BERMUDA ZOOLOGICAL SOCIETY

presents

Sandy Coasts

written by

Dr. Martin L. H. Thomas

Project Nature

Field Study Guides for Bermuda Habitats

Sponsored by

The Bermuda Paint Co. Ltd.

Bermuda Zoological Society

presents

Sandy Coasts

(Second Edition)

Prepared by

Martin L. H. Thomas

Project Nature
Field Study Guide

Sponsored by

The Bermuda Paint Company Limited

"Sandy Coasts"

A completely new edition of the first Project Nature guide
"The Sandy Shore" published in 1994

Published by the Bermuda Zoological Society
in collaboration with
the Bermuda Aquarium, Natural History Museum and Zoo.

Published May 2008

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**

The Bermuda Forests. Anonymous
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**

Sheltered Bays and Seagrass Beds of Bermuda. By Martin L. H. Thomas
First Edition August 2002
Second Edition September 2005. 88 pages. **ISBN: 1-894916-66-2**

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**

A Teaching Guide to the Biology and Geology of Bermuda, By Martin L. H. Thomas
Published March 2006. 573 pages. **ISBN: 1-894916-61-1**

Cover: Horseshoe Bay area
Photo: *Martin L. H. Thomas*

ISBN 978-1-897403-49-5

Foreword

The sandy coast is probably Bermuda's greatest natural attraction for visitors and residents alike. Indeed the pink sand beaches and crystal blue waters are world renowned and a great source of national pride.

Unfortunately, attracting tens of thousands of beach goers annually, the sandy coast is also one of Bermuda's most vulnerable ecological regions to intensive human impact.

This Project Nature Field Guide explores the wonders of our sandy coast providing a comprehensive understanding of its geology, ecology, flora and fauna, complete with field study exercises for students and budding naturalists.

Sandy Coasts is the latest in the series of Project Nature Field Study Guides serving as the Second Edition to The Sandy Shore, which was published in 1994. It is preceded by Rocky Coasts; The Bermuda Forests; Bermuda's Wetlands; Oceanic Island Ecology of Bermuda; Coral Reefs of Bermuda; Sheltered Bays and Seagrass Beds of Bermuda; The Ecology of Harrington Sound, Bermuda and The Open Ocean around Bermuda.

Collectively, the Project Nature series is an incredible resource for promoting the exploration and understanding of the natural wonders of Bermuda to inspire appreciation and care for our island environment.

Brian Lightbourn
Principal Curator
Bermuda Aquarium, Museum & Zoo

May 2008

Acknowledgements

The Sandy Shore was the second in the series of Project Nature field study guides which resulted from the inspirational thoughts of Mary Winchell and Lyn Thompson 15 years ago. The first two issues were the product of a team approach. Those involved in the writing included; Marg Hammond, Lyn Thompson, Felicity Holmes, Mary Winchell, Robin Trimingham, Wolfgang Sterrer, Dorte Westphalen, Jack Ward, Andrew Dobson, David Wingate and Mary Lodge. These first two guides were followed, after a seven-year gap, by a third, “The Bermuda Forests” which showed a transitional approach. A team approach persisted in part but one of the team, Martin Thomas, assumed the responsibility for much of the text and for overall coordination of the project. At this point the focus of the series became much more ecological. The evolution of the series continued with the fourth guide, “Bermuda’s Wetlands” which had a single author, a situation that continues to this day.

The first seven Project Nature field and study guides were produced with the encouragement and advice of Mary Winchell who was the Educational Coordinator for the Bermuda Zoological Society for most of this period. When Mary Winchell left to pursue other interests, leadership was taken over by Holly Holder, the new Education Officer, who strongly supported the Project Nature initiative. This new edition of the first Project Nature Guide was started under her guidance. Holly has now left BZS and the position of education officer has been taken over by Joseph Furbert who will oversee future publications for schools.

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

The illustrations are drawn from a very wide variety of sources and some have been especially drawn for these guides. We are especially grateful to Dr. Wolfgang Sterrer, Curator of the Natural History Museum for his permission to use illustrations from three of his publications, ‘The Marine Fauna and Flora of Bermuda’, ‘Bermuda’s Marine Life’ and the book ‘Bermuda’s Seashore Plants and Seaweeds’ which he co-authored with A.R. Cavaliere. Other illustrations of animals and plants have been contributed by Janet Percy, David Wingate and the author. The full page **habitat** picture of the **sand dunes** has been drawn by Jo-Anne Stevens of the University of New Brunswick in Saint John, Canada. Some text illustrations are from the first edition of this publication others are by the author. The now out of print book ‘Flora of Bermuda’, by N. L. Britton, published in 1918 is an inspiration to all plant lovers in Bermuda and has been widely used in this series.

We are most grateful to the Bermuda Paint Company for their continued support of Project Nature.

Introduction to the New Edition

As this group of publications progressed, feedback from users, and the accumulated experience of the authors and the assembler, showed that changes were required to make the guides more useful and easier to work from. In general the guides have become more focused and the illustrations have been improved and made more comprehensive. In particular, the descriptions of species have been condensed and moved to be presented right beside their illustration. Additionally, all the illustrations and descriptions of animals and plants are now presented in one section that forms a useful field identification guide. Suggested field trips have changed so that they take advantage of modern knowledge and lead students into a transition to further more advanced studies. This approach is also reflected in the text. The most recent innovation is the insertion of 'summary boxes' in the text that can be used both to find quickly the most useful passages of text and also to reinforce the main points being described. Example questions on the subject matter, have also been added.

However, we have not deviated from several important principles embodied in this series. One of these is to prepare the publications in such a way that they can be sold for a very reasonable price. For this reason all the illustrations are in black and white, the only exception being the covers of more recent examples. The lack of colour in the illustrations of animals and plants is compensated by the brief but focused descriptions which highlight aspects of size, colour and behaviour. Furthermore, we have always included the geological background to the biological system covered. This is because geology and biology are very closely linked in Bermuda and cannot be considered in isolation. Additionally, we have maintained an up-to-date approach such that in several cases these guides are the only readily available source of information on new finds and knowledge. Bindings have greatly improved in durability and appearance.

Because of the progressive changes, it became obvious that the first two volumes in the collection should be re-written to conform to the approach incorporated in later examples. This is the second of these two revisions.

In common with previous issues of Project Nature words in bold in the general text are defined in the glossary at the end of the book. Note that bold figure references in the general text are just for emphasis. In other parts of the book, for example, species descriptions, bolding is also used for emphasis only.

Table of Contents

List of Figures

Chapter 1. Introduction to Sandy Coasts

General

In this book we will look at coastlines that are sandy or a mixture of sand and mud; we could call these shorelines sedimentary **environments**. As will be explained in Chapter 2 none of these sedimentary shores were present when Bermuda first emerged from the sea as a volcanic island. At that time it would have been solid rock. There are two main processes which result in the production of **sediments** from rock; these are **physical erosion** and **biological erosion**. Chemical erosion also occurs, but on a smaller scale or as part of biological erosion. Additionally, **sediment** particles are added when animals and plants that have a lot of **limestone** in their tissues die. **Physical erosion** from wave action, water **currents**, weather and gravity, would start as soon as the island emerged from the sea and at that time the sands produced would have been very dark, almost black, in colour, the colour of volcanic rock. Of course, we know that present day sands are very light in colour, so obviously **sediment** producing conditions have changed. This is because the volcanic rock of primitive Bermuda slowly became encased in **limestone**. All this **limestone** is of biological origin, having been produced by marine **seaweeds**, **corals** and other organisms. One might think that such **limestone** rock would be only along the coasts but in fact it is everywhere. The explanation is that sea level over millions of years was very variable. At times, Bermuda would have been submerged by shallow water and then marine organisms grew everywhere. In this way the entire top of the old volcano became capped by a thick layer of **limestone**.

Summary

This book is about coastal sedimentary environments that have sand or sand-mud character. Sediments such as sand and mud have developed in Bermuda through the process of erosion. Erosion is the breakdown of rock by chemical, physical or biological action.

Summary

The first sands to appear would have been of a blackish colour because they were formed from black basalt rock from the old volcano. All the more recent sands are light in colour because they come from limestone rock that has accumulated because of living organisms.

When **sediments** are produced by **erosion** of any kind, they normally consist of particles ranging greatly in size, from boulders and slabs, through gravel to sand to mud and silt. However, if we look at almost any of the sandy beaches that abound in Bermuda, it is obvious that they consist almost entirely of sand and lack the large and small end of the spectrum of particle sizes. This is the result of **sediment sorting** which will be explored in more detail later. The basic picture is that the **sediments** along coastlines reflect the **erosion energy** of the site. Large rocks need either huge waves or fast **currents** to produce and move them, and even then they don't travel far; gravel, sand and mud moves further, but only the fine mud stays in suspension in the water for long. The result is that sand makes up the beaches in locations where there is considerable wave action and the finer particles stay in the water until they reach the quiet **environments** of protected bays, sounds, **salt marshes** or **swamps**. Bermuda has a huge variety of coastal conditions for

Summary

Erosion can break down rock into a mixture of large chunks and a series of smaller particles through gravel sand and mud. However, we usually find beaches in exposed areas that are pure sand and in more sheltered areas that have mixtures of sand and mud. This is a result of natural sediment sorting.

Summary

Water currents can carry fine sediments such as silt or mud for long distances. Along shores they end up mostly in sheltered places where mangrove swamps or salt marshes form.

a small group of islands and as a result we get a large variety of sedimentary **environments.**

Summary

Sediments support a variety of life but the most exposed shores have shifting sand that supports few creatures. In less exposed places the sediment is much more stable and the diversity of life is much higher.

A little thought will suggest that conditions for life in and on the **sediments**, also varies with the erosional energy. Very little can live where boulders and large gravel crash together, or roll around on each other; any life that settles will be killed in the next storm. Conditions for life improve as the **sediment** gets finer but even on the sandy beaches life is difficult as the sand moves as the **tide** rises and falls, and as waves impinge on the shore. If you visit a sandy beach before and after a storm it may be quite different and even the rise and fall of the **tide**, will change the beach surface if there are any waves at all. It is only when we get into shelter where the **sediment** is finer that conditions for life in the **sediments** improve greatly, but even there, there are challenges to life in mud and silt. All these aspects are discussed in this book.

Questions

1) What is the general name that we give to gravels, sands, mud and silt?

2) What is the basic difference between the sediments of very early Bermuda and those of today?

3) What two basic processes convert solid rock into sediment?

4) Under what conditions does physical erosion produce sediments with the largest particles?

5) Name two types of fine sediments.

6) Why are most of the very exposed sandy beaches in Bermuda lacking in fine particles?

7) What types of sediment support the most life?

8) In what type of environment do stable sand/mud mixtures and silts appear?

9) What type of sediment would you expect to find on the bottom of very sheltered bays or swamps?

10) List five types of pieces of rock or sediment starting with the coarsest and finishing with the finest.

Chapter 2. Geological Background

The More Distant Past

Bermuda is called a **ridge island** because it probably arose on the **Mid Atlantic Ridge** of the Atlantic Ocean about110 million years ago. The Mid Atlantic Ridge is a largely underwater geological feature running down the centre of the Atlantic Ocean (**Figure 2.1**). The Mid Atlantic Ridge is a site of intense geological activity because it lies at the **spreading junction** or zone between the European and American **tectonic plates**. Tectonic plates are large sections of the Earth's crust riding on molten **magma** beneath. There are three types of these junctions. At spreading junctions, the surface of the Earth is enlarging as molten **magma** from within rises to the surface and solidifies. At the opposite type, **collision junctions**, one plate slides beneath another, causing earthquakes and building mountain ranges. At collision junctions there is a disappearance of the surface of the Earth. The West coast of North America is an example of this second type. Another example is the area just off the west coast of Indonesia where an earthquake caused by one plate moving under the other, caused the very destructive **Tsunami** in southeast Asia, which resulted in such terrible loss of life in late 2004. Sometimes islands are produced in this type of situation too; these are called **island arcs** because they often occur in arc shaped groups. A third, less common, type of **plate junction,** called a **sliding junction** is where the two plates slide sideways against each other. This type is also characterized by earthquakes.

Summary

Bermuda began 110 million years ago when an undersea volcano erupted on the **Mid Atlantic Ridge**. This ridge is where liquid rock rises from within the Earth to the sea bed forming a new sea bottom. This happens continuously, so the Atlantic Ocean is enlarging about 4cm/ year (1 ½ in). Because of this, the volcano "Mount Bermuda", which probably reached the surface, moved steadily west away from the ridge. About 40 million years ago when it was 1,200 km or 750 miles from the ridge it passed over a "**hot spot**" which added more liquid rock causing another eruption. This one resulted in a group of three volcanoes, one of which the "Bermuda Seamount" became the Bermuda we know today. It now is 2,000 km (1,250 miles) west of the ridge.

Along the Mid Atlantic Ridge new crust material is being added to the sea floor continuously, and as a result the two plates move slowly apart at about 4 cm (1.5 in)/year. Together with the spreading come frequent small tremors, some earthquakes and the creation of a variety of volcanoes. One of these erupting 110 million years ago later probably formed the **seamount** that eventually became the Bermuda islands. This volcano appeared just to the West of the ridge and produced a large cone termed a seamount, which rose close to or above the surface of the sea. This volcano, which has been called Mount Bermuda, was then pushed slowly westward by the new sea-bed forming at the ridge. Consequently it moved away from the ridge, a distance of 1,200 km or 750 miles during 60-80 million years. During this time there was no volcanic activity. Then, 30-60 million years ago, Mount Bermuda went through a second phase of eruption as it passed over a **hot spot** in the Earth's crust, which added more **magma**. At this time Mount Bermuda was enlarged to form the **Bermuda Seamount**, consisting of three volcanic peaks now called the Bermuda Pedestal, the Challenger Bank and the Plantagenet or Argus Bank. If Bermuda had arisen solely as a result of a volcanic eruption away from the Mid Atlantic Ridge, as some geologists suggest, it would be a **hot spot island** rather than a **ridge island**. We may never know which type Bermuda really is. The volcanic rock which comprised all of early Bermuda is very hard, almost black and called **basalt**. **Figure 2.2** shows the basic features of the formation of Mount Bermuda.

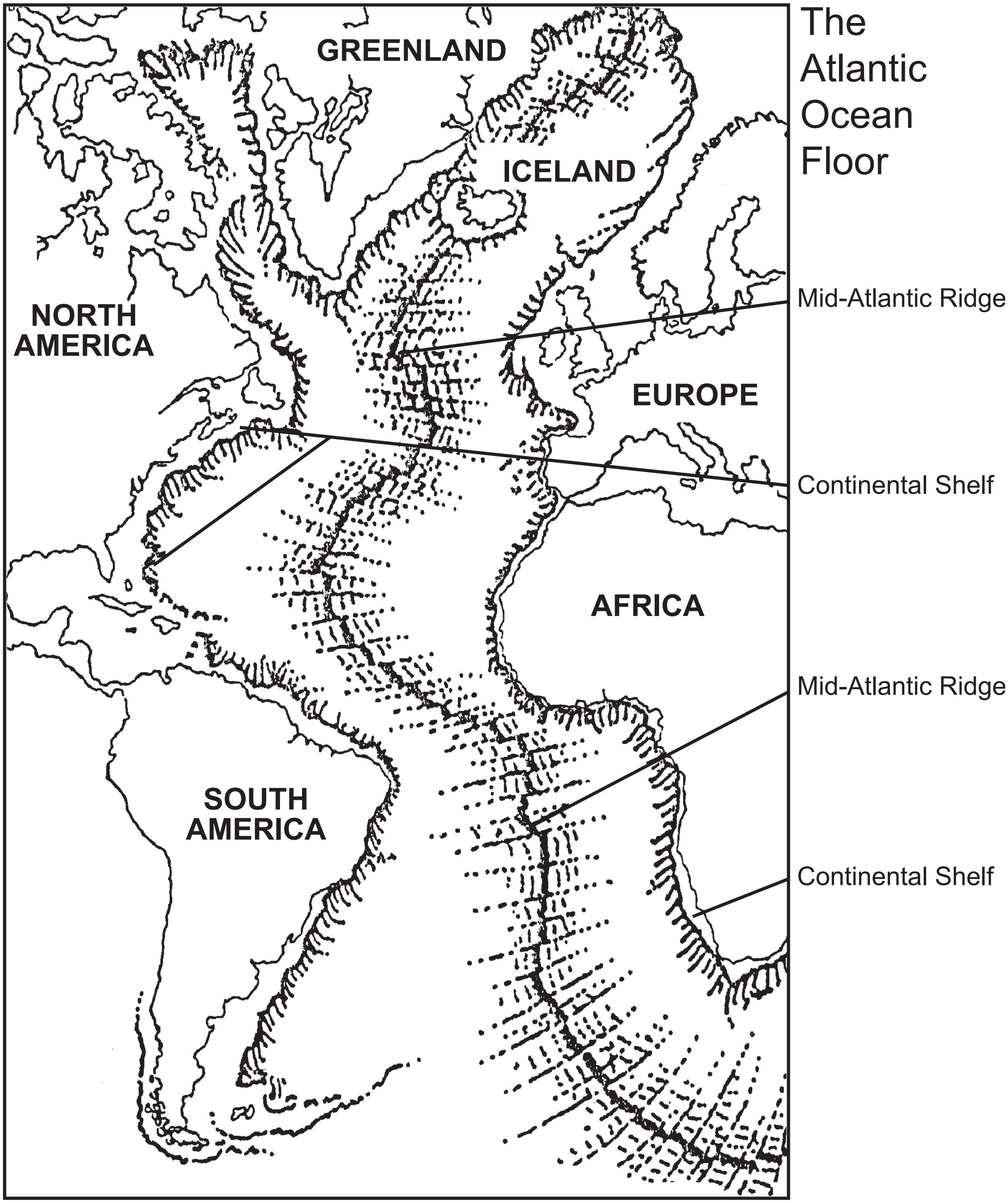


Figure 2.1. The Mid-Atlantic Ridge

The group of peaks, the Bermuda **Seamount**, rises sharply about 4,000 m or 13,000 ft from the surrounding sea-bed but the Bermuda Pedestal is the only one of the three peaks that is 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 30-60 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 in this area as weaknesses in the underlying rock give way under the stress of the spreading process. The last significant earthquake, which was centred 370 km southwest of Bermuda, occurred on March 24, 1978 and measured 5.8 on the **Richter scale**!

During these very early stages in the development of Bermuda, the seamount only rose above the surface at times of low sea level. The main process that causes a fall in sea level is a relatively cold climate that results in the formation of **ice-caps**. Warm climatic periods on the other hand, result in the melting of this ice and the rise of sea level. Smaller changes in sea level can occur when the crust of the Earth rises and falls. For example, when ice caps melt, the Earth's crust that was beneath them rises, because of the reduced weight resting on it. When exposed the shoreline would have been mainly of hard, black, **basalt** that resisted **erosion**. However, over long periods of time, erosion certainly took place and **sediments** were formed. If beaches appeared they would have consisted almost entirely of black sand. Although shells and remains of marine animals and plants, consisting of white **calcium carbonate**, would have been washed up on these beaches, they did not accumulate in any quantity. We have no record of life in these early beaches but no doubt they were colonized by a small variety of marine animals and plants.

Summary

Although the Bermuda seamount probably reached the surface early in its development, it would have disappeared at times of high sea level that occurred when warm periods melted the ice caps. However, even when shallowly submerged, Marine life would have started to settle and would have deposited some limestone on the volcanic cap.

The More Recent Past

Limestone Production

All the **limestone** rock and **sediment** which now make up the land surface and shallow-water features of Bermuda has been produced by animals and plants; this process is called **biodeposition**. This layer of **limestone** rock and **sediment** now caps the older, dark, volcanic rock in a layer averaging over 80 m (250 ft) thick. The production of this **limestone** layer has taken place in well lighted, shallow seawater and probably started as soon as the top of the submarine volcano rose close to the surface. The two main groups of organisms that have laid down this huge cap of **limestone** are **crustose calcareous algae** (often called **crustose coraline algae**) and **corals** which together form **reefs**; however, fragments of the skeletons and shells of a wide variety of marine animals are also important in the formation of **sediment**. **Crustose calcareous algae** are sheet-like **seaweeds**, resembling pink rock, that deposit **calcium carbonate** (**limestone**) within their tissues so becoming rock hard. As the layer of living **seaweed** dies, a new layer forms on top of it. Just how long ago **limestones** started to form in ancient Bermuda is unclear and was dependent on the temperature of the surrounding seawater. Bermuda lies somewhat further north than where seawater warm enough to support reef-forming **corals** can generally be found. At present, warmer water is transported here from further south by the **Gulf Stream**, (**Figure 2.3**) a huge **ocean current**. However, it is likely that warm **ocean currents** have bathed the shores of Bermuda for millions of years and therefore the **reefs** would have been among the early **ecosystems** developed around Bermuda. Rocks formed in this way in the ocean are called **marine deposits**.

Summary

The Bermuda Seamount now has a thick cap of limestone. This limestone was all laid down by animals and plants. A wide variety of marine organisms can do this. The main two were **crustose calcareous algae** and corals both of which produce layers of solid limestone. Other animals and plants added to this.

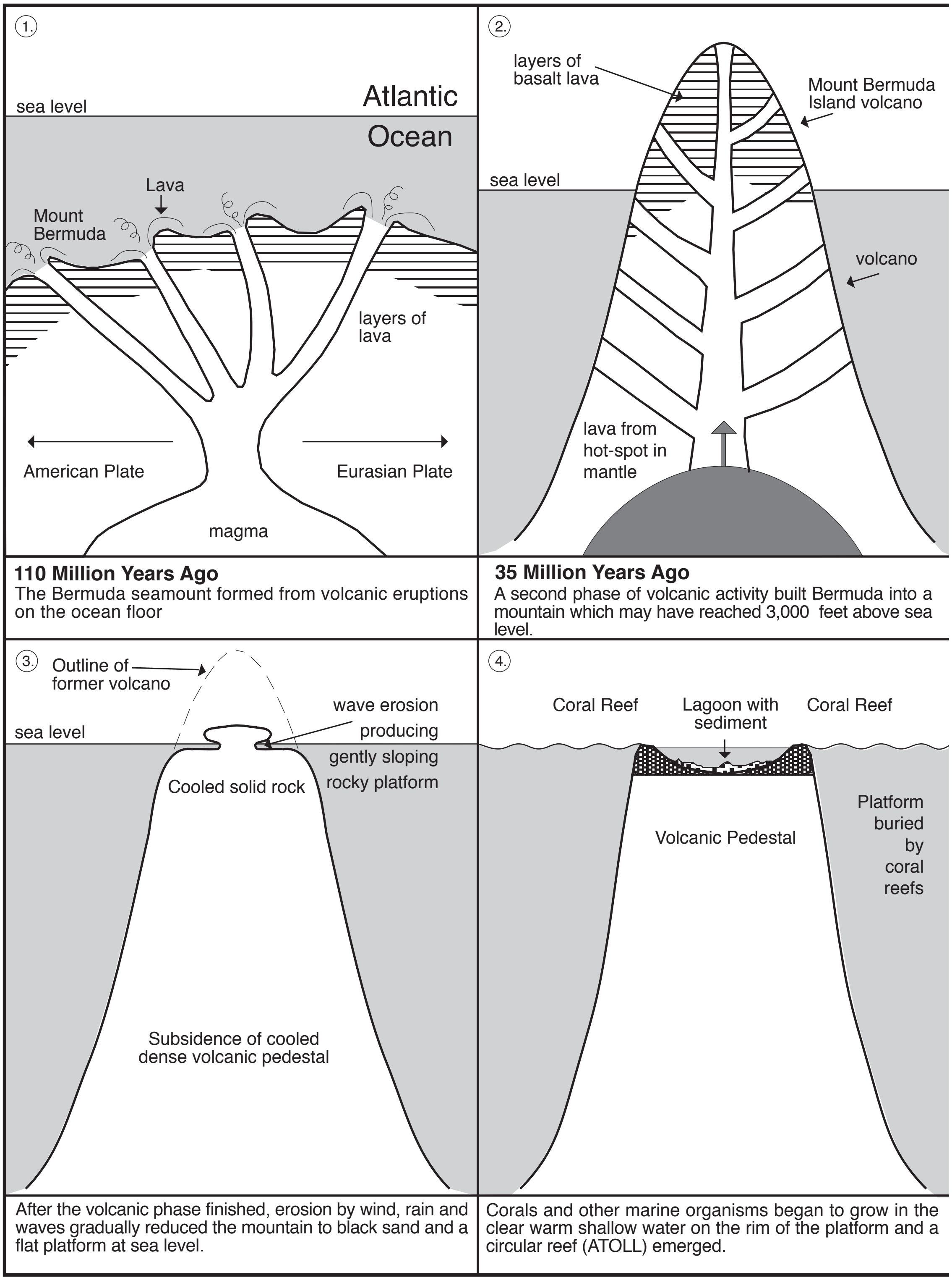


Figure 2.2. The formation of Bermuda

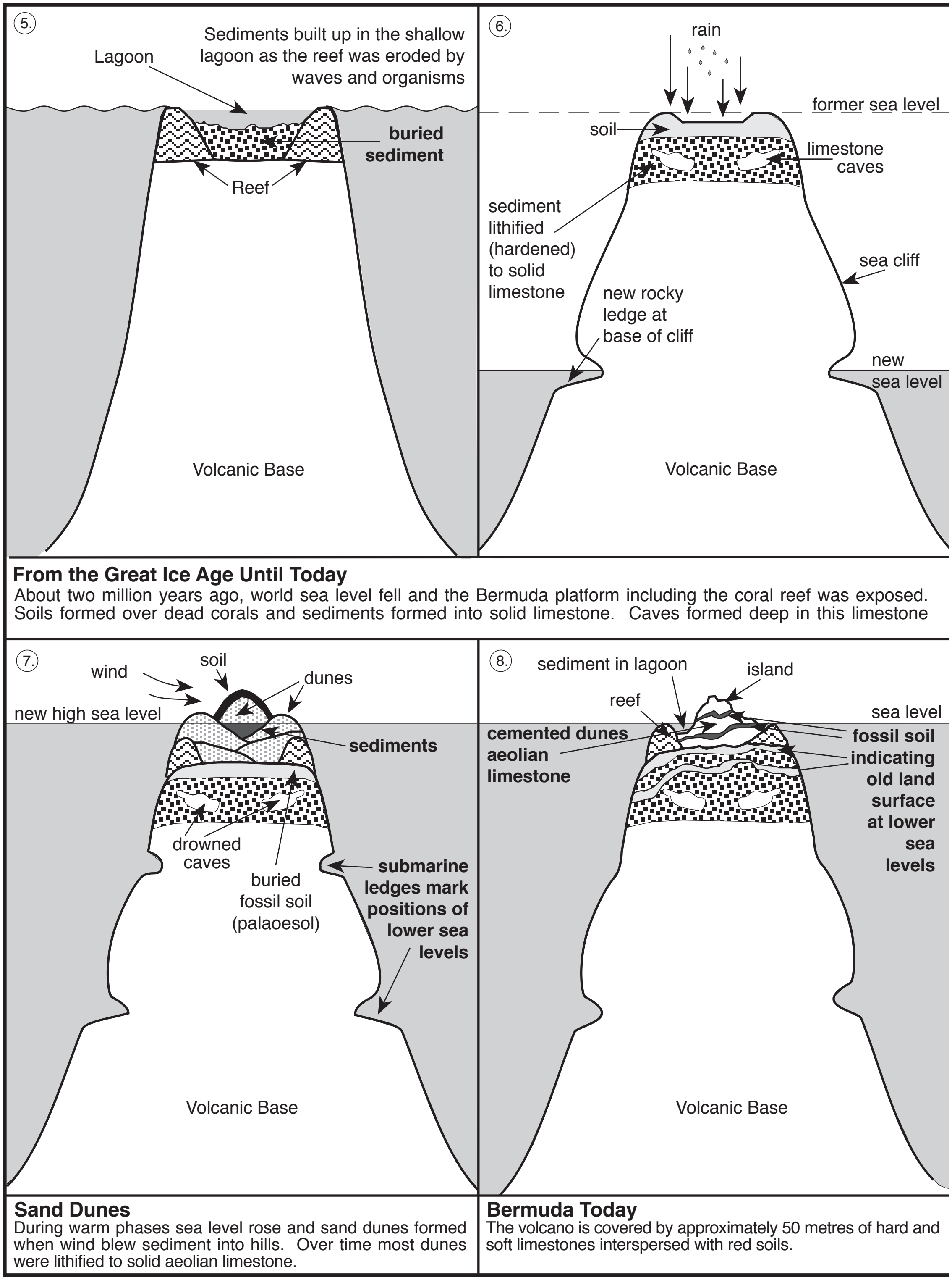


Figure 2.2. The formation of Bermuda (Cont.)

