A FIELD GUIDE TO THE INVERTEBRATES OF SAN SALVADOR

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This Guide has been a "labor of love", allowing us expression of the fascination we feel for the physical and biological environment of San Salvador. This environment is particularly kind to students: its attributes are readily manageable because the Island is, by its very essence, clearly demarcated; one's attention is concentrated thereby. And we are all, above all, students. As you will doubtlessly note, our prose on occasion transcends the sterner stuff of scientific description as our personal impressions surface and take flight. In sharing these impressions, we aim to illuminate the Island. We hope those bound by a stricter objectivity will forgive these transgressions.

All of us owe an incalculable debt of gratitude to Don and Kathy Gerace. Their devotion, enthusiasm and unselfish energy in preparing the natural laboratory of San Salvador have allowed us to enrich our lives through this truly unique learning opportunity. We are especially indebted to Don for commissioning us to prepare this Guide. In flattering us, it has encouraged us to scrutinize carefully our observations and to organize our thoughts more clearly, ultimately improving what scholarly authority we might have. Further, these efforts have been rewarded by the attendant vicarious returns to the Island that they never fail to evoke.

We acknowledge with appreciation the work of Guy Cohen who started this project with us and contributed in many ways and of Mary Lyn Koval and Pavia Wald in preparing the line drawings of selected invertebrates which illustrate this Guide. Bob Knowlton provided critical evaluation of various chapters of the text. We are grateful for his insights and kindly phrased corrections. Bob Titus advised us on several aspects of the Guide, most notably matters pertaining to the shells of San Salvador. The check list in the appendix includes contributions from Robert Titus of Hartwick College, Howard Metzel of Illinois State University, William Lindsay of Elmira College and Jerry Carpenter of Northern Kentucky University.

Lastly and immeasurably, we acknowledge the aid and inspiration given by the students of the University of Virginia who accompanied us here. Virtually without exception, their zeal for San Salvador served to rekindle our interests in teaching and to revitalize our zest for biology. In gratitude, this Guide is dedicated to them.

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I. PREFACE

This guide is intended for interested visitors to San Salvador who wish to examine some of the invertebrates endemic to the island and its surrounding waters. It is assumed that most students who use the guide will have only a rudimentary, introductory biology level acquaintance with zoology. Thus, we have included, in condensed form, the essential, relevant information needed to observe and identify invertebrate organisms in their natural habitats. The main body of the guide is contained in the chapters on "Sites" and "Animals". In the first of these the major observation sites around the island are described and the student is told which animals will likely be found at each site, specific locations which the animals occupy and other helpful information about the locale. The "Animals" section contains descriptions and sketches of the major genera and species of animals commonly encountered at San Sal. Other chapters deal with methods of collection, the various invertebrate groups and their phylogeny, and important features of the major types of habitats found in San Salvador.

Our aim in writing this guide is three-fold:

1. to aid students in observing and classifying the invertebrate organisms found in the San Sal fauna

2. to help students perceive relationships between the distribution of various species and characteristics of their specific habitats

3. to help students develop a greater appreciation of the diversity and beauty of animal life and to stimulate interest in the study of organisms in their natural environment

This guide may be used in any number of ways but we suggest the following: Read through the first four chapters to obtain a general background about the island, its physical features and its invertebrate population, and acquire some knowledge about methods of observation. Then, just prior to visiting a specific site, read through the section which describes what will be encountered. After the field excursion is completed refer to the section on specific animals and identify from memory what you saw in nature. (You may see additional animals not covered in this guide. In this case refer to other keys and guides which give more extensive coverage to selected groups; see Methods chapter). And, finally compare your observations with the compiled list of organisms found at the end of the guide.

Our intentions in preparing this guide are to emphasize the unique characteristics of many of the organisms typical to San Salvador and to indicate the rich diversity of the marine invertebrate fauna of this island. While the guide provides a careful treatment of selected organisms considered representative of the region, it does not contain a detailed description of all organisms likely to be found here. Nor does the guide address the ecology of this marine environment to any significant degree.

It should be emphasized that snorkeling is sufficient to see all of the animals described in the guide. SCUBA will allow longer observation of some deeper water organisms but we anticipate that most guide users will rely on their lung capacity alone to explore the shallow waters and the invertebrates which reside there.

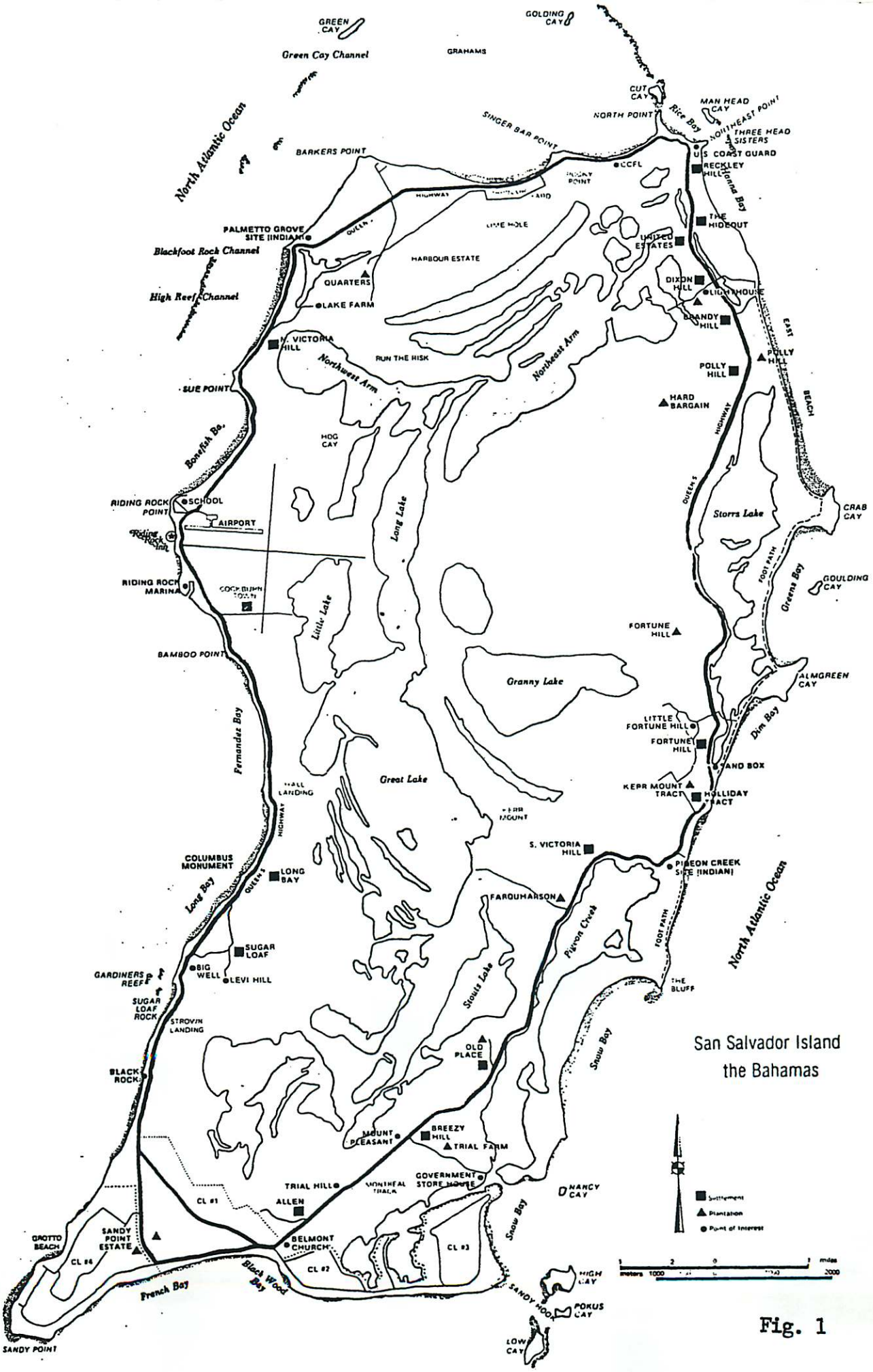

GREEN CAY
Green Cay Channel
GRAHAMS
GOLDING CAY
CUT CAY
MAN HEAD CAY
NORTH POINT
Rice Bay
NORTHEAST POINT
THREE HEAD SISTERS
SINGER BAR POINT
BARKERS POINT
North Atlantic Ocean
U.S. COAST GUARD
RECKLEY HILL
CCFL
HIGHWAY
LIME HOLE
PALMETTO GROVE SITE (INDIAN)
Blackfoot Rock Channel
High Reef Channel
HARBOUR ESTATE
THE HIDEOUT
UNITED ESTATES
DIXON HILL
LIGHTHOUSE
QUARTERS
LAKE FARM
BRANDY HILL
EAST
POLLY HILL
VICTORIA HILL
RUN THE RISK
Northwest Arm
Northeast Arm
SUE POINT
HARD BARGAIN
HIGHWAY
BEACH
Bonefish Bo.
HOG CAY
RIDING ROCK POINT
SCHOOL
AIRPORT
Long Lake
Storrs Lake
CRAB CAY
QUEEN'S
FOOT PATH
RIDING ROCK MARINA
COCKBURN TOWN
Little Lake
Greens Bay
GOULDING CAY
FORTUNE HILL
BAMBOO POINT
Granny Lake
ALMGREEN CAY
LITTLE FORTUNE HILL
Dim Bay
Fernandez Bay
Great Lake
SAND BOX
KEPR MOUNT TRACT
HOLLIDAY TRACT
HALL LANDING
KEPR MOUNT
S. VICTORIA HILL
COLUMBUS MONUMENT
LONG BAY
PIGEON CREEK SITE (INDIAN)
Long Bay
FARQUHARSON
Pigeon Creek
North Atlantic Ocean
SUGAR LOAF
GARDINERS REEF
BIG WELL
LEVI HILL
Storrs Lake
THE BLUFF
SUGAR LOAF ROCK
STROMN LANDING
OLD PLACE
Snow Bay
BLACK ROCK
MOUNT PLEASANT
BREEZY HILL
TRIAL FARM
GOVERNMENT STORE HOUSE
TRIAL HILL
MONTREAL TRACK
NANCY CAY
CL #1
ALLEN
SANDY POINT ESTATE
GROTTO BEACH
CL #6
BELMONT CHURCH
CL #2
CL #3
Snow Bay
French Bay
Black Wood Bay
SANDY HOOK
HIGH CAY
POKUS CAY
LOW CAY
SANDY POINT
San Salvador Island
the Bahamas
Settlement
Plantation
Point of Interest
miles
meters
1000
2000

Fig. 1

I. INTRODUCTION

San Salvador is a roughly rectangular island approximately twelve miles long and six miles wide; the major dimension lies in a north/south direction. It is located in the western Atlantic Ocean at 24°N, 74°30'W, or approximately 30 miles north of the Tropic of Cancer and on the eastern edge of the Great Bahamas Bank. San Salvador is distinctly tropical and Bahamian in its climate, geology and biology. The singular feature of this island, as well as all of the Bahamas archipelago generally, is the overwhelming preponderance of the mineral calcium carbonate. The island is essentially composed of limestone rock and calcareous sand, and the reefs which dominate and characterize the surrounding shelf waters are coralline deposits of the same material. Topographically the island is composed of a system of low hills (maximum elevation 140 ft.) with an interconnecting collection of lakes occupying the low inland areas. Thus, from the sea, San Salvador appears flat; the aerial view reveals that close to half of the island's interior surface is covered by water (Adams et al., Field Guide to the Geology of San Salvador).

Immediately surrounding San Salvador is a shelf less than a mile wide in most places (and less than a quarter mile in a few locations) where the water rarely exceeds three fathoms (18 feet) in depth. Further offshore is a rather narrow zone defined by the 100 fathoms maximum depth line; then the ocean bottom plunges to 1,000 fathoms or more. The island thus is closely bounded on essentially all sides by deep seas. The currents in the surrounding sea tend to be northerly and are warm, born as they are of the North Equatorial Current and the Gulf Stream. The North Equatorial Current arises from the great clockwise pattern of water circulation or "gyre" in the North Atlantic whereby cooler northern water flows southward along the coasts of Europe and Africa. Near the equator the flow turns westward and is warmed in this tropical region. The water is warmed further when it proceeds northward as the North Equatorial Current, a branch of which enters the Caribbean Sea and Gulf of Mexico, emerging as the Gulf Stream. The temperature of the waters of San Salvador range from 22-30°C. Tidal variations in this region of the Atlantic Ocean are not appreciable. The difference in mean high and mean low tides (amplitude) is less than 1.2 feet (Adams *et al.*, Field Guide to Geology of San Sal, p. 61). The prevailing winds in these latitudes are the northeasterly trade winds.

The shallow, 3 fathom band of water bordering San Salvador is fringed and punctuated by coral reefs which provide the habitat for a great variety of marine fauna. The accessibility of this environment to observation and collection by snorkeling and the diversity of the organisms to be found there render San Salvador an exceptional locale for the study of marine zoology. The fauna of San Salvador are essentially those typified as Caribbean even though the island is situated in the Atlantic, separated from the Caribbean Sea by hundreds of miles of intervening ocean and the Greater Antilles Islands of Cuba and Hispaniola (Haiti and the Dominican Republic). Only the Great Barrier Reef off northeastern Australia provides a greater number of marine faunal species than the West Indies. The West Indian Marine Province (Voss, Preface) includes not only the Bahamas and the Greater Antilles, but also the Lesser Antilles which are composed of two main island groups, the Leeward Islands, such as the Virgin Islands, and the Windward Islands, of which Grenada is the southernmost. Bermuda is also considered to be West Indian despite its remoteness from the others. Excepting Bermuda, all of the other islands of the West Indies lie south or southwest of the Bahamas. The West Indies differ dramatically in their topography and geological origins, from the volcanically derived Antilles to the calcereous Bahamas, but they share in large measure a common fauna, the Caribbean faunal group. This Guide describes the invertebrate fauna of this group endemic to the San Salvador area.

The map (Figure 1) reveals the contour of the barrier reef surrounding San Salvador. This reef generally serves as a breakwater, dissipating most of the ocean wave energy approaching the island. Inshore from the barrier reef, waters are calmer. Patch reefs are found sporadically distributed in these areas, rising from the sea floor to within a foot of the surface and sometimes projecting above the surface. Otherwise, the sea floor is smooth sand, often covered by stretches of turtle grass (*Thalassia*) and/or other vegetation. The distribution of animals around San Salvador is not uniform. Animals show preferences in selecting their habitats, and physical and climatic effects such as wind and wave action around San Salvador create local conditions which vary in their suitability for some animals over others. The northeasterly tradewinds are a major influence. The northern and eastern exposures of the island are more likely to be sites of strong wave action, so-called high energy coastlines. Animals preferring such sites include corals such as *Acropora palmata* (elkhorn coral), chitons and

sea fans. Graham's Harbor, on a more sheltered northern corner of San Salvador near CCFL, is a protected low energy area rich in anemones such as *Condylactis gigantea* (pink-tipped anemone) and soft corals like the sea rods (*Plexaura* spp. and *Eunicea* spp.). Sandy Point at the southwest extremity of the island, and thus most protected from the prevailing winds is nevertheless a high energy beach area. This contradiction results because waves driven by the northeasterlies refract around the island, meeting again in destructive interference at this focal point. Just east of Sandy Point along the southern shore is a particularly high energy area with a spectacular collection of patch reefs just offshore. The tops of these reefs are populated by organisms adapted to strong wave action while along their sides and in more sheltered recesses among them other species such as brain coral (*Diploria* spp.) abound.

San Salvador possesses several exceptional features which provide uncommon habitats, such as the inland lakes of hypersaline water, Pigeon Creek (a tidal estuary and delta in the southeastern corner of the island) and a number of caves, both above ground and flooded by marine waters. The occurrence of caves is consistent with the limestone structure of the island. Each of these locations is populated by a characteristic faunal collection and each merits a visit if time allows.

At this time, San Salvador presents a relatively unspoiled marine environment. The people inhabiting the island do not over-exploit the sea (with the possible exception of conch fishing) and the relatively few visitors are students and tourists with an interest in marine biology and, hopefully, a respect for San Salvador's natural treasures. Each of us has a responsibility to maintain this tradition of conservation.

III. INVERTEBRATE ZOOLOGY

Roughly 90% of all existing species of animals can be characterized as invertebrate, or "lacking a backbone". Even if one ignores the huge protozoan and terrestrial arthropod groups, a tremendous task remains for any student who desires to undertake a serious study of the entire spectrum of invertebrates. Many students who come to San Salvador wish to observe and study other natural features of the island such as the geology, plants, fishes, birds, archaeology, or coral reef ecology and do not have the time or inclination to pursue the invertebrates to completeness. Therefore, in order to give a short general overview of invertebrate zoology to novice students or to those who do not want to study them in depth, we have included this material in the guide. Students already knowledgable about invertebrate zoology will find the discussion redundant.

In this section we will present a "phylogenetic tree" of the invertebrates, list the phyla and their relative numbers of species, give a brief word sketch of each major phylum and class and mention briefly the relative abundance of representatives found at San Salvador. Also, for field or laboratory observations of individual animals we have produced a short one-page directive which draws attention to the key theme of adaptation which is so clearly and vividly portrayed in the myriad of diverse structures and functions evident in the invertebrates. Lastly, we have assembled a limited, annotated bibliography of Invertebrate Zoology texts, manuals and guides.

A PHYLOGENETIC TREE: Many zoologists have constructed phylogenetic trees in which all invertebrate groups are arranged in a scheme purporting to show their phylogenetic relationships and their evolutionary histories. Although substantial evidence exists for some of the relationships depicted in the trees, one should keep in mind that they are theoretical constructs and subject to the biases and interpretations of individuals. They can be useful but should not be accepted as fact.

Russell-Hunter in his book "A Life of Invertebrates" (MacMillian 1979) lists nine "major" or "important" phyla of invertebrates (Protozoa; Cnidaria; Platyhelminthes; Chordata; Echinodermata; Mollusca; Arthropoda; Annelida; Nematoda) and 23 additional phyla which he labels "minor". This approach seems reasonable although one should understand what is meant by "major" or "minor". "Major" phylum here refers to the relative number of species in the phylum and to a certain extent, the relative ecological importance of the phylum. "Minor" phyla, therefore, have fewer species and are of lesser ecological importance.

"MAJOR" PHYLA and CLASSES:

1. PHYLUM PROTOZOA. These organisms are contained within a single cell boundary and have been described by some zoologists as "non-cellular organisms". New taxonomic schemes usually place some of them in the kingdom Protista and others in the kingdom Animalia. It is generally agreed that early protozoans, possibly the Flagellates, gave rise to multicellular invertebrates through a mechanism not clearly understood. Protozoans

are small (less than 1 mm long), often rapid moving, usually light or transparent in color and in some cases resemble small invertebrates such as rotifers, gastrotrichs and even annelids. Locomotory mechanisms involve cilia, flagella or pseudopodia. The major groups are the flagellates, ciliates, sarcodina (*Amoeba* and its relatives) and the entirely parasitic sporozoans. Many species of protozoans are present at San Salvador and occupy an incredible array of habitats. Microscopical examination of aquatic debris, interstitial samples, or the surface or interior of many animals will yield living specimens. Although extremely important and interesting, they are often bypassed in a study of invertebrate zoology and few students at San Salvador spend time working on this group.

2. PHYLUM CNIDARIA (formerly Coelenterata). All of the members of this phylum are constructed of 2 body layers with a non-cellular mesoglea between the outer and inner epithelium. Mesoderm is lacking and there is a blind-ended digestive sac, but no body cavity. They lack circulatory and respiratory systems but diffusion provides for an adequate exchange of materials. Nematocysts or stinging cells are unique organelles found only in this phylum and are used in feeding and defense. In jellyfish or the Portuguese-Man-O-War the toxin associated with the nematocysts may cause painful and serious reactions. Life cycles include two body forms; a free living medusa (jellyfish) and an attached polyp. Such alteration of generations is called metagenesis.

Three classes are recognized: Hydrozoa, which includes *Hydra* and numerous fresh water and marine colonies of polyps and in many cases their attendant medusae; Scyphozoa, cnidaria with a relatively large, prominent jellyfish or medusa stage and a reduced polyp (scyphistoma) stage; Anthozoa, which are exclusively polypoid and encompass the familiar anemones and corals.

Cnidaria are important to man as reef builders and in some cases, such as sea nettles, as pesky nuisances. Of additional significance is their evolutionary status as probable close relatives of the primitive stock which gave rise to all other metozoan (multicellular) groups. Many investigators have been intrigued by their unique, net-like nervous system and the repertoire of behavior controlled by it, since it apparently represents the most primitive, or earliest, mechanism of communication between the cells of an animal. Their relatively simple cellular and tissue architecture has led other scientists to use them as model systems in which to study cell differentiation, growth dynamics, pattern formation and morphogenesis.

Cnidaria are especially important components of the San Sal fauna; corals are members of this phylum and, also, many other representatives can be observed around the island, including anemones, cubomedusae, jellyfish and hydroid colonies.

3. PHYLUM PLATYHELMINTHES. Flatworms are relatively successful animals which have free living forms but have evolved parasitic life cycles in two major groups. Three body layers including mesoderm are present but they are solid animals and do not possess a body cavity (acoelous). They lack circulatory and respiratory systems as well and their excretory system is in the form of primitive protonephridia, or flame bulbs. Marine species such as those at San Salvador are often an inch or shorter and extremely thin. Their colors may vary from bright blues and yellows to drab browns or flesh colors. Frequently seen on the undersides of rocks or clinging to other hard substrates, they move slowly with a gliding motion. They are very fragile and can be detached most easily by use of a small water-color brush. Reproduction can be sexual but Platyhelminthes are also capable of asexual binary or multiple fission. The free-living genera, especially planarians, are reknowned for their regenerative powers.

The Classes Trematoda (Flukes) and Cestoda (Tapeworms) are both parasitic as contrasted to the free-living class Turbellaria. The parasites often have intricate life cycles involving one, two, or more hosts and several larval stages. Great fecundity and larval multiplication (polyembryony) combine to yield huge numbers of offspring in the flukes. Cestodes too lay enormous numbers of eggs and many are highly infective in vertebrates, including humans. Occasional parasitic flatworms may be encountered at San Salvador since the adults parasitize fish and birds. Frequently they are found as larvae in a variety of gastropod molluscs.

4. PHYLUM NEMATODA. These small, cylindrical, worm-shaped animals are ubiquitous and may be found in interstitial samples, occasionally on the surface or inside of other animals, or often in association with detritus in or along the edge of the water. Microscopic examination of freshly collected material is usually the only way to detect them and not surprisingly, few students at San Sal encounter representatives of this extremely successful phylum. Most nematodes are free-living but

some are parasitic and infect all sorts of plant, invertebrate and vertebrate hosts including humans. They lay tremendous numbers of eggs, have a resistant cuticle, and show other adaptations for a parasitic existence. Free-living forms, as well as the parasites, all have a rather common structural plan and, except for minor differences, they all have consistent internal and external structure. It is in their physiology and biochemistry that differences in species manifest themselves, which has led some zoologists to comment on a comparison of success in the two great groups, nematodes and insects. The insects have diversified in form and function, while nematodes have emphasized molecular diversity. Nematodes can live on many different food supplies, show a plethora of varied metabolic pathways and are resistant to many environmental conditions that would be lethal to other invertebrates. Also, they have the capacity to encyst, or go into a resting or diapause state for considerable periods of time, thereby escaping some potentially lethal environmental situations. Evolutionarily they are of interest because of their pseudocoelom, a body cavity bounded on the outside by muscles and other tissues derived from mesoderm but having no mesoderm on the inside of the cavity surrounding the gut.

5. PHYLUM ANNELIDA. Beautiful and frilly Christmas tree worms, delicate retractable feather duster worms and noxious bristle worms are all San Salvadoran representatives of the Polychaeta, one class of the Phylum Annelida. There are other members of this exclusively marine class at San Sal. Some are free living, errant forms which resemble somewhat the Oligochaeta, the class of Annelids containing the earthworms. Other Polychaeta likely encountered have calcium carbonate casings attached to hard substrates such as shells or corals or even Sargassum stems. Many of these tubiculous worms are only a millimeter or so in length. In the marine environment one is unlikely to encounter either leeches, which are in the Class Hirudinea, or oligochaetes.

The body cavity of the Annelids is a series of coelomic compartments, bounded on both sides by tissues of mesodermal origin. Mechanically, the fluid-filled coelom allows forces developed by circular and longitudinal muscles in the body wall to be transmitted against another part of the body, resulting in effective movement of the worm through its medium, either by swimming, crawling or burrowing. Thus, the hydrostatic skeleton of the annelids is an effective locomotory adaptation made possible by the presence of a spacious coelom. The coelomic cavity also acts as an auxillary circulatory system and as a site where gonads, nephridia (simple excretory organs) and other internal systems can develop.

There are two major structural patterns in the polychaetes and physiological functions reflect the structural plans. The elongated crawling, errant polychaetes have large parapodial extensions from the body wall used in crawling or swimming and are arrayed with a host of sensory structures (eyes, tentacles, chemoreceptors, etc) and imposing mouth parts used for defense and feeding. On the other hand the sedentary, sessile polychaetes are usually shorter, secrete tubes as cases, have gills and tentacles used for feeding and respiration and depend on retreat and retraction to escape danger. Thus, the polychaetes provide an interesting study of adaptations relating form and function and also demonstrate structural and physiological divergence along two major evolutionary pathways, both of which have led to considerable success.

6. PHYLUM ARTHROPODA. There are three large groups of animals in this enormously successful invertebrate phylum. They are the insects, spiders and crustacea; of these, only the crustacea have any significant representation in the oceans of the world. Therefore, in the water at San Sal, almost every Arthropod encountered will belong to the Class Crustacea. The possible exceptions might be a horseshoe crab of the Class Merostomata, a sea-spider of the Class Pycnogonida, or a marine water strider (*Halobates*) of the Class Insecta.

Body form varies greatly among the Crustacea and life history differences are significant. Crabs, lobsters and shrimps abound at San Salvador and come in many sizes, shapes and colors. Contrasted to these major groups of larger active animals are the sessile barnacles (Cirripedia), the planktonic copepods, the laterally compressed amphipods, and the dorso-ventrally compressed isopods. A common denominator of all Crustacea is the presence of a rather heavy, chitin-calcium exoskeleton which must be molted periodically to allow for growth. This exoskeleton serves as an effective defense mechanism and also allows for the development of strong pincers, which can be used for feeding as well as protection. The gills used in gas exchange are often associated with the appendages. The limbs and mouth parts of crustacea are diverse and specialized, especially in the more "complex" groups such as crabs and

lobsters.

The plankton at San Salvador contains many small adult crustaceans and a host of larval forms. Planktonic copepods are probably the most abundant animals in the world and act as a vital link in the food chain between the algae and small marine predators. A night plankton sample taken at Graham's Harbor or other site near the CCFL station will yield an awesome array of tiny crustacea. The crustacea in the cave at the lighthouse have been extensively studied and several new genera have been described from this one small sampling area. Also, a new genus of isopod, *Bahalina geracei*, has been discovered in the cave. It is white, eyeless and is a true troglobitic (cave) organism well adapted for living in a world without light.

7. PHYLUM MOLLUSCA. There are three major classes of Molluscs: the Gastropoda (snails, limpets, slugs and their relatives), Pelecypoda or Bivalvia (clams, oysters, mussels and related forms) and the Cephalopoda (octopuses, squid, nautili and cuttlefish). In addition, there are four minor kinds of Molluscs. The Class Aplacophora contains the shell-less solanogasters, rather small and insignificant animals which live in the mud or crawl on hydroids and corals in marine environments. There are only about 150 living species of Aplacophorans; their evolutionary status is uncertain. In the class Monoplacophora, thought to be rather primitive molluscs, is placed *Neopilina.* This remarkable genus has a single symmetrical shell, somewhat flattened and overlying a muscular foot. Until 1952, when living specimens of *Neopilina* were dredged from deep ocean water off Costa Rica, this class was known only from fossil skeletons. Since then seven new species of *Neopilina* have been described from living material collected in 2000-7000 meters of water at various sites around the world. Neither Aplacophorans nor Monoplacophorans has been described from San Salvador. The Class Polyplacophora, the chitons, on the other hand, is well represented around the island. They are identified by the flattened foot, 8 calcium shell plates along their back and usually by having a drab brown-gray-green coloration. They are adapted for adhering tightly to rocks and many live in intertidal or splash zones at the edge of the ocean. North Point, Cut Cay and Manhead Cay have large populations. The people living on San Sal occasionally use them for chowder and frequently cut out their soft visceral parts for fish bait. The fourth class of minor molluscs is the Scaphopoda, popularly known as tusk shells or tooth shells. These names reflect the shape of the shell which looks like an elephant tusk open at both ends. The animals live burrowed in the sand and have a worldwide distribution. Most are 2-5 cm in length. Empty shells of *Dentalium* are found along the beach at San Salvador, but living specimens have not been recorded at these sites.

Gastropods have a one-piece shell, often coiled as in snails, conical as in limpets or flattened in the slipper shells and their relatives. In some specialized marine gastropods, such as the sea hares and nudibranchs, the shell is reduced or absent. The shells of many gastropods are brightly colored and often they are decorated with sculpturings of many kinds. Marine gastropods have evolved to fill many niches; some burrow, others live on the bottom at all depths, some drift in the sea as adults or larvae and many notable species live between tide-marks. They feed on many different plant and animal materials although algae grazers predominate. There is great diversity and abundance of gastropods at San Salvador. The large, beautiful and tasty conchs are among the most prized of the Bahamian representatives of this class.

Bivalves are encased in two calcareous valves joined by an elastic hinge mechanism. Many burrow partially into the sand or mud where they filter feed and live a basically sedentary life. Others use byssus threads secreted by a specialized portion of the foot to attach onto a hard substrate. Members of this rather uniform class are mostly marine and have some representation at San Salvador. Students are more apt to find bivalve shells along the sandy beach than to find living bivalves in the water but careful searching at selected sites will produce considerable living material. The mangrove oysters and the pen shells at Pigeon Creek are examples of some of the exciting treasures one can find with diligence and luck.

Cephalopods are active, specialized molluscs with a sophisticated nervous system and a wide repertoire of unusually complex behaviors, including the capacity to be trained. Many people consider them the most highly organized of all the invertebrate animals. All are marine and some live on the ocean floor (octopuses) while others are swimmers (squid, cuttlefish). Giant squid are the largest of all invertebrate animals. Cephalopods show many characteristics common to other molluscs but they have clearly evolved a more rapid, aggressive, predatory life style than organisms in the other classes. There are only about 350 living species world-wide but every visitor to San Salvador should be fortunate

enough to see an octopus or a squid. One of the more unusual treats for some students is to find one of the tiny *Octopus joubini*. These reddish dwarfs, about 1-3 cm in size, are found in tide pools and demonstrate many of the interesting adaptations characteristic of their larger relatives.

8. PHYLUM ECHINODERMATA. Starfish, sea urchins, brittlestars, sea cucumbers and sea lilies are all found at San Salvador and represent the five classes of the Phylum Echinodermata. Some writers have described this phylum as the most unique of the major groups of invertebrates and they are remarkably different in many ways. They are exclusively marine, somewhat sessile animals with a 5-sided symmetry and possess calcareous components in their rough outer dermal-skeleton. These rough calcareous ossicles and the dermal extensions which protrude through it are responsible for their name, which means "spiny-skinned". They have an internal hydraulic system which links fluid-filled canals with a large number of externally located tube-feet used in locomotion and in prey capture. They often have gills or other surface projections from the body which facilitate gas exchange. Those species at San Salvador are abundant, large and conspicuous for the most part and constitute bountiful material for study.

Starfishes and their relatives belong to the Class Asteroidea and are familiar to most students. They have 5 arms attached to a central disc and they move by using rows of tube feet located in oral grooves running the length of the arms. They possess a flexible dermis and feed mainly on other invertebrates such as bivalve molluscs. An eversible stomach pours powerful enzymes over the prey and the partially digested tissue is absorbed across the stomach epithelium. *Oreaster* is a large starfish found in grass beds and open seafloor at San Salvador. Other starfish can also be found, varying from small white dwarfs to the asymmetrical comet star.

Closely related to starfish and yet markedly different in external appearance and habitat are the brittle stars of the Class Ophiuroidea. Many of the tide pools at San Salvador harbor these long-armed rapidly crawling animals whose habitat under rocks gives them protection from many would-be predators. Brittle stars move about by a rowing action of their arms pressed against the substratum.

Sea urchins are classified as Echinoidea and of all the echinoderms seen at San Salvador, these are the most ubiquitous. Long-spined urchins, rock boring urchins of two colors, sea biscuits, sand dollars and many other relatives abound in the rocky intertidal zone and on the reefs. Urchins are equipped with a hard outer test (or skeleton) and movable spines and, consequently, there are few predators which molest them. They feed by using a curious apparatus called Aristotle's Lantern which is made of calcareous teeth joined by muscle bands. The teeth are used to scrape algae from the substratum.

Tide pools at San Salvador provide excellent niches for sea cucumbers, of the Class Holothuroidea. They live in other locations, but the variety and quantity under a single slab of stone in a rich tide pool is enormous. Sea cucumbers have an elongate body, lack arms and have no central disc but they do retain their pentaradiate symmetry. Their outer body wall is leather-like with tiny calcium carbonate ossicles embedded in the outer epithelium. They feed by use of tentacles at the anterior end which can be retracted when conditions are not favorable.

One of the highlights for many students at San Salvador is to glimpse a living member of the Class Crinoidea. The sea lilies and feather stars, as crinoids are commonly called, were very abundant in earlier geologic times and many fossil species have been described. They are rather rare today but at 20 feet depth in Fernandez Bay crinoids live under ledges on some of the coral heads. Crinoids are often sessile, stalked animals with a reduced central disc and long branched arms which are employed in filter feeding. Their ossicles are almost continuous and this gives them a rather hard brittle texture. Many are colored brightly in oranges and reds.

9. PHYLUM CHORDATA. Almost all Chordates have backbones (vertebrates) but about 2000 species are invertebrate. One group of these invertebrate chordates is called the Cephalochordata and the genus Amphioxus (Lancelets) are representative. These so-called "headless fishes" or "lancelets" are about two inches long and live partially buried in the sand. Their distribution is worldwide and their habitat is marine. Arrow or spindle-shaped and laterally compressed, they swim by undulatory flexures of the entire body. They are considered by many biologists to be similar to the earliest vertebrates which were probably primitive fish, possibly resembling modern-day cyclostomes. Amphioxus such as *Branchiostoma* have not been described from San Salvador.

Another successful group of invertebrate chordates is the Class Urochordata, which contains the group known as the tunicates (or sea squirts or ascidians). These soft-bodied

animals may be shaped like a rounded sac or they may be flattened much like an encrusting sponge. Some are solitary and others are colonial, embedded in a common jelly-like mat. The living sessile adult animal has gill slits but lacks a notochord while the fish-shaped motile juvenile has both. They filter feed during larval and adult stages and possess incurrent and excurrent siphons. A number of colonial ascidians can be found encrusting on coral heads at San Salvador. Their external similarity to some sponges makes identification difficult. They, like sponges, are often brightly colored in blues, greens, browns, yellows and even black.

MINOR PHYLA:

1. PHYLUM PORIFERA - Sponges are heterogeneous in form,color, size and texture but all of them are sessile in the adult stage. They may be solitary, with a vase or a tube shape or they may be encrusting, flat sheets. Most are marine. The basic sponge plan involves a series of tubes and canals through which water is pumped; food is extracted and gas exchanged as the water passes across specialized cells. No organs or organ systems are present and "typical" animal tissues are absent. Skeletal elements are secreted by cells in the wall of the sponge and may take the form of hard spicules (calcareous and siliceous in chemical composition) or protein fibers, called spongin. Classification of sponges is based partially on the nature of the skeleton. Sponges are unique in many respects and are sometimes referred to as the Parazoa ("beside the animals"), or as an "evolutionary blind alley". They are well represented at San Salvador, both in numbers of species and in abundance. The patch reefs at Sand Dollar Beach and the deeper waters at Fernandez Bay offer spectacular sponges, as does Pigeon Creek.

