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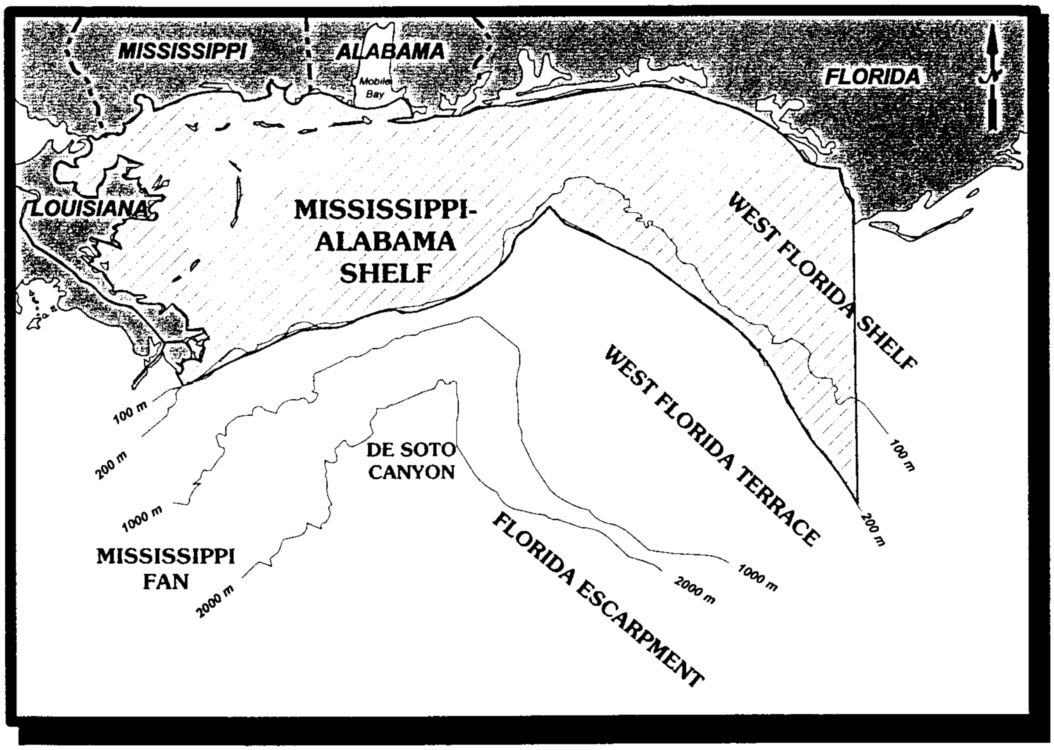

Ecology of Live Bottom Habitats of the Northeastern Gulf of Mexico: A Community Profile

U.S. Department of the Interior
U.S. Geological Survey
Biological Resources Division

U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

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in cooperation with the
MMS
U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region

PROJECT COOPERATION

This study was procured to meet information needs identified by the Minerals Management Service (MMS) in concert with the U.S. Geological Survey, Biological Resources Division (BRD).

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ACRONYMS

BRD	Biological Resources Division
MAMES	Mississippi-Alabama Marine Ecosystem Study
MASPTHMS	Mississippi-Alabama Shelf Pinnacle Trend Habitat Mapping Study
MMS	Minerals Management Service
NDBC	National Data Buoy Center
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
OBS	optical backscattering
OCS	outer continental shelf
ROV	remotely operated vehicle
TSS	total suspended solids
USDOI	U.S. Department of the Interior
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
YBP	years before present

1.0 INTRODUCTION

The Introduction defines live bottom, describes the objectives of this Community Profile, provides historical background on previous research, and discusses the economic significance of live bottom.

1.1 Terminology

The term "live bottom" was first used by Cummins et al. (1962) to describe areas of low relief hard bottom on the continental shelf of the U.S. South Atlantic Bight. The emergent rock substrate and associated epifauna such as sponges, hydroids, corals, and sea whips attracted dense fish populations. In the context of fishery surveys, these areas were considered "live" when contrasted with surrounding soft bottom areas. Although the implication that soft bottom areas are "dead" is unfortunate, the term "live bottom" has since been widely used (Struhsaker 1969; Marine Resources Research Institute 1984; Continental Shelf Associates, Inc. 1987a) and even incorporated into regulatory language. Other terms such as "sponge bottom," "reef habitat," "hard bottom," and "hard ground" are often used interchangeably. This report uses the following definition of live bottom:

> "*...those areas which contain biological assemblages consisting of such sessile invertebrates as sea fans, sea whips, hydroids, anemones, ascidians, sponges, bryozoans, or corals living upon or attached to naturally occurring hard or rocky formations with rough, broken, or smooth topography; or areas whose lithotope favors the accumulation of turtles, fishes, and other fauna.*"

This is the definition[1] used by the Minerals Management Service (MMS), a Federal agency that regulates oil and gas development on the outer continental shelf (OCS). Most surveys and studies of live bottom in the northeastern Gulf of Mexico have been either funded by the MMS or conducted to meet MMS requirements. Its regulatory role is described later in Chapter 6.0.

1.2 Objectives

The objective of this Community Profile is to summarize available data on the ecology of the live bottom communities of the northeastern Gulf of Mexico between the Mississippi River Delta and Cape San Blas (**Fig. 1.1**). The study area extends from the coastline (excluding embayments) to approximately the 200 m (656 ft) isobath. Community profiles help develop a picture of living biological resources and serve as a reference for both research and resource management interest.

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[1]The original MMS definition also includes seagrass communities as live bottom. However, no seagrass beds exist in the deeper offshore waters covered by this community profile.

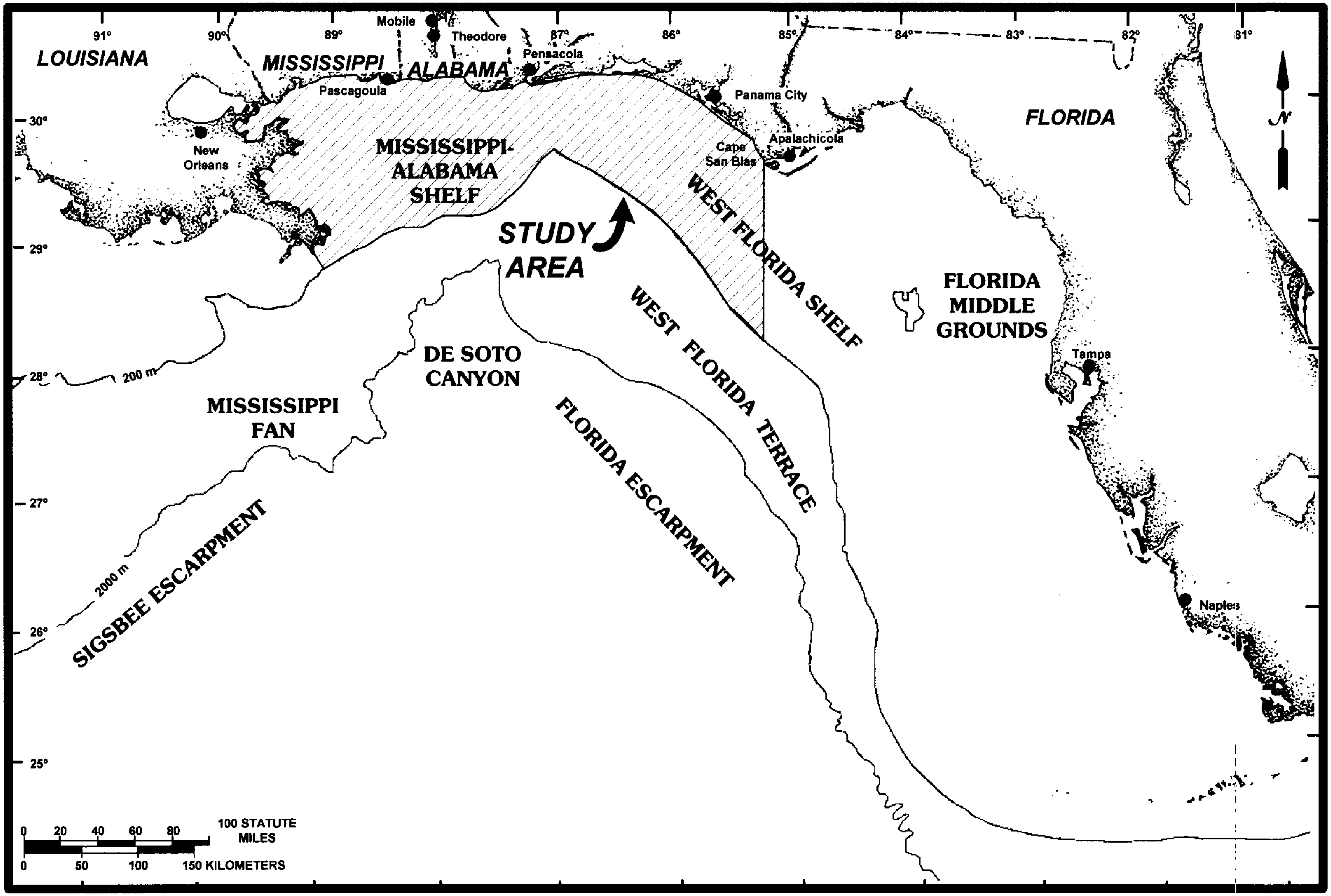

Figure 1.1. Study area in relationship to major physiographic features of the eastern Gulf of Mexico.

An earlier community profile by Jaap (1984) described coral reefs and hard bottom habitats in South Florida and on portions of the west Florida continental shelf. However, the environment and the live bottom communities of the northeastern Gulf of Mexico differ significantly from those of South Florida. For example, there are major differences in geological origin, climate (temperate rather than subtropical), and water clarity (depending on proximity to the Mississippi River outflow). Hence, the need for this new community profile.

1.3 Historical Background

Hard bottom features have been reported along the outer shelf and upper slope of the Gulf of Mexico since the 1930s (Trowbridge 1930). Ludwick and Walton (1957) conducted the first systematic study of these features and documented the presence of a belt of discontinuous, reef-like features ("pinnacles") near the shelf edge between the Mississippi River Delta and De Soto Canyon. Two large-scale studies, the Mississippi-Alabama Marine Ecosystem Study (MAMES) (Brooks and Giammona 1990) and the Mississippi-Alabama Shelf Pinnacle Trend Habitat Mapping Study (MASPTHMS) (Continental Shelf Associates, Inc. 1992c), mapped these features over large areas of the continental shelf (**Fig. 1.2**). Further studies of the pinnacle features are currently underway (Continental Shelf Associates, Inc. and Texas A&M University, Geochemical and Environmental Research Group 1998).

A number of other geological and biological reconnaissance studies have focused on small areas of hard bottom in the northeastern Gulf of Mexico. These include submersible observations of rectangular block-like features at the head of De Soto Canyon (Shipp and Hopkins 1978), a broad survey of hard bottom in several oil and gas lease blocks (Woodward-Clyde Consultants 1979), and numerous individual photodocumentation surveys of individual lease blocks (Continental Shelf Associates, Inc. 1985, 1992b, 1994a,b, 1996) (**Fig. 1.2**).

There have been fewer investigations of live bottom on the shallow, inner shelf. Schroeder et al. (1989a,b) studied hard bottom areas in water depths of 18 to 40 m (59 to 131 ft) off Alabama and northwest Florida (**Fig. 1.2**). Hard bottom habitat in these inner shelf areas included reef-like outcrops with vertical relief of $\leq$2 m (7 ft), moderately sloping ridges of rock rubble and shell hash, and surficial rock and shell rubble with little or no vertical relief.

Biological surveys of northeastern Gulf of Mexico live bottom areas have used rock dredges and combinations of towed video and still cameras, submersibles, or remotely operated vehicles (ROVs) to characterize these communities (Ludwick and Walton 1957; Woodward-Clyde Consultants 1979; Continental Shelf Associates, Inc. 1985, 1994a, 1996). A combination of video and still photography and collections of conspicuous epibenthic biota was made on the pinnacle features during both the MAMES (Gittings et al. 1992) and the MASPTHMS (Continental Shelf Associates, Inc. 1992c) studies. With the exception of the ongoing pinnacle monitoring program (Continental Shelf Associates, Inc. and Texas A&M University, Geochemical and Environmental Research Group 1998), most studies have involved only a single visit to a particular location.

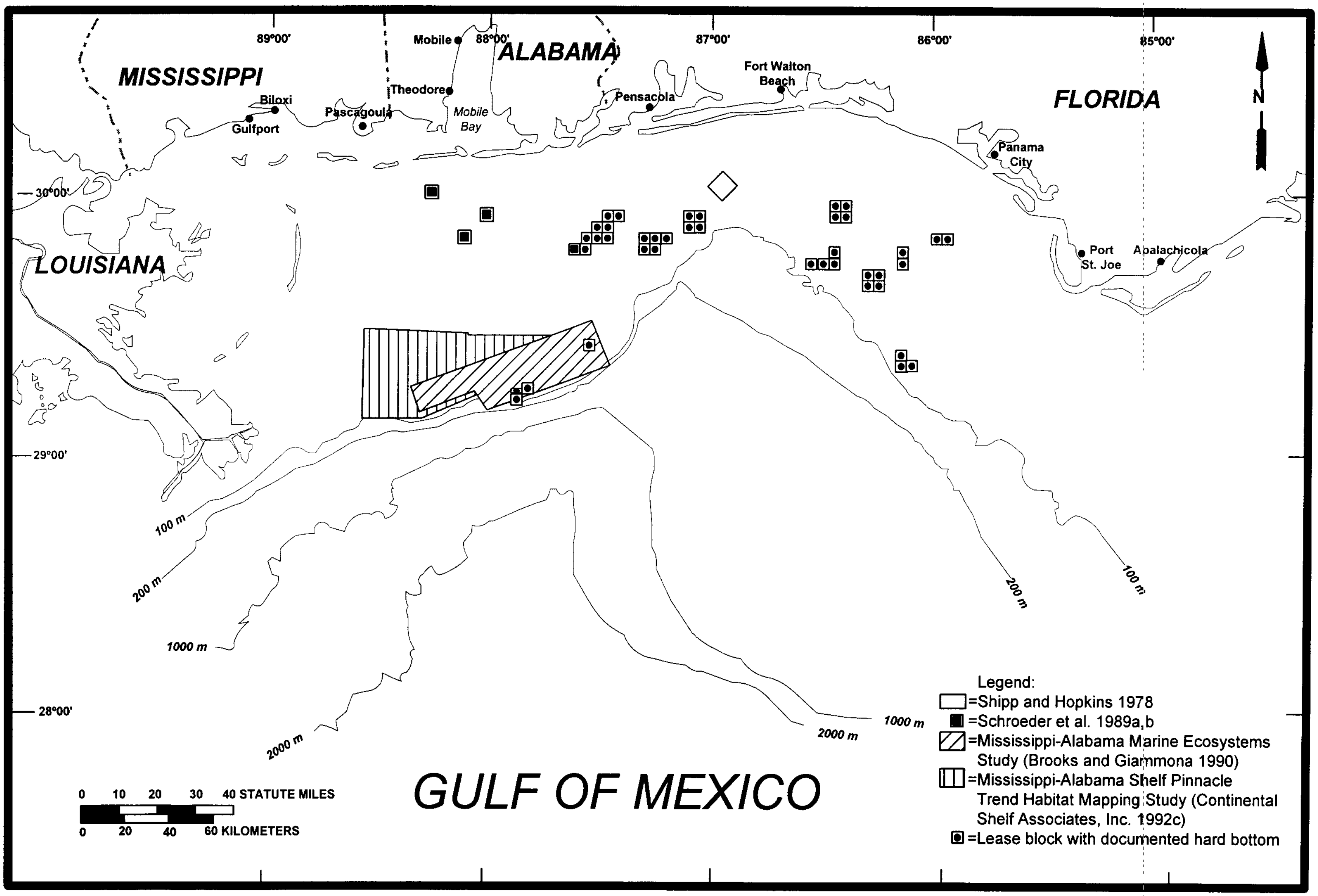

Figure 1.2. Locations of major hard bottom habitat mapping and community analysis surveys in the northeastern Gulf of Mexico.

Most attempts to study the reef fish fauna in the deep live bottom of the northeastern Gulf of Mexico have relied on visual censusing by divers, submersibles, or ROVs (Hastings et al.1976; Smith 1976; Sonnier et al. 1976; Putt et al. 1986; Dennis and Bright 1988a,b). Many cryptic species are likely to be missed in these censuses, resulting in underestimates of true diversity and species composition.

1.4 Economic Significance

The continental shelf off Mississippi, Alabama, and northwest Florida is important as a multiple use area for commerce, fisheries harvest, recreation, and other activities including oil and gas exploration and development (Bell 1997). The fact that scientific interest in live bottom areas originated from fishery investigations (Cummins et al. 1962; Struhsaker 1969) indicates their possible economic importance. Some live bottom areas in the northeastern Gulf of Mexico are well known fishing spots, as evidenced by fishing lines and other debris frequently seen on the bottom and by the paucity of larger, commercially valuable fish (Brooks and Giammona 1990; Continental Shelf Associates, Inc. 1992c). The petroleum industry's interest in the area has brought the need for effective resource management policy into focus. An understanding of the biological communities present and the dominant environmental processes affecting them is critical to managing this valuable resource.

2.0 ENVIRONMENTAL SETTING

The physical environment of the northeastern Gulf of Mexico is reviewed, focusing on those aspects that may influence live bottom communities.

The environmental setting of the northeastern Gulf of Mexico has been reviewed in several recent synthesis documents, including Barry A. Vittor & Associates, Inc. (1985), Texas A&M University (1990), and Science Applications International Corporation (1997). This chapter focuses on aspects of the environment that are most pertinent to understanding the ecology of live bottom communities.

2.1 Geology

There are two main geological aspects of the northeastern Gulf of Mexico that are important to an understanding of live bottom communities. First, the hard bottom features in this area are relict features that developed under different environmental conditions prior to the most recent sea level rise. With the exception of a few limited coralline algal crusts, there is no active reef building activity at present (Gittings et al. 1992). This is in contrast to the western Gulf of Mexico, where some high relief features (e.g., the Flower Garden Banks) protrude into warm, clear, near-surface waters and support reef-building communities with tropical affinities (Bright et al. 1984). Second, the Mississippi-Alabama shelf is geologically transitional between the carbonate Florida platform and the Mississippi Delta region. The west Florida shelf is characterized by carbonate sands and generally clear waters, whereas the Mississippi Delta region is characterized by silts and clays and higher levels of suspended sediments depending on proximity to the Mississippi River outflow.

The continental shelf of the northeastern Gulf of Mexico is complex both geologically and physically. Processes shaping this region include (1) the varying rates of sea level rise following the last glacial maximum approximately 18,000 years before present (YBP); (2) the Loop Current and sediment deposition within the De Soto Canyon; and (3) sediment deposition from the Mississippi and other rivers.

Sediments and bottom topography in the northeastern Gulf of Mexico have been influenced primarily by sea level fluctuations associated with episodes of glaciation and deglaciation. Large quantities of granular, quartzose sediments transported to this area by relict fluvial systems have subsequently been reworked and modified by transgressing sea levels. Recent age (past 12,000 years) deposition has been minimal due to the entrapment of modern-day sediments within the bays and sounds along this coast. This has resulted in a well preserved relict topography across the entire eastern portion of the study area (Ballard and Uchupi 1970).

A thin veneer of Pleistocene (1.6 million YBP [MYBP] to 10,000 YBP) and Holocene (10,000 YBP to present) deposition overlies older sediments in this area (Schnable and Goodell 1968). Sea level lowering during glacial periods is estimated to have ranged from 91 to 152 m (300 to 500 ft) below present sea level. During these periods, nearshore sedimentary environments were displaced across the continental shelf. Older sediments were eroded, oxidized, and compacted during periods of exposure, producing the unconformities in the stratigraphic sequence seen throughout the area.

The head of the De Soto Canyon marks the northern limit of the Florida carbonate platform and forms the boundary between that platform and the silt and clay provinces of the Mississippi-Alabama shelf. West of De Soto Canyon, the Mississippi-Alabama shelf is divided into two sediment regimes. The eastern part of the Mississippi-Alabama shelf is covered with a thin, well sorted layer of fine- to medium-grained quartzose sand transported to the shelf from eastern continental rivers during the Pleistocene and early Holocene. The western part of the upper shelf is covered by a layer of silts, sands, and clays associated with Mississippi River deposition (Mazzullo and Bates 1985).

2.2 Climate

The climate of the northeastern Gulf of Mexico has been reviewed by Hamilton et al. (1997). The area is characterized by two distinct seasons: summer (May through October) and winter (December through March), with November and April being transitional months. From the standpoint of live bottom communities, the most important climate features are severe storms that can resuspend bottom sediments. During winter, the northeastern Gulf of Mexico is often a collision zone between warm, moist maritime and cold, continental polar air masses, resulting in the formation of extratropical cyclones (low pressure centers). During summer, the area is strongly influenced by the northeast trade winds, which can steer tropical storms and hurricanes from the Atlantic into the Gulf of Mexico.

The study area is along the recurring track of extratropical cyclones (low pressure centers) developing in the northwestern Gulf of Mexico (Klein 1957). The area's average annual frequency of extratropical storms is 5 to 10 storms for the period from 1885 to 1978 (Hayden 1981). These storms can produce high and variable wind speeds during winter and spring. For example, an extratropical cyclone (October 1992), and the unnamed "Storm of the Century" (March 1993) were events during which wind speed exceeded 10 m/s (19 kt) for several days (**Fig. 2.1**). (The passage of Hurricane Andrew in August 1992 is also evident on the figure). The "Storm of the Century" event resuspended bottom sediments in the area as measured by increased deposition in sediment traps at a depth of 40 m (131 ft) (Continental Shelf Associates, Inc. 1994b).

During summer months, tropical storms and hurricanes can generate winds sufficient to resuspend bottom sediments in shallow water live bottom areas. **Table 2.1** summarizes the Saffir/Simpson hurricane scale that classifies hurricanes into categories based on wind speed, central pressure, and destructive potential. Based on weather records collected from 1871 to 1973, the frequency of tropical storms and hurricanes for the area is 2.2 entries/100 years/10 nmi of coast (Neumann et al. 1978). The probability of occurrence of tropical storms and hurricanes in any one year for a 80-km (50-mi) segment of coastline is 19% for tropical storms and hurricanes combined and 14% for hurricanes alone (Simpson and Lawrence 1971). The frequency of tropical systems in the area has been somewhat higher during recent years (1985 through 1995) (Hamilton et al. 1997).

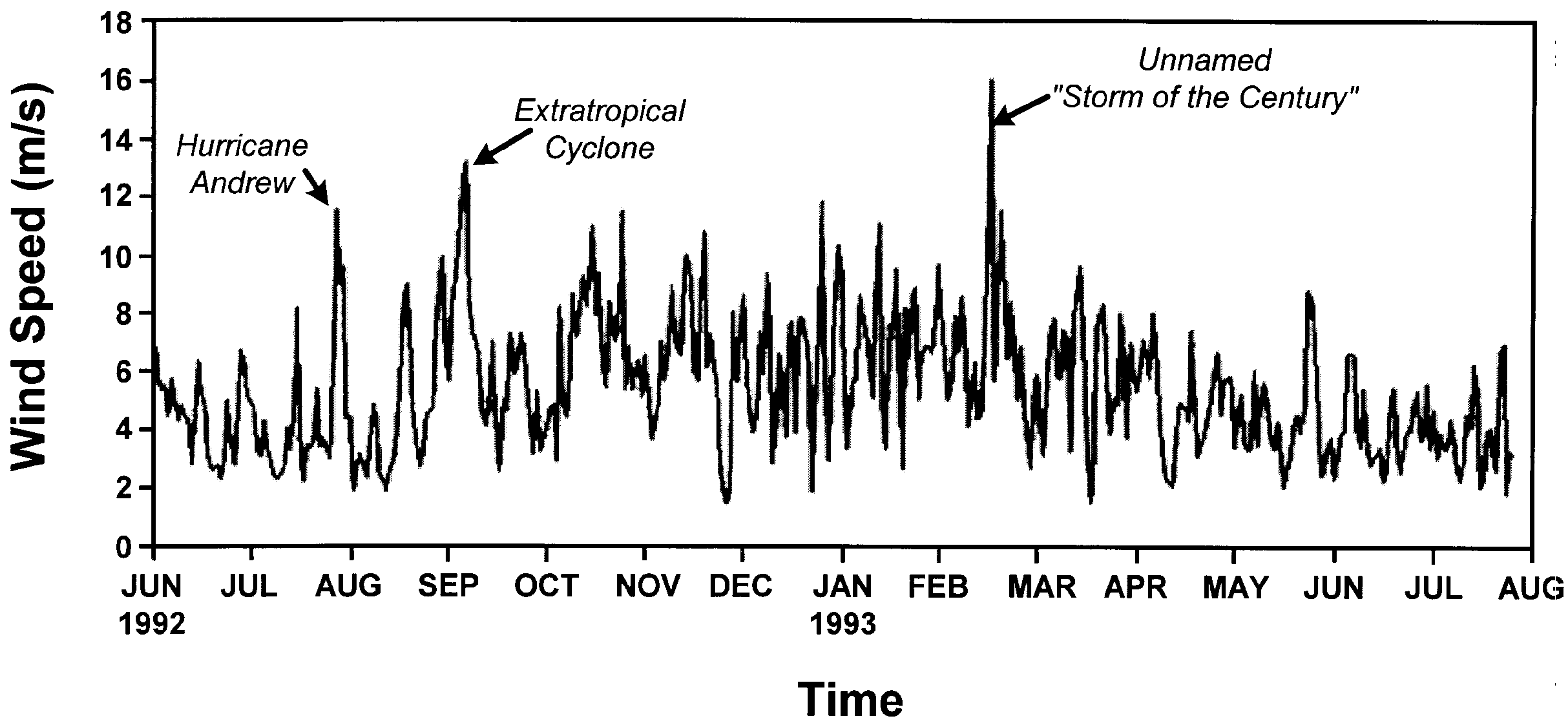

Figure 2.1. A time series of wind speed in Destin Dome Block 56 (Adapted from: Continental Shelf Associates, Inc. 1994b).

Table 2.1. The Saffir/Simpson hurricane scale (Adapted from: Hebert et al. 1993).

Category	Central Pressure		Winds			Surge		Damage	No. Striking NW Florida This Century
	millibars*	inches	m/s	mph*	kn	m	ft*		
1	≥ 980	≥ 28.9	33-42	74-95	64-82	1.2-1.5	4-5	Minimal	9
2	965-979	28.5-28.8	43-49	96-110	83-95	1.6-2.4	6-8	Moderate	7
3	945-964	27.9-28.4	50-58	111-130	96-113	2.5-3.7	9-12	Extensive	6
4	920-944	27.2-27.8	59-69	131-155	114-135	3.8-5.5	13-18	Extreme	0
5	< 920	< 27.2	> 69	> 155	> 135	> 5.5	> 18	Catastrophic	0

* Original units. Conversions are approximate.

2.3 Oceanography

Much of the live bottom in the northeastern Gulf of Mexico is located in the transition zone between nearshore and offshore oceanic environments. The oceanography of this area is influenced by the Loop Current and its eddies, freshwater discharge from the Mississippi and other rivers, variable winds and tides, seafloor topography, and coastal configuration.

Study locations where oceanographic data have been collected in the region are shown in **Fig. 2.2**. Data from the MAMES study (Brooks and Giammona 1990) are particularly useful for describing the physical oceanographic characteristics of the northeastern Gulf of Mexico. Other sources include National Data Buoy Center (NDBC) Buoy 42015, current studies by Pickett and Burns (1988), and the Destin Dome area studies (Continental Shelf Associates, Inc. 1994b).

Currents

The Loop Current is a major feature affecting circulation in the Gulf of Mexico. It enters the gulf through the Yucatan Channel, makes a broad turn or "loop" to the right, and exits through the Florida Straits. Generally, the main boundary of the Loop Current is well to the south of the study area, but there is considerable variability in its northward extent (Vukovich 1988). Even when the Loop Current is far to the south, strong current events are still observed on the northeastern gulf slope. Strong eastward upper level currents (approximately 60 cm/s) can occur between the Mississippi Delta and De Soto Canyon (Molinari and Mayer 1982; Kelly 1990). Most of these events are accompanied by higher water temperatures and are attributed to direct impingement of a Loop Current filament or recently shed eddy on the continental slope. Slope sites closer to the Mississippi delta are more likely to experience these intrusion events than sites further to the east (Hamilton et al. 1997).

The physical oceanography portion of the MAMES program (Brooks and Giammona 1990) concluded that four primary forcing mechanisms drive the continental shelf and slope waters of this region: synoptic scale wind stress, Loop Current-related intrusions, river discharge, and tropical cyclones (Kelly and Guinasso 1998). The generally mild influence of wind forcing results in a cyclonic shelfwide circulation pattern. Loop Current intrusions onto the shelf are unpredictable but potentially significant due to their frequency of occurrence, their marked contrast in water mass properties, and the large shelf area affected (Kelly and Guinasso 1998).

On a local scale, high relief, topographically complex hard bottom features could significantly affect the flow field. The exposure of various vertical and horizontal surfaces to currents and resuspended sediments can be expected to vary greatly and is undoubtedly reflected in the distribution and abundance patterns of epibiota. Although there have been no studies of currents in relation to microtopography in the northeastern Gulf of Mexico, the ongoing pinnacle monitoring program includes development of flow exposure models for hard bottom features (MacDonald 1998).