Erosion and the Formation of Limestone Sediments

Physical Erosion

The creation of sand and finer **sediments** from both the erosion of reef rock, and from the hard parts of organisms, deserves somewhat more explanation. Erosion is a quite diverse process with both physical and biological components. **Physical erosion** (also called **mechanical erosion**) of rock, in seawater, results mostly from the pounding or hydraulic action of wind generated waves along **reefs** and shorelines. Waves created in other ways, for example by underwater earthquakes, add to the erosive power of water.

Summary

Sediment began to appear when the limestone was eroded by physical forces such as wave action. Waves can break away chunks of rock and these in turn, roll around and erode further as well as causing erosion by hitting other rocks.

This primary erosion process produces material of very varied size, from huge blocks of rock down to tiny particles of mud. Subsequently, the larger material is moved around by the waves and in the process grinds against other broken-away material; a process known as **attrition**. This **secondary erosion** results in progressively smaller material. Only when particles are quite small will they be transported in suspension by waves and in water **currents** and re-deposited elsewhere.

Biological Erosion

Another process of great importance is **biological erosion** or **bioerosion** as it is commonly called. This is erosion that results from the action of a very diverse group of marine animals and plants. **Feeding bioerosion** is certainly a major component of **sediment** production in Bermuda. One of the main contributors to this process are the Parrotfishes. Parrotfishes feed mainly by scraping small **seaweeds** off the surface of **reefs** and other rocky bottoms. They have heavy, powerful jaws, somewhat like a parrot's beak, 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.

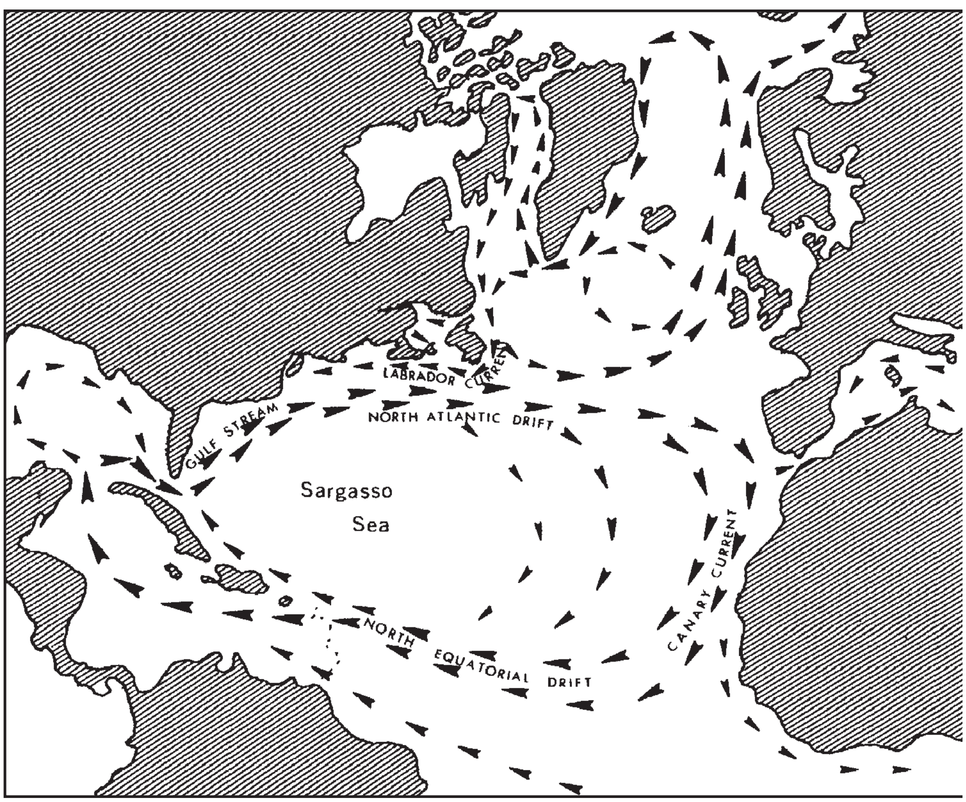


Figure 2.3. Surface currents in the North Atlantic Ocean.

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

Summary

A second and very important method of erosion is **bioerosion.** This is erosion which results from the activities of animals and plants, Burrowing bioerosion is caused when animals or plants burrow into the rock for protection. Several sponges do this as do some clams and barnacles. The plants called blue-green **cyanobacteria** also burrow into the rock.

Summary

Erosion is also caused by biochemical reactions. Burrowing animals and plants produce carbon dioxide, which forms carbonic acid, which dissolves limestone. Some animals secrete other acids.

A third very important type of **bioerosion** can be called **biochemical bioerosion** or **physiological bioerosion**. The natural life-processes of animals and plants result in the production of acids that can erode **limestone** rock. By night, plants and animals constantly produce carbon dioxide, which reacts with water to produce carbonic acid. This in turn can be used together with other organic acid products, to dissolve rock thereby creating a protected living space within it. The result of biochemical erosion can be seen on the rocky shore. A very good example of this is the black-coloured, **blue-green cyanobacterium**, which is virtually universal at the top of the seashore in **limestone** rock. The microscopic 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 that is called **phytokarst**. This term needs explanation. The prefix phyto is used to mean plants. (**Blue-green cyanobacteria** that produce phytokarst here, 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. Typical **Karst topography** occurs in terrestrial **limestone** regions, as a result of solution or chemical **weathering** and is characterized by numerous sharp-pointed hills or small mountains of very variable size. This can produce very spectacular countryside. On Bermuda's seashores, a second common blue-green cyanobacterium, this time pale pink in colour, may be found as

Summary

The result of biochemical erosion can be seen on the rocky shore where it produces a very jagged surface on the rock in the zone where blue-green **cyanobacteria** are abundant within the surface of the rock. This is called **phytokarst**.

a layer 1 cm (1/2 in) or so entirely within the **limestone** rock. In this case the **habitat** of the plant is totally produced by erosion or enlarging of cavities in the rock. These examples result mainly in dissolved **calcium carbonate** in the water, rather than in actual **sediment** production. However, they also weaken the rock making it more prone to **physical erosion**, which results in **sediment**. In animals, biochemical **bioerosion** is often combined with mechanical burrowing to soften rock. In this case, quite strong acids are produced by special cells or glands. Two such examples, the boring sponges and the Black Date Mussel, have been cited above.

The last 20,000 Years

The great majority of the sedimentary coastal systems that will be discussed in this book have been formed in the last 20,000 years. **Sediments** produced in the ways described above have formed the sandy beaches favoured by tourists and Bermudians alike, as well as the muddier **sediments** found in more sheltered locations. Beach **sediments** blown inland by onshore winds have formed the **sand dunes**.

Beach Formation.

The majority of sandy beaches in Bermuda lie along the south shore but there are smaller examples on the other coastlines. The south shore of Bermuda is the most exposed to wave action of all the coasts. The main reason for this is that depth increases very quickly off the south shore whereas the west, north and east shores have quite shallow water stretching well away from the coast. Shallow coastal waters support the coral **reefs** and these rise from the sea-bed close to the surface. The **reefs** in turn form a very effective barrier to large ocean waves and thereby protect the coastline from rapid wave erosion. Along the south shore, the only **reefs** that rise close to the surface are the **cup reefs** or boilers and they are quite small and form only a discontinuous barrier. Large ocean waves passing between these **reefs** strike the shore directly and with great force causing **physical erosion**.

This erosion is more rapid in softer rocks and this results in the formation of small bays and coves. Once bays and coves appear, the erosive power of the waves becomes concentrated on the headlands due to wave refraction as shown in **Figure 2.4** and the sediments so produced are moved onto the areas between headlands by **currents** and waves, creating the beaches. Coastlines subject to this kind of erosion slowly straighten with time.

Summary

Most pure sandy beaches in Bermuda are along the south shore which is exposed to strong wave action. The other coasts are quite protected by coral reefs. The waves cause erosion particularly in areas of softer rock, which become bays. The headlands resulting from this receive heavy wave action and are eroded to rock slabs, gravel, sand and mud.

Sand which is moved onto the beaches is still subject to considerable wave action. As waves approach a sandy shore they change in shape due to interaction with the bottom, they get higher and the front and back slopes get steeper. This eventually results in an unstable wave that breaks producing surf that rolls up the beach moving the sand back and forth. This is shown in **Figure 2.5**. Relatively small waves such as those hitting shores the majority of the time, are **constructive waves.** Constructive waves move sand shoreward and build up the beach. Sand deposited by constructive waves high on the shore can dry at low **tide** and then be blown inland to form **dunes**. During storm conditions, particularly in hurricanes, the huge waves resulting from the storm are **destructive waves;** these waves as suggested by their name, remove sand from the beaches and move it into deeper water. Fine particles from hurricane erosion may move in **currents** away from the islands and be lost forever.

Summary

Mud is dispersed by coastal water currents but the sand is deposited in the bays. There, constructive waves carry it up the shore to create beaches. Destructive waves in strong storms can carry the sand back out to sea.

Waves from the ocean are rarely exactly parallel to the beach since they are generated by a variety of winds and since beaches may also curve. Waves striking the shore at an angle create **alongshore currents** which are water **currents** moving parallel to the shore. Although these **currents** are slow except in storms, they can still move large quantities of sand. In a crescent-shaped bay, opposing alongshore **currents** from each side meet in the centre of the bay and turn together, out to sea, producing **rip currents**. Rip **currents** can be strong and carry bathers away from the shore; however, they are usually narrow and swimming parallel to the shore affords a ready escape, providing you know this!

Fair weather waves striking a shore produce a very typical shore profile. A profile is a cross-section of the beach. A typical beach profile and the names of its various features are shown in **Figure 2.6**. On such shores, the high **tide** line is usually marked by a line of debris such as **seaweed**, mainly Sargasso Weed, and a variety of trash. This is called the **strand line.** Quite often Portuguese Men-O-War (*Physalia physalis*) which are poisonous jellyfish are left at the **strand line** along with other floating sea creatures.

Summary
Sand moving onto the shore creates a characteristic shore profile that is similar from beach to beach.

Sand Dune Formation.

As described above, sand accumulates on beaches in stable weather. In dry windy conditions with a strong onshore wind, the surface layer of sand dries quickly and is then moved inshore by the wind. If the shoreline is low lying and well vegetated, this sand is trapped by plant growth and this fixes the sand in place. If, however, the shore is of unvegetated sand, the wind will produce **sand dunes** called **mobile dunes** which have a characteristic shape as shown in **Figure 2.7**. **Mobile dunes** move slowly down-wind and can engulf plants and objects in their path. Well before man colonized Bermuda, it was a vast, sparsely vegetated, sand plain where **mobile dunes** of large size moved inland. Ever since man colonized the islands several areas along the south shore have produced **mobile dunes** that engulfed houses and roads. Today **mobile dunes** are generated only in violent storms and quickly become vegetated after the storm. Once vegetated dune movement ceases.

Summary
Sand swept to the upper part of the shore will dry in hot, windy weather and if the wind is blowing onto the shore sand will move inland. It is this sand that creates sand dunes. The smallest dunes towards the sea are called embryo dunes. Next are large fore dunes followed by fairly large white dunes, behind which is a sand plain with lower dunes.

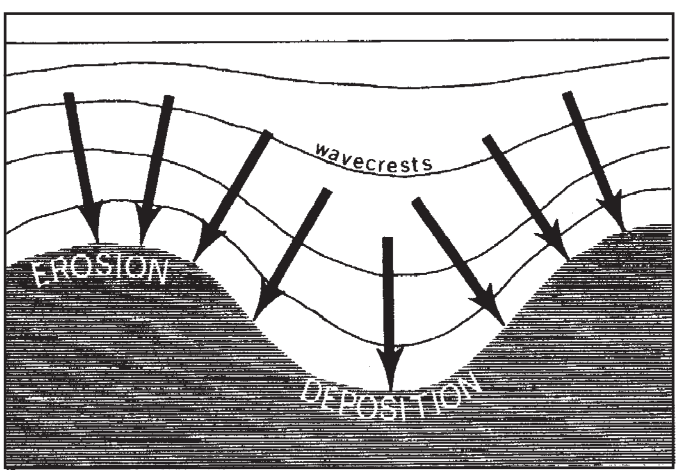


Figure 2.4. Shoreline wave action. The distance between the arrows shows wave intensity.

Most of the time, sand moving up shores is fixed in place in a series of elongated **dunes** lying parallel to the shore. The most seaward of these **dunes** called the **embryo dune** comes and goes with the seasons and is absent on beaches that are raked clean for tourist use. Un-raked beaches usually have an embryo dune in summer that is positioned just above the **strand line**. Floating seeds of beach plants notably Sea Rocket also called Scurvy Grass (*Cakile lanceolata*) get stranded among the flotsam and jetsam and can germinate very rapidly. Young plants trap the moving sand and grow up through it forming a small dune. Starting just above extreme high **tide** level there are a series of much larger **permanent**

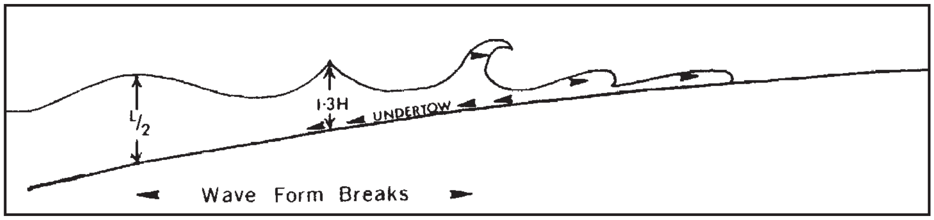


Figure 2.5. Stages in the breaking of waves over a sandy bottom .

dunes that are mainly covered in vegetation. The one nearest to the sea, commonly called the **fore dune,** the **white dune** (called yellow **dunes** on the mainland) lies behind that; this dune still has areas of bare sand but is at least 75% plant covered. In contrast to **mobile dunes** these fixed **dunes** normally have their steepest slope towards the sea. The name yellow dune comes from areas of the world where yellow sand is normal; in Bermuda it should be called the 'white dune'. The seaward face of the fore dune is the most likely site for erosion by high onshore winds and rogue waves. If not severely damaged, it will repair itself rapidly, as the resident plants there are adapted to withstand dune erosion. Behind the white dune there are usually a series of very low **dunes** that in places may be almost flat. This area is called the **sand plain**. These are usually lower in height than the fore dune and are virtually fully vegetated. Scattered among them may be old, now vegetated, **mobile dunes**. Only a small amount of blowing sand gets to these dunes except in violent storms and they are quite stable.

Sediment Behaviour and Classification

Sediments in water are characterized 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.

Sedimentation

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 here. Thus **sedimentation** is rapid with sand and slow with mud and silt particles. If the water-carrying **sediment** in suspension is in motion, then **sediment sorting** will take place with coarse **sediments** being deposited at relatively fast current velocity and fine muds and silts only in comparatively still conditions. Places with frequent wave action (high-energy **environments**), such as the South shore, or of constant high current velocity, such as Flatts Inlet, are characterized by coarse sands. Locations with negligible wave action and very slow **currents**, for example Coot Pond on North Shore, or Sinky Bay on South Shore, are characterized by muddy **sediments**.

Summary

Fine particles of sediment suspended in the water fall to the sea bed, this is called **sedimentation**. The larger particles fall faster than the finer ones.

If the particle sizes of grains comprising 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

Summary

If the particles of sediment are all much the same size it is called a **well sorted sediment**. Sediments with a wide range of particle sizes are called **poorly sorted sediments.**

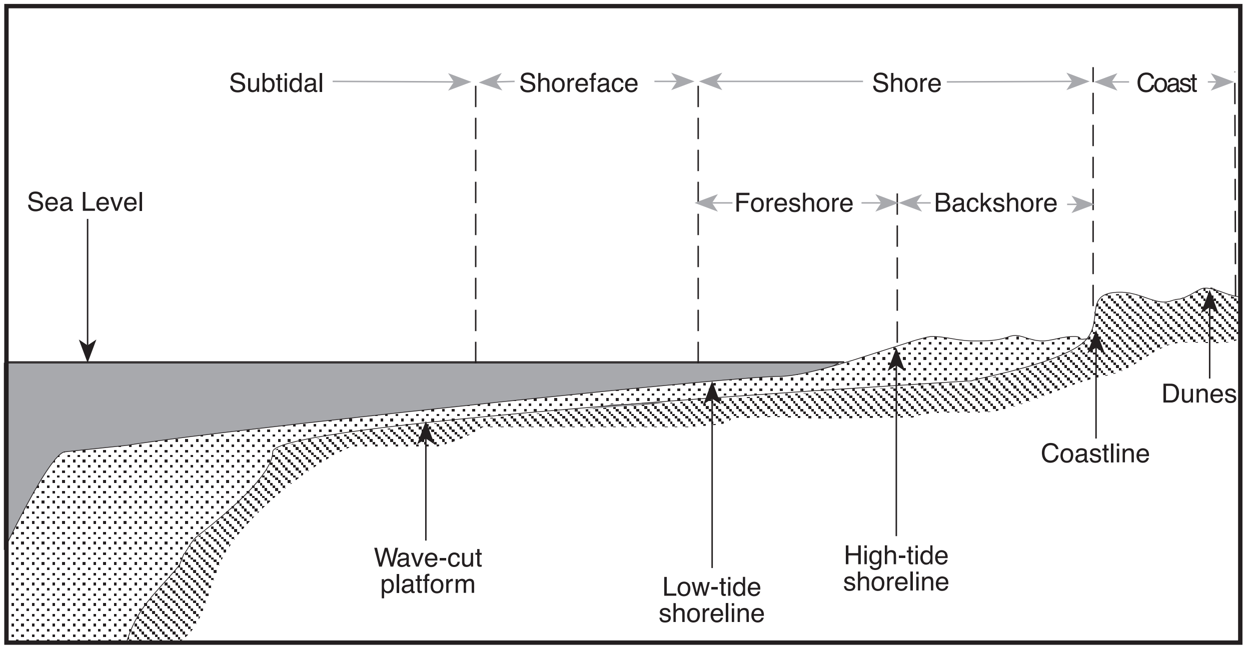


Figure 2.6. Physical features of a typical sandy beach

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 their particles. As the **sediment** sits and settles, 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. As a result they become more and more stable with time and tend to stay put.

Summary

Fine sediments settling on the sea bed contain a lot of water. As they sit there the water is slowly expelled; this is consolidation. Consolidated sediments resist re-suspension in the water.

Sediment Permeability

Another physical attribute of **sediments** that is of great importance to life living in it 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**

Summary

Sediment permeability refers to the open, water-filled spaces between the sand grains. It can be measured by the rate at which water can pass through the sediment. Coarse sands are very permeable whereas fine muds are relatively impermeable. Permeable sediments support interstitial fauna in the spaces between the grains.

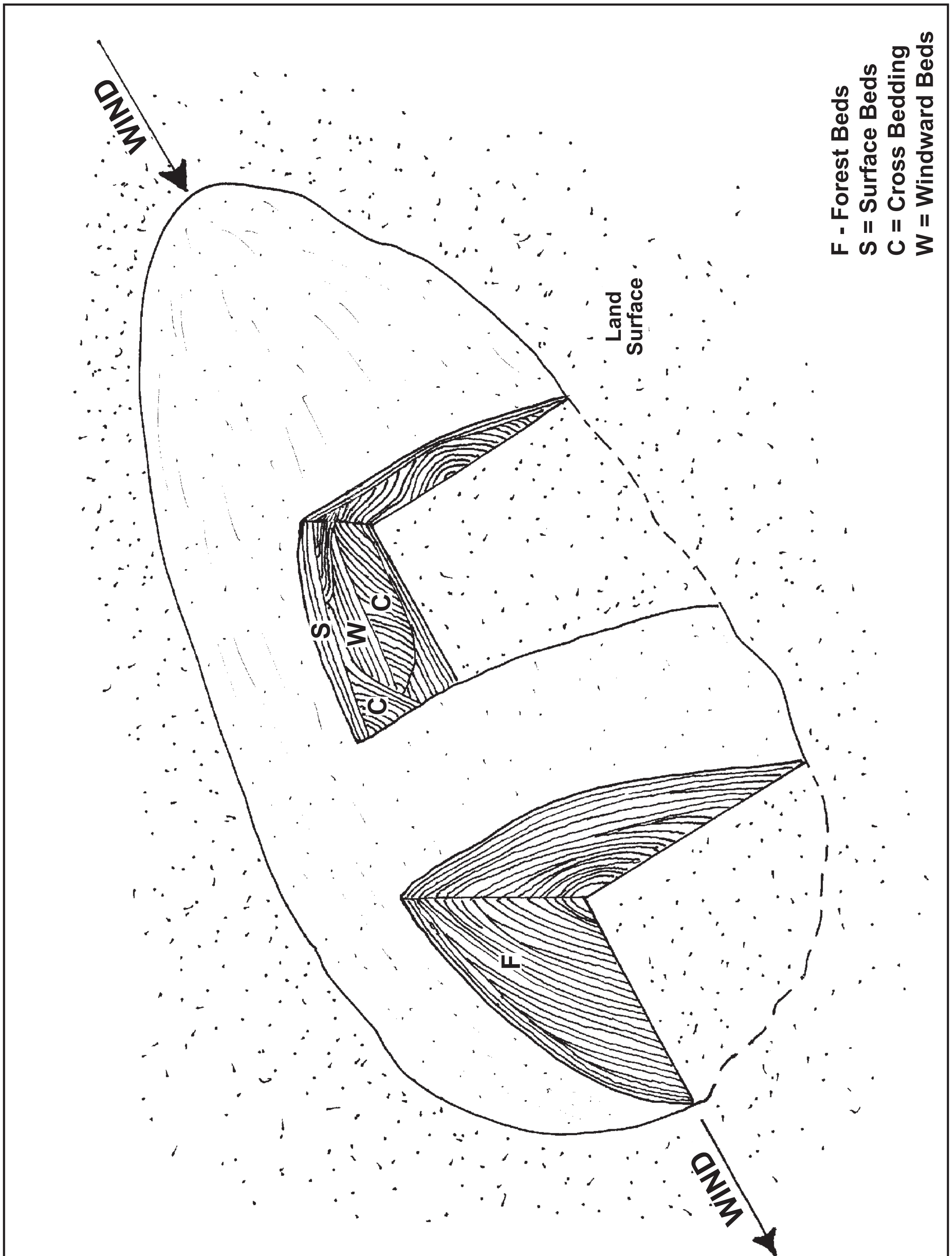


Figure 2.7. Diagram of a mobile dune showing interior bedding features

of constant, tiny particle size. **Well sorted sediments** have greater permeability than **poorly sorted sediments**. The water-filled spaces within permeable **sediments** are often colonized by communities of tiny animals called the **interstitial fauna**. 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 colonize. However, animals adapt to such conditions by pumping surface, oxygen rich water through their burrows.