The four classes of sponges are the Calcarea (spicules of calcium carbonate; organisms usually smaller than in the other 3 classes; often restricted to shallow water), Hexactinellida (siliceous, or glass, spicules of 3 or 6 points; shaped like cup, vase or urn; often pale colored; deep water forms; tropical), Demospongia (frequently brilliant colors; siliceous spicules are single-rayed or six-rayed; spicules may be combined with skeletal protein called spongin; a single species may have both siliceous spicules and spongin or spongin alone; contains largest number of species and most common North American sponges are classified here), Sclerospongia (coralline sponges with internal skeleton of spongin plus siliceous spicules and an external covering which contains calcarous spicules).

2. PHYLUM CTENOPHORA. Comb Jelly is an appropriate name for these animals, which possess large amounts of gelatinous mesoglea and bear on their exterior rows or plates of cilia resembling combs. They are closely related to the Cnidaria and their general form is quite similar to that of a jellyfish. However, they lack nematocysts, do not show alternation of generation and have other distinctive characteristics. Ctenophores are pelagic animals, often bioluminescent, and are occasionally seen in the open waters of Fernandez Bay or at other open water sites.

3. PHYLUM MESOZOA. These very simple animals are parasites of higher invertebrates and can often be found in the kidneys of cephalopods such as squid and octopuses. Their bodies are solid structures with relatively few cells. The life cycles of many are poorly understood. Their evolutionary origins and relationships remain the subject of much debate but little agreement.

4. PHYLUM NEMERTINA (Rhynchocoela). Someone described these elongated ribbon-worms as "highly refined Platyhelminthes" and structurally they do seem to be built upon the basic flatworm theme. One of their main differences is the possession of an extremely long proboscis which can be everted from a sheath lying above the gut. Also, they have a complete digestive tract and rudimentary blood vessels, distinctly uncharacteristic of Platyhelminthes. They have not been described from San Salvador but are probably present and not detected.

5. PHYLUM GNATHOSTOMULIDA. Only recently described, these tiny interstitial worms are rather widespread. They are classified as acoelomates; they have three germ layers (triploblastic) and resemble Gastrotrichs, Rotifers and small flatworms. They may be represented at San Salvador, but scientists have not really searched for them at this location.

6. PHYLUM ENTOPROCTA. The pseudocoelomate Entoprocts look somewhat like tentacled colonies of cnidarian hydroid polyps but their body structure is significantly more complex. There are marine and fresh water species and they could probably be found at San Salvador if one bothered to look extensively on the corals, stones and hard substrates where they encrust. Their name refers to the fact that their

anus opens inside the ring of tentacles which surrounds their head region.

7. PHYLUM ROTIFERA. Most of these "wheel animals", so named because of the ciliated wheel organ (corona) at the anterior of the animal, are marine and so tiny as to easily escape detection. They are pseudocoelomates, and in many genera parthenogenetic reproduction is pronounced. Some are about the size of larger ciliated protozoans and are confused with them in superficial examinations of samples. Interstitial materials or plankton tows from San Salvador may yield an occasional rotifer.

8. PHYLUM GASTROTRICHA. These animals show superficial and internal resemblances to rotifers and close examination is required to distinguish between them. They bear rows of cilia on their ventral side, usually have hair-like extensions from the cuticle in their head region and have a forked tail. They are found in mud, sand and interstitial habitats in both fresh and marine environments. Not recorded in San Sal check lists but are most likely present.

9. PHYLUM ECHINORHYNCHA. "Pseudocoelomates, marine, free-living, microscopic, annulated cuticle, no internal segmentation and recently discovered" all describe this phylum. No records from San Salvador.

10. PHYLUM NEMATOMORPHA. The name of this group means "Nematode-like" and in many respects they structurally resemble the Roundworms. They are pseudocoelomates which live in fresh water as adults and parasitize various arthropods as juveniles. Their extremely elongated and narrow body form, their whip-like swimming motions and their frequent sightings in farm ponds and troughs are responsible for their common name of "horsehair-worms". Not recorded from San Salvador.

11. PHYLUM ACANTHOCEPHALA. This is yet another pseudocoelomate phylum which is adapted for parasitism, in this case as endoparasites of vertebrates. Many have complex life cycles involving one or two intermediate arthropod hosts. The adults are 1-2 cm long and attach to the gut of their host with a proboscis armed with recurved hooks. They show gut reduction and other characteristics common to endoparasites. There are no published reports of their presence in the guts of vertebrates on San Salvador.

12. PHYLUM ONYCHOPHORA. Some biologists have described these soft-bodied, slug-like coelomate animals as a "missing-link" between the arthopods and annelids but it is more likely that they have evolved from some ancestral type that gave rise to these great phyla. They live in the temperate regions of the southern hemisphere and in the tropics. Their internal body plan is annelid in character but they have appendages and a respiratory system which resemble those of arthropods. They have not been sighted in the Bahamas.

13. PHYLUM TARDIGRADA. Most waterbears, as this phylum of minute coelomate animals is called, live on mosses and lichens in or near fresh water, but a few species are marine. They can also go through diapause as cysts and blow through the air to become lodged in cracks of wood, on fence posts and in a variety of sites. When moisture is present they excyst and reproduce. Their exact phylogeny is not clear, but they show a number of characteristics suggesting some relationship to the arthropods. They exist on San Salvador but must be cultured from cysts.

14. PHYLUM LINGUATULIDA (=Pentastomata). "Lingua" refers to the word tongue and these are the tongue-worms. The adults live in vertebrates, especially crocodiles and alligators, and they may have larval stages that live in an intermediate host that will be eaten by the definitive host. They have not been described from San Salvador.

15. PHYLUM SIPUNCULIDA. The "peanut worms" are nonsegmented, marine burrowers with many characteristics related to the annelids. Most live in the intertidal zone and on San Salvador they can be found burrowed into the lithified stone along the tide pools at French Bay and elsewhere. Sipunculids are usually 5-20 cm in size, and their elongated body bears an anterior retractable proboscis (introvert) which bears short tentacles at its tip. They lack appendages. Their coelom is well developed and is used as a component of the hydrostatic system which drives the introvert when they are burrowing or feeding on detritus.

16. PHYLUM PRIAPULIDA. There are only a few species in this phylum, and most live buried in the intertidal zones of cold waters. They use their spine-covered eversible proboscis to capture living invertebrates. A caudal tuft extends posteriorly from their thick body. Their apparent segmentation is a superficial reflection of

annulations in their cuticle and does not indicate internal metamerism. This phylum is not represented at San Salvador.

17. PHYLUM ECHIUROIDEA. Echiuroids are common, small, sedentary, intertidal worms that burrow into the sand or mud. They possess a striking nonretractable proboscis used in feeding and sensory perception; they resemble annelids internally but lack segmentation. Usually they remain permanently in their burrows and feed by filtration or by using mucus to collect detritus. Their distribution encompasses the Bahamas, but San Salvador biologists have not noted their presence.

18. PHYLUM ECTOPROCTA (=Bryozoa). "Moss animals" are abundant in most marine environments (also fresh water) and San Sal is no exception. These shallow water colonial coelomates encrust on hard objects and even though each zooid may be less than 1 mm in size, the colony may spread over a considerable area. The anus is located outside a retractable ring of filtering tentacles but otherwise they superficially resemble entoprocts. Over 4,000 living species have been named.

19. PHYLUM PHORONIDA. Like the ectoprocts, the animals in this phylum bear a lophophore (ring of tentacles) on the head. They live in shallow-water tubes and filter feed. They are usually 5-20 cm in length and can retract rapidly into their tubes if disturbed. They may be present in the Bahamas but are not commonly sighted and are unknown at San Salvador.

20. PHYLUM BRACHIOPODA. Fossil species of this group far outnumber living forms. They possess a bivalved shell and externally resemble pelecypod molluscs. They are benthic and are attached to the bottom either directly or by a stalk. A well developed lophophore lies inside the shell and is used to filter particulate food from water circulated through the shell by ciliary action. Living specimens are rare at San Salvador but are occasionally collected.

21. PHYLUM CHAETOGNATHA. Arrowworms are planktonic, torpedo-shaped coelomates of 1-3 cm length. They are virtually transparent and in some instances bloom into enormous populations. Prey is captured by the bristles around the mouth; their streamlined body allows them to pursue small planktonic invertebrates with rapid movements. Their phyletic affinities remain largely enigmatic. An extensive plankton tow at the Navy Dock or other similar location may yield a few specimens but they are seldom abundant.

22. PHYLUM POGONOPHORA. The giant reddish tube worms found recently at the Pacific deep-sea thermal vents increased the popularity of this previously little known phylum. Other members of the phylum are all deep sea tube- builders. The beardworms, as they are commonly called, filter feed using a unique tightly joined circle of anterior ciliated tentacles and then digest and absorb the food in the canal formed by the tentacle ring. They lack a mouth, digestive tract and anus. Some of their features are more primitive, like those of an annelid or other coelomate worm, while others are more akin to those of Chordates. Consequently their phylogeny is not clear. They are not recorded at San Salvador.

23. PHYLUM HEMICHORDATA. Several characteristics of these soft-bodied acornworms are simliar to those of the chordates and hence their name of "half-chordates". They have gill slits and a rudimentary dorsal nerve cord but no notochord. Most species live in shallow water burrows and filter feed by use of a pharyngeal basket reminiscent of feeding in the tunicates. Acornworms are usually 5-20 cm long but lengths of 50 cm have been attained. They are thought to represent a relatively unsuccessful stock of animals intermediate between the true invertebrates and the chordates. Zoologists working at San Salvador have not uncovered any members of this phylum.

--TO STUDY AN ANIMAL--A CHECK LIST--

A. Individual Attributes:
   1) Appearance
   2) Location/nature of habitat
      a) environmental features
      b) macro & micro differences
   3) Functional anatomy
      a) movement
      b) feeding
      c) gas exchange
      d) circulation
      e) excretion/salt-water balance
      f) reproduction
      g) defense/escape
   4) Phylogeny
   5) Taxonomy
   6) Life history
   7) Special features

a) notable behavior
b) etc

B. Group Attributes - Population Characteristics
1) Density
2) Distribution
3) Interactions
a) with same species
b) with other species
4) Special features

IV. FIELD OBSERVATION AND COLLECTION

The inshore waters around San Salvador constitute, under most climatic conditions, a benign field environment for observation and collection. Water temperatures are a comfortable 22-30°C. Many interesting reef areas are sheltered in the island's lee, and, under optimal conditions, visibility approaches limits set by the physical properties of sea water. Still, there are facts and procedures novices should be aware of in order to assure maximal comfort while deriving the most benefit from the superb marine habitats that surround San Salvador.

Personal collecting and snorkeling gear ought to include at least a comfortable face mask and snorkel, well-fitting swim fins, cloth or leather gloves to protect hands and fingers from sharp or stinging organisms, a mesh bag and small screw cap vials for collecting delicate or tiny organisms. A diver's knife is sometimes useful for prying loose organisms such as barnacles or chitons that may adhere strongly to the substrate. Some student groups employ a life ring with a rope attached and a bucket set inside as a floating aquarium or for tools, gear, cameras and even a place to rest for a tired student.

While snorkeling, most of the time one's back, shoulders and neck are exposed to the overhead sun, and covered by only a shallow layer of water. It is important to realize that these areas are vulnerable to sunburn, even though the water layer may temper the sun's warmth. A bandana tied loosely around the neck and a T-shirt worn in the water are excellent protection for the upper body during the first few days' exposure in the field.

The ideal weather and sea conditions for observing inshore underwater life are a bright overhead sun and absolute calm. Bright sun is the rule in the Bahamas, but there is usually some wind and wave action. If these are heavy, they create poor and often hazardous conditions for underwater observation. Not only are sand and silt stirred up into the water column by wave action, reducing visibility underwater, but heavy waves can drive a swimmer against rocks, coral heads, or hazardous organisms such as fire corals or sea urchins. It is important to enter the water in places where hazards are minimal, especially when there is a strong surf. Lee or sheltered shores are best at such times, but are not always easy to find. It would be foolhardy, if not outright dangerous, to enter the water from rocks or a cliff face exposed to heavy surf. Be prudent. Moving water has great force, and wave periods and amplitude are difficult to predict accurately. Sandy beaches are by far the best entry point, especially when one is encumbered by flippers and collecting gear. Nearly every collecting site described in this guide can be entered from a beach of gently sloping sand; indeed, the presence of this feature played an important part in the selection of these sites for detailed description.

The amount of time spent in the water will depend to a large extent upon ambient conditions of temperature, wind, surface waves, and so forth. As a rule, 45-60 minutes at a time is as long as even the most avid underwater observers will find comfortable. Water temperatures below 80° and strong waves or currents will usually induce more abbreviated observation periods. Since becoming chilled seriously distracts one's interest in anything but getting out of the water, a wet suit top, or a shorty, will be useful during the winter months. It is best to come prepared, especially if you are prone
to discomfort in cool water. .

To the student exposed to skin diving for the first time, even the minimal amount of gear required for snorkeling may seem awkward or uncomfortable, an encumberance rather than an aid. This is normal. It may take several sessions in the water with your mask, snorkel, and flippers before you are comfortable using them. Unless they are grossly ill-fitting, however, they will become less awkward with time.

Many of the observation sites (for example Graham's Harbor) are in comparatively shallow water and pose no problems with respect to water pressure regulation. These are good areas for beginning divers. Some areas, however, are as much as 5 or 8 meters underwater. Since a water column of about 10 meters deep exerts pressure equal to one atmosphere, a dive of 6-7 meters creates a sizeable increase in force upon the eardrum, displacing it toward the middle ear cavity and causing some pain. One remedy, of course, is to remove the excess pressure by surfacing. It is possible to accomplish the same end, however, by increasing the pressure within

the middle ear, via the eustachian tubes, thereby equalizing the forces on either side of the eardrum. This is accomplished by holding the nostrils shut with thumb and forefinger, closing your mouth and forcing a small quantity of air from the lungs into the eustachian tubes. Swallowing often accomplishes the same thing, but you may find it difficult or impossible to swallow with the mouthpiece of your snorkel in place.

A more painful problem sometimes associated with diving is pressure-caused discomfort in the facial sinuses, especially the frontal sinus. Equalizing ear pressure usually does not immediately relieve pain of this type. Experience has shown, however, that sinus pain is most frequently encountered during the first few dives and decreases on successive attempts. If sinus pain is encountered, therefore, do not persist in deep dives, but gradually, over a period of several days, increase the depth at which you feel comfortable. The problem, in other words, usually takes care of itself.

Probably the first thing to do after you enter the water is to establish in your mind's eye the major characteristics of the habitat that surrounds you. Is there shell and coral rubble on the bottom, or is it smooth sand? Is there an abundance of grasses, such as turtle or manatee grass? Is there a noticeable current running? Is there an obvious, predominant animal species evident? What sorts of algae are prevalent? These sorts of observations will be important for your log or record book later on, in that they help to establish the nature of each particular site. Obviously, such physical and biological features are instrumental in determining which invertebrate organisms will find a site most suitable, inferences which can be gained by the number and species of animals that you actually observe.

Your powers of observation will improve after you become familiar with the underwater environment. Learn to peer under ledges and into crevices and to remain still for several moments. As you improve in breath holding ability, your eyes will become better adapted to the low light conditions under ledges, and you will begin to notice more animals.

When you do notice an unusual animal, perhaps one that you would like to collect, approach cautiously at first and notice its reaction to your presence or to the presence of fish or other organisms. What defensive or aggressive properties does it possess? Is it cryptically or strikingly colored? Does it live in groups or is it solitary? Are there obvious commensal associations?

Try to fix the organism in your mind and compare a capsule description of it, as you observe it in the field environment. Since this procedure may take a little time, be prepared to ascend to the surface for air several times. Also remember that air problems constitute a serious handicap when attempting to capture and bag any marine animal.

Numerous invertebrates live *under* rocks and coral rubble on the bottom. These objects can be carefully turned over to explore the animals underneath. Always turn the rocks right side up and replace them in their original space when you are through. Use care not to crush animals beneath.

Collection

Animals removed from their natural environment for later study at the station must be cared for properly, in transit as well as in the laboratory. Coordinate your activities so that no more than one example of each species is brought back to the lab. The areas around San Salvador are subject to intense pressure from various CCFL groups studying marine invertebrates. Over-collection will devastate these habitats if conservation is not rigorously practiced. Do not take specimens on the CCFL endangered or threatened lists.

Small plastic or glass vials are best for individually collecting small molluscs, worms, shrimp, etc. Plastic bags are an alternative, but are more difficult to use. On the shore transfer collected specimens to buckets and containers with freshly collected and aerated sea water. Shade animal containers from the sun. If a protracted period of time will elapse before you return to the lab, replace the sea water in the container at least once per hour. Some animals, like *Octopus*, are extremely prone to oxygen deprivation. They need large volumes of water (5 gallon/animal) which should be changed every 1/2 hour. It is not advisable to take large octopuses back to the lab. They are destructive and usually die, following escape attempts or because of insufficient oxygen.

Sufficient containers should be carried to avoid crowding organisms during transit. Many animals are incompatible with one another and should not be confined together. As a rough rule of thumb, try to keep organisms from different phyla separate from one another. Many higher invertebrates are predators. Don't put small, seemingly delicate specimens in the same containers with large, strong species.

The same rules should be considered when animals are transferred to tanks or containers in the laboratory. Animals left in small containers will die quickly unless the water is changed several times a day. Survival of animals in sea water tanks will be drastically reduced if the tank becomes overcrowded. It is worthwhile to inventory the collection every day, returning to the sea animals upon which studies have been completed. There is no reason to keep animals in the lab for more than two to three days unless a protracted study is underway.

The following bibliography, while not exhaustive, may prove to be useful as adjunct guides to the identification of marine invertebrates found at San Salvador.

An Annotated Bibliography of Invertebrate Zoology

Barnes; "Invertebrate Zoology" 4th Ed. 1980 Saunders Publ. Co. A complete and excellent textbook-reference source covering all of invertebrate biology. Good illustrations.

Barth and Broshears; "The Invertebrate World" 1982 Saunders Publ. Co. Published by the same company as Barnes but shorter and more useful in a one-semester course. Covers the essentials.

Buchsbaum; "Animals Without Backbones" 2nd Ed. 1976. Univ. Chi. Press. Simply written and well illustrated introduction to invertebrates. Ideal for the beginning biology student.

Elson; "Zoology Coloring Book" 1982 Barnes and Noble Publ. Outlines of animals to be colored by number. Not a bad way to learn comparative structures.

Engemann and Hegner; "Invertebrate Zoology" 3rd E. 1981 Macmillan Publ. Introductory Invertebrate Zoology using the "type animal" approach. Illustrations sparse.

Hickman; "Biology of the Invertebrates" 2nd Ed. 1973 Mosby Publ. Phylum by phylum approach to invertebrates. Moderately detailed. Simple, clear illustrations.

Hyman; "The Invertebrates" 1940 McGraw-Hill Publ. A six-volume series on major phyla. Excellent resource for individual groups.

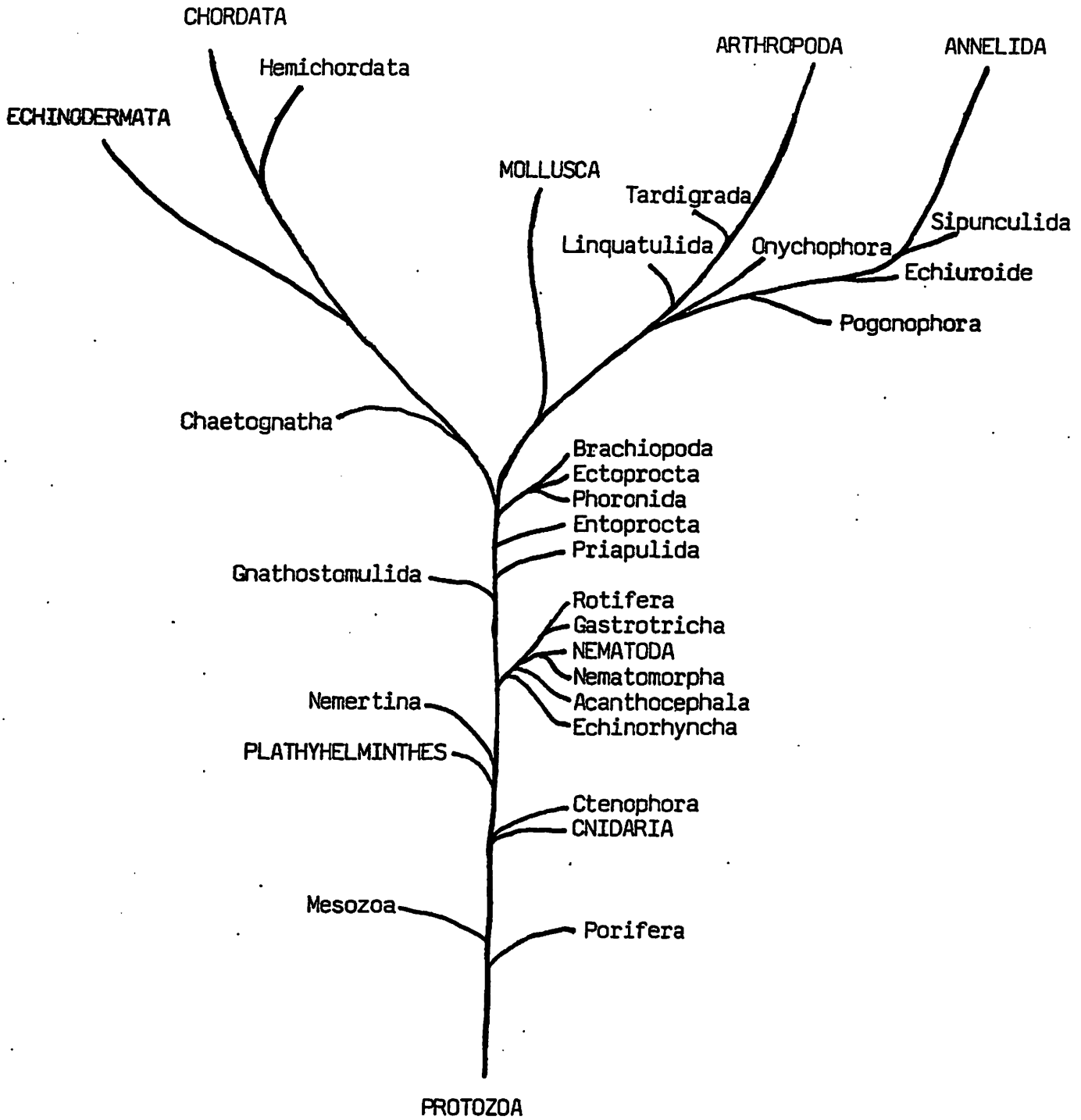
MacGinitie and MacGinitie; "Natural History of Marine Animals" 2nd Ed. 1968 McGraw-Hill Publ. Unusual approach to study of selected invertebrates. Lots of ideas for experiments.

Meglitsch; "Invertebrate Zoology" 2nd Ed. 1972 Oxford U. Press. Very comprehensive. Useful as reference. Not extremely readable.

Russell-Hunter; "A Life of Invertebrates" 1979 Macmillan Publ. Unique approach in which concepts, functional morphology and evolutionary relationships are the unifying themes. Not as valuable for reference, but unsurpassed for integrative, conceptual stimulation.

Sherman and Sherman; "The Invertebrates-Form and Function" 2nd Ed. 1976 Macmillan Publ. A lab manual plus lots of information about the specific animals being studied. Excellent illustrations.

(Other texts are available but these have been selected for their popularity, usefulness and completeness. Most serious students will want to have several of these available as source-reference aids).



A Phylogenetic Tree

Many of the relationships shown in this tree are supported by fossil and modern evidence but some are conjectural and not well documented. In any case, such schemes provide useful, working approximations and give some coherence to the confusing variety seen among the invertebrate phyla. ("Major" phyla are written in upper case on this tree, "minor" phyla in lower case.)

THE INVERTEBRATE PHYLA AND THEIR RELATIVE ABUNDANCE

Phylum Name	Approximate Number of Living Species	Major Habitats (M=marine F=fresh water T=terrestrial P=parasitic)
"Major" Phyla:		
Protozoa	40,000	M,F,T,P
Cnidaria	10,000	M,F
Platyhelminthes	12,000	M,F,P
Nematoda	50,000(estimates vary greatly)	M,F,T.P
Annelida	8,000	M,F,T
Arthropoda	850,000	M,F,T
Mollusca	100,000	M,F,T
Echinodermata	5,000	M
Chordata	45,000	M,F,T
"Invertebrate Chordata"	2,000	M
"Minor" Phyla:		
Porifera	4,300	M
Ctenophora	85	M
Mesozoa	50	P
Nemertina	700	M
Gnathostomulida	90	M
Entoprocta	60	M,F
Rotifera	1,500	M,F
Gastrotricha	160	M,F
Echinorhyncha	100	M
Nematomorpha	200	F,P
Acanthocephala	300	P
Onychophora	75	T
Tardigrada	175	F,T
Linguatulida	65	F,P
Sipunculida	250	M
Priapulida	5	M
Echiuroidea	70	M
Ectoprocta	3,500	M,F
Phoronida	10	M
Brachiopoda	300(plus 12,000 fossil)	M
Chaetognatha	50	M
Pogonophora	75	M
Hemichordata	90	M

V. HABITATS

A. Coral Reef Habitats

The attraction of San Salvador for the biologist derives mainly from its coral reefs. These structures are the present and past accretions of animals of Phylum Cnidaria, Subclass Hexacorallia, Order Scleractinia (Madreporina): the stony corals. Of the 25 genera of Scleractinia found in the Caribbean, six predominate, each having distinctive morphology: *Acropora*, branching corals of the elkhorn type; *Montastrea* and *Siderastrea*, spherical star and starlet corals; *Porites*, knobby corals; *Diploria*, globular brain corals; and *Agaricia*, plate-like lettuce corals. Together with the hydrozoan *Millepora* (fire coral), these six genera comprise over 90% of the total coral reef mass. *Acropora palmata* is the dominant reef builder in the Bahamas (Fox, 1983). Its branching pattern of growth can often be discerned throughout the structure of patch reefs around San Salvador, even though the animals which built the structure are long dead.

Scleractinia are colonial organizations of individual animals, or polyps, which are interconnected laterally. The individual polyps are typically cup-shaped with a mouth opening at the top surrounded by a ring of tentacles which are used to gather food, generally zooplankton. The polyp sits in a limestone cup, called a calyx or corallite, which it has secreted and which supports and protects it. Calcium carbonate is continuously deposited by the polyp at its base. Thus the coral skeleton accumulates under the growing animal, and the coral reef is the result of many years of accumulation by neighboring colonies of various Scleractinia. The polyp body is divided by flat outgrowths (mesenteries) invaginating from the body wall toward the central cavity. These structures increase the internal surface area of the coral polyp, aiding digestion, gas and waste exchange. These mesenteries are supported by thin calcareous plates known as septa. In the Hexacorallia, septa number six or multiples of six, hence the subclass name. (Soft corals such as sea fans and sea rods have eight septa and are members of the subclass Octacorallia). Colonial reef-building corals are found in symbiotic relationship with yellow algae, zooxanthellae, living within the flesh of the coral polyp. Zooxanthellae are dinoflagellates having chloroplasts and requiring light to carry out photosynthesis. Further, the zooxanthellae absorb CO_2 from their animal host and photosynthetically fix it into carbohydrate. This fixation of carbon dioxide is thought to enhance the coral's ability to deposit calcium carbonate by lowering the ambient CO_2 concentration and pulling the following reaction sequence to the right (Barnes, 4th ed., 1980):

$$Ca(HCO_3)_2 \rightleftarrows CaCO_3 + H_2CO_3 \rightleftarrows H_2O + CO_2$$

The importance of the symbiotic relationship is indicated by the fact that reef building corals thrive only under conditions where zooxanthellae can contribute their photosynthetic activity - in clear, shallow, sunlit seas. Most reefs are found at depths of less than 100 feet, apparently due to the need for sufficient light intensity. Corals require temperatures between 73-77°F and salinities between 28-35 parts per thousand. (The normal salinity of sea water is 35 parts per thousand).

Coral reefs vary in their general anatomy and relative location with respect to the shore. Terms used to describe reefs - fringing, barrier, bank, patch - have not been consistently employed by those who write about or discuss these structures. We will follow these guidelines: reef formations along rocky shores extending from the low tide mark seaward are fringing reefs, truly fringing the shore. Only isolated instances of such reefs occur in San Salvador; Dump Reef is a notable example. Fringing reefs show good species diversity and little zonation (Kaplan, 1982). Barrier or bank reefs lie substantially offshore, demarcating the abrupt change in water depth as one moves from the ocean to the shallower banks surrounding most islands. Bank/barrier reefs are usually visible from shore as a line of surf. The bank reef off French Bay is representative of this type. Bank/barrier reefs may not completely surround an island, and some islands tend to have isolated patches of a scattered nature offshore, so-called marginal reefs. The reef line extending northwestward from Cut Cay resembles this pattern. Bank/barrier reefs show substantial zonation. The area confronting the open sea is called the fore reef; *Acropora* predominates here. The reef flat or reef crest which may be many yards wide is generally rubble-strewn and somewhat barren. *Millepora* thrives here, as do calcareous algae (e.g., *Halimeda*) and zooanthids. The back reef or rear zone generally is an area rich in diversity and ideal for snorkeling. Shoreward from the back reef one typically finds large basins of relatively shallow (less than 20 ft.) water with smooth sandy bottoms, so-called lagoons. These areas are evident from shore because the white sand strongly reflects the sunlight, giving these

regions an unforgettable, almost indescribably beautiful light blue hue, tropical cerulean blue. Patch reefs are found shoreward of the barrier reef, scattered about the lagoon. Patch reefs can be small (6 ft. or so), square mounds of coral in relatively shallow water, or they may be huge buttresses of a hundred yards width rising suddenly from the sandy floor in 20 ft. of water. Patch reefs show vertical zonation between their sides and their tops (or reef flats) but may not show much variation relative to their orientation towards land and sea since the lagoon tends to be a protected, more uniform body of water. The patch reefs off Rocky Point are characteristic.

The major impact of the coral reef structure is found in the habitats it creates for other organisms. The ability of Scleractinia to form such structures fosters a discrete ecology, the coral reef ecology. The reef is rife with life amongst its crevices, crannies, nooks and caves, these refuges all providing shelter in one form or another for a plethora of organisms. Reef-dwelling organisms include minute formaniferans, sponges, anemones, snails, clams, annelids, sea stars, sea urchins, crabs and shrimps as well as a spectacular array of fish. These organisms not only live in and around the reefs but can be major contributors to the reworking of reef structure. Urchins graze over the coral surfaces, serpulid worms bore through it and butterfly fish are active predators of the coral polyps. Parrot fish also destroy coral as they ingest it to obtain the animal and the algal symbionts therein.

Despite its stony nature, the reef is not impervious to destruction. Many conditions can lead to the death of coral. Abnormally low tides can cause desiccation; siltation can suffocate the polyps. Fresh water, in the form of rain, can kill the polyps through osmotic stress. It is interesting to note that no coral reefs occur along eastern South America, apparently due to the great effluxes of fresh water and sediment from the Orinoco and Amazon Rivers. The surge of waves born of hurricanes can physically rearrange and destroy coral reef structures. And, even under ideal environmental conditions, the coral remains susceptible to predation by a host of organisms. Clearly, then the coral reef is a dynamic, living entity, subject as all life to the vagaries of many fortunes.

B. Rocky Shore/Tide Pool Habitat

Rocky shores and tide pools are both highly stressed environments. Each habitat presents unique physical features which must be confronted by the organisms characteristic of those areas.

Rocky shores and headlands, such as those on the eastern sides of North Point, Cut Cay, or Manhead Cay constitute vertical bulwarks against which the full energy of the prevailing oceanic wave fronts is rapidly expended. To avoid being taken up by the waves and, subsequently driven against the rock face, organisms which survive on rocky shores have developed physical and behavioral adaptations allowing them to maintain a firm grasp of their substrate. In addition, those animals to which the full force of the breaking waves may be exposed are either heavily armored in thick shells or are shaped so as to deflect most of the wave energy.

Characteristic animals of the rocky shore include primarily molluscs and crustaceans. By far the most noticeable of the crustaceans which make their home in this habitat are two fleet-footed crabs: the Sally Lightfoot crab (*Grapsus grapsus*) and the flattened crab (*Plagusia depressa*). These agile amphibious denizens of the wave-washed rocks seek shelter in cracks and crevices within the rock face, escaping the direct action of the waves by wedging their flattened bodies into recesses or simply climbing above the impact zone (where, however, they are at a great risk from predaceous sea birds). The speed and agility of these crabs are remarkable and attest to their complex nervous system and highly developed skeletal musculature. Their walking legs, like their bodies, are flattened and terminate in a sharp, hard dactyl by which these animals are able to cling tenaciously to flat rock surfaces. The large chelae (claws) of both species terminate in spatulate (spoon-shaped) structures by means of which they can scrape algae from the rock surface. These crabs have demanding oxygen requirements, no doubt reflecting their active lifestyle. They will die quickly if confined in oxygen-depleted water.

The major molluscan fauna of the rocky shores include chitons, limpets, and heavily shelled gastropods such as the bleeding tooth nerite (*Nerita peloronta*) and West Indian top shell (*Cittarium pica*). The latter possess heavy shells, and they seek refuge from wave action under rock ledges, in crevices and within deep pools. The surface of their large, mucous covered foot can be adjusted to conform to the uneven surface of the rock substrate, forming a very tight seal which prevents these animals from being dislodged by wave action. The mechanism

for this adhesion is as follows: the molluscan foot may be regarded as a mass of peripheral muscle. When the muscle is relaxed, it spreads out over the substrate as a flat sheet making a broad area of contact. If the central portion of the muscle then contracts and is retracted off the surface, a pressure differential is created that presses the peripheral region of the foot firmly against the substrate, rendering removal extremely difficult. In addition, the top-like configuration of this heavy shell distributes and deflects much of the energy of the wave impact.

Chitons, such as *Acanthopleura* and *Chiton*, show behavioral adaptations that allow them to dwell in this habitat. Like the top shells they seek out unexposed crevices or depressions in the rock face to which they can adhere tenaciously, using their broad muscular foot. They also ascend above the high tide line, if not above the surf zone, between periods of feeding activity. Chitons are physically protected by eight heavy calcareous plates which form an interlocking dorsal shell. The animals are dorso-ventrally flattened, an adaptation which reduces the drag produced by rapidly moving water, and their armored dorsal shield is ridged and deflects directly approaching water impact. Perhaps the most dramatic example of shell structure modifications that reduce impinging wave energy are found in limpets (e.g., *Acmaea antillarum*) which graze on the algal growth of the directly exposed vertical rock face of the surf zone. Limpet shells are steeply conical, and the energy of approaching waves is largely deflected away from the center of the animal by the lowered angle of incidence. As with other molluscs frequenting this habitat, limpets adhere firmly to the subtrate by their foot.

Because of the tidal and wave-generated variations in water level, as well as the necessity for escaping direct wave action, organisms inhabiting rocky shores must tolerate periods of exposure to the air and, in some cases, rather high ambient temperatures. In general, however, extreme conditions can be avoided by choice of refuge sites.

