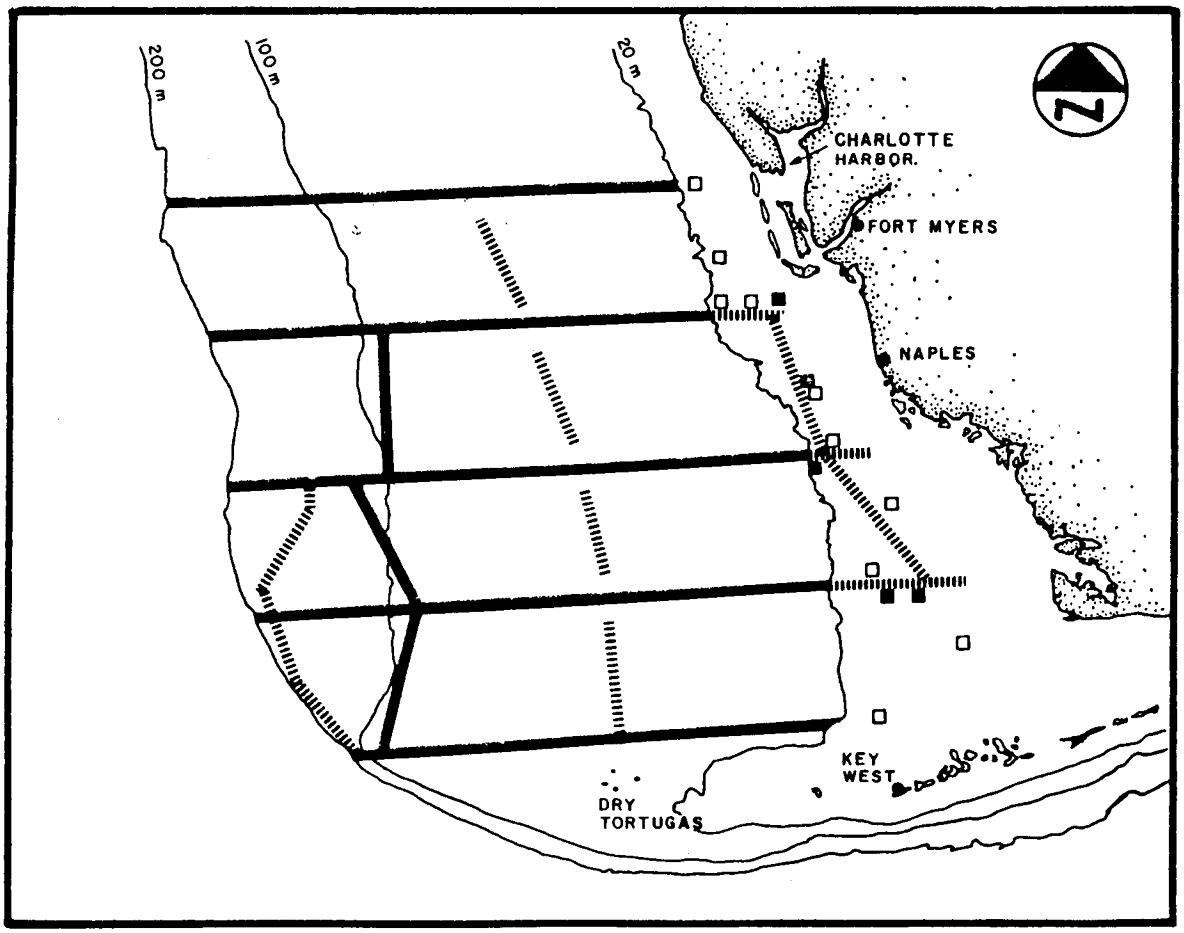
OCS Study
MMS 86-0108

Southwest Florida Shelf Regional Biological Communities Survey: Year 3 Final Report

Volume I
Executive Summary



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

OCS STUDY MMS 86-0108

SOUTHWEST FLORIDA SHELF REGIONAL BIOLOGICAL COMMUNITIES SURVEY

YEAR 3 FINAL REPORT
VOLUME I -- EXECUTIVE SUMMARY

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CONVERSION FACTORS

Multiply	By	To Obtain
Centimeters	0.394	Inches
Meters	3.281	Feet
Square meters	10.765	Square feet
Kilometers	0.621	Miles (statute)
Kilometers	0.540	Miles (nautical)
Square kilometers	0.386	Square miles
Grams	0.035	Ounces
Grams	0.002	Pounds
°C	1.8 (and add 32)	°F

INTRODUCTION

In 1980, the U.S. Department of the Interior began funding environmental studies of the continental shelf off southwestern Florida through the Bureau of Land Management's Environmental Studies Program. Results of two years of field sampling have been presented in reports submitted to the Minerals Management Service (the agency that now supervises the Environmental Studies Program). This report describes the third year of environmental studies.

The Year 3 report consists of three volumes. Volume I is this Executive Summary. Volume II is the final report proper, which details methodology and results. Volume III contains appendices providing methodological details and data listings.

SCOPE AND STUDY ELEMENTS

The study area encompassed water depths of 10 to 200 meters on the continental shelf between Charlotte Harbor and just north of the Dry Tortugas (Figure 1).

Field sampling consisted of three cruises. Cruise I (October 1982) was conducted to map benthic habitats along selected survey transects. Cruises II (December 1982) and III (May-June 1983) were conducted to sample seawater, sediments, and benthic organisms at representative stations.

Major study elements during Year 3 were the same as during the two previous years:

1) Benthic habitat mapping.
2) Benthic station sampling.
3) Hydrographic sampling.

Year 3 differed from the previous study years primarily in geographic scope. The Year 3 study was designed to fill gaps in habitat maps produced during Years 1 and 2 and to sample stations in shallower water depths (10 to 20 meters) than those previously sampled.

Each study element listed above corresponds to one or more chapters in the final report. The following paragraphs summarize the Year 3 study elements in relation to the Year 1 and 2 program.

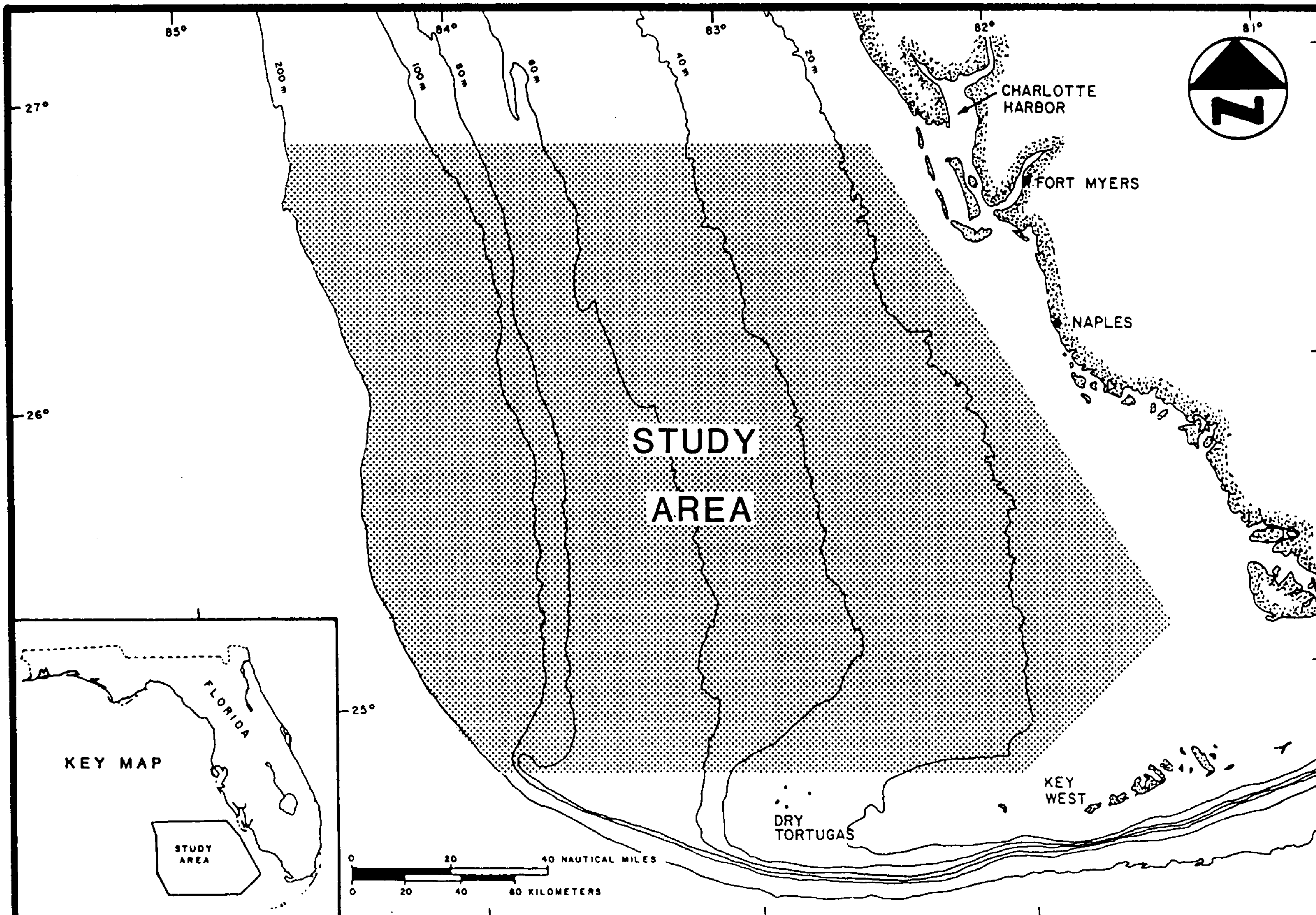

FIGURE 1. STUDY AREA FOR THE SOUTHWEST FLORIDA SHELF REGIONAL BIOLOGICAL COMMUNITIES SURVEY.

Benthic Habitat Mapping. During Years 1 and 2, five east-west transects (A-E) and one north-south transect (F) were surveyed (Figure 2). During Year 3, transects B, C, and D were extended toward shore and six new north-south transects (G-L) were added (Figure 2).

Mapping was accomplished using geophysical and remote photographic instrumentation. Substrates and geologic features were delineated through interpretation of videotapes, photographs, and geophysical records. Benthic habitats were categorized on the basis of visually conspicuous epibiota. Results were compiled into a Year 3 Marine Habitat Atlas (submitted separately to the Minerals Management Service) that supplements an atlas produced during Years 1 and 2.

A major focus of habitat mapping was the delineation of "live bottom." Live-bottom areas are defined as follows:

> "seagrass communities; or 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 and attached to naturally occurring hard or rocky formations with rough, broken, or smooth topography; or whose lithotope favors the accumulation of turtles, fishes, and other fauna."*

Benthic Station Sampling. The locations of stations sampled during Years 1, 2, and 3 are shown in Figure 3. During each study year, new station locations were selected after videotapes from the mapping surveys had been reviewed.

During Year 1, 15 live-bottom stations and 15 soft-bottom stations in water depths of 20 to 100 meters were sampled during fall and spring. During Year 2, 5 live-bottom stations and 4 soft-bottom stations were replaced by new stations in water depths of 100 to 200 meters. These new stations and the remaining Year 1 stations were sampled during summer and winter. During Year 3, 5 new live-bottom stations and 11 new soft-bottom stations were sampled during fall (Cruise II) and spring (Cruise III).

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* U.S. Department of the Interior, Minerals Management Service, 1984. Final Environmental Impact Statement for Lease Sales 94, 98, and 102. Outer Continental Shelf Environmental Impact Statement No. MMS-84-0057.