Sediment Composition

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 2.8** shows a range of commonly seen particles of both animal and plant origins. As with sedimentary particles produced by other means, these fragments are further reduced in size by physical attrition as they rub together or roll over the bottom. Shell fragments and particles of marine **algae** are often readily identifiable in samples of Bermudian marine **sediment**. Shell fragments may be further reduced in size by physical and **bio-erosion**.

Summary

Sediments are usually composed mainly of particles eroded from rock. However, there are also many particles of biological origin.

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 recognized under the microscope. Plateweeds have a plant body that is made up of a group of a series of hard plates, or segments, hinged together. These plates are constantly produced and fall off after a relatively short period. In the Common Plateweed (*Halimeda incrassata*) each segment resembles a three-toed foot about 2.5 mm (1/10 in) long. The red **algae** also produce many **sediment** particles. Perhaps the best examples are 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 are 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**.

Summary

Many of the particles in some sandy **sediments** have come from seaweeds. One of the main contributors are the plateweeds. These have hard segments that fall off when the plant ages. Other sources of particles are the Needleweed, Scale Weeds and Petticoat Algae.

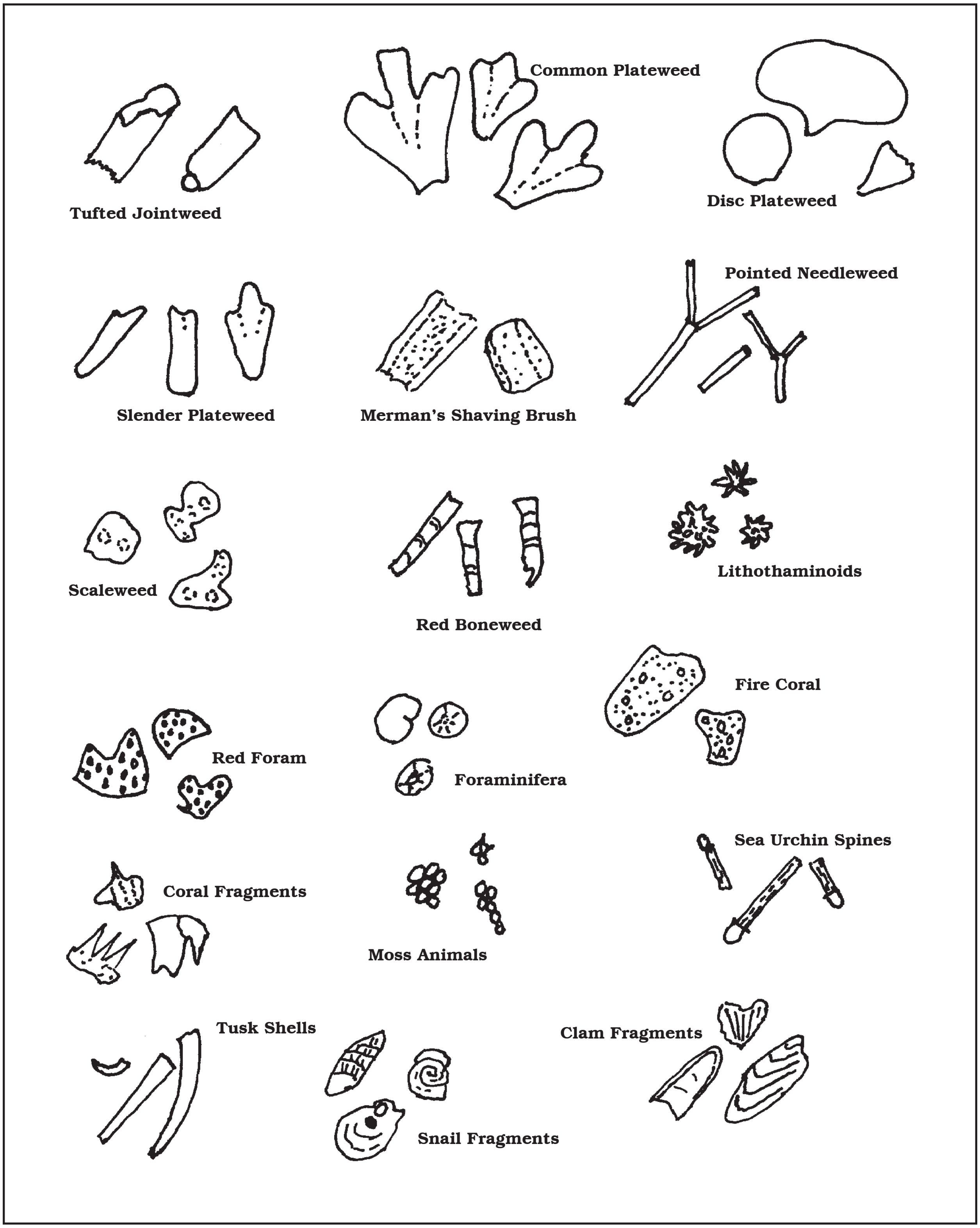


Figure 2.8. Typical sand grains of biological origin, all about 2-4 times actual size.

Sediments of Animal Origin

Many animals contribute particles to the **sediments** but the most famous and easily recognized **sediment** component comes from a protozoan animal called the Red Foram (*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 recognized in **sediments** include **sea urchin** spines, parts of **crustaceans** such as claws, spines and body segments or plates, molluscan shells and shell fragments, fish vertebrae etc.

Summary

Animals supply particles to the sediment in the form of shells, plates and vertebrae.

Sediment as Food

Pure mineral **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 it is more concentrated there. Because of this many animals feed on the surface of the **sediment** rather than deeper down. Bacterial decomposition of **detritus** in **sediments** also releases inorganic plant nutrients. These can be exploited by seagrasses but not by **seaweeds** as is discussed below.

Summary

Very clean sand has no food value at all. However, any sand at the surface of the beach will have a small amount of organic material mixed in and this can be a valuable source of food for animals adapted to use it. Some animals just eat the sediment and extract the food; the sand passes on through. Other animals sort the food from the sediment before swallowing it.

Questions

1) In what kind of situation are Ridge Islands formed?

2) What is a Spreading Junction?

3) Name two of the three volcanic peaks that make up the Bermuda Seamount.

4) What are the names of two types of organism that can produce limestone rock in the sea?

5) What do we call the two main processes by which limestone rock is converted to sand in the ocean?

6) What animal is responsible for creating the Harrington Sound Notch?

7) What is Karst Topography?

8) What type of organism is responsible for forming Phytokarst on a rocky shore?

9) Over time, limestone headlands on wave-beaten shores tend to become shorter and the bays between them grow larger. Why is this so?

10) In what sort of situation do Rip Currents form?

11) What conditions must be present for Sand Dunes to form?

12) What is a Fore Dune?

13) What is the difference between mobile dunes and fixed dunes?

14) Is sedimentation faster with coarse or fine sediments?

15) What characterizes a Well Sorted Sediment?

16) Give an example of where Poorly Sorted sediments might be found.

17) What is Sediment Consolidation?

18) Which will have greater Permeability, a well sorted sediment or a poorly sorted sediment?

19) Where are Interstitial Organisms found?

20) If a sediment sample is dark and smells rotten, is it a well sorted sediment, or a poorly sorted sediment?

21) What are biogenic sediments?

22) Name two seaweeds that produce common grains found in sand.

23) Name two animals that after death produce commonly found sediment particles.

24) What must be added to pure sand to make it a possible source of food?

25) Name one animal that uses sand as a source of food.

Chapter 3. The Open Sandy Shore

Introduction

The open sandy shore is one of the main coastal **environments** of Bermuda. It certainly is part of the basis of the tourist trade and has much appeal as a very beautiful feature of the islands. However, it must be admitted that the ecological health of a beach is incompatible with its use as a bathing location. Indeed, beaches that are heavily used by bathers are raked daily in summer and this raking destroys many of their natural features and discourages colonization by animals and plants. Fortunately there are some good beaches which are not heavily used and which are not raked on a regular basis. Unfortunately, most of these beaches have no public access. One on the south shore of Nonsuch Island is an excellent example.

Regardless of their use, all sandy beaches have some features in common that affect their status as a biological **habitat**. The main one of these is their inherent instability. This is easily observed even in slight wave action. Waves breaking on, or rolling up the shore readily move sand grains around; if you stand in the water moderately wave washed beaches you can feel the moving sand grains hitting your ankles. In heavy storm action, the upper layer of the beach may be completely washed away. Hurricane Fabian in 2003 removed huge amounts of sand from Bermuda's beaches; in 2006 Hurricane Florence did the same thing on a somewhat smaller but still significant scale. After such natural events, it takes many years or even decades to restore the sand to these beaches, and in some cases they never recover. Even though rocky shores are exposed to equal or greater wave forces during storms, they are comparatively little affected, unless entire pieces of rock break away. Even then the harm is local rather than general.

Summary

The open sandy shore forms both recreational beaches and a habitat for a variety of animals and plants. Open sandy beaches are a poor environment for most life because the sand moves around in wave action. Beaches can be washed away in violent storms.

Special Biological Features of the Open Sandy Shore

Compared to other coastal **habitats**, the open sandy shore is very sparsely populated by marine organisms. For heavily used beaches there is nothing in the way of animals visible to the naked eye below high-**tide** mark. At the top level reached by the **tides** and waves there is usually what is called a '**strand line**'. This is only short-lived until the beach is raked, but temporarily contains or supports a few animals and plants either washed in or hiding under, or feeding on, this material. Less frequented beaches have two regular burrowing inhabitants just above low **tide** level. There is often a wealth of animals and plants whose **habitat** is the surface of the ocean at the **strand line**, and these are augmented by the seeds of several coastal plants as well as floating material from far away. There is also a group of specialist beach insects and **crustaceans** that feed on the wealth of food in the **strand line**. Just above the **strand line** the first small beach plants appear, getting taller and more lush further back. This is also the **habitat** of one resident burrowing crab and supports many terrestrial visitors in good weather, especially at night. These include many bird **species**, rats and mice, the occasional lizard and a variety of insects.

Summary

Open sandy shores support very little life. The **strand line** is where material floating in on waves gathers. The strand line supports a variety of life.

The Main Changing Characteristics or Variables

The Tides

There is no doubt that the main environmental variable on any type of shore is the **tide**.

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

Summary

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

The only other heavenly body other than the moon, that has an appreciable effect on the **tides** is the sun. At 14-day intervals, the sun and the moon are roughly in line and their gravitational forces combine to produce **tides** of a larger range. **Tidal range** is the height difference between high and low **tide** levels. These higher **tides** at fortnightly intervals are called **Spring Tides**. Seven days after **spring tides** the sun has negligible effect and the **tidal range** is at its minimum. These smaller **tides** are called **Neap Tides**. Since the orbits of the heavenly bodies are highly predictable, so are **tides**. This allows the production of **tide** tables for any point on Earth that predict the time and height of each **tide**. **Tide** predictions in Bermuda are published in the newspaper and also available as yearly sets looking something like a calendar. The average **tidal range** in oceanic localities such as Bermuda is about 75 cm (2.5 ft); this increases to about a metre (3.2 ft) on **spring tides** and decreases to about 50 cm (1.6 ft) on **neap tides**. These **tides** are small compared to the average for **continental** shores and are quite easily altered by the weather both in timing and range. Nevertheless, the **tides** are amazingly regular; this is very important to organisms along the shore since it is a virtual certainty that a high **tide** will follow a low in a reasonable time. Occasionally, large changes in the atmospheric pressure pattern around Bermuda do occur and at some of these times the **tide** remains low for days at a time. This can result in high mortalities in **intertidal** organisms.

Waves a Big Modifying Factor

The other factor on the shore that moves water up and down is the waves. Additionally, waves place mechanical stress on seashore creatures and consequently they must be adapted to withstand wave action. Think about the Bermudian situation. Here **tides** average 75 cm or about 2.5 ft. On the south shore waves can be at least 5 m (l5 ft) high in storms. So regardless of the **tide** the whole shore will be alternately exposed to air and submerged in water by the waves. Clearly too, wave action can extend well above tidal action. The effect of waves is to extend the marine environment both higher up and lower down the shore. In the most exposed places the wave beaten zone may be <u>10 times as wide</u> as the **tidal range**.

Summary

Waves modify the effect of tides by driving water and spray to higher levels. The more exposed the shore is, the more the effect. The higher the exposure on shores the higher the zones extend vertically.

The part of the shore regularly exposed to liquid seawater under normal conditions, as opposed to spray, is called the **littoral zone**.

Tide and Wave Related Variability on the Sandy Shore

The main environmental stress to exposed shoreline organisms that results from the **tides** and waves is **desiccation** or drying. Virtually all animals and plants of the open shore, except at the very top, have evolved from marine ancestors. They are used to immersion in water and desiccation imposes a severe stress that these organisms must adapt to. The mechanisms of these adaptations will be explored below.

> **Summary**
> Many environmental factors vary with tidal and wave conditions. Organisms are adapted to withstand this variability.
> The main factor is drying or desiccation. Other factors that vary greatly in comparison to the sea are: temperature, salinity, pH, oxygen and carbon dioxide levels etc.

A second significant stress faced by **littoral** marine organisms is **salinity** variation. When animals and plants are immersed by **tide** or wave, they are usually in full strength seawater which around Bermuda is about 36-38 ‰ (parts per thousand of salts in the water). [For more information on seawater see Project Nature 'The Open Ocean around Bermuda', or Project Nature 'A Teaching Guide to the Biology and Geology of Bermuda'.] However, if it is pouring rain and the **tide** is out on a calm day, the **salinity** of the sand surface and a thin layer below this, may drop to close to zero.

Temperature is another major variable. When immersed, the temperature is that of the coastline water, which varies through a range of perhaps 12°C-25°C on an annual basis. However, when exposed on the sand surface, the range can be much greater. Air temperatures vary through at least 5°C to 30°C and high temperatures on the open shore surface are greatly increased by solar heating. Dark objects may reach at least 45°C!

Other environmental factors that vary with **tide** and wave action are pH (acidity), light intensity and concentrations of gasses important to life, including oxygen and carbon dioxide. However, these variations are minor compared to those discussed above.

Adaptations to Open Sandy Shore Conditions

The open sandy shore is a challenging environment for animals and plants to occupy and to live there they must adapt to these conditions. These adaptations fall into three categories, physical, behavioural and physiological. Most sandy shore inhabitants show some adaptation in all three ways.

> **Summary**
> Animals and plants of the open shore are adapted to that habitat. Adaptations may be physical, behavioural or physiological.

<u>Physical Adaptation</u>

Physical adaptation refers to structural features. These can often be observed with the naked eye. For some tiny animals and plants a microscope would be needed.

As explained above, the **littoral** (that zone regularly immersed in seawater) part of the open sandy shore has few inhabitants. Those animals that can live there all have the ability to dig rapidly down into the sand for protection. This is accomplished with strong digging feet in **crustaceans** or by an extensible muscular foot in clams. The sand is a harsh abrasive environment which could damage delicate creatures. So strong, smooth shells are the rule. Clams always have long extensible siphons which they can extend up through the overlying sand to communicate with the surface. An impossible to observe physical adaptation is a gill structure which can exclude sand. Higher up the shore, animals do not have to be so adapted to wave action, although they may occasionally be exposed to it,

> **Summary**
> Physical adaptation involves the structure of the animal or plant. Examples among animals are special feet to dig in sand, the development of long siphons to connect to the sand surface and the ability to exclude sand. Plants have floating seeds and fleshy leaves.

rather many of them are small so that they can keep hidden and feed under the material at the **strand line**. Larger animals such as crabs are adapted so that they can rapidly dig a protective burrow. Plants of the upper sandy shore number only a few kinds but they are highly adapted. The seeds are constructed so that they float on the surface of the water and can be carried in wave or spray to a suitable location; once there, they germinate rapidly in damp weather and grow fast. If buried in sand they can rapidly grow back to the surface to continue normal growth. Pants that grow in this environment typically have thick, fleshy leaves that can store fresh water when it is available in this normally salty environment. Fully salt water is unsuitable for growth of these plants.

Behavioural Adaptation

Behaviour mechanisms of animals of the **littoral** sandy shore that help them to survive there are not easily observed, as they take place in breaking waves and often at night. If exposed by wave action, these animals can either re-dig where they are or, if that location has become unsuitable swim or crawl to a new spot. A virtually invisible behavioural adaptation is the ability of **larvae**, which swim in the ocean, to settle out in a suitable sandy shore location. The food of animals living on the lower sandy shore is organic particles or small living animals and plants that move along the surface of the sand or just up in the water. These animals have a feeding behaviour to capture this material and to efficiently sort out the **sediment** particles inevitably mixed with it. Plants, other than microscopic ones, generally do not show much in the way of behaviour but in this category rapid growth to the surface of buried plants can be considered as a behavioural adaptation.

Summary

Animals are adapted to avoid being damaged by heavy waves and to be able to feed from a burrow. Plants grow very rapidly.

Physiological Adaptation

This type of adaptation can not be seen at all because it involves the internal functioning of the organism. Frequently, animals of the sandy shore are adapted to survive in a low oxygen environment when completely buried. Plants of the upper sandy shore are physiologically adapted to life there. Plants need water for normal functions and growth but seawater is much too salty for this use and the sand itself is at times more salty than the sea. However, rainfall supplies fresh water at times and the plants take it up rapidly. Although some fresh water is absorbed directly by the leaves, most is acquired by the roots. The roots of these plants have mechanisms to exclude salt at the surface of the root.

Summary

Physiological adaptations cannot be seen as they involve the internal functioning of animals and plants.

Fauna and Flora of Open Sandy Shores

1) The lower or littoral shore

Only two animals reside permanently in this, very unstable, part of the shore. These are the Mole Crab (*Hippa testudinaria*) and the Two-spotted False Donax (*Heterodonax bimaculata*).

The Mole Crab is a curious creature, highly adapted to the **habitat**. Living in the lower 1/3 of the shore it is a rapid burrower, but feeds at the surface of the sand on particles it collects there. Mole crabs are only 3 cm or 1.25 in long and protectively coloured to look like sand. The body is short, wide and thick.

Summary

Only two animals live in the lower intertidal sandy shore, the Mole Crab and the Two-spotted False Donax, a clam. Both are rapid burrowers.

The other animal living in this difficult environment is the Two-spotted False Donax a small clam, about 17 mm or 3/4 inch long. It too is a very rapid burrower. The shell is colourful and may be white, purple, yellow or red or any combination of these colours. Neither of these two animals is commonly seen.

2) <u>High tide mark to top of wave-impacted area</u>
This part of the shore is only underwater intermittently but in contrast to the **intertidal** zone, there is a much better food supply, the result of material or flotsam cast up by the waves. There is also temporary shelter under patches of flotsam. This results in a much higher **biodiversity** in this area and creatures of both marine and land **environments** can be found. However, marine animals must be resistant to drying.

Summary
Many animals and one plant are common just above high tide level. Beach Fleas and Ghost Crabs have developed in the sea. Various insects have moved into this area from the land because food and cover are available. Lizards such as the Bermuda Skink and a variety of birds visit this area to feed.

The most common animals of marine origin are the Beach Fleas or Sand Hoppers (*Orchestia* species). These creatures are in the group of **crustaceans** known as Amphipods, most of which are quite small and the body is characteristically flattened from side to side. In the water they can swim on their sides and are often called 'side swimmers'. The Beach Fleas are up to about 13 mm or 3/4 in long. They shelter under patches of cast-up **seaweed** and when this is lifted they scatter rapidly jumping vigorously as they do so. They can also burrow in damp sand and feed on decaying **seaweed**. Although there are several different **species** of Beach Fleas, they are difficult to tell apart. They are all members of the genus *Orchestia* and we will just refer to them as '*Orchestia* species' (*Orchestia* sp). Another animal of marine origin is the Ghost Crab (*Ocypode quadrata*). This very active crab only found in quite undisturbed locations, makes burrows in the sand above high water mark on exposed beaches. It emerges at night to hunt for its food, made up of living or dead creatures.

The other common animals are of land origin and are generally much less common than the Beach Fleas. In the **seaweed** (often called wrack) piles one may find a few Devil's Coach Horses (*Cafius bistriatus*), which are elongated beetles with very short wings. They are active, running or flying away from danger and only just less than 10 mm or 3/8 in long. They too feed on decaying **seaweed**. **Seaweed** piles also support the small **larvae** of Seaweed Flies (*Fucellia intermedia*); these maggots are small pale oblong creatures. The adult flies, 6 mm or 1/4 in long are common on un-raked beaches and can bother bathers. They are coloured reddish-brown and the body is narrow and bristly. Seaweed piles and other wave-cast material may also hide specimens of the Seaside Earwig (*Anisolabis maritima*), a wingless dark-brown insect up to 2.4 cm or an inch, characterized by pincers at the hind end.

A beetle that lives just above high **tide** mark but not in the **seaweed** piles is the Tiger Beetle (*Cicindela trifasciata*) an extremely active flying and crawling beetle of great beauty. The back is iridescent metallic green with copper coloured markings. Its **larvae** called Ant Lions live at the bottom of small conical pit traps in the sand. These beetles are carnivorous and will consume any very small animal.

Because of the abundance of small creatures in this area it is also visited by Bermuda Skinks (*Eumeces longirostris*) and several birds such as the Great Kiskadee (*Pitangus sulphuratus*), Ruddy Turnstones (*Arenaria interpres*), Sanderlings (*Calidrys alba*), Starlings (*Sturnus vulgaris*) and House Sparrows (*Passer domesticus*).

The only land plant that you are likely to find in this area, and then only on non-raked beaches, is Sea Rocket or Scurvy Grass (*Cakile lanceolata*). This fast-growing annual plant grows at the strand line where floating material gathers at high **tide**. It has fleshy leaves and white flowers.

Conservation and Pollution Concerns
There is no doubt that the sandy shore has been grossly affected by marine pollution. All manner of floating trash ends up there as does oil and tar balls. However, it must be realised that

an equally, if not more, deleterious effect stems from the masses of tourists and residents who flock to sandy beaches in the summer. To accommodate their needs, the most popular beaches are mechanically raked at frequent intervals, removing not only garbage and tar balls but also the **strand line**. This also radically disturbs the delicate environment just above the **strand line**. As a result the beaches have become a biologically barren **habitat**. In recent years several hurricanes, including Fabian, have also caused serious damage to many beaches.

Summary

The sandy beach receives pollutants from land and sea but has also been radically degraded by heavy recreational use.

Any improvement in this situation is unlikely as beaches are Bermuda's main tourist attraction and continued pollution is virtually inevitable.

Questions

1) Why are raked beaches poor sites for the study of sandy shores?
2) Why does the open sandy shore support fewer species than other coastal environments?
3) How long after high tide does the next low tide occur?
4) Are tides mostly caused by the sun or the moon?
5) What are Spring Tides?
6) Why are waves such a big modifying factor to the tides in Bermuda?
7) In what main way are intertidal organisms exposed to different conditions than sub-tidal organisms?
8) What are the three types of adaptation found in sandy shore inhabitants?
9) Describe one physical adaptation seen in sandy shore animals.
10) Name one very important behavioural adaptation seen in animals from the sandy shore.
11) Why are physiological adaptations difficult to see?
12) Name one of the two animals found in the lower part of exposed sandy shores.
13) What adaptation to life on sandy shores do the two inhabitants of the lower shore face?
14) What is the Strand Line?
15) What type of animal is the Beach Flea?
16) Name one type of fly that is associated with the piles of seaweed at the strand line.
17) What is the main food of insects found in seaweed piles at and above the strand line.
18) What terrestrial plant is found around the strand line?
19) Name one beetle found at or above the strand line.
20) Name one bird or reptile that moves into the upper sandy shore to feed.

Field Trip # 3.1 to a Typical Sandy Shore

Preparation

Read this section of this field guide. Find out from the newspaper the time of low tide. To find the time of low tide in advance, tide tables are available from the Bermuda Biological Station for Research (or visit www.weather.bm). This field trip must be done within an hour, before or after low tide, and when the sea is relatively calm. Nothing can be achieved by going out when large waves are crashing on the shore. Limit the area to be studied from just above the wave washed zone to the area just above where the strand line, or high tide mark, is. Even if the strand line is missing, as it often is, the high tide mark is usually clearly visible.

Dress

No special clothing is needed. But if it is sunny, those prone to sunburn should apply a sunscreen with a high SPF.

Equipment

Clipboard, pencil and several sheets of good paper, as well as a 30 m (100 ft) survey tape, a few pairs of binoculars for the group, a few flat plastic or metal small trays, and a few plastic bottles.

Suggested Location

Any south shore beach is potentially suitable but for best results pick one that is not popular with tourists.

Observations

1) Beach Profile

   A profile is like a vertical cross-section of an area. It can show the shape of the beach surface and the positions of the main features. Try to come up with an approximate scale. If you have a 30m tape it can be laid from the water line up the beach for this purpose. Alternatively pacing the beach from top to bottom can be substituted Label all features and be sure to put on the water line.