Some of the potentially stressful conditions indigenous to the rocky shore environment are also found on the tidal flats. In general these areas are not often exposed to heavy surf, so the behavioral and structural modifications which protect rocky habitat dwellers from mechanical harm need not be present in the animals which live in tide pools. They do, however, require adaptive modifications for dealing with wide fluctuations in water salinity, oxygen content, and temperature because the receding tide regularly strands them in the shallow pools. In summer, water temperatures as high as 40°C and salinities well above 100 parts per thousand have been measured in pools on the tidal flats around San Salvador. While not all the organisms found in this habitat can survive for long in such extreme conditions, short exposures are tolerated, and the indigenous inhabitants undoubtedly exhibit a relatively greater tolerance than those animals that are never required to leave the more stable conditions of the deeper inshore waters. Mechanisms for dealing with the adverse conditions of the tidal flats include both physiological and behavioral adaptations. Because of the variations in temperature and salinity these animals must acquire specific modifications of their cellular physiology. Different enzymatic isoforms may be selected which operate more efficiently at high temperatures, lower oxygen partial pressures, or at lower blood pH. To deal with osmotic stress caused by higher (evaporative) or lower (following heavy rains) sea water salinities, some animals (osmoregulators) may be particularly efficient in regulating the water and/or salt content of their blood. Others (osmoconformers) can tolerate some variations in blood osmolality, so long as these are acquired gradually. Most crustaceans and molluscs of the tidal flats are osmoregulators. Water balance is maintained by organs which functionally resemble the vertebrate kidney, filtering and selectively excreting various substances, including water and salts, from the animal's blood.

The most prevalent, yet relatively least noticed, of the tidal flat osmoconformers are the numberous errant polychaetes which live in the interstices of the substratum. Some of these animals exist in self-styled micro-environments consisting of tubes in the coral rubble or in the sand. In some cases extreme variations in osmotic fluctuation of the surrounding sea water can be safely "ridden out" by such animals for short periods. Other animals which lack these protective amenities simply tolerate fluctuations in blood osmotic pressure. In consequence body tissues take up or lose water, conditions which can be verified in the laboratory by measuring the resultant variation in body weight. There is wide variability in the extremes, as well as the rate of change of osmotic variation tolerated by tidal flat organisms.

Behavioral adaptations which deal with environmental stress in tidal flat animals include: 1) a predominantly nocturnal activity cycle, 2) avoidance of direct sunlight (and predation) by negative phototaxis, 3) incorporation of light (and

camouflaged) coloration, or 4) actively burrowing into the substrate. During the heat of the day, many land-locked tidal pool organisms seek shelter under rocks. This behavioral adaptation is quite obvious at the Dump Beach tide pool area where scores of sea cucumbers, brittle stars, sea hares (*Aplysia dactylomela*; *Dolobrifora dolobrifora*) and mantis shrimps (*Gonodactylis oerstediae*) can be exposed by turning over rocks. At night these animals may all be seen actively foraging on the flats.

In fact a night trip to the tide pools can be especially rewarding (at low tide) in terms of the different types of organisms encountered moving about.

In summary, the tidal flats and pools offer an opportunity to observe, at close quarters, a wide variety of marine invertebrates which, under favorable circumstances, are temporarily trapped in (or are permanent residents of) shallow natural "aquaria". Like the rocky shores, the tidal flat presents its inhabitants with extreme physical conditions that have been dealt with by a variety of adaptive modifications in anatomy, physiology, and behavior. These two habitats are of special interest, in a comparative sense, as natural laboratories where extreme selective pressures have resulted in evolutionary traits that are, in some cases, nearly identical, while in others, remarkably divergent.

C. Sandy Beach Habitat

One of the most unstable of all marine habitats is the sandy beach. Constantly washed, sometimes pounded, by the ocean, it is exposed to the periodic trauma of tropical storms in addition to the daily wetting and drying caused by the tide's ebb and flow. The sandy beach is devoid of life, or so it may seem to the casual observer, but in actuality many organisms make their home in and on the beach or in some way exploit it as refuge or substratum. Many of the animals are temporary inhabitants, but some reside permanently.

The beaches of San Salvador vary considerably in width, surf exposure, soil texture and composition, and surrounding environments. Physical features of five beaches (CCFL Beach, East Beach, Cut Cay Beach, Sandy Point and Singer Bar Point Beach) are described in detail in Chapter IV, pages 106-112 in the Field Guide to the Geology of San Salvador. Most of the other sandy beaches on San Salvador fit into a general profile of one of the beaches described in the Guide.

The sand along the beaches of San Salvador varies from coarse to very fine but all of it is derived from limestone (calcium carbonate) instead of siliceous materials. Therefore, it is softer than the sand along most U.S. beaches and in addition it can be reworked by nature from small particulate or granular form to rock and vice versa. This process is called lithification and is explained in the Geology Field Guide. Lithification contributes substantially to the instability of this particular habitat and means that the beach structure may change rather frequently and abruptly. Conversely, at certain locations the rapid modification of beach sand into beach rock has contributed to the permanence of certain geographic regions which otherwise might have been eroded away.

The beach actually extends into the water and even though we think of it as being a part of the land it is more accurately depicted as belonging to the ocean. It is the ocean that shapes it and impacts on all facets of the beach ecosystem. Perhaps it is best characterized as a buffer zone that protects the land from the erosion forces of the ocean. Because of the constant movement of sand from ocean to land and back again and also because of the movement of sand along the shore by current, the beach has been referred to as a "River of Sand". Therefore, organisms living in this habitat are faced with some of the same stresses which befall those found in rivers, such as resistance to displacement, fluctuations in moisture and periodic "flooding". Animals living in the intertidal zone are segregated according to size, tolerance to drying air and food availability. Many variable niches are occupied by a variety of organisms from several phyla.

Some organisms which inhabit sandy beaches tend to be small enough to fit between the sand grains (and, therefore, are not usually seen by students). Others, usually larger members of the community, have burrowing capabilities which allow them to penetrate into the substratum or can crawl rapidly enough to move up and down the beach in concert with the wave action. A few live on the surface of the sand or are washed up by the surf, and some specialized forms make their home in or around the *Sargassum* and other seaweeds which form the berm at the high tide mark of the beach.

Food is not abundant in the sandy beach habitat but some materials are washed in with the tide or surf, and some small algae, bacteria and protozooans grow on or between the sand grains. Animal carcasses and other detritus also

provide an energy source for some of the larger beach dwellers such as ghost crabs and hermit crabs.

Predators, most obviously birds and crabs, are numerous on sandy beaches. Gulls, terns and other shore birds capture many small invertebrates on the sandy beach, especially at the water's edge. Molluscs, annelids, crustacea and even small fish provide a rich diet for avian predators. Crabs feed on any living or dead materials which they can forage and are especially active at night, possibly to avoid being devoured by birds.

Dunes are often found at the upper edge of the sandy beach. (East Beach is a classic example.) The grasses growing along the upper reaches of the beach trap blown or washed sand, and the dunes slowly increase in height and width. A prograding beach such as East Beach shows this growth quite clearly.

One of the most informative methods one can use to study the sandy beach habitat and its resident fauna is transect analysis. Mark off a six to ten foot wide transect from the upper beach-dune area to well below the low tide level at the water's edge. Then, examine every living organism which you can locate within that transect area, noting location, specific habitat and other relevant observations. It is best to sift through any detritus for small organisms, dig into the sand, turn over stones, take microscopic samples and in general be as thorough as possible in your search. Comparisons of transects from different beaches around the island will yield interesting results. Sandy beaches which may appear superficially to be very similar may actually vary considerably.

D. Tidal Creek/Tidal Delta Habitat

Only at the southern end of San Salvador does there exist a tidal creek/tidal delta habitat. This is Pigeon Creek (see "Sites"), a tidal lagoon consisting of a common opening to the sea and two bifurcating arms. The length of these arms (1-1/2 and 4 miles, respectively), their relatively narrow width (75-100 yards) and the temporarily swift tidal ebb and flow are highly suggestive of true tidal creeks and rivers.

The tidal creek is a relatively rich environment. At Pigeon Creek's headwaters it covers an extensive (several square miles) area of shallows, primarily characterized by colonies of the red mangrove. The prop roots of these salt-loving plants trap silt and detritus that is continously carried downstream with the outgoing tidal flow. This is a rich source of nutrients for filter feeders of all varieties, especially bivalve molluscs. Some idea of the abundance of these animals in tidal creeks can be seen by the number of *Codakia* and *Lucina* shells which litter the floor of the central ebb channels just west of the dock at Pigeon Creek. The salubrious effects of tidal flow for distributing nutrients is evident in the abundance of other organisms as well. Large numbers of anemones exist in the shallows which border the central surge channels, feeding upon lower members of the food chain, and this area also constitutes an especially favorable environment for the calcareous alga, *Halimeda.* The mangrove thickets which border the tidal creek serve as a nursery to countless small reef fish which feed on the numerous species of crustaceans indigenous to the creek environment. The profusion of prop roots and the reduced light intensity in these thickets furthermore serve to protect young fish from large predators.

As the tide turns to flood, cooler oxygen-rich water is carried back into the tidal lagoon, contributing to the maintenance of gas balance and a neutral pH, and preventing the build-up of inhospitably high temperature. Thus, the secret to the success of the tidal lagoons as rich habitats is their abundant nutritional resources coupled to a reasonable stability in the physical and chemical properties of the ambient sea water.

At the mouth of tidal creeks, a subaqueous delta is invariably present, the result of deposition of sand by the decelerating water as it emerges from a central ebb channel. This delta is especially evident at the mouth of Pigeon Creek and is several acres in extent. It is not difficult to discuss the forces leading to its establishment. The ebb flow may approach 10 knots just inside the narrow mouth of the creek, but the water is much less confined as it emerges into Snow Bay. The total kinetic energy is thus distributed over a much broader area, resulting in a smaller velocity of flow at any one point, and ultimately, in the deposition of the load of suspended sand and silt. Characteristic physical features of all tidal creeks are the presence of this centrally projecting delta beyond the mouth of the creek, and, usually, a pair of flood channels - one on each side of the central delta. Throughout the area near the entrance to such creeks the effects of rapid movements of water are evident. The mouth itself is a region rather sparse *in* biotic forms, but it helps to shape
the rich biotic communities farther upstream: first by partially confining large masses of water in the shallower areas; and second by generating

large velocities of water flow which helps to distribute nutrient-laden bottom water.

E. Lagoon/Turtle Grass Bed Habitat

The bank/barrier reefs lying offshore on the verge of the truly deep waters surrounding San Salvador provide protection to shoreward regions of relatively shallow, calm water, the lagoons. Most of the island's coast, the notable exception being Sandy Point, enjoys such protection from the tempestuous sea. The relative serenity of the lagoons suggests a uniform environment but the evident variation in the brilliance of blue in these waters reflects an underlying diversity of habitat. Some areas, the brightest blues, are expanses of sandy sea floor; others, more darkly hued, betoke sea grass beds while still others, tinged brown, locate the occasional patch reefs. The undifferentiated sandy sea floor would seem an unfavorable locale for creatures needing shelter, and if only casually surveyed, such areas do appear relatively sterile and devoid of life. Careful inspection, however, reveals that many species may be present, buried just beneath the surface. Shallower lagoon areas where high intensities of light can reach the bottom are often profusely covered with sea grasses which proliferate so well in these warm illuminated waters. These meadows enrich the ecological possibilities by generating sustenance and shelter for a variety of animal species.

The nature and diversity of species in a particular lagoon are doubtlessly determined by many factors, but water depth, turbidity and vegetation are often important. An evident example might be the abundance and diversity of sponges in the deeper, clearer lagoon-like regions of Fernandez Bay. Sponges are less common and less diverse in the shallower, more turbid areas near North Point in the Graham's Harbor lagoon. Even more striking is the comparison of fauna found in the sandy expanses with those of the sea grass meadows. The marine meadows of San Salvador are dominated by two species of sea grasses which, unlike algae, have true roots, stems, leaves and flowers. The preeminent of these species is *Thalassia testudinum*, or turtle grass. This plant has <u>flat</u> leaf blades (about 1/2 inch wide and up to 12 inches long) that rise in clusters from short stalks. It is seed-bearing but spreads also by means of rhizomes, root-like structures that extend laterally just below the sand surface, putting forth shoots of leaves at regular intervals. By such means, turtle grass spreads to form acres of greenery. Turtle grass thrives in tranquil lagoons where currents and surf are minimal. Often occurring extensively in conjunction with turtle grass is the second dominant species, *Cymodocea filiforme*, or manatee grass. This grass is readily distinguished by its thin, long, <u>cylindrical</u> leaves (up to 14 inches long). Its rhizomes also lie flat along the bottom, sending shoots forth as *Thalassia* does. Manatee grass may predominate in meadows growing in brackish water. Both of these grasses retard the flow of slow moving currents, causing thereby any water-borne sediment to settle out, consequently providing a filtering action upon the water. Amongst the verdant lushness of turtle/manatee grass meadows are found various beautiful and exotic algae such as the mermaid's wine glass, *Acetabularia crenulata*, delicate clusters of pale green wine glass-shaped stalks, and *Penicillus* sp., so called mermaid's shaving brushes because of their appearance. *Avrainvillea nigricans*, a soft fan alga 2 to 3 inches high and *Udotea flabellum*, the mermaid's fan, a large (8 inch) fan-shaped alga showing distinctive concentric growth lines, can also be easily found. An ecologically important alga in turtle grass meadows is *Halimeda*. Species of this calcareous alga form thick, dark green mats several square meters or more in area in which many small animals - worms, crustaceans, molluscs - find refuge. Turtle grass itself supports on its leaf blades numerous encrusting animals, such as sponges, hydrozoan polyps, flatworms and tunicates. Many larger species graze on the grass or subsist on the detritus generated when the grass dies. Many clams, such as members of the family Lucinidae, live beneath the sand, their presence drawing many predators to this habitat.

Clearly, these *Thalassia*-dominated meadows are essential to the existence of many life forms. Only those of sufficient size (1 inch or greater) to be easily observed with the naked eye receive attention here and only, indeed, the more conspicuous of those. Large invertebrates favoring the lagoon environment include the cushion star *Oreaster reticulatis* and the donkey dung sea cucumber *Holothuria mexicana*; individuals of both species may extend well over 1 foot. Amber pen shells (*Pinna* sp.) 1 foot in length may also be found standing among the sea grass blades. Large marine snails, including the strombs, such as *Strombus gigas*, a favorite Bahamian food source, and Helmets (Family Cassididae) are here feeding on the molluscs buried in the grass beds. As you swim along, be alert for the many feather duster worms (Family Sabellidae) displaying their branchiae in the

passing current. Also beware of the bristle worms or fire worms (Family Amphinomidae) that occur here. Two species are common, *Hermodice carunculata*, the green bristle worm, and *Eurythoe complanata*, the orange bristle worm. Both are voracious, indiscriminate predators on other invertebrates. The sea egg *Tripneustes ventricosus*, a large urchin found in these seas, is found here. Note the many burrows in the sand of the meadows. Mantis shrimps (Family Squillidae) occupy these burrows; some members of this family approach one foot in size and should be approached with caution. Their trivial name of "thumb-splitter" is apt. Even corals occupy the Thalassia meadows. Golf ball-sized starlet coral (*Siderastrea radians*) and rose coral (*Manicina areolata*), a solitary cup-shaped coral several inches long, are found throughout the grass beds.

As one moves into the sandy areas of the lagoon which are devoid of vegetation, the superficial appearance is one of barrenness. However, a number of echinoderms have adapted to these conditions. Sand dollars (Family Scutellidae) can be found partially covered in the sand, browsing on the interstitial organisms which live among the sand grains. Larger echinoderms such as *Tripneustes* and *Meoma ventricosa*, the sea pussy or cake urchin, live in these sand fields. *Meoma* burrows just beneath the sand in waters over 7 feet deep, forming discernible hillocks. The largest indigeneous urchin, *Plagiobrissus grandis*, or the great red-footed urchin, also buries in the sand of the lagoon. These urchins are very difficult to find because they remain buried and are only evident when their rows of translucent spines project 1/4 inch or so above the sand.

Anemones populate the lagoon and fringe its shores. *Condylactis gigantea*, the pink-tipped or giant Caribbean anemone, is found in abundance in shallow lagoon waters. The sun anemone, *Stoichactis helianthus*, buries its long columnar body in the sand at the water's edge, often in large groups, giving a mat-like appearance to the substrate when only their short tapered tentacles protrude.

The lagoon/turtle grass bed habitat can be summarized as a basically flat, vertically undifferentiated sandy region which may or may not be covered with sea grass. The invertebrates which inhabit it are those which crawl along the surface or burrow just below it. A few relatively sessile groups such as anemones occur also. The photosynthetic activity of the meadows provides the base of a food pyramid that provisions the large diversity of animals populating this habitat.

F. Mangrove Habitat

On an island such as San Salvador, the most glamorous setting is the sandy beach stretching into the distance before an azure sea that is punctuated at intervals with coral reefs. A habitat that is biologically more significant, though perhaps esthetically less pleasing, is the mangrove swamp. The word mangrove conjures up an impenetrable thicket of marine vegetation and inspires the imagination to invent a host of horrors to occupy its foreboding recesses. In actuality, this community is more a haven for the juvenile members of the fauna than a place where dreaded denizens lurk.

In common usage, "mangrove" is a general rather than a taxonomic term applied to many families and species of tropical trees and shrubs. While not necessarily related, all of these plants are adapted to loose soils, saline habitats, and periodic submergence by tides; further, they usually have a viviparous life cycle. This generalization then groups together an entire plant community of halophytic species which coexist on the coastal fringes. (Halophyte means plant growing in saline soil). Of course, the dominant members of the community are the true mangroves, of which there are four major types: Red mangrove (*Rhizophora mangle*), Black mangrove (*Avicennia germinans*), White mangrove (*Laguncularia racemosa*), and Buttonwood (*Conocarpus erectus*).

The geographical distribution of mangroves is distinctly tropical, ranging between 25°N and 25°S latitude, and their adaptation to the coastal marine environment of this region is evident in the fact that mangroves occupy more than 70% of the available coastline within these latitudes. Several factors worth noting account for this distribution. The first is climate: mangroves in general do not tolerate extreme temperature fluctuations. The second is salt water: mangroves are facultative halophytes, meaning that they can grow in fresh water or adapt to saline conditions. However, mangrove ecosystems do not develop in strictly fresh water environments because the competition from other species is too keen. Although tidal fluctuation is not required for the success of mangrove communities, the osmotic stress and increased nutrient variability attending the tidal cycle allow mangroves to develop where other species cannot.

Mangroves grow best in riverine or tidal deltas where there is reduced wave energy and

fine-grained soil or silt and mud. These soil types promote anaerobic conditions to which mangrove communities are tolerant, in contrast to most vascular plants. The mangroves serve to stabilize the shoreline against erosion by retarding tidal currents and absorbing the water's energy of motion. Other flora and fauna then flourish. The resulting ecosystem provisions a detritus-based food chain that nourishes countless juvenile marine invertebrates and vertebrates.

On San Salvador, there are many mangrove areas. Two distinctly different areas worthy of exploration are noted here. North of CCFL on the inland side of the Queen's Highway past the bend in the road near the Navy Dock lies the verge of a mangrove community that surrounds the small lake at that location. Though the dense growth is essentially impenetrable, one can get an excellent impression of the refuge such vegetation provides. And certain species of crab, such as *Cardiosoma* and *Gecarcinus* seem more plentiful here. A more spectacular mangrove-dominated region is found at Pigeon Creek. When viewed from the hill described in the "Sites" section on Pigeon Creek, this mangrove habitat reveals many typical attributes. For example, the mangroves crowd the water's edge, perched on their prop roots. Evidence of mangrove colonization is evident in shallow areas of the creek where one or several mangroves have gained a foothold. Their presence will hinder the current, leading to silt deposition and greater likelihood of further population and spreading until eventually a stilted island of mangroves is established. The shelter provided by the mangrove roots can be clearly seen and the productivity of the community is revealed in the panorama; the tidal filling and ebbing of the creek feeds and flushes, complementing the rain of detritus from the plants and giving sustenance to the myriad fauna. More than three tons of organic material is produced by an acre of mangroves each year and this adds immeasurably to the food supplies available to the invertebrates, and eventually the vertebrates, in the community. Small wonder that many countries are beginning to protect their valuable mangrove stands by strict laws and through educational programs.

G. Interstitial Habitat

If one has a microscope, lots of patience and a real desire to study small, often obscure invertebrates, then interstitial fuana will be informative, rewarding and a great deal of fun. Professional zoologists have found a veritable gold mine during the last 25 years by searching out interstitial forms. Several new phyla, many new orders and countless novel genera and species have been described as a result of the resurgence of interest in this long-neglected but ecologically important habitat.

Interstitial organisms live on and between small pebbles and sand grains. The best place to find them is the inshore zone of a pebble-sand beach. They may be up to several millimeters in length, but many are less than a millimeter in size and of necessity must be studied through a dissecting or even compound microscope. Some live at the surface of the substrate but others move deeper into the sand or mud. Soft-bodied forms predominate but shelled interstitial organisms are not uncommon. A random sample will likely yield representatives from many phyla. For example, protozoans from several groups are almost always present, as are gastrotrichs, small worms, molluscan and arthropod larvae. The persistent and thorough investigator can expect to find an almost endless array of taxa, especially if samples are taken from a variety of depths and from different sites around the island. The study of interstitial fauna is an excellent way to analyze how differences in microhabitats influence the distributions of animals.

To collect interstitial materials take a plastic or glass container of 1/2 to 1 liter size and carefully scoop out a sample of sand and small gravels from the floor of the inshore zone. Bring the sample to the lab. Put a small amount of the sand into a petri dish and scan for movement or other signs of life. Us an eye dropper or small brush to transfer any organisms you find into another petri dish containing ocean water. If you wish to concentrate the organisms in the original sample you may either wash the sample repeatedly with ocean water and collect from the wash (by centrifugation or settling) any animals dislodged from the sand or you may leave the original sample setting in the lab for a few hours until the water becomes anoxic and then scrape off the top layer of water and sand which contains the organisms that moved upward toward a higher oxygen level. The washing technique may prove more productive and will yield a higher percentage of viable animals.

H. Open Water Habitat

Fish dominate the open waters around San Salvador but there are a few adult pelagic invertebrates which are frequently encountered.

In addition countless planktonic forms can be found in samples taken from most any open water locale around the island. The invertebrate animals living in this habitat are, in a sense, at the "mercy of the sea" as they are carried passively from place to place by wind, wave or current action, but some do have control over their movements and migrations. Some, such as the plankton, may spend part of their time as pelagic drifters and at other times burrow into the sand or mud bottom.

Many CCFL students are fortunate enough to observe some or all of the following animals. The Portuguese-Man-O-War, *Physalia physalia*, is seen occasionally, either in the water or in the detritus washed on to beaches by on-shore winds. Squid, ctenophores and cnidarian medusae are among the large swimming invertebrates (nekton) encountered in open water. In addition, a night excursion will possibly reveal amphipods, isopods, shrimps, an occasional octopus and, during reproductive seasons, annelids of several species. Nektonic organisms are often translucent or transparent, possibly an adaptation to avoid being detected from below by fish or other predators, but nonetheless a hindrance to the snorkeler trying to locate them against the light background of the water and sky.

Plankton provides the base of the ocean food chain but because of the small size of the organisms which make up the plankton, they are often not seen or appreciated by beginning students. Many of the planktonic animals migrate in a vertical column upward during the night (to feed on algae at a "safer" period when predation is less fierce) and then migrate downward to burrow into the sand or mud during the day. In order to obtain a rich plankton sample it is best to collect at night. Excellent night samples may be taken by walking around the periphery of the Navy Dock at Graham's Harbor while towing a plankton net or, if a boat is available, a plankton tow of 5-10 minutes duration should yield abundant material. In warmer climates the plankton samples should be observed quickly after capture so that the organisms are still alive. Good dissecting and compound microscopes are essential aids in the detection and identification of plankton. Good reference guides are also helpful.

Many of the specimens collected in plankton tows are larval and juvenile stages of molluscs, arthropods and annelids. Some eggs and larvae of fish will be seen. Protozooans, hydromedusae, ephyra larvae of cnidarians, some small adult annelids, adult cumaceans, cladocerans, ostracods and copepods, flatworm and echinoderm larvae, and urochordate larvae are among the animals frequently identified. Additional uncommon or rare organisms are found often enough to make plankton analysis exciting and fun. Good comparative studies can be done on night versus day samples (or samples taken hourly throughout the day and night) or by taking samples from various locations, for example from water over grass beds versus water over sandy bottom or over coral reefs. Qualitative studies may be more rewarding and informative than quantitative ones, especially if sampling techniques cannot be standardized.

I. Sargassum Habitat

Sargassum is a widely distributed genus of alga with over ten different species in the tropical Atlantic. Most of these are benthic, or bottom, species. They all exhibit several advanced features, such as vascular tissue, and all possess gas-filled bladders for buoyancy and to hold the main stalk erect. The benthic varieties tolerate depths as great as 30 m.

In terms of sheer biomass, by far the most important species of *Sargassum* is *S. natans*. As the taxonomic name implies, this is a free-floating organism, and it exists in vast planktonic rafts in the North Atlantic Ocean, especially in the latitudes south of Bermuda, but encompassing most of the West Indian geographic region.

S. natans is a highly-branched species of the genus with frilled, spearhead-shaped leaves and spherical gas bladders. It is a brown alga (Phaeophyta) and, indeed, its coloration is light brown or yellowish olive drab. On bright sunny days, against the background of deep blue oceanic water, the extensive rafts of floating *S. natans* appear as bright yellow tangled mats.

Around San Salvador the best place to collect *Sargassum natans* is on the eastern side of North Point, or, especially on East Beach. On a typical day, the northeast trade winds drive floating *Sargassum* onto East Beach in sufficient quantities for a productive survey of the associated animals commensal with this alga. Many pleasant hours can be spent waist deep in the warm surf, with the sun at your back, carefully sifting through netted clumps of *Sargassum* for small organisms.

Because of its wide distribution in the open ocean far from land, *Sargassum natans* constitutes a truly unique refuge for several different phyletic groups of animals. Even small vertebrates, such as the seahorse (*Hippocampus* sp.) and the pipe fish (*Syngnathus pelagicus*) find temporary shelter and support amongst the

interlacing leaves, branches and floats. The most dramatic vertebrates to live exclusively among *S. natans* colonies are the several species of highly modified *Sargassum* angler fish, *Histrio.* The voracious inch-long animals hover just below the foliage of its floating refuge, readily devouring unwary shrimp, smaller fish, or other animals they can get into their comparatively large mouths. These fish are remarkable in their adaptive camouflage. Their color is the yellow-brown of the *Sargassum*, broken here and there by speckles and splotches of pure white pigment. The fins are ragged at the edges and are not easily distinguishable from the *Sargassum* leaves, while the immobility of the fish completes their deceptive guise. An afternoon's work will usually culminate in the capture of several of these fish by a keen-eyed collector.

More common on inshore *Sargassum* rafts is the *Sargassum* nudibranch, *Scyllea pelagica.* This animal carries its deceptive guise even further than the fish. Its skin is translucent olive, and the internal organs are shaped to resemble the gas floats of its host. Fleshy lobes of the dorsal body wall resemble *Sargassum* leaves, and as the animal slowly makes it way among the branches feeding on a species of small anemone, it is almost invisible to an unexpectant human observer. With the apparent exceptions of a species of the tube-making polychaete, *Spirorbus*, and a white colored bryozoan, extensive cryptic coloration and morphology is an invariant feature of the animals which live in intimate association with Sargassum. At least two species of crab, the grapsoid *Planes minutus* and the portunid, *Portunus sayii*, make their permanent home among the floating algal colonies. Another crustacean, the small olive-colored caridian shrimp, *Palaemon tenuicornis*, is even more numerous. Many of the *Sargassum* branches are covered with a seemingly undiversified species of bryozoan, and every colony of the alga possesses numerous individuals of a tiny anemone and the polychaete, *Spirorbus*. Several small flatworms and unidentified errant annelids are also adapted for this unique habitat.

One of the most interesting aspects of the *Sargassum* community is the relatively small number of kinds of animal that successfully inhabit the floating rafts of *Sargassum* weed. Many thousands of different animals, especially larval forms, must come in contact with this potential refuge, but just a handful are able to compete successfully for a permanent residence in this highly specialized environment. A clue to the success of these animals may be the invariant occurrence among them of strikingly effective camouflage. Indeed, with the exception of the bryozoan and sedentary polychaete - both of which live within protective calcareous skeletons - all of the permanent dwellers are at least cryptically colored, while some, as noted above, possess modified appendages which resemble structures on the host plant. These observations suggest that the *Sargassum* constitutes a highly stressed community characterized by a few, highly selective ecological niches presently occupied by superbly adapted, firmly entrenched species.

VI. SITES

A. Graham's Harbor

Graham's Harbor is a gently curving bay on the north shore of San Salvador. It lies between Barkers Point on the west and the karst cliffs of North Point and Cut Cay on the east. The College Center of the Finger Lakes Bahamian Field Station, or CCFL, is situated virtually at the middle of the coast of Graham's Harbor. These waters are sheltered by the barrier reef and a series of small offshore islands: Gaulin Cay, the low, vegetated island directly in front of CCFL, then to the right, Catto Cay, a higher white limestone buttress, next, in the distance, White Cay, a haven for sea birds, and finally to the west, Green Cay. Columbus visited this site in 1492, remarking in his log that the harbor was large enough to accommodate "all the ships in Christendom." Graham's Harbor is indeed large. This guide will only treat those areas easily accessible by snorkeling from shore. Dump Beach, a part of Graham's Harbor lying west of CCFL along the coast, is distinctive enough to merit its own description. The coastline along Graham's Harbor is particularly scenic. The visitor to San Salvador soon realizes that CCFL has on its threshold one of the most pleasing vistas to be found on an island where beautiful seascapes are commonplace.

The water's edge in front of CCFL is beach rock (lithified calcium carbonate sand). Mussels are found packing the cracks along the littoral zone in these plate-like rock slabs. On rocks above the waterline, periwinkles and nerites (snails) are common. Along the coast to the right, or east, the beach rock is gradually replaced by sandy beach. The smooth, soft sand extends from the shore out perhaps 50 yards before grassy meadows cover the sea floor. Few invertebrates are obvious in this sandy stretch.

This pattern of sandy in shore/grassy meadow continues to the large concrete pier known as the Navy Dock, 0.4 miles east of CCFL, and beyond.

Just northeast of the Navy Dock where the sandy beach ends and the karst landscape of North Point begins is an ideal site to initiate students to San Salvador and the observation of marine invertebrates. This area lies in the lee of North Point, shielded from the northeasterly trades, so its waters are usually calm. Further, for several hundred yards from shore, the water remains shallow (less than 6 ft.), and beginning students can easily stand and readjust as they endure the minor tribulations of learning to snorkel.

A major feature of this region is an extensive grassy meadow, dominated by two species of marine flowering plants: *Thalassia testudinum* or turtle grass, a flat-bladed plant, and *Cymodocea filiforme* or manatee grass, having thin, round blades. The relative proportion of these two grasses varies somewhat from area to area, with manatee grass predominating in regions of greater current and wave action, but generally speaking, the meadows contain both species in roughly equal proportions. Scattered among these bladed grasses are two algae of interest, *Acetabularia crenulata* known by the descriptive common name, merimaid's wine glass, and *Penicillus capitatus*, the mermaid's shaving brush, which protudes from the sea floor, resembling an inverted shaving brush. *Acetabularia* is a single-celled alga which has been used experimentally to demonstrate that genetic determinants reside in the nucleus. Both *Acetabularia* and *Pennicillus* are calcium-depositing algae. These grassy meadows provide a habitat for many animals. Featherduster worms (Family Sabellidae) are buried here, displaying their colorful crowns of tentacles which abruptly withdraw into their tubes at the slightest shadow. The five-toothed sea cucumber (*Actinopyga agassizi*) roams these floors. Sponges 1 ft. or more in diameter dot the lawn, providing refuge to a plethora of small organisms, and occasionally even a pink-tipped sea anemone (*Condylactis gigantea*). These beautiful anemones are very common here, littering the Graham's Harbor seabed, attached in crevices, sponges and dead conch shells and clustered under old coral mounds. The queen conch, *Strombus gigas*, is a major component of the Bahamian's diet and these delicious animals are harvested principally from *Thalassia*-type meadows. Discarded shells become a haven for an astounding diversity and number of animals. Animals found in one conch shell that was systematically broken apart included a baby (less than 1 inch) spiny lobster, 20 or more hermit crabs in a host of different snail shells, several tiny brachyuran crabs, 3 serpulid worms and an array of smaller annelids, a small sea cucumber, 6 green bristle worms and a juvenile butterfly fish which had sought temporary rufuge. Helmet conchs, *Cassis tuberosa*, also live in this environment, and living individuals of the amber pen shell, *Pinna carnea*, protrude from the sand. Echinoderms common in the area include the cushion star, *Oreaster reticulatus*, and the sea egg, *Tripneustes ventricosus*, often with bits of *Thalassia* adhering to its spines.

A few coral formations, not very large and scattered somewhat sparsely, can be found as you move northward along the lee shore some 50 yards out. These coral mounds are heavily encrusted with silt and algae and generally are devoid of living scleractinian corals, though an occasional cluster of yellow *Porites* (*P. asteroides*) or of clubbedfinger coral (*Porites porites*) is encountered. Corky sea fingers (*Briareum asbestinum*) project from the reef. Sea fans (*Gorgonia flabellum* and *Gorgonia ventalina*) wave at right angles to the prevailing currents. Sea rods (*Plexaura*, *Plexaurella*, *Eunicea* spp.) and sea plumes (*Pseudopterogorgia* spp.) can be seen on or near the coral mounds. Occasionally, one finds a flamingo tongue grazing on the soft tissues of these Octacorallia. Flamingo tongues, *Cyphoma gibbosum*, are gastropods having a colorful extensible mantle which can be displayed to cover the shell completely.

Two species of bristle worms or fireworms are prevalent in Graham's Harbor; the orange fireworm, *Eurythoe complanata*, and the green fireworm, *Hermodice carunculata*. These errant polychaetes, 3-6 inches in length, may be encountered on coral formations, among the meadows, under rocks, or as mentioned, in shells. Handle these animals with caution; their name is well deserved! Their fine glass bristles easily pierce the skin, break off and leave a toxin whose painful irritation may persist for several days. Several other noxious animals occur in these waters, but with reasonable care, they can be observed and avoided. Two are hydrozoans, one is a fish. The hydrozoans are the small stinging hydroids, shaped either like branching feathers or minute candelabra, and the fire corals, *Millepora* sp. The hydroids form colorless, branched, stalked colonies. They grow on rocks, dead corals or marine grasses and are hard to detect. Some resemble tiny marine plants. Fire corals are also colonial and grow as flat vertical sheets which are tan to yellow with white tips or as more ornate crenulated structures

of the same color. They may occur as encrusting forms also. They may be distinguished from corals by their fine-grained surface without noticeable corallites. Avoid touching them, or a painful sting from many nematocysts will be received. The fish to be wary of is the spotted scorpionfish. This mottled brown fish rests quietly on the substrate, blending well with the background coloration. If touched, it can cause wounds with its spines which are very painful and require medical attention. Fortunately these fish are relatively rare and, hopefully, will not be encountered.

If you move closer along the shore bordering North Point, carefully turn over rocks along the way. In this infralittoral zone, many creatures live sheltered from wave surge and predators. Typical inhabitants are sea cucumbers, brittle stars of many species, rock-boring urchins, bristle worms, medusa worms and tunicates. If you are both quick and observant, you may find an octopus. Chitons occur in the crevices of rocks receiving moisture from spray. The Bahamians refer to these molluscs as "curbs" and use them for fish bait. Two species occur here. In addition, several species of the gastropod genus *Nerita* reside here; *N. tessellata*, the checkered nerite, *N. versicolor*, the 4-tooth nerite, and, the somewhat larger *N. peloronta*, the bleeding tooth snail, so named because of the red coloration which seemingly drains from the tooth-like inner lip of its shell.

B. Dump Reef

The shoreline of Graham's Harbor is punctuated at its midpoint by a low headland known as Singer Bar Point. The underwater coral formations around this point are known as Dump Reef. This site, if not spectacular, is nonetheless interesting for the variety of organisms other than stony corals which can be found here. Furthermore, not only is it accessible to CCFL by a short walk, but the reef structure is very close to the shore, and, except when there are unusually strong or adverse winds, the waters over the reef are only mildly disturbed by waves.