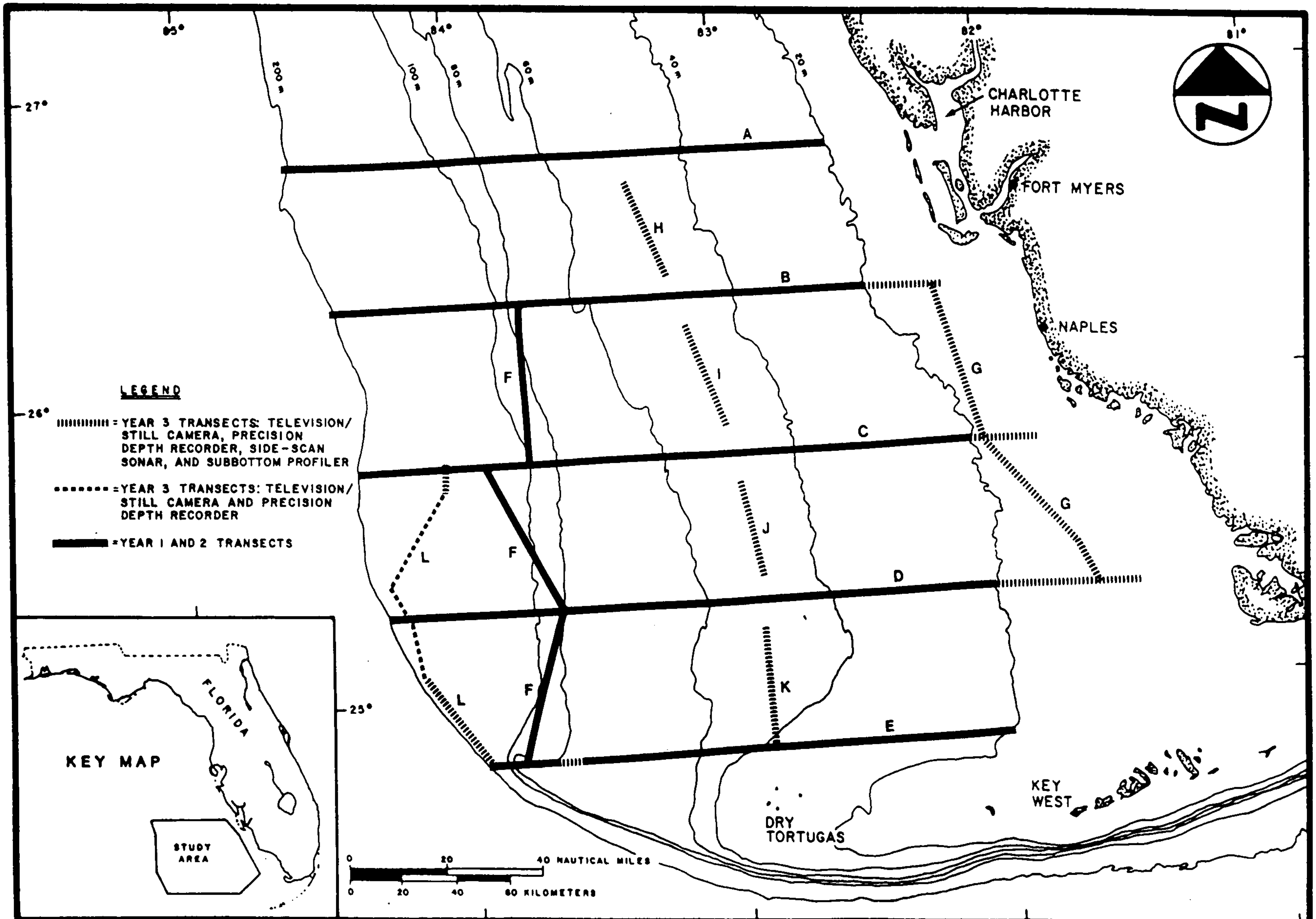

FIGURE 2. LOCATIONS OF YEAR 3 TRANSECTS IN RELATION TO YEAR 1 AND 2 TRANSECTS.

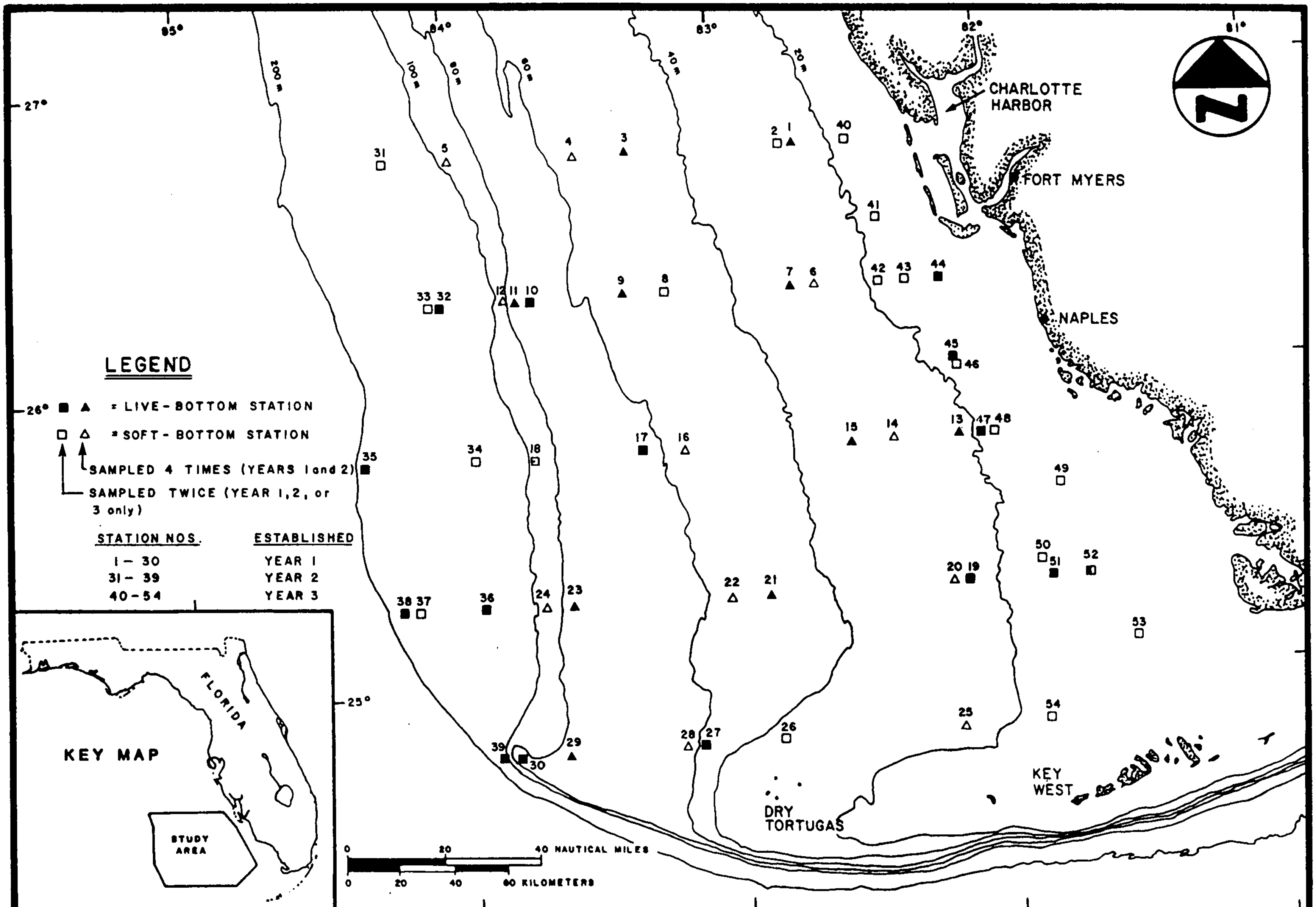

FIGURE 3. LOCATIONS OF YEAR 3 STATIONS IN RELATION TO YEAR 1 AND 2 STATIONS.

All Year 3 stations were in water depths of 10 to 20 meters, where diver sampling methods could be used to supplement or replace remote sampling methods used during previous study years.

At each Year 3 live-bottom station, a remote photographic survey and dredge and trawl sampling were conducted during each cruise. In addition, divers photographed and harvested epibiota, measured sediment thickness, and counted fishes at each station. Sediment trap arrays were deployed at each live-bottom station during Cruise II to be recovered during Cruise III.

At each Year 3 soft-bottom station, divers collected infaunal and sediment samples during each cruise. Sediment samples from all stations were analyzed for grain size and carbonate content. Samples from 10 of 11 stations were analyzed for hydrocarbons.

Hydrographic Sampling. During Year 1, hydrographic profiling (temperature, salinity, dissolved oxygen, nutrients, chlorophyll, water clarity, and light) was conducted at all 30 Year 1 stations during fall and spring. During Year 2, profiling was conducted at 15 stations during summer and winter. During Year 3, profiling was conducted at the 5 live-bottom stations during fall (Cruise II) and spring (Cruise III). No nutrient, chlorophyll, or light measurements were made during Year 3. Additional surface salinity sampling and hydrographic profiling were conducted during the habitat mapping cruise (Cruise I).

STUDY OBJECTIVES

Major study objectives were as follows:

1) To map the distribution of substrate types and benthic community types on the shelf.

2) To characterize the substrate and the benthic community at representative soft-bottom and live-bottom stations.

3) To examine relationships between the composition of benthic communities and factors such as water depth, latitude, and substrate type.

4) To compare and evaluate certain methodologies (e.g., side-scan sonar vs. remote photography; remote vs. diver sampling techniques).

5) To determine the hydrographic structure of the water column at selected locations.

6) To discuss findings in relation to pertinent previous and ongoing studies of the west Florida shelf.

The Year 3 report focuses primarily on data collected during Year 3. However, we have integrated our findings with those of the two previous study years wherever possible in order to fulfill these objectives more completely.

HYDROGRAPHY

Year 3 hydrographic sampling was more limited in scope than that of the two previous study years. Sampling was conducted as follows:

1) During Cruise I (October 1982), surface salinity and temperature samples were collected at approximately 10-kilometer intervals along and between survey transects (Figure 4). Depth profiling of temperature, salinity, dissolved oxygen, and water clarity was conducted at both ends of each transect surveyed (except L--southern end only).

2) During Cruises II (December 1982) and III (May-June 1983), depth profiling of temperature, salinity, dissolved oxygen, and water clarity was conducted at each live-bottom sampling station (Figure 4).

3) During Cruise II, a recording thermograph was deployed near the bottom at Stations 44 and 52. During Cruise III, the thermograph at Station 52 was recovered, but the other one was lost (probably to shrimp trawlers).

In addition, weather and sea-state observations were recorded at approximately 4-hour intervals during each cruise.

TEMPERATURE

During Cruise I (October), surface temperature values ranged from 24°C (southern part of Transect L) to 28.5°C (west end of the Year 3 portion of Transect C). Near-bottom temperatures ranged from 18.5°C at 104 meters depth (southern end of transect L) to 28.5°C at 18 meters depth (west end of Transect C). Temperature profiles indicated the surface mixed layer extended to approximately 35 to 40 meters depth. Wind mixing probably was just beginning to occur as the cruise took place.

Sampling at the live-bottom stations during Cruise II (December) revealed temperatures ranging from 23.9°C to 24.7°C; surface and near-bottom values were similar. Cruise III (May-June) sampling revealed temperatures ranging from 24.0°C to 28.5°C; there was a thermocline at one station (47). Temperatures increased from north to south during both cruises.

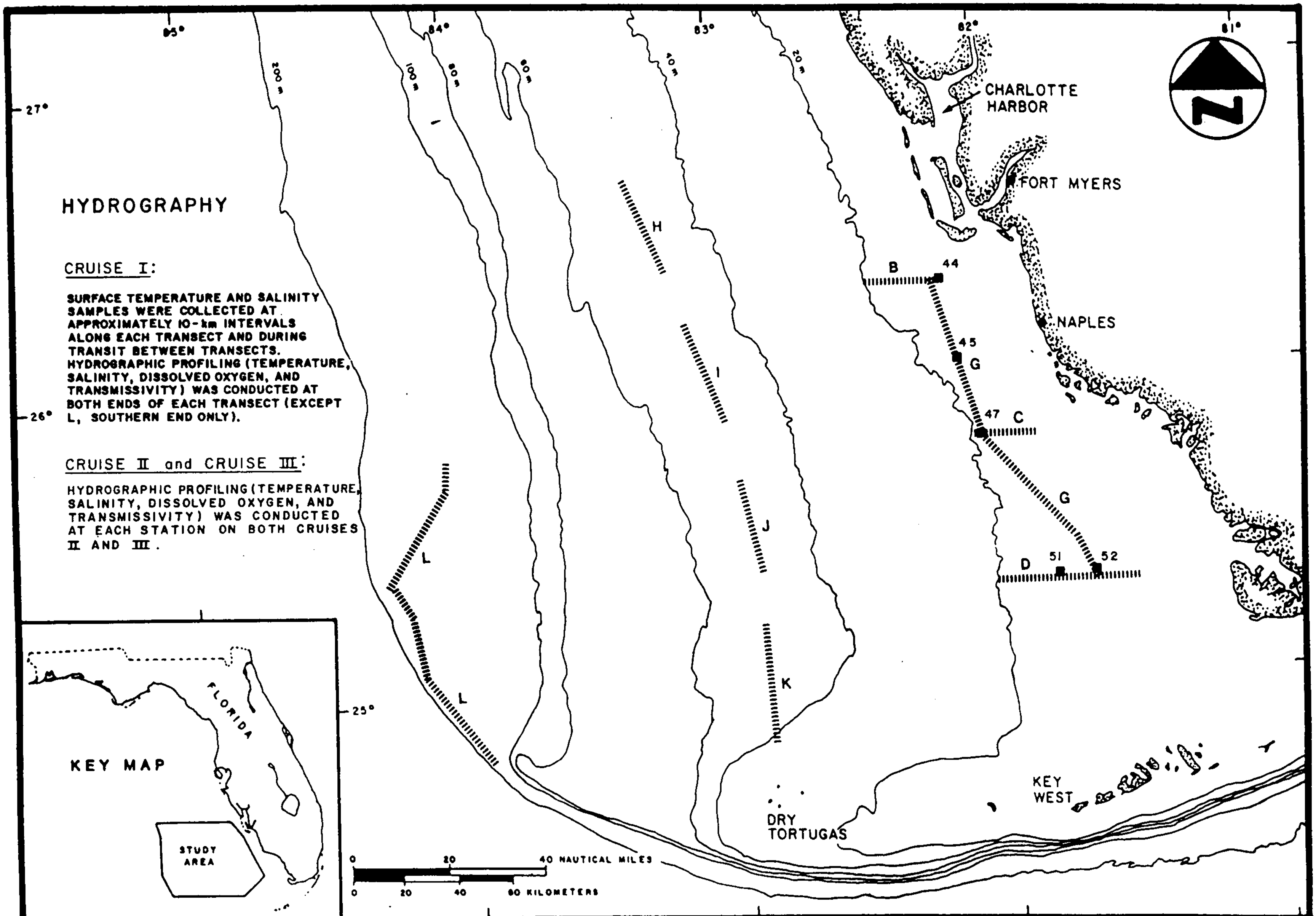

FIGURE 4. LOCATIONS OF CRUISE I SURVEY TRANSECTS AND CRUISE II AND III HYDROGRAPHIC SAMPLING STATIONS.

