaviour that were observed. For example look for examples of feeding or aggression.

Fish Species	Observations on Behaviour

5) Look at the sea fans to see if they grow in a particular orientation. ____________________

____

6) Make a list, by group, of any animals or plants, other than hard corals and fish, that could be identified. Include coral diseases if observed. ____________________

____

Group	Species 1	Species 2	Species 3	Species 4

Field Trip # 15.2 to the Castle Harbour Reefs

General

The Castle Harbour reefs are less interesting than those further out to sea; they have a much lower biodiversity and the visibility in the water is not very good. To keep up the interest, try to visit both a Pinnacle Reef and the Fringing Reef off Walsingham. The weather is not generally a big problem in Castle Harbour, but still, the calmer the better.

Preparation

Read this field guide. If possible visit the Aquarium and practice identifying reef creatures especially corals and fish. Go over all organisational and safety features. Practice swimming with a mask, flippers and snorkel in a shallow water location.

Dress

Whatever the weather be prepared for cooler, wetter conditions. Windproof and waterproof outerwear is a good idea. If possible get or borrow a thin wet suit jacket or body-surfing suit that fits well. Take mask, snorkel and flippers. Pack a good, large towel.

Equipment

No special equipment is required but students should have some way of making notes after they exit the water. Take as many copies of this field guide as possible.

Observations

1) Try to list as many groups of living things that are seen. E.g. Hard Corals, Soft Corals, Fish, Red Seaweeds etc.

a) ______________________ b) ______________________
c) ______________________ d) ______________________
e) ______________________ f) ______________________
g) ______________________ h) ______________________

2) Try to identify and list as many hard corals as possible. Start with the most abundant.

a) ______________________ b) ______________________
c) ______________________ d) ______________________
e) ______________________ f) ______________________
g) ______________________ h) ______________________

3) Try to identify and list as many fish species as possible.

a) ______________________ b) ______________________
c) ______________________ d) ______________________
e) ______________________ f) ______________________
g) ______________________ h) ______________________

4) Look for and describe some examples of fish behaviour that were observed. For example look for examples of feeding or aggression.

Fish Species	Observations on Behaviour

5) Make a list, by group, of any animals or plants, other than hard corals and fish, that could be identified. Include coral diseases if observed.

Group	Species 1	Species 2	Species 3	Species 4

6) If you go to more than one reef, name the types of reef and summarise the differences between them.

Reef Type	Observations

Field Trip # 15.3 to the South Shore Reefs

General

The reefs of the south shore can be very wave beaten and the area should be avoided for boat trips in all but calm weather. A lack of wind is no guarantee of calm conditions on the south shore, as large rollers can come in under any conditions. Do not get in the water around Boiler Reefs unless it is calm enough that no water breaks over them at low tide. Water clarity is usually excellent. Two types of reef can be seen in reasonably shallow water. These are 1) so-called Platform Reefs on fairly level bottom that are quite similar to the Rim Reefs and 2) Cup or Boiler Reefs.

Preparation

Read this field guide. If possible visit the Aquarium and practice identifying reef creatures especially corals and fish. Go over all organisational and safety features. Practice swimming with a mask, flippers and snorkel in a shallow water location.

Dress

Whatever the weather, be prepared for cooler, wetter conditions. Windproof and waterproof outerwear is a good idea. If possible get or borrow a thin wet suit jacket or body-surfing suit that fits well. Take mask, snorkel and flippers. Pack a good, large towel.

Equipment

No special equipment is required but students should have some way of making notes after they exit the water. Take as many copies of this field guide as possible.

1) Observations

a) ____________________ b) ____________________
c) ____________________ d) ____________________
e) ____________________ f) ____________________
g) ____________________ h) ____________________

2) Try to identify and list as many hard corals as possible. Start with the most abundant.

a) ____________________ b) ____________________
c) ____________________ d) ____________________
e) ____________________ f) ____________________
g) ____________________ h) ____________________

3) Try to identify and list as many fish species as possible.

a) ____________________ b) ____________________
c) ____________________ d) ____________________
e) ____________________ f) ____________________
g) ____________________ h) ____________________

4) Look for and describe some examples of fish behaviour that were observed. For example look for examples of feeding or aggression.

Fish Species	Observations on Behaviour

5) Make a list, by group, of any animals or plants, other than hard corals and fish, that could be identified. Include coral diseases if observed.

Group	Species 1	Species 2	Species 3	Species 4

6) If you go to more than one reef, name the types of reef and summarise the differences between them.

Reef Type	Observations

Chapter 16. Lagoons, Bays and Coastal Waters

Shallow-water Habitats

Introduction

Sheltered bays and seagrass beds are all sedimentary environments; most are sandy but a few are muddy. The characteristics of sediments, how they are formed, moved and deposited are described in the introductory section of this book. In this chapter the sedimentary environment will be considered in more detail.

Summary

Shallow coastal situations and bays are all sedimentary habitats. They support many burrowing organisms which cannot be seen. Seagrass beds are a common feature of these environments. It is best to observe these locations by swimming with a mask and snorkel.

The presence of sediment means that a community of burrowing organisms is likely to be present. Naturally these species cannot be readily observed and one has to infer their presence by signs on the surface of the sediment. These may be hollows or mounds, a variety of burrow mouths, meandering lines of disturbed sediment, casts of faecal material or masses of eggs in a variety of shapes. To see well in sandy sheltered bays and over seagrass beds, it is a distinct advantage for field trip participants to be prepared to wade and wear a face mask for better viewing in the water. In most locations there is a further advantage to swimming face-down, with a mask and snorkel, in the shallow water. This not only aids observations but prevents sediment getting stirred up into the water and reducing visibility. What you can see just wading around in shallow water is multiplied many times over by the use of a face mask; additionally, getting into the water and swimming, places the student in the aquatic environment of these habitats. This makes it easier to appreciate the conditions for life in these places.

Sediments of Biological Origin

Sediment is not only formed by the erosion of rock but from particles of the shells or skeletal material of a wide variety of organisms both animal and plant. Most of these particles are of **calcium carbonate**, but a lesser number are of **chitin** and other organic skeletal material. Material that comes from organisms is called **biogenic** and may originate from either animals or plants. Biogenic particles are an exceedingly important component of the sediments of Bermuda, and in some locations make up the majority of particles. **Figure 16.1** shows a range of commonly seen particles of both animal and plant origins.

Summary

Sediments are mainly of biological origin and many of the particles can be identified.

Sediments of Plant Origin

Plant contributors to the sediments come from the brown, red and green algal groups, the latter two being the most important. Among the green algae the Plateweeds (*Halimeda* species) are very important sediment producers and the particles they add are easily recognised under the microscope. Plateweeds have a plant body that is made up of a group of series of hard plates, or segments, hinged together. These plates are constantly produced and fall off after a relatively short period. In the Common Plateweed (*Halimeda incrassata*) each segment resembles a three-toed foot about 2.5 mm (1/10 in) long. The red algae also produce many sediment particles. Perhaps the best examples are found among the Needleweeds (*Amphiroa* species), which like the green Plateweeds are segmented. However, in this case the segments are needle-like or in the shape of short rods **(Figure 16.1)**. The Pointed Needleweed (*Amphiroa fragilissima*) is common in fairly quiet locations. There is also a group of red algae which form rock-hard sheets on the rock

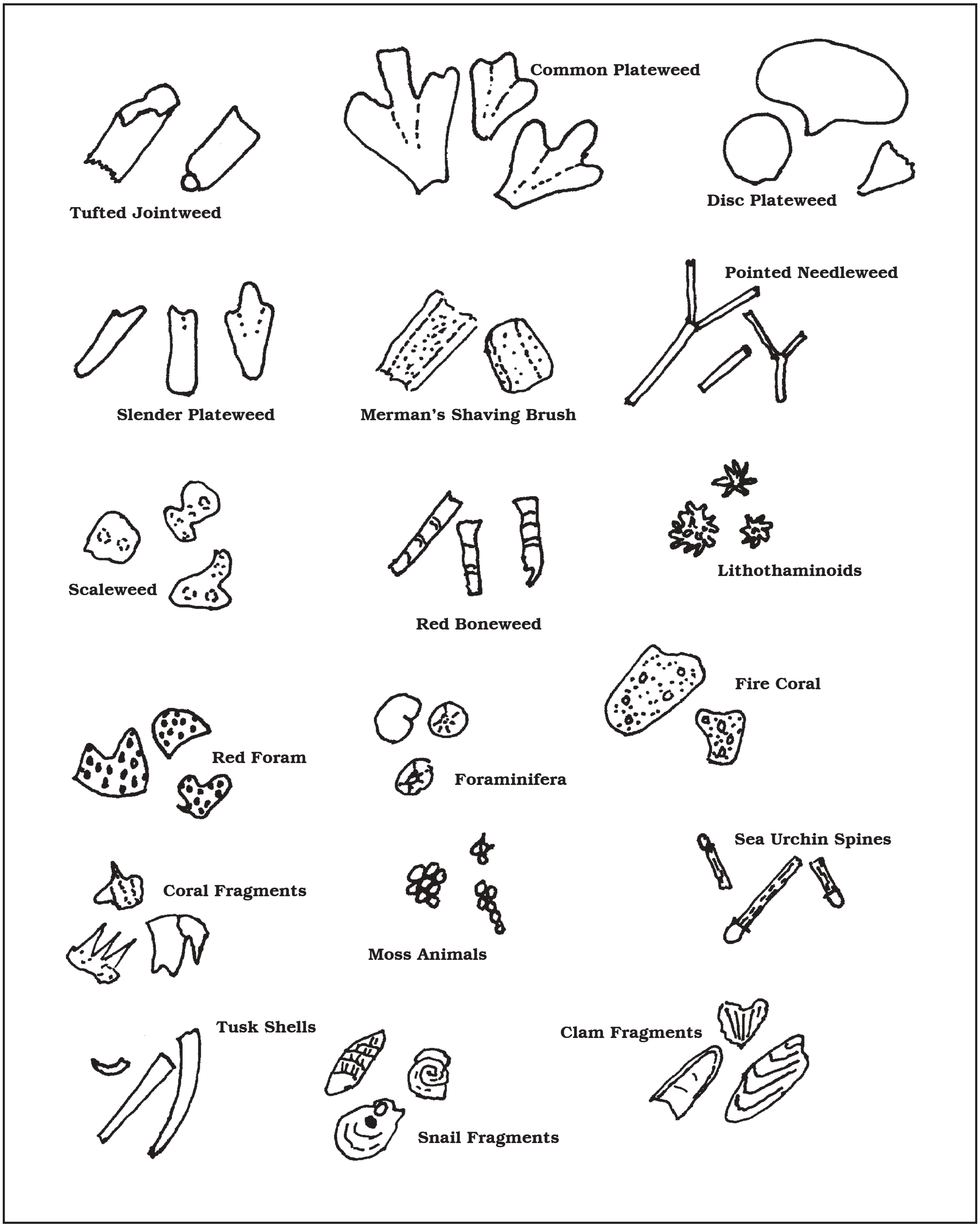


Figure 16.1. Typical sand grains of biological origin, all about 2-4 times actual size.

or other surfaces. These crustose coralline algae have been discussed above in relation to reef formation. A much smaller relative called Scaleweed (*Fosliella farinosa*) grows in abundance on the leaves of seagrasses. These leaves are shed at frequent intervals and as they rot, they release the Scaleweeds to augment sediments. The brown algae are only minor contributors to the sediments but some well-known ones such as the Petticoat Algae (*Padina* species) do produce some calcium carbonate particles that reach the sediments when the plant dies. However, these are never in the form of segments and just form tiny chalk-like particles, which cannot be identified to reveal their origin.

Summary
Many seaweeds have lots of **limestone** in their structures. When they die, the hard parts form sediments. Green, red and brown seaweeds all contribute to the sediments, but the greens, and particularly the Plateweeds are most important.

Sediments of Animal Origin

Many animals contribute particles to the sediments but the most famous and easily recognised sediment component comes from a single-celled (protozoan) animal called the Red Foraminiferan (*Homotrema rubrum*) (**Figure 16.1)**. This species, a relative of the amoeba, forms a test of calcium carbonate (limestone) which is coloured a bright pinkish-red and is surprisingly large, up to 3 mm (1/8 in) long. They look a bit like tiny, irregular, lumpy strawberries and are very hard. These creatures live in reef cavities, under rocks etc and are very common. Death or erosion may break them from the rock surface and they are a prominent component of south shore sediments in Bermuda. They produce the romantic pink sands such as those found at Pink Beach. Other animal particles that are easily recognised in sediments include sea urchin spines, parts of crustaceans such as claws, spines and body segments or plates, molluscan shells and shell fragments, fish vertebrae etc.

Summary
Many animals have hard limey shells and when they die these become part of the sediments. The pink colour of many beaches comes from shells of the Red Foram. Also present are clam and snail shells, sea urchin spines, claws, vertebrae etc.

Sediments as Food

Pure sediment contains only inorganic material and cannot serve as a source of food for animals. However, in nature, sediment rarely remains in the pure form for any length of time. Any sediment in natural water bodies will soon acquire an admixture of organic particles and living organisms. The non-living material will mostly be in the form of **detritus** or partially decomposed remains of dead organisms, which in turn supports a wealth of bacteria and protozoans. When detritus is mixed with limestone sediment, the sediment darkens in colour. Once detritus is present it becomes mixed with the sediment as a result of sediment movement or the activities of animals. Detritus is a source of food, for other animals. If sediment is very rich in detritus it may run out of oxygen and become almost black in colour and foul smelling. Sands usually have only a small admixture of detritus. Thus they form a source of very dilute food. Such food is difficult for larger animals to exploit but some, for example the Sea Pudding (*Isostichopus badionotus*) have very elaborate mechanisms to do so. Some of these adaptations are described below. Detritus continually rains onto the sediment surface and is more concentrated there. Because of this, many animals feed on the surface of the sediment rather than deeper down. Bacterial decomposition of detritus in sediments also releases inorganic plant nutrients. These can be exploited by seagrasses but not by seaweeds as is discussed below.

Summary
Most sediments contain organic material in the form of semi-rotted remains, or **detritus**, of organisms. The more of this that is present, the darker the sediment. Detritus is a valuable source of food for many animals.

The Sediment Surface Habitat

The sediment surface supports species of both animals and plants. The plants tend to be fixed in position, whereas the animals may be either fixed or active. The plants may be seaweeds (algae), or seagrasses, which are flowering plants.

Seaweeds

The algae may be either anchored to the sediment in some way, or unattached. Naturally, free drifting seaweeds such as the Common Pincushion (*Cladophora prolifera*) are confined to very quiet areas. Where there is significant current or wave-action they would be swept away. Those seaweeds anchored to the bottom include a very interesting group of green algae, including the Merman's Shaving Brush (*Penicillus capitatus*) which appear to be rooted. However, algae never have true roots and these root-like structures are just anchors and have no physiological function. This will be discussed further below in relation to ecology.

> **Summary**
> Sediments support a variety of seaweeds. These may be anchored into the sediment, just free or weighted down. Others live on organisms of the sediment surface.

The Anchored Seaweeds

A good number of species among the green algae have developed root-like structures that penetrate the sand. These structures called **rhizoids**, do anchor the plants well, but differ from true roots in that they are physiologically inactive. True roots have the function of extracting plant nutrients such as nitrogen and phosphorus compounds from the sediment. These nutrients, essential to the life of plants are then available for life processes. The rhizoids of the algae cannot take up plant nutrients and so the algae, must extract essential plant nutrients from the water, where they occur only in a very diluted form. This puts the algae at a competitive disadvantage in comparison with the seagrasses, which do have true roots. However, the rhizoids do enable them to colonise a habitat where there is little competition for living space from other algae and where light intensities are quite high, facilitating photosynthesis. Examples of common green algae with rhizoids are the Plateweeds (*Halimeda* species), the Merman's Shaving Brush group (*Penicillus* species), and the Fanweed and Funnelweed group (*Udotea* species). Most algae with rhizoids strengthen their structures with calcium carbonate and are therefore important contributors to the sediment in which they live.

> **Summary**
> Seaweeds have no roots but may be anchored into the sediment by root-like structures called **rhizoids**. Rhizoids cannot absorb plant nutrients from the sediments. Examples of anchored seaweeds are Plateweeds and Merman's Shaving Brushes.

Seaweeds Living on other Plants or Animals

The second group of sediment algae have adopted an epiphytic or epizootic mode of life by living on seaweeds and invertebrate animals. **Epiphytes** use another plant as a firm substratum on which to anchor themselves, whilst **epizooites** are attached to animals in a similar way. Epiphytes, such as Scaleweed (*Fosliella farinosa*), are a very important component of the seagrass community. Curiously, the green algae with rhizoids, referred to above, do not support many epiphytes because they have evolved chemical repellent mechanisms to prevent colonisation in this way. Likewise epizooites on animals are uncommon but do occur.

> **Summary**
> Many seaweeds live attached to other algae or animals of the sediment habitat. Those on algae are called **epiphytes** and those on animals, **epizoites**.

A curious and interesting situation similar to having epizooites is presented by some of the sea urchins such as the Purple Sea Urchin (*Lytechinus variegatus*), which carry around living plant fragments as camouflage.

Algae Weighted Down with Sand

A third group of algae use sediment particles held as weight in a thick tangle of hooked filaments. Thicketweed (*Spyridia hypnoides*) employs this method with great success, colonising large areas of sandy bottom. It also acts as a substratum for epiphytes.

> **Summary**
> Some algae such as Thicketweed are held in place by the weight of sand grains.

Cushion Forming Algae

Employing a similar adaptation to using sand as a weight, some algae trap sediments among a mass of tiny vertical filaments, sometimes starting on individual sand grains. As the sediments accumulate, the filaments grow upward forming a cohesive firm mat. Some tiny green algae such as the Green Cushionweed (*Cladophoropsis membranacea*) do this, as do several species of blue-green cyanobacteria. The blue-greens, as they are commonly known, form structures known as Algal Biscuits (*Phormidium hendersonii*) or algal Stromatolites (*Phormidium corium*) which are gelatinous in texture, sit on the sand surface, and may show daily growth lines as bands in the entrapped sediments.

> **Summary**
> Some seaweeds grow in the form of small cushions on the surface of the sand. The lower surface is attached to sand grains. Both green algae and blue-green **cyanobacteria** do this.

Unattached Algae

The Common Pincushion (*Cladophora prolifera*) is able to live on sediments by the simple method of not attaching to anything, but only growing in the quietest of bays where it just lies on the bottom. During the 1970s and 1980s the Common Pincushion underwent what is called a **population explosion**. In this incident sheltered bays literally filled with this seaweed which formed layers up to at least 1 m (3 ft) in thickness. These masses of seaweed were too dense to allow much light penetration and consequently the algae in the deeper parts of the layer died and decomposed. This, in turn, killed the animals on and in the sediment and thereby caused an ecological catastrophe. The precise cause of this population explosion is still not known but evidence pointed to increased levels of plant nutrients resulting from seepage and run-off from the land.

> **Summary**
> Seaweeds that are completely unattached can only live in very calm situations. However, some of these such as the Common Pincushion can form deep layers that radically change the environment.

Seagrass Beds

Introduction

Figure 16.2 shows a typical Bermudian seagrass bed illustrating all the seagrass species found here as well as some algae and common animals associated with seagrass beds. Look at this illustration to get a good idea of the seagrass bed habitat before visiting one.

Seagrasses in general

The seagrasses belong to a small but widespread group of marine flowering plants that are extremely important in the general ecology of shallow coastal waters. Although there is not a large number of different species of seagrasses, they have been able to colonise shallow sedimentary environments throughout the world, except in polar locations. They are the only flowering plants that live totally submerged in seawater and they are highly adapted to this environment. Where they occur they form large, dense beds that are very important in the stabilisation of shallow coastal sediments. Their role in

> **Summary**
> Seagrasses are marine flowering plants that can form large beds in shallow water. They help stabilise the bottom, preventing erosion. Seagrasses have true roots in the bottom which can take up the plant **nutrients** abundant there. Consequently they are vigorous and have very high **productivity**.

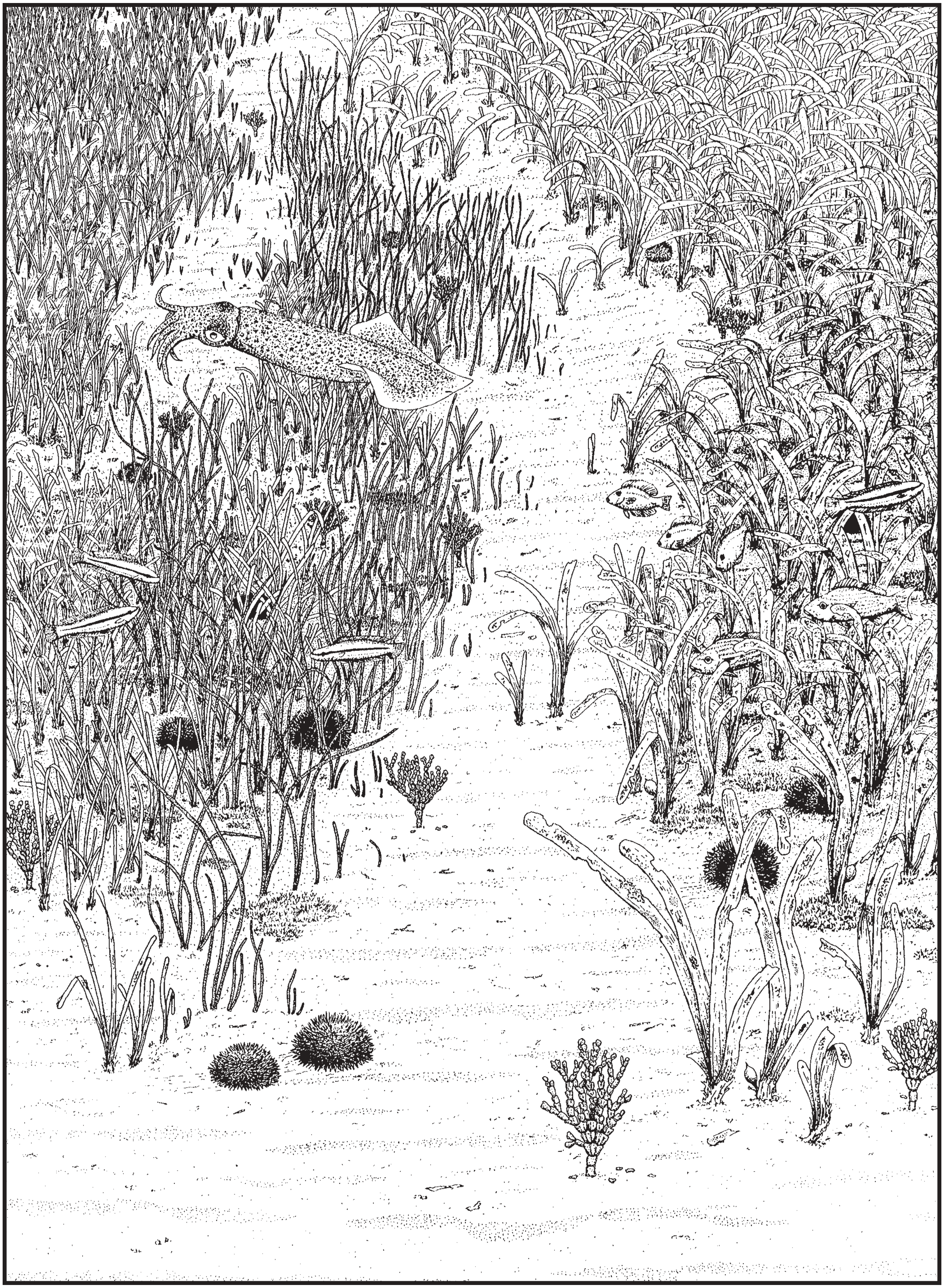


Figure 16.2 A typical seagrass bed in Bermuda showing the three common seagrass species and common associated organisms.

Key to Figure 16.2

Turtle Grass
Thalassia testudinum

Shoal Grass
Halodule wrightii

Manatee Grass
Syringodium filiforme

Thicketweed
Spyridia hypnoides

Scaleweed
Fosliella farinosa

Common Plateweed
Halimeda incrassata

Purple Urchin
Lytechinus variegatus

White Urchin
Tripneustes ventricosus

Slippery Dick
Halichoeres bivittatus

Yellow Grunt
Haemulon sciurus

Doctorfish
Acanthurus chirurgus

Arrow Squid
Loligo plei

stabilising sediments was demonstrated quite accidentally, when a North Atlantic species called Eelgrass (*Zostera marina*), which has been recorded once in Bermuda, was decimated by a disease, called Wasting Disease in the 1930s. As Eelgrass stands disappeared, sandy islands eroded away and whole coastlines changed in character.

One of the factors that has contributed to the ecological success of the seagrasses is that they, as true flowing plants, and unlike the algae, have true roots. Because of this, they are able to exploit the rich supply of plant nutrients that naturally concentrate in the sediments. Seagrasses can absorb nutrient material, through their leaves, from seawater, but unlike the algae, do not have to rely on seawater for their essential nutrients. Seagrasses live where light levels are always high, where water is always present, where competition from algae is negligible and where essential nutrients are in good supply. It is not surprising then that seagrass beds are among the most productive ecosystems on earth. Productivity is measured as the amount of new organic material that is produced during a unit of time and this is demonstrated by the growth of new leaves, roots and entire plants. Seagrass plants consist of tufts of leaves arising at nodes from a buried stem called a **rhizome**. Do not confuse this with the **rhizoids** found in the anchored green algae. Roots also occur as groups at each node. The rhizomes can elongate to enlarge the seagrass bed. Additionally, fragments of rhizomes that are torn away by water currents or the feeding activities of animals can be carried long distances in the water to populate other areas. This is a method of **asexual reproduction**.

Seagrasses have underwater flowers and pollination takes place in the water. The seeds so produced, by this **sexual reproduction**, are released and may germinate close-by or be carried to distant locations by water currents or animals.

Summary
Seagrasses can reproduce sexually by underwater flowers and seeds or asexually by means of fragments of their stems. Both methods can result in population of new areas. The strap-like leaves are in clumps to which new ones are continuously added at the centre.

The leaves, which are continuously added at the centre of each leaf clump are also continuously lost at the outer edges of the clump. Pieces also break away at the tips of leaves as they age. The growing leaves form a direct food supply for creatures such as sea turtles, some fish, manatees, geese and some urchins. However, a probably more important role stems from their involvement in the production of **detritus** when they die. As leaves are shed and decompose, they form detritus particles which are invaded by bacteria and become a protein-rich food source used by a huge variety of marine animals. This detrital food supply is carried far beyond the grass beds by water currents and is important in the ecological economy of the whole coastal zone of the ocean. Ecosystems which supply food to areas outside their boundaries are called **export ecosystems**. Another unseen aspect to food production by the seagrasses is that they release molecules of organic compounds synthesised in the process of photosynthesis, into the water. These molecules can be used directly as food by a variety of invertebrates including clams and worms, but most are probably taken up by bacteria which, in turn, form a food supply for **filter** and **detritus feeders.**

<u>Bermudian Seagrass Beds</u>

The seagrass beds around Bermuda are not constant in location. It has been observed that some are decreasing in size or even disappearing, while others are enlarging and a few are appearing in new locations. There is no firm evidence that shows why these changes are taking place. It is known that seagrasses are very sensitive to trampling by people, which may explain their disappearance or reduction in recent years from some heavily-used bays such as Tobacco Bay and Whalebone Bay. Heavy grazing

Summary
Seagrass beds cover very large areas around Bermuda but their position is rarely constant. In areas frequented by bathers, sea grass beds often die. There are three common seagrasses in Bermuda. The commonest of these is Turtle Grass, others are Shoal Grass and Manatee Grass. They often grow in mixed stands.

may also have had an impact, and some of the most significant damage in the inshore bays, is caused by mooring chains, which swing around a mooring weight, causing a large 'halo' of dead seagrass.

There are three common species of seagrass found in Bermuda and a couple of others have been seen here. By far the commonest of the seagrasses is Turtle Grass (*Thalassia testudinum*) and this is the one that forms the extensive beds. It has long, broad, flat leaves up to 1 cm (1/3 in) across and up to at least 1 m (3 ft) long; however, the average size is one half or less of these figures. Manatee Grass (*Syringodium filiforme*) differs from Turtle Grass in that the leaves are round in section, rather than flat. Growing up to 30 cm (1 ft) high, it sometimes forms quite large dense beds in quiet areas. It is often mixed with Turtle Grass. The third species, Shoal Grass (*Halodule wrightii*), has flat leaves like Turtle Grass, but they are only about 2 mm (1/10 in) wide and only up to 15 cm (6 in) tall. Shoal grass is often found around the edges of Turtle Grass beds and not infrequently, mixed stands of all three occur. All the seagrasses reach a maximum size in shallow, rich muddy bottoms; some especially fine ones are to be seen in the quiet inland saltwater ponds.

Although not as widespread, one other seagrass species found in Bermuda, The Dwarf Seagrass (*Halophila decipiens*), is worth mentioning. It can be found in virtually all tropical shallow oceans. Unlike the three common species it is not grass-like but has small, oval leaves only 2 cm (3/4 in) long. It is found in somewhat deeper water than the common species.

<u>Seagrass Beds as Nursery Grounds</u>

Seagrass beds, as shown in **Figure 16.2**, slow water currents and trap sediments. They also form a refuge on a sedimentary bottom where otherwise there would be little cover. It is not surprising then that they are a vital nursery ground for many fish and invertebrates. In Bermuda, at least 30 species of fish use seagrass beds as nursery grounds. These fish include the Bermuda Bream (*Diplodus bermudensis*), the Shad or Silver Jenny (*Eucinostomus gula*), the Bigeye Mojarra (*Eucinostomus havana*), the Mottled Mojarra (*Eucinostomus lefroyi*), three grunts, the Blue-striped, White and French or Yellow Grunt (*Haemulon sciurus*, *aurolineatum* and *flavolineatum*), the Pinfish (*Lagodon rhomboides*), the Sand Diver (*Synodus intermedius*), the Spotted Goatfish (*Pseudupeneus maculatus*), the Slippery Dick (*Halichoeres bivittatus*), the Slender Filefish (*Monacanthus tuckeri*), as well as the Bucktooth Parrotfish (*Sparisoma radians*) and the Bandtail Puffer (*Sphaeroides spengleri*). The larvae of the Spiny Lobster (*Panulirus argus*) settle in seagrass beds to begin their crawling life. Another aspect of ecological importance is that the seagrass plants act as a substratum for the settlement of algae and sedentary invertebrates. In this way they enhance **biodiversity** to a very significant degree.

Summary
Seagrass beds are important breeding areas or "nursery grounds" for a very wide variety of fish and crustaceans. The young of these species feed and grow in the shelter of the beds until they are large enough to leave.

<u>Seagrass Beds and Turtles</u>

One of the most important aspects of seagrass bed ecology in Bermuda, is that these systems are widely used by the Green Turtle (*Chelonia mydas*) for the feeding grounds of juveniles. When Bermuda was colonised, Green Turtles bred on island beaches and individuals of all ages would feed in the seagrass beds. Adult turtles were ruthlessly exploited for food, the population was decimated and breeding stopped. Turtles always return to breed at the site where they hatched, so breeding never re-commenced. However, individuals hatched elsewhere have continued to migrate to Bermuda to feed and grow. After three or so decades, when nearing maturity these turtles move off to breed

Summary
Seagrass beds are the main feeding grounds of the large number of juvenile Green Turtles seen around Bermuda. As they near maturity these turtles leave to breed further to the south.

elsewhere. Attempts have been made to re-introduce breeding turtles by hatching eggs in Bermuda beaches. Whether this will work or not is uncertain, but if it does, adult turtles should be returning to breed during the next few years.

Burrowing Life in the Bottom

Introduction

The burrowing animals are the most highly adapted but least diverse of the three groups of animals of sedimentary locations. They can be divided into two sub-groups, those that construct semi-permanent burrows and those that move through the sediment with no lasting burrow. Both of these groups must initially be able to burrow down into the sand. Some shrimps, for example, burrow using legs, whilst most of the worms and sea cucumbers burrow by narrowing the body and thrusting the head into the sand then widening the buried part of the body to anchor it, and pulling the hind part down. Others such as the Peanut Worms (Sipunculids) and Clams do this in the reverse direction, the tail end going first. Burrowing snails have a large foot which they thrust through the sediment advancing by muscular contractions of this foot. A variety of common burrowing animals is shown in **Figure 16.3** together with some sediment surface dwellers.

Summary
The burrowing animals are highly adapted to a life within the sand. There are two groups; those that make semi-permanent burrows, and those that move through the sand with no burrow.

Semi-permanent Burrowers

If burrows are going to last any length of time they must be stabilised in some way or they would just collapse and in-fill with sand. Most permanent burrows are lined with a secretion such as mucus, which binds the sand grains together and forms a smooth burrow lining. Many such burrows have two openings to the sand surface and a U shape is common. This also allows the burrowing animal to pass water continuously through the burrow to supply oxygen for respiration. Animals with lasting burrows must have some way either to feed within the burrow, or to extend feeding organs out of the burrow. A good example of an elaborate burrow feeding behaviour is shown by the Cockworm (*Arenicola cristata*). The Cockworm makes a U-shaped burrow extending 30 cm (1 foot) or so into the sediment which is lined with mucus for most of its length (**Figure 16.3**). To feed the Cockworm moves toward the front end of the burrow, which is unlined, so that the head is 10 cm or so below the sand surface and by rhythmic body movements, pumps seawater inward through the remaining sand. The water passes around the body where gills extract oxygen and exits at the hind end of the burrow. As this water passes through the layer of sand above the head of the worm, minute floating plants called **phytoplankton** and particles of dead algae or seagrasses called **detritus** are filtered out by the sand and concentrated above the worm's head. When the sand is rich in this food material, the worm swallows it and the digestive processes extract the food. The waste sand is ejected on to the sand surface at the hind end of the tube by the worm moving backward to that position. This ejected sediment which forms thick, thread-like masses, is called a casting. As this process is repeated over and over, a pit develops at the head end of the burrow and a mound at the tail end. Digging deeply and carefully between the depression and the casting will extract the worm, which is quite soft and delicate with bright red gills. The worm does not need to be tough as it is well protected by the sediment around it. The gills are red because the worm has haemoglobin, much like our own, as a blood pigment. This is unusual for invertebrate animals but is an adaptation found especially among the burrowers. Haemoglobin is very efficient at extracting oxygen from water and useful here as the water quantity in a burrow is small and the oxygen concentration

Summary
Semi-permanent burrowers construct long-lasting burrows that are stabilised with mucus or other linings. Many of them have elaborate feeding behaviour. Some feed by drawing food and **detritus** into the burrow, others extend tubular siphons up above the sediment to gather food.

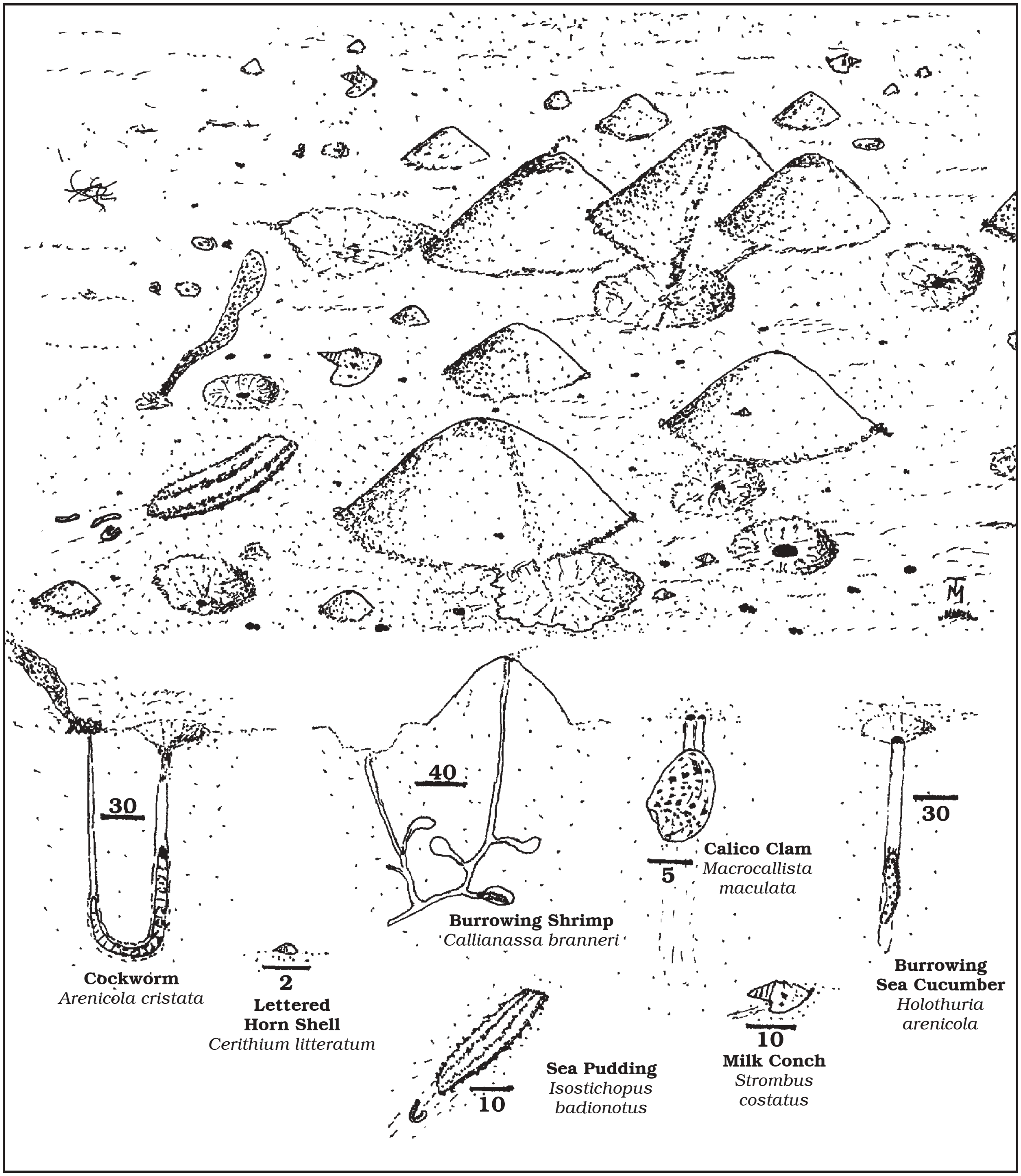


Figure 16.3. Sketch of the appearance of the sediment surface at a location dominated by semi-permanent burrowers. Below are the main organisms. Note that the scale is not constant and indicated by scale bars for each organism.

quite low. The Cockworm also has an interesting reproductive adaptation. The eggs instead of being released into the water, as in almost all worms, are contained in a brown gelatinous mass attached to the sand at the burrow end. Well developed larvae hatch from this mass and may settle in suitable places to colonise new areas or maintain the population.

Another burrower that has a burrow maintained for a long period is the Burrowing Sea Cucumber (*Holothuria arenicola*). Also mucus-lined, the burrow goes straight down for up to 75 cm (30 in) (**Figure 16.3**). This Burrowing Sea Cucumber feeds by quite a different method from the Cockworm. When conditions are quiet the cucumber moves up the burrow towards the water and extends these tentacles over the sand surface. The tentacles are sticky and gather detritus particles that have settled to the surface of the sediment. Tentacles covered in detritus are then withdrawn and wiped clean in the mouth of the sea cucumber.

A third type of feeding behaviour is shown by the Burrowing Shrimp (*Callianassa branneri*). Like the Cockworm the Burrowing Shrimp produces a mound of sediment at the hind end of the burrow, but in this case the mound can be huge and volcano like. However, the burrow structure and feeding method are quite different. The burrow of the Burrowing Shrimp is deep and complex with several small rooms or chambers off the main burrow (**Figure 10.3**). In feeding, the shrimp rises to the surface of the head shaft of the burrow and captures particles of detritus, particularly seagrass leaves from the water. They probably also scrape detritus off the sediment surface. Some of this material is eaten but some is stored in the chambers, where bacterial and fungal action enrich this food source. It can then be eaten later and when surface feeding is impossible due to storms or disturbance. Unlike the Cockworm, the vast bulk of the sand is not swallowed by the shrimp but just ejected from the tail end of the burrow. Observation will show an almost continuous stream of sediment emerging from the top of the volcano-like mound.

The bivalve molluscs are probably the most diverse group among the burrowing fauna. They dig in by means of a powerful muscular foot which is inserted in the sediment, expanded at the tip to form an anchor, and then contracted to pull the shell in. The depth to which the shell is buried varies very greatly in different species. The Calico Clam (*Macrocallista maculata*) is only just buried (**Figure 16.3**) whereas the Sunrise Tellin (*Tellina radiata*) is deeply buried. The deeply buried examples usually have mucus cemented holes leading vertically to the surface. These clams communicate with the water above by means of a pair of tubes called siphons. These siphons carry oxygenated water for respiration and are also used for feeding. Many are filter feeders, drawing water in through an incurrent siphon and filtering plankton and detritus out on large gills; others such as the Tellins have very long extensible siphons that vacuum up food particles from the sediment surface.

Wandering Burrowers

The second group of burrowing animals, those that do not form semi-permanent burrows and do not cement burrow walls, are mostly predators that hunt the other burrowing animals for food. The best known among these are the Moon Snails such as the Milky Moon Snail (*Polinices lacteus*) common in Bermuda. These snails hunt buried clams; they can bore a hole through the shell of the prey to get at the body. Another interesting feature of the life of the Milky Moon Snail is that it leaves a very readily identified egg mass on the sediment surface. This egg mass is called a 'collar' because of its shape. The egg collar does resemble a shirt collar, which is made of sand and eggs cemented smoothly together, in that it forms a circle without joined ends; unlike a collar these ends overlap. The collar is much narrower at the top than the bottom and the sides are beautifully curved.

Summary

The wandering burrowers have no burrow but are mainly predators moving through the sand in search of their prey. An example is the Milky Moon Snail which has a huge burrowing foot. It can bore through the shells of its clam prey.

Several predatory worms from various groups also hunt through the sediment but are rarely seen. However, not all the burrowers that move about in the sediment are predatory. An example of a detritus feeder is the Sand Dollar (*Leodia sexiesperforata*), related to the starfish and sea cucumbers, which roams around just under the surface of the sediment, from which it sorts tiny detritus particles for food.

Crawlers of the Sediment Surface

The crawling animals of the sediment surface are a large and varied group, but only a few of them are easily and regularly seen.

Sea Puddings

Perhaps the most obvious and well known of these is the large sea cucumber known as the Sea Pudding (*Isostichopus badionotus*). Unlike the burrowing sea cucumber this one has a sort of sole on the body, on which it walks very slowly. This locomotion is accomplished by means of numerous tube feet. These tube feet, found in rows along the body, are water-filled tubes with a little suction cup at the end. They can be extended or withdrawn by the animal and can be bent in any direction. The Sea Pudding is highly adapted to life on the sand surface. It gets its food by swallowing the surface sand and its contained detritus. The waste sand is then ejected at the hind end in the form of a casting, rather like curled spaghetti. The total quantity of sand processed by Sea Puddings is immense. One scientist calculated that for Harrington Sound alone, this amounted to up to 1,000 tons/yr!

Summary
Animals that crawl over the sediment surface, feeding as they go, include the Sea Pudding. This sea cucumber swallows large quantities of sand from which it extracts its food.

Conchs

Another large and well known animal adapted to life on the sediment surface is the conch. The only conch seen in coastal shallow bays is the Milk or Harbour Conch (*Strombus costatus*). It cannot be mistaken for anything else when it is an adult, as the shell is very large, up to 20 cm (8 in) long, and very heavy. It also has a characteristic flaring lip. Like the Sea Pudding, the Harbour Conch moves slowly over the sediment on its large foot, but instead of just swallowing sand, it sorts edible material, such as plant fragments and larger detritus particles from the surface sand and eats them. Juvenile Milk Conchs (*Strombus costatus*) are thinner shelled and lack the big lip; they are very common but often mistaken for other species of snail. If the Harbour Conch is flipped over by other creatures or violent water movement, it can rapidly right itself by elongating the foot and curling it down into the sand surface; then with a quick flip it rights itself. The Harbour Conch is not the only snail to live on the sand surface but it is the largest.

Summary
Conchs are very large snails that wander on the sediment surface picking up pieces of **detritus** for food. The Harbour Conch is on the increase since it has been protected.

Sea Urchins

The third, almost universally found, large member of the sand surface community is the Purple Urchin (*Lytechinus variegatus*). The Sea Pudding and the Purple Urchin both belong to the same Phylum of animals, the Echinodermata which also contains the Sand Dollar and many starfish. The Purple Urchin resembles a spiny ball up to about 13 cm (5 in) in diameter. Although more closely related to the Sea Pudding, it feeds more like the Harbour Conch. On the underside of the body of the urchin is a mouth with five powerful jaws which can grind up potential food. The Purple Urchin has the interesting adaptation of carrying

Summary
Sea urchins live both on bare sand bottoms and in seagrass beds. Like the conchs, they feed by picking up particles of **detritus** from the sediment surface. Sea urchin **populations** sometimes reach very large numbers in some bays.

bits of algae, eelgrass or non-living material, on the top of the body as camouflage. These are held in place by the tube feet. However, these creatures are well protected by the spines and only taken as prey by a few fishes such as the Grey Triggerfish (*Balistes capriscus*), which is quite often present over seagrass beds. In the seagrass beds, the Purple Urchin may occur along with the somewhat larger 15 cm (6 in) White Urchin (*Tripneustes ventricosus*), of similar habits.

Lobsters

If one went out at night onto sandy areas or seagrass beds, another large predatory animal would be seen. This is the Spiny Lobster (*Panulirus argus*). This active predator feeds on many members of the sandy bottom community, but hides by day in lairs in rock or rubble. There are also a number of crabs which forage at night.

Shallow-water Fishes and Turtles

Fish

The Sergeant Major, affectionately known in Bermuda as the Cow Polly (*Abudefduf saxatilis*) is one of Bermuda's commonest fish, present in most bays and over seagrass beds. They often nibble at swimmers, so their presence is hard to miss. The Sergeant Major is one of the damselfishes, and is strikingly coloured with a blue head, and with vertical dark bars on a yellow background along its back, grading to light blue beneath. It is a very active small fish.

Another exceedingly common fish found in a great many habitats and locations is the French or Yellow Grunt (*Haemulon flavolineatum*). Wherever you go, on reefs, in bays, along the shore, or in some saltwater ponds, this species will be there, often in large numbers. The grunts get their name from a grinding sound made by teeth in the throat. The French or Yellow Grunt has a relatively deep body, with many yellow stripes. The stripes are parallel close to the back but become diagonal lower down. Grunts may form large schools, often with more than one species present. By day, they tend to be around, reefs, rocks and other cover, but at night they disperse over sandy bottoms and grass beds to feed on small crustaceans.

Summary

An extremely wide variety of fishes inhabit the shallow, sandy bays and the seagrass beds. Some of these live only in these habitats whereas another large group are also found elsewhere. An example of a typical seagrass fish is the Bucktooth Parrotfish. Sandy bottom fishes include the Spotted Eagle Ray, a large fish that digs its clam prey out of the sediment. The Peacock Flounder also feeds on the sand surface. It is wonderfully camouflaged and can also just cover its body with a thin layer of sand as disguise.

One of the really fantastic fishes of these sandy locations is the Spotted Eagle Ray (*Aetobatus narinari*), which is especially common in Harrington Sound. This is a beautiful member of the ray group, and the only one commonly seen around Bermuda. The back is a dark grey with many white spots. Eagle Rays feed by digging up shellfish living in the sand. In doing so they leave a large saucer shaped depression.

Another very characteristic sight in these relatively sheltered waters are large shoals of tiny silvery fish, locally called fry. Five different, related species school in this way; they are the Bermuda Anchovy or Hogmouth Fry (*Anchoa choerostoma*), the Blue Fry (*Jenkinsia lamprotaenia*), the Rush Fry (*Hypoatherina harringtonensis*), the Pilchard (*Harengula humeralis*) and the Anchovy (*Sardinella anchovia*). If the fish you see are really small and numerous, averaging 3-4 cm (1-1 1/2 in) in length, they will be from the first three species. These three are much the commonest of the group. These small fry are highly prized as bait and are caught in large numbers, using seine nets close to the shore. If you see people seine netting along the shores, this is what they are doing. The Pilchard and Anchovy are larger fish up to 10 cm (4 in) in length. All are in the herring family and all feed on tiny animals in the water. It is an awe-inspiring sight to swim slowly through a shoal of these fish and see them neatly divide around your body.

Juvenile Great Barracuda (*Sphyraena barracuda*), up to about 45 cm (18 in) in length, are very frequent in the bays, where they patiently wait, singly or in small groups, for small fish to swim by. Then a short burst of speed will net them a meal. This elongate fish is best recognised by its very large mouth with needle-sharp teeth, and elongated silvery body with dark markings. Two other elongated, very streamlined fish found commonly in bays, are the Needlefish, or Houndfish (*Tylosurus acus*) and the Bermuda Halfbeak, or Garfish (*Hemiramphus bermudensis*), the second being an **endemic** species. The Needlefish has both jaws extending forward, while in the Bermuda Halfbeak, only the lower jaw does so. Both of these fishes swim in small shoals and eat small prey and particles of plants. As with the Spotted Eagle Ray, these fishes are commonly seen in Flatts Inlet.

Another common fish of shallow bay environments is the Slippery Dick (*Halichoeres bivittatus*), a member of the wrasse group. This elongate, slim, little fish, which stays close to the bottom, reaches about 15 cm (6 in) long. It is green and white with two purple-black stripes running the length of the body. The Slippery Dick can dive into the sand to escape capture, and as its name suggests, is extremely slimy if handled.

A pair of fish occupying somewhat deeper bay waters are the Bermuda Chub (*Kyphosus sectatrix*), and the Bermuda Bream (*Diplodus bermudensis*). Both of these fish are mid-water feeders. The Bermuda Bream is the smaller of the two. Both have relatively small heads and eyes, and are a dull silvery-grey in colour. In the case of the Bermuda Chub, however, the overall colour is relieved by many narrow, darker stripes running along the body. The Bermuda Bream and the Bermuda Chub are easily told apart by the presence on the Bermuda Bream of a large dark spot, just above the base of the tail. The Bermuda Bream joins the Bermuda Halfbeak and the Killifish as some of the select few **endemic** saltwater fish.

Although parrotfish occupy a very wide range of habitats, there is one that is usually only seen in bays and inland saltwater bodies, although it is sometimes seen further offshore in seagrass beds. This is the Bucktooth Parrotfish (*Sparisoma radians*). It feeds on leafy seaweeds and seagrasses. It has a proportionately larger eye than the other parrotfish and is quite small reaching only about 18 cm (7 in) long. It is one of the species that changes colour as it matures, starting off with a dull-brown back and white underside and maturing to a fish with mottlings of red and blue on an olive back and yellow belly. This parrotfish can change colour very rapidly to suit its surroundings. Also quite commonly seen in sandy bays and over seagrass beds are the Redtail and Striped Parrotfish (*Sparisoma crysopterum* and *Scarus croicensis*).

Two fish commonly seen feeding or swimming along sandy bottoms are the Yellow Goatfish (*Mulloidichthys martinicus*) and the Sand Diver or Snakefish (*Synodus intermedius*). Yellow Goatfish often form quite large schools, which may be seen digging in the sand for food. A prominent feature are the large barbels around the mouth which aid in finding prey. The Yellow Goatfish is a silvery fish up to about 30 cm (1 ft) long that has a lovely bright yellow lateral stripe and a yellow tail. They are often confused with Yellowtail Snappers (*Ocyurus chrysurus*) but the barbels, absent in the snapper, are a give-away. Sand Divers prefer a bottom with a mixture of rock and sand and are often seen resting there; their greyish bodies with dark patches make them difficult to see. As their name suggests, the body is long, tapering back from the head to a small tail; they reach about 20 cm (8 in) long. They are lie-in-wait predators, who just stay motionless on the bottom until a prey fish swims close.

Some of the fishes present in bays have come to have some very interesting characteristics. One of these is the Sharpnose Puffer (*Canthigaster rostrata*), a charming little fish only about 12 cm (4 in) long, with a large head and tapering body. Dark mauve or brown above and white below, they are quite difficult to spot. Groups of these tiny puffers hang above the bottom, hovering and darting about like dragonflies. A close relative, the Bandtail Puffer (*Sphaeroides spengleri*) has a brown back and white belly and grows much larger, up to about 30 cm (1 ft) long. If disturbed puffers dart to the surface, gulp air and become balloon-like. The Porcupinefish (*Diodon hystrix*) lives in similar habitats to the puffers but can attain twice the size of the Bandtail. It is pale with tiny black spots. It, too, can inflate, but when it does so, numerous long spines appear! A close relative of these two puffer fish that does not inflate is the Honeycomb Cowfish (*Acanthostracion polygonius*), one of the boxfish up to about 30 cm (1 ft) long. It has two little horns between the eyes and a bulbous, very firm body, covered with blackish polygons on a cream background. The tail is large and set on a narrow stalk. Similar in shape and size but lacking the horns, the Smooth Trunkfish (*Lactophrys triqueter*) also has polygons on the body but less obviously displayed in a black background with light spots. The Porcupinefish, Cowfish and Smooth Trunkfish, are solitary and feed along the bottom.

The Longsnout Seahorse (*Hippocampus reidi*) is perhaps the most charming of the little fishes found in bay and seagrass beds but, unfortunately, it is becoming quite rare. If you are lucky enough to see one, it will be clinging by its tail to seaweeds or seagrasses. Seahorses are masters of camouflage and can change colour rapidly. The male broods the young in a pouch on his abdomen.

<u>Turtles</u>
The only common turtle seen in shallow bays and over seagrass beds is the Green Turtle (*Chelonia mydas*). One of the main foods of this turtle is Turtle Grass. Green Turtles seen in Bermuda are all immature individuals which will migrate south to breed. Hawksbill Turtles (*Eretmochelys imbricata*) are occasionally sighted in bays and over seagrass beds. The head is distinctive in that the jaws form a structure like a hawks beak.

Pollution and Conservation Concerns

Sheltered sandy bays are one of the prime recreation locations for islanders and visitors alike. They are also heavily used for educational purposes. Observations have shown that they are poorly able to cope with large numbers of people swimming and bathing in the water. In many heavily used bays such as Tobacco Bay and Whalebone Bay, Seagrass beds formerly luxuriant there have disappeared or have become very degenerated systems. As the seagrass beds have declined so have the populations of burrowing animals and those which formerly frequented the sand surface. Indeed, many coastal, sheltered, sandy bays present a now virtually desert-like bottom. For this field guide some of these heavily used areas are included, but others which have so far escaped heavy impact, are also recommended. It is hoped that directing students and teachers to these places will not further hasten the decline of the biological communities found in shallow bays. Visitors must be aware that these are delicate natural systems, and to act accordingly when there. No digging should be done. The presence of buried life can easily be inferred from burrows, depressions, mounds and casts.

While many serious ecological problems can be definitely traced to human activity, others defy a simple explanation, and may be the result of the combined effect of many small changes in environmental conditions that have occurred since Bermuda's human colonisation. The constantly changing extent of seagrass beds around Bermuda, excluding the bays, is under investigation. Events like the **extirpation** of the large sand burrowing clam called the Tiger Lucina (*Codakia orbicularis*), have also yet to be explained. The Tiger Lucina was formerly very common in sandy bottoms and its empty shells are still numerous. This clam had a curious feeding method in that it had large numbers of sulphur bacteria in its body. The bacteria used the energy of sulphur compounds released in the process of detritus formation into the water, and then absorbed by the clam. In this symbiotic association, the clam then received organic food

Summary
Shallow coastal locations can receive pollution both from land and sea and are also very heavily used for recreational purposes. Shallow sandy bays are quite unstable **environments** and **organisms** in them often show wild changes in number. They are under great environmental stress and need protection and study.

compounds from the bacteria. Because of this very specialised mode of feeding, the clams had no digestive tracts. For some reason, this complex system failed and the clams died. Fortunately, a close relative of the Tiger Lucina, the Dwarf Tiger Lucina (*Codakia orbiculata*) has survived and is reasonably common.

That ecological conditions in shallow sandy bays and waters are quite unstable is suggested by fluctuating population swings in many of the inhabitants. Population explosions and declines seem to be quite frequent. One example, that of the Common Pincushion alga (*Cladophora prolifera*) has been described above. Another, is the recent huge decline in the numbers of Calico Clams (*Macrocallista maculata*) in the early 1980s, that lead to its protected status. The species is now once again abundant in Harrington Sound and recovering well. Great changes in the population density of Purple Urchins (*Lytechinus variegatus*) have also occurred over the last decade or so, whilst the White Urchin (*Tripneustes ventricosus*) is now very hard to find. Other species such as scallops are doing poorly. All these events suggest that the sandy bottom ecosystem is under stress and that further population changes can be expected.

Questions

1) What effect does the size of the bay and its very narrow entrance have on its degree of shelter? ______
2) How many different habitats might you observe in a bay? List them and give a brief description of each. ______
3) If a bay became attractive to tourists, what would be the likely result of greater use? ______
4) Can you suggest any measures to help preserve the ecology of a coastal bay? ______
5) Why is the sediment in seagrass beds often darker than that beyond its borders? ______
6) Why is the sediment in seagrass beds finer than that in surrounding sands? ______
7) How do the seagrass beds benefit other marine communities in the area? ______
8) Which common sea turtle feeds on seagrass beds? ______
9) How do animals that burrow in sand stop their burrows filling with sand? ______
10) What are the names of two common animals that burrow into sand? ______
11) Why are seagrass beds called “nursery grounds”? ______
12) Name a fish that can bury itself in the sand. ______
13) What are fry? ______
14) Name a fish that digs up buried clams for food. ______
15) What are the names of two organisms that help to form sand? ______

Field Trip # 16.1 to a Shallow Bay (Coney Island or Admiralty House)

Introduction

Coney Island and Admiralty House Bays are very well preserved and very small bays accessible in National Parks. These little bays are nowhere deep enough to be a problem, even with quite small students, and additionally they are very sheltered. For tiny bays these have an amazing variety of habitats and species. Do not get into the water immediately, but look at the bay from the high ground around the edge to see what is available there. These locations are especially suitable for younger students.

Approach

For Coney Island, cross the causeway and bridges leading to the island and park in the area to the right immediately within the park. Walk over the road to the left, close to the edge of the motorcycle course past the marine pond. For Admiralty House bay go into the park at its eastern end and walk down the sloping road to the beach of the sheltered bay.

Preparation

Read this field study guide thoroughly. If possible also consult the mangrove material in Chapter 22, and Chapter 18, Rocky Shores. Coney Island Bay has a tiny mangrove swamp and both bays have nice stretches of rocky shore. Alternatively just concentrate on the sandy bottom and seagrass beds on this trip, and plan another so that the whole bay can be appreciated.

Equipment and Supplies

As many copies of this field guide as possible. A clipboard, pencils and paper for each student. A pair of binoculars (or more) for the group in case interesting birds come close-by. A 30 cm metric ruler that can stand immersion in water for each group of students. Some empty jars (Plastic is safest).

Dress

Students should wear sturdy, washable clothing and carry a towel. Take a pair of old footwear suitable for wading in the water. A swimming mask is a good idea. If students are going to swim take appropriate swimming gear and a snorkel.

Observations

1) Before going into the water make a sketch map of the bay showing: A) The entrance; B) Any beaches; C) The position of rocky shores; D) The rough distribution of seagrass beds as shown by the darker areas of bottom; E) The areas occupied by sandy bottoms without seagrass; F) Any boats or other marine equipment in the bay; G) The location of the Mangrove Swamp if present.

2) Wade into the shallow water and look for: A) Dead shells. Pick these up try to identify them and then return them to the bottom; B) Seagrasses. Which of the three species are present? Which is commonest? Which is rarest? C) Burrow mouths and castings. D) Sand waves or ripples. E) Any fish that are around.

3) Go to one area in a seagrass bed. A) Which seagrass are you observing? B) About how many leaves are there per clump? C) About how long are the leaves? D) Can you see round white dots on the leaves? If so what causes them?

4) Collect a sample of sediment from among the seagrasses and on open bottom. Label and cap them and take them back to school after observing. A) Which has the coarsest sediment? Coarser sediments show more current. B) Which has the lightest coloured sediment. Dark sediment has detritus in it.

5) Walk around the shallow water of the bay and identify as many animals and plants as you can. Dead shells or castings can be used as evidence of a species. Note the habitat where each was located, for example, seagrass bed, shallow sandy bottom, deeper sandy bottom, near mangrove swamp etc.

1) **Map of Sandy Bay**

2) Ecological Examination

Object or Organism	Observations
Dead Shells Species	Where Found
Seagrass Species	Common or Rare
Burrows and Casting Identity	Location
Sand Ripple Description	Location
Fish Identity	Location

3) Seagrasses

Organism or Feature	Observations
Identity of Seagrass	Features for Identity
Number of Leaves per Clump	Approximate Leaf Length (cm)
Round White Dots on Leaves?	On old (outer) or young (inner) leaves

4) Sediment

Collect Samples from open bottom and seagrass bed...............Check when done.
Label Samples...............Check when done.
Check which sediment is coarsest. Open bottom............... Seagrass Bed...........................
Check which sediment is lightest in colour. Open bottom............... Seagrass Bed.........

5) **Walkabout**

Plant or Animal	Habitat and Observations

Chapter 17. Sandy Shores

The Sandy Shore Habitat; A Hard Place to Live

Introduction

One of the most attractive features of Bermuda is the wealth of sandy beaches, some of them with a delightful pink hue. These beaches are best developed along the more exposed coastlines, especially that of the south shore. There are, however, small sandy beaches even in relatively sheltered locations such as Harrington Sound. If this sand is observed closely it will be seen to be largely composed of shells and the remains of invertebrate animals and calcareous seaweeds. The pink colour of some south shore beaches results from the large number of the skeletons of a single celled animal called the Red Foraminiferan *(Homotrema rubrum)* a member of the Foraminifera (Protozoa). The formation of sands and beaches, and the action of waves on shorelines is described in the introductory section of this book (see **Figure 7.3** for a beach profile) and the biological content of sediments is covered in the previous chapter (Chapter 16). **Figure 16.1** in that chapter shows diagrams of sand grain particles that can be used to determine their biological origin. That figure will also be useful in considering beach sands.

Summary

Sandy beaches are a typical and attractive feature of the Bermudian coastline. The sand is made up of particles of biological origin many of which can be easily identified.

The Habitat

In the intertidal and wave-washed part of sandy beaches sand grains are being moved around almost constantly when they are underwater or washed by waves. This makes the environment a very unstable one that is difficult for animals and plants to colonise. Because of this, we would expect to see little life in the main part of the sandy beach. However, there are some highly adapted organisms to be found there, particularly on beaches little used for recreation. The more stable areas above the beach and in deeper water below the beach support a wide variety of life specially adapted to those conditions.

Summary

On exposed beaches, sand shifts with the waves making it a difficult **habitat** for organisms to occupy.

Animals and Plants of the Sandy Shore

General

There are five groups of organisms that colonise sandy shores. The **episammon** are micro-organisms, mostly bacteria and cyanobacteria, that live attached to the sand grains. The **interstitial organisms** are those that inhabit the water-filled spaces between the sand grains. They are all very small and difficult to find. Both of these groups are comprised of organisms that are very difficult to see and study. The third group are the **burrowing organisms** that move the sand aside to burrow through the beach. However, in contrast to those described in Chapter 17, the burrowing animals of exposed sandy beaches do not make semi-permanent burrows but rather just burrow into the sand for protection, emerging to feed on the surface. The fourth group of organisms are those of the **strand line**. The strand line is the line of material left at high tide mark by the receding tide and is composed of seaweed, floating organisms of the open sea (see Chapter 14), seeds of coastal organisms and various bits of floating trash. Several insects and crustaceans feed in the strand line and use it for shelter. On beaches

Summary

Five groups of organisms live on sandy beaches, these are the **episammon**, the **interstitial organisms**, the intertidal burrowers, organisms of the strand line and those that feed just above the strand line. The first two are microscopically small.

frequented by tourists the strand line is often raked away each tide and not available for study. The fifth and final group of organisms on the beach are those that feed at or just above the strand line. They may either reside there in burrows or invade the zone from the land when the tide recedes.

The episammon and interstitial fauna and flora

These tiny organisms can not be seen readily and are an unsuitable subject for study by any but specialists. Because of this they will only be discussed in a general way.

The plants or flora of these groups are mainly diatoms, single-celled tiny brownish plants that have a distinctive silica (glass) shell or frustule. (For illustrations of typical diatoms see the section on phytoplankton in the identification section of this book) They have limited powers of movement but some can glide over the surface of sand grains. In beaches where wave action is heavy, diatoms may be found up to a metre (3ft) down. A few beach diatoms come up to the surface of the sand at low tide, retreating several centimetres (inches) down as the tide returns. This is an adaptation to stop them being washed away in the waves. In addition to the diatoms a few other flagellate plant protozoa are found. These have a single, whip-like flagellum that can propel them through the water. A few tiny fungi are also found in the sand.

Summary

The **episammon** and interstitial organisms range from a variety of single celled plants and animals to a wide variety of small muticellular organisms. The commonest single celled plants are diatoms and the commonest multicellular animals are harpacticoid copepods.

The animals range from a variety of single-celled protozoa up to small multicellular animals. Some of this latter group are temporary larvae, which leave the sand when they mature, but most live there permanently. The most common organisms of the interstitial fauna are nematode worms and tiny crustacea called harpacticoid copepods. The nematodes are transparent and slim, but firm bodied, little worms. The harpacticoids are tiny, multi-limbed crustaceans that can swim between, or crawl on, the sand grains. Typical harpacticoid copepods are illustrated at the end of this book in the section on the specialised organisms of the Sargasso Weed. Less common members of the interstitial fauna come from a wide variety of phyla in the animal kingdom.

Burrowing Animals of the Intertidal Beach

Between high and low tide there are very few burrowing animals. The Mole Crab, (*Hippa testudinaria*), is a small, only 3 cm (1 1/2 in) long sand coloured creature that can bury itself in a flash; feeding on **detritus** on the sand surface. It will re-bury itself rapidly if exposed by a wave. A little clam known as the Two-spotted False Donax, (*Heterodonax bimaculata*), only 17 mm (3/4 in) long, is also an active burrower. It is occasionally found on the lower part of the beach. It feeds on particles suspended in the water. It must be admitted, however, that your chances of seeing any of the resident biota of an exposed sandy beach are slight.

Summary

There are only two burrowing animals of the intertidal beach, the Mole Crab and a clam called the Two-spotted False Donax. Both are rapid burrowers.

The Strand Line

What you will see at the **strand line**, are organisms cast up by the waves. These are mostly marine organisms that cannot survive on the beach. The strand line lies at the top extent of wave action and often contains remains of such animals as the Portuguese Man-of-War, (*Physalia physalis*), a very poisonous predatory jellyfish. Do not touch these purple, balloon-like remains as the tentacles can inflict a nasty sting even after the death of the jellyfish. Less often you may find other floating oceanic creatures such as the By-the-wind Sailor (*Velella velella*) and the Common Purple Sea Snail (*Janthina janthina*). For more information on these unusual creatures see Chapter 14 and the identification section at the back of this book. Perhaps the most common organisms left at the strand line are masses of seaweeds of the genus, *Sargassum* or Sargasso Weed. Sargassum, is a brown floating seaweed, common to the East of Bermuda in the Sargasso Sea. It gets swept in large quantities on easterly winds. There are two species of Sargasso Weed (*Sargassum natans* and *S. fluitans*). Both are illustrated in the specialised sargassum community part of the identification section at the end of this book. Also in the strand line are fragments or seeds of shoreline plants which may start to grow there starting the process of colonisation. Another important ecological role of the strand line is that it represents a source of food for a variety of marine and terrestrial organisms. Beach Fleas, (*Orchestia* sp.), small marine crustaceans, are common there. They hop away rapidly if the seaweed is disturbed. Several insects such as the Seaweed Fly (*Fucellia intermedia*) and the Seaside Earwig (*Anisolabis maritima*) also live in rotting piles of seaweed along with two beetles, the Devils Coach Horse (*Cafius bistriatus*) and the Seaweed Beetle (*Phaleria picipes*).

Summary
The **strand line** is a band of floating material left on the shore at the high tide mark. It can contain a wide variety of floating ocean organisms, the commonest of which are Sargasso Weeds. There is also a wide assortment of trash and floating pollutants. The strand line is the home of several organisms such as Beach Fleas.

Above the Strand Line

At night Ghost Crabs (*Ocypode quadrata*) feed there even on the remains of the poisonous Portuguese Man-of-War! Ghost Crabs (*Ocypode quadrata*), once very common on Bermuda beaches are now quite rare and only found on a few beaches where tourists do not penetrate. They are active, nocturnal crabs that make a semi-permanent burrow just above high tide mark. These burrows are sometimes fossilised (see Chapter 10) and when they are there provide an excellent record of the position of the top of the beach. The endemic lizard, the Bermuda Skink (*Eumeces longirostris*), is also known to feed at, and just above, the strand line. Also characteristic of this zone is the beautiful, and very active Tiger Beetle (*Cicindela trifasciata*), of a brilliant iridescent, bright green colour, whose larvae called Ant Lions live in burrows in the sand where they trap other insects and Beach Fleas for food.

Summary
The characteristic marine resident of the area just above the strand line is the Ghost Crab. Once common this crab is now very rare. Bermuda Skinks from the land come down to feed in this area.

Also at and just above the strand line on undisturbed beaches the plant Scurvy Grass or Sea Rocket (*Cakile lanceolata*) is very characteristic. Growing from seed cast up by the tide, this plant is a pioneer of the dune community, which will be discussed in Chapter 19.

Pollution and Conservation Concerns

There is no doubt that the sandy shore has been grossly affected by marine pollution. All manner of floating trash ends up there as does oil and tar-balls. However, it must be realised that an equally, if not more, deleterious effect stems from the masses of tourists and residents who flock to sandy beaches in the summer. To accommodate their needs, the most popular beaches are mechanically raked at frequent intervals, removing not only garbage and tar balls but also the strand line. This also radically disturbs the delicate environment just above the strand line. As a result the beaches have become a biologically barren habitat. In recent years several hurricanes, including Fabian, have also caused serious damage to many beaches.

Any improvement in this situation is unlikely as beaches are Bermuda's main tourist attraction and continued pollution is virtually inevitable.

Summary
The sandy beach receives pollutants from land and sea but has also been radically degraded by heavy recreational use.

Questions

1) Why is there comparatively little life between the tide marks on exposed sandy shores? ________________

2) Describe some of the effects of beach recreation on the beach fauna and flora. ________________

3) What is the name of one animal that can be found in the lower part of sandy shores? ________________

4) What is the interstitial habitat? ________________

5) What is the name of one organism or group of organisms that is part of the interstitial fauna and flora? ________________

6) How is the strand line formed? ________________

7) What types of living and dead things are commonly seen in the strand line? ________________

8) Where is Scurvy Grass found? ________________

9) Where is Sargasso Weed found in nature, before it washes up on the shore? ________________

10) What is a Portuguese Man-of-War? ________________

11) What Endemic animal frequently feeds down at the strand line? ________________

12) Is oil pollution a problem on sandy beaches? Y / N.Why? ________________

Field Trip # 17.1 to a Typical Sandy Shore

Preparation

Read this section of this field guide. Find out from the newspaper the time of low tide. To find the time of low tide in advance, tide tables are available from the Bermuda Biological Station for Research (or visit www.weather.bm). This field trip must be done within an hour, before or after low tide, and when the sea is relatively calm. Nothing can be achieved by going out when large waves are crashing on the shore. Limit the area to be studied from just above the wave washed zone to the area just above where the strand line, or high tide mark, is. Even if the strand line is missing, as it often is, the high tide mark is usually clearly visible.

Dress

No special clothing is needed. But if it is sunny, those prone to sunburn should apply a sunscreen with a high SPF.

Equipment

Clipboard, pencil and several sheets of good paper, as well as a 30 m (100 ft) survey tape, a few pairs of binoculars for the group, a few flat plastic or metal small trays, and a few plastic bottles.

Suggested Location

Any south shore beach is potentially suitable but for best results pick one that is not popular with tourists.

Observations.

1) **Beach Profile**

A profile is like a vertical cross-section of an area. It can show the shape of the beach surface and the positions of the main features. **Figure 7.3** shows a beach profile and can be used as a model. Try to come up with an approximate scale. If you have a 30 m tape it can be laid from the water line up the beach for this purpose. Label all features and be sure to put on the water line.

Beach Profile

2) **Beach Organisms**
Look carefully at the beach below the strand line and identify and list any organisms, or parts of organisms, that you find. Note whether they are living or dead. Give your reasons why living organisms are rare.

a) Organisms found or seen. ______________________________

b) Reasons for lack of living creatures. ______________________________

3) **The Strand Line (if present)** Walk along the strand line and try to identify everything that you see including trash. List your findings.

a) Living things ______________________________

b) Dead Organisms ______________________________

c) Trash ______________________________

4) **The Sand.** From the middle of the beach or anywhere where the sand particles are quite coarse, scoop up a sample in a plastic bottle and spread it out in a tray. (Note: This part may be done either in the field or back at school) Using **Figure 10.1**, identify as many grains as you can to determine their origin.

a) ____________ b) ____________
c) ____________ d) ____________
e) ____________ f) ____________
g) ____________ h) ____________
i) ____________ j) ____________

5) **General Observations.** Write what you think about this environment and its future. Try to suggest some ways in which at least some sandy beaches might be preserved so that their natural fauna and flora may return. How important do you think sandy beach conservation is to Bermuda?

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Chapter 18. Rocky Shores

The Rocky Shore Habitat; Predictably Wet and Dry

Introduction

At first glance, the rocky seashore in Bermuda appears to be a fairly unexciting ecosystem. This is particularly true if you compare it to temperate rocky shores on the mainland. There, rocky shores support heavy growths of seaweed under which there is a wealth of life. At high tide, these rocky shores become seaweed forests, utilized as feeding grounds by many inshore fish and crustaceans. Curiously, the rather barren appearance of rocky shores in Bermuda is not because of the lack of biological activity there, but because there is a very dynamic biological system at work. Two main aspects are critical in looking at the difference between the seaweed dominated mainland shores and the seemingly barren island shores. The first of these is the presence here of a large number of marine animals that graze on the rocky shore. When the shore is covered by the high tide it is a site of great activity as the grazers move in. The main grazers are certainly members of the Parrotfish family but others such as Damselfishes and Doctorfishes also feed there as do some crabs. Even though there appears to be a paucity of seaweeds to graze upon this is not so. In fact the seaweeds are grazed so effectively that all that is left is a very low, but virtually continuous turf of algae. However, these seaweeds grow very rapidly even when exposed to the air, and by the time the next high tide rolls around, another crop is ready for the eating.

> **Summary**
> The **intertidal zone** is small in Bermuda because of the very small **tidal range**. The difference in level from high to low tide averages only 75 cm. On the mainland it may be up to 10 m.

> **Summary**
> The rocky shore habitat appears to be almost barren of life. However, this is caused by very vigorous grazing of the plant life by fish, snails, chitons and crabs at high tide and periwinkles at low tide. The seaweeds are plentiful but grazed daily to a low turf.

The factor that leads to a small rocky intertidal area here is the small range of tides. Tides are discussed in detail in Chapter 8, but to understand the situation on rocky shores, realize that the tidal range in Bermuda is only 75 cm (2 1/2 ft), whereas on mainland shores the range is much larger and in places as much as 10 m (30 ft). In practical terms this means that the amount of shore exposed in Bermuda when the tide goes out is only a narrow band. On mainland shores it may be a huge area. Although this factor limits the size of the shore, it also makes it easy to study and appreciate.

The Biological Attraction of the Rocky Shore

The rocky seashore has been widely studied throughout the world because it shows beautiful examples of biological features and processes in a very small area. The seashore is best noted for its demonstration of the features of **vertical zonation**. This zonation shows a biological response to a changing environment. Mountains are zoned as the climate changes with height, but the zones are wide and often ill defined. On the sea shore the marine climate changes so rapidly that the zones are narrow and very well defined. Such an area of rapid change is called a steep environmental gradient. In addition to showing zonation the sea shore also shows very marked adaptations of the biota to a very variable environment.

> **Summary**
> The rocky shore is best known as the best example of **zonation**. The rapid environmental changes as the tides rise and fall result in characteristic horizontal bands of different animals and plants.

The Changing Characteristics

When we look at a seashore, we are looking at a transition from the terrestrial to the aquatic. Organisms on the shore have either had to become partly terrestrial from a fully aquatic habitat or the reverse. In fact the vast majority of seashore animals and plants are of marine origin. Only a very few have moved down into this habitat from the land; this is especially true in the tropics and subtropics.

Consider the situation on a rocky shore in Bermuda during a daylight tidal cycle in midsummer in calm weather. The time taken from high tide to low tide is just over 6 hrs; there is a high or low tide every 12 1/2 hours. Tide times as explained in Chapter 14, are very predictable even well into the future. As a result animals and plants of the rocky shore can rely on the return of the tide in a few hours except under most unusual weather conditions. As the tide falls from its highest level, resident animals and plants that were submerged emerge into the air. This changes not only the availability of seawater but also the temperature. In summer temperature on the rock surface can increase very rapidly when the tide recedes. If it is raining hard, the available water also changes from salt to fresh. The permanent inhabitants of the shore must have adapted to withstand these huge changes. Were it not for the fact that the tide will definitely return, such an extreme adaptation would be virtually impossible.

Summary
As the **tides** rise and fall the rocky shore is alternately immersed in seawater and exposed to the air. When exposed, the shore can dry and heat, or be washed by rain. Both of these factors result in huge differences in the environment to which organisms must adapt.

Not all the creatures present on the shore at high tide are resident, many come and go with the tide and are never exposed. They show less adaptation than the residents but their behaviour ensures that they are never exposed to the air.

How Animals and Plants have Adapted to Rocky Shore Life

Seashore animals and plants are highly adapted to this harsh environment. Such adaptations may be structural, behavioural or physiological. You will not be able to see adaptations in the physiological category since they concern internal functions. Structural adaptation is shown by such features as heavy strong shells, as in the periwinkles and nerites. Such shells help stop water loss and also offer protection from pounding waves. The periwinkles can further seal the shell opening with an **operculum** or horny disc. Barnacles are firmly cemented onto the rock and Corroding Worm Shells, (*Dendropoma annulatus*), penetrate right into the surface of the limestone. This protects them against wave dislodgment and conserves water. Crabs and other active animals of the shore have strong claws and are very agile, they can avoid waves or simply hang on. These are behavioural adaptations. Other animals just hide in crevices or under other animals. The Burrowing Rock Urchin (*Echinometra lucunter*) which lives in very exposed locations, burrows an open-topped trench in the rock within which it is protected. Look for these features. The seaweeds show structural adaptation in that they are generally strong and very firmly attached to the rock, and no behavioural ones. However, the seaweeds are highly physiologically adapted to withstand great water loss, some dry-out virtually completely during exposure.

Summary
Adaptation to intertidal life may be structural, behavioural or physiological. Common structural adaptations are strong shells, good attachment and streamlined shape. Behavioural adaptation is shown by avoidance of harsh conditions such as waves. Seaweeds able to withstand drying are physiologically adapted.

Unseen, unless you chip off a piece of rock are blue-green cyanobacteria, pink in colour, that live half a centimetre (1/4 in) within the rock itself. There they are totally protected from waves and never dry out; an extreme adaptation.

Tidal invaders

What we do not see on a visit to the rocky shore at low tide, is the flurry of activity that occurs at high tide. As soon as the shore is covered with water the grazing organisms that have retreated to the sea return. The most typical of these are the Parrotfish, they are highly adapted to scraping the algal mat off the rock in that they have a beak-like mouth. With this they scrape away the algal mat and the surface of the rock, thus gaining access to the surface algae and the blue-green cyanobacteria within it. When they do this they leave characteristic marks on the rock, that you can see at low tide. A second result of this activity is that the particles of rock taken in with the food, pass through the gut and are eliminated as waste. Over the course of time this has produced a huge amount of sand.

Other fish such as Damselfishes also feed intertidally but nip off food from the rock surface without actually removing any limestone.

You might think that this feeding activity at high tide would be confined to the part of the shore that is underwater. However, this is not so, crabs such as the Sally Lightfoot Crab (*Grapsus grapsus*) come out of the water and can feed well above high tide line. They scrape algae and blue-green cyanobacteria, particularly Hofmann's Scytonema (*Scytonema hofmanni*) off with their tough, spoon shaped, front claws. In doing so, they leave readily visible grazing marks. Although they do not leave the shore at low tide, the Nerites, Periwinkles, Limpets and Chitons also move around and graze whenever the rock is submerged or wetted by wave action.

> **Summary**
> When the tide is high various fishes and invertebrates come in from the sea. The main fish invaders are the Parrotfishes. Crabs such as the Sally Lightfoot also feed on the shore. All these invaders feed on the algal mat by scraping it from the rock surface.

A lesser, but still significant, impact on the shore comes from the land, however, this activity is at low rather than high tide. Several birds feed on the rocky shore as does the occasional lizard.

Zonation and Exposure on Rocky Shores

<u>The Causes of Zonation</u>

As stated above vertical **zonation** results from a rapid change in the environment with a change in elevation. The main environmental factor that changes on the shore is <u>exposure to the air</u>. The cause of this change is mainly the tides but wave action plays its part. The main result of exposure to the air for a basically aquatic organism is drying out, or <u>desiccation</u>. However, air is not always dry and exposure to rain would result in a drop in salinity. Similarly, air and sea temperature are rarely identical and consequently exposure normally entails a <u>temperature</u> change. We also know that physical and chemical factors such as oxygen levels, carbon dioxide and pH change during exposure. By contrast with the shore, the sea is very environmentally stable. At extreme low tide level the shore differs little from the sea, but with every centimetre (inch) of rise in level the differences increase and the variability becomes greater. At low tide level the daily range of temperature might be two degrees whereas at high tide level it could well be at least 20^{0}C! (70^{0}F). So intertidal organisms have a lot to contend with, and have undergone major adaptations to accomplish this.

> **Summary**
> **Zonation** results from the sorting out of animals and plants according to their level of adaptation. Those marine organisms highly adapted to the effects of exposure are at the top of the shore.

<u>The role of tides in zonation</u>

Since tides are so important on the shore we should briefly review their nature. Tides are discussed in Chapter 14. Tides result from the gravitational pull of the sun and moon acting on the ocean water. The moon is most important and the tides follow its movement. Just imagine a bulge in the water pointed at the moon, moving with the moon, with a similar one on the far side of the Earth. This bulge is a high tide. The result is two high tides each day about 12.5 hours apart, with a low tides in between. High tides on successive days are about one hour later. Because the tides follow the moon, and the moon moves in a totally predictable way, tides times can be forecast with accuracy and are published in tide tables. To work on the shore one just consults the table to find the time of low tide. The effect of the sun is a modifying one only, it does not affect the time of the tide, but it does modify the heights of high and low tide. Every 14 days the sun and moon are almost in line, and their gravitational forces combine, in between, the reverse is true. So every two weeks, we get tides with a wider range called spring tides, seven days later the range is at a minimum and the tides are referred to as neap tides. In an oceanic area like Bermuda, where the tidal range is small, the differences between spring and neap tides are small. Elsewhere where the range is large, for example in the Bay of Fundy on the east coast of Canada, spring and neap tides are really different.

> **Summary**
> The tides are very predictable, low tide following 6 hours after high and so on. Variations in the tidal range result from the interaction of the gravity of the sun and moon. **Spring tides** are twice monthly tides of greater range.

Waves the Big Modifying Factor

The other factor on the shore that moves water up and down is the waves. Additionally, waves place mechanical stress on seashore creatures and they must be adapted to withstand wave action. Think about the Bermudian situation. Here tides average 75 cm or about 2.5 ft. On the south shore waves can be at least 5 m (l5 ft) high in storms. So regardless of the tide the whole shore will be alternately exposed to air and submerged in water by the waves. Clearly too, wave action can extend well above tidal action. The effect of waves is to broaden the size of zones and to extend the marine environment higher up the shore. In the most exposed places the zones may be 10 times as wide as in the most sheltered.

> **Summary**
> Waves modify the affect of tides by driving water and spray to higher levels. The more exposed the shore is, the more the effect.

The Main Features of Zonation

To understand the names given to the zones. We must understand a scientific term, namely littoral. Littoral basically refers to the zone between high and low tides called the intertidal or littoral zone. On the shore, there is a series of defined zones, within, above and below the intertidal. You might expect zones to be defined on a physical basis but this is not so. Animals and plants on the shore are the best indication of actual conditions, so they have been used to indicate the zones. The features of rocky shore zonation have much in common on a world-wide basis and as a result certain groups of animals and plants are used as boundary markers everywhere. This leads to some problems here since one of these groups is missing.

> **Summary**
> There are four **zones** on the shore, two wide and two narrow. The narrow ones are fringes. The zone boundaries are marked by certain animals and plants.

Figure 18.1 shows the zones for a location where wave action is minimal. Think of it as a cliff in a very sheltered bay. In this scheme, in general, narrow zones are called fringes and wider ones zones.

The Zones and their Characteristic Organisms

The Infralittoral Fringe

The bottom zone, the infralittoral fringe, is the most marine and the most stable. It would (in the absence of waves) only be exposed to the air for a few days, on spring tides, every two weeks. This zone has great diversity. However, it is in looking for the top of this zone that we encounter a

> **Summary**
> The lowest **zone**, the infralittoral fringe is most like the sea. Diversity is very high. The top of the zone is marked by the uppermost extent of either urchins, large tube shells or corals.

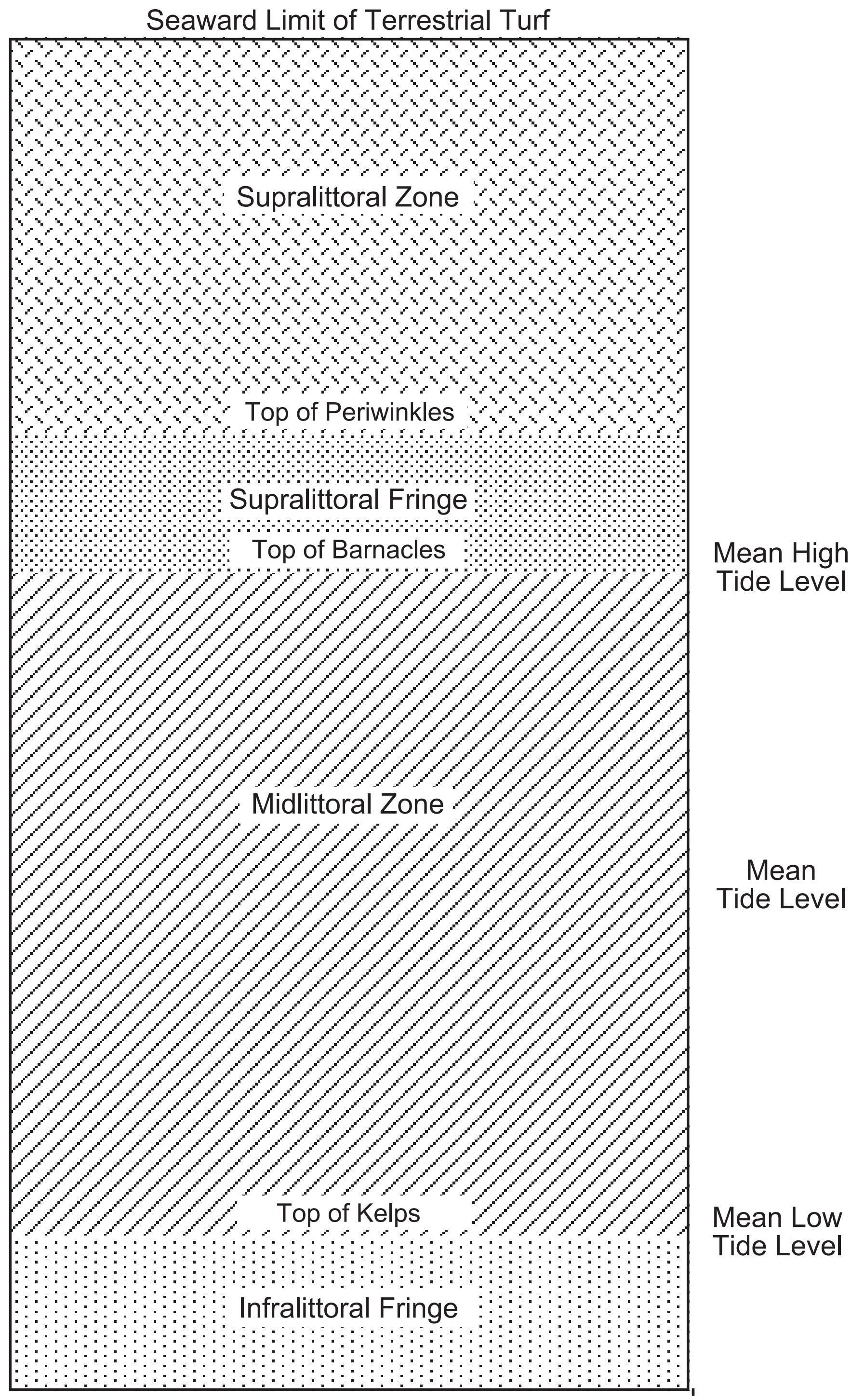

Figure 18.1 Standard world-wide rocky shore zones in relation to tidal level for a fairly sheltered location.

major difficulty. Bermuda has no true kelps or oar weeds , the top of which is the internationally recognised boundary for this zone. We must use something else, on the south shore the Burrowing Rock Urchin will do. Elsewhere, in more sheltered locations, as along the north shore, the Large Tube Shell (*Serpulorbis decussatus*) is useful. If you see corals on the shore they will be in the infralittoral fringe.

The Midlittoral Zone

The next zone is a wide one, the midlittoral zone extending from the top of the infralittoral fringe to the top of barnacles. Barnacles are crustaceans but as adults they are permanently attached to the rock. They are an excellent zone marker because they must be immersed in seawater for a reasonable amount of time every day to feed and breed. However, they are superbly adapted to intertidal life and exist as high as they can on the shore. Everywhere in the world some kind of barnacle has colonised shores to the same level, approximately the average high tide level in shelter. This zone is one where change occurs rapidly and it is frequently subdivided into lower, mid and upper sub zones. Barnacles are characteristic of the top of the zone but do not occupy all of it. The animal most characteristic of the entire zone at a very wide range of exposures is the tiny Corroding Worm Shell (*Dendropoma annulatus*). This is a snail that is cemented into the top of the rock. It cannot move. It relies on the waves and tides to bring it food as it is a **filter feeder** (See Chapter 15). This zone is also covered in a thin mat of seaweed consisting of several species. Generally, they appear yellowish in colour. They are eaten as fast as they grow by a variety of animals. Also common in this zone are two limpets, the West Indian Chiton (*Chiton tuberculatus*) and several nerite species; many other species occur there but less commonly.

Summary

The **midlittoral zone** is wide and is the main part of the shore totally immersed in seawater at high tide. The top of the zone is the upper limit of barnacles and the characteristic organisms are a mat of low red seaweeds and the Corroding Worm Shell. The diversity is quite high including many snails.

The Supralittoral Fringe

Above the midlittoral zone lies the supralittoral fringe another narrow one. This zone is only immersed in water at spring tides in sheltered locations. Inhabitants may be exposed to the air for nearly two-week stretches in calm weather. It is the zone of the periwinkles and stops at their upper limit. There is a problem here, periwinkles are mobile shells and move with the weather, going higher when it is damp. Despite this they are a reasonable zone indicator. In Bermuda four different periwinkles occupy this zone. Three of them are common, the Prickly Winkle, *(Nodilittorina tuberculata)*, the Beaded Periwinkle, *(Tectarius muricatus)*, and the Zebra Periwinkle, (*Littorina ziczac)*. In this zone we should also see a small fuzzy-red seaweed, the Low Siphonweed (*Herposiponia* spp.) and the rock will be blackened by a blue-green cyanobacterium Hofmann's Scytonema, *(Scytonema hofmanni*).

Summary

The **supralittoral fringe** is a narrow zone and the main habitat of periwinkles. Their upper limit is the top of the zone. One red seaweed and black **cyanobacteria** are characteristic.

The Supralittoral Zone

Above the supralittoral fringe is the supralittoral zone (Also see Chapter 14) , usually the widest zone of all. It is often called the splash or spray zone; it is only wetted by storm waves or spray. It is the least marine of the zones and unlike those below it, tends to be colonised by terrestrial plants adapted to marine conditions. However, marine species such as the Sally Lightfoot Crab feed here. This zone is characteristically black owing to the presence of the blue-green cyanobacterium Hofmann's Scytonema, also seen in the supralittoral fringe. This species is the food of the Sally Lightfoot crab. Look for scrape-like grazing marks of this crab in this zone. This is an example of **bioerosion** (see Chapter 7). Another good example of bioerosion is provided by Hofmann's Scytonema. This cyanobacterium lives partly within the rock and dissolves it away.

This leaves a very rough jagged rock surface (phytokarst) in the supralittoral zone (see Chapter 7). Several land plants adapted to salty conditions live in this zone. The commonest is Coast Spurge, (*Euphorbia mesembrianthemifolia*). However, the zone has very low diversity and low abundance of larger organisms, an unusual combination, reflecting ultra-hard conditions for life. This zone ends where a turf of land grasses or herbs begins. Almost all soil entering this zone is washed away in storms leaving the bare rock.

A typical example of intertidal zonation in Bermuda together with the main indicator species and other common inhabitants is shown in **Figure 18.2.**

Summary
The **supralittoral zone** can be very wide in exposed places. Few marine creatures can live in this zone as it is almost terrestrial. Its top is marked by a growth of shrubs, trees or grass.
Animals and plants, other than **cyanobacteria**, are few and those that are present are highly adapted terrestrial organisms.

The Modifying Effect of Waves.
The main effect of wave action in broadening zones has been discussed above. The effect is best shown diagrammatically as in Figure **18.3**. This diagram shows an extremely exposed location and a sheltered one. Note the extension of the supralittoral zone top to a height equivalent to ten times the tidal range.

Seaweeds and Blue-green Cyanobacteria
As mentioned above, the seaweeds are grazed down to a low algal turf. Nevertheless if you look carefully quite a variety of blue-green cyanobacteria and seaweeds can be found. In the supralittoral zone the surface of the rock is blackened by growths of Hofmann's Scytonema, which provides food for Sally Lightfoot crabs and periwinkles. Moving down to around the high tide level the Stiff Sea Moss (*Bostrychia binderi*) can almost always be found in cracks and crevices where it is protected from grazing. The midlittoral zone is characteristically covered in the algal mat described above. Various species occur in this mat, but one of the main ones is Low Siphonweed (*Herposiphonia secunda*). In the infralittoral fringe, a variety of seaweeds are possible but Jamaican Petticoat (*Padina jamaicensis*), Pointed Needleweed (*Amphiroa fragilissima*) and Laurence's Clubweed (*Laurencia obtusa*) are probably the most frequent. Look at **Figure 15.6** for these seaweeds and blue-greens.

Summary
Careful search and attention to detail will show the presence of a variety of red seaweeds and blue-green **cyanobacteria**. Stiff Sea Moss is the only large seaweed extending well up the shore. The **midlittoral zone** is characterised by Low Siphonweed. At the base of the shore, **diversity** increases sharply.

Rocky Shore Animals
Again, starting at the top of the shore, no permanent animal residents of the supralittoral zone are common, but the Wharf Louse (*Ligia baudiniana*) is occasionally observed there. Once we descend to the supralittoral fringe however, periwinkles will start to appear. The highest one is the Beaded Periwinkle (*Tectarius muricatus*), followed closely by the Zebra Periwinkle (*Littorina ziczac*) and then the Prickly Winkle (*Nodilittorina tuberculata*). All these periwinkles occupy only a very narrow zone. Once in the midlittoral animal diversity increases sharply. The top of the zone is marked by the appearance of the barnacles. In exposed locations the species will be the Common Barnacle (*Chthamalus angustitergum*) and in shelter the Striped

Summary
The most common shore animals are marine snails and their relatives. The periwinkles extend highest, followed by the nerites. Countless Corroding Worm Shells occupy the **midlittoral**. Near the bottom are chitons. Also characteristic of the mid-shore are barnacles.

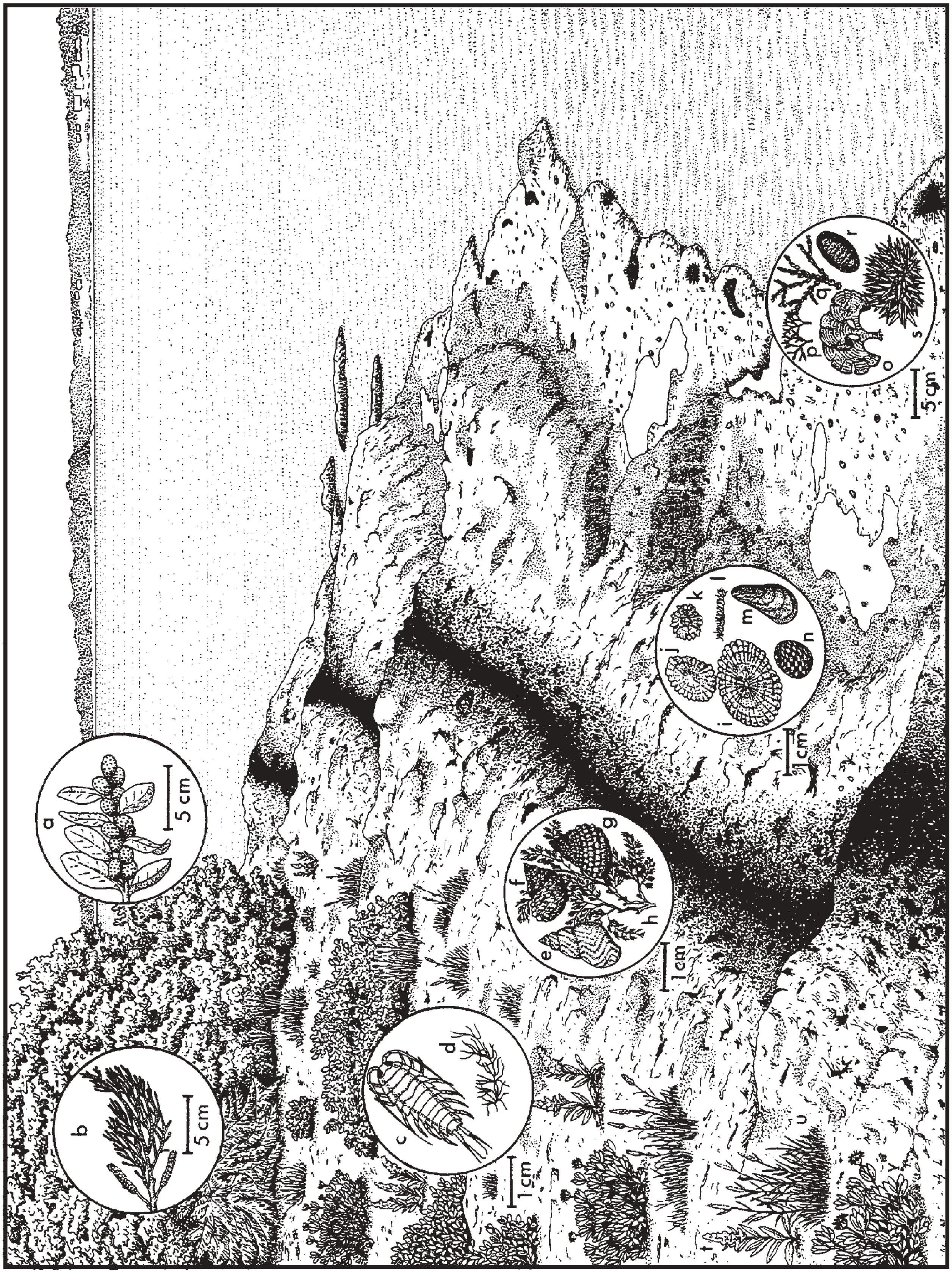
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Figure 18.2 A typical rocky shore zonation in Bermuda for a moderately sheltered sea shore. The prominent organisms for each zone are shown in insets.

Key to Figure 18.2

a Buttonwood
b Tamarisk
c Wharf Louse
d Hoffman's Scytonema
e Zigzag Periwinkle
f Prickly Winkle
g Beaded Periwinkle
h Stiff Sea Moss
i Keyhole Limpet
j Say's False Limpet
k Common Barnacle
l Low Siphonweed
m Scorched Mussel
n Tessellated Nerite
o Jamaican Petticoat
p Pointed Needleweed
q Laurence's Tufted Weed
r West Indian Chiton
s Burrowing Rock Urchin
t Seaside Goldenrod
u Seashore Rush Grass
v Sea Oxeye

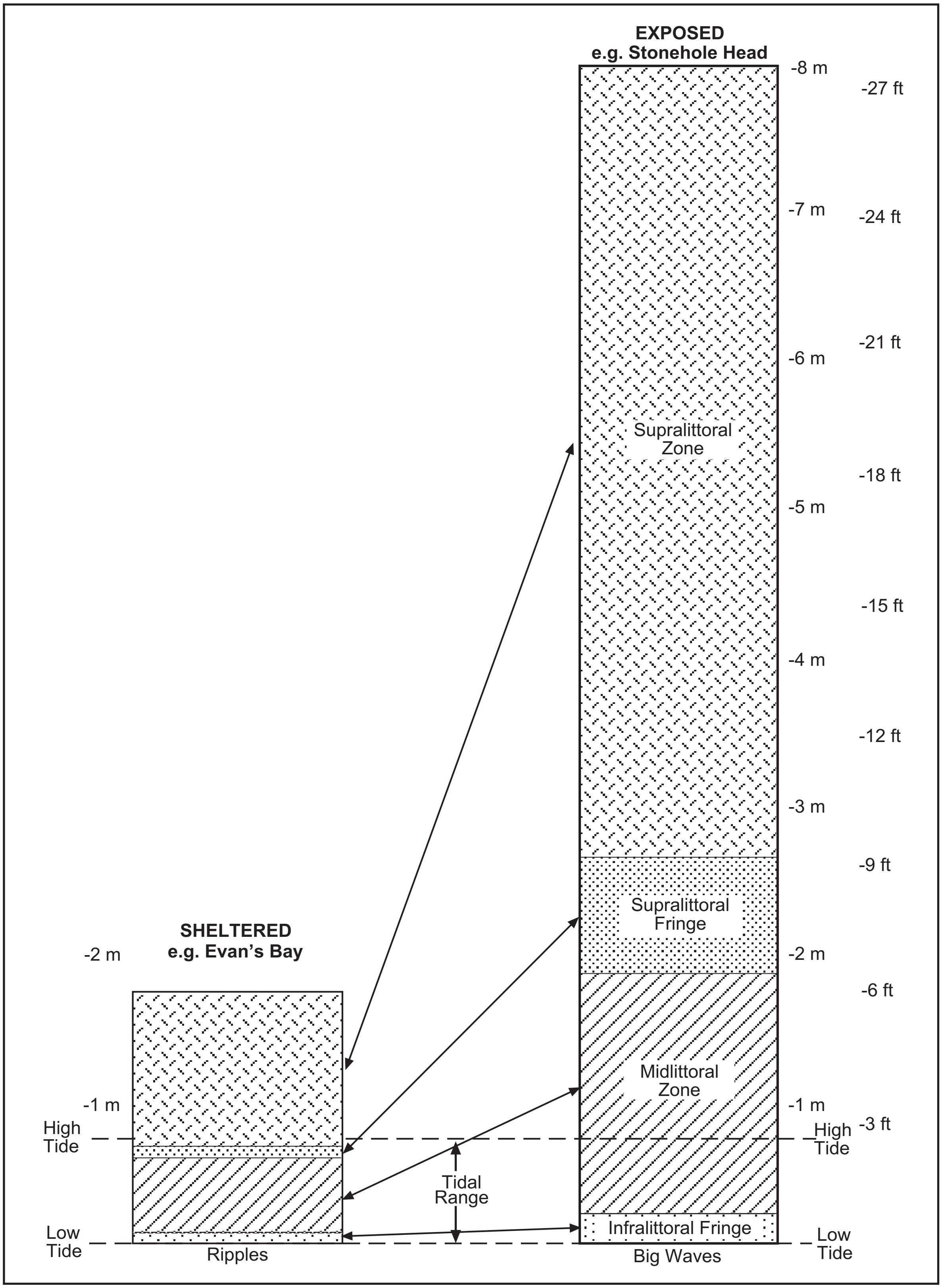


Figure 18.3 The extent of rocky shore zones compared for a sheltered and very exposed location to show zone widening in exposed situations.

Barnacle (*Balanus amphitrite*). Three species of nerites may be found in the midlittoral zone but the most frequent is the Tessellated Nerite (*Nerita tessellata*). This zone is also the home of two limpets, the Keyhole Limpet (*Fissurella barbadensis*) and Say's False Limpet (*Siphonaria alternata*), both of which have conical shells. The Scorched Mussel (*Brachidontes domingensis*) is also found in this zone. The possible animal inhabitants of the infralittoral fringe would make a long list but some very typical ones are the Burrowing Rock Urchin found in exposed areas and the West Indian Chiton (*Chiton tuberculatus*) found over a broader range of conditions. Look for all of these animals in **Figure 18.2.**

Pollution and Conservation Concerns

The rocky shore is probably one of the least polluted environments in Bermuda as trash is usually swept elsewhere by wave action. Oil is quite a frequent problem, and if heavy can smother intertidal life. One other conservation problem is that the seashore is readily accessible and some of its inhabitants are collected either for their beauty or for culinary reasons. The very showy nerite called the Bleeding Tooth (*Nerita peloronta*) has almost been collected out and the Rusty Whelk (*Thais rustica*) is now very rare. The West Indian Top Shell (*Cittarium pica*) was collected to extirpation for the table, has been re-introduced, is doing well and again being eaten!

Summary

The main conservation concerns are oil pollution and the collection of shells.

Questions

1) What are the names of the two zones and two fringes on the rocky shore? ____________________
2) Why does wave action affect the size of the zones? ____________________
3) Which of the zones has life which is terrestrial in origin? ____________________
4) What animal indicates the top of the midlittoral zone? ____________________
5) Where on the shore might rock urchins be found? ____________________
6) How are the barnacles adapted to life on the shore? ____________________
7) Why are there no large seaweeds on the shore? ____________________
8) What are the names of two animals that graze on the rocky shore? ____________________
9) Where might you find Hoffman's Scytonema and what colour is it? ____________________
10) About how long a time is it from high to low tide? ____________________
11) Why are there more seaweeds in cracks and crevices than out on the open shore? ____________________
12) What is the approximate tidal range in Bermuda? ____________________
13) What are two conservation threats on the rocky shore? ____________________
14) Give the common name of one seashell of the rocky shore that has been over collected by shell collectors? ____________________
15) What do you know about the West Indian Top Shell? ____________________

Field Trip # 18.1 to an Exposed Rocky Shore

Preparation

Read this section of this field guide. Find out from the newspaper the time of low tide. To find the time of low tide in advance, tide tables are available from the Bermuda Biological Station for Research. This field trip must be done within an hour, before or after low tide, and when the sea is relatively calm. Nothing can be achieved by going out when large waves are crashing on the shore. Limit the area to be studied from where terrestrial vegetation starts at the top to the waterline.

Dress

No special clothing is needed but shoes should be sturdy and have good non-slip soles. If it is sunny, those prone to sunburn should apply a sun-screen with a high SPF.

Equipment

Clipboard, pencil and several sheets of good paper. A 30 m (100 ft) survey tape. A few pairs of binoculars for the group.

Suggested Location

For best results it is best to pick a fairly exposed area so that the littoral zone is wide. Additionally, work is facilitated if the shore has a fairly low slope, without abrupt drop-offs. If the weather is fairly calm and there is not a surge, the south shore offers some good sites. Possible locations are John Smith's Bay, Spittal Pond and Devonshire Bay Park. If the south shore is unsuitable, there are lots of potential sites along the north shore. Possible study sites are The Tobacco Bay area, the Ferry Point Park area, Coney Island Park, Penhurst Park and Spanish Point Park.

Observations

1) **General appearance of the shore.**
   From a spot where the whole shore is visible, look for evidence of zonation. Look for general colour changes such as are shown in **Figure 18.2**. Make a sketch of the shore from the waterline to where trees, grass or other land vegetation starts. Put an approximate distance along the bottom of your diagram. (Lay a measuring tape down the shore.)

2) The zone indicators.
Look for the organisms that are characteristic zone markers as follows.
A) Top of periwinkles.
B) Top of barnacles.
C) Top of Rock Urchins, Chitons, West Indian Top Shells, Corals or anything not normally exposed to the air, whichever is present. Put an arrow on your sketch, above, showing about where each was found.

3) Diversity of life.
Go slowly down the shore from the top to the bottom and try to find two places where there are the most different species. Don't get confused between abundance and diversity. A place with a whole lot of one kind of organism does not count. Put two stars (✳✳) on your sketch, above, to show where these are.

4) Abundance of life.
Repeat what you just did and look for the one place where there is the greatest number of individuals, regardless of how many different kinds there are. This is a tricky one. Don't get mislead by size. Look very closely at the surface of the rock for small organisms, such as tiny seaweeds or very small animals such as the Corroding Worm Shell (Illustrated in the identification section of this book). Put a small circle, filled in black (●), on the sketch to show where this is.

5) Structural Adaptations to life on the shore.
Pick three different animals (A, B and C) that you have found on the shore, identify them and look at them carefully. Make a small drawing of each. Then describe how you think it is adapted to life on the shore. Hint: Look at shape, shell strength, good attachment etc.

A)

____
____
____
____

B)

____
____
____
____

C)

____
____
____
____

6) General Observations

A) Watch out for birds, both on the shore and at sea. List them.
B) Look just above the shore and describe the kind of vegetation there.
C) Look for evidence of pollution in the form of trash, oil patches etc.

List what you found.

A) ______________________________

____

____

B) ______________________________

____

____

C) ______________________________

____

____

Field Trip # 18.2 to a Sheltered Rocky Shore

Preparation

Read this section of this field guide. Find out from the newspaper the time of low tide. To find the time of low tide in advance, tide tables are available from the Bermuda Biological Station for Research. This field trip must be done within an hour, before or after low tide, and when the sea is relatively calm. Nothing can be achieved by going out when waves are crashing on the shore. Limit the area to be studied from where terrestrial vegetation starts at the top to the waterline.

Dress

No special clothing is needed but shoes should be sturdy and have good non-slip soles. If it is sunny, those prone to sunburn should apply a sun-screen with a high SPF.

Equipment

Clipboard, pencil and several sheets of good paper. A 30 m (100 ft) survey tape. A few pairs of binoculars for the group.

Suggested Location

Work is greatly facilitated if the shore has a fairly low slope, without abrupt drop-offs. This simplifies the situation and gives a good big area for study. To get a sheltered study site, the best locations are in sheltered bays, sounds or harbours. Great Sound has some good locations in the Ireland Island to Somerset areas. Castle Harbour has suitable sites in the Blue Hole area. St. George's Harbour has reasonable sites in Mullet Bay and Whalebone Bay has many possible locations.

Observations

1) **General appearance of the shore**.
   From a spot where the whole shore is visible, look for evidence of zonation. Look for general colour changes such as are shown in **Figure 18.2**. Make a sketch of the shore from the waterline to where trees, grass or other land vegetation starts. Put an approximate distance along the bottom of your diagram. (Lay a measuring tape down the shore.)

Sketch of shore

2) **The zone indicators**.
Look for the organisms that are characteristic zone markers as follows.
A) Top of periwinkles.
B) Top of barnacles.
C) Top of Large Tube Shells, Brown Seaweeds, Corals or anything not normally exposed to the air, whichever is present. Put an arrow on your sketch, above, showing about where each was found.

3) **Diversity of life.**
Go slowly down the shore from the top to the bottom and try to find two places where there are the most different species. Don't get confused between abundance and diversity. A place with a whole lot of one kind of organism does not count. Put two stars on your sketch, above, to show where these are.

4) **Abundance of life.**
Repeat what you just did and look for the one place where there is the greatest number of individuals, regardless of how many different kinds there are. This is a tricky one. Don't get mislead by size. Look very closely at the surface of the rock for small organisms, such as tiny seaweeds or very small animals such as the Corroding Worm Shell (Illustrated in the identification section of this book). Put a small circle, filled in black, on the sketch to show where this is.

5) **Structural Adaptations to life on the shore**.
Pick three different animals that you have found on the shore, identify them and look at them carefully. Make a small drawing of each. Then describe how you think it is adapted to life on the shore. Hint: Look at shape, shell strength, good attachment etc.

A)

B)

C)

6) General Observations

A) Watch out for birds, both on the shore and at sea. List them.
B) Look just above the shore and describe the kind of vegetation there.
C) Look for evidence of pollution in the form of trash, oil patches etc.

List what you found.

A) ______________________________

____

____

B) ______________________________

____

____

C) ______________________________

____

____

Chapter 19. Sand Dunes: A Shrinking Ecosystem

The Sand Dune Habitats

Introduction

In Chapters 5,7 and 8, past conditions in Bermuda were described and in summary we can say that for thousands of years, well before the arrival of man, Bermuda was a country of sand dunes. Coastal dunes developed along coasts and inland there were large dune tracts and inter-dunal low areas. Probably most of the dunes, especially the coastal ones, were quite stable and fixed in place by a cover of vegetation. However, there were also mobile dunes that moved downwind, engulfing things in their path. Even since the arrival of man, there have been extensive areas of sand dunes and on occasion mobile dunes buried buildings and spread inland in some areas. **Figure 19.1** shows the locations where there have been large tracts of dunes since the arrival of man.

Summary
Present day sand dunes In Bermuda are but a tiny fraction of ancient dunes which once covered the entire island. Even since the arrival of man extensive dunes have been present.

The sand dunes are a very harsh environment, very hot and dry and with the added complication of salt coming from the sea. The soil is generally of poor quality, low in organic matter and nutrient minerals and unable to hold much water. The present dunes are all fixed by vegetation and only in severe storms do small mobile dunes develop. They too rapidly become vegetated. Nevertheless, the dunes support a good diversity of plant life, some of which is unique to that habitat, and a few animals also live there.

Summary
Sand dunes are a harsh **ecosystem** being frequently very hot and dry and having poor soil. They are susceptible to storm damage. The harshest conditions exist at the seaward **strand line** and improve steadily moving back.

Sand dunes are a fragile ecosystem and need protection to help keep them as they are. Conditions for life in the dunes are especially harsh at the strand line but ameliorate further back as environmental stability increases. At the strand line the sand is almost entirely inorganic and has little capacity to hold water or plant nutrients. Plants that grow there are usually succulent and store water in their tissues. This is true of Scurvy Grass (*Cakile lanceolata*). Moving back into the dunes the amount of organic matter or humus in the sand increases steadily, and because of this, water and nutrients are retained to some extent. It is still however, a drier environment than further inland and lacking in plant nutrients, it is also still quite saline. Where normal soil, nutrients and low salinity prevail, species from inland out-compete the dune plants and the dune environment disappears.

Animals and Plants of the Dunes

The Strand Line

The **strand line**, which was discussed in Chapter 17 is really the start of the dunes. Onshore winds blow sand that has dried at low tide, up the beach to the strand line and beyond. At the strand line floating seeds such as those of the Scurvy Grass, may be left and then germinate and grow rapidly. The strand line also collects flotsam that floated inshore from the ocean and large quantities of Sargasso Weed (*Sargassum natans* and *S. fluitans*) often pile-up there. Many invertebrate crustaceans and insects live in the strand line as described in Chapter 17.

