BERMUDA ZOOLOGICAL SOCIETY

presents

Sheltered Bays and Seagrass Beds of Bermuda

written by

Dr. Martin L. H. Thomas

Project Nature

Field Study Guides for Bermuda Habitats

Sponsored by

The Bermuda Paint Co. Ltd.

Sheltered Bays and Seagrass Beds of Bermuda

(Second Edition)

Project Nature

Field Study Guide

Sponsored by

The Bermuda Paint Co. Ltd.

Sheltered Bays and Seagrass Beds of Bermuda
Seventh in the series of Project Nature Guides
published by the Bermuda Zoological Society
in collaboration with the
Bermuda Aquarium, Museum & Zoo

Second Edition
Published September 2005

Details of other titles available in the Project Nature series are:

Rocky Coasts. Martin L. H. Thomas
First Edition (The Rocky Coast) April 1993
Second Edition May 2007. 100 pages. **ISBN: 978-1-897403-03-7**

Sandy Coasts, Martin L. H. Thomas
First Edition (The Sandy Shore) November 1994
Second Edition May 2008. 102 pages. **ISBN: 978-1-897403-49-5**

The Bermuda Forests. By BZS Volunteers.
First Edition January 2001.
Second Edition March 2002.
Third Edition December 2005. 114 pages. **ISBN: 1-894916-26-3**

Bermuda's Wetlands. By Martin L. H. Thomas.
First Edition January 2001.
Second Edition March 2002.
Third Edition July 2005
Fourth Edition December 2005. 186 pages. **ISBN: 1-894916-62-X**

Oceanic Island Ecology of Bermuda. By Martin L. H. Thomas.
First Edition February 2002.
Second Edition September 2004.
Third Edition September 2005. 88 pages. **ISBN: 1-894916-63-8**

Coral Reefs of Bermuda. By Martin L. H. Thomas.
First Edition May 2002.
Second Edition September 2005. 80 pages. **ISBN: 1-894916-67-0**

The Ecology of Harrington Sound, Bermuda. By Martin L. H. Thomas.
First Edition May 2003.
Second Edition September 2005. 96 pages. **ISBN: 1-894916-65-4**

The Open Ocean around Bermuda. By Martin L. H. Thomas.
First Edition September 2003.
Second Edition September 2005. 86 pages. **ISBN: 1-894916-64-6**

Cover photograph of Whalebone Bay
by Martin L. H. Thomas

ISBN: 1-894916-66-2

Foreword

Approximately 6,000 years ago, with the end of the most recent ice age, sea levels rose and the lowlands of the Bermuda seamount were flooded. Flowing across the northern marshlands to fill the valleys between Bermuda's highest hills, these rising waters created sheltered harbours and bays. Marine organisms swept north with the warm waters of the Gulf Stream found these quiet waters and settled to populate the unique inshore habitats of this remote oceanic outpost. The environmental challenges of this northern island limited the success of many southern species particularly in the inshore waters where winter temperature lows may have proven lethal. Despite these challenges, a wide range of Caribbean species thrived in Bermuda, making the coastal waters a fascinating area for exploration.

Today, the shape of the Bermuda Island chain is reminiscent of a fishhook, an elongate narrow landmass with no site far removed from the ocean. This shape makes it virtually impossible to spend a day without experiencing open vistas of the ocean, harbours and bays. Indeed, the feeling of space created by these views is critical to Bermuda's aesthetic appeal. Bermuda's inshore waters have become the playground of the people, an area where adults teach their children to swim and young people learn to experience the wonder of the natural world beneath the sea.

This book is the most recent in a series of field guides that are designed to promote the exploration of the natural wonders of Bermuda's varied habitats. The Sheltered Bays and Seagrass Beds of Bermuda leads the reader on a fascinating tour of discovery through these calm and easily accessible areas. Learn how seagrass alters the environment to create stable and protective homes for juveniles of many species. Find out how to identify a wide variety of marine organisms, where to find them and what they do. Then, armed with this knowledge, don your snorkelling gear and search them out. You will not be disappointed.

Jack Ward
Director, Conservation Services
Bermuda Aquarium, Museum & Zoo
August 2002

Acknowledgements

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

Jack Ward, Principal Curator of the Bermuda Aquarium, Museum and Zoo paved the way for its production and enthusiastically supported the work. Mary Winchell, the 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 seven field guides. Holly Holder, the present Education Coordinator has continued Mary Winchell's supportive role and has been a great help. Liz Nash took on the task of preparing the manuscript for printing, including setting up the text, assembling all the illustrations, 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, proof-reading 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, Bobbii Cartwright, Judie Clee, Wolfgang Sterrer, Margaret Emmott, Penny Hill and Richard Winchell.

Figure 2, a drawing of a seagrass bed was prepared by Jo-Anne Stevens of the Department of Biology, University of New Brunswick, Saint John, Canada. Figures 1 and 3 were drawn by the author.

The illustrations of the species of plants and animals important in the sheltered bay and seagrass 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

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 and Zoo have described the Rocky Shores, Sandy Shores, Wetlands, Forests, Oceanic Island Ecology and Coral Reefs 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 more exposed shorelines.

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

There is less information available on sheltered bays and seagrass beds than on more obvious natural systems such as coral reefs or rocky shores. Nevertheless, there are several books that summarise much of this information and can be used as background resources for studies. One of the main ones is "Marine Flora and Fauna of Bermuda" edited by Dr. Wolfgang Sterrer, formerly director of the Bermuda Biological Station for Research and now Curator of the Natural History Museum at the Bermuda Aquarium, Natural History Museum and Zoo. This large book describes and illustrates all but the very uncommon animals and plants found in Bermuda's marine waters. Dr. Sterrer has also produced two other books which present the commoner marine animals and plants at a level suitable to the non-scientist. The first of these "Bermuda's Marine Life" describes common animals and plants of the sea 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. The most recent book about the "Fishes of Bermuda" is by Drs. W. F. Smith-Vaniz, B. B. Collette and B. E. 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 describes all the ecosystems to be found in Bermuda at a level that can be appreciated by the general public. Profusely illustrated in colour, it should appear fairly soon. Other useful sources of information are detailed in the Bibliography at the end of this field guide.

In the general text, words in **bold** are defined in the glossary at the end. In the subsequent sections bolding is used for emphasis.

Scientific names are given for the first mention of any species in the text or section but not for subsequent mentions in the same section. Scientific names are included 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. Additionally, scientific names, once you get used to them also give clues to family relationships of organisms and often are quite descriptive of some feature. For example the scientific names '*arenaria*' or '*arenicola*' mean 'sand dwelling'; a burrowing sea cucumber *Holothuria arenicola* is very common in sheltered bays. Another common inhabitant of the sheltered sandy habitat is the Cockworm, whose

Geological Background

The Origin of the Bermuda Islands

Ancient History

According to the most widely accepted theory, Bermuda had its origins on the Mid Atlantic Ridge of the Atlantic Ocean about 110 million years ago. If this is correct, it 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 other, 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 type of 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, some frequent small tremors, some earthquakes and the creation of a variety of volcanoes. One of these erupting 110 million years ago, later supposedly became the Bermuda islands. The volcano would have appeared just to the West of the ridge and produced a large sea mount which rose close-to or above the surface of the ocean. 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. Some recent theories suggest that Bermuda is indeed a hot spot island and therefore not as old as originally thought. More research may sort out these conflicting ideas.

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

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 and other seismic activity there is virtually constant. One large eruption in the recent past produced Surtsey, a new island consisting of dark volcanic rock. At first, 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 consists of light coloured, alkaline limestone rocks and soils, very different from the original dark coloured and acidic basalt.

The Making of Modern Bermuda

The limestones which are so characteristic of the surface of Bermuda today have all been formed by biological activity in warm, 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. It is unclear just when limestones started to form in ancient Bermuda. This process depends 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. Its warmer than usual waters, for its latitude, are the result of water from further south, transported here 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."

One very important process in the creation of a modern Bermuda was the formation of large areas of sand dunes on top of the limestone cap covering the volcanic seamount. Three features are very important in this regard; the first is the laying down of a mass of limestone by organisms as explained above. Secondly large quantities of sand arose partly from erosion of the limestone and also from particles of calcium carbonate arising from fragments of limy seaweeds, and shell and skeletal material from a wide variety of animals. The third, and most important factor was the lowering of sea level that occurred during the most recent glacial period, when vast quantities of sea water were converted to the ice caps. The lower sea levels exposed both rock and sand to the air. The rock surface eroded to sand which added to that already present. Once dried the sand was blown about by the winds producing sand dunes. Over long periods of time, under the influence of slightly acidic rain, the dunes were re-converted to rock. This rock was called **aeolianite**, and the vast majority of the rock now found in Bermuda is of this type. Aeolian is a word that means wind-created.

Sediment Formation and Erosion

Although rocky outcrops may be present in some sheltered bays, these bays and seagrass beds are primarily sedimentary habitats. This section of the field guide looks at the origin of bays and how the sediment found in them came to be formed and distributed as it is today.

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

Bays in the Making

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

Origins of Sediments

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

On land, wind causes considerable erosion and again the particles that are created are further reduced in size by mechanical abrasion as they move under the influence of wind or gravity. Additionally, erosion on land occurs as the result of the dissolution of limestone in fresh water. This latter process does not directly create particles of sediment, but it does so indirectly as sand grains previously cemented together are freed by the removal of the calcium carbonate cement. Much of this material from the land is washed into the sea in freshwater runoff. Additionally some is blown in by strong winds.

Biological Erosion

Another process of great importance is **biological erosion** or **bio-erosion** as it is commonly called. This is erosion that results from the action of a very diverse group of marine animals and plants.

Feeding bio-erosion is certainly a major component of sediment production in Bermuda. One of the main contributors to this process are the Parrot Fishes (see Project Nature, "Coral Reefs of Bermuda", for more detail). The Parrot Fishes feed mainly by scraping small seaweeds off the surface of reefs and other rocky bottoms. They have heavy, powerful, jaws that remove a surface layer of rock along with their food. The digestive process removes food but passes on ground rock as body waste. Very large quantities of sediment are produced in this way. A variety of marine invertebrates including snails, sea urchins and crabs produce sediment in a similar fashion.

Burrowing bio-erosion is also very important and is carried out by a very wide variety of marine animals. Burrows may be created in either rock or sediment, but it is the former which is most important in the creation of new sediment. Even simple marine animals burrow into rock. A good example is the boring or burrowing sponges, several species of which are common in Bermuda. These sponges create a habitat within rock or molluscan shells by bio-chemically cutting out tiny, very regularly-shaped pieces of limestone which they eject out into the surrounding water. Another very interesting burrower into rock is the Black Date Mussel (*Lithophaga nigra*). This is an example of a creature whose scientific name is very descriptive. Lithophaga means 'rock eater' and nigra means 'black'. The Date Clam is a jet-black rock burrower. This 2.5 cm (one inch) long clam can be found in extraordinarily large numbers in some locations, and they are capable of removing a huge volume of rock. The deep cleft, just below low tide level, in the vertical, rocky shores of Harrington Sound, called the Harrington Sound Notch, results from the boring activities of this species. In this example, tiny larvae settle out from the water onto the rock and burrow into it by a combined chemical and mechanical method. The clam softens the rock with acid and then scrapes it away using the teeth-like structures on the end of the shell. The sediment produced is ejected into the water from a small hole maintained to the outside. It feeds on plankton in the water, drawn in through this same hole. As it grows the clam enlarges the hole. Huge numbers of holes weaken the rock surface causing it to break away. The cavity produced by this activity may extend at least 3 m (9 ft) back into the cliff and makes the cliff face unstable. Thus in this case, bio-erosion promotes physical erosion. The combined process produces huge amounts of sediment.

A third very important type of bio-erosion can be called **biochemical bio-erosion** or physiological bio-erosion. The natural life-processes of animals and plants result in the production of acids that can erode limestone rock. By night plants, and animals constantly, produce carbon dioxide which reacts with water to produce carbonic acid. This in turn can be used together with other organic acid products, to dissolve rock thereby creating a protected living space. A very good example of this is the black-coloured, blue-green cyanobacterium, called Hofmann's Scytonema (*Scytonema hofmanni*), which is virtually universal at the top of the seashore in limestone rock. The body of the organism is partly buried in tiny cavities eroded into the surface of the limestone. This erosion results in a very jagged surface to the upper shore which is called **phyto-karst**. This term needs explanation. Karst topography occurs in terrestrial limestone regions as a result of erosion and is characterised by numerous sharp-pointed hills of very variable size. The prefix 'phyto' is used to mean plants. Blue-green cyanobacteria were previously considered as plants and share with them the presence of photosynthetic pigments. Phyto-karst is on a much smaller scale than true karst topography. A second common blue-green cyanobacterium, this time pale pink in colour, may be found as a layer 1 cm (3/4 in) or so entirely within the limestone rock. In this case the habitat of the plant is totally produced by erosion or enlarging of cavities in the rock. These examples result mainly in dissolved calcium carbonate in the water, rather than in actual sediment production. However, they also weaken the rock making it more prone to physical erosion which results in sediment. In animals, biochemical bio-erosion is often combined with mechanical burrowing to soften rock. In this case quite strong acids are produced by special cells or glands. Two such examples, the boring sponges and the Date Clam, have been cited above.

Sediment Movement and Sorting

Sediment Sorting

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

Sediment Consolidation

Another factor that affects sediment mobility is **sediment consolidation**. In places of very varying current velocity, sediments may be constantly deposited and then re-suspended. Fine sediments when first deposited trap large amounts of water among them. As they sit and settle, this water is slowly expelled, consolidating the sediment. Consolidated sediment is firmer and denser than that which was deposited but the grain size does not change. Consolidated sediments can only be moved by a much higher current velocity than that at which they were deposited. Because of this they become more and more stable with time and tend to stay put.

Sediment Permeability

Another physical attribute of sediments that is of great importance to life therein is **sediment permeability**. Permeability refers to the amount of open, water-filled spaces among sediment grains. It can also be measured by the rate at which water can move through the sediment. This property can be made clearer with examples.

Consider a coarse sand deposited in constant high water velocity; it will lack smaller sediment particles, be very permeable and have lots of water-filled voids. In a second example, varying current velocity has resulted in a sediment of very mixed particle size. In this sediment the voids between large particles are filled with small particles, permeability is poor and spaces are few and far between. Permeability is also low in sediments of constant, tiny particle size. Well sorted sediments have greater permeability than poorly sorted sediments. The water-filled spaces within permeable sediments are often colonised by communities of tiny animals called the **interstitial fauna**. For descriptions of some of these animals refer to the Project Nature Field Guide "The Sandy Shore."

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

Sediment Movement

Gravity and water movement combine to move sediment into low spots both on land and in the sea, and at the same time to reduce the grain size. Thus bays and most coastal waters were naturally floored by sediments. The finest of these sediments, called muds and silts, most readily suspended in water, have finished up in the quietest and most sheltered environments. Examples in Bermuda include the innermost part of Hamilton Harbour at the Foot of Crow Lane, Sinky Bay on the south shore, Coot Pond on the North Shore and the inner part of Mill Creek to the west of Hamilton. The coarser sands, on the other hand, are characteristic of areas with consistent, high wave and/or water current activity. Thus coarser sands tend to be found on exposed beaches, just offshore and where tidal currents are vigorous. In these locations, in common with wind exposed sand on land, the sand tends to form underwater structures rather like dunes. These are often called **sand waves** or **sand ridges**. They are usually much lower in height than sand dunes on land. Sand waves, like dunes, are often mobile moving slowly with the current. However, in many places they become colonised by seagrasses which fix them in place. A good example of this is the seagrass beds off Fort St Catharines on the east end of Bermuda. Aerial photographs of this area show very consistent series of sand ridges colonised by seagrasses. Very nice mobile sand waves may be seen in the central part of Flatts Inlet where tidal currents are strongest.

Sediment Particles of Biological Origin

Sediment is not only formed by the erosion of rock but from particles of the shells or skeletal material of a wide variety of organisms both animal and plant. Most of these particles are of calcium carbonate, but a lesser number are of **chitin** and other organic skeletal material. Material that comes from organisms is called **biogenic** and may originate from either animals or plants. Biogenic particles are an exceedingly important component of the sediments and in some locations make up the majority of particles. Figure 1 shows a range of commonly seen particles of both animal and plant origins.

Sediments of Plant Origin

Plant contributors to the sediments come from the brown, red and green algal groups, the latter two being the most important. Among the green algae the Plateweeds (*Halimeda* species) are very important sediment producers and the particles they add are easily recognised under the microscope. Plateweeds have a plant body that is made up of a group of series of hard plates, or segments, hinged together. These plates are constantly produced and fall off after a relatively short period. In the Common Plateweed (*Halimeda incrassata*) each segment resembles a three-toed foot about 2.5 mm (1/10 in) long. The red algae also produce many sediment particles. Perhaps the best examples fall among the Needleweeds (*Amphiroa* species) which like the green Plateweeds are segmented. In this case however the segments are needle-like or in the shape of short rods. The Pointed Needleweed (*Amphiroa fragilissima*) is common in fairly quiet locations. There is also a group of red algae which form as rock-hard sheets on the rock or other surfaces. These crustose coraline algae have been discussed above in relation to reef formation. A much smaller relative called Scaleweed (*Fosliella farinosa*) grows in abundance on the leaves of seagrasses. These leaves are shed at frequent intervals and as they rot, they release the Scaleweeds to augment sediments. The brown algae are only minor contributors to the sediments but some well known ones such as the Petticoat Algae (*Padina* species) do produce some calcium carbonate particles that reach the sediments when the plant dies. However, these are never in the form of segments and just form tiny chalk-like particles, which cannot be identified to reveal their origin, in sediments.

Sediments of Animal Origin

Many animals contribute particles to the sediments but the most famous and easily recognised sediment component comes from a protozoan animal called the Red Foraminiferan (*Homotrema rubrum*). This amoeba relative forms a test of calcium carbonate which is coloured a bright pinkish-red and is surprisingly large, up to 3 mm (1/8 in) long. They look a bit like tiny, irregular, lumpy strawberries and are very hard. These creatures live in reef cavities, under rocks etc and are very common. Death or erosion may break them from the rock surface and they are a prominent component of south shore sediments in Bermuda. They produce the romantic pink sands such as those found at Pink Beach. Other animal particles that are easily recognised in sediments include sea urchin spines, parts of crustaceans such as claws, spines and body segments or plates, molluscan shells and shell fragments, fish vertebrae etc.

Figure 1 illustrates sediment particles commonly found in Bermudian sand.

Sediment as Food.

Pure sediment contains only inorganic material and cannot serve as a source of food for animals. However, in nature sediment rarely remains in the pure form for any length of time unless it is very deeply buried. Any sediment in natural water bodies will soon acquire an admixture of organic particles and living organisms. The non-living material will mostly be in the form of **detritus** or partially decomposed remains of dead organisms, which in turn supports a wealth of bacteria and protozoans. When detritus is mixed with limestone sediment, the sediment darkens in colour. Once detritus is present it becomes mixed with the sediment as a result of sediment movement or the activities of animals. Detritus always carries a population of bacteria and protozoa which use it as food and also enrich it as a source of food, for other animals, by their own bodies. This activity results in the depletion of oxygen through respiration. If sediment is very rich in detritus it may run out of oxygen and become almost black in colour and foul smelling. Sands usually have only a small admixture of detritus. Thus they form a source of very dilute food. Such food is difficult for larger animals to exploit but some, for example the Sea Pudding (*Isostichopus badionotus*) have very elaborate mechanisms to do so. Some of these adaptations are described below. Detritus continually rains on to the sediment surface and is more concentrated there. Because of this many animals feed on the surface of the sediment rather than deeper down. Bacterial decomposition of detritus in sediments also releases inorganic plant nutrients. These can be exploited by seagrasses but not by seaweeds as is discussed below.

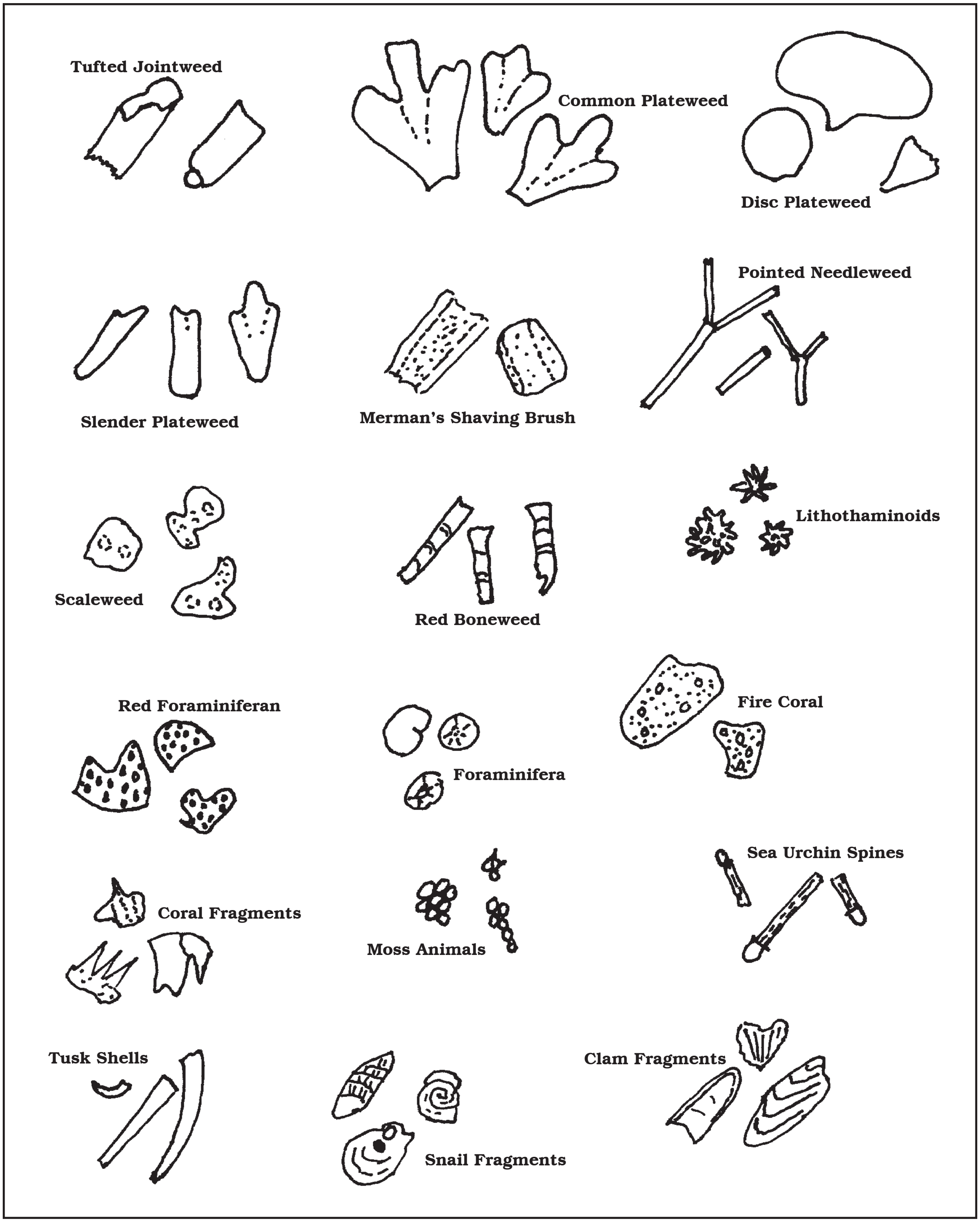


Figure 1. Identification of Sand Grains all about 2-4 times normal size

Biological Background

Features of Shallow Water Sedimentary Habitats

Shallow water sedimentary habitats do not have a high physical diversity but do present a considerable variety of habitats; only those of reasonably sheltered locations are considered in this field guide, but others must be mentioned.

