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presents

Coral Reefs of Bermuda

written by

Dr. Martin L. H. Thomas

Project Nature

Field Study Guides for Bermuda Habitats

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Coral Reefs of Bermuda

(Second Edition)

Project Nature

Field Study Guide

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Coral Reefs of Bermuda
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Cover photograph of Rim reef at North Rock
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Foreword

Protected as we are in Bermuda by the world's northernmost coral reef system, we have the opportunity to step, quite literally from our doorsteps, into an environment that has been likened in its biological diversity to the tropical rainforests of the world. I am sure that we have all stood and gazed from the safety of the shore into the crystal clear waters around us, mesmerised by the kaleidoscope of colours beneath; from Sergeant Major fish to Golf Ball corals and Chicken Liver Sponge, the names themselves conveying something of the incredible variety of living creatures to be discovered on the coral reef. Yet at the same time it is perhaps this enormous, and often confusing diversity of species, coupled with a few logistical challenges, that often leaves us overwhelmed and somewhat reluctant to take an exploratory plunge, particularly with a group of inquiring young minds in tow.

Now though, armed with the sixth book in the Project Nature Series, a Guide to the Coral Reefs, such trepidation can be left ashore. Written by ecologist Dr. Martin Thomas, with support from staff and volunteers at the Bermuda Aquarium, Museum and Zoo and the Bermuda Zoological Society, this book is an informative, illustrative, 'hands on' field guide to exploring Bermuda's coral reefs. Adopting the same, wonderfully adaptive approach of other guides in the Project Nature Series, A Guide to the Coral Reefs includes important background information on reef formation and ecological processes, as well as key identifying features of the most common corals, fish and other reef-dwelling creatures. With examples of simple survey techniques and accompanying worksheets offering a valuable framework for field classes, and helpful tips on equipment needs and safety considerations, this guide is an essential tool for those (be it teacher, student, parent or visitor) eager to jump in and explore this dynamic environment.

With most of the world's coral reefs now under threat, A Guide to the Coral Reefs serves to open our eyes, whet our appetite for adventure and exploration, and arm us with a better understanding of the need to protect this beautiful, but fragile environment.

Anne F. Glasspool
Project Leader, Bermuda Biodiversity Project
Bermuda Zoological Society
April 2002

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Jack Ward, Principal Curator of the Bermuda Aquarium, Museum & Zoo paved the way for its production and enthusiastically supported the work. Mary Winchell, former Education Coordinator, actively helped in the planning stages of the production of this guide and is largely responsible for the entire Project Nature series, now comprising six field guides. Liz Nash took on the mammoth task of preparing the manuscript for printing, including setting up the text, assembling all the illustrations and inserting them in the text and producing the final copy for binding. Her dedication to this task ensured that the final product would be most attractive and relatively error free.

Many people have assisted in the background field, library 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: Alan Logan, Anne Glasspool, Lisa Greene, Brian Lightbourn, Bobbii Cartwright, Judie Clee, Wolfgang Sterrer, Margaret Emmott, Penny Hill and Richard Winchell.

The illustrations of the species of plants and animals important in the coral reef ecology 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, and “Bermuda’s Seashore Plants and Seaweeds” by W. Sterrer and A. R. Cavaliere; others were prepared especially for this publication by the author.

Contents

List of Figures

Introduction

The Project Nature series of field guides produced by the Education Department of the Bermuda Zoological Society in cooperation with the Bermuda Aquarium, Museum & Zoo have described the Rocky Shores, Sandy Shores, Wetlands, Forests and Oceanic Island Ecology of Bermuda and have given guidance to their study by school students. In many cases specific field trips have been suggested, along with general information on pre-study planning and associated in-school related activities. In each Project Nature Field Guide the animals and plants most likely to be encountered have been described and illustrated. Each guide is self contained, but often complemented by other publications in the series. For example, the guide to Oceanic Island Ecology gives information on many of Bermuda's ecosystems in the context of describing their origins and development here. The pair covering Rocky Shores and Sandy Shores, together form a good guide to ecosystems found along Bermuda's shorelines.

One of the great attractions of Bermuda are the coral reefs which surround the islands and which together make up the largest ecosystem, apart from the open sea, that is available for study and enjoyment. These reefs are unique in that they lie in an unusually northerly location and show special characteristics resulting from this. The reefs are also unique in that they are in generally excellent condition, having avoided, either through good fortune or management, catastrophic events which have decimated coral reefs elsewhere. Why then have they been left until now as a subject for the Project Nature series? There are several reasons. The first is that the coral reefs are not as generally accessible as the other systems already covered. A trip to a coral reef requires much more advance planning than one to a location along the shore or on land. Additionally, the cost of a trip to an offshore location is much greater, as a suitable boat must be hired. Safety is also a factor; while there are always some hazards in any outdoor work, these are somewhat increased in studies from a vessel, and the availability of help is more distant. To see well developed coral reefs clearly first hand, pupils must wear a face mask and get into the water. What you can see hanging over the side of a boat is multiplied many times over by the use of a face mask, and additionally getting into the water places the student in the aquatic environment of the reef. So to do any detailed study of reefs at all, students and teachers must be reasonable swimmers, feeling at home in the water and possessing a good mask and snorkel. There is no doubt that some personal floatation device such as a body-surfing suit or jacket or a thin wet suit or jacket, make the transition into the water easier and safer. They also keep students warmer, a good feature, since even in high summer many people feel cold after a short immersion in the sea. However, they all add to the cost and may be beyond the reach of some families. Another major factor which has delayed the production of this guide is the sheer complexity of the reefs. As you will see in this guide there is a huge variety of reef types in Bermuda and each of these has a very high diversity of animals and plants living there. This means that numerous species have to be mentioned and illustrated, many more than in the other field guides. This alone makes this guide the biggest undertaking among the guides produced to date.

On the other hand, there are some resources which make the job easier. Because of the general interest in coral reefs and the environment they create, there is a great deal of background information available. While most of this is at an advanced level, aimed at scientists and university students, it does mean that in comparison with other ecosystems in Bermuda, there is a wealth of available literature. This is augmented by a very large body of literature covering coral reefs in other parts of the world. There are two institutions in Bermuda that have played a very large part in gathering information about the reefs. These are the Bermuda Biological Station for Research Inc. (BBSR) and the Bermuda Aquarium, Natural History Museum & Zoo (BAMZ). Both have fostered a great deal of reef research and both have comprehensive libraries housing the results of this work.

There are also several books that summarise much of this information that can be used as background resources for reef studies. One of the main ones of these is "Marine Fauna and Flora of Bermuda" edited by Dr. Wolfgang Sterrer, formerly director of BBSR and now Curator of the Natural History Museum at BAMZ. This large book describes and illustrates all but the least common animals and plants found in Bermuda's marine waters. Dr. Sterrer has also produced two books which present the more common marine animals and plants at a level suitable to the non-scientist. The first of these, "Bermuda's Marine Life", describes the animals and plants of the sea that are most often seen and gives a wealth of interesting information about them. The second book in this series is "Bermuda's Seashore Plants and Seaweeds" co-written by Dr. Sterrer and Dr. R. Cavaliere, which covers the seaweeds and seashore plants in the same lighthearted, but informative manner. In the future, this series of highly useful books will turn to animals and plants of the land. Bermuda's fish species have recently been listed by Smith-Vaniz, Collette and Luckhurst. The basic ecology of marine communities was covered in the book "A Guide to the Ecology of Shoreline and Shallow Water Marine Communities of Bermuda" by Drs. M. Thomas and A. Logan. Another more general book called "The Natural History of Bermuda" by Dr. M. Thomas has been written and is in the process of publication; it should appear fairly soon. Useful sources of information are detailed in the Bibliography at the end of this field guide.

To get some idea of the reef environment without actually going there and to get background information prior to a trip to a reef, the Bermuda Aquarium is a worthwhile visit. At the Aquarium the "North Rock" exhibit is based on the rim reef bordering the North Lagoon at North Rock and many of the other tanks in the display show examples of reef animals. The fish are especially well represented at the aquarium.

In the text, words in **bold** are defined in the glossary at the end. Scientific names are given for the first mention of any species in the text but not for subsequent mentions. An exception to this is the section called 'Plants and Animals Important in Coral Reef Ecology.' Scientific names are used because they provide a reference to that exact species in other writings. Common names can change from place to place, indeed quite a few apply only in Bermuda. Scientific names also give clues to family affinities of organisms and are often are quite descriptive of some feature.

Geological Background

The Origin of the Bermuda Islands

According to the most widely held theory, Bermuda had its origins on the Mid Atlantic Ridge of the Atlantic Ocean about 110 million years ago. This puts Bermuda in the sub-group of oceanic islands called **ridge islands**. The Mid Atlantic Ridge is a largely underwater geological feature running down the centre of the Atlantic Ocean. The Mid Atlantic Ridge is a site of intense geological activity because it lies at the junction between the European and American **tectonic plates**. There are two types of these junctions; at some the surface of the earth is enlarging as molten **magma** from within rises to the surface and solidifies. Such junctions are called spreading junctions. At the other type, one plate slides beneath the another, causing earthquakes and building mountain ranges. The West coast of North America is an example of the second type. Sometimes islands are produced in this situation too; these are called **island arcs** because they often occur in arc shaped groups. Along the Mid Atlantic Ridge, molten magma from within the earth rises to the surface and hardens to form the plates. This is a continuous process and as a result the two plates move slowly apart at about 4 cm/yr. Because of this process, the Atlantic Ocean is steadily enlarging. 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 seamount 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 further volcanic activity; it then went through a second phase of eruption. At this time Mount Bermuda was enlarged to form the Bermuda Seamount, consisting of three volcanic peaks: 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, it would be a hot spot island rather than a ridge island. Recent theories suggest that Bermuda did indeed arise as a **hot spot island** and is therefore much younger than originally thought.

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 500 miles or 800 km 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!

At first the island which became Bermuda would have been a volcanic island and the rock would have been hard, black basalt resulting from the volcanic eruptions. A good model of very early Bermuda can be seen in the island of Surtsey lying off the south coast of Iceland. Iceland itself is on the Mid Atlantic Ridge and volcanic activity there is virtually constant. One large eruption in the recent past produced Surtsey, a new island consisting of dark volcanic rock. Initially, as in the case of Bermuda, Surtsey had no life but as soon as the rock cooled, animals and plants started to colonise this new habitat. However, Surtsey is far to the north of Bermuda in cool waters and coral reefs will never develop there. In the case of Bermuda, the remains of the original volcanic island are now well below the island surface which today consists of light coloured, alkaline limestone rocks and soils, very different from the original dark coloured and acidic basalt.

The limestones of Bermuda have all been formed by biological activity in well lighted, shallow sea water. 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. 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. As explained later, Bermuda lies somewhat further north than where seawater warm enough to support corals generally can be found. Warmer water is transported here from further south by the **Gulf Stream**, 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 first ecosystems developed around Bermuda. They in turn have been important in the creation of many other terrestrial and shallow-water habitats. More details of this are given in the field guide "Oceanic Island Ecology of Bermuda."

Development of Coral Reef Habitats

For reefs to develop the volcanic seamount which became Bermuda did not have to rise above the sea surface. However, the water had to be shallow enough that bright sunlight penetrated to the bottom. It is not likely that vigorous reef growth occurred in water much over 30 m (100 ft) deep. The reason for this will be explored in Biological Background below. There is good evidence, however, that the volcanic island did rise above sea level in the distant past.

Thus, reefs formed on top of the submerged seamount and also around the edges when the seamount extended above water. Low spots in the reefs were more sheltered than the reef-tops and soon filled with calcareous sand produced by a host of animals and plants associated with the reef environment. Further material was added to the sediments by erosion of the reef rock. The whole process of the production of rock and sediment by biological action is referred to as **biodeposition**. In the early days of the production of the limestone cap of Bermuda, biodepositors laid down large quantities of calcium carbonate so that places that were up to at least 20 m (65 ft) deep rose to the surface.

Fascinating as the very early history is it is only the last 900,000 years or so that has been really important in determining the biological character of the Bermuda coral reefs. This period mainly falls in the middle and late part of the **Pleistocene epoch**. The Pleistocene was the time of the last great glaciation on earth when huge ice-caps built up at the poles lowering sea levels world wide by up to 125 m (350 ft). However, during the Pleistocene the climate was not uniformly cold, but rather slowly changing from warm to cold and back again. 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. At this time reefs formed down the flanks of the seamount. Researchers, using submersible vehicles report that their remains can be seen to at least 125 m (350 ft) today. The lowering of sea level was also important in that it exposed reefs previously formed in sea water which were exposed to the air, where they formed parts of the land mass. There they eroded under the influence of wind, rain and blowing sand, thus increasing the quantity of sediments that would form the soils of Bermuda. Most of the land area of Bermuda today is composed either of limestone soil, or limestone rock formed through solidification of sand. This rock is called **aeolianite**. There are however a few places on land where old, former coral reefs are exposed; this is called **reef rock**.

So the coral reefs of early Bermuda were not only the vital forerunners of today's reefs but also were instrumental in forming the land mass and its rocks and soils. All the shallow sea-floor, freshwater and terrestrial habitats found in Bermuda today owe their existence, at least in

Oceanographic and Climatic Background

For coral reefs to develop in the ocean, certain conditions must be provided. The most important of these are shallow water and warm temperatures. Coral reefs do not develop where minimum water temperatures fall much below $18^{O}C$ ($68^{O}F$) and do best at temperatures between $25\text{-}29^{O}C$ ($77\text{-}85^{O}F$). Their upper temperature limit is about $36^{O}C$ ($97^{O}F$). The sea around Bermuda varies from about $18^{O}C$ ($68^{O}F$) in January to $28^{O}C$ ($83^{O}F$) in August. Inshore waters are much more variable with an annual range of about $15^{O}C$ ($59^{O}F$) to $30^{O}C$ ($86^{O}F$). So Bermuda just barely makes it into the acceptable temperature range.

Bermuda lies at a latitude of about $32^{O}N$, the same latitude as Savannah, Georgia on the east coast of the USA. The Georgia coast has no coral reefs and one has to go well south into Florida before they are common. Why then are Bermuda's marine waters so much warmer then those of the nearby east coast of North America? The answer lies in the surface **ocean currents** of the North Atlantic Ocean and the **Gulf Stream** in particular. These currents are illustrated in Figure 1. Just to the north of the equator the trade winds, blowing all year round from the east, push warm surface water towards the west. Much of this water in the North Equatorial Current passes into the Gulf of Mexico where it is confined, and builds up a head, is deflected north and flows out as a very strong current through the Straits of Florida. This warm current carrying the equivalent of all the rivers in the world combined, is the **Gulf Stream**. It flows in a northeasterly direction up the eastern seaboard of the USA passing to the west of the Bermuda Islands. It provides a continual source of warm sea water to the ocean around Bermuda.

This warm seawater also ameliorates the land climate of Bermuda; mean monthly air temperatures vary from $18.5^{O}C$ ($66^{O}F$) in February to $29.6^{O}C$ ($86^{O}F$) in August. However, water temperatures are much more constant than those in air, and minimum air temperatures can drop to just a few degrees above freezing on occasion.

Although Bermuda is an oceanic island, open to the sea on all sides and bearing the brunt of violent weather at times, the outer reefs are seldom damaged by wave action. They have developed in an environment where violent water movement is normal. Indeed some reef types only develop where virtually constant, heavy wave action occurs. On the other hand the reef tracts around the Bermuda Islands offer very good protection to the islands from large ocean waves. Were it not for the reefs, hurricanes and other storms would inflict much more damage than they do. The degree of protection is highest on the north, east and west coasts, where wide areas of reef stretching well out to sea break the force of the waves. Along the south shore, however, where the sea bed slopes steeply into very deep water, the reefs are limited to a narrow coastal band and are less effective as a wave barrier.