Summary
The **strand line** at the top of the beach is the start of the dunes. Fragile **embryo dunes** develop here when sand is held in place by plants such as Sea Rocket (Scurvy Grass).

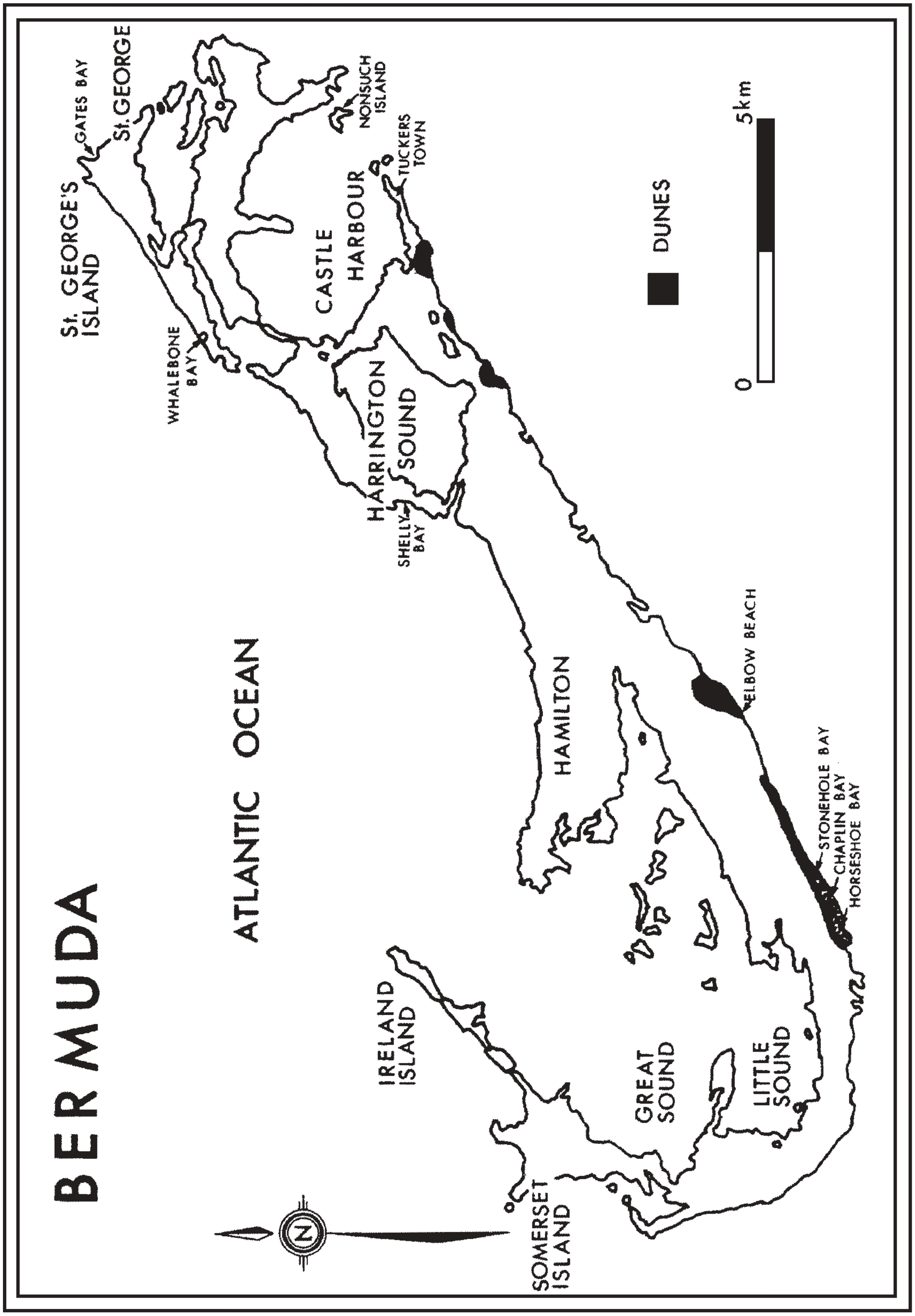


Figure 19.1 A map of Bermuda showing the locations where large dune tracts have developed since colonisation.

The process of dune fixation may be observed to start at the strand line. There highly adapted coastal plants such as Scurvy Grass or Sea Rocket, may root from seeds or plant fragments left by the receding tide. They are tolerant of the poor environmental conditions there and are called **pioneer plants**. Although these pioneer plants have a relatively small chance of survival, being readily removed by large waves, some at higher beach levels do persist.

Embryo Dunes

At the strand line, as the plants grow, sand is trapped forming a small embryo dune. Embryo dunes never get very large and frequently get blown away. On most of the tourist beaches, embryo dunes stand a negligible chance of survival since they are trampled and removed in beach cleaning operations. However, on less trampled southern beaches such as those on Nonsuch Island and in Tucker's Town, embryo dunes are normally present in summer. Scurvy Grass or Sea Rocket (*Cakile lanceolata*) is the characteristic plant of the strand line.

Fore Dunes

Especially persistent embryo dunes may be colonised by other sandy shore plants such as Seashore Rush Grass (*Sporobolus virginicus*). This may then form a second, more permanent, type of dune, the **fore dune**. The most frequent colonisers of the fore dune are Iodine Bush, *(Mallotonia gnaphalodes)* and Beach Lobelia, *(Scaevola plumieri)* but Bay Bean, *(Canavali lineat*a), and Seaside Morning Glory, *(Ipomoea pes-caprae)* are almost always present and Tassel Plant (*Suriana maritima*) is occasionally present. **Figure 19.2** shows a typical fore dune at Stonehole Head and its flora. On the seaward fore dune slope the vegetation is often discontinuous and shifting sand may bury plants. They are, however, adapted to this and normally grow back to the surface. A little further back on the fore dune, vegetation becomes more continuous but bare sand still shows beneath.

Summary

The **fore dunes** are large dunes close to the sea. Their seaward slope is very windswept but fixed in place by Iodine Bush, Beach Lobelia Bay Bean and Seaside Morning Glory. These plants rapidly grow back if buried and pave the way for less tough plants to grow.

The Yellow Dune

Dunes behind the fore dune, but where patches of bare sand still occur are normally termed the yellow dunes because the sand colour shows through. In Bermuda of course, the sand is usually white. The plants are generally similar to the fore dunes but more species are present. Found there are the Beach Croton (*Croton punctatus*), Seaside Morning Glory (*Ipomoea pes-caprae*), Bay Bean (*Canavali lineata*), Burr-grass (*Cenchrus tribuloides*) and Spanish Bayonet (*Yucca aloifolia*) plants and plant remains become more apparent.

Summary

Right behind the foredunes are the **yellow dunes** where a lot of sand is still visible but a wider variety of plants grow. The yellow dunes quickly give way to the **grey dunes** where most of the sand is covered by plants or their remains. Lots of different plants including Bermudiana, Wild Stock, Spanish Bayonet and Seaside Evening Primrose.

The Grey Dunes

Once almost all the dune surface is covered in vegetation or plant debris they are referred to as **grey dunes**. Here grasses such as the Burr-grass become common along with herbs such as the endemic Bermudiana, *(Sysyrinchium bermudiana)*, Seaside Evening Primrose (*Oenothera humifusa*) Seaside Goldenrod (*Solidago sempervirens*), Wild Stock (*Matthiola incana*) and Scarlet Pimpernel (*Anagallis arvensis*) and shrubs such as Spanish Bayonet (*Yucca aloifolia*), and Tassel Plant. Stunted individuals of coastal trees, typically Bay Grape, (*Coccoloba uvifera)*, Casuarina, Australian Whistling Pine or Whispering Pine, (*Casuarina equisetifolia*) and Tamarisk, *(Tamarix gallica)*, also appear.

The Sand Plain

To the landward of the grey dunes, the flora and fauna occupy a flatter area called a **sand plain**, which becomes increasingly like coastal hillside (Chapter 21) as one moves away from the sea.

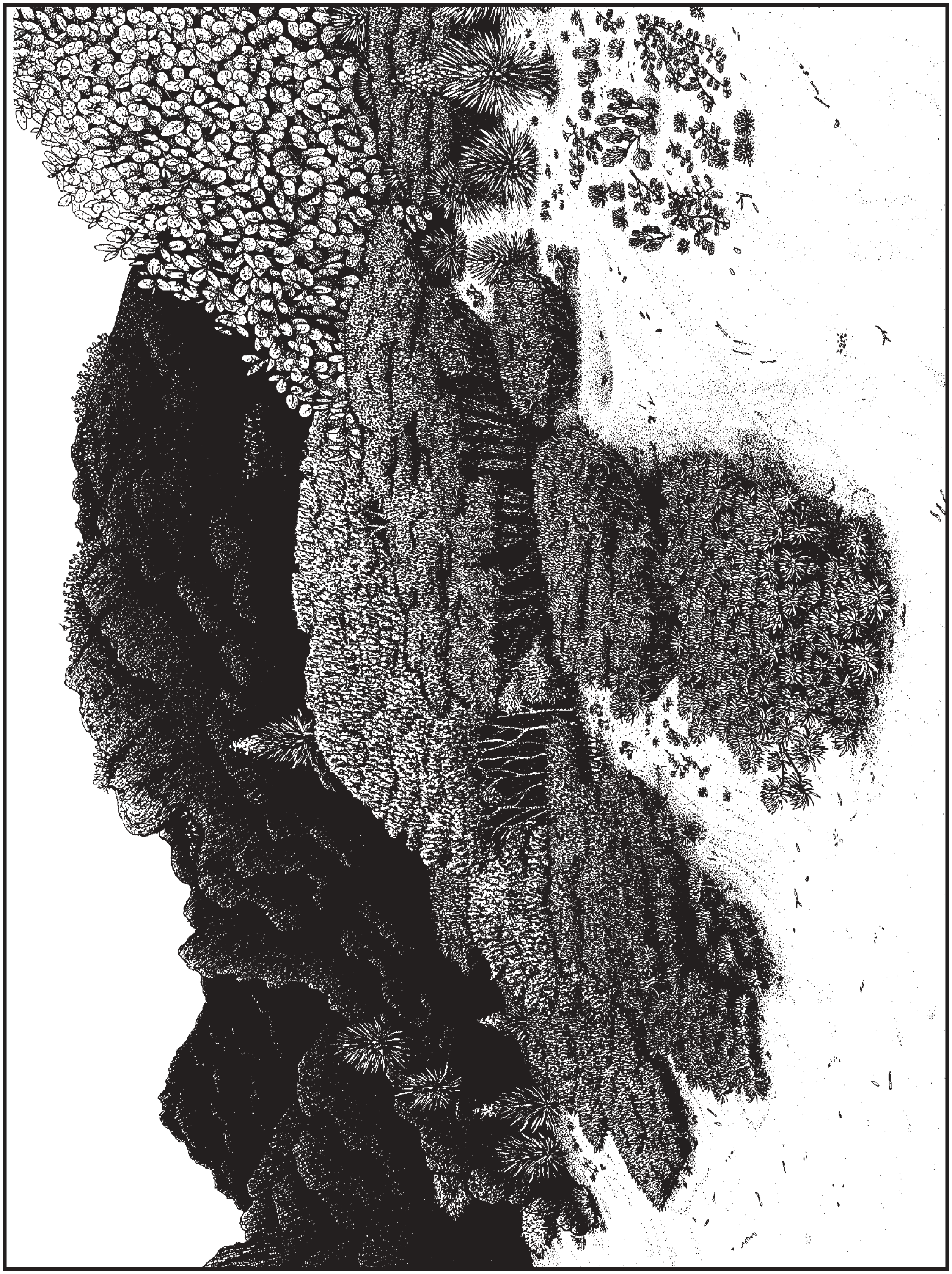


Figure 19.2. A typical fore dune at Stonehole Head showing the characteristic plants. Note that hurricanes may have caused some changes here.

Key to Figure 19.2

Iodine Bush

Seaside Morning Glory

Spanish Bayonet

Tassel Plant

Bay Grape

Sea Oxeye

Here many introduced plants such as Oleander (*Nerium oleander*), Hibiscus (*Hibiscus rosa sinensis*) and Pittosporum or Mock Orange, (*Pittosporum tobira*) appear.

> **Summary**
> Behind the dunes closer to the sea lies a **sand plain** where a variety of trees and shrubs and other herbs grow.

Animal Life in the Dunes

Throughout the dunes the only animal that is resident in any numbers is the Land Crab or Red Land Crab, (*Gecarcinus lateralis*). All that you will see are its burrows, which are mostly back in the grey dunes and sand plain. This animal is on the decline in Bermuda because it is the favourite food of the Yellow-crowned Night Heron which is now very common.

If you look around you will also see colonies of the Argentinian Ant (*Iridomyrex humilis*). You may also be able to spot the food traps of the larvae of Tiger Beetles (*Cicindela trifasciata*). The larvae are called Ant Lions and they make a steep-sided conical pit in the sand where they wait for their ant prey.

> **Summary**
> Very few animals live in the dunes but land crabs, ants are frequent and other insects move in and out.

Various other insects fly into the dunes or appear there temporarily.

Pollution and Conservation Concerns

The sand dunes do not suffer greatly from pollution, but their location right behind the beaches means that there is a great deal of foot traffic through them. Additionally, they are a favourite site for horseback riding. On the heavily travelled paths, no vegetation remains and during violent storms erosion may start there. Conservation efforts need to be aimed at reducing the amount of sand dune habitat that is trampled. In other countries fenced boardwalks are used for this purpose. Boardwalks also allow the opportunity to place educational exhibits that increase public awareness of this delicate ecosystem.

> **Summary**
> The main threats to sand dune systems are trampling by humans and horses and severe storms which can destroy fore dunes.

Questions

1) What kind of plant might you find in an embryo dune? ______________________________

____

2) What is the name of one other pioneer plant of the dunes? ______________________
3) Name one vine (plants with long creeping stems) found in the dunes. ____________
4) What tree found in the dunes grows closest to the ocean? ______________________
5) What is the name of one grass found in the dunes? ____________________________
6) Name one plant found in the grey dunes but not in the fore dunes. ____________
7) How might the delicate ecosystem of the dunes be better protected? ____________

____

8) What is a mobile dune? ____
9) Name one adaptation of dune plants that is important for their survival. __________

____

10) Name one animal that might be found in the dunes. ____________________________
11) Why does the proportion of introduced plants increase away from the sea? ________

____

12) Why are wild animals so uncommon in the dunes? ______________________________

____

13) Name two introduced plants found at the back of the dunes. ____________________

____

14) Name two shrubs found in the seaward half of the dunes. ______________________

____

15) How are pioneer plants adapted to life on the front slope of the dunes? __________

____

Field Trip # 19.1 to the Sand Dunes

Preparation

Read this section of this field guide. Material on the strand line in Chapter 17 is also useful.

Dress

No special clothing is needed but shoes should be sturdy and have good non-slip soles. If it is sunny, those prone to sunburn should apply a sun-screen with a high SPF as the sand dunes are a very sunburn provoking environment.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group.

Suggested Location

The best location for the study of sand dunes is the area just behind Stonehole Head in South Shore Park (Western end) there is a convenient car park there.

Observations

1) **The Dune Ecosystem in General**.
At the back of the dunes, the terrain slopes up steeply towards the south shore road. There is a little flat area about half way up from which a good view of the dunes is presented. From this vantage point, sketch the dunes from the sea back to where you are. You will be able to distinguish various shrubs and trees, so show their location on the diagram.

Sketch of the sand dunes at Stonehole Head

2) **The Fore Dunes** Walk to where the dunes begin in a steep bank at the back of the shore. Identify the plants growing on the bank. Notice which dune plant goes closest to the beach, which comes next, and continue up to plant 4.

A) Plant closest to the beach ____________________

B) Plant second closest to the beach ____________________

C) Plant third closest to the beach ____________________

D) Plant fourth closest to the beach ____________________

3) **The Grey Dunes** Walk back into the dunes along one of the paths. Note the way the vegetation changes and how diversity (number of different plants) and plant cover increase as you go. Stop when you get to a point where the undisturbed vegetation is dense enough that little bare sand is exposed. Identify as many plants as you can and count how many different plants can be seen close to where you are.

   Plants Identified:

   A) ____________________ B) ____________________
   C) ____________________ D) ____________________
   E) ____________________ F) ____________________

   Total Number of different kinds of plants (Diversity) ____________________

4) **The Dune Profile** A profile is really just a cross section through an ecosystem or habitat. It shows how the land surface changes and where the high and low spots are. From your observation area in the grey dunes and remembering how the dunes changed as you moved back, draw an approximate profile of the dunes. Once you have completed the profile mark on it the position of A) The beach. B) The Fore Dunes C) The Yellow Dunes. D) The Grey Dunes. E) The Sand Plain. F) The Back Slope.

Dune Profile at Stonehole Head

5) **Trees and Shrubs**. On the profile above mark in the position of:

   A) The Bay Grape nearest the ocean.
   B) The Casuarina nearest to the ocean.
   C) The Oleander nearest to the ocean.
   D) The Pittosporum nearest to the ocean.

Either do this with an arrow and name for each tree or do a little sketch of each tree and label it.

6) **Flowers** Walk around and list all the flowers that you can identify and for each state which kinds of dunes that they live in.

A) Flower ______________________ Kind of dune ______________________
B) Flower ______________________ Kind of dune ______________________
C) Flower ______________________ Kind of dune ______________________
D) Flower ______________________ Kind of dune ______________________
E) Flower ______________________ Kind of dune ______________________

Chapter 20. Cliffs and Steep Rocky Coasts

Cliffs, their Character, Value and Origin

Introduction

At first glance one might think that cliffs, being highly inaccessible, would be a habitat of negligible importance in the overall ecology of Bermuda. However, a moment's reflection shows that this is not true. The very inaccessibility of cliffs is important since birds can find nesting sites there which predators from the land cannot reach. Additionally, very steep rather than sheer cliffs, although more accessible, are unsuitable for development as building sites and difficult to walk through. Because of this, they are a refuge for endemic and native plants. Indeed Abbott's Cliff, in Harrington Sound, is a park and a treasure trove of endemic and native plants. It is targeted for the removal of invasive, introduced species and may become a nature reserve. One other point in favour of sheer cliffs is that they show off geological features (Chapter 7) wonderfully well and in many places show unique fossil deposits (Chapter 10).

Summary

Although cliffs are very inaccessible they are an important habitat particularly for nesting White-tailed Tropic Birds. Less sheer cliffs support many endemic and native plants. Cliffs also display key geological features.

The Origin of Cliffs

Cliffs occur almost everywhere in Bermuda and are a legacy of its geological past (see Chapter 7). Cliffs are formed by the erosion of the relatively soft aeolianite limestone and are most frequent where erosive action is high.

South Shore Cliffs

It is not surprising that the south shore has a large number of cliffs because that coast is open both to prevailing winds and swell created further to the south. Even storms in the southern hemisphere can generate waves that impinge on the south shore. The south shore also lacks the continuous reef structure that protects the other coasts of Bermuda from heavy seas. The south shore cliffs result from wave erosion that usually is typified by a **wave cut notch** at the base of the cliff. In the case of cliffs that end on a sandy beach, this notch is often buried in the sand. The notch weakens the cliff above and with time, large chunks break off exposing new rock. In places these fallen masses of limestone are visible, but more frequently they are broken down to sand by further erosion and disappear.

Summary

The cliffs of the south shore are a classic example of cliffs caused by the erosive action of waves which cut a notch at the cliff base. This weakens the rock above which falls creating cliffs.

Harrington Sound Cliffs

The cliffs in Harrington Sound look similar to others but are formed by a very different process as explained in Chapter 7. The clue that these cliffs are different is that Harrington Sound is sheltered and large waves cannot be generated there. The cliffs in Harrington Sound are not created by wave erosion but by bio-erosion. Bio-erosion is the result of the action of living organisms. In the case of Harrington Sound, the erosion is caused by a marine mussel, the Black Date Mussel (*Lithophaga nigra*) which bores into the rock to create a protected living space. As it does so, it removes a considerable amount of rock, and since this mussel is very

Summary

The numerous cliffs in Harrington Sound are caused by **bioerosion**. The Black Date Mussel bores into the rock in great numbers creating a sub-tidal notch below low tide level that weakens the overlying rock.

abundant, a huge amount of rock is removed, creating a deep notch at the base of the cliff. In places this notch is 3 m (9 ft) deep and a metre (3 ft) or so high. This notch differs from wave-cut ones in that it is below low tide level rather than above it. However, the result is the same, the cliff collapses. In Harrington Sound, however, since there is very little wave erosion, the displaced masses of aeolianite, tend to stay much longer at the base of the cliff and are clearly visible there.

Inland Cliffs

Cliffs found away from the open coasts or Harrington Sound also result from erosion but the details differ greatly. The cliff types above, all appear in marine environments, whereas the inland ones result from erosion in freshwater. As explained in Chapter 7, freshwater is usually slightly acidic and can dissolve aeolianite limestone. In the past when Bermuda was larger and rain frequent, freshwater draining from higher ground tended to soak into the porous soil, and then follow the most porous deposits to low ground. As it did so, it dissolved away a channel. At the same time rain water just soaking into the soils solidified the mass of sand turning it into limestone. Over hundreds or even thousands of years, water channels enlarged into caves, some of which were immense. If they were close to the surface, the cave roofs weakened by erosion above and the caves collapsed. When this happened, either a sink hole or a pond was created. Walsingham Pond arose in this way; chunks of roof litter the bottom and stalactites are visible on the walls. If the collapse did not go down to sea level then a sink resulted.

Summary

Many inland cliffs result from the collapse of large caves formed by erosion by freshwater. Collapses form **sinks** and inland saltwater ponds. Other cliffs are formed at the mouths of caves. Inland cliffs are a vital habitat for many **endemic** species.

This process also took place on a smaller scale and cliffs were created just at the mouths of caves or where a section of cave tunnel gave way. The Walsingham area is full of such smallish cliffs and they are a very valuable refuge for many rare plants.

The Sheer Rock Habitat

Animal Habitats

Sheer cliffs may descend either into seawater or down to land. Those going into seawater support an array of marine life close to water level. The littoral area of cliffs show all the features described for rocky shores in Chapter 18. If cliffs descend into water that is below low tide level, they support a huge diversity of marine life. Walsingham Pond and Harrington Sound have such cliffs and the diversity of life on them is amazingly high as described in Chapter 23.

Summary

Underwater cliffs support a huge diversity of life in Harrington Sound and Walsingham Pond. Above water cliffs are the nest sites of White-tailed Tropic Birds some of which have been claimed by Rock Doves, reducing the reproductive success of the White-tailed Tropic Birds or Longtails.

Cliffs above the water present natural nesting sites for several birds. Before the arrival of man in Bermuda, the main occupant of holes and crevices on the cliffs, was the White-tailed Tropic Bird or Longtail (*Phaethon lepturus*). These nesting sites were very secure until man arrived but man introduced rats, cats and Pigeons or Rock Doves (*Columba livia*). The predators raided the nests taking eggs and/or fledglings and the Pigeons competed for nest sites. These pressures on the breeding of White-tailed Tropic Birds resulted in the decline of the population. To alleviate this situation the Bermuda Audubon Society has encouraged the use of artificial nesting cavities made of concrete. These look like, and have been dubbed, igloos since they are hemispherical in shape. They are quite successful. Cliffs also support colonies of Honey Bees (*Apis mellifera*), which have escaped from captivity.

Plant Habitats

Sheer coastal cliffs above high tide level offer only limited habitats for plants, nevertheless, some do grow there. Probably the most frequent are stunted Buttonwood Trees (*Conocarpus erectus*) which can survive in very windswept locations with virtually no soil. Also quite frequent are small Casuarinas, Australian Whistling Pines or Whispering Pines ((*Casuarina equisetifolia*) which take hold on small ledges. In addition one might find the odd specimen of Coast Spurge *(Euphorbia mesembrianthemifolia*), Seaside Goldenrod (*Solidago sempervirens*) and Sea Oxeye (*Borrichia arborescens*).

Summary

The plant life of cliffs includes several hardy species which gain a hold on ledges and in crevices. Buttonwood in its stunted form is common as are small Casuarinas. Coast Spurge is quite common as is Seaside Goldenrod. Inland cliffs are the habitat of such rare species as the Cave and Shield Ferns and Wild Bermuda Pepper.

On the other hand, inland cliffs and cave-mouth cliffs are an exceedingly important, often very sheltered, plant habitat, supporting several very rare endemic and native species. Typical of these rare species are the Bermuda Cave Fern (*Ctenitis sloanei*), the Bermuda Shield Fern (*Dryopteris bermudiana*) and the Wild Bermuda Pepper (*Peperomia septentrionalis*). The very common Bermuda Maidenhair Fern (*Adiantum bellum*) also grows on these cliffs. **Figure 20.1** shows a cliff above a cave mouth in the Walsingham district, with some plants found in this habitat. Abbott's Cliff and similar cliffs that are not sheer, support a very wide variety of native, endemic and introduced species.

Steep Rocks and the Life They Support

Most steep rock surfaces are on the coast, since inland ones that once existed have become grown over and the rock lies under a layer of soil. These have mainly become forested over time and their inhabitants are described in Chapter 25.

Along exposed rocky coasts, there are often considerable expanses of almost bare rock, where any soil that accumulates is likely to get swept away in violent storms. The soil in these places is confined to cavities and crevices and there a sparse flora of very tough plants ekes out an existence. These areas are part of the supralittoral fringe and are described in Chapter 18. The only inhabitant of the surface of the bare rock is Hofmann's Scytonema (*Scytonema hofmanni*), a very tough blue-green cyanobacterium. The characteristic flowering plant is the Coast Spurge, but Seaside Goldenrod and Sea Oxeye are frequently present and Spanish Bayonet (*Yucca aloifolia*) and Prickly Pear (*Opuntia stricta*) are occasionally present. Almost no animals reside on these rocky slopes but Sally Lightfoot crabs (*Grapsus grapsus*) may venture up from the sea under wet conditions and Land Crabs (*Gecarcinus lateralis*) and Bermuda Skinks (*Eumeces longirostris*) may come down from above. Additionally a variety of insects from the land can be seen there.

Summary

Steep bare rock slopes along the coast are a harsh **habitat** but support blue-green **cyanobacteria** and a few hardy plants such as Coast Spurge. Sally Lightfoot crabs feed on these slopes when they are wetted by salt spray.

Conservation Issues

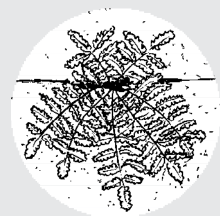
Conservation issues concerning nesting sites for the White-tailed Tropic Bird have already been mentioned. This is an example of an invasive, introduced species, the Pigeon or Rock Dove, interacting with a native one, the White-tailed Tropic Bird. Other conservation issues are mainly the result of invasive terrestrial plants such as the Casuarina and Brazil or Mexican Pepper, (*Schinus terebinthifolia*) which occupy space formerly taken up by native and endemic plants. In a few instances, cliff habitat has been lost to building practices. Cliffs are a valuable habitat and need protection to ensure that they remain viable as a home for Bermuda's fauna and flora.

Figure 20.1. A cliff above a cave mouth in the Walsingham District, showing a variety of plants that are typical of this habitat.

Key to Figure 20.1

Plume Polypody
(*Polypodium plumula*)

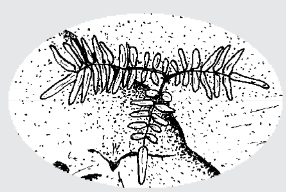
Bermuda Shield Fern
(*Dryopteris bermudiana*)



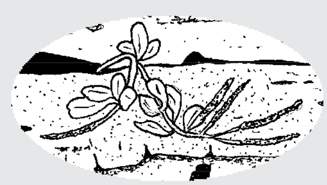
Maidenhair Fern
(*Adiantum bellum*)

White Pellitory
(*Parietaria officinalis*)

Long-leaved Brake
(*Pteris longifolia*)



Wild Bermuda Pepper
(*Peperomia septentrionalis*)



Questions

1) What is one way that cliffs are created? ______________________________
____
2) Why are cliffs more common on the south than the north shore? ______________________________
3) What is the difference between a wave cut notch and a bio-erosional notch?
____
____
____
4) In what inland salt-water body can you find a bio-erosional notch? ______________________________
5} What are the common names of two birds that nest in cliff holes? ______________________________
____
6) What are some of the factors that threaten nesting success in the White-tailed Tropic Bird?
____
7) What are the names of two plants that you might find on cliffs or steep rocky shores?
____
8) What is the name of the rock that composes cliffs in Bermuda? ______________________________
9) Name two animals, other than birds, that you might find on cliffs or steep rocky shores?
____
10) What is the name of one geological feature that is well displayed in Bermudian cliffs
____

Field Trip # 20.1 to Cliff and Steep Rock Locations

Preparation

Read this section of this field guide. Material on Geology in Chapter 7 and Rocky Shores in Chapter 18 is also useful. By their very nature cliffs are a very hazardous environment to man. This field trip must therefore be confined to observation of cliffs rather than hands-on study.

Dress

No special clothing is needed but shoes should be sturdy and have good non-slip soles. If it is sunny, those prone to sunburn should apply a sun-screen with a high SPF as the open coast is a very sunburn provoking environment.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group.

Suggested Locations

Cliff locations are often difficult of access, but where there is a will there is a way. If a good boat is available, it is possible to look at a great variety of cliffs and steep rocky shores in one trip. Harrington Sound is an obvious choice. Cliffs are everywhere there and Abbott's Cliff, one of the best in Bermuda is at the NE end. Additionally there is a good White-tailed Tropic Bird nesting site on Rabbit Island. If you would like to go to an outer shore cliff, then St. David's Head is a great location and lots of steep rocky coastline occur in that area too. If a land approach is desired, several coastal Parks are possible. There are fine cliffs in the eastward part of Astwood Park as there are towards the west end of South Shore Park. There is also a nice cliff with good access at Windsor Beach in Tuckers Town but permission is required to take groups there.

Observations

1) **The Cliff Habitat** From anywhere where you can get a good view of a whole cliff, draw a sketch of the cliff face, showing the geological structures, ledges, holes and where vegetation occurs, if present. Estimate the height of the cliff and add that information to your diagram. If you see White-tailed Tropic Birds going into holes put an arrow on your diagram showing the location.

Sketch of a cliff face

2) **Cliff Dwelling Animals and Plants**. Look carefully at the cliff from a distance (binoculars will help) and up close. Identify as many animals and plants as you can see and note their habitats (e.g. Open Cliff Face, Ledge, Crevice, Hole, etc). List your information below.

A) Identity ____________________ Habitat ____________________
B) Identity ____________________ Habitat ____________________
C) Identity ____________________ Habitat ____________________
D) Identity ____________________ Habitat ____________________
E) Identity ____________________ Habitat ____________________
F) Identity ____________________ Habitat ____________________
G) Identity ____________________ Habitat ____________________
H) Identity ____________________ Habitat ____________________

3) **Details of one Cliff Dweller**. Choose one of the animals or plants that you have listed above. State its identity. Draw a sketch of it showing as much detail as you can. State how it is adapted to live on a cliff face.

Sketch of a cliff dwelling animal or plant

A) Identity ____________________ Animal ❐ or Plant ❐

B) Observations on its adaptation to the cliff environment. ____________________

____

____

____

____

Chapter 21. Exposed Coastal Habitats with Soil

Habitat Characteristics

Introduction

Historical records show that when Bermuda was first colonised, all the coasts above extreme high tide level, were either forested or occupied by very dense growths of shrubs. Non-forested coastal habitats that have a continuous layer of soil are almost certainly a result of the activities of man. Some of these sites were cleared for agriculture and others for human dwellings, only a few in inaccessible locations and on small islands remained in their original condition. Over time most, if not all, of these have become infiltrated with introduced species, particularly the Brazil or Mexican Pepper, (*Schinus terebinthifolia*).

Typical Locations

Non-forested coastal habitats were most extensive on the more exposed coastlines, typically along the south shore. In most of the more sheltered areas, lowland forests grew right up to the shoreline. The best places to see open coastal habitats at present, is in some of the parks and nature reserves. Nonsuch Island has probably one of the best examples, although most of it is wooded, but even there the modifying effect of man's activities is obvious. The remains of dead Bermuda Cedar (*Juniperus bermudiana*) trees, killed by Cedar Blight, introduced by man, extend down the open coastal slope. Additionally there are many specimens of the Casuarina, Australian Whistling Pine or Whispering Pine, (*Casuarina equisetifolia*), planted by man to replace the windbreak previously afforded by the cedars, at the top of the slope. Other good examples of open coastal habitats can be seen in the Spittal Pond Nature Reserve and in Hog Bay Park.

Summary

Open coastal sites that have a layer of soil result from the activities of man. Originally they would have supported **shrubs** in exposed areas or trees in more sheltered ones.

Physical Factors

The main factors which modify vegetation close to an exposed shore are high wind velocities and the presence of salt spray at times. Even where species typical of exposed inland areas, such as the Bermuda Cedar occur, the harsh coastal climate affects them. Trees show more irregular growth and become more stunted as they approach the coastline. This results from both physical and physiological damage to tender growing shoots, which increases with height above the ground. Shoots may be broken off by the wind or physiologically damaged by salt spray and the water loss that accompanies high winds. Damaged twigs grow very slowly, if at all. The damage is always most severe on the side facing the coastline. This results in a growth form called '**weathervaning**', in which trees and shrubs appear to lean downwind

Summary

Open coastal areas have high winds, salt spray and dry out easily; difficult conditions for plants.

Native Trees and Shrubs

Three of the trees which exist in very windswept locations, the Bermuda Cedar and the Buttonwood (*Conocarpus erectus*) and the Bay Grape (*Coccoloba uvifera*) become progressively more prostrate as they approach the shoreline, and extreme examples only extend 10 cm (3 in) or so above the ground. The Bermuda Palmetto (*Sabal bermudana*) is not common in very exposed areas but does occur, there specimens are much shorter than in more sheltered locations. There are, however a few tough native shrubs that are characteristic of open coasts and do not occur inland. The Tassel Plant (*Suriana maritima*) is one of these, it is a shrub commonly about 1 m (3 ft) high that may form dense thickets, almost impossible to penetrate. Another is Coast Sophora (*Sophora tomentosa*) which may reach 2 1/2 m (8 ft) high but tends to drape down the slope. Iodine Bush (*Mallotonia gnaphalodes*), which used to be called Sea Lavender, is not quite as tough as the foregoing two shrubs, but still occupies some quite exposed locations.

Summary
Native Cedars, Fan Palms and Buttonwood trees grow in stunted form in windswept locations. Shrubs such as the Tassel Plant, Coast Sophora and Iodine Bush are adapted to these conditions along with a variety of herbs such as Bay Bean and Cape Weed.

Herbs, Grasses etc.
Like the trees and Shrubs, the flowering plants and grasses of open coastal locations, tend to be either ground hugging or very tough. Typical native examples are the Bay Bean (*Canavali lineata*), Cape Weed (*Phyla nodiflora*), Prickly Pear (*Opuntia stricta*), Spanish Bayonet (*Yucca aloifolia*), Bermudiana (*Sisyrinchium bermudiana*) and Seashore Rush Grass (*Sporobolus virginicus*). The introduced Seaside Daisy (*Wedelia trilobata*) is also very common often forming large mats.

Coastal Forests

Introduction
As mentioned above, the coastal forests occupied more of the original coastline of Bermuda than any other plant community. On more sheltered coastlines the coastal forest was almost indistinguishable from low-land stands of the inland forest. The three main tree species would have been the Bermuda Cedar, the Bermuda Palmetto and Southern Hackberry (*Celtis laevigata*) with occasional specimens or clumps of Bermuda Olivewood (*Cassine laneana*). Bay Grape may or may not have been present as there is still some uncertainty concerning when it reached Bermuda. However, the Bermuda Cedar is the most salt-resistant of all these trees and it occupied more seaward locations. In the most exposed locations, the Bermuda Cedar was the main species present with Buttonwood appearing at the seaward edge of the forest. The native vine Virginia Creeper (*Parthenocissus quinquefolia*), probably climbed tree trunks except right at the coast.

Summary
The original coastal forest supported Bermuda Cedars, Bermuda Palmettos and Southern Hackberry with a few Olivewood. Buttonwood was confined to the seaward edge. Whether Bay Grape was present is uncertain

Introduced Species
Several introduced species have found a place in the coastal forest. The Brazil or Mexican Pepper, is everywhere and common in exposed and sheltered sites. The Casuarina was planted along exposed coastlines as a windbreak. It has become naturalised and is now found everywhere along the coast. Frequently present also is the Surinam Cherry (*Eugenia uniflora*) although it does not tolerate much salt. Also common is the Chinese Fan Palm (*Livistonia chinensis*), which seems able to out-compete the Bermuda Palmetto in all habitats. In more sheltered locations, the Fiddlewood (*Citharexylum spinosum*) often dominates the forest.

Summary
Coastal forests today have many **introduced** species, typically Brazil Pepper, Casuarina, Surinam Cherry, Chinese Fan Palm and, where there is some shelter, Fiddlewood is common.

On the Ground
Ferns and mosses, characteristic of the inland forest floor are intolerant of salt and were probably always absent close to the coast where the ground layer was probably sparse or absent. In sheltered coastal forests many of the understorey plants of inland locations were probably present, including Woodgrass (*Oplismenus setarius*), the Ink-berry or Small Passion Flower , (*Passiflora suberosa*), Wild Coffee (*Psychotria ligustrifolia*), Turkey Berry (*Callicarpa americana*), the Small-Fruited Balloon

Vine (*Cardiospermum microcarpum*), Balloon Vine (*Cardiospermum halicacabum*), Box Briar (*Randia aculeata*), Burr Bush (*Triumfetta semitriloba*) Bear's Foot (*Polymnia uvedalia*), Black Nightshade (*Solanum americanum*), Bird Pepper (*Capsicum baccatum*) and Virgate Mimosa (*Desmanthus virgatus*). These species are now uncommon or rare. Common Sage or Lantana, (*Lantana involucrata*) and Poison Ivy (*Rhus radicans*) were also probably common and have remained so. A wide variety of introduced plants now occur in the coastal forest among the more common ones are Fern Asparagus (*Asparagus densiflorus*) and introduced Morning Glories (*Ipomoea* spp).

Summary
Ferns and mosses are salt intolerant and uncommon beneath coastal trees. Most of the original **ground layer** plants are now rare and have been replaced by **introductions** such as Fern Asparagus, Poison Ivy and Morning Glories.

Lichens

Several lichens are quite common on the trunks and branches of the trees near the coast. These include the branched, greenish-yellow *Ramalina denticulata* which forms clumps and two species *Parmelia martinicana* and *Physcia alba*, both of which form discs of growth on the bark and which are brownish grey and mineral grey respectively.

Animals

The animal life of coastal forest tracts has undoubtedly changed greatly since the arrival of man. It is probable that before colonisation, the Cahow or Bermuda Petrel, (*Pterodroma cahow*), nested in cavities created when cedars were toppled in storms and the Yellow-crowned Night Heron (*Nyctanassa violacea*) undoubtedly nested in the trees. Many of the smaller visiting birds still seen along the coasts would have been there seasonally. These probably included the Ovenbird (*Seiurus aurocapillus*), American Redstart (*Setophaga ruticilla*), Worm-eating (*Helmintheros vermivorus*) and Hooded (*Wilsonia citrina*) Warblers. Much less commonly seen birds, but still possible are Kentucky (*Oporornis formosus*) and Swainson's (*Limnothlypis swainsonii*) Warblers. Other migratory birds that you are likely to see in autumn and winter are; the White-throated Sparrow (*Zonotrichia albicollis*), the Hermit Thrush (*Catharus guttatus*) and the only common woodpecker, the Yellow-bellied Sapsucker (*Sphyrapicus varius*). Swainson's Thrush (*Catharus ustulatus*), the Wood Thrush (*Hylocichla mustelina*) and the American Robin (*Turdus migratorius*) were also probably present and seen from time to time. Some native birds such as the Bermuda White-eyed Vireo or Chick-of-the-village (*Vireo griseus*) probably frequented coastal forests but nested in more sheltered locations. No amphibians or mammals would have been present but the Bermuda Skink (*Eumeces longirostris*) would certainly have been common. Among the invertebrates, the Land Crab (*Gecarcinus lateralis*) or Red Land Crab was locally abundant and present everywhere, as were a wide variety of insects and other small invertebrates. The Land Hermit Crab (*Coenobita clypeatus*) was certainly locally present as this was one of its main habitats.

Summary
The animals of the coastal forest include many birds such as warblers, sparrows and thrushes. In the past, the now rare Bermuda Skink was common along with the Land Hermit Crab. The land crab is the most typical year-round inhabitant.

With the arrival of man the coastal forest was the first wooded area to become degraded, since man tended to settle along the coasts. The introduced Brown or Norway Rat, and Black Rats (*Rattus norvegicus* and *Rattus rattus*) would be evident at night or in poor light. And hogs, goats etc grazed and rooted there. Additionally dogs and cats would hunt for food in the forest. Somewhat later the currently abundant lizard, the Jamaican Anole (*Anolis grahami*), became a common resident of wooded and shrubby areas. Among the amphibians, both the Giant Toad (*Bufo marinus*) and the Whistling Frog (*Eleutherodactylus johnstoni*) became common, particularly in locations with freshwater seepage. Many birds followed man to Bermuda and took up residence or fed in coastal forests these included the Cardinal (*Cardinalis cardinalis*), the Catbird (*Dumatella* *carolinensis*), the Great Kiskadee (*Pitangus sulphuratus*), the Starling (*Sturnus vulgaris*), the Barn Owl *(Tyto alba*) and the European Goldfinch (*Carduelis carduelis*).

Introduced animals and their effects totally changed the coastal forest for all time.

Coastal Scrubland

Introduction

Very exposed locations particularly on headlands along the south shore that were not forested, were covered with nearly impenetrable growths of dwarf trees and low growing, tough shrubs. This is a very dry zone with poor, unproductive, thin, sandy soil and high winds. Only very specialised plants and animals can live there. The vegetation forms a windbreak for organisms further back and prevents erosion of the soil.

Characteristics

Closest to the sea, in most places was a fringe of stunted Buttonwoods and Bermuda Cedars, with, possibly, the occasional Bay Grape, which formed a partial windbreak. Behind these was a variable tract of shrubs found only along coasts. The most common plant was probably the very tough Tassel Plant. This waist-high species is very tough with wiry stems and often forms extensive, growths with virtually no other species present. In other locations the very stunted Buttonwoods close to the water steadily increase in height moving away from the water. They can form dense thickets. With a little increase in shelter, other shrubs such as the Iodine Bush and Coast Sophora appeared and with even more shelter the forest took over. Few introduced species other than the Brazil or Mexican Pepper, appear in these coastal shrublands but in a few places there are extensive thickets of the Simple-leaved Jasmine (*Jasminum simplicifolium*) which can be quite invasive. The same three lichens listed above in the forest section also may be found here. Little animal life would have been present but probably Land Crabs, Land Hermit Crabs or Red Land Crabs and Bermuda Skinks were present along with a variety of insects.

Summary

Impenetrable coastal scrubland originally clothed exposed headlands and some coastal areas. Stunted Cedars and Buttonwoods were right along the coast backed up by Tassel Plant, Coast Sophora and Iodine Plant. Now this **community** is less common and in places has been invaded by Simple-leaved Jasmine.

This coastal community of shrubs was not a favoured area for housing due to its high exposure and therefore it has not been so severely changed as the adjacent forest. However, the extent of these scrubland communities has no-doubt been greatly reduced as man occupied more and more of the coast and disturbance has all but eliminated the animal life. The best remaining examples of this type of coastal community are in Nature Reserves and Parks, particularly Spittal Pond and South Shore Park. There is also a good example on the small peninsula between Hungry Bay and the sea.

Grassy and Herby Coastal Slopes

Introduction

As explained above, grasses and herb inhabited coastal slopes are not a natural habitat in Bermuda, all have arisen as a result of man's activities. Some have arisen when coastal forest was cleared for farming, other areas were cleared for habitation and then abandoned because of their exposed nature. In some cases abandoned, cleared land was subject to wind erosion and gave rise to sand dunes, some of which moved well inland. See Chapter 19 concerning sand dunes. **Figure 19.1** shows where these dunes formed. Since then most of these areas have been used for housing or have reverted to grassy slopes. Now a small variety of native and introduced grasses, herbs and vines characterise these locations.

Summary
These mostly grassy areas followed man's clearance of shrubs and trees. Characteristic plants include Seashore Rush Grass, Crab Grass, Switch Grass, Seaside Daisy, Cape Weed, Bay Bean and Bermudiana.

Characteristics

Whatever is growing on these slopes, grasses are almost always part of the community. Closer to the sea, Seashore Rush Grass (*Sporobolus virginicus*) is characteristic, while further back, Crab Grass or St. Augustine Grass, (*Stenotaphrum secundatum*) and Switch Grass (*Panicum virgatum*) become more common. In some places extensive patches of the introduced Seaside Daisy (*Wedelia trilobata*) with attractive yellow flowers have developed. This herb is sometimes planted to control coastal erosion. Seaside Daisy is classed as an invasive species, but there is no doubt that in some of the man-created coastal areas it forms a very effective defence against erosion. A native, low growing herb that is also very abundant in these situations, is the Cape Weed (*Phyla nodiflora*). A native vine common on these slopes is the Bay Bean (*Canavali lineata*) with large leaves and attractive purple, pea-like flowers. Where grassy slopes grade into true dunes, dune species such as Seaside Evening Primrose (*Oenothera humifusa*), Seaside Morning Glory (*Ipomoea pes-caprae*) and sometimes, Scurvy Grass (*Cakile lanceolata*) and Spanish Bayonet (*Yucca aloifolia*) start to appear. Where open slopes occur in areas that become more rocky, look for Seaside Goldenrod (*Solidago sempervirens*), Prickly Pear (*Opuntia stricta*) and Blodgett's Spurge (*Euphorbia blodgettii*). The native species Bermudiana (*Sisyrinchium bermudiana*) and Darrell's Fleabane (*Erigeron darrellianus*) live in a variety of habitats including these coastal slopes.

Conservation Concerns

There is no doubt that nothing remains of the original coastal forest and in this heavily used part of the Bermuda landscape, it will never regenerate by natural means. Any new growths of forest along the coasts will now be dominated by introduced species. What is left of this natural system can now be seen only in parks and nature reserves. On Nonsuch Island an attempt is being made to return the coastal forest to its original state by removing introduced species gradually. Sudden removal would expose the coast to potentially destructive erosion in high winds. Many other parks, especially the Spittal Pond Nature Reserve, have stretches of forest including introduced species, but still showing some of the original character. It is essential that these locations be protected from further harmful influences.

Coastal shrub thickets still exist in several locations in the National Parks. They are not prime recreational areas and so stay relatively natural. The main problem is certainly the encroachment of Brazil or Mexican Pepper, growths. This species is now so widespread and pervasive that any but very local attempts to remove it are impossible.

The shrubby and grassy coastal slopes, although not a major part of the original landscape of Bermuda, are now characteristic of a wide variety of locations. Luckily some good examples exist in many parks including South Shore Park and Hog Bay Park. Others are rapidly disappearing in the face of expanding demand for housing space.

Questions

1) Before Bermuda was colonised by man, what two plant communities occupied the coastline? ______________________________

2) In what sort of location was coastal shrubland found? ______________________________

3) How have grassy/herby coastal slopes come to be there? ______________________________

4) What two species of tree were likely to found closest to the sea on exposed coasts?
1. ____________________ 2. ____________________

5) Why are trees and shrubs close to exposed shores low and stunted? ____________________

6) Which endemic reptile was characteristic of exposed coastal woodland and shrubland? ______________________________

7) Name two native or endemic trees that were present in coastal forests.
1. ____________________ 2. ____________________

8) Name two native shrubs that occur in exposed shrubland.
1. ____________________ 2. ____________________

9) What is the name of the crab that is common in coastal areas? ____________________

10) Which endemic bird probably nested in coastal forests? ____________________

11) In what ways do coastal forests and shrublands protect the land? ______________________________

12) Name two birds currently common in coastal forests
1. ____________________ 2. ____________________

13) Name an introduced, invasive plant commonly found in grassy/herby coastal slopes. ____________________

14) What important function does the plant mentioned in question (13) perform? ______________________________

15) Which two vines might you expect to see on grassy/herby coastal slopes?
1. ____________________ 2. ____________________

Field Trip # 21.1 to Non-rocky Exposed Coastal Areas

Introduction

It is, of course impossible to visit a coastal forest typical of any that was here before colonisation by man. The best alternative is a visit to Nonsuch Island. This can be arranged through the education department at the Bermuda Aquarium. Guides are available who are knowledgeable about Nonsuch Island. Prior arrangements should be made to make sure emphasis is placed on the coastal forest, the coastal slope and the few grassy areas that exist. For shrubby and grassy/ herby areas Hog Bay Park is quite good. The Stonehole Head area of South Shore Park has some very good coastal shrubby stands and Spittal Pond some fairly good ones on North's Point

Preparation

Read this section of this field guide. It would be helpful to also be familiar with the supralittoral zone material in Chapter 18 of this guide and perhaps that on sand dune vegetation in Chapter 19.

Dress

This is a mainly observational rather than hands-on field trip, so no special clothing is needed.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group.

Observations

At whatever location is visited, note whether the location is forest, shrubs or grassy/herby, identify as many species as possible in the coastal zone, list them and be sure to record whether each is Endemic, Native or Introduced. Additionally, decide whether they are rare, common or abundant. If one plant is more common than any other, or occupies more of the environment than any other, designate it as the dominant plant. For introduced species try to decide if they are benign (not harmful), naturalised (now colonising areas on their own) or invasive (pest species that displace endemic and native species). If more than one habitat (forest, shrub or grassy) is available for observation, do them separately so that they can be compared.

Look for birds, mammals and reptiles. Identify them and list them in a separate table noting where they were observed.

Results.

Name of Location to be Studied ____

Type of Habitat ____

Table of Observations (Plants)

Species	Status (endemic, native, introduced, benign, naturalised, invasive)	Abundance (rare, common, abundant, dominant)

Table of Observations (Animals)

Species	Where Seen	Number Seen

Chapter 22. Mangrove Swamps and Salt Marshes

The Mangrove Swamp Habitat.

Introduction

Mangrove is a name given to both an ecosystem and to the trees that occupy it. Mangrove trees are a group of species many of which are not closely related to each other. This is an example of biological convergence in which a variety of trees came to occupy one habitat and be highly adapted to that environment.

Distribution

Mangrove trees are the only trees that are adapted to live in salt water. **Mangrove swamps**, occupied by these trees have colonised sheltered sedimentary shores, particularly muddy ones, throughout the tropics and sub-tropics. Their northern limit (in this hemisphere) coincides with the **frost line**. A sharp frost will kill mangrove trees and much of their associated fauna and flora. North of the frost line, this same habitat is occupied by salt marshes. Bermuda is peculiar in that it has both salt marshes and mangroves, despite the fact that the islands lie to the south of the frost line. In contrast to the salt marshes, mangrove swamps occupy the entire zone between high and low tide and even extend a little beyond this area. Salt marshes however, which are colonised by much smaller grasses and herbaceous plants, and never trees or shrubs, occupy only the upper half of the intertidal zone and often have mud-flats to the seaward of them.

Summary
Mangrove trees are able to live with their roots in salt water in tropical and sub-tropical climates. Those in Bermuda are close to their northern limit. **Mangrove swamps** developed in sheltered, muddy locations. Further north **salt marshes** occupy this **habitat**.

Adaptation to the Environment

The fact that very few kinds of trees have been able to colonise marine shoreline habitats, shows that it is a difficult environment for them. The main factor that they must adapt to is the salt in the seawater. The fluids within mangrove trees are much less salty than the ocean, despite the fact that the roots are bathed in seawater. This shows that they can somehow exclude or excrete salt. All mangrove trees have special mechanisms in the roots to slow down the entry of salt. One group of mangrove trees, typified by the Black Mangrove (*Avicennia germinans*), common in Bermuda, allows some salt to enter the roots and then excretes this salt through special glands on the leaf surface. On a sunny day these salt crystals can be seen glinting in the sun. All these ways of controlling salt use energy which the tree must replace by photosynthesis. Salt is also shed with leaves when they age.

A second major habitat factor that requires adaptation on the part of the trees is the soft mud, usually lacking in the oxygen, needed by the roots. Soft mud is much less stable than soil where trees usually grow and a variety of adaptations have developed to overcome this. In the Red Mangrove (*Rhizophora mangle*), common here, the trees have developed spreading **prop roots** that arch into the sediment from the trunk, which are aided in their support function by **adventitious roots** that descend from the branches to the mud (see **Figures 22.1, 22.2**). The Black Mangrove has developed a different method in which many shallowly buried roots spread out radially from the trunk (**Figure 22.1**).

Summary
Mangrove trees are adapted to live in salt water by keeping the salt level in their tissues down. Salt is partly excluded by the roots and Black Mangrove leaves secrete salt. For stability in soft mud Red Mangrove trees have **prop roots** while Black Mangroves have wide-spreading, shallow roots.

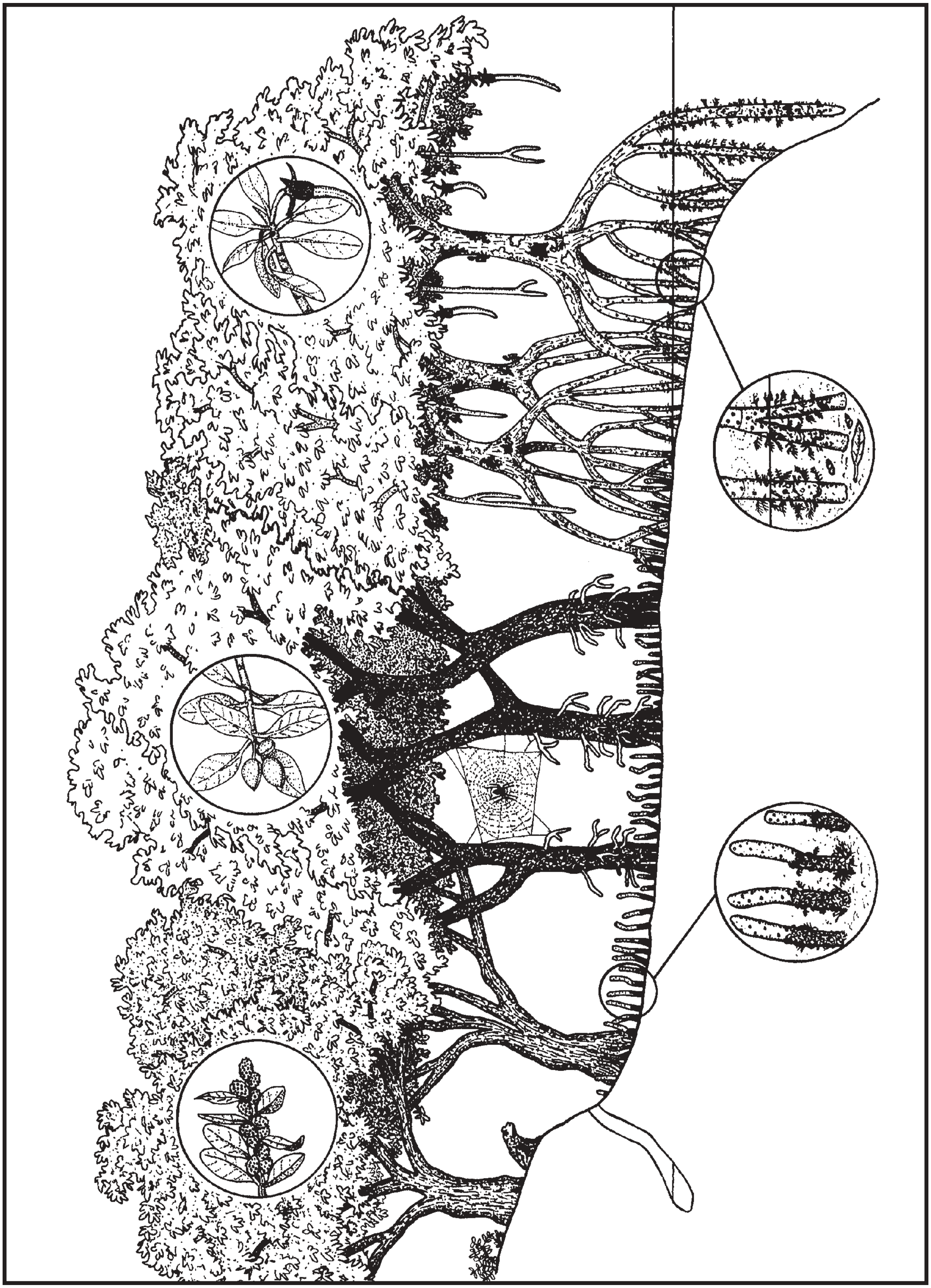


Figure 22.1. Cross section of a typical coastal mangrove swamp in Bermuda, showing tree zonation, details of tree structures and some associated organisms.

Key to Figure 22.1

Buttonwood, *Conocarpus erectus*

Black Mangrove, *Avicennia germinans*

Red Mangrove, *Rhizophora mangle*

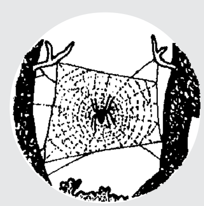
Pneumatophores of Black Mangrove

Prop roots of Red Mangrove

Giant Toad, *Bufo marinus*

Giant Land Crab burrow, *Cardisoma guanhumi*

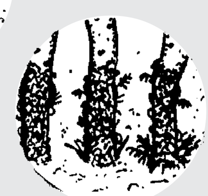
Orb-weaver Spider, *Nephila clavipes*



Mangrove Crab, *Goniopsis cruentata*

Curly Sea Moss on pneumatophores and prop roots

Mat of Crinkle Grass on pneumatophores



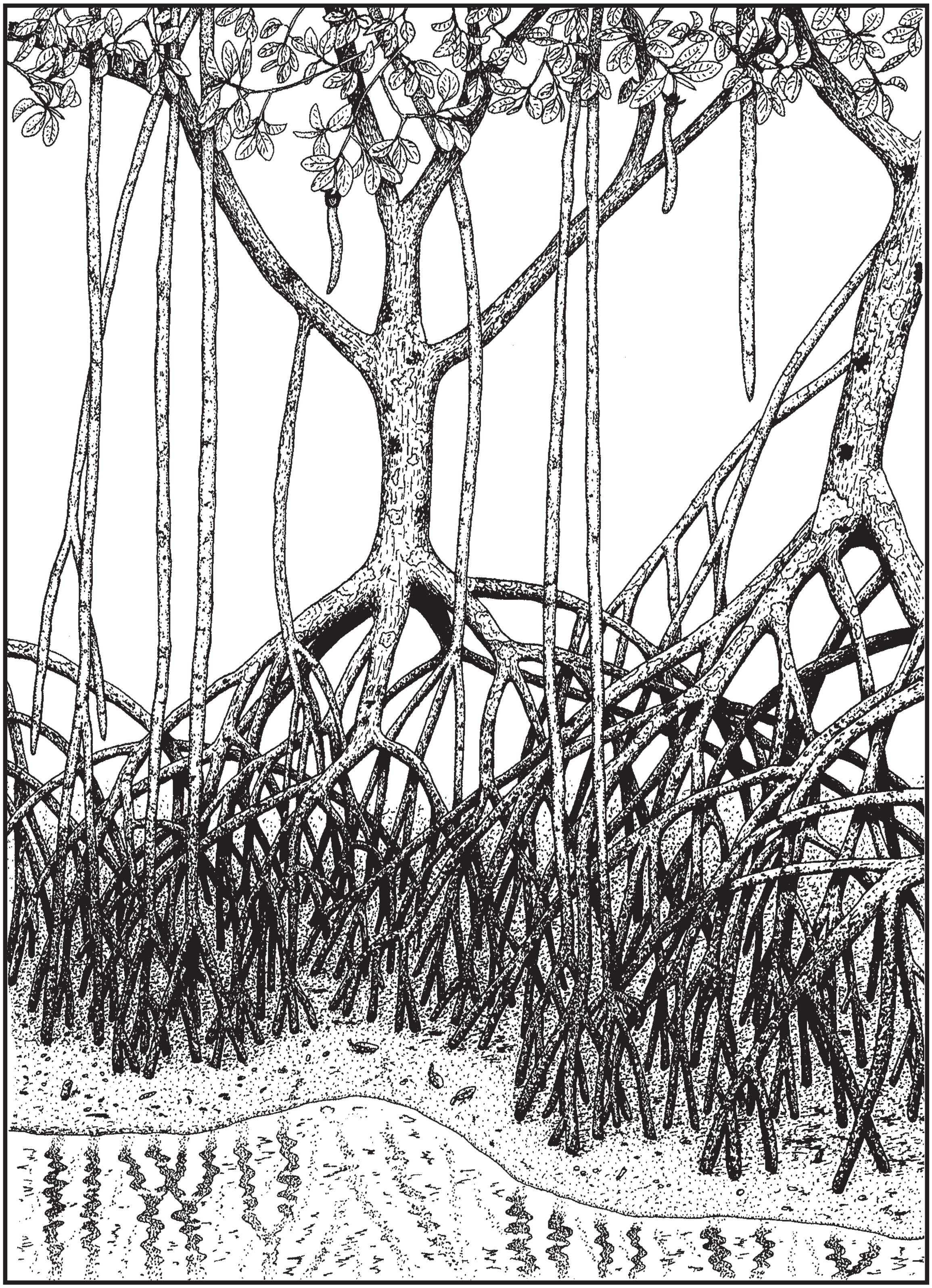


Figure 22.2. Adaptive root structures in Hungry Bay Red Mangrove trees. Adventitious roots descend from branches while prop roots curve out from trunks.

To provide oxygen to the roots, the Black Mangrove has numerous **pneumatophores**, which are pencil-shaped structures rising straight up from the buried roots into the air at low tide, or water at high. Oxygen from the air enters these roots and is distributed through the underground root system. In the Red Mangrove small, whitish knobs called lenticels on the prop roots above the water admit air to the roots.

Summary
The mud in **mangrove swamps** lacks oxygen. To get oxygen to the roots the trees have **lenticels** in the above-water parts that admit air that goes into the roots. To colonise new locations, mangrove trees have special seeds that are large, can float for months and germinate when in suitable places.

The last major area of adaptation to the marine environment is the method of reproduction. Mangrove trees have large seeds, or in the case of the Red Mangrove, embryos (germinating seeds) (See **Figure 22.1**), which drop from the tree when ripe and can float on the ocean to germinate in new locations. It is known that these so-called **propagules** can travel across entire oceans in the surface currents (see Chapter 14).

<u>Structure and Diversity of a Mangrove Swamp</u>

Mangrove swamps combine the characteristics of several habitats. They are part of the forest and show many forest characteristics (see Chapter 25). Thus the tops of the trees form a dense canopy, which is an extension of the terrestrial forest canopy. Terrestrial species, for example the Morning Glories (*Ipomea* spp.), can extend out over the sea in the canopy and many land birds are also seen there. Below the canopy, the sub-canopy is much more open, it is the place where tree trunks and prop roots are the main features. On these a wide variety of animals and smaller plants find a home including Mangrove Crabs (*Goniopsis cruentata*) and Mangrove Periwinkles (*Littorina angulifera*). Just above high tide level, Coffee Bean Snails (*Melampus coffeus*), often may be found on the prop roots. When the tide is in, the lowest layer is mostly water but at the back of the mangrove swamp, above high tide level, there is a well developed ground layer of salt tolerant herbaceous plants such as the Woody Glasswort or Marsh Samphire, (*Salicornia perennis*) and Saltmarsh Oxeye (*Borrichia frutescens*).

Summary
Mangrove swamps combine marine and terrestrial habitats. The tree canopy is the land connection, while the water is marine. **Vines** from the land as well as birds and lizards live in the canopy while the roots support myriad attached marine life. Swimming animals come in with the tide.

The water, at the other extreme from the canopy, is an extension of the ocean. A whole host of marine animals may enter the swamp at high tide and it is a rich nursery ground for juvenile fish and crustaceans. There is also a diverse resident population of attached marine animals and plants on the abundant, firm root surfaces. Literally hundreds of species of seaweeds, blue-green cyanobacteria, sponges, hydroids, moss animals, sea squirts etc may be found. A few species such as the Curly Sea Moss (*Bostrychia montagnei*) and the Coffee Bean Snail have evolved in this habitat and do not occur elsewhere. All this habitat diversity leads to an extremely high biodiversity. The mangrove swamp is among the most diverse in the world.

<u>Bermuda Mangrove Trees and Mangrove Zonation</u>

Three native mangrove species are found in Bermuda these are the Red Mangrove, the Black Mangrove and the Buttonwood (*Conocarpus erectus*). The Red mangrove is found closest to the sea, has broad, shiny, dark green leaves and has prop roots for support. The yellowish flowers are followed by characteristic dangling embryos, with a huge primary root pointing down. The Black Mangrove has narrower greyish-green leaves, which may be coated with salt crystals in dry weather, the white flowers produce nut-like fruit which float. On seashores the Black Mangrove forms a zone behind the red trees, extending to high tide level. The Buttonwood zone is to the landward of the Black Mangroves and the trees are less adapted to salt water. Their roots are above high tide level and as explained in Chapter 22, they also occur on open coastlines in very windy, dry conditions. The leaves are light green and have two characteristic little wings on each side of the leaf stalk. The fruit is cone-like and also floats well in the sea. The only other tree found in mangrove swamps is the invasive pest the Brazil or Mexican Pepper, (*Schinus terebinthifolia*). It invades the back edge of mangroves displacing the native trees. **Figure 22.1** shows the structure and a selection of the fauna and flora of a typical Bermudian mangrove community. **Figure 22.2** illustrates root structures of the Red Mangrove.

> **Summary**
> There are two true **mangrove** species in Bermuda the Red Mangrove and the Black Mangrove, while the Buttonwood occupies the swamp back. Introduced Brazil Peppers are colonising landward mangrove fringes. Mangrove swamps are **zoned** with Red Mangroves to seaward followed by Blacks and then Buttonwoods.

<u>Ecological Importance</u>

In addition to its role as a habitat for countless species, the mangrove swamp is very important because of its outstandingly high biological productivity. By **productivity** we mean the quantity of living material that is produced there. The basis of this is the trees themselves. New leaves, twigs etc. are constantly produced and the leaves age and fall, within a year as new ones grow. The fallen leaves are attacked by bacteria, fungi and protozoa and broken slowly down into fine organic particles called **detritus**. This detritus is a rich food source for many of the animals on the roots. These are the **filter feeders** that strain the water for the detritus in it. As the tide recedes it carries with it a load of detritus, which in turn, is consumed by coastal fish, shrimp etc. This action makes the mangrove swamp an **export ecosystem** with an importance beyond its physical boundaries.

> **Summary**
> **Mangrove swamps** are among the most **productive** on earth, additionally this production, as detritus, moves out to sea to support other **ecosystems**.

<u>Types of Mangrove Swamp in Bermuda</u>

There are two basic types of well-developed mangrove swamps in Bermuda, Bay Mangrove Swamps and Pond Mangrove Swamps and together they total about 33 swamps of varying size. Their locations are shown in **Figure 22.3**. Additionally, there are stretches of fringing mangrove swamps on sheltered shores characterised by scattered or sparse trees, mostly of Buttonwood.

> **Summary**
> In Bermuda we have large coastal **mangrove swamps** and others in marine ponds. **Fringing swamps**, one tree wide line some shorelines.

Dwindling Salt Marshes

<u>Introduction</u>

As explained above, salt marshes are typical of sheltered coastal areas which have frost in winter. Salt marshes are flattish tracts of coastal land sloping gently to the seaward. On the mainland they are always dominated by grasses but here they may be either grass or herbaceous plant dominated. Where there is no frost, salt marshes are normally overgrown by mangrove trees, but, in Bermuda there are a few places where mangroves have failed to colonise, that have remained as marshes. However, these areas of marsh are rapidly declining and may soon disappear forever.

> **Summary**
> **Salt marshes** and **mangroves** do not normally co-exist but in Bermuda we have both although salt marshes are dwindling fast. Salt marshes lack trees and are characterised by grasses such as Sheathed Paspalum or salt-loving herbs such as Marsh Samphire, Salt Marsh Oxeye and Sea Lavender.

<u>Characteristics</u>

The remaining salt marshes in Bermuda are mostly associated with salt water ponds (Chapter 23) where mangroves have colonised only slightly, or not at all, for various reasons. One of the largest is at the east end of Spittal Pond. Like the mainland ones, it is grass dominated, in this

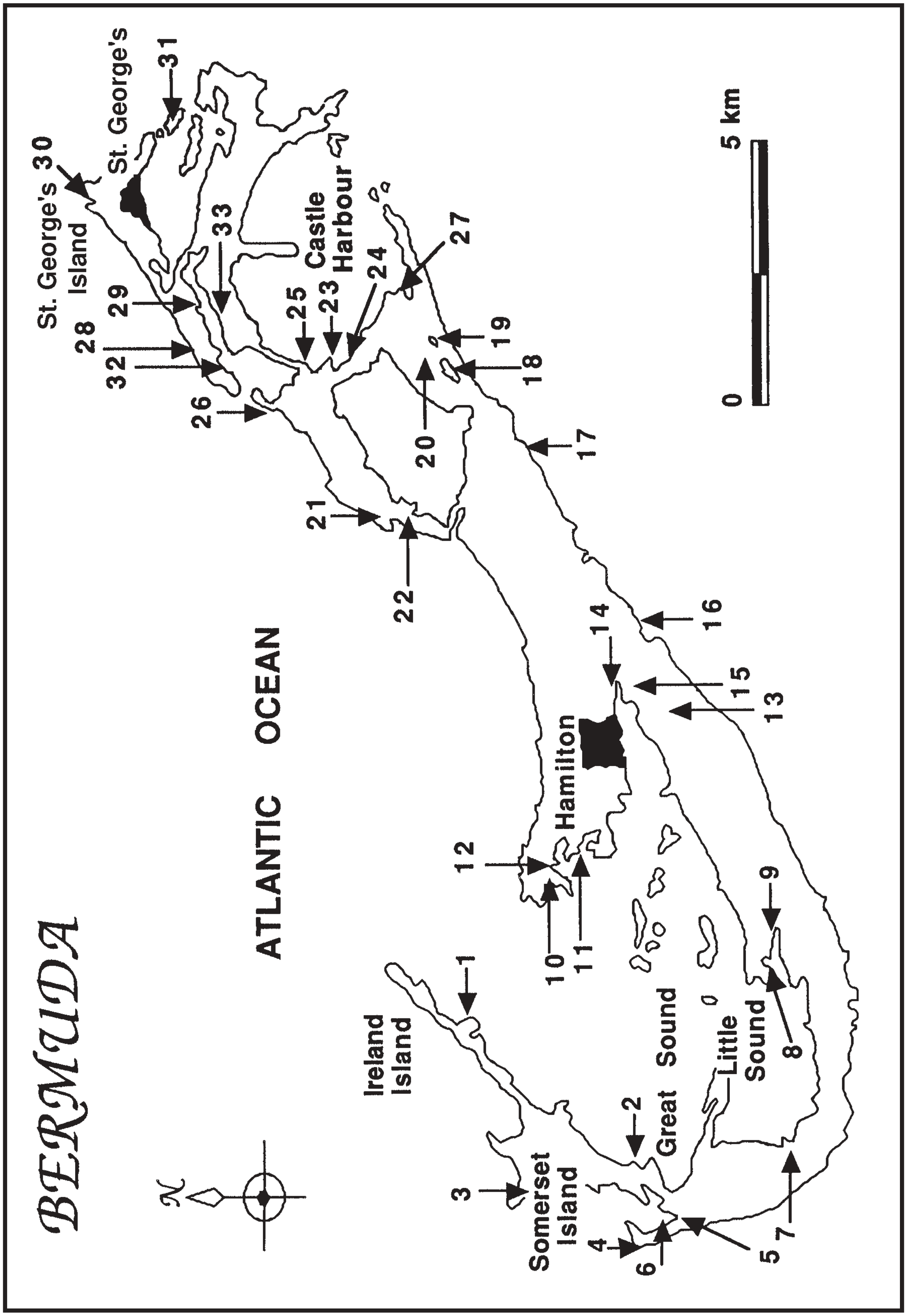


Figure 22.3. The locations of all 33 reasonably large mangrove swamps in Bermuda.

case by the Sheathed Paspalum (*Paspalum vaginatum*) grass. However, a few other species notably the Saltmarsh Oxeye (*Borrichia arborescens*), the Sea Rush (*Juncus maritimus*), Seaside Purslane (*Sesuvium portulacastrum*), Woody Glasswort or Marsh Samphire, (*Salicornia perennis*) and the rare Seaside Heliotrope (*Heliotropium curassavicum*), occur either as in patches or around the edge. This is the only salt marsh available for a visit at present. Other salt marshes which are less accessible and are not dominated by grasses, contain other rare species such as Sea Lavender (*Limonium carolinianum*) and the more common Seashore Rush Grass (*Sporobolus virginicus*).

Bay Mangrove Swamps

Bay Mangrove Swamps are on the coast and subject to the full tidal range. They typically have a zoned structure as described above and illustrated in **Figure 22.1.** Although Bay Mangrove Swamps vary from small patches of trees to the biggest Mangrove Swamp in Bermuda at Hungry Bay, which comprises about 3 hectares (7 acres) and used to be called the 'Great Mangrove'. It is the only mangrove swamp in Bermuda to have a system of channels through which tidal water enters and leaves. Such channels are typical of all large mangrove swamps on mainland shores. In Hungry Bay, some of the drainage channels are man-made or enlarged by man to allow the entry of small boats . In severe weather boats are moved into the swamp for shelter. Most bay swamps are muddy but a few smaller ones have developed in fine sand. Compared to Pond Mangrove Swamps, the biodiversity of attached marine animals and plants is very low, but the biodiversity of terrestrial associated species is very high.

> **Summary**
> **Bay mangrove swamps** occur along the coastline and are characteristically distinctly **zoned**. The largest one, Hungry Bay, has a well-developed system of drainage channels.

Salt-water Pond Mangrove Swamps

Pond swamps are found in the anchialine ponds of Bermuda and are much more variable in structure than the bay swamps. Ponds, such as Walsingham which are very close to the sea and have a large tidal range, typically have indistinctly zoned Red and Black Mangrove trees but no or very few Buttonwoods. They also have a smaller variety of associated terrestrial species but an almost incredibly high biodiversity of attached marine animals and plants (see Chapter 22). There are probably over 100 different species of sponge in the marine ponds of Bermuda. The difference between Bay and this type of Pond mangrove are illustrated in **Figure 22.4**. Mangrove swamps in ponds more distant from the sea and with a smaller tidal range, such as Lover's Lake, Trott's Pond and Mangrove Lake, typically have only one species of mangrove, either the black or the red. In these situations the one species occupies both the zones that would normally be occupied by both species. Evans Pond with good tidal range and a moderate separation from the sea has mainly Black Mangroves but Red Mangroves are present and on the increase.

> **Summary**
> **Mangrove swamps** in marine ponds often contain only either Red or Black Mangroves. If both are present they are indistinctly zoned. **Pond mangroves** have a very rich array of organisms growing on the roots in the water.

Fringing Mangrove Swamps

Fringing Mangrove Swamps are characteristic of sheltered inland coasts with the full tidal range. Very good examples can be seen along Ferry Reach and in Mullet Bay in the eastern part of the islands. These swamps consist of a single line of trees along the shore. Most of the native trees are Buttonwoods but there is the odd Red and Black Mangrove. The Fringing Mangrove Swamps are extensively invaded by Brazil Pepper.

Pollution and Conservation Concerns

Since man's colonisation of Bermuda, the total area of mangrove swamps has been greatly reduced. Places like Mangrove Bay, named for their swamps now have no mangroves at all. It is the Bay

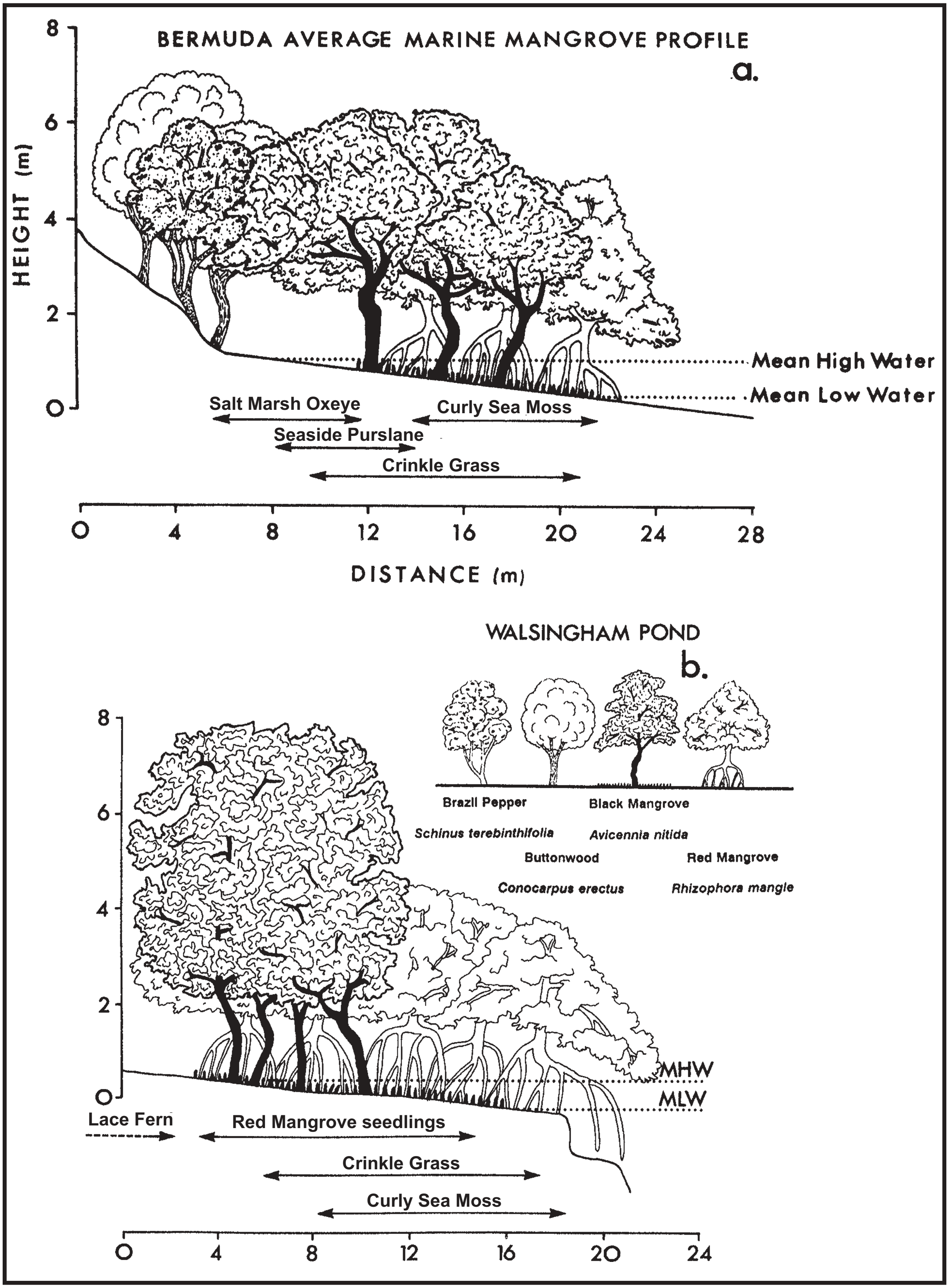


Figure 22.4. Comparison of the profiles of an average marine pond and coastal mangrove swamp.

Mangroves that have taken the brunt of the reduction, while the Pond Mangroves have been only slightly reduced. Fortunately, most of the saltwater ponds are either on private property or in parks and not currently threatened. Bay Mangroves are still being destroyed to make way for buildings, jetties etc. This practice must be curtailed to preserve what is left.

Pollution is also a problem. As an example, the Flat Mangrove Oyster (*Isognomon alatus*) used to be present in many Bay Mangrove swamps but was virtually eradicated by pollution, probably from oil. A few are returning in Mill's Creek, but basically this species is now confined to two Pond Mangroves, Mangrove Lake and Trott's Pond. Many of the species that live on mangrove roots are quite susceptible to dissolved and particulate pollutants because they filter huge quantities of water in their feeding process. Additionally, the ponds collect run-off from surrounding land that may contain herbicides and pesticides and they are poorly flushed by the tides and stay in the ponds a long time.

Summary

Many coastal **mangroves** have been removed by man to make way for coastal development. Pollution is a problem, particularly oil, but other pollutants such as heavy metals and herbicides and pesticides also concentrate there. The trees are quite pollution tolerant but other organisms suffer.

Questions

1) On what type of shore do Mangrove Swamps develop? ____________________

2) On mainland shores, where do mangrove swamps give way to salt marshes? ____________________

3) Describe the major differences between the vegetation of Mangrove Swamps and Salt Marshes.
____
____

4) In Bermuda, what are the two major types of Mangrove Swamp.
1. ____________________ 2. ____________________

5) What is the name of the type of Mangrove Swamp typified by a single line of trees along a sheltered shoreline? ____________________

6) Name two of the three Mangrove Trees found in Bermuda.
1. ____________________ 2. ____________________

7) Name the main adaptation to life in soft mud in 1. The Red Mangrove 2. The Black Mangrove
1. ____________________ 2. ____________________

8) Black Mangrove leaves often have a coating of salt crystals. Where do these come from?
____

9) Where in Bermuda do you find mangrove swamps with only a single species of mangrove present sent? ____________________

10) Tick the swamp type where you would expect to find:
1. Zonation of trees. Bay ❒ Pond ❒
2. All three mangrove tree species.Bay ❒ Pond ❒
3. Flat Mangrove Oysters. Bay ❒ Pond ❒

11) Name two species of crab that are found on Bermudian Mangrove Swamps.
1. ____________________ 2. ____________________

12) Name three species found in Bermuda only in Mangrove Swamps.
1. ____________________ 2. ____________________
3. ____________________

13) Which Mangrove Swamp in Bermuda has a system of drainage channels? ____________________

14) Which Pond Mangrove has only the Black Mangrove Tree? ____________________

15) Is biodiversity of terrestrial plants higher in Bay Mangroves ❒ or Pond Mangroves ❒ ?

16) Is biodiversity of marine animals higher in Bay Mangroves ❒ or Pond Mangroves ❒ ?

Field Trip #22.1 to View the Variety of Mangrove Swamps

Introduction

Depending on your starting location, a variety of Bay Mangrove Swamps are available. From West to East the following are possible sites Ireland Island Lagoon [1], Pilchard Bay [5], Riddell's Bay [9], Fairyland Creek [11], Walsingham Bay [24] and Blue Hole [25]. The numbers are those shown in **Figure 22.3.** The pond mangroves are somewhat more restricted and the best are Mangrove Lake at the H. T. North Nature Reserve [18], Walsingham Pond at Tom Moore's Tavern [23] and Lover's Lake in the Ferry Point Park [28]. It would be very educational to go to both Mangrove Lake, a Red Mangrove only swamp and Lover's Lake, a Black Mangrove only swamp. Caution: Poison Ivy (*Rhus radicans*) is very common at the west end of Lover's Lake, keep well clear of it!

Preparation

Read this section of this field guide. It would be helpful to also be familiar with the marine pond material in Chapter 23 of this guide.

Dress

This is a mainly observational rather than hands-on field trip, so no special clothing is needed.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group.

Observations.

At each site that you visit, fill in the following table of results.

Location 1

1) Name of Location. ________________________________
2) Type of swamp. ________________________________
3) Tick off the trees present in the swamp. Red Mangrove ❒
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒.
4) Which tree is closest to the water? Red Mangrove ❒,
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒.
5) Which tree is at the back of the swamp? Red Mangrove ❒
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒
6) Which tree species is tallest? Red Mangrove ❒
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒.
7) Which tree species is most abundant? Red Mangrove ❒
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒.
8) Look carefully at the swamp. Do you see any zonation of the trees? Yes ❒ No ❒
9) Describe the zonation, stating which zone is broadest, which has the most trees, the degree of overlap between tree species etc. ________________________________
   ____
10) Look under the trees. Do you think that the tide is in or out? In ❒ Out ❒ Can't tell ❒
11) Look under the trees again and identify any animals and plants that you can see and note what type of organism they are (e.g. seaweed, snail) and where they live (their habitat).

Table of Species

Species	Type of Organism	Habitat

12) Try to draw a profile of the swamp to show the slope of the land, tree heights, positions and prominent associated plants and animals. A profile is really a vertical cross-section of a locality. Try to add a scale to the drawing by putting on a bar equal to one metre or yard, Label the drawing.

Mangrove Swamp Profile

Location 2

1) Name of Location. ________________________________
2) Type of swamp. ________________________________
3) Tick off the trees present in the swamp. Red Mangrove ❒
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒.
4) Which tree is closest to the water? Red Mangrove ❒,
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒.
5) Which tree is at the back of the swamp? Red Mangrove ❒
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒
6) Which tree species is tallest? Red Mangrove ❒
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒.
7) Which tree species is most abundant? Red Mangrove ❒
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒.
8) Look carefully at the swamp. Do you see any zonation of the trees? Yes ❒ No ❒
9) Describe the zonation, stating which zone is broadest, which has the most trees, the degree of overlap between tree species etc. ____
   ____
10) Look under the trees. Do you think that the tide is in or out? In ❒ Out ❒ Can't tell ❒
11) Look under the trees again and identify any animals and plants that you can see and note what type of organism they are (e.g. seaweed, snail) and where they live (their habitat).

Table of Species

Species	Type of Organism	Habitat

12) Try to draw a profile of the swamp to show the slope of the land, tree heights, positions and prominent associated plants and animals. A profile is really a vertical cross section of a locality.

Mangrove Swamp Profile

Try to add a scale to the drawing by putting on a bar equal to 1 metre or yard, Label the drawing.

Field Trip # 22.2 to a Bay Mangrove Swamp

Introduction

Depending on your starting location, a variety of Bay Mangrove Swamps are available. From West to East the following are possible sites Ireland Island Lagoon [1], Pilchard Bay [5], Riddell's Bay [9], Fairyland Creek [11], Walsingham Bay [24] and Blue Hole [25]. The numbers are those shown in **Figure 22.3.**

Preparation

Read this section of this field guide. It would be helpful to also be familiar with the marine pond material in Chapter 23 of this guide.

Dress

This is a mainly observational rather than hands-on field trip, so no special clothing is needed.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group.

Observations.

At the site that you visit, fill in the following table of results.

1) Name of Location. ______________________
2) Type of swamp. ______________________
3) Tick off the trees present in the swamp. Red Mangrove ❒
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒.
4) Which tree is closest to the water? Red Mangrove ❒,
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒.
5) Which tree is at the back of the swamp? Red Mangrove ❒
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒
6) Which tree species is tallest? Red Mangrove ❒
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒.
7) Which tree species is most abundant? Red Mangrove ❒
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒.
8) Look carefully at the swamp. Do you see any zonation of the trees? Yes ❒ No ❒
9) Describe the zonation, stating which zone is broadest, which has the most trees, the degree of overlap between tree species etc. ______________________
   ____
10) Look under the trees. Do you think that the tide is in or out? In ❒ Out ❒ Can't tell ❒
11) Look under the trees again and identify any animals and plants that you can see and note what type of organism they are (e.g. seaweed, snail) and where they live (their habitat).

Table of Species

Species	Type of Organism	Habitat

12) Try to draw a profile of the swamp to show the slope of the land, tree heights, positions and prominent associated plants and animals. A profile is really a vertical cross section of a locality. Try to add a scale to the drawing by putting on a bar equal to one metre or yard. Label the drawing.

Mangrove Swamp Profile

Field Trip # 22.3 to a Pond Mangrove Swamp

Introduction.

The pond mangroves are somewhat more restricted than the bay mangroves and the best are Mangrove Lake at the H. T. North Nature Reserve [18], Walsingham Pond at Tom Moore's Tavern [23] and Lover's Lake in the Ferry Point Park [28]. The numbers are those shown in **Figure 22.3.** It would be very educational to go to both Mangrove Lake, a Red Mangrove only swamp, and Lover's Lake, a Black Mangrove only swamp. Caution: Poison Ivy (*Rhus radicans*) is very common at the west end of Lover's Lake, keep well clear of it!

Preparation

Read this section of this field guide. It would be helpful to also be familiar with the marine pond material in Chapter 23 of this guide.

Dress

This is a mainly observational rather than hands-on field trip, so no special clothing is needed.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group.

Observations

At the site that you visit, fill in the following table of results.

1) Name of Location. ________________________________
2) Type of swamp. ___________________________________
3) Tick off the trees present in the swamp. Red Mangrove ❒
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒.
4) Which tree is closest to the water? Red Mangrove ❒,
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒.
5) Which tree is at the back of the swamp? Red Mangrove ❒
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒
6) Which tree species is tallest? Red Mangrove ❒
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒.
7) Which tree species is most abundant? Red Mangrove ❒
   Black Mangrove ❒ Buttonwood ❒ Brazil Pepper ❒.
8) Look carefully at the swamp. Do you see any zonation of the trees? Yes ❒ No ❒
9) Describe the zonation, stating which zone is broadest, which has the most trees, the degree of overlap between tree species etc. ____________________________________
   ____
10) Look under the trees. Do you think that the tide is in or out? In ❒ Out ❒ Can't tell ❒
11) Look under the trees again and identify any animals and plants that you can see and note what type of organism they are (e.g. seaweed, snail) and where they live (their habitat).

Table of Species

Species	Type of Organism	Habitat

12) Try to draw a profile of the swamp to show the slope of the land, tree heights, positions and prominent associated plants and animals. A profile is really a vertical cross section of a locality. Try to add a scale to the drawing by putting on a bar equal to one metre or yard. Label the drawing.

Mangrove Swamp Profile

Field Trip # 22.4 Advanced Mangrove Swamp Profiling Technique for Senior Students

This transect method can result in a nice graphical sketch profile of the shape and structure of a mangrove swamp much like those in **Figure 22.4.** A line can be run by a team of 4-6 students. It is best to do this at low tide, but even then some wading will be needed at the water end of the transect.

TRANSECT METHOD

a) A surveying tape or graduated rope will be laid down from the back (terrestrial side) of the swamp to the start of the sea or the edge of the drainage channel of the swamp. Getting the tape or rope to the outer limit of the swamp trees will give a more complete profile, but to do that two people will have to be prepared to go into the water. If you do this, fasten the tape to the furthest branch of a tree close to the water.

b) Along this rope note the distance of the first and last occurrence of the following: Red Mangrove prop roots, Red Mangrove trunks, Red Mangrove canopy [first and last leaves], Black Mangrove pneumatophores, Black Mangrove trunks, Black Mangrove canopy, Buttonwood trunks, Buttonwood canopy. The Water line. You must add as many other animals and plants that you see as you can. Construct a table in which to enter these results.

c) At the start and at 5 metre intervals, measure the height to the bottom of the canopy of each mangrove species and estimate the height of the canopy top for each species. Do this by imagining how many 2 m (6 ft) people would have to stand on each others heads to reach the top. You might be able to climb some trees to do this more accurately but don't take chances. Construct a table in which to enter these results.

d) Using a line level and a roll of thin but sturdy twine (The twine must be able to lie in the hooks of the line level), find the drop in elevation, in centimetres, every few metres along the transect to the water line. Note that if the slope is even the measurement points can be further apart. The best profile will result from choosing places where the gradient changes as reference points. To do this, put a metre stick upside-down (zero at the bottom), vertically at the lower point and stretch the twine, taught, between that stick and the ground at the upper point. Then move the twine up or down at the lower metre stick until the line level shows that it is precisely level. There must be zero sag in the line. The result you get is an increment of drop. Note, at the top the ground may be covered in vegetation making it impossible to get the line to the surface and running unobstructed to the lower point. In this case use a metre stick, upside down, vertically, at both points and stretch the twine between them so that the line is unobstructed. Get the line level, then take the reading on both metre sticks and subtract the upper reading from the lower, the result is the increment. Repeat this process to the water line. Put your results in the following table.

Transect Profile Data

Point	Distance (m)	Increment of drop (cm)	Total drop (cm)
A Start	0.0	0.0	0.0
B			
C			
D			
E			
F			
G			
H			
I			

Water line is ____________________ m from the start.

When you get to the water, just measure the water depth at intervals. The water surface is level. Note in this case, the readings are not increments, except for the first one, but totals. You can either convert them to increments by subtracting the upper from the lower or use them directly.
e) In the classroom or laboratory, using the information collected, try to draw up a nice cross-section of the swamp. Use **Figure 22.4** as a guide, but you may simplify yours as long as it shows the essential features to scale. Note that the left hand scale must be just enough to accommodate the highest canopy point. Do not try to get the vertical and horizontal scales the same, some vertical exaggeration brings out the details. Remember that the tree height data is from the ground or water surface not the base line!

Chapter 23. Saltwater Ponds

The Saltwater Pond Habitat

Introduction

The salt water ponds are one of the outstanding biological treasures of Bermuda. These ponds are all connected to the sea but the nature of the connection varies and results in very different conditions among the ponds. Technically these ponds are called **anchialine ponds**. Anchialine ponds are not all that common, but are found throughout the world relatively close to coastlines. Most commonly such ponds occur in limestone regions and their connection to the sea is through cracks, fissures and caves that have been eroded into the limestone by the action of freshwater at past times of lowered sea level (see Chapter 7). In some cases the connection to the sea may be simply by percolation through porous limestone. A second group of anchialine ponds are found in areas of volcanic activity and connection to the sea is often by lava pipes but cracks, holes and fissures may also forge connections.

Summary
Saltwater or **anchialine ponds** are an outstanding feature of Bermuda's natural history. These ponds are tidal and connected to the sea by underground passages through the **limestone**. These ponds are fringed by mangroves.

The universal feature of the larger marine ponds is that they are all fringed by **mangrove swamps**. In all but Spittal Pond there are well developed swamps. In Spittal Pond there are just a few patches of mangrove swamp. The characteristics of these pond mangroves has been discussed above in Chapter 22.

Factors Affecting Pond Habitat

The habitat within salt water ponds varies tremendously from pond to pond. The main factors that are of importance are shown in **Figure 23.1.** For a pool to be most like the sea, it would have to be fairly small, close to the sea and have a large connection. Such ponds are said to have high exchange of seawater, and are also called well **flushed**. Those differing most from the sea are commonly fairly large, some distance from the sea and have small connections to the ocean. They have low exchange and poor flushing. The simplest way to get some idea of water exchange and flushing is to compare the tidal range in the pond with that on the adjacent coast. This can be done by fixing a graduated pole vertically in the pond and recording the level at frequent intervals. This same method can also show the **tidal lag** of the pond. Lag is the time difference between high tide, or low tide, in the adjacent ocean and that in the pond. Both distance from the sea and the size of the connection affect lag. Ponds with poor flushing and a long tidal lag tend to be very unstable.

Summary
The ponds all differ depending on their location, the size and location of the connection to the sea, pool size and depth. Ponds in which a high proportion of the water is exchanged with the sea on each tide are termed well **flushed**.

It is also reasonable to include ponds that get an irregular addition of seawater in storms, rather than by tidal exchange. These ponds tend to be brackish which means they have low and variable salinity the majority of the time. The one reasonably sized pond in Bermuda that falls into this category is Spittal Pond.

The location of the connection to the sea also affects pond habitat greatly. If the location is at the surface, as in Evans Pond, Mangrove Lake and Trott's Pond, large additions of freshwater in storms creates a low salinity layer at the surface. This layer does not mix with the salt water

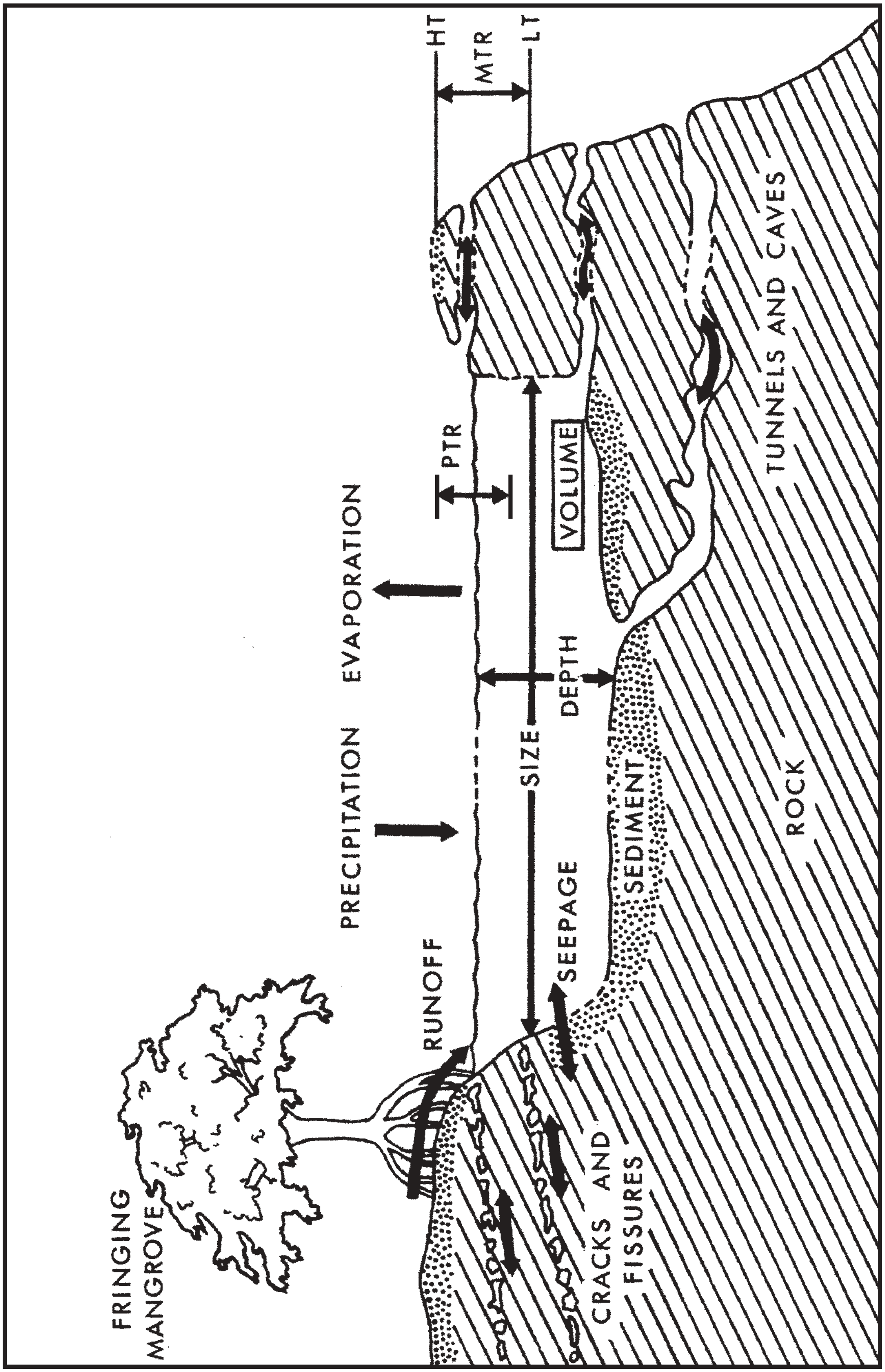


Figure 23.1. Diagrammatic cross-section of a marine pond showing the factors that affect the pond environment.

below unless the storm is very violent and creates significant waves within the pond. This is called stratification and is described in Chapter 14. This freshwater layer then leaves via the connection to the sea, leaving the pond water virtually unchanged. If, on the other hand the connection to the sea is at the deepest point in the pond, then the freshwater layer on top of the salt persists until it is slowly mixed with deeper water. Such ponds may have a virtually constant brackish layer at the surface that limits the establishment of marine life. Such is the case in Lover's Lake.

Another very important factor is the extremely high **biological production** of the mangroves that fringe most ponds or masses of floating plants, such as Widgeon Grass (*Ruppia maritima*), in others. The fundamental concepts of biological production were described in Chapter 22. In brief, a very large quantity of new living material is produced in the ponds at all times and when this material, most commonly mangrove leaves, dies it decays in the water to produce **detritus** a very high quality food for marine life. Detritus typically occurs as small particles suspended in the water and it can be used by the **filter feeders**. Filter feeders are common among marine life and abundant in ponds. They pass large volumes of water through specialised filtering devices, often associated with the gills, and eat the trapped material. The most commonly seen filter feeders are sponges, sea squirts and most clams but there are many others.

Summary
Saltwater ponds are very **productive** thanks to the mangroves around them. This production, in the form of detritus, makes the ponds an exceptionally good feeding location for **filter feeding** marine animals.

Most ponds are quite muddy, but the mangrove roots in many give a large area of hard surface on which many sedentary animals, plants and cyanobacteria can settle and grow. A few ponds, notably Walsingham, have areas of rock face.

<u>The Water Characteristics in the Saltwater Ponds</u>
The nature of the water in the pond is the most important environmental character that affects pond biology.

Well flushed ponds with a large, short entrance at the surface, have water with a salinity (see Chapter 14) close to that of the sea, but often a little higher or lower. They can be expected to have a wide array of marine life but offer a more sheltered location that may favour many species uncommon in the ocean, particularly filter feeders. Biodiversity is exceptionally high in these ponds, typified by Walsingham Pond. In fact, such ponds are examples of systems with the highest biodiversity in the world. These ponds are very stable in character but salinity varies slightly with evaporation and rainfall.

Summary
The water in most well **flushed** ponds differs little from seawater, but where flushing is low or the connection to the sea deep, pond water shows reduced **salinity**. In some ponds freshwater tends to float on the surface; these are termed **stratified** ponds.

As flushing decreases, the water characteristics in ponds becomes less and less stable. Salinity is usually lower than that in the sea, but in exceptional cases can be higher. In Spittal Pond salinity can vary from near zero to at least twice that of seawater, depending on evaporation, rainfall and storm surges of seawater. Other poorly flushed pools such as Mangrove Lake and Trott's Pond have average salinities about 20% lower than the sea. This reduced salinity limits the number of marine species that can survive. However, the excellent food supply favours those that can survive, and incredibly high abundances of some animals results. Examples are the huge populations of Flat Mangrove Oysters (*Isognomon alatus*) in Trott's Pond and Mangrove Lake.

Poorly flushed ponds suffer from one other major environmental problem. They are usually low in dissolved oxygen and at times may have no oxygen in the water, a condition called <u>anoxia</u>. The vast majority of marine animals need oxygen to be present at all times. A few can survive short periods of anoxia, but prolonged loss of oxygen results in death for most. Mass mortalities sometimes happen in some ponds due to this factor. Such events have been recorded for Spittal Pond, Mangrove Lake and Trott's Pond.

Summary
Poorly **flushed** ponds are often low in dissolved oxygen at times. This greatly limits the **biodiversity** of these ponds.

Poorly flushed ponds are also susceptible to pollutants as these linger in this environment.

The Variety of Saltwater Ponds

Figure 23.2 Shows the location of larger saltwater ponds in Bermuda. The most stable and diverse of the marine ponds is Walsingham Pond which is quite deep and has several short, large connections to the sea, both at the surface and deeper. Walsingham Pond has a biodiversity of hundreds of species. Evans Pond comes next. It has a large, but quite long subterranean connection to the ocean at the surface of the pond. Fish such as Shad (*Eucinostomus gula*), also known as Silver Jenny, enter the pond via the connection sometimes in huge numbers. Common Octopusses (*Octopus vulgaris*) also come and go. The biodiversity is intermediate with 50-100 species. Lover's Lake has a large connection to the ocean at the deepest part and often shows a near-freshwater layer at the surface. Its biodiversity is similar to Evans Pond, Trott's Pond and Mangrove Lake. Although large, these three ponds have only very tiny connections to the ocean. These connections are close to the surface in both cases. The salinity is quite stable but reduced, but dissolved oxygen levels vary widely and anoxic patches are frequent in summer. The biodiversity in these ponds is lower, in the range of 25-50 species. The least stable saltwater pond is Spittal Pond which only gets seawater during storms and is frequently anoxic in summer. The salinity is highly variable and this combination of characteristics can be tolerated by very few species. The biodiversity of resident animals and plants is about 10 species, however the Mosquito Fish (*Gambusia holbrooki*) is incredibly common as is Widgeon Grass (*Ruppia maritima*). These characteristics contribute to its being Bermuda's prime location for waterfowl.

Summary
The most stable and **diverse** pond is Walsingham Pond, which supports hundreds of different species. Evans Pond and Lover's Lake have intermediate Biodiversity while Trott's Pond and Mangrove Lake are lower. Spittal Pond supports very few resident species.

Life in the Saltwater Ponds on Rocks and Roots

The attached marine animals and plants are the richest part of the fauna and flora of the ponds, with literally hundreds of species represented. Most are attached to submerged mangrove roots, but rocks support the same array.

An interesting blue-green cyanobacterium (*Lyngbya lutea*) which forms purplish threads is very common close to the surface. If observed alive, under a microscope, the filaments of this species are seen to be on constant oscillating motion, giving it its common name Oscillatoria. Many green seaweeds are common on roots and rocks, but probably the most conspicuous group are the Sand Mosses. The Horsetail Sand Moss (*Caulerpa verticillata*) is very common. There are also a group of thread-like green and red seaweeds which include the Crinkle Grasses (*Rhizoclonium* species) among the greens and Banded Threadweed (*Ceramium byssoideum*) among the reds. Just above low tide level on roots, one normally finds the bushy growths of Curly Sea Moss (*Bostrychia montagnei*), which only lives on mangrove roots.

Summary
Most of the organisms common in salt water ponds are characteristic of the shallow sea. Some, however, are rarely seen except in ponds. Examples are the Flat Mangrove Oyster, the Upside-down Jellyfish, the Etherial Sponge and the Feather-duster Worm.

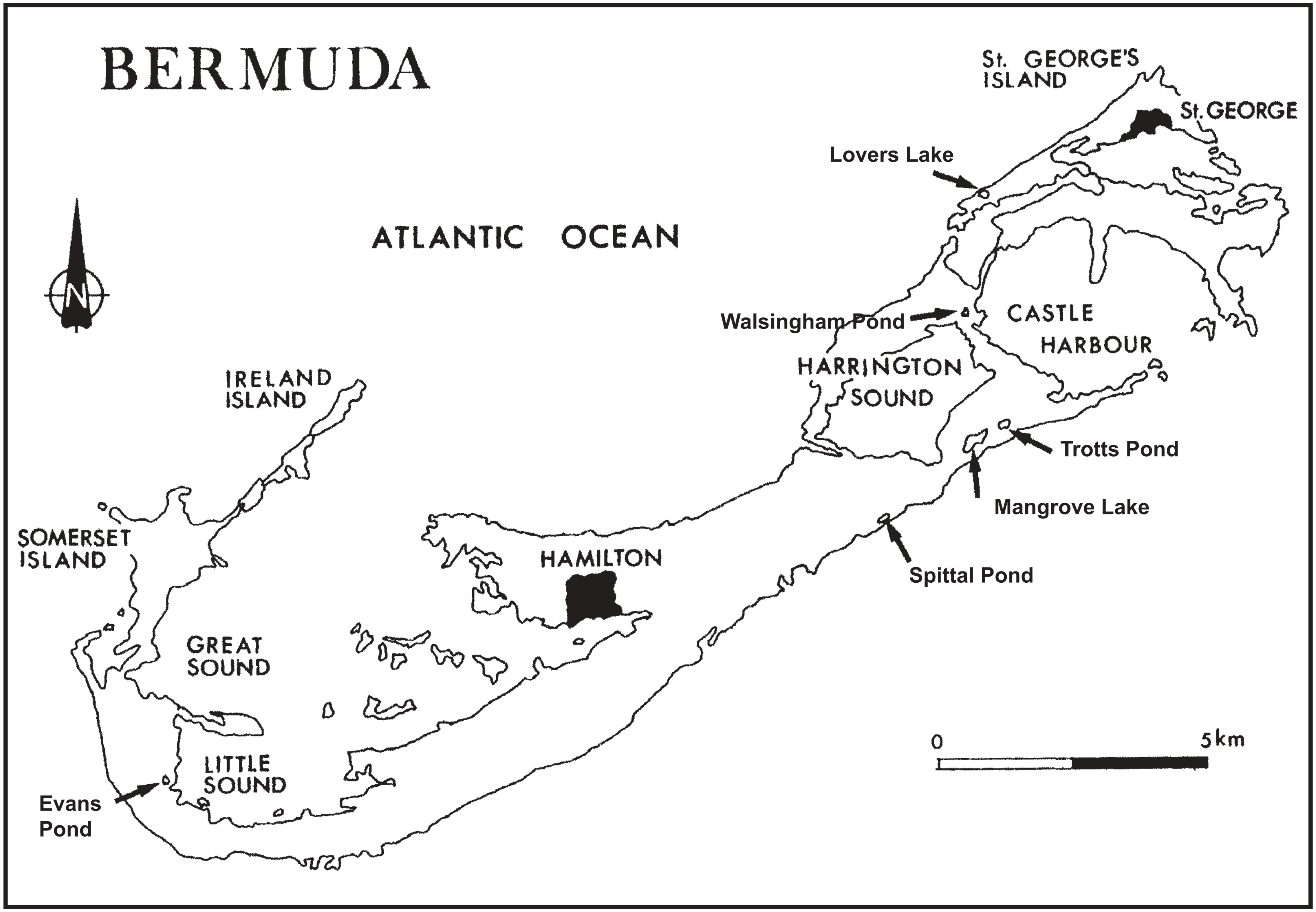


Figure 23.2. Map of Bemuda showing the location of the six largest marine ponds.

Sponges are undoubtedly the most conspicuous marine animal attached to rocks and roots in the ponds. In Walsingham Pond alone there are close to 100 species! The commonest one is probably the Orange Encrusting Sponge (*Biemna microstyla*), but the Chicken Liver Sponge (*Chondrilla nucula*) can often be common and very large. An exquisite light blue sponge, the Etherial Sponge (*Dysidea etheria*) is quite eye-catching. The second-most obvious group of marine animals in this group are the sea squirts. A dozen or so different species can be seen, including a large beautiful one known as the Purple Sea Squirt (*Clavelina picta*). Several different anemones are common; most commonly seen are the Pale Anemone (*Aiptasia pallida*) and the Ringed Anemone (*Bartholomea annulata*). A group of marine worms that live in tubes with a beautiful array of colourful projections that extend into the water and can be withdrawn in an instant are also found in the ponds. The Feather-duster Worm (*Sabella melanostigma*) is common among this group.

Figure 23.3 shows a typical saltwater pond community of animals and plants.

Life in the Waters of the Saltwater Ponds

The open water community shows the least diversity in ponds. It overlies bottoms of soft mud and is usually cloudy. Plankton populations are often low but blooms (brief periods of abundant plankton) do occur in all the ponds. Large swarms of shrimp larvae are often common in Walsingham Pond. Most ponds, especially Walsingham, have significant fish populations**.** Several species of fish occurring in the ponds are of particular interest. The **endemic** (evolved in Bermuda) Bermuda Killifish (*Fundulus bermudae*) is common in most ponds as is the Mosquito Fish (*Gambusia holbrooki*), a species introduced to control Mosquitoes. American Eels (*Anguilla rostrata*) are present in virtually all ponds at times, but rare or absent elsewhere in Bermuda, although they used to move inland through Pembroke Canal before it became so horribly polluted (see marsh section). Common species to be seen in the ponds are listed later. At least three ponds, Walsingham, Evans and Lover's Lake, have marine Green Turtle (*Chelonia mydas*) populations temporarily or permanently and Trott's Pond and Mangrove Lake support Bermuda's only populations of the Diamondback Terrapin (*Malaclemys terrapin*), which lay their eggs in sand bunkers on the Mid Ocean Golf Club course. In several of the ponds there are populations of submerged marine flowering plants. Floating masses of Widgeon Grass (*Ruppia maritima*) are common in Lover's Lake and some smaller ponds. They often harbour a small sea cucumber called the Sticky Synaptula (*Synaptula hydriformis*).

Summary
Many fish are found in the ponds, especially Walsingham Pond and Evans Pond. Two species of endemic Killifish and the American Eel are found only in the ponds.

Life on the Bottom of Saltwater Ponds

Turtle Grass (*Thalassia testudinum*) is very common in several ponds; the other two seagrasses, Manatee Grass *(Syringodium filiforme)* and Shoal Grass *(Halodule wrightii)* are less common but do occur. Of great interest are scattered specimens of the endemic seaweed Bermuda Sargasso Weed (*Sargassum bermudense*) that can reach several metres in height. Several green seaweeds including the Merman's Shaving Brush (*Penicillus capitatus*), the Plateweeds (*Halimeda* species), the Hard Fanweed (*Udotea flabellum*) and the Mermaid's Wine Glass (*Acetabularia crenulata*) are common in the mud or attached to stones on the bottom. The **poisonous** Upside-down Jellyfish (*Cassiopea xamachana*) may be abundant at times in the open-water community. Most individuals stay on the bottom but some swim up into the water. The sting is not serious but it should be avoided.

Summary
Muddy pond bottoms support **populations** of seagrasses and several green seaweeds that can anchor themselves in mud. Masses of Widgeon Grass float at the top in several ponds.

Life on Trunks and Branches

The emerged mangrove root community is very similar to that in the coastal mangrove swamps and supports populations of the Mangrove Periwinkle, (*Littorina angulifera*), Coffee Bean Snails**,** (*Melampus coffeus*), and Mangrove Crabs (*Goniopsis cruentata*).

Summary

On the trunks and branches of the **mangroves** may be found the Mangrove Periwinkle, Coffee Bean Snails and the Fire Lichen. Many birds feed in mangrove trees and the Green Heron nests there.

The community of the trunks, branches and leafy canopy is characterised by such things as the Fire Lichen (*Pyrenula aurantiaca*), Mangrove Crabs**,** a few Mangrove Periwinkles and a host of birds, notably several species of heron, Great Kiskadees (*Pitangus sulphuratus*) and many migratory warblers and other species. The Green Heron (*Butorides virescens*) has recently started nesting in the mangroves around several of the ponds. The Jamaican Anole (*Anolis grahami*) is always abundant.

Pollution and Conservation Concerns

The ponds of Bermuda whether marine or freshwater have never been accorded the respect they deserve, on the contrary they have been used as receptacles for trash and generally ignored. That the marine ones have mainly survived this situation is a testimony to their resilience. It is also significant that at least one, and almost certainly several, new species have evolved in the ponds. Evolution is a slow process and this suggests that the ponds have been a viable environment for a very long time. This does not mean, however, that it is safe to ignore the ponds and assume their survival. Their locations in low places ensures that land run-off drains into them carrying with it traces of herbicides and pesticides as well as commercial fertilisers. This combined with their natural variability places stress on their inhabitants. This can lead to mortalities and loss of biodiversity and has been observed in most of the ponds but so far they always seem to bounce back. However, the next incident may place such a stress that permanent deleterious effects take place. All the ponds need total protection from interference and pollution.

Summary

Marine ponds are highly susceptible to pollution. Trash has been dumped in some, agricultural run-off enters others and hurricanes may fill them with debris. Although they seem resistant to these stresses, mortalities of animals and plants do occur.

