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Coastal and Estuarine Data Archaeology and Rescue Program

RESOURCE SURVEY OF LOOE KEY NATIONAL MARINE SANCTUARY 1983

Looe Key National Marine Sanctuary

December 2002

US Department of Commerce
National Oceanic and Atmospheric Administration
Silver Spring, MD

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RESOURCE SURVEY OF LOOE KEY NATIONAL MARINE SANCTUARY 1983

James A. Bohnsack
(Editor, 1983)

Prepared for: Office of Ocean and Coastal Zone Management
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December 2002

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PREFACE

There is a significant number of documents and data related to the marine environment of Florida that have never been published, and are, therefore, not readily available for use by scientific community and academia. These documents and data are important because they can help define the state of the coastal environment in the past, and can be essential when evaluating the current state of degradation and restoration goals. Due to the nature of the paper and electronic media on which they exist, and, in some cases, the poor conditions in which they are housed, the data and documents are in jeopardy of being irretrievably lost. These materials cannot be located using electronic and manual bibliographic searches because they have not been catalogued or archived in libraries.

One of the objectives of the Coastal and Estuarine Data/Document Archeology and Rescue (CEDAR) Program is to collect unpublished data and documents on the South Florida coastal and estuarine ecosystem; convert and restore those judged valuable to the South Florida restoration effort into electronic and printed form, and distribute them electronically to the scientific community, academia and the public. CEDAR parallels other data and document rescue efforts including the Global Oceanographic Data Archaeology and Rescue (GODAR) of the NOAA National Oceanographic Data Center (NODC)/World Data Center-A for Oceanography (WDC-A). CEDAR, however, is focused on coastal and estuarine data and documents which cover relatively small temporal and spatial scales.

"Data Archaeology" describes the process of seeking out, restoring, evaluating, correcting, and interpreting historical data sets. "Data Rescue" refers to the effort to save data at risk of being lost to the science community. One of the major users of these rescued materials is the South Florida Ecosystem Restoration Task Force.

CEDAR is joint effort between the NOAA National Ocean Service/National Centers for Coastal Ocean Science, and other government and universities in South Florida such as the the NOAA National Marine Fisheries Service, the NOAA Central Library, the University of Miami, Mote Marine Laboratory, and other organizations.

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LIST OF ACRONYMS

BNP	Biscayne National Park
CIMAS	University of Miami/Cooperative Institute for Marine and Atmospheric Studies
cm	Centimeter(s)
DEIS	Draft environmental impact statement
FDNR	Florida Department of Natural Resources
ft	Feet
in	Inch(es)
KLNMS	Key Largo National Marine Sanctuary
km	Kilometer(s)
LKNMS	Looe Key National Marine Sanctuary
LKR	Looe Key Reef
LOP	Loran C lines of position
m	Meter(s)
MHE	Marine Habitats and Ecosystems
NMFS	NOAA/National Marine Fisheries Service
nmi	Nautical mile(s)
NOAA	National Oceanic and Atmospheric Administration
NOS	NOAA/National Ocean Survey
SPD	Sanctuary Programs Division/NOAA Office of Ocean and Coastal Resource Management
USGS	US Geological Survey

FOREWORD

Looe Key National Marine Sanctuary (LKNMS) was designated in 1981 to protect and promote the study, teaching, and wise use of the resources of Looe Key Sanctuary (Plate A). In order to wisely manage this valuable resource, a quantitative resource inventory was funded by the Sanctuary Programs Division (SPD), Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration (NOAA) in cooperation with the Southeast Fisheries Center, National Marine Fisheries Service, NOAA; the Cooperative Institute for Marine and Atmospheric Studies (CIMAS), University of Miami; the Fisher Island Laboratory, United States Geological Survey; and the St. Petersburg Laboratory, State of Florida Department of Natural Resources. This report is the result of this cooperative effort.

The objective of this study was to quantitatively inventory selected resources of LKNMS in order to allow future monitoring of changes in the Sanctuary as a result of human or natural processes. This study, referred to as Phase I, gives a brief summary of past and present uses of the Sanctuary (Chapter 2); and describes general habitat types (Chapter 3), geology and sediment distribution (Chapter 4), coral abundance and distribution (Chapter 5), the growth history of the coral *Montastraea annularis* (Chapter 6), reef fish abundance and distribution (Chapter 7), and status of selected resources (Chapter 8). An interpretation of the results of the survey are provided for management consideration (Chapter 9). The results are expected to provide fundamental information for applied management, natural history interpretation, and scientific research.

Numerous photographs and illustrations were used to supplement the report to make the material presented easier to comprehend (Plate B). We anticipate the information provided will be used by managers, naturalists, and the general public in addition to scientists. Unless otherwise indicated, all photographs were taken at Looe Key Reef by Dr. James A. Bohnsack. The top photograph in Plate 7.8 was taken by Michael C. Schmale. Illustrations were done by Jack Javech, NMFS.

Field work was initiated in May 1983 and completed for the most part by October 1983 thanks to the cooperation of numerous people and organizations. In addition to the participating agencies and organizations we thank the Newfound Harbor Marine Institute and the Division of Parks and Recreation, State of Florida Department of Natural Resources for their logistical support. Special thanks goes to Billy Causey, the Sanctuary Manager, for his help, information, and comments.

We thank in alphabetical order: Scott Bannerot, Margie Bastian, Bill Becker, Barbara Bohnsack, Grant Beardsley, John Halas, Raymond Hixon, Irene Hooper, Eric Lindblad, and Mike Schmale. We dedicate this effort to the memory of Ray Hixon who participated in the study and who loved Looe Key.

Plate A. Aerial photograph of Looe Key National Marine Sanctuary showing approximate boundaries.

Plate B. The high diversity of marine life and lush coral growth distinguish Looe Key National Marine Sanctuary.

ABSTRACT

Looe Key National Marine Sanctuary (LKNMS) was designated in 1981 to protect and promote the study, teaching, and wise use of the resources of Looe Key Sanctuary. A quantitative resource inventory was funded in 1983 by NOAA in cooperation with the University of Miami, the United States Geological Survey, and the Florida Department of Natural Resources. The objective of the study was to quantitatively inventory selected resources of LKNMS in order to allow future monitoring of changes in the Sanctuary as a result of human or natural processes. This study, referred to as Phase I, gives a brief summary of past and present uses of the Sanctuary; and describes general habitat types, geology and sediment distribution, coral abundance and distribution, the growth history of the coral *Montastraea annularis*, reef fish abundance and distribution, and status of selected resources. An interpretation of the results of the survey are provided for management consideration. The results are expected to provide fundamental information for applied management, natural history interpretation, and scientific research.

CHAPTER 1

INTRODUCTION

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Looe Key was named after a British 44 gun frigate, the HMS Loo. (Loo is a city in Cornwall, England; spelling was either Loo or Looe during the 1700's) that grounded on the reef with a companion smaller vessel on 5 February 1744 (Peterson, 1955). The Loo's log and Captain Utting's letters describe a 274 by 91 m sandy island (Key) that existed on the reef during this time. The shipwreck survivors remained on the island for three days before setting fire to the wrecked vessels, and sailing to the Bahamas and Port Royal, South Carolina in a commandeered sloop and small boats. The island was found by Romans in 1775 and still existed in 1851 (Agassiz, 1852). The remains of this island may be the rubble zone on the east end of the reef which is emergent during low tide.

Looe Key National Marine Sanctuary, established in February 1981, is an offshore bank reef community, located approximately 24° 32' N latitude, 81° 24' W longitude, or 12.9 km off the SW point of Big Pine Key, Monroe County, Florida (Figure 1.1). The main axis of the Florida Current flows through the Straits of Florida about 36 km seaward of Looe Key Reef. The entire sanctuary encompasses 5.3 square nmi, and surrounds an inner "core" area of less than 0.5 square nmi encompassing Looe Key Reef. Within the "core" area, "removing or damaging natural features, using harmful fishing methods, removing or damaging distinctive historical or cultural resources" is prohibited.

The sanctuary features include seagrass, coral reef, livebottom, rock, and bare carbonate sand communities. The reef is characterized by a spectacular spur and groove zone compassed of elongate formations of reefal limestone capped by living corals, interspersed with valleys lined with carbonate sand and rubble. Seagrass meadows carpet the bottom inshore of the spur and groove formation. Livebottom, sedimentary, and rock habitats are scattered inshore, east, and west of the spur and groove system. The deeper reef is poorly known; scattered outcrops of irregular relief bottom occur in depths of 30 m. At or about 25 - 30 m the slope changes precipitously and the reef biotope terminates at a flat sand plane, characterized by silty sediments.

The reef was described as an outer reef "par excellance" by Agassiz (1852); he referred to the spur and groove tract as "submarine elongated hillocks"; and reported that the reef was located at the narrowest portion of Hawk Channel (determined by a line running between Big Pine Key and Looe Key). However, modern navigational charts document that Alligator Reef seaward of Matecumbe Key is closer to shore.

Two major assemblages of outer bank reefs with pronounced spur and groove zones and populations of elkhorn coral (*Acropora palmata*) are found in the Florida Reef tract. The northern component is found off Key Largo within the Key Largo National Marine Sanctuary (KLNMS) and Biscayne National Park (BNP), and has a north-south alignment. From north to south the reefs include unnamed reefs in BNP and Carysfort, Elbow, Key Largo Dry Rocks, Grecian, French, and Molasses reefs in KLNMS. The southwestern component extends from seaward of Big Pine Key to slightly beyond Key West. These reefs have a more east-west alignment, reflecting the continental shelf margin which controls the archipelago axis. Reefs in this set include Looe Key, Maryland Shoal, Eastern, Middle, and Western Sambo, Eastern Dry Rocks, Rock Key, Sand Key, and Western Dry Rocks.

The discontinuous distribution of bank reefs in the Florida Reef tract is attributable to the dam effect of the Pleistocene island archipelago. The upper and lower Keys' islands form a dike-like barrier to water exchange between Florida Bay - Gulf of Mexico and the Atlantic. The middle portion of the Keys is typified by small isolated islands and large open channels between the Atlantic and Florida Bay - Gulf of Mexico. These waters exhibit unpredictable water quality; almost every parameter is profoundly influenced within the shallow Florida Bay basin. Temperature is affected by winter cold fronts (Shinn, 1976; Walker *et al.,* 1982; Roberts *et al.,* 1982) and summer doldrums (Jaap, 1979). Salinity is affected through evaporation and the influx of fresh water from the Everglades and Ten Thousand Islands drainage systems. Turbidity is highly variable due to fine carbonate muds and silts which are resuspended during winter and summer storms. Reef coral distribution is controlled by cross platform transport of Florida Bay water into the Atlantic (Ginsburg and Shinn 1964; Shinn, 1976). Areas seaward of large tidal channels have sparse reef development, areas located seaward of larger island masses, such as Key Largo support thriving coral reefs.

Looe Key's location is on the southeast fringe of the lower Keys protected zone. Smaller channels (Niles, Pine, and Bogie) are nearly directly inshore of Looe Key. Major channels (Bahia Honda and Moser) are found short distances to the northeast. Large volumes of Florida Bay water are transported through these channels into the Atlantic. Satellite imagery (USGS, 1974) documents that net water movement in this region moves SW from these channels.

Though *Acropora palmata* (elkhorn coral) is an efficient monopolizer of space on shallow western Atlantic reefs (Glynn, 1973; Adey, 1977), they are sparse at Looe Key. Looe Key appears to be suitable habitat for *A. palmata* and drilling has shown that during earlier periods, *A. palmata* was a significant contributor to spur construction at Looe Key Reef (Shinn *et al.,* 1981). The demise of *A. palmata* may reflect short term environmental events such as hurricanes or thermal shock, or the geologically recent development of Florida Bay caused by rising sea level which allowed water to flow out of the Bay into the Atlantic and detrimentally affect the water quality around Looe Key. There was also minor impact from harvest of elkhorn coral for the souvenir trade (which was legal prior to 1976).

Reefs located southwest of Looe Key (Sambo complex) are less affected by Gulf of Mexico waters due to the larger islands and narrow channels in this area and display a somewhat different pattern of organism abundance. Eastern Sambo for example is capped by thriving populations of *A. palmata*. There are also dense thickets of *Acropora cervicornis* (staghorn coral), just seaward of the spur and groove habitat at the Sambos. The large flow of poor quality water from Florida Bay appears to be the most probable cause for the demise of *A. palmata* populations at Looe Key.

The sequence of events typical in the reef building process for *A. palmata* includes (1) initial recruitment, exploitation and monopolization of the habitat. Much of the success of *A. palmata* is a consequence of its vegetative recruitment via broken fragments which lodge in the substrate and develop into new colonies. (2) Upward growth to low tide level and increase of population densities to a point of overcrowding. Localized deterioration of water quality caused by restricted circulation reduces population vitality, and perhaps allows greater susceptibility to disease, making them less competitive in this now unfavorable micro-habitat.

Disease can exterminate populations of *A. palmata* (Gladfelter, 1982; Peters *et al.,* 1983). Populations usually adjust to these conditions by retreating seaward. As reef growth reached sea level, organisms adjust by recruitment into more favorable niches (Mcintyre and Glynn, 1976). Looe Key is somewhat anomalous in terms of topography. The spurs terminate at about 9 m depth on a sandy plane. Corals require a stable rocky substrate with low sedimentation, therefore at Looe Key, *A. palmata* fragments and larvae find little suitable substrate to colonize seaward of the spurs. Looe Key is also unusual in that the bulk of the spurs are growing over coral rubble and carbonate sands. Looe Key reef growth began ca. 6500 BP; early growth originated on a topographic elevation formed by Pleistocene bedrock and progressed landward, constructing spurs atop coral rubble and sand; the reef flat is a shingle rampart composed of coral fragments lying atop a sedimentary sequence approximately 4 m thick (Shinn *et al.,* 1983; Lidz, this volume).

Understanding the history of Looe Key Reef is important for understanding present conditions discussed in later chapters.

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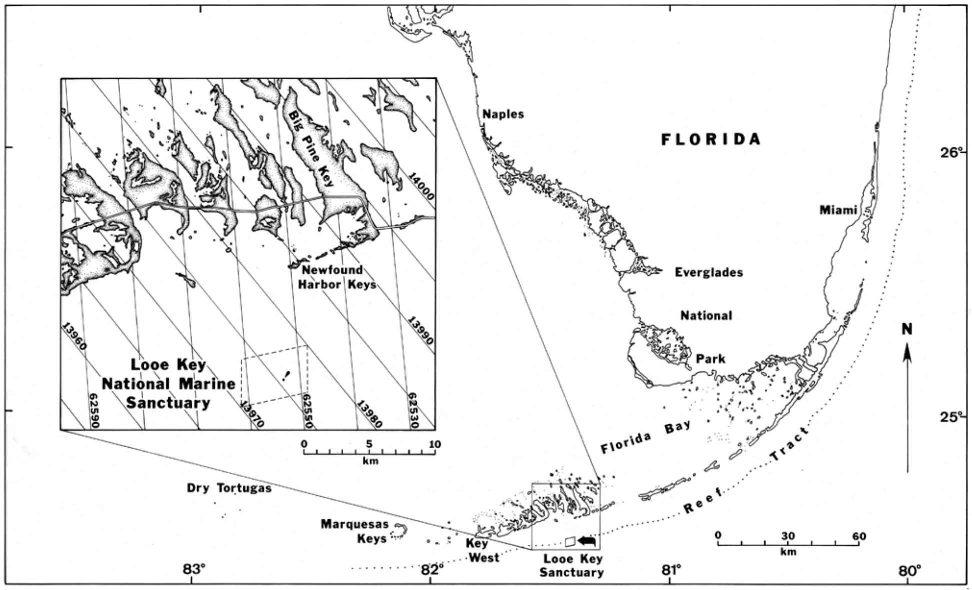

Figure 1.1. Index map for Looe Key National Marine Sanctuary. Loran C lines of position for Stations 1 (13900 µsec) and 4 (62500 µsec) for the Gulf of Mexico were reproduced from National Ocean Service chart #11442. Coast Guard Marker 24 within sanctuary (dashed lines on inset) indicated by standard nautical chart symbol for position of lighted fixed marker.

CHAPTER 2

USES OF THE SANCTUARY

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Looe Key National Marine Sanctuary is an important economic, educational, recreational, cultural, and scientific resource for the southeastern United States. The Sanctuary receives concentrated and often conflicting use because of its unique reef habitat and abundant resources. Here we document present and major recent uses of the Sanctuary. The Draft Environmental Impact Statement (Department of Commerce, 1980) and the Looe Key National Marine Sanctuary Management Plan (Department of Commerce, 1983) provide a history of the development of the Sanctuary.

The most popular recreational use of the Sanctuary is by snorkelers and SCUBA divers who want to experience the aesthetic pleasure of diving on a well-developed coral reef. The forereef area is especially attractive because of the high vertical relief, abundant marine life, and the shallow, usually clear, water. At times during periods of amenable weather, over 50 commercial and private boats may be counted in the small spur and groove zone. Major activities are recreational diving and fishing. Diving businesses teaching SCUBA diving use Looe Key for open-water training.

The major activities of divers are viewing and photographing the lush coral formations and colorful fishes (Plates 2.3 and 2.4). The diversity and abundance of organisms make the reef a popular site for viewing the behavior of organisms in their natural surroundings (Plate 2.4). Attracting fishes by feeding them is also a popular activity (Plate 2.5). Divers may bring bait from shore, but often attract fishes by breaking up sea urchins (Plate 21.5). Inexperienced divers may damage coral by grasping, bumping and standing on coral. Poor seamanship in anchoring and running aground also damage the reef. More detail on human impacts on corals are presented later (Chapter 8).

Direct consumptive uses of the sanctuary involve collecting and fishing for commercial and recreational purposes. Commercial fishing in the Sanctuary concentrates on fishes and lobster. Lobster fishing is done primarily with wooden traps and to a lesser extent by hand. Both methods are prohibited in the forereef by Sanctuary regulations (Plate 2.6). Commercial fishing is done primarily with hook and line at night. Wire trap fishing only recently became popular in southern Florida despite being used for a long time throughout the Caribbean (Plate 2.6). Wire traps were legalized by the Fishery Management councils in 1984 for waters deeper than 100 ft which includes only a small portion of the Sanctuary. Some commercial tropical fish collecting occurred at Looe Key Reef before being banned in the Sanctuary.

Most recreational fishing is by hook and line and is directed toward either food fishes (Plate 2.7) or sport fishes (Plate 2.8). Among food fishes the traditional target species are snapper

(Lutjanidae), grouper (Serranidae), grunt (Haemulidae), mackerel (Scombridae), and the hogfish (*Lachnolainus maximus*, Labridae). Sport fishing traditionally concentrated on barracuda (Sphyraenidae) (Plate 2.8), jacks (Carangidae), and sharks (usually Carcharhinidae). Recreational fishing efforts focus on bottom angling for bottom fishes and trolling for mid-water species. The population of southern Florida has grown dramatically in the last two decades and so has the number of fishermen. The cultural background of the population has also changed dramatically. These changes have resulted in more species being considered as acceptable food items.

Direct or indirect impacts of commercial and recreational fishing on the Sanctuary are not well documented. The amount of harvest from the Sanctuary is not known. Fishing activity results in hooks in fishes, corals and other organisms. Lost lures, hooks, sinkers, leaders, and line entangle octocorals, sponges and branching stony corals. Lobster traps, set on corals or dragged along the bottom by storm waves or during recovery, damage or destroy reef habitat.

The Sanctuary is also used as an educational and scientific resource. Educational institutions such as Seacamp the Newfound Harbor Marine Institute, use Looe Key Reef as a living laboratory for students of all ages and educational levels. The reef is ideal for teaching marine science as well as environmental awareness, appreciation, and understanding. A variety of scientific projects have been done in the sanctuary. Scientific research activities often involve some manipulation or temporary disturbance to the environment (Plate 2.9). Permits are required to collect for scientific or educational purposes.

Regulations have limited some historical consumptive uses in the sanctuary. Harvesting of coral at Looe Key Reef has stopped although it was apparently a common activity before being banned in Florida in the early 1970's. Amateurs and professionals collected coral primarily for tourist souvenirs. Unfortunately, no data are available on the extent to which coral harvesting occurred at Looe Key Reef. Spearfishing (Plate 2.10), tropical fish collecting, and shell collecting were also common activities at LKNMS before being banned with the establishment of the Sanctuary. Some poaching still occasionally occurs, however, either as a deliberate act or through ignorance of Sanctuary regulations.

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Plate 2.3. Observing colorful fishes and beautiful coral formations is one of the major activities by snorkelers and SCUBA divers. The queen angelfish, *Holacanthus ciliaris*, (top) is one of the most colorful and graceful reef fish in Looe Key National Marine Sanctuary. Large colonies of pillar coral (*Dendrogyra cylindrus*) (bottom) are rare in the Florida Keys.

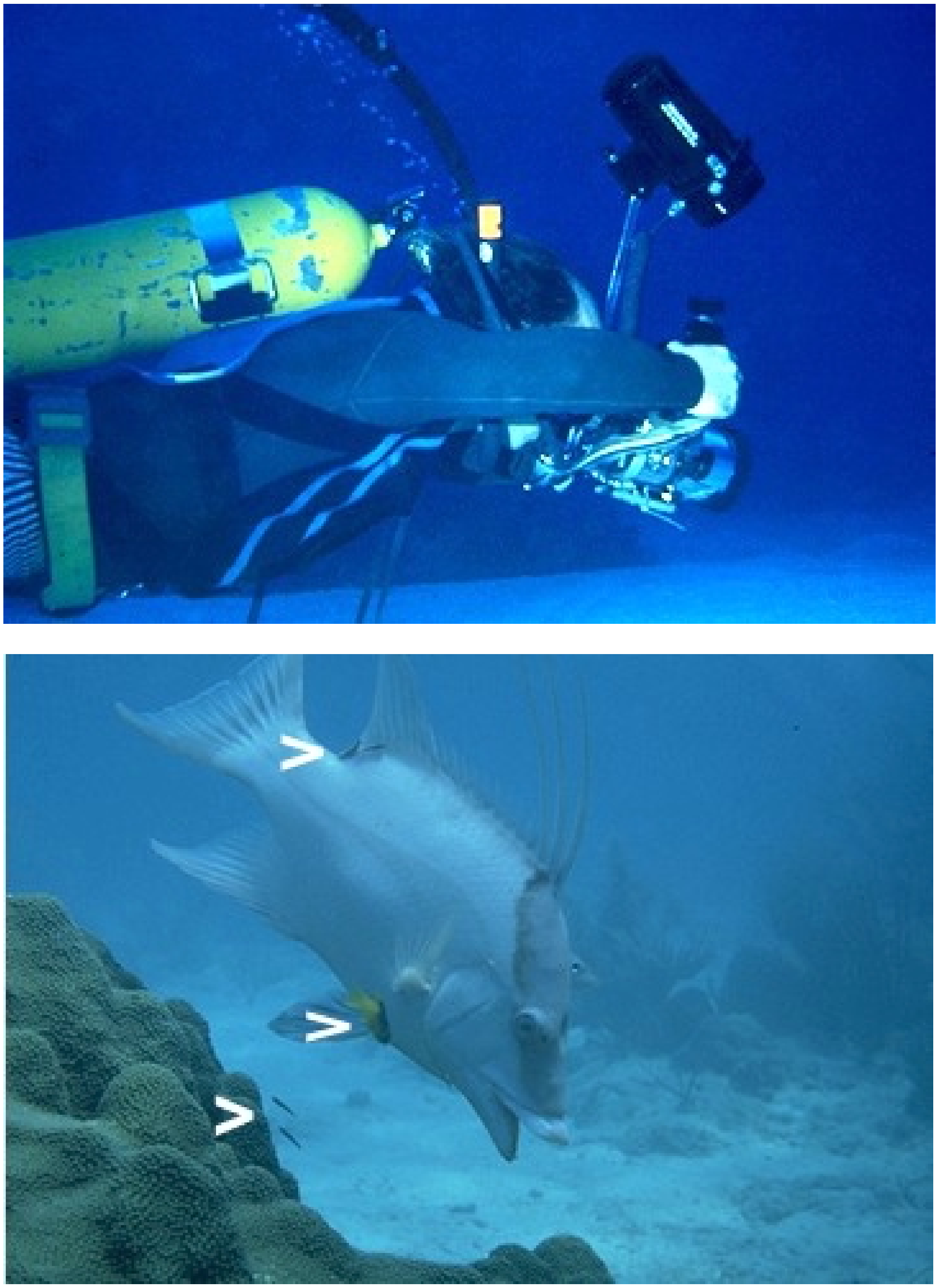

Plate 2.4. Underwater photography. (top) and the observation of natural behavior are popular activities by both scientists and non-scientists at Looe Key Reef. A hogfish, *Lachnolaimus maximus*, (bottom) is being cleaned of parasites at a cleaning station by neon gobies, *Gobiosoma oceanops* (upper and lower arrows), and a Spanish hogfish, *Bodianus rufus* (center arrow). Approaching fishes to observe behavior or to take pictures is very difficult in areas where spearfishing is a common activity.

Plate 2.5. Divers often take food underwater to attract fish such as these yellowtail, *Ocyurus chrysurus* (top). Sometimes sea urchins are broken up to attract smaller fishes (bottom). The impact of this activity is unknown.

Plate 2.6. Commercial fishing with wire fish traps (top) has increased in popularity in the Florida Keys during the last decade. Although fish traps are currently allowed only in waters deeper than 100 ft., there may be effects on fish populations within the Sanctuary. Lobster traps (bottom) are not allowed in the core reef area although an occasional trap is washed onto the reef where it can damage coral through wave action.

CHAPTER 3

GENERAL HABITAT DESCRIPTION AND MAPPING

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Introduction

An important goal of the resource inventory is to qualitatively describe and map the major habitats within the Sanctuary. Accurate maps are necessary to relocate important features in the Sanctuary and to monitor changes resulting from natural or human induced perturbations. Detailed large scale maps of the forereef habitat are particularly desirable because it receives the most intense use.

Methods

Horizontal aerial photographs taken 22 November 1974 by NOAA (NOS 8284 to 8287) were used to map gross habitat features in the Sanctuary (Plate 3.1). Major features were identified by photointerpretation with groundtruth based on verification by divers or surface observations. Large scale maps of the forereef were made (Figs. 3.1, 3.2, Appendix 3.A). from low altitude aerial photographs taken of the forereef and shallow hardbottom habitats at a 200 ft/in (24.4 m/cm) scale. Diver surveys were used to identify and generally characterize the various habitats to a depth of 40 ft (12 m). Deeper depths were not surveyed due to budget and diving safety constraints.

Based on the initial survey, three forereef spur formations were selected for detailed coral, fish, and geological surveys (Figure 3.3).

Two spurs were selected to represent the middle portions of the forereef and one was selected to represent the edge of the forereef. Using the same sites insured that survey results by different specialists would be as comparable as possible. The actual detailed survey results will be reported in separate chapters.

Results

Eight basic habitat types were identified in the Sanctuary although four habitats were subdivided into other classifications (Figure 3.4, Plate 3.1). A general map of the Sanctuary with a transect showing horizontal habitat characteristics and the vertical depth profile was produced from general survey results (Figure 3.5). Below we qualitatively describe general habitat characteristics for each habitat. More detailed descriptions and quantitative analyses of sediments, corals, and fishes are provided in later chapters.

1. Live Bottom. This habitat, sometimes called hardbottom (Marszlek, 1983), is characterized by solid calcium carbonate substrate dominated by scattered sponges, soft corals and isolated hard corals. This habitat has low vertical relief and less hard coral coverage when compared to most true reef habitats (Plate 3.2). Shallow and deep live bottoms were distinguished based on the depth of occurrence and proximity inshore or offshore. Deep live bottom habitat (Plate 3.3) occurs mostly on the eastern and western areas of the sanctuary near the Straits of Florida at depths of 8 to 12 m (25 to 40 ft). The shallow live bottom habitat (Plate 3.4) occurs mostly in

a narrow zone along the northern areas of the sanctuary near the edge of Hawk Channel at depths of 6 to 9 m (18 to 30 ft).

2. Deep Reef. This habitat was not surveyed in this study due to budget and safety constraints. A general description of this habitat was provided in the Draft Environmental Impact Statement (US Department of Commerce, 1980).

3. Buttress. This zone, dominated by hard corals (Plate 3.2), occurs south and west of the forereef spur and groove tract in a depth range of 10 to 12 m (30 to 40 ft). It is characterized by large colonies of the mountainous star coral *Montastraea annularis* although much of this habitat is covered by sponges and soft corals.

4. Forereef. This zone, also called the spur and grove tract, is characterized by high relief coral formations known as spurs separated by sand channels known as grooves (Plate 3.1). The spurs extend seaward from the reef crest, the shallowest portion of the reef. Spur formations are often called "fingers" because their structure and orientation looks from above like giant fingers of a hand resting on the bottom. Shinn *et al.* (1981) cored several of the spurs and found they were composed mainly of elkhorn coral *Acropora palmata*. Sand composes the substrate underneath the forereef, unlike other reefs examined in the Florida Keys which had foundations on solid calcium carbonate platforms (Shinn, *et al.*, 1981).

The forereef can be divided into three zones. The deepest portion of the forereef is the *Montastraea*/octocoral zone or the deep spur and groove zone. It is characterized by a high diversity of coral species but relatively low vertical relief (Figure 3.6, Plate 3.5). The middle zone, known as the *Acropora* transition zone, has the highest species diversity for corals (Figure 3.7, Plates 3.6 and 3.7). It is characterized by the occurrence of *Acropora palmata* (Plate 3.8) although this species in not necessarily present on every spur. The shallowest forereef zone is the *Millepora*/*Palythoa* zone (Figure 3.8, Plates 3.8, 3.9) which is dominated by firecoral (*Millepora complanata*) and the zoanthid (*Palythoa caribaeorum*). This zone is considered a high energy zone because it receives the most wave energy. Damage from wave action is believed to limit the presence of most corals in this zone. The shallowest portion of this zone, the reef crest, is where corals exist near the surface and may be partially exposed during the lowest tides.

5. Rubble. Rubble from dead and broken corals composes two features known as the rubble zone and the rubble horns. The rubble zone occurs immediately shoreward of the forereef reef crest. This zone is composed of broken coral fragments thrown behind the reef by wave action from storms. In parts of the rubble zone nearest the reef, the rubble has been cemented together to form a solid substrate and may have small attached colonies of soft or hard corals (Plate 3.10). Isolated living corals, especially *Acropora palmata*, exist in various areas of the rubble zone (Plate 3.10). The rubble horns (Plate 3.11) are composed of unconsolidated rubble cobble thrown up on the east and west sides of the lagoon by refracted wave patterns and occasional storms (Kissling, 1975). The rubble zone and the rubble horns enclose the lagoon habitat.

6. Lagoon. The lagoon, also called the reef flat (US Department of Commerce, 1983), is a shallow triangular-shaped area bounded by rubble habitat. The base of the triangle is the rubble zone immediately behind the forereef and the other two sides are the rubble horns discussed above. The depths of the lagoon extend from the surface to approximately 3 m (10 ft). The middle of the lagoon is a mixed sand and rubble bottom covered by sand and seagrass beds with occasional isolated coral heads (Plate 3.12). Seagrasses nearest the rubble zone are generally heavily grazed by fishes and sea urchins.

7. Sand Flats. This is generally a uniformly flat, featureless habitat distinguished by sand cover of variable depth (Plate 3.13). Isolated protrusions of coral or a calcium carbonate platform

occur occasionally. This habitat covers the most area in the sanctuary and surrounds most other reef, seagrass, and hard bottom habitats.

8. Seagrass Flats. Much of the Sanctuary is covered by beds of seagrasses dominated by the angiosperms turtle grass, (*Thalassia testudinum*) and eel grass (*Syringodium filliforme*) (Plates 3.12, 1.13, 3.14). Other algae, especially *Halimeda* spp. are scattered throughout the seagrass beds. The edges of these beds may be quite distinct or may gradually taper into sand.

Discussion

General qualitative descriptions of the different zones are basically similar to the descriptions provided in the DEIS proposal (US Department of Commerce, 1980) and will not be repeated here. Quantitative descriptions of species present are given in appropriate later chapters.

Results from this general survey differ in several respects from previous descriptions of the Sanctuary. In particular, the area described as a patch reef zone (US Department of Commerce, 1980) is actually a mixture of seagrasses, sand flats, and live bottom. True "patch reefs" occur near the Newfound Harbor Keys, north of the Sanctuary. Pillar coral (*Dendrogyra cylindrus*) were reported on "patch reefs" (what we call hard bottom) in the Draft Environmental Impact Statement (US Department of Commerce, 1980). Our survey did not find any colonies of pillar coral in the Sanctuary outside the forereef, despite intensive searches along the inshore strip of live bottom. Conversations with local divers indicate that at least one area exists with pillar corals but it is apparently inshore of the Sanctuary boundaries.

Results reported here also differ from the Florida Reef Tract Marine Habitats and Ecosystems (MHE) Maps (Marszlek, 1983) which were based on interpretation of high altitude aerial photographs. The MHE maps do not distinguish between our livebottom and reef classifications. However, the MHE description of hardbottom corresponds to our classification of live bottom. The rubble horns (Figure 3.4) are erroneously listed as coral bottom on the MHE maps. Also, the shallow live bottom band we show near Hawk Channel (Figure 3.4) is not shown on the MHE maps, although it should appear as limestone bedrock. We also observed more coverage by sea grass beds near the eastern Sanctuary boundary than indicated in the MHE maps. The differences between our maps and the MHE maps show the importance of groundtruth verification when interpreting aerial photography.

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Marszalek, D. S. 1983. Florida Reef Tract Marine Habitats and Ecosystems. (Maps). Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, FL.

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U. S. Department of Commerce. 1980. Draft environmental impact statement, proposed Looe Key National Marine Sanctuary, April 1980. Natl. Oceanic Atmospheric Admin., Office Coastal Zone Mgmt. 128 pp.

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Appendix 3.A

Large scale section maps of the Looe Key Reef forereef spur formations.

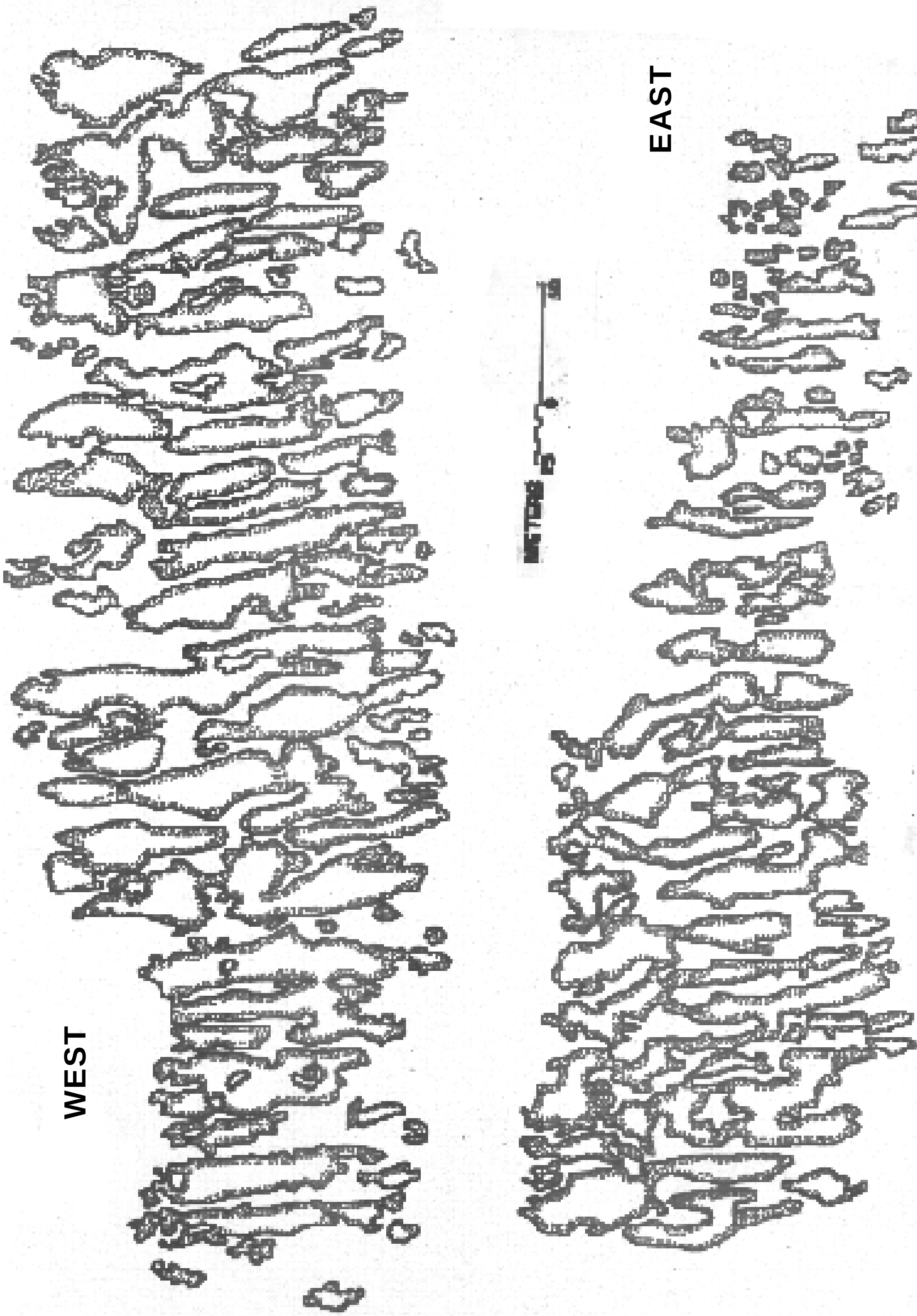


Figure 3.1. Map of the Looe Key forereef.

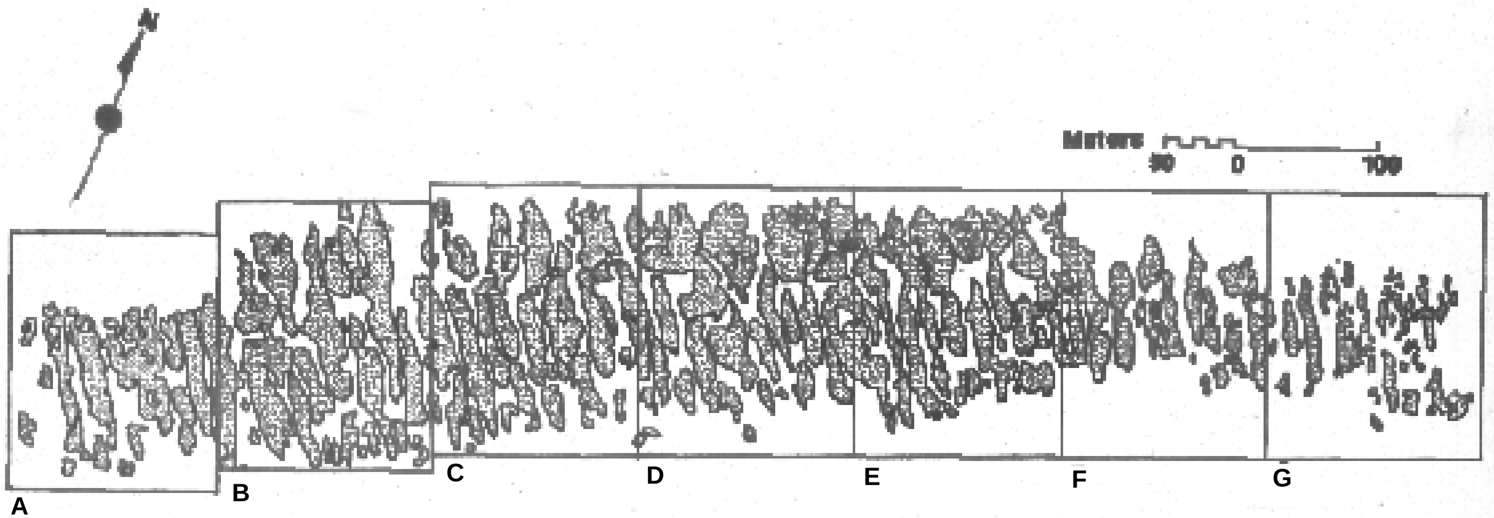


Figure 3.2. Section maps of Looe Key Reef. Stippled portions show spur formations of the forereef zone, the major portion of the reef. This is a key to the section maps on following pages.

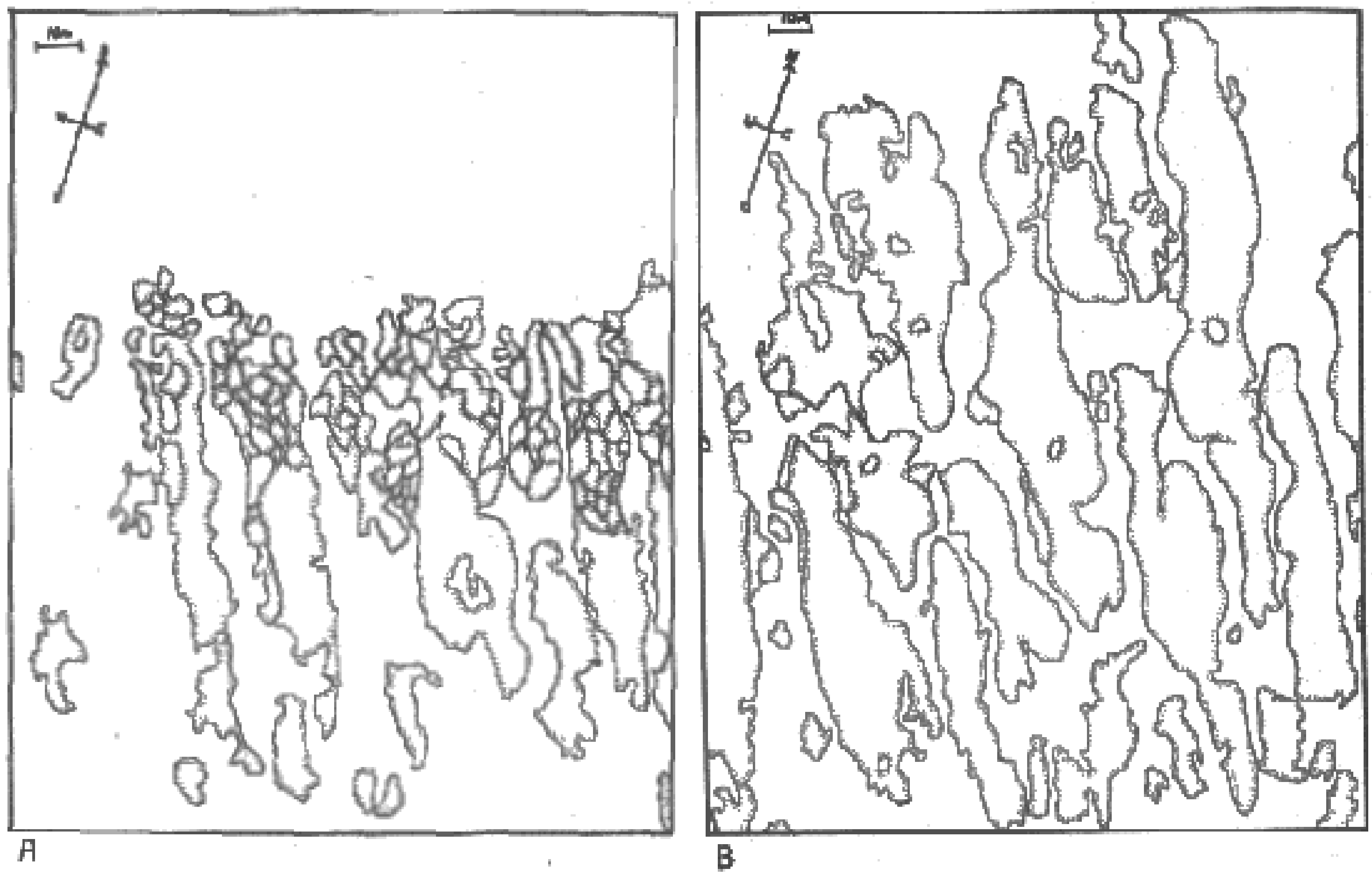


Figure 3.2. Section maps of Looe Key Reef (cont.)

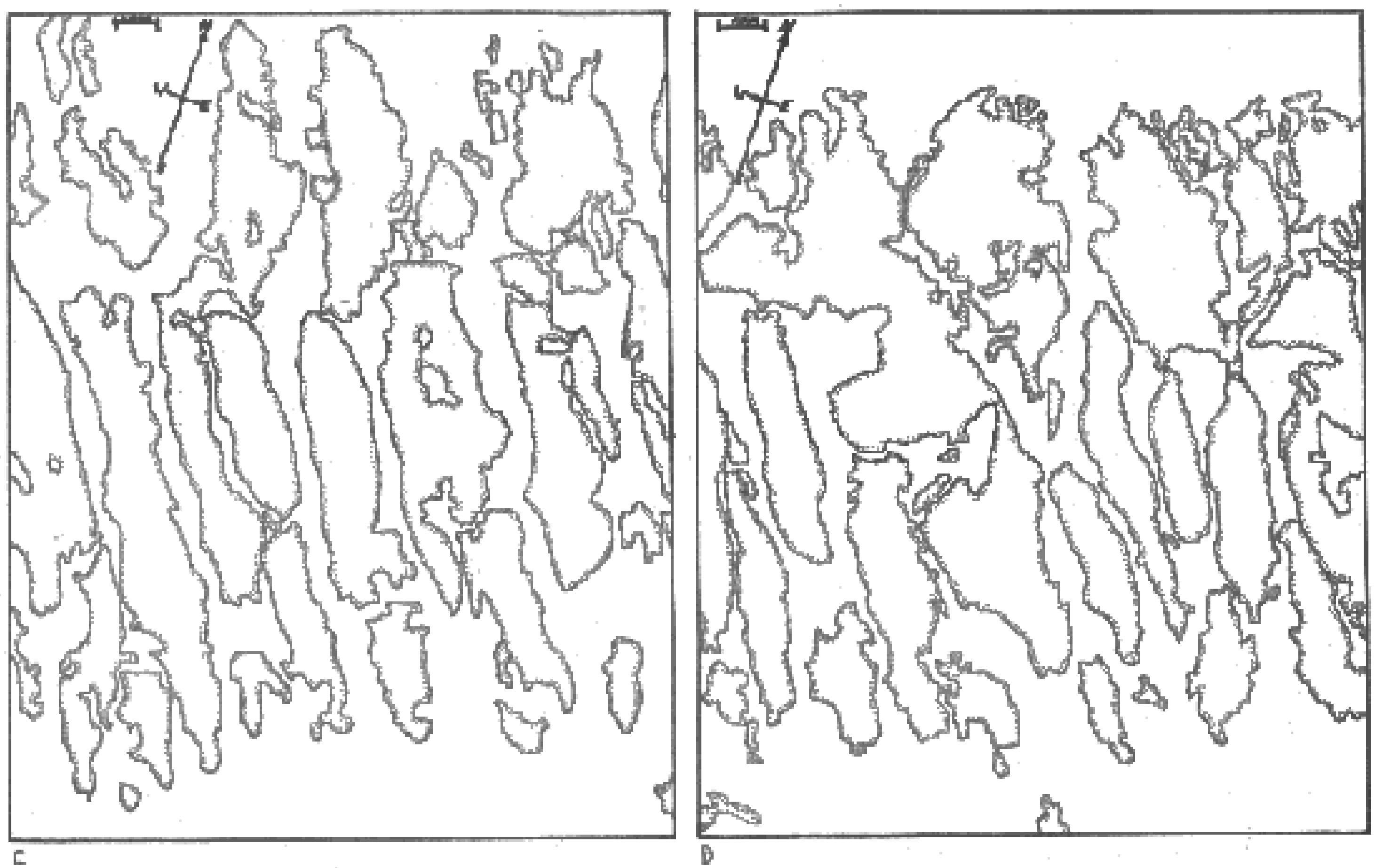


Figure 3.2. Section maps of Looe Key Reef (cont.)

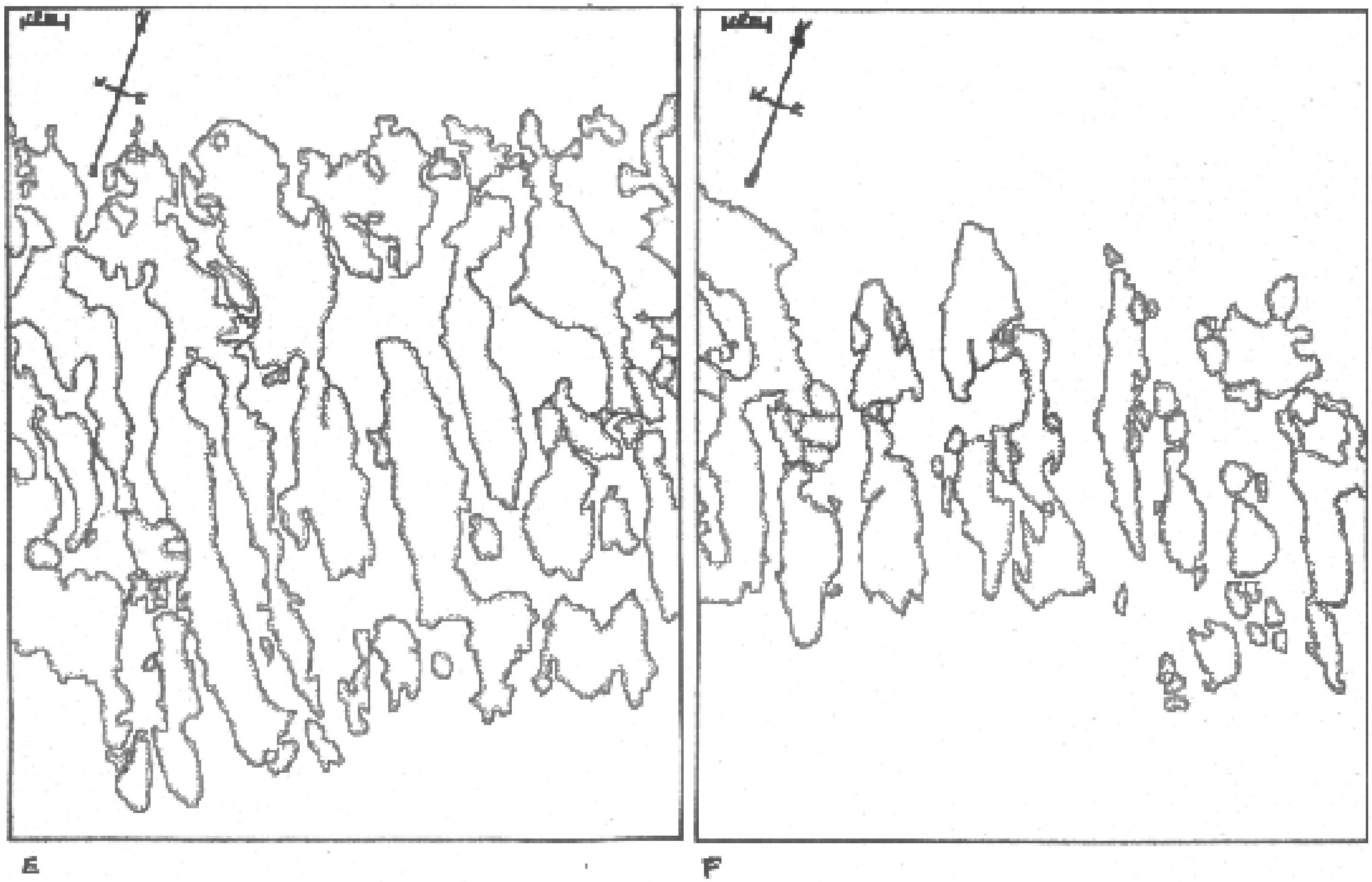


Figure 3.2. Section maps of Looe Key Reef (cont.)

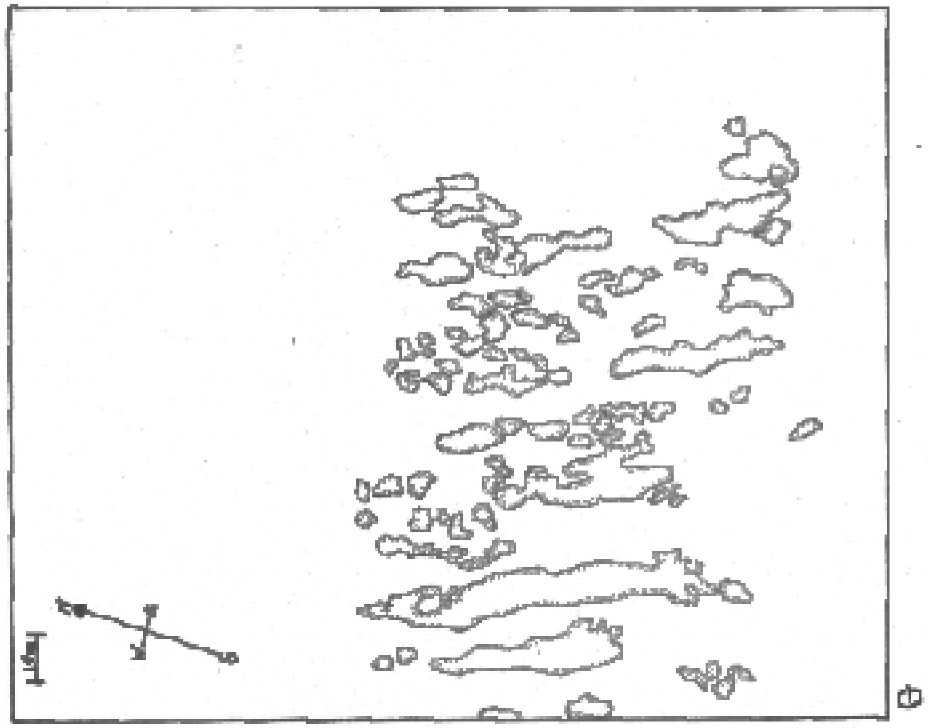


Figure 3.2. Section maps of Looe Key Reef (cont.)

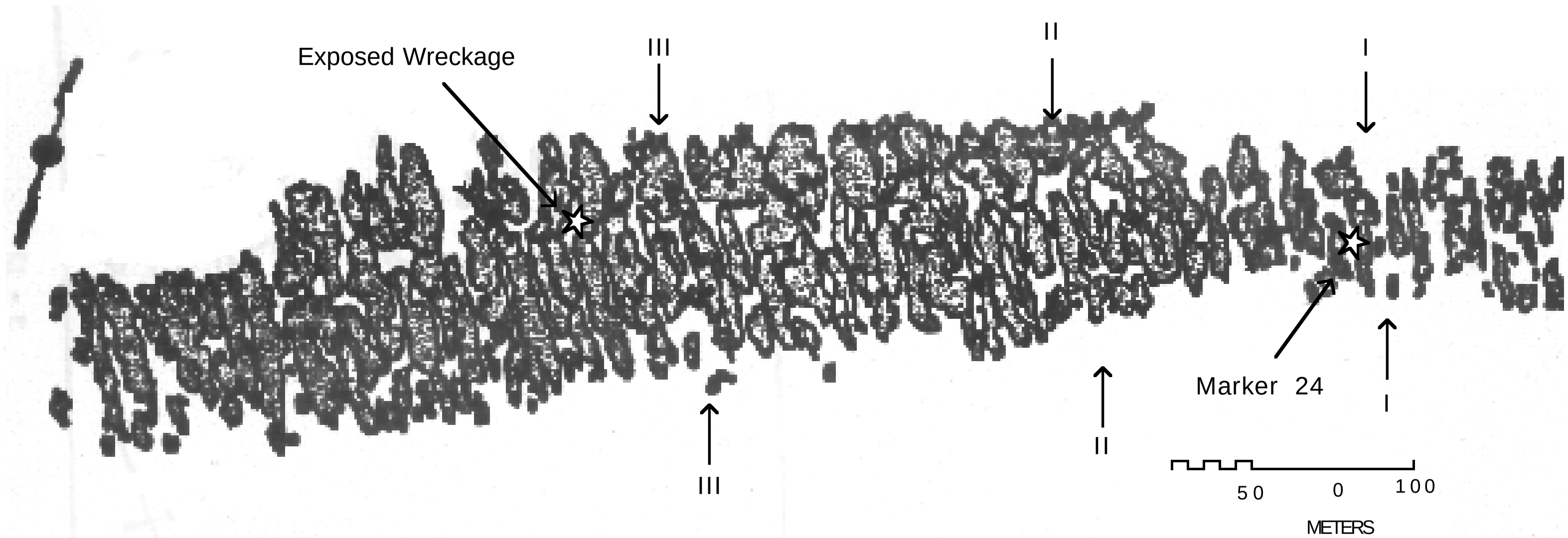


Figure 3.3. Location of permanent study spur on Looe Key Reef.

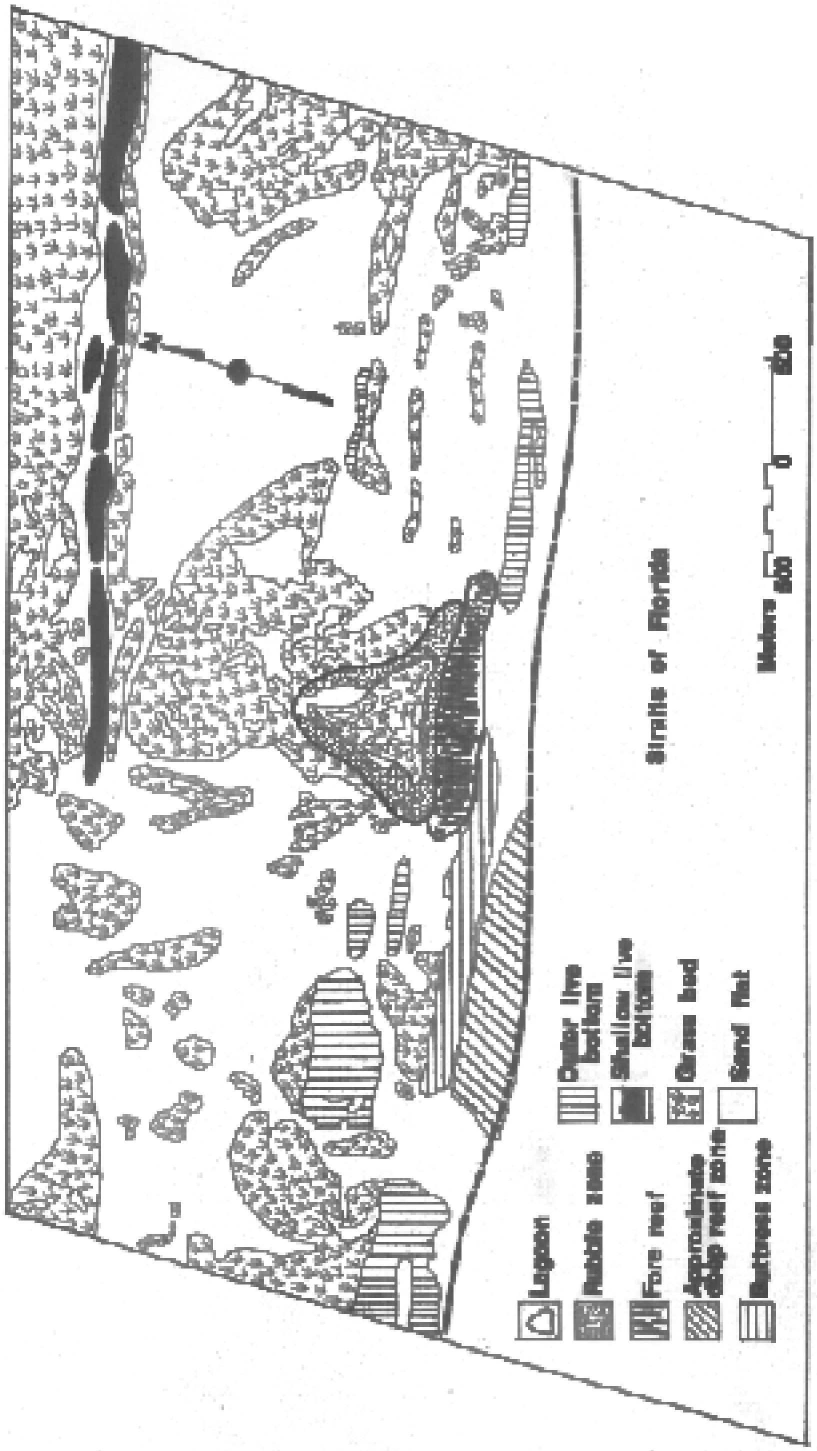


Figure 3.4. Habitat map of Looe Key National Marine Sanctuary.

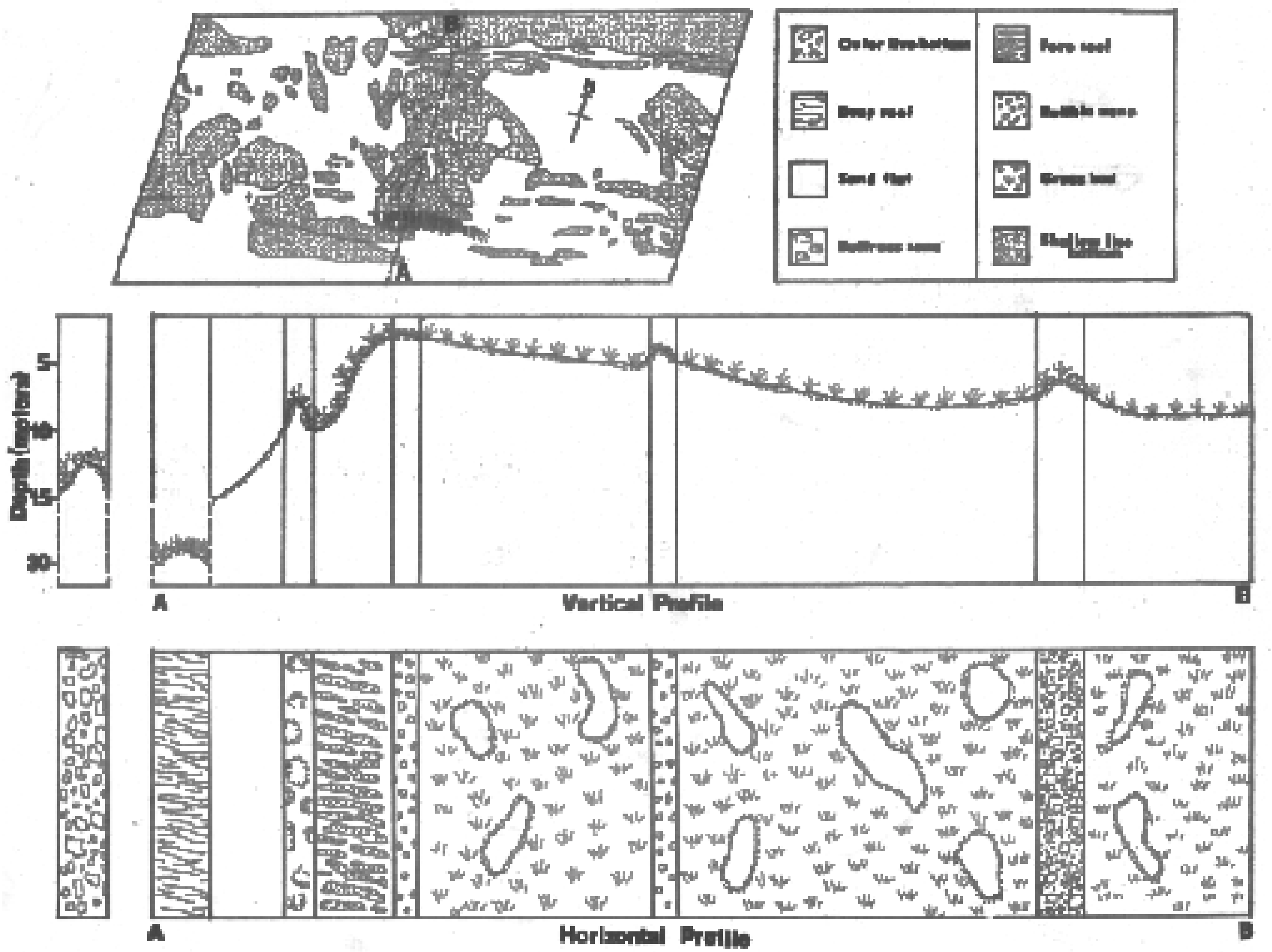


Figure 3.5. Vertical and horizontal profiles in Looe Key National Marine Sanctuary. The profile of deep live bottom habitat on left did not occur along the approximate transect between points A and B but occurs in western and eastern portions of the Sanctuary (see Figure 3.4).

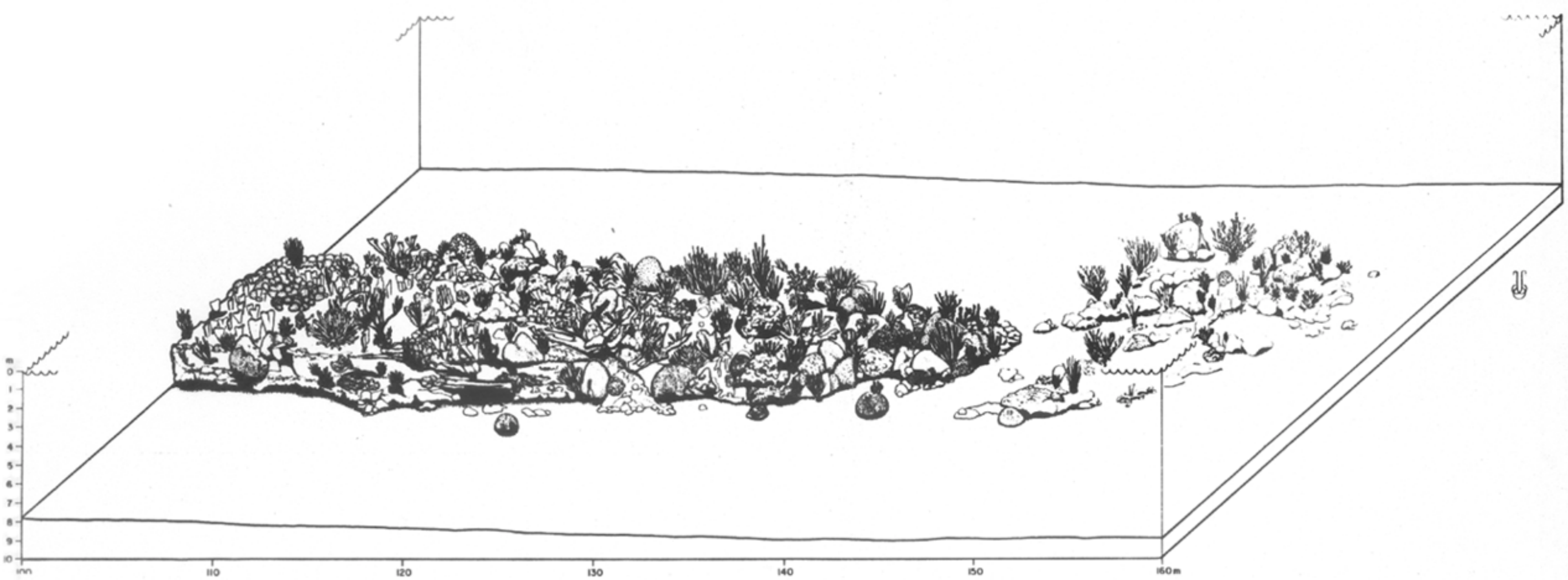


Figure 3.6. Representative view of Acropora transition zone. See Figure 3.9 for identification key.

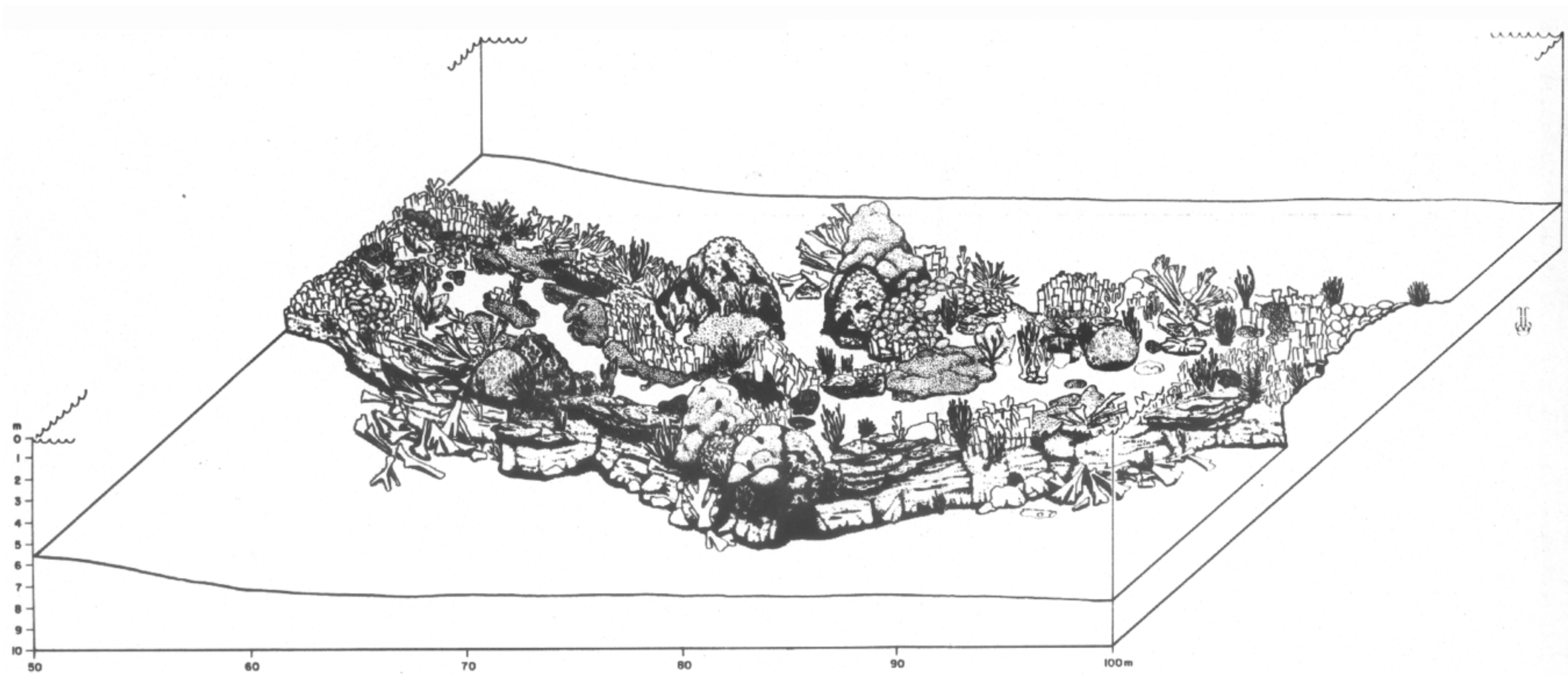


Figure 3.7. Representative view of Acropora transition zone. See Figure 3.9 for identification key.

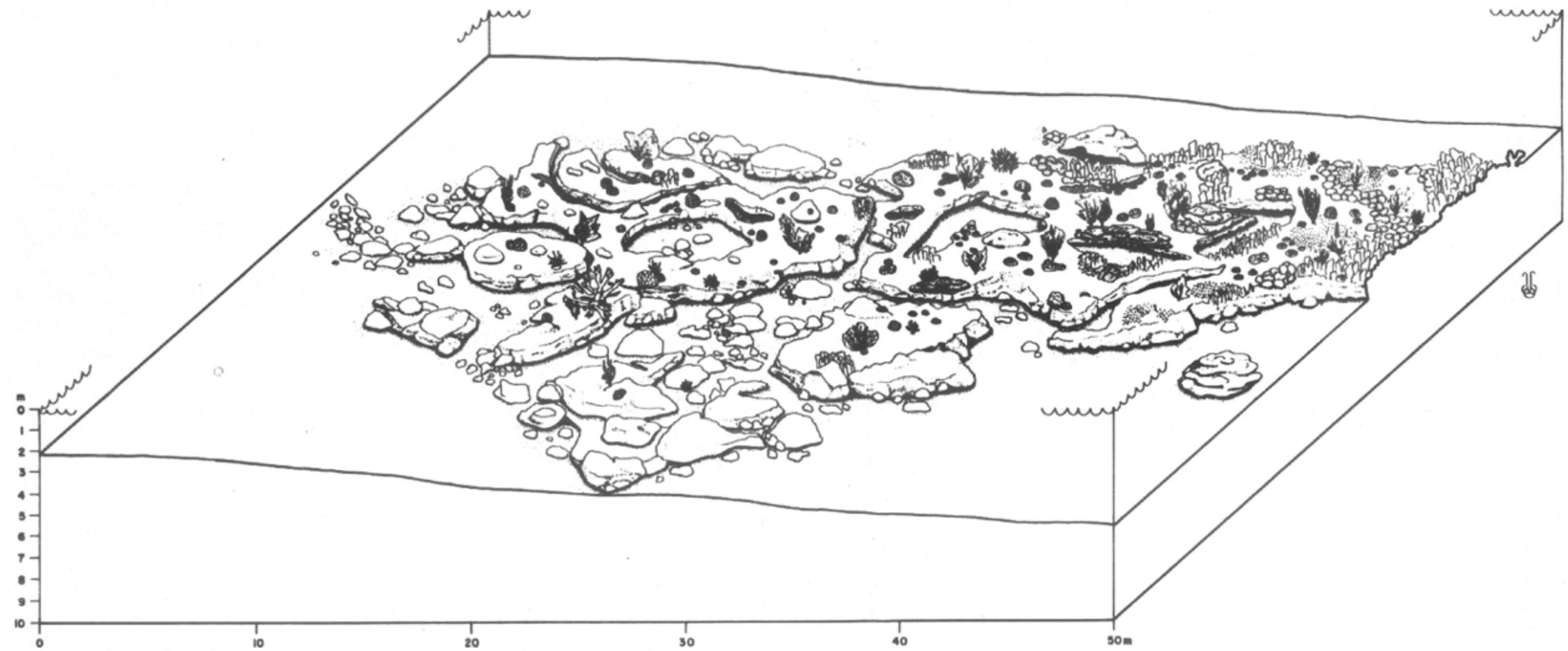


Figure 3.8. Representative view of Millepora/Palythoa zone. See Figure 3.9 for identification key.

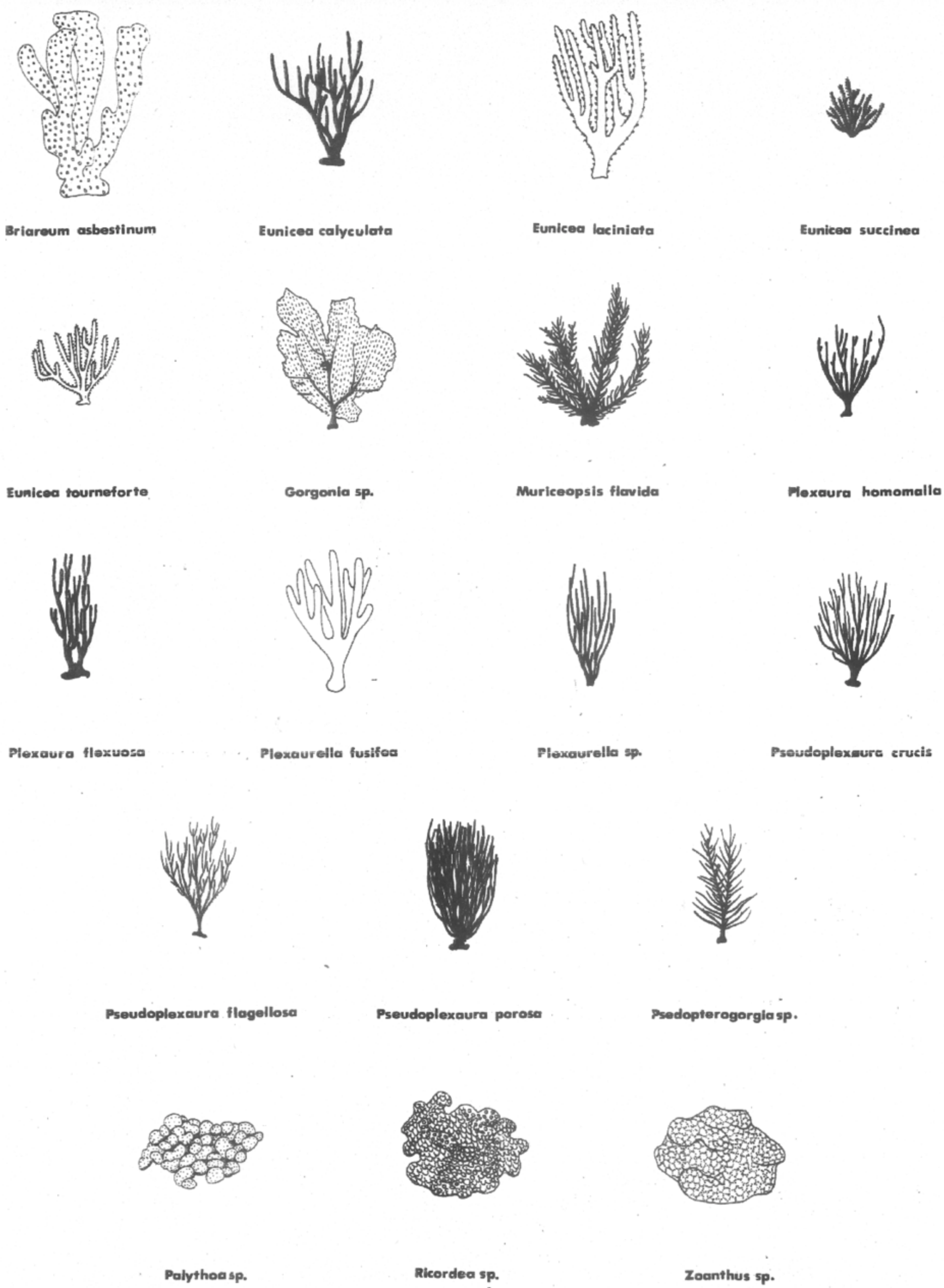


Figure 3.9. Key to coral identification for Figures 3.6, 3.7 and 3.8.

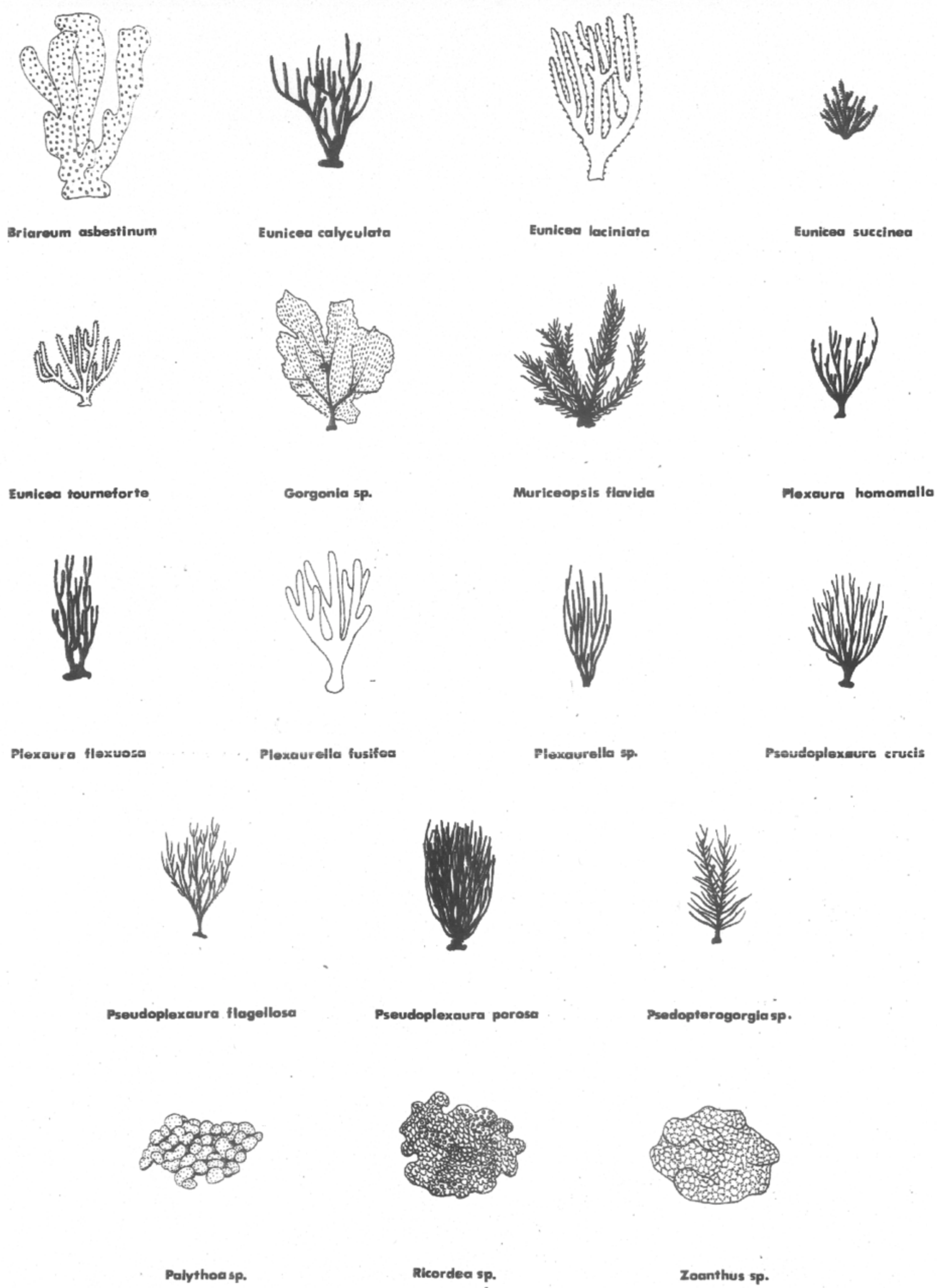
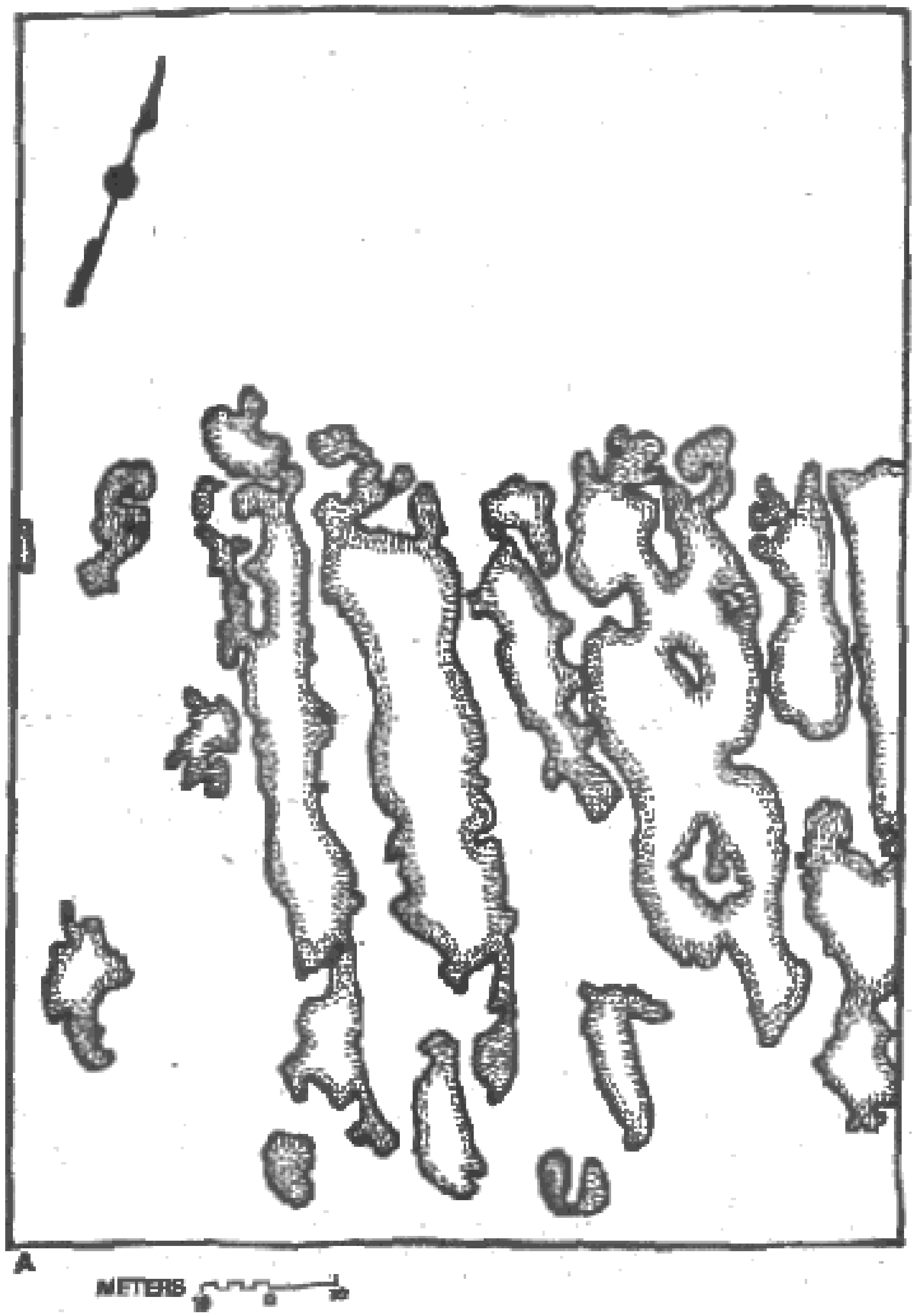
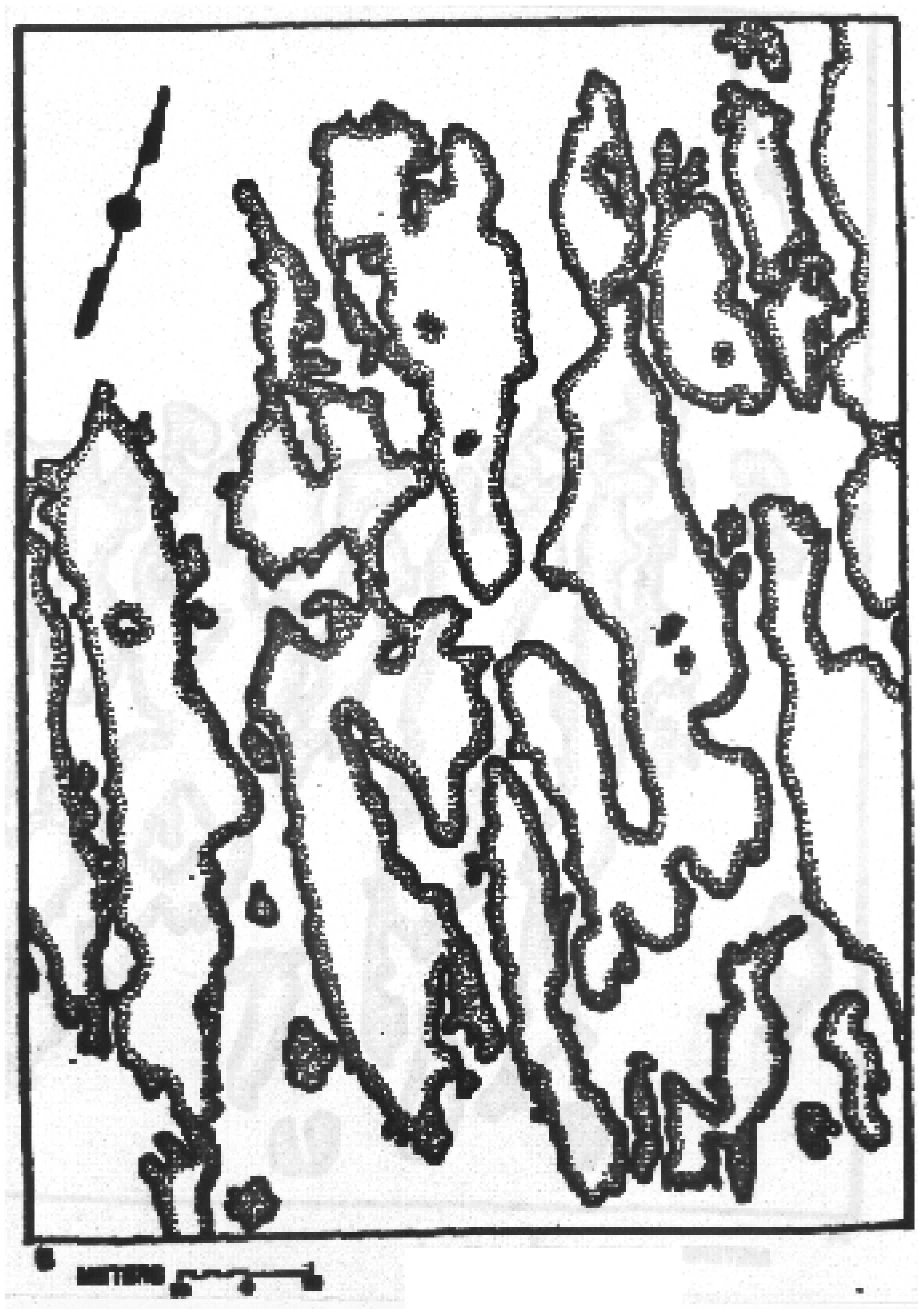


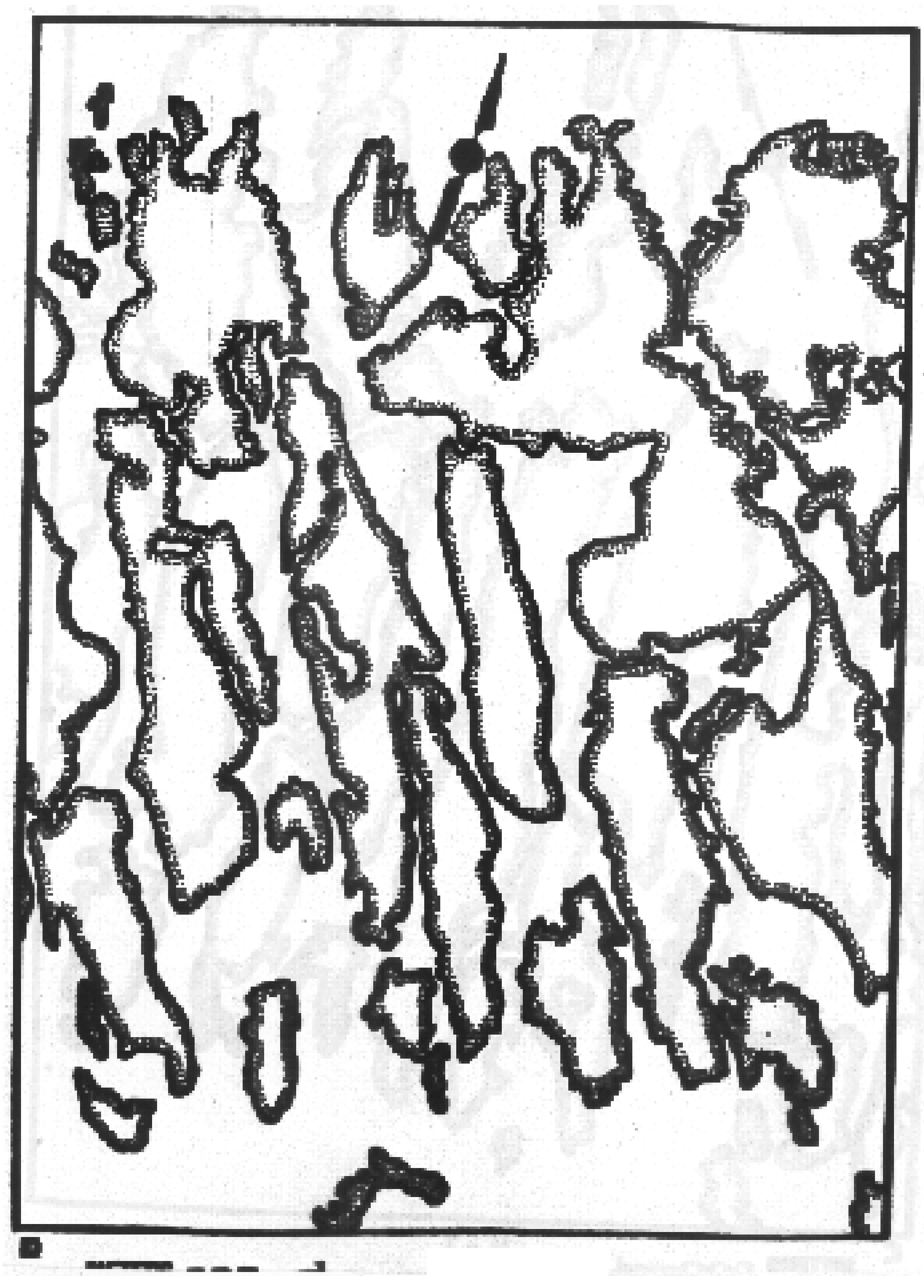
Figure 3.9. Key to coral identification for Figures 3.6, 3.7 and 3.8 (cont.).

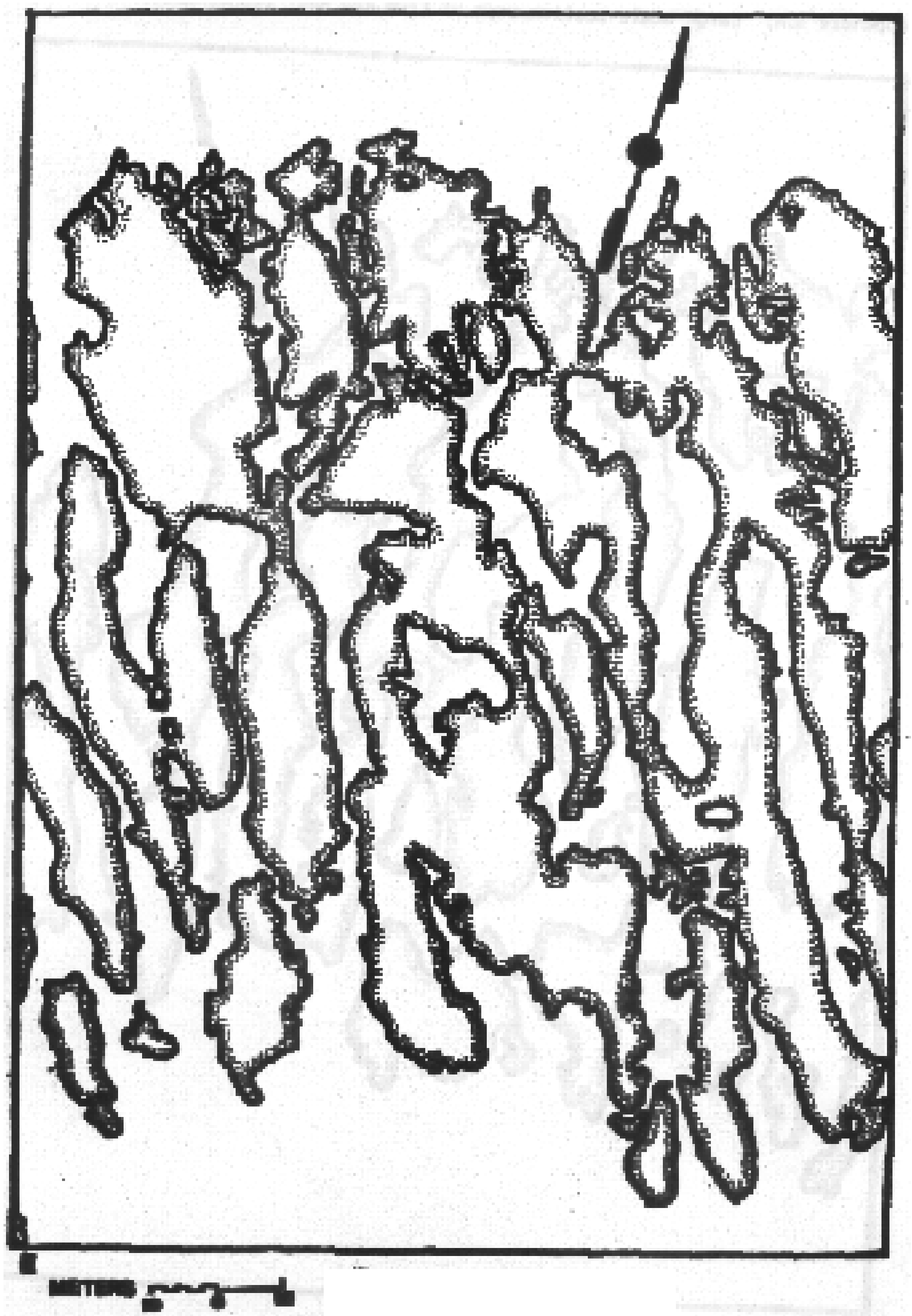
Appendix 3.A. Large scale section maps of the Looe Key Reef forereef spur formations. See Figure 3.2.

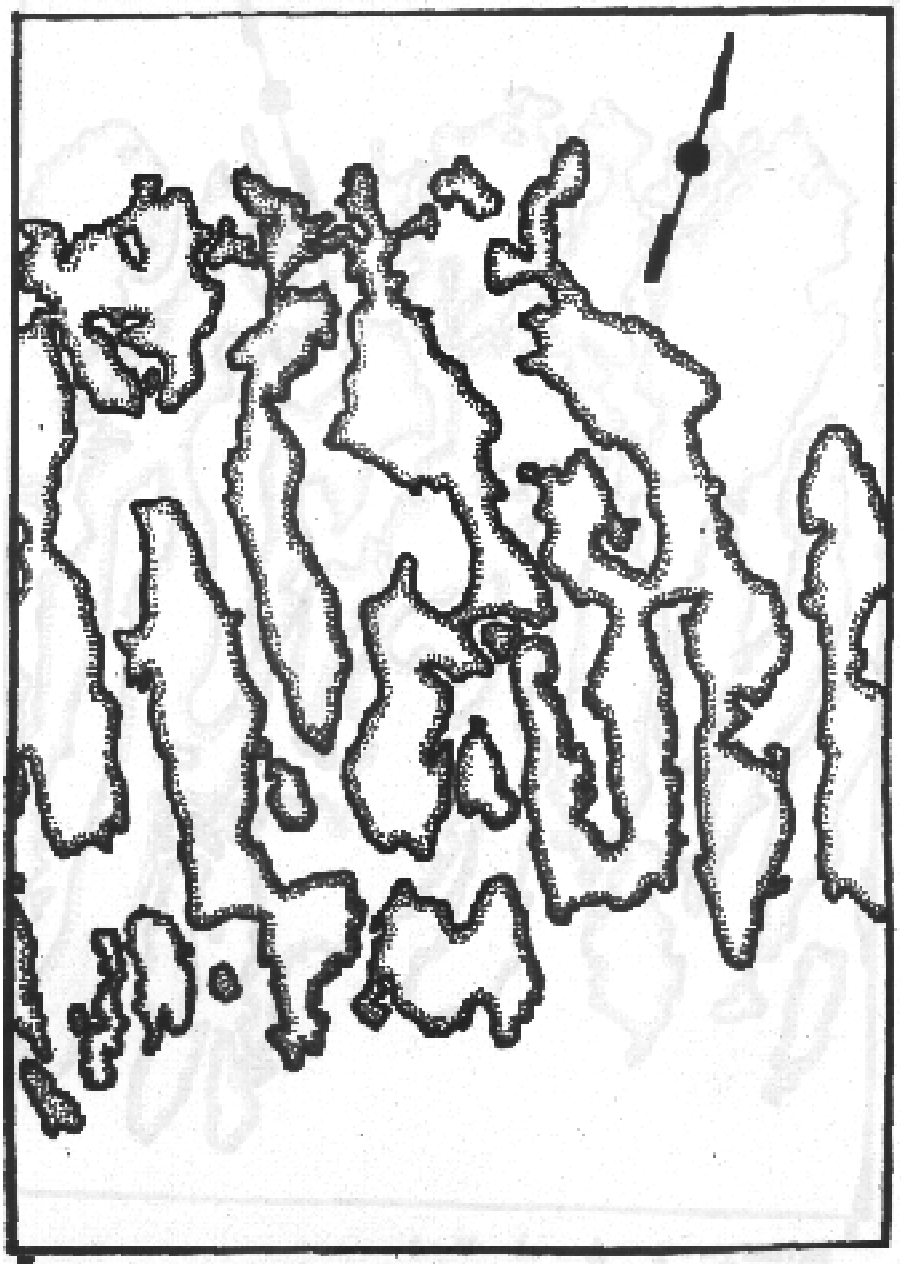


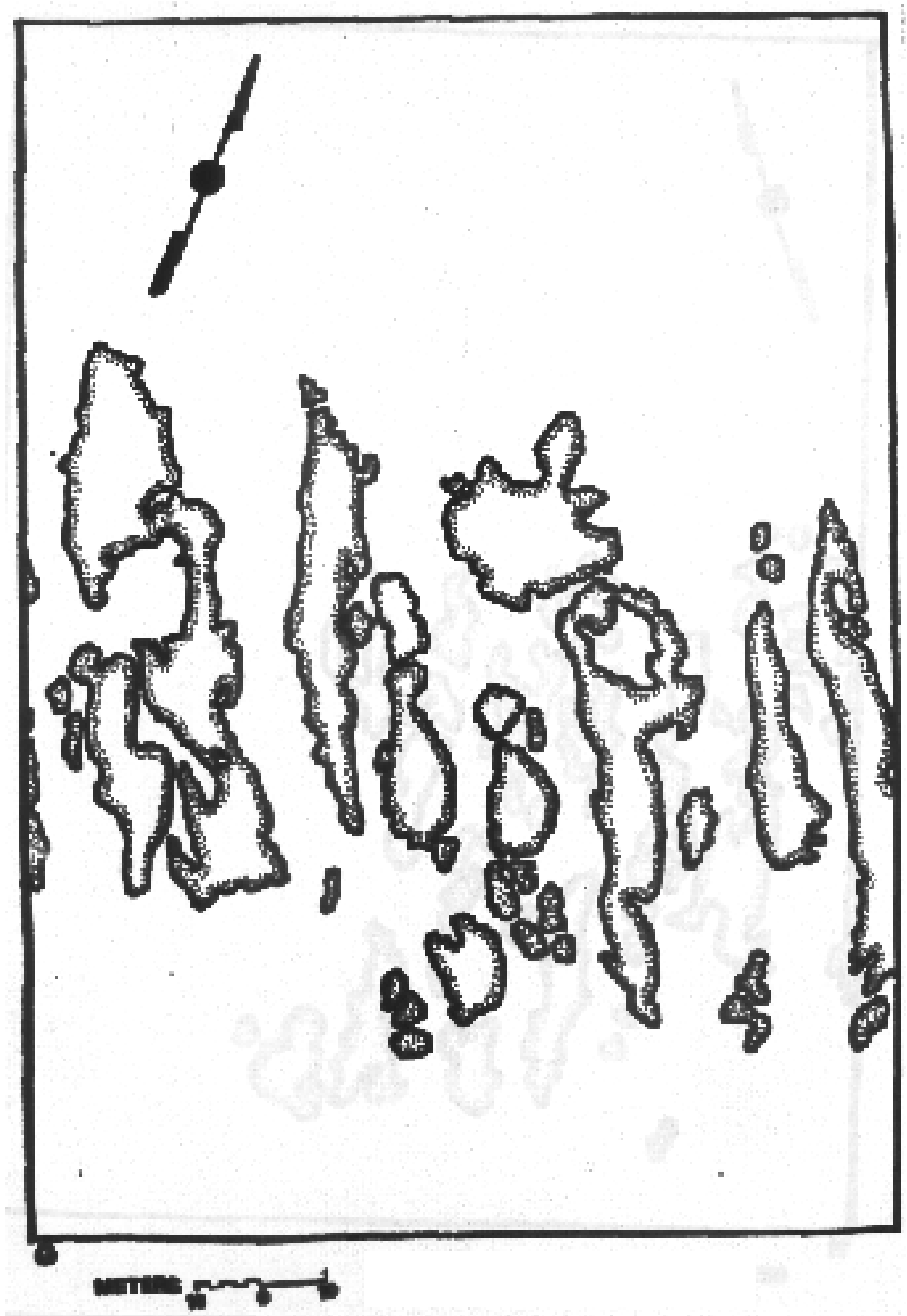


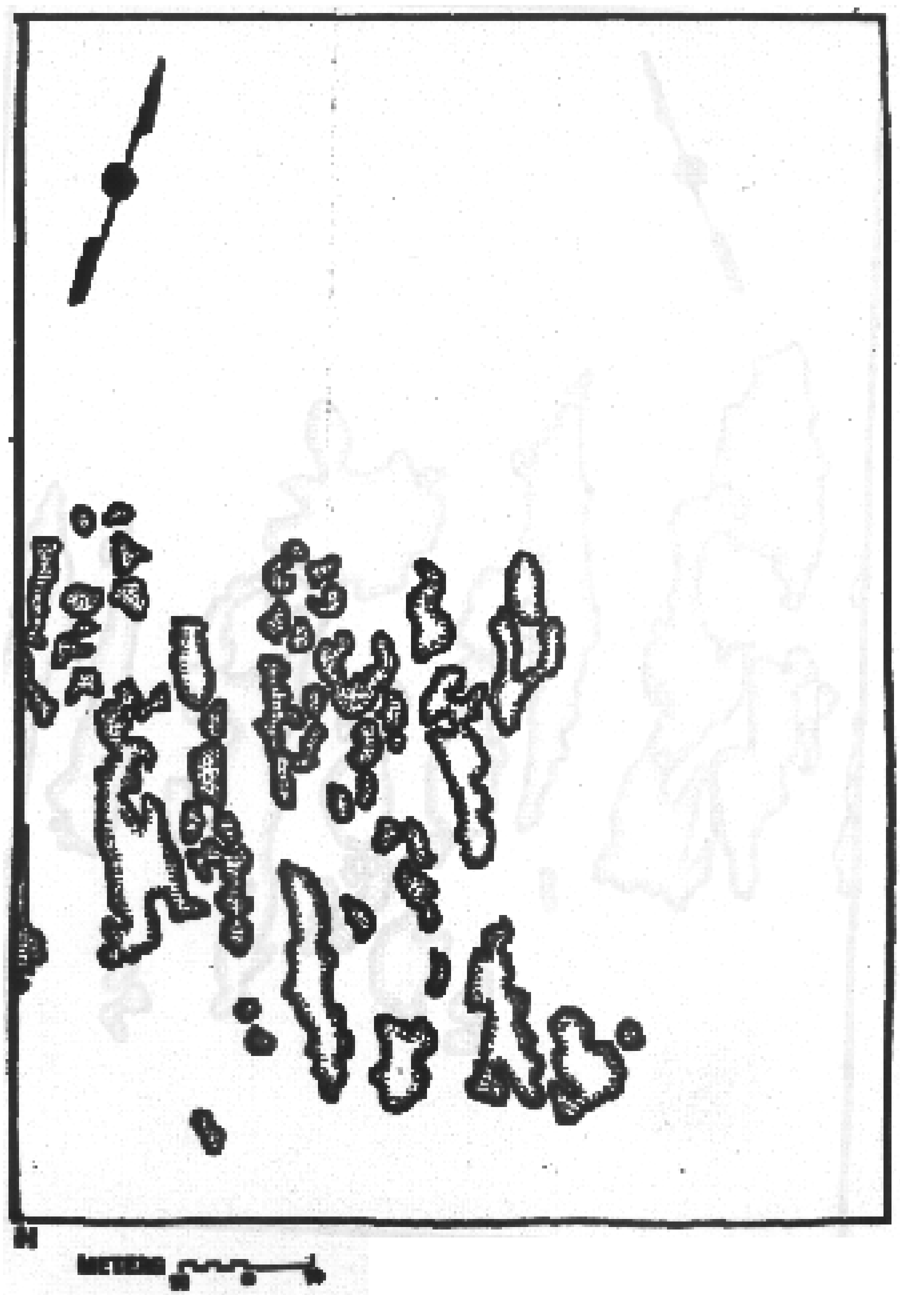

C











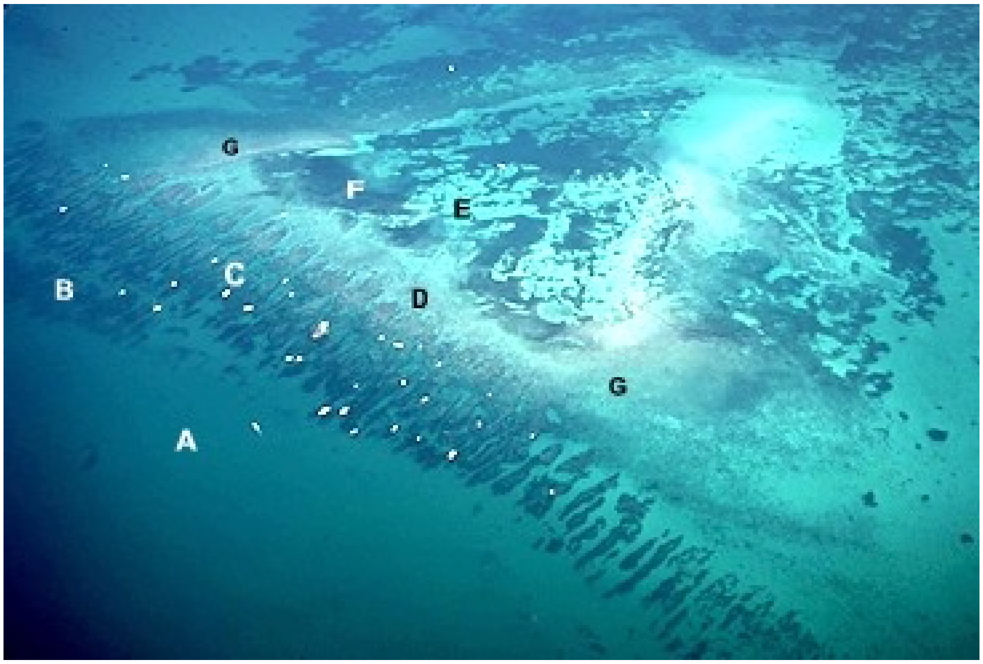


Plate 3.1. Oblique aerial photo of the forereef looking northwest. Letters show several reef Zones: Al deeper sand flats; 89 buttress zone; C, forereef (spur and groove formation); D, rubble zone; E, lagoon sand; F, lagoon grass beds; G, lagoon rubble horn on the west (left) and on the east (right).

