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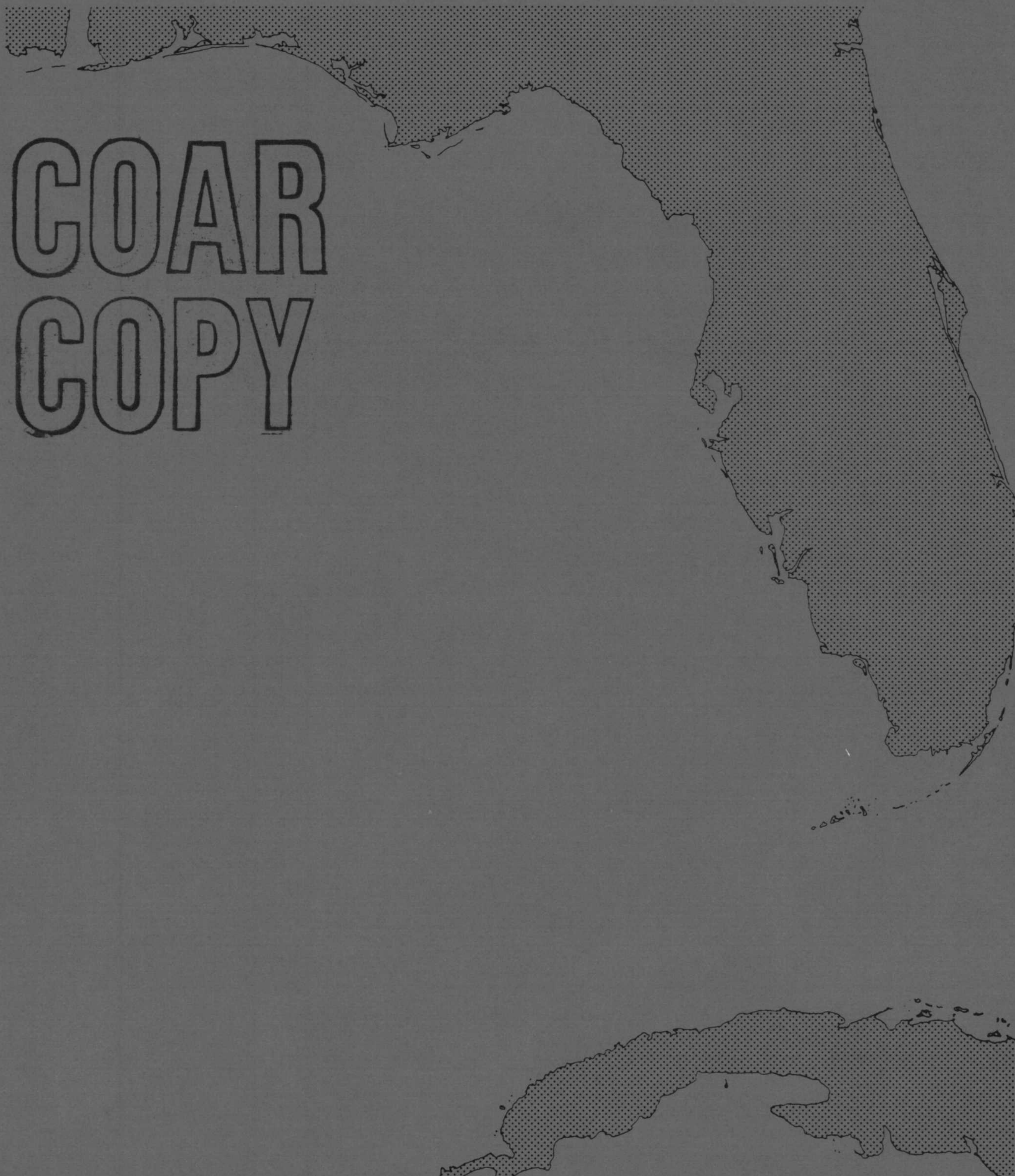

Prepared for:
U.S. Department of the Interior, Minerals Management Service
Gulf of Mexico OCS Region, Metairie, Louisiana
Contract 14-12-0001-29142
April 15, 1983

EXECUTIVE SUMMARY

SOUTHWEST FLORIDA SHELF ECOSYSTEMS STUDY - YEAR 1

Prepared for
U.S. Department of the Interior
Minerals Management Service
Gulf of Mexico OCS Region
Metairie, Louisiana

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Woodward-Clyde Consultants
Consulting Engineers, Geologists and Environmental Scientists

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Continental Shelf Associates, Inc.
CSA
"Applied Marine Science and Technology"

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1.0 INTRODUCTION

To meet present and future energy requirements of the United States, the U.S. Department of the Interior has acted to expedite development of oil and gas deposits beneath the outer continental shelf (OCS). Under the Department's accelerated 5-year leasing program, the Minerals Management Service is proposing to offer for lease certain tracts in the eastern Gulf of Mexico. Proposed lease offerings are currently scheduled for November 1983 and November 1985. At present, five potential gas and oil producing basins are thought to exist off the west coast of Florida, although no wells drilled in the eastern Gulf of Mexico off Florida have produced commercial quantities of hydrocarbons to date. The locations of active, recently offered (Sale 69, Part II), and expired leases within the southwest Florida region are shown in Figure 1-1.

In compliance with the National Environmental Policy Act of 1969, the Marine Environmental Studies Program was implemented by the Bureau of Land Management in 1973. The primary goal of this program is to assess ongoing or potential environmental impacts resulting from oil and gas development activities on the OCS. Recently, responsibilities for this program, as well as for all other aspects of OCS leasing and resource management, were consolidated within the newly created Minerals Management Service (MMS). As a result of the lack of basic environmental information on the southwest Florida OCS area, MMS initiated the present Southwest Florida Shelf Ecosystems Study Program.

The Southwest Florida Shelf Ecosystems Study is a multiyear, multidisciplinary program designed to:

- Determine the potential impacts of outer continental shelf (OCS) oil and gas development activities on "live bottom" habitats and communities,
- Produce sea floor habitat maps showing the nature and distribution of bottom substrates, and
- Identify and describe the biological zonation across the shelf study region.

Study activities will be completed in three phases.

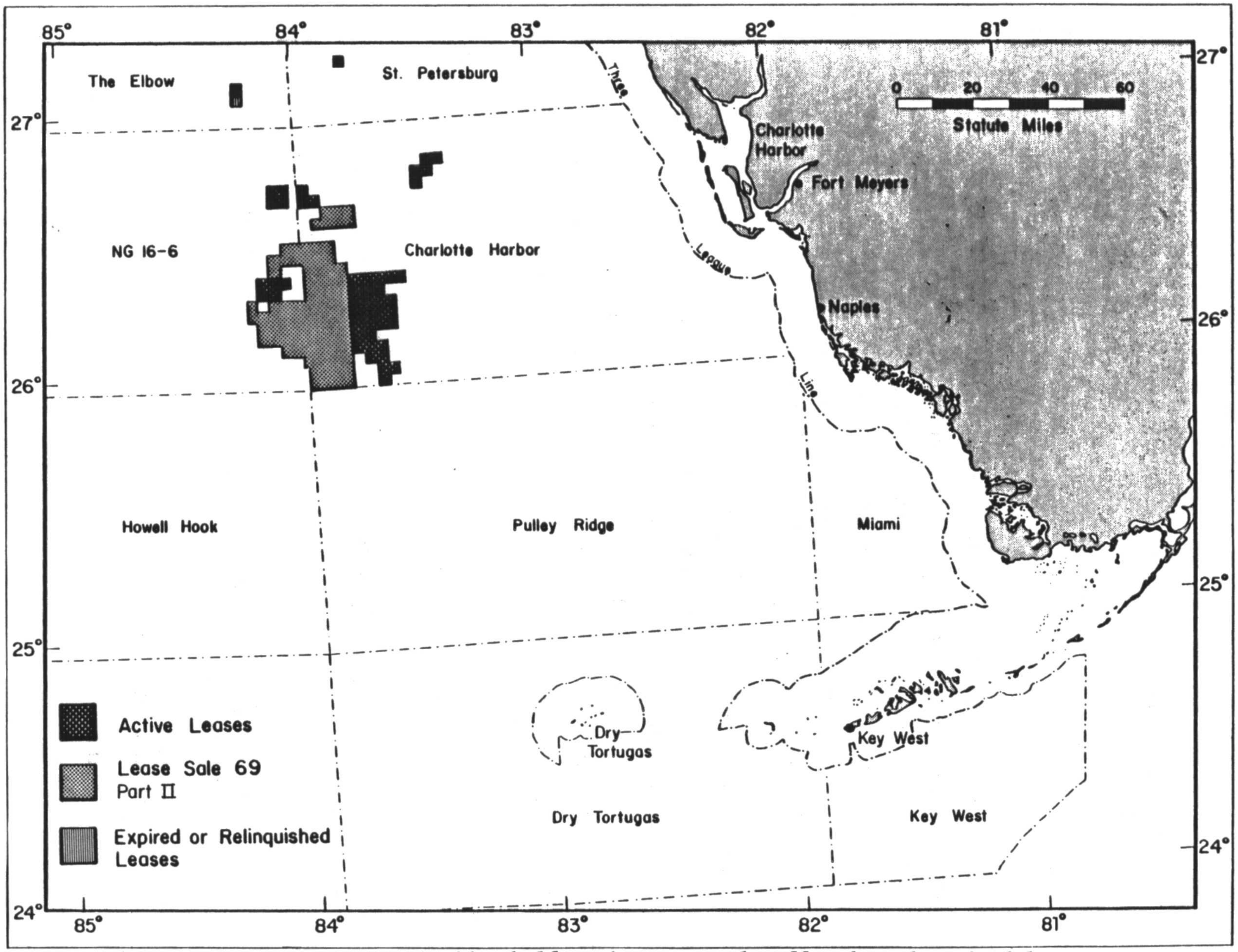

Figure 1-1. Southwest Florida shelf active, recently offered, and expired lease tract areas.

During the first year of the program, a variety of bathymetric, seismic, and side scan sonar data were collected along with visual bottom data (i.e., underwater television and still camera color photography). These data were augmented by analyses of a broad range of hydrographic measurements, water column samples, sediment samples, and benthic biological samples. Sampling stations were established at 30 locations divided among five east-west transects (Figures 1-2 and 1-3). Biological and hydrographic sampling were completed in the fall (October-November, 1980) and spring (April-May, 1981). This report highlights results from this first year study phase.

During the second year, additional visual and geophysical data were collected along a north-south tie-line (Transect F). Twenty-one of the 30 first year hydrographic and biological sampling stations were resampled twice more, once during summer (July-August, 1981), and again during winter (January-February, 1982). In addition, nine new sampling stations were established on Transects A through E, in water depths ranging from 100 to 200 m.

The third year study phase encompasses two seasonal hydrographic cruises (April and September, 1982). Additional data collections will include direct and indirect measurements of primary productivity. Existing and newly obtained hydrographic and primary productivity data will be synthesized into an overview of the driving energetic forces within the southwest Florida shelf regional ecosystem.

The southwest Florida continental shelf includes sandy sea floor substrates, "live bottom", and other areas which favor the development and concentration of marine biota. The distribution of these bottom types and their significance to the regional marine benthic and water column ecosystem is not well known. The interpretation and synthesis of data from this program are directed at a characterization of individual study sites, general characterization of broad areas of the sea floor, and inter-site comparisons; assessment of impact/enhancement potential; methodology evaluation; water mass characterization; and formulation of recommendations for future studies.

In this report, the term "live bottom" habitat has been used to define small areas of broken relief with a rich assemblage of sessile invertebrate fauna and

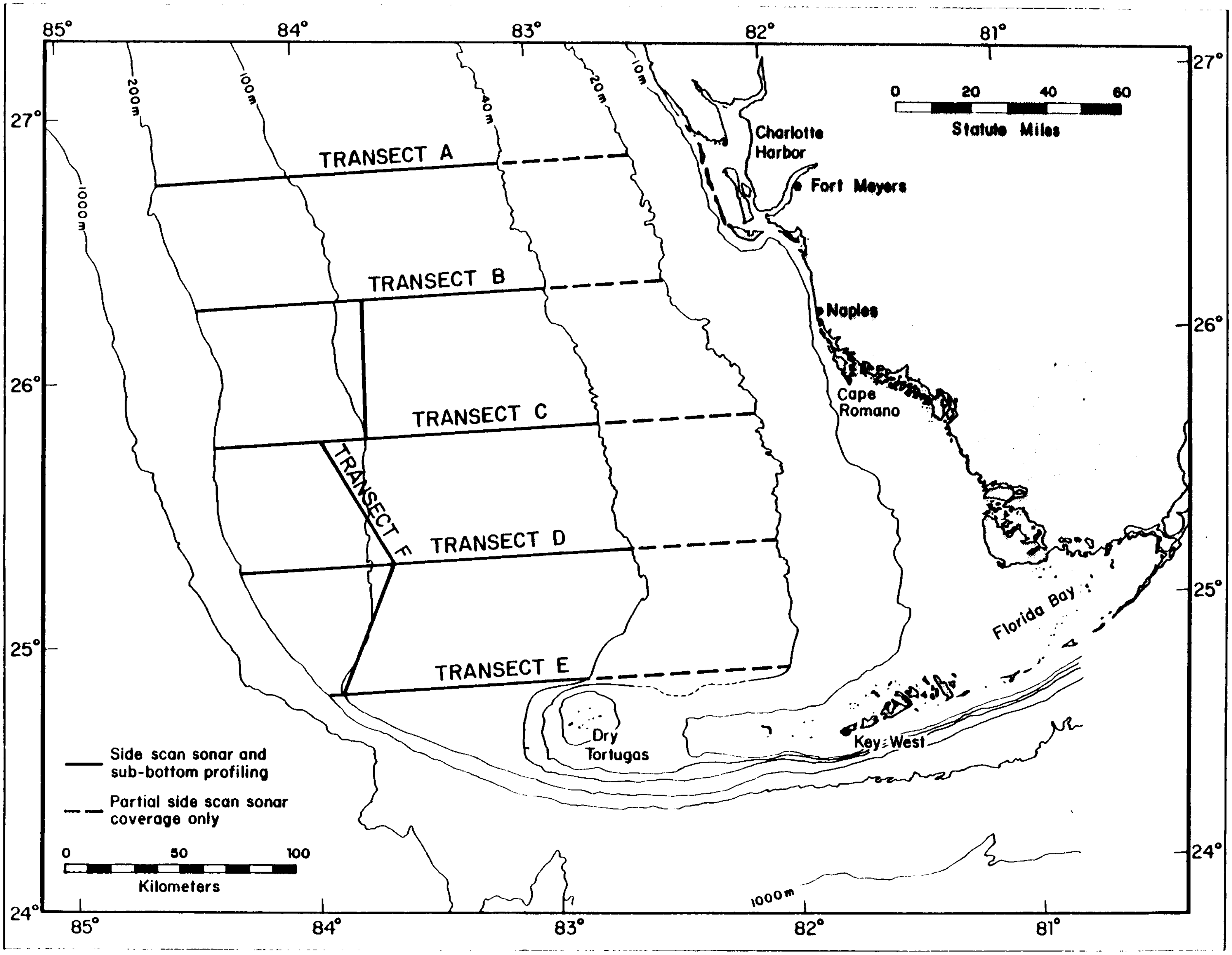

Figure 1-2. Southwest Florida shelf survey transects for first and second year programs (visuals data collected along all lines).