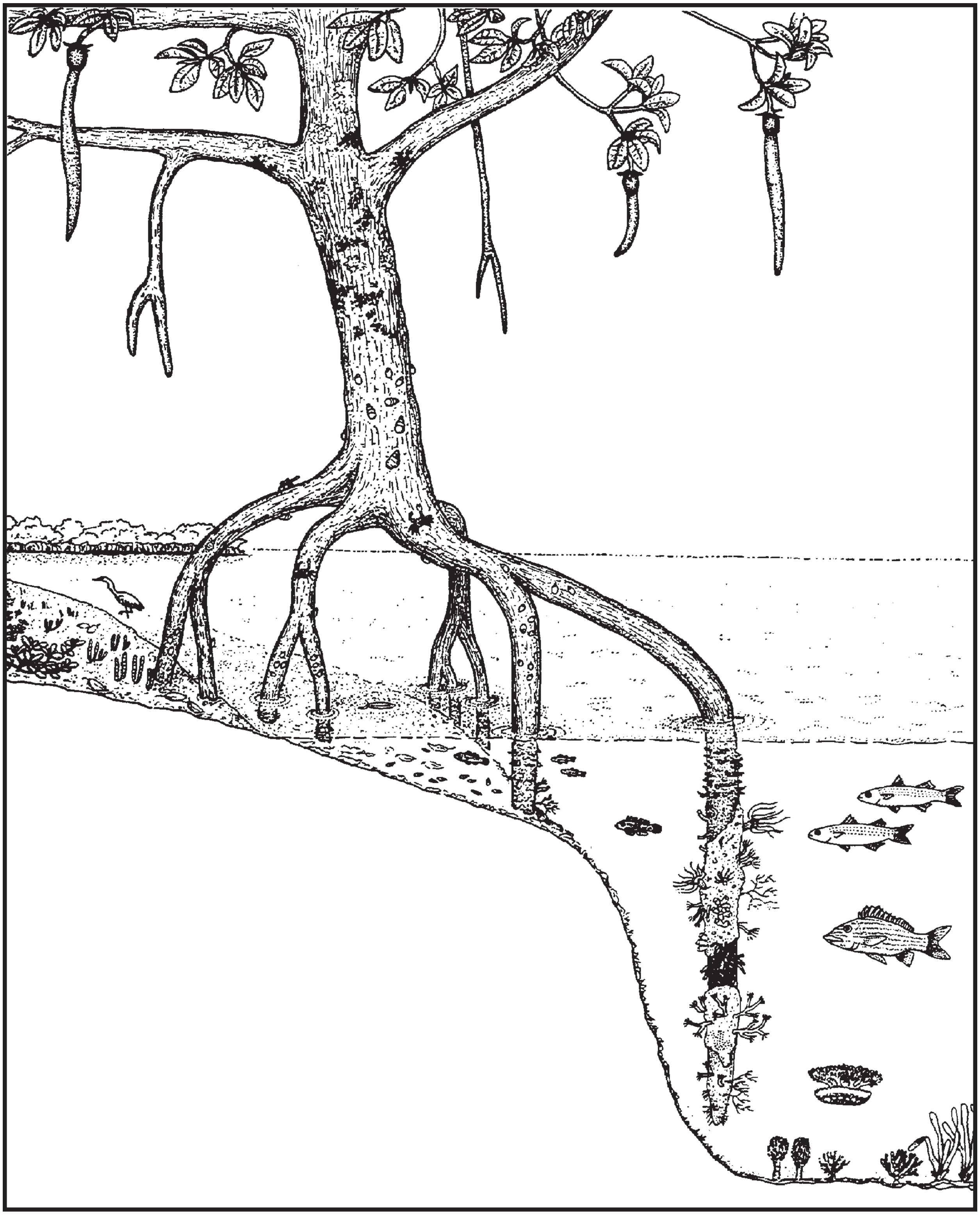


Figure 23.3. The edge of a typical marine pond in Bermuda showing some of the characteristic organisms.

Key to Figure 23.3

Marsh Samphire, *Salicornia perennis*

Sea Purslane, *Sesuvium portulacastram*

Mangrove Crab, *Goniopsis cruentata*

Mangrove Periwinkle, *Littorina angulifera*

Coffee Bean Snail, *Melampus coffeus*

Lichens

Bermuda Killifish, *Fundulus bermudae*

False Cerith, *Batillaria minima*

Crested Goby, *Lophogobius cyprinoides*

Mangrove root organisms

Mullet, *Mugil trichodon*

Blue-striped Grunt, *Haemulon sciurus*

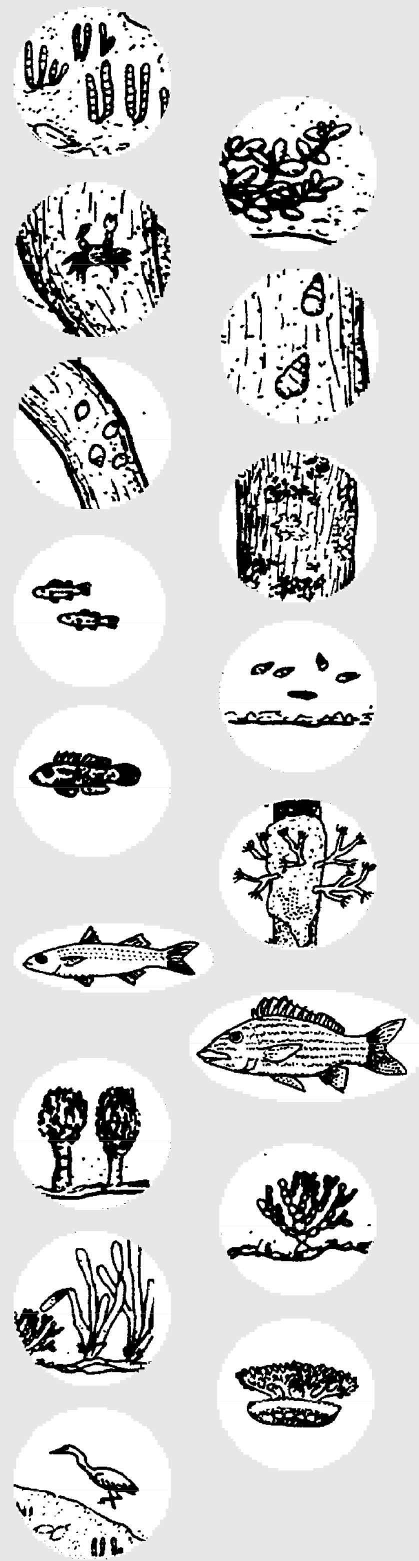
Merman's Shaving Brush, *Penicillus capitatus*

Slender Plateweed, *Halimeda monile*

Turtle Grass, *Thalassia testudinum*

Upside-down Jellyfish, *Cassiopea xamachana*

Snowy Egret, *Egretta thula*



Questions

1) What is the technical name given to the saltwater ponds in Bermuda? ____________________

____

2). What are three ways that the ponds can be connected to the ocean?

1. ____
2. ____
3. ____

3) What community do we find along the edges of all marine ponds? ____________________

4) Why does the tidal range in a pond tell us a lot about the conditions for life therein?

____

____

5) Flushing is a measure of water exchange with the sea. Why is this important? __________

____

____

6) Which Bermudian saltwater pond has the highest biodiversity? ____________________

7) Which Bermudian saltwater pond has the lowest biodiversity? ____________________

8) Name two of the largest saltwater ponds in Bermuda.

1. ____________________ 2. ____________________

9) What is the endemic fish that is characteristic of the ponds? ____________________

10) What is the most obvious group of marine creatures seen on the submerged roots?

____

11) Which marine turtle goes into marine ponds? ____________________

12) Where are sea squirts to be found within the ponds? ____________________

____

13) What are Upside-down Jellyfish, and where would you find them? ____________________

____

14) Which small heron has recently started to breed in the ponds? ____________________

15) What is detritus and why is it very important in marine ponds? ____________________

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Field Trip # 23.1 to Walsingham Pond

Introduction

The marine ponds are one of the most difficult places in which to run field trips. Access to these mangrove surrounded features is difficult. Additionally, swimming in the water must be ruled out except for very experienced people. There are hazards in the water such as the Upside Down Jellyfish, and the bottom is commonly too soft to stand on. Because of these difficulties field work should be observational rather than hands-on. It is certainly possible to do at least two ponds in one afternoon, so combine the field trips if you wish.

At Walsingham Pond there is a good observation point on the small jetty at Tom Moore's Tavern but it can only accommodate a few people at a time. From Tom Moore's it is also possible to walk through the woodland close to the eastern edge of the pond. Several viewing places can be found. Note that if it has been wet, the path will be slippery.

Preparation

Read this section of this field guide. It would be helpful to also be familiar with the marine pond mangrove material in Chapter 22 of this guide.

Dress

This is a mainly observational rather than hands-on field trip, so no special clothing is needed.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group should be sufficient.

Observations.

At the site that you visit, fill in the following table of results.

Table of Results (observations)

1) Name of the pond visited. ______________________________
2) Type of marine pond. Well flushed ❒ Poorly Flushed ❒ Not flushed at all ❒
3) Note the mangrove species present. Red ❒ Black ❒ Buttonwood ❒
4) Note the calmness of the water. Calm ❒ Tiny Ripples ❒ Small waves ❒ Large Waves ❒
5) Water clarity. Turbid (no visibility) ❒ Fairly Clear ❒ Clear ❒.
6) Look in the mangrove and see what species of animal and plant you can see. Fill in the following table.

Species Seen	Location or Habitat	Abundance (common, frequent or rare)

7) Look in the water, on the bottom, on the roots etc. Identify what you can and fill in the following table.

Species Seen	Location or Habitat	Abundance (common, frequent or rare)

8) Write your general impressions of this location. Try to highlight its special characteristics and the things that interest you. ____________________

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Field Trip # 23.2 to Lover's Lake

Introduction

The marine ponds are one of the most difficult places in which to run field trips. Access to these mangrove surrounded features is difficult. Additionally, swimming in the water must be ruled out except for very experienced people. There are hazards in the water such as the Upside Down Jellyfish, and the bottom is commonly too soft to stand on. Because of these difficulties field work should be observational rather than hands-on. It is certainly possible to do at least two ponds in one afternoon, so combine the field trips if you wish.

Lover's Lake lies in Ferry Reach Park and can best be approached by walking along the railway trail from Whalebone Bay. When the lake comes into view, walk down one of the paths until you can see the edge. Avoid Poison Ivy at the east end.

Preparation

Read this section of the field guide. It would be helpful to also be familiar with the marine pond mangrove material in Chapter 22 of this guide.

Dress

This is a mainly observational rather than hands-on field trip, so no special clothing is needed.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group should be sufficient.

Observations.

At the site that you visit, fill in the following table of results.

Table of Results (observations)

1) Name of the pond visited. ____________________
2) Type of marine pond. Well flushed ❐ Poorly Flushed ❐ Not flushed at all ❐
3) Note the mangrove species present. Red ❐ Black ❐ Buttonwood ❐
4) Note the calmness of the water. Calm ❐ Tiny Ripples ❐ Small waves ❐ Large Waves ❐
5) Water clarity. Turbid (no visibility) ❐ Fairly Clear ❐ Clear ❐.
6) Look in the mangrove and see what species of animal and plant you can see. Fill in the following table.

Species Seen	Location or Habitat	Abundance (common, frequent or rare)

7) Look in the water, on the bottom, on the roots etc. Identify what you can and fill in the following table.

Species Seen	Location or Habitat	Abundance (common, frequent or rare)

8) Write your general impressions of this location. Try to highlight its special characteristics and the things that interest you. ______________________________
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Field Trip # 23.3 to Mangrove Lake

Introduction

The marine ponds are one of the most difficult places in which to run field trips. Access to these mangrove surrounded features is difficult. Additionally, swimming in the water must be ruled out except for very experienced people. There are hazards in the water such as the Upside Down Jellyfish, and the bottom is commonly too soft to stand on. Because of these difficulties field work should be observational rather than hands-on. It is certainly possible to do at least two ponds in one afternoon, so combine the field trips if you wish.

Mangrove Lake is best seen from the H.T. North Nature Reserve at the western end. You can walk along the adjacent road and get several good looks into the mangrove swamp and lake.

Preparation

Read this section of this field guide. It would be helpful to also be familiar with the marine pond mangrove material in Chapter 22 of this guide.

Dress

This is a mainly observational rather than hands-on field trip, so no special clothing is needed.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group should be sufficient.

Observations

At the site that you visit, fill in the following table of results.

Table of Results (observations)

1) Name of the pond visited. ______________________________
2) Type of marine pond. Well flushed ❒ Poorly Flushed ❒ Not flushed at all ❒
3) Note the mangrove species present. Red ❒ Black ❒ Buttonwood ❒
4) Note the calmness of the water. Calm ❒ Tiny Ripples ❒ Small waves ❒ Large Waves ❒
5) Water clarity. Turbid (no visibility) ❒ Fairly Clear ❒ Clear ❒.
6) Look in the mangrove and see what species of animal and plant you can see. Fill in the following table.

7) Look in the water, on the bottom, on the roots etc. Identify what you can and fill in the following table.

Species Seen	Location or Habitat	Abundance (common, frequent or rare)

8) Write your general impressions of this location. Try to highlight its special characteristics and the things that interest you. ______________________________

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Field Trip # 23.4 to Spittal Pond

Introduction

The marine ponds are one of the most difficult places in which to run field trips. Access to these mangrove surrounded features is difficult. Additionally, swimming in the water must be ruled out except for very experienced people. There are hazards in the water such as the Upside Down Jellyfish, and the bottom is commonly too soft to stand on. Because of these difficulties field work should be observational rather than hands-on. It is certainly possible to do at least two ponds in one afternoon, so combine the field trips if you wish.

For Spittal Pond go to the west parking lot and proceed down the path towards the pond. There are many good places to observe the pond and its life.

Preparation

Read this section of this field guide. It would be helpful to also be familiar with the marine pond mangrove material in Chapter 22 of this guide.

Dress

This is a mainly observational rather than hands-on field trip, so no special clothing is needed.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group should be sufficient.

Observations.

At the site that you visit, fill in the following table of results.

Table of Results (observations)

1) Name of the pond visited. ______________________________
2) Type of marine pond. Well flushed ❐ Poorly Flushed ❐ Not flushed at all ❐
3) Note the mangrove species present. Red ❐ Black ❐ Buttonwood ❐
4) Note the calmness of the water. Calm ❐ Tiny Ripples ❐ Small waves ❐ Large Waves ❐
5) Water clarity. Turbid (no visibility) ❐ Fairly Clear ❐ Clear ❐

6) Look in the water, on the bottom, etc. Identify what you can and fill in the following table.

Species Seen	Location or Habitat	Abundance (common, frequent or rare)

7) Write your general impressions of this location. Try to highlight its special characteristics and the things that interest you.

Chapter 24. Freshwater Habitats of Bermuda

Introduction

Chapters 22, 23 and 24 describe the wetlands of Bermuda. **Wetlands** are places where the water table under average conditions lies close to, at, or somewhat above the surface of the ground. The **water table** is the level at which ground water comes to rest under normal weather conditions. Naturally in wet spells the water table rises and in dry spells it recedes. Nevertheless the biological community present will be representative of average conditions.

> **Summary**
> Freshwater **wetlands** are places where the water table is close to, at, or above the ground surface. **Marshes**, **ponds** and **swamps** are examples of freshwater wetlands.

Bermuda's wetlands can be conveniently divided into marine and freshwater habitats. The former as Mangrove Swamps, Salt Marshes and Marine Ponds have been covered in Chapters 22 and 23. The freshwater habitats can also be subdivided into marshes, swamps, bogs, ponds and channels and ditches. These will be discussed below.

Classification of Freshwater Wetlands

Freshwater wetlands are globally divided into **marshes**, **swamps**, **bogs**, streams, rivers, ponds and lakes. Marshes are grass dominated freshwater wetlands, swamps are tree dominated, and bogs are populated mostly by mosses. There are no bogs in Bermuda, but in the northern mainland they are common and a source for horticultural peat-moss, which is the compressed partially decomposed remains of moss plants. **Peat** can also form in marshes and swamps. And peat formed in this way has been very important in the development of persistent wetlands here (see Chapter 7). There are currently no streams or Rivers in Bermuda but in the past Mill Creek was a stream that discharged into Mill's Bay. Mill Creek has been dammed with a sluice-gate at the mouth and is heavily polluted. Similarly there are no real lakes but there are a series of ponds of varying size.

> **Summary**
> **Marshes** are freshwater **wetlands** where the water table is at the surface and which are **dominated** by grasses or wetland herbs. Swamps are dominated by trees while ponds have areas of open water.

The Importance of Peat

Thousands of years ago, Bermuda's land mass consisted of mostly coarse sand. This was very porous and any rainfall just percolated into the ground, giving no chance for wetlands to develop. However, some depressions in the land mass were deep enough for some water-loving plants to gain a foothold. Once this critical stage was reached, the fallen leaves and other parts of dead plants started to accumulate. This added organic material to the soil enabling it to store more water. As the process advanced, more and more plants grew and died and their dead remains accumulated. Layers of plant remains several feet thick developed and were then compressed by the weight of plants and material above. This was the start of peat deposition. Peat is virtually impervious to water and seals the surface of the sand or limestone. This then allows the development of a water table and standing water at the surface. This is how marshes, swamps and ponds became established. Without peat none of this would have happened and there is a layer of peat under every freshwater wetland in Bermuda.

> **Summary**
> **Peat**, the semi-decomposed remains of aquatic plants, is vital to wetlands since it seals the surface of the porous **limestone**, allowing water to accumulate.

Colonisation of Wetlands

Wetlands, of course, could not develop until wetland plant seeds reached Bermuda. This topic has been covered in Chapter 8, but the situation can be summarised briefly as follows. As soon as Bermuda appeared as an island, seeds, eggs and even small parts of wetland plants would have started to arrive, carried on the wind, attached to waterfowl and in the intestines of waterfowl. Dropping in a suitable habitat, these could germinate or hatch and grow or develop into wetland animals and plants. This process still goes on and slowly adds to wetland diversity.

Summary
Wetlands have been colonised by plants whose seeds have been wind-blown or carried on or in waterfowl. Animals arrived by similar mechanisms. Most wetland plants are **native** but there are some **invasive introductions** such as the Water Hyacinth.

Introduced Species

In several of the habitats in Bermuda, particularly terrestrial ones, the balance of nature has been seriously disturbed by introduced species. This has happened in wetlands too with plants such as the Water Hyacinth (*Eichornia crassipes*) growing in ponds and the Red-eared Slider (*Trachemys scripta*), a terrapin that was brought in as pets and released. They now can be found in all standing water and eat both animals and plants, some endemic. The exotic Apple Snail (*Pomacea* sp.) is also widespread while native and endemic water snails dwindle and disappear.

Freshwater Marshes and Pollution Control

Because wetlands are natural sediment traps, they also tend to collect particles of trash introduced by man. Additionally, the large amount of organic material present in wetland soils and sediments tends to bind dissolved pollutants and deposit them in the sediments. These rich sediments support large populations of bacteria many of which are capable of breaking down a wide range of pollutants. Thus water is clarified and purified in wetlands. Of course, there are limits to the concentration of pollutants tolerated by wetland organisms and the first sign of overload is usually a decrease in biodiversity.

Summary
Wetlands trap sediments and pollutants and are natural pollution controllers by virtue of the large bacterial populations which can break down many pollutants.

This ability of freshwater wetlands to act as a natural water-purification system is widely exploited throughout the world to improve the quality of surface waters. The wetland used may be a section of a natural one or one created for the purpose by the introduction of suitable plants and sediment.

The Variety of Freshwater Locations

While there are marshes, swamps and ponds in Bermuda, not all of them are natural. Several ponds have been man-made or reclaimed by man from former filled ponds, other ponds in the form of elongated ditches have been created to drain swampy areas and to facilitate Southern House Mosquito (*Culex pipiens*) control. However, in total the wetland areas of Bermuda have been steadily decreasing and some very large marsh areas such as Pembroke Marsh are now virtually gone. Pembroke Marsh originally made up 39% of Bermuda's wetlands. The western part was completely drained and the eastern part was used as a dump until 1994. Toxic material leaching from the dump, effectively wiped out the resident aquatic creatures including an endemic freshwater limpet and an endemic freshwater clam! The stream that drained this marsh complex into Mill's Creek, and provided a pathway for marine fish such as the Tarpon (*Tarpon atlanticus*) and American Eels (*Anguilla rostrata*) to inland areas, is no more. The one

Summary
The **wetlands** of Bermuda include both natural and man-made examples. However, the influence of man has been to steadily reduce the area of wetlands. The biggest freshwater **marsh**, stream, **estuary** complex in Bermuda, Pembroke Marsh has all been built over, used as a dump or severely polluted.

estuary at the mouth of Mill's Creek is no more. The largest marsh area is now Devonshire Marsh but it has been subject to man set fires. In 1914, the "great fire" destroyed its old cedar forest and changed the character of the marsh for all time. Since then it has been dominated by fire-resistant species, typically Saw Grass (*Cladium jamaicense*) and Southern Bracken (*Pteridium aquilinum*). The Bermuda Palmetto (*Sabal bermudana*)is also fire resistant as are plants that grow in standing water. As recently as 1996 a serious fire burned over at least 20 acres of the marsh. The once common pools of standing water supporting native and endemic species are all but gone. The largest freshwater pond is Warwick Pond but it is now very shallow, somewhat polluted and has a low diversity of life. Several other ponds for example Seymour's Pond are grossly polluted and it has been shown that Giant Toad (*Bufo marinus*) eggs laid in there develop into a high proportion of deformed tadpoles.

Recently, the top part of Pembroke Canal which drains the dump area has been greatly expanded by dredging and widening. It will be interesting to see if this new wetland area develops into a viable freshwater system, but it is likely that toxic dump leachates will prevent this.

Freshwater Marshes

Introduction

The plants and animals found in Bermuda's freshwater marshes are very similar to those of the freshwater marshes of eastern North America. The reason for this, as discussed in the general introduction, is that the original colonising organisms came from that area in the form of seeds and spores carried on the wind, and similar material plus perhaps fragments of plants and entire small animals carried on the feet and plumage of waterfowl. Of course only a relatively small number of species were able to move in this way. This group of organisms are the **native** wetland species. Since the arrival of man an additional group of wetland plants and animals has been introduced either accidentally or as ornamental plants; examples are water lilies and water hyacinths.

Summary
Freshwater **marshes** in Bermuda have much in common with those in the southeast USA and Central America.

In wetlands as in other ecosystems, organisms tend to occur in readily recognisable **communities** in which one species of plant is the most important or **dominant**. Communities are normally named from the dominant species in them, and there is usually a fairly constant group of associated species. Often, different communities show the presence of slightly different ecological conditions.

Some of the marshes become quite dry during spells with low rainfall and fires have not been uncommon.

The Marsh Community

The most widespread community of Bermudian freshwater marshes is dominated by Saw Grass**,** *(Cladium jamaicense)*, often growing with the fern Southern Bracken, (*Pteridium aquilinum)*. Saw Grass communities are usually found where the ground is flooded only in periods of high rainfall. Where there is more permanent water on the surface, a Narrow-leaved Cattail, (*Typha angustifolia*), community usually prevails. However, where there are no large shading plants, dense mats of Whorled Marsh Pennywort, (*Hydrocotyle verticillata)*, are common in wetter locations. Also frequent under wetter conditions, and sometimes covering quite large areas, are communities characterised by American Great Bullrush, (*Schoenoplectus lacustris)*, Baldwin's Cyperus, (*Cyperus globulosus)*, Cape Weed, (*Phyla nodiflora*), Bermuda Sedge, (*Carex bermudiana)*, or the Giant Fern,(*Acrostichum danaeifolium*.). Wet locations that are slightly salty

Summary
The most widespread plant community in Bermudian **wetlands** is dominated by Saw Grass often accompanied by Southern Bracken. In wetter spots, Cattails are common along with a variety of rushes. Drier areas often support several shrubs including Doc-Bush and Wax Myrtle.

or brackish are usually dominated by a Sheathed Paspalum, (*Paspalum vaginatum*), community. Where water rarely lies on the surface, marsh-edge communities dominated by Doc-bush, (*Baccharis glomeruliflora)*, Wax Myrtle, (*Myrica cerifera*), Bermuda Cedar, (*Juniperus bermudiana*) or Bermuda Palmetto, (*Sabal bermudana*) are characteristic. These latter shrub and tree dominated communities really form a fringing swamp around the marsh.

Freshwater Swamps

Introduction

Freshwater swamps, also called swamp-forests or treed swamps are not well developed in Bermuda. Mostly, they take the form of fringing or fragmentary ecosystems around or within the marshes. In the past, however, they were large important ecosystems. Prior to the "Great Fire" of 1914, Devonshire Marsh was a Bermuda Cedar swamp. Now the best example of a swamp is the Bermuda Palmetto forest in Paget Marsh. **Figure 24.1** is an artist's impression of the Paget Marsh palmetto swamp that recaptures the essence of the place. In addition to fires, introduced, invasive species such as Guava (*Psidium guajava*) Strawberry Guava *(Psidium cattleianum)*, Pittosporum or Mock Orange *(Pittosporum tobira)*, Carolina Laurel Cherry *(Laurocerasus carolinianum)* and Ardisia *(Ardisia polycephala)*, put stress on these swamps by competing with native and **endemic** species. In recent years the Conservation Division of the Bermuda Government has undertaken a programme of eradication of introduced, **invasive** species where they have been impinging on important native communities. This programme has been remarkably successful and habitats within the swamps have returned to their original condition, fostering the return of several endangered species.

Summary

The two main **endemic** trees Bermuda Cedar and Bermuda Palmetto can both **dominate swamps** or co-exist there. Fires in **marshes** and swamps reduce cedar **populations** in favour of Palmettos.

Communities of freshwater swamps

Although there were Bermuda Cedar dominated swamps in the past, none exist today. The best developed modern swamp is the Bermuda Palmetto swamp in Paget Marsh. Since the removal of introduced, competing species, this community has returned to its original condition and is a fine example of a swamp-forest that was formerly much more widespread. Conditions within this forest foster the growth of many interesting species such as the Royal Fern *(Osmunda regalis)*, the Cinnamon Fern *(Osmunda cinnamomea)*, Southern Bracken, Sword Fern *(Nephrolepis exaltata)*, Wild Bermuda Pepper *(Peperomia septentrionalis)*, the ancient clubmoss Psilotum *(Psilotum nudum)*, Bermuda Sedge *(Carex bermudiana)* and White Moss *(Leucobryum glaucum)*. Two native vines, Virginia Creeper *(Parthenocissus quinquefolia)* and West Indian Cissus *(Cissus sicyoides)* climb up the trunks of the palmettos. Other communities of the freshwater swamps are dominated by Wax Myrtle *(Myrica cerifera)* and Doc-Bush. In some areas the introduced Brazil or Mexican Pepper, *(Schinus terebinthifolia)* seems to be establishing itself as part of the swamp.

Summary

Ferns such as the Royal Fern, the Cinnamon Fern, the Sword Fern and Southern Bracken are common in freshwater **swamps**, while the Giant Fern grows along the outer edges. Various **endemic** and uncommon native plants also live there including the Wild Bermuda Pepper, Psilotum, Bermuda Sedge and the White Moss.

Freshwater Ponds

Introduction

Although the ponds in this category may appear to be quite fresh, most if not all have traces of salt. Bermuda is a small island and the influence of the sea is present everywhere; because of this plants and animals tolerant of traces of salt are characteristic of the ponds. As did those of the marshes, the organisms found in ponds mostly originated in eastern North America. Most of the organisms are **native**, meaning that they arrived naturally but are also found elsewhere. There

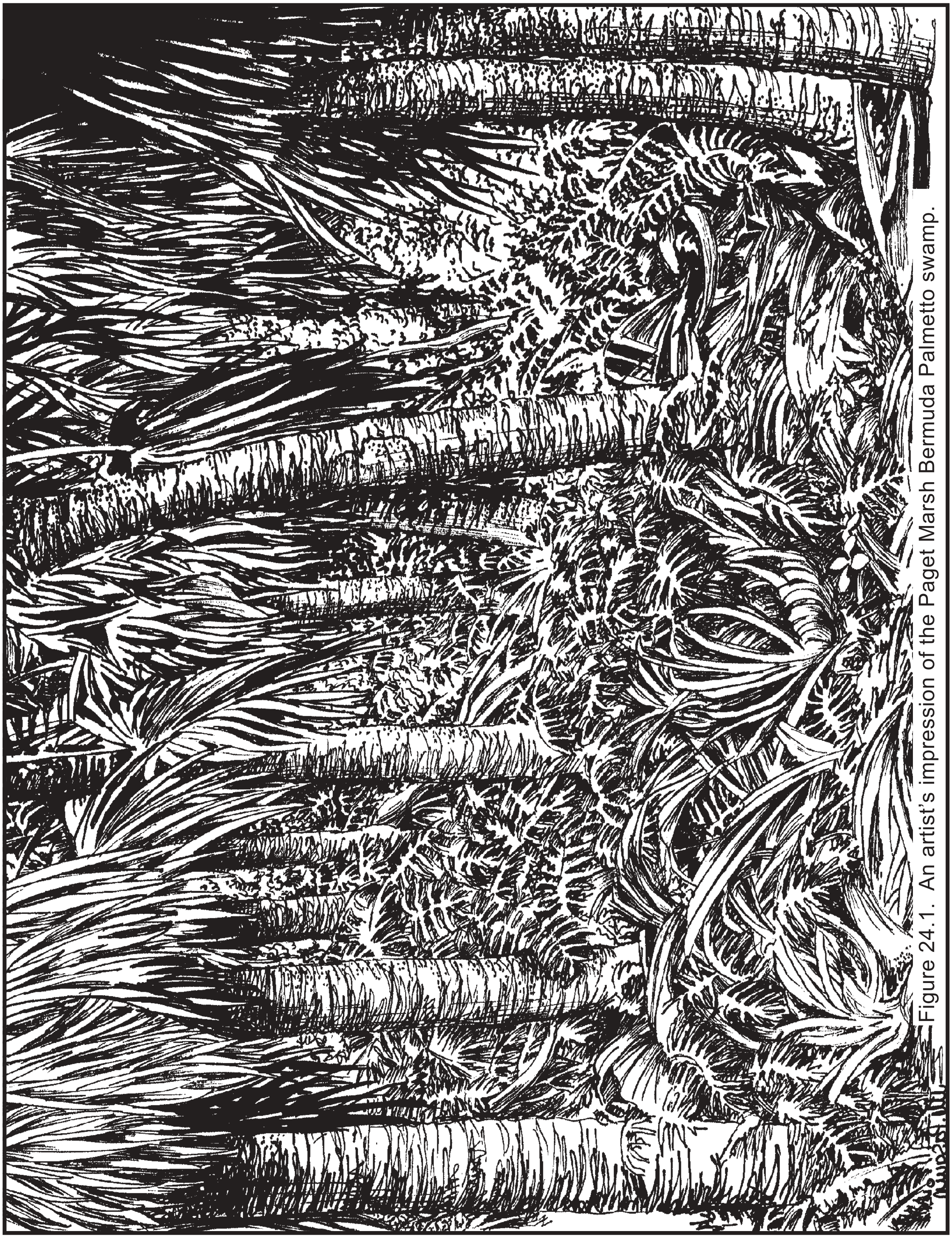

Figure 24.1. An artist's impression of the Paget Marsh Bermuda Palmetto swamp.

are a few **introduced species** but so far as is known the only two **endemic** freshwater species of freshwater ponds in Bermuda are now **extinct** (See the discussion of the Pembroke Marsh complex in the general introduction.). The fact that evolution to form new species took place in Bermuda tells us that there were stable freshwater ponds for thousands of years before the arrival of man.

Summary
Because the sea is always close, all freshwater **ponds** are slightly salty. The animals and plants are not very diverse and are mostly native. Several pond species have become **extinct** or **extirpated** since man arrived in Bermuda. All ponds are polluted to some extent.

However, with the arrival of man the stable era of freshwater ponds terminated. Early residents did not value the ponds and indeed saw them as breeding grounds for disease-carrying mosquitoes. Many ponds were filled; others were used for trash disposal. The introduction of the Mosquito Fish *(Gambusia holbrooki)* in 1928 proved a very effective control for mosquitoes and the rush to eliminate ponds slowed. In recent years the trend to eliminate ponds has fortunately been partially reversed. Several previous ponds have been emptied of trash and are returning to a reasonably sound ecological state. Examples are the new pond in Paget Marsh at the start of the boardwalk, Somerset Long Bay pond and the pond in the Stokes Point Reserve. An entirely new pond has been created on Nonsuch Island as have others in the Spittal Pond Bird Sanctuary.

In several locations man-made ditches function as elongate ponds. Examples are the ditch around Paget Marsh and the very upper end of Pembroke Canal at Glebe Road; they are included here with the freshwater ponds in general.

<u>Communities in freshwater ponds</u>

Around the edges of ponds, communities dominated by the Narrow-leaved Cattail *(Typha angustifolia)* are frequent as are those typified by Joint Grass *(Paspalum distichum)*; these are fringing communities. Other plants which dominate fringing communities less commonly are the Umbrella Sedge *(Cyperus alternifolius)*, the White-Headed Rush *(Rhynchospora colorata)* the Large Marsh Rush *(Juncus acutus)* and Whorled Marsh Pennywort (*Hydrocotyle verticillata*). In addition, Sheathed Paspalum may fringe ponds but really likes brackish conditions. It was mentioned in the previous two chapters in relation both to salt marshes and marine ponds. In the water, Widgeon Grass *(Ruppia maritima)* is a common community dominant and like Sheathed Paspalum is an indicator of slightly salty to brackish conditions. Where the water is virtually fully fresh, Water Smartweed *(Polygonum punctatum)* or Marsh Purslane (*Ludwigia palustris*) may dominate shallow locations while Ditchweed or Hornwort *(Ceratophyllum demersum)* is a less frequent community dominant. Marsh Eclipta *(Eclipta alba))* and Water Hyssop *(Bacopa monnieria)* may be scattered among the other plants. Other possible community indicators are the floating aquatic plant Duckweed *(Lemna minor)*, Mermaid Weed *(Proserpinaca palustris)* and the aquatic Water Fern *(Salvinia olfersiana)*. Very large populations of the Mosquito Fish, are often present in the water.

Summary
The edges of freshwater **ponds** characteristically support **marsh** species such as Cattails, American Great Bullrushes, White-Headed Rushes etc. Floating in the water Duckweeds are very common and the Water Fern less so. In the water, Widgeon Grass is very common and others such as Marsh Purslane, Mermaid Weed and Hornwort occur.

Freshwater Channels and Ditches

These man-made features contribute significantly to the amount of open freshwater in Bermuda. However, if they are not maintained they rapidly fill and disappear or become strip-marshes. Most, if not all are severely polluted; the most blatant example being the Pembroke Canal

Summary
Ditches are man-made for drainage or mosquito control. They support similar species to the **ponds**.

system dug to drain the Pembroke Marshes. Currently the water supports Mosquito Fish and Red-eared Sliders and in the upper part is fringed with introduced plants including Elephant's Ears or Eddoe (*Colocasia esculenta*) and Cow-cane (*Arundo donax*) less polluted examples have similar occupants to the ponds described above.

Pollution and Conservation Concerns

The fact that all freshwater environments are polluted has already been mentioned above. Common problems are heavy metals and hydrocarbons. Either of these pollutants can cause death in animals and some plants, and in combination, they seem more toxic. They can cause death and/ or deformation in animals and probably some species of plants. On the plus side, marshes are useful for reducing the level of pollution as they trap particles and facilitate the growth of bacteria that degrade pollutants. Nevertheless, it must be stressed that freshwater wetlands are heavily polluted and steps need to be taken to reduce the input of pollutants into these systems.

Another problem is that many water-filled ditches which may support rare and endangered species may be dredged and widened without regard to the animals and plants in them. This undoubtedly reduces Biodiversity and promotes ecological instability.

Summary

Pollution is present in all **ponds** in the form of trash and many dissolved materials such as heavy metals, pesticides and herbicides. These reduce **Biodiversity** and are causing deformities in tadpoles of the Giant Toad. Additionally, damage is done by dredging and building practices.

There is a worldwide problem with the disappearance of many species of frogs and toads. These animals commonly live or breed in freshwater habitats and have very thin, delicate skins, particularly in the larval (tadpole) stage of their life histories. This makes them quite vulnerable to the effects of toxins such as heavy metals, pesticides etc. dissolved in the water. The Whistling (Tree) Frogs of Bermuda lay their eggs in small water pockets trapped in the crotches of trees and are somewhat isolated from this problem, but the Giant Toad breeds in a variety of freshwater habitats and is in serious decline. Studies have shown that tadpoles of Giant Toads show bodily deformities in proportion to the pollution load. In some areas a majority of the tadpoles are deformed and cannot develop normally.

Fortunately the dumping of trash in ponds seems to have largely stopped.

Questions

1) Why are freshwater habitats at particular risk in Bermuda? ______________________

____

____

2) List three types of different freshwater habitats in Bermuda.
   a) ______________________
   b) ______________________
   c) ______________________
3) Why is the formation of peat so important in the creation of freshwater habitats? ______

____

____

4) Do you think that any freshwater habitat in Bermuda is free of marine influences? Give reasons for your answer. ______________________________

____

____

____

5) How may freshwater animals and plants have reached Bermuda? Give three possible mechanisms.
   a) ______________________
   b) ______________________
   c) ______________________
6) Name the fire-resistant endemic tree found in Devonshire Marsh. ______________
7) What are the names of two waterfowl that may be observed in freshwater ponds?
   a) ______________________
   b) ______________________
   c) ______________________
8) What species of fish was introduced to control Mosquitoes in freshwater?

____

9) What terrapin has been released from captivity and is now found in freshwater locations?

____

10) When Bermuda was first colonised, what was the largest freshwater marsh? __________

____

11) In what freshwater habitat does Saw Grass occur? ______________________
    As a bonus see if you can name a bird that lives in Saw Grass stands. ____________
12) What do you think is a good approach to help save Bermuda's remaining freshwater wetlands?

____

____

____

13) What is the difference between a swamp and a marsh? ______________________

____

14) List three ways in which you might determine if a freshwater habitat is polluted.
    a) ______________________________________
    b) ______________________________________
    c) ______________________________________
15) There are now no permanent freshwater streams in Bermuda; what structure replaced the one that was here? ______________________________

Field Trip # 24.1 to Paget Marsh

Introduction

Paget Marsh is a wonderful location for a field trip to observe freshwater habitats in Bermuda. It is one of the restored habitats discussed earlier in this field guide and as a result you will see mainly native and endemic species there. Additionally, it has an elevated boardwalk that traverses a variety of habitats, giving an excellent view, but preventing damage to these delicate areas. It also provides dry footing and protection from Poison Ivy, which occurs there. **Figure 24.2** shows a map of the Paget Marsh area, the habitats and the location of the boardwalk. Paget Marsh is a Nature Reserve administered jointly by the Bermuda National Trust and the Bermuda Audubon Society. Paget Marsh lies in a depression in the central part of the main island. It is very important because it supports a great variety of natural wetland systems. The centre of the marsh lies just below sea level and is flooded with a mixture of seawater and freshwater making it a brackish anchialine pond. The pond is surrounded by a Red Mangrove swamp. As the ground rises away from the saltwater flooded area, it quickly becomes quite fresh at the surface and the mangroves are replaced by a freshwater swamp-forest dominated by Bermuda Palmetto with Bermuda Cedar as a sub-dominant. Note that the mangrove swamp near to the start of the boardwalk is an extension of the central pond one. The swamp-forest surrounding the mangrove swamp is very close to the original, typical lowland forest of Bermuda, particularly where invading species have been cleared out. There are also significant areas of freshwater marsh where Saw Grass and Narrow-leaved Cattail predominate and which show all the typical features of Bermudian freshwater marshes. Although there is no true, natural freshwater pond, a pond has been created at the start of the boardwalk, and drainage ditches dug around the outer edge of the depression have pond like character and show abundant Duckweed and Water Fern. Thus virtually all the wetland types discussed in this field guide could be studied at this one location. Do not leave the boardwalk for any reason. It is there both for the protection of visitors and to preserve this delicate area; additionally Poison Ivy is present and Saw Grass has very sharp leaf edges.

Preparation

Read this section of this field guide covering freshwater marshes, ponds and swamps. Find out anything else that you can on Bermudian freshwater habitats.

Dress

No special dress is needed as all observations are made from the boardwalk.

Equipment

A copy of this Field Guide. Clip board and pencil. Metre or yard sticks. 10 m or 30 ft measuring tape. At least one pair of binoculars for the group would be good.

Observations

1) All work at this location will be done from the boardwalk to avoid trampling this very important ecological site. Walk along the boardwalk to the end and identify the various habitats described above. The freshwater marshes will stand out as grass dominated areas among the forested habitats. Fill in the following table.

Habitats along the boardwalk

Habitat or Ecosystem	Location along Board-walk	Main Features
Freshswater Pond		
Red Mangrove Swamp		
Saw Grass		
Palmetto Swamp-forest		

2) From the boardwalk look at the marsh area. Locate the dominant grasses or grass like plants, Narrow-leaved Cattail and Saw Grass and a few Wax Myrtle shrubs. Are these interspersed with each other or in discrete patches? Make a judgement about which one is most important (dominant) and which comes second (sub-dominant). If you think they are of equal importance call them co-dominants.

   Dominant plant ______________________ Sub-dominant plant ______________________

3) Look for and identify any other plants found in this marsh. Try to identify them from the pictures included in this field guide. Examples of ferns, herbs and other grasses, sedges or rushes may be seen. List all those you find in the following table and note where they were growing.

Plant Identity	Where seen growing

4) Walk to where the marsh grades in to surrounding systems. At this point grasses will cease to be dominant and trees will become important. This change-over zone is called an **ecotone**. Look carefully at this area. All ecotones have special features, one of which is increased biodiversity. Biodiversity can most simply be judged by counting the number of different species present. Take no notice of the abundance of each species. Pick a reasonable area of marsh, ecotone and woodland. About 4 square metres (or 4 square yards) would be about right. Judge this as the area enclosed by a square of 8 metre or yard sticks, laid two to a side. You can lay out such an area on the boardwalk if it will help and then mentally transfer this area to the ground. Note the biodiversity, expressed as number of different species, in each of the three areas. For added detail list all the species that you find in the following table.

	Marsh	Ecotone	Swamp-forest
Biodiversity as number of different species seen			
List of species identified			

5) Write a list of marsh plants with the one that penetrates furthest into the trees first and the one that penetrates least last. Such a list is a hierarchy. It gives a good idea of the adaptability of the plants you are observing.

First ______________________ Second ______________________

Third ______________________ Fourth ______________________

Last ______________________

6) In the Bermuda Palmetto-Bermuda Cedar swamp-forest, identify these two trees and as many associated species as you can see. The two vines clinging to the trunks are Virginia Creeper and West Indian Cissus. Under the trees you should be able to see ferns such as Southern Bracken, Cinnamon Fern, Sword Fern and Royal Fern. Also look for the clubmoss, Psilotum a very ancient species. The White Moss should also be visible. Several other plants are possible. List everything that you identify.

List of identified species.

1) ______________________ 2) ______________________

3) ______________________ 4) ______________________

5) ______________________ 6) ______________________

7) ______________________ 8) ______________________

7) A swamp is a wetland forest. Forests are one of the best examples of a stratified or vertically layered ecosystem. The topmost layer containing the crown of the trees and the bulk of their leaves is the canopy. Look up to the canopy and estimate the height above the ground of the top and bottom of this stratum. A metre or yard stick can be used to help make this estimate, just imagine how many would have to be placed end-to-end to reach the heights you are estimating. Estimation is a valuable scientific method and with practice it can be reasonably accurate. Below the canopy, the sub-canopy, a quite open area extends down to the top of the ground layer. The ground layer may be almost devoid of plants where the canopy is thick, but have a diverse flora of shrubs and/or herbs where there is a reasonable amount of light. Ferns are often dominant or quite common in this layer.

	Approximate ht. of top (metre or yard)	**Approximate Height of bottom (metre or yard)**
Canopy		
Sub-canopy		
Ground Layer		

8) Using your height estimates draw a sketch of the vertical structure of the forest.

9) Look for animal life. List any birds that you see. Also look for Giant Toads and Jamaican Anoles. Look for insects and other invertebrates. Make a list of everything that you can identify.

List of Animals Seen

1) ____________________ 2) ____________________
3) ____________________ 4) ____________________
5) ____________________ 6) ____________________
7) ____________________ 8) ____________________

10) The biological structure of the forest modifies the climate of the location. If it is windy note that the highest wind velocity is at the top of the canopy. Wind strength drops rapidly moving down into the canopy, but may rise somewhat again in the more open sub-canopy. Within the ground layer the wind speed drops almost to zero at the ground surface. Notice that light intensity is much lower within the swamp. If the canopy shades out more than 90% of sunlight, the ground layer will be very poorly developed. Another physical change to look for on a sunny day is a lower air temperature in the shade of the trees than outside (at night the opposite effect would occur). All these changes increase the physical stability of the forest. Summarise your observations on the modification of local climate by the forest.

Observations ____________________

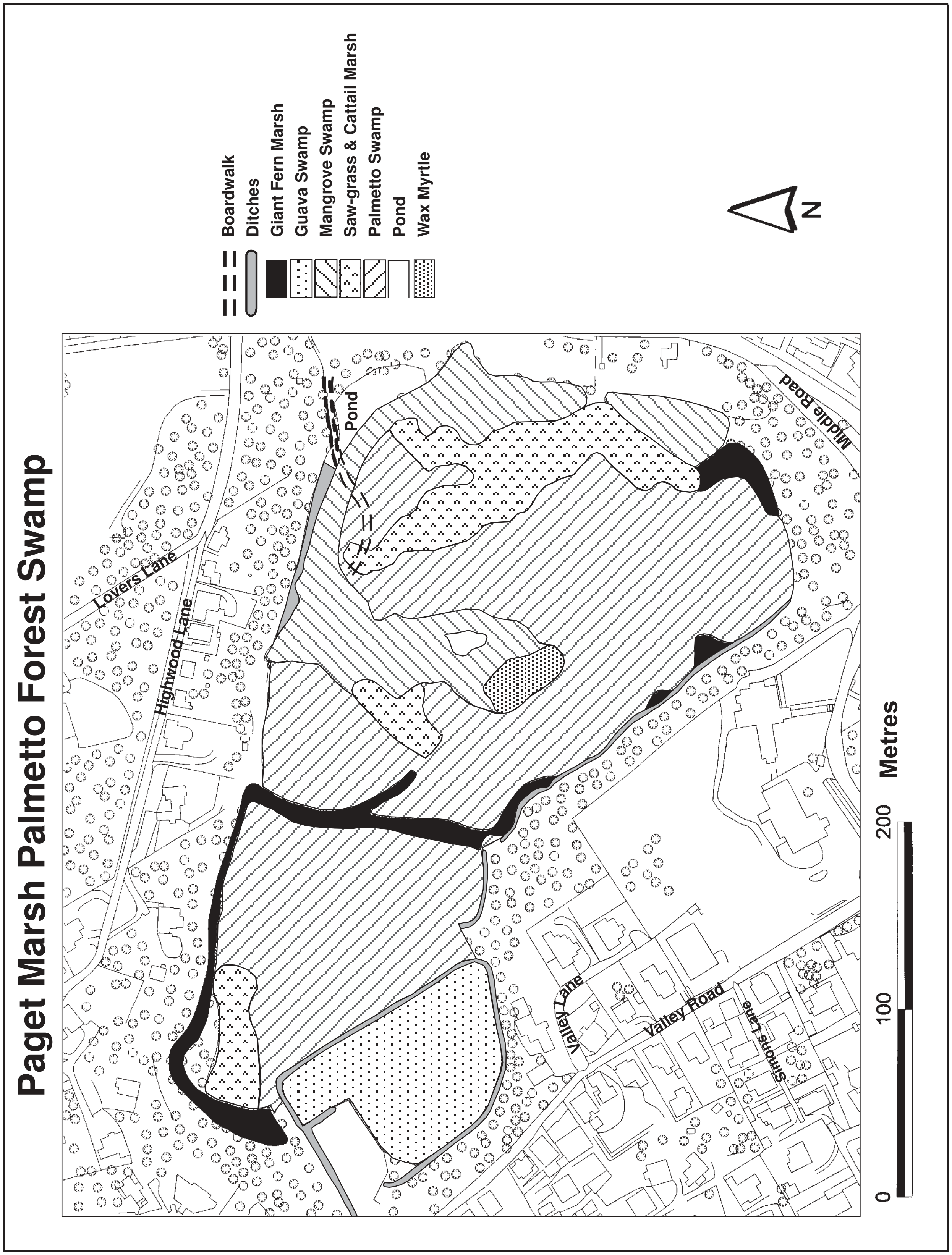

Figure 24.2 Map of Paget Marsh Palmetto Forest Swamp

Field Trip # 24.2 to Devonshire Marsh

Introduction

Devonshire Marsh is the largest remaining wetland area in Bermuda, while it is largely an impenetrable Saw Grass marsh, it also has smaller areas with Bermuda Palmetto swamp-forests, stands of Giant Fern, Wax Myrtle thickets, pond habitat in ditches and isolated pockets and many examples of areas dominated by invasive, introduced species such as Water Hyacinth and Brazil Pepper trees. Devonshire Marsh has had a long history of man-made fires which have changed its nature for all time; what is left is a group of fire-resistant wetland species. For example almost all the Bermuda Cedars, which are not fire-resistant have been eliminated, while the very fire-resistant Bermuda Palmettos have persisted in some areas.

In recent years, Devonshire Marsh has become very overgrown and difficult to walk into, additionally Poison Ivy is becoming very common in places. For these reasons, field work at this location must be confined to observations around the edge.

Preparation

Read this section of this field guide.

Dress

No special clothing is needed.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group.

Suggested Route

Middle Road runs along the southern edge of the marsh, however, the only reasonable observation location lies behind the Howard's store on middle road. There is parking behind the market. From the parking area, an old, unfinished road or causeway runs out into the marsh. Walk a short distance out along this road to where it is open on the right side, from there several features of the marsh should be visible. The edge of the marsh is characterised by areas of rushes, interspersed with areas invaded by Brazil Pepper trees, giving way further in to Saw Grass and Wax Myrtle. Narrow-leaved Cattail stands show the locations of old drainage ditches, now overgrown.

Vesey Street runs along the north border of the marsh area and there are several places where observations of various plant communities can be made. A large drainage ditch follows the road for most of the way and prevents access to the marsh itself. There are several stands of fringing swamp along the far side of the ditch. Most of these are Bermuda Palmetto Swamp but there are also areas dominated by the shrub, Wax Myrtle.

Figure 24.3 shows the approximate locations of useful observational areas around Devonshire Marsh. The best way to carry out a field trip to this location is to start at the Howard's store on Middle Road, then to proceed on to Vesey Street and make several stops at places where good observation is possible, especially in the Winifred Gibbons and Freer Cox nature reserves towards the western end of the marsh.

Observations

A. Howard's store area.
1) Examine the marsh on both sides of the old causeway noting the open area on the right. It is also open to the left but the view is obscured by bushes. Look for examples of marsh plant communities and their characteristics. Communities are named from the dominant (most important) plant in them. Look for the following communities.

Narrow-leaved Cattail
Saw Grass
Wax Myrtle
Brazil Pepper

Rushes (such as White-headed Rush, American Great Bullrush, Large Marsh Rush).
For each community observe:

i) its habitat, for example marsh edge, marsh interior, causeway margin etc,
ii) its structural features including whether it is dominated by bushes or herbs, rushes and grasses, whether there is standing water present and whether it is dense (impenetrable) or open,
iii) identify as many other plants present in the community as you can and
iv) decide whether the dominant plants are native or introduced. Fill in the following table.

Devonshire Marsh at Howard's store

Community Name Dominant Plant Native or Introduced	**Habitat**	**Structural Features**	**List of other plants present**

B) Vesey Street locations.

1) At each location look at the marsh edge. Along much of the northern boundary of Devonshire Marsh there are fringing swamp-forests, forming a narrow band close to the ditch, beyond this fringe the open marsh is mostly dominated by Saw Grass. Look at the ditch and identify the plants in it and decide whether they are native or introduced. You may also see specimens of the introduced and invasive terrapin the Red-eared Slider but they quickly submerge when disturbed. Look for the dominant (most important) tree in the swamp-forest beyond the ditch, identify it and decide whether it is endemic, native or introduced. Complete the following table for two of your stops.

Devonshire Marsh Vesey Street Locations

Location	List of Ditch Plants	Native or Introduced	Dominant Swamp Tree	Native or Introduced
Location 1				
Location 2				

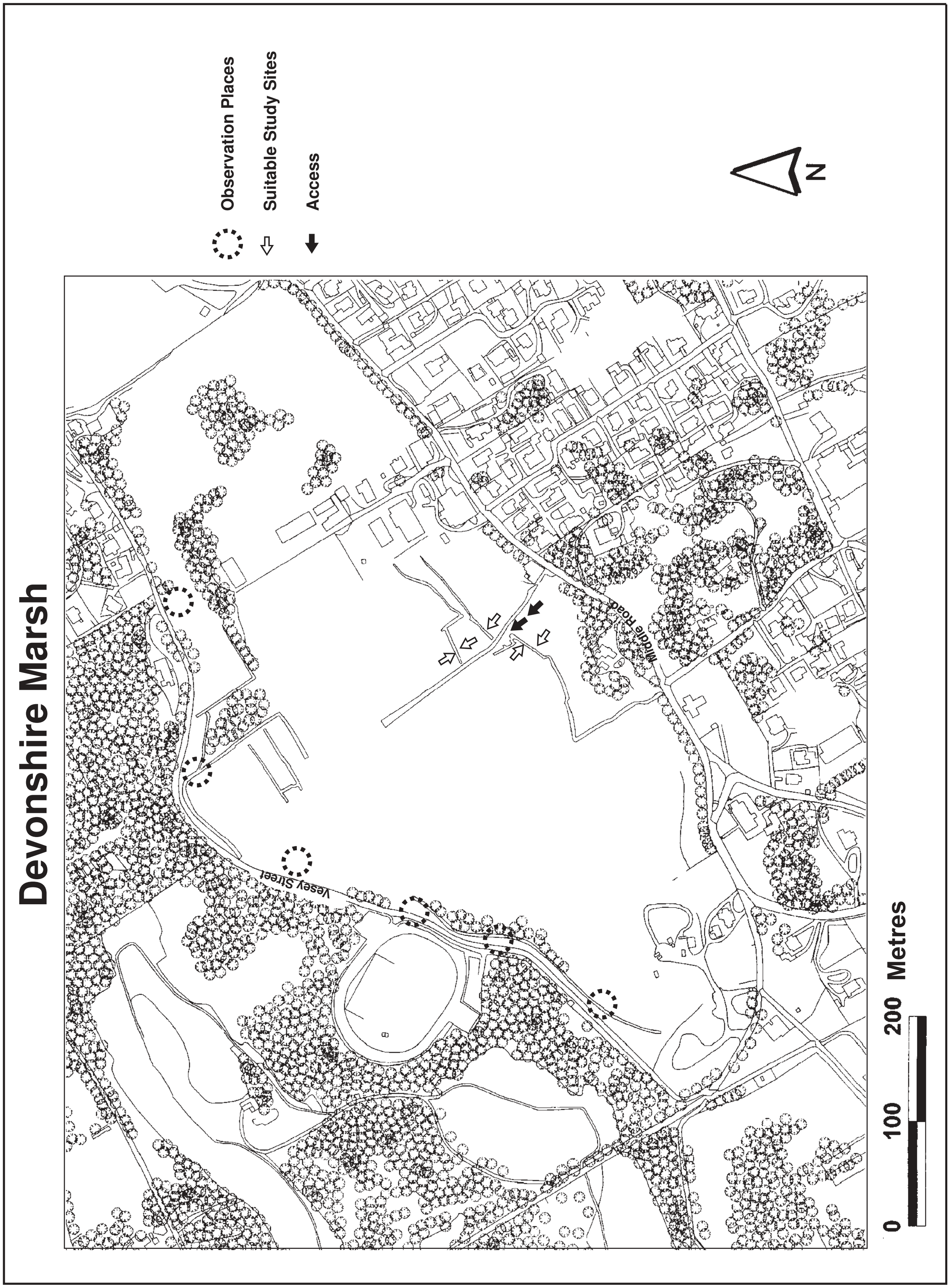

Figure 24.3 Map of Devonshire Marsh

Field Trip # 24.3 to Pembroke Marsh and Canal

Introduction

The Pembroke Marsh complex was the largest marsh area in Bermuda at the time of colonisation. Pembroke Marsh West stretching from Mill Creek to the centre of northern Hamilton and Pembroke Marsh East going from there to the eastern edge of the currently being reclaimed dump site, were drained by Pembroke Stream, Bermuda's only brook which discharged as an estuary into Mill Creek. None of this remains in its original form, Pembroke Marsh west is completely built over with industrial sites, Pembroke Marsh East now comprises recreational areas, some Narrow-leaved Cattail marshes, limited open water and the former extensive dump site. Pembroke Stream has been converted to Pembroke Canal, which is now little more than an open sewer draining the area; the entry of seawater at high tide is blocked by a sluice gate at the mouth of the canal in Mill Creek. This field trip serves as a reminder of the former extensive marsh complex and further shows the degradation caused by pollution in what little remains.

The sources of pollution in the area are many, there is no doubt that some human waste enters the canal but a greater source of toxic pollutants is industrial waste. One of the main problems is oil from various sources but principally the BELCO electricity generating plant which lines part of Pembroke Canal on both banks. Another big problem is what is called leachate which emanates from the former dump site. Leachate is water borne pollution draining from the huge mass of garbage of all descriptions at the former dump site. Although the surface of the waste is now sealed and being reclaimed as a park, there is no way to isolate the waste that lies beneath. Groundwater will continue to percolate through this material for the foreseeable future. Fortunately, there is a thick layer of peat underneath the waste pile that prevents leachates from moving down into the freshwater lens.

The very polluted nature of water in the area covered by this field trip means that work must be restricted to observation only. On no account wade into or touch any water that you see. Concentrate on trying to imagine the former marshes and their beauty, the way that man has changed this and the effects of the severe pollution that you will see. Try to think of ways that pollution can be reduced and affected areas cleaned up.

Preparation

Read this section of this field guide and anything else that you can find about the former Pembroke Marsh complex. It would also be useful to find out what you can about the former dump, the construction of Pembroke Canal and pollution in the area.

Dress

No special clothing is needed.

Equipment

Clipboard, pencil and several sheets of good paper.

Suggested Route

The route suggested takes you from the former inland extremity of Pembroke Marsh East to the seaward mouth of Pembroke Canal at Mill Creek, which formerly was the western extreme of the Pembroke Marsh complex. Remember that the former marshes covered all the lowland between these two extremes. The stops will be:

1) The Glebe Road just north of Parsons Road, where the eastern extremity of Pembroke Canal goes under The Glebe Road.
2) The new park off Parsons Road just to the west of Glebe Street.
3) Behind Transport Control off North Street.
4) On Woodlands Road opposite to Canal Road.
5) At the BELCO site on Cemetery Road beside the bridge over Pembroke Canal.
6) At the far end of Mill Creek Road where Pembroke Canal enters Mill Creek at the sluice gate.

Observations

Stop 1. The Glebe Road.

This is the very inner end of Pembroke Canal. To the west the canal enlarges greatly where it has been dredged to create an area of open water between the old dump site and Parsons Road. To the east the canal is little more than a damp ditch which soon peters out.

Look at the areas on both sides of Glebe Road around the canal location. Realise that this would have been the very eastern extremity of the Pembroke Marsh complex. It would probably have been either a Saw Grass marsh or an area dominated by various rushes. Trees such as Bermuda Cedar and Bermuda Palmetto probably fringed the wetter marsh area. The site of the canal to the east of The Glebe Road was a stream in wet weather and a damp gully at other times. As it proceeded towards the sea the stream would have become progressively wetter, soon being water-filled at all seasons. Realise that fill has been dumped on both sides of the road at various times to create dry land.

Draw a sketch map of this location as it is now, showing the location of The Glebe Road and Pembroke Canal. Cross hatch in an area that you think would have been marshland.

Sketch Map of Pembroke Canal at Glebe Road

Stop 2. Parsons Road Park.

This area would have been well developed marshland, about a metre or 3 feet lower than at present. It was quite probably a Saw Grass marsh. The level has been raised by dumping fill. Pembroke Canal has been greatly enlarged at this point creating one of the largest areas of open freshwater in Bermuda. However, it is heavily polluted and little animal life exists in the water. However, Mosquito Fish are present and you should see them at the surface. The open freshwater also attracts waterfowl such as ducks, various herons and American Coots. The original location of Pembroke Stream is unknown but it was probably fairly close to the canal site and would have been permanently water-filled. There is no doubt that it would have supported a wide diversity of freshwater life including, water snails and limpets, a variety of larval dragonflies, water boatmen etc. Until it was dredged in recent years, this area still supported one of the most diverse populations of freshwater organisms in Bermuda. Mosquito Fish and Giant Toads would not have been present as they were introduced later on. However, the endemic Bermuda Killifish would have been there along with American Eels. A wide variety of wetland birds including rails, herons and various ducks would have been common.

Beyond the canal look at the upper end of the huge mound of garbage, now covered in soil, that was dumped in Pembroke Marsh east. Along the margins of the canal you should see the very large leaves of Elephant's Ears or Eddoe an invasive, introduced, water margin plant. Beyond the canal at the base of the slope look for the huge grass, Cow-cane, also introduced and invasive.

Draw a sketch map of the area showing Parson's Road, the parkland, Pembroke Canal and the covered garbage pile. Cross hatch the area that would have formerly been Saw Grass marsh.

Sketch Map of Pembroke Marsh East north of Parson's Road

Stop 3. Transport Control Parking Lot.
Although this location is similar in many respects to stop 2, it shows an earlier stage of man's alterations of the marsh complex. The wide canal here was enlarged many years ago and has a large side channel going to the western end of the former garbage dump, where there is a large pond that was created when the weight of dumped garbage and fill compressed the underlying peat. At the time of colonisation, this general area would have been an extensive marsh. It is possible that there were some small ponds dotted about, but the larger ponds you see today are all a result of the activity of man. Leachate from the western part of the dump now enters the canal at this point. The fauna and flora are similar to that at stop 2 but show more mature stands of Cow-cane and Elephant's Ears or Eddoe and the native Narrow-leaved Cattail is common along the water's edge. Pollution is high at this location and all that is visible in the water is a large population of Mosquito Fish. We know that an endemic freshwater clam and an endemic freshwater limpet used to live close to this location. Both are now extinct, casualties of pollution and habitat change.

Draw a sketch map similar to that for stop 2. Remember that in the past Pembroke Stream would not have been as large as the present canal and the dump-site would have been an extensive marsh probably dominated by Saw Grass. Include the channel going to the dump-site in your sketch map and again cross-hatch areas which were probably marshland

Sketch Map of Pembroke Marsh East at Transport Control.

Stop 4. Woodlands Road at Canal Road and BAA.
This stop shows Pembroke Canal in its typical form for the middle part of its course. Where it lies in relation to the old Pembroke Stream is anybody's guess but we can assume that the original stream followed a more meandering course such as is typical of streams in flat lowlands.

The canal lies right at the edge of the road and its far bank is the edge of the Bermuda Athletic Association (BAA) playing fields. Walk along the sidewalk looking at the canal. Note the dirty, polluted water and the garbage in it. You may see specimens of the Red-eared Slider, an introduced, invasive, terrapin. Ducks are often present in this area too. There is virtually no life in the water. Where the canal leaves the road edge, the banks flatten out somewhat and support a community dominated by the Whorled Marsh Pennywort, a beautiful low little water's edge plant. A bridge into the BAA grounds at this point offers a good look at the canal in both directions.

We know that in the past this location was about at the junction between Pembroke Marshes East and West. Pembroke Stream was probably tidal up to about here since we know that mangroves lining the stream occurred here.

Draw a sketch map of the canal from where it emerges at Canal Road to the BAA bridge. Show the road, the canal, the bridge, the edge of the BAA grounds the Whorled Marsh Pennywort and the hedge between the canal and the BAA.

Sketch Map of Pembroke Canal at Woodlands Road

Stop 5. Pembroke Canal at BELCO.
On the west side of the bridge carrying Cemetery Road over Pembroke Canal, there is a good observation site to see pollution at its worst. Oil pollution is particularly bad here and weirs have been built across the canal to trap floating oil. Note the very filthy water, the floating oil, the obnoxious smell and the absence of life in the water itself. Below the weirs where it is a bit cleaner, look for Mosquito Fish. This species is very pollution resistant and can breath air at the surface, there may also be Red-eared Sliders. The canal banks downstream of the weirs support a wide variety of flowering herbs and grasses.

Draw a sketch map of the area showing the bridge over Cemetery Road, Pembroke Canal, the weirs and the closest parts of the electricity generating plant.

Sketch Map of Pembroke Canal at BELCO

Stop 6. Pembroke Canal at Mill Creek.
This location is where the only estuary in Bermuda occurred where Pembroke Stream entered into the sea. Imagine that the mangrove swamp now almost confined to the seaward side of the road formerly extended well inland from here, lining the creek banks as far back as just above the high tide mark. The stream almost certainly meandered through these stands of mangrove trees. This would have been an area of great biodiversity as marine and estuarine species mingles with salt tolerant freshwater ones. A large, marine fish that breeds in such areas, the Tarpon, was common here then and occasionally seen in Mill Creek today. It is known that American Eels and Shad migrated up Pembroke Stream from here. It was also a favourite location for early settlers to go for a Sunday row. The marsh was partly marine, forming a salt marsh behind the mangroves in which were numerous tidal pools teeming with Bermuda Killifish. Saltmarsh herbs such as Woody Glasswort, Sea Lavender, Seaside Heliotrope, Saltmarsh Oxeye and Seaside Purslane were undoubtedly common and stands of the Sea Rush probably occupied extensive areas. It is uncertain what community dominated the slightly marine to seaward zone of the fully freshwater. Saw Grass dominated marshes but it quite possibly was characterised by Sheathed Paspalum as is found at the east end of Spittal Pond. (see Chapter 23).

On the seaward side of the road observe the sluice gate which closes as the tide rises and opens as it falls. This is designed to exclude seawater from areas above the sluice gate, but, there is some leakage and the canal just above the gate is partly salty or brackish.

Draw a sketch map of the area showing the canal, the sluice gate, part of the mangrove swamp, the roads, and a few aspects of the industrial area around the canal. Cross hatch an area above the bridge where you think that mangrove swamps would have extended previously. Mark where the stream might have flowed using dashed lines for its sides.

Sketch Map of Where Pembroke Canal meets the Ocean

Field Trip # 24.4 to Seymour's Pond

Introduction

Seymour's Pond lying at the junction of South and Middle Roads in Southampton Parish is probably the best remaining freshwater pond in Bermuda, however, like all the freshwater ponds it is somewhat polluted and on the decline. Giant Toad tadpoles monitored at this site show a high percentage of abnormalities resulting from pollution. The biodiversity at this site is higher than at most freshwater localities but nevertheless it supports only a relatively small number of species.

The area of pond margin available for study is very small and visits to this site must be limited to groups of 10 or less. Additionally it is used as an experimental site for studies on amphibians. No installations seen there should be disturbed in any way. Similarly, no animals and plants should be removed from this site in the interests of conservation of the very limited freshwater habitats.

The area is generally free of hazards but on no account should anyone step into the pond itself. The mud is deep and soft and will not support your weight. However, be aware that you are a hazard to the pond and this small nature reserve. Try to disturb nothing and to leave it as you found it. The only exception to this rule is that trash can be removed and placed in proper disposal containers.

Preparation

Read this section of this field guide and anything else that you can find about freshwater ponds in Bermuda.

Dress

The edge of the pond is very wet, particularly after rainy periods. Rubber boots are virtually a necessity. Clothing should be sturdy and readily washable.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group. A good dip-net would help in observation of water creatures. A 30 m water-resistant surveying tape. Several metre sticks could be substituted for the tape. Plastic bowls or buckets.

Suggested Route

Figure 24.4 shows a map of the pond and the access to the best area for study.

Observations

1) Before you start any detailed work, observe the pond area and list any wildlife that you can see now or that you disturbed as you approached. In the water you might see American Coots, the Common Gallinule or Moorhen or a variety of ducks, depending on the season. Around the water look for herons and egrets. These long necked wading predators could be wading in the water, in the vegetation surrounding the pool or even perching in the trees around the pond. Additionally, look for birds not closely tied to water that have a broad enough habitat range to use pond-side environments. Great Kiskadees and Starlings are likely to be present and others may be. Record your observations in the following table.

Wildlife Species	Location or Habitat	Number	Comments

2) Briefly describe the surroundings of the pond. Is it woodland or agricultural fields. If it is woodland, what are the main trees present, if cultivated, what is being grown there? At the South end of the pond the water ends in a fringe of Tamarisk shrubs; this is an unusual habitat for this salt tolerant tree or small shrub more commonly seen along the North Shore.

Observations ____

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3) Lay out a tape or tapes (students can be grouped for this exercise) with zero at the waters edge and running at right angles to the shoreline, up the slope, back towards the woods or fields. If the tape reaches woods or fields, stop there. Working along the tape from either end, determine where different types of vegetation start and stop, and where they are most abundant. Generally classify each thing that you look at as rare, common or abundant. For instance, where do grasses occur? What herbs can you find and where along the tape are they situated? How common are they. Communities are normally named on a basis of the most abundant plant. Can you distinguish any plant communities around the pond? It is likely that there will be a grass community close to the water, composed of Sheathed Paspalum, followed by a second grass community characterised by Para Grass or Joint Grass and a herb community farther back. Identify as many plants as you can from the pictures in this field guide. For those you know the identity of, make sure you have recorded where they were along the tape and how common they were. Record your results in the following table.

Species	Start and Finish Distances	Point of Maximum Abundance	Observations

4) From where you have been working, look to both sides of the tape and (on around the pond). Decide if any communities form distinct zones or bands around the pond. If they do draw a sketch map of the pond area showing the pond itself and the zones of vegetation around it. This can also be done if the vegetation forms patches rather than distinct zones. Both patches and zones show changing environmental conditions where they start and stop.

Sketch Map of Vegetation Communities Around Seymour's Pond

5) Remain in groups and turn your attention to the pond itself. Try to determine what water weeds are present. Widgeon Grass is the most likely but look for others. Thread-like green algae will also very likely be there. If you see any fish try to determine what they are. Mosquito Fish are likely to be found. List what you find.

Water Plants

1) ______________________________
2) ______________________________
3) ______________________________

Water Animals

1) ______________________________
2) ______________________________
3) ______________________________

6) Take a bowl or other container and fill it with pond water from the edge of the pond. Do not step into the water. Using a net with a handle, sweep it gently through the water weeds and open spaces. Try not to catch masses of weed. Shake the catch into the bowl of water. If clumps of weed are in the net they can be shaken over the water too. Some animals may cling to the weed and will need to be gently dislodged. Observe what you have caught and identify as many things as possible from the pictures in this guide. Some interesting things may be very small. Depending on season, much of what you get may be larvae or immature stages of aquatic insects that spend their adult lives out of the water. Others may be insects that spend all or most of their lives in water. Some of these, such as water boatmen can fly and may decide to leave the bowl. Try to distinguish between larvae and adults. When you have finished observing the pond creatures, it is important that you return your catch to the water.

Observations ____

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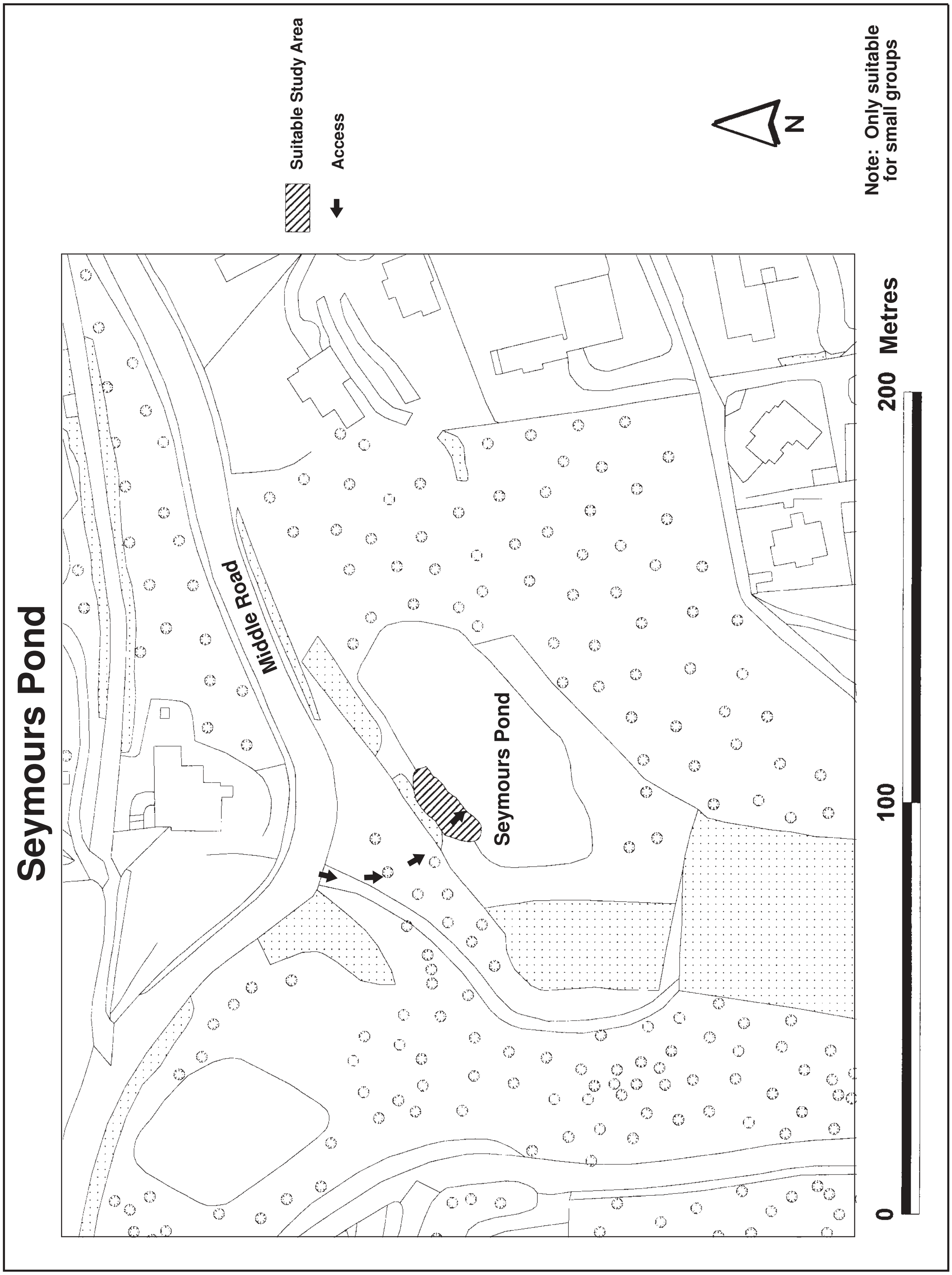

Figure 24.4 Map of Seymour Pond

Chapter 25. The Forests

Introduction

Were it not for the activities of man, forests which are ecosystems dominated by trees, would cover most land areas except in very dry or very cold climates. Tree sensitivity to cold is shown by the presence of a tree line (where trees stop), both as one moves north or south towards the poles and on mountains where temperature decreases with height. Trees are virtually absent from deserts and also from the vast tracts of dry grassland variously known as prairie, pampas, veldt etc., showing their sensitivity to low rainfall. At the other end of the scale, the best developed and most bio-diverse forests are found in areas of high rainfall. Thus we have the tropical rain forests, and temperate rain forests, now much in the news because of de-forestation.

> **Summary**
> Forests are the normal **dominant ecosystem** in all but very cold or very dry terrestrial **environments** on Earth. Wood from forests is a vital raw material and additionally forests help to maintain the composition of the Earth's atmosphere.

Forests have world-wide importance for several reasons. One of these is that they are important in the maintenance of the balance of gasses in the air. Huge volumes of oxygen are produced during forest photosynthesis while carbon dioxide is consumed. Their other very large area of importance is that they produce huge quantities of wood used in building and for fuel and paper making. Forest products are in huge demand and the net result of this is that, on the whole forests are being used at a greater rate than they are regenerating or being re-forested. Nowhere is this trend clearer than in Bermuda.

At the time of colonisation the land areas of Bermuda were completely forested with dense stands of trees. Only along windswept coasts, did trees give way to lower growths of shrubs and herbs (Chapter 21). As soon as man arrived trees started to be cut down and this trend continues to this day.

> **Summary**
> Forests which covered virtually all of Bermuda before colonisation were the first casualties of development and are now virtually gone.

Forest Structure and Functioning

Structure

Forests are an example of what is called a stratified ecosystem. Basically this means that there are readily recognised layers in the structure. The environment is distinctly different in each layer. The uppermost layer, consisting of the bulk of the leaves and branches of the dominant trees is called the **canopy**. The canopy cuts out most of the light, which is absorbed by the leaves and used as the energy source for photosynthesis. The canopy also greatly affects physical conditions. Wind velocity drops very quickly within and below the canopy and there is much less variation in temperature and humidity than in the air above.

> **Summary**
> Forests are a good example of a **stratified** ecosystem. The top layer is the **canopy**, followed by the **sub-canopy**, the **shrub layer** and the **ground layer**. The soil can be considered as a fifth layer. Most of the sunlight is absorbed in the canopy. If over 90% is absorbed in the upper layers there will be little or no ground layer.

Below the canopy is the **sub-canopy**, it is a much more open area than the canopy and there may be more wind there than in the canopy above. The make up of the two layers below the sub-canopy depends very much on the amount of sunlight absorbed by the canopy. If the canopy

absorbs 90% or more of the light, the area below the sub-canopy will support little in the way of plant life. If more light penetrates, the lower forest layers may be quite densely vegetated.
The third layer down may be called the **shrub layer** or the **understorey**. At any rate this layer is characterised by shrubs up to 5 m or 15 ft in height. They may be sparse or dense depending on light levels. This layer further stabilises climatic variations. Wind velocity is low, humidity high and temperature fairly constant. The lowest layer above the ground is the **herb layer** or **ground layer**. Where it is well-developed it supports fungi, ferns, mosses, clubmosses, various herbs and also juvenile trees and shrubs. It has the most constant physical conditions of all the layers. Wind is very low to negligible, humidity very high and temperature relatively constant. Because of this, it is the forest habitat that supports most small animals such as insects, millipedes, spiders, crustaceans and snails.

Of course, the soil itself can be considered as a further layer. Containing the roots and masses of fungal threads, it is also rich in burrowing insects and worms.

<u>Forest Functioning</u>
On the whole forests are very productive ecosystems and are efficient at recycling essential mineral plant nutrients, for example nitrates, phosphates and potassium compounds. Photosynthesis, mainly in the canopy produces organic compounds which are distributed throughout the tree or used as raw materials for growth of leaves and branches and flowers. Some of this **production** is used by herbivorous insects and other creatures. The trees are the base of food webs both in the air and in the soil. A lesser amount of photosynthesis also occurs in the lower levels of the forest and is used similarly.

Leaves are the main product of the forest and are either dropped continuously as in the evergreen trees such as the Bermuda Cedar (*Juniperus bermudiana*) or seasonally as in the deciduous trees, for example the Fiddlewood (*Citharexylum spinosum*). In Bermudian forests there are deciduous trees that drop their leaves at different seasons. For example Southern Hackberry (*Celtis laevigata*) leaves fall in winter whereas Fiddlewood leaves are shed in spring. Trees like Yellow-wood (*Zanthoxylum flavum*) and Forestiera (*Forestiera segregate)*) never shed all their leaves but do drop most of them in either spring or autumn. The falling leaves accumulate on the ground and rot rapidly, releasing plant nutrients, and forming leaf mould or detritus which is a rich food source for many invertebrates and fungi. This is another way in which trees contribute to the forest food web. All the herbivorous and **detritivorous** creatures are themselves preyed upon by carnivores including spiders, insects, snails, centipedes, birds and reptiles.

Summary
Forests are **productive ecosystems** especially in warmer and wetter climates. Leaves are produced continually and may drop regularly or seasonally. Fallen leaves on the ground are attacked by bacteria and fungi to produce leaf-mould or **detritus**, a food source for a variety of insects and other soil dwellers

Forests all change with time in a process called **succession**. If man had not appeared to alter fundamental forest ecological processes, it is likely that the Bermudian forests would be mostly mature climax forests. **Climax** forests are the end result of succession and are normally stable and highly productive.

It is important to realise that even without the disturbance caused by man, the Bermudian forests would have formed a mosaic of differing forest communities at various stages of succession. This is because natural events such as severe storms, hurricanes, tornados and naturally caused fires would have set forest patches back to various pre-climax stages. Heavy

Summary
Forests continually change in a process called **succession** until a reasonably stable climax forest is reached. Before colonisation most Bermudian forests would have been **climax** forests, now our forests are in various successional changes.

outbreaks of insect pests could also have contributed to this situation. Nevertheless, with the arrival of man forest disturbance became general, both because of the direct effect of harvesting and grazing but also because introduced species began competing very severely with the native and endemic forest flora. Only time will tell what the new forest climax will be, if indeed there are forests that survive long enough for this to take place.

The old Forest and its Remnants

Evolution in the Old Forests

Some of the original trees reaching Bermuda evolved into distinct new species after they started to grow and reproduce here; these are the **endemic** species that occur naturally nowhere else but Bermuda. The two supreme examples of this process are the Bermuda Cedar (*Juniperus bermudiana*) and the Bermuda Palmetto (*Sabal bermudana*). There is little doubt that these two trees dominated the original forest. Both were useful to man and their presence was therefore well documented. When these trees arrived they would have found a very different environment to that of their mainland forebears. One of the main differences would have been that competition from other species would have been at a very low level. On the continent they could live only in areas to which they were uniquely adapted, whereas in Bermuda, without competition, they could move into a wider variety of habitats. This certainly happened in both of these cases. Palmettos which gave rise to the Bermuda Palmetto are characteristic of low damp areas whereas the cedars, from which the Bermuda Cedar evolved, are more typical of higher, drier ground. There is good evidence that in Bermuda, palmettos were common trees in the upland forest as well as dominating some swamp-forests (See Chapter 24), while cedar dominated the upland forests but also formed swamp forests in areas such as Devonshire Marsh. In the original upland forests, Bermuda Cedar became dominant and Bermuda Palmetto sub-dominant. **Figure 25.1** is an artistic impression of how the old forest probably looked.

Summary

Evolution in the old forests led to the two original forest dominants, the Bermuda Cedar and the Bermuda Palmetto. Cedar dominated most upland areas while palmettos were commonest in lowland sites. However, both were adaptable and both formed lowland **swamps**.

Another tree, the Bermuda Olivewood (*Cassine laneana*) also evolved in the Bermudian forests. This beautiful, very compact tree up to 10 m or 30 ft high was probably never common in any forest but was scattered among the cedars, palmettos and native trees; its bark was used for tanning by early settlers.

As the forest became established, a unique new habitat was created under the trees and there other new species evolved in this damp, stable environment. Examples of these are the Bermuda Sedge (*Carex bermudiana*), the moss Bermuda Trichostoma (*Trichostomum bermudanum*), the Bermuda Maidenhair Fern (*Adiantum bellum*) and the shrub, Bermuda Snowberry (*Chiococca bermudiana*).

Summary

The Olivewood is another **endemic** forest tree but it never dominated large areas. Under the trees other plants **evolved** including Bermuda Sedge, the Trichostoma moss, Bermuda Maidenhair Fern and the Snowberry.

Important Native Trees of the Original Forest

Native species are those that arrived in Bermuda by natural means but remain essentially identical with their forebears elsewhere. Thus they arrived by the same means as the endemics but did not evolve into new species. The reasons for this may never be clear; perhaps they arrived later than those which formed the endemics but had characteristics which adapted them to the structure of the already created upland forest. Alternatively, they may

Summary

The old forest supported other, now rare **native** species including the Yellow-wood, Lamarck's Trema Southern Hackberry, Forestiera, Jamaica Dogwood and White Stopper.

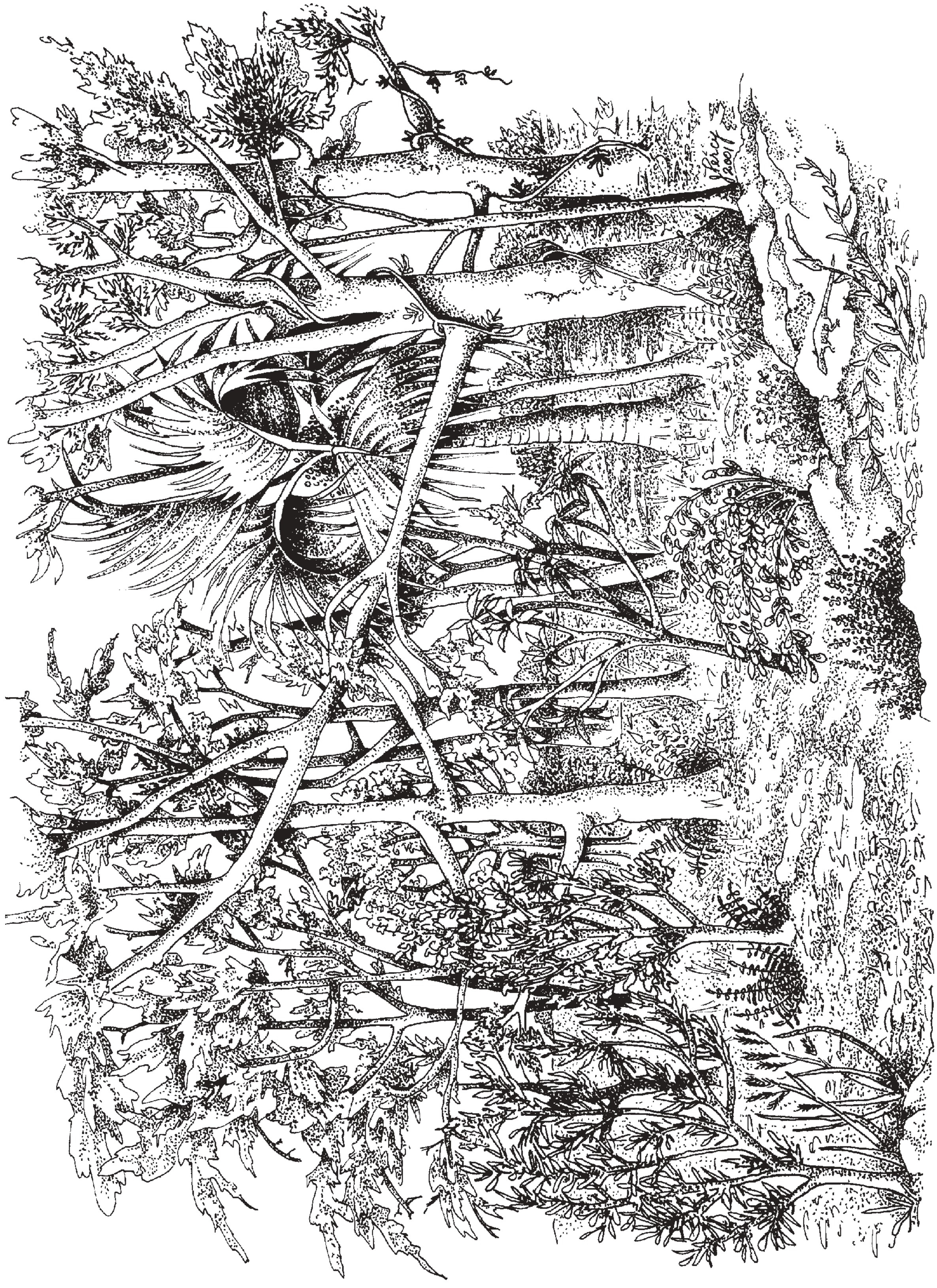

Figure 25.1. An artist's impression of the probable character of an early Bermudian cedar forest.

have arrived very early but were not well adapted to Bermudian conditions and only flourished after the endemics evolved to create a forest structure. Several of these formerly quite common trees are now very rare and endangered. Perhaps the best known of these is the Yellow-wood now existing as only a few specimens in the Walsingham limestone formation. Yellow-wood was common at the time of settlement, but its wood was valued for furniture making; it was heavily exploited and it seems not to reproduce well in the altered forest of today. The Southern Hackberry was also probably widely distributed in the valleys and on sheltered hillsides. This tree up to 15 m (45 ft) high is native of the southeast United States. Like the Yellow-wood it was probably scattered or occurred in small clumps among the cedars and palmettos. Another interesting native tree is Lamarck's Trema (*Trema lamarckiana*), a small shrubby tree of untidy growth form. Now quite rare, this tree was probably much more common before the arrival of man.

Several other native species important in the original forest, never form large trees and are usually classified as shrubs. These are Forestiera, White Stopper (*Eugenia axillaris*) and Jamaica Dogwood (*Dodonaea viscosa*). These shrubs growing up to 7 m (20 ft) in height probably formed what is called the understorey, growing beneath the canopy of the larger trees.

The real character of the forests before the arrival of man can only be the subject of conjecture. Were they like a dense jungle in character, or were they of more open character that one could easily walk through? There is some evidence for both possibilities and it seems likely that there were stands of both dense and more open forest. Some of the earliest settlers commented on the impenetrable forest, but they were very likely referring to more coastal areas. The fact that some native and endemic plants that require quite high light levels now do well only in cleared areas of upland forests, strongly suggests that in the past, areas of more open forest were common. The very dense character of the upland forests today is largely the result of species introduced by man.

Summary

It is likely that inland forests were fairly open in character, at least in places, while those along the coasts were much denser.

Forests since Colonisation

<u>Changes that Resulted from Introduced Species and Diseases</u>

Not only do introduced species out-compete the native and endemic ones, but also diseases and pests arrive on introduced species and spread to those already present. Pests of introduced species may be much more harmful on related endemic plants than to their original host. The reason for this is that the host tree and pest evolved together, away from Bermuda, and the host developed, at least partial, natural resistance. The related endemic species had evolved in isolation from the pest and would not have developed natural resistance. The pest population, therefore, could explode on the endemic relative.

The best examples of this are the Oystershell Scale *(Insulaspis pallida*) and the Cedar Scale (*Carulaspis minima*), both of which attacked the Bermuda Cedar. The scale insects are tiny creatures that are protected by a shell-like covering. They feed on plant sap and spread virus diseases. The Oystershell scale was introduced in 1940 and the Cedar Scale probably in 1942, both on ornamental junipers closely related to Bermuda Cedar. The Oystershell Scale attacked Bermuda Cedars right away but did not rival the devastation of the Cedar Scale. By 1949 over 15,000 dead cedar trees had been cut down; by 1953 90% of the population was dead. A total of over 3 million trees had been lost because of the Cedar Scale! Fortunately, some of the surviving Bermuda Cedars had some resistance to the scale and others have been bred from these. Today, the Bermuda Cedar is being reintroduced on a wide scale and in places is quite

Summary

The old forests were reduced by clearance and by harvesting wood for building and fuel. However, introduced species including several pests of cedars and palmettos also played a huge role in forest degradation. Well over 90% of the remaining cedars were killed by the Oystershell Scale and Cedar Scale.

common. Another scale insect, the Palmetto Scale (*Comstockiella sabalis*), introduced on ornamental palms, attacked the endemic Bermuda Palmetto but its effects have, fortunately, not been as severe as with the Cedar Scale.

The New Lowland Forest

Although a few remnants of upland forest maintain a little of the character and species composition of the original forest, this is hardly true of lower valley areas. These were virtually all totally cleared by man and the few that persisted in areas that were harder to develop were changed for all time by the Cedar Blight carried by the Scale Insects. One side effect of the death of almost all the cedars was that the effect of tropical storms became much more pronounced in low valleys and along shorelines. Bermuda Cedars are excellent windbreak trees and few are uprooted even in hurricanes. When they were gone, the need for an alternative windbreak tree was obvious. The tree that was introduced for this purpose was the Casuarina, Australian Whistling Pine or Whispering Pine, (*Casuarina equisetifolia*). This tree native to Australia was planted in large numbers in the 1950s and 1960s. As far as introductions go, this one was moderately successful and the young trees, if planted densely, formed good windbreaks. However, this tree grows up to 22 m (65 ft) high and at this size has little foliage at the lower levels. Additionally in very severe storms Casuarinas tend to uproot or break off some distance above the ground. Additionally, they don't seem to penetrate upland forests to any extent but they are now naturalised in lower well-drained areas. Where they are growing densely they tend to form a characteristic forest with a closed canopy and open understorey with very little vegetation growing on the ground beneath them. Some nice stands have developed in Ferry Point Park and in Spittal Pond Nature Reserve. The tree is also being used as a temporary windbreak in locations such as Nonsuch Island where the Bermuda Cedars are slowly becoming re-established.

Summary

Present day Bermuda forests are **dominated** by **introduced species**. The Casuarina introduced as a wind-break is very common as is the Fiddlewood which now dominates many woodlands. Indian Laurel is now on the increase together with Brazil Pepper and the Chinese Fan Palm. Surinam Cherry now dominates woodland in several areas.

Many other introduced trees are now quite common and increasing. An example is the Indian Laurel tree (*Ficus retusa*), a large tree in the Fig Tree group. This tree has been present for many years but did not start to really spread until the Ficus Wasp (*Parapristina verticillata*), which pollinates the tree, was introduced in the 1900s. Another tree that is on the increase is the Chinese Fan Palm (*Livistonia chinensis*) which seems able to out compete and out reproduce the endemic Bermuda Palmetto. Literally hundreds of other introduced trees are potential members of the new forest in Bermuda.

The Role of Introduced Species in the Upland Forest

Most of the upland forests in Bermuda today are strongly dominated by introduced trees. The main two species in this group are the Fiddlewood(*Citharexylum spinosum*) and the Allspice (*Pimenta dioica*) although the Brazil or Mexican Pepper, (*Schinus terebinthifolia*) has also become very common in recent years. An introduced shrub, the Surinam Cherry (*Eugenia uniflora*) now dominates many areas that were originally treed forest. All these species, although introduced, have become **naturalized**. This means that they reproduce naturally in the wild and are now widespread.

Fiddlewood, is quite a large broad leaf tree attaining at least 17 m or 50 ft in height, that was introduced in about 1830 in the Paynter's Vale area. The wood is light-weight and brittle and not used for fiddle making although it makes good firewood. It now dominates large areas of forest. It is unusual in that the leaves turn orange and fall in spring. The habitat in these forests does not favour the growth of native and endemic forest plants. Allspice is not nearly as large as Fiddlewood, rarely exceeding 13 m or 40 ft but nevertheless forms dense monoculture stands in many areas.

The Brazil or Mexican Pepper , a medium sized tree up to 10 m (30 ft) high, has become a problem more recently than the preceding two. However it is now widely established in a great variety of upland and lowland treed habitats. It too now forms dense monoculture stands but is also widespread among other trees. No doubt it will increase in abundance in the future; it is exceedingly difficult to remove. Surinam Cherry has delicious fruits, which is the reason for its introduction. It is small and shrubby, rarely over 8 m or 24 ft tall, but tends to grow in very dense stands which exclude other species.

Animals and Plants of the Forests

Introduction

Summary
A wide variety of plants and animals can be observed in the forests. There is evidence that the Cahow or Bermuda Petrel once nested in the forests. It is now confined to small islands.

The plants and animals of the Bermuda forests, commonly termed the 'forest biota', are made up of a wide variety of ecological groups. Some are typical forest species that live nowhere else. Others are from a broader ecological group of organisms which are found in a variety of habitats but can tolerate forest conditions. This latter group can be expected to frequent forest edges more often than the deep interiors of woodland. Quite a few of the animals, especially birds, are not by any means permanent forest dwellers but move in and out seasonally, in migration or when certain food sources become available. Others use forest habitat as a protected nesting site, but feed elsewhere. An interesting example of this is the Cahow *(Pterodroma cahow*) or Bermuda Petrel, which nested in burrows in the forest floor at the time of colonisation. Relentless exploitation by man drove it to its present nesting sites on offshore islands. The forest is a very highly structured system that has habitats within it that are extremely stable. One example is the forest floor where humidity is high, temperature very stable and light levels low. This unique environment supports many delicate animals and plants unable to live in harsher conditions. Additionally, there is a rich micro-flora and fauna within the forest leaf litter and soil. These specialised organisms are beyond the scope of this guide, but be aware that they are there.

Principal Herbs, Shrubs, Grasses and Vines of the Bermuda Forests

Summary
Original forest **ground layer** plants included Woodgrass, Bermuda Sedge, Wild Bermuda Pepper, Turkey Berry, Small Passion Flower and Wild Coffee; all are now rare. Virginia Creeper and West Indian Cissus vines climbed the tree trunks and other shrubs and vines occupied various areas.

The shaded environment within the forests excluded many species, but still there was a characteristic associated flora. This would have included Woodgrass (*Oplismenus setarius*), a native, now very rare grass; Bermuda Sedge (*Carex bermudiana*), a very rare endemic; Wild Bermuda Pepper (*Peperomia septentrionalis*), an endemic now very localised; Ink-berry or Small Passion Flower (*Passiflora suberosa*), an uncommon native; Wild Coffee (*Psychotria ligustrifolia*), a seldom seen native shrub; Turkey Berry (*Callicarpa americana*), a native herb that was extirpated but now re-introduced in several nature reserves; Virginia Creeper (*Parthenocissus quinquefolia*), a common native vine that would have climbed tree trunks; Bermuda Snowberry (*Chiococca bermudiana*), an endemic vine-like shrub was widespread in uplands. Balloon Vine (*Cardiospermum halicacabum*), a native vine of shrubby places; Burr Bush (*Triumfetta semitriloba*), a smallish native shrub of forest openings and Bear's Foot (*Polymnia uvedalia*), a small native shrub of the forest edge would also have been present. Bird Pepper (*Capsicum baccatum*), a tall native herb of the forest fringe; Black Nightshade (*Solanum americanum*), a native small shrub of forest openings with poisonous berries, and Virgate Mimosa (*Desmanthus virgatus*), an uncommon native shrub were other inhabitants.

Three other plants of doubtful status should be mentioned. Poison Ivy (*Rhus radicans*) is now very common in forest and marsh habitats. It has been considered a native but there is some evidence that it may have been introduced. If a native it was probably widespread in the forests. Common Sage or Lantana (*Lantana* sp.) presents the opposite case; it was thought to be introduced but one of the species may have been native. Again it would very likely have been common in the understorey of the forest. Bay Grape *(Coccoloba uvifera)*, once thought to be native, may have been introduced; certainly it only became common after the arrival of man.

Animals associated with the Bermudian Forests

Both vertebrate and invertebrate animals are quite common in Bermudian forests. Resident birds that might be expected are the endemic Bermuda White-eyed Vireo or Chick-of-the-village (*Vireo griseus*), the Cardinal (*Cardinalis cardinalis*), the Catbird (*Dumatella carolinensis*), the Great Kiskadee (*Pitangus sulphuratus*), the Starling (*Sturnus vulgaris*), the Barn Owl *(Tyto alba)*, the European Goldfinch (*Carduelis carduelis*)) and the Yellow Crowned Night Heron (*Nyctanassa violacea*). Many migrating warblers would be present in autumn and less commonly at other times. The commonest warblers seen in forested areas are the Ovenbird (*Seiurus aurocapillus*), American Redstart, (*Setophaga ruticilla*)Palm (*Dendroica palmarum*), Yellow-rumped (Myrtle) Warbler (*Dendoica coronata*), the Common Yellowthroat (*Goethlypis trichas*), and the Black-and-white Warbler (*Mniotilta varia*). Other migratory birds that you are likely to see in autumn and winter are; The White-throated Sparrow (*Zonotrichia albicollis*), the Hermit Thrush (*Catharus guttatus*) and the only common woodpecker, the Yellow-bellied Sapsucker (*Sphyrapicus varius*). Swainson's Thrush (*Catharus ustulatus*), the Wood Thrush (*Hylocichla mustelina*) and the American Robin (*Turdus migratorius*) are also seen from time to time. The introduced Brown Rat or Norway and Black Rats (*Rattus norvegicus)* and *Rattus rattus*) would be evident at night or in poor light. Among the lizards, the Jamaican Anole (*Anolis grahami*) is a common resident of wooded areas. Both the Giant Toad (*Bufo marinus*) and the Whistling Frog (*Eleutherodactylus johnstoni*) are common in damper locations.

Summary

The main animal inhabitants of the forest are undoubtedly the birds. A wide variety of warblers, sparrows, thrushes, vireos and herons were found in old forests and many are still to be seen there. Bermuda Skinks were probably common but now are confined to a few coastal areas. The only mammals are **introduced** rats, cats and dogs.

Invertebrates of many groups are often abundant in the sheltered, humid environment offered by the forest. These include spiders, centipedes, millipedes, pill-bugs, snails, slugs and a whole host of insects. Common examples are shown in the illustrations that are contained in this guide.

Forest Conservation Issues

It has already been mentioned that no really natural original forest remains in Bermuda. The old remnants that do remain are continually invaded by introduced species and their character is changing rapidly. The only bright spot is that some restored areas, where invasive species are systematically removed, are regaining the characteristics of the original forest. Examples of this are the lowland Bermuda Palmetto forest in Paget Marsh, the upland Palmetto Forest in Butterfield Park, the forest on Nonsuch Island and some small areas in the Walsingham Park complex. Elsewhere the pressure on the remaining forests is relentless. A good example is the one remaining population of Yellow-wood trees. There are only about a dozen specimens of this tree left in Bermuda, all in the general Walsingham area. They no longer breed naturally and their environment is invaded by many introduced plants, which change the ecological conditions. Land

Summary

The old forests are gone and will never return. However, the feeling of the old forests can still be captured in a few remnants such as Butterfield Park and in several restored areas such as Nonsuch Island. Several forest species are critically endangered and great efforts are needed to save and restore them. However pressure will remain to remove forest areas for building. A balance between the needs of progress and the conservation of what remains must be struck.

development creeps ever closer to this little enclave of trees and although efforts are being made to preserve them, their future is seriously in doubt.

The basic problem is that Bermuda is a very small island with a very large population. New sites for buildings, golf courses etc. are in high demand and the best remaining sites are mostly forested. Although planning processes attempt to preserve areas of forest, the remaining forests continue to be removed. Now the situation is such that not only are the original forests all but gone but the areas of new forest dominated by introduced trees are also in jeopardy. We are heading for the time when the only remaining forest will be in parks, nature reserves and other protected areas.

Questions

1) Why are there so few remnants of natural forest left in Bermuda? Give three reasons.
   a) ______________________________
   b) ______________________________
   c) ______________________________
2) Name the two main trees that composed the bulk of the old forest of Bermuda.
   a) ______________________________
   b) ______________________________
3) The two trees named above (if correct) are both endemic. What does this term mean?
   ____
   ____
4) The two trees referred to above seemed to be able to colonise a much wider range of habitats than their ancestors did in mainland North America. Give two reasons why this could happen.
   a) ______________________________
   b) ______________________________
5) Is the Yellow-wood Native or Endemic in Bermuda? Native ❒ Endemic ❒.
6) What are two factors that contributed to the decline of Bermuda Cedars?
   a) ______________________________
   b) ______________________________
7) What are the names of four introduced trees that can be found in modern woodlands in Bermuda?
   a) ____________________ b) ____________________
   c) ____________________ d) ____________________
8) What are the names of one lizard, one amphibian and two birds that may be seen in the forest?
   Lizard ____________________ Amphibian ____________________
   Bird 1 ____________________ Bird 2 ____________________
9) Cahows or Bermuda Petrels currently nest on offshore islands. Where else may they have nested before colonisation?
   ____
   ____
10) Name two trees that may be found in both upland and lowland forests. For each show whether they are endemic, native or introduced.
   a) ______________________________ Endemic ❒ Native ❒ Introduced ❒.
   b) ______________________________ Endemic ❒ Native ❒ Introduced ❒.
11) Give a short account of how the structure of a forest affects the climate within it.
   ____
   ____
   ____
   ____
12) If 90% of the light is absorbed above the ground layer, what will the ground surface look like?
   ____
   ____
   ____
   ____

13) What are the names of two endemic plants other than trees or shrubs that are found in Bermuda forests?

a) ____

b) ____

14) When does the Fiddlewood shed its leaves? ________________________________

15) In your opinion, what can be done to protect the remaining forest areas of Bermuda?

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Field Trip # 25.1 to a Forest Remnant

Introduction

There is virtually no original forest left in Bermuda and restored forests are either inaccessible or unsuitable for study because of hazards such as poison ivy. It is therefore difficult to find a field trip site and the one suggested here is probably not representative of the bulk of old upland forests. Nevertheless, Butterfield Park in Point Shares is an absolute treasure, being an old upland Bermuda Palmetto forest which somehow has escaped development over the years and is now a small park. One must appreciate that sites like this are still vulnerable to damage and that it is imperative to be very careful of the environment on a visit. Do not leave the path at all. In the ground layer there is at least one very rare endemic plant, the Bermuda Sedge which is vulnerable to trampling. This field trip is designed so that it can be carried out from the path. This field trip should be carried out with only a small group of students and must be well supervised.

Preparation

Read this section of this field guide and anything else about Bermuda Forests and their trees, especially the Bermuda Palmetto.

Dress

No special clothing is needed.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group.

Suggested Route

The park can be found by taking Fairyland Road then Point Shares Road.

Observations

1) Proceed into the forest up the path from the road until you are away from the band of introduced trees around the edge. The forest is fairly open. Look through the trees and decide which tree is dominant and which is sub-dominant. The dominant tree is the most important one and contributes the most **biomass** or living weight. The sub-dominant has the second-most biomass etc. Try to identify five tree species, rank them by biomass and state whether they are endemic, native or introduced (Status).

Rank	Species	Status
1. Dominant		
2. Sub-dominant		
3.		
4.		
5.		

2) Next look at the forest structure, particularly its **stratification** or layering. Remember there are four layers in a well developed forest, the canopy at the top, the sub-canopy, the shrub-layer and the ground layer. Determine which species is commonest in each layer.

Stratum	Commonest Species
Canopy	
Sub-canopy	
Shrub Layer	
Ground Layer	

3) The third observation involves a judgement of how the forest structure affects the forest climate. Remember what the wind was like before you entered the forest or look at the canopy top for the fronds waving in the wind. Starting at the very top, move your gaze slowly down until you reach the ground. Then fill in the table below calling the windiest place high. Then rank the others as moderate, low and very low.

Stratum	Wind Ranking
Canopy	
Sub-canopy	
Shrub Layer	
Ground Layer	

4) How much light do you think penetrates to the forest floor? This is difficult to judge because your eyes accommodate to low light intensities. However, nature does the job for you. If the ground layer is dense enough to cover the ground, then probably over 50% of the outside (incident) light reaches the forest floor. If the forest floor is bare of plants then less than 10% of the incident light reaches that level. With this in mind put X in the correct blanks below. This will vary from place to place so do it as accurately as you can for one particular spot.

Percent of ground covered by foliage. 100%___ 50%___ 25%___ 10%___ 5%___ 1%___
Percent of incident light at the ground. 50%___ 25%___ 10%___ 5%___ 1%___

5) To assess the Biodiversity of the forest, count the number of different species in each layer of the forest and then total them. Remember there will be things hidden and others too small to see, so your estimate will be an under-estimate.

Stratum	Number of Different Species
Canopy	
Sub-canopy	
Shrub Layer	
Ground Layer	
Total	

6) The greatest hazards to forest remnants are habitat destruction by building, natural disasters etc. and invasion by introduced species. A park is protected from building, so in this case, invasive, introduced species present the main risk. Walk along the path from top to bottom looking for invasive species. These will be most common at the edges but present throughout. List all the invasive species that you can find and state, for each, whether they are a tree, shrub, grass or sedge, fern, moss or flowering plant. Add information on where each species was found. For example along the edges only, scattered throughout the forest, in clumps among the trees etc.

Plant Species	Type of Plant	Notes on distribution

7) Bermuda Palmettos were used in many ways by early settlers. One thing that they did was to tap the sap to make a drink called Bibby. To do this they cut the bark in a V, near to the top of the trunk so that the sap would drain down to a point. Although this has not been done for a long time, the resulting 'Bibby Marks' can still be seen on trees in Butterfield Park. From the path only, look for these marks. They will now be partway down the trunks due to growth at the top. If you find one, make a drawing of it.

8) The Bermuda Palmetto trees in this park are of a variety of ages. The oldest ones have gnarled and bent trunks at the bottom, possibly resulting from storm damage or other incidents. Find

a really old tree and sketch the entire tree. Comment on its possible age and what might have deformed it.

Comments ____

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9) Write a paragraph on the status of forests in Bermuda and give your ideas on how we might preserve what is left.

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Field Trip # 25.2 to a Typical Modern Forest

Introduction

This field trip is designed so that in can be carried out in any piece of woodland. Results will be best if the woodland is fairly mature, with good-sized trees. Do not work at the edge but proceed into the forest so that your surroundings are typical of the forest interior. Do not choose a place where poison ivy is present

Preparation

Read this section of this field guide and anything else you can find about Bermudian forests past and present.

Dress

No special clothing is needed, but long pants are advised to prevent scratching by twigs etc.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group. Several metre or yard sticks. A 10 m or 30 ft tape. A stiff wire probe at least 30 cm (1 ft) long. (A coat hanger can be cut and straightened to make this)

Observations.

1) Decide whether you are in an upland or lowland forest giving reasons for your decision.
   Upland ❒ Lowland ❒ Can't Tell ❒.
   Reasons ____
   ____
2) Look through the trees and decide which tree is dominant and which is sub-dominant. The dominant tree is the most important one and contributes the most **biomass** or living weight. The sub-dominant has the second-most biomass etc. Try to identify five tree species, rank them by biomass and state whether they are endemic, native or introduced (Status).

Rank	Species	Status
1. Dominant		
2. Sub-dominant		
3.		
4.		
5.		

3) Next look at the forest structure, particularly its **stratification** or layering. Remember there are four layers in a well developed forest, the canopy at the top, the sub-canopy, the shrub-layer and the ground layer. Determine which species is commonest in each layer

Stratum	Main Species
Canopy	
Sub-canopy	
Shrub Layer	
Ground Layer	

4) The next observation involves a judgement of how the forest structure affects the forest climate. Remember what the wind was like before you entered the forest or look at the canopy top for the fronds waving in the wind. Starting at the very top, move your gaze slowly down until you reach the ground. Then fill in the table below calling the windiest place high. Then rank the others as moderate, low and very low.

Stratum	Main Species
Canopy	
Sub-canopy	
Shrub Layer	
Ground Layer	

5) How much light do you think penetrates to the forest floor? This is difficult to judge because your eyes accommodate to low light intensities. However, nature does the job for you. If the ground layer is dense enough to cover the ground, then probably over 50% of the outside (incident) light reaches the forest floor. If the forest floor is bare of plants then less than 10% of the incident light reaches that level. With this in mind put X in the correct blanks below. This will vary from place to place so do it as accurately as you can for one particular spot.

Percent of ground covered by foliage. 100%___ 50%___ 25%___ 10%___ 5%___ 1%___
Percent of incident light at the ground. 50%___ 25%___ 10%___ 5%___ 1%___

6) To assess the Biodiversity of the forest, count the number of different species in each layer of the forest and then total them. Remember there will be things hidden and others too small to see, so your estimate will be an under-estimate.

Stratum	Number of Different Species
Canopy	
Sub-canopy	
Shrub Layer	
Ground Layer	
Total	

7) Look at the ground surface. Is it covered with plants or leaves? If by leaves what was the source tree? Would this vary at different seasons and if so why? ____________________________

____

8) Scrape away some leaves or look among the plants at the soil. Is it light or dark coloured? A dark colour would show the presence of humus or partly rotted plant remains. Use a wire probe to see if the soil is shallow or deep.

Light colour r, Dark Colour ❐ Intermediate Colour ❐

Depth of probe penetration in cm ____________________ Deeper than probe ❐.

9) Look for larger animals such as lizards, toads, rats, mice, or birds. List those you can see and state whether they are endemic, native or introduced (status) and where they were seen.

Species	Type of Animal	Status	Location

10) Look carefully for insects and snails. Some may be tiny and difficult to identify, in which case just call them insect 1, snail 1, etc. Try to see what they are eating. If they are resting give the habitat.

Species	Food	Habitat

11) Look for evidence of pollution or disturbance and for signs of new invasive species moving in. Comment on what you see and its probable effects on the forest. ______________________________

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Chapter 26. Parks and Nature Reserves in Bermuda

Introduction

In a very small country such as Bermuda, parks and nature reserves are critically important for the protection and preservation of both habitats and species. About 7% of the land area of Bermuda is composed of parks, nature reserves and other protected areas. However, a considerable amount of the area within National Parks is heavily used for recreation and cannot be considered as useful habitat for wild plants or wildlife, offsetting this are some areas of privately owned land that are relatively undisturbed. Looking at the total picture about 420 hectares (1,000 acres) are protected of the 55 square kilometres or 21 square miles land area of Bermuda. Nature reserves give the greatest protection to the environment and its wild animals and plants; there are 34 such areas in Bermuda making up 140 hectares (346 acres) or about 2% of the land area. However, the majority of this area (90 hectares (222 acres) is contained in the six larger reserves. In addition to the cases mentioned above, there are about 42 hectares or 100 acres of Government-owned land that is not officially designated as parkland but used as such. Two such areas are Lagoon Park in Ireland Island South, and Clearwater Beach in St. George's Parish. The latter is currently under study and parts of it will become Nature Reserves. Also important are the parts of the old railway right of way that have become the Railway Trail. There are considerable lengths of Railway Trail throughout Bermuda and these form important green corridors that link other protected areas. Considering the continual demand for building land, the opportunity for adding much more area in the form of parks and nature reserves is very limited. Indeed, there will certainly be pressure to allow building in some areas that are now protected.

Summary

Parks, nature reserves and sanctuaries are critically important in the maintenance of terrestrial species and **habitats** in Bermuda. About 420 hectares of land are protected in this way. Nature Reserves giving the highest level of protection enclose about 140 hectares or 2% of the land area.

Bermuda's marine ecosystem has a much higher proportion of protected area, but enforcement of this protection is very difficult, if not impossible. For example, all marine areas below high tide level are potentially protected as this is considered as Crown land. Two Coral Reef Preserves have some protection. One in the central part of North Lagoon comprises 3,950 hectares (9,750 acres) and the second one along the eastern part of the south shore contains 140 hectares (350 acres). Only the second of these has any shoreline areas. However, the level of protection of organisms in the Coral Reef Preserves is incomplete, as only animals and plants attached to the seabed are protected. In addition to these areas, there is a marine park in Castle Harbour adjacent to the Blue Hole Park where 24.9 hectares (61.7 acres) of shallow marine habitat, mostly seagrass beds, and the shoreline are protected. Shorelines within National Parks are also afforded some protection. Thus, there is about ten times as much marine habitat protected as land area. In addition there are about 4,490 hectares (11,100 acres) of marine areas off the east and west ends of the island that are seasonally protected as the spawning grounds of groupers, the most prized group of fishes for eating.

Summary

A much higher proportion of areas is protected in the sea than on the land. About 4,100 hectares are protected in two Coral Reef Preserves and there is one small Marine Park in Castle Harbour. Grouper spawning grounds have seasonal protection.

Another type of protection of Bermuda's natural history, is the ban on exploitation of certain groups and species of animals and plants. This includes almost all birds, all marine turtles, all marine mammals and some species of fish and shellfish. Particularly notable individual trees, or groups of trees are protected by tree protection orders. Animals and plants designated as endangered species are protected, as are important areas of habitat for these species. Critically endangered species will have rehabilitation plans put in place as the need arises.

> **Summary**
> Several groups of animals are protected from exploitation including most birds, all marine mammals, several fish and shellfish and important individual or groups of trees.

Types of Park and their Natural History Function

Parks and nature reserves fall into three main categories of ownership. The main one of these is the Bermuda Government and the other two are the Bermuda National Trust and the Bermuda Audubon Society. There are also a few small municipally owned parks such as Somer's Gardens in Saint George and Par-la-Ville Gardens, Victoria Park and Fort Hamilton, in Hamilton.

Government owned protected areas can be further subdivided into Terrestrial National Parks, The Botanical Gardens, National Nature Reserves, The Railway Trail, Lagoon Park, Clearwater Beach, One Marine Park, the Coral Reef Preserves and Seasonally Protected Spawning Areas.