Very Exposed Locations
Sedimentary bottoms are found almost universally in locations of either fairly constant high wave action, or fairly constant high current velocity. Only under incredibly rough or exceedingly high current conditions is the seafloor swept clear of sediment. Conditions for life are difficult in sediments with high water movement energy in the overlying water. This is because such sediments are <u>unstable</u>. Either they are constantly shifting or they are constantly being deposited and re-suspended or both. Such unstable conditions are the rule in sandy sediments along Bermuda's south shore, both intertidal and sub-tidal. Only very specialised animals can live on or in such sands and plants are absent. For animals that might be found on intertidal wave-swept sandy beaches refer to the Project Nature Field Guide "The Sandy Shore."

Sedimentary Environment Habitats
Sandy sediments in lower water energy locations are much more stable than those described above. Sediments that are at least reasonably stable offer a variety of possible habitats for life and variety increases with stability. These habitats can generally be divided into two general types, those <u>on the sediment surface</u> and those <u>within the sediment</u> itself. A third associated habitat exists <u>in the water above the sediment</u>.

The Sediment Surface Habitat
The sediment surface supports species of both animals and plants. The plants tend to be fixed in position, whereas the animals may be either fixed or active. The plants may be either seaweeds (algae) or seagrasses which are flowering plants. The algae may be either anchored to the sediment in some way or free. Naturally, free drifting seaweeds such as the Common Pincushion (*Cladophora prolifera*) are confined to very quiet areas. Where there is significant current or wave-action they would be swept away. Those seaweeds anchored to the bottom include a very interesting group of green algae, such as the Merman's Shaving Brush (*Penicillus capitatus*) which appear to be rooted. However, algae never have true roots and these root-like structures are just anchors and have no physiological function. This will be discussed further below in relation to ecology. Many of the animals of the sediment surface are slow moving creatures, examples being the Sea Pudding (*Isostichopus badionotus*) and the Harbour or Milk Conch (*Strombus costatus*). Most of the animals that are fixed in position are attached to the seagrasses or seaweeds. Examples include the Fire Sponge (*Tedania ignis*), the Violet Finger Sponge (*Haliclona molitba*), the Brown Lumpy Sponge (*Halisarca dujardini*), the Red Bushy Hydroid (*Eudendrium carneum*) and the Coiled Tube Worm (*Spirorbis formosus*). In addition to these animals and plants which are readily visible you should be aware that there is a large community of microscopic animals and plants living on the sediment surface. Many of the plants are single-celled and the most common are members of the Diatom group. Diatoms may be either colonial or solitary and most solitary ones are somewhat mobile, having a slow gliding motion. Some move down into the sediment in bright light and back onto the surface as light dims. This may result in a distinctly different sediment colour at different times of the day! Microscopic animals of the sediment surface are very varied ranging from single celled protozoa to multi-cellular creatures such as flat worms or tiny crustaceans.

Many shallow-water animals move into sheltered bays or onto seagrass beds to spawn. Their juvenile stages or larvae may augment the permanent fauna of the sediment surface at times.

The Buried Animals

The fauna that are buried in the sediment fall into three general groups, sedentary animals with semi-permanent burrows, animals that actively burrow through the sediment seeking prey, having no permanent burrows and the interstitial fauna that live between the sediment particles. An example of an animal with a semi-permanent burrow is the Cockworm (*Arenicola cristata)*; the Milky Moon Snail (*Polinices lacteus*) is an example of a hunting burrower without a permanent burrow. The interstitial fauna are beyond the scope of this guide; some examples are illustrated in the Project Nature Field Guide "The Sandy Shore".

The Water Above the Sediment

The water above the sediment and seagrass beds is the habitat of a wide variety of fish, some squids and a few sea turtles. Seagrass beds are also used as nursery grounds by many fish and some crustaceans. This water habitat exhibits a much higher **biodiversity** than either the sediment surface or the sediment itself.

One of the most characteristic groups of fishes seen over shallow sedimentary bottoms are the "fry". These little silvery fishes, often in very large shoals consist of five different species. A common one is the Bermuda Anchovy or Hogmouth Fry (*Anchoa choerostoma*). They are commonly netted for use as bait for fishing. There is one fish that is uniquely adapted to life on sand, the Peacock Flounder (*Bothus lunatus*); this flatfish can change colour and mottling pattern of its skin to blend in with the bottom, and also can just bury itself in the sediment with only the stalked eyes showing. The Green Turtle (*Chelonia mydas*) is the characteristic large vertebrate of seagrass beds. Indeed its normal food the Turtle Grass (*Thalassia testudinum*) gets its name from this association.

Ecology of Bermuda's Sheltered Bays and Seagrass Beds

Introduction

There are a few general terms that group animals living on and in the sediment and in the water above the sediment. The general term for animals living on or in the bottom of water bodies is the **benthos**. They are called **benthic organisms**. Those that are buried beneath the surface of the sediment are the **infauna.** The word **fauna** refers to animal life only and so infauna is somewhat misleading. While all the large organisms are animals there are fungi, bacteria and some tiny plants present. However, you will see only the animals with the naked eye. The organisms or **biota** that live on the surface of the bottom are termed **epibiota**. This includes all living organisms whether animals, plants, fungi, bacteria, or other forms of life. The creatures that swim in the water over the bottom are part of the **nekton.** In this case they are principally fishes but also include turtles and squids. One further group of organisms will be present in the water over the bottom, these are the **plankton**, the vast majority of which are very tiny animals and plants that are suspended in the water. Some can swim weakly but could not swim against a current.

General Adaptation among the Seaweeds to Sedimentary Life

Introduction

There are two groups of plants that can be readily observed in sedimentary locations. The first of these is the algae or seaweeds and the second is the seagrasses which are flowering plants. They will be discussed later. Generally speaking, the algae are poorly adapted to life in sedimentary environments as they are generally attached to firm substrates by what is called a holdfast. Sediments can not be considered as firm substrates, so it is perhaps surprising that there is quite a wide diversity of seaweeds present. There are at least five ways that algae have used to adapt to the sedimentary environment.

The Anchored Seaweeds

The main one of these adaptations is that a good number of species among the green algae have developed root-like structures that penetrate the sand. These structures called **rhizoids**, do anchor the plants well, but differ from true roots in that they are physiologically inactive. True roots have the function of extracting plant nutrients such as nitrogen and phosphorus compounds from the sediment. These nutrients essential to the life of plants are then available for life processes. Sediments are generally very rich in plant nutrients in comparison with the water, since the decay of organisms is concentrated there, and it is this decay that returns the nutrients contained in organisms back to the environment. The rhizoids of the algae cannot take up plant nutrients and so these algae, in common with those lacking rhizoids, must extract essential plant nutrients from the water where they occur only in a very diluted form. This puts the algae at a competitive disadvantage in comparison with the seagrasses. However, the rhizoids do enable them to colonise a habitat where there is little competition for living space from other algae and where light intensities are quite high, facilitating photosynthesis. Examples of common green algae with rhizoids are the Plateweeds (*Halimeda* species), the Merman's Shaving Brush group (*Penicillus* species), and the Fanweed and Funnelweed group (*Udotea* species). Most algae with rhizoids strengthen their structures with calcium carbonate and are therefore important contributors to the sediment in which they live.

Seaweeds Living on other Plants or Animals

The second main adaptation is the adoption of an epiphytic or epizootic mode of life by seaweeds and invertebrates. **Epiphytes** use another plant as a firm substratum to which to anchor themselves and **epizooites** are attached to animals in a similar way. Epiphytes are a very important component of the seagrass community. Curiously, the green algae with rhizoids, referred to above, do not support many epiphytes because they have evolved chemical repellant mechanisms to prevent colonisation in this way. Likewise epizooites are uncommon but do occur. A curious and interesting situation similar to having epizooites is presented by some of the sea urchins such as the Purple Urchin (*Lytechinus variegatus*), which carry around living plant fragments as camouflage.

Algae Weighted Down with Sand

A third adaptation evolved by algae so that they can colonise sediments is the use of sediment particles held as weight in a thick tangle of hooked filaments. Thicketweed (*Spyridia hypnoides*) employs this method with great success, colonising large areas of sandy bottom. It also acts as a substratum for epiphytes.

Cushion Forming Algae

A rather similar adaptation to using sand as a weight is the entrapping of sediments among a mass of tiny vertical filaments sometimes starting on individual sand grains. As the sediments accumulate, the filaments grow upward forming a cohesive firm mat. Some tiny green algae such as the Green Cushionweed (*Cladophoropsis membranacea*) do this, as do several species of blue-green cyanobacteria. The blue-greens, as they are commonly known, form structures known as Algal Biscuits (*Phormidium hendersonii*) or Stromatolites (*Phormidium corium*) which are gelatinous in texture and may show daily growth lines as bands in the entrapped sediments.

Unattached Algae

The Common Pincushion (*Cladophora prolifera*) is able to live on sediments by the simple method of not attaching to anything, but only growing in the quietist of bays where it just lies on the bottom. During the 1970's and 1980's the Common Pincushion underwent what is called a **population explosion**. In this incident sheltered bays literally filled with this seaweed which formed layers up to at least 1 m (3 ft) in thickness. These masses of seaweed were too dense to allow much light penetration and consequently the algae in the deeper parts of the layer died and decomposed. This, in turn, killed the animals on and in the sediment and thereby caused an ecological catastrophe. The precise cause of this population explosion was not found but evidence pointed to increased levels of plant nutrients resulting from seepage and run-off from the land.

Ecological Aspects of Seagrass Beds

Introduction

Figure 2 shows a typical Bermudian seagrass bed illustrating all the seagrass species found here as well as some algae and common animals associated with seagrass beds. Look at this illustration to get a good idea of the seagrass bed habitat before visiting one.

Seagrasses in general

The seagrasses belong to a small but widespread group of marine flowering plants that are extremely important in the general ecology of shallow coastal waters. Although there is not a large number of different species of seagrasses, they have been able to colonise shallow sedimentary environments throughout the world, except in polar locations. They are the only flowering plants that live totally submerged in sea water and they are highly adapted to this environment. Where they occur they form large, dense beds that are very important in the stabilisation of shallow coastal sediments. Their role in stabilising sediments was demonstrated quite accidentally, when a North Atlantic species called Eelgrass (*Zostera marina*), which has been recorded once in Bermuda, was decimated by a disease, called Wasting Disease in the 1930's. As Eelgrass stands disappeared, sandy islands eroded away and whole coastlines changed in character.

One of the factors that has contributed to the ecological success of the seagrasses is that they, as true flowing plants, and unlike the algae, have true roots. Because of this, they are able to exploit the rich supply of plant nutrients that naturally concentrate in the sediments. Seagrasses can absorb nutrient material from sea water, but unlike the algae, do not have to rely on seawater for their essential nutrients. Seagrasses have exploited a habitat where light levels are always high, where water is always present, where competition from algae is negligible and where essential nutrients are in good supply. It is not surprising then that seagrass beds are among the most productive ecosystems on earth. Productivity is measured as the amount of new organic material that is produced during a unit of time and this is demonstrated by the growth of new leaves, roots and entire plants. Seagrass plants consist of tufts of leaves arising at nodes from a buried stem called a **rhizome**. Do not confuse this with the **rhizoids** found in the anchored green algae. Roots also occur as groups at each node. The rhizomes can elongate to enlarge the seagrass bed. Additionally, fragments of rhizomes that are torn away by water currents or the feeding activities of animals can be carried long distances in the water to populate other areas. This is a method of asexual reproduction.

Seagrasses have underwater flowers and pollination takes place in the water. The seeds so produced, by this sexual reproduction, are released and may germinate close-by or be carried to distant locations by water currents or animals.

The leaves which are continuously added at the centre of each leaf clump are also continuously lost at the outer edges of the clump. Pieces also break away at the tips of leaves as they age. The growing leaves form a direct food supply for creatures such as sea turtles, some fish, manatees, geese and some urchins. However, a probably more important role stems from their involvement in the production of detritus when they die. As leaves are shed and decompose, they form **detritus** particles which are invaded by bacteria and become a protein-rich food source used by a huge variety of marine animals. This detrital food supply is carried far beyond the grass beds by water currents and is important in the ecological economy of the whole coastal zone of the ocean. Ecosystems which supply food to areas outside their boundaries are called **export ecosystems**. Another unseen aspect to food production by the seagrasses is that they release into the water molecules of organic compounds that were synthesised in the process of photosynthesis. These molecules can be used directly as food by a variety of invertebrates including clams and worms but most are probably taken up by bacteria which, in turn, form a food supply for filter and detritus feeders.

Bermudian Seagrass Beds

The seagrass beds around Bermuda are not constant in location. It has been observed that some are decreasing in size or even disappearing, while others are enlarging and a few are appearing in new locations. There is no firm evidence that shows why these changes are taking place, but it is known that seagrasses are very sensitive to trampling by people. Because of this they have disappeared in recent years from some heavily-used bays such as Tobacco Bay and have been greatly reduced in extent in others such as Whalebone Bay.

Seagrass Beds as Nursery Grounds

Seagrass beds, as shown in Figure 2, slow water currents and trap sediments. They also form a refuge on a sedimentary bottom where otherwise there would be little cover. It is not surprising then that they are a vital nursery ground for many fish and invertebrates. In Bermuda, at least 30 species of fish use seagrass beds as nursery grounds. These fish include the Bermuda Bream (*Diplodus bermudensis*), the Shad or Silver Jenny (*Eucinostomus gula*), the Bigeye Mojarra (*Eucinostomus havana*), the Mottled Mojarra (*Eucinostomus lefroyi*), three grunts, the Blue-striped, White and French (*Haemulon sciurus, aurolineatum* and *flavolineatum*), the Pinfish (*Lagodon rhomboides*), the Sand Diver (*Synodus intermedius*), the Spotted Goat Fish (*Pseudupeneus maculatus*), the Slippery Dick (*Halichoeres bivittatus*), the Slender Filefish (*Monacanthus tuckeri*), as well as the Bucktooth Parrotfish (*Sparisoma radians*) and the Bandtail Puffer (*Sphaeroides spengleri*). The larvae of the Spiny Lobster (*Panulirus argus*) settle in seagrass beds to begin their crawling life. Another aspect of ecological importance is that the seagrass plants act as a substratum for the settlement of algae and sedentary invertebrates. In this way they enhance **biodiversity** to a very significant degree.

Seagrass Beds and Turtles

One of the most important aspects of seagrass bed ecology in Bermuda, is that these systems are widely used by the Green Turtle (*Chelonia mydas*) for the feeding grounds of juvenile individuals. When Bermuda was colonised, Green Turtles bred on island beaches and individuals of all ages would feed in the seagrass beds. Adult turtles were ruthlessly exploited for food, the population was decimated and breeding stopped. Turtles always return to breed at the site where they hatched so breeding never re-commenced. However, individuals hatched elsewhere have continued to migrate to Bermuda to feed and grow. After three or so decades, when nearing maturity these turtles move off to breed elsewhere. Attempts have been made to re-introduce these turtles by hatching eggs in Bermuda beaches. Whether this will work or not is uncertain, but if it does, adult turtles should be returning to breed during the next few years.

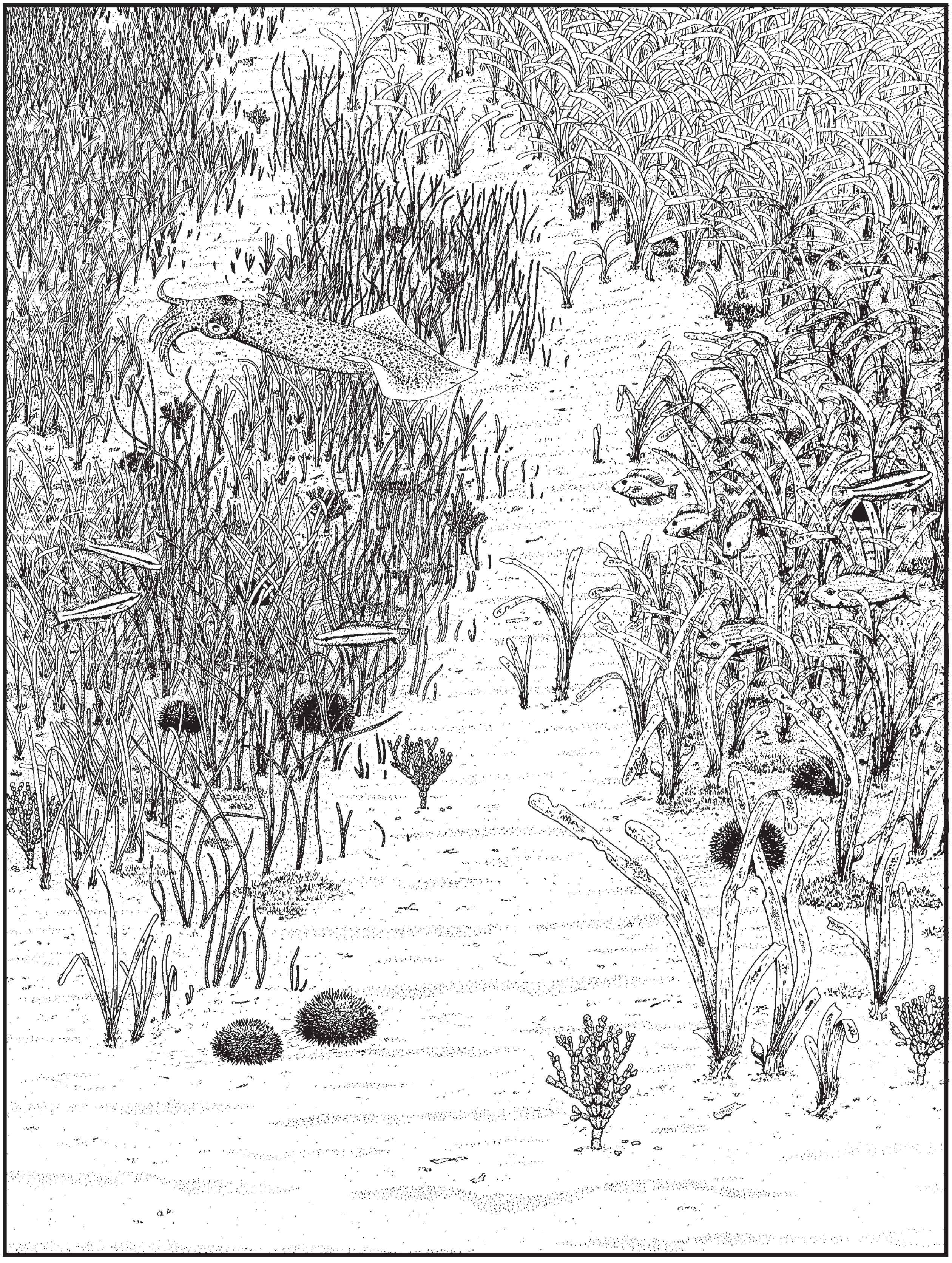


Figure 2. A typical seagrass bed in Bermuda showing communities dominated by the two commonest species, Turtle Grass and Manatee Grass.

Key to Figure 2

Turtle Grass
Thalassia testudinum

Shoal Grass
Halodule wrightii

Manatee Grass
Syringodium filiforme

Thicketweed
Spyridia hypnoides

Scaleweed
Fosliella farinosa

Common Plateweed
Halimeda incrassata

Purple Urchin
Lytechinus variegatus

White Urchin
Tripneustes ventricosus

Slippery Dick
Halichoeres bivittatus

French Grunt
Haemulon sciurus

Doctorfish
Acanthurus chirurgus

Arrow Squid
Loligo plei

Seagrass Species in Bermuda

There are three common species of seagrass found in Bermuda and a couple of others have been seen here. By far the commonest of the seagrasses is Turtle Grass (*Thalassia testudinum*) and this is the one that forms the extensive beds. It has long, broad, flat leaves up to 1 cm (1/3 in) across and up to at least 1 m (3 ft) long; however, the average size is one half or less of these figures. Manatee Grass (*Syringodium filiforme*) differs from Turtle Grass in that the leaves are round in section, rather than flat. Growing up to 30 cm (1 ft) high, it sometimes forms quite large dense beds in quiet areas. It is often mixed with Turtle Grass. The third species, Shoal Grass (*Halodule wrightii*), has flat leaves like Turtle Grass, but they are only about 2 mm (1/10 in) wide and only up to 15 cm (6 in) tall. Shoal grass is often found around the edges of Turtle Grass beds and not infrequently, mixed stands of all three occur. All the seagrasses reach a maximum size in shallow, rich muddy bottoms; some especially fine ones are to be seen in the quiet inland saltwater ponds.