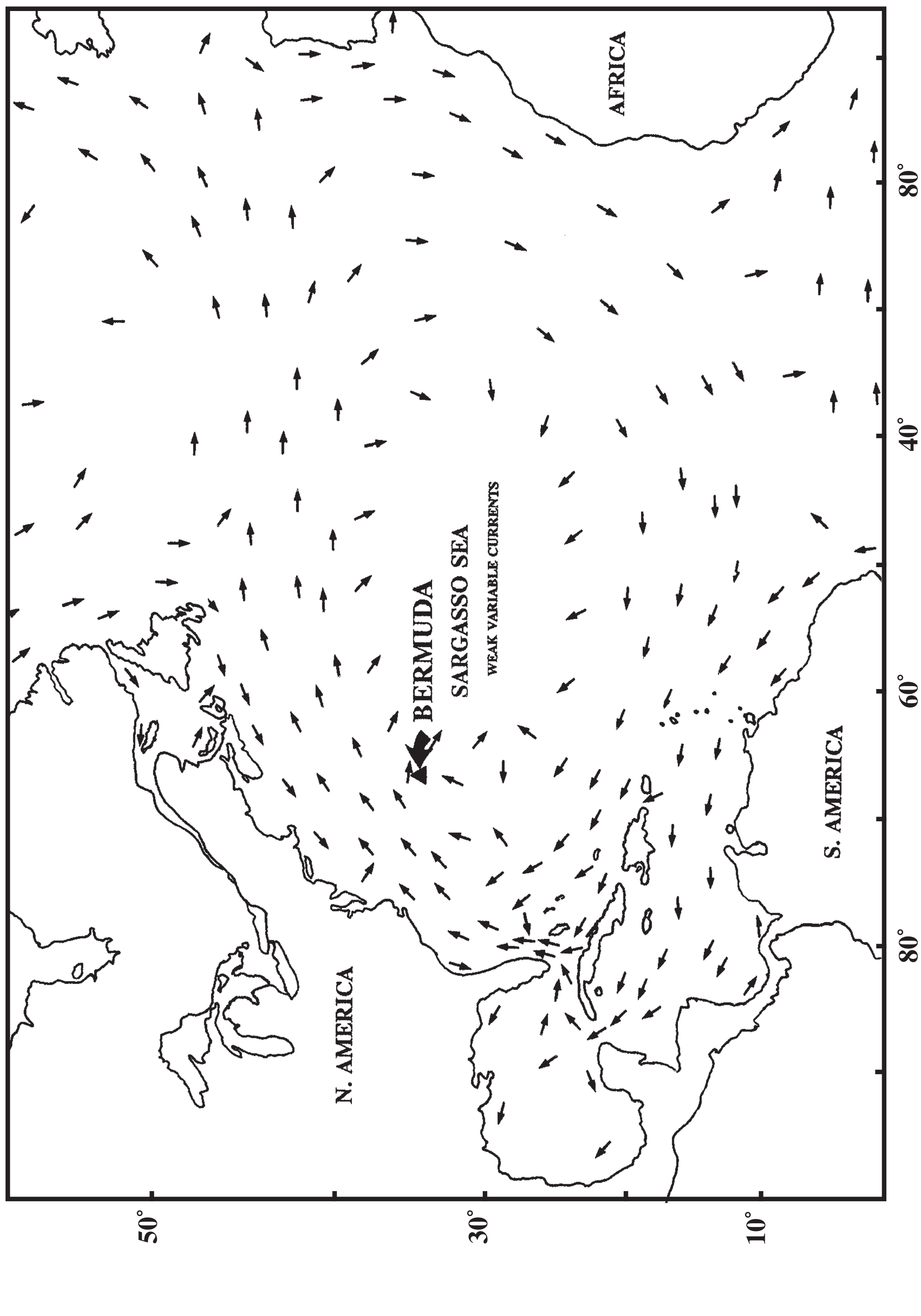


Figure 1. Generalised surface current flow patterns in the North Atlantic Ocean.

Biological Background

Corals and Reefs in General

Corals and their Relatives
Corals are invertebrate animals in the Phylum Cnidaria. Cnidarians, also called coelenterates, are relatively simple animals with tube-like or disc-like bodies; most have tentacles or long filaments that are used in the capture of their food. Examples of groups of **coelenterate** animals are the hydroids, the anemones, the soft corals, the hard corals, the jellyfish and the siphonophores. The last two groups are swimming organisms as adults, whereas the first four groups are usually attached to the bottom or other attached organisms. However, all groups have swimming larval stages. A colonial habit is common. The only group that does not have colonial members is the jellyfish. Hydroids and anemones have both colonial and solitary species; the corals are almost all colonial and the siphonophores are always a highly specialised colony. In the hydroids and corals the individuals, or **polyps**, are often very small, but the colonies can be quite large. This is especially true of the hard corals which can produce massive stony colonies of distinctive shapes.

One interesting property common to all Cnidarians is the presence of highly specialised stinging cells called **nematocysts**. They may be used both for food capture and defense. Stinging cells are usually concentrated on the tentacles or filaments and when stimulated by touch they produce a tiny hollow, finger-like projection that may transfer a very potent poison to the prey or attacker. In most species of Cnidarians this poison can barely be felt by humans, but in some cases it can have severe consequences. In Bermuda, the cnidarian animal of the greatest danger to humans is the siphonophore called the Portugese Man-of-War (*Physalia physalis*). The Portugese Man-of-War trails long purple filaments in the water below the swimming body. These tentacles are loaded with very poisonous stinging cells. This creature is a hazard to swimmers and warnings are posted on beaches when they are present. Even dead ones on the beach can still sting! Corals do not inflict a sting noticeable to humans; however, the Fire Coral (*Millepora alcicornis*), which is not a true coral but a colonial hydroid, does inflict a sharp, non-harmful sting. It is the burning sensation from this sting which gives the Fire Coral its name.

Coral Reef Formation
It is a variety of hard corals and one hydroid that are important in the construction of coral reefs in Bermuda. Soft corals in the form of Sea Whips, Sea Rods, Sea Plumes and Sea Fans are also common on the reef, but do not add to the massive structure. The hard corals all lay down an internal skeleton of **limestone** or **calcium carbonate** at the base of the polyps. This chemical is extracted from seawater which is virtually saturated with calcium carbonate. The location of each polyp is marked by a distinctive pattern on the surface of the limestone, which is termed a **corallite**. These patterns are unique to each species of coral, and often very pretty, and so dead specimens can be identified to species as readily as live ones can. Indeed, because the living tissue of the polyps is thin and almost clear, the patterns in the limestone can be seen readily in most living corals. The individual polyps vary in size from less than a millimeter (1/25 in) to several centimeters (inches) in diameter. Each polyp is built like a short tube with a crown of tentacles at the top. However, by day the tentacles are often withdrawn and cannot be seen. Even when extended they are difficult to see in species with tiny polyps. Limestone is added to the skeleton virtually constantly, more rapidly in summer when growth is faster. If the rock under a coral is cut with a diamond saw, clear growth bands are often visible, much like the annual rings in trees. These are used by coral scientists to determine growth patterns and growth rates and provide a record of growth going back far into the past.

Coral Characteristics
Not only are the patterns left in the limestone rock laid down by corals distinctive, but the shape of the colony is often also very distinctive. Only closely related corals have similar colony forms. Colonies may be large domes, large flattish plates, a series of knobs or fingers, a branching

erect structure, a hollow inverted cone, a small dome or knob, a disc or in some species can be incredibly variable. In Bermuda large dome like structures up to a metre (3 ft) or so across with wavy patterns on the surface are the Brain Corals (*Diploria* spp.), of which there are two species. Large platy corals are usually the Star Corals (*Montastrea* spp.), also with two different species. The Ivory Bush Corals (*Oculina* spp.) form upright branching colonies which are quite delicate as is the Chinese Hat Coral (*Agaricia fragilis*) which forms an inverted cone. The common names are often descriptive of the colony form; the Finger Coral (*Porites porites*) has finger or thumb like projections, whereas the Yellow Pencil Coral (*Madracis mirabilis*) has pencil-like ones. The Golf Ball Coral (*Favia fragum*) is well named as it is a golf-ball sized sphere. Rather than being descriptive of the colony structure the common name may refer to the detailed pattern on the colony surface. This is true of the Starlet Corals (*Siderastrea* spp.), both species of which show a pattern of small stars. Alternatively the name may echo the colour of the coral; the Rose Coral (*Isophyllia sinuosa*) is usually quite colourful and may be white, grey, green, yellow or brown sometimes with highlights of orange or blue! The most variable of form is the Fire Coral which, as explained above, is not a true coral, but a hydroid. It can grow in almost any form from a flat sheet to a branched bush.

The six (or multiples of six) tentacles of hard corals can capture small particles and organisms from the water but unlike most of their near relatives this is not their principal way of getting food. This aspect will be discussed further in Coral Reef Ecology.

The corals of Bermudian reefs all live below low tide level. They are only exposed to the air on freak low tides and generally have a metre (3 ft) of water over them even at low tide. In more tropical locations, other species of corals resistant to exposure to air occur, and the reef top may be exposed on normal low tides.

Other Reef-building Organisms

It must be stressed that hard corals although very important on the reef, are not the only living things that contribute to the reef structure. At least as important as the corals are the **Crustose Coralline Algae**. These are really red seaweeds that grow in a sheetlike 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. Like the corals the crustose coralline algae extract the calcium carbonate from the surrounding seawater, and as they grow it is left behind as solid limestone. In another similarity to corals, this limestone of algal origin, may show growth lines. 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 or 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 Bermuda the crustose coralline algae are, on the average, somewhat more important than the corals in terms of limestone production.

Physical Diversity on Coral Reefs

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.

Bioconstruction and Bioerosion

The biological process in which massive limestone rock is laid down by living organisms is called **bioconstruction**. Although the corals and crustose coralline algae are the main bioconstructors on the coral reef, there are many other contributing organisms. Notable among these are some bivalve molluscs such as the Rock Scallop (*Spondylus ictericus*), which cements its lower shell to the rock surface. The molluscan contributors also include the worm shells (Vermetidae), which are snails that live a **sedentary** life with the shell cemented to the bottom. Also important is a protozoan animal, the Red Foraminiferan (*Homotrema rubrum*), which lives in reef cavities but also has a hard skeleton of calcium carbonate.

When reefs are on the increase, bioconstruction is a dominant process, but under stable conditions, bioconstruction is balanced by **bioerosion** or the removal of reef rock by living organisms. Many grazing and boring animals and algae do this, but the most obvious are the parrot fish (Scaridae). These fish with their parrot-like beaks can scrape away at the surface of the reefs to get their algal food. They gouge right into the crustose coralline algae leaving characteristic grazing marks. Also important as bioeroders are boring animals and plants including some barnacles, bivalve molluscs, sponges and blue-green cyanobacteria.

Coral Reefs help to Create Other Ecosystems

While reefs are important in their own right it must be pointed out that they are important in creating other environments and ecosystems. Reefs are usually surrounded by sedimentary areas that support their own community of organisms. Examination of these sediments shows that they are derived from reefs. Parrot fish 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.

Reefs where Corals are Uncommon or Absent

As a finale to this section it must be pointed out that as important as corals are in reef construction, they are not universally present. The role of reef construction in the boiler reefs of the south shore is principally taken by Worm Shells (Vermetid Gastropod Molluscs) and Crustose Coralline Algae. The bulk of the limestone rock deposited in these reefs is made up of tiny worm shells, with crustose coralline algae also being very important. 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. Boiler reefs take the form of very large wine-glass shaped structures with the rim at low tide level. Each reef may be up to about 30 m (100 ft) across and at least 10 m (30 ft) in height. Often they join together forming very large complex groups. 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.

Coral Reef Organism transportation to Bermuda

The importance of the Gulf Stream in giving warm sea water and a sub-tropical climate to Bermuda has already been stressed. This warm current not only gives these attributes, but also carries organisms, mostly marine, but also floating, terrestrial material to the shores of the islands. It is not surprising that the naturally occurring living organisms of Bermuda resemble those of the marine environments of the Caribbean and central America. There is no doubt that the vast majority of the coral reef organisms of Bermuda got here in this way. Thus the coral reef fauna and flora is almost all **native**. This is in contrast to the terrestrial situation where the majority of the fauna and flora are **introduced** by man. A very few reef organisms may have been introduced on the bottoms of ships but they are not prominent.

After passing Bermuda the Gulf Stream flows to the NE, eventually crossing the North Atlantic Ocean and affecting the climate of Great Britain and western Europe. In doing this it carries material picked up in its passage around Bermuda. Most living organisms die as the current cools to the north, but some examples, such as mangrove seedlings, survive the crossing. In this way, organisms can be transferred across entire oceans. However, there is no evidence that coral reef organisms could survive such a journey.

Although Bermuda has this constant supply of Gulf Stream water from the south, the islands can still be considered to be very isolated. Few organisms can survive the journey from their distant origins, others have no swimming stage and many cannot survive the somewhat colder conditions in Bermuda. A good example are the corals which reach their northern limit in Bermuda and show a much lower species diversity here than further south, even though most have swimming larvae that could survive the journey.

Development of the Coral Reef community in Bermuda

There is very little direct evidence that shows the nature of early reefs in Bermuda. However, it is known that the influence of the Gulf Stream has been present for a long time. Additionally the corals are an old group of animals and the species present in the Caribbean have been there a very long time. It is likely therefore that the early reefs closely resembled those of today and had the same principal species. Of course some reefs died as sea levels rose too fast for them to keep up and others were exposed to the air as sea levels fell; however, the constant supply of larval material in the Gulf Stream meant that new reefs could be established relatively quickly and would resemble earlier examples.

Ecology of Bermuda's Coral Reefs

Coral Reef Ecology

Basic Energy Acquisition

The two main factors in energy acquisition by corals were briefly mentioned above. These were, firstly, that although corals have tentacles with stinging cells and can catch small organisms and particles with them, this was not their main feeding method. The second and more important point was that crustose coralline algae and corals share a common method of obtaining basic food energy. This method is **photosynthesis**. Photosynthesis is the process by which pigmented plants use the energy of the sun to build organic compounds from inorganic components. Stated very simply, the sun's energy is used to combine carbon dioxide and water to form a carbohydrate. Carbohydrates and other organic compounds are the food of all organisms except the pigmented plants. Animals and un-pigmented plants then break these organic compounds down to release energy, and carbon dioxide is produced at the same time. Since corals are animals, how can they use a plant method for energy acquisition? The answer lies in the phenomenon of **symbiosis**, or the combination of two organisms living together for their mutual benefit. Corals and some other Cnidarians have developed some of the most sophisticated examples of symbiosis found in nature. Were it not for this, coral reefs would not exist, as the food supply in tropical oceans is at too low a level to support such vast ecosystems.

In corals the two organisms involved are the coral itself and a microscopic, single celled brown alga. If you look at corals this brown colour 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 is required for photosynthesis but some inorganic nutrients, particularly nitrogen, phosphorus and a range of trace elements are also needed. The corals grow up toward the surface where the light readily penetrates their transparent tissues. The carbon dioxide used by the zooxanthellae to synthesise organic compounds is released in the respiration of the corals or absorbed from seawater. The corals also supply the nutrients, which they get by capturing small organisms and particles on their tentacles and breaking them down in the process of digestion. Zooxanthellae may also absorb some elements directly from sea water. So the zooxanthellae are provided with light, carbon dioxide, nutrients and protection and can grow freely. In this system they produce more organic compounds than they need themselves and the balance is available to the corals. In fact, it is known that the corals can regulate the output of the zooxanthellae and even dictate the organic compounds produced. 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.

Biological Productivity in Tropical Waters

To appreciate the importance of this system it is helpful to look at the basic ecology of tropical oceanic surface waters. Just a mile or so beyond the reefs the oceanic water is very clear and of a deep blue colour. This is because there are virtually no small organisms or **plankton** there to impede light penetration. Such water is very unproductive, meaning that very little photosynthesis is going on, and without this there is very little food for animals. Consequently the whole food web is very limited. Why is this so? There is obviously lots of light and the temperatures are warm. The answer lies in the lack of essential inorganic plant nutrients. As plants grow they take up these nutrients and combine them into body substance. When an organism dies these nutrients are released and recycled. However, in warm tropical waters the thin layer of well lighted surface water does not mix with the cooler, deeper water beneath. Thus, anything that dies tends to sink into the dark, deeper water where it decomposes, keeping nutrients contained at depth. Whilst in cooler, temperate waters, deep and surface waters mix in a seasonal cycle and the nutrients are regularly replenished, in the tropics, such mixing occurs only rarely. However on the coral reefs, the symbiotic relationship between the corals and the zooxanthellae overcomes the problem of nutrient lack, since the essential nutrients are efficiently recycled within the coral body.

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 extends well beyond the reefs, as organisms and other products from the reefs spread into adjacent shallow waters. 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. One possible culprit is sediment in the water which will settle out on to the surface of the corals. This sediment has to be removed; corals trap it in mucus which they secrete, and then move 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. This uses energy and in large flattish corals can be a significant factor. The quantity of sediment increases in the water the closer we move toward shore, and if you study coral distribution it is immediately apparent that large flat or domed coral colonies are most common on the offshore reefs where sediment is less of a problem. As we move to inshore locations the most common corals are smaller species with knobby, finger-like or branching growth forms. These coral can shed sediment much more readily than the larger flatter ones. An interesting example of this is Castle Harbour which before the dredging to build the airport during the Second World War, had very clear water for a coastal location, and a good population of large Brain Corals. 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. This 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 by the presence of warm shallow water.

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.

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 coralyticum*. 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.

Soft Corals on the Coral Reef
Although the hard corals along with the crustose coralline algae are the reef builders, there is 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. 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.

Reef Food Webs

Food webs show the feeding interrelationships among a group of organisms. At the base of the food web are the organisms that can synthesise organic compounds from inorganic ones using the energy of sunlight. This energy is then passed through the food web by the feeding process. The organisms at the base are the **primary producers**; feeding on them are the **herbivores** whilst the **carnivores** feed at the top of the food web. There may be several levels of carnivores starting with first order carnivores, which are eaten by second order carnivores and so on. In the sea, third order carnivores are common, whereas on land there are generally only second order carnivores. Of course not all organisms fit into these basic levels. **Omnivores** are those that eat at a variety of web levels. Humans are omnivores as are lobsters on the reef. Because energy is lost at each step of the web, the largest mass of organisms is at the base of the web and the smallest mass at the top. Another tricky group in terms of feeding relationships are the **detritivores**. **Detritus** consists of particles of non-living organic material in the water and is a major food source on the reef. Detritus is produced when organisms die and decompose, but it is also produced by living organisms as partly digested food, or as mucus used to protect delicate tissues. Corals can produce large quantities of mucus and its role in sediment removal has already been mentioned. **Biomass** is the term given to the weight of organisms. All organisms within the food web are dependant on the primary producers at the base.