> **Summary**
> Most parks and reserves are government property but the Bermuda National Trust and the Bermuda Audubon Society own 33 very important nature reserves and sanctuaries. Several smaller parks are in municipal hands. A few privately owned areas contain important habitats.

The Bermuda National Trust has 20 properties that preserve natural history throughout Bermuda as well as a number of historic properties. Some of the National Trust properties are designated as sanctuaries and are closed to the public. The Bermuda Audubon Society has 13 nature reserves. In many cases National Trust and Audubon properties are adjoining thus creating larger protected areas. Examples occur in both Devonshire and Paget Marshes (Chapter24).

All the terrestrial parks and reserves provide areas mostly free of housing and development and many contain critically rare habitats and species. Without these parks the state of terrestrial natural history would be infinitely worse than it is. The Marine Park, Preserves and Seasonally Closed areas help in marine conservation, but the marine ecosystems are not nearly as vulnerable to degradation and damage as those on land.

Nature Reserves and Sanctuaries

Nature reserves and sanctuaries on land are the most important areas from the point of view of the preservation and conservation of habitats and species on land. Several of the most important ones will be discussed individually below.

The terrestrial National Nature Reserves are 12 in number and comprise about 45 hectares (115 acres.) One of the most important reserves is the Castle Harbour Islands Nature Reserve. It includes the incomparable restored area of Nonsuch Island, which will be discussed below, islands used as nesting sites for the endemic Cahow or Bermuda Petrel (*Pterodroma cahow*) and other islands supporting the largest remaining populations of the endemic Bermuda Skink (*Eumeces longirostris*) (Chapter 12). Other important Nature Reserves at Spittal Pond and Walsingham are covered in detail below. The reserves at Hungry Bay, Lover's Lake, Shelly Bay and Evans Pond support both important mangrove swamps (Chapter 22) and marine ponds (Chapter 23). Pembroke Marsh Nature Reserve contains a

> **Summary**
> There are 12 National Nature Reserves. A very important one is the Castle Harbour Islands Nature Reserve which among other things protects the breeding sites of the **endemic** and endangered Bermuda Petrel or Cahow. Spittal Pond Nature Reserve contains the best site for migrating waterfowl in Bermuda as well as several other important habitats.

Narrow-leaved Cattail (*Typha angustifolia*) marsh. Two small island reserves, Daniel's Island off the western end of Bermuda and Godet's Island in Great Sound provide examples of small island habitats.

Reserves administered by the Bermuda National Trust and the Bermuda Audubon Society, also protect many unique and important habitats. That of the restored Paget Marsh, jointly administered by both groups, will be covered below. Another area with adjoining properties is in Devonshire Marsh the only large freshwater marsh left in Bermuda (Chapter 22). Other sites owned by one or the other organisations include the Somerset Long Bay nature reserve with its interesting, reconstructed brackish water Pond which is a good waterfowl location, Seymour's pond (Chapter 24) and Warwick Pond which is the largest freshwater pond in Bermuda.

Summary
Reserves administered by the National Trust and Audubon Society are particularly important in the protection of freshwater **wetlands**.

Marine Conservation Areas

The main marine conservation areas are the Coral Reef Preserves which although they cover large areas do not provide a high-enough level of protection. Only animals and plants attached to the sea bed are protected, which leaves a huge variety of fish, lobsters and other marine invertebrates without protection. The South Shore Coral Reef Preserve does contain some valuable and vulnerable coastline, but it must be admitted that there is no real enforcement of this protection. It is the case that for both of the Coral Reef Preserves, better and more unspoiled examples of reefs and shorelines exist outside their boundaries. The Walsingham Marine Park does, theoretically, protect everything within it, but it is a small, shallow-water location that contains only seagrass beds and sandy bottom communities. A really bio-diverse marine park is badly needed so that both diverse habitats and vulnerable species are protected. The seasonal areas for the protection of grouper spawning grounds are performing an important function but were really created too late to save the grouper stocks. Many grouper species remain rare and others are showing only slow improvement.

Summary
The two Coral Reef Preserves cover large areas in North Lagoon and along the south shore, but afford protection only to organisms attached to the sea bed. The Walsingham Marine Park in Castle Harbour offers complete protection but is not a very diverse or important habitat.

The Walsingham Complex of Parks and Reserves

The Walsingham area lying between Castle Harbour and Harrington Sound, known as the "Walsingham Tract", is undoubtedly one of the most important areas for natural history and geology in Bermuda. It is situated on the oldest limestone formation in Bermuda, the Walsingham Formation (Chapter 7). This limestone formation has a very rugged topography with a very uneven surface. This feature has limited past building operations in this area. The area is also riddled with caves, many containing rare and fragile animals and plants. There are also a number of marine ponds all harbouring rare and interesting marine flora and fauna. Luckily, quite large areas of the Walsingham Tract had been set aside as parks and reserves before modern building practice was able to handle the rough terrain.

The main problem in the terrestrial areas of the Walsingham Park-Reserve complex is undoubtedly invasive plants. Large areas of Surinam Cherries (*Eugenia uniflora*) have invaded and colonised the forest along with other species such as Brazil or Mexican Pepper Pepper, (*Schinus*

Summary
The Walsingham Tract area of Bermuda is home to a large number of **endemic** and endangered animals and plants. Much of it is protected by a complex of parks and reserves that contain the majority of important cave-mouth habits in Bermuda. **Introduced** and **invasive** species are a big problem.

terebinthifolia), Allspice (*Pimenta dioica*), Chinese Fan Palm (*Livistonia chinensis*) and Fiddlewood (*Citharexylum spinosum*). In limited areas these invasive species are being culled to restore the forest to a more original condition. Despite the invasives a few specimens of rare trees such as Lamarck's Trema (*Trema lamarckiana*) and Yellow-wood (*Zanthoxylum flavum*) remain, as do patches of the endemic Bermuda Olivewood (*Cassine laneana*), the native Southern Hackberry (*Celtis laevigata*) and the rare native shrub Forestiera (*Forestiera segregata*). There are also a large number of introduced flowering plants especially the so-called Fern Asparagus species (*Asparagus densiflorus)* and Lace or Bridal Fern (*Asparagus setaceus)*). Nevertheless, several rare endemic plants including the Wild Bermuda Pepper (*Peperomia septentrionalis*) and the Bermuda Bean (*Phaseolus lignosus*) do persist in fair numbers..

Terrestrial cave mouths in the Walsingham Tract are also the habitat of several rare and endemic ferns including the Bermuda Cave Fern (*Ctenitis sloanei*) and the Bermuda Shield Fern (*Dryopteris bermudiana*), and previously supported the now almost extinct Governor Laffan's Fern (*Diplazium laffanianum*) now surviving only in captivity.

The marine ponds also harbour several endemic marine species of algae, the endemic Bermuda Killifish (*Fundulus bermudae*) and many rare and unusual animals (Chapter 23)

Paget Marsh

Paget Marsh lies in a big sink hole in the central part of present-day Bermuda. Disturbance at this site was much less severe than in other peat marshes. About 1965, the Bermuda National Trust and the Bermuda Audubon Society obtained most of the marsh together to protect it for all time. This location was principally a Bermuda Palmetto (*Sabal bermudana*) swamp-forest, but also contained stands of Saw Grass (*Cladium jamaicense*), and impressive communities dominated by the Giant Fern (*Acrostichum danaeifolium*). The site was also rich in other fern species, and contained two endemic mosses. There were also a few specimens of the very rare, leafless, primitive plant Psilotum (*Psilotum nudum*). Quite a number of very large Bermuda Cedars (*Juniperus bermudiana*) were also present. The marsh had been drained for mosquito control and the large ditches created, were colonised by the Water Fern (*Salvinia olfersiana*). Also present in the central part of the marsh was a Red Mangrove (*Rhizophora mangle*) stand around an almost fresh pond. Although this basis of a natural peat marsh-palmetto swamp was there, the location had been extensively invaded by introduced shrubs. These introduced bushes were mainly Guava (*Psidium guajava*) and Ardisia (*Ardisia polycephala*). Much of the marsh has been carefully cleared of these and other invasives, and the area has returned to a condition closely resembling a pre-colonisation peat marsh. To walk in the palmetto forest of Paget Marsh is a wondrous and uplifting experience, truly stepping back into the past. In 1999, an environmentally friendly boardwalk with self-guiding displays was constructed to allow public access without undue disturbance.

Summary

Paget Marsh is a unique lowland and **wetland** habitat. It contains the only significant Bermuda Palmetto **Swamp-forest** in Bermuda as well as freshwater **ponds**, Giant Fern **communities**, Saw Grass marshes and a very unusual Red **Mangrove swamp** in freshwater. These habitats are all available for observation via a boardwalk. The Palmetto swamp forest has been restored to its near-original condition by the removal of **invasive species**.

Devonshire Marsh

Devonshire Marsh lying fairly centrally in the land-mass of Bermuda is the largest remaining freshwater marsh in Bermuda. Devonshire Marsh was predominantly a Bermuda Cedar swamp up until 1914, when the so-called "Great Fire" destroyed the forest and changed the character of the marsh for all time. Fortunately, while Bermuda Cedar is fire sensitive, Bermuda Palmetto is fire tolerant, and many of the latter have persisted in Devonshire Marsh.

As recently as 1996, Devonshire Marsh was severely burned. The effect of severe fire on freshwater marshes is to promote the dominance of fire-resistant species, such as Saw Grass (*Cladium jamaicense*) and Southern Bracken (*Pteridium aquilinum*). Other fire resistant species such as the Bermuda Palmetto may become more prominent but not usually dominant.

The most widespread plant community found in Devonshire Marsh is dominated by Saw Grass. Saw Grass communities are favoured in wetland areas where standing water does not persist for long, except in prolonged wet periods. The appearance of patches dominated by Lesser Bullrush shows somewhat wetter locations, as does the presence of Giant Fern.

Common associates of Saw Grass are Southern Bracken, Wax Myrtle (*Myrica cerifera*), and Doc-bush (*Baccharis glomeruliflora*); these latter two associates are both shrubs, and tend to be in fringing or drier parts. Scattered among the Saw Grass, occasional specimens of the Blue Dawn Flower or Morning Glory (*Ipomoea indica*) may be spotted by their conspicuous blue, trumpet-shaped flowers on long slender vines. Saw Grass characteristically forms a very dense stand up to about 2 m 6 (ft) high, therefore it discourages possible invading plants by the dense shade at ground level. It also discourages human exploration because its common name is really accurate. If you look at the long, broad Saw Grass leaves closely you will see that the edges are like a very fine saw, sharp and keenly cutting! However, some birds, such as the Sora (*Porzana carolina*), take advantage of the dense cover, and move and feed freely among the stalks, where they are most difficult to spot. The dense stands are also a very suitable insect habitat. In fire, the above ground portions are destroyed, but the roots remain unharmed and quickly re-sprout. The same is true for the roots of Southern Bracken.

Summary
Devonshire Marsh in central Bermuda is the only remaining large area of **marshland**. It has had a history of man-set fires which have altered its character forever. Nevertheless it does support extensive Saw Grass marshes, some **ponds** and ditches, limited Bermuda Palmetto swamps and areas dominated by Wax Myrtle shrubs. In the undergrowth are a wide variety of ferns. The marsh is an excellent birdwatching area.

Nonsuch Island

The restoration of Nonsuch Island has been called the “Living Museum” project. The island consists of 5.9 hectares (14.5 acres) of land: although this is quite small, it contains most of the land habitats available in Bermuda, and also has a coastline with rocky shores and sandy beaches. What really got Nonsuch Island biological recognition was the discovery of 7 breeding pairs of Cahows (*Pterodroma cahow*) by Robert Cushman Murphy of the American Museum of Natural History, and Louis Mowbray, Curator of the Bermuda Aquarium in 1951. These endemic birds had been considered to be extinct for over 300 years, and their re-discovery was a really astounding event. Although they were not on Nonsuch Island itself, but on adjacent small islands, Nonsuch Island was an obvious base for conservation and study of this highly endangered species. This was especially true after the breeding islands gained sanctuary status in 1951. The small islands were a good refuge from predators, including humans, but were short of good breeding habitat. The addition of artificial burrows was to break this barrier, and they were successful, except that other burrow-nesting seabirds, such as the Longtail (*Phaethon lepturus*), competed for this space. By 1961, the breeding population had risen to 11 pairs, and a baffle at the entrance of the nest tunnel solved the competition problem.

Summary
Nonsuch Island is the most important nature reserve in Bermuda and is the site of the “Living Museum” project. In this project the entire island is slated for restoration to a pre-colonial condition and much of this has already been accomplished. Additionally it has also been the main site for Cahow or Bermuda Petrel research, the re-introduction of Yellow-crowned Nigh Herons and a scheme to return a breeding population of Green Turtles to Bermuda.

In 1962, David Wingate who had carried on the Cahow research, was installed as Warden of Nonsuch, and in 1963 he began the 'Living Museum' project aimed at the restoration of the island to pre-colonial condition. In 1966, he became Bermuda's first Conservation Officer. For this type of restoration, the small size of Nonsuch Island has an advantage, in that the entire island can be monitored with minimal personnel, and new introductions can be eliminated promptly. Nonsuch Island did retain many native and exotic species before the project began, and so the start was not quite from scratch. Unfortunately, before restoration began in 1963, the heavy cedar stand on the island was decimated by Cedar Blight, and almost all the cedars died. This was a particular problem on Nonsuch because the island has an open southerly exposure, and also receives large ocean swells. Such swells which may arise as far away as the southern hemisphere, reach the south shore with little impediment. Because of this combination of factors, there was considerable concern that erosion would degrade island soils and that reintroduced plants would not have a suitable habitat in which to grow. To get around this, the decision was made to plant Casuarinas (*Casuarina equisetifolia*) as a temporary windbreak.

With Nonsuch being the centre for conservation work in Bermuda, it was natural that a project attempting to restore breeding populations of the Green Turtle should be centred there, especially as the South Beach on Nonsuch was a former nesting site. During the period 1967-1978, 16,000 Green Turtles were hatched there and released to sea. If they have survived as a viable population, they should begin returning early in the new Millennium.

By 1975, the restoration of the native flora of Nonsuch Island was well underway, but the natural habitats did not include wetlands. Other mainland wetlands had been drastically reduced, and to provide examples that could be managed, two ponds were planned for Nonsuch. The freshwater pond was dug in a central location, but leaking problems necessitated its re-excavation, and the addition of a permanent liner in 1993. Native and endemic pond and marsh species from other Bermuda wetlands were planted in and around the pond and have done well. The saltwater pond was excavated behind the South Beach, creating a small dune habitat between it and the sea. Red Mangroves and the Bermuda Killifish were introduced in 1976. In 1992, this new pond was enlarged and Black Mangroves were added to the flora, along with other species typical of brackish ponds in Bermuda. It was destroyed by Hurricane Fabian in 2003.

Summary

Nonsuch Island offers a wide variety of marine and terrestrial **environments**, including rocky and sandy shores, cliffs, open coastal areas, lowland forest, and a freshwater **pond**. A marine pond was destroyed in Hurricane Fabian, but the rest of the island was only lightly damaged. Nonsuch Island is available for visits through tours from the Bermuda Biological Station for Research or the Bermuda Aquarium, Natural history Museum and Zoo.

Nonsuch was also the site of two notable re-introductions of species that had previously been extirpated. Between 1976 and 1978, forty-four Yellow-crowned Night Herons (*Nyctanassa violacea*), hand -reared on a diet of Land Crabs (*Gecarcinus lateralis*), were released. This heron had previously been common in Bermuda but had been **extirpated**; its natural prey were Land Crabs and the two lived in balance. With the herons gone, the Land Crab population exploded and attempted control with DDT had disastrous side effects. About 8 years after their re-introduction, Yellow-crowned Night Herons were breeding naturally in the Walsingham area, and the success of the re-introduction appears to be assured. However, Land Crab populations have dropped to a very low level, indicating that a full ecological balance may be some years away. The second re-introduction, that of the West Indian Top Shell (*Cittarium pica*), which had been collected for food and extirpated, was carried out on Nonsuch in 1982, when a quantity of these large gastropods from the Bahamas became available fortuitously and were released. By 1986, they were breeding successfully, and have spread widely since. However, although they are a protected species, they are again being decimated by use as human food.

By 1990, the new forest on Nonsuch had progressed to the state where successful self-propagation of many species had begun, and the Casuarinas, installed as a wind break, could be gradually cut back or removed. The area has survived Hurricanes Emily, Dean, Felix, Gert and Fabian without severe damage! Much remains to be done, but the Nonsuch experiment has been an unprecedented success, which serves as an example to the rest of the world. Dr. Wingate has said "The 'Living Museum' has succeeded beyond my wildest dreams and I believe this is because I took a holistic approach to the restoration, by reintroducing everything within its original context the native heritage has restored itself. You can turn the clock back by understanding nature and working with it, rather than against it".

Spittal Pond Nature Reserve and Park

This reserve and park is one of the main natural history treasures of Bermuda because it exhibits such a wide variety of habitats and species. In a visit there you can see a large brackish water pond, that is Bermuda's best waterfowl location, a salt marsh, a stretch of superb rocky shore with cliffs, coastal forest and an exposed headland. The park's coastline also is a good location for fossils.

Spittal Pond differs from the other saltwater pond locations (Chapter 23) in that it is not anchialine. That is to say that it is not currently connected to the sea by subterranean passages. It really is intermediate between fresh and saltwater ponds and is called a "brackish pond". However, the amount of salt (salinity) in the water is immensely variable. In storms or hurricanes, seawater floods the pond from the south shore; by contrast during very heavy rain, the pond fills with virtually freshwater. If a long dry spell follows salt-water inundation, evaporation can raise the salt content to very high levels indeed. Added to this natural variability, is stress from organic pollution derived from the dairy farm along the pond's north shore. Spittal Pond is a very unstable, stressed location and in consequence its biodiversity is very low indeed and mass mortalities of some resident organisms are common. You may see large numbers of Mosquito Fish (*Gambusia holbrooki*) which were introduced into Bermuda to combat mosquito populations which had spread malaria. Little else in the way of higher organisms can be seen although American Eels (*Anguilla rostrata*) are present in winter and the odd snail may be found. The water of the pond has large areas of Widgeon Grass (*Ruppia maritima*) which is a food source for waterfowl. In warm weather, large white, grey or black patches of the **Sulphur Oxidising Bacteria** (*Beggiatoa* species) are very common and a sulphurous smell is usually present. Whenever you detect a sulphurous smell in nature, you can safely assume that the oxygen content in that environment is very low. Since almost all living organisms need oxygen, this makes life difficult. Mosquito Fish can handle this situation because they can breathe atmospheric air. Sulphur Oxidising Bacteria are an example of a life-form that is typical of places where oxygen is only present in tiny amounts.

Summary

Spittal Pond is a natural history treasure, located on the south shore, it has spectacular cliffs and good rocky shores. It is a good location for **fossils**. Inland are several ponds, the largest remaining **salt marsh** and extensive forest tracts. The main pond is a large **brackish** pond in which the water **salinity** and oxygen levels are extremely variable. Because of this, life in the pond is very limited in **diversity** but high in abundance. It is an excellent feeding site for waterfowl.

The salt marsh is typical in that it is grass dominated; grasses, including rushes are the most important plants present by far! It is also typical in that it is very flat and only moderately wet. There are two plant species that dominate two clearly different areas of the salt marsh. These are the Sea Rush (*Juncus maritimus*) and Sheathed Paspalum (*Paspalum vaginatum*) grass. A few patches of Saltmarsh Oxeye (*Borrichia frutescens*) dot the salt marsh. Scattered around the pond edge are a few Black Mangrove (*Avicennia germinans*) trees, but not enough to make a swamp. In an area between the salt marsh and the shore is a transitional area which is flooded by seawater in storms. There several other salt marsh plants can be found including the uncommon Seaside

Heliotrope (*Heliotropium curassavicum*), Seaside Purslane (*Sesuvium portulacastrum*), Purslane (*Portulaca oleracea*), Seaside Goldenrod (*Solidago sempervirens*), Seashore Rush Grass (*Sporobolus virginicus*) and stunted specimens of Buttonwood (*Conocarpus erectus*) trees.

The rocky shore (Chapter 18) is an exposed one and much of it is too steep to allow easy access. The best place to look at it is opposite to the east end of Spittal Pond, but everywhere one must be careful of the, usually vigorous, wave action.

Cliffs (Chapter 20) abound in the park and provide nesting sites for White-tailed Tropic Birds or Longtails (*Phaethon lepturus*) and invasive Pigeon or Rock Doves , (*Columba livia*) which are displacing the Longtails from their nesting sites.

The coastal forest (Chapter 21) within the park, contains a good mixture of endemic, native and introduced species and supports a good diverse ground layer. Specimens of the very rare, endemic Poecilozonites snails have been found in the undergrowth. In some areas, introduced trees and shrubs are being removed to promote the growth of native and endemic species. Along the exposed coastline, are a variety of hardy shrubs and flowering plants including Iodine Bush (*Mallotonia gnaphalodes*), Tassel Plant (*Suriana maritima*) and Coast Sophora (*Sophora tomentosa*).

All things considered, Spittal Pond is one of the best locations to visit to see a wide variety of habitats and species.

Ferry Point Park

In the East end of Bermuda, Ferry Point Park is outstanding; it is a large tract of near-shore woodland, which clearly shows the old Bermuda Cedar forest, as a sea of dead skeletons of trunks; the hills are a superb example of fossilised dunes (Chapter 7). The Railway Trail runs the length of this large park which has great northern coast exposures. Although Ferry Point Park does not contain a flourishing forest, it does have extensive areas where the skeletonised trunks of the once dominant Bermuda Cedars give an idea of the old forest. Scattered Bermuda Palmettos among the numerous dead cedars also evoke images of former times. The Easter Lily (*Lilium longiflorum*), formerly grown in large quantities for export, now adorns the grassy hillsides in the park. This is an example of a plant that was formerly used to make perfume. The Natal Plum (*Carissa grandiflora*) shrub occurs in large clumps on the western side of Whalebone Bay in Ferry Point Park.

Also within the park is Lover's Lake, an inland saltwater pond, fringed with a pure stand of the Black Mangrove. This mangrove swamp is usually a good place to observe the Crab Spider or Spiny-bellied Orb Weaver, spider (*Nephilla clavipes*) and its huge webs. The coastline, which is exposed to the north, has excellent communities of native coastal plants and is one of the best places to see how the shore has been melded into small spikes by the cyanobacterium Hofmann's Scytonema (*Scytonema hofmanni*). The open coastal habitat above the rocky shore is one of the best locations to see the flora typical of such places. Seaside Goldenrod, Sea Oxeye (*Borrichia arborescens*), Seashore Rush Grass and Coast Spurge (*Euphorbia mesembrianthemifolia*) are all abundant. Whalebone Bay is an overused but excellent place to snorkel over sandy bottoms, limited seagrass beds and some inshore coral reef formations. Be careful not to disturb the seagrasses and other attached marine organisms; the heavy human impact in this bay has reduced these organisms to a fraction of their former state.

Summary

Ferry Point Park is a large area of north shore coastal **environment**. It is the only area in Bermuda where the old Bermuda Cedar forest is still clearly visible in the form of skeletal trunks of dead trees. The park contains an extensive area of **fossilised** sand dunes and the marine pond Lovers Lake, fringed by Black **Mangroves**, lies in an old inter-dunal low. The cliff top shows a good example of open-coastal flora and Whalebone Bay is a nice sheltered bay for exploration of bay life. There are also good fossil deposits.

The Botanical Gardens and Arboretum

The Botanical Gardens deserve special mention as one of the most worthwhile visits for natural history enthusiasts in Bermuda. This beautifully situated and well maintained park, in a central location, has outstanding collections of **exotic**, as well as **native** and **endemic** plants, that are properly maintained and thoroughly labelled.

The Botanical Gardens started life as the Public Gardens in 1898 as a 4 hectare (10 acre) garden. In 1921, an adjacent 4 hectares (10 acres) was added to the site. Their future became secure in 1928, when a full-time trained horticulturist was hired to develop and maintain the gardens. In 1958, the property became the Bermuda Botanical Gardens. In 1966, the adjacent Camden Estate was added to the park, bringing the total size to 13.9 hectares (34.3 acres). At this time, seeds and plants were donated to the gardens by some of the foremost horticultural parks in the world, and the gardens graduated to a world-class exhibit.

Highlights of the Botanical Gardens are the Cactus and Succulent Collection, the native and endemic plant displays, the Fern Collection which includes some endangered Bermudian species, the Sub-tropical Fruit Garden, the Fig Tree Collection and the Palm Garden. Of special interest is the Blind or Sensory Garden thoughtfully planted with species that have characteristic smells or fragrances, as well as others with unusual textures. There is also a very attractive, restful, Formal Garden which provides interest at every season.

Summary
While the majority of the collections in the Botanical Gardens and Arboretum are of **introduced** species, **native** and **endemic** plants are there too. The gardens present an unparalleled opportunity to see excellent examples of tropical and sub-tropical plants.

There are some really outstanding trees in the Botanical Gardens, both in specialised groupings and scattered around the grounds. These form the best Arboretum in Bermuda, far superior to the park called “The Arboretum,” in which the trees are not nearly so noteworthy.

Guided tours of the Botanical Gardens are available on a regular basis and can be arranged for school groups, these tours show things which one might ordinarily miss. The guides are always ready to answer questions. There is usually a good selection of wild birds around the park which add to the overall interest of this wonderful location.

South Shore Park

The South Shore Park running from Warwick Long Bay to Horseshoe Bay is an outstanding location to look at exposed coastal habitats. It contains the only remaining tract of sand dunes and excellent exposed headlands. The beaches although they are good sandy beaches are so heavily used by tourists that any native fauna and flora of these beaches is either gone or reduced to small fragments.

Summary
South Shore Park contains not only top-ranking tourist beaches but also the only remaining sand dune tract in Bermuda, and the best example of very exposed headlands. The beaches are cleaned and raked for tourists and do not show typical features. The sand dunes, however, demonstrate dune features very well. The headlands not only show the effects of extreme exposures on intertidal life, but also provide a wonderful view of the unique tract of **boiler reefs** along the south shore.

The sand dunes (Chapter 19) show most typical dune features from the exposed primary dunes close to the sea, to more sheltered secondary dunes behind. Plants such as Seaside Morning Glory (*Ipomoea pes-caprae*), Iodine Bush and Beach Lobelia (*Scaevola plumieri*), typify the exposed dune faces, and can grow back quickly after storms deposit or withdraw sand. Further back, less hardy small plants such as Seaside Evening Primrose (*Oenothera humifusa*), Bay Bean (*Canavali lineata*), Burr-grass (*Centrus tribuloides*) and Wild Stock (*Matthiola incana*) become common along with Bay Grape (*Coccoloba uvifera*) and Spanish Bayonet (*Yucca aloifolia*) shrubs. Introduced plants are not common except at the back of the dunes.

Exposed headlands such as Stonehole Head in the park are some of the most wave beaten rocky shore habitats in Bermuda. There are excellent examples of bio-constructional lips (Chapter 18) and the intertidal zones are very broad. There are often extensive thickets of Tassel Plant shrubs on the headland tops. Just off shore are an abundance of boiler reefs (Chapter 15) that can easily be observed from the cliff tops and compared with the **bio-constructional lips**.

Conservation Aspects

The Park and reserve areas of Bermuda are absolutely vital for the preservation of many of the habitats and species of Bermuda that are under stress. They provide locations where development and building are restricted or absent and are also valuable recreational areas. Without the park and reserve systems many unique and valuable aspects of the ecology of Bermuda would already have been lost.

The Government of Bermuda, the Bermuda Audubon Society and the Bermuda National Trust all make great efforts to ensure that parks and nature reserves are maintained and where human activity is undesirable, sanctuaries set off small areas from all disturbance. However, we must not lose sight of the fact that there is always great pressure to develop currently wild areas for housing, golf courses and other amenities. This pressure must be resisted or we will lose more of our precious, natural history treasures. Additionally, it is imperative that areas that are not now parks, which shelter vulnerable endemic and native species be given a protected status.

Everyone can do their part to preserve parks, reserves and rare species, by being aware of them, and their value, and by speaking up to friends, neighbours, politicians and developers when any critical habitat or species is threatened.

Summary

There is limited opportunity to create new parks and reserves but any opportunity to do so needs pursuing. Additionally, the level of protection of wildlife in parks, reserves, sanctuaries and Coral Reef Preserves needs enhancing and the level of enforcement heightened. Everyone can do their part to maintain these areas in good condition by respecting them and using them wisely.

Questions

1) How do parks and reserves help to preserve, habitats, fauna and flora in Bermuda? Give your answer in point form.

a) ______________________________
b) ______________________________
c) ______________________________
d) ______________________________
e) ______________________________

2) Put parks, sanctuaries and nature reserves in order of the greatest protection they provide. Call the most protected 1 etc.

Nature reserves ___ Parks ___ Sanctuaries ___.

3) What are the three types of marine protected areas in Bermuda?

a) ______________________________
b) ______________________________
c) ______________________________

4) Name three uses that the parks are put to by tourists and residents of Bermuda.

a) ______________________________
b) ______________________________
c) ______________________________

5) Name one park in each of the west, central and eastern parts of Bermuda.

West) ______________________________
Central) ______________________________
East) ______________________________

6) The Railway Trail is a sort of elongated park. Why is this important from a natural history point of View?

7) Give three reasons why the group of parks and reserves in the Walsingham area are especially important.

a) ______________________________
b) ______________________________
c) ______________________________

8) What steps do you think should be taken to preserve the existing Yellow-wood and other native trees in Walsingham? List as many as you can.

a) ______________________________
b) ______________________________
c) ______________________________
d) ______________________________

9) What group of fishes are protected by the seasonal marine reserves and what do these fishes do in these areas?

a) ____________________ b) ____________________

10) Name two parks or nature reserves that support mangrove swamps.

a) ______________________ b) ______________________

11) If you wanted to look at an anchialine pond, what two parks would allow this?

a) ______________________ b) ______________________

12) Name four habitats that are available for study in the Spittal Pond Nature Reserve?

a) ______________________
b) ______________________
c) ______________________
d) ______________________

13) What steps could be taken to give more protection to marine organisms in the Coral Reef Preserves? Try to think of three.

a) ______________________
b) ______________________
c) ______________________

14) If a bird watching friend visited you from overseas and had time to visit three parks or nature reserves, which ones would you suggest and why?

a) ______________________
____
b) ______________________
____
c) ______________________
____

15) If you were a government official in charge of parks, nature reserves and sanctuaries, what three steps would you suggest should be taken to improve their role in the preservation of Bermuda's natural history heritage?

a) ______________________
____
b) ______________________
____
c) ______________________
____

Note: The field trips set out for this chapter are designed to show the features of the various major parks and reserves. There are other field trips in other chapters which explore in more detail specific habitats or ecosystems within the parks. See the list of field trips at the front of this book.

Field Trip# 26.1 to the Walsingham Park/Reserve Area

Introduction

The Walsingham Tract is very varied and only the main aspects can be visited in one trip. A detailed field trip to Walsingham Pond is included in Chapter 23.

Preparation

Read this section of this field guide. Additional relevant material can be found in Chapters 22, 23, 24 and 25. The ground surface in the Walsingham Tract is very uneven and it can be quite slippery after rain. Sharp spikes of limestone stick out in places and in others there are deep holes and crevices. It is wise to stick to the well worn trails in this area and even then watch your footing carefully.

Dress

Participants should wear good, sturdy footwear with non-slip soles. Long pants are advised to prevent scratches.

Equipment

Clipboard, pencil and several sheets of good paper or a note pad. A few pairs of binoculars for the group.

Suggested Route

The suggested route assumes that transportation will be provided for the group that can pick participants up at a different location from where they started. If this is impossible, a return to the start point will have to be made.

Start at the parking lot in Blue Hole Park off Blue Hole Hill, just before the Longbird Causeway. Proceed out of the parking lot along the footpath, almost immediately you will see a restored fresh or brackish water pond on the right. Go to its bank. Next follow the road a short distance to an opening through the bushes on the right leading to Causeway Cave mouth and proceed there. Next, proceed along the road past the toilets and the side road to the shore and follow the footpath to the right to where it enters the woodland through a swing-gate. Keep following the path through the forest to Walsingham Pond, and proceed out on to the road at Tom Moore's Tavern. This will be the pick up point.

Observations

a) The first stop is the brackish pond in Blue Hole Park. From the top of the steep bank down to the pond observe the pond and its contents. This is a restored pond previously filled with trash and soil. Animals and plants have been transferred from other ponds to create a typical brackish pond fauna and flora. In the water are large patches of Widgeon Grass (*Ruppia maritima*) and masses of filamentous green algae. There may also be patches of the white, pink, grey or blackish bacteria, *Beggiatoa* at the surface; if there are you will probably smell sulphur! Now look into the water for fish, Grey Mullet (*Mugil trichdon*) which are often quite large are common, as are Mosquito Fish, you may also see the small snail the False Cerith (*Batillaria minima*) on the aquatic plants. Make a list of each species that you identify and the habitat (e.g. open water, on vegetation etc.) for each.

Species	Habitat

b) Stop 2, Causeway Cave Mouth.

This cave mouth has a good observation point with a railing. Do not clamber over the railing or up the slope at the back. Cave mouths are an important habitat for endemic and rare plants. Look particularly at the rock face above the water in the cave and try to identify as many plants as possible that are living on it. At least two endemic species, perhaps more, are usually present. Look for the endemic Bermuda Maidenhair Fern (*Adiantum bellum*) which is common. Less common is the endemic Wild Bermuda Pepper (*Pepperomia septentrionalis*) with fleshy, broad leaves. Other ferns and herbs may be present along with the common endemic moss (*Trichostomum bermudanum*). The varied green to bluey-green patches on the rock are caused by Blue-green Cyanobacteria. Draw a sketch of a section of the rock surface that supports several plants. Add the plants and label them.

c) Stop 3. The woodland beyond Blue Hole Park.
After leaving the Blue Hole Park at the swing-gate, go on until you are well away from the forest edge. Look around you and list all the trees and shrubs that you can see and note whether they are endemic, native or introduced (Status).

Tree or Shrub	Status

Then look at the ground layer of plants and see what you can find there, rank them in order of abundance.

Species	Abundance
	Most Abundant
	Least Abundant

This is not a mature forest. How can this fact be determined?

---

d) Stop 4. Walsingham Pond at Tom Moore's Tavern.
Walsingham Pond is one of the most bio-diverse ponds in Bermuda and probably the world. It is an anchialine pond (Chapter 23) with several inlets and outlets to the sea and to other adjacent ponds and caves. You will not see details of the fauna and flora of the pond on this field trip but be aware that it is there. Walsingham Pond is only separated from the sea by the roadway to Tom Moore's Tavern and this provides an opportunity to compare features of the pond and bay mangrove swamps.

From the jetty at Tom Moore's look at the pond and the mangrove swamp which completely surrounds it. Notice that the numerous adventitious roots of the mangrove go down into the water. These roots provide a habitat for a rich attached fauna and flora which you can only glimpse from the jetty. Look at the mangrove swamp and see which species of mangrove are present and whether they are zoned (arranged in bands) in the swamp. Then cross the road and compare these features carefully with the bay mangrove swamp.

Pond Mangrove	Bay Mangrove
Red Mangrove present ❒	Black Mangrove present ❒
Black Mangrove present ❒	Black Mangrove present ❒
Buttonwood present ❒	Buttonwood present ❒
Mangrove trees zoned in bands ❒	Mangrove trees zoned in bands ❒

Look carefully for other features that differ in the two locations and describe them below.

___

___

Look into the water in the pond, you will probably see fishes milling around. See if you can identify any of these. Look for other living things in the water. List what you can see.

1) ____________ 2) ____________
3) ____________ 4) ____________

Walk back a little way towards the swing-gate at the start of the woodland, that you came through earlier. Behind the lawn there is a little saltmarsh at the back of the mangrove. See if you can find the following plants. Hint not all of these are there!

Saltmarsh Oxeye ❒ Seaside Purslane ❒ Woody Glasswort (*Salicornia perennis*) ❒
Seaside Goldenrod ❒ Seashore Rush Grass ❒ Sheathed Paspalum ❒

Field Trip# 26.2 to Nonsuch Island

Introduction

Nonsuch Island is a Nature Reserve and the most completely restored areas on the island. So that it will be retained in good condition, visits to the island have to be limited and can only be made with a trained guide to oversee the group. Visits to the island must be arranged through either the Bermuda Biological Station for Research or the Bermuda Zoological Society at the Aquarium. A brochure on Nonsuch Island is provided to each participant in official tours.

Preparation

Read this section of this field guide and any other information that you can find on Nonsuch Island and the restored areas (Chapter 12).

Dress

No special clothing is needed.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group.

Suggested Route

The route will be explained by the tour guide.

Observations

Listen carefully to everything that the tour guide says and ask questions whenever you do not understand anything, or when you would like additional information. After the field trip write a sentence or two about each of ten things you learned about the island, and its fauna and flora on this field trip.

1) ____

2) ____

3) ____

4) ____

5) ____

6) ____

7) ____

8) ____

9) ____

10) ____

Field Trip# 26.3 to the Spittal Pond Nature Reserve

Introduction

The Spittal Pond Nature Reserve is one of Bermuda's most important natural areas and a wide variety of habitats can be observed there. These include the large, unique brackish pond, a salt marsh, cliffs, rocky shore, an exposed headland, open coastal habitat and coastal forest. Some geological features are also well displayed in the reserve. The pond itself is covered in a field trip in Chapter 23.

Note that this field trip covers a wide variety of habitats and they cannot all be explored in detail. For more detailed excursions to specific habitats see the appropriate chapters of this book

Be prepared for a fairly long walk in this Nature Reserve.

Preparation

Read as much as you can on the habitats covered in this field trip. Chapters 18, 20, 21, 23 and 25, contain pertinent material.

Dress

No special clothing is needed but sturdy shoes are advised as there is lots of walking involved.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group.

Suggested Route

Start at the east parking lot of the Spittal Pond Nature Reserve and proceed down the footpath to the bottom of the slope for a good view of the pond and salt marsh. Then go on a short distance, stopping well before the east end of the pond itself. After looking at the salt marsh find the path leading towards the sea and clamber up onto the rocky ridge to get a good view of the rocky shore and nearby cliffs. After this, return through the salt marsh and proceed along the path to where you can get a good view of the pond itself. Do not venture into the Sheathed Paspalum grass fringing the pond, or you will get wet feet. After studying the pond keep going along the main path which will lead up a slope into the forest. Look for a short path to the right leading to a small freshwater pond and take it to look at the pond. Next, just continue along the path a short way to any convenient place to study the forest. After this keep going along the main path until it emerges as the top of the coastal cliffs, stop where there is a good, but safe, view of the sheer coastline. The path you will follow now ducks back into the woods after another glimpse of the main pond and a second freshwater pond beside it. Continue along the path through the forest, but close to the main pond until you emerge into the open again where the west end of the pond nears the coast. Take a short path on the left here to a geological formation known as the 'checkerboard'. After this, continue along the main path until it starts to ascend steeply; go half-way up the slope for the final stop in the Casuarina Forest. Return to the east parking lot by the same route

Observations

Stop 1. Overview of the pond and salt marsh. Note that the pond lies in a low area among hills. It is the site of an old inter-dunal low (Chapter 7). This pond is no longer connected to the sea by underground fissure as all of these have been blocked by thick peat deposits. Look at the east end of the pond and draw a sketch map showing: a) The pond end, b) the salt marsh, c) mangrove trees, d) the path, e) the coastal forest. Use binoculars to look for waterfowl and list those that you can identify.

Sketch Map of Spittal Pond East

List of Waterfowl

a) ______________________________ b) ______________________________
c) ______________________________ d) ______________________________

Stop 2. The Salt Marsh.
This salt marsh has two very distinct plant communities in it, the Sheathed Paspalum community and the Sea Rush community. The Sheathed Paspalum forms a fairly low turf light green in colour, while the Sea Rush is taller and darker. Both these communities are almost **monospecific**, meaning that each is composed mostly of one species of plant, however, clumps of the Saltmarsh Oxeye can be seen among the Sheathed Paspalum. Look also at the few Black Mangrove trees where the salt marsh joins the pond. Along the path and that to the seashore edge, you should be able to see other salt marsh plants such as Seaside Purslane, Purslane, Seaside Heliotrope, Seashore Rush Grass and Woody Glasswort. Stunted Buttonwood bushes are also present in this area. See how many different species you can find and check them off in the list below.

Sheathed Paspalum ❏ Sea Rush ❏ Saltmarsh Oxeye ❏ Black Mangrove ❏,
Seaside Purslane ❏ Purslane ❏ Seaside Heliotrope ❏ Seashore Rush Grass ❏
Woody Glasswort ❏ Stunted Buttonwood ❏.

Stop 3. The Rocky Shore.
Be careful on the rocks and do not get close to the edge. This is a southerly exposure and large waves are normal. Try to get a good look at a piece of the shore or a cliff base that is exposed to waves and spray. See if you can detect zones on the shore as indicated by different colour shadings. You should see a yellowish zone, possibly a whitish zone and certainly a blackish zone. At the very bottom there may be a greener area. Draw a sketch of the shore showing the relative widths of these zones.

Stop 4. The Main Pond.
This pond is quite heavily polluted so do not touch or get into the water, simply observe from the bank where it is dry and solid! This pond is definitely a stressed habitat and one of the effects of stress is low biodiversity. Look into the water and list the animals and plants you can see, the list will be short since there is very low diversity there. You should at least see Mosquito Fish and Widgeon Grass and probably Sheathed Paspalum trails in the water. Look for black, grey, pink or white patches of the Bacterium, Beggiatoa. This pond regularly runs out of dissolved oxygen which would kill most fish but Mosquito Fish can breathe air at the surface to get around this problem.

a) ____
b) ____
c) ____

Stop 5 Freshwater Pond.
We are calling this pond freshwater, but in truth it is somewhat brackish because of its proximity to the sea. Like the main pond, the Biodiversity is low and the conditions in the water somewhat stressful. However, it is a great spot for waterfowl. Look around the pond for birds and in the water for anything you can identify, note the habitats in which animals or plants were seen. Enter your results in the table below.

Species	Habitat

Stop 6. The Coastal Forest.

The forest here is very close to the sea but sheltered by the Spanish Rock bluff, so it is not exposed to the full brunt of southerly gales and the trees are tall and well formed. Some introduced trees have been removed and endemic ones planted so this is a location that is partially restored. Look at the trees and identify as many as you can, note whether they are endemic, native or introduced (their status) and whether they appear to have grown there naturally or have been planted.

Tree Species	Status	Natural or Planted

Stop 7. Coastal Cliff View.

This is a very exposed coastline and there is probably lots of wave action. Look in the water at the base of the cliffs and you should see ridges of rock, roughly parallel to the shoreline but several metres (yards) out to sea. These are bio-constructional lips (Chapter 18) constructed by worm-shells and coralline algae. These same organisms make the boiler reefs that you may see further out. Now turn your attention to the cliff top environment, a very harsh one. Trees will be less well developed than at the previous stop and there are some very stunted Buttonwoods closest to the sea. Look also for 'weather-vaneing' in the trees. This is shown by their bending away from the south winds. See if you can see Prickly Pear (*Opuntia dilleni*) plants and Seaside Goldenrod (*Solidago sempervirens*) both of which can stand harsh conditions. Look also for coastal birds that may be using the cliffs for nesting. Check off the features that you can see.

a) Bio-constructional lips ❒ Boiler Reefs ❒ Coastal Birds ❒
Stunted Buttonwoods ❒ Prickly Pear ❒ Seaside Goldenrod ❒ Weather-vaneing ❒

Stop 8. The Checkerboard.
Amongst the rocks towards the sea is an area of flat rock with regular crevices forming an almost pavement like area. This is a geological formation called 'limestone pavement' which was laid down in the distant past. Draw a diagram of this rock formation.

Stop 9. The Casuarina or Australian Whistling Pine Grove.
Casuarinas were introduced into Bermuda as a windbreak when the Bermuda Cedars were at a low ebb, due to exploitation and scale insect attacks. Look at these trees and compare them with what you know of Bermuda Cedars which you saw at Stop 6. Fill out the table below to summarise your results.

Feature	Bermuda Cedar	Whispering Pine
Tallest	❐	❐
Get blown over in storms	❐	❐
Tend to break part-way up	❐	❐
Needle-like leaves	❐	❐
Scale-like leaves	❐	❐
Discourage undergrowth	❐	❐

Field Trip # 26.4 to Ferry Point Park

Introduction.

Ferry Point Park is a quite open north shore park with plenty of different habitats both marine and terrestrial. One of the unique features of this park is that it shows remnants of the old Bermuda Cedar forest that covered the fossilised dunes here. The cedars are virtually all dead but skeletons of their former trunks persist. This allows a good view of the ancient fossilised dunes characteristic of this area. Lover's Lake an anchialine saltwater pond lies in a well-defined inter-dunal low in the central part of this large park. Another feature of note is Whalebone Bay near to the western end of the park. This is a lovely, sheltered bay heavily used by Bermudians, tourists and students and it shows the effects of stress from these sources. There is also quite a well developed coastal mangrove swamp on Ferry Reach opposite to Whalebone Bay but land access to it is poor. The bridge to the island where Ferry Reach discharges into North Lagoon is a good place to watch for Bermuda Fireworms (*Odontosyllis enlopa*), which appear on the third night after the full moon, 56 minutes after sunset.

Preparation

Read as many appropriate sections section of this field guide as possible Chapters 7, 18, 20, 21, 22, 23 and 25.

Dress

No special clothing is needed but a fair bit of walking is involved and sturdy shoes are a good idea.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group. A few metre sticks or yard sticks.

Suggested Route

From the parking area at the end of Ferry Road, move on to the Railway Trail which goes round the inland edge of Whalebone Bay. Observe the bay and its surroundings from the Railway Trail, on the west side of the bay there is a large thicket of Natal Plum shrubs, an introduced shrub. Then continue along the Railway Trail until Lover's Lake just appears on the right and there is a seating bench on the left. Near to this point a gully runs towards the sea. Just off the main trail on the far side of this gully is an exposure of the fossilised shells of an extinct, terrestrial Poecilozonites snail. Look at these carefully but don't scrape the fossils out of the rock. Next proceed along the trail to about the centre of Lover's Lake and observe it from this point. Do not go down to the lake as there is poison ivy there. From roughly the same spot look at the fossilised dunes and the old cedar skeletons. Continue on along the trail to about the old railroad storage shed and look at the area between the Railway Trail and the sea. Do not go close to steep drop-offs, but look around at the plants of this open coastal habitat. Return to the parking lot by the same route but stop in the deepest rock cut after Lover's Lake.

Observations

Stop 1, Whalebone Bay.

At this point, standing on the Railway Trail, draw a sketch map of the bay and surrounding land marking on: the water, the bay mouth, the sandy beach, rocky shores, the Railway Trail and the Natal Plum thicket, add anything else you can identify.

Stop 2. The Fossil Bed.
Look carefully at the fossilised shells, they are in really good condition but have been dead thousands of years. These snails probably lived in wood or scrub-land and ate vegetation. Draw a little bit of the rock with the fossilised shells.

Stop 3. Lover's Lake.
Look at the situation of the lake nestled among the old dunes. It is connected to the sea by a pipe-like structure at the deepest point at the east end. The pond is lined with mangrove trees. Even from the trail it is obvious that they are all of one species, the Black Mangrove. There are often patches of Widgeon Grass in the water at the east end of the pond. This pond is quite tidal and flushes well, but rainwater tends to form a layer at the surface in wet weather. This creates a suitable habitat for the Widgeon Grass. The slope down to the pond is clothed in a mixture of mostly introduced species the main one of which is Fern Asparagus. There are also patches of Natal Plum and in spring the odd Easter Lily. Tick off the features that you can see below.

Lover's Lake ❑ Fossilised dunes ❑ The Inter-dunal low ❑ Black Mangrove Trees ❑

Widgeon Grass ❑ Fern Asparagus ❑ Natal Plum ❑ Easter Lily ❑

Stop 4. Ancient Dunes.
Around Lover's Lake and in both directions to the side are a range of fossilised sand dunes covered with the remains of an old Bermuda Cedar forest. Look at these dunes and imagine them as they were far in the past as a range of sand dunes. At that time, the cedar forest would have been absent and the dunes sparsely vegetated with dune grasses and flowering plants. Later as the dunes became fixed as limestone, the forest developed, but judging by the smallish tree remains the cedars remained quite small. This suggests poor soil and a windy environment. Among the dead cedars are scattered Bermuda Palmettos which were probably present with the cedars. Draw a sketch diagram of the hills, showing the dead cedars and Lover's
Lake in the inter-dunal low.

Stop 5. Open Coastal Vegetation.
This is an excellent spot to look at the typical vegetation of an open coastline. Ecological conditions here are harsh, there is little soil, little fresh moisture, lots of wind and few plant nutrients. Only specialised plants can live here and they often take advantage of every bit of shelter. Starting closest to the sea look for the following plants and note their habitat. Note also that some show the adaptation of succulence. Succulent plants have fleshy leaves to store freshwater. They will virtually all be native plants. Coast Spurge (very low growing). Seaside Purslane, Purslane, Seaside Goldenrod, Seashore Rush Grass, Sea Oxeye, Prickly Pear. Fill in the table below with your observations.

Species	Habitat	Native or Introduced	Succulent?	Height cm	Flowering?

Stop 6. A Rock Cutting.
In the middle of the rock cut stop and look at the rock. Look for strata or layering and look for layers or pockets of red soil or rock. This is red bed or Terra Rossa. See if you can see the tops of the old dunes, stratification may make an abrupt change at this point. Draw a diagram of the rock face showing strata and red beds. Look also for any plants growing in the rock wall and try to identify them.

List of rockwall plants.

a) ____________________ b) ____________________

c) ____________________ d) ____________________

Field Trip # 26.5 to The Botanical Gardens

Introduction

The Botanical Gardens is best explored in a guided tour given by a member of staff of the gardens, or an experienced volunteer. There are hundreds of different plants in the gardens representing endemic, native and introduced species. Many of the plants are labelled so that you will be able to note down what you see. Remember that the Botanical Gardens do not attempt to reproduce past conditions in Bermuda but rather show the ornamental and cultural value of plants from all over the world. There are usually lots of birds in the gardens, attracted by the wealth of habitats and a supply of food.

Preparation

Read this chapter of this field guide and anything else you can find out about the Botanical Gardens.

Dress

No special clothing is needed.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group.

Suggested Route

The guide will choose a route through the gardens that will maximise your chances of seeing the greatest variety of plants.

Observations

Make good notes as you move around the Botanical Gardens. Ask questions if you do not understand or wish to know extra facts about the plants that you see. After you finish the tour, write a paragraph or two summarising what you saw. Mention the special collections of different plant groups and describe things that you saw that interested you. If you saw endemic species, be sure to include them in your write-up.

Field Trip # 26.6 to South Shore Park

Introduction

South Shore Park presents wonderful examples of coastal habitats along the exposed south shore of Bermuda. It is also one of the main tourist attractions of Bermuda and this has put pressure on several, if not all the habitats there. Remember that everything that you see is probably somewhat or greatly altered by human activity; this is especially true of the beach areas. Nevertheless, this park is the only location where you can see a fairly large tract of sand dunes. When looking at them remember that even in fairly recent times these dunes were much more extensive and that in the distant past, virtually all of Bermuda was a vast dune tract. The park also has some of the best examples of very exposed headlands, and the tops of these afford good spots to view the lines of boiler reefs (Chapter 15), that are characteristic of the south shore. You can also gaze out to sea and see the colour of the water darken over the deep water that, here, lies quite close to the shore.

Preparation

Read this section of this field guide and anything else you can find about the south shore of Bermuda. Read Chapter 19 on sand dunes.

Dress

No special clothing is needed. On a sunny day the dunes can get very hot and the sand you walk on may be too hot to touch. Be prepared for this with sturdy shoes which will also help with the walking on soft sand.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group.

Suggested Route

Take the exit from south shore road to Jobson's Cove and Stonehole Head that is opposite to the gate of the Bermuda Regiment. The parking lot at the bottom of the slope lies behind the main dune expanse. From the parking lot, head out into the dunes from the east end of the parking area. Stop a little way into the dunes. Next proceed toward the ocean but stop again before the dunes become beach. Proceed on to the beach and look first at the dune slope facing the sea and secondly at the beach itself. Find a path ascending on to one of the headlands and proceed to where you can get a good view of the coastline and the ocean but stay well away from the cliff edge. From the headland return to the path along the seaward edge of the dunes and proceed east to look at the main Warwick Long Bay West beach. To finish this field trip, head back west along the path in the middle of the dunes and watch for a path that goes back towards the road and rises to an open, grassy area to give a good view of the whole area you have explored.

Observations

Stop 1. The dunes close to the parking lot.

When you leave the parking lot, you will be in a central part of the dunes. This area is somewhat protected from southerly winds by other dune formations toward the sea. Plants that are not quite so tough as those nearer the sea can survive here, but the habitat is still harsh. Look at the sand. It dries easily and lacks plant nutrients and organic matter. No, or very few animals can survive here permanently. Identify as many plants that you can and list them below. These should include Seaside Evening Primrose, Burr-grass, Fennel (*Foeniculum vulgare*), Seaside Morning Glory, Spanish Bayonet and Beach Croton (*Croton punctatus*), all are native plants. A few Casuarinas, Bay Grape (*Coccoloba uvifera*)and the odd Tamarisk (*Tamarix gallica*) may be seen in the background. List all the plants you can find, state whether they are endemic, native or introduced (status) and describe where they are growing.

Species	Status	Growth Location

Stop 2. The Fore Dunes. These dunes just behind the beach are called fore dunes. They are more exposed to wind and weather than dunes further behind and so the habitat is very harsh. List any plants you see here that you did not see at the last stop. Look for Tassel Plant (*Suriana maritima*), Scurvy Grass or Sea Rocket (*Cakile lanceolata*), Iodine Bush (*Mallatonia gnaphalodes*)and Beach Croton.

Species	Status	Growth Location

Stop 3. Dune-beach transition zone.
This is the harshest of the sand dune environments. It is open to the sea and the sand is unstable. Storms may either erode sand away or deposit it on top of the vegetation. Plants that live here must be able to re-grow from buried stems or re-colonise the area by seeds or fragments. The plants here are called 'pioneers' and they are exceedingly important in coastal protection. Sketch a section of the dune slope showing the pioneer plants.

Stop 4. The beach.
This beach is a great tourist attraction. The sand is kept clear of flotsam and jetsom and any tar balls that the tide brings in. This makes it a poor natural environment for beach-dwelling animals and plants. Perhaps all that you will see is the 'strand-line' left by the high tide. In an unused beach this would be where vegetation started. Plants of Scurvy Grass or Sea Rocket grow from seeds left in the strand line and start the process of dune formation. The strand line would also support animals such as Beach Fleas (*Orchestia* spp) and several insects. Ghost Crabs (*Ocypode quadrata*). If a strand line is present describe what you see in it.

____
____
____
____

Stop 5. The headland.
From the headland, you should be able to see Boiler Reefs close to shore and Bio-constructional Lips on the headland tips. Both these reef types are built by Worm Shells and Coraline Algae. Further out you should see a second line of Boiler Reefs and beyond them darker deep water. Also note the hardy plants that live here, probably including Coast Spurge, Seashore Rush Grass and probably Prickly Pear. Further back there will be thickets of Tassel Plant, these are all native plants. List the headland plants and describe their habitats.

Species	Habitat

Stop 6. Warwick Long Bay Beach.
This is a typical tourist beach and in good weather it is heavily used. As at Stop 4, note the lack of natural beach features.
List 3 things or organisms absent from this beach that would be there if it were undisturbed

a) ______________________________
b) ______________________________
c) ______________________________

Stop 7. The Back of the Dunes. From a good observation point look for the places that you have been and get a good view of a typical south shore location. Look around you and notice that introduced herbs, shrubs and trees are more common here.
List as many introduced species as you can that were absent closer to the sea. And state whether they are herbs, shrubs or trees.

a) ______________________________
b) ______________________________
c) ______________________________
d) ______________________________

Chapter 27. Natural History in the City, Town and Villages, Way-sides and Gardens

Introduction

You may wonder why a chapter of urban areas is included in a book on natural history. Surely, the natural history of these areas is more like un-natural history. In a sense this is true, but in a country like Bermuda, where the majority of the land surface consists of cities, towns, villages, roads, parking lots, golf courses and other paved or concreted areas, urban areas can hardly be ignored. They have played a major role in the degradation of the natural fauna and flora since introduced species and their pests and diseases, were brought in for ornamental use in urban areas or for food, flavouring, medicines, dyes etc. used by the inhabitants of mainly urban areas. The role of introduced species in the natural history of Bermuda has been a frequent subject in this book. Additionally, these introduced species are not without natural history importance. They introduce us to some of the fauna and flora of other subtropical and tropical areas in the world, many line city streets and others are food items.

Summary

Urban areas may show little of natural conditions but still have natural history lessons to teach. Urban areas show many examples of **introduced** species that demonstrate aspects of natural history in other areas of the world. Additionally many of the plants seen in built-up areas have great ornamental value.

Many of the species introduced into Bermuda for ornamental or practical use, did not survive because the environment was unsuitable, this gives us some insight into the natural processes of natural colonisation, competition, survival and disappearance as the fauna and flora of Bermuda developed. An example of this is the Grape which was grown for a while and did give rise to some wine of poor quality. Both climate and soil were unsuited to grapes. Introduced species may also provide useful natural indicators of environmental change in Bermuda. An example of this is the Fig which was introduced and flourished for a fairly long period, only to decline. The cause of this problem is said to be the declining levels of organic material in Bermuda soils; a change which is no-doubt detrimental to some native and endemic plants.

It is easy to think that introductions have done more harm than good but the actual situation has both beneficial and detrimental aspects. Some introductions have had disastrous effects, others have blended in almost naturally, while yet others have been highly beneficial.

Urban Natural History

Most of the organisms of interest in urban areas are plants, animals do, of course, occur there but these are mostly either pets or pests. The Black Rat (*Rattus rattus*) and the Brown or Norway Rat (*Rattus norvegicus*) are both frequent. Being nocturnal they are not often seen by day. Cats and Dogs are, of course, common and the most frequently encountered birds are introduced species often regarded as a nuisance. The House Sparrow (*Passer domesticus*), the Starling (*Sturnus vulgaris*) and the Pigeon or Rock Dove (*Columba livia*) are all common in urban areas. One perhaps would not expect amphibians in built up areas but Giant Toad (*Bufo marinus*) tadpoles are frequently seen in ornamental pools such as those in front of Hamilton City Hall. The introduced terrapin, the Red-eared Slider (*Trachemys scripta*), has become quite common in the heavily polluted Pembroke Canal that runs right through Hamilton. A variety of

Summary

Most of the mammals and birds seen in urban areas can be regarded as pests, examples being rats, Starlings and House Sparrows. Nevertheless, wild birds do occur. Ruddy Turnstones are common along waterfronts and ducks are often seen where water is present. Marine toads breed in ornamental ponds.

ducks also may be seen on this waterway. The marine waterfronts in both St. George's and Hamilton also support a variety of fish of which the Sergeant Major or Cow Polly (*Abudefduf saxatilis*) is probably the most common. Where there are open areas along these waterfronts, the Ruddy Turnstone (*Arenaria interpres*), the commonest shorebird in Bermuda, can frequently be observed. A wide variety of other birds can be seen in city and town parks, such as Par-la-Ville Gardens, Victoria Park and Fort Hamilton in Hamilton and Somer's Gardens in St. George's. These parks all contain very fine introduced trees including many palms and Victoria Park houses a magnificent specimen of the London Plane Tree (*Platanus acerifolia*); another tree worth mentioning is the wonderful specimen of the Mahogany (*Swietenia mahogani*) at the junction of Harrington Sound Road and North Shore Road in Flatts Village.

Summary

Urban areas display a very wide variety of trees that include not only ornamental **introductions** but **endemic native** species such as the Bermuda Cedar, Bermuda Palmetto and Olivewood. Some very notable trees can be found such as the London Plane Tree in Victoria Park, Hamilton, and the Mahogany in Flatts Village

A wide variety of introduced ornamental trees, some with very lovely flowers, have been planted along streets in urban areas. Fortunately an effort has been made to include endemic and native trees of ornamental value along streets too. These include many specimens of the Bermuda Cedar (*Juniperus bermudiana*), the Bermuda Palmetto (*Sabal bermudana*) and the Bermuda Olivewood (*Cassine laneana*). In cities, towns and villages, look also for specimens of the Indian Laurel tree (*Ficus retusa*), one of the Rubber Tree family. This is an example of an introduced tree of great ornamental value that seemed to be a benign introduction at first. It did not set seed and spread only where planted. However, all this changed, when a small wasp which pollinates this tree was accidentally introduced. Now this species of large, hardy tree is spreading everywhere, and may even be seen in crevices in walls or on roofs!

There are a huge variety of flowers planted in beds in parks and along roads and also growing in private gardens in the urban areas.

Along Roads, Trails and Paths

Some of the finest ornamental trees, particularly palms, have been planted beside roads all over Bermuda. As you travel around you can see these, all but the occasional specimen of the Chinese Fan Palm or Bermuda Palmetto are introduced; at least 35 introduced palm species are quite common. Another tree often seen beside roads that has magnificent flowers in early summer is the Royal Poinciana (*Delonix regia*) which is a handsome wide-spreading, large tree with smooth grey bark.

Hedges are commonly constructed of several introduced species including Oleander (*Nerium oleander*), Hibiscus (*Hibiscus rosa sinensis*), Natal Plum (*Carissa grandiflora*), Surinam Cherry (*Eugenia uniflora*) and Pittosporum or Mock Orange (*Pittosporum tobira*). All of these have become naturalized throughout the island.

A large variety of herbaceous flowering plants and a few ferns are common along roadsides. Very few of these, for example the Bermudiana (*Sisyrinchium bermudiana*) and the Bermuda Maidenhair Fern (*Adiantum bellum*) are endemic. Several, including the Purple Wood Sorrel (*Oxalis martiana*) and Cape Weed (*Phyla nodiflora*) are native, but the vast majority are introduced and many are invasive. A good example of this seen almost everywhere are the Fern Asparagus (*Asparagus densiflorus*) and the Lace or

Summary

Roads, trails and paths are often lined with interesting trees, such as stately palms. Other examples have hedges constructed of common introduced shrubs such as Hibiscus, Oleander, Surinam Cherry, Natal Plum and Pittosporum. Open areas give examples of many introduced herbs including the Fern Asparagus, Fennel and Nasturtium. **Native** and **endemic** species such as Cape Weed and Bermudiana are also common.

Bridal Fern (*Asparagus setaceus*). Neither of these plants are ferns and both are pests. Also common along roadsides and even occasionally growing between paving stones is Fennel (*Foeniculum vulgare*) introduced as an herb and Nasturtium (*Tropaeolum majus*) introduced as a garden plant.

Somewhat intermediate between a trail and a park, the Railway Trail (see Chapter 26) is a special example. It cuts through all types of habitat including urban and rural. It provides magnificent views of both inland and coastal areas and supports a huge variety of Bermudian plants in endemic, native, introduced and naturalized categories.

Summary
The Railway Trail is special in that it provides a 'green corridor' linking together all kinds of different **habitats**.

Gardens

Gardens and agricultural areas are as you would expect mostly planted with introduced species. Nevertheless gardeners have been encouraged to plant endemic and native species of ornamental value. A good example is the Bermuda Snowberry (*Chiococca bermudiana*) an endemic shrub, now found mostly in gardens. This is also true of the very attractive shrub the Virgate Mimosa (*Desmanthus virgatus*).

Most of the fruits now commonly grown in Bermuda were introduced into early gardens and small farms; these include the citrus fruits, bananas, peaches etc. One introduced fruit the Guava (*Psidium guajava*) was introduced for its fruit, but it quickly became naturalized, stopped bearing useful fruit and invaded damp environments such as Paget Marsh (Chapter 24) from where it has had to be culled to restore the natural environment; the Surinam Cherry has done much the same thing. Other fruits including the Papaya (*Carica papaya*) or Paw-paw, Loquat (*Eriobotrya japonica*) and Natal Plum (*Carissa grandiflora*) have become naturalized, but so far have not been very invasive.

Conservation Connections

As examples cited above show, the urban areas have conservation connections of all kinds, both positive and negative. Some rare and endangered endemic and native species have been planted there increasing their natural populations. City and town parks and waterfronts provide good habitats for a variety of birds. Plants in cities help to absorb pollutants in the air and reduce noise. They also have aesthetic values to the population.

On the other hand, urban areas have been responsible for the eradication of important Bermudian wild areas and habitats. Perhaps the best example of this is the total disappearance of Pembroke Marsh West, the Pembroke Stream and Bermuda's only estuary at Mill Creek (Chapter 24). Additionally, as mentioned in Chapter 25, urban development and building have been largely responsible for the demise of a whole ecosystem, the Bermuda forests. Countless smaller habitats have also disappeared and undescribed endemic species have almost certainly been rendered extinct.

Urban areas are also the source of most of the pollution in Bermuda. This pollution has degraded a host of environments and has resulted in all the freshwater habitats in Bermuda being dangerously polluted.

It is difficult to balance the needs of the human population of Bermuda against its wonderful natural heritage of plants and animals. Nevertheless, if good examples of wild places and organisms are to be preserved a balance has to be established and the continual encroachment on reasonably natural areas stopped. Every resident of Bermuda must play a part in this difficult challenge.

Questions

1) Name two introduced mammals that one might see in a town or city. If it is a pest or nuisance say so.

a) ______________________________

b) ______________________________

2) Name two introduced birds that one might see in a town or city. If it is a pest or nuisance say so.

a) ______________________________

b) ______________________________

3) Name two introduced trees that one might see in a town or city. If it is a pest or nuisance say so.

a) ______________________________

b) ______________________________

4) Name two endemic species that one might see in a town or city.

a) ______________________________

b) ______________________________

5) Why is it important that towns, cities and villages try to get some native and endemic plants growing within their limits?

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6) Species of introduced plants in urban areas can teach us useful things. List three of these things.

a) ______________________________

b) ______________________________

c) ______________________________

7) Indian Laurel trees became invasive in the recent past. Why did this happen?

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8) Where would you be likely to see Ruddy Turnstones in urban areas?

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9) What is the name of an introduced terrapin that might be seen in Pembroke Canal?

____

10) Where in Bermuda can you be sure of seeing a London Plane Tree?

____

11) Where in Bermuda can you be sure of seeing a Mahogany Tree?

____

12) Give three features of the Railway Trail that are of importance to Bermuda's natural history.

a) ____________________
b) ____________________
c) ____________________

13) Give three reasons why there is an advantage of planting trees along streets and roads.

a) ____________________
b) ____________________
c) ____________________

14) Think about the expanding built-up areas of Bermuda and give three ways that this trend might be stopped.

a) ____________________
b) ____________________
c) ____________________

15) What three features of the city do you think have importance to the natural history of Bermuda? Do not confine your answers to material covered in this chapter.

a) ____________________
b) ____________________
c) ____________________

Field Trip# 27.1 to the Railway Trail

Introduction

This field trip is a general one. More detailed field trips to specific habitats and locations are given in previous chapters

Preparation

Read this section of this field guide and if possible Chapter 26. Some knowledge of basic geology would also be of benefit (Chapter7).

Dress

No special clothing is needed but remember that walking is required and some areas of the trail can be very muddy in the rainy season, so use appropriate footwear.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group.

Suggested Route

There are several sections of the Railway Trail that pass through varied surroundings. Two examples are the section going west from Flatts and the section from just west of Somerset Bridge going towards the northeast. Other areas are equally good and consultation of a good Bermuda map will show the trail and access points in areas convenient to you.

Observation

The following suggested activities are applicable to any reasonably diverse section of the Railway Trail.

1) At the start point on the trail just go a few metres (yards) and stop. Listen and look around very thoroughly and decide what type of situation the trail is running through. Is it housing and if so how dense, is it woodland, waste ground, park, cliff-top, rock cutting etc. Look around carefully and try to list two endemic species, two native species and two introduced species. If either of the two native species is naturalized or invasive. Add that information. Fill out the form below.

   a) Description of the area around the trail. Give reasonable detail.

   ____
   ____
   ____
   ____
   ____

b)

Status of Species	Species	Naturalised/Invasive
Endemic 1		
Endemic 2		
Native 1		
Native 2		
Introduced 1		
Introduced 2		

2) Start walking along the trail. Where there is a significant difference in surroundings, repeat the observations made at stop.

   a) Description of the area around the trail. Give reasonable detail.

b)

Status of Species	Species	Naturalised/Invasive
Endemic 1		
Endemic 2		
Native 1		
Native 2		
Introduced 1		
Introduced 2		

3) Continue walking along the trail stopping again as in stop 2.

   a) Description of the area around the trail. Give reasonable detail.

Status of Species	Species	Naturalised/Invasive
Endemic 1		
Endemic 2		
Native 1		
Native 2		
Introduced 1		
Introduced 2		

4) Repeat stop 3.

a) Description of the area around the trail. Give reasonable detail.

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____
____
____
____

b)

Status of Species	Species	Naturalised/Invasive
Endemic 1		
Endemic 2		
Native 1		
Native 2		
Introduced 1		
Introduced 2		

5) Repeat stop 3.

a) Description of the area around the trail. Give reasonable detail.

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b)

Status of Species	Species	Naturalised/Invasive
Endemic 1		
Endemic 2		
Native 1		
Native 2		
Introduced 1		
Introduced 2		

6) The Railway Trail can be considered as a ‘green corridor’ that links up other wild areas in parks, reserves and private property. How do you think this function helps to maintain the natural history of Bermuda?

Field Trip # 27.2 to Downtown Hamilton

Introduction

Hamilton is the only city in Bermuda and it covers a wide area. With such an impact on natural systems, it is important that the city attempt to foster some natural, semi-natural flora and fauna within its boundaries. Additionally there is the opportunity presented to maintain endemic and native species in parks and along streets. This field trip is to examine these aspects of the city.

Preparation

Read this section of this field guide.

Dress

No special clothing is needed.

Equipment

Clipboard, pencil and several sheets of good paper. A few pairs of binoculars for the group.

Suggested Route

Start on Front Street near the cruise-ship terminals, then proceed to walk to near to the Ferry Terminal, on to Par-la-Ville Park then on to City Hall and finally, Victoria Park.

Observations

Stop 1) Front Street.

Look around and briefly describe where you are then list what you can see in terms of street trees, flower beds and birds and where they are (situation). If possible identify several organisms and state their status as endemic, native or introduced. Give their rough abundance, e.g. one only, several, lots.

Description. ____

____

____

List of organisms seen:

Species	Situation	Status	Abundance

Stop 2, Near Ferry Terminal.

Pick a spot where you can look into the water. Then repeat the observations carried out at stop1.

Description. ____

____

____

List of organisms seen:

Species	Situation	Status	Abundance

Stop 3. Par-la-Ville Park.
Go to a roughly central place in the park and look around carefully. Can you see any endemic or native species? If so list them below.

a) ____________________ b) ____________________
c) ____________________ d) ____________________

Then pick one introduced species, make a sketch of it and describe its main features.

Features ____________________

Stop 4. In front of City Hall.
Repeat the observations detailed in stop 1.
Description. ____

____

____

List of organisms seen:

Species	Situation	Status	Abundance

Stop 5. Victoria Park. Repeat the observations detailed for stop 3.

a) ____________________ b) ____________________
c) ____________________ d) ____________________

Then pick one introduced species, make a sketch of it and describe its main features.

Features ____

____

____

Chapter 28. Looking to the Future

Introduction

Many of the problems involved in the maintenance of species biodiversity, habitats and ecosystems, have been mentioned in the previous chapters of this book. This chapter will bring this information together and attempt to explore practical solutions.

Summary

Small, heavily populated **oceanic islands** like Bermuda have tremendous conservation problems. Even without people, such locations are difficult ones for animals and plants to colonise and development inevitably leads to loss of **species** and **habitats**. Habitat loss not only results from building and other development, but is greatly increased by the large number of **introduced** and **invasive** plants and pests that man has brought.

To maintain the natural history of Bermuda in a reasonably intact state is a terrific problem with many facets. We must remember that Bermuda is an oceanic island of very small size that is very densely populated with people. None of these basic facts can be altered and the population situation is likely to get worse. Any solutions must recognise this basic situation.

Oceanic islands have a high rate of **extinction** and Bermuda is no exception, some loss of species is inevitable but the presence of man accelerates the process. Probably one of the main stresses on natural systems in Bermuda is habitat loss, every time a house is built, a road constructed, a golf course developed or an anchor dropped, habitat is lost. One may think that habitat can be protected to make up for this loss, but, we must remember that habitat is also lost constantly because of the indirect effects of man. The main process here is associated with the myriad of **introduced species** many of which have become **invasive**. Even if all building development ceased, natural habitat would be continuously lost because the presence of introduced species changes the situation for all time. Introduced species compete with native and endemic ones for space, light, food, nutrients etc., and those that become invasive obviously compete successfully. When they become common, introduced species alter the micro-climate around other organisms, they change soil structure water balance and a host of other things. This makes the area more suitable for them and less so for the **endemics** and **natives**. As we have seen, introductions also bring unseen pests and diseases with disastrous consequences, for example the Cedar Blight. Some intentional introductions, brought in for excellent reasons, have not behaved as expected. Take, for example, the predatory snail the Rosy Euglandina (*Euglandina rosea*) or Predaceous Snail introduced to control the Edible Snail (*Otala lactea*), another introduction that was destroying crops. The predatory snail did indeed eat Edible Snails and their numbers declined producing an imbalance, lots of predators and declining food, predictably the predator turned to other snail food including the endemic Poecilozonites snails, which then disappeared or declined to perilously low levels. The lizard, the Jamaican Anole (*Anolis grahami*), is another example, introduced to control harmful fruit flies, it turned its diet to other things, including Ladybird beetles introduced to control scale insects. Benign introductions are hard to find; the Yellow-crowned Night Heron (*Nyctanassa violacea*) was present in Bermuda originally, but was exterminated then re-introduced. This seems like a scenario free of trouble, it would result in the reduction of the Land Crab (*Gecarcinus lateralis*) population, which had exploded without its predator. This certainly happened, but the hoped-for perfect balance is elusive. There is evidence that the herons now eat other endangered species such as the Bermuda Skink (*Eumeces longirostris*). The lesson is that species introduced to a new area may change their habits in unforeseen ways. The results of introductions are unpredictable and very frequently harmful. Recognising this, introductions are carefully monitored but unforeseen ones still occur. There are plant species around the airport that have certainly arrived unseen on visiting aircraft.

Habitat loss due to development and introduced species is compounded by that resulting from pollution. Pollution may also kill animals and plants directly. Pollution has many sources including sewage, trash and litter, oil spills, herbicides, pesticides, detergents, solvents, agricultural chemicals, anti-fouling paints, incinerator ash, etc. All these have potential to degrade environments and many do. As an example there is no un-polluted natural fresh water area left in Bermuda. Even areas of the ocean such as the sewage outfall off Hungry Bay and Castle Harbour where material is dumped are polluted.

Summary
The general problem of wildlife conservation is also complicated by extensive pollution. All freshwater habitats in Bermuda are now quite heavily polluted and most road sides are littered with trash. The ocean is plagued with oil pollution and areas are polluted with sewage

Summarised like this, the problems seem almost insoluble. We hope this is not true and there are many initiatives aimed at stopping or at least greatly slowing down activities that degrade or destroy habitats and the species within them.

Laws are enacted to help to preserve habitats and species, this helps, but enforcement is an almost insoluble problem. The key to success is education, not only of children but the entire population and the thousands of people who visit. If everyone in Bermuda is convinced that their natural history heritage is in peril and sets out to do something about it, the battle may be won!

Protection of Habitats

There are many ways in which habitats are protected in Bermuda including the National Parks, Nature Reserves and Sanctuaries. Added to these are those areas that are maintained by the Bermuda National Trust and the Bermuda Audubon Society. Among these categories the greatest legal protection is afforded to Nature Reserves within the National Park system where no collecting, harvesting or development is permitted. Nature Reserves outside the parks, designated by the Development and Planning Act are protected only from development, not from collecting or harvesting. Private Nature Reserves, have less protection in law than parks used for recreation. Critically endangered habitats outside the parks, reserves and sanctuaries have no general protection but can be protected under the Endangered Species Act providing that species designated as critically endangered live there

Summary
Habitats are protected in parks, reserves and sanctuaries but the level of protection needs enhancing.

Protection of Species

If we look at the array of species in Bermuda we find that some groups of organisms have been afforded protection through various laws enacted in the past. For examples all birds except the House Sparrow (*Passer domesticus*), Common Crow (*Corvus brachyrhynchos*), Great Kiskadee (*Pitangus sulphuratus*) and the Starling (*Sturnus vulgaris*) are protected. All marine mammals are protected, as are a list of molluscs including the Queen Conch (*Strombus gigas*) and the Calico Clam (*Macrocallista maculata*). Groupers are protected at spawning time. Specific specimens of important trees are protected by Tree Preservation orders under the Development and Planning Act.

Any species may be protected under the Endangered Species Act wherever it occurs in Bermuda. To be placed on the endangered species list an animal or plant must be shown to be in low numbers and in danger of becoming extirpated or extinct. If considered 'critically endangered' then a species recovery plan must be drawn up that has some chance of success. Once this is done, both the species

Summary
Some species such as most birds and all marine mammals are protected in older laws. A newer law 'The Endangered Species Act' makes provisions so that **endangered** species can be listed and protected. Species listed as critically endangered must have species recovery plans in place.

and its habitat receive protection under law. This system recognises the fact that it is no good designating a species as critically endangered if there is no possible way to protect it. It is also a spur to the study of endangered species, as a survival plan is impossible to draw up without solid information on a species and its habitat.

What Needs to be Done

1) Education. The most critical need is education on the status of Bermuda's natural history at all levels. The schools are an obvious place to start but adult education is equally important. If everyone is aware of the situation then correcting problems becomes much more straightforward.

There are many institutions in Bermuda making great efforts to impart knowledge on the state of natural history. One of the main ones is the Bermuda Zoological Society and its sister institution the Bermuda Aquarium, Museum and Zoo.

Together these organisations produce educational material for the schools as well as for adults. They sponsor books, periodicals and pamphlets on a wide variety of topics and also offer a series of public lectures. Experienced guides lead field trips to many locations of great importance and interest. The Bermuda Biological Station for Research is also very active in education, particularly at the university level. They also foster research on Bermudian species and habitats. The Bermuda Audubon Society and the Bermuda National Trust are dedicated to the preservation of important environments and in teaching the public about them. Organisations such as the Bermuda Underwater Institute and Dolphin Quest, also play a big part in this educational endeavour. Government too is active at several levels including education, the formulation of protective laws and their enforcement.

Summary
Although laws help, the key to success in conservation is education at all age levels in the population. Many organisations in Bermuda are dedicated to increasing this level of education and to instilling a general awareness that the preservation of what natural history remains is absolutely critical to the continuation of a good standard of life in Bermuda.

All these broadly educational efforts are vital to the conservation of species and environments and deserve a greater level of support from government and the public.

2) Knowledge. A great deal more needs to be done in regard to learning about Bermuda's natural environment and the species that live there. We cannot intelligently protect species and where they live, if we do not have accurate and detailed information about their ecology. In particular efforts must be concentrated on the ecology of endangered species, particularly those designated as critically endangered.

3) Pollution Abatement. There is no doubt that pollution is a very big problem in Bermuda, and that it is worsening as time progresses. Trash litters roadsides and areas of near-shore seabed as well as freshwater and marine wetlands. Raw sewage is discharged at sea, cesspits leak into the water table, and pesticide and herbicide residues are everywhere. Great efforts need to be made to reduce this source of environmental degradation.

4) Introduced Species. Although this source of trouble can never be stopped since natural events contribute to it, more attention needs to be paid to preventing

Summary
Other critical needs are a better knowledge of all rare, important and **endangered** species, a reduction of pollution in all **environments**, a greater effort to stop introductions, a higher level of protection of **species** and **habitats** in protected areas and enforcement of all existing laws that protect wildlife and its habitats in Bermuda.

additional species from becoming established. Any proposed intentional introductions need to be very carefully scrutinised before being approved, and efforts to curtail or remove present invasive species need to be intensified. If everyone removed an invasive plant occasionally much good would result. Additionally, people must be made aware of the fact that the release of pets into nature is extremely dangerous practice. The Red-eared Slider (*Trachemys scripta*), which arrived in this way, is a very serious threat to the already stressed freshwater environments of Bermuda.

5) Enhanced Protection. Although there is limited opportunity to establish new parks, reserves and nature sanctuaries, opportunities to do this do arise and should be seized upon. Additionally, landowners that have areas of particular natural history interest, can try to make sure these areas remain in good condition or alternatively consider donating them to an organisation that will do this.

6) Enforcement of Existing Protection. Enforcement of present laws protecting species and habitats can certainly be improved, but it is a costly and time consuming process. Everyone can help by pointing out problems and by informing offenders of the harm they are doing.

What You can do

1) Learn more about the natural history of Bermuda and its delicate nature.

2) Inform others that great efforts are needed to preserve Bermuda's natural balance.

3) Pick up trash when you see it and refrain from leaving any.

4) Try to reduce the use of harmful chemicals which degrade the environment.

5) Safely dispose of hazardous materials.

6) In wild places, parks and reserves try not to disturb anything. Keep to established paths and collect nothing except photographs and memories.

7) Help to enforce existing laws that protect species and habitats.

8) Try to recycle everything that can be recycled and urge government towards more complete recycling.

9) Join an organisation or club dedicated to environmental improvement, such as the Bermuda Zoological Society, the Bermuda Audubon Society and the Bermuda National Trust.

10) Attend lectures, summer courses, natural history camps etc. on Bermuda's Natural History.

11) Petition politicians and members of the public that have an influence on government to move towards a greater level of protection for the natural environment and wild species of Bermuda.

12) Do all that you can to foster an improved attitude towards the conservation of Bermuda's wonderful but fragile natural history. Unless the majority of the population develop this respect, the overall situation will continue to decline

Summary
The list at the left summarises what you can do to help.

Questions

1) Name three main threats to species and environments in Bermuda.

   a) ______________________________
   b) ______________________________
   c) ______________________________

2) Why are introduced species such a major threat to native and endemic species? Give three reasons.

   a) ______________________________
   b) ______________________________
   c) ______________________________

3) Describe one intentional introduction that produced unforeseen results.

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____

4) What is a "species survival plan" and how would it work?

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5) Put any four environments in Bermuda in order of their vulnerability to pollution damage, starting with the most susceptible and ending with the least.

   a) ____________________ b) ____________________
   c) ____________________ d) ____________________

6) How are individual trees of special importance protected in Bermuda?

____
____
____

7) Describe three ways in which education can help to preserve the natural history of Bermuda.

   a) ______________________________
   b) ______________________________
   c) ______________________________

8) Existing laws designed to protect the environment are difficult to enforce. Why is this so?

____
____
____

9) Name three birds that are not protected in Bermuda.

a) ______________________________
b) ______________________________
c) ______________________________

10) Which group of mammals is totally protected in Bermuda?

____
____

11) Name four things you can do to help protect Bermuda's fauna and flora.

a) ______________________________
b) ______________________________
c) ______________________________
d) ______________________________

12) What are two things that you are permitted to take with you after visiting a nature reserve?

a) ____________________ b) ____________________

13) List three organisations in Bermuda that help to protect its natural history.

a) ______________________________
b) ______________________________
c) ______________________________

14) If you were the minister of the environment, what would you make your top priority in environmental protection? Give your reasons.

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____

15) Name one pet animal that has been released to the wild in Bermuda and is now invading a stressed habitat. ______________________________

Part 4. Identification Guide to Geologic Features and the Common, Rare, Endemic, Native and Important Animals and Plants found in Bermuda

How to use this part

Introduction

This part has been included in this book to enable you to identify any reasonably common geological feature, animal or plant that you encounter on the field trips detailed in the previous parts of this book. If you find something that is not included in this part it may be rare or damaged in some way so that it does not show the typical features.

It is advisable to identify what you see in the field. It is bad practice to collect living organisms and bring them back to the school or laboratory for identification, but occasionally it may be allowable in the case of abundant plants, where removal of a small branch or twig, may help in identification later. Although you may think that the collection of dead animal or plant parts cannot do any harm, this is not true. Dead parts may form microhabitats for other organisms, may provide a food source for another creature or may be used by another organism as a shell. This latter is true of hermit crabs. Alternatively dead material may be collected for use as camouflage, as is done by some sea urchins and insect larvae. However, probably the most frequent way that dead material is used, is that it is attacked by microscopic bacteria and fungi and broken down into **detritus**. Detritus itself is a widely used food but equally important is the fact that the breakdown process releases inorganic nutrients required by plants and animals.

To identify what you find in the field, a group will need several copies of this identification guide. If the guide is in short supply, then make good notes of the appearance of whatever you are trying to identify. Especially important are size, colour, texture, habitat, and if appropriate, behaviour. It is especially helpful if you know which group of organisms the specimen falls into, for instance, ferns, red seaweeds, trees, flowering herbs, birds, mammals, fish, crabs, sea urchins etc. However, this may not be easy in some cases, for example a blue-green cyanobacterium may resemble a red seaweed, and a moss animal may resemble a brown seaweed. In such cases just note as much detail as you can and try to remember what the organism looked like. It is especially helpful to make a good sketch including a scale bar that shows a standard length such as a centimetre, a metre, an inch or yard. A scale bar is simply a line representing the unit of measure that you choose.

Identification in this guide is primarily by the use of pictures, but there is a key (explained below) to help you to get to the right group of organisms. Each feature or organism is shown in a black and white illustration that is accompanied by a short written description. If colour is important to identification it will be mentioned in the written description. For all organisms, sizes in both metric and imperial units are given, but be aware these are the average sizes and actual specimens may be either somewhat larger or smaller.

The guide to the identification of living organisms is mainly organised on a taxonomic basis. This simply means that we start with bacteria, followed by plants and then animals. Within each of these groups more primitive ones come first and more highly developed ones later. Generally, more simply organised ones precede more complex ones, but be aware that some highly developed animals may be quite simple in structure, for example the sea squirts are very advanced creatures, not much different from those which gave rise to the higher animals. So be careful not to jump to conclusions. In a few cases, the key is organised on a habitat basis rather than a taxonomic one. This is only done where there is virtually no overlap in organism content between habitats. The main examples here are the plant plankton, the animal plankton and the Sargassum Weed community. If you are working with any of these communities you can go to that part of the identification section as shown in the list below.

Identification Procedure
First decide if the specimen is a geological feature or an organism. For geological features go to the section of the guide immediately following this and compare what you see with the pictures. Be aware that some geological features are very large and others quite small. Some of the illustrations in Chapter 7 may also be of help.

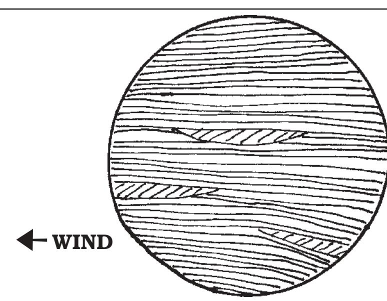
For organisms several approaches are possible. If you already know which group of living things the specimen belongs to, you can go directly to that group in the list of groups and their page numbers listed below. This is obviously the best approach for groups such as birds, lizards, butterflies and ants as well as many others. However, do not jump to conclusions in cases where you are not sure. For example a hydroid may be confused with an anemone and a moss animal with a brown or red seaweed. If you do not know which group of organisms the specimen belongs to, then try the key to Groups of Organisms below. This will work in most cases but not in all. In the latter situation the best approach is to get advice from someone who knows the groups of living organisms well.

If you have not used a key before some instruction is needed. The first rule is always start at the beginning. If you jump in part way through the key, you may miss an essential feature mentioned earlier. The second main point about a key is that you proceed according to the numbers given in each step. The first step will have a number 1 before two or more choices. At this stage ignore the numbers following each choice. Look at all the choices with the number 1 at the left and decide which one fits your specimen. Having done this, look at the number at the end of your choice, which may be any number higher than 1. This tells you where to go next. If your selected choice is followed by a 2, go to the choices preceded by a 2. If your best choice is followed by 50, jump through the key to that point. Proceed in this way until your selection is followed by the name of a group instead of a number. Then find that group and the page number it begins on in the following list. Note that if the group is followed by the words (**in part**) other members of the group will be keyed out by following a different route through the key.

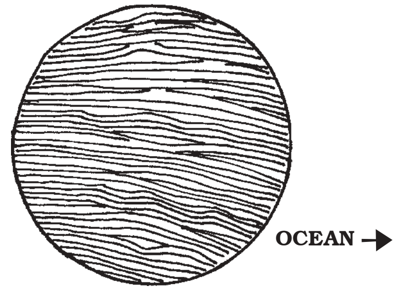
Once you have arrived at a group by whatever means was appropriate, compare your specimen with those described and shown in the illustrations. If some feature, for example size is obviously wrong, check again. It is best to note both the scientific and common names of organisms you identify for reasons given in chapter 3.

Illustrations of Geological Features

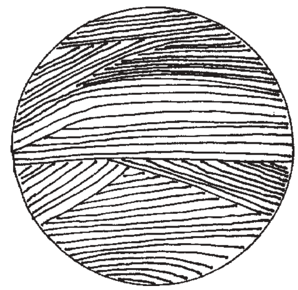
Backset or Windward Beds
Groups of strata laid down on the windward side of sand dunes. These strata are typically fairly gently sloping at angles of between 10 and 20 degrees to the horizontal.



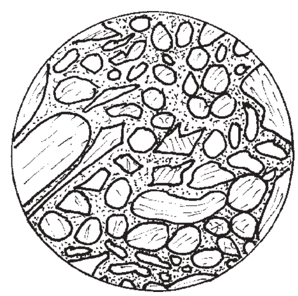
Backshore Beds
Marine deposits above the high tide line of sandy beaches only reached by storm waves. These beds are quite variable and may undulate but slope slightly towards the sea. Often with coarse particles or shell remains.



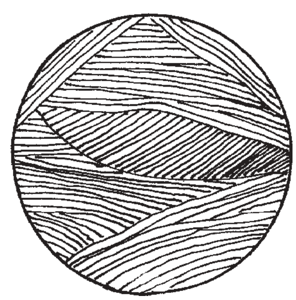
Bedding (Strata)
The layering of sedimentary rocks. In Bermuda the layers or strata are the fossilised remains of layers of limestone sand laid down during dune formation and then lithified to become aeolianite. Strata are commonly a few mm to a few cm (1 1/10 to a few in) in thickness.



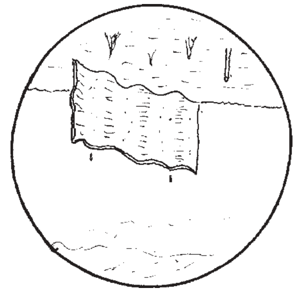
Conglomerate
A rock type consisting of broken pieces of rock, cemented together in a matrix of finer particles. In Bermuda this type of rock forms along precipitous coastlines as aeolianite collapses in rubble which in-fills with sand and is later lithified.



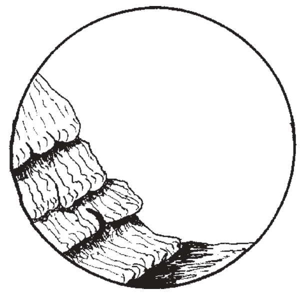
Cross Bedding
Bedding in which there is a mixture of bed types as the result of erosion of one dune body and the subsequent laying down of beds on the eroded surface.



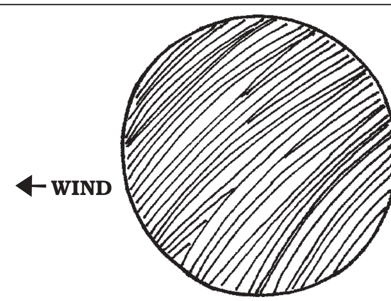
Curtains
Speleothems or cave features found hanging from the roofs of caves, formed when water saturated with lime evaporates all along a crack or elongated bump. Curtains are uncommon undulating formations that are very variable in length and thickness.



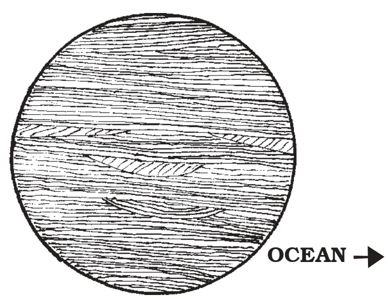
Flow Stones
Speleothems or cave features formed when water flowing down a cave wall or incline evaporates. Flowstones are generally ridged in a lateral direction and waved or undulating in the longitudinal direction.



Foreset or Leeward Beds
Groups of strata laid down on the leeward side of sand dunes. These strata are typically steeply sloping at an angle of about 35° to the horizontal.

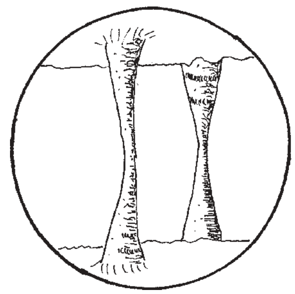


Foreshore Beds
These are marine beds representing the inter-tidal or middle portion of a sandy beach. The strata are typically thin and the slope just a few degrees to the horizontal, towards the sea. There are often small sections with mild cross bedding.

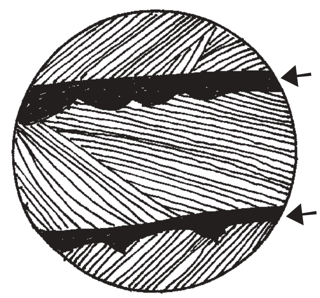


Phytokarst
The very spiky or jagged surface in the supralittoral zone of rocky limestone shores produced by the action of blue-green cyanobacteria, particularly Hofmann's Scytonema. The spikes are up to 12 cm (5 in) high.

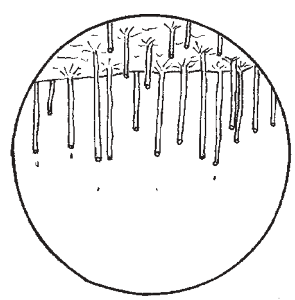
Pillars or Columns
Speleothems or cave features formed when a stalactite joins to a stalagmite forming a vertical pillar. Once joined the pillar increases very slowly in width.



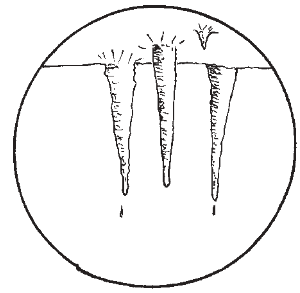
Red Beds or Red Geosols
Layers of lithified red soil laid down in stable periods in the past and consisting of a mixture of atmospheric dust particles and sand grains. These beds are rusty-red in colour and vary from a few cm to 1 m (inches to a few feet) thick.



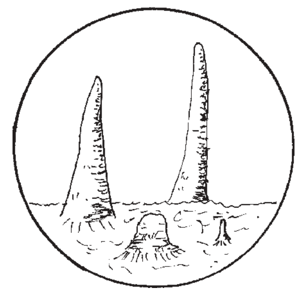
Soda Straws
Speleothems or cave features found hanging down from the roofs of many caves. These features are about the size and shape of a drinking straw and very delicate. They are generally straight but odd ones curl or grow sideways. Up to about 1 m long.



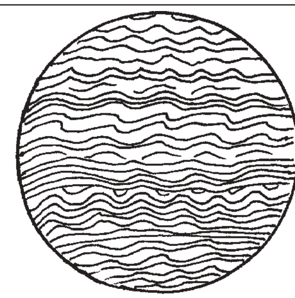
Stalactites
Speleothems or cave features formed through the evaporation of water saturated with calcium carbonate as it drips from the roof of the cave. Their formation is a very slow process and the shape is an elongated cone. The size is very variable.



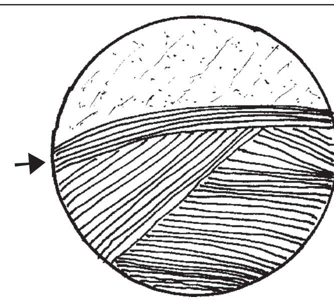
Stalagmites
Speleothems or cave features formed through the evaporation of water saturated with calcium carbonate as it drips from the end of a stalactite or the cave roof to the cave floor. There are elongated cone forms sticking up. The size is very variable.



Subtidal Beds (Nearshore)
Beds formed in sand just below low tide level. These beds are characterised by a rippled or wavy structure formed in the oscillating currents close to the shore.



Surface or Topset Beds
Beds Strata laid down parallel to the surface of dunes in a convex set on the top of the dune. Not always present as they are often removed by later erosion of the surface.



Groups of Animals and Plants that are Discussed and Illustrated

Key to Groups of Organisms

1. Colonies of the organism appear as pink or black patches, sometimes with white areas, at the surface of brackish, polluted water bodies. There is often an accompanying smell of hydrogen sulphide (rotten eggs). – **Bacterium**. (*Beggatiotoa* species). 395.

1. Organism an immobile brown rubbery lump, an oil-like black spot or layer on intertidal rock, a matte black coating of supralttoral rocks, a pink layer within limestone, a dark circle on living corals or a dark purplish layer on mangrove roots just above high tide level. – **Blue-green Cyanobacteria.** 395.

1. Organism attached to, or rooted in soil, an animal, plant or rock, and colourless, whitish, grey, green, brown or reddish in colour. In full sunlight may be bleached to a very pale shade. – **2.**

1. Organism usually very small and drifting or swimming weakly below the surface of the open ocean or other saltwater body. – **3.**

1. Organism living in a raft of Sargasso Weed at the surface of the ocean or in a bay. **– Sargassum Community**. 463.

1. Organism a mobile animal. – **4**.

2. Living on land. – **5**.
2. Living in water. – **6**.

3. Usually mostly colourless and often very transparent, weakly swimming or drifting. –**Animal Plankton**. 454.
3. Usually pigmented but may be very pale, weakly swimming or drifting. – **Plant Plankton**. 397.

4. Living on land or in freshwater. – **7**.
4. Living in or right on the edge of seawater. – **8**.

5. Some shade of grey in colour and on the bark of trees and shrubs. – **Lichens**. 400.
5. With at least some green parts. – **9**.

6. Organism clearly tubular in structure or some other shape and dotted with small openings. – **10.**
6. Organism some other shape. If tubular only on a very small scale. If openings are present, they are few in umber and relatively large. – **11**.

7. With 6 or more legs (Note microscopic examination may be needed for small individuals). – **12**.
7. With 4 or 2 legs or without legs. – **13**.

8. With obvious legs or arms, or legs modified as flippers. – **14**.
8. Without obvious legs. - **15**

9. Leafless or with very tiny leaves. – **16**.
9. Having leaves or fronds that are clearly visible – **17**.

10. A hard tube cemented to rock or lying in sediment – **Gastropoda (in part) [Tube shells]** 504.
10. A soft tube or some other shape with a porous surface or dotted with numerous openings. – **Sponges (in part)** 471.

11. Organism bright green (may be a pale pastel shade). – **Seaweeds - Green Algae**. 400.
11. Organism some other colour. – **18**.

12. With 6 jointed legs. – **Insects**. 485.
12. With more than 6 legs. – **19**.

13. With 4 legs. – **20.**
13. With less than 4 or no legs. – **21**.

14. With legs modified as flippers. – **Whales and Dolphins**. 567.
14. With arms or jointed legs. – **22**.

15. Swimming in the water. – **23**.
15. Crawling on, or burrowing in the bottom. – **24**.

16. In swampland at the base of trees. **Clubmosses**. 415.
16. In saltmarshes or at the back of mangrove swamps. **Herbaceous Flowering Plants (in part)** (*Salicornia perennis*, Woody Glasswort). 420.

17. Small plants of damp locations with numerous, small scale-like leaves. **Mosses**. 411.
17. Larger plants with fronds or flattened leaves. – **25**.

18. Reddish, pinkish or a very pale pastel pink in colour. May form a hard sheet on rock, or have a firm or soft branched structure. – **Seaweeds - Red Algae**. 407.
18. Some other colour. – **26.**

19. With 8 legs. – **Spiders. (Ticks and Mites).** 496.
19. With numerous legs. – **Centipedes and Millipedes.** 495.

20. With hair or fur, warm blooded. – **Land Mammals**. 567.
20. With a smooth or scaly body or a body encased in a hard carapace. – **27**.

21. With 2 legs and feathers. – **Birds**. 553.
21. With a single foot. – **Gastropoda - Slugs and Snails (in part).** 505.

22. With 2-10 arms bearing suckers. – **Squids and Octopuses (in part)**. 517.
22. With jointed legs – **Crustacea (in part)**. 497.

23. With at least 4 tentacles trailing from a soft body. **Jellyfishes**. 480.
23. With a firm body with fins. – **Fish**. 523.

24. Crawling on or moving over the bottom. – **28**.
24. Burrowing into the bottom. – **29**.

25. Plants with fountain-like groups, or single, graceful fronds, or as a group of simple, small rounded leaves at the surface of freshwater, and never flowering. – **Ferns**. 412.
25. Plants with flattened or elongated leaves. – **30**.

26. Organisms are brown and thread-like or have flattened blades or a branched structure and may be stiff but not hard. – **31**.
26. Organisms of many shapes and textures. – **32**.

27. Body encased in a hard carapace. – **Turtles and Terrapins**. 551.
27. Body scaly, smooth or warted. – **33**.

28. With jointed legs – **Crustacea (in part)**. 497.
28. With a single foot or no apparent feet, may have arms. – **34**.

29. With a bivalved shell. – **Clams and Mussels (in part)**. 513.
29. Lacking a bivalved shell. – **35**.

30. Plant a tree. – **Trees**. 447.
30. Plant not a tree. – **36**.

31. Flattened blades with a small honeycomb-like texture, quite stiff. - **Moss Animals (in part)**.
31. Surface texture smooth or slightly rough. – **Seaweeds - Brown Algae**. 406.

32. Organisms forming <u>hard</u> mounds, lumps, disks, lobes, bivalved or branched structures on reefs or rocks. – **37.**
32. Organism not hard. – **38.**

33. Body scaly or smooth. Living in dry habitats. – **Lizards**. 551.
33. Body smooth or warted. Living in damp habitats. – **Frogs and Toads**. 550.

34. With a single foot. – **39**.
34. With no visible foot, but may have arms. – **40**.

35. With a single coiled shell. – **Gastropoda-Snails (in part)**. 505.
35. Without a shell. – **41**.

36. Plant a shrub, usually having several stems arising from the ground. – **Shrubs**. 440.
36. Plant not a shrub. – **42**.

37. Animal a bivalved shell cemented to rock or reef surface. – **Clams and Mussels (in part).** 513.
37. Animal is a hard dome, lump, branched structure, disc, funnel shape or pillar attached to a reef surface. **Corals.** 477. **(Note the coral-like hydroid, Fire Coral also keys out here)**

38. Animal very small with a stem or stems, from which arise tiny projections with a ring of tentacles. – **Hydroids**. 474.
38. Animal not very small. – **43**.

39. With a single coiled or conical shell. – **Gastropoda-Snails (in part)**. 505.
39. Without a shell or with an uncoiled or segmented shell. – **44**.

40. With 8 arms bearing suckers. – **Octopus**. 517.
40. With no visible foot. – **Echinoderms (in part)**. 519.

41. Having a relatively stout body. – **Echinoderms-Sea Cucumbers (in part)**. 521.
41. Having a relatively slender body. – **Polychaete Worms (in part)**. 484.

42. Plant with a long trailing stem. – **Vines**. 437.
42. Plant without a long trailing stem. – **45**.

43. Animal with an unprotected soft body and a ring of tentacles. – **Anemones**. 481.
43. Animal lacking either a ring of tentacles or an unprotected body. – **46**.

44. With a segmented shell, found in the lower rocky intertidal zone. – **Chitons**. 503.
44. Without a shell or with an uncoiled shell – **47**.

45. Without a true flower and generally with elongated leaves. – **Grasses**. 415. **Sedges** (419) **and Rushes** (418).
45. Having a true flower (may be present only seasonally). – **Herbaceous Flowering Plants (in part)**. 420.

46. Animal with a ring of tentacles and a body encased in a protective tube. – **Polychaete Worms (in part)**. 484.
46. Animal without a protective tube. – **48**.

47. With an uncoiled conical shell in the rocky intertidal zone. – **Limpets**. 504.
47. Without a shell. – **Sea Slugs**. 504.

48. Animal encased in a tiny, red, coiled, perforated shell underneath submerged rocks. – **Foraminiferans**. 471.
48. Animal not tiny. – **49**.

49. Animal lumpy, tubular or sheet-like with numerous openings at the surface of the body. – **Sponges (in part)**. 471.
49. Animal attached to or burrowed in rock or shell, tall and branched or whip like, or barrel-shaped. – **50.**

50. Animal encased in rock or shell, showing as numerous red, orange or yellow spots. - **Sponges (in part)**. 471.
50. Animal not encased in rock. – **51**.

51. Animal a whip-like or branched upright but not hard structure on reefs or rocks. - **Soft Corals**. 475.
51. Animal either a solitary rubbery individual or a colony of smaller softer individuals, both having two openings near the top of the body. – **Sea Squirts**. 522.

Note on the 'List of Species' following: Common names are listed in the first column except where there is no accepted common name, in these cases the scientific name is used. For each group of organisms, the common names are in alphabetical order. The habitat codes defined in the key before the list show where organisms are commonly found. The illustrations following this list are in the same order as the list and are also accompanied by habitat codes. If you wish to find information on a single species use the index to find the pages where the species is mentioned.

List of Species Mentioned and/or Illustrated in this Book

Key to Habitat Codes

B = Lagoons, Bays and Coastal Waters	OC = Open Coastal
C = Coral Reefs	R = Rocky Shores
CA = Caves and Cave Mouths	S = Sandy Shores
CL = Cliffs and Steep Rocky Coasts	SD = Sand Dunes
EX = Extinct	SG = Seagrass Beds
F = Forest	SP = Saltwater Ponds
FW = Freshwater Habitats	U = Urban Environments
M = Mangrove Swamps and Salt Marshes	W = Wasteland, Open Spaces, Wayside
O = Open Ocean	

Note: Common names are listed in the first column except where there is no accepted common name, in these cases the scientific name is used. For each group of organisms, the common names are in alphabetical order. The habitat codes defined in the key before the list show where the organisms are commonly found. The illustrations following this list are in the same order as the list and are also accompanied by habitat codes. If you wish to find information on a single species use the index to find the pages where the species is mentioned.