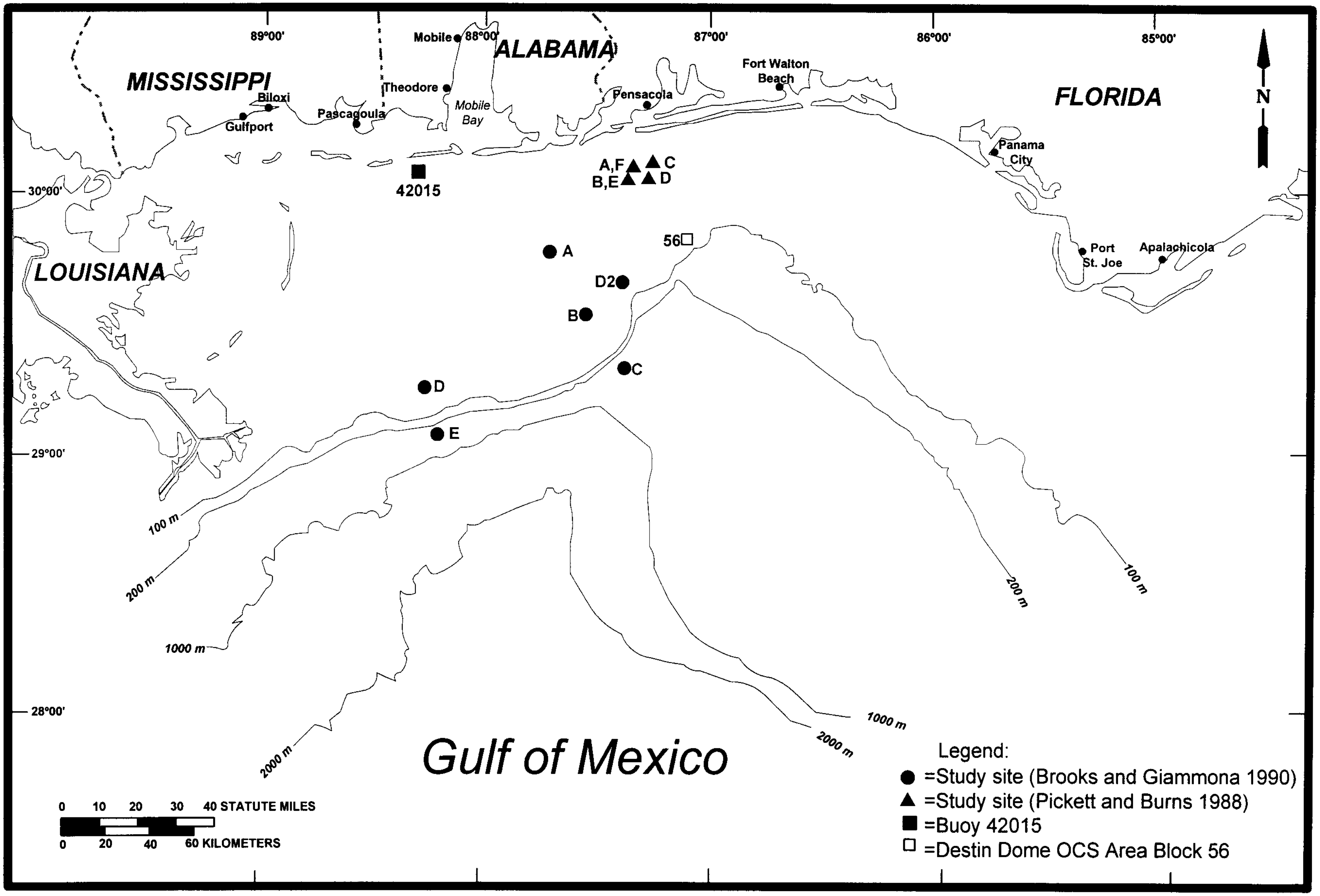

Figure 2.2. Physical oceanography data collection locations.

Temperature and Salinity

Seawater temperature and salinity strongly influence chemical, biological, and ecological patterns and processes. Dynamic features such as the Loop Current, eddies, and river plumes can create sharp discontinuities in temperature and salinity (density) that may act to concentrate and direct buoyant material such as detritus and plankton. The turbid, less saline water that characterizes the near coastal shelf is separated by a density front from the open-shelf regime about 30 to 50 km (19 to 31 mi) offshore. Fronts associated with temperature and salinity discontinuities promote lateral movement of materials along the front rather than across the front.

Generally, benthic communities of the northeastern Gulf of Mexico are exposed to a seasonally variable, warm temperate climate. Monthly average temperature and salinity data from MAMES Mooring B from December 1987 to January 1990 are presented in **Fig. 2.3**. This buoy was located in 60 m (197 ft) of water with a surface sensor deployed at 10 m (33 ft) and a bottom sensor at 57 m (187 ft). The record showed an annual range in surface temperature from 17° to 27°C (63° to 81°F), while the range in bottom temperature was from 17° to 22°C (63° to 72°F). While bottom salinity was relatively constant through the year (about 36 ppt), surface salinity ranged from 33 to 36 ppt, with the lowest values recorded during June and July 1989. The low near-surface salinity corresponds with periods of greatest discharge from the Mississippi, Alabama, and Tombigbee Rivers (Kelly 1990).

Water Clarity and Suspended Matter

The concentration of suspended matter in the water column is an important component of water quality because it helps determine the maximum depth of the photic zone and affects the quality of light that reaches the bottom. In addition, high suspended matter concentrations and deposition rates can stress epibiota.

The MAMES study (Brooks and Giammona 1990) provided data on light transmission from three transects across the continental shelf. There were no consistent patterns in water clarity across the shelf (i.e., with water depth), either at the surface or near the bottom. Clarity was almost uniformly higher during summer than winter. Not surprisingly, more suspended matter was generally present in the water column at stations close to the Mississippi Delta, particularly during winter. The more distant De Soto Canyon transect generally had the highest water clarity, and near-bottom values along this transect varied little with station depth.

Episodic sediment resuspension is believed to be an important influence on live bottom communities (Gittings et al. 1992). To study this phenomenon, optical backscattering (OBS) sensors were deployed at two locations within the Destin Dome area (Continental Shelf Associates, Inc. 1994b). One location was within a sand bottom area, where the sensor was deployed near the seafloor at a depth of 34 m (112 ft). The other location was farther offshore, and the OBS sensors were deployed at mid-water and near-bottom depths of 65 and 70 m (213 and 230 ft), respectively. Concentrations of total suspended solids (TSS) were estimated based on empirical relationships developed in the laboratory (Continental Shelf Associates, Inc. 1994b). Both sites tended to have low TSS concentrations most of the time, but occasionally very high concentrations were observed (**Fig. 2.4**). Generally, turbid waters were more frequently observed at the

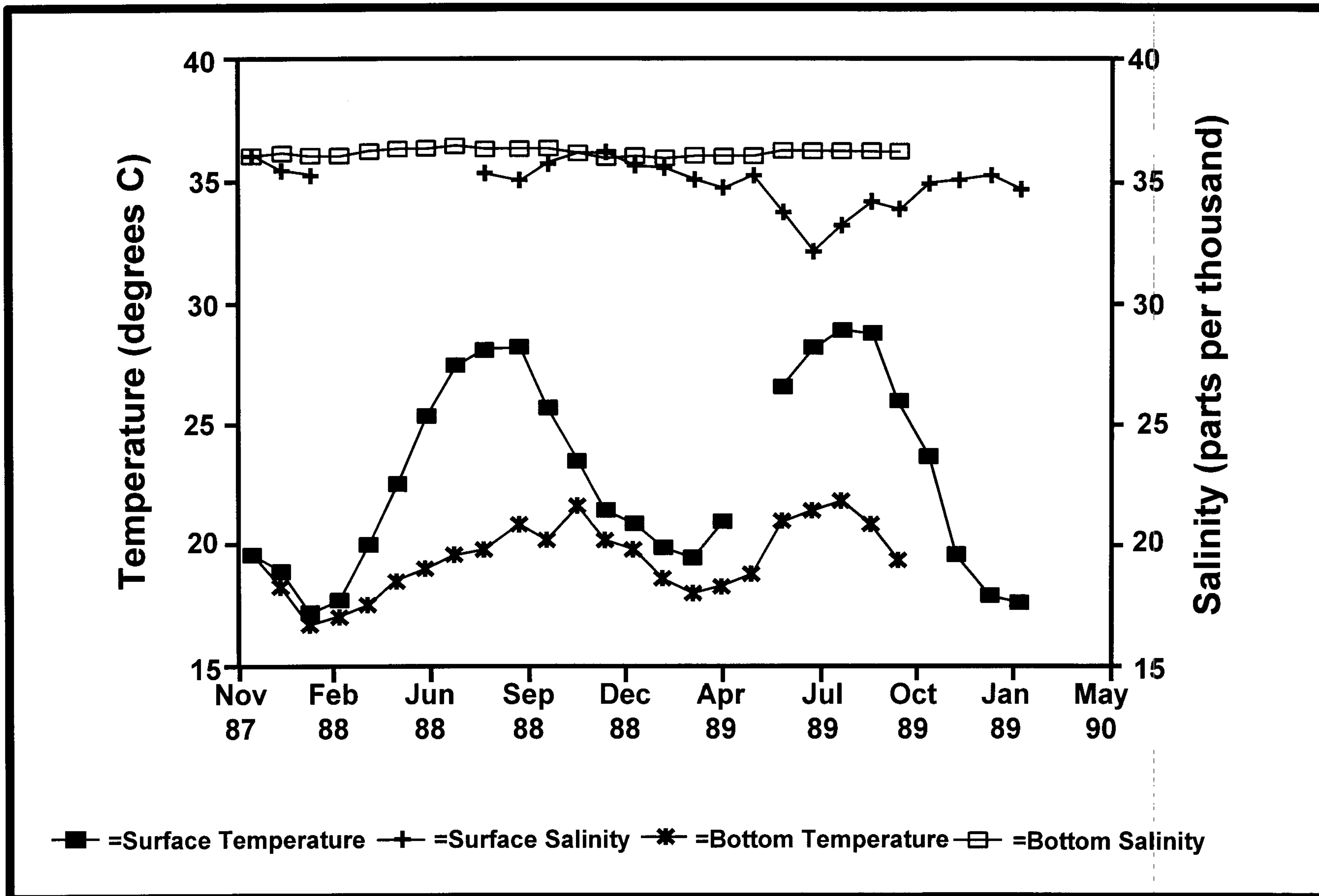

Figure 2.3. Monthly mean near-surface and bottom temperature and salinity at Mooring B (Adapted from: Kelly 1990).

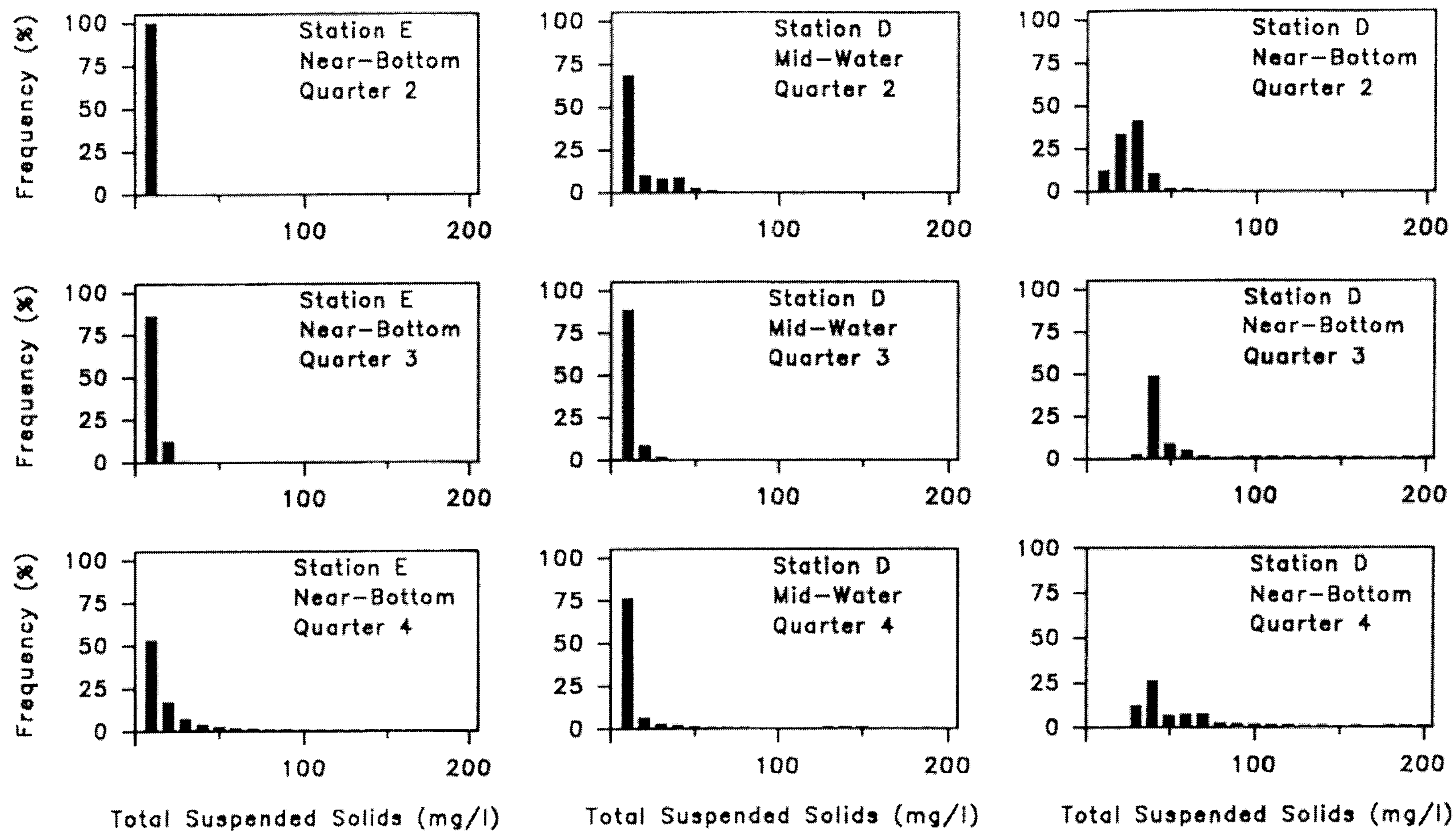

Figure 2.4. Frequency distributions of total suspended solids calculated from optical backscattering sensor data (From: Continental Shelf Associates, Inc. 1994b).

deeper station and particularly at the near-bottom sensor. For example, from October 1992 to January 1993, over 99% of the TSS concentrations at the shallow sandy station were less than 10 mg/L (although a concentration exceeding 210 mg/L was observed). In contrast, at the deeper station, less than 12% of the estimated concentrations near the seafloor were less than 10 mg/L, and the maximum concentrations exceeded 440 mg/L. Storm events possibly contributing to the sediment resuspension include Hurricane Andrew (August 1992) and two extratropical storms (one in October 1992, the other the unnamed "Storm of the Century" in March 1993).

Data on suspended matter deposition and mineralogy are available from the same study (Continental Shelf Associates, Inc. 1994b). Sediment traps were deployed on a quasi-quarterly basis at two moorings within the area. **Fig. 2.5** summarizes sedimentation rates at Mooring E (depth of 40 m [131 ft]) and Mooring D (depth of 70 m [230 ft]) for each period of deployment. Sedimentation rates ranged from <5 to 60 $g/m^2/day$, with most values below 10 $g/m^2/day$. Higher sedimentation rates were observed at the shallower mooring, which is likely due to greater resuspension of bottom sediments during storms. The highest sedimentation rate was observed during the first deployment (summer-fall) when Hurricane Andrew and a strong northeaster (extratropical storm) occurred. A high sedimentation rate was also observed during the third period (winter to early spring) when the unnamed "Storm of the Century" occurred. Sedimentation rates at the bottom were generally higher than at the top of the mooring. Mineralogy of the inorganic fraction of the suspended matter collected in sediment traps did not show apparent spatial and temporal trends. The proportions of various minerals including smectite, illite, kaolinite, quartz, calcite, and dolomite differed little between the two moorings and through the four periods of deployment. Metal concentrations in the trapped material were about 30% to 40% of values reported for typical Mississippi River suspended sediments and were between 74% and 97% higher than the sampled bottom sediments. This suggested that the incoming sediment trap flux of particles were rich in continental clays relative to the bottom sediments. However, this fine-grained material was not being deposited in area sediments but was moving along and across the shelf to be deposited in deeper water (Continental Shelf Associates, Inc. 1994b).

Other Water Quality Variables

<u>Dissolved Oxygen</u>

Nearshore and open gulf waters are normally at or near oxygen saturation (U.S. Environmental Protection Agency [USEPA] 1988; Brooks and Giammona 1990). However, high organic loading, high bacterial activity related to decomposition of organic material, and restricted circulation due to stratification of the water column during summer can cause near-bottom waters to be depleted of oxygen. These hypoxic events may cause avoidance, stress, or death in some sensitive species. More severe anoxic conditions may cause mass mortality due to asphyxiation and the toxic effects of hydrogen sulfide. Severe anoxic events are generally observed in waters west of the Mississippi Delta (Rabalais 1992). Oxygen depletion problems occur with regular frequency over the Louisiana inner shelf and infrequently over the Mississippi inner shelf. Oxygen depletion problems also have been reported on parts of the Alabama inner shelf, but not on the inner shelf of the Florida Panhandle. Toxic or noxious algal blooms have been reported over the whole inner shelf from Louisiana to the Florida Panhandle. Oxygen depletion is found in most of the embayments along the coast.

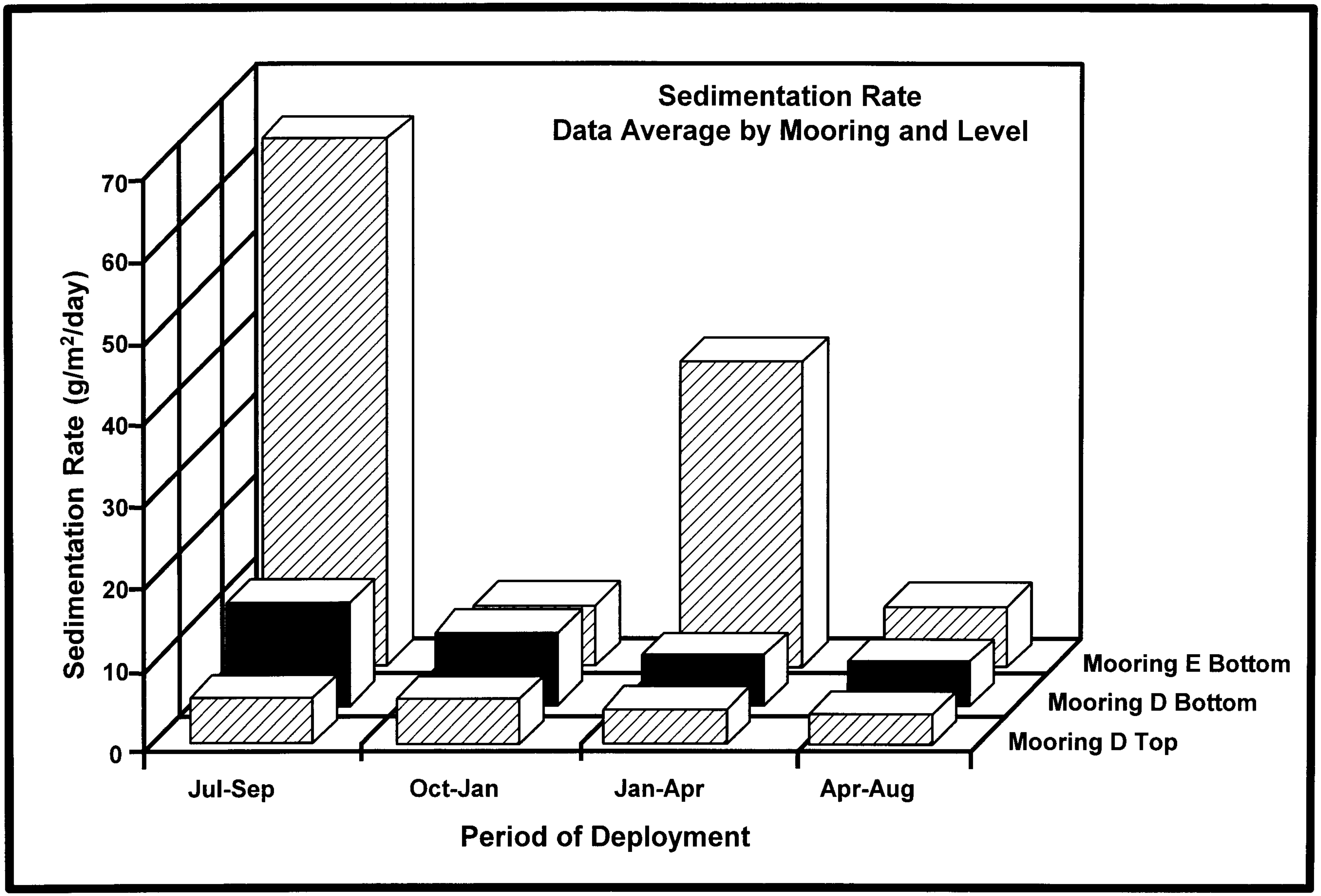

Figure 2.5. Sedimentation rate measured at two moorings in the Destin Dome Unit from July 1992 to August 1993 during the Baseline Survey (From: Continental Shelf Associates, Inc. 1994b).

Nutrients

The northeastern Gulf of Mexico is oligotrophic. During the MAMES study, winter nitrate concentrations in surface waters were generally low (overall mean of 0.47 μM). Average concentrations at all depths were higher at the Chandeleur transect (0.92 μM) compared to the De Soto Canyon transect (0.16 μM). During summer, lower nitrate concentrations were observed (overall mean of 0.12 μM), and there were no apparent differences among the three transects and across the shelf (Brooks and Giammona 1990). The observed spatial and temporal patterns are probably due to nutrients brought in by increased riverine discharge during winter and spring, particularly from the Mississippi River, and increased biological activity during summer (Darnell 1991).

In contrast, phosphate concentrations were uniformly low for both seasons during the MAMES study; overall mean concentrations were 0.15 and 0.17 μM for winter and summer, respectively. The uniformly low phosphate concentrations are likely due to chemical and biological activity. Phosphates are strongly adsorbed by clay particles and readily assimilated by phytoplankton. For this reason, most dissolved phosphate inputs from riverine discharge and upwelling of deep, phosphate-enriched waters are taken up by phytoplankton or adsorbed to suspended clay particles that are subsequently deposited (Darnell 1991).

Contaminants

The available data indicate that the study area has low levels of contaminants such as hydrocarbons and metals (Alexander et al. 1977; Dames & Moore 1979; USEPA 1988; Brooks and Giammona 1990; Continental Shelf Associates, Inc. 1994a; Kennicutt 1998). Sediment hydrocarbon and metal concentrations tend to increase towards the Mississippi River delta and toward deeper water due to increased silt and clay content. Locally elevated barium concentrations have been documented around an exploratory drillsite (Continental Shelf Associates, Inc. 1994a). It is unlikely that contaminant concentrations are a significant influence on live bottom communities in the northeastern Gulf of Mexico at this time.

3.0 HARD BOTTOM DISTRIBUTION, CLASSIFICATION, AND ORIGIN

The location, extent, and geologic origins of hard bottom features on the northeastern Gulf of Mexico continental shelf are discussed.

3.1 Incidence of Hard Bottom

Fig. 3.1 shows the locations of all mapped hard bottom in the northeast Gulf of Mexico. Continental Shelf Associates, Inc. (1992a), summarizing previous research and mapping studies, estimated that only about 8% of the area had been surveyed in sufficient detail for habitat mapping. At the time, 22,175 h (54,795 ac) of hard bottom had been identified, which equals about 5% of the total area surveyed (**Table 3.1**). It is unlikely that this figure has changed much since 1992, as there have not been any new broad-scale surveys outside previously studied areas and few additional lease block surveys. For estimating the true percentage of hard bottom on the shelf, these numbers are of mixed usefulness. Some surveys were specifically oriented toward hard bottom features and would tend to overestimate their regional incidence, whereas others may be more representative because they were conducted without any previous knowledge of the presence of hard bottom (e.g., surveys of entire oil and gas lease blocks).

Parker et al. (1983) estimated the percentage of "reef habitat" (areas of rock, coral, and sponge) on the Gulf of Mexico continental shelf by lowering a camera to the bottom at random locations in water depths of 18 to 91 m (60 to 300 ft). They estimated that about 3% of the continental shelf between Pensacola, Florida and Pass Cavallo, Texas consists of "reef habitat." About 50% of the reef habitat was high relief (>1 m or 3 ft). The incidence is much higher on the west Florida shelf (about 38% between Key West and Pensacola). Parker et al. (1983) did not present geographic detail to estimate the percentage of "reef habitat" for the northeastern gulf study area, but their data and the results cited above (Continental Shelf Associates, Inc. 1992a) suggest it is closer to 3% than 38%.

3.2 Classification and Geologic Origin

The De Soto Canyon divides the continental shelf of the northeastern Gulf of Mexico into two sedimentological regimes (Mazzullo and Bates 1985). East of the De Soto Canyon, on the Florida carbonate platform, mapped hard bottom areas consist of scattered patches of primarily low relief (> 1 m or 3 ft) limestone. These areas, which have been aerially weathered and eroded, are characteristic of the eroded limestone forming the west Florida Shelf (Continental Shelf Associates, Inc. 1985, 1992a). West of De Soto Canyon, broad bands, or belts, of hard bottom have been found running parallel with the bathymetric contours of the outer shelf and upper slope. Isolated patches of geologically dissimilar hard bottom occur along the middle and inner shelf. Further discussion of three sets of hard bottom features is presented below: (1) the "pinnacle trend" region studied during the MAMES and MASPTHMS studies (Sager et al. 1990, 1992); (2) nearshore hard bottom features off Mobile Bay studied by Schroeder et al. (1989a,b); and (3) hard bottom features near the head of De Soto Canyon, including the De Soto Canyon "rim feature" (Benson et al. 1997).

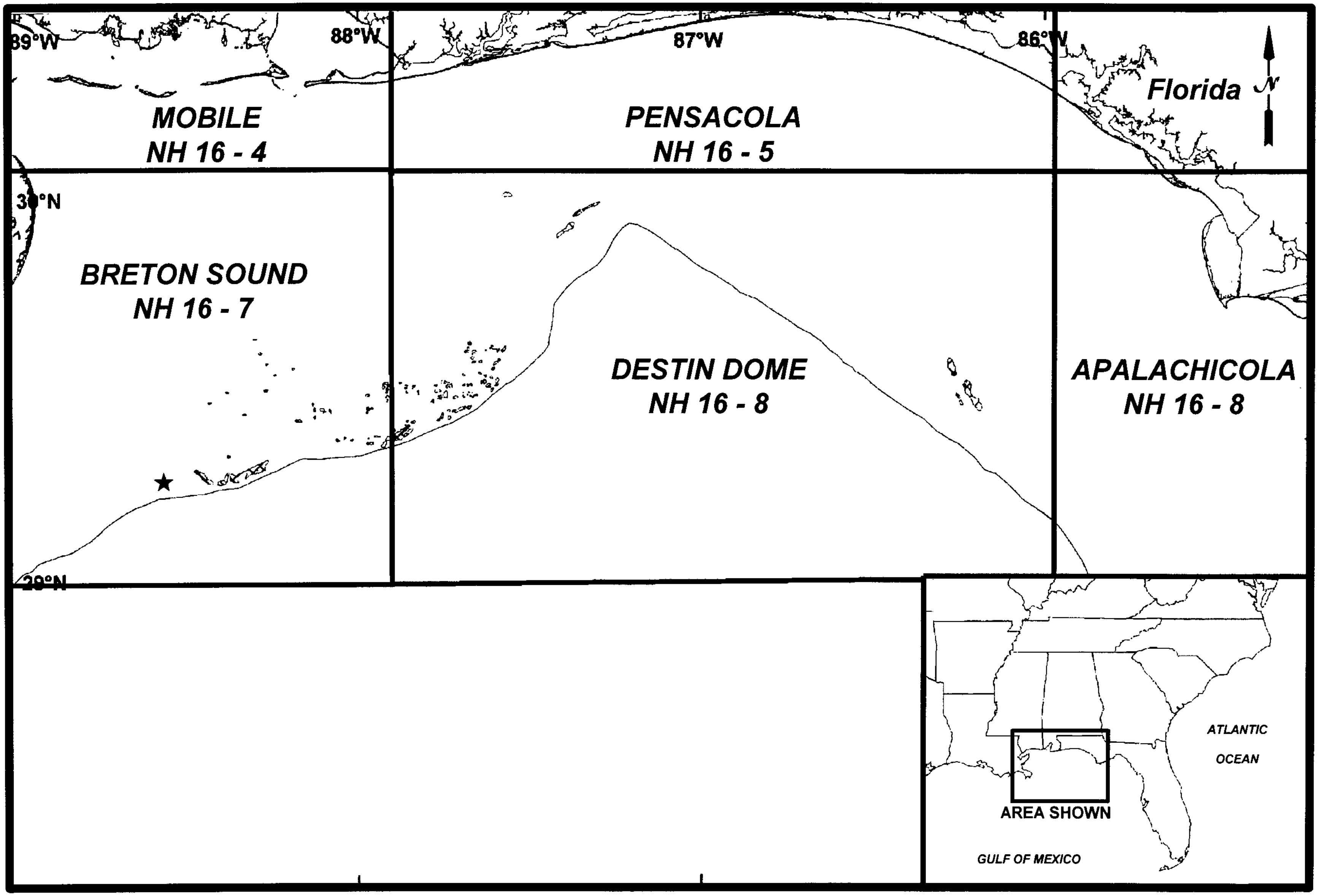

Figure 3.1. Areas in the northeastern Gulf of Mexico where hard bottom has been surveyed in sufficient detail to permit mapping (Adapted from: Continental Shelf Associates, Inc. 1992a).

Table 3.1. Summary of mapped hard bottom habitat in the northeastern Gulf of Mexico (From: Continental Shelf Associates, Inc. 1992a).

Outer Continental Shelf (OCS) Map Area *	Area Surveyed		Incidence of Hard Bottom (Percentage of Surveyed Area)			
	Hectares (acres)	Percentage of Total OCS Map Area	High Relief	Low Relief	Pinnacles	Total
Mobile NH 16-4	7,924 (19,579)	5.1	0	0	0	0
Breton Sound NH 16-7 (east of Birds Foot Delta)	144,588 (357,272)	12.3	2.4	0	1.5	3.9
Pensacola NH 16-5	58,244 (143,918)	14.1	0	0.5	0	0.5
Destin Dome NH 16-8	227,175 (561,341)	9.2	2.8	4.2	0	7.0
Apalachicola NH 16-9	2,331 (5,760)	0.2	0	10.5	0	10.5
Overall	**440,262 (1,087,870)**	**7.7**	**2.2**	**2.3**	**0.5**	**5.0**

*OCS Map Areas are shown on **Fig. 3.1.**

Pinnacle Trend Area

Ludwick and Walton (1957) documented the presence of a belt of discontinuous, reef-like features ("pinnacles") near the shelf edge between the Mississippi River Delta and De Soto Canyon and to the east along the West Florida Shelf. Most knowledge of these features comes from the MAMES and MASPTHMS studies, as well as the ongoing pinnacle monitoring program (Continental Shelf Associates, Inc. and Texas A&M University, Geochemical and Environmental Research Group 1998). The MAMES and MASPTHMS studies mapped thousands of carbonate mounds ranging in diameter from less than a few meters to nearly a kilometer, arrayed mostly in two parallel bands along the isobaths (Sager et al. 1992). Isobath-parallel ridges were also mapped in the shallower depth zone. Both features are thought to be related to sea level stillstands during the last deglaciation (Sager et al. 1992).

