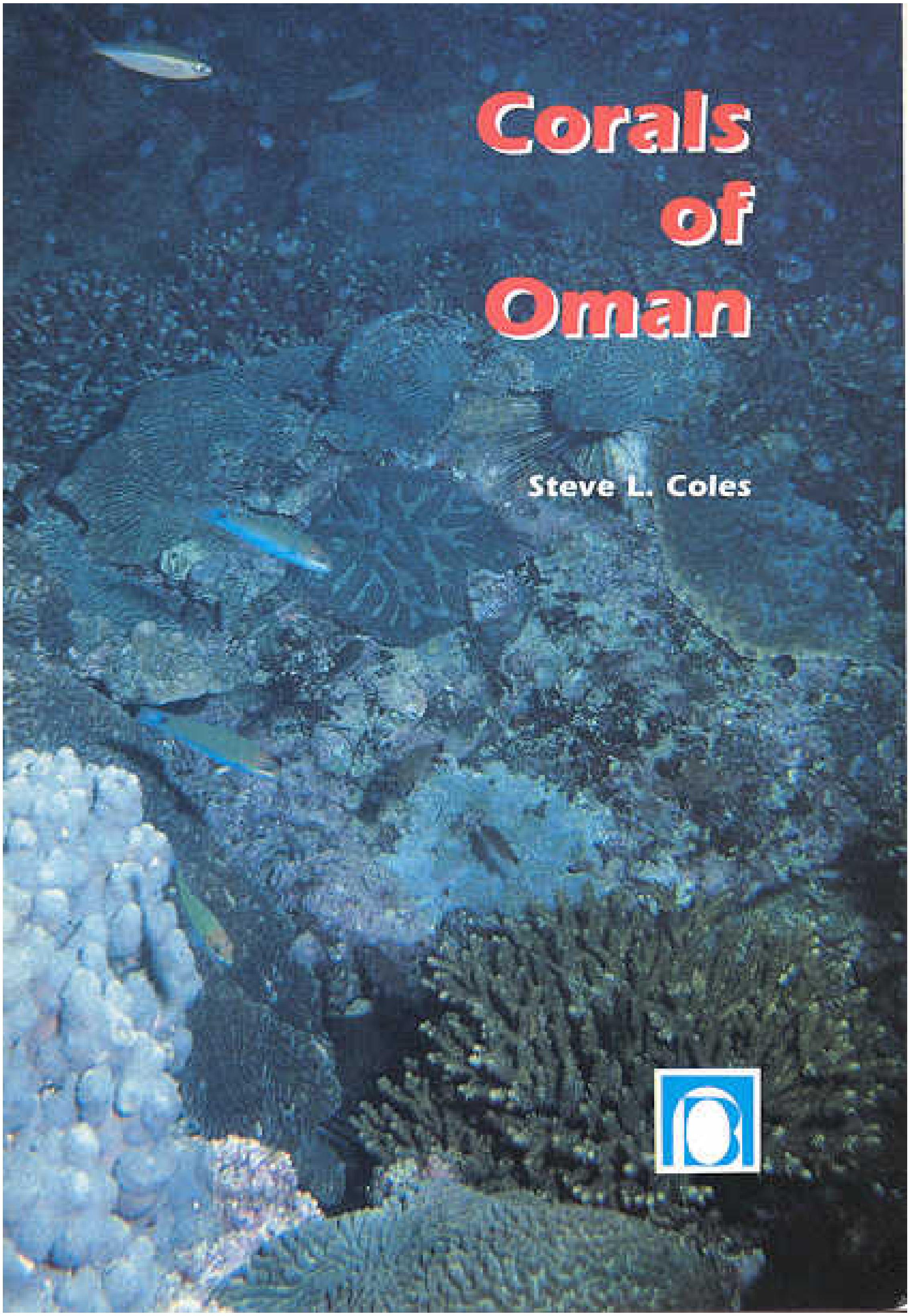

Corals of Oman

Steve Coles

Contents

[BACK COVER]

Foreword

Early accounts of Oman's marine realm recognized, but greatly underestimated, the wealth and diversity of its biological treasure. The last decade has divulged more and more of these secrets and inspired global interest in the Sultanate for its turtles, whales, fishes and fisheries, coral reefs, and awe-inspiring coastal scenery. More has been written about turtles, dolphins, and whales, waders and seabirds, than corals. However, the corals of Oman have surpassed early expectations and confounded predictions. Oman's seas have yielded a far greater variety of corals and both more and older reefs than anticipated. There have been reef fishes and corals new to science including the living fossil *Parasimplastrea simplicitexta.* This coral was known and described from fossils and assigned to a family all of which were believed to be extinct until its discovery alive in Oman.

Corals are generally little appreciated creatures. We tend to perceive them more as architects or scenery rather than as oases of life. As founders of a complex ecosystem, corals sustain important fisheries as well as our pleasure as snorkellers and divers.

Use this book to open doors to new interest in the Sultanate's seas, and please take care to treat corals with consideration. They are fragile creatures, despite their robust appearance, and a careless kick, a casual anchor, or the weight of a standing person. can destroy decades of coral growth.

It is easy to be inspired by the wild and scenic coastline of Oman and its wealth of life. However, identifying the creatures there and pursuing a naturalist's inclination to probe deeper into the names and habits of this profusion of life has been difficult without adequate field guides. Understanding marine life leads to greater appreciation and is an important step to conserving and using it wisely. This book joins an increasingly large and valuable collection for the seashore naturalist's collection and is a most welcome addition.

Rodney V.Salm

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John Hoover: Plates 7, 8, 10, 38, 57, 59, 60.

Rodney Salm: Plates 20, 26, 47.

Jose Stirn: Plate 3, 21.

Front Cover :
A coral community dominated by the Brain Corals ***Symphyllia*** (centre) and ***Platygyra*** (edges) along with clusters of ***Echinopora*** and branching ***Acropora***.

Back Cover:
Daisy Coral ***Goniopora*** lying amidst clumps of the soft coral ***Paramuricea***.

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I am very grateful to my students Dawoud Suleiman Al Yahyai and Khalifa Saif Al Kiyumi who have so painstakingly translated this book into Arabic.

Finally. I can only but express my thanks and deep appreciation to The National Bank of Oman, who were extremely generous to support the publication of this book.

This book is dedicated to the people of the Sultanate of Oman, both nationals and expatriates, who

have experienced or will experience the joy of diving or snorkelling on Oman's coral reefs. I hope that the information in this book will add to their enjoyment and inform them of some of the aspects of the life of the corals which form this unique and beautiful environment.

Introduction

Reef corals are one of the simplest multicellular life forms, but they provide some of the most distinctive and beautiful structures to be found in nature. By their growth and reproduction, corals form the building blocks of one of nature's most beautiful and diverse environments, the coral reef.

In Oman's shallow, nearshore waters, reef corals occur in those areas where hard surfaces provide a base for their attachment and growth. The corals found in the Sultanate of Oman are part of the coral community that lives in the great Indo-Pacific region, which stretches across half the world from the east coast of Africa and the Red Sea to the west coast of South and Central America. In this region over a thousand species or types of coral occur, with the highest numbers located in the central area around the Philippines and the South China sea. The Sultanate of Oman, lying near the western fringe of this region has only approximately 75 species, with the greatest number of species and highest coral coverage occurring in the Muscat area and the Dimaniyat Islands, near the major population center of the country.

Interest and concern in Oman's marine environment is increasing rapidly among both residents of Oman and visitors. Corals and the reefs that they form by their growth are probably the most visually impressive and beautiful shallow water communities that a snorkeler or diver will encounter. The numbers of snorkelers and trained SCUBA divers frequenting Oman's waters are increasing rapidly; and this trend will rise with both increasing tourism and a level of prosperity in the country that will promote learning of snorkelling and SCUBA diving by Omanis.

This book describes and illustrates most of the common hard and soft corals found in the waters of the Sultanateof Oman and provides a resource for identifying corals at least to genus and in most cases to species. For those less concerned with biological terms, common English names are given, and a narrative for each type provides information about the usual habitat where the coral is found, unique features of this type of coral, and important environmental information especially relevant for corals of Oman. Basic information is also presented about the biology and geology of corals and how the coral communities of Oman relate to those elsewhere in the Indianand Pacific Oceans.

I hope that the information contained in this book will stimulate interest in Oman's corals and coral reefs and will enable a basic understanding of the biological processes of these beautiful animals and of the geological structures that they form. In an era when coral reefs in much of the world are under continual and apparently mounting stress from both natural and man-related forces, hopefully this book will help to promote concern in studying and preserving this important resource for Oman's future generations.

CHAPTER ONE

What is a Coral?

What we commonly call corals includes a variety of types of organisms that biologists refer to as coelenterates or cnidarians. One of the main physical characteristics of this group is that they all have a single body cavity and opening, a coelenteron, that doubles both for the ingestion of food and for the release of digested wastes. Another characteristic is that corals and other coelenterates have stinging cells, or nematocysts, that are normally carried within special cells on the animal's surface-. When potential food prey is present in the water, the coral ejects these stinging cells to entangle or poison the prey, which the coral can then consume.

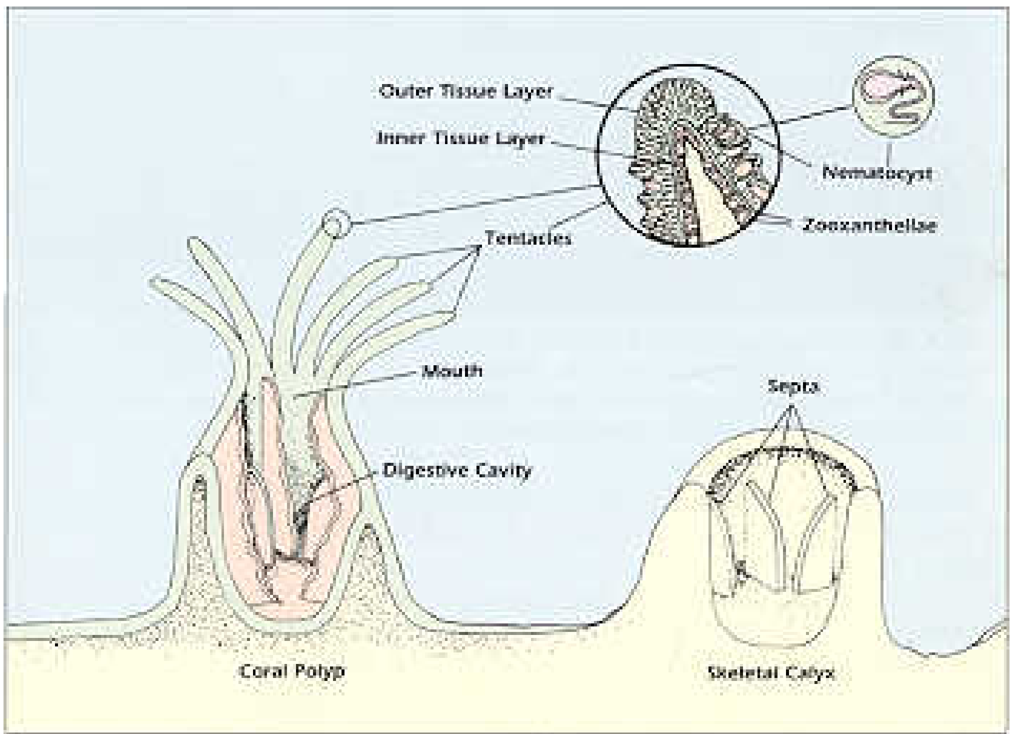

Figure 1. Diagram of coral polyp and calyx structures .

The body structure of corals and their close relatives, the sea anemones, appears as an upward facing, radially or biradially symmetrical polyp. In each polyp the animal's mouth lies in the center of a ring of tentacles that surround the perimeter of the oral disk. The nematocysts are most abundant on the surface of these tentacles, which can elongate dramaticaJly when the coral is actively feeding. Within the body cavity, digestion is accomplished on the surfaces of specialised filaments or mesenteries, which secrete enzymes that quickly reduce ingested prey to its components. Most corals are, therefore, potentially efficient predators, although many types seem to have developed other means of meeting their energy requirements (see below).

Plate 1. Expanded polyp of a specimen of the coral *Manicina areolata* actively feeding on brine shrimp in the laboratory. Note the highly expanded tentacles, some with captured prey, and the greenish-brown color of the coral tissue which is due to zooxanthellae algae.

Although the term "coral" is often used in a general sense, it usually refers to reef or hard corals, which are more formally called scleractinians. These are the corals that may form large coral heads and which are the primary building blocksof coral reefs in tropical oceans: The common characteristic of. this group is the secretion of a basal skeleton of calcium carbonate as the mineral aragonite. The livng portion of thIs group usually has its radial symmetry divided into multtiples of six, which is most apparent in the numbers of tentacles that surround each polyp. This pattern is also shown in the pattern of the calyx, (plural=calyces) or cup, which is secreted by each polyp, and which remains after the live tissue is cleaned from a coral skeleton. Each calyx is divided by a number of septa, again usually in multiples of six, which look like sharp ridges radiating from the center of the calyx.

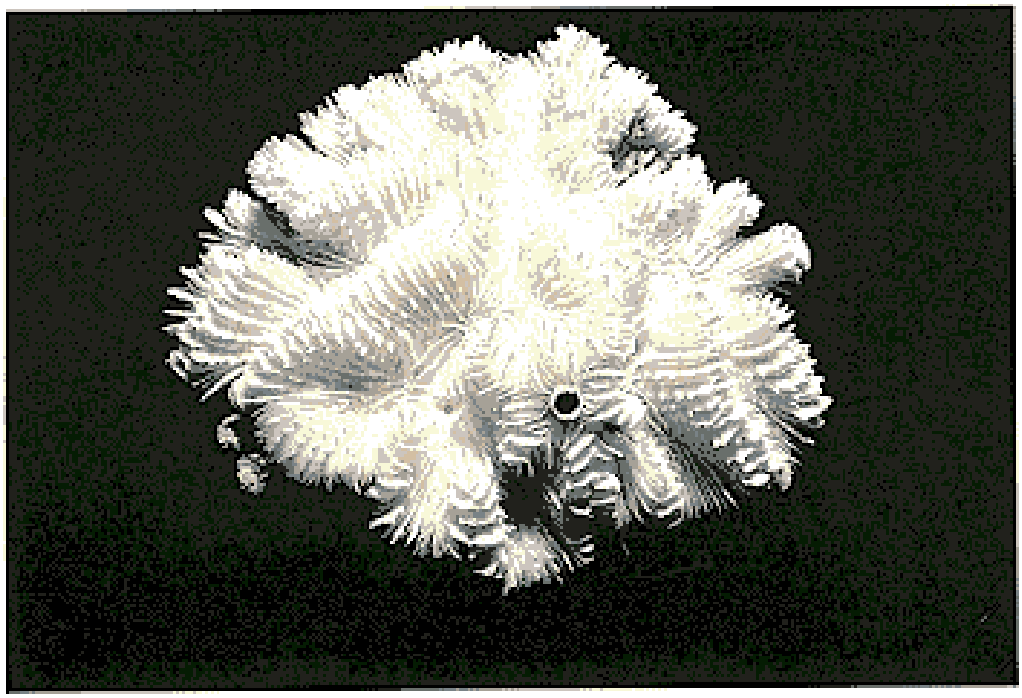

Plate 2. Cleaned calcium carbonate skeleton of Greater Brain Coral *(Symphyllia radians)* showing multiple calyces with heavily toothed primary septa and fine toothed secondary septa.

A reef coral can be a single polyp and calyx, but in most cases reef corals grow as colonies with hundreds, even thousands of polyps and calyces on the same coral skeleton. The variety of forms that are created by this colonial growth make up some of the most beautiful structures to be found in nature. These structures can range from delicate, branching bushes and arbors, to robust tables, intricate flower-like leaves, and multiple starbursts to branching fingers and massive boulders that have brain-Iike fissures on their surface. The variety of shapes is determined by the pattern of budding of new polyps from older polyps as the coral grows, and whether the polyps become separated or continue to share a common mouth within the original ring of tentacles. The calcium carbonate skeleton also varies substantially in density and strength according to the coral species. Some corals have very dense skeletons and can resist a great deal of wave disturbance, while others are light and porous and are restricted to the calm waters of embayments. However, these porous corals have the advantage of having faster growth rates and may have live tissue penetrating the coral skeleton. This tissue within the skeleton gives these corals a greater ability to recover from stresses which may kill off the coral surface tissue.

Because of their flower-like appearance, corals were classically referred to as "zoophytes", indicating that they were recognized as animals, but had many external characteristics of plants in their patterns of growth. Now we know that this original descriptive term was quite valid, but for a different reason.
Coral biologists have long recognized that all hard corals with rapid growth rates contain massive numbers of single celled algae called zooxanthellae within the cells of the coral tissue. These algal cells appear under the microscope as yellowish-brown spheres, and they are extremely abundant in the coral tissue, normally numbering millions of cells per square centimeter of coral surface. The zooxanthellae provide the major coloration of most living hard corals and many soft corals, which usually appears as shades of brown or green.

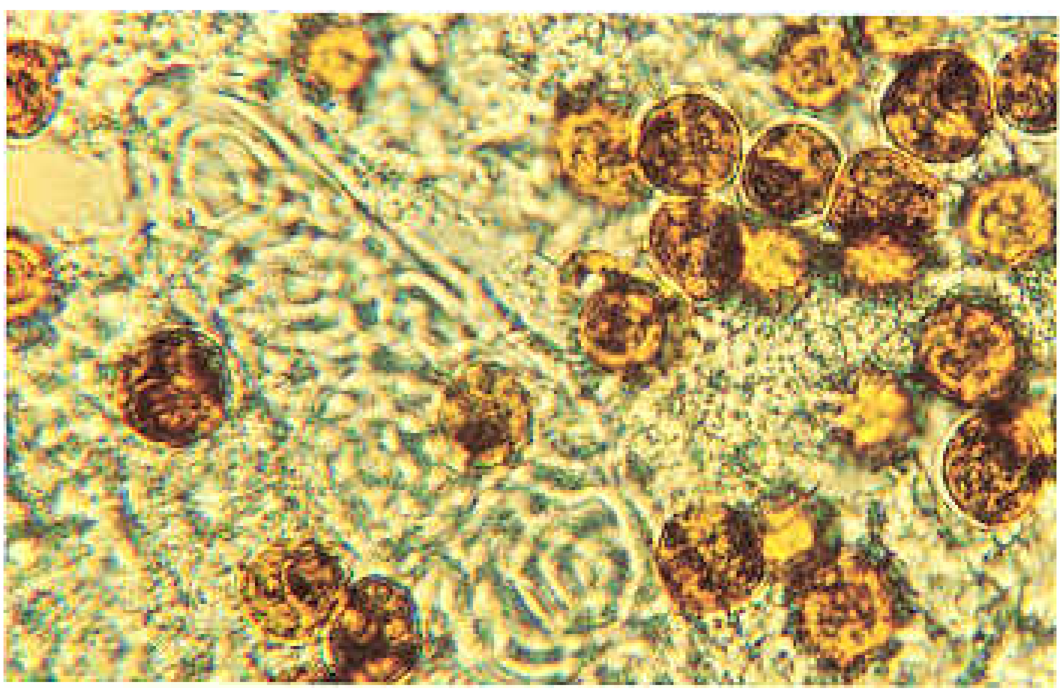

Plate 3. Photomicrograph of coral tissue showing the brown, spherical zooxanthellae which give the coral most of its color, and a nematocyst coiled within its capsule ready for discharge.

The actual functional relationship of these internal algae to the coral has been studied intensively and was a subject of controversy for many years. Coral biologists always recognized that the presence of the intracellular algae was necessary for hard corals to achieve the rapid growth rates which enable them to reach massive sizes and form coral reefs. Most non-reef forming or solitary corals, although they have similar calcium carbonate skeletons, do not contain zooxanthellae and do not grow to large sizes. The question remained as to how the association between the corals and their zooxanthellae might aid or benefit either of the partners? When rapid growth occurs, an animal produces metabolic carbon, phosphorus and nitrogen wastes that must be removed or they will poison the growth process. Corals, being very simple organisms, have no specialized structures for such waste removal. However, the abundant zooxanthellae within the coral tissue provide a mechanism for removing wastes and therefore permit rapid coral growth. The waste products produced by the coral tissue are the raw materials used for photosynthesis by the zooxanthellae and thus are kept from rising to toxic concentrations. The zooxanthellae, on the other hand, benefit by having a ready supply of nutrients for photosynthesis. This is an example of what is termed mutualistic symbiosis, where both partners benefit from being joined in a close association.

For many years, this removal of waste products was considered to be the only benefit to the coral provided by the algae. However, the question remained whether the organic matter produced by the zooxanthellae could be utilized in any way by the coral tissue, i.e. was the plant partner of the association producing food for the animal? Research in the past twenty five years has verified that such a nutritional relationship does exist. A major portion of the energy fixed by the zooxanthellae passes directly to the animal tissue in a highly usable dissolved form. Coral therefore do "feed" on their zooxanthellae, although not by conventional means.

Plate 4. Close up of branch of a yellow gorgonian sea fan showing expanded polyps, each with eight tentacles.

The term "corals" often includes other varieties of coelenterates that have somewhat different characteristics than scleractinian corals. The largest of these groups are the octocorals which includes both hard and soft forms and the gorgonians or horny corals. Their common characteristic is that, instead of being in multiples of six like the hard corals, the structures of their polyps, such as tentacles, grow in multiples of eight. The tentacles of these octocoral polyps are pinnate or feather-like. The most common hard octocoral is the organ pipe coral, which grows from a deep red skeleton which is formed by parallel rows of tubes. In life, however, this coral shows the white coloration of its polyps and feathery tentacles, which resemble thousands of small white flowers.