Common Name	**Scientific Name**	**Taxonomy**	**Habitat Code**
Beggiatoa	Beggiatoa species	Bacterium	SP
Algal Biscuits	Phormidium hendersonii	Blue-green Cyanobacteria	B
Black Band Disease	Phormidium corallyticum	Blue-green Cyanobacteria	C
Hofmann's Scytonema	Scytonema hofmanni	Blue-green Cyanobacteria	R
Oil-spot Blue-green	Calothrix crustacea	Blue-green Cyanobacteria	R
Oscillatoria	Lyngbya lutea	Blue-green Cyanobacteria	M, SP
Pink Blue-Green	Entophysalis deusta	Blue-green Cyanobacteria	R
Stromatolites	Phormidium corium	Blue-green Cyanobacteria	B, SG
Trichodesmium thiebautii	Trichodesmium thiebautii	Plant Plankton - Blue-green Cyanobacteria	O
Cerataulina bergonii	Cerataulina bergonii	Plant Plankton - Diatoms	O
Chaetoceros glaudazii	Chaetoceros glaudazii	Plant Plankton - Diatoms	O
Guinardia flaccida	Guinardia flaccida	Plant Plankton - Diatoms	O
Leptocylindrus danicus	Leptocylindrus danicus	Plant Plankton - Diatoms	O
Rhizosolenia shrubsoleii	Rhizosolenia shrubsoleii	Plant Plankton - Diatoms	O
Thalassonema nitzschoides	Thalassonema nitzschoides	Plant Plankton - Diatoms	O
Anoplosolenia brasiliensis	Anoplosolenia brasiliensis	Plant Plankton - Coccolithophores	O
Discosphaera tubifera	Discosphaera tubifera	Plant Plankton - Coccolithophores	O
Emiliana huxleyi	Emiliana huxleyi	Plant Plankton - Coccolithophores	O
Ceratium furca	Ceratium furca	Plant Plankton - Dinoflagellates	O
Ceratium fusus	Ceratium fusus	Plant Plankton - Dinoflagellates	O
Gonyaulax polygramma	Gonyaulax polygramma	Plant Plankton - Dinoflagellates	B, O
Gyrodinium spirale	Gyrodinium spirale	Plant Plankton - Dinoflagellates	B, O
Peridinium brochii	Peridinium brochii	Plant Plankton - Dinoflagellates	O
Prorocentrum gracile	Prorocentrum gracile	Plant Plankton - Dinoflagellates	B, O
Pyrocystis noctiluca	Pyrocystis noctiluca	Plant Plankton - Dinoflagellates	O
Fire Lichen	Pyrenula aurantiaca	Lichens	M
Parmelia martinicana	Parmelia martinicana	Lichens	F, OC
Physcia alba	Physcia alba	Lichens	F
Ramalina denticulata	Ramalina denticulata	Lichens	F
Black Sea Threads	Cladophora catenata	Seaweeds - Green Algae	B, R
Common Pincushion	Cladophora prolifera	Seaweeds - Green Algae	B
Common Plateweed	Halimeda incrassata	Seaweeds - Green Algae	B
Common Sea Kale	Anadyomene stellata	Seaweeds - Green Algae	B, R

Crinkle Grasses	Rhizoclonium spp.	Seaweeds - Green Algae	B, M
Crisp Sea Threads	Cladophora crispula	Seaweeds - Green Algae	R
Dead Man's Finger (Alga)	Codium decorticatum	Seaweeds - Green Algae	B
Disc Plateweed	Halimeda tuna	Seaweeds - Green Algae	B
Feather Sand Moss	Caulerpa sertularioides	Seaweeds - Green Algae	B, SP
Flathead Shaving Brush	Penicillus pyriformis	Seaweeds - Green Algae	B
Grape Sand Moss	Caulerpa racemosa	Seaweeds - Green Algae	B, SP
Green Cushionweed	Cladophoropsis membranacea	Seaweeds - Green Algae	B
Hard Fanweed	Udotea flabellum	Seaweeds - Green Algae	B, SP
Hard Funnelweed	Udotea cyathiformis	Seaweeds - Green Algae	B
Horsetail Sand Moss	Caulerpa verticillata	Seaweeds - Green Algae	B
Light Brittle Grass	Chaetomorpha linum	Seaweeds - Green Algae	M, R
Mermaid's Wine Glass	Acetabularia crenulata	Seaweeds - Green Algae	B, SP
Merman's Shaving Brush	Penicillus capitatus	Seaweeds - Green Algae	B, SP
Mexican Sand Moss	Caulerpa mexicana	Seaweeds - Green Algae	B, M, SP
Sea Balloon	Valonia macrophysa	Seaweeds - Green Algae	B
Sea Down	Bryopsis plumosa	Seaweeds - Green Algae	B
Sea Feather	Bryopsis pennata	Seaweeds - Grean Algae	B, C
Sea Intestines	Enteromorpha flexuosa	Seaweeds - Green Algae	B
Seathreads	Cladophora spp.	Seaweeds - Green Algae	B, R
Slender Plateweed	Halimeda monile	Seaweeds - Green Algae	B
Soft Fanweed	Avrainvillea nigricans	Seaweeds - Green Algae	B, SP
Strap Sea Lettuce	Ulva fasciata	Seaweeds - Green Algae	R
Tapered Shaving Brush	Penicillus dumetosus	Seaweeds - Green Algae	B
Thin Sea Lettuce	Monostroma oxyspermum	Seaweeds - Green Algae	B, R
Tufted Jointweed	Cymopolia barbata	Seaweeds - Green Algae	B
Bermuda Sargasso Weed	Sargassum bermudense	Seaweeds - Brown Algae	SP
Common Ribbonweed	Dictyota menstrualis	Seaweeds - Brown Algae	B, C
Iridescent Stripeweed	Stypopodium zonale	Seaweeds - Brown Algae	C
Jamaican Petticoat	Padina jamaicensis	Seaweeds - Brown Algae	B
Banded Threadweed	Ceramium byssoideum	Seaweeds - Red Algae	B, C
Crustose Coralline Algae	Lithothamnion spp., Lithophyllum spp.	Seaweeds - Red Algae	B, C
Curly Sea Moss	Bostrychia montagnei	Seaweeds - Red Algae	M
Heartweed	Halymenia bermudensis	Seaweeds - Red Algae	B, SP
Laurence's Clubweed	Laurencia obtusa	Seaweeds - Red Algae	B, SG, R
Laurence's Tufted Weed	Laurencia papillosa	Seaweeds - Red Algae	B
Low Siphonweed	Herposiphonia secunda	Seaweeds - Red Algae	R
Pointed Needleweed	Amphiroa fragilissima	Seaweeds - Red Algae	B, C
Red Boneweed	Galaxaura obtusa	Seaweeds - Red Algae	B, C
Red Tongueweed	Caloglossa leprieurii	Seaweeds - Red Algae	B, C
Scaleweed	Fosliella farinosa	Seaweeds - Red Algae	SG
Siphonweeds	Polysiphonia spp.	Seaweeds - Red Algae	B, C, R
Soft Spineweed	Acanthophora spicifera	Seaweeds - Red Algae	B
Stickweed	Wurdemannia miniata	Seaweeds - Red Algae	B
Stiff Sea Moss	Bostrychia binderi	Seaweeds - Red Algae	R
Thicketweed	Spyridia hypnoides	Seaweeds - Red Algae	B
Bermuda Campylopus	Campylopus bermudiana	Mosses	F, FW
Bermuda Trichostoma	Trichostomum bermudanum	Mosses	F, FW, OC, U, W
White Moss	Leucobryum glaucum	Mosses	FW
Bermuda Cave Fern	Ctenitis sloanei	Ferns	CA
Bermuda Maidenhair Fern	Adiantum bellum	Ferns	CA, CL, F, W
Bermuda Shield Fern	Dryopteris bermudiana	Ferns	F, CA
Cinnamon Fern	Osmunda cinnamomea	Ferns	FW
Giant Fern	Acrostichum danaeifolium	Ferns	FW

Governor Laffan's Fern	Diplazium laffanianum	Ferns	EX
Long Spleenwort	Asplenium heterochroum	Ferns	CA, F, W
Long-leaved Brake	Pteris longifolia	Ferns	F, U, W
Marsh Shield Fern	Thelypteris thelypteroides	Ferns	FW
Plume Polypody	Polypodium plumula	Ferns	CL, F
Royal Fern	Osmunda regalis	Ferns	FW
Southern Bracken	Pteridium aquilinum	Ferns	FW
Sword Fern	Nephrolepis exaltata	Ferns	F
Ten-Day Fern	Polystichum adiantiforme	Ferns	FW
Virginia Chain Fern	Woodwardia virginica	Ferns	FW
Water Fern	Salvinia olfersiana	Ferns	FW
Psilotum	Psilotum nudum	Clubmosses	F, FW
Burr-grass	Cenchrus tribuloides	Grasses	SD
Cow-cane	Arundo donax	Grasses	FW, W
Crab Grass or St. Augustine Grass	Stenotaphrum secundatum	Grasses	OC, W
Joint Grass	Paspalum distichum	Grasses	FW, W
Para Grass	Brachiaria mutica	Grasses	FW, W
Saw Grass	Cladium jamaicense	Grasses	FW
Seashore Rush Grass	Sporobolus virginicus	Grasses	OC, R
Sheathed Paspalum	Paspalum vaginatum	Grasses	FW, SP
Switch Grass	Panicum virgatum	Grasses	FW, OC
Woodgrass	Oplismenus setarius	Grasses	F
American Great Bullrush	Schoenoplectus lacustris	Rushes	FW
Bermuda Spike Rush	Eleocharis bermudiana	Rushes	FW
Knotted Spike Rush	Eleocharis interstincta	Rushes	FW
Large Marsh Rush	Juncus acutus	Rushes	FW
Narrow-leaved Cattail	Typha angustifolia	Rushes	FW
Sea Rush	Juncus maritimus	Rushes	M
Stipitate Beaked Rush	Rhynchospora stipitata	Rushes	FW
White-Headed Rush	Rhynchospora colorata	Rushes	FW
Baldwin's Cyperus	Cyperus globolusus	Sedges	FW
Bermuda Sedge	Carex bermudiana	Sedges	F
Short-leaved Kyllinga	Kyllinga brevifolia	Sedges	FW
Umbrella Sedge	Cyperus alternifolius	Sedges	FW
Beach Croton	Croton punctatus	Herbaceous Flowering Plants	SD
Beach Lobelia	Scaevola plumieri	Herbaceous Flowering Plants	SD
Bear's Foot	Polymnia uvedalia	Herbaceous Flowering Plants	F, W
Beggar-ticks or Shepherd's Needle	Bidens pilosa	Herbaceous Flowering Plants	F, W
Bermuda Bedstraw	Galium hispidulum	Herbaceous Flowering Plants	F, W
Bermudiana	Sisyrinchium bermudiana	Herbaceous Flowering Plants	OC, U, W
Bird Pepper	Capsicum baccatum	Herbaceous Flowering Plants	F
Black Nightshade	Solanum americanum	Herbaceous Flowering Plants	F, W
Blodgett's Spurge	Euphorbia blodgetti	Herbaceous Flowering Plants	CL, OC, W
Cape Weed	Phyla nodiflora	Herbaceous Flowering Plants	OC, SD, W
Coast Spurge	Euphorbia mesembrianthemifolia	Herbaceous Flowering Plants	R
Common Plantain	Plantago major	Herbaceous Flowering Plants	U, W
Darrell's Fleabane	Erigeron darrellianus	Herbaceous Flowering Plants	W
Day Flower	Commelina longicaulis	Herbaceous Flowering Plants	FW
Ditchweed or Hornwort	Ceratophyllum demersum	Herbaceous Flowering Plants	FW
Dog Fennel	Eupatorium capillifolium	Herbaceous Flowering Plants	FW
Duckweed	Lemna minor	Herbaceous Flowering Plants	FW
Dwarf Seagrass	Halophila decipiens	Herbaceous Flowering Plants	B, SG
Easter Lily	Lilium longiflorum	Herbaceous Flowering Plants	W
Elephant's Ear or Eddoe	Epiremnium aureum	Herbaceous Flowering Plants	FW

English Plantain	Plantago lanceolata	Herbaceous Flowering Plants	W
False Nettle	Boehmeria cylindrica	Herbaceous Flowering Plants	FW
Fennel	Foeniculum vulgare	Herbaceous Flowering Plants	U, W
Fern Asparagus	Asparagus densiflorus	Herbaceous Flowering Plants	F, W
Flopper or Life Plant	Kalanchoe pinnata	Herbaceous Flowering Plants	U, W
Jamaica Vervain	Stachytarpheta jamaicensis	Herbaceous Flowering Plants	OC, SD, W
Jamaica Weed	Nama jamaicense	Herbaceous Flowering Plants	OC, W
Joseph’s Coat	Euphorbia heterophylla	Herbaceous Flowering Plants	U, W
Lace Fern or Bridal Fern	Asparagus setaceus	Herbaceous Flowering Plants	F, W
Low Cudweed	Gnaphalium viliginosum	Herbaceous Flowering Plants	W
Manatee Grass	Syringodium filiforme	Herbaceous Flowering Plants	B, SG
Marsh Eclipta	Eclipta alba	Herbaceous Flowering Plants	FW
Marsh Purslane	Ludwigia palustris	Herbaceous Flowering Plants	FW
Mermaid Weed	Proserpinaca palustris	Herbaceous Flowering Plants	FW
Monnier’s Hedge Hyssop	Bramia monniera	Herbaceous Flowering Plants	W
Nasturtium	Tropaeolum majus	Herbaceous Flowering Plants	U, W
New Zealand Spinach	Tetragonia tetragonioides	Herbaceous Flowering Plants	M, W
Ovate Leaved Marsh Pennywort	Centella asiatica	Herbaceous Flowering Plants	W
Prickly Pear	Opuntia stricta	Herbaceous Flowering Plants	OC, W
Purple Wood Sorrel	Oxalis martiana	Herbaceous Flowering Plants	W
Purslane	Portulaca oleracea	Herbaceous Flowering Plants	F, O
Red Pellitory	Parietaria floridana	Herbaceous Flowering Plants	W
Rhacoma	Crossopetalum rhacoma	Herbaceous Flowering Plants	F
Saltmarsh Oxeye	Borrichia frutescens	Herbaceous Flowering Plants	M
Scarlet Pimpernel	Anagallis arvensis	Herbaceous Flowering Plants	S, SD
Scurvy Grass or Sea Rocket	Cakile lanceolata	Herbaceous Flowering Plants	S, SD
Sea Lavender	Limonium carolinianum	Herbaceous Flowering Plants	M
Sea Oxeye	Borrichia aborescens	Herbaceous Flowering Plants	OC
Seaside Daisy	Wedelia trilobata	Herbaceous Flowering Plants	OC, SD
Seaside Evening Primrose	Oenothera humifusa	Herbaceous Flowering Plants	SD
Seaside Goldenrod	Solidago sempervirens	Herbaceous Flowering Plants	OC
Seaside Heliotrope	Heliotropium curassavicum	Herbaceous Flowering Plants	M
Seaside Purslane	Sesuvium portulacastrum	Herbaceous Flowering Plants	OC, R
Shoal Grass	Halodule wrightii	Herbaceous Flowering Plants	B, SG
Spanish Bayonet	Yucca aloifolia	Herbaceous Flowering Plants	OC, SD, W
St. Andrew’s Cross	Hypericum macrosepalum	Herbaceous Flowering Plants	FW, W
Turkey Berry	Callicarpa americana	Herbaceous Flowering Plants	F
Turnera	Turnera ulmifolia	Herbaceous Flowering Plants	W
Turtle Grass	Thalassia testudinum	Herbaceous Flowering Plants	B, SG
Water Hyacinth	Eichornia crassipes	Herbaceous Flowering Plants	FW
Water Hyssop	Bacopa monnieria	Herbaceous Flowering Plants	FW
Water Smartweed	Polygonum punctatum	Herbaceous Flowering Plants	FW
White Eupatorium	Eupatorium riparium	Herbaceous Flowering Plants	F, U, W
White Pellitory	Parietaria officinalis	Herbaceous Flowering Plants	W
Whorled Marsh Pennywort	Hydrocotyle verticillata	Herbaceous Flowering Plants	FW
Widgeon Grass	Ruppia maritima	Herbaceous Flowering Plants	FW, SP
Wild Bermuda Pepper	Peperomia septentrionalis	Herbaceous Flowering Plants	CA, F
Wild Stock	Matthiola incana	Herbaceous Flowering Plants	SD
Wire-weed	Sida carpinifolia	Herbaceous Flowering Plants	W
Woody Glasswort or Marsh Samphire	Salicornia perennis	Herbaceous Flowering Plants	M
Balloon Vine	Cardiospermum halicacabum	Vines	F, U
Bay Bean	Canavali lineata	Vines	F, OC, SD
Bermuda Bean	Phaseolus lignosus	Vines	F

Blue Dawn Flower or Morning Glory	Ipomea indica	Vines	F, M, W
Brier-Bush or Grey Nickers	Caesalpinia bonduc	Vines	F
Ink-berry or Small Passion Flower	Passiflora suberosa	Vines	F, W
Maurandya Vine	Asarina scandens	Vines	F
Seaside Morning Glory	Ipomoea pes-caprae	Vines	SD
Simple-leaved Jasmine	Jasminum simplicifolium	Vines	F, OC, W
Small-Fruited Balloon Vine	Cardiospermum microcarpum	Vines	F
Virginia Creeper	Parthenocissus quinquefolia	Vines	F, FW
West Indian Cissus	Cissus sicyoides	Vines	F, FW
Bermuda Holly	Ilex vomitoria	Shrubs	F, OC
Bermuda Snowberry	Chiococca bermudiana	Shrubs	F
Box Briar	Randia aculeata	Shrubs	OC
Burr Bush	Triumfetta semitriloba	Shrubs	F, W
Bush Clerodendron	Clerodendrum glabrum	Shrubs	F
Carolina Laurel Cherry	Laurocerasus carolinianum	Shrubs	F, FW
Coast Sophora	Sophora tomentosa	Shrubs	R
Common Sage or Lantana	Lantana involucrata	Shrubs	F, OC, U, W
Doc-bush	Baccharis glomeruliflora	Shrubs	F, FW, W
Hibiscus	Hibiscus rosa sinensis	Shrubs	SD, U, W
Iodine Bush	Mallotonia gnaphalodes	Shrubs	OC, SD
Jamaica Dogwood	Dodonaea viscosa	Shrubs	F
Jumbie Bean, Acacia or Wild Mimosa	Leucaena glauca	Shrubs	W
Madagascar Buddleia or Snuff Plant	Buddleia madagascariensis	Shrubs	U, W
Natal Plum	Carissa grandiflora	Shrubs	W
Oleander	Nerium oleander	Shrubs	U
Pittosporum or Mock Orange	Pittosporum tobira	Shrubs	F, U, W
Poison Ivy	Rhus radicans	Shrubs	F, FW, W
Shrubby Fleabane	Pluchea odorata	Shrubs	F, FW, W
Surinam Cherry	Eugenia uniflora	Shrubs	F, W
Tassel Plant	Suriana maritima	Shrubs	OC, SD
Virgate Mimosa	Desmanthus virgatus	Shrubs	F, W
Wax Myrtle	Myrica cerifera	Shrubs	FW, W
White Stopper	Eugenia axillaris	Shrubs	F
Wild Coffee	Psychotria ligustrifolia	Shrubs	F
Allspice	Pimenta dioica	Trees	F
Ardisia	Ardisia polycephala	Trees	F, FW
Bay Grape	Coccoloba uvifera	Trees	F, OC
Bermuda Cedar	Juniperus bermudiana	Trees	F, OC, U, W
Bermuda Olivewood	Cassine laneana	Trees	F, U
Bermuda Palmetto	Sabal bermudana	Trees	F, OC, U
Black Mangrove	Avicennia germinans	Trees	M
Brazil or Mexican Pepper	Schinus terebinthifolia	Trees	F, M, OC, W
Buttonwood	Conocarpus erectus	Trees	M, OC
Casuarina, Australian Whistling Pine or Whispering Pine	Casuarina equisetifolia	Trees	F, OC, W
Chinese Fan Palm or Chinese Fountain Palm	Livistonia chinensis	Trees	F, U, W
Fiddlewood	Citharexylum spinosum	Trees	F
Forestiera	Forestiera segregata	Trees	F
Guava	Psidium guajava	Trees	FW, W
Indian Laurel	Ficus retusa	Trees	F, U, W

Lamarck's Trema	Trema lamarckiana	Trees	F
London Plane Tree	Planatus x acerifolia	Trees	U
Mahogany	Swietenia mahogani	Trees	U
Mulberry	Morus nigra	Trees	F, U
Papaya or Paw-paw	Carica papaya	Trees	U, W
Red Mangrove	Rhizophora mangle	Trees	M
Royal Poinciana	Delonix regia	Trees	U, W
Southern Hackberry or Hackberry	Celtis laevigata	Trees	F
Strawberry Guava	Psidium cattleianum	Trees	F, U, W
Tamarisk	Tamarix gallica	Trees	F, OC
White Cedar	Tabebuia pallida	Trees	U
Yellow-wood	Zanthoxylum flavum	Trees	F
Globigerinoides ruber	Globigerinoides ruber	Animal Plankton - Foraminifera	O
Globorotalia truncatulinoides	Globorotalia truncatulinoides	Animal Plankton - Foraminifera	O
Orbulina universa	Orbulina universa	Animal Plankton - Foraminifera	O
Amphilonche elongata	Amphilonche elongata	Animal Plankton - Acantharia	O
Lithoptera tetraptera	Lithoptera tetraptera	Animal Plankton - Acantharia	O
Coelodendrum ramosissimum	Coelodendrum ramosissimum	Animal Plankton - Radiolaria	O
Hexalonche amphisiphon	Hexalonche amphisiphon	Animal Plankton - Radiolaria	O
Sphaerozoum punctatum	Sphaerozoum punctatum	Animal Plankton - Radiolaria	O
Thalassolampe maxima	Thalassolampe maxima	Animal Plankton - Radiolaria	O
Tintinnopsis campanula	Tintinnopsis campanula	Animal Plankton - Ciliata	O
Agalma okeni	Agalma okeni	Animal Plankton - Cnidaria	O
Chelophyes appendiculata	Chelophyes appendiculata	Animal Plankton - Cnidaria	O
Cytaeis tetrastyla	Cytaeis tetrastyla	Animal Plankton - Cnidaria	O
Liriope tetraphylla	Liriope tetraphylla	Animal Plankton - Cnidaria	O
Rhopalonema velatum	Rhopalonema velatum	Animal Plankton - Cnidaria	O
Beroe ovata	Beroe ovata	Animal Plankton - Ctenophora	O
Sea Gooseberry	Pleurobrachia pileus	Animal Plankton - Ctenophora	O
Acartia bermudensis	Acartia bermudensis	Animal Plankton - Crustacea	B
Calanopia americana	Calanopia americana	Animal Plankton - Crustacea	B
Candacia ethiopica	Candacia ethiopica	Animal Plankton - Crustacea	O
Centropages violaceus	Centropages violaceus	Animal Plankton - Crustacea	O
Clausocalanus furcatus	Clausocalanus furcatus	Animal Plankton - Crustacea	O
Common Krill	Euphausia brevis	Animal Plankton - Crustacea	O
Conchoecia spinirostris	Conchoecia spinirostris	Animal Plankton - Crustacea	O
Corycaeus flaccus	Corycaeus flaccus	Animal Plankton - Crustacea	B
Evadne spinifera	Evadne spinifera	Animal Plankton - Crustacea	O
Evadne tergestina	Evadne tergestina	Animal Plankton - Crustacea	B
Farranula rostrata	Farranula rostrata	Animal Plankton - Crustacea	O
Hyperia bengalensis	Hyperia bengalensis	Animal Plankton - Crustacea	O
Oithona nana	Oithona nana	Animal Plankton - Crustacea	B
Oithona plumifera	Oithona plumifera	Animal Plankton - Crustacea	O
Oncaea venusta	Oncaea venusta	Animal Plankton - Crustacea	O
Penilia avirostris	Penilia avirostris	Animal Plankton - Crustacea	B
Podon polyphemoides	Podon polyphemoides	Animal Plankton - Crustacea	B
Pontella atlantica	Pontella atlantica	Animal Plankton - Crustacea	O
Sapphirina auronitens	Sapphirina auronitens	Animal Plankton - Crustacea	O
Siriella thompsoni	Siriella thompsoni	Animal Plankton - Crustacea	O
Thysanoëssa gregaria	Thysanoëssa gregaria	Animal Plankton - Crustacea	O
Cavolinia gibbosa	Cavolinia gibbosa	Animal Plankton - Mollusca	O
Clio pyramidata	Clio pyramidata	Animal Plankton - Mollusca	O
Diacria trispinosa	Diacria trispinosa	Animal Plankton - Mollusca	O
Limacina inflata	Limacina inflata	Animal Plankton - Mollusca	O
Styliola subula	Styliola subula	Animal Plankton - Mollusca	O

Sagitta bipunctata	Sagitta bipunctata	Animal Plankton - Chaetognatha	O
Sagitta minima	Sagitta minima	Animal Plankton - Chaetognatha	O
Sagitta serratodentata	Sagitta serratodentata	Animal Plankton - Chaetognatha	O
Doliolum denticulatum	Doliolum denticulatum	Animal Plankton - Thaliacea	O
Iasis zonaria	Iasis zonaria	Animal Plankton - Thaliacea	O
Oikopleura longicauda	Oikopleura longicauda	Animal Plankton - Thaliacea	O
Pyrosoma atlanticum	Pyrosoma atlanticum	Animal Plankton - Thaliacea	O
Salpa fusiformis	Salpa fusiformis	Animal Plankton - Thaliacea	O
Common Sargasso Weed or Common Gulfweed	Sargassum natans	Sargassum Community - Plants	O
Sargasso Weed or Broad-toothed Gulfweed	Sargassum fluitans	Sargassum Community - Plants	O
Aglaophenia latecarinata	Aglaophenia latecarinata	Sargassum Community - Cnidaria	O
Clytia cylindrica	Clytia cylindrica	Sargassum Community - Cnidaria	O
Clytia noliformis	Clytia noliformis	Sargassum Community - Cnidaria	O
Dark Star Anemone	Pseudactinia melanaster	Sargassum Community - Cnidaria	B, C, O
Dynamena quadridentata	Dynamena quadridentata	Sargassum Community - Cnidaria	O
Halecium nanum	Halecium nanum	Sargassum Community - Cnidaria	O
Obelia dichotoma	Obelia dichotoma	Sargassum Community - Cnidaria	B, O
Obelia hyalina	Obelia hyalina	Sargassum Community - Cnidaria	O
Plumularia margaretta	Plumularia margaretta	Sargassum Community - Cnidaria	O
Plumularia setaceoides	Plumularia setaceoides	Sargassum Community - Cnidaria	O
Plumularia strictocarpa	Plumularia strictocarpa	Sargassum Community - Cnidaria	O
Sertularia inflata	Sertularia inflata	Sargassum Community - Cnidaria	O
Sertularia meyeri	Sertularia meyeri	Sargassum Community - Cnidaria	O
Zanclea costata	Zanclea costata	Sargassum Community - Cnidaria	O
Acerotisa notulata	Acerotisa notulata	Sargassum Community - Flatworms	O
Gnescioceros sargassicola	Gnescioceros sargassicola	Sargassum Community - Flatworms	O
Platynereis dumerilii	Platynereis dumerilii	Sargassum Community - Polychaete Worms	B, O
Coiled Tube Worm	Spirorbis formosus	Sargassum Community - Polychaete Worms	B, O, R, SG
Amonardia phyllopus	Amonardia phyllopus	Sargassum Community - Crustacea	O
Biancolina sp.	Biancolina sp.	Sargassum Community - Crustacea	O
Carpias bermudensis	Carpias bermudensis	Sargassum Community - Crustacea	O
Dactylopodia tisboides	Dactylopodia tisboides	Sargassum Community - Crustacea	O
Harpacticus gurneyi	Harpacticus gurneyi	Sargassum Community - Crustacea	O
Hemiaegina minuta	Hemiaegina minuta	Sargassum Community - Crustacea	O
Hippolyte coerulescens	Hippolyte coerulescens	Sargassum Community - Crustacea	O
Latreutes fucorum	Latreutes fucorum	Sargassum Community - Crustacea	O
Leander tenuicornis	Leander tenuicornis	Sargassum Community - Crustacea	O
Macrochiron sargassi	Macrochiron sargassi	Sargassum Community - Crustacea	O
Paralaophonte congenera	Paralaophonte congenera	Sargassum Community - Crustacea	O
Sargasso Barnacle	Lepas pectinata	Sargassum Community - Crustacea	O
Sargassum Crab	Planes minutus	Sargassum Community - Crustacea	O
Sargassum Swimming Crab	Portunus sayi	Sargassum Community - Crustacea	O
Scutellidium longicauda	Scutellidium longicauda	Sargassum Community - Crustacea	O
Sunampithoë pelagica	Sunampithoë pelagica	Sargassum Community - Crustacea	O
Endeis spinosa	Endeis spinosa	Sargassum Community - Pycnogonida	O
Sargassum Sea-spider	Anoplodactylus petiolatus	Sargassum Community – Pycnogonida	O
Brown Sargassum Snail	Litiopa melanostoma	Sargassum Community - Mollusca	O
Pygmy Doto	Doto pygmaea	Sargassum Community - Mollusca	O
Sargassum Nudibranch	Scyllaea pelagica	Sargassum Community - Mollusca	O
Membranipora tuberculata	Membranipora tuberculata	Sargassum Community - Bryozoa	O
Pugnose Pipefish	Syngnathus pelagicus	Sargassum Community - Fishes	B, O

Sargassum Fish	Histrio histrio	Sargassum Community - Fishes	O
Red Foraminiferan	Homotrema rubrum	Foraminiferans	C
Blue Bleeder	Pseudoceratina crassa	Sponges	B, C
Brown Lumpy Sponge	Halisarca dujardini	Sponges	B, SP
Chicken Liver Sponge	Chondrilla nucula	Sponges	B, SP
Dead Man's Finger (Sponge)	Leucetta microraphis	Sponges	B, SP
Etherial Sponge	Dysidea etheria	Sponges	B, SP
Fire Sponge	Tedania ignis	Sponges	B, SG, SP
Golf Ball Sponge	Tethya actinia	Sponges	B, SP
Green Boring Sponge	Cliona caribbaea	Sponges	B
Green Chimney Sponge	Amphimedon viridis	Sponges	B
Lavender Anemone Sponge	Niphates erecta	Sponges	B, SG
Orange Boring Sponge	Cliona lampa	Sponges	B, C
Orange Encrusting Sponge	Biemna microstyla	Sponges	M
Vase Sponge	Callyspongia vaginalis	Sponges	C
Violet Finger Sponge	Haliclona molitba	Sponges	B, SG
Fire Coral	Millepora alcicornis	Hydroids and Coral-like Hydroids - Coral-like Hydroids	B, C
Obelia dichotoma	Obelia dichotoma	Hydroids and Coral-like Hydroids -Hydroids	B, O
Red Bushy Hydroid	Eudendrium carneum	Hydroids and Coral-like Hydroids -Hydroids	B, O
Bent Sea Rod	Plexaura flexuosa	Soft Corals	C
Dark Sea Rod	Eunicea tourneforti	Soft Corals	C
Porous Sea Rod	Pseudoplexaura porosa	Soft Corals	C, R
Purple Sea Fan	Gorgonia ventalina	Soft Corals	C, R
Sea Plume	Pseudopterogorgia americana	Soft Corals	C
Yellow Sea Whip	Pterogorgia citrina	Soft Corals	C
Artichoke Coral	Scolymia cubensis	Corals	C
Chinese Hat Coral	Agaricia fragilis	Corals	B, C
Common Brain Coral	Diploria strigosa	Corals	C
Double-ridged Brain Coral	Diploria labyrinthiformis	Corals	C
Elliptical Star Coral	Dichocoenia stokesi	Corals	C
Finger Coral	Porites porites	Corals	B, C
Golf Ball Coral	Favia fragum	Corals	B, C
Great Star Coral	Montastrea cavernosa	Corals	C
Ivory Bush Coral	Oculina diffusa	Corals	B, C
Lesser Starlet Coral	Siderastrea radians	Corals	C, SP
Massive Starlet Coral	Siderastrea siderea	Corals	C
Maze Coral	Meandrina meandrites	Corals	C
Mustard Coral	Porites astreoides	Corals	C
Rose or Cactus Coral	Isophyllia sinuosa	Corals	B, C
Small Star Coral	Montastrea annularis	Corals	C
Small-eyed Star Coral	Stephanocoenia michelinii	Corals	C
Ten-ray Star Coral	Madracis decactis	Corals	C
Yellow Pencil Coral	Madracis mirabilis	Corals	B, C
By-the-wind Sailor	Velella velella	Jellyfishes	O
Porpita	Porpita porpita	Jellyfishes	O
Portuguese Man-of-War	Physalia physalis	Jellyfishes	O
Upside-down Jellyfish	Cassiopea xamachana	Jellyfishes	B, SP
Antillean Anemone	Bunodeopsis antilliensis	Anemones	M
Brown Sea Anemone	Lebrunia danae	Anemones	B, C
Brown Sea Mat	Palythoa variabilis	Anemones	B, C
Coral Anemone	Discosoma sanctithomae	Anemones	C
Dark Star Anemone	Pseudactinia melanaster	Anemones	B, C, O
Green Sea Mat	Zoanthus sociatus	Anemones	B, C

Pale Anemone	Aiptasia pallida	Anemones	B, SP
Purple-tipped Sea Anemone	Condylactis gigantea	Anemones	B, C
Red Anemone	Actinia bermudensis	Anemones	R
Ringed Anemone	Bartholomea annulata	Anemones	B, C, SP
Bermuda Fireworm	Odontosyllis enlopa	Polychaete Worms	B
Cockworm	Arenicola cristata	Polychaete Worms	B
Coiled Tube Worm	Spirorbis formosus	Polychaete Worms	B, O, R, SG
Feather Duster Worm	Sabella melanostigma	Polychaete Worms	SP
Ringed Tube Worm	Spiochaetopterus costarum oculatus	Polychaete Worms	B
Argentinian Ant	Iridomyrex humilis	Insects - Ants	F, SD, U, W
Big-headed or Brown House Ant	Pheidole megacephala	Insects - Ants	U
Juniper Aphid	Cinara tujafilina	Insects - Aphids	F, OC, U
Spittlebug	Clastoptera undulata	Insects - Aphids	F, W
Honey Bee	Apis mellifera	Insects - Bees	U, W
Devil's Coach Horse	Cafius bistriatus	Insects - Beetles	S
Donkey Beetle	Diaprepes esuriens	Insects - Beetles	F, U, W
June Beetle or Hardback	Ligyrus tumulosus	Insects - Beetles	U, W
Ladybird Beetle	Exochamus jamaicensis	Insects - Beetles	U, W
Predacious Diving Beetle	Thermonectes sp.	Insects - Beetles	FW
Seaweed Beetle	Phaleria picipes	Insects - Beetles	S
Tiger Beetle	Cicindela trifasciata	Insects - Beetles	S
Green Stink Bug	Nezara viridula	Insects - Bugs	U, W
Harlequin Bug	Murgantia histrionica	Insects - Bugs	F, U
Ocean Skater	Halobates micans	Insects - Bugs	O
Water Boatmen	Corixa spp.	Insects - Bugs	FW
Buckeye Butterfly	Junonia coenia	Insects - Butterflies	F, U, W
Cabbage Butterfly	Pieris rapae	Insects - Butterflies	U, W
Cloudless Sulphur	Phoebis sennae	Insects - Butterflies	F, U, W
Gulf Fritillary	Agraulis vanillae	Insects - Butterflies	F, U, W
Monarch Butterfly	Danaus plexippus	Insects - Butterflies	U, W
Cicada or Bermuda Singer	Tibicen bermudiana	Insects - Cicadas	EX, F
American Cockroach	Periplaneta americana	Insects - Cockroaches	U
American Black Cricket	Gryllus firmus bermudensis	Insects - Crickets and Grasshoppers	F, U, W
Bermuda Flightless Grasshopper	Paroxya bemudensis	Insects - Crickets and Grasshoppers	EX
Katydid or Cone-headed Grasshopper	Neoconocephalus triops	Insects - Crickets and Grasshoppers	W
Blue Dasher	Pachydiplax longipenna	Insects - Dragonflies	FW
Damselfly	Ischnura ramburii	Insects - Dragonflies	FW
Vermilion Glider	Tramea abdominalis	Insects - Dragonflies	FW
Earwig	Labidura riparia	Insects - Earwigs	U
Seaside Earwig	Anisolabis maritima	Insects - Earwigs	S
Eye Fly	Liohippelates pusio	Insects - Flies and Mosquitos	U, W
Mediterranean Fruit Fly	Ceratitis capitata	Insects - Flies and Mosquitos	U
No-See'um Midges	Culicoides bermudensis	Insects - Flies and Mosquitos	FW, U
Salt Marsh Horse Fly	Tabanus nigrovittatus	Insects - Flies and Mosquitos	M
Seaweed Fly	Fucellia intermedia	Insects - Flies and Mosquitos	S
Southern House Mosquito	Culex pipiens	Insects - Flies and Mosquitos	FW, U
Giant Grey Sphinx Moth	Pseudosphinx tetrio	Insects - Moths	F, U, W
Cedar Scale	Carulaspis minima	Insects - Scales	F, W
Oystershell Scale	Insulaspis pallida	Insects - Scales	F, OC, U
Palmetto Scale	Comstockiella sabalis	Insects - Scales	F, OC, U
Wood Termite	Kalotermes approximatus	Insects -Termites	F, U
Mud Dauber	Sceliphron caementarium	Insects - Wasps	O, U

Paper Nest Wasp	Polistes bellicosus	Insects - Wasps	W
St. David's Centipede	Scolopendra subspinosa	Centipedes and Millipedes - Centipedes	F, U, W
Church Worm	Julus sp.	Centipedes and Millipedes - Millipedes	F, U, W
Millipede,Thousand Legs or Galley-worm	Spirobolus heilprini	Centipedes and Millipedes - Millipedes	F, U, W
Crab Spider or Spiny-bellied Orb Weaver	Gasteracantha cancriformis	Spiders	F, M, U
Golden Silk Spider	Nephila clavipes	Spiders	F, M, U
Beach Flea	Orchestia sp.	Crustacea - Amphipods	S
Boring Barnacle	Lithotrya dorsalis	Crustacea - Barnacles	C
Common Barnacle	Chthamalus angustitergum	Crustacea - Barnacles	C
Common Goose Barnacle	Lepas anatifera	Crustacea - Barnacles	O
Striped Barnacle	Balanus amphitrite	Crustacea - Barnacles	R
Anemone Shrimp	Periclimenes anthophilus	Crustacea - Shrimps	B, C
Banded Coral Shrimp	Stenopus hispidus	Crustacea - Shrimps	C
Banded Snapping Shrimp	Alpheus armillatus	Crustacea - Shrimps	C, R
Burrowing Shrimp	Callianassa branneri	Crustacea - Shrimps	B
Locust or Slipper Lobster	Scyllarides aequinoctialis	Crustacea - Lobsters	B, C
Spiny Lobster	Panulirus argus	Crustacea - Lobsters	B, C
Land Hermit Crab	Coenobita clypeatus	Crustacea - Hermit Crabs	F, M, OC
Tricolor Hermit Crab	Clibanarius tricolor	Crustacea - Hermit Crabs	R
Verrill's Hermit Crab	Calcinus verrilli	Crustacea - Hermit Crabs	C
Arrow Crab	Stenorhynchus seticornis	Crustacea - Crabs	C
Common Spider Crab	Mithrax forceps	Crustacea - Crabs	B, C
Ghost Crab	Ocypode quadrata	Crustacea - Crabs	S
Giant Land Crab	Cardisoma guanhumi	Crustacea - Crabs	M
Land Crab or Red Land Crab	Gecarcinus lateralis	Crustacea - Crabs	OC
Mangrove Crab	Goniopsis cruentata	Crustacea - Crabs	M
Mole Crab	Hippa testudinaria	Crustacea - Crabs	S
Ocellated Box Crab	Calappa ocellata	Crustacea - Crabs	B
Sally Lightfoot Crab	Grapsus grapsus	Crustacea - Crabs	R
Yellow Box Crab	Calappa gallus	Crustacea - Crabs	B
Pill-bug or "Roly Poly"	Armadillidium vulgare	Crustacea - Isopods	F, U, W
Wharf Louse	Ligia baudiniana	Crustacea - Isopods	R
West Indian Chiton	Chiton tuberculatus	Chitons	R
Keyhole Limpet	Fissurella barbadensis	Gastropoda - Limpets	R
Say's False Limpet	Siphonaria alternata	Gastropoda - Limpets	R
Blue Glaucus	Glaucus atlanticus	Gastropoda - Sea Slugs	O
Spotted Sea Hare	Aplysia dactylomela	Gastropoda - Sea Slugs	B
Garden Slug	Milax gagates	Gastropoda - Slugs	U, W
Great Slug	Leidyula sloanii	Gastropoda - Slugs	U, W
American Toothed Snail	Polygyra appressa	Gastropoda - Snails	F
Apple Snail	Pomacea sp.	Gastropoda - Snails	FW
Beaded Periwinkle	Tectarius muricatus	Gastropoda - Snails	R
Bleeding Tooth Nerite	Nerita peloronta	Gastropoda - Snails	R
Coffee Bean Snail	Melampus coffeus	Gastropoda - Snails	M
Colourful Atlantic Natica	Natica canrena	Gastropoda - Snails	B
Common Purple Sea Snail	Janthina janthina	Gastropoda - Snails	O
Corroding Worm Shell	Dendropoma annulatus	Gastropoda - Snails	C, R
Dwarf Cerith or Horn Shell	Cerithium lutosum	Gastropoda - Snails	B
Edible Snail	Otala lactea	Gastropoda - Snails	W
False Cerith	Batillaria minima	Gastropoda - Snails	B, M
Flamingo Tongue	Cyphoma gibbosum	Gastropoda - Snails	C
Large Tube Shell	Serpulorbis decussatus	Gastropoda - Snails	R

Lettered Horn Shell	Cerithium litteratum	Gastropoda - Snails	B, SG
Little Orb Helicina	Helicina convexa	Gastropoda - Snails	F
Mangrove Periwinkle	Littorina angulifera	Gastropoda - Snails	M
Milk or Harbour Conch	Strombus costatus	Gastropoda - Snails	B
Milky Moon Snail	Polinices lacteus	Gastropoda - Snails	B
Planorbis Snail	Planorbis sp.	Gastropoda - Snails	FW
Poecilozonites	Poecilozonites spp.	Gastropoda - Snails	EX, F
Pond Snails	Physa spp.	Gastropoda - Snails	FW
Prickly Winkle	Nodilittorina tuberculata	Gastropoda - Snails	R
Queen Conch	Strombus gigus	Gastropoda – Snails	B, SG
Rosy Euglandina or Predaceous Snail	Euglandina rosea	Gastropoda - Snails	F, U, W
Rusty Whelk or Rustic Rock Shell	Thais rustica	Gastropoda - Snails	R
Shiny Puppilla	Pupoides nitidulus	Gastropoda - Snails	F
Spiral Snail	Rumina decollata	Gastropoda - Snails	F, W
Tessellated Nerite	Nerita tessellata	Gastropoda - Snails	R
Tree Snail	Succinea bermudensis	Gastropoda - Snails	F
Varicose Alaba	Alaba incerta	Gastropoda - Snails	B
Variegated Nerite	Nerita versicolor	Gastropoda - Snails	R
West Indian Top Shell	Cittarium pica	Gastropoda - Snails	R
White Snail	Eulota similaris	Gastropoda - Snails	F
Zebra Periwinkle	Littorina ziczac	Gastropoda - Snails	R
Atlantic Grooved Macoma	Psammotreta intastriata	Clams and Mussels	B
Bermuda Scallop	Pecten ziczac	Clams and Mussels	B
Black Date Mussel	Lithophaga nigra	Clams and Mussels	B, C
Calico Clam	Macrocallista maculata	Clams and Mussels	B
Calico Scallop	Argopecten gibbus	Clams and Mussels	B
Dwarf Tiger Lucina	Codakia orbiculata	Clams and Mussels	B
Flat Mangrove Oyster	Isognomon alatus	Clams and Mussels	M
Gould’s Cerina	Gouldia cerina	Clams and Mussels	B
Leaf-like Oyster	Lopha frons	Clams and Mussels	C, R
Leafy Jewel Box	Chama macerophylla	Clams and Mussels	B, C, R
Rock Scallop	Spondylus ictericus	Clams and Mussels	C, R
Scorched Mussel	Brachidontes domingensis	Clams and Mussels	R
Sunrise Tellin	Tellina radiata	Clams and Mussels	B
Sunset Clam	Tellina laevigata	Clams and Mussels	B
Tiger Lucina	Codakia orbicularis	Clams and Mussels	B
Two-spotted False Donax	Heterodonax bimaculata	Clams and Mussels	S
Zebra Mussel	Arca zebra	Clams and Mussels	B
Arrow Squid	Loligo plei	Squids and Octopuses - Squids	B, C
Common Paper Nautilus	Argonauta argo	Squids and Octopuses - Squids	O
Onykia caribbaea	Onykia caribbaea	Squids and Octopuses - Squids	O
Orange-back Squid	Ommastrephes pteropus	Squids and Octopuses - Squids	O
Rams Horn Shell	Spirula spirula	Squids and Octopuses - Squids	O
Reef Squid	Sepioteuthis sepioidea	Squids and Octopuses - Squids	B, C
Vampire Squid	Vampyroteuthis infernalis	Squids and Octopuses - Squids	O
Common Octopus	Octopus vulgaris	Squids and Octopuses - Octopuses	B, C
Greybeard Sea Moss	Zoobotryon verticillatum	Moss Animals	B, SP
Pink Sea Moss	Schizoporella errata	Moss Animals	B
Vidovici’s Amathia	Amathia vidovici	Moss Animals	B, SP
Spiny Sea Star	Coscinasterias tenuispina	Echinoderms - Starfishes	B, SP
Burrowing Rock Urchin	Echinometra lucunter	Echinoderms - Sea Urchins	C, R
Heart Urchin	Moira atropos	Echinoderms - Sea Urchins	B
Longspine Sea Urchin	Diadema antillarum	Echinoderms - Sea Urchins	C
Purple Urchin	Lytechinus variegatus	Echinoderms - Sea Urchins	B, SG
White Urchin	Tripneustes ventricosus	Echinoderms - Sea Urchins	SG

Sand Dollar	Leodia sexiesperforata	Echinoderms - Sand Dollars	B
Burrowing Sea Cucumber	Holothuria arenicola	Echinoderms - Sea Cucumbers	B
Sea Pudding	Isostichopus badionotus	Echinoderms - Sea Cucumbers	B
Sticky Synaptula	Synaptula hydriformis	Echinoderms - Sea Cucumbers	SP
Black Sea Squirt	Phallusia nigra	Sea Squirts	B
Lacy Sea Squirt	Botrylloides nigrum	Sea Squirts	SP
Orange Sea Squirt	Ecteinascidia turbinata	Sea Squirts	B, SP
Purple Sea Squirt	Clavelina picta	Sea Squirts	B, SP
Blue Shark	Prionace glauca	Fish - Sharks	O
Dusky Shark	Carcharhinus galapagensis	Fish - Sharks	O
Scalloped Hammerhead	Sphyrna lewini	Fish - Sharks	O
Short-finned Mako	Isurus oxyrinchus	Fish - Sharks	O
Whale Shark	Rhincodon typus	Fish - Sharks	O
Spotted Eagle Ray	Aetobatus narinari	Fish - Rays	B, O
Tarpon	Tarpon atlanticus	Fish - Tarpons	M, O
Bonefish	Albula vulpes	Fish - Bonefishes	B, SP
Blue Fry	Jenkinsia lamprotaenia	Fish - Anchovies	B
Anchovy	Sardinella anchovia	Fish - Herrings	B
Bermuda Anchovy or Hogmouth Fry	Anchoa choerostoma	Fish - Herrings	B
Pilchard	Harengula humeralis	Fish - Herrings	B
American Eel	Anguilla rostrata	Fish - Eels	FW, O
Green Moray	Gymnothorax funebris	Fish - Moray Eels	C
Purplemouth Moray	Gymnothorax vicinus	Fish - Moray Eels	C
Spotted Moray	Gymnothorax moringa	Fish - Moray Eels	C
Inshore Lizardfish	Synodus foetens	Fish - Lizardfishes	B
Sand Diver or Snakefish	Synodus intermedius	Fish - Lizardfishes	B
Bristle Mouth	Gonostoma elongatum	Fish - Lantern Fishes	O
Cocca Lantern-fish	Gonichthys coccoi	Fish - Lantern Fishes	O
Hatchet Fish	Sternoptyx diaphana	Fish - Lantern Fishes	O
Lantern Fish	Myctophum nitidulum	Fish - Lantern Fishes	O
Sargassum Fish	Histrio histrio	Fish - Frogfishes	O
Black Dragonfish	Idiacanthus fasciola	Fish - Gulper Eels	O
Bermuda Halfbeakor Garfish	Hemiramphus bermudensis	Fish - Needlefish and Halfbeaks	B
Needlefish or Houndfish	Tylosurus acus	Fish - Needlefish and Halfbeaks	B
Fourwing Flying Fish	Hirundichtys affinis	Fish - Flying Fishes	O
Spotfin Flying Fish	Cypselurus furcatus	Fish - Flying Fishes	O
Mosquito Fish	Gambusia holbrooki	Fish - Mosquito Fishes	FW, SP
Bermuda Killifish	Fundulus bermudae	Fish - Killifishes	SP
Rush Fry	Hypoatherina harringtonensis	Fish - Silversides	B
Longspine Squirrelfish	Holocentrus rufus	Fish - Squirrelfishes	B, C
Squirrelfish	Holocentrus ascensionis	Fish - Squirrelfishes	B, C
Longsnout Seahorse	Hippocampus reidi	Fish - Seahorses	B, SG
Pugnose Pipefish	Syngnathus pelagicus	Fish - Pipefishes	B, O
Trumpet Fish	Aulostomus maculatus	Fish - Trumpetfishes	C
Barred Hamlet	Hypoplectrus puella	Fish - Groupers	B
Black Rockfish	Mycteroperca bonaci	Fish - Groupers	C, O
Coney	Cephalopholis fulva	Fish - Groupers	C. O
Creole-fish or Barber	Paranthias furcifer	Fish - Groupers	O, R
Graysby	Cephalopholis cruentata	Fish - Groupers	C, O
Red Hind	Epinephelus guttatus	Fish - Groupers	C, O
Yellowfin Grouper	Mycteroperca venenosa	Fish - Groupers	C, O
Yellowmouth Grouper	Mycteroperca interstitialis	Fish - Groupers	C, O
Bigeye Mojarra	Eucinostomus havana	Fish - Mojarras	B
Mottled Mojarra	Eucinostomus lefroyi	Fish - Mojarras	B
Shad or Silver Jenny	Eucinostomus gula	Fish - Mojarras	B, SP
Sharksucker or Remora	Echeneis naucrates	Fish - Remoras	B, O

Greater Amberjack	Seriola dumerili	Fish - Jacks and Pompanos	O
Horse-eye Jack	Caranx latus	Fish - Jacks and Pompanos	B, O
Mackerel Scad	Decapterus macarellus	Fish - Jacks and Pompanos	O
Rainbow Runner	Elagatis bipinnulatus	Fish - Jacks and Pompanos	B, O
Dolphin Fish	Coryphaena hippurus	Fish - Dolphinfishes	O
Grey Snapper	Lutjanus griseus	Fish - Snappers	B, C
Yellowtail Snapper	Ocyurus chrysurus	Fish - Snappers	B, SP
Bermuda Bream	Diplodus bermudensis	Fish - Chubs and Breams	B
Bermuda Chub	Kyphosus sectatrix	Fish - Chubs and Breams	B
Blue-striped Grunt	Haemulon sciurus	Fish - Grunts	B
French or Yellow Grunt	Haemulon flavolineatum	Fish - Grunts	B
White Grunt or Tomtate	Haemulon aurolineatum	Fish - Grunts	B
Pinfish	Lagodon rhomboides	Fish - Porgies	B, SP
Spotted Goatfish	Pseudupeneus maculatus	Fish - Goatfishes	B
Yellow Goatfish	Mulloidichthys martinicus	Fish - Goatfishes	B
Foureye Butterflyfish	Chaetodon capistratus	Fish - Butterflyfishes	B, C
Blue Angelfish	Holacanthus bermudensis	Fish - Angelfishes	B
Queen Angelfish	Holacanthus ciliaris	Fish - Angelfishes	B, C
Townsend Angelfish	Holacanthus ciliaris x bermudensis	Fish - Angelfishes	B, C
Beaugregory	Stegastes leucostictus	Fish - Damselfishes	B, C
Blue Chromis	Chromis cyaneus	Fish - Damselfishes	B, C
Cocoa Damselfish	Stegastes variabilis	Fish - Damselfishes	B
Sergeant Major or Cow Polly	Abudefduf saxatilis	Fish - Damselfishes	B, C
Three-spot Damselfish	Stegastes planifrons	Fish - Damselfishes	B, C
Bluehead Wrasse	Thalassoma bifasciatum	Fish - Wrasses	B, C
Creole Wrasse	Clepticus parrae	Fish - Wrasses	B
Hogfish	Lachnolaimus maximus	Fish - Wrasses	B, C
Puddingwife	Halichoeres radiatus	Fish - Wrasses	B
Slippery Dick	Halichoeres bivittatus	Fish - Wrasses	B
Spanish Hogfish	Bodianus rufus	Fish - Wrasses	B, C
Yellowhead Wrasse	Halichoeres garnoti	Fish - Wrasses	B, C
Grey Mullet	Mugil trichodon	Fish - Mullets	B, SP
Great Barracuda	Sphyraena barracuda	Fish - Barracudas	B, C, O
Hairy Blenny	Labrisomus nuchipinnis	Fish - Blennies	B, SP
Crested Goby	Lophogobius cyprinoides	Fish - Gobies	B, SP
Blue Tang	Acanthurus coeruleus	Fish - Surgeonfishes	B, C
Doctorfish	Acanthurus chirurgus	Fish - Surgeonfishes	B, C
Ocean Surgeonfish	Acanthurus bahianus	Fish - Surgeonfishes	B, C
Blackfin Tuna	Thunnus atlanticus	Fish - Tunas	O
Little Tunny or Mackerel	Euthynnus alletteratus	Fish - Tunas	O
Wahoo	Acanthocybium solandri	Fish - Tunas	O
Yellowfin Tuna	Thunnus albacares	Fish - Tunas	O
Tapioca Fish	Ruvettus pretiosus	Fish - Oilfishes	O
Blue Marlin	Makaira nigricans	Fish - Billfishes	O
White Marlin	Tetrapturus albidus	Fish - Billfishes	O
Man-of-war Fish	Nomeus gronovii	Fish - Man-of-war Fishes	O
Peacock Flounder	Bothus lunatus	Fish - Flatfishes	B
Grey Triggerfish	Balistes capriscus	Fish - Triggerfishes	B, C
Queen Triggerfish	Balistes vetula	Fish - Triggerfishes	B, C
Slender Filefish	Monacanthus tuckeri	Fish - Leatherjackets	B
Honeycomb Cowfish	Acanthostracion polygonius	Fish - Trunkfishes	B
Smooth Trunkfish	Lactophrys triqueter	Fish - Trunkfishes	B
Bandtail Puffer	Sphaeroides spengleri	Fish - Puffers and Porcupine Fishes	B
Porcupinefish	Diodon hystrix	Fish - Puffers and Porcupine Fishes	B
Sharpnose Puffer	Canthigaster rostrata	Fish - Puffers and Porcupine Fishes	B

Slender Mola	Ranzania laevis	Fish - Puffers and Porcupine Fishes	O
Blue Parrotfish	Scarus coeruleus	Fish - Parrotfishes	B, C
Bucktooth Parrotfish	Sparisoma radians	Fish - Parrotfishes	B, SG
Midnight Parrotfish	Scarus coelestinus	Fish - Parrotfishes	B, C
Princess Parrotfish	Scarus taeniopterus	Fish - Parrotfishes	B, C
Queen Parrotfish	Scarus vetula	Fish - Parrotfishes	B, C
Rainbow Parrotfish	Scarus guacamaia	Fish - Parrotfishes	B, C
Redband Parrotfish	Sparisoma aurofrenatum	Fish - Parrotfishes	B, C
Redtail Parrotfish	Sparisoma crysopterum	Fish - Parrotfishes	B, C
Stoplight Parrotfish	Sparisoma viride	Fish - Parrotfishes	B, C
Striped Parrotfish	Scarus croicensis	Fish - Parrotfishes	B, C
Whistling Frog	Eleutherodactylus johnstoni	Frogs and Toads - Frogs	F, FW, U
Giant Toad	Bufo marinus	Frogs and Toads - Toads	F, FW, U, W
Bermuda Skink	Eumeces longirostris	Lizards	F, OC
Jamaican Anole	Anolis grahami	Lizards	F, M, U, W
Atlantic Ridley Turtle	Lepidochelys kempi	Turtles and Terrapins - Turtles	B, O,
Green Turtle	Chelonia mydas	Turtles and Terrapins - Turtles	B, O, SG
Hawksbill Turtle	Eretmochelys imbricata	Turtles and Terrapins - Turtles	B, O
Leatherback Turtle	Dermochelys coriacea	Turtles and Terrapins - Turtles	O
Loggerhead Turtle	Caretta caretta	Turtles and Terrapins - Turtles	B, C, O, SG
Diamondback Terrapin	Malaclemys terrapin	Turtles and Terrapins - Terrapins	SP
Red-eared Slider	Trachemys scripta	Turtles and Terrapins - Terrapins	FW
American Coot	Fulica americana	Birds - Coots and Moorhens	FW
Moorhen or Common Gallinule	Gallinula chloropus	Birds - Coots and Moorhens	FW
Common Crow	Corvus brachyrhynchos	Birds – Crows and Jays	CL, F, U, W
Ground Dove	Columbina passerina	Birds - Doves	F, W
Mourning Dove	Zenaida macroura	Birds - Doves	F, U, W
Pigeon or Rock Dove	Columba livia	Birds - Doves	F, R, U, W
Blue-winged Teal	Anas discors	Birds - Ducks and Geese	FW
Green-winged Teal	Anas carolinensis	Birds - Ducks and Geese	FW
Mallard	Anas platyrhynchos	Birds - Ducks and Geese	FW
Cardinal	Cardinalis cardinalis	Birds - Finches	F, U, W
European Goldfinch	Carduelis carduelis	Birds - Finches	F, U, W
Great Kiskadee	Pitangus sulphuratus	Birds - Flycatchers	F, U, W
Pied-billed Grebe	Podilymbus podiceps	Birds - Grebes	FW
Osprey	Pandion haliaetus	Birds - Hawks	B
Cattle Egret	Bubulcus ibis	Birds - Herons	FW, SP
Great Blue Heron	Ardea herodias	Birds - Herons	FW
Great Egret	Casmerodius albus	Birds - Herons	FW, M
Green Heron	Butorides virescens	Birds - Herons	FW, SP
Little Blue Heron	Florida coerulea	Birds - Herons	FW
Snowy Egret	Egretta thula	Birds - Herons	FW, M
Yellow-crowned Night Heron	Nyctanassa violacea	Birds - Herons	F, M, SP
Belted Kingfisher	Ceryle alcyon	Birds - Kingfishers	FW
Catbird	Dumatella carolinensis	Birds - Mockingbirds	F, U
Barn Owl	Tyto alba	Birds - Owls	F, U
Cahow or Bermuda Petrel	Pterodroma cahow	Birds - Petrels and Shearwaters	O, OC
Cory's Shearwater	Calonectris diomeda	Birds - Petrels and Shearwaters	O
Greater Shearwater	Puffinus gravis	Birds - Petrels and Shearwaters	O
Leach's Storm Petrel	Oceanodroma leucorhoa	Birds - Petrels and Shearwaters	O
Manx Shearwater	Puffinus puffinus	Birds - Petrels and Shearwaters	O
Sooty Shearwater	Puffinus griseus	Birds - Petrels and Shearwaters	O
Wilson's Storm Petrel	Oceanites oceanicus	Birds - Petrels and Shearwaters	O
Sora	Porzana carolina	Birds - Rails	FW
Ruddy Turnstone	Arenaria interpres	Birds - Shorebirds	B, OC

Common Snipe	Gallinago gallinago	Birds - Snipes	FW
House Sparrow	Passer domesticus	Birds - Sparrows	U, W
White-throated Sparrow	Zonotrichia albicollis	Birds - Sparrows	U, W
Starling	Sturnus vulgaris	Birds - Starlings	F, U, W
Common Tern	Sterna hirundo	Birds - Terns	B
American Robin	Turdus migratorius	Birds - Thrushes	F, U, W
Hermit Thrush	Cattarus guttatus	Birds - Thrushes	F
Northern Waterthrush	Seiurus noveboracensis	Birds - Thrushes	F, FW
Swainson's Thrush	Catharus ustulatus	Birds - Thrushes	F
Wood Thrush	Hylocichla mustelina	Birds - Thrushes	F
White-tailed Tropic Bird or Longtail	Phaethon lepturus	Birds - Tropic Birds	B, CL, O
Bermuda White-eyed Vireo or Chick-of-the-village	Vireo griseus	Birds - Vireos	F, U
American Redstart	Setophaga ruticilla	Birds - Warblers	F, W
Black-and-white Warbler	Mniotilta varia	Birds - Warblers	F, M
Common Yellowthroat	Goethlypis trichas	Birds - Warblers	F, M
Hooded Warbler	Wilsonia citrina	Birds - Warblers	F, M
Kentucky Warbler	Oporornis formosus	Birds - Warblers	F, M
Northern Parula	Parula americana	Birds - Warblers	F, M
Ovenbird	Seiurus aurocapillus	Birds - Warblers	F
Palm Warbler	Dendroica palmarum	Birds - Warblers	F, FW, M, W
Prothonotary Warbler	Protonotaria citrea	Birds - Warblers	F, M
Swainson's Warbler	Limnothlypis swainsonii	Birds - Warblers	F
Worm-eating Warbler	Helmintheros vermivorus	Birds - Warblers	F, FW, M
Yellow-rumped (Myrtle) Warbler	Dendroica coronata	Birds - Warblers	F, FW, M
Cedar Waxwing	Bombycilla cedrorum	Birds - Waxwings	F, U, W
Yellow-bellied Sapsucker	Sphyrapicus varius	Birds - Woodpeckers	F, U
Black Rat	Rattus rattus	Land Mammals	F, U
Brown Rat or Norway Rat	Rattus norvegicus	Land Mammals	F, U
Common Dolphin	Delphinus delphis	Marine Mammals - Dolphins	O
Cuvier's Beaked Whale	Ziphius cavirostris	Marine Mammals - Whales	O
Humpback Whale	Megaptera novaeangliae	Marine Mammals - Whales	O
Minke Whale	Balaenoptera acutorostrata	Marine Mammals - Whales	O
Pilot Whale or Pothead	Globicephala melaena	Marine Mammals - Whales	O
Sperm Whale	Physeter macrocephalus	Marine Mammals - Whales	O

Species Illustrations and Descriptions

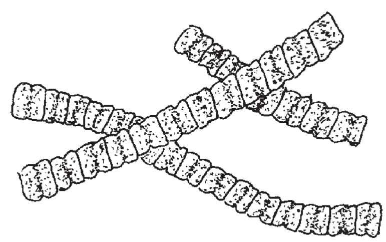
Key to Habitat Codes

B	Lagoons, Bays and Coastal Waters	OC	Open Coastal
C	Coral Reefs	R	Rocky Shores
CA	Caves and Cave Mouths	S	Sandy Shores
CL	Cliffs and Steep Rocky Coasts	SD	Sand Dunes
EX	Extinct	SG	Seagrass Beds
F	Forest	SP	Saltwater Ponds
FW	Freshwater Habitats	U	Urban Environments
M	Mangrove Swamps and Salt Marshes	W	Wasteland, Open Spaces, Wayside
O	Open Ocean		

Bacterium

SP

Beggiatoa
Beggiatoa species
Beggiatoa is a sulphur oxidising bacterium found in polluted water with very low oxygen present. It forms patches at the water surface which range from black, through grey to white. When Beggiatoa is present the water usually smells foul. The individual bacteria are filamentous and microscopic but the patches may reach 50 cm (1.6 ft) across. **Native.**



Blue-green Cyanobacteria

B

Algal Biscuits
Phormidium hendersonii
In texture and colour algal biscuits are rather like the stromatolites described above except that they form flattish plates up to about 8 cm (3 in) in diameter and 1 cm (1/2 in) thick. The picture is of a microscopic view. **Native**.

C

Black Band Disease
Phormidium corallyticum
A disease of large domed and platy hard corals that is typified by a circular light patch with a black border extremely variable in size, 1-20 cm (1/2-8 in) across. **Native**.

Hofmann's Scytonema
Scytonema hofmanni
This species is very important in sediment formation but is not seen on sandy bottoms. It forms the black zone at the top of rocky shores and is characterised by a spiky surface to the rock. Spikes up to 12 cm (5 in) high. **Native**.

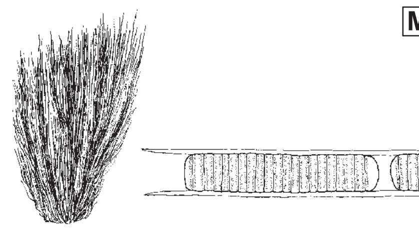
R

Oilspot Blue-green
Calothrix crustacea
This blue-green cyanobacterium of just above high tide mark and the upper intertidal may appear in at least two forms. The first is just like a jet-black heavy oil spot, the second a fuzzy, very small black mound up to about 4 mm (3/16 in) high. **Native**.

R

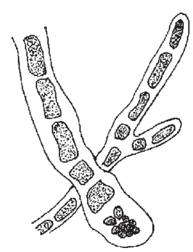
Oscillatoria
Lyngbya lutea
A variable species but most often appearing as purple patches at about high tide level on mangrove roots. Microscopically, it consists of fine filaments which constantly slide back and forth. 1-8 cm (1/2-3 in) high. **Native.**

M, SP



Pink Blue-green
Entophysalis deusta
Microscopic cells and filaments often embedded in limestone rock (endolithic). Usually gives the rock a pinkish colour at just above high tide level although other colours are possible. Common. 1/10-1 mm (1/32-1/16 in) long. **Native**.

R



Stromatolites
Phormidium corium
The Blue-green Cyanobacteria that you might see are all composed of tiny filaments of various colours. The *Phormidium* species are usually light yellow in colour.This species is best recognised by the structures, called stromatolites that they form. These stromatolites are up to about 5 cm (2 in) in height and width. They form domes, weakly attached to the bottom, which are jelly-like in texture and show growth-lines parallel to the surface when cut vertically. **Native**.

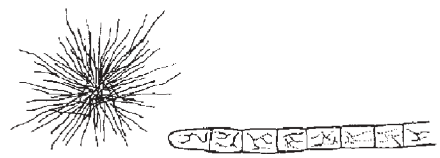
B, SG

Plant Plankton

Note: Plant Plankton are very small and can only be collected with special equipment and they are very delicate. A high-powered microscope is needed for identification. There are no common names. Sizes in metric units only. A μm is one thousandth of a mm.

Blue-green Cyanobacteria (Blue-green algae)

Trichodesmium thiebautii
This cyanobacterium is a major component of the phytoplankton around Bermuda. It occurs as a ball of radiating filaments, reddish-brown to yellowish in colour and up to about 3 mm in diameter. **Native.**



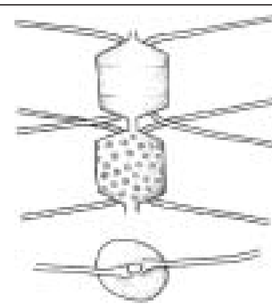
O

Diatoms (Plant protozoa with a silica skeleton)

Cerataulina bergonii
This species is very common both in inshore and offshore waters forming chains that are often twisted in appearance. The individual cells are quite large, about 25-50 μm in diameter. **Native.**

O

Chaetoceros glaudazii
This species is typically oceanic but sometimes extremely common near to shore. The squarish cells each have four long hair-like structures and are united into chains by a narrow connection giving a string-of-beads like appearance. The cells are each 15-20 μm wide and 30-35 μm long. **Native.**



O

Guinardia flaccida
This diatom common in oceanic plankton has broad cells linked end-to-end in chains. The cell diameter is about 30-50 μm and the chain length up to 0.1 mm. **Native.**

O

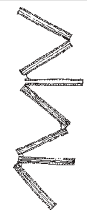
Leptocylindrus danicus
This species has very narrow, elongated cells, linked end-to-end in chains. The cell diameter is only 6-11 μm and the chain length up to 0.12 mm. Common in nearshore and oceanic plankton. **Native.**

O

Rhizosolenia shrubsoleii
A very widely distributed species most common in inshore plankton. It usually occurs as single cells of very characteristic shape, but may form short chains. The cells are about 15 µm in diameter and up to 0.5 mm long. **Native.**

O

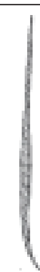
Thalassonema nitzschoides
The cells are rectangular in shape and form chains with zigzag and star-shaped parts. The narrow cells are 2-5 by 30-90 µm. A common species around Bermuda. **Native.**



O

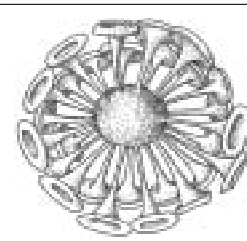
Coccolithophores (Plant protozoa with calcareous plates)

Anoplosolenia brasiliensis
The cell is extremely elongated being 70-110 µm long and 4-7 µm in width and tapers from the middle to both ends. This is one of the coccolithophores and is covered in tiny, elongated calcareous plates. Common inshore and in the ocean. **Native.**



O

Discosphaera tubifera
This very interesting coccolithophore is common offshore. Projecting from the cell 10 µm in diameter are numerous trumpet shaped processes each about 10 µm in length. A winter member of the plankton. **Native.**



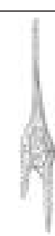
O

Emiliana huxleyi
A typical spherical coccolithophore 5-12 µm in diameter. The tiny plates or coccoliths covering the cell are elliptical in shape. Very common in winter. **Native.**

O

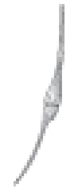
Dinoflagellates (Plant protozoa with flagellae)

Ceratium furca
This species is common in both shallow and deep water and is widely distributed. The 210-280 µm long cell has a very distinctive shape with one long horn on top and two shorter ones below. **Native.**



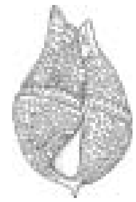
O

Ceratium fusus
Common in all situations at sea, this tall, narrow dinoflagellate is distinguished by its two long horns, one sticking up and the other down. The long cell is about 300-500 μm in length. **Native.**



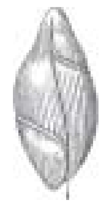
O

Gonyaulax polygramma
Armoured by plates on the outside and having two distinct grooves one longitudinal and one transverse, housing the flagellae. About 60 μm in diameter. Greenish-brown. Common. **Native.**



B, O

Gyrodinium spirale
Has an elongated cell shape with longitudinal marks. One of the two flagellae is in a spiral groove, the other in a longitudinal one. About 80 μm long. Greenish-brown. **Native**.



B, O

Peridinium brochii
This species has a triangular top and a hemispherical bottom part with two horns. The armour plates are strongly sculptured. About 80 μm long. Present all year long. **Native.**

O

Prorocentrum gracile
Flattened from side to side and armoured with two plates. Has one flagellum at one end. About 50 μm long. Greenish. **Native.**

B, O

Pyrocystis noctiluca
Although not very common, this species is well known for its ability to produce light. Noctiluca means night light. The shape is spherical and up to 1 mm across. **Native.**

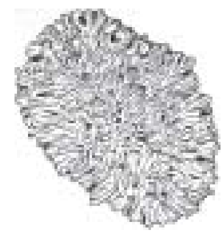
O

Lichens

Fire Lichen
Pyrenula aurantiaca
The fire lichen forms bright orange patches on the trunks and branches of the Red Mangrove tree. 2-10 cm (3/4-4 in) across. **Native.**

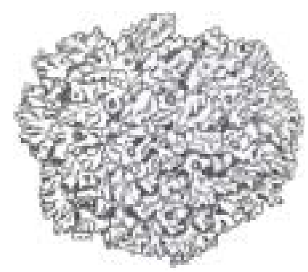
M

Parmelia martinicana
Forms oval or near circular discs on the trunks and branches of trees, close to the shore. The colour a pale, tannish grey, blackish on the underside. 3-9 cm (1 1/4-3 1/2 in) across. **Native.**



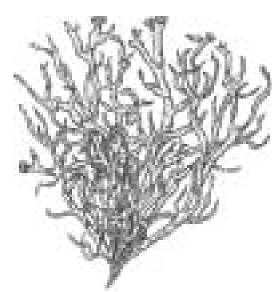
F, OC

Physcia alba
This lichen forms roughly circular patches with rather a rough surface texture, but fairly flat. The colour is a whitish mineral grey with white spots on top and white underneath. There are numerous narrow lobes around the margin. This lichen is common on trees exposed to sun and wind. Up to about 10 cm (4 in) across. **Native**.



F

Ramalina denticulata
The body of this lichen is divided into many lobes which are narrow and divided forming a tuft. The colour is a pale greenish-yellow. The texture is leathery with many small lumps on the upper surface. This lichen lives on the trunks and branches of trees in open woodland. Up to 10cm (4 in) high. **Native**.



F

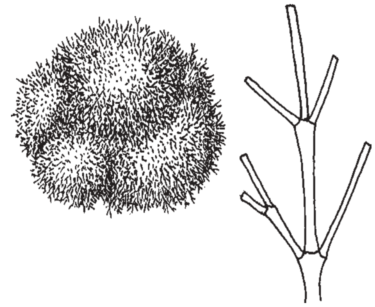
Seaweeds

Green Algae

Black Sea Threads
Cladophora catenata
Black Sea Threads live in surf-beaten areas as well as intertidally. The 2 cm (3/4 in) long fronds branch once or twice. Usually bright green it turns black if exposed to the air. **Native.**

B, R

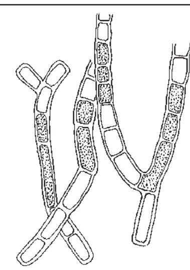
Common Pincushion B
Cladophora prolifera
This often uncommon seaweed may ‘bloom’ under suitable conditions to form a layer on the bottom of quiet bays. The plants are unattached and just lie on the bottom as a roughly ball shaped cluster of branching filaments about 8 cm (3 in) across. The colour in life is a deep green. **Native**.



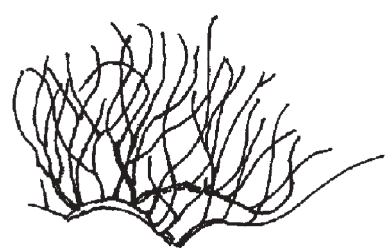
Common Plateweed B
Halimeda incrassata
This green alga commonly about 10 cm (4 in) high consists of a series of small, three ridged plates, jointed together. It is a green seaweed but it incorporates calcium carbonate into its tissues, giving it a hard texture and whitish-green colour. **Native**.

Common Sea Kale B, R
Anadyomene stellata
This alga often grows in groups coating rock surfaces down to 100 m in depth. The small crisp, sheet-like fronds are 2-8 cm (3/4-3 in) high. **Native.**

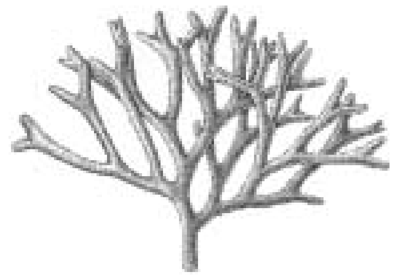
Crinkle Grasses B, M
Rhizoclonium spp.
A group of wiry, bright green thread-like seaweeds which form tangled masses on mangrove roots or on the surface of the mud in mangrove swamps. 2-15 cm (3/4-6 in) long. **Native.**



Crisp Sea Threads R
Cladophora crispula
This is a tiny seaweed found in very wave-beaten areas such as Boiler Reefs and Bioconstructional Lips. The stiff, hair-like filaments are commonly only 0.5 cm (1/8 in) high. It may form a low turf. **Native.**



Dead Man's Fingers (Alga)
Codium decorticatum
This dark green seaweed up to about 25 cm (10 in) high does not deserve its derogatory name. Although it is finger like, the colour is a rich dark green, the texture is velvety and the growth form of divided fingers, extremely attractive. In quiet situations. **Native.**

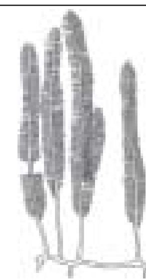


B

Disc Plateweed
Halimeda tuna
Less common that the other plateweeds, the Disc Plateweed is still frequently found in clumps up to about 6 cm (2 1/4 in) high. The unique feature of this plateweed are the broad, fan-shaped or kidney-shaped segments. Quite easily identified when seen in sediments. **Native**.

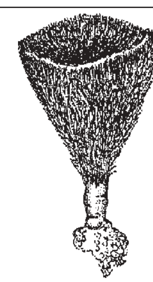
B

Feather Sand Moss
Caulerpa sertularioides
This lovely bright green seaweed about 10- 15 cm (4-6 in) high, grows in shallow, still places such as ponds, sometimes forming huge mats. Each plant body is shaped like an elongate, delicate feather. **Native.**



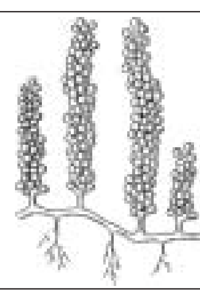
B, SP

Flathead Shaving Brush
Penicillus pyriformis
This species is about 10 cm (4 in) high and has a short stalk capped by a brush that is flattened or even dish-shaped at the top. Not as common as the other two species of shaving brush, but found regularly on quiet sandy bottoms. **Native**.



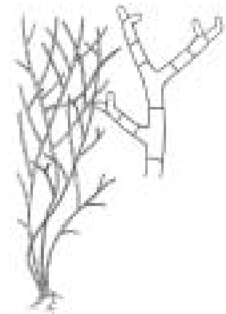
B

Grape Sand Moss
Caulerpa racemosa
This very common seaweed has a stem that hugs the bottom from which arise branches bearing small grape-like branchlets. Common on lagoonal and inshore reefs. Up to 50 cm (1.5 ft) long and 10-15 cm (4-6 in) high. **Native**.



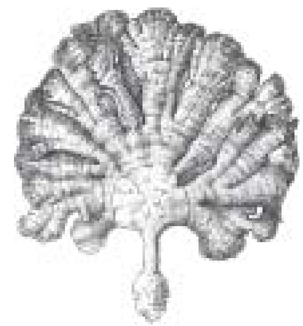
B, SP

Green Cushionweed
Cladophoropsis membranacea
This is a very tiny, usually only 1 cm (1/3 in) high filamentous green seaweed that grows as a mat on the bottom among seagrasses, or out in the open. All that can be seen are the bright green tips of the filaments protruding from a soft layer of sediment. The bottom is usually slightly raised where it occurs. **Native**.



B

Hard Fanweed
Udotea flabellum
The Hard Fanweed is one of Bermuda's prettiest green seaweeds. Anchored in the sediment, it has a short, robust stalk which bears a fan shaped structure with distinct growth lines. About 10 cm (4 in) in height this seaweed is quite heavily calcified and consequently very firm to the touch. **Native**.

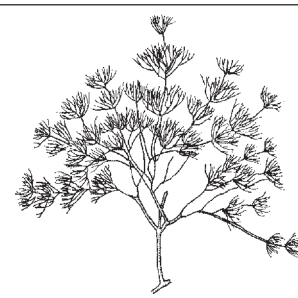


B, SP

Hard Funnelweed
Udotea cyathiformis
The Hard Funnelweed is about 15 cm (6 in) in height and like its relative above is well calcified giving it a whitish cast. It is surmounted by a funnel shaped structure which is usually divided by several splits. **Native**.

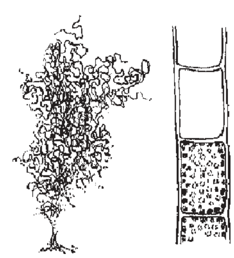
B

Horsetail Sand Moss
Caulerpa verticillata
A very beautiful small, bright green alga of quiet places, such as the marine ponds. Very common on mangrove roots, forming masses up to 15 cm (6 in) across. The individual plants up to 2.5 cm (1 in) wide have a very finely divided appearance. **Native.**



B

Light Brittle Grass
Chaetomorpha linum
For a green filamentous seaweed this one is quite robust and the stiff filaments can easily be seen with the naked eye being up to at least 1 mm (1/32 in) wide. On mud among mangrove trees. **Native.**



M, R

B, SP

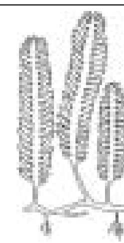
Mermaid's Wine Glass
Acetabularia crenulata
A charming little green seaweed only 5 cm (2 in) high, consisting of a slender stalk on which are one or more curved green discs with radial bands. In quiet waters. **Native.**

B, SP

Merman's Shaving Brush
Penicillus capitatus
A robust greenish white alga, anchored in soft bottoms by root-like organs, The plant is 10-15 cm (4-6 in) high and consists of a stout stalk surmounted by a brush-like array of greenish filaments. Widely distributed. **Native.**

B, M, SP

Mexican Sand Moss
Caulerpa mexicana
Bright green in colour and with a pretty frond about 10 cm (4 in) high shaped like a very coarse feather. On mangrove roots, rocks etc. in still waters. Common in saltwater ponds. **Native.**



B

Sea Balloon
Valonia macrophysa
This seaweed is well named as it consists of one or more somewhat elongated tiny, shiny balloon-like fronds, quite stiff to the touch. It is highly resistant to wave action and common on Boiler Reefs and Bioconstructional Lips. 1-2 cm (1/4-3/4 in) high. **Native**.

B

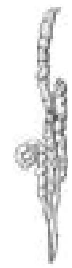
Sea Down
Bryopsis plumosa
Sea Down is similar to the previous species except that the feather-like parts of the fronds are confined to the tips of filaments. About 10 cm (4 in) high. This plant likes quiet waters and may be seen on inshore reefs. **Native.**

B, C

Sea Feather
Bryopsis pennata
This green alga consists of clumps of small feather-like, upright fronds about 10 cm (4 in) tall. It is common on inner lagoonal and inshore reefs. **Native**.

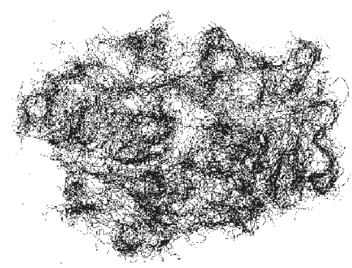
B

Sea Intestines
Enteromorpha flexuosa
The name is unattractive but the seaweed is distinctive as it consists of a group of green tubes about 4 mm (1/8 in) in diameter and 10-15 cm (4-6 in) long. There are often bubbles within the tubes. On rocks or roots. **Native.**



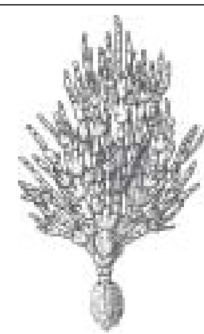
B, R

Seathreads
Cladophora spp.
When you see slimy green masses of tangled very fine filaments it is probably one of the Cladophoras. These weeds in masses from a few cm (in) to a few metres (ft) across are common in fresh, brackish and salt waters. **Native.**



B

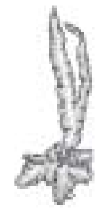
Slender Plateweed
Halimeda monile
The Slender Plateweed is similar in size to the Common Plateweed and forms similar clumps. They can be distinguished by the narrower, non-ridged plates that this species has close to the branch tips. An important contributor to shallow water sediments. Up to 15 cm (6 in) high. **Native**.



B, SP

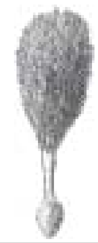
Soft Fanweed
Avrainvillea nigricans
The Soft Fanweed has a luxuriant velvety texture, a result of its being made up of very numerous filaments closely pressed together. Above the sediment anchor the broad stalk rises up to 10 cm (4 in) before it expands into a 10 cm (4 in) high, quite thick green fan. It is only very lightly calcified. **Native**.

Strap Sea Lettuce
Ulva fasciata
A soft, flat green seaweed often found on the roof of the notch. The elongated blades may divide and reach about 15 cm (6 in). **Native.**



R

Tapered Shaving Brush
Penicillus dumetosus
Only 10 cm (4 in) in height, this species differs from the one above in that the stalk is shorter than the brush portion and the brush tapers more slowly from the base. **Native**.



B

Thin Sea Lettuce
Monostroma oxyspermum
This alga consists of a very thin film of dark green tissue up to 10 cm (4 in) across. Delicate and easily torn it is a plant of very sheltered saltwater locations such as the ponds. **Native.**

B, R

Tufted Jointweed
Cymopolia barbata
This 5-15 cm (2-6 in) high, calcified, green alga is very common where a sheltered rocky shoreline gives way to sediment just below low tide. It can be recognised by its jointed branched structure, with each branch ending in a tuft of green filaments. **Native**.

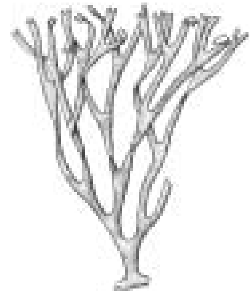
B

Brown Algae

Bermuda Sargasso Weed
Sargassum bermudense
A large seaweed, of which there are at least a dozen different forms, it is often found washed up on the rocky shoreline. Most often free-floating, it has "leafy" branches, often with spine-like projections and spherical float bladders. It commonly harbours small marine animals such as shrimps and crabs. Up to at least 2 m (6 ft) high. **Endemic**.

SP

Common Ribbonweed
Dictyota menstrualis
A light brown seaweed that forms clumps of fronds that divide repeatedly into two similar branches. On reefs the clumps are commonly about 10 cm (4 in) high but in other locations it can be much bigger. Common on inner lagoonal and inshore reefs. **Native.**

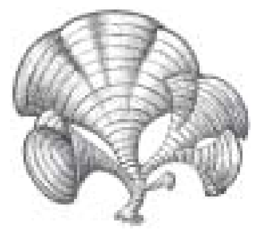


B, C

Iridescent Stripeweed
Stypopodium zonale
This seaweed is characteristic of the outer deep-water reefs where it is very common. It has a flat, divided blade with horizontal stripes, and is an attractive iridescent blue-green. About 10-30 cm (4-12 in) high, it may also be found occasionally on reefs at shallower depths. **Native**.

B

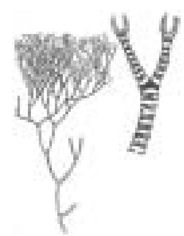
Jamaican Petticoat
Padina jamaicensis
This is a brown, fan shaped seaweed about 10-15 cm (4-6 in) high. The fan is generally banded with lighter zones reflecting the light calcification present. Widely common. **Native**.



B

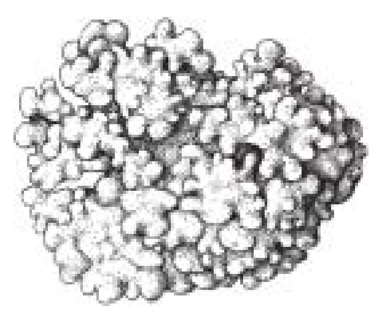
Red Algae

Banded Threadweed
Ceramium byssoideum
A small red, threadlike seaweed, generally looking like pink turf or small clumps. Microscopically, the characteristic red-banded appearance shows up. Grows to 10 cm (4 in) high. **Native**.



B, C

Crustose Coralline Algae
Lithothamnion spp., *Lithophyllum* spp.
These algae are the main rock-builders of the coral and algal-vermetid reefs. They form smooth to knobby sheets of pale pink, rock hard algae. However, they may be hidden by a thin overgrowth of turf-like red seaweeds. These species can create very large expanses of growth and all are highly resistant to both wave action and heavy grazing. Very variable in size, commonly to 30 cm (1 ft) across. **Native.**



B, C

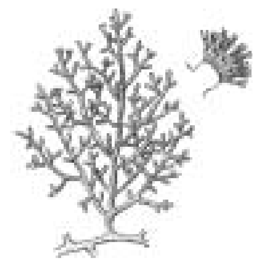
Curly Sea Moss
Bostrychia montagnei
A small red seaweed, usually appearing as a very dark reddish brown mass. Most easily identified from the habitat which is exclusively on mangrove roots at high tide level. About 8 cm (3 in) tall. **Native.**

M

Heartweed
Halymenia bermudensis
A beautiful bright-red seaweed of quiet waters and saltwater ponds. The fronds are broad and flat and the plant is up to 30 cm (1 ft) across. **Native.**

B, SP

Laurence's Clubweed
Laurencia obtusa
Commonly found in seagrass beds this red alga grows in clumps about 15 cm (6 in) high. The plant is copiously branched and tends to a yellowish colour except for the tips of the branches which are a vivid pink. **Native**.

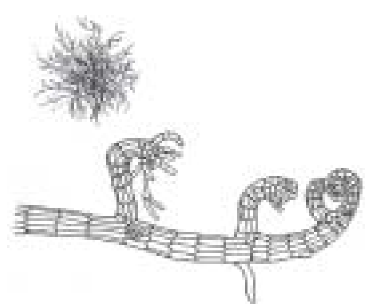


B, SG, R

Laurence's Tufted Weed
Laurencia papillosa
This is one of a group of Laurence's Weeds that grow as small tufts about 10 cm (4 in) tall. The greenish stems divide repeatedly but have characteristic knobby ends with a red tip. These plants are quite common on reefs protected from violent wave action. **Native.**

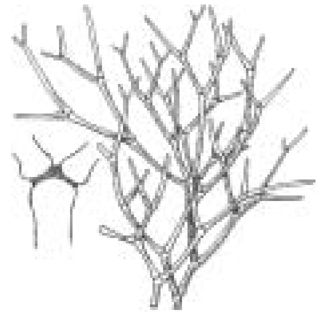
B

Low Siphonweed
Herposiphonia secunda
As the common name suggests, this is a small seaweed. It is typical of wave-washed rocky shores and boiler reefs. It appears as a low reddish-yellow fuzz that is frequently grazed down to resemble velvet. Never more than 2 cm (3/4 in) high, it is usually only a few mm (1/10 in) tall. **Native**.



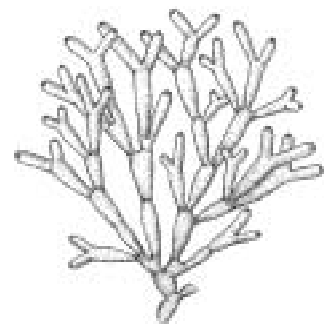
R

Pointed Needleweed
Amphiroa fragilissima
This common alga is heavily calcified with calcium carbonate and a light pink in colour. The hard, thread-like branches divide repeatedly and evenly. In quiet areas it may form bush-like growths 15 cm (9 in) high, but on reefs it is usually part of the low turf dominated by Siphonweeds. **Native.**



B, C

Red Boneweed
Galaxaura obtusa
This seaweed and other close relatives are hard to the touch due to the presence of calcium carbonate in the tissues. They have chunky, cylindrical branches that form small bushes up to about 12 cm (4 1/2 in) high. Quite common on inshore reefs where the dense growth form makes a good habitat for small creatures. **Native.**

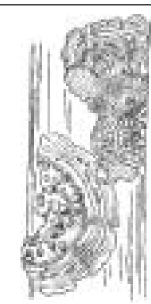


B, C

Red Tongueweed
Caloglossa leprieurii
This tiny red weed, generally less than 1 cm (3/8 in) high has flat fronds with a prominent midrib. It may form a turf with other low-growing red weeds such as Siphonweeds. Found on the rock surface of lagoonal and inshore reefs. **Native.**

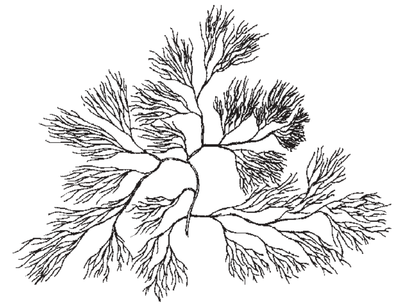
B, C

Scaleweed
Fosliella farinosa
A red seaweed but showing up as white circular, tiny patches about 2 mm (1/16 in) in diameter on seagrass leaves, where it can be very abundant. This is one of the crustose coralline algae and it incorporates large amounts of calcium carbonate in the tissues. **Native**.



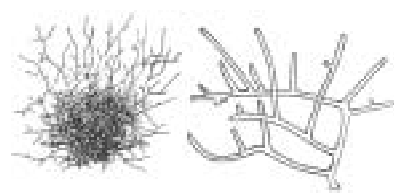
SG

Siphonweeds **B, C, R**
Polysiphonia spp.
The Siphonweeds are probably the most common seaweed of the reefs. They can grow in heavily grazed areas where they form an almost invisible low turf with other red algae such as Pointed Needleweed. Ungrazed they could be several cm (in) high but the commonly found turf is but a mm (1/20 in) thick. It can grow in very wave-washed habitats including the lips of Boiler Reefs. **Native.**

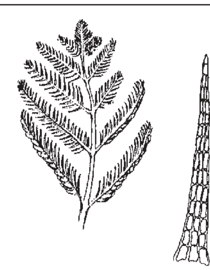


Soft Spineweed **B**
Acanthophora spicifera
This sparsely branched pale yellow to reddish, red alga, gets its common name from the spiny final branches. It is a plant of sheltered rock bottoms such as inshore reefs. Commonly 10-15 cm (6-9 in) high, it may reach twice this size. **Native.**

Stickweed **B**
Wurdemannia miniata
A tiny, red seaweed forming mats up to 3 cm (1 1/3 in) deep. Consisting of entangled clumps of dividing filaments. Dull red in shady places to light pink if exposed to sun. On rocks or roots. **Native.**



Stiff Sea Moss **R**
Bostrychia binderi
A generally purple to black red alga that may bleach to yellowish in intense sunlight. Generally only about 2 cm (3/4 in) high this seaweed is commonly found in small depressions in the upper intertidal zone. **Native**.



B

Thicketweed
Spyridia hypnoides
This red seaweed found in tangled masses on sandy bottoms and among seagrasses, often appears more yellowy-brown than red, as it entraps a lot of sediment which anchors it to the bottom. Often found in a mat 5-8 cm (1 3/4-3 in) deep and of variable extent, it has a branching, spiny appearance with many hook-shaped branches near to the tips. **Native**.

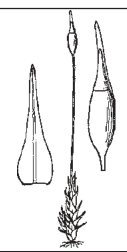
Mosses

F, FW

Bermuda Campylopus
Campylopus bermudiana
A rare moss found at the bases of Bermuda Palmetto trees in Paget Marsh. The moss is dark green in colour, about 6 cm (2.5 in) high and has bunches of leaves along the stem. **Endemic**.

F, FW, OC, U, W

Bermuda Trichostoma
Trichostomum bermudanum
A very common moss only about 2.5 cm (1 in) high, occurring in bright green to yellowish green patches on rocks, walls and in marshes. **Endemic**.

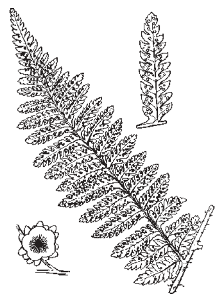


FW

White Moss
Leucobryum glaucum
This moss is found in compact pale green cushions in marshes and swamps. It is medium sized for a moss at about 5 cm (2 in) high and has very numerous tiny leaves. **Native**.

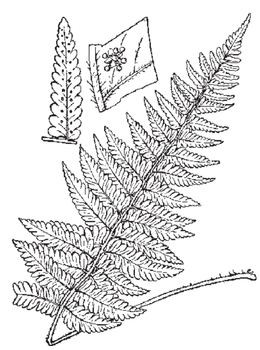
Ferns

Bermuda Cave Fern CA
Ctenitis sloanei
A delicate and now, very rare fern surviving in only a few locations in the Walsingham area. The leaves are twice-pinnate and the leaflets have toothed edges. Rather similar to the Bermuda Shield Fern. Up to 30 cm (1 ft) high. Also found in Florida, where it is called the Florida Tree Fern. **Native.**



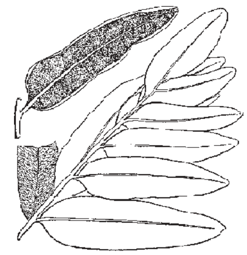
Bermuda Maidenhair Fern CA, CL, F, W
Adiantum bellum
A dainty fern endemic to Bermuda.The leaves are thin and delicate and are divided into fan-shaped leaflets. The stem is black and wiry. This delicate plant varies in size and texture according to the amount of light it receives. It is common throughout the island on shady rocks and walls. Spores are held in clusters on the underside edge of the fan shaped. The leaves are 10-15 cm (4-6 in) long. **Endemic.**

Bermuda Shield Fern F, CA
Dryopteris bermudiana
A very rare endemic fern, once common in the Walsingham and Castle Harbour areas but now on the verge of extinction. This fern has very attractive, twice-pinnate leaves arising in a clump from a compact centre. The leaflets are smooth edged. Dark sporangia appear in rows along the underside of the leaflets. Up to 30 cm (1 ft) high. **Endemic.**



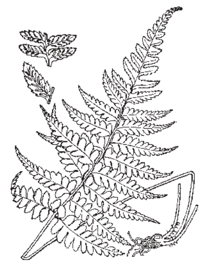
Cinnamon Fern FW
Osmunda cinnamomea
A medium sized fern up to about 1 m (3 ft) high. The leaves arise from a compact centre at the ground surface. This fern derives its name from the fruiting bodies on a central stalk with masses of cinnamon-brown sporangia for the top 15 cm (6 in). In freshwater swamps and marshes. **Native**.

Giant Fern
Acrostichum danaeifolium
This is a simply huge fern often growing in near-pure stands of about 2.6 m (8 ft) in height. The leaves are fairly simple and leathery. Common around the edge of Paget Marsh and in N. Devonshire Marsh. **Native**.



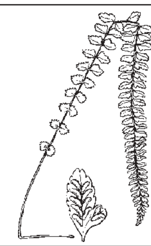
FW

Governor Laffan's Fern
Diplazium laffanianum
Extirpated from the wild by 1905 and now only exists in captivity. It is a medium sized fern of shaded cave mouths. The pinnae (small leaflets) are toothed and oval in shape. Up to 25 cm (10 in) high. **Endemic.**



EX

Long Spleenwort
Asplenium heterochroum
This native fern is common on cliffs, walls and shaded rocks. It is a tiny fern only 5 cm (2 in) high, with tiny, rounded, toothed leaflets. **Native.**

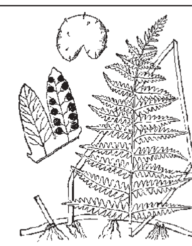


CA, F, W

Long-leaved Brake
Pteris longifolia
The leaf is 15-30 cm (6 to 12 in) long. The leaflets are long and thin. At the tip of the leaf stalk is an extra long leaflet which can be twice as long as the other leaflets. This fern is usually found on walls and banks. The covering of the reproductive cells which are found on the undersides of the leaflets is a yellowish brown. About 1 m (3 f) high. **Naturalized.**

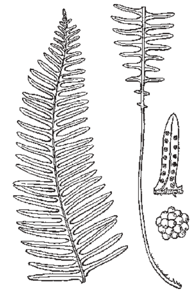
F, U, W

Marsh Shield Fern
Thelypteris thelypteroides
A fern with slender creeping, brown to black roots from which arise 35-100 cm (1-3 ft) long leaves. The leaves are quite complex and widest in the centre, tapering slowly to the tip. **Native**.



FW

Plume Polypody
Polypodium plumula
A very graceful fern found in forest habitats, particularly in Walsingham. The fronds are long and narrow and form a spray-like clump. Each frond is once pinnate and dark green in colour. Size is very variable but the plant grows up to about 60 cm (2 ft) tall. **Native**.

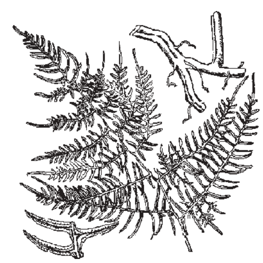


CL, F

Royal Fern
Osmunda regalis
A medium to fairly large fern up to 1.7 m (5 ft) in height and of very graceful appearance. The leaves are simpler than in most ferns with the leaflets along the leaf-stalk undivided, all arising as a central, compact clump at the surface of the ground. In freshwater swamps and marshes. **Native**.

FW

Southern Bracken
Pteridium aquilinum
Bracken differs from the ferns in that the leaves arise singly from the ground. The leaves are stiff with medium-fine sub-divisions and about 1 m (3 ft) high. Bracken dies back in winter. Common in swamps and marshes. **Native**.



FW

Sword Fern
Nephrolepis exaltata
The Sword Fern has a simpler leaf than most ferns with the leaflets along the leaf stalk being undivided. It is a medium to small fern up to about 70 cm (2 ft) high. In marshes and drier ground. **Native**.

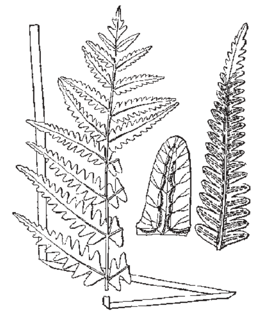
F

Ten-Day Fern
Polystichum adiantiforme
The ten day fern is medium in size and has a creeping root from which arise groups of a few leaves 35-135 cm (1-4 ft) long. The leaflets arising from the central leaf stalk have smoothly toothed lobes and are quite wide. Very rare, found in Devonshire Marsh only. **Native**.

FW

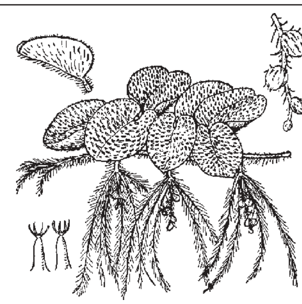
FW

Virginia Chain Fern
Woodwardia virginica
This small fern has a stout horizontal root which is shiny and purplish brown in colour; black where it starts. The leaves are quite short being 30-50 cm (1-1 1/2 ft) long; there are about 20 leaflets along the leaf stalk, each leaflet divided into about 20 lobes. Marshes and swamps. Common only in Devonshire. **Native**.



FW

Water Fern
Salvinia olfersiana
The only floating water fern. This species is quite small with several simple leaves about 1 cm (3/8 in) long from a central stem creeping along the water surface. Short roots hang down into the water. Droplets on the leaves often shine in the sun. **Naturalised**.



Clubmosses

F, FW

Psilotum
Psilotum nudum
Psilotom is an exceedingly interesting plant of great antiquity. Psilotum is a small, stiff, leafless plant with green stems, Not common except in Paget Marsh. About 15-20 cm (6-8 in) high. **Native.**

Grasses

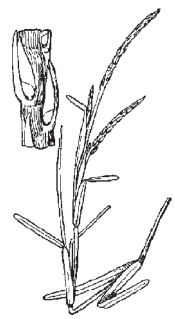
SD

Burr-grass
Cenchrus tribuloides
This is easy to recognize in the summer and autumn as its sharply burred fruit will become attached to your clothing! Beware...the barbed spines on the burrs can inflict painful wounds. It flowers from spring to autumn. Like all dune grasses, it is important in stabilizing sand dunes. About 25 cm (10 in) tall. **Native**.

Cow-cane
Arundo donax
This one is hard to confuse with others as it towers 3-9 m (9-25 ft) tall and has a very large flower 50-100 cm (1 1/2-3 ft) long. When present, as in Pembroke Marsh East it forms large prominent stands along the banks of the waterways but not in the water itself. **Introduced** from the Mediterranean.

FW, W

Crab Grass or **St. Augustine Grass**
Stenotaphrum secundatum
This is one of several Bermuda grasses called crab grass. This one lives in partly salty environments such as the back of mangrove swamps. This grass tends to form springy beds about 30 cm (1 ft) deep. The stems are stiff and wiry, and the leaves bend sharply as they leave the stem. **Native.**

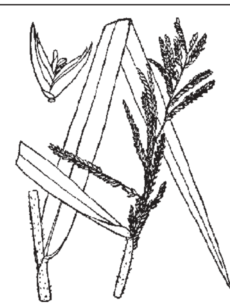


OC, W

Joint Grass
Paspalum distichum
A large, hairy grass 75-130 cm (2-4 ft) tall. Like all the Paspalums it has prominent leaf sheaths where the leaves join the stem. The leaves are quite narrow less than 7 mm (1/2 in). The flower head is V shaped. Often in quite dense stands with few associated species in moderately wet locations. **Native**.

FW, W

Para Grass
Brachiaria mutica
A grass with creeping stems 1-2 m (3-6 ft) long with upright portions 65-100 cm (2-3 ft) high. Flowers 10-12 cm (6-8 in) long. A good recognition feature are the wide leaves, up to 1 cm (3/4 in) across. In damp places. **Naturalized** from South and Central America.

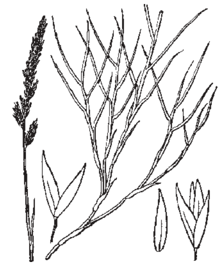


FW, W

Saw Grass
Cladium jamaicense
A very large grass which can form large, dense stands. It has long leaves with saw-tooth edges which give it its name. It is the only marsh grass to show this feature. The flower is a diffuse spray. 1-3m (3-9ft) high. **Native.**

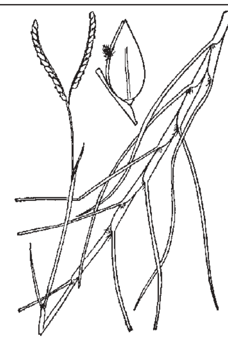
FW

Seashore Rush Grass
Sporobolus virginicus
This is a fairly low trailing grass of partly salty places. The stems are stout, firm and scaly rising above the soil. The narrow 4 mm (1/8 in) wide leaves are numerous, and their basal sheaths overlap. About 40 cm (15 in) high. **Native.**



OC, R

Sheathed Paspalum
Paspalum vaginatum
A grass of quite wet places, often spreading out into the water. It forms dense, springy, pure stands 12-65 cm (8-24 in) thick, which are difficult to walk through. The leaf sheaths, where the leaves join the stem, are crowded and often overlapping. Tolerant of considerable salinity. The flower is V-shaped. **Native**.



FW, SP

Switch Grass
Panicum virgatum
A grass of coastal areas and marsh borders. It grows in prominent clumps that may reach 2 m (6 ft) in height. The delicate flower sprays change from purple to brown as the season progresses. The leaves are long and strap-like, brown, dead ones persist into the next season. **Native.**

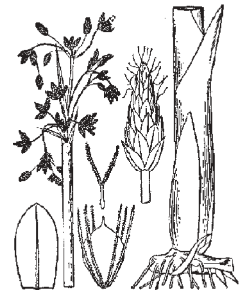
F, W, OC

Woodgrass
Oplismenus setarius
Woodgrass is a rare native grass typical of the forest habitat. It requires considerable shade. It has a whorl of long, slender basal leaves, followed by much shorter, elongate leaves up the stem that are broadest at the base. The inconspicuous flowers are on long, initially coiling stems. To 30 cm (1 ft) high. **Native**.

F

Rushes

American Great Bullrush
Schoenoplectus lacustris
A large rush, 1-3 m (3-9 ft) tall with a robust, round solid stem up to 1 1/2 cm (3/4 in) in diameter at the base and a spray flowers at the tip. Leaves small or absent. Common in freshwater marshes either scattered or in distinct communities. **Native**.

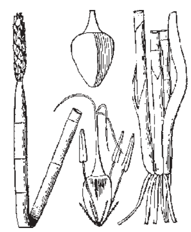


FW

Bermuda Spike Rush
Eleocharis bermudiana
A small rush with small, rounded, flower heads. The Bermuda Spike Rush lives in marshes and is extremely rare. 15 cm (6 in) high. **Endemic.**

FW

Knotted Spike Rush
Eleocharis interstincta
A sturdy rush up to 1m (3 ft) high. Leaves with a sharp point. Flower like a slender elongated cone at the tip of the stem. Common in marshes. **Native**.

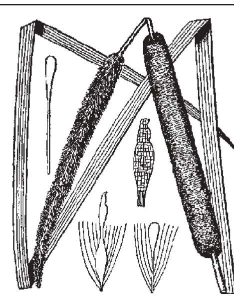


FW

Large Marsh Rush
Juncus acutus
Recognisable from the round stems and leaves both about 85-125 cm (2 1/2-3 1/2 ft) long. The leaves having sharp ends. In marshes. **Naturalized**.

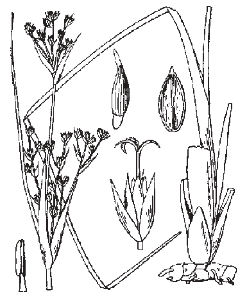
FW

Narrow-leaved Cattail
Typha angustifolia
A well known rush 1.3-2.5 m (4-10 ft) tall. The flowering stems are very characteristic with a very large, dark-brown, compact, club-shaped flower up to 15 cm (10 in) long and long strap-shaped leaves. In quite wet places and often forming large, virtually pure stands. **Native**.



FW

Sea Rush
Juncus maritimus
Common in eastern North America but confined to a few locations in Bermuda. Most easily observed at the East end of Spittal Pond. This rush has spiky, round, hollow leaves up to about 1 m (3 ft) high in dense clumps. The flowers are in inconspicuous greenish sprays. **Native**.



M

Stipitate Beaked Rush
Rhynchospora stipitata
A medium sized rush 80-120 cm (2 1/2-3 1/2 ft) high with triangular stems and flat leaves. The flowers are borne in clumps at the tip of the stems. Found only in Devonshire Marsh.
Native.

FW

White-Headed Rush
Rhynchospora colorata
A smallish rush with triangular stems about 1 50-75 cm (1/2-2 ft) tall. the distinctive feature is the group of white bracts around the flower at the top of the stem. Grows in quite wet locations.
Native.

FW

Sedges

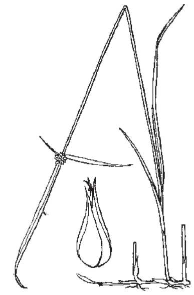
Baldwin's Cyperus
Cyperus globulosus
A medium sized rush up to about 70 cm (2 ft) high with a cluster of star-like flowers surrounded by leaves at the tip of the round, solid stalk. Other leaves arise at the base of the stalk. Occasional in the drier parts of freshwater marshes. **Native**.

FW

Bermuda Sedge
Carex bermudiana
This sedge has triangular stems and flat leaves as long as the stems. Fertile stems have several compact flower clusters at the tip. 50-85 cm (1.5-2.5 ft) high. Endemic. **Native**.

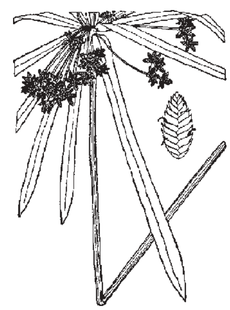
F

Short-leaved Kyllinga
Kyllinga brevifolia
One of the smallest of the rushes about 6-40 cm (4-15 in) tall. The stems are round and slender and the leaves fairly short and narrow. The small dense flower at the tip of the stem has several scales of varying length below it forming a rough star shape. Common along the drier borders of marshes. **Native**.



FW

Umbrella Sedge
Cyperus alternifolius
This sedge has triangular stems that are 100- 150 cm (3-4 1/2 ft) tall. At the top of the stem is a very characteristic whorl of leaves forming the umbrella shape that gives this sedge its name. Just above the whorl of leaves is the spreading flower adding to the striking appearance. **Introduced** as an ornamental from Africa.



FW

Herbaceous Flowering Plants

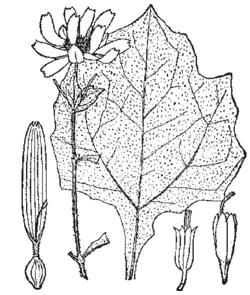
Beach Croton
Croton punctatus
This is a smallish shrub with grey leaves, which are spotted on the underside, and with tiny almost camouflaged flowers. Presumably it was transported here by the ocean. It can survive being almost buried by sand as newly buried stems grow roots. Grows 30-95 cm (1-3 ft) tall. **Native**.

SD

Beach Lobelia
Scaevola plumieri
This native shrub has thick, fleshy, waxy leaves. Individual stems grow right out of the dune, growing taller as the sand accumulates. Its odd shaped whitish flowers can be seen from spring to autumn followed by two seeded, juicy, purplish-black berries. Leaves 3-8 cm (1-3 in) long. Plant to 1m (3 ft) high. **Native**.

SD

Bear's Foot
Polymnia uvedalia
This plant in the daisy family has very attractive yellow flowers and large, finely haired, rather triangular leaves that have a wavy margin. Native to the eastern U.S.A. this plant is naturalised in hilly locations. About 1 m (3 ft) high. **Naturalized**.

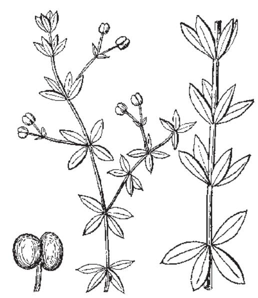


F, W

Beggar-ticks or **Shepherd's Needle**
Bidens pilosa
This intriguingly named plant is another in the large daisy family. The name is derived from the elongate two-clawed seed. It has attractive white flowers with an orange-yellow centre up to 2 cm (3/4 in) across. The light green leaves are elongated, pointed at both ends and with a toothed margin. This daisy is a common sight along roadsides and in waste places as well as in open woodland. It is up to 1 m (3 ft) high. An **introduced** plant now **naturalized**,

F, W

Bermuda Bedstraw
Galium hispidulum
This native plant has declined rapidly as old forests disappeared. Found on hillsides, this small plant has square stems and whorls of pointed, small leaves. The plant has tiny white flowers followed by reddish to dark blue, berry-like fruit. Up to 60 cm (2 ft) high. **Native**.



F, W

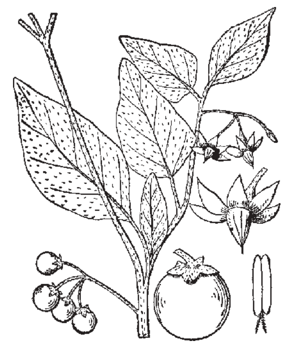
Bermudiana
Sisyrinchium bermudiana
Often called the National Flower of Bermuda, Bermudiana grows from a bulb and bears blue flowers in spring. The plant has strap-like leaves. Very common. 15-30 cm (6-12 in) high. **Endemic.**

OC, U, W

Bird Pepper
Capsicum baccatum
This is a true Pepper which produces tiny, bright red peppers that can be used to flavour food. The flowers are small and white with 5 petals. The plant grows up to about 1 m (3 ft) high. It is found in rocky, upland woodland. **Native**.

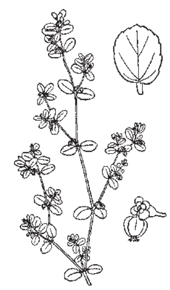
F

Black Nightshade
Solanum americanum
The nightshades are a poisonous group of small shrubs or tall herbs. Never eat the berries. This native plant is common in uncultivated ground and open woodland. The flowers are smallish with a ring of pointed white petals around a characteristic compact, pointed, yellow centre. The leaves are simple, rounded at the base and broadly pointed at the tip. The plant may reach at least 1 m (3 ft) high and has stiff stems. **Native**.



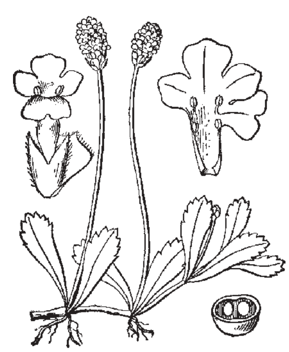
F, W

Blodgett's Spurge
Euphorbia blodgettii
This is a small, tough plant that grows almost in contact with the ground, never rising more than a few millimeters (1/8 in), however, it may spread at least 20 cm (8 in). The leaves are small and rounded, well spaced out along the branching stem. The flowers are small and insignificant. **Native.**



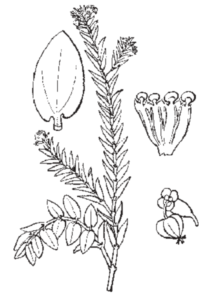
CL, OC, W

Cape Weed
Phyla nodiflora
This very widespread herb grows in a variety of habitats, including swamps and marshes, and may be mixed with other plants, for example in lawns, or grow in pure mats 15-25 cm (6-10 in) deep. The leaves are small up to 5 cm (1 3/4 in) long and have about 7 teeth on each side on the broad end. The flowers are like small buttons and very pale pink in colour. Originally from the African tropics the plant arrived naturally. **Native**.



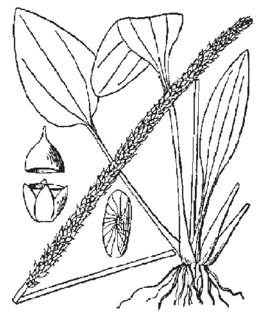
OC, SD, W

Coast Spurge
Euphorbia mesembrianthemifolia
This plant of the supra-littoral fringe of the rocky coast grows along the rock surface or is found in small depressions. The leaves are small and arranged along the sides of the stem. The flowers are minute and yellowish. 1-3 cm (1/2-1 1/2 in) high. **Native.**



R

Common Plantain
Plantago major
The plantains have a basal rosette of broad leaves, tapering to a point at the tip. In the Common Plantain these leaves are up to 15 cm (6 in) long and have prominent veins. The flowers are spike-like on a 15-25 cm (6-10 in) stalk and a dull purple in colour. Lives in a variety of habitats. **Introduced**.



U, W

Darrell's Fleabane
Erigeron darrellianus
Darrell's Fleabane is a shrubby, perennial plant. In spring it is covered with masses of tiny daisy-like flowers. The flowers are white with yellow centers. The leaves are spear shaped with toothed edges. The lower leaves grow from 3 to 5 inches. This plant is named for Mr. J. K. Darrell. Grows from 30 cm to 1.5 m (1-4 1/2 ft) high. **Endemic.**

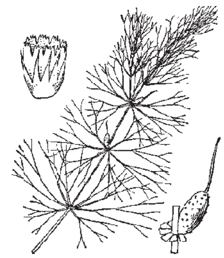
W

Day Flower
Commelina longicaulis
This is a creeping flower with small leaves streaked with lighter green, pointed at the tip and broadest near the base, which are attached directly to the stem without stalks. The small blue flower, less than 1 cm (1/2 in) across, has two petals larger than the others. Very common in wet areas such as swamps, the banks of Pembroke Canal etc. **Naturalized**.

FW

FW

Ditchweed or **Hornwort**
Ceratophyllum demersum
A fully aquatic plant which floats freely in the water. The stems are long and bear many whorls of 7-10 very finely divided leaves giving a delicate appearance; there are no roots at any time. Up to 30 cm (1 ft) long. **Native**.

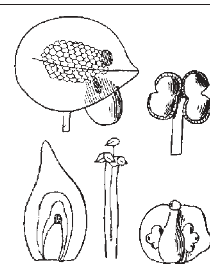


FW

Dog Fennel
Eupatorium capillifolium
This strangely named plant looks little like Fennel and has no particular attraction to dogs. Usually found on rubble fill areas in marshes. Up to about 70 cm (4 ft) high, the herb has a tough, thick stem and masses of thread shaped leaves. The flowers are small white daisies. **Native**.

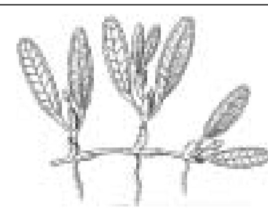
FW

Duckweed
Lemna minor
A very small floating plant consisting of up to three floating green discs which resemble leaves. A few very short roots hang in the water. The plant body is 4 mm (1/4 in) or less in diameter. **Native**.



B, SG

Dwarf Seagrass
Halophila decipiens
This rare species of harbours and sounds has broad, oval leaves up to about 2 m (3/4 in) long arising from a buried rhizome. **Native**.



W

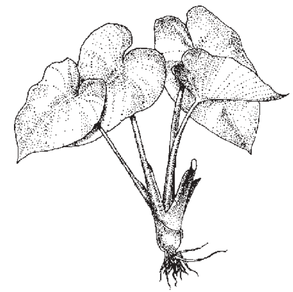
Easter Lily
Lilium longiflorum
The Easter Lily was once grown extensively in Bermuda for export. Many now grow wild in Ferry Point Park. The large, very fragrant, trumpet shaped, white flowers appear in spring, several to a stalk. The leaves in a cluster from the base are strap-like. Up to about 60 cm (24 in) high. **Introduced**.

Elephant's Ear or **Eddoe**

FW

Epiremnium aureum

Eddoe, sometimes called Elephant Ears, is a plant that lines the upper part of Pembroke Canal. The large leaves are shaped like an elongated heart and are dark green often with contrasting light, prominent veins. The flowers are insignificant. Up to 1.1m (3.5 ft) high. **Introduced**.

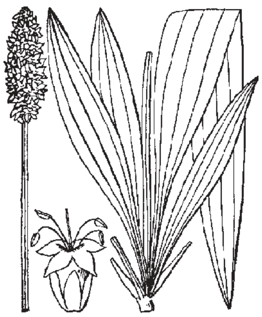


English Plantain

W

Plantago lanceolata

The plantains have a basal rosette of fairly broad leaves, tapering to a point at the tip. In this species the leaves are fairly slender and about 12 cm (4 1/2 in) long; they have prominent parallel veins. The flower is a brownish-blue spike on a 15 cm (6 in) stalk. A plant of waste places and marshes. **Introduced**.

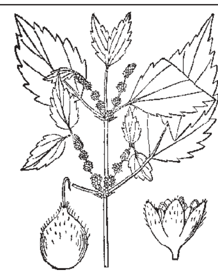


False Nettle

FW

Boehmeria cylindrica

Common in marsh and wasteland habitats, this 70 cm (2 ft) plant has long, thin, sprays of very inconspicuous flowers arising from the leaf axils. The fairly broad leaves are coarsely toothed and arise in pairs from stem nodes. **Native**.

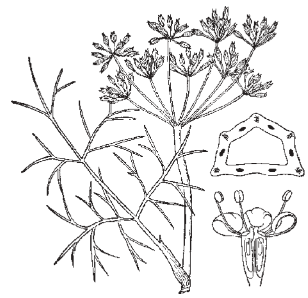


Fennel

U, W

Foeniculum vulgare

This well known aromatic herb is used in cooking. The stout stems rise up to 1.3 m (4 ft) or occasionally more and bear the large, flat flower heads with small yellow flowers. The leaves are very finely divided but quite large, up to 30 cm (1 ft) long. **Introduced** from Europe.

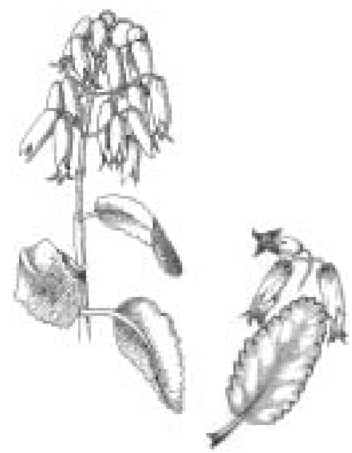


F, W

Fern Asparagus
Asparagus densiflorus
This is not a true fern (true ferns never have flowers). The roots are tuberous while the older stems are woody with some spines and can grow to 1 m (3 ft). Foliage is yellow-green and resembles pine tree needles. The minute flowers are white or pale pink and the mature fruit are bright red berries. This is a sprawling, invasive plant found everywhere. **Introduced** and **naturalized**.

U, W

Flopper or **Life Plant**
Kalanchoe pinnata
This is a common succulent plant. The yellowish green leaves tend to be oval and they are notched along the edge. They feel rubbery. The edge of the leaf is often outlined in a dark brown so that it looks embroidered. The flowers are four centimeters (an inch and a half) long. They resemble long, thin, pale green bells with a reddish blush. The flowers appear in the cooler weather from winter to early summer. Grows from 35 cm-1.5 m (1 to 4 ft). Originally an **introduced** plant, it rapidly became **naturalized.**

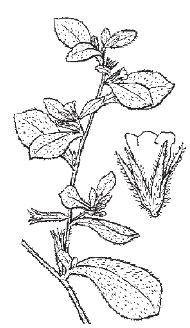


OC, SD, W

Jamaica Vervain
Stachytarpheta jamaicensis
This is an extremely pretty little plant. The 5-petalled flowers in a heavenly shade of blue are scattered on a tall flower spike. The oval, toothed leaves are paired on a robust, hairy stem. Found in a variety of habitats including open woodland. Up to 50 cm (1 1/2 f)t in height. **Native**.