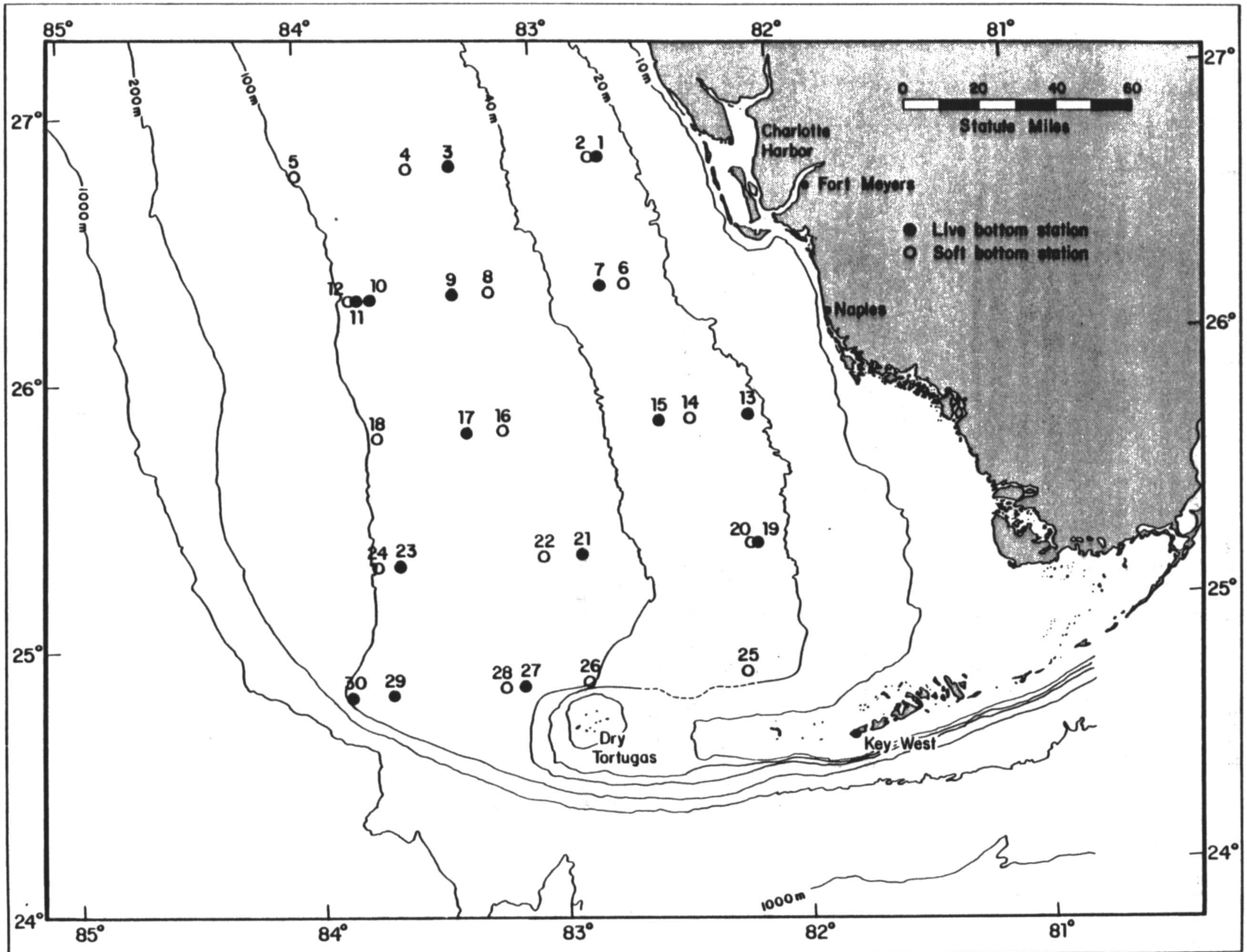

Figure 1-3. Sampling station locations for biological/hydrographic studies.

fishes. "Hard bottom" has been used to describe either a rocky outcrop on the sea floor or a rocky area covered by a sand veneer of variable thickness. Rocky outcrops are probably always covered with epifauna and have associated fish populations (i.e., live bottoms). A "soft bottom" is defined as a substrate that will support macroinfauna (worms, crustaceans, bivalves, etc.) and epifauna (starfish), but not attached epifauna (sea whips, sponges, etc.).

For the purposes of this study, the southwest Florida shelf has been divided into three depth dependent regions:

Inner Shelf:	0 to 40-m water depths
Middle Shelf:	40 to 100-m water depths
Outer Shelf:	100 to 200-m water depths

These designations were originally established to reflect differences between the first and second year contract scope, as well as preliminary geophysical interpretations. As the geophysical results were worked up, this division of the shelf was supported by more objective criteria. The benthic biological data were found to support the subdivisions in a general manner, however, exceptions to the arbitrary depth limits were evident.

This Executive Summary is one of the four volumes that constitute the Year One Final Report.

2.0 MARINE GEOPHYSICAL INVESTIGATIONS

The objectives of the marine geophysical investigations were to provide reconnaissance information on bottom topography and sediment structure, and to identify potential geologic hazards to oil and gas operations on the southwest Florida shelf. The shelf area from Port Charlotte to the north, the Dry Tortugas to the south, and between the 20 and 200-m isobaths was surveyed along five east-west transects during the Year 1 Program (Figure 1-2). An additional north-south transect in the water depth range of 80 to 120 m was surveyed as part of the Year 2 Program.

Geophysical surveys generally consisted of simultaneous data collection with navigation systems, depth sounder, side scan sonar, and a subbottom profiler. In all, over 2,438 km of geophysical transect data were collected during the Year 1 and 2 Programs.

On the inner shelf (20 to 40-m water depth), the sea floor slopes gently to the west at less than 0.02° (0.3 m per km). On the four northernmost transects, bedrock is exposed as localized small-scale outcrops or is covered by a thin layer of mobile sand (Figure 2-1). In the southern portion of the study area (Transect E), fine-grained surficial sediments are found to overlie Holocene and Pleistocene sediments.

The middle shelf (40 to 100-m water depth) sea floor is relatively smooth and dips to the west with slopes of 0.02 to 0.1° (0.3 to 1.7 m per km). Localized zones of irregular topography, steeper slopes, and depressions are found in this shelf area (Figure 2-2). Inshore from the 70-m depth contour, the sea floor has a thin sand veneer covering a wedge of the late Tertiary to Quaternary sediments. In the water depth range of 70 to 90 m, partially exposed or sand covered reef-like structures were seen on all but the northernmost transects.

The outer shelf region (100 to 200-m water depths) ranges from a width of about 10 km on the southernmost transect to 65 km on the northernmost transect. Bottom slopes average approximately 0.2° (3.5 m per km) with local maxima to 1°

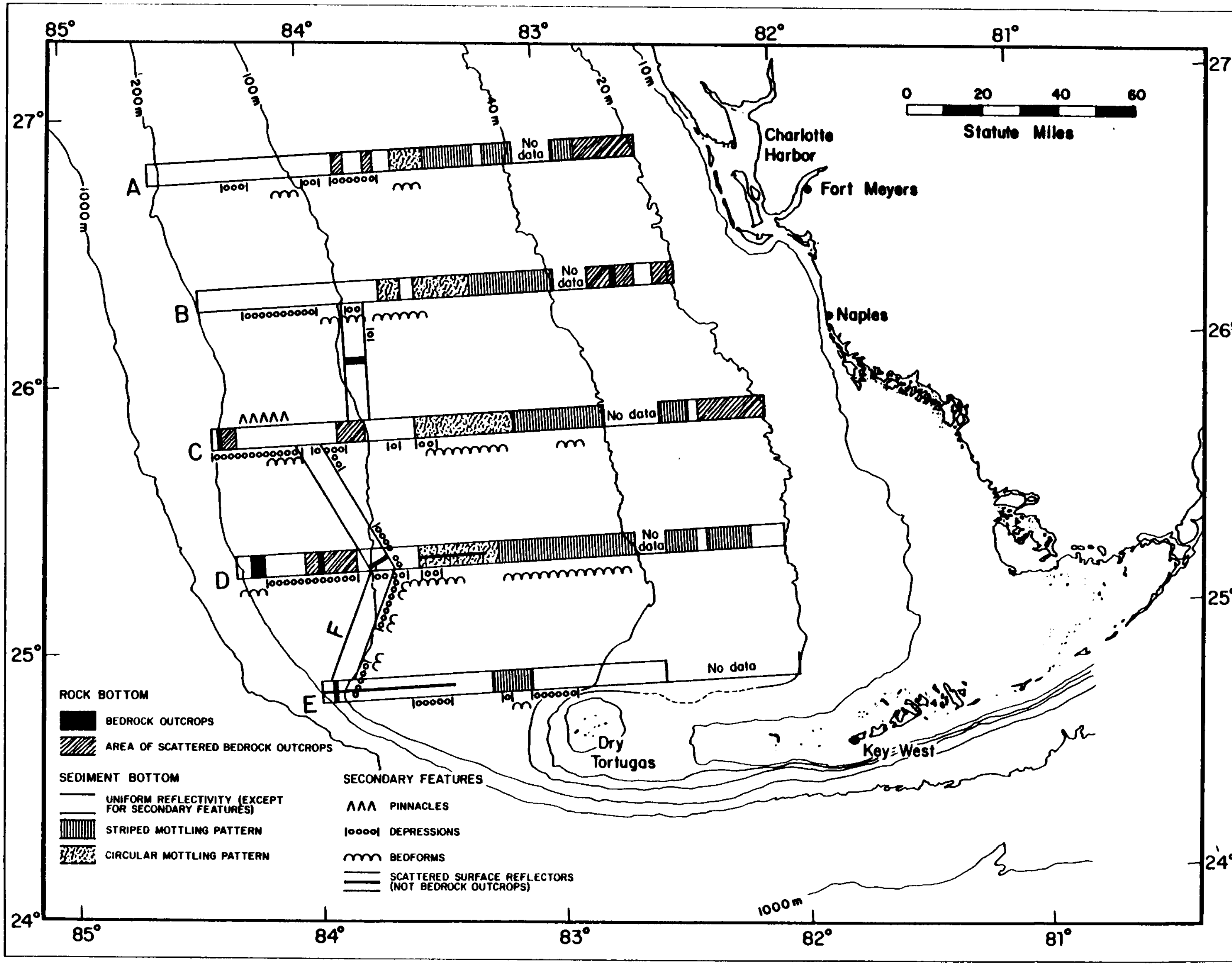

Figure 2-1. Generalized distribution of side scan sonar patterns.

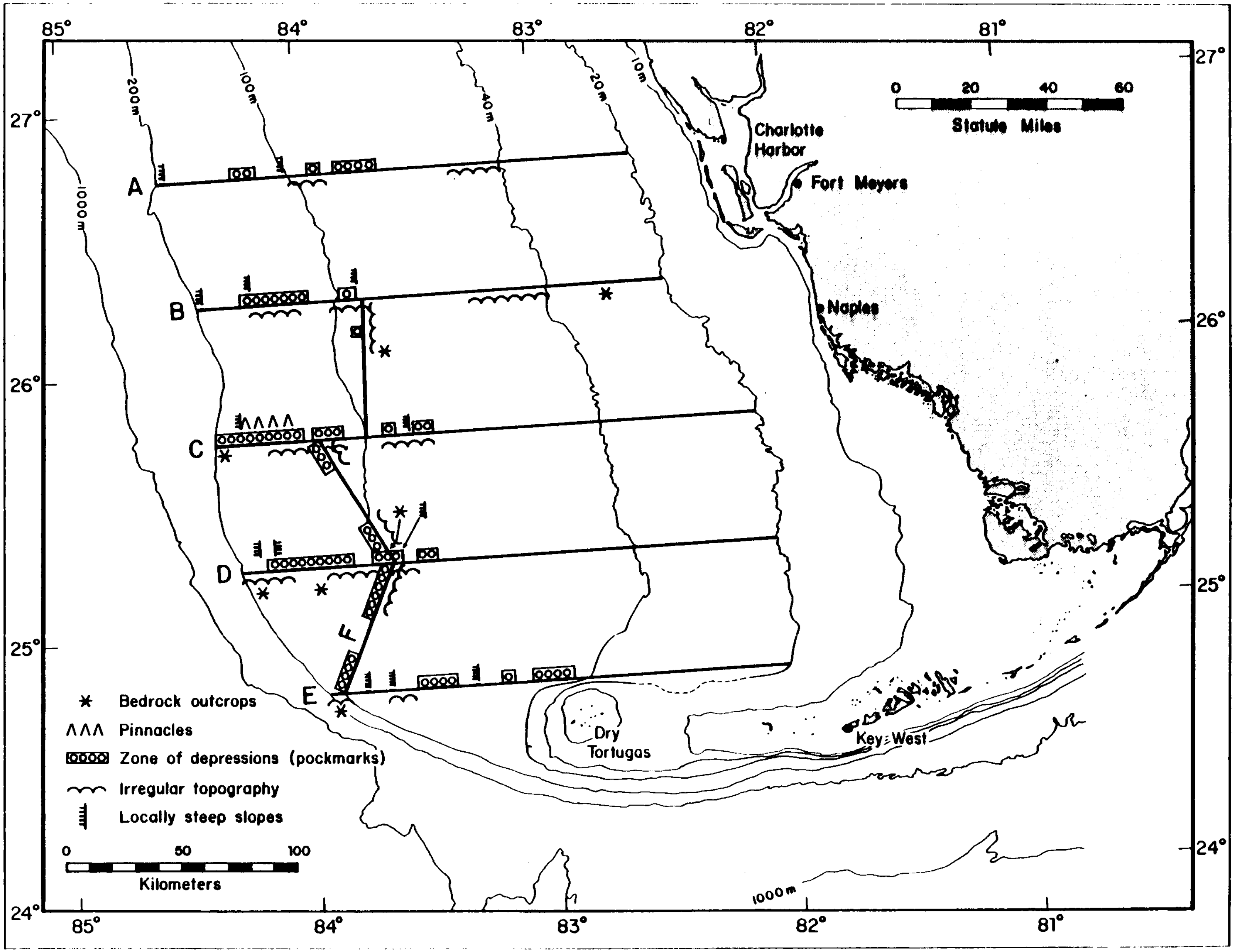

Figure 2-2. Sea floor topographic features (generalized from the Marine Habitat Atlas).