Beach Profile

2) Beach Organisms
Look carefully at the beach below the strand line and identify and list any organisms, or parts of organisms, that you find. Note whether they are living or dead. Give your reasons why living organisms are rare.

a) Organisms found or seen. ____________________

____

b) Reasons for lack of living creatures. ____________________

____

____

3) The Strand Line (if present)
Walk along the strand line and try to identify everything that you see including trash. List your findings.

a) Living things

____

____

____

____

b) Dead Organisms

____

____

____

c) Trash

____

____

____

4) The Sand
From the middle of the beach or anywhere where the sand particles are quite coarse, scoop up a sample in a plastic bottle and spread it out in a tray. (Note: This part may be done either in the field or back at school) Using **Figure 2.8**, identify as many grains as you can to determine their origin.

a) ____________________ b) ____________________

c) ____________________ d) ____________________

e) ____________________ f) ____________________

g) ____________________ h) ____________________

i) ____________________ j) ____________________

5) General Observations
Write what you think about this environment and its future. Try to suggest some ways in which at least some sandy beaches might be preserved so that their natural fauna and flora may return. How important do you think sandy beach conservation is to Bermuda?

____

____

____

____

____

Chapter 4. More Sheltered Sand/Mud Shores

Introduction

The more sheltered sandy shores covered in this book are still relatively exposed locations. Sedimentary shores in sheltered locations tend to be muddy rather than sandy because the strong **currents** needed to transport sand there are absent.

The shores discussed below tend to form along open coasts where there is some structure offshore that reduces wave action. The usual structures associated with these shores are near shore **coral reefs** of extensive nature. However, small partially sheltered sandy shores may be found behind breakwaters or other man-made structures. Because of the distribution of **reefs** around Bermuda most of these somewhat sheltered sandy shores lie along the west coast. To the west of Bermuda, large tracts of coral reef are found from just offshore to several kilometres (miles) out to see. These **reefs** are submerged, but they reduce the size of large waves so that they do not strike the shore with the same energy as those on other shores.

Summary

Somewhat sheltered sandy shores are found in locations where there is reduced but still significant wave action. The east and west ends of the island have many such shores. The amount of mud mixed with the sand increases as shelter gets more complete.

The reduced wave action on these shores affects the structure of their **sediments**. While these are still mostly sand, the sand grains are smaller than on very exposed shores and the **sediments** are less well sorted. This is because finer **sediments** tend to fill the spaces between the sand grains. This results in reduced permeability and poorer penetration of oxygen rich water. However, these factors all tend to increase the stability of the **sediments**. In comparison to exposed shores the sand grains on somewhat sheltered shores move around a lot less. Good environmental stability fosters good **biodiversity** and as a result many more **species** are present in the **intertidal** part of the shore.

Environmental Conditions on Sand/Mud Shores

The main environmental difference between very exposed shores and those of a slightly more sheltered nature is the reduction in wave action. Waves are smaller and their effect extends to a shallower depth. As a result of this water movement is reduced which in turn allows finer **sediments** to settle and to remain where they fall. In turn, this means that **sediments** are more consolidated than in more exposed locations. One other factor is that on these shores wave action is more severe at the top than at the bottom of the shore. This is because at high **tide** there is a greater depth of water over the reef tops and because of this, waves remain larger. The beach above high **tide** mark which is impacted by these waves is often of pure sand rather than a mixture of sand and mud and is similar to the upper beach of more exposed sandy locations.

Summary

Compared to open sandy shores these ones have greatly reduced wave action. This makes the sand much more stable and a better habitat for animals and plants. At high tide mark there may still be heavy wave action. However, compared to open sandy shores the sediments tend to have a poor oxygen content that decreases rapidly with depth. Animals living there must adapt to this.

However, all these effects are not positive ones in terms of the animal and plant residents. One very noticeable environmental effect is that well oxygenated water penetrates only shallowly into the **sediment**, and deeper **sediments** are poorly oxygenated and tend to be darker in colour than surface ones. This is an obstacle to burrowing animals and they have to be adapted to these conditions to live there. Another effect is that due to finer **sediment** particles lying among the coarser sand grains, the interstitial space is lowered and the **interstitial fauna** is reduced in **diversity** and abundance.

Nevertheless, the overall effect of a more sheltered location is positive and both **biodiversity** and abundance of animals and plants are increased. Additionally while there are virtually no sand-surface dwelling animals and plants on the **intertidal** part of very exposed shores, this group of animals and plants is well-represented on the more sheltered sandy shores.

Adaptation to Conditions on Sand/Mud Shores

Physical Adaptation

The ability to dig into the sand is as essential as on more exposed shores, but here it is shown in a greater variety of animals. Many of the worms dig by thrusting the head into the sand, then expanding it as an anchor to pull more body down. This process is repeated until the entire body is buried. Some snails such as the Moon Snail use the large foot in much the same way and can pull the entire shell under the surface. Sand Dollars only bury shallowly by moving sand grains over the top of their body with their numerous tube feet. **Crustaceans**, for example burrowing shrimp have strong digging legs. Burrowing **Sea Cucumbers** are worm like in appearance and burrow in much the same way as worms do.

Summary

Most organisms living in sandy mud shores can burrow efficiently to escape danger or to create a home. Many burrows last for a long time and are stabilized with a lining. Since the sediment is low in oxygen, burrow dwellers pump seawater down from the surface of the sand to provide a supply of oxygen. Most burrowing animals are long and quite thin to enable them to burrow into, or move through the sediment relatively easily.

However, the lower permeability of the **intertidal sediments** means that oxygen is in poor supply a little way down. All the animals need oxygen to live. The main way that this is achieved in almost all burrowers is the addition of a lining to the burrow walls so that the burrow stays open. Mucous is the commonest burrow lining material; it holds the sand in place and lasts for a considerable time. With the burrow stabilized in this way, the inhabitant can pump oxygenated water through it. The method of pumping varies with the animal. Worms move a widened section of the body resembling waves back, moving water between the waves. This type of pumping is called peristaltic pumping. In many of these animals oxygen uptake is helped by the presence of large gills through which blood is pumped. Such gills may be very delicate but the burrow **habitat** is also very protective. Burrowing worms also generally have strong bristles on the side of each segment which help them to grip the burrow walls. Shrimps pump water through their burrows using their strong legs. Burrowing clams tap into surface water by means of a long tube-like siphon which extends to the surface; waste water is pumped out through a similar second siphon.

Behavioural Adaptation

In all **intertidal** organisms, behaviour to prevent problems of exposure to air are critical; most animals of this **habitat** can re-burrow rapidly or seek shelter among marine plants or under rocks. Burrowing carnivorous snails can find their prey even when it is buried quite deeply. Burrowing animals such as worms, **anemones** etc. that have semi-permanent burrows, are very sensitive to vibrations that could be caused by an approaching enemy. They can then retreat to the deepest part of the burrow. Some burrowing clams can form new burrows amazingly rapidly if removed from their old burrows.

Summary

Animals of the shore escape harmful drying by burrowing or seeking cover. The plants found there can all withstand drying.

Physiological Adaptation

There are a few marine plants on these somewhat sheltered shores. Although they live well towards low **tide** level, they must be capable of drying out without harm as even a few minutes exposure on a hot, dry day can result in great water loss. They must also be physiologically adapted to withstand low salinities when they are exposed in pouring rain. They are also adapted so that they can function normally very rapidly after being re-immersed in seawater.

Summary
Seagrasses and seaweeds exposed on the shore are quite resistant to drying. Some of the burrowing animals have haemoglobin as a blood pigment. This makes the blood red and better able to extract oxygen from the water when it is in poor supply

Some of the burrowing animals have adapted to the low oxygen levels in the **sediments** by using haemoglobin as a blood pigment. Haemoglobin is much more efficient at taking up oxygen than the more usual light coloured blood pigments found in most invertebrate animals. These animals are often bright red in contrast to relatives with colourless or very pale coloured blood.

Fauna and Flora of more Protected Sandy Shores

Introduction

In contrast to the rather simple **habitat** present between the **tide** marks on exposed sandy shores, that on more sheltered sandy shores is much more complex and as a result, the **biodiversity** is much higher. There are really three major types of **habitat** in the **intertidal zone** of these shores. These are 1) the sand surface, 2) semi-permanent burrows in the **sediment** and 3) the **sediment** itself.

Summary
There is much more life on quite sheltered sandy shores than on exposed ones. Additionally there are more habitats available. The main three ones are the sand surface, long lasting burrows made in the sediment and the sediment itself.

The sand surface **habitat** has a number of sub-**habitats** which include, under stones and rocks scattered on the sand surface; among patches of **seaweed** or seagrass growing there, and the open sand surface. The first two of these provide refuges for many animals and plants and also shelter from the drying effects of the sun and air when the **tide** is out. This enables animals more typical of other situations such as rocky shores and just below low **tide** mark to live on the shore at least temporarily and greatly increases the **diversity** of life in contrast to more open sandy locations.

Life on the surface of the sediment

Plants

Both seagrasses and **seaweeds** can be found at the **sediment** surface. Both are confined to the lower 1/3 of the shore and may not appear at all on **Neap Tides** or when sea levels are running higher than normal due to atmospheric conditions.

There are three common seagrasses in Bermuda, Turtle Grass (*Thalassia testudinum*), Shoal Grass (*Halodule wrightii*) and Manatee Grass (*Syringodium filiforme*). All three can be found rooted on somewhat sheltered sandy shores where the slope is low and seawater tends to lie in depressions or ripple marks. In this **habitat** all will be much shorter than their typical heights. Turtle Grass is much the most common with the other two found around the edges of Turtle Grass patches. On very low **Spring Tides** and when sea levels are running below normal, these grasses tend to die back from the leaf tips towards the leaf base, a process that keeps them short. The seagrasses provide shade and shelter and help to retain moisture when exposed to the air. Several **seaweeds** may exist attached to the blades of the seagrasses. The most typical of these, Scaleweed (*Fosliella farinosa*) is a red

Summary
All three common seagrasses found in Bermuda can extend into the lower part of somewhat sheltered shores. These are Turtle Grass, Shoal Grass and Manatee Grass.

seaweed that appears as whitish discs on the leaf surface. Tangled in the leaves there may be clumps of one of the Seathreads (*Cladophora* spp.) which are green, hair-like **seaweeds**.

Most **seaweeds** require a firm, stable surface on which to grow and sand does not fit this need. However, there is a group of green **seaweeds** that anchor themselves in sand by growing a mass of root-like fibers that extend into the **sediment** as an anchorage. These fibres are not roots such as are found on seagrasses. True roots take up chemical nutrients from the **sediments** whereas the anchors of these **seaweeds** do not do this. The **seaweed** from this group which can be found on sandy shores that are somewhat sheltered and are fairly flat is the Common Plateweed (*Halimeda incrassata*). Specimens found on the shore will be shorter than those found below low **tide** level but may form dense patches that afford shelter and retain water at low **tide**. Although this **seaweed** is a member of the green **algae**, it is rarely really green in colour but may be a pale greenish white or even red or brown. These latter two colours result from a layer of tiny **seaweeds** that may cover the surface. Plateweeds are better distinguished by their structure than their colour. They are constructed of a series of small, hard plates that are hinged together in chains. The Common Plateweed tends to branch quite freely, forming small bushes. In the Common Plateweed, each plate, or segment, is like a rounded triangle with three lobes at the top. The hardness of the segments is a result of **calcium carbonate**, or lime, that the plant extracts from the seawater and deposits in the segments. When the plant dies these segments turn white and become part of the **sediment**. **Figure 2.8** illustrates typical **seaweed** fragments found in **sediments**. On very low **tides**, a few Merman's Shaving Brush (*Penicillus capitatus*) **seaweeds** may be just exposed. As its name suggests, this **seaweed** resembles s short, fat brush. In places where the seawater never quite drains away, or where a small stream erupts from the sand, one can find the bright-green, small, elongated, tubular **seaweed** called by the unattractive name of Smooth Sea Intestines (*Enteromorpha flexuosa*). Other very small, red **seaweeds** may also be found attached to small stones, seagrasses or **seaweeds**; most of these are difficult to identify.

Summary
The leaves of the seagrasses are themselves a small but important habitat. On them live Scaleweed and a variety of other small seaweeds. The most common of the larger seaweeds on the shore are the Plateweeds. These form another habitat and are also important contributors to the sediment itself when they die back.

Summary
Other seaweeds that may be found include the Merman's Shaving Brush and the Smooth Sea Intestines. Just above high tide mark Scurvy Grass or Sea Rocket is very common.

Above high **tide** mark where water rarely reaches the Sea Rocket or Scurvy Grass (*Cakile lanceolata*) is quite common. This fast-growing annual plant has fleshy leaves and white flowers. It is rich in vitamin C and used to be used to treat Scurvy, a disease caused by Vitamin C lack once common among sailors.

Animals

The surface of the sand both in exposed and fairly sheltered places is not a **habitat** in which you will find many animals; however, there are more in somewhat sheltered locations. The commonest animal of such places is the False Cerith (*Batillaria minima*), as the minima part of its scientific name suggests this is a small but elongate snail rarely over 15 mm or 5/8 in long. It is a dark colour and difficult to spot; however as it forages over the surface of damp sand it leaves a trail or groove in the sand which is quite easy to spot. Find a trail and follow it in the right direction and the snail will be there. Less commonly the actual rather than false cerith can be

Summary
Snail tracks are often seen on the surface of the sand. Most are made by the False Cerith but the larger Lettered Horn Shell is also quite common. Less common snails include the well camouflaged Clear Haminoea and the predatory hunting snail the Tinted Cantharus.

seen living in a similar way. This snail is about twice as big as the False Cerith and is called the Lettered Horn Shell (*Cerithium litteratum*). The lettered (or *litteratum*) part of its name comes from the fact that the shell is often light coloured with darker splotches; however, the colour is highly variable, ranging from black to almost white. It is less able to stand being out of water than the False Cerith.

A few other snails may be found by diligent searching near to low **tide** level. The Clear Haminoea, (*Haminoea antillarum*) reaches about 8 mm or 1/3 in long and has a smooth shell with a large opening. It blends in almost perfectly with the sand surface and is commonest among **seaweeds**. The Tinted Cantharus, (*Pisania tincta*) is much larger (27 mm 1 in long) but very uncommon. It is a carnivorous snail that feasts on the other snails on the sand surface. They feed when covered by the water by catching small live or dead organisms with their short tentacles.

Another possible find on this type of shore is a **colonial anemone** called the Green Sea Mat, (*Zoanthus sociatus*). Colonies of this **anemone** with 30 or so individuals make small dark green patches on the sand surface. They extend hardly at all above the sand surface and tend to trap water among themselves at low **tide**.

Summary
A colonial sea anemone called the Green Sea Mat forms small patches on the surface of the sand. Several kinds of crab may be seen scuttling along the surface from one place of shelter to another.

Occasionally one sees a crab running from one patch of cover to another. These are generally small individuals and may be of several different **species** of crab. The most likely ones here in Bermuda are the Common Mud-crab, (*Panopeus herbstii*) and the Florida Mud Crab, (*Cataleptodius floridanus*.) The Mottled Swimming Crab (*Portunus depressifrons*) is less commonly encountered. The Mud-crabs, as their common name suggests, like muddier locations best but do extend onto sandy shores. Both are mottled brown in colour with dark tips to the large claws. They can be told apart by the number of teeth on the front of the shell between the eye and the widest point. Five in the Common, and four in the Florida. The Mottled Swimming Crab has the fifth pair of legs flattened like oars to enable them to swim rapidly away from predators at high **tide**.

All these animals live in the wetter part of the shore that is covered twice daily by the **tides**. Above high **tide** mark one can find most of the animals found in similar **habitats** on the exposed sandy shores. These include the Beach Fleas or Sand Hoppers (*Orchestia* species) the Ghost Crab (*Ocypode quadrata*), Devil's Coach Horses (*Cafius bistriatus*), **Seaweed** Flies (*Fucellia intermedia*) and the Seaside Earwig (*Anisolabis maritima*). Ghost Crabs hunt on the shore at night for living or dead animals. The other two are found under piles of stranded **seaweed**. The Tiger Beetle (*Cicindela trifasciata*) found in open sunny places is a beautiful iridescently coloured beetle living on the open sand in sunny places. It can run and fly very fast.

Summary
The part of the shore above high tide mark is quite similar to that on more open shores. There Ghost Crabs roam at night and insects such as The Devil's Coach Horse, the Seaside Earwig and Seaweed Flies live on or under piles of seaweed.

Because of the large numbers of small creatures in this area it is also visited by the **endemic** lizard, the Bermuda Skink (*Eumeces longirostris*) and several birds such as the Great Kiskadee (*Pitangus sulphuratus*), Ruddy Turnstones (*Arenaria interpres*), Sanderlings (*Calidrys alba*), Starlings (*Sturnus vulgaris*) and House Sparrows (*Passer domesticus*) all of which eat the small prey living there.

Summary
The Bermuda Skink hunts for food at night above high tide mark. By day several birds feed in this area.

Life within the sediment

Plants.

Plants, whether they are **seaweeds** or flowering plants normally need light to survive. They are virtually absent from the sand except for a few mobile, very tiny single-celled plants that move down when the **tide** is out to avoid drying out. You will not see these, but do realize that they are there.

Summary
The only plants within the sediment are extremely small and difficult to see.

Animals

The **sediment** on the sheltered sandy shore has one big similarity to the soil on land in that it is the home of many worms and worm-like animals. An elongated worm-like shape is uniquely suitable to the burrowing life. However, a big difference from the worms found on land is the very high **diversity** of marine worms; there is a large variety of different worms in the sea.

It is important to understand that the term worm is not restricted to relatives of worms on land, but is rather the name given mostly to elongate animals that make burrows in **sediments**. There are, however, many other creatures called worms in a wide variety of land, freshwater and marine **habitats.**

Summary
A variety of worms live in the sand. However not all of these are closely related to earthworms. In the sea many long, slender animals are called 'worms'.

First we will explore a few worms found on somewhat sheltered sandy shores that are quite different from earthworms. A good example is the Sharp-head Nemertine (*Cerebratulus leidyi*). In this worm the body is quite smooth in contrast to the more usually present rings around the body. The head is not separated from the body at all. This carnivorous worm is a uniform deep red in colour and grows to about 20 cm (8 in) long. This worm does not make a semi-permanent burrow but ranges through the sand hunting for prey. This worm stays well down in the **sediment** by day but may emerge at night. They are even known to swim up in the water towards a light! Another curious worm is the Burrowing Spiny Head (*Sipunculus norvegicus*) which does have a shallowly-ringed body which has a snout with a spiny tip, on the head. This small-thin worm can reach 9 cm (3 1/2 in) in length and is a pinkish colour. Although it does not actually burrow, the Pale Flatworm (*Notoplana binoculata*) is never seen on the **sediment** surface but rather lives just within the **sediment** under a stone or other object on the shore. This worm reaching 35 mm or 1 1/2 in long; is extremely flat and somewhat transparent. The colour is a pinkish-white. There are two dark eyes near to the rounded front end.

Summary
Some of the worms that are not related to earthworms are the Burrowing Spiny Head, the Sharp-head Nemertine and the Pale Flatworm. They are generally light in colour.

Summary
Worms that are related to earthworms and may look rather similar are the Red Glycera, the Round-head Notomastus the Golden Burrowing worm and the Red Tube Worm. They vary in colour as their names suggest.

The more typical worms are what are called Annelid Worms. All are segmented which means that the body is mostly made up of quite short sections separated by deep grooves. Each segment characteristically has a spiny 'foot' on each side. The majority of the segments may be quite similar to one another or there may be two regions of the body that have very different segments. Some of these worms make burrows that are long lasting others have temporary burrows. A good example of the latter type which is quite common is the Red Glycera (*Glycera abranchiata*). This is a hunting worm that is very active and grows to about 10 cm (4 in) long and as its common name suggests it is a bright red in colour, a result of the pigment haemoglobin in the blood. The Round-head Notomastus (*Notomastus latericeus*) is another reddish worm. This one forms a long-lasting burrow and superficially resembles an earthworm. Close examination will reveal that the body is made up of two distinct regions. At the front the segments are wider and more robust than those at the back, which taper slowly towards the tail. The Golden Burrowing Worm (*Naineris setosa*) reaches about 95 mm or 4 in long, with a brownish body accented by clumps of shiny, golden bristles on the sides of each segment. It feeds on organic material in the **sediment**. The Red Tube Worm (*Loimia medusa*) has a mode of life quite different to that of the worms described above. It builds a robust burrow vertically in the **sediment** extending to the surface. The worm lives head-up in this burrow and can retract well down if danger threatens. Normally, the head of the worm is level with the **sediment** surface and it extends a mass of very thin, bright red filaments over the sand surface. These tentacles capture the tiny particles of organic matter that form its food from the surface of the **sediment**. The Cockworm or Lug-worm (*Arenicola cristata*) is often dug for bait and is one of the most highly adapted worms of the semi-sheltered sandy shore. This worm is quite large reaching over 25 cm (10 in) in length. The body is quite thick. It has red, haemoglobin rich blood that can be seen in the thread-like gills. The Lug-worm makes a long-lasting burrow of a U-shape with both ends close to the surface. It can simply swallow food-rich **sediment** as food (**deposit feeding**), ejecting sand at the hind end as a stringy '**casting**' or in a more elaborate feeding method, it can pump water through a plug of sand above the head. The sand filters organic particles, which are food for the worm, from the water. Periodically the worm swallows this food enhanced sand.

Summary
One very interesting and highly specialized worm is the Cockworm or Lugworm. It is often dug for bait and can be up to nearly a foot long. It makes a U shaped burrow in the sand with a crater at the head end and coiled castings at

Sea anemones are not usually thought of as burrowers in sand; however, there are several **species** which do so. One quite common in Bermuda, is the Burrowing Sea Anemone (*Arachnanthus nocturnus*). This difficult-to-spot animal lives near to low **tide** level. It makes a tough tube of fine sand or gravel grains cemented together. The lower end of the tube is often fastened to a buried stone. The **anemone** can go deeply into the tube for shelter when the **tide** is out, or can extend up to the surface when immersed in water. At this time the tentacles which are pale coloured with dark bars, are extended up into the water to catch its food.

Summary
Two unrelated but rather similar animals that live head-up in a burrow going straight down are the Burrowing Sea Anemone and the Burrowing Sea Cucumber. Both are very difficult to see and both go to the bottom of their burrows if disturbed.

Another curious burrowing animal occasionally exposed on a good low **tide** is the Burrowing **Sea Cucumber** (*Holothuria arenicola*). If you look back to the Cockworm you will note the similarity in the scientific names. Both contain the word *arenicola*; this is no accident as this word means 'sand dwelling'. The burrowing **sea cucumber** up to 25 cm (10 in) long; has a long-lasting, deep burrow down into the **sediment**. It can go way down to the base of the burrow if threatened or at low **tide**. However, when covered in water the head rises level with the sand surface where it feeds on organic **detritus**.

The Moon Snails are a family of snails with very globular shells which burrow into the **sediment** in search of food. The Milky Moon Snail (*Polinices lacteus*) is common in Bermuda and has a characteristic milk-white shell up to 2 cm (3/4 in) across. It is typically found subtidally but may be found **intertidally** on extra low **tides**. These snails have a very large, strong foot with which they pull themselves through the sand. When they die, the shells usually rise to the surface of the sand.

Summary
The Milky Moon Snail and the Sand Dollar both move through the sand without forming a burrow. The Sand Dollar stays very close to the surface but the Milky Moon Snail goes deep in search of its prey.

The Sand Dollar (*Leodia sexiesperforata*) a relative of the better-known **sea urchins**, is only rarely exposed in the **intertidal**. It has a disk-shaped shell which moves just below the surface of the **sediment** from which it extracts its food. As it goes it leaves a characteristic disturbed trail as wide as the 8 cm or 3 1/2 in diameter shell. This is an interesting animal well worth looking out for.

In other locations a variety of burrowing clams extend into the **intertidal** zone, but those common here are mostly well confined to sub-tidal **habitats**. However, there is one which may sometimes be found **intertidally** on more sheltered sandy shores. This is the Purple Mussel (*Asaphis deflorata*), a colourful clam growing up to about 75 mm or 3 in long. The shell may range in colour from purple through, red, yellow or pure white. This clam or mussel is quite deeply buried to at least 15 cm (4 in) into the **sediment**. It feeds by extending two long siphons or tubes up to the **sediment** surface. One siphon draws water in, the other expels it. Food is filtered from the incoming water by the gills.

Life on and Between the Sand Grains

This section of this book requires some basic explanation. Most of the creatures and plants described in this guide to sandy coasts can be readily seen if you happen to find them. Here we are going to look at some very small animals and a few plants that will remain unseen unless you use a microscope and know how to separate the organisms from the sand.

In the geological section of this book (Chapter 2) the structure of **sediments** was introduced. One important topic was that of **sediment permeability**. Permeability refers to the rate with which water can run through a sample of the **sediment**. If the sand grains are all quite large there are many spaces between particles and water can percolate through it freely. This type of **sediment** is called **well sorted sediment**. If, however, there are a variety of sizes of **sediment** grains present, small ones can fill the spaces between large ones and the permeability will be poor. This type of **sediment** is often referred to as poorly sorted. It is the former type of sand that will support life between the sand grains while the latter kind will not. This is not only because there is space available for tiny organisms, but also because such **sediments** are well oxygenated by virtue of all the water moving through them. **Poorly sorted sediments** are often dark in colour and have an unpleasant smell, because of the lack of oxygen. The tiny animals living between sand grains are termed **interstitial fauna**, the microscopic plants **bacteria** and animals attached to the surface of the grains are called **episammon**. In addition there are also tiny **burrowers** that actually push the sand grains apart in order to move among them.