On the reef the main primary producers are the crustose coralline algae and the zooxanthellae within the corals. Together they comprise the majority of the biomass on the reef. These principal producers are augmented by other algae (seaweeds) on the surface of the reef and plant plankton or **phytoplankton** in the water. There are also a few other animals with zooxanthellae. Corals themselves are difficult to place in the food web. They are principally herbivorous since they get the bulk of their food from the zooxanthellae; however, as explained above they can also feed on minute plants and animals in the water. Strictly speaking they are omnivores. The reef herbivores are a very diverse group. Certainly a major group of herbivores are the parrot fish and a few other herbivorous fishes. Snails are also herbivores as are sea urchins. Omnivores which eat partly plant food and partly animal food are very common and include lobsters, crabs, several fish and some worms. **Detritivores** are really specialised omnivores since the particles they consume can come from any living source. Most of the detritivores on the reef are **filter feeders** which strain the sea water to obtain their food. There is a huge variety of filter feeders on and around the reef. The soft corals all feed in this way as do the sponges, hydroids, sea squirts, bivalve molluscs, worm shells, some fish, most larvae in the water, most **zooplankton**, barnacles, many worms, the corals to some extent and several other minor groups.

The main carnivores of the reefs are certainly fish. Top carnivores found on the reef are such fish as the Great Barracuda (*Sphyraena barracuda*), various groupers, the odd shark and many others. There are also carnivores among the plankton in the water over the reef.

Reef Diversity

Diversity or **biodiversity** as it is commonly called refers to the number of different species of animals and plants in an ecosystem or natural community. Biodiversity has been shown to

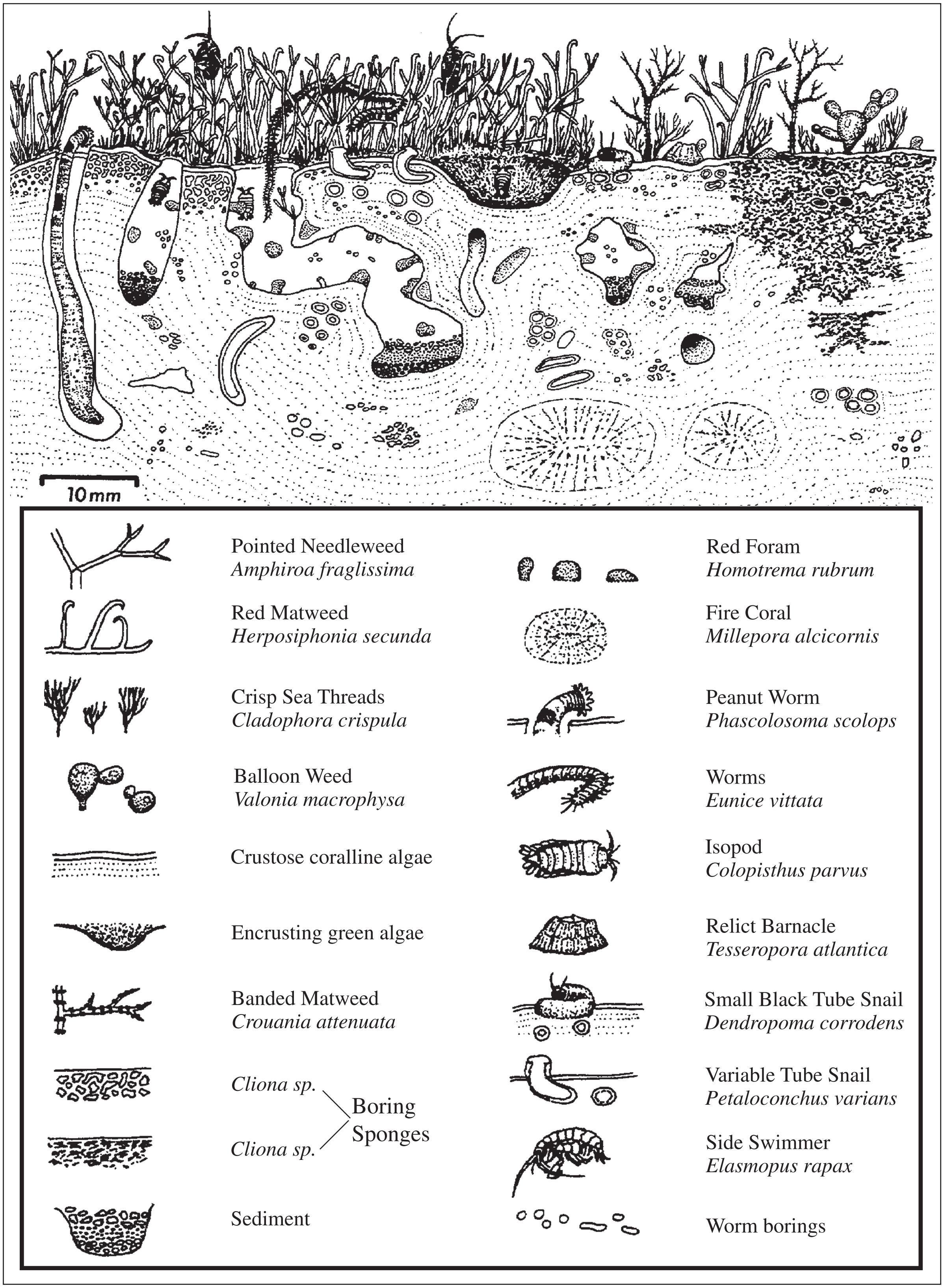


Figure 2. Cross section of constructional lip-cup reef lip surface to a depth of about 40 mm showing epi- and endo-biota. Note the presence of abundant *Homotrema rubrum* and layered sediments in most of the void spaces.

be a good indicator of the stability or overall health of a biological system. Stress on a natural system reduces the biodiversity and also lowers stability, or the systems ability to respond to natural variability. Grossly polluted systems have very low biodiversity as do those in very physically unstable environments, for example mobile sand dunes. Natural ecosystems with very high biodiversity include coral reefs and tropical rain forests. Both of these are very biologically productive, very stable and have incredibly high biodiversities. Such systems also typically have effects that stretch far beyond their boundaries. Tropical rain forests affect climate and the gaseous make up of the atmosphere. Coral reefs result in huge areas of tropical ocean, that would normally be quite barren, being highly productive.

It is easy to see evidence of the biodiversity of coral reefs if you visit one, particularly if you get in the water with a mask and snorkel, so that you can appreciate small details as well as the big picture! The great variety of corals and soft corals is readily apparent as is the presence of a very large variety of fish, often in large numbers. Closer inspection will show a host of smaller animals and plants on the surface of the reef. These will include molluscan shellfish such as the Rock Scallop and several different worm shells. However, we should appreciate that the largest variety of reef inhabitants will not be visible to the naked eye. Looking even more carefully will reveal large numbers of cavities in the rock as well as the presence of burrow mouths that contain living organisms. An example of the latter is the Boring Barnacle (*Lithotrya dorsalis*) that even penetrates living corals and shows up as a dark slit in the smooth coral surface. Swimming around you will also be able to see large cave-like cavities in the reef sides that harbour a special community that lives in dimly lighted conditions. If you visited a reef at night a whole host of creatures not seen by day will be apparent. The water over the reef also contains a wide variety of microscopic organisms including phytoplankton, zooplankton and a host of planktonic larval forms. The number of different species present on a typical Bermudian coral reef is in the thousands and our reefs are not nearly as biodiverse as those in more tropical locations. A single coral head analysed in detail could show the presence of hundreds of different species. Figure 2 shows a cross section of a boiler reef edge in Bermuda detailing the tiny species of fauna and flora. Most of those seen in this diagram would not be visible to the naked eye.

The animals and plants described below will be limited to those that can be readily seen. To cover all the species present would require a large book

The Variety of Coral Reefs in Bermuda

The main distribution of reefs around Bermuda is shown by the dark areas on the map in Figure 3. A cross section of the Bermuda Platform shown in Figure 4, 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 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.

The deepest reefs of the fore reefs 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 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.

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. 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 (*Diploria strigosa*), the Small Star Coral (*Montastrea annularis*), the Ten-ray Star Coral (*Madracis decactis*) and the Mustard Coral (*Porites astreoides*). Soft corals are common as is the Vase-shaped Sponge, *Callyspongia vaginalis*. Figure 5 shows the main terrace reef at a depth of 30 m (100 ft) to the north of North Rock.

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.

A drawing of rim reefs at the locality we suggest for a visit appears in Figure 6. 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 (*Porites astreoides*). 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 the 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 parrot fish being especially abundant.

Lagoonal Reefs

There is a wide variety of 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

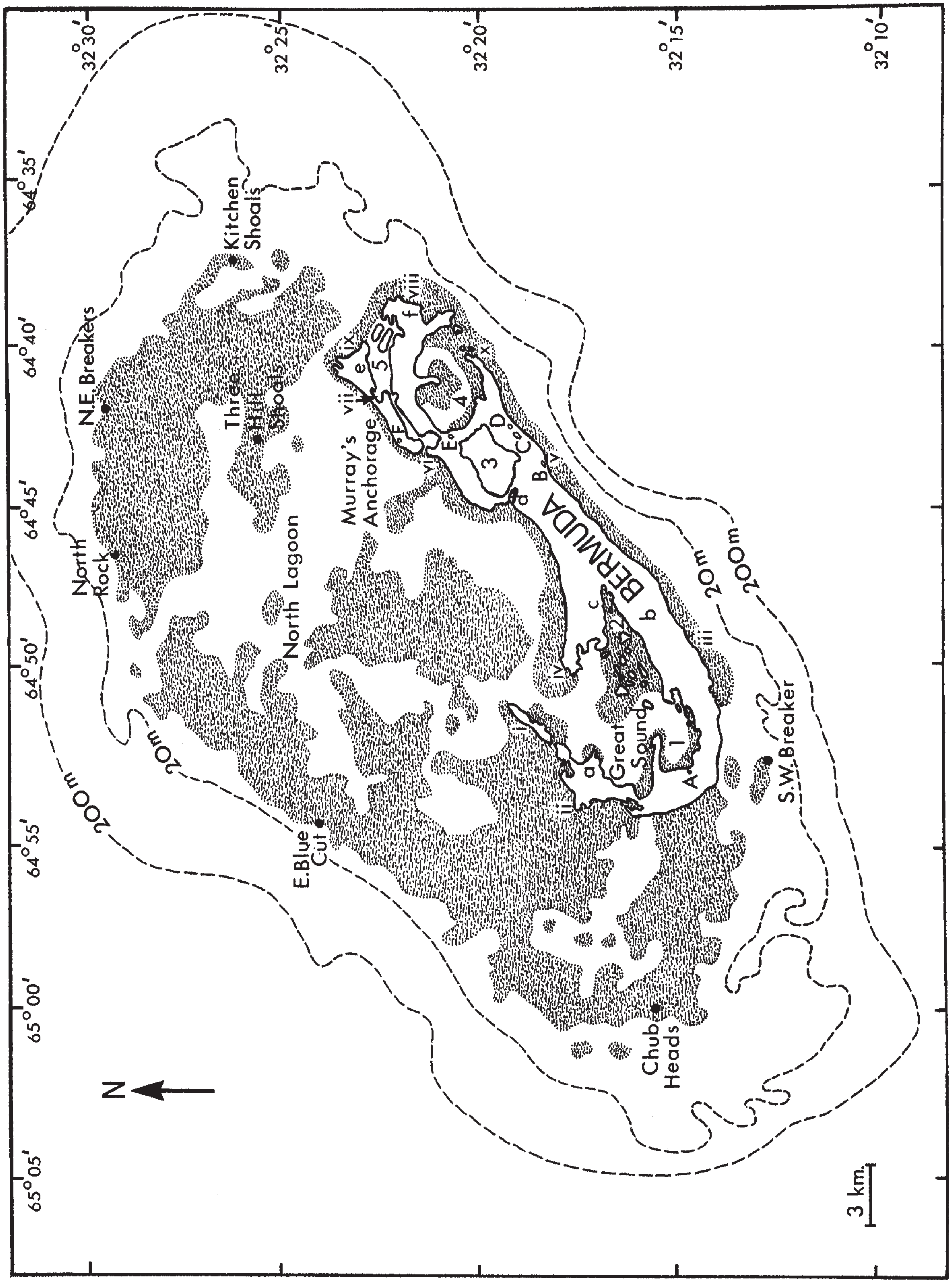

N.E. Breakers
North Rock
Kitchen Shoals
Three Hill Shoals
North Lagoon
Murray's Anchorage
BERMUDA
Great Sound
S.W. Breaker
E. Blue Cut
Chub Heads
20m
200m
3 km.
N
32°30'
32°25'
32°20'
32°15'
32°10'
64°35'
64°40'
64°45'
64°50'
64°55'
65°00'
65°05'

Figure 3. Map of Bermuda showing important landmarks and the main locations discussed in the text.

Key to Figure 3

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)

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.

Linear Reefs

These are elongated low reefs in shallow-water that follow ridges in the sea bed. 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. More 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 fairly common on the Knob and Pinnacle Reefs. Corals are not abundant on these reefs and cover only about 12% of the rock surface. However there is a wide variety of red, green and brown seaweeds which are of considerable interest.

Cup Reefs

As mentioned above, 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 tube snail (Vermetids) found commonly on the sea shores. Consequently these reefs are referred to as **Algal-Vermetid Reefs**. The tube 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 (yd^2). Together the algal mass and snails embedded in it form a very hard limestone. Cup Reefs are difficult to observe and 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. 7), 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 7 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 7. 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.

Other Reefs

The only other reefs found in Bermuda that are constructed by organisms are a few reefs off Spanish Point that are made up almost entirely of vermetid snails. However, the species of snail constructing these reefs differs from the one helping to construct the boilers. The **Vermetid Reefs** are constructed by the Large Tube Snail (*Serpulorbis decussatus*). This snail 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.

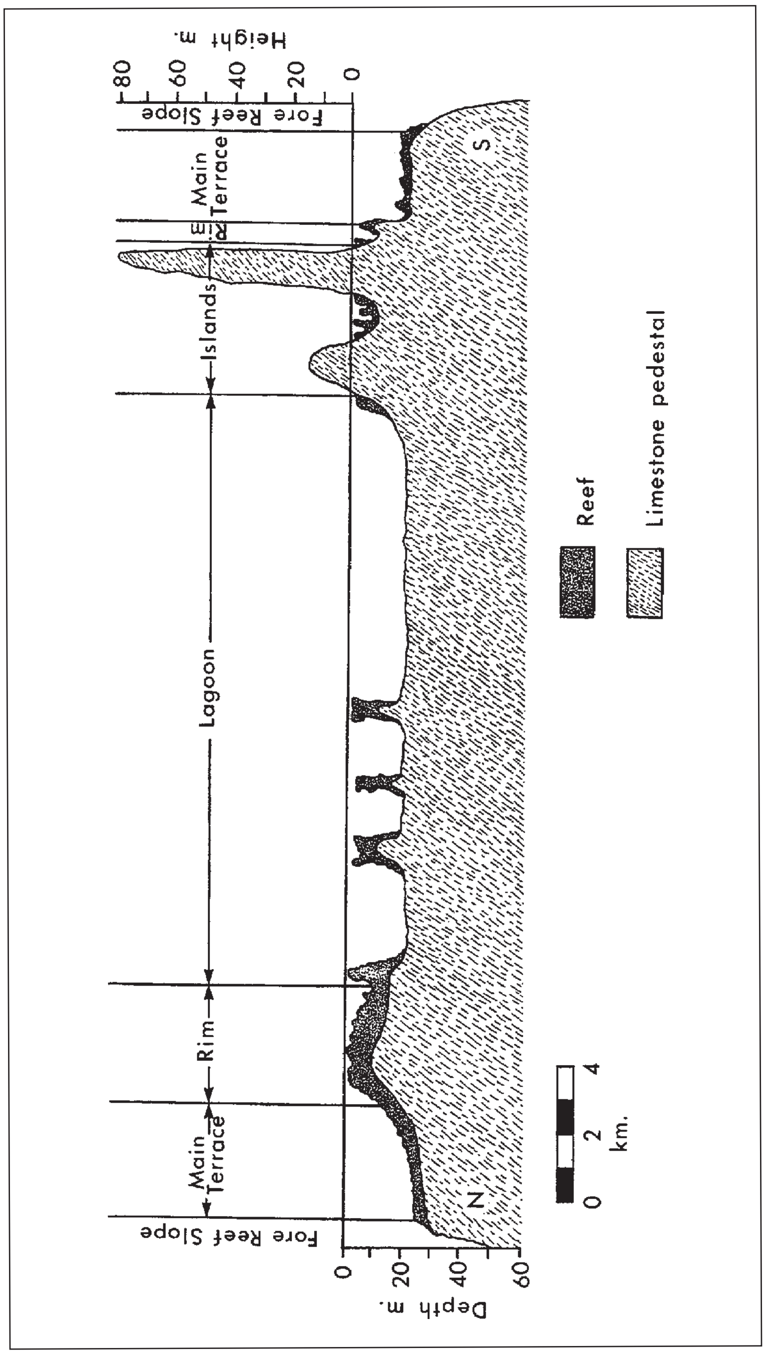


Figure 4. Cross section of Bermuda showing the main physiographic regions. Note the height of land in relation to the depth of water in the lagoon, a feature which differentiates it from true atolls.