(17 m per km). The outer shelf is broken by old wave-cut terraces. Sea floor depressions are also present, primarily in water depths of 100 to 150 m.

The sea floor on the outer shelf is generally covered with a sand veneer, although several outcrop areas were noted in the southern half of the survey area (Figure 2-1).

Potential geologic hazards identified in the study area were bedrock outcrops, pinnacles, irregular topography, locally steep slopes, depressions (pockmarks), buried channels, collapse features (karst?), and shallow faulting (Figures 2-2 and 2-3).

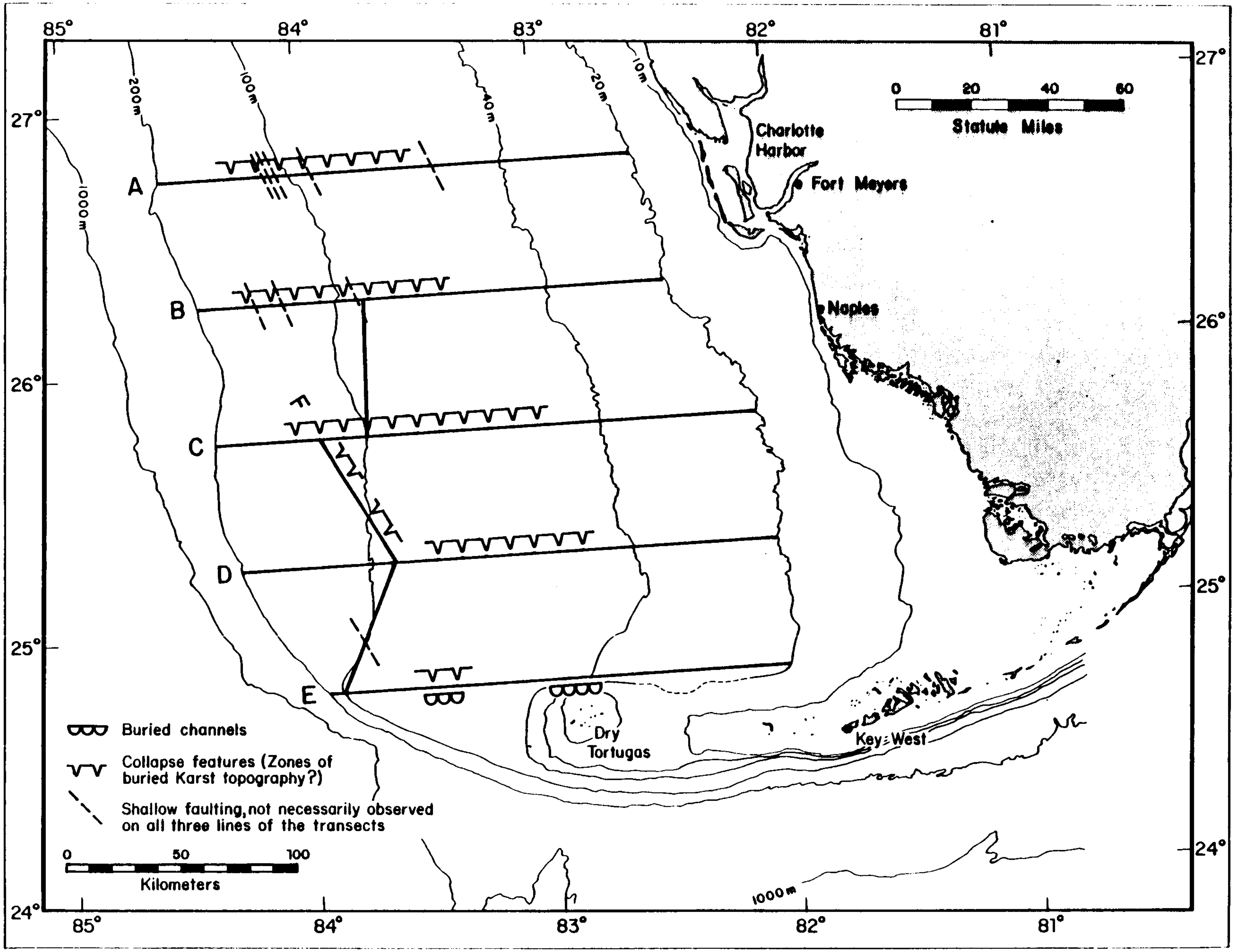

Figure 2-3. Buried geologic features of the southwest Florida shelf (generalized from the Marine Habitat Atlas).

3.0 UNDERWATER TELEVISION AND STILL CAMERA OBSERVATIONS

Visual observations (underwater television and still camera) of the benthic environment were used to assess epibiotal community composition and distribution, and to "ground-truth" substrate types identified by remote sensing geophysical methods. The biological assemblages and substrate types were characterized in terms of five substrate categories (Figure 3-1).

1. Rock Outcrops/Hard Bottom

   Typically, this bottom type included relatively localized rock ledges or exposed low-relief rocky areas covered by distinctive indicator epibiota.

2. Thin Sand over Hard Substrate

   This bottom type, transitional between Rock Outcrops/Hard Bottom and Sand Bottom/Soft Bottom, consisted of a thin veneer of sand covering a more consolidated (hard) substrate. The presence of key biological organisms such as large gorgonians and sponges that had to be attached to the buried hard substrate was used to identify this bottom type.

3. Sand Bottom/Soft Bottom

   This is a morphologically variable bottom type which encompassed a number of forms including open planar bottoms, areas of sand waves and ripples, bioturbated areas, and soft bottoms covered with algae. Sediment grain size and chemical composition were variable; constituents ranged from quartz clastics to carbonate muds.

4. Coralline Algal Nodule Layer over Sand

   This bottom type consisted of patches of coralline algal nodules and rubble covering soft bottom areas. It was usually found in water depths greater than 60 m.

5. Algal Nodule Pavement with Agaricia Accumulations

   This bottom type was similar to the Coralline Algal Nodule Layer over Sand described above, but differed in having a fused coralline algae-dead hard coral pavement overgrowing a soft bottom.

Of the total sea floor study transects videotaped and photographed between 20 and 200 m, approximately half was initially categorized as Sand Bottom/Soft Bottom. Thin Sand over Hard Substrate was intermixed with the Sand Bottom/Soft Bottom across all transects. Taken together these two substrate categories accounted for nearly 90% of the total.

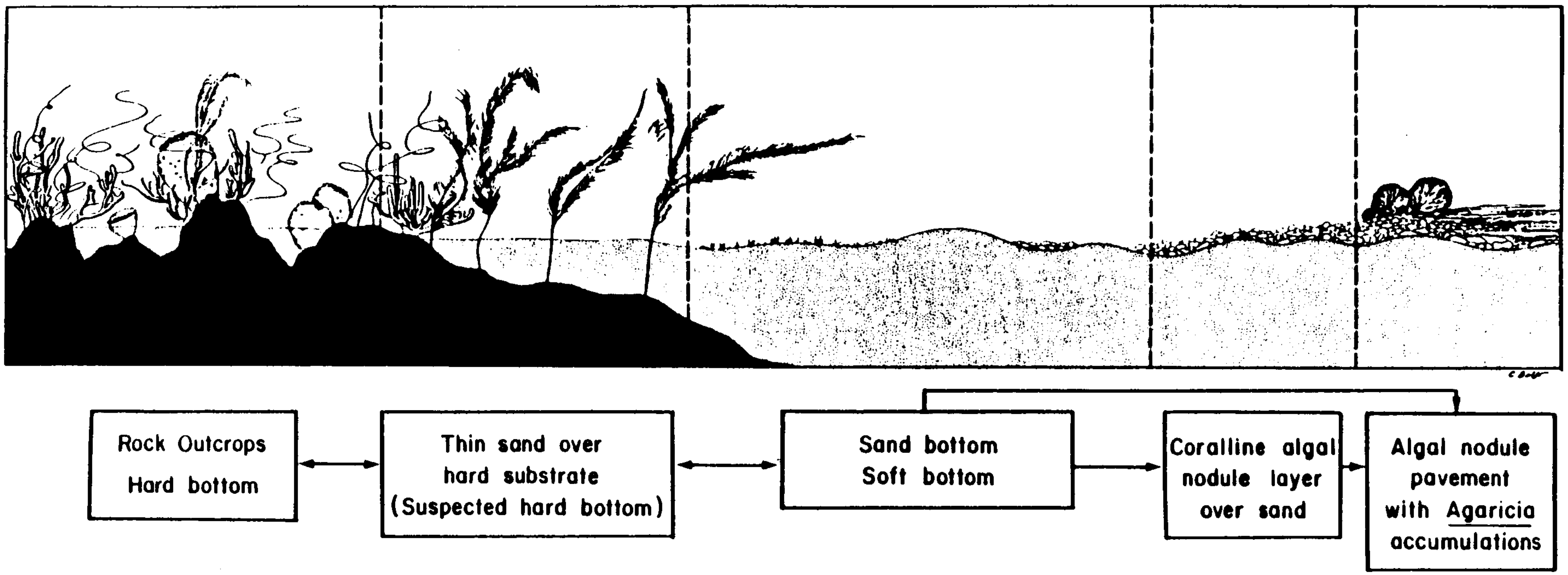

Figure 3-1. Generalized classification scheme for sea floor substrate types.

Nine major biological assemblages were distinguished from the television and still camera observations. Two of these assemblages were soft bottom related; seven were classified as "live bottom" assemblages. Soft bottom assemblages (by arbitrary definition) had an attached macroepifaunal density which was generally less than one individual per m^2; live bottom assemblages had much higher macroepifaunal densities.

Additional observations obtained with the television/still camera system included phenomena such as turbidity fronts and sea floor depressions or pockmarks. Turbidity fronts were observed during both Fall and Spring Cruises and appeared to be related to resuspension of bottom sediments. Pockmarks ranged in diameter from 1 to 25 m and were generally less than 2 m in depth. Their origin remains unknown but may reflect either the presence of underwater springs, or buried karst features.

4.0 INTEGRATION OF THE GEOPHYSICAL AND GROUND-TRUTH DATA SETS

The interpretations of the geophysical data (bottom characteristics) were integrated with the results of the underwater television and still camera surveys (substrate types and biological assemblages) and presented in a two volume Marine Habitat Atlas. Volume 1 presents the distribution of substrate types, biological assemblages, and bathymetry in a series of index and summary maps and cross sections at scales of 1:500,000 and 1:48,000. Volume 2 presents supporting information on field survey techniques, data analyses, and mapping procedures.

Integration of the geophysical and "ground-truth" data extended mapping of marine habitats over a larger area than was possible from visual observations only. A summary of the results of this integration is presented in Figures 4-1 and 4-2.

A comparison of these integrated habitat/substrate maps (Figures 4-1 and 4-2) with the geophysical interpretation maps (Figures 2-1, 2-2, and 2-3) indicates that there is not a one-to-one correspondence between the habitat/substrate patterns indicated by the different techniques. Of five substrate categories identified from the southwest Florida shelf, a combination of side scan sonar and subbottom profiler records allows the identification and mapping of: (1) Rock Outcrops/Hard Bottom, (2) Thin Sand over Hard Substrate, and (3) Sand Bottom/Soft Bottom. These same geophysical techniques appear unable to consistently identify and separate (4) Coralline Algal Nodule Layer over Sand and (5) Algal Nodule Pavement with Agaricia Accumulations -- either from each other, or from Sand Bottom/Soft Bottom (3) substrates. The television and still camera ground-truth systems -- in the absence of distinctive hard bottom epibiota -- are unable to reliably separate (2) Thin Sand over Hard Substrate from (3) Sand Bottom/Soft Bottom. The subbottom profiler records, however, fill this gap. The usefulness of side scan sonar for mapping substrates (4) and (5) also increases when it is adjusted to a short-range scale, however this significantly decreases the area of sea floor being mapped per unit time. Thus, it would appear that a combination of geophysical and ground-truthing techniques is needed to provide the most complete representation, each data set contributing to a more accurate and complete interpretation of the other.