Plate 3.2. Typical live bottom (left) and buttress zone coral reef formation (right). Live bottom is characterized by expanses of dead calcium carbonate substrate dominated by sponges and soft corals (Octocoralla) with occasional colonies of hard coral (Scleractinia). Coral reefs are characterized by a dominance of living hard corals. Live bottoms generally have low vertical relief relative to coral reefs.

Plate 3.3. Representative deep live bottom (top) with sponges, soft corals, and isolated colonies of hard corals. A bluehead wrasse, *Thalassoma bifasciatum*, is swimming in the foreground. A diver (bottom) provides scale and shows the gene al low relief habitats typical of live bottoms.

Plate 3.4. Shallow live bottom habitats (top and bottom) exist in a narrow line along the northern boundary of the Sanctuary near the edge of Hawk Channel. Sponges, soft corals, and small hard coral colonies dominate the benthic fauna.

Plate 3.5. Spur and groove formation of the forereef habitat showing typical low relief formations on the seaward ends of spurs in closeup (top) and at a distance (bottom).

Plate 3.6. Representative views of middle spur formation showing a large colony of brain coral, *Colpophyllia natans*, (top) and two growth forms of mountainous star coral, *Montastrea annularis* (bottom).

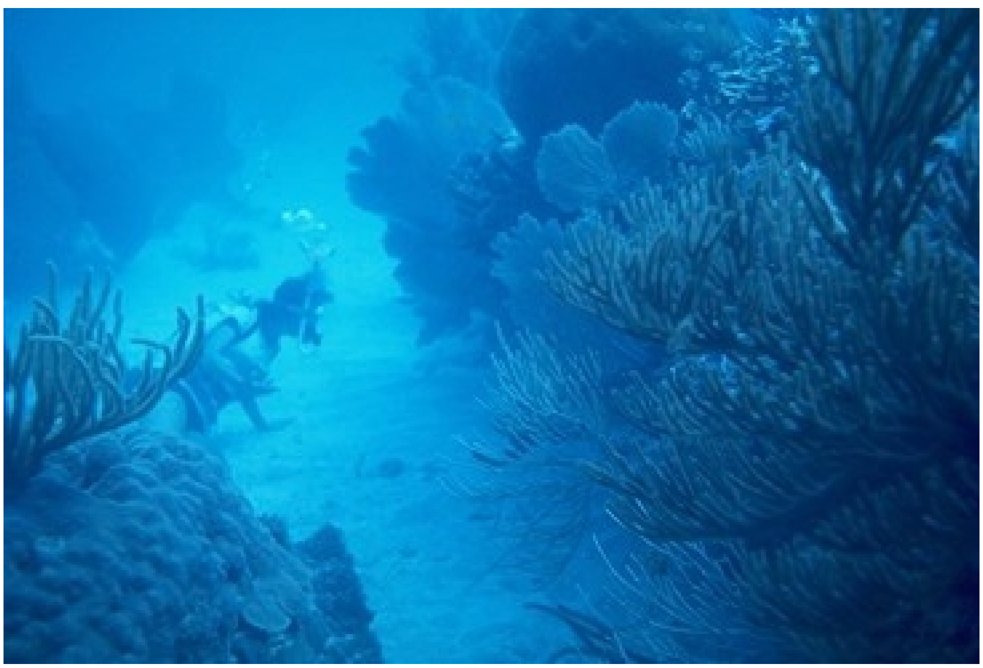


Plate 3.7. The portions of many spurs form nearly vertical walls (top) which frequently have lush growths of soft coral (bottom).

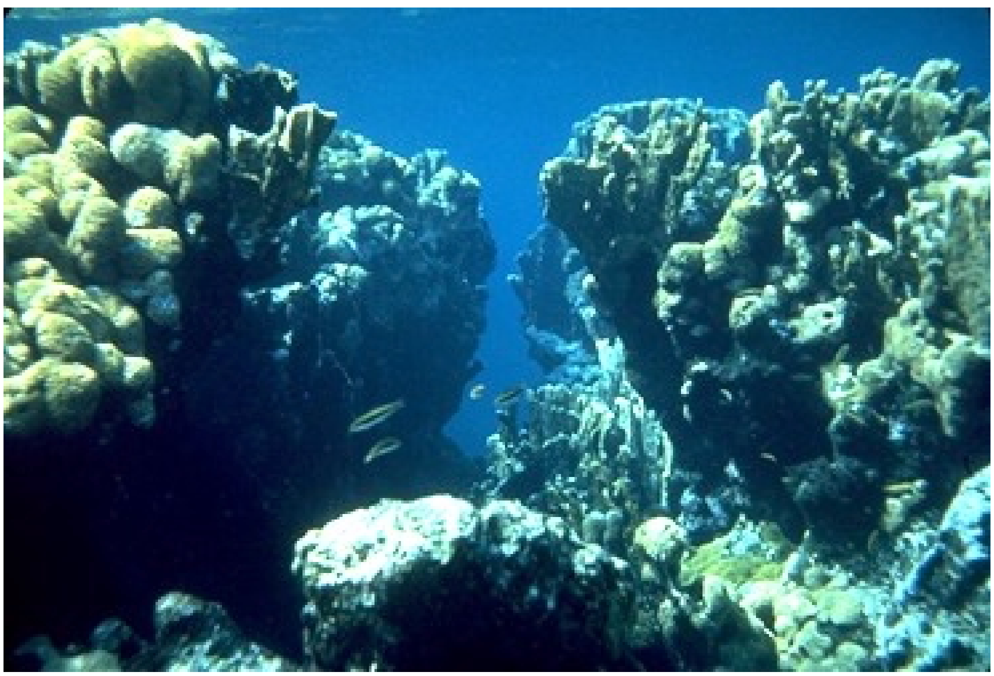


Plate 3.8. Spurs formation has historically been based on elkhorn coral, *A. palmata*, which in some areas forms extensive stands (top) that provide shelter for many species of reef fish. In shallow water spurs are usually topped by firecoral (*Millepora complanata*) and the zoanthid *Palythoa caribaeorum* (bottom).

Plate 3.9. View looking seaward (top) showing the top of a typical shallow spur formation. The tops of spurs in shallow water are usually nearly flat and dominated by firecoral (*M. complanata*) and the zoanthid *Palythoa caribaeorum* (bottom).

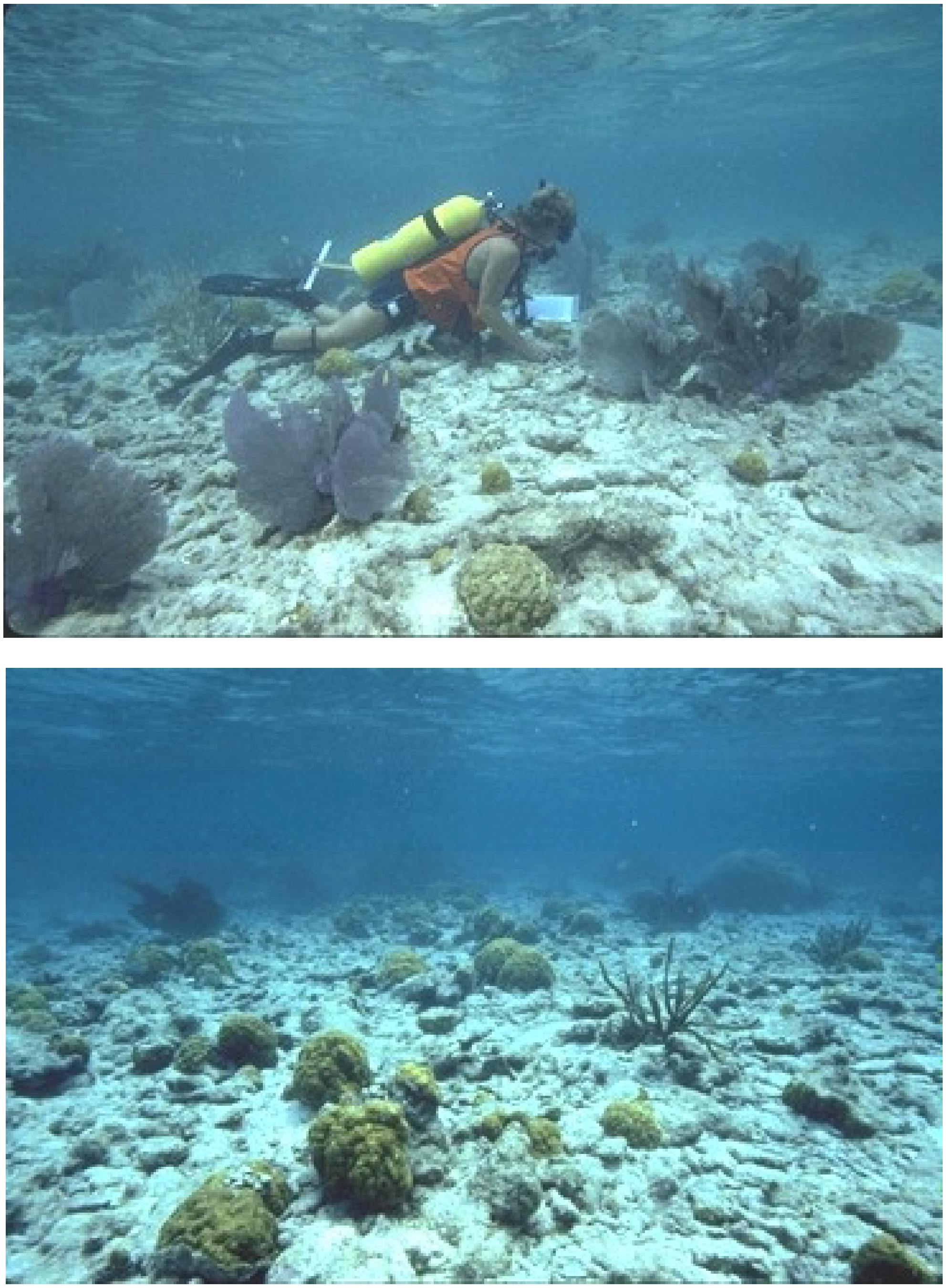


Plate 3.10. Only isolated colonies of soft coral (top) and hard coral (bottom) occur in the rubble zone which is composed mostly of dead coral fragments thrown up behind the forereef after major storms.

Plate 3.11. Typical rubble (top) found on the rubble horns on the east and west sides of the lagoon. Isolated colonies of elkhorn coral (*Acropora palmata*) (bottom) frequently occur in the rubble zone just landward of the forereef crest.

Plate 3.12. A few isolated coral heads (top) are infrequently found in lagoonal grass beds. Typical grass beds (bottom) are dominated by turtle grass (*Thalassia testudinum*, wide blades) and eel grass (*Syringodium filiforme*, narrow rounded blades). In the lagoon the substrate is often a mixture of rubble and sand.

Plate 3.13. Sand flats (top) dominate much of the Sanctuary and have little relief except for occasional isolated coral patches. Sparse sea grasses (bottom) occur most commonly near hard bottom and reef areas.

Plate 3.14. Typical views of medium density (top) and high density (bottom) sea grass beds. These habitats are important sources of food for many reef organisms.

CHAPTER 4

HOLOCENE SEDIMENT THICKNESS AND FACIES DISTRIBUTION, LOOE KEY NATIONAL MARINE SANCTUARY, FLORIDA

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Introduction

The purpose of this report is to characterize sediment components, thickness, and depositional processes within the Looe Key National Marine Sanctuary and to map underlying pre-Holocene bedrock topography. The relatively small (3.6 x 5.2 km) sanctuary is located in the southernmost extension of the Florida reef tract approximately 13 km southwest of Big Pine Key and 8 km southwest of Newfound Harbor Keys (Figure 4.1). Focus of this work was on the entire sanctuary rather than Looe Key reef alone; the reef occupies a small (approximately 0.2-km-wide by 1-km-long) area within the sanctuary. For administrative purposes, the reef has been set aside like a sanctuary within a sanctuary for better concentration of enforcement; the reef area within the sanctuary is called the "core" area.

The first study to characterize and identify the distribution of constituent sedimentary particles in the Florida reef tract was by Ginsburg (1956). His work was centered in the upper Keys reef area off Key Largo, where prevailing southeasterly winds and waves are perpendicular to the platform margin and island chain. Swinchatt (1965) identified sediment composition in transects from the reefs shoreward in the lower Keys off Marathon, where prevailing winds and waves impinge on the platform margin at an acute angle. Our research concentrates on the area within the boundaries of the Looe Key Sanctuary, where winds and waves essentially parallel the platform margin and consequently have a different influence on the distribution and transport of carbonate sedimentary grains than in the middle and upper Keys. The most notable effect in the lower Keys is the piling up of sand on the seaward side of reefs (Shinn *et al.,* 1981). Shinn *et al.* (1981) have suggested that carbonate sand, which has covered part of the deep reef seaward of the main spur-and-groove zone at Looe Key, was transported parallel to and offshore from the platform margin during heavy weather, most likely during hurricanes, tropical storms, or winds associated with periodic winter cold fronts that blow offshore in the lower Keys. Ball *et al.* (1967) described the effects of Hurricane Donna in the upper Keys and pointed out that the major direction of transport was landward, away from the platform margin. Landward movement of sediment during a hurricane was also documented by Perkins and Enos (1968). Enos (1977) mapped the thickness and distribution of sediments and reefs through the entire Florida reef tract from Miami to Key West using high-resolution seismic sparker profiles and also documented predominantly landward transport of carbonate sediments.

This paper describes the bathymetry, sediment composition and thickness (of carbonate sediment and reefal debris overlying Pleistocene bedrock), as well as bedrock topography which has a major effect on subsequent depositional processes. The work is based on interpretation of 2380 cumulative data points along 114 km of high-resolution subsea seismic-reflection profiles and thin section analyses of 96 surface sediment samples throughout the sanctuary. Rotary cores drilled through the Looe Key reef by the US Geological Survey's Fisher Island staff (see Shinn *et al.*, 1981) were used to verify subsurface reflectors and sediment thickness interpreted from the seismic records. Whereas emphasis of this research was on the entire sanctuary, most of the other work presented in this volume was restricted to the Looe Key reef and central core area immediately surrounding the reef. Subsequent to compilation of reports for this volume in 1983, Lidz *et al*. (1985) condensed and published this chapter. That paper should be used as the formal literature citation.

Methods

Subbottom profiling

The 114 km of high-resolution seismic-reflection profiles were shot in July 1983 using an ORE Boomer* with a power output of 100J filtered at 1.0 - 1.5 kHz. The boomer plate trailed 20 m behind the boat along with a 12-element hydrophone streamer which provided input to an EPC 4100 recorder. In addition to direct paper chart readouts, upon which the majority of this study is based, all data were recorded on $^1/_4$-inch magnetic tape for later filtering and manipulation. Because of the high quality of the seismic records, data enhancing techniques were not necessary.

To interpret these profiles, the Pleistocene bedrock reflector was first identified and traced with a transparent-color marking pen. Selected examples showing major topographic features (of the bedrock and sediment geometry) are shown in Figure 4.2. Identification of the bedrock horizon and its depth along nearly all 114 km of the profiles provided 771 data points from which thickness of the overlying material could be calculated. All measurements were based on the average velocity of sound in sea water (1500 m/sec). A simple scale consisting of a clear plastic strip graduated in meters based on a sound velocity of 1500 m/sec was used to measure water depth and distance to subsurface reflectors.

Most data points were recorded at 5-min intervals. If the profiles showed unusual topography or sediment geometry, however, additional data points defining these particular features were taken from the records at more closely spaced intervals. Loran C coordinates from a Texas Instruments 9000A Loran C receiver were recorded simultaneously with each data point. Each data point was transferred to a Loran C grid chart/base map (constructed later), resulting in plots of track line location, interpreted water depth (uncorrected for tidal changes), sediment thickness and depth to Pleistocene bedrock. Data plotted on these respective base maps were then contoured (Figures 4.3 - 4.6).

Sediment sampling and preparation

Surface sediment samples, collected with an $11^1/_2$-oz Planters Peanut can with fitted plastic top, were taken during the same study period in transects (indicated on Figures 4.3 and 4.7) throughout the sanctuary principally by skin diving to a water depth of approximately 15 m. In closely spaced transects just seaward of the sanctuary core boundary, samples were collected using Scuba. In the deeper (>30 m) water seaward of Looe Key reef, samples were recovered with a 0.1 m^3 Peterson grab deployed by hand with 1-cm-diameter nylon line. In all cases, sediment collected was restricted to grains of very coarse sand size (2 mm) and smaller. Where possible (i.e., within the core area), sample sites were identified in conjunction with aerial photographs. Loran C coordinates, depth (except as noted in footnotes on Table 4.1) and a brief bottom description were recorded for the 96 sample stations.

Sediment samples were later oven-dried, mixed, and split into smaller subsamples that were placed in plastic ice cube trays and vacuum-impregnated with polyester resin. After hardening, the sediment/plastic cubes were cut in half vertically with a band saw, then mounted on glass slides and ground to a thickness of approximately 30 µm. The thin sections were placed under a petrographic microscope with mechanical stage and point counted. Counting was accomplished

* Use of brand names does not constitute endorsement by the USGS.

by making three transects across each thin section and petrographically identifying the grain under or closest to the crosshairs after each 250-µm advance of the mechanical stage. Point count transects were run from top to bottom across the cube-shaped thin section in order to account for any compositional changes that might be caused by sorting during sample preparation. Some sorting (i.e., coarse at the bottom and finer at the top of the cube) was noted in a few slides but did not occur often enough to influence counts or warrant further discussion. Three transects across the slides resulted in a total point count of 15,890 grains with an average count per slide of 166 grains (maximum 184, minimum 141).

Carbonate grains were identified based on previous experience and according to the carbonate petrography manual compiled by Scholle (1978). Six categories were tabulated (Table 4.1; Figure 4.8), three of which comprised the most common particles (coral, mollusc and *Halimeda*), and four of which comprised the least common (echinoid, bryozoa/red algae, benthic foraminifers, and "other"). The "other" category included pelagic foraminifers, worm tubes, spicules of sponges, tunicates and alcyonarians, ooids, mud, and "unknown." Since the percentages of the last four categories were too low to construct meaningful maps, only the percentages of the three major constituent particles were plotted on the grid base map and contoured (Figures 4.9 - 4.11). The purpose of contouring these data was to show facies distribution and to see if this distribution would identify the direction of sediment transport. Traditional sieving for grain-size distribution, a procedure normally done in siliciclastic sediment studies, was not attempted. Such analyses were considered of questionable value in studies of skeletal carbonate sands.

Navigation problems and water depth

No navigation chart with accurate Loran C Lines of Position (LOPs) was found to exist for the Looe Key Sanctuary. A recent Sanctuary Boundary Survey Plan, conducted by the Department of Army Corps of Engineers in 1983 and based on National Geodetic Survey data, gives latitude and longitude for sanctuary location. Regional Loran C LOPs overprinted on National Ocean Service (1983) nautical charts (cf. chart #11442, Sombrero Key to Sand Key, from which sanctuary location and Loran C grid for Stations 1 and 4, shown in Figure 4.1 inset, were reproduced) are not accurate, being off by more than 1 km in places. Precision of the Loran C receiver, however, is high. Once "true fixes" are taken at a particular place, it is usually possible to return to within at least 15 m of that site.

A Loran C grid chart (Figure 4.3) was therefore constructed using Loran C chain designation 7980 for the Gulf of Mexico (Time Differences or TDs = LOPs in microseconds for Loran C designation 7980, Stations 1 and 4). During the July 1983 study period, Loran C Stations 1 (13900 µsec) and 4 (62500 µsec) were used exclusively. Reception of Loran C Stations 2 and 3 was inconsistent; thus, Stations 1 and 4 provided the TDs or Lines of Position used for navigation, fixed-object location and construction of the Loran C grid chart/base map shown in Figure 4.3.

Comparison of the sanctuary position and Loran C TDs on the above National Ocean Service chart (Figure 4.1 inset) with those shown in Figure 4.3 indicates that the location of the sanctuary differs by as such as 750 m to the north (Figure 4.1) of its actual location (Figure 4.3). In other words, in this case the Loran C LOPs overprinted on the chart are off by 750 m to the north, and the sanctuary boundaries printed on the chart are not an accurate location of the sanctuary. Two Loran C receivers used simultaneously during the study period consistently received identical TDs and repeatedly provided the same coordinates for position of the boundary markers for the duration of the study period. They consistently showed that the boundary marker buoys are actually moored 750 m south of the position indicated on the nautical chart. This study has therefore resulted in construction of the only reliable Loran C grid chart (Figure 4.3) available for the Looe Key Sanctuary. Position of marker buoys and distinct bottom features, as well as the sample sites and seismic track lines described in this study, can only be reoccupied with reasonable accuracy using the chart shown in Figure 4.3 and a Loran C receiver tracking Stations 1 and 4.

Location of the inner core area shown on Figures 4.3 - 4.6 was defined by Loran C coordinates for the core area marker buoys (Table 4.2) and differs from that indicated by latitude and longitude on the Corps of Engineers Sanctuary Boundary Survey Plan (1983). Use of latitude and longitude alone can provide, at best, only a general location. The location shown on our charts is accurate in that the south markers for the inner core area are placed between Looe Key reef and the dropoff, instead of at the dropoff as indicated by the Boundary Survey, and the north markers are accordingly farther north on our charts. In addition, the Boundary Survey placed three of the four core area marker buoys in much deeper water (see Table 4.2) than depths actually occupied. The same Survey also described the sanctuary as being "located in the Straits of Florida."

Loran C fixes were recorded for each sediment sample location and at least every 5-min-interval mark on the seismic-reflection records. Readings were also taken at buoys (Table 4.2) marking the inner core area, the northwest and northeast corners and southeast boundary of the sanctuary (the southwest boundary marker was off station), at Coast Guard Marker 24 located within the southeast corner of the core area, and at prominent bottom features easily identified on aerial photographs. Using the Corps of Engineers Sanctuary Boundary Survey Plan (1983) as a guide from which to trace the sanctuary boundaries and based on Loran C coordinates for the sanctuary marker buoys and Marker 24, a Loran C grid chart was prepared by division of the area between the fixed points into precisely measured increments using 10-point dividers and a Gerber scale. The completed grid, upon which the core area Loran C coordinates were plotted, was then inked onto transparent Stabelene mylar drafting film.

All data were taken within a 10-day study period, and to our knowledge the Loran C station signals used did not drift during this period. During an attempt to ground-truth fathometer readings six months later, however, we were unable to obtain true TDs from Loran C Stations 1 and 4 for the position of Marker 24 (a fixed tripod) or those of the on-station sanctuary boundary and core area marker buoys. The TDs had drifted considerably. Loran C signals are known to be affected by climatic conditions; fortunately, climatic conditions were calm, warm and stable during the July study period. Revisitation to the area in January 1984, however, immediately followed passage of a wind-driven cold front, and neither station's signal could be duplicated without first determining a (coincidental) correction factor of +10.0 for both LOPs.

Depth measurements throughout the sanctuary were based on interpretation of seismic-reflection records and use of weighted measuring tapes where possible (Figure 4.4; Tables 4.1, 4.3). Since tidal fluctuation in the lower Keys was less than 1 m during the study period (National Ocean Service, 1983, Key West tidal station), no correction factor was applied to the interpreted depths. Divers' depth gauges were used at two locations. A depth finder and Precision Depth Recorder were also employed during the study, but their values could not be incorporated into the bathymetric map due to inconsistent readings.

Results

Bathymetry

Contoured bathymetry of the area within the sanctuary and approximately 2.8 km landward of the north boundary, as interpreted from 838 data points along the seismic-reflection profiles, is shown in Figure 4.4. The most prominent topographic feature is a distinct east-west dropoff immediately seaward of the inner core area (also see Figures 4.2 and 4.5). The dropoff is sharp, and diving revealed a 30° - 40° slope extending from approximately 20 m down to 30 -

33 m, depending upon location. Two seismic-reflection profiles (see track line 1 in Figure 4.3) were run approximately 2 km seaward beyond the sanctuary and dropoff out to a depth of 80 m. Limited data from these nearly parallel tracks provided the basis for the contours which extend south of the boundary in Figures 4.4 - 4.6.

The dropoff extends from the east to west margin of the sanctuary and probably continues for several kilometers in either direction. Probably nowhere, however, is the degree of dropoff more spectacular than seaward of the southwest corner of the core area, where the slope is coral encrusted. Seaward of the southeast core area boundary, however, diving showed the slope to be less steep (Figure 4.2) and covered with carbonate sand.

Aside from the dropoff and Looe Key reef, parts of which are exposed at low tide, the third notable bathymetric/topographic feature is the broad depression which begins at a depth of 7 m near the north margin of the sanctuary. The depression deepens landward to a maximum of 14 m (Figures 4.4 and 4.5). This depression, called Hawk Channel on navigation charts, is part of the shelf lagoon that extends throughout the entire reef tract from Miami to Key West and beyond.

The bulk of the sanctuary therefore encompasses a 1- to 2-km-wide ridge between Hawk Channel and Looe Key reef. Throughout the reef tract, the seaward edge of the ridge (or outer margin of Enos, 1977) is ornamented with linear reefs composed principally of *Acropora palmata*. The top and landward parts of the ridge are generally ornamented with subcircular patch reefs composed of massive head corals and alcyonarians. Patch reefs also occur in Hawk Channel, but in the vicinity of Looe Key Sanctuary, they are sparse.

Bedrock topography

Given water quality favorable for coral growth, probably no single feature influences reef distribution more than the underlying bedrock topography. Previous core drilling studies (Shinn *et al.,* 1977; Shinn *et al.,* 1981) have confirmed that most major reefs in the Florida Keys overlie either small bedrock highs or the seaward side of large, broad topographic highs. Enos (1977) found that some patch reefs were located over topography formed by mudbanks during the early Holocene when sea level was lower.

With the exception of the spurs and grooves, bedrock topography clearly has controlled reef distribution in the study area. The subsurface Pleistocene horizon was identified in almost all 114 km of the seismic-reflection profiles, resulting in 771 data points that were used to illustrate bedrock configuration (Figure 4.5). Comparison of Figures 4.4 and 4.5 shows that the prominent sedimentary lobe south of the southeast corner of the core area is controlled by a Pleistocene bedrock feature. Reef growth has caused buildup along the seaward edge of this bedrock feature in the west half of the sanctuary. Reef growth effectively retards seismic returns and is responsible for the "no data" areas in Figures 4.5 and 4.6. East of the no data zones, seismic penetration was possible due to extensive carbonate sand cover. Figure 4.5 shows that one can confidently project the existence of a major change in slope beneath the southernmost no data zone.

It is also clear from Figure 4.5 that the bathymetric deepening of the sanctuary into Hawk Channel to the north is controlled by bedrock topography. Depth from water surface to bedrock in the axis of the channel ranges from 16 - 17 m, whereas beneath the east-west ridge underlying most of the sanctuary, depth to bedrock ranges from 12 - 14 m except for several localized depressions up to 18 m deep. Bedrock lows are usually filled with sediment, whereas bedrock highs are generally sites of modern reef growth. Reef growth apparently began on this ridge but transgressed landward with rising sea level so that today the major part of the reef overlies a sand-filled bedrock depression (Figure 4.12). This upward and landward transgression of coral reefs through time during a period of rising sea level has been documented by core drilling at several reefs along the Florida reef tract (Shinn *et al.,* 1977; Shinn, 1980; Robbin, 1981; Shinn *et al.,* 1981).

Sediment thickness

Isopachous variations in sediment cover (Figure 4.6) also reflect the relationship between sedimentary processes and underlying topography. Areas of thick sediment generally occur over localized bedrock lows, where sediment has simply filled depressions in the basement rock. A notable example is the 10- to 12-m-thick deposit filling the depression in the north half of the inner core area. Core drilling at sites LK-1, LK-9 and LK-10 (Shinn *et al.,* 1981; this paper, Figure 4.7) show that sediment thickness in this depression closer to the reef ranges from 13 - 15 m.

Only a thin sediment cover is generally maintained in the area of the steep dropoff with one localized exception: the thickest accumulation in the sanctuary lies southeast of Marker 24 (Figure 4.6) on the dropoff slope on the east side of a bedrock lobe that protrudes to the south (Figure 4.5). This lobe has apparently acted as a barrier to westward moving sediment, causing it to spill downslope in a southerly direction and accumulate behind the bedrock feature. Farther offshore, sediment thickness increases (with respect to the generally thin cover on the dropoff) below 30-m depths. In the most seaward area examined about 2 km south of the sanctuary, the deeper water deposits form accumulations as much as 9 m thick.

Rates of accumulation

Data concerning the recent Holocene relative rise in sea level (Scholl, 1964; Stockman *et al.,* 1967; Shinn, 1980; Robbin, 1984) indicate that the reefs and unconsolidated sediment deposits have formed and accumulated during the past 6,000 - 7,000 years. Prior to 7,000 years ago, the underlying Pleistocene bedrock within the sanctuary was dry land. Average sediment thickness within the sanctuary is 5.7 m, as determined from 410 measurements interpreted from the seismic-reflection records. Calculations based on the 5.7-m average and radiocarbon dates of Shinn *et al.* (1981) from material near the base of rock core LK-5 (Figure 4.12) infer an average rate of accumulation within the sanctuary of approximately 1 m/1,000 years since coral growth began. Within the bedrock depression immediately landward of Looe Key reef (north half of the core area) at the site of core LK-1, the average rate of sedimentation has been on the order of 2 m/1,000 years. Previous core drilling through the Looe Key reef (Shinn *et al.,* 1981, Figure 4.6) shows that initial coral growth began an the bedrock high just seaward of the reef. As sea level rose, the reef grew landward until it reached its present position overlying a thick deposit of carbonate sand (Figure 4.12).

Sediment composition

Thin sections of sediment samples were point counted for percent constituent particles, as described in the methods section. Results are tabulated in Table 4.1. In descending order of abundance are coral, molluscs and *Halimeda*, together comprising more than 72% of all samples regardless of grain size. The fact that these three components dominate the sediment is in accord with previous studies in the reef tract (Ginsburg, 1956; Swinchatt, 1965; Enos, 1977). The order of dominance in the sanctuary, however, differs from the generally accepted view that carbonate sands of the Florida reef tract usually contain more *Halimeda* than any other type of grain.

Percentages for particulate coral, mollusc and *Halimeda* grains were contoured on respective maps (Figures 4.9 - 4.11; cumulative 231 data points) to detect areas of high productivity, if possible, and to see if contours would suggest sediment transport direction. The latter was attempted because previous work and diver observations (Shinn *et al.,* 1981) had suggested east-to-west transport to such an extent that seaward parts of Looe Key reef had been smothered. Contoured east-west closures and "noses" in parts of Figures 4.9 and 4.11 are thought to support the east-to-west transport hypothesis. Alternatively, the contours may simply be reflecting underlying bedrock topography and/or sediment thickness which is more clearly related to bedrock topography.

Regardless of source area and direction of transport, sedimentary analyses produced surprising information concerning composition of reef tract sand in the Looe Key Sanctuary. As mentioned earlier, previous studies (Ginsburg, 1956; Swinchatt, 1965; Enos, 1977) have emphasized the prevalence of *Halimeda* within Florida reef tract sand, even in close proximity to coral reefs.

Coral

Coral was the single greatest component in 47 (49%) of the 96 sediment samples with an average grain count of 28% (range 3 - 53; Tables 4.1, 4.4; Figure 4.8). Coral sand distribution (Figure 4.9) shows that the presence of coral decreases markedly offshore, as one would expect, and comprises 10 - 15% of the finer grained sediment in the deep water seaward of the dropoff. Percent coral increases rapidly to more than 50 on and just above the dropoff due south and west of the core area. A closure with a high concentration (>55%) of coral occurs in an area of extensive coral growth in the west area of the sanctuary. High concentrations also occur near the northeast and north boundary, where a series of low-lying hardbottoms (also called live bottoms elsewhere in this volume) and patch reefs populated by hard and soft corals occurs. Although sediment samples were not taken in Hawk Channel north of the sanctuary, it is likely that coral percentage is low in those finer grained sediments. Coral patches and reefs are sparse in this part of the channel. Contours in the northwest corner of the sanctuary (Figure 4.9) support the relative absence of source areas by suggesting a decrease in coral particles to the north.

Sediment particles in the core area are typically dominated by coral. Data points within the core area were not contoured because of local irregularity of bottom depth and its effect on sediment content and transport. The core area contains zones of pebble- to boulder-size (4 to >256 mm) coral rubble (Figure 4.7, Plate 4.1) as well as the spur-and-groove system that forms Looe Key reef. This high- and low-relief seafloor topography influences sediment entrainment and creates pockets of trapped sands. Figure 4.7, illustrating Looe Key reef and the coral rubble zones that form behind the reef, shows distribution of the 19 uncontoured sample sites within the core area. Although only one of those samples (LKS-90) contained more than 50% coral, 10 others (LKS-52, 54, 59, 62 - 63, 91 - 95) were also coral-dominant (see Tables 4.1 and 4.4). The rubble "horns" are composed of nearly 100% coral, but because of the large size of the component blocks, they were not addressed by this study. Coral pebbles and boulders also occur sporadically within the reef in grooves separating the spurs.

The coral rubble has accumulated mainly behind or landward of Looe Key reef, as is the case for similar features worldwide [cf. the Great Barrier Reef of Australia (Davies, 1983)], yet much of the sand-size sediment southwest of the reef in depths of 10 - 20 m (Figure 4.4) contains up to 50% coral. Since Looe Key is the closest source of coral debris, this implies local offshore transport of sand-size coral in a southerly direction, whereas pebble- to boulder-size coral has been transported in a northerly (landward) direction.

Molluscs

The second surprise in the study was that molluscan fragments also exceed *Halimeda* in abundance. Excluding the 47 coral-dominant samples, 32 (or 33%) of the remaining samples were composed principally of mollusc particles. Molluscs also show a similar intermediate, with respect to coral and *Halimeda*, grain count average of 24% (range 7 - 50; Tables 4.1 and 4.4, Figure 4.8). Because the thin section pointcount method does not permit differentiation between fragments of pelecypods or gastropods, nor can they readily be identified as to species, it is difficult to determine the source areas. The contours of percentages in Figure 4.10, however, do give some clues. The broad areas containing 10 - 20% molluscs are mainly carbonate sand terraines (as observed on aerial photographs and by diving; see Table 4.1 for bottom description at sampling sites). In general, these desert-like areas, barren of coral and *Halimeda*, lack the productivity of grass-covered areas, which in turn are less productive than hardbottoms or coral areas. Note the broad areas north and west of the core area in Figure 4.10, where the bottom is either carpeted by *Thalassia* or contains coral patches. The molluscan content there ranges between 20 and 40%. In the highly diverse coral-rich area of the deep reef west and southwest of the southwest corner of the core area, molluscan particulates reach 50%. The best explanation for these percentages is that both grass-covered and coral-covered areas represent the living sites of molluscs and that upon breakdown into sand-size particles, both by biological and physical processes, transport has been relatively minor. The baffling and binding effect of sea grasses aids sediment stabilization and has probably prevented extensive transport beyond the source areas.

Of the 19 samples within the inner core area, mollusc fragments are dominant in seven (LKS-51, 53, 55-56, 58, 60, 64; Figure 4.7; Tables 4.1, 4.4). These seven samples are from sites within or proximal to areas of grooves between the spurs, high-energy habitats where molluscs are not normally endemic. Although the contours within the sanctuary suggest that offshore transport of a molluscan death assemblage is minimal, the high mollusc fragment concentration within the grooves at Looe Key reef appears to be a reflection of the constraints afforded by the irregular seafloor relief.

Halimeda

The calcified codiacian alga *Halimeda* is probably the dominant sediment producer throughout the Caribbean. One species, *H. incrassata*, forms small, widely scattered colonial "tufts" whereas another species, *H. opuntia*, grows as large (20- to 50-cm-diameter) colonial "cushions" that thrive in and around *Thalassia*-covered bottoms, on hard substrates within reefs, and especially on reef flats and boulder-covered areas. Storms periodically break up and disperse these living tufts and cushions as individual sand-size plates, but because of their proliferous growth rate, the plant recovers rapidly. Hudson (1985) has documented conspicuous growth demonstrated by *H. opuntia* in the Marquesas Keys off southwest Florida (Figure 4.1). His work has shown that this species produces as many as seven new plates along the upper edge of a single mature plate in a period of a few weeks.

It was thus interesting to note that this distinct and prolific alga was dominant in only 13 (14%) of the 96 samples with a grain count average of 20% (range 3 - 46; Tables 4.1 and 4.4, Figure 4.8). A possible (but thought to be negligible) influence on the generally low percentages may have resulted from a combination of two factors: the relatively large (some as much as 1500 µm wide) size of whole algal plates present in the sand-size material and the procedure used in the point-count method. Each grain of any component particle that appeared beneath the crosshairs was point counted only once. If a particularly large grain, for example one 1000 - 1500 µm in size, appeared under the crosshairs and was counted, as many as four or more additional 250-µm stops may have been required to advance the thin section beyond the large grain, depending upon its orientation at the time of count. When this occurred, therefore, as many as four or more other grains nearest the crosshairs were counted at the additional advance stops. Once past the original large grain, point count of grains falling directly beneath the crosshairs was resumed. Although first glance at many of the thin sections suggested an abundance of *Halimeda* grains, actual percentage may have been influenced slightly using this procedure. The same procedure, however, was also applied when counting large mollusc and coral grains, thus providing a similar bias and balance which would have uniformly affected the count of all large particles regardless of grain type. The fact remains, however, that percent coral sufficiently exceeded percent *Halimeda* so that even if the other four or more smaller grains (some coral, some molluscan) nearest the large algal plate under the crosshairs had not been counted, the percent of particulate coral would probably remain dominant in overall average as well as in total samples examined.

Figure 4.11 shows that in some cases the percentage of *Halimeda* is high in the same areas as that of molluscs. The area in the east and north parts of the sanctuary, however, where *Halimeda* content is high is also the same area where the percentage of molluscs is low, a non-grassy, desert-like area of rippled sand. This is not surprising because *Halimeda* plates are light in weight, being riddled with natural tubules and canals, and due to their disc-like shape as well, they are easily transported by tide and wave-driven currents. The high percentages of 40 - 45 near the east boundary are probably related to the extensive grass and hardbottom areas that begin just east of the east margin. The contours showing decreased percentages away from this source area supports the hypothesis of westward transport mentioned earlier.

Minor particles

Minor sediment components consisting of echinoid, bryozoa/red algae, benthic foraminifers and unknown particles (including mud) were identified in thin section (Table 4.1) but were not contoured as separate maps. Mud is particulate matter less than 62 µm across, whose origin usually cannot be determined using standard light microscopes. In most samples the mud became clotted during sample preparation, so what was identified as mud was usually a sand-size agglomerate of clots or lumps. Mud was most abundant in samples seaward of the major dropoff in water more than 30 m deep. In some samples sand-size particles have been highly micritized by boring algae and mud infill, as described by Bathurst (1967). In some cases such micritized grains are indistinguishable from clots of carbonate mud (see Figure 4.8).

Benthic foraminifers dominated all other particles in only one sample (LKS-77) and comprised more than 15% (range 1 - 22) of the point-counted particles in 4 (4%) of the samples (Tables 4.1, 4.4). Foraminifers were found to be concentrated in the muddy sands seaward of the dropoff (>30 m of water). No attempt was made to quantify the various foraminiferal families identified other than to note that among the most common tests were members of the miliolid, soritid, rotalid, discorbid and amphisteginid families. These families are characteristic of a carbonate platform margin environment [0 - 40 m depths (Rose and Lidz, 1977)], of which the Florida reef tract is an example.

Local current patterns and shallow-water features such as basins, mudbanks and patch reefs influence the distribution and abundance of benthic foraminifers. Benthic species generally prefer calm, protected living areas behind the area of agitated water at the shelf break, where tidal flushing also occurs. In general, miliolids dominate mudbanks and "lakes" of a carbonate platform and soritids prefer the seagrass areas. Abundance of live specimens across a platform generally decreases in an offshore direction, and in deeper water beyond the platform edge, abundance of individuals, albeit of different, deeper water species, again increases. The observation that the greatest concentration of platform foraminifers was found seaward of the dropoff does not imply a less favorable habitat landward of the reef but is more likely a reflection of offshore transport.

Neither bryozoa/red algae nor echinoid percentages showed any meaningful trend. Both comprised more than 10% of the sediment (Tables 4.1, 4.4) in a few samples scattered at random throughout the sanctuary regardless of type of bottom, water depth, or proximity to the reef. The bryozoa/red algae group dominated all other grain types in one sample (LKS-76) and formed more than 1.5% (range 2 - 23) of the point-counted particles in 4 of the samples. Echinoid fragments also composed greater than 15% (range 1 - 18) of the sediment in 4 samples, while more than 15% (range 2 - 22) of the particles counted could not be identified in 15 (16%) samples.

Discussion

Coral rubble and sand transport

Although bedrock topography has a shape similar to that of other areas in the Florida Keys, i.e., a broad ridge near the edge of the platform and a landward trough (Hawk Channel), the dropoff in the seaward part of the sanctuary is more pronounced than anywhere else of similar depth in the reef tract. In the upper Keys area, where the platform margin is essentially perpendicular to prevailing winds, both sediment and coral rubble are consistently transported landward (Ball *et al.,* 1967; Perkins and Enos, 1968). In the Looe Key area, however, where the platform margin is nearly parallel to wind direction, carbonate sand has accumulated both landward and seaward of the reef. Forereef accumulation has been so extensive that a deeper outer part of Looe Key reef has been smothered, and coral rubble (pebble- to boulder-size but mainly in the size range of cobbles, or 64 - 256 mm; Figure 4.7, Plate 4.1) has collected landward of the reef.

The large waves and swells produced by storms must come from the deep water seaward of the reef, whereas storm waves from the north and northeast must be smaller due to shallow water depth and lack of sufficient fetch. Seas moving in a landward direction in such storms apparently deposited the coral boulders behind the reef where they are not likely to be removed by the smaller waves and swells emanating from a landward direction. On the other hand, sand-size material can be transported by seas moving in any direction. This combination of depth, wave direction and fetch is thought to be the explanation for the distribution of coral boulders (Plate 4.1) landward of the reef and coral-rich sands (Figure 4.9) seaward of the reef. Rapid sediment transport and deposition (approximate rate 2 m/1,000 years) accounts for the 12- to 15-m-thick section of carbonate sands behind the reef in the north half of the core area (Figure 4.12).

As discussed above, sediment transport appears to be related to the east-west trend of the platform margin and the angle at which storms and hurricanes impinge on the platform. Historically, most hurricanes have approached Florida from the southeast. Because hurricane winds rotate counterclockwise, the first winds to obtain landfall will blow offshore from the northeast. In addition, the strongest winds in a Caribbean hurricane that is moving in a northwest direction are in the northwest quadrant. Therefore, the first and strongest winds to hit the lower Keys will be from the northeast, precisely the direction required to explain the sand accumulation seaward of Looe Key reef. In the upper Keys, where the trend of the platform margin is essentially north-south, strong northeast winds move sediment primarily in a landward direction (Ball *et al.,* 1967; Perkins and Enos, 1968), although Ball *et al.* (1967) also reported a lesser degree of offshore transport in a few passes between large reefs. This offshelf movement was thought to occur as the hurricane progressed northwestward and winds in its southeast quadrant blew mainly in an offshore direction. Such winds, combined with receding water that had been piled up on the shelf by onshore winds, would probably account for some seaward movement of the sand.

Sediment composition

One of the more surprising discoveries of the sediment analysis was that both coral and mollusc grains were more common than *Halimeda*. In the classic study by Ginsburg (1956) and later confirmed by Swinchatt (1965), *Halimeda*-derived grains were found to dominate reef tract sediment. Figure 9 of Ginsburg (1956) shows that, although *Halimeda* dominates all other sedimentary particles in his study area, its relative percentage was less in the middle Keys off Marathon than in transects in the upper Keys. This observation suggests a trend of decreasing *Halimeda* sand content from north to southwest along the reef tract, which is compatible with our discovery that *Halimeda* is subordinate to mollusc and coral fragments in the Looe Key Sanctuary.

Coral growth has been retarded in the middle and lower Keys due to rising sea level and consequent influx of estuarine and turbid, cold Gulf of Mexico water to the reef areas during winter (Ginsburg and Shinn, 1964; Shinn, 1976; Lighty, 1977; Roberts *et al.,* 1982). Living reefs are absent opposite major breaks in the Florida Keys. One such reef opposite a 1.0-km-wide breach in the island chain (Hudson, this volume) is Alligator reef in the middle Keys. Drilling at Alligator reef showed the reef to have been constructed by *Acropora palmata*, which is almost non-existent there today (Robbin, 1981). Core drilling of the spurs at Looe Key reef by Shinn *et al.* (1981) also showed *A. palmata* to have been the major reef builder, although today it is sparse on the spurs drilled. Both studies suggested that *A. palmata* growth began to diminish about 4,000 years ago. According to published sea-level curves (Scholl, 1964; Stockman *et al.,* 1967; Robbin, 1981), sea level 4,000 years ago was approximately 3 m lower than today. Under such conditions, Florida Bay and most of the tidal passes through the Florida Keys would not have existed, and water quality along the platform margin facing the Straits of Florida would have been more favorable for coral growth than it is today.

Farther down the island chain to west of the Marquesas Keys (Figure 4.1), however, *Halimeda* particles increase markedly to comprise at least 90% of the sediments, as shown by ongoing studies by the US Geological Survey Fisher Island staff in an area known as the Quicksands. Here, the algal sand forms accumulations as much as 12 m thick that cover a 13 km x 29 km area (Shinn *et al.,* 1982; Shinn *et al*., 1990). In this case, it was concluded that a combination of cold Gulf of Mexico water and prevailing poor water visibility have prevented coral reef establishment while concurrently permitting extensive *Halimeda* growth. Whether or not *Halimeda* growth rates are actually faster west of the Marquesas than in other areas of the Keys is not known, although Hudson (1985) has documented extremely rapid growth. Unfortunately, there have been no companion studies In the upper Keys for comparison.

The most plausible explanation for coral sand dominance at Looe Key Sanctuary, therefore, is not a reduced *Halimeda* growth but increased production of coral-derived grains. Except for Looe Key reef, whose corals are less prolific and diverse than those comprising reefs to the north (for example, in the Key Largo Coral Reef Marine Sanctuary), coral growth within the entire sanctuary is diminished with respect to other areas along the reef tract. In fact, reefs immediately to the east of the sanctuary are considered dead by Caribbean standards, and the patch reefs or hardbottoms that are scattered throughout the north half of the sanctuary are composed of dead coral. Relatively few living corals other than alcyonarians can be found on these patches.

Dead coral is more readily attacked by boring organisms, such as pholad clams, boring sponges and parrot fish, than is living coral. Thus, when a reef dies, incipient deterioration is immediate as boring sponges initiate the first stage of coral reduction into silt- and sand-size particles through erosive actions (Neumann, 1966; Rützler, 1975; Hudson, 1977; Moore and Shedd, 1977). Hudson (1977) found that corals at Hen and Chickens reef in the middle Keys, killed in 1969 by cold water, were attacked by *Cliona* (a boring sponge) and other organisms which destroyed dead *Montastraea annularis* heads at a rate of about 7 mm/year, a rate which is slightly less than the growth rate (8.5 mm/year) for the species. Prior to the 1969 kill, the sand between coral heads at Hen and Chickens consisted almost entirely of whole *Halimeda* plates. Post-1969 observations (J. H. Hudson and E. A. Shinn) revealed that sediment composition had been converted to silt-size coral-dominant sand. The sudden increase in silt-size coralline sediment was often cited as the cause of coral death, when in actuality it resulted from coral death and subsequent bioerosion (Hudson and Shinn, pers. observation). We conclude, therefore, that bioerosion of dead coral substrates rather than reduced *Halimeda* production is responsible for dominance of coral particles in sediments at Looe Key Sanctuary and probably in the lower Keys in general, because the ratio of dead to live corals is higher than in the Key Largo Coral Reef Sanctuary off the upper Keys.

Conclusions

Carbonate sedimentary particles, sediment thickness, depositional processes and mapping of underlying pre-Holocene bedrock topography have been described for the area in the lower Florida reef tract known as the Looe Key National Marine Sanctuary. This work has documented the dominance of particulate coral over *Halimeda* grains in the sanctuary. Although *Halimeda* is considered the principal sediment-producer in the Caribbean, it becomes increasingly subordinate to coral and mollusc particles in the sediment from north to southwest along the Florida reef tract. This trend complements a similar trend in live to dead reef corals that allows bioerosion of dead coral heads to contribute progressively greater percentages of particulate coral to the sediment than *Halimeda* grains. At the same time, *Halimeda* production is thought not to have been reduced.

Movement of sediment in the sanctuary occurs in a predominantly east-to-west direction, a direction that is supported by the contoured percentages of coral and *Halimeda* fragments. Sediment thickness indicates that rate of accumulation has been 1-2 m/1,000 years.

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Table 4.1. Brief bottom description of each surface sediment sample location, total grain count per thin section, and percentage for each of seven constituent particles. "Other" category includes mud and unidentifiable grains. Location of samples is shown in Figures 4.3 and 4.7.

			Percent Constituent particles						
Sample no.*	Bottom description	Grain count	*Halimeda*	Mollusc	Coral	Echinoid	Bryozoa + Red algae	Benthic foraminifers	Other
LKS-1	*Thalassia*, *Penicillus*, *Syringodium*	174	40.2	17.2	20.1	8.6	3.5	2.9	7.5
LKS-2	Sparse grasses	165	28.0	18.8	17.6	4.8	3.6	4.8	22.4
LKS-3	Grassy	147	46.2	15.7	21.1	2.7	5.4	1.4	7.5
LKS-4	Sandy, rocky, patchy *Sargassum*, *Thalassia*	145	41.7	25.7	11.1	3.4	3.5	1.4	13.2
LKS-5	Patchy *Thalassia*, sponges, sand, alcyonarians	175	33.7	13.0	31.4	2.9	5.8	4.0	9.2
LKS-6	Barren, rocky outcrops, rare alcyonarians	154	43.5	16.9	24.0	2.6	5.9	3.9	3.2
LKS-7	Barren	154	37.0	10.4	31.8	1.9	9.8	3.9	5.2
LKS-8	*Thalassia*-covered, rare *Udotia* (?)	154	40.9	7.8	27.9	5.8	11.0	1.3	5.3
LKS-9	Barren, wide sand waves ~5 cm high x 15 cm wide	166	36.2	16.3	30.1	3.0	7.2	2.4	4.8
LKS-10	Dense grass (*Thalassia*, *Syringodium)*, patchy sand	163	21.5	12.9	28.8	6.8	3.6	4.9	21.5
LKS-11	Little sand, 50% *Thalassia,* 50% *Syringodium*	162	24.7	20.4	25.9	3.1	3.8	6.7	15.4
LKS-12	Reef rubble, *Millepora*, *Diadema*, light cover alcyonarians, no grass	166	25.9	13.9	39.8	5.4	3.0	3.6	8.4
LKS-13	Typical backreef community, small head corals, no grass, no buildup, some large alcyonarians, *Diadema*	171	15.8	7.0	52.6	6.4	2.4	2.9	12.9
LKS-14	Uniform 30 cm long x 1 cm high sand waves, bare except for sparse *Penicillus* and *Udotia*	165	33.9	22.4	15.8	6.1	2.4	4.2	15.2
LKS-15	Sandy, sparse *Thalassia* and red algae	166	27.1	16.9	29.5	4.2	6.6	1.8	13.9
LKS-16	Moderate *Thalassia,* sparse *Udotia* and alcyonarians, large loggerhead sponge	162	37.7	22.8	25.3	3.7	4.3	1.2	4.9[Δ]
LKS-17	Barren, sandy, sparse red algae and *Udotia*, irregular sand waves 10 - 15 cm long x 1 cm high	174	17.2	13.8	33.3	4.0	12.2	4.0	15.5
LKS-18	Barren, small community of large loggerhead sponges + alcyonarians, single *Halimeda incrassata*	151	21.2	18.6	34.4	4.6	5.3	3.3	12.6
LKS-19	Barren	175	19.4	18.3	36.0	5.1	6.3	4.6	10.3
LKS-20	Barren, sparse red algae	178	18.0	20.8	37.6	3.9	9.0	2.3	8.4

Table 4.1. Brief bottom description of each surface sediment sample location, total grain count per thin section, and percentage for each of seven constituent particles. "Other" category includes mud and unidentifiable grains. Location of samples is shown in Figures 4.3 and 4.7 (cont.)

Sample no.*	Bottom description	Grain count	Percent Constituent particles: *Halimeda*	Mollusc	Coral	Echinoid	Bryozoa + Red algae	Benthic foraminifers	Other
LKS-21	Begin spur and groove with typical reef community, low amplitude 5 cm high x 10 cm long sand waves, peaks 30 - 40 cm apart	178	21.4	25.8	23.0	5.1	8.4	5.6	10.7
LKS-22	Barren, sandy, 1 sponge, regular sinuous peaked sand waves 5 cm high, peaks 30 - 40 cm apart	175	26.3	24.6	27.4	2.3	10.3	2.3	6.8
LKS-23A	Moderate grass cover (*Batophora, Syringodium*, *Thalassia)*, *Halimeda* on rubble, feather-like green alga	143	14.7	19.6	31.4	4.2	6.3	7.0	16.8
LKS-23B	Sand waves, some red algae and *Udotia*	176	21.0	30.7	22.7	1.1	8.0	8.5	8.0
LKS-24	Dense *Thalassia, Syringodium*	160	23.0	31.9	15.0	11.9	6.9	3.8	7.5
LKS-25	Barren, small patches light *Thalassia*	165	26.7	24.2	19.4	7.2	6.1	5.5	10.9
LKS-26	Moderate *Thalassia*, some sand patches, alcyonarians	155	23.9	16.1	34.8	6.5	5.8	4.5	8.4
LKS-27	Dense *Thalassia*, light *Syringodium,* sparse *Penicillus*, some red or brown algae	158	29.1	31.0	22.1	9.5	3.2	1.3	3.8
LKS-28	Typical low relief backreef with small head corals, alcyonarians	177	16.4	25.4	37.3	5.1	4.5	3.4	7.9
LKS-29	Patchy sand, moderate *Thalassia*, sparse *Penicillus* and large red-stalked alga	153	32.0	20.2	26.8	3.9	4.0	2.0	11.1
LKS-30	Barren, sparse red algae, *Udotia*	155	22.6	24.5	23.9	5.8	12.3	4.5	8.4
LKS-31	Dense *Thalassia*, some *Syringodium*	175	16.0	18.3	29.7	10.3	2.3	4.0	19.4
LKS-32	Barren, very sparse *Udotia*, *Thalassia*	167	24.0	12.0	34.7	3.6	6.0	2.4	17.3
LKS-33	Patchy sand and grass, moderate *Thalassia* in grassy area, sparse *Udotia* in sand	161	23.6	14.3	33.5	3.7	6.2	3.1	15.5^{Δ}
LKS-34	Loggerhead sponges, dense *Thalassia*, *Syringodium*	156	14.7	12.2	34.0	10.9	7.0	2.6	18.6
LKS-35	Live hardbottom	163	13.5	20.3	42.3	1.8	8.0	1.2	12.9

Table 4.1. Brief bottom description of each surface sediment sample location, total grain count per thin section, and percentage for each of seven constituent particles. "Other" category includes mud and unidentifiable grains. Location of samples is shown in Figures 4.3 and 4.7 (cont.)

Sample no.*	Bottom description	Grain count	Percent Constituent particles: *Halimeda*	Mollusc	Coral	Echinoid	Bryozoa + Red algae	Benthic foraminifers	Other
LKS-36	Patchy sand, alcyonarians, some exposed rock	152	11.8	45.4	19.7	0.7	5.9	4.6	11.8^{Δ}
LKS-37	Live hardbottom, moderate *Acropora cervicornis*	161	6.8	50.3	17.4	4.4	9.9	3.7	7.5
LKS-38	Barren, isolated red algae and *Udotia*	167	19.1	32.9	24.0	4.8	4.2	3.0	12.0
LKS-39	Barren, some small, sparse patches *Thalassia*, *Syringodium*	170	24.7	41.2	8.8	3.5	4.7	5.3	11.8
LKS-40	Light cover *Thalassia* and *Syringodium*	141	14.9	38.3	13.5	7.8	4.2	2.1	19.2
LKS-41	*Halimeda*, red and green algae, no grasses	168	31.5	31.5	6.6	13.1	4.2	5.4	7.7
LKS-42	Light *Halimeda*, *Thalassia*, some *Udotia*	181	28.2	35.4	9.4	17.7	2.7	3.3	3.3
LKS-43	Hardbottom, several good-size colonies *Oculina*, some coral, rest barren	165	13.9	27.3	26.7	7.3	4.2	3.6	17.0
LKS-44	Live hardbottom	172	4.1	39.4	43.0	4.1	4.7	0.6	4.1
LKS-45	"Scruffy" live hardbottom	166	13.3	24.1	36.2	5.4	9.0	4.2	7.8
LKS-46	Good live hardbottom, dead clump *Acropora cervicornis*	178	3.4	16.8	57.9	1.7	9.0	1.7	9.5
LKS-47	Reefal, 0.5 m high buildup, live corals on top, patchy	177	7.9	29.9	37.9	4.5	7.3	2.3	10.2
LKS-48	Barren, very sparse small pieces live red algae	179	14.0	31.3	32.4	3.3	2.3	3.9	12.8
LKS-49	Live hardbottom, fewer head corals and more alcyonarians than earlier live hardbottom sites	184	8.7	23.4	49.5	0.5	7.6	2.2	8.1
LKS-50	Barren except for abundant baby conch on sticky fine-grained bottom	173	15.0	37.6	2.9	13.3	4.6	7.5	19.1
LKS-51	Depth 8.0 m, sand in groove next to core LK-1 (1980) and LK-9 (1983), first groove west of pot wreck sandhole	167	15.6	26.9	25.1	3.0	8.4	5.4	15.6
LKS-52	Depth 1.0 m, coral rubble in coarse sand matrix, $^{1}/_{2}$ sand halo west of grass	183	8.7	21.3	39.9	2.7	9.9	3.8	13.7
LKS-53	Depth 2.0 m, coral rubble in coarse sand matrix	180	13.3	35.6	25.6	2.8	13.3	3.9	5.5
LKS-54	Depth 5.3 m, coarse sand	171	14.0	27.5	36.3	5.3	7.6	3.5	5.8
LKS-55	Depth 7.3 m, coarse sand	177	16.4	33.9	27.7	5.6	5.6	2.8	7.9^{Δ}
LKS-56	Depth 8.3 m, coarse sand	168	21.4	36.9	25.0	1.8	5.4	3.0	6.5

Table 4.1. Brief bottom description of each surface sediment sample location, total grain count per thin section, and percentage for each of seven constituent particles. "Other" category includes mud and unidentifiable grains. Location of samples is shown in Figures 4.3 and 4.7 (cont.)

Sample no.*	Bottom description	Grain count	*Halimeda*	Mollusc	Coral	Echinoid	Bryozoa + Red algae	Benthic foraminifers	Other
			Percent Constituent particles						
LKS-57	Depth 10.7 m, rippled, stabilized by algal scum	167	22.2	31.7	28.1	1.8	10.8	0.6	4.8
LKS-58	Depth 4.5 m, seaward edge of rubble zone, coarse sand	160	23.1	34.4	20.0	0.6	13.1	3.1	5.6$^{\Delta}$
LKS-59	Depth 5.5 m, east edge of Marker 24, fine sand	182	23.1	20.3	32.4	4.4	5.0	6.0	8.8
LKS-60	Depth 8.6 m, coarse sand	163	30.7	31.3	20.2	4.9	7.4	3.7	1.8
LKS-61	Depth 9.9 m, coarse sand	157	12.7	26.8	38.2	1.3	11.4	3.8	5.7$^{\Delta}$
LKS-62	Depth 5.4 m, coarse sand	173	17.3	27.2	33.0	2.9	9.8	4.6	5.2
LKS-63	Depth 7.0 m, coarse sand	159	20.8	25.2	40.2	2.5	5.0	2.5	3.8
LKS-64	Depth 8.0 m, coarse sand	161	29.2	31.7	21.1	1.2	8.1	3.1	5.6
LKS-65	Depth 8.9 m, coarse sand	165	20.6	27.3	29.1	5.4	7.3	4.2	6.1
LKS-66	Depth 17.7 m, top of slope	168	24.4	16.0	30.4	4.8	8.9	10.1	5.4
LKS-67	Depth 30 m, near toe of slope, coarse sand	159	21.4	24.5	24.5	6.9	8.2	6.3	8.2
LKS-68	Coarse sand	166	18.1	19.3	39.8,	1.8	12.0	3.6	5.4
LKS-69	Silt and mud in coarse sand, abundant large ($^{1}/_{2}$ cm) dead *Sorites* tests	154	22.1	19.5	32.5	3.9	8.4	9.1	4.5
LKS-70	Silt and mud, no coarse sand	142	10.6	20.4	26.1	9.2	6.3	21.8	5.6
LKS-71	Coarse sand in fine matrix	155	9.7	31.6	7.1	16.1	7.7	12.9	14.8$^{\Delta}$
LKS-72	Coarse and fine sediment	167	17.4	29.3	32.3	2.4	6.6	9.0	3.0
LKS-73	Coarse and fine sediment	173	27.2	36.4	15.6	1.7	8.7	6.9	3.5
LKS-74	Coarse and fine sediment	164	17.1	15.9	38.4	6.1	9.1	6.7	6.7
LKS-75	Coarse and muddy sediment	164	9.8	30.5	21.3	7.3	6.1	9.1	15.9
LKS-76	Fine-grained, *Manicina*	148	9.5	21.6	8.8	12.8	23.0	15.5	8.8
LKS-77	Mud	171	11.1	19.3	12.9	15.2	13.5	19.9	8.1
LKS-78	Live *Halimeda*, *Udotia* in mud, allochthonous ooids	156	12.8	18.6	22.4	10.9	10.9	11.5	12.7$^{\Diamond}$
LKS-79	Mud	157	13.4	29.3	18.5	8.3	11.4	13.4	5.7
LKS-80	Mud	161	16.1	24.2	8.1	14.3	15.5	13.7	8.1
LKS-81	Mud	175	8.6	12.0	52.0	8.6	13.7	2.9	2.2
LKS-82	Mud	184	21.2	26.6	24.5	6.0	7.0	8.2	6.5
LKS-83	Mud, dead *Thalassia* with roots	164	9.8	31.1	22.6	9.1	11.0	9.1	7.3
LKS-84	Mud	179	12.3	26.8	16.2	11.7	15.6	11.2	6.1$^{\Delta}$
LKS-85	Mud	170	16.5	20.0	14.7	10.6	14.7	8.8	14.7
LKS-86	Mud, a few large ($^{1}/_{2}$ cm) *Sorites*	172	13.3	19.8	20.9	15.7	11.1	11.6	7.6
LKS-87	Mud	159	19.5	31.4	14.5	11.3	8.8	10.1	4.4
LKS-88	Mud	161	19.2	21.1	8.7	11.8	17.4	17.4	4.4
LKS-89	Fine sand on north edge of rubble horn, regular sinuous sand waves	166	22.9	20.5	39.2	3.6	8.4	1.8	3.6
LKS-90	Coarse rubble behind reef	148	9.5	22.3	52.0	0.7	8.8	2.7	4.0
LKS-91	*Thalassia*, *Syringodium*	168	23.2	18.4	40.4	5.4	4.2	4.2	4.2

Table 4.1. Brief bottom description of each surface sediment sample location, total grain count per thin section, and percentage for each of seven constituent particles. "Other" category includes mud and unidentifiable grains. Location of samples is shown in Figures 4.3 and 4.7 (cont.)

			Percent Constituent particles						
Sample no.*	Bottom description	Grain count	*Halimeda*	Mollusc	Coral	Echinoid	Bryozoa + Red algae	Benthic foraminifers	Other
LKS-92	Small (2 m) fine-grained sand patch in grassy area	164	15.9	22.5	40.9	1.8	8.5	3.7	6.7
LKS-93	Sandy blowout, closely spaced sand waves 4 - 5 cm high, ~10 cm between peaks	171	15.2	19.3	45.6	0.6	9.9	4.1	5.3
LKS-94	Sandy blowout, sand waves similar to those at LKS-93	174	22.4	23.0	36.2	2.9	6.3	4.6	4.6
LKS-95	*Thalassia*, *Syringodium*	180	18.9	17.8	28.3	8.3	7.8	8.9	10.0

Total grain count - 15,890; maximum 184; minimum 141; mean 166.

* See Figure 4.4 for bathymetry as interpreted from the seismic profiles. Depths taken with weighted tape measure are given for samples LKS-51 through LKS-65. Depths for LKS-66 and LKS-67 were read from diver's depth gauge.
∆ Total percent - 99.9.
◊ Total percent - 99.8.

Table 4.2. Comparative data for boundary marker buoys. Loran C coordinates defining accurate locations of Coast Guard Marker 24 and sanctuary and core area boundary buoys (described by Corps of Engineers as tie down anchors). Coordinates were obtained from Loran C receivers tracking Loran C TDs for Stations 1 and 4 at 13900 and 62500 µsec, respectively. Note that the SE and SW sanctuary buoys are located in the middle of the east and west boundaries and not at the south corners; both south corners lie in approximately 40 - 45 m of water (Figure 4.4) at the edge of the Gulf Stream. Also note that the SW buoy marking the west sanctuary boundary and buoy at the SW corner of the core area are described as being "off station." Both marker buoys were actually missing at the time of study.

	Location			Water depths	
	This Paper Loran C	Corps of Engineers Boundary Survey Plan Latitude	Corps of Engineers Boundary Survey Plan Longitude	This Paper m (ft)	Corps of Engineers Boundary Survey Plan m (ft)
Looe Key Sanctuary Boundary Markers					
NE buoy (corner)	13979.4, 62547.3	24°34'91"	81°23'00"	9 (30)	9 (30)
SE buoy (due east of Marker 24)	13977.4, 62547.8	24°32'12"	81°22'59"	15 (49)	12 (40)
NW buoy (corner)	13972.8, 62560.1	24°33'34"	81°25'59"	11(36)	9 (30)
SW buoy (due west of Marker 24)	Off Station	24°31'37"	81°26'00"	12 (40)	12 (40)
Core Area Boundary Markers					
NE buoy (corner)	13975.3, 62553.0	24°33'04"	81°24'16"	4(13)	9 (30)
SE buoy (corner)	13975.2, 62552.4	24°32'45"	81°24'05"	4(13)	11 (35)
NW buoy (corner)	13974.2, 62554.7	24°32'50"	81°24'41"	7(23)	9 (30)
SW buoy (corner)	Off Station	24°32'37"	81°24'38"	11(36)	9 (30)
Coast Guard Marker 24	13975.1, 62552.6	Not given		3 (11)	Not given

Table 4.3. Water depths within inner core area taken by weighted tape measure at sites of 19 sediment samples, locations of 11 reef rock core holes and nine coral core stations.

Sediment Samples			Reef Core Samples			Coral Core Samples		
Sample	Depth		Sample	Depth		Station	Depth*	
No.	(m)	(ft)	No.	(m)	(ft)	No.	(m)	(ft)
LKS-51	8.0	26.2	LK-1	3.2	10.0	A	4.1	1.2
LKS-52	1.0	3.3	LK-2	2.0	6.6	B	5.3-6.5	17.4-21.3
LKS-53	2.0	6.6	LK-3	4.9	16.0	C	5.3-6.2	17.4-20.3
LKS-54	5.3	17.9	LK-4	5.8	19.0	D	3.8-4.1	12.5-13.4
LKS-55	7.3	29.9	LK-5	6.0	19.7	E	6.4	21.0
LKS-56	8.3	27.2	LK-6	8.0	26.2	F	3.8	12.5
LKS-58	4.5	14.8	LK-7	8.0	26.2	G	5.8	19.0
LKS-59	5.5	18.0	LK-8	9.4	31.0	H	4.7-5.5	15.4-18.0
LKS-60	8.6	28.2	LK-9	1.0	3.3	I	4.3	14.1
LKS-62	9.9	32.5	LK-10	awash				
LKS-63	7.0	23.0	LK-11	4.6	15.0			
LKS-64	8.0	26.0						
LKS-89	2.5	8.2						
LKS-90	<1.0	<3.3						
LKS-91	1.0	3.3						
LKS-92	1.3	4.3						
LKS-93	2.0	6.6						
LKS-94	2.5	8.2						
LKS-95	3.2	10.0						

*Depths were measured from water surface to top of coral head cored. Water depths at Stations B, C, D and H are given as ranges due to coring of two or more head corals.

Table 4.4. Summary of dominant-grain percentages of all samples analyzed, their percent average and range of total grains counted, and their percent dominance within inner core area.

Grain	% of 96 Samples in which grain is dominant	% Average grain count	% Range grain count	% of 19 Samples within core area in which grain is dominant	Minor particles >10% of grain count
Coral	49.0	27.7	3-53	63.2	NA
Mollusc	33.3	24.1	7-50	36.8	NA
Halimeda	13.5	20.3	3-46	0.0	NA
Bryozoa/red algae	1.0	7.7	2-23	0.0	20.8
Benthic foraminifers	1.0	5.4	1-22	0.0	12.5
Echinoid	0.0	5.7	1-18	0.0	15.6
Other	0.0	9.1	2-22	0.0	35.4
Total	97.8*	100.0		100.0	

* Two samples (LKS-41 and LKS-67) were not figured in percent of 96 samples because they had equal percentage concentrations of *Halimeda* and molluscs, and coral and molluscs, respectively. Together, their percent value is 2.1, bringing the total to 100.0.

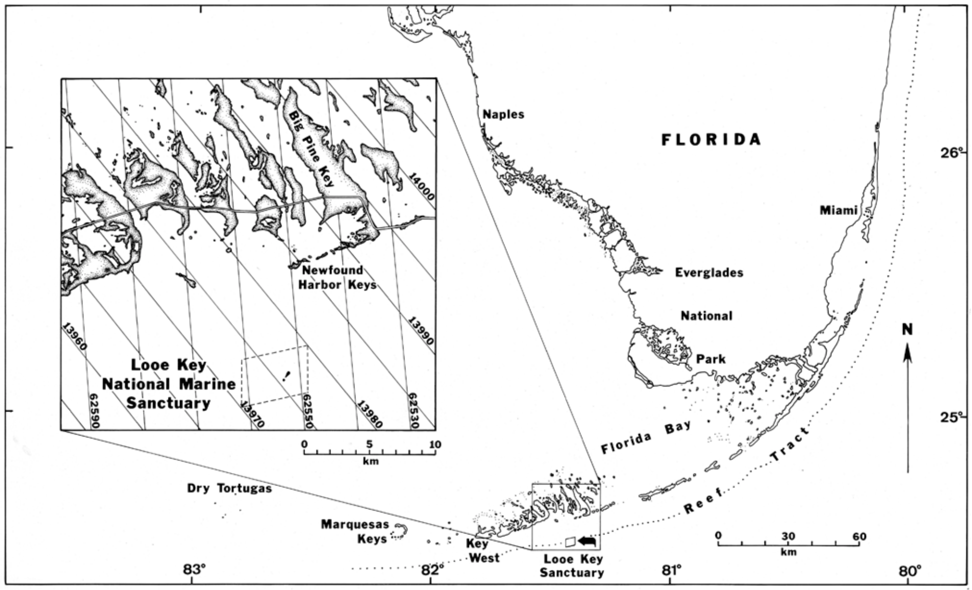


Figure 4.1. Index map for Looe Key National Marine Sanctuary. Loran C TDs for Stations 1 (13900 µsec) and 4 (62500 µsec) for the Gulf of Mexico were reproduced from National Ocean Service chart #11442. Coast Guard Marker 24 within sanctuary (dashed lines on inset) indicated by standard nautical chart symbol for position of lighted fixed marker.

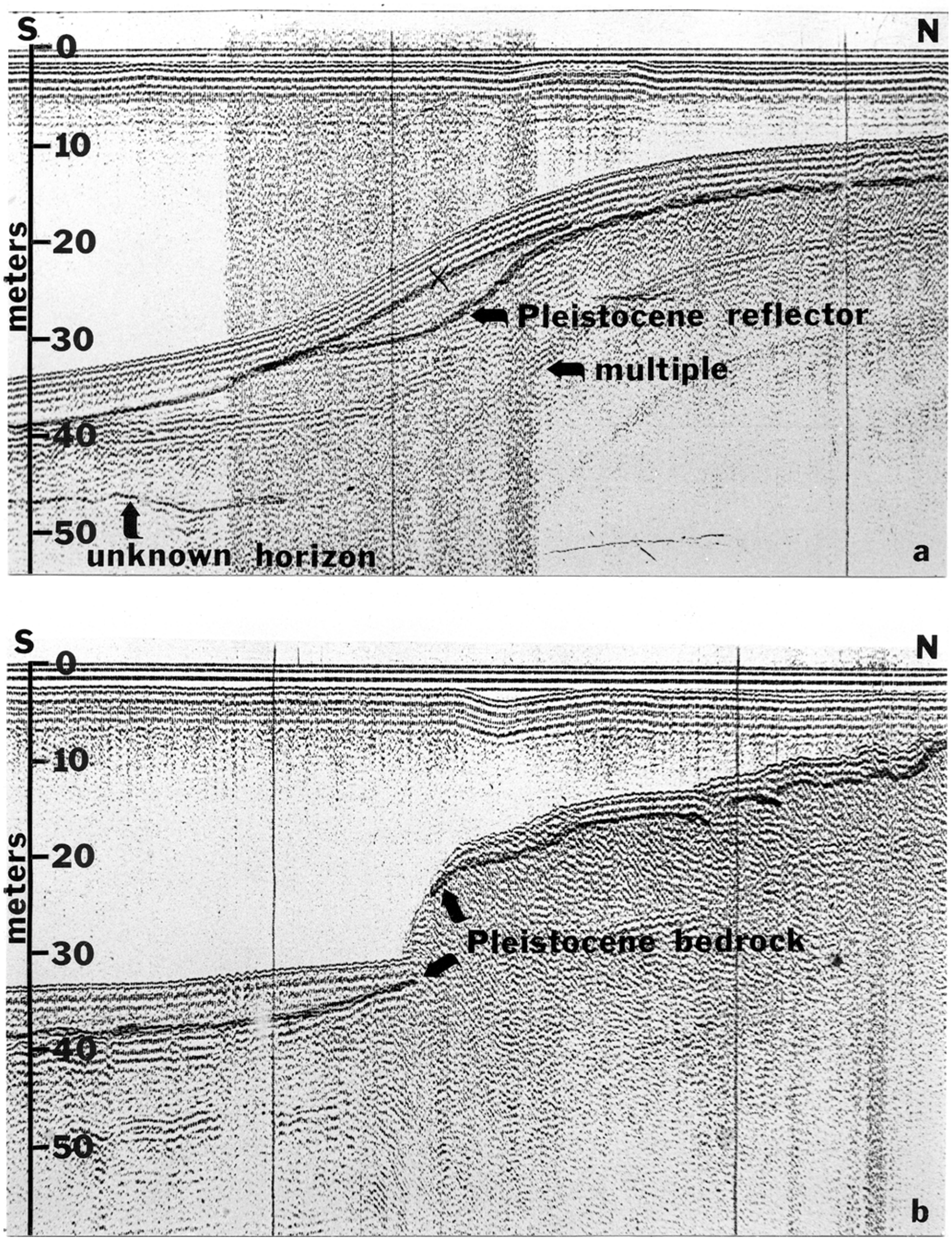


Figure 4.2. Two examples of seismic-reflection profiles (from track line 1, Figure 4.3) showing dropoff south of core area. (a) shows dropoff south of Marker 24 (east end of core area) where migrating sand has blanketed and smoothed slope. (b) shows crossing south of west edge of core area where slope has not been covered with sand. Pleistocene bedrock reflector was outlined with colored marking pen. In (a) the 'X' indicates false interpretation of Pleistocene bedrock.

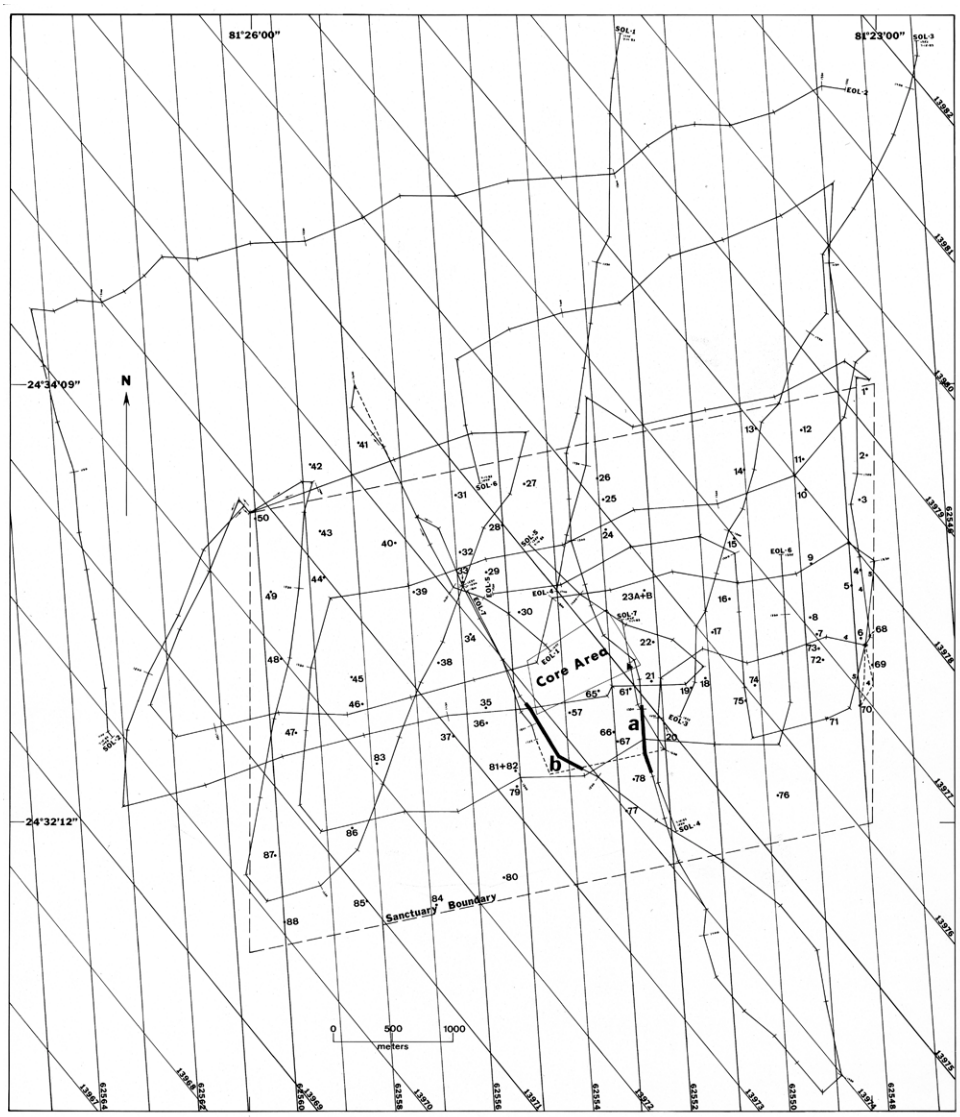


Figure 4.3. Loran C grid chart/base map showing seismic track lines (SOL - Start of Line; EOL - End of Line) and sediment sample locations. Additional 19 sample sites in core area are shown in Figure 4.7. Tick marks on track lines indicate 5-min-interval data points used to construct Figures 4.4 - 4.6. Short dashed lines on tracks 1, 4 and 7 indicate sections of seismic records rendered invalid by sharp course changes.

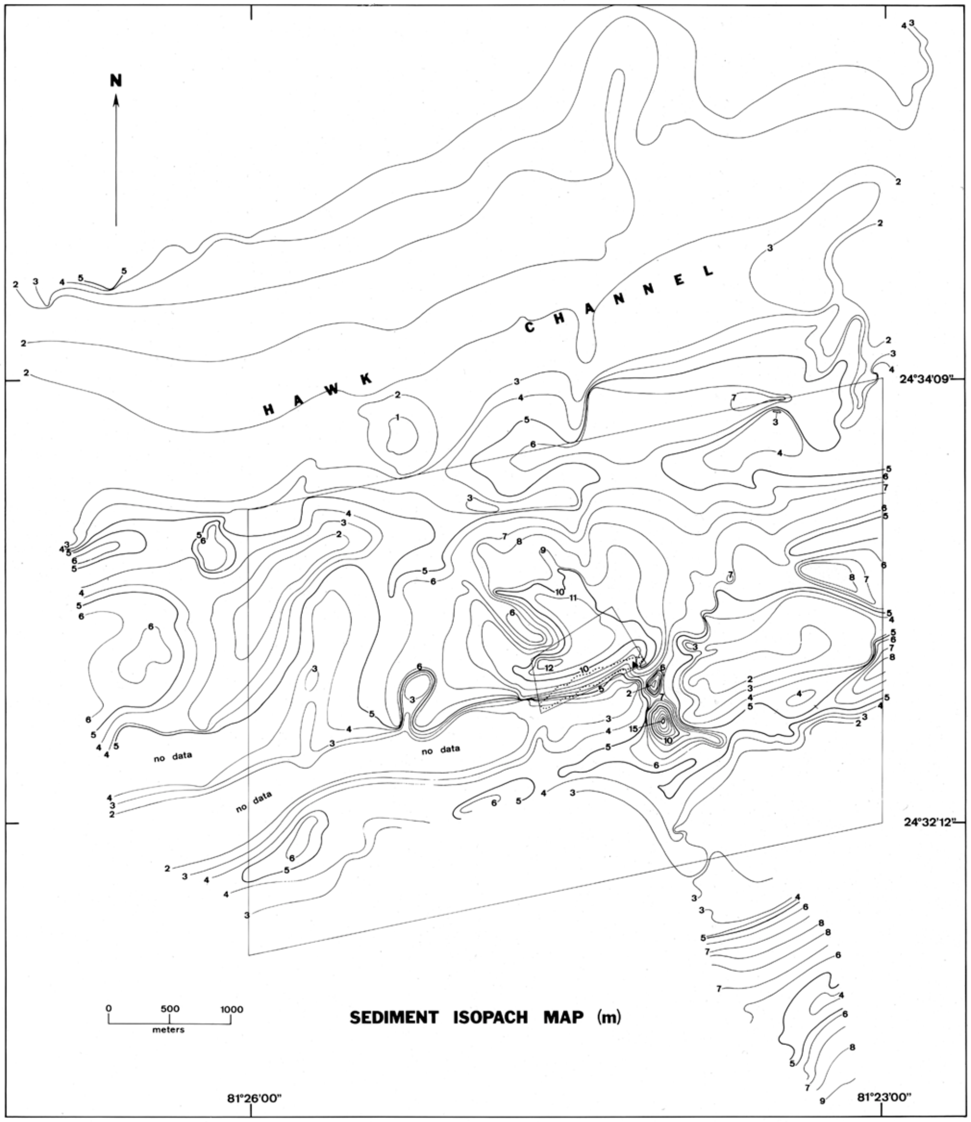


Figure 4.4. Bathymetric map based an 838 seismic data points. Core area not covered due to shallow water. Note prominent east-west dropoff south of core area.

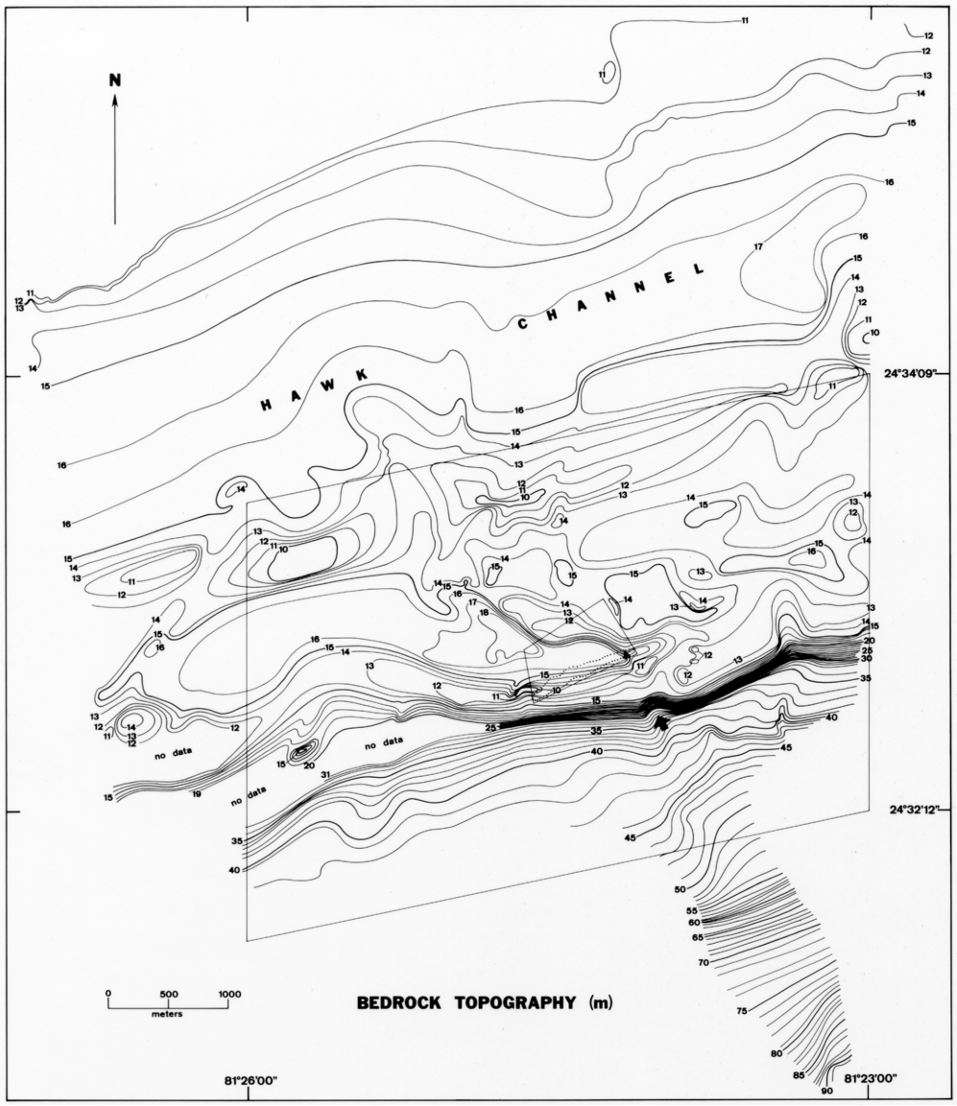


Figure 4.5. Subsurface Pleistocene bedrock topography. Note no data zones where overlying Holocene reef growth prevented penetration of seismic signals. Contours in core area inferred except where depth to bedrock is known from rock cores (see Figure 4.7).

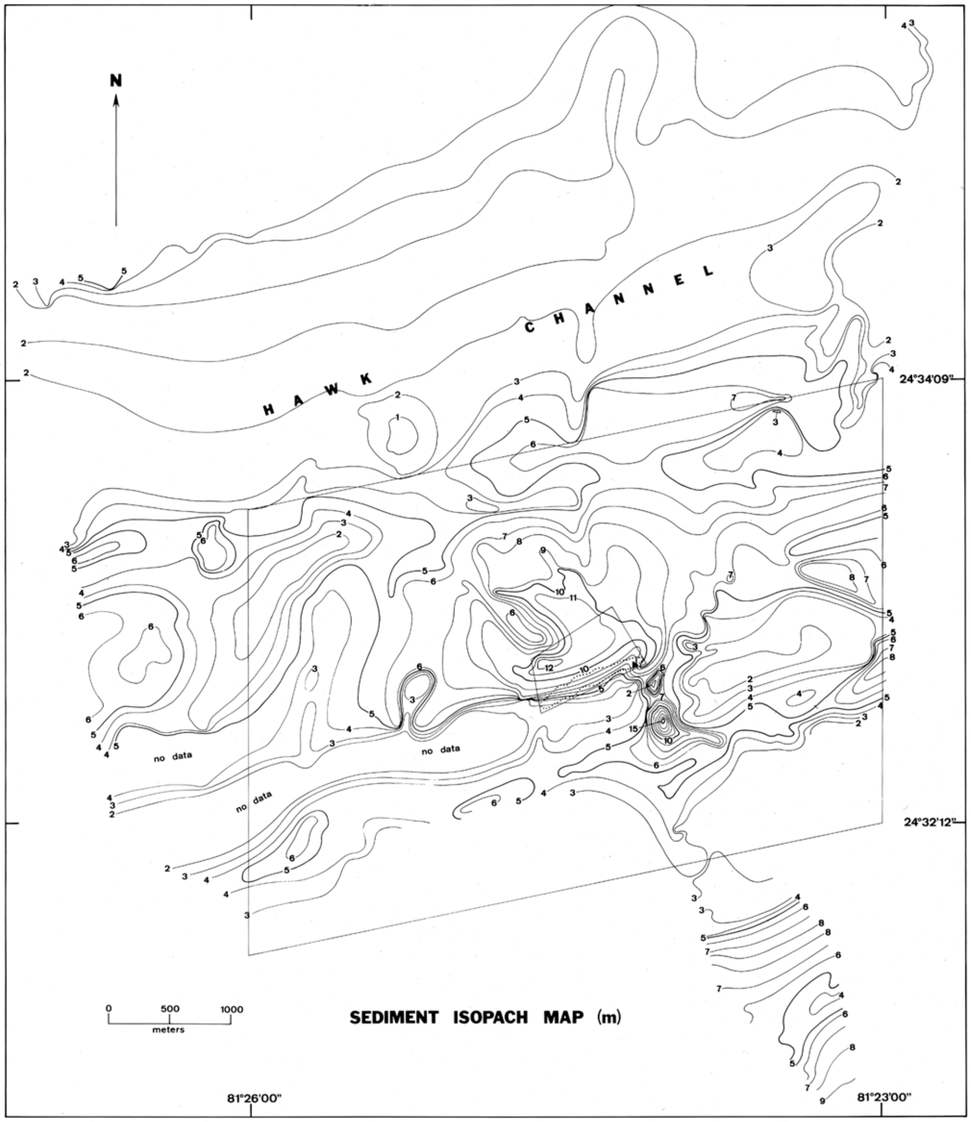


Figure 4.6. Isopachous map of unconsolidated carbonate sands and reef material based on difference between depth to seafloor and depth to bedrock. Contours in core area inferred from projection of data points outside core area. Note thickest accumulations in core area are north of 10-m contour.

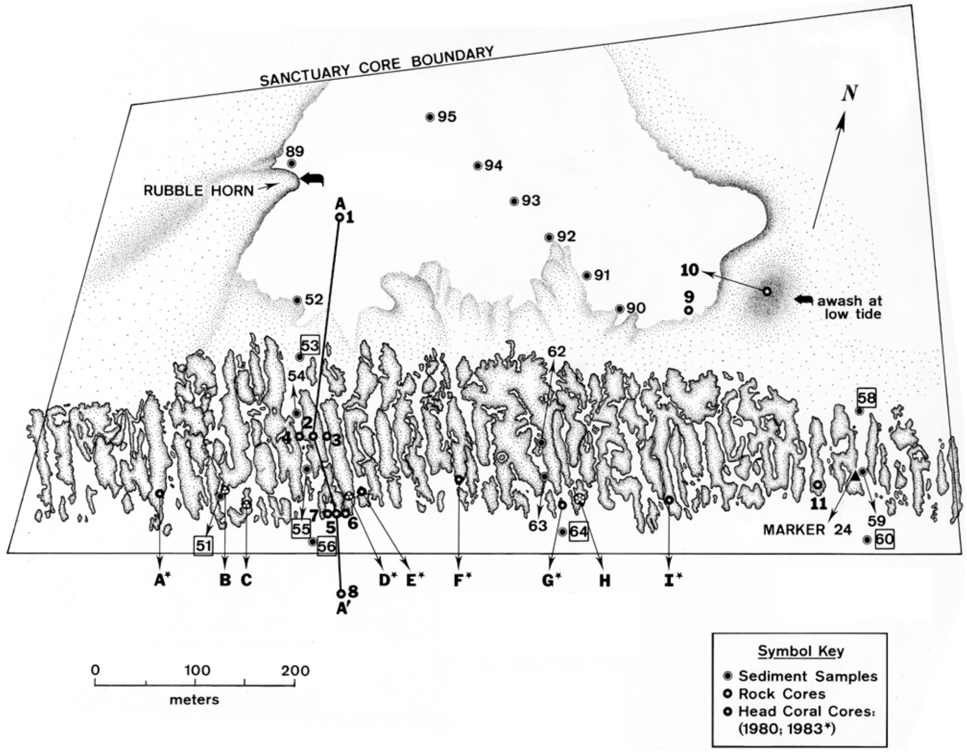
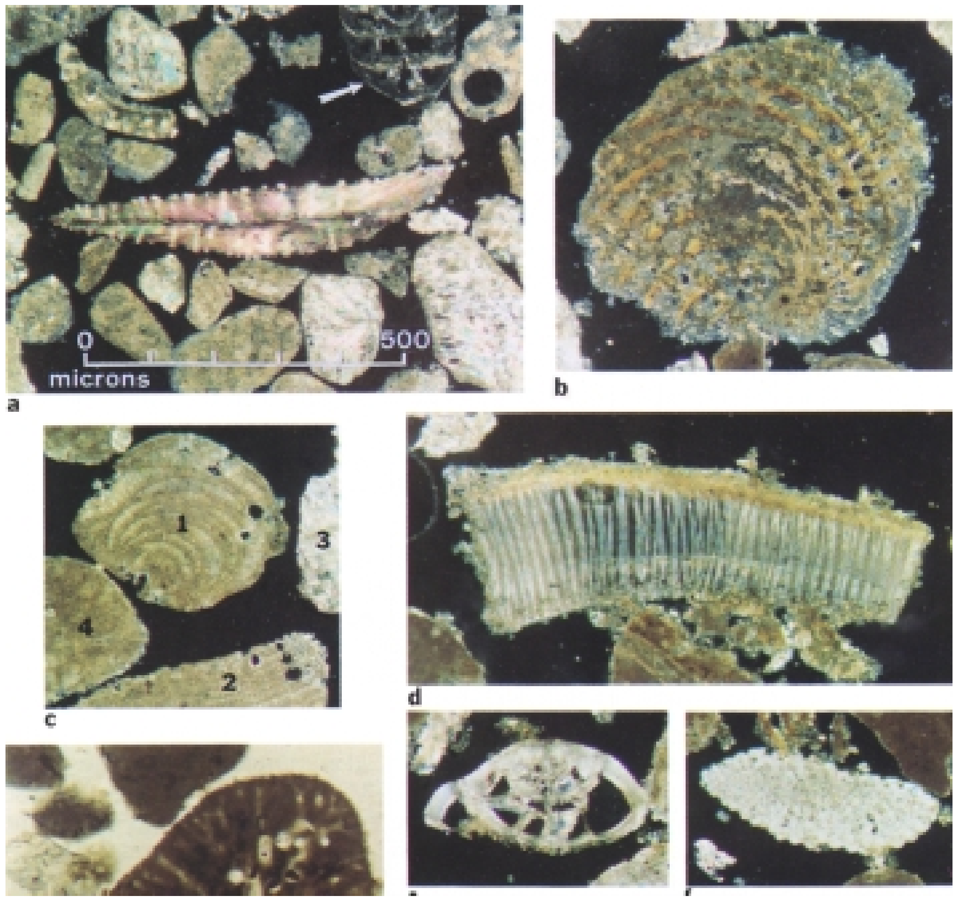


Figure 4.7. Sanctuary inner core area traced from aerial photomosaic and showing location of 19 sediment sample sites along with core holes drilled in earlier study (Shinn *et al.,* 1981). Stippled area behind reef is coral rubble zone. Cross section A-A' based an rock core drilling is shown in Figure 4.12. Also shown are locations of *Montastraea annularis* coral cores described by Hudson (this volume). Small white dots within each large black dot indicate number of head corals drilled per site. Rubble horn shown by arrow formed after 1981, probably during Tropical Storm Dennis (September 1982).


0
500
microns
a
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3
4
2
c
d

CHAPTER 5

GROWTH HISTORY OF *MONTASTRAEA ANNULARIS* AT LOOE KEY NATIONAL MARINE SANCTUARY, FLORIDA

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Introduction

The main objective of this study is to produce a permanent and accurate record of vertical skeletal growth in Looe Key *Montastraea annularis* that extends back in time a minimum of 100 years. A secondary goal is to analyze these data for possible clues to past environmental perturbations that may have influenced health and growth of not only *M. annularis* but the entire Looe Key reef ecosystem as well. In addition, long-term growth rate trends of Looe Key *M. annularis* will be compared with those from the Key Largo Coral Reef Marine Sanctuary to determine if patterns of coral growth observed at Looe Key can be seen in those *M. annularis* growing off Key Largo. Also reported here are results of a new method developed by the author for sealing core sample holes in *M. annularis* with plugs of live coral. Data for this report were compiled from measurements of yearly growth bands revealed in x-radiographs of *M. annularis* core slabs. This sclerochronology technique is based on the work of Knutson *et al.,* (1972), who used autoradiograpby and x-radiography to prove the annual nature of density bands in several species of Pacific (Enevetak Atoll) massive corals.

In addition to being used as precise indicators of age and growth rate, the various characteristics of *M. annularis* density bands have also been evaluated by numerous workers for use as indicators of past changes in ocean environment. Among these are studies by Dodge *et al.* (1974), Hudson *et al.* (1976), Druffel and Linick (1978), Emiliani *et al.* (1978), Fairbanks and Dodge (1979), Highsmith (1979), Hudson (1981a, 1981b), and Druffel (1982). Of these, only the work of Hudson *et al.* (1976), Druffel and Linick (1978), Emiliani *et al.* (1978), Hudson (1981a, 1981b), and Druffel (1982) focus an *M. annularis* from Florida reefs. Their Investigations, however, were restricted to areas in the middle and upper portions of the Florida reef tract. Except for a limited survey by Landon (1975) of *M. annularis* growth rates on reefs off Key West (Figure 5.1), to this author's knowledge, there have been no previous sclerochronology studies of this species in the vicinity of the lower Keys Looe Key reef area (Figure 5.1).