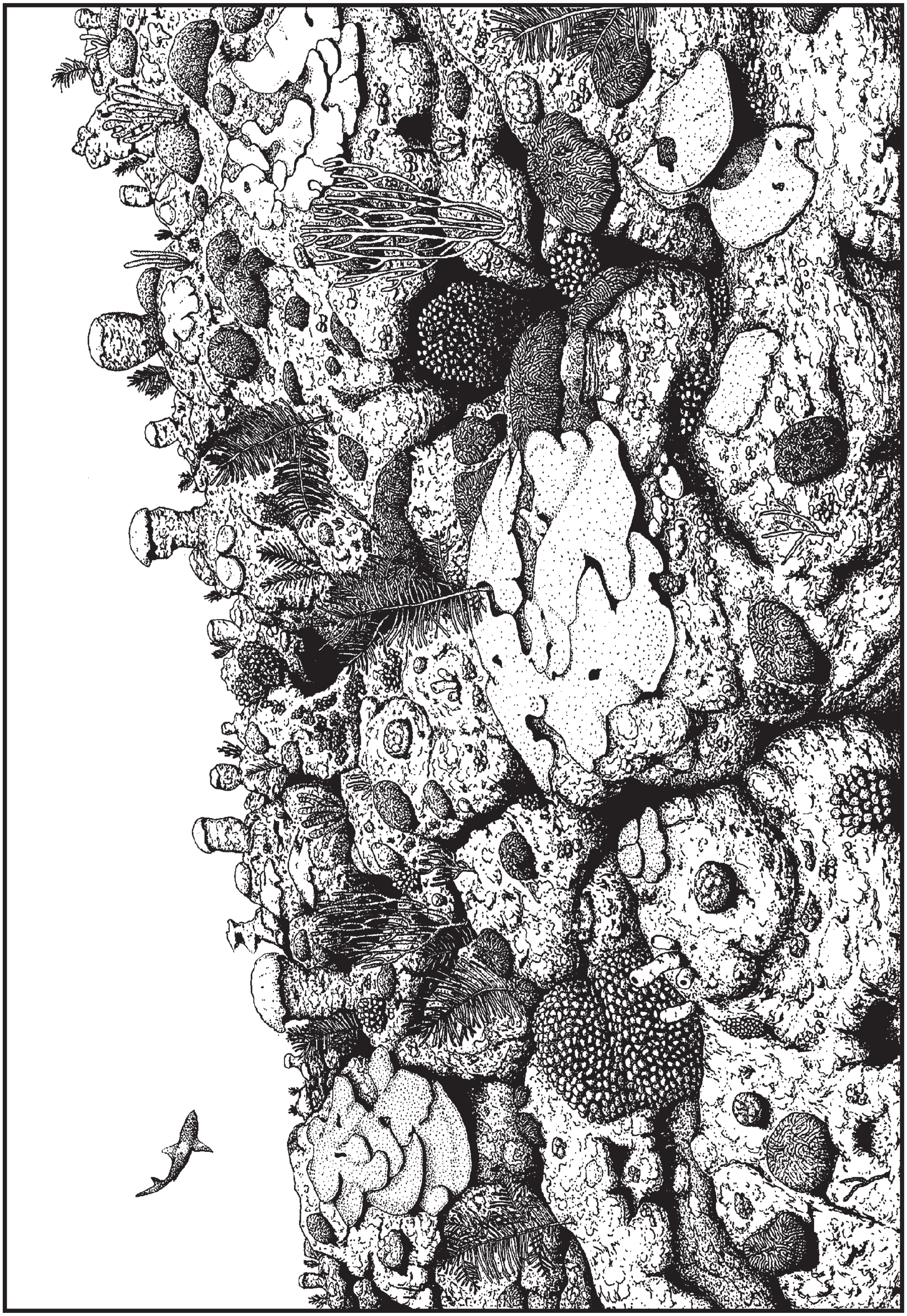


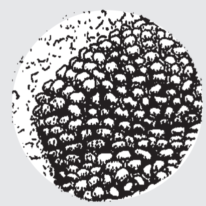
Figure 5. Typical three-dimensional substrate of fore-reef slopes at 30 m depth north of North Rock beacon, with domal *Diploria* spp., platy *Montastrea annularis*, branching *Madracis decactis* and gorgonaceans.

Key to Figure 5

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
Callyspongoa vaginalis

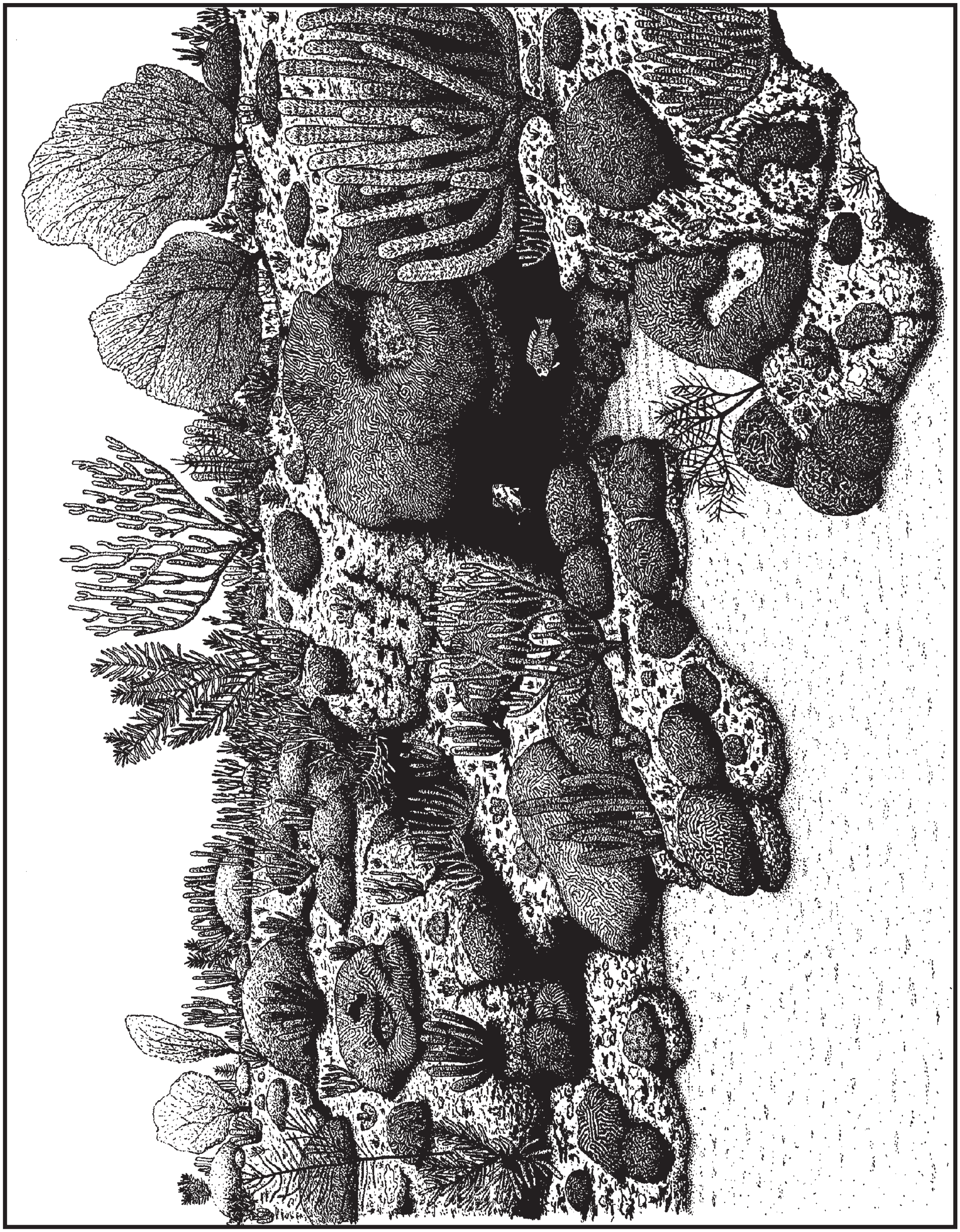


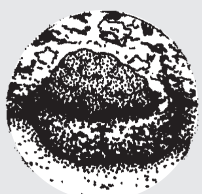
Figure 6. Underwater landscape of corals (mainly species of *Diploria* and *Porites astreoides*) and gorgonaceans, with small and large cavities, on rim reefs at North Rock, at a depth of 8 m to base of sand channel

Key to Figure 6

Double-ridged Brain Coral
Diploria labyrinthiformis

Common Brain Coral
Diploria strigosa

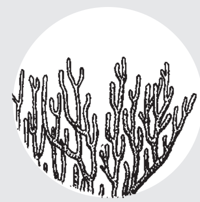
Mustard Coral
Porites astreoides



Star Coral
Montastrea spp.

Purple Sea Fan
Gorgonia ventalina

Porous Sea Rod
Pseudoplexaura



Dark Sea Rod
Eunicea tourneforti

Sea Plume
Pseudopterogorgia americana

Parrotfish
Scarid spp.

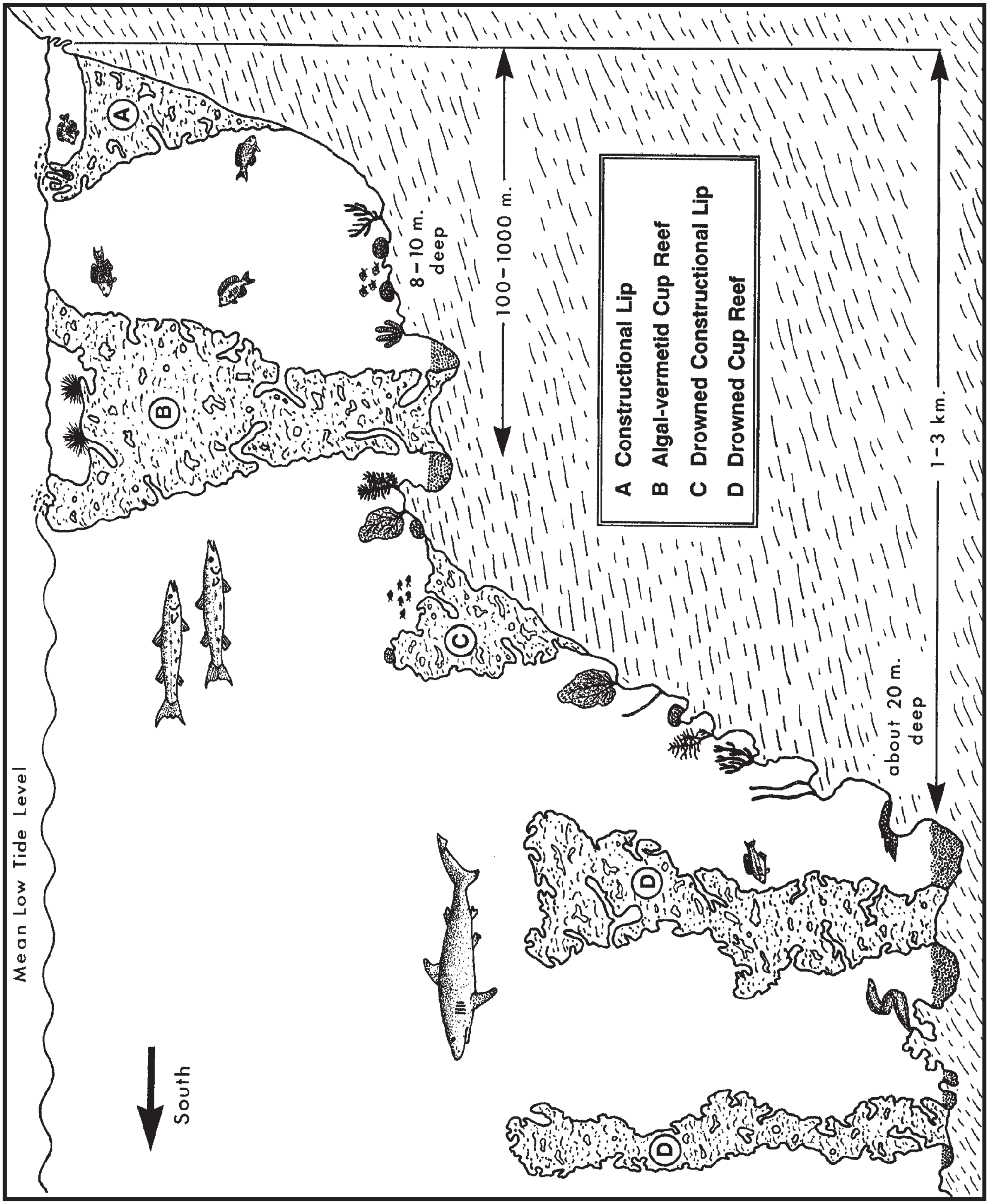

Mean Low Tide Level
South
A
B
C
D
D
8–10 m.
deep
100–1000 m.
about 20 m.
deep
1–3 km.
A Constructional Lip
B Algal-vermetid Cup Reef
C Drowned Constructional Lip
D Drowned Cup Reef

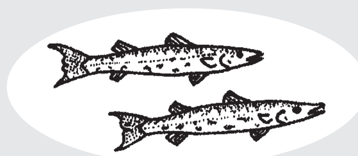
Figure 7. Idealised representation of present and former constructional lips and cup reefs on the south shore. Note sparse coral fauna, bioeroding fish and urchins and the porous nature of the reefs.

Key to Figure 7

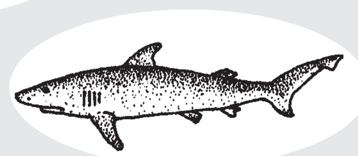
Burrowing Urchin
Echinometra lucunter

Branching and fan gorgonaceans

Great Barracuda
Sphyraena barracuda



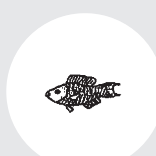
Bermuda Dusky Shark
Carcharhinus galapagensis



Moray Eel
Lycondontis sp.

Doctorfish
Acanthurus chirurgus

Parrotfish
Scarid spp.



Reef Fish Ecology and Behaviour

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.

The Importance of Grazing

If you snorkel over the healthy rim reef at North Rock you will notice that there are few or no large, upright, fleshy 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. It would become a seaweed forest with greatly reduced diversity, productivity and stability. The growth of seaweeds on coral reefs is normally kept in check by grazing animals. The most important group of these are the parrotfish. The parrotfish were mentioned before in relation to sediment production from the reef, but seaweed grazing is, perhaps, a more critical role. 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 declined to marine wastelands. Another aspect of grazing is that many of the crustose coralline algae need to be grazed to release their spores by which means new plants start and these important plants spread to new areas.

Generalist Fish found both on Coral Reefs and Elsewhere

There is 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 commonest 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 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; however, in the absence of such locations, a flat rock or even a sandy location is used. The area cleaned may be up to1 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.

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. 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 important ecologically group of fishes in all tropical waters. Parrot fish 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 chrysopterum*), 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, are a 30 cm (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. The one that you will probably notice first is 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. Other fish in this group occur on the reefs and will be discussed below.

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 both 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, that frequents bays and shallow water as well as further out, 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. 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! 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 that eat sponges as the principal diet item; 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 behavior 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. The Blue Angelfish is another species that moves further out from shore as they get older and so those on the rim reefs are usually quite large.

Specialist Fishes of the Reefs

The widest variety of fishes is found on and around the reefs, and most locations have excellent populations. Outstanding fish observing locations 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, especially in Bermuda. 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.

A really unique 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 to make 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 behaviors. 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 stalk with herbivorous fishes, particularly the parrot fish. In this case, they are exploiting the fact that other fishes do not move away as parrot fish approach, since parrot fish would never attack. In another tactic, they may lie on their sides on a sandy piece of bottom. At any rate, Trumpetfish usually get their intended prey; they are the most refined predator on the reef.

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 eel-like fish have a reputation for biting, but are actually very retiring and would only bite if their lair was threatened. Moray Eels hunt mainly by smell but are very efficient predators; other fish have learned this, and groups of other 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 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 group. The Coney reaches about 25 cm (10 in) long. The Coney is a prized food fish now that larger groupers have been fished to low numbers (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.

At the start of this section, the critical role of the grazing fish in maintaining reef health was stressed. The key group of fish in this process are the parrot fish, although damselfishes also play a part. Parrot fish, 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 change through 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 parrot fish 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. Parrot fish 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.

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 parrot fish 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 Fish 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 meshes. 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 but 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 overfished 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 death of corals and other reef fauna. The entire reef diversity declines rapidly and reefs come to resemble algae-filled wastelands!

Groupers are a prized table fish and many species have been reduced to low numbers. In the past, Black Rockfish 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. Some, such as the Mutton Hamlet, Gag and Tiger Grouper are now locally extirpated.

Plants and Animals Important in Coral Reef Ecology

List of Species Mentioned and/or Illustrated in this Guide

Key to Habitat Codes					
B	=	Lagoons, Bays and Coastal Waters	R	=	Rocky Shores
C	=	Coral Reefs	SG	=	Seagrass Beds
O	=	Open Oceans	SP	=	Saltwater Ponds

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 show where the organisms are commonly found. The illustrations following the list are in the same order as the list and are also accompanied by habitat codes.