OC, W

Jamaica Weed
Nama jamaicense
This is a small herb with tiny pink flowers that grow in the axils of hairy leaves which are broadest near to the end. The stem is somewhat trailing. It can be found as a weed in cultivated planting ground, scattered in waste ground and in open woodland. Rarely over 25 cm (1 ft) in height. **Introduced.**

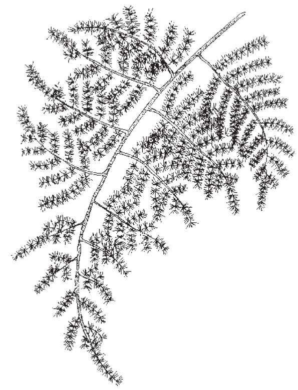


U, W

Joseph's Coat
Euphorbia heterophylla
An annual that grows 70 cm-1 m (2-3 ft) high, Joseph's Coat has eye catching bright red and green central bracts which surround tiny flowers. They look as though someone painted the leaves red. The appearance is of a tiny poinsettia. The leaves vary in shape from thin and long to fiddle shaped. The seed capsule is roundish and is found in the centre of the reddish bracts.
Native.

F, W

Lace Fern or **Bridal Fern**
Asparagus setaceus
An evergreen plant with woody climbing stems, this more delicate looking asparagus fern has pale to lime-green foliage in flat sprays. The tiny white flowers bloom throughout the foliage creating a lovely lace like appearance. The fruit is a purple-black berry. It is a native of South Africa. Like its relative, *A. densiflorus*, this plant can be found everywhere. Again, like its relative, this is not a true fern. Up to 90 cm (3 ft) high.
Introduced and **naturalized**.

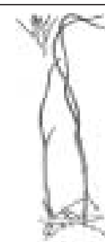


W

Low Cudweed
Gnaphalium viliginosum
A plant with greyish-green leaves and small globular, yellow flowers in spring. Likes sandy locations. 30 cm (1ft) high. **Introduced**.

B, SG

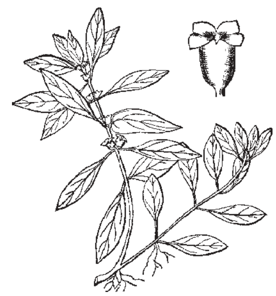
Manatee Grass
Syringodium filiforme
Leaves round in cross section, narrow and up to 30 cm (6 in) long. Quite common in small stands and mixed with the other two species of seagrass. **Native.**



Marsh Eclipta
Eclipta alba
This herb reaching about 70 cm (2 ft) high has fluffy white flowers about 1.5 cm (1/2 in) in diameter. The leaves are elongated and coarsely toothed, pointed at the tip arising without stalks from the stem nodes. Common in marshes. **Native**.

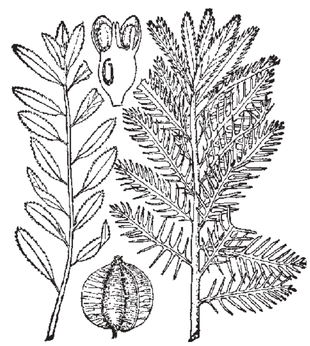
FW

Marsh Purslane
Ludwigia palustris
This aquatic plant has long trailing stems and smooth edged leaves 25 mm wide by 12 mm long (1 in by 1/2 in), widest at the middle. The flowers are tiny in the leaf axils. Submerged and emerged leaves are identical. May be in the water or on mud. **Native**.



FW

Mermaid Weed
Proserpinaca palustris
An aquatic plant which may be partly emergent from the water. The submerged leaves are feathery but the emergent leaves on stems up to 30 cm (1 ft) tall are simple, quite long and widest in the centre. The flowers are inconspicuous in the axils of the emerged leaves. Found in Devonshire Marsh only and rare there. **Naturalized**.



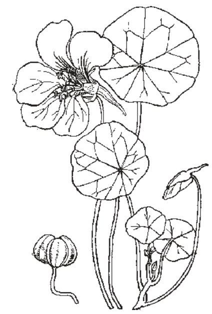
FW

Monnier's Hedge Hyssop
Bramia monniera
A prostate fleshy-stemmed plant with small spatulate leaves and small star-shaped yellow flowers on the leaf axils. 8-50 cm (3-20 in) long. **Native**.

W

U, W

Nasturtium
Tropaeolum majus
Nasturtiums are a well known annual garden plant. The stem is trailing and up to at least 1m (3ft) long. The leaves are almost perfectly circular with the stem in the centre. The flowers, which are rather trumpet-shaped with a spur at the back, may be any shade of yellow to bright red. The plant forms a mat up to 25 cm (10 in) high. **Introduced**.

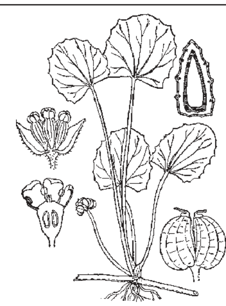


M, W

New Zealand Spinach
Tetragonia tetragonioides
This plant has a trailing, soft stem from which branches about 45 cm (18 in) tall ascend. The branches have numerous quite large leaves up to 10 cm (4 in) long and rather triangular in shape. The small, yellow flowers appear in the leaf axils. Highly edible. Common in dryish mangrove swamps. **Introduced.**

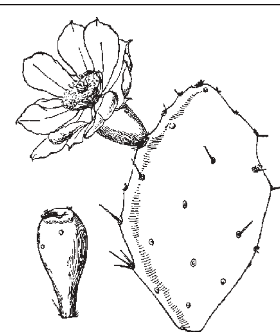
W

Ovate Leaved Marsh Pennywort
Centella asiatica
This small herb growing close to water and also on hillsides, has long creeping stems from which arise small heart-shaped leaves on short stalks. The leaves are about 2 cm (3/4 in) in diameter. The small and insignificant flowers are in the axils of the leaves. **Native**.



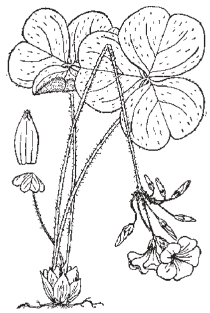
OC, W

Prickly Pear
Opuntia stricta
This cactus with oval pads can hardly be mistaken for anything else. The pads up to 12 cm (5 in) long form bushes or clumps up to 1 m (3 ft) high. The spines are stout and sharp and the flowers a showy yellow. The pear-like fruits are a magenta-red when mature and very tasty. **Native.**



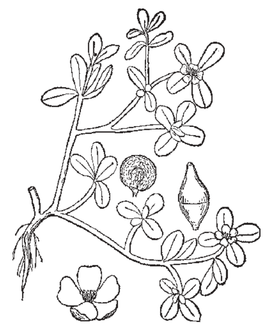
W

Purple Wood Sorrel
Oxalis martiana
The sorrels are easily recognised by their small, clover-like leaves with three leaflets, each of which has an indentation, making them heart-shaped. The attractive, pastel-purple flowers borne in a cluster on a short stalk, have five petals. Plants are up to about 25 cm (10 in) high. **Introduced.**



F, OC

Purslane
Portulaca oleracea
This is a suculent plant, having fleshy leaves. It is common in damp places even quite close to the sea. The rounded leaves are often a bright red in winter. Purslane can be distinguished from the closely related Seaside Purslane by its more rounded leaves and yellow flowers rather than pink.Up to about 10 cm (4 in) high but may spread 35 cm (14 in). **Native.**



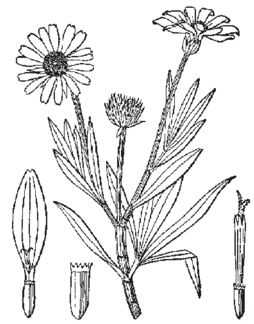
SD

Red Pellitory
Parietaria floridana
On the leeward side of the dunes, in the shade of other plants, the native Red Pellitory grows like a dense carpet. Its flowers, which are almost hidden and protected by leaves, grow close to the stem and are followed by little, bright red berries. About 15 cm (6 in) tall. **Native**.

F

Rhacoma
Crossopetalum rhacoma
Rhacoma is an endangered native shrub, found in only a few locations in upland forest. The flowers are tiny and red in colour and found in small groups. They are followed by small green berries which turn red when ripe. The leaves are broadest near to the tip with widely separated teeth around the margin. Up to 1.5 m (5 ft) high. **Native.**

Saltmarsh Oxeye
Borrichia frutescens
A herb with thick, fleshy leaves and stout stems. It occurs in salt-marshes and the back of mangrove swamps. The flowers are daisy-like and yellow about 2.5 cm (1 in) across. The outer whorl of petals is somewhat irregular, with occasional gaps. Up to 1.5 m (4.5 ft) high.
Native.

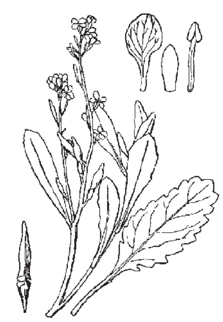


M

Scarlet Pimpernel
Anagallis arvensis
This is a small flowering herb found in the sand dunes and coastal grassland. It grows close to the ground, seldom reaching more than 8 cm (3 in) high. The very attractive, small flowers have five red, rounded petals; the opposite leaves have a broad, rounded base and bluntly-pointed tip.
Naturalised. **Introduced**.

S, SD

Scurvy Grass or **Sea Rocket**
Cakile lanceolata
This is a fleshy plant most typical of the strand-line of sandy shores, but also occurring in mangrove swamps and salt-marshes. The plant grows up to 70 cm (24 in) high. The 2-7 cm (1-2 1/2 in) long leaves are somewhat dished and the edges wavy. The 4-petalled flowers are white in a terminal spike. **Native**.



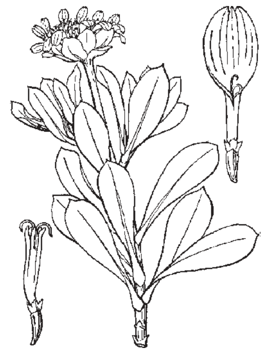
S

Sea Lavender
Limonium carolinianum
This rare salt-marsh plant has a basal rosette of leaves up to 15 cm (6 in) long which taper very gradually away from the base and then become broad near to the tip. The tall flower has small but pretty blue flowers arranged along vertical thin stalks. About 30-60 cm (12-24 in) high when in flower. **Native**.

M

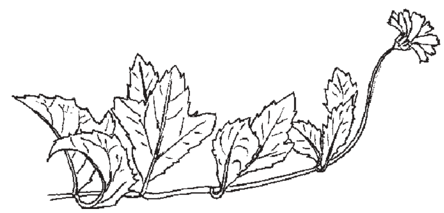
OC

Sea Oxeye
Borrichia arborescens
Also native, the sea oxeye is a shrubby herb seen very commonly along Bermuda's rocky shoreline. It is variable in height, sometimes growing low to the ground and sometimes reaching 1.5 m (4 ft) or so in height. The colour of its leaves can also vary between grey and green, often on the same plant. It bears single, yellow, daisy-like flowers at the top of the stem, throughout most of the year. **Native.**



OC, SD

Seaside Daisy
Wedelia trilobata
This is a very invasive plant which covers waste ground and can be very common in marshes. The light green leaves arise from a trailing stem and are coarsely toothed on the edges, broader at the base. The yellow flowers about 2 cm (1/2 in) in diameter appear in summer and fall. **Introduced.**



S, SD

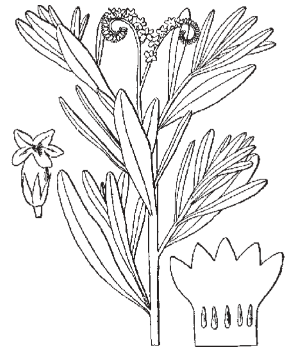
Seaside Evening Primrose
Oenothera humifusa
This native grows mostly along the ground in sunny areas. Its yellow flowers turn pinkish-maroon by the end of the day, and bloom during summer and autumn. About 20 cm (8 in) high. **Native.**

OC

Seaside Goldenrod
Solidago sempervirens
This herbaceous plant has an exceedingly wide geographic distribution and occupies a wide range of habitats. The stem is stout with the long leaves closely arranged around the stem. The stem is crowned by a long flower head with very numerous, small yellow flowers, each daisy-like in appearance. Flowers in summer and autumn. About 70-100 cm (2-3 ft) high. **Native.**

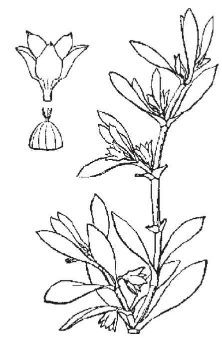
M

Seaside Heliotrope
Heliotropium curassavicum
This salt-marsh plant is common only at a few locations such as Spittal Pond; it flowers in spring. The leaves are somewhat fleshy and about 5 cm long (2 in). The stems, about 25 cm (10 in) tall, culminate in a very characteristic flower head. This collection of flowers is divided into two equal elongate halves, each of which spirals away from the other. The individual flowers are small and light purple. **Native.**



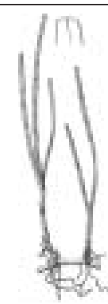
OC, R

Seaside Purslane
Sesuvium portulacastrum
Seaside Purslane has a fleshy, creeping stem on which very fleshy leaves are borne in opposite pairs. The whole plant rises no more than about 5 cm (2 in) above the ground. The blunt-tipped leaves are broadest about 2/3 of the way along and are often tinged with a reddish colour. The pretty flowers are solitary and pink. Frequent at the backs of mangrove swamps. **Native.**



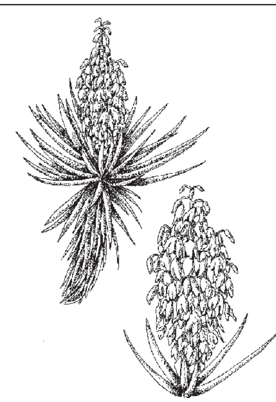
B, SG

Shoal Grass
Halodule wrightii
The smallest of the common Bermudian seagrasses. The leaf blades are flat and narrow, up to15 cm (6 in) long and 2 mm (1/16 in) wide. Commonly found around the edges of Turtle Grass beds or mixed in with the other two species. **Native.**



OC, SD, W

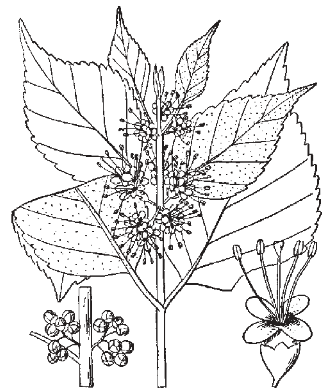
Spanish Bayonet
Yucca aloifolia
Easily recognizable by its long, needle-like leaves, this is a plant seen very commonly along the south shore of Bermuda. It has very thick, fleshy leaves often with serrations along the edges. The flowers are white, growing on spikes of about 70 cm (2 ft) in length which appear from spring to autumn. These flowers are pollinated by night-flying moths. When not in flower the plant grows to 3m (10 ft). **Native**.



St. Andrew's Cross
Hypericum macrosepalum
Plant about 45-70 cm (18-24 in) high. Leaves narrow and without stalks, arising in whorls from the stem. Flowers single, showy and yellow, about 1.5 cm (3/4 in) across, with 4 petals. Rare. **Endemic**.

FW, W

Turkey Berry
Callicarpa americana
This rare native plant used to be quite common in woodlands, however it could not compete with invasive introduced woodland plants and died out between 1900 and 1950. It was re-introduced and is now on the increase again in managed areas where invasive introduced plants are culled out. It has clumps of small, pretty, pink flowers borne in repeated clusters along the end of the stalks. The leaves are fairly large and broadest about one third of the way from base to tip. They are coarsely toothed. About 65 cm (2 ft) tall. **Native**.



F

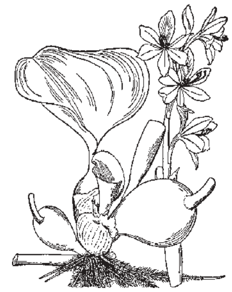
Turnera
Turnera ulmifolia
A shrubby plant with yellow flowers. The leaves are spear shaped, feel sandpapery and have saw toothed edges. They may grow to a length of 10 cm (4 in). The flowers open in the morning, summer through autumn. Turnera used to be found in many rock walls in Bermuda. Turnera grows 35-70 cm (1-2 ft) tall. **Native.**

W

Turtle Grass
Thalassia testudinum
The largest and most common of the common seagrasses. Leaves flat and up to 1 m (3 ft) long and 5 mm (1/4 in) wide and commonly encrusted with epiphytes. Grows in clumps of leaves arising from a buried rhizome. Forms extensive beds. Important in sediment stabilisation and as food for turtles. **Native.**

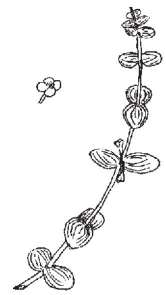
B, SG

Water Hyacinth
Eichornia crassipes
This is a large freshwater, floating plant with very attractive spires of pale blue flowers. The leaves are unique having an inflated base which acts as a float from which the leaf stalk arises supporting a broad, shiny leaf with a blunt tip. Roots hang in the water. About 25 cm (10 in) high. **Introduced.**



FW

Water Hyssop
Bacopa monnieria
A sprawling or creeping water plant with small, opposite, nearly round leaves, up to about 20 cm (8 in) high. The plant may float or root at the nodes. The flowers are tiny, yellow and on short stalks in the leaf axils. Frequent in all marshes. **Native**.



FW

Water Smartweed
Polygonum punctatum
A small aquatic plant with stems emerging from the water. Leaves delicate and pointed about 4 cm (1 1/2 in) long. Flowers above the water in spikes of numerous, small white flowers. **Native**.

FW

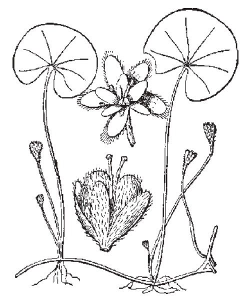
White Eupatorium
Eupatorium riparium
A small roadside plant. The stems are often widely branched. Leaves are lance-like with saw-toothed edges. The leaves are 5-10 cm (2-4 in) long and 1-2.5 cm (1/2 to 1 in) wide. Small daisy-like flowers grow in clusters at the end of a stem. Eupatorium flowers in winter and spring. Grows from 55-85 cm (1 1/2 to 2 1/2 ft) high. **Introduced.**

F, U, W

White Pellitory
Parietaria officinalis
A somewhat floppy herb about 30 cm (1 ft) in height, with hairy stems and leaves. The leaves are thin and 1-5 cm (1/2-2 in) long. The inconspicuous flowers are in whorls around the axils of the stems where the leaves originate. Flowering in all seasons. **Naturalized**.

W

Whorled Marsh Pennywort
Hydrocotyle verticillata
A low growing marsh herb up to about 15 cm (6 in) high common in open wet areas such as channel banks. Often forming a dense mat, this plant has round, shiny leaves about 2 cm (3/4 in) across and small insignificant flowers. **Native**.



FW

Widgeon Grass
Ruppia maritima
An aquatic plant typical of slightly salty (brackish) waters. Despite its name this is not a grass but a flowering plant. The leaves are long and thin, arising from a submerged stem. The flowers rise to the water surface on twisted stalks and are quite small. Typical of both brackish and saltwater ponds. Up to 60 cm (2 ft) long. **Native**.

FW, SP

Wild Bermuda Pepper
Peperomia septentrionalis
This plant lives in shaded areas and cave mouths. It is only locally common. It has rather fleshy leaves broadest close to the tip but with a slight indentation there. The flower spike is very characteristic, being brown and pencil shaped with very minute blossoms. About 15 cm (6 in) high. **Endemic.**

CA, F

SD

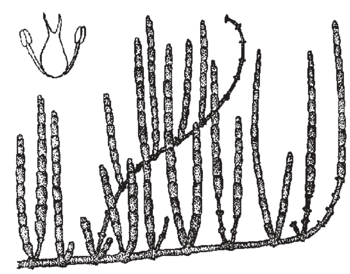
Wild Stock
Matthiola incana
Wild Stock has very attractive purple flowers in the spring. This plant grows in somewhat sheltered dune areas such as in the lee of rocky headlands and may also be found in places on the roadside along the south shore. The leaves are grey-green and oblong in shape. About 35 cm (14 in) high. **Naturalized**.

W

Wire-weed
Sida carpinifolia
Wire-weed grows from 35 cm-1 m (1-3 ft) tall. Minute hairs cover the plant. Leaves are 1-4 in long. They are lance shaped with the edges of the leaves irregularly saw-toothed. The leaves have a short stem that runs from about one sixth of an inch long to one third of an inch long. Flowers are creamy yellow. They run from a quarter inch long to half an inch long. **Introduced** but possibly **native**.

M

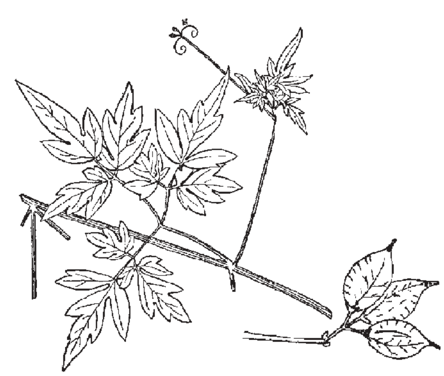
Woody Glasswort or **Marsh Samphire**
Salicornia perennis
This most interesting plant of the backs of mangrove swamps is often called samphire and is quite edible. The plant is leafless but the stalks are fleshy and green and rise up to about 50 cm (18 in) above the mud. The flowers are minute. **Native.**



Vines

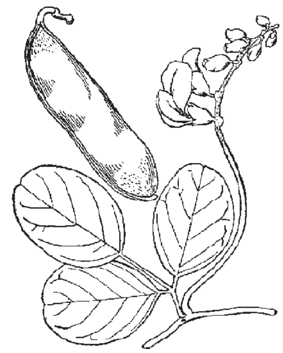
F

Balloon Vine
Cardiospermum halicacabum
Originally a forest plant, the Balloon Vine is now more common in hedges and gardens. It can climb to a considerable height using tendrils to grip the supporting twigs. The leaves vary but are usually compound, the leaflets have coarsely toothed margins. Flowers are borne in clumps and are yellowish-white in colour. The characteristic fruit capsule is an inflated balloon-like structure about 2 1/2 cm (1 in) long, containing black fruit. Up to 10 m (30 ft) long. **Naturalized**.



F, OC, SD

Bay Bean
Canavali lineata
This is easily confused with seaside morning glory when it is not in bloom. It has rounded leathery leaves which grow on little branches, in threes, along the vine. Its flowers, which look like miniature purple sweet peas, can be seen in the autumn and winter. Wide pods can be seen on the vine all year. It has the capacity for rapid vertical and horizontal growth so it can deal with the problem of shifting sand. The vine may grow as long as 7.5 m (25 ft). **Native**.

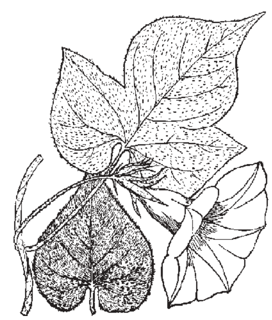


F

Bermuda Bean
Phaseolus lignosus
The Bermuda Bean is now rare, but was once very common. The flowers are pea-like and vary from yellow to blue. The leaves are heart-shaped with a sharp tip. It is a vine up to 3.2 m (10 ft) long. **Endemic.**

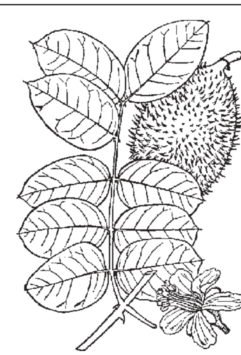
F, M, W

Blue Dawn Flower or **Morning Glory**
Ipomoea indica
The Blue Dawn Flower is one of the Morning Glories. The plant is a vine up to several yards (m) long that trails over ground and up other foliage. The very pretty, trumpet-shaped, blue flowers appear in the morning and fade later. This plant can be a pest. Up to 10 m (30 ft) long. **Native**.

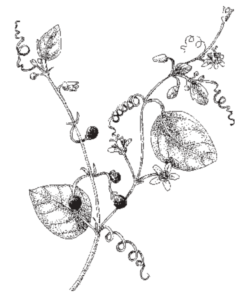


F

Brier-Bush or **Grey Nickers**
Caesalpinia bonduc
The Brier-Bush, which is native, is now very rare and localised in a few patches of shoreline woodland. It is a large rambling vine. Its most noticeable feature are the large recurved spines on the stems, leaves and fruit pod. The leaves are compound and the flowers, borne in spikes are an attractive yellow colour. Reaching at least 5 m (15 ft) in length. **Native.**



Ink-berry or **Small Passion Flower**
Passiflora suberosa
A ground covering vine whose leaves from 5-15 cm (2-6 in) may be covered with short downy hairs. The leaves are egg shaped in outline. Flowers are tiny, greenish-white passion flowers. The purple to black berries are oval or somewhat globular. Up to 5 m (15 ft) long. **Native.**

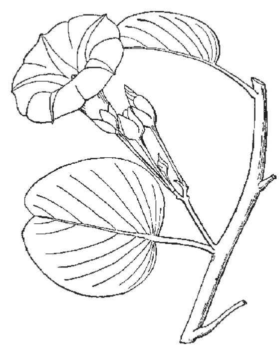


F, FW

Maurandya Vine
Asarina scandens
This vine is also known as the Climbing Foxglove and is an introduced plant native to Mexico. It prefers wilder tracts of woodland and climbs shrubs and trees up to 3 m (10 ft) high. The purple, tubular flowers arise in the leaf axils from the long twining stem. The leaves are very triangular with three sharp points. **Introduced**.

F

Seaside Morning Glory
Ipomoea pes-caprae
As Seaside Morning Glory is able to grow horizontally and vertically it can escape from being buried by shifting sand. This native vine has leaves which are rounded at the base and notched at the tip. Its purple-mauve flowers can be seen during the summer and autumn. (The bay bean's leaves are similar and often confused.) Up to 10 m (30 ft) long. **Native.**



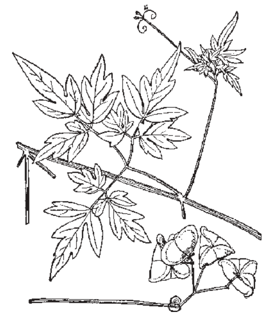
SD

Simple-leaved Jasmine
Jasminum simplicifolium
This vine is common in woodland in the Castle Harbour area. The vine climbs through the trees, sometimes in quite dense masses. The white star-shaped flowers have been used in Bermuda for perfume production and are very fragrant. As the scientific name suggests the leaves are very simple, broadest in the middle and found in pairs along the stalk. Up to 10 m (30 ft) long. **Introduced.**

F, OC, W

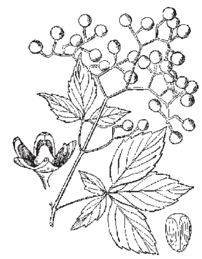
F

Small-Fruited Balloon Vine
Cardiospermum microcarpum
Like its relative the Balloon Vine, which it closely resembles, this tall climbing, or trailing, native vine is a forest plant now uncommon but found in protected land. For characteristics see the balloon vine above. This one differs in having a smaller fruit capsule only about 1 cm (1/2 in) long. Up to 10 m (30 ft) long. **Native**.



F, FW

Virginia Creeper
Parthenocissus quinquefolia
A tall-growing clinging vine. Easily recognised by the vine habit and the leaves with five prominent leaflets. The leaves turn red in autumn. Common in swamps. Up to at least 10 m (30 ft) high. **Native.**



F, FW

West Indian Cissus
Cissus sicyoides
A tall, clinging vine of the swamps and marshes. May completely cover small trees with its foliage. It has characteristic heart-shaped, shiny, light green leaves about 6 cm (2.5 in) long. Up to 7 m (20 ft) high. **Native.**

Shrubs

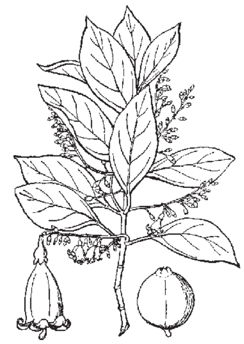
F, OC

Bermuda Holly
Ilex vomitoria
As suggested by the scientific name the berries have been used as a purgative. Holly is a shrub about 2 m (6 ft) high with simple leaves, that bears bright red berries in autumn. Survives in Devonshire Marsh. **Naturalized**.

Bermuda Snowberry F

Chiococca bermudiana

A sprawling shrub that normally grows to two meters (six feet) but Bermuda Snowberry is sometimes vine-like and branches can grow up to 5 m (10 ft) long. It has shiny leathery leaves 5-10 cm (2-4 in) long. The leaves are shaped like an oval that is pointed on both ends. They grow opposite one another on the stem. Sprays of small yellow bell flowers appear in autumn and develop into pure white berries. Up to 2 m (6 ft) high. **Native.**



Box Briar OC

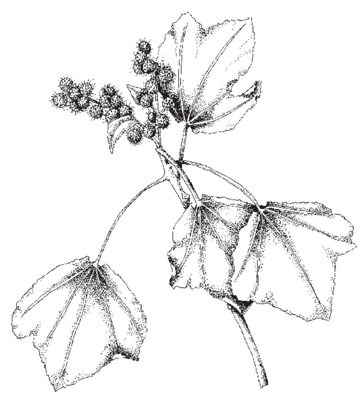
Randia aculeata

A shrub, now rare, that formerly grew in upland forests and exposed coastal forests. Characterised by stout spines and small leaves. Grows to about 1.5 m (5 ft) high. **Native.**

Burr Bush F, W

Triumfetta semitriloba

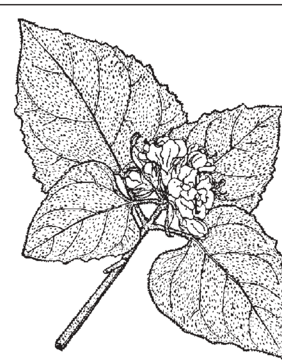
This plant is native to Florida and the West Indies. It is of very wide distribution in Bermuda but particularly common in woodland and wild areas. This shrub takes its name from the groups of spiny burrs found on the plant after its late summer flowering. These burrs up to 1 cm (3/8 in) in diameter look like tiny mines. The leaves alternate along the stem and are quite large, broadest at the base and coarsely toothed. Considered to be **native**.



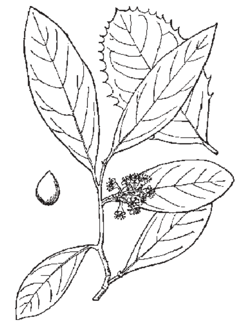
Bush Clerodendron F

Clerodendrum glabrum

A shrub or small tree. The leaves are thin pointed ovals up to 13 cm (5 in) long. The leaves grow opposite one another or in a whorl. They have a distinctive, bitter smell when crushed. Small, fragrant, pinkish flowers with the stamen protruding cluster along terminal spikes. The fruit is a pale grey berry about the size of a pea. Can grow to 5 m (15 ft). **Introduced.**

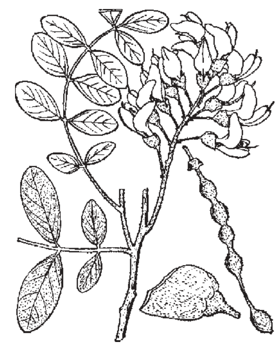


Carolina Laurel Cherry
Laurocerasus carolinianum
A small tree up to 12 m (40 ft) high with a slender trunk. The 6-10 cm (3-4 in) long leaves are leathery, oblong and pointed on a short stalk. The flowers are white and small, borne in the leaf axils. The fruit is black and plum-like 3 cm (3/4 in) long. Invading swamp-forests. **Introduced**.



F, FW

Coast Sophora
Sophora tomentosa
A tall shrub with a woody stem, the sophora has leathery leaves covered with downy hairs and forming pairs along the stem. The flowers, which occur from summer to spring, are most often yellow, sometimes white or even purple and similar to those of the pea family. They form pods rather like peapods after flowering. 90 cm to 2.7 m (2.5-9 ft) in high. **Native**.



R

Common Sage or **Lantana**
Lantana involucrata
This is the common very fragrant sagebush of Bermuda. A relatively small shrub up to 1.3 m (4 ft) high it is common in many habitats as well as in cultivation. The leaves about 2.5 cm (1 in) long are oval in shape with a scalloped edge. The flowers vary somewhat in colour as they mature but are basically reddish-purple. **Native.**

F, OC, U, W

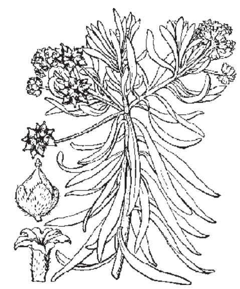
Doc-bush
Baccharis glomeruliflora
A shrub reaching 3 m (10 ft) high that is common in most peat marshes and uplands. It is evergreen and the light greenish-yellow leaves about 8 cm (3 in) long have a few coarse teeth near to the pointed tip. The fruits have hairy tufts. **Native**.

F, FW, W

Hibiscus
Hibiscus rosa sinensis
A shrub with a great many cultivars having large, trumpet-shaped flowers, from white to red, borne over a long season. This shrub is widely planted in gardens, parks and hedgerows and is one of the commonest introduced shrubs. Growing to 4 m (12 ft). **Introduced.**

SD, U, W

Iodine Bush
Mallotonia gnaphalodes
A low-growing native shrub, the bay lavender has numerous long fleshy leaves which are covered in downy hair. The flowers which grow up through the centre of the leaf cluster are white and bell-shaped, appearing from spring to autumn. To 90 cm (3 ft) high. **Native.**



OC, SD

Jamaica Dogwood
Dodonaea viscosa
A shrub whose bark on the trunk is a reddish brown and it has string like strips. The yellow green leaves are lance like to 12 cm (4 3/4 in) long. They are rough textured with distinctive veins, particularly the central vein. The stems of the leaves are angular. The flowers are tiny and grow on short spikes. Pinkish-brown papery fruit made up of three capsules or segments produce winged seeds. This plant is sticky. About 2 m (6 ft) tall. **Native.**

F

Jumbie Bean, Acacia or **Wild Mimosa**
Leucaena glauca
Shrub or small tree. The delicate leaf is made up of many tiny paired leaflets and is 10 cm (4-12 in) long. The flowers are small, whitish, puffballs that can be more than 3 cm in diameter. The seeds are brown bean shaped seeds in long flat pods. Jumbie Bean is common in waste and cultivated ground. Up to 10 m (30 ft) tall. **Introduced** and **naturalized**.

W

Madagascar Buddleia or **Snuff Plant**
Buddleia madagascariensis
A straggling vine like shrub whose leaves are spear like and 13 cm (5 in) long. They are grey-green above with a white or yellow woolly underside. The branches are also covered with a white woolly or felt-like substance. The flowers are small, orange tubes. They produce an extremely sweet scent. Flowers appear in spring and summer. Grows to 7 m (20 ft). **Introduced.**

U, W

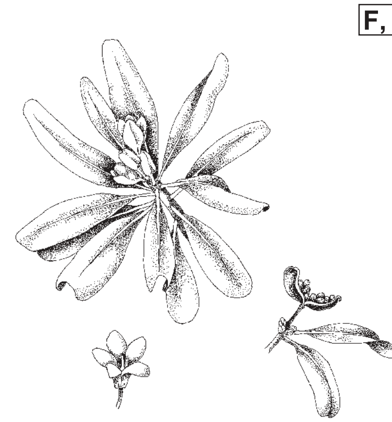
Natal Plum
Carissa grandiflora
This is a versatile plant the light red fruit borne all summer are edible, the plant forms good hedges and because of the stout thorns, borne in pairs, it is a good burglar deterrent if grown beneath windows. The leaves are leathery and the flower is white and showy. To 2.5 m (8 ft) high. **Introduced.**

W

Oleander
Nerium oleander
The oleander was introduced in 1790. It was known as "The South Sea Rose" and was often used to decorate wedding cakes. It is now naturalized. It blooms mainly in the spring and summer. The oleander provides a good windbreak for plants growing on the leeward side of the dunes. To 3 m (10 ft) high. **Introduced** and **naturalized**.

U

Pittosporum or **Mock Orange**
Pittosporum tobira
A shrub or small tree. The leaves, which can grow to 10 cm (4 in) long, are egg shaped with the broader end above the middle. They are dark green, shiny and leathery in texture. The edges of the leaf are rolled toward the underside of the leaf. The leaves have quite a distinctive smell when crushed. Five-petalled flowers are white to lemon-yellow. The half inch long flowers grow in fragrant clusters. The fruit is a green capsule which splits into three segments containing attractive, red, sticky seeds. Can grow to 6.5 m (18 ft). **Introduced.**



F, U, W

Poison Ivy
Rhus radicans
This nasty little shrub or low vine, up to 1 m (3 ft) high is common both in swamps and marshes and also occurs at the back of mangrove swamps and around ponds. The three-lobed leaves are shiny, but varied in shades of green, and sometimes exude a black liquid. The whole leaf is about 7-10 cm (3-4 in) across. About 1 m (3 ft) high. Very poisonous. **Probably native**.

F, FW, W

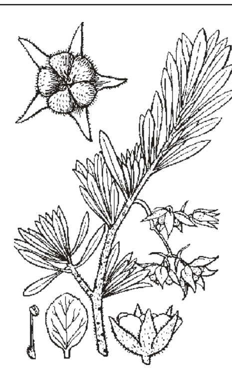
Shrubby Fleabane
Pluchea odorata
This is an aptly named shrub with typical fleabane character. The leaves are oblong from 8-16 cm (3-6 in) long. White flowers are small and daisylike. Numerous flowers are arranged in flat topped clusters. Growing from 1-2.5 m (3-8 ft) tall. **Native.**

F, FW, W

Surinam Cherry
Eugenia uniflora
A shrub or small tree that was introduced and has become naturalised in Bermuda. The leaves are 4-7 cm (1-2 1/2 in) long. They are dark green and shiny, somewhat spear shaped, rounded at the base and pointed at the tip. The leaves grow opposite each other. New leaf growth is reddish. The smell is distinctive when the leaves are crushed. The small, white flowers have four or five petals. The fruit is bright red and round with deep grooves. The bark of the trunk is a smooth, pale brown with patches that are easy to peel off. Can grow up to 8 m (25 ft). **Introduced** and **naturalised**.

F, W

Tassel Plant
Suriana maritima
A shrub of sandy coasts often growing in dense thickets. It has clustered leaves and varies in height from the low-growing to fairly tall. The leaves are soft in texture and covered with fine, silky hairs. The yellow flowers, appearing mostly from spring to autumn, are protected by "tassel-like" leafy clusters giving the plant its name. 1.5-2 m (4-6 ft) high. **Native**

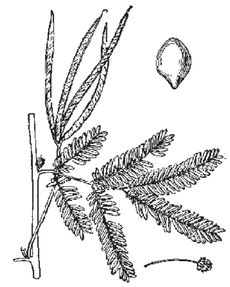


OC, SD

Virgate Mimosa F, W

Desmanthus virgatus

Its most obvious feature is the long, delicate pinnate leaves found in opposite pairs along the stalk. It has flowers in feathery balls which are followed by brown, slender, pointed seed pods. The plant commonly grows 2 m (6 ft) high. **Native**.



Wax Myrtle FW, W

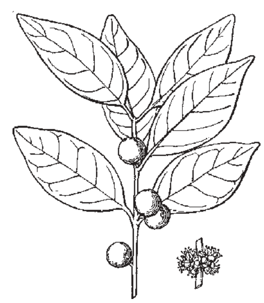
Myrica cerifera

Wax Myrtle is a large shrub that may form almost pure stands in some marsh-swamp habitats, such as parts of Devonshire Marsh. The leaves are quite long, pointed at the end, with 2-3 large teeth on the outer part of each leaf-edge, and leathery in texture. The flowers are rather inconspicuous. Up to 6.5 m (20 ft) high. **Native.**

White Stopper F

Eugenia axillaris

A shrub or small tree that grows up to 5 m (15 ft) tall that is now quite rare. It is most commonly seen in the Walsingham district and has been re-introduced to Nonsuch Island. The rather leathery leaves are almost always attacked by a leaf mining insect that leaves sinuous, whitish, obvious tracks within the leaves. **Endemic.**



Wild Coffee F

Psychotria ligustrifolia

This is a rare shrub growing in woodland. It flowers in spring and then bears bright red fruits. The leaves are elongate and pointed without marginal teeth. The leaves leave prominent leaf scars on the stem when they are shed. Up to about 1.5 m (5 ft) in height. **Native**.

Trees

Allspice F

Pimenta dioica

Allspice is a tree. The leaves are narrow oblong or slightly lance shaped, approximately 10 cm (6 in) long. They are leathery and shiny. When crushed they produce the fragrant smell of allspice. The small white flowers are produced in broad flat-topped clusters. They are followed by green berries which turn black when ripe. The green berries are dried and ground to make the culinary allspice. The bark has a mottled olive-green and tan appearance, like camouflage. Growing up to 13 m (40 ft) high. **Introduced** and **naturalized**.

Ardisia F, FW

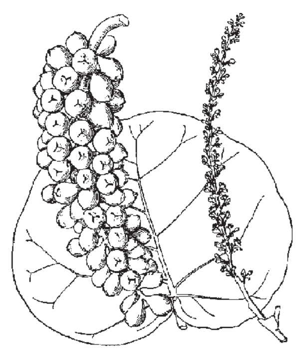
Ardisia polycephala

An invading shrub of the swamp-forests. The leaves are 10-15 cm (4-6 in) long and pointed. The greenish-purple flowers are in flat groups at the end of branches or on side shoots. Up to about 3-3.5 m (9-10 ft) high. **Introduced.**

Bay Grape F, OC

Coccoloba uvifera

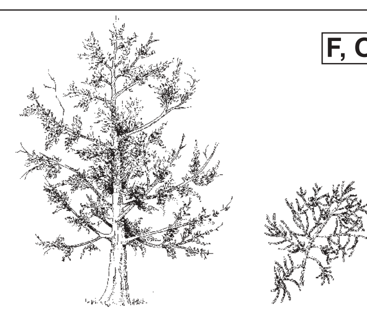
Commonly found either as a large shrub or a tree, this native plant has a short, twisted trunk and large rounded leathery leaves, highly resistant to salt spray. The flowers are borne on long spikes from spring to autumn and are tiny and whitish in colour. The fruit that follow resemble grapes in size and colour and are often used in jams and jellies. Variable in height 2-18 m (6-18 ft). **Native.**



Bermuda Cedar F, OC, U, W

Juniperus bermudiana

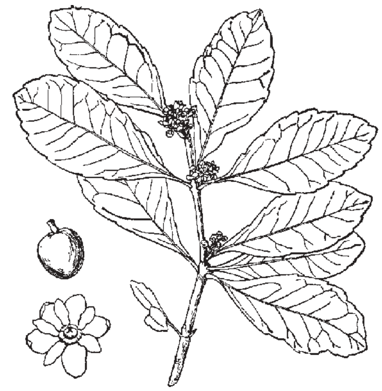
Bermuda Cedar was a dominant upland tree when the islands were colonised but has since been decimated by exploitation and insect damage. The wood is highly aromatic. Cedar is a large tree with scale-like foliage and purple-black berries. Up to 13 m (40 ft) high. **Endemic.**



Bermuda Olivewood **F, U**

Cassine laneana

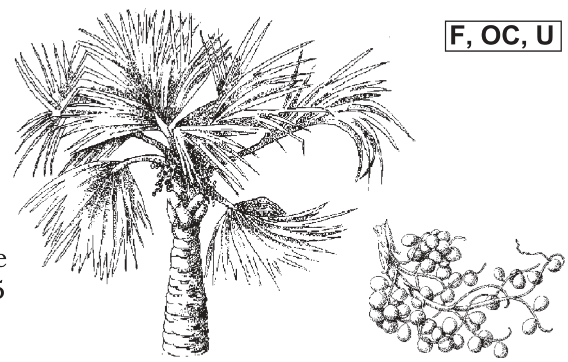
An endemic tree. Compact and oval when young. The mature leaves are dark green and somewhat leathery. They are slightly toothed. The edges of the leaf are rolled toward the underside. The leaves are egg shaped with the broader end above the middle of the leaf. The young leaves are a light yellowish-green, contrasting with the dark green older foliage. Small greenish or white flowers are either male or female and grow in clusters. The female flowers produce a fleshy yellowish, olive-shaped fruit about an inch long. The bark was used for tanning in the early days of Bermuda. Can grow to 10 m (30 ft) tall. **Endemic.**



Bermuda Palmetto **F, OC, U**

Sabal bermudana

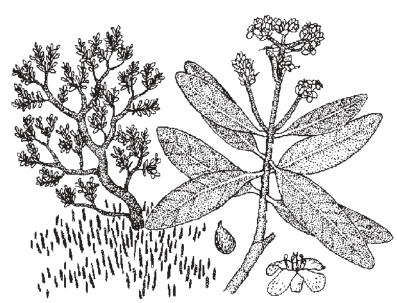
Bemuda Palmettos were once the dominant lowland tree of Bermuda. They have been exploited quite heavily in the past and are out-competed by some introduced fan-palms. The trunks are stout with numerous leaf-scars and the fan-shaped fronds emerge in a mass from the top. Fruit black in large clusters. Up to 8.5 m (25 ft) high. **Endemic.**



Black Mangrove **M**

Avicennia germinans

The characteristic tree of the back of mangrove swamps. The size is very variable but it can be a big tree. The trunk is scaly black and the leaves a leathery elongate oval, blunt at the tip and a greyish-green in colour. A definitive diagnostic character are the pencil-like pneumatophores or air breathing roots, rising out of the sediment. Up to 17 m (50 ft) high. **Native.**



Brazil or **Mexican Pepper**

F, M, OC, W

Schinus terebinthifolia

This tree has occupied a huge variety of habitats in Bermuda. It competes with native trees in mangroves and swamps and is encroaching in marshes. The leaves are compound and pungent if crushed. The large groups of small berries borne in winter ripen to a deep red. Up to 7 m (20 ft) high. **Introduced.**

Buttonwood

M, OC

Conocarpus erectus

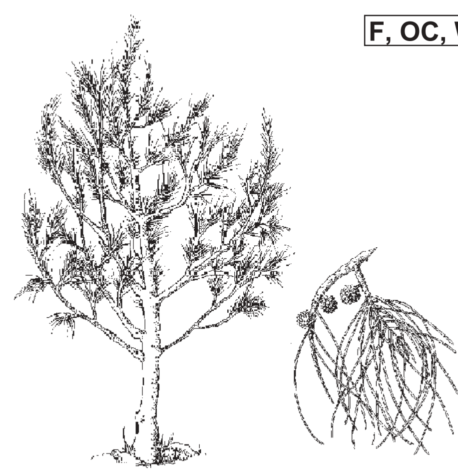
A tree which does not live up to its “erectus” name since some specimens in exposed places are sprawling or even ground hugging. A tree of very varied height. Sometimes considered a mangrove, it is common as the rear tree of mangrove swamps or forming fringing stands along sheltered coasts. The leaves are oval, fairly broad and leathery and have two little keels on either side of the leaf stalk. The flowers are white fuzz-balls and the fruit small cone-like structures, turning red when mature. Height from a few cm (in) to 6.5 m (20 ft). **Native.**

Casuarina, Australian Whistling Pine or **Whispering Pine**

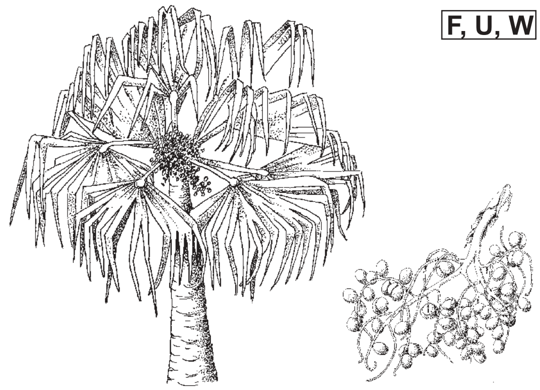
F, OC, W

Casuarina equisetifolia

Casuarina is a shallow rooted tree. It resembles a conifer but the “pine needles” are segmented branchlets about 1 cm.(3/8 in) long with tiny leaf scales appearing at the segments. The branchlets appear in sprays. There are separate male and female flowers. The female flowers produce a prickly cone with tiny winged seeds. This fast growing tree was planted in large numbers during the 1940s, following the Bermuda Cedar blight. Grows from 10-25 m (30 to 80 ft) high. **Introduced.**



Chinese Fan Palm or **Chinese Fountain Palm**
Livistonia chinensis
This fan palm has leaf stalks that are toothed toward the base. The large leaf blade has prominent accordion pleats. The leaves droop producing a fountain-like effect. Flowers are produced in clusters of up to 6. The resulting fruit are blue-green, egg shaped and are nearly 2.5 cm (1 in) long. The pulp of the fruit is an intense orange. Growing up to 10 m (30 ft) or more high. **Introduced.**



F, U, W

Fiddlewood
Citharexylum spinosum
A tree up to 15 m (50 ft) high and with a trunk up to 1 m (3 ft) in diameter. The large leaves are shaped like an elongated heart and are unique in that they turn yellow and fall in early summer. The white flowers borne in long strings are small and fragrant. Common. **Naturalized**.

F

Forestiera
Forestiera segregata
A small, bushy, deciduous tree with a trunk that can be up to 15 cm (6 in) but is usually less. The leaves are roughly spear shaped, 2.5-6.5 cm (1 to 3 in) long. The flowers are very small. The fruit is oblong and fleshy up to 3 mm (1/6 in) long. Forestiera flowers in the autumn and winter. Leaf fall is very erratic, normally occurring as the result of drought or insect infestation that can grow up to 7 m (20 ft). **Native.**

F

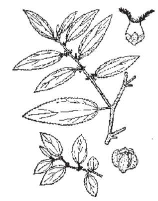
Guava
Psidium guajava
An evergreen shrub or small tree with blunt, oval leaves 6 cm (2.5 in) long. The yellow fruits are spherical and about 1.5 in (3.5 cm) across. A useful identification feature is that the bark sheds in patches, leaving areas of varying colour on the trunk. Up to 10 m (30 ft) high. **Introduced.**

FW, W

Indian Laurel
Ficus retusa
A real pest tree that has become established in a wide variety of habitats. Up to 50 ft (16 m) high it has small leaves and gives dense shade. **Introduced**.

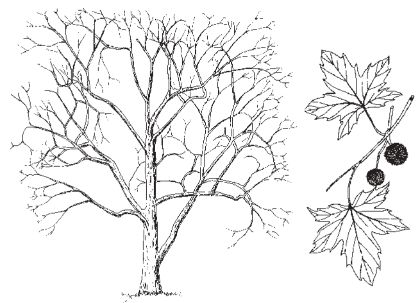
F, U, W

Lamarck's Trema
Trema lamarckiana
A small tree with a rather straggly growth form. Rare now but formerly much more common. Up to about 3 m (9 ft) in height. **Native.**



F

London Plane Tree
Platanus **x** *acerifolia*
A large deciduous tree up to 21 m (70 ft) in height with a large, straight trunk. This tree is a cross between the American Sycamore and the Oriental Sycamore. The leaves have a maple-like shape. It is very tolerant of urban conditions and widely planted in Europe. **Introduced.**

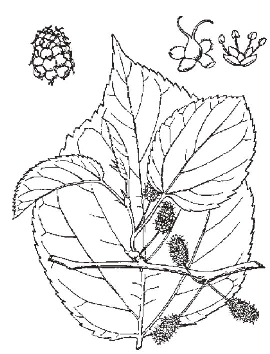


U

Mahogany
Swietenia mahogani
A large heavily-built tree with a spread equal to or greater than the height. Grows up to 30 m (100 ft) high. The leaves are simple with a rounded base and sharp tip. The wood is valued for furniture making. A notable specimen is in Flatts, others may be found in gardens. Native to Cuba and Jamaica. **Introduced.**

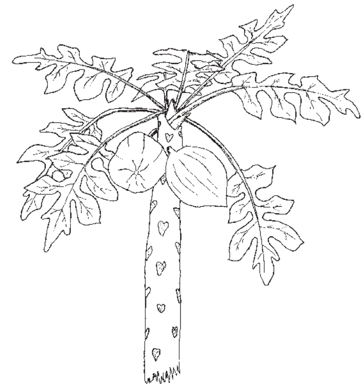
U

Mulberry
Morus nigra
The history of mulberries in Bermuda is a bit mysterious. The Black Mulberry is considered native to western Asia. It is a smallish tree up to 8 m (25 ft) high bearing elongate toothed leaves and flowers in drooping catkin-like structures. The delicious fruits are red to black in colour with a large central stone. About 5 m (15 ft) high. Either **native** or **introduced.**



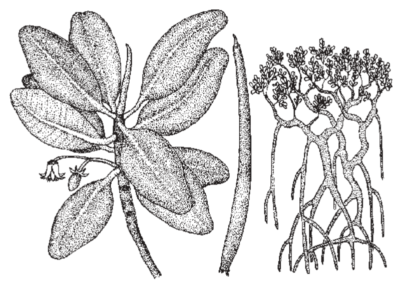
F, U

Papaya or **Paw-paw**
Carica papaya
This small tree with edible fruit originated in Columbia. The trunk is thick but not hard and shows prominent leaf-scars from dropped leaves. The leaves, in a clump at the top of the trunk, are very distinctive being large with seven lobes. Male and female trees are separate. The large fruit can be eaten green as a vegetable or when ripe and yellow as a fruit. Up to about 7 m (23 ft) high. Naturalised widely. **Introduced.**



U, W

Red Mangrove
Rhizophora mangle
This is the most highly adapted of the Bermuda mangroves to a salt-water existence. The diagnostic feature are the wide-spreading prop roots arching into the water. Adventitious roots dropping from the branches are also present. The leaves are dark green, large, broad and shiny; the flowers are yellowish-white and fragrant. A second unique feature is the large embryos. Commonly 3-5 m (15-25 ft) high but it can be much larger. **Native.**

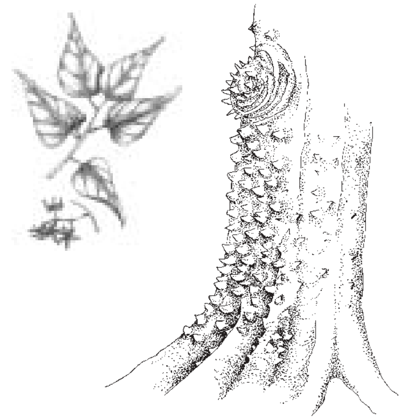


M

Royal Poinciana
Delonix regia
This tree is native to tropical Africa and India. It is widely spreading, the trunk dividing quickly into stout spreading branches so that the spread of the tree may approach twice the height of up to 12 m, (40 ft). It has compound leaves which are shed in autumn, showy red flowers and large black seed pods. **Introduced**.

U, W

Southern Hackberry or **Hackberry**
Celtis laevigata
A deciduous tree with thin, pale green, spear like, rough textured leaves which are alternate on the stem and grow up to 10 cm (4 in) long. The flowers are small and greenish. They produce small orange-red fruit that ripen to dark purple. Hackberry is fairly uncommon but can be found in Walsingham and small pockets of upland forest. The bark can have a warty appearance. Southern Hackberry spreads by root suckers. Grows to 13 m (40 ft) high. **Native.**



F

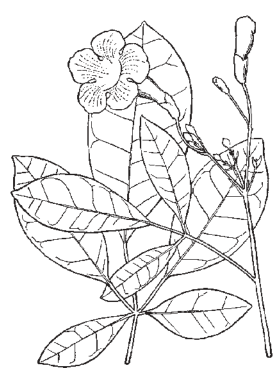
Strawberry Guava
Psidium cattleianum
An evergreen shrub or small tree up to 10 m (30 ft) high with blunt, oval leaves 6 cm (2 1/2 in) long. The yellow fruits are spherical and about 3.5 cm (1 1/2 in) across. A useful identification feature is that the bark sheds in patches, leaving areas of varying colour on the trunk. **Introduced**.

F, U, W

Tamarisk
Tamarix gallica
A small tough tree or large shrub, typical of windswept shorelines and very common along the North shore. It is also found bordering ponds and scattered in other habitats. The branches are arching and the leaves small and scale-like. The attractive pink flowers appear in sprays. It is often called “spruce”. Up to about 5 m (15 ft) high. **Introduced**.

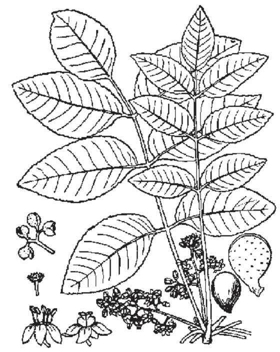
F, OC

White Cedar
Tabebuia pallida
This attractive tree has leaves with three to five spear shaped leaflets which are up to 11 cm (4 1/2 in) long. Flowers are showy trumpets that are lilac-white with a yellow throat. The flowers are solitary or several in a cluster. The fruit is a long, pod-like capsule with many white winged seeds. Bark is dark brown and is rough with raised lines that sometimes form diamond patterns. Grows up to 20 m (60 ft) tall. **Introduced.**



U

Yellow-wood
Zanthoxylum flavum
Yellow-wood trees were common in the upland forests when Bermuda was colonised. They form beautiful, robust trees that have wood that was highly prized for furniture making. Sadly, now only a handful of these trees survive and young ones are not found. They need special protection. The tree has nice compound leaves. The clusters of white flowers are followed by purplish-black berries. Up to 13 m (40 ft) high. **Native.**



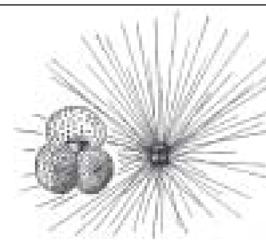
F

Animal Plankton

Note: Zooplankton, although larger than phytoplankton are generally quite small**.** A compound or stereo microscope is needed for identification, depending on the size of the specimens. Sizes are given in metric units only.

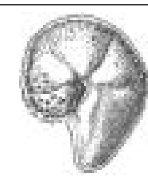
Foraminifera (Protozoa with a calcareous skeleton)

Globigerinoides ruber
A common open ocean species. The calcareous, central test is multi-chambered and about 0.6 mm in diameter. Numerous, long, calcareous spines project radially out from the test to bring the diameter to 5 mm or so. **Native.**



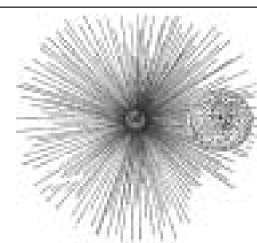
O

Globorotalia truncatulinoides
This foraminiferan is very common in the open ocean. The calcareous test is rather snail-like in shape and 0.8 mm in length. **Native**.



O

Orbulina universa
As its name suggests this species is common and widespread in the oceans. The spherical test is about 1 mm in diameter and from it project numerous fine, calcareous spines which bring the total diameter to about 5 mm. **Native**.

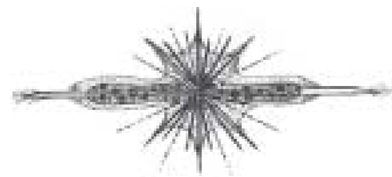


O

Acantharia (Protozoa with strontium sulphate skeleton)

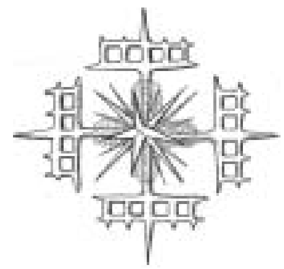
O

Amphilonche elongata
This species has two of the 20 spines much longer than the others and emerging from the center opposite to one another and giving the organism an elongated appearance reaching 0.6 mm long. Found in the near-surface depths. **Native**.



O

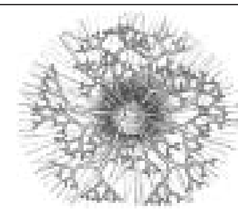
Lithoptera tetraptera
This species is unmistakable if seen in collections from near to the surface. The distinguishing feature is the presence of four, larger spines arranged in a circle each having a crossbar with four squares. The other simple spines are shorter. The diameter is about 0.5 mm. **Native**.



Radiolaria (Protozoa with silica skeletons)

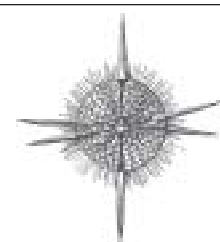
O

Coelodendrum ramosissimum
This species is a striking member of the group having long, evenly branched spicules arising from the small central capsule about 1.5 mm in diameter. **Native**.



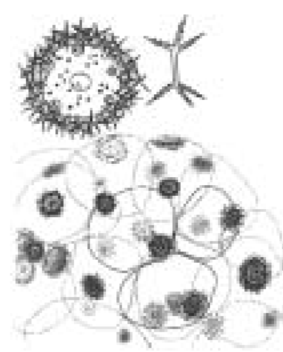
O

Hexalonche amphisiphon
This species is a typical radiolarian having a clear, spherical shell from which project six large spines and numerous small ones. Found at depths to about 100 m (300 ft). About 0.45 mm in diameter. **Native**.



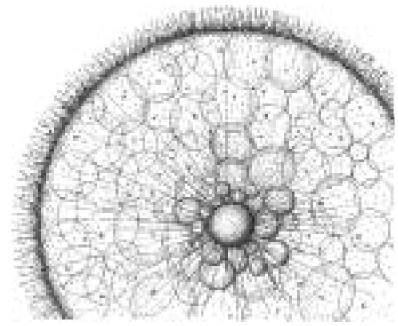
O

Sphaerozoum punctatum
This interesting radiolarian is a colony the tiny individuals of which are embedded in a gelatinous ball about 3 mm in diameter. The ball is covered by a layer of spicules having needle-like projections armed with short spines. Another interesting feature of this species is that the central ball containing the individuals also has **zooxanthellae**. These are members of the phytoplankton living in a symbiotic relationship with this member of the zooplankton. Common near to the surface of the ocean. **Native**.



O

Thalassolampe maxima
As the second of the scientific names suggests, this is a large species for this general group of zooplankton, in fact it is the largest known radiolarian. The body appears as a sphere up to 12 mm (1/2 in) in diameter covered in a transparent membrane, minutely hairy on the outside. Unlike most radiolarians, there are no spicules. Common near to the surface of the ocean. **Native**.



Ciliata (Ciliated protozoa)

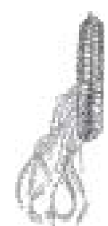
O

Tintinnopsis campanula
This species has a loosely fitting shell, shaped like a wine-glass with no foot, composed of irregular grains which the protozoon produces. The emerging part of the organism has a prominent crown of long cilia. Very widespread in surface waters. About 0.15 mm long. **Native**.

Cnidaria (Hydroids, jellyfish, etc)

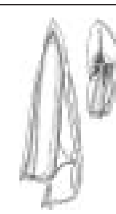
O

Agalma okeni
The elongated body measures up to 15 mm and contains many specialised individuals. The species is almost totally transparent and hard to spot. It is common offshore from the surface to 200 m (650 ft) deep. **Native**.



O

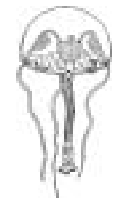
Chelophyes appendiculata
About 15 mm long this species has a pointed top and skirt-like bottom. It is very common and aggregates at the surface on moonlit nights off Bermuda. **Native**.



O

Cytaeis tetrastyla
A small medusa about 6 mm across which is quite common. There are four tentacles below a bell-shaped body. **Native**.

Liriope tetraphylla
One of the larger medusas being up to 24 mm across. It has a hemispherical body with four long tentacles. It is very common in oceanic surface waters. **Native**.



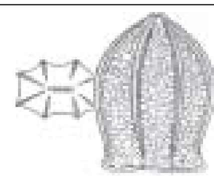
O

Rhopalonema velatum
Up to about 10 mm across, this species is quite common. There is a shallow bell-shaped body with 8 longer club-shaped tentacles and many smaller ones. **Native**.

O

Ctenophora (Comb Jellies)

Beroe ovata
A large comb-jelly up to 50 cm across. The body is bell shaped. It feeds on other ctenophores. **Native**.



O

Sea Gooseberry
Pleurobrachia pileus
This is a very widespread species which brings to mind the common name of sea gooseberry. The body is almost spherical with longitudinal ciliated bands. There are two long tentacles. Body up to 20 mm in diameter. **Native.**

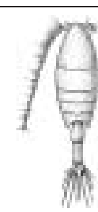
O

Crustacea (Copepods, shrimps, crabs etc)

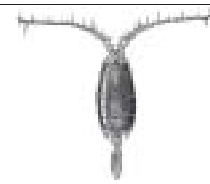
Acartia bermudensis
This is a member of the permanent plankton and is a calanoid crustacean. Shaped rather like a grain of rice with two long antennae almost as long as the body. The length is about 1.2 mm and the body is almost colourless. **Native**.

B

Calanopia americana
This calanoid crustacean is a member of the permanent plankton. The body is an elongated oval with antennae about 2/3 of the body length. About 1.4 mm long. Basically colourless. **Native**.

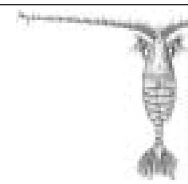


B



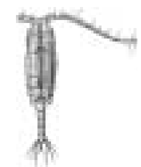
O

Candacia ethiopica
Measuring about 2.5 mm in length this species is an unusual pale chocolate-brown in colour. **Native**.



O

Centropages violaceus
About 2.5 mm long is pale violet in colour; this crustacean is found in near-surface oceanic water. **Native**.

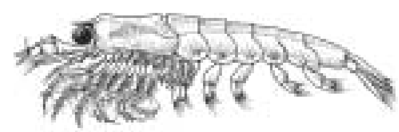


O

Clausocalanus furcatus
This is a typical calanoid crustacean of near-surface oceanic waters. The virtually clear body is about 1.2 mm long. **Native**.

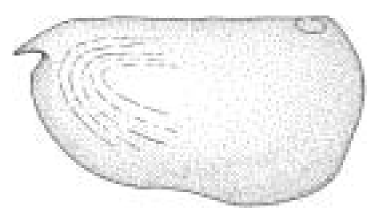
O

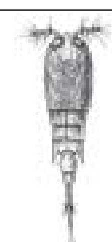
Common Krill
Euphausia brevis
This is the commonest of the krill found in the ocean around Bermuda. It ranges from the surface to 300 m in depth and reaches 10 mm in length. **Native.**



O

Conchoecia spinirostris
The body of this species is enclosed in a bivalved shell about 1.2 mm long. The front of the shell has a short, sharp projection. The body is hidden within the shell. Common near to the surface. **Native**.

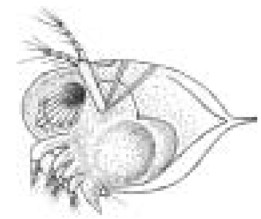




B

Corycaeus flaccus
A cyclopoid crustacean and a member of the permanent plankton. The colourless body has two prominent eyes and is broadest at the front, tapering steadily back. The antennae are short. Colourless. About 1.6 mm in length. **Native**.

Evadne spinifera
This is a small species with a body about 0.7 mm long with a large, prominent eye. The shell is colourless, thin and simple, covering the hind end and finishing in a short spine. Found in surface waters of the Sargasso Sea. **Native**.

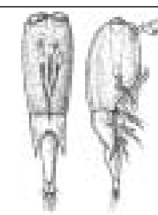


O

Evadne tergestina
Very similar to the species above except that the hind end of the shell is rounded and the head is more clearly set off from the body. About 0.7 mm in length. **Native**.

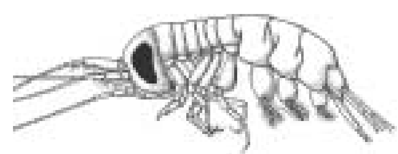
B

Farranula rostrata
This species of surface water oceanic situations is small, only 0.7 mm long. The body is blunt at the front with two large eyes. The antennae are not visible from above. **Native**.



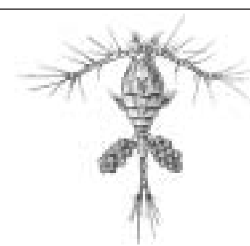
O

Hyperia bengalensis
This planktonic amphipod crustacean is flattened from side-to-side and characterised by the presence of two very large, dark eyes. Commonly about 6 mm long this crustacean is common in offshore waters. **Native**.



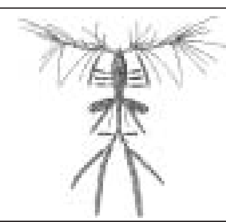
O

Oithona nana
A small cyclopoid crustacean of the permanent plankton. This species has a single eye at the front and females often have two egg sacs. The antennae are about half the length of the body. Colourless. About 0.6 mm long. **Native**.



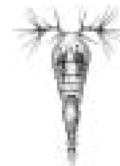
B

Oithona plumifera
This is an unmistakable species characterised by very long, feathery spines on the antennae, body and tail. Up to 1.2 mm long this oceanic species is found close to the surface. **Native**.



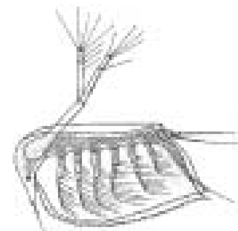
O

Oncaea venusta
The body is only 1 mm long and much broader at the front than elsewhere. The antennae are comparatively short. **Native**.



O

Penilia avirostris
This cladoceran crustacean has a small but obvious eye and antennae almost as long as the body. It has a beak-like point on the head and a rather rectangular body. About 1.1 mm long this creature is colourless. **Native**.

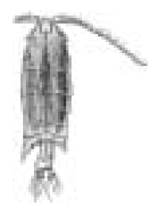


B

Podon polyphemoides
A cladoceran crustacean with large prominent eyes and a hump-backed body. The body is colourless and the antennae very short. Length about 0.7 mm. **Native**.

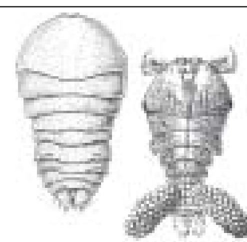
B

Pontella atlantica
Pontella is comparatively large for this group of planktonic crustacea, measuring up to 5.5 mm long. A pale, clear blue in colour it occurs in offshore surface waters. **Native**.



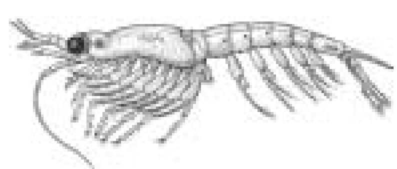
O

Sapphirina auronitens
The body in this species about 2 mm in length is very chunky and the antennae are tiny. Unlike most zooplankton the body is coloured and iridescent. An oceanic species typical of near-surface waters**. Native**.



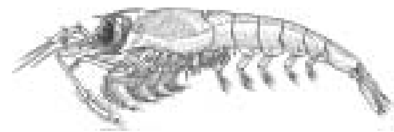
O

Siriella thompsoni
This is a mysid shrimp which can be collected at the ocean surface at night using a light. Measuring about 10 mm long. Colourless. **Native**.



O

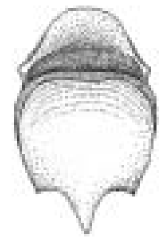
Thysanoëssa gregaria
This krill may reach 12 mm in length and is characterised by bright red colour on the back and sides. Found from the surface to 200 m deep. **Native**.



O

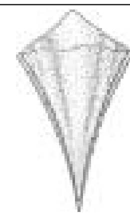
Mollusca (Snails and Clams)

Cavolinia gibbosa
Of all the sea butterflies this one has the most globose shell which is up to 10 mm long. There are three weak points at the hind end, one central and two lateral. The colour is a light brown. Common worldwide. **Native**.



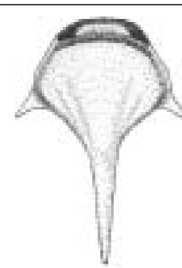
O

Clio pyramidata
One of the larger sea butterflies with a shell up to 21 mm in length. The shape is conical with incurved sides. The colour is often pale red. Common worldwide**. Native**.



O

Diacria trispinosa
This species has a very distinctive shell shape, having three horns, one large one at the hind end and two smaller ones on each side hence the scientific name 'trispinosa'. The colour may be either brown or clear. Common worldwide**.** 20 mm long. **Native**.



O

Limacina inflata
This general group of snails is called the 'sea butterflies' This species has a coiled shell up to 1.5 mm wide. In life, lobes of the foot extend from the shell opening, like butterfly wings, and serve in locomotion in the water. **Native**.

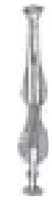
O

Styliola subula
This sea butterfly has a relatively simple, conical shell about 10 mm in length and of a delicate rose colour. Very common worldwide. **Native**.

O

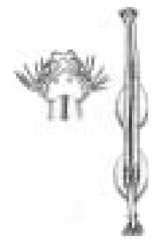
Chaetognatha (Arrow Worms)

Sagitta bipunctata
This is a fairly large arrow worm reaching18 mm (3/4 in). It is very similar to the species above and found in the top 200 m (600 ft) of water. **Native**.



O

Sagitta minima
Almost transparent with a fairly rigid body. Length about 10 mm (1/3 in). Like the other arrow worms this species can dart rapidly, for a short distance to capture prey. Common in the top 300 m (1,000 ft) of water. **Native**.



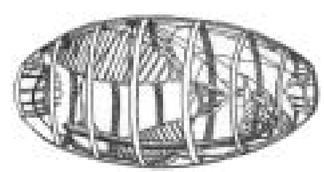
O

Sagitta serratodentata
Very similar to the species described above but reaching 13 mm (1/2 in) long and having more prominent fins and tail. One of the commonest offshore arrow worms. **Native**.

O

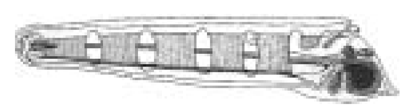
Thaliaceans (Salps etc.)

Doliolum denticulatum
This species and its near relatives resemble a barrel in shape. They move with the long axis of the barrel horizontal in the water. Very transparent. About 4 mm in length. Common at all times. **Native**.



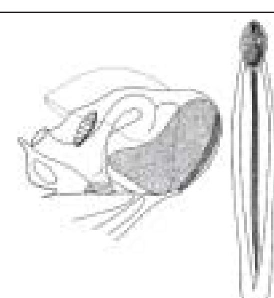
O

Iasis zonaria
An elongated species that is abundant offshore at all times of the year. The length is up to 50 mm. **Native**.



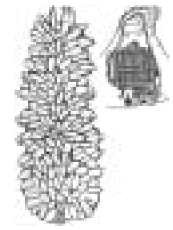
O

Oikopleura longicauda
This is a common member of a group called the Larvacea. The individual resembles a tiny tadpole. However, it lives in a complex ‘house’, 4 mm or so long, which it secretes and propels through the water. The house can be abandoned very quickly and a new one built. Very common offshore close to the surface. **Native**.



O

Pyrosoma atlanticum
This is a colonial member of the zooplankton. The individuals are small and the colony of hundreds of individuals is up to 50 cm long. Occurring from the surface to a depth of 200 m the colonies are often in large groups. **Native**.



O

Salpa fusiformis
The body may be either blunt or sharp-ended depending on the stage of the life history. Extremely common in offshore surface waters especially in winter. 25 mm long. **Native**.

O

Sargassum Community

Plants (Brown algae)

Common Sargasso Weed or **Common Gulfweed**
Sargassum natans
The dominant seaweed in the sargassum rafts. Common throughout the year at sea and washed up on shore. Each plant may be up to 50 cm (20 in) long and consists of many branches with elongated, coarsely serrated leaves and numerous bladders each bearing a terminal spine. **Native**.

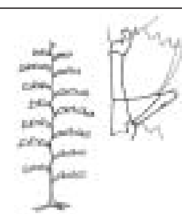
O

Sargasso Weed or **Broad-toothed Gulfweed**
Sargassum fluitans
Almost exactly like the species above except that the bladders have no spine. Fairly common. Each plant is up to 50 cm (20 in) across. **Native**.

O

Cnidaria (Hydroids, jellyfish, etc)

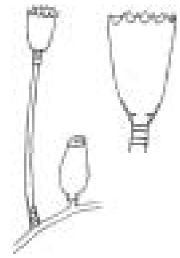
Aglaophenia latecarinata
The vertical branches of this hydroid, which are about 20 mm (3/4 in) high, branch very regularly and alternately on opposite sides of the stalk. Very common. **Native**.



O

O

Clytia cylindrica
The individuals of the colony arise from a threadlike base attached to the sargassum. Each individual occupies a cup-like protective structure with rounded, marginal teeth on top of a stalk Each individual is only 7 mm (1/4 in) tall. Common. **Native**.

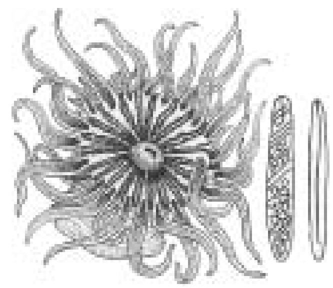


O

Clytia noliformis
Rather similar to the species above but much smaller, the individuals being only 2 mm (1/12 in) tall. The edge of the protective cup has closely set marginal teeth. Common. **Native.**

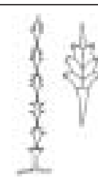
B, C, O

Dark Star Anemone
Pseudactinia melanaster
This is the only sea anemone commonly found on sargassum. It has 32 tentacles and is about 10 mm (3/8 in) in diameter. The colour of the body is fawn to reddish-brown, while the top disk has a star-shaped pattern of dark and light stripes radiating from the center. Very common. **Native**.



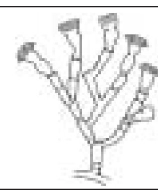
O

Dynamena quadridentata
The stocky branches with individuals closely spaced in groups of 1-6 individuals are about 10 mm (3/8 in) tall. Very common. **Native**.



O

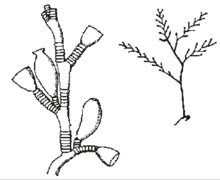
Halecium nanum
This is another small hydroid with the vertical stalks of the colony only 3 mm (1/8 in) high. The stalks branch irregularly. Common. **Native**.



B, O

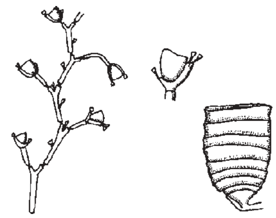
Obelia dichotoma
In this rather feathery species, the individuals of the colony are quite closely set together on vertical stalks arising from a connecting structure on the sargassum. The vertical branches are about 10 mm (3/8 in) tall. Common. **Native**.

Obelia hyalina
Closely related to the above species but much larger, the upright stalks, which may branch, reaching 25 mm (1 in) tall. Common. **Native**.



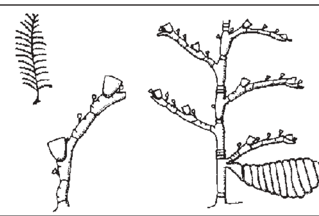
O

Plumularia margaretta
As the scientific name suggests these hydroids are plume-like or feather-like, branching very regularly from the central stalk, with a single individual on each branch. Branches 15 mm (5/8 in) high. Common. **Native**.



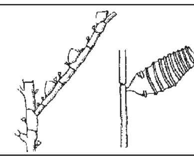
O

Plumularia setaceoides
Rather similar to the above species except that there are several individuals per branch and the branches reach 25 mm (1 in) high. Common. **Native**.



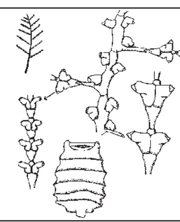
O

Plumularia strictocarpa
A quite large species in which the branches reach 50 mm (2 in) long. Common. **Native**.



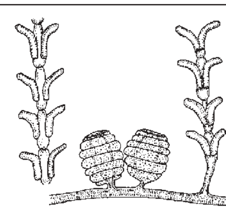
O

Sertularia inflata
The upright stalks up to about 50 mm (2 in) high have the individuals alternating on the central stalk but opposite on the short side branches. The side branches alternate. Common. **Native**.



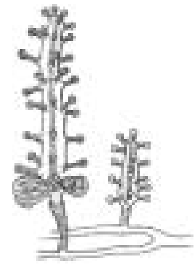
O

Sertularia meyeri
This is a small, delicate species with the branches only about 12 mm (7/8 in) high. The uprights do not branch and the individuals are arranged oppositely. Common. **Native**.



O

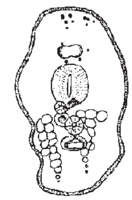
Zanclea costata
The whole colony of this minute hydroid is small and takes the form of a branching, threadlike base, attached to the sargassum. From this base arise the individuals which are only 1.5 mm (1/16 in) tall bearing a few short tentacles. Very common**. Native**.



O

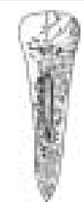
Flatworms

Acerotisa notulata
A tiny, colourless little flatworm 1 mm (1/32 in) long crawling on sargassum. There are two groups of tiny eyes at the front end. Common. **Native**.



O

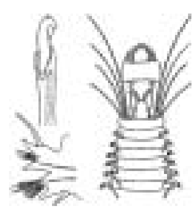
Gnescioceros sargassicola
A milky coloured flatworm with faint brown spots, reaching 10 mm (3/8 in) long. The body is broadest at the front then tapers steadily back. Common. **Native**.



O

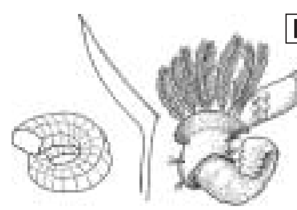
Polychaete Worms (Spiny marine worms)

Dumeril's Ragworm
Platynereis dumerilii
This worm growing to 60 mm (2 3/8 in) long forms transparent, weak tubes on the sargassum. There are up to 90 segments. Very common. **Native**.



B, O

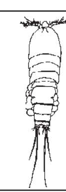
Coiled Tube Worm
Spirorbis formosus
This worm makes very distinctive small, anti-clockwise-coiled, white tubes about 3 mm (1/8 in) across on the surface of the sargassum. Very common. **Native**.



B, O, R, SG

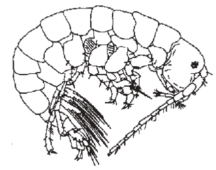
Crustacea (Copepods, shrimp, crabs etc.)

Amonardia phyllopus
This copepod has a body about 0.3 mm long broad at the front, tapering to the back. It has a large, single red eye. Common. **Native**.



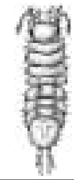
O

Biancolina sp.
Another small amphipod crustacean reaching only 2 mm long. The body is very slender. Common. **Native**.



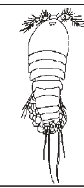
O

Carpias bermudensis
A tiny flat isopod crustacean, 2 mm (1/16 in) long, whitish-brown in colour with darker spots. Common. **Native**



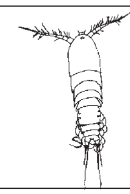
O

Dactylopodia tisboides
In this species about 0.5 mm long the body tapers steadily and is of a reddish-brown colour. Common. **Native**.



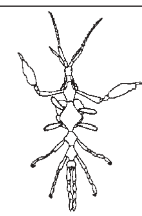
O

Harpacticus gurneyi
A copepod with a steadily tapered body about 0.5 mm long. It is coloured a light reddish orange. Common. **Native**.



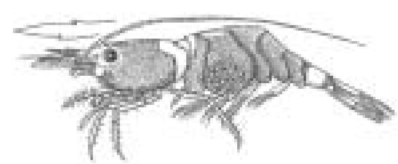
O

Hemiaegina minuta
As suggested by the name, this is a tiny shrimp only 4 mm (3/16 in) long. The antennae and legs are all very long and the body slender. Common. **Native**.



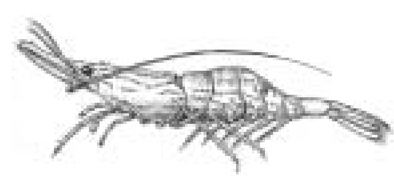
O

Hippolyte coerulescens
A shrimp about 30 mm (1 1/4 in) long. The body is banded in brownish-yellow so that it is well camouflaged among the sargassum. Common. **Native**.



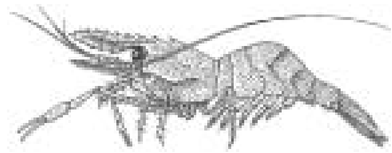
O

Latreutes fucorum
This shrimp is about 20 mm (3/4 in) long. The body is coloured brownish-yellow with white areas and it blends in well with the colour of sargassum. Very common. **Native**.



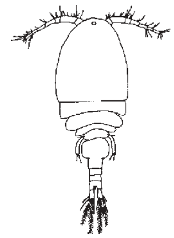
O

Leander tenuicornis
A shrimp reaching 50 mm (2 in) long having a strongly serrated spine between the eyes. The body is yellowish-brown with numerous, small darker brown spots. Very common. **Native**.



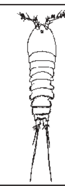
O

Macrochiron sargassi
This is a small copepod crustacean only about 1 mm (1/32 in) long, lacking colour or whitish. Front part of body much broader than the rear. Moves over the surface of the sargassum. Common. **Native**.



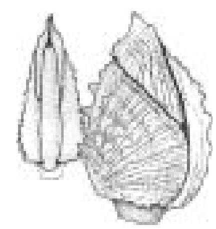
O

Paralaophonte congenera
This copepod has a tapered body, widening slightly 2/3 of the way back. 0.6 mm long. Common. **Native**.



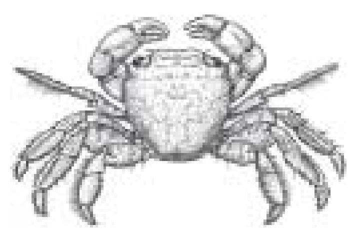
O

Sargasso Barnacle
Lepas pectinata
This is the most common Goose Barnacle found on sargassum. The stalk is very short. The plates on the body are very grooved and often spiny. The total length is about 20 mm (3/4 in). Common. **Native**.



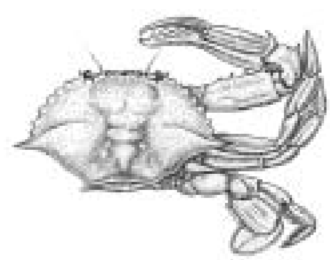
O

Sargassum Crab
Planes minutus
This species is a small crab up to 20 mm (3/4 in) long. The shell is about as broad as it is long. The colour is yellowish-brown. Very common. **Native**.



O

Sargassum Swimming Crab
Portunus sayi
This crab about 25 mm (1 in) across is characterised by its broad hind limbs which are modified for swimming. In colour it may be brown or purplish-brown with olive-green or brown shading and orange markings on the front claws. Common. **Native**.

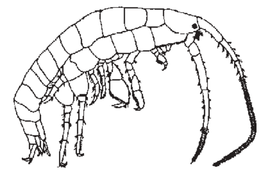


O

Scutellidium longicauda
A small copepod about 0.7 mm in length, has a body which is broad and rounded at the front and very narrow at the rear. Common. **Native**.

O

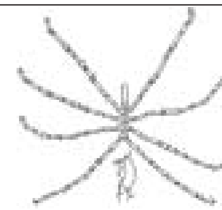
Sunampithoë pelagica
A small amphipod crustacean, flattened from side-to-side and reaching 4 mm (3/16 in) long. Common. **Native**.



O

Pycnogonida (Sea Spiders)

Endeis spinosa
This sea spider up to 30 mm (1 1/4 in) long has extremely long, slender legs and a slender body about half the length of the legs. It is greenish in colour. Common. **Native.**



O

Sargassum Sea-spider
Anoplodactylus petiolatus
A small sea spider reaching only 4 mm (1/8 in) long. The body is short and stocky but the legs are very long and slender. Very common. **Native**.

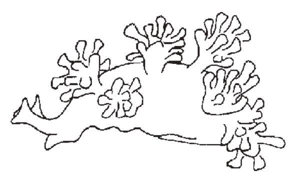
O

Mollusca (Snails, Clams and Slugs)

Brown Sargassum Snail
Litiopa melanostoma
This small snail about 5 mm (3/16 in) long is coloured yellowish-brown to dark brown. The shell is light and thin and has about 9 whorls. Very common. **Native**.

O

Pygmy Doto
Doto pygmaea
A tiny sea slug about 3 mm 1/8 in) long. There are several knobby processes on the back, the colour is dark brown. Common. **Native**.



O

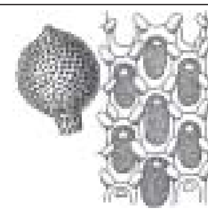
O

Sargassum Nudibranch
Scyllaea pelagica
This large sea slug about 50 mm (2 in) long has a very characteristic shape the body is thickest in the middle and has three long, leaf like processes on each side. The colour is a translucent olive-brown to orange-brown. It blends in well with the sargassum. Common. **Native**.

Bryozoa (Moss Animals)

O

Membranipora tuberculata
This colonial animal forms a thin, encrusting, lacy sheet over the surface of the sargassum and its bladders. Colour is a pastel brown. Very common. **Native**.



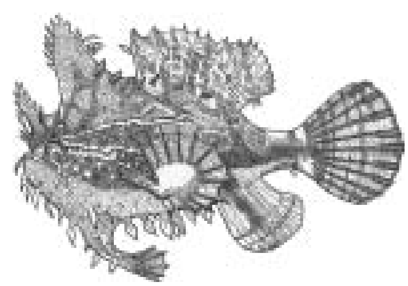
Fishes

B, O

Pugnose Pipefish
Syngnathus pelagicus
A very slender fish up to about 12 cm (4 3/4 in) in length. The fins are small and the anal fin is absent. The colour is highly variable but is generally some combination of light and dark brown rings around the body. Common. **Native**.

O

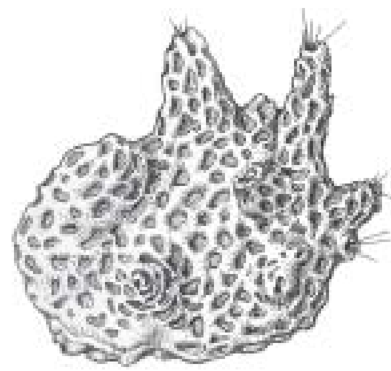
Sargassum Fish
Histrio histrio
A member of the Frogfish family this chunky fish up to 15 cm (6 in) long fish is beautifully camouflaged to blend in to the sargassum. The colour is a mottled mix of brown, tan and yellow and the fins and protrusions on the body resemble sargassum leaves. Common. **Native**.



Foraminiferans

C

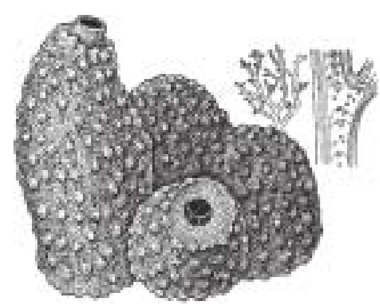
Red Foraminiferan
Homotrema rubrum
Protozoans are normally single-celled animals that are invisible to the naked eye. The Red Foraminiferan is an exception in that individuals may be 5 mm (1/4 in) across. This is still small but the bright red colour is very obvious. Living individuals are abundant in reef crevices and cavities and look like irregular strawberries. This protozoan lays down large amounts of calcium carbonate in a skeleton known as a test. Following death it often breaks loose to become part of the sediments. In places the red tests are so numerous in the sediment that the sand becomes a pinkish red colour. **Native**.



Sponges

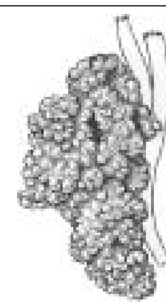
B, C

Blue Bleeder
Pseudoceratina crassa
The Blue Bleeder is a medium-sized sponge up to 15 cm (6 in) high. The shape is a group of blunt finger-like extensions which are covered in small bumps. At the tip of each 'finger' is a prominent hole. The sponge is grey-green or golden brown in life, but if removed from the water it turns bluish-purple and 'bleeds' a staining, blue fluid. This property gives it its common name. Found on inner reefs. **Native**.

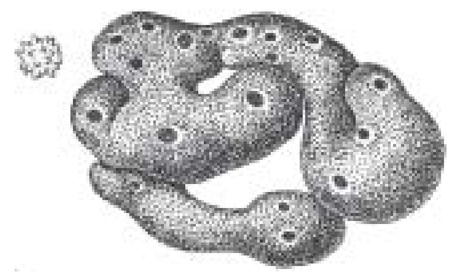


B, SP

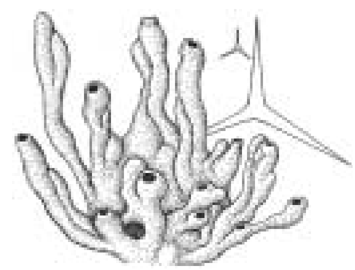
Brown Lumpy Sponge
Halisarca dujardini
Found both on dead shells and on seagrass leaves in sheltered bays. This sponge is a delicate yellowish-brown in colour and usually consists of several irregular lobes covered with small, warty bumps. About 10 cm (4 in) thick. **Native**.



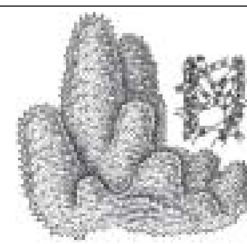
Chicken Liver Sponge B, SP
Chondrilla nucula
This sponge varies greatly in size but is commonly up to 15 cm (6 in) in size. It consists of groups of rounded oblong extensions, which are closely attached to the rock. The colour is greenish to brownish and the texture very smooth, hence its common name. This sponge also has plants within its body in a symbiotic relationship but in this case they are Blue-green cyanobacteria (formerly called Blue-green Algae). Common in many environments including all types of reef. **Native**.



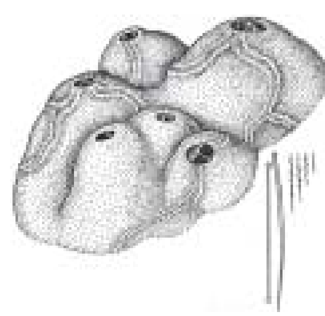
Dead Man's Fingers (Sponge) B, SP
Leucetta microraphis
A well named sponge as the upright finger-like lobes with a hole at the top are a deathly white colour. Common in the notch as well as in caves. A medium sized sponge up to 50 cm (20 in) high. **Native**.



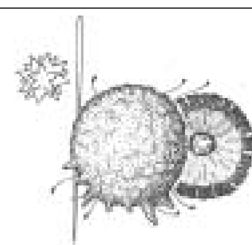
Etherial Sponge B, SP
Dysidea etheria
This sponge is hard to mistake for any other as it is a clear sky blue. It is a small sponge, consisting of rounded lobes rarely over 5 cm (2 in) high in sheltered places. **Native**.



Fire Sponge B, SG, SP
Tedania ignis
This sponge up to about 10 cm (4 in) high may be found attached to both seagrasses and Thicket Weed. It is generally shaped like a thumb but may have several lobes. The main distinguishing feature is its red colour. This sponge can inflict a sting, so do not touch any red sponges. **Native.**

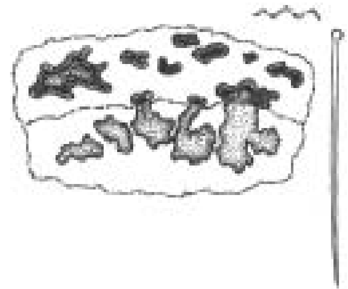


Golf Ball Sponge SP, B
Tethya actinia
This is a small round, yellow sponge of quiet waters, just about the size of a golf ball 4 cm (1 3/4 in). It is fastened to rock with yellow threads. Common in Walsingham Pond. **Native.**



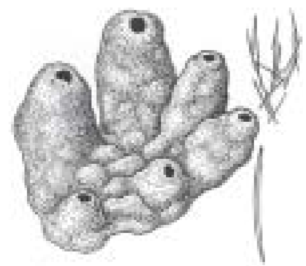
B

Green Boring Sponge
Cliona caribbaea
The Boring Sponges are an interesting group of sponges which, although very common, really have to be searched for as the sponge is embedded in limestone or a molluscan shell. These sponges are important bioeroders. This species, like the corals and many anemones, cultures symbiotic zooxanthellae in its tissues. It also filter feeds. All that is visible of the sponge are greenish-brown patches at the surface of the rock. It is abundant on reefs. Colonies to 30 cm (12 in) across. **Native**.



B

Green Chimney Sponge
Amphimedon viridis
This dull green sponge consists of thick chimneys in a group. Each chimney has a hole at the tip. A smallish sponge up to about 18 cm high (7 in) high. Very common in the notch and in caves. **Native**.

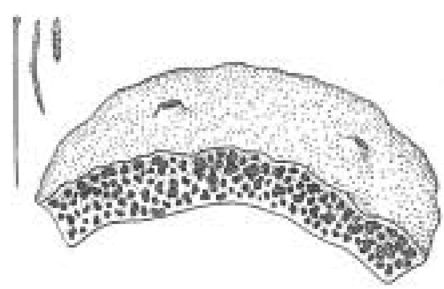


B, SG

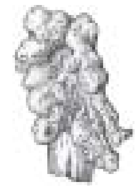
Lavender Anemone Sponge
Niphates erecta
This species which reaches about 15 cm (6 in) high is common on lagoonal and inshore reefs. Of an attractive lavender colour it consists of groups of irregular protrusions growing up into the water. Careful examination will usually reveal that the surface of the sponge includes many tiny anemones called Parazoanthus parasiticus. **Native**.

B, C

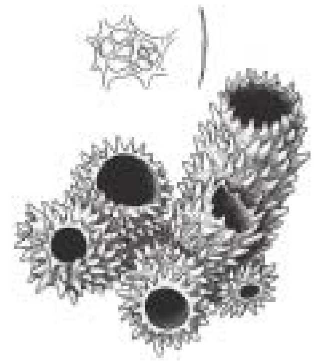
Orange Boring Sponge
Cliona lampa
Visible as small patches and low bumps on the rock, this species is orange or yellow-orange in colour. The boring sponges erode limestone by a combination of chemical and mechanical methods, and eject very characteristic cubic particles which become incorporated into the sediments. A very common species on shallow inshore reefs and under Flatts bridge. Colonies to 30 cm (12 in) across. **Native**.



Orange Encrusting Sponge M
Biemna microstyla
This bright orange sponge forms thin films on mangrove roots, 5 cm (2 in) or so in extent, but very variable. No structure is visible. **Native.**



Vase Sponge C
Callyspongia vaginalis
The vase sponge is the typical reef sponge of Bermuda; it is not common in any other habitat. More common on the outer reefs, particularly in deeper water. This 25 cm (10 in) sponge is grey-green to lavender in colour and takes the form of a group of thin-walled tubes with conical protrusions on the outside. This sponge often has tiny anemones called *Parazoanthus parasiticus*, embedded in the surface (See Lavender Anemone Sponge). **Native**.

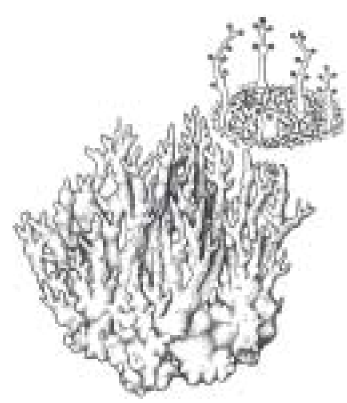


Violet Finger Sponge B, SG
Haliclona molitba
This sponge is a beautiful clear violet colour. It is typically finger like in shape and about 5-10 cm (2-4 in) long. Its general habitat is as an epiphyte on seagrasses or seaweeds in coastal bays. **Native**.

Hydroids and Coral-like Hydroids

Coral-like Hydroids

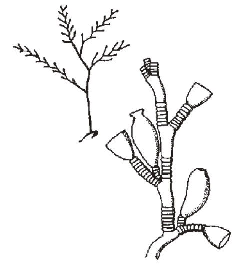
Fire Coral B, C
Millepora alcicornis
This is a hydrozoan that looks just like a coral. Of a pale dusky ochre colour, it can take almost any form, from a flat plate to a highly branched colony. It is smooth in texture and can inflict a mild sting, persisting for a few hours. Persons very sensitive to it can be in quite severe pain, so touching it is not recommended. It is a very important reef builder where wave action is severe, but common even in very sheltered, inshore situations. It is extremely variable in size. Up to 1 m (3 ft) high. **Native**.



Hydroids

B, O

Obelia dichotoma
In this rather feathery species, the individuals of the colony are quite closely set together on vertical stalks arising from a connecting structure on the sargassum. The vertical branches are about 10 mm (3/8 in) tall. Common. **Native**.



B, O

Red Bushy Hydroid
Eudendrium carneum
This is a delicate bush-like hydroid up to about 15 cm (6 in) high that is of a soft red colour. This hydroid is common in bays and may be attached either to a hard object or to seagrass leaves. **Native**.

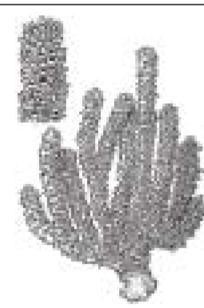
Soft Corals

C

Bent Sea Rod
Plexaura flexuosa
This is probably the commonest soft coral in shallow reef locations. It is usually purple in colour and likes clear water. It is built like a small tree with a stout main stem and sturdy branches. The final branches are relatively wide. It is a medium sized sea rod commonly growing to about 40 cm (16 in) in height. **Native**.

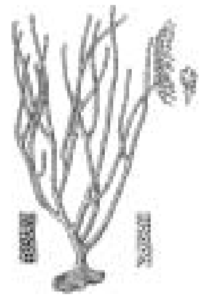
C

Dark Sea Rod
Eunicea tourneforti
A soft coral of the Rim Reef and beyond. Reaching up 60 cm (18 in) high, it is distinctive in having few very stout branches. It is also darker in colour than other soft corals being dark grey, deep brown or even black in hue. Up to at least 1 m (3 ft) in diameter. **Native**.



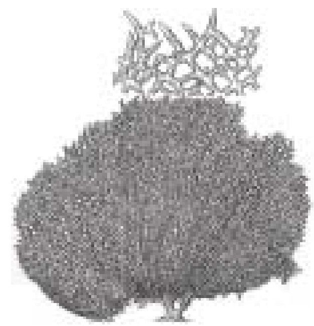
C, R

Porous Sea Rod
Pseudoplexaura porosa
This sea rod is like a sparsely branched bush up to 60 cm (2 ft) high and half this in width, and is common on all the outer reefs. Careful observation will show that the rod-like, firm but flexible skeleton is pierced by quite large holes from which the polyps extend. About 20 cm (8 in) across. **Native**.



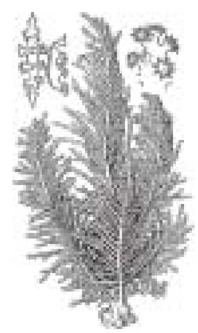
C, R

Purple Sea Fan
Gorgonia ventalina
This sea fan resembles a fan shaped piece of pastel-purple lace up to 50 cm (1 1/2 ft) high and just as wide. These sea fans are very common on the Rim Reef and are oriented so that the surge strikes the broad side; an adaptation to efficient filter feeding. They are quite firm in texture but do sway gently in the surge. **Native**.



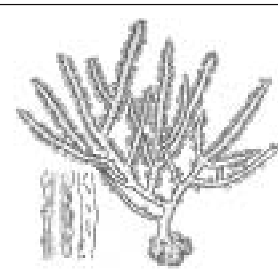
C

Sea Plume
Pseudopterogorgia americana
Sea plumes are loosely feather-like in structure with slender side-branches arising from a group of stouter central stems. Colonies which are common on all but inshore reefs are quite large, up to 1 m (3 ft) high. This species produces a lot of mucus and is very slimy to the touch when alive. Pale yellow or light purple in colour. **Native**.



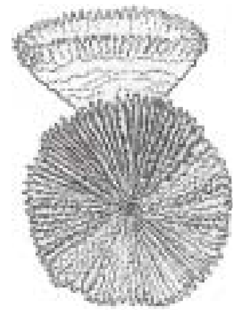
C

Yellow Sea Whip
Pterogorgia citrina
This is one of the smaller soft corals of the reefs, seldom exceeding 45 cm (17 in) high. It is yellow in colour and found on inner reefs. The colony is in the form of a sparsely and irregularly branched bush with stout twigs. **Native**.



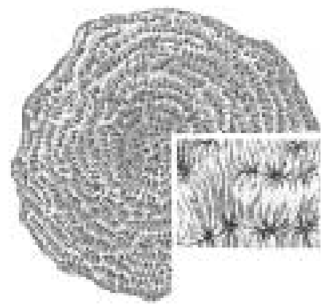
Corals

Artichoke Coral
Scolymia cubensis
Although this coral is uncommon, it is readily recognised because it is solitary rather than colonial, and has but a single, disc-like polyp up to 10 cm (4 in) across. The Artichoke Coral does not like bright light and if found in shallow water, will be in a shaded location, such as a reef cavity. **Native**.



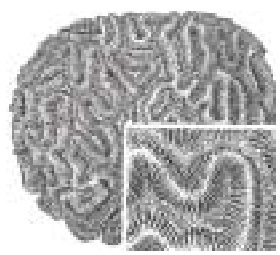
C

Chinese Hat Coral
Agaricia fragilis
The Chinese Hat Coral is a delicate coral of shady locations. It is typically found on the near-vertical sides of the reefs. Attached to the rock by a short stalk it grows into a thin, brownish conical structure up to 30 cm (1 ft) across, resembling a Chinese hat. It is not a reef builder. **Native**.



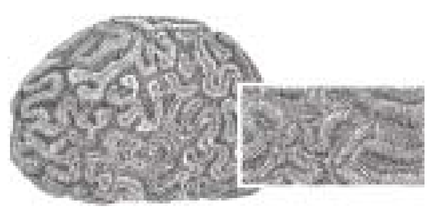
B, C

Common Brain Coral
Diploria strigosa
So called because it looks somewhat like an exposed brain, the colonies grow as hemispheres covered with sinuous ridges. Brain corals are yellowish in colour and can grow up to at least 1 m (3 ft) across, and half that height. **Native**.



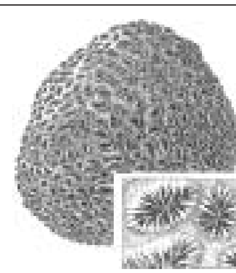
C

Double-ridged Brain Coral
Diploria labyrinthiformis
This species is very similar to the Common Brain Coral with the difference that the ridges have a groove down the middle. Up to at least 1 m (3 ft) in diameter. **Native**.



C

Elliptical Star Coral
Dichocoenia stokesi
This coral is variable and uncommon. It may be found either as small flattened plates or as a rounded dome. The polyps are usually of an elliptical shape. About 20 cm (8 in) across. **Native**.

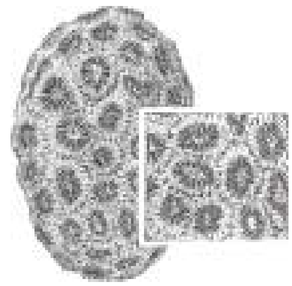


C

Finger Coral
Porites porites
This is a very variable coral, which can form quite large colonies up to 1.3 m (4 ft) across. It consists of finger or thumb like protrusions, which branch one to several times. Generally grey in colour, it can on rare occasions be a beautiful lavender shade. This species is becoming rare in Bermuda. **Native**.

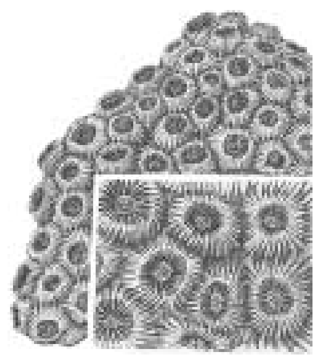
B, C

Golf Ball Coral
Favia fragum
While this coral is not very common it is easy to spot, because in this case the common name is very descriptive. The coral colony takes the form of a ball like structure 2.5-5 cm (1-2 in) across. It has comparatively large polyps and may be found on reef flanks or shallow cavities. **Native**.



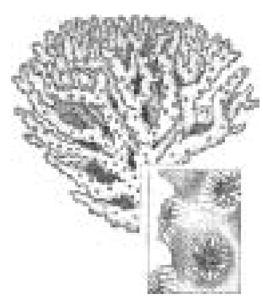
B, C

Great Star Coral
Montastrea cavernosa
This coral has an overall greenish colour cast and quite large coral polyps that can easily be seen with the naked eye. The common name is derived from the pattern these polyps leave on the face of the dead coral. This coral and the closely related Small Star Coral form large flattish plates measuring up to least 2 m (6 ft) across, which hug the rock surface and may overlap their neighbours. **Native**.



C

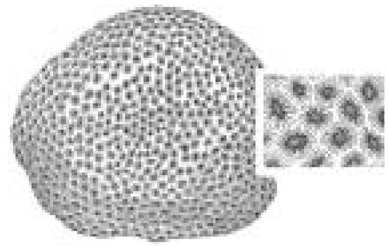
Ivory Bush Coral
Oculina diffusa
Ivory Bush Coral can form multi-branched, bush-like structures up to 75 cm (2 1/2 ft) high on quiet reefs such as those in Castle Harbour. In places it may form dense ‘forest-like’ communities. It is a delicate and beautiful coral. **Native**.



B, C

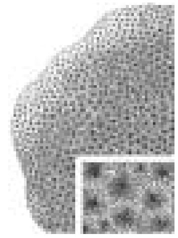
C, SP

Lesser Starlet Coral
Siderastrea radians
The Lesser Starlet Coral is smaller than the Massive Starlet Coral and lives in shallower water. It may even be seen on rock surfaces in Walsingham Pond. Usually 20 cm (8 in) across. **Native**.



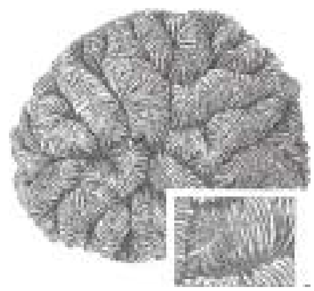
C

Massive Starlet Coral
Siderastrea siderea
This species tends to form domed colonies, which may be quite large, up to 1 m (3 ft) in diameter. The name comes from the small multi-rayed impressions left by the polyps. **Native**.



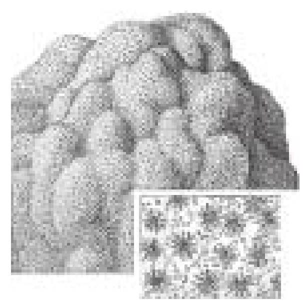
C

Maze Coral
Meandrina meandrites
This coral is closely related to the Golf Ball Coral and has a superficial resemblance to the brain coral in that it has a ridged surface. It takes many forms, ranging from flat plates through pillars to domes. It is very uncommon on shallow reefs. Up to 50 cm (2 1/2 ft) across.   **Native**.



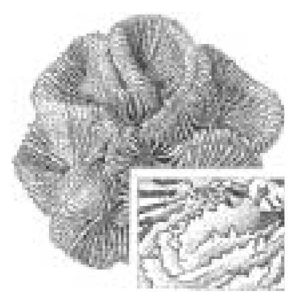
C

Mustard Coral
Porites astreoides
The Mustard Coral is another massive coral which can't be mistaken for the others because of its bright mustard yellow colour, and very small polyps. The surface of the Mustard Coral is almost smooth. It can be a flat plate or a dome but the surface is always covered with smallish bumps. Colonies up to 60 cm (2 ft). **Native**.



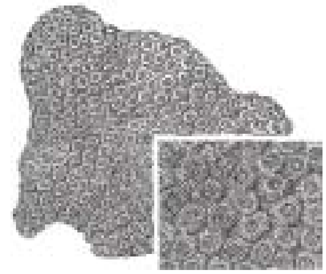
B, C

Rose or **Cactus Coral**
Isophyllia sinuosa
The most impressive feature of this small coral is the colour, which may be white, grey, green, yellow or brown, sometimes with iridescent highlights of orange or blue. It forms small domed, ridged colonies up to about 20 cm (8 in) across and lives on near-shore reefs. **Native**.



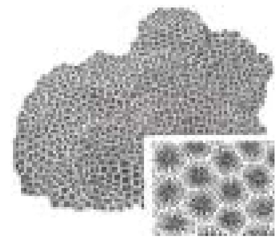
C

Small Star Coral
Montastrea annularis
This species is more abundant than the Great Star coral. It is of a yellowish colour, and has somewhat smaller polyps than the Great Star Coral and may grow either as sheets or as irregular domes. Variable in size up to 1 m (3 ft) across. **Native**.



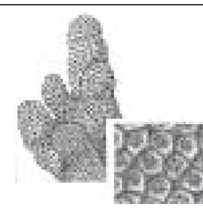
C

Small-eyed Star Coral
Stephanocoenia michelinii
Occurs as irregular patches up to 10 cm (4 in) across in quiet inshore waters, including ponds, The colour is whitish-grey with dark marks where the polyps are. **Native.**



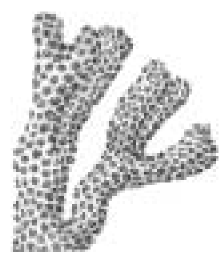
C

Ten-ray Star Coral
Madracis decactis
The colonies are generally less than 30 cm (1 ft) across and consist of a collection of brownish knobs, closely grouped together. **Native.**



B, C

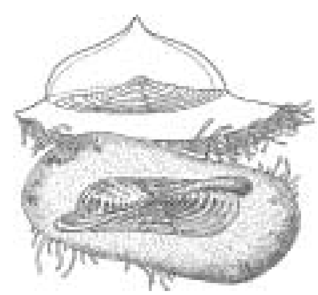
Yellow Pencil Coral
Madracis mirabilis
The Yellow Pencil Coral is rather similar to the Finger Coral except that the colour is yellow to green, usually lighter at the tips, and the branches are pencil-size rather than thumb-size. About 20 cm (8 in) tall. **Native.**



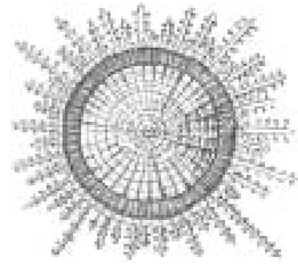
Jellyfishes

O

By-the-wind Sailor
Velella velella
A common species found floating at the surface and equipped with a triangular sail that propels it through the water. This cnidarian may occur in enormous numbers and be driven onshore in storms. The colourless float is about 10 cm (4 in) long. **Native**.



Porpita
Porpita porpita
Porpita has a circular float within which are gas-filled chambers that keep it at the sea surface. Unlike the previous species there is no sail and it is much less common and smaller. About 3 cm (1 1/2 in) in diameter. **Native**.

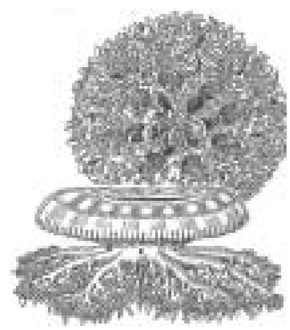


O

Portuguese Man-of-War
Physalia physalis
This large and very well-known member of the neuston is actually a colony and is highly poisonous. The top of the colony consists of a large purple, gas filled float, up to 20 cm (8 in) long, with a pleated sail. Many tentacles which may be meters long dangle beneath and serve to catch prey. They contain the poisonous nematocysts. **Native**.

O

Upside-down Jellyfish (Poisonous)
Cassiopea xamachana
This jellyfish is quite poisonous and has the unusual habit of lying upside-down on the bottom, with the greenish tentacles waving up in the water. Small individuals and occasionally large ones swim up into the water. Up to 25 cm (10 in) in diameter, they should be avoided. Very common in the ponds. **Native.**



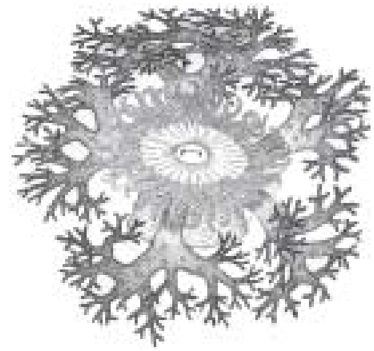
B, SP

Anemones

Antillean Anemone (Poisonous)
Bunodeopsis antilliensis
This poisonous anemone is bright purple in colour and lives on mangrove roots. Up to 2.5 cm (1 in) long, it can walk around on the tips of its tentacles. **Native.**

M

Brown Sea Anemone
Lebrunia danae
This is a strange, quite large anemone found in reef cavities and similar places. About 30 cm (12 in) in diameter, it is distinctive in that it has two types of tentacles, short finger-like ones and longer branched ones. These branched tentacles, brown in colour contain numerous zooxanthellae. Its food supply comes both from the cultured zooxanthellae and from animals captured at night. **Native**.