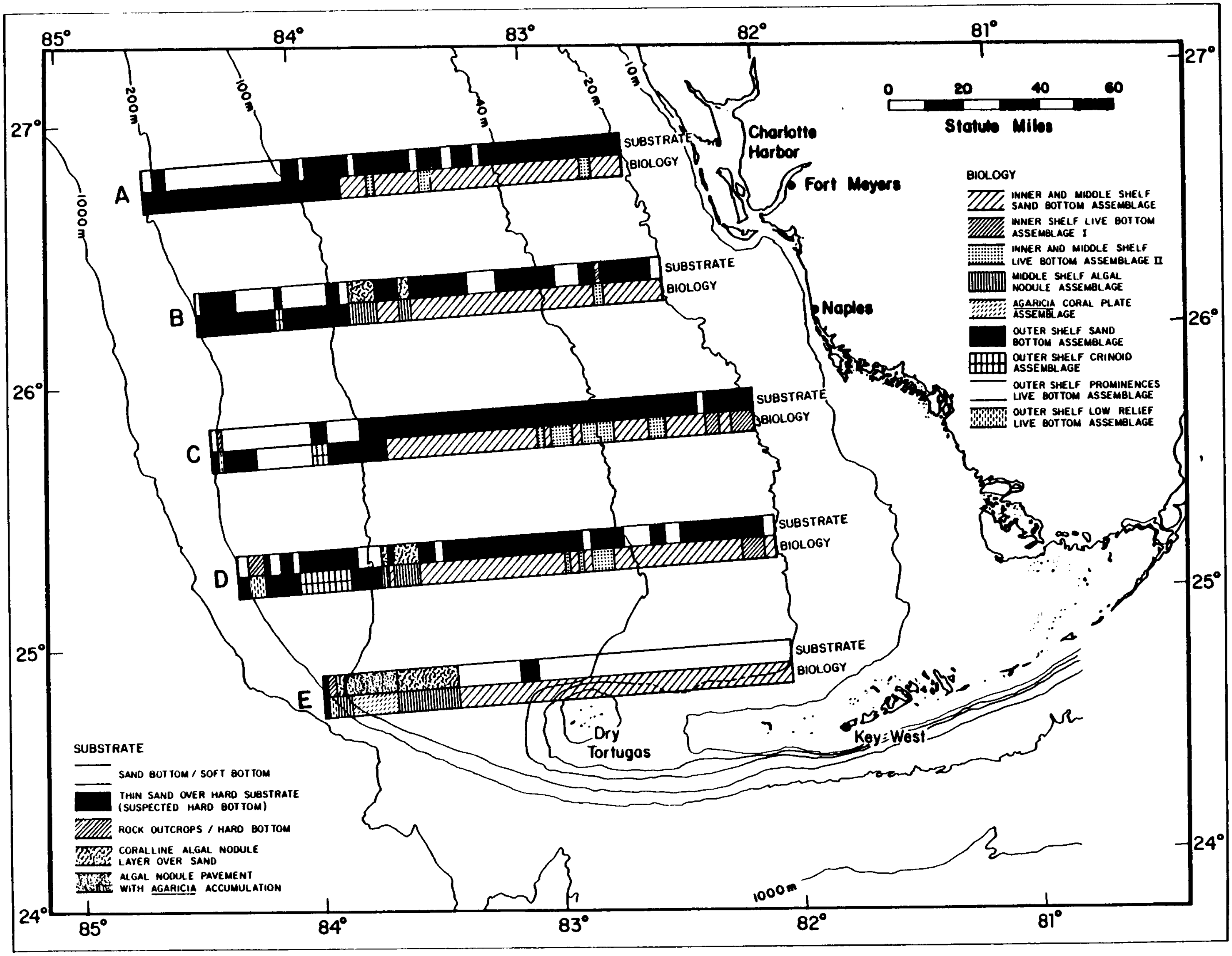

Figure 4-1. Generalized map of marine habitats along Transects A through E.

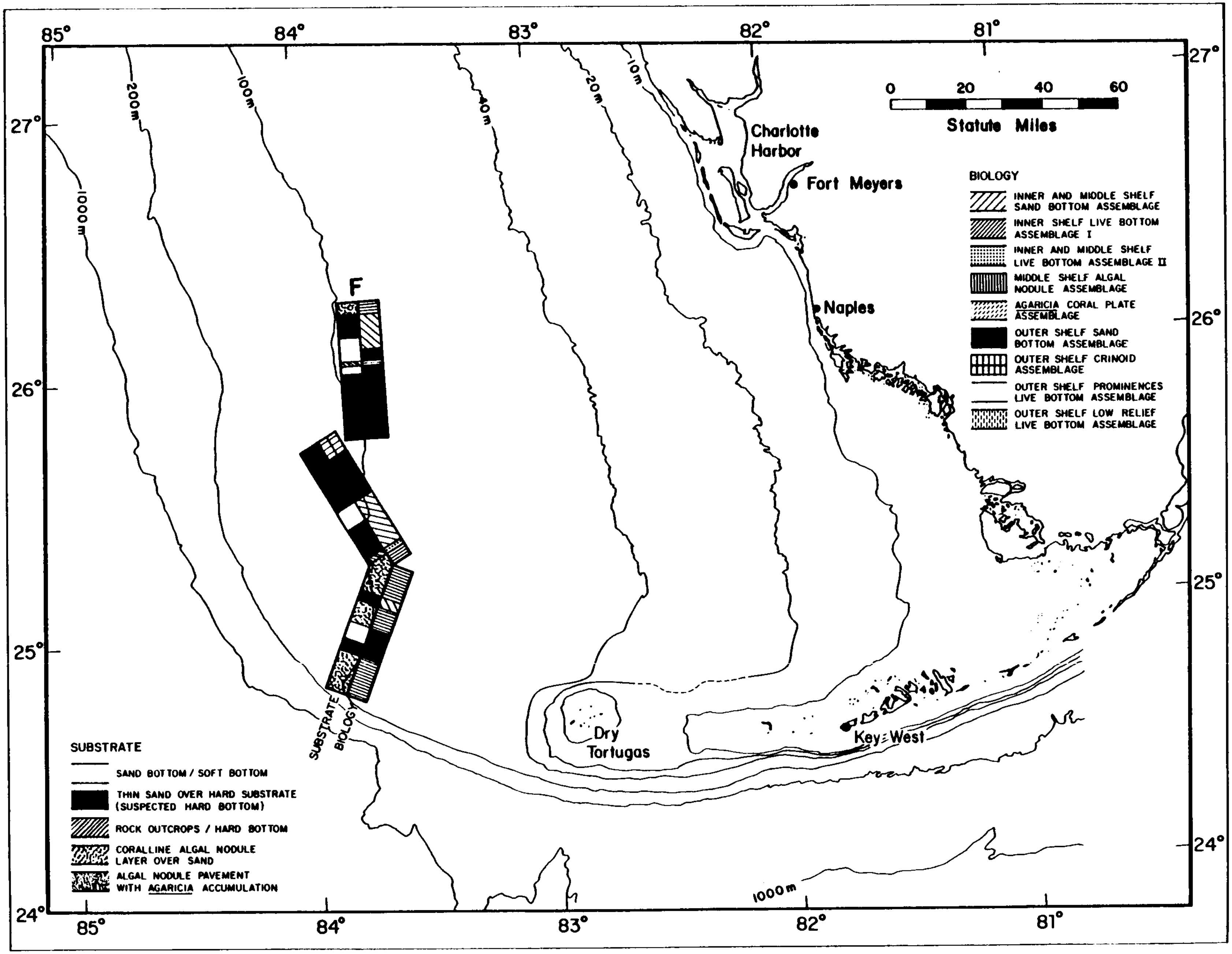

Figure 4-2. Generalized map of marine habitats along Transect F.

5.0 SAMPLING DESIGN FOR LIVE AND SOFT BOTTOM STATIONS

Sampling stations for two seasonal biological/hydrographic cruises were selected after analyses of videotapes and logs recorded during a preceding "ground-truthing" (underwater television and still camera) cruise. Fifteen live bottom and 15 soft bottom stations were sampled during both a fall and spring season cruise (Figure 1-3). Each station consisted of a 1,000-m square block situated around a designated station center point. Data collected at each station were divided between water column and benthic categories:

Water Column Data (all stations)

- STD/DO Profile
- Salinity Samples (Near-Surface and Near-Bottom)
- Dissolved Oxygen Samples (Near-Surface and Near-Bottom)
- Temperature (Reversing Thermometer)
- Transmissivity Profile
- Photometer Profile (daylight only)
- Nutrients (Inorganic Nitrogen, Phosphate and Silicate)
- Chlorophyll *a*
- Yellow Substance

Benthic Data

- Television Videotapes (black and white) (all stations)
- Still Camera Photographs (35 mm color) (all stations)
- Box Cores (soft bottom stations)
  - Macroinfauna (soft bottom stations)
  - Sediment Grain Size (soft bottom stations)
  - Sediment Total Carbonate (soft bottom stations)
  - Sediment Hydrocarbons (soft bottom stations)
  - Sediment Trace Metals (Ba, Cd, Cr, Cu, Fe, Pb, Ni, V, Zn) (soft bottom stations)
- Triangle Dredge Epifauna and Macroalgae (live bottom stations)
- Otter Trawl Epifauna and Macroalgae (all stations)

As a means for coordinating the processing and dissemination of these collected data, the data management effort provided three functions; these were: (1)

inventory and control of data; (2) data synthesis and analysis; and (3) recording and archiving. A system of sample identifiers and parameter codes was established for data base files. Error checks were completed at different file construction phases. Analyses applied to individual data files were primarily specified by project PIs. These analyses consisted primarily of evaluation of various statistical indices (mean, variance, maximum, minimum, skewness, kurtosis, Shannon-Wiener index, equitability, etc.), cluster analyses, weighted discriminate analyses, and correlations. Interpretation of results was also primarily the responsibility of individual PIs.

6.0 WATER QUALITY

Hydrographic data were collected at 30 shelf stations during a spring season (22 April to 5 May 1981) cruise and a fall season (25 October to 23 November 1980) cruise. Both spring and fall are transitional seasons for shelf distributions.

During the spring (April-May) period of thermal restratification, a decrease in turbulent forces is apparent and a gradual warming of the water column begins. Isotherms spread horizontally across the shelf and become more compacted, forming a sharp thermocline only in the shallower nearshore regions. Mid-shelf temperature minima (19° to 20°C) near the bottom are a prominent feature of this transition. Salinities are generally mixed from surface to bottom although several isolated pockets of higher salinity (>36.8 °/oo) were observed in the study area. Dissolved oxygen values were generally high (5.76 to 7.71 ml l^{-1}) throughout the study area and were consistent from surface to bottom. Transmissivity values during the Spring Cruise showed a number of consistent, very clear (>95 percent) areas (e.g., the range of variability along Transects A and B was only 8 percent), near bottom turbidity maxima, or nepheloid layers, as well as similarities to the temperature and salinity distributions. No evidence of strong bottom currents in the offshore region was apparent in the data. Increased amounts of suspended particulate matter and plankton were indicated nearshore. In most cases, further offshore, accumulation of organic matter and plankton caused the near-bottom nepheloid layers. This is supported by the general increase in chlorophyll-a values with depth. The highest chlorophyll-a values (0.5 to 0.7 mg/m^3) usually occurred at subsurface depths. Dissolved micronutrient (phosphate, nitrite-nitrate, and dissolved silica) concentrations were generally low with maxima also occurring at subsurface depths. Several of these parametric distributions as well as satellite thermal imagery about the time of the Spring Cruise suggest the possible intrusion of Loop Current water onto the shelf.

During the October-November fall season transition, atmospheric cold fronts begin to penetrate into the south Florida region. The Fall Cruise data showed the results of a wind-induced mixing and water surface cooling where the remnant summer thermocline is gradually mixed out to deeper waters. The surface mixed layer extended to about 40 to 60 m. Above the thermocline, water temperatures generally decreased in a southerly direction; below the thermocline and especially at the stations situated furthest offshore, temperatures tended to increase in the same direction. Concurrent salinity changes corresponded well to temperature changes. A high level of nutrients and general proximity of the Loop Current suggested that either the Loop Current or winds may have induced an upwelling of deeper waters onto the near-bottom environment. The euphotic zone (1% light level) on the shelf often penetrated to the bottom with the highest chlorophyll-a concentrations found in the bottom samples. Dissolved oxygen values were mixed throughout the water column and had no definitive features except for low values (about 4.3 ml l^{-1}) near the bottom at the offshore stations.

The Everglades appear to show no obvious influence on outer continental shelf waters. Yellow substance concentrations from both cruises were extremely low and no salinity configurations or fluctuations indicative of Everglades input were noted.

7.0 SUBSTRATE CHARACTERISTICS

Quantitative analyses of 35-mm color slides taken at each live bottom station during both seasonal cruises were used to sort the observed bottom types into the five substrate categories described in Section 3.0 and the Marine Habitat Atlas. Although most of the shelf contains bottom types that can be classified as either "Thin Sand over Hard Substrate" or "Sand Bottom/Soft Bottom", several stations near the 100-m isobath (especially near the southern end of the survey area, west of the Dry Tortugas) showed the presence of algal nodules either as "Coralline Algal Nodule Layer over Sand" or "Algal Nodule Pavement with *Agaricia* Accumulations". The substrate was composed mainly of sand at a majority of the sampled live bottom stations.

Sand ripples were observed principally at shallow water stations during the Spring Cruise but not the Fall Cruise. Their estimated heights and lengths ranged from 5 to 20 and 15 to 64 cm, respectively. Evidence of bioturbation, most commonly as mounds, burrows, and tracks, was prevalent throughout the shelf study area.

The results of grain size and carbonate analyses from samples collected at soft bottom stations indicated that there were three distinct sediment types present on the shelf; an insoluble quartz clastics facies, a fine-grained carbonate mud, and a carbonate sand. Carbonate sand was the predominate sediment type, covering the majority of soft bottom stations.

8.0 HYDROCARBON ANALYSIS OF SURFICIAL SEDIMENTS

Surficial sediment hydrocarbons of the southwest Florida shelf were characterized at 15 soft bottom stations during the fall, 1980 (Figure 1-3). Three major sediment hydrocarbon types were identified: (1) biogenic hydrocarbons of marine origin, (2) biogenic marine and terrigenous hydrocarbons, and (3) biogenic marine, terrigenous, and petrogenic hydrocarbons. Results showed that the sediments of the southwest Florida shelf generally contain low levels of primarily marine biogenic hydrocarbons. Station 12, offshore, was the only site at which petroleum hydrocarbon input was evident (Figure 8-1). These petrogenic hydrocarbons most likely originated in the northern Gulf and Mississippi River area and were carried southward in association with Loop Current clay particles. Evidence of terrigenous hydrocarbons in other offshore stations (Stations 5 and 24) provides support for a Mississippi River origin. Terrigenous hydrocarbons were also found at all three stations of the southernmost transect (Transect E). These could reflect recent hydrocarbon input from the southern Florida coastal mangrove areas and the Everglades. Since the shelf sediments show a characteristic, low-level background concentration of primarily marine biogenic hydrocarbons, any significant hydrocarbon input from petroleum development activities should be readily apparent and easily detectable.