Area description

Shinn *et al.* (1981) divided Looe Key reef into four major ecological zones: grass flat, reef flat, spur and groove. and deep-reef spur and groove. Although some *M. annularis* can be found in all areas of the reef, it is estimated that at least 90% of the Looe Key *M. annularis* population is concentrated in the spur and groove zone. Within this area, most of the *M. annularis*, including those specimens selected for sampling, are situated along the seaward half of prominent reef spurs (Figure 5.2) in water depths ranging from 3 to 8 m (Figure 5.3).

Methods

Core samples were collected from 12 *M. annularis* colonies at Looe Key National Marine Sanctuary during August 27 - 30, 1980. An additional eight corals were cored there during July 14 - 18, 1983. During the 1983 sampling period, a short (20-cm long) core was also taken adjacent to the sealed core hole of each coral sampled in 1980, so that chronologies of these previously collected corals could be extended to 1983. Underwater coring techniques and x-ray processing were identical to those used by the author in a similar study of *M. annularis* in the Key Largo Coral Reef Marine Sanctuary (Hudson, 1981a) with one exception. A new method of sealing core sample holes with plugs of live coral was tested on the eight Looe Key *M. annularis* sampled in 1983. The remaining core holes were filled with pre-cast cement plugs of the type used by the author in the Key Largo study. Both methods perform the same function, that of closing off the lesion to the outside environment, but, whereas four years or more are required for surrounding tissue and skeletal elements to completely cover the cement plug (pers. observation), it is anticipated that live core plugs will require only 12 - 18 months to achieve the same results (Figures 5.4 A-B, 5.5 A-B, and 5.5 C-D).

Procedures used to collect and install live tissue core plugs are as follows. A specially constructed 10.75-cm diameter x 20-cm long core plug barrel was used to obtain short cylinders of live coral from the base of each *M. annularis* subjected to core sampling. To reduce possibility of tissue rejection, plugs were only used on the corals from which they were taken. Since the plug barrel is slightly larger in diameter (0.7 cm) than the barrel used to collect the core samples, a plug is produced that fits snugly into the core hole. In order to maintain plugs flush with the top of the coral colony and to prevent their removal by divers, a shimming material of fiberglass reinforced packaging tape was wrapped around each plug's base to create a wedging effect so that plugs had to be forcibly inserted. The hole left at the coral's base by removal of the live core plug was sealed with a coded pre-cast cement plug to prevent infection and bioerosion, as described in Hudson (1981a), and to maintain identity of individual corals. Closeup color photographs are being taken of all core plugs at intervals of approximately two months so that healing times of coring lesions can be determined (Figures 5.4, 5.5). Average water depth over the 12 corals selected for study was 5.0 m, with a range of 3.8 to 6.4 m. Depth measurements were made by divers from the water surface to the top of each core plug.

Results

Growth history records of 20 *M. annularis* were constructed and analyzed from x-radiographs of core material collected at Looe Key reef during 1980 and 1983. Of these, eight were de-selected on the basis of having insufficient growth records or indistinct annual density bands. Annual growth rates of the 12 remaining corals were tabulated and each coral's yearly growth rate averaged at 5-year intervals (Figures 5.6 - 5.9). This allowed a direct comparison with published growth history data of this species from a similar study (Hudson, 1981a) in the Key Largo Coral Reef Marine Sanctuary (Figure 5.10). The youngest coral in the present study is 105 years of age, while the oldest has a density band chronology that dates back to 1793, a span of 190 years. Since ages of corals varied greatly (as much as 85 years), it was decided that only those growth rate data that are represented in growth records of all 12 corals would be used for comparative analysis.

Averaged growth rates of each colony together with maximum-minimum growth deviations were plotted as line graphs at 5-year intervals, so that significant changes in growth of individual corals could be recognized. In addition, growth rate data from all corals were combined into a single graph (Figure 5.9) to illustrate long-term trends in growth within the *M. annularis* community at Looe Key reef.

Individual growth history graphs reveal that 10 of 12 Looe Key *M. annularis* studied have a 60- to 75-year history of declining annual growth, a condition that was apparently initiated between 1908 and 1923. This trend, characterized by a gradual decrease in skeletal accretion rates, is even more evident when growth data of all Looe Key *M. annularis* are combined (Figure 5.9). Of particular interest is that during the most recent 5-year growth period (1978 - 1983), only two colonies (shown as E4' and D1' in Figure 5.9) increased their rate of vertical growth. Since determinate growth (reduction of growth rate with age) is generally not thought to be operational in reef-building corals (Highsmith, 1979), it appears that a gradual deterioration in some aspect of the reef environment is most likely responsible for the observed long-term decline.

Coincident with the decline of *M. annularis* growth rates at Looe Key reef in 1908 was the construction of Henry Flagler's Overseas Railway from Miami to Key West, Florida. Begun in 1904 and completed in 1916 (Corliss, 1953), this southernmost extension of the Florida East Coast Railroad Line was in operation until 1935. That year a disastrous; storm, the infamous "Labor Day Hurricane," struck the Florida Keys, severely damaging many miles of railway embankments there (Corliss, 1953). This catastrophic event, together with worsening economic conditions brought about by the great depression, forced owners of the railroad to abandon the Florida Keys segment of the line. The company sold this portion of the railway to the State of Florida, which in turn eventually converted it into a road for automobile traffic (today's Overseas Highway) by building a roadbed directly on top of the original railway.

Except for the recent building of new and wider bridges and widening of existing fills and embankments to accommodate more vehicular traffic, most of the modifications to land and water made by the building of the Overseas Railway remain unchanged today. Of these alterations, the most profound was the construction of permanent earthen causeways to bridge shoal areas between islands. This cost effective technique was used most extensively in the middle Keys area between Marathon and Upper Matecumbe Key (Figure 5.11). Here, tidal passes that had previously permitted water exchange between Florida Bay and the Atlantic Ocean were partially blocked by manmade embankments. According to Corliss (1953), about 20 miles (32 km) of the 106-mile (170-km) route between Jewfish Creek and Key West (Figure 5.11) were bridged by fills or embankments. Materials for these elevated causeways of mud, sand and rock were dredged and blasted from the surrounding Bay bottom and islands along the railway's path.

In order to determine if these perturbations could have contributed to the, observed decline in growth of Looe Key *M. annularis*, natural tidal openings and the manmade causeways that partially block them were both measured from modern navigational charts issued by the National Ocean Service. Copies of the US Coast and Geodetic Survey maps of the Florida Keys that were issued between 1895 and 1900 were obtained from the National Archives and used in conjunction with those charts previously mentioned to establish where natural land ended and manmade landfill began. Measurements taken by the author from National Ocean Service chart #11449 (Matecumbe to Grassy Key) indicate that, due to causeway construction, the effective tidal opening between Grassy Key and Long Key was reduced from 8.7 km to 4.0 km, while open water from Long Key to Lower Matecumbe Key was reduced from 5.8 km to 2.0 km. Similarly, the tidal exchange area separating Lower Matecumbe Key from Upper Matecumbe Key was reduced from 3.5 km to only 1.0 km (Figure 5.11).

Of the 18 km of natural tidal passes that existed between Grassy Key and Upper Matecumbe Key prior to building of the railway extension, 11 km (61%) were lost as a direct result of causeway construction there. In contrast, causeways were used only sparingly to bridge large tidal passes below Grassy Key (National Ocean Service charts #11445 and #11449). Of these, the opening spanned by the Seven Mile Bridge is by far the largest tidal pass in the entire Florida Keys. Prior to construction, it was approximately 10.5 km across. Space now occupied by embankments, together with Pigeon Key (a small island over which the bridge passes), amount to about 1.0 km, leaving a post-construction opening of 9.5 km. Tidal passes at both Bahia Honda Channel and Spanish Harbor Channel were each about 1.6 km across before building of the railway. Loss of tidal opening at Bahia Honda Channel from embankment building was only about 0.1 km, leaving a 1.5 km opening. Spanish Harbor Channel, however, was reduced nearly 0.5 km, leaving only about 1.1 km for tidal relief there.

Other tidal channels that could conceivably effect Looe Key reef are: Pine, Wiles, Kemp and Bow Channels (Figure 5.11). Before alterations by railway construction, the combined openings of these four channels amounted to approximately 4.5 km. Embankment building blocked off about 2.1 km of these passes, leaving about 2.4 km of tidal openings. Although these passes are directly inshore of the study area, they are considerably narrower and much shallower than those previously described. Average water depth of less than 2 m prevails over large areas in all four channels, whereas depths in excess of 3 m are common along both the Gulf and Atlantic Ocean sides of Spanish Harbor Channel, Bahia Honda Channel and Moser Channel (spanned by Seven Mile Bridge). Bahia Honda Channel with depths of 7 - 8 m at the bridge span is the deepest tidal pass between Key West and Miami.

Ginsburg and Shinn (1964) suggested that the absence of living reefs opposite major tidal passes in the Florida Keys is the result of chilled turbid water from Florida Bay and the Gulf of Mexico flowing out these tidal openings onto the reef tract during periods of severe winter storms. A recent study by Hudson (1981b) indicated that growth and survival of *M. annularis* on Florida reefs are strongly influenced by both heated and chilled waters that are generated in the Gulf of Mexico and Florida Bay. A landmark study by Roberts *et al.* (1982) proved conclusively that outbreaks of severe winter weather (cold fronts) that periodically impinge on the Florida Keys are capable of lowering inshore water temperatures to levels that have been proven lethal to major reef-building corals, including *M. annularis* (Mayor, 1914). In addition, Roberts *et al.* (1982) documented transport of these chilled water masses to offshore reef areas through major tidal passes in the middle and lower Florida Keys.

Based upon evidence presented earlier in this report, it is clear that passage of tidal waters through major breaches in the Florida Keys has been moderately to severely restricted as a result of embankment construction across tidal openings. It is this author's contention that extensive use of landfill embankments between Grassy Key and Upper Matecumbe Key between 1905 and 1908 created a barrier of sufficient magnitude that a substantial portion of tidal waters normally exiting there is now being diverted westward to deeper less restricted openings such as Moser Channel, Bahia Honda Channel and Spanish Harbor Channel. If this is true, then the added discharge of unsuitable water from this portion of Florida Bay could conceivably account for the decline in coral growth rate at Looe Key.

It in interesting to note that average growth of 10 *M. annularis* (Figure 5.10) an inshore patch reef in the Key Largo Coral Reef Marine Sanctuary (Figure 5.1) began to increase following completion of Flagler's railway. Farther offshore in an environment similar to that of Looe Key reef, 10 *M. annularis* at Molasses reef (Station L) also registered a slight increase in their rate of growth (Figure 5.10). During this same time period, 10 *M. annularis* at nearby Station K (Red Num Buoy 4DS) increased their average rate of vertical growth (Figure 5.10). Although circumstantial, timing of these growth rate increases does coincide with extensive construction of embankments in tidal passes of the middle Keys. It seems reasonable to assume that growth of *M. annularis* would be enhanced in those areas where tidal water discharge detrimental to their growth was reduced. The abrupt drop in growth rate at Station D is presumed to have been caused by cold water stress during the winter of 1941 - 1942. Cause of the 1918 - 1923 growth decline on the two outer reefs is unknown.

Discussion and conclusions

Critical examination of 1,550 yearly growth bands revealed few instances of major growth interruptions in Looe Key *M. annularis*. Although detectable winter stress bands are visible in some corals, particularly at the 1941-42 and 1969-70 horizons, there is little evidence to suggest an environmental trauma, such as the cold-water catastrophe at Hen and Chickens Reef, that could have inflicted severe damage to these corals. Proximity of Looe Key reef to warm clear waters of the Florida Current undoubtedly enable this ecosystem to survive periodic insults of unsuitable tidal waters from the Gulf of Mexico and Florida Bay. Partial shielding by the lower Florida Keys land masses has also played a vital role in maintaining this reef's vitality. A virtual absence of large flourishing reefs directly opposite major tidal passes is convincing evidence of protection by land masses. Whether or not reefs in the middle Keys have responded favorably to the reduction in tidal outflow has yet to be investigated. There is still considerable tidal exchange in the middle Keys area, particularly through the viaduct at Long Key.

In conclusion, this study indicates a 60- to 75-year suppression in vertical skeletal accretion rates of Looe Key reef's most prominent reef-building coral. Whether or not the observed reduction in growth rate is primarily attributable to building of the Overseas Railway or to a such broader based ecological perturbation remains to be proven. Although there were brief periods of a slight overall growth resurgence in the *M. annularis* community in 1953 and 1978, the long-term trend in most specimens examined has been one of gradual decline. Future periodic examination of growth rate trends in *M. annularis* at Looe Key reef will provide a continuing and valuable index of this sanctuary's vitality.

Acknowledgments

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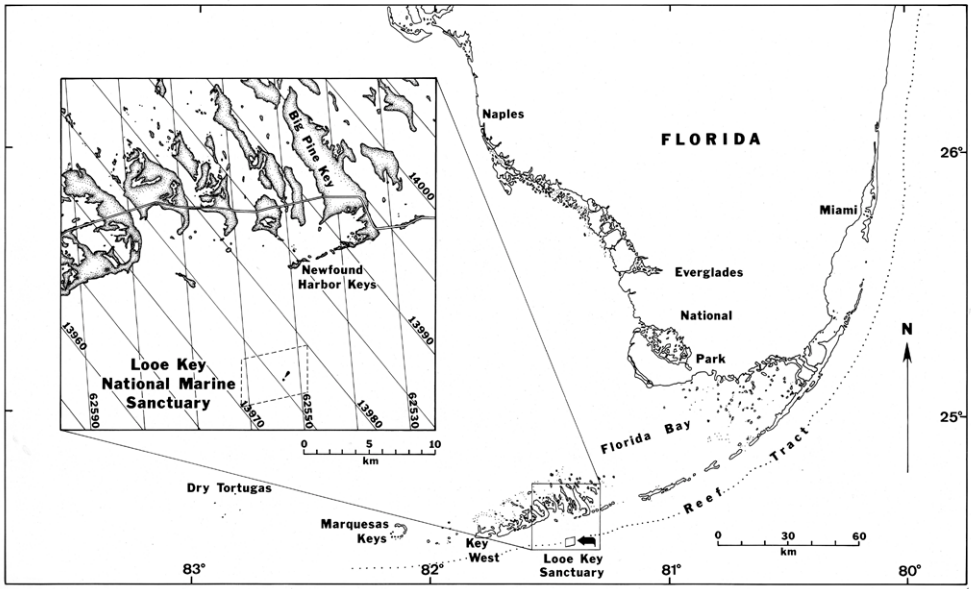

Figure 5.1. Index map for Looe Key National Marine Sanctuary. Loran C lines of position for Stations 1 (13900 µsec) and 4 (62500 µsec) for the Gulf of Mexico were reproduced from National Ocean Service chart #11442. Coast Guard Marker 24 within sanctuary (dashed lines on inset) indicated by standard nautical chart symbol for position of lighted fixed marker.

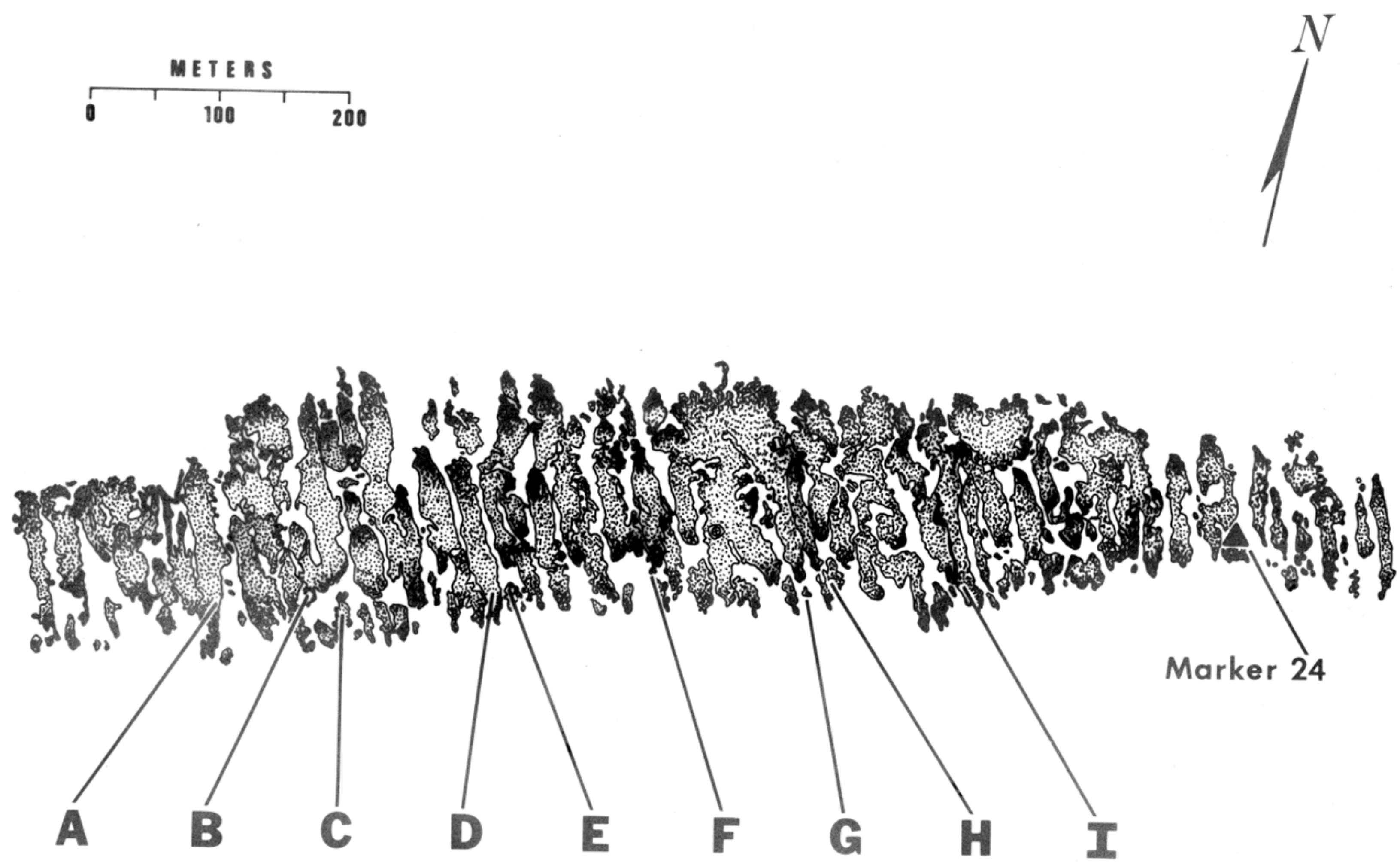

Figure 5.2. Map of core area in Looe Key National Marine Sanctuary showing spur and groove system of coral buttresses.

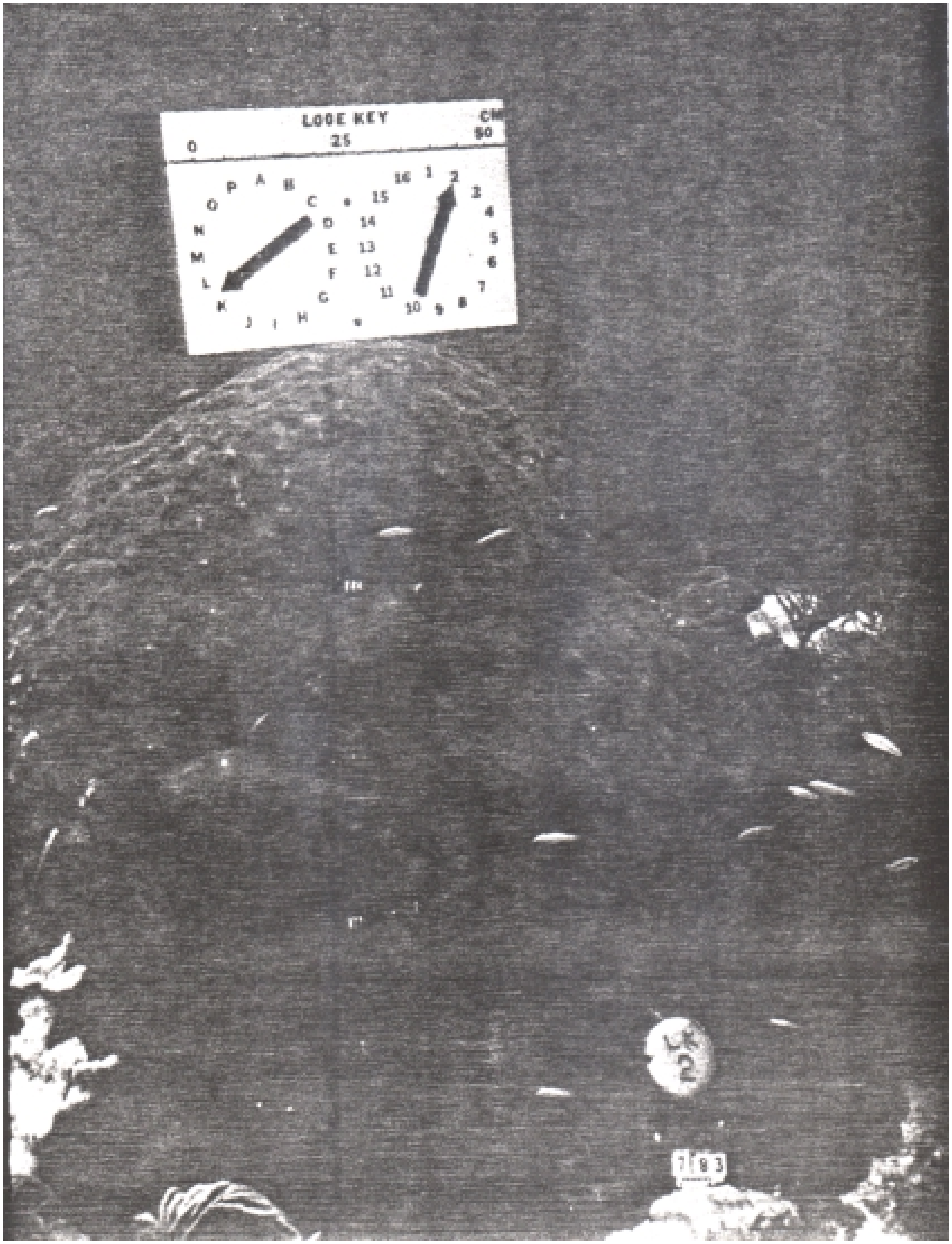

Figure 5.3. Panoramic view of 2-m high *Montastraea annularis* on seaward tip of spur buttress at Looe Key reef. Cement plug in foreground seals hole left by removal of live core plug.

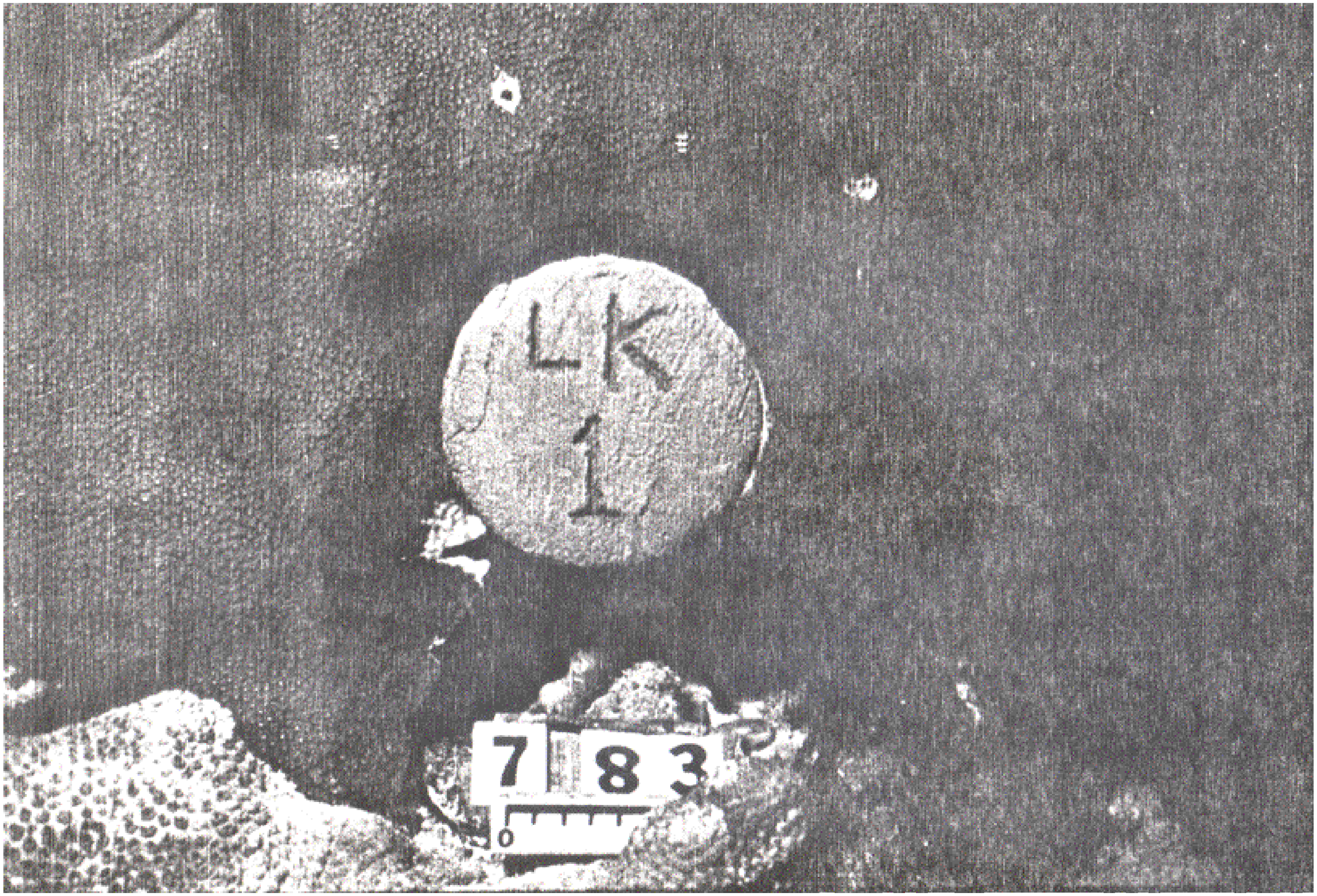

Figure 5.4A. Newly installed pre cast cement plug (LK1) fills hole left by removal of live core plug. Note two small nail holes above cement plug from installation of coring template. Scale bar is in centimeters.

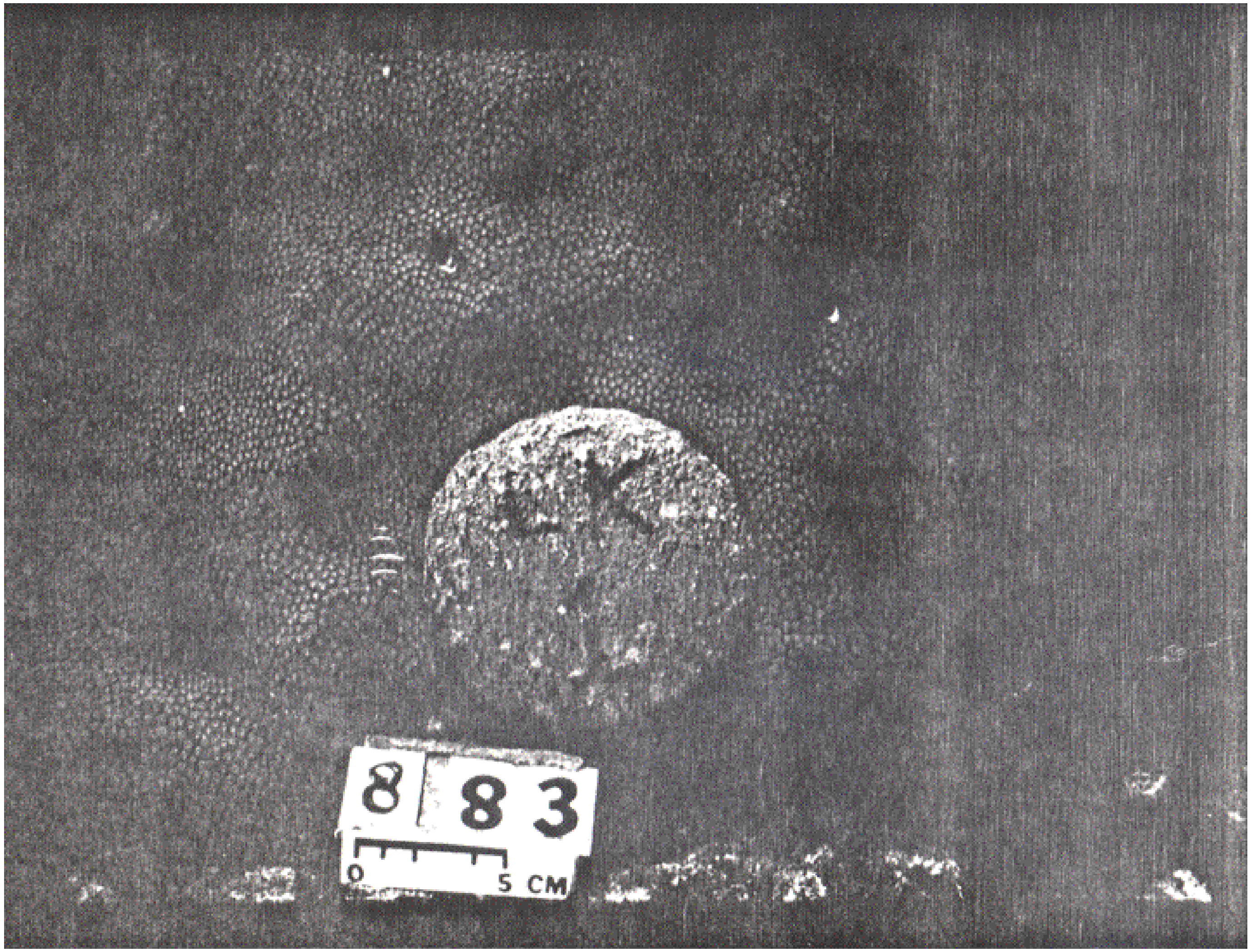

Figure 5.4B. Cement plug (LK1) rephotographed one month after installation. Note that lesions have been covered with new tissue. Also note that most of the lesions associated with coring have healed.

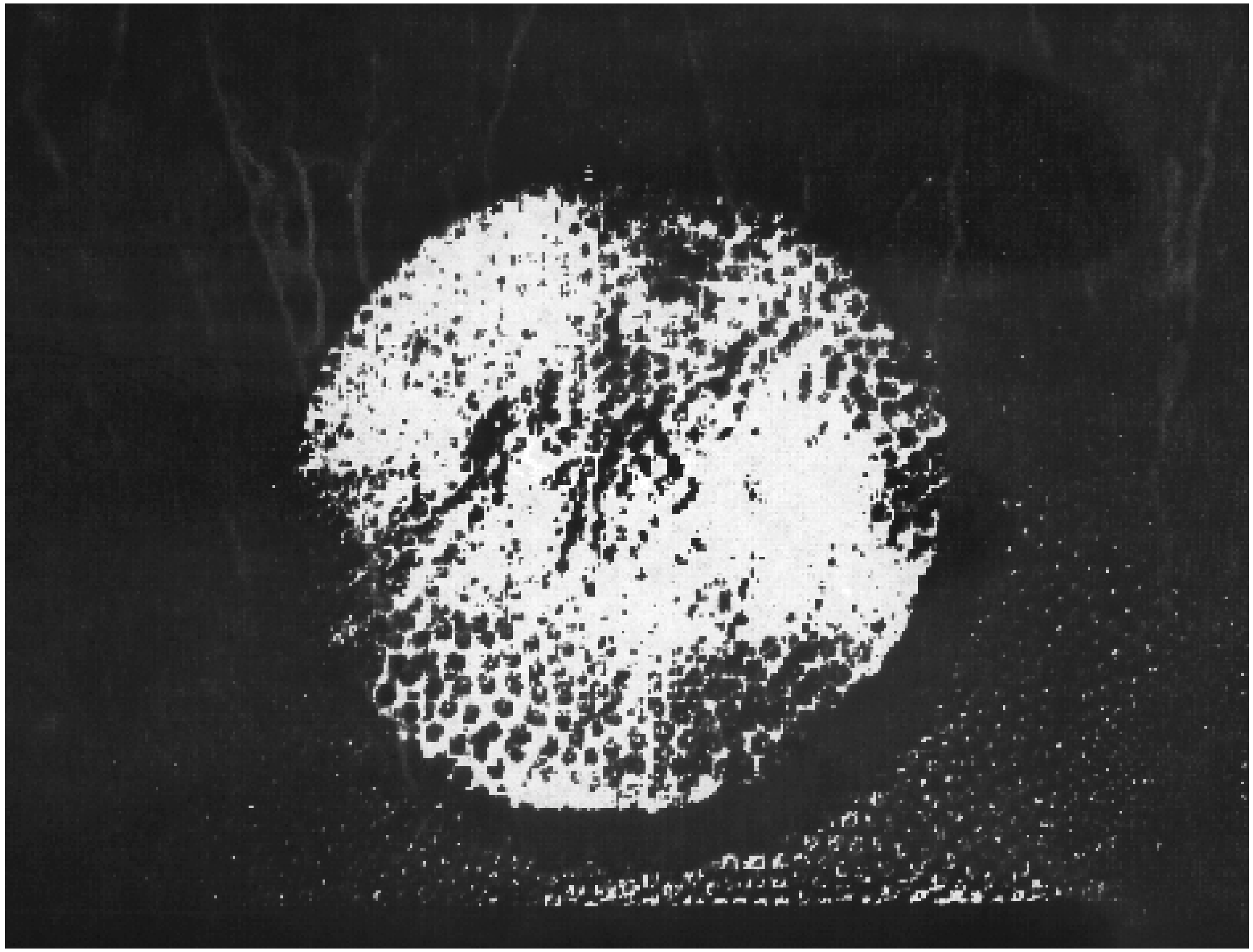

Figure 5.5A. Closeup photograph of live core plug (LK6) three months after being implanted. White appearance of coral tissue is due to expulsion of zooxanthella and is probably the result of transplant stress. Plug diameter is approximately 10.5 cm.

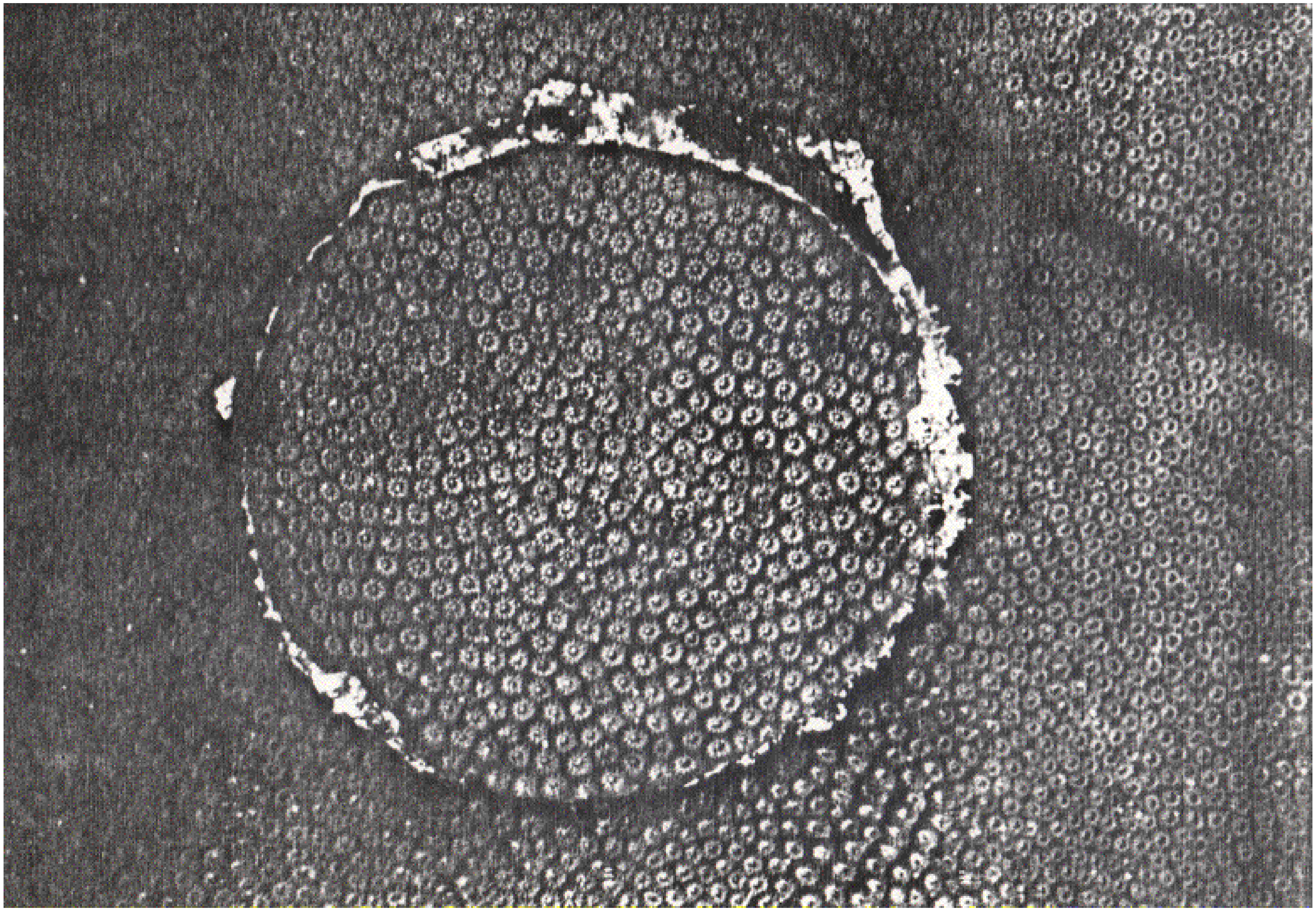

Figure 5.5B. Closeup photograph of live core plug (LK6) six months after being implanted. Note that plug color has returned to normal and surfaces of both core hole and core plug have healed over. Plug diameter is approximately 10.5 cm.

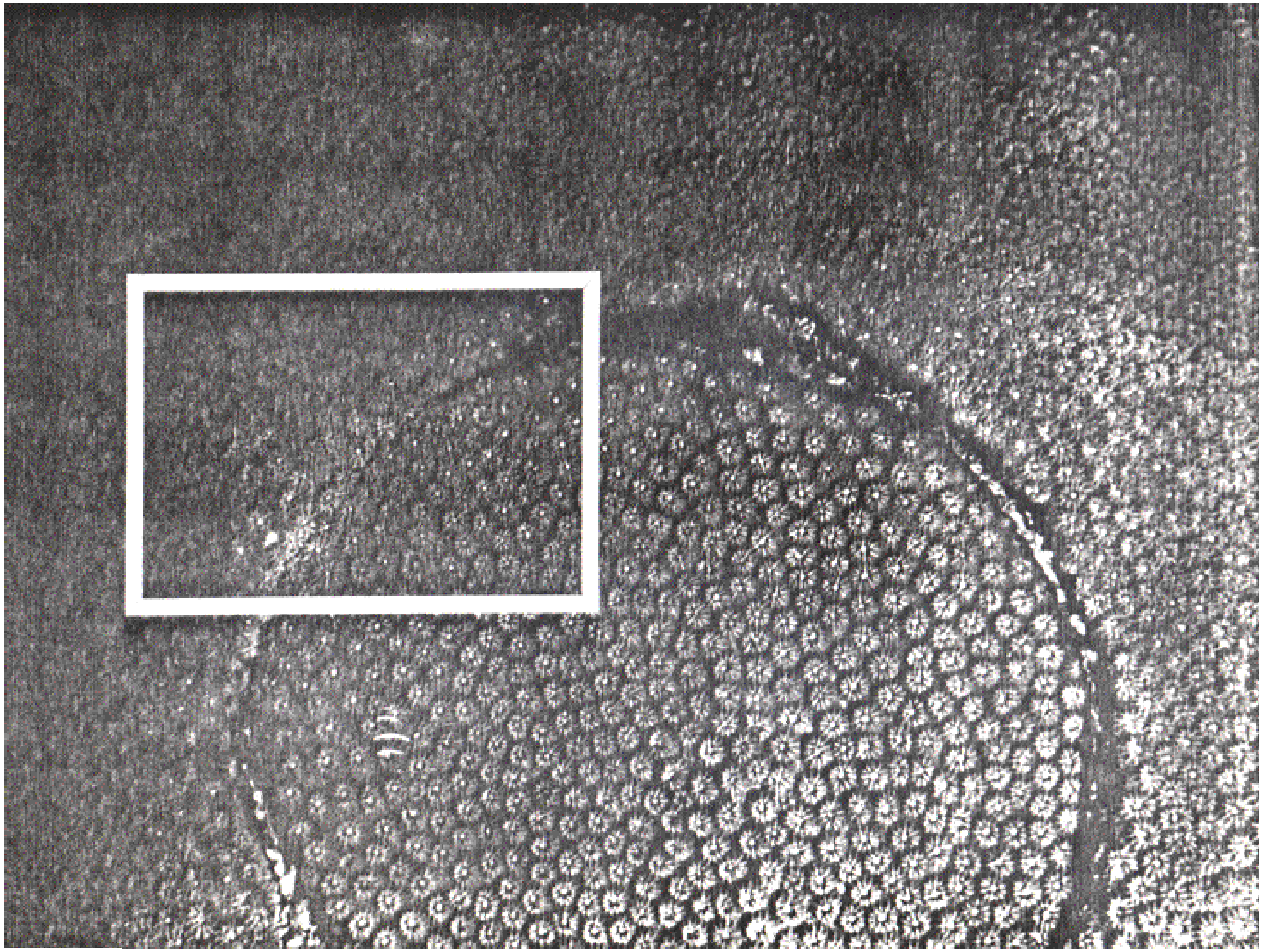

Figure 5.5C. Closeup of live core plug (LK1) nine months after implanting. Note fusion of polyps between parent coral and implanted plug. Plug diameter is approximately 10.5 cm.

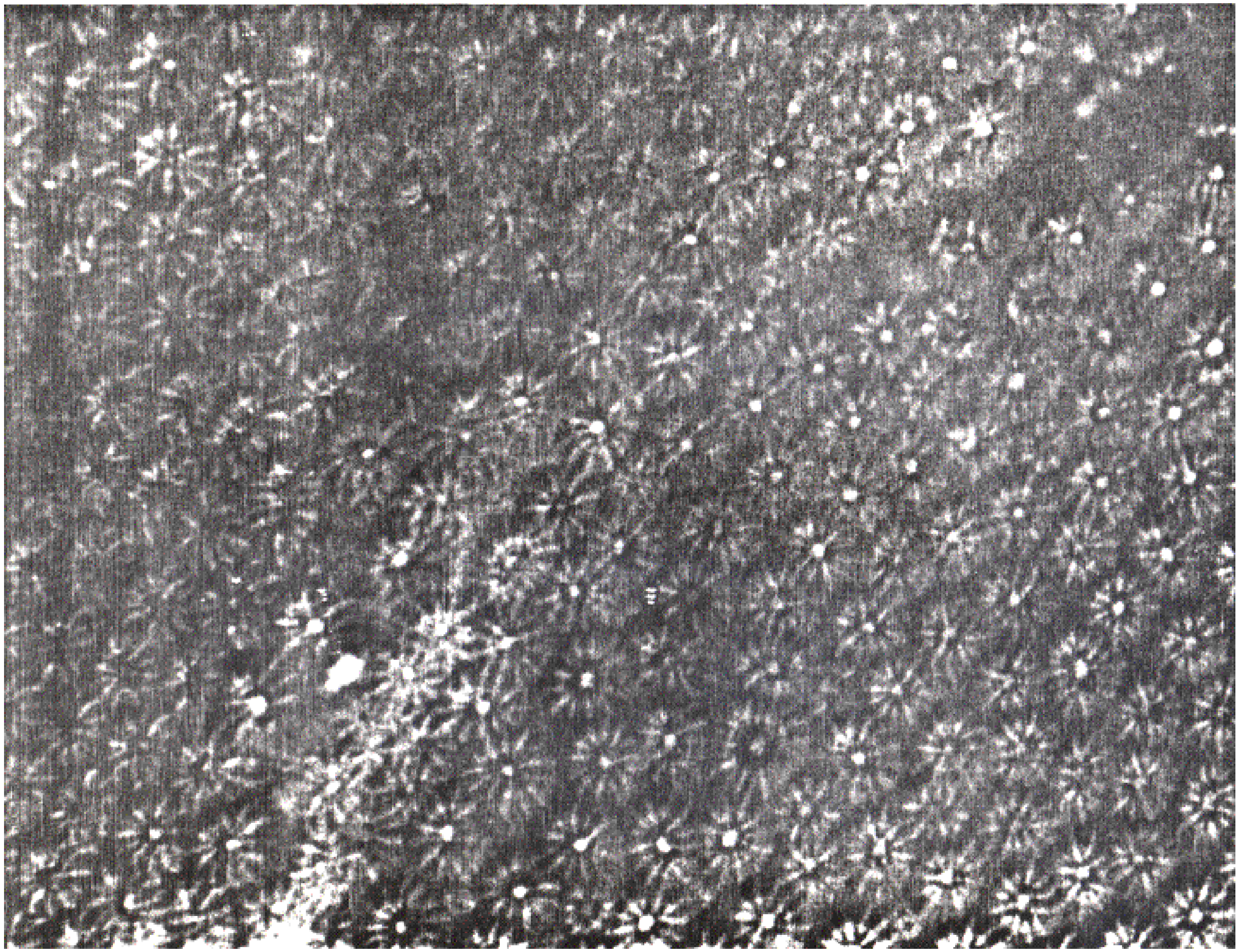

Figure 5.5D. Magnification (x 5) of inset in Figure 5.5C. Note closure and partial overlap of core plug suture line by newly formed polyps.

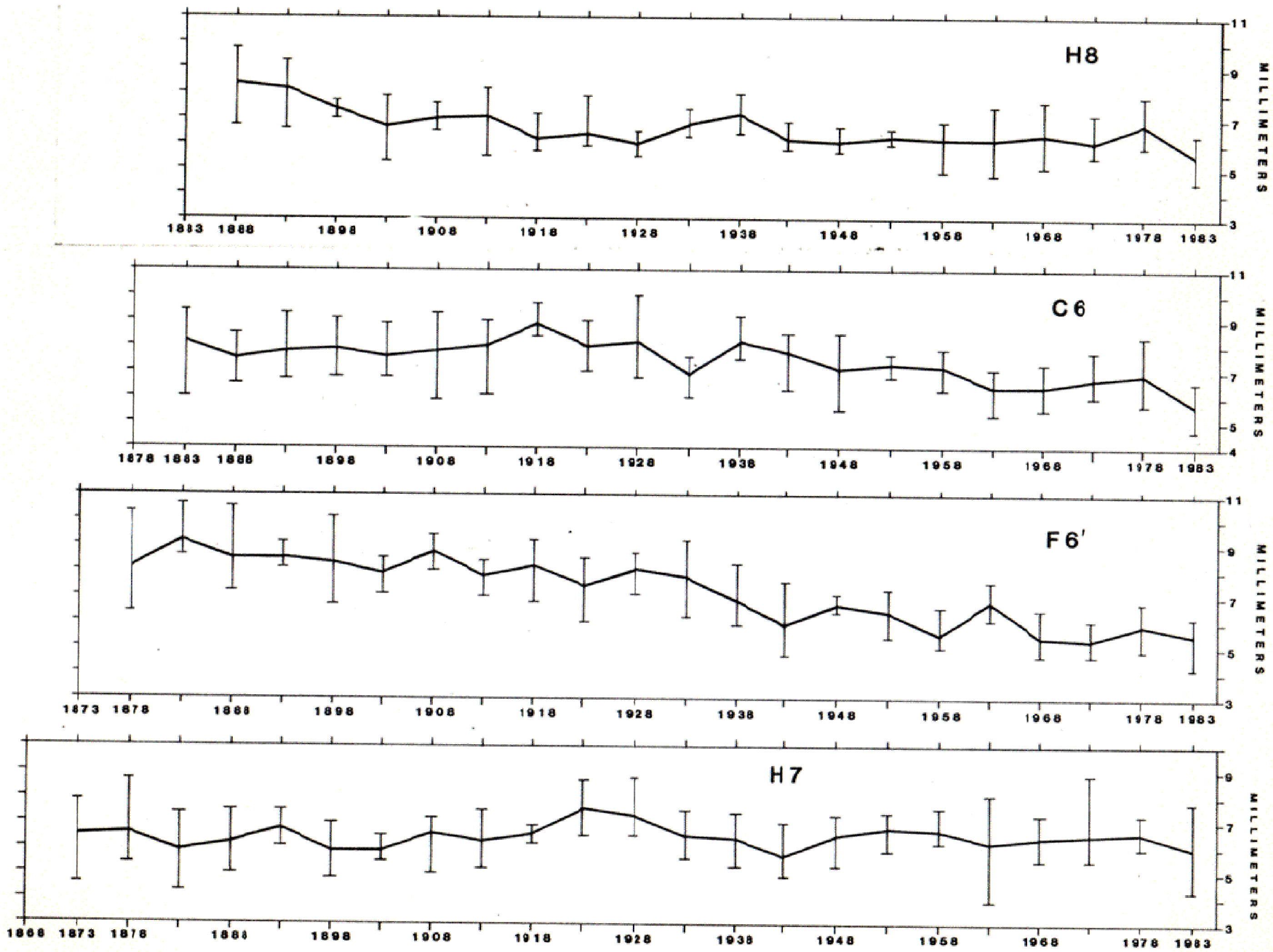

Figure 5.6. Growth history graphs of individual Looe Key *Montastraea annularis* plotted at 5-year intervals. Solid line indicates growth rate average. Vertical bars indicate maximum-minimum growth rates. Letter/number code identifies individual corals. Use this code to find location of specific corals in Figure 5.2.

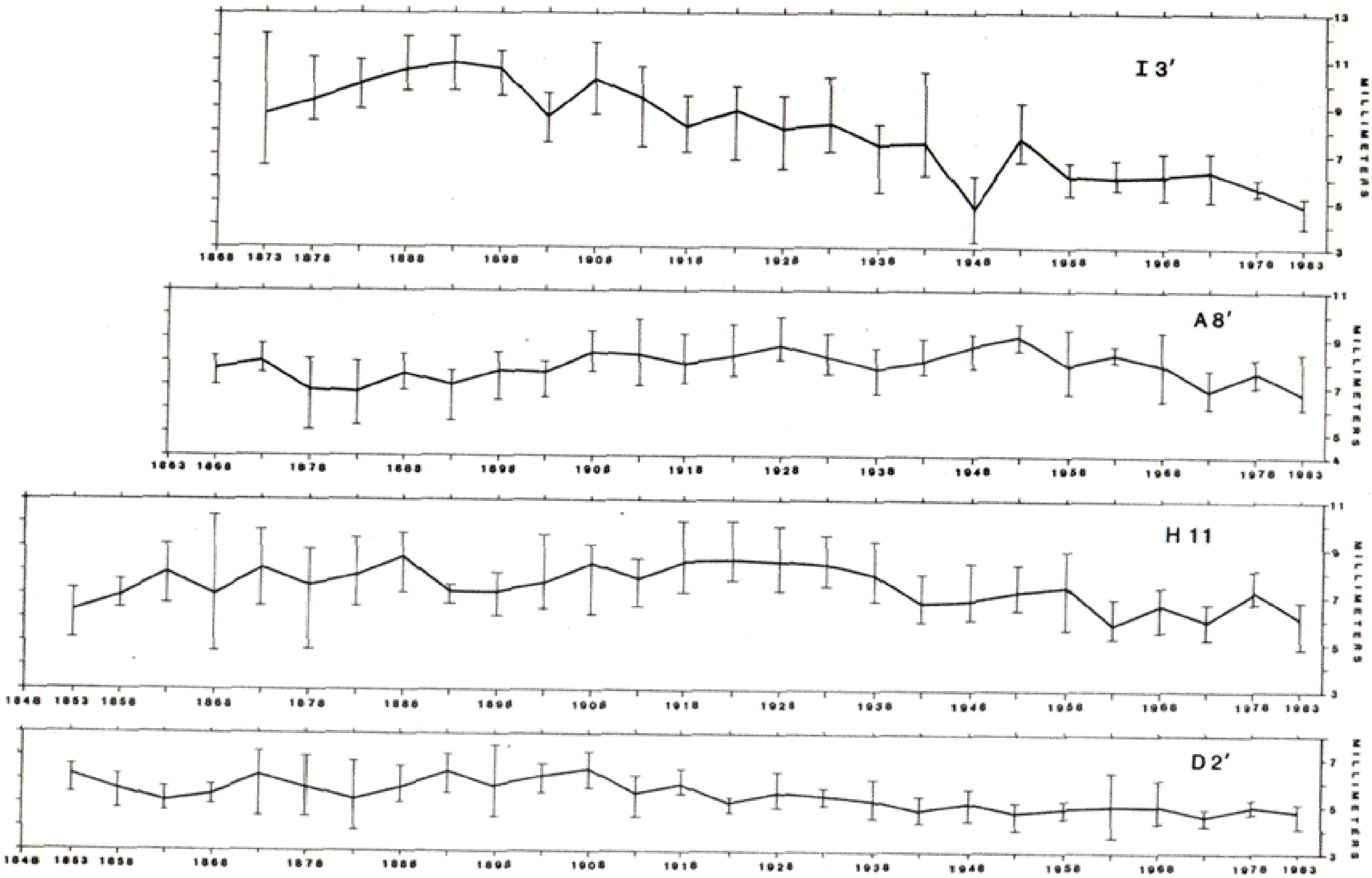

Figure 5.7. Growth history graphs of individual Looe Key *Montastraea annularis* plotted at 5-year intervals. Solid line indicates growth rate average. Vertical bars indicate maximum-minimum growth rates. Letter/number code identifies individual corals. Use this code to find location of specific corals in Figure 2.

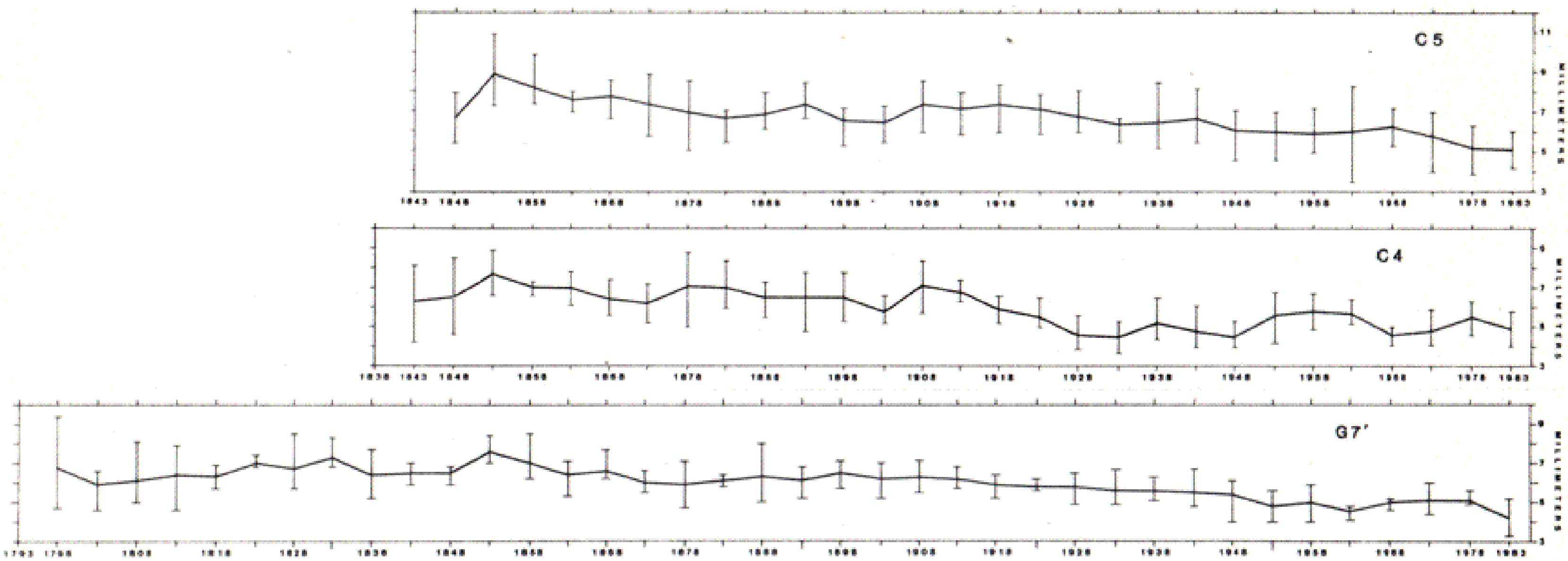

Figure 5.8. Growth history graphs of individual Looe Key *Montastraea annularis* plotted at 5-year intervals. Solid line indicates growth rate average. Vertical bars indicate maximum-minimum growth rates. Letter/number code identifies individual corals. Use this code to find location of specific corals in Figure 5.2. Note that GV is the oldest coral cored in this study.

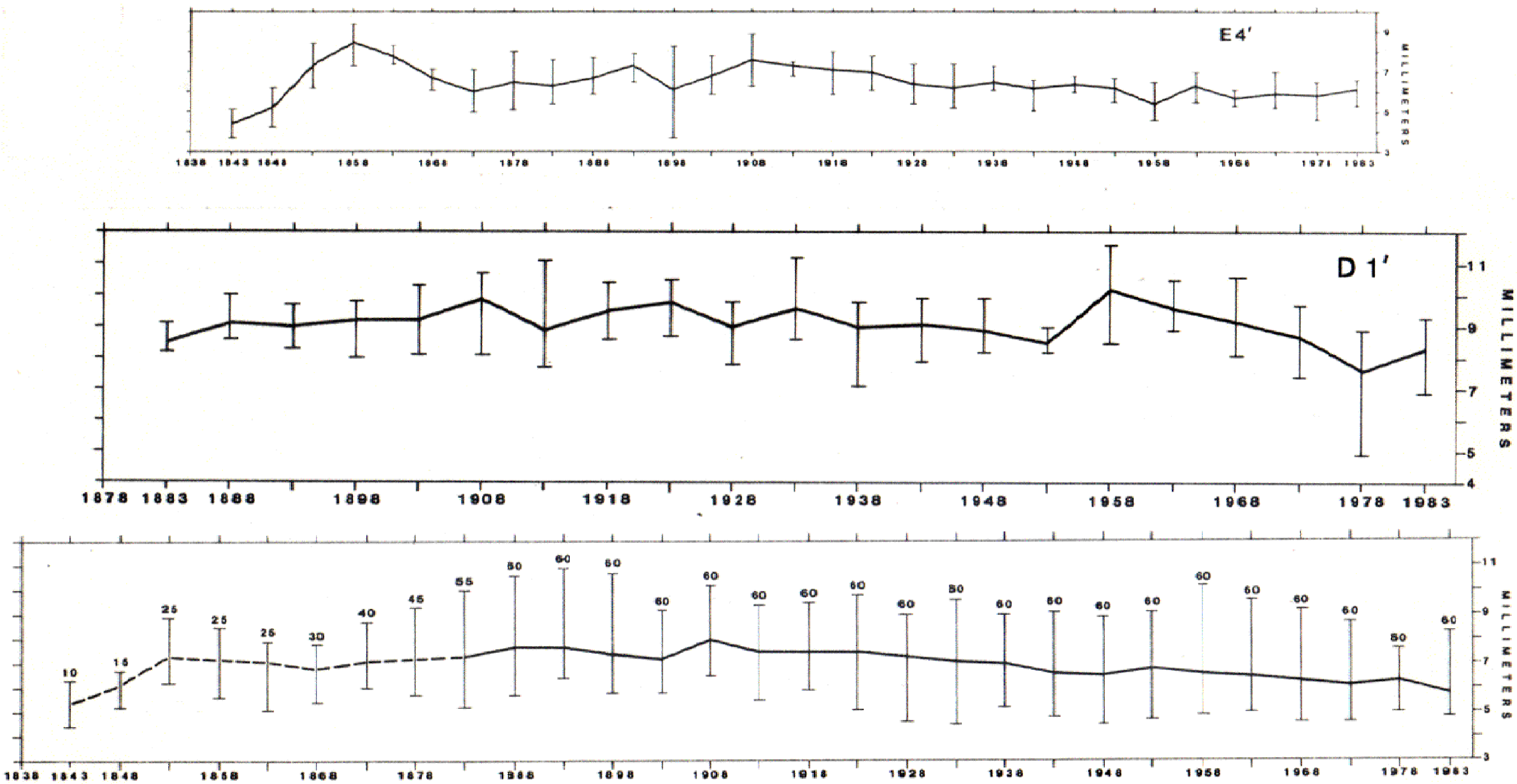

Figure 5.9. Growth history graphs of individual Looe Key *Montastraea annularis* plotted at 5-year intervals. Solid line indicates growth rate average. Vertical bars indicate maximum-minimum growth rates. Letter-number code identifies individual corals. Use this code to find location of specific corals in Figure 5.2. Corals EV and DI are the individuals that show a growth rate increase during 1978 - 1983. Graph at bottom shows combined growth rate average, for all corals at Looe Key reef. Note growth decline from 1908 to present.

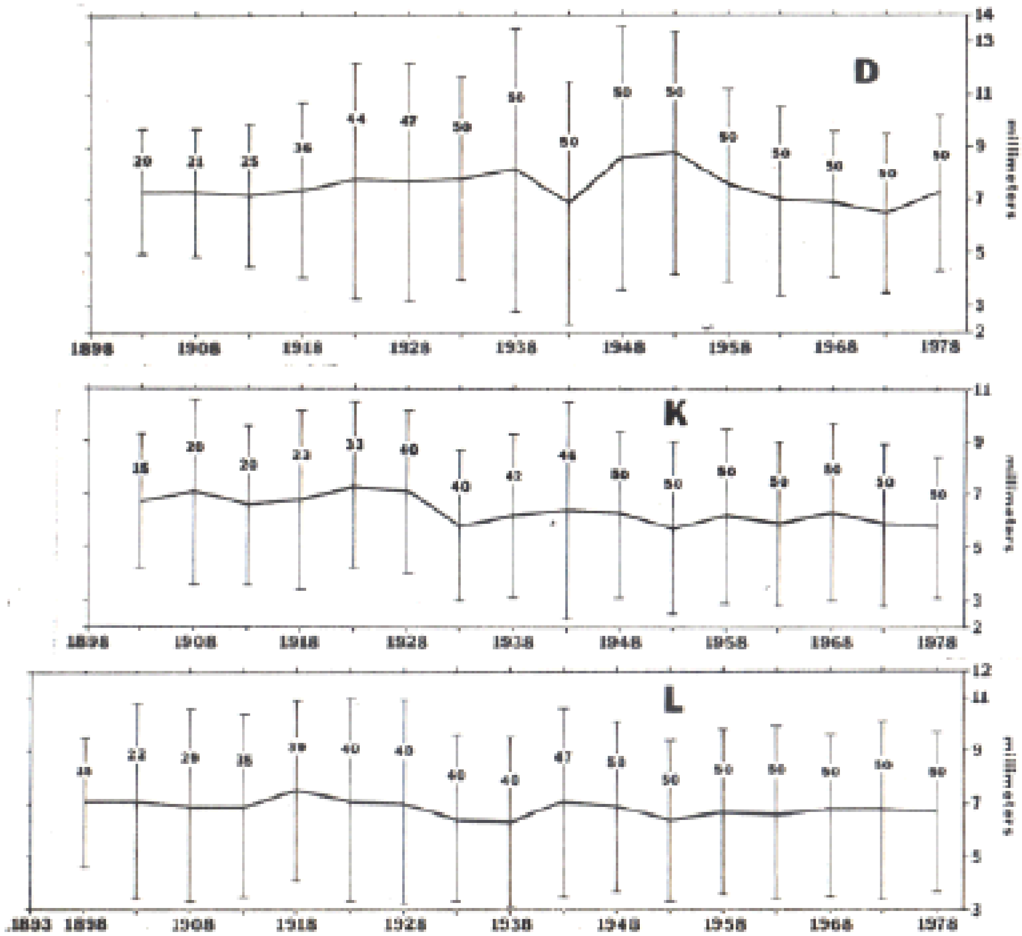

Figure 5.10. Composite growth history graphs showing average growth rate of 10 *Montastraea annularis* from the Key Largo Coral Reef Marine Sanctuary. Vertical bars represent maximum-minimum growth at the 65% level. Solid line represents average growth rate. Numbers in vertical bars represent total number of yearly measurements for each 5-year period. Station D is Basin Hill Shoal; Station L is Molasses Reef; Station K is Red Num Buoy ADS.

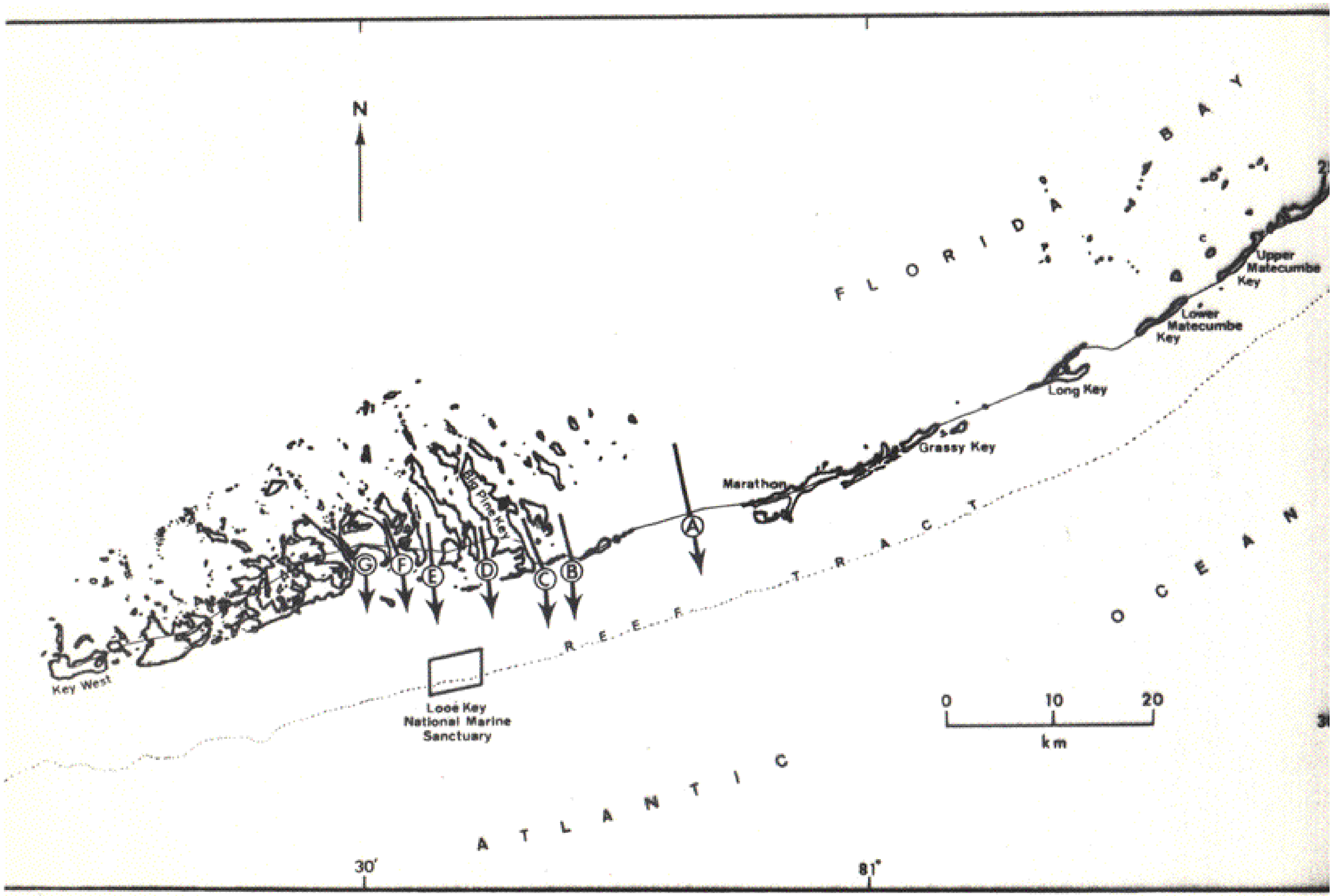

Figure 5.11. Map of Florida Keys from Upper Matecumbe Key to Key West. Lettered arrows A through G indicate: A) Moser Channel, 3) Bahia Honda Channel, C) Spanish Harbor Channel, D) Pine Channel, E) Niles Channel, F) Kemp Channel, and G) Bow Channel.

CHAPTER 6

LOOE KEY NATIONAL MARINE SANCTUARY RESOURCE SURVEY: CORALS AND OTHER MAJOR BENTHIC CNIDARIA

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Introduction

The HMS Looe, a 44-gun British frigate, wrecked on a Florida Keys reef in February 1744 (Peterson, 1955). The small emergent rubble island on the reef flat was named Looe Key. Cannons and other artifacts of the Looe were removed long ago and the island has since disappeared, but evidence of the wreck still can be seen in the eastern fore reef.

Looe Key reef is a bank reef located 12.9 km, 200° off the SW tip of Big Pine Key, Florida (24° 37' N, 81° 24' W) (Figure 6.1a). The reef and adjacent coral and seagrass communities, encompassing a 5.3 nmi^2 area, were designated as Looe Key National Marine Sanctuary (LKNMS) in January 1981.

Agassiz (1852) in his early studies of Florida reefs, described Looe Key reef as a "series of submarine elongate hillocks rising above sealevel in the form of islands or boulders in a few places". Recently published research on Looe Key reef is scarce. Antonius *et al.* (1978) conducted a pre-sanctuary resource survey. An environmental impact statement was provided by NOAA (1980) in due process of Implementing the sanctuary status. A study by Shinn *et al.* (1981) provided Information on the reef's age and Its spur and groove development.

Consistent with the main goal of the national marine sanctuary program to "...promote and coordinate research to expand scientific knowledge of significant marine resources and improve management decision making," NOAA's Sanctuary Programs Division funded a multi-disciplinary survey at LKNMS coordinated through National Marine Fisheries Service Southeast Fisheries Center. The survey's main purpose was to develop a resource map of sanctuary coral, sponge and reef fish resources through in situ observations and measurements of physical features. The following work provides baseline information an corals and other benthic Cnidaria that are major faunal components.

Methods and materials

A snorkeling /SCUBA reconnaissance of Looe Key reef was conducted in June 1983. Reef fish and coral scientists and management personnel made preliminary site selections based on low level, high resolution aerial photographs. Areas designated for quantitative coral sampling included sites in the eastern, middle and western spur and groove formation, a forereef community (to 11 m maximum depth) and livebottom communities WNW and N of the main spur and groove tract.

In August 1983, six sites (Figure 6.2) were quantitatively sampled along traverses using 1-m^2 plots and a matrix of transects at each site (Table 6.1). Site I was located adjacent to navigational marker "24" at the eastern fringe of the spur and groove tract (Figure 2). A small spur was sampled with eight 1-m^2 quadrats at random meter numbers along a 100 m traverse generally bisecting the spur from north to south. Sites II and III were in the middle and western spur and groove tract, respectively (Figure 6.2). A 200-m traverse was established at both sites extending from the seaward southern tip bisecting the finger over the reef flat into the rubble zone. East and west transects were set at randomly selected meter numbers within habitat zones along the 200-m traverse. Quadrats were sampled at odd or even numbers along east or west laid transects, respectively. Fifty-six 1-m^2 quadrats were censused at middle spur and groove site II; 55 at western spur and groove site III (Table 6.1). Depths were taken at 10-m intervals on top and at the base of the spurs (Table 6.2).

An area seaward of western spur and groove site III dominated by *Montastraea* buttresses was selected as site IV (Figure 6.2). Sixteen 1-m^2 quadrats were censused at random meter numbers along a 100-m traverse run due west through the habitat (Table 6.1). Site V was an intermediate depth livebottom community WNW of the main spur and groove tract (Figure 6.2, insert). A traverse was established through the approximate center of the community and extended 83 m into sand with sparse gorgonians. Data were gathered from 18 1-m^2 quadrats at random meter numbers along the traverse (Table 6.1). Site VI was located in a shallow livebotton community extending east to west inshore of the main spur and groove tract (Figure 6.2, insert). Two traverses, 50 and 82 m long, were established here. A total of 19 1-m^2 quadrats were sampled at random meter numbers (Table 6.1).

Data acquisition followed Weinberg's (1981) drawn map technique which included species identification and abundance of octocorals, stony corals (Milleporina and Scleractinia) and per cent stony coral cover within each 1-m^2 quadrat. Sampling adequacy was determined by asymptote of stony and octocoral species area curves. The common zoanthids, *Palythoa caribbea* and *Zoanthus sociatus*, and the corallimorph, *Ricordea florida*, were also censused.

Vouchers were collected for laboratory confirmation of questionable identifications. Qualitative photographs were taken to document habitats and zones therein.

Analyses of data included calculation of species composition, frequency, abundance, density/m^2 ($\bar{x} \pm s$), diversity (H') $\log_2$, and evenness (J').

The ORDANA benthic analysis IBM 360/370 program (Bloom *et al.,* 1977) was used to compute intersite faunal similarities. Classification analyses were based on cnidarian species abundance data. Data were transformed to presence-absence for qualitative species co-occurrence (Czekanowski's Qualitative Coefficient) and to 4th root $x^{1/4}$ (Field *et al.,* 1981) for quantitative analyses [Czekanowski's Quantitative (Bray-Curtis) Community Coefficient] (Bloom, 1981). The octocoral and stony coral faunas were analyzed independently for all six sites and for all zones within sites II and Ill. Analyses were then repeated for all Cnidaria combined. Values were rounded to two decimal points. Results are presented on habitat maps.

Results and Discussion

Looe Key National Marine Sanctuary encompasses a mosaic of seagrass, sedimentary, reef and livebottom communities. The last two are the subject of the present study.

The outer Florida reef platform is composed of three topographic types: (1) flourishing reefs displaying coral zonation, (2) barren outer reef flats, and (3) outer reef rubble mounds (Hulter, 1971). Looe Key reef is in the first category and exhibits only minor differences from other bank-barrier reefs in the Florida reef tract. Distinctive features of these reefs include vertical zonation of coral off the reef front, the presence of spur and groove formations, and the presence of *Acropora palmata*.

Geologically, *Acropora palmata* formed the reef flats of many Florida outer reefs as colonies grew in place to sea level and died from overcrowding (Shinn, 1963). *Acropora palmata* was not responsible for Looe Key reef flat formation which is essentially consolidated rubble overlying a sediment filled bedrock depression, but the species was Looe Key's primary spur builder 800 - 1,000 years ago (Shinn *et al.,* 1981). At present, *A. palmata* is scarce on shallow parts but more common on deeper parts of the spur and groove system. Although overall abundance is low compared to that at other reefs, *A. palmata* is present on more than 70% of the spurs (Bohnsack, this volume). The species often attains large size and provides important habitat for schools of snappers, grunts, and other fishes which seek refuge beneath its branches. *Acropora palmata* grows rapidly and uses fragmentation recruitment to exploit spatial resources; broken branches form new colonies in a relatively short time.

Inshore of the main spur and groove, the back-reef is comprised of seagrasses (*Thalassia* and *Syringodium*) and sand-filled blowouts several meters in diameter. Thick mats of seagrass rhizomes and roots form ledges overhanging the deeper holes. Isolated coral colonies *Diplora clivosa*, *Montastraea annularis*, *Acropora palmata*, *Gorgonia ventalina* and *Pterogorgia anceps*), some washed from more seaward zones, survive here with the queen conch (*Strombus gigas*) and other typical grass flat organisms. Water depths rarely exceed 3 - 4 m.

Spur and groove systems generally are aligned to prevailing waves and swells, i.e., perpendicular to the platform margin; some form at a slight angle to the prevailing sea. Looe Key spurs deviate slightly from a perpendicular orientation (Shinn *et al.,* 1981), with their axes projecting SSE-NNW (Figures 6.1b, 6.2). The spur and groove system at Looe Key (Figure 6.3) extends roughly 1200 m east to west with Individual spurs attaining a length of about 200 m. A band of rubble separates the landward seagrasses from the reef flat. The shallowest portion of the spur and groove system is emergent at low tide. The shallow zone of the spur and groove habitat is characterized by expansive golden mats of *Palythoa* and dense clusters of the bladed firecoral, *Millepora complanata*, both adapted to the environmental. unpredictability of the zone. The few stony coral and octocoral species encountered here represent the hardiest, most successful and abundant species in the adjacent seaward zone.

As relief of the spurs increases in the transition from a relatively flat, high energy shallow reef to an elevated (to 4 m) three dimensional benthic profile, the increased depth and spatial heterogeneity provide numerous niches for octocoral and stony coral exploitation. *Acropora palmata* occurs on top and the lettuce coral, *Agaricia agaricites*, proliferates on the vertical faces of the spurs in this zone. Octocorals become more common, with twice as many species as in the preceding shallower zone. Expansive sheets of *Palythoa* are replaced by small isolated mats. *Millepora complanata* is still moderately abundant.

Octocorals proliferate on top of the spurs as relief of the spurs diminishes toward their termination in about 9 in depth. Colonies of *Montastraea*, *Diploria*, *Colpophyllia*, and *Siderastrea* reach massive proportions and often are excavated on their undersides, creating cavernous Interiors. Increased biotic complexity in this zone can be attributed partially to increased cryptic habitat. These hollow corals are a favorite refuge for spiny lobster (*Panulirus argus*) and other reef organisms.

Slightly offshore of the main spur and groove system, a buttress forereef community reaches its greatest expansion toward the west. Shinn *et al.* (1981) described this as "...an Intermediate reef accumulation with vague, low amplitude, imperfectly-formed spurs." The visual perspective of the area is dominated by massive mounds of *Montastraea annularis*. Smaller stony coral species and numerous octocorals occupy the low relief rocky platform, which is frequently interrupted by wide sedimentary areas.

Expansive livebottom areas occur within the Sanctuary, east, west and inshore (north) of the main Looe Key reef. These areas of relatively low relief are dominated by octocorals and sponges, with small colonies of stony corals. Generally their margins fade into patchy sand with sparse octocoral growth and then to an entirely sedimentary community. Livebottom communities differ from the typical patch reefs which have areas of high relief formed by large stony coral colonies and fairly well defined boundaries surrounded by sand halos.

Spur and groove community

Site I consisted of a small, low relief, somewhat homogeneous spur (Figure 6.2) with a cnidarian fauna dominated by octocorals. *Plexaura flexosa* was most abundant and four other species, *Eunicea succinea*, *Pseudopterogorgia americana*, *Muricea atlantica*, and *Gorgonia ventalina* were common. These five comprised nearly 70% of all octocorals encountered (Table 6.3). Six species of stony corals were censused (Table 6.4). *Millepora complanata* contributed about 45% and *Favia fragum* 22% to the stony coral population. The golden sea mat anemone, *Palythoa caribbea*, represented about 11% of all cnidarians sampled (Tables 6.3, 6.4, 6.5).

The shallow rubble zone (Table 6.1) at sites II and III (Figure 6.2) extended 40 - 50 m from the seagrass beds (Plate 6.1) seaward to the reef flat. Although this zone is characterized by a comparative lack of macrobenthos, whole and fragmented colonies of *Acropora palmata* and *A. cervicornis* live here, likely transported inshore by storm waves from deeper spur and groove zones. Some large colonies are overturned and generating new growth (Plate 6.2). These isolated colonies provide shelter for dense populations of *Diadema antillarum* (urchin) and small fish. *Porites astreoides* (Plate 6.3), the most abundant stony coral in this zone, forms thin veneers on the rubble. Seafans (*Gorgonia ventalina*) (Plate 6.4) are abundant, but few other octocoral species were observed. Sparsely scattered colonies of *Plexaura flexosa*, *Eunicea tourneforti* and *Pterogorgia citrina* were attached to the reef limestone or unstable rubble. *Eunicea succinea* was the only octocoral in quantitative samples.

Coalesced spurs seaward of the rubble zone form a discontinuous barrier or platform sometimes awash at low tide. The spurs emerge as distinct relief features 20 - 30 m seaward of the rubble zone (Table 6.2). Overall their relief ranges from 0.3 - 3.9 m. Their width is as great as 21 m adjacent to the reef flat and narrows to 3 - 6 m at their termination where maximum water depth is nearly 9 m (Table 6.2). The generally continuous spur at site II measures 168 m from origin to seaward termination. At site III, the 174 m long spur is broken into two segments by a small cleft about 74 m seaward of the rubble zone.

Four zones are distinctly recognizable at sites II and III. Although the rubble zone is basically barren, the three remaining zones are characterized by changes in species abundance patterns within the cnidarian fauna.

Fauna of the shallow spur and groove (Table 6.1) live in a physically controlled environment. Heavy wave surge, intense solar radiation, wide range of temperature fluctuation, and occasional desiccation during spring low tides limit habitation in this zone. Horizontal surfaces of the spurs are covered almost entirely by *Millepora complanata* (Plate 6.5) and *Palythoa caribbea*, therefore the area is referred to as the *Millepora/Palythoa* zone. *Ricordea florida*, a corallimorph, and *Zoanthus sociatus*, another zoanthid anemone, are interspersed among the *Palythoa* mats (Plate 6.6) and *Millepora* colonies.

Millepora complanata, *Agaricia agaricites* and *Porites astreoides* comprised the majority of the stony coral fauna sampled at both sites (Tables 6.6, 6.7). Only four species of octocorals occurred in shallow spur and groove samples, and their relative abundances varied widely (Tables 6.8, 6.9). *Gorgonia ventalina* dominated at site II but was scarce in this zone at site III. *Plexaura flexosa* was most abundant at site III but occurred in few site II samples. *Plexaura* *homomalla* and *Eunicea succinea* were the only other octocorals sampled in this shallow zone at either site.

The *Acropora*/transition zone (Plate 6.7) begins about 70 - 110 m seaward of the rubble zone (Table 6.1). Depths range from 2.4 to 7.0 m on top of the spurs to a maximum of 8.2 m down the vertical sides to the sand channels (Table 6.2). This zone extends 55 m seaward in these depths at site II and 40 m seaward at site III. *Palythoa* occurred in fewer, more isolated sate, but .14. complanata was still relatively abundant. (Tables 6.10, 6.11).

The number of stony coral species was more than twice that of the adjacent shallower zone. The three species most abundant in the shallow spur zone, *M. complanata*, *A. agaricites* and *P. astreoides*, together with *Acropora cervicornis* and *Porites porites*, comprised the bulk of the stony coral population (Tables 6.10, 6.11). *Agaricia agaricites* surpassed *M. complanata* as the single most abundant stony coral species, proliferating in this zone due to its morphology and microbabitat preferences. In the shallow spur zone, *A. agaricites* forms thumb-sized colonies in small pockets and depressions, whereas in this high relief zone, it forms leaf or plate-like colonies on vertical faces of the spurs, in some ewes virtually excluding all other stony corals (Plate 6.8). Tall stands of *Acropora palmata* (Plate 6.9) occurred in about one third of the samples at site II (Table 6.10). The species was not present in quantitative samples at the western spur site III, although colonies were observed within the *Acropora*/transition zone at several other locations there. *Acropora palmata* occurs in aggregated thickets resulting from fragmentation recruitment. Propagules are only transported a limited distance from parent colonies. Consequently, the importance of *A. palmata* was not reflected in quantitative sampling at site Ill.

Even though there were nearly twice as many stony coral species as octocoral species in the *Acropora*/transition zone, the number of octocoral species was still nearly twice that of the previous zone. The four species that occurred in the shallow spur zone were the most abundant species here (Tables 6.12, 6.13). *Plexaura flexosa* comprised nearly half the octocoral population at both sites. *Palythoa* also occurred in about half of the samples (Table 6.5).

The most seaward zone (Table 6.1) of the spur and groove habitat extends 25 - 45 m from the previous zone to the spur's termination onto a level sedimentary plain (Table 6.2). This *Montastraea*/octocoral zone (Plate 10) is characterized at its beginning by high relief with steep vertical overhangs diminishing rapidly as the spur terminates. Much of the relief Is attributable to massive colonies of *M. annularis* growing on the spurs or standing free beside them.

The dominant stony coral species of this zone differed between sites II and III (Tables 6.14, 6.15). *Montastraea cavernosa*, *A. cervicornis* and *A. palmata* constituted 60% of the stony coral population at the middle spur (II), whereas *Siderastrea siderea*, *Mycetophyllia lamarckiana*, *M. annularis*, *A. agaricites*, *Millepora alcicornis*, and *A. cervicornis* comprised 62.1% of the stony coral population at the western spur (III). *Montastraea cavernosa* was the most abundant stony coral species at site II, comprising 30.3% of all individuals. *Siderastrea siderea* was most abundant at site III, representing 11.4% of all stony coral species. A total of 25 stony coral species were censused in the *Montastraea*/octocoral zone (22 at site II, 20 at site III). Species found at site II but not at site III included *A. palmata*, *Diploria labyrinthiformis*, *Diploria strigosa*, *Manicina areolata*, and *Dendrogyra cylindrus*. The last species, commonly known as pillar coral (Plate 6.11), is rare throughout the Caribbean and was present in only one sample during our survey. *Acropora prolifera*, *Eusmilia fastigiata, Mycetophyllia ferox*, and *Oculina diffusa* were limited to site III.

Although the greatest number of octocoral species occurred in this zone (Tables 6.16, 6.17), *Plexaura flexosa* still dominated the fauna. Numerically, the species comprised about half of all octocoral colonies censused, and it occurred in more then three fourths of the samples. *Plexaura homomalla* constituted about one fourth of all colonies censused but also was represented in about half of the samples. *Eunicea succinea* still occurred frequently. *Pseudoplexaura porosa* became one of the four most abundant octocorals, in this zone (Plate 6.12), replacing *Gorgonia ventalina*. The zoanthild *Palythoa* was recorded in about half of the cnidarian samples, but *Zoanthus* and *Ricordea* were rare (Table 6.5).

Montastraea buttress community

Due south of the seaward boundary of the western spur site III in 9 m depth (Figure 6.2), the area of generally uniform relief Is broken by "haystacks" of *Montastraea annularis* (Plate 6.13) greater than 2 m high and 3 m in diameter. This community of coral and sponge aggregations interrupted by large expanses of sand was designated site IV. Nearly equal numbers of stony coral and octocoral species were encountered. *Montastraea cavernosa*, *M. annularis*, *A. cervicornis*, *M. alcicornis*, and *S. siderea* were the most abundant stony corals (Table 6.18). Although *A. cervicornis* was relatively abundant in some samples, it occurred infrequently. Each of the eleven remaining species contributed less than 5% to the population.

Plexaura flexosa and *P. homomalla* comprised about half of the octocoral population. *Eunicea succinea* and *Eunicea calyculata* were next in abundance, and the 11 remaining octocoral species each contributed less than 7% (Table 6.19). Stony corals and octocorals occurred in about the same density, each with averages of about seven colonies and four species/m^2.

Ricordea and *Zoanthus* were not recorded, but *Palythoa* was represented in about one third of the samples (Table 6.5).

Livebottom community

The composition of coral communities in two areas outside the reef proper (sites V and VI) differed from others encountered at Looe Key. Site V was in about 9 a depth WNW of the main spur and groove formation (Figure 6.2). Only a vestige of spur and groove development was observed in this area of generally uniform low relief.

Octocorals were slightly more abundant and diverse than were stony corals in this complex reef limestone habitat (Tables 6.20, 6.21). *Plexaura flexosa* did not exhibit such strong dominance as at previous sites; seven other species (*E. succinea*, *E. tourneforti*, *Plexaurella fusifera*, *Muriceopsis flavida*, *Muricea atlantica*, *Pseudopterogorgia americana*, and *calyculata*) occurred in at least half of the samples. *Eunicea succinea* was most abundant but contributed little more to the population than did *P. flexosa* (Table 6.20).

Porites astreoides, *A. agaricites*, *A. cervicornis*, *M. alcicornis*, and *S. siderea* were encountered in at least half of the samples; their abundances in the stony coral population were fairly equally represented (Table 6.21). None of the eleven other species contributed more then about 52 to the population.

Site VI was in a linear band inshore and parallel to the major east-west axis of the reef proper (Figure 6.2). Two segments were sampled in a maximum depth of 6 m. These shallow reef limestone hard grounds were pocketed with sediment-filled depressions and dominated by octocoral and sponge growth (Plate 6.14). *Plexaura flexosa* and *E. succinea* were again the most abundant octocorals. The first occurred in all samples and was accompanied in high frequency by its co-dominant, as wall as by *P. homomalla*, *G. ventalina*, *M. atlantica*, and *P. porosa.* Four other species, *E. tourneforti*, *B. asbestinum, P. americana, and M. flavida*, occurred in more than half of the samples (Table 6.22).

Numerically, there were about half as many stony corals as there were octocorals at site VI (Table 6.23). *Millepora alcicornis* attained Its greatest abundance in the shallow livebottom, and *Siderastrea siderea* and *S. michelini* were also common. Although *P. astreoides*, and *A. agaricites* occurred in more than half of the samples, each contributed numerically slightly less than 7% to the stony coral population. The remaining 16 species were even less common, and all but one occurred in a third or fewer of the samples (Table 6.23).

Palythoa was least common in the livebottom communities and was found in only 11 and 16% of the samples at sites V and VI, respectively (Table 6.5).

Summary

Three major types of reef communities (spur and groove, buttress and livebottom) were censused during the surveys The spur and groove tract Included sites I through III; site IV was in the buttress community, and sites V and VI were in the livebottom areas outside the main reef. Generally, octocorals were most prominent in livebottom communities, whereas stony corals were most successful in the spur and groove formation (Tables 6.24, 6.25). Milleporids and zoanthids effectively dominated the reef flat/shallow spur and groove zone of the main reef. Stony coral species richness (22) was greatest in the *Montastraea*/octocoral zone of the middle spur (Table 6.25), and a survey maximum of 26 species was recorded at site II (Table 6.26). Estimated stony coral cover was likewise greatest at site II (middle spur) in the *Montastraea*/octocoral zone. Although overall site diversity (3.49) was highest at this site, the *Montastraea*/octocoral zone at the western spur site III had a slightly greater (3.87) zonal diversity. Highest average numbers of stony coral colonies were about 10/m^2 at both middle and western spur and groove sites. Reduced stony coral colony density (i.e., lower numbers of colonies per unit area) within the *Montastraea*/octocoral zone (Table 25) resulted from larger colonies of *Montastraea*, *Diploria*, *Colpophylia* and *Siderastrea* monopolizing spatial resources, thereby limiting the number of colonies occurring within a samples, in extreme cases, a single colony filled the 1-m^2 quadrat.

The greatest number of octocoral species (15) in the spur and groove tract occurred et the middle spur site II (Table 6.27). Like the stony corals, they were more successful in the deeper *Montastraea*/octocoral zones. Diversity (3.26) and mean numbers of colonies/m^2 (10) were greatest at the eastern fringe spur (site I). Disregarding the *Millepora*/*Palythoa* zones, mean numbers of colonies/m^2 were 6 and 9 at the two zones of the western spur but only 2 and 6 at the respective middle spur zones (Table 6.24).

The *Montastraea*/buttress community (site IV) of the fore-reef was apparently equally favorable to stony corals and octocorals, which were represented by nearly equal numbers of species (16; 15), species density/m^2 (3.88; 4.19), colony density/m^2 (7.63; 7.56), species diversity (3.01; 3.12) and evenness (0.75; 0.80) (Tables 24, 25).

Octocorals were more abundant than stony corals in the deeper livebottom area (site V) and were markedly more dominant in the Inshore shallow livebottom area (site VI). Although numbers of species of stony corals (21) and octocorals (22) were about the same, there were nearly twice as many octocoral as stony coral colonies/m^2 (20.58 vs. 11.53). Octocoral diversity (3.72) and evenness (0.83) were highest in this community and were greater than stony coral diversity (3.44) and evenness (0.78) (Tables 6.24, 6.25).

Quantitatively and qualitatively, intersite similarity was high for comparisons of all sampled Cnidaria (Milleporina, Octocorallia, Zoanthidae, Scleractinia) among the two livebottom habitats (sites V and VI) and the *Montastraea*/buttress community (Figure 6.4a and b). Middle and western spur and groove tract sites II and III also showed high similarity, whereas the eastern fringe spur site I was least similar to other sites by both comparisons. Classification based on quantitative (relative abundance) analyses resulted in generally lower similarity values between sites than did those based on qualitative (species presence/absence) analyses (Figures 6.4, 6.5, 6.6). Because many species were broadly distributed among the sites, qualitative analyses imply generally high intersite similarity. Quantitative analyses detect variability of the relative abundance or species dominance between sites and therefore may provide a better view of community structure.

Overall, the octocoral fauna was quantitatively more similar among sites than was the stony coral fauna. Seven of 15 octocoral Intersite comparisons resulted in similarity values greater than 0.50, whereas only 2 of 15 comparisons yielded values greater than 0.50 for stony corals (Figures 6.5, 6.6). As with the combined Cnidaria, greatest octocoral and stony coral intersite similarities were between livebottom sites V and VI and between spur and groove sites II and III (Figures 6.5, 6.6). A greater disparity existed between qualitative and quantitative values for stony coral Intersite comparisons than for octocorals. Occurrences of similar species with significantly different abundances likely caused the disparity; generally low similarity values reflect differences in species abundance and dominance between sites.

Generally, corresponding zones within middle and western sites II and III in the spur and groove tract harbored a more similar fauna, both quantitatively and qualitatively, than did adjacent zones on the same spur (Figures 6.7, 6.8). An exception occurred within the octocoral fauna and was correspondingly reflected in analyses for combined Cnidaria. Quantitatively and qualitatively, the octocoral fauna at the site III *Montastraea*/octocoral zone bore greater similarity to that of the adjacent *Acropora*/transition zone than to the more distant site II *Montastraea*/octocoral zone (Figures 6.7a, c; 6.8a, c).

Generally, *Acropora*/transition zones within both sites were more similar to adjacent, seaward *Montastraea*/octocoral zones than to adjacent inshore *Millepora*/*Palythoa* zones. Only the combined Cnidaria and stony coral comparisons at the western spur site III showed similarity greater than 0.50 between the shallow *Millepora*/*Palythoa* and the seaward *Montastraea*/octocoral zones.

A total of 59 cnidarian species was censused during this survey (Table 6.28). Anthozoans obviously dominated the macrobenthic community. Members of the family Plexauridae (16 species) were the most abundant of the 23 octocoral species which together comprised 1317 colonies (Table 6.29). Three species (*Plexaura flexosa*, *Eunicea succinea* and *Plexaura homomalla*) comprised almost 55% of the octocoral fauna. The 31 scleractinian species (1278 colonies) were distributed among ten families, of which the Faviidae and Mussidae had the most species (Table 6.28). *Agaricia agaricites*, and *Porites astreoides* were most abundant (Table 6.30). The two hydrozoan milleporids (292 colonies; Table 6.30) were both relatively abundant; however, *Millepora complanata* was restricted to the spur and groove formation. Only one "false" coral (Scleractinia: Corallimorpharia) and two zoanthid species were censused (Table 6.31).

Previous coral surveys at Looe Key were conducted by Antonius *et al.* (1978) and by the Florida Department of Natural Resources (FDNR) in 1980. Differences in reported species (Tables 6.32, 6.33) can be attributed to differences in sampling methods, depths, reef locations and possible field identification errors. Antonius *et al.* used a line point intersect (one piece of Information collected each meter) method of data acquisition; their deepest observations were to 45 m, although 6 - 18 transect sampling was limited to depths less than 35 m. The majority of the 1980 work by FDNR involved a survey along 2 traverses using continuous line transects to 10.7 m depth in the spur and groove formation, with qualitative observations at 18 - 30 m and an additional transect at 27.4 m; only 18 1-m^2 quadrats were sampled. A total of 24 octocoral and 32 stony coral species were recorded in 1980, of which only 14 octocoral and 20 stony coral species were sampled in the shallow reef areas. *Plexaura flexosa*, *Plexaura* *homomalla*, *Gorgonia ventalina*, *Porites astreoides*, *Millepora complanata*, and *Agaricia agaricites* were the three most abundant octocorals and stony corals, respectively, during this cursory survey.

The three surveys had twelve octocoral species in common from reef flat and shallow reef records to 11 m depths; nine additional species were common to two of the three surveys. Records of *Eunicea asperula, Plexaurella dichotoma, Muricea muricata*, and *Pseudopterogorgia bipinnata* by Antonius *et al.* (1978) from the shallow reef were not substantiated in our current survey nor in the 1980 work (which included a deep reef *P. bipinnata* record). All shallow reef species recorded in 1980 were previously listed by Antonius *et al.* and again in our 1983 work. *Pseudoplexaura crucis* was the only 1983 species not previously reported by Antonius *et al.* They did not include *Briareum asbestinum, Erythropodium caribaeorum* and *Eunicea succinea* among their shallow reef records, although they did report those species from patch reefs. Deep water records for *Eunicea clavigera, Eunicea pinta, Muricea laxa*, *Pseudopterogorgia elisabethae* (FDNR, 1980), *Iciligorgia schrammi*, and *Ellisella barbadensis* (Antonius *et al.,* 1978; FDNR, 1980) add these species to the Looe Key faunal list (Table 6.32).

Twenty-two stony coral species were recorded at shallow reef stations (<11 m) during all three surveys, and six others were recorded during two of the three surveys (Table 6.33). Two additional species, *Scolymia lacera* and *Isophyllastrea rigida*, were recorded at reef shallows only during the present survey. Three of four other stony coral taxa reported from the shallow reef by Antonius *et al.* are problematical and will be discussed elsewhere. Antonius *et al.* reported 14 taxa of stony corals from the deep reef; none of those appear on our list among taxa recorded at the shallow reef (Table 6.33), although three appear to be other names for shallow reef taxa. Two of the deep reef species reported by Antonius *et al.* were also recorded in our 1980 survey. Species of Agariciidae were reported to be common on the deep ridge (Antonius *et al.,* 1978). They reported the agariciids *Agaricia undata, A. lamarcki*, and *A. fragilis*, and the mussids *Mycetophyllia dansana* and *M. aliciae* in the text, but their habitats were not delimited in the tables. These five species were not recorded during our 1980 nor our 1983 surveys, but all are species which typically occur at depths greater than those we sampled and whose occurrence at the deep reef seaward of Looe Key would seem reasonable.

Antonius *et al.* (1978) and the FDNR 1983 survey included sites outside the main reef tract. Patch reefs surveyed by Antonius *et al.* and our inshore (6 m) livebottom site VI are somewhat comparable. Twenty octocoral species were common to both (Table 6.32). Six octocorals (*Eunicea mammosa, Eunicea fusca, Eunicea asperula, Plexaurella dichotoma, Muricea muricata*, and *Pterogorgia guadalupensis*) reported by Antonius *et al.* were not recorded at the inshore livebotton site during our 1983 study. *Pseudoplexaura crucis* and *Plexaurella grises* were added to the list from 1983 records. Likewise, nineteen stony coral species were common to both. Antonius *et al.* reported nine taxa from patch reefs (*Millepora complanata*, *M. squamosa*, *Agaricia danai, Diploria clivosa*, *Diploria strigosa*, *Solenastrea hyades*, *Oculina varicosa*, *Dendrogyra cylindrus*, and *Mussa angulosa*) which were not recorded at the inshore livebottom site during our 1983 survey. *Scolymia lacera* and *Eusmilia fastigiata* were added to the list from that habitat during our 1983 work.

Antonius *et al.* (1978) reported 55 stony coral taxa (3 hydrocoral species and 52 scleractinian taxa comprising 47 species) (Table 6.33). Discounting the deep reef species previously discussed, thirteen other taxa were not recorded by us in either 1980 or 1983. Four of these names supposedly represent varieties or ecophenotypes (formae) of *Agaricia agaricites* (*A. a. danai, carinata, purpurea*, and *humilis*). Additionally, *Porites divaricata* and *P. furcata* are standardly accepted as varieties or Peophenotypes of *P. Porites* (fide Squires, 1958; Brakel, 1977). Such distinctions were not utilized during our 1980 and 1983 studies. *Millepora squarrosa* is synonymous with *M. complanata* (fide Stearn and Riding, 19713; DeWeert, 1981). Thus, seven taxonomic designations used by Antonius *et al.* were not deemed appropriate for our use. Four of the remaining six species are not typically dwellers of south Florida reefs. *Oculina varicosa* commonly constructs bank reefs in more temperate areas (Reed, 1980); the Antonius *et al.* record is more likely of *Oculina diffusa*. *Madracis asperula* is typically an ahermatype; *M. mirabilis* is the typical reef species. *Tubastrea aurea* is a rare photophobic cave dweller. *Sphenotrochus auritus* is an Ahermatypic solitary coral described from Cape Frio, Brazil (Pourtales, 1874) and not otherwise reported from Florida. Its presence at Looe Key requires verification. *Agaricia tenuifolia* and *A. grahamae* are also tropical species not previously reported from Florida reefs. Goreau and Wells (1967) reported what *A. tenuifolia*, was restricted to depths less than 18 m, where it commonly builds spur formations in the western Caribbean (Carrie Bow Cay, Belize; Roatan, Bay Islands, Honduras). The record (Antonius *et al.,* 1978: p. 22) of *A. tenuifolia* from 45 m depth on the deep ridge is thus questionable. A revised list of corals from the three Looe Key surveys would include 36 octocorals, 39 scleractinians and 2 hydrocoral species.

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Table 6.1. Synopsis of quantitative coral sampling sites, Looe Key, August 1983.

Site	Reef Locale	Depth (m)	Traverse length (m)	Number of 1-m^2 Quadrats	Characteristics
I	Eastern spur and groove tract	2-6	100	8	Homogeneous low relief spur
II	Middle spur and groove tract	0-9	200*	56*	Well developed spur with distinct zonation
	Rubble zone	1	32	0	"Barren" zone
	Shallow spur and groove zone	0 - 5	68	17	*Millepora*/ *Palythoa*
	Intermediate depth spur and groove	2 - 7	55	19	*Acropora*/ transition
	Deep spur and groove zone	5 - 9	45	20	*Montastraea*/ octocoral
III	Western spur and groove tract	1 - 9	200*	55*	Well developed spur with distinct zonation
	Rubble zone	1	26	1	Barren zone
	Shallow spur and groove zone	1 - 7	109	15	*Millepora*/ *Palythoa*
	Intermediate depth spur and groove	4 - 8	40	22	*Acropora*/ transition
	Deep spur and groove zone	7 - 9	25	17	*Montastraea*/ octocoral
IV	Western fore-reef	9	100	16	*Montastraea* buttress
V	Livebottom WNW of spur and groove	9 - 11	83	18	Low relief hard grounds
VI	Inshore (north) livebottom parallel to spur and groove tract	6	132	19	Low relief hard grounds

* Represents total sampling effort at the middle and western spurs.

Table 6.2. Morphological characteristics, depths, and zones at sites II and III, spur and groove tract, Looe Key, August 1983.

A. Middle Spur II Traverse distance (m) from shallow to deep*	Spur width (m)	Spur height (relief) (m)	Water depth top of spur (m)	Water depth in groove (m)	Zone
0	na	na	1.4	na	Barren
10	na	na	1.4	na	
20	na	na	1.4	1.4	
30	coalesced	0	1.5	1.5	*Millepora/*
40	coalesced	0	1.5	1.5	*Palythoa*
50	coalesced	0	0.3	1.5	
60	3.0	1.2	0.6	1.8	
70	coalesced	0.9	2.1	3.0	
80	coalesced	1.6	2.1	3.7	
90	17.5	2.8	2.1	4.9	
100	5.5	2.8	2.4	5.2	*Acropora/*
110	8.0	3.4	2.4	5.8	transition
120	15.5	3.1	3.0	6.1	
130	13.0	3.6	3.7	7.3	
140	8.0	2.7	4.6	7.3	
150	12.0	2.4	5.2	7.6	
160	12.5	2.1	5.8	7.9	*Montastraea/*
170	11.0	2.4	5.8	8.2	octocoral
180	12.0	2.1	6.1	8.2	
190	13.3	1.2	7.3	8.5	
200	3.3	0.3	8.5	8.8	

Table 6.2. Morphological characteristics, depths, and zones at sites II and III, spur and groove tract, Looe Key, August 1983 (cont.)