Sager et al. (1990, 1992) identified three classes of topographic hard bottom features from the outer shelf and upper slope:

1) Pinnacles (**Fig. 3.2**), possibly formed by coral-algal assemblages. These features showed a vertical relief from 2 to 20 m (7 to 66 ft) and widths of 2 to 200 m (7 to 656 ft) and were scattered between the 74- to 82-m (243- to 269-ft) and again between the 105- to 120-m (344- to 394-ft) depth bands;

2) Linear ridges (**Fig. 3.3**), possibly formed from lithified coastal dunes. These low relief linear ridges typically had continuous lengths of over 1,000 m (3,280 ft) and widths of approximately 20 m (66 ft). Parallel ridge features were commonly observed, and they were generally located along the same depth bands as the pinnacles; and

3) Features with enigmatic origin which consisted of small topographic mounds with vertical relief of 1 to 2 m (3 to 7 ft) and 1 to 4 m (3 to 13 ft) in width and small depressions with a width 5 to 10 m (16 to 33 ft). Depressions were most commonly asymmetrical with a bumpy rim. Depressions were also commonly found in large concentrations or "fields" within the study area. Antoine (1972) has suggested, based on the fact these mounds appear to be associated with shallow gas structures, that these mound features may have occurred atop gas-formed topographic highs. If this is true the observed depression fields may arise from surface sediment collapse after gas accumulations have escaped.

The reef-like mounds clustered along two isobath bands, 74 to 82 m (243 to 269 ft) and 105 to 120 m (344 to 394 ft). Their origin appears to be biogenic in nature based on limited samples recovered from these features. The shallower reef-like mound cluster, described as "large flat-top reefs and fields of thousands of small patch reef-like mounds," and most of the ridges formed about the same time during a slowdown in the rate of sea level rise. The deeper area of reef-like mounds, including the Ludwick and Walton (1957) "pinnacles," probably formed during sea level rise at the beginning of the late Wisconsin deglaciation. Tall, steep-sided "pinnacle" mounds may have formed during a period of faster sea level rise, whereas the widespread shallower mounds may represent a short period of sea level stabilization during the deglaciation (Sager et al. 1992; Sager 1998).

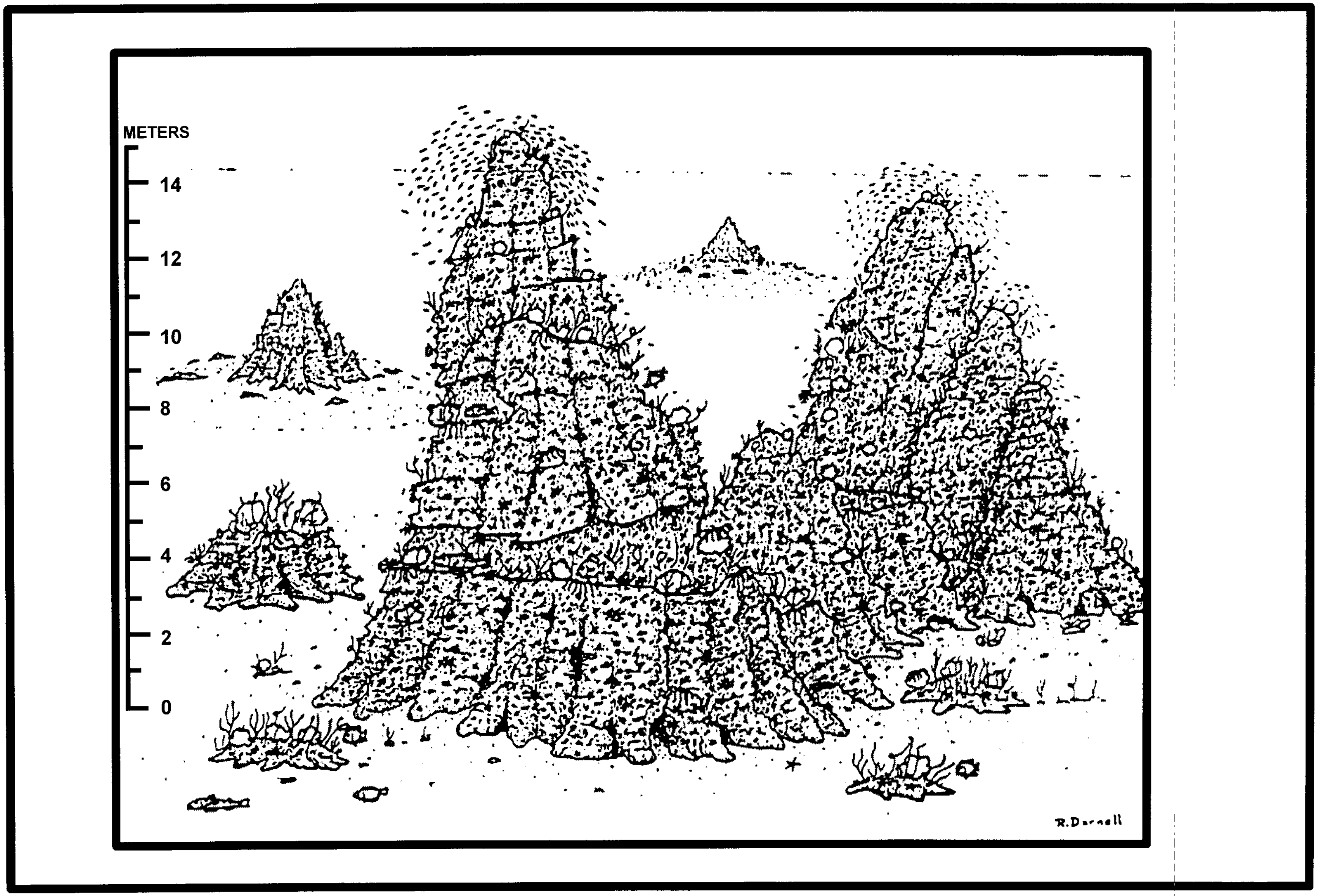

Figure 3.2. Perspective sketch of submerged pinnacles as visualized from side-scan sonar and ROV information (From: Brooks and Giammona 1990).

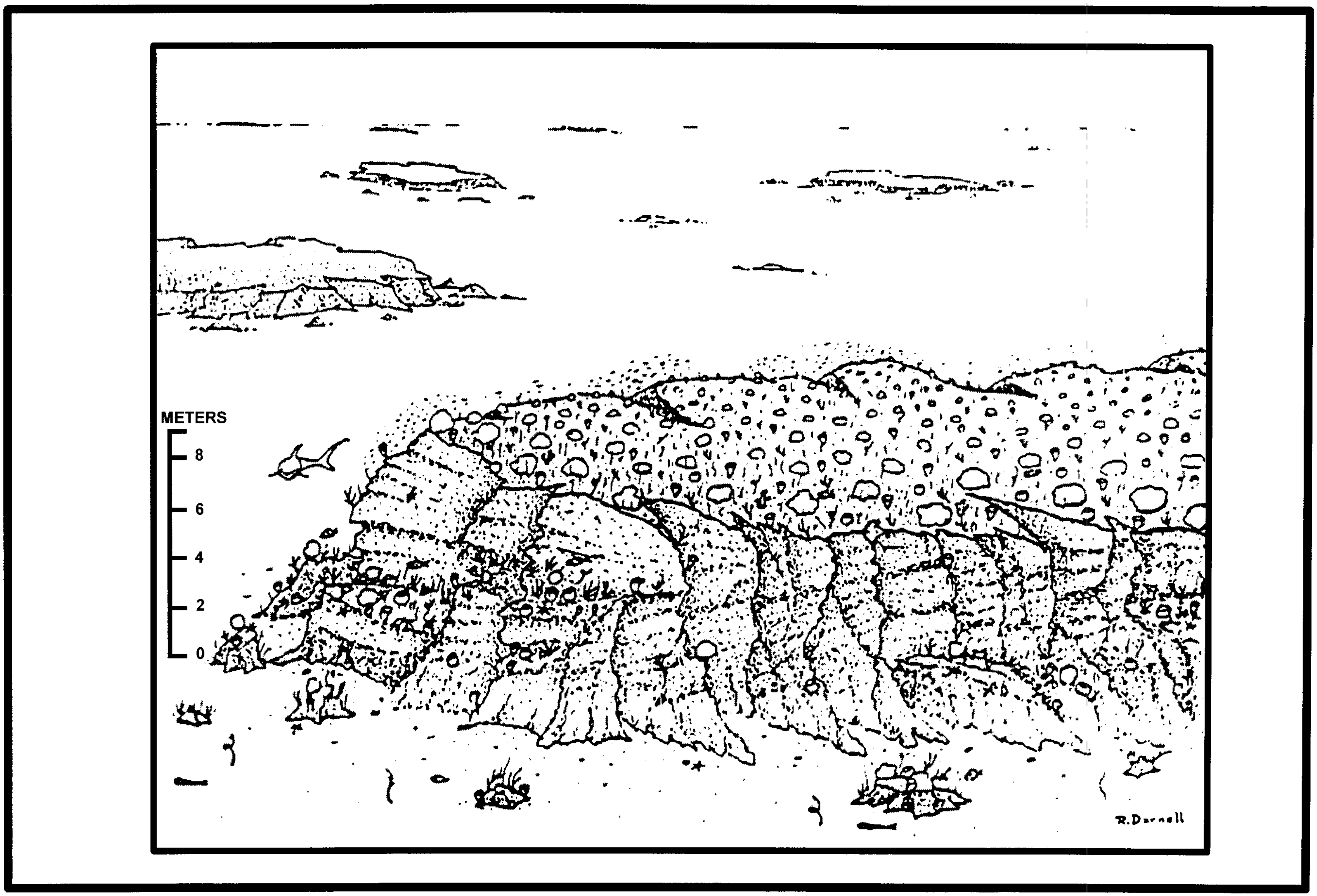

Figure 3.3. Perspective sketch of submerged flat-topped ridge feature as visualized from side-scan sonar and ROV information (From: Brooks and Giammona 1990).

Radiocarbon ages of 12,000 ±90 YBP and 11,380 ±110 YBP were obtained from carbonate rock fragments (composed mostly of coralline algae, serpulid worms, and bryozoa) collected from the exterior of one of the tall pinnacles during a 1987 National Oceanic and Atmospheric Administration/National Underwater Research Center/University of North Carolina at Wilmington-sponsored submersible cruise in the northeastern Gulf of Mexico. The dates suggest that the most recent production of exterior frame-building occurred 12,000 to 11,000 YBP. This is consistent with the interpretation of Ludwick and Walton (1957), who described the pinnacles as intermediate in stage between active growth and fossilization and reported that no living representatives of calcareous algae were found on the pinnacles.

Rock samples were collected at three sites within the MAMES area (Flat-top Reef, Patch Reefs, and Western Shoreline Ridges) during a 1991 submersible mission (Schroeder et al. 1993, 1995). The samples consisted mainly of bindstone (i.e., bryozoa, red algae, and serpulid worms) and yielded radiocarbon ages that range between 11,100 ±60 YBP to 13,300 ±120 YBP, consistent with an origin early to mid-way during the deglacial sea level rise. Three samples, one a fine-grained, carbonate-cemented sandstone from a flat-top reef and the other two small sandstone fragments dredged from the patch reefs area during the MAMES study, display carbon isotope ratios typical of carbonate authigenesis at methane seeps, and thereby suggest one possible origin for the basement or foundation material for any biologically produced features.

During the summer of 1995, scientists from the University of Alabama (Principal Investigator, W.W. Schroeder) collected rock cores from selected topographic features in support of their continuing investigation of the geologic framework of the continental margin off of Mississippi, Alabama, and northwest Florida. The main objective of this phase of the study was to determine the composition and age of shelf margin carbonate structures in order to gain insight into the environmental controls that regulate or govern the architectural nature and areal distribution of these features. Using a newly developed rock drill on the *Johnson Sea Link* submersible, two cores each were successfully drilled from the Western Shoreline and Flat-top Reef sites in the MAMES area. Petrologic descriptions of the cores are presently being prepared. Unfortunately, the submersible drilling effort was cut short by Hurricane Erin, which passed over the study area.

Nearshore Hard Bottom Areas

Nearshore hard bottom areas in the northeastern Gulf of Mexico have been studied extensively by Schroeder et al. (1989a,b). They identified four types of hard bottom formations along the inner shelf of the northeastern gulf at water depths of 18 to 40 m (59 to 131 ft). Geologically, these inner shelf hard bottom habitats were described as follows:

1) Slabby aragonite-cemented coquina and sandstone outcrops in the central part of the shelf;

2) Irregular small outcrops of dolomitic sandstones on the inner western shelf area;

3) Massive to nodular sideric sandstones and mudstones widely dispersed in the central and western shelf; and

4) Calcite-cemented algal calcirudite in reef-like knobs at the offshore edge of the inner shelf in the 30 m (100 ft) depth range.

Mineralogy and isotope ratios in the sandstones, mudstones, and cemented coquina suggest cementation took place in marine rather than freshwater situations. The present day extent and distribution of hard bottom in this area appears to result not only from deposition and cementation patterns, but also from modern shelf processes such as sedimentation and energetic storm events (Schroeder et al. 1989a).

Low relief outcrops covered by a thin sand veneer have also been reported by Continental Shelf Associates, Inc. (1992b) in a water depth of 32 to 36 m (105 to 118 ft) south of Mobile Bay.

De Soto Canyon Rim

Numerous hard bottom areas are found along the rim of the De Soto Canyon. Shipp and Hopkins (1978) described a hard bottom formation located approximately 25 km (15 mi) north-northeast of the De Soto Canyon (**Fig. 1.2**). This formation in a depth of 50 to 60 m (164 to 197 ft) was described as a block-like substrate consisting of rectangular blocks of granular limestone (**Fig. 3.4**). The hard bottom formation had vertical relief ranging from barely detectable to nearly 10 m (33 ft). The granular limestone outcroppings were oriented from east/northeast to west/southwest and consisted of one to three ridges divided by sand flats. The ridges were approximately 20 m (66 ft) wide.

Near the area visited by Shipp and Hopkins (1978) and about 45 km (24 nmi) to the northeast of the MAMES and MASPTHMS study areas lies a sandstone hard bottom area near the head of the De Soto Canyon (**Fig. 1.2**). The most prominent feature in this area is a 12 km (7.5 mi) long ridge, termed the "De Soto Canyon rim feature" (Benson et al. 1997). The rim feature parallels the northeast-southwest isobaths between depths of 52 and 61 m (170 and 200 ft). There are large variations in ridge slope, width, and cross-sectional profile along the feature. Recent petrological studies have indicated that the lithified sediments composing this feature have a terrigenous, fluvial origin, and were probably transported to their present position near the continental margin during a sea level lowstand. Lithification probably occurred during the Holocene transgression and may have occurred during periods of sea level stillstand or short term reversals in sea level rise (Benson et al. 1997). A thin sand veneer is present along portions of the plateau. The steeper slopes along the ridge show signs of major structural faulting within the block framework. Block framework separation has created large rock talus along slopes.

Scattered low relief hard bottom areas in the area also are oriented along the isobaths. For example, discontinuous, tier-like rock formations composed of numerous ledges and crevices oriented in a north-northeast/south-southwest direction have been reported 10 km (5.4 nmi) to the northwest of the head of the De Soto Canyon (Continental Shelf Associates, Inc. 1992b).

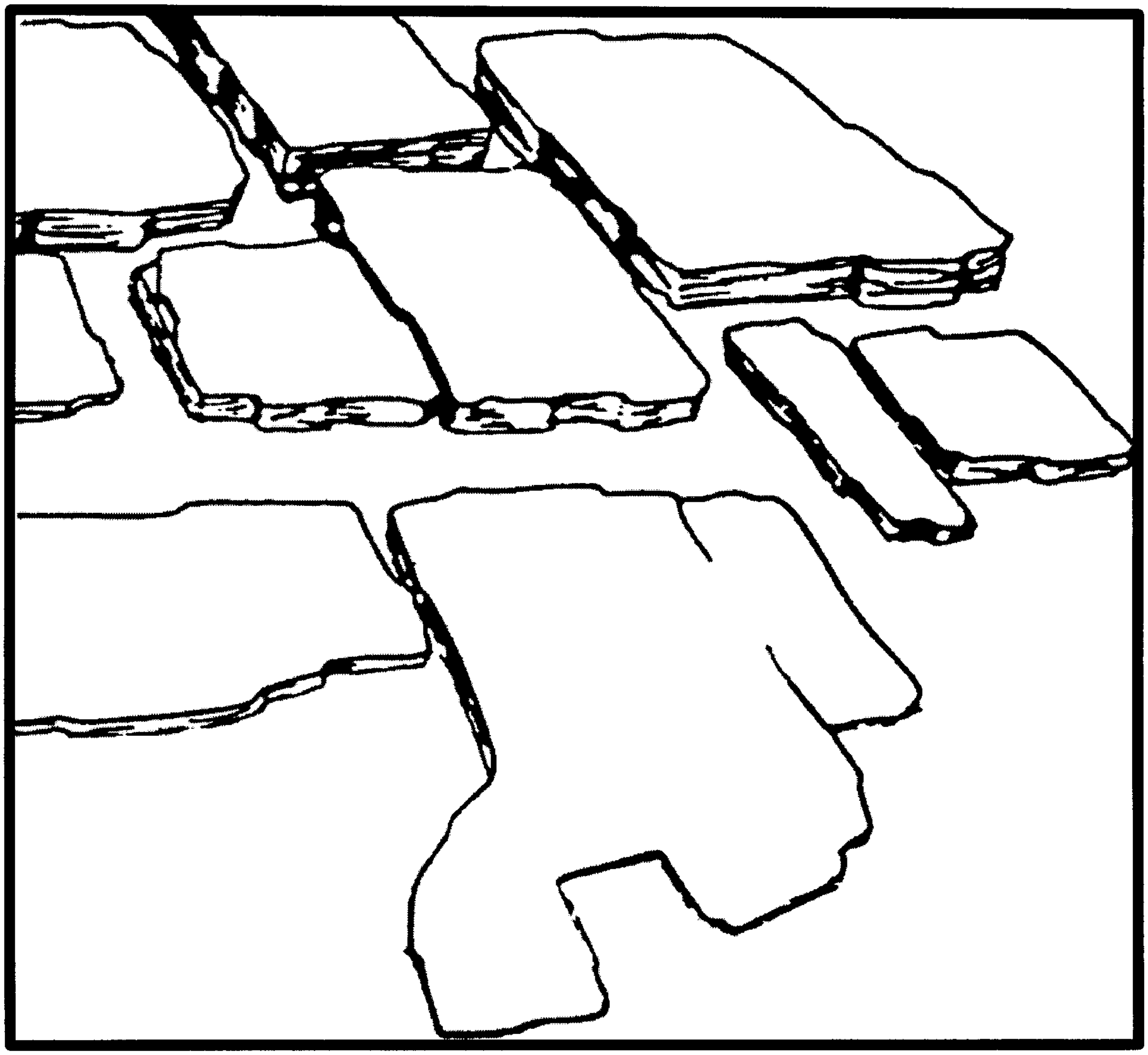

Figure 3.4. Illustrator's reconstruction of the block-like hard bottom substrate north of the head of the De Soto Canyon (From: Shipp and Hopkins 1978).

4.0 COMMUNITY DESCRIPTION

Studies in the pinnacle trend area and along the rim of De Soto Canyon provide the most detailed biological descriptions of live bottom communities in the northeastern Gulf of Mexico.

For most live bottom areas that have been visited, biological information is limited to qualitative observations and species lists from photographs, videotapes, and dredge samples. In some cases, quantitative photographs are also available. This chapter focuses mainly on two areas that have been studied in some detail (**Fig. 4.1**). The first is the pinnacle trend area, which was the subject of two major MMS-sponsored studies: MAMES (Brooks and Giammona 1990) and MASPTHMS (Continental Shelf Associates, Inc. 1992c). A second detailed study area is along the rim of De Soto Canyon. Early observations in this area were reported by Shipp and Hopkins (1978). Subsequently, Continental Shelf Associates, Inc. (1985, 1989, 1992b, 1994a,b, 1996) conducted several detailed photodocumentation and habitat mapping surveys in this area. Additional survey work has been done by Barry A. Vittor & Associates, Inc., DeepSea Development Services - Science Applications International Corporation, the University of North Carolina at Wilmington, and Harbor Branch Oceanographic Institution (Barry A. Vittor & Associates, Inc. 1995, 1996; Benson et al.1997).

4.1 Pinnacle Trend Area

Both the MAMES and MASPTHMS studies focused on shelf edge topographic features, or pinnacles. The discussion here is based on the MASPTHMS study. During that study, a total of 12 ROV dives were conducted (**Fig. 4.2**). Three of these dives (dive numbers 6, 7, and 8) were conducted in soft bottom areas and are not relevant. The remaining nine dives were conducted within areas of high relief hard bottom. **Table 4.1** lists the species seen and their relative abundance on various surfaces (pinnacle base, vertical walls, horizontal rock faces, and pinnacle crest).

Dives 1, 2, and 3 were conducted on a major topographic feature known as 36 Fathom Ridge. A biological description of 36 Fathom Ridge from the MASPTHMS report (Continental Shelf Associates, Inc. 1992c) is presented below. Dives 4-5 and 9-10 were conducted on smaller topographic features that had similar biota to 36 Fathom Ridge; no detailed description is presented here. Dives 11-12 covered topographic features that had more of a moundlike topography with few jutting vertical surfaces, and these are described briefly.

36 Fathom Ridge

36 Fathom Ridge is located at 29°15'13"N, 88°20'47"W. This feature ranges in depth from approximately 90 m (295 ft) at the base to 65 m (213 ft) at the top. It forms a narrow ridge, about 250 m (820 ft) wide, that extends in a north-south direction for approximately 1 km (0.6 mi). This feature was initially identified and mapped by researchers from Texas A&M University during the MAMES study (Brooks and

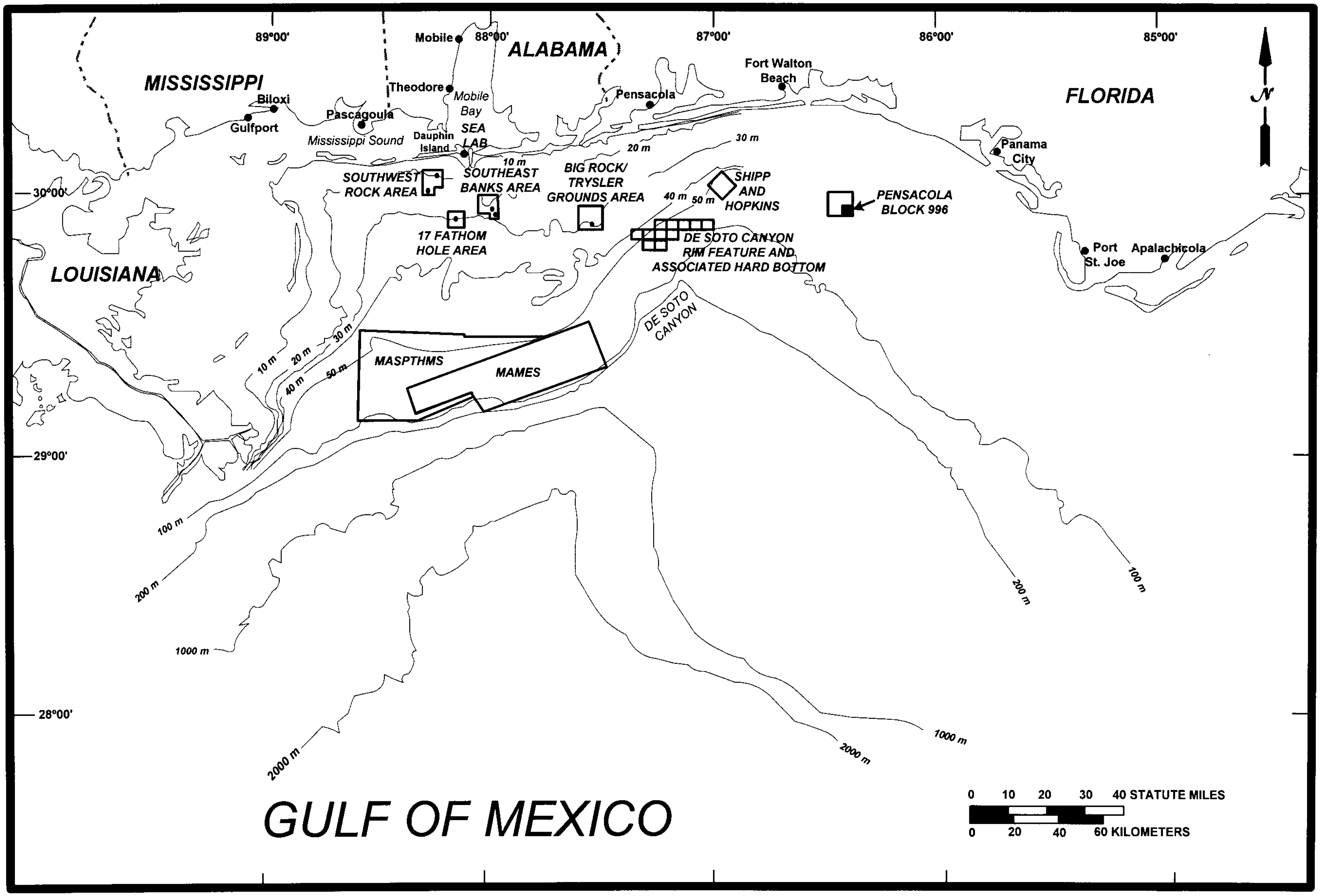

Figure 4.1. Location of hard bottom sites discussed in detail in this chapter.

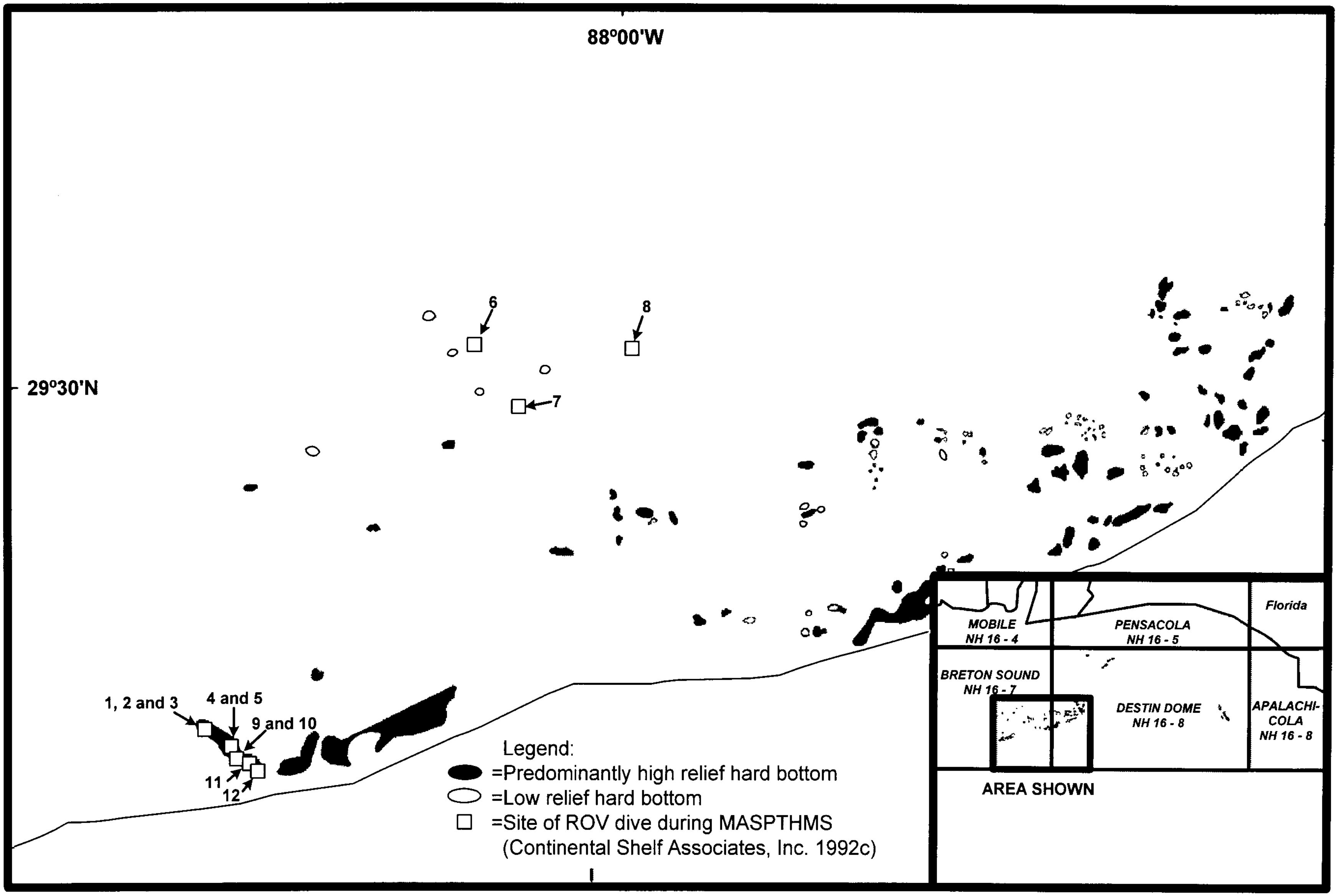

Figure 4.2. Location of remotely operated vehicle (ROV) dives made during the Mississippi-Alabama Shelf Pinnacle Trend Habitat Mapping Study (MASPTHMS) (Adapted from: Continental Shelf Associates, Inc. 1992c).

Table 4.1. Species seen on videotapes and still photographs from ROV dives on pinnacle features during the MASPTHMS (Continental Shelf Associates, Inc. 1992c). Key to abundance: ■ = frequent, ● = occasional, ◊ = rare. The four entries under each column indicate abundance on four sets of dives (1-3, 4-5, 9-10, and 11-12).