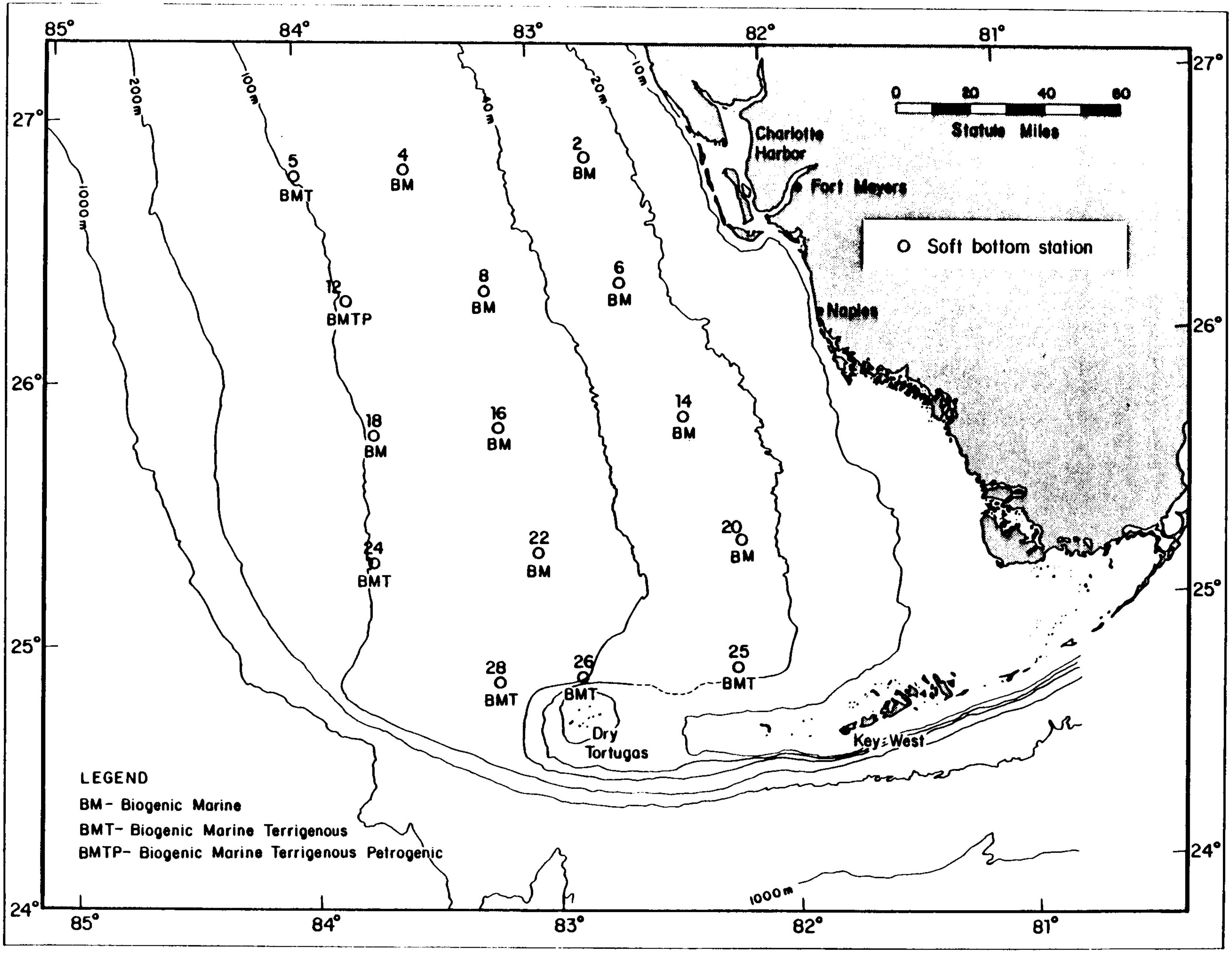

Figure 8-1. Distribution of hydrocarbon types.

9.0 TRACE METALS

Concentration levels of nine trace metals were investigated in surficial sediments at 15 soft bottom stations during the fall, 1980. Analyses for Ba, Cd, Cr, Cu, Fe, Ni, Pb, V, and Zn showed both low levels and uniform distributions across the southwest Florida shelf. These observed levels are directly related to the sediment mineralogy which showed carbonate levels in excess of 90% at 13 of 15 sampled stations. Except for Cu and Zn, no significant correlations between trace metal concentrations and grain size were evident.

The generally low concentration levels of trace metals in the carbonate rich sediments of the southwest Florida shelf are indicative of "pristine" conditions. Any significant trace metal input from oil and gas development activities would be readily detected should it occur.

10.0 SOFT BOTTOM BIOTA

Epibiota and macroinfauna were characterized qualitatively and quantitatively at 15 soft bottom stations located on the southwest Florida shelf (Figure 1-3). Sampling included collection of visual (television and still camera), otter trawl, and box core data during fall, 1980 and spring, 1981.

Epiflora

Photographic data indicated that macrophytes were widely distributed, being present at all but three stations (Figure 10-1). Photographic resolution was sufficient to distinguish taxon groups among Chlorophycophyta, and biomass dominants (e.g., *Caulerpa* spp., *Halimeda* spp., *Udotea* spp.) were recognizable. However, forms of red and brown algae and mixtures of species from more than one division were less distinct. In terms of average percent coverage, *Caulerpa* spp. were greatest among recognizable taxon groups, comprising nearly 60% of total vegetated areas.

Box core and otter trawl collections provided more detailed information on epifloral taxonomic composition (Table 10-1). The number of species found at each station was low, ranging from one to eight and averaging from three to four species. The most abundant species, both in terms of frequency of occurrence and estimated biomass, was *Caulerpa sertularioides*; *Halimeda discoidea* ranked second. Although 50% fewer species were observed during the Spring Cruise, no clear temporal patterns were evident. In comparison with previous investigations in the same general area, the number of epifloral species collected at soft bottom stations was quite limited (Dawes, Earle, and Crowley, 1967; Dawes and Van Breedveld, 1969; Earle, 1969; etc.). This appears to be an artifact of sampling effort, methodology, and subjective station selection.

Epifauna and Fishes

Fall Cruise otter trawl fish collections yielded 99 taxa; Spring Cruise collections, 77 taxa. Fifty-eight taxa were common to both collections.

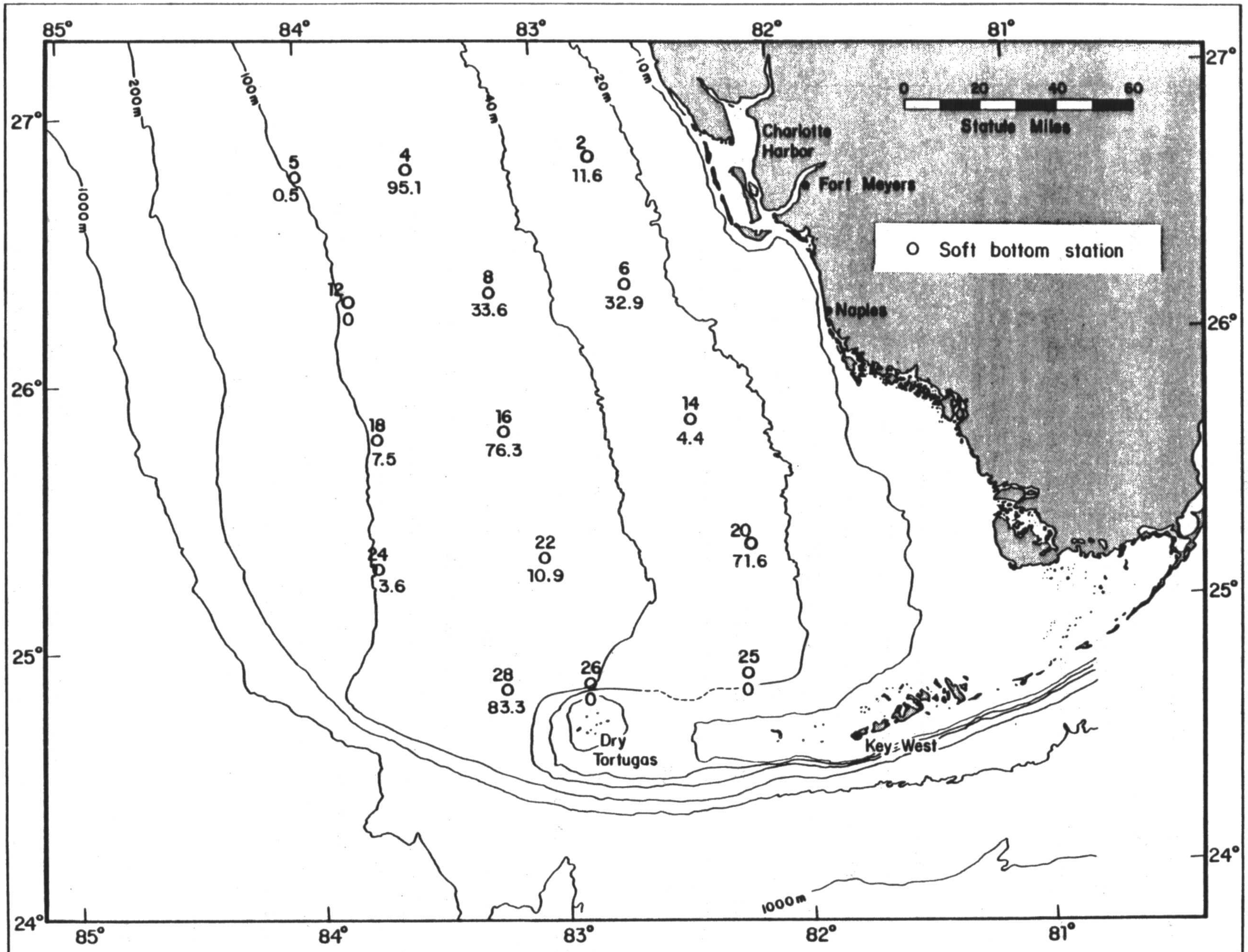

Figure 10-1. Mean percent incidence of macroalgae among still camera photos taken at soft bottom stations.

Table 10-1. Algal species composition of vegetated stations based on box core and trawl samples (+ denotes presence, 0 denotes absence).

Station	Species	Fall Cruise	Spring Cruise
2	Halimeda discoidea	+	+
	Pseudocodium floridanum	+	0
	Udotea conglutinata	+	0
	Udotea cyathiformis	+	0
	Sargassum hystrix	+	0
	Chondria floridana	+	+
	Fauchea peltata (?)	+	+
	Unknown fragment 1	+	0
4	Caulerpa sertularioides	+	0
	Halimeda discoidea	+	+
	Pseudocodium floridanum	+	0
	Dictyota sp.	+	0
	Fauchea peltata (?)	+	+
5	Halimeda discoidea	0	+
6	Caulerpa sertularioides	+	0
	Fauchea peltata (?)	+	0
8	Caulerpa sertularioides	+	+
	Halimeda discoidea	+	+
	Fauchea peltata (?)	0	+
14	Caulerpa sertularioides	+	+
	Halimeda discoidea	+	0
	Unknown fragment 2	+	0
16	Caulerpa sertularioides	+	+
	Halimeda discoidea	+	+
	Sargassum filipendula	+	+
	Sargassum polycertatium	+	+
	Fauchea peltata (?)	0	+
18	Caulerpa sertularioides	+	0
	Sargassum natans	+	0
22	Caulerpa sertularioides	+	+
	Unknown fragment 3	+	0
24	Caulerpa sertularioides	+	+
	Sargassum hystrix	0	+
28	Caulerpa sertularioides	+	+
	Halimeda discoidea	+	+
	Sargassum hystrix	0	+
	Unknown fragment 4	+	0
	Unknown fragment 5	+	0

Of almost 2,400 individuals examined from the Fall Cruise, 44% were accounted for by five species: dusky flounder Syacium papillosum (16%), inshore lizardfish Synodus foetens (12%), bank sea bass Centropristis ocyurus (6%), dwarf sand perch Diplectrum bivittatum (5%), and fringed filefish Monacanthus ciliatus (5%).

Four fish species constituted 48% of approximately 2,000 individuals collected during the Spring Cruise: ragged goby Bollmannia communis (17%), Synodus foetens (12%), Syacium papillosum (11%), and Centropristis ocyurus (7%).

The more abundant fish taxa were distributed throughout the study area, and faunal composition was similar from station to station. Little seasonal variation in faunal composition was detected between the fall and spring sampling periods.

Visual observations indicated generally low epifaunal abundances at soft bottom stations. Trawl data further substantiated these observations, although a number of soft bottom stations had isolated sponges and corals present.

Clustering analyses of trawl data (epibiota and fishes) revealed distinct onshore-offshore bathymetric distribution patterns but little latitudinal variation in faunal composition. No distinctive trends in temporal variation were indicated from the analyses.

Macroinfauna

Five box core samples were collected at each soft bottom station during each cruise, and processed for macroinfauna (i.e., those infaunal organisms retained on a 0.5-mm sieve). Evaluation of taxon-area curves revealed that in terms of number of taxa collected, sample replication was generally adequate at all but two of the sampled stations.

Infaunal taxonomic richness was extremely high, 1,033 taxa being identified from almost 56,000 organisms collected during both cruises. Excluding meiofaunal components (nematodes, ostracods, and copepods), eight taxa were considered dominants in the study area: Oligochaeta, Nemertina, Paraonidae (polychaete), Fabricia sp. (polychaete), Prionospio cristata (polychaete), Synelmis albini (polychaete), Ampharete acutifrons (polychaete), and Lucina radians (bivalve). Spatial and temporal patterns of taxonomic richness are shown in Figure 10-2. Station 28 (southernmost offshore station) yielded the greatest number of taxa during both cruises. In general, deeper water stations (>60 m) on each transect exhibited greater taxonomic richness than inner shelf stations. Latitudinal and seasonal variations in taxonomic richness were minimal. Infaunal richness values were considerably higher than those recorded during previous investigations on the southwest Florida shelf.

In contrast to infaunal richness, total infaunal density appears to be inversely related to depth; i.e., deeper stations generally exhibit lower faunal densities (Figure 10-3). Temporal variations were occasionally pronounced in nearshore areas, but did not substantially affect relative abundances among major faunal groups. Among the infauna, polychaetes were most abundant (52.4%, Fall Cruise; 53.1%, Spring Cruise) followed by crustaceans (14.9%, Fall Cruise; 12.0%, Spring Cruise) and molluscs (12.0%, Fall Cruise; 10.0%, Spring Cruise).