Although it is only locally found in Bermuda, one other seagrass species, The Dwarf Seagrass (*Halophila decipiens*), is worth mentioning. It can be found in virtually all tropical shallow oceans. Unlike the three common species it is not grass-like but has small, oval leaves only 2 cm (3/4 in) long. It is found in somewhat deeper water than the common species.

The Burrowing Animals

Introduction

The burrowing animals are the most highly adapted but least diverse of the three groups of animals of sedimentary locations. They can be divided into two sub-groups, those that construct semi-permanent burrows and those that move through the sediment with no lasting burrow. Both of these groups must initially be able to burrow down into the sand. Some, such as the burrowing shrimps, burrow using legs, others such as most of the worms and sea cucumbers burrow by narrowing the body and thrusting the head into the sand then widening the buried part of the body to anchor it, and pulling the hind part down. Others such as the Peanut Worms (Sipuncula) and Clams do this in the reverse direction, the tail end going first. Burrowing snails have a large foot which they thrust through the sediment advancing by muscular contractions of this foot. A variety of common burrowing animals is shown in Figure 3 together with some sediment surface dwellers.

Semi-permanent Burrowers

If burrows are going to last any length of time they must be stabilised in some way or they would just collapse and in-fill with sand. Most permanent burrows are lined with a secretion such as mucus which binds the sand grains together and forms a smooth burrow lining. Many such burrows have two openings to the sand surface and a U shape is common. This also allows the burrowing animal to pass water continuously through the burrow to supply oxygen for respiration. Animals with lasting burrows must have some way either to feed within the burrow or to extend feeding organs out of the burrow. A good example of an elaborate burrow feeding behaviour is shown by the Cockworm (*Arenicola cristata*). The Cockworm makes a U shaped burrow extending 30 cm (1 foot) or so into the sediment which is lined with mucus for most of its length (Figure 3). To feed the Cockworm moves toward the front end of the burrow, which is unlined, so that the head is 10 cm or so below the sand surface and by rhythmic body movements, pumps seawater inward through the remaining sand. The water passes around the body where gills extract oxygen and exits at the hind end of the burrow. As this water passes through the layer of sand above the head of the worm, minute floating plants called **phytoplankton** and particles of dead algae or seagrasses called **detritus** are filtered out by the sand and concentrated above the worm's head. When the sand is rich in this food material, the worm swallows it and the digestive processes extract the food. The waste sand is ejected on to the sand surface at the hind end of the tube by the worm moving backward to that position. This ejected sediment which forms thick, thread-like masses, is called a casting. As this process is repeated over and over, a pit develops at the head end of the burrow and a mound at the tail end. Digging deeply and carefully between the depression and the casting will extract the worm, which is quite soft and delicate with bright red gills. The worm does not need to be tough as it is well protected by the

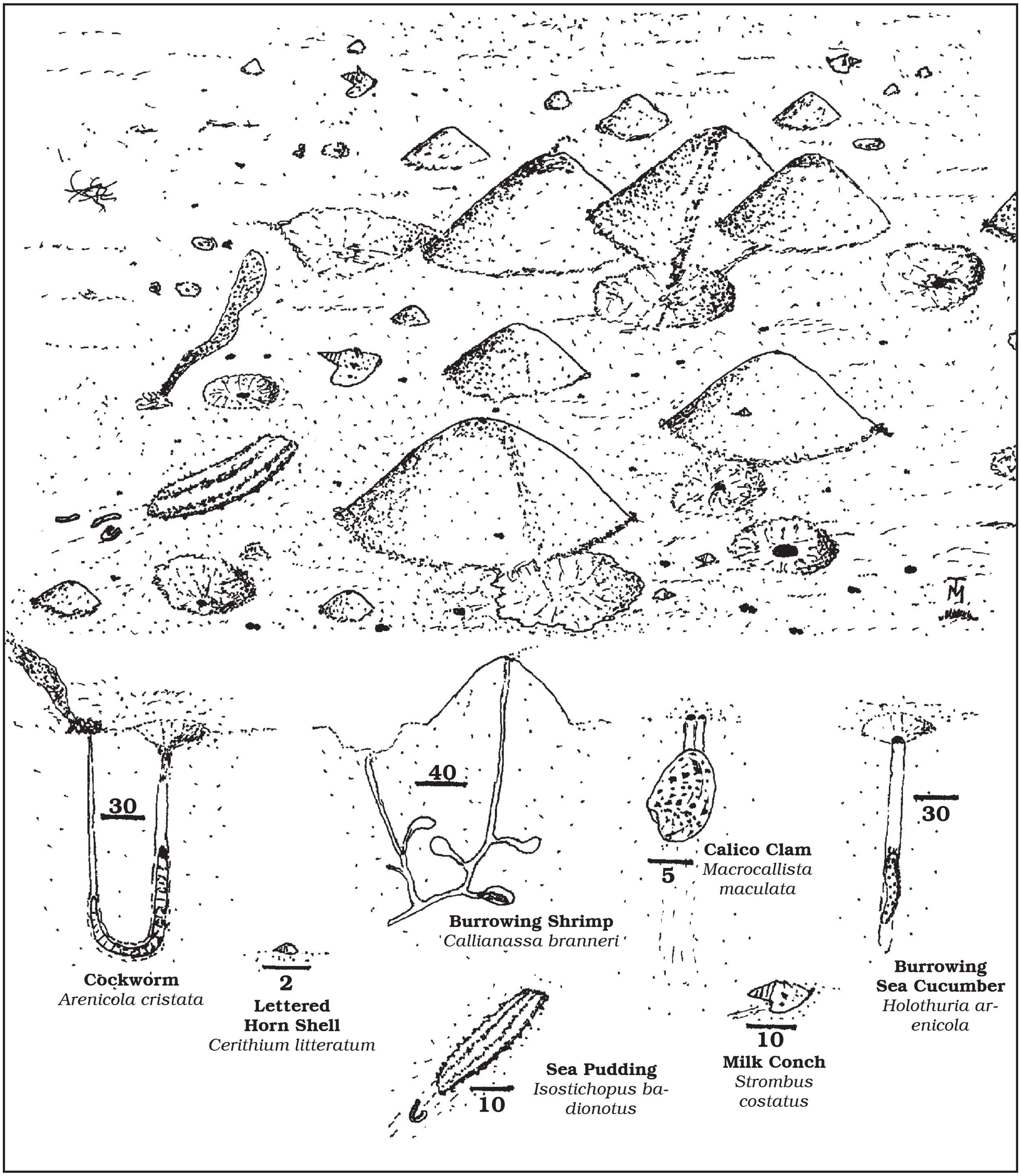


Figure 3. Top Sketch of the appearance of the sediment surface at a location dominated by semi-permanent burrow dwellers. Below Burrow structures and key to the organisms illustrated. Note: Scale differs between species. Bar and number 30 show scale in centimeters (10 cm = 4 in).

sediment around it. The gills are red because the worm has haemoglobin, much like our own, as a blood pigment. This is unusual for invertebrate animals but is an adaptation found especially among the burrowers. Haemoglobin is very efficient at extracting oxygen from water and useful here as the water quantity in a burrow is small and the oxygen concentration quite low. The Cockworm also has an interesting reproductive adaptation. The eggs instead of being released into the water, as in almost all worms, are contained in a brown gelatinous mass attached to the sand at the burrow end. Well developed larvae hatch from this mass and may settle in suitable places to colonise new areas or maintain the population.

Another burrower that has a burrow maintained for a long period is the Burrowing Sea Cucumber (*Holothuria arenicola*). Also mucus-lined, the burrow goes straight down for up to 75 cm (30 in) (Figure 3). This Burrowing Sea Cucumber feeds by quite a different method from the Cockworm. When conditions are quiet the cucumber moves up the burrow towards the water and extends these tentacles over the sand surface. The tentacles are sticky and gather detritus particles that have settled to the surface of the sediment. Tentacles covered in detritus are then withdrawn and wiped clean in the mouth of the sea cucumber.

A third type of feeding behaviour is shown by the Burrowing Shrimp (*Callianassa branneri*). Like the Cockworm the Burrowing Shrimp produces a mound of sediment at the hind end of the burrow, but in this case the mound can be huge and volcano like. However, the burrow structure and feeding method are quite different. The burrow of the Burrowing Shrimp is deep and complex with several small rooms or chambers off the main burrow (Figure 3). In feeding, the shrimp rises to the surface of the head shaft of the burrow and captures particles of detritus, particularly seagrass leaves from the water. They probably also scrape detritus off the sediment surface. Some of this material is eaten but some is stored in the chambers, where bacterial and fungal action enrich this food source. It can then be eaten later and when surface feeding is impossible due to storms or disturbance. Unlike the Cockworm, the vast bulk of the sand is not swallowed by the shrimp but just ejected from the tail end of the burrow. Observation will show an almost continuous stream of sediment emerging from the top of the volcano-like mound.

The bivalve molluscs, often called clams, are probably the most diverse group among the burrowing fauna. They dig in by means of a powerful muscular foot which is inserted in the sediment, expanded at the tip to form an anchor, and then contracted to pull the shell in. The depth to which the shell is buried varies very greatly in different species. The Calico Clam (*Macrocallista maculata*) is only just buried (Figure 3) whereas the Sunrise Tellin (*Tellina radiata*) is deeply buried. The deeply buried examples usually have mucus cemented holes leading vertically to the surface. These clams communicate with the water above by means of a pair of tubes called siphons. These siphons carry oxygenated water for respiration and are also used for feeding. Many of these bivalves are filter feeders that feed by drawing water in through an incurrent siphon and filtering plankton and detritus out on large gills; others such as the Tellins have very long extensible siphons that vacuum up food particles from the sediment surface.

Wandering Burrowers

The second group of burrowing animals, those that do not form semi-permanent burrows and do not cement burrow walls, are mostly predators that hunt the other burrowing animals for food. The best known among these are the Moon Snails such as the Milky Moon Snail (*Polinices lacteus*) common in Bermuda. These snails hunt buried clams; they can bore a hole through the shell of the prey to get at the body. Another interesting feature of the life of the Milky Moon Snail is that it leaves a very readily identified egg mass on the sediment surface. This egg mass is called a 'collar' because of its shape. The egg collar does resemble a shirt collar, which is made of sand and eggs cemented smoothly together, in that it forms a circle without joined ends; unlike a collar these ends overlap. The collar is much narrower at the top than the bottom and the sides are beautifully curved.

Several predatory worms from various groups also hunt through the sediment but are rarely seen. However, not all the burrowers that move about in the sediment are predatory. An example of a detritus feeder is the Sand Dollar (*Leodia sexiesperforata*), related to the starfish and sea cucumbers, which roams around just under the surface of the sediment, from which it sorts tiny detritus particles for food.

Crawling Animals of the Sediment Surface

The crawling animals of the sediment surface are a large and varied group, but only a few of them are easily and regularly seen. Perhaps the most obvious and well known of these is the large sea cucumber known as the Sea Pudding (*Isostichopus badionotus*). Unlike the burrowing sea cucumber this one has a sort of sole on the body on which it walks very slowly. This locomotion is accomplished by means of numerous tube feet. These tube feet found in rows along the body are water-filled tubes with a little suction cup at the end. They can be extended or withdrawn by the animal and can be bent in any direction. The Sea Pudding is highly adapted to life on the sand surface. It gets its food by swallowing the surface sand and its contained detritus. The waste sand is then ejected at the hind end in the form of a casting, rather like curled spaghetti. The total quantity of sand processed by Sea Puddings is immense. One scientist calculated that for Harrington Sound alone, this amounted to up to 1,000 tons/yr!

Another large and well known animal adapted to life on the sediment surface is the conch.

The only conch seen in coastal shallow bays is the Milk or Harbour Conch (*Strombus costatus*). It cannot be mistaken for anything else when it is an adult, as the shell is very large, up to 20 cm (8 in) long, and very heavy. It also has a characteristic flaring lip. Like the Sea Pudding, the Harbour Conch moves slowly over the sediment on its large foot, but instead of just swallowing sand, it sorts edible material, such as plant fragments and larger detritus particles from the surface sand and eats them. Juvenile Harbour Conchs are thinner shelled and lack the big lip; they are very common but often mistaken for other species of snail. If the Harbour Conch is flipped over by other creatures or violent water movement it can rapidly right itself by elongating the foot and curling it down into the sand surface; then with a quick flip it rights itself. The Harbour Conch is not the only snail to live on the sand surface but it is the largest.

The third, almost universally found, large member of the sand surface community is the Purple Urchin (*Lytechinus variegatus*). The Sea Pudding and the Purple Urchin both belong to the same Phylum of animals, the Echinodermata which also contains the Sand Dollar and many starfish. The Purple Urchin resembles a spiny ball up to about 13 cm (5 in) in diameter. Although more closely related to the Sea Pudding, it feeds more like the Harbour Conch. On the underside of the body of the urchin is a mouth with five powerful jaws which can grind up potential food. The Purple Urchin has the interesting adaptation of carrying bits of algae, eelgrass or non-living material, on the top of the body as camouflage. These are held in place by the tube feet. However, these creatures are well protected by the spines and only taken as prey by a few fishes such as the Grey Triggerfish (*Balistes capriscus*), which is quite often present over seagrass beds. In the seagrass beds the Purple Urchin may occur along with the somewhat larger (15 cm [6 in]) White Urchin (*Tripneustes ventricosus*), of similar habits.

If one went out at night onto sandy bay areas or seagrass beds, another large predatory animal would be seen. This is the Spiny Lobster (*Panulirus argus*). This active predator feeds on many members of the sandy bottom community but hides by day in lairs in rock or rubble. There are also a number of crabs which forage at night.

Probably one of the most extreme set of adaptations to life on the sandy bottom is shown by the Peacock Flounder (*Bothus lunatus*). Although it may burrow a cm (1/2 in) or so into the sediment surface for protection, it is really a denizen of the top of the sand. This fish, about 30 cm (1 ft) long, is a 'flatfish', which means that it has come to lie on one side, with both eyes on the upper side and has a very wide, thin body. Like many flatfishes, it is a master of camouflage and can change the body colour and patterning so that it is almost indistinguishable from the sand on which it lies. To make this even more effective, the Peacock Flounder fans sand over the body with its large fins. This fish is a voracious predator and must be able to locate its prey by sight. To facilitate this, the eyes are raised above the body, and the covering of sand, on short stalks, and are able to swivel around to look in any direction. When prey comes very close the Peacock Flounder rapidly explodes from the sand.

Fishes of Sandy Bays and Seagrass Beds

Many fishes are found in these habitats either at some phase of their life history or all the time. Those using seagrass beds as nursery grounds have been mentioned above as has the Peacock Flounder of open sandy bays.

The Sergeant Major, affectionately known in Bermuda as the Cow Polly (*Abudefduf saxatilis*) is Bermuda's commonest fish, certainly present in most bays and over seagrass beds. They often nibble at swimmers, so their presence is hard to miss. The Sergeant Major is one of the damselfishes, and is strikingly coloured with a blue head, and with vertical dark bars on a yellow background along its back, grading to light blue beneath. It is a very active small fish, up to 15 cm (6 in) long. It has a very interesting breeding behaviour. First, the male carefully cleans an area, usually on a vertical 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 to 1 m (3 ft) across. When ready, the male attracts females by swimming in a loop up into the water. At this time, the male becomes a dark bluish-purple. Several females may be attracted but pair spawning is the rule. During spawning white blotches appear on both male and female. The eggs are laid in a mass on the sides of the cleaned rock, and then defended and ventilated by the male until they hatch and the young can go off alone. Sergeant Majors have a wide diet and often boil at the surface around floating food.

Another exceedingly common fish found in a great many habitats and locations is the French Grunt (*Haemulon flavolineatum*), one of eleven 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. They generally swim in schools and most are brightly coloured. 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)

One of the really fantastic fishes of these sandy locations is the Spotted Eagle Ray (*Aetobatus narinari*), which is especially common in Harrington Sound. This is a beautiful member of the ray group, and the only one commonly seen around Bermuda. The back is a dark grey with many white spots. Eagle Rays feed by digging up shellfish living in the sand. In doing so they leave a large saucer shaped depression.

Another very characteristic sight in these relatively sheltered waters are large shoals of tiny silvery fish, locally called fry. Five different, related species school in this way; they are the Bermuda Anchovy or Hogmouth Fry (*Anchoa choerostoma*), the Blue Fry (*Jenkinsia lamprotaenia*), the Rush Fry (*Allanetta harringtonensis*), the Pilchard (*Harengula humeralis*) and the Anchovy (*Sardinella anchovia*). If the fish you see are really small and numerous, averaging 3-4 cm (1-1/2 1in) in length, they will be from the first three species. These three are much the commonest of the group. These small fry are highly prized as bait and are caught in large numbers, using seine nets close to the shore. If you see people seining along the shores, this is what they are doing. The Pilchard and Anchovy are larger fish up to 10 cm (4 in) in length. All are in the herring family and all feed on tiny animals in the water. It is an awe-inspiring sight to swim slowly through a shoal of these fish and see them neatly divide around your body.

Juvenile Great Barracuda (*Sphyraena barracuda*), up to about 45 cm (18 in) in length, are very frequent in the bays, where they patiently wait, singly or in small groups, for small fish to swim by. Then a short burst of speed will net them a meal. This elongate fish is best recognised by the very large mouth with needle-sharp teeth, and elongated silvery body with dark markings. Two other elongated, very streamlined fish found commonly in bays, are the Needle Fish, or Houndfish (*Tylosurus acus*) and the Bermuda Halfbeak, or Garfish (*Hemiramphus bermudensis*), the second being an **endemic** species. The Needle Fish has both jaws extending forward, while in the Halfbeak, only the lower jaw does so. Both of these fishes swim in small shoals and eat small prey and particles of plants. As with the Spotted Eagle Ray, these fishes are commonly seen in Flatts Inlet.

One really fascinating fish of the bays where any rock occurs, is the Beaugregory *(Stegastes leucostictus*). These fish are a close relative of the Sergeant Major, found virtually everywhere. Both are typical damselfishes. Beau Gregories are quite small fish 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. Beau Gregories vigorously defend both feeding and breeding territories. The breeding site, on a rock, is prepared by the male, who then, after the eggs are deposited, also defends and fans them. The outer part of Whalebone Bay is an excellent location to observe Beau Gregories and their behaviour.

Another common fish of shallow bay environments is the Slippery Dick (*Halichoeres bivittatus*), another member of the wrasse group. This elongate, slim, little fish, which stays close to the bottom, reaches about 15 cm (6 in) long. It is green and white with two purple-black stripes running the length of the body. Like most of the wrasse family, it goes through a series of colour and sex changes as it grows. The Slippery Dick can dive into the sand to escape capture, and as its name suggests, is extremely slimy if handled.

Another pair of fish occupying somewhat deeper bay waters are the Bermuda Chub (*Kyphosus sectatrix*) , and the Bermuda Bream (*Diplodus bermudensis*). Both of these fish are mid-water feeders. The Bermuda Bream is the smaller of the two, 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. In the case of the Bermuda Chub, however, the overall colour is relieved by many narrow, darker stripes running along the body. The Bermuda Bream and the Bermuda Chub are easily told apart by the presence on the Bermuda Bream of a large dark spot, just above the base of the tail. The Bermuda Bream joins the Halfbeak and the Killifish as some of the select few **endemic** saltwater fish.

Although parrotfish occupy a very wide range of habitats, there is one that is usually only seen in bays and inland saltwater bodies, although it is sometimes seen further offshore in seagrass beds. This is the Bucktooth Parrotfish (*Sparisoma radians*). It feeds on leafy seaweeds and seagrasses. It has a proportionately larger eye than the other parrotfish and is quite small reaching only about 18 cm (7 in) long. It is one of the species that changes colour as it matures, starting off with a dull-brown back and white underside and maturing to a fish with mottlings of red and blue on an olive back and yellow belly. This parrotfish can also change colour very rapidly to suit its surroundings. Also quite commonly seen in sandy bays and over seagrass beds are the Redtail and Striped Parrotfish (*Sparisoma crysopterum* and *Scarus croicensis*).

Two fish commonly seen feeding or swimming along sandy bottoms are the Yellow Goatfish (*Mulloidichthys martinicus*) and the Sand Diver or Snakefish (*Synodus intermedius*). Yellow Goatfish often form quite large schools, which may be seen digging in the sand for food. A prominent feature are the large barbels around the mouth which aid in finding prey. They also may move onto reefs at times. The Yellow Goatfish is a silvery fish up to about 30 cm (1 ft) long, that has a lovely bright yellow lateral stripe and a yellow tail. They are often confused with Yellowtail Snappers (*Ocyurus chrysurus*) but the barbels, absent in the snapper, are a give-away. Sand Divers prefer a bottom with a mixture of rock and sand and are often seen resting there; their greyish bodies with dark patches make them difficult to see. As their name suggests, the body is long, tapering back from the head to a small tail; they reach about 20 cm (8 in) long. They are lie-in-wait predators, who just stay motionless on the bottom until a prey fish swims close.