The soft octocorals have many features in common with the hard corals. Most grow as upwardly facing polyps, contain symbiotic zooxanthellae and have tentacles and nematocysts that may be used in food capture. The primary difference is that the soft corals do not lay down an external hard skeleton that remains as a permanent structure after the coral dies. Instead, the soft corals get their structure and body support from calcium carbonate spicules that are deposited within their body walls. These corals may look like quite drab leather-like gray-green sheets on the reef surface, or they can be very colorful and beautiful, such as the dendronepthid or teddy bear corals which have a crown of red to orange tentacles on a translucent white stalk.

Plate 5. Close up of an alcyonacean Teddy Bear Coral (*Dendronepthya* sp.) showing expanded polyps with eight tentacles each and internal white spicules which provide body support and structure.

The gorgonian octocorals grow in a variety of forms such as elaborate sea fans and sea whips. Their supporting structures, instead of being external calcium carbonate skeletons or internal spicrules, are rods of horny material that form the backbone of each net-like fan or branching whip. The living tissue and polyps grow on the surface of this rod. Sea whips are generally quite small, but sea fans can grow to two or three meters in diameter, forming a large net of feeding polyps that make up an efficient network of plankton feeders. These forms depend on zooplankton for food, rather than organic matter fived by internal zooxanthellae. Therefore, they are usually most abundant where they have clean hard surfaces to attach themselves to, and in areas of moderate to strong currents where plankton are abundant.

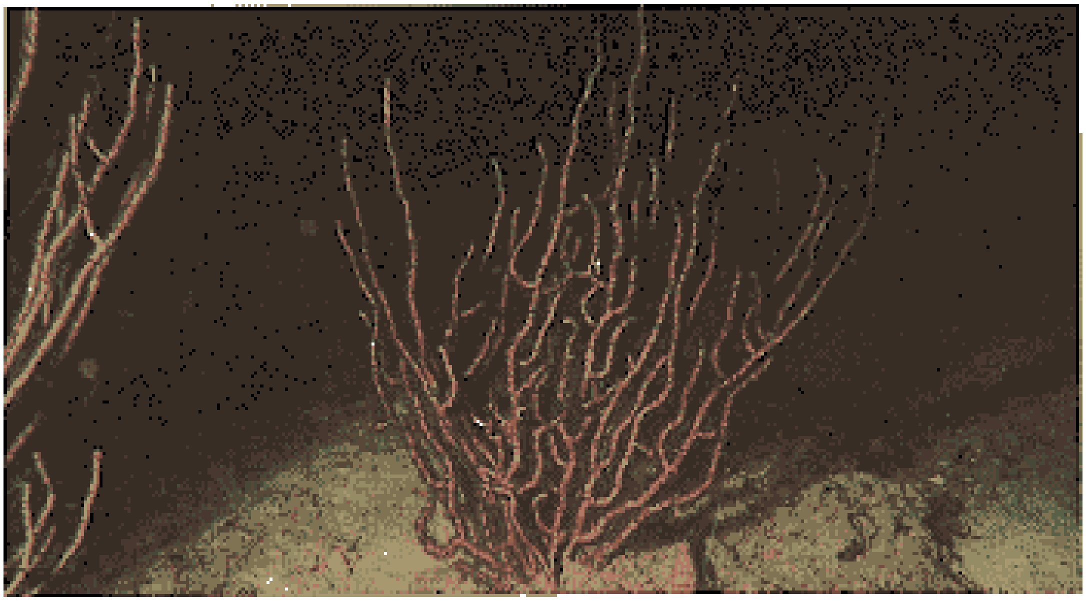

Plate 6. Specimens of a gorgonian purple sea fan on the reef showing partly expanded polyps.

Plate 7. Colony of the hydrozoan Fire Coral (*Millepora* sp.) photographed at As-Swada, Dhofar. Fire Coral is very rare in Oman.

Fire coral is abundant in most areas in the tropics, but in Oman it is only found in the Dhofar region. Fire coral belongs in yet another coelenterate group called the hydrozoa. many of the toxic and stingiging animals such as the Portuguese Man O' War found in ocean waters are also members of this group. Fire coral's calcium carbonate, basal skeleton grows in a wide variety of shapes, and it is always a rich yellowish brown in color. Fire coral is distinct from all other corals in that its calyces appear as pin holes with neither septa nor tentacles being visible. The appearance of these pin holes is the source of fire coral's scientific name, ***Millepora***. The potency of its capability as a predator is confirmed by the painful stings that it will inflict on a person who comes in contact with its surface and nematocysts.

The final group of animals that are generally referred to as corals are the precious corals. The term "coral colored", classically refers to the color of deep living; pink precious coral which has been used as jewelry and treasure since ancient times. Of somewhat similar appearance is a certain type of hydrozoan called ***Stylaster***, which is actually more closely related to fire coral and occurs in shallow water, but is of no commercial value. Pink precious coral ranges in color from deep red to pale pink. It is the hard internal skeleton of a type of gorgonian that usually occurs deep in the ocean to thousands of meters, but may be found in the Mediterranean Sea as shallow as 100 meters. A closely related, equally beautiful type is gold precious coral, which also is a deep living gorgonian. Traditionally taken as a by-product of deep water fishing with tangle nets, these precious corals have been harvested in more recent years using deep water submersibles.

Plate 8. Specimens of non-precious Pink Coral *Stylaster* sp.growing among white sea anemones under a ledge.

Black coral is also used commercially in making jewelry and small sculptures. Black coral trees generally occur in intermediate depths within the range of SCUBA divers who may harvest the trees for profit. The trees can grow up to several meters in height in areas where currents are strong and plankton food plentiful. While alive, black coral may appear white, yellow or even red depending on the color

Plate 9. A colony of Black Coral *(Antipathes* sp.*)* with partly expanded yellow polyps. The horny black internal skeleton can be seen on the branches where the yellow tissue has sloughed off .

of the live polyps which cover the internal skeleton, similar to gorgonians. Cleaning off the live tissue reveals a hard black, somewhat spiny skeleton which, when ground and polished, shows a beautiful shiny surface, as do pink and gold corals. Another close relative of black coral, wire coral, has a similar structure of polyps growing on a supporting rod, which in this case is tightly coiled and can be several meters long. However, wire coral never grows sufficiently thick to be used in jewelry making.

Plate 10. A specimen of Wire Coral (*Cirripathes* sp.) with partly expanded polyps. The coiled structure is characteristic for wire corals.

The scleractinian hard corals are the most common and abundant coral type to be found on most coral reefs in the tropical world and in the coral growing areas of Oman. Certain types such as gorgonians and black corals are relatively uncommon in Oman. and others such as organ pipe coral and fire coral occur only in the Dhofar region. This book will therefore concentrate on the hard and soft corals which are abundant in Oman's nearshore waters and which are easily available to be seen by snorkelers and SCUBA divers. Before these corals are described. the coral communities of Oman will be reviewed in the context of their relationship with reef corals that occur in the Indian and Pacific Oceans.

CHAPTER TWO

Occurrence and Abundance of Corals and Coral Reefs in Oman

The corals of Oman are part of a great group of marine animals called the Indo-Pacific fauna that extends across the Pacific and Indian Oceans from the east coast of Africa to the west coast of the Americas. Many of the same types of corals that occur in Oman also live as far away as Hawaii, Tahiti, and the west coast of Panama. This region, therefore, represents the greatest continuous biological community on earth. However, the species composition of a coral reef will not be exactly the same from one area of the Indo-Pacific region to another. Rather, the most common types to be found in one area may be rare or even absent in another, depending on the environmental conditions that prevail and how far an area is from the zone of maximum abundance of that species. Interestingly, some of the coral species that are found in the Arabian Gulf and the Gulf of Oman are also among the most common in Hawaii, a half a world away, and are relatively uncommon at points in between.

The maximum numbers of species of this great Indo-Pacific distribution of animals occur in the warm tropical seas surrounding Indonesia and the Philippines, and decrease in all directions from this central point. Oman is relatively distant from this center of maximum diversity, and fewer types of corals exist along Oman's coast than in most areas of the tropical Indian and Pacific Oceans. Although high coverages of reef corals are found in Oman, reef development is generally limited, and the number of coral types present is low. Of over 700 coral species identified for the Indo-Pacific region and over 200 for the Red Sea, only about 75 reef forming species inhabit in Oman waters.

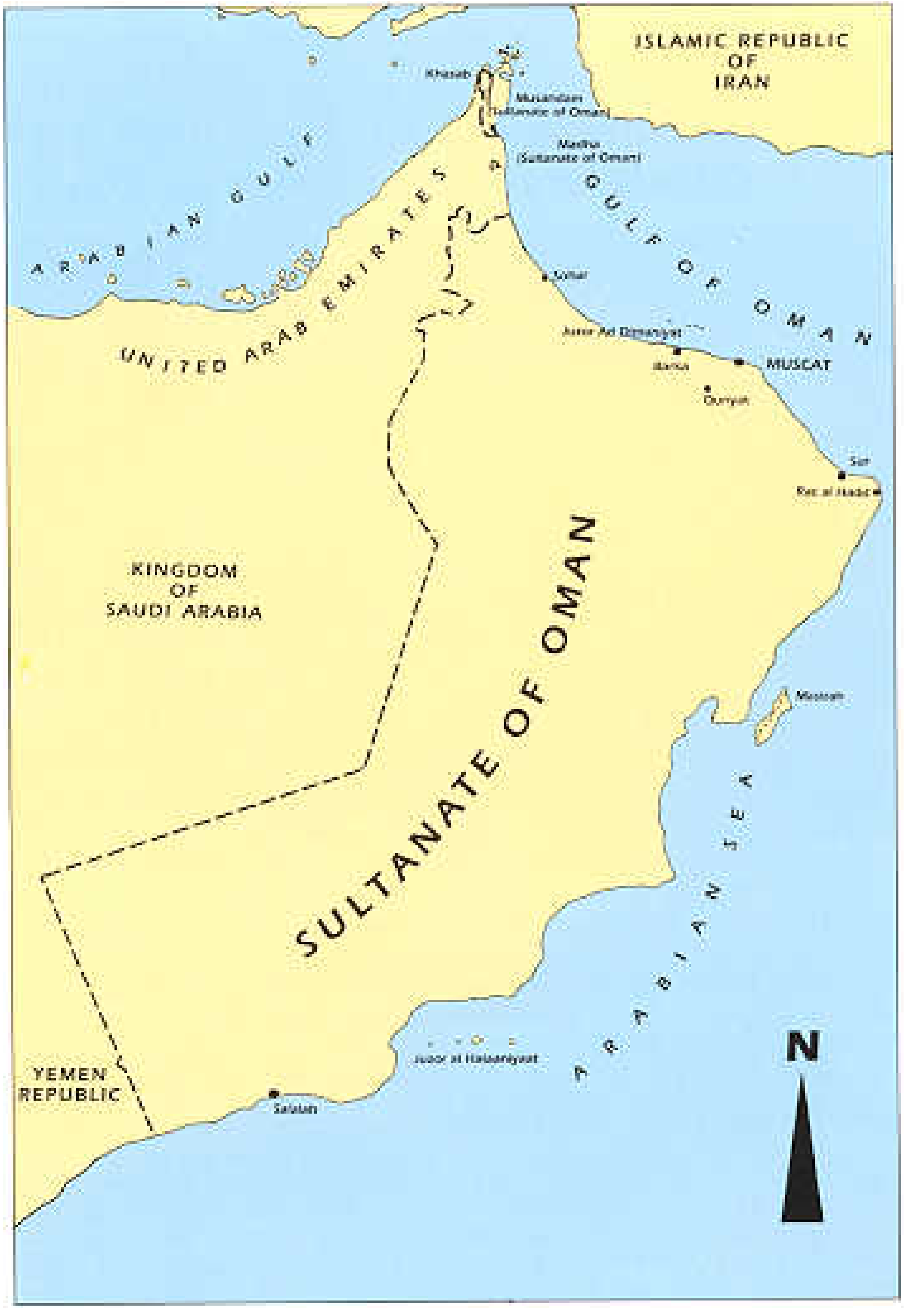

Figure 2. Map of the Sultanate of Oman

There are only four principal areas of coral growth along the entire 1,700 km Oman coast: 1) the khawrs and fjords of the Musandam Peninsula near the Strait of Hormuz, 2) the Muscat-Capital Area coast and islands from the Daymaniyat Islands to Ras al Hadd, 3) the south and west coast of Masirah Island and 4) the Dhofar area from the Al Halaaniyaat (Kuria Muria) Islands to Salalah. In none of these areas are coral reefs highly developed. Coral growth is generally restricted to those areas where they can grow directly on a rock substratum. Where reefs do occur, they are usually small and restricted to embayments or lee areas which are protected from wave disturbance. The exceptions to this are well developed reefs with a variety of coral species in the Damaniyat Islands and reefs made by the growth of a single species in the Gulf of Masirah southwest of Masirah Island and south of Barr al Hikman.

There are a number of reasons for Oman's limited species diversity, coverage and reef development, which are related to the biological requirements for reef coral survival and growth. First, there is the lack of a suitable substratum along most of Oman's coast. Most corals require a hard bottom for the settlement of their larval stage, called planula, to begin the first stages of calcification and development of the adult coral. The nearshore bottom, from the Al Halaaniyaat (Kuria Muria) Islands to Masirah Island, from Masirah to Ras al Hadd, and along the Batinah coast, is mostly loose sand and, therefore, unsuitable for coral settlement and growth. Second, the coastline of Oman is geologically young, having resulted from rising sea levels in the last 8;000 years, which have flooded former coastal plains and moved the shoreline landward by up to 10 kilometers. Therefore, there has been only a limited time for coral migration, colonization, growth and reef development on the limited amount of suitable bottom. Third, the physical environment of the Arabian Sea, and to a less extent, the Gulf of Oman, is highly variable and unstable, especially with respect to temperature. Because of the annual summer southeast monsoon and, the resulting upwelling of cold, deep water, the temperatures of the coral habitat fall to stressful levels, which may act to restrict the survival of many species and inhibit the growth rates of those species which do survive (Chapter 4).

Descriptions of Principal Coral Growing Areas in Oman

The Musandam Peninsula

This region of Oman, which is separated from the main portion of the country by the U. A. E., has a coastline on either side of the Strait of Hormuz, along both the Gulf of Oman and the Gulf of Arabia. Both areas are typified by sheer walls which extend steeply to depths of 40 m close to the shoreline and by fjord like inlets (khawrs) which follow the wadi courses. Since the Musandam shoreline is rapidly subsiding into the ocean and is exposed to waves and rock boring animals, the sheer rock surfaces are continually eroding off and tumbling into the depths. The substratum for coral settlement is therefore unstable and there has been limited chance for development of coral reefs except at the heads of khawrs which are not subject to sedimentation. Air temperatures within the khawrs soar during summer months, exposing corals to temperatures that are probably the highest in Oman waters, and cause stress to corals that may approach or exceed their tolerance limits (Chapter 4).

Plate 11. Headland at Khawr as Sham in the Musandam. The steep shoreline tends to erode and break off, restricting long term growth of corals and development of coral reefs.

Coral coverage is generally limited and highly variable, depending on the local environmental conditions and the availability of a stable bottom at depths and temperatures suitable for coral growth. The greatest coral abundances occur in shallow bays. in areas sheltered from wind and wave action, and where the bottom is relatively flat and turbidity is relatively low. Coral growth consists primarily of a thin veneer of corals growing directly on bedrock, with infrequent patch reefs, usually composed of growth by a single species. Also. fewer coral species occur overall than further south and east along Oman's coast. Surveys have found only 51 reef forming corals to be present along the Musandam coast, compared to 61 in the Capital Area; while 10 non-reef forming corals can be found compared to 7 in the Capital Area.

Muscat Capital Area

This area extends from the As Sawadi and the Daymaniyat Islands on the west to Ras Abu Daud on the east and includes some of the best growth of hard corals and development of coral reefs that occur in Oman. Being located in the population center of the country, the Capital Area affords the greatest opportunity for both visitors and residents to view and appreciate the largest variety of corals and the best developed reef formations.

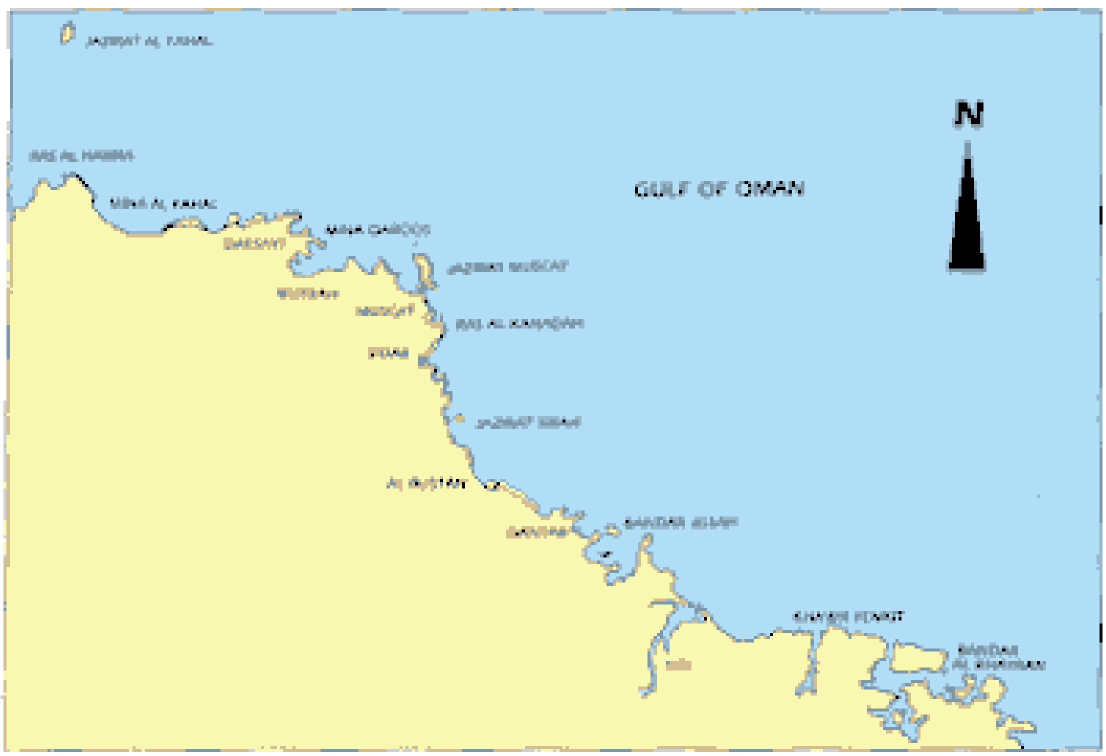

Figure 3. Map of the Capital Area of Muscat

Plate 12. Aerial view of the Daymaniyat Islands. The islands are formed from ancient fossil reefs and limestone that have emerged from the ocean. Some of the richest coral cover and best coral reef development in Oman occur in these islands, and they are the proposed site of the country's first national marine nature reserve.

The As Sawadi and Daymaniyat Islands are made of fossilized coral reef and sediments that lay below the ocean approximately 30 mi/lion years ago, as did virtually the entire coastline of the Capital Area. The As Sawadi Island are located close to the shore of the Batinah coast and have limited coral coverage and no modern reefs. By contrast, the Damaniyats are approximately 20 km offshore and are remote from both shoreline related sedimentary effects and from upwelling related temperature instability that may limit coral development further east in the Capital Area (Chapter 4). The Daymaniyats consist of nine islands and many submerged rocks, in an east to west alignment, which form the base for well developed coral reefs. The island's southern shores and those northern shores which have embayments sheltered from offshore waves have formed substantial patch and fringing reefs, growing up from the original rock base. Abundant coral growth extends to up to 20 m depth, in water that has the highest clarity of any coral growing area in Oman. The species-abundance structure for the area suggests a relatively continuously stable physical environment, which has favored the long term growth of the relatively few species that have occupied the available habitat space.

The remaining areas of substantial coral cover in the Muscat area occur further east, along the rocky shores and offshore islands from Qurm to Ras Abu Daud. Many of these areas are accessible from shore and provide relatively easy access to a variety of coral habitats. Most of these are east of Muscat and Mutrah harbors. Local areas of interest are Kalbuh, Cemetery Bay, Darsayt, Cat Island off the Marine Science and Fisheries Center, east of the Al Bustan Palace Hotel, in Bandar Jissah, Bandar Khayran and a small bay at As Sheik. For those with access to a boat, the corals and reefs of Al Fahl Island offer some of the most beautiful reefs and abundant diverse coral coverage to be found in Oman. Of the 39 genera of corals that have been found in the Muscat area, all but three occur at Al Fahl Island, on three nearby rock pinnacles which range in depth from 17 to 35 m or on the sandy bottom between Al Fahl Island and Ras al Hamra.

Plate 13. Located about 4 km off Ras al Hamra in the Capital Area, Al Fahl Island and two nearby deep reefs have the most diverse coral community in Oman.

Coral along the Muscat coast is generally sparse on shorelines which face eastward and northward and which are, therefore, more frequently exposed to wave turbulence from the open ocean. Coral coverage on these exposed areas tends to be dominated by two species of soft corals. The major coral coverage and best reef development occurs in coves and embayments sheltered from wind and waves. Where reefs do exist, they are generally small, formed by abundant and contiguous growth of one or two dominant coral species, and the reefs are only a few meters thick. However, reef development exceeds that found in both the Musundam and the Dhofar areas, suggesting that conditions in Muscat waters are the best suited of any in Oman to long term coral growth and survival. Bandar Jissah and Bandar Khayran provide the greatest areas of such sheltered habitat in the Capital Area, and sites of high coral cover and well developed reefs are common in both areas, particularly on the lee sides of the islands that isolate these large embayments from the open ocean.