B. Middle Spur III Traverse distance (m) from shallow to deep*	Spur width (m)	Spur height (relief) (m)	Water depth top of spur (m)	Water depth in groove (m)	Zone
0	na	na	1.4	1.4	Barren
10	na	na	1.4	1.4	
20	na	na	1.4	1.4	
30	9.5	0.5	0.6	1.1	*Millepora/*
40	16.5	0.5	0.6	1.1	*Palythoa*
50	15.0	0.7	0.8	1.5	
60	18.0	1.3	0.8	2.1	
70	21.0	1.5	0.9	2.4	
80	15.5	2.8	1.2	4.0	
90	8.5	3.4	1.2	4.6	
100	6.5	2.6	2.3	4.9	*Acropora/*
110	13.0	3.5	2.3	5.8	transition
120	16.0	3.7	3.0	6.7	
130	15.0	3.9	3.4	7.3	
140	13.5	3.3	4.0	7.3	
150	11.0	3.0	4.6	7.6	
160	15.5	1.8	5.8	7.6	*Montastraea/*
170	4.0	1.2	7.0	8.2	octocoral
180	14.0	1.8	6.7	8.5	
190	10.0	1.5	7.3	8.8	
200	6.0	0.3	8.5	8.8	

Traverses at site II and III were not fully extended through the barren rubble zone into the back-reef seagrass beds.

Table 6.3. Abundance of octocorals, site I (east spur), Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency
Plexaura flexosa	16	20.00	0.75
Eunicea succinea	12	15.00	0.75
Pseudopterogorgia americana	10	12.50	0.37
Muricea atlantica	9	11.25	0.62
Gorgonia ventalina	8	10.00	0.62
Pterogorgia citrina	7	8.75	0.25
Plexaura homomalla	6	7.50	0.50
Eunicea tourneforti	4	5.00	0.37
Plexaurella fusifera	3	3.75	0.37
Eunicea calyculata	2	2.50	0.25
Pseudoplexaura flagellosa	2	2.50	0.12
Plexaurella grisea	1	1.25	0.12
Total: species 12	colonies 80		

Table 6.4. Abundance of stony corals, site I (east spur), Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency	Density $\bar{x}$	Density S
Millepora complanata	8	44.44	0.38	1.00	1.77
Favia fragum	4	22.22	0.13	0.50	1.41
Siderastrea radians	2	11.11	0.13	0.25	0.71
Porites astreoides	2	11.11	0.25	0.25	0.46
Diploria clivosa	1	5.56	0.13	0.13	0.35
Millepora alcicornis	1	5.56	0.13	0.13	0.35
Total: species 6	colonies 18				

Table 6.5. Abundance of Zoanthidae and coral limorpharia at six sites, Looe Key, August 1983.

Site	Species	Abundance	Percent abundance	Frequency	Density/ m^2 $\bar{x}$	S	Estimated cover $\bar{x}$	S
I	*Palythoa caribbea*	12	100	0.55	1.50	1.60	4.69	7.13
II_1	*Palythoa caribbea*	25	78.13	0.53	1.47	1.81	3.56	24.45
	Ricordea florida	7	21.88	0.25	0.41	0.87		
II_2	*Ricordea florida*	42	58.33	0.89	2.21	1.51	13.55	16.25
	Palythoa caribbea	30	41.67	0.68	1.58	1.35		
II_3	*Palythoa caribbea*	17	80.95	0.55	0.85	1.04	1.84	2.01
	Ricordea florida	3	14.29	0.10	0.15	0.49		
	Zoanthus sociatus	1	4.76	0.05	0.05	0.22		
III_1	*Palythoa caribbea*	30	56.60	0.73	2.00	1.69	21.41	15.00
	Ricordea florida	23	43.40	0.60	1.53	1.96		
III_2	*Palythoa caribbea*	16	61.54	0.32	0.73	1.32	3.75	7.86
	Ricordea florida	9	34.62	0.28	0.41	0.80		
	Zoanthus sociatus	1	3.85	0.05	0.05	0.21		
III_3	*Palythoa caribbea*	30	88.24	0.53	0.88	1.05	6.32	6.56
	Ricordea florida	4	11.76	0.24	0.24	0.44		
IV	*Palythoa caribbea*	10	100	0.38	0.63	0.96	1.09	2.58
V	*Palythoa caribbea*	2	100	0.11	0.11	0.32	0.28	0.81
VI	*Palythoa caribbea*	3	60.00	0.16	0.16	0.37	0.53	1.34
	Ricordea florida	2	40.00	0.11	0.11	0.32		

[1] *Millepora*/*Palythoa* zone.
[2] *Acropora*/transition zone.
[3] *Montastraea*/octocoral zone.

Table 6.6. Abundance of stony corals, site II (middle spur), *Millepora/Palythoa* zone, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency	Density $\bar{x}$	Density S
Porites astreoides	72	44.44	0.88	4.24	3.80
Agaricia agaricites	39	24.07	0.59	2.29	3.62
Millepora complanata	34	20.99	0.82	2.00	1.54
Favia fragum	17	10.49	0.35	1.00	1.73
Total: species 4	colonies 162				

Table 6.7. Abundance of stony corals, site III (western spur), *Millepora/Palythoa* zone, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency	Density $\bar{x}$	Density S
Millepora complanata	47	41.23	0.93	3.13	1.77
Agaricia agaricites	28	24.56	0.60	1.87	2.39
Porites astreoides	26	22.81	0.53	1.73	2.22
Porites porites	7	6.14	0.27	0.47	0.92
Mycetophyllia lamarckiana	2	1.75	0.13	0.13	0.35
Siderastrea siderea	2	1.75	0.13	0.13	0.35
Montastraea cavernosa	2	1.75	0.13	0.13	0.33
Total: species 7	colonies 114				

Table 6.8. Abundance of octocorals, site II (middle spur), *Millepora/Palythoa* zone, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency
Gorgonia ventalina	15	75.00	0.41
Eunicea succinea	2	10.00	0.05
Plexaura flexosa	2	10.00	0.11
Plexaura homomalla	1	5.00	0.05
Total: species 4	colonies 20		

Table 6.9. Abundance of octocorals, site III (western spur), *Millepora/Palythoa* zone, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency
Plexaura flexosa	12	60.00	0.46
Eunicea succinea	4	20.00	0.26
Plexaura homomalla	3	15.00	0.13
Gorgonia ventalina	1	5.00	0.06
Total: species 4	colonies 20		

Table 6.10. Abundance of stony corals, site II (saddle spur), *Acropora* transition zone, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency	Density $\bar{x}$	Density S
Agaricia agaricites	39	20.31	0.68	2.05	2.30
Millepora complanata	35	18.23	0.57	1.58	2.50
Porites astreoides	28	14.58	0.68	1.47	1.93
Acropora cervicornis	20	10.42	0.26	1.05	2.53
Acropora palmata	17	8.85	0.32	0.89	1.89
Porites porites	13	6.77	0.36	0.68	1.00
Montastraea cavernosa	9	4.69	0.21	0.47	1.07
Favia fragum	8	4.17	0.21	0.42	1.02
Montastraea annularis	7	3.65	0.11	0.37	1.21
Millepora alcicornis	3	1.56	0.16	0.16	0.37
Mycetophyllia lamarckiana	3	1.56	0.11	0.16	0.50
Siderastrea siderea	2	1.04	0.11	0.11	0.32
Stephanocoenia michelini	2	1.04	0.11	0.11	0.32
Colpophyllia natans	2	1.04	0.11	0.11	0.32
Eusmilia fastigiata	1	0.52	0.05	0.05	0.32
Isophyllastrea rigida	1	0.52	0.05	0.05	0.32
Isophyllia sinuosa	1	0.52	0.05	0.05	0.32
Mycetophyllia ferox	1	0.52	0.05	0.05	0.32
Total: species 18	colonies 192				

Table 6.11. Abundance of stony corals, site III (western spur), *Acropora*/transition zone, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency	Density $\bar{x}$	Density S
Agaricia agaricites	78	34.98	0.68	3.55	4.03
Millepora complanata	37	16.59	0.50	1.68	2.10
Porites astreoides	27	12.11	0.64	1.23.	1.27
Porites porites	25	11.21	0.45	1.14	1.70
Montastraea annularis	14	6.28	0.41	0.64	0.95
Mycetophyllia lamarckiana	13	5.83	0.41	0.59	0.85
Stephanocoenia michelini	9	4.04	0.23	0.41	0.96
Millepora alcicornis	5	2.24	0.14	0.23	0.69
Siderastrea siderea	5	2.24	0.23	0.23	0.43
Favia fragum	2	0.90	0.09	0.09	0.29
Dichocoenia stokesi	2	0.90	0.05	0.09	0.43
Eusmilia fastigiata	2	0.90	0.09	0.09	0.29
Montastraea cavernosa	1	0.45	0.05	0.05	0.21
Mycetophyllia ferox	1	0.45	0.05	0.05	0.21
Meandrina meandrites	1	0.45	0.05	0.05	0.21
Siderastrea radians	1	0.45	0.05	0.05	0.21
Total: species 16	colonies 223				

Table 6.12. Abundance of octocorals, site II (middle spur), *Acropora*/transition zone, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency
Plexaura flexosa	17	41.46	0.36
Gorgonia ventalina	8	19.51	0.21
Eunicea succinea	6	14.63	0.26
Plexaura homomalla	5	12.20	0.21
Pseudoplexaura porosa	3	7.32	0.15
Pseudopterogorgia americana	1	2.44	0.05
Pseudoplexaura flagellosa	1	2.44	0.05
Total: species 7	colonies 41		

Table 6.13. Abundance of octocorals, site III (western spur), *Acropora*/transition zone, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency
Plexaura flexosa	58	43.61	0.86
Plexaura homomalla	22	16.54	0.50
Eunicea succinea	20	15.04	0.63
Gorgonia ventalina	12	9.02	0.40
Pseudoplexaura porosa	9	6.77	0.27
Pseudopterogorgia americana	4	3.01	0.18
Briareum asbestinum	3	2.26	0.13
Pseudoplexaura flagellosa	2	1.50	0.09
Muricea atlantica	1	0.75	0.04
Muriceopsis flavida	1	0.75	0.04
Eunicea tourneforti	1	0.75	0.04

Total: species 11 colonies 133

Table 6.14. Abundance of stony corals, site II (middle spur), *Montastraea*/octocoral zone, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency	Density $\bar{x}$	Density S
Montastraea cavernosa	59	30.26	0.65	2.95	5.12
Acropora cervicornis	33	16.92	0.40	1.65	2.70
Acropora palmata	25	12.82	0.25	1.25	2.94
Montastraea annularis	24	12.31	0.40	1.20	2.57
Millepora alcicornis	11	5.64	0.40	0.55	0.76
Siderastrea siderea	8	4.10	0.40	0.40	0.50
Millepora complanata	7	3.59	0.20	0.35	0.81
Porites porites	3	1.54	0.10	0.15	0.49
Mycetophyllia lamarckiana	3	1.54	0.15	0.15	0.37
Agaricia agaricites	3	1.54	0.15	0.15	0.37
Dichocoenia stellaris	3	1.54	0.15	0.15	0.37
Meandrina meandrites	2	1.03	0.10	0.10	0.31
Stephanocoenia michelini	2	1.03	0.10	0.10	0.31
Dendrogyra cylindrus	2	1.03	0.05	0.10	0.45
Favia fragum	2	1.03	0.05	0.10	0.45
Porites astreoides	2	1.03	0.10	0.10	0.31
Diploria labyrinthiformis	1	0.51	0.05	0.05	0.22
Diploria strigosa	1	0.51	0.05	0.05	0.22
Diploria clivosa	1	0.51	0.05	0.05	0.22
Manicina areolata	1	0.51	0.05	0.05	0.22
Colcophyllia natans	1	0.51	0.05	0.05	0.22
Mycetophyllia sp.	1	0.51	0.05	0.05	0.22
Total: species 22	colonies 195				

Table 6.15. Abundance of stony corals, site III (western spur), *Montastraea*/octocoral zone, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency	Density $\bar{x}$	Density S
Siderastrea siderea	15	11.36	0.53	0.88	1.05
Mycetophyllia lamarckiana	14	10.61	0.41	0.82	1.13
Montastraea annularis	14	10.61	0.41	0.82	1.13
Agaricia agaricites	14	10.61	0.41	0.82	1.24
Millepora alcicornis	13	9.85	0.47	0.76	1.03
Acropora cervicornis	12	9.09	0.24	0.71	1.36
Porites porites	10	7.58	0.41	0.59	1.00
Millepora complanata	7	5.30	0.18	0.41	1.06
Porites astreoides	6	4.55	0.29	0.35	0.61
Montastraea cavernosa	5	3.79	0.24	0.29	0.59
Eusmilia fastigiata	5	3.79	0.29	0.29	0.99
Colpophyllia natans	3	2.27	0.12	0.18	0.53
Diploria clivosa	3	2.27	0.12	0.18	0.53
Mycetophyllia ferox	2	1.52	0.12	0.12	0.33
Acropora prolifera	2	1.52	0.12	0.12	0.49
Oculina diffusa	2	1.52	0.12	0.12	0.33
Stephanocoenia michelini	2	1.52	0.12	0.12	0.33
Favia fragum	1	0.76	0.06	0.06	0.24
Meandrina meandrites	1	0.76	0.06	0.06	0.24
Dichocoenia stellaris	1	0.76	0.06	0.06	0.24
Total: species 20	colonies 132				

Table 6.16. Abundance of octocorals, site 11 (middle spur), *Montastraea*/octocoral zone, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency
Plexaura flexosa	60	48.78	0.85
Plexaura homomalla	24	19.51	0.50
Eunicea succinea	9	7.32	0.40
Pseudoplexaura porosa	8	6.50	0.25
Eunicea tourneforti	4	3.25	0.20
Plexaurella fusifera	3	2.44	0.10
Briareum asbestinum	3	2.44	0.10
Gorgonia ventalina	2	1.63	0.10
Pseudopterogorgia americana	2	1.63	0.10
Eunicea calyculata	2	1.63	0.10
Pseudoplexaura crucis	2	1.63	0.10
Plexaurella grisea	1	0.81	0.05
Muriceopsis flavida	1	0.81	0.05
Eunicea laciniata	1	0.81	0.05
Pseudoplexaura flagellosa	1	0.81	0.05
Total: species 15	colonies 123		

Table 6.17. Abundance of octocorals, site III (western spur), *Montastraea*/octocoral zone, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency
Plexaura flexosa	64	42.11	0.88
Plexaura homomalla	26	17.11	0.76
Pseudoplexaura porosa	17	11.18	0.64
Briareum asbestinum	16	10.53	0.05
Eunicea succinea	12	7.89	0.41
Gorgonia ventalina	5	3.29	0.23
Pseudoplexaura flagellosa	3	1.97	0.17
Pseudopterogorgia americana	2	1.32	0.11
Plexaura fusifera	2	1.32	0.11
Muricea atlantica	1	0.66	0.05
Muriceopsis flavida	1	0.66	0.05
Eunicea calyculata	1	0.66	0.05
Eunicea tourneforti	1	0.66	0.05
Erythropodium caribaeorum	1	0.66	0.05
total: species 14	colonies 152		

Table 6.18. Abundance of stony corals, site IV, *Montastraea* buttress community, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency	Density $\bar{x}$	Density S
Montastraea cavernosa	52	42.62	0.69	3.25	3.61
Montastraea annularis	10	8.20	0.50	0.63	0.72
Acropora cervicornis	10	8.20	0.19	0.63	1.54
Millepora alcicornis	9	7.38	0.44	0.56	0.73
Siderastrea siderea	9	7.38	0.44	0.56	0.81
Porites porites	6	4.92	0.38	0.38	0.50
Siderastrea radians	6	4.92	0.06	0.38	1.50
Mycetophyllia lamarckiana	5	4.10	0.25	0.31	0.60
Dichocoenia stellaris	3	2.46	0.19	0.19	0.40
Porites astreoides	3	2.46	0.19	0.19	0.40
Agaricia agaricites	2	1.64	0.13	0.13	0.34
Diploria labyrinthiformis	2	1.64	0.13	0.13	0.34
Meandrina meandrites	2	1.64	0.13	0.13	0.34
Manicina areolata	1	0.82	0.06	0.06	0.25
Solenastrea bournoni	1	0.82	0.06	0.06	0.25
Stephanocoenia michelini	1	0.82	0.06	0.06	0.25
Total: species 16	colonies 122				

Table 6.19. Abundance of octocorals, site IV, *Montastraea* buttress community, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency
Plexaura flexosa	37	30.58	0.75
Plexaura homomalla	23	19.01	0.56
Eunicea succinea	12	9.92	0.37
Eunicea calyculata	11	9.09	0.50
Pseudopterogorgia americana	8	6.61	0.31
Gorgonia ventalina	7	5.79	0.37
Muricea atlantica	5	4.13	0.31
Eunicea tourneforti	5	4.13	0.18
Plexaurella fusifera	4	3.31	0.25
Pseudoplexaura flagellosa	3	2.48	0.18
Muricea elongata	2	1.65	0.12
Muriceopsis flavida	1	0.83	0.06
Pseudoplexaura crucis	1	0.83	0.06
Pseudoplexaura porosa	1	0.83	0.06
Briareum asbestinum	1	0.83	0.06
Total: species 15	colonies 121		

Table 6.20. Abundance of octocorals, site V, 9 m livebottom community, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency
Eunicea succinea	47	20.00	0.88
Plexaura flexosa	33	14.04	0.83
Eunicea tourneforti	22	9.36	0.55
Plexaurella fusifera	21	8.94	0.72
Muriceopsis flavida	21	8.94	0.61
Muricea atlantica	20	8.51	0.66
Pseudopterogorgia americana	18	7.66	0.50
Eunicea calyculata	14	5.96	0.61
Plexaurella grisea	8	3.40	0.33
Plexaura homomalla	7	2.98	0.38
Gorgonia ventalina	6	2.55	0'33
Plexaurella nutans	6	2.55	0:27
Muricea elongata	3	1.28	0.11
Briareum asbestinum	3	1.28	0.16
Eunicea laciniata	2	0.85	0.11
Pseudoplexaura crucis	2	0.85	0.11
Pseudopterogorgia acerosa	1	0.43	0.05
Pseudoplexaura porosa	1	0.43	0.05
Total: species 18	colonies 235		

Table 6.21. Abundance of stony corals, site V, 9 m livebottom community, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency	Density $\bar{x}$	Density S
Porites astreoides	31	16.06	0.78	1.72	1.36
Agaricia agaricites	30	15.54	0.67	1.67	1.71
Acropora cervicornis	28	14.51	0.56	1.56	1.82
Millepora alcicornis	25	12.95	0.72	1.39	1.24
Siderastrea siderea	23	11.92	0.83	1.28	1.07
Porites porites	11	5.70	0.44	0.61	0.98
Montastraea cavernosa	8	4.15	0.39	0.44	0.62
Dichocoenia stellaris	8	4.15	0.39	0.44	0.62
Dichocoenia stokesi	7	3.36	0.17	0.39	1.04
Stephanocoenia michelini	6	3.11	0.22	0.33	0.69
Solenastrea bournoni	6	3.11	0.28	0.33	0.59
Meandrina meandrites	3	1.55	0.17	0.17	0.38
Manicina areolata	2	1.04	0.11	0.11	0.32
Montastraea annularis	2	1.04	0.11	0.11	0.32
Diploria labyrinthiformis	2	1.04	0.11	0.11	0.32
Scolymia lacera	1	0.52	0.06	0.06	0.24
Total: species 16	colonies 193				

Table 6.22. Abundance of octocorals, site VI, inshore (6 m) live bottom community, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency
Plexaura flexosa	90	23.02	1.00
Eunicea succinea	63	16.11	0.89
Plexaura homomalla	26	6.65	0.78
Gorgonia ventalina	23	5.88	0.78
Muricea atlantica	23	5.88	0.78
Eunicea tourneforti	21	5.37	0.52
Briareum asbestinum	20	5.12	0.52
Pseudopterogorgia americana	19	4.86	0.57
Muriceopsis flavida	19	4.86	0.57
Pseudoplexaura porosa	19	4.86	0.73
Eunicea calyculata	17	4.35	0.42
Plexaurella fusifera	14	3.58	0.36
Pseudoplexaura crucis	9	2.30	0.26
Pseudopterogorgia acerosa	6	1.53	0.21
Pterogorgia anceps	4	1.02	0.15
Pseudoplexaura flagellosa	4	1.02	0.21
Muricea elongata	3	0.77	0.15
Plexaurella grisea	3	0.77	0.10
Pseudoplexaura wagenaari	3	0.77	0.15
Plexaurella nutans	2	0.51	0.10
Eunicea laciniata	2	0.51	0.05
Erythropodium caribaeorum	1	0.26	0.05
Total: species 22	colonies 391		

Table 6.23. Abundance of stony corals, site VI, inshore (6 m) livebottom community, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency	Density $\bar{x}$	Density S
Porites astreoides	31	16.06	0.78	1.72	1.36
Millepora alcicornis	50	22.83	0.74	2.63	2.22
Siderastrea siderea	49	22.37	0.79	2.58	2.43
Stephanocoenia michelini	27	12.33	0.68	1.42	1.35
Porites astreoides	15	6.85	0.58	0.79	0.79
Agaricia agaricites	15	6.85	0.53	0.79	0.92
Porites porites	10	4.57	0.42	0.53	0.70
Dichocoenia stellaris	9	4.11	0.32	0.47	0.77
Montastraea cavernosa	7	3.20	0.32	0.37	0.60
Siderastrea radians	7	3.20	0.21	0.37	0.76
Dichocoenia stokesi	6	2.74	0.16	0.32	0.82
Meandrina meandrites	3	1.37	0.11	0.16	0.50
Solenastrea bournoni	3	1.37	0.16	0.16	0.37
Oculina diffusa	3	1.37	0.16	0.16	0.37
Acropora cervicornis	3	1.37	0.05	0.16	0.69
Colcophyllia natans	2	0.91	0.11	0.11	0.32
Favia fragum	2	0.91	0.11	0.11	0.32
Montastraea annularis	2	0.91	0.05	0.11	0.46
Diploria labyrinthiformis	2	0.91	0.05	0.11	0.46
Scolymia sp.	2	0.91	0.11	0.11	0.32
Manicina areolata	1	0.46	0.05	0.05	0.23
Eusmilia fastigiata	1	0.46	0.05	0.05	0.23
Total: species 21	colonies 219				

Table 6.24. Summary, octocoral analyses, Looe Key, August 1983.

Site	No. of 1-m^2 Quadrats	Total no. Species	Species/m^2 Range	Species/m^2 $\bar{x}$	Species/m^2 S	Total no. Colonies	Colonies/m^2 Range	Colonies/m^2 $\bar{x}$	Colonies/m^2 S	H'	J'
I	8	12	0-9	5.13	3.00	80	0-24	10.00	8.42	3.26	0.91
II_1	17	4	0-2	0.65	0.79	20	0-4	1.18	1.47	1.19	0.60
II_2	19	7	0-5	1.32	1.70	41	0-9	2.16	3.00	2.30	0.82
II_3	20	15	0-6	3.00	1.81	123	0-15	6.15	4.20	2.53	0.65
II_T	56	15	0-6	1.71	1.81	184	0-15	3.29	3.80	2.65	0.68
III_R	1	1	1	-	-	1	1	-	-	-	-
III_1	15	4	0-3	0.93	1.22	20	0-6	1.33	2.02	1.53	0.77
III_2	22	11	0-7	3.23	1.72	133	0-15	6.05	4.41	2.46	0.71
III_3	17	14	1-7	4.18	1.91	152	1-18	8.94	4.63	2.62	0.69
III_T	54	14	0-7	2.89	2.08	306	0-18	5.65	4.91	2.56	0.67
IV	16	15	0-9	4.19	2.43	121	0-16	7.56	4.53	3.12	0.80
V	18	18	3-11	7.33	2.17	235	3-24	13.06	5.99	3.56	0.86
VI	19	22	5-13	9.47	2.46	391	10-30	20.58	4.79	3.72	0.83
TOTAL	172	23	0-13	3.91	3.33	1317	0-30	7.66	7.24	3.49	0.77

R - Rubble zone.
1 - *Millepora*/*Palythoa* zone, spur and groove formation.
2 - *Acropora*/transition zone, spur and groove formation.
3 - *Montastraea*/octocoral zone, spur and groove formation.
T - Intrasite totals for combined zones, sites II and III, respectively.

Table 6.25. Summary, stony coral (Milleporina, Scleractinia less Corallimorpharia) analyses, Looe Key, August 1983.

Site	No. of 1-m^2 Quadrats	Total no. Species	Species/m^2 Range	Species/m^2 $\bar{x}$	Species/m^2 S	Total no. Colonies	Colonies/m^2 Range	Colonies/m^2 $\bar{x}$	Colonies/m^2 S	H'	J'	Stony coral cover Estimate percemt $\bar{x}$	Stony coral cover Estimate percemt S
I	8	6	0-2	1.13	1.13	18	0-9	2.25	3.11	2.17	0.84	1.56	1.29
II_1	17	4	1-4	2.53	1.23	162	1-24	9.59	6.36	1.83	0.91	5.88	4.41
II_2	19	18	2-6	4.00	1.89	192	2-17	10.11	5.77	3.36	0.80	18.55	12.95
II_3	20	22	0-8	4.16	1.95	195	0-19	9.75	6.09	3.25	0.73	28.50	21.39
II_T	56	26	0-8	3.54	1.90	549	0-24	9.82	5.96	3.49	0.74	-	-
II_R	1	0		-	-	-	0	-	-	-	-	-	-
III_1	15	7	1-5	2.73	1.62	114	2-14	7.60	4.40	2.07	0.73	15.63	17.48
III_2	22	16	1-10	4.14	2.47	223	1-24	10.18	6.88	2.93	0.73	11.25	9.41
III_3	17	20	3-7	4.59	1.37	132	4-14	7.65	3.44	3.87	0.90	21.76	18.43
III_T	54	22	1-10	3.59	2.05	469	1-24	8.76	5.39	3.34	0.75	-	-
IV	16	16	0-7	3.88	1.96	122	0-15	7.63	4.76	3.01	0.75	21.41	23.56
V	18	16	1-9	6.00	2.17	193	1-20	10.83	5.22	3.43	0.86	8.89	6.20
VI	19	21	3-8	5.74	1.24	219	5-17	11.53	4.11	3.44	0.78	9.87	6.74
TOTAL	171	32	0-10	3.89	1.47	1570	0-24	9.71	2.61	3.89	0.79	14.33	8.29

R - Rubble zone
1 - *Millepora*/*Palythoa* zone, spur and groove formation.
2 - *Acropora*/transition zone, spur and groove formation.
3 - *Montastraea*/octocoral zone, spur and groove formation.
T - Intrasite totals for combined zones, sites II and III, respectively.

Table 6.26. Stony corals, site II (middle spur), Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency	Density $\bar{x}$	Density S
Porites astreoides	102	18.58	0.54	1.82	2.89
Agaricia agaricites	81	14.75	0.46	1.45	2.56
Millepora complanata	76	13.84	0.52	1.36	1.88
Montastraea cavernosa	68	12.39	0.29	1.20	3.35
Acropora cervicornis	53	9.65	0.29	0.95	2.25
Acropora palmata	42	7.65	0.20	0.75	2.08
Montastraea annularis	31	5.65	0.18	0.55	1.74
Favia fragum	27	4.92	0.20	0.48	1.19
Porites porites	16	2.91	0.16	0.29	0.71
Millepora alcicornis	14	2.53	0.20	0.25	0.55
Siderastrea siderea	10	1.82	0.18	0.18	0.39
Mycetophyllia lamarckiana	6	1.09	0.09	0.11	0.37
Stephanocoenia michelini	4	0.73	0.07	0.07	0.26
Dichocoenia stellaris	3	0.55	0.05	0.05	0.23
Colpophyllia natans	3	0.55	0.05	0.05	0.23
Meandrina meandrites	2	0.36	0.04	0.04	0.19
Dendrogyra cylindrus	2	0.36	0.02	0.04	0.27
Diploria labyrinthiformis	1	0.18	0.02	0.02	0.13
Diploria strigosa	1	0.18	0.02	0.02	0.13
Diploria clivosa	1	0.18	0.02	0.02	0.13
Manicina areolata	1	0.18	0.02	0.02	0.13
Eusmilia fastigiata	1	0.18	0.02	0.02	0.13
Isophyllastrea rigida	1	0.18	0.02	0.02	0.13
Isophyllia sinuosa	1	0.02	0.02	0.02	0.13
Mycetophyllia ferox	1	0.02	0.02	0.02	0.13
Mycetophyllia sp.	1	0.02	0.02	0.02	0.13
Total: species 26	colonies 549				

Table 6.27. Abundance of octocorals, site II (middle spur), Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency
Plexaura flexosa	79	42.93	0.46
Plexaura homomalla	30	16.30	0.26
Gorgonia ventalina	25	13.59	0.23
Eunicea succinea	17	9.24	0.25
Pseudoplexaura porosa	11	5.98	0.14
Eunicea tourneforti	4	2.17	0.07
Pseudopterogorgia americana	3	1.63	0.05
Plexaurella fusifera	3	1.63	0.03
Briareum asbestinum	3	1.63	0.03
Eunicea calyculata	2	1.09	0.03
Pseudoplexaura crucis	2	1.09	0.03
Pseudoplexaura flagellosa	2	1.09	0.03
Plexaurella grisea	1	0.54	0.01
Muriceopsis flavida	1	0.54	0.01
Eunicea laciniata	1	0.54	0.01
Total: species 15	colonies 184		

Table 6.28. Systematic listing of Cnidaria sampled at six sites, Looe Key, August 1983.

Phylum CNIDARIA (Hatschek, 1888)
- Class HYDROZOA Owen, 1843
  - Order MILLEPORINA Hickson, 1901
    - Family MILLEPORIDAE Fleming, 1828
      - *Millepora alcicornis* Linné, 1758
      - *M. complanata* Lamarck, 1816
- Class ANTHOZUA Ehrenberg, 1834
- *Subclass OCTOCORALLIA Haeckel, 1866
  - Order ALCYONACEA Lamouroux, 1816 (emended Verrill, 1866; Bayer, 1981)
    - Family BRIAREIDAE Gray, 1840
      - *Briareum asbestinum* (Pallas, 1766)
    - Family ANTHOTHELIDAE Broch, 1916
      - *Erythropodium caribaeorum* (Duchassaing and Michelotti, 1860)
    - Family PLEXAURIDAE Gray, 1859
      - *Plexaura homomalla* Esper, 1792
      - *P. flexosa* Lamouroux, 1821
      - *Eunicea succinea* (Pallas, 1766)
      - *Eunicea laciniata* Duchassaing and Michelotti, 1860
      - *E. tourneforti* Milne Edwards and Haime, 1857
      - *E. calyculata* Ellis and Solander, 1786
      - *Muriceopsis flavida* (Lamarck, 1815)
      - *Plexaurella nutans* (Duchassaing and Michelotti, 1860)
      - *P. grisea* Kunze, 1916
      - *P. fusifera* Kunze, 1916
      - *Muricea atlantica* (Kukenthal, 1919)
      - *M. elongata* Lamouroux, 1821
      - *Pseudoplexaura porosa* (Houttuyn, 1772)
      - *P. flagellosa* (Houttuyn, 1772)
      - *P. wagenaari* (Stiasny, 1941)
      - *P. crucis* Bayer, 1961
    - Family GORGONIIDAE Lamouroux, 1812
      - *Pseudopterogorgia acerosa* (Pallas, 1766)
      - *P. americana* (Gmelin, 1791)
      - *Gorgonia ventalina* Linné, 1758
      - *Pterogorgia citrina* (Esper, 1792)
      - *P. anceps* Pallas, 1766)
- Subclass ZOANTHARIA de Blainville, 1830
  - Order ZOANTHINIARIA van Beneden, 1898
    - Family ZOANTHIDAE Gray, 1840
      - *Palythoa caribbea* Duchassaing and Michelotti, 1860
      - *Zoanthus sociatus* Le Sueur, 1817
  - Order SCLERACTINIA
  - Suborder ASTROCOENIINA Vaughan and Wells, 1943
    - Family ASTROCOENIIDAE Koby, 1890
      - *Stephanocoenia michelini* Milne Edwards and Haime, 1848
    - Family ACROPORIDAE Verrill, 1902
      - *Acropora palmata* (Lamarck, 1816)
      - *A. cervicornis* (Lamarck, 1816)
      - *A. prolifera* (Lamarck, 1816)

Table 6.28. Systematic listing of Cnidaria sampled at six sites, Looe Key, August 1983 (cont.).

Suborder FUNGIINA Verrill, 1865
- Family AGARICIIDAE Gray, 1847
  - *Agaricia agaricites* (Linné, 1758)
- Family SIDERASTREIDAE Vaughan and Wells, 1943
  - *Siderastrea radians* (Pallas, 1766)
  - *S. siderea* (Ellis and Solander, 1786)
- Superfamily PORITICAE Gray, 1842
- Family PORITIDAE Gray, 1842
  - *Porites astreoides* Lamarck, 1816
  - *P. Porites* (Pallas, 1766)

Suborder FAVIINA Vaughan and Wells, 1943
- Superfamily FAVIICAE Gregory, 1900
- Family FAVIIDAE Gregory, 1900
  - *Favia fragum* (Esper, 1795)
  - *Diploria labyrinthiformis* (Linné, 1758)
  - *D. clivosa* (Ellis and Solander, 1786)
  - *D. strigosa* (Dana, 1846)
  - *Manicina areolata* (Linné, 1758)
  - *Colpophyllia natans* (Houttuyn, 1772)
  - *Montastraea cavernosa* (Linné, 1767)
  - *M. annularis* (Ellis and Solander, 1786)
  - *Solenastrea bournoni* Milne Edwards and Haime, 1850
- Family OCULINIDAE Gray, 1847
  - *Oculina diffusa* Lamarck, 1816
- Family MEANDRINAE Gray, 1847
  - *Meandrina meandrites* (Linné, 1758)
  - *Dichocoenia stellaris* Milne Edwards and Haime, 1849
  - *D. stokesi* Milne Edwards and Haime, 1849
  - *Dendrogyra cylindrus* Ehrenberg, 1834
- Family MUSSIDAE Ortmann, 1890
  - *Scolymia lacera* (Pallas, 1766)
  - *Scolymia* sp.
  - *Isophyllia sinuosa* (Ellis and Solander, 1786)
  - *Isophyllastrea rigida* (Dana, 1846)
  - *Mycetophyllia lamarckiana* Milne Edwards and Haime, 1849
  - *M. ferox* Wells, 1973
  - *Mycetophyllia* sp.

Suborder MYOPHINA Vaughan and Wells, 1943
- Superfamily CARYOPHYLLIICAE Gray, 1847
- Family CARYOPHYLLIIDAE Gray, 1847
  - *Eusmilia fastigiata* (Pallas, 1766)

**Suborder CORALLIMORPHARIA Carlgren, 1940
- Family RICORDEIDAE Watzl, 1922
  - *Ricordea florida* Duchassaing and Michelotti, 1860

* According to most recent revision (Beyer, 1981).

** According to Den Hartog, 1980.

Table 6.29. Abundance of octocorals at six sites, Looe Key, August 1983.

Species	Abundance	Percent abundance
Plexaura flexosa	389	29.54
Eunicea succinea	188	14.27
Plexaura homomalla	143	10.86
Gorgonia ventalina	87	6.61
Pseudopterogorgia americana	64	4.86
Muricea atlantica	59	4.48
Eunicea tourneforti	58	4.40
Pseudoplexaura porosa	58	4.40
Plexaurella fusifera	47	3.57
Eunicea calyculata	47	3.57
Briareum asbestinum	46	3.49
Muriceopsis flavida	44	3.34
Pseudoplexaura flagellosa	16	1.21
Pseudoplexaura crucis	14	1.06
Plexaurella grisea	13	0.99
Muricea elongata	8	0.61
Plexaurella nutans	8	0.61
Pterogorgia citrina	7	0.53
Pseudopterogorgia acerosa	7	0.53
Eunicea laciniata	5	0.38
Pterogorgia anceps	4	0.30
Pseudoplexaura wagenaari	3	0.23
Erythropodium caribaeorum	2	0.15
Total: species 23	colonies 1317	

Table 6.30. Abundance of stony corals (Milleporina, Scleractinia[◊]) at six sites, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency[Δ]
Agaricia agaricites	248	13.50	0.80
Porites astreoides	212	11.54	1.00
*Millepora complanata**	175	9.53	0.70
Montastraea cavernosa	143	7.78	0.80
*Millepora alcicornis**	117	6.37	0.80
Siderastrea siderea	113	6.15	0.80
Acropora cervicornis	106	5.77	0.60
Porites porites	85	4.63	0.80
Montastraea annularis	73	3.97	0.70
Stephanocoenia michelini	49	2.67	0.70
Acropora palmata	42	2.29	0.20
Mycetophyllia lamarckiana	40	2.18	0.60
Favia fragum	36	1.96	0.70
Dichocoenia stellaris	24	1.31	0.50
Siderastrea radians	16	0.87	0.40
Dichocoenia stokesi	15	0.82	0.30
Meandrina meandrites	12	0.65	0.60
Solenastrea bournoni	10	0.54	0.30
Eusmilia fastigiata	9	0.49	0.40
Colpophyllia natans	8	0.44	0.40
Diploria labyrinthiformis	7	0.38	0.40
Diploria clivosa	5	0.27	0.30
Oculina diffusa	5	0.27	0.20
Manicina areolata	5	0.27	0.40
Mycetophyllia ferox	4	0.22	0.30
Acropora prolifera	2	0.11	0.10
Dendrogyra cylindrus	2	0.11	0.10
Scolymia sp.	2	0.11	0.10
Diploria strigosa	1	0.05	0.10
Scolymia lacera	1	0.05	0.10
Isophyllia sinuosa	1	0.05	0.10
Isophyllastrea rigida	1	0.05	0.10
Mycetophyllia sp.	1	0.05	0.10
Total: species 33	colonies 1570		

◊ Corallimorpharia excluded.

Δ Frequency expressed as presence or absence of a species within sampling sites or zones, N = 10 attributes.

* Milleporina.

Table 6.31. Abundance of non-coral Cnidaria at six sites, Looe Key, August 1983.

Species	Abundance	Percent abundance	Frequency
Palythoa caribbea	175	9.53	1.00
Zoanthus sociatus	2	0.11	0.20
Ricordea florida[Δ]	90	4.90	0.70
Total: species 3	colonies 267		

[Δ] Zoanthidae, Corallimorpharia.

Table 6.32. Comparison of Looe Key Octocorallia records.

Coral Surveys*

Species	Antonius *et al.* 1978	FDNR 1980	FDNR 1983
Briareum asbestinum	P D		L S
Erythropodium caribaeorum	P D	S	L S
Iciligorgia schrammi	D R	D	
Plexaura flexosa	P S D	S D	L S
Plexaura homomalla	P S D	S	L S
Pseudoplexaura porosa	P S D	S D	L S
Pseudoplexaura flagellosa	P S D	S D	L S
Pseudoplexaura wagenaari	P S D	S	L S
Pseudoplexaura crucis			L S
Eunicea asperula	P S D		
Eunicea calyculata	P S D	S D	L S
Eunicea fusca	P D		
Eunicea laciniata	P S D		L S
Eunicea mammosa	P S D	S	
Eunicea succinea	P D	S	L S
Eunicea tourneforti	P S D		L S
Eunicea clavigera		D	
Eunicea pinta		D	
Plexaurella dichotoma	P S D		
Plexaurella fusifera	P S D	S D	L S
Plexaurella grisea	S		L S
Plexaurella nutans	P S D	D	L S
Muricea atlantica	PS	S D	L S
Muricea muricata	P S D		
Muricea elongata	P S D		L S
Muricea laxa		D	
Muriceopsis flavida	P S D	D	L S
Gorgonia ventalina	P S D	S D	L S
Pseudopterogorgia bipinnata	S D	D	
Pseudopterogorgia acerosa	P S D	S D	L S
Pseudopterogorgia americana	P S D	S D	L S
Pseudopterogorgia elisabethae		D	
Pterogorgia citrina	S	S	S
Pterogorgia anceps	P		L S
Pterogorgia guadalupensis	P		
Ellisella barbadensis	D R	D	

L - livebottom.
P - patch reef.
S - shallow reef (0 - 11 m depth).
D - plateau (10 - 18 m depth); drop off (25 - 35 m depth).
R - ridge (45 m depth).

* Only portions of above depths were sampled in any one survey.

Table 6.33. Comparison of Looe Key stony coral (Milleporina and Scleractinia) records.

Coral Surveys*

Species	Antonius *et al.* 1978	FDNR 1980	FDNR 1983
Millepora alcicornis	P S D	S D	L S
Millepora complanata	P S D	S	S
Millepora squarrosa[1]	P S		
Stephanocoenia michelini[2]	P S D	S D	L S
Madracis decactis	D	D	
Madracis mirabilis	D	Q	
Madracis asperula	D		
Acropora palmata	S	S	S
Acropora cervicornis	P S D	S	L S
Acropora prolifera	S		S
Agaricia agaricites	P S D	S D	L S
Agaricia agaricites forma *danai*	P S D		
Agaricia agaricites forma *carinata*	*		
Agaricia agaricites forma *purpurea*	D		
Agaricia agaricites forma *humilis*	*		
Agaricia tenuifolia	D		
Agaricia undata	D		
Agaricia lamarcki	D		
Agaricia grahamae	D		
Agaricia fragilis	D		
Helioseris cucullata	D	D	
Siderastrea siderea	P S D	S D	L S
Siderastrea radians	P S	S	L S
Porites astreoides	P S D	S	L S
Porites porites	P S D	S	L S
Porites divaricata[3]	D		
Porites furcata[3]	D		
Favia fragum	P S	S	L S
Diploria clivosa	P S	Q	S
Diploria labyrinthiformis	P S D	D	L S
Diploria strigosa	P S D	S D	S
Manicina areolata	P S	Q	L S
Colpophyllia natans	P S D	S	L S
Montastraea annularis	P S D	S D	L S
Montastraea cavernosa	P S D R	S	L S
Solenastrea hyades	P S D		
Solenastrea buornoni	P S D	Q	L S
Oculina diffusa	P S D	S	L S
Meandrina varicosa	P S D		
Meandrina meandrites	P S D	S	L S
Dichocoenia stokesi	P S D	Q	L S
Dichocoenia stellaris	P S D	D	L S
Dendrogyra cylindrus	P S	Q	S
Mussa angulosa	P S D	Q	
Scolymia lacera	D		L S

Table 6.33. Comparison of Looe Key stony coral (Milleporina and Scleractinia) records (cont.).

Coral Surveys*

Species	Antonius *et al.* 1978	FDNR 1980	FDNR 1983
Isophyllia sinuosa	D	Q	S
Isophyllastrea rigida	D		S
Mycetophyllia lamarckiana	D	S D	S
Mycetophyllia daniana	D		S
Mycetophyllia ferox	D	S	S
Mycetophyllia aliciae	D		
Eusmilia fastigiata	D	S D	L S
Sphenotrochus auritus	*		
Tubastrea aurea	*		

L - livebottom.
P - patch reef.
S - shallow reef (0 - 11 m depth).
D - plateau (10-18 m depth); drop off (25 - 35 m depth).
R - ridge (45 m depth).
Q - qualitative observation.
* Included in a systematic list of species (Appendix) by Antonius *et al.* (1978); not discussed in text nor reported in the tables.
[1] *Millepora squarrosa* is a synonym of *Millepora complanata* (*fide* Stearn and Riding, 1973).
[2] *Stephanocoenia michelini* was reported as *S. intersepta* by Antonius *et al.* (1978).
[3] Varieties of *Porites porites* (*fide* Squires, 1958).

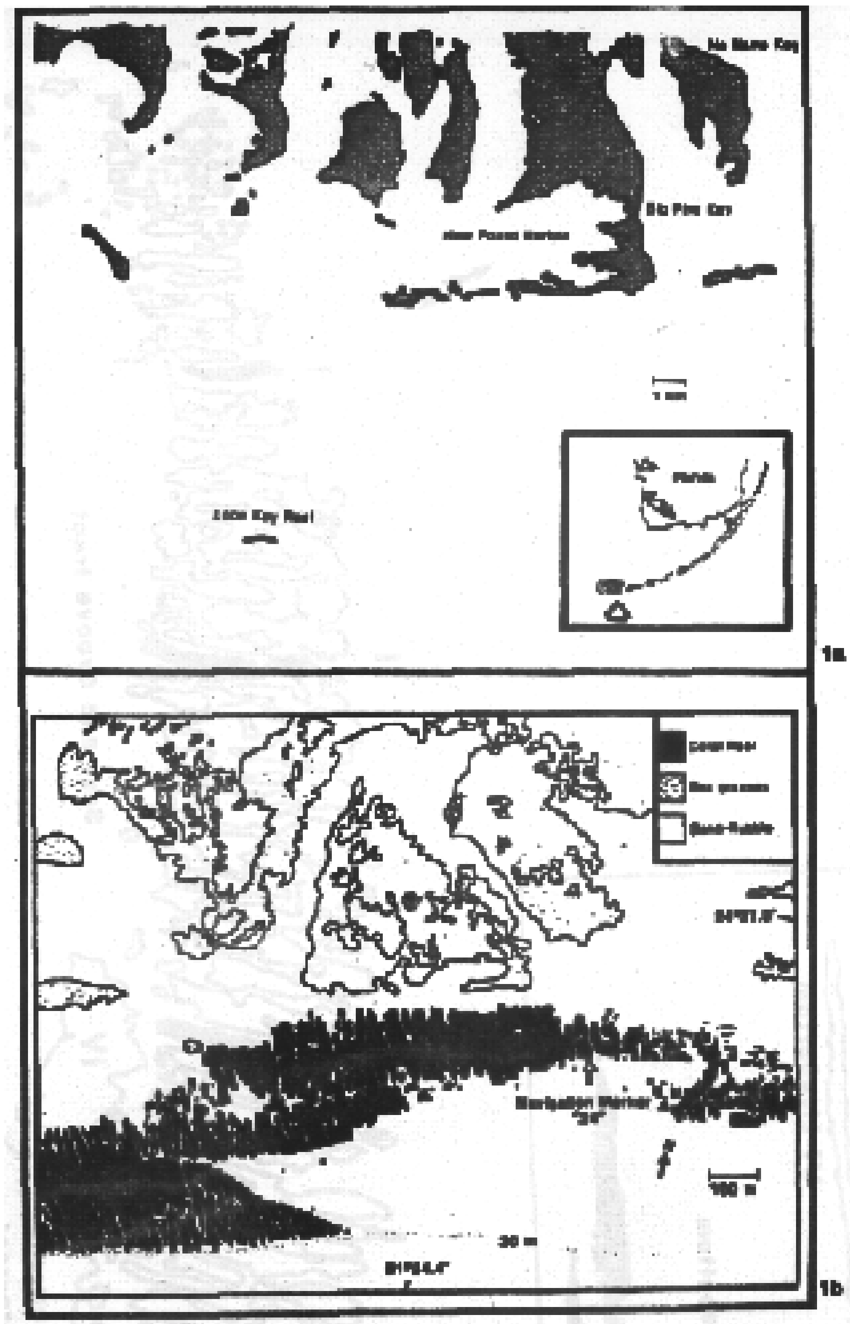


Figure 6.1. a. Geographic location of Looe Key, Florida. b. Orientation of main spur and groove tract, Looe Key reef.

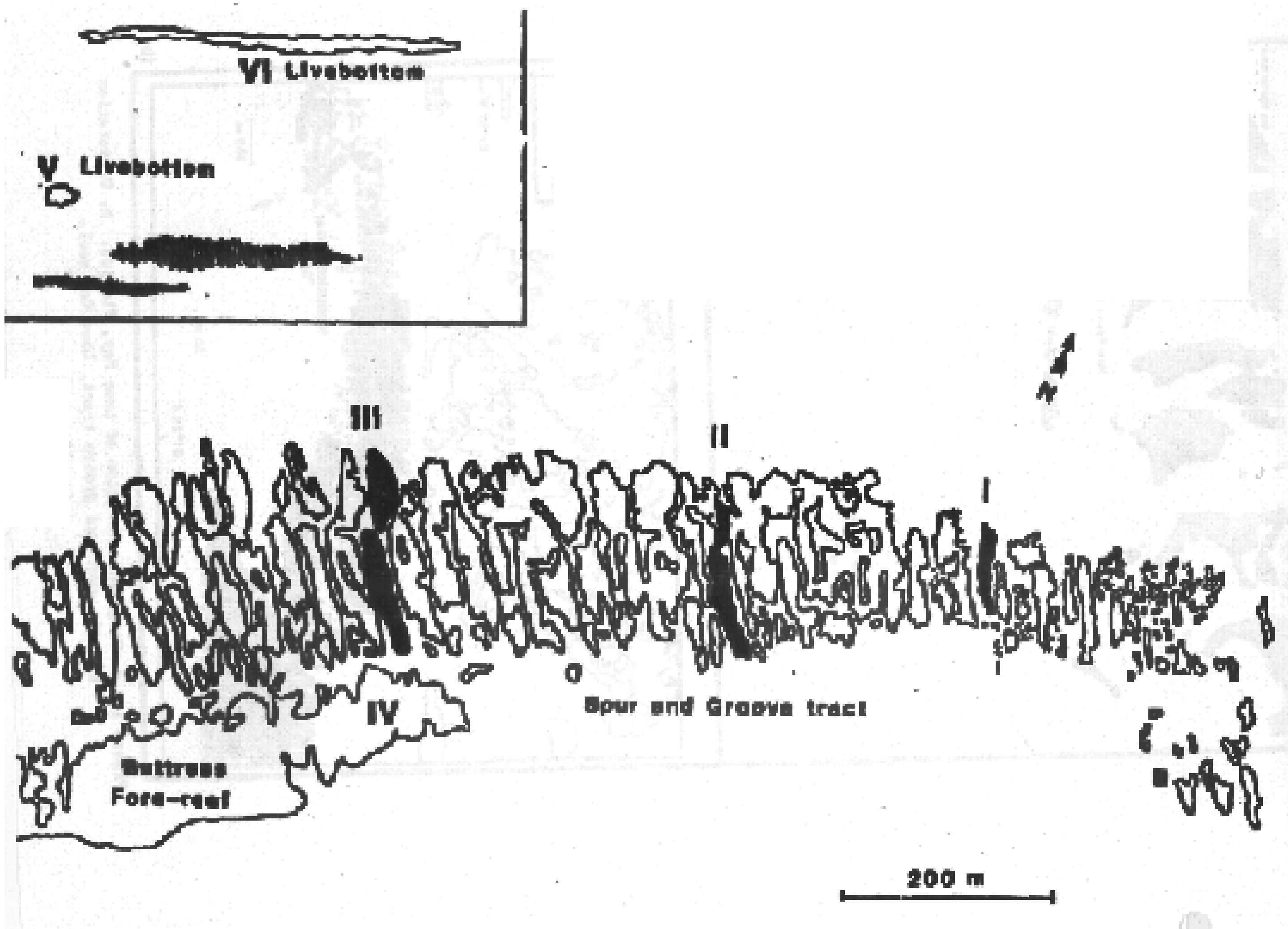


Figure 6.2. Looe Key quantitative coral sampling sites, August 1983.

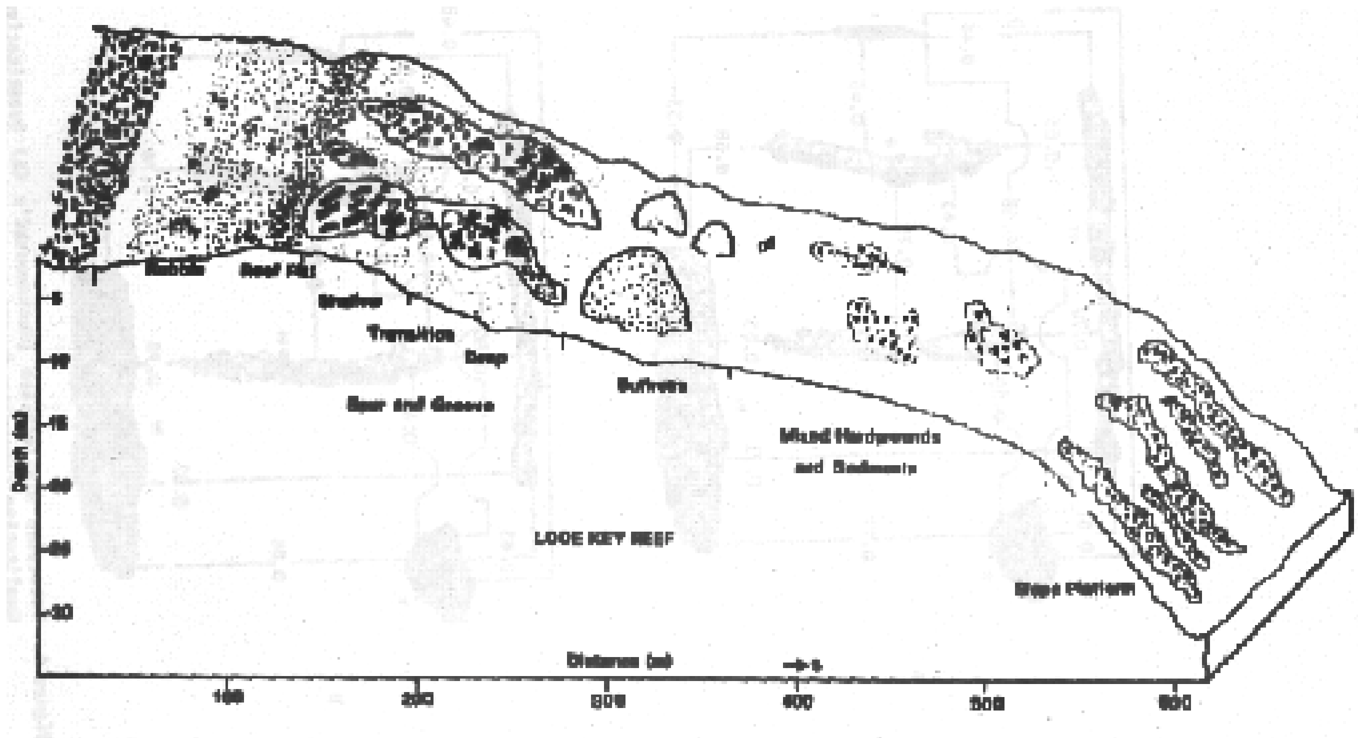
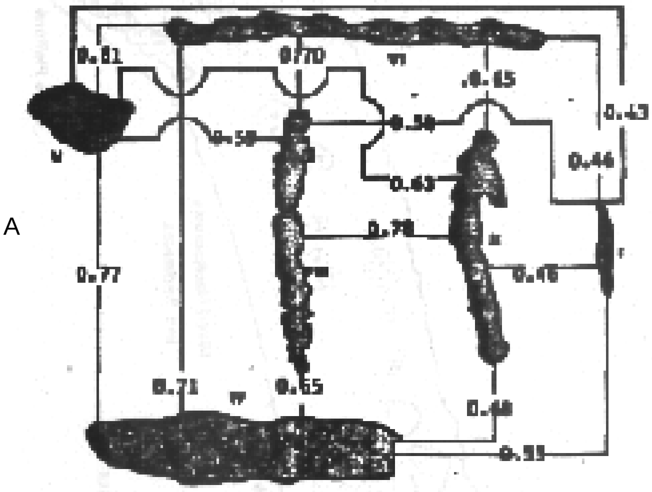


Figure 6.3. Looe Key reef, spur and groove tract, zonation patterns.

A



B

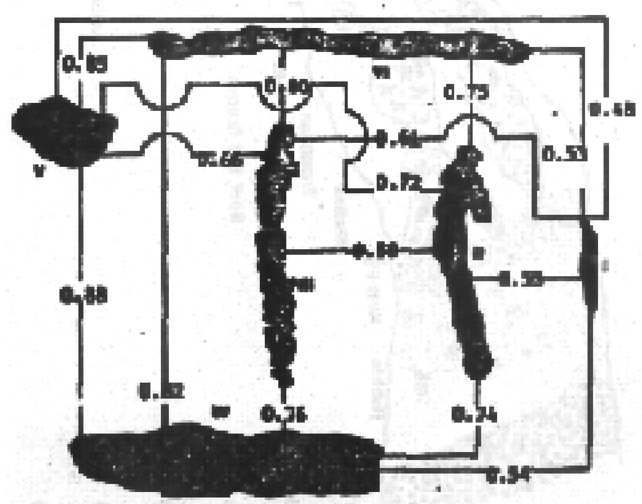
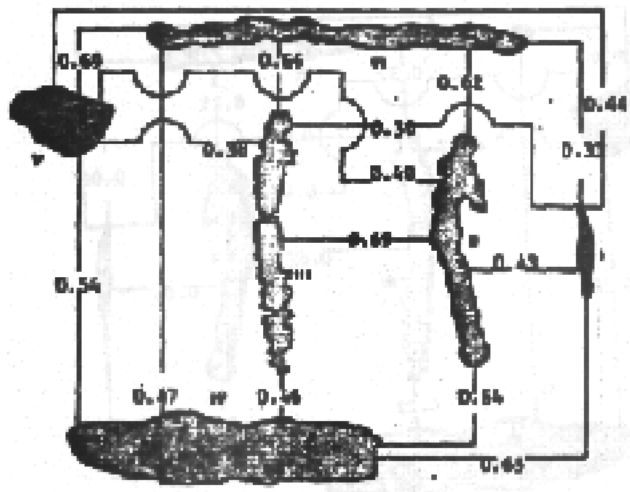


Figure 6.4. Intersite similarities [Czekanowski's (A) Quantitative and (B) Qualitative Community Coefficients] of cnidarian fauna sampled at six sites, Looe Key National Marine Sanctuary, August 1983.

A



B

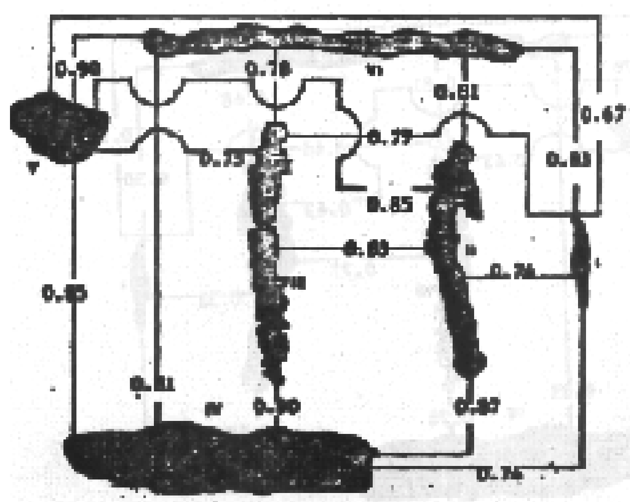
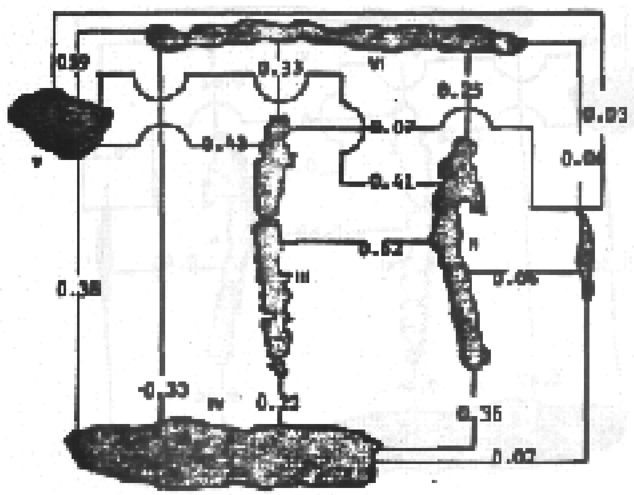


Figure 6.5. Intersite similarities [Czekanowski's (A) Quantitative and (B) Qualitative Community Coefficients] of octocoral fauna sampled at six sites, Looe Key National Marine Sanctuary, August 1983.

A



B

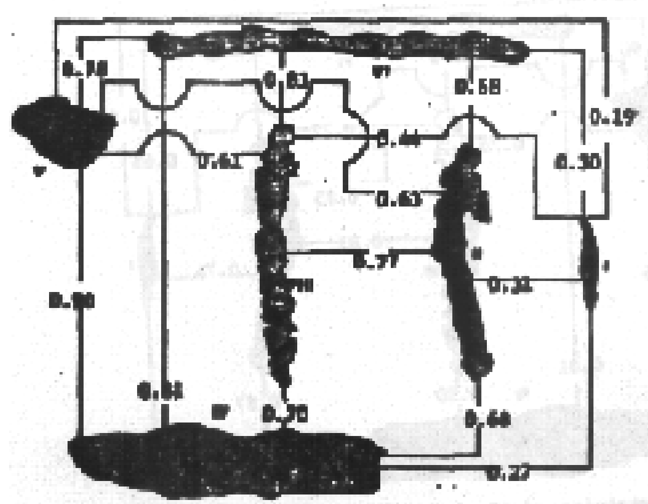


Figure 6.6. Intersite similarities [Czekanowski's (A) Quantitative and (B) Qualitative Community Coefficients] of stony coral fauna sampled at six sites, Looe Key National Marine Sanctuary, August 1983.

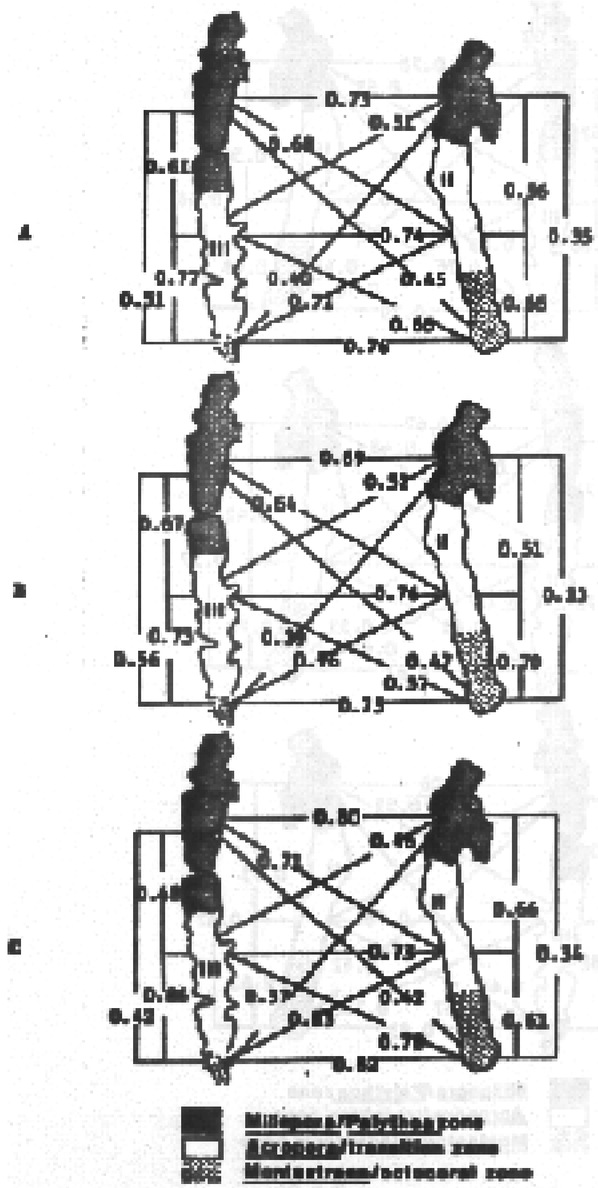


Figure 6.7. Intersite similarities Czekanowski's Quantitative Community Coefficients for (A) all sampled Cnidaria, (B) stony corals, (C) octocorals at sites II and III, Looe Key National Marine Sanctuary, August 1983.

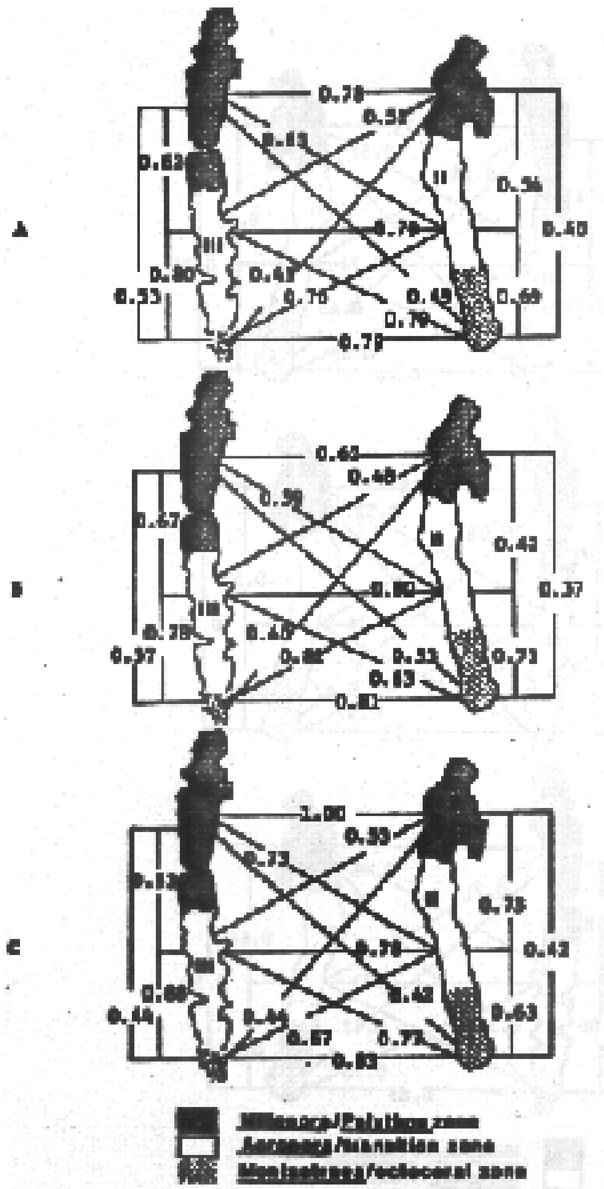
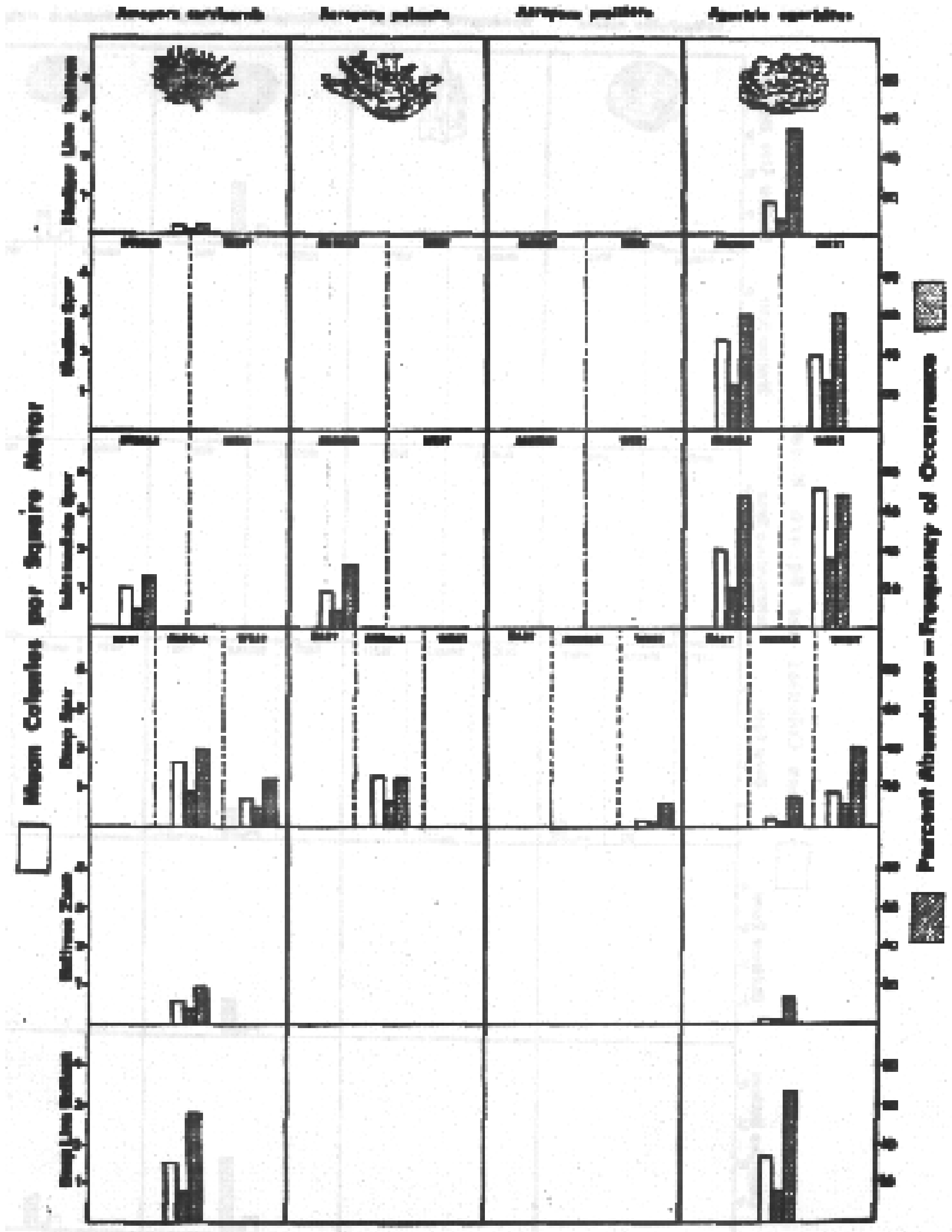
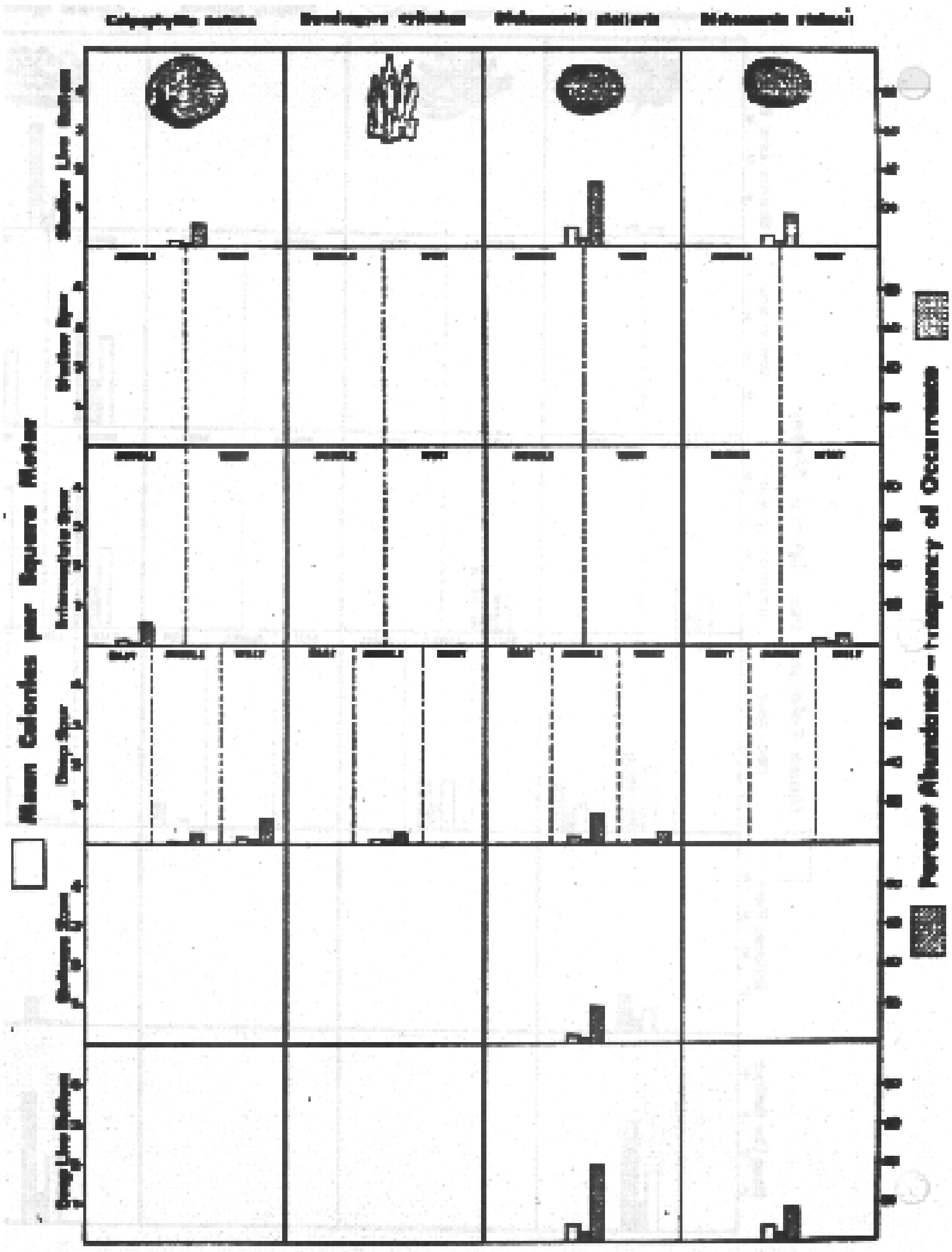
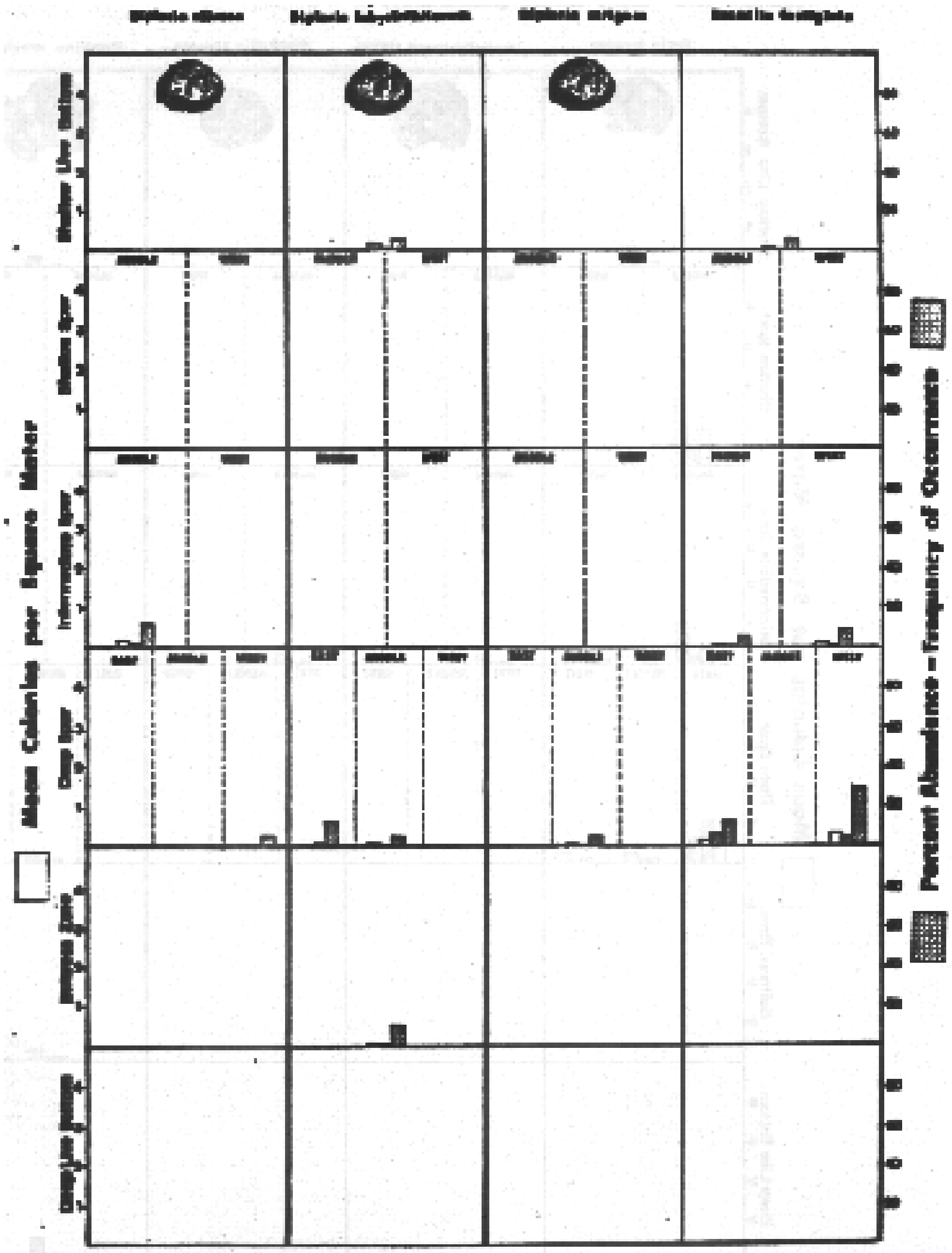


Figure 6.8. Intersite similarities Czekanowski's Quantitative Community Coefficients for (A) all sampled Cnidaria, (B) stony corals, (C) octocorals at sites II and III, Looe Key National Marine Sanctuary, August 1983.

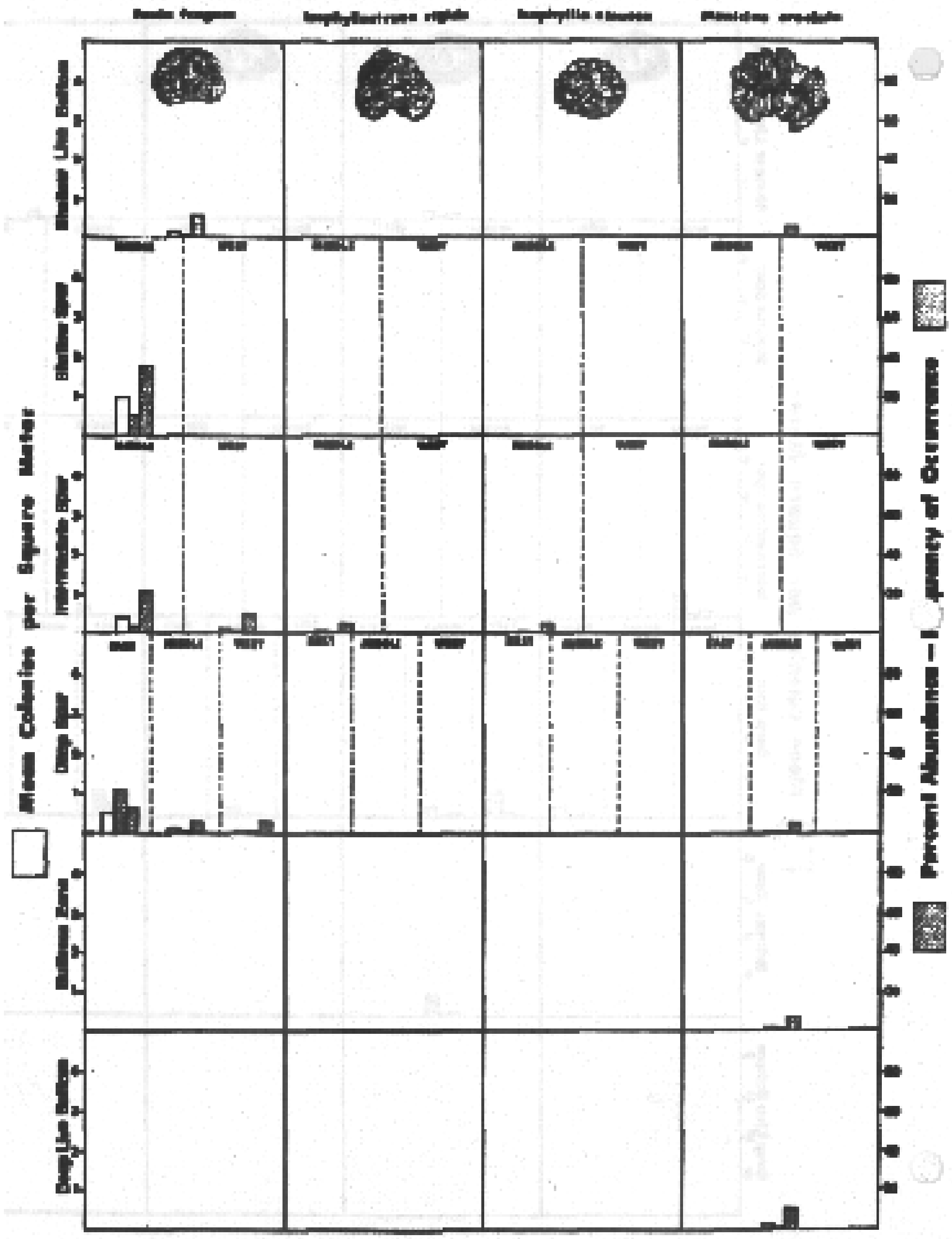
Appendix 6.A. Stony coral abundance and distribution, Looe Key Reef.

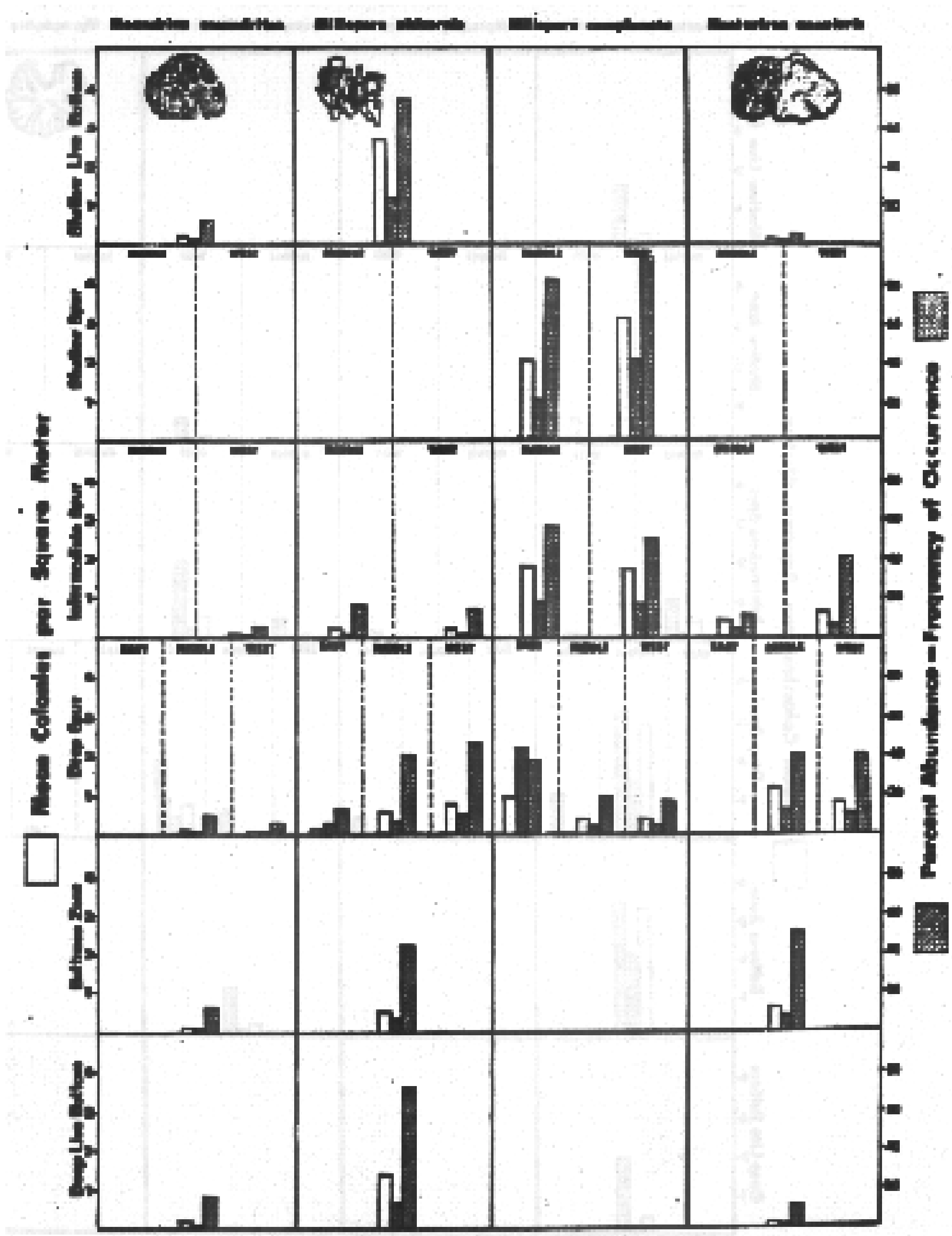


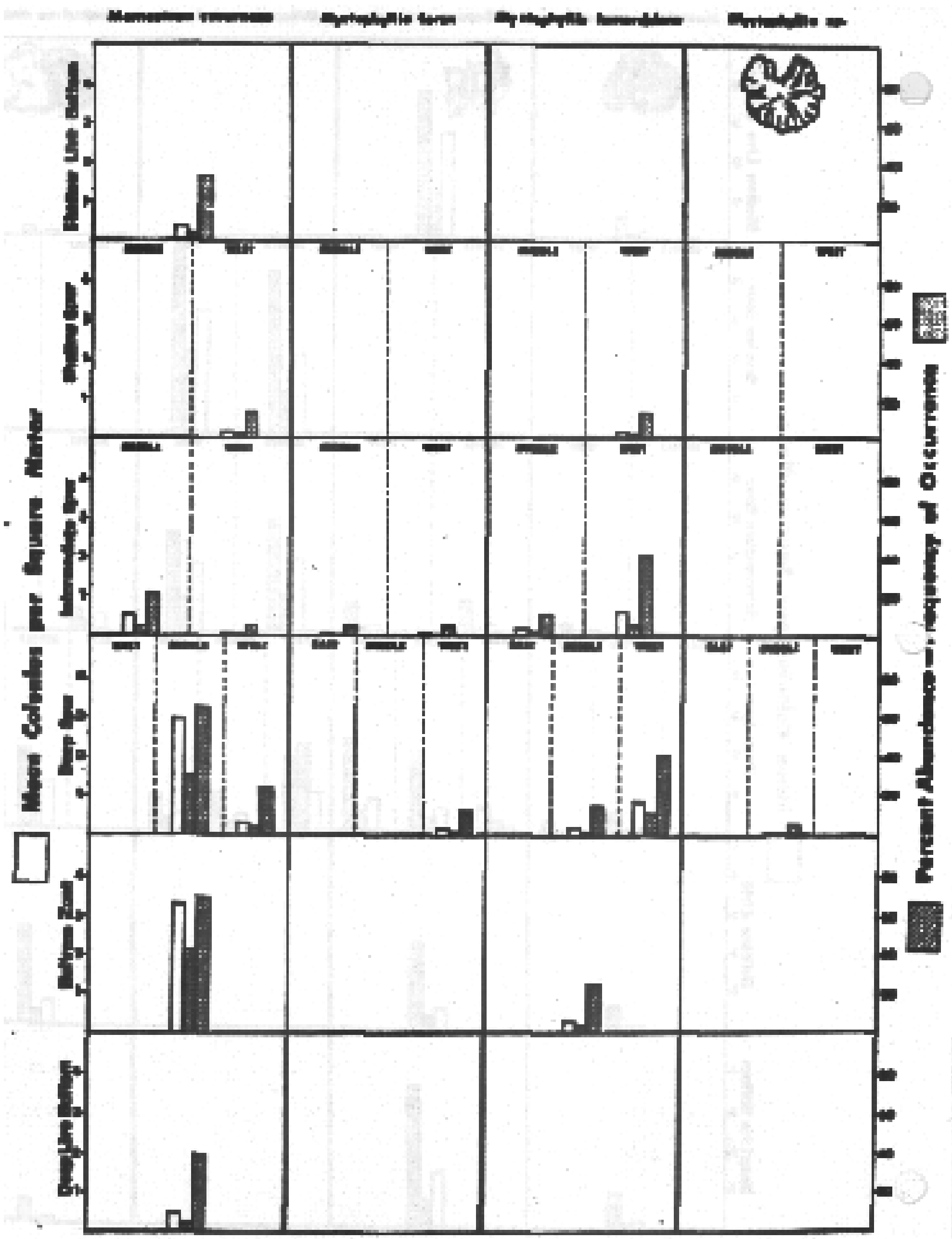


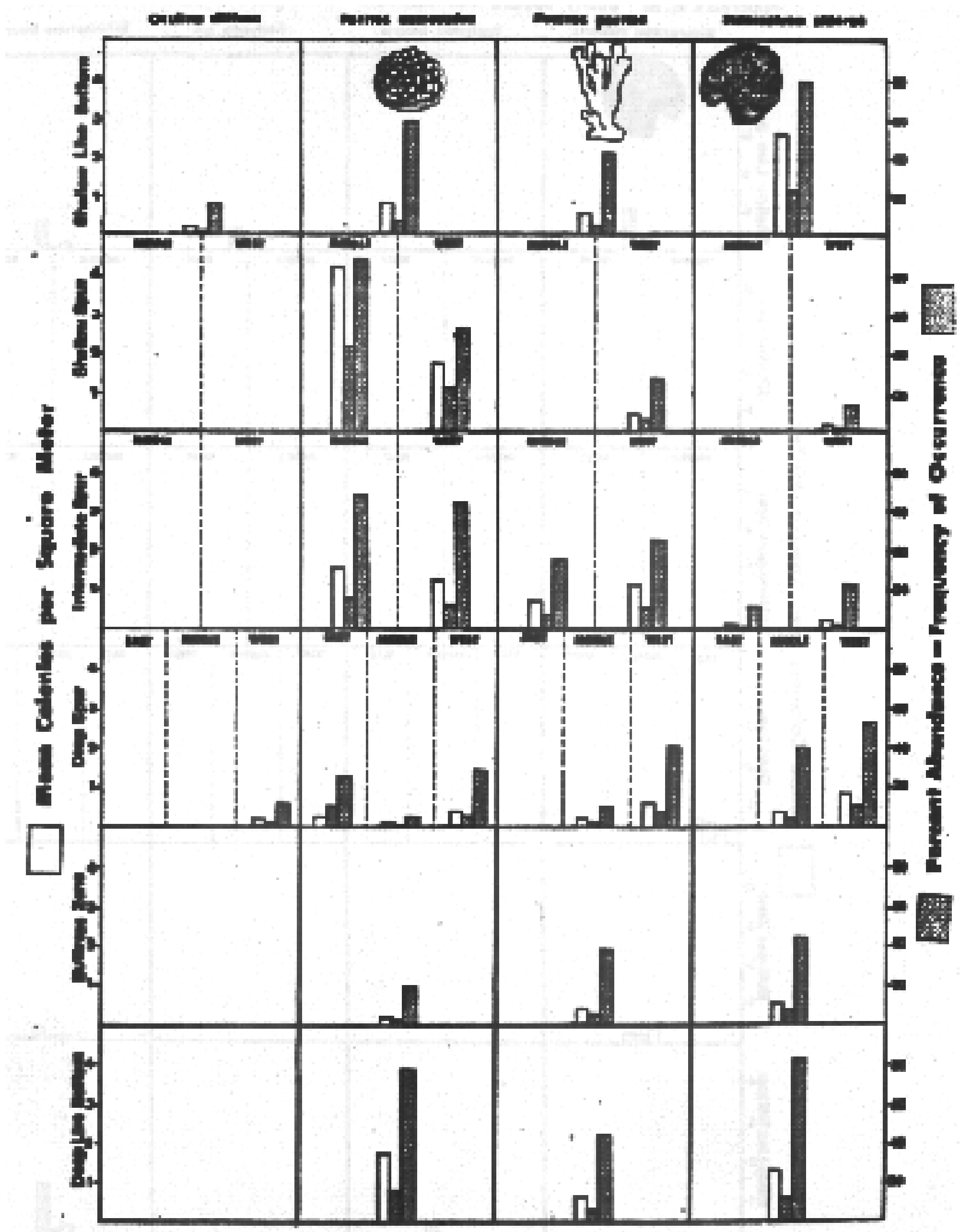


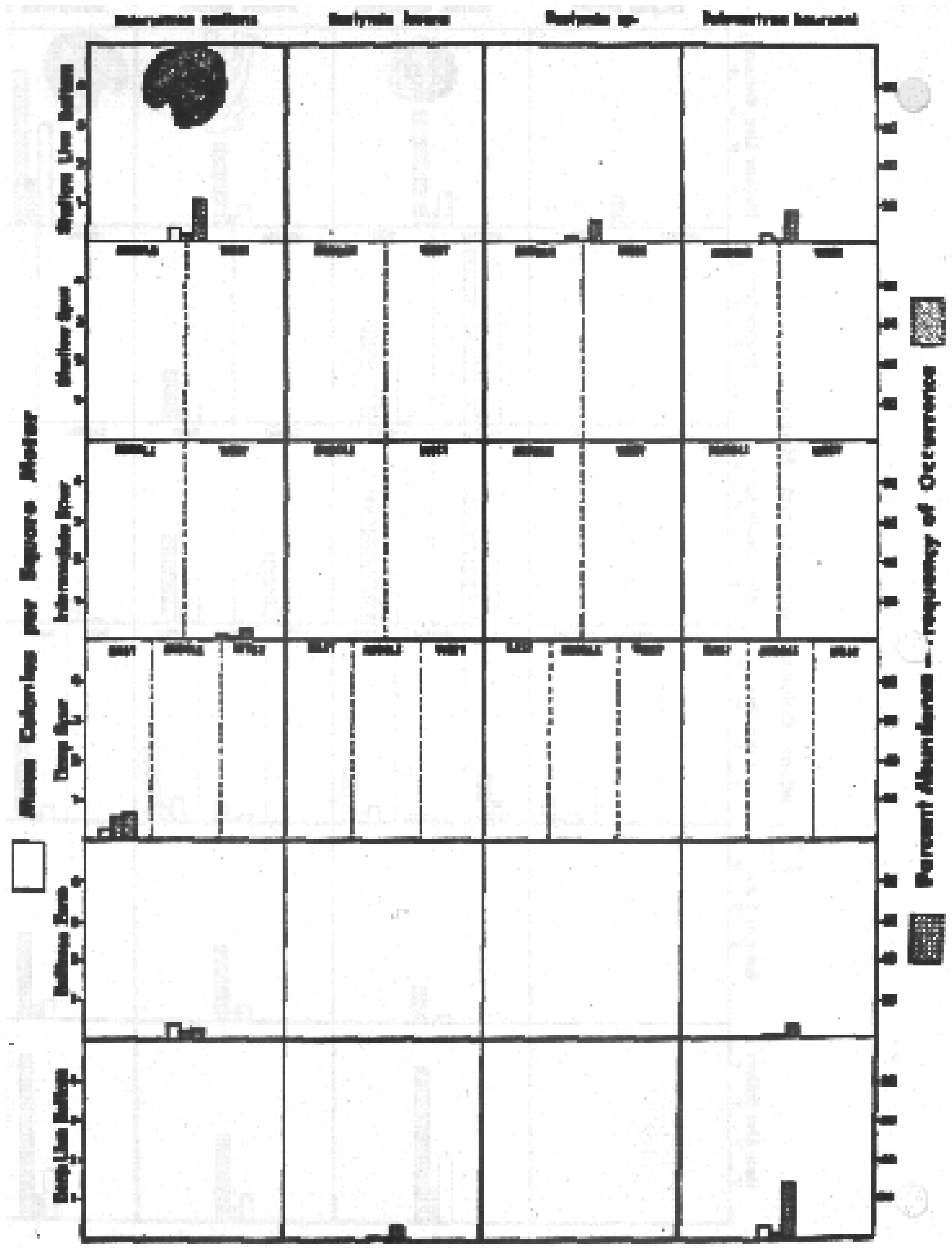
Mean Colonies per Square Meter
Percent Abundance - Frequency of Occurrence

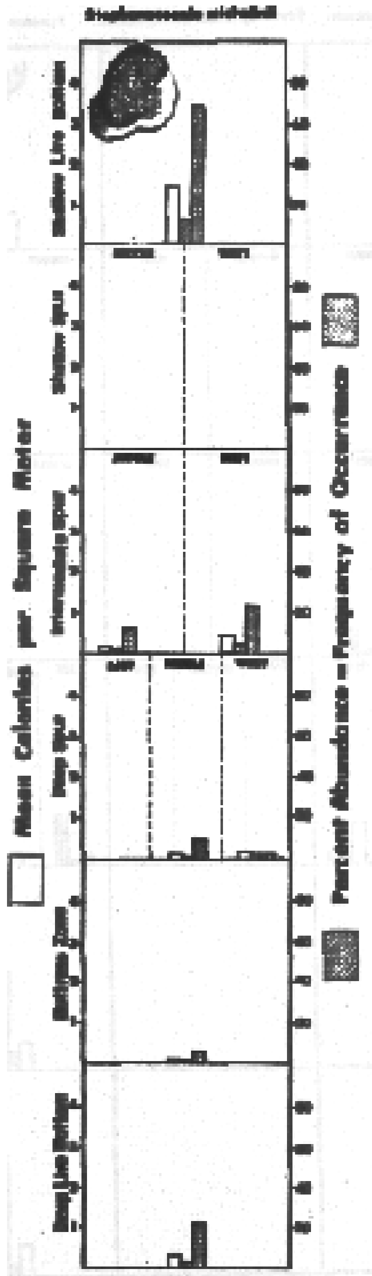

Mean Colonies per Square Meter

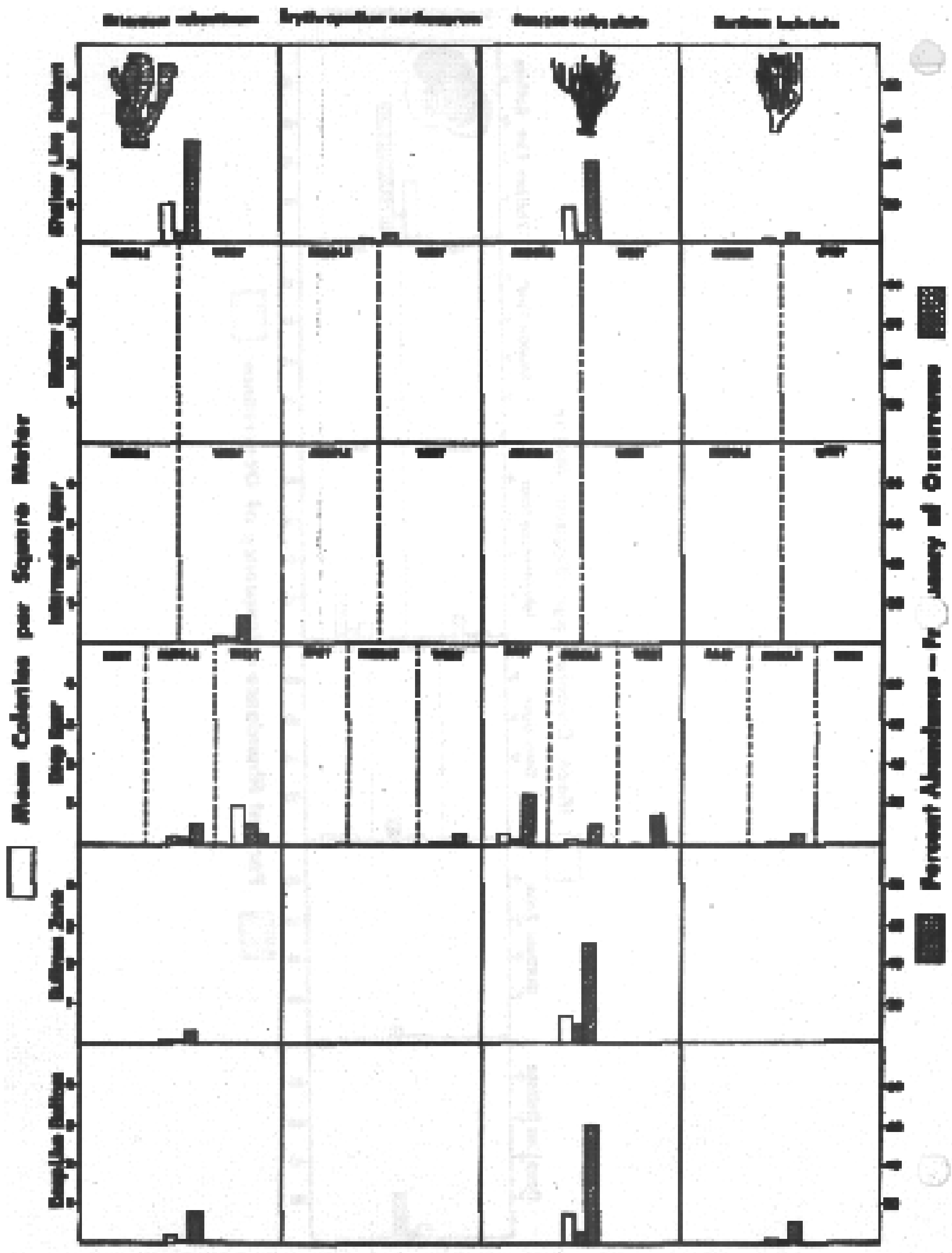

Mean Colonies per Square Meter
Percent Abundance = Frequency of Occurrence

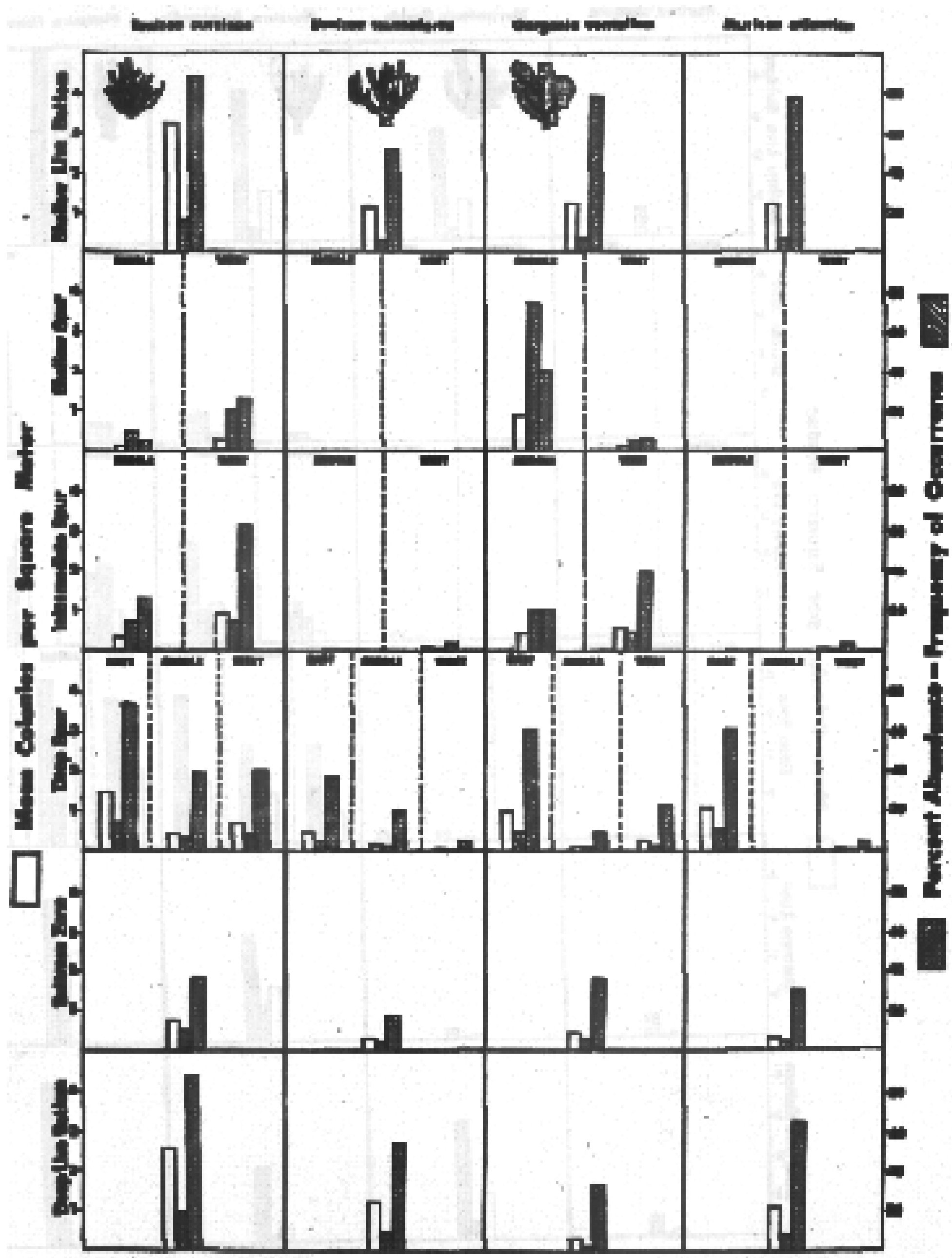

Mean Colonies per Square Meter


Mean Colonies per Square Meter
Percent Abundance – Frequency of Occurrence




Mean Colonies per Square Meter
Percent Abundance - Frequency of Occurrence




Mean Colonies per Square Meter
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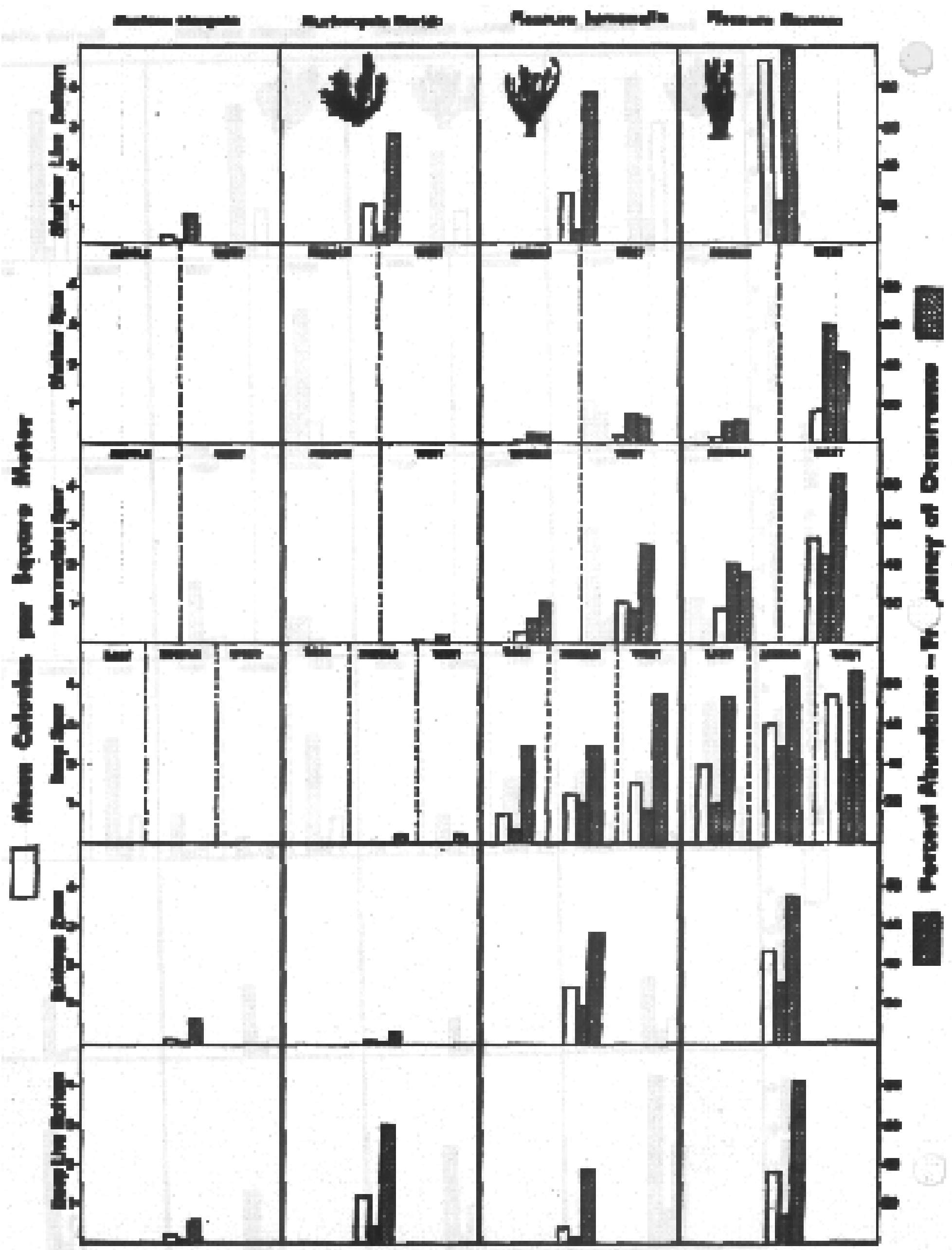