The recording thermograph deployed at Station 52 provided details of winter and spring temperatures near the seafloor (Figure 5). Temperatures decreased from about 24°C on 10 December to a minimum of 17.8°C near the end of January. Temperatures less than 18°C (considered a lower tolerance limit for many tropical marine species) persisted for only four days. Temperatures rose gradually from the end of January to about 26°C at the time of recovery (4 June).

SALINITY

A summary of Cruise I (October 1982) surface salinity data is provided in Figure 6. The prominent features are an area of high salinity to the southeast (Florida Bay region) and an area of low salinity off Charlotte Harbor. The former may be due to low Everglades runoff and high evaporation rates in the shallow Florida Bay region. The latter reflects freshwater outflow from the Charlotte Harbor estuary.

Salinities at the nearshore stations ranged from about 35.15°/oo (parts per thousand) to 36.00°/oo during both Cruise II (December) and Cruise III (May-June); there were minimal differences between surface and near-bottom values. The low salinities within this range were observed at Station 44, which is relatively close to freshwater outflow from Charlotte Harbor.

DISSOLVED OXYGEN

Dissolved oxygen values measured during Cruise I ranged from 4.4 to 6.5 milliliters per liter, with the lowest values measured in near-bottom waters (104 meters depth) at the southern end of Transect L. Cruise II and III values at the nearshore stations were in the range of 6 to 7 milliliters per liter. All of the values are indicative of well oxygenated seawater.

WATER CLARITY

Cruise I transmittance values (a measure of water clarity) ranged from 39% to 100%. Waters collected from the Florida Bay region (southeast corner of study area) were turbid, whereas waters collected near the shelf edge (Transect L) were clear. Nearshore waters were turbid from surface to bottom. On the middle shelf, surface waters were clear and turbidity was elevated slightly (transmittance was lower) near the bottom. Outer shelf waters were clear from surface to bottom.

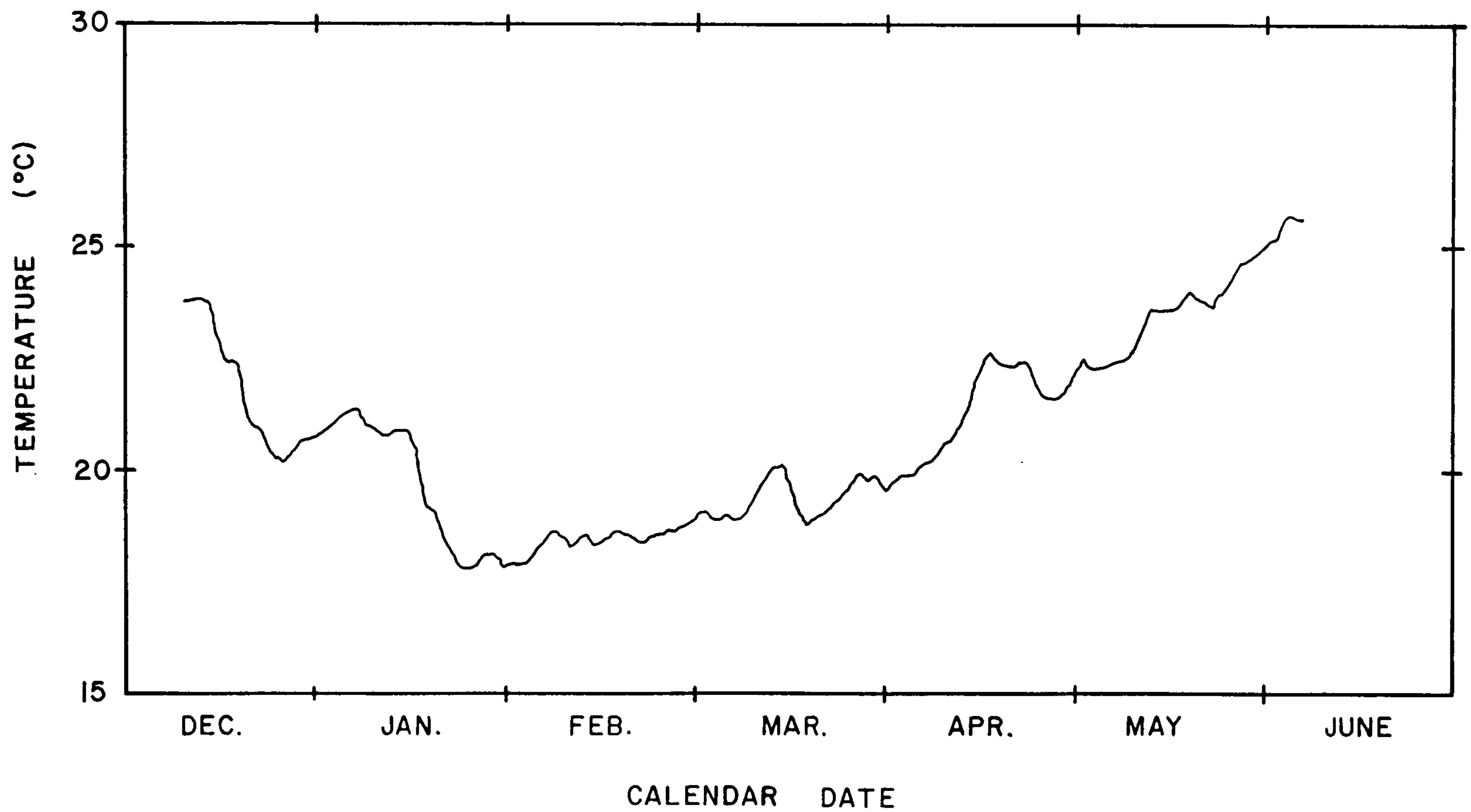

FIGURE 5. NEAR-BOTTOM TEMPERATURES RECORDED BY THERMOGRAPH DEPLOYED AT STATION 52 BETWEEN 10 DECEMBER 1982 AND 4 JUNE 1983 .

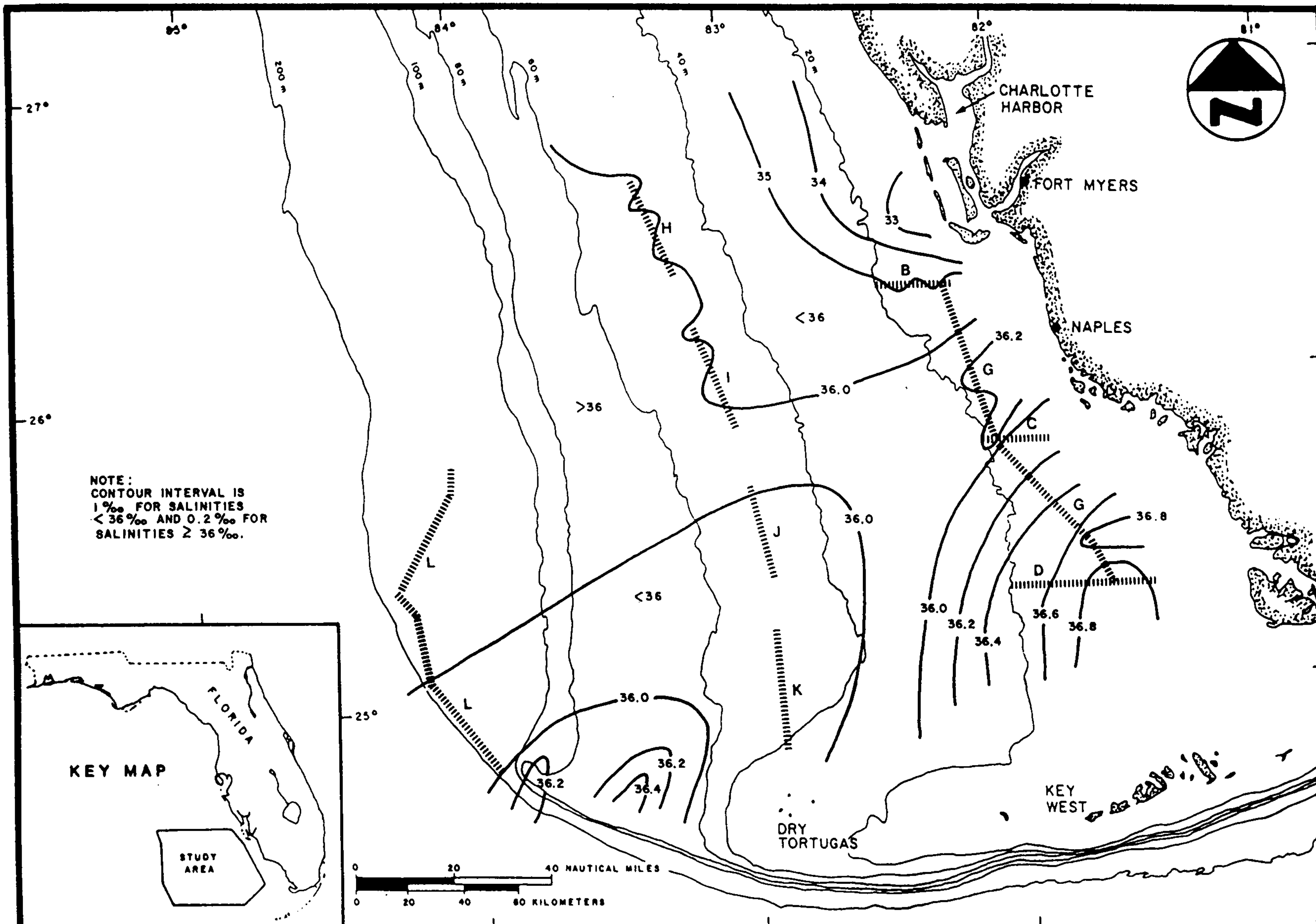

FIGURE 6. SURFACE SALINITY CONTOURS BASED ON CRUISE I DATA.

At the nearshore stations sampled during Cruises II and III, percent transmittance ranged from the 30's to the low 80's during both cruises, with the lowest values (most turbid water) observed at the southernmost stations (especially Station 52) in each case.

Nearshore turbidity in the study area probably is due to resuspension of bottom sediments by storms. In the Florida Bay area, sediments contain a higher percentage of easily resuspended carbonate silt, which may explain the especially high turbidity at the southernmost stations.

BENTHIC HABITAT MAPPING

Year 3 habitat mapping efforts were designed to fill gaps in coverage of the two preceding years. Year 3 transects in relation to Year 1 and 2 transects are shown in Figure 7. During Year 3, Transects B, C, and D were extended landward of the 20-meter depth contour, a portion of Transect E characterized by an algal nodule pavement was surveyed again, and north-south transects G through L were added.

Geophysical and remote photographic instrumentation was used to survey the transects during Cruise I (October 1982). The geophysical equipment consisted of side-scan sonar, a subbottom profiler, and a precision depth recorder. Photographic equipment consisted of a black-and-white television camera and a 35-mm color still camera, both mounted on a towed sled (Figure 8). During the surveys, the sled was towed near the bottom at a speed of one meter per second. The television picture was viewed on a shipboard monitor and recorded on videotape; still photographs were taken at the discretion of the observer. Navigational fixes were recorded concurrently on geophysical records and on the audio track of the videotapes.

Twenty-three maps at a scale of 1:48,000 were produced to summarize the data. The maps were assembled with appropriate legends and key maps into a Marine Habitat Atlas, which was submitted to the Minerals Management Service.*

SUBSTRATES AND GEOLOGIC FEATURES

For mapping purposes, the major substrate types recognized were soft bottom, thin sand over hard bottom, algal nodule layer over sand, and algal nodule pavement. Identification and differentiation of the latter two substrate types depended exclusively upon photographic observations. Major geologic features recognized were rock outcrops--typically low-relief (less than one meter) features; prominences--steep-walled outcrops protruding several meters above thick sand near the shelf edge; and giant sand waves.