A dirt path off the main road about 1/4 mile east of CCFL must be taken to reach Dump Reef. Its entrance is marked by an almond tree on the right side of the main road. The dirt track leads back through the scrub toward the sea, eventually terminating in the old dump established by the Navy. Before reaching the dump, however, the track passes close to the edge of a low limestone cliff. Climb down this cliff to a small sandy beach and look westward. A limestone shelf intervenes between the beach and the distant point, and slopes gently into the water. The limestone in this region has hardened into an insidiously sharp substance referred to as a paleosol. It has suffered dissolution and erosion, and the result is a formidably pitted and fractious surface which has the same texture as broken glass.

The shelf extends into the water for about 50 yards before being covered by sand. In the intervening region it forms a platform for an old coral reef. This platform and reef continue around the point to the west. At its seaward edge, the reef ends abruptly in 6-10 feet of water. In some places the macrostructure of the reef constitutes a continuous, if pitted, platform upon and within which a variety of algae (primarily *Padina*) have taken hold. At other places the reef structure is grossly channelized or indented with sand-floored embayments, and the walls and overhangs of the platform in such places afford refuge to a variety of tubicolous annelids (*Spirobranchus sp*; *Pomotostegus sp*), crustaceans such as the banded coral shrimp, *Stenopus hispidis* and the arrow crab, *Stenorhyncus seticornis*, gorgonians of several different species, octopuses, and small colonies of hard corals such as *Acropora*, *Porites*, and *Agaricia*. In any event, the crenulated and cavernicolous nature of the reef infrastructure suggests its origin as an interlacing stand (now long dead) of *Acropora palmata* coral, with much secondary encrustation and overlay by more recent activity of other forms. In this respect, Dump Reef is similar to the reef structure at Rocky Point.

Seaward, beyond the reef structure, the limestone platform is covered with a silty sand which supports beds of turtle grass (*Thalassia*) and manatee grass (*Cymodocea*). Tile fish at their burrows, queen conchs (*Strombus gigas*), sea egg urchins (*Tripneustes ventricosus*) and other grass dwelling organisms are found here commonly.

Perhaps the most important and productive features of the Dump Reef area, however, are the extensive flats of tide pools which extend seaward for 200 yards to the west of Singer Bar Point. Walk up the beach platform toward the point. The karst in this area is highly pigmented by iron oxide. Around the point, at a good low tide, numbers of small pools in the limestone and flat rocks partially covered by water provide an almost endless array of

dwelling places for intertidal organisms.

The ideal time for observing tide pool organisms is, of course, when the water is lowest at spring tides, when there is a bright overhead sun, and when there is no wind to ruffle the surface of the water. The best strategy for finding animals is to pick pools containing loose rocks which can be overturned. Many organisms will be found either attached to the underside of the rock or on the substrate beneath the rock. *Phymanthus crucifer*, the speckled anemone, is very common here; its speckled form is well camouflaged against the sandy bottoms of the tide pools. Echinoderms are well represented and include many nocturnally active species such as rock boring urchins, *Echinometra lucunter* and *E. viridis*, the red brittle star, *Ophiocoma wendti*, and the snakeskin brittle star, *Ophioderma appressum*.

Associated with *Echinometra*, and apparently feeding upon their tube feet are the tiny bumblebee shrimp, *Gnathophyllum americanum*. Occasionally a lima shrimp, *Microprosthema semilaeve*, may be seen, striking in its brilliant scarlet color. The banded snapping shrimp, *Alpheus armillatus*, may also be found, but these animals are more apt to remain in their burrows within the rock substrate. Their numbers in this area are attested to by the continual cacophony of bright snapping sounds which can be heard on the flats at low tide. Another shrimp often found here is the two clawed shrimp, *Brachycarpus biunguiculatus*, which is often seen scuttling around the bottom of the pools.

Holothuria sea cucumbers are encountered in quantity under the tide pool rocks, often in company with one or more individuals of the mottled sea hare, *Aplysia dactylomela*. Less commonly encountered is the green sea hare, *Dolobrifera dolobrifera*, having a warty grey-green skin.

Since many of the animals seeking refuge under rocks are nocturnally active, it is productive to visit the tide pools with a good light at night. The sea hares noted above can be seen grazing on algae in the pools at such times. At night several of the burrowing sea cucumbers can be seen actively extending their tentacles for feeding. These include a long white species, *Holothuria princeps*, and *Chirodata rotifera*, a red species.

Numerous crabs seek refuge beneath the tide pool rocks. Sharp eyes will reveal the decorator crab, *Macrocoeloma trispinosum*, clinging firmly to rock undersides, in company with *Megalobrachium poeyi*, the porcelain crab, more closely related to hermit crabs (Anomura) than the true crabs (Brachyura). This crustacean is notable for its absurdly outsized claws. Of course, the ubiquitous Sally Lightfoot crab, *Grapsus grapsus*, is often seen, if briefly. These nimble-footed sprites of spray and rock are very difficult to catch for closer observation, and they often autotomize limbs during their capture. The opposing digits on the chelae of Sally Lightfoot are spoon shaped for scraping algae from rock surfaces. They do not deliver a very impressive pinch, unlike most other crabs.

One of the most frequently observed and active members of the tide pool community is the stomatopod crustacean, *Gonodactylus oerstedii*. The large raptorial claws of this rapidly moving animal are capable of delivering a deep puncture wound to curious or incautious fingers. The claws are capable of striking out very rapidly by using the following mechanisms. Normally the raptorial claws are kept locked in a flexed position close to the animal's body. When the animal is disturbed, the extensor muscles of the claw are activated and generate large tensions, kept stored in elastic structural elements within the muscle until the *Gonodactylus* unlocks the claws suddenly, allowing them to extend forward with great speed and impaling their hapless victim. These animals also use the hardened, heavily calcified frontal surface of their claws to chop burrows in coral rubble.

Dump Reef tide pools harbor a rich variety of organisms, but recently, diversity and numbers have been depleted. To avoid further damage, animals which have been removed for study should be returned to this area.

C. Rice Bay

When one considers proximity, ease of access, attractiveness and scientific merit as criteria for selecting a snorkeling site to visit early in the CCFL stay, Rice Bay emerges as a logical choice. The bay is located one mile east of CCFL, opposite the entrance to the former U.S. Coast Guard Station. A slight incline in the main road culminates at the hilltop, with the vast expanse of water called Rice Bay on the left (north-facing). The bay is bordered on the west by North Point and Cut Cay and on the east by a protrusion of the mainland called Northeast Point. A shallow area of coral runs from this point to Manhead Cay and in a sense this shallow-water reef connection plus Manhead Cay serve as the eastern boundary for Rice Bay.

The old Coast Guard Station housed Loran navigational equipment but was closed in 1981 when the newest generation of Loran obviated

the need for the San Sal facility. One can only marvel at the exquisite taste shown by the U.S. Coast Guard in selecting this prime aesthetic seascape, possibly the most beautiful on the island, for their Loran station. To locate the inshore reefs, stand at the *Casuarina* (Australian Pine) tree just across the road from the entrance to the Coast Guard Station and look directly across the water toward the north-northeast point of Manhead Cay. The reefs appear as dark patches in the water about 40 yards offshore. The reef crests, called Three Head Sisters, are often exposed at low tide. Entering the water here is quite easy with the only hazard being several large rocks just beyond the tide line. They are partially exposed at low tide and are 10-15 feet offshore at high tide.

In the direction of the far points of Manhead Cay, the water is initially shallow and you will swim over a large area of silted-over-coral and sparse patches of turtle grass. Although this area appears barren and inactive during the daylight, it is another world entirely after dark. While night diving, it is not unusual to see spiny lobsters (*Panulirus argus*), long spined sea urchins (*Diadema antillarum*), an occasional coral crab (*Carpilius corallinus*) and the common reef octopus (*Octopus briareus*) foraging in this sandy area. The reefs appear as distinct pillars, forming a column running roughly parallel to the shore.

On the shore side of the reef, as well as the tops of the reefs, many hard corals such as *Porites* and *Millepora* and a few soft corals (*Gorgonians*) grow. On the ocean side, fans, whips and plumes abound. Wave action and other physical forces account for differential distributions. Throughout the reefs *Diadema* are the most obvious non-coral animals, inhabiting many of the available crevices and depressions. (In the early 1980's there was an apparent decline in world-wide *Diadema* populations and a decrease in numbers of *Diadema* at San Salvador has been noted by the authors. The future is uncertain; *Diadema* may become scarce or, more hopefully, reestablish themselves to previous high concentrations.) Diligent searching will reveal solitary and colonial zooanthideans, anemones, tubicolous polychaetes, decapod crustacea, encrusting sponges and tunicates, and possibly a bivalve or gastropod mollusc.

From this first reef you can continue on to Manhead Cay, which is about 400-500 yards distant or follow the line of patch reefs extending westerly to the left. The patch reefs in this direction are from 5-10 yards apart and continue along the shore for several hundred yards. On the ocean side these reefs abound with enormous soft corals, including *Plexaura*, *Eunicea* and *Plexaurella*. Also common are *Briareum*, *Leptogorgia*, *Pseudopterogorgia*, and *Gorgonia*. Additionally, there are some *Muricea* and *Pterogorgia*. As for the hard corals (Scleractinia), the *Montastrea*, *Siderastrea*, and *Porites* immediately attract one's attention as being the most abundant. The hydrozoans are represented by both the encrusting and flat topped fire coral (*Millepora alcicornis*, *M. complanata*). Although the reef in Rice Bay has a wide variety of corals it is obvious that in the recent past it has been under extreme ecological stress. The sparse new growth of elkhorn coral (*Acropora palmata*) on these reefs is encouraging, since it has been shown that elkhorn is one of the major reef building organisms in most areas.

Leave the water at your initial entry point, but on the return leg of your swim examine the rock ledge just under water off the left end (westerly end) of Coast Guard Beach. As you move from the patch reefs toward the rock ledge you will swim over a shallow, sandy area. The most striking feature here is the large number of solitary flower corals, especially rose coral (*Municina aerolata*). This is a particularly interesting coral with two growth forms, a small hemispherical form which may or may not be attached to the substrate and a cup-shaped form usually unattached on sandy bottoms. Rose coral is well adapted for this substratum; it has a high tolerance for sediment and can actually right itself, if overturned by wave action or a careless snorkeler. This is accomplished by a unique mechanism in which the polyp inflates its tissues and makes rolling movements. Other animals abounding in this area are small sea fans (*Gorgonia spp.*) and a few sea rods (*Eunicea* and *Plexaura*).

Be cautious when approaching the underwater ledge. Wave surges at low tide can toss an unwary snorkeler against the rough bottom or a rocky ledge protrusion. The reason for this excursion is to glimpse the abundance of rock boring urchins, *Echinometra*, which have riddled the ledge with burrows. Nearly every hole harbors either a red urchin, *E. lucunter*, or a green one, *E. viridis*. Each urchin excavates a burrow by scraping off small amounts of algae-encrusted rock with its Aristotle's Lantern feeding apparatus and by rotating its spiny body within its lithified calcium carbonate cavitation. Several species of chitons can be seen tightly adhering to the rock ledge. *Acanthopleura granulata* is the most common and can be recognized by its fuzzy mantle surface. They,

too, degrade the rock ledge surfaces as they graze on algae.

D. Cut Cay

The constant battering of waves against the east side of the peninsula known as North Point has gradually eroded away the soft lithified substratum and at one spot created a complete cut through the land mass. This cut now separates the tip of North Point and the newly created island known appropriately as Cut Cay. While standing on the road in front of CCFL station, one can see that the North Point-Cut Cay peninsula extends northward from the Navy dock and terminates at the eastern end of the barrier reef. This site offers a beautiful promenade for walking, viewing a sunset or establishing contact with the beauty and wonder of nature. Within the waters surrounding Cut Cay a variety of habitats house an abundance of different organisms.

You can access the Cut Cay site in two ways. Some classes choose to enter the water at the beach north of the dock in Graham's Harbor and swim to the cut or enter at some convenient point on the west side of North Point which is closer to Cut Cay. An alternate, more direct route is to walk to the tip of North Point, climb down the steep, jagged north face and into the channel. The longer swim is safer but requires more time. Be especially careful about entry at the far tip of North Point. The rocks are sharp, the cliff steep and the channel can be dangerous if the current is moving rapidly or if high winds are causing large waves to enter the cut. The authors prefer the following scheme: walk out North Point to the last narrow part of the penninsula about 50 yards from the point. If you walk west to the cliff's edge you will be able to climb down a sandy-rocky precipice and enter the water via the sandy beach. Then swim to the cut and climb up onto Cut Cay about midway through the channel. Once on Cut Cay follow the path along its eastern side, being careful to stay far back from the edge to avoid falling on the jagged rock below in case some of the undercut material should break off as you walk on it.

The walk across Cut Cay can be informative. Many specimens of land hermit crabs, (*Coenobita clypeatus*), the pulmonate gastropod *Cerion* and other land snails are scattered along the path and in the vegetation. An overturned rock may uncover an unusual arachnid, such as a uropygian, or a small crab, probably the black land crab, *Gecarcinus lateralis*. Drop down along the face of the cliff at a safe place and observe the distribution patterns and diversity of snails clinging to the rock or gliding along any water-containing depressions. Chitons abound, mostly the fuzzy chiton, *Acanthopleura granulata*. The large tidal pools formed in the rocky intertidal zone on the northern and eastern sides of Cut Cay are not very productive - the wave action is severe and the resultant scouring of the rock prevents extensive colonization except by a few snails and chitons.

Enter the water on the western side of Cut Cay, just inside the barrier reef. Eroded and jagged upper intertidal rock gives rise to smoother algae covered ledges at the lower tidal levels, which then extend into a sandy sea bottom that is interrupted frequently by grass beds and small patch reefs. Sea rods, plumes and an occasional fan predominate. (If the sea is calm a short swim out to and along the barrier reef will reveal the size and abundance of sea fans which characterize such a surf zone). Flamingo tongues are frequently spotted. A relative of the flamingo tongue called the Common West Indian Simnia, is present, but rare. Many of the coral heads in the patch reefs close to shore are composed of dead coral. Wherever living coral grows, it is usually small. Corky sea fingers, *Briarium asbestinum*, *Porites spp.*, and *Eunicea spp.* are common. The normal array of crustaceans, sponges and a host of other small animals may be revealed by looking carefully under ledges, inside reef holes and in any crevices. Numbers of living queen conchs may be found in the grass beds.

Some 20 yards north of the channel separating Cut Cay from North Point the underwater terrain and the fauna change. Patch reefs give way to rocks lying interspersed in the sand. An extensive grass bed has developed just out from the beach area north of the cut and the occasional rocks and empty conch shells found in the grass offer hard substrates for animal habitats. Here are found several mixed species of snails, yellow and purple feather dusters and bristle worms. Closer to the cut, an underwater ledge extending from the rocky cliff bottom provides attachment opportunities for several species of anemones. The most common are sun anemones of the genus *Stoichactis*, the annulate tentacled *Bartholomea*, pink-tipped *Condylactis* and *Phymanthus*, the burrowing anemone.

Within the channel of the cut a surprisingly large number of animals are noteworthy. Nearly every rock covers one or more brittle stars, often with several species living under the same rock. Bristle worms and calcareous, tube-building

annelids are well represented, as are encrusting sponges. Various small crabs, medusa worms, *Euapta lappa* - the sticky synaptid and other holothurians are common. Pen shells, snapping shrimp (both *Alpheus armatus*, which is often commensal with *Bartholomea* anemones, and *A. armillatus*), and octopuses have been seen at this location. Large solitary tunicates and smaller colonial, encrusting ones are attached to the under surface of rocks. Hard corals are not abundant but flattened plates of grooved brain coral, *Diploria mancini* and a few golf-ball sized *Siderastrea* can be sighted. Rose coral (*Municina areolata*) is also present. The steep walls of the channel harbor chitons and snails. It is well to remember that there is one overriding physical feature of the cut channel that determines which animals dominate the community structure, namely the tidal current which is often of high velocity and accompanied by extensive wave action.

E. Manhead Cay

This attractive, small island sitting about four hundred yards off the northeast tip of San Salvador has a unique character and should be visited if time and weather conditions permit. It is necessary to snorkel across open water from the beach in Rice Bay to the sandy beach visible on the southwest corner of Manhead Cay. This can be a taxing swim if the seas are high, so use good judgement. On the way to Manhead, initially you pass over a few of the coral patches mentioned in the Rice Bay site. Examine them if you wish. Sandy sea floor is encountered next and here conchs (*Strombus gigas* primarily) and helmet shells (*Cassis madagascarenis*) are often sighted. Keep your eyes alert for fishes such as the southern stingray, spotted eagle ray, tilefish and other open water inhabitants. Look upwards occasionally to detect medusae or ctenophores which might be floating close to the surface. Near Manhead Cay there are grass beds (turtle grass) and a few small, mostly inactive coral heads. The best of these are located further to the north along the western edge of the island.

An alternate route to Manhead Cay, and perhaps the more interesting of the two possible routes, is to walk down the beach in Rice Bay to its eastern tip (Northeast Point) and snorkel along the ledge and reef which lead to Manhead Cay. Near shore you will see a silted, dying reef which houses only a few species of living coral. However, as one swims toward Manhead Cay the reef changes its physical as well as biological character. The wave action and shallow ledge structure produce a high energy situation. Gorgonian corals, especially *Gorgonia spp.* and *Pseudopterogorgia spp.* are the most prevelant species with many flamingo tongues (*Cyphoma gibbosum*) attached to their branches. Also in this area you can see *Agaricia spp.* and *Porites spp.*, with the former being represented by a unique species, most likely *A. lamarkii*. Although sparse, both *Acropora palmata* and *A. cervicornis* are found on the reef. Some new growth suggests a recovery in the reef. In addition to offering a glimpse of several unique species of coral, this route to Manhead Cay is decidely shorter. We suggest you go out to Manhead Cay by open water and return by way of the ledge-reef.

Upon reaching the beach at Manhead there will be a large rocky cliff jutting out into the water on your left. Immediately ahead and to the east is a soft calcium carbonate cliff face which can be traversed to reach the top of the island. However, due to its loose, sandy nature, the footing is not solid so the rocky ascent is the safest.

The rock iguana (*Cyclura rileyi*) is rarely sighted on San Salvador proper. However, many of the small outlying cays have colonies, and Manhead is no exception. If you climb quietly onto the rock face and look in the brushy undercover it is possible to hear and sometimes see an iguana. These animals are grayish-green to reddish-brown and can attain an overall length of two to three feet. They are extremely quick and virtually impossible to catch. They are an endangered, and therefore, protected species and are not to be captured without permission of the Bahamian government.

Walking across the main portion of the island in a northwesterly direction you will come to the rock cliffs which border the northwest shore of the island. Be extremely cautious here because years of forceful wave action have eroded the soft underlying calcium carbonate base, leaving unsupported ledges which may break under stress. You may notice the collapsed ledges here which resemble the ones on North Point. Proceed carefully around the island to its most westerly side, continually maintaining a safe distance from the edge. In some areas you will have to bushwhack through the brush. In more open areas of rocks and sand note the many periwinkles (*Tectarius muricatus*). These live well above the highest tide line but receive necessary moisture from the salt spray. Occasionally terrestrial arthropods may be exposed by lifting rocks and carefully examining the underlying soil and sand.

Continue along the ledge until a large protected alcove appears at the bottom of the cliff. It is frequented by many large fish and it is not uncommon to see groupers, parrot fish, and tangs swimming in this area. Toward the tip of the island the rocks descend to a large flat area with numerous pools, some spacious enough to sit in, and all connected by an algae covered substrate. These pools abound with crabs; Sally Lightfoot (*Grapsus grapsus*), and the calico crab (*Eriphia gonagra*) are common. West Indian top shells (*Cittarium pica*) are numerous. After exploring these pools continue around the most westerly point of the island. Chitons and snails (especially nerites) of all sizes and of several species are attached to the rocks in the intertidal region as well as in the splash zone. In the upper regions of this rocky area there are small pools which receive water only when the waves are high or when it rains. These pools, although limited in diversity, often abound with numerous individuals of a given species. The salinity can reach extremes as high as 100 parts per thousand (normal sea water is approximately 35 ppt) and temperatures in excess of 40°C. Species living in pools with such extremes are adapted in remarkable ways, showing a level of tolerance much beyond that of most organisms. Along the most western point of Manhead in the shallow waters close to shore small colonies of hard coral (*Porites* and *Montastrea*) as well as a few *Gorgonians* are visible. Several areas have high concentrations of the hydrozoans *Millepora* so be careful when entering the water. If you return to the beach area by walking or wading along the west face of the island, you will see numerous chitons, nerites, periwinkles and often a *Murex*. These latter snails have interesting shell patterns and the ability to exude (for defensive purposes) a purple ink which is particularly odoriferous and very hard to remove from one's hands.

If you care to enter the water at the northwest tip of the cay and snorkel back to the beach you will see numerous patch reefs close to shore. They harbor the usual assortment of smaller corals and other reef organisms typical of the relatively protected lee side of an island.

F. East Beach

The prevailing north-easterly winds of San Salvador constantly drive waves against its eastern coast. East Beach stretches along the upper third of the east coast of the island as a prograding, low-energy beach, even though it is on the windward side of the island. Its relatively low energy is due to the barrier reef lying several hundred yards offshore which tends to dissipate some of the wave action. Even so, there is often quite a bit of siltation and stress near the ever-growing shore line and consequently the close-in reefs are not rich in coral development. Also, visibility is often poor due to longshore currents that sweep the near-reef area much of the time. At certain times of the year, when long periods of calm weather prevail, some of the reefs a little further out are easily accessible and can be rewarding. See pages 118-119 in the Geology Guide for a more detailed description of these reefs and some of the corals which characterize them. The geology of East Beach is discussed on pages 108-109 of the Geology Guide. It is of interest to the zoologist that the sand on East Beach includes shell debris, reef fragments and bits of red foraminiferans. Few intact shells or shell remnants are seen, other than the small coiled internal shell of the cephalopod mollusc, *Spirula*.

Comparatively, East Beach has little to offer for reef study but it is easily reached and can provide a good supply of sargassum for anyone interested in examining the *Sargassum* faunal community. Also, dead plant material lies at the high tide line (or strand line) and can be examined for beach fleas (jumping amphipods belonging to several genera that are not easily identified). Other organisms that may be found among the decaying plants are gooseneck barnacles (*Lepas spp.*). Pompilid wasps of the genus *Anoplius* nest in the blown out areas on the upper beach.

To visit East Beach from CCFL, go north and take the road that leaves the Queen's Highway directly across from the lighthouse road. The road will traverse a causeway over Fresh Lake (a misnomer), meander past a well and garden, across several dunes, and eventually reach the softer sand of the most seaward dunes. Use care driving down the narrow road and do not go too far. The sand is soft and it is possible to mire a vehicle in the sand. The best technique is to walk the quarter of a mile from the last dune to the beach. An alternate route to East Beach is Brandy Hill Road which turns left from the main road 0.6 miles south of the lighthouse.

Beachcombing for inanimate objects at East Beach can be fun and informative if one does not mind the pervasive tar or dwell too long on the ecological consequences of man's use of the world's oceans as a convenient garbage disposal.

G. Rocky Point/Sand Dollar Beach

Rocky Point (Polaris Point) lies on the northwestern corner of San Salvador 3.5 miles west of CCFL along the Queen's Highway. The beach south of Rocky Point, Sand Dollar Beach, is one of the more attractive sites along the western perimeter but the property along the roadway is privately owned and access to this beach is restricted. Nevertheless, Rocky Point and the series of patch reefs lying directly off it are accessible. Follow the path from the highway along the northern side of the point to the beach and walk left until you reach the rocky endpoint. The promontory extends WNW and straight out from it are a series of large patch reefs. These reefs are visible from the Point; the first is about 50 yards out, and beyond it are several others forming a row extending toward the barrier reef, the farthest being several hundred yards offshore. A little further north of the point are a few small reefs, within 50 feet of the shore. The rocks on the point are sharply eroded karst 6 feet above the sea, but the sandy beach reaches almost to the point along the north side.

Enter the water from the beach on the north side of the point and work westward examining the small reefs. These reefs have a good representation of the characteristic fauna but are not vigorously healthy due to the sediment load they receive because of their nearness to shore. Note the many encrusting organisms (sponges, coral, etc.), especially down along the reef sides. The water is about six feet deep even though these reefs are close to shore. Note and beware of the fire coral. Two species are abundant here, the planar *Millepora complanata* and the fairy castle-like *Millepora alcicornis*. *Spirobranchus giganteus giganteus*, the feathered Christmas tree worm, often burrows within fire coral and the colorful whorled branchial crown of this serpulid lends interesting decoration to its stinging hydrozoan host. The Octacorallia are well represented here. Both the Bahamian sea fan or Venus fan, *Gorgonia flabellum*, and the common sea fan, *Gorgonia ventalina*, are present in good numbers, and both the yellow and the purple varieties are found. Corky sea fingers, *Plexaura*, *Eunicea*, *Plexurella* and spiny *Muricea* are here, projecting their highly branched, flexible trunks to receive the benefits of the water currents. Sea plumes wave gracefully from their firm attachments on the substratum. In the caves and crannies, a variety of small fish hide, including tangs, hatchet-shaped glassy sweepers, wrasses and many more.

Now swim out over the intervening sandy sea floor to inspect the first of the large patch reefs. Depending on wave and tide, you can work around the perimeter of the reef, or you can cross the reef top to survey the variety of organisms and habitats associated with these structures. The reef is a porous network formed of many interconnecting old coral branches. It rises like a huge buttress from the sandy seabed. The influence of *Acropora palmata* as the major Bahamian reef builder is readily discernible in these massive structures. Envision countless years and generations of elkhorn coral gradually building and interlacing with other coral species, and you have an accurate image of the reef before you. Depositions by coralline algae contributed to rounding out the major framework. The crenulations, hollows and branching caverns give rise to a stony fortress of habitats for myriads of invertebrates and fish. Red encrusting sponges are particularly prevalent, coating the undersides of the coral projections. As occurs inshore, gorgonians of many varieties populate this reef. Countless clumps of *Porites asteroides* dot the reef flat with brilliant yellow color. All three species of fire coral, the box-like *Millepora squarrosa*, the flat topped *Millepora complanata*, and the crenulated or ruffle-edged *Millepora alcicornis* occur in numbers. Small, dime-sized colonies of blue tunicates contribute their unique hue to the spectacle, as do carpets of zooanthidians (colonial anemones) of green, white or even powder blue clusters. One of the most colorful reef fish, the stoplight parrotfish, is well represented here; less colorful parrotfish species and juveniles abound as well. During a visit in January, 1984, we observed an impressive green moray eel, four feet long, resting quietly under a ledge along the fore reef. In past years, *Diadema antillarum* has been a dominant urchin species. Only a few individuals were observed in early 1984, a period during which Diadema numbers were in decline throughout the Caribbean generally. Yellow sabellids spread their brilliant 'featherdusters' from tubes in many of the reef crevices. In the center of the reef flat are large stands of elkhorn coral and, along the verge of an intrareef lagoon, a wide area is strewn with living and dead staghorn coral (*Acropora cervicornis*). Brown encrusting sponges, banded coral shrimps, the bivalve *Lima scabra*, green bristle worms (feeding on *Briareum asbestinum*), *Echinometra*, stinging hydroids (*Macrorhyncia philippina*), brain coral (*Diploria labyrinthiformis*) and *Agaricia* beds by their presence in number testify to the diversity of this reef's inhabitants.

Returning toward shore, you can visit the area south of the point. In contrast to the northern side, the coast is vertical, sharp limestone riddled with pockets and niches where chitons and other littoral molluscs such as nerites and periwinkles are found. This area along the point also has an abundance of juvenile fish.

In the cove formed by Rocky Point and Sand Dollar Beach to the south is a smooth sandy sea floor where echinoderms (sea pussys, great red-footed sea urchins) can be seen on the surface or uncovered by light digging (Kaplan, 1982). Chitons adhere to the rocky shelf and a few snails find niches alongside them. The tests of six-holed sand dollars (*Mellita sexiesperforata*) abound here, giving name to this beautiful beach.

H. Barkers Point (Barkus Point)

This is another of the several rocky points of land on the northwest side of San Salvador where patch reefs have developed. While it lacks the coral development found at some sites, it is nevertheless a good area at which to introduce students to invertebrates on San Salvador's reefs. Park at the spot where a road enters the Queen's Highway from the right, approximately 2-1/2 miles west of CCFL and opposite the entrance to Jake Jones' Road. Walk the paved road and its unpaved extension to the end of Barkers Point, and enter the water at a sandy area just south of the point. Here, small patch reefs parallel the shore.

Initially the bottom is sandy with scattered algae. Many yellow-green sun anemones, *Stoichactis helianthus*, occur in the sand. Their protruding flat-topped tentacles feel sticky to the hand, the result of their release of nematocysts. Avoid touching them with uncalloused parts of the body.

The long patch reef which parallels the shore is largely algal covered, but many colonies of *Porites astreoides* occur upon it. Individuals of the Christmas tree worm, *Spirobranchus giganteus*, are common within these corals at this site. Other corals include the lettuce coral, *Agaricia agaricites*, star coral, *Dichocoenia stokesi*, and a few encrusting colonies of the brain coral, *Diploria clivosa*. Fire coral, *Millepora complanata*, occurs along the outer edges of this reef. Several commonly seen alcyonarians include knobby candelabra, *Eunicea* species, the sea fans, *Gorgonia flabellum* and *G. ventalina*, and slimy sea plume, *Pseudopterogorgia americana*. Individuals of the flamingo tongue, *Cyphoma gibbosum*, are often seen feeding on the alcyonarians. In the crevices of this reef octopuses and spiny lobsters may be seen. Reef squid, *Sepioteuthis sepioidea*, are sometimes seen swimming over the surface of the reef.

Beyond the first patch reef are several separated heads of *Montastrea annularis*, which also bear a number of soft corals. The area directly north of the point is covered with algae, and while it bears a few colonies of *Porites astreoides*, is less suitable for study.

I. Bonefish Bay

Bonefish Bay is a shallow concavity in the western coast 5.4 miles south of CCFL and about 1 mile north of the airstrip. Midway along this bay and approximately 20 yards offshore is a rock-covered bar which uncovers at low tide, revealing many pools having a fauna somewhat different than those at other locales. In particular, an abundance and diversity of tunicates are found under the rocks. Tunicates are protochordates and form a subphylum of the phylum chordata. Their apparent similarity to invertebrates and their position intermediate between invertebrates and higher chordates in phylogenetic schemes generally leads to their consideration in invertebrate zoology texts. Their name derives from the possession of a sac-like coat or tunic which encloses the soft-bodied animal or colony of animals, individuals of which are called zooids. This tunic is made of cellulose, a polymer uncommon in the animal kingdom. It may be transparent or opaque; it is also referred to as a test. The tunicates found here are ascidians (members of the Class Ascidiacea), known commonly as sea squirts. Turn over rocks in these tidal pools and you will find their undersides coated with tunicates of many colors. In some, their colonial organization is evident from the visible presence of individual zooids.

The other prevalent class of organisms here is the Ophiuroidea. Under virtually every rock are several brittle stars of various species, red and black *Ophiocomas*, *Ophiothrix* and others. Other organisms occuring in these pools are urchins, particularly *Echinometra* and a few small *Diadema*, sponges, free-living polychaetes, medusa worms, and a number of gastropods.

J. Fernandez Bay

Fernandez Bay is a gently curving, shallow indentation of the west coast of San Salvador, approximately 3.5 miles wide, and extending from Cockburn Town in the north to Sugar Loaf Rocks in the south. This bay reputedly was the site of

Columbus' first landing on San Salvador. He reportedly noted the large, flat blocks of lithified beach sand that constitute an important physical feature of Fernandez Bay and assumed that they would serve in the construction of "government buildings". The cracks and separations in these blocks of limestone create numerous tide pools. This is a major intertidal collecting area and has, in the past, been exposed to overcollecting from CCFL students. No organism should be removed permanently from these sites. The destructive effects of overcollecting are not quickly repaired. Several reefs of interest in Fernandez Bay are described below.

1. Very beautiful, well preserved reef formations called Telephone Pole are found about 200 yards offshore at Fernandez Bay, especially off the point of beach marked by a telephone pole that stands on the seaward side of the road. This is an important orientation landmark to assure that you locate the richest area of the patch reef complex. As you drive toward Fernandez Bay from Cockburn Town, the telephone pole in question is easily noticed because it is paired with a second, stabilizing pole on the opposite side of the road. It is about 1/4 mile south of the beginning of a stone wall that flanks the seaward side of the main road. The swim to Telephone Pole Reef may be considered taxing by some. The depth of the reef (20-30 feet) and the currents, which can be strong, make Fernandez Bay snorkeling relatively difficult. It may be advisable for weaker swimmers to wear a buoyancy compensating vest on this excursion or to tow along a life ring. It is imperative to maintain a buddy system in case of fatigue or the need to return to shore.

Except when the sea is calm, entering the water at Fernandez Bay also can be difficult. The beach rock shelf that is fractured into slabs higher up on the shore continues under the water, where it has been battered and eroded, and contains small caves, pits, and cracks. All of these recesses afford refuge to sea urchins, predominantly the rock boring urchin, *Echinometra*, and the long spined urchin, *Diadema*. Be careful when entering or leaving the water! The beach rock shelf continues out for roughly 50 yards. Small caves in the surface of the rock harbor individuals of the ringed anemone, *Bartholomea annulata*. An interesting commensal relationship exists between *Bartholomea* and a red snapping shrimp, *Alpheus armatus*, at least one individual of which is nearly always found within the same recess occupied by the anemone. The antennae of this shrimp are striped red and white, and even if the animal itself cannot be seen, the antennae are readily observed waving in company with their host's tentacles. The shrimp has been demonstrated to protect the anemone from predation by the fireworm, *Hermodice carunculata*, by snapping its chela at the worm.

As you swim outward the beach rock is replaced by sand, and numerous large sponges are obvious on the sea floor. These include the sheepswool sponge, *Hippospongia lachne*, and the Cuban reef sponge, *Spongia obligua*. These and other sponges are remarkable for the multitude of commensals including annelids, crustaceans and echinoderms, which make their home in the sponge's water passages. These dimimutive animals can be found by dissecting a sponge upon returning to the beach. The organisms you remove from the sponge should be put into a shallow tray of sea water for closer observation. One large sponge may yield several hundred individual commensals of various species.

As you swim further out be sure to keep the 2 telephone poles aligned. When you observe increased numbers of sea plumes (*Muriceopsis*) on the sandy bottom, you are getting close to the reef. A notable feature of Telephone Pole Reef is the staghorn coral, *Acropora cervicornis*, much of which exists as a boneyard of dead colonies that are being encrusted by other species, most notably *Porites*. This reef abounds with horny corals (gorgonians) such as sea plumes, sea feathers (*Pseudopterogorgia*), plexaurans, and candelabrum corals (*Eunicea*). Common to this area is the carnivorous mollusc, *Cyphoma gibbosum* (flamingo tongue), which grazes extensively upon the various gorgonians.

2. Another lovely reef, called Snapshot Reef, is located about 5 telephone poles to the north. This reef is remarkably pristine with a wide diversity of reef fishes and a unique population of the orange crinoid, *Nemaster rubiginosa*. This nocturnal animal seeks refuge within the reef interstices during the day. The animal can also be seen in large numbers on the deep wall face a few hundred yards to the west of Telephone Pole Reef. Because of the water depth and the secretive nature of *Nemaster*, a snorkeler will find the discovery of an individual to be an exciting event.

For reasons which are not entirely clear, the waters offshore in Fernandez Bay are host to numerous pelagic ctenophores and cnidarians. These nearly transparent animals are usually found within about one foot of the sea surface, and it takes sharp eyes to spot them. If the sun is shining, the ctenophores are, at certain angles,

made visible by the iridescence of rows of ciliated comb plates. Species of ctenophores include the very beautiful Venus' girdle, *Cestum*, which has the form of a flat transparent belt about an inch wide and 6 inches long. Another ctenophore, *Mnemiopsis sp.*, may also be seen. This animal is shaped somewhat like a large walnut. It is bioluminescent at night and emits a flash of green/blue light when mechanically agitated. Cnidarian medusae are not common but may include small individuals of the moon jellyfish, *Aurelia aurita*, or the stinging cubomedusae, *Corybelea* or *Chiropsalmus*.