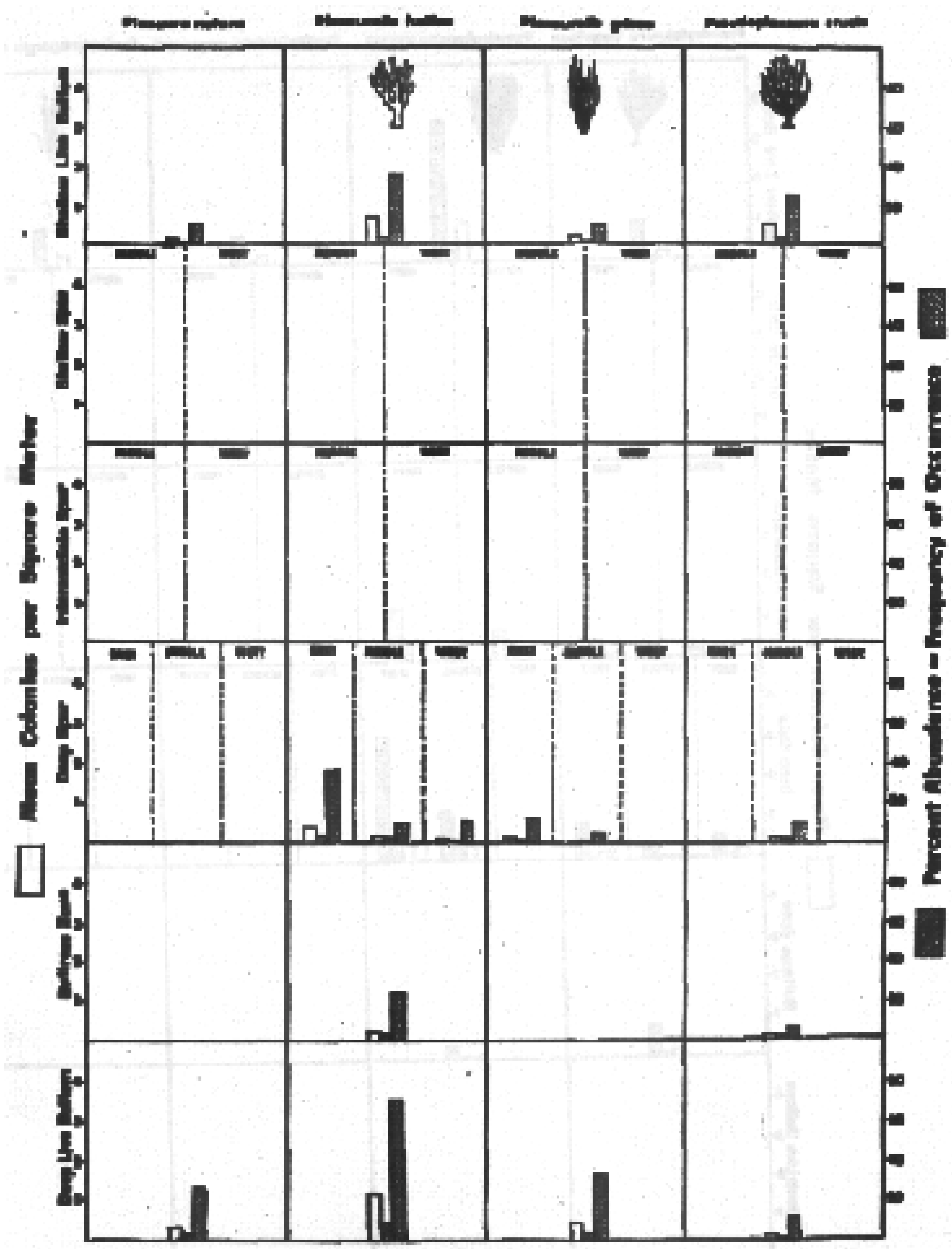
Mean Colonies per Square Meter
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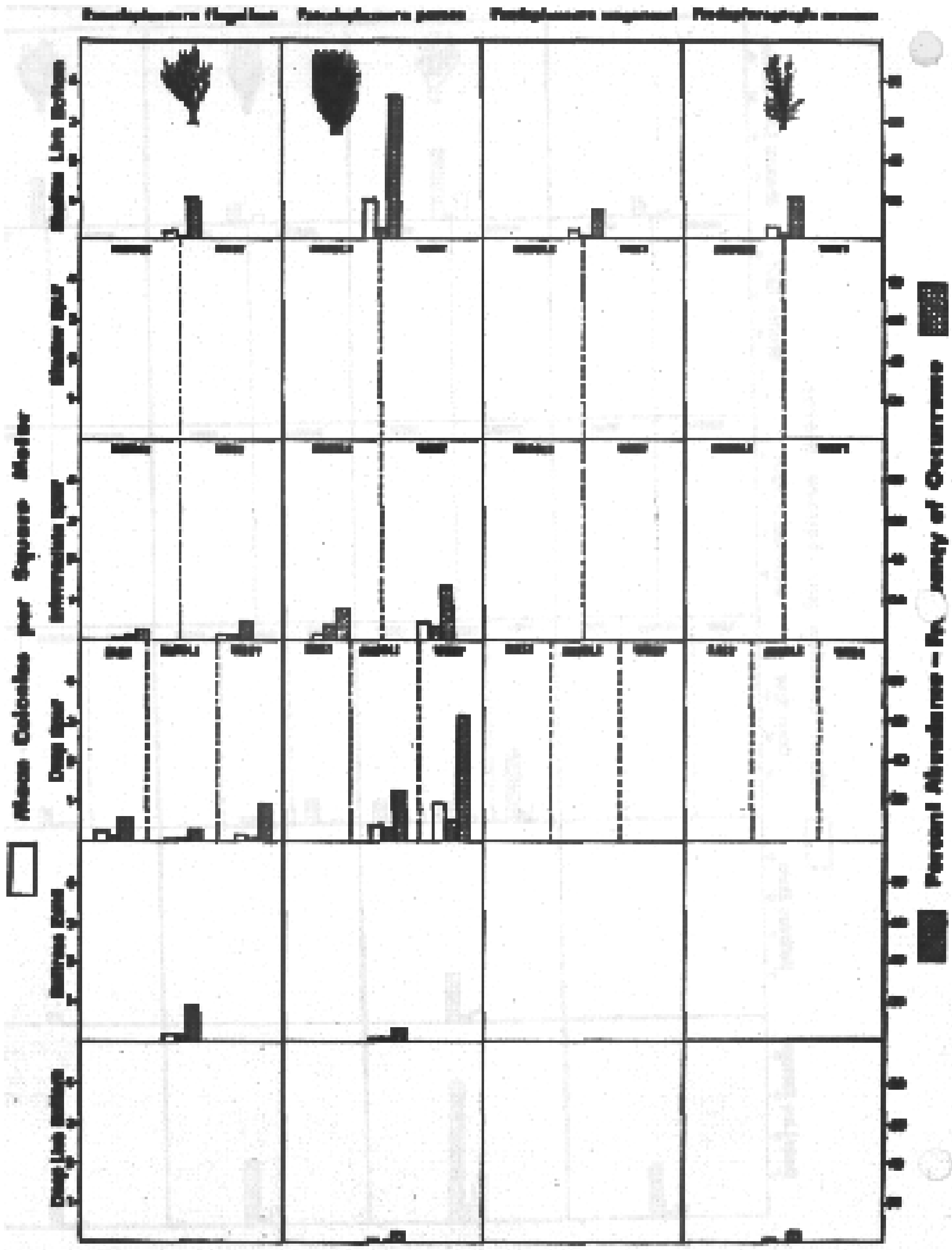

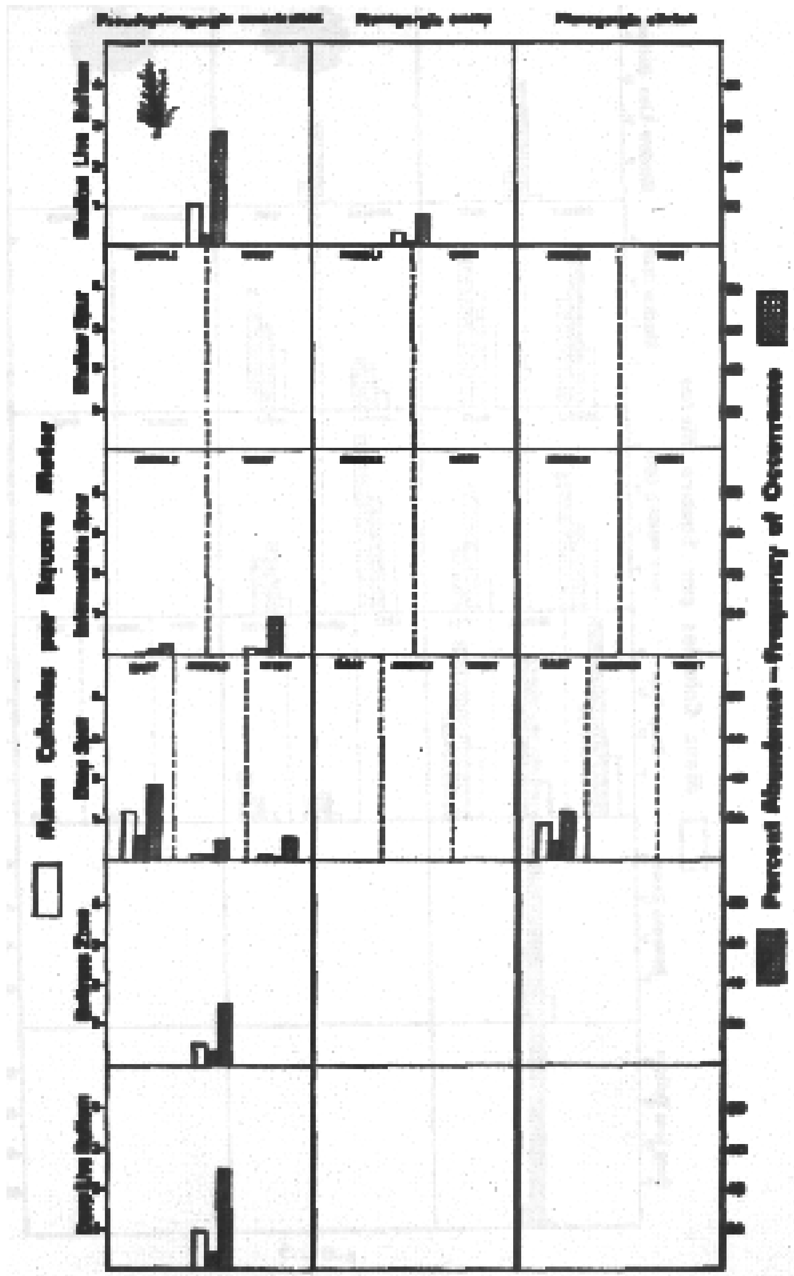

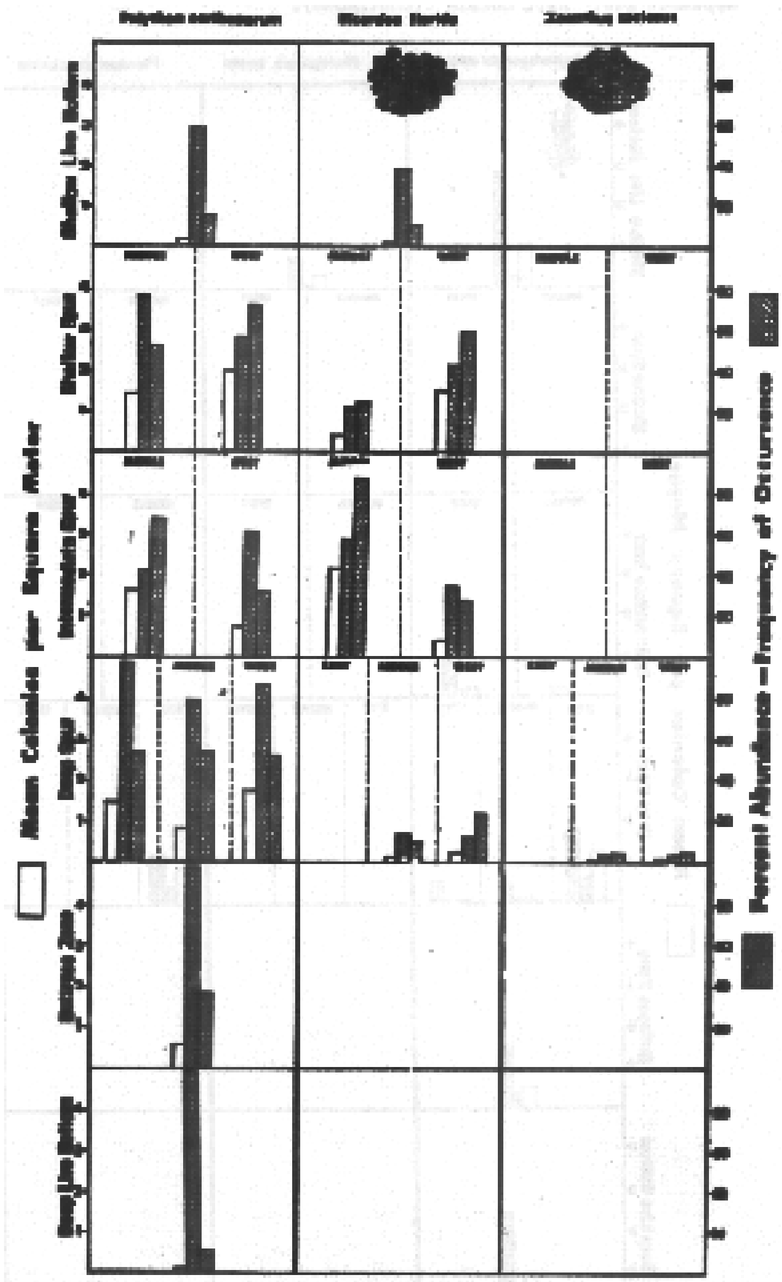

Mean Colonies per Square Meter
Percent Abundance –Frequency of Occurrence

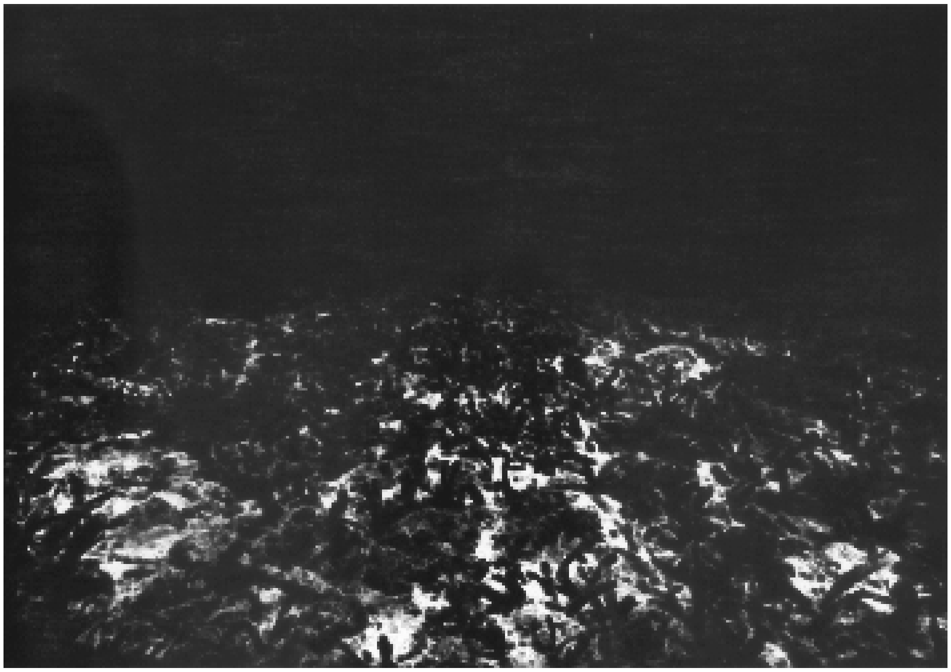

Plate 6.1. Sparse seagrass community inshore of rubble zone, Looe Key, August 1983.

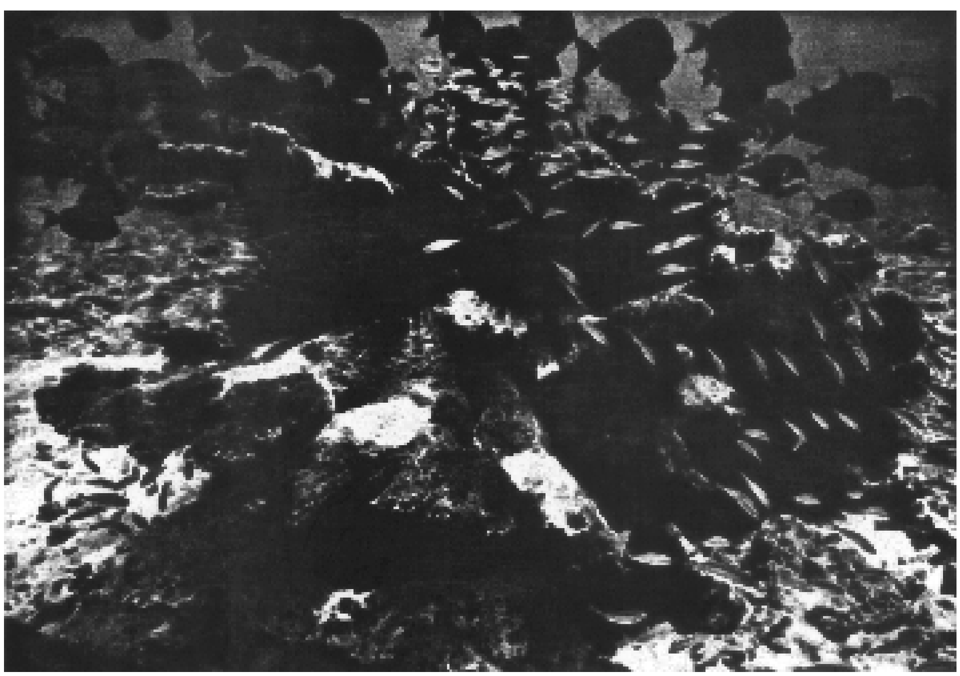

Plate 6.2. Rubble zone, Looe Key, August 1983. *Diadema antillarum* (urchin) sheltered by overturned *Acropora palmata* with hovering reef fish.

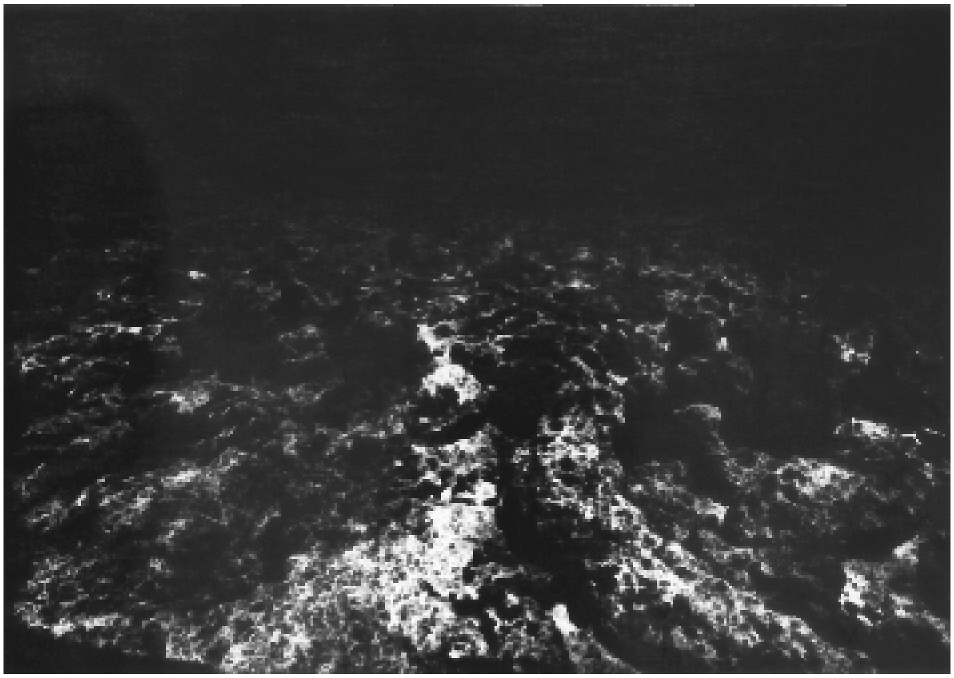

Plate 6.3. *Porite porites* on boulders in rubble zone, Looe Key, August 1983.

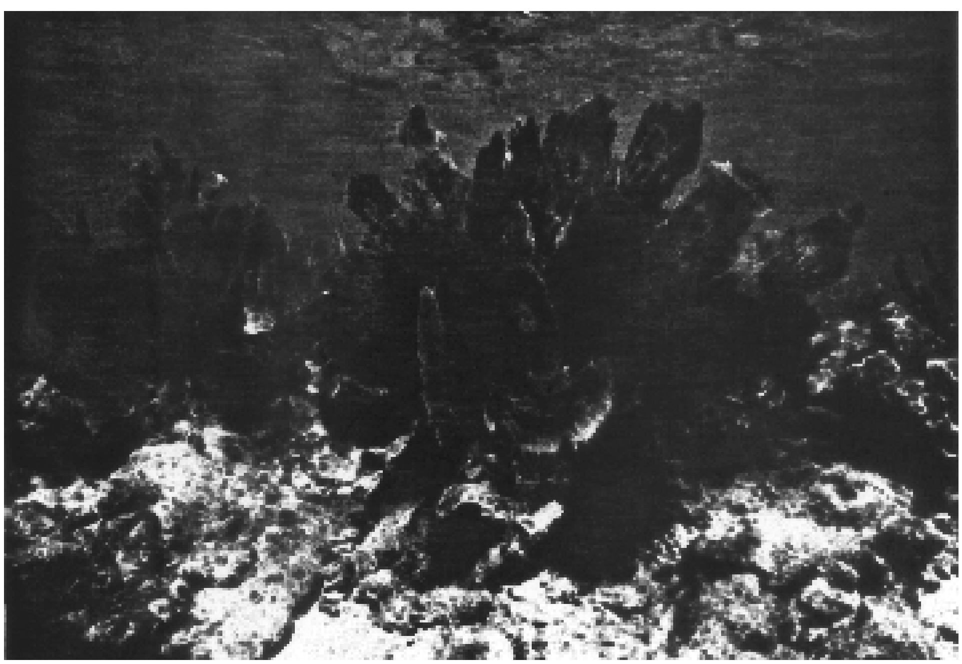

Plate 6.4. *Gorgonia ventalina* (seafan) cluster, rubble zone, Looe Key, August 1983.

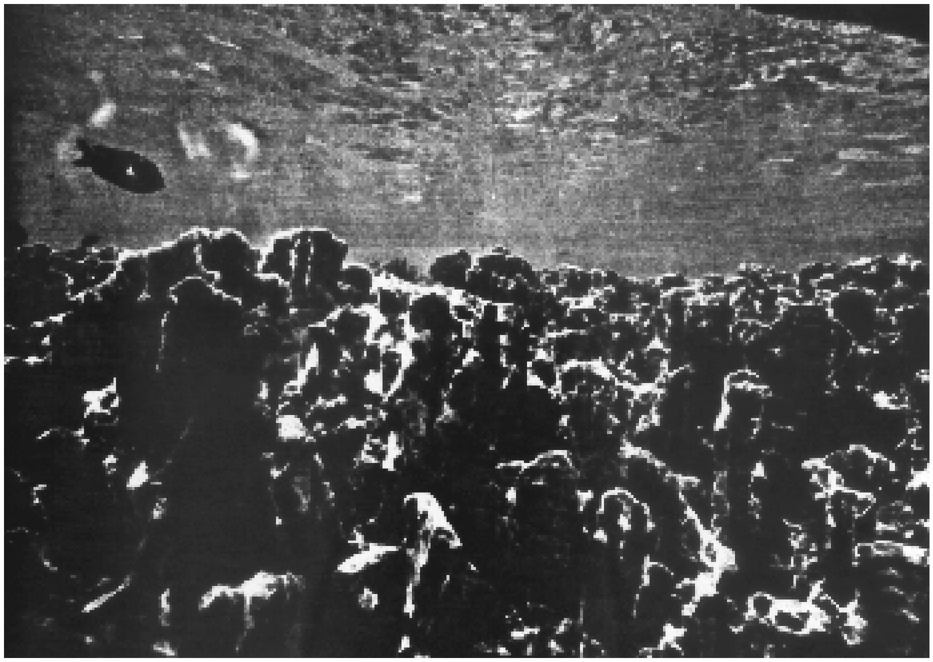

Plate 6.5. *Millepora complanata*, shallow spur and groove, Looe Key, August 1983.

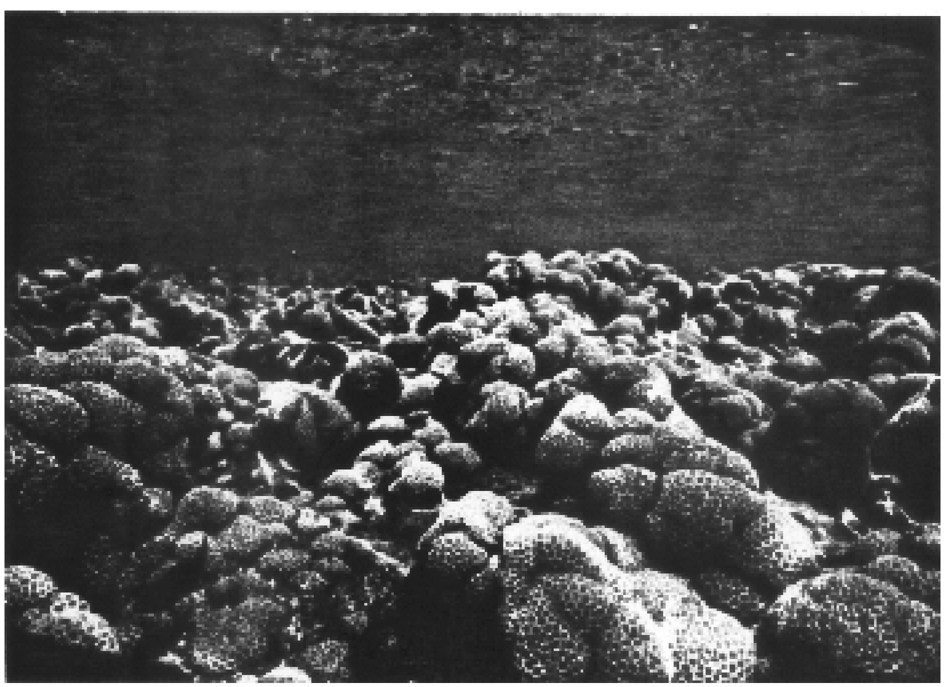

Plate 6.6. *Palythoa caribaerum* (golden sea mat) with *Zoanthus soriatus* (green zoanthid), shallow spur and groove, Looe Key, August 1983.

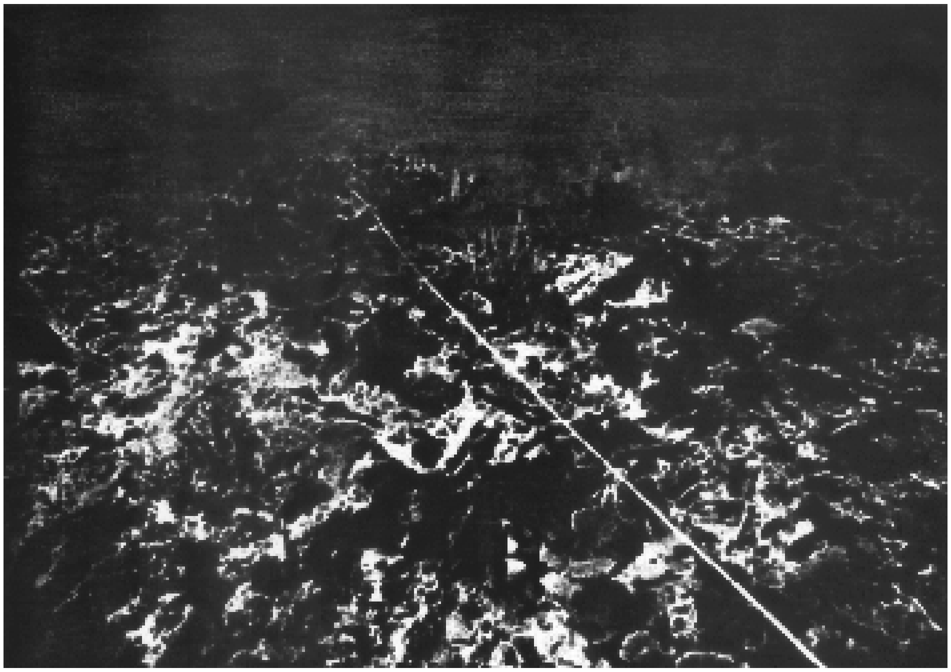

Plate 6.7. Colonies of *Acropora palmata*, top of spur, *Acropora*/transition zone, Looe Key, August 1983.

Plate 6.8. *Agaricea agaricites* (lettuce coral) and *Plexaura homomalla* (lower left), *Acropora*/transition zone, Looe Key, August 1983.

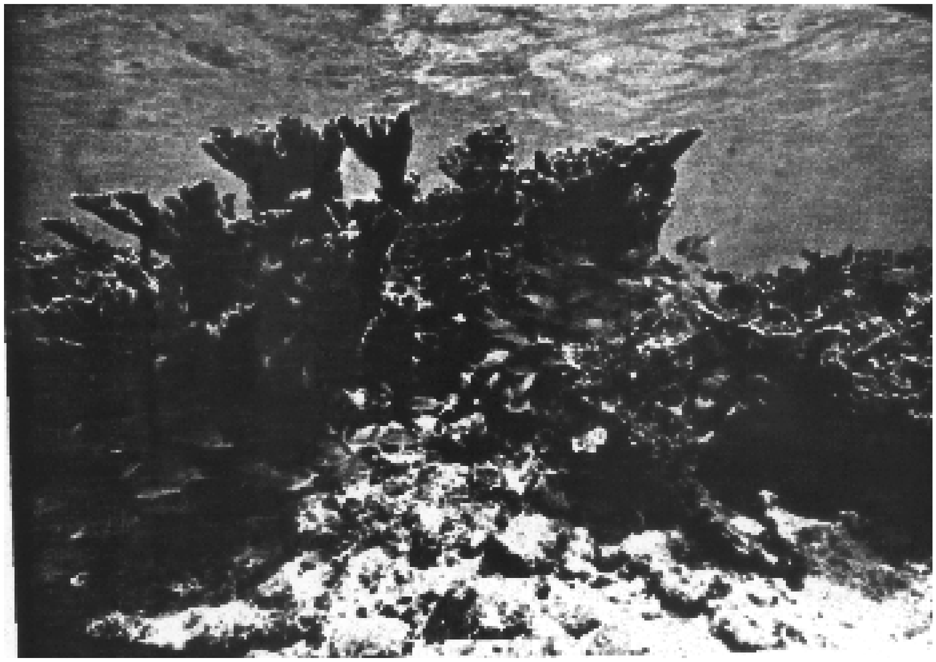

Plate 6.9. Stands of *Acropora palmata* with schools of reef fish, *Acropora*/transition zone, Looe Key, August 1983.

Plate 6.10. *Montastraea*/octocoral zone, deep spur and groove zone, Looe Key, August 1983.

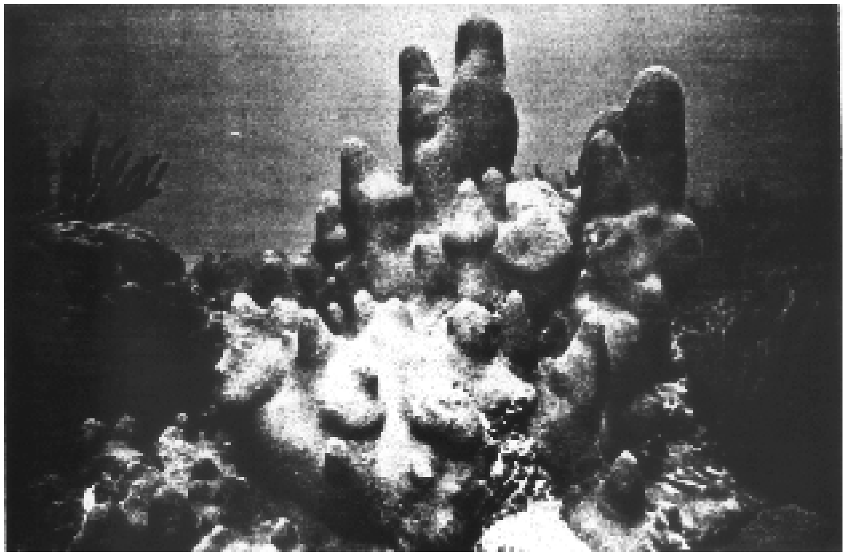

Plate 6.11. *Dendrogyra cylindricus* (pillar coral), *Montastraea*/octocoral zone, Looe Key, August 1983.

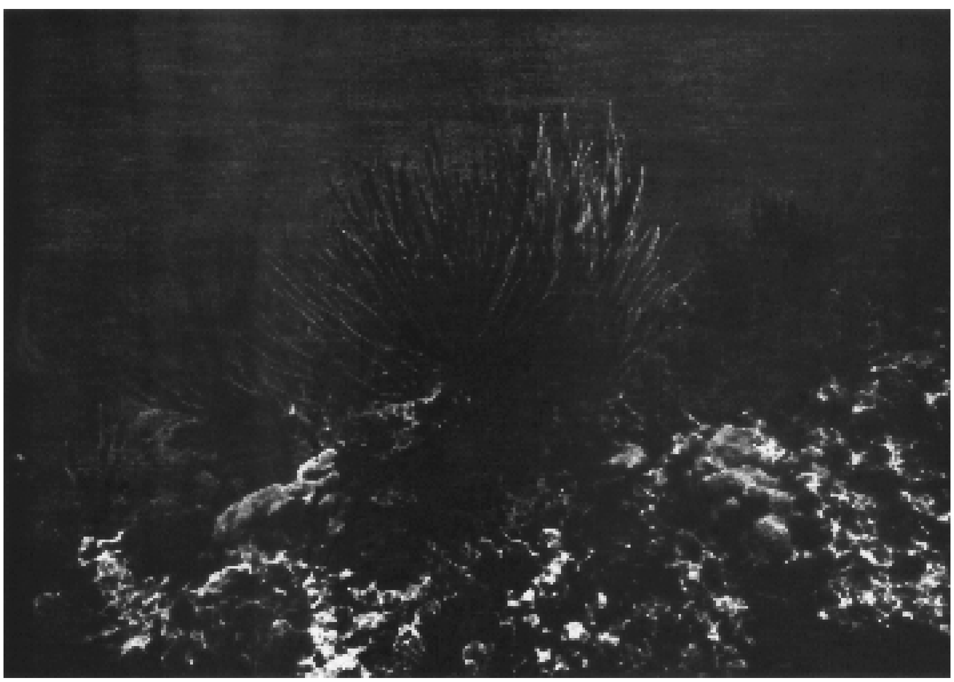

Plate 6.12. *Plexaura* sp., *Montastraea*/octocoral zone, Looe Key, August 1983.

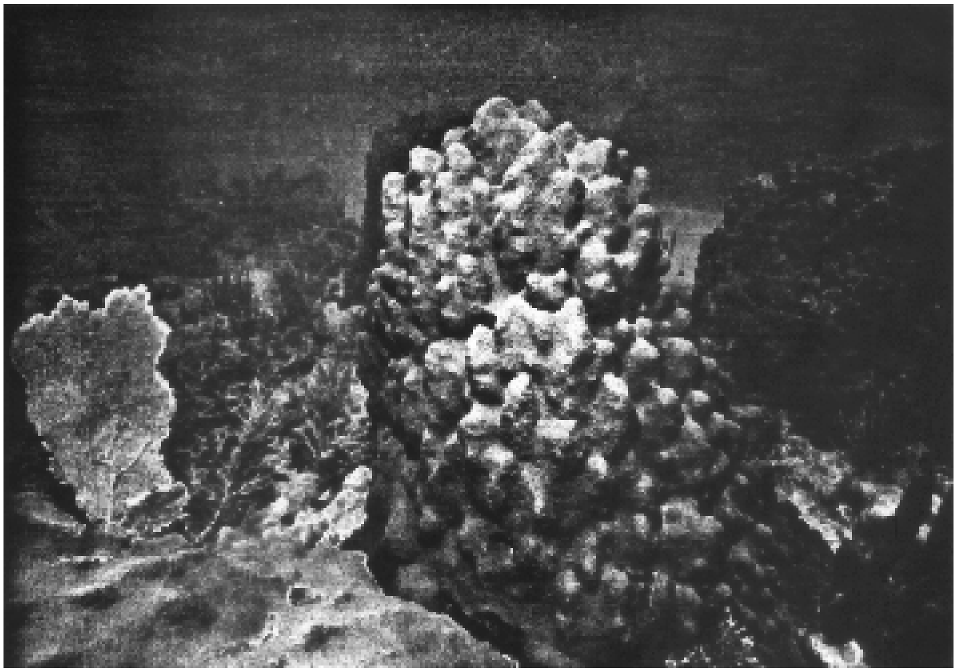

Plate 6.13. *Montastraea annularis, Montastraea*/buttress community, forereef, Looe Key, August 1983.

Plate 6.14. Shallow livebottom community, inshore of main spur and groove, Looe Key, August 1983.

CHAPTER 7

RESOURCE SURVEY OF FISHES WITHIN LOOE KEY NATIONAL MARINE SANCTUARY

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Introduction

Coral reefs have the highest concentration and diversity of fish species found on Earth. Coral reef fishes can be defined as fishes that spend part of their life cycle in close association with coral reefs. Defining a coral reef fish more precisely is probably not a useful scientific endeavor. Starck (1968) divided species into primary and secondary reef fish species depending, respectively, on whether they were closely associated with reef habitats or whether they were more closely associated with some other habitat. In reality, the definition of a coral reef fish is arbitrary because reef fishes are distributed in a continuous gradient ranging from obligate species, almost completely associated with corals, to opportunistic species, whose occurrence on a reef is incidental or accidental. Probably all Caribbean reef fishes spend part of their life cycle away from reefs in the plankton as eggs or larvae.

Coral reefs provide food and shelter for reef fishes (Plate 7.1). Unfortunately, little is known about the dynamics and community structure of coral reef fishes and their microhabitat requirements. Few quantitative studies of reef fish community structure on large reefs are reported (Talbot and Goldman, 1973; Jones and Chase, 1975; Alevizon and Brooks, 1975; Goldman and Talbot, 1976; Gladfelter and Gladfelter, 1978; Smith, 1979; Gladfelter *et al.,* 1980). Most quantitative studies have concentrated on small sections of reef, on sparsely populated reefs, or on small isolated patch reefs or coral heads (Randall, 1963; Risk, 1972; Smith and Tyler, 1972, 1973a, 1973b, 1975; Reese, 1973; Smith, 1973, 1978; Russell *et al.,* 1974; Sale, 1974, 1975, 1976a, 1976b, 1977, 1978; Sale and Dybdahl, 1975, 1978; Nolan, 1975; Luckhurst and Luckhurst, 1977, 1978; Russell *et al.*, 1977; Itzkowitz, 1977; Molles, 1978; Talbot *et al.,* 1978; Bohnsack, 1979). With one exception (Alevizon and Brooks, 1975), no quantitative data exist from large reefs in the Florida Keys except for frequency data (Thompson and Schmidt, 1977; Jones and Thompson, 1978; Bohnsack, 1979; Colton and Alevizon, 1979; Tilmant, 1981; Bannerot and Schmale, 1983). Unfortunately, frequency data have only limited value.

This research was designed to provide quantitative data on reef fish populations in different habitats at Looe Key National Marine Sanctuary (LKNMS), Florida, The intent of this study is to provide a detailed baseline for future comparisons and to provide a better understanding of reef fish distribution and ecology. No studies of reef fish zonation have been published for Caribbean fishes although several studies have been done in the Indo-Pacific region (e.g. Hiatt and Strasburg, 1960; Talbot and Goldman, 1973; Harmelin-Vivien, 1981; and others). Also, the effects of a marine sanctuary on biotic resources, including fishes, has never been documented. Antonius (1978) conducted a qualitative preliminary survey of Looe Key Reef, however, no quantitative data were provided.

Methods

Study area

Looe Key Reef (LKR) is located on the outer reef tract (Lat 24° 33' N and Long 81° 24' W), 12.9 km south of the Newfound Harbor Keys and Big Pine Key, Florida, in the 5.3 nmi^2 Looe Key National Marine Sanctuary (LKNMS). LKR is a large reef with well developed spur and groove formations which provide high vertical relief. The Sanctuary also includes several reef-associated habitats. We divided the Sanctuary into nine habitats for investigation: deep live bottom, deep sand, buttress zone, forereef, rubble zone, lagoon sand, lagoon seagrass beds, shallow sand, seagrass beds, and shallow live bottom. Detailed descriptions of basic habitats were provided in Chapter 3. We decided to separate sand and live bottom habitats into shallow and deep zones because it appeared that depth and location inshore or offshore may have influenced fish composition more that habitat type alone. The lagoon sand and seagrass beds were also treated separately because of their proximity to the main reef and their shallow depth (1 to 3 m). All observations were taken in LKNMS.

Field methods

Reef fishes were censused with SCUBA using a random point visual census method described below. Management considerations required a non-destructive quantitative sampling method that could be repeated without harm to the sanctuary resources. Visual censusing methods were ideal because of the predominately clear waters in the Sanctuary and the ease with which coral reef fishes could be identified. Visual sampling was non-destructive and provided data suitable for statistical treatment. Traditional sampling techniques utilizing ichthyocides, trawls or blasting were not possible or were undesirable because of potential damage to the reefs. Data were collected between 0930 and 1630 hours from May through October 1983 using a team of four divers.

Random point censuses

All observable fishes were censused by a diver standing on the bottom at randomly selected points in each habitat in the Sanctuary. At each point we recorded all species observed in 5 min within an imaginary cylinder extending from the surface to the bottom with an 8 m radius from the observer. Numbers of observed individuals of each species were counted and the mean and range of fork lengths were estimated for each species. A ruler held out perpendicularly at the end of a meter stick aided in making size estimates by reducing apparent magnification errors. Size estimates of large fishes were made relative to the meter stick. Bohnsack (1979) found a significant correlation ($r^2 = 0.99$, $p < 0.01$) between estimated and measured fish lengths.

A rigorous sampling regime was used to avoid bias and prevent counting the same individuals more than once. All sample points were selected using a table of random numbers. Divers began each sample by facing seaward and listing all species within the field of view in the sample radius. When no new species were noted, new sectors were scanned by rotating to the left. New species were listed as observed. This process was continued for five minutes. Several complete rotations usually were made for each sample. Individuals were counted and size estimated immediately for species with few individuals (e.g. pomacanthids, chaetodontids, scarids) or for species not likely to remain in the sample area (e.g. carangids and *Clepticus parrai*). Species that were always present in the sample area (e.g. *Thalassoma bifasciatum* and *Abudefduf saxatilis*) and species not likely to leave the sample area (e.g. damselfishes) were initially listed as observed and counted after the initial five minute sample period. At the end of the initial five minute sample period, divers would make one 360° revolution for each species in the latter two groups, during which data were collected. To avoid bias, divers would always work back up the list counting and measuring each species in reverse order to their initial sighting. This procedure eliminated the bias towards counting species which were particularly noticeable and abundant. With the addition of the last procedure, each point census took approximately 20 min to complete. At each sample point, bottom features were recorded.

Rapid visual samples

A total of 16 rapid visual samples (Thompson and Schmidt, 1977; Jones and Thompson, 1978) were taken to provide comparative data for surveys done at other reefs in southern Florida (Jones and Thompson, 1977; Bannerot and Schmale 1983). In this method divers attempt to find all observable species in 50 minute periods. Each species is given a score from 5 to 1 depending on which sequential 10 min interval the species was first observed. The survey area for this method only included the buttress, forereef, and lagoon areas. The same divers that collected data in the Bannerot and Schmale (1983) study collected 13 of the 16 samples reported here for Looe Key Reef.

Data analysis

Data were computerized and analyzed on a Burroughs 7800 computer system at the Southeast Fisheries Center, National Marine Fisheries Service, Miami, Florida, USA. Means and standard error estimates were calculated for abundance-data and percent frequency of occurrence with 95% confidence intervals were calculated for each species in each habitat zone. Species were then classified according to activity patterns and trophic characteristics based on published literature about the same or similar species (Hiatt and Strasburg, 1960; Starck and Davis, 1966; Randall, 1967; Smith and Tyler, 1972, 1973a, 1973b; Hobson, 1974, 1975; Hobson and Chess, 1976; Gladfelter and Johnson, 1983). We assigned species to trophic categories based on primary items found in the diet of adults (few juvenile fishes were observed for most species). This classification was used to characterize the trophic ecology of the observed reef fish community structure. Activity patterns were classified as diurnal, nocturnal, crepuscular, and generally active day and night. Trophic classifications used were herbivore, planktivore, carnivorous browser, microinvertivore, macroinvertivore, and piscivore. Feeding activity was characterized as being primarily near the bottom, in midwater, or at the surface.

Results

A total of 189 fish species in 48 families (Table 7.1) were observed during censuses in 9 habitat zones (Table 7.2) in LKNMS between 25 May 1983 and 17 September 1983. A total of 165 species (158 in five minute samples and 7 species after five minutes) were observed in 417 point samples and a total of 147 species were observed in 16 rapid visual samples (Jones and Thompson, 1977). To save space, some tables use a code for each species based on the first three letters of the genus and the first four letters of the trivial name. Full names can be identified in an alphabetical species list (Table 7.3). Six families had 8 or more species: Serranidae (14), Scaridae (13), Pomacentridae (12), Haemulidae (12), Labridae (11), and Gobiidae (8).

Random point samples included a total of 73,981 censused individuals. Families that included more than 1% of the observed individuals were Pomacentridae (29%), Labridae (27%), Haemulidae (20%), Gobiidae (6%), Scaridae (5%), Lutjanidae (3%), Acanthuridae (3%), Carangidae (1%), and Chaetodontidae (1%). For each observed species, total observed abundance and frequency of occurrence in all random point samples and the total scores and frequency of occurrence in rapid visual samples are reported (Table 7.3). Random point data are summarized by species and habitat for abundance (Table 7.4) and frequency of occurrence (Table 7.5). Graphical presentations are provided for selected species that were particularly abundant or ecologically important (Appendix 7.A).

All observed species were classified according to trophic level, major periods of feeding activity, and the depth zone in which they normally feed (Table 7.6). From this data a summary of the trophic ecology of observed reef fishes was produced (Table 7.7). Trophic classification of 189 species observed yielded 33 herbivores (14% of all individuals); 31 planktivores (48% of individuals); 14 browsers (2% of individuals); 32 microinvertivores (10% of individuals); 52 macroinvertivores (24% of individuals); and 27 piscivores (2% of individuals). Herbivorous species were dominated by scarids, pomacentrids (i.e. *Pomacentrus*), acanthurids, and kyphosids (Plates 7.2, 7.3, 7.4). Carniverous browsers, dominated by pomacanthids, chaetodontids, ostraciids, and tetradontids (Plate 7.5, 7.7), fed by taking bites out of animals such as sponges, tunicates, and polychaete worms. Microinvertivores (Plate 7.7, 7.8), dominated by clinids, labrids, and smaller serranids, were mostly active during the day. Planktivores were usually found just above the reef in midwater and were dominated by pomacentrids (i.e. *Chromis* and *Abudefduf*) and labrids during the day (Plate 7.6, 7.8) and by apogonids and phompherids (Plate 7.9) at night. Macroinvertivores, dominated by haemulids, holocentrids, mullids, and some lutjanids (Plates 7.10, 7.11, 7.12, 7.13) tended to feed actively at night although some fed at other times (Plate 7.14). Piscivores varied greatly in size (Plates 7.15 to 7.19), were dominated by crepuscularly active species, and included resident, visiting, and transient species. Piscivores were dominated by lutjanids (Plate 7.13, 7,16), muraenids (Plate 7.15), serranids (Plate 7.15, 7.18), carangids (Plate 7.16), sphyraenids (Plate 7.17) and elopids (Plate 7.8), Carcharhinids (requiem sharks), the largest predators known to occur in the sanctuary, tend to be crepuscularly or nocturnally active and were not observed during censuses.

Discussion and conclusions

The 189 total species observed in LKNMS is consistent with other reef fish studies from the Florida Keys based on visual techniques. Jones and Thompson (1978) found a total 165 species (146 species on reefs in Key Largo and 134 species on reefs in the Dry Tortugas). Bannerot and Schmale (1983) recorded a total of 228 species from 18 sites (including non-reef habitats) in Key Largo.

Longley and Hildebrand (1941) reported a total of 440 species of fishes from the Dry Tortugas region of Florida and Starck (1968) reported a total of 517 species of fishes from the Alligator Reef region of the Florida Keys. Only 389 species, however, were associated with reefs of which 253 species were primarily associated with reefs and 134 were more characteristic of other habitats (Starck 1968). Differences in sampling methods explain the greater number of species found by Longley and Hildebrand (1941) and Starck (1968). These two studies were based on sampling for many years in a variety of habitats and used a variety of sampling techniques which collected fishes not easily observed by visual sampling. This study did not sample deeper reef areas which would certainly have added additional species.

Rapid visual census data

Comparison of rapid visual census data with previous studies using the same methods indicates that Looe Key Reef is comparable to other outer reefs in Key Largo, Florida. We found a total of 128 species in each of two independent sets of 8 rapid visual samples at Looe Key Reef (147 species in 16 samples). Jones and Thompson (1989) and Bannerot and Schmale (1983), respectively, reported 120 and 123 species from Molasses Reef, 118 and 126 species from French Reef, and 104 and 131 (n = 12 samples) species from Carysfort Reef in eight rapid visual samples. Elbow Reef had 118 species (Bannerot and Schmale, 1983). The slightly higher number of species reported for Looe Key Reef is not statistically significant ($p > 0.05$). More detailed comparisons were not undertaken for this report because they would not serve any useful purpose. Clearly, the reef fish fauna in LKNMS is well developed and cannot be considered marginal.

This study was not intended to be a comparison of rapid visual censusing with random point sampling methods. Data from the two methods presented in Table 7.3 are not directly comparable because the two methods sampled different habitat zones. Although both methods census similar species, the rapid visual censusing method probably is better at detecting rare and some cryptic and secretive species (e.g., apogonidae). The random point census method, however, is probably better at providing more precise quantitative data on abundance, size, and habitat specificity. Bannerot and Schmale (1983) and DeMartini and Roberts (1982) document and discuss several problems and biases associated with the rapid visual censusing technique.

Random point data

Abundance data reported from random point samples is an index of abundance that probably underestimates the true abundance of most species because some individuals are not likely to be seen from any one vantage point. Thus, calculations of absolute density are inappropriate. However, the data do provide an estimate of relative abundance and should be quantitatively comparable when contrasting similar habitats between reefs or the same locations through time, Bohnsack and Bannerot (in prep) provide further discussion on the random point census technique.

Data presented here provide a static description (or snapshot) of reef fish community structure at LKNMS because they only apply to the time period from May through September 1983, Data presented (Table 7.4 and 7.5) do not show seasonal changes (intrayear) or normal between year (interyear) variation. Natural occurrences such as storms (Kaufman, 1983), epidemic diseases, cold kills (Bohnsack, 1983a; see Plate 7.20), and variations in recruitment can affect reef fish communities. Betweem 18 June and 9 July 1980 one of us (JAB) documented large numbers of fishes killed at Looe Key Reef and other reefs by an unknown disease. Species most effected included pomacanthids, lutjanids, balistids, and holocentrids. Nothing is known about the causes or ecological impacts of such epidemics of reef fishes at Looe Key reef.

Little is known about natural seasonal or yearly dynamic changes in reef fish populations although a major controversy exists regarding the stability of reef fish populations and communities. One group considers reef fish fauna on large reefs essentially stable while another considers the fauna quite variable (e.g. Gladfelter and Gladfelter, 1978; Smith 1978, Gladfelter *et al.,* 1980; Sale, 1980a, 1980b; Ogden and Ebersole, 1981; Williams and Sale, 1981; Bohnsack, 1983b). Results reported here, however, can be used as basis for detecting any future changes, whether from natural or human causes. We should point out that 1983 turned out to be an unusual year for weather because of El Niño conditions that affected much of the world's weather and the Caribbean and Eastern Pacific regions in particular (Canby, 1984). We did not, however, note any unusual phenomena involving reef fishes that could have been directly attributed to unusual weather conditions.

One important result of this survey is the documentation of variation in species occurrence and abundance between different reef habitat zones (Tables 7.4, 7.5 and Appendix 7.A). A reef is an association of several different habitats. Many past studies have reported population values from reefs based on censuses which lumped different habitat zones (Jones and Thompson, 1978; Bannerot and Schmale, 1983). Results presented here suggest that such figures may be misleading without taking into account the relative effort in different zones and the absolute amount of different habitat comprising a reef. Patterns of species distribution between habitat zones over a distance of a couple of km in this study is similar to patterns found along distances well over 100 km in the Great Barrier Reef (Anderson, *et al.,* 1981; Williams, 1982). Each species tends to have its unique patterns of abundance and frequency of occurrence (Appendix 7.A) although there is a clear trend for planktivores to be associated with the forereef zone where plankton resources are abundant and can be easily exploited.

Data for all observed species are presented for future reference purposes. Too often only common, abundant, or economically important species are treated while other species are ignored. However, rare species can be important because they are often more sensitive to environmental changes. Over time rare species can become abundant and showing these changes may be as important as showing declines for abundant species.

Trophic ecology

Average numbers of species and individuals observed per sample (Figure 7.1) show that fishes are closely associated with the presence of reef habitat. Whether this close association with coral habitat is a consequence of availability of food, shelter, or both cannot be ascertained from this study.

We have attempted to examine the trophic ecology of observed reef fishes instead of simply reporting abundance and frequency of occurrence. Our intent is only to show general community patterns, Assigning species into trophic or ecological categories is imprecise and often arbitrary. Most species are food generalists and will eat a wide variety of items available (Randall, 1967; Sale, 1977) (see Plate 7.20). Diets often change greatly depending on habitat and individual size (Starck 1968). Despite these misgivings, trophic and activity analysis provides some insight into the ecology of the reef fish fauna in LKNMS.

Classification of the 189 species observed showed 17% were herbivores, 16% planktivores, and the remaining 67% were carnivores (Table 7.6). Harmelin-Vivien (1981) used a slightly different classification but found similar results from reefs in Madagascar: 9% hervivores, 17% omnivores, and 74% carnivores at some level. Almost half (48%) of the 73,981 censused individuals were planktivorous, 14% were herbivorous, while the remaining 38% were carnivorous at some level (Table 7.7). Only about 2% of the observed individuals could be considered primarily piscivores. Harmelin-Vivien (1981) reviewed reports from other reefs and found similar percentages worldwide. Low percentages of herbivores reported here were also reported by Randall (1963, 1967), Goldman and Talbot (1976), Bakus (1967), and Goldman and Talbot (1976), but not by Odum and Odum (1955).

Other studies have reported an inverse pyramid of biomass for reef fishes from other areas (Bardach, 1959; Randall, 1963; Talbot and Goldman 1973). This study gives a similar pattern although data are not directly comparable because we use number of individuals and these previous studies were based on biomass. Most planktivores are small fishes while predators tend to be larger fishes, so biomass would be skewed more in favor of the top carnivores than numbers of individuals alone reflect.

Activity patterns

Harmelin-Vivien (1981) found 60% of reef fish species sampled in Madagascar were diurnally active, 32% nocturnally active, and 8% active by day and night. We found similar results: 61% diurnal, 34% nocturnal (including 10% primarily creprescular), and only 5% active day and night. Harmelin-Vivien (1981), using explosives and rotenone, found 63.5% of individuals were active during the day. Similarly, using visual methods, we found 73% of the individuals were active during the day. This is surprising similarity considering visual methods are probably greatly biased against detecting nocturnally active species and individuals.

Primary patterns of feeding activity are closely related to trophic structure (Table 7.7). Herbivores and browsers were entirely diurnally and microinvertivores were almost entirely diurnally active. These fishes probably require good light conditions to see their food resources. Planktivorous fishes are divided into diurnally active and nocturnally active species with no overlap. Nocturnally active planktivores have large eyes for nighttime feeding. Macroinvertivores and piscivores have representatives in all classifications of activity, although, most macroinvertivores are nocturnal and most piscivores are creprescular. Most nocturnal macroinvertivores are schooling species that remain in inactive schools on reefs during the day and forage away from the reef at night (Randall, 1965; Ogden and Ehrlich, 1977). This daytime resting behavior is thought to be an adaptation to avoid predation (McFarland *et al.*, 1979). Piscivores have eyes particularly adapted for changing crepuscular light conditions which probably gives them advantages over species that are either diurnally or nocturnally active, All fishes active both day and night are carnivorous as found by Harmelin-Vivien (1981). Most also tend to be large, and thus, may escape predation.

In conclusion, the objective of this investigation was to quantitatively describe reef fish resources in LKNMS using visual methods. This study is the most detailed description of reef fish community structure ever done on a large reef system using nondestructive sampling methods. An index of abundance with standard errors and percent frequency of occurrence with 95% confidence intervals have been provided for observed reef fishes in nine habitat zones. Results demonstrate the usefulness of visual sampling of reef fish populations and provide an insight to reef fish trophic ecology. Results also provide a basis for monitoring and detecting any significant future changes in reef fish distribution or abundance within the Sanctuary. The reef fish fauna at LKNMS is abundant, complex, and similar to reef fish community structure found on well-developed reefs worldwide.

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Table 7.1. Phylogenetic listing of species observed at Looe Key National Marine Sanctuary during surveys. All names used are according to Robins *et al.* (1980). Species codes used elsewhere are derived using the first three letters of the genus and the first four letters of the trivial name.

ORECTOLOBIDAE	Carpet Sharks
Ginglymostoma cirratum	Nurse shark
DASYATIDAE	
Dasyatis americana	Southern stingray
Urolophus jamaicensis	Yellow stingray
MYLIOBATIDAE	Eagle rays
Aetobatus narinari	Spotted eagle ray
ELOPIDAE	Tarpons
Megalops atlanticus	Tarpon
MURAENIDAE	Morays
Enchelycore nigricans	Viper moray
Gymnothorax funebris	Green moray
Gymnothorax moringa	Spotted moray
Muraena miliaris	Goldentail moray
CLUPEIDAE	Herrings
Jenkinsia spp.	Unknown herring
Jenkinsia lamprotaenia	Dwarf herring
ENGRAULIDAE	Anchovies
Anchoa lyolepis	Dusky anchovy
SYNODONTIDAE	Lizardfishes
Synodus intermedius	Sand diver
BELONIDAE	Needlefishes
Strongylura notata	Redfin needlefish
Strongylura timucu	Timucu
Tylosurus crocodilus	Houndfish
ATHERINIDAE	Silversides
Atherinomorus stipes	Hardhead silverside

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HOLOCENTRIDAE	Squirrelfishes
Holocentrus ascensionis	Squirrelfish
Holocentrus coruscus	Reef squirrelfish
Holocentrus rufus	Longspine squirrelfish
Holocentrus vexillarius	Dusky squirrelfish
Myripristis jacobus	Blackbar soldierfish
AULOSTOMIDAE	Trumpetfishes
Aulostomus maculatus	Trumpetfish
SERRANIDAE	Sea Basses
Diplectrum formosum	Sand perch
Epinephelus adscensionis	Rock hind
Epinephelus cruentatus	Graysby
Epinephelus fulvus	Coney
Epinephelus guttatus	Red hind
Epinephelus itajara	Jewfish
Epinephelus morio	Red grouper
Epinephelus striatus	Nassau grouper
Hypoplectrus gemma	Blue hamlet
Hypoplectrus nigricans	Black hamlet
Hypoplectrus puella	Barred hamlet
Hypoplectrus unicolor	Butter hamlet
Mycteroperca bonaci	Black grouper
Paranthias furcifer	Creole-fish
Serranus baldwini	Lantern bass
Serranus tabacarius	Tobaccofish
Serranus tigrinus	Harlequin bass
Serranus tortugarum	Chalk bass
GRAMMISTIDAE	Soapfishes
Rypticus saponaceus	Greater soapfish
PRIACANTHIDAE	Bigeyes
Priacanthus cruentatus	Glasseye snapper
APONGONIDAE	Cardinalfishes
Apogon binotatus	Barred cardinalfish
Apogon maculatus	Flamefish
Apogon pseudomaculatus	Twospot cardinalfish
Apogon quadrisquamatus	Sawcheck cardinalfish

Table 7.1. Phylogenetic listing of species observed at Looe Key National Marine Sanctuary during surveys. All names used are according to Robins *et al.* (1980). Species codes used elsewhere are derived using the first three letters of the genus and the first four letters of the trivial name (cont.).

MALACANTHIDAE	Tilefishes
Malacanthus plumieri	Sand tilefish
ECHENEIDAE	Remoras
Echeneis naucrates	Sharksucker
CARANGIDAE	Jacks
Alectis ciliaris	African pompano
Caranx bartholomaei	Yellow jack
Caranx crysos	Blue runner
Caranx ruber	Bar jack
Decapterus macarellus	Mackerel scad
Decapterus punctatus	Round scad
Seriola dumerili	Greater amberjack
Trachinotus falcatus	Permit
LUTJANIDAE	Snappers
Lutjanus analis	Mutton snapper
Lutjanus apodus	Schoolmaster snapper
Lutjanus griseus	Gray snapper
Lutjanus jocu	Dog snapper
Lutjanus mahogoni	Mahogony snapper
Lutjanus synagris	Lane snapper
Ocyurus chrysurus	Yellowtail snapper
GERREIDAE	Mojarras
Gerres cinereus	Yellowfin mojarra
HAEMULONIDAE	Grunts
Anisotremus surinamenis	Black margate
Anisotremus virginicus	Porkfish
Haemulon album	Margate
Haemulon aurolineatum.	Tomtate
Haemulon carbonarium	Caesar grunt
Haemulon chrysargyreum	Smallmouth grunt
Haemulon flavolineatum	French grunt
Haemulon macrostomum	Spanish grunt
Haemulon melanurum	Cottonwick
Haemulon parra	Sailors choice
Haemulon plumieri	White grunt
Haemulon sciurus	Bluestriped grunt

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INERMIIDAE	Bonnetmouths
Inermia vittata	Boga
SPARIDAE	Porgies
Calamus spp.	Unknown porgy
Calamus bajonado	Jolthead porgy
Calamus calamus	Saucereye porgy
Calamus penna	Sheepshead porgy
Pagrus pagrus	Red porgy
SCIAENIDAE	Drums
Equetus acuminatus	High-hat
Equetus lanceolatus	Jackknife-fish
Equetus punctatus	Spotted drum
Odontoscion dentex	Reef croaker
MULLIDAE	Goatfishes
Mulloidichthys martinicus	Yellow goatfish
Pseudupeneus maculatus	Spotted goatfish
PEMPHERIDAE	Sweepers
Pempheris schomburgki	Glassy sweeper
KYPHOSIDAE	Sea chubs
Kyphosus sectatrix	Bermuda chub
EPHIPPIDAE	Spadefishes
Chaetodipterus faber	Atlantic spadefish
CHAETODONTIDAE	Butterflyfishes
Chaetodon capistratus	Foureye butterflyfish
Chaetodon ocellatus	Spotfin butterflyfish
Chaetodon sedentarius	Reef butterflyfish
Chaetodon striatus	Banded butterflyfish

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POMACANTHIDAE	Angelfishes
Holacanthus bermudensis	Blue angelfish
Holacanthus tricolor	Rock beauty
Holacanthus ciliaris	Queen angelfish
Pomacanthus arcuatus	Gray angelfish
Pomacanthus paru	French angelfish
POMACENTRIDAE	Damselfishes
Abudefduf saxatilis	Sergeant major
Chromis cyaneus	Blue chromis
Chromis insolata	Sunshinefish
Chromis multilineata	Brown chromis
Chromis scotti	Purple reeffish
Microspathodon chrysurus	Yellowtail damselfish
Pomacentrus diencaeus	Longfin damselfish
Pomacentrus fuscus	Dusky damselfish
Pomacentrus leucostictus	Beaugregory
Pomacentrus partitus	Bicolor damselfish
Pomacentrus planifrons	Threespot damselfish
Pomacentrus variabilis	Cocoa damselfish
CIRRHITIDAE	Hawkfishes
Amblycirrhitus pinos	Redspotted hawkfish
LABRIDAE	Wrasses
Bodianus pulchellus	Spotfin hogfish
Bodianus rufus	Spanish hogfish
Clepticus parrai	Creole wrasse
Talichoeres bivattatus	Slippery dick
Halichoeres garnoti	Yellowhead wrasse
Halichoeres maculipinna	Clown wrasse
Halichoeres pictus	Rainbow wrasse
Halichoeres poeyi	Blackear wrasse
Halichoeres radiatus	Puddingwife
Hemipteronotus novacula	Pearly razorfish
Hemipteronotus splendens	Green razorfish
Lachnolaimus maximus	Hogfish
Thalassoma bifasciatum	Bluehead

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SCARIDAE	Parrotfishes
Cryptotomus roseus	Bluelip parrotfish
Scarus coelestinus	Midnight parrotfish
Scarus coeruleus	Blue parrotfish
Scarus croicensis	Striped parrotfish
Scarus guacamaia	Rainbow parrotfish
Scarus taeniopterus	Princess parrotfish
Scarus vetula	Queen parrotfish
Sparisoma aurofrenatum	Redband parrotfish
Sparisoma chrysopterum	Redtail parrotfish
Sparisoma radians	Bucktooth parrotfish
Sparisoma rubripinne	Redfin parrotfish
Sparisoma viride	Stoplight parrotfish
SPHYRAENIDAE	Barracudas
Sphyraena barracuda	Barracuda
OPISTOGNATHIDAE	Jawfishes
Opistognathus aurifrons	Yellowhead jawfish
CLINIDAE	Clinids
Acanthemblemaria spp.	unknown blenny
Acanthemblemaria aspera	Roughhead blenny
Acanthemblemaria chaplini	Papillose blenny
Hemiemblemaria simulus	Wrasse blenny
Malacoctenus gilli	Dusky blenny
Malacoctenus macropus	Rosy blenny
Malacoctenus triangulatus	Saddled blenny
Malacoctenus versicolor	Barfin blenny
Paraclinus nigripinnis	Blackfin blenny
BLENNIIDAE	Combtooth blennies
Hypleurochilus spp.	unknown blenny
Ophioblennius atlanticus	Redlip blenny
Scartella cristata	Molly miller
GALLIONYMIDAE	Dragonets
Callionymus bairdi	Lancer dragonet

Table 7.1. Phylogenetic listing of species observed at Looe Key National Marine Sanctuary during surveys. All names used are according to Robins *et al.* (1980). Species codes used elsewhere are derived using the first three letters of the genus and the first four letters of the trivial name (cont.).

GOBIIDAE	Gobies
Coryphopterus dicrus	Colon goby
Coryphopterus glaucofraenum	Bridled goby
Coryphopterus personatus	Masked goby
Coryphopterus sp.	unidentified goby
Gnatholepis thompsoni	Goldspot goby
Gobiosoma macrodon	Tiger goby
Gobiosoma oceanops	Neon goby
Ioglossus calliurus	Blue goby
Microgobius carri	Seminole goby
ACANTHURIDAE	Surgeonfishes
Acanthurus bahianus	Ocean surgeon
Acanthurus chirurgus	Doctorfish
Acanthurus coeruleus	Blue tang
SCOMBRIDAE	Mackerels/Tunas
Scomberomorus cavalla	King mackerel
Scomberomorus maculatus	Spanish mackerel
Scomberomorus regalis	Cero
SCORPAENIDAE	Scorpionfishes
Scorpaena plumieri	Spotted scorpionfish
BALISTIDAE	Triggerfishes/Filefishes
Aluterus schoepfi	Orange filefish
Aluterus scriptus	Scrawled filefish
Balistes capriscus	Gray triggerfish
Balistes vetula	Queen triggerfish
Cantherhines macrocerus	Whitespotted filefish
Cantherhines pullus	Orangespotted filefish
Canthidermis sufflamen	Ocean triggerfish
Monacanthus tuckeri	Slender filefish
OSTRACIIDAE	Trunkfishes
Lactophrys bicaudalis	Spotted trunkfish
Lactophrys polygonia	Honeycomb cowfish
Lactophrys quadricornis	Scrawled cowfish
Lactophrys triqueter	Smooth trunkfish

Table 7.1. Phylogenetic listing of species observed at Looe Key National Marine Sanctuary during surveys. All names used are according to Robins *et al.* (1980). Species codes used elsewhere are derived using the first three letters of the genus and the first four letters of the trivial name (cont.).

TETRADONTIDAE	Puffers
Canthigaster rostrata	Sharpnose puffer
Sphoeroides spengleri	Bandtail puffer
DIODONTIDAE	Porcupinefishes
Diodon hystrix	Balloonfish
Diodon holocanthus	Porcupinefish

Table 7.2. Distribution of numbers of species by family at Looe Key Reef based on censuses of 73,981 individuals.

FAMILY COMMON NAME	TOTAL SPECIES	PERCENT OF TOTAL INDIV.	DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	SPUR & GROOVE	LAGOON RUBBLE	LAGOON GRASSES	LAGOON SAND	GRASS FLATS	SHALLOW SAND	SHALOW LIVE BOTTOM
ACANTHURIDAE (Surgeonfishes)	3	2.55	3	2	3	3	3	1	2	2	2	3
APOGONIDAE (cardinalfishes)	1	0.00									1	
ATHERINIDAE (silversides)	*	-										
AULOSTOMIDAE (trumpetfishes)	1	0.04			1	1	1					1
BALISTIDAE (leatherjackets)	7	0.06			3	6	3			1	1	3
BELONIDAE (needlefishes)	2	0.00				1	1		1			
BLENNIIDAE (combtooth blennies)	2	0.09		2		1	2		1	1	1	1
CALLIONYMIDAE (dragonets)	*	-										
CARANGIDAE (jacks)	6	1.30	2	2	3	3	1	2	1	1	5	2
CHAETODONTIDAE (butterflyfishes)	4	1.12	4		4	4	3		1	2		4
CIRRHITIDAE (hawkfishes)	1	0.00	1			1						
CLINIDAE (clinids)	6	0.02		2		1	4					1
CLUPEIDAE (herrings)	*	-										
DASYATIDAE (stingrays)	1	0.01	1							1	1	1
DIDONTIDAE (porcupinefishes)	2	0.00	1			1						
ECHENEIDAE (remoras)	1	0.01	1		1	1						
ELOPIDAE (tarpons)	1	0.00				1						
ENGRAULIDAE (anchovies)	*	-										
EPHIPPIDAE (spadefishes)	1	0.00			1							
GERREIDAE (mojarras)	1	0.92					1					
GOBIIDAE (gobies)	8	6.31	5	4	6	6	5	1	1	5	2	6
GRAMMIDAE (bassists)	*	-										
GRAMMISTIDAE (soapfishes)	*	-										
HAEMULIDAE (grunts)	12	19.86	3	4	7	12	9	5	4	5	5	3
HOLOCENTRIDAE (squirrelfishes)	3	0.05			1	2	1					
INERMIIDAE (bometmouths)	1	0.48				1					1	1
KYPHOSIDAE (sea chubs)	1	0.55			1	1	1					

Table 7.2. Distribution of numbers of species by family at Looe Key Reef based on censuses of 73,981 individuals (cont.).

FAMILY COMMON NAME	TOTAL SPECIES	PERCENT OF TOTAL INDIV.	DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	SPUR & GROOVE	LAGOON RUBBLE	LAGOON GRASSES	LAGOON SAND	GRASS FLATS	SHALLOW SAND	SHALOW LIVE BOTTOM
LABRIDAE (wrasses)	11	26.94	6	8	8	11	9	7	8	8	8	8
LUTJANIDAE (snappers)	7	3.02	1	2	4	6	4	1	2		2	1
MALACANTHIDAE (tilefishes)	1	0.01		1	1	1						
MULLLIDAE (goatfishes)	2	0.57	1	1	2	2	2				1	1
MURAENIDAE (morays)	2	0.01				1	1					
MYLIOBATIDAE (eagle rays)	*	-										
OPISTOGNATHIDAE (jewfishes)	1	0.06		1		1	1			1	1	1
ORECTOLOBIDAE (carpet sharks)	1	0.00					1					
OSTRACIIDAE (boxfishes)	3	0.01	1			2				1		
PEMPHERIDAE (boxfishes)	1	0.67			1	1	1					
POMACANTHIDAE (angelfishes)	5	0.38	5	1	4	5	3				1	5
POMACENTRIDAE (damelfishes)	12	28.95	8	3	9	12	7		7	4	4	6
PRIACANTHIDAE (bigeyes)	1	0.01				1	1				1	
SCARIDAE (parrotfishes)	13	4.77	7	4	10	10	10	3	6	6	8	8
SCIAENIDAE (drums)	3	0.13	1		2	3	1					1
SCOMBRIDAE (mackerels)	3	0.01	1			2					1	
SERRANIDAE (we basses)	14	0.60	7	3	6	9	5		3	3	4	6
SPARIDAE (porgies)	5 Δ	0.18	1	1	2	2				2	2	3
SPHYRAENIDAE (barracudas)	1	0.14	1	1	1	1	1	1		1	1	1
SYNODONTIDAE (lizardfisties)	1	0.00				1				1		
TETRAODONTIDAE (puffers)	2	0.07	2		1	3	1					1

* Observed only in samples using the rapid visual technique.
Δ Includes one unidentified individual as a separate species.

Table 7.3. Alphabetical listing of fishes observed in Looe Key National Marine Sanctuary during visual surveys using the Bohnsack and Bannerot (1983) Random Point Visual Technique (RPT) and the Jones and Thompson (1977) Rapid Visual Technique (J-T). The J-T technique only surveyed major reef areas including buttress, forereef and rubble zones. The RPT surveyed all habitats although effort varied between habitats. Dashes indicate that species was not observed by that technique. * indicates that the species was observed during point samples but after the initial 5 minute sample period and thus no abundance estimate data were recorded.

SCIENTIFIC NAME	COMMON NAME	RAPID VISUAL SAMPLES		RANDOM POINT SAMPLES	
		FREQUENCY	SCORE	FREQUENCY	TOTAL ABUNDANCE
Maximum Value		16	60	417	N/A
Abudefduf saxatilis	Sergeant major	16	80	185	6799
Acanthemblemaria chaplini	Papillose blenny	4	14	1	5
Acanthemblemaria spp.	Unidentified blenny	6	20		
Acanthurus bahianus	Ocean surgeon	16	80	265	1231
Acanthurus chirurgus	Doctorfish	11	34	53	97
Acanthurus coeruleus	Blue tang	16	77	189	561
Aetobatus narinari	Spotted eagle ray	1	1		
Alectis ciliaris	African pompano	1	4		
Aluterus schoepfi	Orange filefish	2	7	4	6
Aluterus scriptus	Scrawled filefish	7	18	7	7
Amblycirrhitus pinos	Redspotted hawkfish	9	35	2	2
Anchoa lyolepis	Dusky anchovy	1	1		
Anisotremus surinamenis	Black margate	2	9	1	1
Anisotremus virginicus	Porkfish	12	42	20	28
Apogon binotatus	Barred cardinalfish	3	7		
Apogon maculatus	Flamefish	8	24		
Apogon pseudomaculatus	Twospot cardinalfish	3	8	1	2
Apogon quadrisquamatus	Sawcheek cardinalfish	1	1		
Atherinomorus stipes	Hardhead silverside	1	3		
Aulostomus maculatus	Trumpetfish	14	44	23	27
Balistes capriscus	Gray triggerfish	-		3	4
Balistes vetula	Queen triggerfish	-		2	2
Bodianus pulchellus	Spotfin hogfish	1	3		
Bodianus rufus	Spanish hogfish	16	77	129	218
Calamus sp.	Unidentified porgy	1	4	1	1
Calamus bajonado	Jolthead porgy	4	14	27	35
Calamus calamus	Saucereye porgy	7	27	65	94
Calamus penna	Sheepshead porgy	-		2	3
Callionymus bairdi	Lancer dragonet	3	9		
Cantherhines macrocerus	Whitespotted filefish	3	15		
Cantherhines pullus	Orangespotted filefish	9	28	15	17
Canthidermis sufflamen	Ocean triggerfish	1	1	6	7
Canthigaster rostrata	Sharpnose puffer	16	72	42	53
Caranx bartholomaei	Yellow jack	4	14	18	48
Caranx crysos	Blue runner	-		1	28
Caranx ruber	Bar jack	14	65	93	661

Table 7.3. Alphabetical listing of fishes observed in Looe Key National Marine Sactuary during visual surveys using the Bohnsack and Bannerot (1983) Random Point Visual Technique (RPT) and the Jones and Thompson (1977) Rapid Visual Technique (J-T). The J-T technique only surveyed major reef areas including buttress, forereef and rubble zones. The RPT surveyed all habitats although effort varied between habitats. Dashes indicate that species was not observed by that technique. * indicates that the species was observed during point samples but after the initial 5 minute sample period and thus no abundance estimate data were recorded (cont.).

SCIENTIFIC NAME	COMMON NAME	RAPID VISUAL SAMPLES		RANDOM POINT SAMPLES	
		FREQUENCY	SCORE	FREQUENCY	TOTAL ABUNDANCE
Chaetodipterus faber	Atlantic spadefish			1	1
Chaetodon capistratus	Foureye butterflyfish	16	80	206	555
Chaetodon ocellatus	Spotfin butterflyfish	13	49	90	162
Chaetodon sedentarius	Reef butterflyfish	2	7	12	18
Chaetodon striatus	Banded butterflyfish	11	35	53	92
Chromis cyaneus	Blue chromis	15	74	107	324
Chromis insolata	Sunshinefish	-		1	1
Chromis multilineata	Brown chromis	13	53	59	892
Chromis scotti	Purple reeffish	6	19	12	47
Clepticus parrai	Creole wrasse	15	54	14	274
Coryphopterus dicrus	Colon goby	9	32	45	111
Coryphopterus glaucofraenum	Bridled goby	13	55	119	623
Coryphopterus personatus	Masked goby	12	50	69	3611
Coryphopterus sp.	Unidentified goby	-		*	*
Cryptotomus roseus	Bluelip parrotfish	-		8	22
Dasyatis americana	Southern stingray	1	1		
Decapterus macarellus	Mackerel scad	-		1	70
Decapterus punctatus	Round scad	-		1	150
Diodon holocanthus	Balloonfish	2	4	1	1
Diodon hystrix	Porcupinefish	3	7	1	1
Diplectrum formosum	Sand perch	-		13	59
Echeneis naucrates	Sharksucker	5	13	6	6
Enchelycore nigricans	Viper moray	-		*	*
Epinephelus adscensionis	Rock hind	1	1		
Epinephelus cruentatus	Graysby	15	71	114	133
Epinephelus fulvus	Coney	1	5		
Epinephelus guttatus	Red hind	1	2		
Epinephelus itajara	Jewfish	1	1		
Epinephelus morio	Red grouper			1	1
Epinephelus striatus	Nassau grouper	5	20	2	2
Equetus acuminatus	High-hat	3	9	7	7
Equetus lanceolatus	Jacknife-fish	1	5		
Equetus punctatus	Spotted drum	3	7	1	1
Fry	Unidentified species	-		1	15
Gerres cinereus	Yellowfin mojarra	-		6	681
Ginglymostoma cirratum	Nurse shark	-		1	1

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SCIENTIFIC NAME	COMMON NAME	RAPID VISUAL SAMPLES		RANDOM POINT SAMPLES	
		FREQUENCY	SCORE	FREQUENCY	TOTAL ABUNDANCE
Gnatholepis thompsoni	Goldspot goby	16	68	39	108
Gobiosoma macrodon	Tiger goby	-		1	3
Gobiosoma oceanops	Neon goby	16	75	60	132
Gymnothorax funebris	Green moray	5	22	2	2
Gymnothorax moringa	Spotted moray	-			
Haemulon album	Margate	-		9	49
Haemulon aurolineatum	Tomitate	16	80	138	10842
Haemalon carbonarium	Caesar grunt	16	51	23	355
Haemulon chrysargyreum	Smallmouth grunt	14	49	21	877
Haemulon flavolineatum	French grunt	16	79	175	714
Haemulon macrostomum	Spanish grunt	9	31	40	90
Haemulon melanurum	Cottonwick	1	5	8	22
Haemulon parrai	Sailor's choice	9	32	11	62
Haemulon plumieri	White grunt	15	70	163	1122
Haemulon sciurus	Bluestriped grunt	15	65	111	542
Halichoeres bivittatus	Slippery dick	15	67	258	3590
Halichoeres garnoti	Yellowhead wrasse	16	80	251	1110
Halichoeres maculipinna	Clown wrasse	16	74	246	1512
Halichoeres pictus	Rainbow wrasse	1	1		
Halichoeres poeyi	Blackear wrasse	-		40	119
Halichoeres radiatus	Puddingwife	16	71	123	252
Hemiemblemaria simulus	Wrasse blenny	-		1	1
Hemipteronotus novacula	Pearly razorfish	1	4	2	2
Hemipteronotus splendens	Green razorfish	1	1	49	267
Holacanthus bermudensis	Blue angelfish	8	29	17	18
Holacanthus ciliaris	Queen angelfish	10	27	23	23
Holacanthus tricolor	Rock beauty	13	61	58	77
Holocentrus ascensionis	Squirrelfish	10	40	6	7
Holocentrus coruscus	Reef squirrelfish	1	4		
Holocentrus rufus	Longspine squirrelfish	14	51	20	32
Holocentrus vexillarius	Dusky squirrelfish	6	19	1	1
Hypleurochilus spp.	unidentified blenny	1	5		
Hypoplectrus gemma $^{\Delta}$	Blue hamlet	2	6	16	18
Hypoplectrus nigricans $^{\Delta}$	Black hamlet	-		1	1
Hypoplectrus unicolor	Butter hamlet	2	5	31	38
Hypoplectrus puella $^{\Delta}$	Barred hamlet	-		3	3
Ioglossus calliurus	Blue goby	-		15	75

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SCIENTIFIC NAME	COMMON NAME	RAPID VISUAL SAMPLES		RANDOM POINT SAMPLES	
		FREQUENCY	SCORE	FREQUENCY	TOTAL ABUNDANCE
Inermia vittata	Boga	2	6	6	352
Jenkinsia lamprotaenia	Dwarf herring	3	11		
Jenkinsia spp.		1	4		
Kyphosus sectatrix	Bermuda chub	13	44	39	407
Lachnolaimus maximus	Hogfish	12	43	70	98
Lactophrys bicaudalis	Spotted trunkfish	1	5	2	2
Lactophrys polygonia	Honeycomb cowfish	1	4		
Lactophrys quadricornis	Scrawled cowfish	2	7		
Lactophrys triqueter	Smooth trunkfish	9	32	5	5
Liopropoma rubre	Peppermint bass	3	8		
Lutjanus analis	Mutton snapper	1	1	6	6
Lutjanus apodus	Schoolmaster snapper	16	68	42	206
Lutjanus griseus	Gray snapper	11	44	29	157
Lutjanus jocu	Dog snapper	2	8	1	1
Lutjanus mahogoni	Mahogany snapper	3	6	3	9
Lutjanus synagris	Lane snapper	4	19	17	254
Malacanthus plumieri	Sand tilefish	2	6	7	10
Malacoctenus gilli	Dusky blenny	1	4	2	6
Malacoctenus macropus	Rosy blenny	4	10	1	1
Malacoctenus triangulatus	Saddled blenny	5	21	5	5
Malacoctenus versicolor	Barfin blenny	-		*	*
Megalops atlanticus	Tarpon	5	21	2	2
Microgobius carri	Seminole goby	-		3	5
Microspathodon chrysurus	Yellowtail damselfish	16	79	180	974
Monacanthus tuckeri	Slender filefish	-		3	4
Mulloidichthys martinicus	Yellow goatfish	16	73	53	346
Muraena miliaris	Goldentail moray	2	10	2	2
Mycteroperca bonaci	Black grouper	10	28	9	9
Myripristis jacobus	Blackbar soldierfish	1	3		
Ocyurus chrysurus	Yellowtail snapper	16	80	259	1602
Odontoscion dentex	Reef croaker	16	67	37	87
Opistognathus atlanticus	Redlip blenny	13	39	19	38
Opistognathus aurifrons	Yellowhead jawfish	2	9	17	43
Opistognathus maxillosus	Mottled jawfish	-			
Paranthias furcifer	Creole-fish	-		2	2
Paraclinus nigripinnis	Blackfin blenny	-		1	1
Pagrus pagrus	Red Porgy	-		1	1

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SCIENTIFIC NAME	COMMON NAME	RAPID VISUAL SAMPLES		RANDOM POINT SAMPLES	
		FREQUENCY	SCORE	FREQUENCY	TOTAL ABUNDANCE
Pempheris schomburgki	Glassy sweeper	15	62	15	493
Pomacanthus arcuatus	Gray angelfish	11	47	96	121
Pomacanthus paru	French angelfish	10	40	35	45
Pomacentrus diencaeus	Longfin damselfish	9	33	21	109
Pomacentrus fuscus	Dusky damselfish	10	30	82	692
Pomacentrus leucostictus	Beaugregory	3	11	46	132
Pomacentrus partitus	Bicolor damselfish	16	80	322	10021
Pomacentrus planifrons	Three spot damselfish	14	69	152	1257
Pomacentrus variabilis	Cocoa damselfish	9	29	61	166
Priacanthus cruentatus	Glasseye snapper	9	22	6	6
Pseudupeneus maculatus	Spotted goatfish	11	37	36	78
Rypticus saponaceus	Greater soapfish	2	5		
Scartella cristata	Molly miller	3	6	12	20
Scarus coelestinus	Midnight parrotfish	12	34	14	51
Scarus coeruleus	Blue parrotfish	12	44	30	61
Scarus croicensis	Striped parrotfish	16	74	212	1645
Scarus guacamaia	Rainbow parrotfish	7	23	15	20
Scarus taeniopterus	Princess parrotfish	4	6	84	215
Scarus vetula	Queen parrotfish	14	54	34	57
Scomberomorus cavalla	King mackerel	-		1	1
Scomberomorus maculatus	Spanish mackerel	-		1	1
Scomberomorus regalis	Cero mackerel	3			3
Scorpaena plumieri	Scorpion fish	1	1		
Seriola dumerili	Greater amberjack	-		*	*
Serranus baldwini	Lanternfish	6	16	8	11
Serranus tabacarius	Tobaccofish	-		*	*
Serranus tigrinus	Harlequin bass	15	62	113	185
Serranus tortugarum	Chalk bass	-		2	2
Sparisoma atomarium	Greenblotch parrotfish	-		3	7
Sparisoma aurofrenatum	Redband parrotfish	15	69	160	441
Sparisoma chrysopterum	Redtail parrotfish	3	14	84	190
Sparisoma radians	Bucktooth parrotfish	1	5	43	246
Sparisoma rubripinne	Yellowtail parrotfish	15	65	76	200
Sparisoma viride	Stoplight parrotfish	16	76	167	386
Sphoeroides spengleri	Bandtail puffer	-		1	1
Sphyraena barracuda	Barracuda	15	63	69	107
Strongylura notata	Redfin needlefish	-		*	*

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SCIENTIFIC NAME	COMMON NAME	RAPID VISUAL SAMPLES		RANDOM POINT SAMPLES	
		FREQUENCY	SCORE	FREQUENCY	TOTAL ABUNDANCE
Strongylura timucu	Timucu	-		1	1
Synodus intermedius	Inshore lizardfish	4	7	2	2
Thalassoma bifasciatum	Bluehead wrasse	16	80	328	12484
Trachinotus falcatus	Permit	3	10	6	8
Tylosurus crocodilus	Houndfish	-		3	3
Urolophus jamaicensis	Yellow stingray	-		9	9

- Observed only during random point samples.

∆ Now considered color Forms of H. unicolor (American Fisheries Society, 1980).

Table 7.4. Mean abundance (± standard error) of selected species in different habitats at Looe Key National Marine Sanctuary. Unidentified species are deleted. "*" distribution plotted in Appendix 7.A.

					HABITAT					
SPECIES CODE	DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	FORE-REEF ZONE	LAGOON RUBBLE	LAGOON GRASS	LAGOON SAND	SHALLOW SAND	GRASS FLATS	SHALLOW LIVE BOTTOM
N	18	9	34	160	37	16	11	35	41	56
ABU SAXA*	0	0.56	22.38	32.20	21.50	5.20	0	0	0.02	0.18
	-	(0.29)	(7.87)	(4.10)	(7.40)	(3.30)	-	-	(0.02)	(0.18)
ACA CHAP	0	0	0	0	0.14	0	0	0	0	0
	-	-	-	-	(0.14)	-	-	-	-	-
ACA BAHI*	1.67	1.67	2.38	3.08	10.16	0.19	4.36	1.66	0.46	1.95
	(0.24)	(0.60)	(0.33)	(0.49)	(1.61)	(0.14)	(1.65)	(0.48)	(0.20)	(0.31)
ACA CHIR*	0.17	0	0.15	0.24	0.11	0	0	0	0.05	0.79
	(0.12)	-	(0.15)	(0.05)	(0.08)	-	-	-	(0.05)	(0.24)
ACA COER*	0.67	0.33	1.12	1.61	3.68	0	1.45	0.03	0	1.64
	(0.20)	(0.24)	(0.27)	(0.21)	(0.83)	-	(0.62)	(0.03)	-	(0.77)
ALU SCHO	0	0	0	0.01	0	0	0	0	0	0.07
	-	-	-	(0.11)	0	0	-	-	-	(0.06)
ALU SCRI	0	0	0	0.04	0	0	0	0	0	0.02
	-	-	-	(0.02)	-	-	-	-	-	(0.02)
AMB PINO	0.06	0	0	0.01	0	0	0	0	0	0
	(0.06)	-	-	(0.01)	-	-	-	-	-	-
ANI SURI	0	0	0.29	0.11	0	0	0	0	0	0
	-	-	(0.11)	(0.04)	-	-	-	-	-	-
ANI VIRG	0	0	0.29	0.11	0	0	0	0	0	0
	-	-	(0.11)	(0.04)	-	-	-	-	-	-
APO PSEU	0	0	0	0	0	0	0	0	0.15	0
	-	-	-	-	-	-	-	-	(0.15)	-
AUL MACU	0	0	0.18	0.12	0	0	0	0	0	0.02
	-	-	(0.09)	(0.03)	-	-	-	-	-	(0.02)
BAL CAPR	0	0	0.18	0.01	0.03	0	0	0	0	0
	-	-	(0.09)	(0.01)	(0.03)	-	-	-	-	-
BAL VETU	0	0	0	0	0	0	0	0.06	0	0
	-	-	-	-	-	-	-	(0.04)	-	-
800 RUFU*	0.22	0	1.06	0.99	0.32	0	0	0	0	0.07
	(0.10)	-	(0.16)	(0.09)	(0.10)	-	-	-	-	(0.04)
CAL BAJO*	0	0	0.29	0.14	0	0	0	0	0	0.04
	-	-	(0.11)	(0.03)	-	-	-	-	-	(0.03)

Table 7.4. Mean abundance (± standard error) of selected species in different habitats at Looe Key National Marine Sanctuary. Unidentified species are deleted. "*" distribution plotted in Appendix 7.A (cont.).

	HABITAT									
SPECIES CODE	DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	FORE-REEF ZONE	LAGOON RUBBLE	LAGOON GRASS	LAGOON SAND	SHALLOW SAND	GRASS FLATS	SHALLOW LIVE BOTTOM
CAL CALA	0.44 (0.17)	0.11 (0.11)	0.27 (0.08)	0.08 (0.03)	0 -	0 -	0 -	0.37 (0.24)	0.10 (0.07)	0.71 (0.10)
CAL PENA	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0.05 (0.05)	0 -
CAN PULL	0 -	0 -	0.03 (0.03)	0.08 (0.03)	0.05 (0.23)	0 -	0 -	0 -	0.02 (0.02)	0 -
CAN SUFF	0 -	0 -	0.03 (0.03)	0.03 (0.02)	0.03 (0.03)	0 -	0 -	0 -	0 -	0 -
CAN ROST	0.39 (0.12)	0 -	0.18 (0.12)	0.17 (0.04)	0.03 (0.03)	0 -	0 -	0 -	0 -	0.21 (0.06)
CAR BART*	0.11 (0.08)	1.56 (1.31)	0.29 (0.29)	0.14 (0.10)	0 -	0.25 (0.19)	0 -	0 -	0.49 (0.03)	0.05 (0.54)
CAR CRYS	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0.68 (0.68)	0 -
CAR RUBR*	0.06 (0.06)	1.67 (1.67)	2.03 (1.18)	0.32 (0.69)	0.32 (0.13)	0.31 (0.18)	0.18 (0.12)	2.54 (1.51)	0.10 (0.05)	0.20 (0.10)
CHA FABE	0. -	0 -	0.03 (0.03)	0 -	0 -	0 -	0 -	0 -	0 -	0 -
CHA CAPI*	3.00 (1.24)	0 -	2.18 (0.25)	1.62 (0.12)	0.84 (0.20)	0 -	0.27 (0.27)	0 -	0 -	2.38 (0.30)
CHA OCEL	4.44 (0.19)	0 -	0.74 (0.14)	0.49 (0.90)	0.16 (0.08)	0 -	0 -	0.06 (0.04)	0 -	0.75 (0.17)
CHA SEDE	0.50 (0.20)	0 -	0.03 (0.03)	0.02 (0.01)	0 -	0 -	0 -	0.03 (0.03)	0 -	0.07 (0.04)
CHA STRI	0.50 (0.26)	0 -	0.27 (0.12)	0.37 (0.06)	0 -	0 -	0 -	0 -	0 -	0.13 (0.06)
CHR CYAN*	3.22 (0.73)	0 -	1.26 (0.39)	1.33 (0.15)	0 -	0 -	0 -	0 -	0 -	0.18 (0.09)
CHR INSO	0 -	0 -	0 -	0.01 (0.01)	0 -	0 -	0 -	0 -	0 -	0 -
CHR MULT*	0.56 (0.35)	0 -	3.03 (1.57)	4.90 (1.40)	0 -	0 -	0 -	0 -	0 -	0 -
CHR SCOT	0.06 (0.06)	0 -	0.50 (0.28)	0.18 (0.14)	0 -	0 -	0 -	0 -	0 -	0 -

Table 7.4. Mean abundance (± standard error) of selected species in different habitats at Looe Key National Marine Sanctuary. Unidentified species are deleted. "*" distribution plotted in Appendix 7.A (cont.).

	HABITAT									
SPECIES CODE	DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	FORE-REEF ZONE	LAGOON RUBBLE	LAGOON GRASS	LAGOON SAND	SHALLOW SAND	GRASS FLATS	SHALLOW LIVE BOTTOM
CLE PARR*	0	0	5.00	0.61	0	0	0	0	0	0
	-	-	(3.70)	(0.30)	-	-	-	-	-	-
COR DICR*	0.67	0.11	0.09	0.23	0.38	0	0	0.29	0	0.79
	(0.39)	(0.11)	(0.07)	(0.06)	(0.22)	0	0	(0.29)	-	(0.29)
COR GLAU*	8.50	0.89	2.82	1.14	0.68	0.06	0.09	0.37	0.32	2.32
	(2.10)	(0.56)	(0.92)	(0.19)	(0.28)	(0.06)	(0.09)	(0.15)	(0.27)	(0.48)
COR PERS*	50.20	0	2.94	14.60	0	0	0	0	0	4.10
	(14.60)	-	(1.35)	(6.10)	-	-	-	-	-	(1.30)
CRY ROSE	0	0.22	0	0	0	0	0	0.06	0.44	0
	-	(0.22)	-	-	-	-	-	(0.06)	(0.26)	-
DEC MACA	0	0	0	0	0	0	0	0	1.70	0
	-	-	-	-	-	-	-	-	(1.70)	-
DEC PUNC	0	0	0	0	0	0	0	0	3.70	0
	-	-	-	-	-	-	-	-	(3.70)	-
DID HOLD	0.06	0	0	0	0	0	0	0	0	0
	(0.06)	-	-	-	-	-	-	-	-	
DID HYST	0	0	0	0.01	0	0	0	0	0	0
	-	-	-	(0.01)	-	-	-	-	-	-
DIP FORM	0	0.11	0	0.10	0	0	0	0.43	0.49	0
	-	(0.11)	-	(0.10)	-	-	-	(0.18)	(0.27)	-
ECH NAUC	0.06	0	0	0.02	0.05	0	0	0	0	0
	(0.06)	-	-	(0.01)	(0.04)	-	-	-	-	-
EPI CRUE*	0.78	0	0.53	0.51	0.11	0	(0.09	0	0	0.25
	(0.21)	-	(0.10)	(0.06)	(0.05)	-	(0.09)	0	0	(0.06)
EPI GUTT	0	0	0	0.01	0	0	0	0	0	0
	-	-	-	(0.01)	-	-	-	-	-	-
EPI MORI	0	0	0	0	0	0	0	0	0	0.02
	-	-	-	-	-	-	-	-	-	(0.02)
EPI STRI	0	0	0.03	0	0	0	0	0	0	0.02
	-	-	(0.03)	-	-	-	-	-	-	(0.02)
EQU ACUM	0.11	0	0.03	0.01	0	0	0	0	0	0.05
	(0.08)	-	(0.03)	(0.01)	-	-	-	-	-	(0.03)
EQU PUNC	0	0	0	0.01	0	0	0	0	0	0
	-	-	-	(0.01)	-	-	-	-	-	-

Table 7.4. Mean abundance (± standard error) of selected species in different habitats at Looe Key National Marine Sanctuary. Unidentified species are deleted. "*" distribution plotted in Appendix 7.A (cont.).