East of Bandar Khayran a rich variety of species and good coral coverage occurs at a few sites accessible only by boat, and on either side of a small bay at Khaysat as Sheik, which is accessible by road. Generally, coral abundance decreases further east. as the effects of wave turbulence become more dominant. Corals and incipient reefs are found at Ras Abu Daud and Qalhat, but most areas southeast to Ras al Hadd have little coral cover and no reefs. South of Ras al Hadd to the Gulf of Masirah the nearshore environment is entirely sedimentary and corals are absent.

Plate 14. Bandar Khayran and nearby Bandar Jissah are the largest protected embayments providing sheltered habitat in Oman's waters. Numerous coves, inlets and shallow areas support many areas of high coral abundance.

Gulf of Masirah

The Gulf of Masirah is partially isolated from the open ocean by the 60 km barrier of Masirah Island, which creates a sheltered environment that receives airborne transport of sand and dust from the adjacent Wahiba Sands. This relatively quiet, somewhat turbid area is the location of Oman's only substantial seagrass beds, and is the habitat of some unique reefs formed primarily by a single species, the Cabbage Coral (***Montipora foliosa***). This species is common on the northwest and southwest coast of Masirah Island. Reefs comprised of Cabbage Coral and Brain Coral grow along southeast and southwest coasts of Barr al Hikman to the west of Masirah Island. These form the largest and most spectacular coral reefs in Oman. Corals of this type are more tolerant of higher levels of sedimentation and turbidity than most species, and it appears that the quiescent, somewhat silty conditions of the Gulf of Masirah are optimal for growth of this species. Few corals and no developed reefs survive on the east side of Masirah Island, which is subjected to heavy wave turbulence and seasonal upwelling that greatly reduces temperatures along the east shore of the island compared to the west shore.

Dhofar Coast and Al Halaaniyaat (Kuria Muria) Islands

Because of the predominantly sedimentary environment and lack of hard bottom, corals are scarce to absent on the coastline from south of Masirah Island to Kuria Maria Bay. From this area southward the 800 km Dhofar coast and the Al Halaaniyaat Islands provide rocky surfaces and habitat for a variable coverage of reef corals and limited reef development. However, the dominant environmental factor affecting marine life in this region is coastal upwelling of deep, cold water that results form the southeast monsoon winds blowing from May to September. Corals growing in this region must therefore contend annually with water temperatures that drop below 18°C during summer months and must compete with blooms of macroalgae and kelp that respond to the high nutrients that arise during upwelling This unstable physical environment and macroalgal competition undoubtedly restricts the growth and development of corals and coral reefs from what would otherwise be achieved. Despite these restrictions 52 reef forming coral species have been reported for the Dhofar region, less than for the Muscat Capital Area, but one species more than for the Musandam, At least five species of reef corals, one hard alcyonarian (organ pipe coral) and two hydrozoans (fire coral and ***Stylaster***)exist in Dhofar but are not found elsewhere along the Oman coast, probably due to the relative proximity of Dhofar to the Red Sea where these varieties are relatively abundant.

Live coral coverage is maximum in the AI Halaaniyaat Islands and east of Marbat where cover can range up to 99% of available substratum. Small reefs up to 3 m thick can be found in these areas. Available coral habitat diminishes toward the Yemen border, especially west of Al Mughsayl where steep cliffs extend only a few meters into the water to a sand bottom. The primary coral growing areas for the region are further east where relatively sheltered bays occur at Marbat,Wadi Zead and As Sadh.

Plate 15. Hoon's Bay (Raha) east of Marbat provides one of the few sheltered areas on the Dhofar coast where corals can thrive.

For further information regarding optimal locations for viewing live corals and coral reefs in Oman the reader is referred to the excellent diving guide by Salm and Baldwin, as well as other publications listed in the present bibliography. We will now concentrate on providing detailed descriptions of the various corals species that are commonly seen in Oman.

CHAPTER FOUR

Oman's Unique Coral Environment

In Chapter 2, we pointed out that both the general abundance and numbers of coral types found in Oman are substantially less than elsewhere in the Indo-Pacific region. This may be partly explained by the remoteness of Oman from the regional center of coral abundance and diversity, by the geological youth of the coastline and by the lack of suitable surfaces for coral settlement and growth. However, the Red Sea is even more isolated than Oman from the rest of the Indo-Pacific region and is also one of the world's most recent ocean regions, still in the process of formation. Much of the Red Sea's nearshore environment is sedimentary, yet the Red Sea supports some of the world's most flourishing and diverse coral reef communities, not far from the coast of Oman.

A principal reason for this difference in corat reef development between the two areas is that corals and reefs along most of the Oman coast are exposed to one of the most unique temperature and nutrient environments of any coral growing area in the world. This is most pronounced in the Dhofar region where summer upwelling generated by the southwest monsoon's winds from June through August reduces surface water temperatures to 16-19°C (61-66°F). This is approximately 10°C (18°F) lower than the temperatures that are considered optimal for coral growth and development. At the same time, the concentrations of dissolved phosphorus and nitrogen nutrients increase by as much as 100 times their normal values, causing dramatic elevations in plankton populations, decreases in water clarity and possibly, bloomsof toxic algal forms. These changes in temperature, nutrients and turbidity also produce rapid growth of brown macroalgae and kelps that may completely overgrow reef corals during the summer. Because the shallow water, benthic communities of temperate areas are usually dominated by macroalgae, and tropical areas are usually dominated by reef corals, this shift in community dominants during the summer has been termed a 'pseudo-high latitude effect'. This occurs annually, despite the fact that coral growing areas in southern Oman are at about 17°N latitude, well within the normal tropical zone.

PIate 77. Diver placing recording thermograph for measuring sea water temperatures at 10 m depth, AI Fahl Island.

The low temperatures and elevated nutrients from upwelling are probably the principal limitation to the developmentof reef structures in the Dhofar area and act as a barrier to spreading of more coral species from the Red Sea. This annual upwelling effect is continuous and pronounced as far north as Ras al Hadd. Upwelling effects have been measured on coral reefs in the Capital Area, where summer temperatures can decrease and vary radically over short time periods, as gyres of cold, deep water sweep into shallow areas. At some locations in the Muscat area not only do corals have to withstand exposure to low temperatures, they may also have to resist again being exposed within a few hours to high temperatures that are near their upper lethal limits. The figure below (Figure 4) shows temperatures neasured every three hours by a continuously recording instrument at 10 m depth on the south side of Al Fahl Island in the summer months of 1994. During July and August, when the influence of upwelling was at its maximum, temperatures at this site and depth routinely ranged from around 32°C (90°F) to below 24°C (75°F). On five days from August 8 through August

11 temperature fluctuated daily by 7 to 8°C (12.6 to 14.4°F), rising each day to 31°C or more.

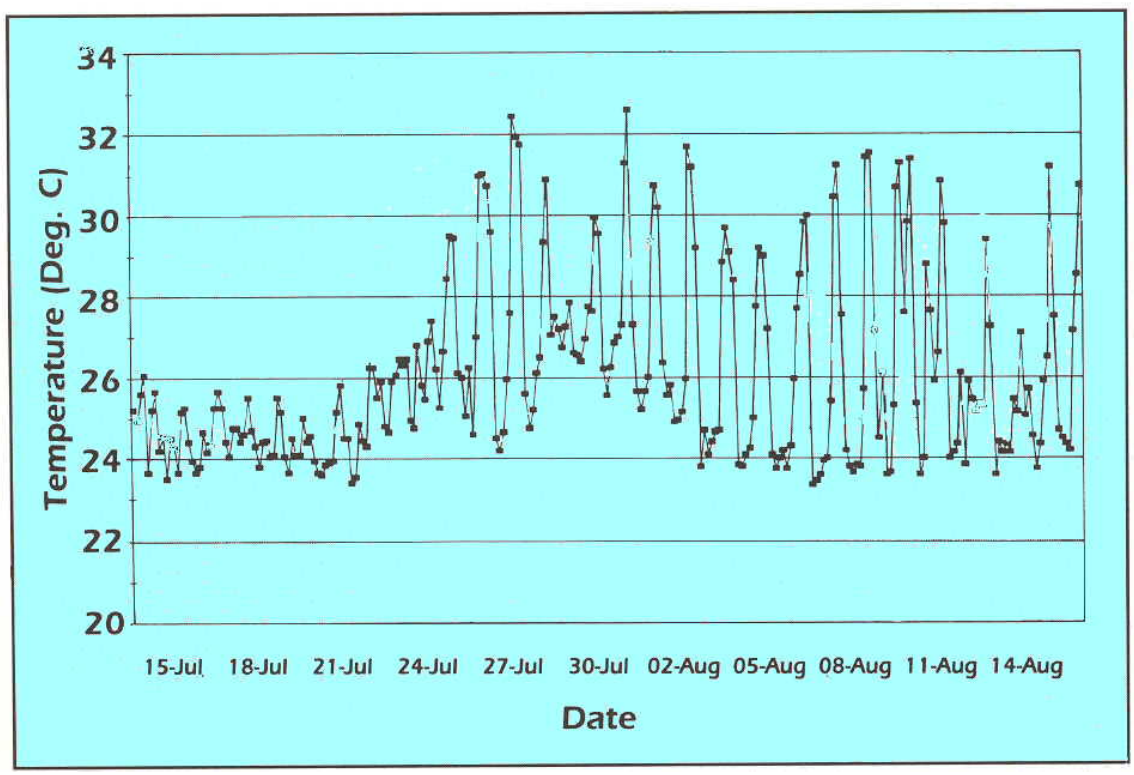

Figure 4. Water temperatures recorded at 10 m depth, Al Fahl Island, 1994

Very similar results were measured at this site in late August 1992, indicating that this is a normal annual occurrence at locations in the Capital Area, at intermediate depths which can be affected by both warm surface and cold deep water during the summer. These temperature fluctuations, which exceed any previously reported for short term periods anywhere in the world where reef corals grow, were measured on a flourishing reef with abundant coral species which have apparently adapted well to these erratic temperature conditions.

Along with these rapid summer temperature fluctuations Oman's reef corals can experience maximum temperatures which are among the highest that have been measured in the world and which would normally be considered lethal to corals. The earliest and most visible symptom of this high temperature stress is the disruption of the symbiotic association between a coral's tissue and its zooxanthellae algae (Chapter 1). The zooxanthellae, which are normally contained within the animal's cells and give the coral its characteristic brown or green color, are ejected from the coral when temperatures exceed a maximum tolerance, leaving the coral in a pale or 'bleached' condition in which the white coral skeleton is clearly visible through the transparent tissue. If lower temperatures return, the coral can re-acquire its complement of zooxanthellae and continue with normal growth. However, extended periods of elevated temperature will result in mortality of bleached corals and a decline in the structural integrity of the coral reef. Instances of coral bleaching has been much more widely reported throughout the tropics in the last decade than in previous years, and coral bleaching has been proposed as a possible symptom of global warming due to the "greenhouse effect" resulting from increased concentrations of carbon dioxide and other gases in the earth's atmosphere.

Plate 78. Cauliflower coral (*Pocillopora damicornis*)in early stages of bleaching caused by elevated temperatures. Many of the symbiotic zooxanthellae have been ejected from the coral tissue, resulting in the pale condition.

Oman's normal summer maximum sea surface temperatures of around 32°C (90°F) are well above the temperatures that have previously been found to induce coral bleaching. inareas such as Panama, Tahiti and the Great Barrier Reef, where annual maximum temperatures are around 29°C (84°F), extensive coral bleaching has resulted when unusual environmental conditions have raised temperatures to above 30°C (86°F) for extended periods. Coral bleaching does not normally occur at 32°C on Oman's reefs or further north in the Arabian Gulf where summer temperatures may reach even higher, suggesting that corals in this region have been able to adapt to higher temperatures. However, coral bleaching has been previously reported by Dr Rodney Salm in the waters of Oman during periods of exceptionally high temperatures. Coral bleaching took place in the Muscat area in 1990 when shallow water temperatures were reported to reach 39°C (102°F). However there was little sign of coral mortality a few months later, suggesting that even these high temperatures were sublethal for the timeof their exposure. By contrast, mortality of up to 95% of the corals in depths of less than 3 m occurred in the Musandam area following coral bleaching during the same year. Water temperatures at Musandam ranged only from 32 to 35°C (90 to 95°F) during this period, but were considered to have been more continuous than at Muscat, since the Musandam is beyond the influence of cold water upwelling. Therefore, the much higher temperatures that occurred in the Capital Area compared to the Musandam were probably too brief to be lethal to corals.

These examples indicate the unusual and stressful temperature environment that corals and other coral reef organisms must withstand to live along the coast of Oman. These conditions are virtually unique in the world, and we must surmise that only the species which are most tolerant to temperature stress can survive here. Other physical factors, such as the instability of the rock cliffs in the Musandam, periodic high levels of nutrient and turbidity, and general lack of suitable hard substratum must all contribute to general lack of reef development and limited number of species that occur along Oman's coast. However, temperature extremes, both long and short term, are almost certainly the primary factors limiting reef coral growth and survival in this unusual environment.

CHAPTER THREE

Descriptions of Oman Corals and Their Habitats

A Note About Names

The common English names of corals and other organisms usually are based on an obvious physical characteristic which might be similar to another object with which the layman may already be familiar, *e. g.* Cauliflower Coral, which superficially looks like a cauliflower. However such familiar names may not adequately define a given species; because other closely related species may share such a characteristic. For naming organisms more precisely biologists use something called the binomial system, first used by the great biologist Carl von Linne (Linneaus), who developed the systematic naming and description of animals and plants in the eighteenth century. This system of naming involves an italicized or underlined genus name followed by a species name for every organism, e. g. ***Pocillopora damicomis***. Such names may be changed if a subsequent biologist decides that the species should be grouped with another previously described species, or if he decides that a specimen is sufficiently different to warrant identifying it as a new and separate species. These rather confusing issues are only resolved by specialists in the field, but the intention is that any identified and described species should be genetically separate and distinct from all others.

Most books which are directed to non-specialists use only common or descriptive names, or scientific identifications go only to the genus level. In order to educate and provide more of the available information available for a coral type, this book will use both common English names that have been used in previous publications on Oman corals, and identifications to species where these can be accurately made. Where a species may be in some doubt the term cf. will be used, e. g. ***Porites*** cf. ***compressa***, and where the species is unidentified but the genus known, the genus name will be followed by sp., e. g. ***Goniopora*** sp.

Oman Hard Corals and their Habitats

Phylum Cnidaria (Coelenterata)
Class Zoantharia
Order Scleractinia
Family Astrocoeniidae
Scientific Name ***Stylocoeniella guntheri***
Common Name "Thorn Coral"
Color Greenish brown to dark brown, with white to reddish brown polyps.

Plate 16. Thorn Coral (*Stylocoeniella guntheri*).

Distinguishing Characteristics
Thorn coral usually exists as quite small, nondescript encrustations on the bottom which are easily overlooked. Its most characteristicfeature is small, thorn-like projections that lie between closely spaced calyces which are only 8-10 mm in diameter and less than 5 mm apart. The spiny projections give the coral a rough sandpapery surface, especially in the cleaned skeletons.

Habitat
This species is encountered across a wide depth range and conditions of wave exposure and turbidity.

Family Pocilloporidae
Scientific Name ***Pocillopora damicomis***
Common Name "Cauliflower Coral"
Color Usually reddish brown to dark brown, sometimes greenish brown.

Plate 17. A coral reef off Fahl Island comprised entirely of Cauliflower Coral (*Pocillopora damicornis*).

Distinguishing Characteristics
Individual colonies of this species grow as small and bushy coral heads. but many colonies may grow together in wave protected areas to form extensive monospecific fringing reefs made of this fast growing species. The coral is highly branching and its branches are usually thin and quite delicate when the coral is growing in quiet, wave protected areas. However, growth form is highly variable, and branches can grow to be much thicker and more robust on corals living in more wave exposed areas where they must withstand turbulence. The coral's calyces are small, less than 1 mm in diameter, and the ends of its branches divide into small sub-branches that appear knobby or club-like. Often a branch will show an enlarged, fan-like shape which marks the home of a resident symbiotic crab which lives within the coral's skeleton. Other colorful symbiotic crabs and shrimp

live in mating pairs within the spaces among the coral branches which form a complex internal space that provides both a protective habitat and food from mucus produced by the coral.

Habitat

Cauliflower coral can thrive in a variety of environments, but it is most abundant in bays such as Bandar Jissah and Bandar Khayran or in shallow water along wave protected sides of islands where it may grow in large monospecific stands many tens of meters in area and a few meters thick.

Miscellaneous

This was the first coral species to have been named and described by Linaeus in 1758, and it is one of the most widely distributed species in the world. It is found throughout the tropical Indo-Pacific, all the way from the Red Sea Coast of Africa to the west coast of Panama in Central America. It was the dominant coral species in these regions, forming large, monospecific stands similar to the kind we see in Oman today. However, the El Nino warming of 1982-1983 induced mass mortality in the Panama populations of this species.

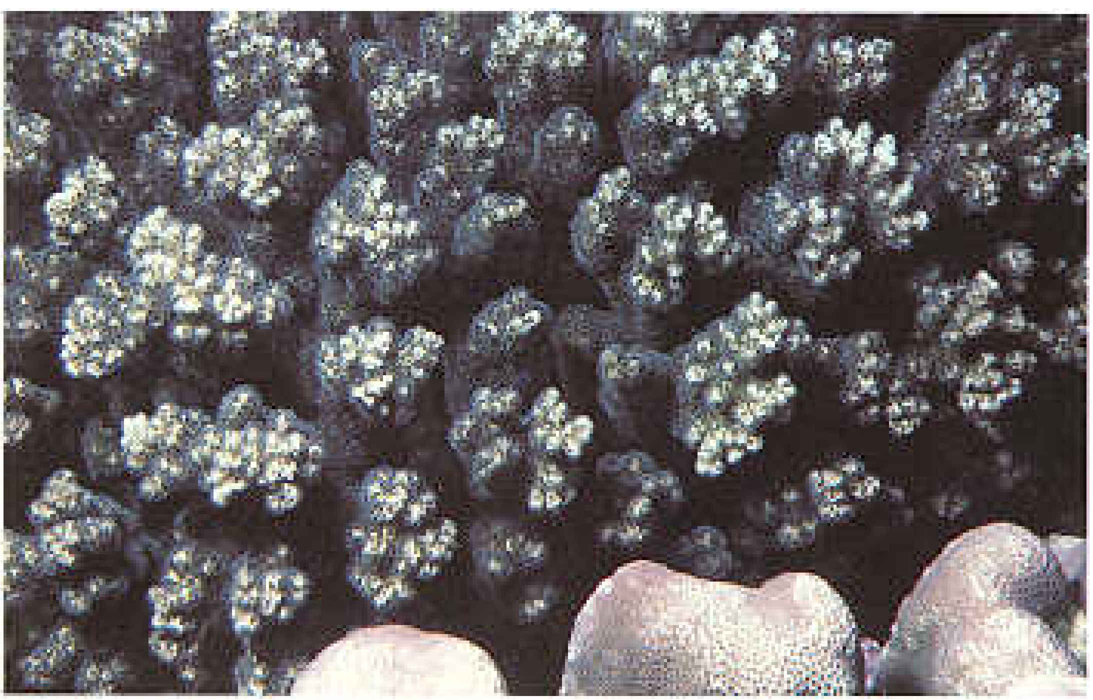

Plate 18. Close up of Cauliflower Coral *(Pocillopora damicornis)* showing partly expanded polyps and club shaped ends of branches. Branches of

Finger Coral *(Porites compressa)* are at bottom right.

Scientific Name ***Stylophora pistillata***
Common Name "Hood Coral"
Color Pale to medium brown.

Plate 19. Close up of *Stylophora pistillata* showing partly expanded polyps in hooded calyces.

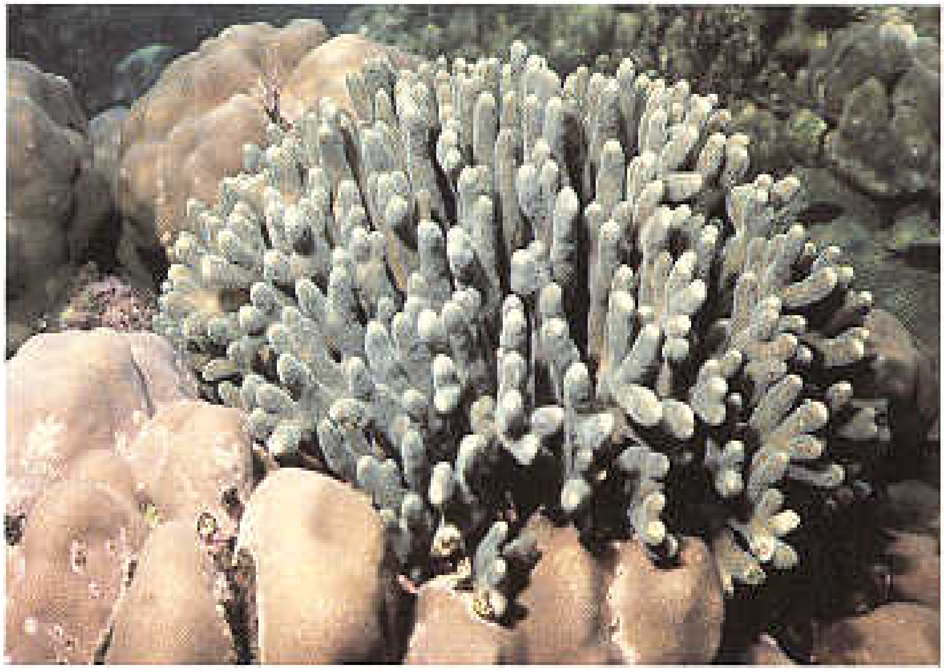

Plate 20. Hood Coral (*Stylophora pistillata*) growing on colony of Hump Coral (*Porites lutea*).