Summary

Animals that live between the sand grains are called interstitial fauna. Animals and plants that live attached to the surface of the sand grains are called **episammon**. A third group of inhabitants are tiny burrowers.

The **episammon** on the surface of the grains are all extremely tiny, such that they cannot be seen in detail even with a powerful microscope. They will not be described here because it requires very specialized knowledge and experience to examine them.

The **interstitial fauna** are still tiny but with care can be observed under a good microscope. They are a very diverse group of animals that range from single celled animals to multi-cellular ones. This varied and remarkable group of tiny organisms leads a largely ignored life right under your feet as you walk along a beach. They populate the water-filled spaces (interstices) between sand grains, often in enormous numbers, from as far up on the beach as the sand is moist down the offshore slope as far as sand can be found. Most are 1 mm or less in length and most are extremely thin so they may squeeze through the tight

Summary

The interstitial fauna are all very small animals that range in size from a single cell to organisms of complex structure. Cilliates and foraminiferans are examples of smaller ones. Larger ones are from many groups in the animal kingdom.

spots between sand grains. The smallest are ciliates and **foraminiferans** and then protozoans such as amoebae and flagellates. Somewhat larger examples include, flatworms, gastrotrichs, nematodes, archiannelids and copepod **crustaceans;** these are all somewhat worm-like in appearance. Examples are shown in Chapter 6 in the **interstitial fauna** section. Some glide elegantly over sand grains, propelled by cilia (ciliates, flatworms, gastrotrichs), others writhe like snakes (nematodes) or move along on short robust legs (**copepods**).

It is natural to think that such tiny and hard to find organisms are relatively unimportant. This is not so; they occur in huge numbers and have an important ecological role. As waves roll up the shore some of the water moves between the sand grains and the **interstitial fauna** capture tiny organic particles that result from the death of plankton in the sea as well as the waste products of larger animals; also present are numerous **bacteria**. The **interstitial fauna** use all this material as food and in doing so cleanse the water. We can think of the beach as a natural filter. A second important role is that the interstitial animals are themselves food for larger creatures, they are part of the base of the **food chain** that continues to include fish, shellfish and **crustaceans** that are used as human food. Additionally, they contribute to the **biodiversity** of coastal waters and it has been shown that diverse biological systems are more stable than less diverse ones.

Summary
The **interstitial fauna** may be small but they are numerous and are extremely important. They filter the water that enters the sand and are also important animals in the shoreline **food**

The burrowers are larger than the **interstitial fauna** and are more easily seen although many of them are almost colourless. The nematode worms are the main group in this category. Nematodes are often thought of as mainly parasitic creatures but in fact most **species** are free living and have a variety of feeding habits. These worms are comparatively slender and have quite a firm, smooth-skinned body. They tend to move in a writhing motion.

The feeding habits of the interstitial and burrowing sand fauna are varied. Some are **detritus feeders**, others scrape the microflora (tiny plants) from the sand grains, others are predators eating smaller animals and a few are **filter feeders**. **Filter feeders** strain food particles from the water on some type of filtering apparatus.

Summary
Interstitial fauna feed on a great variety of foodstuffs and even on each other.

On sandy shores there is a trade-off that prevents the development of a rich **interstitial fauna** in locations where the sand is most permeable. This is because such sands are most common in exposed locations, and there, the surface sand grains are in frequent motion and tend to grind off any living inhabitants. More sheltered shores have **sediments** that are quite stable but are less permeable. As mud increases permeability declines. This tends to reduce the **interstitial fauna**. The net result of these two opposing factors is that **interstitial fauna** are best developed in conditions of intermediate exposure.

Conservation and Pollution Concerns

These beaches are not nearly so susceptible to storm damage as more open ones but some damage always occurs in severe storms. Additionally, the stranding of marine garbage is a constant problem.

A small amount of damage is the inevitable result of digging for bait worms but this appears to be a minor threat.

Summary
Conservation concerns are relatively minor but include, storm damage, garbage and worm digging.

Questions

1) Why is there a greater variety of life on somewhat sheltered sandy shores than on exposed ones?

2) Why is there a greater degree of wave action at high tide as compared to low tide?

3) Why does the sediment on somewhat sheltered shores tend to get darker with depth into the sand as compared to exposed sandy shores?

4) Why are sand surface living animals and plants better represented on the more sheltered shores?

5) Name two habitats that can be found on relatively sheltered sandy shores.

6) Describe how sand surface dwelling organisms are adapted to withstand or avoid drying.

7) Name two different types of burrowing animals of the sandy shore.

8) Describe two ways in which sand burrowing animals have adapted to live where oxygen is in poor supply.

9) What is a typical reaction of a burrowing animal to vibration of the sand?

10) Name two plants that might be found growing on the surface of the sand in fairly sheltered locations.

11) Why is the diversity of life greater just above low tide level than just above high tide level?

12) Describe two ways in which plants change the environment on the fairly sheltered sandy shore.

13) Worms is a general name given to many burrowing animals. Name two different groups of animals which are called worms.

14) Name one snail that lives on the surface of the sediment and another which is buried.

15) Name one burrowing animal that has a burrow going straight down.

16) Name one burrowing worm that has a U-shaped burrow.

17) Give an example of a predatory, hunting burrowing worm.

18) What is an example of a burrower in the sandy shore that lives head-up within the burrow?

19) How are fairly long lasting burrows prevented from collapsing?

20) Name the blood pigment found in many burrowing worms that helps to extract needed oxygen from the water.

21) How does a casting differ from a trail?

22) Which burrowing worm uses the sediment itself as a filter to extract food from the water just above the sediment?

23) Why is permeable sand a better habitat for interstitial fauna than sand through which water moves only very slowly?

24) What is the episammon?

25) What are the names of two animal groups found in the interstitial fauna?

26) What types of feeding behaviour are found in the interstitial fauna?

27) Why are the interstitial fauna very important on a sandy beach?

28) On a typical fairly sheltered sandy beach, where would you find a) the largest animals and b) the smallest animals.

29) Name a crab that lives in burrows in the sand above high tide level and emerges at night to hunt its prey.

30) Where might one find a “Devils Coach Horse”?

Field Trip # 4.1 to a Typical Somewhat Sheltered Sandy Shore

Preparation
Read this section of this field guide. Find out from the newspaper the time of low tide. To find the time of low tide in advance, tide tables are available from the Bermuda Biological Station for Research (or visit www.weather.bm). This field trip should be done within an hour, before or after low tide, and when the sea is relatively calm. Nothing can be achieved by going out when waves are breaking on the shore. Limit the area to be studied from just above the low tide level to the area just above where the strand line, or high tide mark lies. Even if the strand line is missing, as it occasionally is, the high tide mark is usually clearly visible.

Dress
No special clothing is needed. But if it is sunny, those prone to sunburn should apply a sunscreen with a high SPF. Waterproof foot-wear is an advantage.

Equipment
Clipboard, pencil and several sheets of good paper, as well as a 30 m (100 ft) survey tape, a few pairs of binoculars for the group, a few flat plastic or metal small trays, and a few plastic bottles.

Suggested Location
Any somewhat sheltered beach is potentially suitable but for best results pick one that is not popular with tourists. Most quite sheltered sandy beaches lie on either the east or west ends of Bermuda. An especially good one can be found by walking through the Somerset Long Bay Park.

Observations
1) Beach Profile
   A profile is like a vertical cross-section of an area. It can show the shape of the beach surface and the positions of the main features. Try to come up with an approximate scale. If you have a 30m tape it can be laid from the water line up the beach for this purpose. Alternatively pacing the beach from top to bottom can be substituted. Label all features and be sure to put on the water line and strand line.

Beach Profile

2) Beach Organisms
Look carefully at the beach from the strand line to low tide mark; roughly divide the beach into an upper third, middle third and lower third and identify and list any organisms, or parts of organisms, that you find in each section. Note whether they are living or dead. Give your reasons why living organisms are more common towards the sea.

a) Organisms found or seen.

Upper Third ______________________________

____

Middle ______________________________

____

Lower ______________________________

____

b) Reasons for increased diversity towards the sea. ______________________________

____

____

3) The Strand Line (if present)
Walk along the strand line and try to identify everything that you see including trash. List your findings.

a) Living things ______________________________

____

____

____

b) Dead Organisms ______________________________

____

____

____

c) Trash ______________________________

____

____

4) The Sand
From the upper beach or anywhere where the sand particles are quite coarse, scoop up a sample in a plastic bottle and spread it out in a tray. (Note: This part may be done either in the field or back at school) Using **Figure 2.8**, identify as many grains as you can to determine their origin.

a) ____________________ b) ____________________

c) ____________________ d) ____________________

e) ____________________ f) ____________________

g) ____________________ h) ____________________

i) ____________________ j) ____________________

5) General Observations. Write what you think about this environment and its future. Try to suggest some ways in which at least some reasonably sheltered sandy beaches might be preserved so that their natural fauna and flora may remain. How important do you think sandy beach conservation is to Bermuda?

Chapter 5. Sand Dunes

Introduction
As discussed above in the geological background chapter, Bermuda in the not-too-distant past was almost entirely composed of **sand dunes** that were especially well developed around the coasts. Inland the **dunes** tended towards flatter areas of sand often called sand plains.

The two essentials for sand dune formation are a supply of dry sand and the presence of onshore winds. The sand comes from two main sources, the **weathering** of rock and the breakdown of the hard parts of dead animals and plants. In Bermuda the interrelations of sand and rock are quite complex. The surface sands and rocks of Bermuda are all the result of biological activity. They started to form long ago when **seaweeds** which deposit very large amounts of **calcium carbonate** in their tissues started to grow on the top of the old volcano when it reached close to or above the sea surface. When dead, the remains of these **seaweeds** form a very hard **calcium carbonate** rock. This, in turn, provided a good stable base for animals such as **corals** which have a dense **calcium carbonate** skeleton to grow. Many other animals and **seaweeds** added to the rock and others broke down when dead, directly into sand. Other animals and a few **seaweeds** burrowed into the new rock for protection and in doing so produced more sand; this process is called **bioerosion**. These biological processes were augmented by **physical erosion** of the **limestone** rock by wave action, crawling animals, moving rocks etc. Over time, very large quantities of sand accumulated and **currents** and waves moved it towards the coastline. There some of it was inevitably exposed on low **tides** and dried in the sun and wind. This dry sand moved inland in onshore winds and piled up to create **sand dunes**. However, much of the sand that formed **dunes** on land was converted back to rock. As slightly acid rainwater percolated through it dissolved some **limestone**; when this water evaporated the dissolved **limestone** again became solid, cementing the grains of sand solidly together. This rock which makes up most of Bermuda is called **aeolianite**, a word which basically means 'formed by the wind'. The cycle of sand to rock was often repeated many times as rock weathered back to sand.

Summary
Present day sand dunes In Bermuda are but a tiny fraction of ancient dunes which once covered the entire island. Most of the ancient dunes have been converted to the rock called **aeolianite**, which makes up the bulk of Bermuda. However, even since the arrival of man extensive dunes have been present along the south coast.

In Chapter 2 past conditions in Bermuda were described and in summary we can say that for thousands of years, well before the arrival of man, Bermuda was a country of **sand dunes**. **Coastal dunes** developed along coasts and inland there were large dune tracts and inter-dunal low areas. Probably most of the **dunes**, especially the coastal ones, were quite stable and fixed in place by a cover of vegetation. However, there were also **mobile dunes** that moved downwind, engulfing things in their path. Slowly as time progressed, most of the **dunes** became well covered in vegetation or turned to **aeolianite** rock; the remaining sand became soil as dead organic remains of plants was steadily mixed in. Only along the coasts, particularly to the south, did active dune formation continue. Most of the inland dune systems were flooded with sea water as sea level rose.

Even since the arrival of man, there have been extensive areas of **sand dunes** and on occasion **mobile dunes** buried buildings and spread inland in some areas. **Figure 5.1** shows the locations where there have been large tracts of **dunes** since the arrival of man.

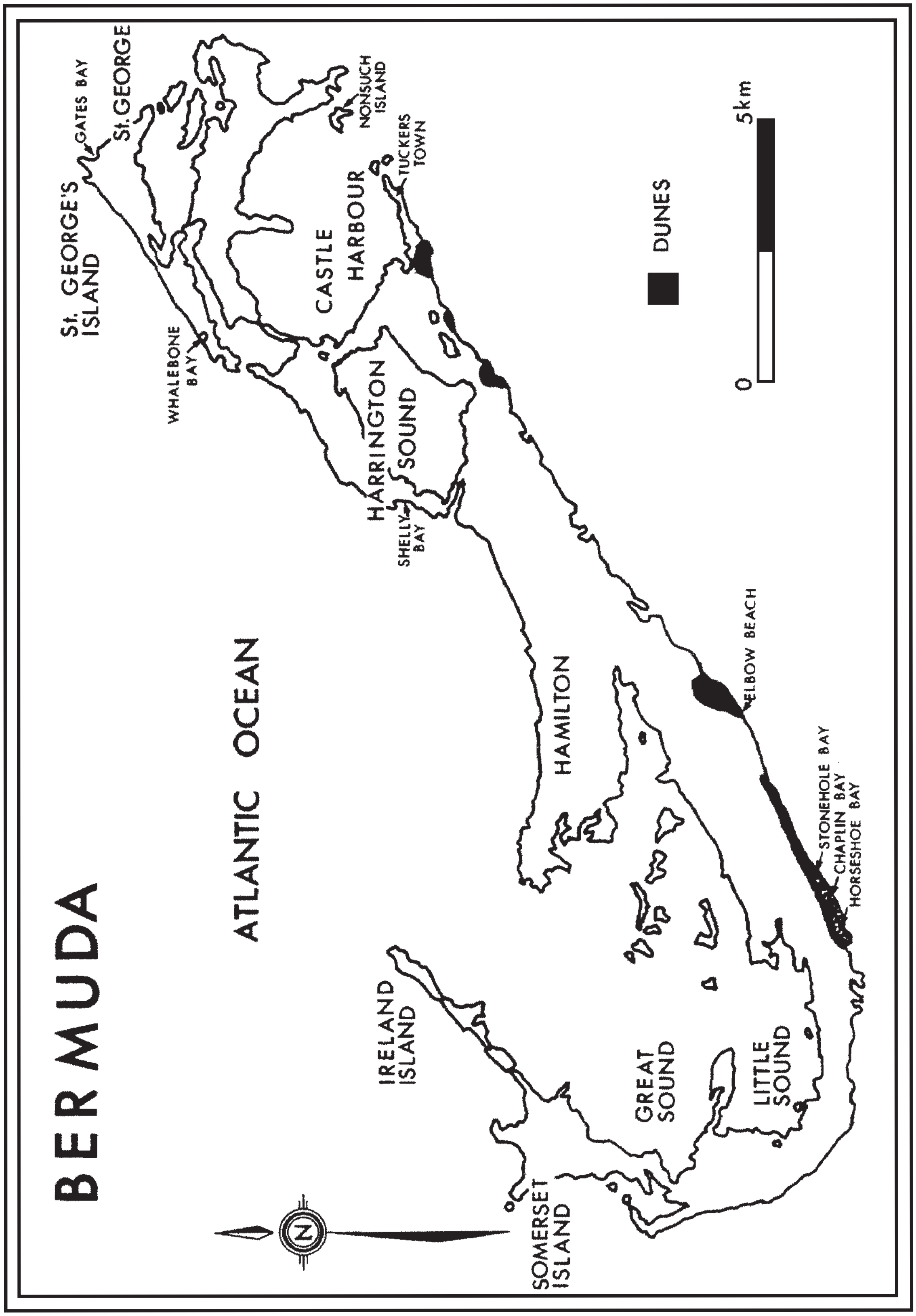


Figure 5.1. A map of Bermuda showing the locations where large dune tracts have developed since colonisation.

Environmental Conditions in Sand Dunes

The present day coastal **sand dunes** are a very harsh **environment**. They are very hot and dry in summer and all year there is the added complication of salt coming from the sea. They are exposed to strong winds from southerly directions and tropical storms and hurricanes also generally come from the south. A modern harmful complication is trampling by the feet of innumerable tourists and the hooves of horses used for recreational riding. The sand has not been in place long enough for organic matter to accumulate to any great extent. Even at the back of the **dunes**, the soil is generally of poor quality, low in organic matter and nutrient minerals and unable to hold much water. Most of the rain that falls simply percolates away through the very porous sand. It takes thousands of years for organic matter to build up enough for the soil to hold significant water. Another requirement is for the spaces between the grains to be filled by finer sand resulting from erosion, or by tiny soil grains carried by the wind from other parts of the world. The organic matter itself holds water but the reduction in permeability resulting from fine inorganic particles is also essential for good soil to develop. Within the dune system soil conditions are worst at the seaward front, improving slightly in the inland direction.

Summary

Sand dunes are a harsh **ecosystem** being frequently very hot and dry and having poor soil. They are susceptible to storm damage. The harshest conditions exist at the seaward **strand line** and improve steadily moving back.

The present **dunes** are all fixed by vegetation and only in severe storms do small **mobile dunes** develop. They too rapidly become vegetated. Nevertheless, the **dunes** support a good **diversity** of plant life in part because they receive a continual supply of seeds floating in on the ocean from the south. Several of the many **species** found on the **dunes** are unique to that **habitat**, and are threatened by disturbance of the dune **habitat**. The **dunes** are a poor **habitat** for animals and those that are resident there are tough and adapted to hot, dry conditions. However, the few resident animals are augmented by others, particularly insects, that fly in and can leave by the same means when conditions become intolerable.

Types of Dunes Found in Bermuda

Sand dunes are an excellent example of the ecological process called **succession. Succession** is a predictable and orderly change in a **habitat** or **ecosystem**. As **succession** proceeds, biological **diversity** increases and the physical characteristics of the environment change so that stability increases. **Succession** may take place <u>in time</u> or <u>in space</u>. When **succession** in time occurs, the changes happen in one location. In other words, the **community** of organisms and the physical environment change steadily at the same spot. **Succession** in space refers to the situation where these changes take place as you move through a series of adjoining locations. **Sand dunes** are particularly interesting and informative about **succession** as both **succession** in time and **succession** in space can be observed at the same general location.

Succession in space is the most obvious and can be observed as one moves from the seaward edge of the **dunes** towards the back of the **dunes** further inland. In Bermuda the first stage of **succession** is often removed in beach cleaning operations. It can, however, be readily observed on un-raked beaches such as Windsor Beach in Tuckers Town (Permission from Mid Ocean Club needed for a visit) or the South Beach on Nonsuch Island (Accessible only on tours of the island run by the Bermuda Zoological Society, for Bermuda Conservation Services[Aquarium]). This first stage of dune **succession** is called the **embryo dune**. It is found close to the **strand line** for the high **spring tides** (Chapter 3). The embryo dune can be recognised as a small ridge or series of pile of sand on which some plant life is present. Plants that colonise new **habitats** are called **pioneer plants** and the one found here is Scurvey Grass also known as Sea Rocket (*Cakile lanceolata*). The second common name is quite accurate. This is an annual plant that can grow exceedingly fast from seed carried in on the **tide**. Its structure slows the wind causing wind-blown sand to accumulate there. Unless other plants such as the Seashore Rush Grass (*Sporobolus virginicus*) colonise the embryo dune it will inevitably be destroyed by wave or storm-wind action.

In the past, dune systems in Bermuda commenced with the formation of embryo **dunes**.

The first really obvious dune behind the embryo dune (if present) is called the **fore dune;** it is typically a quite high dune and is often the highest in the dune system. The fore dune takes the form of a ridge of sand with the occasional low area. The fore dune is usually fairly well colonised by plant life but there are always some open patches where the white sand shows through. This is particularly true on the seaward slope. The plants that live there are the toughest of the dune **community** and are typically fast growers, that can rapidly send shoots up to the surface if they are buried in blown sand. Several of these plants are vines with tough wiry stems, such as the Seaside Morning Glory (*Ipomoea pes-caprae*) others are low wiry shrubs, for example the Iodine Bush (*Mallotonia gnaphalodes*). On the landward slope the plant **diversity** is higher and plant form much more varied. For instance, the well known Spanish Bayonet (*Yucca aloifolia*) is frequently present. The amount of shelter on the back slope is much greater than on the seaward slope. In severe storms, the **fore dunes** can be breached by water or wind action.

Summary

At the high tide mark at the top of sandy beaches, dunes begin with the small **embryo dune** which is usually temporary. Behind this is the **fore dune**, usually high and always partly plant covered. The next group of dunes going back are the **white dunes** which are more fully vegetated but still with sand showing through. Finally there is the sand plain with a virtually complete cover of plants and only low dunes.

In severe storms, the **fore dunes** can be breached by water or wind action, and the sand then moves back with the wind as a temporary **mobile dune.** Mobile dunes forming in Bermuda are usually short-lived as vegetation re-colonises them in a few months following a storm. The breach in the fore dune heals slowly as new vegetation grows in from the sides and traps blowing sand.

The next dune behind the fore dune has been called the **yellow dune,** a name that is a bit confusing here as our sand is white in contrast to the yellow sand prevalent in mainland **dunes**. We can call it the **white dune.** The name is derived from the fact that this dune is not fully plant covered and little patches of white sand show through all over the dune. However, this dune is much more sheltered than the fore dune and a wider **diversity** of plants of many growth habits can be found. One typical one is the Seaside Evening Primrose (*Oenothera humifusa*).

Summary

The dune behind the fore dune is the white dune. Here patches of white sand among the plants are frequent. The number of different plants that live here is higher than nearer to the sea.

Behind the white dune, in small dune systems such as those found in Bermuda, the terrain typically flattens out with only small **dunes** present and forms what is called a **sand plain**. When Bermuda was covered in extensive **dunes** much of the inland area would have been a sand plain. In the sand plain, plant cover is typically almost complete; however, in Bermuda, trampled paths have exposed quite a lot of sand. In the sand plain, soil conditions have improved quite a bit and typical land plants such as Cape Weed (*Phyla nodiflora*), Bermudiana (*Sisyrinchium bermudiana*) and Fennel (*Foeniculum vulgare*) are quite common.

Adaptations to Life in the Sand Dunes

Virtually all the plants found from the embryo dune through to the back of the white **dunes**, are highly adapted to salty soil, dry conditions, high winds and low levels of essential **plant nutrients**. Those nearest to the sea can also withstand burial by rapidly growing back to the surface.

Summary

Plants living in the sand dunes are adapted to dry,salty soil, a lack of plant nutrients and harsh winds. Many are tough and wiry and some have fleshy leaves to store water. Most can grow back to the surface if buried in sand. Many have large, floating seeds that can be carried to new locations by ocean currents.

One obvious adaptation is a tough wiry plant body very resistant to the force of the wind. Several vines there grow close to the ground where wind velocity is lower. These plants also have leathery leaves that reduce water loss from the leaf surfaces. Except in very windswept areas, many plants have a succulent structure. This shows up as thick leaves, roots and stems that can store water. These plants absorb rain water rapidly when it is present and store it to be used in dry weather. A typical example of a succulent plant is Sea Rocket. Seaside Evening Primrose is also quite succulent. Although these plants take up fresh water from rain when it is available they inevitably also absorb quite a lot of salt. They are all adapted to internal salt levels that would be lethal to most plants.

.

Another useful adaptation is the production of quite large buoyant seeds that can float on sea water and be dispersed to colonise new areas.

Fauna and Flora of the Sand Dunes

Embryo Dunes

Scurvy Grass or Sea Rocket (*Cakile lanceolata*) is the characteristic plant of the **strand line**. If embryo **dunes** persist for many months Seashore Rush Grass (*Sporobolus virginicus*) may also take hold there. These **dunes** usually disappear in winter and are easily destroyed by storms.

Summary
Sea Rocket is the characteristic plant of embryo dunes

Fore Dunes

The most frequent colonisers of the **fore dunes** are Iodine Bush, *(Mallotonia gnaphalodes)* and Beach Lobelia, *(Scaevola plumieri)* but Bay Bean, *(Canavali lineat*a), and Seaside Morning Glory, *(Ipomoea pes-caprae)* are almost always present and Tassel Plant (*Suriana maritima*) is occasionally present. **Figure 5.2** shows a typical fore dune at Stonehole Head and its flora.

Summary
Iodine Bush, Beach Lobelia, Bay Bean and Seaside Morning Glory characterize fore dunes. The Tassel Plant shrub is present in places.

The White Dunes

The plants are generally similar to the fore **dunes** but more **species** are present. Found there are the Seaside Evening Primrose (*Oenothera humifusa*), Beach Croton (*Croton punctatus*), Bay Grape (*Coccoloba uvifera*), Seaside Morning Glory (*Ipomoea pes-caprae*), Bay Bean (*Canavali lineata*), Burr-grass (*Cenchrus tribuloides*) and Spanish Bayonet (*Yucca aloifolia*), Scarlet Pimpernel (*Anagallis arvensis*), Seaside Goldenrod (*Solidago sempervirens*), plants and plant remains become more apparent.

Summary
The diversity of plants increases as one moves landward through the dunes. Seaside Evening Primrose is common in the white dunes as are Beach Croton and small Bay Grape trees. Burr Grass, Spanish Bayonet and Scarlet Pimpernel are also found.

The Seaward part of the Sand Plain

Here grasses such as the Burr-grass become common along with herbs such as the **endemic** Bemudiana, *(Sysyrinchium bermudiana)*, Seaside Evening Primrose (*Oenothera humifusa*) Wild Stock (*Matthiola incana*) and Scarlet Pimpernel (*Anagallis arvensis*) and shrubs such as Spanish Bayonet (*Yucca aloifolia*), and Tassel Plant (*Suriana maritima*). Fennel (*Foeniculum vulgare*) often forms large patches and is scattered elsewhere. Stunted individuals of coastal trees, typically Bay Grape, (*Coccoloba uvifera)*), also appear, a few Casuarina or Whispering Pine (*Casuarina equisetifolia*) and Tamarisk, (*Tamarix gallica*) stunted trees may also be found.