Some of the fishes common in bays have come to have some very interesting characteristics. One of these is the Sharpnose Puffer (*Canthigaster rostrata*), a charming little fish only about 4 in (12 cm) long, with a large head and tapering body. Dark mauve or brown above and white below, they are quite difficult to spot. Groups of these tiny puffers hang above the bottom, hovering and darting about like dragonflies. A close relative, the Bandtail Puffer (*Sphaeroides spengleri*) has a brown back and white belly and grows much larger, up to about 30 cm (1 ft) long. If disturbed puffers dart to the surface, gulp air and become balloon-like. The Porcupinefish (*Diodon hystrix*) lives in similar habitats to the puffers but can attain twice the size of the Bandtail. It is pale with tiny black spots. It, too, can inflate, but when it does so, numerous long spines appear! A close relative of these two puffer fish that does not inflate is the Honeycomb Cowfish (*Acanthostracion polygonius*), one of the boxfish up to about 30 cm (1 ft) long. It has two little horns between the eyes and a bulbous, very firm body, covered with blackish polygons on a cream background. The tail is large and set on a narrow stalk. Similar in shape and size but lacking the horns, the Smooth Trunkfish (*Lactophrys triqueter*) also has polygons on the body but less obviously displayed in a black background with light spots. The Porcupinefish, Cowfish and Smooth Trunkfish, are solitary and feed along the bottom.

The Longsnout Seahorse (*Hippocampus reidi*) is perhaps the most charming of the little bay and seagrass bed fishes but, unfortunately, it is becoming quite rare. If you are lucky enough to see one, it will be clinging by its tail to seaweeds or seagrasses. Seahorses are masters of camouflage and can change colour rapidly. The male broods the young in a pouch on his abdomen.

South shore bays, such as Church Bay, are excellent for looking at the typical fish of wave-washed rocky shorelines; the Ocean Surgeonfish (*Acanthurus bahianus*), and its close relative in the doctorfish group, the Blue Tang (*Acanthurus coeruleus*). Another member of the same family, the Doctorfish (*Acanthurus chirurgus*), is more wide-ranging and is not infrequently seen over seagrass beds. All these fishes are deep in the body, and while the Surgeonfish is a dull brown, the Blue Tang is a brilliant blue, the Doctorfish is always some shade of blue but has a series of vertical bars on the body lacking in the Blue Tang. All normally feed by nipping off algae but they also eat tentacles and polyps of shoreline creatures. All three reach a maximum size of 38 cm (15 in) and have the 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. 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.

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, that has 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.

Endangered Habitats and Conservation

Sheltered sandy bays are one of the prime recreation locations for islanders and visitors alike. They are also heavily used for educational purposes. Observations have shown that they are poorly able to cope with large numbers of people swimming and bathing in the water. In many heavily used bays such as Tobacco Bay and Whalebone Bay, seagrass beds formerly luxuriant there have disappeared or have become very degenerated systems. As the seagrass beds have declined so have the populations of burrowing animals and those which formerly frequented the sand surface. Indeed, many coastal, sheltered, sandy bays present a now virtually desert-like bottom. For this field guide some of these heavily used areas are included but others which have so far escaped are also recommended. It is hoped that directing students and teachers to these places will not further hasten the decline of the biological communities found in shallow bays. Visitors must be aware that these are delicate natural systems and to act accordingly when there. No digging should be done. The presence of buried life can easily be inferred from burrows, depressions, mounds and casts.

While many serious ecological problems can be definitely traced to human activity, others defy a simple explanation, and may be the result of the combined effect of many small changes in environmental conditions that have occurred since the coloniation of Bermuda by man. The constantly changing extent of seagrass beds around Bermuda, excluding the bays, so far defies explanation as does events like the **extirpation** of the large sand burrowing clam called the Tiger Lucina (*Codakia orbicularis*). The Tiger Lucina was formerly very common in sandy bottoms and its empty shells are still numerous. This clam had a curious feeding method in that it had large numbers of sulfur bacteria in its body. The bacteria used the energy of sulfur compounds released in the process of detritus formation into the water and then absorbed by the clam. The clam in this symbiotic association then received organic food compounds from the bacteria. Because of this very specialised mode of feeding, the clams had no digestive tracts. For some reason, this complex system failed and the clams died. Fortunately a close relative of the Tiger Lucina, the Dwarf Tiger Lucina (*Codakia orbiculata*) has survived and is reasonably common.

That ecological conditions in shallow sandy bays and waters are quite unstable is suggested by wild population swings in many of the inhabitants. Population explosions and declines seem to be quite frequent. One example, that of the common Pincushion alga (*Cladophora prolifera*) has been described above. Another is the recent huge decline in the numbers of Calico Clams (*Macrocallista maculata*) in the early 1980's, that lead to its protected status. The species is now once again abundant in Harrington Sound and recovering well. Great changes in the population density of Purple Urchins (*Lytechinus variegatus*) have also occurred over the last decade or so and the White Urchin (*Tripneustes ventricosus*) is now very hard to find. Other species such as scallops are doing poorly. All these events suggest that the sandy bottom ecosystem is under stress and that further population changes can be expected.

The Variety of Life in Sheltered Bays and Seagrass Beds

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
M = Mangrove Swamps and Salt Marshes	S = Saltwater Ponds
O = Open Ocean	

Note: Common names are listed in the first column except where there is no accepted common name, in these cases the scientific name is used. For each group of organisms, the common names are in alphabetical order. The habitat codes defined in the key 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
Algal Biscuits	Phormidium hendersonii	Blue-green Cyanobacteria	B
Hofmann's Scytonema	Scytonema hofmanni	Blue-green Cyanobacteria	R
Stromatolites	Phormidium corium	Blue-green Cyanobacteria	B, SG
Common Pincushion	Cladophora prolifera	Seaweeds - Green Algae	B
Common Plateweed	Halimeda incrassata	Seaweeds - Green Algae	B
Disc Plateweed	Halimeda tuna	Seaweeds - Green Algae	B
Feather Sand Moss	Caulerpa sertularioides	Seaweeds - Green Algae	B, SP
Flathead Shaving Brush	Penicillus pyriformis	Seaweeds - Green Algae	B
Grape Sand Moss	Caulerpa racemosa	Seaweeds - Green Algae	B, SP
Green Cushionweed	Cladophoropsis membranacea	Seaweeds - Green Algae	B
Hard Fanweed	Udotea flabellum	Seaweeds - Green Algae	B, SP
Hard Funnelweed	Udotea cyathiformis	Seaweeds - Green Algae	B
Horsetail Sand Moss	Caulerpa verticillata	Seaweeds - Green Algae	B
Mermaid's Wine Glass	Acetabularia crenulata	Seaweeds - Green Algae	B, SP
Merman's Shaving Brush	Penicillus capitatus	Seaweeds - Green Algae	B, SP
Mexican Sand Moss	Caulerpa mexicana	Seaweeds - Green Algae	B, M, SP
Slender Plateweed	Halimeda monile	Seaweeds - Green Algae	B
Soft Fanweed	Avrainvillea nigricans	Seaweeds - Green Algae	B, SP
Tapered Shaving Brush	Penicillus dumetosus	Seaweeds - Green Algae	B
Tufted Jointweed	Cymopolia barbata	Seaweeds - Green Algae	B
Jamaican Petticoat	Padina jamaicensis	Seaweeds - Brown Algae	B
Banded Threadweed	Ceramium byssoideum	Seaweeds - Red Algae	B, C
Laurence's Clubweed	Laurencia obtusa	Seaweeds - Red Algae	B, SG, R
Pointed Needleweed	Amphiroa fragilissima	Seaweeds - Red Algae	B, C
Scaleweed	Fosliella farinosa	Seaweeds - Red Algae	SG
Thicketweed	Spyridia hypnoides	Seaweeds - Red Algae	B
Dwarf Seagrass	Halophila decipiens	Herbaceous Flowering Plants	B, SG
Manatee Grass	Syringodium filiforme	Herbaceous Flowering Plants	B, SG
Shoal Grass	Halodule wrightii	Herbaceous Flowering Plants	B, SG
Turtle Grass	Thalassia testudinum	Herbaceous Flowering Plants	B, SG
Pugnose Pipefish	Syngnathus pelagicus	Sargassum Community - Fishes	B, O
Red Foraminiferan	Homotrema rubrum	Foraminiferans	C
Brown Lumpy Sponge	Halisarca dujardini	Sponges	B, SP
Fire Sponge	Tedania ignis	Sponges	B, SG, SP
Violet Finger Sponge	Haliclona molitba	Sponges	B, SG
Red Bushy Hydroid	Eudendrium carneum	Hydroids and Coral-like Hydroids - Hydroids	B, O

Upside-down Jellyfish	Cassiopea xamachana	Jellyfishes	B, SP
Bermuda Fireworm	Odontosyllis enlopa	Polychaete Worms	B
Cockworm	Arenicola cristata	Polychaete Worms	B
Coiled Tube Worm	Spirorbis formosus	Polychaete Worms	B, O, R, SG
Burrowing Shrimp	Callianassa branneri	Crustacea - Shrimps	B
Spiny Lobster	Panulirus argus	Crustacea - Lobsters	B, C
Ocellated Box Crab	Calappa ocellata	Crustacea - Crabs	B
Spotted Sea Hare	Aplysia dactylomela	Gastropoda - Sea Slugs	B
Dwarf Cerith or Horn Shell	Cerithium lutosum	Gastropoda - Snails	B
False Cerith	Batillaria minima	Gastropoda - Snails	B, M
Lettered Horn Shell	Cerithium litteratum	Gastropoda - Snails	B, SG
Milk or Harbour Conch	Strombus costatus	Gastropoda - Snails	B
Milky Moon Snail	Polinices lacteus	Gastropoda - Snails	B
Queen Conch	Strombus gigus	Gastropoda – Snails	B, SG
Varicose Alaba	Alaba incerta	Gastropoda - Snails	B
Atlantic Grooved Macoma	Psammotreta intastriata	Clams and Mussels	B
Black Date Mussel	Lithophaga nigra	Clams and Mussels	B, C
Calico Clam	Macrocallista maculata	Clams and Mussels	B
Dwarf Tiger Lucina	Codakia orbiculata	Clams and Mussels	B
Sunrise Tellin	Tellina radiata	Clams and Mussels	B
Sunset Clam	Tellina laevigata	Clams and Mussels	B
Tiger Lucina	Codakia orbicularis	Clams and Mussels	B
Arrow Squid	Loligo plei	Octopus and Squid - Squid	B, C
Reef Squid	Sepioteuthis sepioidea	Octopus and Squid - Squid	B, C
Purple Urchin	Lytechinus variegatus	Echinoderms - Sea Urchins	B, SG
White Urchin	Tripneustes ventricosus	Echinoderms - Sea Urchins	SG
Sand Dollar	Leodia sexiesperforata	Echinoderms - Sand Dollars	B
Burrowing Sea Cucumber	Holothuria arenicola	Echinoderms - Sea Cucumbers	B
Sea Pudding	Isostichopus badionotus	Echinoderms - Sea Cucumbers	B
Spotted Eagle Ray	Aetobatus narinari	Fish - Rays	B, O
Blue Fry	Jenkinsia lamprotaenia	Fish - Anchovies	B
Anchovy	Sardinella anchovia	Fish - Herrings	B
Bermuda Anchovy or Hogmouth Fry	Anchoa choerostoma	Fish - Herrings	B
Pilchard	Harengula humeralis	Fish - Herrings	B
Inshore Lizardfish	Synodus foetens	Fish - Lizardfishes	B
Sand Diver or Snakefish	Synodus intermedius	Fish - Lizardfishes	B
Bermuda Halfbeak or Garfish	Hemiramphus bermudensis	Fish - Needlefish and Halfbeaks	B
Needlefish or Houndfish	Tylosurus acus	Fish - Needlefish and Halfbeaks	B
Rush Fry	Allanetta harringtonensis	Fish - Silversides	B
Longsnout Seahorse	Hippocampus reidi	Fish - Seahorses	B, SG
Bigeye Mojarra	Eucinostomus havana	Fish - Mojarras	B
Mottled Mojarra	Eucinostomus lefroyi	Fish - Mojarras	B
Shad or Silver Jenny	Eucinostomus gula	Fish - Mojarras	B, SP
Sharksucker or Remora	Echeneis naucrates	Fish - Remoras	B, O
Yellowtail Snapper	Ocyurus chrysurus	Fish - Snappers	B, SP
Bermuda Bream	Diplodus bermudensis	Fish - Chubs and Breams	B
Bermuda Chub	Kyphosus sectatrix	Fish - Chubs and Breams	B
Blue-striped Grunt	Haemulon sciurus	Fish - Grunts	B
French or Yellow Grunt	Haemulon flavolineatum	Fish - Grunts	B
White Grunt or Tomtate	Haemulon aurolineatum	Fish - Grunts	B
Pinfish	Lagodon rhomboides	Fish - Porgies	B, SP
Spotted Goatfish	Pseudupeneus maculatus	Fish - Goatfishes	B
Yellow Goatfish	Mulloidichthys martinicus	Fish - Goatfishes	B
Beaugregory	Stegastes leucostictus	Fish - Damselfishes	B, C
Sergeant Major or Cow Polly	Abudefduf saxatilis	Fish - Damselfishes	B, C
Hogfish	Lachnolaimus maximus	Fish - Wrasses	B, C
Slippery Dick	Halichoeres bivittatus	Fish - Wrasses	B

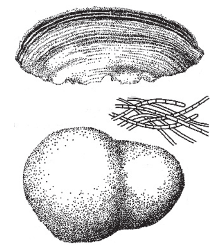
Grey Mullet	Mugil trichodon	Fish - Mullets	B, SP
Great Barracuda	Sphyraena barracuda	Fish - Barracudas	B, C, O
Peacock Flounder	Bothus lunatus	Fish - Flatfishes	B, SP
Hairy Blenny	Labrisomus nuchipinnis	Fish - Blennies	B, SP
Crested Goby	Lophogobius cyprinoides	Fish - Gobies	B, SP
Blue Tang	Acanthurus coeruleus	Fish - Surgeonfishes	B, C
Doctorfish	Acanthurus chirurgus	Fish - Surgeonfishes	B, C
Ocean Surgeonfish	Acanthurus bahianus	Fish - Surgeonfishes	B, C
Grey Triggerfish	Balistes capriscus	Fish - Triggerfishes	B, C
Queen Triggerfish	Balistes vetula	Fish - Triggerfishes	B, C
Slender Filefish	Monacanthus tuckeri	Fish - Leatherjackets	B
Honeycomb Cowfish	Acanthostracion polygonius	Fish - Trunkfishes	B
Smooth Trunkfish	Lactophrys triqueter	Fish - Trunkfishes	B
Bandtail Puffer	Sphaeroides spengleri	Fish - Puffers and Porcupine Fishes	B
Porcupinefish	Diodon hystrix	Fish - Puffers and and Porcupine Fishes	B
Sharpnose Puffer	Canthigaster rostrata	Fish - Puffers and and Porcupine Fishes	B
Bucktooth Parrotfish	Sparisoma radians	Fish - Parrotfishes	B, SG
Redtail Parrotfish	Sparisoma crysopterum	Fish - Parrotfishes	B, C
Stoplight Parrotfish	Sparisoma viride	Fish - Parrotfishes	B, C
Striped Parrotfish	Scarus croicensis	Fish - Parrotfishes	B, C
Green Turtle	Chelonia mydas	Turtles and Terrapins - Turtles	B, O, SG
Common Tern	Sterna hirundo	Birds - Terns	B

Species Illustrations and Descriptions

Blue-green Cyanobacteria

B

Algal Biscuits
Phormidium hendersonii
In texture and colour algal biscuits are rather like the stromatolites described above except that they form flattish plates up to about 8 cm (3 in) in diameter and 1 cm (1/2 in) thick. The picture is of a microscopic view. **Native**.

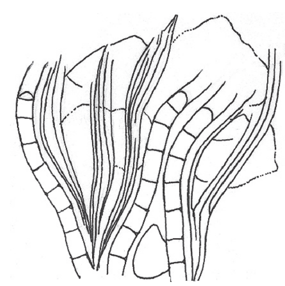


R

Hofmann's Scytonema
Scytonema hofmanni
This species is very important in sediment formation but is not seen on sandy bottoms. It forms the black zone at the top of rocky shores and is characterised by a spiky surface to the rock. Spikes up to 12 cm (5 in) high. **Native**.

B, SG

Stromatolites
Phormidium corium
The Blue-green Cyanobacteria that you might see are all composed of tiny filaments of various colours. The *Phormidium* species are usually light yellow in colour.This species is best recognised by the structures, called stromatolites that they form. These stromatolites are up to about 5 cm (2 in) in height and width. They form domes, weakly attached to the bottom, which are jelly-like in texture and show growth-lines parallel to the surface when cut vertically. **Native**.

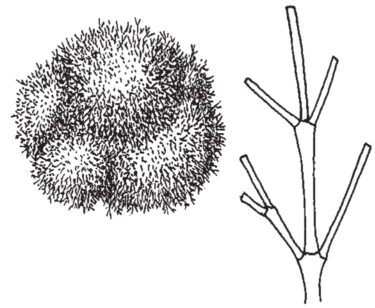


Seaweeds

Green Algae

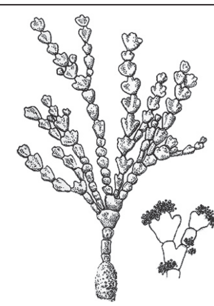
B

Common Pincushion
Cladophora prolifera
This often uncommon seaweed may 'bloom' under suitable conditions to form a layer on the bottom of quiet bays. The plants are unattached and just lie on the bottom as a roughly ball shaped cluster of branching filaments about 8 cm (3 in) across. The colour in life is a deep green. **Native**.



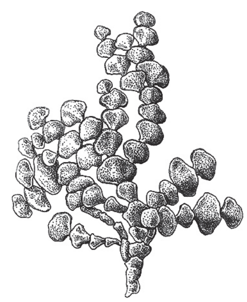
B

Common Plateweed
Halimeda incrassata
This green alga commonly about 10 cm (4 in) high consists of a series of small, three ridged plates, jointed together. It is a green seaweed but it incorporates calcium carbonate into its tissues, giving it a hard texture and whitish-green colour. **Native**.



B

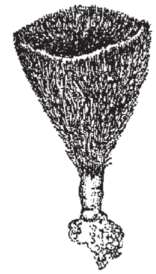
Disc Plateweed
Halimeda tuna
Less common that the other plateweeds, the Disc Plateweed is still frequently found in clumps up to about 6 cm (2 1/4 in) high. The unique feature of this plateweed are the broad, fan-shaped or kidney-shaped segments. Quite easily identified when seen in sediments. **Native**.



B, SP

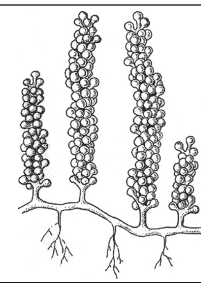
Feather Sand Moss
Caulerpa sertularioides
This lovely bright green seaweed about 10- 15 cm (4-6 in) high, grows in shallow, still places such as ponds, sometimes forming huge mats. Each plant body is shaped like an elongate, delicate feather. **Native.**

Flathead Shaving Brush
Penicillus pyriformis
This species is about 10 cm (4 in) high and has a short stalk capped by a brush that is flattened or even dish-shaped at the top. Not as common as the other two species of shaving brush, but found regularly on quiet sandy bottoms. **Native**.



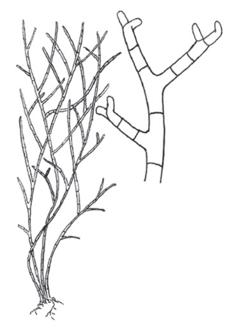
B

Grape Sand Moss
Caulerpa racemosa
This very common seaweed has a stem that hugs the bottom from which arise branches bearing small grape-like branchlets. Common on lagoonal and inshore reefs. Up to 50 cm (1.5 ft) long and 10-15 cm (4-6 in) high. **Native**.



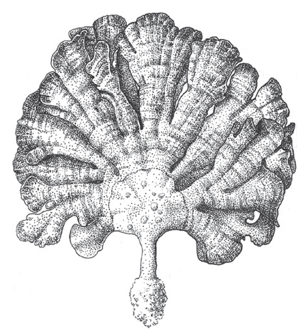
B, SP

Green Cushionweed
Cladophoropsis membranacea
This is a very tiny, usually only 1 cm (1/3 in) high filamentous green seaweed that grows as a mat on the bottom among seagrasses, or out in the open. All that can be seen are the bright green tips of the filaments protruding from a soft layer of sediment. The bottom is usually slightly raised where it occurs. **Native**.



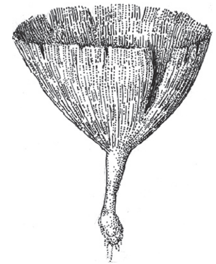
B

Hard Fanweed.
Udotea flabellum
The Hard Fanweed is one of Bermuda's prettiest green seaweeds. Anchored in the sediment, it has a short, robust stalk which bears a fan shaped structure with distinct growth lines. About 10 cm (4 in) in height this seaweed is quite heavily calcified and consequently very firm to the touch. **Native**.



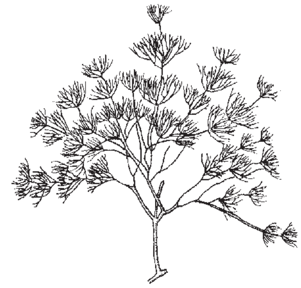
B, SP

Hard Funnelweed
Udotea cyathiformis
The Hard Funnelweed is about 15 cm (6 in) in height and like its relative above is well calcified giving it a whitish cast. It is surmounted by a funnel shaped structure which is usually divided by several splits. **Native**.