Faunal similarity analyses were conducted using Morisita (Morisita, 1959) and Bray-Curtis (Bray and Curtis, 1957) indices. These analyses clearly indicated an offshore macroinfaunal zone (60 to 90-m water depth) dominated by the polychaete Synelmis albini. Some nearshore (~20-m water depth) and mid-depth (~50-m water depth) station groupings were also evident from the cluster analyses. However, these groupings were not as distinct as the offshore zone.

Results of the present investigation indicate that factors related to depth and distance from shore, sediment characteristics (grain size, silt/clay content), and epifaunal abundance may influence infaunal distributions across the shelf.

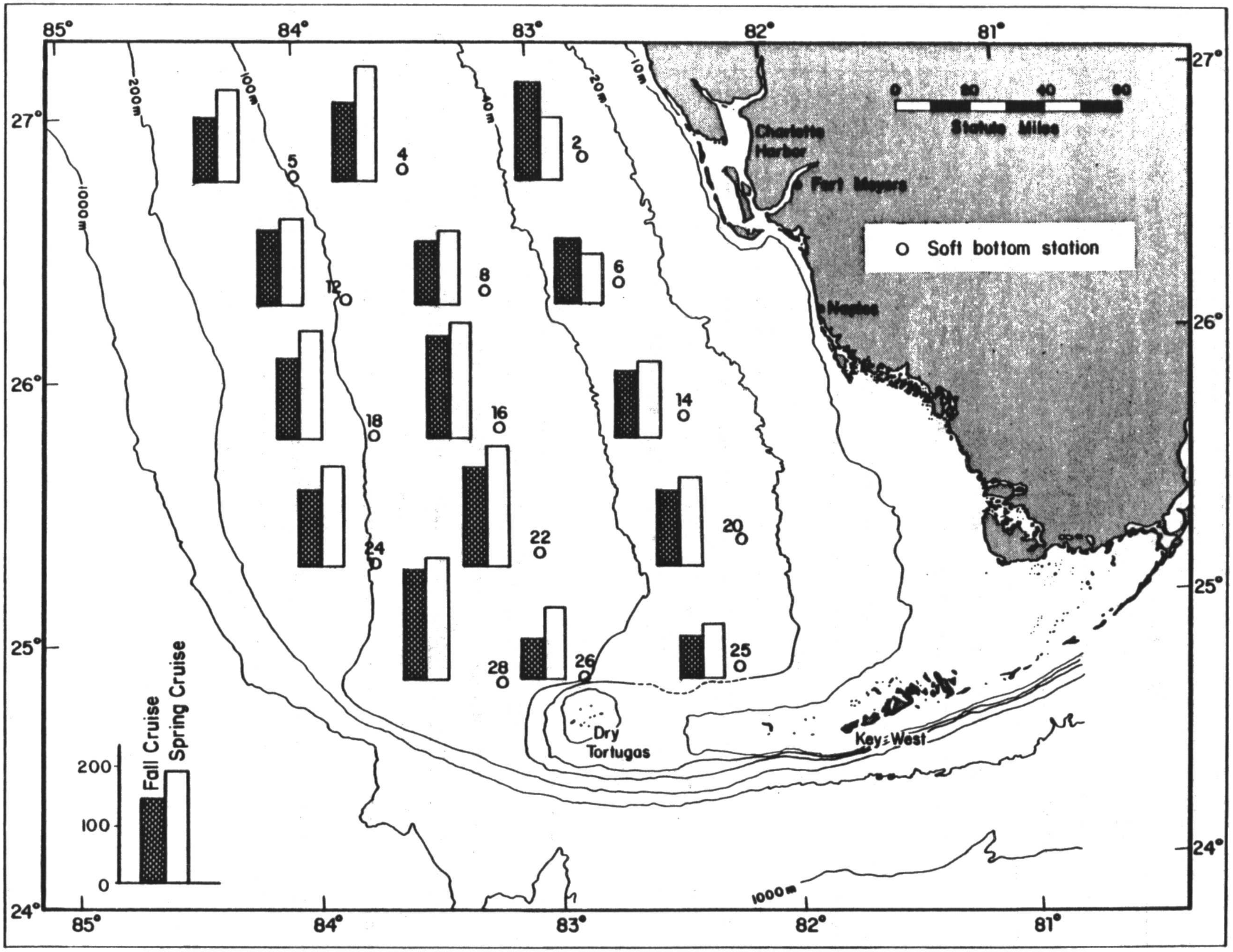

Figure 10-2. Taxonomic richness (number of taxa per station) of macroinfauna collected by box core.

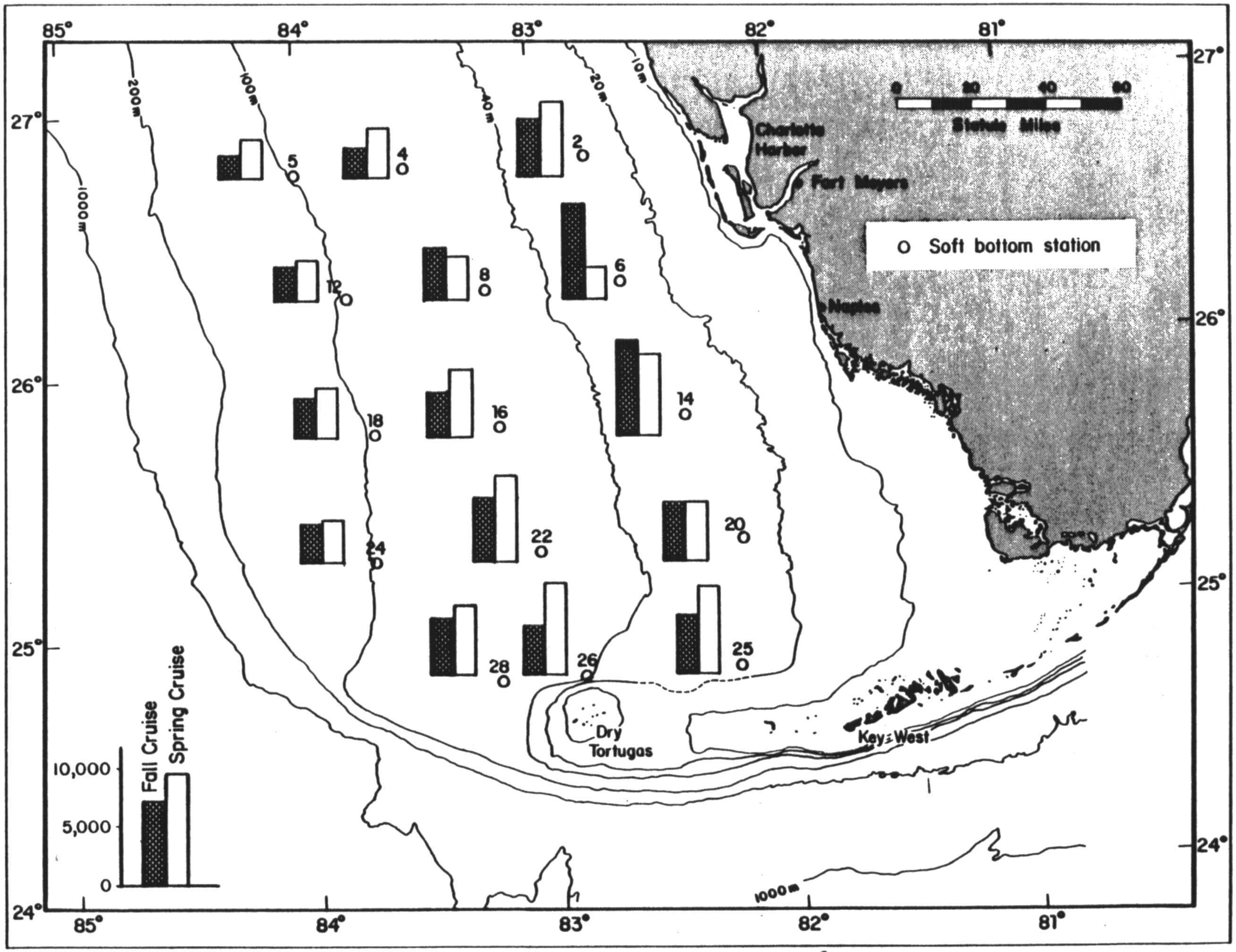

Figure 10-3. Total density of infauna (individuals per m^2) collected by box core.

11.0 LIVE BOTTOM BIOTA

Southwest Florida shelf populations of epibiota were characterized during the fall and spring at 15 live bottom stations. Characterization was accomplished through a synthesis of photographic (television and still camera) and biological (otter trawl and triangular dredge) data.

Quantitative analysis of 35-mm slides provided estimates of percent coverage of epibiota within live bottom patches at each station (Figure 11-1). In general, low biotal coverages were found over a majority of the live bottom stations. Exceptions to this generalization included those stations in the southwestern portion of the study area (Stations 23, 29, and 30), where relatively high percent coverages were observed. Increased coverage at these stations appears to be due to higher percent coverages of the green alga _Anadyomene menziesii_, coralline algae of the order Cryptonemiales, and the coralline alga _Peyssonnelia simulans_. Station 29, which had the greatest epibiotal coverage, also showed high densities of the hard coral _Agaricia_ spp.

Temporal variations in total epibiotal coverages were usually minor. An exception was the large fluctuation noted at Station 11. During the Fall Cruise, 41% of the live bottom patches at Station 11 were covered by epibiota, while only 7% were covered during the Spring Cruise. This seasonal difference in coverage was due primarily to increased coverage by the green algae _Halimeda_ spp. during the fall.

Epifloral contributions to the total epibiota coverages ranged from 3 to 95%. Relatively high percent coverages were noted at Stations 1, 9, 10, 11, 17, 23, 29, and 30 (Figure 11-2). Dominant epifloral groups included the green algae _Halimeda_ spp., _Anadyomene menziesii_, _Caulerpa_ spp., and Chlorophycophyta; the coralline algae Cryptonemiales and _Peyssonnelia simulans_; the brown algae Phaeophycophyta; and the red algae Rhodophycophyta.

In contrast to epifloral coverage, epifauna dominated live bottom patches at Stations 3, 7, 15, 19, 21 and 27 during both cruises and at Stations 13 and 17 during the Spring Cruise (Figure 11-3). Percentages of total epibiota contributed by epifauna ranged from 5 to 97%. Dominant epifaunal groups

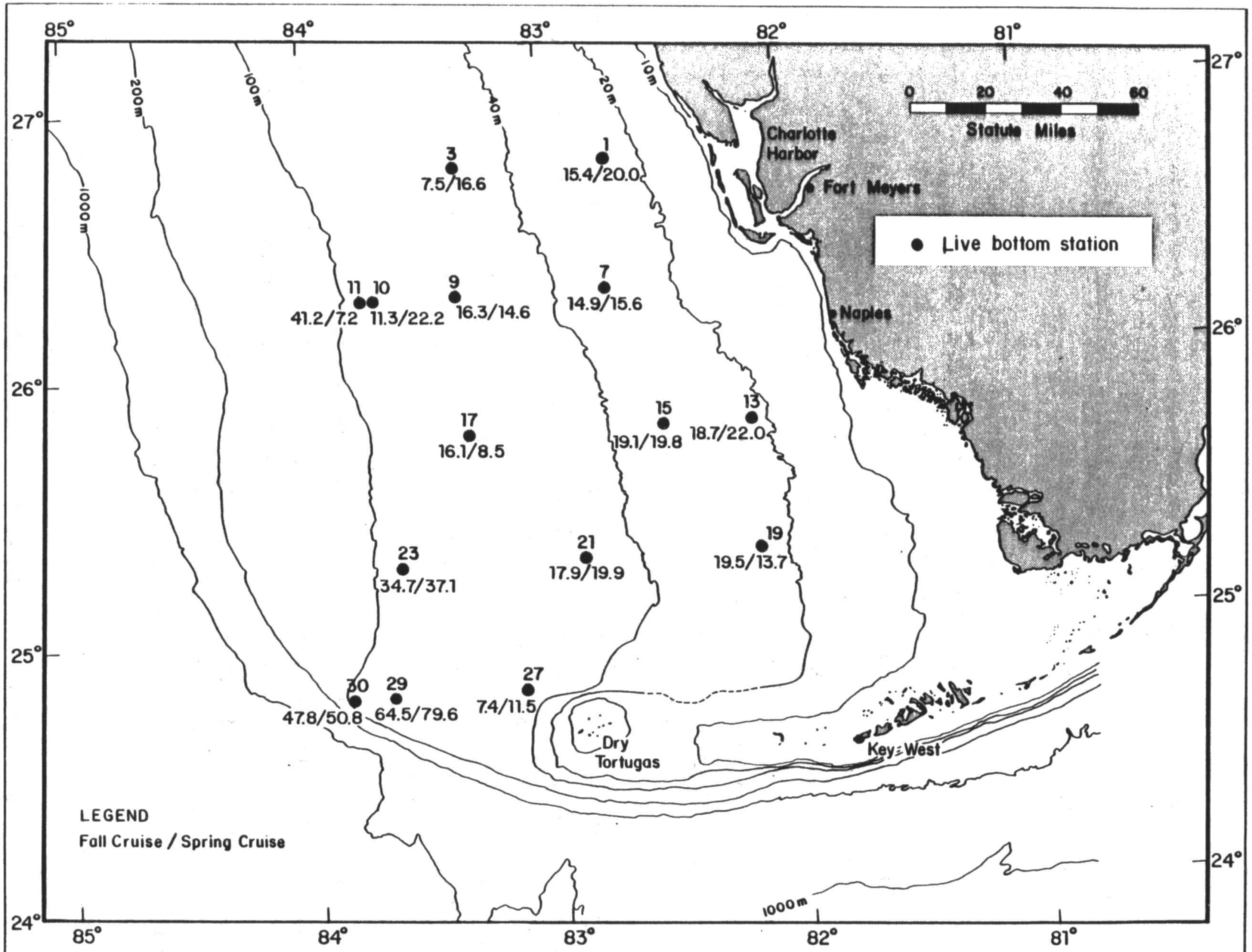

Figure 11-1. Percent coverage of biota within sample station live bottom patches.