Distinguishing Characteristics

Colonies are usually small (10-15 cm diameter) and branching, with branches about 1 mm thick, sometimes bifurcated into small club-like ends which mark a new branching point. Calyces are about 1 mm in diameter and each calyx is partly bordered by a small hood which is the source of this species' common name. The coral's skeleton is dense and heavy, and therefore capable of resisting strong wave action. This species also plays host to a complement of symbiotic crabs and shrimp, similar to Cauliflower Coral.

Habitat

Hood Coral is found to depths of 50 m and under a variety of environmental conditions, but it is most common in shallow areas. It may live in areas with extreme turbidity such as on mangrove roots, and it is one of the most resistant of corals to various physical stresses. It may be the dominant species on shallow reefs that are periodically exposed to changes in temperature or salinity. It has a high reproductive potential, which enables it to rapidly colonize areas where most other species may be killed or unable to compete.

Family Acroporidae
Scientific Name ***Acropora clathrata***
Common Name "Table Coral"
Color Pale to medium reddish brown.

Plate 21. Side view of a colony of Table Coral *(Acropora clathrata)* showing branches interconnected in a single plane.

Distinguishing Characteristics
This is one of the dominant species in Oman of the very diverse family Acroporidae, which has over 200 recognized species. Branches of ***Acropora*** species have an nearly colorless apical polyp on the branch end that is the most rapidly growing part of the colony with slower growing lateral polyps future back on the branch. Calyces of this species look like numerous small tubes or ear-like projections from the coral branch. Small colonies of ***A. clathrata*** may appear fan-like with lacy branches. As these grow they form large tables which range up to 3 m in diameter. Smaller tables show numerous branches and sub-branches which, as the table grows, coalesce to form solid plates. Branchlets of large tables almost never turn upward but remain in the plane of the plate which forms the table. Large tables on wave exposed coastlines are extremely robust and dense, unlike

most members of this family. which have porous and delicate skeletons.

Habitat
This species occurs in almost all areas which support reef corals in Oman, from the most protected bays to the most exposed coasts, where large, very dense and strong tables may be the dominant coral. Table corals, like most other members of this family, grow very fast and can establish monospecific reefs like Cauliflower Coral, often in the same immediate area.

Scientific Name ***Acropora valenciennesi***
Common Name "Table Coral"
Color Pale to medium reddish brown.

Plate 22. Side view of a Table Coral (*Acropora valenciennesii*)with branch tips projecting above the table surface.

Distinguishing Characteristics
This species is similar to ***Acropora clathrata,***but is more loosely branched and its branches do not coalesce into plates as the coral grows larger. Branch ends may curve upward instead of remaining in the same plane of the table top. Lateral calyces are neatly arranged in rows along the sides of branches.

Habitat
Acropora valenciennesi, similar to ***Acropora clathrata***, is found mostly between 5 and 20 m deep in sheltered areas.

Scientific Name ***Acropora valida***
Common Name "Bush Coral"
Color Pale to medium brown, sometimes with overtones of green, blue or pink.

Plate 23. Colonies of Bush Coral (*Acropora valida*).

Distinguishing Characteristics
This is the second most abundant ***Acropora*** species present in Oman. It usually appears in groups of small, bushy colonies each about 10-20 cm diameter with pale or colorless, terminal polyps. It often forms thickets composed of this single species in the same areas as ***Acropora clathrata.***

Habitat
This species usually exists in sandy areas in sheltered embayments where it may be a dominant species in clear to turbid water conditions. It is the most common ***Acropora*** species in the world and is found from the Red Sea to the west coast of Central America, suggesting that it can thrive in a variety of environmental conditions. Like many other species of bush-like ***Acropora***, this species provides

food and habitat for a group of colorful symbiotic crabs similar to those that inhabit Cauliflower Coral and Hood Coral.

Scientific Name ***Montipora aequituberculata***
Common Name "Encrusting Pore Coral"
Color Tan to pinkish brown.

Plate 24. Close up of Encrusting Pore Coral (*Montipora aequituberculata*).

Distinguishing Characteristics
The calyces of this coral are minute, 0.5 mm or less, and recessed within projections called papillae which surround and project above the calyces and give the coral surface a grainy appearance, even in live specimens. Adjacent papillae are sometimes fused. The growth form is encrusting or plate forming but never branching, and colonies grow in irregular shapes over areas up to 2 m in their longest dimension.

Habitat
This and other encrusting species of ***Montipora*** are frequently found on upper reef slopes and sheltered areas and can become more dominant in areas of moderate turbidity.

Scientific Name ***Montipora circumvallata***
Common Name "Porous Leaf Coral"
Color Rich brown to pinkish brown.

Plate 25. Large colony of Porous Leaf Coral (*Montipora circumvallata*) with a complex structure of leaves, plates and small branches.

Distinguishing Characteristics
This species is in many respects similar to Cabbage Coral in forming leafy plates and foliaceous growths. However, its growth form is more variable than Cabbage Coral in that it may form fingers, small spires and somewhat branching structures as well as simple encrustations, all within the same colony. The calyces of its skeleton are small, about 5 mm in diameter, and do not align themselves in rows as in Cabbage Coral. Small projections surround the calyces which give the surface of cleaned skeletons a rough, grainy texture.

Habitat
This species is very common in embayments in the Capital Area, where it is often the dominant form in turbid areas and may monopolize many meters of the bottom as monospecific reefs. It is usually seen in shallow water, often in sandy areas

where no other corals occur.

Scientific Name ***Montipora foliosa***
Common Name "Cabbage Coral"
Color Rich brown to pinkish brown

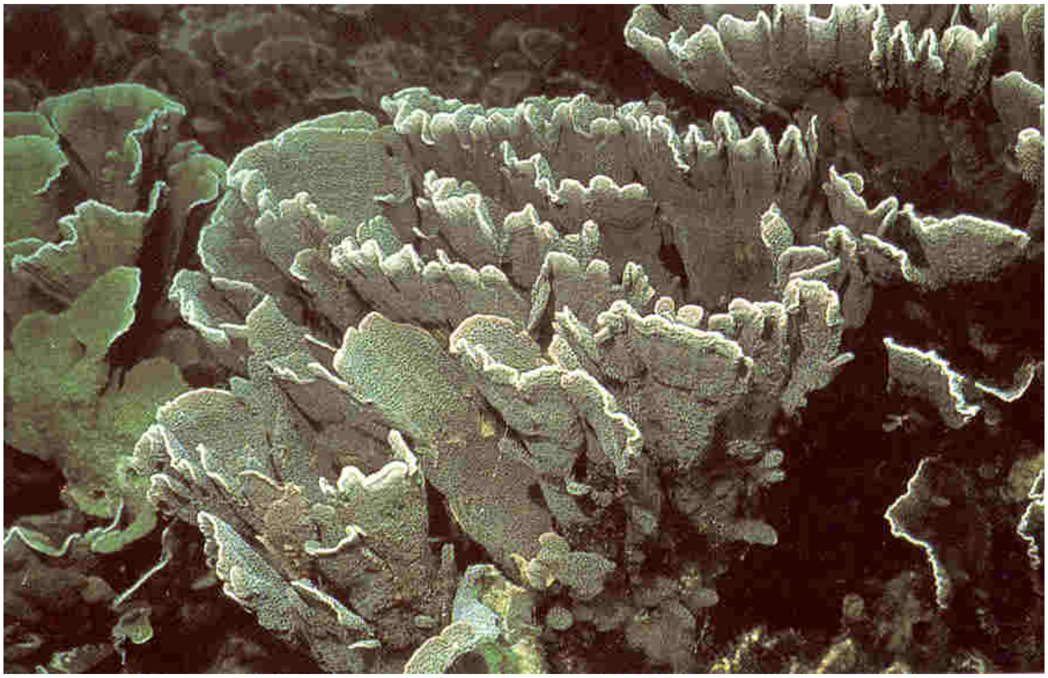

Plate 26. Cabbage Coral (*Montipora foliosa*) showing highly foliaceous plate growth.

Distiguishing Characterstics

Cabbage Coral forms large encrusting colonies with leafy plates that may grow into large, beautiful reefs composed of this single species. Each plate may form the site of origin of many more plates and leaves as the colony grows. This species may completely dominate and overgrow an area with its beautiful formations. Calyces are tiny, almost pin prick size, and arranged in rows along ridges that radiate from the center of a growing plate to the plates margin.

This species can be extremely abundant in areas where water is calm and relatively turbid. It is the most common coral on the western side of Masirah Island and the southeast to southwest coasts of Barr al Hikman, where its rapid growth forms the largest reefs along any Oman coast. It is also common in embayments and sheltered waters from Musandam to Dhofar.

Scientific Name ***Astreopora myriophthalma***
Common Name "Porous Star Coral"
Color Creamy pale brown to medium brown.

Plate 27. Colony of Porous Star Coral (*Astreopora myriophthalma*).

Distinguishing Characteristics
This species is easily distinguished by the shape of its calyces, which are 1-2 mm in diameter, raised like small cones above the surface of the skeleton and are granulated and evenly spaced. The coral colonies can vary in shape, from simple encrustations or lobes to heavy branching forms which can be intricately formed, but colonies are always robust and strong. The skeleton is much denser than most of the other members of the Acroporidae family.

Habitat
Astreopora myriophthalma is wide spread from the Red Sea to the Tuamotus in the South Pacific, in all types of habitats and depths where turbidity is not high. In Oman this species is commonly found in areas of moderate to high wave

turbulence.

Family Poritidae
Scientific Name ***Porites*** cf.***compressa***
Common Name "Finger Coral"
Color Pale green to olive green.

Plate 28. View of a reef at the Dimaniyat Islands showing Finger Coral (*Porites compressa*) at left and Hump Coral (*Porites lutea*) at right.

Distinguishing Characteristics
This species is highly branched but unlike Cauliflower Coral and Hood Coral the calyces, which are about 1.5 mm in diameter, are shallow and the coral surface is nearly smooth. The branches average about 1.5 cm thick and are fused at their bases into a massive trunk. This is the only distinctly branching species of ***Porites*** in Oman.

Habitat
This species is almost always found in embayments where it may form monospecific stands and fringing reefs similar to those formed by ***Pocillopora damicomis***. It is relatively tolerant of turbidity. sedimentation and reduced salinity

and therefore is likely to dominate in those areas closest to freshwater runoff.

Plate 29. Close up of Finger Coral (*Porites compressa*).

Miscellaneous
This species was first described from specimens obtained in Hawaii and has been reported at very few locations other than Hawaii and the coasts of Arabia. It is the dominant species on the nearshore reefs of the northern Arabian Gulf where it appears to be the coral that is the most adapted to *low* winter water temperatures of this area.

Scientific Name ***Porites lutea***
Common Name "Hump Coral"
Color Green to greenish brown.

Plate 30. Close up of Hump Coral (*Porites lutea*).

Distinguishing Characteristics
This species has similar calyces as ***Porites compressa***, but it grows as massive colonies without distinct branching. Its primary growth form is hemispherical. up to many meters in diameter, but in bays or areas with sediment input it may grow in thick columnar shapes. It forms large, nearly monospecific reefs, such as can be seen in Cemetery Bay at Muscat. Although its growth rate is relatively slow, a single coral colony can grow for many hundreds to a thousand years, and its growth will crowd out other species when environmental conditions are stable over long time periods.

Habitat:
Although this species may grow along wave exposed open coastlines, in Oman, Hump Coral is most common and most dominant in wave protected shores and embayments where it forms massive reefs in similar locations as ***Porites compressa*** and ***Pocillopora damicomis***. In these areas individual colonies often exceed 5 m in diameter, representing hundreds of years of continuous growth.

Scientific Name ***Goniopora*** sp.
Common Name "Daisy Coral"
Color Green to gray-green.

Plate 31. Close up of expanded polyps of Daisy Coral (*Goniopora* sp).

Distinguishing Characteristics

This genus is easily recognized from its highly expanded flower-like polyps which project several centimeters above the coral's skeleton, waving back and forth with each passing current or wave. When disturbed, the polyps will be retracted and show a smooth coral surface, but often polyps can not be pulled completely into the calyx and are easily detached from the corals surface. Unlike most corals, this species usually has its polyps highly extended during the day. The skeleton of individual coral is massive but usually smaller than 1 m diameter, with larger, deeper set calyces than ***Porites*** species. It can assume a variety of growth forms, from massive or columnar, to highly irregular shapes.

Habitat

This species grows at a variety of depths and conditions of wave exposure, but is most common in quiet water in embayments. Like its close relatives the ***Porites***, it often forms large monospecific stands in protected areas.

Family Siderastreidae

Scientific Name ***Siderastrea savigniyana***

Common Name "African Pillow Coral"
Color Creamy white with pale brown centers.

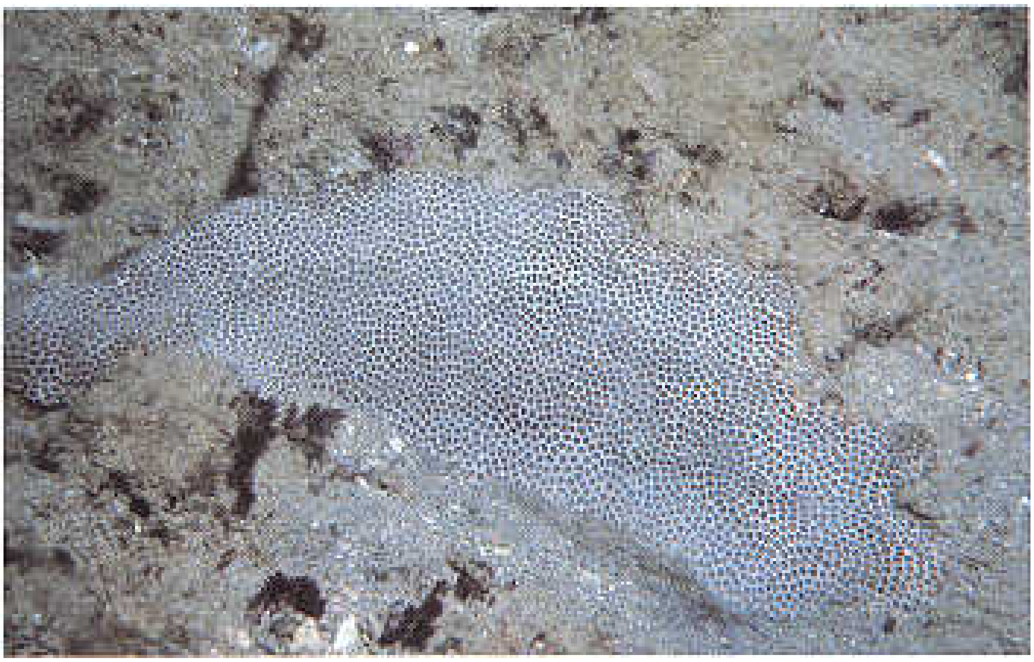

Plate 32. Colony of African Pillow Coral (*Siderastrea savigniyana*).

Distinguishing Characteristics
This coral forms small colonies that are slightly rounded or flat encrustastions on the the bottom. Its calyces are polygonal, about 3 mm in diameter and separated by broad walls which appear much paler than the tissue in the polyps of the live specimens. Many of the calyces in cleaned skeletons show fusion of three or four adjacent septa, resulting in fewer septa reaching the center of the calyx than are at its perimeter.

Habitat
This species is almost always in areas where a thin layer of sand covers the hard bottom and probably inhibits the settlement and growth of species more sensitive to sedimentation and scour. Therefore, this coral may be common in sedimented embayments and at the bottom of steep coral covered slopes, but it never occupies more than a small portion of the bottom. Specimens are always small, usually less than 20 cm in their largest dimension.

Scientific Name ***Pseudosiderastrea tayami***
Common Name "False Pillow Coral"
Color Pale brown with white polyp walls.

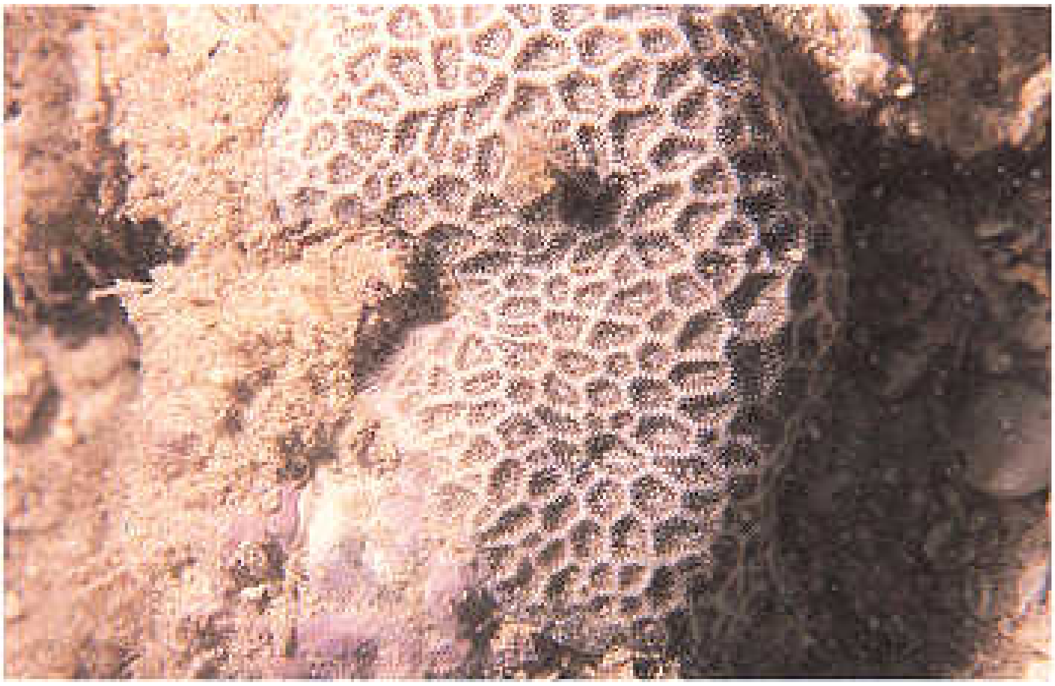

Plate 33. Colony of False Pillow Coral (*Pseudosiderastrea tayami*).

Distinguishing Characteristics
False Pillow Coral is found in the same areas as the African Pillow Coral which it resembles. The present species has polygonal calyces 3-6 mm in diameter with distinct, narrow wallswhich are usually much fighter in color than the polyp centers. Its evenly spaced septa have fine teeth and fuse together in fan shapes. Coloniesare usually small and encrusting or convex.

Habitat
The usual habitat for False Pillow Coral is on or at the base of reef slopes in calm water.

Scientific Name ***Anomastraea irregularis***
Common Name "Crisp Pillow Coral"
Color Pale brown.

Plate 34. Colony of Crisp Pillow Coral (*Anaomastrea irregularis*)

Distinguishing Characteristics
Colonies of this species are small and usually humped or conical, rising 10 to 20 cm above the hard bottom. The coral surface is smooth, with calyces 3-5 mm diameter, irregularly shaped and with walls shared between adjacent calyces. Septa are numerous and are densely packed within the calyces, and they angle steeply into the calycal centers.

Habitat
This species is most common at the bases of reefs in turbid, sandy environments where there is good water movement. Itis most common in the northern Arabian Gulf and, therefore, appears to be adapted to withstand cold temperatures. Although it is not found in the Red Sea, its only other occurrence worldwide is on the east coast of Africa west of Madagascar, again in a low temperature region.

Scientific Name ***Psammocora contigua***
Common Name "Branched Sandpaper Coral"
Color Pale to dark brown or gray.

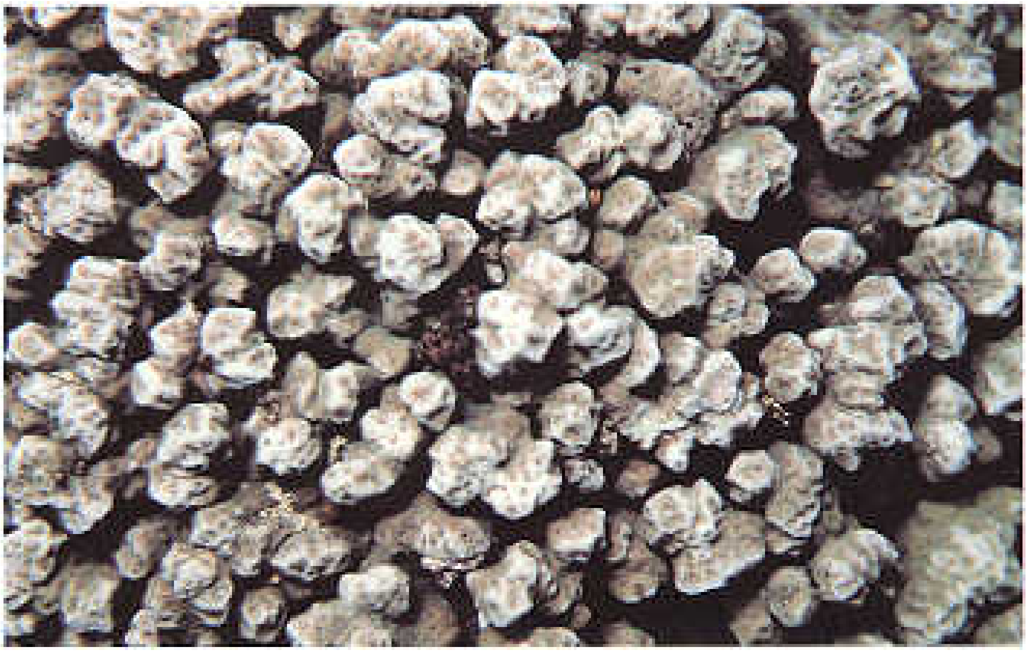

Plate 35. Close up of Branched Sandpaper Coral (*Psammocora contigua*).