Species	Pinnacle Base	Vertical Walls	Horizontal Faces	Pinnacle Crest
ALGAE				
Unidentified coralline algae	– – – –	● – – –	– – – –	● – – –
PORIFERA				
Unidentified Leucettida	– – – ◊	● – – –	● – – –	– – ◊ ●
?*Aplysina* spp.	– – – –	– – – –	– – – –	◊ ● – –
Ircinia campana	◊ – – –	– – – –	– – – –	– – – –
?*Cliona* spp.	– – – –	◊ – – –	– – – –	– – – –
Cinachyrella spp.	◊ – – –	– – – –	● – – –	– – – –
Geodia neptuni	– – – –	– – – –	◊ – – –	– – – –
Geodia spp.	◊ – – –	– – – –	– – – –	◊ ● ◊ ●
CNIDARIA				
Eudendrium spp.	– – – ●	◊ – – –	– – – –	– ● ● ●
Unidentified hydroid	– – – ●	● ◊ ◊ –	● – – –	– ◊ ◊ ●
Siphonogorgia agassizii	– – – –	◊ – – –	◊ – – –	– – – ◊
Bebryce spp.	– – – –	– – – –	– – – –	● ■ ■ –
?*Scleracis* spp.	◊ – – –	– – – –	– – – –	◊ ● – ●
Thesea spp.	– – – –	– – – –	– – – –	◊ – – ●
Ellisella spp.	● – – ●	■ ● ■ –	■ – – –	■ ■ ■ ■
Nicella spp.	– – – –	– – – –	◊ – – –	● ● ● ●
Unidentified Scleractinia	– – – –	◊ – – –	– – – –	– – – –
Madracis myriaster	– – – ◊	● ● ● –	● – – –	● ● ● ■
Madrepora carolina	– – – ◊	– – – –	– – – –	– – – ■
Oculina diffusa	– – – –	● – ● –	● – – –	● – ● ■
Rhizopsammia manuelensis	● – – ◊	■ ■ ■ –	■ – – –	■ ■ ■ ■
?*Balanophyllia floridana*	– – – –	● ◊ ● –	◊ – – –	◊ ● ● ●
Antipathes spp.	● – – ●	■ ■ ■ –	■ – – –	● ■ ■ ■
Antipathes atlantica	● – – ●	■ ● ● –	■ – – –	● ■ ● ●
Antipathes furcata	● – – –	■ ● ● –	■ – – –	● ● ● –
Stichopathes ?lutkeni	● – – ●	■ ● ■ –	■ – – –	■ ● ● ●
MOLLUSCA				
Unidentified Gastropoda	– – – –	– – – –	◊ – – –	– – – ◊
ANNELIDA				
Hermodice carunculata	◊ – – –	– – – –	– – – –	– – – –
ECHINODERMATA				
Unidentified Comatulida	● – – ●	■ ● ■ –	■ – – –	■ ■ ■ ●
?*Linckia spp.*	◊ – – –	– – – –	– – – –	– – – –
Unidentified Gorgonocephalidae	– – – –	● ● ● –	● – – –	● ● ● ●
Eucidaris tribuloides	– – – –	● – – –	– – – –	– ◊ – –
Stylocidaris affinis	– – – –	◊ – – –	● – – –	◊ ● ◊ ●
Diadema antillarum	– – – –	◊ – – –	◊ – – –	◊ ◊ ● ◊

Giammona 1990). During Dive 1, observations were made at the base of the feature and vertically along several steep walls/faces up to a depth of 78 m (256 ft). Dive 2 investigated the vertical reef face/rock walls of the feature at depths ranging from 70 to 78 m (230 to 256 ft). Dive 3 investigated the top portions of the feature, including the upper reef faces, the reef crest, and several areas of reef flat. Water depths ranged from 65 to 72 m (213 to 236 ft).

Pinnacle Base. At the base of the feature, biotic cover was relatively low. The ahermatypic black coral, *Rhizopsammia manuelensis*, was the dominant organism observed. Several species of antipatharian (*Antipathes atlantica, A. furcata, Antipathes* spp.) were also occasionally observed. Several unidentifiable species of comatulid crinoids typically occurred throughout the area. A single fireworm, *Hermodice carunculata*, was observed at the base of the wall. Commonly, the rock faces were surrounded by aprons of relatively coarse sand and rubble that had accumulated around the base of the feature. In some locations, gradual sloping faces of the feature graded into the surrounding sediment and were often covered by very coarse rubble and rocks. These areas typically had very little attached biota, suggesting that the surface may be eroding or breaking down and the resulting rubble precluding attachment by encrusting epifaunal organisms.

Vertical Walls. The walls of the feature were densely populated with a variety of organisms. As observed at deeper locations around the base of the feature, *R. manuelensis* was the dominant species; however, it became more abundant as the ROV ascended the rock walls. Several species of soft corals (*Antipathes* spp., *Cirripathes luetkeni*, and *Ellisella* sp.) were frequently present. Additionally, several ahermatypic stony corals were occasionally observed on vertical walls. These included *Madracis myriaster, Oculina diffusa,* and a small cup coral, possibly *Balanophyllia floridana*. Comatulid crinoids were occasionally observed on the sheer rock walls.

Biologically, the upper portions of the vertical rock faces (Dive 3) were not markedly different than the deeper areas. While locally there were some areas of very dense biological growth, the overall density of organisms did not appear greater than in similar substrate types at greater depths.

Horizontal Faces. Investigations along the wall during Dive 2 revealed the presence of relatively horizontal flat areas interspersed between sheer vertical walls. These flat areas occurred sporadically along the reef faces and had considerably increased biotic cover relative to adjacent vertical surfaces. This is probably due to the horizontal orientation which appeared more suitable for colonization and growth. The dominant species present were similar to those observed on the vertical rock substrate of the reef face.

Several other species not observed on the vertical reef face were present on the reef flats. These included several sponges (*Geodia neptuni*, *Cinachyrella* sp.), several unidentified orange sponges, and an unidentified soft coral (possibly *Nicella* sp.).

Pinnacle Crest. The crest of 36 Fathom Ridge formed a very irregular rock surface, showing jutting and jagged areas interspersed with depressions typically about 1 to 2 m (3 to 7 ft) deep. Depressions often contained accumulations of coarse rubble and sand. *R. manuelensis* was present on a majority of hard protruding and jutting surfaces.

Several soft corals were present, including *Bebryce* sp., *Ellisella* sp., *Cirripathes* sp., and *Antipathes atlantica*. Comatulid crinoids were frequent throughout the reef crest. Unlike the deeper areas of this feature, coralline algae were observed on hard substrates. **Figs. 4.3** and **4.4** show photographs taken on the reef crest during Dive 3.

Several other organisms were occasionally observed in the reef crest area. These included a bushy orange-red sea fan (possibly *Nicella* sp.), the ascidian *Didemnum* sp., and gorgonocephalids. Other invertebrates rarely observed included the urchin *Stylocidaris affinis*, a branching sponge (possibly *Aplysinia* sp.), the sponges *Geodia neptuni*, and several unidentified sponges. The long-spined urchin *Diadema antillarum* also was observed on the reef crest.

Smaller Pinnacle Features

MASPTHMS Dives 4, 5, 9, and 10 were conducted on topographic features that were smaller than, but similar to, 36 Fathom Ridge. Only the vertical walls and reef crests were surveyed, and the biota were quite similar to those observed on the larger feature (**Table 4.1**); no detailed description is presented here. **Fig. 4.5** shows a photograph from Dive 4. **Figs. 4.6 and 4.7** show photographs from Dives 9 and 10, respectively.

Moundlike Features

MASPTHMS Dives 11 and 12 were conducted on smaller features that were somewhat different from the others visited. No vertical sheer rock reef face was present and most of the substrate had a sloping horizontal terrain, giving these features a moundlike topography. Only the crest and base of these features were surveyed. As the two features were similar, only Dive 11 observations are summarized below.

The topographic feature visited during Dive 11 was located at 29°13'49"N, 88°18'35"W, and ranged in depths from 94 m (308 ft) at the base to 83 m (272 ft) at its crest. This feature was smaller than those previously investigated, being approximately 200 m (656 ft) in width (east-west) and 250 m (820 ft) in length (north-south). During the dive, surveyed depths ranged from 83 to 93 m (272 to 305 ft). At the very deepest portion of the survey, increased turbidity was evident. Visibility ranged from approximately 3 to 5 m (10 to 16 ft) in this area. Water clarity significantly improved with only a slight decrease in depth (i.e., at approximately 90 m [295 ft] water depth). It was not clear if this turbid water was a nepheloid layer or a localized turbidity plume.

The base of the feature was an area overlain with coarse sand and rubble. Small emergent rocks, colonized by several epifaunal species, protruded from areas of coarse sand. At the base of the emergent portion of the feature, small rock ledges (typically 1 to 2 m [3 to 6 ft] in height) were noted bordered by coarse sand and rubble. In these lower regions, relatively few species were observed. *R. manuelensis* was the most common species present, occurring primarily on vertical surfaces. The soft corals *Ellisella* sp. and *Cirripathes* sp., comatulid crinoids, and several antipatharians (*Antipathes* spp.) were also observed occasionally.

Significant differences in epibiota were apparent higher on the feature. *R. manuelensis* was present in increased density, as well as several other ahermatypic corals including *Madrepora carolina*, *Madracis myriaster*, and *Oculina* sp. All three species frequently

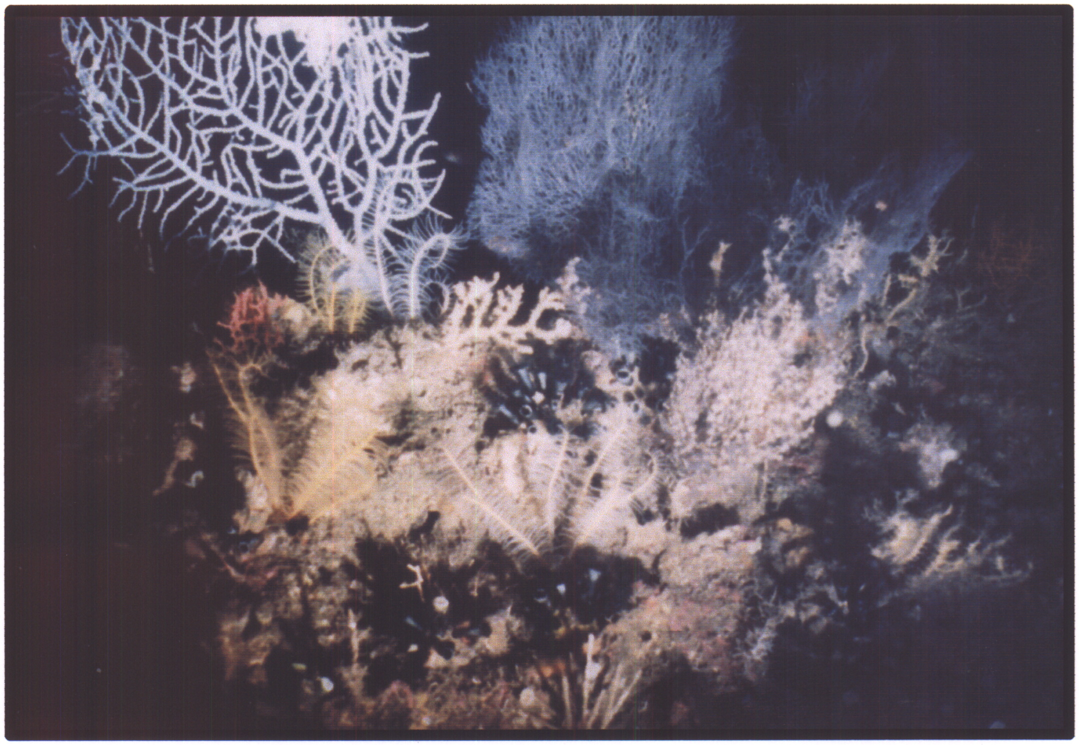

Figure 4.3. Heavy coverage of epibiota on reef top observed during MASPTHMS Dive 3. Black coral *(Antipathes* sp.) and a large sea fan (*Hypnogorgia pendula*) are present in the upper center of the photo.

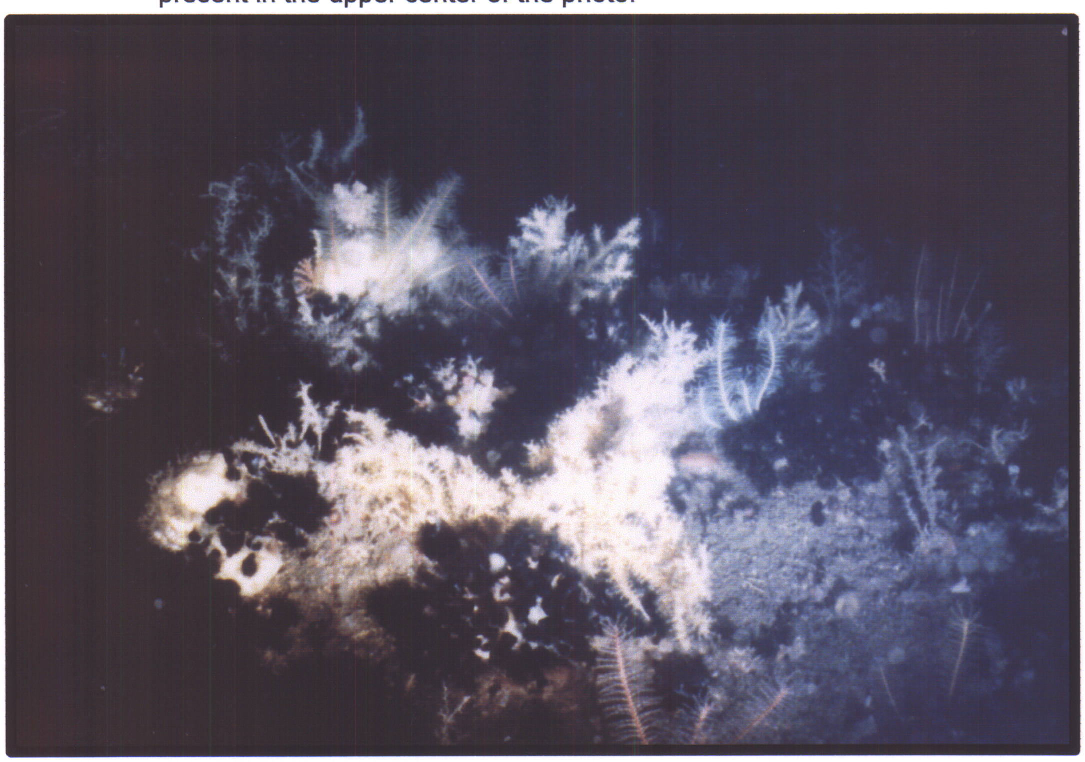

Figure 4.4. Dense epibiotal growth on reef top surveyed in MASPTHMS Dive 3. Numerous comatulid crinoids as well as the black hard coral *Rhizopsammia manuelensis* are present in the photo.

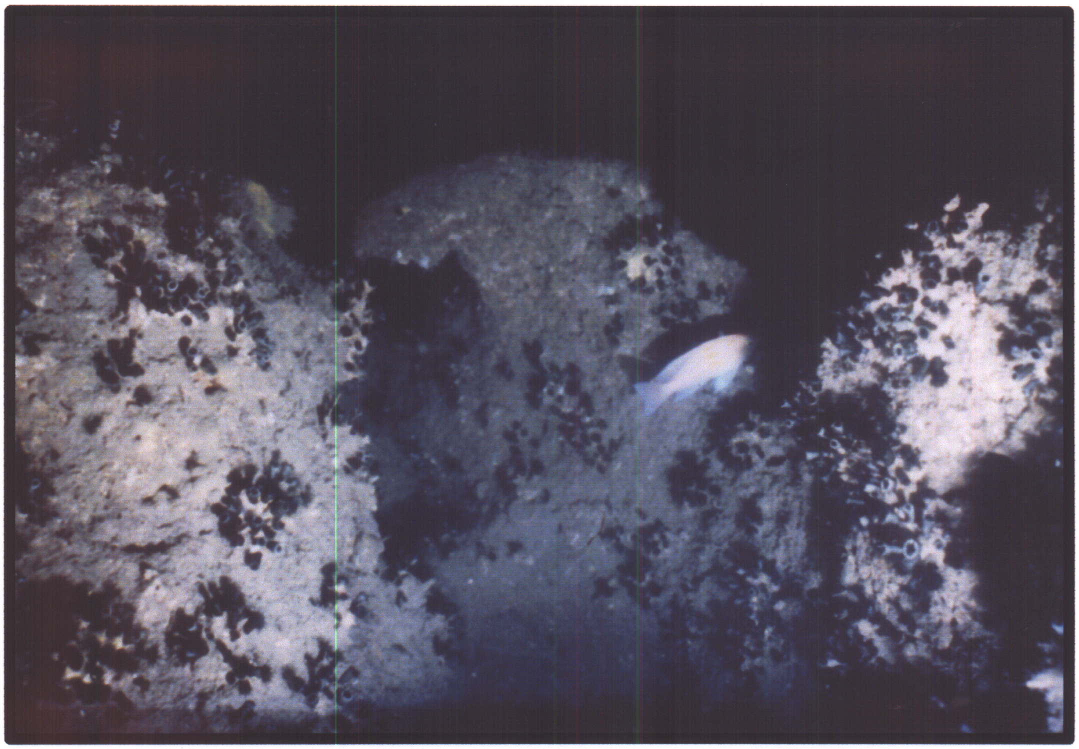

Figure 4.5. Jagged top of the feature investigated during MASPTHMS Dive 4. An anthiid (*Anthias nicholsi*) swims among the outcrops populated with the ahermatypic hard coral *Rhizopsammia manuelensis*.

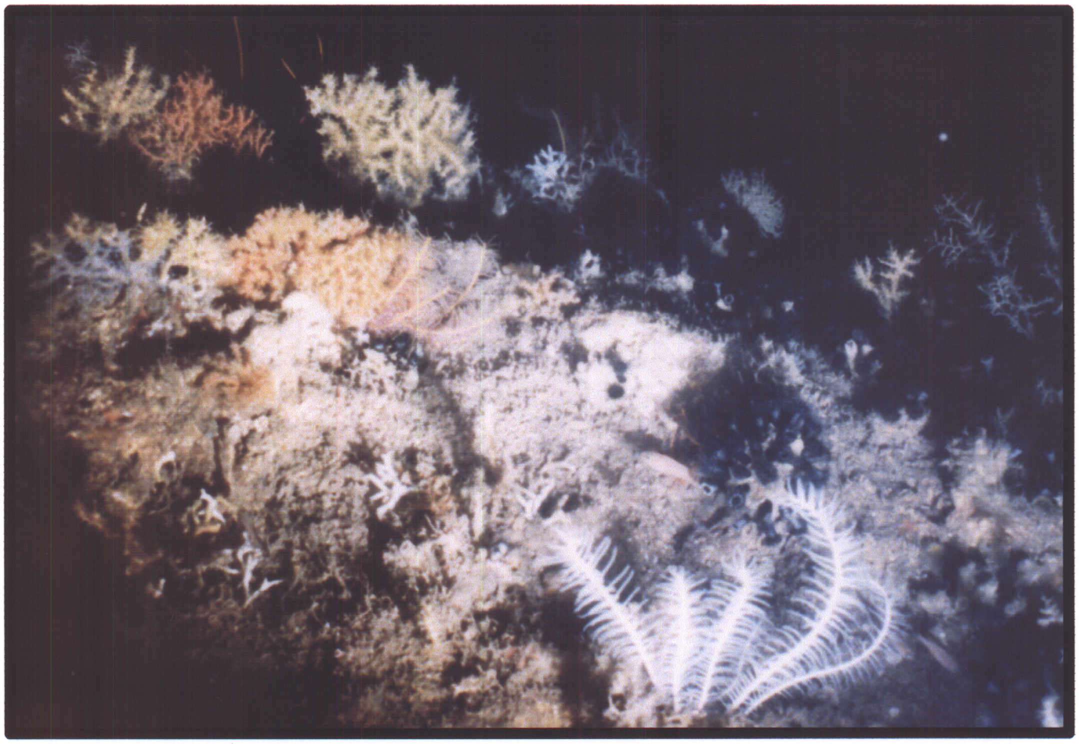

Figure 4.6. Epibiota observed on reef during MASPTHMS Dive 9. A comatulid crinoid and small colonies of the hard coral *Madracis myriaster* are present in the foreground.

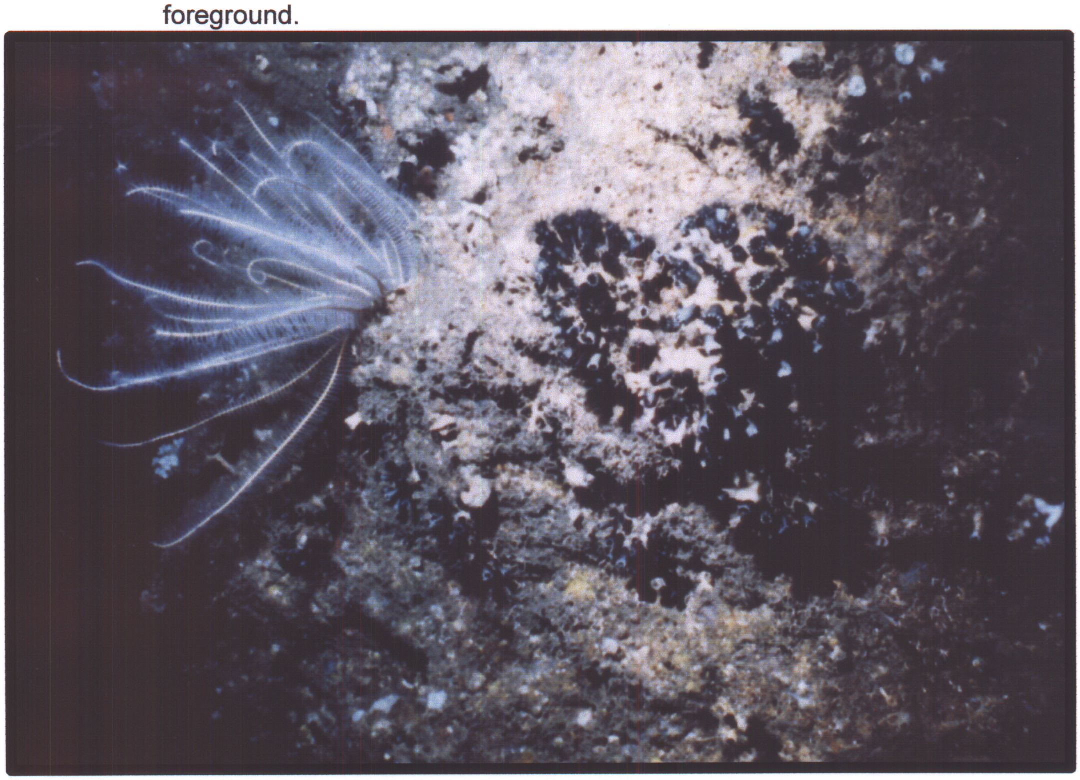

Figure 4.7. Comatulid crinoid on reef face observed during MASPTHMS Dive 10. The black hard coral *Rhizopsammia manuelensis* is also present.

were present. Also present were antipatharians (*Antipathes* spp.), comatulid crinoids, several soft corals (probably *Nicella* sp. and *Scleracis* sp.), a solitary cup coral (probably *Balanophyllia floridana*), gorgonocephalids, and several unidentified sponges.

Fish Communities

Table 4.2 lists the fish species observed on videotapes from the MAMES and MASPTHMS studies (Gittings et al. 1990; Continental Shelf Associates, Inc. 1992c). The sea bass family (Serranidae) was the most conspicuous group associated with deep water live bottom. The anthiin serranids (*Holanthias martinicensis* and *Hemanthias* spp.), known as streamer basses, are often numerically dominant on deep reef habitats and undoubtedly serve as forage for a number of piscivorous species. Other serranids typically found in these habitats range from small species such as tattler (*Serranus phoebe*) and wrasse bass (*Liopropoma eukrines*) to some of the larger groupers such as snowy grouper (*Epinephelus niveatus*) and warsaw grouper (*Epinephelus nigritus*). Other species frequently occurring on deep reefs include bank butterflyfish (*Chaetodon aya*), yellowtail reeffish (*Chromis enchrysurus*), blackbar drum (*Pareques iwamotoi*), short bigeye (*Pristigenys alta*), and amberjacks (*Seriola* spp.).

During the MASPTHMS study, the number of fishes present on each feature was surprisingly low considering the significant amount of vertical relief present. The reasons are not known. However, the presence of primarily small individuals of most species may be indicative of fishing pressure (Continental Shelf Associates, Inc. 1992c).

Discussion

The MAMES and MASPTHMS studies showed that, generally, a similar suite of epibiota was present on most topographic features. However, density varied depending on the location, relief, and orientation of the hard bottom substrate. For example, the density and relative number of species present near the base of a feature was low. At the base of each feature where rock faces were surrounded by aprons of coarse sediment, the lower 1 to 2 m (3 to 7 ft) of rock substrate exhibited very little, if any, biotic cover. This may be due to increased turbidity resulting from resuspension of bottom sediments by water currents circulating around the base of these features. Species that were present were typically taller forms (i.e., gorgonians *Ellisella* spp. and *Cirripathes* sp.) which would not be smothered by high loadings of suspended sediment. Relatively few small ahermatypic corals were present, and those that did exist in this zone occurred on vertical faces, thereby reducing their susceptibility to sedimentation.

At higher elevations (i.e., away from the base of features) it appears sedimentation plays a lesser role in community development than does suitable substrate for attachment. On vertical rock faces, the relative density of organisms was considerably less than on horizontal flat areas and pinnacle tops. This trend, as observed during all the investigations of topographic features, appears to be indicative of the relative ability of these organisms to colonize vertical as opposed to horizontal surfaces. Species observed within these habitats on each of the features investigated were similar. However, on horizontal surfaces there was a decrease in certain species of soft corals (e.g., *Bebryce* sp. and *Nicella* sp.) and a relative decrease in the densities of ahermatypic corals. This may also be related to the amount of sedimentation occurring in these habitats.

Table 4.2. Fishes seen during ROV dives on outer shelf "pinnacle" features. Data are from two MMS-sponsored studies, MAMES (Brooks and Giammona 1990) and MASPTHMS (Continental Shelf Associates, Inc. 1992c).

Fish Species	MAMES	MASPTHMS
CLASS ELASMOBRANCHIOMORPHA		
Family Dasyatidae		
Dasyatis sp. - stingray	x	--
CLASS OSTEICHTHYES		
Family Muraenidae - morays		
Gymnothorax moringa - spotted moray	x	--
Gymnothorax saxicola – honeycomb moray	x	--
Muraena retifera - reticulate moray	x	--
Family Nettastomatidae - duckbill eels		
Hoplunnis macrurus - freckled pike-conger	x	--
Family Ophichthidae - snake eels		
Ophichthus ophis - spotted snake eel	x	--
Family Synodontidae – lizardfishes		
Synodus intermedius - sand diver	x	--
Family Batrachoididae – toadfishes		
Opsanus beta - Gulf toadfish	x	--
Family Ogcocephalidae – batfishes		
Ogcocephalus corniger - longnose batfish	x	--
Ogcocephalus nasutus – shortnose batfish	x	--
Ogcocephalus spp. – batfishes	--	x
Family Holocentridae – squirrelfishes		
Holocentrus sp. – squirrelfish	--	x
Family Scorpaenidae – unidentified scorpionfish	--	x
Family Gadidae – cods		
Urophycis floridana – southern hake	x	--
Family Ophidiidae – cusk-eels		
Lepophidium jeannae - mottled cusk eel	x	--
Famile Serranidae – sea basses		
Anthias nicholsi - yellowfin bass	--	x
Centropristis ocyurus - bank sea bass	x	--
Centropristis ?philadelphica - rock sea bass	x	--
Diplectrum sp. - sand perch	x	--
Epinephelus ?nigritus - Warsaw grouper	x	--
Gonioplectrus hispanus - Spanish flag	--	x
Hemanthias aureorubens – streamer bass	x	--
Holanthias martinicensis – roughtongue bass	x	x
Liopropoma eukrines - wrasse bass	x	x
Paranthias furcifer - creole-fish	--	x
Serranus phoebe - tattler	x	x
Serranus tabacarius - tobaccofish	x	--
Family Priacanthidae - bigeyes		
Priacanthus arenatus - bigeye	x	--
Pristigenys alta - short bigeye	x	x
Family Apogonidae - cardinalfishes		
Apogon pseudomaculatus - twospot cardinalfish	x	--
Family Rachycentridae - cobias		
Rachycentron canadum - cobia	x	--
Family Carangidae - jacks		
Caranx sp. - jack (juvenile)	x	--
Decapterus ?punctatus - round scad	x	--
Trachurus ?lathami - rough scad	x	--
Seriola dumerili - greater amberjack	x	x
Seriola rivoliana - almaco jack	x	--
Family Lutjanidae - snappers		
Lutjanus campechanus - red snapper	x	x
Rhomboplites aurorubens - vermilion snapper	x	x
Family Sparidae - porgies		
Calamus bajonado - jolthead porgy	x	--
Calamus nodosus - knobbed porgy	x	--
Pagrus pagrus - red porgy	x	--
Stenotomus caprinus - longspine porgy	x	--
Family Sciaenidae - drums		
Equetus punctatus - spotted drum	x	--
Menticirrhus sp. - kingfish	x	--
Micropogonias undulatus - Atlantic croaker	x	--
Family Chaetodontidae - butterflyfishes		
Chaetodon aya - bank butterflyfish	x	x
Chaetodon ocellatus - spotfin butterflyfish	x	--
Chaetodon sedentarius - reef butterflyfish	x	--
Family Pomacanthidae - angelfishes		
Holacanthus bermudensis - blue angelfish	x	x
Family Pomacentridae - damselfishes		
Chromis enchrysurus - yellowtail reeffish	x	--
Microspathodon chrysurus - yellowtail damselfish	x	--
Family Labridae - wrasses		
Halichoeres bivittatus - slippery dick	x	--
Family Scombridae - mackerels		
Sarda sarda – Atlantic bonito	x	--
Family Stromateidae - butterfishes		
Peprilus burti - Gulf butterfish	x	--
Family Triglidae - searobins		
Prionotus spp. – searobins	x	--
Family Bothidae – lefteye flounders	x	--
Family Ostraciidae - boxfishes		
Lactophrys quadricornis - scrawled cowfish	x	--
Lactophrys polygonia - honeycomb cowfish	x	--

Both the MAMES and the MASPTHMS studies found that live bottom community development varied significantly between sampling sites. Community development increased with increasing amounts of exposed hard bottom, texture (rugosity), and topographic complexity. Faunal assemblages were marginal or depauperate on features with relief of less than 2 m (7 ft). Faunal density increased on features with 2 to 6 m (7 to 20 ft) of vertical relief, and all high relief features with 6 to 18 m (20 to 60 ft) relief showed dense assemblages in which faunal composition varied with substrate orientation. The horizontal summits of features showed larger populations of sponges, tall antipatharians and gorgonians, and comatulid crinoids. Ahermatypic corals were most abundant on vertical or rugged surfaces. Variations in epibenthic community development were attributed to differences in the potential rate of sedimentation in these locations (Gittings et al. 1990, 1992; Continental Shelf Associates, Inc. 1992c). Longitudinal variability in certain species such as ahermatypic corals was also observed (Gittings et al. 1990). Environmental influences are discussed further in Chapter 5.0.

4.2 De Soto Canyon Rim

Shipp and Hopkins (1978) reported submersible observations of a hard bottom area near the head of De Soto Canyon (**Fig. 4.1**). The feature in a water depth of about 55 m (180 ft) was described as a block-like substrate consisting of rectangular blocks of granular limestone. The hard bottom areas showed vertical relief ranging from barely detectable to nearly 10 m (33 ft). Rocky ridges were colonized by sponges, the hard coral *Oculina diffusa*, the soft corals *Lophogorgia cardinalis* and *L. hebes*, and the solitary antipatharian *Antipathes sp.* The ichthyofauna associated with this live bottom community consisted primarily of families characteristic of Caribbean reefs. Sea basses (Serranidae) and damselfishes (Pomacentridae) comprised the most visible components, but cardinalfishes (Apogonidae), butterflyfishes (Chaetodontidae), bigeyes (Priacanthidae), drums (Sciaenidae), squirrelfishes (Holocentridae), and snappers (Lutjanidae) were also present in large numbers. Other families, especially grunts (Haemulidae) and porgies (Sparidae) were seen less frequently (Shipp and Hopkins 1978).