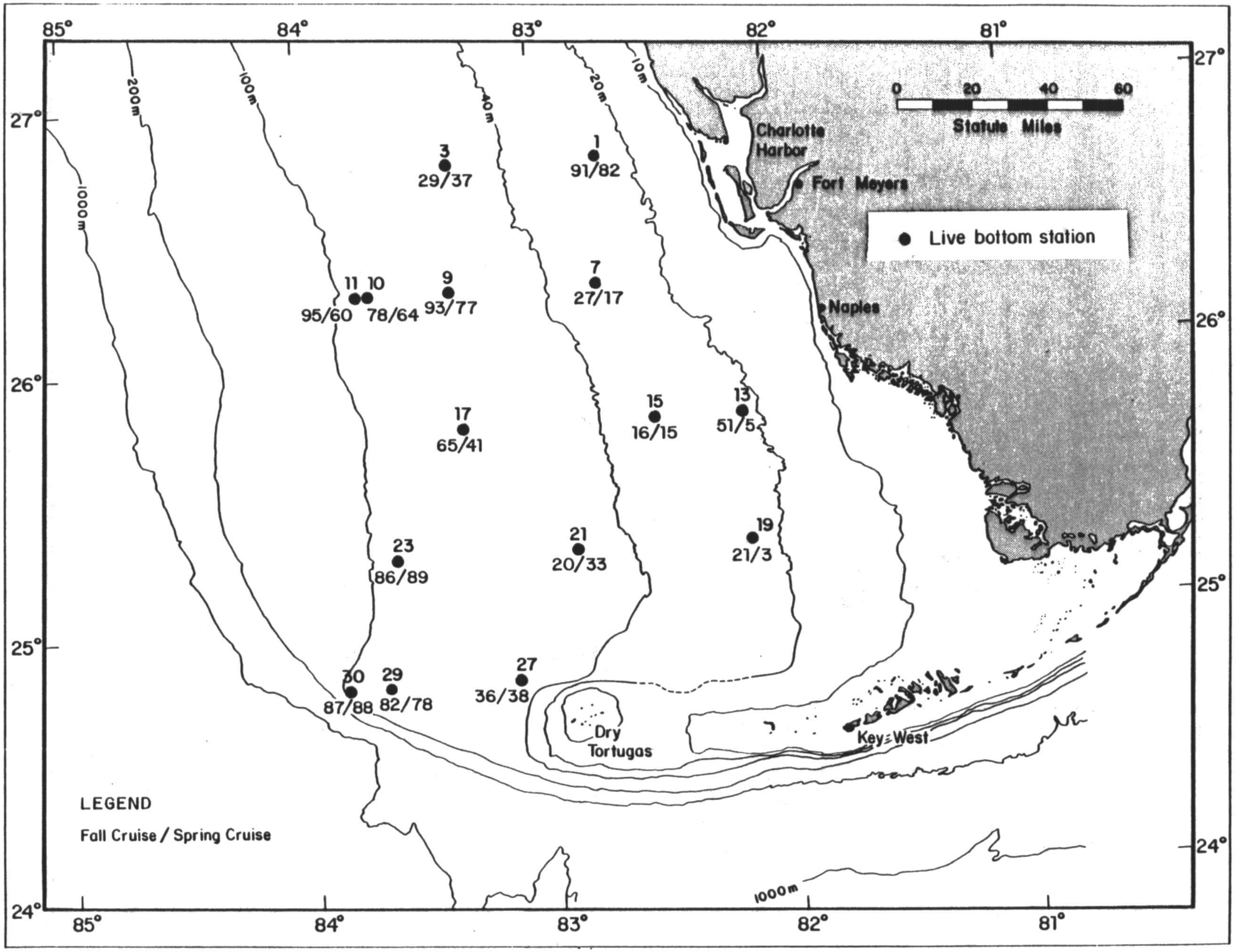

Figure 11-2. Epifloral (algae) coverage expressed as percent of total epibiotal coverage within sample station live bottom patches.

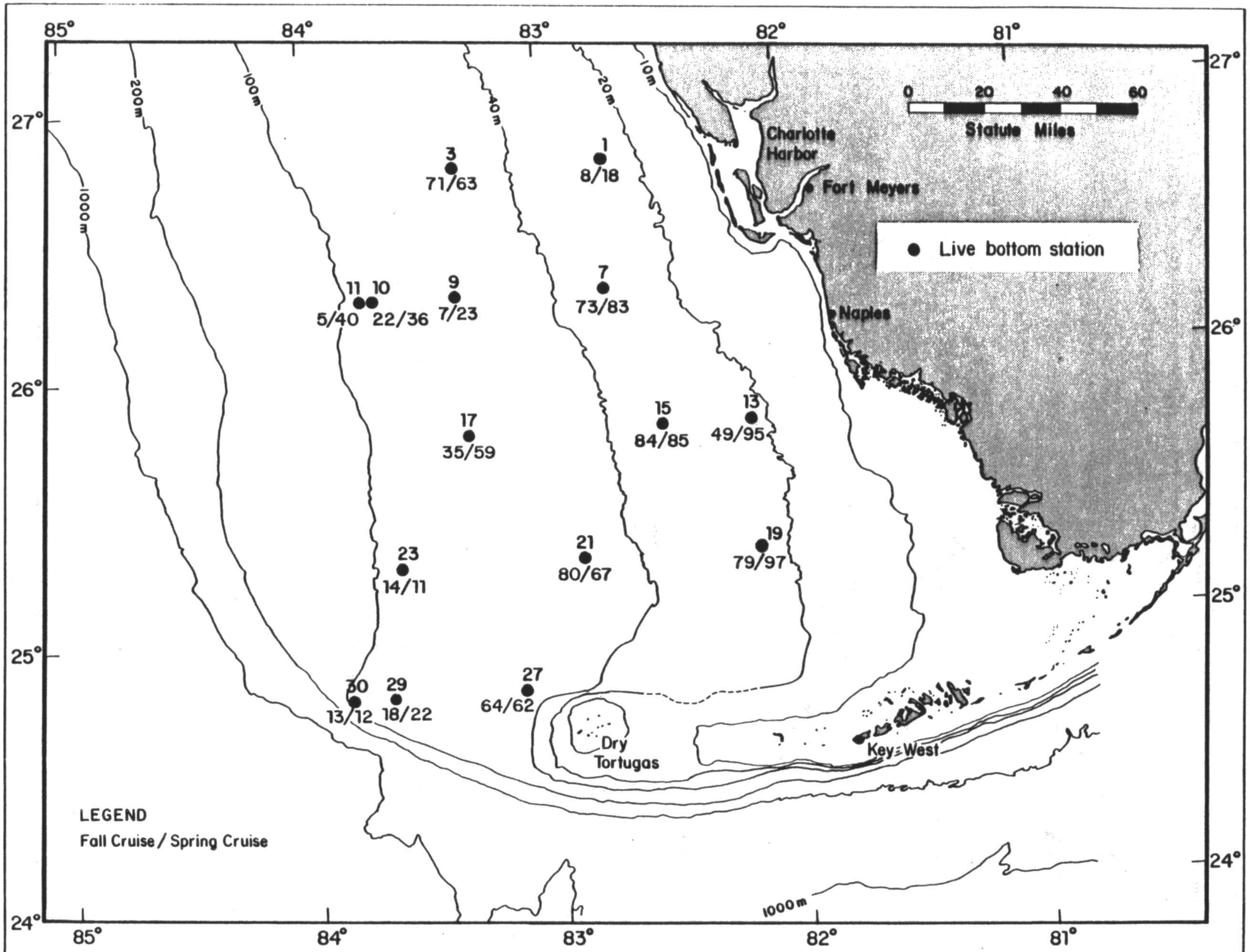

Figure 11-3. Epifaunal coverage expressed as percent of total epibiotal coverage within sample station live bottom patches.

included the sponges Porifera, Calcarea, *Placospongia melobesioides*, and *Geodia* spp.; Hydrozoa; and the hard corals *Agaricia* spp.

Otter trawl and triangular dredge samples provided qualitative, but more detailed, information concerning the taxonomic composition of the epibiota at live bottom stations. A minimum of 28 new species of sponges, 3 new species of fish, 1 new species of echinoderm, and 4 new species of molluscs were collected during the present investigation. Numerous geographical range extensions for epibiota were also discerned (Table 11-1). In addition, 211 specimens representing 19 species of relict molluscs, previously known only from Pliocene and Pleistocene deposits, were collected from live bottom sites across the shelf (Figure 11-4).

Species richness (number of species) from trawl and dredge collections varied over wide ranges (Figures 11-5 and 11-6). Numbers of species taken at stations ranged from 40 (Station 29, Fall Cruise) to 138 (Station 3, Fall Cruise) for trawl samples and from 61 (Station 23, Spring Cruise) to 198 (Station 13, Fall Cruise) for dredge samples.

Otter trawl and triangular dredge data were subjected to clustering analysis (Bray-Curtis Index). The results of these analyses, the results of quantitative slide analyses, and television observations at specific stations were synthesized to determine the zonation of southwest Florida shelf epibiota. Distinct onshore-offshore patterns were revealed and assemblages within each zone were temporally stable. Three epibiotal zones were delineated for the shelf; an Inner Shelf Zone, an Inshore Middle Shelf Zone, and an Offshore Middle Shelf Zone (Figure 11-7).

Table 11-1. Range extensions from Southwest Florida Shelf Ecosystems Study - Year 1.

Taxa	Previous Recorded Range
Sponges	
Dysidea ? *avara*	Pacific
Siphonodictyon coralliphagum	West Indies, Caribbean
Microciona ? *microchela*	West Indies
Neofibularia nolitangere oxeata	Western Atlantic
Halichondria ? *magniconulosa*	Western Atlantic
Oxeostilon burtoni	Western Atlantic
Axinella bookhouti	Western Atlantic
Pseudaxinella lunaecharta	Bahamas, West African Coast
Pseudaxinella rosacea	Western Atlantic
Teichaxinella morchella	Bahamas
Teichaxinella ? *corrugata*	Western North Atlantic
Hemectyon ? *pearsei*	Western North Atlantic
Anthosigmella varians forma *incrustans*	Bahamas
Cliona schmidti	Circumtropical
Cliona delitrix	Bahamas, West Indies
Geodia neptuni	Western Atlantic
Erylus formus	Western Atlantic
Hydroids	
Plumularia nigra	Cuba
Octocorals	
Lignella richardii	Western Atlantic
Lophogorgia barbadensis	Western Atlantic
Nicella schmitti	Western Gulf of Mexico, Western Caribbean
Telesto fruticulosa	Western Atlantic
Telesto operculata	West Indies, Northwestern Gulf of Mexico

Table 11-1. (Continued)

Taxa	Previous Recorded Range
Octocorals (Continued)	
Thesea parviflora	Caribbean
Caliacis nutans	Caribbean
Eunicea fusca	Bermuda, West Indies, Caribbean
Keratoisis flexibilis	West Indies, Caribbean
Leptogorgia euryale	Western Atlantic, Western Caribbean, Western Gulf of Mexico
Leptogorgia stheno	Western Atlantic
Virgularia presbytes	Western Atlantic
Crustaceans	
Pagurus carolinensis	Western Atlantic
Echinoderms	
Luidia sagamina	Eastern Atlantic, Western Pacific
Hemichordates	
Rhabdopleura compacta	Bermuda
Fish	
Neomerinthe beanorium	West Indies, Caribbean
Pseudogramma bermudensis	West Indies
Chaenopsis roseola	Western Atlantic, Northern Gulf of Mexico

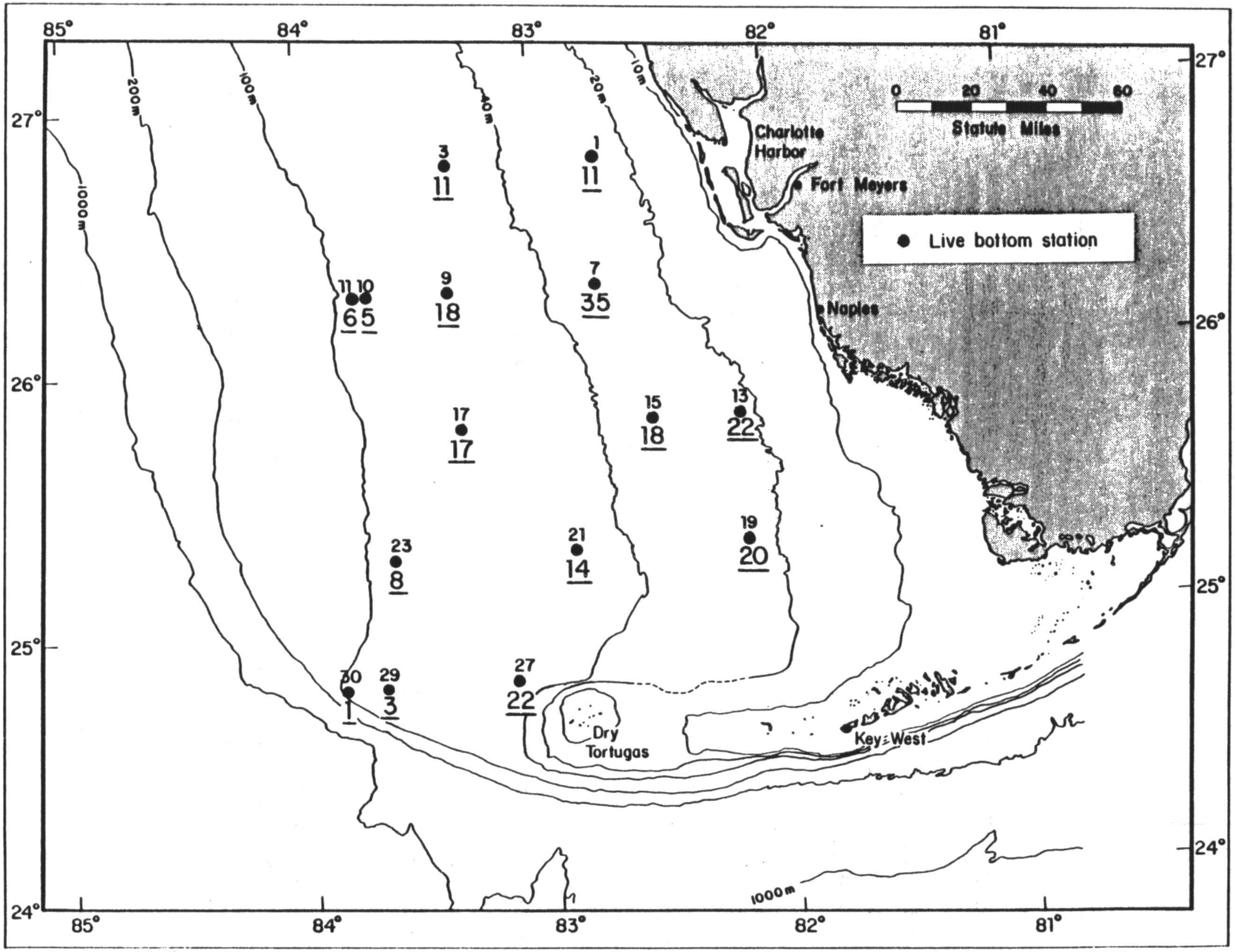

Figure 11-4. Total numbers of relict gastropods collected from each sample location, Fall and Spring Cruises combined (abundances underlined).