Distinguishing Characteristics
The branches of this coral are thick and flattened at the ends, giving a somewhat club shaped appearance. The common name is derived from its coarse, sandpapery surface, most apparent in the cleaned specimen, but which shows even in the tissue covered live coral. This texture results from the porous nature of the coral skeleton, and its calyces and septa are rather sparse and indistinct among the skeletal pores.

Habitat
This species grows to a height of about 10 cm above the reef surface and is almost always found in shallow water, usually in areas of moderate to high turbidity and sedimentation which may restrict other species. It is often the coral growing nearest the shoreline, indicating the resistance of this species to physical stresses.

Scientific Name***Psammocora*** cf. ***haimeana***
Common Name "Encrusting Sandpaper Coral"
Color Brown or gray.

Plate 36. Close up of Encrusting Sandpaper Coral (*Psammocora* cf. *haimeana*).

Distinguishing Characteristics
The coarse, sandpapery surface of this species is very similar to that of branching sandpaper coral and calices are approximately the same size. Also, the prominant septa in calyces for both species are thickened toward calyx perimeters, giving the septa the appearance of flower petals. The primary difference between the two species is that this one does not form branches. Instead, the coral is encrusting or slightly lobate, with the calyces lying in slight depressions or short meandering valleys.

Habitat
This species grows at intermediate depths in clear to turbid water conditions. It is inconspicuous and may dwell in depressions or recessed areas in the reef substratum.

Scientific Name ***Coscinarea monile***
Common Name "Wrinkle Coral"
Color Brown to pale brown in calyces, with lighter coloron septal ridges.

Plate 37. Wrinkle Coral (*Coscinarea monile*).

Distinguishing Characteristics

This coral appears to have some of the characteristics of the brain corals described below, i.e. meandering continuous valleys of polyp mouths within the same tentacular ring which gives the appearance of a brain surface. On closer inspection however, it can be seen that the adjacent calyces of this species are more distinctly separated than in the brain corals, and that the brain-like appearance results from alignment of septa between adjacent calyces. The calyx diameter of up to 7 mm is the largest of any species in this family, and walls and septa are thick. The coral generally grows as small hemispherical colonies and is usually a minor, although common component of the total coral cover in Oman.

Habitat

This species favors turbid water and low temperatures is in a variety of habitats from shallow subtidal to 50 m depth. It is most abundant where cold water conditions periodically prevail. such as in the northern Arabian Gulf and in areas of cold upwelling on the Dhofar coast. In Australia this genus is not encountered in tropical areas, but is restricted to southern temperate waters.

Family Pavonidae

Scientific Names ***Pavona cactus*** and ***Pavona decussata***
Common Name "Leaf Corals"
Color Pale to dark brown, sometimes with greenish hue.

Plate 38. Colony of Leaf Coral (*Pavona cactus*) in front of Brain Coral (*Platygyra daedalea*), and a Leafy Hedgehog Coral (*Echinopora lamellosa*) at lower left.

Distinguishing Characteristics
These two species are similar enough to suggest that they might be different growth forms of the same species. However, they can be differentiated on the basis of the thickness of their distinctive leaf-Iike structures and the sizes of their calyces. Both form vertical, irregular leaves that appear as sinuous, sometimes delicate, flower-like petals. The septa of the small calyces extend over the tops of the leaves, giving them a finely serrated appearance. This delicate structure is most developed in ***Pavona cactus,*** which has thin leaves no more than 5 mm thick and smaller calyx diameters of less than 1 mm. In deeper quiet waters up to 10 m depth this form can be very abundant on reef slopes and have a very fragile growth form. ***Pavona decussata***, which is more common in shallow areas, is more robust in appearance, has thicker leaves up to 10 mm thick and calyx diameters up to 3 mm.

Habitat

Both species are common in sheltered quiet waters, either in shallow bays and lagoons or on reef slopes below the zone of active wave action. They appear to compete best against other species when water is moderately turbid and subject to sedimentation.

Scientific Name ***Pavona explanulata***
Common Name "Peacock Coral"
Color Various from gray. pink to purple. or brown to green.

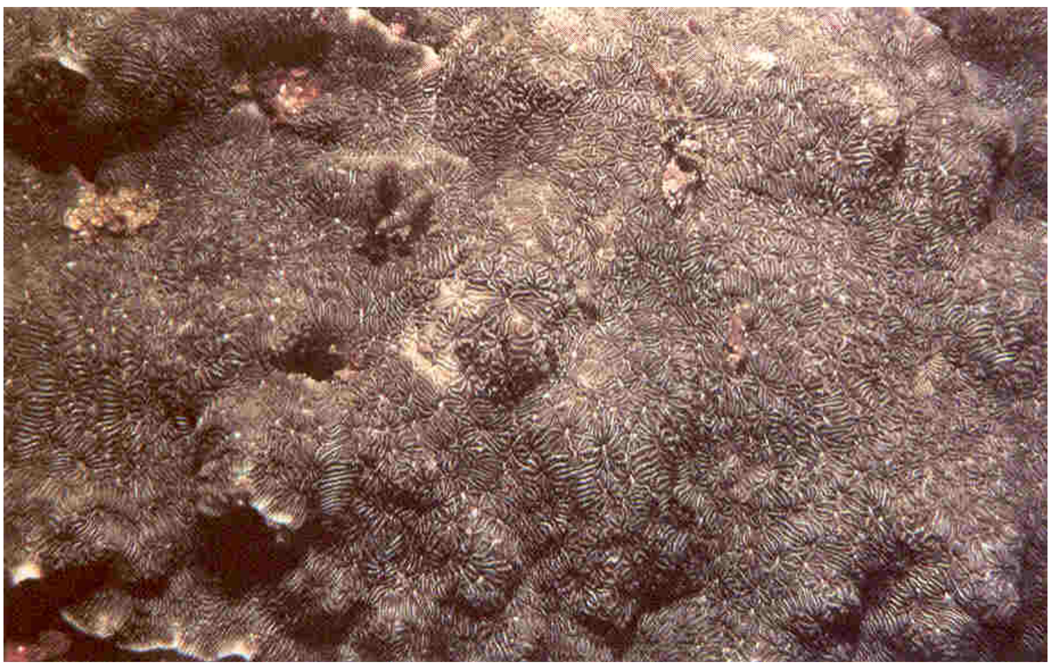

Plate 39. Close up of Peacock Coral (*Pavona explanulata*).

Distinguishing Characteristics

The coarse septa on this species extend between calyces and alternate in thickness, giving a hash-marked appearance. This structural detail may not be apparent when the polyps of the coral are expanded. Leaves are seldom developed, and the coral is usually encrusting with little relief, although rarely delicate, leaflike structures can occur. Calyx diameter is 3-4 mm with variable separation between calyces dependent on water depth and clarity.

Habitat

This ubiquitous species is usually found as a minor component of the coral cover at a wide range of depths, light and environmental conditions from Madagascar to the Philippines. It reaches its greatest abundance at intermediate depths on reef slopes.

Scientific Name ***Leptoseris mycetoseroides***
Common Name "Slender Lettuce Coral"
Color Mottled brown to green.

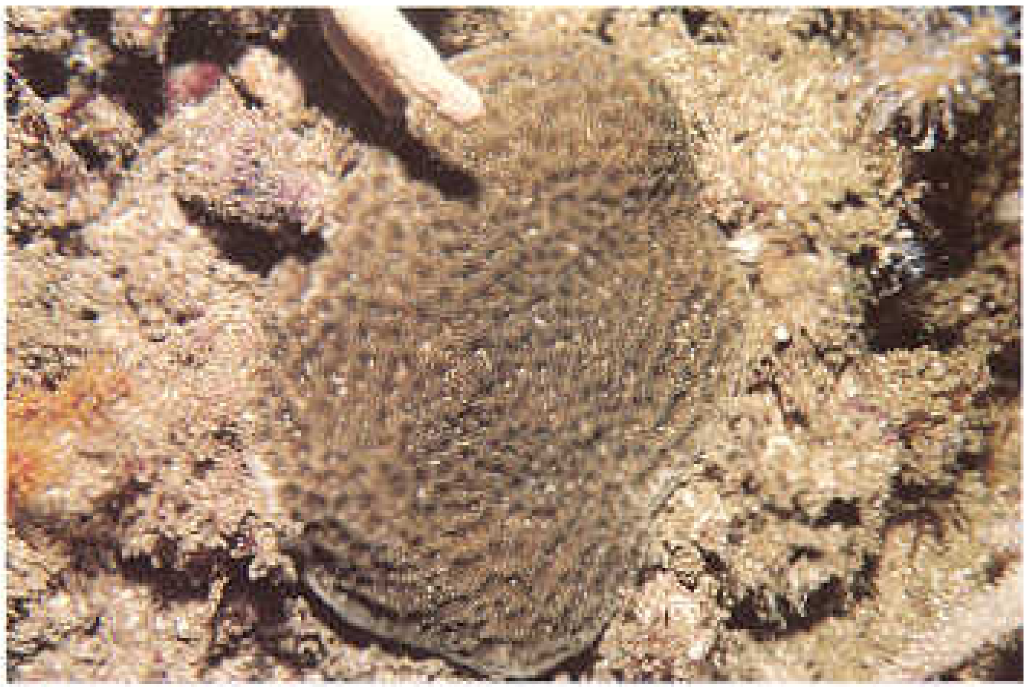

Plate 40. Slender Lettuce Coral (*Leptoseris mysetoseroides*)

Distinguishing Characteristics
This coral forms small encrusting colonies or foliose leaves with various degrees of folding. The coral often has a delicate brain-like appearance with the calyces lying within valleys formed by ridges that may meander over the corals surface. The fine septa extend evenly over the ridges between calyces

Habitat
The Slender Lettuce Coral is found in a variety of habitats and depths, but

primarily on steeply sloping walls in deep water, such as Deep and Shallow Reefs near Al Fahl Island.

Family Fungiidae
Scientific Name ***Cycloseris patelliformis***
Common Name "Kneecap Coral"
Color Pale-brown to cream with possibly brown perimeter.

Plate 41. Kneecap Coral (*Cycloseris patelliformis*).

Distinguishing Characteristics
This coral and other members of its family are unique in that a single polyp makes up the entire coral colony and the coral lives with no attachment to the bottom. This means that the coral can live in soft sand and is capable of limited movement by differential swelling of its body. This coral is circular in shape, up to 4-5 cm in diameter with the evenly spaced, prominent septa running in neat radii from the central mouth area to the disk's perimeter. When tentacles are expanded they protrude from between the septa at various distances from the polyp mouth.

Habitat
This coral is extremely rare in Oman and thus far is known only from one

specimen collected near Marbat in Dhofar. Its primary habitat is in the sand at intermediate depths outside of reefs.

Scientific Name ***Daseris distorta***
Common Name "Wedge Coral"
Color Brown to cream.

Plate 42. Wedge Coral (*Diaseris distorta*).

Distinguishing Characteristics
Appearing like a Kneecap Coral that has fragmented into a number of fan-like wedges is an apt description for this small and easily overlooked coral species. In fact, this fragmentation is how the wedges are formed as the coral grows, with wedges having "radii" up to 7 crn and thickly beaded septa. Short tentacles can protrude from between the septa when the tentacles are expanded.

Habitat
This coral has been found thus far in Oman at only one site. It is relatively abundant at about 20 m depth on a submarine ridge that lies between Ras al Hamra and Fahl Island in the Capital Area. The bottom at this location is light sand over calcareous rock and water is usually turbid, conditions that are known to

favor this species.

Miscellaneous
Despite Wedge Coral and Kneecap Coral having been known to occur all the way from the Red Sea to Central America, this is the first report of these two species from the family Fungiidae for Oman waters.

Family Oculinidae
Scientific Name ***Galaxea fascicularis***
Common Name "Starburst Coral"
Color Usually brown with green protruding tentacles.

Plate 43. Sunburst Coral (*Galaxea fascicularis*) showing partly expanded tentacles.

Distinguishing Characteristics:
This very beautiful coral is well described by its common name, which can pertain to both the living coral and the cleaned skeleton. The 3-5 mm diameter calyces are raised like pegs, up to 1 cm above the coral surface, and the septa are thick and protuberant, giving the skeleton the appearance of exploding aerial fireworks. Although this skeletal appearance may be somewhat lessened by the presence of

fleshy tissue on the live coral, when the corals tentacles are expanded, the starburst effect is enhanced by the appearance of the tentacles protruding out of each calyx. The coral is usually encrusting but can develop branching or foliaceous growth forms.

Habitat
This species is relatively uncommon, and is found at shallow depths under a variety of condition of water clarity. It forms a large monospecific stand in the clear water of the Damaniyat Islands, where it is relatively abundant compared to most areas.

Family Pectiniidae
Scientific Name***Echinophyllia aspera***
Common Name "Flat Lettuce Coral"
Color Various from pale or red-brown to dark brown. sometimes with green polyp centers.

Plate 44. Flat lettuce Coral (*Echinophyllia aspera*).

Distinguishing Characteristics
This species grows as low lying plates or broad leaves with free edges lying dose

to the reef surface. Polyps are 1cm in diameter and widely spaced on the coral's upper surface. Calyces may protrude well above or lie even with the surface and calycal septa, and the surface between the calyces is very spiny. Spines are coarse and sharp rather than bead-like as in Hedgehog Coral. ,

Habitat

This species is usually found in mid to deep water on or at the base of reef slopes, but may occur in shallow water under clear conditions. It is a minor component of the coral community at many sites in the Capital Area which have steep slopes and rich coral coverage such as at Al Fahl Island and at wave protected areas along the shoreline from Bandar Khayran to As Sheik.

Scientific Name ***Oxypora lacera***
Common Name "Porous Lettuce Coral"
Color Gray green to pale brown

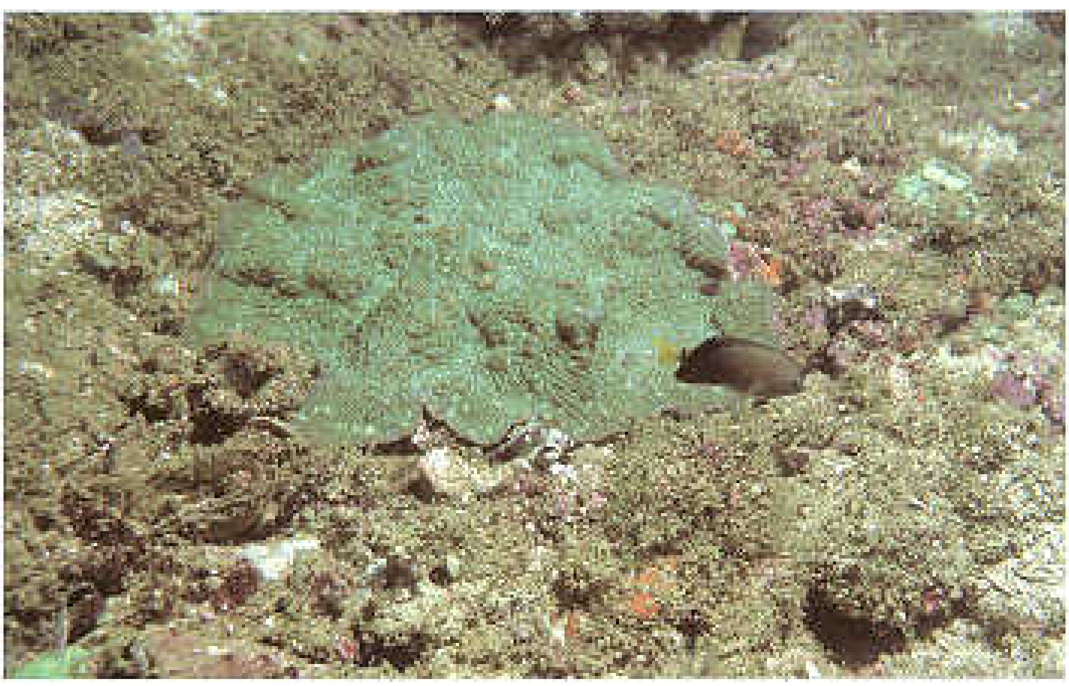

Plate 45. Porous lettuce coral (*Oxypora lacera*).

Distinguishing Characteristics

This species looks very similar in the field to its close relative Flat Lettuce Coral, with spiny ridges on upper surfaces extending between sparsely spaced calyces, usually on a flat, plate-like growth form. The species differ primarily in the degree of protrusion of their calyces above the coral surface and the spination of the ridges on the underside of the coral. The calyces of ***Oxypora*** are smaller and protrude less than ***Echinophyllia***, resulting in a smoother overall coral surface with calyces less visible. The ridges on the ***Oxypora*** lower surface are spiny, while those on ***Echinophyllia*** are smooth.

Habitat:
Like Flat Lettuce Coral, this species usually occurs in deeper water of 25 m or more in sheltered areas receiving little sedimentation and limited currents.

Family Mussidae
Scientific Name ***Acanthastrea echinata***
Common Name "Starry Cup Coral"
Color Dark brown often with green polyp centers, sometimes all greenish.

Plate 46. Starry Cup Coral *(Acanthastrea echinata)*

Distinguishing Characteristics
The calyces of this species are variable with diameters of 1 to 3 cm and are irregular in shape. The species is best distinguished by the pronounced spines on the skeletal septa, which are usually quite visible even through the thick tissues of

the live specimen and are the most apparent characteristic on the cleaned skeleton. These spiny septa continue as toothed ridges across the walls which are shared between calyces. When retracted the fleshy polyps show thick concentric folds.

Habitat
The coral colony usually grows as small hemispheres or encrustations on the reef surface or in crevices and under ledges. It is common over a full range of depths and environmental conditions down to 30 m and is tolerant of turbid water conditions.

Scientific Name ***Acanthastrea maxima***
Common Name "Fleshy Artichoke Coral"
Color Dark brown or green.

Plate 47. Fleshy Artichoke Coral (*Acanthastrea maxima*).

Distinguishing Characteristics
Like the starry cup coral, heavy septal spines are the dominant characteristic of this species. However, the diameters of its calyces are much larger, up to 5 cm, and polyps may expand to twice this diameter. This species is endemic to Oman, meaning that it has been encountered in only Oman waters, having been described

from a specimen first found off Ras al Hamra.

Habitat
Thus far, fleshy artichoke coral is very uncommon and has only been collected from the ridge area lying between Ras al Hamra and Al Fahl Island in the Muscat area, and in the nearshore waters at Sahd, Dhofar. It appears to be favored by relatively low light and high turbidity conditions that are present over sandy bottoms where most other coral species are not abundant.

Scientific Name ***Blastomussa merleti***
Common Name "Branched Cup Coral"
Color Highly variable, from reddish through greenish brown or blue-gray.

Plate 48. Branched Cup Coral (*Blastomussa merleti*).

Distinguishing Characteristics
When this species has its fleshy polyps expanded, it resembles a colonial anemone growing on the reef surface. Causing the polyps to retract reveals separate or nearly separate 1 cm diameter calyces on stalks up to 3 cm long with no tissue on their bases. Septa within the calyces are coarse and relatively few. Colonies are usually small and infrequently found.

Habitat

The Branched Cup Coral is usually seen in deeper water and in cracks and crevices on the reef slope. It is less common in shallow areas and in areas of high coral cover and diversity such as Al Fahl Island and Bandar Khayran to As Sheik.

Scientific Name ***Symphyllia radians***
Common Name "Greater Brain Coral"
Color Dark brown. .

Plate 49. Greater Brain Coral (*Symphyllia radians*)

Distinguishing Characteristics

This species is similar to Brain Coral in having a brain like appearance with the calyces as meandering valleys. However, these valleys are very much bigger in this species, with the width of valley walls ranging 2 to 3 cm. The skeleton of this coral is massive and very spiny, with large sharp spines projecting from along the ridge walls. However, the spines may not show in live specimens because they are hidden by its very fleshy polyps. Colonies may reach 2 m diameter but more often are in the 0.5 to 1 m range.

Habitat

Although this species can be found in sheltered bays and coastlines, it is more commonly seen in exposed offshore areas. With its massive growth form it is well adapted to strong surf conditions. and it therefore tends to dominate in the most turbulent areas.

Family Merulinidae
Scientific Names ***Hydnophora micronos*** and ***Hydnophora exesa***
Comon Name "Spine Corals"
Color Cream, brown or green.