3. Another reef in Fernandez Bay is named for Dr. William Lindsay of Elmira College who introduced many classes to this excellent formation. To reach Lindsay Reef, continue past the Columbus Monument below Cockburn town, and park where a dirt road branches to the right from the main highway. Walk about 250 yards along the beach, and enter the water where the reef approaches the shore.

The reef's shape resembles a golf club: the main reef forms the head which lies perpendicular to the shore, and a narrow strip which forms the handle runs parallel to the beach along the north side. The shallow bottom in front of the reef is very silty with a few scattered rocks. Algae, especially *Padina* and *Turbinaria*, predominate. Many large pink-tipped anemones, *Condylactis gigantea*, are buried in the soft bottom. There are occasional ringed anemones, *Bartholomea annulata*, in the rock crevices. Many of the ringed anemones at this reef have associated snapping shrimp, *Alpheus armatus*. At the shallow end of the reef a few small colonies of the hard corals, *Porites astreoides* and *Montastrea annularis*, occur.

This rather extensive reef can be studied either by swimming around its entire periphery or by swimming over its top. We suggest both approaches since the environments on the sides and top of the reef are very different. Start at the north side of the main reef to begin circling the periphery. The reef drops off sharply on this side, and massive colonies of *Montastrea annularis* create numerous crevices where large fish can hide. Large, much-branched colonies of *Gorgonia flabellum* occur along the reef's north edge. Some colonies of *Millepora complanata* also occur there. The thin edge of coral that forms the golf club's "handle" is colonized mainly by *Montastrea annularis* and *Siderastrea*. At the south side of the junction between this strip and the main reef, a colony of *Acropora cervicornis* has developed. Large colonies of *Porites porites* occur on the sea floor along the south side of the reef's edge.

By swimming over the top of this reef at high tide, you may obtain a different view of the invertebrates living there. At the shallow end of the reef there are many soft corals. The most common species are *Briareum asbestinum*, *Pseudopterogorgia americana*, *Plexaura flexuosa*, *P. homomalla* and the *Eunicea* species. At this reef, predatory flamingo tongue snails, *Cyphoma gibbosum*, are often seen feeding on a variety of soft corals besides their usual hosts, the *Gorgonia* species.

The most common coral on the main reef is *M. annularis*, but there are some large round colonies of *Dichocoenia stokesii*, rare colonies of *M. cavernosa*, and colonies of the two *Porites* species often cover dead *M. annularis*. Some of the very large *Porites astreoides* colonies contain one to several individuals of the Christmas tree worm, *Spirobranchus giganteus*.

Crevices in the colonies of *M. annularis* provide numerous hiding places for crabs. Among those that may be seen are the coral crab, *Carpillus corallinus*, the decorator crab, *Macrocoeloma trispinosum*, and the urchin crab, *Percnon gibbesi*. The latter often occurs in crevices with the relatively rare long-spined urchin, *Diadema antillarum*, or the more common rock-boring urchins, *Echinometra* species.

Since the reef extends directly out from shore, it is easily reached for night snorkeling. A fire on the beach makes a good beacon for such activities. The changes that occur with increasing depth on this reef may be demonstrated by surveys with modified transect techniques.

4. Several patch reefs occur offshore at the Columbus Monument below Cockburn town. The reefs may be reached by swimming offshore to the north of the Columbus monument. The alga *Padina* is very abundant, virtually carpeting some of the patch reefs. *Montastrea annularis* is very common, with *Porites porites* and *P. astreoides* also abundant. *Diploria clivosa*, sharp-hilled brain coral, also occurs. The green rock boring urchin, *Echinometra viridis*, is common on these reefs. Crevices in the reef are hiding places of *Octopus spp.* and the spiny lobster, *Panulirus argus*.

In summary, Fernandez Bay offers the opportunity to observe some well preserved reef habitats, an uncommonly large population of sponges, and the chance to see some organisms which are not commonly observed in shallow inshore areas. In addition, extensive tide pools make this a rich study area with natural resources which should be left undisturbed.

K. Grotto Beach

The Columbus Landings Corporation subdivided hundreds of acres of land at the southern end of San Salvador during the 1970's and laid out an extensive road system to serve the anticipated homes, shopping centers, schools, apartment complexes and hotels. Most of the planned development never materialized, and only a few homes were built on prime shore lots. The roads still remain, often covered by creeping vegetation, and the golf course fairways along the edge of the sea can be faintly discerned, but most of the project remains a dream. However, one action taken by Columbus Landings has been of immense value and enjoyment to countless CCFL students and faculty, namely the preservation of Grotto Beach as a public park.

This beautiful little cove is bounded on one side by a vertical rock face 15-20 feet high that is undercut by erosive wave action and on the other side by a sandy beach that slopes gently down to a depth of about 6 feet when 40-50 feet away from shore. Its water is usually deep blue-aqua and is clear and inviting. Grotto Beach may be more reknowned among CCFL students as a place to cap off a productive and enjoyable stay at San Salvador than as a site for conducting serious biological field study, but it is included in this guide because it has some small patch reefs rather near to shore which are worthy of attention.

Grotto Beach is reached via the Queen's Highway. After passing through Cockburn Town, by the Columbus Monument and past the dual highway which exits to the left, look for the road on the right which is marked by the power lines leaving their run beside the Queen's Highway and heading toward the coast. This is a distance of several miles. Follow the power lines as they go east for a short distance and then south again when the road makes a 90° turn to run along the coast. After passing several homes the road climbs slightly, and Grotto Beach is seen on the right. It is marked by a small, rectangular gazebo which can be approached by a dirt road leading down a steep incline.

The reefs are located outside the Grotto Beach cove, about 100 yards offshore. Stand on the rock outcropping at the far end of the beach and the reefs can be seen as dark patches diagonally situated in about 10-15 feet of water. The usual hard and soft corals are abundant with these reefs dominated by brain coral, *Diploria labyrinthiformis*. Many of the invertebrates found on healthy reefs at other sites can be discovered. The fish populations are outstanding, and even Invertebrate Zoology students can appreciate their abundance, diversity of form and striking coloration! Take some time to observe the behavioral repertoire of a single individual or a group. Note their feeding strategy, schooling patterns, escape responses, swimming mode, interspecific responses, and any cleaning activity.

Serious shell collectors will find a stroll down the extensive beach just around the corner from Grotto Beach rewarding. Tellins, cowries, angel wings, cone shells, murexes and scaphopods are among the most common.

L. Sandy Point

Sandy Point is approached by heading south along the perimeter road from French Bay. The road gradually runs south, then west again and climbs a low hill. Final approach to Sandy Point is made by a cut in the hill's crest followed by a short descent past a private home on the right.

Sandy Point constitutes the extreme southwest corner of a peninsula that extends along a line bearing roughly 210°. The point results from the deposition of sand, caused by destructive interaction of surface waves in this region of the island's perimeter. Many of the Bahamian outer islands have similar southwest corner "sandy points". The wave interference derives from the fact that northeast trade winds drive the surface waters southward on both sides of the island. The resulting wave fronts are usually out of phase as they meet at the island's southwest corner, and this promotes deposition of their load of suspended sand particles as they dissipate.

The paved road ends abruptly at Sandy Point. Facing the sea, you will be confronted by an apron of sand that is several hundred yards wide and must be crossed to reach the water. Looking to your right the water color offshore is seen to change abruptly from green to dark blue. This marks the boundary where, just to the west of Sandy Point, the 1000 fathom depth line runs within a few hundred yards of the beach. Here there are few accessible coral formations. Southeast of the point, however, the water depth remains moderate for about 1/4 mile from shore, and extensive patch reefs exist. The initial slope of the bottom off this stretch of beach is steep, however, and water 25 to 30 feet deep may be found within 50 yards of the shoreline. In these waters large and often very dramatic coral formations can be reached with relative ease, unless there is an extensive swell running. Weak

swimmers should probably be discouraged from snorkeling at this site, but for all other students it offers unique and interesting coral populations.

Cross the sand apron from the road's end and bear left (southeastward). Walk parallel to the water for a distance of about 300 yards. The coral formations just off the beach here are dominated by massive colonies of elkhorn, aligned generally with the branch axes parallel to the prevailing wave surge. Some colonies of elkhorn coral are 8-10 feet in their major dimensions and are thus equally as dramatic as the formations commonly seen on the relatively inacessible fringing reef off Gaulin Cay to the north of the island. Other dominant species in this area are the large brain corals (*Diploria*) and the encrusting porous coral, *Porites astreoides*. Fire coral is also common at this site, and one needs to exercise caution when swimming over the reef tops, especially if there is any surge.

As noted previously, the coral colonies off Sandy Point rise out of fairly deep water, and these 'heads' are separated from each other by stretches of white sandy sea floor about 30 ft. deep. This makes the site truly spectacular, and while the coral species that can be seen here present no surprises or unique varieties, they attain a grandeur normally seen only in areas with very high wave energy. Occasional sightings of small nurse sharks are made off Sandy Point. These elasmobranchs are usually found napping on the sandy floor beneath overhanging coral ledges. Enjoy their presence; they are harmless and placid animals that tend to lethargy.

M. French Bay

The name of this large bay on the south of the island suggests some link to Europe or to French-related settlers in the New World. No one presently associated with CCFL or living on San Salvador seems to know the derivation of the name, but it is exciting to conjure up the vision of a French Man-O-War sinking off the shore or a French pirate using the bay as a hideaway! The bay is frequently turbulent but when northwesterly winds persist it can offer a calm haven for the study of tidepools and reefs.

There is only one direct approach to the bay. Driving south from CCFL one passes through Cockburn Town, by the Columbus Monument and the adjacent Mexico City Olympics Monument and continues directly south. Approximately 6 miles south of Cockburn Town a dual highway intersects the main road on the left. Do not take this road but, instead, continue due south on the main road another 1.3 miles from this intersection. At this point the perimeter road, which runs around the circumference of the island, crosses your route perpendicularly. A small hill descends to the intersection. Straight ahead past the intersection a road can be seen, which is actually a continuation of the main road. Take this road, which elevates slightly; just beyond its crest the wooden government pier is visible. (Park at the crest of the hill or on the inland side so that there is no danger of the vehicle rolling toward the water or becoming stuck in loose sand.)

From the pier, the vast expanse of the bay stretches out to the east and west. It curves around on both sides and is bounded straight ahead by the barrier, or bank, reef approximately 1/2 mile off shore. Such reefs surround much of the island and serve as natural breakwaters that dissipate some of the wave energy impacting on the coastline. The barrier reef in French Bay is shallow enough to cause breakers to form. These can be seen as a straight line of whitecaps which appear to run parallel to shore.

A nice series of tidepools is exposed to the right of the pier at low tide. They have formed just behind the lithified rock at the shore's edge and are actually made up of sand and rock sides and bottom. The pools extend 100 yards west of the pier and it is possible to find a great abundance and diversity of animals here. Patience and sharp eyes are valuable tools for tidepool observation and with practice one should be able to see a high percentage of the organisms which live in this unusual habitat. Tidepools are stressed environments, characterized by constant variations in temperature and water availability, and any animals living in them must have evolved suitable adaptations.

The major patch reef formations are visible at about 45° to the right (SW) of the far end of the pier. They are approximately 75 yards offshore at the closest point and, except at the highest of tides, a stand of elkhorn coral (*Acropora palmata*) juts above the water and clearly marks the larger reef area.

Access to the water can be gained by entering from the shore on either side of the pier, or by climbing down the old pier stairs at the far end. (Be careful to avoid exposed nails and rotting timbers). If the tide is high, it is possible to jump off the end of the pier but use caution; the water is not very deep and numerous empty queen conch shells on the bottom may cause injury.

As you begin to swim toward the reefs you

will pass over an extensive bed of turtle grass. Note the silt which has fallen onto the grass and onto the occasional conch shells scattered among the grass. The siltation results from the dumping of fine sand particles by low energy waves as they move across the shallow ocean bottom near the shore. The grass itself acts as a drag on the water and encourages siltation; as a consequence of the silt deposition few animals live in the turtle grass area. Corals and other sedentary animals are especially susceptible to siltation damage and are totally excluded from such a habitat. A few small animals which are resistant to fouling live here, but are usually missed except by the experienced observer.

Once the reef closest to shore is located, all of its sides and the top should be examined. Various faces of a reef support a differential distribution of animals. New coral growth is seen in the easterly half of the reef and other signs of vitality are apparent. In contrast, the western end appears silted or adversely affected by other forces.

Corals of many species rivet one's attention at this site. Extending off the sides and top of the reef are various sea fans, sea plumes and sea rods. Hard corals are abundant and diverse. This is an ideal location at which to study the differences in the two most abundant species of gorgonian fans, *G. flabellum* and *G. ventalina*. Make note of variations in coloration, growth patterns, size and overall shape. Remember that the Venus fan, *G. flabellum*, has more right angle side branches than does the common sea fan, *G. ventalina*. Other soft corals which predominate at this location are corky sea fingers and several species of *Plexaura*, a sea rod. *Pseudopterogorgia*, a sea plume and *Pterogorgia*, a sea whip are found here.

The most spectacular hard corals are the racks of branching, flat-stemmed elkhorn or palmata corals, the delicate and fragile beds of lettuce coral, the well defined, solitary heads of brain coral and a galaxy of star and starlet corals. (Care must be taken in identifying star, starlet and brain coral since subtle differences in cup shape and neighbor-cup arrangements
distinguish species or even genera). Scattered among these corals but somewhat less abundant are clubbed finger *Porites*, flower corals of several shapes and varieties, and the irritating hydrozoan fire coral, *Millepora*. Fire coral grows mainly as standing sheets at French Bay and is abundant in certain parts of the coral heads where heavy currents strike. There is an abundance of Christmas tree worms with their ornament of spiraling filamentous gills (responsible for their name, *Spirobranchus*, which means "spiral gills"). They secrete calcium carbonate tubes on the surface of fire coral and other hard objects and will withdraw into their tubes when stimulated by touch or shadow. At other times they remain extended partially out of their tubes to filter water for food and gas exchange. Flamingo tongue gastropods, with their overlain, brightly colored mantle which mimics the markings on gorgonian corals, are uncommon but sufficiently spectacular to warrant a search. Most often they will be found on sea fans, but occasionally one spots them on sea rods or sea plumes.

The reefs hold numerous crustacea, annelids, tunicates, sponges and molluscs other than those mentioned above. The most oft-encountered crustacea are the banded coral shrimp, several types of cleaning shrimp, the coral crab, Spanish lobsters and many small, lesser-known crabs and shrimps. Most of the latter live in inaccessible niches or under the reef surface and therefore are infrequently encountered. The annelids are represented mainly by tube-building polychaetes such as the feather dusters, and an occasional bristle worm. Tunicates spread across dead coral and are often difficult to distinguish from encrusting sponges. Both are often brightly colored and have the same general appearance. To distinguish one from the other, sponges are rougher and of a looser, less substantial texture than are the smooth, rubbery and more solid tunicates. An appropriate analogy would be the comparison of a kitchen sponge (=sponge) to a hard boiled egg (=tunicate). Tunicates and sponges are both difficult to key from external, naked-eye observations. The only highly visible molluscs are the queen conchs spotted occasionally in the sand or turtle grass beds between the patch reefs, and flamingo tongues on the gorgonians.

Overall, the French Bay reefs are extremely productive. The location of the bay at the more protected south edge of the island, the presence of a well-defined barrier reef and the relatively shallow water contribute to its richness. Notable for their absence at this site are the urchins, especially the long-spined *Diadema* and rock-boring *Echinometra*, so prevalent on other San Sal reefs. An occasional urchin is seen, but the reasons for their scarceness are not clear.

The tide pools around San Salvador have been collected heavily during the past ten years and their continued usefulness depends on the care and respect accorded them by CCFL students. This is especially true at French Bay, Dump Reef, and Fernandez Bay where hundreds of

students have combed the pools. Please use good judgement and courtesy when you study the pools. No animals are to be brought back to the station and should only be used for *in situ* viewing. Return all rocks to their former positions with care.

The crustaceans and echinoderms are among the most common motile tide pool inhabitants. Rock crabs, porcellanid crabs of many genera, and juvenile stages of semi-terrestrial Sally Lightfoot crabs and swimming crabs abound. Representatives from the shrimps include intertidal adult forms of the large-armed or snapping families, tiny bumblebee shrimp and young of the edible penaid shrimps. A separate order of crustacea, the stomatopods, or mantis shrimps, appear frequently. The stomatopods should be handled with care; remember their common name is "thumb splitter".

Many small adult urchins as well as juvenile stages live in the tidepools. *Lytechinus* (white and rounded), *Echinometra* (the rock boring urchin), and an occasional slate-pencil urchin (Eucidaris) are usually present. Brittle stars and sea cucumbers can be exposed by lifting up rocks. Occasionally a pygmy octopus will be uncovered. Note its general morphology, movement and behavior, including chromatophore-controlled color changes. Treat the octopus gently; it is a very fragile and reclusive animal and must have plenty of well-aerated water to survive.

Many encrusting sponges and tunicates can be seen under ledges and along edges of submerged rocks. An occasional flatworm is sighted in the tide pools. Use care in handling these turbellarians. They are easily torn or damaged. Their taxonomy is poorly defined so beware of picture keys or casual reference in identification books which purport to assign species names.

Sipunculids are present but not immediately visible. These are members of the phylum Sipunculida, also called peanut worms. They are probably closely related to annelids but are accorded a separate phylum status. Individual specimens can be exposed by breaking open a piece of lithified beach rock from the seaward side of the tide pool. Sipunculids burrow into the rocks and are only rarely detected as free individuals in the pools. Notice the protruding proboscis which has small tentacles at the end.

N. Pigeon Creek

Pigeon Creek is a novel and interesting site in which to observe marine invertebrates. This Creek is actually a bifurcated tidal lagoon flooding the southeast corner of San Salvador. Its two branches extend from a common mouth, one tending in a southwestern direction behind Sandy Hook for about 1.5 miles and the other running northeasterly for over 4 miles. Both are separated from the ocean by intervening dune complexes which form parts of the southern and eastern island shores. The mouth is a channel less than 150 yards wide. As the tide changes, large volumes of water must flow in or out of this channel since Pigeon Creek covers an area of over two square miles. It is this water flow which suggests the name creek even though Pigeon Creek is not a creek in the usual sense of the word. Since this tidal lagoon is also rather shallow, the current at times of maximal tide flow is very strong, and may even reach 9 knots for brief periods in the main channel. As much as one billion gallons of water pass through this narrow gap with each tidal cycle. Extending from the mouth of the lagoon out into the bay is a large subaqueous delta formed from sediment borne by the outward flow. Upstream of the lagoon mouth in both arms of Pigeon Creek are *Thalassia* meadows covered by 1 to 2 feet of water and pocketed with pools up to 10 feet deep where no grasses grow. These pools may be analogous to the lunate megaripples formed in sandy sea floors exposed to strong currents (Fox, 1982). The shores of Pigeon Creek are lined with mangroves whose prop roots provide refuge for a variety of organisms.

To reach Pigeon Creek, drive southward from CCFL past Cockburn Town for 16.6 miles where you will intersect on the left with the Columbus Landings divided highway. Take this road for 1.8 miles; the Queen's Highway from French Bay rejoins this road just at the point where it is no longer a dual highway. After a brief stretch, you meet a fork in the road. The left fork is the continuation of Queen's Highway toward the Farquharson and South Victoria Hill settlements at the ruins of Belmont Church. Take the right fork along the Columbus Landings Road. After a few hundred yards, you should be able to note the Belmont Church remains back on your left as a landmark. Follow this road along the southern coast for 3.4 miles. You will pass the eastern edge of French Bay where the fringing reef abuts the shore. A little further along is the Blowhole, then several houses of the Columbus Landings development come into view. The panorama of Snow Bay and its distinctive small islands, Low, Middle and High Cays, is evident. The leftmost cay is Nancy Cay. Upon reaching an intersection where five lanes meet, take the

second one from the left (virtually straight ahead) and when it ends, turn left and drive to the top of the small hill before you. Stop here and look back to the right. Pigeon Creek is displayed before you. The southwestern branch is nearest this road and evidence of colonization of new areas of the lagoon by red mangroves is readily visible. At low tide you can see the sandy burrows of callianassid shrimp. The northeastern branch of Pigeon Creek extends away from you in the distance. The convergence of the two branches to form the mouth of the lagoon is apparent, as is the subaqueous delta which lies almost behind you on the verge of Snow Bay, easily visible from the light blue green hue it imparts to the water. Note the small pier extending into the southeastern branch of Pigeon Creek near you. Turn your vehicle around, drive back down the hill and take the first road on the left to reach this pier. You can enter the water directly from this pier, or from the shore just to the left of it. First, however, take careful note of the current. It may be flowing rapidly in from right to left with the incoming tide, or it may be going rapidly left to right with the outgoing tide. Or, if the tide is at its high or low point, there may be no current. Be aware, however, that this latter condition will not last for long. It is advisable to consult the tide tables before embarking on a journey to Pigeon Creek so that you are cognizant of the conditions prevailing during your tour. Although the current may be very strong, its worst effects can be avoided by staying near the creek shores when working against it. Be judicious in your decisions and you can explore any area which interests you. Exploit the current by taking advantage of it; go with the flow.

Upon entering Pigeon Creek at the pier, note the mounds of discarded conch shells. Many provide substrate for the pink-tipped anemone, *Condylactis gigantea*, which are particularly abundant. Look carefully among their tentacles and you may see Pederson's Cleaning Shrimp (*Periclimenes pedersoni*), a transparent, purple-tinged one-inch commensal inhabitant of these anemones. Two other anemones are common in Pigeon Creek, the ringed anemone *Bartholomea annulata* and the burrowing anemone *Phymanthus crucifer* which lives in the sandy bottoms of the pools. Porifera are another prevalent group of organisms here; sponges are scattered profusely in the *Thalassia* beds. Note their size, color, general morphology and the arrangement of pores and oscula (pores by which water is circulated through these filter feeders). Brick-red, yellow, brown and black sponges of irregular globular shape ranging from softball- to bucket-size are common. The red sponges may be irritating to the skin; handle them with gloves. Black, branching, pencil-sized sponges also occur in the *Thalassia* meadows. Many other organisms inhabit sponges. Kaplan (1982) cites the remarkable variety and number of sponge-dwellers which find protection in the crannies and canals of the sponges. These include brittle stars, snapping shrimp (*Synalpheus spp.*), annelids, juvenile spiny lobsters, stomatopods, and many others. If you carefully break apart one of the sponges you will find many of these animals.

Swim along the edge of the mangroves, noting their prop root formation. This mangrove verge is part of the mangrove swamp community discussed in Smith, "Field Guide to the Vegetation of San Salvador", 1982. Hiding back in this underwater forest are mangrove crabs and many fish, including quite large Nassau groupers and barracuda (up to 2 ft). As you swim to the left up the southwestern arm of Pigeon Creek, along the left side you will find beds of the green calcareous alga *Halimeda* which contain 3 inch white clam shells of the genera *Lucina* and *Codakia*. Along the far bank of mangroves, stinging hydroids are occasionally found as small colonies growing on the turtle grass or mangrove roots. These pale, almost transparent colonies resemble branched feathers or candelabra. Their sting can be very irritating, and because of their inconspicuous nature, they are often found by accident. A variety of small organisms lives burrowed into old mangrove roots and branches which have fallen into the water. Carefully peel back the bark to reveal worms and tiny crustacea. Swept in by the tide are large clumps of *Sargassum* which harbor a unique fauna. Further, pelagic organisms like *Cassiopeia*, the upside-down jellyfish, may be encountered.

If you catch an outgoing tide, you can ride it down the creek and out the mouth, observing on the way. Beyond the mouth along the eastern side of Snow Bay, the shore is being colonized by red mangroves and a variety of infralittoral organisms are found - decorator crabs, blue crabs, snapping shrimp, etc. It is easier to go ashore on the western bank of Snow Bay and walk back to your vehicle than to try to swim back to the pier against the current. Or, if you are patient, wait for the tide to change.

O. Snow Bay

Snow Bay is an ambiguous geographical reference to the coastal waters washing the

southeastern edges of San Salvador. Even official Bahamian Government maps are vague in their designation of Snow Bay as covering all of those waters from south of Sandy Hook, around past the mouth of Pigeon Creek and including the large bay up to the Bluff. Snow Bay is listed in this Guide as an optional site to visit when in the neighborhood of Pigeon Creek. The diversity and richness of its fauna does not seem to match other sites, and its relative inaccessibility further diminishes its lure. Nevertheless it does have several interesting features, including a coastal zone which appears to be in transition both from sandy beach to mangrove community and from loose sand substratum to a partially lithified sand with semi-hard small crevices and tunnels which create housing for a host of organisms. This area is also an attractive site for beachcombers because of its exposure to the prevailing currents and the beauty of the offshore cays. This Guide discusses only the seacoast of the southernmost parts of the peninsula between the northeastern branch of Pigeon Creek and the ocean.

Drive to Pigeon Creek, following the directions given for that area, which will place you on the Sandy Hook side of Pigeon Creek. To reach the sites discussed here, you must cross the mouth of Pigeon Creek. It is very important to be informed about the tides on the day of your visit. Tidal currents in the mouth can be substantial; even the strongest swimmers cannot swim against them. Further, be aware that the tide flow in or out of Pigeon Creek will not change punctually with the times given in the tide tables. Pigeon Creek is a large drainage area and the flows in or out of it will lag substantially (1 hour or more) behind the stipulated times of high or low tide. A good indicator of the direction of flow is given by the *Thalassia* grass. Its stem will always point in the direction of the current. The task is to reach the shore directly across. Walk out along the subaqueous delta at low tide and swim across. You can then ride the incoming tide back when your excursion is done. Take tennis shoes or similar footgear with you. Some of the areas are rocky.

Upon reaching shore, walk eastward along the coast, taking note of the sandy beach until you approach the crook of the cove where mangrove colonization is occuring. The sand in the littoral zone here has become partially lithified, and on this crust you may find calcareous algae. This semi-rocklike material is a haven for mud crabs, porcelain crabs, snapping shrimp (*Alpheus armatus*), oysters, tunicates and purple sponges. At low tide, the air is filled with the sharp clicking sounds of the snapping shrimps. Portunid crabs, like *Callinectes*, can be found roaming the grassy bottom of the cove. Walk through the water past the mangrove stand. The coast becomes rockier. Periwinkles dot the jetsam on shore, and nerites occupy the rocks at water's edge. In the tidal pools along this stretch and around the promontory before you are rock-boring urchins (*Echinometra*), variegated urchins (*Lytechinus*), sipunculids, brittle stars (red and black *Ophiocoma*), crabs, sponges, tunicates, lots of annelids (both free and tubicolous ones living in soft tubes under the rocks), keyhole and other limpets, sea cucumbers, West Indian top snails and occasionally, a moray eel. Wide-mouth Rock snails (*Purpura patula*) occur along with chitons higher up on the rocks. Further along, high on the beach is a large (3 ft. diameter) mahogany log which journeyed afloat for a long time judging by the way it is riddled with the burrows of shipworms (*Teredo*). Note the distinctive teredo shells lying in the crevices. At first glance, they appear to be the inedible fragments of some predator's mollusc dinner. On closer examination, you will see that these 'fragments' are uniform in shape and represent the shells of these unique boring bivalves.

The Bluff dominates the northern end of Snow Bay and below it lie some of the finest tide pools around San Salvador. The area may be reached by continuing north along Snow Bay for about two miles. The site may also be approached from the north: following the Queen's Highway north through South Victoria Hill, park at the path running to the beach about one quarter mile north of the Pigeon Creek archeological site, and walk south along the beach to the Bluff. If you are driving south along the island's east side, you will find the path to the beach between 1/4 and 1/2 mile south of a cemetery on the left side of the road. Some groups climb the Bluff and descend to the tide pools at the end, but erosion has undercut the edge of the cliff, and this can be dangerous. When the tide is low it is possible to walk through the water at the base of the Bluff. Since either approach to the site requires a long drive and a walk of at least 45 minutes, it is best to visit this area when low tide occurs at midday.

At the base of the Bluff several large, quiet tide pools have formed. Here a few colonies of *Porites astreoides* are found. A series of rocks extending from the bluff divide the ocean, on the east, from Snow Bay. At low tide it is possible to walk along this row of rocks and view the reef where *Acropora palmata* and *Millepora complanata*

are often exposed on the ocean side. Along the ocean side nearer the bluff, extensive rocky tidal flats are exposed as the tide recedes. The rocks forming these flats are honeycombed with holes produced by the activities of the rock-boring urchin, *Echinometra lucunter*. Hundreds of individuals can be seen here. A few colonies of *Porites porites* have developed on the tidal flats, and the knobby zoanthidean, *Palythoa mammillosa*, is common there. Small colonies of the rose coral *Manicina areolata* are also found.

A number of echinoderms are common in the tide pools here. Besides the rock-boring urchin, others, less commonly seen, include *Diadema antillarum*, and the sea egg, *Tripneustes ventricosus*. A small commensal shrimp living among the spines of the sea egg may be collected here. Brittle stars under the rocks include *Ophiocoma echinata*, *Ophioderma appressum* and *O. brevispinum*, and *Ophiomyxa flaccida*. The small gray sea cucumber, *Holothuria grisea*, also occurs here. Occasionally a sipunculid, *Phascolosoma antillarum*, will also be discovered under a rock.

Sabellid fanworms commonly occur in the tide pools. The bristleworm, *Hermodice carunculata*, may be encountered under rock or observed feeding on various cnidarians. Two species of mat anemones, the cream-colored knobby zoanthidean, *Palythoa mammillosa*, and green sea mat, *Zoanthus sociatus*, occur here. The former is common along the tidal flats, while the latter can be seen in sandy areas around the periphery of Snow Bay. Many individuals of the sun anemone, *Stoichactis helianthus*, are exposed on the tidal flats. These greenish anemones with many flat-topped tentacles, are capable of delivering a severe sting. Pale striated tentacles of the ringed anemone, *Bartholomea annulata*, can be seen protruding from crevices in the rock. By probing within their tentacles with a pencil, you may induce the associated snapping shrimp, *Alpheus armatus*, to respond.

A number of crustaceans may be seen at this site. The crabs include the small decorator crab, *Macrocoeloma trispinosum*, which is usually covered with bits of algae; the calico crab, characterized by dark-tipped claws which also bear purplish tubercles, and the ubiquitous Sally Lightfoot, often seen running over the rocks. Under rocks, mantis shrimp of the genus *Gonodactylus* may be seen. Banded coral shrimp, *Stenopus hispidus*, have been found in the deeper tide pools. Individuals of the volcano-shaped ribbed barnacle, *Tetraclita stalactifera*, are exposed on the rocks.

The usual rock-dwelling species of *Nerita* can be studied at this site too. Other gastropods found along the rocks include the magpie, or West Indian top shell, *Cittarium pica*, and the deltoid rock shell, *Thais deltoidea*. Sea hares are also encountered. The spotted sea hare, *Aplysia dactylomela* is relatively common, but the green sea hare, *Dolabrifera dolabrifera*, may also be seen. The pale green, warty dorsal surface of this species is well camouflaged against the algae and sand of the tidal flats where it occurs. Occasionally at low tide an octopus may also be seen.

This site is a rich area for tide pool studies, because it has escaped the overcollecting at more accessible sites. Therefore, to maintain the diversity at the site collecting here, too, is discouraged.

P. Inland Lakes

Almost half of the land mass of San Salvador is covered by inland lakes, ponds, holes and creeks. One can best appreciate this feature of island topography by a visit to the lighthouse or by flying over at a low altitude. Each of the water containments has its particular endemic population of organisms; we will only discuss those found in two easily accessible sites, Little Lake and Blue Hole II. Salinity varies greatly from lake to lake and during different times of the year in the same lake. Little Lake, for instance, can reach a high of over 85 ppt and a low approaching the 35 ppt of normal sea water. Any organisms facing such a fluctuation and/or extreme must have appropriate survival adaptations. Fluxes in water temperature are also more pronounced in the inland lakes than in the ocean, since they are much smaller and relatively shallow. Obviously this is a stressed environment and consequently, diversity is low. Nevertheless, those organisms that do thrive here show a rather high density.

Little Lake is found at the end of the road which leads due east off the Queen's Highway in Cockburn Town. (The road is bumpy and narrow and the turnaround minimal, so you might want to walk from the last intersection to the edge of the lake). A small concrete pier extends out from the shore of Little Lake straight ahead. Mangrove crabs and *Gecarcinus*, the black land crab, can be found in the stands of red, black and buttonwood mangrove to the right and left. The crabs are most prevalent at night but can be seen by turning over rocks or pieces of wood. Around the pier Atlantic pearl oysters and small

snails attach to the algae covered rocks and concrete pillars. A small unidentified serpulid polychaete, possibly in the genus *Spirorbis*, encrusts on mollusc shells, rocks, broken glass and other solid objects in the water. Free-living polychaetes abound under a variety of lake bottom debris. A few small amphipods can be detected among the algal mats. If you snorkel into deeper water, look toward the surface periodically and you will probably see calanoid copepods of mixed sizes and taxa. At times their populations become quite large. There are lots of bivalve shells in the water and washed upon shore. Most are from the genus *Pseudocyrena*, the marsh clam. Small fish may be sighted from the pier and when snorkeling.

You may wish to visit a smaller inland lake, or blue hole, on one of your excursions to the south of the island. There are several sinkholes of a similar nature on San Salvador; the particular one designated by Hobbs (1978) as Blue Hole II is located about a mile from French Bay just to the left hand side of the Queen's Highway when heading south. It is about 100 x 75 feet in size and increases in depth from about one foot at the edge to a central funnel area over 20 feet deep. The substrate of the blue hole is made up largely of shells from a pelecypod, *Polymesoda sp.*, and the gastropods, *Batillaria sp.*, *Cerithidea sp.*, and *Melampus sp.* The most dramatic inhabitant is the reddish-orange shrimp *Barbouria cubensis*. Rather large numbers of these animals sometimes can be found. Little of their biology is known. Two genera of fish may be sighted, *Cyprinodon sp.* and *Gambusia sp.*

Overall, the inland lakes of San Salvador are not as rich in organisms as are the ocean sites. However, they offer a good model ecosystem in which to study adaptations and relationships of specialized forms. If you have the inclination, other lakes may be explored. For example, Great Lake, which runs north-south over half the length of the island, lies just behind Little Lake to which it is connected by a waterway. Great Lake may also be reached by a trail from the lighthouse.

Q. Lighthouse Cave

Caves hold horror for some individuals and fascination for others. Whatever your own prejudices, Lighthouse Cave is an interesting and educational speliological excursion and a visit to it is advised. It will give you the opportunity to study from a unique perspective some of the karst landscape features and limestone geology of San Salvador. Also, several of the organisms you will see are true cave, or troglobitic, species and some of them were described for the very first time from collections made in this cave.

Most Bahamian caves were probably formed by the slow uneven dissolution of limestone as acidic waters percolated into the substratum (see Field Guide to the Geology of San Salvador, Chapter II). As the calcite and other components of the limestone dissolved, small openings developed into increasingly larger underground conduits which carried water from input areas at one elevation to discharge points at lower elevations. Usually the underground passages which form in this manner are at sea level and carry water laterally to the coast of the island. Since sea levels have changed through time a number of caves have developed at different depths. The cave at the Dixon Hill Lighthouse is near the present level of the ocean and the depth of the slightly hypersaline water in it fluctuates with the tide. This probably indicates an indirect link with the sea via a honeycomb of submerged cave passages reflecting earlier, lower sea levels, rather than any direct connection. In other words, although the water rises and falls with the tide, there is little exchange between cave water and ocean water. The total amount of water in the cave may vary over periods of time longer than tidal cycles due to more or less surface water entering and evaporative loss.