	HABITAT									
SPECIES CODE	DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	FORE-REEF ZONE	LAGOON RUBBLE	LAGOON GRASS	LAGOON SAND	SHALLOW SAND	GRASS FLATS	SHALLOW LIVE BOTTOM
GER CINE	0	0	0	0	18.40	0	0	0	0	0
	-	-	-	-	(8.10)	-	-	-	-	-
GIN CIRR	0	0	0	0	0.03	0	0	0	0	0
	-	-	-	-	(0.03)	-	-	-	-	-
GNA THOM	0.17	0.67	0.09	0.36	0.62	0	0	0.03	0	0.25
	(0.12)	(0.37)	(0.07)	(0.09)	(0.29)	-	-	(0.03)	-	(0.12)
GOB MACR	0	0	0	0	0.08	0	0	0	0	0
	-	-			(0.08)	-	-	-	-	-
GOB OCEA	0.94	0	0.50	0.39	0.08	0	0	0	0	0.59
	(0.37)	-	(0.24)	(0.08)	(0.06)	-	-	-	-	(0.31)
GYM MORI	0	0	0	0	0.03	0	0	0	0	0.02
	-	-	-	-	(0.03)	-	-	-	-	(0.02)
HAE ALBU	0	0.89	0	0.17	0.14	0	0	0.23	0.02	0
	-	(0.68)	-	(0.16)	(0.08)	-	-	(0.16)	(0.02)	-
HAE AURO*	2.78	0.76	87.97	34.03	2.32	1.81	1.64	61.02	1.98	0
	(2.78)	(0.36)	(19.00)	(5.70)	(1.18)	(1.44)	(1.35)	(21.00)	(1.55)	-
HAE CARB	0	0	0.03	2.20	0.03	0	0	0	0	0
	-	-	(0.03)	(1.50)	(0.03)	-	-	-	-	-
HAE CHRY*	0	0	0	2.89	11.20	0	0	0	0	0
	-	-	-	(1.00)	(8.80)	-	-	-	-	-
HAE FLAV*	1.50	0	1.62	1.60	7.30	0.13	5.50	0.29	0	0.37
	(0.99)	-	(0.19)	(0.15)	(2.80)	(0.13)	(5.10)	(0.29)	-	(0.15)
HAE MACR	0	0	0	0.35	0.33	0.70	0	0	0	0
	-	-	-	(0.11)	(0.09)	(0.70)	-	-	-	-
HAE MELA	0	0.89	0	0.01	0	0	0	0.23	0.07	0
		(0.68)	-	(0.01)	-	-	-	(0.23)	(0.05)	-
HAE PARR	0	0	0	0.33	0.11	0.06	0	0	0.10	0
	-	-	-	(0.20)	(0.05)	(0.06)	-	-	(0.10)	-
HAE PLUM*	0.67	1.22	0.76	0.85	3.90	0.88	0.36	2.80	5.19	8.25
	(0.21)	(0.52)	(0.25)	(0.21)	(1.70)	(0.36)	(0.15)	(1.53)	(2.70)	(2.30)
HAE SCIU*	0	0	1.29	1.86	2.65	0.13	0	0	0	1.73
	-	-	(0.29)	(0.46)	(1.25)	(0.13)	-	-	-	(0.68)
HAL BIVI*	0.50	18.00	2.44	3.88	36.50	13.70	10.27	9.86	13.00	2.80
	(0.25)	(4.60)	(0.77)	(0.75)	(4.80)	(4.00)	(2.55)	(1.45)	(3.30)	(0.60)
HAL GARN*	4.28	1.56	3.97	3.98	1.32	0.06	0.27	0.47	0.98	3.29
	(0.95)	(0.88)	(0.61)	(0.34)	(0.41)	(0.06)	(0.27)	(0.19)	(0.06)	(0.48)

Table 7.4. Mean abundance (± standard error) of selected species in different habitats at Looe Key National Marine Sanctuary. Unidentified species are deleted. "*" distribution plotted in Appendix 7.A (cont.).

	HABITAT									
SPECIES CODE	DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	FORE-REEF ZONE	LAGOON RUBBLE	LAGOON GRASS	LAGOON SAND	SHALLOW SAND	GRASS FLATS	SHALLOW LIVE BOTTOM
HAL MACU*	1.56 (0.36)	3.89 (1.20)	2.91 (0.61)	4.58 (0.64)	8.62 (1.35)	0.09 (0.09)	0.55 (0.31)	2.57 (1.04)	2.12 (0.80)	2.04 (0.40)
HAL POEY	0 -	2.11 (1.05)	0 -	0.01 (0.01)	0.41 (0.21)	0.62 (0.27)	0.27 (0.20)	0.31 (0.15)	1.41 (0.63)	0.04 (0.03)
HAL RADI*	0 -	0.33 (0.24)	0.61 0.24)	0.67 (0.10)	1.51 (0.27)	0.81 (0.46)	0.46 (0.28)	0.94 (0.29)	0.15 (0.07)	0.32 (0.09)
HEM SIMU	0 -	0 -	0 -	0 -	0.03 (0.03)	0 -	0 -	0 -	0 -	0 -
HEM NOVA	0 -	0 -	0 -	0.01 (0.01)	0 -	0 -	0.09 (0.09)	0 -	0 -	0 -
HEM SPLE	0 -	0.56 (0.44)	0 -	0.01 (0.01)	0.03 (0.03)	1.19 (0.48)	0.18 (0.18)	3.23 (0.73)	3.07 1.31)	0 -
HOL BERM	0.11 (0.32)	0 -	0 -	0.05 (0.02)	0 -	0 -	0 -	0 -	0 -	0.14 (0.05)
HOL CILI	0.06 (0.06)	0 -	0.09 (0.05)	0.08 (0.02)	0.03 (0.03)	0 -	0 -	0 -	0 -	0.09 (0.04)
HOL TRIC*	0.94 (0.22)	0.44 (0.11)	0.59 (0.04)	0.23 (0.05)	0.14 (0.07)	0 -	0 -	0 -	0 -	0.02 (0.02)
HOL ASCE	0 -	0 -	0 -	0.04 (0.02)	0 -	0 -	0 -	0 -	0 -	0 -
HOL RUFU	0 -	0 -	0.21 (0.11)	0.16 (0.04)	0 -	0 -	0 -	0 -	0 -	0 -
HOL VEXI	0 -	0 -	0 -	0.03 (0.03)	0 -	0 -	0 -	0 -	0 -	0 -
HYP UNIC (all forms)	1.22 (0.21)	0 -	0.03 (0.03)	0.04 (0.02)	0.03 (0.03)	0 -	0 -	0 -	0 -	0.53 (0.10)
H0G CALL	0 -	0.22 (0.15)	0.06 (0.06)	0 -	0 -	0 -	0 -	1.80 (0.87)	0.15 (0.12)	0.04 (0.04)
INE VITT	0 -	0 -	0 -	0.19 (0.17)	0 -	0 -	0 -	0 -	7.80 (5.40)	0.02 (0.02)
KYP SECT	0 -	0 -	0.76 (0.36)	2.23 (0.74)	0.65 (0.54)	0 -	0 -	0 -	0 -	0 -
LAC MAXI	0.33 (0.11)	0.14 (0.73)	0.53 (0.14)	0.19 (0.04)	0.08 (0.05)	0 -	0 -	0.14 (0.07)	0.29 (0.16)	0.41 (0.11)
LAC BICA	0 -	0 -	0 -	0.01 (0.01)	0 -	0 -	0 -	0 -	0 -	0 -

Table 7.4. Mean abundance (± standard error) of selected species in different habitats at Looe Key National Marine Sanctuary. Unidentified species are deleted. "*" distribution plotted in Appendix 7.A (cont.).

	HABITAT									
SPECIES CODE	DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	FORE-REEF ZONE	LAGOON RUBBLE	LAGOON GRASS	LAGOON SAND	SHALLOW SAND	GRASS FLATS	SHALLOW LIVE BOTTOM
LAC QUAD	0.06	0	0	0	0	0	0	0	0	0
	(0.06)	-	-	-	-	-	-	-	-	-
LAC TRIQ	0	0	0	0.03	0	0	0	0.03	0	0
	-	-	-	(0.03)	-	-	-	(0.03)	-	-
LUT ANAL*	0	0.11	0	0.02	0.03	0	0	0	0.02	0
	-	(0.11)	-	(0.01)	(0.03)	-	-	-	(0.02)	-
LUT APOD*	0	0	1.76	0.81	0.46	0	0.18	0	0	0
	-	-	(0.63)	(0.22)	(0.21)	-	(0.12)	-	-	-
LUT GRIS*	0	0	1.65	0.62	0	0	0	0	0	0
	-	-	(1.47)	(0.28)	-	-	-	-	-	-
LUT JOCU	0	0	0.03	0	0	0	0	0	0	0
	-	-	(0.03)	-	-	-	-	-	-	-
LUT MAHO	0	0	0	0.06	0	0	0	0	0	0
	-	-	-	(0.04)	-	-	-	-	-	-
LUT SYNA*	0	0	0	1.59	0	0	0	0	0	0
	-	-	-	(0.50)	-	-	-	-	-	-
MAL PLUM	0	0.33	0.15	0.01	0	0	0	0	0	0
	-	(0.24)	(0.10)	(0.01)	-	-	-	-	-	-
MAL GILL	0	0	0	0.16	0	0	0	0	0	0
	-	-	-	(0.12)	-	-	-	-	-	-
MAL MACR	0	0.11	0	0	0	0	0	0	0	0
	-	(0.11)	-	-	-	-	-	-	-	-
MAL TRIA	0	0	0	0.02	0.03	0	0	0	0	0.02
	-	-	-	(0.01)	(0.03)	-	-	-	-	(0.02)
MEG ATLA	0	0	0	0.01	0	0	0	0	0	0
	-	-	-	(0.01)	-	-	-	-	-	-
MIC CARR	0	0	0	0	0	0	0	0.14	0	0
	-	-	-	-	-	-	-	(0.08)	-	-
MIC CHRY*	0	0	2.88	4.92	2.05	0	1.00	0	0	0
	-	-	(0.55)	(0.44)	(0.43)	0	(0.65)	-	-	-
MON TUCK	0	0	0	0.01	0	0	0	0	0	(0.04)
	-	-	-	(0.01)	-	-	-	-	-	(0.03)
MUL MART*	0	0	1.59	0.81	0	0	0	0	0	0
	-	-	(0.62	(0.42)	-	-	-	-	-	-
MUR MILI	0	0	0	0.01	0	0	0	0	0	0
	-	-	-	(0.01)	-	-	-	-	-	-

Table 7.4. Mean abundance (± standard error) of selected species in different habitats at Looe Key National Marine Sanctuary. Unidentified species are deleted. "*" distribution plotted in Appendix 7.A (cont.).

	HABITAT									
SPECIES CODE	DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	FORE-REEF ZONE	LAGOON RUBBLE	LAGOON GRASS	LAGOON SAND	SHALLOW SAND	GRASS FLATS	SHALLOW LIVE BOTTOM
MYC BONA	0.06 (0.06)	0 -	0.06 (0.24)	0.03 (0.01)	0 -	0 -	0.09 (0.09)	0 -	0 -	0 -
OCY CHRY*	0.39 (0.14)	0.89 (0.39)	9.38 (1.27)	6.92 (0.82)	2.43 (0.69)	1.12 (0.26)	0.36 (0.20)	0 -	0.27 0.13)	0.68 0.14)
ODO DENT	0 -	0 -	0.38 (0.17)	0.45 (0.14)	0.05 (0.04)	0 -	0 -	0 -	0 -	0 -
OPH ATLA	0 -	1.00 (1.00)	0 -	0.15 (0.05)	0.11 (0.07)	0 -	0.09 (0.09)	6 -	0 -	0 -
DPI AURI	0	1.00 (0.60)	0 -	0.05 (0.03)	0.16 (0.09)	0 -	0 -	0.23 (0.13)	0.12 (0.07)	0.13 (0.13)
PAR FURC	0 -	0 -	0.06 (0.04)	0 -	0 -	0 -	0 -	0 -	0 -	0 -
PAR NIGR	0 -	0.11 (0.11)	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -
PAG PAGR	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0 -	0.02 (0.02)
PEM SCHO	0 -	0 -	6.40 (5.90)	1.70 (1.30)	0.03 (0.03)	0 -	0 -	0 -	0 -	0 -
POM ARCU*	0.50 (0.51)	0 -	0.76 (0.13)	0.32 (0.05)	0.05 (0.04)	0 -	0 -	0 -	0.02 (0.02)	0.61 (0.11)
POM PARU	0.44 (0.17)	0 -	0.03 (0.03)	0.13 (0.03)	0 -	0 -	0 -	0 -	0 -	0.27 (0.08)
POM DIEN	0 -	0 -	0 -	0.64 (0.17)	0.03 (0.03)	0 -	0.45 (0.45)	0 -	0 -	0 -
POM FUSC*	0.11 (0.08)	0 -	0.91 (0.49)	3.75 (0.69)	1.54 (0.46)	0 -	0.09 (0.09)	0 -	0 -	0 -
POM LEUC	0.39 (0.20)	0.22 (0.22)	0.03 (0.03)	0.09 (0.03)	2.32 (0.66)	0 -	1.1B (0.50)	0.09 (0.05)	0.05 (0.03)	0.07 (0.05)
POM PART*	54.60 (6.70)	13.90 (5.20)	29.70 (4.80)	35.60 (2.30)	24.10 (6.60)	0 -	4.09 (1.56)	6.50 (1.90)	5.10 (1.90)	14.90 (2.30)
POM PLAN*	4.67 (2.16)	0 -	6.15 (1.47)	5.09 (0.65)	0.49 (0.26)	0 -	0 -	0 -	0 -	2.36 (0.53)
POM VARI	0.83 (0.31)	0.76 (0.55)	0 -	0.45 (0.16)	0.70 (0.23)	0 -	0.18 (0.12)	0.17 (0.12)	0.07 (0.05)	0.62 0.19)
PRI CRUE	0 -	0 -	0 -	0.01 (0.01)	0.03 (0.03)	0 -	0 -	0.03 (0.03)	0.05 (0.04)	0 -

Table 7.4. Mean abundance (± standard error) of selected species in different habitats at Looe Key National Marine Sanctuary. Unidentified species are deleted. "*" distribution plotted in Appendix 7.A (cont.).

	HABITAT									
SPECIES CODE	DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	FORE-REEF ZONE	LAGOON RUBBLE	LAGOON GRASS	LAGOON SAND	SHALLOW SAND	GRASS FLATS	SHALLOW LIVE BOTTOM
PSE MACU*	0.22	0.22	0.06	0.11	0.35	0	0	0	0.24	0.54
	(0.13)	(0.15)	(0.04)	(0.04)	(0.12)	-	-	-	(0.24)	(0.17)
SCA CRIS	0	1.11	0	0	0.11	0	0	0.09	0.05	0.02
	-	(0.48)	-	-	(0.09)	-	-	(0.05)	(0.03)	(0.02)
SCA COEL	0	0	1.15	0.06	0.05	0	0	0	0	0
	-	-	(0.91)	(0.02)	(0.04)	-	-	-	-	-
SCA COER	0.06	0	0.29	0.30	0.03	0	0.09	0	0	0
	(0.06)	-	(0.14)	(0.13)	(0.03)	-	(0.09)	-	-	-
SCA CROI*	7.44	0.89	4.09	3.50	11.80	0	2.45	0.51	0.71	5.23
	(0.95)	(0.89)	(1.03)	(0.41)	(2.60)	-	(1.10)	(0.27)	(0.51)	(0.66)
SCA GUAC	0	0	0.12	0.06	0.16	0	0	0	0	0
	-	-	(0.06)	(0.03)	(0.11)	-	-	-	-	-
SCA TAEN	1.33	0	0.65	0.42	1.68	0	0	0	0.15	0.61
	(0.34)	-	(0.31)	(0.07)	(1.12)	-	-	-	(0.15)	(0.30)
SCA VETU	0	0	0.15	0.26	0.11	0	0	0	0	0.09
	-	-	(0.06)	(0.06)	(0.07)	-	-	-	-	(0.09)
SCO CAVA	0	0	0	0.01	0	0	0	0	0	0
	-	-	-	(0.01)	-	-	-	-	-	-
SCO MACU	0	0	0	0.01	0	0	0	0	0	0
	-	-	-	(0.01)	-	-	-	-	-	-
SCO REGA	0.06	0	0	0	0	0	0	0	0.05	0
	(0.06)	-	-	-	-	-	-	-	(0.03)	-
SER BALD	0	0.33	0	0.01	0.08	0	0.18	0	0.02	0
	-	(0.24)	-	(0.01)	(0.06)	-	(0.18)	-	(0.02)	-
SER TIGR	1.83	0.67	0.47	0.28	0.19	0	0	0.03	0.10	1.34
	(0.44)	(0.37)	(0.11)	(0.04)	(0.12)	-	-	(0.03)	(0.06)	(0.17)
SER TORT	0	0	0	0	0	0	0	0.03	0.02	0
	-	-	-	-	-	-	-	(0.03)	(0.02)	-
SPA ATOM	0	0	0	0	0	0	0	0.06	0.12	0
	-	-	-	-	-	-	-	(0.06)	(0.09)	-
SPA AURO*	1.78	0.67	1.12	1.60	0.61	0	0	0.03	0.05	1.36
	(0.46)	(0.47)	(0.21)	(0.15)	(0.29)	-	-	(0.03)	(0.03)	(0.20)
SPA CHRY*	0.22	0	0.41	0.39	1.00	0.44	0.55	0.11	0.95	0.30
	(0.17)	-	(0.41)	(0.39)	(0.24)	(0.18)	(0.37)	(0.07)	(0.76)	(0.10)
SPA RADI	0	1.56	0	0	0.68	2.00	0.46	0.11	4.00	0.02
	-	(0.78)	-	-	(0.36)	(0.68)	(0.25)	(0.53)	(1.45)	(0.02)

Table 7.4. Mean abundance (± standard error) of selected species in different habitats at Looe Key National Marine Sanctuary. Unidentified species are deleted. "*" distribution plotted in Appendix 7.A (cont.).

	HABITAT									
SPECIES CODE	DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	FORE-REEF ZONE	LAGOON RUBBLE	LAGOON GRASS	LAGOON SAND	SHALLOW SAND	GRASS FLATS	SHALLOW LIVE BOTTOM
SPA RUBR*	0.39 (0.29)	0 -	0.49 (0.19)	0.59 (0.10)	1.62 (0.45)	0.06 (0.06)	0.09 (0.09)	0 -	0 -	0.27 (0.15)
SPA VIRI*	0.50 (0.23)	0 -	1.44 (0.24)	1.64 (0.17)	1.22 (0.24)	0 -	0.18 (0.18)	0 -	0 -	0.34 (0.10)
SPH SPEN	0 -	0 -	0 -	0.01 (0.01)	0 -	0 -	0 -	0 -	0 -	0
SPH BARR*	0.06 (0.06)	0.22 (0.15)	0.27 (0.09)	0.43 (0.10)	0.41 (0.15)	0.25 (0.11)	0 -	0.03 (0.03)	0.10 (0.05)	0.04 (0.03)
STR TIMU	0 -	0 -	0 -	0 -	0.03 (0.03)	0 -	0 -	0 -	0 -	0 -
SYN INTE	0 -	0 -	0 -	0.01 (0.01)	0 -	0 -	0 -	0 (0.03)	0 -	0 -
THA BIFA*	26.44 (5.30)	6.56 (1.38)	26.60 (4.50)	59.70 (5.20)	17.60 (2.50)	0.69 (0.51)	2.09 (1.01)	3.29 (1.06)	2.22 (0.96)	10.68 (1.24)
TRA FALC	0	0	0.15 (0.10)	0.02 (0.01)	0 -	0 -	0 -	0 -	0 -	0 -
TYL CROC	0 -	0 -	0 -	0.01 (0.01)	0 -	0 -	0.09 (0.09)	0 -	0 -	0 -
URO JAMA	0.11 (0.08)	0 -	0 -	0 -	0 -	0 -	0 -	0.06 (0.04)	0.05 (0.03)	0.54 (0.03)

Table 7.5. Percent frequency of occurrence (±95% confidence intervals) of selected speces in different habitats at Looe Key National Marine Sanctuary. Unidentified species are deleted. "*", distribution plotted in Appendix 7.A.

	HABITAT									
SPECIES CODE	DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	FORE-REEF ZONE	LAGOON RUBBLE	LAGOON GRASS	LAGOON SAND	SHALLOW SAND	GRASS FLATS	SHALLOW LIVE BOTTOM
CODE N	18	9	34	160	37	16	11	35	41	56
ABU SAXA*	0	33	85	78	62	36	0	0	2	2
	0 - 19	7 - 70	68 - 95	71 - 84	45 - 78	15 - 66	0 - 29	0 - 10	0 - 13	0 - 10
ACA CHAP	0	0	0	0	14	0	0	0	0	0
	0 - 19	0 - 34	0 - 10	0 - 2	4 - 29	0 - 21	0 - 29	0 - 10	0 - 9	0 - 6
ACA BAHI*	94	67	82	73	86	13	45	34	20	68
	73 - 100	30 - 93	65 - 93	66 - 60	71 - 96	2 - 38	17 - 77	19 - 52	9 - 35	54 - 80
ACA CHIR*	11	0	15	16	5	0	0	0	2	30
	1 - 35	0 - 34	5 - 31	11 - 23	1 - 18	0 - 21	0 - 29	0 - 10	0 - 13	19 - 44
ACA COER*	44	22	56	66	76	0	45	3	0	38
	21 - 69	3 - 60	38 - 73	58 - 74	59 - 88	0 - 21	17 - 77	0 - 15	0 - 9	25 - 52
ALU SCHO	0	0	0	1	0	0	0	0	0	4
	0 - 19	0 - 34	0 - 10	0 - 4	0 - 10	0 - 21	0 - 29	0 - 10	0 - 9	0 - 12
ALU SCRI	0	0	0	4	0	0	0	0	0	2
	0 - 19	0 - 34	0 - 10	1 - 8	0 - 10	0 - 21	0 - 29	0 - 10	0 - 9	0 - 10
AMB PINO	6	0	0	1	0	0	0	0	0	0
	0 - 27	0 - 34	0 - 10	0 - 4	0 - 10	0 - 21	0 - 29	0 - 10	0 - 9	0 - 6
ANI SURI	0	0	0	1	0	0	0	0	0	0
	0 - 19	0 - 34	0 - 10	0 - 4	0 - 10	0 - 21	0 - 29	0 - 10	0 - 9	0 - 6
ANI VIRG	0	0	21	8	0	0	0	0	0	0
	0 - 19	0 - 34	9 - 38	4- 14	0 - 10	0 - 21	0 - 29	0 - 10	0 - 9	0 - 6
APO PSEU	0	0	0	0	0	0	0	0	2	0
	0 - 19	0 - 34	0 - 10	0 - 2	0 - 10	0 - 21	0 - 29	0 - 10	0 - 13	0 - 6
AUL MACU	0	0	12	11	0	0	0	0	0	2
	0 - 19	0 - 34	3 - 27	7 - 17	0 - 10	0 - 21	0 - 29	0 - 10	0 - 9	0 - 10
BAL CAPR	0	0	3	1	3	0	0	0	0	0
	0 - 19	0 - 34	0 - 15	0 - 4	0 - 14	0 - 21	0 - 29	0 - 10	0 - 9	0 - 6
BAL VETU	0	0	0	0	0	0	0	6	0	0
	0 - 19	0 - 34	0 - 10	0 - 2	0 - 10	0 - 21	0 - 29	1 - 19	0 - 9	0 - 6
BOD RUFU*	22	0	65	56	27	0	0	0	0	7
	6 - 48	0 - 34	46 - 80	48 - 64	14 - 44	0 - 21	0 - 29	0- 10	0 - 9	2 - 17
CAL BAJO*	0	0	21	11	0	0	0	0	0	4
	0 - 19	0 - 34	9 - 36	7 - 17	0 - 10	0 - 21	0 - 29	0 - 10	0 - 9	0 - 12
CAL CALA	33	11	26	7	0	0	0	11	5	57
	13 - 59	0 - 48	13 - 44	3 - 12	0 - 10	0 - 21	0 - 29	3 - 27	1 - 17	43 - 70

Table 7.5. Percent frequency of occurrence (±95% confidence intervals) of selected speces in different habitats at Looe Key National Marine Sanctuary. Unidentified species are deleted. "*", distribution plotted in Appendix 7.A (cont.).

	HABITAT									
SPECIES CODE	DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	FORE-REEF ZONE	LAGOON RUBBLE	LAGOON GRASS	LAGOON SAND	SHALLOW SAND	GRASS FLATS	SHALLOW LIVE BOTTOM
CAL PENA	0 0 - 19	0 0 - 34	0 0 - 10	0 0 - 2	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	2 0 - 13	0 0 - 6
CAN PULL	0 0 - 19	0 0 - 34	3 0 - 15	7 3 - 21	5 1 - 16	0 0 - 21	0 0 - 29	0 0 - 10	2 0 - 13	0 0 - 6
CAN 5UFF	0 0 - 19	0 0 - 34	3 0 - 15	3 1 - 7	3 0 - 14	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
CAN ROST	39 18 - 65	0 0 - 34	9 2 - 23	13 8 - 23	3 0 - 14	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	5 1 - 15
CAR BART*	11 1 - 35	33 8 - 70	3 0 - 15	4 1 - 8	0 0 - 10	13 2 - 38	0 0 - 29	0 0 - 10	2 0 - 13	2 0 - 10
CAR CRYS	0 0 - 19	0 0 - 34	0 0 - 10	0 0 - 2	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	2 0 - 13	0 0 - 6
CAR RUBE*	6 0 - 27	11 0 - 48	32 17 - 51	35 28 - 43	19 8 - 35	19 4 - 46	19 2 - 52	7 0 - 19	10 3 - 23	9 3 - 20
CHA FABE	0 0 - 19	0 0 - 34	3 0 - 15	0 0 - 2	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
CHA CAPI*	100 81 - 100	0 0 - 34	82 65 - 93	65 57 - 72	38 22 - 55	0 0 - 21	9 0 - 41	0 0 - 10	0 0 - 9	73 60 - 84
CHA OCEL*	28 10 - 54	0 0 - 34	50 32 - 68	26 20 - 34	11 3 - 25	0 0 - 21	0 0 - 29	6 1 - 19	0 0 - 9	36 23 - 50
CHA SEDE	28 10 - 54	0 0 - 34	3 0 - 15	2 0 - 5	0 0 - 10	0 0 - 21	0 0 - 29	3 0 - 15	0 0 - 9	5 0 - 15
CHA STRI	22 6 - 48	0 0 - 34	15 5 - 31	22 16 - 29	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	9 3 - 20
CHR CYAN*	89 65 - 99	0 0 - 34	41 25 - 59	45 37 - 53	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 0	9 3 - 20
CHR IN50	0 0 - 19	0 0 - 34	0 0 - 10	1 0 - 4	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
CHR MULT*	17 4 - 41	0 0 - 34	26 13 - 44	29 22 - 36	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
CHR SCOT	6 0 - 27	0 0 - 34	15 5 - 31	4 0 - 8	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
CLE PARR*	0 0 - 19	0 0 - 34	15 5 - 31	6 3 - 11	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
COR DICR*	22 6 - 48	11 0 - 46	6 1 - 20	12 7 - 16	16 6 - 32	0 0 - 21	0 0 - 29	3 0 - 15	0 0 - 9	21 12 - 34

Table 7.5. Percent frequency of occurrence (±95% confidence intervals) of selected speces in different habitats at Looe Key National Marine Sanctuary. Unidentified species are deleted. "*", distribution plotted in Appendix 7.A (cont.).

	HABITAT									
SPECIES CODE	DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	FORE-REEF ZONE	LAGOON RUBBLE	LAGOON GRASS	LAGOON SAND	SHALLOW SAND	GRASS FLATS	SHALLOW LIVE BOTTOM
COR GLAU*	61 36 - 83	33 8 - 70	44 27 - 62	28 21 - 36	22 10 - 38	6 0 - 30	9 0 - 41	17 7 - 34	7 2 - 20	48 35 - 62
COR PERS*	72 46 - 90	0 0 - 34	24 11 - 41	19 13 - 26	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	30 19 - 44
CRY ROSE	0 0 - 19	11 0 - 48	0 0 - 10	0 0 - 2	0 0 - 10	0 0 - 21	0 0 - 29	3 0 - 15	15 6 - 29	0 0 - 6
DEC MACA	0 0 - 19	0 0 - 34	0 0 - 10	0 0 - 2	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	2 0 - 13	0 0 - 6
DEC PUNC	0 0 - 19	0 0 - 34	0 0 - 10	0 0 - 2	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	2 0 - 13	0 0 - 6
DID HOLD	6 0 - 27	0 0 - 34	0 0 - 10	0 0 - 2	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
DID HYST	0 0 - 19	0 0 - 34	0 0 - 10	1 0 - 4	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
DIP FORM	0 0 - 19	11 0 - 48	0 0 - 10	1 0 - 4	0 0 - 10	0 0 - 21	0 0 - 29	11 3 - 27	10 3 - 23	0 0 - 6
ECH NAUC	6 0 - 27	0 0 - 34	0 0 - 10	2 0 - 5	5 1 - 18	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
EPI CRUE*	55 31 - 79	0 0 - 34	50 32 - 68	43 35 - 51	11 3 - 25	0 0 - 21	9 0 - 41	0 0 - 10	0 0 - 9	23 13 - 36
EPI GUTT	0 0 - 19	0 0 - 34	0 0 - 10	1 0 - 4	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
EPI MORI	0 0 - 19	0 0 - 34	0 0 - 10	0 0 - 2	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	2 0 - 10
EPI STRI	0 0 - 19	0 0 - 34	3 0 - 15	0 0 - 2	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	2 0 - 10
EQU ACUM	11 0 - 35	0 0 - 34	3 0 - 15	1 0 - 4	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	2 0 - 10
EQU PUNC	0 0 - 19	0 0 - 34	0 0 - 10	1 0 - 4	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
GER CINE	0 0 - 19	0 0 - 34	0 0 - 10	0 0 - 2	16 6 - 32	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
GIN CIRR	0 0 - 19	0 0 - 34	0 0 - 10	0 0 - 2	3 0 - 14	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
GNA THOM	11 1 - 35	33 7 - 70	6 1 - 20	13 8 - 20	16 6 - 32	0 0 - 21	0 0 - 29	3 0 - 15	0 0 - 9	9 0 - 20

Table 7.5. Percent frequency of occurrence (±95% confidence intervals) of selected speces in different habitats at Looe Key National Marine Sanctuary. Unidentified species are deleted. "*", distribution plotted in Appendix 7.A (cont.).

SPECIES CODE	DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	FORE-REEF ZONE	LAGOON RUBBLE	LAGOON GRASS	LAGOON SAND	SHALLOW SAND	GRASS FLATS	SHALLOW LIVE BOTTOM
	HABITAT									
GOB MACR	0 0 - 19	0 0 - 34	0 0 - 10	0 0 - 2	3 0 - 94	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
GOB OCEA	39 18 - 65	0 0 - 34	19 13 - 26	5 1 - 18	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	20 10 - 32
GYM MORI	0 0 - 19	0 0 - 34	0 0 - 10	0 0 - 2	3 0 - 14	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	2 0 - 10
HAE ALBU	0 0 - 19	11 0 - 46	0 0 - 10	1 0 - 4	8 1 - 22	0 0 - 21	0 0 - 29	6 1 - 19	2 0 - 13	0 0 - 6
HAE AURO*	6 0 - 27	36 7 - 70	74 56 - 87	48 40 - 56	16 6 - 32	19 4 - 46	27 6 - 61	37 21 - 55	15 6 - 29	0 0 - 6
HAE CARB	0 0 - 19	0 0 - 34	3 0 - 15	12 7 - 18	3 0 - 14	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
HAE CHRY*	0 0 - 19	0 0 - 34	0 0 - 10	11 7 - 17	36 20 - 53	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
HAE FLAV*	17 4 - 41	0 0 - 34	82 65 - 93	68 60 - 75	54 37 - 71	6 0 - 30	36 11 - 69	3 0 - 15	0 0 - 9	16 8 - 28
HAE MACR	0 0 - 19	0 0 - 34	26 13 - 44	19 13 - 26	3 0 - 14	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
HAE FELA	0 0 - 19	22 3 - 60	0 0 - 10	1 0 - 4	0 0 - 10	0 0 - 21	0 0 - 29	3 0 - 15	5 0 - 17	0 0 - 6
HAE PARR	0 0 - 19	0 0 - 34	0 0 - 10	3 1 - 7	11 3 - 25	6 0 - 31	0 0 - 29	0 0 - 10	2 0 - 13	0 0 - 6
HAE PLUM*	44 21 - 69	44 14 - 79	41 25 - 59	40 32 - 48	43 27 - 61	38 15 - 65	9 0 - 41	17 7 - 34	22 11 - 38	46 33 - 60
HAE SCIU*	0 0 - 19	0 0 - 34	56 38 - 73	35 28 - 43	46 30 - 63	6 0 - 30	0 0 - 29	0 0 - 10	0 0 - 9	29 17 - 42
HAL BIVI*	28 10 - 54	100 66 - 100	44 27 - 62	49 41 - 57	95 82 - 99	94 70 - 100	73 39 - 94	83 66 - 93	80 65 - 91	55 41 - 69
HAL GARN*	100 81 - 100	44 14 - 79	88 73 - 97	83 76 - 89	32 18 - 50	6 0 - 30	9 0 - 41	14 5 - 30	7 1 - 20	80 68 - 90
HAL MACU*	67 41 - 87	76 40 - 97	62 44 - 78	74 66 - 80	78 62 - 90	9 0 - 61	27 17 - 49	31 17 - 49	32 18 - 48	54 40 - 67
HAL POEY	0 0 - 19	44 14 - 79	0 0 - 10	1 0 - 4	14 4 - 29	38 16 - 65	18 2 - 52	14 5 - 30	37 23 - 53	4 0 - 12
HAL RADI*	0 0 - 19	78 40 - 97	21 9 - 38	34 27 - 42	65 47 - 80	25 7 - 52	28 6 - 61	31 17 - 49	12 4 - 26	23 13 - 36

Table 7.5. Percent frequency of occurrence (±95% confidence intervals) of selected speces in different habitats at Looe Key National Marine Sanctuary. Unidentified species are deleted. "*", distribution plotted in Appendix 7.A (cont.).

	HABITAT									
SPECIES CODE	DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	FORE-REEF ZONE	LAGOON RUBBLE	LAGOON GRASS	LAGOON SAND	SHALLOW SAND	GRASS FLATS	SHALLOW LIVE BOTTOM
HEM SIMU	0 0 - 19	0 0 - 34	0 0 - 10	0 0 - 2	3 0 - 14	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 -6
HEM NOVA	0 0 - 19	0 0 - 34	0 0 - 10	1 0 - 4	0 0 - 10	0 0 - 21	9 0 - 41	0 0 - 10	0 0 - 9	0 0 - 6
HEM SPLE	0 0 - 19	22 3 - 60	0 0 - 10	1 0 - 4	3 0 - 14	44 20 - 71	9 0 - 41	71 47 - 89	29 15 - 45	0 0 - 6
HOL BERM	11 1 - 35	0 0 - 34	0 0 - 10	4 1 - 8	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	14 6 - 26
HOL CILI	6 0 - 27	0 0 - 34	9 2 - 23	8 4 - 14	3 0 - 14	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	9 3 - 20
HOL TRIC*	67 41 - 87	35 7 - 70	6 1 - 20	17 11 - 24	11 3 - 25	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	2 0 - 10
HOL ASCE	0 0 - 19	0 0 - 34	0 0 - 10	4 1 - 2	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
HOL RUFU	0 0 - 19	0 0 - 34	12 3 - 27	10 6 - 16	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
HOL VEXI	0 0 - 19	0 0 - 34	0 0 - 10	0 0 - 2	3 0 - 14	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
HYP UNIC (all forms)	83 59 - 96	0 0 - 34	3 0 - 15	4 1 - 8	3 0 - 14	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	41 26 - 55
IOG CALL	0 0 - 19	22 31 - 60	3 0 - 15	0 0 - 2	0 0 - 10	0 0 - 21	0 0 - 29	26 13 - 43	49 33 - 65	2 0 - 10
INE VITT	0 0 - 19	0 0 - 34	0 0 - 10	2 0 - 5	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	7 2 - 20	2 0 - 10
KYP SECT	0 0 - 19	0 0 - 34	18 7 - 35	18 12 - 26	11 3 - 25	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
LAC MAXI	33 13 - 59	11 0 - 48	38 22 - 56	15 10 - 22	8 2 - 22	0 0 - 21	0 0 - 29	11 3 - 27	10 3 - 23	27 16 - 41
LAC BICA	0 0 - 19	0 0 - 34	0 0 - 10	1 0 - 4	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 -6
LAC QUAD	6 0 - 27	0 0 - 34	0 0 - 10	0 0 - 2	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
LAC TRIQ	0 0 - 19	0 0 - 34	0 0 - 10	3 1 - 7	0 0 - 10	0 0 - 21	0 0 - 29	3 0 - 15	0 0 - 9	0 0 - 6
LUT ANAL*	0 0 - 19	11 0 - 48	0 0 - 10	2 0 - 5	3 0 - 14	0 0 - 21	0 0 - 29	0 0 - 10	2 0 - 13	0 0 - 6

Table 7.5. Percent frequency of occurrence (±95% confidence intervals) of selected speces in different habitats at Looe Key National Marine Sanctuary. Unidentified species are deleted. "*", distribution plotted in Appendix 7.A (cont.).

	HABITAT									
SPECIES CODE	DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	FORE-REEF ZONE	LAGOON RUBBLE	LAGOON GRASS	LAGOON SAND	SHALLOW SAND	GRASS FLATS	SHALLOW LIVE BOTTOM
LUT APOD*	0	0	32	14	16	0	19	0	0	0
	0 - 19	0 - 34	17 - 51	9 - 20	6 - 32	0 - 21	2 - 52	0 - 10	0 - 9	0 - 6
LUT GRIS*	0	0	12	15	0	0	0	0	0	0
	0 - 19	0 - 34	3 - 26	10 - 22	0 - 10	0 - 21	0 - 29	0 - 10	0 - 9	0 - 6
LUT JOCU	0	0	3	0	0	0	0	0	0	0
	0 - 19	0 - 34	0 - 15	0 - 2	0 - 10	0 - 21	0 - 29	0 - 10	0 - 9	0 - 6
LUT MAHO	0	0	0	2	0	0	0	0	0	0
	0 - 19	0 - 34	0 - 10	0 - 5	0 - 10	0 - 21	0 - 29	0 - 10	0 - 9	0 - 6
LUT SYNA*	0	0	0	11	0	0	0	0	0	0
	0 - 19	0 - 34	0 - 10	7 - 17	0 - 10	0 - 21	0 - 29	0 - 10	0 - 9	0 - 6
MAL PLUM	0	22	9	1	0	0	0	0	0	0
	0 - 19	3 - 60	2 - 23	0 - 4	0 - 10	0 - 21	0 - 29	0 - 10	0 - 9	0 - 6
MAL GILL	0	0	0	0	5	0	0	0	0	0
	0 - 19	0 - 34	0 - 10	0 - 2	1 - 18	0 - 21	0 - 29	0 - 10	0 - 9	0 - 6
MAL MACR	0	11	0	0	0	0	0	0	0	0
	0 - 19	0 - 48	0 - 10	0 - 2	0 - 10	0 - 21	0 - 29	0 - 10	0 - 9	0 - 6
NAL TRIA	0	0	0	2	3	0	0	0	0	2
	0 - 19	0 - 34	0 - 10	0 - S	0 - 14	0 - 21	0 - 29	0 - 10	0 - 9	0 - 10
MEG ATLA	0	0	0	1	0	0	0	0	0	0
	0 - 19	0 - 34	0 - 10	0 - 4	0 - 10	0 - 21	0 - 29	0 - 10	0 - 9	0 - 6
MIC CARR	0	0	0	0	0	0	0	9	0	0
	0 - 19	0 - 34	0 - 10	0 - 2	0 - 10	0 - 21	0 - 29	2 - 23	0 - 9	0 - 6
MIC CHRY*	0	0	74	81	59	0	27	0	0	0
	0 - 19	0 - 34	56 - 87	74 - 87	42 - 75	0 - 21	6 - 61	0 - 10	0 - 9	0 - 6
MON TUCK	0	0	0	1	0	0	0	0	0	4
	0 - 19	0 - 34	0 - 10	0 - 4	0 - 10	0 - 21	0 - 29	0 - 10	0 - 9	0 - 12
MUL MART*	0	0	41	24	0	0	0	0	0	0
	0 - 19	0 - 34	25 - 59	17 - 31	6 - 10	0 - 21	0 - 29	0 - 10	0 - 9	0 - 6
MUR MILI	0	0	0	1	0	0	0	0	0	0
	0 - 19	0 - 34	0 - 10	0 - 4	0 - 10	0 - 21	0 - 29	0 - 10	0 - 9	0- 6
MYC BONA	6	0	6	3	0	0	9	0	0	0
	0 - 27	0 - 34	1 - 20	1 - 7	0 - 10	0 - 21	0 - 41	0 - 10	0 - 9	0 - 6
OCY CHRY*	33	44	97	94	62	75	27	0	13	41
	13 - 59	14 - 79	85 - 100	89 - 97	45 - 76	48 - 93	6 - 61	0 - 10	4 - 26	28 - 55

Table 7.5. Percent frequency of occurrence (±95% confidence intervals) of selected speces in different habitats at Looe Key National Marine Sanctuary. Unidentified species are deleted. "*", distribution plotted in Appendix 7.A (cont.).

SPECIES CODE	HABITAT: DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	FORE-REEF ZONE	LAGOON RUBBLE	LAGOON GRASS	LAGOON SAND	SHALLOW SAND	GRASS FLATS	SHALLOW LIVE BOTTOM
ODO DENT	0	0	21	16	5	0	0	0	0	0
	0 - 19	0 - 34	9 - 38	12 - 26	1 - 18	0 - 21	0 - 29	0 - 10	0 - 9	0 - 6
OPH ATLA	0	11	0	9	8	0	9	0	0	0
	0 - 19	0 - 48	0 - 10	5 - is	2 - 22	0 - 21	0 - 41	0 - 10	0 - 9	0 - 6
OPH AURI	0	33	0	2	8	0	0	11	7	2
	0 - 19	7 - 70	0 - 10	0 - 5	2 - 22	0 - 21	0 - 29	3 - 27	2 - 20	0 - 10
PAR FURC	0	0	6	0	0	0	0	0	0	0
	0 - 19	0 - 34	1 - 20	0 - 2	0 - 10	0 - 21	0 - 29	0 - 10	0 - 9	0 -6
PAR NIGR	0	11	0	0	0	0	0	0	0	0
	0 - 19	0 - 48	0 - 10	0 - 2	0 - 10	0 - 21	0 - 29	0 -10	0 - 9	0 - 6
PAG PAGR	0	0	0	0	0	0	0	0	0	2
	0 - 19	0 - 34	0 - 10	0 - 2	0 - 10	0 - 21	0 - 29	0 - 10	0 - 9	0 - 10
PEM 5CHO	0	0	21	4	3	0	0	0	0	0
	0 - 19	0 - 34	9 - 38	1 - 8	0 - 14	0 - 21	0 - 29	0 - 10	0 - 9	0 - 6
POM ARCU*	50	0	56	26	5	0	0	0	2	41
	26 - 74	0 - 34	38 - 73	20 - 34	1 - 18	0 - 21	0 - 29	0 - 10	0 - 12	28 - 55
POM PARU	33	0	3	11	0	0	0	0	0	20
	13 - 59	0 - 34	0 - 15	7 - 17	0 - 10	0 - 21	0 - 29	0 - 10	0 - 9	10 - 32
POM DIEN	0	0	0	12	3	0	9	0	0	0
	0 - 19	0 - 34	0 - 10	7 - 18	0 - 14	0 - 21	0 - 41	0 - 10	0 - 9	0 -6
POM FUSC*	11	0	57	36	35	0	9	0	0	0
	1 - 35	0 - 34	38 - 73	29 - 44	20 - 53	0 - 21	0 - 41	0 - 10	0 - 9	0 - 6
POM LELIC	22	11	3	26	51	0	45	9	5	4
	6 - 48	0 - 48	0 - 15	20 - 34	34 - 68	0 - 21	17 - 77	2 - 23	1 - 17	0 - 12
POM PART*	94	89	91	96	65	0	45	57	27	93
	73 - 100	52 - 100	76 - 98	92 - 99	48 - 80	0 - 21	17 - 77	39 - 74	14 - 43	83 - 98
POM PLAN*	44	0	76	52	11	0	0	0	0	55
	21 - 69	0 - 34	59 - 89	44 - 60	3 - 25	0 - 21	0 - 29	0 - 10	0 - 9	41 - 69
POM VAR!	33	33	0	13	27	0	9	6	5	29
	13 - 59	7 - 70	0 - 10	8 - 20	14 - 44	0 - 21	0 - 41	1 - 19	1 - 17	17 - 42
PRI CRUE	0	0	0	1	3	0	0	3	5	0
	0 - 19	0 - 34	0 - 10	0 - 4	0 - 14	0 - 21	0 - 29	0 - 15	0 - 17	0 - 6
PSE MACU*	17	22	59	4	22	0	0	0	2	23
	4 - 41	3 - 60	41 - 75	1 - 8	10 - 38	0 - 21	0 - 29	0 - 10	0 - 13	13 - 36
SCA CRIS	0	11	0	0	3	0	0	9	5	2
	0 - 19	0 - 48	0 - 10	0 - 2	0 - 14	0 - 21	0 - 29	2 - 23	1 - 17	0 - 10

Table 7.5. Percent frequency of occurrence (±95% confidence intervals) of selected speces in different habitats at Looe Key National Marine Sanctuary. Unidentified species are deleted. "*", distribution plotted in Appendix 7.A (cont.).

SPECIES CODE	DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	FORE-REEF ZONE	LAGOON RUBBLE	LAGOON GRASS	LAGOON SAND	SHALLOW SAND	GRASS FLATS	SHALLOW LIVE BOTTOM
SCA COEL	0 0 - 19	0 0 - 34	9 2 - 23	6 3 - 11	5 1 - 18	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
SCA COER	6 0 - 27	0 0 - 34	18 7 - 35	13 8 - 20	3 0 - 14	0 0 - 21	9 0 - 41	0 0 - 16	0 0 - 9	0 0 - 6
SCA CROI*	94 73 - 100	13 0 - 48	56 38 - 73	59 51 - 67	76 59 - 88	0 0 - 21	45 17 - 77	11 3 - 27	10 3 - 23	71 58 - 83
SCA GUAC	0 0 - 19	0 0 - 34	12 3 - 27	5 2 - 10	8 2 - 22	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
SCA TAEN	78 52 - 94	0 0 - 34	24 11 - 41	29 22 - 36	16 6 - 32	0 0 - 21	0 0 - 29	0 0 - 10	2 0 - 13	11 7 - 29
SCA VETU	0 0 - 19	0 0 - 34	18 7 - 35	15 10 - 22	0 2 - 22	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	2 0 - 10
SCO CAVA	0 0 - 19	0 0 - 34	0 0 - 10	1 0 - 4	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
SCA REGA	6 0 - 27	0 0 - 34	0 0 - 10	0 0 - 2	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	5 1 - 17	0 0 - 6
SER BALD	0 0 - 19	11 0 - 48	0 0 - 10	1 0 - 4	5 1 - 18	0 0 - 21	9 0 - 41	0 0 - 10	2 0 - 13	0 0 - 6
5ER TIGR	78 52 - 94	33 7 - 70	38 22 - 56	23 16 - 31	11 3 - 25	0 0 - 21	0 0 - 29	3 0 - 15	7 2 - 20	70 56 - 82
SER TORT	0 0 - 19	0 0 - 34	0 0 - 10	0 0 - 2	0 0 - 10	0 0 - 21	0 0 - 29	3 0 - 15	2 0 - 13	0 0 - 6
SPA ATOM	0 0 - 19	0 0 - 34	0 0 - 10	0 0 - 2	0 0 - 10	0 0 - 21	0 0 - 29	3 0 - 15	5 1 - 17	0 0 - 6
SPA AURO*	78 52 - 94	22 3 - 60	58 41 - 75	62 54 - 69	24 12 - 42	0 0 - 21	0 0 - 29	3 0 - 10	49 33 - 65	59 45 - 72
SPA CHRY*	11 1 - 35	0 0 - 34	26 13 - 44	20 14 - 27	43 27 - 61	31 11 - 59	27 6 - 69	9 2 - 23	10 3 - 23	18 9 - 30
SPA RADI	0 0 - 19	33 7 - 70	0 0 - 10	0 0 - 2	19 8 - 35	44 20 - 71	27 6 - 61	6 1 - 19	49 33 - 65	2 0 - 10
SPA RUBR*	13 1 - 35	0 0 - 34	19 7 - 35	28 21 - 36	43 27 - 61	6 0 - 30	9 0 - 41	0 0 - 10	0 0 - 9	7 2 - 17
SPA VIRI*	22 6 - 48	0 0 - 34	68 50 - 83	66 58 - 74	59 42 - 75	0 0 - 21	9 0 - 41	0 0 - 10	0 0 - 9	21 12 - 34
SPH SPEN	0 0 - 19	0 0 - 34	0 0 - 10	1 0 - 4	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6

Table 7.5. Percent frequency of occurrence (±95% confidence intervals) of selected speces in different habitats at Looe Key National Marine Sanctuary. Unidentified species are deleted. "*", distribution plotted in Appendix 7.A (cont.).

	HABITAT									
SPECIES CODE	DEEP LIVE BOTTOM	DEEP SAND	BUTTRESS ZONE	FORE-REEF ZONE	LAGOON RUBBLE	LAGOON GRASS	LAGOON SAND	SHALLOW SAND	GRASS FLATS	SHALLOW LIVE BOTTOM
SPH BARR*	6 0 - 27	22 3 - 60	24 11 - 41	24 17 - 31	22 10 - 36	25 7 - 52	0 0 - 29	3 0 - 15	10 3 - 23	4 0 - 12
STR TIMU	0 0 - 19	0 0 - 34	0 0 - 10	0 0 - 2	3 0 - 14	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 -6
SYN INTE	0 0 - 19	0 0 - 34	0 0 - 10	1 0 - 4	0 0 - 10	0 0 - 21	0 0 - 29	3 0 - 15	0 0 - 9	0 0 - 6
THA BIFA*	100 82 - 100	100 66 - 100	97 85 - 100	98 95 - 100	89 75 - 97	19 4 - 46	36 11 - 69	34 19 - 52	27 14 - 43	88 76 - 95
TRA FALC	0 0 - 19	0 0 - 34	9 2 - 23	2 0 - 5	0 0 - 10	0 0 - 21	0 0 - 29	0 0 - 10	0 0 - 9	0 0 - 6
TYL CROC	0 0 - 19	0 0 - 34	0 0 - 10	1 0 - 4	0 0 - 10	0 0 - 21	9 0 - 41	0 0 - 10	0 0 - 9	11 0 - 6
URO JAMA	11 1 - 35	0 0 - 34	0 0 - 10	0 0 - 2	0 0 - 10	0 0 - 21	0 0 - 29	6 1 - 19	5 1 - 17	5 1 - 15

Table 7.6. Trophic structure of fishes at Looe Key National Marine Sanctuary. Species, listed alphabetically by family and genus, are grouped according to times of major feeding activity (diurnal, nocturnal, crepuscular, and generally active). Abundance values are based on all random point samples in all habitats irrespective of effort in different habitats. Trophic level codes: H, herbivore; P, planktivore; 8, browser; Mi, microinvertivore; Ma, macroinvertivore; F, piscivore. Principal feeding zones: 5, surface; M, midwater, B, bottom. 'off' indicates feeding is usually away from the reef proper. Dashes indicate species observed in rapid visual samples but not in point samples. "*" indicates species observed after 5 min in random point samples.

TAXON	COMMON NAME	FREQUENCY (N = 417)	TOTAL ABUNDANCE	TROPHIC LEVEL (H,P,B, Mi,Ma,F)	FEEDING ZONE (S,M,B)	FEEDS OFF REEF
DIURNALLY FEEDING FISHES						
ACANTHURIDAE (surgeonfishes)						
Acanthurus bahianus	Ocean surgeon	265	1231	H	B	
Acanthurus chirurgus	Doctorfish	53	97	H	B	
Acanthurus coeruleus	Blue tang	189	561	H	B	
AULOSTOMIDAE (trumpetfishes)						
Aulostomus maculatus	Trumpetfish	23	27	F	B	
BALISTIDAE (leatherjackets)						
Aluterus schoepfi	Orange filefish	4	6	H	B	
Aluterus scriptus	Scrawled filefish	7	7	B,H	B	
Balistes capriscus	Gray triggerfish	3	4	Ma	B	
Balistes vetula	Queen triggerfish	2	2	Ma	B	
Cantherhines macrocerus	Whitespotted filefish	-	-	H	B	
Cantherhines pullus	Orangespotted filefish	15	17	H,B	B	
Canthidermis sufflamen	Ocean triggerfish	6	7	P,Ma	B	
Monacanthus tuckeri	Slender filefish	3	4	Mi	B	
BELONIDAE (needlefishes)						
Strongylura notata	Redfin needlefish	*	*	F	S	
Strongylura timucu	Timucu	1	1	F	S	
Tylosurus crocodilus	Houndfish	3	3	F	S	
BLENNIIDAE (combtooth blennies)						
Hypleurochilus spp.	Unidentified blenny	1	5	H	B	
Ophioblennius atlanticus	Redlip blenny	19	38	H	B	
Scartella cristata	Molly miller	12	20	H	B	

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TAXON	COMMON NAME	FREQUENCY (N = 417)	TOTAL ABUNDANCE	TROPHIC LEVEL (H,P,B, Mi,Ma,F)	FEEDING ZONE (S,M,B)	FEEDS OFF REEF
CALLIONYMIDAE (dragonets)						
Callionymus bairdi	Lancec dragonet	-	-	Mi	B	
CHAFTODONTIDAE (butterflyfishes)						
Chaetodon capistratus	Foureye butterflyfish	206	555	B	B	
Chaetodon ocellatus	Spotfin butterflyfish	90	162	B	B	
Chaetodon sedentarius	Reef butterflyfish	12	18	Mi	B	
Chaetodon striatus	Banded butterflyfish	53	92	B	B	
CIRRHITIDAE (hawkfishes)						
Amblycirrhitus pinos	Redspotted hawkfish	2	2	Mi	B	
CLINIDAE (clinids)						
Acanthemblemaria chaplini	Papillose blenny	1	5	P	B	
Acanthemblemaria spp.	unidentified blenny	-	-	P	B	
Malacoctenus gilli	Dusky blenny	2	6	P,Mi	B	
Malacoctenus macropus	Rosy blenny	1	1	P,Mi	B	
Malacoctenus triangulatus	Saddled blenny	5	5	P,Mi	B	
Malacoctenus versicolor	Barfin blenny	-	-	P,Mi	B	
Paraclinus nigripinnis	Blackfin blenny	1	1	P,Mi	B	
DIODONTIDAE (porcupinefishes)						
Diodon holocanthus	Balloonfish	1	1	Ma	B	
Diodon hystrix	Porcupinefish	1	1	Ma	B	
EPHIPPIDAE (spadefishes)						
Chaetodipterus faber	Atlantic spadefish	1	1	Ma	B	off

Table 7.6. Trophic structure of fishes at Looe Key National Marine Sanctuary. Species, listed alphabetically by family and genus, are grouped according to times of major feeding activity (diurnal, nocturnal, crepuscular, and generally active). Abundance values are based on all random point samples in all habitats irrespective of effort in different habitats. Trophic level codes: H, herbivore; P, planktivore; 8, browser; Mi, microinvertivore; Ma, macroinvertivore; F, piscivore. Principal feeding zones: 5, surface; M, midwater, B, bottom. 'off' indicates feeding is usually away from the reef proper. Dashes indicate species observed in rapid visual samples but not in point samples. "*" indicates species observed after 5 min in random point samples (cont.).

TAXON	COMMON NAME	FREQUENCY (N = 417)	TOTAL ABUNDANCE	TROPHIC LEVEL (H,P,B, Mi,Ma,F)	FEEDING ZONE (S,M,B)	FEEDS OFF REEF
G0BIIDAE (gobies)						
Coryphopterus dicrus	Colon goby	45	111	H	B	
Coryphopterus glaucofraenum	Bridled goby	119	623	H	B	
Coryphopterus personatus	Masked goby	69	3611	P	B	
Coryphopterus sp.	unidentified goby	*	*	H	B	
Gnatholepis thompsoni	Goldspot goby	39	106	H	B	
Gobiosoma macrodon	Tiger goby	1	3	Mi	B	
Gobiosoma oceanops	Neon goby	60	132	Mi	B	
Ioglossus calliurus	Blue goby	15	75	P	B	
Microgobius carri	Seminole goby	3	5	P	B	
GRAMMIDAE (basslets)						
Liopropoma rubre	Peppermint bass	-	-	Ma	B	
HAEMULIDAE (grunts)						
Haemulon album	Margate	9	49	Ma	B	
KYPH0SIDAE (sea chubs)						
Kyphosus sectatrix	Bermuda chub	39	407	H	M,S	

Table 7.6. Trophic structure of fishes at Looe Key National Marine Sanctuary. Species, listed alphabetically by family and genus, are grouped according to times of major feeding activity (diurnal, nocturnal, crepuscular, and generally active). Abundance values are based on all random point samples in all habitats irrespective of effort in different habitats. Trophic level codes: H, herbivore; P, planktivore; 8, browser; Mi, microinvertivore; Ma, macroinvertivore; F, piscivore. Principal feeding zones: 5, surface; M, midwater, B, bottom. 'off' indicates feeding is usually away from the reef proper. Dashes indicate species observed in rapid visual samples but not in point samples. "*" indicates species observed after 5 min in random point samples (cont.).

TAXON	COMMON NAME	FREQUENCY (N = 417)	TOTAL ABUNDANCE	TROPHIC LEVEL (H,P,B, Mi,Ma,F)	FEEDING ZONE (S,M,B)	FEEDS OFF REEF
LABRIDAE (wrasses)						
Bodianus pulchellus	Spotfin hogfish	-	-	Mi	B	
Bodianus rufus	Spanish hogfish	129	218	Ma,Mi	B	
Clepticus parrai	Creole wrasse	14	274	P	M	
Halichoeres bivittatus	Slippery dick	258	3590	Mi,Ma	B	
Halichoeres garnoti	Yellowhead wrasse	251	1110	Mi,Ma	B	
Halichoeres maculipinna	Clown wrasse	246	1512	Mi,Ma	B	
Halichoeres pictus	Rainbow wrasse	-	-	P	M	
Halichoeres poeyi	Blackear wrasse	40	119	Mi,Ma	B	off
Halichoeres radiatus	Puddingwife	123	252	Mi,Ma	B	
Hemiemblemaria simulus	Wrasse blenny	1	1	Mi,P	B	
Hemipteronotus novacula	Pearly razorfish	2	2	Mi,Ma	B	off
Hemipteronotus splendens	Green razorfish	49	267	Mi,Ma	B	off
Lachnolaimus maximus	Hogfish	70	98	Ma	B	
Thalassoma bifasciatum	Bluehead wrasse	328	12484	P,Mi	B,M	
MALACANTHIDAE (tilefishes)						
Malacanthus plumieri	5and tilefish	7	10	Mi,Ma	B	
MULLIDAE (goatfishes)						
Pseudupeneus maculatus	Spotted goatfish	36	78	Mi	B	
OPISTOGNATHIDAE (jawfishes)						
Opistognathus aurifrons	Yellowhead jawfish	17	43	P	B	
Opistognathus maxillosus	Mottled jawfish	-	-	Mi	B	
OSTRACIIDAE (boxfishes)						
Lactophrys bicaudalis	Spotted trunkfish	2	2	B	B	
Lactophrys polygonia	Honeycomb cowfish	-	-	B	B	
Lactophrys quadricornis	Scrawled cowfish	-	-	B	B	
Lactophrys triqueter	Smooth trunkfish	5	5	B	B	

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TAXON	COMMON NAME	FREQUENCY (N = 417)	TOTAL ABUNDANCE	TROPHIC LEVEL (H,P,B, Mi,Ma,F)	FEEDING ZONE (S,M,B)	FEEDS OFF REEF
POMACANTHIDAE (angelfishes)						
Holacanthus bermudensis	Blue angelfish	17	18	B	B	
Holacanthus ciliaris	Queen angelfish	23	23	B	B	
Holacanthus tricolor	Rock beauty	58	77	B	B	
Pomacanthus arcuatus	Gray angelfish	96	121	B	B	
Pomacanthus paru	French angelfish	35	45	B	B	
POMACENTRIDAE (damselfishes)						
Abudefduf saxatilis	Sergeant major	185	6799	P	M,S	
Chromis cyaneus	Blue chromis	107	324	P	M	
Chromis insolata	Sunshinefish	1	1	P	M	
Chromis multilineata	Brown chromis	59	892	P	M	
Chromis scotti	Purple reeffish	12	47	P	M	
Microspathodon chrysurus	Yellowtail damselfish	180	974	H	B	
Pomacentrus diencaeus	Longfin damselfish	21	109	H	B	
Pomacentrus fuscus	Dusky damselfish	82	692	H	B	
Pomacentrus leucostictus	Beaugregory	46	132	H	B	
Pomacentrus partitus	Bicolor damselfish	322	10021	P,H	B	
Pomacentrus planifrons	Three spot damselfish	152	1257	H	B	
Pomacentrus variabilis	Cocoa damselfish	61	166	H	B	
SCARIDAE (parrotfishes)						
Cryptotomus roseus	Bluelip parrotfish	8	22	H	B	
Scarus coelestinus	Midnight parrotfish	14	51	H	B	
Scarus coeruleus	Blue parrotfish	30	61	H	B	
Scarus croicensis	Striped parrotfish	212	1645	H	B	
Scarus quacamaia	Rainbow parrotfish	15	20	H	B	
Scarus taeniopterus	Princess parrotfish	84	215	H	B	
Scarus vetula	Queen parrotfish	34	57	H	B	
Sparisoma atomarium	Greenblotch parrotfish	3	7	H	B	
Sparisoma aurofrenatum	Redband parrotfish	180	441	H	B	
Sparisoma chrysopterum	Redtail parrotfish	84	190	H	B	
Sparisoma radians	Bucktooth parrotfish	43	246	H	B	
Sparisoma rubripinne	Yellowtail parrotfish	76	200	H	B	
Sparisoma viride	Stoplight parrotfish	167	386	H	B	

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TAXON	COMMON NAME	FREQUENCY (N = 417)	TOTAL ABUNDANCE	TROPHIC LEVEL (H,P,B, Mi,Ma,F)	FEEDING ZONE (S,M,B)	FEEDS OFF REEF
SERRANIDAE (groupers)						
Diplectrum formosum	Sand perch	13	59	Ma,Mi	B	off
Hypoplectrus gemma$^{\Delta}$	Blue hamlet	16	16	Mi	B	
Hypoplectrus nigricans$^{\Delta}$	Black hamlet	1	1	Mi	B	
Hypoplectrus unicolor	Butter hamlet	31	38	Mi	B	
Hypoplectrus puella$^{\Delta}$	Barred hamlet	3	3	Mi	B	
Serranus baldwini	Lanternfish	8	11	Mi	B	
Serranus tabacarius	Tobaccofish	*	*	Mi	B	off
Serranus tigrinus	Harlequin bass	113	185	Mi	B	
Serranus tortugarum	Chalk bass	2	2	Mi	B	off
Paranthias furcifer	Creole-fish	-	-	P,F	M	off
SPARIDAE (porgies)						
Calamus sp.	Unidentified porgy	1	1	Ma	B	
Calamus bajonado	Jolthead porgy	27	35	Ma	B	
Calamus calamus	Saucereye porgy	65	94	Ma	B	
Calamus penna	Sheepshead porgy	2	3	Ma	B	
Pagrus pagrus	Red Porgy	1	1	Ma	B	
TETRADONTIDAE (puffers)						
Canthigaster rostrata	Sharpnose puffer	42	53	B,H	B	
Sphoeroides spengleri	Bandtail puffer	1	1	Mi,B	B	
Other (unclassified)						
Fry	Unidentified species	1	15	P	M	

$^{\Delta}$ Now considered color forms of *H. unicolor* (American Fisheries Society, 1980).

Table 7.6. Trophic structure of fishes at Looe Key National Marine Sanctuary. Species, listed alphabetically by family and genus, are grouped according to times of major feeding activity (diurnal, nocturnal, crepuscular, and generally active). Abundance values are based on all random point samples in all habitats irrespective of effort in different habitats. Trophic level codes: H, herbivore; P, planktivore; 8, browser; Mi, microinvertivore; Ma, macroinvertivore; F, piscivore. Principal feeding zones: 5, surface; M, midwater, B, bottom. 'off' indicates feeding is usually away from the reef proper. Dashes indicate species observed in rapid visual samples but not in point samples. "*" indicates species observed after 5 min in random point samples (cont.).

TAXON	COMMON NAME	FREQUENCY (N = 417)	TOTAL ABUNDANCE	TROPHIC LEVEL (H,P,B, Mi,Ma,F)	FEEDING ZONE (S,M,B)	FEEDS OFF REEF
NOCTURNALLY FEEDING FISHES						
APOGONIDAE (cardinalfishes)						
Apogon binotatus	Barred cardinalfish	-	-	P	M	
Apogon maculatus	Flamefish	-	-	P	M	
Apogon pseudomaculatus	Twospot cardinalfish	1	2	P	M	
Apogon quadrisquamatus	Sawcheek caradinalfish	-	-	P	M	
ATHERINIDAE (silversides)						
Atherinomorus stipes	Hardhead silverside	-	-	P	M	off
CLUPEIDAE (herrings)						
Jenkinsia lamprotaenia	Dwarf herring	-	-	P	M	off
Jenkinsia spp.	Unidentified *Jenkinsia*	-	-	P	M	off
ENGRAULIDAE (anchovies)						
Anchoa lyolepis	Dusky anchovy	-	-	P	M	off
GERREIDAE (mojarras)						
Gerres cinereus	Yellowfin mojarra	6	681	Ma,Mi	B	off

Table 7.6. Trophic structure of fishes at Looe Key National Marine Sanctuary. Species, listed alphabetically by family and genus, are grouped according to times of major feeding activity (diurnal, nocturnal, crepuscular, and generally active). Abundance values are based on all random point samples in all habitats irrespective of effort in different habitats. Trophic level codes: H, herbivore; P, planktivore; 8, browser; Mi, microinvertivore; Ma, macroinvertivore; F, piscivore. Principal feeding zones: 5, surface; M, midwater, B, bottom. 'off' indicates feeding is usually away from the reef proper. Dashes indicate species observed in rapid visual samples but not in point samples. "*" indicates species observed after 5 min in random point samples (cont.).

TAXON	COMMON NAME	FREQUENCY (N = 417)	TOTAL ABUNDANCE	TROPHIC LEVEL (H,P,B, Mi,Ma,F)	FEEDING ZONE (S,M,B)	FEEDS OFF REEF
HAEMULIDAE (grunts)						
Anisotremus surinamenis	Black margate	1	1	Ma	B	off
Anisotremus virginicus	Porkfish	20	28	Ma	B	off
Haemulon aurolineatum	Tomtate	138	10842	Ma	B	off
Haemulon carbonarium	Caesar grunt	23	355	Ma	B	off
Haemulon chrysargyreum	Smallmouth grunt	21	877	Ma	B	off
Haemulon flavolineatum	French grunt	175	714	Ma	B	off
Haemulon macrostomum	Spanish grunt	40	90	Ma	B	off
Haemulon melanurum	Cottonwick	8	22	Ma	B	off
Haemulon parrai	Sailor's choice	11	62	Ma	B	off
Haemulon plumieri	White grunt	163	1122	Ma	B	off
Haemulon sciurus	Bluestriped grunt	111	542	Ma	B	off
HOLOCENTRIDAE (squirrelfishes)						
Holocentrus ascensionis	Squirrelfish	6	7	Ma,Mi	B	
Holocentrus coruscus	Reef squirrelfish	-	-	Ma,Mi	B	
Holocentrus rufus	Longspine squirrelfish	20	32	Ma,Mi	B	
Holocentrus vexillarius	Dusky squirrelfish	1	1	Ma,Mi	B	
Myripristis jacobus	Blackbar soldierfish	-	-	P	M	off
INERMIIDAE (bonnetmouths)						
Inermia vittata	Boga	6	352	P	M	off
LUTJANIDAE (snappers)						
Lutjanus analis	Mutton snapper	6	6	Ma,F	B	off
Lutjanus apodus	Schoolmaster snapper	42	208	F,Ma	B	off
Lutjanus griseus	Gray snapper	29	157	F,Ma	B	off
Lutjanus jocu	Dog snapper	1	1	F,Ma	B	off
Lutjanus mahogoni	Mahogany snapper	3	9	F,Ma	B	off
Lutjanus synagris	Lane snapper	17	254	Ma,F	B	off
Ocyurus chrysurus	Yellowtail snapper	259	1602	Ma,F	B	off

Table 7.6. Trophic structure of fishes at Looe Key National Marine Sanctuary. Species, listed alphabetically by family and genus, are grouped according to times of major feeding activity (diurnal, nocturnal, crepuscular, and generally active). Abundance values are based on all random point samples in all habitats irrespective of effort in different habitats. Trophic level codes: H, herbivore; P, planktivore; 8, browser; Mi, microinvertivore; Ma, macroinvertivore; F, piscivore. Principal feeding zones: 5, surface; M, midwater, B, bottom. 'off' indicates feeding is usually away from the reef proper. Dashes indicate species observed in rapid visual samples but not in point samples. "*" indicates species observed after 5 min in random point samples (cont.).

TAXON	COMMON NAME	FREQUENCY (N = 417)	TOTAL ABUNDANCE	TROPHIC LEVEL (H,P,B, Mi,Ma,F)	FEEDING ZONE (S,M,B)	FEEDS OFF REEF
MULLIDAE (goatfishes)						
Mulloidichthys martinicus	Yellow goatfish	53	346	Mi	B	off
MURAENIDAE (morays)						
Enchelycore nigricans	Viper moray	*	*	F	B	
Gymnothorax funebris	Green moray	2	2	Ma,F	B	
Gymnothorax moringa	Spotted moray	-	-	F	B	
Muraena miliaris	Goldentail moray	2	2	Ma	B	
ORECTOLOBIDAE (carpet sharks)						
Ginglymostoma cirratum	Nurse shark	1	1	F,Ma	8	
PEMPHERIDAE (sweepers)						
Pempheris schomburgki	Glassy sweeper	15	493	P	M	
PRIACANTHIDAE (bigeyes)						
Priacanthus cruentatus	Glasseye snapper	6	6	Ma,P	M	
SCIAENIDAE (drums)						
Equetus acuminatus	High-hat	7	7	Ma	B	
Equetus lanceolatus	Jacknife-fish	-	-	Ma	B	
Equetus punctatus	Spotted drum	1	1	Ma	B	
Odontoscion dentex	Reef croaker	37	87	Ma	B	

Table 7.6. Trophic structure of fishes at Looe Key National Marine Sanctuary. Species, listed alphabetically by family and genus, are grouped according to times of major feeding activity (diurnal, nocturnal, crepuscular, and generally active). Abundance values are based on all random point samples in all habitats irrespective of effort in different habitats. Trophic level codes: H, herbivore; P, planktivore; 8, browser; Mi, microinvertivore; Ma, macroinvertivore; F, piscivore. Principal feeding zones: 5, surface; M, midwater, B, bottom. 'off' indicates feeding is usually away from the reef proper. Dashes indicate species observed in rapid visual samples but not in point samples. "*" indicates species observed after 5 min in random point samples (cont.).

TAXON	COMMON NAME	FREQUENCY (N = 417)	TOTAL ABUNDANCE	TROPHIC LEVEL (H,P,B, Mi,Ma,F)	FEEDING ZONE (S,M,B)	FEEDS OFF REEF
CREPUSCULARLY (Twlight) FEEDING FISHES						
CARANGIDAE (jacks)						
Alectis ciliaris	African pompano	-	-	Ma	B	off
Caranx bartholomaei	Yellow jack	18	48	F	M	
Caranx crysos	Blue runner	1	28	F	M	off
Caranx ruber	Bar jack	93	661	F	M	
Seriola dumerili	Greater amberjack	*	*	F	M	off
Trachinotus falcatus	Permit	6	8	Ma	B	off
GRAMMISTIDAE (soapfishes)						
Rypticus saponaceus	Greater soapfish	-	-	Ma,F	B	
SCORPAENIDAE (scorpionfishes)						
Scorpaena plumieri	Scorpion fish	-	-	F	B	
SERRANIDAE (sea basses)						
Epinephelus adscensionis	Rock hind	-	-	Ma,F	B	
Epinephelus cruentatus	Graysby	114	133	Ma,F	B	
Epinephelus fulvus	Coney	-	-	Ma,F	B	
Epinephelus guttatus	Red hind	-	-	Ma,F	B	
Epinephelus itajara	Jewfish	-	-	Ma,F	B	
Epinephelus morio	Red grouper	1	1	Ma,F	B	
Epinephelus striatus	Nassau grouper	2	2	Ma,F	B	
Mycteroperca bonaci	Black grouper	9	9	F	B	
SPHYRAENIDAE (barracudas)						
Sphyraena barracuda	Barracuda	69	107	F	M	
SYNODONTIDAE (lizardfishes)						
Synodus intermedius	Sand diver	2	2	F	B	

Table 7.6. Trophic structure of fishes at Looe Key National Marine Sanctuary. Species, listed alphabetically by family and genus, are grouped according to times of major feeding activity (diurnal, nocturnal, crepuscular, and generally active). Abundance values are based on all random point samples in all habitats irrespective of effort in different habitats. Trophic level codes: H, herbivore; P, planktivore; 8, browser; Mi, microinvertivore; Ma, macroinvertivore; F, piscivore. Principal feeding zones: 5, surface; M, midwater, B, bottom. 'off' indicates feeding is usually away from the reef proper. Dashes indicate species observed in rapid visual samples but not in point samples. "*" indicates species observed after 5 min in random point samples (cont.).

TAXON	COMMON NAME	FREQUENCY (N = 417)	TOTAL ABUNDANCE	TROPHIC LEVEL (H,P,B, Mi,Ma,F)	FEEDING ZONE (S,M,B)	FEEDS OFF REEF
	DAY AND NIGHT FEEDING FISHES					
CARANGIDAE (jacks)						
Decapterus macarellus	Mackerel scad	1	70	P	M	off
Decapterus punctatus	Round scad	1	150	P	M	off
DASYATIDAE (stingrays)						
Dasyatis americana	Southern stingray	-	-	Ma	B	off
Urolophus jamaicensis	Yellow stingray	9	9	Ma	B	off
ECHENEIDAE (remoras)						
Echeneis naucrates	Sharksucker	6	6	F	M	off
ELOPIDAE (tarpons)						
Meqalops atlanticus	Tarpon	2	2	F	S,M	off
MYLIOBATIDAE (Eagle rays)						
Aetobatus narinari	Spotted eagle ray			Ma	B	off
SCOMBRIDAE (mackerels)						
Scomberomorus cavalla	King mackerel	1	1	F	M	off
Scomberomorus maculatus	Spanish mackerel.	1	1	F	M	off
Scomberomorus regalis	Cero	3	3	F	M	off

Table 7.7. Summary of trophic activity analysis of fishes censused in Looe Key National Marine Sanctuary. Data summarized from Table 7.6. Classification was based an primary behavior of adults.

PRIMARY TROPHIC CLASSIFICATION:	HERBIVORE	PLANKTI-VORE	CARNIVOROUS BROWSER	MICRO-INVERTI-VORE	MACRO INVERTI-VORE	PISCIVORE	TOTAL
NUMBER OF SPECIES							
DIURNAL SPECIES	33	18	14	31	16	4	116 (62%)
NOCTURNAL SPECIES	0	11	0	1	25	8	45 (24%)
CREPUSCULAR SPECIES	0	0	0	0	8	10	18 (9%)
GENERALLY ACTIVE SPECIES	0	2	0	0	3	5	10 (5%)
TOTAL	33 (17%)	31 (16%)	14 (8%)	32 (17%)	52 (27%)	27 (14%)	189 (100%)
NUMBER OF INDIVIDUALS							
DIURNAL SPECIES	10,095	34,603	1,160	7,362	577	31	53,828 (73%)
NOCTURNAL SPECIES	0	847	0	346	17,341	378	18,912 (26%)
CREPU5CULAR SPECIES	0	0	0	0	141	858	999 (1%)
GENERALLY ACTIVE SPECIES	0	220	0	0	9	13	242 (0%)
TOTAL	10,095 (14%)	35,670 (48%)	1,160 (2%)	7,706 (10%)	18,068 (24%)	1,280 (2%)	73,981 (100%)

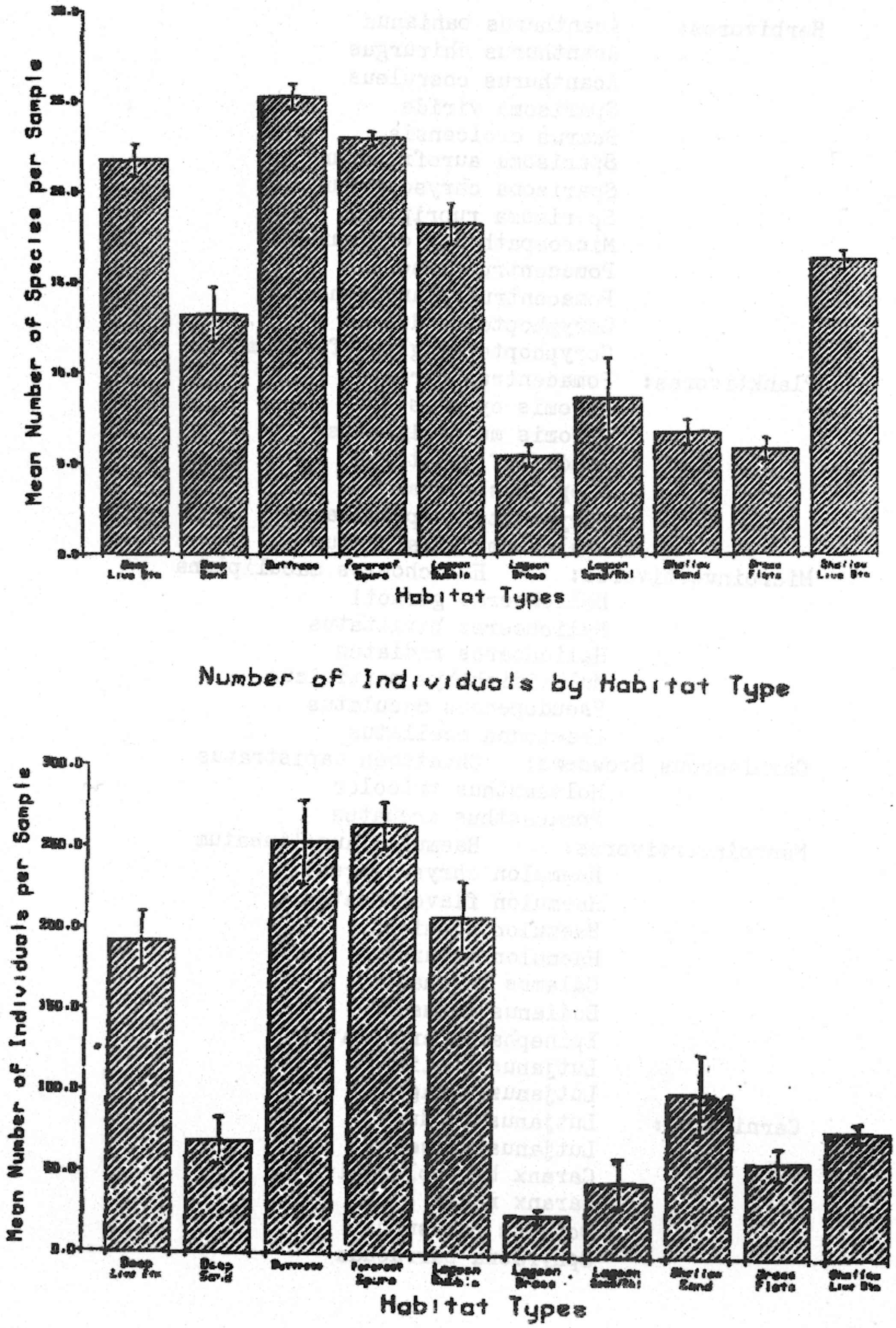
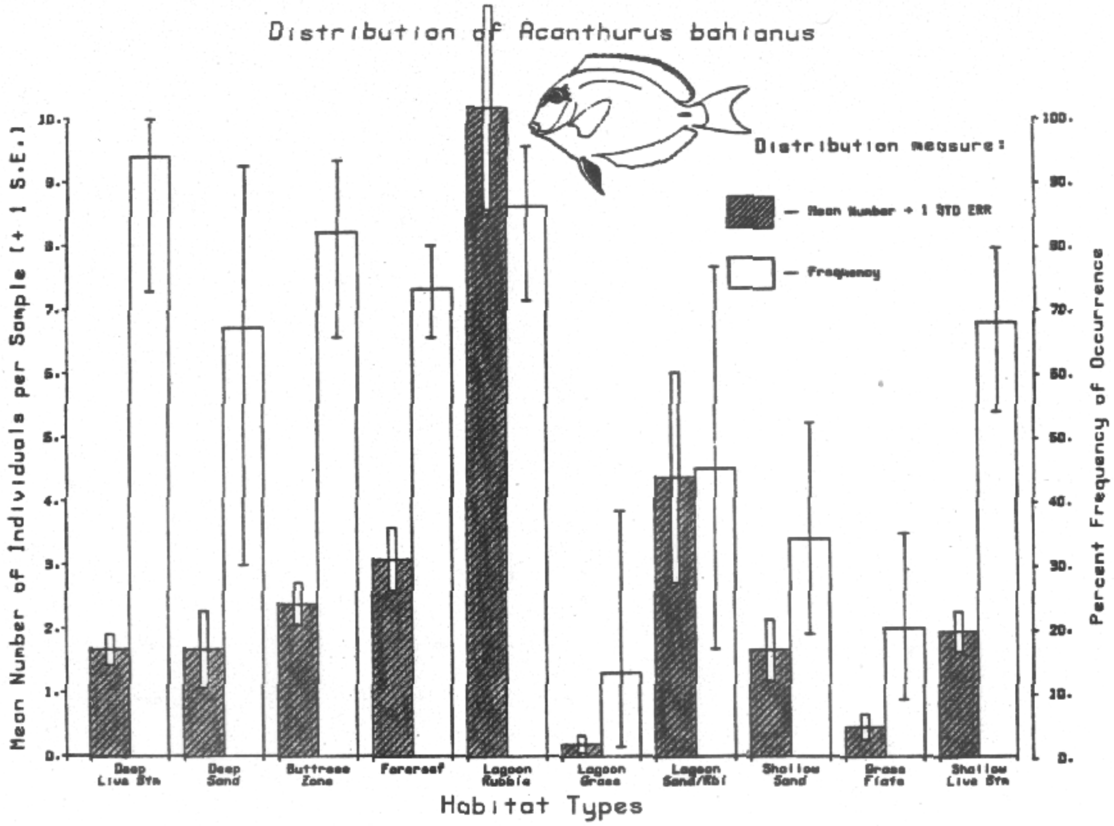
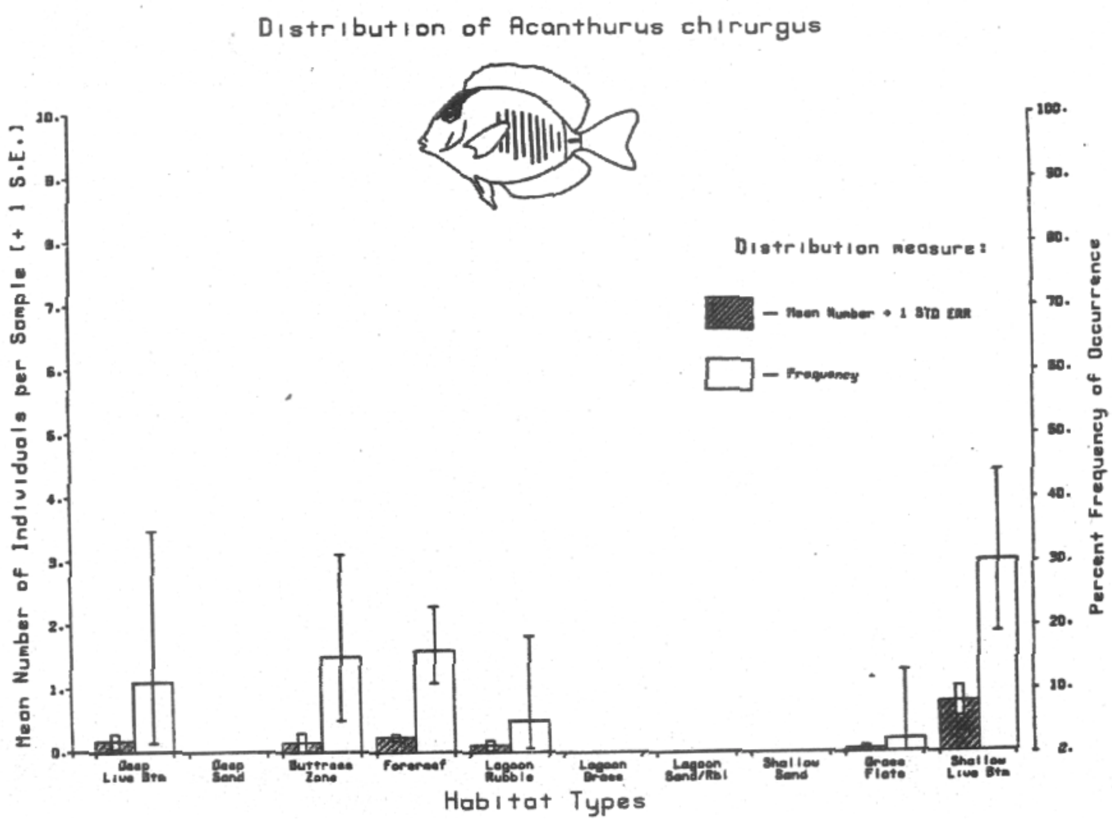


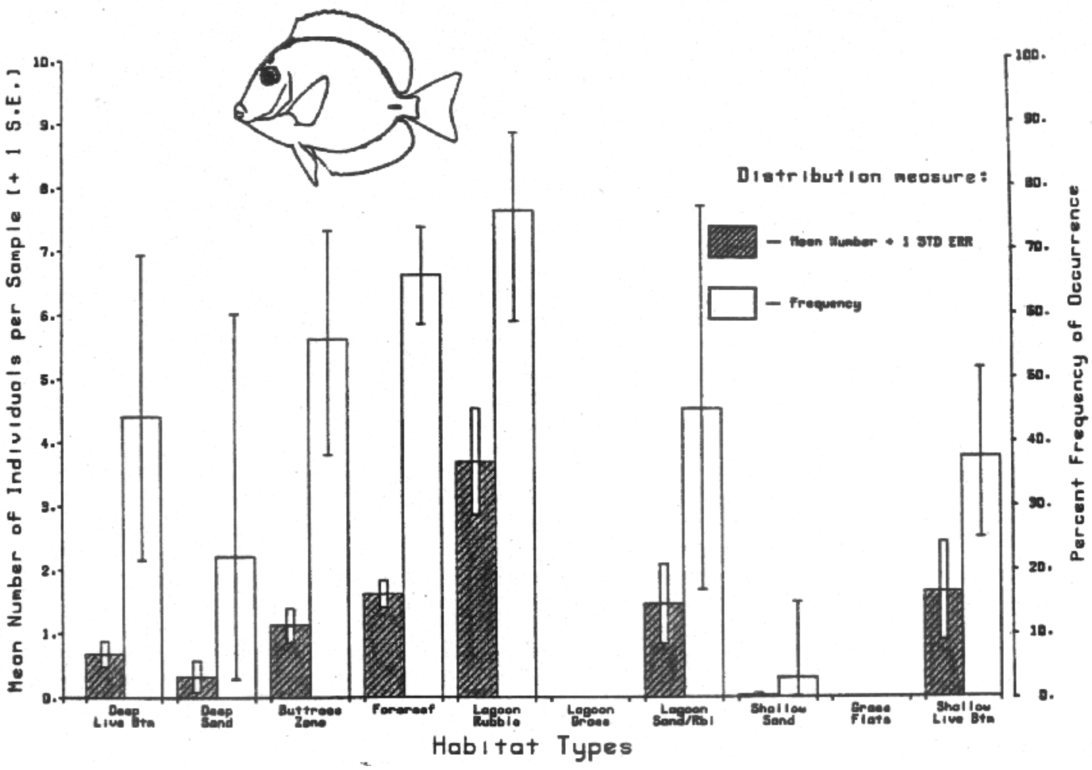
Figure 7.1. Mean number of species and individuals per point sample by habitat. Vertical lines show ±1 standard error of the mean.

Appendix 7.A. Abundance, distribution, and frequency of occurrence of selected species at Looe Key National Marine Sanctuary. Vertical bars show 95% confidence limits and vertical lines show ± one standard error of the mean. Data are presented in Tables 7.4 and 7.5.

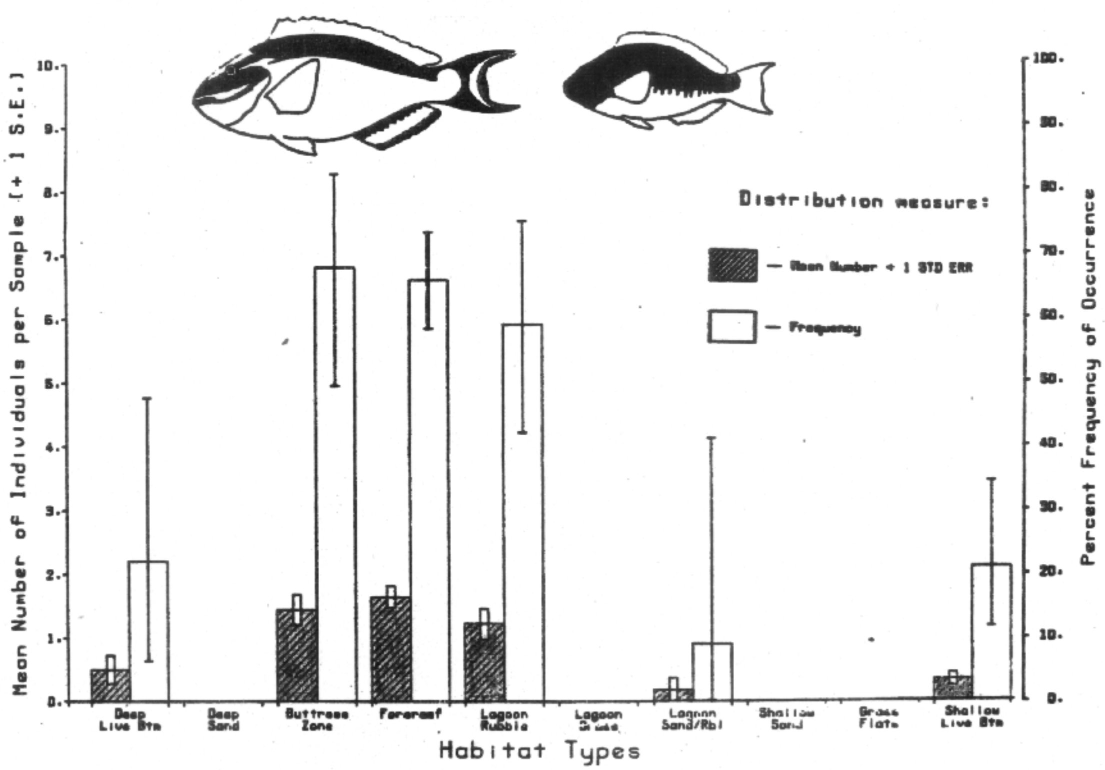

Distribution of Acanthurus bahianus
Distribution measure:
— Mean Number + 1 STD ERR
— Frequency
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types


Distribution of Acanthurus chirurgus
Distribution measure:
— Mean Number + 1 STD ERR
— Frequency
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types

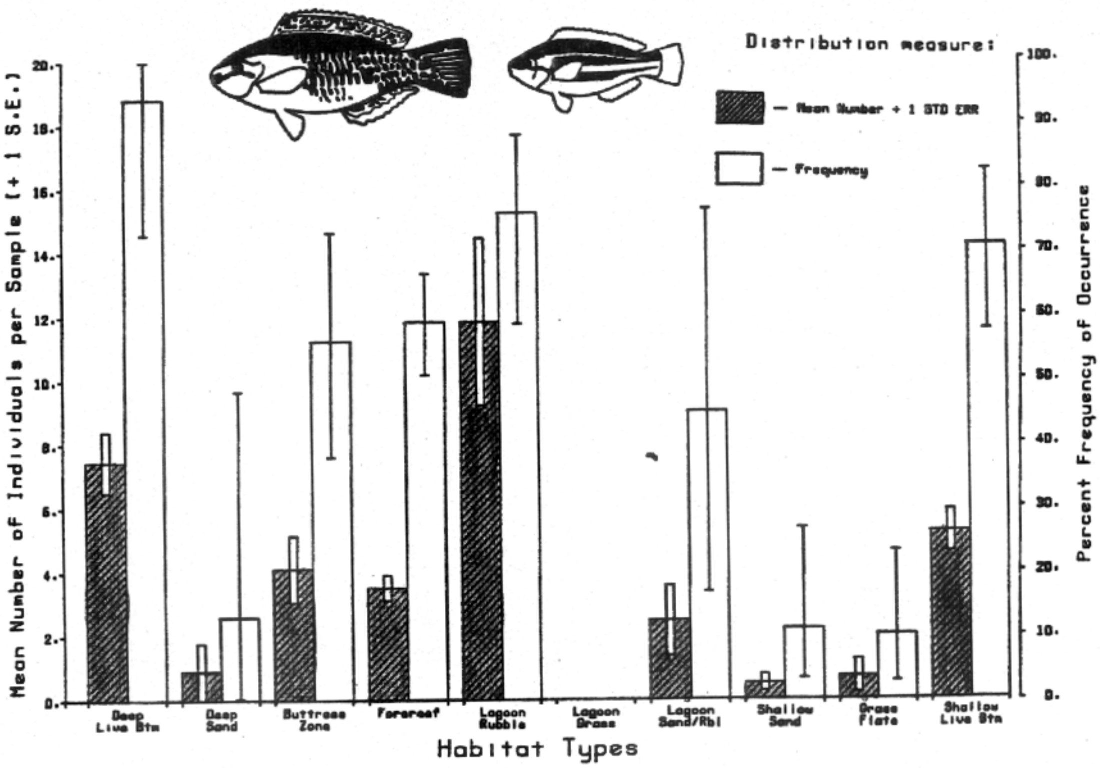
Distribution of Acanthurus coeruleus



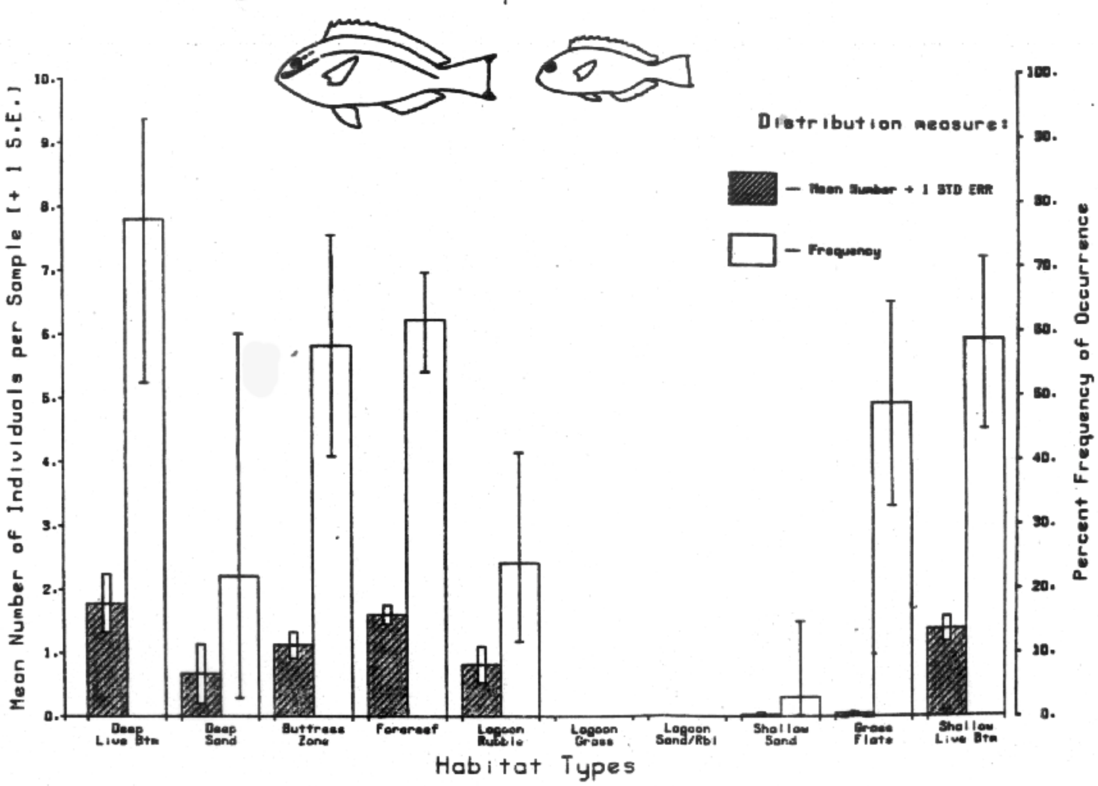
Distribution of Sparisoma viride

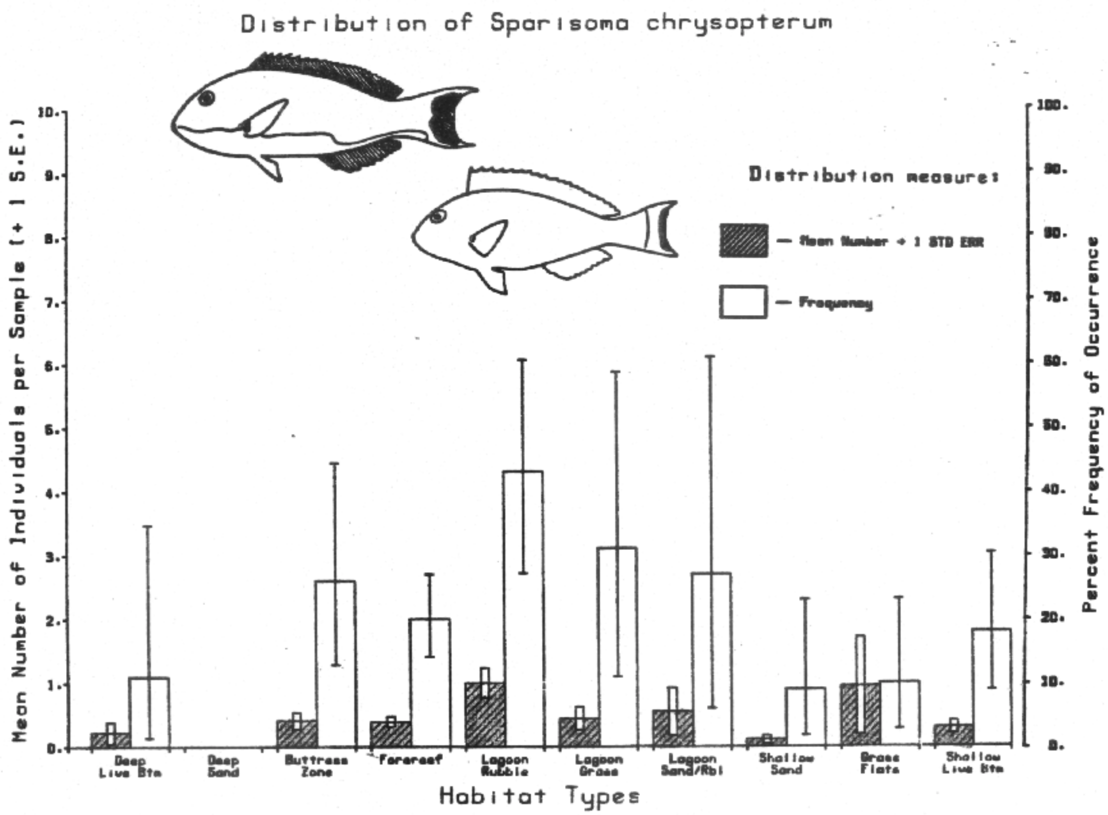


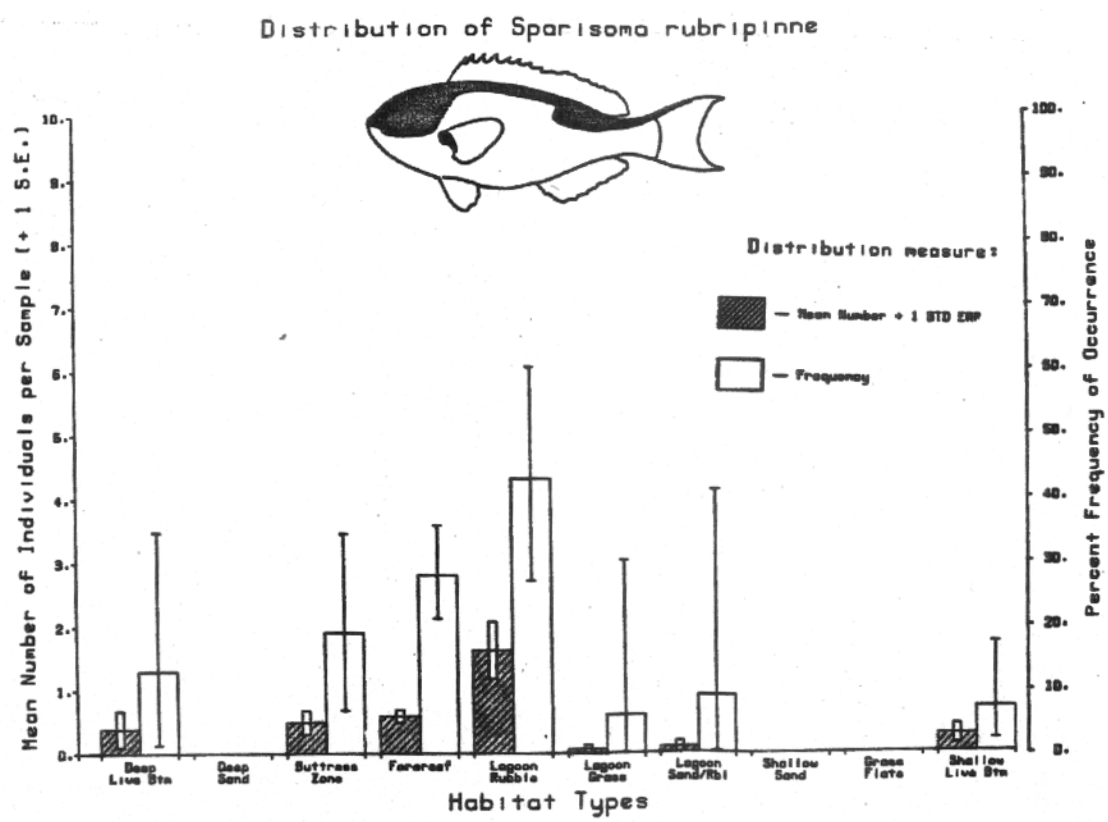
Distribution of Scarus croicensis



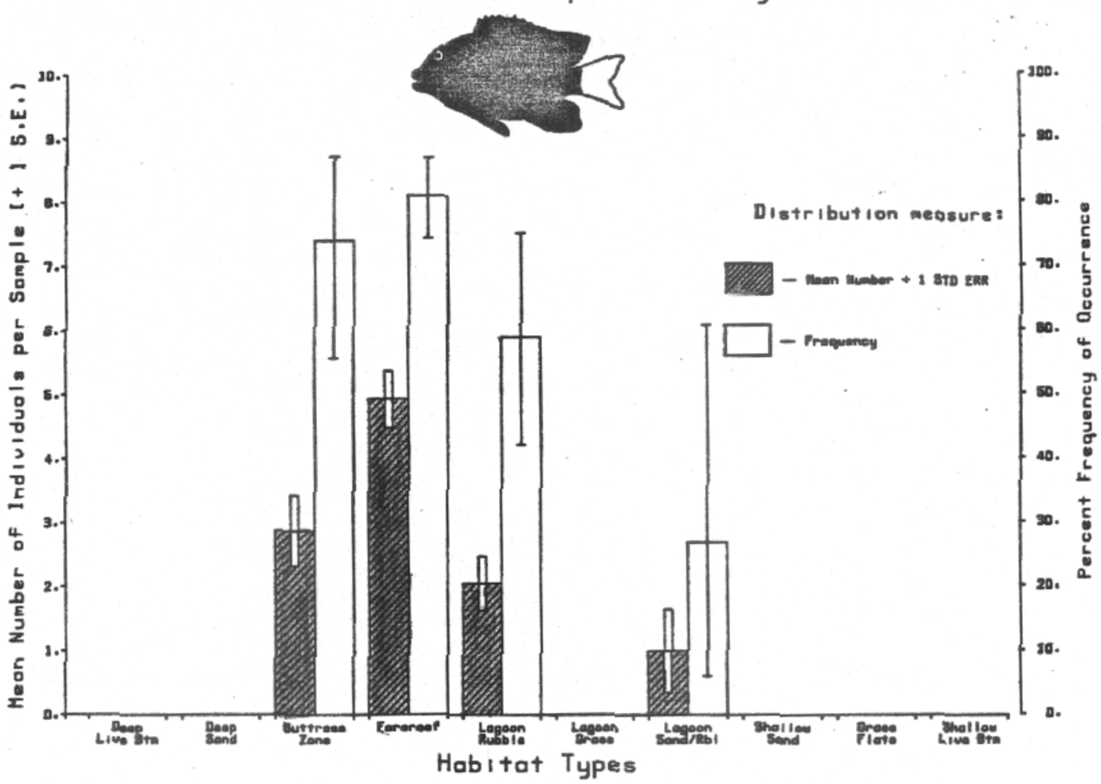
Distribution of Sparisoma aurofrenatum



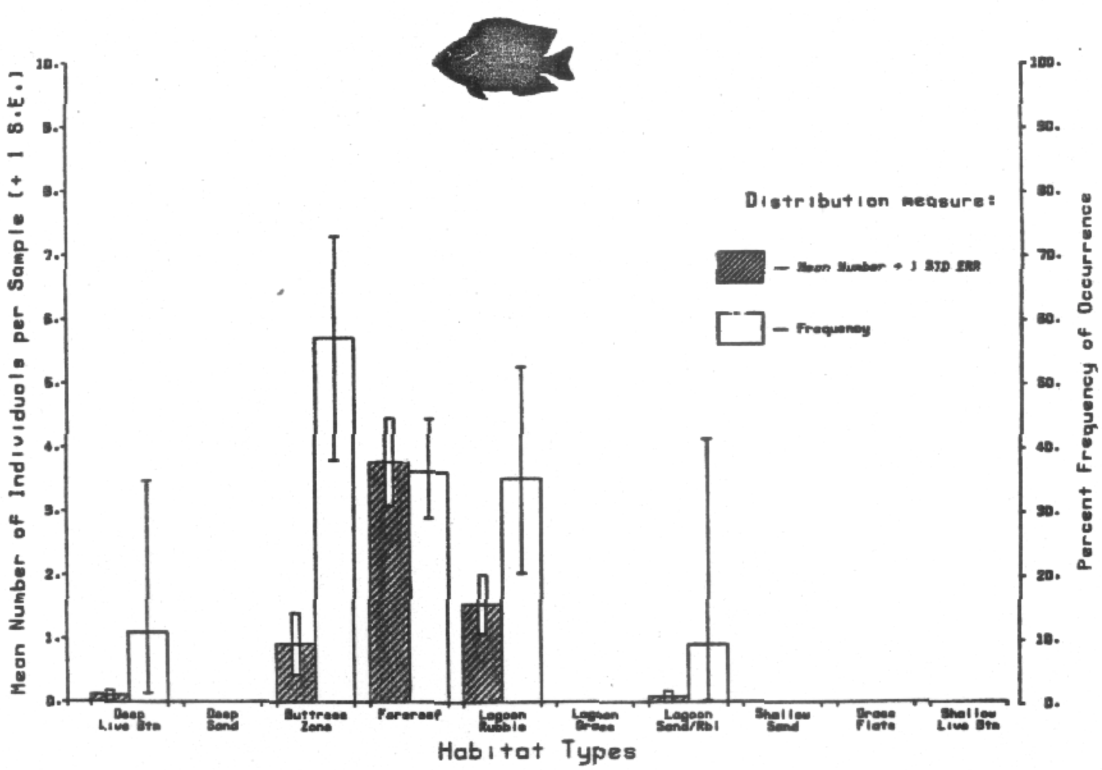

Distribution of Sparisoma chrysopterum
Distribution measure:
— Mean Number + 1 STD ERR
— Frequency
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types