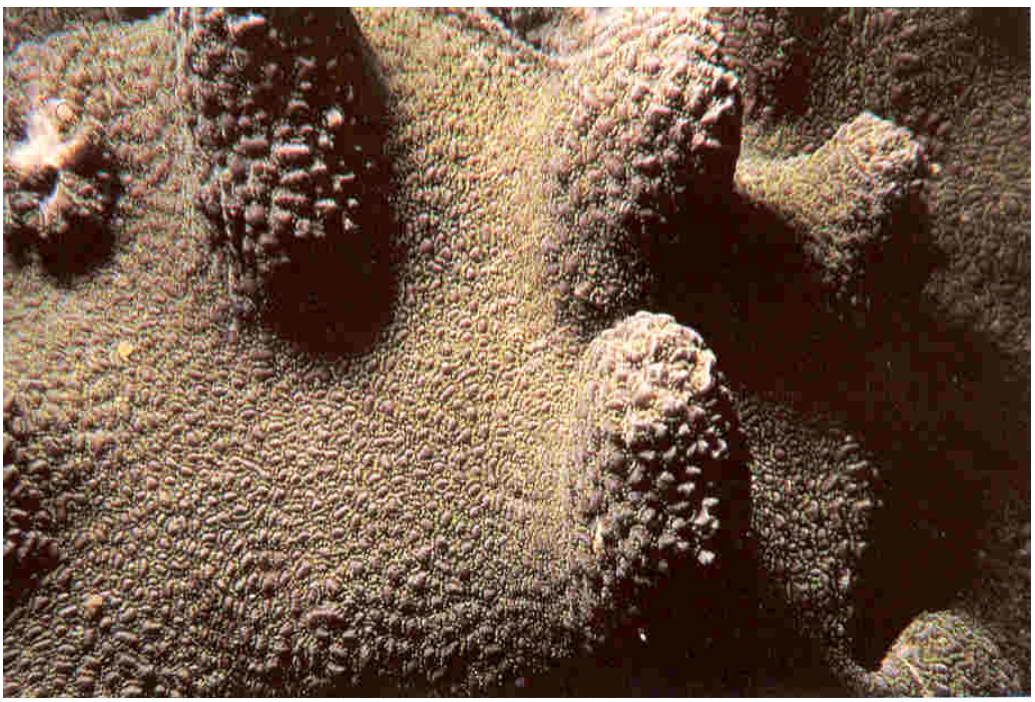

Plate 50. Close up of Spine Coral (*Hydnophora microconos*) with polyps retracted, showing hydnophores

Distinguishing Characteristics
These corals have distinctive conical humps called hydnophores which rise evenly among the calyces. The septa from the calyces continue up the humps and converge at their tops, so that each hump looks like a small hill with ridges evenly spaced around it. The two species are very similar, except that the humps are larger in ***Hydnophora exesa***, 5-8 mm in diameter, compared to ***Hydnophora***

microconos, 2-3 mm in diameter. ***Hydnophora exesa*** also can have irregular growth forms with thick branching or plates, while ***Hydnophora micronos*** colonies are usually encrusting or rounded.

Habitat
Both species occur widely on sheltered and exposed areas with low turbidity. ***Hydnophora microconos*** is more common at shallower depths while ***Hydnophora exesa*** occurs to as deep as 25 m.

Family Faviidae
Scientific Name ***Favia pallida***
Common Name "Knob Coral"
Color Pale to dark brown, often with green centers.

Plate 51. Knob Coral (*Favia pallida*).

Distinguishing Characteristics
Like all members of this genus, the calyces of this species are slightly separated from each other, instead of sharing a common wall as in the closely related and similar genus ***Favites***, and the caIycaI shape is very irregular. This species most typifies this ***Favia*** structure. The calyces are highly variable in shape and may

range from 5 mm to over 1 cm on a single coral. Calyx rims are raised slightly above the coral surface and septa are coarse, irregular and widely spaced.

Habitat
This is the most abundant ***Favia*** species and small colonies may be found in most environments from open reef slopes in clear water to turbid lagoons and embayments.

Scientific Name ***Favia speciosa***
Common Name "Larger Knob Coral"
Color Pale to dark brown, or green.

Plate 52. Larger Knob Coral (*Favia speciosa*).

Distinguishing Characteristics
Colonies are lobate or massive and similar to Knob Coral except that calyces are larger, up to 15 mm in diameter, with up to 6 mm between adjacent calyces. Also, septa are more fine and numerous within the calyces.

Habitat
Occupies a similar range and variety of environments as Knob Coral. but is much less abundant.

Scientific Name ***Favites chinensis***
Common Name "Larger Star Coral"
Color Brown to greenish or yellowish brown.

Plate 53. Larger Star Coral *(Favites chinensis*).

Distinguishing Characteristics
Adjacent calyces share a common wall in this species, which clearly distinguishes this species from ***Favia speciosa***, which it may otherwise superfici.ally resemble. Calyces range from 10 to 15 mm in diameter, are somewhat irregular in outline and their rims show a tooth-like appearance that is caused by the incomplete development of one cycle of septa. The growth form is primarily encrusting, but small colonies may have a distinctly hemispherical shape.

Habitat
This is another hardy favid coral that is often found nearshore on reef flats and other areas that may subjected to wave turbulence. or in areas where extremes of temperature and salinity prevail which may restrict more sensitive species.

Scientific Name ***Favites pentagona***
Common Name "Lesser Star Coral"
Color Brown, often with green centers.

Plate 54. Lesser Star Coral (*Favites pentagona*).

Distinguishing Characteristics
The calyces of this species are usually less than 6 mm in diameter, relatively small for a favid coral, and are angular in shape, often five-sided as the species name suggests. Adjacent calyces share common walls as. in other species of ***Favites*** and calyces are relatively deep in relation to their diameters. The growth form can vary from encrusting to highly irregular, with groups of calyces raised in club-like, almost columnar, protrusions.

Habitat
This species is quite common in virtually all locations. Colonies of this species are usually quite small, seldom reaching 1m in longest dimension.

Scientific Name ***Favites peresi***
Common Name "Honeycomb Coral"
Color Yellow to yellow brown.

Plate 55. Honeycomb Coral (*Favites peres*).

Distinguishing Characteristics

This is one of the most distinct species of ***Favites***, having polygonal calyces 1 to 2 cm in diameter with thin, sharp walls which quite resemble honeycombs, especially when the polyps are yellow. The calyces are deep, with low lying and thin septa. Colonies are usually encrusting to lobate, but may be leaf-like.

Habitat

In Oman this species only occurs in the Dhofar region where it is common on flats and slopes at intermediate depths with other favid corals. It can be easily seen at Hoons Bay /Raha near Marbat. where it is one of the more common species nearshore.

Scientific Name ***Parasimplastrea simplicitexta***
Common Name "Fleshy Star Coral"
Color Brown, often with green centers.

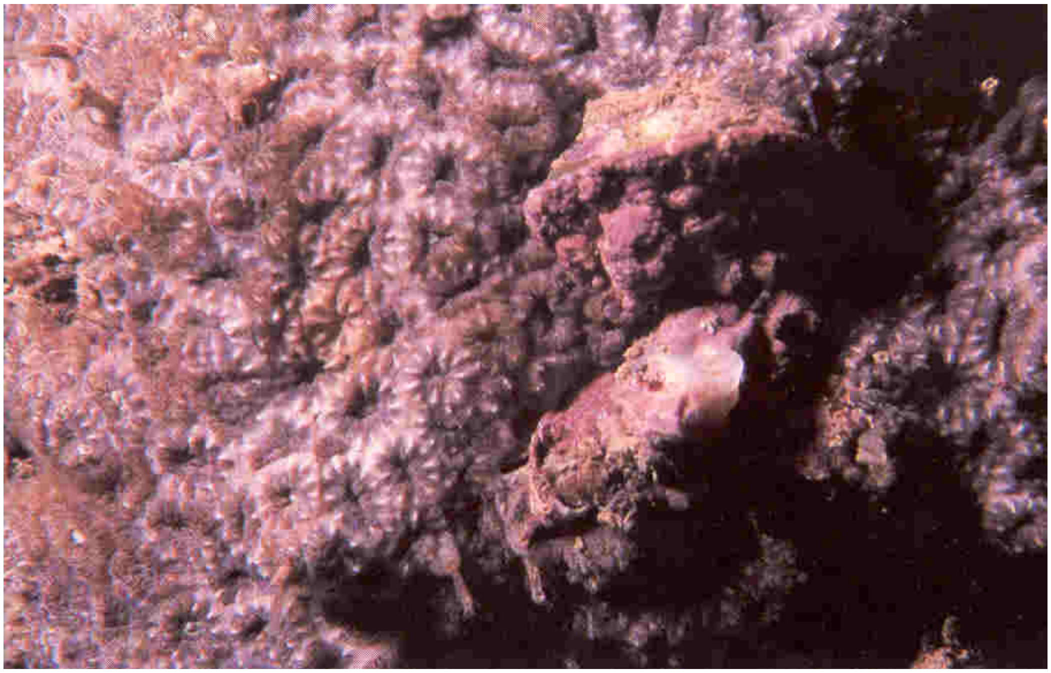

Plate 56. Fleshy Star Coral (*Parasimplastrea simplicitexta*).

Distinguishing Characteristics

This species is often most recognizable in the field by its fleshy, almost furry appearance when its polyps are expanded during the day. With polyps withdrawn or on cleaned skeletons, the coral shows characteristics of both ***Favia*** and ***Favites*** by having some adjacent calyces share walls while other calyces on the samecoral may have a pronounced groove between the walls of adjacent calyces. Calycal diameter ranges 4 to 6 mm, and this species is further distinguished from other favid corals by having relatively few septa within the calyces. These septa appear quite thick and robust when viewed on the cleaned skeletons.

Habitat

This coral occurs in the Muscat area on reef slopes at intermediate depths and in up to moderately turbid conditions.

Miscellaneous

Until recently this Oman endemic species was considered to be extinct and known only from fossil specimens described from New Guinea. At present live specimens have only been reported from Oman, where it is relatively common in the Capital Area.

Scientific Name ***Platygyra daedalea***
Common Name "Brain Coral"
Color Pale to dark brown, sometimes with grey or green valleys.

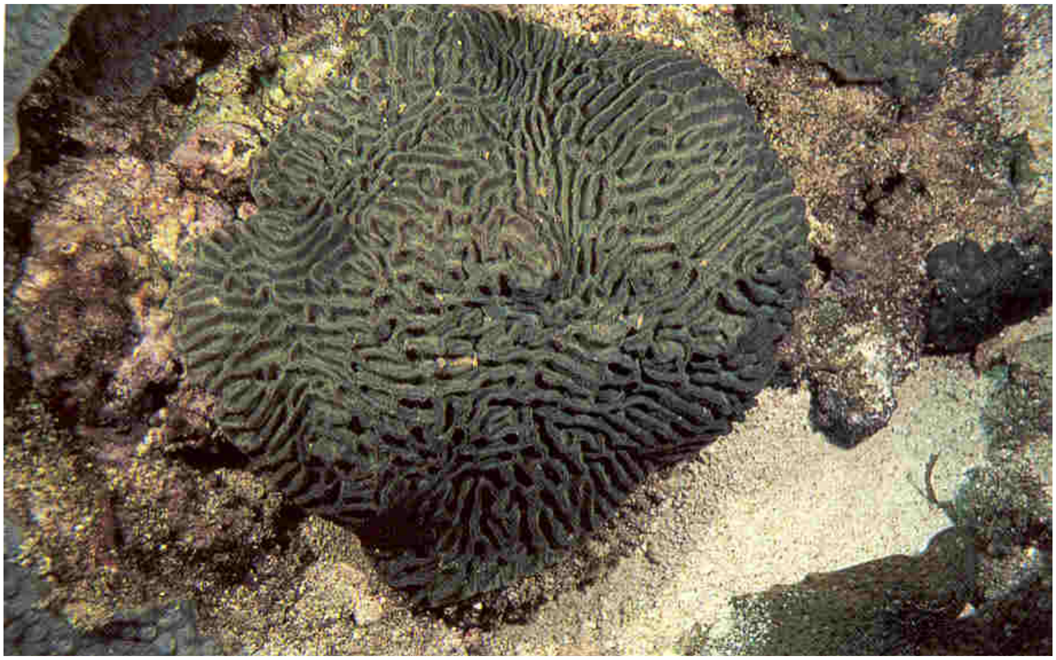

Plate 57. Brain Coral (*Platygyra daedalea*).

Distinguishing Characteristics
This is the common 'brain coral' on which the calyces wind in meandering valleys over the massive skeleton, giving an external appearance similar to a well developed brain. This configuration results from multiple mouths forming within a single polyp and tentacle ring as the coral grows. The width of the valley walls is about 5 mm. Coral heads are dense and massive or encrusting, ranging in size up to a meter or more in diameter.

Habitat
This species is common in both sheltered and relatively turbid waters of embayments and in depths up to I5 m in exposed offshore areas, where *it* shares dominance with table ***Acropora***. It is highly resistant to both inshore turbidity and to offshore wave turbulence.

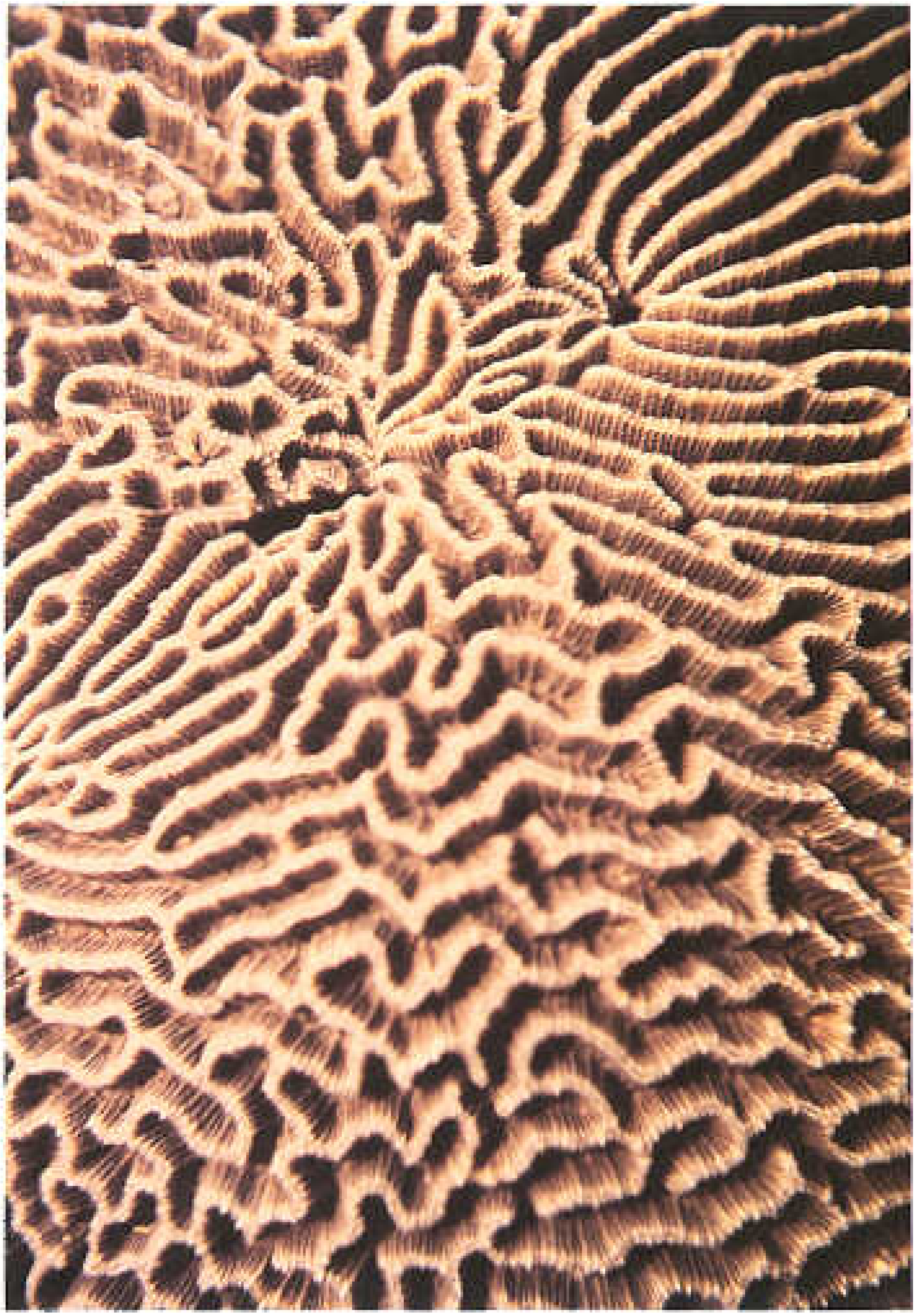

Plate 58. Close up of Brain Coral (*Platygyra daedalea*) showing detail of septa and meandering calyces.

Scientific Name ***Leptoria phrygia***
Common Name "Lesser Brain Coral"

Color Cream to dark brown, sometimes with grey or green alleys.

Plate 59. Lesser Brain Coral (*Leptoria phrygia*).

Distinguishing Characteristics

This species appears similar to brain coral in live specimens except that the polyp valleys are usually more narrow and are very uniform in their stucture. The valley walls may form extensive straight sections or may meander greatly, even on the same coral colony. Inspection of the cleaned skeleton reveals that the septa that form the brain ridges are very evenly spaced and heavily calcified, giving a less ragged appearance than for ***Platygyra***. Coral colonies are massive and usually lobate with a dense skeleton.

Habitat

The Lesser Brain Coral is found on reef slopes or flats, in shallow waters which are exposed to moderate or strong wave turbulence.

Plate 60. Close up of Lesser Brain Coral (*Leptoria phrygia*) showing fine septa and narrow calycal valleys.

Scientific Name ***Plesiastrea versipora***
Common Name "Small Knob Coral"

Color Various from yellowish brown to brown or green.

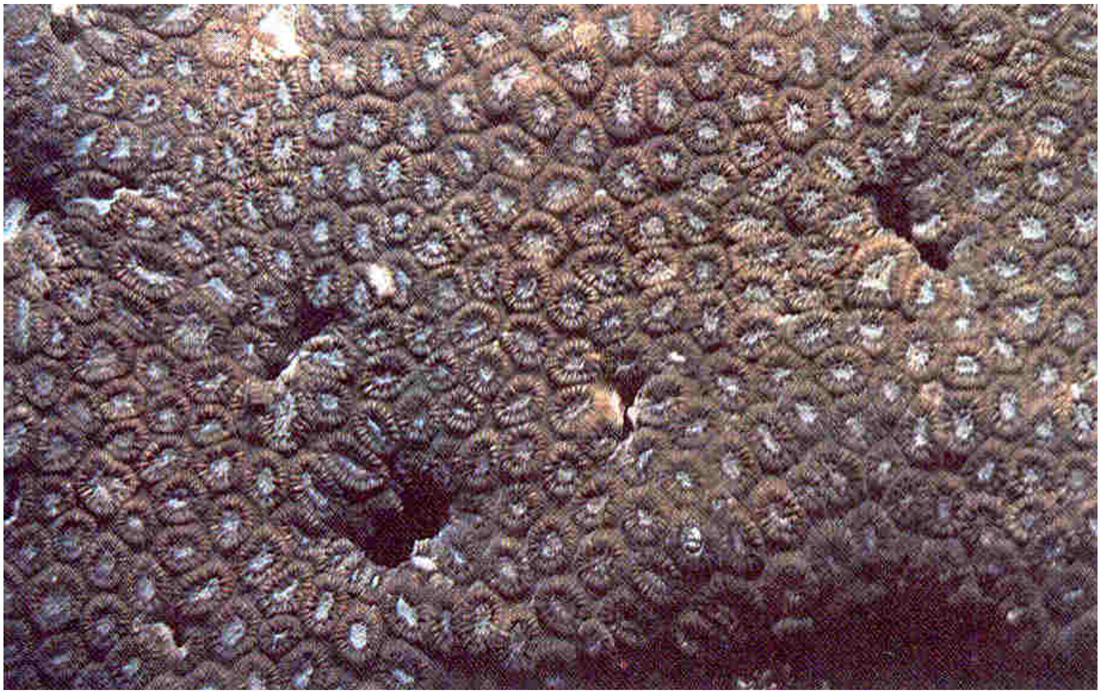

Plate 61. Close up of Smaller Knob Coral (*Plesiastrea versipora)* .

Distinguishing Characteristics
Calycal diameter ranges 2 to 5 mm and the calyces are clearly separated and slightly protruding from the coral surface. Most calyces are circular, but some may be irregular and enlarged. Septa are thin, and on cleaned specimens a distinct ring is formed around the center of the calyx by a raised area on each septum called a paliform lobe.

Habitat
This species usually occurs as small colonies in shallow to medium depths on reef slopes where it is a minor component of the total coral cover. It is also seen in shallow areas protected from wave action.

Scientific Name ***Leptastrea inaequalis***
Common Name "Grooved Crust Coral"
Color Brown, often with green centers.

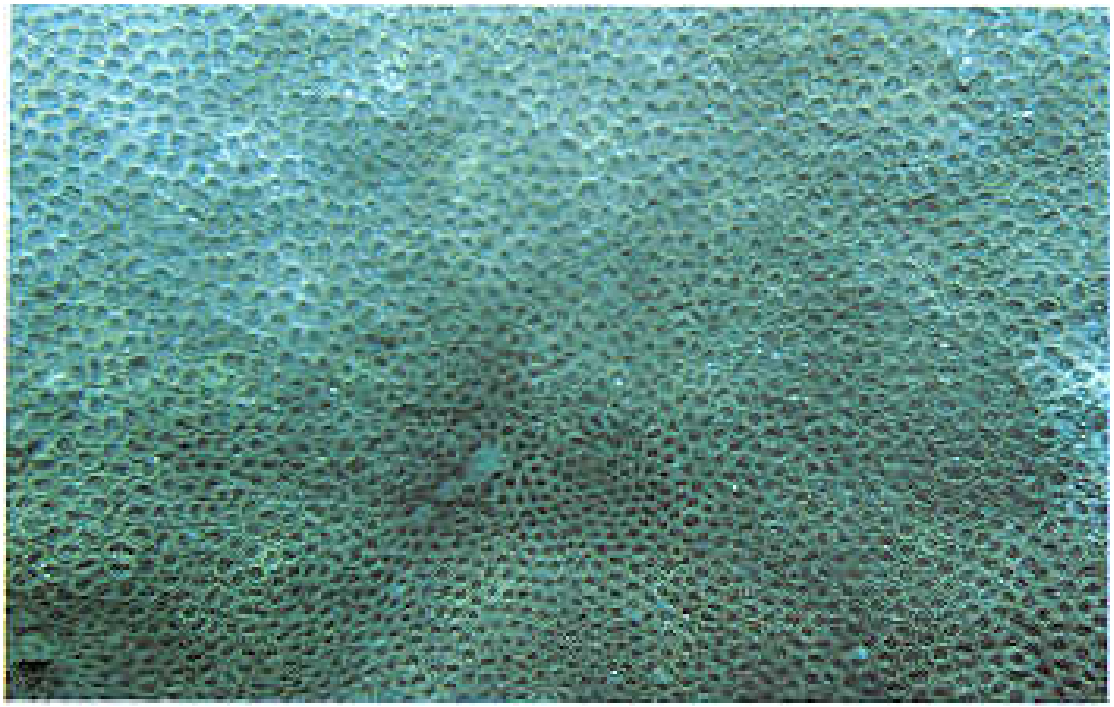

Plate 62. Grooved Crust Coral (*Leptastrea inequalis*).