Near the area visited by Shipp and Hopkins (1978) and about 45 km (24 nmi) to the northeast of the MAMES and MASPTHMS study areas lies a sandstone hard bottom near the head of the De Soto Canyon (**Fig. 4.1**). The most prominent feature in this area is a 12 km (7.5 mi) long ridge, termed the "De Soto Canyon rim feature" (Benson et al. 1997). Continental Shelf Associates, Inc. (1985, 1989, 1992b, 1994a,b, 1996) conducted several detailed photodocumentation and habitat mapping surveys. Additional survey work in this area has been done by Barry A. Vittor & Associates, Inc., DeepSea Development Services - Science Applications International Corporation, the University of North Carolina at Wilmington, and Harbor Branch Oceanographic Institution (Barry A. Vittor & Associates, Inc. 1995, 1996; Benson et al. 1997).

This area represents a unique opportunity to compare northeastern Gulf of Mexico OCS live bottom communities because various types of hard bottom features are seen at varying depths close to one another. Hard bottom topography in the outer shelf area at this location is highly variable with respect to vertical relief and spatial continuance. **Fig. 4.8** shows hard bottom locations relative to OCS lease blocks in the Destin Dome Area that were surveyed. Four main hard bottom areas were observed:

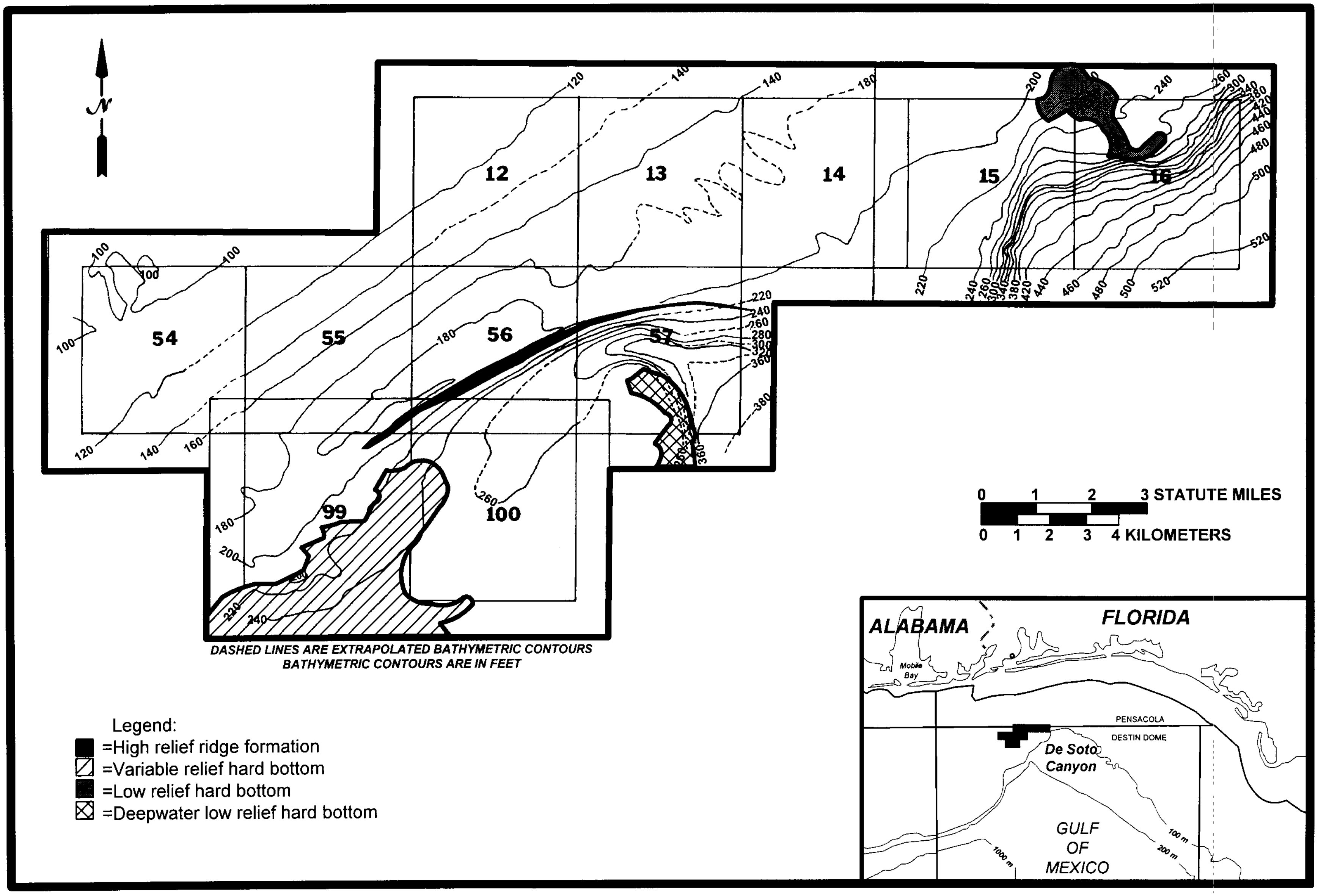

Figure 4.8. Hard bottom habitats surveyed near the head of the De Soto Canyon (Adapted from: Continental Shelf Associates, Inc. 1994a).

- **High relief ridge formation**. A high relief (1 to 8 m or 3 to 26 ft) ridge formation, the "De Soto Canyon rim feature," parallels the northeast-southwest isobath between 52 and 61 m (170 and 200 ft) of water in Blocks 99, 55, 56, and 57;

- **Variable relief hard bottom**. A southwest-northeast discontinuous hard bottom trend, with variable relief, is offshore of the southwestern end of the ridge feature in depths ranging from 61 to 76 m (200 to 250 ft), in Blocks 99 and 100;

- **Low relief hard bottom trend**. A northeast-southeast low relief (≤1 m) hard bottom trend is present in 61 to 79 m (200 to 260 ft) of water at the northeastern end of the study area in Blocks 15 and 16; and

- **Deepwater low relief hard bottom**. Isolated low relief (≤1 m) hard bottom occurs within the south central portion of the study area in water depths of 76 to 104 m (250 to 340 ft) in Block 57.

The live bottom community associated with each of these habitats is discussed below, followed by some quantitative comparisons. Some additional low relief hard bottom areas located several kilometers to the northwest in shallower water (32 to 38 m) are referred to in the discussion. These areas, located in Blocks 51 and 52, consisted of discontinuous, tier-like rock formations with numerous ledges and crevices with vertical relief up to 2 m (7 ft) (Continental Shelf Associates, Inc. 1991).

High Relief Ridge Formation

The large ridge formation with vertical relief of 1 to 8 m (3 to 26 ft) is located in a water depth of 52 to 61 m (170 to 200 ft) and oriented southwest/northeast with the ridge face directed southeast (Continental Shelf Associates, Inc. 1994a). The ridge formation is up to 230 m (750 ft) wide. The northwest and southeast edges of the ridge formation consist of low relief (≤1 m) rock outcrops interspersed among sand. Moving east past the leading-edge outcrops of the ridge, rock becomes the dominant substrate and moderately to abruptly slopes upward (depending on the location along the formation). Multiple ridge crests are observed at various locations along the ridge formation. These well defined ridge crests are divided by small sand flats whose crest dimensions generally increase toward the southeast. The northwest slope of the ridge formation partially levels off to a gradually sloping plateau consisting of fractured stone blocks (**Fig. 4.9**). This plateau is not always well defined and drops off more sharply on the southeastward or seaward slope. Both the landward and seaward slopes along this feature are made up of large stone blocks and irregular boulders creating many ledges and crevices. Cracks or fissures ranging in width from about 1 to 10 cm occur along the plateau (**Fig. 4.10**). The ridge formation gradually diminishes to scattered rock outcrops with vertical relief of 0 to 2 m (0 to 6.6 ft) at its northeastern end.

The high relief ridge formation supports an epibiota visually dominated by sponges (*Chondrosia* sp., ?*Cliona* sp., *Erylus* sp., and *Pseudoceratina crassa*), various cnidarians (*Thyroscyphus marginatus*, ?*Lytocarpus clarkei*, *Bebryce* spp., *Ellisella* spp., ?*Thesea* sp., *Stichopathes* ?*lutkeni*, and *Antipathes* spp.), and calcareous algae (Corallinaceae and *Peyssonnelia* spp.). Other biota commonly observed on the ridge formation include encrusting sponges, the arrow crab (*Stenorhynchus seticornis*), bryozoans (e.g., *Cellaria*

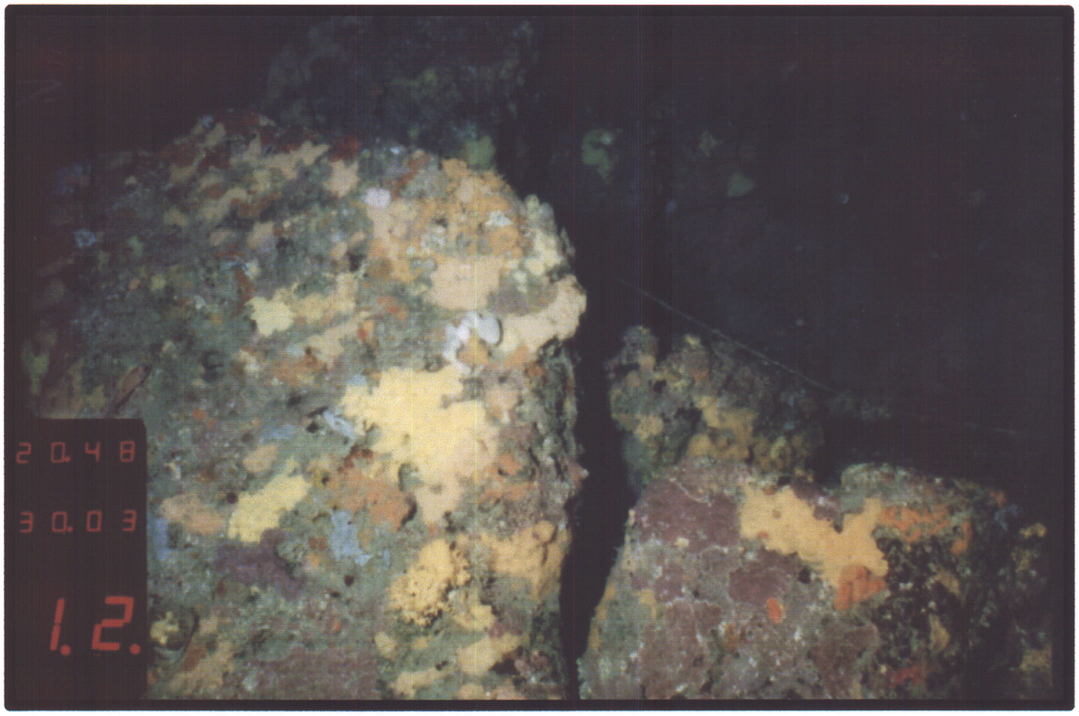

Figure 4.9. Interlocking stone blocks forming the northwest slope of ridge formation seen in Destin Dome Block 56.

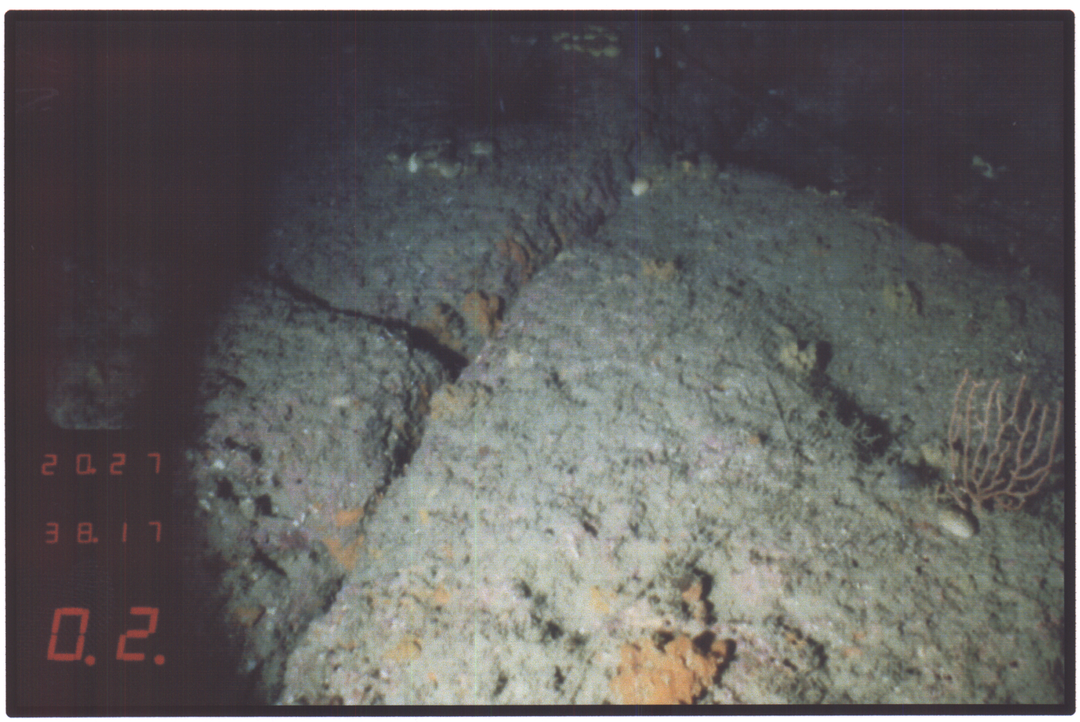

Figure 4.10. Ridge plateau with boulders showing cracks or fissures.

irregularis), feather stars (Crinoidea), basket stars (*Astrocyclus caecilia*), and the long-spined urchin (*Diadema antillarum*). Slipper lobsters (*Scyllarides nodifer*) were observed along the edges of the ridge formation. Ramose colonies of the ivory coral (*Oculina ?diffusa*) were occasionally observed attached to irregular south slope edges of the ridge formation. An ahermatypic coral (*Paracyathus pulchellus*) was seen and collected previously on the ridge.

The ridge formation also supports an abundance of fishes. Sea basses (Serranidae) contribute the greatest number of species and possibly the most individuals observed from photographs and video. Diminutive anthiin serranids (red barbier, *Hemanthias vivanus*) and roughtongue bass (*Holanthias martinicensis*) are most conspicuous and commonly occur in schools around rock ledges and crevices. Single individuals of other serranids such as the tattler (*Serranus phoebe*), the wrasse bass (*Liopropoma eukrines*), and the bank sea bass (*Centropristis ocyurus*) also are observed frequently. Scamp (*Mycteroperca phenax*) and red grouper (*Epinephelus morio*) were the only grouper observed along the ridge formation. Representatives from other fish families commonly observed include bigeyes (*Priacanthus arenatus* and *Pristigenys alta*), butterflyfish (*Chaetodon aya* and *C. ocellatus*), spotfin hogfish (*Bodianus pulchellus*), twospot cardinalfish (*Apogon pseudomaculatus*), and angelfish (*Holacanthus* sp.). Reeffish (*Chromis enchrysurus* and *C. scotti*) were quite abundant along ledges. Less conspicuous species such as batfish (*Ogcocephalus* spp.) and scorpionfish (*Scorpaena* spp.) were probably more numerous than visual/video observations would indicate. Important commercial species such as red grouper (*Epinephelus morio*), scamp (*Mycteroperca phenax*), red snapper (*Lutjanus campechanus*), vermilion snapper (*Rhomboplites aurorubens*), and jacks (*Seriola dumerili*, *S. rivoliana*, and *S. zonata*) have been observed on the ridge formation.

Variable Relief Hard Bottom

A variable relief hard bottom trend is located in water depths between 61 and 76 m (200 and 250 ft) (Continental Shelf Associates, Inc. 1994a) in Blocks 99 and 100 (**Fig. 4.8**). Hard bottom features consist of rock outcrops with highly variable vertical relief up to 8 m (26 ft). High relief (exceeding 1 m or 3 ft) rock outcrops are a predominant feature of the southern portion and western edge of the hard bottom trend. The high relief hard bottom consists of a series of large rock mounds/ridges separated by sand and low relief rock outcrops, but these large rock mounds/ridges are not laterally contiguous. In contrast, the northern portion and eastern edge of the trend consists mainly of small, low relief (≤1 m or 3 ft) rock outcrops. Some hard bottom is covered with a thin sand veneer, particularly in areas between rock outcrops of variable vertical relief. The presence of hard bottom under a thin sand veneer can be easily recognized by the presence of attached epibiota.

The variable relief hard bottom trend supported an epibiota visually dominated by bryozoans (*Cellaria irregularis*, *Crisia* sp., *Idmidronea atlantica*, and *Parasmittina* spp.), soft corals (*Bebryce* spp., *Ellisella* spp., and *Thesea* spp.), black corals (*Antipathes* spp. and *Stichopathes ?lutkeni*), sponges (*Halichondria* spp. and *Teichaxinella shoemakeri*) and plumose hydroids (*?Aglaophenia elongata*, *?Gymnangium sinuosum*, and *?Lytocarpus clarkei*). Other commonly observed biota included arrow crab (*Stenorhynchus seticornis*), seastars (*Coronaster briareus*, *Linckia nodosa*, *Narcissia* *trigonaria*, and ?*Echinaster* sp.), the large bright red brittle star *Ophioderma devaneyi*, basket stars (*Asteroporpa annulata* and ?*Astrocyclus caecilia*), and the solitary ascidian *Polycarpa circumarata*. Feather stars (Crinoidea) were occasionally seen in rock crevices on both the low and high relief outcrops. Calcareous algae (Corallinaceae and *Peyssonnelia* spp.) were more commonly observed on the higher relief rock outcrops. The solitary hard coral *Paracyathus pulchellus* was observed on both the low and high relief outcrops. Other solitary hard corals (*Rhizopsammia manuelensis* and ?*Balanophyllia floridana*) and colonial hard corals (*Madracis* ?*myriaster*, *Oculina* ?*diffusa* and *Madrepora carolina*) were observed, often in close proximity, only on the higher relief outcrops. *Oculina* ?*diffusa* and *Madrepora carolina* were attached on steeply sloped rock faces and overhangs. *Oculina* ?*diffusa* was the most common of the colonial hard corals and often was observed in multiple large ramose colonies. Areas of the exposed rock had varying amounts of epibiota, ranging from little or no attached epibiota to heavy coverage.

The ichthyofauna observed on the variable relief hard bottom trend is similar to that observed on the ridge formation. The recently described sciaenid fish, the blackbar drum (*Pareques iwamotoi*) (Miller and Woods 1988), was observed on both the ridge formation and the variable relief hard bottom trend.

Low Relief Hard Bottom Trend

A low relief (≤1 m) hard bottom trend is located along the northern border of the area surveyed by Continental Shelf Associates, Inc. (1994a) at a water depth of about 61 to 79 m (200 to 260 ft), in Blocks 15 and 16 (**Fig. 4.8**). Much of the area is characterized by small, discontinuous bumpy or moundlike rock outcrops with attached epibiota, surrounded by sand bottom areas with sparse coverage (**Fig. 4.11**).

The low relief hard bottom supports an epibiota and an ichthyofaunal community similar to the low relief hard bottom areas within the variable relief hard bottom area discussed above. Multiple ramose colonies of *Oculina* ?*diffusa* were observed on a single higher relief outcrop. Anthiin serranids and other reef fishes (e.g., *Chromis* spp., *Lutjanus campechanus*, and *Priacanthus arenatus*) were not as frequently observed here as on the variable relief hard bottom. Sciaenid fishes (*Pareques iwamotoi* and *Equetus umbrosus*) also were observed less frequently.

Deepwater Low Relief Hard Bottom

Isolated low relief (≤1 m) hard bottom formations occur in a water depth of 76 to 104 m (250 to 340 ft) (Continental Shelf Associates, Inc. 1994a) in Block 57 (**Fig. 4.8**). These formations consist of sparse rock outcrops interspersed among hard bottom covered with a thin sand veneer. In this area, the bottom drops off rapidly toward De Soto Canyon.

Visually dominant epibiota in the deepwater low relief hard bottom include paramuricid soft corals (*Bebryce grandis*, *Scleracis guadalupensis*, *Thesea* spp., and *Villogorgia nigrescens*) and black corals (*Antipathes* spp. and *Stichopathes* ?*lutkeni*). Other commonly observed biota include the sponge *Halichondria* ?*magniconulosa*, the bryozoan *Cellaria irregularis*, arrow crab (*Stenorhynchus seticornis*), feather stars

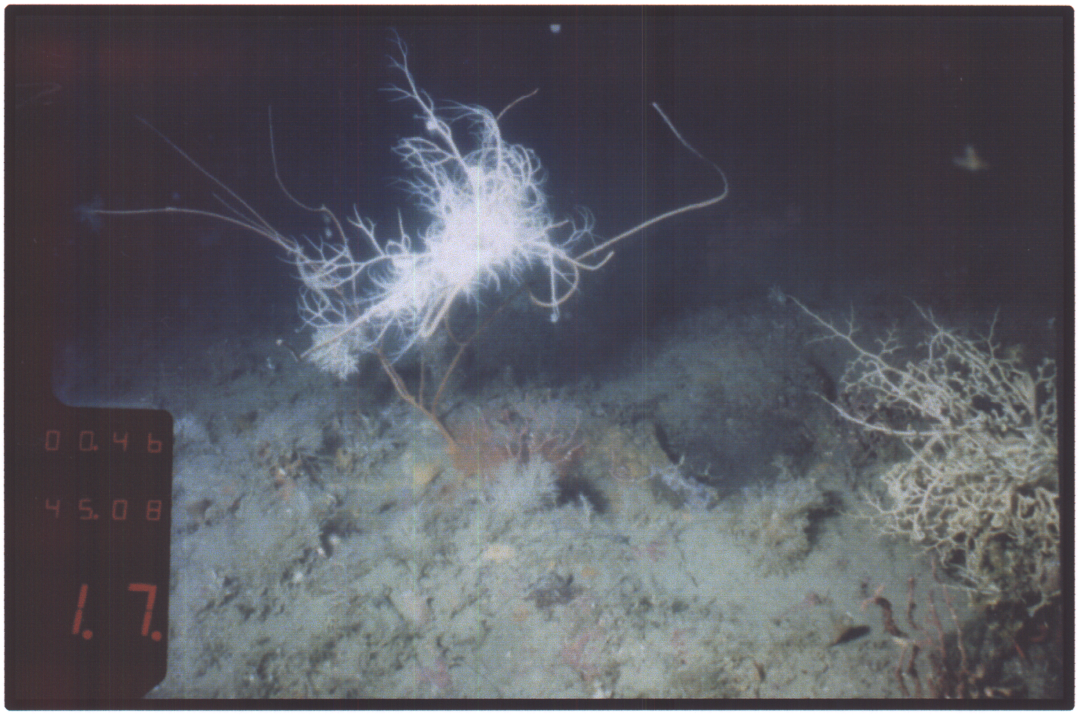

Figure 4.11. Basket stars (Gorgonocephalidae) on the soft coral *Ellisella* sp. attached to a low relief hard substrate.

(Crinoidea), stout-spined seastar (*Goniaster tesselatus*), brittle stars (*Asteroporpa annulata* and *Ophioderma devaneyi*), the echinoid *Stylocidaris affinis*, and the solitary tunicate *Polycarpa circumarata*. The only hard coral observed was *Paracyathus pulchellus*, an ahermatypic form.

The most commonly observed fish was short bigeye (*Pristigenys alta*), which was closely associated with exposed rock. Other commonly observed species included searobins (Triglidae), wenchman (*Pristipomoides aquilonaris*), bank butterflyfish (*Chaetodon aya*), and pelagic rough scad (*Trachurus lathami*). Shortspine boarfish (*Antigonia combatia*) was seen only in this habitat. Blackbar drum (*Pareques iwamotoi*) also was observed.

Quantitative Comparisons: Epibiota

Photographs. Biotic cover estimates from the four hard bottom areas described above, as well as nearby hard bottom areas in Blocks 51 and 52 (Continental Shelf Associates, Inc. 1994b), are summarized in **Table 4.3**. For broad comparisons, the table lists total cover of major groups rather than individual taxa. **Table 4.4** lists the visually dominant taxa.

Biotic cover was highest on the ridge formation (about 20%) and lowest in the deepwater, low relief area (6%). On the ridge formation, calcareous red algae and sponges contributed about two-thirds of the biotic cover. Five of the cover dominants (top 11 taxa) on the ridge formation were not dominant anywhere else. Conversely, nearly all of the taxa that were dominant at any hard bottom area were present or dominant on the ridge formation.

The shallow (32 to 38 m), low relief hard bottom in Blocks 51 and 52 had the second highest biotic cover (about 15%) and had higher sponge and algal cover than any area except the ridge formation. Two other low to high relief areas in deeper water (Blocks 15/16 and 99/100) had about the same biotic cover (15%), but bryozoans and cnidarians (mainly hydroids, octocorals, and black corals) were the predominant groups. The decreasing importance of algae with increasing water depth is evident in these areas.

On the deepwater, low relief hard bottom, cnidarians (mainly octocorals and black corals) accounted for over one-half of the low biotic cover, and unidentified biota accounted for another 30%. The relatively high percentage of unidentified biota in deep water was partly due to poor water clarity and heavy siltation.

Dredge Samples. Eighteen dredge samples were collected from hard bottom areas in the surveyed Destin Dome Area (Continental Shelf Associates, Inc. 1994a). These samples contained a total of 344 taxa. Of the 18 dredge samples, 8 were collected from shallow, low relief hard bottom; 4 from deep, low relief hard bottom; 3 from an area of thin sand covering hard bottom; and 3 from the high relief ridge formation. **Table 4.5** shows the taxonomic composition of the dredge samples from each substrate type, and **Table 4.6** lists taxa that occurred in at least two-thirds of the dredges from one or more substrate types.

Table 4.3. Mean biotic coverage in hard bottom areas surveyed in the Destin Dome Area (From: Continental Shelf Associates, Inc. 1994b). Values are mean coverage for each area based on 100 randomly selected slides. Shading indicates top groups cumulatively contributing at least two-thirds of the identifiable cover in each area. Columns are presented in order of increasing water depth.

	Coverage (%)				
Taxa	**Blocks 51/52**	**Blocks 55/56/57/99 (Ridge Formation)**	**Blocks 99/100**	**Blocks 15/16**	**Block 57**
Water depth:	*32-38 m*	*52-61 m*	*61-76 m*	*61-79 m*	*76-104 m*
Relief:	*0-2 m*	*1-8 m*	*0-8 m*	*<1 m*	*<1 m*
Algae	1.39	4.10	0.22	0.30	0.02
Sponges	7.93	8.29	0.45	1.64	0.13
Cnidarians	0.34	3.08	4.96	3.15	3.50
Crustaceans	0.00	0.01	0.00	0.03	0.01
Molluscs	0.03	0.00	0.01	0.00	0.01
Annelids	0.03	0.09	0.00	0.00	0.00
Bryozoans	1.89	0.88	4.50	6.12	0.22
Echinoderms	0.07	0.09	0.03	0.03	0.22
Ascidians	0.35	0.12	0.44	0.07	0.06
Fishes	0.00	0.14	0.15	0.00	0.09
Unidentified Biota	3.14	3.47	2.44	3.70	1.86
TOTAL BIOTA	**15.17**	**20.27**	**13.20**	**15.04**	**6.12**

Table 4.4. Dominant hard bottom taxa in the surveyed Destin Dome Area in terms of biotic cover (From: Continental Shelf Associates, Inc. 1994b). Taxa listed were among the top 10 in cover in one or more areas, based on quantitative analysis of 100 randomly selected slides from each area. Legend: (●) = among the top 10 taxa; (o) = present; (-) = absent. Columns are presented in order of increasing water depth.

Taxa	Cover Dominants				
	Blocks 51/52	Blocks 55/56/57/99 (Ridge Formation)	Blocks 99/100	Blocks 15/16	Block 57
Water Depth:	*32-38 m*	*52-61 m*	*61-76 m*	*61-79 m*	*76-104 m*
Relief:	*0-2 m*	*1-8 m*	*0-8 m*	*<1 m*	*<1 m*
ALGAE					
Corallinaceae	●	●	●	o	o
Peyssonnelia inamoena	o	●	o	o	-
Peyssonnelia simulans	-	●	●	●	-
SPONGES					
Aplysina sp.	●	-	-	o	-
Chondrosia sp.	●	●	-	-	-
Cinachyrella alloclada	●	o	-	-	-
Cliona sp.	●	●	o	o	-
Erylus sp.	-	●	-	o	-
Halichondria ?lutea	-	o	o	●	-
?Halichondria sp.	-	●	-	-	o
Ircinia campana	●	o	-	o	-
Placospongia melobesioides	●	o	-	-	-
Pseudaxinella lunaecharta	●	-	-	-	-
Pseudoceratina crassa	o	●	-	-	o
CNIDARIANS					
Antipathes ?atlantica	-	o	●	●	●
Antipathes furcata	-	●	-	o	●
Antipathes ?gracilis	-	o	-	o	●
Antipathes ?lenta	-	o	-	-	●
Antipathes sp.	-	o	●	●	-
Bebryce ?cinerea	-	●	-	-	-
Bebryce ?grandis	-	-	●	●	o
?Bebryce sp.	-	o	●	●	●
?Scleracis sp.	-	o	-	o	●
?Thesea sp.	-	o	●	●	●
BRYOZOANS					
Cellaria irregularis	-	o	●	●	●
?Crisia sp.	●	o	●	●	-
?Stylopoma spongites	-	o	o	●	-
ECHINODERMS					
Stylocidaris affinis	-	-	-	-	●
ASCIDIANS					
Didemnum sp.	●	o	o	o	-
Polycarpa circumarata	-	-	●	-	●

Table 4.5. Taxonomic composition of dredge samples from the surveyed Destin Dome Area (From: Continental Shelf Associates, Inc. 1994a).

Group	Number of Taxa				
	Shallow, Low Relief Hard Bottom	Deep, Low Relief Hard Bottom	Thin Sand over Hard Bottom	Sand Bottom	Ridge Formation
Algae	0	0	0	3	5
Sponges	22	20	9	3	44
Cnidarians	34	16	10	20	17
Molluscs	24	10	9	23	7
Annelids	0	1	0	1	0
Arthropods	19	12	9	19	8
Bryozoans	31	13	5	19	24
Echinoderms	10	8	6	10	5
Ascidians	4	2	1	1	2
Fishes	2	4	2	6	0
TOTAL TAXA	**146**	**86**	**51**	**105**	**112**

Table 4.6. The most frequently collected taxa in dredge samples from the surveyed Destin Dome Area. Only taxa collected in at least two-thirds of the dredges from at least one substrate type are listed. Legend: (●) = present in at least two-thirds of dredges; (o) = present in fewer than two-thirds of dredges; (-) = absent (From: Continental Shelf Associates, Inc. 1994a).