B

Horsetail Sand Moss
Caulerpa verticillata
A very beautiful small, bright green alga of quiet places, such as the marine ponds. Very common on mangrove roots, forming masses up to 15 cm (6 in) across. The individual plants up to 2.5 cm (1 in) wide have a very finely divided appearance. **Native.**



B

Mermaid's Wine Glass
Acetabularia crenulata
A charming little green seaweed only 5 cm (2 in) high, consisting of a slender stalk on which are one or more curved green discs with radial bands. In quiet waters. **Native.**

B, SP

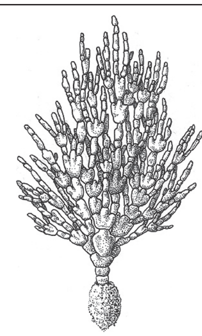
Merman's Shaving Brush
Penicillus capitatus
A robust greenish white alga, anchored in soft bottoms by root-like organs, The plant is 10-15 cm (4-6 in) high and consists of a stout stalk surmounted by a brush-like array of greenish filaments. Widely distributed. **Native.**

B, SP

Mexican Sand Moss
Caulerpa mexicana
Bright green in colour and with a pretty frond about 10 cm (4 in) high shaped like a very coarse feather. On mangrove roots, rocks etc. in still waters. Common in saltwater ponds. **Native.**

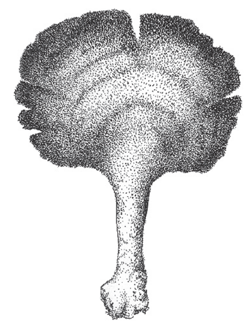
B, M, SP

Slender Plateweed
Halimeda monile
The Slender Plateweed is similar in size to the Common Plateweed and forms similar clumps. They can be distinguished by the narrower, non-ridged plates that this species has close to the branch tips**.** An important contributor to shallow water sediments. Up to 15 cm (6 in) high. **Native**.



B

Soft Fanweed
Avrainvillea nigricans
The Soft Fanweed has a luxuriant velvety texture, a result of its being made up of very numerous filaments closely pressed together. Above the sediment anchor the broad stalk rises up to 10 cm (4 in) before it expands into a 10 cm (4 in) high, quite thick green fan. It is only very lightly calcified. **Native**.

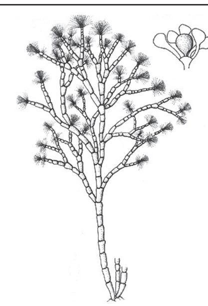


B, SP

Tapered Shaving Brush
Penicillus dumetosus
Only 10 cm (4 in) in height, this species differs from the one above in that the stalk is shorter than the brush portion and the brush tapers more slowly from the base. **Native**.

B

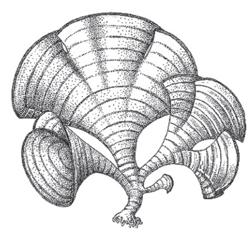
Tufted Jointweed
Cymopolia barbata
This 5-15 cm (2-6 in) high, calcified, green alga is very common where a sheltered rocky shoreline gives way to sediment just below low tide. It can be recognised by its jointed branched structure, with each branch ending in a tuft of green filaments. **Native**.



B

Brown Algae

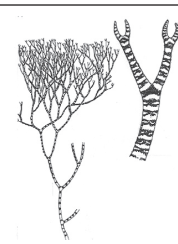
Jamaican Petticoat
Padina jamaicensis
This is a brown, fan shaped seaweed about 10-15 cm (4-6 in) high. The fan is generally banded with lighter zones reflecting the light calcification present. Widely common. **Native**.



B

Red Algae

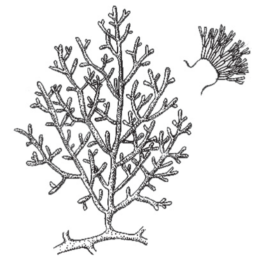
Banded Threadweed
Ceramium byssoideum
A small red, threadlike seaweed, generally looking like pink turf or small clumps. Microscopically, the characteristic red-banded appearance shows up. Grows to 10 cm (4 in) high. **Native**.



B, C

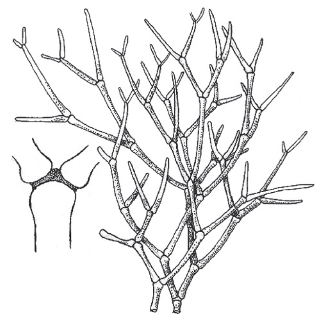
B, SG, R

Laurence's Clubweed
Laurencia obtusa
Commonly found in seagrass beds this red alga grows in clumps about 15 cm (6 in) high. The plant is copiously branched and tends to a yellowish colour except for the tips of the branches which are a vivid pink. **Native**.



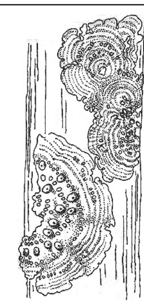
B, C

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



SG

Scaleweed
Fosliella farinosa
A red seaweed but showing up as white circular, tiny patches about 2 mm (1/16 in) in diameter on seagrass leaves, where it can be very abundant. This is one of the crustose coralline algae and it incorporates large amounts of calcium carbonate in the tissues. **Native**.

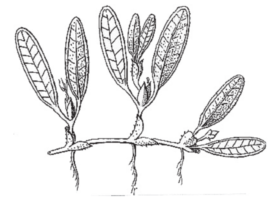


B

Thicketweed
Spyridia hypnoides
This red seaweed found in tangled masses on sandy bottoms and among seagrasses, often appears more yellowy-brown than red, as it entraps a lot of sediment which anchors it to the bottom. Often found in a mat 5-8 cm (1 3/4-3 in) deep and of variable extent, it has a branching, spiny appearance with many hook-shaped branches near to the tips. **Native**.

Herbaceous Flowering Plants

Dwarf Seagrass
Halophila decipiens
This rare species of harbours and sounds has broad, oval leaves up to about 2 m (3/4 in) long arising from a buried rhizome. **Native**.

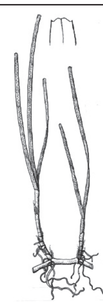


B, SG

Manatee Grass
Syringodium filiforme
Leaves round in cross section, narrow and up to 30 cm (6 in) long. Quite common in small stands and mixed with the other two species of seagrass. **Native.**

B, SG

Shoal Grass
Halodule wrightii
The smallest of the common Bermudian seagrasses. The leaf blades are flat and narrow, up to15 cm (6 in) long and 2 mm (1/16 in) wide. Commonly found around the edges of Turtle Grass beds or mixed in with the other two species. **Native.**



B, SG

Turtle Grass
Thalassia testudinum
The largest and most common of the common seagrasses. Leaves flat and up to 1 m (3 ft) long and 5 mm (1/4 in) wide and commonly encrusted with epiphytes. Grows in clumps of leaves arising from a buried rhizome. Forms extensive beds. Important in sediment stabilisation and as food for turtles. **Native.**

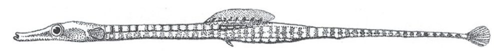
B, SG

Sargassum Community

Fishes

B, O

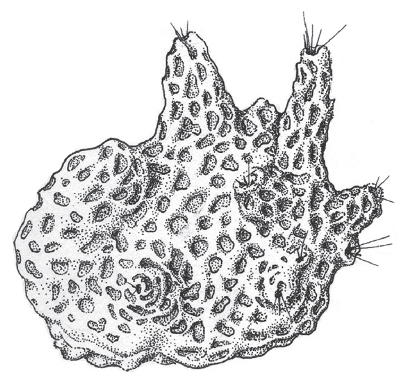
Pugnose Pipefish
Syngnathus pelagicus
A very slender fish up to about 12 cm (4 3/4 in) in length. The fins are small and the anal fin is absent. The colour is highly variable but is generally some combination of light and dark brown rings around the body. Common. **Native**.



Foraminiferans

C

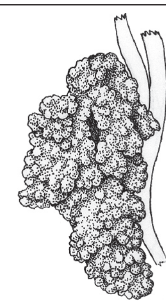
Red Foraminiferan
Homotrema rubrum
Protozoans are normally single-celled animals that are invisible to the naked eye. The Red Foraminiferan is an exception in that individuals may be 5 mm (1/4 in) across. This is still small but the bright red colour is very obvious. Living individuals are abundant in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

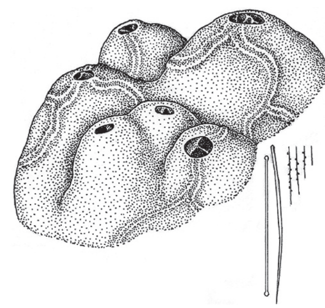
B, SP

Brown Lumpy Sponge
Halisarca dujardini
Found both on dead shells and on seagrass leaves in sheltered bays. This sponge is a delicate yellowish-brown in colour and usually consists of several irregular lobes covered with small, warty bumps. About 10 cm (4 in) thick. **Native**.



Fire Sponge
Tedania ignis
This sponge up to about 10 cm (4 in) high may be found attached to both seagrasses and Thicket Weed. It is generally shaped like a thumb but may have several lobes. The main distinguishing feature is its red colour. This sponge can inflict a sting, so do not touch any red sponges. **Native.**

B, SG, SP



Violet Finger Sponge
Haliclona molitba
This sponge is a beautiful clear violet colour. It is typically finger like in shape and about 5-10 cm (2-4 in) long. Its general habitat is as an epiphyte on seagrasses or seaweeds in coastal bays. **Native**.

B, SG

Hydroids and Coral-like Hydroids

Hydroids

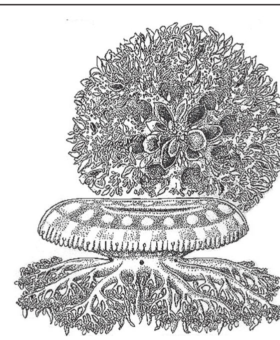
Red Bushy Hydroid
Eudendrium carneum
This is a delicate bush-like hydroid up to about 15 cm (6 in) high that is of a soft red colour. This hydroid is common in bays and may be attached either to a hard object or to seagrass leaves. **Native**.

B, O

Jellyfishes

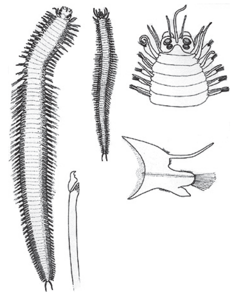
Upside-down Jellyfish (Poisonous)
Cassiopea xamachana
This jellyfish is quite poisonous and has the unusual habit of lying upside-down on the bottom, with the greenish tentacles waving up in the water. Small individuals and occasionally large ones swim up into the water. Up to 25 cm (10 in) in diameter, they should be avoided. Very common in the ponds. **Native.**

B, SP



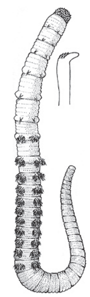
Polychaete Worms

Bermuda Fireworm
Odontosyllis enopla
We only see this worm when swarms of them mate in a blaze of green light, especially in the summer months, 56 minutes after sunset on the third night after the full moon. It has a small, slender body and three antennae. To 35 mm (1 3/4 in). **Native**.



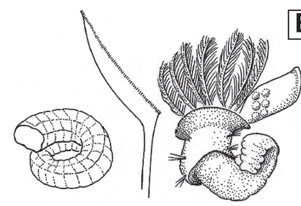
B

Cockworm
Arenicola cristata
A large worm that constructs U-shaped burrows that develop a pit at the head end and a mound of castings at the tail end. The worm is up to 25 cm (10 in) long and 1 cm (1/2 in) wide. The soft body has a series of bright red gills. Used widely as bait. **Native.**



B

Coiled Tube Worm
Spirorbis formosus
This worm makes very distinctive small, anti-clockwise-coiled, white tubes about 3 mm (1/8 in) across on the surface of the sargassum. Very common. **Native**.

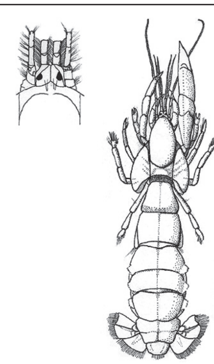


B, O, R, SG

Crustacea

Shrimps

Burrowing Shrimp
Callianassa branneri
A quite large, somewhat lobster-like shrimp common in sandy, shallow bays. The burrow locations are easily recognised by a large, volcano-like mound of sand with a hole at the top through which sand is ejected. The rarely seen shrimp is about 10 cm (4 in) long, cream in colour, with a large abdomen and one large claw. **Native.**

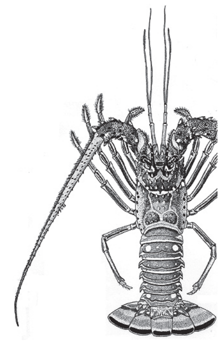


B

Lobsters

B, C

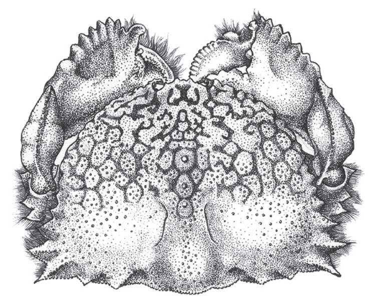
Spiny Lobster
Panulirus argus
The Spiny Lobster is the main lobster fished for food in Bermuda and the Caribbean. Living in crevices and caves within the reefs, it emerges at night to feed on a wide variety of food. These lobsters can measure up to 50 cm (1.5 ft) or more in length. They have no large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



Crabs

B

Ocellated Box Crab
Calappa ocellata
This fascinating, chunky crab, about 10 cm (4 in) across the back, is difficult to find, as by day it lies buried in the surface of the sand, with which it is well camouflaged, being a mottled creamy-brown**.** If disturbed the crab becomes a very compact shape with all legs tucked out of sight. It is a nocturnal predator at the sand surface. **Native.**

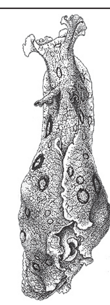


Gastropoda

Sea Slugs

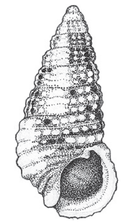
B

Spotted Sea Hare
Aplysia dactylomela
This gastropod has no visible shell. It has a large foot, two pairs of fleshy horns on its head and is coloured light brown to olive green with black spots. When disturbed, it discharges a purple fluid. Found in tide pools grazing on the alga *Laurencia*. To 120 mm. **Native**.



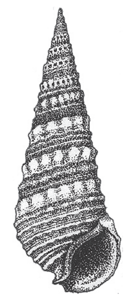
Snails

Dwarf Cerith or **Horn Shell**
Cerithium lutosum
This species can be confused with the False Horn Shell but it is stockier, less pointed and dark brown in colour. To 1.2 cm. It is found under rocks and in tide pools. **Native**.



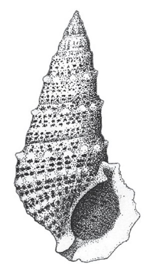
B

False Cerith
Batillaria minima
These little shells often occur in almost countless profusion on sheltered shores, particularly where there is both rock and sediment. Reaching only 15 mm (5/8 in) in length, the shell is very tall and slender with numerous whorls of ridges and small bumps. **Native**.



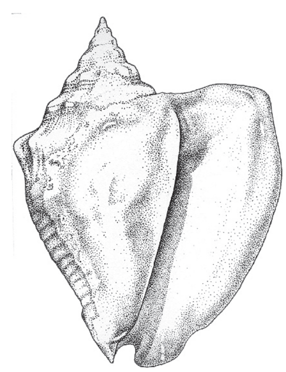
B, M

Lettered Horn Shell
Cerithium litteratum
This is a tall, heavy-shelled snail up to 3 cm (1 1/4 in) in length. It is a very variable shell but the surface is usually ornamented with whorls of smooth bumps and patterned with small dots. Common in bays and seagrass beds. **Native.**



B, SG

Milk or **Harbour Conch**
Strombus costatus
As an adult the Harbour Conch is virtually impossible to confuse with anything else. The shell is large and very heavy, measuring up to 20 cm (8 in) in length. The shell opening has a large flared lip. The colour is generally whitish often with tinges of pink. Juvenile Harbour Conchs are very common in many shallow bays and seagrass beds. They have a much less heavily built shell and there is no flared lip. **Native.**

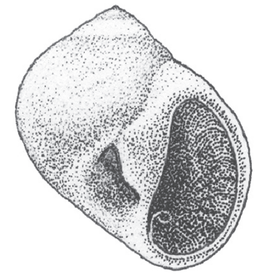


B

Milky Moon Snail B

Polinices lacteus

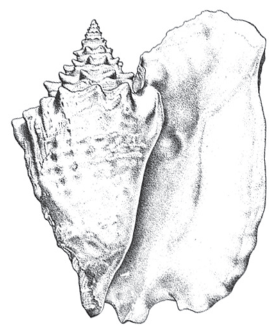
This moon snail has a very globose shell about 2 cm (3/4 in) long. The shell is glossy milk-white in colour and is commonly found empty on the sand surface. The living snail has a very large foot and it burrows randomly through the sediment in search of its clam victims. This snail makes a very distinctive egg collar found on the sediment surface**. Native.**



Queen Conch B, SG

Strombus gigas

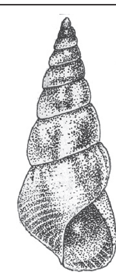
This large and very beautiful sea snail was once common but used both for the meat and as an ornamental shell. The main feature of mature Queen Conch's is the very wide flaring lip of the shell, which is a beautiful orange-pink colour on the lower side (inside). Queen Conchs live mainly in seagrass beds well offshore but a few populations live quite close to the shoreline. This species is fully protected and seems to be making a very slow recovery. Up to 30 cm (12 in) long. **Native**.



Varicose Alaba B

Alaba incerta

This elongated, almost smooth snail, reaching 7 mm (1/4 in) in length is common in sand. The shell has faint spiral grooves and is yellow to light brown in colour. Shells of this snail are commonly washed up on shore. **Native.**

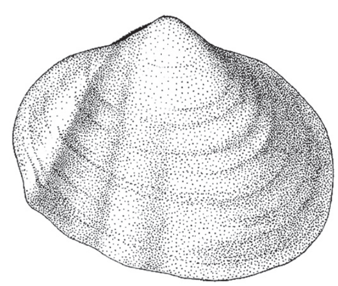


Clams and Mussels

Atlantic Grooved Macoma B

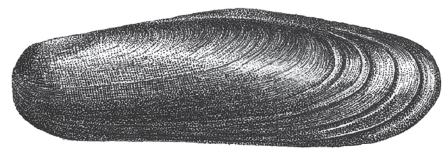
Psammotreta intastriata

The thin, rounded shell is a dull white and quite strongly inflated; length up to 6 cm (2 1/2 in). This deep-living clam has a siphon that reaches beyond the sand surface. The characteristic feature is that one end of the shell is twisted. **Native.**



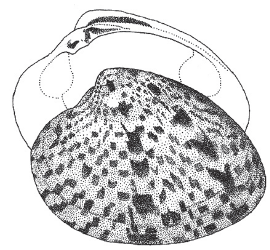
Black Date Mussel
Lithophaga nigra
This is a species which can only be seen as an oval hole showing the mouth of the burrow in the limestone. The mussel looks very like a large date pit, with ridges on the larger end of the shell. Up to 4 cm (1 1/2 in) long these shells can be present in very large numbers. To enlarge the burrow as they grow they both dissolve the limestone and scrape it away. They are filter feeders. **Native**.

B, C



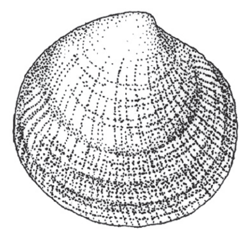
Calico Clam
Macrocallista maculata
Shell thick and shiny, up to 8 cm (3 in) long and 6 cm (2 1/4 in) wide. Shell ornamented with very attractive checkerboard-like markings in brown on a beige background. A shallow burrower. A filter feeder. **Native.**

B



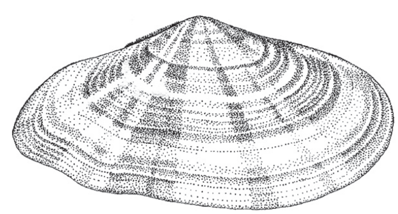
Dwarf Tiger Lucina
Codakia orbiculata
This is a dwarf version of the Tige Lucina, being up to 3 cm (1 1/4 in) across. The rough, dull, thick, chalky-white shell has circular and radial ridges. **Native.**

B



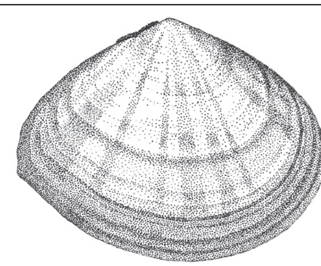
Sunrise Tellin
Tellina radiata
A deep-burrowing clam that feeds on detritus at the sediment surface through a long siphon. The elongate-oval, thin shell, up to 10 cm (4 in) long has radiating pinkish-red rays on a creamy background. **Native.**

B



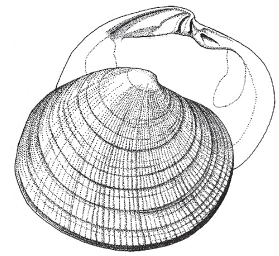
Sunset Clam
Tellina laevigata
This clam has a deep burrow but feeds at the sand surface by means of a long extensible siphon. The smooth, creamy, rounded-oval shell may reach 10 cm long. The shell is ornamented by salmon-pink radiating rays. **Native.**

B



B

Tiger Lucina
Codakia orbicularis
This probably **extirpated** species has a very rounded shell up to 9 cm (3 1/2 in) across, that is chalk-white and robust. There are obvious radiating and circular ridges, making the shell rough in texture. A shallow, burrower. **Native.**

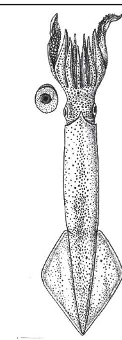


Squids and Octopusus

Squids

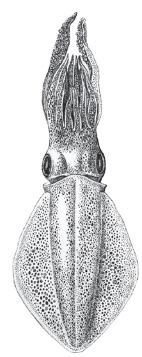
B, C

Arrow Squid
Loligo plei
This squid can reach 30 cm (1 ft) in length but ones seen inshore and over seagrass beds may be half this size. The body is long and slender with the fins at the hind end only. The greyish colour is enhanced by small brown spots. Like other squids this species may swim slowly forward or dart rapidy backward. **Native.**



B, C

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**.