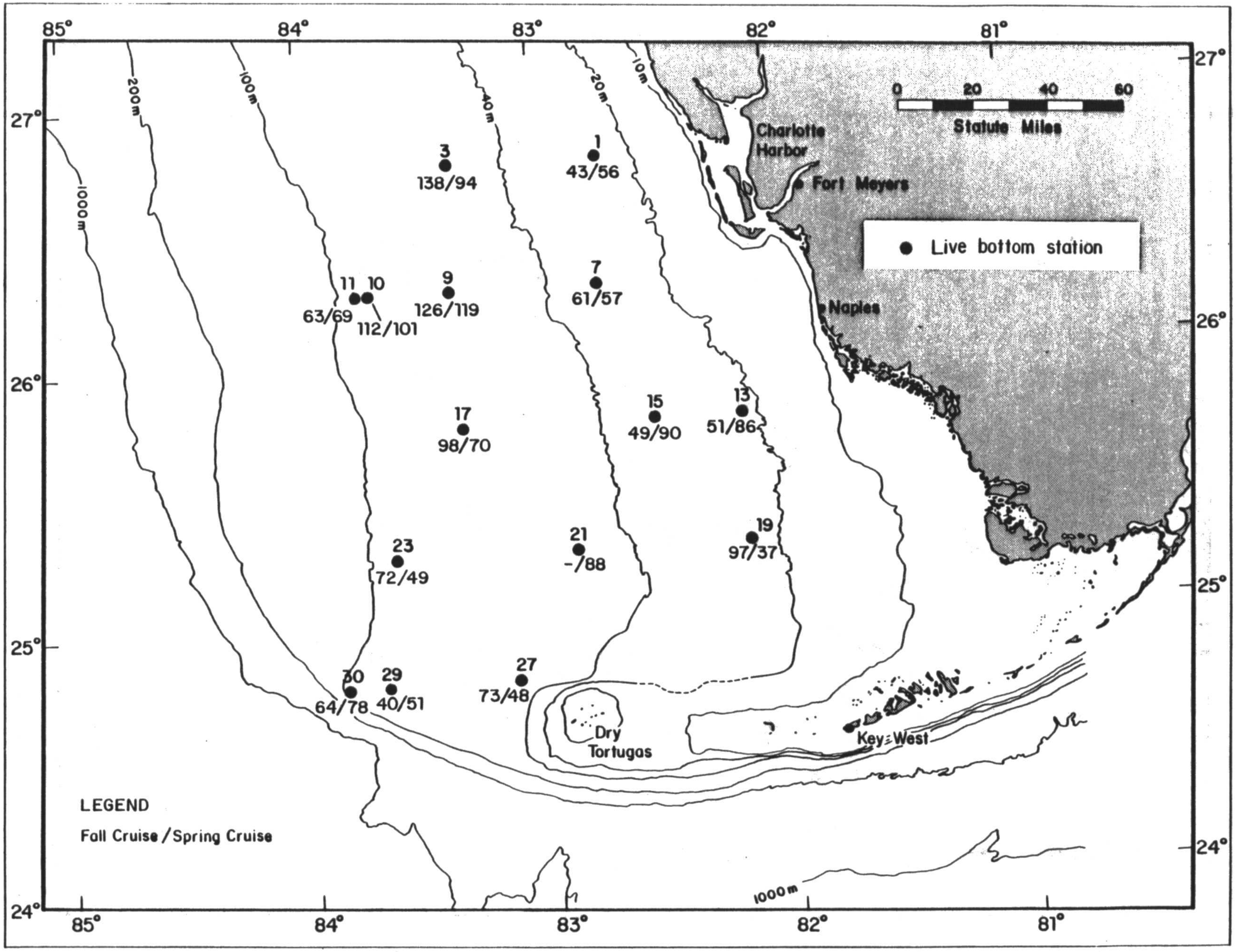

Figure 11-5. Species richness values from Fall and Spring Cruise trawl samples.

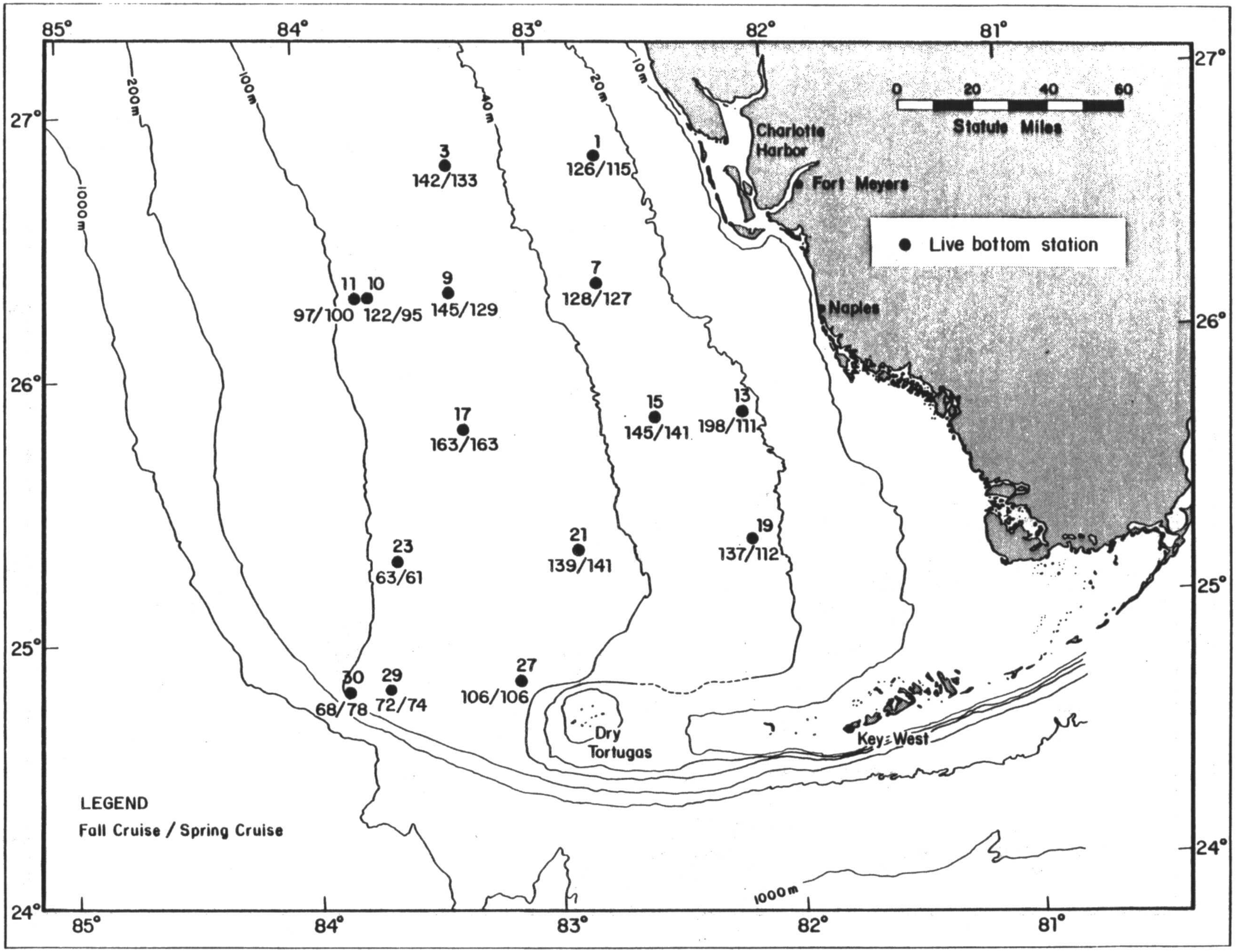

Figure 11-6. Species richness values from Fall and Spring Cruise dredge samples.

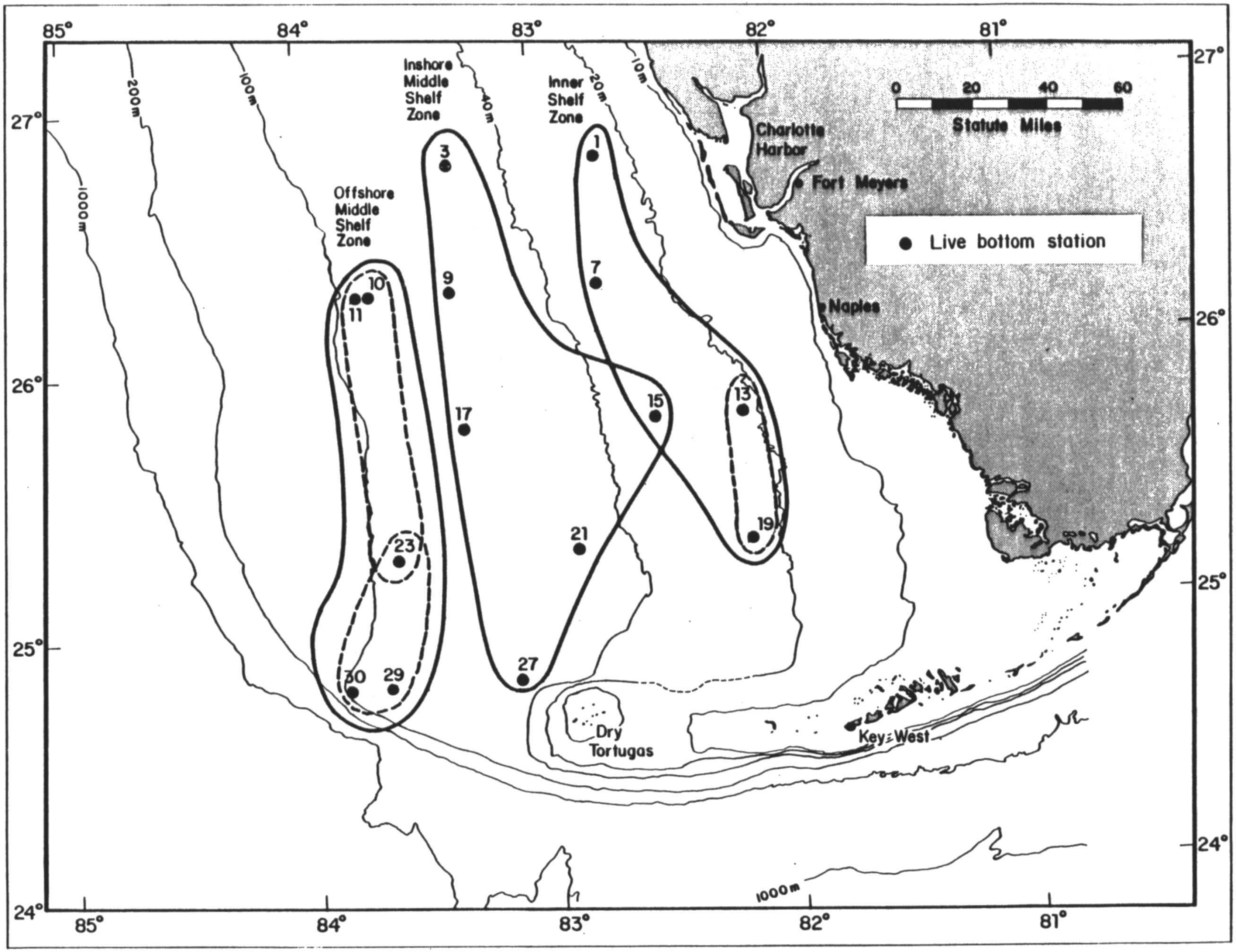

Figure 11-7. Live bottom epibiotal zones of the southwest Florida shelf.

12.0 POTENTIAL IMPACTS OF OIL AND GAS OPERATIONS ON SOUTHWEST FLORIDA SHELF ECOSYSTEMS

Initial impacts on the regional biota of the southwest Florida shelf will probably occur during the exploratory drilling phases of lease block operations. Potential impacts will be associated with activities such as anchoring and placement of platforms and discharge of effluents. These discharges will probably consist of drilling muds, drill cuttings, cooling water, sanitary wastes, or deck drainage and may affect benthic communities in four ways:

1) smothering of sessile invertebrates,
2) changes in community structure due to decreased availability of hard bottom,
3) burial of infauna inhabiting sand cover, and
4) decreased algal growth due to increased turbidity.

Smothering of sessile invertebrates and covering of emergent rock will probably cause the most severe impacts on live bottom assemblages. Complex interactions between components of the biota may either mitigate or intensify these impacts, making them difficult to assess.

Prior to platform placement, the drillsite should be surveyed for buried channels and karst features, minor near-surface faults, rock outcrops, sea floor depressions, and live bottom assemblages. The type of sea floor impact will depend upon the platform utilized.

During production and development operations, potential environmental impacts may result from the discharge of produced water as well as larger quantities of drilling mud and cuttings. Since the present concentrations of hydrocarbon and trace metals in the surficial sediments are relatively low, any contamination of these components caused by oil and gas development activities should be readily distinguishable.

Impacts of drilling mud discharges will differ between shunted (subsurface or near-bottom) and unshunted (surface or near-surface) discharges. In the latter case, the lighter discharge components will remain in the water column and may cause potential impacts because of their toxicity, reduction in primary and secondary productivity, and bioaccumulation. In the former case, effects in surficial sediment samples are generally not evident beyond about 1 km of the discharge point.

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For pubic information purposes, key contributors to the study are identified below. Their educational backgrounds and respective roles within the program are also specified. Woodward-Clyde Consultants gratefully acknowledges the unique personal contribution of each individual to the overall success of the study.

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