Taxa	Common Name	Substrate Type and Dredge Numbers: Shallow, Low Relief Hard Bottom	Deep, Low Relief Hard Bottom	Thin Sand Over Hard Bottom	Sand Bottom	Ridge Formation
ALGAE						
Mesophyllum mesomorphum	red alga	-	-	-	-	●
Peyssonnelia inamoena	red alga	-	-	-	●	●
Rhodymenia ?divaricata	red alga	-	-	-	o	●
SPONGES						
Auletta sycinularia	sponge	-	-	-	-	●
Bubaris sp.	sponge	-	o	-	-	●
Chondrosia sp.	sponge	-	-	-	-	●
Cinachyrella alloclada	sponge	-	-	-	-	●
Cinachyrella kuekenthali	sponge	-	-	-	-	●
Ciocalapata gibbsi	sponge	-	-	-	-	●
Corallistes sp.	sponge	-	-	-	-	●
Discodermia sp.	sponge	-	-	-	-	●
Erylus sp.	sponge	-	-	-	-	●
Halichondria magniconulosa	sponge	-	●	-	-	o
Ircinia campana	sponge	-	-	-	-	●
Ircinia strobilina	sponge	-	-	-	-	●
Leucetta sp.	sponge	-	-	-	-	●
Myrmekioderma styx	sponge	-	-	-	-	●
Oceanapia fistulosa	sponge	-	-	●	-	-
Phakellia folium	sponge	-	-	-	-	●
Raspailia ?tenuis	sponge	o	-	-	-	●
Raspailia sp.	sponge	-	●	-	-	-
Smenospongia sp.	sponge	-	-	-	-	●
Teichaxinella shoemakeri	sponge	●	-	-	-	-
Teichaxinella sp.	sponge	-	-	-	-	●
CNIDARIANS						
Aglaophenia elongata	hydroid	o	-	-	●	-
Antipathes atlantica	black coral	●	●	-	-	-
Antipathes furcata	black coral	-	●	-	-	-
Antipathes lenta	black coral	o	●	●	o	-
Bebryce cinerea	soft coral	o	-	-	-	●
Bebryce grandis	soft coral	o	●	-	-	-
Diodogorgia nodulifera	soft coral	-	-	-	-	●
Dynamena dalmasi	hydroid	-	-	-	o	●
Gymnangium sinuosum	hydroid	-	-	-	-	●
Lafoea sp.	hydroid	-	-	-	-	●
Leptogorgia stheno	soft coral	-	-	-	●	-
Lytocarpus ?clarkei	hydroid	-	-	-	-	●
Nemertesia simplex	hydroid	o	-	-	●	-
Nidalia occidentalis	soft coral	o	o	●	o	-
Oculina tenella	hard coral	-	-	-	●	●
Paracyathus pulchellus	hard coral	o	●	●	o	●
Placogorgia atlantica	soft coral	-	-	●	-	o
Sertularella gayi	hydroid	●	o	-	o	-
Swiftia casta	soft coral	-	o	-	-	●

Table 4.6. (continued).

Taxa	Common Name	Substrate Type and Dredge Numbers				
		Shallow, Low Relief Hard Bottom	Deep, Low Relief Hard Bottom	Thin Sand Over Hard Bottom	Sand Bottom	Ridge Formation
CNIDARIANS (continued)						
Telesto sanguinea	soft coral	o	-	-	●	-
Thesea parviflora	soft coral	●	o	●	-	-
Thesea sp.	soft coral	-	●	-	-	-
Thyroscyphus marginatus	hydroid	-	-	-	-	●
Villogorgia nigrescens	soft coral	-	●	-	-	-
MOLLUSCS						
Argopecten gibbus	Atlantic calico scallop	o	-	●	o	-
Conus mazei	cone snail	-	-	-	●	-
Distorsio clathrata	Atlantic distorsio	-	-	-	●	-
Fusinus eucosmius	apricot spindle	●	-	-	-	-
Hipponix antiquatus	white hoof snail	-	-	●	-	-
Pecten raveneli	scallop	-	-	o	o	-
Plicatula gibbosa	Atlantic kittenpaw	o	-	-	-	●
Turritella exoleta	eastern turretsnail	o	-	o	●	-
ANNELIDS						
Filograna implexa	polychaete	-	-	-	●	-
ARTHROPODS						
Anoplodactylus lentus	sea spider	-	-	●	o	o
BRYOZOANS						
Bracebridgia subsulcata	bryozoan	-	-	-	●	-
Cellaria irregularis	bryozoan	●	●	o	-	●
Celleporaria albirostris	bryozoan	-	-	-	-	●
Celleporaria magnifica	bryozoan	-	-	-	-	●
Crisia eburnea	bryozoan	o	-	-	●	●
Diaperoecia floridana	bryozoan	-	o	-	●	-
Halophila johnstoniae	bryozoan	o	-	-	-	●
Hippoporidra edax	bryozoan	o	-	●	o	-
Idmidronea atlantica	bryozoan	●	-	-	-	o
Idmidronea flexuosa	bryozoan	o	-	-	-	●
Parasmittina nitida	bryozoan	o	-	-	-	●
Parasmittina spathulata	bryozoan	o	-	-	o	●
Schizoporella cornuta	bryozoan	-	-	-	●	-
Sertella marsupiata	bryozoan	-	-	-	-	●
Steginoporella magnilabris	bryozoan	-	-	-	-	●
Stylopoma spongites	bryozoan	●	o	o	●	o
ECHINODERMS						
Asteroporpa annulata	brittle star	o	●	o	-	o
Luidia clathrata	lined seastar	-	-	-	●	-
Ophioderma holmesii	brittle star	-	-	-	o	-
Ophiothrix angulata	angular brittle star	o	o	-	-	●
Psolus tuberculosus	sea cucumber	o	o	●	-	-
ASCIDIANS						
Didemnum sp.	colonial ascidian	o	o	o	o	●
Polycarpa circumarata	solitary ascidian	o	●	-	-	-
FISHES						
Halieutichthys aculeatus	pancake batfish	o	o	o	●	-
Monacanthus hispidus	planehead filefish	-	o	●	-	-

Dredge samples collected along low relief hard bottom (≤1 m) had a total of 146 taxa. Cnidarians and bryozoans contributed the highest number of taxa, with 34 and 31, respectively. Species occurring in at least six of the eight dredges were the sponge *Teichaxinella shoemakeri*, the black coral *Antipathes atlantica*, the hydroid *Sertularella gayi*, the soft coral *Thesea parviflora*, the gastropod mollusc *Fusinus eucosmius*, and the bryozoans *Cellaria irregularis*, *Idmidronea atlantica*, and *Stylopoma spongites*.

Dredge samples collected from the deepwater hard bottom area had a total of 86 taxa. Sponges and cnidarians were the largest groups, with 20 and 16 taxa, respectively. Taxa occurring in at least three of the four dredges were the sponges *Halichondria magniconulosa* and *Raspailia* sp.; the black corals *Antipathes atlantica*, *A. furcata*, and *A. lenta*; the soft corals *Bebryce grandis*, *Thesea* sp., and *Villogorgia nigrescens*; the ahermatypic hard coral *Paracyathus pulchellus*; the bryozoan *Cellaria irregularis*; the long ringed-arm brittle star *Asteroporpa annulata*; and the solitary ascidian *Polycarpa circumarata*.

Dredge samples collected along the high relief ridge formation had a total of 112 taxa. Sponges were by far the largest group with 44 identified taxa. Bryozoans and cnidarians followed with 24 and 17 taxa, respectively. Species occurring in at least two of the three dredge samples included the red algae *Mesophyllum mesomorphum*, *Peyssonnelia inamoena*, and *Rhodymenia ?divaricata*; 17 species of sponges; several hydroids (*Thyroscyphus marginatus*, *Dynamena dalmasi*, *Gymnangium sinuosum*, *Lafoea* sp., and *Lytocarpus ?clarkei*); the soft corals *Bebryce cinerea*, *Diodogorgia nodulifera*, and *Swiftia casta*; the hard corals *Oculina tenella* and *Paracyathus pulchellus*; the Atlantic kittenpaw bivalve *Plicatula gibbosa*; 10 species of bryozoans; the brittle star *Ophiothrix angulata*; and the colonial ascidian *Didemnum* sp.

The ridge formation had a distinct epibiota that was not very similar to the variable and low relief hard bottom communities. The ridge formation dredges had a large number of taxa (112), of which more than one-half were not present in dredges from other areas (**Table 4.6**). Taxa in common between the high relief live bottom of the ridge formation and the variable and low relief live bottom areas included the sponge *Teichaxinella shoemakeri*, the hard coral *Paracyathus pulchellus*, and the bryozoans *Cellaria irregularis* and *Halophila johnstoniae*.

Quantitative Comparisons: Fishes

Seventy-one fish taxa were observed in video and photographs from the surveyed Destin Dome Area (**Table 4.7**). High relief hard bottom had the largest number of fish taxa (50), followed by sand bottom (43), and low relief hard bottom (30). The largest group (26 taxa) was associated exclusively with hard bottom (low or high relief). Of these, 16 taxa were seen only near high relief hard bottom. These included primary reef fishes such as Spanish hogfish (*Bodianus rufus*), spotfin butterflyfish (*Chaetodon ocellatus*), wrasse bass (*Liopropoma eukrines*), blackbar soldierfish (*Myripristis jacobus*) and scamp (*Mycteroperca phenax*). The remaining nine taxa occurred more frequently, but not exclusively, over high relief hard bottom. Sea basses (Serranidae) contributed the greatest number of species and (probably) individuals on the ridge formation. Small anthiin serranids were most conspicuous and commonly occurred in schools around rock ledges and crevices.

Table 4.7. Percentage occurrence of fishes in video/still camera segments over substrate types surveyed in the Destin Dome Area. Data indicate the percentage of total occurrences of each species that were associated with a particular substrate type (i.e., each row sums to 100%). Numbers in parenthesis on left indicate top 15 taxa in overall frequency of occurrence (From: Continental Shelf Associates, Inc. 1994a).

	Taxa	Common Name	Substrate Type: Sand Bottom	Low Relief Hard Bottom	High Relief Hard Bottom
	Archosargus probatocephalus	sheepshead	100	--	--
	Bellator militaris	horned searobin	100	--	--
	Equetus lanceolatus	jackknife-fish	100	--	--
	Fistularia tabacaria	bluespotted cornetfish	100	--	--
	Halichoeres sp.	wrasses	100	--	--
	Labridae	wrasses	100	--	--
	Otophidium omostigmum	polka-dot cusk-eel	100	--	--
	Raja eglanteria	clearnose skate	100	--	--
	Syacium papillosum	dusky flounder	100	--	--
	Muraenidae	morays	75	--	--
	Lepophidium brevibarbe	blackedge cusk-eel	67	--	--
	Congridae	conger eels	62	--	--
	Diplectrum formosum	sand perch	50	--	--
	Halieutichthys aculeatus	pancake batfish	50	--	--
	Raja sp.	skate	50	--	--
	Prionotus rubio	blackwing searobin	43	--	--
	Prionotus roseus	bluespotted searobin	33	--	--
(15)	*Prionotus* sp.	searobin	87	--	13
	Mullus auratus	red goatfish	80	--	20
	Gymnothorax saxicola	honeycomb moray	75	25	--
	Gymnothorax sp.	moray	67	--	33
	Ogcocephalidae	batfishes	67	--	33
(13)	Bothidae	lefteye flounder	67	25	8
(7)	Ophichthidae	snake eel	72	10	18
(6)	*Synodus* sp.	lizardfish	69	16	15
(11)	*Hemipteronotus novacula*	pearly razorfish	67	23	10
(12)	*Synodus intermedius*	sand diver	64	9	27
(10)	*Monacanthus hispidus*	planehead filefish	43	43	14
	Ophidiidae	cusk-eels	44	33	23
(4)	*Stenotomus caprinus*	longspine porgy	47	27	26
(3)	Sparidae	porgies	41	27	32
(8)	*Pagrus pagrus*	red porgy	38	24	38
	Lutjanidae	snappers	29	28	43
(5)	*Centropristis ocyurus*	bank sea bass	10	54	36
(9)	Scorpaenidae	scorpionfishes	26	31	43
(2)	*Serranus phoebe*	tattler	7	27	66
	Tetraodontidae	puffers	33	--	67
	Pareques iwamotoi	blackbar drum	18	45	37
	Holocentridae	squirrelfishes	25	25	50
	Lactophrys quadricornis	scrawled cowfish	33	--	67
(1)	*Pristigenys alta*	short bigeye	12	39	49
	Lutjanus sp.	snappers	11	33	56
	Anthiinae	streamer basses	10	20	70
	Rypticus sp.	soapfishes	--	100	--
	Apogon pseudomaculatus	twospot cardinalfish	--	40	60
	Chromis enchrysurus	yellowtail reeffish	--	40	60
	Equetus umbrosus	cubbyu	--	40	60
	Apogonidae	cardinalfishes	--	25	75
	Holacanthus bermudensis	blue angelfish	--	25	75
	Holanthias martinicensis	roughtongue bass	--	25	75
	Serranidae	sea basses	--	25	75
	Chaetodon sedentarius	reef butterflyfish	--	17	83
(14)	*Chaetodon aya*	bank butterflyfish	--	14	86
	Aluterus schoepfi	orange filefish	--	--	100
	Apogon sp.	cardinalfishes	--	--	100
	Bodianus rufus	Spanish hogfish	--	--	100
	Chaetodon ocellatus	spotfin butterflyfish	--	--	100
	Chaetodontidae	butterflyfishes	--	--	100
	Epinephelus sp.	groupers	--	--	100
	Gymnothorax moringa	spotted moray	--	--	100
	Halichoeres bathyphilus	greenband wrasse	--	--	100
	Holacanthus sp.	angelfishes	--	--	100
	Liopropoma eukrines	wrasse bass	--	--	100
	Lutjanus campechanus	red snapper	--	--	100
	Mycteroperca phenax	scamp	--	--	100
	Myripristis jacobus	blackbar soldierfish	--	--	100
	Ogcocephalus corniger	longnose batfish	--	--	100
	Opsanus pardus	leopard toadfish	--	--	100
	Sphoeroides sp.	common puffers	--	--	100
	Total Taxa (all substrates) = 69		**43**	**30**	**50**

4.3 Other Inner and Middle Shelf Areas

Four live bottom areas on the western side of De Soto Canyon have been surveyed by Schroeder et al. (1989a,b) (**Fig. 4.1**). Basic site descriptions for these two inner shelf and two middle shelf sites are available, but there are no quantitative biological data.

- The Southeast Bank site consists of a rock rubble field on a moderately sloping bottom of shell hash and silty sand (Schroeder et al. 1989a). Water depth ranges from 21 to 26.5 m (69 to 87 ft), and most of the rocks had a light to moderate epifaunal encrustation, primarily of the soft corals *Leptogorgia virgulata* and *Lophogorgia hebes*. Many of the rocks surfaces were pitted due to *Lithophaga* borings (Schroeder et al. 1989b).

- The area known as "Southwest Rock" is actually composed of two rocks lying in approximately 21 m (70 ft) of water and separated by approximately 10 m (33 ft). The larger rock is 7 to 9 m (23 to 30 ft) across and rises 1 to 1.5 m (3 to 5 ft) above the sea floor. The smaller is approximately 1.5 to 3.5 m (5 to 11 ft) across and rises only slightly from a rock rubble substrate. Epifauna here consisted primarily of barnacles, serpulids, and bryozoa (Schroeder et al. 1989a).

- The Big Rock/Trysler Grounds areas, surveyed by Schroeder et al. (1989a,b) are located in 30 to 35 m (98 to 115 ft) of water. Both features consist of moundlike structures of rock rubble that rise as much as 5 m (16 ft) from the surrounding hammocky sea floor. Epifaunal communities were dominated by serpulids, bryozoans, and solitary hard corals (Schroeder et al. 1989 a,b).

- At the 17 Fathom Hole site in water depths of 30 to 32 m (98 to 105 ft) two features were investigated. The first was a large reef-like structure approximately 100 m (328 ft) long by 35 m (115 ft) wide with a vertical relief of 2 m (6.5 ft). The second was a moundlike feature of rock rubble covering approximately 300 m^2 (3,228 ft^2) and rising 2 m (6.5 ft) from the surrounding sea bottom (Schroeder et al. 1989a, b).

Schroeder et al. (1989b) reported *Leptogorgia virgulata* and *Lophogorgia hebes* as dominating the live bottom community seen on the inner shelf hard bottom areas off Alabama in depths of 35 m (115 ft), while hydroids and bryozoans were less obvious elements of the community.

Several photodocumentation surveys have been conducted on the continental shelf east of De Soto Canyon (**Fig. 4.1**). These live bottom communities tend to be associated with areas of rock outcrops interspersed with hard bottom areas covered by a thin sand layer. Exposed hard bottom may show some vertical relief or may be seen in the shallow depressions (solution features) caused by the aerial weathering of the west Florida limestone shelf during periods of lower sea level (Ballard and Uchupi 1970). Attached epifauna is more prominent on those features showing vertical relief. As an example, data from a survey in Pensacola Block 996 are presented in **Table 4.8**. Biotic cover at two locations within the block was about 13% and 23%, respectively, with bryozoans accounting for about half of the total. Algae and sponges were also significant contributors.

Table 4.8. Cover of biota and substrates in live bottom areas in Pensacola Block 996, east of De Soto Canyon (From: Continental Shelf Associates, Inc. 1988).

Taxa	Mean Biotic Cover (%)	Percent of Total Biota
ALGAE		
Rhodophyta	1.61	
Corallinaceae	0.13	
Peyssonnelia inamoena	0.13	
Gracilaria sp.	0.13	
Codium sp.	0.87	
Peyssonnelia simulans	0.04	
Total Algae	2.91	16.39
PORIFERA		
unidentified Porifera	1.31	
Aplysina sp.	0.04	
Leucetta sp.	0.33	
Ircinia campana	0.03	
Siphonodictyon sp.	0.08	
Axinellidae	0.03	
Placospongia melobesioides	0.04	
Clathriidae	0.15	
Total Porifera	2.01	11.32
CNIDARIA		
Hydroida	0.24	
Gorgonacea	0.02	
Plumulariidae	0.33	
Total Cnidaria	0.59	3.32
POLYCHAETA		
unidentified Polychaeta	0.42	
Total Polychaeta	0.42	2.37
CRUSTACEA		
Petrochirus diogenes	0.02	
Total Crustacea	0.02	0.11
BRYOZOA		
unidentified Bryozoa	5.33	
Crisia sp.	1.46	
Cellaria sp.	1.46	
Parasmittina sp.	0.10	
Amathia convoluta	0.04	
Celleporaria albirostris	0.03	
Stylopoma spongites	0.02	
Steganoporella magnilabris	0.03	
Celleporaria sp.	0.02	
Total Bryozoa	8.49	47.80
ASCIDIACEA		
Didemnum sp.	1.13	
Total Ascidiacea	1.13	6.36
UNIDENTIFIED BIOTA	**2.19**	**12.33**
TOTAL BIOTA	**17.76**	**100.00**
SUBSTRATE TYPE		
Sand	76.85	n/a
Rock	5.39	n/a
TOTAL SUBSTRATE	**82.24**	**n/a**

5.0 ECOLOGICAL RELATIONSHIPS

Environmental influences, community ecology, and zoogeographic affinities of northeastern Gulf of Mexico live bottom communities are discussed.

Little is known about the ecology of northeastern Gulf of Mexico live bottom communities beyond basic descriptive information. Reconnaissance surveys have identified and described major habitat types and representative species. However, little is known of seasonal patterns of distribution and abundance, basic ecological relationships, or factors that determine susceptibility to human activities. The ongoing pinnacle monitoring program is attempting to address this problem by focusing on temporal changes and environmental processes (Continental Shelf Associates, Inc. and Texas A&M University, Geochemical and Environmental Research Group 1998). In the meantime, the influence of environmental factors such as relief, turbidity, and sedimentation have been inferred from distributional patterns (Gittings et al. 1992).

5.1 Environmental Influences

Epibiota such as stony corals and gorgonians grow slowly and are very sensitive to environmental variables such as temperature, water clarity, and sedimentation (Coles 1984; Brown and Howard 1985). These factors are reflected in both the broad-scale and local distribution patterns of live bottom communities.

Broad Scale Patterns

In general, the northern Gulf of Mexico is not suitable for the development of reef-building communities due to temperature range, variable water clarity, and high sedimentation loads. Most of the Mississippi discharge flows to the west, restricting live bottom community development within some 300 km (186 mi) to the west of the delta (Rezak et al. 1985, 1990). The East and West Flower Garden Banks and a few other offshore banks in the northwestern gulf are exceptional. These high relief features are located well away from the Mississippi River and protrude into warm, clear waters, supporting coral communities with tropical affinities (Bright et al. 1984; Rezak et al. 1985).

In contrast, nearshore live bottom communities in the northeastern Gulf of Mexico are subjected to environmental conditions that support warm temperate, "Carolinian Province" communities typical of the eastern seaboard (Briggs 1974; Marine Resources Research Institute 1984; Schroeder et al. 1989b). Inner and middle shelf live bottom communities are particularly sensitive to physical disturbance by storms. In addition to the potential for attached animals to be torn free or buried, severe weather events also stress live bottom communities by increasing sediment loads, which can smother or abrade epibiota.

There is a very sharp contrast between the clear, open gulf waters along the shelf break and the usually highly turbid waters along the inner shelf west of the De Soto Canyon (Barry A. Vittor & Associates, Inc. 1985). Water clarity on this inner shelf is directly related to waves and currents as they interact with the benthic boundary layer, and to the turbidity and sediment input from local rivers (Schroeder 1992). Live bottom habitat is not a conspicuous feature in the turbid water and finer grain sediments of the western inner Mississippi-Alabama shelf.

Communities in deeper water such as those in the pinnacle trend area are probably less susceptible to storm-induced sediment resuspension, but they may still be exposed to intermittent benthic nepheloid layers (Walsh 1998). The water depth and the intermittent turbidity do not favor the development of reef-building corals and indeed, only a few coralline algal crusts typically are seen (Gittings et al. 1992). The coralline algae have not been reported to occur at depths greater than 78 m (255 ft) and are limited to shallower depths closer to the Mississippi River Delta, apparently due to reduced light levels.

Although conditions that could limit live bottom community development (such as turbidity and freshwater intrusion) are much more significant to the west of the delta, eastward transport off the mouth of the Mississippi has been shown to occur frequently (Kelly 1990). Gittings et al. (1992) hypothesized that turbid (and sometimes low salinity) water from the Mississippi River plume inhibits live bottom community development within about 70 km east of the delta. This "Mississippi Threshold" was based on the observation that development within certain specific groups, notably the ahermatypic corals, was poorest in those areas closest to the mouth of the Mississippi, and progressively improved to the east. The extent to which the Mississippi River plume was a limiting factor to conspicuous live bottom organisms varied from species to species. Ellisellid sea whips and encrusting sponges occur closer to the Mississippi River Delta, while stony corals do not appear until approximately 70 km (44 mi) east of the delta (Gittings et al. 1992).

Local Variations

On a local scale, vertical relief and topographic complexity of individual hard bottom features are major factors affecting community development. Several studies have demonstrated higher frequencies of occurrence and higher numbers of species with increasing vertical relief (Shipp and Hopkins 1978; Schroeder et al.1989a,b; Gittings et al. 1992; Continental Shelf Associates, Inc. 1992c, 1994b). While Gittings et al. (1992) pointed out that topographic features do not have to be extensive in area or exceptionally tall to have well developed communities, the highest numbers of species and richest communities were found on those features with the greatest surface area. Community development was more extensive on low relief features that were part of a series or complex of such features than on isolated low relief features of the same size. Variability in community development appeared greatest on low relief features (Gittings et al. 1992). Continental Shelf Associates, Inc. (1994b) reported their lowest percent biotic cover from the deep, low relief, live bottom habitat.

Vertical relief is a strong influence on community structure because suspension feeders are sensitive to sedimentation. The sides and tops of high relief structures are typically dominated by low growing ahermatypic stony corals. On features with extensive flat summits, those summits are dominated by taller gorgonians, erect sponges, and comatulid crinoids. Low growing stony corals appear to be limited in these flat areas due to the accumulation of sediments (Gittings et al. 1992; Continental Shelf Associates, Inc. 1992c). Low relief live bottom habitats such as those observed near the head of the De Soto Canyon have limited populations of stony corals and generally are dominated by taller gorgonians and antipatharians (Continental Shelf Associates, Inc. 1994a).

The reduced biotic coverage reported by both Brooks and Giammona (1990) and Continental Shelf Associates, Inc. (1992c) around the base of pinnacles, along with the increased biotic coverage seen on elevated horizontal surfaces, suggest that sediment resuspension may be a critical factor in influencing outer shelf and upper slope live bottom community structure in the northeastern Gulf of Mexico.

Topographically influenced currents may also be a significant factor in community development. The exposure of various vertical and horizontal surfaces to currents and resuspended sediments can be expected to vary greatly and is undoubtedly reflected in the distribution and abundance patterns of epibiota. MacDonald et al. (1996) have recently precisely measured the distribution and orientation of almost 1,000 gorgonians in an area of about one square kilometer and obtained a set of physical measurements to validate and complement the biological observations. The results demonstrated the influence of circulation patterns at a community level and considered the role of fine-scale topographic features in determining this effect. The ongoing pinnacle monitoring program includes development of local flow exposure models for hard bottom features (MacDonald 1998).

5.2 Community Ecology

Little is known about the community ecology of live bottom areas in the northeastern Gulf of Mexico other than what can be inferred from the roles of similar organisms in reef communities.

Trophic relationships in northeastern Gulf of Mexico hard bottom areas have not been studied extensively. Most of the visually conspicuous epifauna associated with the pinnacles are suspension feeders, including stony corals, gorgonians, antipatharians, sponges, and crinoids. Predation, which plays a major role in Caribbean gorgonian community structure (Vreeland and Lasker 1989), does not appear to be a major factor affecting live bottom gorgonians in the northeastern gulf (Mitchell et al. 1992). Instead, many hard bottom fishes may feed on plankton, or on soft bottom benthos in adjacent sandy areas. For example, preliminary observations from the pinnacle monitoring program indicate that streamer basses are the most frequently occurring fishes around the pinnacles (Snyder 1998). These species feed upon plankton exported from waters surrounding the pinnacles and are commonly observed hovering above the substrate picking plankton from the water column. Streamer basses provide forage for a number of piscivorous species (e.g., amberjacks, groupers, sharks, and mackerels). Food habits of hard bottom fishes have been studied extensively in the South Atlantic Bight (Grimes 1979; Grimes et al. 1982; Manooch 1977; Sedberry 1983; 1985; 1993), and a literature review of possible trophic relationships is being conducted as part of the pinnacle monitoring program (Snyder 1998).

5.3 Zoogeographic Affinities

Based on depth, development, and faunal characteristics, live bottom communities of the northeastern Gulf of Mexico resemble those of the northwestern gulf, but there are notable differences (Gittings et al. 1992). Species not encountered in the northeastern Gulf of Mexico that are conspicuous in the northwestern gulf include the actiniarians *Condylactis gigantea* and *Lebrunia danae*, the scleractinians *Leptoseris cucullata* and *Montastraea cavernosa*, and to a large extent the hydroid *Millepora* sp. In the northeastern gulf, the ahermatypic stony coral *Rhizopsammia manuelensis* and the alcyonarian *Siphonogorgia agassizii* are conspicuous, while these species do not appear in the western gulf.

Offshore live bottom communities in the northern Gulf of Mexico have some tropical affinities but are much less diverse than their counterparts in the southern Gulf of Mexico and Caribbean (Gittings et al. 1992). Studies by Continental Shelf Associates, Inc. (1987a) on hard bottom areas off the southwest coast of Florida described live bottom communities similar in many respects to those seen along the northeastern gulf. However, southwest Florida shelf live bottom communities have more tropical affinities, extensive growths of fleshy algae, and even some reef-building activity in the form of crusts and pavements formed by algal nodules and the deepwater hermatypic coral *Agaricia*. These community differences are attributed to greater light penetration in the clearer, warmer waters off southwestern Florida (Gittings et al. 1992).

6.0 MANAGEMENT AND RESEARCH NEEDS

Anthropogenic stresses in northeastern Gulf of Mexico live bottom communities are discussed, existing regulatory procedures are described, and research needs are evaluated.

6.1 Existing Human Impacts

Direct impacts from human activities on live bottom communities of the northeastern Gulf of Mexico appear to be minimal at this time. Despite chemical pollution in certain neighboring bays and estuaries, the offshore waters and sediments of the northeastern Gulf of Mexico show no real evidence of this pollution in terms of trace metals or high molecular weight hydrocarbons (Kennicutt et al. 1995; Kennicutt 1998).

The most observable human impact in these communities is the accumulation of debris. This debris seems to be limited to individual items such as plastic cups, aluminum cans, cables or rope, and monofilament fishing lines. In shallow water, cables and lines can become entangled in reef communities and damage organisms while being dragged about by wave action. In deep water, cables and lines probably have less effect once they have become lodged against the reef structure. Although debris is not necessarily abundant at any specific site, it seems to be a common feature (Shipp and Hopkins 1978; Brooks and Giammona 1990; Continental Shelf Associates, Inc. 1992c). Considering the limited amount of survey work and the remoteness of these habitats relative to large human populations, the ubiquitous presence of human debris accumulation is worrisome from the perspective of long term environmental quality.

Fishing pressure in these live bottom areas may be reducing the population of larger, commercially or recreationally valuable fish species normally associated with these habitats. Both the MAMES and MASPTHMS studies commented on the relative paucity of larger commercially valuable fish (Brooks and Giammona 1990; Continental Shelf Associates, Inc. 1992c). Fishing pressure is, however, difficult to quantify. The commercial and recreational fisheries in the northeastern Gulf of Mexico share a common resource. Recent studies in the Florida Panhandle have shown that while the number of registered commercial fishing vessels in the eight counties surveyed has remained essentially constant since 1983, the number of recreational vessels has risen from 45,000 to 55,000 (Continental Shelf Associates, Inc. 1996).

While there has been a certain amount of oil and gas exploration in the northeastern Gulf of Mexico, these activities have had little identifiable impact on live bottom communities. In part this is due to lease stipulations which regulate drilling activities near live bottom features (see below, Resource Management). Shinn et al. (1993) surveyed six offshore oil exploratory drilling sites in the northeastern Gulf of Mexico. One of these sites was drilled in 1990 in a region of rocky pinnacles, and the wellsite was about 1 m (3 ft) south of a 4 to 5 m (13 to 16 ft) pinnacle. Debris such as hose, wire, cuttings, and welding rods was found on and adjacent to the pinnacle near the wellhead. Although Shinn et al.