The route to Lighthouse Cave is rather easy to follow. Park at the junction of the Queen's Highway and the road leading up Dixon Hill. Walk toward the lighthouse and pass through the gate in the wall to your left. Turn right and take the path along the wall. It soons veers left, descends a grade and meanders through the underbrush. You will leave the taller shrubs and bushes after several hundred yards and, once in the more open area, the path is intersected. Take the right-hand branch which will probably show more signs of use. The main entrance to the cave is about 200 yards down this trail.

The cave is marked by several vertical openings into the ground. Drop into the Aeolian Chamber (see map; p. 75, Guide to Geology of San Salvador) via one of the openings. Observe the water on your left. It is here that shrimp will likely be found, especially if you do not disturb them. Bats may fly overhead; sleeping individuals hang from some of the more secluded dome areas. A number of terrestrial organisms are supported in the cave by a food web based on bat manure, or guano, as it is called. The invertebrates found in the outer chambers are likely to be members of surface-dwelling groups that "wandered" into the

cave. Cockroaches, crickets, terrestrial isopods, land crabs, hermit crabs, ants and a variety of other small arthropods appear in various checklists of the cave's fauna. An evaniid wasp which parasitizes cockroach egg cases has been collected several times.

Once you have explored the various reaches of this large chamber, enter the water and begin to follow it deeper into the cave. Tennis shoes, old blue jeans, a mask and snorkel, gloves and an underwater light are essential. Proceed slowly and try not to disturb the fine sediment on the floor of the water passage. Shine your underwater light on the floor and walls to locate various organisms. Three sponges, unclassifiable except by experts, can be seen. These are *Pellina penicilliformis*, the hairy-pencil sponge; *Cinachura subterranea*, the subterranean sponge; and the newly described *Prosuberites geracei*, Gerace's sponge, known only from Lighthouse Cave samples. Small spirorbid polychaetes encrust on the rocks but are not easily seen. Crustacea are well represented by the red shrimp *Barbouria cubensis*, mentioned earlier, small ostracods, isopods and copepods only visible by microscopic examination of plankton tows, and the large, white troglobitic isopod named *Bahalina geracei* in honor of the CCFL director and his wife. Serious scientific work continues in the cave, most of it involving the discovery and identification of additional species from this rich lode of unique animal life.

As you proceed into the farther reaches of the cave make sure to note landmarks which will guide you back out again. The cave is not particularly dangerous, but you should not take chances by attempting to crawl or swim into confining spaces or to enter passages which appear cramped. It is advisable to take more than one light since underwater lights sometimes leak or short out. Normal safety and common-sense rules should be observed. Generally it is best to visit the cave at low tide. Groups of more than 10 people at one time can cause sufficient disturbance in the water so as to preclude observation of many of the animals. Students who use good judgment, patience, consideration and perserverance will find the cave visit a very worthwhile experience. You should refrain from taking animate and inanimate objects from the cave since it is small and very vulnerable to accidental and intentional damage. It is one-of-a-kind on San Salvador - a special treat for any students who have never had the opportunity to explore a cave or cavern.

VII. THE ANIMALS OF SAN SALVADOR

This compilation of descriptions and sketches is not intended to be comprehensive but rather to present some of the more commonly encountered animals. In some cases drawings do not accompany the word descriptions; you may sketch the animal in the space provided or find a drawing in one of the accessory guides or keys listed in the bibliography. Making labelled diagrams (better yet, with colored pencils) can be a great aid in learning to recognize animals and their distinguishing structural characteristics. Structural characteristics, in turn, allow one to infer a number of functional and ecological attributes.

PORIFERA

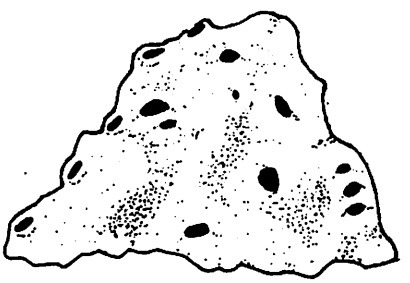
DEMOSPONGIA

Chondrilla nucula, Chicken Liver Sponge

This thin rubbery sponge with the consistency and appearance of chicken liver encrusts on a variety of substrates from grass leaves to reef concretions. The oscula are distinct. Colors range from gray to brown; mottling is common. Grows abundantly in shallow water and on deeper reef heads. Other encrusting sponges are found at San Sal but identification of most species is difficult without spicule analysis.

Haliclona rubens, Red Sponge

This species assumes a variety of forms-cylindrical, branches flattened, encrusting, or a rounded mass of 3-6 inches diameter. Most common in beds of Turtle Grass. Brick red color with a "spongy" consistency. Fairly common in a variety of locales around the island.



Tedania ignis, Fire Sponge

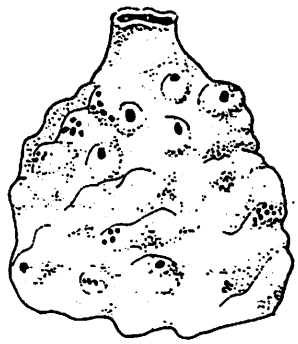
Bright orange-red color, as are many irritating or dangerous marine animals. Fire sponges encrust on hard objects or may grow profusely in grass beds, such as those in Pigeon Creek. The oscula are prominant on these 4-10 inch sponges. As their name implies they sting like fire if their spicules become embedded in the skin. Gloves provide adequate protection. Symbiotic relations are common in this species; the sponge can be easily ripped apart for inspection.

PORIFERA

DEMOSPONGIA

Hippospongia lachne, Sheepswool Sponge

May reach height and width of one foot or more. Attached to hard bottom, prominent raised oscula. Commercially important in certain areas because of their soft yet tough texture when cleaned. Dull brown or black, usually seen as solitary forms. These sponges may harbor small shrimps or other commensals.

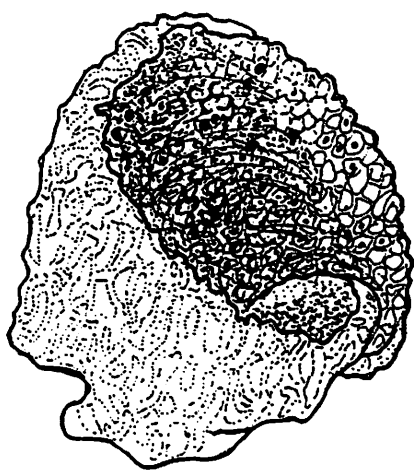


Ircina fasiculata, Stinker Sponge

As the name implies these sponges stink! They grow in irregularly shaped masses 6-12 inches across and are usually yellow or brownish-yellow. They grow in grass beds (abundantly in Pigeon Creek) or attached to hard substrata. They have a tough, rubbery consistency. Their large oscula are clearly visible. A number of animals live within their tissues.

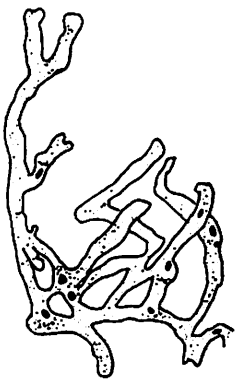
Ircina campana, Vase Sponge

Reportedly growing to two feet across and 3 feet tall in some tropical areas, these vase- or cup-shaped sponges are usually somewhat smaller in the waters around San Sal. They are dull brown, reddish green or some intermediate hue and are noted for their coarse texture, mildly unpleasant odor and the emission of a blue dye if handled roughly. Distinct bumps dot the surface. They are found from shallow bays to deeper waters. Common at Fernandez Bay.



PORIFERA

DEMOSPONGIA



Verongia longissima, Branching Candle Sponge

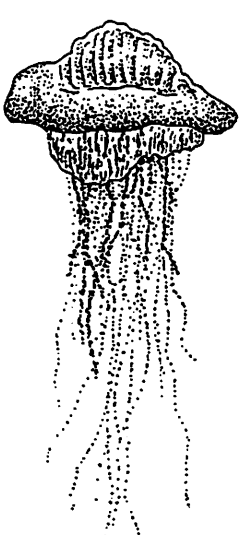
The irregular, slender branches and light yellow color of Verongia distinguish it from most San Sal sponges. It grows in clumps among grass beds and attached to reef surfaces. Pores are clearly visible along its surface. Rather common, sometimes called the Pencil Sponge.

CNIDARIA

HYDROZOA

Hydroids from several genera and species.

Small colonies of pinkish or whitish, transparent hydroids are often seen growing on rocks, pilings, corals and any virtually other substratum. They usually have a feathery texture and grow in regular branched arrays. Some look like candelabra. A few, such as the pinkish hydroids growing amongst the grasses in Pigeon Creek, can deliver an irritating, persistent sting. Hydroids are often difficult to key but many of the San Sal species belong to the families Sentulariidae and Plumulariidae.



Physalia physalia, Portugese Man-O-War

More dreaded than any other Cnidarian, these gas-filled floating assemblages of highly differentiated hydrozoan polyps are occasionally seen in the water (especially at Pigeon Creek) or along the shores of San Salvador. The violet-tinged sail or float may be any size but occasionally reaches 6-12 inches in length and the trailing, nearly

invisible tentacles often stretch to 40-50 feet.

CNIDARIA

SCYPHOZOA

Carybdea sp., Cubomedusae or Sea Wasps

Cubomedusae of the Pacific are extremely virulent but their Bahamian relatives deliver a sting of limited pain and danger. Carybdea is cube or box shaped, with four tentacles hanging from the corners of the oral surface. Transparent and small, they are seldom found in shallow water except at night when they rise to the surface, especially if attracted by light. They are most frequently encountered when night diving or when the water temperature is quite warm.

Cassiopea xamachana, Upsidedown Jellyfish

At San Sal these jellyfish are most often found at Pigeon Creek, usually along the mangrove roots. They swim by pulsations of the bell in a typical Scyphozoan manner, but turn onto their backs (aboral surface) when they settle to the bottom. Their mouth area contains numerous frilly extensions of the oral arms, within which reside symbiotic algae. The upsidedown position facilitates algal exposure to the sun, and therefore photosynthesis. Presumably some of the algal metabolites are passed on to nourish the jellyfish. Most are 4-6 inches across but larger specimens have been noted. This is a very beautiful animal and is relatively harmless as compared to some jellyfish; its sting is barely noticable to most people.

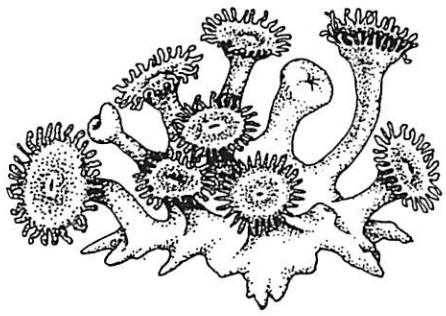
CNIDARIA

SCYPHOZOA

Pelagia noctiluca, The Pelagic Jellyfish

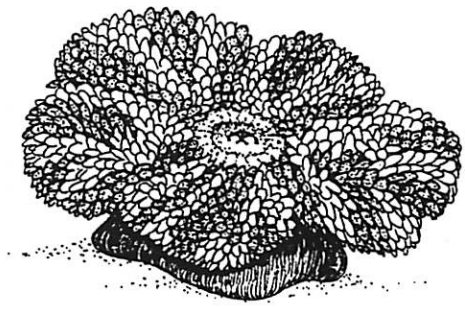
The bell of Pelagia is a beautiful purple or bluish rose color and combined with its bioluminescent quality it is one of the most beautiful of the medusae. It is about four inches in diameter and swims with an active, pulsing motion. Eight tentacles and sixteen shorter lappets hang from the bell margin and oral lips extend as intricate folds which are touch-sensitive.

ANTHOZOA



Zoanthus sp., Mat Anemones

These small, anemone-shaped animals are greenish or bluish in appearance. They usually grow in colonial mats on sub-tidal rocks or occasionally in tide pools. Their tentacles are short and they retract if disturbed. They present a variety of colony forms, colors, shapes and sizes. Identification to genus and species is difficult.



Stoichactis helianthus, Sun Anemone

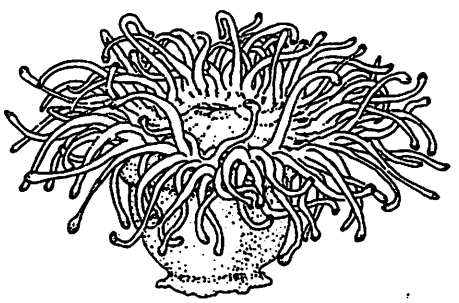
The short, stubby tentacles of this pale green anemone are full of nematocysts (stinging threads) which make them quite sticky. The tentacles are not irritating to calloused areas of human hands but are quite adequate to paralyze small crustacea or other animals which brush against them. These animals have a mat-like appearance and sometimes lie partially buried in the sand or grow in groups along a rock or ledge. They may attain a rather large size (up to 6 inches) and in some places they grow profusely.

CNIDARIA

ANTHOZOA

Condylactis gigantea, Pink-Tipped Anemone

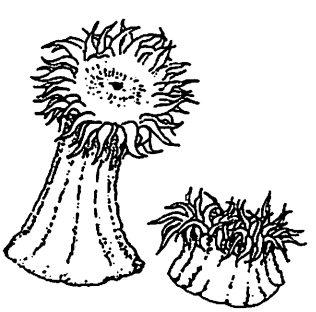
The species name of this easily identified animal suggests its large size as compared to most other San Sal anemones. The tips of the white or pale tentacles are pink or occasionally blue. It grows on a variety of substrates from corals or rocks to empty conch shells, and ranges from shallow, rocky areas to deeper, silt-free environments. These anemones do not retract as readily as others when touched. They can move about slowly by pedal disc creeping. Some reach a diameter of 6 inches or more and they are one of the most common animals in shore and reef areas.



Bundosoma cavernata, Warty Sea Anemone

Reddish warts, or vesicles, arranged in vertical rows dot the stout column. Color ranges from green to brown on the column, with various shades of green on the tentacles and red around the oval surface. About 2-3 inches long when expanded.

Best observed at night, often contracted during the day. This anemone is unique in appearance and easy to identify. Moderately common on a variety of solid substrates around San Sal.



CNIDARIA

ANTHOZOA

Bartholomea annulata, Ringed Anemone; Annulated Anemone

Stalk short and thick, smooth base, brown. Elongated tentacles are tan with lighter brown or white annulations along their length. Many thin tentacles which may droop off the oval disc margin. Attached to undersides of rocks, in beach rock crevices, on conch shells, occasionally in depressions in sandy-rocky sediment.

Has commersal relationship with Spotted Cleaner Shrimp, Periclimenes yucatanensis, and Brown Snapping Shrimp, Alphaeus armatus. A fairly common anemone at San Sal. Withdraws rapidly when touched.

Phymanthus crucifer, Beaded Anemone

These anemones are often found in the sand with their light toned olive, brown, or white disk lying flat, ready to retract below the surface if disturbed. Bumps or small ridges radiate from the mouth to the disc edge where 100-200 short, tapered tentacles attach. A slight tinge of red may be seen in some specimens but is not diagnostic.

CTENOPHORA

Cestum veneris, Venus' Girdle

This is one of the most delicate and graceful of all marine animals. Cilia arranged in rows along the edge of the body and undulatory movements of the elongated, flattened body propel it. Usually 4-6 inches long, 1-2 inches high and very thin. Bioluminescent. Difficult to spot in open water unless vigilant survelliance of mid to upper water levels is maintained.

CTENOPHORA

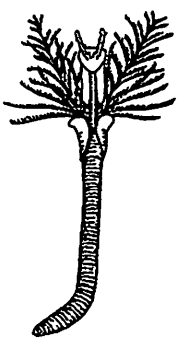
Mnemiopsis macradyi, Lobed Comb Jelly or Sea Walnut

The transparent, jelly-like composition makes this animal nearly invisible to the snorkeling student. It swims using rows (combs) of cilia which can be seen under correct lighting. Bioluminescence of unusual duration and brightness aids night time detection. This species is 3-4 inches long and is characterized by 2 prominent oral arms or lobes which reach below the mouth. Tentacles are small and rarely noticed. Other species of Mnemiopsis are found in the Bahamas but this is one of the most common.

ANNELIDA

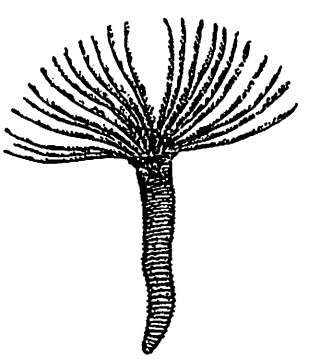
POLYCHAETA

Spirobranchus giganteus, Christmas Tree Worm



The double spiraling branchial crowns of these reef inhabitants are quickly withdrawn when even slightly stimulated by touch or shadow. The tube which they construct of calcium is often buried in fine coral, or in other hardened components of the reef. The textures, colors and behavior of these polychaetes make them attractive and interesting.

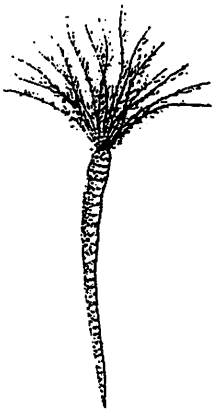
Sabellastarte magnifica, Magnificant Feather Duster



This common sabellid is large and showy. A 3-4 inch crown of tentacles adorns a shorter body of 1-2 inches. Colors of the tentacles range from deep brown to mahagony with spots or bands of tan, white or shades between. The tentacles may spread 6 inches when extended out of the non-attached end of the mucus-lined, tough parchment tube. They retract when touched or shaded but slowly habituate to repeated stimuli. Often grow in clumps attached to shells or reef sides. Occasionally in tide pools.

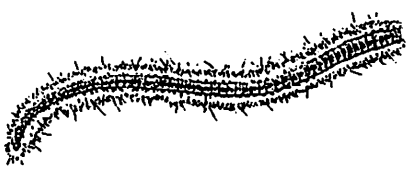
ANNELIDA

POLYCHAETA



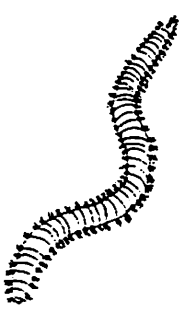
Sabella melanostigma, Black-Spotted Sabellid or Fanworm

Small, usually less than one inch long and lives in parchment tubes attached to hard substrate. May appear in clumps. The tentacles have black "eyespots" on their branches. Difficult to distinguish from juvenile Magnificant Feather Dusters (Sabellastarte magnifica).



Hermodice carunculata, Green Bristle Worm or Fire Worm

Similar to Eurythöe (below) except for longer size, greenish color and transverse ridges along the thick caruncle. Same general habitats, carnivorous feeding mode and anatomical features. Bristles equally irritating.

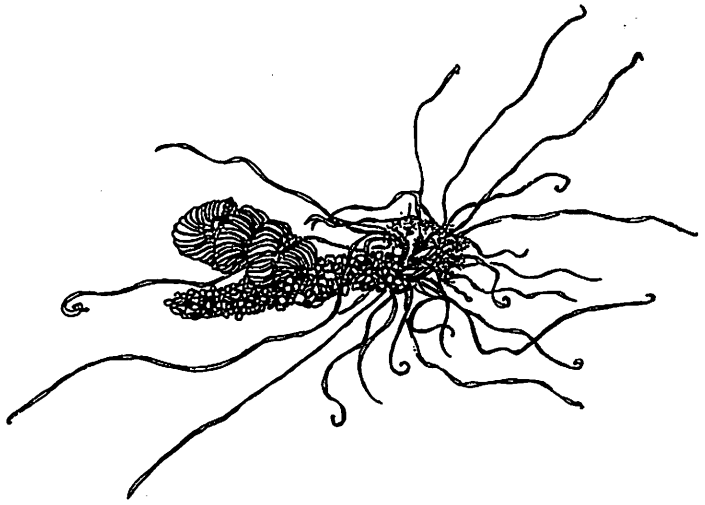


Eurythöe complanata, Orange Bristle Worm or Fire Worm

To find this animal look under stones and shells in grass beds and reef flats or else try to locate them in early morning or late evening when they vacate their safe habitat to feed in the grassbeds or on the reefs. Their siliceous bristles easily penetrate human skin and cause painful irritation so care should be exercised in handling. Most specimens are slender (4-6 iches long) and have gills arranged along the parapodia. The orange (yellow-orange) color is diagnostic. This species can be distinguished from other similar ones by the presence of a smooth, non-ridged caruncle, or lobe, which grows along the top of the head to the first 4 segments.

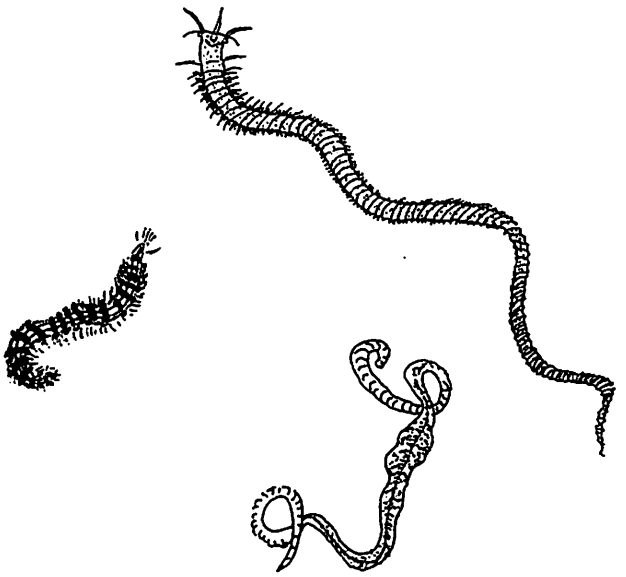
ANNELIDA

POLYCHAETA



Loimia medusa, Medusa Worm

Adult animals are about 6 inches long and are creamy-gray colored with circular bands of pink or purple. A mottled or checked appearance is not unusual. A mass of long extrusible tentacles extends 2-3 feet from the front of the worm and carries food particles back to the mouth. The tentacles retract rapidly if disturbed. Frequent habitats are the undersurfaces of rocks or shells, in the aperature region of empty conch shells or partially buried in the sand. They secrete a delicate mucus tube which is overlain with small stones and sand. Quite common.

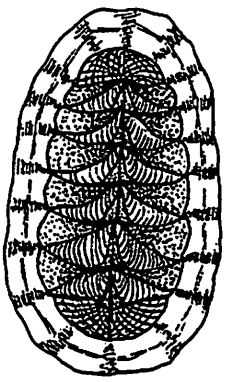


Representative specimens of errant polychaetes, not identified.

Many small (1/2 - 6 inches long), errant (free-swimming) polychaetes live in a variety of habitats, in the waters, sands and reefs around San Salvador. Identification and classification of such polychaetes is notoriously difficult and therefore in this guide no attempt is made to differentiate between various genera or species. It is far easier and more profitable to dwell on the adaptive significance of their peculiar anatomical and behavioral repertoires.

MOLLUSCA

POLYPLACOPHORA



Chiton tuberculatus, Common West Indian Chiton or Tuberculate Chiton

A common denizen of rock faces near the high tide line. The eight dorsal plates are heavily keeled. The best diagnostic feature is the girdle which is scaled and mottled green and black, suggestive of snake skin. The length is 2 1/2 - 3 inches. This animal is common on the exposed eastern sides of North Point and Manhead Cay where it exists with a similar species, Acanthopleura granulata.

MOLLUSCA

POLYPLACOPHORA

Acanthopleura granulata, Fuzzy Chiton

Marginal edge or girdle of this chiton has a fuzzy texture. The chiton's shell is composed of 8 overlapping, hinged plates. These animals graze on algae growing on rocks in the intertidal zone. Noctural, they spend the day in niches to which they return after foraging, displaying homing behavior.

GASTROPODA

Astraea caelata, Star Shell

About 3 inches high, this large, rugged, conical-shelled mollusc is found in shallow waters. The whorled pattern of protuberances give it its name. A similar species, Astraea phobeia, the long-spined star shell is flatter (height-1 inch), with a diameter greater than 2 inches, and a whorled series of projecting spines giving it a highly ornamental appearance.

Busycon contrarium, Lightning Whelk

B. contrarium is a sinistral or left-handed snail contrary to most snails whose shells show a right-handed (dextral) spiral. Specimens are 7 to 15 inches in length. Like conchs, whelks are carnivorous species. Whelks can sometimes be distinguished from strombs (conchs) if their whorls are convex, but the common terms conch, whelk and tulip shell are often used so casually in reference to various species as to preclude their accuracy in formal distinctions.

MOLLUSCA

GASTROPODA

The Family Cassididae, the Helmet Shells

These animals are mostly large, with heavy shells. Since the shell layers vary from the richly colored nacreous layer through more lightly hued inner layers, these shells are choice material for cameo cutting. The shell aperature is typically long, ending in a recurved canal. The heavy outer lip has regular ridges or teeth, as does the inner lip. These animal inhabit the sandy bottoms of lagoon areas.

Cassis flammea, Flame Helmet

This animal, 3-6 inches in height, has about 6 whorls culminating in a small pointed spire. The aperture is elongated and the outer lip is prominently toothed. The inner lip has distinctive wrinkles. The outer lip has heavy brown bars on its margin. The body whorl of the shell has many knobs.

Cassis madagascariensis spinella, Clench's Helmet

The largest helmet indigenous to this area, reaching a height of 14 inches. The shell is ponderous with virtually no spire. The large body whorl is somewhat smooth, excepting 3 spiral ridges with blunt knobs. The outer lip is thick with a few large teeth; the inner lip has many riblike smaller teeth.

Cassis madagascariensis lamarck, Emperor Helmet

As might be anticipated from their scientific names, this helmet and Clench's Helmet are not easily distinguished. Even authorities disagree in their descriptions (compare Morris's "A Field Guide to Shells" with Zeiller's "Tropical Marine Invertebrates"). Emperor Helmets have richly dark nacreous lips. C. madagascariensis is reputed to be a rapacious feeder upon Diadema antillarum, the Long Spined Sea Urchin.

MOLLUSCA

GASTROPODA

Phaliun granulatum, Scotch Bonnet

The Scotch Bonnet is a small helmet which burrows in the sandy bottom. The shell is 2-4 inches, having about 5 whorls and a short spire. Square pale brown spots are distributed evenly over the pale shell. A regular array of deep revolving lines pattern the major body whorl. These shells can be found just under the sand when beachcombing at low tide.

Cassis tuberosa, King Helmet

Triangular shell, large (6"), color buffy, brown bands, beautiful shell prized for cameo cutting. Found on sandy seafloors.

Cyphoma gibbosum, Flamingo Tongue

This mollusc preys on sea fans and other gorgonians and has an extensible mantle that is bright orange with black ringed spots. This mantle provides cryptic coloration for the mollusc while grazing on the sea fan network. The shell of flamingo tongues has an elongate opening running longitudinally and a pronounced ridge running laterally across the dorsal side. Flamingo tongues seem to decline in abundance each year at San Salvador, perhaps because their attractiveness tempts collectors. Since their beauty is largely lost on death, such collection should be resisted.

MOLLUSCA

GASTROPODA

Cittarium pica, Magpie Shell

This handsome gastropod is commonly found at the eastern point of Manhead Cay. It is identified by its large size (height about 4 inches) and its striking black and white checkered shell. The strong operculum has concentric whorls. The heavy shell has 5 or 6 whorls. Many people erroneously identify this animal as Tegula lividomaculata, the West Indian Tegula.

Cypraea sp.-Cowrie

These animals are nocturnal and return to the undersides of rocks during the day. The body extends out from under the edges of the shell and usually the mantle has a ruffled appearance. The shell is olive-brown in many species with lighter spots not uncommon. Empty shells are commonly found along the beach at Fernandez Bay. Some species of cowries are prized by malacologists and others have been used as money by primitive people. (Refer to the shell collection for more precise descriptions of sampled specimens).

Diodora cayenensis, Keyhole Limpet

There are several limpets which go under the general term "keyhole", referring to the small hole at the apex of their volcano-shaped shell. This group is abundant around the island of San Salvador and individuals cling tightly to smooth surfaces underwater and in the low intertidal zone. The limpet shell is ridged, greenish-gray in color and usually less than an inch across. The living animal is slow-moving as it grazes on rock-encrusting algae by using its radular apparatus.

MOLLUSCA

GASTROPODA

Fasciolaria tulipa, Tulip Shell

This smooth surfaced, snail-shaped animal may reach a length of 6-8 inches and lives a voracious, carnivorous existence. It is usually dark in color and has lines or bands across its surface. Its flesh is red. The columella is long and narrow in the tulip shells. There are several other species of tulips in the grass beds and shallow reef areas; a shell book will clarify identifying features.

Murex sp., Murex Snails

The murex snails are represented on San Salvador by several species of the genus Murex, including the Giant Eastern Murex and the Apple Murex. Although murex means "purple shell", the outer covering may be brownish, green or a gray-cream colored. The purple effect is from a fluid released by the animals if strongly disturbed and the aperature of the shell is often a purplish hue. (The purplish ink may be putrid or foul smelling). Long spines are diagnostic of some murex species while others have pronounced ridges. They may be browsers, or in some cases, carnivores.

Nerita peloronta, Bleeding Tooth

These 1-inch snails are common in the littoral zone of rocky areas. The species can be distinguished from the apparently similar Nerita versicolor (Variegated Nerite), with which it is often found, by the prominent red stain below the teeth on the inner lip of the shell. Nerita peloronta and N. versicolor both have zigzag bars of red and black on their whitish, yellowish shell, but N. peloronta are easily picked out from among a mixed population because of their slightly larger size; N. versicolor lacks the distinctive red stain. A somewhat smaller (1/2-3/4") nerite, N. tessellata also occurs with N. peloronta and N. versicolor. N. tessellata, the checkered nerite, is distinctive by its more obviously checkered black and white pattern and its smaller size.

MOLLUSCA

GASTROPODA

Strombus alatus, Florida Fighting Conch

This stromb has a shell of about 4 inches with a winged lip. S. pubilis is a species more common in the West Indies and is of similar size but with prominent spines on its last two whorls, where S. alatus has spines only on the last whorl. The body whorl of both is smooth; seven whorls culminating in a pointed apex are characteristic of both, and both are shallow water species. The fighting description of this animal derives from its wildly flailing behavior when held, an escape response wherein the gastropod kicks out its pointed operculum to flip away from its captor.

Strombus gigas, Queen Conch

This large (1 ft.) conch is common in turtle grass of shallow lagoons. Its flesh is edible and the abundance of this conch makes it a major component of the Bahamian diet. The meat is collected by making a hole in the spire of the shell through which a blade can be inserted to cut the muscle holding the animal to its shell. Typically this hole is made by pounding the spire of the victim with the apex of another Strombus shell. Empty, holed Strombus shells are piled on San Sal's lagoon shores. The shells themselves are prized because of the spectacular bright pink color of the nacreous layer lining the inner lip and aperature. These shells are occasionally exported for cutting into cameos.

Conch dishes eaten by the Bahamians include conch fritters, conch salad, conch chowder, conch steak, and particularly delicious, deep fried, cracked conch. Conch themselves are active predators, feeding mainly on bivalves in the sea floor. In turn, starfish prey on them. The vigorous escape response of Strombus gigas can be elicited by presenting a forceps-held starfish tube foot to the conch. It responds by kicking out violently with its pointed operculum to flip itself away from this apparent predator.

MOLLUSCA

GASTROPODA

Aplysia dactylomela, Spotted Sea Hare.

Large, may be up to 14-16". Shell is vestigial, internal in this mollusc which resembles a hare because of its rabbit ear-like sensory organs (rhinophores) on its head and its rabbit-shaped body. Found in Turtle Grass beds grazing on algae. Emit a purple cloud of ink when disturbed. Aplysia have been studied by neurobiologists interested in learning and biological clocks because of their simple, accessible nervous system and circadian behavior.

Bulla occidentalis, Common West Indian Bubble

The shells of these animals are often found among the debris washed on to San Sal beaches. The living animals are active at night and burrow into the substrate during the day. They are 1-2 inches in length and the shell are brownish with bands or splotches of white, gray or darker brown colors. The thin-walled shell and rounded appearance contribute to the "bubble" description.

Dolabrifera dolabrifera, Green Sea Hare

This somewhat rounded, green animal is cryptically protected as it grazes among algae or as it rests during the day under algae-covered rocks or in coral crevices. Its internal $CaCO_3$ shell is not visible and does not aid in protection. The surface is rough or warty in texture and the animal is usually 2-4 inches in length. Tidepools are its favorite habitat.

MOLLUSCA

GASTROPODA

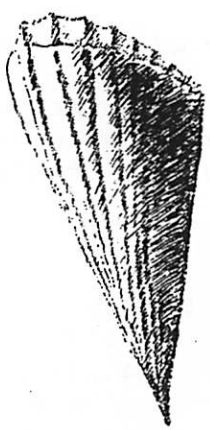
Nudibranchs, Sea Slugs

Although these beautiful, often brightly-colored animals are encountered rather frequently at San Salvador, it is usually difficult to place them in their correct taxa. Some have distinguishing characteristics that can be detected by beginning students but most are difficult to key to genus and species. They are notable because they have no remaining vestige of the molluscan shell. Their name means "naked gills" and their branchia are obvious external structures, often gaily colored and decorated. These animals appear virtually defenseless to any predator but they are not readily eaten, perhaps because they taste terrible. (Bright colors in nature often advertise poisonous or unpalatable properties in otherwise defenseless organisms).

PELECYPODA

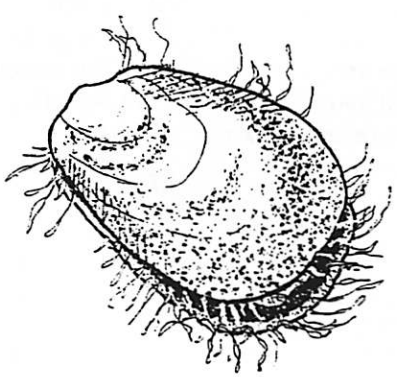
Pinna carnea, Flesh Pen Shell, Amber Pen Shell

Thin, fragile, wedged-shaped shell up to 1 ft. long. Found in shallow water attached by byssus to substrate. Small shrimps, Pontonia mexicana or pen shrimp, live in commensal relationship within the shell of Pinna species.



Lima scabra, Rough File Clam

Moderately thick shell, oval, up to 2", white, having brilliant orange to red mantle with many long streaming tentacles. Found in shallow water, among reef crevices. A small shrimp, Microprosthema semilaevis, the lima shrimp, can be found living near, but not in, Lima scabra. Also, a similar clam, Lima scabra tenera, the delicate file clam, represents a subspecies to L. scabra, distinguishable by its smoother, ridge-free shell.



MOLLUSCA

PELECYPODA

Pteria colymbus, Atlantic Pearl Oyster

This flattened wing shell is often found attached to soft corals. The brown colored shell is diversified by radiating bands of white, from umbones to the margin of the shell. The length is 1 1/2 - 4 inches.

Pecten ziczac, Zigzag Scallop

This scallop is named for the jerky motion of its swimming as it propels itself by snapping its valves. Scallops are bivalves having somewhat unequal valves, the upper being flatter, the lower strongly convex. The shell surfaces are usually ribbed and the margins scalloped. A row of tiny eyes lines the fringe of the mantle. In P. ziczac, the valves are rather smooth and dark in color, the upper being ornamented with black zigzag lines. The eyes are blue. P. ziczac and other Pecten species are being investigated as suitable subjects for mariculture.

Spondylus americanus, Atlantic Thorny Oyster

Found embedded in coral or attached to wrecks, these 3- to 5-inch long oysters have many distinctive long spines extending in all directions. The valves have interlocking teeth, making them very difficult to open without fracturing. Also known as the spiny oyster or chrysanthemum shell.