Summary
The sand plain has many plants also found further inland and along coasts. Examples are Hibiscus, Pittosporum, Jamaica Vervain, Fennel and Cape Weed. Trees and shrubs are more stunted than further inland.

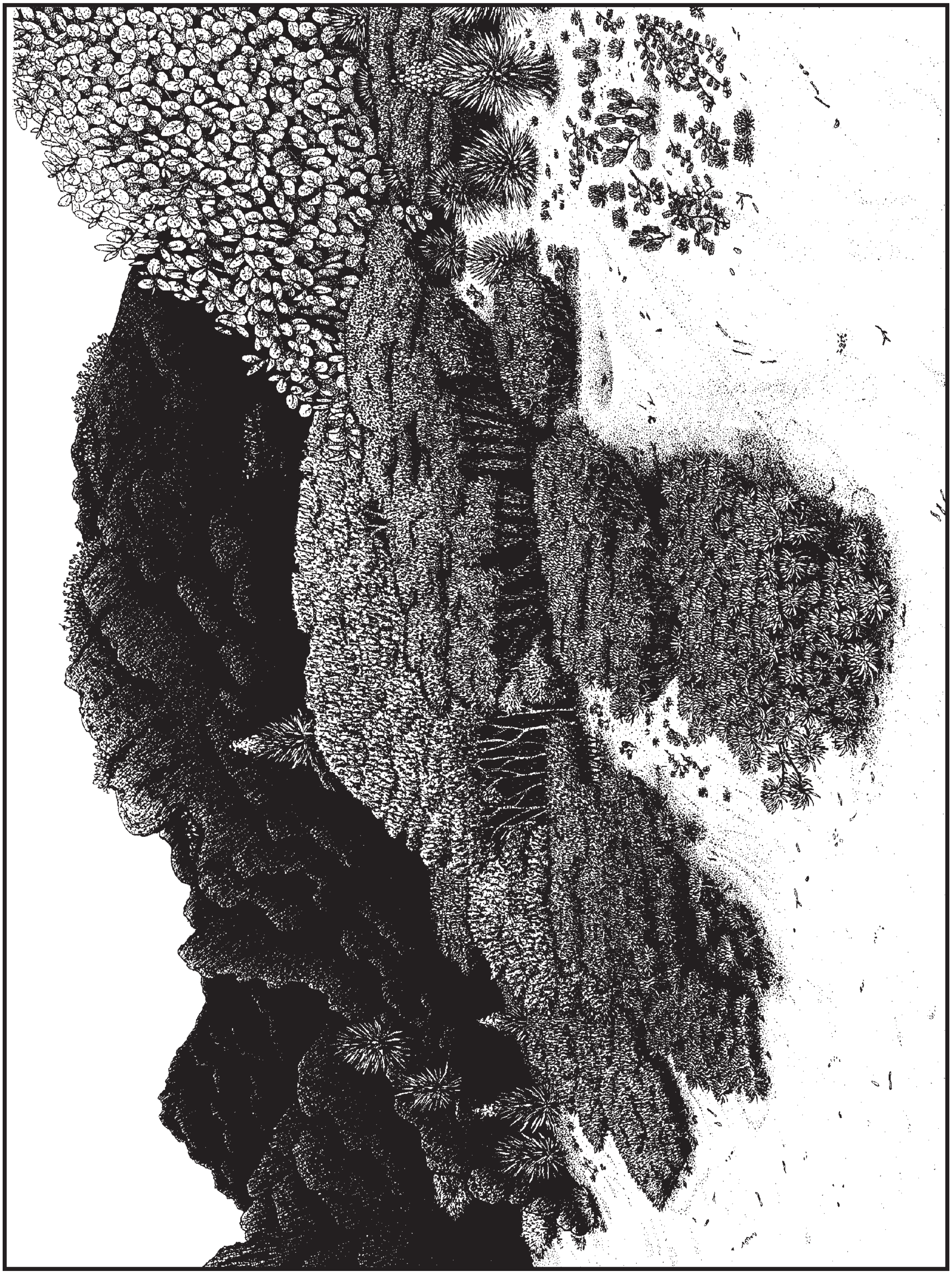
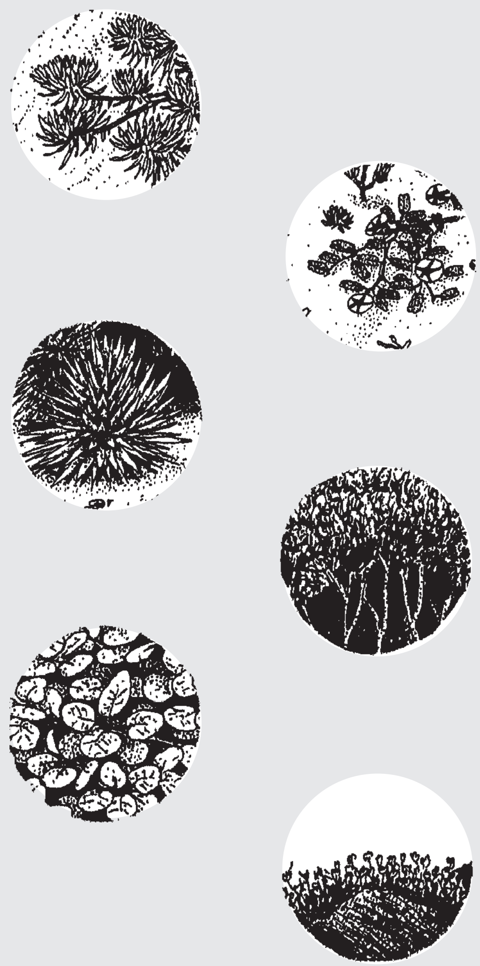


Figure 5.2. A typical fore dune at Stonehole Head

Figure 5.2. A typical fore dune at Stonehole Head showing the characteristic plants. Note that hurricanes may have caused some changes here.

Key to Figure 5.2



Iodine Bush

Seaside Morning Glory

Spanish Bayonet

Tassel Plant

Bay Grape

Sea Oxeye

The Landward Part of the **Sand Plain**

Here many introduced shrubs such as the Oleander *(Nerium oleander*), Hibiscus (*Hibiscus rosa sinensis*) and Pittosporum or Victoria Box (*Pittosporum tobira*) appear. Small herbs such as Jamaica Vervain (*Valerianoides jamaicensis*) and Cape Weed (*Lippia nodiflora*) also become common

Summary

Very few animals live in the dunes but land crabs and ants are frequent and other insects move in and out.

Animal Life in the Dunes

Throughout the **dunes** the only large animal that is resident in even small numbers is the Red Land Crab (*Gecarcinus lateralis*). All that you will see are its burrows, which are mostly back in the grey **dunes** and sand plain. This animal is on the decline in Bermuda because it is the favourite food of the Yellow-crowned Night Heron which is now very common.

If you look around you will also see colonies of the Argentinian Ant (*Iridomyrmex humilis*) or the Big-headed Ant (*Pheidole megacephala*). You may also be able to spot the food traps of the larvae of Tiger Beetles (*Cicindela trifasciata*). The **larvae** are called Ant Lions and they make a steep-sided conical pit in the sand where they wait for their ant prey.

Various other insects fly in and out of the **dunes** or appear there temporarily.

Conservation and Pollution Concerns

The **sand dunes** do not suffer greatly from pollution, but their location right behind the beaches means that there is a great deal of foot traffic through them. Additionally, they are a favourite site for horseback riding. On the heavily travelled paths, no vegetation remains and during violent storms erosion may start there. Conservation efforts need to be aimed at reducing the amount of sand dune **habitat** that is trampled. In other countries fenced board-walks are used for this purpose. Board-walks also allow the opportunity to place educational exhibits that increase public awareness of this delicate **ecosystem**.

Summary

The main threats to sand dune systems are trampling by humans and horses and severe storms which can destroy fore dunes and create mobile dunes.

Questions

1) What kind of plant might you find in an embryo dune?
2) What is the name of one other pioneer plant of the dunes?
3) Name one vine (plants with long creeping stems) found in the dunes.
4) What tree found in the dunes grows closest to the ocean?
5) What is the name of one grass found in the dunes?
6) Name one plant found in the white dunes but not in the fore dunes.
7) How might the delicate ecosystem of the dunes be better protected?
8) What are the features of succulent plants?
9) Name one adaptation of dune plants that is important for their survival.
10) Name one animal that might be found in the dunes.
11) Why does the proportion of introduced plants increase away from the sea?
12) Why are wild animals so uncommon in the dunes?
13) Name one kind of ant that occurs in the dunes.
14) Name two shrubs found in the seaward half of the dunes.
15) How are pioneer plants adapted to life on the front slope of the dunes?
16) Under what conditions do mobile dunes form?
17) Why is the term 'yellow dune' inappropriate in Bermuda?
18) Why are there no sand dunes in Bermuda except along parts of the south shore?
19) Where in the dunes might you find Spanish Bayonet plants.
20) Why do sand dune plants have to be resistant to salt within their structure?

Field Trip # 5.1 to the Sand Dunes

Preparation
Read this section of this field guide. Material on the strand line in Chapter 3 is also useful.

Dress
No special clothing is needed but shoes should be sturdy and have good non-slip soles. If it is sunny, those prone to sunburn should apply a sun-screen with a high SPF as the sand dunes are a very sunburn provoking environment.

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

Suggested Location
The best location for the study of sand dunes is the area just behind Stonehole Head in South Shore Park (Western end) there is a convenient car park there.

Observations

1) The Dune Ecosystem in General
   At the back of the dunes, the terrain slopes up steeply towards the south shore road. There is a little flat area about half way up from which a good view of the dunes is presented. From this vantage point, sketch the dunes from the sea back to where you are. You will be able to distinguish various shrubs and trees, so show their location on the diagram.

Sketch of the sand dunes at Stonehole Head

2) The Fore Dunes
Walk to where the dunes begin in a steep bank at the back of the shore. Identify the plants growing on the bank. Notice which dune plant goes closest to the beach, which comes next, and continue up to plant D.

A) Plant closest to the beach ____________________

B) Plant second closest to the beach ____________________

C) Plant third closest to the beach ____________________

D) Plant fourth closest to the beach ____________________

3) The White Dunes
Walk back into the dunes along one of the paths. Note the way the vegetation changes and how diversity (number of different plants) and plant cover increase as you go. Stop when you get to a point where the undisturbed vegetation is dense enough that little bare sand is exposed. Identify as many plants as you can and count how many different plants can be seen close to where you are.

Plants Identified

A) ____________________ B) ____________________

C) ____________________ D) ____________________

E) ____________________ F) ____________________

Total Number of different kinds of plants (Diversity) ____________________

4) The Dune Profile
A profile is really just a cross section through an ecosystem or habitat. It shows how the land surface changes and where the high and low spots are. From your observation area in the grey dunes and remembering how the dunes changed as you moved back, draw an approximate profile of the dunes. Once you have completed the profile mark on it the position of A) The beach. B) The Fore Dunes C) The Yellow Dunes. D) The Grey Dunes. E) The Sand Plain. F) The Back Slope.

Dune Profile at Stonehole Head

5) **Trees and Shrubs**. On the profile above mark in the position of

   A) The Bay Grape nearest the ocean
   B) The Whispering Pine nearest to the ocean
   C) The Oleander nearest to the ocean
   D) The Victoria Box nearest to the ocean

   Either do this with an arrow and name for each tree or do a little sketch of each tree and label it.

6) **Flowers** Walk around and list all the flowers that you can identify and for each state which kinds of dunes that they live in.

   A) Flower ______________________________
      Kind of dune ______________________________
   B) Flower ______________________________
      Kind of dune ______________________________
   C) Flower ______________________________
      Kind of dune ______________________________
   D) Flower ______________________________
      Kind of dune ______________________________
   E) Flower ______________________________
      Kind of dune ______________________________

Chapter 6. The Variety of Life along Sandy Coasts

List of Species Mentioned and/or Illustrated in this Book

Key to Habitat Codes

B	=	Lagoons, Bays and Coastal Waters	S	=	Sandy Shores
C	=	Coral Reefs	SD	=	Sand Dunes
F	=	Forest	SG	=	Seagrass Beds
M	=	Mangrove Swamps and Salt Marshes	SP	=	Saltwater Ponds
OC	=	Open Coastal	U	=	Urban Environments
R	=	Rocky Shores	W	=	Wasteland, Open Spaces, Wayside

Note: Common names are listed in the first column except where there is no accepted common name, in these cases the scientific name is used. For each group of organisms, the common names are in alphabetical order. The habitat codes defined in the key before the list show where the organisms are commonly found. The illustrations following this list are in the same order as the list and are also accompanied by habitat codes.

Common Name	Scientific Name	Taxonomy	Habitat Code
Common Plateweed	Halimeda incrassata	Seaweeds - Green Algae	S, B
Merman's Shaving Brush	Penicillus capitatus	Seaweeds - Green Algae	B, SP
Seathreads	Cladophora spp.	Seaweeds - Green Algae	B, R
Pointed Needleweed	Amphiroa fragilissima	Seaweeds - Red Algae	B, C
Scaleweed	Fosliella farinosa	Seaweeds - Red Algae	SG
Burr-grass	Cenchrus tribuloides	Grasses	SD
Seashore Rush Grass	Sporobolus virginicus	Grasses	OC, R
Beach Croton	Croton punctatus	Herbaceous Flowering Plants	SD
Beach Lobelia	Scaevola plumieri	Herbaceous Flowering Plants	SD
Bermudiana	Sisyrinchium bermudiana	Herbaceous Flowering Plants	OC, U, W
Cape Weed	Phyla nodiflora	Herbaceous Flowering Plants	OC, SD, W
Fennel	Foeniculum vulgare	Herbaceous Flowering Plants	U, W
Jamaica Vervain	Stachytarpheta jamaicensis	Herbaceous Flowering Plants	OC, SD, W
Manatee Grass	Syringodium filiforme	Herbaceous Flowering Plants	B, SG
Scarlet Pimpernel	Anagallis arvensis	Herbaceous Flowering Plants	S, SD
Scurvy Grass or Sea Rocket	Cakile lanceolata	Herbaceous Flowering Plants	S, SD
Seaside Evening Primrose	Oenothera humifusa	Herbaceous Flowering Plants	SD
Seaside Goldenrod	Solidago sempervirens	Herbaceous Flowering Plants	OC
Shoal Grass	Halodule wrightii	Herbaceous Flowering Plants	B, SG
Spanish Bayonet	Yucca aloifolia	Herbaceous Flowering Plants	OC, SD, W
Turtle Grass	Thalassia testudinum	Herbaceous Flowering Plants	B, SG
Wild Stock	Matthiola incana	Herbaceous Flowering Plants	SD
Bay Bean	Canavali lineata	Vines	OC, SD
Seaside Morning Glory	Ipomoea pes-caprae	Vines	SD
Hibiscus	Hibiscus rosa sinensis	Shrubs	SD, U, W
Iodine Bush	Mallotonia gnaphalodes	Shrubs	OC, SD
Oleander	Nerium oleander	Shrubs	U
Pittosporum, Mock Orange or Victoria Box	Pittosporum tobira	Shrubs	F, U, W
Tassel Plant	Suriana maritima	Shrubs	OC, SD
Bay Grape	Coccoloba uvifera	Trees	F, OC

Casuarina, Australian Whistling Pine or Whispering Pine	Casuarina equisetifolia	Trees	F, OC, W
Tamarisk	Tamarix gallica	Trees	F, OC, SD
Condylostoma arenarium	Condylostoma arenarium	Interstitial Animals - Ciliates	S, B
Geleia nigriceps	Geleia nigriceps	Interstitial Animals - Ciliates	S, B
Helicoprorodon gigas	Helicoprorodon gigas	Interstitial Animals - Ciliates	S, B
Tracheloraphis incaudatus	Tracheloraphis incaudatus	Interstitial Animals - Ciliates	S, B
Carcharodorhynchus sp.	Carcharodorhynchus sp.	Interstitial Animals - Flatworms	S, B
Paramyozonaria bermudensis	Paramyozonaria bermudensis	Interstitial Animals - Flatworms	S, B
Pseudominona dactylifera	Pseudominona dactylifera	Interstitial Animals - Flatworms	S, B
Macrodasys sp.	Macrodasys sp.	Interstitial Animals - Belly-Hairlings	S, B
Tetranchyroderma sp.	Tetranchyroderma sp.	Interstitial Animals - Belly-Hairlings	S, B
Cyttaronema reticulatum	Cyttaronema reticulatum	Interstitial Animals - Belly-Hairlings	S, B
Eubostrichus dianae	Eubostrichus dianae	Interstitial Animals - Belly-Hairlings	S, B
Paramonohystera weiseri	Paramonohystera weiseri	Interstitial Animals - Belly-Hairlings	S, B
Batillipes pennaki	Batillipes pennaki	Interstitial Animals - Water Bears	S, B
Echiniscoides sigismundi	Echiniscoides sigismundi	Interstitial Animals - Water Bears	S, B
Florarctus antillensis	Florarctus antillensis	Interstitial Animals - Water Bears	S, B
Orzeliscus belopus	Orzeliscus belopus	Interstitial Animals - Water Bears	S, B
Parastygarctus sterreri	Parastygarctus sterreri	Interstitial Animals - Water Bears	S, B
Bulbamphiascus imus	Bulbamphiascus imus	Interstitial Animals - Crustacea	S, B
Leptastacus macronyx	Leptastacus macronyx	Interstitial Animals - Crustacea	S, B
Paralaophonte brevirostris	Paralaophonte brevirostris	Interstitial Animals - Crustacea	S, B
Phyllopodopsyllus hermani	Phyllopodopsyllus hermani	Interstitial Animals - Crustacea	S, B
Red Foraminiferan	Homotrema rubrum	Foraminiferans	C
Burrowing Sea Anemone	Arachnanthus nocturnus	Anemones	S, B
Green Sea Mat	Zoanthus sociatus	Anemones	B, C
Pale Flatworm	Notoplana binoculata	Flatworms	S, B
Sharp-head Nemertine	Cerebratulus leidyi	Ribbonworms	S, B
Burrowing Spiny Head	Sipunculus norvegicus	Spiny-headed Worms	S, B
Cockworm	Arenicola cristata	Polychaete Worms	S, B
Golden Burrowing Worm	Naineris setosa	Polychaete Worms	S, B
Red Glycera	Glycera abranchiata	Polychaete Worms	S, B
Red Tube Worm	Loimia medusa	Polychaete Worms	S, B
Round-head Notomastus	Notomastus latericeus	Polychaete Worms	S, B
Argentinian Ant	Iridomyrmex humilis	Insects - Ants	F, SD, U, W
Big-headed or Brown House Ant	Pheidole megacephala	Insects - Ants	U, SD
Devil's Coach Horse	Cafius bistriatus	Insects - Beetles	S
Tiger Beetle	Cicindela trifasciata	Insects - Beetles	S
Seaside Earwig	Anisolabis maritima	Insects - Earwigs	S
Seaweed Fly	Fucellia intermedia	Insects - Flies and Mosquitos	S
Beach Flea	Orchestia sp.	Crustacea - Amphipods	S
Common Mud Crab	Panopeus herbstii	Crustacea - Crabs	S, B
Florida Mud Crab	Cataleptodius floridanus	Crustacea - Crabs	S, B
Ghost Crab	Ocypode quadrata	Crustacea - Crabs	S
Land Crab or Red Land Crab	Gecarcinus lateralis	Crustacea - Crabs	OC, SD
Mole Crab	Hippa testudinaria	Crustacea - Crabs	S
Mottled Swimming Crab	Portunus depressifrons	Crustacea - Crabs	S, B
Clear Haminoea	Haminoea antillarum	Gastropoda - Snails	S, B
False Cerith	Batillaria minima	Gastropoda - Snails	B, M
Lettered Horn Shell	Cerithium litteratum	Gastropoda - Snails	B, SG
Milky Moon Snail	Polinices lacteus	Gastropoda - Snails	S, B
Tinted Cantharus	Pisania tincta	Gastropoda - Snails	S, B
Black Date Mussel	Lithophaga nigra	Clams and Mussels	B, C
Purple Mussel	Asaphis deflorata	Clams and Mussels	S, B

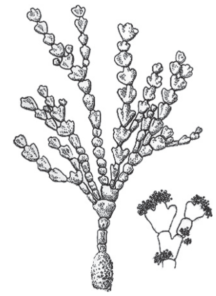
Two-spotted False Donax	Heterodonax bimaculata	Clams and Mussels	S
Sand Dollar	Leodia sexiesperforata	Echinoderms - Sand Dollars	B
Burrowing Sea Cucumber	Holothuria arenicola	Echinoderms - Sea Cucumbers	B
Sea Pudding	Isostichopus badionotus	Echinoderms - Sea Cucumbers	B
Bermuda Skink	Eumeces longirostris	Lizards	F, OC
Great Kiskadee	Pitangus sulphuratus	Birds - Flycatchers	F, U, W
Ruddy Turnstone	Arenaria interpres	Birds - Shorebirds	B, OC
Sanderling	Calidrys alba	Birds - Shorebirds	S
House Sparrow	Passer domesticus	Birds - Sparrows	U, W
Starling	Sturnus vulgaris	Birds - Starlings	F, U, W

Species Illustrations and Descriptions

Seaweeds

Green Algae

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**.

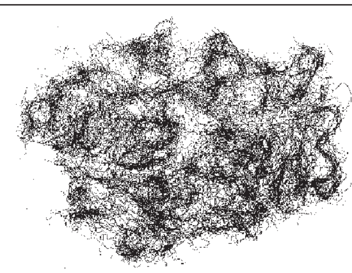


S, B

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

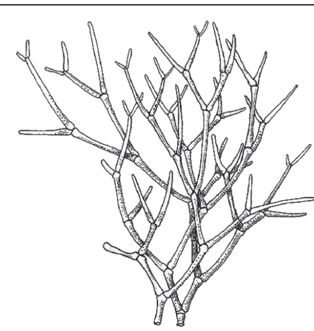
Seathreads
Cladophora spp.
When you see slimy green masses of tangled very fine filaments it is probably one of the Cladophoras. These weeds in masses from a few cm (in) to a few metres (ft) across are common in fresh, brackish and salt waters. **Native.**



B, R

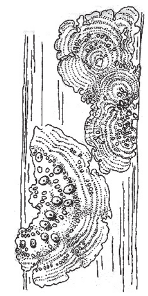
Red Algae

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



B, C

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



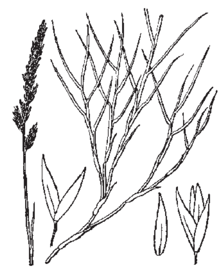
SG

Grasses

Burr-grass
Cenchrus tribuloides
This is easy to recognize in the summer and autumn as its sharply burred fruit will become attached to your clothing! Beware...the barbed spines on the burrs can inflict painful wounds. It flowers from spring to autumn. Like all dune grasses, it is important in stabilizing sand dunes. About 25 cm (10 in) tall. **Native**.

SD

Seashore Rush Grass
Sporobolus virginicus
This is a fairly low trailing grass of partly salty places. The stems are stout, firm and scaly rising above the soil. The narrow 4 mm (1/8 in) wide leaves are numerous, and their basal sheaths overlap. About 40 cm (15 in) high. **Native.**



OC, R

Herbaceous Flowering Plants

Beach Croton
Croton punctatus
This is a smallish shrub with grey leaves, which are spotted on the underside, and with tiny almost camouflaged flowers. Presumably it was transported here by the ocean. It can survive being almost buried by sand as newly buried stems grow roots. Grows 30-95 cm (1-3 ft) tall. **Native**.

SD

SD

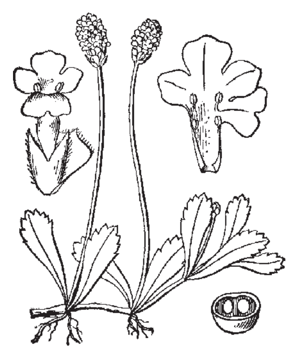
Beach Lobelia
Scaevola plumieri
This native shrub has thick, fleshy, waxy leaves. Individual stems grow right out of the dune, growing taller as the sand accumulates. Its odd shaped whitish flowers can be seen from spring to autumn followed by two seeded, juicy, purplish-black berries. Leaves 3-8 cm (1-3 in) long. Plant to 1m (3 ft) high. **Native**.

OC, U, W

Bermudiana
Sisyrinchium bermudiana
Often called the National Flower of Bermuda, Bermudiana grows from a bulb and bears blue flowers in spring. The plant has strap-like leaves. Very common. 15-30 cm (6-12 in) high. **Endemic.**

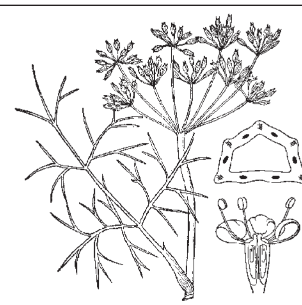
OC, SD, W

Cape Weed
Phyla nodiflora
This very widespread herb grows in a variety of habitats, including swamps and marshes, and may be mixed with other plants, for example in lawns, or grow in pure mats 15-25 cm (6-10 in) deep. The leaves are small up to 5 cm (1 3/4 in) long and have about 7 teeth on each side on the broad end. The flowers are like small buttons and very pale pink in colour. Originally from the African tropics the plant arrived naturally. **Native**.