(1993) were unable to fully evaluate the impact of drilling on bottom fauna at this site, the gorgonians, antipatharians, crinoids, and non-reef-building corals attached to the pinnacle and nearby hard bottom visually did not appear to have been affected.

6.2 Resource Management

Several governmental agencies have regulations or research programs that relate to human activities on and near live bottom areas in the northeastern Gulf of Mexico.

Minerals Management Service

The Minerals Management Service (MMS) of the Department of the Interior (USDOI) is the agency with jurisdiction over mineral and petroleum resources in federal waters over the continental shelf. Factors associated with oil and gas exploration and production that may impact live bottom communities include (1) mechanical damage due to anchoring and platform installation, and (2) discharges of drilling mud and cuttings. Both activities are regulated by the MMS, and drilling discharges are also regulated by the USEPA (see below).

The live bottom habitats discussed in this community profile are found in both the Central and Eastern Gulf of Mexico OCS planning areas (**Fig. 6.1**). Slightly different regulations are applied in these two planning areas. Within the Central Planning Area some 70 oil and gas lease blocks have been classified as being within the "pinnacle trend" area, and a special "Live Bottom (Pinnacle Trend) Stipulation" is assigned to leases in those blocks (USDOI, MMS 1997). This stipulation requires a lessee to submit a bathymetric map of the lease block showing the location of any live bottom present based on remote sensing techniques relative to any proposed activities prior to those activities being permitted. If it is determined that live bottom areas may be adversely impacted, the MMS may require the lessee to undertake any measure deemed economically, environmentally, and technically feasible to protect the live bottom area. These actions may include but are not limited to (1) relocation of operations; or (2) monitoring to assess the impact of the activity on the live bottom community.

If correctly implemented, the Live Bottom (Pinnacle Trend) Stipulation should provide a level of protection to these live bottom communities. However, Shinn et al. (1993) reported that a well drilled in 1990 was 1 m (3 ft) from a pinnacle that was 4 to 5 m (13 to 16 ft) in relief. They also documented the presence of two trenches, 2 to 3 m (7 to 10 ft) wide and up to 1 m (3 ft) deep, cut into a carbonate crust extending from the wellhead template to the northwest for an unknown distance. The trenches were thought to be the result of the legs of the jack-up drilling rig being dragged across the bottom when the rig was originally positioned at the site. Drill cuttings accumulations and high concentrations of barium were noted around the wellsite (Shinn et al. 1993). It is not clear why the lease stipulation did not work in this case.

A more stringent lease stipulation applies in the Eastern Planning area, which essentially encompasses the west Florida continental shelf. Drilling activity in the Eastern Planning Area has been quite limited. All blocks within this planning area in 100 m (328 ft) of water or less have lease stipulations that require that remote sensing data be interpreted for the possible presence of live bottom and that photodocumentation surveys of the

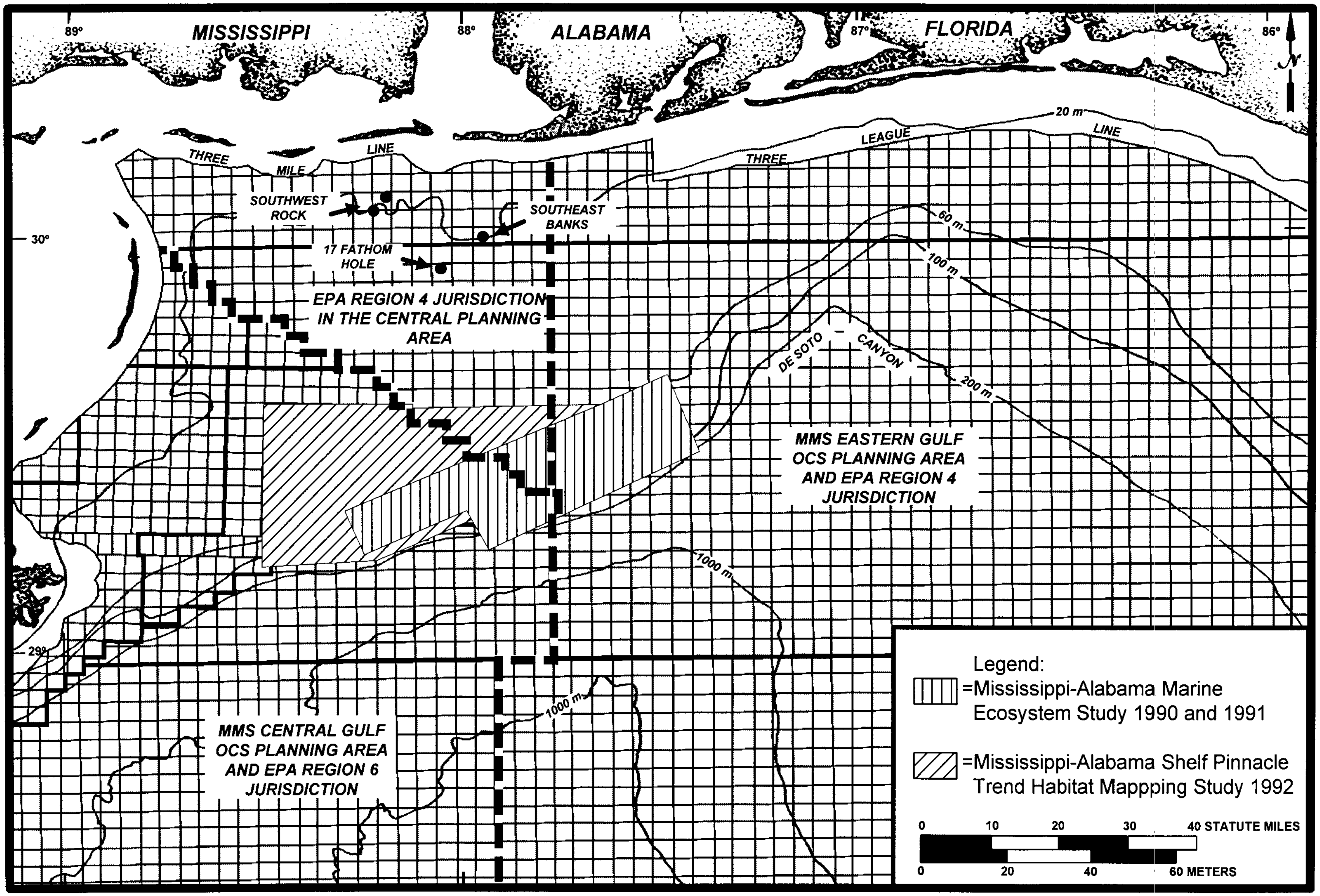

Figure 6.1. EPA Region 4 jurisdiction in the Central Planning Area.

seafloor be conducted within 1,000 m (3,281 ft) of drilling activities. As in the Central Planning Area, the MMS may require the operator to undertake any economically, environmentally, and technically feasible measure to protect identified live bottom areas. However, the photodocumentation surveys and associated reporting requirements make it very unlikely that hard bottom features near a drillsite could be missed.

U.S. Environmental Protection Agency

The U.S. Environmental Protection Agency (USEPA) regulates discharges to marine waters through the National Pollutant Discharge Elimination System (NPDES) permitting process. There are two USEPA regions with jurisdiction in the northeastern Gulf of Mexico (**Fig. 6.1**), and their regulatory approaches differ somewhat. Region 4 has jurisdiction in the Eastern Gulf of Mexico Planning Area and part of the Central Gulf of Mexico Planning Area, which includes the eastern half of the pinnacle trend region. Region 6 has jurisdiction in the remainder of the Central Planning Area, including the western half of the pinnacle trend region.

The main concern in relation to live bottom areas is the discharge of drilling muds and cuttings. Cuttings are rock fragments that are displaced as the drill bit moves through geological formations. Drilling muds are specially formulated fluids that cool, lubricate, and partially support the drill bit; seal and control pressure in the well; and transport drill cuttings to the surface. Drilling muds are composed mainly of water, barite, and clay minerals and contain numerous special purpose additives (National Research Council 1983). Onboard the drilling rig, solids control equipment removes most of the cuttings, which are discharged more or less continuously to the ocean. Small amounts of muds are discharged with the cuttings, and larger mud discharges occur when the mud system is changed or upon completion of a well.

Both USEPA Regions 4 and 6 regulate most drilling mud and cuttings discharges under NPDES general permits. The general permit for Region 6 includes rate restrictions on drilling discharges within 544 m (1,785 ft) of "areas of biological concern," including live bottom areas. The discharge restrictions are based on dispersion modeling and are intended to minimize the possibility of depositing significant amounts of drilling muds and cuttings on such areas. Areas of biological concern are those identified on MMS leasing maps; no additional photodocumentation surveys are required by USEPA Region 6.

USEPA Region 4 requirements are more stringent, as summarized in the new NPDES general permit (USEPA 1998). Proposed discharges within 1,000 m (3,280 ft) of areas of biological concern are specifically excluded from the general permit and require an individual permit. The purpose is to provide more stringent review and to allow USEPA to determine the appropriate conditions and monitoring for each site. Within the Central Planning Area, 11 lease blocks within the pinnacle trend with previously identified hard bottom (Brooks and Giammona 1990; Continental Shelf Associates, Inc. 1992c), as well as three inner shelf hard bottom areas studied by Schroeder et al. (1989b), are specifically identified as areas of biological concern. In addition, photodocumentation surveys are required for every proposed facility at water depths of 100 m (328 ft) or less in the Region 4 portion of the Central Planning Area. As noted previously, a photodocumentation survey is already required by the MMS for lease blocks in a water depth of 100 m (328 ft) or less in the Eastern Planning Area. In the Eastern Planning

Area, EPA has required photodocumentation surveys in a water depth of 200 m (656 ft) rather than the 100 m (328 ft) required by MMS. Region 4's photodocumentation survey requirements and individual permitting process for areas of biological concern are likely to provide a higher level of protection for live bottom areas under its jurisdiction.

National Marine Fisheries Service

The National Marine Fisheries Service (NMFS), through the enactment of the Fisheries Management Act of 1976, is responsible for the management of fisheries seaward of all state waters. This jurisdiction includes both fisheries stocks and habitats. The NMFS has an ongoing program of mapping hard bottom habitats on the continental shelf of the Gulf of Mexico and interacts with the MMS in terms of preserving these habitats.

U.S. Geological Survey, Biological Resources Division

The Biological Resources Division (BRD) of the U.S. Geological Survey (USGS) has assumed the role once played by the U.S. Fish and Wildlife Service in interacting with the MMS with regards to offshore resource development. It has funded and/or managed several studies to evaluate marine ecosystems in the northeastern Gulf of Mexico, such as the Northeastern Gulf of Mexico Coastal and Marine Ecosystem Program: Data Search and Synthesis (Science Applications International Corporation 1997), the Northeastern Gulf of Mexico Coastal and Marine Ecosystem Program: Ecosystem Monitoring, Mississippi/Alabama Shelf (Continental Shelf Associates, Inc. and Texas A&M University, Geochemical and Environmental Research Group 1998), and this study.

6.3 Management-Oriented Research Needs

Based on the present state of knowledge, the existing protective measures for live bottom communities in the northeastern Gulf of Mexico appear to be adequate in terms of protecting these habitats. At present, the USGS BRD is funding research to describe and monitor biological communities and environmental conditions at high, medium, and low relief hard bottom features along the Mississippi-Alabama shelf. The objective of this research program is "to describe and monitor seasonal and interannual changes in community structure and zonation and relate these to changes in environmental conditions (i.e., dissolved oxygen, turbidity, temperature, salinity, etc.)." The data collected during this study may allow the MMS to fine tune their lease stipulation to provide additional protection for these live bottom communities.

Middle and inner shelf live bottom communities in the area remain relatively unstudied. These communities may have a wide tolerance of fluctuating environmental conditions such as temperature and turbidity (Peckol and Searles 1984). While they are not as striking as the pinnacles, some level of research effort needs to be directed toward determining how these communities interact with the soft bottom shelf areas surrounding them as well as with the more extensive live bottom areas seen farther offshore.

Questions remain as to whether or not live bottom habitats are being overfished in the northeastern gulf. Most commercial fishermen are of the opinion that the advent of advanced navigation systems (Loran C and now Global Positioning Systems) have allowed an ever increasing number of fishermen (sports and commercial) to identify and return to the same live bottom areas again and again. This has increased the fishing pressure on these habitats and may have led to the decreased number of larger commercial and sports fish observed there. Detailed analysis of catch per unit effort for certain key reef species may help in evaluating the question of overfishing.

Northeastern Gulf of Mexico live bottom habitats are isolated from one another and are individually limited in areal extent. Some research should be directed toward ascertaining a maximum sustainable yield for commercially and recreationally valuable fish species from various sized northeastern Gulf of Mexico live bottom habitats. Questions concerning recruitment and growth rates for individual fish species also need to be addressed if the live bottom resource is to be effectively managed for the benefit of all potential users.

Debris accumulation in and around live bottom features needs to be reviewed in some quantitative manner. Discarded ropes and lines tend to drift across the seafloor until they become entangled in some object. Once tangled in a reef, they become a permanent part of the feature. Rates of accumulation of these as well as other types of human debris around live bottom habitats should be studied. The fate and effects of anthropogenic debris collecting around live bottom habitats are not understood at this time.

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APPENDIX A

EXAMPLE LIVE BOTTOM COMMUNITIES FROM THE NORTHEASTERN GULF OF MEXICO

Pinnacle Trend Communities

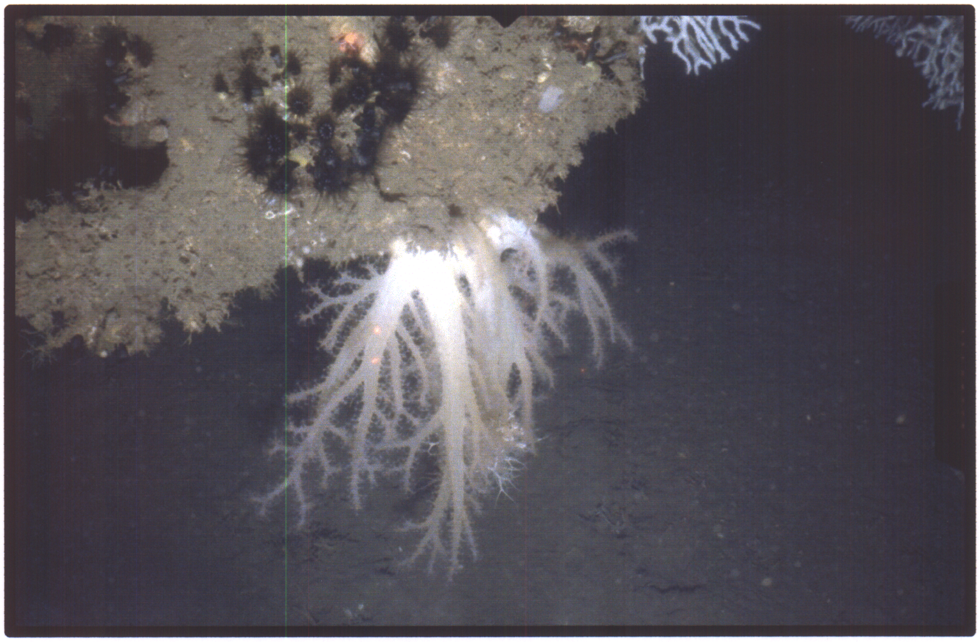

Image 1 - An alcyonarian soft coral (*Siphonogorgia agassizii*), clusters of black hard coral (*Rhizopsammia manuelensis*), and colonies of the striate finger coral *Madracis myriaster* are attached to a overhanging rock ledge rock. A basket star (Gorgonocephalidae) is partially hidden behind the alcyonarian soft coral.

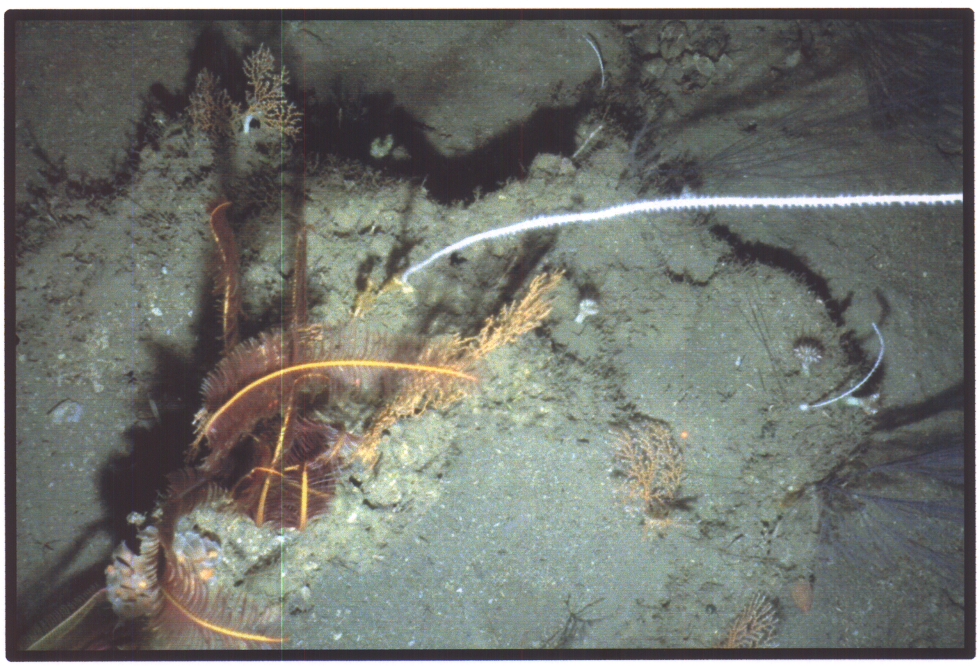

Image 2 - Small outcrop at the base of a large rock formation provides habitat for 10-arm feather stars (Crinoidea), orange sea fans (*Nicella* sp.), white sea whips (*Ellisella* spp.), "horse tail" black corals (*Antipathes ?furcata*), and large solitary hard corals (*?Javania cailleti*) with extended tentacles. The gelatinous egg of an unidentified mollusk is attached to the rock substrate in the left foreground partially hidden below the arm of the feather stars.

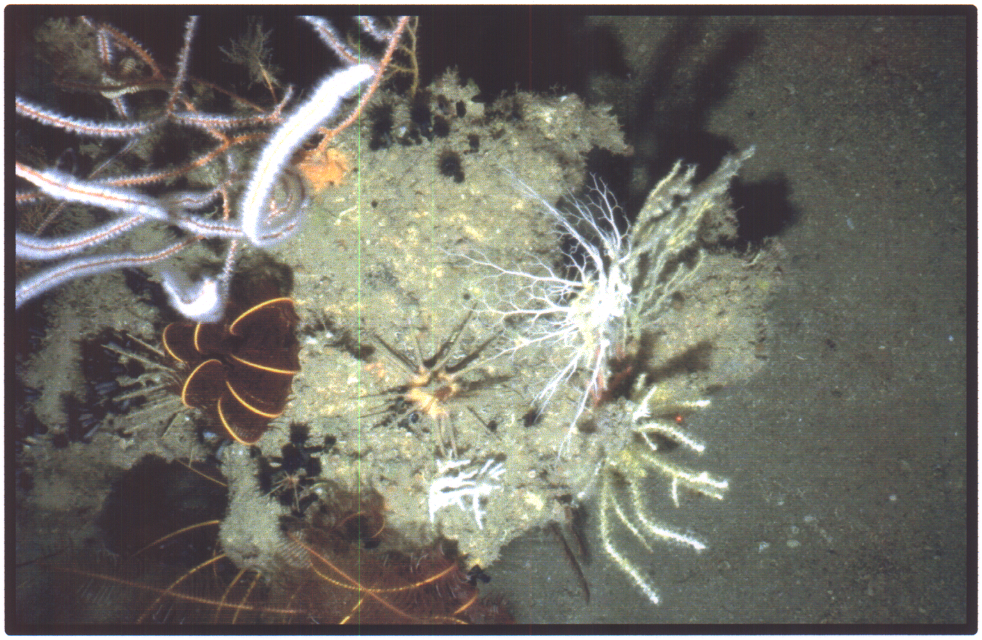

Image 3 - Large branching red sea whip (*Ellisella* sp.) with white polyps, 10-arm feather stars (Crinoidea), branching soft corals (Stenogorgiinae), slender-spined urchins (*Stylocidaris affinis*), a feeding basket star (?*Astrocyclus caecilia)*, clusters of black hard coral (*Rhizopsammia manuelensis*), and a colony of white striate finger coral (*Madracis myriaster*) (center foreground) inhabit the peak of the high-relief rock formation.

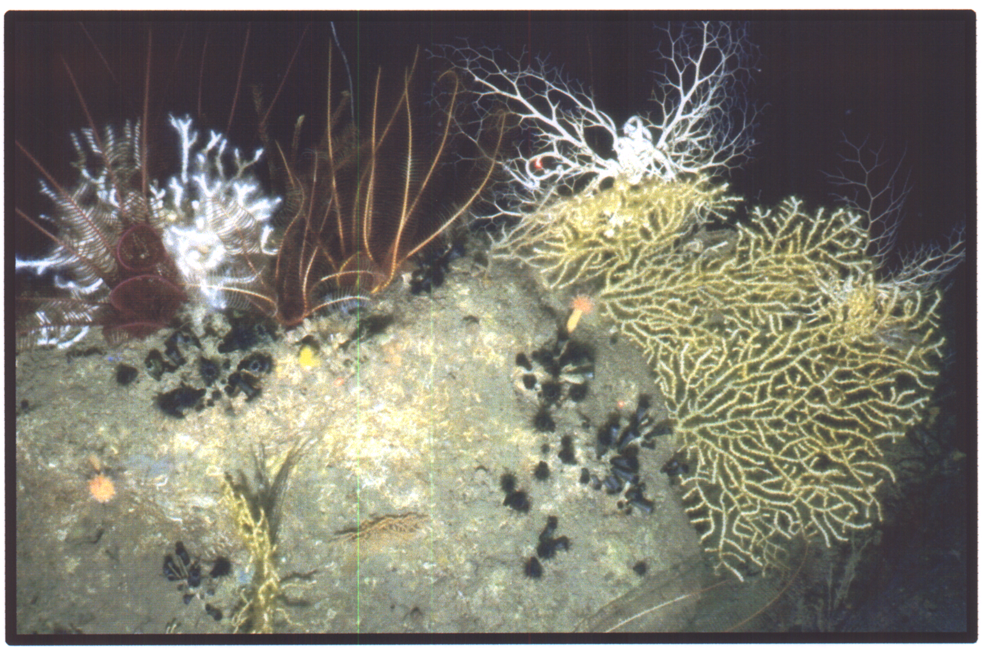

Image 4 - The peak of the rock pinnacle provides substrate for the attachment of sea fans (?*Scleracis* sp., yellow and *Nicella* sp., orange), numerous feather stars (Crinoidea), a large colony of white striate finger coral (*Madracis myriaster*), solitary hard corals including clusters of black hard coral (*Rhizopsammia manuelensis*), orange "club shaped" colonies of the alcyonarian soft coral *Nidalia occidentalis*, an unidentified yellow sponge, and basket stars (?*Astrocyclus ceacilia)* attached to the large sea fan.

Nearshore Hard Bottom Communities

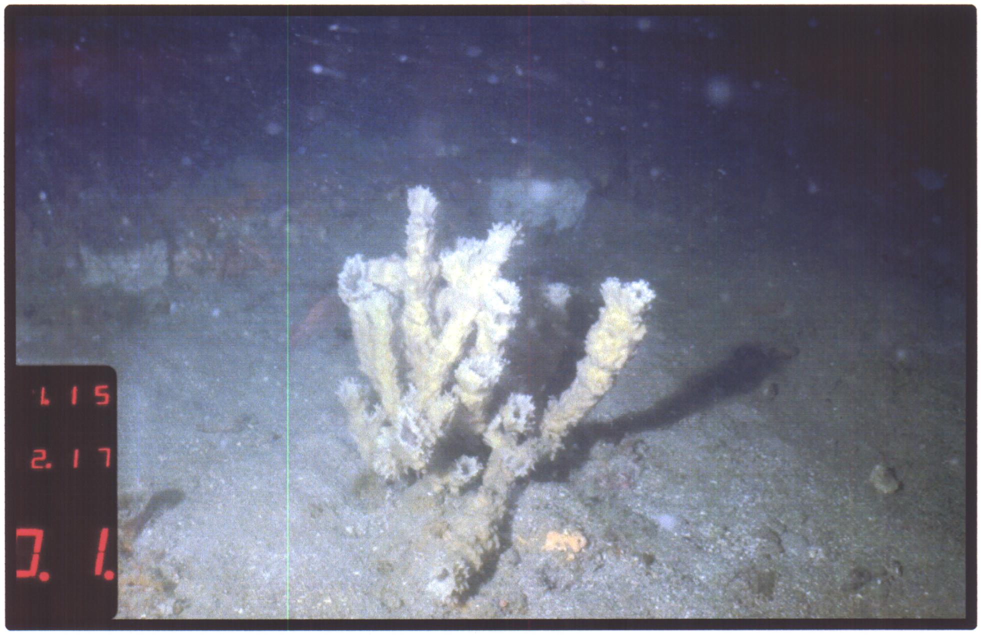

Image 5 - Concrescent tubes of the pale-green sponge *Callyspongia* (*Spinosella*) *vaginalis* attached to hard substrate with a coarse sand veneer. Other attached epibiota are visible in the background.

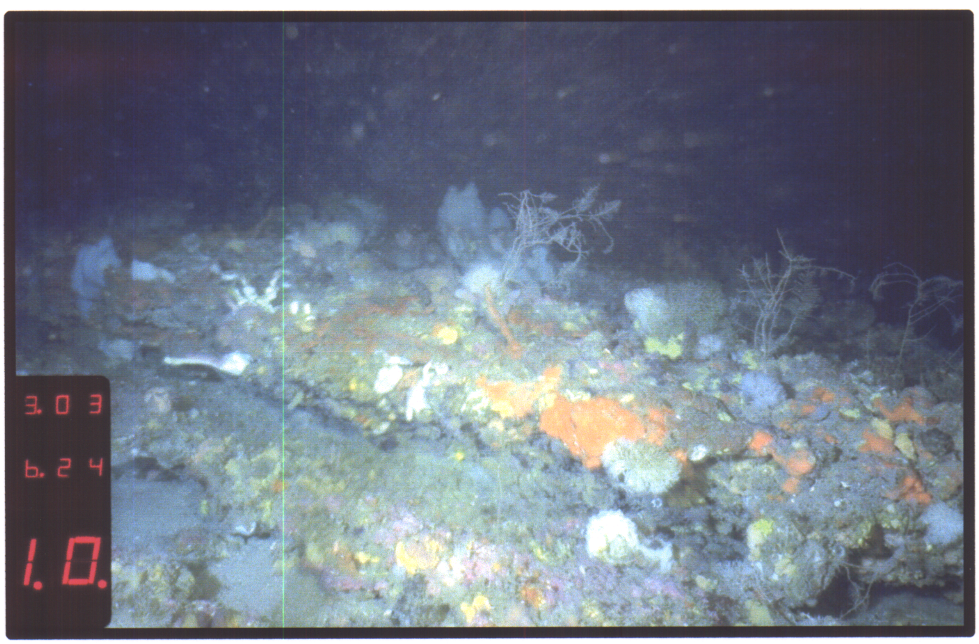

Image 6 - Heavy coverage of attached epibiota on a tiered rock formation. Visually dominant epibiota include various sponges, soft corals, bryozoa, and coralline algae. The slightly murky water conditions present in the photograph are commonly observed in the relatively shallow nearshore environment.

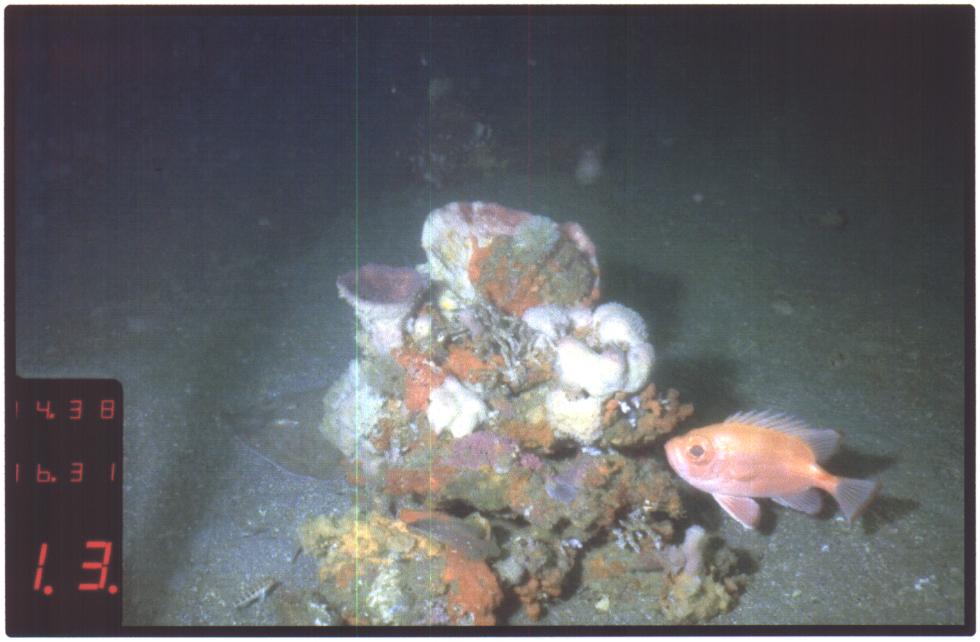

Image 7 - A short bigeye (*Pristigenys alta*) hovers closely by a small rock outcrop that is densely covered predominantly by sponges. The head of a clear-nosed skate (*Raja eglanteria*) is visible behind and to the left of the outcrop.