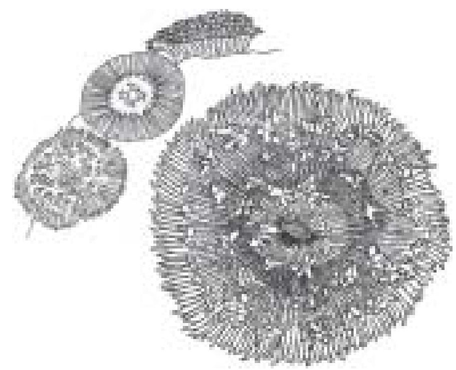


B, C

Brown Sea Mat
Palythoa variabilis
Equally common to the above species and of comparable size, this colonial anemone is deep brown in colour. Common on shallow-water reefs. May form mats 1 m (3 ft) across. **Native**.

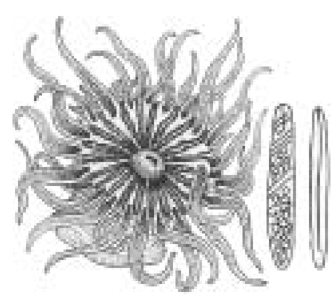
B, C

Coral Anemone
Discosoma sanctithomae
This anemone-like creature has the coral-like feature in that it houses abundant zooxanthellae in its tissues. Unlike the corals however, it does also actively feed on worms, crustaceans and small fish. Each polyp is about 4 cm (1 in) in diameter. It is a colourful species being deep green or red with blueish highlights. This anemone may produce quite large colonies and is frequently seen on the sides of Boiler Reefs. It has short, stubby tentacles. **Native.**



C

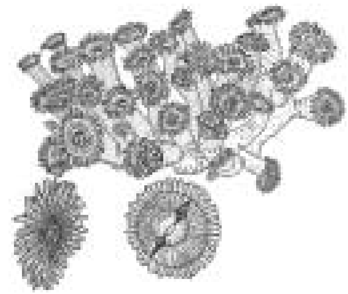
Dark Star Anemone
Pseudactinia melanaster
This is the only sea anemone commonly found on sargassum. It has 32 tentacles and is about 10 mm (3/8 in) in diameter. The colour of the body is fawn to reddish-brown, while the top disk has a star-shaped pattern of dark and light stripes radiating from the center. Very common. **Native**.



B, C, O

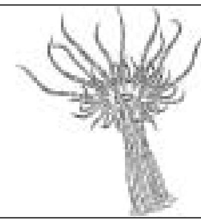
B, C

Green Sea Mat
Zoanthus sociatus
The Green Sea Mat is the commonest of the sheet-forming colonial anemones common on nearshore and inshore reefs. It forms a layer on the bottom which may be at least 1 cm (3 ft) across. The individual anemones are about 1 (3/8 in) across and bright green in colour. **Native**.



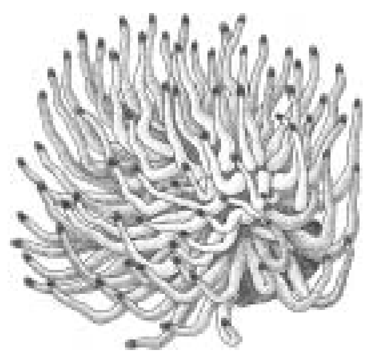
B, SP

Pale Anemone
Aiptasia pallida
This is a small, light brown anemone up to 4 cm (1 1/2 in) long, common in masses on mangrove roots and rocks in quiet places. **Native.**



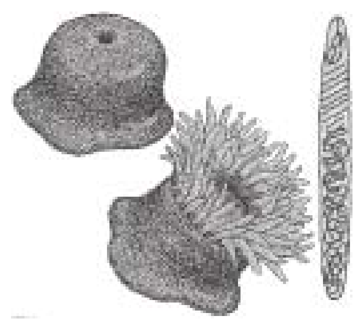
B, C

Purple-tipped Sea Anemone
Condylactis gigantea
This pale green, very distinctive large anemone has purple-tipped, robust tentacles and is up to 30 cm (1 ft) in diameter. The body of the anemone is usually hidden in a crevice, but the crown of tentacles is very obvious. Careful examination of this anemone will usually reveal the presence of one or more cleaner shrimps among the tentacles. Present on all types of reef. **Native**.

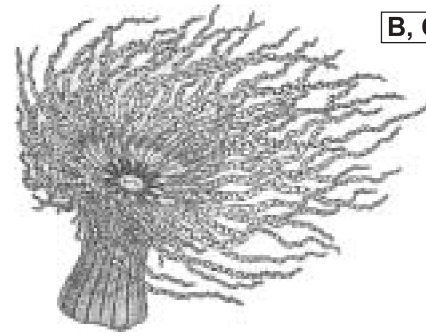


R

Red Anemone
Actinia bermudensis
Anemone with a low dark red to brownish column and more highly coloured tentacles. When the tide is out it is always contracted to a red hemisphere. It is found in crevices in the midlittoral zone of exposed rocky shores and under stones intertidally. Base up to 4 cm (1 3/4 in). **Native**.



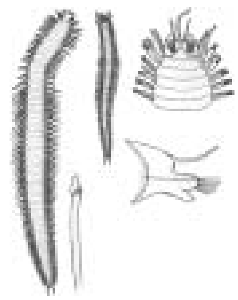
Ringed Anemone
Bartholomea annulata
This medium sized, common, pale brown anemone has numerous tentacles which have distinctive lighter rings around them. Normally about 6 cm (2 1/4 in) in diameter including the tentacles it is found in an amazing variety of habitats from mangrove swamps to the outer reefs. **Native**.



B, C, SP

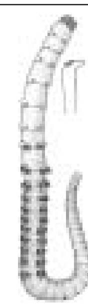
Polychaete Worms

Bermuda Fireworm
Odontosyllis enopla
We only see this worm when swarms of them mate in a blaze of green light, especially in the summer months, 56 minutes after sunset on the third night after the full moon. It has a small, slender body and three antennae. To 35 mm (1 3/4 in). **Native**.



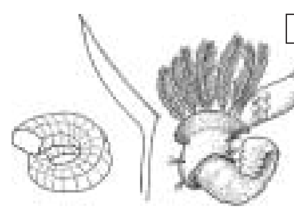
B

Cockworm
Arenicola cristata
A large worm that constructs U-shaped burrows that develop a pit at the head end and a mound of castings at the tail end. The worm is up to 25 cm (10 in) long and 1 cm (1/2 in) wide. The soft body has a series of bright red gills. Used widely as bait. **Native.**



B

Coiled Tube Worm
Spirorbis formosus
This worm makes very distinctive small, anti-clockwise-coiled, white tubes about 3 mm (1/8 in) across on the surface of the sargassum. Very common. **Native**.



B, O, R, SG

SP

Feather Duster Worm
Sabella melanostigma
This worm has a leathery tube within which it can withdraw. When undisturbed it expands a circle of brightly banded tentacles about 1.3 cm (1 in) in diameter. Most commonly found on mangrove roots. **Native.**

B

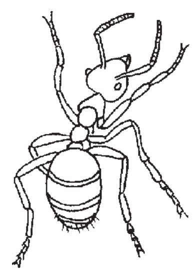
Ringed Tube Worm
Spiochaetopterus costarum oculatus
This worm is much more likely to be found in a fishes stomach than elsewhere. The body is slender and up to 60 mm (2 1/4 in) long, with two very long antennae. The tube the worm inhabits is parchment-like with regular rings. **Native**.

Insects

Ants

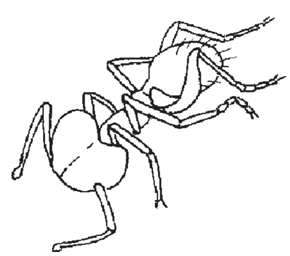
F, SD, U, W

Argentinian Ant
Iridomyrex humilis
This small ant is very common in a wide variety of habitats from houses to sand dunes. It lives in large colonies in holes or cavities excavated into the ground. It is often abundant under trash lying on the ground. These ants are brownish and only 3 mm (1/8 in) long. **Naturalized**.



U

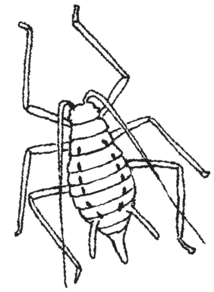
Big-headed or **Brown House Ant**
Pheidole megacephala
The Big-headed Ant originated in Africa but is now widespread throughout the tropics and sub-tropics. Accidentally introduced to Bermuda in the latter part of the 19th century, the Big-headed Ant drove the native ants to extinction and has since been replaced in many habitats by the more aggressive Argentinian Ant. 7mm (1/4 in) long. **Introduced.**



Aphids

F, OC, U

Juniper Aphid
Cinara tujafilina
The most important host of the Juniper Aphid in Bermuda is the Bermuda Cedar. The aphid is very dark in colour, ranging from purple through brown to almost black. It is quite large compared to other aphids being 2-3 mm (1/8 in) long. **Introduced.**



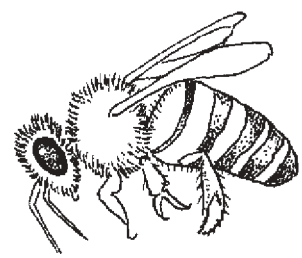
U

Spittlebug
Clastoptera undulata
This common pest of the Casuarina tree was first recorded in Bermuda in 1959. The adults and nymphs suck the juice of foliage and the nymphs secrete a protective covering of bubbly fluid, which appears as little balls of white foam seen at the base of the needles. The Spittlebug eggs are laid in the tree needles and twigs in May and the Spittlebug population peaks in October. Adults 5 mm (1/5 in) long. **Introduced.**

Bees

U, W

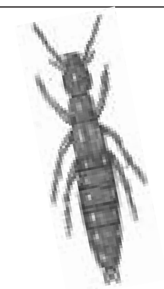
Honey Bee
Apis mellifera
There are approximately 500 colonies of bees kept on Bermuda. In addition there are many wild hives in such places as hollow trees and vents in buildings. There are three castes in a hive: one queen and small number of drones (males) and as many as 80,000 workers (sterile females). 1.5 cm (1/2 in) long. **Introduced**.



Beetles

S

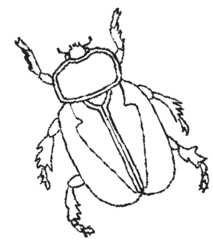
Devil's Coach Horse
Cafius bistriatus
This is an active, small, elongated rove beetle with very small wing covers and a six-segmented abdomen. Dark brown in colour it is found crawling around in dead seaweed at the strand line of sandy shores. Grows only to 10 mm (3/8 in) long. **Native.**



Donkey Beetle
Diaprepes esuriens
One of the largest beetles on Bermuda and greyish-brown in colour. Adults feed on the foliage of citrus, Hibiscus and other ornamental trees and shrubs. Larvae live in the soil and feed on roots. About 3 cm (1 1/4 in) long. **Native.**

F, U, W

June Beetle or **Hardback**
Ligyrus tumulosus
A chunky reddish-brown beetle with a clumsy flight. Adults are very common at night at lights. The larvae, known as white grubs, feed on plant material in the soil. About 2.5 cm (1 in) long. **Native**.



U, W

Ladybird Beetle
Exochomus jamaicensis
Introduced in 1951 to control cedar scale. Adults and larvae are now commonly found feeding on a wide range of scale insects. About 2 cm (3/4 in) long. **Introduced**.

U, W

Predacious Diving Beetle
Thermonectes sp.
These beetles have aquatic larvae and the adults are winged so that they can move among freshwater locations. These blackish beetles 1 cm (3/8 in) long feed in the water by diving for their prey, but breathe at the surface. **Native**.

FW

Seaweed Beetle
Phaleria picipes
This is a small, oval beetle which is dark brown in colour. It has characteristic clubbed antennae. A scavenger, it is found in beached seaweed piles on sandy shores. the larvae are buried in the sand. 6 mm (1/4 in) long. **Native**.

S

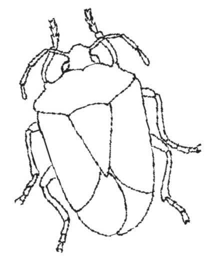
S

Tiger Beetle
Cicindela trifasciata
This beetle often seen on the surface of the sand in the upper shore is an active runner and swift flyer. The colour is an irridescent bright green. The larvae, called Ant Lions, make pits in the sand to catch prey. 10 mm (3/8 in) long. **Native**.

Bugs

U, W

Green Stink Bug
Nezara viridula
This flattened bug is a common pest of weeds, vegetables and ornamentals. Adults and nymphs possess large stink glands on their lower surface from which copious amounts of foul smelling fluid are discharged when the insects are disturbed. 2.5 cm (1 in) long. **Introduced**.

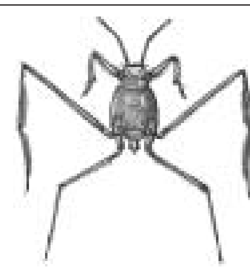


F, U

Harlequin Bug
Murgantia histrionica
A member of the stinkbug family, this colourful insect is commonly found on cabbage and tomato crops. It is barrel-shaped and black and white. Eggs are laid on the underside of leaves. 2.5 cm (1 in) long. **Introduced**.

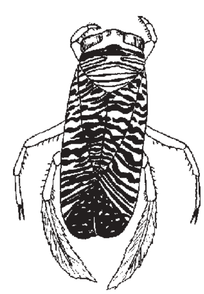
O

Ocean Skater
Halobates micans
This very unusual insect can stand on the surface of the ocean where it catches zooplankton, small fish etc. as they rise to the surface. It is about 5 mm (3/16 in) across. **Native**.



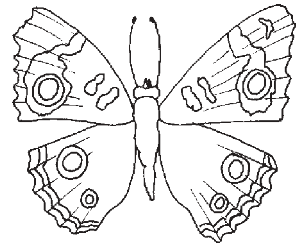
FW

Water Boatmen
Corixa spp.
These insects live in the water but readily fly from water body to water body. They vary in size from about 5-20 mm (1/8-1/2 in) and are readily recognised by the long, oar-like back pair of legs used for swimming. They hang at the surface to breed or rest. Some swim upside-down. **Native**.



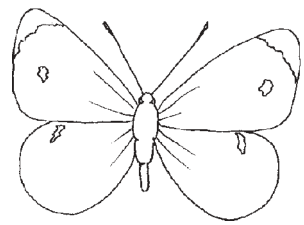
Butterflies

Buckeye Butterfly
Junonia coenia
Probably the most common butterfly on Bermuda. The caterpillar feeds on snapdragon, plantain, and other low herbs. The adult is a swift flyer . It is brown overall with blue and red markings. About 4 cm (1.5 in) across. **Native**.



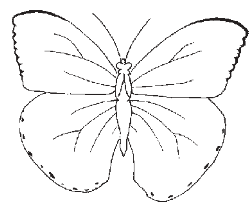
F, U, W

Cabbage Butterfly
Pieris rapae
A small white butterfly which is most abundant in the spring. The larvae are important pests of plants in the cabbage family. Adults are nectar feeders. About 4 cm (1.5 in) across. **Introduced**.



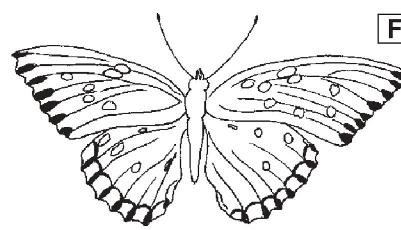
U, W

Cloudless Sulphur
Phoebis sennae
This butterfly is a striking yellow colour. The adult feeds on nectar and the larvae eat foliage of *Cassia spp*. 3.5 cm (1 1/4 in) across. **Native**.



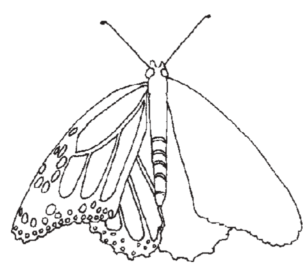
F, U, W

Gulf Fritillary
Agraulis vanillae
Smaller than the monarch, it is also black and orange, however with silver patches on the underside of the wing. Feeds on passion flower vine. 2.5 cm (1 in) across. **Native**.



F, U, W

Monarch Butterfly
Danaus plexippus
This impressive orange and black butterfly is migratory in other locations but many of those seen in Bermuda are members of a resident population. Feeds primarily on milkweed. 8 cm (3 in) across. **Native**.

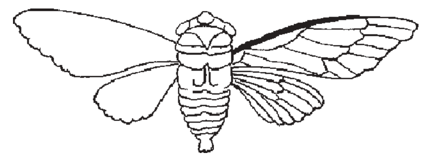


U, W

Cicadas

EX, F

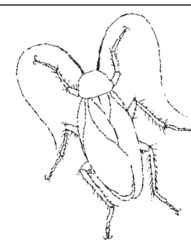
Cicada or **Bermuda Singer**
Tibicen bermudiana
One of the earliest insects recorded from Bermuda, being mentioned by Butler in 1691 as the "good housewife" by virtue of the sound they make like the whirring of a spindle. Singers were formerly widespread and common. Numbers dropped dramatically in the 1950s after the blight on the cedar trees and the introduction of the Kiskadee. The Cicada nymphs feed on the root of the Bermuda Cedar during their seven-year larval period. It is also thought that the Kiskadee has been a major predator of the cicada. 3 cm (1 1/4 in) long. **Extinct.**



Cockroaches

U

American Cockroach
Periplaneta americana
One of the most comon cockroaches on Bermuda. Although most often found in houses, it also lives under decaying debris. 4 cm (1 1/2 in) long. **Introduced**.



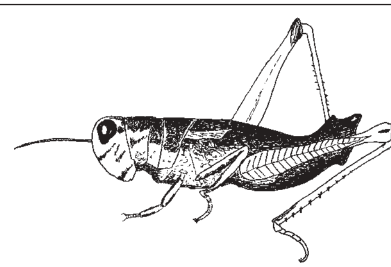
Crickets and Grasshoppers

F, U, W

American Black Cricket
Gryllus firmus bermudensis
Common. Lives under stones, logs and debris in fairly open terrain. Adult males "sing" loudly at night and less frequently during the day all year round. 4 cm (1 1/2 in) long. **Introduced**.

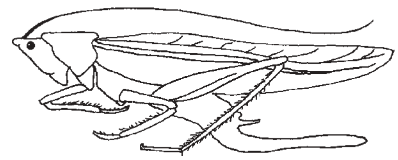
EX

Bermuda Flightless Grasshopper
Paroxya bermudensis
This grasshopper is of typical grasshopper form except that in the adult, the wings are useless stubs. It could still, however, move around by jumping. It fed on a variety of vegetation. Up to 5 cm (2 in) long. **Extinct**.



W

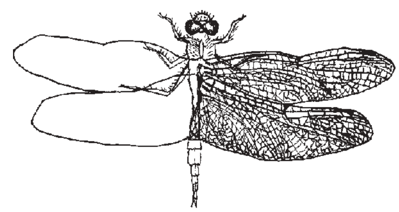
Katydid or **Cone-headed Grasshopper**
Neoconocephalus triops
Bright light green in colour, this grasshopper is commonly found in long grass and low vegetation. In the evenings, the male produces a distinctive penetrating buzzing sound. 5.5 cm (2 in) long. **Native**.



Dragonflies

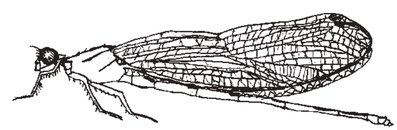
FW

Blue Dasher
Pachydiplax longipenna
These are the classic dragonflies about 8 cm (3 in) long with a wingspan somewhat greater than this. The body is red and the wings black-veined. The larvae are predatory and aquatic. Around ponds and fresh waterways. **Native**.



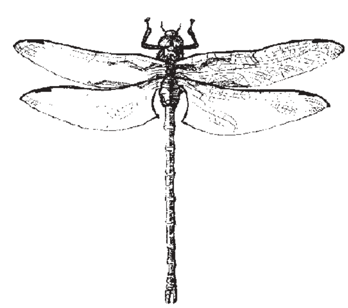
FW

Damselfly
Ischnura ramburii
The damselflies are smaller, more slender members of the dragonfly group. The larvae are predatory and aquatic; the adults bluish in colour are about 5 cm (2 in) long, with prominent paired wings. Around freshwater ponds and waterways. **Native**.



FW

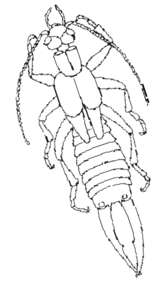
Vermilion Glider
Tramea abdominalis
A fairly common dragonfly 14-15 cm (1.7-2.0 in) long with red body and clear wings with reddish patches at the base of the rear pair. It flies constantly, is island-wide in distribution and can be spotted hovering over ponds. It hunts, eats, mates and lays eggs 'on the wing' (whilst in flight). Eggs hatch into creatures that are voracious feeders and spend their life existence below the surface of the water. This nymphal stage lasts about a year, at which point the insect climbs out of the water and a final moult occurs and the dragonfly emerges. **Native**.



Earwigs

U

Earwig
Labidura riparia
Lives on the ground under debris and feeds on insects and mites. Eggs laid in a nest. Female remains with nymphs until young are able to go off on their own. May produce an unpleasant odour when handled but will not harm one's ears, as one might believe. About 3 cm (1 1/4 in) long. **Introduced**.



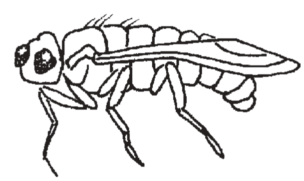
S

Seaside Earwig
Anisolabis maritima
A typical earwig with crossing pincers at the rear end. There are no wings and the body is dark brown with paler legs. This earwig is found under piles of rotting seaweed at the strand line of sandy beaches. About 20 mm (3/4 in) long. **Native**.

Flies and Mosquitos

U, W

Eye Fly
Liohippelates pusio
Eye flies or eye gnats, which peak in August and September, are a great annoyance to man and domestic animals, as they are attracted to the eye secretions. There seems to be no practical means of obtaining complete relief; however, insect repellant may be helpful and smoking a pipe or cigar is reported to keep them away. Luckily, they are active only during daylight and do not attack indoors. 7 mm (1/4 in) long. **Native**.

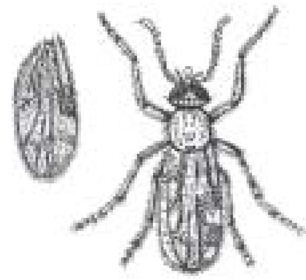


U

Mediterranean Fruit Fly
Ceratitis capitata
A small fly; a pest of fruit crops. Now extirpated. 9 mm (3/8 in) long. **Introduced.**

FW, U

No-See'um Midges
Culicoides bermudensis
A tiny fly often described as "jaws with wings" which is only 2 mm (1/10 in) in length and can pass easily through window screens. As is the case with mosquitoes, only the female biting midges are blood-suckers. They become active at dusk and are most troublesome when there is no wind in the summer months. The bites of no-see'ums are often followed by a burning sensation and severe itching. Female midges lay their eggs in wet soils which may be in marshes, coastal areas or even decaying vegetation. **Native**.

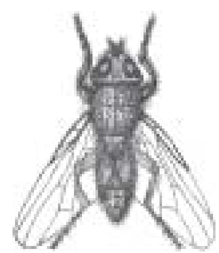


M

Salt Marsh Horse Fly
Tabanus nigrovittatus
These large, blackish, biting, two-winged flies are about 1 cm (3/8 in) long. They are silent fliers and can bite without warning. The larvae are grub-like creatures burrowing in salt-marsh muds. **Native.**

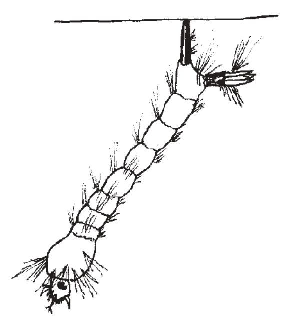
S

Seaweed Fly
Fucellia intermedia
This slender, reddish-brown seaweed fly is common on beach wrack and seaweed. It prefers to lay its eggs on seaweed where the larvae complete their development. It is a familiar nuisance to sunbathers. To 6 mm 1/4 in). **Native**.



FW, U

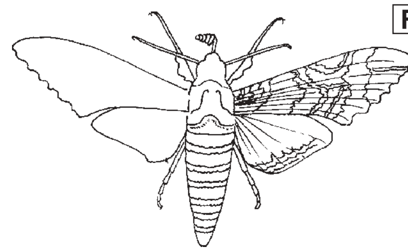
Southern House Mosquito
Culex pipiens
Mosquitos were formerly much more common than they are today. They were carriers of diseases such as malaria, and it was to control them that the Mosquito Fish was introduced. The larvae are about 4 mm (1/8 in) long comma shaped creatures which hang at the water surface. The adults are small, biting flies about 8 mm (1/4 in) long. **Native**.



Moths

F, U, W

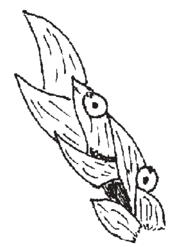
Giant Grey Sphinx Moth
Pseudosphinx tetrio
Apparently established since 1930s, the large caterpillar feeds on the frangipani tree and sometimes causes severe defoliation. Although not very common it is striking by its size. 9 cm (3.5 in) long. **Native.**



Scales

F, W

Cedar Scale
Carulaspis minima
This tiny pest species was first found in 1945, and eventually resulted in the death of over 90% of the Bermuda Cedars. It is an inconspicuous flattened insect adhering tightly to cedar leaves. 3 mm (1/8 in) long. **Introduced.**

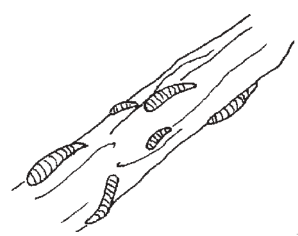


F, OC, U

Oystershell Scale
Insulaspis pallida
A tiny insect with an elongated larva, found on Bermuda Cedars. 3mm (1/8 inch) long. **Introduced**.

F, OC, U

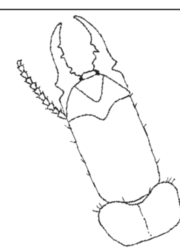
Palmetto Scale
Comstockiella sabalis
This scale attacks the Bermuda Palmetto. The scale was first recorded in 1921 when it was restricted to the eastern end of Bermuda; by 1933 it had spread throughout the islands. About 4 mm (1/6 in) long. **Introduced**.



Termites

F, U

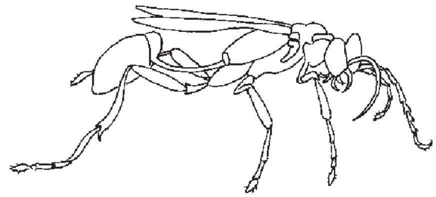
Wood Termite
Kalotermes approximatus
The most common of the three species of dry wood termites which occur in Bermuda may be found in almost any dead cedar tree. About 2 cm (3/4 in) long. **Introduced**.



Wasps

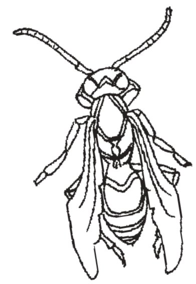
O, U

Mud Dauber
Sceliphron caementarium
A common solitary wasp. The female constructs a cell of mud and provisions it with paralysed spiders. An egg is laid on the spider and the cell closed. Additional cells are built parallel to the first. Adults feed on nectar. 2.5 cm (1 in) long. **Native**.



W

Paper Nest Wasp
Polistes bellicosus
Common throughout the island, this social wasp builds a paperlike nest in low shrubs, weeds and the lower surface of palm leaves. Adults are nectar feeders but feed the young on pre-chewed insects. The female can inflict a painful sting if disturbed. 2.5 cm (1 in) long. **Native**.

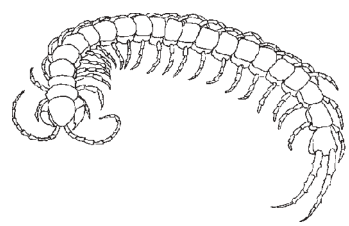


Centipedes and Millipedes

Centipedes

F, U, W

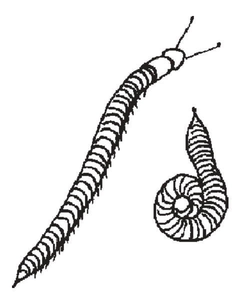
St. David's Centipede
Scolopendra subspinosa
During the day this centipede is usually found under stones and old logs. Once very common, now found mainly at the east end and Dockyard. One theory is that toads have reduced their numbers. Like all centipedes this species is predaceous and generally beneficial; however, it may inflict a powerful, poisonous bite if handled. Up to 15 cm (6 in) long. **Native**.



Millipedes

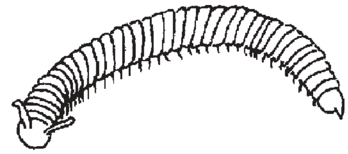
F, U, W

Church Worm
Julus sp.
This terrestrial isopod crustacean is very common. The body is flattened and brownish-grey. It is usually found in protected locations such as under rocks or logs. It may sometimes become a household pest. Produces a distinctive odour when handled. 1 cm (3/8 in) long. **Native**.



F, U, W

Millipede, Thousand Legs or **Galley-worm**
Spirobolus heilprini
Recorded on Bermuda in 1889, this common worm found under stones is a native of the Azores. Adults have chestnut brown bodies with reddish brown legs. Young have a black dorsal line bordered with yellow and a row of black spots on each side. Millipedes often attack sprouting seeds or roots and bulbs. About 2 cm (1/4 in) long. **Introduced**.



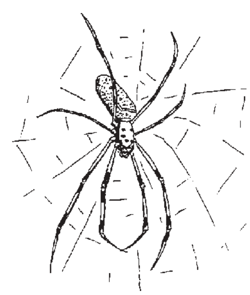
Spiders

F, M, U

Crab Spider or **Spiny-bellied Orb Weaver**
Gasteracantha cancriformis
First recorded in the 1930s and now common. This small spider builds a new web (orb) each night and eats the old web to conserve protein. Glands produce silk in liquid form as a protein called fibroin, which is pumped out through spigot-like spinnerets at the creature's abdomen. When stretched the fibroin hardens into a thread. About 1 cm (3/8 in) across. **Introduced**.

F, M, U

Golden Silk Spider
Nephila clavipes
The females of this species are the largest spiders in Bermuda and the very large net may be many metres (feet) across. The female spider may be 15 cm (6 in) across including the legs. The body is banana-shaped and the colour yellow with brown bands. **Native.**

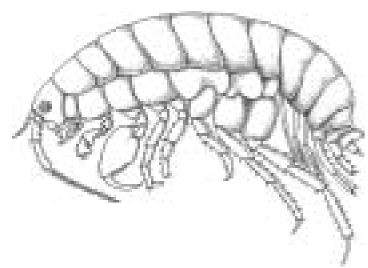


Crustacea

Amphipods

S

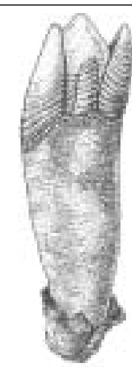
Beach Flea
Orchestia sp.
This terrestrial beach hopper is very commonly found under beached Sargassum weed or under the sand above the high tide line. It is aptly named, for it can jump almost a metre by flexing its powerful abdomen. Greyish-brown in colour. It feeds on detritus at the strand line. To 13 mm (1/2 in). **Native**.



Barnacles

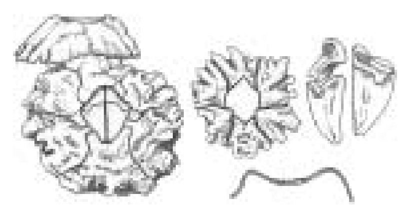
C

Boring Barnacle
Lithotrya dorsalis
This barnacle is typical of the reefs. The body of the barnacle is embedded in the rock or in a coral and all that one sees is a dark elongated slit about 1 cm (1/8-3/8 in) in length. If you are close enough you may see the legs extend as they filter-feed in the water. They are easiest to spot when embedded in the light-coloured Brain Corals. **Native**.



C

Common Barnacle
Chthamalus angustitergum
This barnacle is a dull white in colour. There are six plates in the conical shell. This is the common species of exposed shores and is often abundant. Its upper limit marks the top of the midlittoral zone. Up to 1 cm (3/8 in) across. **Native**.



O

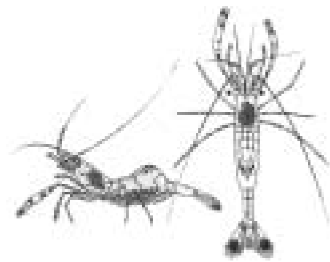
Common Goose Barnacle
Lepas anatifera
This barnacle is commonly found attached to objects such as wood or bottles floating at the surface. It grows up to at least 50 mm (2 in) long and has a stout stalk and a body encased in four calcareous plates. **Native**.

Striped Barnacle
Balanus amphitrite
This barnacle, common on rocky shores occurs at near to high tide level. It is conical with stripes running up the sides of the cone. The opening at the top can be closed with four plates. Up to about 1 cm (3/8 in) in diameter but usually much smaller. **Native.**

R

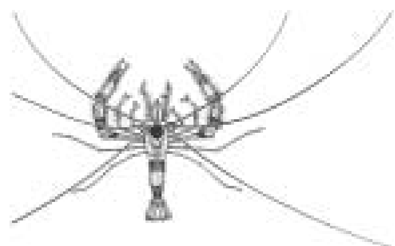
Shrimps

Anemone Shrimp
Periclimenes anthophilus
This shrimp is found among the tentacles of the Purple-tipped Sea Anemone *(Condylactis gigantea)* described above. It is virtually clear and about 5 cm (2 in) long. This shrimp is **endemic** to Bermuda.



B, C

Banded Coral Shrimp
Stenopus hispidus
These 7 cm (2 3/4 in) shrimps have exceedingly long antennae (feelers) and a pale body with red bands. They live in crevices most of the time, but are 'cleaner shrimps', removing parasites and dead skin from reef fishes. They thus have an important ecological role. **Native**.

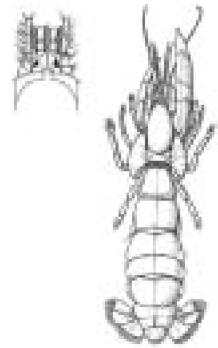


C

Banded Snapping Shrimp
Alpheus armillatus
You will probably never see this shrimp as it lives in cavities of the reef rock. However, you will probably hear it if you drift quietly over a shallow reef. The snapping noises it makes are surprisingly loud. They are small, 5 cm (2 in), shrimps with one very large claw. **Native.**

C, R

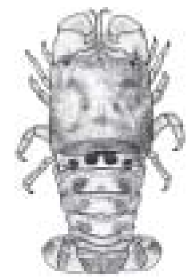
Burrowing Shrimp
Callianassa branneri
A quite large, somewhat lobster-like shrimp common in sandy, shallow bays. The burrow locations are easily recognised by a large, volcano-like mound of sand with a hole at the top through which sand is ejected. The rarely seen shrimp is about 10 cm (4 in) long, cream in colour, with a large abdomen and one large claw. **Native.**



B

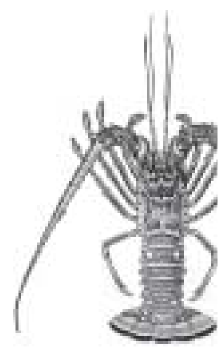
Lobsters

Locust or **Slipper Lobster**
Scyllarides aequinoctialis
This lobster is a squat, slow moving creature having neither long antennae or large claws. It is an omnivore that feeds at night, venturing forth from crevices in the reefs. It is edible and fished by sport fishermen to some extent. 25 cm (10 in) long. **Native**.



B, C

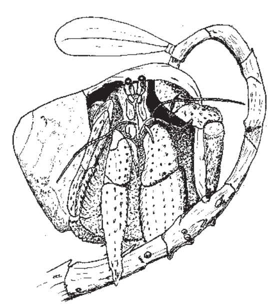
Spiny Lobster
Panulirus argus
The Spiny Lobster is the main lobster fished for food in Bermuda and the Caribbean. Living in crevices and caves within the reefs, it emerges at night to feed on a wide variety of food. These lobsters can measure up to 50 cm (1.5 ft) or more in length. They have no large claws but do have long, robust antennae. The colour is reddish brown. **Native**.



B, C

Hermit Crabs

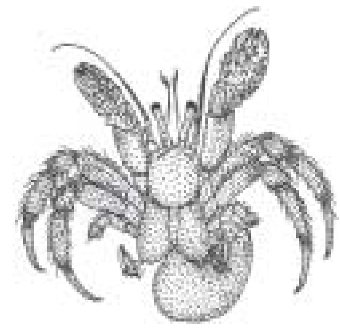
Land Hermit Crab
Coenobita clypeatus
This now rare crab is present at only a few locations on the south shore and declining rapidly. It occupies the black-and-white shells of the West Indian Top Shell, *Cittarium pica*. The crab's front, large claws are a bright purple in colour. The shells housing the crab may be up to 8 cm (3 in) wide. **Native.**



F, M, OC

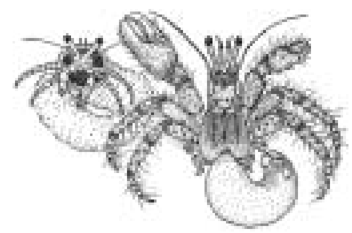
R

Tricolor Hermit Crab
Clibanarius tricolor
This crab can be found in the shallow water of tide pools, protecting its soft abdomen by living inside a borrowed shell abandoned by its former tenant. Its large claws are uneven, the left one being larger than the right. The eye stalks are blue and the base of the antennae is orange. Segments of the legs are coloured variously orange, blue, white and yellow. To 1 cm (1/2 in). **Native**.



C

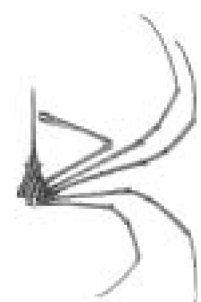
Verrill's Hermit Crab
Calcinus verrilli
This is another of the very few marine species **endemic** to Bermuda. It is a curious small hermit crab that has taken up a mode of life similar to the tube snails (*Vermetidae*). Indeed it lives in abandoned tube shells and is very common on the Boiler Reefs and Bioconstructional Lips. A maximum of 2 cm (3/4 in) long, These crabs are very colourful being bright purple with red spots. **Native**.



Crabs

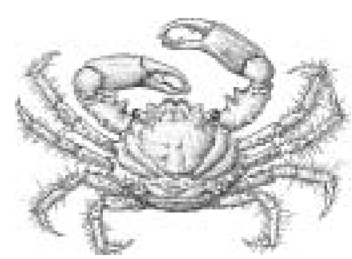
C

Arrow Crab
Stenorhynchus seticornis
This furtive, very long-legged, spindly-bodied crab with grey and brown stripes on the body, lives under reef overhangs and around Purple-tipped Sea Anemones. It is only about 2.5 cm (1 in) in size but is very numerous. It is an omnivorous scavenger on the reefs at all depths. **Native.**



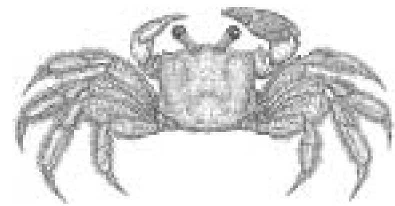
B, C

Common Spider Crab
Mithrax forceps
This is another denizen of the cracks and crevices of the reefs. About 2.5 cm (1 in) long it has a chunky, reddish-brown, ribbed body and shortish legs. Hard to spot but nevertheless common, it is another reef scavenger. **Native**.



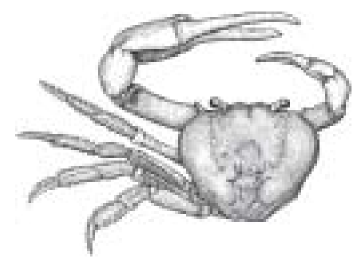
S

Ghost Crab
Ocypode quadrata
The Ghost Crab is a pale nocturnal crab of undisturbed sandy shores where it makes burrows just above high tide mark. It is an omnivore scavenging the shore at low tide for material cast up by the tide, including Portuguese Man-o-War. Length to 4 cm (1 3/4 in). **Native**.



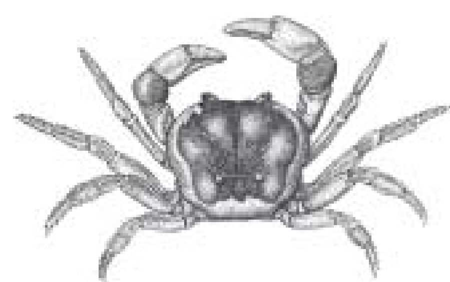
M

Giant Land Crab
Cardisoma guanhumi
This is one of Bermuda's endangered species. The habitat of this crab is the landward part of mangrove swamps, where they live in large burrows, excavated to just below the water level. The adult males have one very large claw. These are big crabs with a body at least 10 cm (4 in) across and long legs. They are brown in colour, omnivorous and nocturnal. **Native.**



OC

Land Crab or **Red Land Crab**
Gecarcinus lateralis
The most common land crab in Bermuda, this species inhabits burrows in the treed and grassy areas of the shoreline. The carapace is oval in shape, wider rather than long. It is coloured dark, reddish brown. The chelipeds are red or purple and are large and unequal in the male. The legs are paler and narrow at the tips, making them unsuitable for swimming. To 4.5 cm. **Native**.



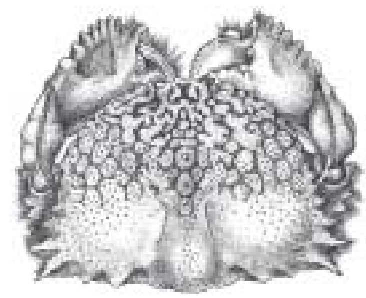
M

Mangrove Crab
Goniopsis cruentata
These crabs are really fast and you have to be alert to catch sight of them in the mangrove swamp. They will climb the trees but have burrows in the mud. The shells are about 5 cm (2 in) across and brownish green. **Native.**

Mole Crab
Hippa testudinaria
This small crab buries itself in the sand at low tide level and is rarely seen. It can rapidly burrow down to escape predators or avoid wave action. Marbled white in colour. About 3 cm (1 1/4 in) in length. **Native.**

S

Ocellated Box Crab
Calappa ocellata
This fascinating, chunky crab, about 10 cm (4 in) across the back, is difficult to find, as by day it lies buried in the surface of the sand, with which it is well camouflaged, being a mottled creamy-brown**.** If disturbed the crab becomes a very compact shape with all legs tucked out of sight. It is a nocturnal predator at the sand surface. **Native.**

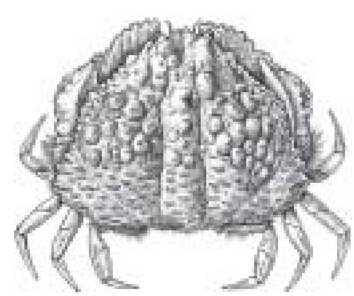


B

Sally Lightfoot Crab
Grapsus grapsus
This shore crab with a nearly circular carapace (shell) is found throughout the intertidal and supralittoral zones on very exposed rocky shores and cliffs. Its colour varies but its carapace and legs are dark reddish brown with pale blue markings. It feeds on the algal turf and blue-green cyanobacteria. It is aptly named for its quickness as it escapes a crashing wave or curious human. To 12 cm (4 1/2 in) across. **Native.**

R

Yellow Box Crab
Calappa gallus
You may find this true crab in shallow, sandy bays. It is distinguished by its broad carapace which is lined with two grooves and covered at the front by round bumps. The legs and upper body parts are orange, while the underparts are yellow. There are projections resembling wings on the front end of the carapace. To 5 cm (2 in). **Native**.

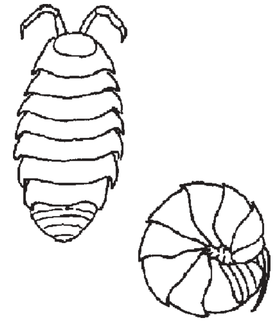


B

Isopods

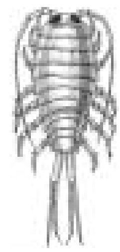
F, U, W

Pill-bug or **“Roly Poly”**
Armadillidium vulgare
This isopod crustacean has a grey body with plate-like segments which somewhat resemble a miniature armadillo. The pill-bug is originally from Europe but now found world-wide. Can be found under stones, in moist leaf litter and in cellars. Like the Sow-bug it is sometimes called the Wood Louse. They feed on the tender roots and shoots of plants. About 1 cm (3/8 in) long. **Introduced**.



R

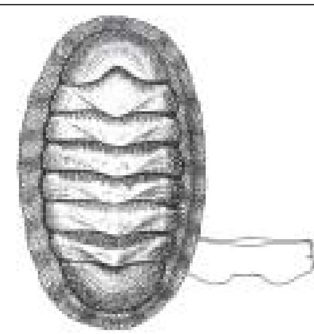
Wharf Louse
Ligia baudiniana
A very active, dark grey, flattened crustacean about 2 cm (3/4 in) long, very common along sheltered shores and around ponds, just above the water-line. It hides rapidly when disturbed. **Native.**



Chitons

R

West Indian Chiton
Chiton tuberculatus
This West Indian Chiton has an oval greenish segmented shell. The central area of each shell segment is smooth, while the edge is broad and rough with bands of green and black. Found only at the very bottom of the intertidal zone on moderately to highly exposed shores. It can reach 7.5 cm (3 1/2 in) in length. **Native.**

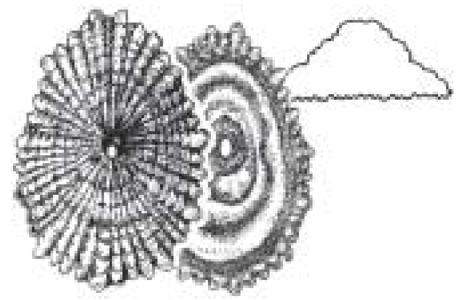


Gastropoda

Limpets

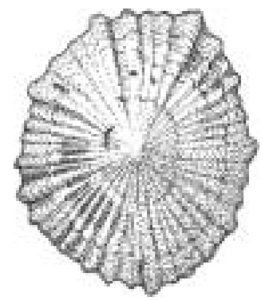
R

Keyhole Limpet
Fissurella barbadensis
This species has a conical shell of variable shape with a round or oval hole on the top, circled with pink. The shell is coloured cream, greyish white or olive green, with ribs highlighted in brown. It is common intertidally, grazing on algae and always finding its way back to its "home" place on the rock before the tide subsides. To 25 mm (1 in) long. **Native.**



R

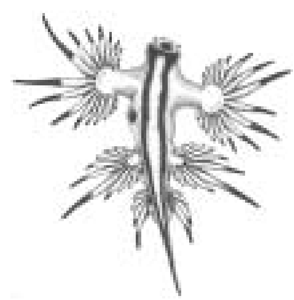
Say's False Limpet
Siphonaria alternata
This air-breathing limpet has a flattened conical shell with no opening at the top. Brownish in colour with stripes or patches. The interior is glossy tan, brown or cream. Its homing ability is exceptional. Found in tide pools or around the high tide mark. To 20 mm (3/4 in). Very common. **Native**.



Sea Slugs

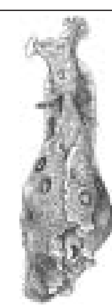
O

Blue Glaucus
Glaucus atlanticus
This is really a planktonic sea slug but it swallows air to keep it right at the surface, where it feeds on floating cnidarians. The Blue Glaucus is a very strikingly beautiful species being a bright blue in colour and up to 50 mm (2 in) in length. Three or four fan-shaped projections extend from each side of the body. **Native**.



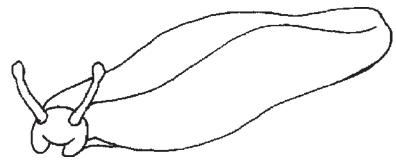
B

Spotted Sea Hare
Aplysia dactylomela
This gastropod has no visible shell. It has a large foot, two pairs of fleshy horns on its head and is coloured light brown to olive green with black spots. When disturbed, it discharges a purple fluid. Found in tide pools grazing on the alga *Laurencia*. To 120 mm. **Native**.



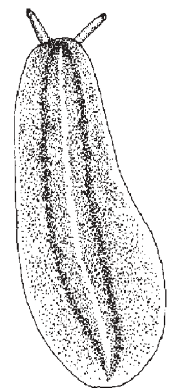
Slugs

Garden Slug
Milax gagates
Introduced to Bermuda prior to 1875. Now common and found in moist locations in walls and under debris. To 8 cm (3 in) long. **Introduced**.



U, W

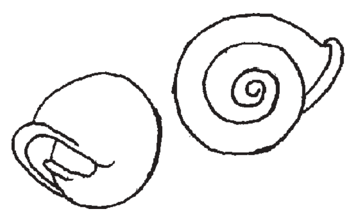
Great Slug
Leidyula sloanii
Reported by early writers and thought to be accidentally introduced to Bermuda. It is common and nocturnal in its habits. It is easily collected in moist locations, in walls and under debris. The colour is dark slate-grey, almost black, or more or less mottled. It secretes a large amount of very sticky slime, when irritated, but does not ordinarily leave a trail of slime behind it when it crawls naturally. Grows up to 38 cm (15 in) in length. **Introduced**.



W, U

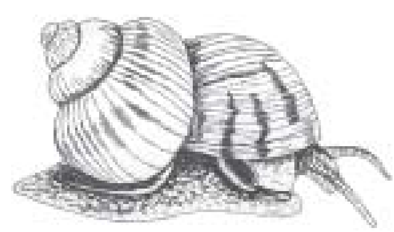
Snails

American Toothed Snail
Polygyra appressa
Introduced from Southern USA prior to 1852. It is nocturnal in its habits and may be found during the day concealed under stones. The shell is almost circular and the lip is rolled; there is a prominent tooth in the aperture. Pale brown in colour. This snail is herbivorous. 1.5 cm (1/2 in) in diameter. **Introduced**.



F

Apple Snail
Pomacea sp.
The Apple Snail was brought to Bermuda for use in aquariums. Predictably it got free and is now much more common than native water snails. A large, banded snail, with a very large aperture, up to 6 cm (2 1/2 in) long, it lays masses of bright pink-orange eggs above the water. Now widely distributed in warm climates of the world, Apple Snails are among the most destructive of invasive species, eating both plant life and small animals including other snails. **Introduced**.

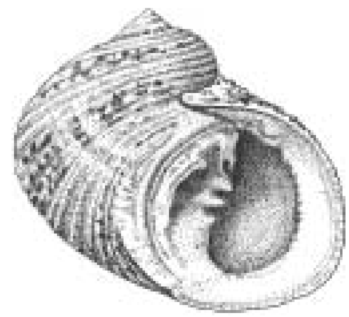


FW

Beaded Periwinkle
Tectarius muricatus
This large periwinkle species is coloured grey on the outside and dark brown on the inside. The spirals are covered with evenly spaced knobs. This species occupies a zone slightly higher up the shore than the other periwinkles. To 2.5 cm (1 in). **Native**.

R

Bleeding Tooth Nerite
Nerita peloronta
This is one of the nerites which have a rounded, thick-shell. The colour is basically pale yellow, there are orange, red, purple or black markings. A blood-red mark on the two teeth-like formations called denticles on the shell's inner lip gives it its name. It is found in the midlittoral where there is moderate wave action. Formerly common, now rare. To 4 cm. (1 3/4 in). **Native.**



R

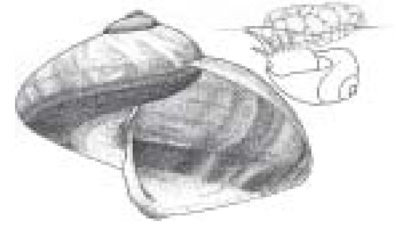
Coffee Bean Snail
Melampus coffeus
These snails living on mangrove roots are aptly named being about the size and shape of a coffee bean. About 1 cm (3/8 in) long, they come in a great variety of colours from solid brown, through various brown and beige bandings to a light colour. **Native.**

M

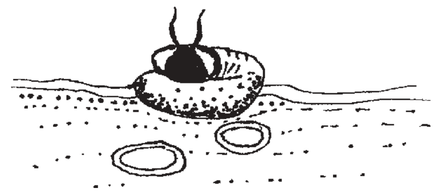
Colourful Atlantic Natica
Natica canrena
This common moon snail can be found on sand. It has variable colouring with brown zigzag lines laid over alternating spiral bands of cream, light brown and brown. It feeds on gastropods and bivalves. To 40 mm. **Native**.

B

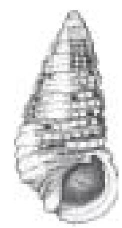
Common Purple Sea Snail O
Janthina janthina
These specialised snails which feed on By-the-wind Sailors float at the surface of the sea on a raft made of bubbles which the snail produces. The very fragile shell is a beautiful purple in colour and up to 35 mm (1 1/2 in) long. **Native**.



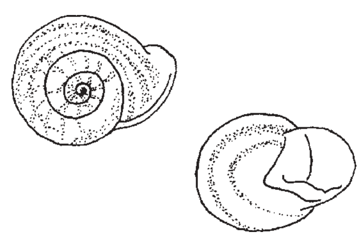
Corroding Worm Shell C, R
Dendropoma annulatus
This tiny member of the worm shell family is the most abundant animal of the exposed midlittoral zone but is rarely noticed. The shell is mostly buried in the rock and the 1 mm (1/25 in) black opening is all that can be clearly seen. Feeds on suspended detritus. **Native.**



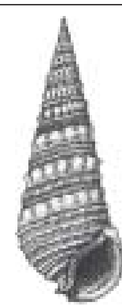
Dwarf Cerith or **Horn Shell** B
Cerithium lutosum
This species can be confused with the False Horn Shell but it is stockier, less pointed and dark brown in colour. To 1.2 cm. It is found under rocks and in tide pools. **Native**.



Edible Snail W
Otala lactea
A serious garden pest which is now found island-wide. It is one of the edible snails of Europe, recognized by its large size (diam. 4 cm) and brown and white spiral bands which vary in width and darkness with habitat. The thick shell has a lip at the aperture in mature snails; dark brown columella, and a low spire. Up to 3 cm (1 1/4 in) in diameter. **Introduced.**

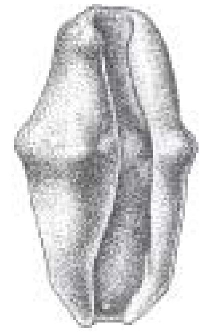


False Cerith B, M
Batillaria minima
These little shells often occur in almost countless profusion on sheltered shores, particularly where there is both rock and sediment. Reaching only 15 mm (5/8 in) in length, the shell is very tall and slender with numerous whorls of ridges and small bumps. **Native**.



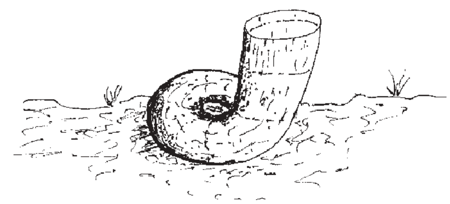
Flamingo Tongue
Cyphoma gibbosum
The Flamingo Tongue is a magnificent snail. While the shell itself is an attractive, very smooth orange structure, it is covered, when the snail is active by a magnificent pink layer of skin set with spots of orange with burgundy borders. This snail is about 3 cm (1 1/8 in) long and can occasionally be found on soft corals on which it preys. **Native**.

C



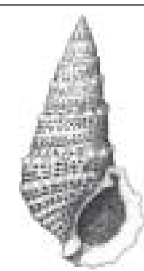
Large Tube Shell
Serpulorbis decussatus
This is the largest tube shell in Bermuda with an opening up to 7 mm (1/4 in) in diameter. The rim of the shell is exceedingly sharp and can puncture even stout footwear. The shell is white but the snail within comes in either white or red colour phases. There is no operculum. Usually, the shell is cemented to the rock, but sometimes the shells are cemented to each other in huge numbers to form Vermetid (Worm Shell) Reefs. **Native**.

R



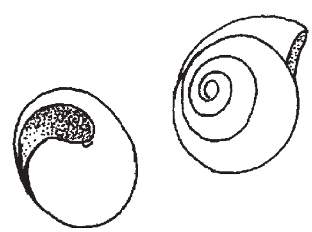
Lettered Horn Shell
Cerithium litteratum
This is a tall, heavy-shelled snail up to 3 cm (1 1/4 in) in length. It is a very variable shell but the surface is usually ornamented with whorls of smooth bumps and patterned with small dots. Common in bays and seagrass beds. **Native.**

B, SG



Little Orb Helicina
Helicina convexa
This snail has a small pale shell with a low spire and a large comma-shaped opening. Found under forest litter. 1 cm (3/8 in) across. **Introduced.**

F



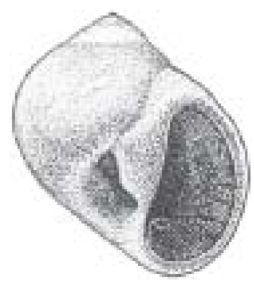
Mangrove Periwinkle
Littorina angulifera
This snail is larger than its close relatives on the rocky shore with a shell up to 3 cm (1 1/4 in) long. Found crawling on mangrove prop roots, it is herbivorous. The colour is streaked brown. **Native.**

M

Milk or **Harbour Conch**
Strombus costatus
As an adult the Harbour Conch is virtually impossible to confuse with anything else. The shell is large and very heavy, measuring up to 20 cm (8 in) in length. The shell opening has a large flared lip. The colour is generally whitish often with tinges of pink. Juvenile Harbour Conchs are very common in many shallow bays and seagrass beds. They have a much less heavily built shell and there is no flared lip. **Native.**

B

Milky Moon Snail
Polinices lacteus
This moon snail has a very globose shell about 2 cm (3/4 in) long. The shell is glossy milk-white in colour and is commonly found empty on the sand surface. The living snail has a very large foot and it burrows randomly through the sediment in search of its clam victims. This snail makes a very distinctive egg collar found on the sediment surface**. Native.**



B

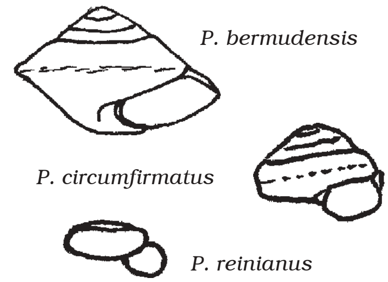
Planorbis Snail
Planorbis sp.
This freshwater planorbid is a flat discoid snail to 1 cm (1/2 in) in diameter. **Native**.

FW

Poecilozonites F, EX

Poecilozonites spp.

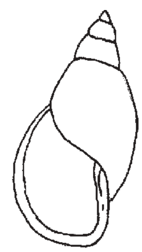
This snail, unique to Bermuda, evolved into 15 species, most of which subsequently died out during high stands of interglacial seas. Living specimens of three *(P. reinianus , P. circumfirmatus* and *P. bermudensis)* were collected by well-known biologist Stephen Gould in 1969; however, only *P. circumfirmatus* have been reliably observed since then. Varied in size. 5 mm to 6 cm (3/16-2 1/2 in). **Endemic** or **Extinct.**



Pond Snails FW

Physa spp.

The pond snails vary considerably in size but most are in the order of 1 cm (1/2 in) long. The spiral shells are elongate and pointed at the tip. The aperture is oval. Pond snails are herbivorous. **Native**.



Prickly Winkle R

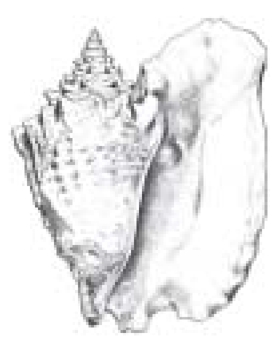
Nodilittorina tuberculata

This species has a grey-brown conical shell covered with spiralled rows of pointed knobs. Found on exposed rocky shores in a narrow band at the top of the midlittoral zone, often in depressions or crevices. This is by far the commonest of the intertidal periwinkles. From 1.2-2 cm (1/2-3/4 in) in size. **Native**.

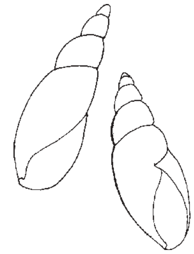
Queen Conch B, SG

Strombus gigas

This large and very beautiful sea snail was once common but used both for the meat and as an ornamental shell. The main feature of mature Queen Conch's is the very wide flaring lip of the shell, which is a beautiful orange-pink colour on the lower side (inside). Queen Conchs live mainly in seagrass beds well offshore but a few populations live quite close to the shoreline. This species is fully protected and seems to be making a very slow recovery. Up to 30 cm (12 in) long. **Native**.

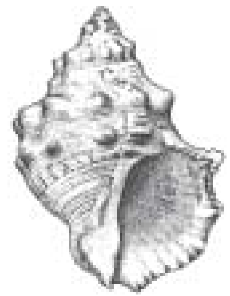


Rosy Euglandina or **Predaceous Snail**
Euglandina rosea
Introduced from Cuba as a biological control of the Edible Snail *Otala lactea*, it is carnivorous and common in the inland forest. The adult has a pale pink shell which is translucent in younger specimens. Up to 5 cm (2 in) long. **Introduced**.



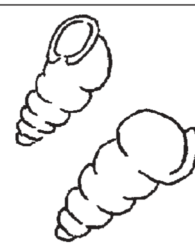
F, U, W

Rusty Whelk or **Rustic Rock Shell**
Thais rustica
A thick-shelled species with large whorls and a wide oval aperture marked with long denticles on the inner lip and a prominent groove at the front. It is grey with bands of brown and purple. A carnivore, it is rare, found intertidally feeding on barnacles and mussels. To 3.5 cm (1.5 in) long. **Native**.



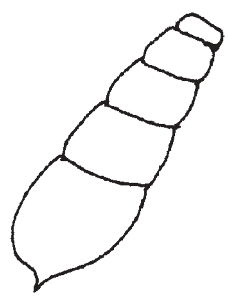
R

Shiny Puppila
Pupoides nitidulus
This is a small, shiny, smooth, 1 cm (3/8 in) long snail found under bark or fallen leaves in the forest. It has a lip around the opening. **Introduced**.



F

Spiral Snail
Rumina decollata
The shell of this species is quite elongated and the apex is characteristically worn away, giving it a blunt tip. Accidentally introduced by Governor Lefroy with growing plants from Tenerife in 1876. Pale translucent brown in colour. A common snail in gardens. 3 cm (1 1/8 in) long. **Introduced.**



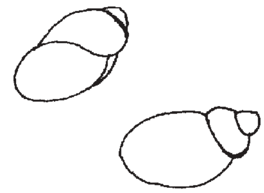
F, W

Tessellated Nerite
Nerita tessellata
This species has a spotted black and white shell with spiralling grooves. Some are black. Found in large numbers with other nerite species along the rocky north and south shores, they prefer areas of moderate wave action and feed on algae and seek shelter at low tide. To 2 cm (3/4 in). **Native**.

R

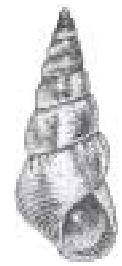
F

Tree Snail
Succinea bermudensis
This medium-sized snail has a white inflated looking shell with a very large aperture. It can be found under rocks and on tree trunks. To 7 mm (1/4 in) long. **Endemic**.



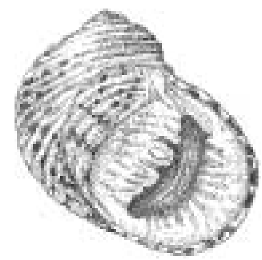
B

Varicose Alaba
Alaba incerta
This elongated, almost smooth snail, reaching 7 mm (1/4 in) in length is common in sand. The shell has faint spiral grooves and is yellow to light brown in colour. Shells of this snail are commonly washed up on shore. **Native.**



R

Variegated Nerite
Nerita versicolor
A species shaped like the other nerites above and coloured greyish-white with markings of red and black. The inner lip is yellow with four denticles. Found in the mid-littoral zone with other nerites. To 25 mm (1 in). **Native**.

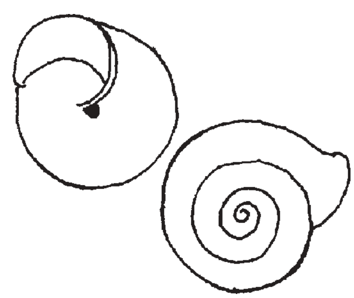


R

West Indian Top Shell
Cittarium pica
This is the largest Bermudian marine snail. It has a checkered black and white shell and may reach at least 10 cm (4 in) across. Extirpated then recently re-introduced and now doing well. Up to 12 cm (5 in) in diameter. **Native**.

F

White Snail
Eulota similaris
Probably introduced to Bermuda from the West Indies, it was first recorded from Bermuda in 1889. The shell is translucent and pale yellowish-white in colour. A herbivorous snail. The shell is somewhat flattened and circular. 2.5 cm (1 in) in diameter. **Introduced.**



R

Zebra Periwinkle
Littorina ziczac
The shell is oval-shaped, greyish-white in colour with irregular oblique purplish brown stripes. Found on exposed rocky shores in a narrow band at the top of the mid-littoral zone. To 2 cm (3/4 in). **Native**.

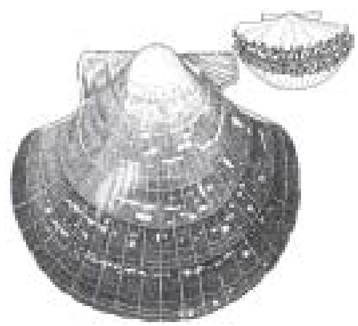
Clams and Mussels

B

Atlantic Grooved Macoma
Psammotreta intastriata
The thin, rounded shell is a dull white and quite strongly inflated; length up to 6 cm (2 1/2 in). This deep-living clam has a siphon that reaches beyond the sand surface. The characteristic feature is that one end of the shell is twisted. **Native.**

B

Bermuda Scallop
Pecten ziczac
Scallops lie just at the sediment surface where they may be camouflaged with a thin layer of sediment. If disturbed they can swim a short distance by flapping the shells. The Bermuda Scallop up to 8.5 cm (3 1/4 in) across has a flat upper and strongly convex lower shell. Variable in colour but usually a reddish brown. **Native**.



B, C

Black Date Mussel
Lithophaga nigra
This is a species which can only be seen as an oval hole showing at the mouth of the burrow in the limestone. The mussel looks very like a large date pit, with ridges on the larger end of the shell. Up to 4 cm (1 1/2 in) long these shells can be present in very large numbers. To enlarge the burrow as they grow they both dissolve the limestone and scrape it away. They are filter feeders. **Native**.

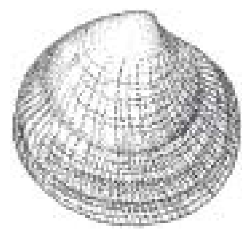
Calico Clam
Macrocallista maculata
Shell thick and shiny, up to 8 cm (3 in) long and 6 cm (2 1/4 in) wide. Shell ornamented with very attractive checkerboard-like markings in brown on a beige background. A shallow burrower. A filter feeder. **Native.**

B

Calico Scallop
Argopecten gibbus
Like the Bermuda Scallop the calico scallop lies on the sediment and can swim briefly. One shell, the lower, is slightly more convex than the other is. Growing to 7 cm (2 3/4 in) across the scallop is mottled in brown, red, purple and yellow on white. **Native**.

B

Dwarf Tiger Lucina
Codakia orbiculata
This is a dwarf version of the Tiger Lucina, being up to 3 cm (1 1/4 in) across. The rough, dull, thick, chalky-white shell has circular and radial ridges. **Native.**

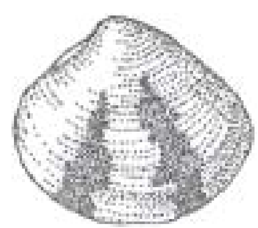


B

Flat Mangrove Oyster
Isognomon alatus
Found on red mangrove prop roots, under the water, these oysters can be exceedingly numerous. While the shells may be 5 cm (2 in) long, they are very thin. The colour is blackish. Now restricted to a few locations. **Native.**

M

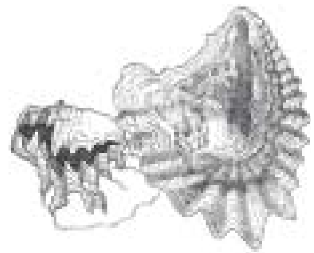
Gould's Cerina
Gouldia cerina
This small clam about 1 cm (3/8 in) lives in the deep mud bottom of Harrington Sound. The rounded shell, slightly heart-shaped, is bone white with brown mottlings. **Native**.



B

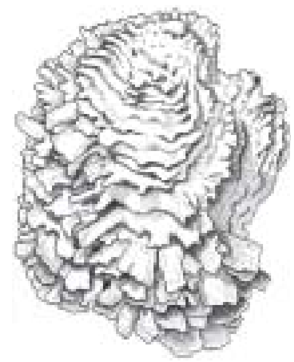
C, R

Leaf-like Oyster
Lopha frons
This oyster, about 6 cm (2 1/4 in) in diameter, is most easily identified by the zigzag edges of the two shells where they join together. The shell is reddish-brown in colour and has concentric fold-like ridges. **Native**.



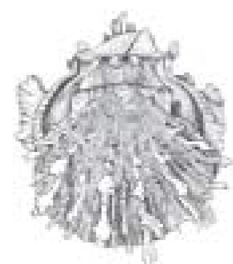
B, C, R

Leafy Jewel Box
Chama macerophylla
This is a very heavily built shell that is found cemented by one valve to the surface of the reef. The surface of the shell, shaped like an irregular circle, about 8 cm (3 in) across, is ornamented with many scale-like plates. The colour may be very varied from yellow to orange, red, or lavender, but the outside is often overgrown with other organisms. The interior is very smooth and colourful, hence the common name. **Native**.



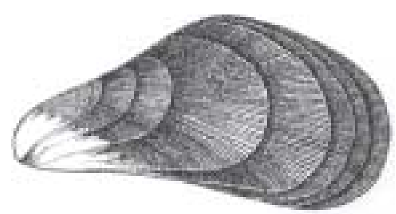
C, R

Rock Scallop
Spondylus ictericus
The rock scallop may be found living with its lower shell firmly cemented to the reef surface. The upper shell, which is almost circular, is ornamented with numerous, flattened spines. The colour may be white, yellow orange or red. To 13 cm (5 in) across. **Native**.



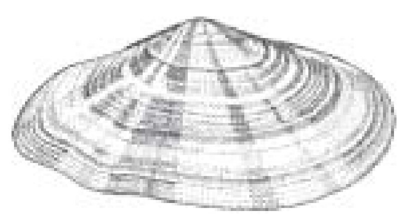
R

Scorched Mussel
Brachidontes domingensis
A small mussel of the mid-littoral zone. The shell is elongated, black and ribbed. Attached to the rock by byssal threads. Often clustered in cracks and crevices. 1 cm (3/8 in) long. **Native**.



B

Sunrise Tellin
Tellina radiata
A deep-burrowing clam that feeds on detritus at the sediment surface through a long siphon. The elongate-oval, thin shell, up to 10 cm (4 in) long has radiating pinkish-red rays on a creamy background. **Native.**

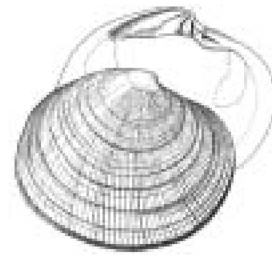


B

Sunset Clam
Tellina laevigata
This clam has a deep burrow but feeds at the sand surface by means of a long extensible siphon. The smooth, creamy, rounded-oval shell may reach 10 cm (4 in) long. The shell is ornamented by salmon-pink radiating rays. **Native.**

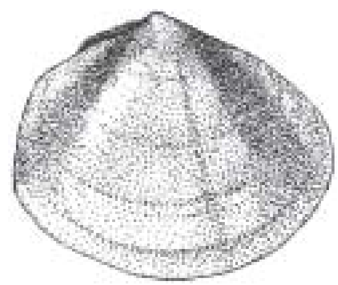
B

Tiger Lucina
Codakia orbicularis
This probably **extirpated** species has a very rounded shell up to 9 cm (3 1/2 in) across, that is chalk-white and robust. There are obvious radiating and circular ridges, making the shell rough in texture. A shallow burrower. **Native.**



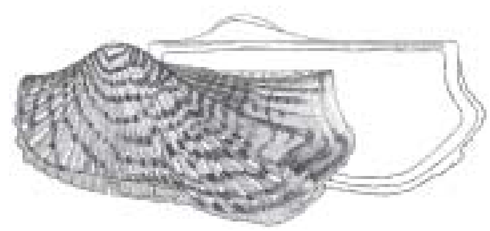
S

Two-spotted False Donax
Heterodonax bimaculata
A small clam of the lower intertidal of sandy shores that can rapidly dig itself deeper if disturbed. The smoothish, oval shell may be white, purple, yellow, red or combinations of these colours. Grows to about 17 mm (3/4 in) long. **Native**.



B

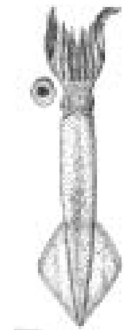
Zebra Mussel
Arca zebra
Often called the 'Bermuda Mussel' and formerly used in mussel pie, this shellfish has an elongated thick shell which is absolutely straight along the long hinge between the shells. As suggested by the common name, the light brown shell has prominent dark brown zigzag markings. This mussel is normally attached to hard surfaces by means of strong dark threads called byssus. Grows to about 8 cm (3/4 in) long. **Native.**



Squids and Octopusus

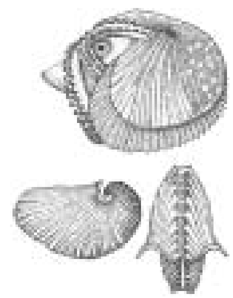
Squids

Arrow Squid
Loligo plei
This squid can reach 30 cm (1 ft) in length but ones seen inshore and over seagrass beds may be half this size. The body is long and slender with the fins at the hind end only. The greyish colour is enhanced by small brown spots. Like other squids this species may swim slowly forward or dart rapidy backward. **Native.**



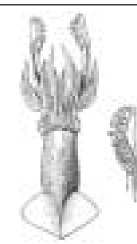
B, C

Common Paper Nautilus
Argonauta argo
This is really an octopus with a thin, slightly coiled shell. The female reaches 30 cm (12 in) in length but the shell-less male is only 1.5 cm (1/2 in). The very ridged shells are sometimes washed ashore. This species lives close to the surface but is not commonly seen. **Native**.



O

Onykia caribaea
This is a small, typical oceanic squid which lives close to the surface and is often found under sargassum rafts. The colour is a deep, iridescent blue and the body length is up to 7 cm (3 in). Common. **Native**.

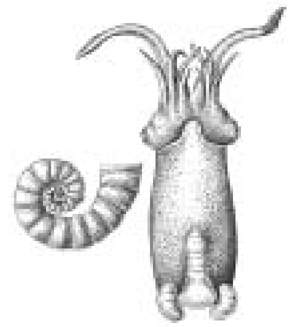


O

Orange-back Squid
Ommastrephes pteropus
The Orange-back Squid is a medium-sized one with a body length up to 40 cm (16 in). This squid lives in the upper few hundred m (<1,000 ft) of water and is a strong swimmer. It often congregates, at night, at the surface around lighted vessels. The colour is a striking deep red or maroon. Common. **Native**.

O

Rams Horn Shell
Spirula spirula
This species is rarely seen alive but is common and the shells of dead specimens, up to 2.5 cm (1 in) are often washed up on beaches. The squid which lives in the shell is about 7 cm (2 3/4 in) long . There are two long tentacles and eight short ones. Comes up to 100 m (300 ft) depth by night but is deeper by day. **Native**.

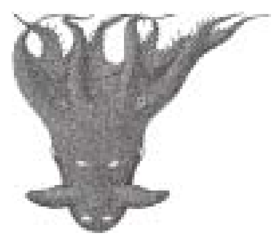


O

Reef Squid
Sepioteuthis sepioidea
Up to 30 cm (12 in) long, these squid occur in groups over the reefs and inshore waters. They are quite transparent but are covered in small brown dots and show iridescent blue colour as they move. They feed on small fish and swimming crustacea. When threatened they can produce a cloud of ink and retreat backwards at high speed. **Native**.

B, C

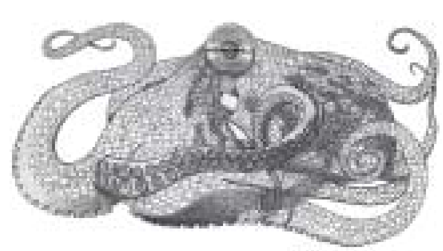
Vampire Squid
Vampyroteuthis infernalis
This black squid with red eyes rarely comes closer than 300 m (1,000 ft) to the surface. It has eight quite short tentacles. The body is up to 28 cm (11 in) long. Uncommon. **Native**.



O

Octopuses

Common Octopus
Octopus vulgaris
Octopuses are mainly nocturnal hiding by day in cavities in the reefs. Just at the mouth of these dens there is usually a patch of bivalve mollusc shells, the remains of their main food. Octopuses can change colour rapidly but are usually some shade of dappled brown; however they can range from near-white to nearly black. The Common Octopus is a widespread species that can reach up to over 1 m (3 ft), including the arms. Usually seen moving along on the arms, they can retreat backwards at speed and emit ink when threatened. **Native**.



B, C

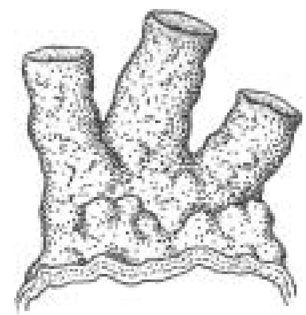
Moss Animals

B, SP

Greybeard Sea Moss
Zoobotryon verticillatum
This moss animal or Bryozoan is constructed of a series of transparent very light grey coarse threads. It usually hangs down from the notch top, but may be on a buoy or submerged branch. Up to 10 cm (3 in) long. **Native**.

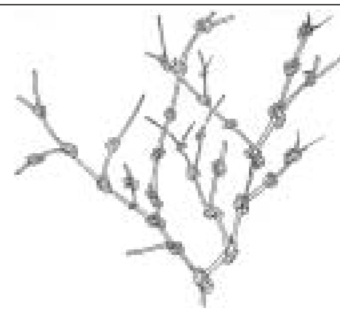
B

Pink Sea Moss
Schizoporella errata
This is an encrusting seamoss in which the colony forms a thin, flat sheet with a slightly upturned edge, attached to the rock. In colour it is an orangy-pink and the texture is quite rough. The tiny individual animals are just visible to the naked eye. Colonies may be at least 15 cm (6 in) across. **Native.**



B, SP

Vidovici's Amathia
Amathia vidovici
This is a quite unusual moss animal. In the water it appears as a mass of long clear stalk-like strings with bumps at intervals. The strings may be 50 cm (20 in) long and dangle down in the water. Common in Walsingham Pond. **Native.**

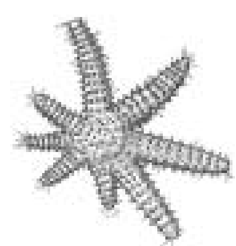


Echinoderms

Starfishes

B, SP

Spiny Sea Star
Coscinasterias tenuispina
This is a small starfish with cylindrical arms, often found in Walsingham Pond. Often one or more of the five arms is missing. The starfish is up to 8 cm (3 in) in diameter, and a dirty brown in colour. **Native.**

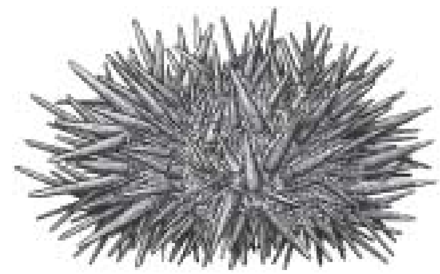


Sea Urchins

Burrowing Rock Urchin C, R

Echinometra lucunter

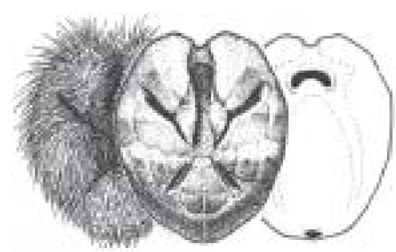
This deep purple urchin with short, conical spines is up to about 8 cm (3 in) long and has a somewhat ovoid body, when viewed from above. They are found occupying elongate, shallow burrows in the surface limestone of Boiler Reefs and Bioconstructional Lips. They do not leave these burrows and feed on the algae growing within them. The burrows are vigorously defended. These animals occupy one of the harshest reef environments in Bermuda. **Native**.



Heart Urchin B

Moira atropos

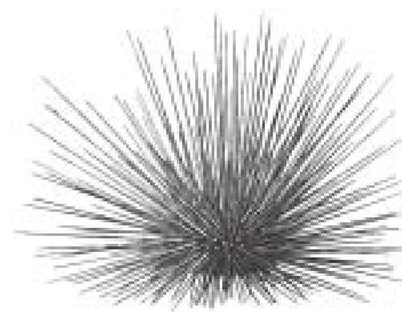
This small heart urchin is delicate and burrows deeply in the mud or muddy sand. If seen it is a delicate orange brown and covered in short spines. Only reaching 5 cm (2 in) long it is almost spherical in shape and the small mouth is on the underside. **Native**.



Longspine Sea Urchin C

Diadema antillarum

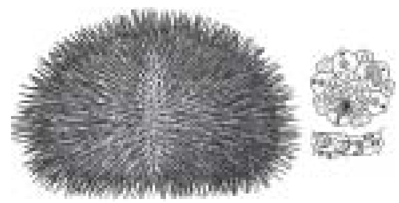
This urchin was formerly common and particularly so in the depressions of Boiler Reefs. However, in the 1980's an epidemic disease spread throughout the entire Caribbean area and decimated populations. The species is still occasionally seen and is readily identified by the very long black spines. Up to 30 cm (1 ft) in diameter including the spines. **Native**.



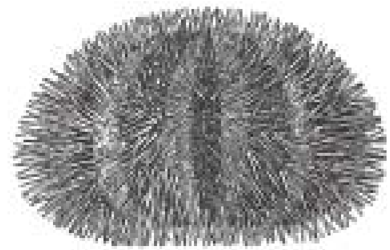
Purple Urchin B, SG

Lytechinus variegatus

This is the commonest urchin of sandy bays and seagrass beds. It is deep purple in colour and the body commonly about 8 cm (3 1/4 in) in diameter. The spines are quite short and thickly placed. This urchin often carries pieces of flotsam and seaweed on its back for camouflage. **Native.**



White Urchin
Tripneustes ventricosus
This handsome urchin of the seagrass beds has white spines which contrast with the somewhat darker body. Growing up to about 10 cm (4 in) in diameter this species has been getting less common in recent years. **Native.**

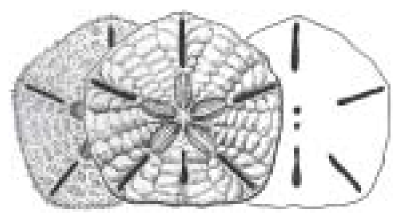


SG

Sand Dollars

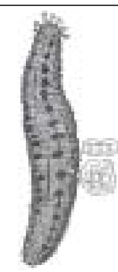
Sand Dollar
Leodia sexiesperforata
This very flattened echinoderm has a virtually circular body which has six slit-like perforations one of which is keyhole-shaped**.** This pale brown animal moves just beneath the sediment surface leaving an irregular meandering trail. Commonest where there is some current. About 8 cm (3 1/2 in) across. **Native.**

B



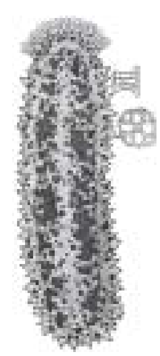
Sea Cucumbers

Burrowing Sea Cucumber
Holothuria arenicola
This deeply burrowing, large sea cucumber is very rarely seen but is common. The body reaches 25 cm (10 in) long and 4 cm (1 1/2 in) wide. It is dark-brown with darker patches. **Native.**



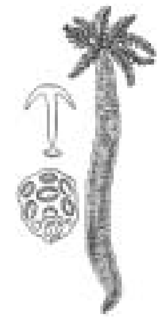
B

Sea Pudding
Isostichopus badionotus
The sea cucumber known in Bermuda as the sea pudding. Cannot be confused with anything else. The elongated, rubbery body is domed on top and forms a flat foot-like organ on the bottom. The colour varies from entirely light brown to near black, or is blotched in these colours. A large animal reaching 35 cm (14 in) long. **Native**.



B

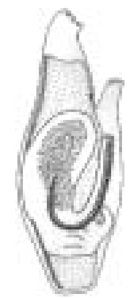
Sticky Synaptula
Synaptula hydriformis
A tiny, almost colourless sea cucumber found clinging to vegetation in some marine ponds. Usually, 1 cm (1/2 in) or less in length, but can be larger, it feels sticky to the touch as it has numerous hooked spines. It can stand quite low salinity, an unusual feature for a sea cucumber. **Native**.



SP

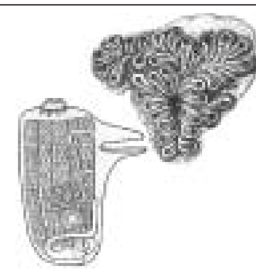
Sea Squirts

Black Sea Squirt
Phallusia nigra
This is a very obvious, solitary sea squirt commonly attached in the notch or on underwater cliffs. The colour is jet-black and the body smooth. The sac-like body is up to 7 cm (2 3/4 in) in length and has two prominent openings. **Native.**



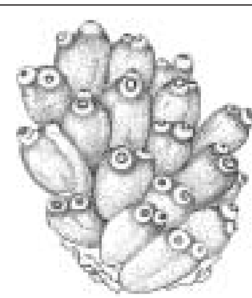
B

Lacy Sea Squirt
Botrylloides nigrum
The Lacy Sea Squirt is really a colony of small sea squirts. The whole colony may be 5 cm (2 in) across, but quite thin. The colour is a very striking bright orange. Common in marine ponds on roots. **Native.**



SP

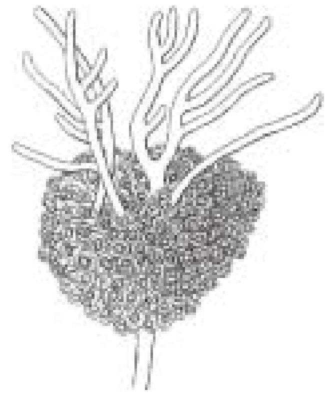
Orange Sea Squirt
Ecteinascidia turbinata
This species lives in just the same habitats as the Purple Sea Squirt but the individuals are a little smaller as are the colonies reaching only about 15 cm (6 in) across. The colour is a fairly uniform soft orange with a darker ring at the apex. Sea squirts are filter feeders. **Native**.



B, SP

B, SP

Purple Sea Squirt
Clavelina picta
This sea squirt and the preceding species may often be found in colonies on the stalks of soft corals as well as on rocks and mangrove roots. Each individual is of great beauty, consisting of an almost transparent sack about 1 cm (3/8 in) in length, through which can be seen the internal organs. The colonies can reach 40 cm (15 in) across. At the top of the sack a brilliantly iridescent purple ring, with an inner margin of white is very obvious around the larger of the two openings. **Native**.



Fish

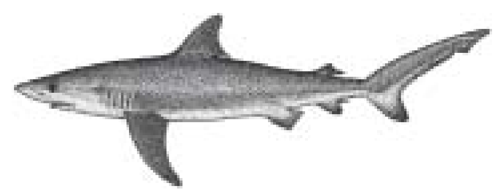
Sharks

O

Blue Shark
Prionace glauca
This 3.8 m (12 ft) shark sticks to the open ocean where it feeds on fish and squid. It is dark-blue on the back, bright blue on the sides and white below. Sport fishermen take this species. Uncommon. **Native**.

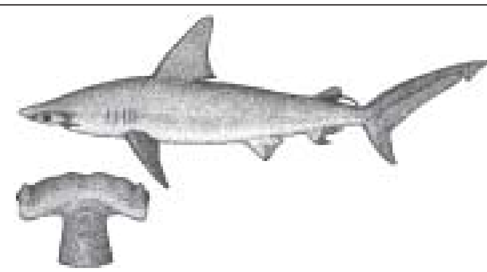
O

Dusky Shark
Carcharhinus galapagensis
This smallish shark may be found in both oceanic and near shore environments. It reaches a length of 3.7 m (11 ft). It is dark-grey above and virtually white below. This shark is caught on hook and line and by long-lining. Uncommon. **Native**.



O

Scalloped Hammerhead
Sphyrna lewini
As its common name suggests this shark has a hammer-shaped head. It is grey above shading to whitish below and grows up to 4.2 m (14 ft). An entirely oceanic shark, it feeds on fish, squid and krill. Uncommon. **Native**.

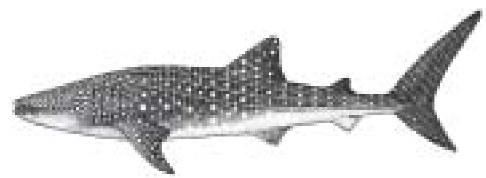


O

Short-finned Mako
Isurus oxyrinchus
This oceanic shark is a dark blue-grey on the back, grey on the sides and whitish beneath; it reaches a length of 4 m (12 ft). It feeds on fish and squid and is occasionally caught on hook and line. Not common. **Native**.

O

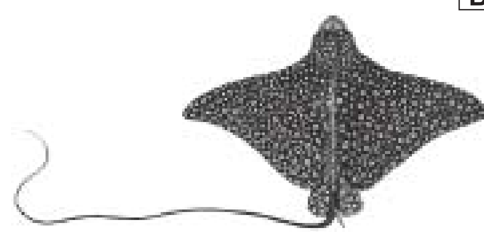
Whale Shark
Rhincodon typus
The largest of the sharks reaching 12 m (38 ft), the Whale Shark is a filter feeder feeding on small fish, krill etc. It is a slow swimmer and totally harmless. The body is chocolate-brown above and yellowish below. There are white spots on the back, sides and fins. Uncommon. **Native**.



Rays

B, O

Spotted Eagle Ray
Aetobatus narinari
This ray, common over sandy bottoms where it hunts its shellfish prey, is unmistakable. Up to 1.5 m (4 1/2 ft) across, but commonly smaller, The Spotted Eagle Ray has a very wide flat body and a long tail. The back is dark-grey and covered with light spots with a dark centre. **Native.**



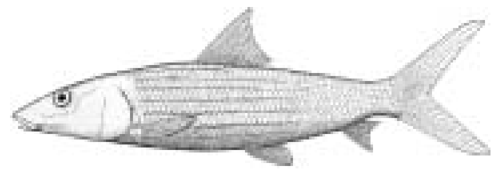
Tarpons

M, O

Tarpon
Tarpon atlanticus
A large fish as an adult. This species starts life in drainage channels leading to the sea, and in coastal mangrove swamps. This silvery fish grows to 2.5 m (8 ft) long. **Native**.

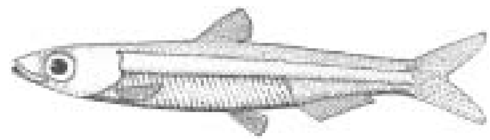
Bonefishes

Bonefish **B, SP**
Albula vulpes
This fairly large fish growing up to 1 m (3 ft) long often feeds in shallow water. It is silvery in colour with several thin horizontal lines on the front half of the body, and a good swimmer. Common in the ponds, they often jump considerable distances. **Native.**



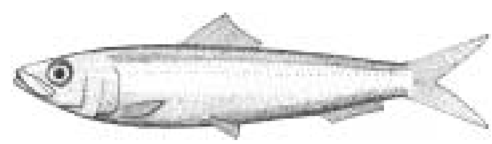
Anchovies

Blue Fry **B**
Jenkinsia lamprotaenia
A very small, silvery fish with a streamlined body and large eye. The mouth is small, ending at the front edge of the eye. Grows to 6.5 cm (2 1/2 in) but is usually half this length. Swims in large schools with other fry. **Native.**

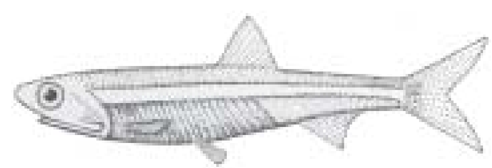


Herrings

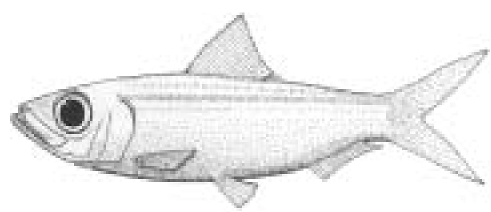
Anchovy **B**
Sardinella anchovia
This fish is the largest of this group of small herrings found in bays and over seagrass beds. It may reach 30 cm (1 ft) in length. The eye is medium in size as is the mouth which extends back to the centre of the eye. **Native.**



Bermuda Anchovy or **Hogmouth Fry** **B**
Anchoa choerostoma
This is one of the tiny fish called ‘fry’, that are much used as bait. The body is streamlined, silvery, and up to 10 cm (4 in) long but usually about 4 cm (1 1/2 in). The mouth is large, extending to well behind the eye. **Endemic**.



Pilchard **B**
Harengula humeralis
A larger member of the ‘fry’ group, the Pilchard grows up to 15 cm (6 in) in length. The eye is very large, the body somewhat flattened from side to side. Silvery with a blueish tinge it is common in bays. **Native.**



Eels

American Eel
Anguilla rostrata
The American Eel, up to 1.5 m (4.5 ft) in length is an oceanic spawner. It lays its eggs in the Sargasso Sea and the larvae travel in ocean currents until they are ready to swim ashore. Spawning has never been observed but newly laid eggs have been taken in nets. Found in saltwater ponds only. **Native**.

FW, O

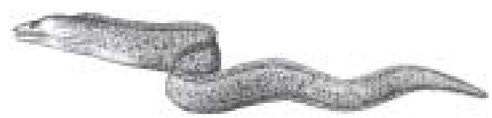
Moray Eels

Green Moray
Gymnothorax funebris
A large moray, reaching almost 2 m (6 ft) in length of a uniform green colour. **Native**.

C

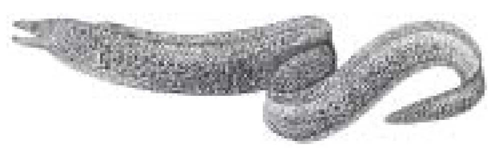
Purplemouth Moray
Gymnothorax vicinus
The Purplemouth Moray reaches about 110 cm (3 1/4 ft). The colour may be either a mottled green or greenish-brown with dark brown freckles. The dark dorsal (top) fin has a whitish edge. **Native**.

C



Spotted Moray
Gymnothorax moringa
This medium sized moray reaching 120 cm (3 1/2 ft) long has a dark purple-black basic colour. Fine whitish-yellow lines break the ground colour up to give an irregular spotted appearance. **Native**.

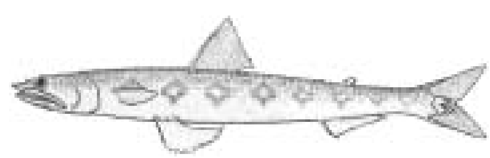
C



Lizardfishes

Inshore Lizardfish
Synodus foetens
Very similar to Sand Diver, the Inshore Lizardfish grows to about 30 cm (1 ft) long and has a long mouth in a forward-tapered head. The body tapers steadily back to the small tail. The sides and back are adorned with square, brown spots on a green blue background**. Native**

B



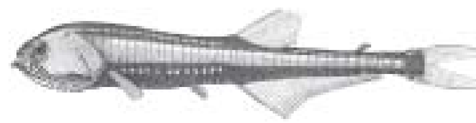
B

Sand Diver or **Snakefish**
Synodus intermedius
This 30 cm (12 in) long fish is a real bottom dweller. Usually seen resting on the sand, the Sand Diver has a large head leading to a steadily tapering body, longitudinally striped in blue and yellow. The distinctive feature is a dark spot at the upper end of the gill cover. The mouth is upturned. **Native**.

Lantern Fishes

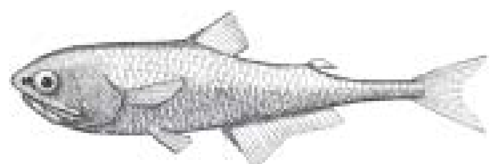
O

Bristle Mouth
Gonostoma elongatum
This dark-brown to black fish may ascend to 700 m (2,300 ft) by night but goes very deep during the day. It has a large head with many sharp teeth. It feeds on zooplankton and reaches a length of 27 cm (11 in). Common. **Native**.



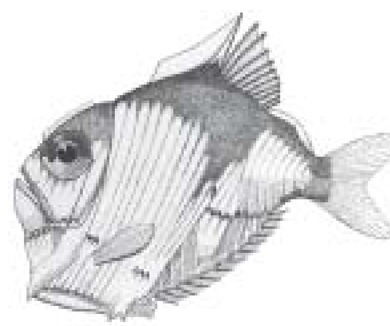
O

Cocco Lantern-fish
Gonichthys coccoi
One of the lantern fishes this species swims deeply by day but comes to the surface at night to feed on zooplankton. It has a row of **photophores** on the rear bottom side. About 10 cm (4 in) long. Blackish above, silver to golden below. Common. **Native**.



O

Hatchet Fish
Sternoptyx diaphana
Hatchet Fish have a body flattened from side-to-side and are silvery except for a dark line along the back. The eyes are very large and the photophores very well developed. Although it ascends to the surface at night it goes down to 2,000 m (6,500 ft) by day! Up to 4.5 cm (1 3/4 in) long. Common. **Native**.



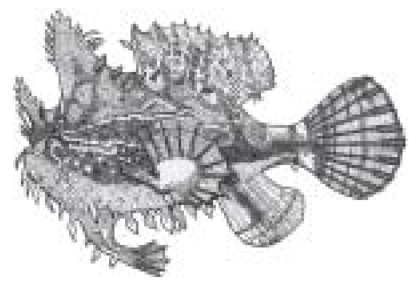
O

Lantern Fish
Myctophum nitidulum
A Lantern Fish found at the surface at night and down to 850 m (2,700 ft) by day. The length is about 10 cm (4 in) and it has photophores on the sides and bottom. Silvery-black above and silver below. Common. **Native**.

Frogfishes

O

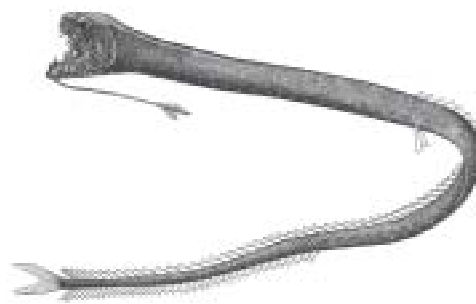
Sargassum Fish
Histrio histrio
A member of the Frogfish family this chunky fish up to 15 cm (6 in) long is beautifully camouflaged to blend in to the sargassum. The colour is a mottled mix of brown, tan and yellow and the fins and protrusions on the body resemble sargassum leaves. Common. **Native**.



Gulper Eels

O

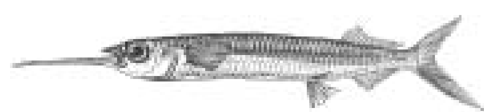
Black Dragonfish
Idiacanthus fasciola
Females are much larger than the males and may reach 30 cm (12 in). This is an elongated, eel-like fish with a large head bearing a prominent barbel on the chin. Black in colour. Although it ascends to the surface at night it goes down to 2,000 m (6,500 ft) by day! Fairly common. **Native**.



Needlefish and Halfbeaks

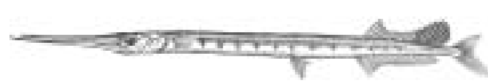
B

Bermuda Halfbeak or **Garfish**
Hemiramphus bermudensis
This fish is often referred to as the Garfish. It is a lightly built, slender fish averaging about 30 cm (1 ft) long. The eye is very large and the Bermuda Halfbeak has the lower jaw prolonged into a needle-like structure. **Endemic**.



B

Needlefish or **Houndfish**
Tylosurus acus
The Needlefish is a very slender silvery fish up to 1 m (3 ft) in length but those commonly seen are about 50 cm (1 1/2 ft). The eye is large and both jaws are elongated and very thin. **Native.**



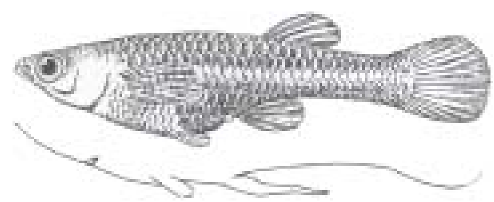
Flying Fishes

Fourwing Flying Fish O
Hirundichthys affinis
A flying fish of the open ocean that sometimes comes inshore. The juveniles are quite different and have much enlarged pelvic fins as well as the pectoral fins. Silvery-grey in colour and reaching a length of 25 cm (10 in). Common. **Native**.

Spotfin Flying Fish O
Cypselurus furcatus
The flying fishes have much enlarged pectoral fins which can act like wings and enable the fish to glide for considerable distances. This species grows to 30 cm (1 ft) in length and is a silvery-grey. Common. **Native**.

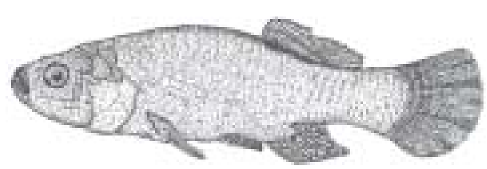
Mosquito Fishes

Mosquito Fish FW, SP
Gambusia holbrooki
A tiny but important fish. Mosquito Fish can live in water of very poor quality because they are able to breathe atmospheric air. Introduced to control mosquitos. They are in virtually all ponds and ditches and mass at the surface when water quality is very bad. Often called “Guppies” they can grow up to 7 cm (2.5 in) long but are commonly only half this length. Female above, male below. **Introduced.**



Killifishes

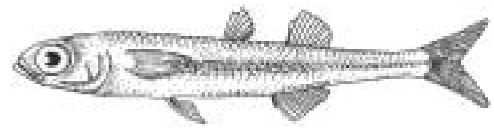
Bermuda Killifish SP
Fundulus bermudae
The Killifish is a small fish up to about 4 in (10 cm) in length. The colour varies from light brown to pale greenish-yellow. The body is rather cylindrical in shape and the tail rounded. Very common in saltwater ponds. **Endemic**.



Silversides

B

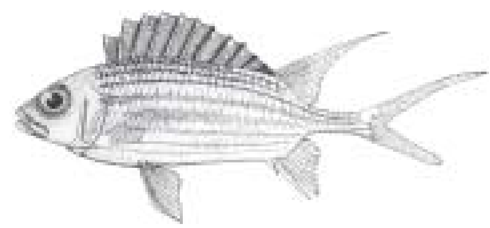
Rush Fry
Hypoatherina harringtonensis
Although very similar to the fry described previously this fish is actually in a different family. It can be distinguished from the other 'fry' by its having a larger head and a body which tapers steadily from the back of the head. Grows to 8 cm (3 in) but is usually about 4 cm (1 1/2 in) long. **Native.**



Squirrelfishes

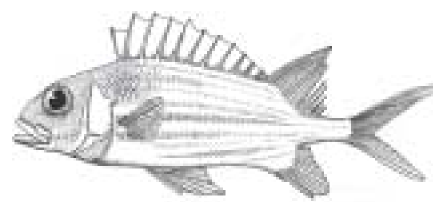
B, C

Longspine Squirrelfish
Holocentrus rufus
The two common squirrelfish are about the same size, usually about 20 cm (8 in), but occasionally they may reach twice this size. Body colouration is also rather similar in both, the body being striped in red and white; however, in the Squirrelfish, the red colour has a distinctly gold tinge. The spiny dorsal fin is darker in the Longspine Squirrelfish, and has small, triangular, light patches at the edge. **Native**.



B, C

Squirrelfish
Holocentrus ascensionis
Similar to the Longspine Squirrelfish (see above) except that the red colour has a golden tinge and the spiny dorsal is lighter in colour and has no triangular patches. Usually about 23 cm (9 in) long **Native**.



Seahorses

B, SG

Longsnout Seahorse
Hippocampus reidi
Unfortunately these amazing little fish are becoming rare in Bermuda. Found on seaweeds and seagrass beds where they attach themselves with the tail. Usually about 8 cm (3 in) tall, seahorses can change colour to blend in with the background. **Native**.

Pipefishes

B, O

Pugnose Pipefish
Syngnathus pelagicus
A very slender fish up to about 12 cm (4 3/4 in) in length. The fins are small and the anal fin is absent. The colour is highly variable but is generally some combination of light and dark brown rings around the body. Common. **Native**.

Trumpetfishes

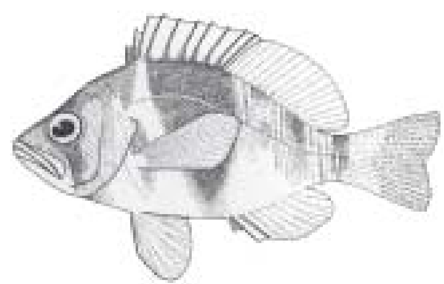
C

Trumpet Fish
Aulostomus maculatus
This elongated fish, up to 1 m (3 ft) long but usually less, tends to hang motionless among the sea whips and fans where it is difficult to spot. When on the move, they swim horizontally. They can change colour with their surroundings to make seeing them an even more difficult task. **Native**.

Groupers

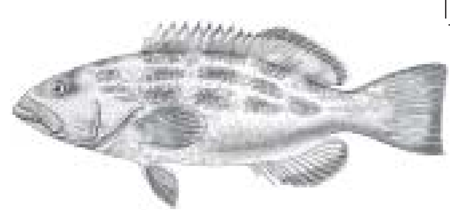
B

Barred Hamlet
Hypoplectrus puella
This fish is a small member of the grouper family. It is a charming little fish that is quite deep in the body and having a tan to yellowish overall colour with 4-5 dark bands on each side. The band below the spiny dorsal fin is much broader than the others. There are also blue and yellow diagonal streaks especially on the head. Up to about 13 cm (5 in) in length. Common in bottom rubble in deeper bays. **Native.**



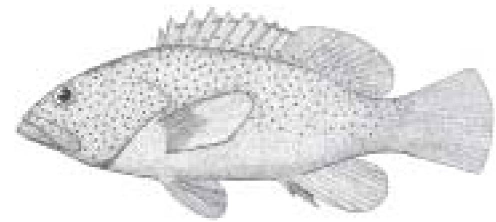
C, O

Black Rockfish
Mycteroperca bonaci
A really big grouper reaching 170 cm (5 ft) in length. The body is a light tan to brownish-olive colour broken up by lighter longitudinal and vertical bands. **Native**.



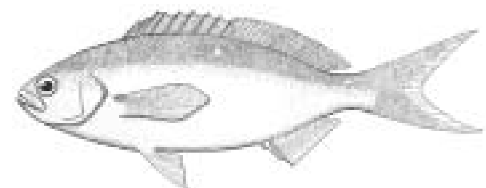
C, O

Coney
Cephalopholis fulva
This fish is a smaller member of the grouper family. The Coney reaches about 25 cm (10 in) long. In colour, it is quite variable; a common type is orange-brown with numerous dark-edged blue spots, a variant of this being a dark reddish-brown above and white below, while yet another variation shows an all yellow body. **Native**.



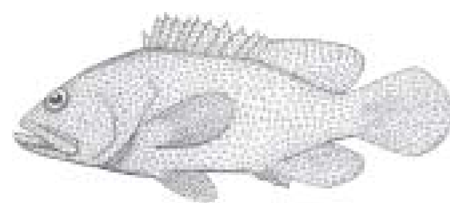
O, R

Creole-fish or **Barber**
Paranthias furcifer
The Barber is one of the smaller Groupers reaching only 35 cm (13 in). The back is a dark browny red or blue and the belly a silvery pink. The tail is much more forked than in other Groupers. There is a bright orange spot at the base of the pectoral fins and a series of white spots along the back under the dorsal fin. **Native**.



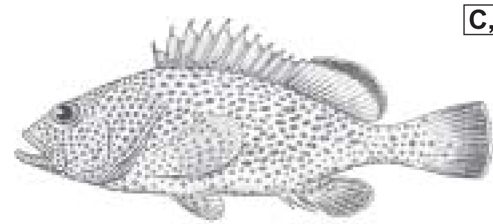
C, O

Graysby
Cephalopholis cruentata
The Graysby is reddish to greenish-grey in colour with very numerous, densely spaced reddish-brown spots. A smallish 35 cm (13 in) grouper commonest on shallower reefs. **Native**.



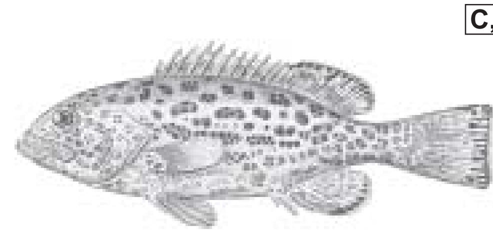
C, O

Red Hind
Epinephelus guttatus
This is a strikingly coloured grouper. The body is pink with small, evenly sized dark red spots. The tip of the spiny dorsal fin is bright yellow. Can attain 60 cm (2 ft) in length but commonly much smaller. **Native**.



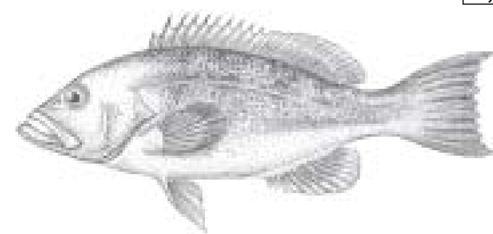
C, O

Yellowfin Grouper
Mycteroperca venenosa
The body is an olive-green to grey with darker blotches; however, in deeper water the body becomes bright red. The pectoral fins have a broad yellow border, the other fins a fine white edge. This grouper can reach 90 cm (2 3/4 ft) in length. **Native**.



C, O

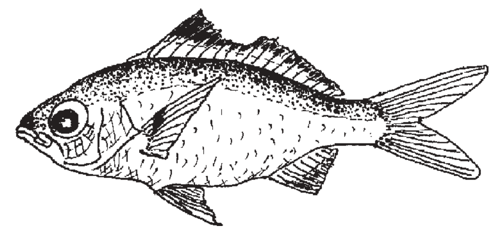
Yellowmouth Grouper
Mycteroperca interstitialis
This large grouper which can reach 80 cm (2 1/2 ft) long is usually a uniform dull brown colour but it may also be brown with pale yellow lines forming irregular spots. The mouth is yellow. Juveniles have a dark back and white belly. **Native**.



Mojarras

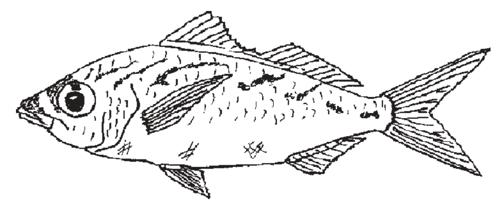
B

Bigeye Mojarra
Eucinostomus havana
This fish while very similar to the Shad or Silver Jenny described below is distinguished by its larger eye and the black border on the front dorsal fin. The length is up to about 13 cm (5 in). **Native**.



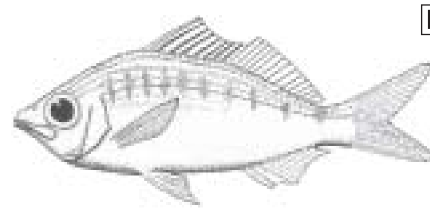
B

Mottled Mojarra
Eucinostomus lefroyi
Quite similar to the Shad or Silver Jenny below, and about the same size, up to 13 cm (5 in). However, this species can usually be distinguished by the mottling on the back and always by the square dark spot in the upper part of the eye. **Native.**



B, SP

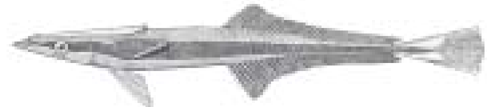
Shad or **Silver Jenny**
Eucinostomus gula
This deep-bodied silvery little fish grows to about 13 cm (5 in) long. The back, or dorsal fin has a dark smudge at the top front. Shad often occur in large numbers. **Native**.



Remoras

B, O

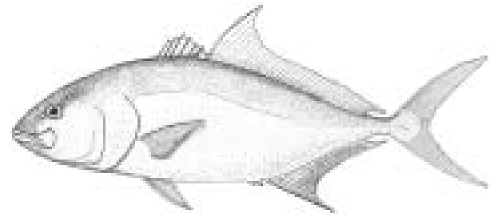
Sharksucker or **Remora**
Echeneis naucrates
This is a very slim fish up to 1 m (3 ft) long, with its dorsal fin modified to form an elaborate sucker on top of the head. While, as their name suggests, this sucker can be used to attach to sharks or rays, many Remoras swim freely around. They have been known to attach to many other things, including underwater cameras and even human swimmers! **Native**.



Jacks and Pompanos

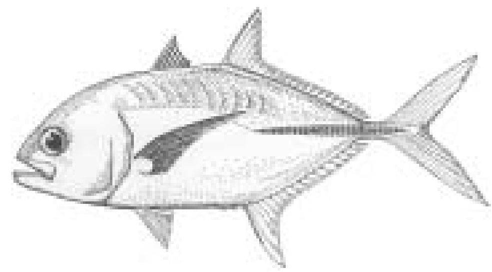
O

Greater Amberjack
Seriola dumerili
The Greater Amberjack is a large fish reaching 200 cm (6.5 ft) long. It is an important sport-fishery fish. The tail is deeply forked and the body is brownish above and silvery-white on the belly. Common. **Native**.



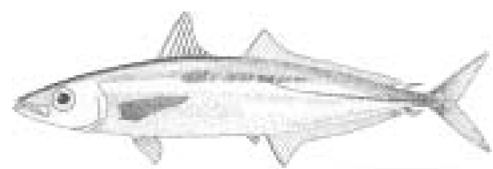
B, O

Horse-eye Jack
Caranx latus
The Jacks are silvery-blue or silvery-green fishes with a fairly deep body and a deeply forked tail. In the Horse-eye Jack, the tail is yellow and there is a black spot on the edge of the gill cover. The body is dark blue-grey on top and silver below. Feeds mainly on small fish. Length to 100 cm (3.3 ft) but those in the sound are usually half this. **Native**.



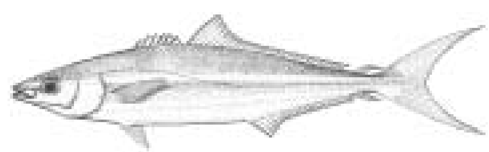
O

Mackerel Scad
Decapterus macarellus
This is a slender mackerel-like fish up to 40 cm (45 in) long. It is deep blue on the back and silvery beneath. There is a narrow golden stripe on the side. An offshore fish found in 20-200 m (60-650 ft) of water. Common. **Native**.



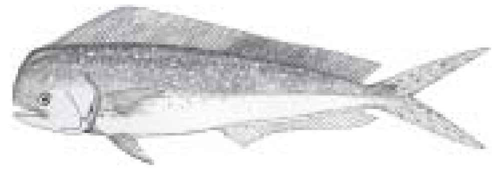
B. O

Rainbow Runner
Elagatis bipinnulatus
This fish is occasionally seen nearshore but is usually well out to sea. Growing to 130 cm (50 in) long. The tail is very deeply forked and the colour is a bluish-green above with two blue stripes on each side separated by a yellow band. Common. **Native**.