Distribution of Sparisoma rubripinne
Distribution measure:
— Mean Number + 1 STD ERR
— Frequency
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types

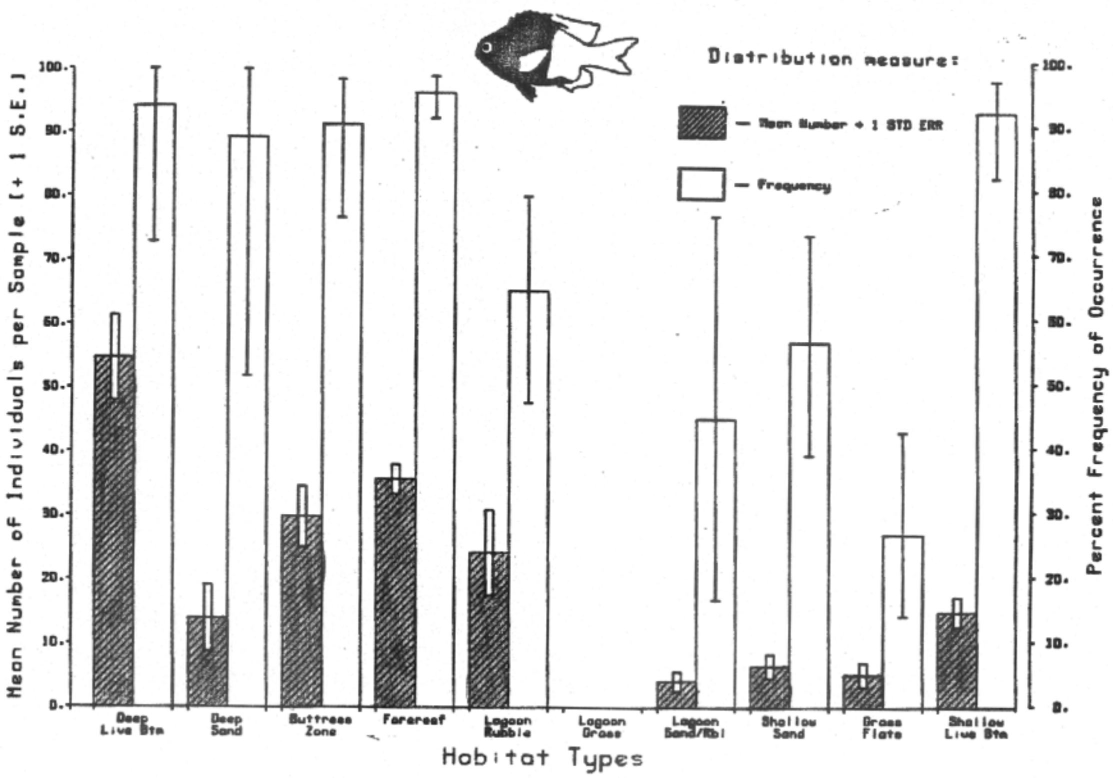
Distribution of *Microspathodon chrysurus*



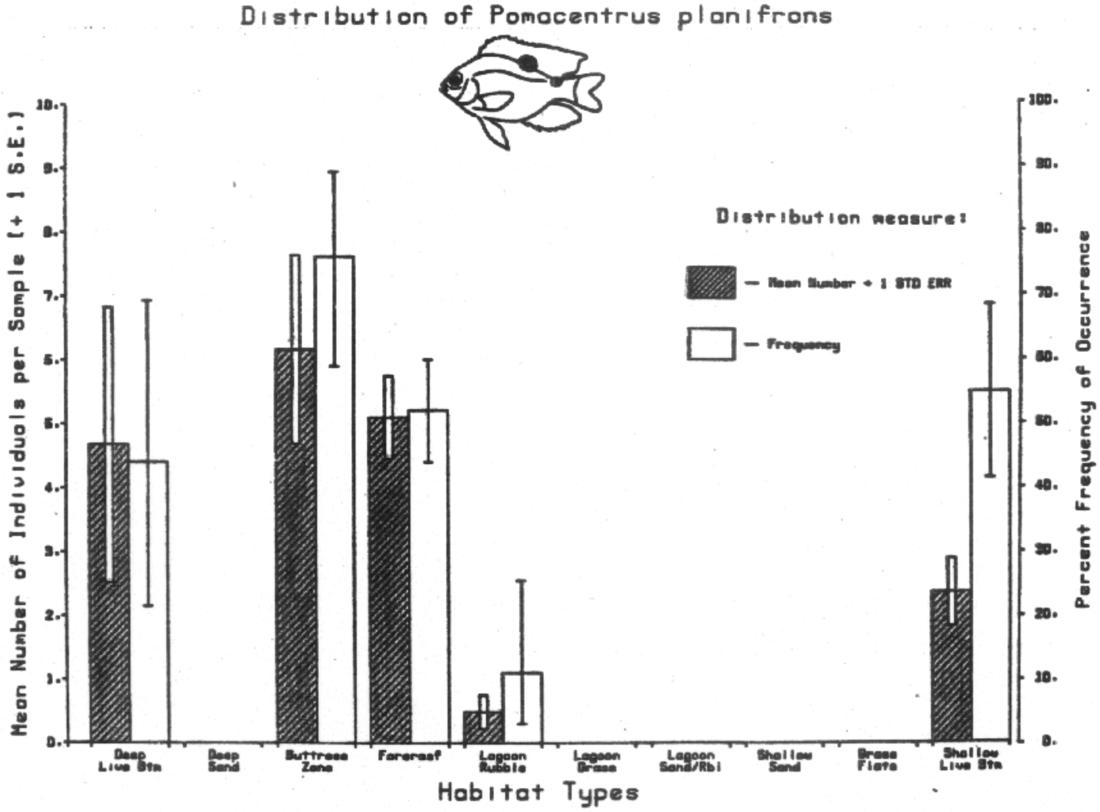
Distribution of *Pomacentrus fuscus*



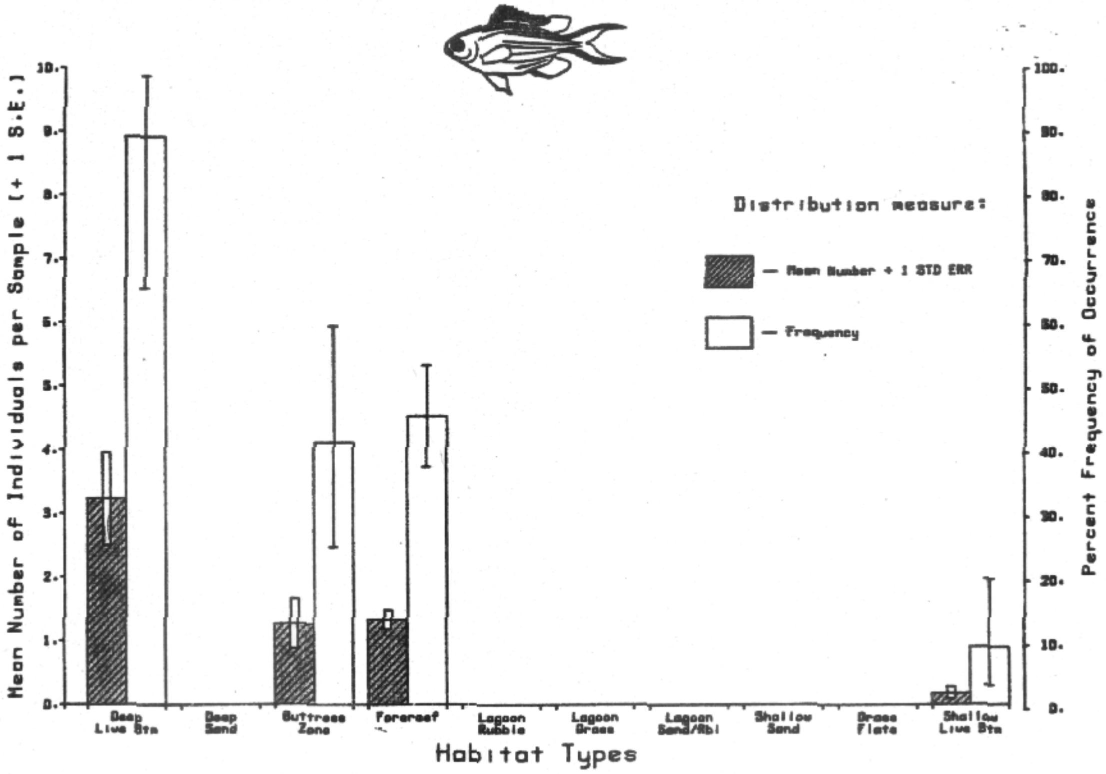
Distribution of Pomacentrus partitus



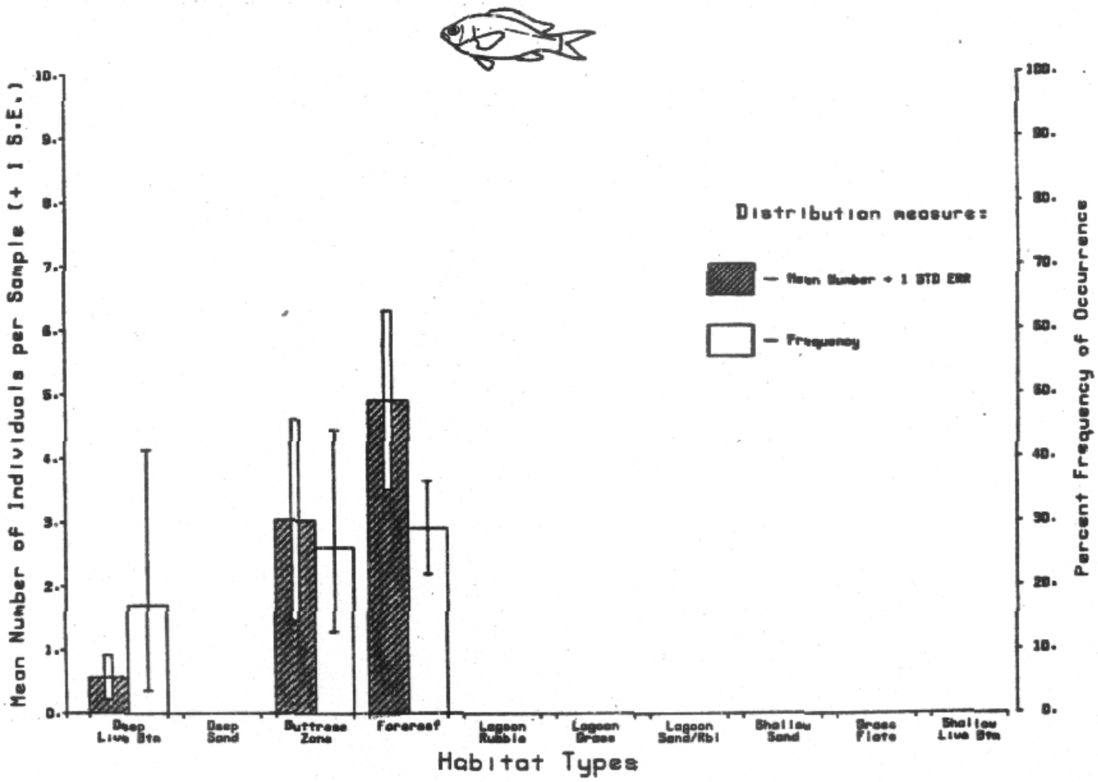
Distribution of Pomacentrus planifrons

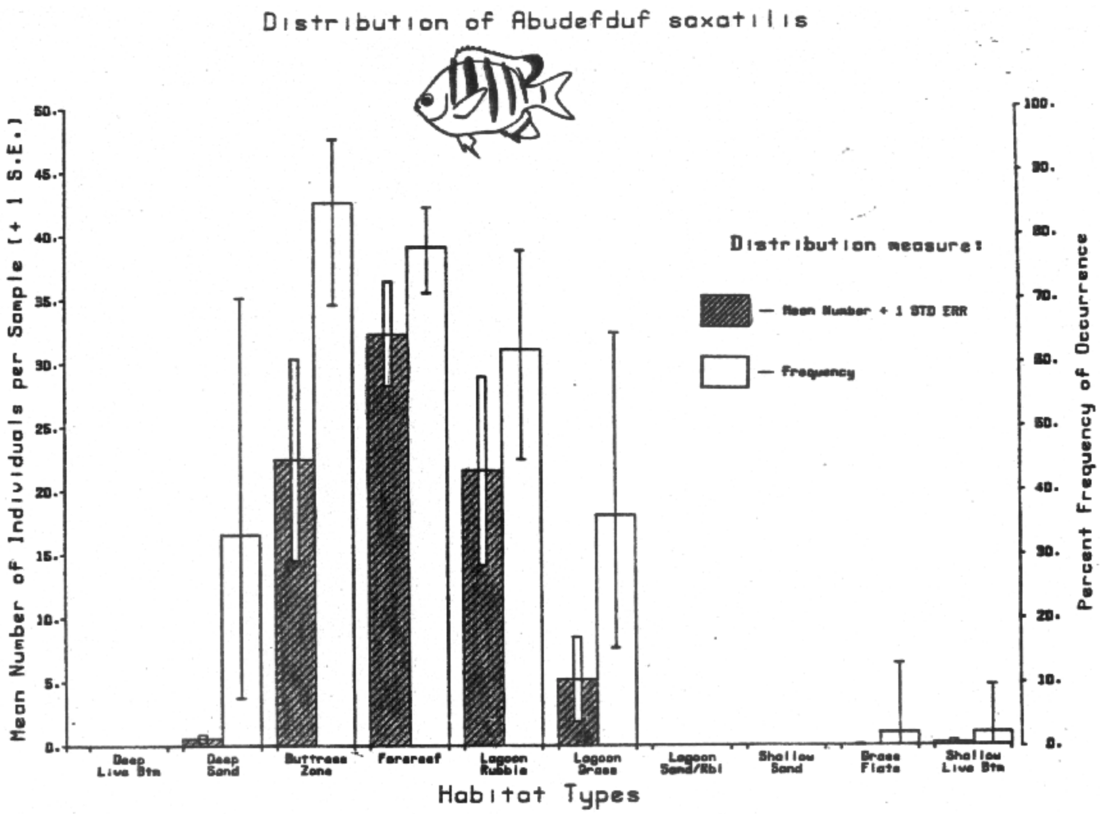


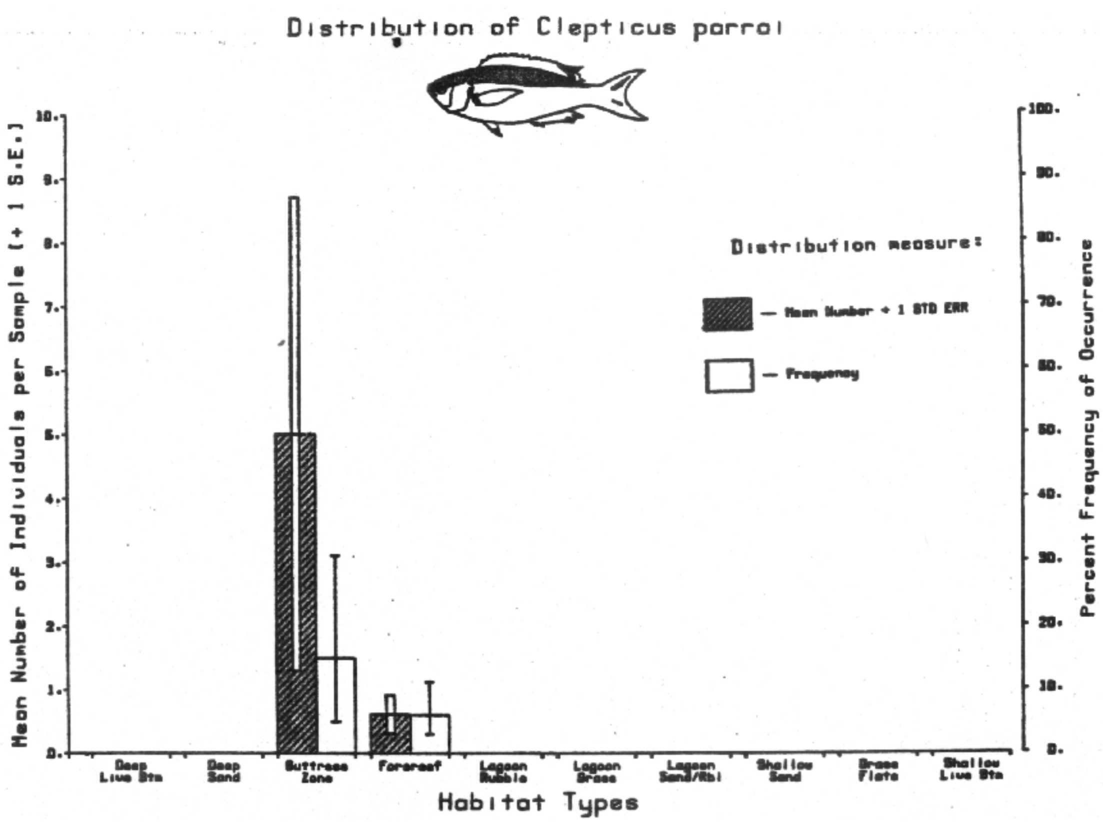
Distribution of Chromis cyaneus

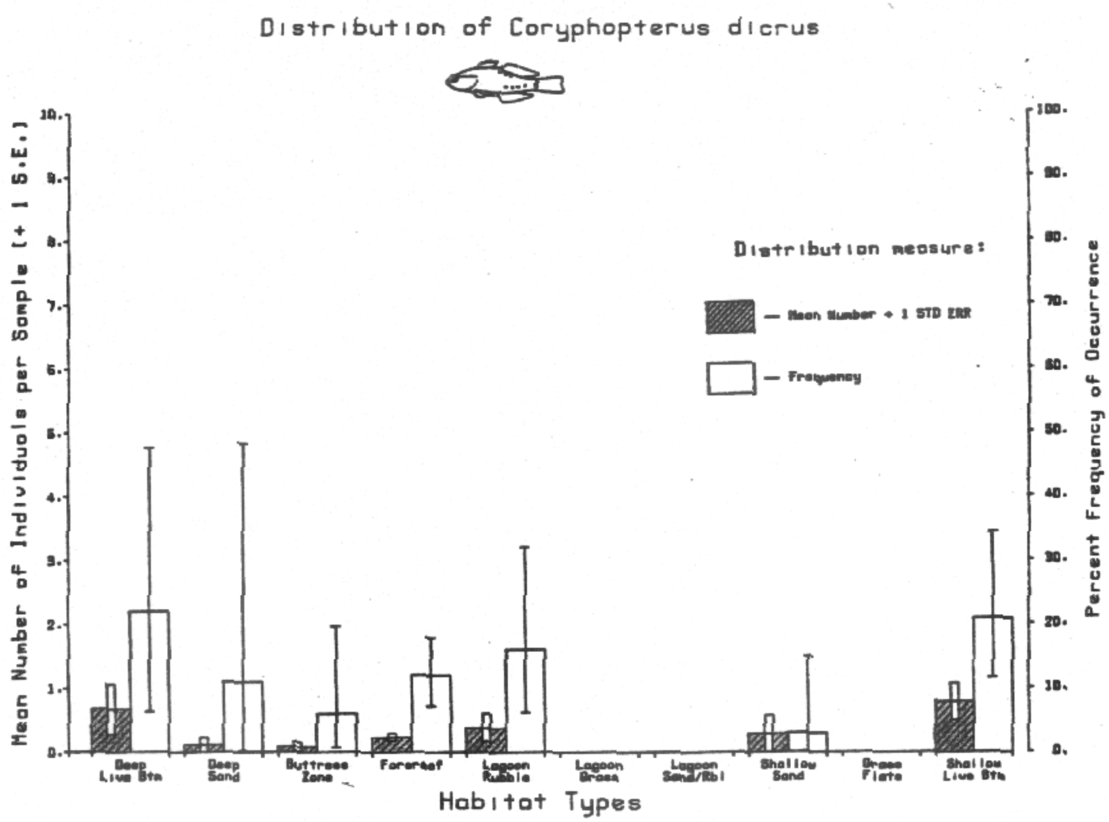


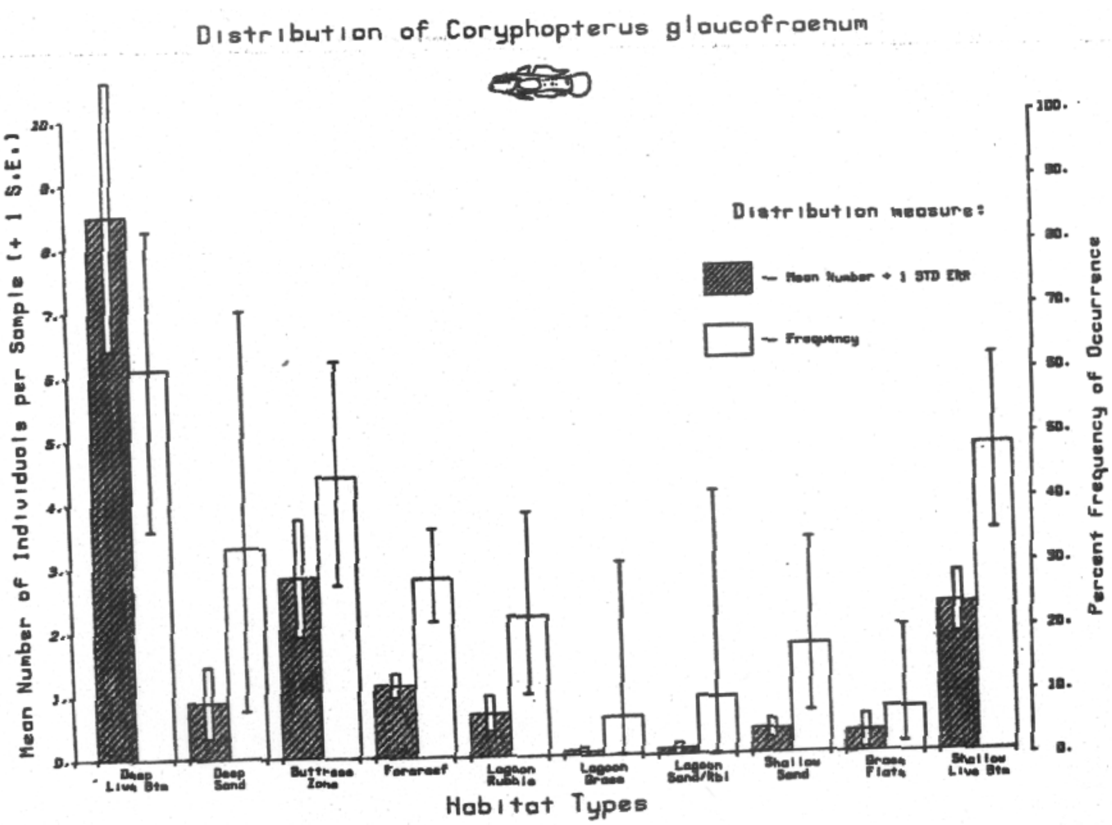
Distribution of Chromis multilineatus



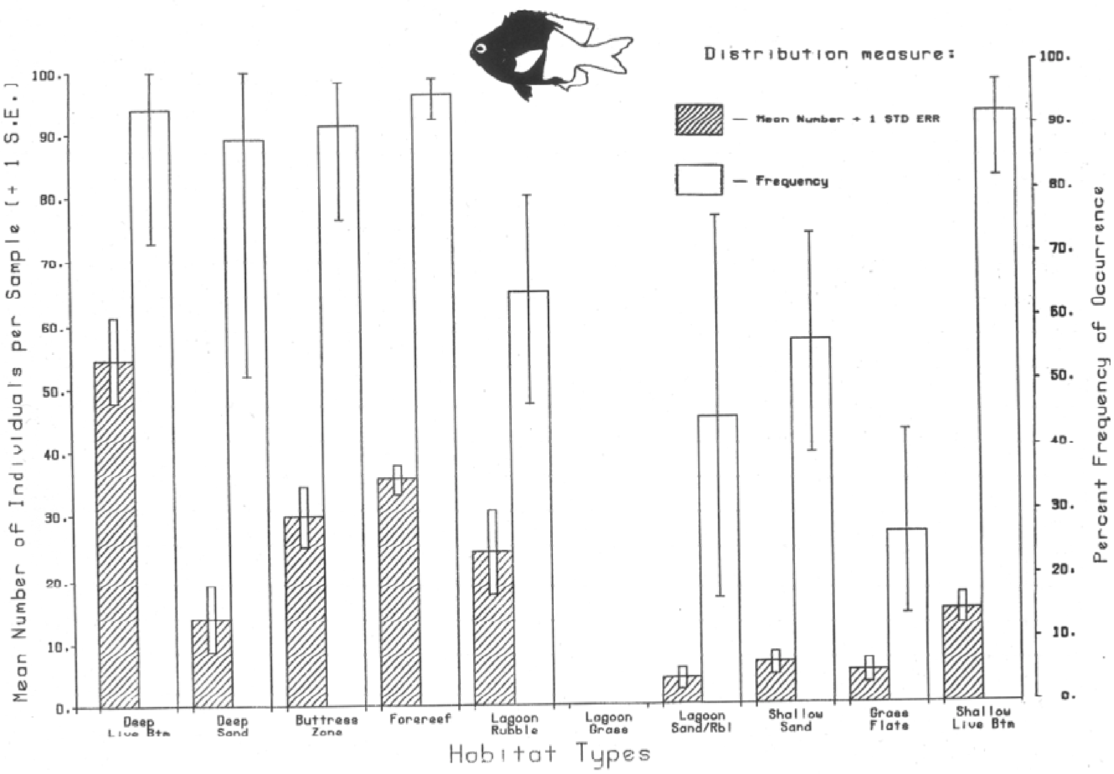

Distribution of Abudefduf saxatilis
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Distribution measure:
— Mean Number + 1 STD ERR
— Frequency
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types


Distribution of Clepticus parrai
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Distribution measure:
— Mean Number + 1 STD ERR
— Frequency
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types

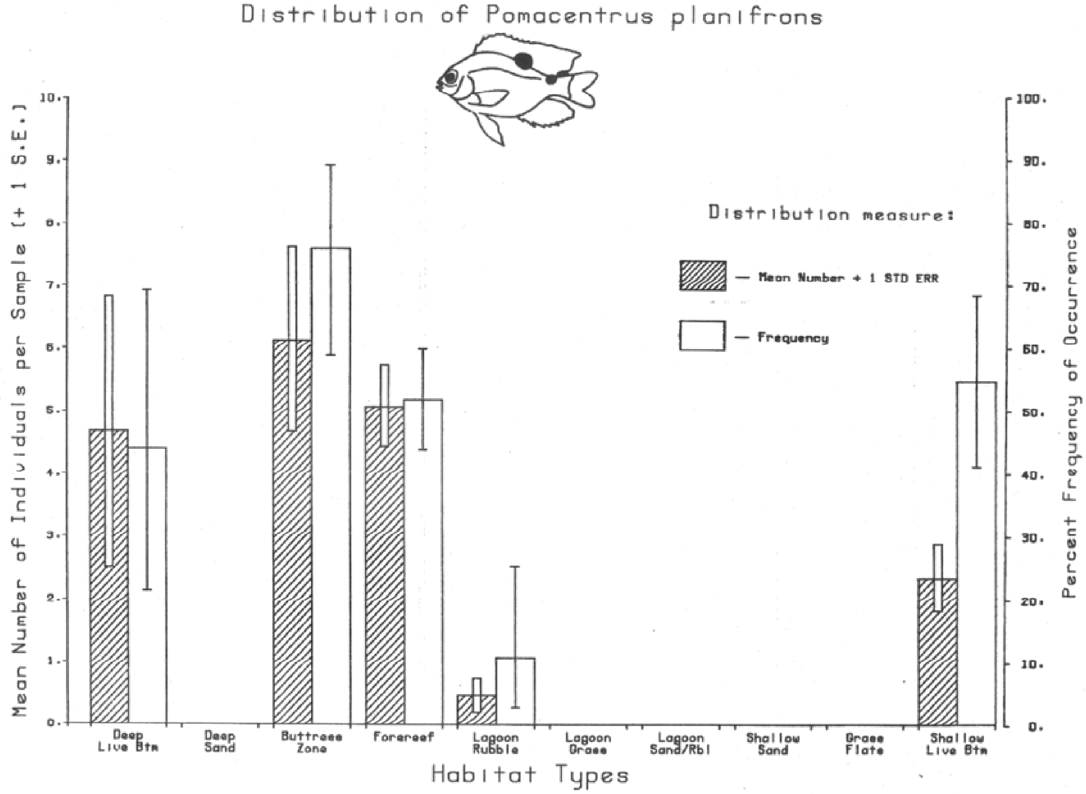

Distribution of Coryphopterus dicrus
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Distribution measure:
— Mean Number + 1 STD ERR
— Frequency
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types

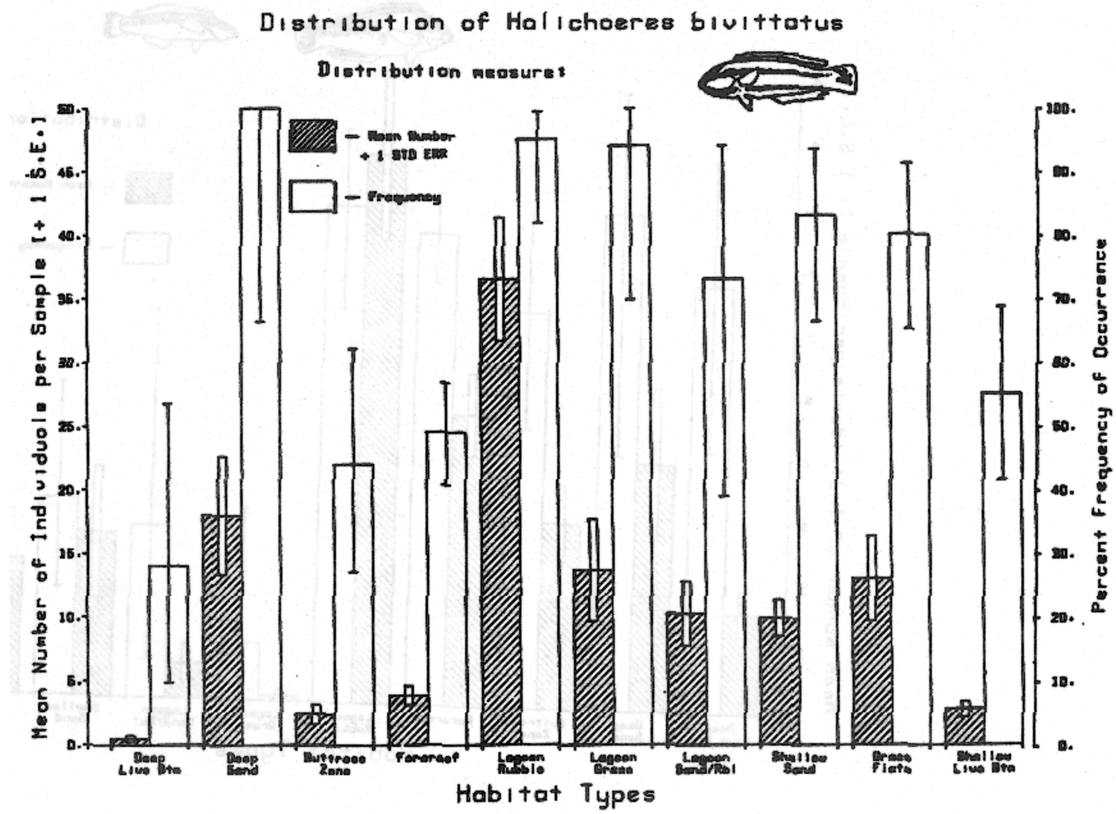

Distribution of Coryphopterus glaucofraenum
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Distribution measure:
— Mean Number + 1 STD ERR
— Frequency
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types

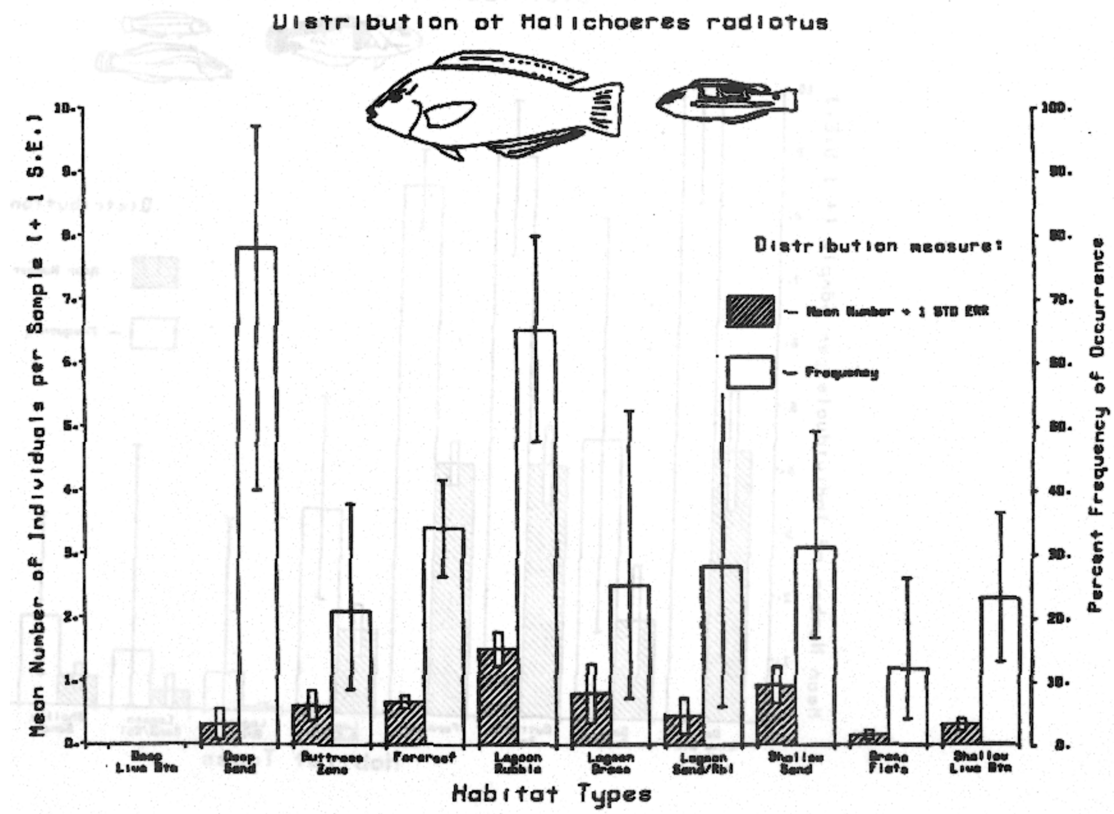
Distribution of Pomacentrus partitus



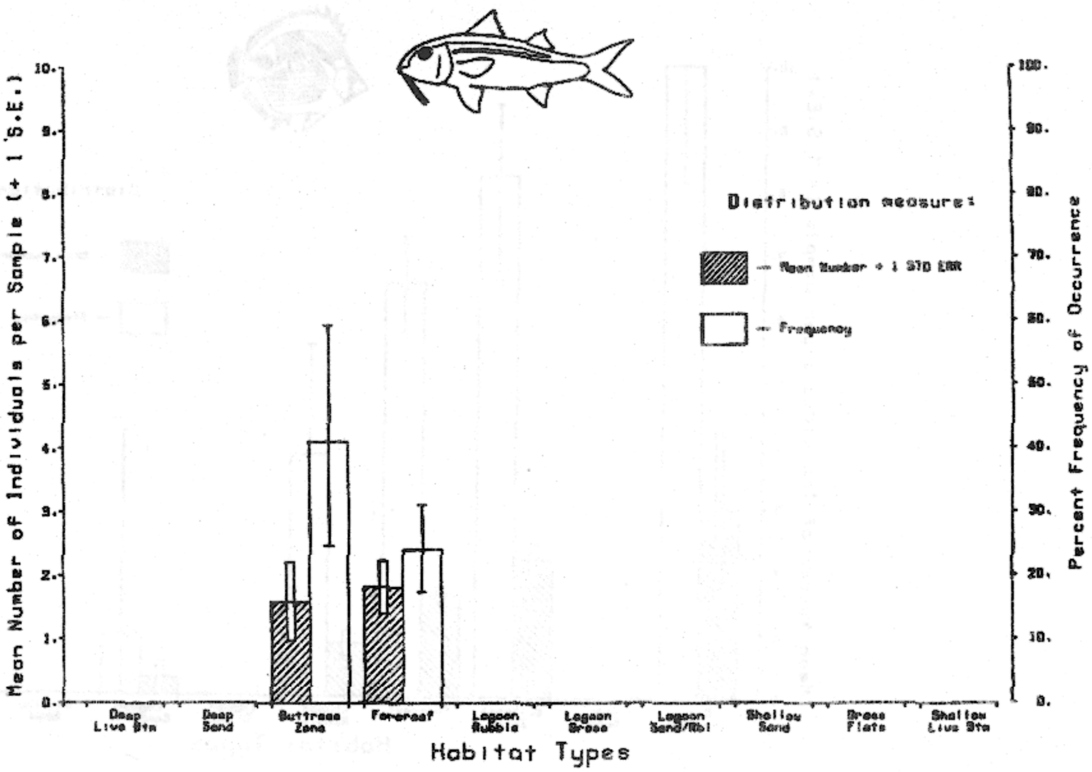
Distribution of Pomacentrus planifrons



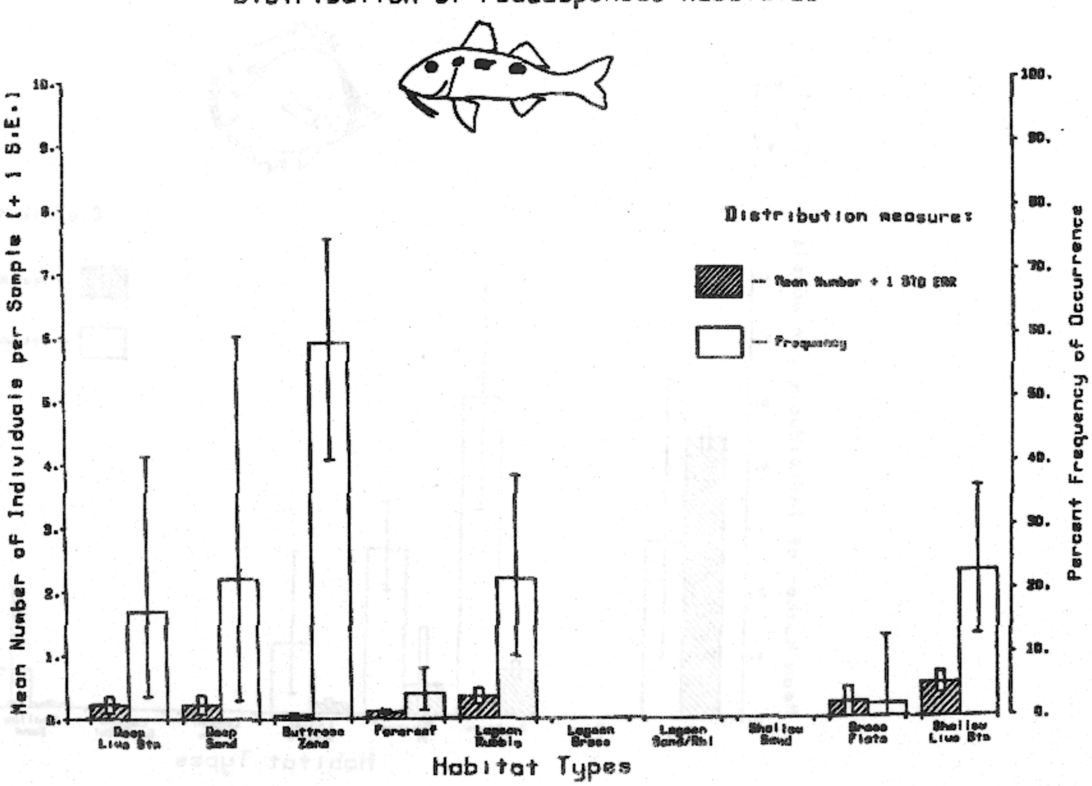

Distribution of Halichoeres bivittatus
Distribution measure:
— Mean Number + 1 STD ERR
— Frequency
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types

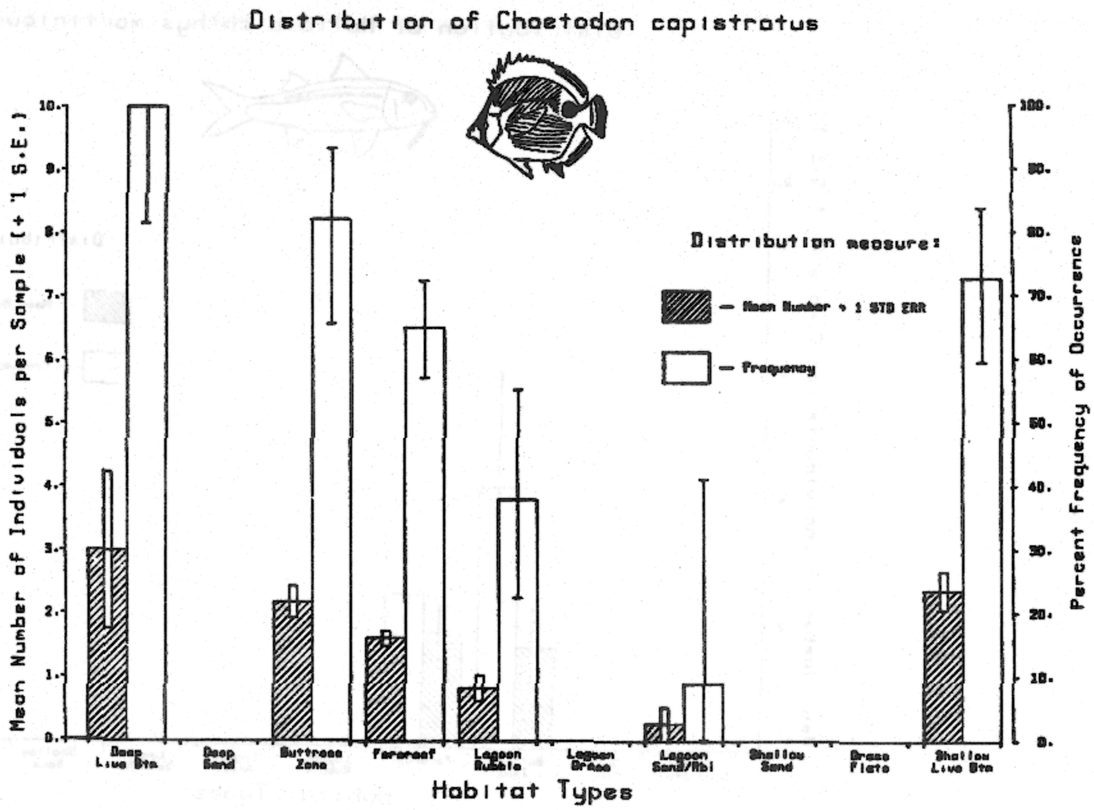

Distribution of Halichoeres radiatus
Distribution measure:
— Mean Number + 1 STD ERR
— Frequency
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types

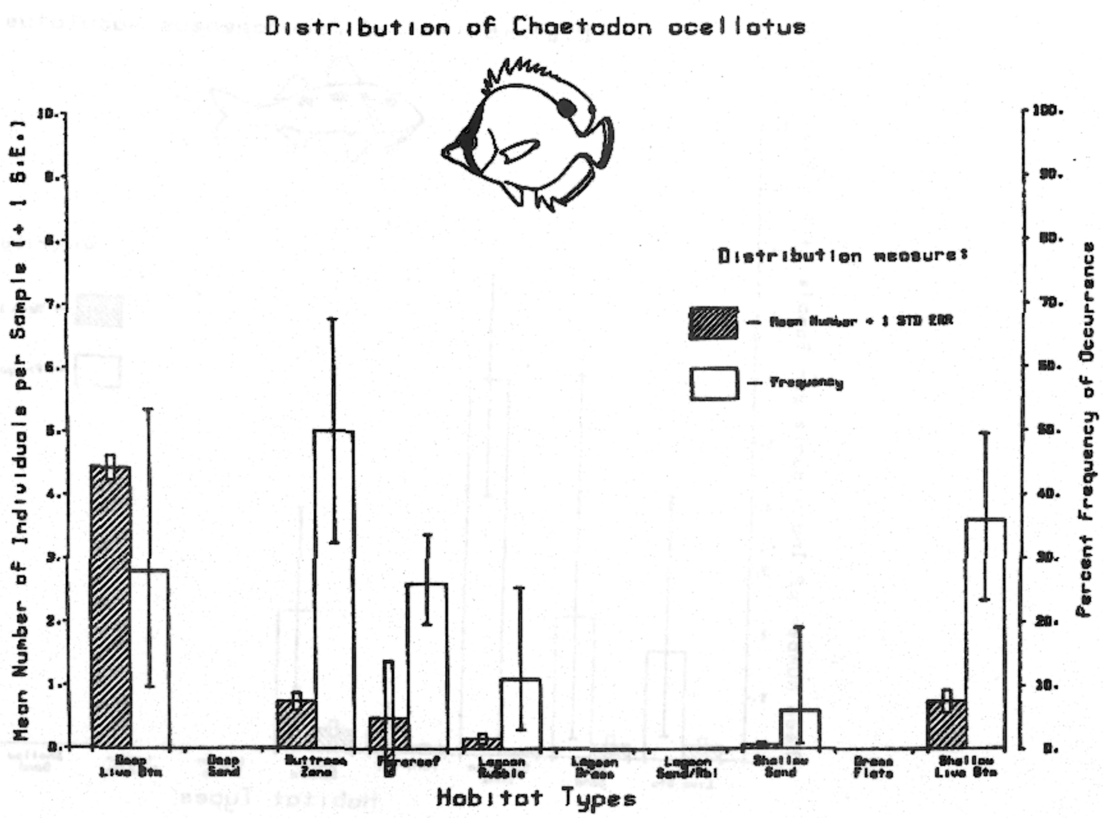
Distribution of Mulloidichthys martinicus



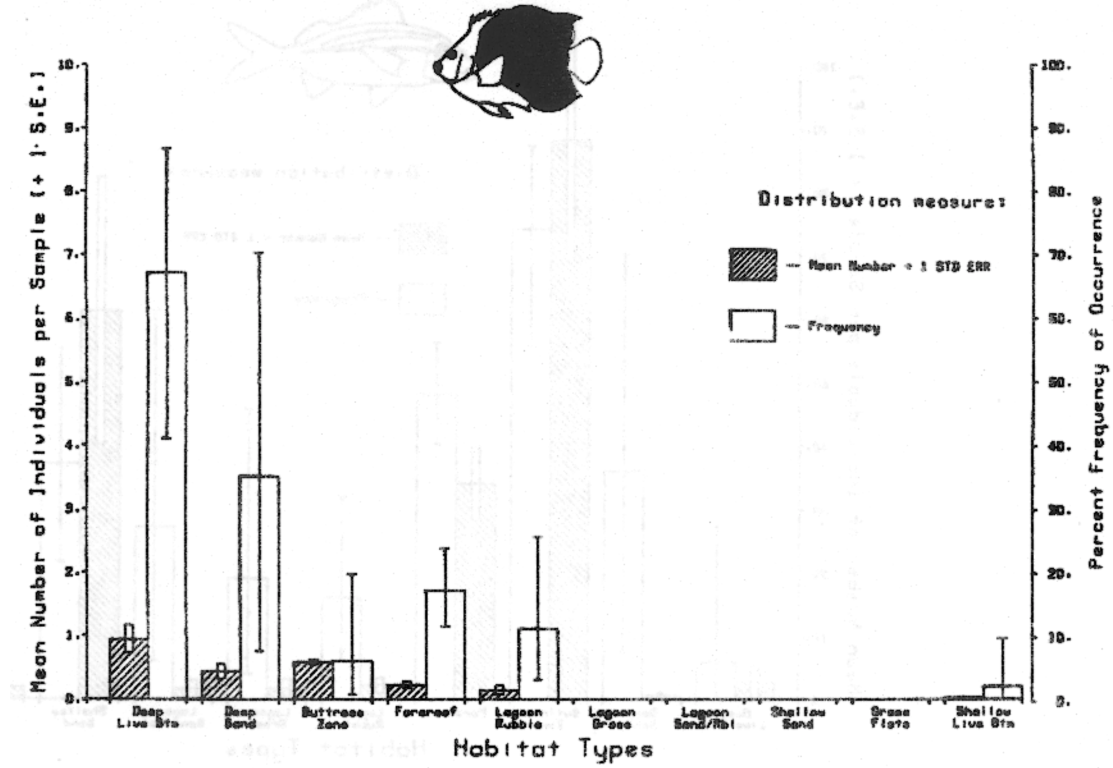
Distribution of Pseudopeneus maculatus



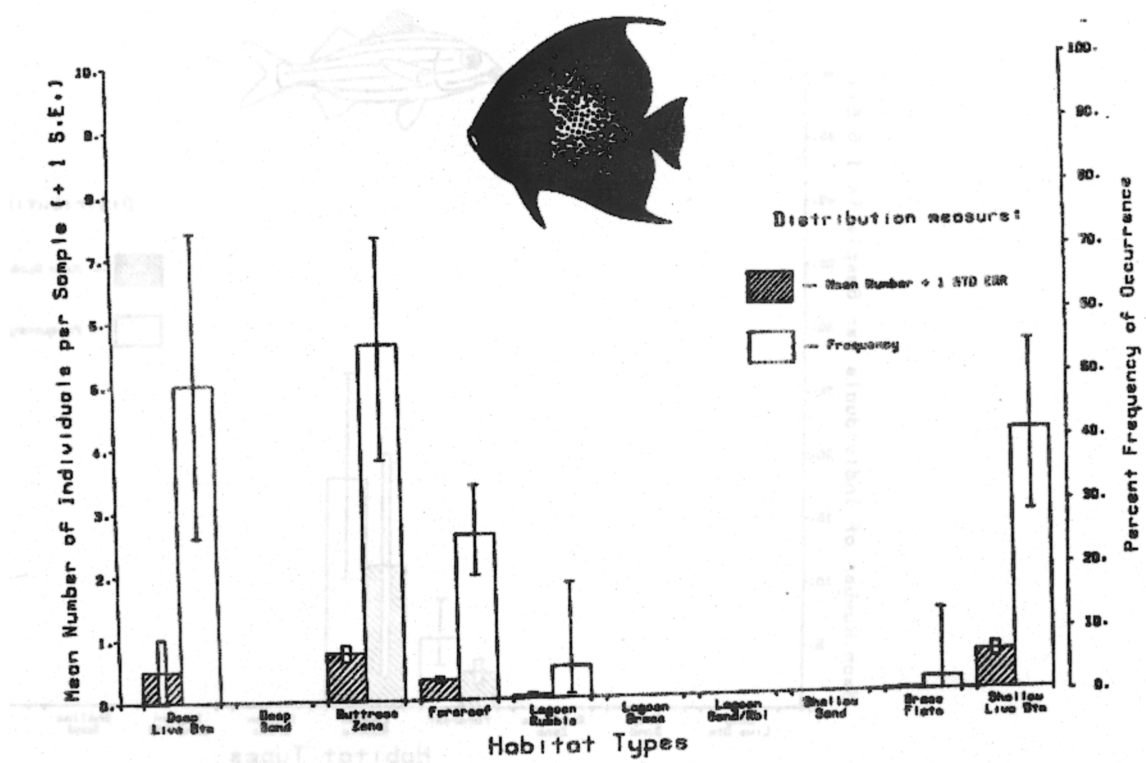

Distribution of Chaetodon capistratus
Distribution measure:
— Mean Number + 1 STD ERR
— Frequency
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types


Distribution of Chaetodon ocellatus
Distribution measure:
— Mean Number + 1 STD ERR
— Frequency
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types

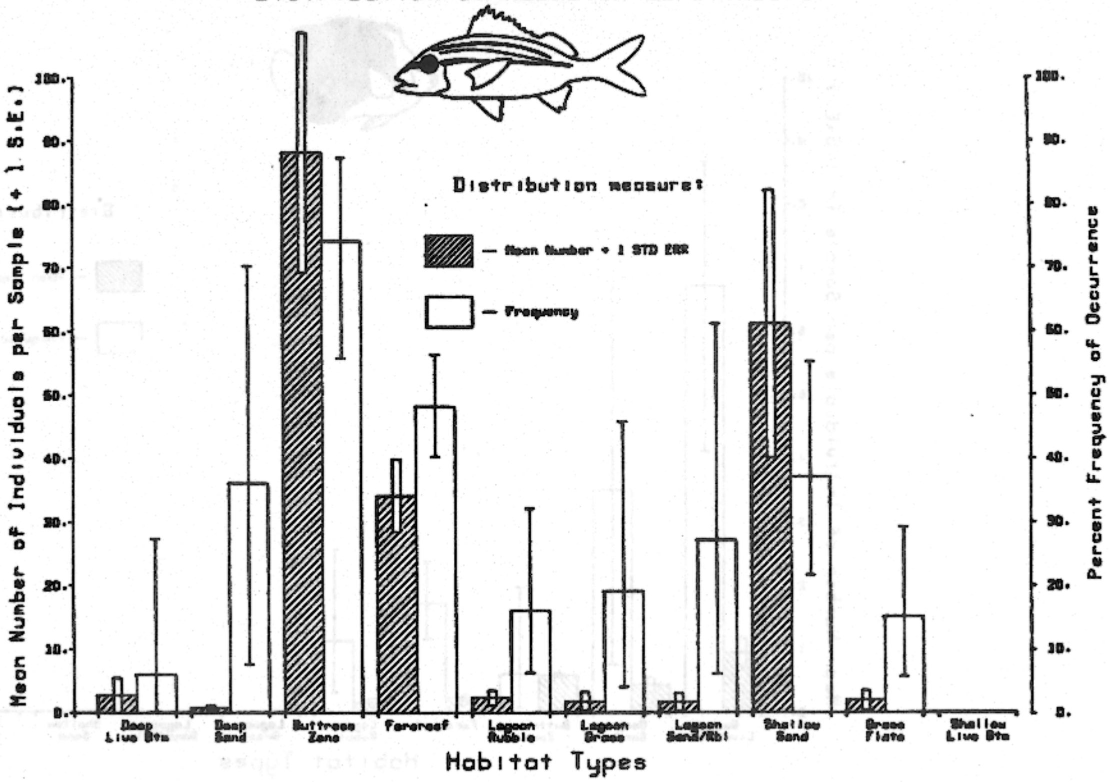
Distribution of Holacanthus tricolor



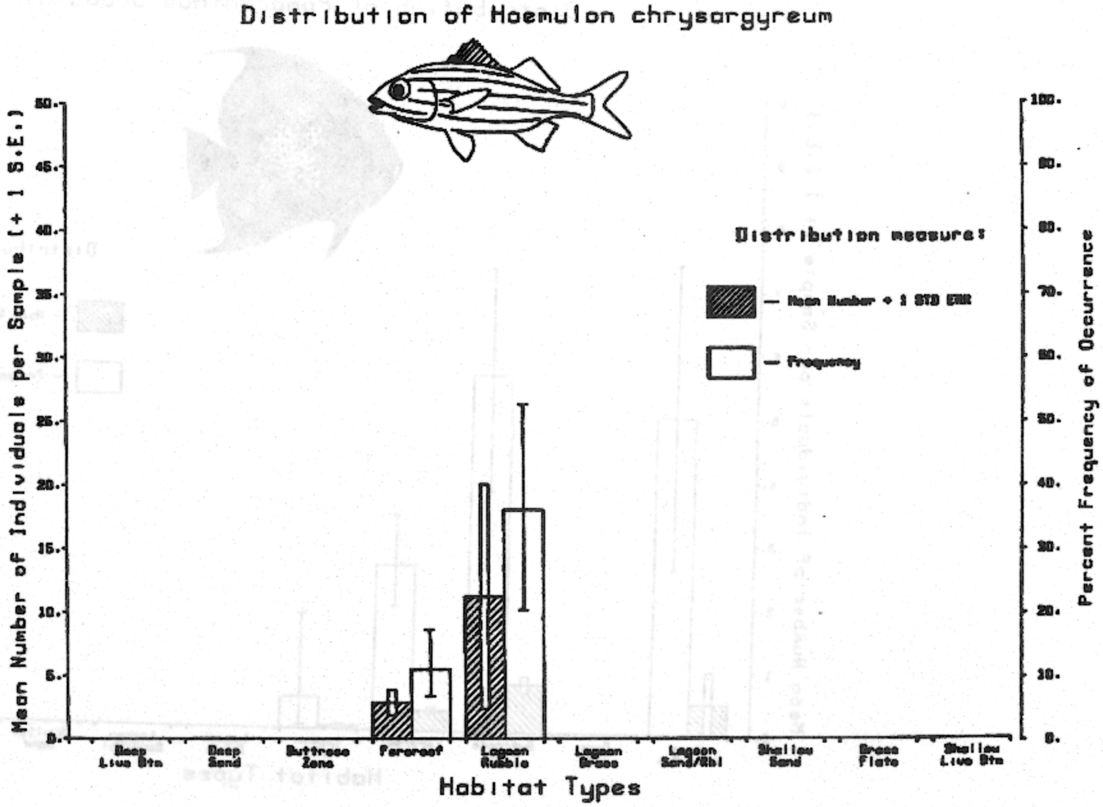
Distribution of Pomacanthus arcuatus



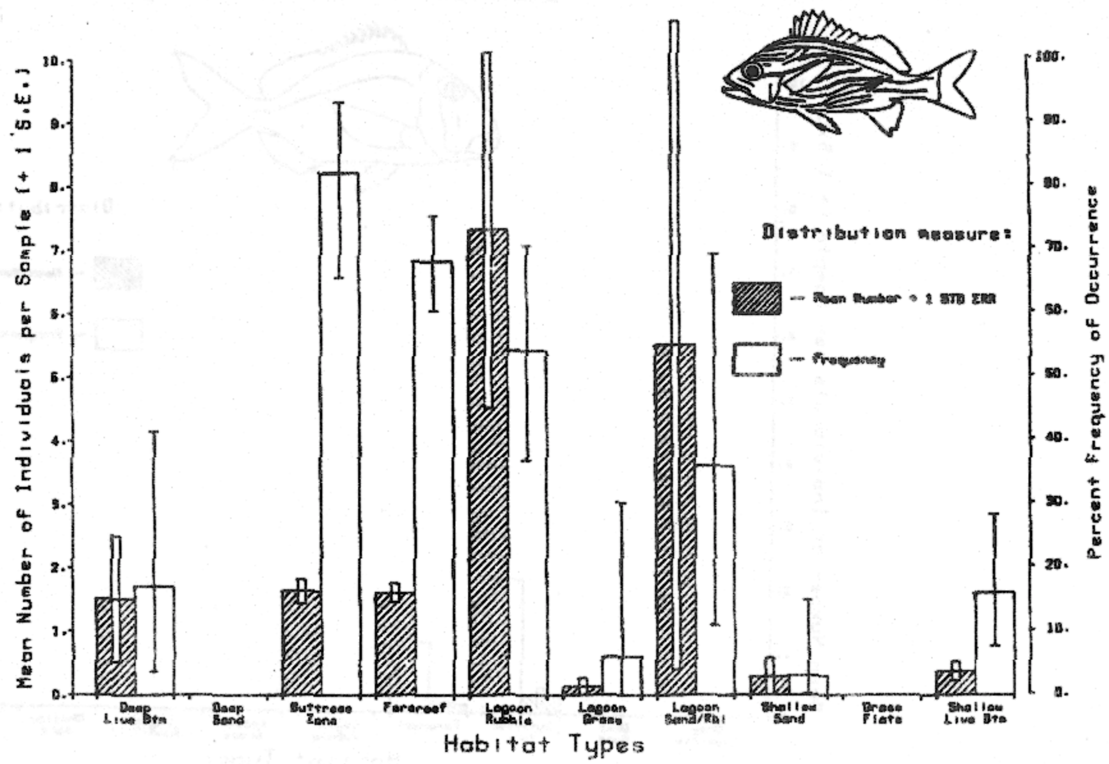
Distribution of Haemulon aurolineatum



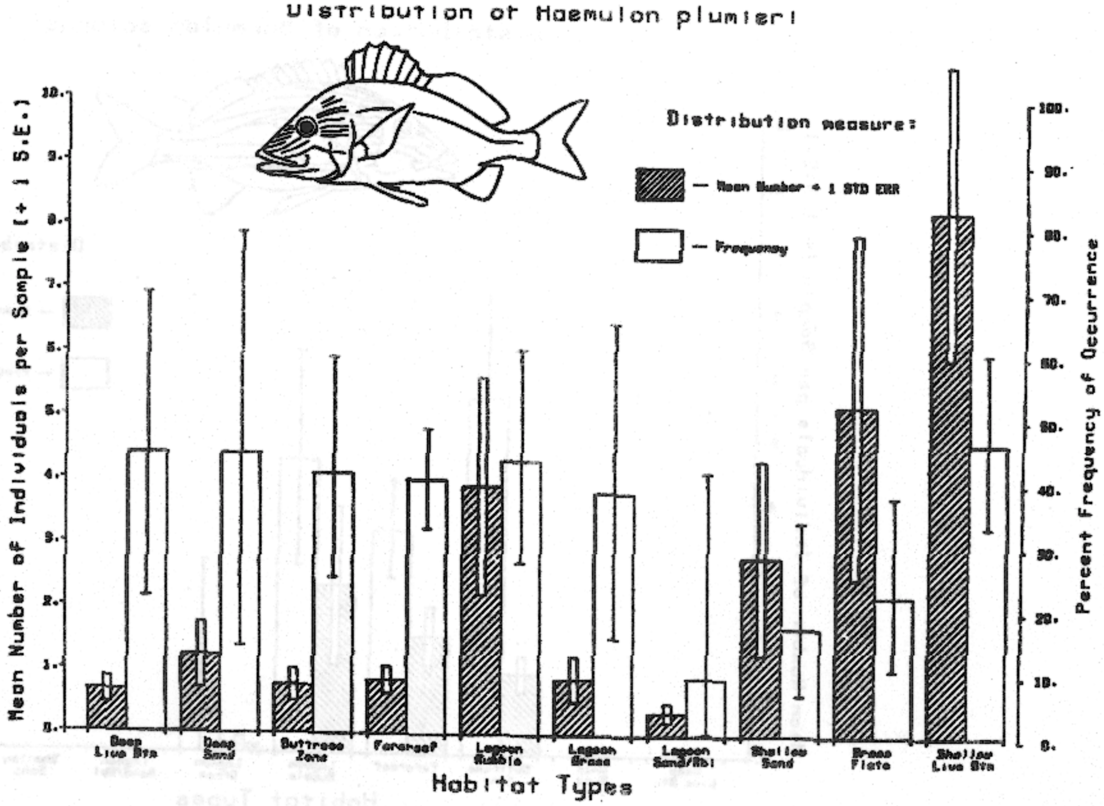
Distribution of Haemulon chrysargyreum



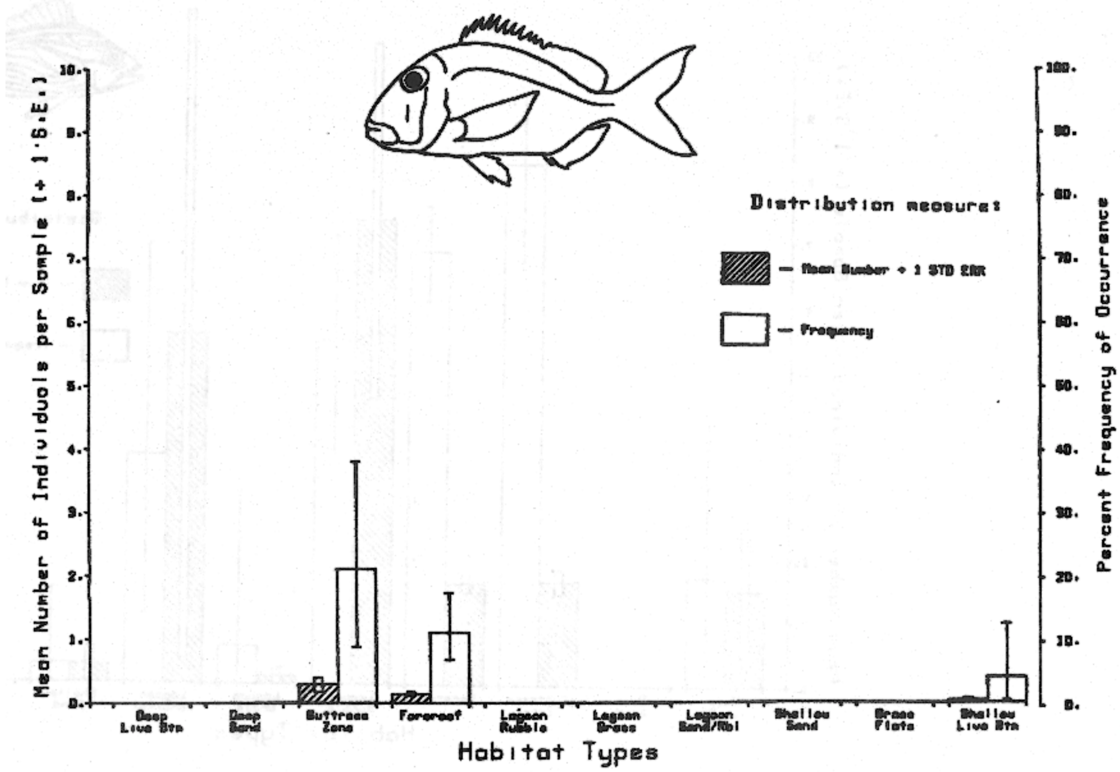
Distribution of Haemulon flavolineatum



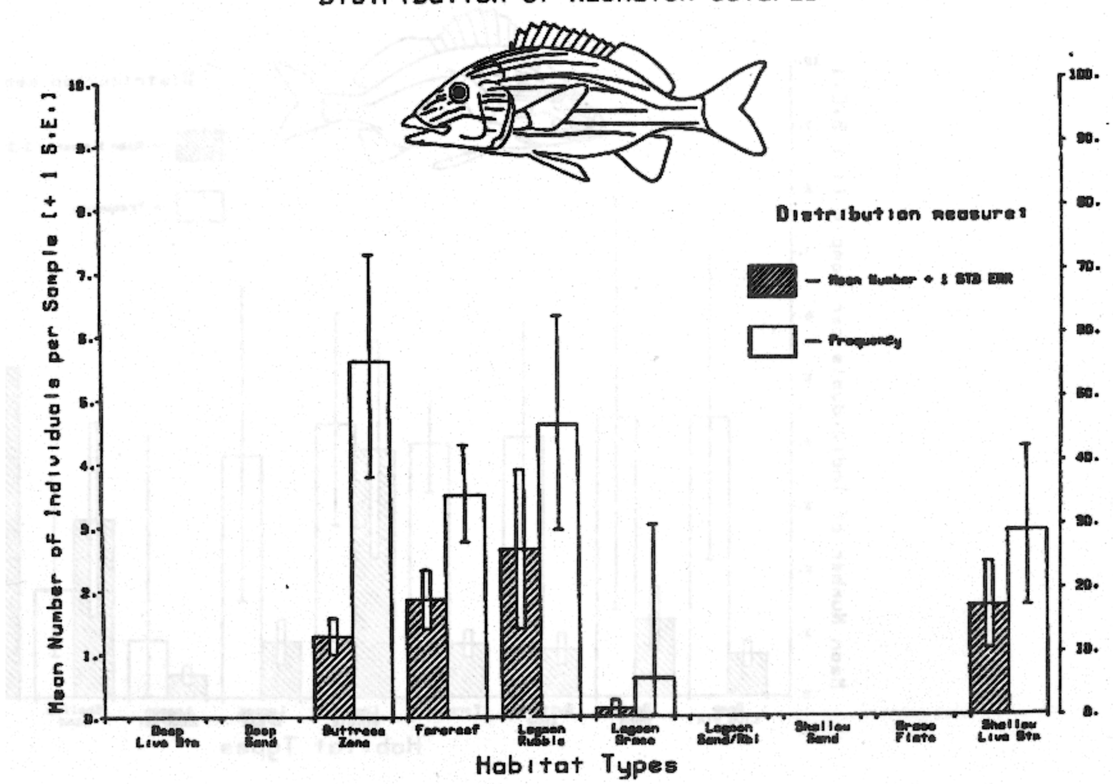
Distribution of Haemulon plumieri

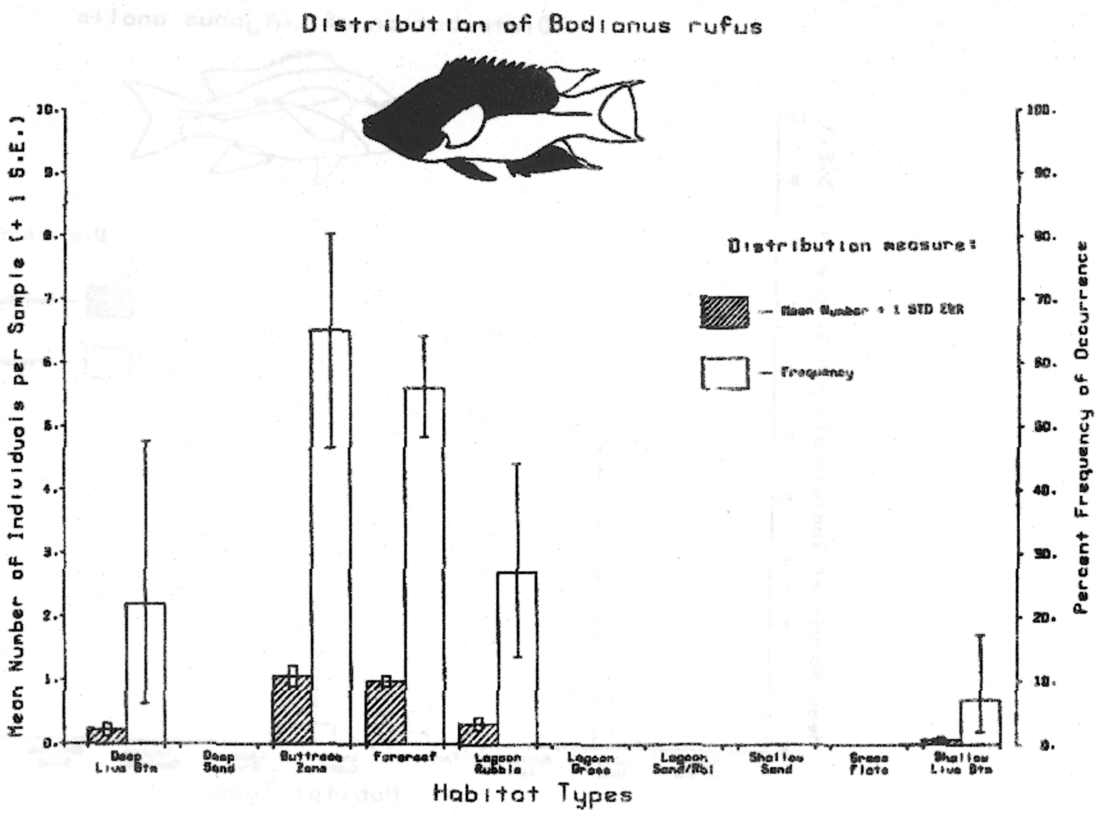


Distribution of Calamus bajonado

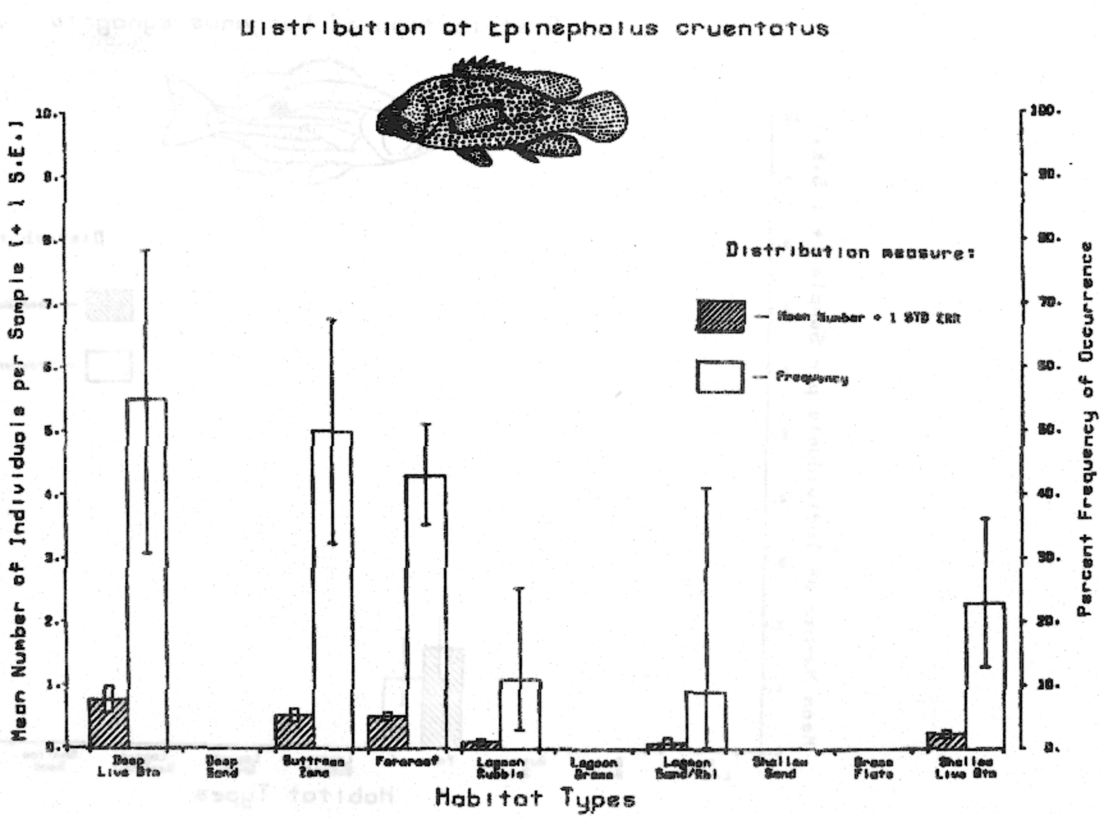


Distribution of Haemulon sciurus

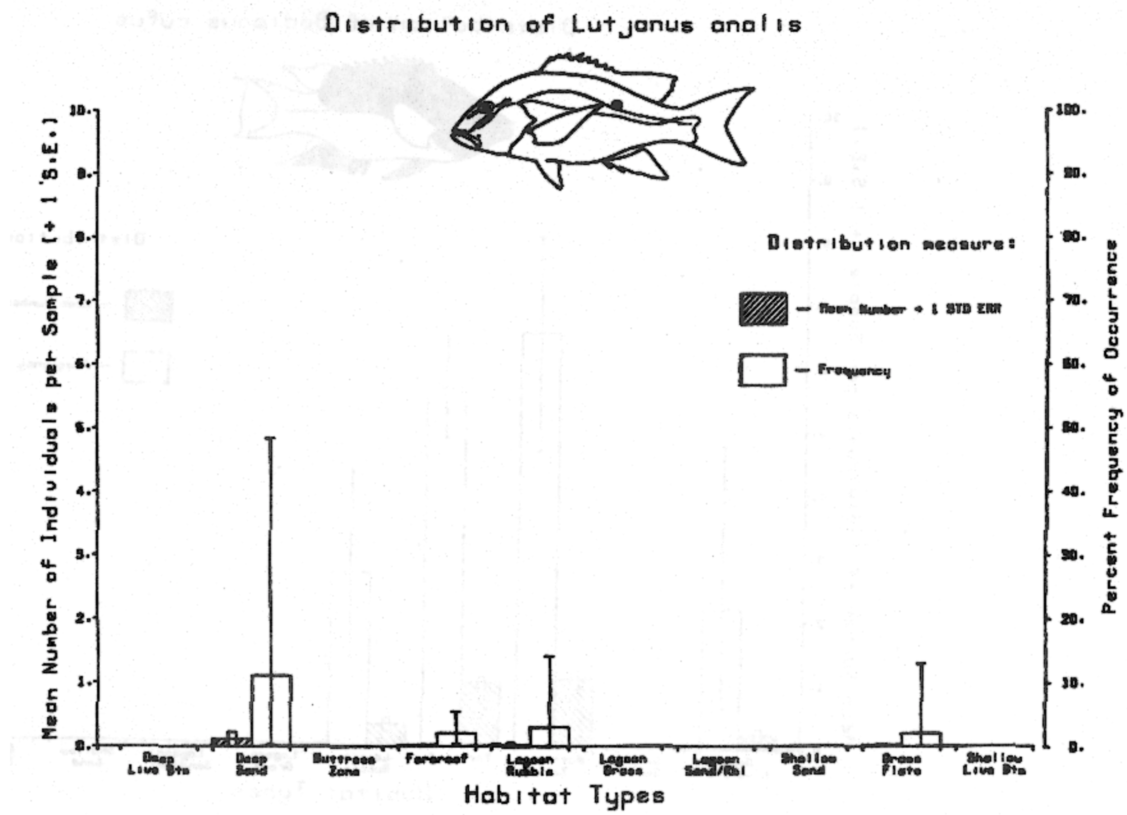


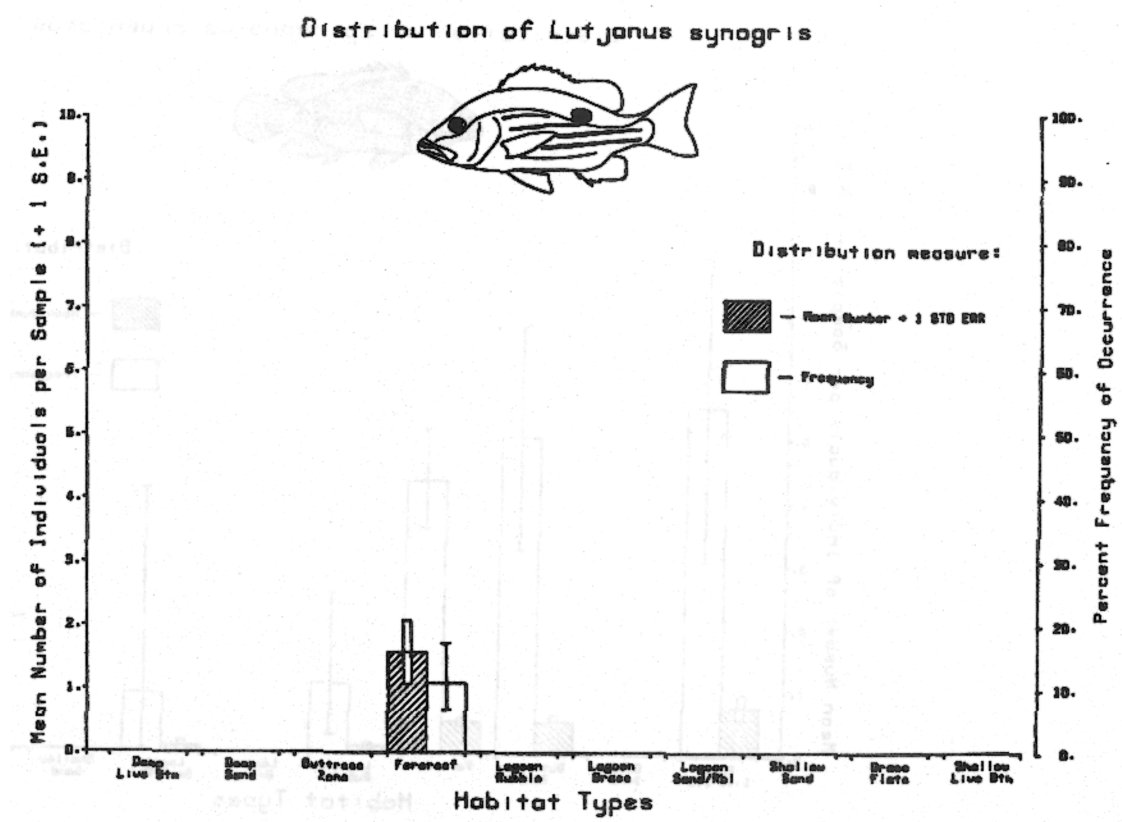


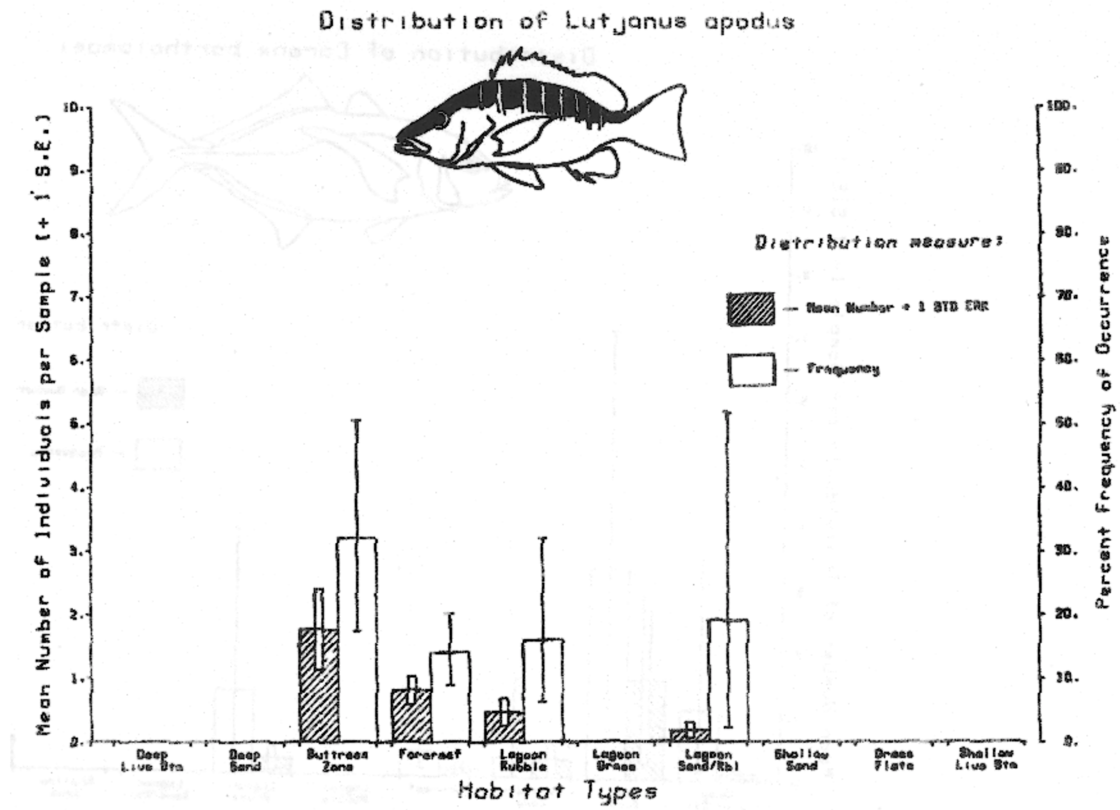
Distribution of Bodianus rufus
Distribution measure:
— Mean Number + 1 STD ERR
— Frequency
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types

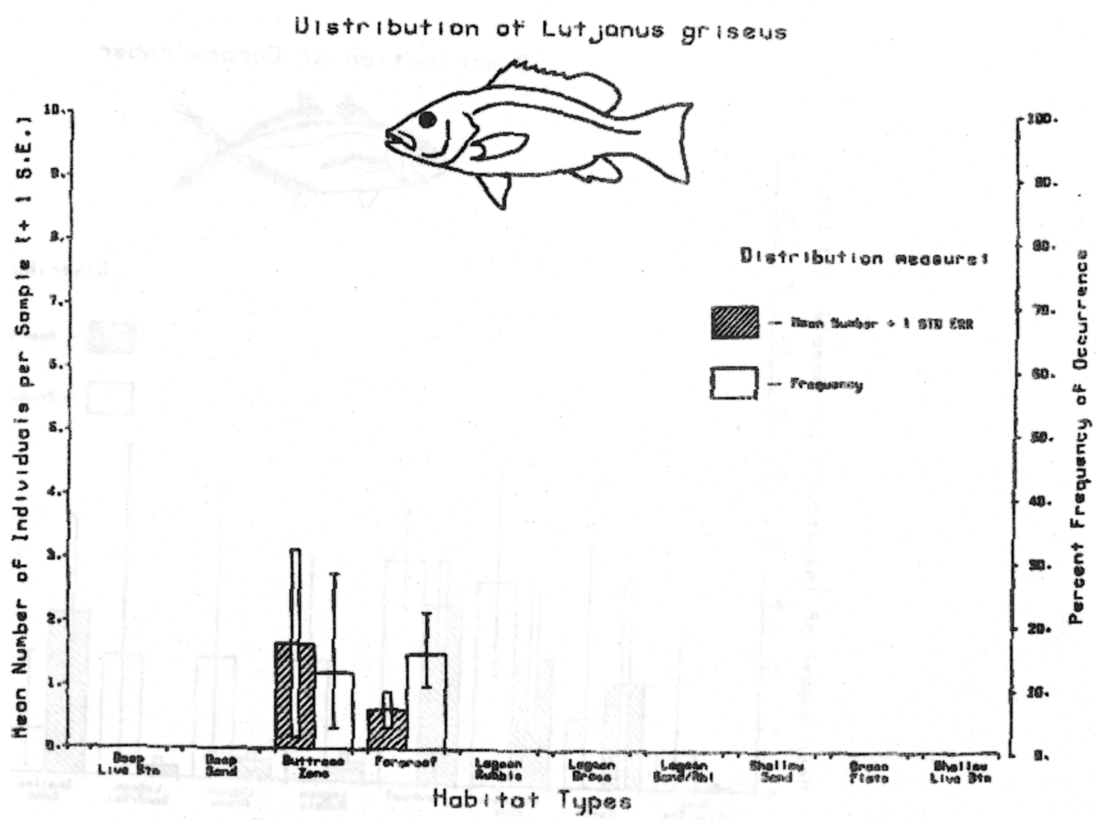


Distribution of Epinephalus cruentatus
Distribution measure:
— Mean Number + 1 STD ERR
— Frequency
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types

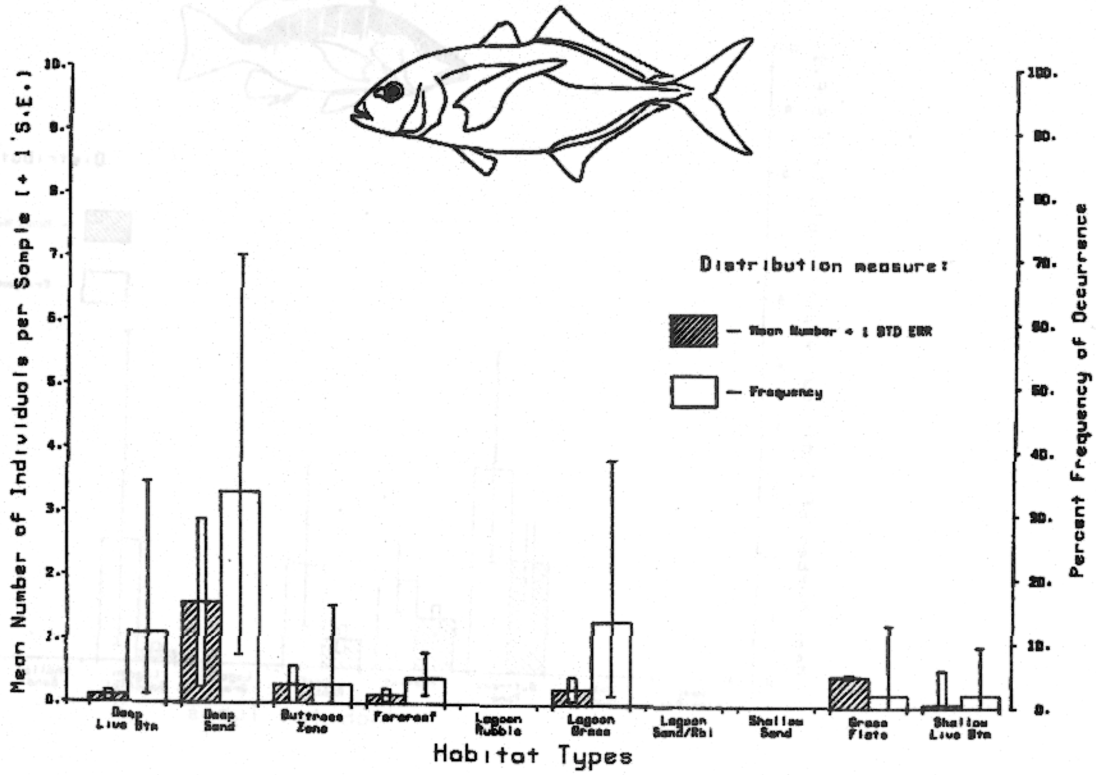

Distribution of Lutjanus analis
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Distribution measure:
— Mean Number + 1 STD ERR
— Frequency
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types


Distribution of Lutjanus synagris
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Distribution measure:
— Mean Number + 1 STD ERR
— Frequency
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types

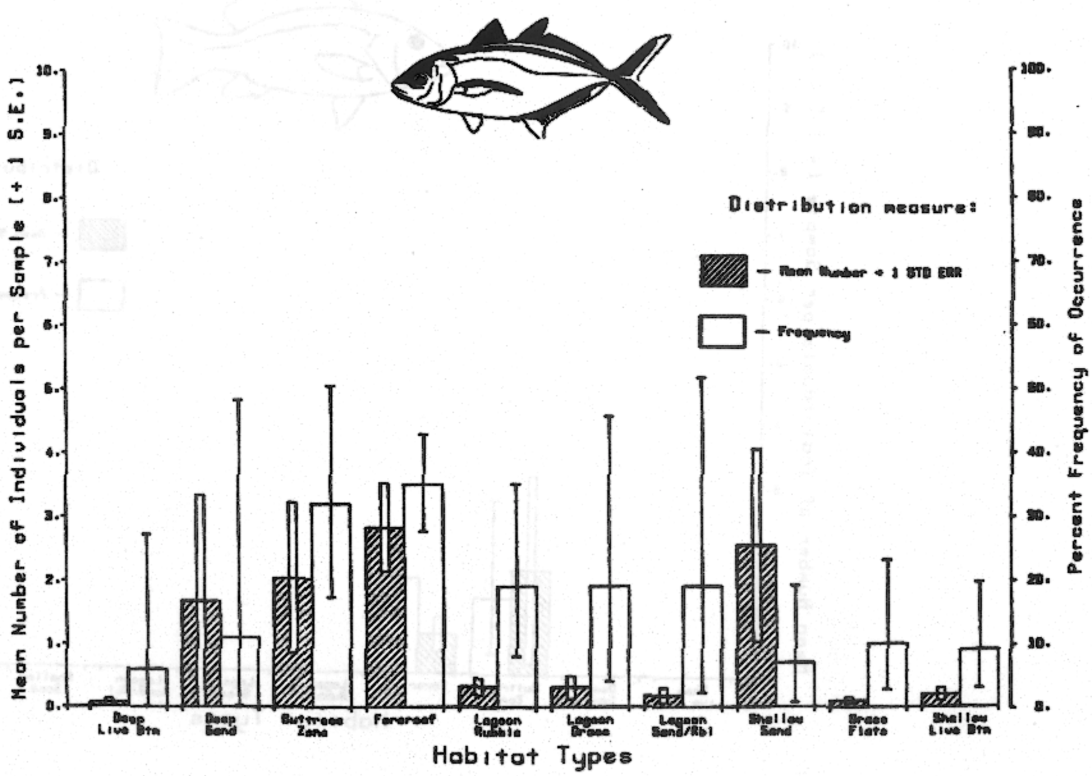

Distribution of Lutjanus apodus
Distribution measure:
Mean Number + 1 STD ERR
Frequency
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types

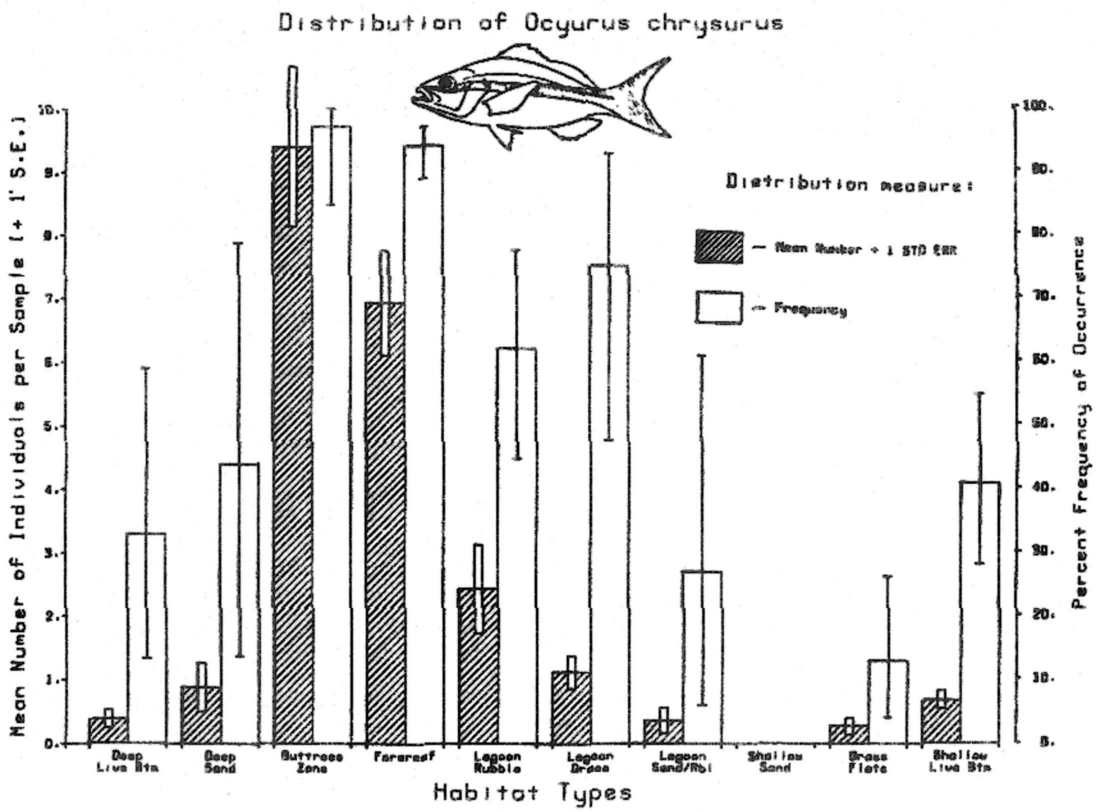

Distribution of Lutjanus griseus
Distribution measure:
Mean Number + 1 STD ERR
Frequency
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types

Distribution of Caranx bartholomaei



Distribution of Caranx ruber




Distribution of Ocyurus chrysurus
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Distribution measure:
Mean Number + 1 STD ERR
Frequency
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types

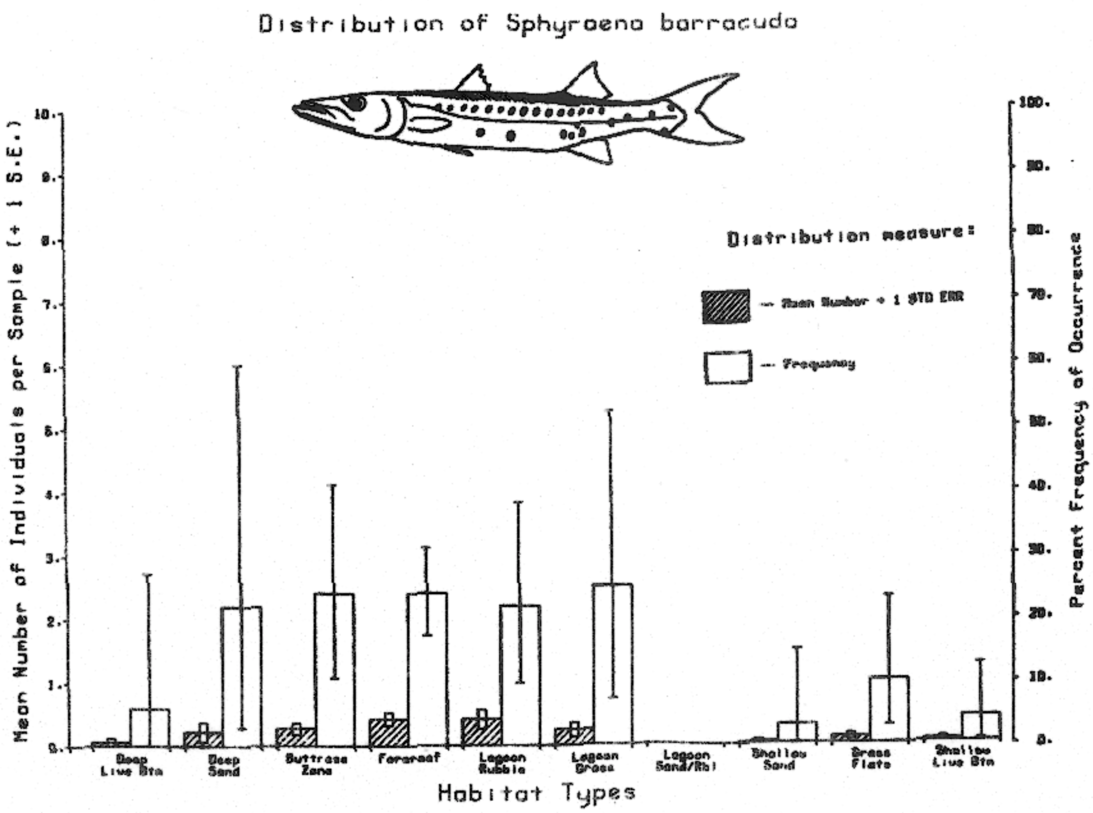

Distribution of Sphyraena barracuda
Mean Number of Individuals per Sample (+ 1 S.E.)
Percent Frequency of Occurrence
Distribution measure:
Mean Number + 1 STD ERR
Frequency
Deep Live Btm
Deep Sand
Buttress Zone
Forereef
Lagoon Rubble
Lagoon Grass
Lagoon Sand/Rbl
Shallow Sand
Grass Flats
Shallow Live Btm
Habitat Types

Plate 7.1. Ledges along the forereef spur formations are a favorite shelter for many reef fishes.

Plate 7.2. Parrotfishes, the largest herbivores, are frequently seen in the forereef, buttress, and rubble zones. Shown are schools of rainbow parrotfish (*Scarus guacamaia*) in the rubble zone (top) and midnight parrotfish (*S. coelestinus*) in the forereef zone (bottom).

Plate 7.3. The three spot damselfish (*Pomacentrus planifrons*) (top) is herbivorous and usually found defending a territory in branches of elkhorn coral (*A. palmata*). These fishes are one of the most aggressive species on the reef and will not hesitate to attack a fish (or diver) hundreds of times its size. Often large schools of surgeonfishes (bottom) or parrotfishes temporarily overwhelm the defenses of a single damselfish before moving on to new areas. The predatory trumpetfish, shown in the center of the photograph, often uses the confusion created by the activity of these schools of fish to approach and attack small reef fishes.

Plate 7.4. Two of the larger schooling midwater fishes are the Bermuda chub (*Kyphosus sectatrix*) (top) that feeds primarily an drifting algae and the yellowtail snapper (*Ocyurus chrysurus*) (bottom) that feeds primarily on plankton when small and on fishes when larger.