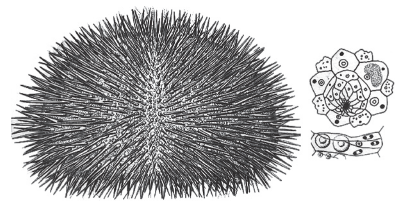


Echinoderms

Sea Urchins

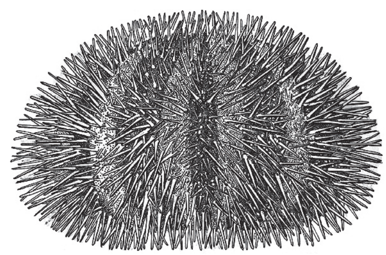
B, SG

Purple Urchin
Lytechinus variegatus
This is the commonest urchin of sandy bays and seagrass beds. It is deep purple in colour and the body commonly about 8 cm (3 1/4 in) in diameter. The spines are quite short and thickly placed. This urchin often carries pieces of flotsam and seaweed on its back for camouflage. **Native.**



SG

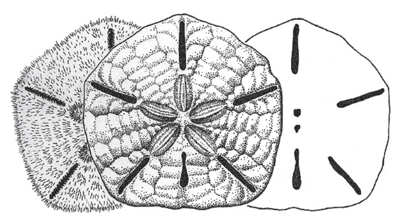
White Urchin
Tripneustes ventricosus
This handsome urchin of the seagrass beds has white spines which contrast with the somewhat darker body. Growing up to about 10 cm (4 in) in diameter this species has been getting less common in recent years. **Native.**



Sand Dollars

B

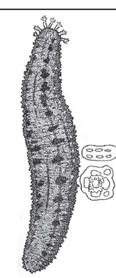
Sand Dollar
Leodia sexiesperforata
This very flattened echinoderm has a virtually circular body which has six slit-like perforations one of which is keyhole-shaped**.** This pale brown animal moves just beneath the sediment surface leaving an irregular meandering trail. Commonest where there is some current. About 8 cm (3 1/2 in) across. **Native.**



Sea Cucumbers

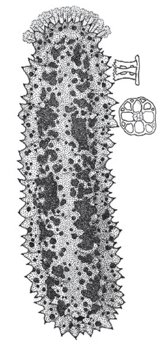
B

Burrowing Sea Cucumber
Holothuria arenicola
This deeply burrowing, large sea cucumber is very rarely seen but is common. The body reaches 25 cm (10 in) long and 4 cm (1 1/2 in) wide. It is dark-brown with darker patches. **Native.**



B

Sea Pudding
Isostichopus badionotus
The sea cucumber known in Bermuda as the sea pudding. Cannot be confused with anything else. The elongated, rubbery body is domed on top and forms a flat foot-like organ on the bottom. The colour varies from entirely light brown to near black, or is blotched in these colours. A large animal reaching 35 cm (14 in) long. **Native**.

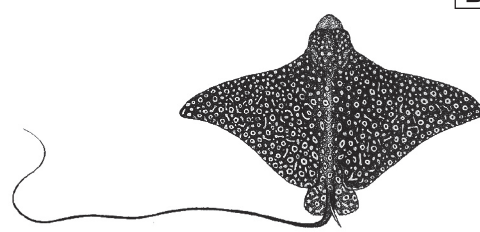


Fish

Rays

B, O

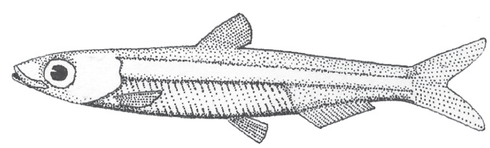
Spotted Eagle Ray
Aetobatus narinari
This ray, common over sandy bottoms where it hunts its shellfish prey, is unmistakable. Up to 1.5 m (4 1/2 ft) across, but commonly smaller, The Spotted Eagle Ray has a very wide flat body and a long tail. The back is dark-grey and covered with light spots with a dark centre. **Native.**



Anchovies

B

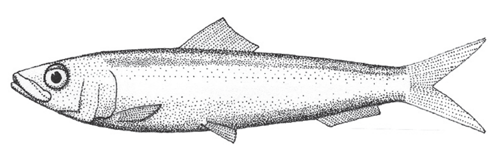
Blue Fry
Jenkinsia lamprotaenia
A very small, silvery fish with a streamlined body and large eye. The mouth is small, ending at the front edge of the eye. Grows to 6.5 cm (2 1/2 in) but is usually half this length. Swims in large schools with other fry. **Native.**



Herrings

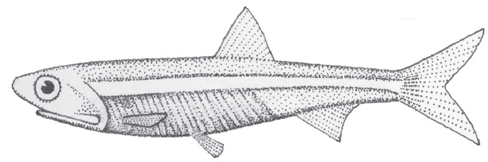
B

Anchovy
Sardinella anchovia
This fish is the largest of this group of small herrings found in bays and over seagrass beds. It may reach 30 cm (1 ft) in length. The eye is medium in size as is the mouth which extends back to the centre of the eye. **Native.**



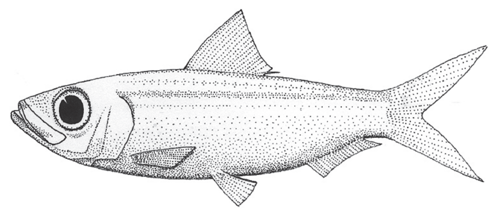
Bermuda Anchovy or **Hogmouth Fry**
Anchoa choerostoma
This is one of the tiny fish called 'fry', that are much used as bait. The body is streamlined, silvery, and up to 10 cm (4 in) long but usually about 4 cm (1 1/2 in). The mouth is large, extending to well behind the eye. **Endemic**.

B



Pilchard
Harengula humeralis
A larger member of the 'fry' group, the Pilchard grows up to 15 cm (6 in) in length. The eye is very large, the body somewhat flattened from side to side. Silvery with a blueish tinge it is common in bays. **Native.**

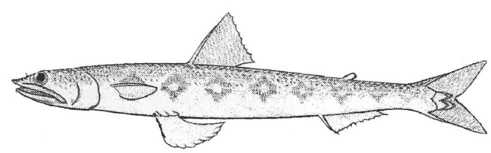
B



Lizardfishes

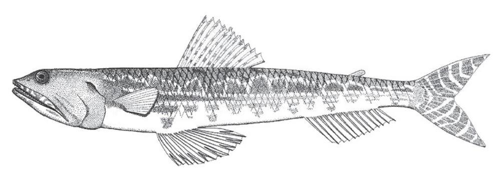
Inshore Lizardfish
Synodus foetens
Very similar to Sand Diver, the Inshore Lizardfish grows to about 30 cm (1 ft) long and has a long mouth in a forward-tapered head. The body tapers steadily back to the small tail. The sides and back are adorned with square, brown spots on a green blue background**. Native**

B



Sand Diver or **Snakefish**
Synodus intermedius
This 30 cm (12 in) long fish is a real bottom dweller. Usually seen resting on the sand, the Sand Diver has a large head leading to a steadily tapering body, longitudinally striped in blue and yellow. The distinctive feature is a dark spot at the upper end of the gill cover. The mouth is upturned. **Native**.

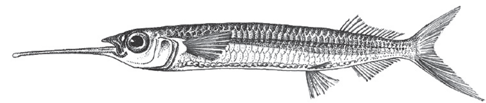
B



Needlefish and Halfbeaks

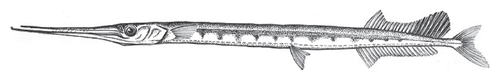
B

Bermuda Halfbeak or **Garfish**
Hemiramphus bermudensis
This fish is often referred to as the Garfish. It is a lightly built, slender fish averaging about 30 cm (1 ft) long. The eye is very large and the Bermuda Halfbeak has the lower jaw prolonged into a needle-like structure. **Endemic**.



B

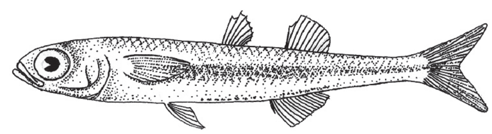
Needlefish or **Houndfish**
Tylosurus acus
The Needlefish is a very slender silvery fish up to 1 m (3 ft) in length but those commonly seen are about 50 cm (1 1/2 ft). The eye is large and both jaws are elongated and very thin. **Native.**



Silversides

B

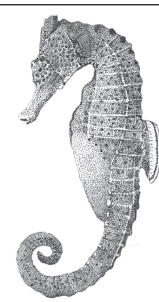
Rush Fry
Hypoatherina harringtonensis
Although very similar to the fry described previously this fish is actually in a different family. It can be distinguished from the other 'fry' by its having a larger head and a body which tapers steadily from the back of the head. Grows to 8 cm (3 in) but is usually about 4 cm (1 1/2 in) long. **Native.**



Seahorses

B, SG

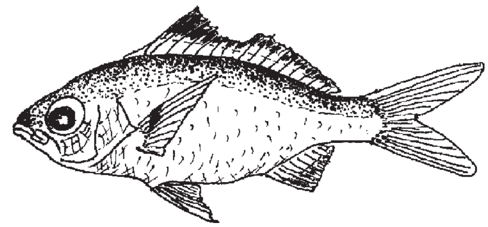
Longsnout Seahorse
Hippocampus reidi
Unfortunately these amazing little fish are becoming rare in Bermuda. Found on seaweeds and seagrass beds where they attach themselves with the tail. Usually about 8 cm (3 in) tall, seahorses can change colour to blend in with the background. **Native**.



Mojarras

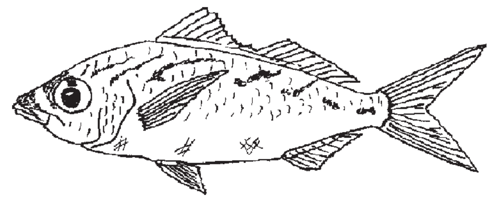
B

Bigeye Mojarra
Eucinostomus havana
This fish while very similar to the Spotfin Mojarra described above is distinguished by its larger eye and the black border on the front dorsal fin. The length is up to about 13 cm (5 in). **Native**.



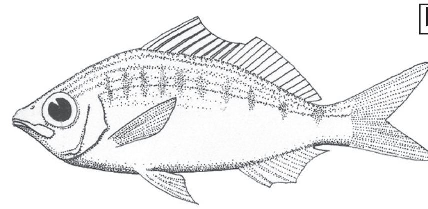
B

Mottled Mojarra
Eucinostomus lefroyi
Quite similar to the Spotfin Mojarra below, and about the same size, up to 13 cm (5 in). However, this species can usually be distinguished by the mottling on the back and always by the square dark spot in the upper part of the eye. **Native.**



B, SP

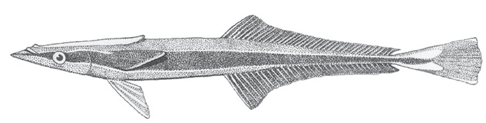
Shad or **Silver Jenny**
Eucinostomus gula
This deep-bodied silvery little fish grows to about 13 cm (5 in) long. The back, or dorsal fin has a dark smudge at the top front. Shad often occur in large numbers. **Native**.



Remoras

B, O

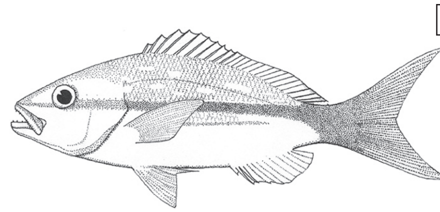
Sharksucker or **Remora**
Echeneis naucrates
This is a very slim fish up to 1 m (3 ft) long, with its dorsal fin modified to form an elaborate sucker on top of the head. While, as their name suggests, this sucker can be used to attach to sharks or rays, many Remoras swim freely around. They have been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



Snappers

B, SP

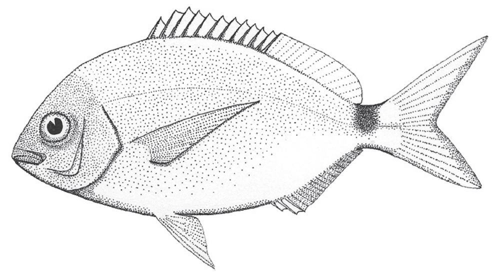
Yellowtail Snapper
Ocyurus chrysurus
A very attractive fish with a silvery-blue body, about 30-60 cm (1-2 ft) long, with a very prominent yellow stripe from the eye, extending into the deeply-forked tail. **Native**.



Chubs and Breams

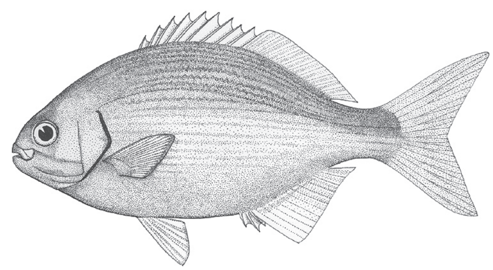
B

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

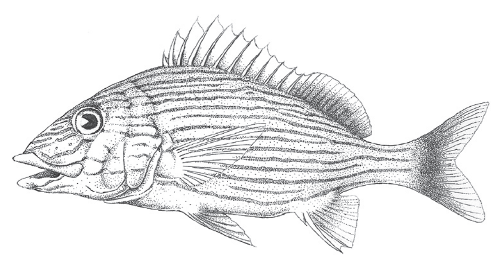
Bermuda Chub
Kyphosus sectatrix
The Bermuda Chub can reach 76 cm (30 in) and a weight of up to 9 kg (20 lb). Bermuda Chub have relatively small heads and eyes, and are a dull silvery-grey in colour. The overall colour is relieved by many narrow, darker stripes running along the body. **Native.**



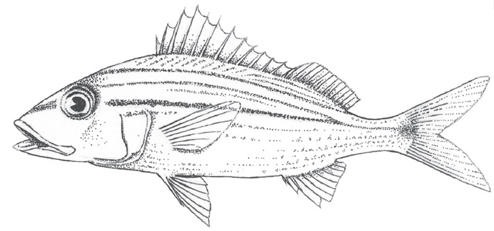
Grunts

B

Blue-striped Grunt
Haemulon sciurus
From the side the grunts have an arched back and flattish lower side. The Blue-striped Grunt growing to 35 cm (14 in) long is a basically yellow fish with numerous, bold, blue stripes on the head and body and a dark tail and hind dorsal fin. **Native.**

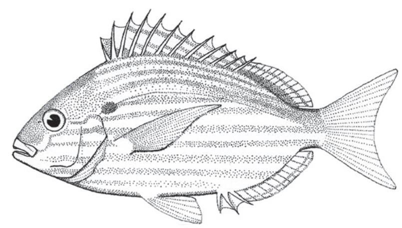


White Grunt or **Tomtate** B
Haemulon aurolineatum
This very common fish of bays and sounds is basically a silvery colour ornamented with two bold stripes, one through the eye and the other above it. There are other faint yellow lines. This fish reaches 25 cm (10 in) long but is mostly half this size. **Native.**



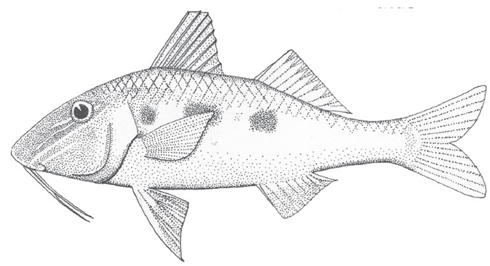
Porgies

Pinfish B, SP
Lagodon rhomboides
The Pinfish is relatively deep in the body and takes its name from sharp spines in the dorsal and pelvic fins. Growing to about 20 cm (8 in) long it has blue, longitudinal stripes on a yellowish to greenish-silver body. **Native.**

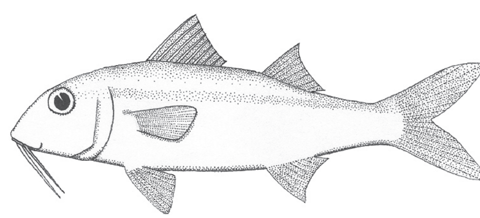


Goatfishes

Spotted Goatfish B
Pseudupeneus maculatus
This interesting fish reaching 23 cm (9 in) long. When swimming up in the water the two barbells beneath the chin are distinctive. The eyes are large and the body heavy. The active colour phase shows three large, dark spots on the body. In the inactive phase the spots fade and rusty-red patches appear. **Native.**

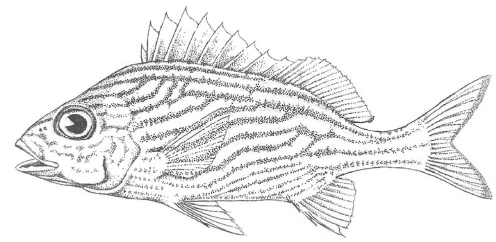


Yellow Goatfish B
Mulloidichthys martinicus
This is an attractive, bottom-living fish of sandy places. Growing up to 30 cm (1 ft) long it has a yellow mid-body stripe and a yellow tail. A distinctive feature is the presence of two barbells or feelers under the chin. **Native.**



B

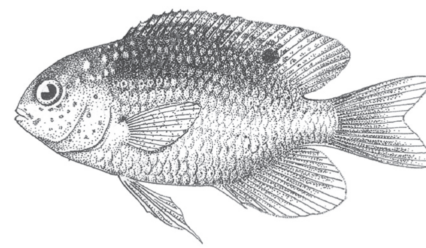
French or **Yellow Grunt**
Haemulon flavolineatum
This is one of eleven members of this family found in Bermuda. The French Grunt, has a relatively deep body, blue in colour with many yellow stripes. The stripes are parallel close to the back but become diagonal lower down. Grunts may form large schools, often with more than one species present. By day, they tend to be around, reefs, rocks and other cover, but at night they disperse over sandy bottoms and grass beds to feed on small crustaceans. The length in adults ranges from 15-25 cm (6-10 in). **Native.**



Damselfishes

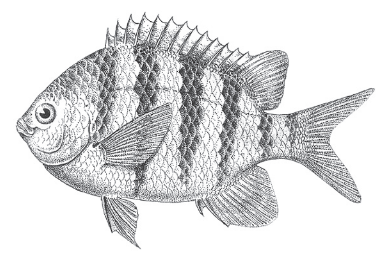
B, C

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

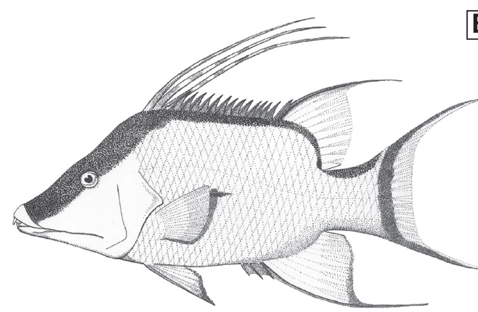
Sergeant Major or **Cow Polly**
Abudefduf saxatilis
The Sergeant Major is one of the damselfishes, and is strikingly coloured with a blue head, and with vertical dark bars on a yellow background along its back, grading to light blue beneath. It is a very active small fish, up to 15 cm (6 in) long.



Wrasses

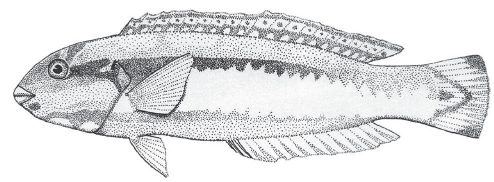
B, C

Hogfish
Lachnolaimus maximus
Hogfish have a strongly tapered head and a large mouth and are very varied in colour. They can change colour quickly, but are generally a mottled reddish-brown. Older males have a conspicuous, very dark purple patch, along the back, from the snout to the start of the dorsal fin. Hogfish can reach 1 m (3 ft) long. **Native**.