U, W

Fennel
Foeniculum vulgare
This well known aromatic herb is used in cooking. The stout stems rise up to 1.3 m (4 ft) or occasionally more and bear the large, flat flower heads with small yellow flowers. The leaves are very finely divided but quite large, up to 30 cm (1 ft) long. **Introduced** from Europe.



Jamaica Vervain
Stachytarpheta jamaicensis
This is an extremely pretty little plant. The 5-petalled flowers in a heavenly shade of blue are scattered on a tall flower spike. The oval, toothed leaves are paired on a robust, hairy stem. Found in a variety of habitats including open woodland. Up to 50 cm (1 1/2 f)t in height. **Native**.

OC, SD, W

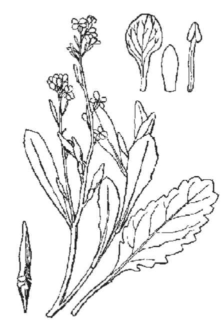
Manatee Grass
Syringodium filiforme
Leaves round in cross section, narrow and up to 30 cm (6 in) long. Quite common in small stands and mixed with the other two species of seagrass. **Native.**

B, SG

Scarlet Pimpernel
Anagallis arvensis
This is a small flowering herb found in the sand dunes and coastal grassland. It grows close to the ground, seldom reaching more than 8 cm (3 in) high. The very attractive, small flowers have five red, rounded petals; the opposite leaves have a broad, rounded base and bluntly-pointed tip. **Naturalised**. **Introduced**.

S, SD

Scurvy Grass or **Sea Rocket**
Cakile lanceolata
This is a fleshy plant most typical of the strand-line of sandy shores, but also occurring in mangrove swamps and salt-marshes. The plant grows up to 70 cm (24 in) high. The 2-7 cm (1-2 1/2 in) long leaves are somewhat dished and the edges wavy. The 4-petalled flowers are white in a terminal spike. **Native**.



S

Seaside Evening Primrose
Oenothera humifusa
This native grows mostly along the ground in sunny areas. Its yellow flowers turn pinkish-maroon by the end of the day, and bloom during summer and autumn. About 20 cm (8 in) high. **Native.**

S, SD

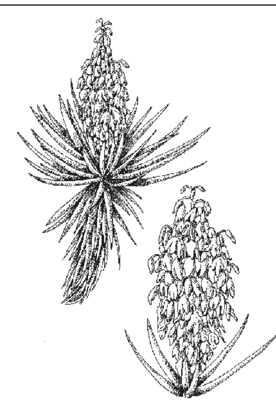
Seaside Goldenrod
Solidago sempervirens
This herbaceous plant has an exceedingly wide geographic distribution and occupies a wide range of habitats. The stem is stout with the long leaves closely arranged around the stem. The stem is crowned by a long flower head with very numerous, small yellow flowers, each daisy-like in appearance. Flowers in summer and autumn. About 70-100 cm (2-3 ft) high. **Native.**

OC

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

Spanish Bayonet
Yucca aloifolia
Easily recognizable by its long, needle-like leaves, this is a plant seen very commonly along the south shore of Bermuda. It has very thick, fleshy leaves often with serrations along the edges. The flowers are white, growing on spikes of about 70 cm (2 ft) in length which appear from spring to autumn. These flowers are pollinated by night-flying moths. When not in flower the plant grows to 3m (10 ft). **Native**.



OC, SD, W

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

B, SG

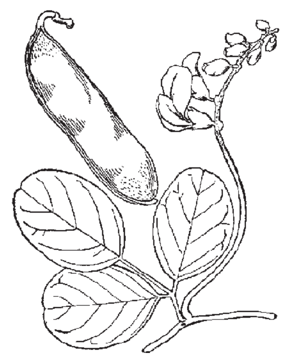
SD

Wild Stock
Matthiola incana
Wild Stock has very attractive purple flowers in the spring. This plant grows in somewhat sheltered dune areas such as in the lee of rocky headlands and may also be found in places on the roadside along the south shore. The leaves are grey-green and oblong in shape. About 35 cm (14 in) high. **Naturalized**.

Vines

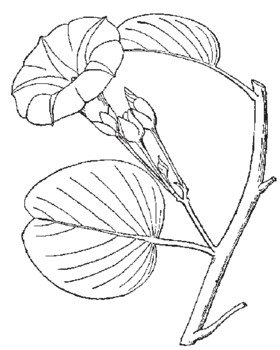
OC, SD

Bay Bean
Canavali lineata
This is easily confused with seaside morning glory when it is not in bloom. It has rounded leathery leaves which grow on little branches, in threes, along the vine. Its flowers, which look like miniature purple sweet peas, can be seen in the autumn and winter. Wide pods can be seen on the vine all year. It has the capacity for rapid vertical and horizontal growth so it can deal with the problem of shifting sand. The vine may grow as long as 7.5 m (25 ft). **Native**.



SD

Seaside Morning Glory
Ipomoea pes-caprae
As Seaside Morning Glory is able to grow horizontally and vertically it can escape from being buried by shifting sand. This native vine has leaves which are rounded at the base and notched at the tip. Its purple-mauve flowers can be seen during the summer and autumn. (The bay bean's leaves are similar and often confused.) Up to 10 m (30 ft) long. **Native.**



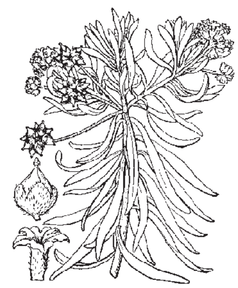
Shrubs

SD, U, W

Hibiscus
Hibiscus rosa sinensis
A shrub with a great many cultivars having large, trumpet-shaped flowers, from white to red, borne over a long season. This shrub is widely planted in gardens, parks and hedgerows and is one of the commonest introduced shrubs. Growing to 4 m (12 ft). **Introduced.**

OC, SD

Iodine Bush
Mallotonia gnaphalodes
A low-growing native shrub, the bay lavender has numerous long fleshy leaves which are covered in downy hair. The flowers which grow up through the centre of the leaf cluster are white and bell-shaped, appearing from spring to autumn. To 90 cm (3 ft) high. **Native.**

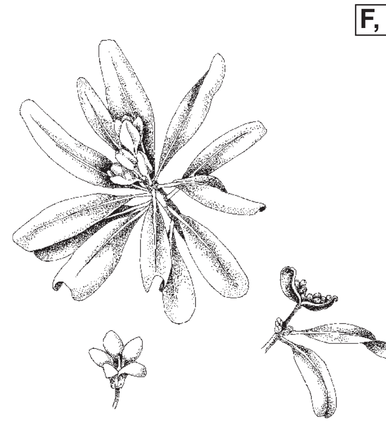


U

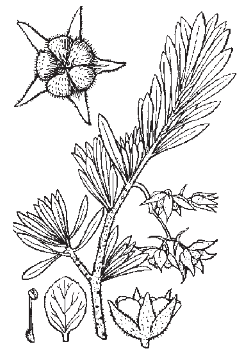
Oleander
Nerium oleander
The oleander was introduced in 1790. It was known as “The South Sea Rose” and was often used to decorate wedding cakes. It is now naturalized. It blooms mainly in the spring and summer. The oleander provides a good windbreak for plants growing on the leeward side of the dunes. To 3 m (10 ft) high. **Introduced** and **naturalized**.

F, U, W

Pittosporum, Mock Orange or **Victoria Box**
Pittosporum tobira
A shrub or small tree. The leaves, which can grow to 10 cm (4 in) long, are egg shaped with the broader end above the middle. They are dark green, shiny and leathery in texture. The edges of the leaf are rolled toward the underside of the leaf. The leaves have quite a distinctive smell when crushed. Five-petalled flowers are white to lemon-yellow. The half inch long flowers grow in fragrant clusters. The fruit is a green capsule which splits into three segments containing attractive, red, sticky seeds. Can grow to 6.5 m (18 ft). **Introduced.**



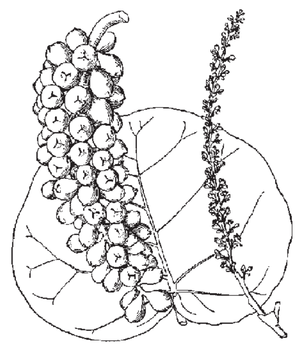
Tassel Plant
Suriana maritima
A shrub of sandy coasts often growing in dense thickets. It has clustered leaves and varies in height from the low-growing to fairly tall. The leaves are soft in texture and covered with fine, silky hairs. The yellow flowers, appearing mostly from spring to autumn, are protected by "tassel-like" leafy clusters giving the plant its name. 1.5-2 m (4-6 ft) high. **Native**



OC, SD

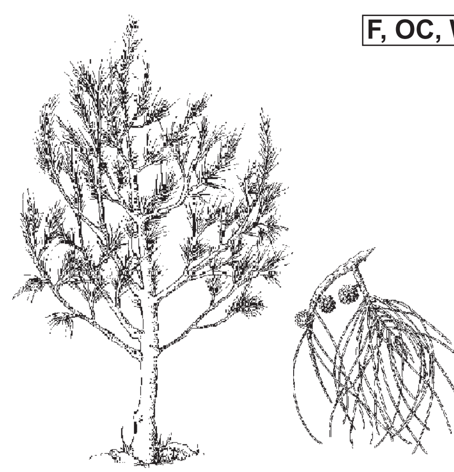
Trees

Bay Grape
Coccoloba uvifera
Commonly found either as a large shrub or a tree, this native plant has a short, twisted trunk and large rounded leathery leaves, highly resistant to salt spray. The flowers are borne on long spikes from spring to autumn and are tiny and whitish in colour. The fruit that follow resemble grapes in size and colour and are often used in jams and jellies. Variable in height 2-18 m (6-18 ft). **Native.**



F, OC, SD

Casuarina, Australian Whistling Pine or **Whispering Pine**
Casuarina equisetifolia
Casuarina is a shallow rooted tree. It resembles a conifer but the "pine needles" are segmented branchlets about 1 cm.(3/8 in) long with tiny leaf scales appearing at the segments. The branchlets appear in sprays. There are separate male and female flowers. The female flowers produce a prickly cone with tiny winged seeds. This fast growing tree was planted in large numbers during the 1940s, following the Bermuda Cedar blight. Grows from 10-25 m (30 to 80 ft) high. **Introduced.**



F, OC, W

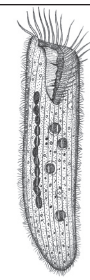
Tamarisk
Tamarix gallica
A small tough tree or large shrub, typical of windswept shorelines and very common along the North shore. It is also found bordering ponds and scattered in other habitats. The branches are arching and the leaves small and scale-like. The attractive pink flowers appear in sprays. It is often called “spruce”. Up to about 5 m (15 ft) high. **Introduced**.

F, OC

Interstitial Animals

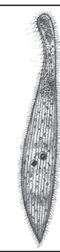
Ciliates

Condylostoma arenarium
Although this tiny protozoan animal only just over 0.6 mm (1/32 in) long, has no common name its second scientific name ‘arenarium’ tells us that it is a sand dweller. It is quite broad in the body and one end has a ‘cup’ surrounded by longer hairs.



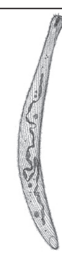
S, B

Geleia nigriceps
A tiny protozoan animal reaching just over 0.6 mm (1/32 in) that is found among sand grains can only be observed with a microscope. It is a slim pear-shape and almost colourless.



S, B

Helicoprorodon gigas
As suggested by the scientific name this protozoan reaching over 2 mm (1/16 in) long is a ‘giant’ among its relatives. It is covered with fine hairs or cilia and is rather sickle-shaped.



S, B

Tracheloraphis incaudatus
This tiny protozoan that lives between the sand grains reaches just over 0.6 mm (1/32 in) long. It is slim, covered with tiny, beating hairs and can only be seen by using a microscope.

S, B

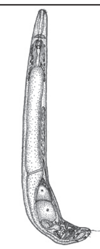
Flatworms

S, B

Carcharodorhynchus sp.
When a scientific name has sp. at the end it simply means that there are several similar species that are hard to tell apart. Under a microscope this flatworm appears as a yellowish-brown slim worm only 1.2 mm (1/16 in) long.

S, B

Paramyozonaria bermudensis
A small brown flatworm named for its discovery in Bermuda but also found elsewhere. It is only 1.2 mm (1/16 in) long, quite slim and not uncommon among the grains of sand.



S, B

Pseudominona dactylifera
This very small flatworm only just over 2 mm (1/16 in) long slides among the sand grains. It is very slim and can be distinguished from relatives by the three finger-like extensions at the rear end.

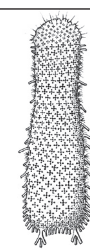
Belly-Hairlings

S, B

Macrodasys sp.
These very tiny animals glide over the surface of sand grains. There are small spines scattered on the back. These can only be seen under a good microscope, as they are less than 1 mm (1/64 in) long. This one has a pointed rear-end.

S, B

Tetranchyroderma sp.
A very tiny worm only 0.28 mm (1/110 in) long is shaped like a slim pear and has a scaly back with occasional stout spines. They prey on other tiny sand-dwelling creatures.



Round Worms

Cyttaronema reticulatum
This tiny worm is less than 1.1 mm (1/16 in) long. It is common on all sand bottoms from the bottom of the shore out. It has numerous rings around the body and feeds on decaying organic material.

S, B

Eubostrichus dianae
This is an extremely abundant little roundworm that reaches about 2.6 mm (3/32 in) in length. It is found in darkish coloured fine sand both inter-tidally and just offshore. The body looks hairy but in fact the 'hairs' are tiny organisms attached to the skin.

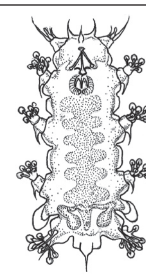
S, B

Paramonohystera wieseri
Roundworms as a group vary greatly in size and habitat. This example is small, very slim and burrows between sand grains. It can live in fine sand that is blackened in colour and lacking much oxygen and reaches about 2.6 mm (3/32 in) in length.

S, B

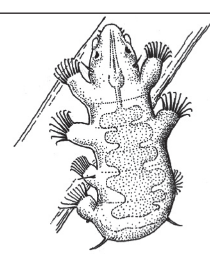
Water Bears

Batillipes pennaki
This Water Bear has much shorter leg-like appendages than most of its relatives. This tiny animal is only about 0.2 mm (1/100 in) long. It also extends further up into the intertidal zone than many of its cousins and is very common in Bermuda,



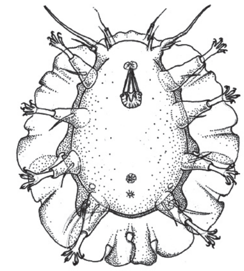
S, B

Echiniscoides sigismundi
A tiny Water Bear typical of coarse sands, this microscopic animal reaches only 0.2 mm (1/100 in) long, and can only be observed under a powerful microscope. It has 8 leg-like extensions on the side of the body.



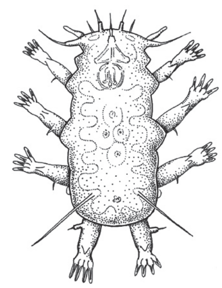
S, B

Florarctus antillensis
A tiny Water Bear only 0.2 mm (1/100 in) long, this one has a membrane between all the leg-like extensions that resembles a flaring skirt. It is very common in coarse sands below low tide mark and occasionally within the lower intertidal area.



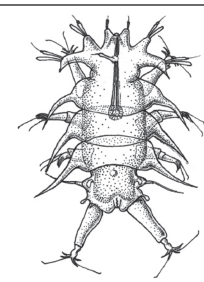
S, B

Orzeliscus belopus
As with its close relatives this is a tiny creature only 0.2 mm (1/100 in) long. It is usually only seen by specialists using microscopes. There are two long spines at the back as well as the 8 leg-like extensions typical of Water Bears.



S, B

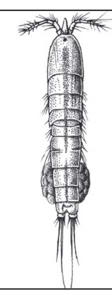
Parastygarctus sterreri
This fascinating little animals is named after Wolfgang Sterrer, a specialist in this group of tiny animals who has been the Curator of the Bermuda Aquarium Natural History Museum. Only 0.2 mm (1/100 in) long these are found in coarse sands.



S, B

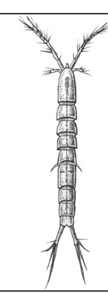
Crustacea

Bulbamphiascus imus
This small, active crustacean burrows in sand-silt lower shores and subtidal areas. It is just less than 0.8 mm (1/16 in) long and grayish-yellow in colour. The body is slim tapering back. There are two short antennae at the front.



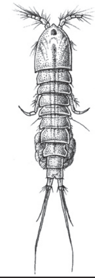
S, B

Leptastacus macronyx
Typical of well-sorted, medium-grained beach sand this little shrimp-like crustacean is often the most common member of this group found well above low tide level. It is only about 0.7 mm (1/32 in) long and can easily be overlooked.



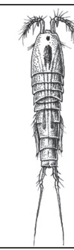
S, B

Paralaophonte brevirostris
This animal is very small measuring only about 0.6 mm (1/32 in) long. It lives between the sand grains of fairly coarse sand lower shores and bays. It has two short antennae at the front and two long appendages at the back.



S, B

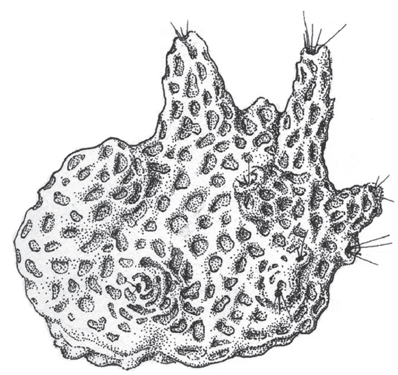
Phyllopodopsyllus hermani
This small shrimp-like crustacean can be very abundant in well sorted medium to coarse grained sub-tidal and lower intertidal sand. It is just less than 0.8 mm (1/16 in) long, has two short, back curving antennae.



S, B

Foraminiferans

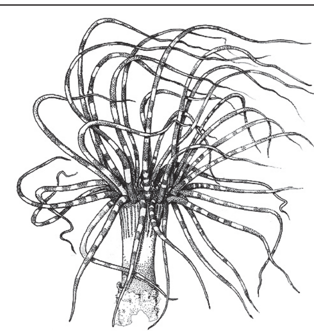
Red Foraminiferan
Homotrema rubrum
Protozoans are normally single-celled animals that are invisible to the naked eye. The Red Foraminiferan is an exception in that individuals may be 5 mm (1/4 in) across. This is still small but the bright red colour is very obvious. Living individuals are abundant in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



C

Anemones

Burrowing Sea Anemone
Arachnanthus nocturnus
This anemone makes a tube of sand or fine gravel in the sand. The bottom is usually attached to a stone. Living at about low tide mark, it is difficult to spot as it disappears into the tube. The tentacles are quite long pale with darker brown bars. An extended individual can reach 15 cm (6 in) long including the body. **Native**.



S, B

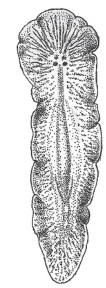
S, B

Green Sea Mat
Zoanthus sociatus
The Green Sea Mat is the commonest of the sheet-forming colonial anemones common on nearshore and inshore reefs. It forms a layer on the bottom which may be at least 1 m (3 ft) across. The individual anemones are about 1 cm (3/8 in) across and bright green in colour. **Native**.

Flatworms

S, B

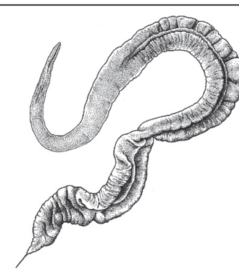
Pale Flatworm
Notoplana binoculata
As the name suggests this is a very flat worm that may be found under rocks in the lower shore. The pinkish-white body may reach 35 mm (1 1/2 in) in length. There are two dark eyes near to the rounded, broader front end. Behind the eyes, the body tapers steadily to a blunt point. **Native**.



Ribbonworms

S, B

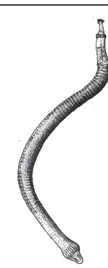
Sharp-head Nemertine
Cerebratulus leidyi
This is a curious worm that is never seen on the surface when the tide is low. At high tide they do sometimes emerge and may swim to lights. This burrowing worm can reach 20 cm (8 in) in length. It is a deep red in colour and has no markings. **Native**.



Spiny-headed Worms

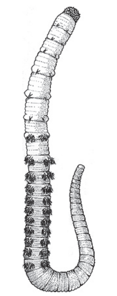
S, B

Burrowing Spiny Head
Sipunculus norvegicus
This very strange worm burrows in the intertidal zone of somewhat sheltered sand/mud shores. It grows to about 9 cm (3 1/2 in) in length. The head has a long ‘snout’ with a spiny tip. The worm is flesh coloured. **Native**.



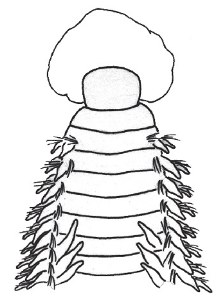
Polychaete Worms

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.**



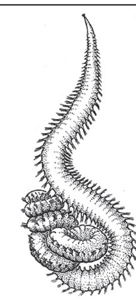
S, B

Golden Burrowing Worm
Naineris setosa
This worm grows to just less than 95 cm (4 in) in length. The bristles down each side of the body are golden in colour, giving the worm its common name. This worm burrows in muddy sand and feeds on organic material in the sand that it swallows in large quantity. Very common. **Native**.



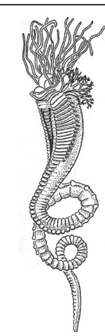
S, B

Red Glycera
Glycera abranchiata
This worm growing to about 10 cm or 4 inches is an active burrower in intertidal sand/mud shores. It is a carnivore hunting its prey within the sediment. Unlike many other worms in this habitat, its burrow is only temporary. The head is conical with a pointed tip and the colour is red. **Native**.



S, B

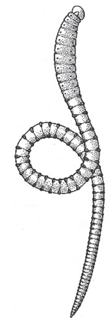
Red Tube Worm
Loimia medusa
This tube-dwelling worm has a very descriptive scientific name since the front end has a mass of long, thin tentacles that can be drawn back into the tube. The body, up to about 20 cm (8 in) long has two distinct regions; the forward part is thick and robust while the hind-end tapers gradually to a bluntly pointed tip. In life the worm is flesh coloured. **Native**.



S, B

S, B

Round-head Notomastus
Notomastus latericeus
This marine worm is rather like terrestrial earthworms. The head is quite globular and the body is divided into two distinct regions. The fore body is broad and the hind body slimmer and tapering towards the tail. This is quite a large worm reaching about 30 cm (1 ft); the colour is reddish. A long-lasting burrow is formed. **Native**.

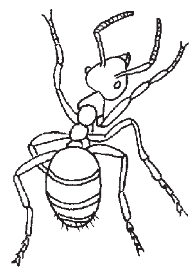


Insects

Ants

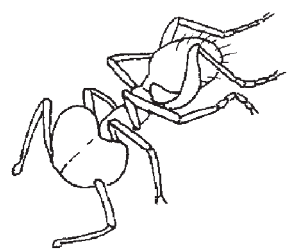
F, SD, U, W

Argentinian Ant
Iridomyrmex humilis
This small ant is very common in a wide variety of habitats from houses to sand dunes. It lives in large colonies in holes or cavities excavated into the ground. It is often abundant under trash lying on the ground. These ants are brownish and only 3 mm (1/8 in) long. **Naturalized**.



U, SD

Big-headed or **Brown House Ant**
Pheidole megacephala
The Big-headed Ant originated in Africa but is now widespread throughout the tropics and sub-tropics. Accidentally introduced to Bermuda in the latter part of the 19th century, the Big-headed Ant drove the native ants to extinction and has since been replaced in many habitats by the more aggressive Argentinian Ant. 7mm (1/4 in) long. **Introduced.**



Beetles

S

Devil's Coach Horse
Cafius bistriatus
This is an active, small, elongated rove beetle with very small wing covers and a six-segmented abdomen. Dark brown in colour it is found crawling around in dead seaweed at the strand line of sandy shores. Grows only to 10 mm (3/8 in) long. **Native.**

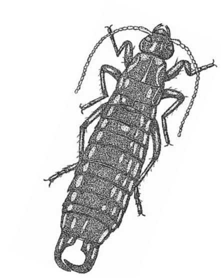
S

Tiger Beetle
Cicindela trifasciata
This beetle often seen on the surface of the sand in the upper shore is an active runner and swift flyer. The colour is an iridescent bright green. The larvae, called Ant Lions, make pits in the sand to catch prey. 10 mm (3/8 in) long. **Native**.

Earwigs

S

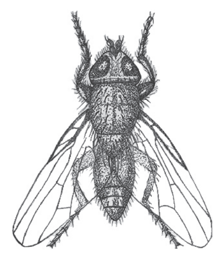
Seaside Earwig
Anisolabis maritima
A typical earwig with crossing pincers at the rear end. There are no wings and the body is dark brown with paler legs. This earwig is found under piles of rotting seaweed at the strand line of sandy beaches. About 20 mm (3/4 in) long. **Native**.



Flies and Mosquitos

S

Seaweed Fly
Fucellia intermedia
This slender, reddish-brown seaweed fly is common on beach wrack and seaweed. It prefers to lay its eggs on seaweed where the larvae complete their development. It is a familiar nuisance to sunbathers. To 6 mm 1/4 in). **Native**.