Distinguishing Characteristics

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Like ***Favites***, species of ***Leptastrea*** share common walls between adjacent calyces. However, in this species this characteristic is somewhat disguised, since most calyces are separated by distinct grooves surrounding each calyx. On live corals this grooved area can appear as white between the brown polyps. Calyces are about 3 mm in diameter and usually quite round.

Habitat

This species occurs as a minor component of many reef environments from moderately turbid embayments to moderately exposed reef slopes.

Scientific Name ***Leptastrea purpurea***
Common Name "Crust Coral"
Color Brown to pale brown.

Plate 63. Crust Coral (*Leptastrea purpurea*)showing partly expanded polyps.

Distinguishing Characteristics
This is the most common and widespread ***Leptastrea*** species, occurring from the Red Sea and West African coast eastward to Hawaii and the Marquesas Islands. Its calyces are highly irregular in size and outline, sometimes ranging from 2 mm to more than 1cm in longest dimension on a single coral colony. In contrast to Grooved Crust Coral the calyces of this species are closely packed together and the upper surface of the coral is relatively flat and smooth.

Habitat
Crust Coral is very common on exposed flats in shallow water and is highly resistant to strong wave action and extremes of other physical stresses. It may also extend into more sheltered deep water areas as a minor component of the total cover.

Scientific Name ***Cyphastrea microphthalma***
Common Name "Lesser Knob Coral"
Color Brown to reddish brown.

Plate 64. Lesser Knob Coral (*Cyphastrea microphthalma*), showing 10 septa per calyx.

Distinguishing Characteristics
In terms of calyx size this species resembles Grooved Crust Coral, having circular calyces with diameters of 3 mm or less. However, this species is clearly distinguished by the pronounced separation of its calyces from each other and by their elevation above the surface of the coral basal skeleton. Closer inspection reveals an even more distinct characteristic that pertains to this species alone. The septa of each calyx are in multiples of 10 rather than 12 as in all other corals. This attribute can be used to separate this species from its close relative ***Cyphastrea serailia***, which it closely resembles, but which has septa in multiples of 12.

Habitat
This species is as widespread as and even more common than crust coral and thrives under physical conditions too extreme for many species. It is most abundant on exposed reef flats but it can extend to the bases of reef slopes.

Scientific Name ***Cyphastrea serailia***
Common Name "Lesser Knob Coral"
Color Brown to reddish brown.

Plate 65. Lesser Knob Coral (*Cyphastrea serailia*) showing 12 septa per calyx.

Distinguishing Characteristics
This species resembles in all aspects ***Cyphastrea microphthalma*** with regards to growth form, calyx size and color. However the two species can easily be separated on the basis of the number of septa within the calyces. This species has 12 primary septa which can be counted on live specimens or more easily on their cleaned skeletons.

Habitat
Same as for the previous species, with which it often co-occurs.

Scientific Name ***Echinopora gemmacea***
Common Name "Hedgehog Coral"
Color Reddish to medium brown to blue-gray.

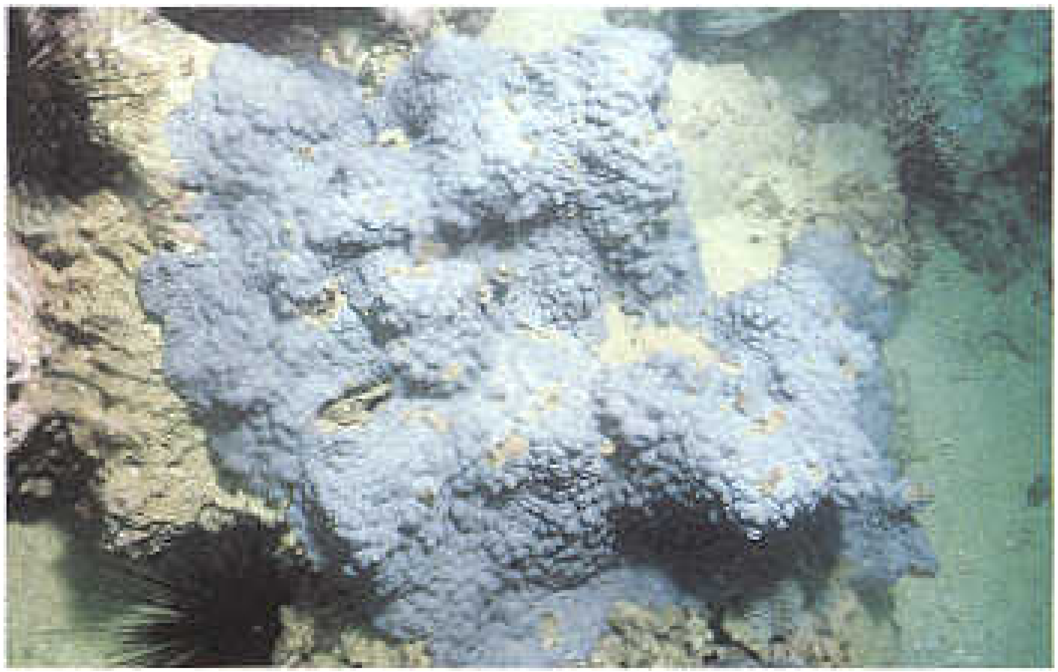

Plate 66. Hedgehog Coral (*Echinopora gemmacea*).

Distinguishing Characteristics

This species usually grows as encrusting plates and thick leaves, or more rarely may have a branching growth form. Where its growth is prolific, it may completely overgrow dead reef surfaces and live corals, resembling a relatively smooth, almost plastic-like brown surface that covers and follows the contours of tens of square meters of reef. Its calyces are up to 7 mm in diameter, protrude prominently from the coral surface, are moderately spiny, and are closely spaced together.

Habitat

This species is very common and achieves largest sizes in moderately exposed offshor,e waters with high clarity down to 30 m depth. However, it may also occur in more turbid shallow embayments.

Scientific Name ***Echinopora lamellosa***
Common Name "Leafy Hedgehog Coral"
Color Reddish to medium brown to blue-gray.

Plate 67. Close up of Hedgehog Coral (*Echinopora gemmacea*).

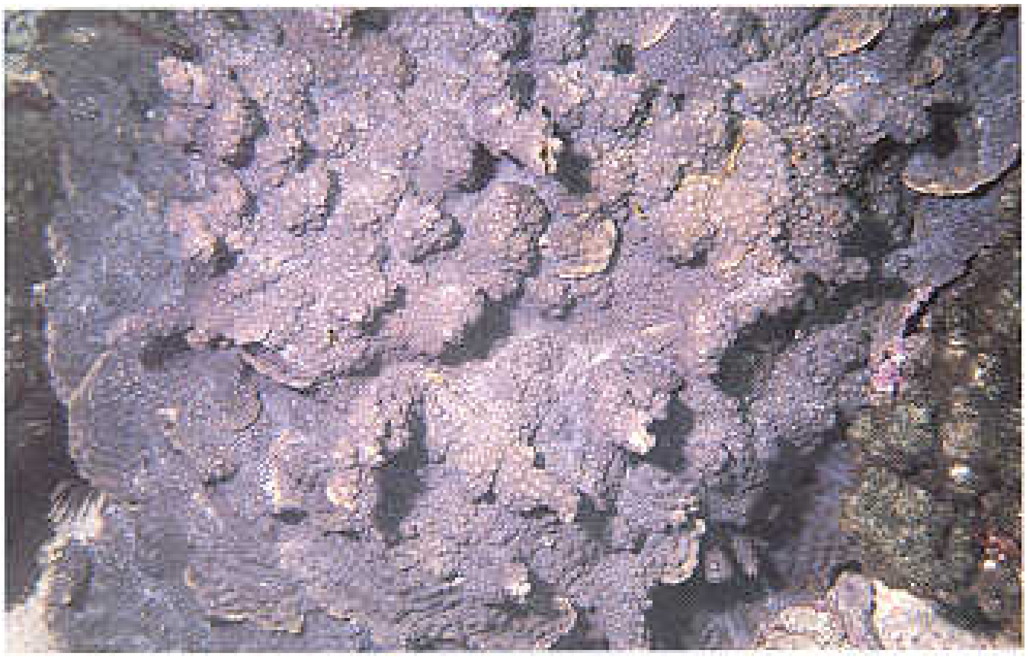

Plate 68. Leafy Hedgehog Coral (*Echinopora lamellosa*) growing over an large area of reef.

Distinguishing Characteristics

This species is in many respects similar to its close relative the Hedgehog Coral in the appearance of its calyces, color, growth form and occurrence. However it can be distinguished in the field by the fact that it usually grows in thin sheets with free edges rather than heavier plates or encrustations. Its calyces are slightly smaller. less protruding and spaced at least a calyx diameter apart on the corals surface. Like Hedgehog Coral its unrestricted growth also covers over large areas of reef and presents an even smoother, more plastic-like appearance.

Habitat

This species shapes a srmilar habitat to the Hedgelog Coral, with which it often co-occurs.

Family Dendrophylliidae
Scientific Name ***Turbinaria mesenterina***
Common Name "Vase Coral"
Color Pale to yellowish brown or greenish brown.

Plate 69. Vase Coral (*Turbinaria mesenterina*)

Distinguishing Characteristics
Small colonies of this distinctive species look like small plates on stalks which are attached to the substratum. As a colony grows it becomes more and more vase-like, with a thin lip around a central depression. The lip of the vase can be quite convoluted and the overall structure is often very beautiful. Colonies can form large vases standing up to 1 m above the substratum, to which they are always firmly attached to resist wave turbulence. Polyps on the interior of the vase are uniformly about 2 mm in diameter and are evenly spaced on the coral's surface.

Habitat
The Vase Coral is usually found at. the base or lower sections of slopes and in relatively turbid water subject to sedimentation. Because of its high density and firm attachment to the substratum, it is often seen in wave exposed, turbid areas where other species are mostly excluded .

Scientific Name ***Turbinaria peltata***
Common Name "Disk Coral"
Color Pale to yellowish brown or greenish brown.

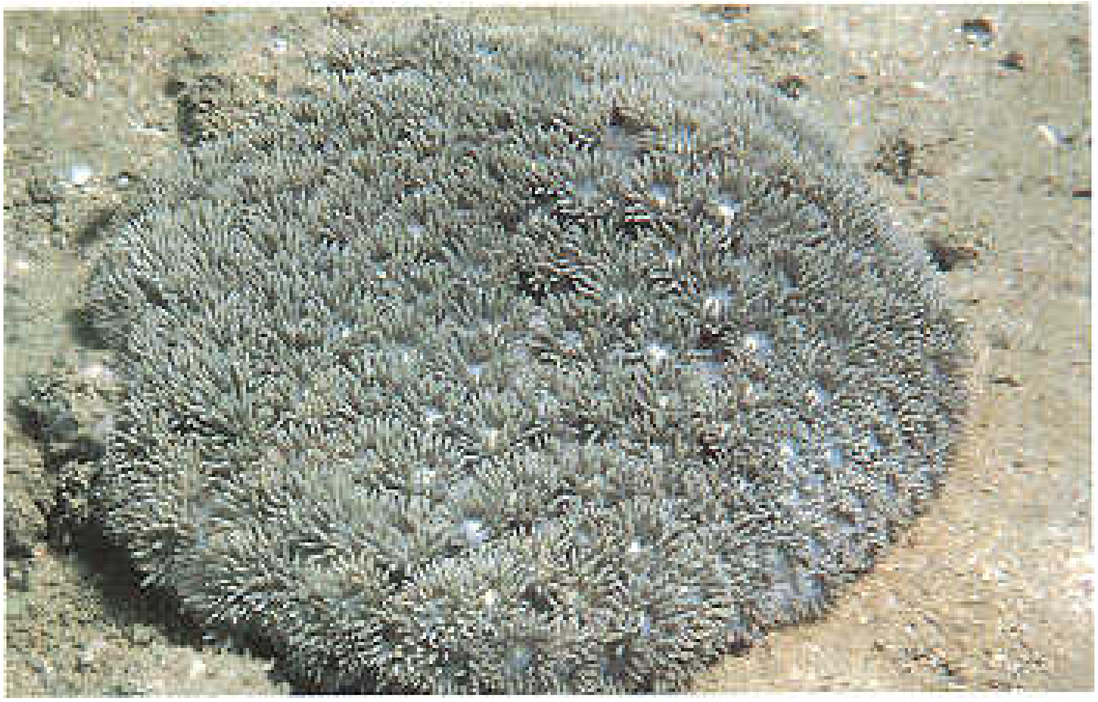

Plate 70. Disk Coral (*Turbinaria peltata*)with expanded polyps.

Distinguishing Characteristics
This is the second most common of the three ***Turbinaria*** species found in Oman, but it is far less abundant than vase coral. with which it usually co-occurs. Instead of a vase-like appearance the coral grows as a flat, thick disk which seldom exceeds 10 cm diameter. Calyces on the disk's upper surface are larger than for vase coral. averaging 5 mm diameter, are evenly spaced. and often show expanded or partly expanded polyps during the day.

Habitat
The Disk Coral is found with Vase Coral in flat areas greater than 8 m depth where turbidity is relatively high and loose sediments abundant. Unusually large specimens up to 0.5 m diameter occur in water 3 to 5 m deep along the cliff headland at Qurm in the Capital Area. .

Scientific Name ***Heteropsammia cochlea and Psammoseris*** sp.
Common Name "Shoe Corals"
Color Brown or reddish brown with pale septa.

Plate 71. Shoe Coral (*Heteropsammia cochlea*),with a proboscis of a symbiotic sipunculid worm extended from the coral's base.

Distinguishing Characteristics

Both species are small solitary corals in which the diameter and height of the coral is only 1 cm or less. ***Heteropsammia*** tends to bud into two polyps and its corallites are generally taller than broad, while ***Psammoseris*** does not bud and is more flattened. However, the two species can only reliably be distingushed by examining the septa of their cleaned skeletons, on which the septa of ***Psammoseris*** fuse laterally while those of ***Heteropsammia*** do not. It is also difficult to distinguish these species from ***Heterocyathus*** sp. of the Family Caryophyllidae which has a very similar structure, habitat and life history. The primary difference lies in the larger size of ***Heterocyathus***, which may range up to 2.5 cm diameter, and the property of the septa of ***Heteropsammia*** and ***Psammoseris***to fuse together in the center of the calyx (called the Pourtales Plan) which does not apply to ***Heterocyathus***.

Habitat

All three corals are mostly known from their dead skeletons which are found among shells washed up on the beach. They all live at intermediate depths in turbid water and in sediments. where they thrive but are difficult to recognize because of their small sizes and turbid water conditions. They are very abundant on the sediments at 15 to 20 m depth in the area between Fahl Island and Ras Al Hamra in the Capital Area.

Miscellaneous

These fascinating little corals share a common charactistic of having a symbiotic association with a small invertebrate called a sipunculid or peanut worm, which gives the corals mobility and the ability to stay on the surface of the soft sediments in the environment where they live. The symbiotic association begins when the larval coral settles on a small snail shell as the first phase of the coral's adult life. As the coral grows and its skeletal deposition nearly engulfs the shell, the peanut worm takes up residence inside the shell and through its own activity maintains a channel through the coral skelton to the outside. By the eversion and retraction of its feeding proboscis into or onto the soft sediment, the peanut worm can move the coral to a new position and keep it from being buried.

Scientific Name ***Dendrophyllia*** sp.
Common Name "Tree Coral"
and
Scientific Name ***Tubastrea*** sp.
Common Name "Cave Coral"
Color Red to deep purple skeletons with expanded polyps in various colors of yellow, red green or black.

Plate 72. Tree Coral (*Dendrophyllia* sp.*)* with polyps expanded and withdrawn.

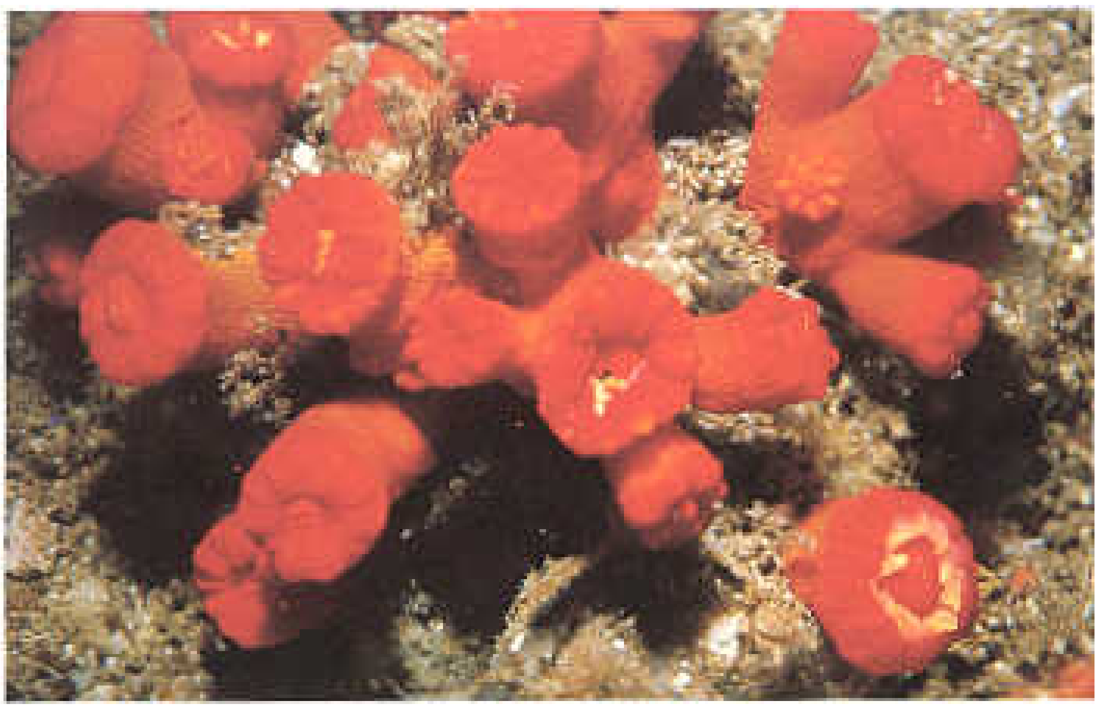

Plate 73. Cave Coral (*Tubastrea* sp.) with tentacles withdrawn.

Distinguishing Characteristics

These types of coral do not contain symbiotic zooxanthellae in their tissues, and their red to deep purple appearance is solely due to their own pigments. Not requiring light for food energy, these corals populate the roofs and walls of caves or under ledges where other hard corals will not survive. They obtain their energy solely by feeding on zooplankton, and the sight of their large, colorful polyps and tentacles expanded for feeding can be spectacular. They grow as either solitary or small branching forms and therefore are not reef-forming, and their skeletons are light and porous. Members of these and related groups can occur in very deep and cold water throughout the world, unlike the reef-forming corals which are primarily restricted to the tropics in warm sunlit water.

Species of ***Dendrophyllia*** are often differentiated from ***Tubastrea*** in the field on the basis of the smaller size of their calyces and by a greater tendency for branching and forming arborescent colonies. However, these are unreliable charactersistics for accurate identification. since some ***Dendrophyllia*** grow as small clumps similar to ***Tubastrea***. Also, both types may occur in a variety of colors. although ***Tubastrea*** is inaccurately considered to be primarily red. The two genera can be differentiated from the structure of the septa of their cleaned skeletons. In ***Dendrophyllia,***the calyces follow the Pourtales Plan wherein the septa fuse in groups of three together at the center of the calyx. ***Tubastrea*** conversely shows no central fusion of the septa.

Habitat

Tubastrea sp. is found under conditions of reduced or no light under ledges or in caves on or at the base of steep slopes. It can usually be found in intermediate to deep depths, but can occur in shallow water where right conditions are reduced.

Plate 74. Cave Coral *(Tubastrea* sp.) with tentacles expanded.

Class Alcyonaria
Order Alcyonaceae
Family Alcyonidae

Two representatives of the soft coral family Alcyonidae are presented here because of their high frequency of occurrence and abundance on Oman's reefs.

Scientific Name ***Sinularia* cf. *polydactyla***
Common Name "Leathery Soft Coral"
Color Pale to yellowish brown or greenish brown.

Plate 75. Leathery Soft Coral *(Sinularia* cf. *polydactyla*).

Distinguishing Characteristics
Sinularia cf. ***polydactyla*** grows as large, single species carpets which are tightly attached to large areas of bottom and which exclude the growth of hard corals or any other benthic organisms. Its polyps and tentacles are usually retracted, giving it a smooth leathery surface with small, finger-like lobes and projections. The coral is very flexible and easily torn, since support is provided only by microscopic spicules within the soft tissue which bind the structure together. If polyps can be found in an expanded state, they will show the eight rayed plan of feather-Iike tentacles characteristic of alcyonarian octocorals.

Habitat

This species is very common along open coasts and in bays at shallow to intermendiate depths under a full range of conditions of water turbidity.

Scientific Name ***Sarcophyton trocheliophorum***
Common Name "Gray-Green Soft Coral"
Color Pale to yellowish brown or greenish brown.