Common Name	Scientific Name	Taxonomy	Habitat Code
Black Band Disease	Phormidium corallyticum	Blue-green Cyanobacteria	C
Black Sea Threads	Cladophora catenata	Seaweeds - Green Algae	B, R
Common Sea Kale	Anadyomene stellata	Seaweeds - Green Algae	B, R
Crisp Sea Threads	Cladophora crispula	Seaweeds - Green Algae	R
Grape Sand Moss	Caulerpa racemosa	Seaweeds - Green Algae	B, SP
Horsetail Sand Moss	Caulerpa verticillata	Seaweeds - Green Algae	B
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
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
Laurence's Tufted Weed	Laurencia papillosa	Seaweeds - Red Algae	B
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
Siphonweeds	Polysiphonia spp.	Seaweeds - Red Algae	B, C, R
Soft Spineweed	Acanthophora spicifera	Seaweeds - Red Algae	B
Red Foraminiferan	Homotrema rubrum	Foraminiferans	C
Blue Bleeder	Pseudoceratina crassa	Sponges	B, C
Chicken Liver Sponge	Chondrilla nucula	Sponges	B, SP
Green Boring Sponge	Cliona caribbaea	Sponges	B
Lavender Anemone Sponge	Niphates erecta	Sponges	B, SG
Orange Boring Sponge	Cliona dioryssa	Sponges	B, C
Vase Sponge	Callyspongia vaginalis	Sponges	C
Fire Coral	Millepora alcicornis	Hydroids and Coral-like Hydroids - Coral-like Hydroids	B, C
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
Ten-ray Star Coral	Madracis decactis	Corals	C
Yellow Pencil Coral	Madracis mirabilis	Corals	B, C
Brown Sea Anemone	Lebrunia danae	Anemones	B, C
Brown Sea Mat	Palythoa variabilis	Anemones	B, C
Coral Anemone	Discosoma sanctithomae	Anemones	C
Green Sea Mat	Zoanthus sociatus	Anemones	B, C
Purple-tipped Sea Anemone	Condylactis gigantea	Anemones	B, C
Ringed Anemone	Bartholomea annulata	Anemones	B, C, SP
Boring Barnacle	Lithotrya dorsalis	Crustacea - Barnacles	C
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
Locust or Slipper Lobster	Scyllarides aequinoctialis	Crustacea - Lobsters	B, C
Spiny Lobster	Panulirus argus	Crustacea - Lobsters	B, C
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
Corroding Worm Shell	Dendropoma annulatus	Gastropoda - Snails	C, R
Flamingo Tongue	Cyphoma gibbosum	Gastropoda - Snails	C
Large Tube Shell	Serpulorbis decussatus	Gastropoda - Snails	R
Black Date Mussel	Lithophaga nigra	Clams and Mussels	B, C
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
Reef Squid	Sepioteuthis sepioidea	Squids and Octopuses - Squids	B, C
Common Octopus	Octopus vulgaris	Squids and Octopuses - Octopuses	B, C
Burrowing Rock Urchin	Echinometra lucunter	Echinoderms - Sea Urchins	C, R
Longspine Sea Urchin	Diadema antillarum	Echinoderms - Sea Urchins	C
Orange Sea Squirt	Ecteinascidia turbinata	Sea Squirts	B, SP
Purple Sea Squirt	Clavelina picta	Sea Squirts	B, SP
Green Moray	Gymnothorax funebris	Fish - Moray Eels	C
Purplemouth Moray	Gymnothorax vicinus	Fish - Moray Eels	C
Spotted Moray	Gymnothorax moringa	Fish - Moray Eels	C
Longspine Squirrelfish	Holocentrus rufus	Fish - Squirrelfishes	B, C
Squirrelfish	Holocentrus ascensionis	Fish - Squirrelfishes	B, C
Trumpet Fish	Aulostomus maculatus	Fish - Trumpetfishes	C
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
Sharksucker or Remora	Echeneis naucrates	Fish - Remoras	B, O
Grey Snapper	Lutjanus griseus	Fish - Snappers	B, C

Bermuda Bream	Diplodus bermudensis	Fish - Chubs and Breams	B
Bermuda Chub	Kyphosus sectatrix	Fish - Chubs and Breams	B
French or Yellow Grunt	Haemulon flavolineatum	Fish - Grunts	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
Spanish Hogfish	Bodianus rufus	Fish - Wrasses	B, C
Yellowhead Wrasse	Halichoeres garnoti	Fish - Wrasses	B, C
Great Barracuda	Sphyraena barracuda	Fish - Barracudas	B, C, O
Blue Tang	Acanthurus coeruleus	Fish - Surgeonfishes	B, C
Doctorfish	Acanthurus chirurgus	Fish - Surgeonfishes	B, C
Ocean Surgeonfish	Acanthurus bahianus	Fish - Surgeonfishes	B, C
Queen Triggerfish	Balistes vetula	Fish - Triggerfishes	B, C
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
Blue Parrotfish	Scarus coeruleus	Fish - Parrotfishes	B, C
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
Loggerhead Turtle	Caretta caretta	Turtles and Terrapins - Turtles	B, C, O, SG

Species Illustrations and Descriptions

Blue-green Cyanobacteria

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**.

Seaweeds

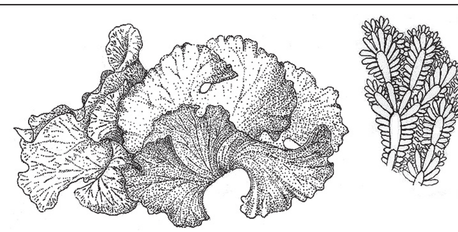
Green Algae

B, R

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.**

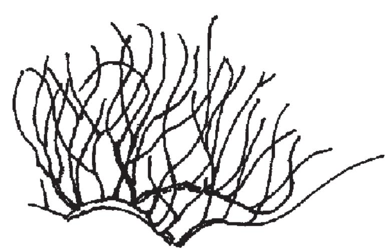
B, R

Common Sea Kale
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.**



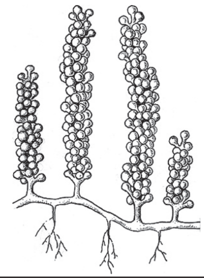
R

Crisp Sea Threads
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.**



B, SP

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**.

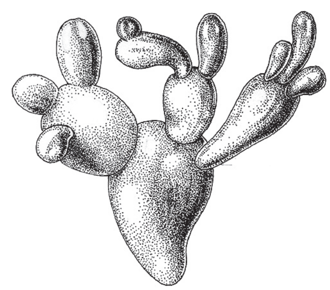


B

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.**

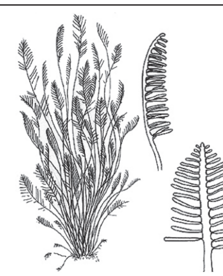
B

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.**



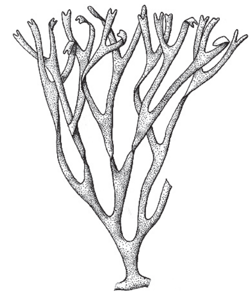
B, C

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**.

Brown Algae

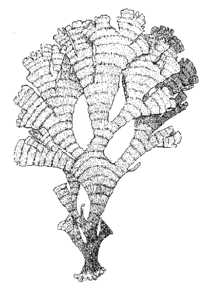
B, C

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.**



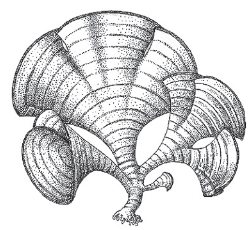
B

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

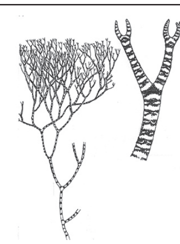
Jamaican Petticoat
Padina jamaicensis
This is a brown, fan shaped seaweed about 10-15 cm (4-6 in) high. The fan is generally banded with lighter zones reflecting the light calcification present. Widely common. **Native**.



Red Algae

B, C

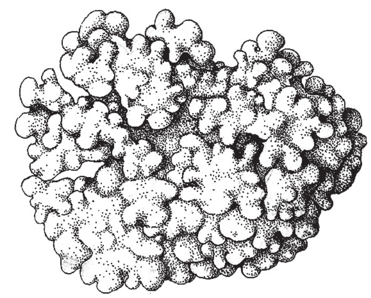
Banded Threadweed
Ceramium byssoideum
A small red, threadlike seaweed, generally looking like pink turf or small clumps. Microscopically, the characteristic red-banded appearance shows up. Grows to 10 cm (4 in) high. **Native**.



Crustose Coralline Algae B, C

Lithothamnion spp., *Lithophyllum* spp.

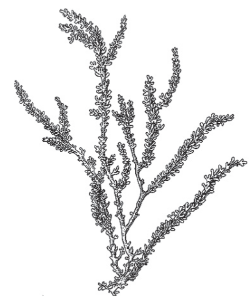
These algae are the main rock-builders of the coral and algal-vermetid reefs. They form smooth to knobby sheets of pale pink, rock hard algae. However, they may be hidden by a thin overgrowth of turf-like red seaweeds. These species can create very large expanses of growth and all are highly resistant to both wave action and heavy grazing. Very variable in size, commonly to 30 cm (1 ft) across. **Native.**



Laurence's Tufted Weed B

Laurencia papillosa

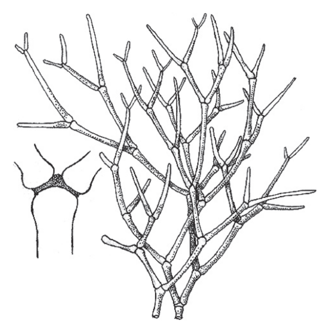
This is one of a group of Laurence's Weeds that grow as small tufts about 10 cm (4 in) tall. The greenish stems divide repeatedly but have characteristic knobby ends with a red tip. These plants are quite common on reefs protected from violent wave action. **Native.**



Pointed Needleweed B, C

Amphiroa fragilissima

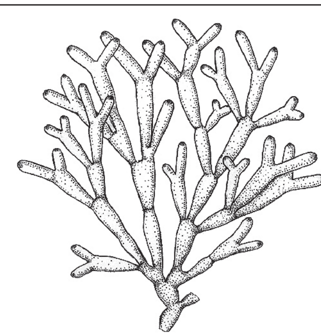
This common alga is heavily calcified with calcium carbonate and a light pink in colour. The hard, thread-like branches divide repeatedly and evenly. In quiet areas it may form bush-like growths 15 cm (9 in) high, but on reefs it is usually part of the low turf dominated by Siphonweeds. **Native.**



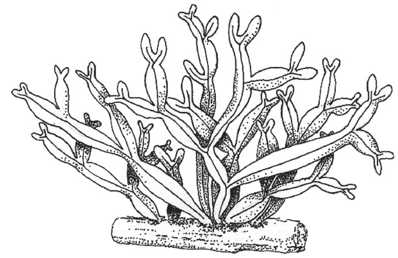
Red Boneweed B, C

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.

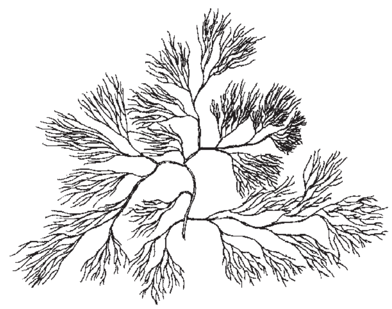


Red Tongueweed
Caloglossa leprieurii
This tiny red weed, generally less than 1 cm (3/8 in) high has flat fronds with a prominent midrib. It may form a turf with other low-growing red weeds such as Siphonweeds. Found on the rock surface of lagoonal and inshore reefs. **Native.**



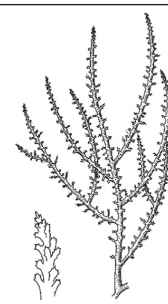
B, C

Siphonweeds
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.**



B, C, R

Soft Spineweed
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.**

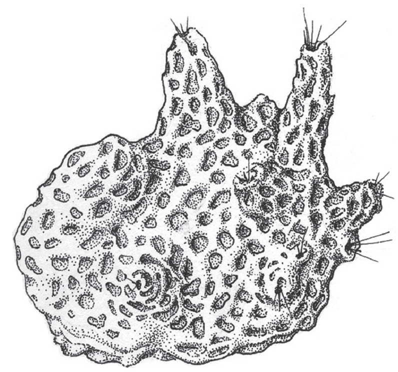


B

Foraminiferans

C

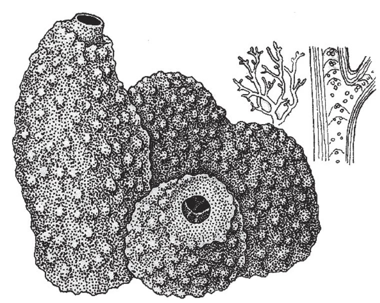
Red Foraminiferan
Homotrema rubrum
Protozoans are normally single-celled animals that are invisible to the naked eye. The Red Foraminiferan is an exception in that individuals may be 5 mm (1/4 in) across. This is still small but the bright red colour is very obvious. Living individuals are abundant in 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

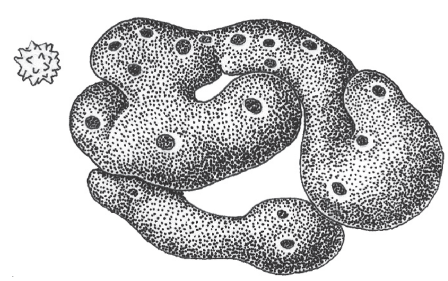
B, C

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**.



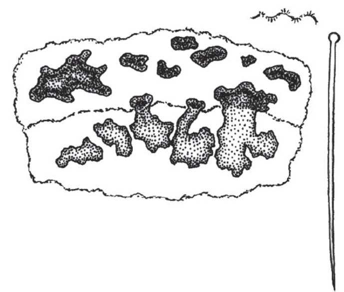
B, SP

Chicken Liver Sponge
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



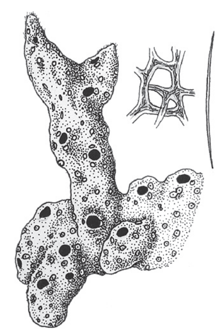
B

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**.



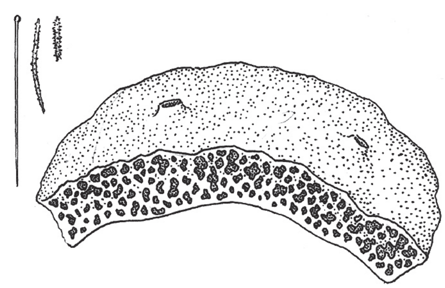
B, SG

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**.



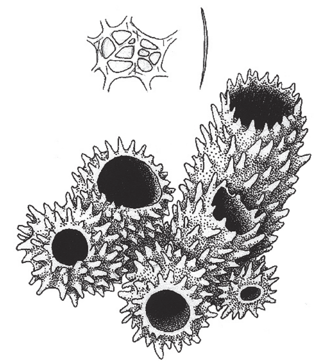
B, C

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**.



Vase Sponge
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**.

C

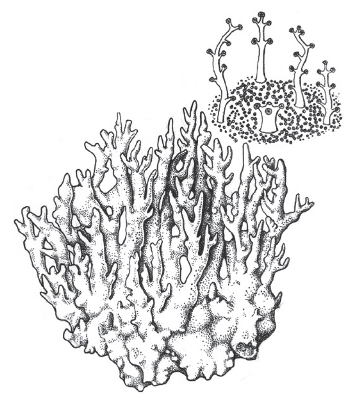


Hydroids and Coral-like Hydroids

Coral-like Hydroids

Fire Coral
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**.

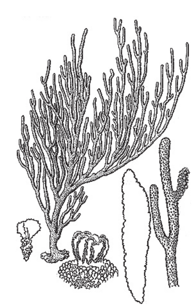
B, C



Soft Corals

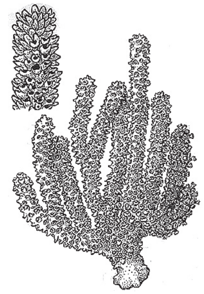
Bent Sea Rod
Plexaura flexuosa
This is probably the commonest soft coral in shallow reef locations. It is usually purple in colour and likes clear water. It is built like a small tree with a stout main stem and sturdy branches. The final branches are relatively wide. It is a medium sized sea rod commonly growing to about 40 cm (16 in) in height. **Native**.

C



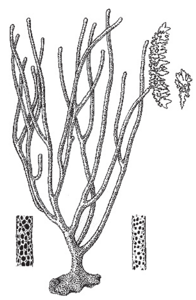
C

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**.



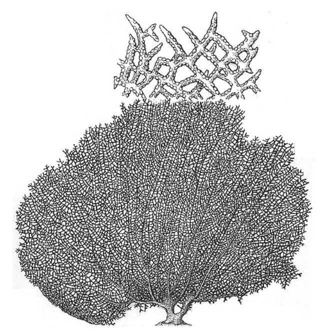
C, R

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

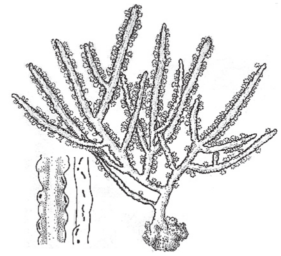
Purple Sea Fan
Gorgonia ventalina
This sea fan resembles a fan shaped piece of pastel-purple lace up to 50 cm (1 1/2 ft) high and just as wide. These sea fans are very common on the Rim Reef and are oriented so that the surge strikes the broad side; an adaptation to efficient filter feeding. They are 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**.

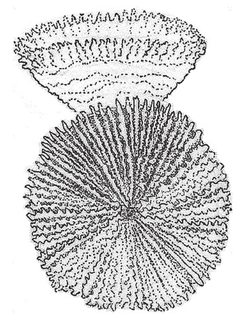
Yellow Sea Whip
Pterogorgia citrina
This is one of the smaller soft corals of the reefs, seldom exceeding 45 cm (17 in) high. It is yellow in colour and found on inner reefs. The colony is in the form of a sparsely and irregularly branched bush with stout twigs. **Native**.



C

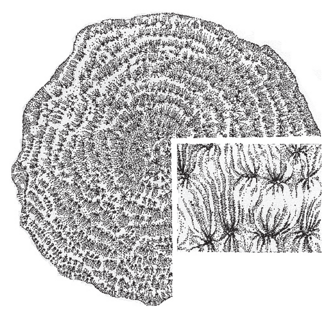
Corals

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**.