B

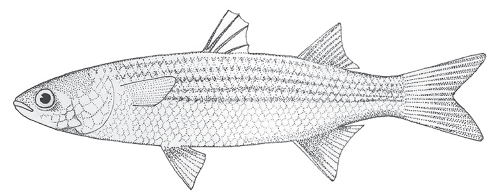
Slippery Dick
Halichoeres bivittatus
Like many of the wrasses this 18 cm (7 in) long wrasse of bays and seagrass beds, goes through a bewildering series of colour changes as it matures. Juveniles are whitish with a dark stripe down the centre of each side. Intermediate phase individuals vary greatly but are mostly greens with brown markings. Terminal phase adults have longitudinal bars of green, yellow and pinkish-brown. **Native.**



Mullets

B, SP

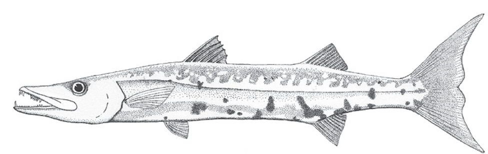
Grey Mullet
Mugil trichodon
The Grey or Fan-tailed Mullet is a fish of quiet waters often seen in groups sunning themselves at the surface. A slow swimmer, the mullet can survive in water of poor quality and it is unusual in being herbivorous. The colour is a dull grey and the length up to about 40 cm (16 in). **Native.**



Barracudas

B, C, O

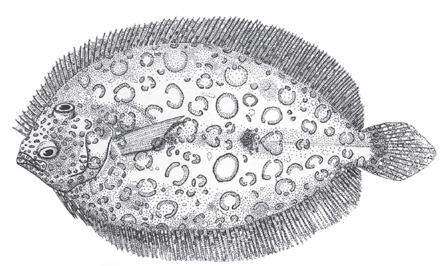
Great Barracuda
Sphyraena barracuda
Juveniles, up to about 45 cm (18 in) in length, are very frequent in the bays. Adults up to at least 1 m (3 ft) long may be seen on the reefs. This elongate fish is best recognised by the very large mouth with needle-sharp teeth, and elongated silvery body with dark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



Flatfishes

B

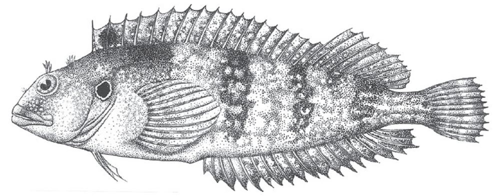
Peacock Flounder
Bothus lunatus
This flounder is one of the flatfishes, which are a group of fish that lie on the bottom on one side. Both eyes are on the upward side. Most flatfishes are very adept at changing their colour to match that of the bottom. The Peackock Flounder not only does this but also wafts some of the bottom sand over its body. Often just the eyes remain visible. Common on sandy bottoms. Up to 45 cm (18 in) long. **Native.**



Blennies

B, SP

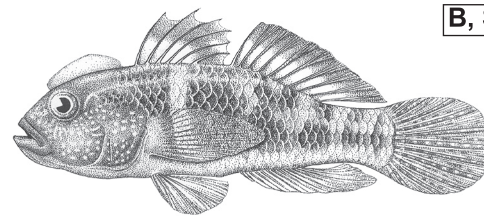
Hairy Blenny
Labrisomus nuchipinnis
This fish, up to 20 cm (8 in) long, but usually smaller is typical of shallow waters in algal or seagrass beds. The colour varies with the habitat from near-white to near-black, but males are dark with red fringed fins and there is a spot on the gill cover. The head is large. **Native.**



Gobies

B, SP

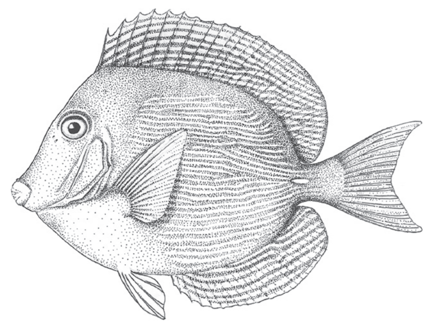
Crested Goby
Lophogobius cyprinoides
A small, dark fish with a very large head and a lot of character. Up to 10 cm (4 in) long the fish is dark-brown to olive and lives in the mangrove root habitat. **Native.**



Surgeonfishes

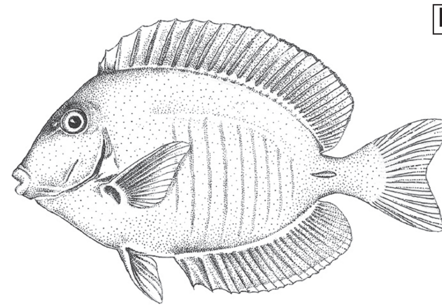
B, C

Blue Tang
Acanthurus coeruleus
These fish are deep in the body is a brilliant blue. They reach a maximum size of 38 cm (15 in) and have very sharp ridges, resembling the edge of a scalpel, at the base of the tail. The striking, brilliant blue of the adult Blue Tang is all the more remarkable when we learn that the juveniles are coloured a brilliant yellow with faint, darker longitudinal lines. This fish has the same razor-sharp ridges at the base of the tail as the Ocean Surgeonfish. **Native**.



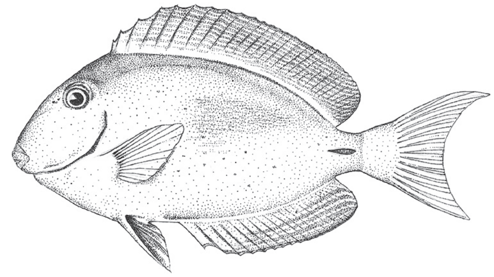
B, C

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



B, C

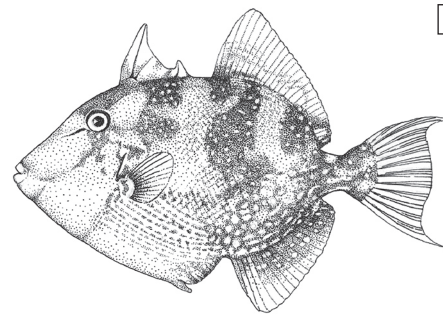
Ocean Surgeonfish
Acanthurus bahianus
The Ocean Surgeonfish like the Blue Tang (above) is a member of the surgeonfish family. The fish are deep in the body, and the Surgeonfish varies from a dull brown colour to a pale grey. It reaches a maximum size of 38 cm (15 in) and has very sharp ridges, resembling the edge of a scalpel, at the base of the tail. These razor-sharp features give the group their name, and are something to beware of if you get the chance to handle one. **Native**



Triggerfishes

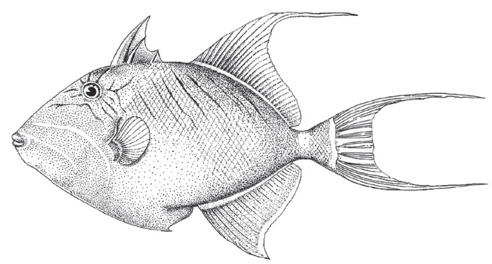
B, C

Grey Triggerfish
Balistes capriscus
Triggerfish have a medium deep body with the eyes set back on a long sloping forehead, it reaches about 35 cm (1 ft) long but those seen in shallow water are usually half this length or less. The basic body colour may be grey to yellowish-brown but there are always blue spots and lines on the upper body and fins. **Native**.



B, C

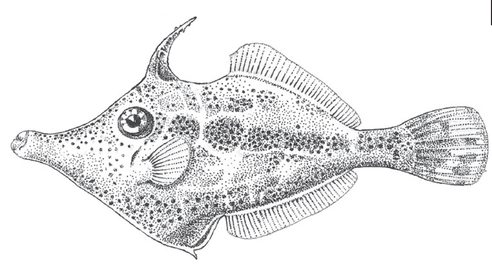
Queen Triggerfish
Balistes vetula
Triggerfish have a medium deep body with the eyes set back on a long sloping forehead. This is the most striking of all triggerfish, with a purple-blue lower body and fins, and a yellowish back and head. The large fins have trailing edges. There are two diagonal clear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



Leatherjackets

B

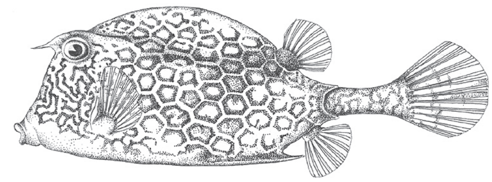
Slender Filefish
Monacanthus tuckeri
The Slender Filefish has a very distinctive body shape and is only 10 cm (4 in) long. The snout is almost tube like but gives way to a high head with very large eyes. Above the eye on the back is a stout, curving spine. The brown body usually has a white chequerboard pattern. **Native.**



Trunkfishes

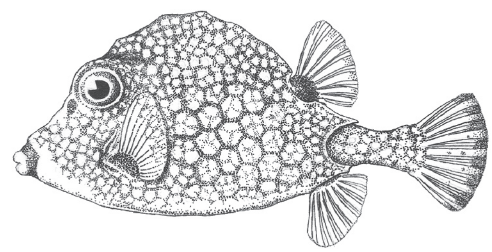
B

Honeycomb Cowfish
Acanthostracion polygonius
This is one of the Boxfish family, growing up to about 30 cm (1 ft) long. It has two little horns between the eyes and a box-like, very firm body, covered with blackish polygons on a cream background. The tail is large and set on a narrow stalk. **Native**.



B

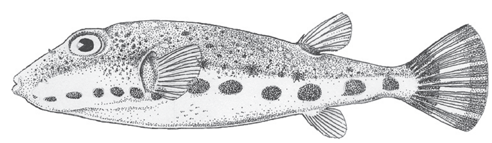
Smooth Trunkfish
Lactophrys triqueter
Like the Honeycomb Cowfish this species grows up to about 30 cm (1 ft) long and also has a box-like, very firm body. This species also has polygons on the body but they are less obviously displayed in a black background with light spots. The tail is large and set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



Puffers and Porcupine Fishes

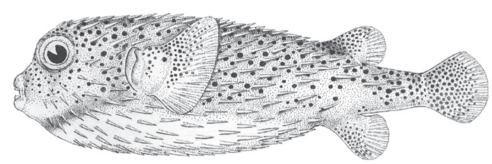
B

Bandtail Puffer
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**.



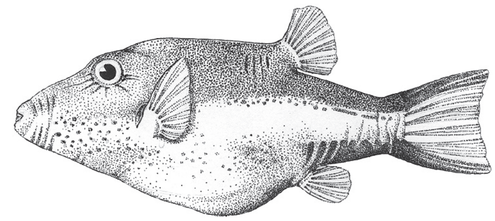
B

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

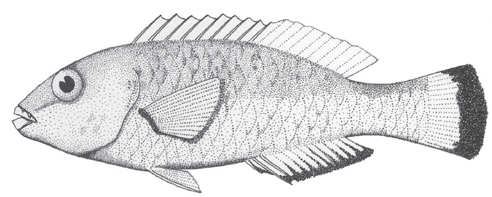
Sharpnose Puffer
Canthigaster rostrata
This is a charming little fish only about 12 cm (4 in) long, with a large head and tapering body. Dark mauve or brown above and white below, they are quite difficult to spot. Groups of these tiny puffers hang above the bottom, hovering and darting about like dragonflies.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



Parrotfishes

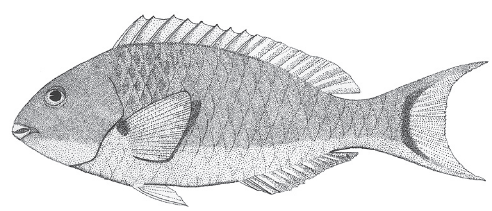
B. SG

Bucktooth Parrtofish
Sparisoma radians
This is the characteristic parrotfish of seagrass beds. It is smaller than most other parrotfish reaching a size of 19 cm (7 1/2 in) long. The colour is very variable, having mottles, patches or stripes of muted browns, yellows and reds. There is a distinctive black margin to the tail. Juvenile specimens are mottled in greens, yellows and browns to blend in with the seagrasses. **Native.**



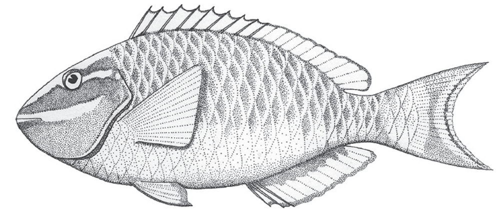
B, C

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



B, C

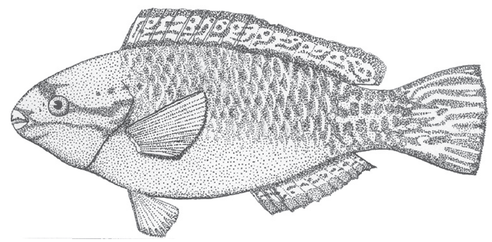
Stoplight Parrotfish
Sparisoma viride
In the initial color phase all fish are red-green above and bright red below with red fins. The terminal colour phase of mature males is mainly green. There are three diagonal orange bands on the head. The fins are yellow and blue. This species is commonly about 40 cm (15 in) long. **Native**.



Striped Parrotfish B, C

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**.



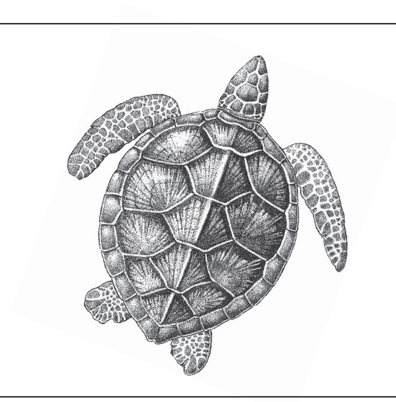
Turtles and Terrapins

Turtles

Green Turtle B, O, SG

Chelonia mydas

The Green Turtle is the commonest of the marine turtles seen in Bermuda and used to breed here. Up to at least 1 m (3 ft) long, they may be any shade of colour between dull, dark green and virtually black. The adults feed on sea-grasses and seaweeds and the occasional sessile invertebrate. Always present in Walsingham Pond and occasionally seen in others. **Native**.



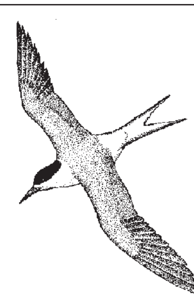
Birds

Terns

Common Tern B

Sterna hirundo

This tern used to breed in Bermuda in large numbers but now only about 25 pairs do so. Terns fish in shallow waters, diving to catch fry or other small species. 35 cm (about 1 ft) in wingspan they can be recognised by the black top to the head and the V-shaped tail. **Native.**



Field Trips

General Note

Field trips to sheltered bays and seagrass beds should be very thoroughly planned in advance. If possible the teacher in charge should visit the chosen site and make sure that it is suitable. These locations can change quite fast at different seasons and after storms. It is an advantage to go at low tide as more material will be exposed in shallower water. Tide times are given in the daily newspaper. However, at any state of the tide, it will help in observing animals and plants to actually wade in the water. In doing this it is advisable for everyone to wear a pair of old running shoes, mud shoes etc, to guard against sharp objects on the bottom. Even while just wading, a face mask can help in seeing things clearly in the water. All that people need to do is to bend forward so that the glass is immersed in the water. In deeper locations of about a metre (3 ft) it may be better to actually swim slowly through the water using a mask and snorkel. This is particularly effective in observing seagrass beds since it prevents sediment and detritus being stirred up into the water. If students are to swim, a light wet suit top or body surfing jacket is a good idea.

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

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

There are few hazards in these shallow water environments, but accidents are always possible and a good first aid kit is essential. Someone in authority in the group should also have a cellular telephone in case help is needed. The first aid kit should include a bottle of rubbing alcohol as it is a good treatment for stings in the unlikely event that some occur and is also a good general cleanser and antiseptic.

Most locations have other types of habitats around or within them that are not described in this field guide but are discussed in others. The ones most likely to be useful are those to Sandy Shores and to Rocky Shores although the guide to Wetlands will be helpful if there are mangrove trees around as there are at several of the suggested locations.

No collecting of any material alive or dead should be permitted on field trips. Try to identify everything that you see from this guide. If rocks are turned over they must be carefully replaced as they were. It is suggested that no digging be permitted as this is likely to kill buried animals rather than retrieving them. If any shallow excavations are made by hand fill them in.

Field Trip # 1, Coney Island Bay

Introduction. Coney Island Bay is a very well preserved and very small bay that is accessible in a National Park. The little bay is nowhere deep enough to be a problem even with quite small students, and additionally it is very sheltered as it has only a very narrow entrance to the sea. For a tiny bay this one has an amazing variety of habitats and species. Do not get into the water immediately but look at the bay from the high ground around the edge to see what is available there. This location is especially suitable for younger students.

Approach. Cross the causeway and bridges leading to the island and park in the area to the right immediately within the park. Walk over the road to the left close to the edge of the motorcycle course past the marine pond.

Preparation. Read this field study guide thoroughly. If possible also consult the Mangrove Swamp section of the guide "Bermuda's Wetlands" and the guide to the Rocky Shores. The Bay has a tiny mangrove swamp and a nice stretch of rocky shore. Alternatively just concentrate on the sandy bottom and seagrass beds this trip and plan another so that the whole bay can be appreciated.

Equipment and Supplies. As many copies of Sheltered Bays and Seagrass Beds of Bermuda as possible. A clipboard, pencils and paper for each student. A pair of binoculars (or more) for the group in case interesting birds come close-by. A 30 cm metric ruler that can stand immersion in water for each group of students. Some empty jars (Plastic is safest).

Dress. Students should wear sturdy, washable clothing and carry a towel. Take a pair of old footwear suitable for wading in the water. A swimming mask is a good idea. If students are going to swim take appropriate swimming gear and a snorkel.

Observations

1) Before going into the water make a sketch map of the bay showing: A) The entrance; B) Any beaches; C) The position of rocky shores; D) The rough distribution of seagrass beds as shown by the darker areas of bottom; E) The areas occupied by sandy bottoms without seagrass; F) Any boats or other marine equipment in the bay; G) The location of the Mangrove Swamp.

2) Wade into the shallow water and look for: A) Dead shells. Pick these up try to identify them and then return them to the bottom; B) Seagrasses. Which of the three species are present? Which is commonest? Which is rarest? C) Burrow mouths and castings. D) Sand waves or ripples. E) Any fish that are around.

3) Go to one area in a seagrass bed. A) Which seagrass are you observing? B) About how many leaves are there per clump? C) About how long are the leaves? D) Can you see round white dots on the leaves? If so what causes them?

4) Collect a sample of sediment from among the seagrasses and on open bottom. Label and cap them and take them back to school after observing. A) Which has the coarsest sediment? Coarser sediments show more current. B) Which has the lightest coloured sediment. Dark sediment has detritus in it.

5) Walk around the shallow water of the bay and identify as many animals and plants as you can. Dead shells or castings can be used as evidence of a species.. Note the habitat where each was located, for example, seagrass bed, shallow sandy bottom, deeper sandy bottom, near mangrove swamp etc.

Map of Coney Island Bay

2) Ecological Examination

Object or Organism	Observations
Dead shells Species	Where Found
Seagrass Species	Common or Rare
Burrows and Casting Identity	Location
Sand Ripple Description	Location
Fish Identity	Location

3) Seagrasses

Organism or Feature	**Observations**
Identity of Seagrass	Features for Identity
Number of Leaves per Clump	Approximate leaf Length cm
Round White Dots on Leaves?	On Old (outer) or Young (inner) Leaves

4) Sediment

Collect Samples from open bottom and seagrass bed...............Check when done.
Label Samples................Check when done.
Check which sediment is coarsest. Open bottom............... Seagrass Bed...........................
Check which sediment is lightest in colour. Open bottom............... Seagrass Bed.........

5) Walkabout

Plant or Animal	Habitat and Observations

Questions to Think about

1) What effect does the size of the bay and its very narrow entrance have on its degree of shelter?

2) How many different habitats did you observe in this bay? List them and give a brief description of each.

3) If this bay became attractive to tourists, what would be the likely result of greater use?

4) Can you suggest any measures to help preserve the ecology of this bay?

5) Why is the sediment in seagrass beds often darker than that beyond its borders?

6) Why is the sediment in seagrass beds finer than that in surrounding sands?

Field Trip # 2, Whalebone Bay

Introduction. Whalebone Bay is the largest bay to which field trips are suggested. Because of this it is best suited to classes of older students who can swim in the shallows of the bay, using mask and snorkel. For this purpose it would be especially helpful if students could wear a thin wet suit, body surfing suit or other protection from the cold. In this sort of situation it is essential that there are enough supervisors present who are good swimmers. Students can be broken into small groups each with a supervisor. It is also a good idea to have at least one responsible person remain on shore to keep track of all participants and to call back any who stray too far away. In any case stay within the inner part of the bay and avoid the area around the mouth of the bay. It is deeper and rougher and has more reef environment than bay and seagrass bed environments. The seagrass beds are mainly on the west side of the bay in about 1 m (3 ft) of water. Some are suffering badly from trampling and are diminishing in extent but enough are left to observe. Note that Whalebone Bay is an *absolutely no collecting* area to try to slow down its degradation

Approach. Proceed to the end of Ferry Road where there is parking and walk north over the Railway Trail to Whalebone Bay. The best base of operations is the sandy beach at the end of the bay.

Preparation. Read this field study guide thoroughly. It might also be helpful to look at material on rocky shores as those in the bay are quite good.

Equipment and Supplies. As many copies of Sheltered Bays and Seagrass Beds of Bermuda as possible. A clipboard, pencils and paper for each student. A pair of binoculars (or more) for the group in case interesting birds come close-by. A 30 cm metric ruler that can stand immersion in water for each group of students. Some empty jars (Plastic is safest).

Dress. Students should wear sturdy, washable clothing and carry a towel. Take a pair of old footwear suitable for wading in the water as well as a swim suit. A thin wet suit, body surfing suit or other flotation and protection device is a good idea. A swimming mask and snorkel is essential for observation in the water. If students are going to swim take appropriate swimming gear and a snorkel

Observations.

1) Before going into the water make a sketch map of the bay showing: A) The entrance; B) Any beaches; C) The position of rocky shores; D) The position of any boats or marine gear in the bay.

2) Wade or swim into the shallow water and look for: A) Dead shells. Pick these up try to identify them and then return them to the bottom; B) Seagrasses. Which of the three species are present? Which is commonest? Which is rarest? C) Burrow mouths and castings. D) Sand waves or ripples. E) Any fish that are around.

3) Go to one area in a seagrass bed. A) Which seagrass are you observing? B) Abouthowmany leaves are there per clump? C) About how long are the leaves? D) Can you see round white dots on the leaves? If so what causes them?

4) Collect a sample of sediment from among the seagrasses and on open bottom. Label and cap them and take them back to school after observing. A) Which has the coarsest sediment? Coarser sediments show more current. B) Which has the lightest coloured sediment. Dark sediment has detritus in it.

5) Walk around the shallow water of the bay and identify as many animals and plants as you can. Dead shells or castings can be used as evidence of a species.. Note the habitat where each was located, for example, seagrass bed, shallow sandy bottom, deeper sandy bottom, near mangrove swamp etc.

1) Map of Whalebone Bay

2) Ecological Examination

Object or Organism	Observations
Dead Shells Species	Where Found
Seagrass Species	Common or Rare
Burrows and Casting Identity	Location
Sand Ripples	Location
Fish Species	Location

3) Seagrasses

Organism or Feature	**Observations**
Identity of Seagrass	Features for Identity
Number of Leaves per Clump	Approximate leaf Length cm
Round White Dots on Leaves?	Explanation

4) Sediment

Collect Samples from open bottom and seagrass bed...............Check when done.
Label Samples...............Check when done.
Check which sediment is coarsest. Open bottom............... Seagrass Bed...........................
Check which sediment is lightest in colour. Open bottom............... Seagrass Bed.........