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* Continental Shelf Associates, Inc. 1985. Southwest Florida Shelf Regional Biological Communities Survey Marine Habitat Atlas. Prepared for the U.S. Department of the Interior, Minerals Management Service Gulf of Mexico OCS Region, Metairie, LA. Two volumes.

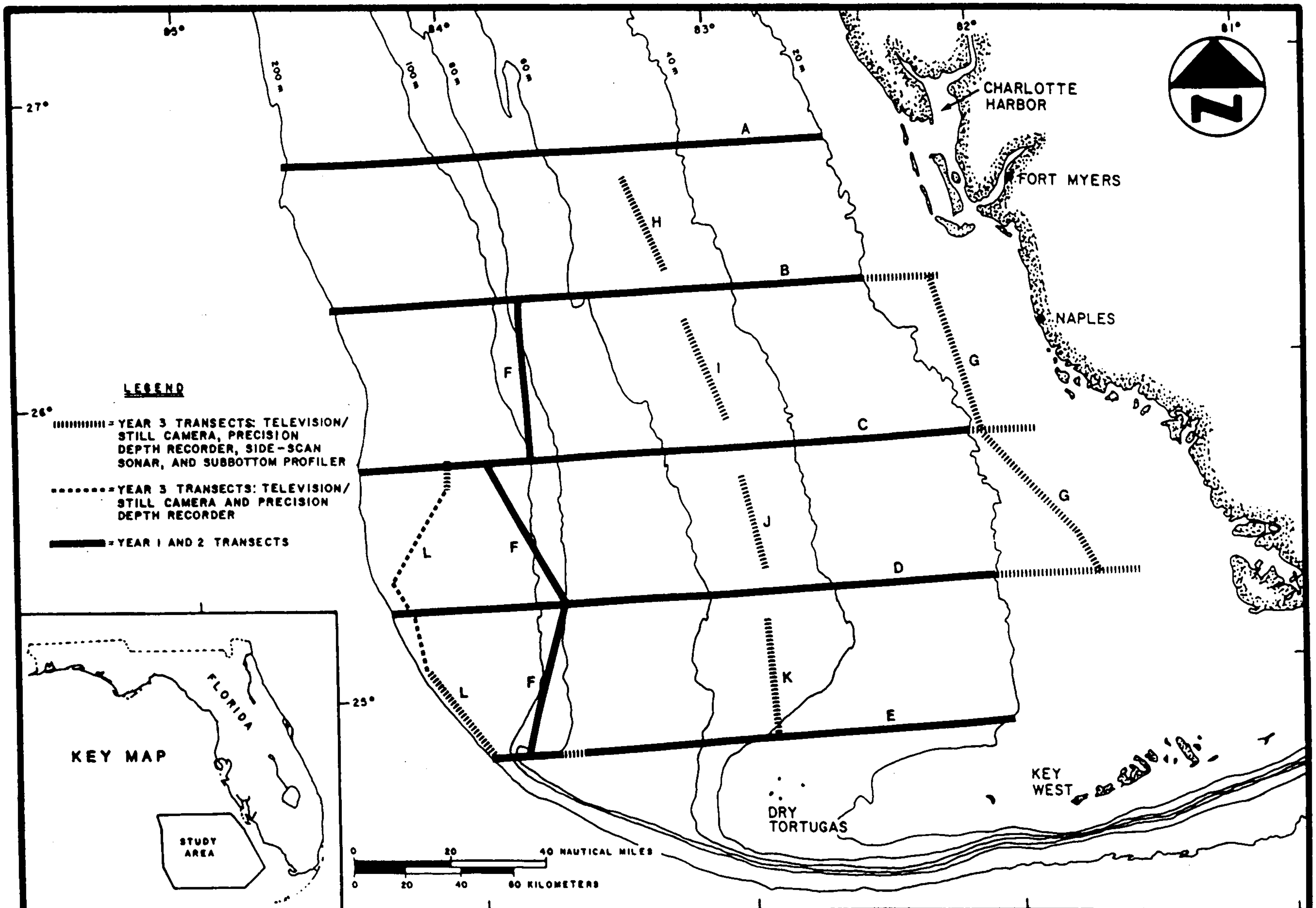


FIGURE 7. LOCATIONS OF YEAR 3 TRANSECTS IN RELATION TO YEAR 1 AND 2 TRANSECTS.

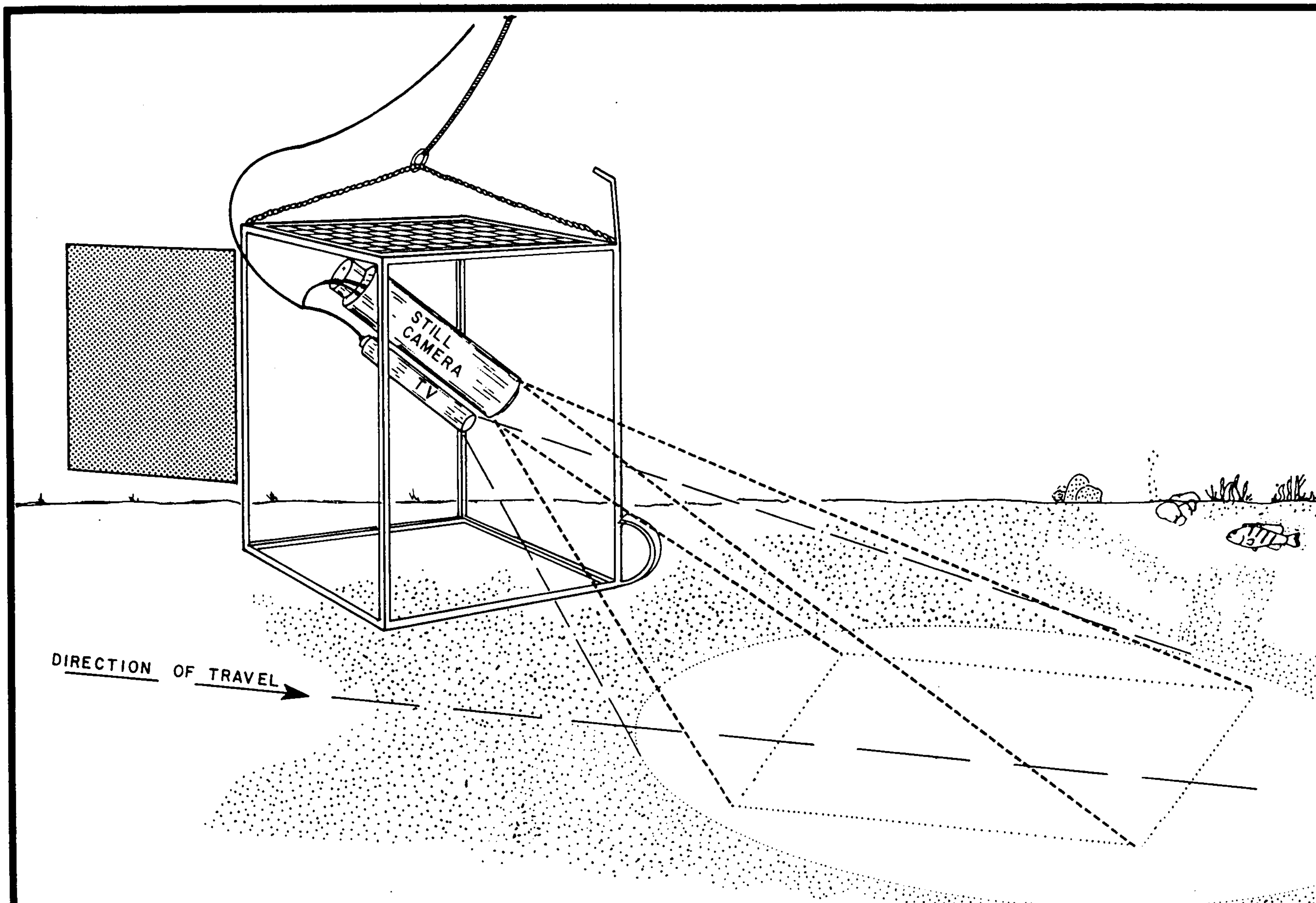


FIGURE 8. UNDERWATER TELEVISION/STILL CAMERA SYSTEM.

Photographic observations indicated substrates along the nearshore transects (G and extensions of B, C, and D) were soft bottom (56%) or thin sand over hard bottom (44%). A few small areas of rock outcrops were seen or detected geophysically. Giant sand waves (bed forms with wavelengths greater than 100 meters and a height of one to three meters) were seen along the inshore extension of Transect B.

Along middle shelf Transects H, I, J, and K, the average incidence of thin sand over hard bottom was lower (18%) and the incidence of soft bottom higher (82%) than on the inner shelf. This probably reflects a progressive seaward thickening of the sand veneer overlying hard bottom. More rock outcrop areas were seen on the middle shelf transects than on the inner shelf transects, though none were extensive enough to be detected geophysically.

The portion of Transect E that was surveyed again was characterized exclusively by algal nodule layer over sand (66%) or algal nodule pavement (34%). The nodules and pavement are formed by two genera of coralline algae (*Lithophyllum* and *Lithothamnium*). Attempts to recognize specific geophysical signatures for these substrate types were unsuccessful.

The southern portion of outer shelf Transect L was characterized by a continuous area of thin sand over hard bottom, with rock outcrops observed frequently. The northern portion of the transect was characterized by soft bottom; prominences were seen near the intersection with Transect C.

Figure 9 summarizes the overall distribution pattern of substrates and geological features emerging from Year 1, 2, and 3 mapping surveys. Some important conclusions are as follows:

1) Soft bottom and thin sand over hard bottom are the most common substrate types on the shelf.

2) Rock outcrops are rare, the main exception being near the shelf edge, where partially buried remnants of ancient reef features are exposed.

3) Algal nodule rubble occurs primarily in the 60 to 90 meter depth range. The substrate type occurs more widely and nodule density is greater toward the south within this depth range.

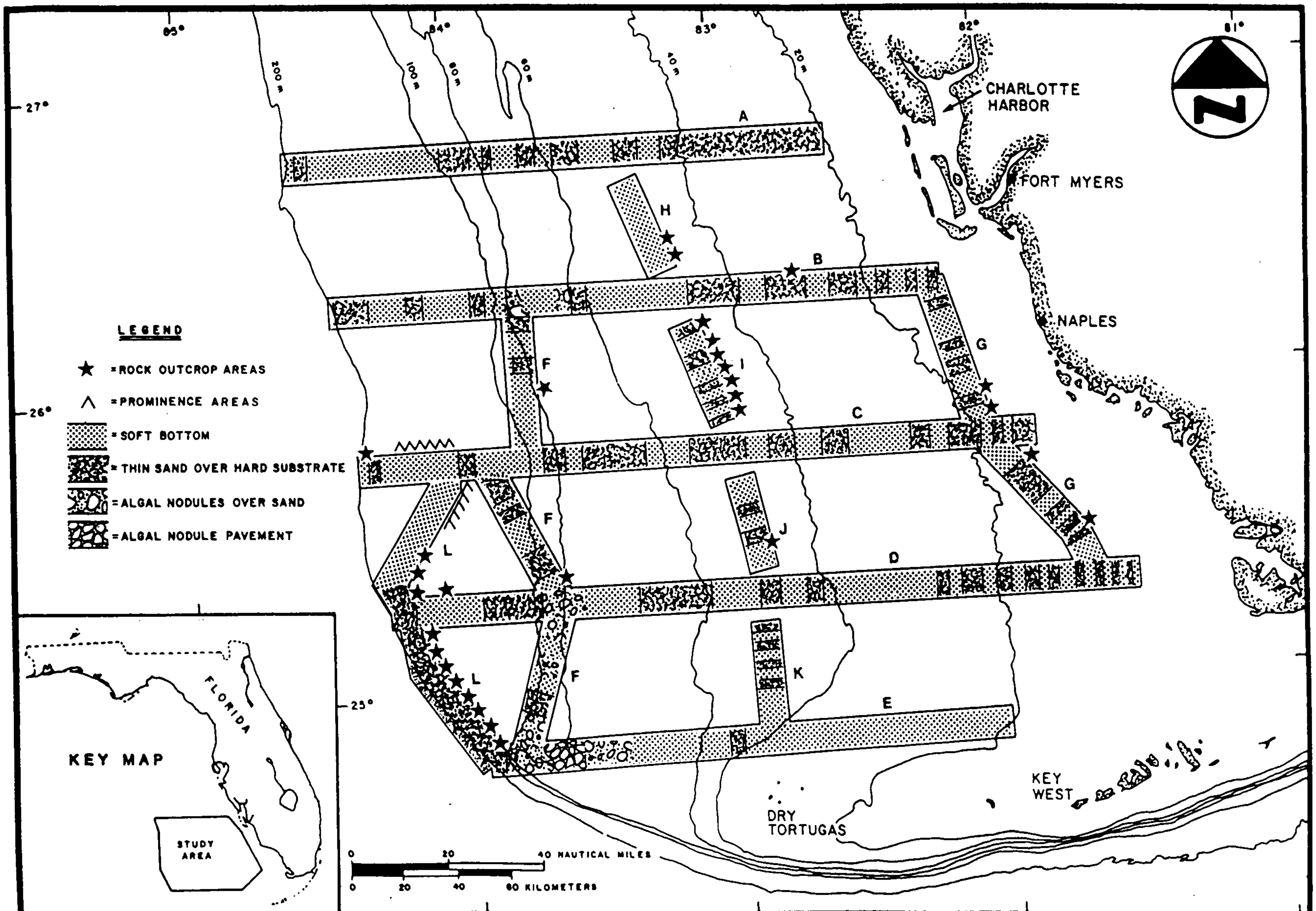


FIGURE 9. DISTRIBUTION OF SUBSTRATE TYPES AND GEOLOGIC FEATURES IDENTIFIED FROM TELEVISION/STILL CAMERA SURVEYS DURING YEARS 1, 2, AND 3.