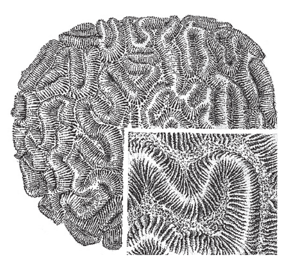
C

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**.



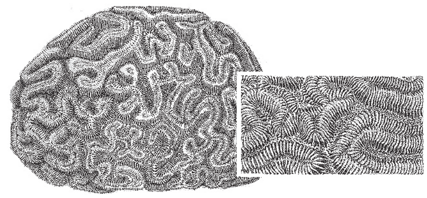
B, C

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**.



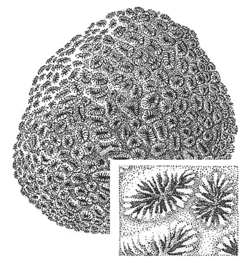
C

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**.



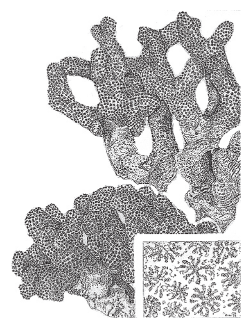
C

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**.



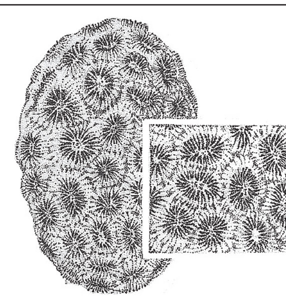
C

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

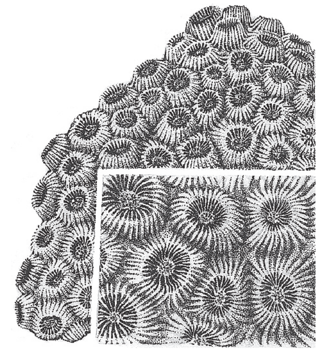
Golf Ball Coral
Favia fragum
While this coral is not very common it is easy to spot, because in this case the common name is very descriptive. The coral colony takes the form of a ball like structure 2.5-5 cm (1-2 in) across. It has comparatively large polyps and may be found on reef flanks or shallow cavities. **Native**.



B, C

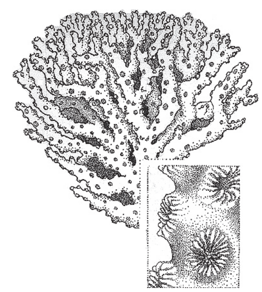
C

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**.



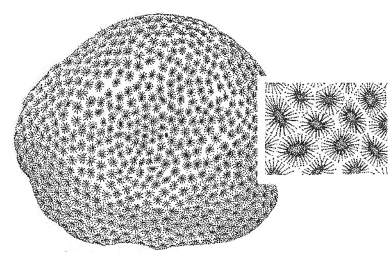
B, C

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**.



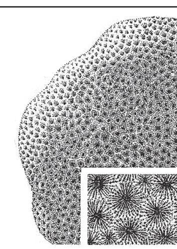
C, SP

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**.



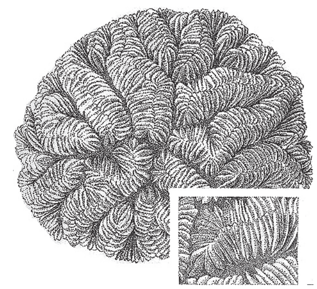
C

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**.



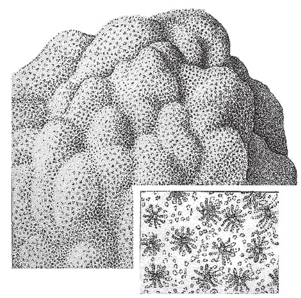
C

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**.



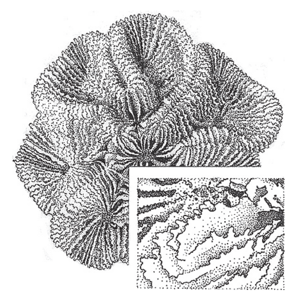
C

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**.



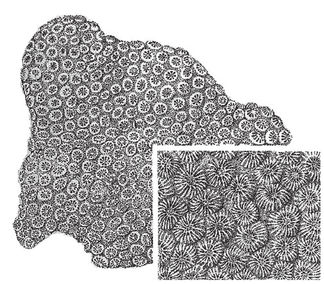
B, C

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**.



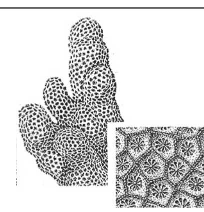
C

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**.



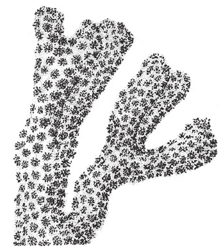
C

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

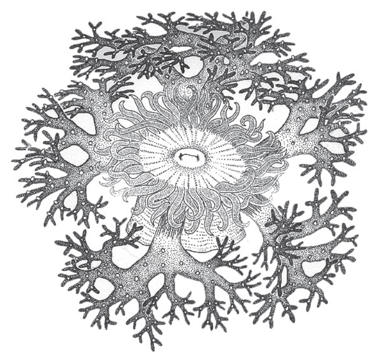
Yellow Pencil Coral
Madracis mirabilis
The Yellow Pencil Coral is rather similar to the Finger Coral except that the colour is yellow to green, usually lighter at the tips, and the branches are pencil-size rather than thumb-size. About 20 cm (8 in) tall. **Native.**



Anemones

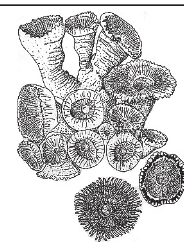
B, C

Brown Sea Anemone
Leb*runia 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**.



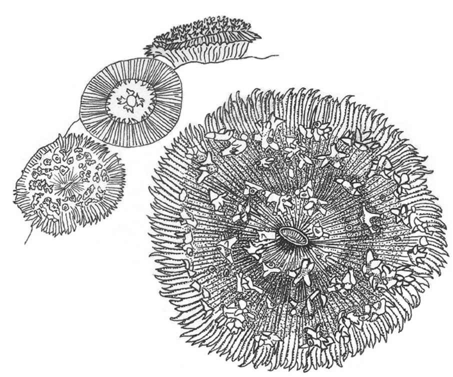
B, C

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**.



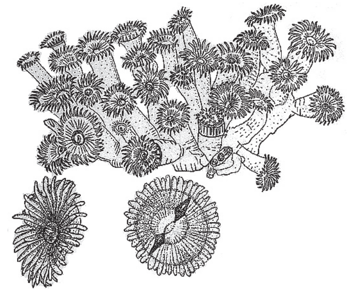
C

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.**



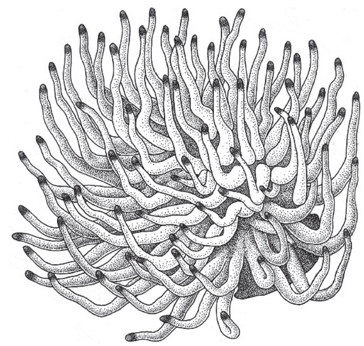
B, C

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.



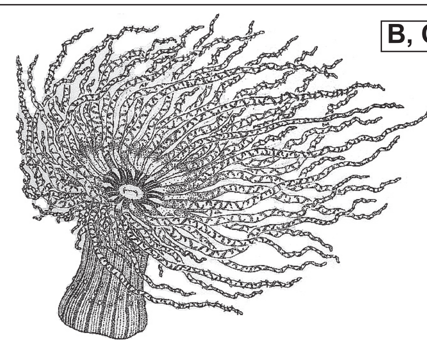
B, C

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**.



B, C, SP

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**.



Crustacea

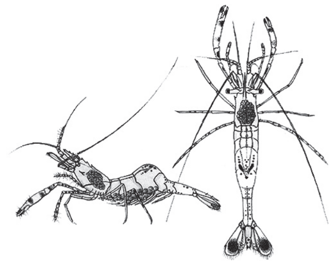
Barnacles

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**.

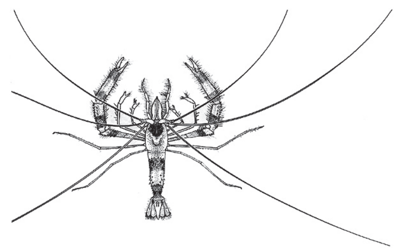
Shrimps

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.



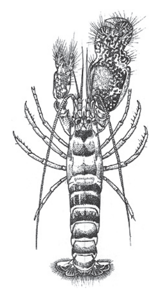
B, C

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

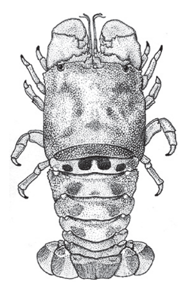
Banded Snapping Shrimp
Alpheus armillatus
You will probably never see this shrimp as it lives in cavities of the reef rock. However, you will probably hear it if you drift quietly over a shallow reef. The snapping noises it makes are surprisingly loud. They are small, 5 cm (2 in), shrimps with one very large claw. **Native.**



C, R

Lobsters

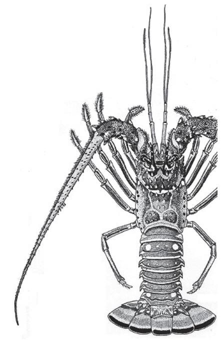
Locust or **Slipper Lobster**
Scyllarides aequinoctialis
This lobster is a squat, slow moving creature having neither long antennae or large claws. It is an omnivore that feeds at night, venturing forth from crevices in the reefs. It is edible and fished by sport fishermen to some extent. 25 cm (10 in) long. **Native**.



B, C

B, C

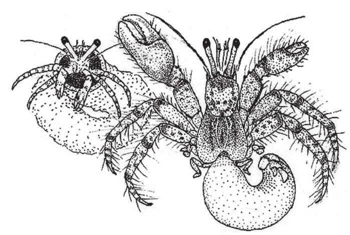
Spiny Lobster
Panulirus argus
The Spiny Lobster is the main lobster fished for food in Bermuda and the Caribbean. Living in crevices and caves within the reefs, it emerges at night to feed on a wide variety of food. These lobsters can measure up to 50 cm (1.5 ft) or more in length. They have no large claws but do have long, robust antennae. The colour is reddish brown. **Native**.



Hermit Crabs

C

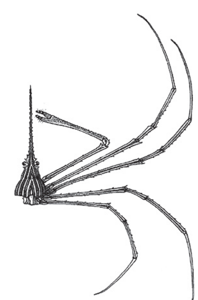
Verrill's Hermit Crab
Calcinus verrilli
This is another of the very few marine species **endemic** to Bermuda. It is a curious small hermit crab that has taken up a mode of life similar to the tube snails (*Vermetidae*). Indeed it lives in abandoned tube shells and is very common on the Boiler Reefs 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

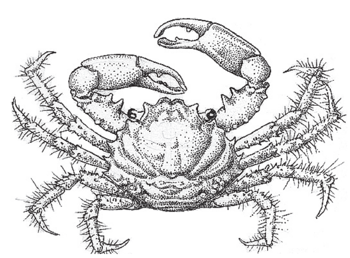
C

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**.

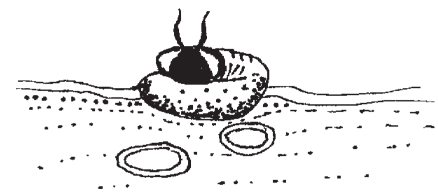


Gastropoda

Snails

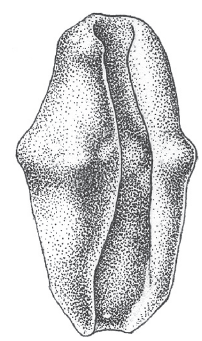
C, R

Corroding Worm Shell
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.**



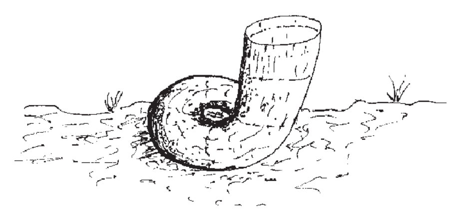
C

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**.



R

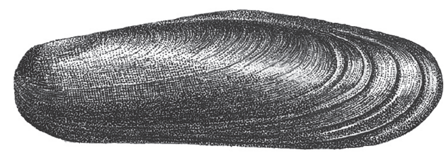
Large Tube Shell
Serpulorbis decussatus
This is the largest tube shell in Bermuda with an opening up to 7 mm (1/4 in) in diameter. The rim of the shell is exceedingly sharp and can puncture even stout footwear. The shell is white but the snail within comes in either white or red colour phases. There 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**.



Clams and Mussels

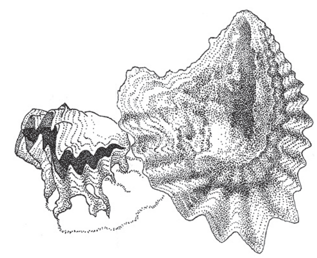
B, C

Black Date Mussel
Lithophaga nigra
This is a species which can only be seen as an oval hole showing 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**.



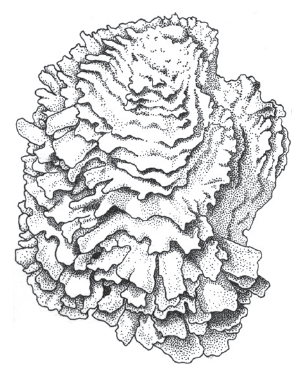
C, R

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**.



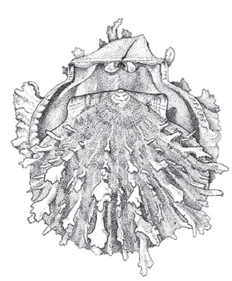
B, C, R

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**.

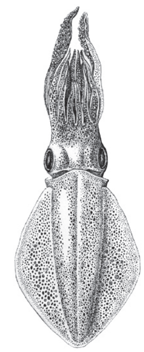


Squids and Octopusus

Squids

B, C

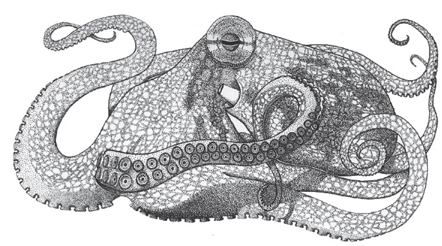
Reef Squid
Sepioteuthis sepioidea
Up to 30 cm (12 in) long, these squid occur in groups over the reefs and inshore waters. They are quite transparent but are covered in small brown dots and show iridescent blue colour as they move. They feed on small fish and swimming crustacea. When threatened they can produce a cloud of ink and retreat backwards at high speed. **Native**.



Octopuses

B, C

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**.

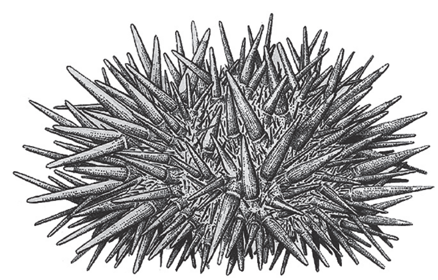


Echinoderms

Sea Urchins

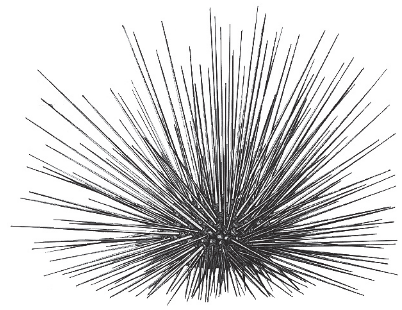
C, R

Burrowing Rock Urchin
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**.



C

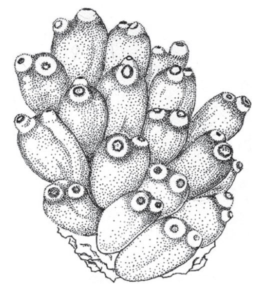
Longspine Sea Urchin
Diadema antillarum
This urchin was formerly common and particularly so in the depressions of Boiler Reefs. However, in the 1980's an epidemic disease spread throughout the entire Caribbean area and decimated populations. The species is still occasionally seen and is readily identified by the very long black spines. Up to 30 cm (1 ft) in diameter including the spines. **Native**.



Sea Squirts

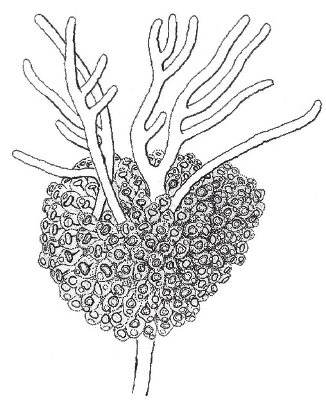
B, SP

Orange Sea Squirt
Ecteinascidia turbinata
This species lives in just the same habitat 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. **Native**.



B, SP

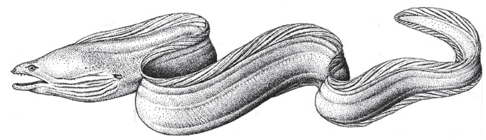
Purple Sea Squirt
Clavelina picta
This sea squirt and the following species may often be found in colonies on the stalks of soft corals. Each individual is of great beauty, consisting of an almost transparent sack about 1 cm (3/8 in) in length, through which can be seen the internal organs. The colonies 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. Sea squirts are filter feeders. **Native**.