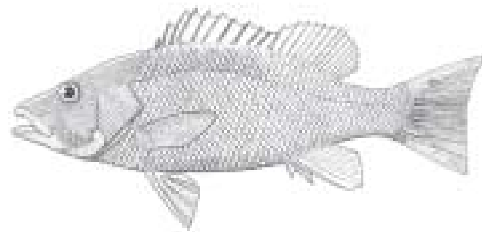
Dolphinfishes

Dolphin Fish O
Coryphaena hippurus
A much prized game fish that reaches 200 cm (6.5 ft) in length and a weight of 40 kg (100 lb). Its characteristic feature is the large, blunt head with small eyes. The colour is a brilliant blue with patches of yellow and gold. Common. **Native**.



Snappers

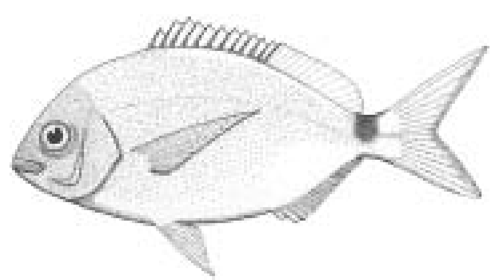
Grey Snapper B, C
Lutjanus griseus
The Grey Snapper can reach 61 cm (2 ft) in length but the ones commonly seen in small groups along shores, around wharves, in grass beds, mangroves and some saltwater ponds are much smaller. Large specimens of this grey-coloured fish are common on reefs and beyond. Young specimens have an oblique dark line through the eye. **Native**.



Yellowtail Snapper B, SP
Ocyurus chrysurus
A very attractive fish with a silvery-blue body, about 30-60 cm (1-2 ft) long, with a very prominent yellow stripe from the eye, extending into the deeply-forked tail. **Native**.

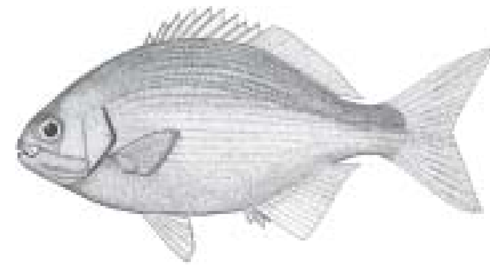
Chubs and Breams

Bermuda Bream B
Diplodus bermudensis
The Bermuda Bream is similar to but smaller than the Bermuda Chub growing to 40 cm (16 in). Bermuda Bream have relatively small heads and eyes, and are a dull silvery-grey in colour. The Bermuda Bream and the Bermuda Chub are easily told apart by the presence on the Bermuda Bream of a large dark spot, just above the base of the tail. **Endemic.**



B

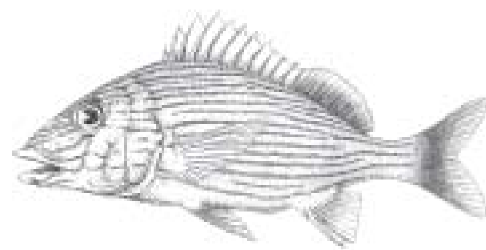
Bermuda Chub
Kyphosus sectatrix
The Bermuda Chub can reach 76 cm (30 in) and a weight of up to 9 kg (20 lb). Bermuda Chub have relatively small heads and eyes, and are a dull silvery-grey in colour. The overall colour is relieved by many narrow, darker stripes running along the body. **Native.**



Grunts

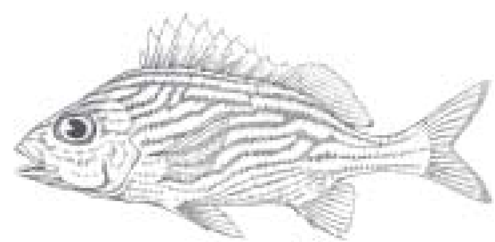
B

Blue-striped Grunt
Haemulon sciurus
From the side the grunts have an arched back and flattish lower side. The Blue-striped Grunt growing to 35 cm (14 in) long is a basically yellow fish with numerous, bold, blue stripes on the head and body and a dark tail and hind dorsal fin. **Native.**



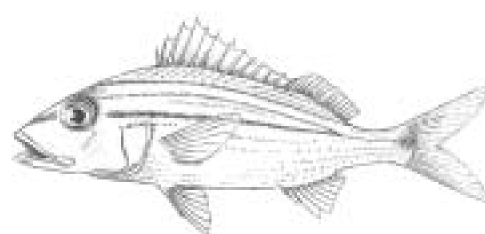
B

French or **Yellow Grunt**
Haemulon flavolineatum
This is one of eleven members of this family found in Bermuda. The French Grunt, has a relatively deep body, blue in colour with many yellow stripes. The stripes are parallel close to the back but become diagonal lower down. Grunts may form large schools, often with more than one species present. By day, they tend to be around, reefs, rocks and other cover, but at night they disperse over sandy bottoms and grass beds to feed on small crustaceans. The length in adults ranges from 15-25 cm (6-10 in). **Native.**



B

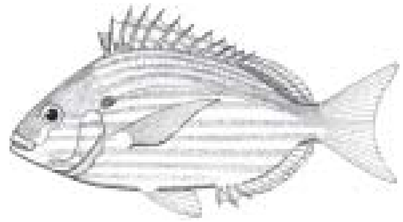
White Grunt or **Tomtate**
Haemulon aurolineatum
This very common fish of bays and sounds is basically a silvery colour ornamented with two bold stripes, one through the eye and the other above it. There are other faint yellow lines. This fish reaches 25 cm (10 in) long but is mostly half this size. **Native.**



Porgies

B, SP

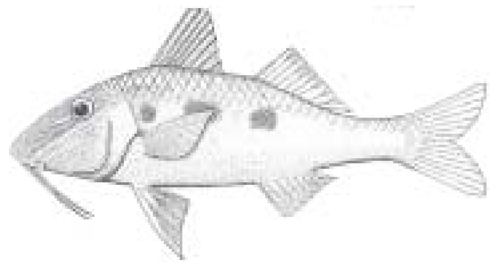
Pinfish
Lagodon rhomboides
The Pinfish is relatively deep in the body and takes its name from sharp spines in the dorsal and pelvic fins. Growing to about 20 cm (8 in) long it has blue, longitudinal stripes on a yellowish to greenish-silver body. **Native.**



Goatfishes

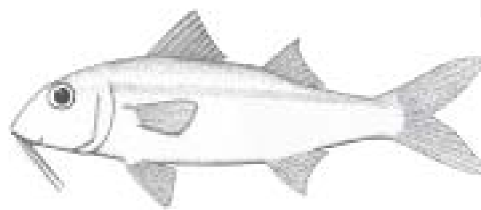
B

Spotted Goatfish
Pseudupeneus maculatus
This interesting fish reaching 23 cm (9 in) long. When swimming up in the water the two barbels beneath the chin are distinctive. The eyes are large and the body heavy. The active colour phase shows three large, dark spots on the body. In the inactive phase the spots fade and rusty-red patches appear. **Native.**



B

Yellow Goatfish
Mulloidichthys martinicus
This is an attractive, bottom-living fish of sandy places. Growing up to 30 cm (1 ft) long it has a yellow mid-body stripe and a yellow tail. A distinctive feature is the presence of two barbels or feelers under the chin. **Native.**



Butterflyfishes

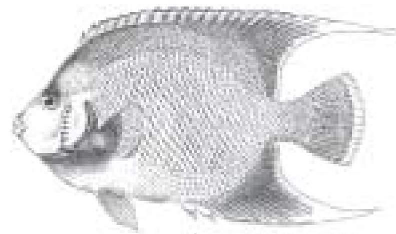
B, C

Foureye Butterflyfish
Chaetodon capistratus
This is a small 10 cm (4 in) but very active fish, that when looked at from the side, cannot be mistaken for any other. The body is flat and almost round. There is a bold, black stripe through the eye and a large black spot at the base of the tail. **Native**.

Angelfishes

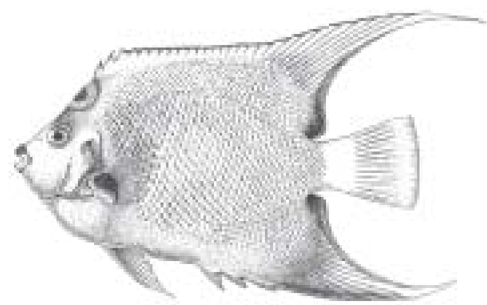
B

Blue Angelfish
Holacanthus bermudensis
This is one of the most beautiful of the Bermuda fishes. It is a medium-sized fish, usually 20-35 cm (8-14 in) long, with a deep body, blunt head and large trailing fins. The body is a soft blue and the fins are edged in yellow. **Native**.



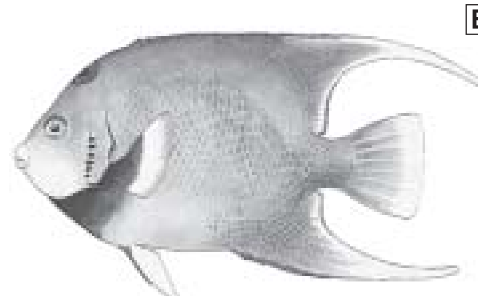
B, C

Queen Angelfish
Holacanthus ciliaris
The Queen Angelfish is boldly coloured, the body being blue with yellow edges to the scales, while the tail is bright yellow and the head has blue, yellow and green areas. The large trailing dorsal and anal fins are orange-yellow with blue edges. The distinctive feature is a black patch with a bright blue border on the forehead. Juvenile specimens show much more yellow on the body, and have bold narrow, blue vertical stripes. Large adults reach 45 cm (18 in) long. **Native**.



B, C

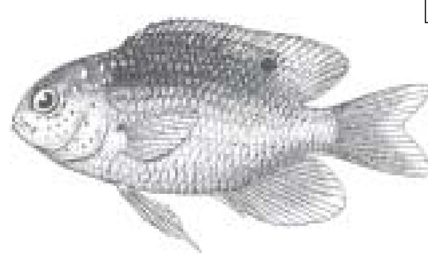
Townsend Angelfish
Holacanthus ciliaris x bermudensis
The Townsend Angelfish is a hybrid between the Queen Angelfish and the Blue Angelfish. The Townsend is rather like the Queen Angelfish described above, but the blue border around the smaller black forehead patch is narrower and the bright yellow tail is missing. Intermediate in size between the two parent species 40 cm (16 in). **Native**.



Damselfishes

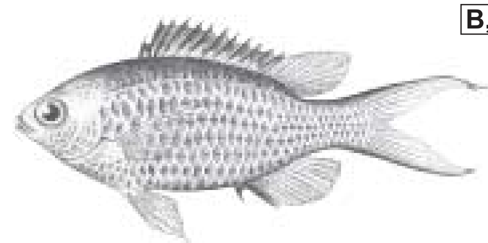
B, C

Beaugregory
Stegastes leucostictus
Beaugregories are quite small damselfish up to 10 cm (4 in) long. Except in older individuals, the body is blue on top and yellow beneath. Older fish become more dusky in appearance with blue spots on the dorsal fin. About 10 cm (4 in) long. **Native.**



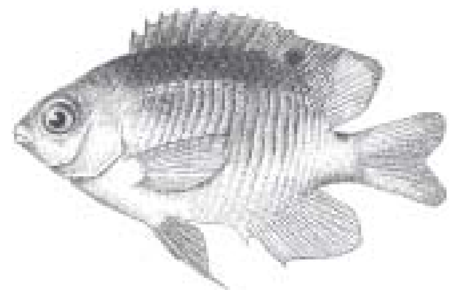
B, C

Blue Chromis
Chromis cyaneus
This fish, although it is a damselfish, has the same slim shape as the Creole Wrasse and is bright blue. It is often seen swimming with Creole Wrasses. The Blue Chromis is up to about 12 cm (4 1/2 in) in length. **Native**.



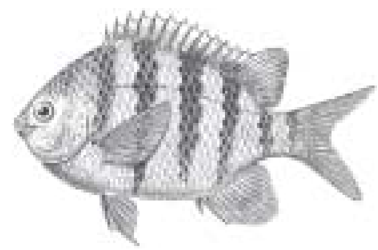
B

Cocoa Damselfish
Stegastes variabilis
In the juvenile phase, both the Cocoa and Beaugregory Damselfishes are basically yellow, but in the Cocoa, the back is purple and there is a spot on the back at the base of the tail. Adult Cocoa Damselfish are a beautiful light brown, grading to bluish on the back and up to about 12 cm (4 1/2 in) in length. **Native**.



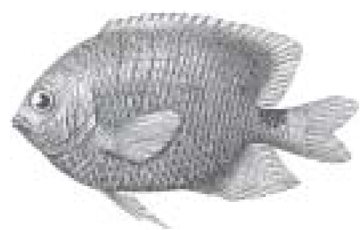
B, C

Sergeant Major or **Cow Polly**
Abudefduf saxatilis
The Sergeant Major is one of the damselfishes, and is strikingly coloured with a blue head, and with vertical dark bars on a yellow background along its back, grading to light blue beneath. It is a very active small fish, up to 15 cm (6 in) long. **Native**.



B, C

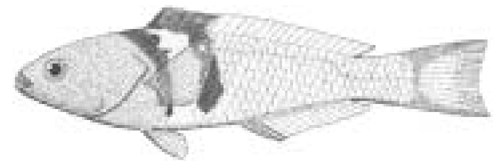
Three-spot Damselfish
Stegastes planifrons
The Damselfish is reddish-brown, becoming purplish on the back and is up to 12 cm (4 1/2 in) in length. Juvenile fish are yellow with three black spots. **Native**.



Wrasses

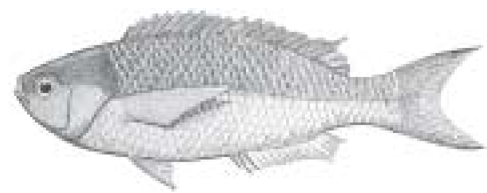
B, C

Bluehead Wrasse
Thalassoma bifasciatum
A small 15 cm (6 in) fish found schooling on reefs. There are three colour phases, juvenile, initial and terminal. Juveniles are yellow with dark spots behind the eye and on the dorsal fin. Initial fish are all female and have a yellow back, a dark mid-body stripe and a bluish belly. Large initial phase fish may become terminal males with a very distinctive blue head followed by two dark vertical bars, then a bright greenish-blue hind body. **Native**.



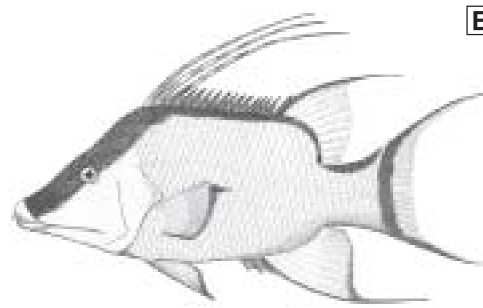
B

Creole Wrasse
Clepticus parrae
The Creole Wrasse, unlike the other wrasses, is not associated with the bottom but is always up in the water column, where it feeds on animal plankton. Young Creole Wrasses are blue on the back, with a silver belly. The terminal male has a black forehead, a deep blue fore-body and a yellow-green hindbody with a reddish tail. Up to 35 cm (13 in) long. **Native**.



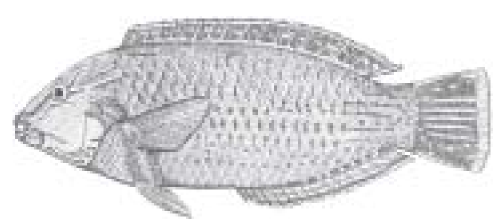
B, C

Hogfish
Lachnolaimus maximus
Hogfish have a strongly tapered head and a large mouth and are very varied in colour. They can change colour quickly, but are generally a mottled reddish-brown. Older males have a conspicuous, very dark purple patch, along the back, from the snout to the start of the dorsal fin. Hogfish can reach 1 m (3 ft) long. **Native**.



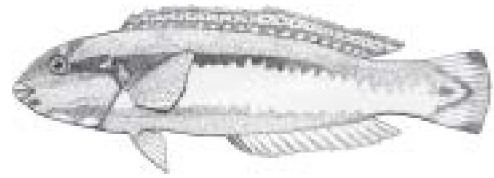
B

Puddingwife
Halichoeres radiatus
Another wrasse reaching a maximum size of 45 cm (18 in) it is much larger than the Bluehead and Yellowhead Wrasse, and its colour changes are less extreme. The adult Puddingwife is always a bluish-green, but the intermediate phase has several white blotches along the back. Juveniles, on the other hand, are basically bright yellow with blue stripes and bars, and with a large black spot on the upper body and dorsal fin. **Native**.



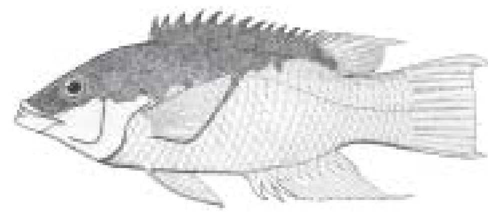
B

Slippery Dick
Halichoeres bivittatus
Like many of the wrasses this 18 cm (7 in) long wrasse of bays and seagrass beds, goes through a bewildering series of colour changes as it matures**.** Juveniles are whitish with a dark stripe down the centre of each side. Intermediate phase individuals vary greatly but are mostly greens with brown markings. Terminal phase adults have longitudinal bars of green, yellow and pinkish-brown. **Native.**



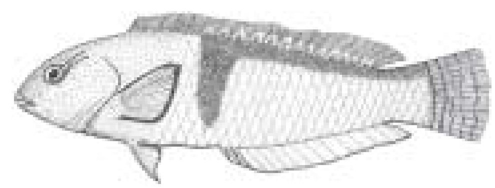
B, C

Spanish Hogfish
Bodianus rufus
The Spanish Hogfish is beautifully coloured, the adults having a yellow body with a large purple patch on the back, from just behind the eyes nearly to the tail. The dorsal and caudal fins have black edges. Juveniles are much more purple, including the head. Spanish Hogfish can reach 65 cm (2 ft) long; the ones most frequently seen in coastal locations are much less than half this length. **Native**.



B, C

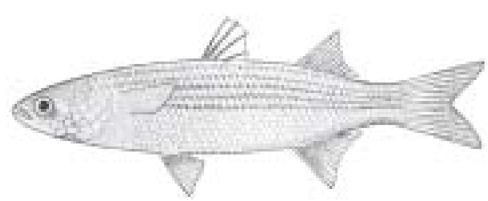
Yellowhead Wrasse
Halichoeres garnoti
About the same size as the Bluehead, but much less gregarious. They, too, go through three colour phases, finishing up in the terminal phase with a bright yellow fore-body, a bright red upper hind-body and whitish lower hind-body. Up to 20 cm (8 in) long. **Native**.



Mullets

B, SP

Grey Mullet
Mugil trichodon
The Grey or Fan-tailed Mullet is a fish of quiet waters often seen in groups sunning themselves at the surface. A slow swimmer, the mullet can survive in water of poor quality and it is unusual in being herbivorous. The colour is a dull grey and the length up to about 40 cm (16 in). **Native.**



Barracudas

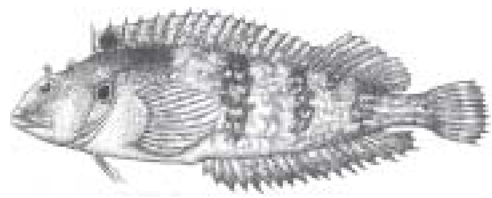
B, C, O

Great Barracuda
Sphyraena barracuda
Juveniles, up to about 45 cm (18 in) in length, are very frequent in the bays. Adults up to at least 1 m (3 ft) long may be seen on the reefs. This elongate fish is best recognised by the very large mouth with needle-sharp teeth, and elongated silvery body with dark markings. **Native**.

Blennies

B, SP

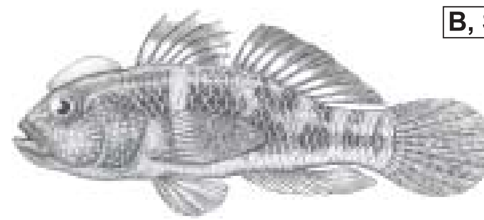
Hairy Blenny
Labrisomus nuchipinnis
This fish, up to 20 cm (8 in) long, but usually smaller is typical of shallow waters in algal or seagrass beds. The colour varies with the habitat from near-white to near-black, but males are dark with red fringed fins and there is a spot on the gill cover. The head is large. **Native.**



Gobies

B, SP

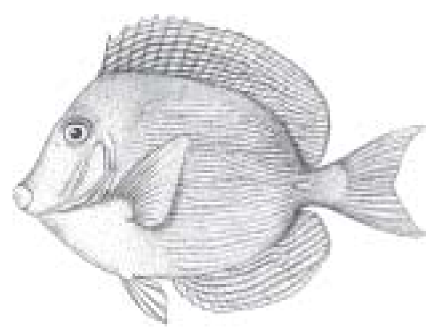
Crested Goby
Lophogobius cyprinoides
A small, dark fish with a very large head and a lot of character. Up to 10 cm (4 in) long the fish is dark-brown to olive and lives in the mangrove root habitat. **Native.**



Surgeonfishes

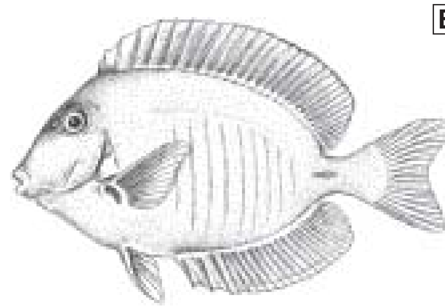
B, C

Blue Tang
Acanthurus coeruleus
These fish are deep in the body is a brilliant blue. They reach a maximum size of 38 cm (15 in) and have very sharp ridges, resembling the edge of a scalpel, at the base of the tail. The striking, brilliant blue of the adult Blue Tang is all the more remarkable when we learn that the juveniles are coloured a brilliant yellow with faint, darker longitudinal lines. This fish has the same razor-sharp ridges at the base of the tail as the Ocean Surgeonfish. **Native**.



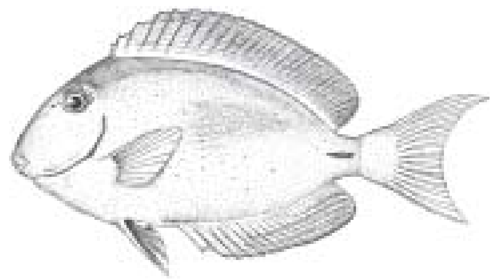
B, C

Doctorfish
Acanthurus chirurgus
This is a typical member of the surgeonfish family, having a large eye set high on the head and a small mouth below a long, sloping forehead. The colour is blue and may be dark or light but the distinctive feature is a set of vertical darker bars on the body, which may be difficult to see. Up to 30 cm (1 ft) long. **Native.**



B, C

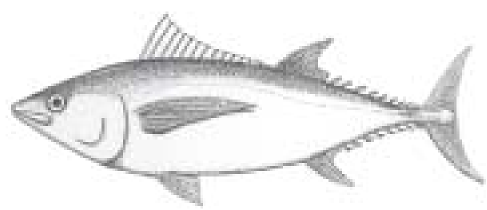
Ocean Surgeonfish
Acanthurus bahianus
The Ocean Surgeonfish like the Blue Tang (above) is a member of the surgeonfish family. The fish are deep in the body, and the Surgeonfish varies from a dull brown colour to a pale grey. It reaches a maximum size of 38 cm (15 in) and has very sharp ridges, resembling the edge of a scalpel, at the base of the tail. These razor-sharp features give the group their name, and are something to beware of if you get the chance to handle one. **Native**



Tunas

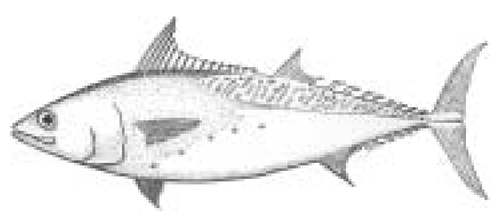
O

Blackfin Tuna
Thunnus atlanticus
A typical tuna reaching 95 cm (3 ft) in length. There are 7-9 finlets top and bottom before the smoothly forked tail. The back is dark blue which changes through dark gold to silvery-white on the belly. Quite common. **Native**.



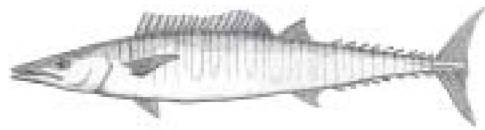
O

Little Tunny or **Mackerel**
Euthynnus alletteratus
Although it is fairly small, 50 cm (3 ft), this is a prized game fish. It has a moderately deep body, slightly forked deep tail and 7 finlets before the tail on top and bottom. The back is dark blue with a complex pattern of stripes. Quite common. **Native**.



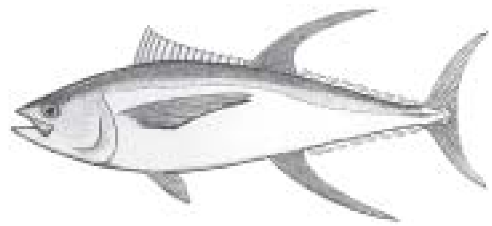
Wahoo
Acanthocybium solandri
A game fish reaching almost 2 m (6 ft) with a very long body and a deep, slightly forked tail. There are 7-10 finlets before the tail on both top and bottom. Dark bluish-black grading down to silvery with numerous irregular dark blue vertical bars. Quite common. **Native**.

O



Yellowfin Tuna
Thunnus albacares
This oceanic fish is most commonly seen over offshore banks and drop-offs. It is a typical tuna with a moderately deep, muscular body. The colour is a shining dark blue on the back, grading through yellow on the sides to a gleaming white underside. In large specimens the second dorsal and anal fins are very long. The non-paired dorsal and ventral fins are bright yellow, hence its common name. Grows to about 2 m (7 ft) long. Widely used as human food. **Native**.

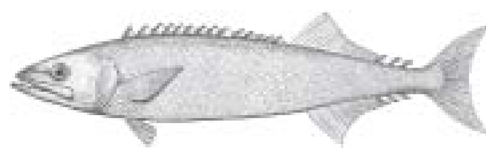
O



Oilfishes

Tapioca Fish
Ruvettus pretiosus
A slender oceanic fish usually found from about 75-200 m (200-650 ft) deep, but occasionally at the surface on dark nights. The fish is a uniform dull brown and the most distinctive feature is the low front dorsal fin with 13-15 stout spines. Grows to 250 cm (10 ft) long. Not eaten by man because this results in severe digestive upset. **Native**.

O



Billfishes

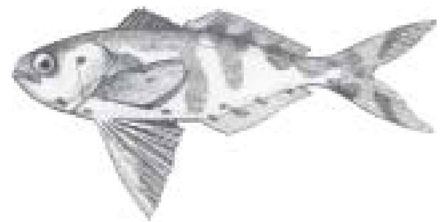
Blue Marlin
Makaira nigricans
A very large, heavy fish reaching 400 cm (13 ft) in length. The body is dark blue on top and silvery-white underneath. There are about 15 pale blue vertical bars on the sides. The upper jaw is a long, sword-like projection. It eats fish, squid and crustaceans. Quite common. **Native**.

O

White Marlin O
Tetrapturus albidus
A prized game fish reaching 200 cm (6 1/2 ft) long. The back is humped near to the front and there is a tall lobe of the top fin in the same location. The upper jaw is prolonged into a sword-like projection. Dark blue above, silvery beneath. Quite common. **Native**.

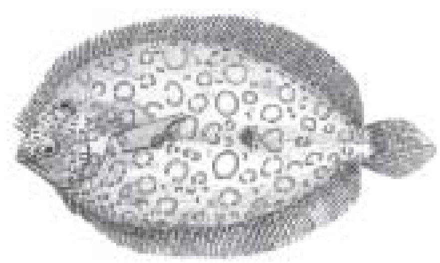
Man-of-war Fishes

Man-of-war Fish O
Nomeus gronovii
This fish lives among the tentacles of the Portuguese Man-of-war. Growing up to 20 cm (8 in), it has two pairs of large, paired fins at the front. The body colour is a blue shade in patches or bars. Not often seen. **Native**.



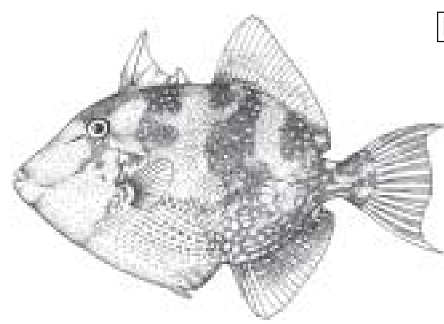
Flatfishes

Peacock Flounder B
Bothus lunatus
This flounder is one of the flatfishes, which are a group of fish that lie on the bottom on one side. Both eyes are on the upward side. Most flatfishes are very adept at changing their colour to match that of the bottom. The Peacock Flounder not only does this but also wafts some of the bottom sand over its body. Often just the eyes remain visible. Common on sandy bottoms. Up to 45 cm (18 in) long. **Native.**



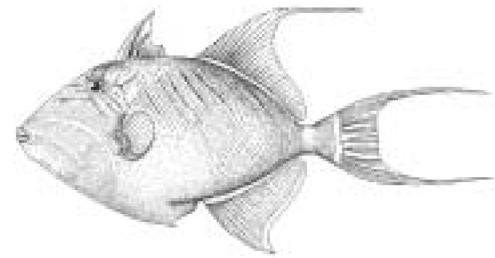
Triggerfishes

Grey Triggerfish B, C
Balistes capriscus
Triggerfish have a medium deep body with the eyes set back on a long sloping forehead, it reaches about 35 cm (1 ft) long but those seen in shallow water are usually half this length or less. The basic body colour may be grey to yellowish-brown but there are always blue spots and lines on the upper body and fins. **Native**.



B, C

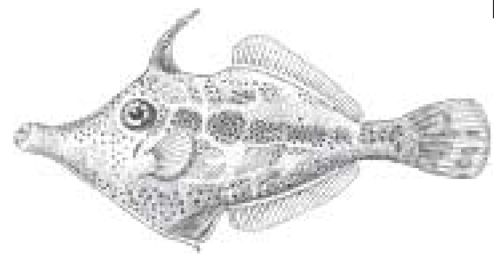
Queen Triggerfish
Balistes vetula
Triggerfish have a medium deep body with the eyes set back on a long sloping forehead. This is the most striking of all triggerfish, with a purple-blue lower body and fins, and a yellowish back and head. The large fins have trailing edges. There are two diagonal clear blue stripes on the head. Large adults reach 45 cm (18 in) long. **Native**.



Leatherjackets

B

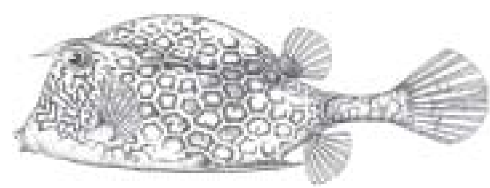
Slender Filefish
Monacanthus tuckeri
The Slender Filefish has a very distinctive body shape and is only 10 cm (4 in) long. The snout is almost tube like but gives way to a high head with very large eyes. Above the eye on the back is a stout, curving spine. The brown body usually has a white chequerboard pattern. **Native.**



Trunkfishes

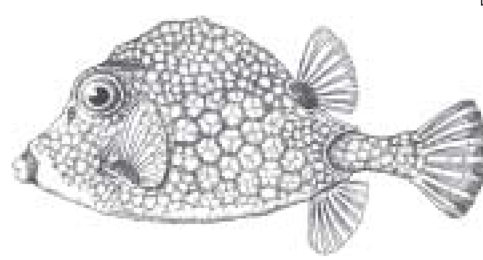
B

Honeycomb Cowfish
Acanthostracion polygonius
This is one of the Boxfish family, growing up to about 30 cm (1 ft) long. It has two little horns between the eyes and a box-like, very firm body, covered with blackish polygons on a cream background. The tail is large and set on a narrow stalk. **Native**.



B

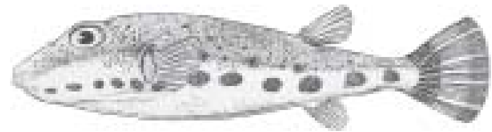
Smooth Trunkfish
Lactophrys triqueter
Like the Honeycomb Cowfish this species grows up to about 30 cm (1 ft) long and also has a box-like, very firm body. This species also has polygons on the body but they are less obviously displayed in a black background with light spots. The tail is large and set on a narrow stalk. **Native**.



Puffers and Porcupine Fishes

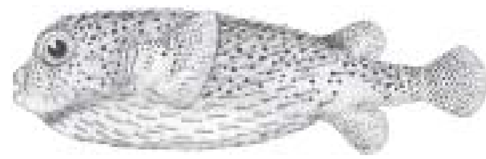
B

Bandtail Puffer
Sphaeroides spengleri
Like the Sharpnose Puffer the Bandtail Puffer has a large head and tapering body. The Bandtail Puffer has a brown back and white belly and grows up to about 30 cm (1 ft) long. This species can inflate just like the Sharpnose Puffer below. **Native**.



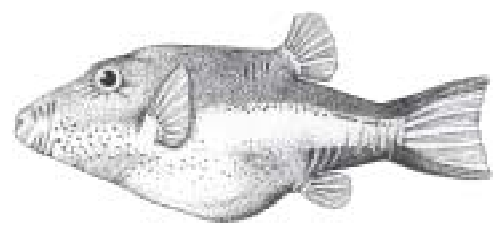
B

Porcupinefish
Diodon hystrix
These fish live in similar habitats to the pufferfishes above but can reach 60 cm (2 ft) long. The Porcupine Fish is pale with tiny black spots. It too, like the Puffers above, can inflate, but when it does so, numerous long spines appear, hence the name Porcupinefish. **Native**.



B

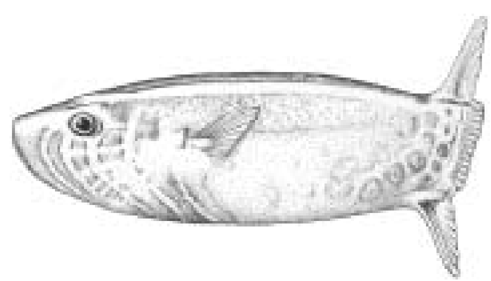
Sharpnose Puffer
Canthigaster rostrata
This is a charming little fish only about 12 cm (4 in) long, with a large head and tapering body. Dark mauve or brown above and white below, they are quite difficult to spot. Groups of these tiny puffers hang above the bottom, hovering and darting about like dragonflies. If threatened pufferfish gulp in water and inflate like a balloon. **Native**.



Sunfishes

O

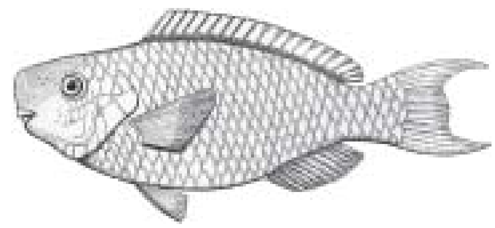
Slender Mola
Ranzania laevis
This is a member of the sunfish group that have very limited swimming abilities, drifting close to the surface of the open ocean. The body is very deep and chunky and the tail is reduced to a fringe. Grows to 60 cm (2 ft). The back is a bright, deep purple. The sides are ornamented with green lines and the underside is white. Not often seen. **Native**.



Parrotfishes

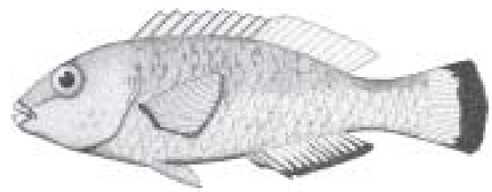
B, C

Blue Parrotfish
Scarus coeruleus
The Parrotfishes are quite distinctive with their blunt heads, stocky bodies and indented tails. The Blue Parrotfish, up to 1 m (3 ft) long, is a fairly uniform medium blue, whether immature or adult. They are important algal grazers on the reef, but also penetrate into mangrove swamps at high tide and are in larger ponds. **Native.**



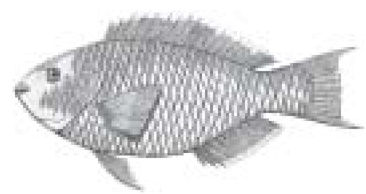
B. SG

Bucktooth Parrtofish
Sparisoma radians
This is the characteristic parrotfish of seagrass beds. It is smaller than most other parrotfish reaching a size of 19 cm (7 1/2 in) long. The colour is very variable, having mottles, patches or stripes of muted browns, yellows and reds. There is a distinctive black margin to the tail. Juvenile specimens are mottled in greens, yellows and browns to blend in with the seagrasses. **Native.**



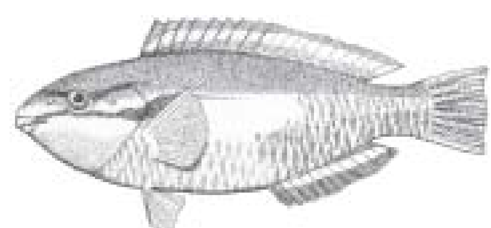
B, C

Midnight Parrotfish
Scarus *coelestinus*
Midnight Parrotfish are all navy blue with bright blue markings on the head and grow to about 1 m (3 ft). **Native**.

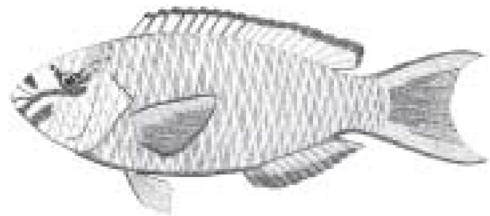


B, C

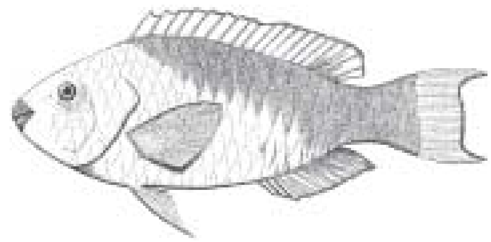
Princess Parrotfish
Scarus taeniopterus
The primary colour phase shows three, longitudinal dark brown stripes on the upper half of the body. The terminal male has a red top to the head and a pinkish bottom with two narrow blue-green stripes. The body is bluish-green and orange with a broad pale yellow stripe on the upper front. The tail is blue with bright orange upper and lower edges. Length to 35 cm (13 in). **Native**.



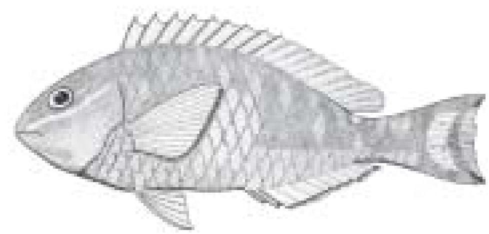
Queen Parrotfish **B, C**
Scarus vetula
The primary colour phase is grey to dark red-purple-brown with a broad white stripe on the lower part of the body. The terminal males are a bluish-green with scales bordered in red. The head has alternating bands of blue-green and orange. This fish can reach 55 cm (1 3/4 ft). **Native**.



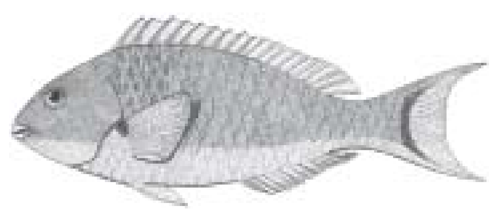
Rainbow Parrotfish **B, C**
Scarus guacamaia
This is one of the largest of the parrotfish, growing to a length of 1 m (3 ft). It lives in a variety of habitats from the rocky coast to the outer reefs. This parrotfish has green scales rimmed with orange and orange fins with a streak of green and a blue edge. Adults are more deeply coloured than juveniles but colours in both sexes are the same. **Native**.



Redband Parrotfish **B, C**
Sparisoma aurofrenatum
The primary colour phase is greenish-brown or mottled brown with a touch of blue. Along the lower side this changes to a pale mottled red. In the terminal male the body is orange to green-blue and has a diagonal pale orange stripe from the mouth to the top of the gill cover. There is an orange spot behind the gill cover and a white one at the end of the caudal fin. A small parrotfish reaching 30 cm (1 ft). **Native**.

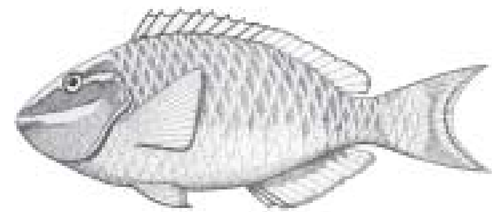


Redtail Parrotfish **B, C**
Sparisoma crysopterum
This Parrotfish has a distinctive crescent-shaped mark on the tail. The primary colour phase is olive-green on the back, a mottled reddish colour on the sides and with a pale belly. Terminal males are green with brown-bordered scales. On the sides the body is blue-green becoming clear blue lower down. The fins are all reddish. One of the smaller parrotfish reaching about 35 cm (13 in). **Native**.



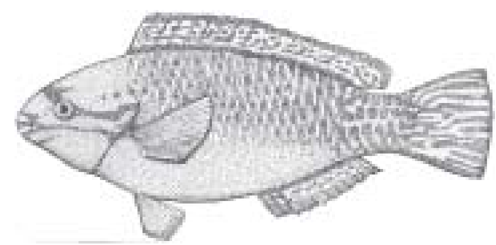
B, C

Stoplight Parrotfish
Sparisoma viride
In the initial color phase all fish are red-green above and bright red below with red fins. The terminal colour phase of mature males is mainly green. There are three diagonal orange bands on the head. The fins are yellow and blue. This species is commonly about 40 cm (15 in) long. **Native**.



B, C

Striped Parrotfish
Scarus croicensis
The primary phase shows three broad, dark brown stripes running the length of the body. The lowest stripe is lighter in colour. The body is whitish with a yellow snout. The terminal male has a pink lower head and chest. The top of the head is orange and a green-blue stripe runs through the centre. The body is blue-green and orange with a central pink stripe on the forward half. Fins are blue and orange. Grows to about 35 cm (13 in). **Native**.



Frogs and Toads

Frogs

F, FW, U

Whistling Frog
Eleutherodactylus johnstoni
This is a tree frog of small size. The length is about 2 cm (1 in) and the body is pinkish brown. There are suckers on the feet. This frog along with other amphibians is on the decline in Bermuda. **Introduced.**

Toads

F, FW, U, W

Giant Toad
Bufo marinus
The Giant Toad can be quite large measuring up to 23 cm (9 in) long. It is brown with darker blotches and has poison secreting glands behind the head. The only amphibian that can stand quite salt water. Breeds in ponds but lives in a wide variety of habitats. **Introduced**.

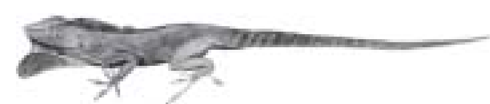
Lizards

F, OC

Bermuda Skink
Eumeces longirostris
This is the only non-introduced lizard in Bermuda. It is now endangered being reduced to a few small populations mostly along the south shore. This is a small, rather stiff lizard with short legs and clawed feet. Blunt-nosed and dark greyish-brown except for mature adults which have a reddish throat. Length 15-20 cm (6-8 in). **Endemic.**

F, M, U, W

Jamaican Anole
Anolis grahami
The common lizard of Bermuda. The colour is a blueish green but some males are a chocolate brown. In virtually all habitats. The length with tail is up to about 17 cm (7 in). **Introduced.**

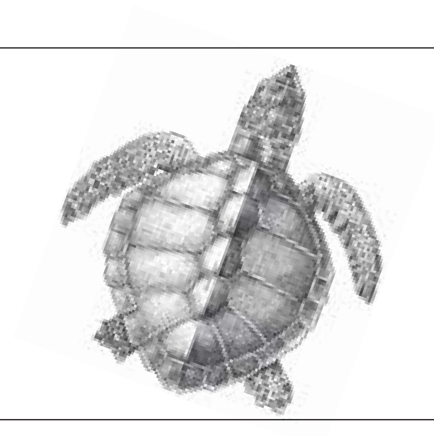


Turtles and Terrapins

Turtles

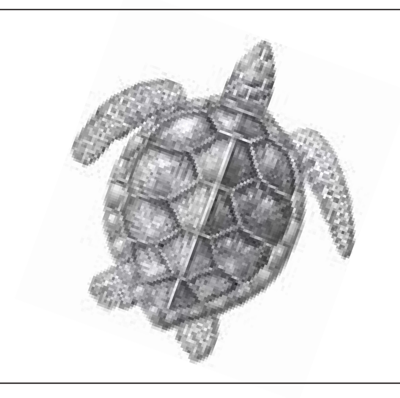
B, O

Atlantic Ridley Turtle
Lepidochelys kempi
This is the smallest of the sea turtles not exceeding 75 cm (2 1/4 ft) in length. The shell on the back is grey to olive green. The distinguishing feature is that the central row of plates in the shell on the back are much smaller than other shelled turtles. This species breeds only on one beach in Mexico and is on the verge of extinction. Very rare**. Native.**



B, O, SG

Green Turtle
Chelonia mydas
The Green Turtle is the commonest of the marine turtles seen in Bermuda and used to breed here. Up to at least 1 m (3 ft) long, they may be any shade of colour between dull, dark green and virtually black. The adults feed on sea-grasses and seaweeds and the occasional sessile invertebrate. Always present in Walsingham Pond and occasionally seen in others. **Native**.



Hawksbill Turtle **B, O**

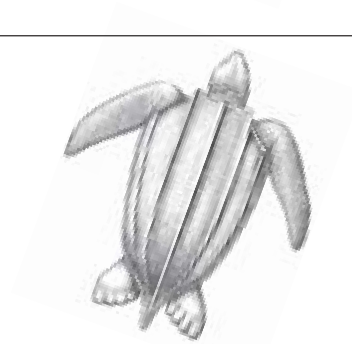
Eretmochelys imbricata

This turtle reaches a length of 95 cm (3 ft). The shell on the back has an attractive pattern with streaks of black, brown, amber and olive green. The head is distinctive as the jaws form a hawksbill-like shape which gives the turtle its name. Although it is most commonly seen near to coasts it makes oceanic migrations. Uncommon**. Native.**

Leatherback Turtle **O**

Dermochelys coriacea

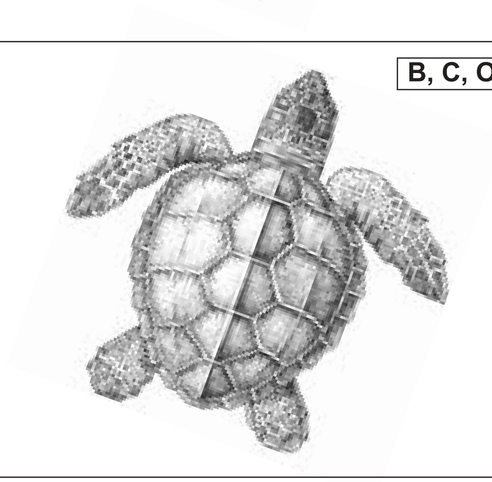
This turtle is unusual in that it does not have bony plates forming a shell but rather is covered with a thick leathery skin. On the back there are seven longitudinal keels and the colour is black. A very large turtle reaching 180 cm (5 1/2 ft). Feeds on jellyfish. Uncommon**. Native.**



Loggerhead Turtle **B, C, O, SG**

Caretta caretta

Several species of turtle may be occasionally observed crossing Bermuda's reefs, but the Loggerhead is the one that tends to feed there, as they have a broad diet which includes animals and plants growing on the reefs. This turtle can be quite large reaching about 115 cm (4 ft) in length but those seen around Bermuda are usually less than half this size. The colour is reddish brown above and lightish yellow below. **Native.**

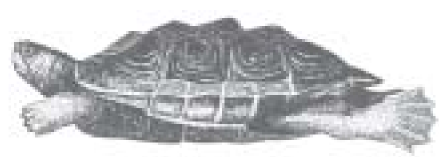


Terrapins

Diamondback Terrapin **SP**

Malaclemys terrapin

A small brackish water terrapin found only in Mangrove Lake and Trott's Pond. It is a shy species that nests in golf club bunkers. The brown top shell has striking plates each with a bold polygonal pattern. About 23 cm (9 in) long. **Native**.



FW

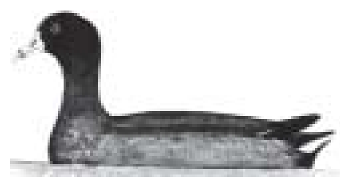
Red-eared Slider
Trachemys scripta
A freshwater terrapin which resulted from escape or liberation of pets. A terrapin of the southern USA. This terrapin is omnivorous and now a great pest in all standing freshwater environments. Up to 24 cm (9 in) long. **Introduced**.

Birds

Coots and Moorhens

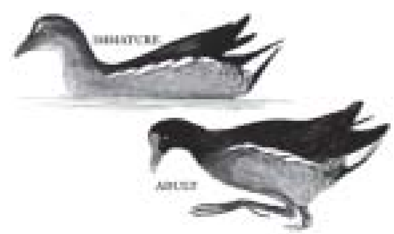
FW

American Coot
Fulica americana
This 38 cm (15 in) long bird is dark grey, with a white beak and white shield above the beak ending in a red swelling on the forehead. The toes are lobed. **Native**.



FW

Moorhen or **Common Galinule**
Gallinula chloropus
Also called the "Common Galinule" this 33 cm (13 in) long duck-like bird lives in fresh water ponds. It constantly bobs its head while swimming and is slate-grey with a yellow-tipped, red beak. **Native**.



Crows and Jays

CL, F, U, W

Common Crow
Corvus brachyrhynchos
This bird is black everywhere, feathers, beak, legs and eyes. The Common Crow is one of the largest common birds in Bermuda, up to 45 cm (18 in) in length. They are considered among the most intelligent of birds. Common Crows were introduced to Bermuda and rapidly became naturalised, they are considered a pest species and are not protected. **Introduced**.

Doves

F, W

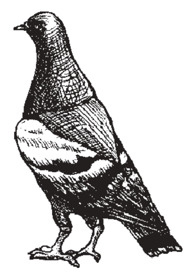
Ground Dove
Columbina passerina
This delightful bird is usually seen feeding on the ground. It is rather plump in stature and grey in colour with a short square tail 15-16 cm (6-6 1/2 in) long. Probably **introduced**, now **Naturalized**.

F, U, W

Mourning Dove
Zenaida macroura
This common dove reaches a length of 30 cm (12 in). The Mourning Dove is slender and long-tailed. They are an attractive brownish-grey with darker spots on the wings and black tips to the major wing feathers. They are usually seen in pairs and the name comes from the somewhat mournful but pleasant song. **Native.**

F, R, U, W

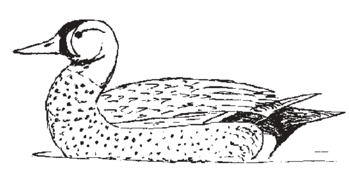
Pigeon or **Rock Dove**
Columba livia
Introduced in the 1600s but remained rare until 1977 when the population exploded. This bird is variable in colour due to captive breeding but grey is the commonest colour. The Rock dove is about the size of a crow. They nest in a variety of places including holes in cliffs where they compete with the White-tailed Tropic Bird. About 25 cm (10 in) long. **Introduced**.



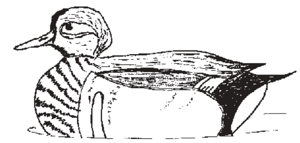
Ducks and Geese

FW

Blue-winged Teal
Anas discors
This small duck is almost always seen in small flocks on freshwater ponds and very occasionally on salt water. It does not breed in Bermuda and is absent in mid-summer. It is a brown duck, both sexes having a pale blue area on the front of the wing. The male has a pale crescent in front of the eye. About 28 cm (11 in) long. **Native**.



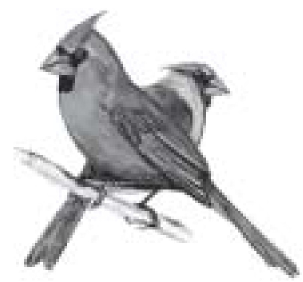
Green-winged Teal FW
Anas carolinensis
A small duck 30-41 cm (12-16 in) long. It is a generally dark duck, but the male has a chestnut head, a green ear patch and a green patch on the wing. A pond duck. **Native**.



Mallard FW
Anas platyrhynchos
The commonest of the ducks, quite large in size, measuring 49-69 cm (18-27 in) long. The male has a green head and a white neck ring, chestnut breast and greyish body. The female is mottled brown with a white tail. Common. **Native**.

Finches

Cardinal F, U, W
Cardinalis cardinalis
This bird commonly known as the "Redbird" in Bermuda cannot be confused with any other species. The male is the only all red bird with a crest and the female is yellowish brown. Cardinals are about 20-22 cm (8-9 in) in length. They are common in the edges of woodland and in gardens. **Naturalized**.



European Goldfinch F, U, W
Carduelis carduelis
A seed-eater, found in parks, gardens, woodland (especially casuarina trees) and overgrown fields. The goldfinch is about 13 cm (5 in) long bird. It is basically brown but with striking red face and yellow on the wings. **Naturalized.**

Flycatchers

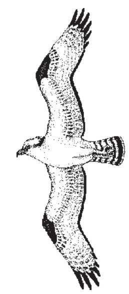
Great Kiskadee F, U, W
Pitangus sulphuratus
This is a large, basically yellow flycatcher with a black and white striped head and a raucous call. It is 27 cm (10 1/2 in) long and has a broad black beak. The back is browner than the underparts. **Introduced** to control lizards.

Grebes

Pied-billed Grebe FW
Podilymbus podiceps
A pigeon-sized bird measuring 30-38 cm (12-15 in) in length. It is a stocky, uniformly brownish water bird with a stout, whitish beak. The beak has a white ring in spring. **Native**.

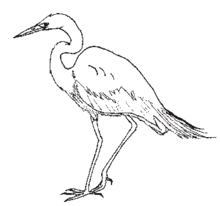
Hawks

Osprey B
Pandion haliaetus
This fish-hawk is a regular visitor to Bermuda but does not breed here. The beak is strongly hooked and there is a broad dark stripe through the eye. When fishing it swoops down to the surface and carries off the prey in its strongly hooked claws. About 55 cm (18 in) long. **Native**.

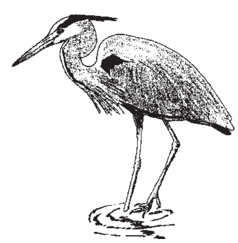


Herons

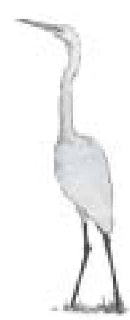
Cattle Egret FW, SP
Bubulcus ibis
A small, stocky, white heron 51 cm (20 in) long. The legs are pale yellow or orange in adults. Common around ponds. **Native**.



Great Blue Heron FW
Ardea herodias
This large heron measures 99-132 cm (39-52 in) in length. It is mainly pale grey in colour with a pale or yellow beak. The crown is white with a black streak below. Flies with its neck folded. **Native**.

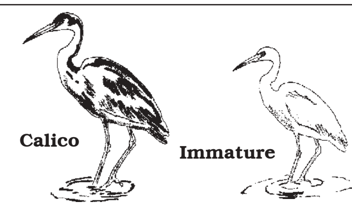


Great Egret FW, M
Casmerodius albus
Regular vagrant from eastern North America. The Egret is a large long-necked white heron with yellow bill and black legs. Seen throughout the year walking in ones or twos and small flocks usually with other species of herons, around the edges of ponds. Can also be seen in fields. About 1-1 1/2 m (3-4 1/2 ft) high. **Native.**

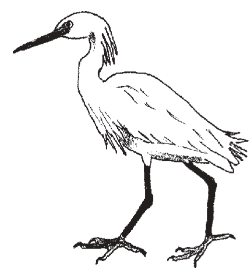


Green Heron FW, SP
Butorides virescens
A small heron 41-56 cm (16-22 in) long. Crown black, back and wings dark greyish green. Beak dark, legs bright orange. Nests in Trott's Pond and Mangrove Lake mangroves. **Native**.

Little Blue Heron FW
Florida coerulea
A medium-sized heron 64-76 cm (25-30 in) long which is slate-blue with a maroon neck. The beak is greyish and the legs greenish. **Native**.



Snowy Egret FW, M
Egretta thula
A member of the heron family found in freshwater marshes and mangrove swamps. This bird has snow-white plumage a black, slender beak and legs and bright yellow feet. In comparison to other white herons it is slimmer and more active. 50 cm (20 in) long. **Native**.



Yellow-crowned Night Heron F, M, SP
Nyctanassa violacea
A rather small heron. The adult is slate-grey with a black head capped with a yellowish crown and plumes. The beak is black and the legs yellow to orange. Now very common after re-introduction. Eats mainly land crabs. 56-69 cm (22-27 in) long. **Native**.

Kingfishers

Belted Kingfisher FW
Ceryle alcyon
A common migrant and winter visitor, arriving in August and departing in April. This bird has a large head with bushy crest and a dagger-like bill. It is blue-grey above and white below with a broad blue-grey chestband. The female has an additional rusty-brown breastband. 28-35 cm (11-14 in) long. **Native**.

Mockingbirds

F, U

Catbird
Dumatella carolinensis
Very visible in spring and summer but at other times hidden in dense thickets, hedges and woodland. The catbird is a slender dark grey bird with a black cap. It imitates the calls of other birds. 20-22 cm (8-9 in) long, **Native**.

Owls

F, U

Barn Owl
Tyto alba
A resident and rare migrant, this owl is crow-sized. It is tan above and white below with a pronounced heart-shaped white face and dark brown eyes. Feeds over marshes and golf courses in Bermuda. 46 cm (18 in). **Introduced.**

Petrels and Shearwaters

O, OC

Cahow or **Bermuda Petrel**
Pterodroma cahow
This bird is endemic to Bermuda where it breeds on islands in the southeast. Most of its life is spent at sea where it feeds on near-surface plankton. This bird is rarely, if ever, observed over the ocean. 38 cm (15 in) long. **Endemic**.

O

Cory's Shearwater
Calonectris diomedea
This is the largest of the shearwaters seen in the vicinity of Bermuda, reaching a length of 53 cm (21 in). It has a dark grey head top which blends gradually to white on the throat. A wide ranging bird of the open Atlantic Ocean. Occasional. **Native**.

Greater Shearwater
Puffinus gravis
Despite its common name this bird is smaller than the Cory's Shearwater described above, reaching 48 cm (19 in). This species has a dark cap on the head which changes abruptly to white below. The white of the lower head extends as a band over the back of the neck. Occasional. **Native.**

O

Leach's Storm Petrel
Oceanodroma leucorhoa
A small bird reaching 20 cm (8 in). A very dark brownish-black in colour except for a white band on top of the tail at the base. Has a very erratic manner of flight. Occurs in both the open Atlantic and Pacific Oceans. Occasional. **Native.**

O

Manx Shearwater
Puffinus puffinus
This is the smallest of the shearwaters seen on the open sea around Bermuda. The length is 33 cm (13 in). A boldly black and white bird, black on the back and top of the head and white beneath except for the wing-tips. Occasional. **Native.**

O

Sooty Shearwater
Puffinus griseus
The common name is quite descriptive as the bird is almost entirely dark coloured everywhere, the only lighter patches being on the underside of the wings. A medium-sized shearwater reaching 43 cm (17 in). Occasional. **Native.**

O

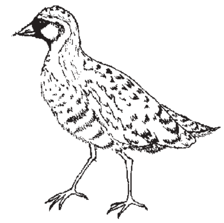
Wilson's Storm Petrel
Oceanites oceanicus
This is a very tiny bird only 18 cm (7 in) in length. It flies like a swallow and often patters its feet on the surface. It is sooty-black in colour except for a white band at the top base of the tail, feet yellow. One of the most abundant birds in the world. Occasional. **Native.**

O

Rails

FW

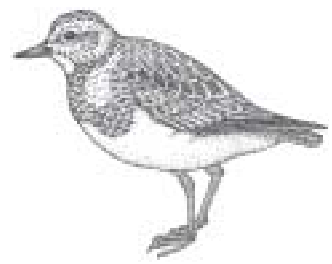
Sora
Porzana carolina
This rail is a bird of the marshes. It measures 20-25 cm (8-10 in) long. It has a short yellow beak and a black face. The upper body is mottled brown and the belly black. **Native**.



Shorebirds

B, OC

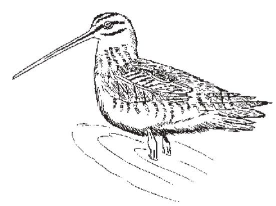
Ruddy Turnstone
Arenaria interpres
The commonest shore-bird in Bermuda especially in the cooler months but does not breed here. Found anywhere along the coast including lawns. The colour is patchy brown, black and white, the beak is black and the legs bright red 20-24 cm (8-9 1/2 in) long. **Native**.



Snipes

FW

Common Snipe
Gallinago gallinago
This long-beaked marsh bird is 27 cm (10 1/2 in) long and streaked brown in colour. The belly is white. The snipe has a fast and erratic flight. **Native**.



Sparrows

U, W

House Sparrow
Passer domesticus
An introduced sparrow which is really a weaver finch. This bird is common from the Arctic to sub-tropics virtually everywhere where man has colonized. A patchy red-brown in colour, 15-18 cm (6-7 in) long. **Naturalized**.

F, U, W

White-throated Sparrow
Zonotrichia albicollis
An uncommon migrant and winter visitor. The breast is greyish and there is a white throat patch. The top of the head is striped black and white and there is a yellow spot between the eye and beak. A bird of thickets and shrubby forest edges. This sparrow measures 16-19 cm (6 1/2 to 7 1/2 in) in length. **Native**.

Starlings

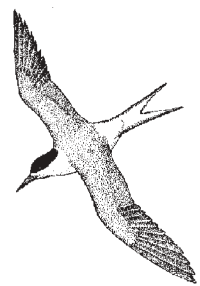
F, U, W

Starling
Sturnus vulgaris
Abundant and widespread throughout Bermuda. The Starling measures 20 cm (8 in) long. This iridescent blackish bird has a short tail and a long yellow beak. **Introduced** from Europe to the US, from where it extended its range to Bermuda. **Naturalized**.

Terns

B

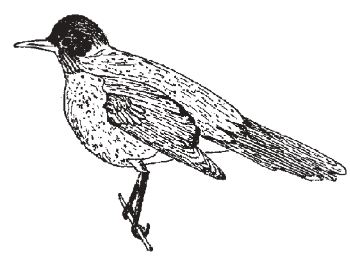
Common Tern
Sterna hirundo
This tern used to breed in Bermuda in large numbers but now only about 25 pairs do so. Terns fish in shallow waters, diving to catch fry or other small species. 35 cm (about 1 ft) in wingspan they can be recognised by the black top to the head and the V-shaped tail. **Native.**



Thrushes

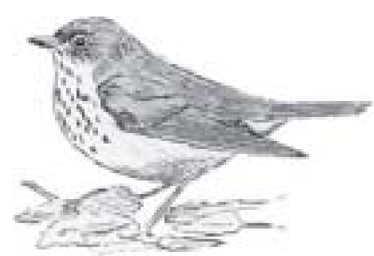
F, U, W

American Robin
Turdus migratorius
An uncommon vagrant to Bermuda. This is really quite an unmistakable bird with its characteristic reddish breast and grey back. In the male the head and tail are blackish; in the female these parts are grey. More a bird of meadows than woodland, it is nevertheless often seen in fairly open woodland in winter. 21-26 cm (8 1/2-10 1/2 in) long. **Native**.



F

Hermit Thrush
Catharus guttatus
The Hermit Thrush has a brown back and a spotted breast. The tail is a conspicuous rusty-red and the beak is slender. Very secretive, feeds on the ground in the understorey of woodland and mangroves. About 16-19 cm (6 1/2-7 1/2 in) in length. **Native**.



Northern Waterthrush F, FW

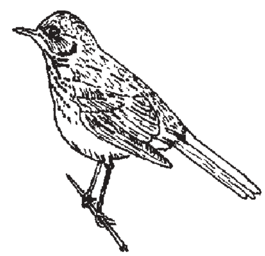
Seiurus noveboracensis

A common migrant from northern North America seen in the spring, fall and winter walking on the edges of ponds, tidal flats and rain pools. This bird has a dark brown back, bright eyebrow, streaked below. The underparts and eyebrow are usually tinged yellow, sometimes more white. Most spend the winter in the mangroves but they can also be seen in woods and parks. Usually solitary and secretive but rather noisy. About 20 cm (8 in) long. **Native**.

Swainson's Thrush F

Catharus ustulatus

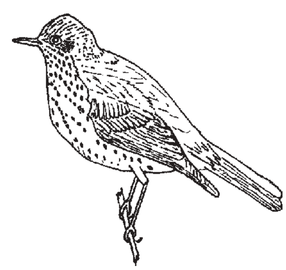
This thrush is very dull in colouration. The back is grey to olive brown, the breast streaked with spots and there is a beige eye-ring. A very uncommon migrant. 16-19 cm (6 1/2-7 1/2 in) long. **Native**.



Wood Thrush F

Hylocichla mustelina

The Wood Thrush is one of the larger thrushes. The breast and the sides are heavily spotted on a whiteish background. The back of the head is a very reddish brown which fades down the back. This thrush likes well-developed woodland. A rare migrant. Measuring 19-21 cm (7 1/2- 8 1/2 in) in length. **Native**.



Tropic Birds

White-tailed Tropic Bird or **Longtail** B, CL, O

Phaethon lepturus

The Longtail or White-tailed Tropic Bird is a summer breeder in Bermuda. It nests in holes in the cliffs and suffers competition from Rock Doves and predation from rats. The distinctive feature of this bird is the extremely long and graceful tail feathers. The wingspan is about 90 cm (3 ft). **Native.**

Vireos

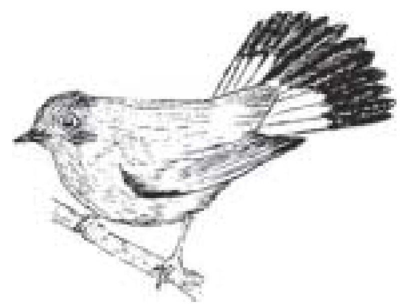
F, U

Bermuda White-eyed Vireo or
Chick-of-the-village
Vireo griseus bermudianus
The "Chick of the Village" is a small vireo measuring 13 cm (5 in) long. It is olive green above and white below with yellow sides. The adult has a white eye but more distinctive is the yellow eye-ring and double wing-bar. The Bermuda sub-species is **endemic.**

Warblers

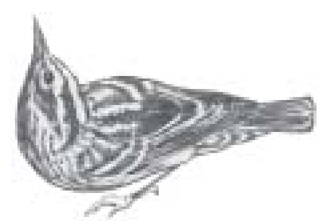
F, W

American Redstart
Setophaga ruticilla
This warbler is common migrant and winter visitor to Bermuda. It tends to flit around rather like a butterfly. The male and female are rather different, the male being almost all black with bright orange patches on the tail and wings. The female, on the other hand is olive brown on the back and white below with yellow patches on wings and tail. Found in parks, gardens, mangroves and golf courses as well as woodlands. This small warbler is about 11-14 cm (4 1/2-5 1/2 in) long. **Native**.



F, M

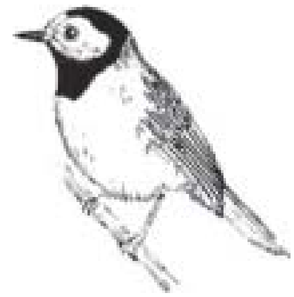
Black-and-white Warbler
Mniotilta varia
A bold stripe, black streaks on back and sides. The adult male has a black throat and cheeks. This bird is a common vagrant from eastern North America seen in the fall and spring in gardens, woods, orchards and mangroves feeding on the trunks and branches of trees. 13 cm (5 in) long. **Native**.



F, M

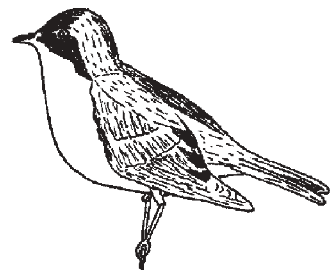
Common Yellowthroat
Geothlypis trichas
A brilliant yellow throat contrasts with white neck spot, black face and black stripes on sides. Grey back with white wing bars. This bird is a common vagrant from North America seen in the fall, spring and winter foraging for food in weedy wastelands, hedgerows, dunes and golf courses, dumps, aquatic vegetation around ponds. 13 cm (5 in) long. **Native**.

Hooded Warbler
Wilsonia citrina
This is a smallish warbler. Both sexes are brownish-green above and yellow below, but the male has a distinctive black hood on the head connecting to a black chin-patch. There are white areas at the outer corners of the tail. A warbler of thick woodlands and wooded swamps. Measuring 14-19 cm (5 1/2-7 1/2 in) long. **Native**.



F, M

Kentucky Warbler
Oporornis formosus
This warbler's main identification feature is a broad black stripe running down from the eye down the side of the yellow throat. There is a yellow ring around the eye. The back is olive-green. This warbler is typical of woodland thickets. Measures about 14 cm (5 1/2 in) long. **Native**.

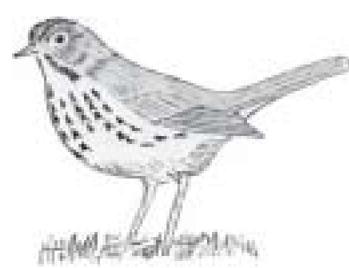


F, M

Northern Parula
Parula americana
A regular and common migrant warbler seen in spring and fall foraging in foliage in ones, twos, and small flocks on golf courses, in mangroves, parks, gardens, overgrown fields and woods. Blue-grey above, white wing bar, limited yellow throat and pale eye crescents. Adult male has black and rust chest bands. About 14 cm (5 1/2 in) long. **Native**.

F, M

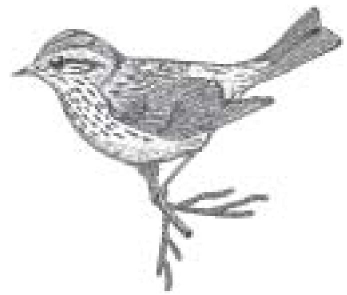
Ovenbird
Seiurus aurocapillus
The Ovenbird is one of the larger warblers, being sparrow- sized. It is a ground-feeding warbler of woodland. It is olive-brown on the back and striped on the breast. A good aid to identification is the orange patch on top of the head. One of Bermuda's most commonly occurring migrant warbler and winter visitor.14-16 cm (5 1/2-6 1/2 in) long. **Native**.



F

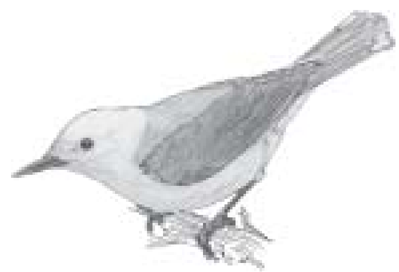
F, FW, M, W

Palm Warbler
Dendroica palmarum
A medium sized warbler 14 cm (5.5 in) long which is olive-brown on the back and yellow, streaked with chestnut below. There is a dark eye stripe. This warbler has a habit of wagging its tail while feeding on the ground. This bird is a common vagrant in Bermuda and may be seen in a variety of habitats including woodland, gardens and open spaces. **Native.**



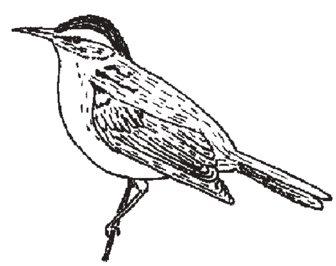
F, M

Prothonotary Warbler
Protonotaria citrea
A regular, fairly common migrant from southeastern North America. Golden yellow head and chest, white under tail, blue-grey wings and tail with white tail spots. Female duller than the male. Most abundant in the early fall but can also be spotted in the spring and winter. Beautiful golden-yellow colour. Can be seen foraging in foliage in ones, twos and small flocks with other warblers. 12 cm (4 3/4 in) long. **Native**.



F

Swainson's Warbler
Limnothlypis swainsonii
This small warbler is olive brown above and a dirty white beneath. There is a conspicuous whitish stripe above the eye. Likes wooded swamps or thick shrub growths. A rare migrant. 13 cm (5 in) in length. **Native**.



F, FW, M

Worm-eating Warbler
Helmintheros vermivorus
This small warbler measures 12-14 cm (5 - 5 1/2 in) long. The body is a dull olive-green with alternating black and creamy stripes on the head. A stripe runs through each eye. Its habitat is shady woodlands where it feeds on hanging dead foliage. A regular migrant and winter visitor in small numbers. **Native**.

F, FW, M

Yellow-rumped (Myrtle) Warbler
Dendroica coronata
A regular migrant from northern North America, abundant in the fall and spring and seen occasionally in the winter. This bird has a bright yellow rump patch, white spots in its tail, and small yellow patch at the side of its chest. It has a white throat and well-defined cheek patch. The yellow-rump patch is obvious as the bird flies away. Usually seen in flocks with other land birds feeding on the ground on golf courses, farm land, parks, gardens and fields. 12-14 cm (5- 5 1/2 in) long. **Native**.

Waxwings

F, U, W

Cedar Waxwing
Bombycilla cedrorum
Cedar Waxwings are quite frequently spotted in Bermuda but are not resident. Their most striking feature is a prominent crest, although the bright red spots, resembling wax droplets, at the tips of the main wing feathers are unique to waxwings. They are a delicate brownish-grey in colour and have a prominent black stripe through the eye. They reach 18 cm (7 in) in length and are fond of berries for food. **Native**.

Woodpeckers

F, U

Yellow-bellied Sapsucker
Sphyrapicus varius
A scarce migrant and winter visitor. The Sapsucker is a small woodpecker about 20-21 cm (8 - 8 1/2 in) long. The diagnostic feature is a longitudinal broad, white stripe on the fore part of the largely black wing. It has a red forehead patch and the male has a red throat. The throat on the female is white. A forest bird that feeds on sap that exudes from holes made in the bark. Evidence of feeding are the horizontal rows of holes around the trunks of trees. **Native**.

Land Mammals

F, U

Black Rat
Rattus rattus
The species is said to have been introduced into Bermuda on a captured Spanish grain ship towed into St. Georges by the privateer Frith in 1613. Blackish-grey in colour, the tail is always longer than the body. The eyes and ears are relatively large and the nose pointed. Adult body size, 17-23 cm (7-9 in). **Introduced.**

F, U

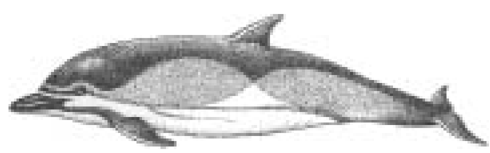
Brown Rat or **Norway Rat**
Rattus norvegicus
The Norway rat probably reached the island on ships about the mid 18th Century. The tail is always shorter than the body and the nose blunt. Eyes and ears are relatively small. The pelt is rough and brownish and the underside grey. Adult body size, 20-28 cm (8-11 in). **Introduced**.

Marine Mammals

Dolphins

O

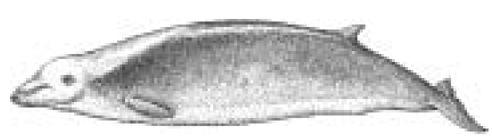
Common Dolphin
Delphinus delphis
This is a small dolphin reaching about 2 m (6 ft) long. The body is almost black on the back, the sides are grey and ochre and the bottom white. The grey and ochre side markings curve so that there is a white triangle below the dorsal fin. Usually seen in small groups well offshore. Occasional. **Native.**



Whales

O

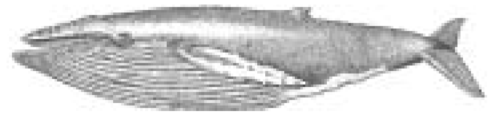
Cuvier's Beaked Whale
Ziphius cavirostris
A small whale of about 8 m (25 ft) in length. It has a relatively small head and short flippers and fins. Occasional. **Native.**



Humpback Whale O

Megaptera novaeangliae

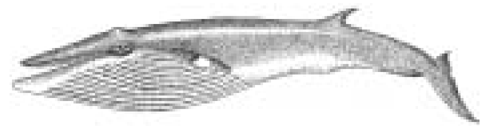
This filter-feeding whale may reach 19 m (62 ft) long and has a very deep body. The distinguishing features are the long flippers which are very pale in colour. The head and flippers have irregular protuberences. Individuals can be identified by colour markings and protruberances. Regular visitor in northerly migration. **Native.**



Minke Whale O

Balaenoptera acutorostrata

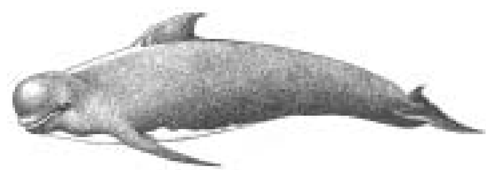
The distinguishing feature of this mid-sized whale is the wide, pure-white band across the middle of the flipper. This whale reaches about 11 m (33 ft) long and is a filter feeder utilising krill and other larger zooplankton. This whale will come close to a boat. Occasional. **Native.**



Pilot Whale or **Pothead** O

Globicephala melaena

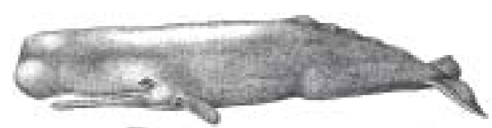
A very large dolphin reaching 6.5 m (20 ft) in length. The characterising feature is the very globose head. The flippers are long and pointed. When seen, this species is in herds of 100 or more. Occasional. **Native.**



Sperm Whale O

Physeter macrocephalus

This is the largest of the whales seen around Bermuda as it may reach 19 m (62 ft). The characteristic feature is the massive head which may be 1/3 the length of the body. The lower jaw is long and toothed and the eye small. The front of the body is almost square. A hunting whale that dives very deeply to secure its prey of large squid. Occasional. **Native.**



Glossary

Abyssal plain	The very flat part of the ocean bed lying from the foot of the continental slope to the edge of the trenches. Mostly about 5,000 m (16,000 ft) deep.
Acantharians.	These unique members of the zooplankton have a skeleton of strontium sulphate, which consists of 20 regularly arranged spines.
Adaptable	Able to change to live in new or changing habitats. To colonise new areas organisms need to be adaptable.
Adaptive radiation	Evolution of a group of species from a common ancestor. Each of the new species is adapted to different environmental conditions.
Aeolinite	Limestone rock form by the natural cementation of grains of wind-blown calcareous sand.
Algae	Photosynthetic, plantlike organisms generally found growing in aquatic or damp locations.
Algal Mat	A cohesive layer of algae of one or more species.
Algal-Vermetid reefs	Reefs of very hard limestone laid down principally by a combination of crustose coraline algae and vermetid gastropod snails (Tube Snails). The south shore Boiler Reefs are algal vermetid reefs.
Anchialine Ponds	Marine inland saltwater ponds connected to the sea by subterranean passages.
Anoxia	A lack of oxygen.
Anoxic	A lack of oxygen in a system.
Anterior	At or toward the front end (in bilaterally symmetrical animals).
Aquatic Systems	Natural systems where the environment is composed almost entirely of water.
Arrow Worms	Members of the phylum Chaetognatha**.** Colourless, fish-like, invertebrate, predatory, zooplankton.
Associated Species	A species normally found with another species.
Atmosphere	The mantle of gasses surrounding a planet. The atmosphere of the Earth principally nitrogen with water vapour, carbon dioxide and oxygen.

Atoll	A tropical oceanic island usually in the form of a circle, formed by the growth of marine corals and calcareous algae around the edge of a just-submerged seamount.
Backset Beds	Another name for the windward beds of a sand dune.
Backshore	The back portion of a sandy beach above high tide level.
Backwash	The seaward return of water after a rush of waves onto the beach foreshore.
Bacteria	A large group of microscopic organisms that multiply by fission or by forming spores. Bacteria are typically filamentous, spherical, spiral, rod-shaped, or comma shaped, and most kinds have no chlorophyll and no distinct membrane-bound nucleus. Certain species cause disease such as pneumonia, typhoid fever etc.; others are concerned in such processes as fermentation and nitrogen fixation.
Basalt	Hard, dark volcanic rock, originating from the magma.
Bathythermograph	An oceanographic instrument, which is lowered from a ship into the ocean where it graphs temperature against depth.
Bedding	The layering of sediments or lithified sediments in geological formations.
Benthos	All the **biota** living on or in the bottom of bodies of water.
Berm	A ridge of sand on land. Commonly found at the high tide level on sandy beaches.
Bio-constructional lips	Limestone lips on the ends of south shore headlands that have the same structure and **biota** as algal-vermetid reefs.
Bio-deposition	The formation of rock living organisms. Coral reefs are examples of biodeposition.
Biodiversity	In its simplest form the number of different species present at a location. More complex measures of diversity also incorporate relative abundance or biomass.
Bioerosion	The removal of rock by biological organisms.
Bioerosional Notch	A notch cut into rock by living organisms. The Harrington Sound Notch is an example.
Biological Control	The use of living organisms to control pests.
Bioluminescent	An organism, which can produce light.

Biosphere	The part of the planet that supports living organisms. It extends from deep trenches to a few hundred metres into the air.
Biota	This word is used when all types of organism in a biological system are being included.
Bivalve	A class of mollusk (Pelecypoda) with two hinged shells or valves, which enclose the soft parts of the animal. Commonly referred to as clams.
Bloom	A dramatic increase in the quantity of plankton.
Blue-green algae	More properly called blue-green cyanobacteria. Pigmented bacteria that can photosynthesise. Common among tropical phytoplankton.
Blue-green cyanobacteria	See blue-green algae above.
Bog	A freshwater wetland dominated by mosses.
Bony fish	Fish that have a skeleton made of bone.
Brackish	Seawater measurably diluted with freshwater.
Breaker	A wave breaking on a shore, over a reef, or other mass in a body of water.
Bryozoa	A phylum of colonial, invertebrate animals. The individuals of the colony are small and the colony may be bushy or sheet-like.
Budding	A type of asexual reproduction in which a new individual develops as a direct growth from the body of the parent and may subsequently become detached.
Byssus	A clump of strong, flexible threads that serves as an anchor in some bivalves particularly mussels.
Calcareous algae	Seaweeds that incorporate calcium carbonate into their tissues. Calcareous algae may be sheet-like as in the crustose coraline algae or upright.
Calcium carbonate	The chemical compound making up the bulk of limestone. Seawater is saturated with calcium carbonate.
Canary Current	A surface (wind driven) ocean current, which passes south along the North African coast.
Canopy	The top layer of a forest containing the bulk of the tree leaves.
Carapace	A hard case covering the head and thorax of many crustaceans.

Carnivores	Animals that eat either herbivores or other carnivores but not plant material.
Cartilaginous fish	Fish that have a skeleton made of gristly cartilage.
Casts	Characteristically shaped faecal material found on the bottom. Casts can be used in some cases to identify animals that can't otherwise be seen.
Centrate	A term applied to diatoms that are shaped like a short cylinder.
Chaetognaths	Members of the phylum Chaetognatha**.** Colourless, fish-like, invertebrate, predatory zooplankton.
Chitin	A component of the shells of crustaceans and some other invertebrates that is resilient and protective but not hard.
Chlorophyta	The group of green algae or seaweeds**.**
Ciliates	Protozoa found in all moist environments on Earth. The single cell is covered with a layer of small cilia which beat to cause movement.
Clam	A general term used to describe molluscs with a shell consisting of two parts hinged together (in life).
Climax	The final community in succession in which change is very slow.
Cnidarians	The cnidarians always have a body shaped like a **polyp** or a **medusa** and they always have specialised stinging cells called nematocysts.
Coastal dunes	Dunes formed along coastlines usually showing ridges parallel to the shore.
Coccolithohore oozes	Very fine oceanic sediments consisting mainly of the tests of coccolithophores.
Coccolithophores	Members of the phytoplankton that have the cell armoured with tiny calcareous plates.
Coelenterates	The animal phylum that includes the jellyfish, corals, hydroids, siphonophores and sea anemones. Coelenterates typically have tentacles for feeding and a simple tube-like body.
Colonial organisms	Organisms in which many individuals live together to form a larger organism. Most corals are colonial organisms.
Colonisation	The occupation of new areas by living organisms.

Comb Jellies	Members of the phylum Ctenophora. Often called sea-gooseberries. They have a gelatinous body on which cilia are arranged in rows for locomotion.
Community	A naturally occurring group of organisms.
Compensation depth	The depth in water at which, on the average, the energy fixed in photosynthesis balances that used in respiration.
Competition	A biological process where two or more organisms attempt to utilise the same essential resource.
Competitive Exclusion	When two different species compete for the same niche the result is normally the death of the least fit of the two.
Compound leaf	One leaf made up of several to many small "leaves". Example Royal Poinciana.
Conglomerate	A rock composed of large stones or rock lumps cemented together.
Conifer	An evergreen tree of a group usually bearing cones, includes pines, yews, cedars and redwoods.
Conservation	The protection, preservation and careful management of natural resources and of the environment.
Consumers	All organisms that get their energy by consuming other organisms or their dead remains.
Continental islands	Islands formed on continental shelves rather than in the deep sea, for example Newfoundland and Madagascar.
Continental shelf	The relatively shallow, coastal, sea bed extending to about 300 m in depth.
Continental slope	The slope in the sea bed from the outer edge of the continental shelf into the abyss.
Convergent species	Species that are not closely related but appear quite similar that have come to live in a particular natural system.
Copepods	The most abundant and important crustacean zooplankton. Most are herbivourous and resemble a small grain of rice with numerous legs.
Coralite	The distinctive mark left by the coral polyp on the surface of the skeleton.
Corals	Coelenterate animals most of which are colonial that have a tubular body and a crown of tentacles. The colonies are distinctive for each species. The hard corals have an external skeleton of limestone, the soft coral have a skeleton of organic material.

Crustacea	Members of the phylum Arthropoda, containing crabs, lobsters, shrimps, copepods barnacles etc.
Crustose calcareous algae	Red algae (Rhodophyta) growing in a sheet like form on the substrate that incorporate calcium carbonate into their tissues and lay down a layer of limestone. They are very important reef builders.
Crustose coraline algae	Another expression for crustose calcareous algae.
Ctenophores	Members of the phylum Ctenophora. Often called sea-gooseberries. They have a gelatinous body on which cilia are arranged in rows for locomotion.
Currents	Directional movements of water. Examples are surface currents and deep currents.
Curtains	Undulating thin sheets of limestone hanging from cave roofs.
Cyanobacteria	Pigmented bacteria that can photosynthesise. Common on rocky shores and among tropical phytoplankton.
Deciduous	Shedding all or nearly all of the foliage each year.
Demersal	Living in association with the bottom.
Density	Weight per unit volume.
Density Currents	Water currents that arise due to differences in density of water masses. Typically, water cooled at the surface (with a rise in density) sinks to deeper levels and then proceeds horizontally.
Deposit feeder	An animal that feeds on sediment containing detritus.
Depression	An enclosed low area of land caused by cave collapse or erosion.
Detritivores	Animals that eat detritus.
Detritus	Semi-decomposed organic material in particulate form.
Diatomaceous ooze	Fine oceanic ooze principally consisting of the siliceous tests of planktonic diatoms.
Diatoms	Single-celled plants with a silica frustule. The dominant plant group in the phytoplankton.
Dinoflagellates	Single-celled organisms many of which are phytoplankton. Most have two flagellae, one trailing and one in a groove around the cell.

Diurnal vertical migration	A daily migration pattern common in zooplankton in which individuals swim up to the surface at dusk and return to deeper water at dawn.
Diversity	The number of different species of biota in a natural system such as an ecosystem or community. Diversity may also be used in relation to a habitat or environment, more complex examples being described as more diverse.
Doldrums	A part of the Atlantic Ocean centred on the equator, which is usually virtually windless.
Dominant	Refers to the most important organism in a community. Usually taken as the one contributing the greatest biomass.
Dune	A hill of sand created by the wind.
Echinodermata	The animal phylum containing the sea cucumbers, starfish, sea urchins, sand dollars and sea lilies. They are generally radially symmetrical. If they move it is generally by means of numerous tiny tube feet, although some walk on spines or on the tips of the legs.
Ecological Export	The movement of food in the form of organic material or organisms beyond the boundary of an ecological system.
Ecology	The scientific study of natural history.
Ecosystem	A large area of habitats and associated organisms that have many features in common. For example, the tropical rain forest or the open ocean.
Ecotone	The natural boundary zone between two communities or ecosystems.
Embryos	Early developmental form of an animal or plant.
Emergent Plants	Aquatic plants in which part of the plant body extends up into the air.
Endangered species	Species that are in danger of extinction or extirpation from a locality.
Endemic species	Species that have evolved to be a new species in a specific area. They may subsequently spread to other areas.
Endemism	The proportion of endemic species arising from native species in a given location.
Endolithic	Living inside rock.
Energy flow	The flow of energy along a food chain, starting with the primary producers and ending with the top carnivore.

Entomology	The study of Insects.
Environment	Living and non-living surroundings of natural groups of organisms
Epibiota	All the organisms, both animal and plant, living on the surface of the sea bed.
Epiphytes	Plants or animals using a plant as a substratum to which they anchor themselves.
Epizooites	Plants or animals using an animal as a substratum to which they anchor themselves.
Erosion	The break-down of rock to sediment or the movement of sediment by physical, chemical or biological means.
Estuaries	Where rivers meet the sea. Estuaries show intermediate characteristics between marine and fresh water conditions.
Euphausid Shrimps	Often called Krill. Planktonic shrimps that are comparatively large for zooplankton. A very important food source for many marine animals including great whales.
Evergreen	A plant whose leaves remain green and functional throughout the year.
Evolution	The natural creation of new species.
Exoskeleton	The external supportive covering of certain invertebrates, such as arthropods.
Exotic species	A species not occurring naturally in an area.
Export Ecosystem	An ecosystem from which ecological export takes place. The coral reef is an export ecosystem.
Extinct Species	A species which has been wiped out from its entire range.
Extinction	The total disappearance of a species from the Earth.
Extirpated Species	A species, which has been wiped out of a discrete part of its range.
Feeding bio-erosion	Bio-erosion resulting from the feeding activities of organisms. Parrotfish are the best example of feeding bio-eroders.
Feral	A domestic animal that has reverted to the wild.
Fetch	The distance across open water across which a wind can blow.

Filter feeders	Animals that obtain their food by filtering organic particles or organisms out of water.
Flagellae	Tiny whip-like hairs used in locomotion by single celled organisms.
Flatworm	Members of the phylum Platyhelminthes. There are both free-living and parasitic examples.
Flow stones	Cave features formed where water cascades down a slope, evaporating as it does so.
Flowering plants	Higher plants that reproduce by means of flowers. They may be uni-sexual or bi-sexual. All produce seeds of some sort.
Flushing	Exchange of water from one water body to an adjacent one.
Fushing Rate	The rate at which water in a water body is exchanged with water from an adjacent body. Often expressed in % per tidal cycle (12.5 hr units).
Foliage	Leaves.
Food chains	The feeding relationships between trophic groups in an ecological unit such as an ecosystem or community, arranged to begin with the primary producers and proceeding through herbivores to carnivores.
Food webs	The feeding relationships in an ecological unit such as an ecosystem or community arranged to begin with the primary producers and proceeding through herbivores to carnivores.
Foraminifera	Single celled protozoa in the amoeba group having a chambered calcareous exoskeleton. Common in the plankton.
Foraminiferan ooze	A fine deep sea ooze made up of the calcareous skeletons of foraminifera.
Foreset Beds	Steeply sloping beds on the leeward face of a dune or lithified dune.
Foreshore	The part of a sandy beach between high and low tide levels.
Forest stand	An area of forest characterised by a particular tree.
Formation	A rock complex formed during a specific past geological period. In Bermuda formed during periods of relatively fast dune growth.

Fossil	Remains of the hard parts of living organisms or geological features, buried in sediment or incorporated into rock. The original structure may remain or be replaced by minerals.
Fragmentary Ecosystems	Ecosystems, formerly large, now reduced to small patches.
Fringing Mangrove Swamps	Narrow bands of mangrove trees growing along the edges of marine waterways.
Frond	Leaf of a fern; sometimes used in the general sense of a large compound leaf, especially of palms.
Fruit	The part of the plant that carries the seeds. It is not necessarily edible.
Frustule	The box-like silica exoskeleton of diatoms.
Fungi	Plants that lack pigment. They are all saprophytic or parasitic. Most are formed of threads called hyphae. Very important in the production of organic detritus and soil formation.
Gastropod	A mollusc with a single, normally coiled, shell. E.g. A snail.
Genus (pl. genera)	A closely related group within a family of organisms. A family may contain many genera.
Ground Layer	The layer, or stratum, of a forest community growing on the soil but excluding the mature trees.
Gulf Stream	The very large ocean current originating in the Gulf of Mexico, passing through the Straits of Florida and proceeding northeast up the eastern seaboard of North America.
Gyre	A surface current travelling in a roughly circular path.
Habitat	A small area of an ecosystem or environment. The characteristic living space of a species.
Halophytes	Flowering plants that are adapted to saline conditions.
Hard Corals	Corals found only in warm sea water, which lay down a skeleton of hard calcium carbonate or limestone. Hard corals are very important in the creation of coral reefs.
Head (of water)	A stand of water higher than its surroundings, which if released will flow down under the influence of gravity.
Herb	A relatively small non-woody flowering plant. Culinary herbs are those used in food.

Herb Layer — The layer of a forest immediately above the ground, dominated by herbs.

Herbicides — Poisons used to eliminate unwanted plant growth.

Herbivores — Animals that eat primary producers (plants).

Hermaphrodite — An organism with both male and female organs and producing both eggs and sperm.

Holdfast — Root-like structure serving to anchor algae. Does not act as a true root.

Holoplankton — Plankton that spend their entire lives suspended in the water.

Hot spot islands — Islands that originate when a volcano forms from liquid magma that erupts through a small area of the sea bed.

Hydrography — The study of the characteristics of a body of water.

Hydroids — Members of the phylum coelenterata. Most hydroids are colonial and consist of numerous, small, anemone-like polyps connected together by a branching stalk. Most have a distinctive exoskeleton of tubes and cups.

Hydrometer — An instrument to measure the specific gravity of liquids.

Ice Ages — Long periods of time in the history of the Earth when global temperatures were well below average. The last ice age was the pleistocene.

Ice Cap — Accumulation of ice around the poles during an ice age.

Impermeable — Not allowing fluids to pass through.

Infauna — Organisms living buried in sediment at the bottom of water bodies.

Infra-red solar radiation — Energy received from the sun in the form of heat.

Inherited — Passed on from generation to generation by genetic processes.

Insecticide — A substance used to kill insects. Some synthetic insecticides are quite persistent in the environment.

Inter-dunal lows — Low areas among tracts of dunes often deepened by runoff.

Interstitial fauna — Small animals living in the spaces between grains of sediment.

Intertidal Zone — The zone around water bodies that is regularly covered and uncovered by the tides.

Intra-specific competition	Competition between members of the same species.
Introduced species	Species brought to a new area by man.
Invasive species	An introduced animal or plant, which has become naturalised and grows and reproduces aggressively, displacing native and endemic plants. (e.g. Mexican Pepper).
Invertebrates	Animals without backbones.
Island arcs	Groups of islands formed along the collision zones of tectonic plates.
Isolated	Separated from other areas or organisms by some barrier.
Krill	Planktonic shrimps that are comparatively large for zooplankton. A very important food source for many marine animals including great whales.
Land Snails	Snails or gastropod mollusca that live in terrestrial habitats.
Landlocked	Surrounded or almost surrounded by land.
Larvae	The juvenile stages of animals. There are often several distinct larval stages.
Leachate	Water borne pollutant flowing from accumulations of trash and garbage.
Lee	Sheltered from the wind.
Leeward beds	The same as foreset beds
Lenticels	Air breathing organs found on the roots of mangrove trees.
Lichens	A symbiotic group of associations between algae and fungi which are accorded specific status and which are very hardy.
Limestone	A rock made up principally of Calcium carbonate.
Lithification	The cementation of sand or other sediment into rock.
Littoral Zone	The zone around water bodies that is subject to wetting by tides, splash or spray.
Liverworts	A group of small non-vascular plants of damp locations showing alternation of generations in which the gametophyte is a free living plant and the sporophyte is parasitic on the gametophyte.
Longshore drift	Materials moved laterally by waves and currents of the littoral zone.

Lowland Forest	A forest developed in relatively well drained valleys.
Magma	Molten rock under the Earth's crust, circulating in vast convection cells.
Mammals	Warm blooded animals with backbones that suckle their young.
Mangrove Swamp	A marine coastal wetland dominated by trees.
Mangrove Tree	A tree adapted to life in a marine coastal swamp.
Marine Deposits	Rock laid down under seawater.
Marsh	Wetland dominated by grasses, ferns or grass-like plants.
Mass Mortality	Unusually heavy mortality of one or more species at one time.
Mechanical erosion	See physical erosion below.
Medusas	The planktonic members of the phylum coelenterata. They may be either holoplanktonic or meroplanktonic. Typically of jellyfish-like form they range in size from very tiny to very large.
Metamorphose	To undergo the process of metamorphosis or to undergo an abrupt change in body structure, transforming from the larval to the adult stage, e.g. a caterpillar metamorphoses into a butterfly. The process is widespread among marine invertebrates e.g. arthropods such as barnacles.
Microhabitat	A very small habitat.
Midlittoral Zone	The main, broad zone on the rocky seashore that in sheltered locations lies roughly between the high and low tide marks, but rises higher in exposed locations. The top of this zone is marked by barnacles.
Migration	Migrating animals regularly move between locations on Earth usually on a seasonal basis.
Mites	Small eight legged arthropods that may be parasitic or free living and in which the body consists of a single part.
Moat	A shallow, circular, surrounding depression filled with water.
Mobile Dune	A sand dune that moves steadily downwind.
Mollusca	The phylum of invertebrate animals containing the snails, clams, squids, slugs and octopuses.

Native species An organism that has colonised an area by completely natural means.

Naturalised Species A species introduced by man. Not endemic or native but self-propagating and firmly established.

Natural Selection The process in which the fittest species survive and the less fit become extinct.

Natural Variation Variation within a species that shows up as differences between individuals that is inherited by their progeny.

Neap Tides Tides of smaller range occurring every two weeks.

Nekton The strongly swimming animals living in water.

Nematocyst Intracellular stinging capsule typical of cnidarians.

Neuston Pelagic animals associated with the water surface.

Niche The unique environment of a species. No two species inhabiting the same area can have identical niches.

North Equatorial Current The wind-driven current flowing from east to west north of the equator driven by the northeast trade winds.

Ocean currents Large currents in the ocean that move in a predictable pattern.

Ocean ridges Spreading zones in the ocean floor where tectonic plates move apart. Characterised by frequent earthquakes and occasional volcanoes.

Oceanic In the ocean.

Oceanic Island An island in the ocean, well away from a continent.

Oceanography The study of the oceans.

Omnivores Animals that eat food that has both animal and plant origins.

Operculum A lid like disc used to close the shell opening of some snails and worms.

Ornamental Plants Plants that have been introduced for their decorative value (e.g. Hibiscus and Oleander).

Overturn A term used to describe the event in which surface and deeper waters mix in a water body.

Palaeosols Old soils between formations of rock formed in past periods of low dune activity in the presence of vegetation.

Palynology The study of plant pollen. Used in the reconstruction of past plant communities.

Paralytic shellfish poisoning Poisoning resulting from the consumption of shellfish, which have eaten toxic phytoplankton.

Parasite A relationship in which one organism lives on or in another (its host), at the expense of the latter.

Peat The partially decomposed remains of bog, swamp or marsh vegetation. Usually very acidic in nature.

Pelagic Living in the water column.

Pennate A group of diatoms in which the silica frustule is elongated.

Perennial A plant with a natural life-span of 3 or more years.

Permanent thermocline A horizontal layer in the ocean where temperature decreases rapidly with depth that does not disappear seasonally.

Pesticides Poisons used to eradicate animals or plants that have become perceived pests.

Photic zone The lighted upper zone of the sea. Its depth depends on water clarity and the amount of plankton. Off Bermuda it can be very deep.

Photometer An instrument to measure light intensity.

Photophores Light producing organs

Photosynthesis The synthesis of organic compounds from inorganic substances using the energy of sunlight, carried out by pigmented plants.

Physical erosion The break down of rock, or particles of rock, into smaller particles by physical means such as wave action, wind, gravity water currents and grinding.

Phyto-karst The characteristic jagged surface texture of upper seashore rocks caused by bio-erosion by blue-green cyanobacteria.

Phytoplankton Plant plankton.

Pillars Columnar structures in caves resulting from the uniting of a stalactite and stalagmite.

Pioneer Plant A plant adapted to the colonisation of newly created environment.

Plankton — The usually very small animals and plants of the open ocean that have no or very limited swimming abilities.

Planktonic — Belonging to the plankton.

Plate tectonics — The study of the structure and movement of crustal plates.

Pleistocene Epoch — The last epoch which was characterised by the development of huge ice caps at the north and south ends of the Earth.

Pneumatocysts — Stinging cells found only in coelenterate animals that are used in prey capture and defence.

Pneumatophores — Vertical, quill or pencil-like air breathing roots.

Polychaetes — Marine members of the phylum annellida. Worms with many bristles.

Polyps — The bodies of coelenterate animals characterised by a circle of tentacles.

Pond — A relatively small, relatively shallow body of water.

Poorly sorted sediment — Sediment consisting of particles with a wide range of sizes.

Population — A group of individuals of the same species in a given area.

Population explosion — A sudden and very rapid increase in the population density of a species. Often linked to a change in environmental conditions.

Pre-adapted — A species arriving in a new area to which it is adapted to survive because of its previous existence elsewhere.

Predatory — Using animals as food.

Pre-historic — Before history recorded by man.

Prevailing westerly winds — Winds that blow from a westerly direction most of the time.

Prevailing winds — The most usual winds in a given area.

Primary producers — Plants that obtain their energy supplies through the process of photosynthesis.

Primary Succession — A predictable and orderly change in an ecosytem starting with rock.

Propagules — Any part or reproductive product of a plant, which can serve to produce a new individual.

Prop Roots	Spreading secondary roots of swamp trees. An adaptation to provide support in soft mud.
Pseudopodia	Elongate streamers of protoplasm produced by members of the amoeba group of protozoa.
Pulmonata	Snails and slugs.
Radiolarian ooze	A fine deep-sea ooze principally composed of the silica remains of radiolarians.
Radiolarians	Marine protozoan zooplankton with a skeleton consisting mainly of silica rods.
Red Beds	Accumulations of reddish soil (palaeosols) derived from atmospheric fallout.
Red Geosols	The same as red beds.
Red tide	A water mass coloured red by the presence of numerous red-coloured dinoflagellates. These organisms are often toxic and may lead to paralytic shellfish poisoning.
Reef rock	Rock that is the remains of a bio-deposited reef.
Reefs	Hard, raised areas of the sea bed. They may be composed of living animals and their remains, for example coral reefs, or of any kind of rock. Often a hazard to shipping.
Resources	Environmental components which are essential to life. Resources may be living or non-living.
Rhizoids	Root-like organs developed by green algae to enable them to colonise sedimentary habitats. Rhizoids act only as anchors and do not function as true roots.
Rhizome	The buried stem of a flowering plant from which roots and leaves emerge. Fragments of rhizomes may be carried in water currents to establish the plant in a new habitat.
Ridge islands	Islands that originate along mid-ocean ridges, for example Bermuda.
Rift	The gully-like centre of an ocean ridge.
Run-off	Water derived from rainfall draining on the surface into low areas.
Salinity	The quantity of salts per unit volume of water.
Salinometers	Instruments used to measure salinity.
Salps	Advanced invertebrate zooplankton from the phylum urochordata. Many are barrel-shaped.

Salt Marsh	A grass dominated wetland on a marine coast.
Saltwater Ponds	Relatively small and shallow ponds close to coastlines, filled with sea water.
Sand Dunes	Wind-blown mounds of sand.
Sand ridges	Wave like formations on the surface of sandy areas in either land or aquatic situations.
Sand waves	Underwater features in sandy sediments where the surface of the sand forms wave-like ridges.
Sargassum weed patch	A patch of the floating brown seaweed sargassum or sargasso weed.
Saturation point	The point at which a liquid can absorb no more of a dissolved substance.
Scientific names	Names composed of a mixture of Greek and Latin used to describe organisms. There are two names the first is the genus name and the second the species name.
SCUBA	Self-contained underwater breathing apparatus.
Sea anemones	Animals in the phylum coelenterata, living attached to the bottom and lacking skeletal structures. They have a soft, cylindrical body and a ring of tentacles.
Sea Cucumbers	Echinoderm animals shaped like a cucumber.
Sea Urchins	Spiny, near spherical echinoderm animals.
Seamount	A mountain in the ocean resulting from an undersea volcano. Some come above the surface.
Sea-spiders	Marine animals in the class pycnogonida. They are spider-like but usually with 10 legs.
Seaweeds	The common name given to green, brown and red algae in the sea.
Secchi disc	A flat white disc with two black quadrants, which is lowered into the water to give an estimate of light penetration and water clarity.
Secondary Succession	A predictable and orderly change in an ecosystem where sediment is already present.
Sedentary animals	Animals that cannot move to another location. Many sedentary animals are cemented to the rock, for example hard corals.

Sediment	Deposit composed of small fragments of rock shell or skeletal particles. Sand, mud and clay are examples of sediments.
Sediment consolidation	A process taking place in fine sediments such as mud, which, in time, results in a lower trapped water content, higher density and increased physical stability.
Sediment permeability	This refers to the amount of open space within a sediment it can also be measured by the rate at which water can move through a sediment.
Sediment sorting	The sorting out of different particle size sediments from a mixture in a situation of decreasing current velocity
Sedimentation	The process in which sediment suspended in the water is deposited on the bottom.
Sere	A stage in succession.
Shrub	A woody plant smaller than a tree with very short stems or trunks and branches near the ground.
Siliceous	Made of silica or glass.
Siphonophores	Colonial animals in the phylum coelenterata that form complex colonies in which the individuals perform different functions, such as swimming, feeding or defence.
Soda straws	Slender tubes of calcium carbonate hanging from cave roofs.
Solar system	The sun and the planets around it.
Species	The basic unit in scientific classification applied to organisms that are genetically and physically similar. They can interbreed naturally and produce viable offspring.
Species diversity	The number of different species in an area.
Specific gravity	Weight per unit volume.
Specific heat capacity	The amount of heat required to raise 1 gram of water 1^{o}C.
Specific name	The second name in a scientific name that is usually descriptive in nature.
Speleothems	Geological features found in caves formed when calcium carbonate laden water evaporates.
Spiders	Eight legged predatory arthropods whose body is divided into two distinct parts.

Spore	A simple reproductive body usually composed of a single detached cell, and containing a nucleated mass of protoplasm (but no embryo).
Spreading zones	Zones on the surface of the earth where molten magma rises to the surface. There is a spreading zone at the centre of ocean ridges.
Spring Tides	Tides of large tidal range that occur at 14 day intervals.
Stalactites	Elongated, hard cone like structures of limestone hanging from cave roofs.
Stalagmites	Elongated, hard cone like structures of limestone rising from cave floors.
Strand line	The line on shore where floating material is stranded at the level of high tide.
Stratum	A more or less horizontal layer.
Stratified	Horizontally layered.
Subduction zones	Zones where tectonic plates collide and one plate descends under the other.
Subtidal	Below low tide level.
Succession	An orderly and predictable series of changes in an ecosystem.
Succulent Plant	A plant with juicy, fleshy leaves or stems, which are used for storing water.
Supralittoral Fringe	A narrow zone on the seashore lying immediately above the midlittoral zone, characterised by the presence of periwinkles.
Surface beds	The beds of sand that lie just beneath, and parallel to the surface of a dune.
Suspension feeder	An animal, which engages in suspension feeding, i.e. feeding on particles suspended in the water.
Swamp	A wetland dominated by trees.
Swell	Ocean waves that have originated from wind action at a distant location.
Swim bladder	A gas filled bladder found in shallow-water bony fishes that gives them neutral buoyancy.
Symbiosis	A mutually beneficial association between two different organisms.

Tectonic plates	Large rock plates on the surface of the Earth, which move under the influence of convection cells in the molten magma beneath.
Temperature Range	The highest and lowest temperature encountered in a specific situation.
Tendril	A threadlike, often spiral plant organ used to anchor some vines to their support.
Terra rossa	The same as red beds.
Terrestrial Systems	Natural systems where the water table lies significantly below the surface of the ground.
Test	A skeletal structure found in several types of protozoa. It may be of calcium carbonate or silica in structure.
Thermocline	The vertical location in a water body where the temperature changes rapidly.
Ticks	Parasitic eight legged mites.
Tidal Current	A current in water resulting from the rise and fall of the tides. Tidal currents usually reverse with the tides.
Tidal range	The vertical height between high tide level and low tide level.
Tides	The regular and predictable rise and fall of sea level resulting principally from the gravitational pull of the moon.
Top carnivores	The top of a food chain. A top carnivore has no predators.
Trade Winds	Winds that blow virtually constantly in areas just to the north and south of the equator. In the North Atlantic Ocean these are the NE Trade Winds.
Traits	Characteristics that are inherited from generation to generation.
Trenches	Elongated troughs in the sea bed that form the deepest places in the oceans.
Trophic level	A feeding level in a food chain. For example primary producers and carnivores.
Trough	Depression in between wave crests.
Understorey	The forest layer above the ground layer and below the canopy, usually shrub or fern-dominated.
Vascular Plants	Plants that have tissues organised in regular tracts for the transportation of fluids.

Vermetid Reefs	Reefs made up of worm shells (Vermetid gastropods).
Vine	An elongated plant that is not self-supporting. It may either trail along the ground or grow up using other plants or structures for support.
Water masses	Large bodies of water with fairly uniform characteristics.
Water Table	The level at which water lies with respect to the surface of the ground.
Wave cut notch	A horizontal shoreline notch in rock resulting from wave action.
Wave height	The vertical height between wave crests and troughs.
Wavelength	The horizontal distance between wave crests.
Weathering	Erosion resulting from the action of weather.
Weathervaning	The distortion of tree growth in exposed locations such that the majority of growth appears on the downwind side of the tree. The trunk may also bend downwind.
Weed	A plant growing where it is not wanted.
Well sorted sediment	Sediment in which the component particles fall into a narrow range of sizes.
Westerly intensification	A phenomenon seen in surface currents where they are more intense against eastern shores. This is a result of the rotation of the Earth.
Wetland	An ecosystem where the water table lies close to the ground surface.
White Geosols	Layers of fine, white, calcareous sediment formed during a short period of low dune building activity while vegetation was present.
Wind-driven Currents	Surface currents that arise from the action of wind.
Windward Beds	Characteristically gently sloping beds of sand on the windward dune surface.
Zonation	Regular horizontal banding of communities within an ecosytem in response to changing environmental conditions.
Zooplankton	Animal plankton.
Zooxanthellae	Members of the phytoplankton, which live inside animals in a symbiotic relationship. They are found in many corals, a variety of other invertebrates, and several zooplankton species.

Reading Material

Amos, Eric J. R. 1991. **A Guide to the Birds of Bermuda.** Corncrake, Warwick, Bermuda, 206p.

Anon. 2000. **Growing with trees: Millennium Tree Planting Guide.** Bermuda Electric Light Company and the Bermuda Ministry of the Environment. 28p.

Benchly P. And J. Gradnohl. 1995. **Ocean Planet: Writings and Images of the Sea**. Abrams, Times Mirror Magazine and Smithsonian Institution. 192p.

Britton, Nathaniel Lord. 1918, **Flora of Bermuda**, Charles Scribner's Sons, New York. 585 p.

Butler, J. N., B.N. Morris, J. Cadwallader and A.W. Stoner. 1983. **Studies of Sargassum and the Sargassum Community**. Bermuda Biological Station for Research, Special Publication No. 22. 266p.

Cavaliere, A.R., Barnes, R.D., and C.B. Cook,, 1987, **Field Guide to the Conspicuous Flora and Fauna of Bermuda, 2nd ed**., Special Publication No. 28, Bermuda Biological Station for Research, Bermuda. 82 p.

Collett, Jill. 1987. **Bermuda her Plants and Gardens 1609-1850.** Bermuda National Trust~Macmillan, 104p.

Cousteau J. Y. and F. Dumas. 1953. **The Silent World.** Harper Bros., N.Y. 266p

Deloach, Ned. 1999. With Photographer Paul Humann. **Reef Fish Behavior.** New World Publications Inc., 361p.

Dobson, Andrew. 2002. **A Birdwatching Guide to Bermuda**. Arlequin Press, 173p.

Hayward, Stuart, Gomez, Vicki and Wolfgang Sterrer. [Eds.], 1982. **Bermuda's Delicate Balance: People and the Environment.** The Bermuda National Trust. 402p.

Humann, Paul.1989. **Reef Fish Identification.** New World Publications Inc., 424p.

Humann, Paul.1992. **Reef Creature Identification.** New World Publications Inc., 344p.

Humann, Paul.1993. **Reef Coral Identification.** New World Publications Inc., 252p.

Morris B. and D. D. Mogelburg **Identification Manual to the Pelagic Sargassum Fauna**. Bermuda Biological Station for Research Special Publication No. 11.

Ogden, George [Ed.] 2002. **Bermuda: A Gardener's Guide**. The Garden Club of Bermuda, 225p.

Phillips-Watlington, Christine. 1996. **Bermuda's Botanical Wonderland: A Field Guide.** Macmillan Education Ltd., 128p

Raine, André. 2003. **A Field Guide to the Birds of Bermuda.** Caribbean Pocket Natural History Series, 146p.

Rowe, Mark P. 1998. **An Explanation of the Geology of Bermuda.** Bermuda Government, Ministry of the Environment, 30p

Sterrer, Wolfgang E. 1986. **Marine Fauna and Flora of Bermuda.** Wiley Interscience Publication, 742p.

Sterrer, Wolfgang E. 1992. **Bermuda's Marine Life.** Bermuda Natural History Museum and Bermuda Zoological Society, 307p.

Sterrer, Wolfgang E. and A. Ralph Cavaliere. 1998. **Bermuda's Seashore Plants and Seaweeds.** Bermuda Natural History Museum and Bermuda Zoological Society, 269p.

Taylor, W. R., 1960. **Marine Algae of the Eastern Tropical and Subtropical Coasts of the Americas**, University of Michigan Press, Michigan. 823 pp.

Thomas, Martin. L. H. and Alan Logan. 1991. **A Guide to the Ecology of Shoreline and Shallow-water Marine Communities of Bermuda.** Bermuda Biological Station for Research Special Publication Number 30. Wm. C. Brown Publishers, Dubuque, Iowa, U.S.A., 345p.

Thomas, Martin. L. H. 1998. **Marine and Island Ecology of Bermuda**. Bermuda Aquarium, Natural History Museum and Zoo, Bermuda Zoological Society and Friends of the Bermuda Aquarium, 148p.

Thomas, Martin L.H. 2003. **Marine Ecology of Harrington Sound Bermuda**. Scientific Reports of the Bermuda Aquarium, Natural History Museum and Zoo, 49p.

Thomas, Martin L. H. 2004. **The Natural History of Bermuda**. Bermuda Zoological Society, 256p.

Two Halves Publishing. 1997. **Sporty little Field Guide to Bermuda for the Curious and Confused.** Two Halves Publishing, Bermuda, 48p.

Wardman, Elfrida L. [Ed.]. 1971. **The Bermuda Jubilee Garden.** The Garden Club of Bermuda. 349p.

Wingate, David B., 1973, **Breeding Songbirds and Smaller Landbirds of Bermuda**, Poster, Bermuda Press.

Wingate, David B., 1973, **Waterfowl and Larger Landbirds of Bermuda**, Poster, Bermuda Press.

Wingate, David B., 1973, **Terrestrial Reptiles and Amphibians of Bermuda**, Poster, Bermuda Press.

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Note:
a. Entries in **bold** indicate the location of major information sections on that topic.
b. Entries that are underlined indicate the location of important information sections on that topic.
c. Page numbers in **bold** show the location of an illustration of that feature or species.

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