4) The fused algal nodule pavement occurs only along the southernmost transect (E) in a depth range of 64 to 80 meters.

EPIBIOTA

A classification scheme developed during Year 1 and 2 surveys was used to map benthic epibiota. The eight visually distinct "assemblages" (types of live bottom) are described briefly below.

Along the nearshore transects (G and extensions of B, C, and D), the overall incidence of live bottom was 58%. Two types of live bottom were seen. One, referred to as Inner Shelf Live Bottom Assemblage I, was characterized by large gorgonians and numerous sponges and macroalgae occurring on hard bottom covered by a thin sand veneer. The other, the Inner Shelf Seagrass/Algal Bed Live Bottom Assemblage, was typified by the seagrass Halophila decipiens and a variety of macroalgae occurring on relatively thick sand bottom.

Live-bottom incidence was lower (18%) on the middle shelf transects (H, I, J, and K) than on the nearshore transects. All of the live bottom seen was typified by a large diversity of sponges and algae (but not the gorgonians seen near shore). The assemblage is referred to as Inner and Middle Shelf Live Bottom Assemblage II.

On the portion of Transect E that was resurveyed, the incidence of live bottom was 100%. Two related types of live bottom were seen. One consisted of various calcareous algae and sponges associated with a substrate of coralline algal nodules (Middle Shelf Algal Nodule Assemblage). In the other, the coralline algae had formed a fused crust or pavement, and leafy green algae and plate corals (Agaricia) were abundant (Agaricia Coral Plate Assemblage).

On Transect L, the average incidence of live bottom was 81%. The epibiota, consisting primarily of antipatharians, octocorals, crinoids, and small sponges, were associated either with hard bottom covered by a thin sand veneer (Outer Shelf Low-Relief Live Bottom Assemblage) or high-relief prominences protruding through thick sand (Outer Shelf Prominences Live Bottom Assemblage).

Figure 10 shows the overall pattern of live bottom occurrence emerging from Year 1, 2, and 3 surveys. The figure is a greatly

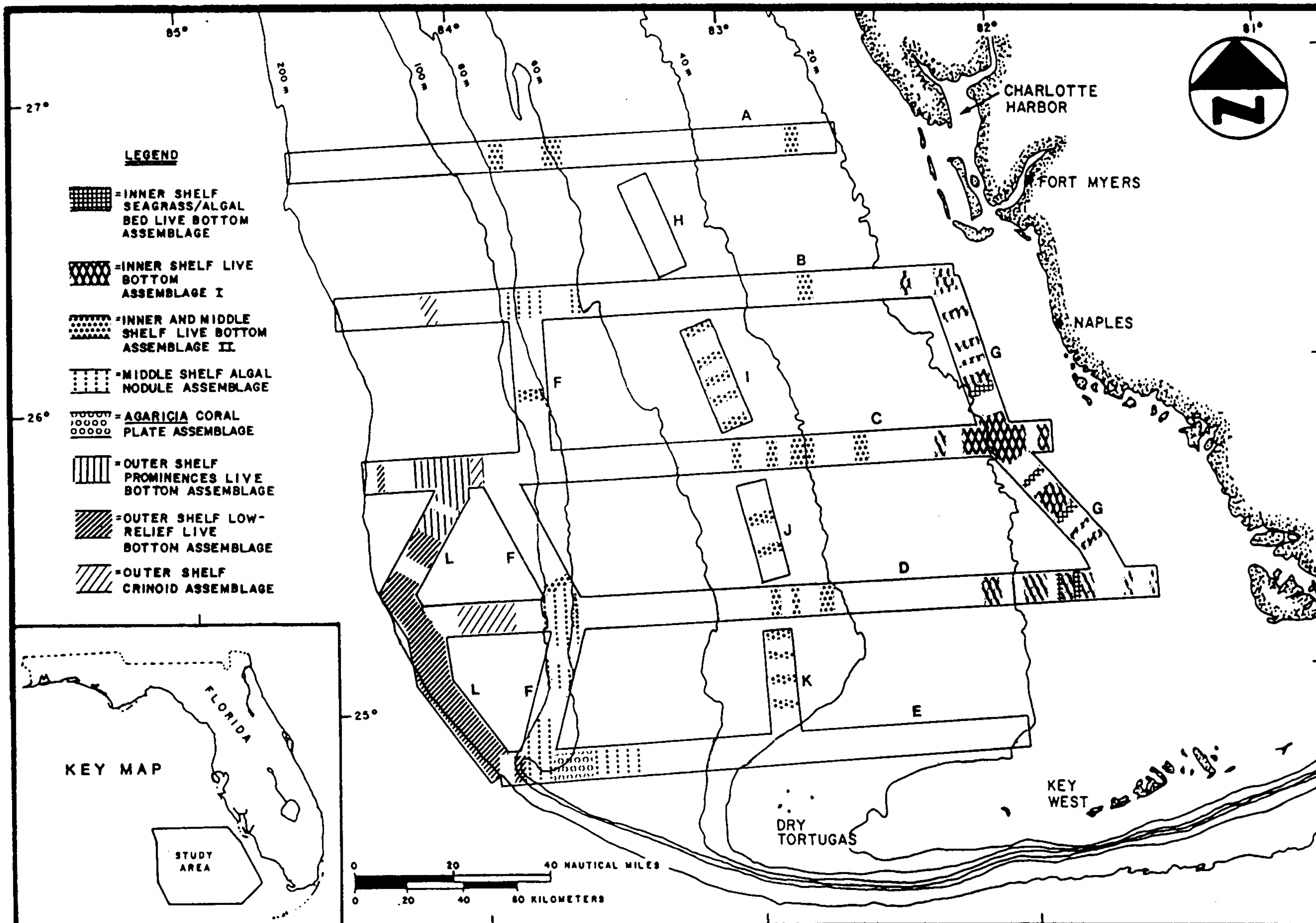


FIGURE 10. DISTRIBUTION OF LIVE-BOTTOM ASSEMBLAGES IDENTIFIED FROM TELEVISION/STILL CAMERA SURVEYS DURING YEARS 1, 2, AND 3.

simplified composite of maps presented in the Marine Habitat Atlases prepared for Years 1 and 2 and Year 3. An additional live-bottom assemblage not mentioned above, the Outer Shelf Crinoid Assemblage, is included. This type of live bottom seen during Year 2 surveys was typified by crinoids and small sponges occurring on rubble or low-relief exposed rock in water depths of 118 to 168 meters.

Some general conclusions based on the combined Year 1, 2, and 3 benthic biological mapping:

1) The average incidence of live bottom is about 33%.

2) Most live bottom is associated with thin sand over hard bottom or with surface rubble layers (coralline algal nodules or pavement, shell rubble, etc.) rather than with rock outcrops.

3) Occurrence patterns of the "assemblages" suggest that zonation of epibiota is related primarily to water depth. There is a latitudinal gradient in water depths of 60 to 90 meters: the algal nodule pavement and associated plate corals (Agaricia) occur only on the southernmost transect (E) in this depth range.

4) Both geophysical and photographic survey techniques have limitations for purposes of mapping live bottom. Because the field of view of the towed television is very narrow, geophysical profiling affords greater breadth of coverage along a given transect. However, certain types of live bottom cannot be detected or differentiated on the basis of geophysical interpretation alone.

LIVE-BOTTOM STATIONS

During Year 3, five new live-bottom stations in water depths ranging from 13 to 19 meters were sampled during Cruise II (December 1982) and Cruise III (May-June 1983) (Figure 11). At each station, a photographic survey and dredge, trawl, and quadrat sampling were conducted during each cruise. In addition, divers conducted a fish count to supplement trawl fish data. Finally, sediment trap/thermograph arrays were deployed during Cruise II to be recovered during Cruise III.

PHOTOGRAPHIC SURVEYS

At each station, a television/still camera system was towed over a distance of several kilometers within a square kilometer block. The system was similar to the one shown in Figure 8 except that the still camera was aimed downward to allow quantitative photography. Videotapes were analyzed to determine the presence and relative density of live bottom. Still photographs were screened to eliminate those containing few or no epibiota; then 100 photographs were analyzed by using a random dot overlay method to estimate percent cover for each type of substrate and epibiota.

Television survey results are illustrated in Figure 12, which shows a map of live-bottom occurrence and density at Station 52 (Cruise II). The average incidence of live bottom ranged from 79% (Station 52) to 100% (Station 45). In terms of average live-bottom density (each patch of live bottom was scored as occasional, thin, medium, or dense as illustrated in Figure 12), Station 45 was highest and Station 47 lowest.

Analysis of still photographs indicated the highest percent biotic cover was at Station 45 (about 40%). At the other stations, biotic cover values generally ranged from 15% to 20%. However, higher cover percentages (about 40% to 50%) were noted at Stations 51 and 52 on Cruise II (December) due to a single species of brown algae (*Dictyopteris jamaicensis*). Gorgonians, sponges, and algae were major cover constituents, with gorgonians especially abundant at Station 45.

DREDGE, TRAWL, AND QUADRAT SAMPLING

Three triangle dredge samples and one otter trawl sample were collected at each station on each cruise. At Station 52, dredge and trawl sampling was conducted during the day in addition to the usual

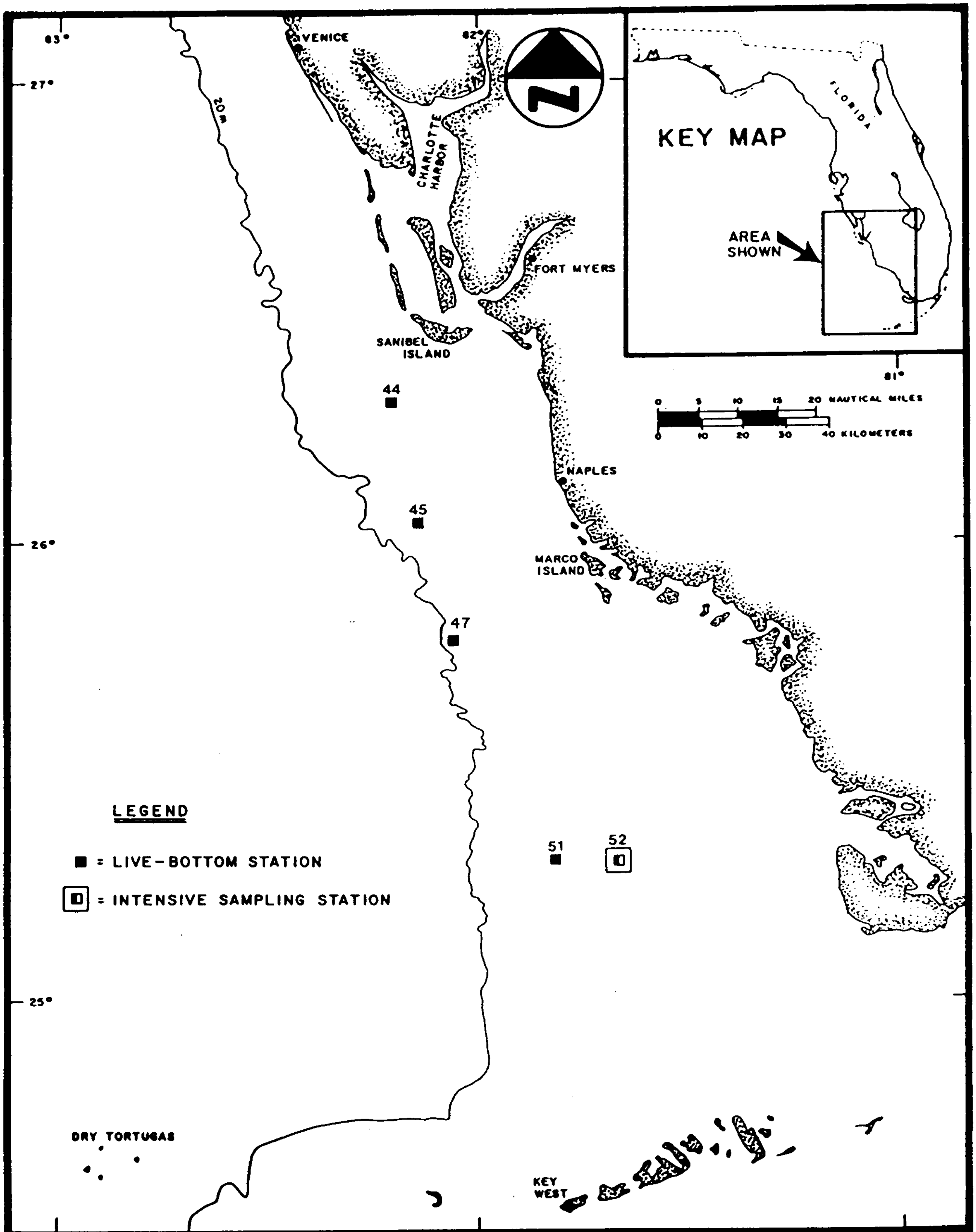


FIGURE 11. LOCATIONS OF LIVE-BOTTOM STATIONS SAMPLED DURING CRUISES II AND III.