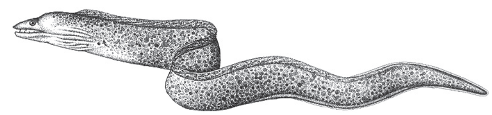
Fish

Moray Eels

Green Moray C
Gymnothorax funebris
A large moray, reaching almost 2 m (6 ft) in length of a uniform green colour. **Native**.



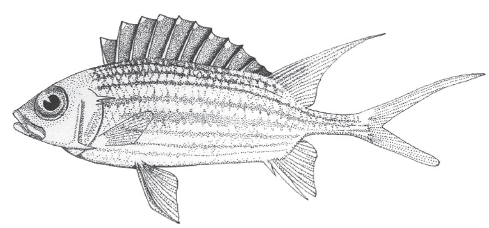
Purplemouth Moray C
Gymnothorax vicinus
The Purplemouth Moray reaches about 110 cm (3 1/4 ft). The colour may be either a mottled green or greenish-brown with dark brown freckles. The dark dorsal (top) fin has a whitish edge. **Native**.



Spotted Moray C
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**.

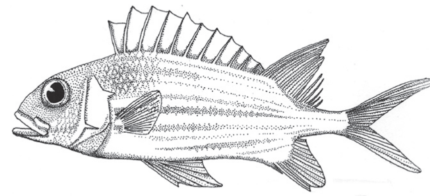
Squirrelfishes

Longspine Squirrelfish B, C
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

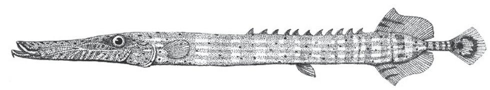
Squirrelfish
Holocentrus ascensionis
Similar to the Longspine Squirrelfish (see above) except that the red colour has a golden tinge and the spiny dorsal is lighter in colour and has no triangular patches. Usually about 23 cm (9 in) long **Native**.



Trumpetfishes

C

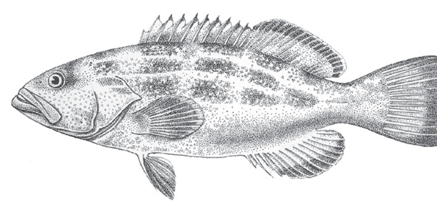
Trumpet Fish
Aulostomus maculatus
This elongated fish, up to 1 m (3 ft) long but usually less, tends to hang motionless among the sea whips and fans where it is difficult to spot. When on the move, they swim horizontally. They can change colour with their surroundings to make seeing them an even more difficult task. **Native**.



Groupers

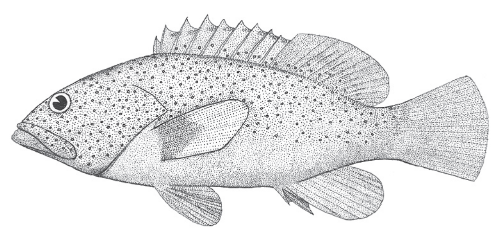
C, O

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**.



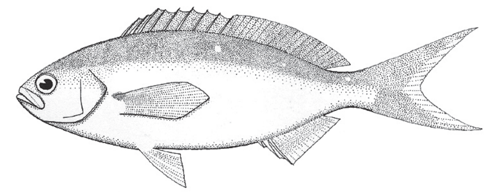
C, O

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**.



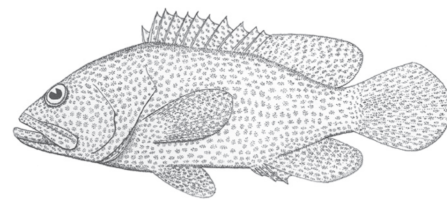
O, R

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**.



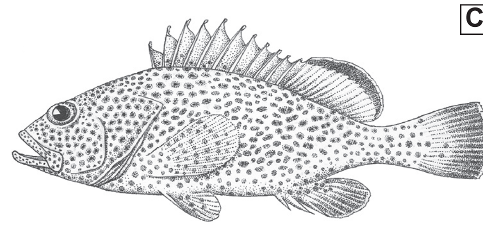
C, O

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**.



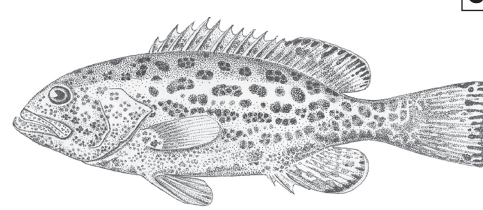
C, O

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**.



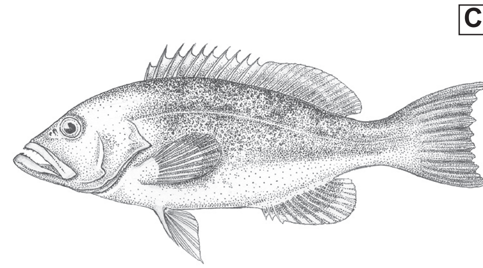
C, O

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

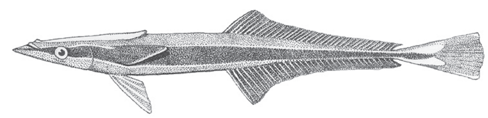
Yellowmouth Grouper
Mycteroperca interstitialis
This large grouper which can reach 80 cm (2 1/2 ft) long is usually a uniform dull brown colour but it may also be brown with pale yellow lines forming irregular spots. The mouth is yellow. Juveniles have a dark back and white belly. **Native**.



Remoras

B, O

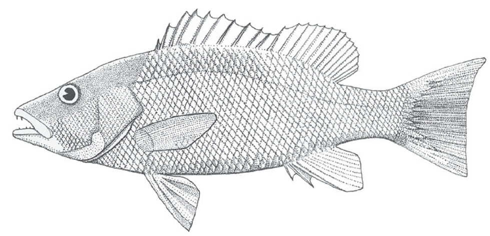
Sharksucker or **Remora**
Echeneis naucrates
This is a very slim fish up to 1 m (3 ft) long, with its dorsal fin modified to form an elaborate sucker on top of the head. While, as their name suggests, this sucker can be used to attach to sharks or rays, many Remoras swim freely around. They have been known to attach to many other things, including underwater cameras and even human swimmers! **Native**.



Snappers

B, C

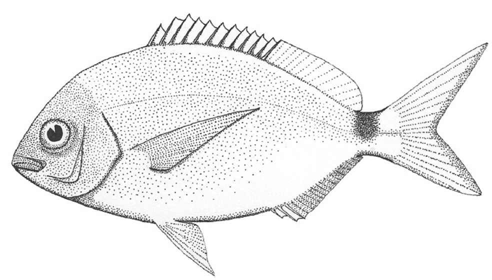
Grey Snapper
Lutjanus griseus
The Grey Snapper can reach 61 cm (2 ft) in length but the ones commonly seen in small groups along shores, around wharves, in grass beds, mangroves and some saltwater ponds are much smaller. Large specimens of this grey-coloured fish are common on reefs and beyond. Young specimens have an oblique dark line through the eye. **Native**.



Chubs and Breams

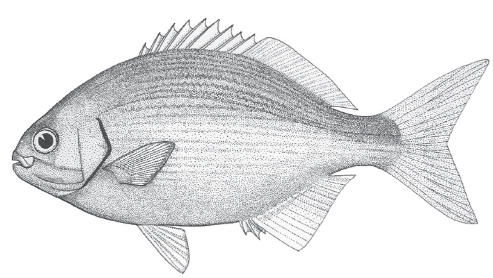
B

Bermuda Bream
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

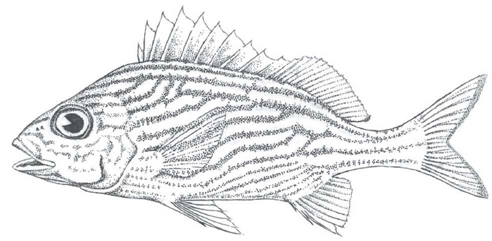
Bermuda Chub
Kyphosus sectatrix
The Bermuda Chub can reach 76 cm (30 in) and a weight of up to 9 kg (20 lb). Bermuda Chub have relatively small heads and eyes, and are a dull silvery-grey in colour. The overall colour is relieved by many narrow, darker stripes running along the body. **Native.**



Grunts

B

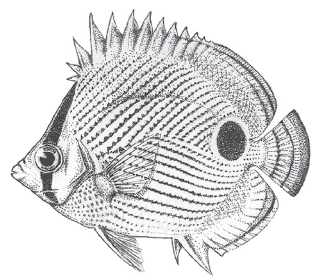
French or **Yellow Grunt**
Haemulon flavolineatum
This is one of eleven members of this family found in Bermuda. The French Grunt, has a relatively deep body, blue in colour with many yellow stripes. The stripes are parallel close to the back but become diagonal lower down. Grunts may form large schools, 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.**



Butterflyfishes

B, C

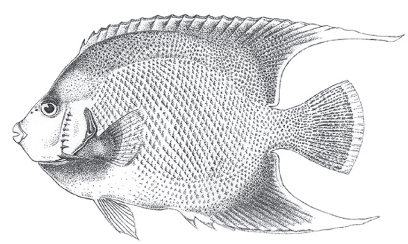
Foureye Butterflyfish
Chaetodon capistratus
This is a small 10 cm (4 in) but very active fish, that when looked at from the side, cannot be mistaken for any other. The body is flat and almost round. There is a bold, black stripe through the eye and a large black spot at the base of the tail. **Native**.



Angelfishes

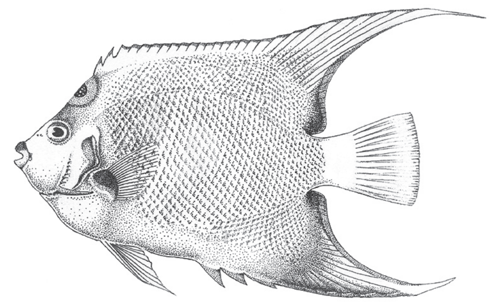
B

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**.



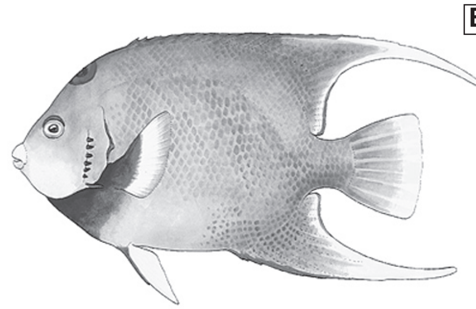
B, C

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

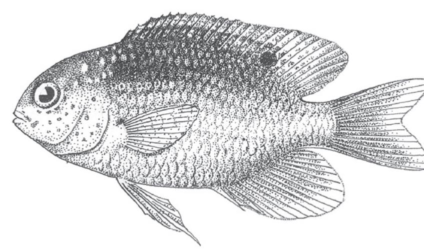
Townsend Angelfish
Holacanthus ciliaris x bermudensis
The Townsend Angelfish is a hybrid between the Queen Angelfish and the Blue Angelfish. The Townsend is rather like the Queen Angelfish described above, but the blue border around the smaller black forehead patch is narrower and the bright yellow tail is missing. Intermediate in size between the two parent species 40 cm (16 in). **Native**.



Damselfishes

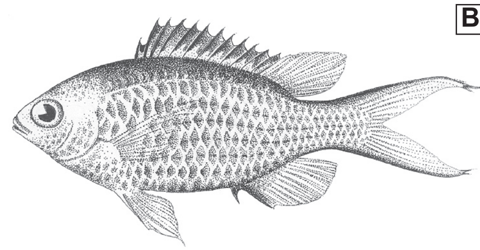
B, C

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.**



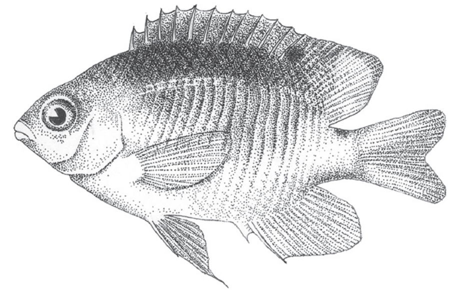
B, C

Blue Chromis
Chromis cyaneus
This fish which, 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**.



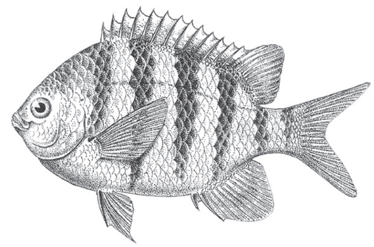
B

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**.



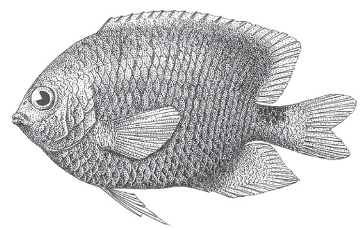
B, C

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.



B, C

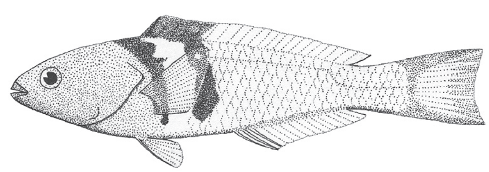
Three-spot Damselfish
Stegastes planifrons
The Damselfish is reddish-brown, becoming purplish on the back and is up to 12 cm (4 1/2 in) in length. Juvenile fish are yellow with three black spots. **Native**.



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**.

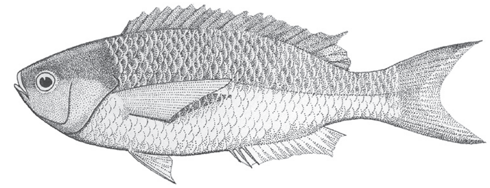


Creole Wrasse

B

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**.

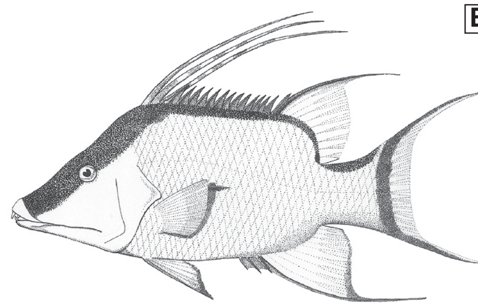


Hogfish

B, C

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**.

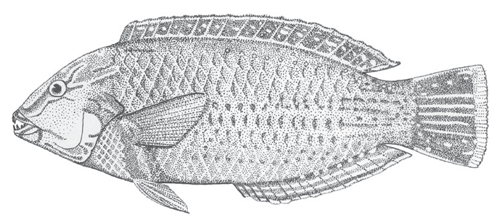


Puddingwife

B

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**.

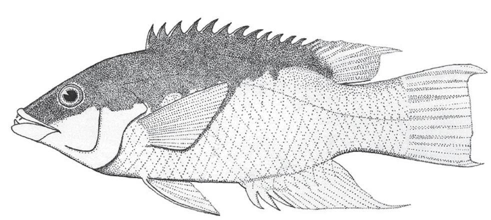


Spanish Hogfish

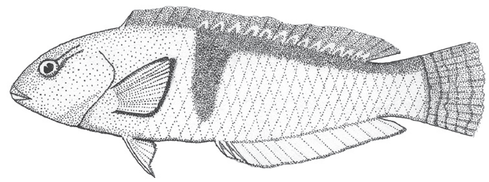
B, C

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**.



Yellowhead Wrasse B, C
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**.

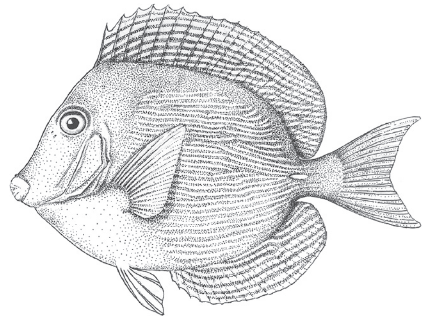


Barracudas

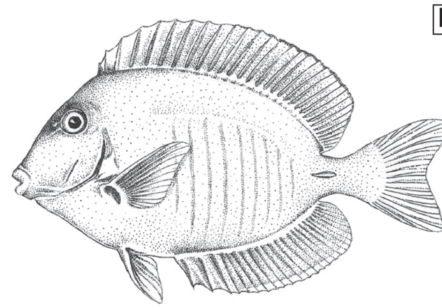
Great Barracuda B, C, O
Sphyraena barracuda
Juveniles, up to about 45 cm (18 in) in length, are very frequent in the bays. Adults up to at least 1 m (3 ft) long may be seen on the reefs. This elongate fish is best recognised by the very large mouth with needle-sharp teeth, and elongated silvery body with dark markings. **Native**.

Surgeonfishes

Blue Tang B, C
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**.