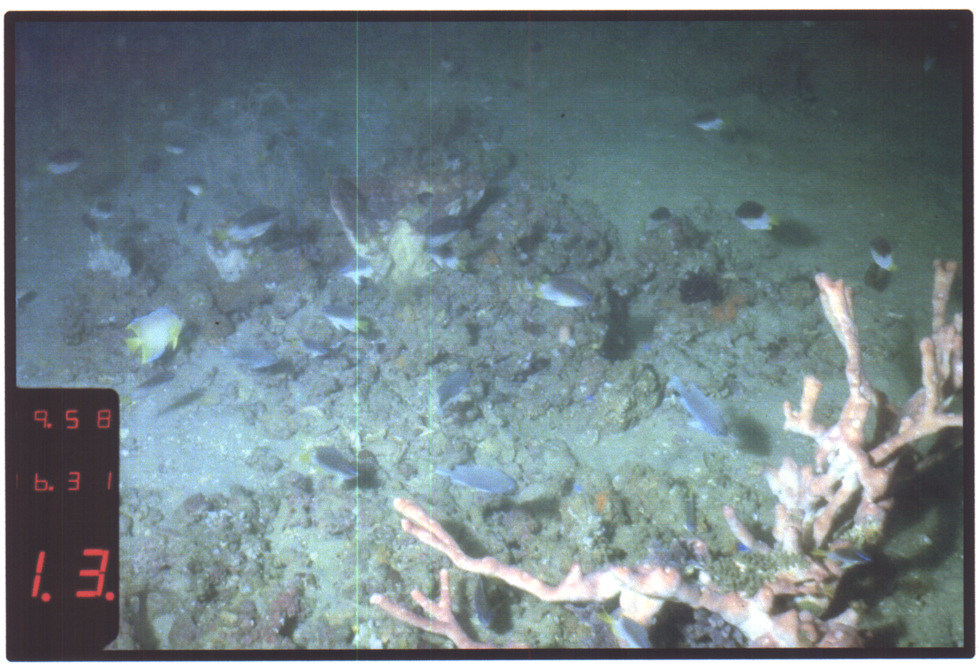

Image 8 - Low-relief hard substrate and attached branching sponge (*Aplysina fistularis*) (foreground) and the vase sponge *Ircina campana* (middle background) provide habitat for schooling yellowtail reeffish (*Chromis enchrysurus*) and an angelfish (*Holacanthus* sp., left).

Outershelf High Relief Communities

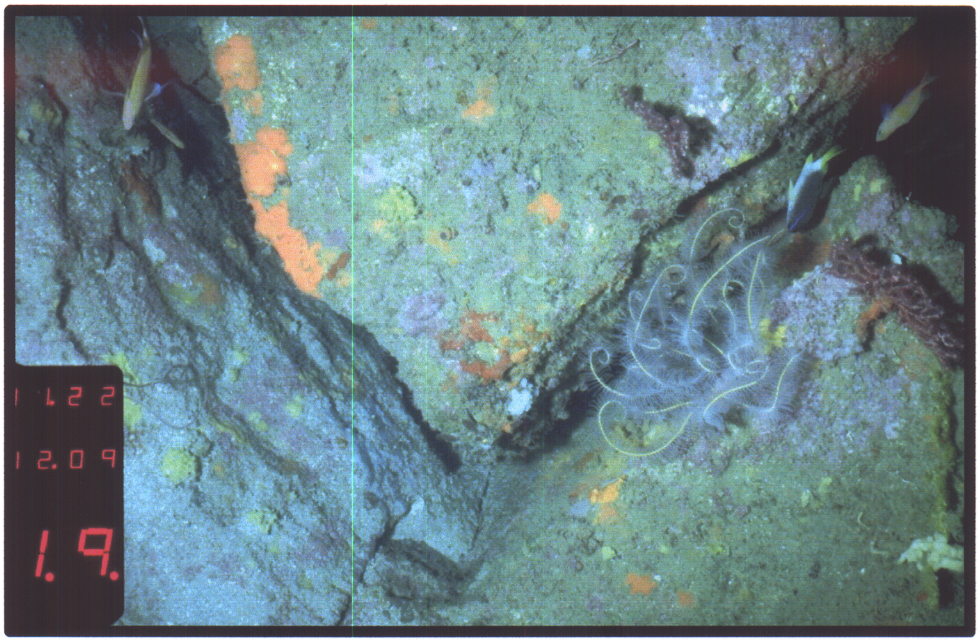

Image 9 - Large "block-like" boulders at edge of ridge slope provide substrate for 20-arm feather star (Crinoidea), soft corals (*Thesea* sp., purple and *Bebryce* sp., yellow), various sponges including *Auletta sycinularia* (bottom right), calcareous red algae, and encrusting bryozoa. Yellowtail reeffish (*Chromis enchrysurus*), roughtongue bass (*Holanthias martinicensis*) and an unidentified streamer bass are seen along the rock crevices.

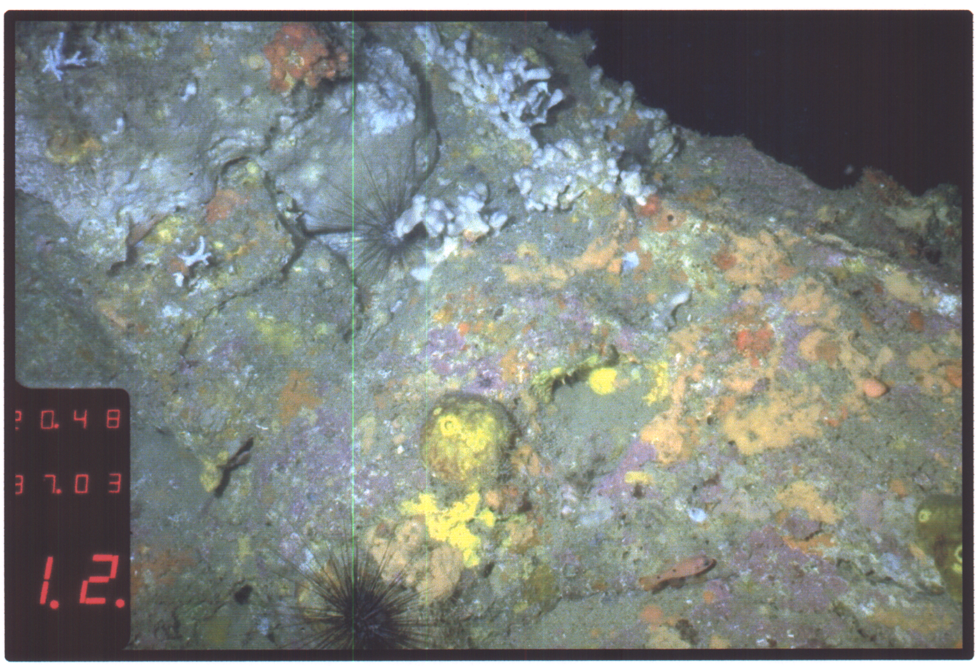

Image 10 - Ridge face with relatively heavy coverage of epibiota that includes various sponges (*Erylus* sp., *Ulosa* sp., and unidentified species), calcareous red algae, small colonies of ivory bush coral (*Oculina* sp.) upper left, encrusting bryozoa, and a pair of long-spined urchins (*Diadema antillarum*). A twospot cardinalfish (*Apogon pseudomaculatus*) is visible in the foreground.

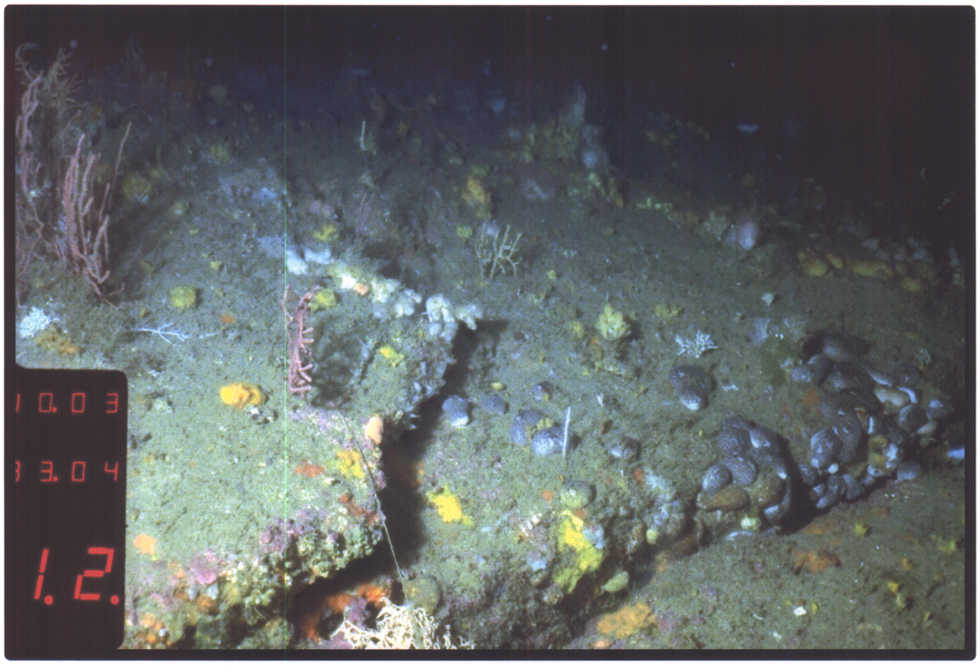

Image 11 - Ridge "plateau" provides substrate for soft corals (*Thesea* sp., purple and other Stenogorgiinae), various sponges including ?*Chondrosia* sp. (blue/grey lobes), bryozoans, and the basket star ?*Astrocyclus caecilia* (foreground). A snagged fishing line draped over the tiered rock ledges is visible in the foreground.

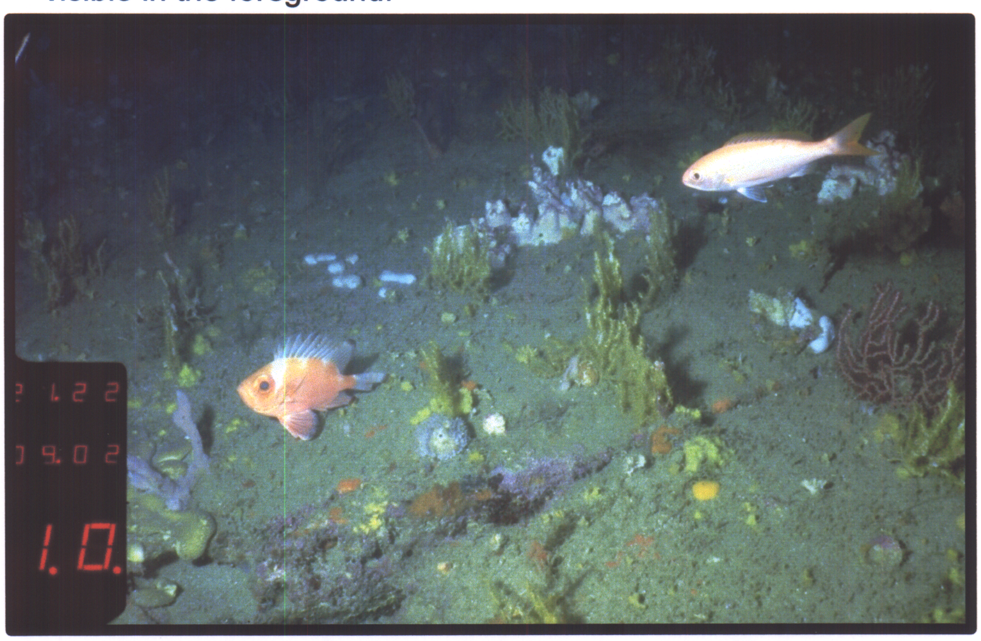

Image 12 - Ridge "plateau" visually dominated by soft corals (*Thesea* sp., purple, *Bebryce* spp., yellow, and possibly other Stenogorgiinae), various sponges, and calcareous red algae. Both vermilion snapper (*Rhomboplites aurorubens*) and short bigeye (*Pristigenys alta*), present in the photograph, commonly were observed along the ridge feature.

Outershelf Variable Relief Communities

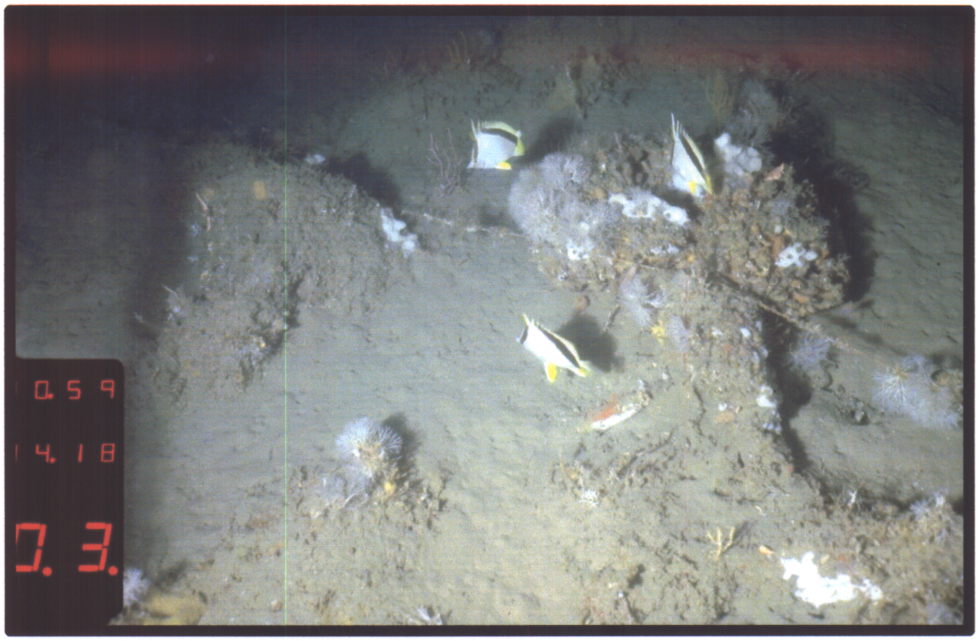

Image 13 - Low-relief hard bottom provides habitat for white tufted bryozoans (*Cellaria* sp.), white encrusting colonial ascidians (Didemnidae, right foreground), branching soft corals (Stenogorgiinae), sponges, and bank butterflyfish (*Chaetodon aya*). A fouled line stretches between the rock outcrops.

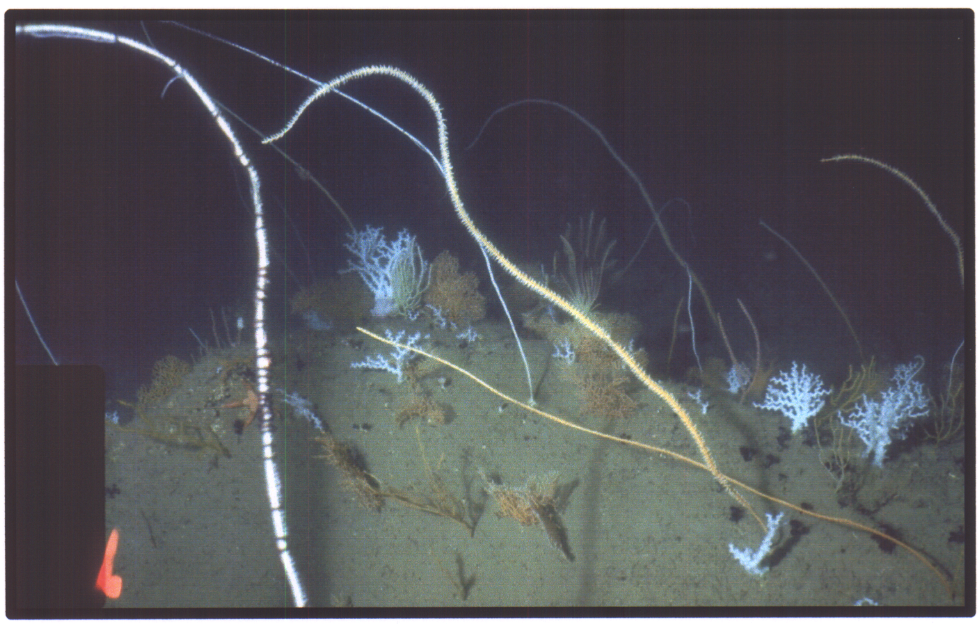

Image 14 - Rock ledge colonized by numerous sea whips (*Ellisella* spp.), orange sea fans (*Nicella* sp.), branching soft corals (Stenogorgiinae), white branching hard coral (*Madrepora carolina*), 20-arm feather stars (Crinoidea), and solitary hard corals (including *Rhizopsammia manuelensis*, black). The tightly wrapped arms and disc of the brittle star *Asteroschema* sp. form the dark bands around the sea whip in the left foreground. A sea star (Ophioasteridae) is on the ledge behind this sea whip.

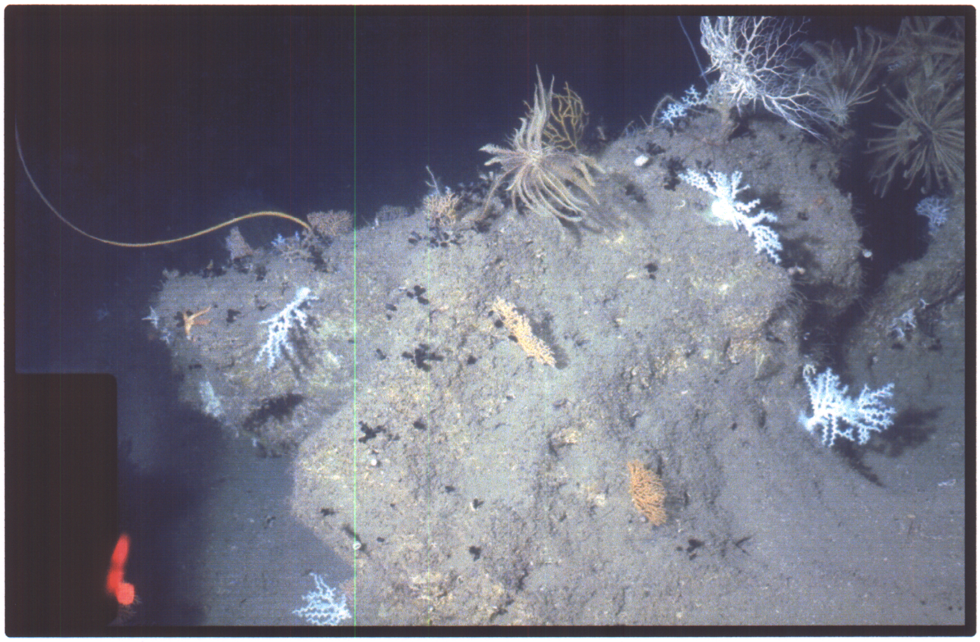

Image 15 - A rock prominence provides habitat for white branching hard coral (*Madrepora carolina*), orange sea fans (*Nicella* sp.), 20-arm feather stars (Crinoidea), solitary hard corals (including *Rhizopsammia manuelensis* - black), branching soft corals (Stenogorgiinae), sea whips (*Ellisella* spp.), and the basket star ?*Astrocyclus caecilia*. Other less noticeable biota include a sea star (Ophioasteridae) on the far left tip of the prominence.

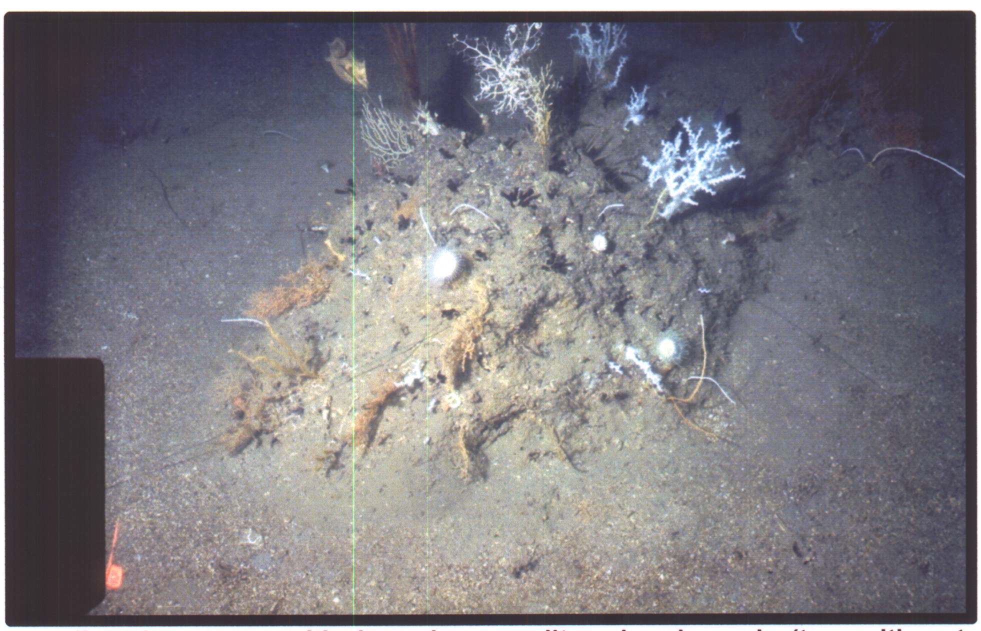

Image 16 - A small rock outcrop with three large solitary hard corals (two with extended tentacles), white branching hard coral (*Madrepora carolina*), orange sea fans (*Nicella* sp.), sea whips (*Ellisella* spp.), and branching soft corals (Stenogorgiinae). Other biota include a feeding basket star (?*Astrocyclus caecilia)* with extended arms and an Atlantic wing oyster (*Pteria colymbus*) attached to a branching soft coral at the upper left of the outcrop.

Outershelf Low Relief Communities

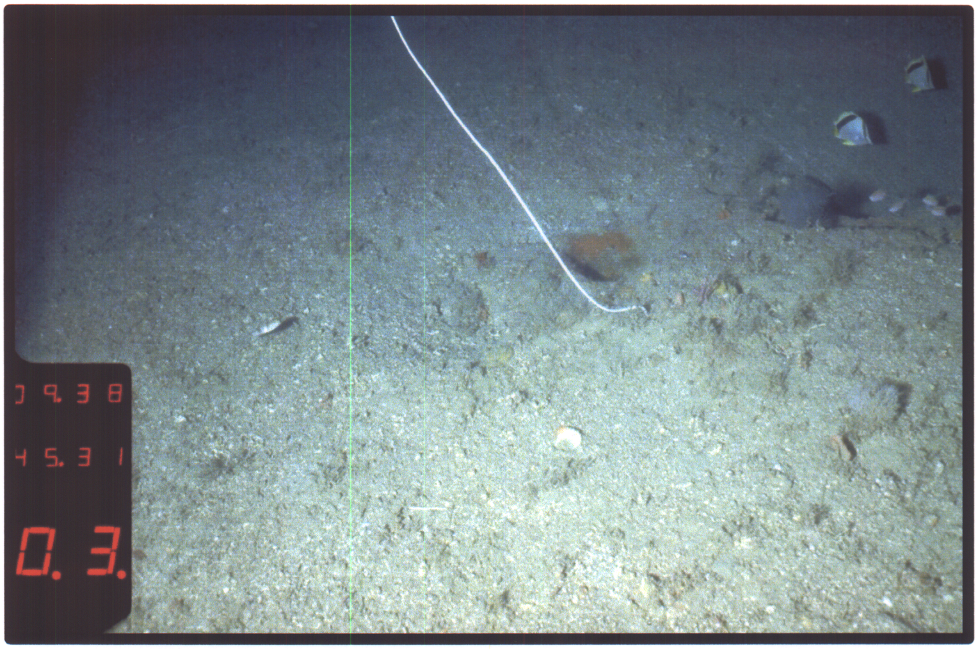

Image 17 - Low-relief hard bottom with coarse sand veneer provides substrate for the non-branching soft coral *Ellisella* sp. (white), the small bushy black coral *Antipathes* sp. (back right), various sponges, and a tufted bryozoan (far right). A pair of bank butterflyfish (*Chaetodon aya*) and other unidentified fishes congregate above a depression in the rock substrate.

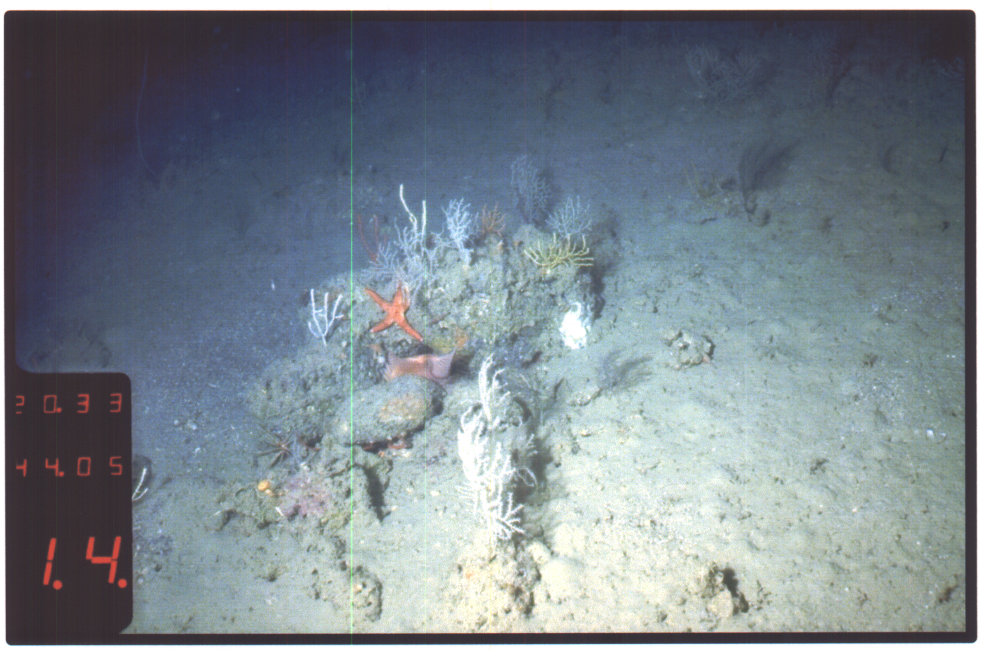

Image 18 - Soft corals (*Thesea* sp. and other Stenogorgiinae) dominate the biota associated with a rock outcrop; other biota include the orange sea star ? *Tamaria halperni*, slender-spined urchin (*Stylocidaris affinis*), branching black coral (*Antipathes* spp.) (blue-gray), the large red brittle star *Ophioderma devaneyi* (partially hidden under rock in foreground), calcareous red algae, and partially hidden short bigeye (*Pristigenys alta*) (center).

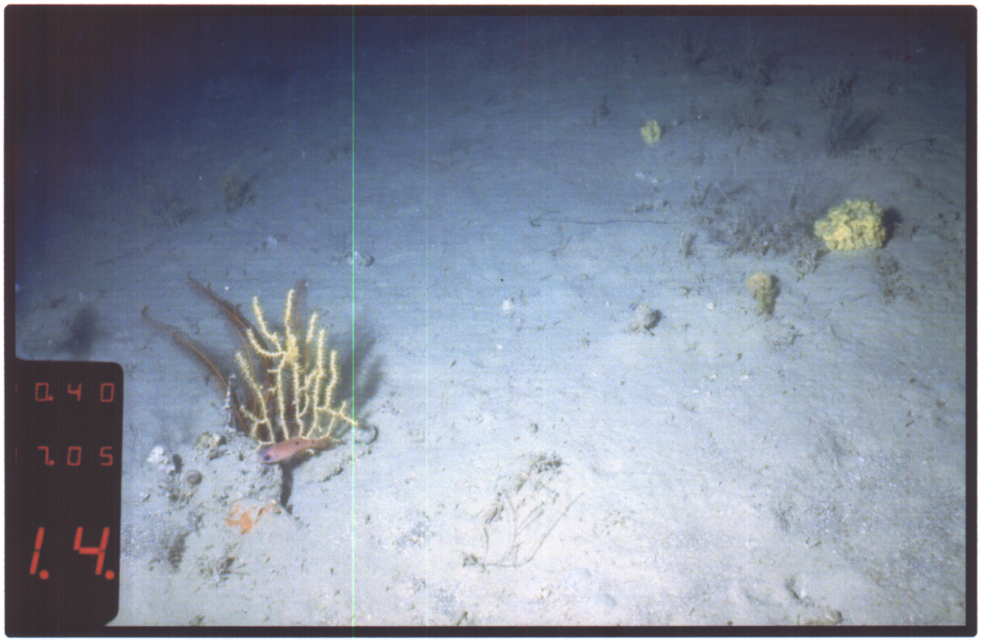

Image 19 - Branching soft coral (*Bebryce* sp.) and 10-arm feather star (Crinoidea) attached to small rock outcrop provide cover for twospot cardinalfish (*Apogon pseudomaculatus*). Surrounding low-relief hard bottom with sand veneer provides substrate (right background) for small branching black coral (*Antipathes* sp.), various sponges, soft corals (Stenogorgiinae), and bryozoans.

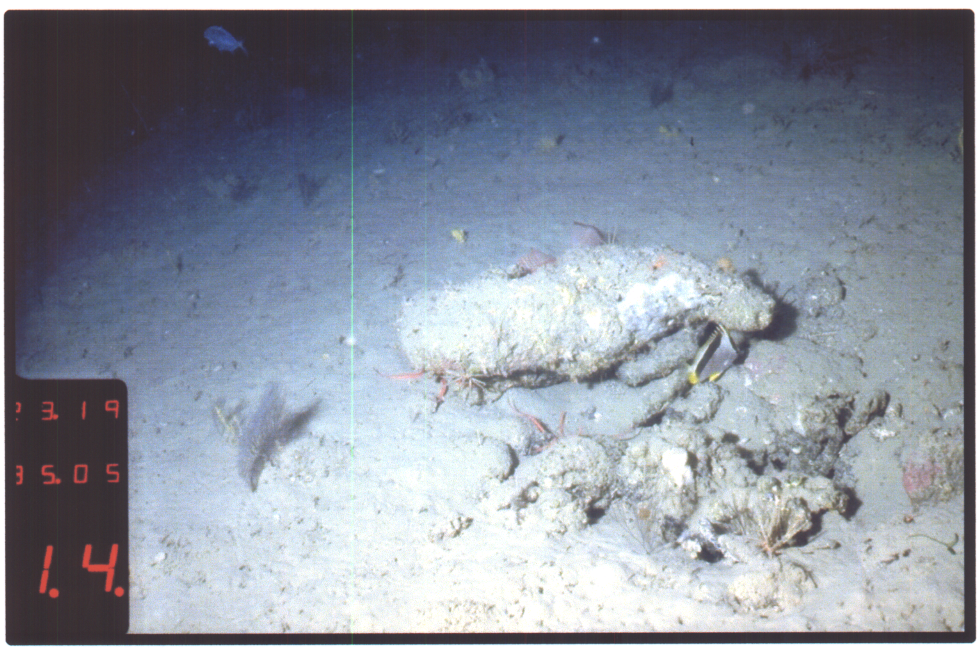

Image 20 - Small rock outcrop provides habitat for biota, which includes bank butterflyfish (*Chaetodon aya*), partially hidden short bigeye (*Pristigenys alta*), a pair of red brittle stars (*Ophioderma devaneyi*), slender-spined urchin (*Stylocidaris affinis*), black coral (*Antipathes* spp.) (blue-gray), calcareous red algae, and sponges.

U.S. Department of the Interior
U.S. Geological Survey
Biological Resources Division

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Minerals Management Service
Gulf of Mexico OCS Region

Managing America's offshore energy resources

Protecting America's coastal and marine environments