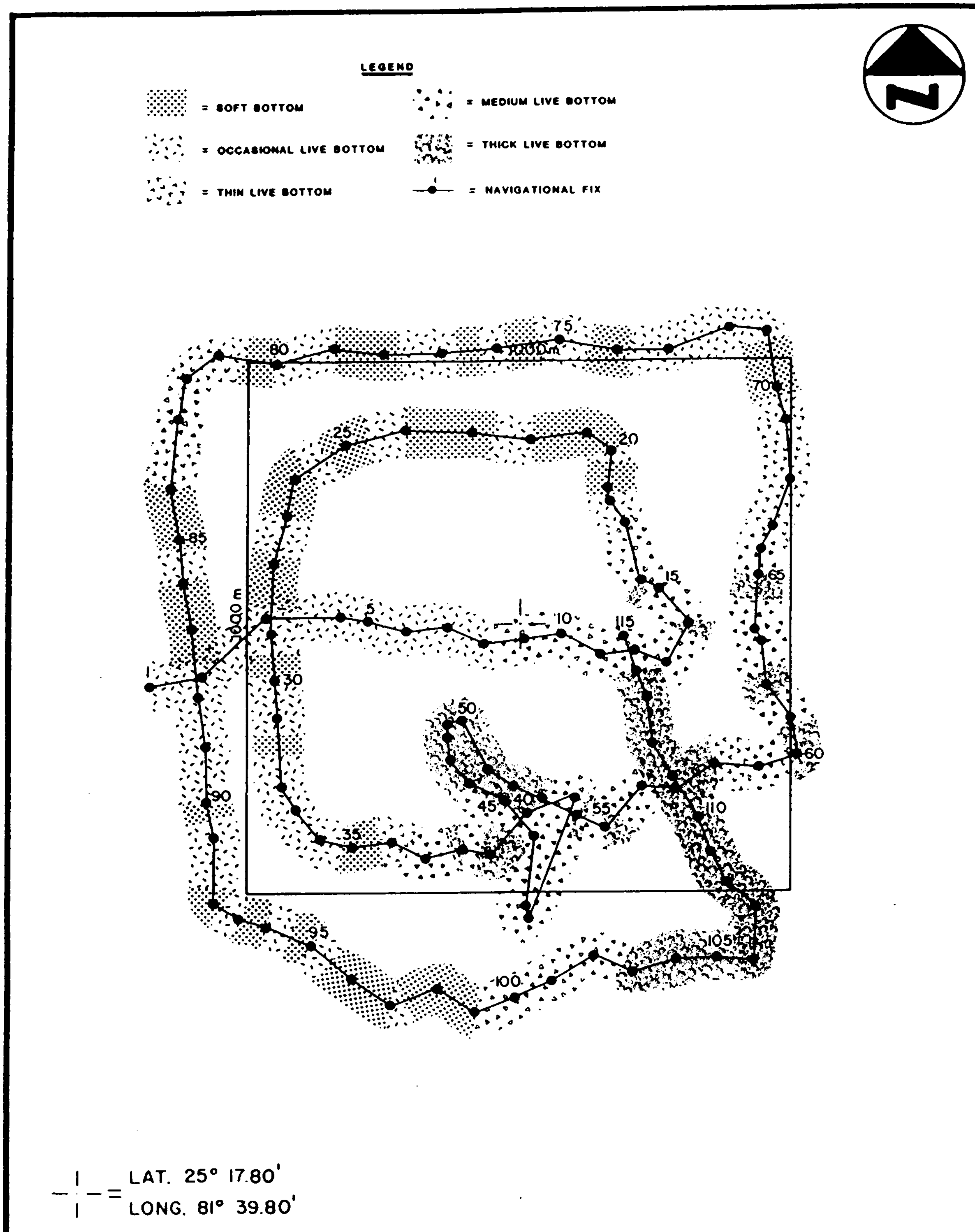


FIGURE 12. EXAMPLE HABITAT MAP FOR STATION 52, CRUISE II.

night sampling. At Station 51 during Cruise II, a set of dredge and trawl samples was collected in a soft-bottom area in addition to the samples from the live-bottom area.

To supplement the remote (dredge and trawl) collections, divers sampled 35 or more quadrats at each station on each cruise. Sampling consisted of photographing the quadrat, measuring sediment thickness, and harvesting epibiota.

Dredge, trawl, and quadrat specimens were sorted and identified with the assistance of taxonomic experts. Quadrat epibiota were weighed to determine biomass of groups such as hard corals, sponges, gorgonians, and algae.

The total numbers of species identified were 539 from dredges, 280 from trawls, and 449 from quadrats. Molluscs, crustaceans, sponges, and algae accounted for about two-thirds of the total in the dredge and quadrat collections and over one-half in the trawl collections. Fishes accounted for about one-fifth of the total species trawled.

Frequently collected sessile epibiota included sponges (Anthosigmella varians, Cinachyra alloclada, Geodia gibberosa), hard corals (Phyllangia americana, Siderastrea radians, Solenastrea hyades), hydroids (Campanularia marginata), bryozoans (Schizoporella unicornis), and algae (Dictyopteris jamaicensis, Udotea conglutinata). Common motile epifauna included brittle stars (Ophiothrix angulata) and crabs (Paguristes tortugae, Petrolisthes galathinus, Pilumnus sayi). Common fishes trawled included scrawled cowfish (Lactophrys quadricornis), white grunt (Haemulon plumieri), planehead filefish (Monacanthus hispidus), jackknife-fish (Equetus lanceolatus), and dusky cardinalfish (Phaeoptyx pigmentaria).

Cluster analysis results for dredge data are illustrated in Figure 13. Station 47, the deepest Year 3 station (19 meters), differed markedly from the others in species composition. Also, Stations 51 and 52 were more similar to each other than to the more northerly stations (44 and 45). Similar patterns were evident in the trawl and quadrat data. Other cluster analyses showed that day/night and seasonal (between-cruise) differences in species composition were less pronounced than spatial (between-station) differences.

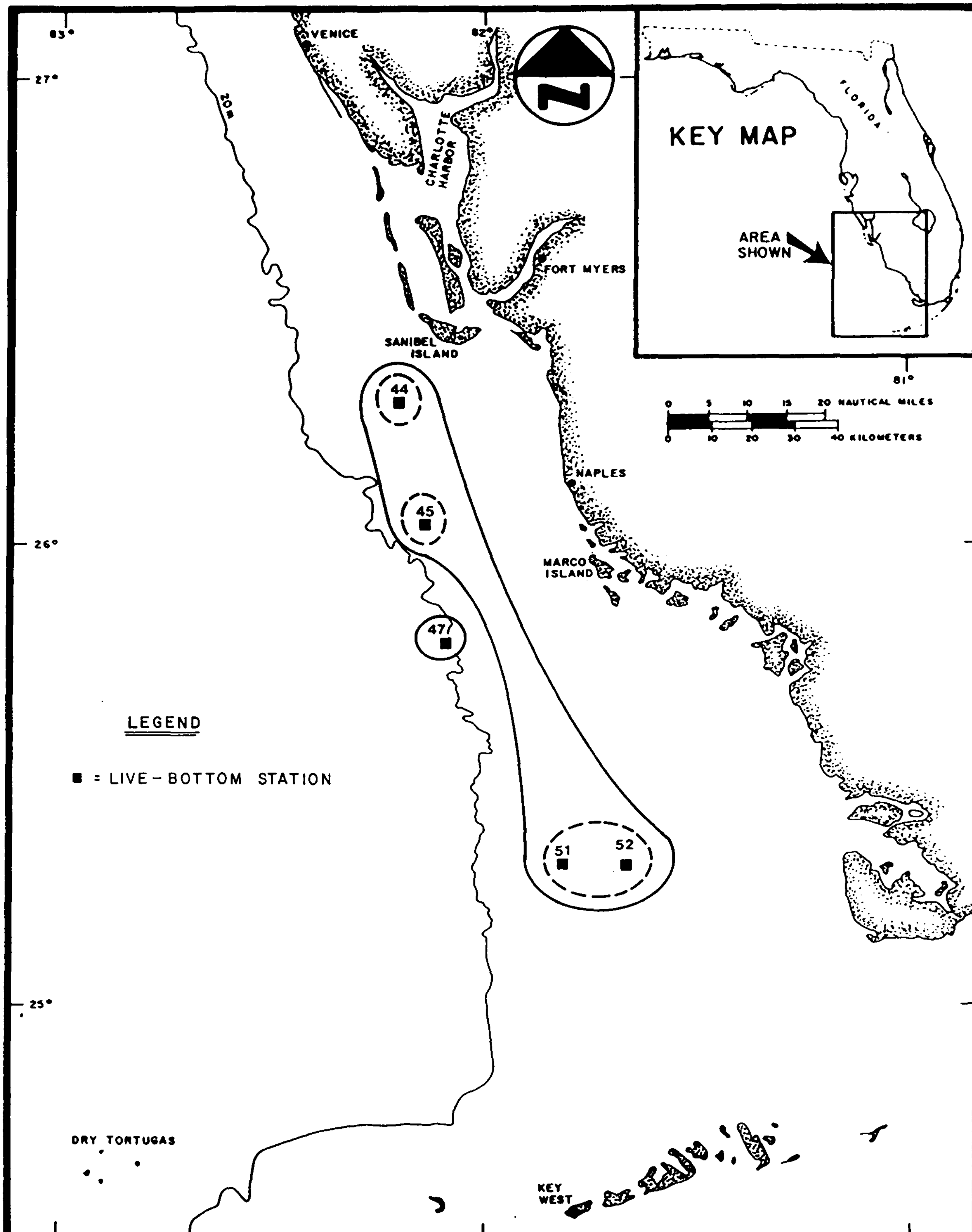


FIGURE 13. DREDGE CLUSTER ANALYSIS RESULTS FOR YEAR 3 (BOTH CRUISES COMBINED).