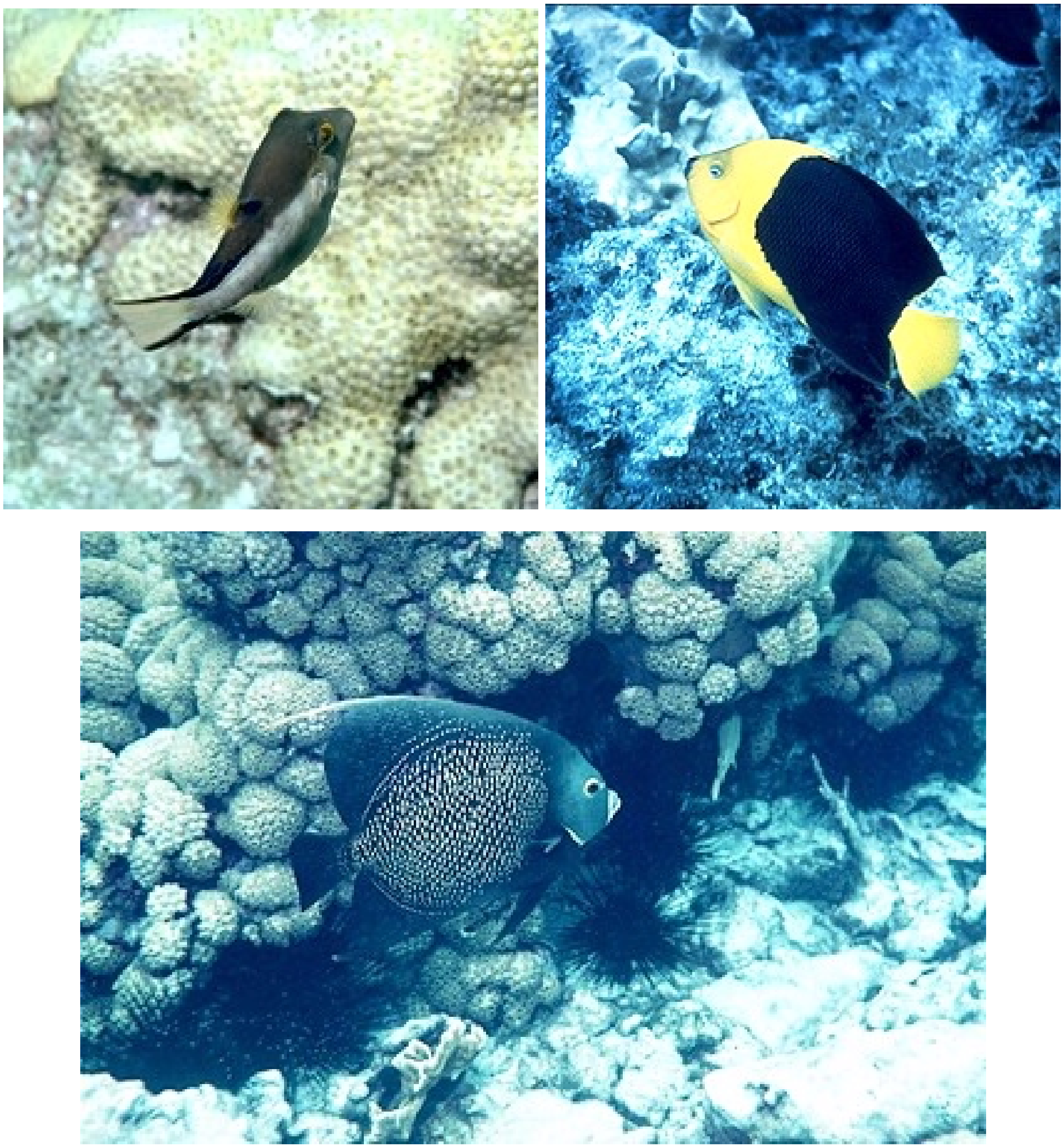


Plate 7.5. The sharpnose puffer (*Canthigaster rostrata*) (top left) feeds by picking small microinvertebrates off the bottom. Angelfishes primarily browse on sponges. Shown are the rock beauty (*Holocanthus tricolor*) (top right) and an adult French angelfish (*Pomacanthus paru*) (bottom).

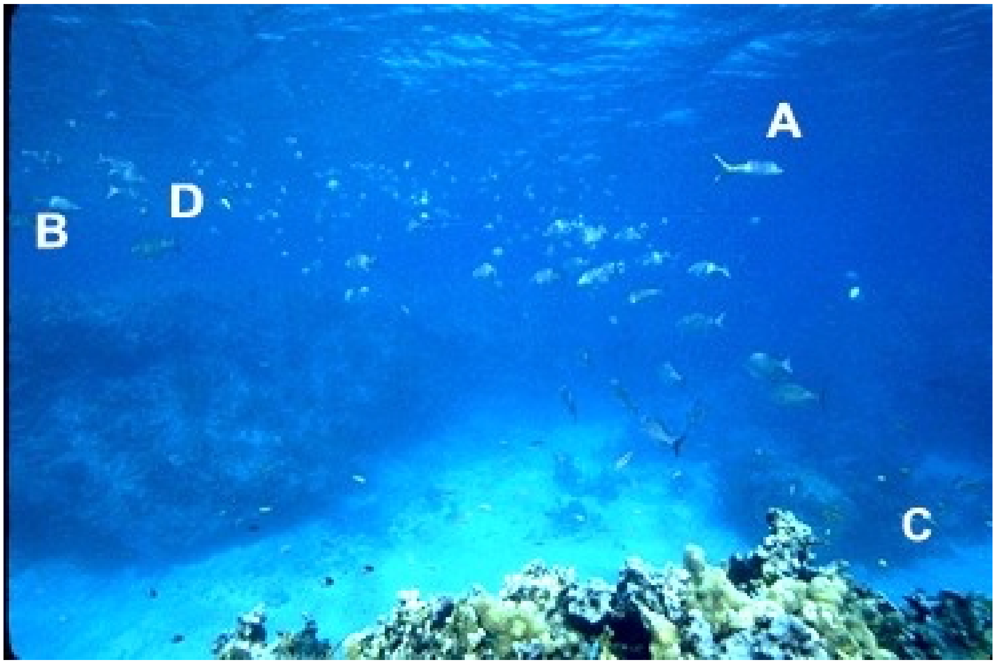


Plate 7.6. Typical assemblages of fishes feeding in midwater: (top) *A. piscivorous* yellowtaii (*Ocyurus chrysurus*); B. algivorous bermuda chub (*Kyphosus sectatrix*); and C. planktivorous bluehead wrasses (*Thalassoma bifasciatum*); D. sergeant majors (*Abudefduf saxatilis*); E. bicolor damselfishes (*Pomacentrus partitus*); and (bottom) A. brown chromis (*Chromis multilineatus*) and B. blue chromis (*Chromis cyaneus*).

Plate 7.7. Common diurnally active microinvertivores include the foureye butterflyfish (*Chaetodon capistratus*) (top) and the harlequin bass (*Serranus tigrinus*) (bottom).

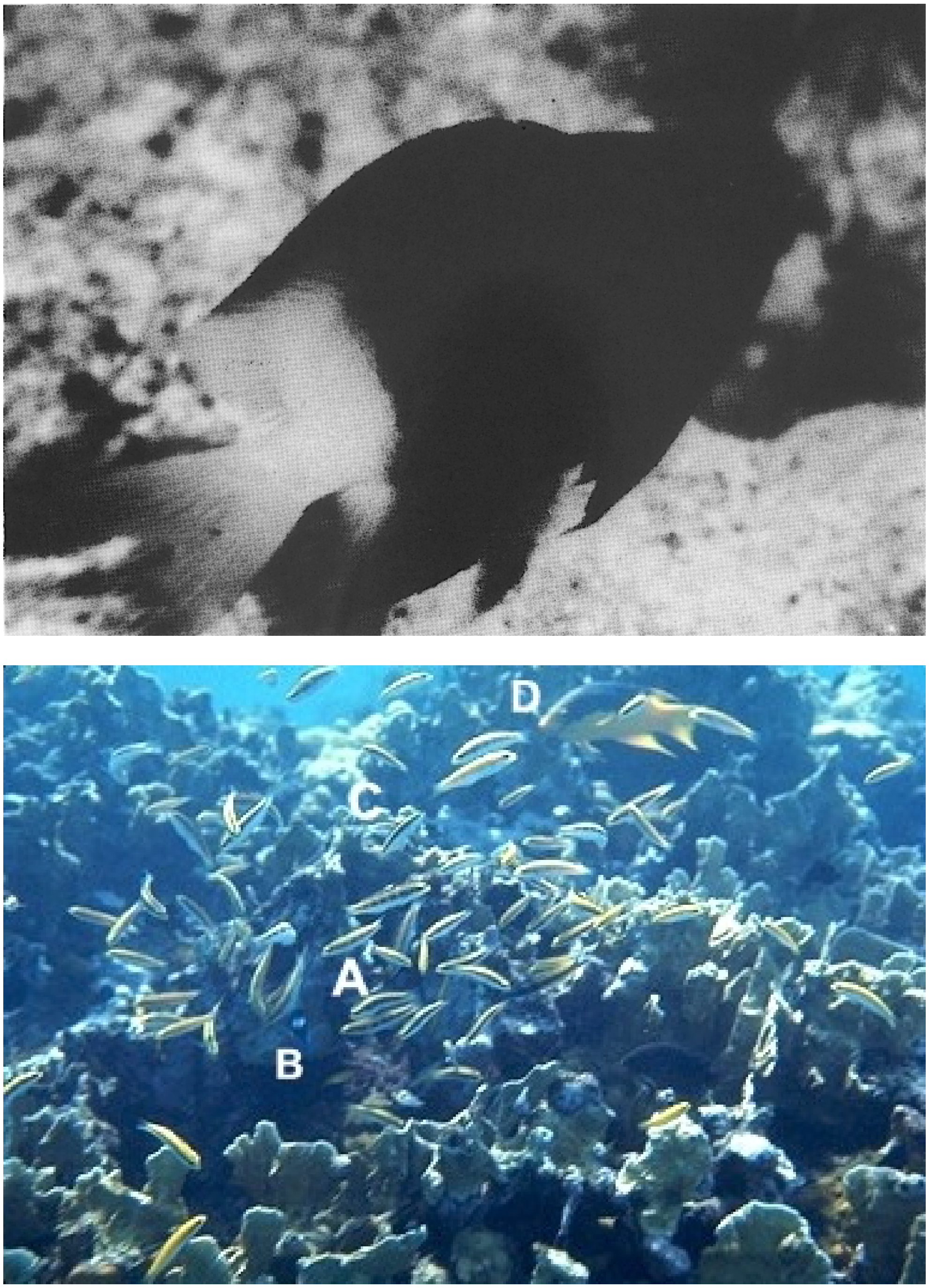


Plate 7.8. Two of the most abundant fishes at Looe Key Reef are the bicolor damselfish (*Pomacentrus partitus*) (top) and the bluehead wrasses (*Thalassoma bifasciatum*) (bottom). Many wrasses change sex and color with age. Shown are mostly (A) juvenile colored blueheads, (B) a supermale bluehead, (C) a clown wrasse (*Halichoeres maculipinna*), and (D) a hogfish (*Bodianus rufus*).

Plate 7.9. Glassy sweepers (*Pempheris schomburgki*) (top) and the twospot cardinalfishes (*Apogon pseudomaculatus*) (bottom) hide in caves in the reef by day and come out to feed on plankton at night.

Plate 7.10. Grunts (Haemulidae) are one of the most important groups of reef fishes in terms of species, abundance, and biomass. Although seen in schools on the reef during the day, most species feed on invertebrates away from the reef at night. The white grunt (*Haemulon plumieri*) (top) is most abundant on inshore hard bottoms. The tomtate (*H. aurolineatum*) dominates the forereef zone.

Plate 7.11. Goatfish and mojarra feed primarily on microinvertebrates in sand bottoms. Shown are schools of yellowfin mojarra (*Gerres cinereus*) (top) and yellow goatfish (*Mulloidichthys martinicus*) (bottom).

Plate 7.12. The sailor's choice (*Haemulon parrai*, Haemulidae) (top) and the hagfish (*Lachnolaimus maximus*, Labridae) (bottom) are two typical macroinvertivores. Large schools of sailor's choice were first observed at Looe Key Reef after it became a Sanctuary. The hagfish was a favorite spearfishing target that became more frequent after the Sanctuary was established.

Plate 7.13. The schoolmaster snapper (top), the most common snapper (Lutjanidae) observed in the Sanctuary, was frequently seen in schools around colonies of elkhorn coral (*Acropora palmata*) (bottom).

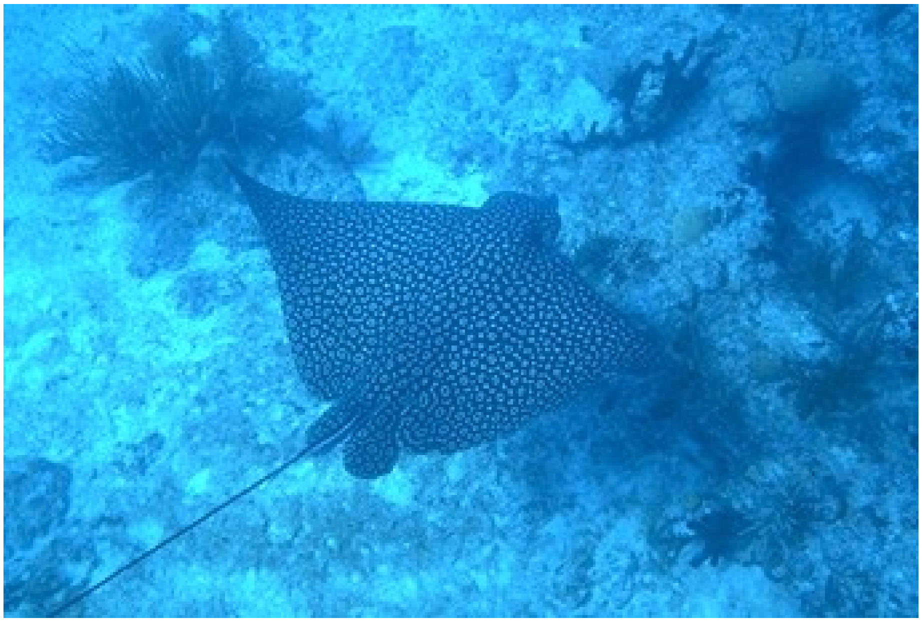


Plate 7.14. Two species that feed primarily on the larger macroinvertebrates on sand bottoms are the jolthead porgy (*Calamus bajonado*) (top) and the eagle ray (*Aetobatus narinari*) (bottom).

Plate 7.15. Moray eels and groupers are two small predators that feed on macroinvertebrates and fishes. Eels are more active at night and grouper more active during the day. Shown are a spotted moray (*Gymnothorax moringa*) being fed by a diver (top) and a graysby (*Epinephelus cruentatus*), the most common grouper at Looe Key Reef (bottom).

Plate 7.16. The bar jack (*Caranx ruber*) (top) and the yellowtail snapper (*Ocyurus chrysurus*) (bottom) are midwater fishes that feed primarily on plankton when small and on fishes when larger.

Plate 7.17. The great barracuda (*Sphyraena barracuda*) is a piscivorous predator that feeds on small fishes when medium in size (top) and large fishes when large in size (bottom). This is one of many species not seen in the Sanctuary as juveniles.

Plate 7.18. Adult tarpon (*Megalops atlanticus*) (top) are piscivourous predators frequently seen over reef areas in the Sanctuary. The Nassau grouper (*Epinephelus striatus*) (bottom) is a large grouper that feeds mostly on large invertebrates.

Plate 7.19. The bull shark (*Carcharhinus leucas*) is one of the largest predators in the Sanctuary. Although often caught in the Sanctuary at night they are rarely seen an the reef during the day.

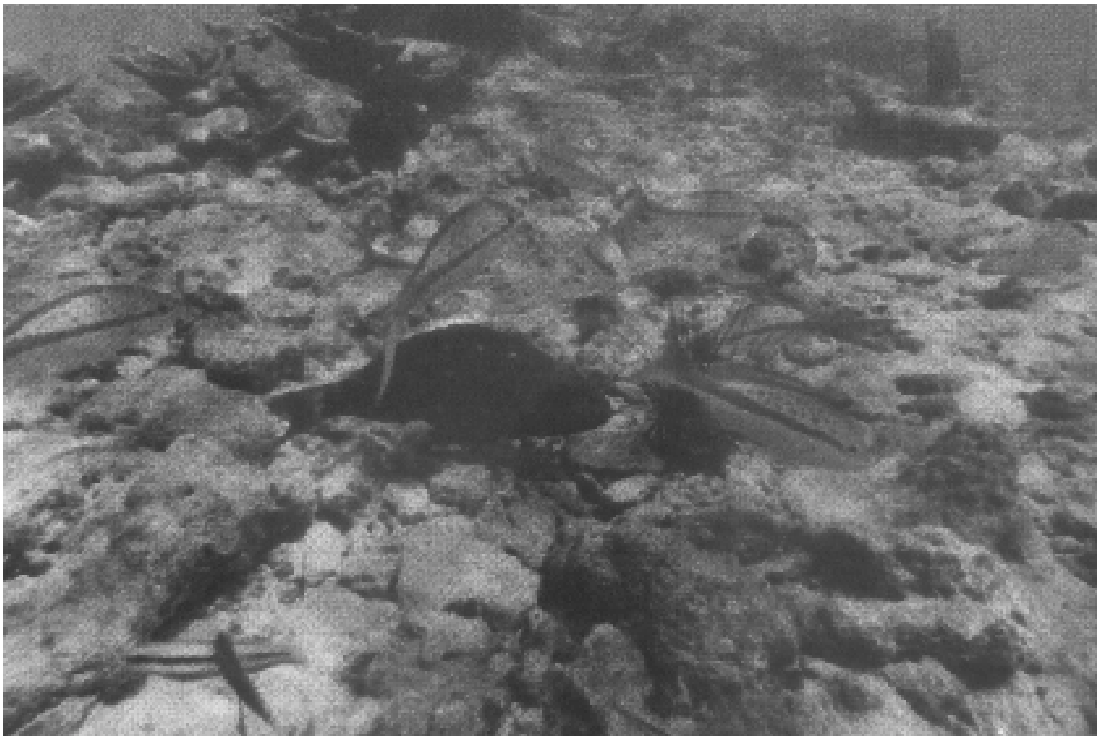


Plate 7.20. Classifications of reef fishes into trophic categories is somewhat misleading because most reef fishes are opportunists and will eat almost anything available. A stoplight parrotfish, *Sparisoma viride*, is normally herbivorous but could be seen attacking and eating sick long-spined urchins (*Diadema antillarum*) (top) during an unusual sea urchin die off in the summer of 1983. Similar disease epidemics and winter cold spells have killed reef fishes in or around the Sanctuary. Dead fishes (bottom) in Cupon Bight, just north of the Sanctuary, killed by a severe January 1977

CHAPTER 8

STATUS OF SELECTED CORAL RESOURCES

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Introduction

The purpose of this chapter is to present more detailed information on selected reef resources at Looe Key National Marine Sanctuary. The information provided here is intended to provide a better understanding on the status of selected coral species and potential sources of damage and mortality from natural and human causes. We provide maps of the distributions of two important corals, document sources of coral damage and mortality, and document the 1983 epidemic mortality of the long-spined urchin (*Diadema antillarum*).

Elkhorn coral (*Acropora palmata*) and pillar coral (*Dendrogyra cylindrus*) are two important coral species. Elkhorn coral is ecologically important as shelter and a major source of rubble. Shinn *et al.* (1981) found that elkhorn coral was the major historical source of material for spur formation and that living colonies were no longer abundant on the reef. Further decline of elkhorn coral may result in erosion and decline of the reef (See Chapter 4). Pillar coral on the other hand is a beautiful but relatively rare coral in the Caribbean. Its presence at Looe Key Reef was one of the reasons for nominating the Sanctuary (US Department of Commerce, 1980).

We also photographically documented sources of coral damage and mortality which are important management considerations. A better understanding of natural- and human-caused damage and mortality is important for developing effective management policies. Finally, we report data collected to document long-spined urchin densities during and after a major sea urchin disease epidemic at Looe Key Reef in 1983.

Methods

Detailed surveys were conducted to locate colonies of elkhorn coral and pillar coral in the forereef and shallow hard bottom areas of LKNMS. Divers recorded the location of all colonies of these two species on maps of the forereef and the backreef livebottom habitat. The location of patches of staghorn coral *A. cervicornis* were also noted in the forereef, although very small colonies may have been overlooked.

A series of photographs were assembled to document sources of coral damage and mortality. Most pictures were taken during this survey although some were taken over the past decade. Unless otherwise noted all photographs were taken by the author at Looe Key Reef or in the immediate surrounding area. Sources of coral damage and mortality were classified as primarily natural or human origin. No attempt was made to quantify the importance of any factor. Billy Causey, Sanctuary Manager for Looe Key National Marine Sanctuary, provided information used to map the general locations of recent vessel groundings.

During 1983 an epidemic disease of unknown origin caused mass moralities of the long-spined urchin over much the Caribbean region (Plate 8.8). The disease was first noticed at Looe Key Reef during the last week in August and was over by the middle of September. Sea urchin densities were measured along replicate 1 x 15 m (3 x 50 ft) transects conducted along the top shallow portion of the middle study spur (Chapter 3). Normally, sea urchin density was high in this area. Data were taken when the disease epidemic was first noted on 29 August and after active signs of the disease had disappeared on 16 September 1983 and in June 1984. Abundance values for four transects from the same location were transformed with $\log_{10}(n + 1)$ and analyzed by a one way analysis of variance.

Results

Mapping

Maps were constructed showing the distribution of colonies of elkhorn coral, pillar coral, and staghorn coral *A. cervicornis* (Figure 8.1). We found only four colonies of pillar coral in the entire Sanctuary. Photographs of the four colonies are provided so that any future changes in their condition could be detected (Plates 8.2, 8.3, 8.1, 8.3).

Natural sources of damage and mortality

Damage from wave action, especially during severe winter storms and hurricanes, has been considered the greatest source of physical damage to corals (Blumenstock, 1961; Stoddart, 1963; Vermeer, 1963; Bull *et al.*, 1967; Endean, 1976; Shinn, 1976; Randall and Eldredge, 1977; Ogg and Koslow, 1978; Highsmith, *et al.* 1980; Porter, *et al.* 1981; Tilmant and Schmahl, 1981; Woodley, *et al.* 1981). Branching corals such as elk-horn coral, are particularly vulnerable to wave damage (Plate 8.2). However, elkhorn coral depends on damage as a source vegetative reproduction and its rapid growth counteracts wave damage under normal end i ions .

Extreme water temperatures can stress and kill corals. The coldest temperatures are likely to occur during short winter cold spells and have caused of mortality in certain areas of the Keys (Plate 8.3) (Kinsman, 1964; Glynn, 1973; Endean, 1976; Jokiel and Coles, 1977; Shinn, 1976; Bohnsack, 1983). During this survey in 1983 some corals at Looe Key Reef showed stress by bleaching due to high water temperatures (32° C, Plate 8.3) (Jaap, 1979).

Natural predation and competition are sources of damage and mortality for corals (Plate 8.4). Documented Caribbean coralivores include bristle worms, other invertebrates, and, to a limited extent, fishes (Dart, 1972); Sammarco *et al.*, 1974; Bak and Van Eys, 1975; Bak *et al.*, 1976. Ogden and Lobel, 1978; Glynn *et al.*, 1979; Highsmith *et al.*, 1980; Sammarco, 1980). Sea urchins and some fishes can weaken coral colonies by scraping and eroding dead coral. Close contact between corals or corals and other sessile (non-motile) organisms results in direct competition for space (Lang, 1973; Endean, 1976; Maguire and Porter, 1977; Stern *et al.*, 1977; Buss and Jackson, 1979; Buss *et al.*, 1980; Porter *et al.*, 1982). Some corals compete directly by attempting to digest each other with mesentarial filaments. Usually a dominance hierarchy exists where certain species tend to win specific encounters. Indirect competition also occurs where corals with faster growth rates tend to shadow out slower growing corals. Branching corals, such as elkhorn and staghorn corals, are fast growing species that tend to overgrow and dominate slower growing rounded corals, such as brain coral (*Colcophyllia natans*). Periodic major storm damage may reverse the outcome of this competition by damaging more colonies of the fragile branching species than the stronger, storm resistant, rounded species. Thus, an equilibrium exists where species with both strategies are maintained. A final form of competition, not illustrated, occurs from erosion of dead coral by coral boring organisms such as sponges, polychaete worms, mollusks and tunicates.

Turbidity from natural or human disturbance can be an important source of injury and mortality to corals (Plate 8.5). Sediments can directly cover and kill coral tissue (Loya, 1972, 1976; Ray and Smith, 1971; Bak, 1974; Dodge *et al.,* 1974, 1977; Marszalek, 1981; Dallmeyer, *et al.*, 1982; Dodge, 1982). Suspended sediments can indirectly kill corals by reducing light levels for prolonged periods of time. Corals tend to exist in areas were normal sediment levels are low, however unusual events can temporarily increase turbidity to damaging or lethal levels.

Diseases affect corals (Garrett and Ducklow, 1975; Mitchell and Chet, 1975; Voss, 1973). Some have unknown origin (Plates 8.5, 8.6, 8.7) while others are better known like black ring disease (Plate 8.6). Black ring disease is caused by a bluegreen algae *Ocelletoria submembracea* (Sp. ??) which is believed to attack a coral colony more easily after it has been damaged. During the course of this survey several coral with disease symptoms were noted. Often disease epidemics occur over widespread reef areas.

Diseases also affect organisms besides corals. The long-spined sea urchin population declined drastically as the result of a disease epidemic at Looe Key Reef (Table 8.1). Analysis of variance shows a highly significant ($p < 0.001$) decline in population size, The initial decline from an average of 51 to 7 individuals per transect was highly significant ($p < 0.001$), The secondary decline from an average of 7 to 3 individuals per transect was not significant ($p = 0.18$).

Human sources of damage and mortality

Human activity can directly and indirectly cause injury and mortality for corals (Voss, 1973; Endean, 1976; Dahl, 1977, 1981; Davis, 1977; Tilmant and Schmahl, 1981). The forereef area receives especially heavy direct use and abuse (Plate 8.9). Careless navigating (Plate 8.9) and poor anchoring practices (Plate 8.10) are a major causes of direct coral damage. Anchors, anchor chain, and line can damage coral tissue and break fragile colonies. The ecological impacts of this damage have not been extensively documented, however, it is at least an aesthetic problem. Objects deposited on the reef accidentally or deliberately (Plate 8.11) can also damage coral or alter the aesthetic experience for divers. Another direct problem is from careless and inexperienced divers who touch live corals damaging their tissues (Plate 8.11). Whether this is an ecologically important factor or serious problem is not known.

Groundings and shipwrecks have had important impacts on the reef besides providing a name for Looe Key Reef (See Introduction, Chapter 1). In the recent past a number of shipwrecks and groundings have occurred at Looe Key Reef (Table 8.2). Carelessness, errors in judgment, and lack of local knowledge are causes for vessel run aground on the spur formations. Damage has been both temporary and long lasting from a variety of vessels and over a considerable portions of the reef (Fig 8.2, Plates 8.12, 8.13, 8.14, 8.15, 8.16, 8.17). The detrimental effects of groundings include physical damage to the reef and water column pollution from fuel, liquid waste, leaks, discarded narcotics, and lost cargo. In most cases the vessels were salvaged and removed. However, physical scars and wreckage are still visible for long periods of time. Despite new and improved aids to navigation the potential for a major future disasters still exists and presents a major management problem (Plate 8.18). Surprisingly, the wreckage of the Robby Dale, a wrecked narcotics smuggler, is an attraction for may divers because it is a convenient reference point, the extensive wreckage is dramatic and different from the natural habitat, and many fishes congregate around the wrecked superstructure.

Human activities can also indirectly affect the reef resources of LKNM. The Florida Keys are a region with much shipping activity and oil spills of various magnitudes are a frequent occurrence (Plate 8.19). Other sources of human pollution may impact the reef. Big Fine Key is the second largest Key in the Florida Keys and is immediately north of the Sanctuary. Most of Big Pine Key has yet to be extensively developed although activity is likely to increase in the near future as other Keys become saturated. Land clearing on Keys adjacent to the Sanctuary may have indirect effects on the Sanctuary by destroying mangrove forests (sources of food and habitat); increasing sediments from runoff; increasing pollutants from insecticide sprays and runoff; and increasing human use and subsequent damage to the Sanctuary (Plate 8.20).

Discussion and conclusions

Maps of coral distributions document the present location of important corals from which any changes can be ascertained. Although both *Acropora* species have a wide depth range, staghorn coral is more common in deeper water while elkhorn coral is more common in moderate depth water. Maps show that the east forereef, which has the poorest development of spur formation, also has no live *Acropora* colonies (Figure 8.1). Whether their absence is due to natural causes or harvesting activities is not known. However, both the east and west spurs show cracks that are signs of erosion (Figure 8.1, see Chapter 4). Finally, a disproportionate number of *A. palmata* colonies seem to occur on the west edges of spurs (Figure 8.1). This pattern is a possible consequence of prevailing seas from the southeast which would tend to wash broken coral fragments to the west and north side of spur formations.

The initial 86% population decline of the long-spined urchin can directly be attributed to the disease epidemic which was rapidly affected the population over a period of a two weeks. The secondary decline from 14% to 6% of the original population level, noted over the next 9 months was probably not due to disease. Two possibilities for the decline are that surviving urchins redistributed into other habitats and urchin predators (which were not directly impacted by disease) continued to reduce urchin population sizes. No data are available to substantiate these or other possible hypotheses. The continued decline) however, indicates that urchin recovery may not be rapid. The *Diadema* disease outbreak occurred during a period with the highest recorded water temperatures for the summer on the outer reef (30.9 °C). However, the inshore patch reef area just south of the Newfound Harbor Keys had higher temperatures (32.5 °C) and was not affected at this time. The disease was over on the forereef at Looe Key Reef by 14 September (the next visit after 31 August), but did not affect the inshore patch reef just south of the Newfound Harbor Keys until 16 October, over a month later. This information impunes the hypothesis that temperature was the sole source of the epidemic.

Natural and human impacts on the reef are complex and poorly understood. The photographs presented show a wide range of natural and human factors that effect corals and other reef resources. However, different factors can interact synergetically. A coral stressed by one detrimental factor is more vulnerable to stress from another factor. A better understanding of the causes, interactions, and consequences of stress is essential for wise resource management.

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Table 8.1. Changes in long-spined urchin densities as a result of the 1983 disease epidemic at Looe Key Reef. Transects were established in areas of high density urchin abundance on top of spurs in the shallow forereef zone. Paired transects were done contiguous to each other and each covered 1 x 15 m. Transect sites 1 and 2 were on the middle permanent study spur and sites 3 and 4 were on the first spur to the east, Healthy urchins showed no obvious visual signs of disease during survey. Urchins were considered diseased if they showed discoloration or loss of spines. No diseased urchins were observed after August 1983.

Site	DURING DISEASE OUTBREAK 30 August 1983			AFTER OUTBREAK 16 September 1983	A YEAR LATER 17 June 1984
	HEALTHY	DISEASED	TOTAL	TOTAL	TOTAL
1A	47	11	58	3	8
1B	53	10	63	3	2
2A	27	13	40	11	2
2B	28	14	42	11	0
3A	-	-	-	5	0
3B	-	-	-	4	0
4A	-	-	-	6	0
4B	-	-	-	5	0
Mean/transect			50.75	6.0	1.5
Standard Deviation			11.47	3.25	2.78
Density (No./m^2)			3.4	0.4	0.1

Table 8.2. Recent shipwrecks at Looe Key Reef. Information provided by John Halas, Billy Causey, Chet Alexander, and Florida Department of Natural Resource files.

Vessel	Size (ft.)	Date	Estimated Impacted Area (m^2)
Lola	110	5 March 1976	445
Robby Dale	70	18 May 1977	?
Miss Alissa	70	15 October 1982	3
Noah Smith	70	15 October 1982	10
Cleo	87	28 May 1983	12 - 15
Pacific Bell	49	17 June 1983	19
Marylin	27	10 July 1983	1.4
Papillion	41	12 March 1984	?

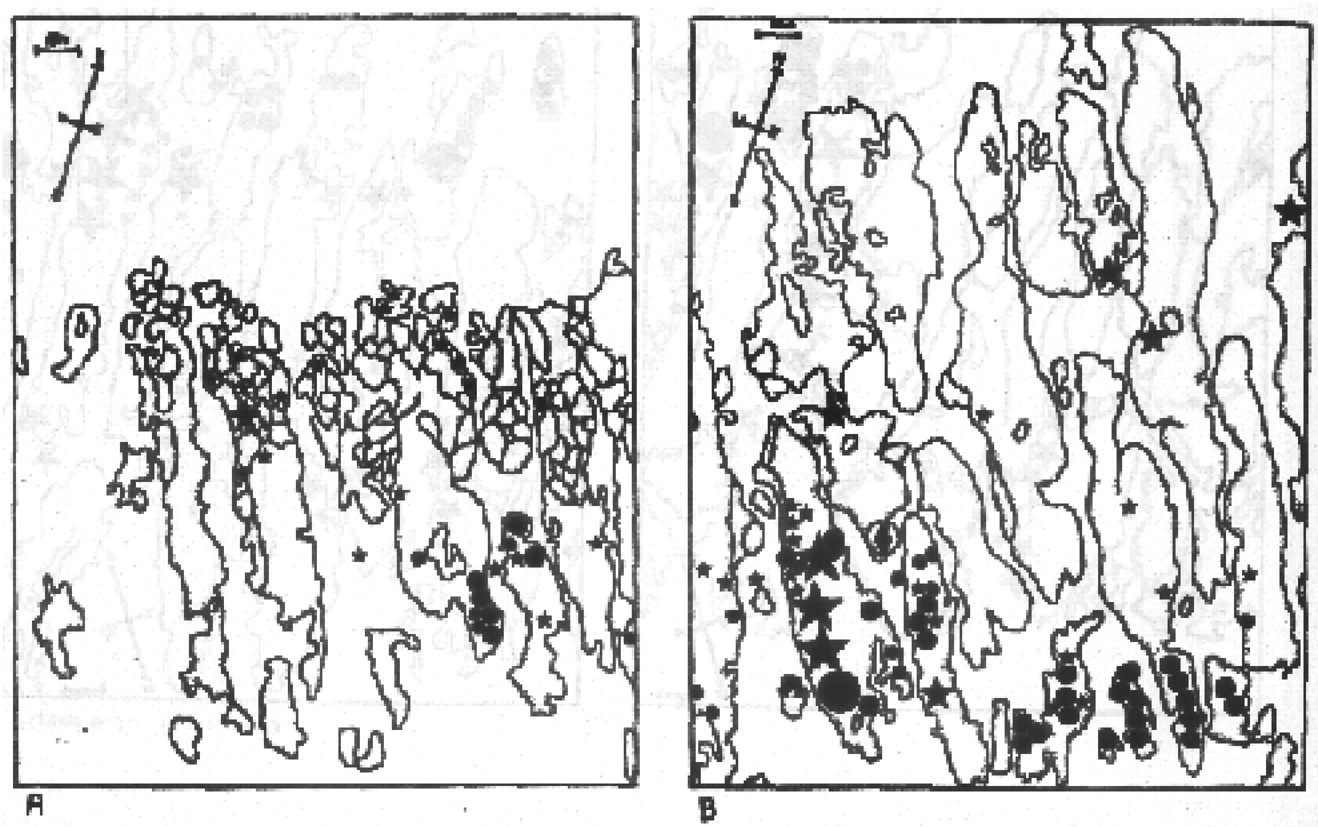
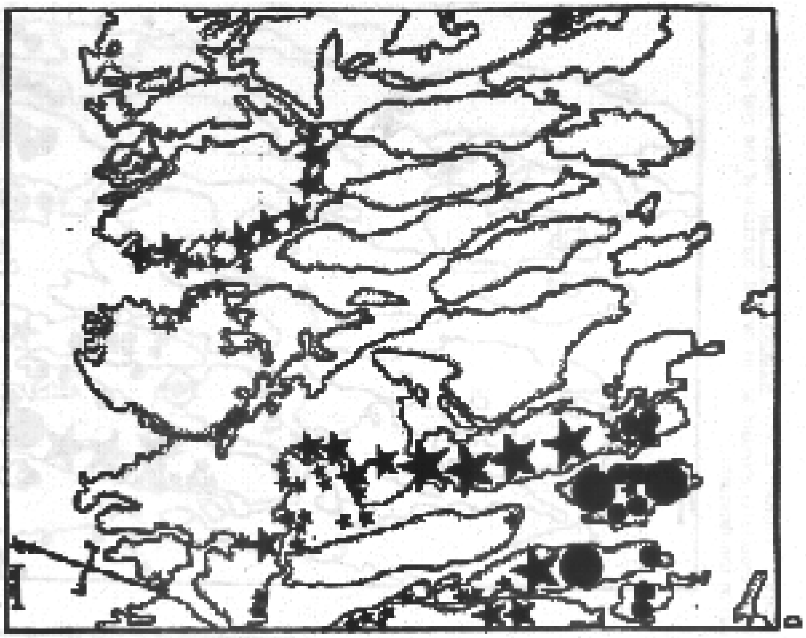
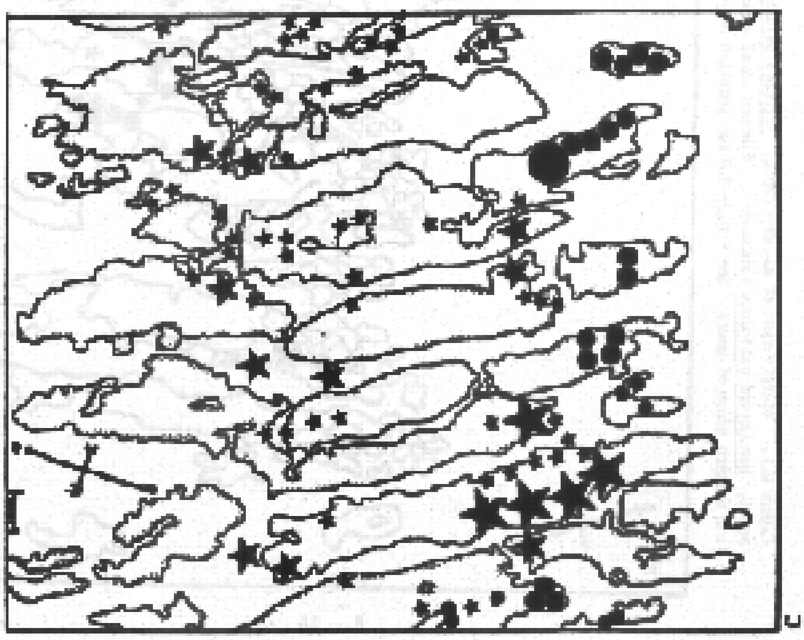
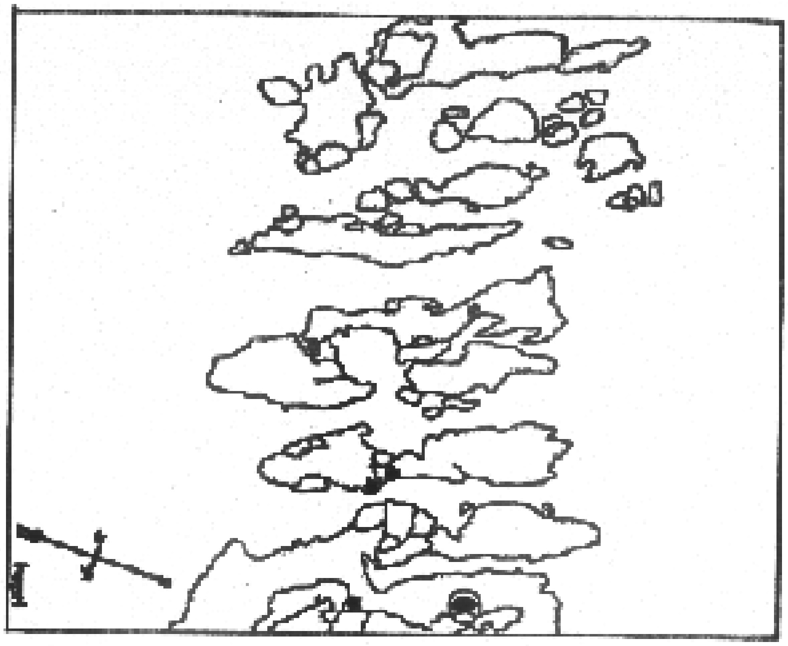
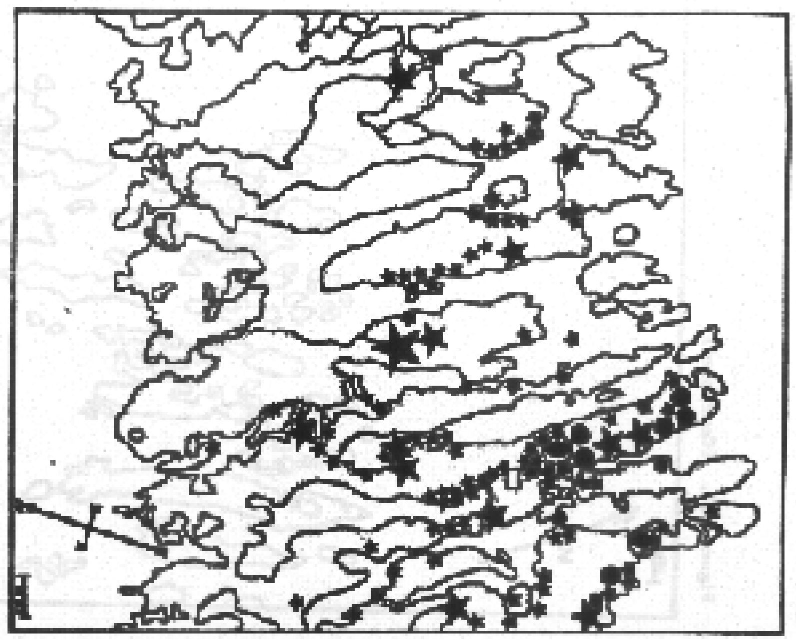


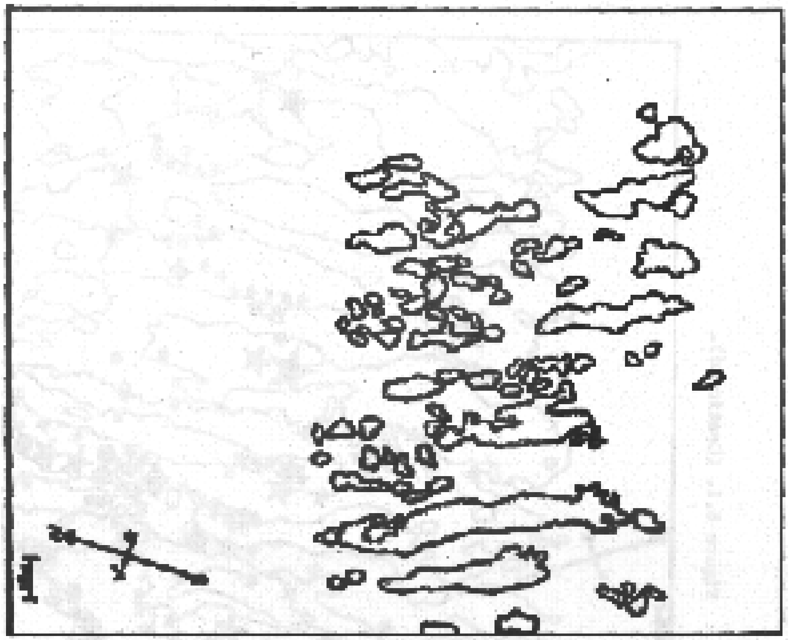
Figure 8.1. Distribution of elkhorn coral, *Acropora palmata*, (stars); staghorn coral, *Acropora cervicornis*, (dots); and pillar coral *Dendrogyra cylindricus* (diamonds). Elkhorn coral appears to be especially abundant in the central portions of the reef and on the western edges of spurs. See Figure 3.2 for location on each map on the forereef.











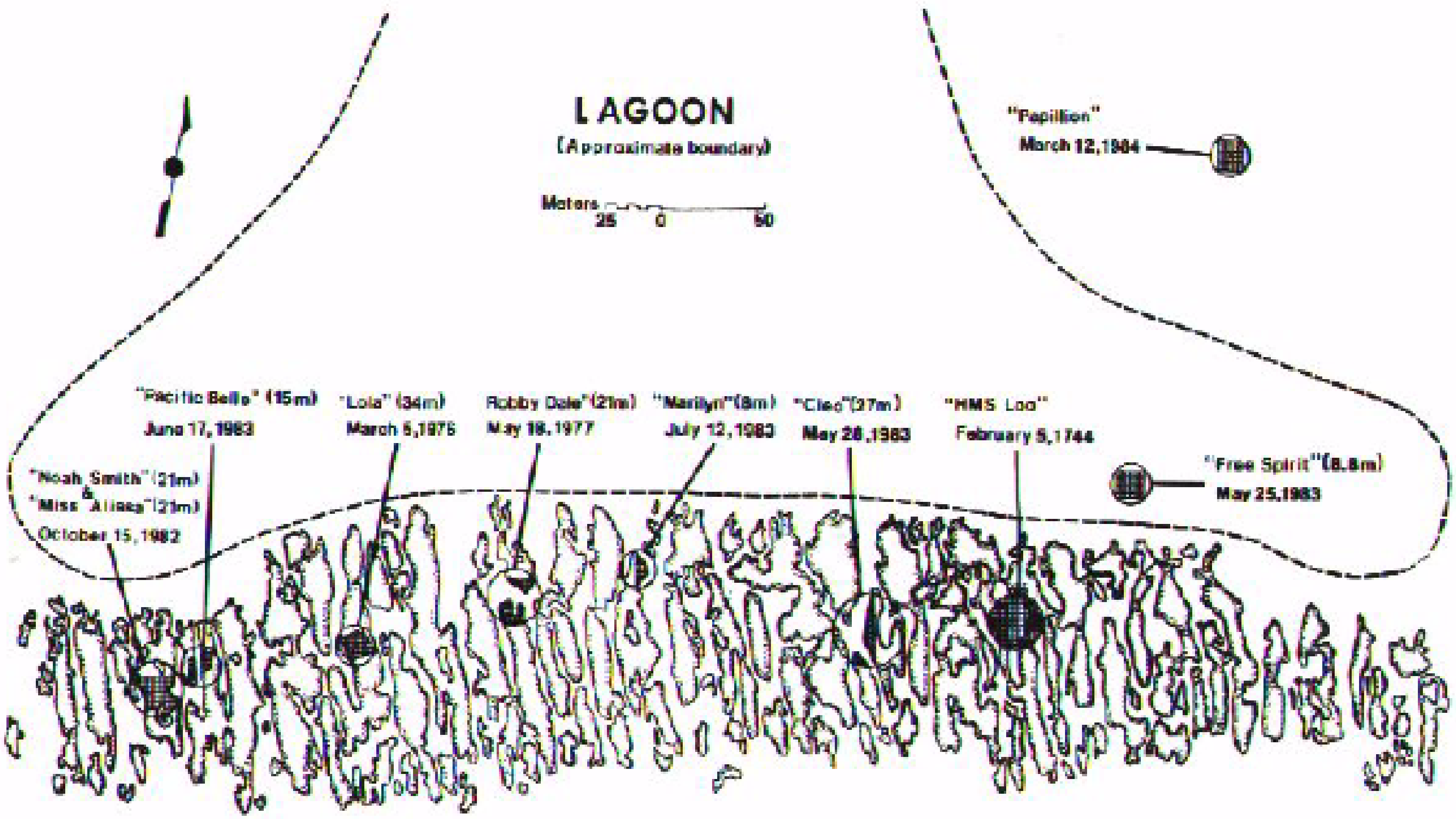


Figure 8.2. Map showing approximate locations of vessel groundings at Looe Key Reef.

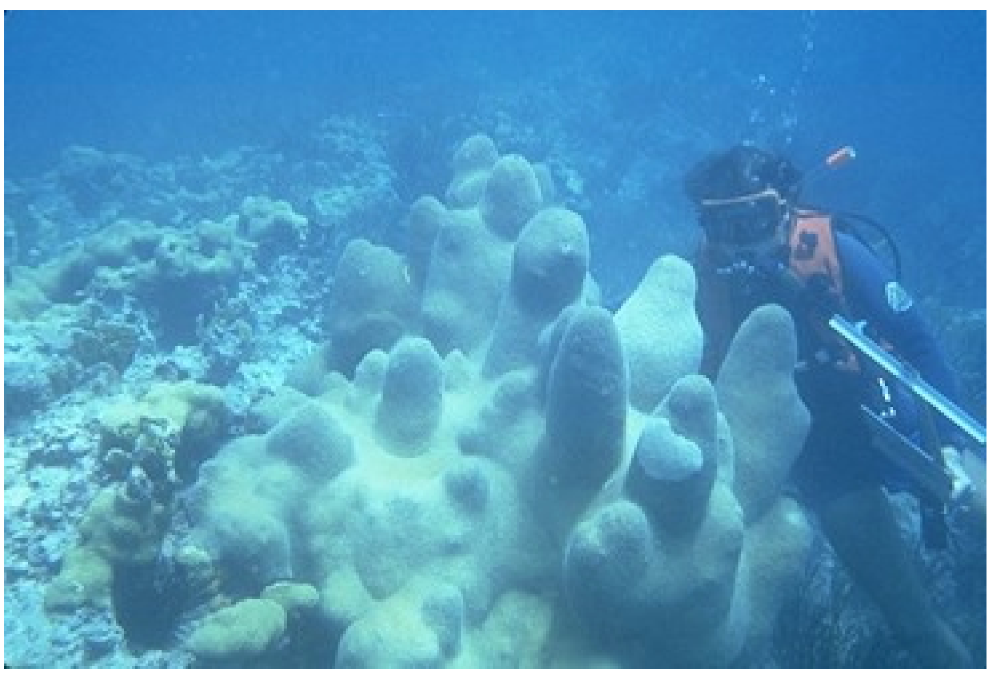


Plate 8.1. Pillar coral, *Dendrogyra cylindrus*, colonies were found in only four places on the forereef. Locations of colonies are shown in Figure 8.1. Photographs of other colonies appearing Plates 8.2, 8.3 and 8.3.

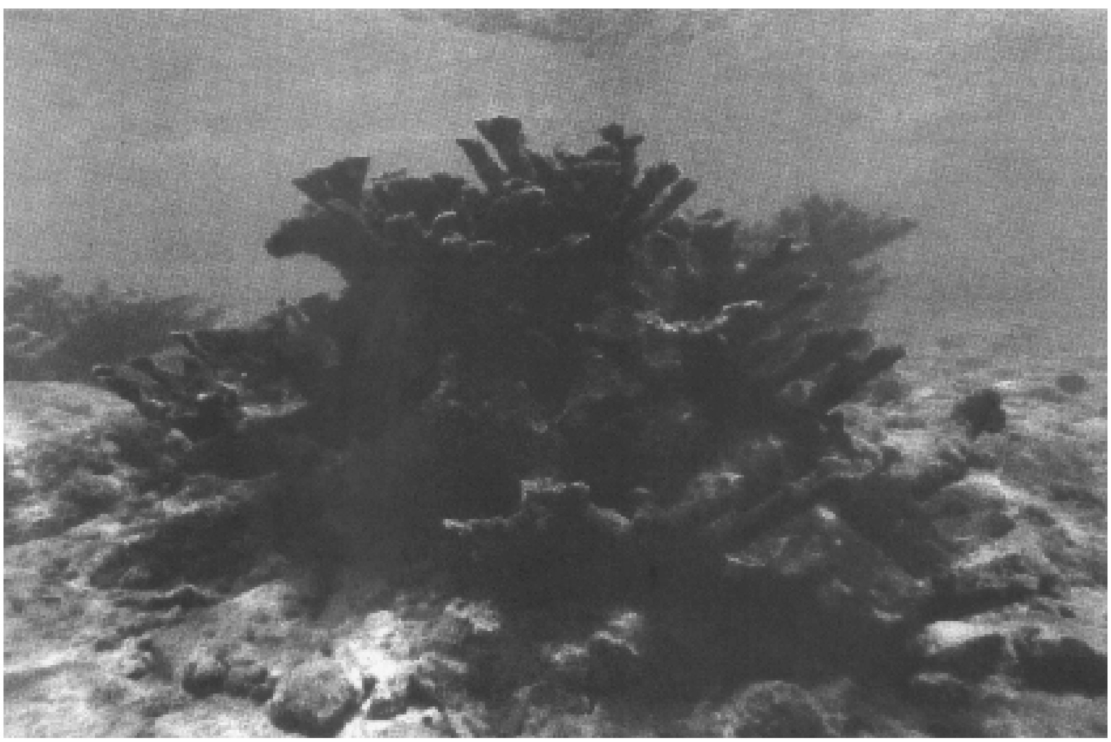


Plate 8.2. Natural storms are a major source of damage to corals. A colony of elkhorn coral (*Acropora palmata*) (top) was turned over after a severe winter storm. *A. palmata* is a rapidly growing branching coral and is a major contributor to reef rubble formation through wave damage. Despite being easily broken, the broken fragments are an important source of vegetative reproduction for the species. A colony (bottom) is beginning to spread and grow upward after being turned over.

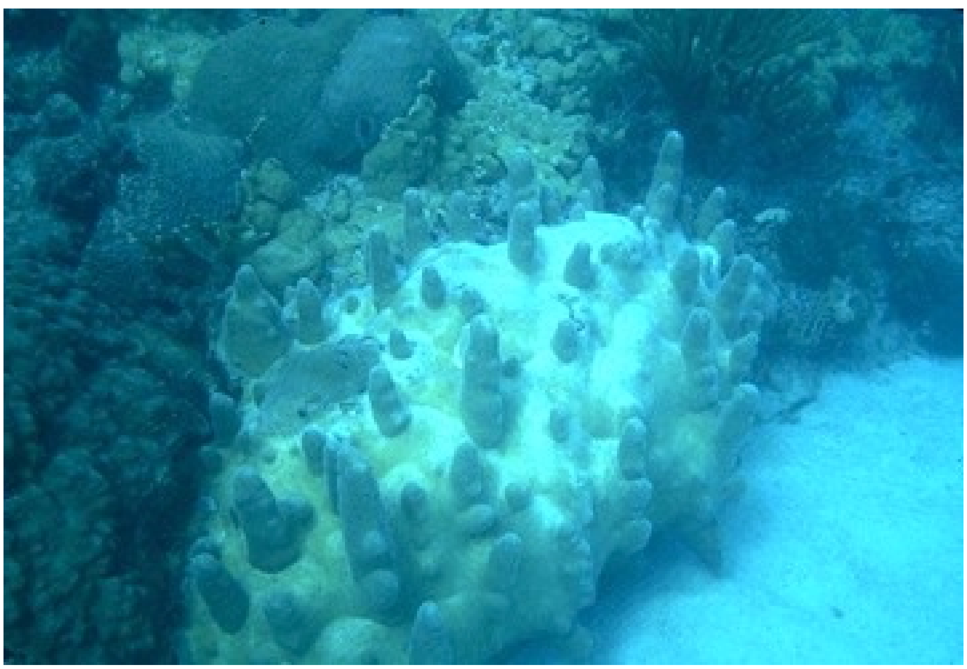


Plate 8.3. Severe heat and cold temperatures can kill coral. Staghorn coral (*A. cervicornis*) killed in the Dry Tortugas by the January 1977 cold spell (top). A large colony of pillar coral (*Dendrogyra cylindrus*) showing discoloration from warm water stress in 1983 (bottom). The arrow shows bleached areas where the stressed coral expelled its symbiotic algae.

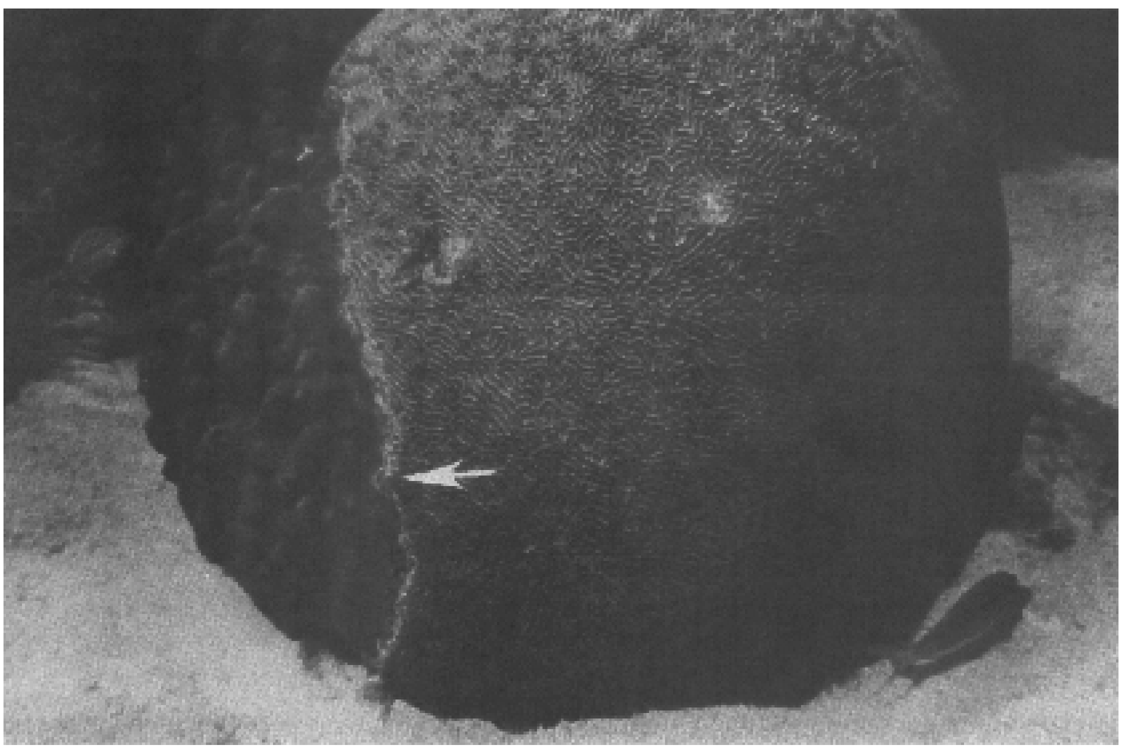


Plate 8.4. Some animals such as this bristle worm (*Hermodice* sp.) (top) feed on coral tissues. Direct and interference competition between corals (bottom) is a common occurrence. The arrow shows the site of direct interaction between two corals which are attempting to digest each other with mesentary filaments. A more common form of competition is indirect where corals shade each other from light.

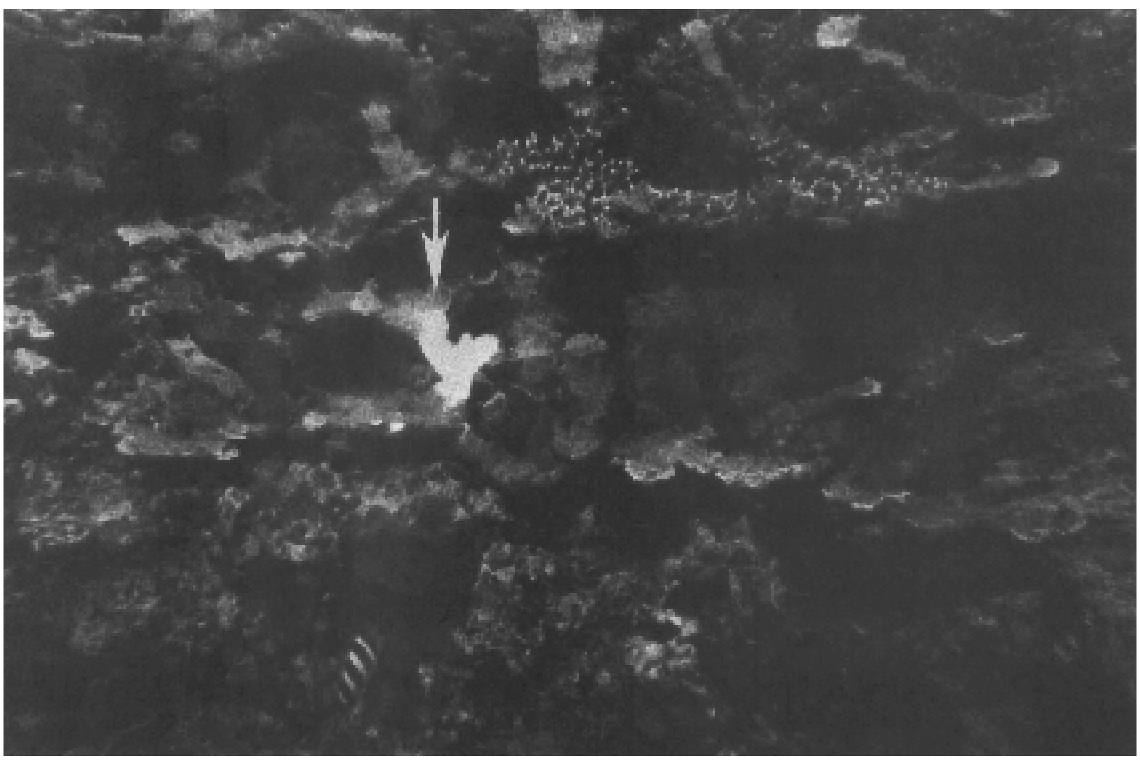


Plate 8.5. The lower white portion of the coral (top) has been killed recently by being temporarily buried by sediments. Lighter patches on the upper half of the colony show unhealthy tissue exposed to excessive sediment stress. The white area of the elkhorn coral (bottom) was recently killed by unknown causes.

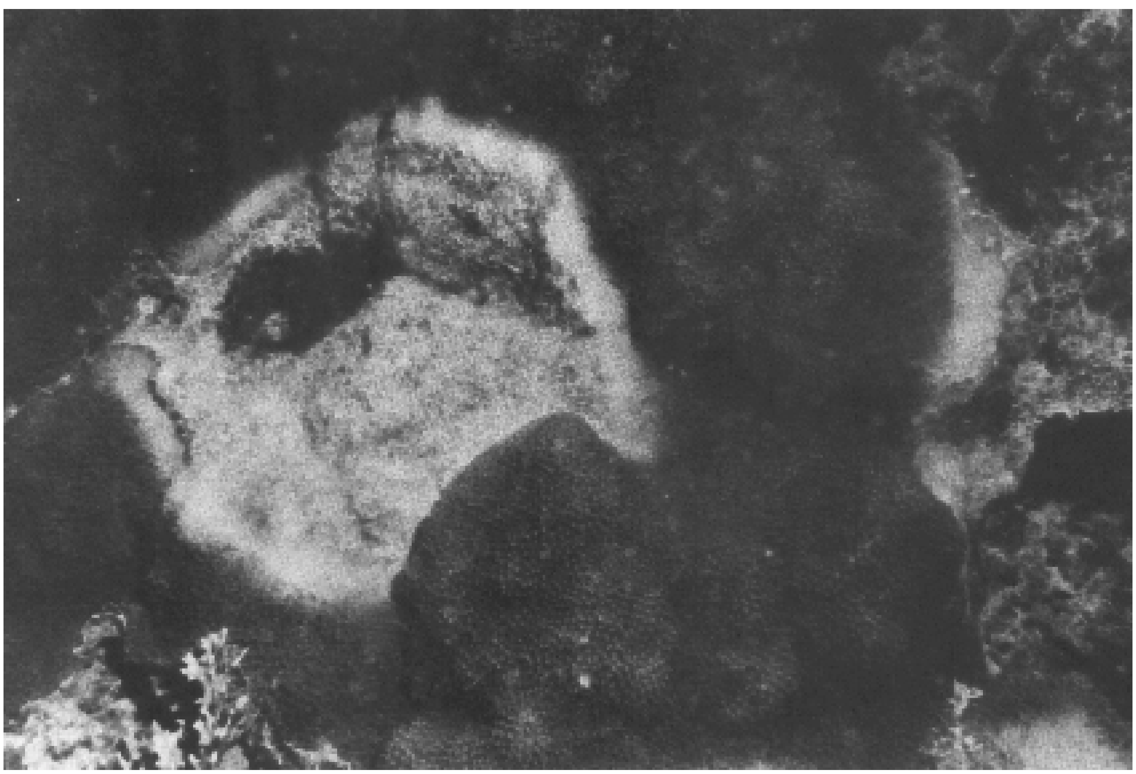


Plate 8.6. Two common coral diseases are black ring disease caused by a bluegreen algae (top) and white ring disease of unknown cause (bottom).

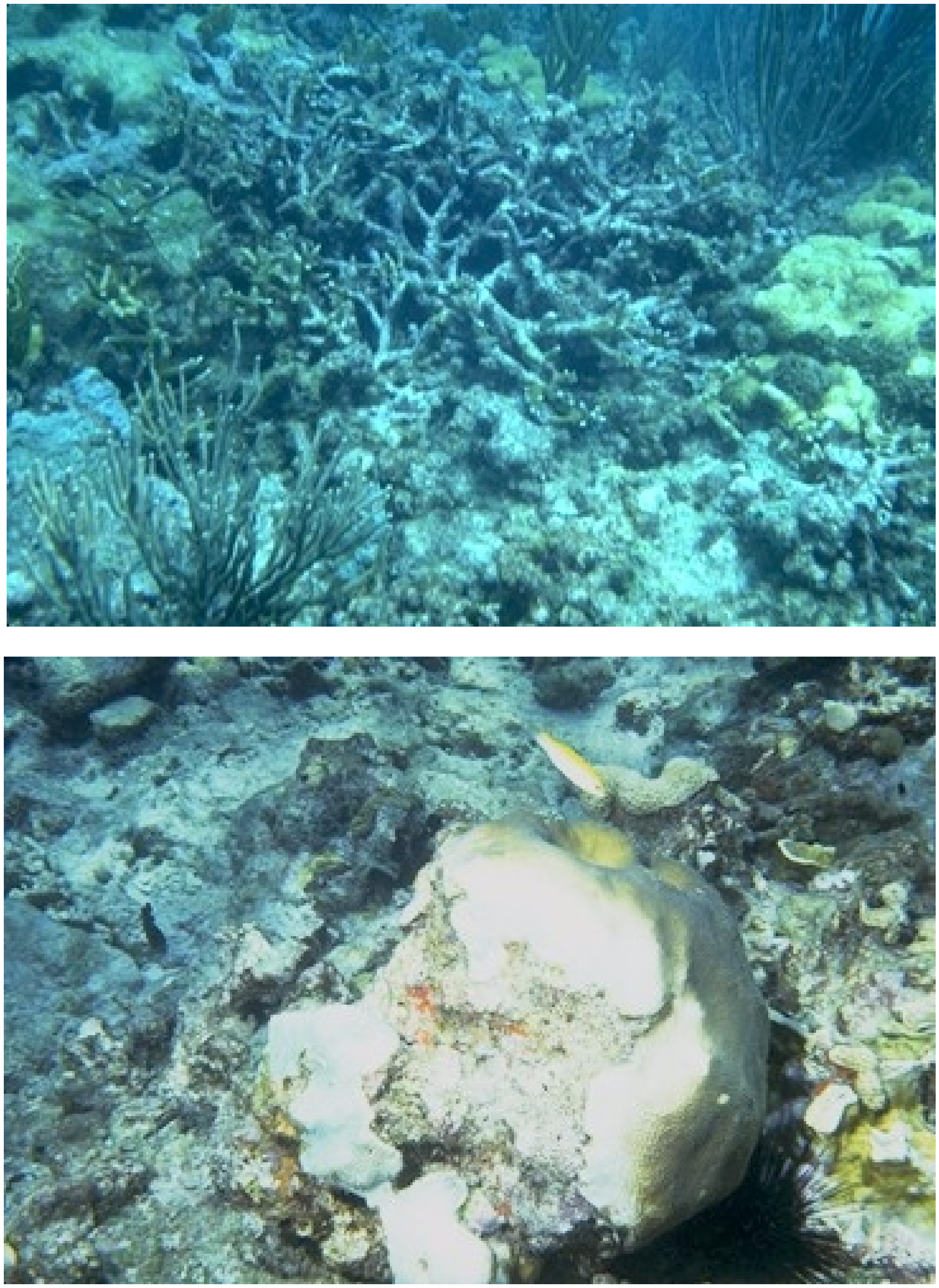


Plate 8.7. Periodic diseases of unknown origin affect several species of coral. Dead staghorn coral (*Acropora cervicornis*) (top) recently killed at Looe Key reef. *Montastrea annularis* (bottom) in the process of bleaching (arrow) and dying.

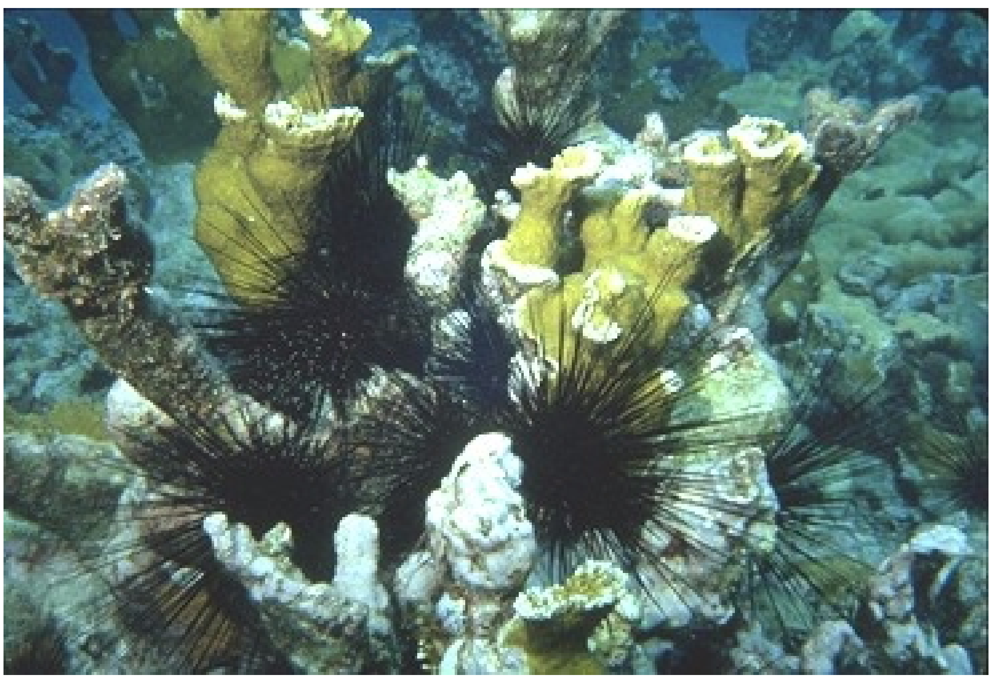


Plate 8.8. During late August 1983 a disease killed most of the long-spined urchins (*Diadema antillarum*) found within the Sanctuary. Although still alive, loss of spines and discoloration characterize the disease whose cause has not been identified (top). Normally, urchins are an abundant and conspicuous member of the herbivorous reef community (bottom).

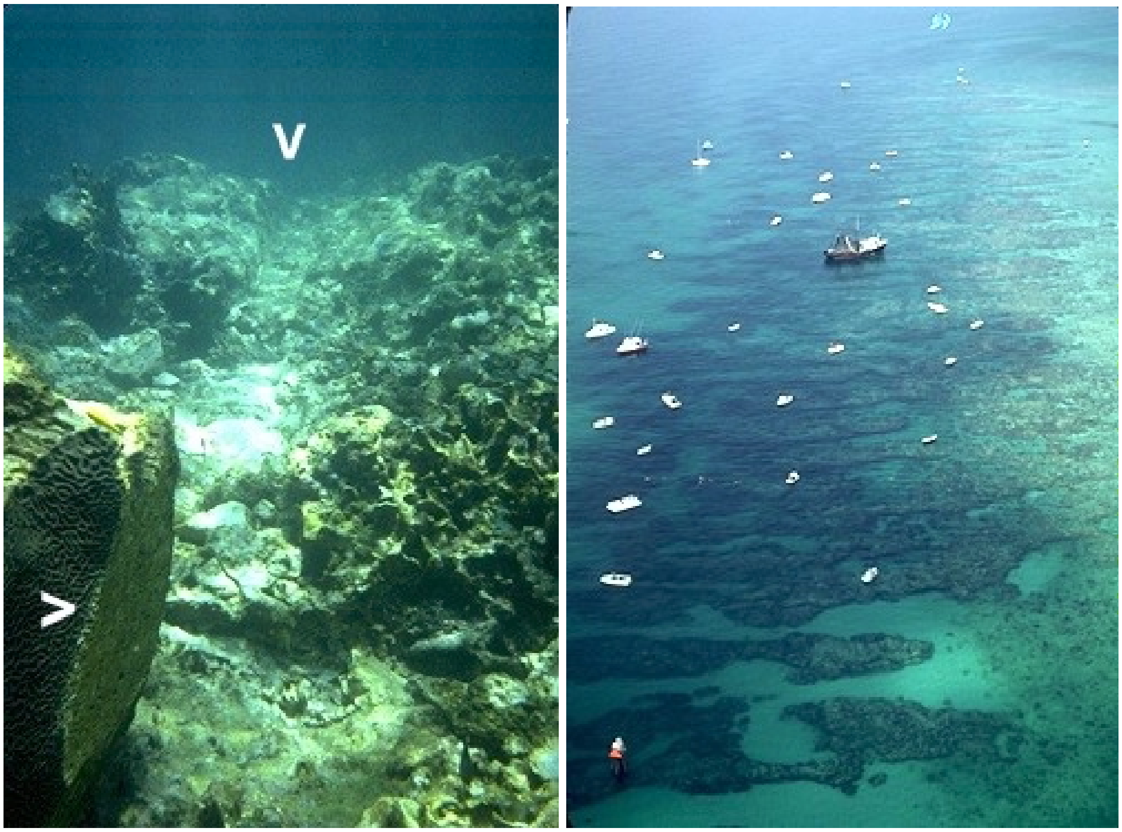


Plate 8.9. The forereef is the most intensively used area in the Sanctuary (left). The shrimp boat Cleo in the center had run aground on the reef and damaged the coral. The top arrow (right) shows a grove the Cleo's keel cut into the spur and bottom arrow shows a colony of brain coral (*Colpophyllia natans*) cut in half by the vessel.

Plate 8.10. Poor anchoring practices damage coral (left and right). Anchors should be placed only on sand or rubble bottoms. Broken coral from poor anchoring practices is certainly an aesthetic problem, however, its ecological consequences may be less important because many corals are adapted to (and may require) periodic physical damage.

Plate 8.11. A cross was deposited in the forereef as a monument (top). Excessive amounts of human materials may reduce the aesthetic experience of visiting a natural reef. Inexperienced divers may damage corals by deliberately or accidentally touching the tissues (bottom). The ecological impact of such treatment are unknown.

Plate 8.12. Wreckage and a groove cut into a coral spur from the Robby Dale. The engine (bottom) of the Robby Dale shortly after its sinking on 18 March 1977. The salvaging of the engine further damaged the reef.

Plate 8.13. Wreckage of the Robby Dale seen extending above surface shortly after its sinking on 18 May 1977 (top) and as it appeared during the survey in 1963 (bottom).

Plate 8.14. Wreckage of the Robby Dale shortly after sinking in 1977 (top) and in 1983 (bottom).

Plate 8.15. Damage to the reef caused by groundings of the shrimp boat Noah Smith on 15 Oct 1982. View of the beginning of the impact area with a 3 ft groove (top). View of the core impact area showing crushed coral (bottom). Photos by John Halas.

Plate 8.16. Aerial view of Looe Key Reef showing damage from the grounding of the 110-ft Lola grounding of 5 March 1976 (top). Arrows show light areas on spur where surface coral was crushed and killed (Photo by Bill Becker). Closeup view (bottom) of groove cut into a spur by the keel of the Cleo, a 88 ft shrimper, grounded on 28 May 1983.

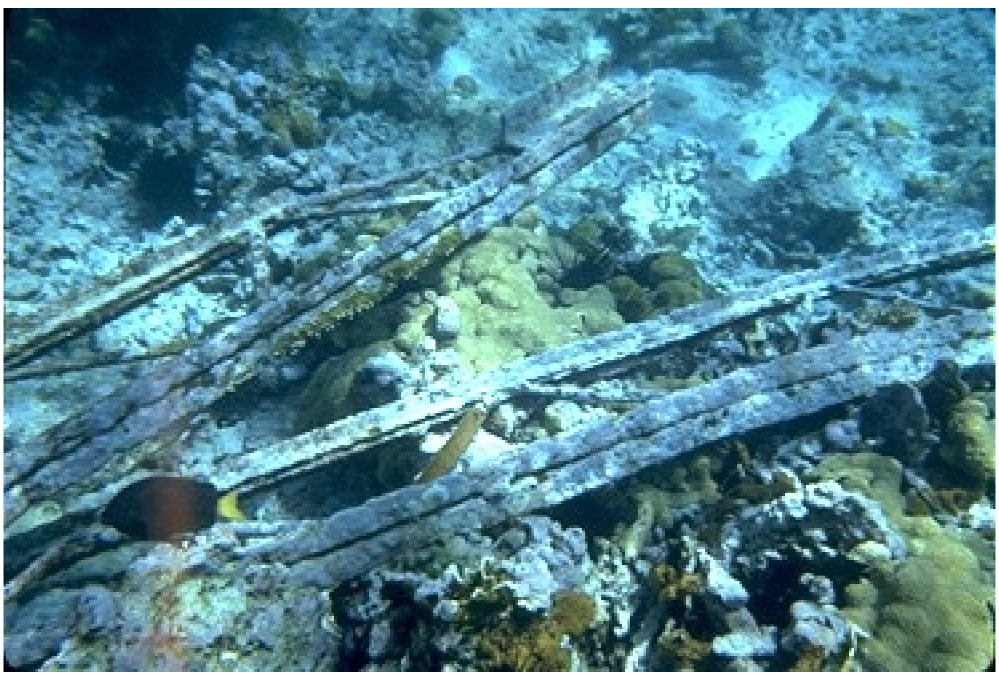


Plate 8.17. Wreckage materials left by the grounding of the 110-ft Lola, grounding of 5 March 1976 (top and bottom). Materials from previous wrecks are common on Looe Key forereef.

Plate 8.18. A potential exists for a major disaster caused by collision of a large ship with the reef. Ships traveling west frequently pass close to the forereef in order to avoid strong easterly currents in the Straights of Florida (top). Although a modern wreck of a large ship on a reef would be considered a major calamity, the wreckage of the warship H.M.S. Loo (bottom) and her prize are considered historical artifacts of great cultural value. Although much of the Loo has been removed, balast materials (below diver) can still be seen on the reef and are protected by the Sanctuary.

Plate 8.19. Oil spills have frequently occurred in the Florida Keys. An oil slick (top) can be seen with the Lower Florida Keys in the background (21 July 1975). Oil floating over shallow sea grass beds (bottom) north of the Sanctuary (21 July 1975).

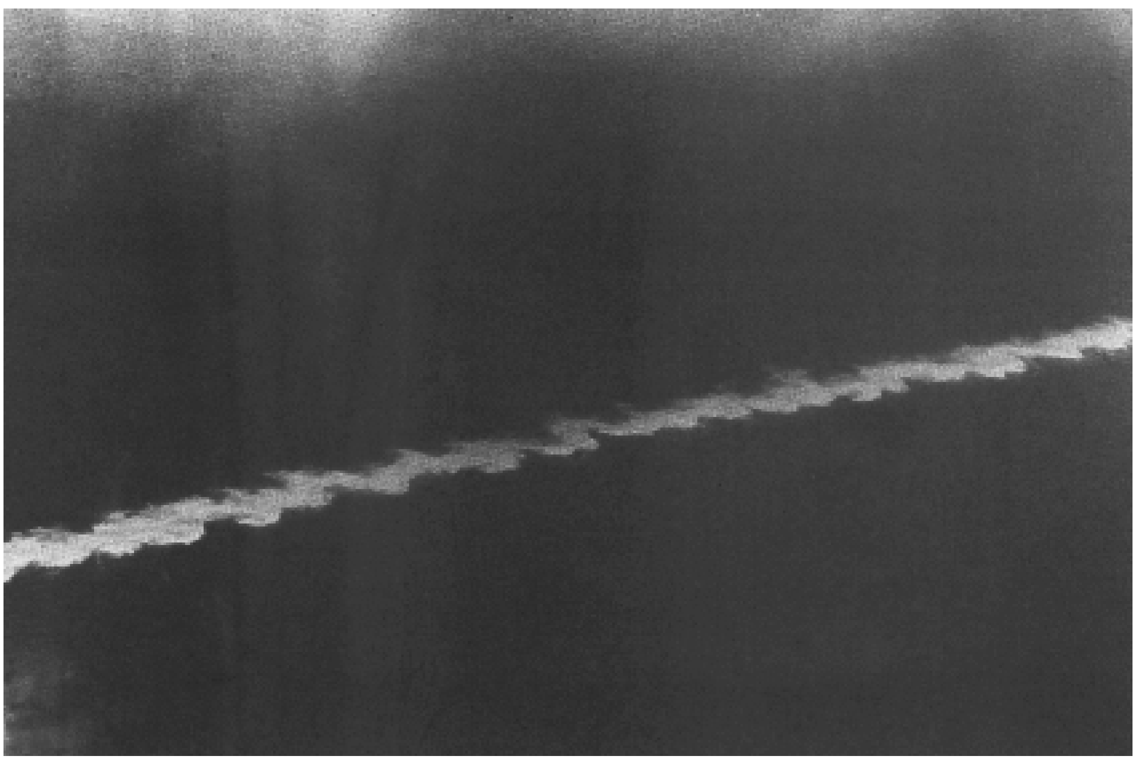


Plate 8.20. Land cleared for development on Big Pine Key north of the Sanctuary (top). Turbidity in Hawk's channel caused by a tugboat pushing a barge (bottom).

CHAPTER 9

MANAGEMENT CONSIDERATIONS

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The purpose of this chapter is to provide comments on implications of resource inventory for wise resource management. Results presented in previous chapters document resource features and abundance. In many cases, almost nothing is known about the population dynamics of most living coral reef resources. Many hypotheses have been suggested regarding the status and health of various resources and the environmental factors responsible for influencing resources. Many of the hypotheses presented need further testing or verification.

Results clearly indicate that Looe Key National Marine Sanctuary is an open ecological system and is therefore not self-sufficient. Water masses originating outside the sanctuary influence the health and perhaps the recruitment of corals (Chapters 4, 5 and 6), Most individuals of other species probably recruit to the Sanctuary from other areas. No juveniles were observed for many of the reef fishes censused, which suggests that they settle and grow in areas outside the Sanctuary. The importance of plankton as a food resource for the reef fish community was demonstrated (Chapter 7). The fact that many reef fishes migrate or feed away from the reef also shows that, the sanctuary is an open ecological system. Coastal mangrove forests, shallow flats, and seagrass beds are probably important sources of food and shelter for reef associated species. The fact that LKNMS is an open ecological system indicates that future research, monitoring, and management must consider factors outside the boundaries of the Sanctuary such as coastal development, reef resource utilization, and water quality.

The ability to distinguish between human induced changes and natural is a critical general requirement for management. In order to accomplish this, an understanding of natural and human processes involving the Sanctuary are necessary. In most cases this will involve considerably more fundamental and applied knowledge than is available at present. Monitoring the resources is important and the only way to detect changes in the sanctuary. However, determining the causes of observed changes is equally important and usually requires considerably more effort and the use of controlled experiments.

Although research funds are now and will continue to be limited, managers must be careful to emphasize fundamental as well as applied research in the Sanctuary. Only by understanding fundamental processes can applied actions have the desired effect. Obvious direct impacts on the Sanctuary tend to be the most noticed and get immediate attention. Managers should be aware, however, that subtle indirect factors may eventually have more impact on the health of the Sanctuary. For example, near shore pollution or loss of habitat may affect the survival and recruitment of species that depend on those habitats for part of their life cycle. Many reef fishes have home ranges that extend far beyond the sanctuary and may be vulnerable to excessive harvesting outside sanctuary boundaries.

Perhaps the major management decision will be to actively or passively manage the Sanctuary. Passive management minimizes intervention involving natural or human disturbances and is based on the premise that natural processes alone are sufficient to maintain the system in a healthy, natural state. Active management involves direct action with regard to natural or human perturbations and is based on the premise that human interference with the system is sufficiently great that, natural processes alone will not maintain a healthy natural system.

Usually human and natural events cannot be separated. For example, a severe cold spell may cause much greater devastation because current patterns have been altered by human activities, or low level pollution has weakened corals, making them more susceptible to cold mortality. As another example, human damage to corals may make them more susceptible to hurricane damage.

Evidence presented in this volume suggests that some potential impacts are of sufficient magnitude that active, creative management may be necessary. Creative management requires anticipating problems rather that merely reacting to situation as they occur. Evidence presented in this volume suggests several potential problems worth considering. Potential human impacts include intense direct exploitation of the sources, indirect damage from non-consumptive use of the resources, major collisions by ships, pollution, and other habitat deterioration. Natural disasters may also demand active management. Severe cold weather and hurricanes could potentially devastate the reef. Management should anticipate what preventive, corrective, or mitigative actions could be taken. For example, the loss of elkhorn coral has been identified as a detrimental impact on the reef in terms of geological time (Chapter 4 and 5). Sudden catastrophic loss from a natural or human created disaster could be devastating to the health and future of Looe Key Reef. A possibility exists that elkhorn coral could be artificially planted to mitigate, improve, or correct damage to the resource. Appropriate research would be to develop transplanting techniques and to demonstrate the feasibility of artificial coral propagation. Another possible example of creative active management is the construction and use of artificial reefs away from the reef proper in order to reduce or redistribute the impact of human use.

Several specific management problems have been identified in the resource inventory. Shinn *et al.* (Chapter 4) have noted the possible problem of reef areas being impacted by chilled Florida Bay water and being swallowed by sediment plumes. Hudson (Chapter 5) has suggested a decline in coral growth has occurred at Looe Key which may be a result of human activities. Jaap (Chapter 1 and 6) and Bohnsack *et al.* (Chapter 8) have emphasized the absence of elkhorn coral in much of its prime habitat at Looe Key Reef. Many direct and indirect impacts on coral and fishes resulting from human activities were documented in Chapters 2 and 7 including: vessel groundings, anchor damage, direct hook and line fishing, use of fish traps in surrounding waters, and others. Wise management of Looe Key National Marine Sanctuary will require monitoring, research, and an active role by creative managers.

TAXONOMIC APPENDIX

The Integrated Taxonomic Information System (ITIS) <http://www.itis.usda.gov/>, a taxonomic information database on plants, animals, fungi, and microbes of North America and the world, is a partnership of US, Canadian, and Mexican agencies (ITIS-North America); other organizations; and taxonomic specialists. ITIS is also a partner of Species 2000 and the Global Biodiversity Information Facility. Universal Resource Locator (URLs) addresses are listed below for the species mentioned in this document.

In some computer systems, the links will appear in color, usually blue. Clicking on the link will take the reader directly to the appropriate location in the ITIS database. The computer system must be connected to the Internet.

The links were operational at the time of publication in December 2002.

	URL to ITIS website
Abudefduf saxatilis (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170046
Acanthemblemaria aspera (Longley, 1927)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171450
Acanthemblemaria chaplini Boehlke, 1957	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171452
Acanthemblemaria Metzelaar, 1919	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171449
Acanthurus bahianus Castelnau, 1855	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=172252
Acanthurus chirurgus (Bloch, 1787)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=172253
Acanthurus coeruleus Schneider, 1801	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=172254
Acropora cervicornis (Lamarck, 1816)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52862
Acropora palmata (Lamarck, 1816)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52861
Acropora prolifera (Lamarck, 1816)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52863
Aetobatus narinari (Euphrasen, 1790)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=160978
Agaricia agaricites (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53050
Agaricia agaricites forma *carinata*	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53053

Agaricia agaricites forma *danai*	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53054
Agaricia agaricites forma *humilis*	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53064
Agaricia agaricites forma *purpurea*	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53052
Agaricia fragilis Dana, 1846	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53055
Agaricia grahamae Wells, 1973	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53062
Agaricia lamarcki Milne-Edwards and Haime, 1851	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53058
Agaricia tenuifolia Dana, 1846	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53060
Agaricia undata (Ellis and Solander, 1786)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53061
Alectis ciliaris (Bloch, 1787)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168602
Aluterus schoepfi (Walbaum, 1792)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=173131
Aluterus scriptus (Osbeck, 1765)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=173134
Amblycirrhitus pinos (Mowbray, 1927)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170224
Anchoa lyolepis (Evermann and Marsh, 1900)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=161842
Anisotremus surinamensis (Bloch, 1790)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169084
Anisotremus virginicus (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169086
Apogon binotatus (Poey, 1867)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168202
Apogon maculatus (Poey, 1860)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168204
Apogon pseudomaculatus Longley, 1932	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168207
Apogon quadrisquamatus Longley, 1934	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168207

Atherinomorus stipes (Mueller and Troschel, 1847)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=166006
Aulostomus maculatus Valenciennes, 1845	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=166411
Balistes capriscus Gmelin, 1789	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=173138
Balistes vetula Linnaeus, 1758	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=173139
Bodianus pulchellus (Poey, 1860)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170483
Bodianus rufus (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170484
Briareum asbestinum (Pallas, 1766)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52083
Calamus bajonado (Schneider, 1801)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169197
Calamus calamus (Valenciennes, 1830)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169198
Calamus penna (Valenciennes, 1830)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169205
Calamus sp. Swainson, 1839	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169195
Callionymus bairdi (Jordan, 1887)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171744
Cantherhines macrocerus (Hollard, 1854)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=173157
Cantherhines pullus (Ranzani, 1842)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=173158
Canthidermis sufflamen (Mitchill, 1815)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=173170
Canthigaster rostrata (Bloch, 1786)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=173320
Caranx bartholomaei Cuvier, 1833	*http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168606*
Caranx crysos (Mitchill, 1815)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168612
Caranx ruber (Bloch, 1793)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168614
Chaetodipterus faber (Broussonet, 1782)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169539

Chaetodon capistratus Linnaeus, 1758	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169558
Chaetodon ocellatus Bloch, 1787	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169556
Chaetodon sedentarius Poey, 1860	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169562
Chaetodon striatus Linnaeus, 1758	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169563
Chromis cyanea (Poey, 1860)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170080
Chromis insolata (Cuvier, 1830)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170082
Chromis multilineata (Guichenot, 1853)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170084
Chromis scotti Emery, 1968	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170086
Clepticus parrae (Bloch and Schneider, 1801)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170496
Colpophyllia natans (Houttuyn, 1772)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53289
Coryphopterus dicrus Boehlke and Robins, 1960	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171752
Coryphopterus glaucofraenum Gill, 1863	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171754
Coryphopterus personatus (Jordan and Thompson, 1904)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171757
Coryphopterus sp.	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171749
Cryptotomus roseus Cope, 1871	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170857
Dasyatis americana Hildebrand and Schroeder, 1928	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=160951
Decapterus macarellus (Cuvier, 1833)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168724
Decapterus punctatus (Cuvier, 1829)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168725
Dendrogyra cylindrus Ehrenberg, 1834	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53428

Diadema antillarum (Philippi, 1845)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=157877
Dichocoenia stellaris Milne-Edwards and Haime, 1848	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53421
Dichocoenia stokesi Milne-Edwards and Haime, 1848	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53420
Diodon holocanthus Linnaeus, 1758	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=173392
Diodon hystrix Linnaeus, 1758	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=173391
Diplectrum formosum (Linnaeus, 1766)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167793
Diploria clivosa (Ellis and Solander, 1786)	*http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53285*
Diploria labyrinthiformis (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53286
Diploria strigosa (Dana, 1846)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53287
Eunicea tourneforti (Milne-Edwards and Haime)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52195
Echeneis naucrates Linnaeus, 1758	*http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168575*
Ellisella barbadensis (Duchass. and Michelotti, 1864)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52286
Enchelycore nigricans (Bonnaterre, 1788)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=161180
Epinephelus adscensionis (Osbeck, 1765)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167696
Epinephelus cruentatus (Lacepede, 1802)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167741
Epinephelus fulvus (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167739
Epinephelus guttatus (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167700
Epinephelus itajara (Lichtenstein, 1822)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167695
Epinephelus morio (Valenciennes, 1828)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167702

Epinephelus striatus (Bloch, 1792)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167706
Equetus acuminatus (Schneider, 1801)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169313
Equetus lanceolatus (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169314
Equetus punctatus (Schneider, 1801)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169317
Erythropodium caribaeorum (Duchass. and Michelotti, 1860)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52197
Eunicea asperula Milne-Edwards and Haime, 1857	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52197
Eunicea calyculata (Ellis and Solander, 1786)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52184
Eunicea clavigera Bayer, 1961	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52190
Eunicea fusca Duchassaing and Michelotti, 1860	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52187
Eunicea laciniata Duchassaing and Michelotti, 1860	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52189
Eunicea mammosa Lamouroux, 1816	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52192
Eunicea pinta	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52194
Eunicea succinea (Pallas, 1766)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52196
Eunicea tourneforti forma *tourneforti*	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52195
Eusmilia fastigiata (Pallas, 1766)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53622
Favia fragum (Esper, 1795)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53267
Gerres cinereus (Walbaum in Artedi, 1792)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169032
Ginglymostoma cirratum (Bonnaterre, 1788)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=159977
Gnatholepis thompsoni Jordan, 1902	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171828

Gobiosoma macrodon Beebe and Tee-van, 1928	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171795
Gobiosoma oceanops (Jordan, 1904)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171796
Gorgonia ventalina Linnaeus, 1758	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169032
Gymnothorax funebris Ranzani, 1839	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=161186
Gymnothorax moringa (Cuvier, 1829)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=161188
Haemulon album Cuvier, 1830	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169060
Haemulon aurolineatum Cuvier, 1830	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169058
Haemulon carbonarium Poey, 1860	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169063
Haemulon chrysargyreum Guenther, 1859	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169064
Haemulon flavolineatum (Desmarest, 1823)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169065
Haemulon macrostomum Guenther, 1859	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169066
Haemulon melanurum (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169067
Haemulon parra (Desmarest, 1823)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169074
Haemulon plumieri (Lacepede, 1801)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169059
Haemulon sciurus (Shaw, 1803)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169069
Halichoeres bivittatus (Bloch, 1791)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170503
Halichoeres garnoti (Valenciennes, 1839)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170506
Halichoeres maculipinna (Mueller and Troschel, 1848)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170507
Halichoeres pictus (Poey, 1860)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170508
Halichoeres poeyi (Steindachner, 1867)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170509

Halichoeres radiatus (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170510
Helioseris cucullata (Ellis and Solander, 1786)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53037
Hemiemblemaria simulus Longley and Hildebrand, 1940	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171474
Hemipteronotus novacula (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170537
Hemipteronotus splendens (Castlenau, 1872)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170539
Hermodice Kinberg, 1857	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=65197
Holacanthus bermudensis Goode, 1876	*http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169626*
Holacanthus ciliaris (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169623
Holacanthus tricolor (Bloch, 1795)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169625
Holocentrus adscensionis (Osbeck, 1765)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=166172
Holocentrus coruscus (Poey, 1860)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=166180
Holocentrus rufus (Walbaum, 1792)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=166173
Holocentrus vexillarius (Poey, 1860)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=166184
Hypleurochilus Gill, 1861	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171197
Hypoplectrus gemma Goode Bean	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167809
Hypoplectrus nigricans Poey	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167812
Hypoplectrus puella Cuvier	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167813
Hypoplectrus unicolor (Walbaum, 1792)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167806
Iciligorgia schrammi Duchassaing, 1870	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52098

Inermia vittata Poey, 1861	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168832
Ioglossus calliurus Bean, 1882	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171866
Isophyllastrea rigida (Dana, 1846)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53495
Isophyllia sinuosa (Ellis and Solander, 1786)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53476
Jenkinsia lamprotaenia (Gosse, 1851)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=161759
Jenkinsia Jordan and Evermann, 1896	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=161758
Kyphosus sectatrix (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169506
Lachnolaimus maximus (Walbaum, 1792)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170566
Lactophrys bicaudalis (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=173238
Lactophrys polygonia (Poey, 1876)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=173241
Lactophrys quadricornis (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=173240
Lactophrys triqueter (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=173239
Liopropoma rubre Poey, 1861	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167820
Lutjanus analis (Cuvier, 1828)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168849
Lutjanus apodus (Walbaum in Artedi, 1792)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168850
Lutjanus griseus (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168848
Lutjanus jocu (Bloch and Schneider, 1801)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168857
Lutjanus mahogoni (Cuvier in Cuvier and Valenciennes, 1828)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168858
Lutjanus synagris (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168860
Madracis asperula Milne-Edwards and Haime, 1849	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53008

Madracis decactis (Lyman, 1859)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53009
Madracis mirabilis Duchassaing and Michelotti, 1860	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53011
Malacanthus plumieri (Bloch, 1787)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168548
Malacoctenus gilli (Steindachner)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171421
Malacoctenus macropus (Poey, 1868)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171422
Malacoctenus triangulatus Springer, 1959	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171423
Malacoctenus versicolor (Poey	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171426
Manicina areolata (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53281
Meandrina meandrites (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53423
Meandrina varicosa	[Not found in ITIS]
Megalops atlanticus Valenciennes in Cuvier and Valenciennes, 1847	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=161116
Microgobius carri Fowler, 1945	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171810
Microspathodon chrysurus (Cuvier in Cuvier and Valenciennes, 1830)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170116
Millepora alcicornis Linnaeus, 1758	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=50877
Millepora complanata Lamarck, 1816	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=50880
Millepora squarrosa Lamarck, 1816	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=50878
Monacanthus tuckeri Bean, 1906	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=173180
Montastraea annularis (Ellis and Solander, 1786)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53256
Montastraea cavernosa Linnaeus, 1767	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53255

Mulloidichthys martinicus (Cuvier, 1829)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169408
Muricea atlantica (Riess, 1919)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52162
Muraena miliaris (Kaup, 1856)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=161239
Muricea elongata Lamouroux, 1821	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52175
Muricea laxa Verrill, 1864	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52176
Muricea muricata (Pallas, 1766)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52179
Muriceopsis flavida (Lamarck, 1815)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52223
Muriceopsis flavida (Lamarck, 1815)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52223
Mussa angulosa (Pallas, 1766)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53474
Mycetophyllia aliciae Wells, 1973	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53482
Mycetophyllia daniana Milne-Edwards and Haime, 1849	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53480
Mycetophyllia ferox Wells, 1973	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53481
Mycetophyllia lamarckiana Milne-Edwards and Haime, 1848	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53479
Mycetophyllia sp.	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53478
Mycteroperca bonaci (Poey, 1860)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167760
Myripristis jacobus Cuvier, 1829	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=166211
Oculina diffusa Lamarck, 1816	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53395
Ocyurus chrysurus (Bloch, 1790)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168907
Odontoscion dentex (Cuvier, 1830)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169325
Ophioblennius atlanticus (Valenciennes, 1836)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171203

Opistognathus aurifrons (Jordan and Thompson, 1905)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170928
Opistognathus maxillosus (Poey, 1860)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170927
Plexaura flexosa Lamouroux, 1821	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52209
Plexaurella grisea Kunze, 1916	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52202
Pseudoplexaura crucis Bayer, 1961	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52207
Pseudoplexaura flagellosa (Houttuyn, 1772)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52206
Pseudoplexaura porosa (Houttuyn, 1772)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52204
Pseudoplexaura wagenaari (Stiasny, 1941)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52205
Pseudopterogorgia americana (Gmelin, 1791)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52259
Pterogorgia anceps (Pallas, 1766)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52258
Pagrus pagrus (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169207
Palythoa caribbea	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52436
Paraclinus nigripinnis (Steindachner, 1867)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171434
Paranthias furcifer (Valenciennes, 1828)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167838
Pempheris schomburgki Mueller and Troschel, 1848	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169472
Plexaura flexosa Lamouroux, 1821	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52209
Plexaurella fusifera Kunze, 1916	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52200
Plexaura homomalla (Esper, 1792)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52211
Plexaurella dichotoma (Esper, 1791)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52201

Plexaurella grisea Kunze, 1916	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52202
Plexaurella nutans (Duchass. and Michelotti, 1860)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52199
Pomacanthus arcuatus (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169632
Pomacanthus paru (Bloch, 1787)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169633
Pomacentrus diencaeus (Jordan and Rutter, 1897)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170152
Pomacentrus fuscus Cuvier in Cuvier and Valenciennes, 1830	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170178
Pomacentrus leucostictus Mueller and Troschel, 1848	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170180
Pomacentrus partitus Poey, 1868	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170189
Pomacentrus planifrons Cuvier, 1830	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170184
Pomacentrus variabilis Castelnau, 1855	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170186
Porites astreoides Lamarck, 1816	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53184
Porites divaricata	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53185
Porites furcata Lamarck, 1816	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53187
Porites porites (Pallas, 1766)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53180
Priacanthus cruentatus (Lacepede, 1801)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168179
Pseudoplexaura crucis Bayer, 1961	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52207
Pseudoplexaura flagellosa (Houttuyn, 1772)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52206
Pseudoplexaura porosa (Houttuyn, 1772)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52204
Pseudoplexaura wagenaari (Stiasny, 1941)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52205

Pseudopterogorgia acerosa (Pallas, 1766)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52255
Pseudopterogorgia americana (Gmelin, 1791)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52259
Pseudopterogorgia bipinnata (Verrill, 1864)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52260
Pseudopterogorgia calyculata	[Not found in ITIS.]
Pseudopterogorgia elisabethae Bayer, 1961	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52264
Pseudupeneus maculatus (Bloch, 1793)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=169421
Pterogorgia anceps (Pallas, 1766)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52267
Pterogorgia citrina (Esper, 1792)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52268
Pterogorgia guadalupensis Duchassaing and Michelin, 1846	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52266
Ricordea florida Duchassaing and Michelotti, 1860	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52484
Rypticus saponaceus (Schneider, 1801)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167990
Stephanocoenia michelini Milne-Edwards and Haime, 1848	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52843
Scartella cristata (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=171307
Scarus coelestinus Valenciennes, 1839	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170812
Scarus coeruleus (Bloch, 1786)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170811
Scarus croicensis Bloch, 1790	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170813
Scarus guacamaia Cuvier, 1829	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170814
Scarus taeniopterus Desmarest, 1831	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170815
Scarus vetula Schneider, 1801	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170816

Scolymia lacera (Pallas, 1766)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53485
Scolymia sp.	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53484
Scomberomorus cavalla (Cuvier, 1829)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=172435
Scomberomorus maculatus (Mitchill, 1815)s	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=172436
Scomberomorus regalis (Bloch, 1793)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=172437
Scorpaena plumieri Bloch, 1789	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=166825
Seriola dumerili (Risso, 1810)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168689
Serranus baldwini (Evermann and Marsh, 1900)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167852
Serranus tabacarius (Cuvier, 1829)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167859
Serranus tigrinus (Bloch, 1790)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167859
Serranus tortugarum Longley, 1935	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=167861
Siderastrea radians (Pallas, 1766)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53091
Siderastrea siderea (Ellis and Solander, 1786)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53090
Solenastrea bournoni Milne-Edwards and Haime, 1850	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53253
Solenastrea hyades (Dana, 1846)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53252
Sparisoma atomarium (Poey, 1861)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170862
Sparisoma aurofrenatum (Valenciennes, 1839)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170863
Sparisoma chrysopterum (Bloch and Schneider, 1801)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170864
Sparisoma radians (Valenciennes, 1839)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170865

Sparisoma rubripinne (Valenciennes, 1839)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170866
Sparisoma viride (Bonnaterre, 1788)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170867
Sphenotrochus auritus De Pourtalès, 1874	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=572437
Sphoeroides spengleri (Bloch, 1782)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=173300
Sphyraena barracuda (Walbaum in Artedi, 1792)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170429
Stephanocoenia michelini Milne-Edwards and Haime, 1848	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52843
Strongylura notata (Poey, 1860)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=165553
Strongylura timucu (Walbaum in Artedi, 1792)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=165554
Synodus intermedius Agassiz	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=162377
Thalassoma bifasciatum (Bloch, 1791)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=170568
Trachinotus falcatus (Linnaeus, 1758)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=168709
Tubastrea aurea	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=53807
Tylosurus crocodilus (Peron and Lesueur, 1821)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=165577
Urolophus jamaicensis (Cuvier, 1816)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=160965
Zoanthus sociatus (Ellis and Solander, 1786)	http://www.itis.usda.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=52440