MOLLUSCA

PELECYPODA

Barbatia domingensis, White Miniature Ark or Reticulate Ark

Careful scrutiny of the face of a rich coral head will often reveal these small (about 1-inch long) bivalves. They are well camoflagued by their ridged surface, grayish color and encrusting pink foraminiferans and are somewhat difficult to spot. If touched they pull back tightly against the substratum by use of their byssal threads and thereby resist detachment or dislodgement. A good location in which to find this organism is the near reef heads at Barker's Point by Sanddollar Beach.

The Family Lucinidae, The Lucins

Lucins are clams with generally round, compressed equal-sized valves, white in color. Their shells are abundant in Pigeon Creek, particularly in the craters. Lucin shells are also recovered in archaeological digs at Indian settlements, indicating that they were a common food source. Codakia orbicularis, the Great White Lucine, is a particularly abundant species. Its white shell, about 3 inches long, is heart-shaped, and its surface is marked with many narrow ribs crossed by the marginal growth lines, thus giving it a cross-hatched appearance.

Teredo navalis, Common Shipworm

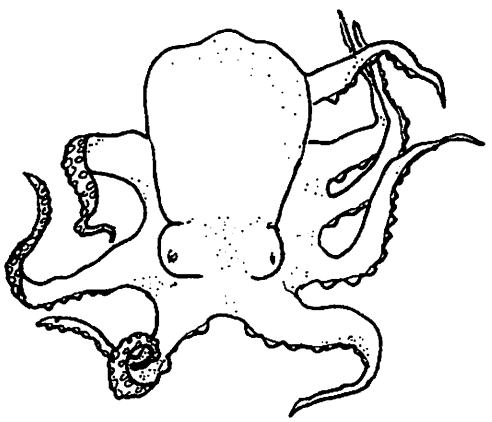
This bivalve bores into wood, secreting a shelly tube which may reach several inches long. The two valves are vestigial and serve as boring devices. The common shipworm is very destructive to wooden ships and wharves. Infested timbers become honeycombed and eventually disintegrate. Examples of Teredo infested timbers can occasionally be found among the flotsam strewn along San Salvador's windward shores.

MOLLUSCA

CEPHALOPODA

Octopus sp.

A number of octopus species are found in San Sal's waters, all readily recognizable by their eight arms, two eyes and soft bodies. These animals are among the most active and intelligent invertebrates and are particularly interesting to observe because of their ability to rapidly change color, either to meld with their background as a defensive gesture or to exaggerate their presence through wavelike patterns of color and iridescence. Species common to San Sal include Octopus vulgaris, the common Atlantic octopus, and Octopus briareus. O. vulgaris is the largest of the shallow water octopuses and specimens 3 ft. in length occur here. Its front and rear pairs of arms are shorter than the side pairs, with the front pair being shortest. The longest arms are typically four times the body length. In contrast, O. briareus has arms that are relatively longer and thinner. It does not exceed 1 1/2 ft. in length and is usually found near shores or in tide pools. The common reef octopus, O. briareus, is usually mottled while the common Atlantic octopus, O. vulgaris is whitish with smooth skin and is less mottled, but their colors can vary momentarily. Octopuses have a remarkable ability to hide in the smallest crevice or escape through the littlest crack. To find them, explore every nook and cranny; to keep them, leave no exits.



MOLLUSCA

CEPHALOPODA

Sepioteuthis sepioidea, Reef Squid

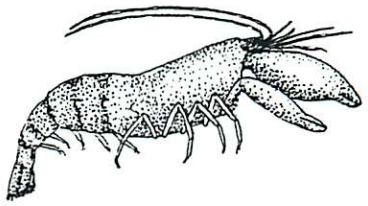
Spotting a squid or school of squid and observing the behavior of these hovering, effortlessly gliding, or rapidly darting molluscs ranks as a highlight of the San Sal experience for students whose keen observational skills in the water is matched with a little luck. The 3-8 inch long reef squid is somewhat foreshortened as compared to some of its longer relatives and it possesses long fins and moderate length arms. Colors may vary according to chromatophore patterns of display but the background is usually a rather translucent pearl-gray brown with darker spots over the entire surface.

Squid are used extensively for biological research and, in many parts of the world, as food. They have a highly developed nervous system and like their relatives, the octopuses, exhibit unusual and highly intricate patterns of behavior. In many ways it is difficult to imagine that the sessile, filter-feeding clam belongs to the same phyum as this highly evolved, hunting carnivore.

CRUSTACEA

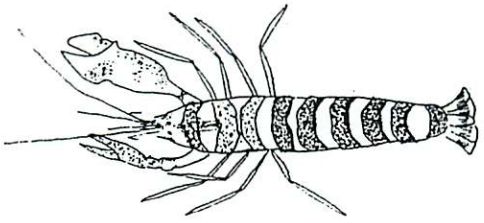
Alpheus armatus, Brown Snapping Shrimp

To 1 1/2". Body and claws dark red or brown with white spots. Antennae striped red and white. This shrimp is found invariably in association with the beaded anemone, Bartholomea annulata, and usually occurs in breeding pairs. Disturbing the anemone may cause the shrimp to emerge from its refuge within the anemone's nitch and to snap its large claw at the intruder. Rather common.



Alpheus armillatus, Banded Snapping Shrimp

Body 1 1/2" long, with alternating dark green and tan rings. Claws mottled green and white. As in other snapping or pistol shrimps, one claw is grotesquely enlarged and modified to be closed very rapidly, resulting in the production of a jet of water and, incidentally, producing a snapping noise. The water jet is used in territorial defense against conspecifics. Found intertidally under rocks and in coral reef interstices. On tidal flats large numbers of these shrimps may produce a cacaphony of snips, snaps, clicks and reports. Common.



Brachycarpus biunguiculatus, Two-clawed Shrimp

A circumtropical shrimp about 1" long with rather long, conspicuous red and white banded claws. The body is reddish to brown and somewhat translucent. Commonly found in tide pools, tidal flats and on reef crests.

Gnathophyllum americanum, Bumble Bee Shrimp

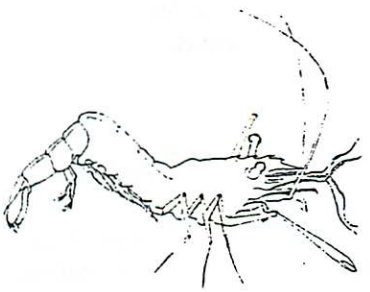
A small (1/2") dark brown or black, thick bodied shrimp with short legs and antennae. Cephalothorax and abdomen are crossed by fine white or yellow stripes. The legs have alternating brown and white bands. This little shrimp is found most often in tide pools where it is not uncommon. It feeds on the tube feet of sea urchins, animals with which the Bumble Bee Shrimp is frequently associated.

Microprosthema semilaevis, Lima Shrimp

3/4" long, a brilliant scarlet relative of the banded coral shrimp, Stenopus. The third pair of thoracic limbs are chelate. These little shrimps are found in tide pools under rocks and ledges. Uncommon.

Periclemenes sp., Cleaning Shrimp

Several species make up the genus of these exquisitely beautiful little caridean shrimp. About 1" long, they are virtually transparent in the water, made visible only by the patterns of brilliant purple, blue, red or white exoskeletal pigmentation that gives away their position. Their antennae are prominent and white and are thrashed about by these shrimp as an indication that they are cleaning organisms. They commonly set up a cleaning station near a Condylactus amemone. When a fish arrives for "servicing", the shrimp climbs over its body picking off small parasites, fungus patches, and loose dead skin. Common.



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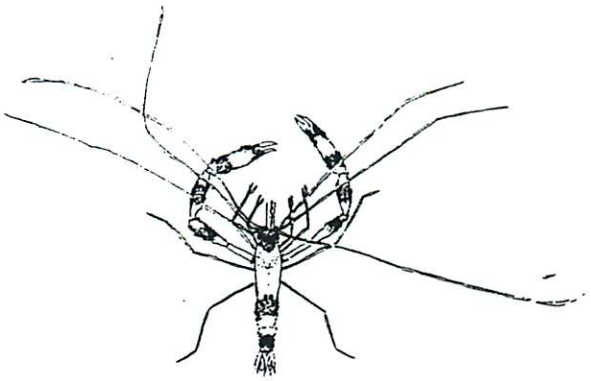
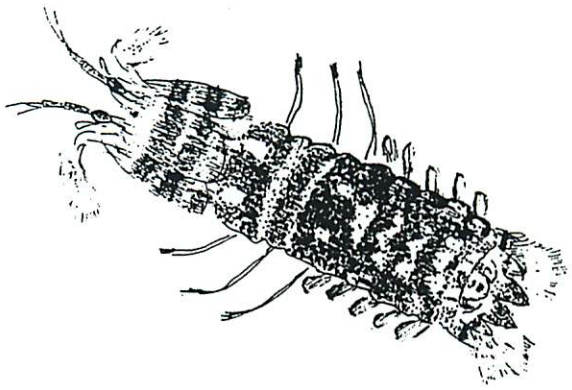


Stenopus hispidis, Banded Coral Shrimp

Body length to 2", 3rd pereiopods large and chelate. Body and chelae banded crimson and white. Antennae, antennules exaggerated, white; leg bases purple.

This very beautiful shrimp is a fish cleaner and waves its long graceful antennae to attract customers! It is found under coral ledges and rocks subtidally, usually in pairs. It is popular with tropical fish enthusiasts and, consequently, may be endangered. Do not collect.



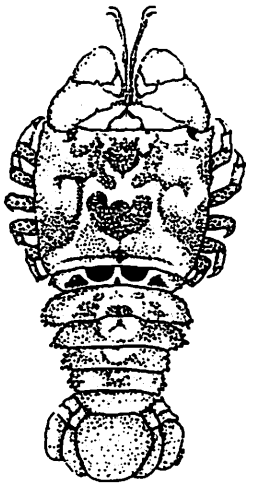
Gonodactylus sp., Rock Mantis Shrimp

To 4" long, raptorial claw without spines. Color pea green, cream with green mottling, or dark mottled green to black. Lives under rocks or ledges in tide pools. Swims rapidly using abdominal swimmerettes. This little shrimp may cause a deep puncture wound using its strong raptorial claw. Use caution.

Panulirus argus, Spiny Lobster

To 36". A heavily armored, large crustacean easily recognized by the elongated, many-spined antennae. Color is cream with purple or brown variegated markings. Eyes are prominent. These animals move about mainly at night but are often seen under deep ledges in coral reef areas during daylight hours. They are difficult to extricate from such retreats. Grabbing an antenna almost always leads to its separation from the lobster! Common.

CRUSTACEA

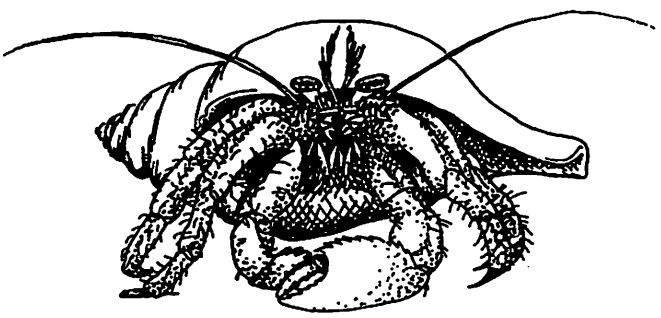


Scyllarides aequinoctialis, Spanish Lobster

A stout, heavy shelled, short legged lobster that may attain a length of 12". Color dark brown with darker blotches. Abdomen and thorax more dorsoventrally compressed than is the case with Panulirus. Scyllarides inhabits grass beds and edges of coral reef areas. Occasional. May be confused with S. nodifer, the Slipper Lobster.

Clibanarius vittatus, Striped Hermit Crab

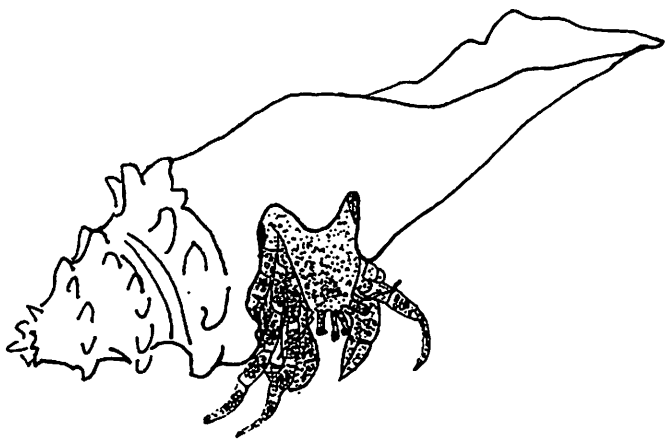
A medium sized hermit crab having claws of equal size. Color is dark, usually brown, with noticeable longtudinal, light-colored stripes on the legs. Found very commonly in tide pools and on the shore above high water.



Dardanus fucosus, Bar-eyed Hermit Crab

A large hermit crab having hairy and spiny legs and chelipeds. The color is orange with white bandings. This animal is similar to D. venosus but is distinguished by the black bar across each eye. Not uncommon.

CRUSTACEA



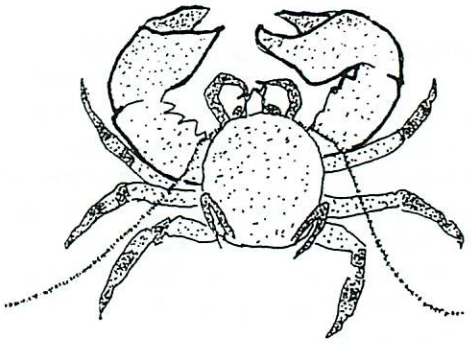
Petrochirus diogenes, Giant Hermit Crab

This is the largest hermit crab of the Caribbean area, reaching a total length of over 12". Heavy, large chelipeds that are slightly asymmetrical. Coloration is usually brick red with white stripings on the antennae. This large animal may even inhabit large shells of the queen couch (Strombus). Not uncommon.

Coenobita clypeatus, Purple Land Hermit Crab

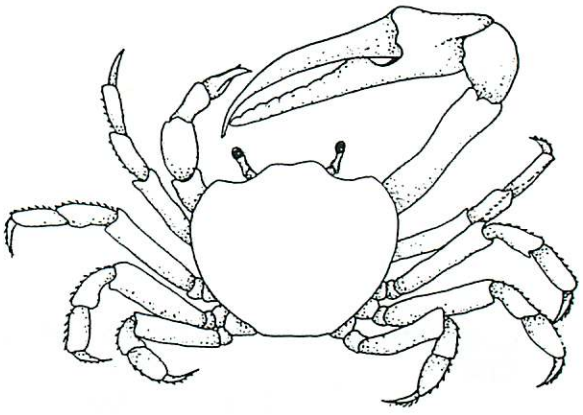
Medium-sized hermit crabs with strong, swollen claws. These animals inhabit unused shells of gastropods, such as Magpie Shells. Found inland, especially as adults, these crabs are numerous in the bushes on North Point.

CRUSTACEA



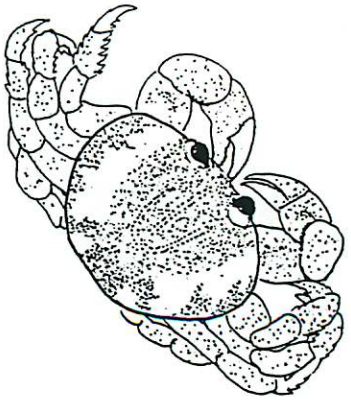
Porcellana sayana, Porcelain Crab

This anomuran crab has a round, flat carapace 1/2" in diameter. Chelipeds are very large and out of proportion to body. Color is white to red. These animals are found under rocks and in coral rubble, clinging to rough surfaces with surprising tenacity. Rough handling causes them to autotomize one or both of their claws.



Cardisoma guanhumi, Great Land Crab

The largest land crab in the Caribbean area. The white or gray colored carapace may be 5" across and the chelipeds may have an outstretched spread of more than 2 ft. These animals are usually found in the interior of San Salvador. They dig burrows in the ground and are secretive, emerging at dark or just before a rain. Natives of San Salvador consider them a delicacy. Locally common.



Gecarcinus ruricola, Mountain or Black Land Crab

Stout elleptical body, up to 3" in carapace width. Carapace is dark maroon to black while the legs are cream colored. These are shy crabs, only venturing forth from their burrows in the early evening or before rainstorms. At the first sign of danger, they quickly retreat underground. Very common.

CRUSTACEA

Ocypode quadrata, Ghost Crab

This fleet-footed beach dwelling crab digs burrows in the sand above high tide line. To 1 1/2" carapace width. Body and legs are white. The crepuscular habits, protective coloration, and extreme rapidity with which this crab moves make it difficult to see, hence its common name. Very common.

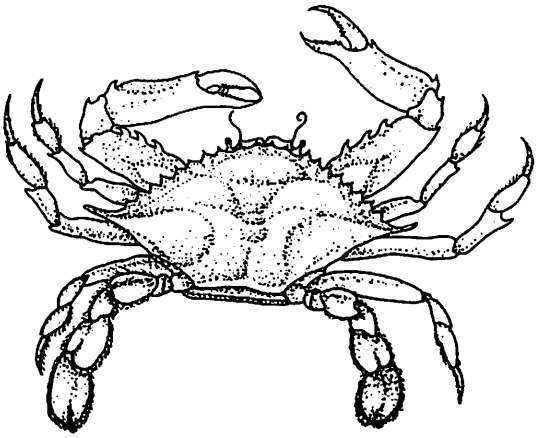
Aranaeus cribrarius, Speckled Crab

This is a large (5 inch) portunid crab that resembles Callinectes. Carapace and limbs are brown with pronounced whitish or yellowish mottling. This crab is found on grass flats in moderately shallow water. Not uncommon.

Callapa flammaea, Flamed Boxcrab

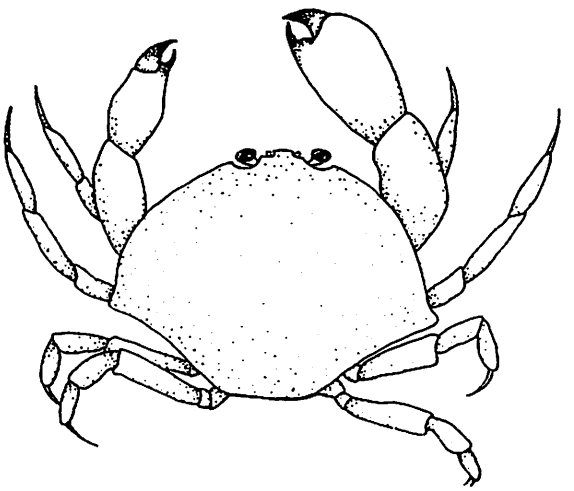
Large, carapace to 5". Color is yellowish with purple brown markings on the shell. Claws are large and heavy and are held against the front of the crab, protecting the mouth region. These crabs eat molluscs which they dig out of the sand. They occur subtidally to moderate depths. Occasional.

CRUSTACEA



Callinectes sp., Blue Crab

Fast swimming portunid crabs of the tidal flats and grass beds. They are easily recognized by the sharp pointed lateral margins of the carapace, which can be up to 6 inches across. Different species are colored in different patterns, from slate gray to mottled ochre. The famous "Beautiful Swimmers" of the Chesapeake Bay belong to this genus.



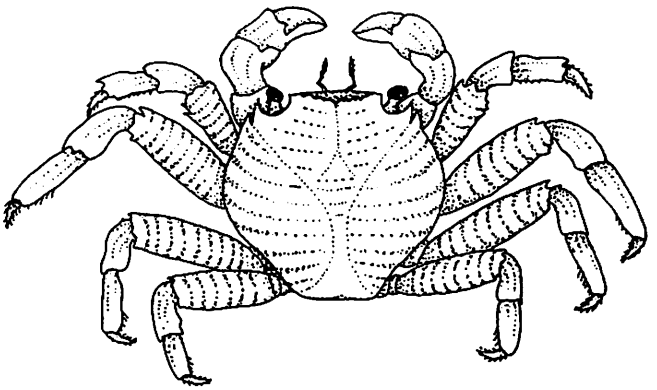
Carpilius corallinus, Bat Crab

A large (6") brick red crab of the coral reef. Claws are heavy and tipped in brown. Shell very smooth, often utilized as food. It is highly prized. Occasional.

Dromidia antillensis, Lesser Sponge Crab

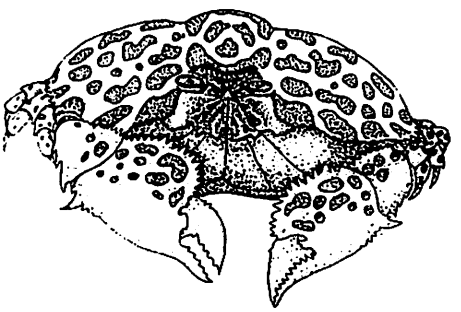
Less than 4" wide. The carapace and limbs are covered with dense hairs. Color is brown to green. A piece of sponge or a group of colonial ascidians or anemones is carried on the carapace and is held in place by the last pair of legs. This crab is not uncommon in tide pools. Well camouflagued.

CRUSTACEA



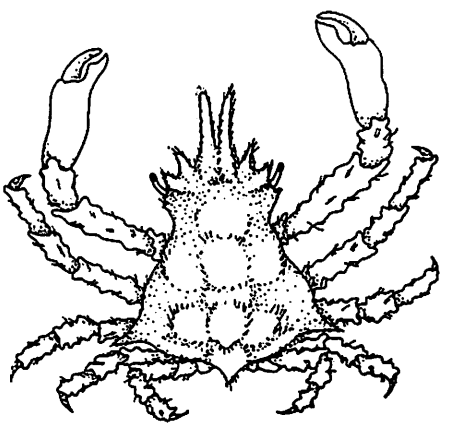
Grapsus grapsus, Sally Lightfoot Crab

A gray to black grapsoid crab with a carapace of up to 3" in width. Body and legs dorso-ventrally flattened. Claws bright red. This crab is extremely agile and fast. It lives exclusively on exposed rock shores or concrete wharves where it seems as much at home above the water line as below it. Very common and pantropical in distribution.



Hepatus ephelicticus, Callico Crab

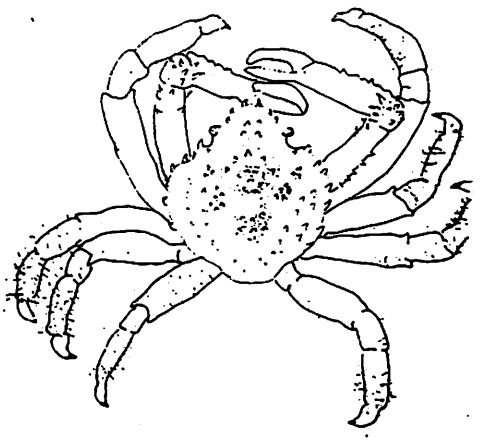
The carapace of this crab is oval shaped and mottled heavily in yellowish white and brown or dark red. Legs are held close against the body. Found in sandy areas of shallow water. Occasional.



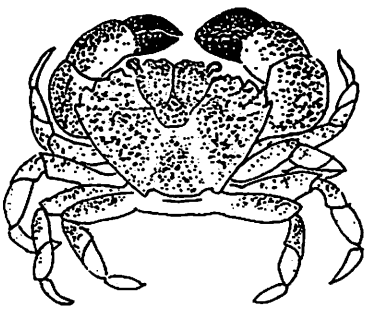
Microphrys sp., Decorator Crabs

These smallish (1 1/2") crabs live in tide pools and also on reef rubble. The arrow head-shaped carapace is heavily decorated with sponges, algae, and other sessile organisms that disguise the crabs to a remarkable degree. The behaviors of these crabs add to this deception, as they move about extremely slowly and punctuate periods of movement with numerous periods of complete immobility. Common.

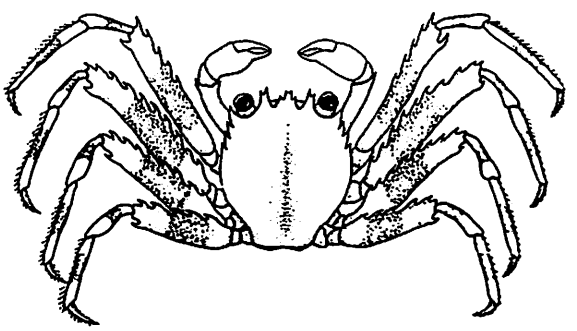
CRUSTACEA



Mithrax spinosissimus, Spiny Spider Crab
This is the largest marine brachyuran crab of the Caribbean area reaching a spread between outstretched claws of over two feet. The color is brick red. Although primarily nocturnal, this crab is sometimes seen crawling around coral rubble during daylight. Uncommon.

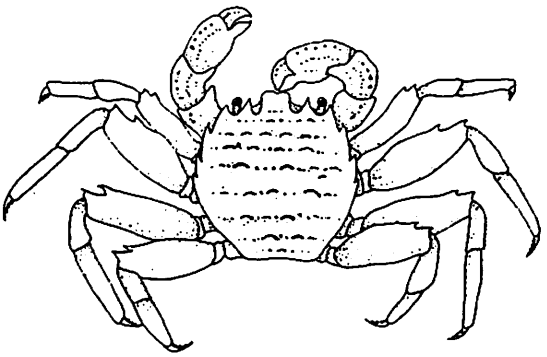


Panopeus sp., Rock Crab
A medium sized (to 2") brachyuran crab with a heavy carapace, heavy chelipeds and black tipped claws. Commonly found under rocks in tide pools and at the shore line. Several similar species make individuals of this genus difficult to identify.

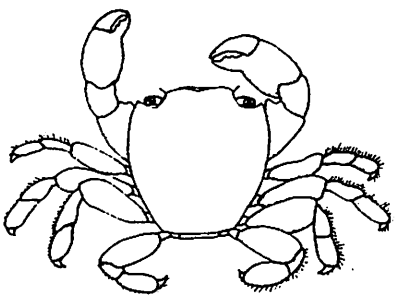


Percnon gibbesi, Spray or Urchin Crab
A very beautiful, small (l"), dorsoventrally flattened crab of coral reefs. The circular carapace is chocolate brown with pink mottling and a median blue stripe. An iridescent green band runs around the front. Legs are brown striped with pink. An agile crab often found in association with the long spined sea urchin, Diadema. Common.

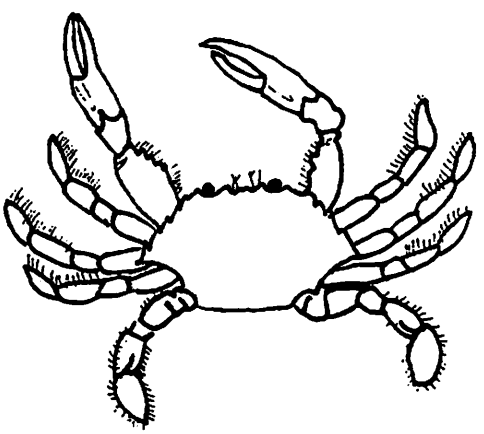
CRUSTACEA



Plagusia depressa, Flattended Plagusia
The carapace of this crab is nearly circular. The claws are prominent and spatulate. Shell is grey to red. This crab inhabits rocky shores in company with Sally Lightfoot Crabs, and it is almost as agile. Common.



Planes minutus, Gulf Weed Crab
A small (1/2") grapsoid crab of floating Sargassum in which it is very common. Carapace almost square in outline. Protective coloration is yellowish olive with white dorsal patches. Often found under freshly beached patches of Sargassum on the sand.



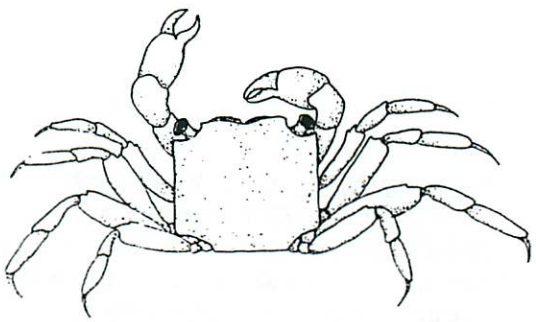
Portunus sayii, Sargassum Portunid
A small 2" portunid crab easily identified by its association with floating Sargassum and its laterally pointed carapace. The color is yellowish brown to olive, mottled with white. As in all portunids the last pair of legs is modified as paddles for swimming. Shows protective coloration.

Portunus spinimanus, Spiny Handed Portunid

A medium sized (to 3") portunid in which the carapace is covered in a mat of short, thick hairs. The penultimate segment of the cheliped bears two spines on the uppermost surface. Found in shallow water on sand flats. Uncommon.

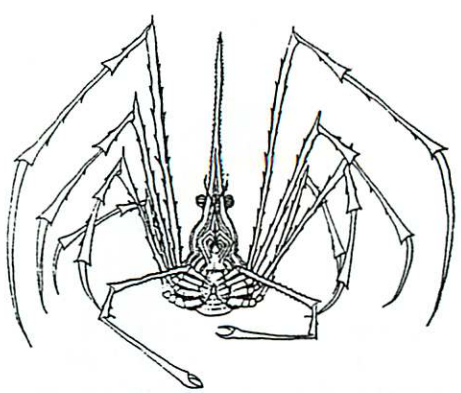
Sesarma cinereum, Friendly Crab

A small (1/2") grapsoid crab found at the shore line, under rocks, along wharves, or in beach rubble. Color is gray to brown. It is very common.



Stenorhynchus seticornis, Arrow Crab

An unusually shaped brachyuran crab, very easy to identify. The body is small and triangular, ending in a sharp anterior rostrum. Carapace is brown with darker line markings. Legs are extremely long and slender. The long chelipeds are tipped in blue. Found among reef interstices. Occasional.



CRUSTACEA

CIRRIPEDIA

Balanus eburneus, Ivory Barnacle

A common sessile barnacle found cemented to rocks, pilings, or other structures. It has conical, smooth walls and occurs primarily below the low tide line. Similar to other species in this region.

Lepus sp., Goose Barnacle

Up to several inches long, these animals comprise a fleshy stalk ending in a flat body covered by several close-fitting calcareous plates. These animals are found worldwide and are usually seen attached to floating debris washed onto the shore. Sargassum is a likely habitat.

ECHINODERMATA

OPHIUROIDEA

Ophiactis savignyi, Savigny's Brittle Star

Small, up to 2 inches. Arms long and slender with short spines. Variegated green and white in color. Juveniles have 6 arms; found in sponges and coralline algae. Adults have 5 arms, live in coral crevices or under rocks. Common.

Ophiothrix oerstedii, Oersted's Brittle Star

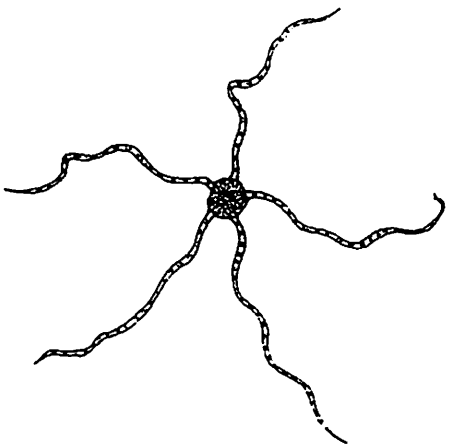
Medium - up to 8 inches. Body disk to 3/4", arms to 3 1/2". Spines on arms glassy, long. Vary greatly in color but always identifiable by fine, white, zebra-like lines across arms (no radial stripes). Rather common in Turtle Grass beds, also in sandy areas of back reef.

Ophiothrix swensonii, Swenson's Brittle Star.

Disk to 1/2 inch, arms to 10 inches; usually smaller. Similar to Ophiothrix oerstedii, but spines very long, barbed, glassy and radial shield large, bare. Lavender or bright red with bold purple to black radial stripes on arms. Found inside sponges or soft corals on the reef or reef flat. Very beautiful brittle star.

ECHINODERMATA

OPHIUROIDEA



Ophionereis reticulata, Reticulate Brittle Star

Medium, to 7 inches. Disk about 1/2 inch. Arms long, slender. Disk bluish gray with network of dark lines; arms whitish to pale yellow with narrow brown or black bands identify this animal. Found under rocks in sandy areas.

Ophiocoma echinata, Spiny Brittle Star or Spiny Ophiocoma

Large, 6 to 10 inches. Disk to 1 1/2 inches, arms to over 4 inches. Black, often mottled with white or grey but never red. Large spines on arms, decreasing toward tip. Common under rocks of tide pools; also on reefs and Turtle Grass beds, shallow water.

Ophiocoma wendtii, Red Ophiocoma

Large, up to 12 inches. Similar to Ophiocoma echinata but can be larger, having longer arm spines; never shows any white or gray markings but has very strong reddish cast. Found in shallow water under rocks or in grass beds or reef flats. Frequently found with Ophiocoma echinata.

ECHINODERMATA

OPHIUROIDEA

Ophioderma appressum, Snakeskin Brittle Star, Harlequin Brittle Star

Disk to about 1 inch, arms to 4 inches; short, cigar-shaped arm spines. Color variable: grayish or brownish, but usually greenish. Arms banded green, gray or brown and white. Arms minutely serrated. Under rocks in shallow water. Closely related to species O. brevispinum.

Ophioderma brevispinum, Short-Spined Ophioderma, Short-Spined Brittle Star

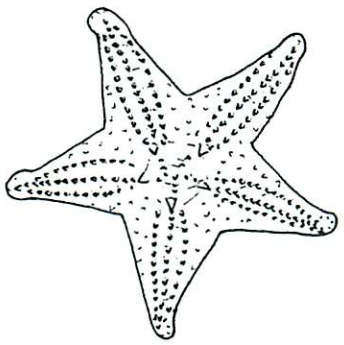
Disk 1/2" or less, smaller than O. appressum. Short, cylindrical arm spines, at 30-45^{0} angle to arm axis. Arms appear serrated. Two color patterns: disk mottled pale green and white with arms banded with shades of green, or disk orangish green, arms either orange, gray or green banded. Found in Turtle Grass.

Ophiomyxa flaccida, Slimy Brittle Star

Disk to 3/4 inch. Covered with smooth, slimy opaque skin, arms smooth, long, slender, tapered with short pinnate spines. Variable coloration: off white to orange, brown gray or dark green, mottled. Arms banded with same colors. Large, active. Found in shallow waters on back reef or turtle grass.

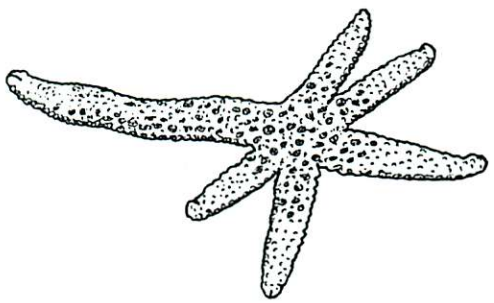
ECHINODERMATA

ASTEROIDEA



Oreaster reticulatus, Cushion Sea Star

Up to 20 inches. 5 pointed, thick, short arms; thick-bodied. Firm, hard, spiny skeleton. Juveniles green, adults orange to brownish red with reticulate pattern of squares and triangles. Ventral surface yellowish. Two rows of thick tube feet. Found in shallow (6 ft) water on sandy or grassy bottoms. It is becoming locally rare because of its attractive size, color and ease of collecting. This is unfortunate, especially since specimens deteriorate rapidly and cannot be preserved.



Linckia guildingii, Common Comet Sea Star

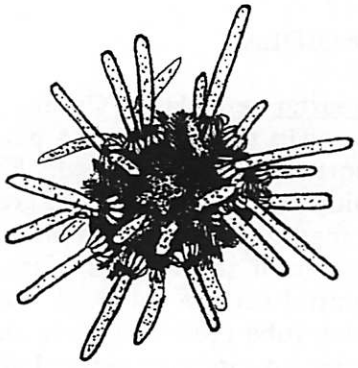
Medium size, up to 9 inches. Long, slender, parallel-sided rays with blunt tips. Rays are 10 times body diameter. Surface smooth to the touch, feels turgid. Flesh colored, tan or reddish. Linckia shows remarkable regenerative powers. A single arm can generate a new animal; from its body end, small new arms bud out, giving it a comet-like appearance where the parent ray represents the tail of the comet. Often has 6 arms. Found in shallow water on sandy bottoms or reefs.