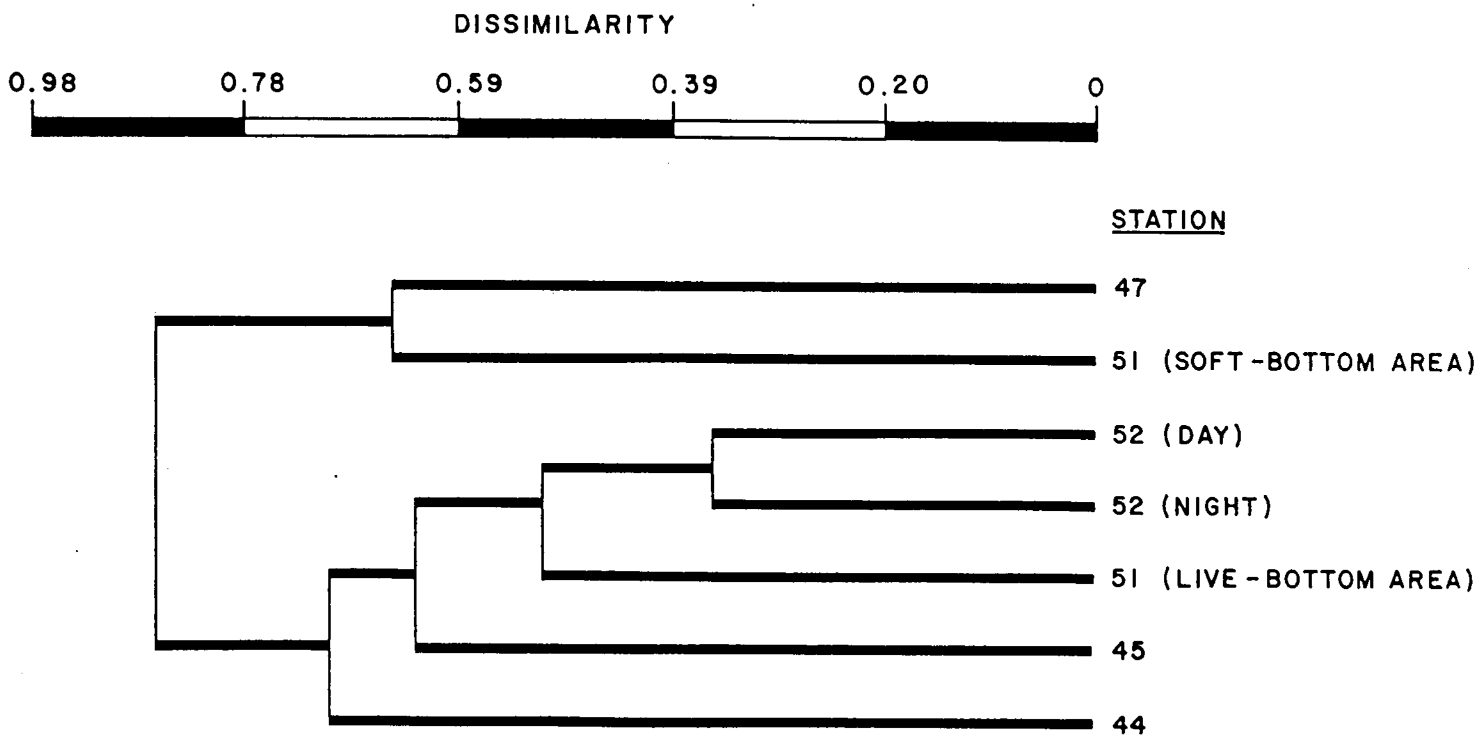
Biomass in each half-square-meter quadrat ranged from 312 to 2,162 grams (wet weight). Sponges accounted for 58% of total biomass. Hard corals, bivalves, and gorgonians (especially at Station 45) were secondary contributors. Percent cover values from quadrat photography were similar to those from remote photography.

Biomass, percent cover, and species composition data all indicate the importance of sediment thickness as a factor affecting the occurrence and density of live bottom. High biomass and percent cover at Station 45 were associated with mean sediment thicknesses of 0 to 2 centimeters, whereas low biomass and percent cover at Station 47 were associated with mean sediment thicknesses of 4 to 5 centimeters. Dredge and trawl cluster analyses showed that Station 47, where sediment was thick, was much more similar in species composition to the soft-bottom area at Station 51 than to the other live-bottom stations (Figure 14). Many sessile organisms characteristic of live bottom must initially attach to exposed rock. Where the sand veneer is thicker than a few centimeters, the underlying rock probably is exposed and colonized infrequently.

FISH COUNTS VS. TRAWLS

Fish counts were conducted to supplement trawl sampling of fishes. At each station, a diver swam a 20-minute transect during each cruise and noted the presence and relative abundance of all fishes seen. Fifty-nine species were identified. Common fishes seen included red grouper (*Epinephelus morio*), high-hat (*Equetus acuminatus*), tomtate (*Haemulon aurolineatum*), belted sandfish (*Serranus subligarius*), whitespotted soapfish (*Rypticus maculatus*), and white grunt (*Haemulon plumieri*).

Most of the fish species seen by divers are primary reef dwellers (fishes associated primarily or exclusively with reef-like habitats), whereas most species collected in trawls are soft-bottom dwellers or secondary reef dwellers (species that are commonly found in either habitat type). Most of the species seen by divers but not collected by trawl also are primary reef dwellers. Trawling was conducted away from very dense live bottom due to the likelihood of net damage or loss; thus, species that do not range far from dense live bottom were not effectively trawled. Fish counts, which were conducted only during the day, missed some species that are active only at night (e.g., dusky cardinalfish, *Phaeoptyx pigmentaria*).



NOTE: THE FARTHER TOWARDS THE RIGHT STATIONS ARE JOINED, THE MORE SIMILAR THEY ARE IN SPECIES COMPOSITION.

FIGURE 14. TRAWL CLUSTER ANALYSIS DENDROGRAM FOR YEAR 3 (CRUISE II).

SEDIMENT TRAPS AND THERMOGRAPH

Sediment trap arrays containing traps at one- and two-meter heights above the seafloor were deployed at each station during Cruise II (December 1982). Two of the arrays also contained a recording thermograph to measure bottom temperature continuously through the winter. During Cruise III (May-June 1983), arrays at three of five stations were recovered, including one with its recording thermograph. The others were lost, probably to shrimp trawling.

Mean daily deposition rates in the traps ranged from 461 to 912 grams dry weight, when standardized to a square meter surface area. There was no indication of systematic differences in deposition between locations or heights above bottom. Most of the material deposited probably consists of sediments resuspended during storms.

Thermograph data (previously shown in Figure 5) indicated minimum bottom temperatures of 17.8°C during the winter. Temperatures below 18°C, considered a minimum tolerance limit for many tropical species, persisted for only a few days.

INTEGRATION WITH YEAR 1 AND 2 DATA

Twenty-five live-bottom stations were sampled during the Year 1 and 2 program. Year 3 data can be integrated with Year 1 and 2 data because remote sampling methods (television/still camera survey, dredge and trawl sampling) were comparable during the three study years.

Table 1 summarizes Year 1, 2, and 3 quantitative photographic data. Biotic cover was highest at Stations 29, 30, and 23, which are located in 60 to 80 meters water depth on the southwestern part of the shelf. Most of the cover at these stations consisted of leafy, green algae (Anadyomene menziesii) and crustose, red algae (Peyssonnelia rubra and P. simulans). Biotic cover was lowest at the outer shelf stations (32, 35, 36, and 38), where the conspicuous epibiota consisted of crinoids, antipatharians, and small sponges. Seasonal variations in biotic cover were evident at most stations.

Cluster analyses of dredge and trawl data from Years 1, 2, and 3 were conducted. Figure 15 illustrates the results obtained using dredge data (including representatives of all taxonomic groups). Distinct depth zonation is apparent. (Slightly different results were obtained using trawl data or data for individual groups such as crustaceans, molluscs,

TABLE 1. SUMMARY OF QUANTITATIVE PHOTOGRAPHIC DATA FROM YEAR 1, 2, AND 3 LIVE-BOTTOM STATIONS.

Station	Water Depth (m)	Percent Biotic Cover*					Major Cover Constituents
		Spring	Summer	Fall	Winter	Mean	
1	24	20	27	15	13	19	Algae, sponges
3	50	17	19	8	13	14	Sponges, algae, ascidians
7	30	16	18	15	14	16	Sponges, algae
9	56	15	19	16	13	16	Algae (*Halimeda*), bryozoans
10	71	22	--	11	--	16	Algae (*Peyssonnelia*), sponges
11	77	7	31	13	15	16	Algae (*Peyssonnelia*), sponges
13	20	22	60	19	22	31	Gorgonians, algae, sponges
15	32	20	50	19	30	30	Sponges, algae
17	58	8	--	16	--	12	Algae (*Halimeda*), sponges, bryozoans
19	22	14	--	20	--	17	Sponges, algae (*Caulerpa*), gorgonians
21	44	20	57	18	23	30	Sponges, algae
23	70	37	68	34	26	41	Algae (*Peyssonnelia*, *Anadyomene*)
27	54	12	--	8	--	10	Sponges, algae (*Caulerpa*, *Halimeda*)
29	62	80	90	64	75	77	Algae (*Anadyomene*, *Peyssonnelia*), hard coral (*Agaricia*)
30	76	50	--	48	--	49	Algae (*Peyssonnelia*, *Anadyomene*), sponges
32	137	--	9	--	8	8	Sponges, crinoids
35	159	--	21	--	6	14	Sponges, antipatharians, encrusting algae
36	127	--	9	--	14	12	Crinoids, sponges, antipatharians
38	159	--	16	--	11	14	Crinoids, sponges, encrusting algae
39	152	--	54	--	17	36	Encrusting algae, sponges
44	13	15	--	18	--	16	Sponges, gorgonians, algae
45	17	39	--	41	--	40	Gorgonians, sponges
47	19	21	--	17	--	19	Gorgonians, sponges
51	16	21	--	49	--	35	Algae (*Dictyota*) seagrass, sponges, gorgonians
52	14	22	--	39	--	30	Algae (*Dictyota*) sponges, gorgonians

*Biotic cover values are from quantitative analysis of still photographs. Photographs showing few or no epibiota were excluded from analysis; thus, the values are representative of live-bottom patches within stations.

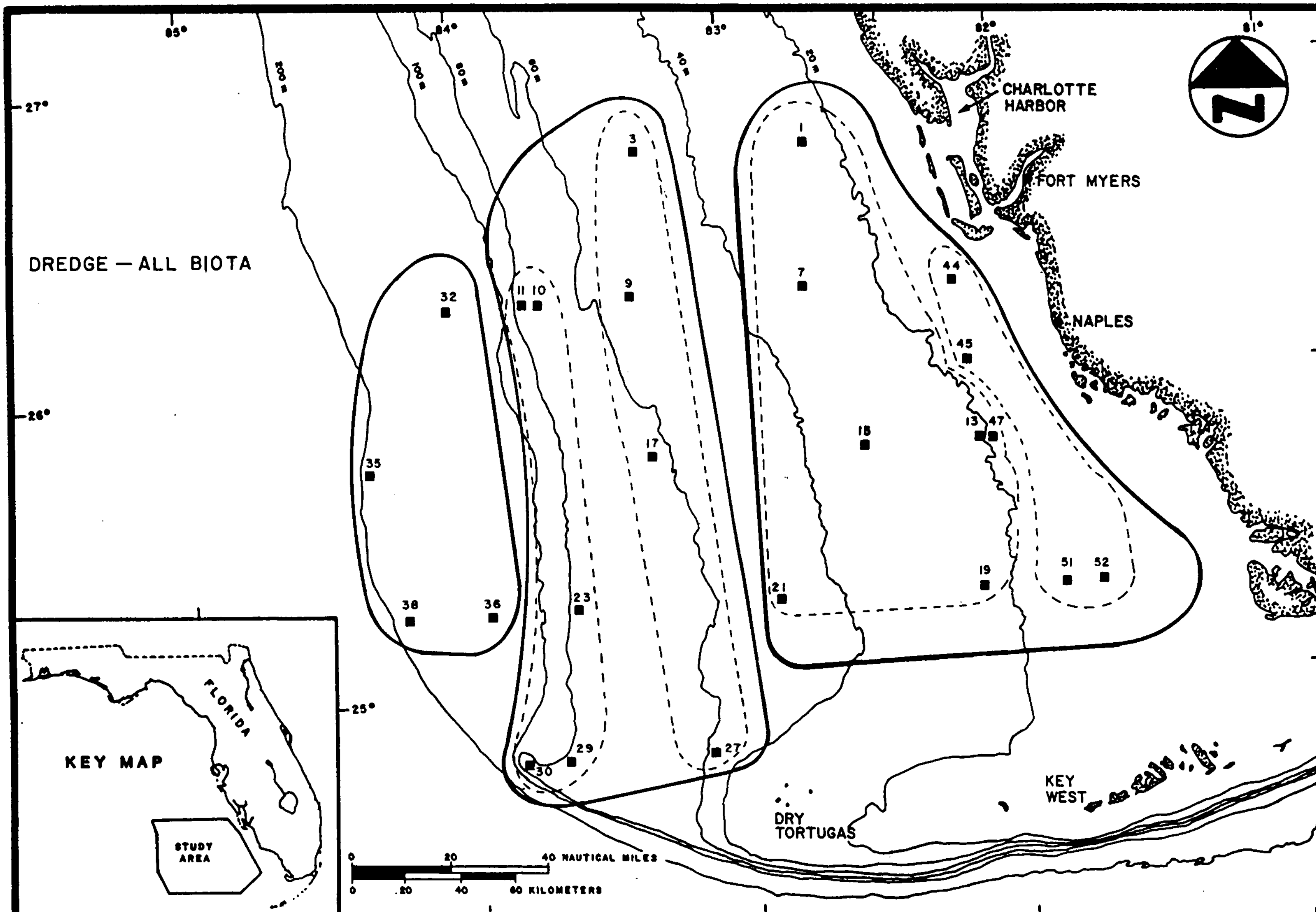


FIGURE 15. STATION GROUPINGS FROM CLUSTER ANALYSIS OF DREDGE DATA, ALL BIOTA.

algae, fishes, etc.). The results suggest that zonation of epibiota on the shelf is related primarily to environmental variables that are correlated with water depth. Likely influential variables include light, temperature, sediment thickness, frequency of seafloor disturbance, concentrations of various inorganic nutrients, and deposition rate of particulate organic matter.