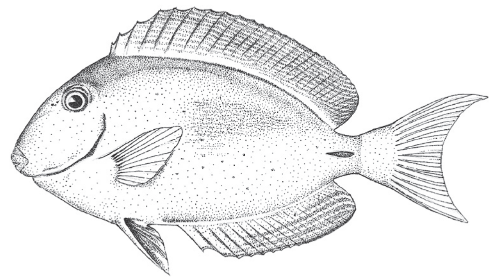


Doctorfish B, C
Acanthurus chirurgus
This is a typical member of the surgeonfish family, having a large eye set high on the head and a small mouth below a long, sloping forehead. The colour is blue and may be dark or light but the distinctive feature is a set of vertical darker bars on the body, which may be difficult to see. Up to 30 cm (1 ft) long. **Native.**



B, C

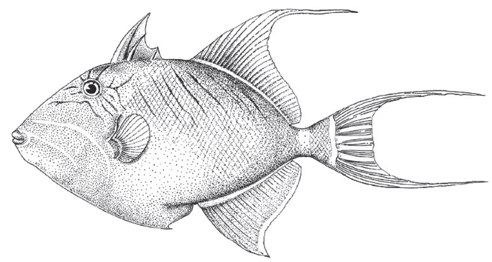
Ocean Surgeonfish
Acanthurus bahianus
The Ocean Surgeonfish like the Blue Tang (above) is a member of the surgeonfish family. The fish are deep in the body, and the Surgeonfish varies from a dull brown colour to a pale grey. It reaches a maximum size of 38 cm (15 in) and has very sharp ridges, resembling 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**



Triggerfishes

B, C

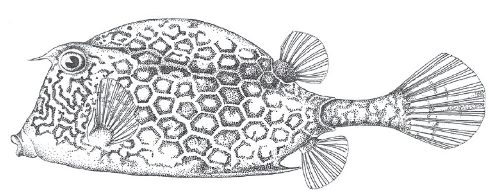
Queen Triggerfish
Balistes vetula
Triggerfish have a medium deep body with the eyes set back on a long sloping forehead. This is the most striking of all triggerfish, with a purple-blue lower body and fins, and a yellowish back and head. The large fins have trailing edges. There are two diagonal clear blue stripes on the head. Large adults reach 45 cm (18 in) long. **Native**.



Trunkfishes

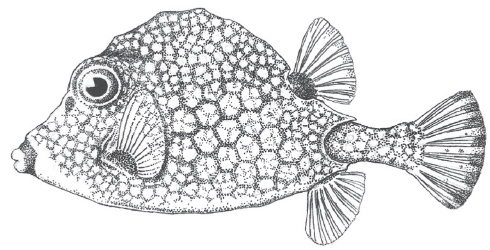
B

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

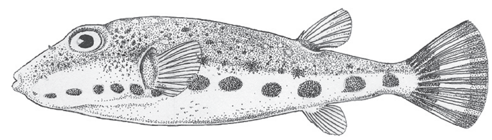
Smooth Trunkfish
Lactophrys triqueter
Like the Honeycomb Cowfish this species grows up to about 30 cm (1 ft) long and also has a box-like, very firm body. This species also has polygons on the body but they are less obviously displayed in a black background with light spots. The tail is large and set on a narrow stalk. **Native**.



Puffers and Porcupine Fishes

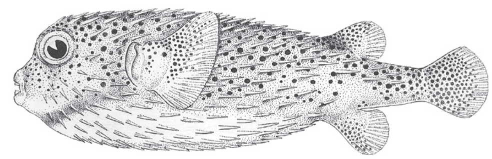
B

Bandtail Puffer
Sphoeroides 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**.



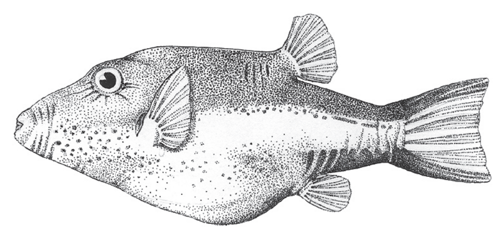
B

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

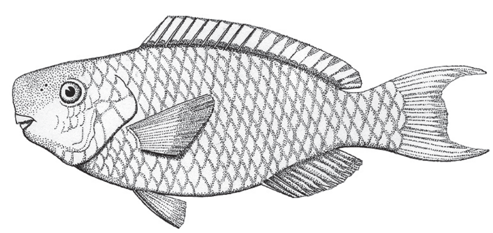
Sharpnose Puffer
Canthigaster rostrata
This is a charming little fish only about 12 cm (4 in) long, with a large head and tapering body. Dark mauve or brown above and white below, they are quite difficult to spot. Groups of these tiny puffers hang above the bottom, hovering and darting about like dragonflies. If threatened pufferfish gulp in water and inflate like a balloon. **Native**.



Parrotfishes

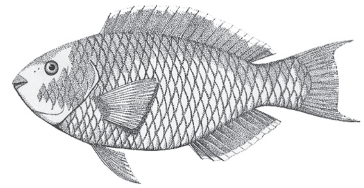
B, C

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.**



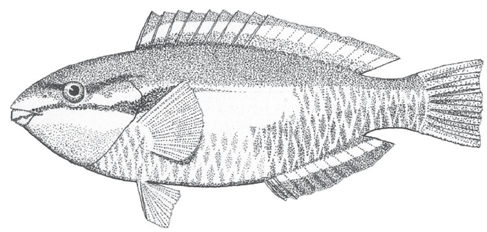
B, C

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**.



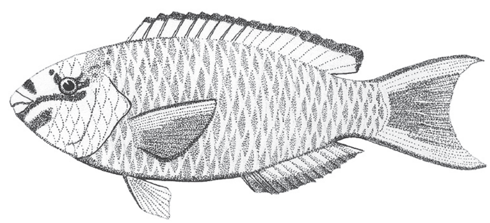
B, C

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 pinkisk 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**.



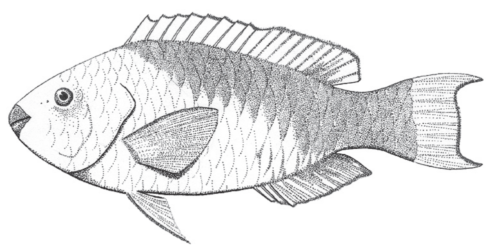
B, C

Queen Parrotfish
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**.



B, C

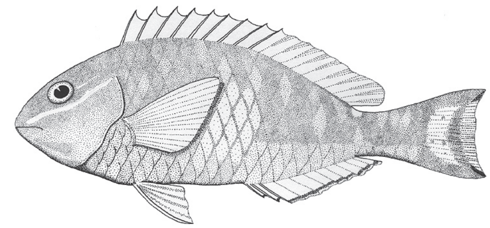
Rainbow Parrotfish
Scarus guacamaia
This is one of the largest of the parrotfish, growing to a length of 1 m (3 ft). It lives in a variety of habitats from the rocky coast to the outer reefs. This parrotfish has green scales rimmed with orange and orange fins with a streak of green and a blue edge. Adults are more deeply coloured than juveniles but colours in both sexes are the same. **Native**.



Redband Parrotfish B, C

Sparisoma aurofrenatum

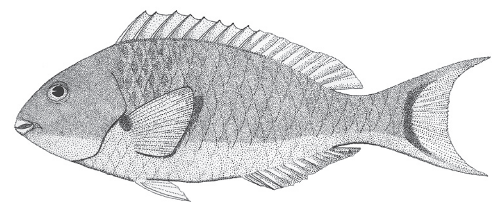
The primary colour phase is greenish-brown or mottled brown with a touch of blue. Along the lower side this changes to a pale mottled red. In the terminal male the body is orange to green-blue and has a diagonal pale orange stripe from the mouth to the top of the gill cover. There is an orange spot behind 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

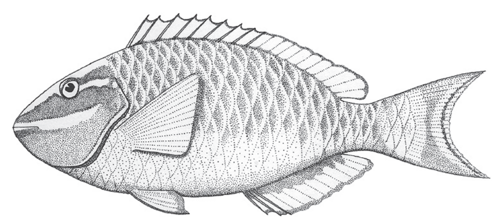
This Parrotfish has a distinctive crescent-shaped mark on the tail. The primary colour phase is olive-green on the back, a mottled reddish colour on the sides and with a pale belly. Terminal males are green with brown-bordered scales. On the sides the body is blue-green becoming clear blue lower down. The fins are all reddish. One of the smaller parrotfish reaching about 35 cm (13 in). **Native**.



Stoplight Parrotfish B, C

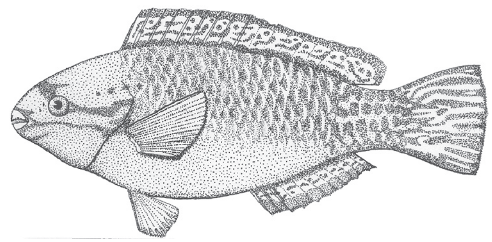
Sparisoma viride

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**.

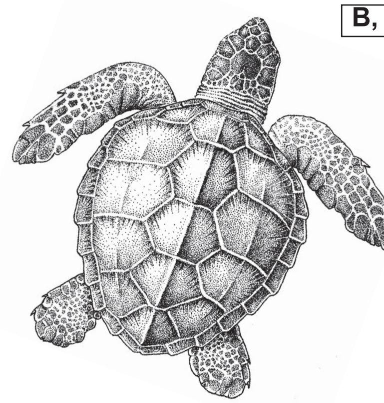


Turtles and Terrapins

Turtles

B, C, O, SG

Loggerhead Turtle
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.**



Field Trips

General Note

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, 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 Inc. or by the Bermuda Aquarium, Museum & Zoo offer advantages as they are used to this type of work and have knowledgeable employees as a back up.

The weather is also critical and winter is best avoided. At any season good waterproof and windproof 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.

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 Bermuda Biological Station for Research and the Bermuda Aquarium, Museum & Zoo 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 to ensure 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 to the boat at once if any problem occurs, using a pre-agreed signal. An example could be a shark sighting (unlikely but possible) or a deterioration in the weather. A good first aid kit must be carried and the vessel must be capable of ship-to-shore communication. Thin wet suits or wind surfing suits are a terrific advantage as they give some extra floatation 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.

All participants should be thoroughly briefed in advance of the field trip. An introductory trip to the Aquarium is a very good idea, and will help students to be able to identify some of the corals and fishes.

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.

Field Trip # 1, North Rock

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 depending on the boat it may 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 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.

Observations

1) Try to list as many groups as possible of living things that are seen. Eg. Hard Corals, Soft Corals, Fish, Red Seaweeds etc.
2) Try to identify and list as many species of hard coral as possible.
3) Try to identify and list as many fish species as possible.
4) Look for and describe some examples of fish behaviour that were observed. For example look for examples of feeding or aggression.
5) Look at the sea fans to see if there is some order to the way that they grow.
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.

Questions to Think About

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 parrot fish do.
4) What two groups of organisms are mainly responsible for building the coral reefs?
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.

Field Trip # 2, Lagoonal Reefs

General. North Lagoon has lots of reefs but they get more numerous, more diverse (physically and biologically) and the water gets much clearer, further from shore. Setting off from the Aquarium or the Biological Station puts you within reach of a variety of reefs. Bear in mind that the outer lagoonal reefs are up to 10 km (8 mi) from shore and that it will take a good half to three quarters of an hour to get there. If it is windy stay closer to land.

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 as possible of living things that are seen. Eg. Hard Corals, Soft Corals, Fish, Red Seaweeds etc.
2) Try to identify and list as many species of hard coral as possible.
3) Try to identify and list as many fish species as possible.
4) Look for and describe some examples of fish behaviour that were observed. For example look for examples of feeding or aggression.
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.
6) If you go to more than one reef, name the types of reef and summarise the differences between them.

Questions to Think About

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 parrot fish do.
4) What two groups of organisms are mainly responsible for building the coral reefs?
5) Why are seaweeds (algae) relatively little seen on coral reefs?
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.

Field Trip # 3, 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 as possible of living things that are seen. Eg. Hard Corals, Soft Corals, Fish, Red Seaweeds etc.
2) Try to identify and list as many species of hard coral as possible.
3) Try to identify and list as many fish species as possible.
4) Look for and describe some examples of fish behaviour that were observed. For example look for examples of feeding or aggression.
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.
6) If you go to more than one reef, name the types of reef and summarise the differences between them.

Questions to Think About

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 parrot fish do.
4) What two groups of organisms are mainly responsible for building the coral reefs?
5) What is the cause of all the dead Brain Corals on the Fringing Reef?
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.

Field Trip #4, 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 so calm that no water breaks over them at low tide. Water clarity is usually excellent. There are two types of reef accessible 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.

Observations

1) Try to list as many groups as possible of living things that are seen. Eg. Hard Corals, Soft Corals, Fish, Red Seaweeds etc.
2) Try to identify and list as many species of hard coral as possible.
3) Try to identify and list as many fish species as possible.
4) Look for and describe some examples of fish behavior that were observed. For example look for examples of feeding or aggression.
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.
6) If you go to more than one reef, name the types of reef and summarise the differences between them.

Questions to Think About

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 parrot fish do.
4) What two groups of organisms are mainly responsible for building the coral reefs?
5) What two organisms are mainly responsible for constructing the Boiler or Cup Reefs?
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) Why are the waters of the south shore of Bermuda so much rougher than those of the other outer shores?

Field Trip # 5, The Bermuda Aquarium

General. The Bermuda Aquarium provides a wonderful opportunity to look at some of the features of the coral reefs. In particular the North Rock Exhibit is very educational. Another highlight of the aquarium is the fish. There are a wide diversity of locally occurring fish on display. The aquarium is perhaps best used as an introduction to a later field trip. However, if a field trip is impossible for any reason the aquarium provides the next-best alternative.

Preparation. Read this field guide and any other material on coral reefs that you can find.

Dress. Normal.

Equipment. A notebook and pencil are essential. A copy of this field guide.

Observations

1) Try to list as many groups as possible of living things that are seen. Eg. Hard Corals, Soft Corals, Fish, Red Seaweeds etc.
2) Try to identify and list as many species of hard coral as possible.
3) Try to identify and list as many coral reef fish species as possible.
4) Look for and describe some examples of fish behavior that were observed. For example look for examples of feeding or aggression.
5) Make a list, by group, of any animals or plants, other than hard corals and fish, that could be identified and that would be found on coral reefs.

Questions to Think About

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 parrot fish do.
4) What two groups of organisms are mainly responsible for building the coral reefs?
5) What two organisms are mainly responsible for constructing the Boiler or Cup Reefs?
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.

Glossary

Aeolianite — Limestone rock formed by the natural cementation of grains of wind-blown calcareous sand.

Algal-Vermetid reefs — Reefs of very hard limestone laid down principally by a combination of crustose coralline algae and vermetid gastropod snails (Tube Snails). The south shore Boiler Reefs are algal vermetid reefs.

Bio-constructional lips — Limestone lips on the ends of south shore headlands that have the same structure and biota as algal-vermetid reefs.

Biodeposition — The formation of rock by living organisms. Coral reefs are examples of biodeposition.

Biodiversity — The number of different species of biota in a natural system such as an ecosystem or community.

Bioerosion — The removal of rock by biological organisms.

Biota — Both animals and plants (fauna and flora) together.

Calcareous algae — Seaweeds that incorporate calcium carbonate into their tissues. Calcareous algae may be sheet-like as in the crustose coralline algae or upright.

Calcium carbonate — The chemical compound making up the bulk of limestone. Seawater is saturated with calcium carbonate.

Carnivores — Animals that eat either herbivores or other carnivores but not plant material.

Coelenterate — Coelenterate is the name given to a group of fairly simple, radially symetrical animals also called Cnidaria, most of which have a tube-like, or disc-like, body with a circle of tentacles. Corals, anemones, jellyfish and hydroids are coelenterates.

Colonial organisms — Organisms in which many individuals live together to form a larger organism. Most corals are colonial organisms.

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 corals have a skeleton of organic material.

Corallite — The distinctive mark left by the coral polyp on the surface of the skeleton.

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 coralline algae	Another expression for crustose calcareous algae.
Detritivores	Animals that eat detritus.
Detritus	Semi-decomposed organic material in particulate form.
Diversity	The number of different species of biota in a natural system such as an ecosystem or community.
Ecological Export	The movement of food in the form of organic material or organisms beyond the boundary of an ecological system.
Endemic Species	Species that have evolved to be a new species in a specific geographic area. They may subsequently spread to other areas.
Export Ecosystem	An ecosystem from which ecological export takes place. The coral reef is an export ecosystem.
Filter feeders	Animals that obtain their food by filtering organic particles or organisms out of water.
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.
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.
Herbivores	Animals that eat only plant material.
Hot spot islands	Islands that originate when a volcano forms from liquid magma that erupts through a small area of the sea bed.
Introduced species	Species brought to a new area by man.
Island arcs	Groups of islands formed along the collision zones of tectonic plates.
Limestone	A rock made up principally of calcium carbonate.
Magma	Molten rock under the Earth's crust, circulating in vast convection cells.
Native species	An organism that has colonised an area by completely natural means.

Ocean currents	Large currents in the ocean that move in a predictable pattern.
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.
Photosynthesis	The synthesis of organic compounds from inorganic substances using the energy of sunlight, carried out by pigmented plants.
Phytoplankton	Plant plankton.
Plankton	The animals and plants of the open ocean that have no or very limited swimming abilities. They are usually very small.
Pleistocene Epoch	The last epoch which was characterised by the development of huge ice caps at the north and south ends of the Earth.
Nematocysts	Stinging cells found only in coelenterate animals that are used in prey capture and defence.
Polyp	The individual organism of members of the cnidaria. Coral colonies are made up of numerous inter-connected polyps.
Primary producers	Plants that obtain their energy supplies through the process of photosynthesis.
Reef rock	Rock that is the remains of a biodeposited reef.
Ridge islands	Islands that originate along mid-ocean ridges, for example Bermuda.
Sedentary animals	Animals that cannot move to another location. Many sedentary animals are cemented to the rock, for example hard corals.
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.
Vermetid Reefs	Reefs made up of worm shells (Vermetid gastropods). Zooplankton Animal plankton.
Zooxanthellae	Algal cells in a symbiotic association with an animal. Most corals contain zooxanthellae.

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Index

D

N

O

P

Q

R

S

BERMUDA ZOOLOGICAL SOCIETY