Echinaster spinulosus, Brown Spiny Sea Star. Also known as West Indian Star.

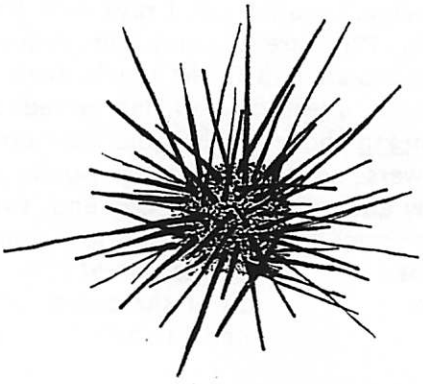
Medium size-up to 6 inches, 5 long tapering arms, with short spines of contrasting color. Greenish or reddish brown. Found on soft bottoms in mangrove channels. Echinaster sp. are attracted by light and are often found in the open on sunny days.

ECHINODERMATA

ECHINOIDEA



Eucidaris tribuloides, Slate-Pencil Urchin
Test 2 1/2" wide, 1 1/4" high, spines 2 1/2". Primary spines long, very stout, blunt-tipped, resemble slate pencils. Test brown with lighter spots, often greenish or reddish tinge. Spines may carry encrusting coralline algae, sponges or bryazoans. Found in crevices on reef, common in turtle grass beds, and in shallow water niches.

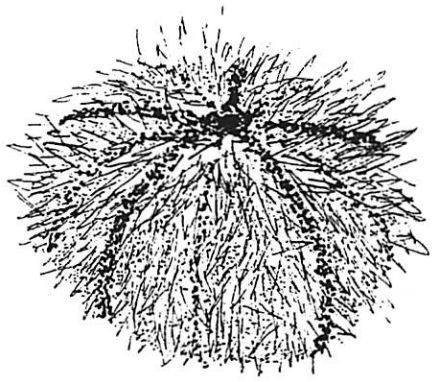


Diadema antillarum, Long-Spined Urchin, Long-Spined Black Urchin
Most characteristic reef urchin, large, black. Tests to 4" diameter, spines very long (to 16"), slender, sharp, brittle; contain toxin. Animal is generally nocturnal, emerging from crevices to graze over reef. Juveniles have banded black and white spines. Often found near shore in beach rock crevices. Upon touching or uneven local illumination, animal orients spines in direction of stimulus as a defensive posture; response is rapid.

Lytechinus variegatus, Green Urchin, Variegated Urchin, Variable Urchin
Very common on grassy sand flats, color variable but usually whitish spines. Test 3" diameter. Camouflages itself with bits of grass debris. Short spines; easily handled.

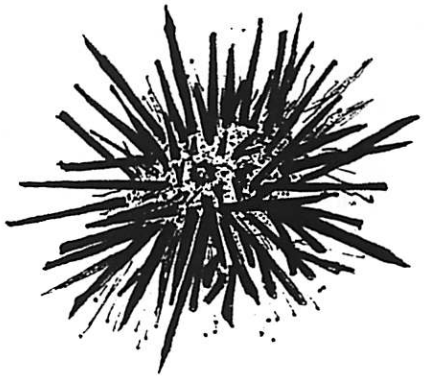
ECHINODERMATA

ECHINOIDEA



Tripneustes ventricosus

Largest of the Caribbean urchins, test round, up to 6" diameter; dark brown to purple in color. Spines numerous, short (1/2"), white. Eggs of Tripneustes are edible and sought after by West Indians. Often found with Lytechinus in Turtle Grass beds.



Echinometra lucunter, Rock-Boring Urchin, Red Rock Urchin, Rock Urchin

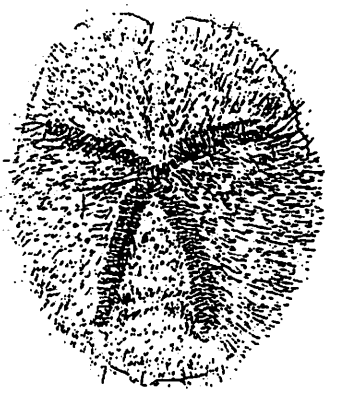
Elliptical test, to 3", spines to 3"; can bore holes to build a refuge, found on rocky shores just below water's surface, or in tide pools. Spines red to reddish black. Echinometra viridis, the green rock-boring urchin, is similar and occurs in similar habitats. Distinguishable by its primary spines having a bright olive green color with purple to violet tips.

Clypeaster rosaceus, Sea Biscuit, Brown Sea Biscuit, Inflated Sea Biscuit.

Large (5"), inflated, thick test with pentamerous petallike decoration consisting of five oval petals dominating test, clearly seen when shell is cleared of spines. Animal is reddish to brown, common in Turtle Grass beds, sandy areas. Dead, clean tests are very white, oval, having central concavity beneath.

ECHINODERMATA

ECHINOIDEA

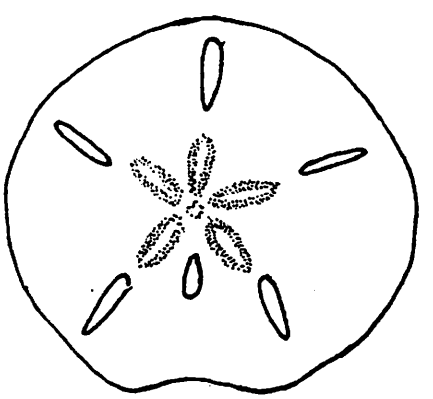


Meoma ventricosa, West Indian Sea Biscuit, Sea Pussy, Cake Urchin

Large (5-7") oval, 4 groovelike depressions on dorsal surface (fifth, completing pentamerous array, is indistinct). Reddish brown, bristly. Found just under sand surface, creating hillocks, in lagoons of water depth 6-20 ft. Nocturnal. Secretes a yellowish repellant when disturbed.

Plagiobrisus grandis, Great Red-Footed Urchin, Long-Spined Sea Biscuit.

Very large, to 10". Oval, light yellow to tan. Spines on dorsal surface up to 4", sharp. Thick red podia around mouth and anus. Buries in the sand of lagoons in depths 20-50 ft. Once thought rare, but easily found if you know how to look (Kaplan, p.13).



Mellita sexiesperforata, Six-Hole Sand Dollar

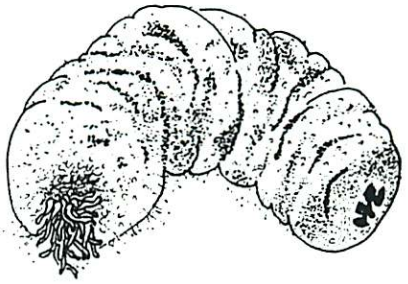
To 4", immediately recognized by the six holes or lunules. Juveniles are silvery gray while adults are brownish. Animal buries itself just beneath the sand surface by rotating its body. Tests are decorative symbols of the sea; they litter the sea floor at Sand Dollar Beach.

ECHINODERMATA

HOLOTHUROIDEA

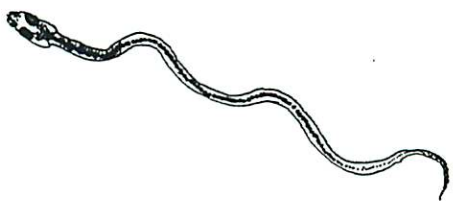
Stichopus badionotus, Four-Sided Sea Cucumber

Flattened on four sides, bottom somewhat wider than top; angles rounded. 10-14" overall, 2" wide. Three rows of podia on lower surface. Texture varies from smooth to very rough. Dark colored usually but mottled forms common. Found in grass beds from intertidal zone to 6 ft.



Actinopyga agassizii, Five-Toothed Sea Cucumber

Large (up to 1 ft.), variable color-gray, brown or spotted. Distinguished by 5 conspicuous calcareous teeth visible in anus when animal exhales. Found in Turtle Grass beds in shallow water, often with Three-Rowed and Donkey Dung Cucumbers (Isostichopus badionotus and Holothuria mexicana). Often, Carpus or pearlfish, is found living commensally in the cloacal cavity of Actinopyga. This long, slender fish backs into its anal refuge, actually residing in the cucumber respiratory tree. Placing a specimen of A. agassizii in an enamel dish filled with sea water overnight may allow viewing of the pearlfish.

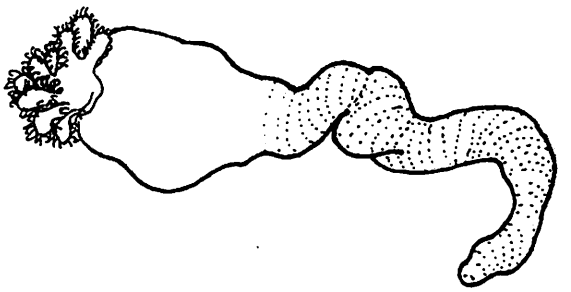


Holothuria grisea, Grey Sea Cucumber

Medium sized, to 8". Gray or mottled, covered with warts, ventral surface slightly flattened and covered with yellow podia. Bushy yellow tentacles; among rocks or in grass beds.

ECHINODERMATA

HOLOTHUROIDEA



Uapta lappa, Sticky-Skinned Sea Cucumber

Long, worm-like, extensible. Has spicules which extend from its surface and cause it to adhere lightly to skin when handled, endowing it with a fascinating quality not altogether unpleasant.

CRINOIDEA

Nemaster discoidea, Beaded Sea Lily

Orange, calyx usually hidden in crevice, 20 arms, several visible protruding, curled at tips. Usually in water greater than 30 ft deep, but can be observed at Fernandez Bay Telephone Pole Reef. Beautiful, "feather star".

VII. A CHECKLIST OF MARINE INVERTEBRATES OF SAN SALVADOR

During a one or two week visit to San Salvador many students will see well over a hundred different species of invertebrates in addition to numerous algae, shrubs, trees, fishes, birds and other forms of life which inhabit the island. Some of these organisms will be immediately recognizable to students and faculty but others may require extensive keying. It is important to keep track of what is seen and where and to have a reference source with which to compare one's own identification efforts. Therefore, a checklist such as this one for the invertebrates can serve as a convenient record-keeping device and also insure the observer that the animals they have found and described actually exist on the island.

In this checklist the animals are arranged in their proper taxa and both scientific names and common names are given when both are known. No attempt has been made to identify the site location or specific habitat where an organism might be found since the list was compiled from several sources and such information was not available for every species. Space is provided for checking off each sighting, the site(s) and/or habitat(s) where found, and any additional notes. Also, the Guide user is encouraged to add any organisms to the list which may not be included at present and if possible to notify the authors or Dr. Gerace of their observations so that future editions might incorporate additional animals.

Many prose and picture keys may be found which make reference to animals found in the Bahamas but several seem especially useful for students working on San Salvador. The following three books contain a proponderance of the animals described in this Guide and should prove to be useful supplements. The shell book is especially relevant since we have not included sketches or notes in the Guide about a majority of the shelled molluscs found at San Salvador. Several additional references are indicated which may prove useful.

Primary References:

"Seashells of North America" by R.T. Abbott. Golden Press, N.Y.
"A Field Guide to Coral Reefs of the Caribbean and Florida" by E.H. Kaplan. Houghton Mifflin Co., Boston.
"Seashore Life of Florida and the Caribbean" by G.L. Voss. Banyan Books, Inc., Miami.

Other References:

"Caribbean Reef Invertebrates and Plants" by P. Colin. T.F.H. Publications, Neptune City, New Jersey.
"Marine Life" by D. and J. George. Wiley, New York.
"Guide to Corals and Fishes of Florida, Bahamas and Caribbean" by I. and J. Greenberg. Seahawk Press, Miami.
"Ocean Realm Guide to Corals of Florida, Bahamas, Caribbean" by P. Humann. Ocean Realm Publishing, Miami.
"Field Book of Seashore Life" by A.W. Miner. Putnam Press.
"A Guide to Marine Coastal Plankton and Marine Invertebrate Larvae" by D. Smith. Kendall-Hunt, Dubuque, Iowa.
"Marine Flora and Fauna of Bermuda" by W. Sterrer. Academic Press, New York.
"Tropical Marine Invertebrates" by W. Zeiler, Wiley, New York.

Also CCFL maintains a library collection of keys for selected groups of organisms indigenous to San Salvador.

Scientific Name (Common Name)

PHYLUM: PROTOZOA

Class: **Sarcodina**
Order: **Foraminifera**
Family: Homotrematidae

Homotrema rubrum (red foram)

PHYLUM: PORIFERA (sponges)

Class: **Calcarea**
Order: **Heterocoela**
Family: Heterocoelidae

Leucettusa imperfecta

Class: **Demospongea**
Order: **Keratosa**
Family: Spongiidae

Hippospongia lachne (sheepswool sponge)
Oligoceras hemorrhages (bleeding sponge)
Ircinia strobilina (loggerhead)
Ircinia fasciculata (stinker sponge)
Ircinia compana (vase sponge)
Spongia obliqua (Cuban reef sponge)

Order: **Haplosclerina**
Family: Haliclonidae

Haliclona rubens (red sponge)
Haliclona viridis (green sponge)
Haliclona hogarthi

Family: Desmacidonidae

Iotrichota birotula (purple bleeding sponge)

Family: Callyspongidae

Callyspongia vaginalis (tube sponge)

Family: Tedaniidae

Tedania ignis (fire sponge)

Family: Aplysinidae

Aplysine fistularis (yellow tube sponge)

Family: Oceanapiidae

Pellina penicilliformis

Scientific Name (Common Name)

Order: **Hadromerine**
Family: Choanitidae

Spheciospongia vesparia (manjack)

Family: Suberitidae

Prosuberites geracei

Order: **Spirophorida**
Family: Tetillidae

Cinachyra subterranea

Order: **Carnosa**
Family: Chondrillidae

Chondrilla nucula (chicken liver sponge)

PHYLUM: CNIDARIA

Class: **Hydrozoa**
Order: **Hydracorallinae**
Family: Milleporidae

Millepora alcicornis (crenulated fire coral)

Millepora complanata (flat-topped fire coral)

Millepora squarrosa (encrusting fire coral)

Order: **Siphonophora**
Family: Rhizophysaliidae

Physalia physalia (Portuguese man-of-war)

Family: Velellidae

Porpita linneana (blue button)

Order: **Leatomedusae**
Family: Sertulariidae

Macrorhynchia philippina (stinging hydroid)

Class: **Scyphozoa**
Order: **Samaeostomeae**
Family: Ulmaridae

Cassiopea xamachana (Jamaican cassiopea or upsidedown jellyfish)

Aurelia aurita (moon jellyfish)

Order: **Cubomedusae**

Chiropsalmus sp.

Carybdea alata (sea wasp)

Scientific Name (Common Name)

Class: **Anthozoa**
Order: **Zoanthidea**
Family: Zoanthidae

Zoanthus pulchellus (mat anemone)

Zoanthus sociatus (green sea mat)

Palythoa mammillosa (knobby zoanthidean)

Order: **Actinaria**
Family: **Actiniidae**

Actinia bermudensis (maroon anemone)

Condylactis gigantea (pink-tipped anemone)

Bunodosoma cavernata (warty sea anemone)

Family: Stoichnoiactiidae

Stoichactis helianthus (sun anemone)

Family: Phymanthidae

Phymanthus crucifer (speckled anemone)

Family: Aiptasiidae

Aiptasia pallida (pale anemone)

Bartholomea annulata (ringed anemone)

Family: Aliciidae

Lebrunia danae (stinging anemone)

Order: **Ceriantharia**
Family: Cerianthidae

Ceriantheopsis americanus (tube-dwelling anemone)

Order: **Scleractinia**
Family: Astrocoeniidae

Stephanocoenia michelini

Family: Acroporidae

Acropora cervicornis (staghorn coral)

Acropora palmata (elkhorn coral)

Family: Agariciidae

Agaricia agaricites (lettuce coral)

Agaricia lamarkii (lettuce coral)

Helioseris culcullata (lettuce coral)

Scientific Name (Common Name)

Family: Siderastreidae
- Siderastrea radians (starlet coral)
- Siderastrea siderea (starlet coral)

Family: Poritidae
- Porites porites (clubbed finger coral)
- Porites astreoides (yellow porites)
- Porites furcata (thin finger coral)

Family: Faviidae
- Favia fragum (star coral)
- Diploria clivosa (sharp-hilled brain coral)
- Diploria labyrinthiformis (depressed brain coral)
- Diploria strigosa (grooved brain coral)
- Colpophyllia natans (brain coral)
- Manicina areolata (rose coral)
- Cladocora arbuscula (tube coral)
- Solenastrea hyades (lobed star coral)
- Montastrea annularis (star coral)
- Montastrea cavernosa (large star coral)

Family: Trochosmiliidae
- Meandrina meandrites (tan brain coral)
- Dichocoenia stokesii (star coral)
- Dendrogyra cylindrus (pillar coral)

Family: Mussidae
- Mussa angulosa (large flower coral)
- Mycetophyllia lamarckiana (large cactus coral)
- Isophyllia sinuosa (cactus coral)

Family: Caryophyllidae
- Eusmilia fastigiata (flower coral)

Order: **Alcyonaria**
Family: Briareidae
- Briareum asbestinum (corky sea fingers)

Family: Plexauridae
- Plexaura flexuosa (bent plexaura)
- Plexaura homomalla (black sea rod)

Scientific Name (Common Name)

Plexaurella dichotoma (double-forked plexaurella)
Plexaurella grisea (gray plexaurella)
Plexaurella fusifera
Eunicea mammosa (mammillated eunicea)
Eunicea calyculata (warty eunicea)
Eunicea lacinata
Eunicea tourneforti
Pseudoplexaura crucis
Muricea muricata (spiny muricea)
Muricropsis sp.

Family: Gorgoniidae
Pseudopterogorgia americana (slimy sea plume)
Pseudopterogorgia acerosa (dry sea plume)
Pseudopterogorgia bipinnata (bipinnate sea feather)
Gorgonia ventalina (common sea fan)
Gorgonia flabellum (Bahamian sea fan)
Pterogorgia citrina (yellow sea whip)
Leptogorgia sp.

Order: **Pennatulacea**
Family: Renillidae
Renilla reniformis (common sea pansy)

PHYLUM: CTENOPHORA (comb jellies)

Class: **Tentaculata**
Order: **Cestida**
Cestum sp. (Venus' girdle)

Order: **Lobata**
Mnemiopsis sp. (sea walnut)

PHYLUM: PLAYHELMINTHES

Class: **Turbellaria**
Order: **Polycladida**
Pseudoceros crozieri (Crozier's flatworm)

PHYLUM: ANNELIDA

Class: **Polychaeta**
Family: Amphinomidae
Hermodice carunculata (green bristleworm)
Eurythoe complanata (orange bristleworm)

Scientific Name (Common Name)

Family: Onuphidae

Onuphis magna (shaggy parchmentworm)

Family: Eunicidae

Eunice schemacephala (Atlantic palolo)

Eunice longisetis (long bristle eunice)

Family: Terebellidae

Loimia medusa (medusa worm)

Family: Sabellidae

Sabella sp.

Sabella melanostigma (black-spotted sabellid worm)

Branchiomma nigromaculata (black-spotted feather duster)

Sabellastarte magnifica (magnificent feather duster)

Hypsicomus elegans (elegant fanworm)

Family: Serpulidae

Pomatostegus sp. (featherworm)

Spirobranchus giganteus (Christmas tree worm)

Family: Pectinariidae

Cistenides gouldii (golden tube worm)

PHYLUM: SIPUNCULIDA (peanut worms)

Phascolosoma antillarum (Antillean sipunculid)

PHYLUM: ARTHROPODA

Subphylum: **Crustacea**
Class: **Cirripedia** (barnacles)
Family: Balanidae

Balanus eburneum (ivory barnacle)

Balanus regalis (acorn barnacle)

Tetraclita stalactifera (ribbed barnacle)

Chelonibia patula

Family: Lepidae

Lepas anatifera (gooseneck barnacle)

Class: **Malacostraca**
Order: **Stomatopoda** (mantis shrimps)
Family: Squillidae

Squilla rugosa (armored mantis shrimp)

Scientific Name (Common Name)

Pseudosquilla ciliata (ciliated false squilla)
Gonodactylus sp. (rock mantis shrimp)

Order: **Decapoda**
Family: Stenopodidae
Stenopus hispidus (banded coral shrimp)
Microprosthema semilaeve (lima shrimp)

Family: Penaeidae
Penaeus duorarum (pink shrimp)

Family: Alpheidae (snapping shrimps)
Alpheus armillatus (banded snapping shrimp)
Alpheus armatus (brown snapping shrimp)
Alpheus formosus (striped snapping shrimp)
Synalpheus brevicarpus (common snapping shrimp)

Family: Gnathophyllidae
Gnathophyllum americanum (bumblebee shrimp)
Gnathophyllum splendens

Family: Palaemonidae
Brachycarpus biunguiculatus (two-clawed shrimp)
Periclimenes yucatanensis
Periclimenes pedersoni (Pederson's cleaning shrimp)

Family: Hippolytidae
Barbouria cubensis

Family: Palinuridae
Panulirus argus (spiny lobster)
Panulirus guttatus (rock lobster)

Family: Scyllaridae
Scyllarides aequinoctialis (spanish lobster)

Family: Axiidae
Axiopsis sp. (black burrowing shrimp)

Family: Porcellanidae
Megalobrachium poeyi (porcelain crab)
Porcellana sayana (spotted porcelain crab)

Scientific Name (Common Name)

Family: Coenobitidae
- Coenobita clypeatus (land hermit crab)

Family Paguridae
- Clibanarius vittatus (spotted hermit crab)
- Dardanus fucosus (bar-eyed hermit crab)
- Dardanus venosus (star-eyed hermit crab)
- Petrochirus diogenes (giant hermit crab)

Family: Hippidae
- Emerita talpoida (common mole crab)

Family: Dromiidae
- Dromia erythropus (sponge crab)
- Dromidia antillensis (lesser sponge crab)

Family: Calappidae
- Calappa flammea (flamed box crab)

Family: Cancridae
- Carpilius corallinus (coral crab)

Family: Portunidae
- Portunus sayi (sargassum crab)
- Portunus spinimanus (swimming crab)
- Callinectes sapidus (blue crab)
- Callinectes marginatus (marginal crab)

Family: Xanthidae
- Actanea acantha (spiny actanea)
- Eriphia gonagra (calico crab)

Family: Grapsidae
- Grapsus grapsus (mottled shore crab)
- Sesarma ricordi (beach crab)
- Plagusia depressa (flattened plagusia)
- Percnon gibbesi (spray crab)

Family: Gecarcinidae
- Gecarcinus ruricola (land crab)
- Gecarcinus lateralis (black land crab)

Scientific Name (Common Name)

Family: Ocypodidae
Ocypode quadrata (ghost crab)

Family: Majiidae
Stenorhynchus seticornis (arrow crab)
Mithrax sculptus (green coral crab)
Mithrax spinosissimus (spiny spider crab)
Mithrax verrucosus (granulated spider crab)
Macrocoeloma trispinosum (grass crab)

Order: **Isopoda**
Family: Ligydidae
Ligia baudiniana (sea roach)

Family: Cymothoida
Anilocra sp.

Family: Gnathostenetroididae
Neostenetroides stocki

Family: Cirolanidae
Bahalina geracei (Gerace's cave isopod)
Exocirolana braziliensis

Family: Exocorallanidae
Exocorallana tricornis

Family: Oniscidae
Porcellionides pruinosus

Family: Stenoniseidae
Stenoniscus pleonalis

Family: Scyphacidae
Armadilloniscus sp.

Class: **Copepoda**
Order: **Calanoida**
Family: Epicterisadae
Enantiosis cavernicola

Family: Ridgewayiidae
Ridgewayia sp.

Scientific Name (Common Name)

PHYLUM: MOLLUSCA

Class: **Polyplacophora** (chitons)
Family: Chitonidae

Chiton tuberculatus (tuberculate chiton)

Acanthopleura granulata (fuzzy chiton)

Family: Cryptoplacidae

Acanthochitona hemophilli (red glasshaired chiton)

Class: **Scaphopoda** (tusk shells)
Family: Dentaliidae

Dentalium laqueatum (panelled tusk)

Dentalium eboreum (ivory tusk)

Dentalium floridense (Florida tusk)

Class: **Cephalopoda**
Family: Octopodidae

Octopus vulgaris (common Atlantic octopus)

Octopus briareus (common reef octopus)

Family: Loliginidae

Sepioteuthis sepioidea (reef squid)

Family: Spirulidae

Spirula spirula (ram's horn)

Class: **Pelecypoda** (bivalves)
Family: Arcidae (ark shells)

Arca imbricata (mossy ark)

Arca zebra (turkey wing)

Barbatia cancellaria (hairy ark)

Anadara notabilis (eared ark)

Family: Glycymeridae (bittersweet shells)

Glycymeris decussata (grooved bittersweet)

Glycymeris pectinata (comb bittersweet)

Family: Mytilidae (mussels)

Modiolus americanus (tulip mussel)

Brachidontes citrinus (yellow mussel)

Brachiodontes exustus (scorched mussel)

Family: Isognomidae (purse shells)

Isognomon radiatus (Lister's tree oyster)

Isognomon bicolor (bicolor tree oyster)

Scientific Name (Common Name)

Family Pteriidae (pearl oysters)
Pinctada radiata (Atlantic pearl oyster)

Family: Pinnidae (pen shells)
Pinna carnea (flesh pen shell)
Atrina serrata (saw-toothed pen shell)

Family: Pectinidae (scallops)

Chlamys imbricata (little knobby scallop)

Chlamys ornata (ornate scallop)

Chlamys sentis (thorny scallop)

Lyropecten sp.

Aquipecten gibbus (calico scallop)

Family: Limidae (file shells)
Lima lima (spiny file shell)
Lima pellucida (inflated file shell)
Lima scabra scabra (rough file shell)
Lima scabra tenera (smooth file shell)

Family: Spondylidae
Spondylus americanus (Atlantic spiny oyster)

Family: Ostreidae (oysters)
Ostrea frons (coon oyster)

Family: Corbiculidae (marsh clams)
Pseudocyrena sp.

Family: Lucinidae (lucines)
Lucina pennsylvanica (Pennsylvania lucine)
Codakia orbicularis (great white lucine)
Codakia orbiculata (little white lucine)
Divaricella quadrisulcata (crosshatched lucine)

Family: Chamidae (jewelboxes)
Chama macerophylla (jewelbox)
Chama sinuosa (smooth-edged jewelbox)

Scientific Name (Common Name)

Family: Cardiidae (cockles)

Americardia media (Atlantic strawberry cockle)
Laevicardium laevigatum (egg cockle)
Laevicardium pictum (Ravenel's egg cockle)
Laevicardium mortoni (Morton's egg cockle)
Papyridea soleniformis (spiny paper cockle)
Cerastoderma pinnulatum (little cockle)

Family: Veneridae

Periglypta listeri (Lister's venue)
Chione cancellata (cross-barred chione)

Family: Tellinidae (tellins)

Tellina radiata (sunrise tellin)
Tellina listeri (speckled tellin)
Tellina laevigata (smooth tellin)
Arcopagia fausta (faust tellin)
Strigilla mirabilis (white strigilla)

Family: Sanguinolariidae (gari shells)

Asaphis deflorata (gaudy asaphis)

Class: **Gastropoda**
Family: Fissurellidae (keynote limpets)

Fissurella angusta (pointed keyhole limpet)
Fissurella barbadensis (Barbados keyhole limpet)
Fissurella nodosa (knobby keyhole limpet)
Fissurella fascicularis (rocking-chair keyhole limpet)
Diodora cayenensis (little keyhole limpet)
Diodora minuta (minute keyhole limpet)
Hemitoma emarginata (emarginate limpet)

Family: Acmaeidae (limpets)

Acmaea antillarum (southern limpet)
Acmaea pustulata (spotted limpet)
Acmaea leucopleura (Cuban limpet)

Family: Trochidae (top shells)

Callistoma jubinum (mottled top shell)
Cittarium pica (magpie top shell)

Scientific Name (Common Name)

Tegula fasciata (colorful top shell)
Tegula lividomaculata (West Indian top shell)
Tegula heliacus

Family: Turbinidae (turban shells)

Turbo canaliculatus (channeled turban)

Turbo castaneus (knobby turban)

Astraea americana (American star shell

Astraea caelata (carved star shell)

Astraea phoebia (long-spined star shell)

Astraea tecta (imbricated star shell)

Arene cruentata (star arene)

Arene tricarinata (three-corder arene)

Family: Neritidae (nerites)

Nerita peloronta (bleeding tooth)
Nerita fulgurans (Antillean nerite)
Nerita tessellata (checkered nerite)
Nerita versicolor (four-toothed nerite)
Puperita pupa (zebra nerite)
Smaragdia viridis viridemaris (emerald nerite)

Family: Littorinidae (periwinkles)

Littorina mespillum (dwarf periwinkles)
Littorina angulifera (southern periwinkle)
Littorina lineolata (lineolate periwinkle)
Echininus nodulosus (false prickly winkle)
Tectarius muricatus (knobby periwinkle)

Family: Siliquariidae

Siliquaria anguillae (slit worm shell)

Family: Planaxidae

Planaxis nucleus (black planaxis)

Family: Modulidae

Modulus modulus (Atlantic modulus)

Scientific Name (Common Name)

Family: Potamididae

Cerithidea costata (costate horn shell)

Cerithidea sp.

Family: Cerithidae (horn shells)

Cerithium eburneum (ivory horn shell)

Alabina cerithidioides (miniature horn shell)

Family: Epitoniidae

Epitonium lamellosum (trellis wentletrap)

Family: Hipponicidae (hoof shells)

Hipponix antiquatus (hoof shell)

Cheilea equestris (false cup and saucer limpet)

Family: Xenophoridae

Xenophora trochiformis (common carrier shell)

Family: Strombidae

Strombus gigas (queen conch)

Strombus raninus (hawkwing conch)

Strombus costatus (milk conch)

Family: Naticidae (moon shells)

Polinices lacteus (milky moon shell)

Natica canrena (colorful moon shell)

Natica pusilla (miniature moon shell)

Natica livida (livid natica)

Family: Cypraeidae (cowries)

Cypraea cinerea (gray cowry)

Cypraea spurca acicularis (yellow cowry)

Cypraea zebra (measled cowry)

Cypraea cervus (deer cowry)

Family: Eratoidae (sea buttons)

Trivia nix (white globe trivia)

Trivia pediculus (coffee bean trivia)

Trivia suffusa (suffuse trivia)

Family: Ovulidae (simnias)

Cyphoma gibbosum (flamingo tongue)

Cyphoma signatum (fingerprint cyphoma)

Neosimnia acicularis (common West Indian simnia)

Scientific Name (Common Name)

Family: Cassididae (helmet shells)
- Phalium cicatricosum (polished scotch bonnet)
- Phalium granulatum (scotch bonnet)
- Cypraecassis testiculus (baby bonnet)
- Cassis tuberosa (king helmet)
- Cassis madigariensis (emperor helmet)
- Cassis flammea (flame helmet)

Family: Cymatiidae (tritons)
- Cymatium nicobaricum (gold-mouthed triton)
- Cymatium femorale (angular triton)
- Cymatium muricinum (wide-mouthed triton)
- Charonia variegata (trumpet shell)

Family: Tonnidae (tun shells)
- Tonna maculosa (tun shells)

Family: Muricidae (rock or dye shells)
- Murex pomum (apple murex)

Family: Thaididae (rock shells)
- Drupanodulosa (blackberry snail)
- Purpurea patula (wide-mouthed rock shell)
- Thais deltoidea (deltoid rock shell)
- Thais lapillus (dogwinkle)

Family: Columbellidae (dove shells)
- Columbella rusticoides (spotted dove shell)
- Columbella mercatoria (mottled dove shell)
- Anachis avara (greedy dove shell)
- Pyrene ovulata (ovate dove shell)

Family: Nasariidae (dog whelks)
- Nassarius albus (variable dog whelk)

Family: Fasciolariidae (tulip shells)
- Leucozonia ocellata (white spotted latirus)
- Latirus infundibulum (brown-lined latirus)
- Fasciolaria tulipa (tulip shell)
- Fasciolaria hunteria (banded tulip shell)
- Pleuroploca sp.

Scientific Name (Common Name)

Family: Olividae

Olivella nivea (West Indian dwarf olive)

Olivella floralia (rice olivella)

Family: Mitridae (miter shells)

Mitra barbadensis (Barbados miter)

Mitra nodulosa (nodular miter)

Family: Conidae (cone shells)

Conus verrucosus (warty cone)

Conus mus (mouse cone)

Conus regins (crown cone)

Family: Xancidae (chank shell)

Xancus angulatus (lamp shell)

Family: Terebridae (auger shells)

Terebra hastata (shiny auger)

Family: Pyramidellidae (pyramid shells)

Pyramidella dolobrata (giant Atlantic pyram)

Family: Bullidae (true bubble shells)

Bulla occidentalis (common bubble)

Family: Ellobiidae (salt marsh shells)

Melampus coffeus (coffee-bean shell)

Family: Elysiidae

Tridachia crispata (lettuce slug)

Family: Aplysiidae

Aplysia dactylomela (spotted sea hare)

Dolabrifera dolabrifera (green sea hare)

Family: Pleurobranchidae

Pleurobranchus areolatus (rough sea slug)

Family: Doriidae

Platydoris angustipes (leathery nudibranch)

Family: Aeolidiidae

Spurilla neoploitana (spurred nudibranch)

Scientific Name (Common Name)

PHYLUM: ECHINODERMATA

Class: **Asteroidea**
Family: Astropecteniidae
Astropecten sp.

Family: Oreasteridae
Oreaster reticulatus (cushioned star)

Family: Ophidiasteridae
Linckia guildingii (common comet star)

Family: Echinasteridae
Echinaster spinulosus

Class: **Ophiuroidea**
Family: Ophiactidae
Ophiactis savignyi (Savigny's brittle star)

Family: Ophiotrichidae
Ophiotrix oerstedii (Oersted's brittle star)
Ophiothrix swensonii (Swenson's brittle star)

Family: Ophiochitonidae
Ophionereis reticulata (reticulate brittle star)

Family: Ophiocomidae
Ophiocoma echinata (black brittle star)
Ophiocoma wendtii (red ophiocoma)

Family: Ophiodermatidae
Ophioderma appressum (snakeskin brittle star)
Ophioderma brevispinum (short-spined brittle star)

Family: Ophiomyxidae
Ophiomyxa flaccida (slimy brittle star)

Class: **Echinoidea**
Family: Cidaridae (club urchins)
Eucidaris tribuloides (club pencil urchin)

Family: Diadematidae
Diadema antillarum (long-spined urchin)

Family: Arbacidae
Arbacia punctulata (common arbacia)

Scientific Name (Common Name)

Family: Echinidae

Lytechinus variegatus (green urchin)

Tripneustes ventricosus (sea egg)

Family: Echinometridae

Echinometra lucunter (rock-boring urchin)

Echinometra viridis (green rock-boring urchin)

Family: Clypeasteridae

Clypeaster rosaceus (brown sea biscuit)

Family: Scutellidae

Mellita sexiesperforata (six-hole urchin)

Family: Spatangidae

Meoma ventricosa (West Indian sea biscuit)

Plagiobrissus grandix (great red-footed urchin)

Class: **Holothuroidea**
Family: Holothuridae

Stichopus badionotus (four-sided sea cucumber)

Actinopyga agassizii (five-toothed sea cucumber)

Holothuria thomasae (Thomas's cucumber)

Holothuria mexicana (donkey dung sea cucumber)

Holothuria princeps

Holothuria grisea (gray sea cucumber)

Parathyone surinamensis

Family: Synaptidae

Euapta lappa (sticky skinned sea cucumber)

Chirodota rotifera (Pourtale's sea cucumber)

Family: Cucumariidae

Pentacta pygmaea (pygmy sea cucumber)

Class: **Crinoidea**
Family: Comatulidae

Nemaster discoidea (beaded sea lily)

PHYLUM: CHORDATA

Class: **Ascidiaceae**
Family: Styelidae

Synplegma viride (green encrusting tunicate)