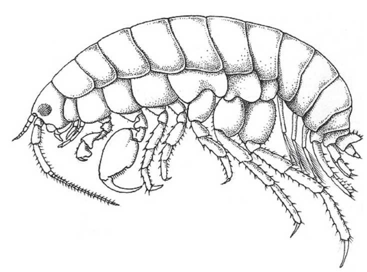


Crustacea

Amphipods

S

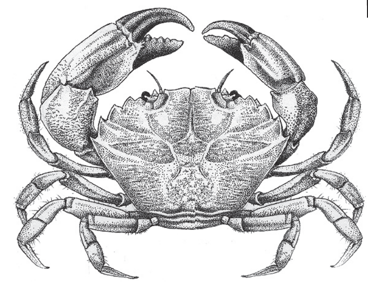
Beach Flea
Orchestia sp.
This terrestrial beach hopper is very commonly found under beached Sargassum weed or under the sand above the high tide line. It is aptly named, for it can jump almost a metre by flexing its powerful abdomen. Greyish-brown in colour. It feeds on detritus at the strand line. To 13 mm (1/2 in). **Native**.



Crabs

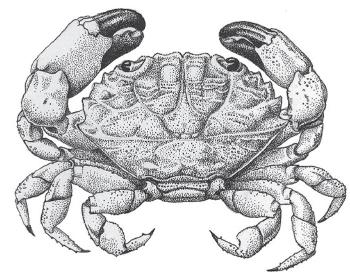
S, B

Common Mud Crab
Panopeus herbstii
This is a moderately sized crab with a shell about 5 cm (2 in) across. There are five distinct teeth between the eyes and the widest part of the back. The back is brown, mottled with green and various shades of brown. The large claws are black-tipped. It is a scavenger that lives in burrows that it digs in the lower intertidal zone. **Native**.



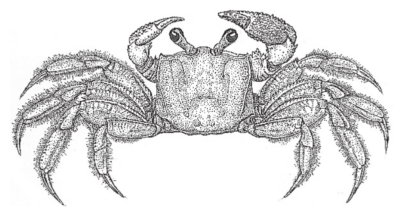
S, B

Florida Mud Crab
Cataleptodius floridanus
This is a small crab less than 3.5 cm (1 1/2 in) across the back. The top of the main shell is strongly grooved and there are four strong teeth between the eyes and the broadest point. The colour is a mottled brown on a lighter background. The tips of the large claws are darker in colour. When the tide is out this crab hides under the cover of stones or marine plants. **Native**.



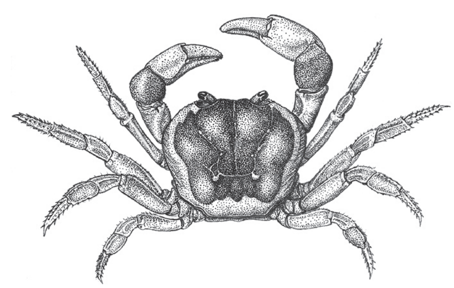
S

Ghost Crab
Ocypode quadrata
The Ghost Crab is a pale nocturnal crab of undisturbed sandy shores where it makes burrows just above high tide mark. It is an omnivore scavenging the shore at low tide for material cast up by the tide, including Portuguese Man-o-War. Length to 4 cm (1 3/4 in). **Native**.



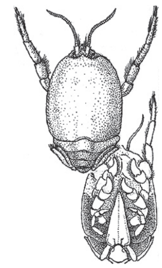
OC, SD

Land Crab or **Red Land Crab**
Gecarcinus lateralis
The most common land crab in Bermuda, this species inhabits burrows in the treed and grassy areas of the shoreline. The carapace is oval in shape, wider rather than long. It is coloured dark, reddish brown. The chelipeds are red or purple and are large and unequal in the male. The legs are paler and narrow at the tips, making them unsuitable for swimming. To 4.5 cm. **Native**.



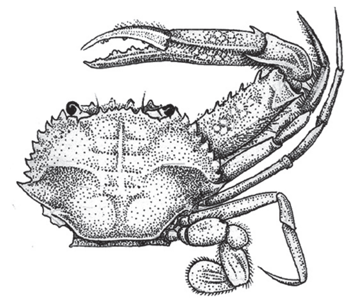
S

Mole Crab
Hippa testudinaria
This small crab buries itself in the sand at low tide level and is rarely seen. It can rapidly burrow down to escape predators or avoid wave action. Marbled white in colour. About 3 cm (1 1/4 in) in length. **Native.**



S, B

Mottled Swimming Crab
Portunus depressifrons
This is one of the swimming crabs that are characterised by very flattened hind legs, which it uses to swim rapidly through the water when disturbed. The flattened body is about 27 mm (1 in) across and the curved front margin has many small teeth. The back of the body is mottled in various shades of yellowish grey. **Native**.

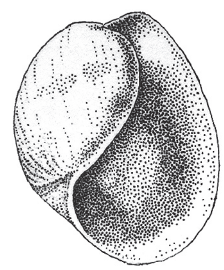


Gastropoda

Snails

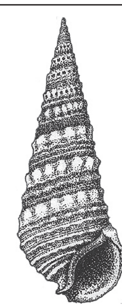
S, B

Clear Haminoea
Haminoea antillarum
This snail about 8 mm (1/3 in) long has a yellowish clear shell that is almost globular in shape. The shell opening is very wide and there is no visible spire. The Clear Haminoea crawls along the surface and takes shelter in seaweeds or sea-grasses. **Native**.



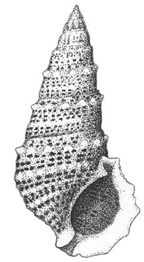
B, M

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**.



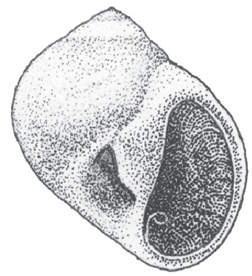
B, SG

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.**



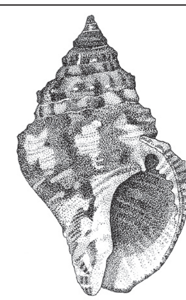
S, B

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



S, B

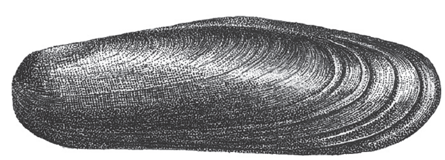
Tinted Cantharus
Pisania tincta
This snail is one of the whelks which are carnivorous snails mostly feeding on other snails and clams. This snail grows to just over 27 mm (1 in) long. It has a thick shell with a characteristic groove on the lower front end. It is a brownish-purple with milky-white mottling. **Native**.



Clams and Mussels

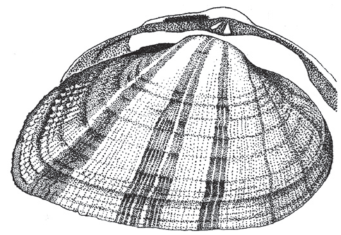
B, C

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



S, B

Purple Mussel
Asaphis deflorata
This clam, about 75 mm (3 in) long, lives buried in coarse sand or gravel just above low tide mark. The colour of the shell is usually purple but varies through red and yellow, to white. The shell is somewhat elongate and is ornamented with darker coloured radiating bars. This clam or mussel is not very common and lives 15 cm (4 in) down in the sediment **Native**.



S

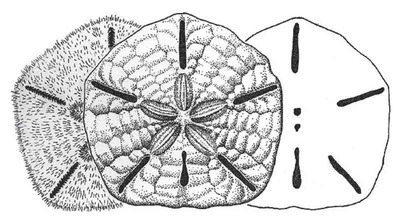
Two-spotted False Donax
Heterodonax bimaculata
A small clam of the lower intertidal of sandy shores that can rapidly dig itself deeper if disturbed. The smoothish, oval shell may be white, purple, yellow, red or combinations of these colours. Grows to about 17 mm (3/4 in) long. **Native**.

Echinoderms

Sand Dollars

B

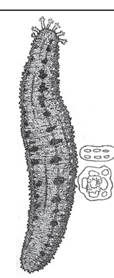
Sand Dollar
Leodia sexiesperforata
This very flattened echinoderm has a virtually circular body which has six slit-like perforations one of which is keyhole-shaped**.** This pale brown animal moves just beneath the sediment surface leaving an irregular meandering trail. Commonest where there is some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



Sea Cucumbers

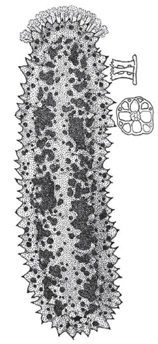
B

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**.



Lizards

F, OC

Bermuda Skink
Eumeces longirostris
This is the only non-introduced lizard in Bermuda. It is now endangered being reduced to a few small populations mostly along the south shore. This is a small, rather stiff lizard with short legs and clawed feet. Blunt-nosed and dark greyish-brown except for mature adults which have a reddish throat. Length 15-20 cm (6-8 in). **Endemic.**

Birds

Flycatchers

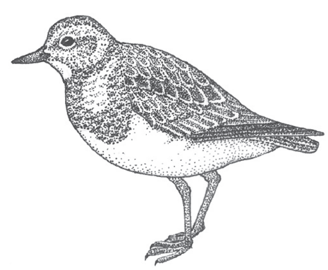
F, U, W

Great Kiskadee
Pitangus sulphuratus
This is a large, basically yellow flycatcher with a black and white striped head and a raucous call. It is 27 cm (10 1/2 in) long and has a broad black beak. The back is browner than the underparts. **Introduced** to control lizards.

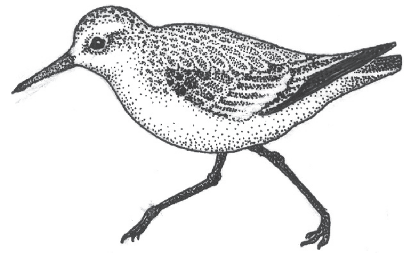
Shorebirds

B, OC

Ruddy Turnstone
Arenaria interpres
The commonest shore-bird in Bermuda especially in the cooler months but does not breed here. Found anywhere along the coast including lawns. The colour is patchy brown, black and white, the beak is black and the legs bright red 20-24 cm (8-9 1/2 in) long. **Native**.

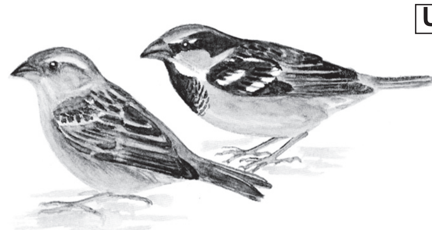


Sanderling S
Calidrys alba
This shorebird is a small, plump sandpiper measuring 18-22 cm (7-8 1/2 in) in length. It is typically seen at the water-line and it moves quickly up and down the beach with the waves. It has a bold, contrasting white stripe on all but the tip of the wing; the head and upper parts are a rusty-brown and the under-parts are white. In autumn the white is more extensive. The beak and legs are black and sturdy. **Native**.



Sparrows

House Sparrow U, W
Passer domesticus
An introduced sparrow which is really a weaver finch. This bird is common from the Arctic to sub-tropics virtually everywhere where man has colonized. A patchy red-brown in colour, 15-18 cm (6-7 in) long. **Naturalized**.



Starlings

Starling F, U, W
Sturnus vulgaris
Abundant and widespread throughout Bermuda. The starling measures 20 cm (8 in) long. This iridescent blackish bird has a short tail and a long yellow beak. **Introduced** from Europe to the US, from where it extended its range to Bermuda. **Naturalized**.

Glossary

Abyssal plain	The very flat part of the ocean bed lying from the foot of the continental slope to the edge of the trenches. Mostly about 5,000 m (16,000 ft) deep.
Aeolianite	Limestone rock form by the natural cementation of grains of wind-blown calcareous sand.
Algae	Photosynthetic, plantlike organisms generally found growing in aquatic or damp locations.
Alongshore currents	Water currents caused by waves, that move parallel to the shore.
Anaerobic	A lack of oxygen in a system.
Anemone	A coelenterate animal with a ring of tentacles on top of a soft stalk.
Anoxia	A lack of oxygen.
Anoxic	See anaerobic above.
Attrition	The loss of material from rock or sediment.
Bacteria	A large group of microscopic organisms that multiply by fission or by forming spores. Bacteria are typically filamentous, spherical, spiral, rod-shaped, or comma shaped, and most kinds have no chlorophyll and no distinct membrane-bound nucleus. Certain species cause disease such as pneumonia, typhoid fever etc.; others are concerned in such processes as fermentation and nitrogen fixation.
Basalt	Hard, dark volcanic rock, originating from the magma.
Bermuda Seamount	The seamount on which the islands of Bermuda are situated.
Biochemical erosion	The erosion of rock by biochemical means. See Physiological erosion.
Biodeposition	The formation of rock **or** sand by living organisms. Coral reefs are examples of biodeposition.
Biodiversity	In its simplest form the number of different species present at a location. More complex measures of diversity also incorporate relative abundance or biomass.
Bioerosion	The removal of rock by biological organisms.
Biogenic	Produced by a living organism.

Blue-green algae — More properly called blue-green cyanobacteria. Pigmented bacteria that can photosynthesise. Common among tropical phytoplankton.

Blue-green cyanobacteria — See blue-green algae above.

Burrowing bioerosion — The erosion of rock resulting from the burrowing activity of animals or plants.

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

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

Carapace — A hard case covering the head and thorax of many crustaceans.

Casts — Characteristically shaped faecal material found on the bottom. Casts can be used in some cases to identify animals that can't otherwise be seen.

Chitin — A firm material used in the construction of shells.

Coastal dunes — Dunes formed along coastlines usually showing ridges parallel to the shore.

Collision junctions — Where tectonic plates collide.

Colonial anemones — Anemones that live in groups or colonies.

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

Community — A naturally occurring group of organisms.

Conservation — The protection, preservation and careful management of natural resources and of the environment.

Continental islands — Islands formed on continental shelves rather than in the deep sea, for example Newfoundland and Madagascar.

Continental slope — The slope in the sea-bed from the outer edge of the continental shelf into the abyss.

Continental shelf — The relatively shallow, coastal, sea-bed extending to about 300 m in depth.

Copepods — The most abundant and important crustacean zooplankton. Most are herbivourous and resemble a small grain of rice with numerous legs.

Corals	Coelenterate animals most of which are colonial that have a tubular body and a crown of tentacles. The colonies are distinctive for each species. The hard corals have an external skeleton of limestone, the soft coral have a skeleton of organic material.
Crustacea	Members of the phylum Arthropoda, containing crabs, lobsters, shrimps, copepods, barnacles etc.
Crustose calcareous algae	Red algae (Rhodophyta) growing in a sheet-like form on the substrate that incorporate calcium carbonate into their tissues and lay down a layer of limestone. They are very important reef builders.
Crustose coraline algae	Another expression for crustose calcareous algae.
Cup reefs	Coral reefs that rise to the surface and are shaped like a large cup or wine glass. Often called 'boilers'.
Currents	Directional movements of water. Examples are surface currents and deep currents.
Cyanobacteria	Colonial bacteria that are pigmented and resemble seaweeds.
Deposit feeder	An animal that feeds on sediment containing detritus.
Destructive waves	Waves that carry sediment off the shore.
Detritivores	Animals that eat detritus, also called Detritus Feeders.
Detritus	Semi-decomposed organic material in particulate form.
Diversity	The number of different species of biota in a natural system such as an ecosystem or community. Diversity may also be used in relation to a habitat or environment, more complex examples being described as more diverse.
Dunes	Hills of sand created by the wind.
Earth's Crust	The hard layer of rock making up the surface of the Earth. Below the crust is molten magma.
Ecosystem	A large area of habitats and associated organisms that have many features in common. For example, the tropical rain forest or the open ocean.
Ecology	The scientific study of natural history.
Embryo dunes	Very small, usually temporary sand dunes that form at the strand line.
Endemic species	Species that have evolved to be a new species in a specific area. They may subsequently spread to other areas.

Environment Living and non-living surroundings of natural groups of organisms.

Episammon Organisms that live on the surface of sand grains.

Erosion energy The quantity of energy used to erode shorelines. Greater where wave energy is high.

Feeding bioerosion Bioerosion resulting from the feeding activities of organisms. Parrotfish are the best example of feeding bioeroders.

Filter feeders Animals that obtain their food by filtering organic particles or organisms out of water.

Food chains The feeding relationships between trophic groups in an ecological unit such as an ecosystem or community, arranged to begin with the primary producers and proceeding through herbivores to carnivores.

Food webs The feeding relationships in an ecological unit such as an ecosystem or community arranged to begin with the primary producers and proceeding through herbivores to carnivores.

Foraminifera Single celled protozoa in the amoeba group having a chambered calcareous exoskeleton. Common in the plankton.

Fore dunes Large sand dunes that are closest to the ocean.

Gastropod A mollusc with a single, normally coiled, shell. Eg. A snail.

Genus (pl. genera) A closely related group within a family of organisms. A family may contain many genera.

Gulf Stream The very large ocean current originating in the Gulf of Mexico, passing through the Straits of Florida and proceeding northeast up the eastern seaboard of North America.

Habitat A small area of an ecosystem or environment. The characteristic living space of a species.

Hot spot A thin place in the Earth's crust where molten magma is likely to erupt.

Hot spot islands Islands that originate when a volcano forms from liquid magma that erupts through a small area of the sea-bed.

Ice cap A large accumulation of ice in polar regions.

Impermeable Not allowing fluids to pass through.

Inter-dunal lows Low areas among tracts of dunes often deepened by runoff.

Interstitial fauna Small animals living in the spaces between grains of sediment.

Intertidal Zone	The zone around water bodies that is regularly covered and uncovered by the tides.
Island arcs	Groups of islands formed along the collision zones of tectonic plates.
Karst topography	A land form in limestone areas characterized by sharp peaks.
Larvae	The juvenile stages of animals. There are often several distinct larval stages.
Limestone	A rock made up principally of Calcium carbonate.
Lithification	The cementation of sand or other sediment into rock.
Littoral Zone	The zone around water bodies that is subject to wetting by tides, splash or spray.
Longshore drift	Materials moved laterally by waves and currents of the littoral zone.
Magma	Molten rock under the Earth's crust, circulating in vast convection cells.
Marine Deposits	Rock laid down under seawater.
Mechanical erosion	The erosion of rock or other hard material by physical means.
Mid Atlantic Ridge	The ridge of rocky mountains down the course of the Mid Atlantic Spreading Zone.
Microhabitat	A very small habitat.
Mobile Dune	A sand dune that moves steadily downwind.
Mollusca	The phylum of invertebrate animals containing the snails, clams, squids, slugs and octopuses.
Native species	An organism that has colonised an area by completely natural means.
Neap Tides	Tides of smaller range occurring every two weeks.
Ocean currents	Large currents in the ocean that move in a predictable pattern.
Oceanic Island	An island in the ocean, well away from a continent.
Permanent dune	A sand dune that is fixed in place by a cover of vegetation.
Photosynthesis	The synthesis of organic compounds from inorganic substances using the energy of sunlight, carried out by pigmented plants.
Physical erosion	The break down of rock, or particles of rock, into smaller particles by physical means such as wave action, wind, gravity water currents and grinding.

Physiological bioerosion	The erosion of rock that results from the physiological processes of living organisms.
Phyto-karst	The characteristic jagged surface texture of upper seashore rocks caused by bioerosion by blue-green cyanobacteria.
Pioneer plants	Plants that have adapted to colonise unvegetated areas.
Plate junctions	Where two tectonic plates come together.
Plate tectonics	The study of the structure and movement of crustal plates.
Pleistocene Epoch	The last epoch which was characterised by the development of huge ice caps at the north and south ends of the Earth.
Poorly sorted sediment	Sediment consisting of particles with a wide range of sizes.
Predators	Animals or plants that eat animals.
Prevailing winds	The most usual winds in a given area.
Reefs	Hard, raised areas of the sea-bed. They may be composed of living animals and their remains, for example coral reefs, or of any kind of rock. Often a hazard to shipping.
Richter Scale	The scale that is used to describe the magnitude of earthquakes.
Ridge islands	Islands that originate along mid-ocean ridges, for example Bermuda.
Rip currents	Currents that move rapidly away from the shore where opposing alongshore currents meet.
Salinity	The quantity of salts per unit volume of water.
Salt marshes	Relatively flat areas dominated by grasses or low growing herbs situated in the upper intertidal zone along sedimentary coastlines.
Sand Dunes	Wind-blown mounds of sand.
Sand Plains	Rather flat sandy areas to the landward of coastal dunes.
Sand ridges	Wave-like formations on the surface of sandy areas in either land or aquatic situations.
Sand waves	Underwater features in sandy sediments where the surface of the sand forms wave-like ridges.
Scientific names	Names composed of a mixture of Greek and Latin used to describe organisms. There are two names; the first is the genus name and the second the species name.

Sea anemones	Animals in the phylum coelenterata, living attached to the bottom and lacking skeletal structures. They have a soft, cylindrical body and a ring of tentacles.
Sea Cucumbers	Echinoderm animals shaped like a cucumber.
Sea Urchins	Spiny, near spherical echinoderm animals.
Seamount	A mountain in the ocean resulting from an undersea volcano. Some come above the surface.
Seaweeds	The common name given to green, brown and red algae in the sea.
Secondary erosion	The erosion of larger particles into smaller ones following primary erosion.
Sediment	Deposit composed of small fragments of rock shell or skeletal particles. Sand, mud and clay are examples of sediments.
Sediment consolidation	A process taking place in fine sediments such as mud, which, in time, results in a lower trapped water content, higher density and increased physical stability.
Sediment permeability	This refers to the amount of open space within a sediment; it can also be measured by the rate at which water can move through a sediment.
Sediment sorting	The sorting out of different particle-size sediments from a mixture in a situation of decreasing current velocity.
Sedimentation	The process in which sediment suspended in the water is deposited on the bottom.
Sliding Junctions	Where two tectonic plates in the Earth's crust come together moving in laterally in opposite directions.
Species	The basic unit in scientific classification applied to organisms that are genetically and physically similar.They can interbreed naturally and produce viable offspring.
Species diversity	The number of different species in an area.
Spreading junctions	The junction between tectonic plates that are moving away from each other.
Spreading zones	Zones on the surface of the Earth where molten magma rises to the surface.There is a spreading zone at the center of ocean ridges.
Spring Tides	Tides of large tidal range that occur at 14 day intervals.
Strand line	The line on shore where floating material is stranded at the level of high tide.

Subtidal	Below low tide level.
Succession	An orderly and predictable series of changes in an ecosystem.
Supralittoral Fringe	A narrow zone on the seashore lying immediately above the midlittoral zone, characterised by the presence of periwinkles.
Suspension feeder	An animal which engages in suspension feeding, i.e. feeding on particles suspended in the water.
Swamps	Wetlands dominated by trees.
Tectonic plates	Large rock plates on the surface of the earth which move under the influence of convection cells in the molten magma beneath.
Tidal Current	A current in water resulting from the rise and fall of the tides. Tidal currents usually reverse with the tides.
Tidal range	The vertical height between high tide level and low tide level.
Tides	The regular and predictable rise and fall of sea level resulting principally from the gravitational pull of the moon.
Tsunamis	Large waves on the surface of the ocean created by violent movement of the sea-bed. These waves are very destructive.
Weathering	Erosion resulting from the action of weather.
Well sorted sediment	Sediment in which the component particles fall into a narrow range of sizes.
White dunes	Sand dunes that have some vegetation but where the sand shows through in bare patches. Found behind fore dunes.
Yellow dunes	Another name for white dunes used where the sand colour is yellowish.

Reading Material

Amos, Eric J. R. 1991. **A Guide to the Birds of Bermuda.** Corncrake, Warwick, Bermuda, 206p.

Anon. 2007. **The Bermuda Atlas.** Macmillan-Caribbean. 72p.

Benchley P. and J. Gradnohl. 1995. **Ocean Planet: Writings and Images of the Sea**. Abrams, Times Mirror Magazine and Smithsonian Institution. 192p.

Britton, Nathaniel Lord. 1918, **Flora of Bermuda**, Charles Scribner's Sons, New York. 585 p.

Cavaliere, A.R., Barnes, R.D., and C.B. Cook,, 1987, **Field Guide to the Conspicuous Flora and Fauna of Bermuda, 2nd ed**., Special Publication No. 28, Bermuda Biological Station for Research, Bermuda. 82 p.

Cousteau J. Y. And F. Dumas. 1953. **The Silent World.** Harper Bros., N.Y. 266p

Dobson, Andrew. 2002. **A Birdwatching Guide to Bermuda**. Arlequin Press, 173p.

Hayward, Stuart, Gomez, Vicki and Wolfgang Sterrer. [Eds.], 1982. **Bermuda's Delicate Balance: People and the Environment.** The Bermuda National Trust. 402p.

Phillips-Watlington, Christine. 1996. **Bermuda's Botanical Wonderland: A Field Guide.** Macmillan Education Ltd., 128p

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

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

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

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

Taylor, W. R., 1960. **Marine Algae of the Eastern Tropical and Subtropical Coasts of the Americas**, University of Michigan Press, Michigan. 823 pp.

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

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

Thomas, Martin L.H. 2003. **Marine Ecology of Harrington Sound Bermuda**. Scientific Reports of the Bermuda Aquarium, Natural History Museum and Zoo, 49p.

Thomas, Martin L. H. 2004. **The Natural History of Bermuda**. Bermuda Zoological Society, 256p.

2 Halves Publishing. 1997. **Sporty little Field Guide to Bermuda for the Curious and Confused.** Two Halves Publishing, Bermuda, 48p.

Index

BERMUDA ZOOLOGICAL SOCIETY