5) **Walkabout**

Plant or Animal Identity	Observations

Questions to Think about

1) What effect does the size of the bay have on its degree of shelter?

2) What is the effect of heavy use for recreation and teaching on the ecological status of the bay?

3) Why is the collecting of organisms totally prohibited in Whalebone Bay?

4) Can you suggest any measures to help preserve the ecology of this bay?

5) Why is the sediment in seagrass beds darker than that beyond its borders?

6) Why is the sediment in seagrass beds finer than that in surrounding sands?

7) Why are seagrass beds often shallower than surrounding water?

Field Trip # 3, Tobacco Bay and Coot Pond

Introduction. Tobacco Bay is small and very heavily used by Bermudians and tourists. Because of this it is best used as an example of a much over-used bay. It used to have beautiful seagrass beds and a host of burrowing and crawling organisms as well as Ghost Crabs on the beach. Nevertheless careful search of the bottom should reveal some burrows and castings and there is a host of fish. Some of the rocky shores are also interesting and a rocky shore field trip could be combined with this one. The other worthwhile approach is to compare Tobacco Bay and Coot Pond. These natural systems are very close but very different. The reasons for this should be obvious if a careful comparison is made.

Approach. Park anywhere in the Tobacco Bay or Coot Pond areas and walk.

Preparation. Read this field study guide thoroughly. If possible also consult the Mangrove Swamp section of the guide “Bermuda’s Wetlands” and the guide to the Rock Shores. Coot pond has an extensive mangrove swamp and a soft muddy bottom.

Equipment and Supplies. As many copies of Sheltered Bays and Seagrass Beds of Bermuda as possible. As a minimum photocopy the specific field trip outline for each student. A clipboard, pencils, ruler and paper for each student. A pair of binoculars (or more) for the group in case interesting birds come close-by. Some empty jars (Plastic is safest).

Dress. Students should wear sturdy, washable clothing and carry a towel. Take a pair of old footwear suitable for wading in the water. A swimming mask is a good aid for observation in the water. If students are going to swim take appropriate swimming gear and a snorkel.

Observations

A) Tobacco Bay

1) Make a sketch map of Tobacco Bay showing: A) The entrances; B) Any beaches; C) The position of rocky shores; D) The position of any boats or marine gear in the bay. This will be compared to a map of Coot Pond to be drawn next.

2) Wade into the shallow water and look for: A) Dead shells. Pick these up try to identify them and then return them to the bottom; B) Any seaweeds that are present on the surface of the sand. Identify if possible C) Burrow mouths and castings. Try to identify and describe what you see D) Sand waves or ripples. Note where they are found. E) Any fish that are around. Try to decide on a habitat for each. E.g. Along rocky shore. On bottom in centre of bay. Up in the water in the shallows.

3) Collect a sample of sediment from the open bottom. Label and cap it.

1) Map of Tobacco Bay

5) Map of Coot Pond

2) Ecological Survey

Organism or Observation	Organism or Observation
Dead Shell Identity	Seaweed Identity
Burrows Mouths and Casting Identity	Description
Sand Waves and Ripples	Location
Fish Identified	Habitat

Observations

B) Coot Pond. Coot Pond is for observation from the side only. It is muddy and full of trash, and dangerous to wade into. Work from the bank of Coot Pond.

5) Draw a sketch map of Coot Pond noting the location of the mangrove swamp, the seagrass beds. Most of the bottom supports seagrasses; you should be able to see them. Note approximately where boats are moored. Identify the seagrasses that you can see.

6) Try to get a sediment sample of the muddy bottom. Cap and label it.

7) Look for fish and try to identify them. Note their habitat.

5) Seagrass Identities

7) Fish Identity

Fish Identities	Habitat

Questions about these locations

1) Give as many reasons as you can why Coot Pond is more sheltered than Tobacco Bay? Hints: Think about waves. Entrances to the sea. Surrounding systems.

2) Look at the two sediment samples and try to A) describe them in terms of colour and grain size; B) Try to explain the differences that you see between the two sediments.

3) Why is Tobacco Bay without seagrass beds while Coot Pond supports these plants?

4) Can you suggest any ways in which bays like Tobacco Bay can be protected from over-use?

5) Give some reasons why the trash and pollution in Coot Pond harm the animals and plants living there.

Field Trip # 4, Admiralty House Bay

Introduction. Admiralty House bay is a small and quite sheltered bay although it does get waves in a northeast wind. It is heavily used for recreation but some small seagrass beds survive and other organisms are present. This location can be studied by wading but snorkelling in slightly deeper water will add to the experience.

Approach. Go into the park at its eastern end and walk down the sloping road to the beach of the sheltered bay

Preparation. Read this field study guide thoroughly. If possible also consult the guide to the Rock Shores. The Bay has a nice stretch of rocky shore. Alternatively just concentrate on the sandy bottom and seagrass beds this trip and plan another so that the whole bay can be appreciated.

Equipment and Supplies. As many copies of Sheltered Bays and Seagrass Beds of Bermuda as possible. A clipboard, pencils and paper for each student. A pair of binoculars (or more) for the group in case interesting birds come close-by. A 30 cm metric ruler that can stand immersion in water for each group of students. Some empty jars (Plastic is safest).

Dress. Students should wear sturdy, washable clothing and carry a towel. Take a pair of old footwear suitable for wading in the water. A swimming mask is a good idea. If students are going to swim take appropriate swimming gear and a snorkel

Observations

1) Before going into the water make a sketch map of the bay showing: A) The entrance; B) Any beaches; C) The position of rocky shores; D) The rough distribution of seagrass beds as shown by the darker areas of bottom; E) The areas occupied by sandy bottoms without seagrass; F) Any boats or other marine equipment in the bay.

2) Wade into the shallow water and look for: A) Dead shells. Pick these up try to identify them and then return them to the bottom; B) Seagrasses. Which of the three species are present? Which is commonest? Which is rarest? C) Burrow mouths and castings. D) Sand waves or ripples. E) Any fish that are around.

3) Go to one area in a seagrass bed. A) Which seagrass are you observing? B) About how many leaves are there per clump? C) About how long are the leaves? D) Can you see round white dots on the leaves? If so what causes them?

4) Collect a sample of sediment from among the seagrasses and on open bottom. Label and cap them and take them back to school after observing. A) Which has the coarsest sediment? Coarser sediments show more current. B) Which has the lightest coloured sediment. Dark sediment has detritus in it.

5) Walk around the shallow water of the bay and identify as many animals and plants as you can. Dead shells or castings can be used as evidence of a species. Note the habitat where each was collected, for example, seagrass bed, shallow sandy bottom, deeper sandy bottom, near mangrove swamp etc.

1) Map of Admiralty House Bay

2) Ecological Survey

Object or Organism	Observations
Dead Shell Species	Where Found
Seagrass Identity	Most Common and Most Rare
Burrow Mouths and Casting Identity	Locations
Sand Waves and Ripples	Location
Fish Identity	Habitat

3) Seagrasses

Identification	Observation
Seagrass Identity	Number of Leaves per Clump
Round White Dots on Leaves?	Explanation

5) Walkabout

Identification	Habitat

Questions to Think About

1) How does the heavy recreational use of this bay affect the fauna and flora?

2) How do the two sediment samples differ in colour and texture?

3 Can you explain the reasons for the differences between the sediment samples?

4) Was there any evidence of pollution at this location?

5) How might bays such as this be protected from overuse?

Field Trip # 5, Flatts Inlet

Introduction. Flatts Inlet can be used as a field study site in a somewhat different way to the others that are suggested. There is a shallow, sandy location that can be used as a wading-study site but there is also the possibility of using a boat to make observations of the area on a somewhat larger scale.

Approach. For a simple wading study walk from the Aquarium car park past the wharf to the far end of the Bermuda Zoological Society Building. There a set of (slippery) steps leads down to a sandy beach at low tide or a shallow bay at high tide. If you have arranged to use a boat, embark at the Aquarium wharf.

Preparation. Read this field study guide thoroughly.

Equipment and Supplies. As many copies of Sheltered Bays and Seagrass Beds of Bermuda as possible. A clipboard, pencils and paper for each student. 12 inch waterproof rulers that read in centimeters. A pair of binoculars (or more) for the group in case interesting birds come close-by. Some empty jars (Plastic is safest).

Dress. Students should wear sturdy, washable clothing and carry a towel. Take a pair of old footwear suitable for wading in the water. A swimming mask is a good idea. If students are going to swim take appropriate swimming gear and a snorkel.

Observations

A) Wading Study of Shallow Bay

1) Before going into the water make a sketch map of the bay showing: A) Beaches; B) The shoreline in the immediate vicinity. C) The position of trees; D) The rough distribution of seagrass beds as shown by the darker areas of bottom; E) The areas occupied by sandy bottoms without seagrass; F) Any boats or other marine equipment in the bay.

2) Wade into the shallow water and look for: A) Dead shells. Pick these up and try to identify them and then return them to the bottom; B) Seagrasses. Which of the three species are present? Which is commonest? Which is rarest? C) Burrow mouths and castings. D) Sand waves or ripples. E) Any fish that are around.

3) If possible go to one area in a seagrass bed. A) Which seagrass are you observing? B) About how many leaves are there per clump? C) About how long are the leaves? D) Can you see round white dots on the leaves? If so what causes them?

4) Collect a sample of sediment from among the seagrasses and on open bottom. Label and cap them and take them back to school after observing. A) Which has the coarsest sediment? Coarser sediments show more current. B) Which has the lightest coloured sediment. Dark sediment has detritus in it.

1) Map of Flatts Inlet Bay

2) Ecological Survey

Identification	Observation
Dead Shell Identity	Where Found
Seagrass Identity	Most Common and Most Rare
Burrow Mouth and Casting Identity	Locations
Sand Waves and Ripples	Location
Fish Identity	Habitat

3) Seagrasses

Identification	Observation
Seagrass Identity	Number of Leaves per Clump
White Dots on Leaves	Explanation

B) Boat Observation Study

1) Proceed down Flatts Inlet slowly; all students must be able to see into the water. As you go look for a) sand waves in the bottom, b) fish. There are large sand waves in the inlet that are formed by the vigorous water currents present.

2) When seagrass beds appear on the left (W side), move over into the beds and stop. At low tide just get the boatman to ground in shallow water. If possible get out and wade. A) Which seagrass are you observing? B) About how many leaves are there per clump? C) About how long are the leaves? D) Can you see round white dots on the leaves? If so what causes them? Use table 3) to record results.

3) Proceed to the west side of the mouth of the inlet and drift over shallow sandy bottoms around Gibbett Island. Look for: A) Dead shells. Pick these up with a long-handled net and try to identify them and then return them to the bottom; B) Seagrasses. Which of the three species are present? Which is commonest? Which is rarest? C) Burrow mouths and castings. D) Sand waves or ripples. E) Any fish that are around. Record results on table 2

Questions to think about

1) How does the current through Flatts inlet affect the ecological conditions there? Think about sediment movement. Food supply to organisms. The way sediments get sorted etc.

2) Try to explain the differences in colour and texture between the sediment samples. If you could get a sediment sample on the crest of one of the sand waves, what would you expect it to look like?

3) Seagrasses produce lots of detritus which is good food. Where might detritus from Flatts Inlet end up? What will be its ecological importance there?

4) Why do you think that seagrasses grow so well along the west side of Flatts Inlet?

5) There are lots of fishes of different kinds at this location. Why do you think that this is the case?

Field Trip # 6, Fairylands

Introduction. The very sheltered bay at Fairylands does not show all the features that we would like, but it does generally have seagrasses in very shallow water and there are plenty of seaweeds to observe. It is not a good location for sedimentary studies but sandy bottoms can be observed on the seaward side of the causeway. This is a shallow wading site only do not swim.

Approach. Go down Fairylands Road and proceed onto Point Shares Road. In 100yds or so the causeway and sheltered bay on the left will appear

Preparation. Read this field study guide thoroughly. There is some rock here so the Rocky Shore guide may be helpful. This is also a mangrove swamp locality. Mangrove swamps are discussed in the Bermuda's Wetlands field guide

Equipment and Supplies. As many copies of Sheltered Bays and Seagrass Beds of Bermuda as possible. A clipboard, pencils and paper for each student. 12 inch waterproof rulers that read in centimeters. A pair of binoculars (or more) for the group in case interesting birds come close-by. Some empty jars (Plastic is safest).

Dress. Students should wear sturdy, washable clothing and carry a towel. Take a pair of old footwear suitable for wading in the water. A swimming mask is a good idea.

Observations

1) Before going into the water make a sketch map of the bay showing: A) Beaches; B) The location of rocky shores; C) The position of mangrove trees; D) The rough distribution of seagrass beds as shown by the darker areas of bottom; E) The areas occupied by sandy bottoms without seagrass if any.

2) Wade or look into the shallow water and look for: A) Dead shells. Pick these up try to identify them and then return them to the bottom; B) Seagrasses. Which of the three species are present? Which is commonest? Which is rarest? C) Burrow mouths and castings. D) Any fish that are around.

3) If possible go to one area in a seagrass bed. A) Which seagrass are you observing? B) About how many leaves are there per clump? C) About how long are the leaves? D) Can you see round white dots on the leaves? If so what causes them?

4) Collect a sample of sediment from among the seagrasses and on open bottom. (Outside the causeway if possible). Label and cap them and take them back to school after observing. A) Which has the coarsest sediment? Coarser sediments show more current. B) Which has the lightest coloured sediment. Dark sediment has detritus in it.

1) Map of Fairylands Bay

3) Seagrasses

Identification	**Observation**
Seagrass Identity	Number of Leaves per Clump
White Dots on Leaves	Explanation

2) Ecological Survey

Identification	Observation
Dead Shell Identity	Where Found
Seagrass Identity	Most Common and Most Rare
Burrow Mouth and Casting Identity	Locations
Sand Waves and Ripples	Location
Fish Identity	Habitat

Questions to Think About

1) How does the water get in and out of Fairylands Bay? Look at the causeway structure to answer this.

2) How do you think that the limited water exchange with the outer bay affects what lives in the inner bay?

3) How do the two sediment samples differ in colour and texture?

4) Can you explain the reasons for the differences between the sediment samples?

5) Was there any evidence of pollution at this location?

6) How might bays such as this be protected from pollution and habitat destruction?

Class Exercise. Examination of a sediment sample and identification of grains

1) Use a sediment sample or samples collected on a field trip, or one collected in a sandy bay.
2) Put the sample in a large bowl or dish.
3) Flood with fresh water and stir. Let settle.
4) Carefully pour off the water without losing any sediment.
5) Dry the sediment in the sun. A cool oven can speed the process. Occasional gentle stirring is a good idea.
6) When thoroughly dry, examine a sample of the sediment spread out in a small container (A petri-dish is ideal). A good hand-lens is a help. If available, a stereo microscope is a great help.
7) Identify all the grains that you can using Figure 1 and judge their abundance in the sample.

Grain Identity	Abundance

Question. How would the location that the sample was collected from affect the sample? Think about waves, currents and the biological characteristics of the area.

Glossary

Aeolianite	Rock formed on land, from the solidification (lithification) of wind-blown sand.
Benthic Organisms	All the **biota** living on or in the bottom of bodies of water.
Benthos	All the **biota** living on or in the bottom of bodies of water.
Biochemical bio-erosion	The erosion of rock by biochemical products of animals or plants.
Biodiversty	In its simplest form biodiversity is measured as the number of different species occurring in a given habitat. More complex aspects also include the relative abundance of the species array.
Bio-erosion	The break down of rock resulting from biological activity.
Biological erosion	See bio-erosion above.
Biota	This word is used when all types of organism in a biological system are being included.
Burrowing bio-erosion	Bio-erosion resulting from the burrowing activities of marine animals.
Castings	Waste material ejected by burrowing or crawling, bottom living animals. These castings may be stringy, pellet-like or just lumpy.
Chitin	A component of the shells of crustaceans and some other invertebrates that is resilient and protective but not hard.
Corals	Relative simple marine animals which form generally colonies consisting of groups of polyps, which resemble small tubes with a mouth at the top, which also have a ring of tentacles.
Crustose Calcareous Algae	Seaweeds of the red algal group which lay down very hard, sheet-like, deposits of calcium carbonate. These algae look like pink rock and are also called **Crustose Coralline Algae**. Crustose calcareous algae are vital to the formation of coral reefs.
Crustose Coralline Algae	See Crustose Calcareous Algae above.
Echinodermata	The animal phylum containing the sea cucumbers, starfish, sea urchins, sand dollars and sea lilies. They are generally radially symmetrical. If they move it is generally by means of numerous tiny tube feet, although some walk on spines or on the tips of the legs.

Endemic	Endemic species are those which have evolved in Bermuda. Most occur only in Bermuda but a few have spread to other locations or been introduced there.
Epibiota	All the organisms that live on the surface of the bottom of bodies of water.
Epiphytes	Any plant that grows upon or is in some manner attached to another plant or object.
Epizooites	Any animal that grows upon or is in some manner attached to another plant or object.
Export ecosystems	Ecosystems which produce food that is used beyond their own boundaries.
Fauna	Animal life.
Feeding bio-erosion	Bio-erosion resulting from the feeding activities of organisms. Parrotfish are the best example of feeding bio-eroders.
Gulf Stream	A very large, swift ocean current arising in the Gulf of Mexico, passing through the Straits of Florida and proceeding north and east along the east coast of North America. The Gulf Stream passes just to the west of Bermuda.
Habitat	A small area of environment.
Hard Corals	Corals found only in warm sea water which lay down a skeleton of hard calcium carbonate or limestone. Hard corals are very important in the creation of coral reefs.
Hot Spot Islands	Oceanic islands that form away from the edges of **tectonic plates** when molten **magma** breaks through a weak spot in the earth's crust. Hot spot islands typically result from volcanic activity.
Infauna	Organisms living buried in sediment at the bottom of water bodies.
Interstitial fauna	Tiny animals which can live between the grains of permeable sediments.
Island Arcs	Groups of oceanic islands, generally in arc-shaped groups that appear along the collision zones of **tectonic plates**.
Lithification	The formation of rock from sediment.
Magma	Molten rock lying beneath the earth's crust. Magma is in slow motion in giant convection cells. This motion moves the **tectonic plates**.

Mechanical erosion	See physical erosion below.
Native	A native animal or plant is one that has come to live in its habitat by natural means but that is also found naturally elsewhere.
Nekton	Animal life that swims freely in water.
Physical erosion	The breakdown of rock, or particles of rock, into smaller particles by physical means such as wave action, wind, gravity water currents and grinding.
Phyto-karst	The characteristic jagged surface texture of upper seashore rocks caused by bio-erosion by blue-green cyanobacteria.
Plankton	The drifting life of water bodies. Plankton are mostly small and if they can swim, cannot do so against a water current.
Population explosion	A sudden and very rapid increase in the population density of a species. Often linked to a change in environmental conditions.
Poorly sorted sediment	Sediment consisting of particles with a wide range of sizes.
Rhizoids	Root-like organs developed by green algae to enable them to colonise sedimentary habitats. Rhizoids act only as anchors and do not function as true roots.
Rhizome	The buried stem of a flowering plant from which roots and leaves emerge**.** Fragments of rhizomes may be carried in water currents to establish the plant in a new habitat.
Ridge Islands	Islands formed along oceanic ridges such as the Mid-Atlantic Ridge. These ridges are places where **tectonic plates** spread apart under the influence of movements in the molten **magma** lying beneath the earth's crust.
Sand Waves	Underwater features in sandy sediments where the surface of the sand forms wave-like ridges.
Sand Ridges	Wave like formations on the surface of sandy areas in either land or aquatic situations.
Sediment consolidation	A process taking place in fine sediments such as mud, which, in time, results in a lower trapped water content, higher density and increased physical stability.
Sediment permeability	This refers to the amount of open space within a sediment it can also be measured by the rate at which water can move through a sediment.

Sediment sorting The sorting out of different particle size sediments from a mixture in a situation of decreasing current velocity.

Tectonic Plates Large sections of the earth's crust. Tectonic plates are formed at spreading junctions such as the Mid-Atlantic ridge and are thrust down into the magma at collision zones such as that along the west coast of North America.

Well sorted sediment Sediment in which the component particles fall into a narrow range of sizes.

Bibliography

Humann, Paul.1989. **Reef Fish Identification.** New World Publications Inc., 424p.

Rowe, Mark P. 1998. **An Explanation of the Geology of Bermuda.** Bermuda Government, Ministry of the Environment, 30p

Smith-Vaniz, William F., Collette, Bruce B. and Brian E. Luckhurst. 1999. **Fishes of Bermuda: History, Zoogeography, Annotated Checklist, and Identification Keys.** American Society of Ichthyologists and Herpetologists, Special Publication Number 4, 424p.

Sterrer, Wolfgang. 1986. **Marine Fauna and Flora of Bermuda.** Wiley Interscience Publication, 742p.

Sterrer, Wolfgang. 1992. **Bermuda's Marine Life.** Bermuda Natural History Museum and Bermuda Zoological Society, 307p.

Sterrer, Wolfgang and A. Ralph Cavaliere. 1998. **Bermuda's Seashore Plants and Seaweeds.** Bermuda Natural History Museum and Bermuda Zoological Society, 269p.

Thomas, Martin L. H. and Alan Logan. 1991. **A Guide to the Ecology of Shoreline and Shallow-water Marine Communities of Bermuda.** Bermuda Biological Station for Research Special Publication Number 30. Wm. C. Brown Publishers, Dubuque, Iowa, U.S.A., 345p.

Thomas, Martin L. H. 1998. **Marine and Oceanic Island Ecology of Bermuda**. Bermuda Aquarium, Natural History Museum & Zoo, Bermuda Zoological Society and Friends of the Bermuda Aquarium, 148p.

BERMUDA ZOOLOGICAL SOCIETY