Plate 76. Close-up of Gray-Green Soft Coral (*Sarcophyton* cf. *trocheliophorum*) showing partly expanded polyps.

Distinguishing Characteristics

This is the second soft coral commonly occurring in Oman's waters. It differs from ***Sinularia*** in having globular, folded, mushroom like lobes protruding from stalks which are attached to the bottom. ***Sarcophyton*** is even more easily torn than ***Sinularia***, and it frequently has its polyps expanded with its eight rayed tentacles easily visible.

Habitat

Sarcophyton trocheliophorum often co-occurs with ***Sinularia***, but usually extends into greater depths up to 10 m under all condtions of wave exposure, tubidity and bottom type.

CHAPTER FIVE

Natural and man-related disturbances to Oman's corals and coral reefs

The stressful temperature environment described in Chapter 4 is one of many factors that may limit the viability and development of corals and coral reefs in Oman's waters. Other natural influences such as competition with or predation from other bottom living organisms, possible toxic effects from blooms of algalplankton and unexplained outbreaks of coral diseases have all been experienced by Oman's coral communities in recent years. Man-related impacts from nearshore gill net fishing, boat anchoring and sport diving are all undetermined in terms of their seriousness as negative factors on coral vitality. Fishing and diving have increased dramatically in the last ten years in Oman and are likely to continue at an even higher rate with increasing population, prosperity and modernization of the country. In this chapter we will describe some of the negative influences on coral reefs that have occurred in Oman and attempt to evaluate their respective importance as threats to coral reef survival and development.

Probably the most publicised natural danger to reef corals world wide has been the Crown of Thorns starfish ***Acanthaster planci.*** This is the largest of the starfish, growing up to 0.5 m in diameter and sometimes having more than 20 arms. It feeds exclusively on corals by everting its stomach through its mouth on to the live coral surface and directly digesting the coral's tissue. The Crown of Thorns achieved fame during the 1970's and 80's when it underwent dramatic population increases on many coral reefs in the tropical Pacific, especially on the Great Barrier Reef, Guam, Tahiti and Hawaii. In these and other areas where its population rapidly increased, great numbers of Crown of Thorns starfish virtually stripped large areas of reef of live corals, leaving behind dead coral skeletons.

This devastation of reefs prompted serious concern at the time that such unprecedented destruction would permanently degrade the coral reef environment and seriously affect the people living on low-lying coral atolls. Both the wave protection and the fisheries habitat that is provided by coral reefs are an essential part of both the culture and the economies of many tropical island nations.

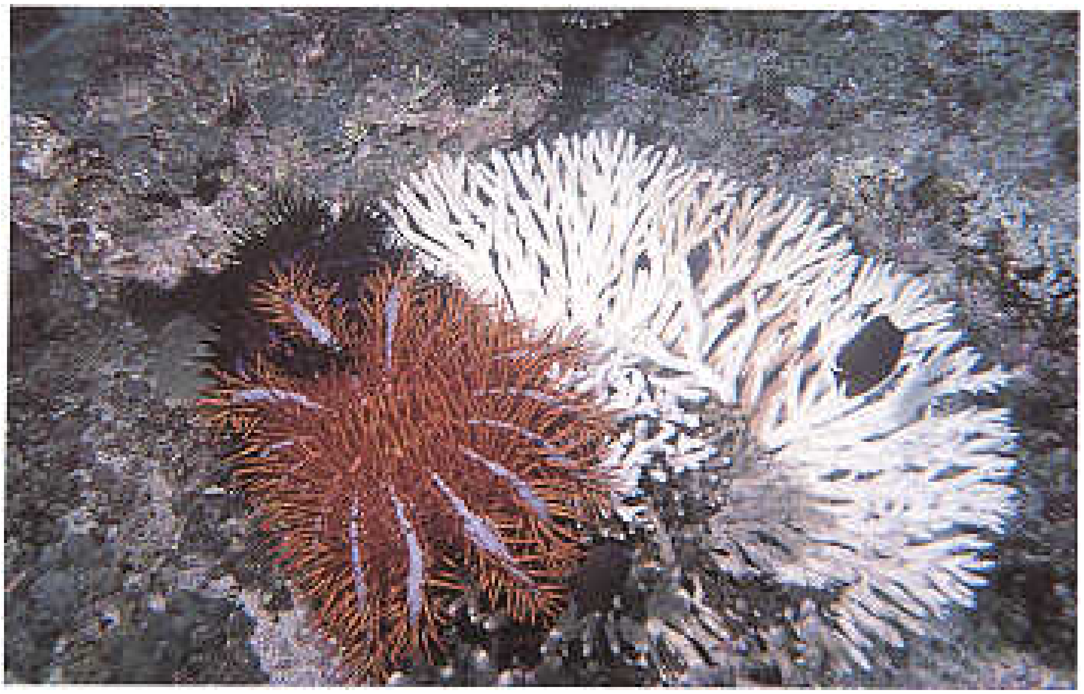

Plate 79. Crown of Thorns Starfish (*Acanthaster planci*) feeding on Table Coral (*Acropora clathrata*) at Dimaniyat Islands.

Programs of both study and eradication initiated in the 1970s have greatly increased our knowledge of the Crown of Thorns and its impact on coral reefs. Although we still do not know what induces the outbreaks of the starfish, there is now good evidence that such outbreaks have occurred repeatedly in the past. On the Great Barrier Reef where the most extensive reef damage was seen 25 years ago, and which has received the greatest amount of study, coral populations have re-established themselves, and the coral community appears to be normal. It may be that the periodic outbreak of Crown of Thorns populations may be a normal and necessary event for maintaining high coral species diversity on reefs by preventing the monopolization of habitat space by those coral types which compete best over the long term.

In Oman it is interesting that concern over sightings of Crown of Thorns starfish were the motivation for the first survey of Oman's corals and reefs, performed by Dr Peter Glynn in 1982 under sponsorship of Oman's Ministry of Agriculture and Fisheries. This study extended from the Musandam to Dhofar and determined that Crown of Thorns were not abundant in most of Oman's coral growing areas at that time. The greatest starfish concentrations were in the Damaniyat Islands and in Bandar Jissah, where up to 42 starfish were counted, and their recent feeding scars could be seen on many corals. No mass infestations of starfish were observed, and the study concluded that Crown of Thorns was not a threat to Oman's corals or reefs.

Recent extensive suveys in 1992-94 of the entire rocky shore coastline in the Muscat Area and the Dimaniyat Islands concurred with the findings of the 1982 study. Of a total of 517 transects along the shoreline and offshore islandsfrom Qurm to Bandar Khayran, Crown of Thorns was seen on only two transects, or less than 1%. In the Dimaniyat Islands the starfish was more abundant, occurring on 11of 84 transects, or 13%. Feeding scars were also more common on corals in the Damaniyats than along the Capital Area shoreline, but feeding scars were only on selected coral species. No indication has been found of mass feeding on corals by Crown of Thorns starfish in Oman, nor any evidence that starfish populations have ever risen above modest numbers.

Other isolated disturbances have recently taken place on corals in the Muscat area which are more difficult to explain than Crown of Thorns predation, but which apparently have also occurred in the past. In October 1993 most of the corals at depths of 5 to 10 m in the "Bill's Bumps" bay north of Al Fahl Island showed a condition known as "White Band Disease" in which most of the live tissue on a coral head rapidly decomposes and sloughs off the coral skeleton, leaving a coral head partly alive but with the skeleton partly exposed. On sufaces of corals where this condition has been recognised the exposed skeletonis pure white, but it becomes coated with sediment and algae with time, while the part of the coral which retains tissue continues to grow, resultingin strangely shaped corals with large cavities in their skeletal bases.

Plate 80. Brain Coral (*Platygyra daedalea*) dying from White Band Disease at Al Fahl Island. White areas are bare coral skeleton from which coral tissue has recently decomposed.

The White Band Disease condition was first described for cor:als from the Caribbean in the 1970's and has been reported in many parts of the world, including the Red Sea. There is, as yet, no known physical or biological explanation for the condition, and it is usually found in limited and isolated circumstances, although White Band Disease has recently been reported to be a serious factor in the decline of the dominant reef forming Acroporid species in the Caribbean. In the case of the Al Fahl Island incident, the outbreak took place at the end of an especially intense season of upwelling when strongly elevated dissolved nutrient concentrations and blooms of toxic phytoplankton were measured in the Capital Area, and shallow areas around Al Fahl Island were highly affected by water from upwelling (Chapter 4). Whether these upwelling effects were important in this particular White Band Disease episode can not be determined. However, many corals in shallow water in the Musandam show the same misshapen growth that results from an occurrence of White Band Disease, suggesting that upwelling effects are not necessary for this condition to occur.

Another even more unusual and infrequent coral disease that also has been previously reported elsewhere has occurred at two sites in Bandar Khayran. This is a cancerous condition where the growing tissues of corals lose their normal tissue structure and their capability to deposit calcium carbonate in a normal manner to form normal calycal and basal structures. Instead, these corals deposit skeleton as spherical tumorous masses which have only a thin overlying tissue layer with no zooxanthellar pigmentation. These colorless skeletal tumors begin as smal lumps at the base of a branch, but their rapid growth and proliferation results in the dominance of an infected coral by tumors up to 5 cm in diameter and a dead zone which spreads from the center of the coral outwards. This condition has been reported for a variety of coral species in many parts of the world. Tumor development has always been confined to small areas of reef and a limited number of corals, and no factor has been identified which may induce the formation of these tumors.

Plate 81. Table Coral (*Acropora clathrata*) with skeletal tumors at Bandar Khayran. The central portion of the table has died while large tumors are present outside of dead area and small tumors are forming on the corars peripheral branches.

It may well be that certain corals in a population are genetically prone to develop these tumors in response to an as yet undetermined environmental stimulus. One candidate for such a stimulus might be a lack of pigments and compounds in a tumorous coral's tissue which would normally provide protection from ultra-violet radiation that reaches corals in abundance on a reef. However, recent measurements that have been made on tumorous corals in Oman have indicated that the concencentrations of these ultra-violet absorbing compounds are as high in the colorless tissues of tumors as in tissues from normal corals.

In Oman the cancerous corals at Bandar Khayran were of two species of ***Acropora***, Table Coral and Bush Coral. Table Corals with tumors were first found in May 1992 in a small area only a few meters from the beach near the road entrance to Bandar Khayran. By January 1994 virtually all the Table Corals (***Acropora clathrata***) on an area of about 2.5 square meters on this reef had tumors in various stages of development and many corals were in a state of decline. The growth and proliferation of these tumorous corals were studied until January 1994 when all corals on the entire reef were killed by freshwater runoff during a massive rainstorm. In May 1994 more corals with tumors were discovered at depths from 0.3 to 3.3 m just inside of the small island that lies about 1.5 km offshore of the road entrance to Bandar Khayran. These were all Bush Coral (***Acropora valida***) and they were more widespead on the reef; occurring on about 150 square meters of bottom. However, tumorous corals were more intermittent in this affected area and mortality of these affected corals by January 1995 did not appear to be nearly as complete as previously observed for the table corals at the first site.

Both White Band Disease and coral tumor formation are interesting conditions that have thus far occurred infrequently in Oman and in isolated circumstances, similar to the manner in which this condition has been reported elsewhere in the world. As such, these diseases cannot be considered important threats to survival and growth of corals or reef development. A more widespread disturbance to corals and reefs that is especially common in Oman is related to the fishing methods that are presently most in use there. The most common method of nearshore fishing is by gill nets which are deployed by the hundreds In shallow nearshore areas and left for long periods of time. When nets break loose from their moorings they may drift onto reefs or areas of coral growth and become entangled on large areas of live corals. Derelict nets are especially common in embayments or on the leeward sides of islands where they come to rest in the quiet water where corals are usually most abundant. In 1992-1994 surveys conducted on the Capital Area shoreline and offshore islands from Ourm to Bandar Khayran more than 27 derelict nets were found on 25% of the 109 transects which were in areas of active coral growth.

Plate 82. Gill nets entangling a reef of Cauliflower Coral (*Pocillopora damicornis*) near Cat Island. Note how some corals have grown above the decomposing net.

What has not been determined is just how damaging these nets are to the reef corals which they entangle and cover. Certainly a reef which has an aging and decaying net lying over it is much less aesthetically pleasing to dive upon and view than one in its natural state. However, the damage that is imparted by these nets to live corals or reef growth has yet to be measured and no definite conclusions can be drawn. Preliminary observations made on many of these net impacted coral beds suggest that the corals can continue to live and grow, eventually growing above the nets as the nets age and decompose. In many areas live corals project through nets which have apparently been in place for long periods of time and are in advanced state of decay, while the corals appear to be in a healthy condition. The exception to this occurs when nets entangle corals in areas of active wave disturbance. Dr Rod Salm has described this situation at a site in the Daymaniyat Islands, where nets under wave action have destroyed or damaged 25 to 80% of the Cauliflower Coral (***Pocillopora damicomis***) entangled on reefs, tearing the live corals from their bases.

The potential damage to reef coralsfrom net entanglement is therefore dependent on specific conditions at individual sites. However, derelict nets will always represent a direct threat to fishes through "ghost fishing" of fishes that continue to get trapped in the net's mesh and lost both to the fish population and to the fisherman. As fishing effort along Oman's coast continues to increase, the total environmental impacts from lost nets could become more serious. From time to time dive clubs in the Capital Area have organized net removal efforts that have temporarily reduced the numbers of derelict nets in local reefs and areas of coral growth. These activities show a commendable concern for the aesthetics and ecology of the local coral environment. However, the manner in which the nets are removed is important. If care were not taken to avoid damaging entangled corals in the process of removing nets, their removal might prove to be more harmful than leaving the nets in place to decompose and eventually be overgrown by the corals. Again, no information is available to evaluate the effectiveness of these net removal efforts for protecting corals and reefs.

Boat anchoring represents another potentially serious impact to reefs and coralsthat may increase with time unless preventative measures are taken. Damage to live coral caused by a single occurence of pulling up a stuck anchor on a reef may require years of coral growth to repair. A system of boat mooring bouys in the vicinity of frequently visited coralareas has been discussed for many years for the Capital Area. Installation of these bouys would provide needed protection as boat usage and anchoring in these areas increases in the future. Other impacts to corals and reefs that could increase with diving activities are damage from physical contact of divers swimming close to the reef and the handling of corals and other marine organisms. Most coral growing areas in

Oman are on relatively low relief slopes rather than sheer walls. The corals are, therefore, susceptible to diver impacts such as being trampled on, knelt on, or exposed to sediments resuspended by diver's fin movements. At present the level of diving activities in Oman is low, and there are no reported indications of reef damage by dIver impact. However, if Oman develops more of a tourist based economy, which will surely include diving oriented visitors, diver related impacts could be of concern, especially considering that relatIvely few prime dIve spots will probably receive the major portion of the visitors.

Oman is fortunate in that relatively little water borne pollution reaches its coastal waters that could affect reef corals or other sensitive marine organisms. No sewage, treated or untreated, is discharged into the ocean, no industrial effluents are released, and freshwater runoff seldom occurs that can lower seawater salinity or increase sedimentation to levels not tolerated by marine organisms. Large volumes of high temperature brine are released as effluent from desalination and electricity production at Al Athaiba in the Capital Area, but this area is remote from areas of coral growth and reef habitats. One source of water pollution that might significantly affect reef corals is the potential impact of petroleum hydrocarbon pollution from oil spills at sea. More than half the world's ocean transported crude oil passes through the Strait of Hormuz and along Oman's coast. Also, crude oil is loaded into tankers offshore of Mina Al Fahl, only about 5 km from one of Oman's most pristine and diverse coral areas in the vicinity of Al Fahl Island. To date no major spills have occurred at this terminal which have had any reported impact on the Al Fahl Island reefs, a commendable record that we hope will continue .

In regard to offshore oil spills, it appears that, to date, these have occurred without recognizable impacts on Oman's corals and reefs. This is primarily due to the fact that spilled oil remains on the surface of the water, well above the corals growing on the bottom. When an oil spill takes place at sea, much of its volume and toxic compunds rapidly evaporate to the atmosphere in a few days, leaving a residue of tar floating on the sea surface that will float with wind and currents until it reaches the shore. Here it is evident as beach tar that is a major nuisance to beachgoers and can negatively impact intertidal organisms, especially if the quantity of tar totally covers the shoreline. However, there is little or no evidence to indicate that infrequent oil spills and tar significantly damage adult corals or other shallow water organisms, even when the spills are massive. Observations made following the Kuwait War indicated that the largest oil spill in history had not visibly affected corals, reefs or other sensitive benthic communities right up to the shoreline in the northern Arabian Gulf. No effects were observed or reported on Capital Area corals or reefs from an offshore oil spill that produced up to 11 kg of beach tar per meter of shoreline in November 1993 in the Muscat area.

It should be noted that oil pollution can be a major threat to the long term vitality of corals and other reef organisms by affecting their reproductive and early life stages. The eggs, sperm and fertilized gametes of recently spawned corals rise to the water's surface and remain at shallow depths for various times before they settle. Since oil concentrations and toxic compounds are at their maximum at the water surface, oil slicks have high potential of producing toxic or lethal effects on the coral's vulnerable young stages, as well as to larvae of other organisms. Therefore, long term damage to coral communities has been reported for areas where oil spills are continuous or frequent and in enclosed embayments such as for oil terminals in the Gulf of Aqaba, and the impact has been shown to be greatest on coral reproductive processes.

For the most part and to the present time the generalization can be made that Oman's corals and reefs are in good condition and relatively unaffected by man-related pollution or destructive impacts that have come to affect reefs in other parts of the world. Oman's nearshore areas have a unique coral community that lives under unusual conditions of natural temperature stress, and the habitat provided by corals and coral reefs for other marine invertebrates and abundant fishes is one of the most valuable natural resources of Oman. We sincerely hope that the readers of this book will have become more aware of the beauty and importance of this resource and will be influenced to help maintain and protect Oman's corals and reef environment.

References for further reading on Corals of Oman and Arabia

Available in Bookstores

Green, F. and Keech, R. 1986. **The Coral Seas of Muscat.** Middle East Economic Digest Ltd., London.

Salm, R. and Baldwin, R. 1991. **Snorkeling and Diving in Oman**. Motivate Publishing, Dubai. 88 pp.

Scientific References

Burchard, J. E. 1979. **Coral fauna of the western Arabian Gulf**. ARAMCO Environmental Affairs Div., Dhahran, Saudi Arabia. J 28 pp.

Coles, S. L. 1994. **Extensive coral disease outbreak at Fahl Island, Gulf of Oman, Indian Ocean**. Coral Reefs 13:242.

Coles, S. L. 1997. **Reef coral assemblages occurring in a highly fluctuating temperature environment at Fahal Island, Gulf of Oman (Indian Ocean)**. Coral Reefs 16:269-272.

Coles, S. L. and Al-Riyamy, K. A. 1996. **Beach tar concentrations on the Muscat shoreline, Gulf of Oman, Indian Ocean**. Mar. Poll. Bull. 32:609-614.

Coles, S. L. and Seapy, D. G. 1998. **Ultra-violet absorbing compounds and tumorous growths on acroporid corals from Bandar Khayran, Gulf of Oman, Indian Ocean**. Coral Reefs 17:195-198

Edwards, A. J. and Head, S. M. (eds.) 1987. **Red Sea.** Pergamon Press, Oxford.

Glynn, P. W. 1993. **Monsoonal upwelling and episodic *Acanthaster* predation as probable controls of coral reef distribution and community structure in**

Oman, Indian Ocean. Atoll Res. Bull. 379:1-66.

Salm, R. V. 1993. **Coral reefs of the Sultanate of Oman.** Atoll Res. Bull. 380: J - 85

Scheer G. and Pillai, C. S. G. 1983. **Report on the stony corals from the Red Sea**. Zoologica 122: 1-75.

Sheppard, C. Price, A and Roberts, C. 1992. **Marine Ecology of the Arabian Region**. Academic Press, London.

Sheppard, C. R. C and Sheppard A. L. S. I 99 I. **Coralsand coral communities of Arabia**. Fauna of Saudi Arabia 12:1-70.

Sheppard, C. R. C. and Salm, R. V. 1988. **Reef and coral communities of Oman, with a description of a new coral species (Order Scleractinia, genus *Acanthastrea*)**. J. Nat. History 22:263-279.

Sheppard, C. R. C. 1988. Similar trends, different causes: **Responses of corals to stressed environments in Arabian seas**. Proc. 6th Intern. Coral Reef Symp. 3:297-302

Sheppard, C. R. C. 1987. **Coral species of the IndianOcean and Adjacent Seas: A synonymized compilation and *some* regional distribution patterns.** Atoll Res. Bull. No. 307.

Veron, J. E. N. 2000. **Corals of the World**. Australian Institute of Marine Science, Townville. 3 Volumes

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About the Author

Steve Coles first observed live corals in the Florida Keys over 25 years ago and was, struck by the beautiful growth forms of these remarkable animal-plants. Since then he has had the opportunity to look at corals and coral reefs throughout the world in such diverse locations as the islands of the Bahamas, Bermuda, Hawaii, Enewetak Atoll, Guam, Palua, the Red Sea, the Arabian Gulf and the coast of Oman from Dhofar to the Musandam peninsula. He has conducted basic and applied research on corals in many of these places and has published the results of these studies in numerous scientific journals, reports, book chapters and conference proceedings.

Prior to coming to Oman Dr Coles worked for five years in the Arabian Gulf, conducting a comprehensive survey of baseline conditions of the marine environment, including coral reefs, along the Saudi Arabian coastline before the 1990-91 Gulf War. For the past three years. he has conducted extensive surveys of reef coral coverage in the Muscat Capital Area of Oman and has visited and dived in all of the major areas where corals occur.

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