SOFT-BOTTOM STATIONS

During Year 3, 11 new soft-bottom stations in water depths ranging from 10 to 18 meters were sampled during Cruise II (December 1982) and Cruise III (May-June 1983) (Figure 16). Infaunal samples and sediment samples for grain size, carbonate, and hydrocarbon analyses were collected at each station during each cruise.

SEDIMENT GRAIN SIZE AND CARBONATE

Sediment samples were collected at each station during Cruise II (three replicates) and Cruise III (two replicates). The samples were analyzed for grain size and percent carbonate.

Sediments at all stations were predominantly sand. Silt/clay content generally was less than 5%, with the exception of the three southernmost stations (11% at Station 52, 5%-9% at Station 53, and 30-40% at Station 54) and the northernmost station (9%-15% at Station 40). Sediments at Station 52 (where both live and soft bottom were present) consisted of a mixture of shell hash, coarse sand, and silt/clay.

Sediments at most stations were predominantly carbonate (greater than 75%, ranging up to 99%) rather than quartz. Two stations (40 and 49) had predominantly quartz sediments (less than 25% carbonate), and two others (41 and 42) had sediments that were 25% to 50% carbonate.

INFAUNA

Ten infaunal core samples, each 1/64 square meter in surface area, were collected at each station on each cruise. Additional sampling was conducted at Station 52, which also was a live-bottom station. Here, divers collected infaunal samples within the live-bottom area and at distances of 5, 8, 30, and 75 meters from live bottom.

In the laboratory, eight of each set of ten infaunal samples were processed, and the infauna were identified with the assistance of taxonomic experts.

The total number of species identified from infaunal collections was 579, including 243 polychaetes, 187 crustaceans, and 122 molluscs. The

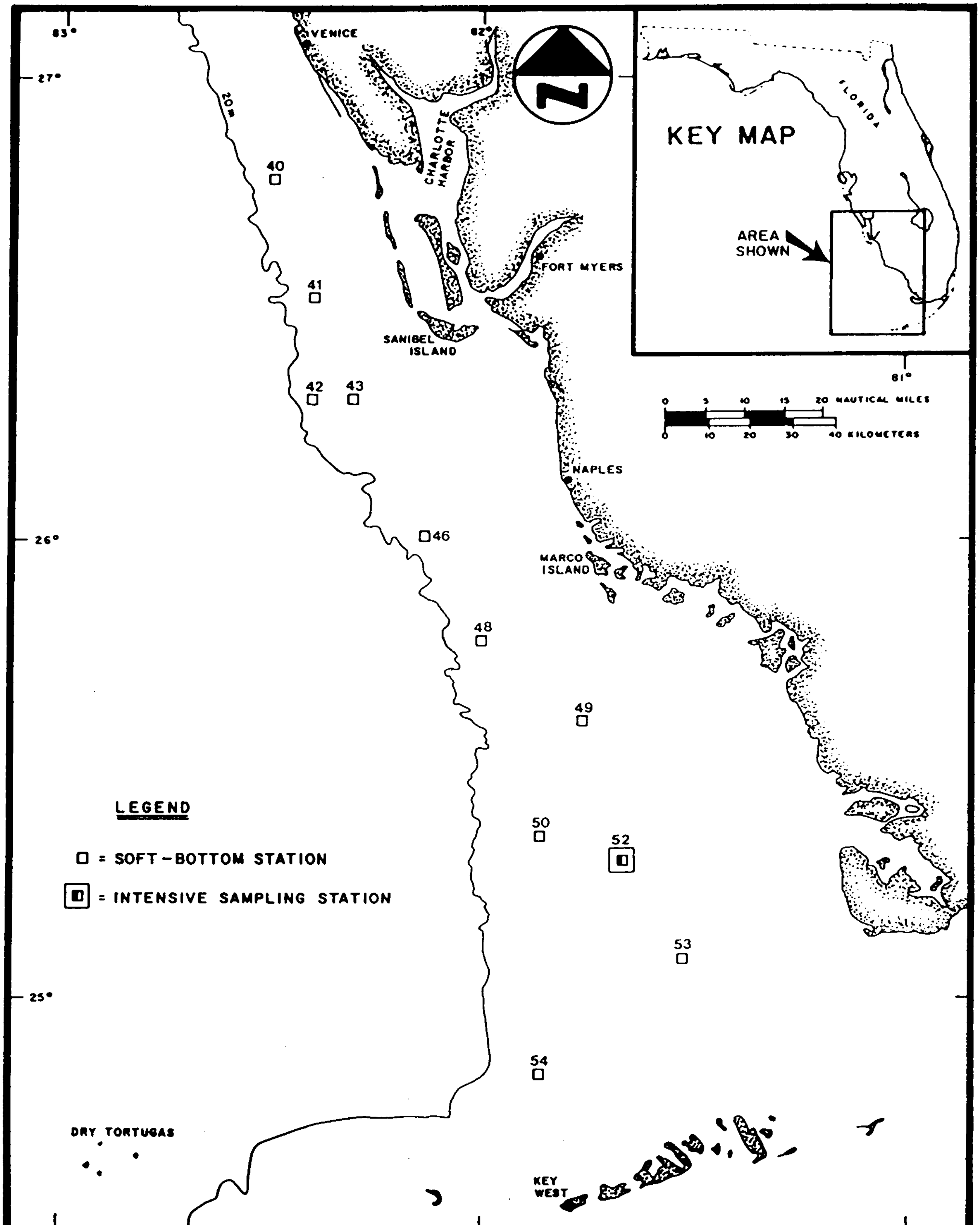


FIGURE 16. LOCATIONS OF SOFT-BOTTOM STATIONS SAMPLED DURING CRUISES II AND III

number of species per station ranged from 88 (Station 40) to 200 (Station 52). Generally, fewer species were collected per station during Cruise III than during Cruise II.

Mean infaunal densities ranged from 3,000 to 13,272 individuals per square meter. There was no consistent spatial or seasonal difference in densities. Polychaetes accounted for about 60% of the total during Cruise II and 45% of the total during Cruise III. Particularly abundant polychaetes included Armandia maculata, Cirrophorus americanus, Goniadides carolinae, Mediomastus californiensis, Myriochele oculata, Paraprionospio pinnata, and Prionospio cristata. Paraprionospio pinnata and Mediomastus californiensis were very abundant at Station 40 during Cruise II, where they accounted for 75% of total density.

Cluster analysis results, illustrated in Figure 17, show that species composition varied primarily in relation to latitude rather than water depth. Some of the apparent latitudinal variation is attributable to differences in sediment grain size. Seasonal (between-cruise) differences in species composition were greater than or equal to between-station differences at most stations.

At Station 52, there were no consistent relationships between proximity to live bottom and infaunal abundance, species richness, or diversity. However, there was a gradient in species composition with distance from live bottom. Infauna closer than 75 meters to live bottom differed in species composition from infauna of the other soft bottom stations; that is, there was a distinctive "near live bottom" infauna. Motile carnivores/scavengers (such as syllid polychaetes) were characteristic of the infauna near live bottom, whereas surface and subsurface deposit feeders generally predominated elsewhere.

SEDIMENT HYDROCARBONS

Composited sediment samples from all soft-bottom stations except Station 52 were analyzed for hydrocarbons by gas chromatography. Selected samples were analyzed by gas chromatography/mass spectrometry for further characterization of hydrocarbons.

Hydrocarbons were present in low concentrations and were of predominantly marine biogenic origin. There was no evidence for petroleum hydrocarbon contamination at any of the Year 3 stations.

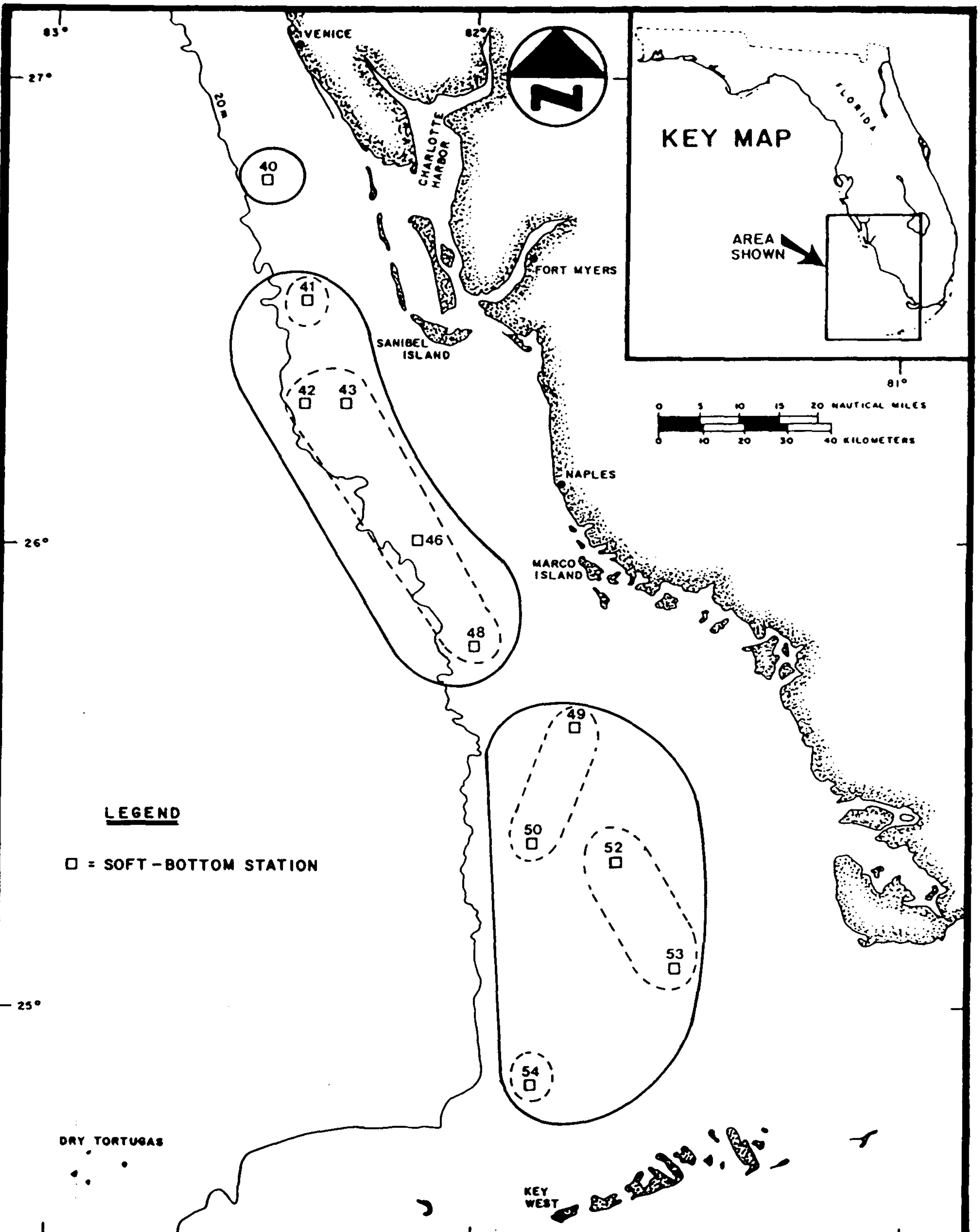


FIGURE 17. INFAUNAL CLUSTER ANALYSIS RESULTS FOR YEAR 3 (CRUISE II).

INTEGRATION WITH YEAR 1 AND 2 DATA

Infaunal and sediment samples were collected at 24 soft-bottom stations during Years 1 and 2. Year 3 data can be integrated with Year 1 and 2 data to produce an overview of sediments and infauna of the shelf.

General patterns of sediment texture and carbonate content drawn from Year 1, 2, and 3 data are shown in Figure 18. Sediments overlying most of the shelf are carbonate sand. Sediments consisting of sandy, carbonate silt occur in the vicinity of the Dry Tortugas. A zone of predominantly quartz sand (<25% carbonate) parallels the coast, extending to about 30 to 50 kilometers offshore. Transitional sediments (25% to 50% carbonate) occur in a narrow zone that widens off Charlotte Harbor, probably due to the action of strong tidal currents that carry nearshore, predominantly quartz sediments offshore.

Average infaunal densities ranged from about 1,000 to 14,000 individuals per square meter during the three study years; density varied seasonally and generally decreased with increasing water depth. Cluster analysis results suggest that species composition varies primarily in relation to water depth (Figure 19). Some zonation patterns not related to water depth are attributable to differences in sediment composition. For example, high silt/clay content of sediments at Station 25 resulted in a distinctive infaunal assemblage.

Hydrocarbon data from Year 3 are similar to those reported for Years 1 and 2. The data are indicative of a pristine environment removed from major contamination sources (e.g., the Mississippi River). Any petroleum hydrocarbon contamination resulting from future offshore oil drilling will be readily apparent.

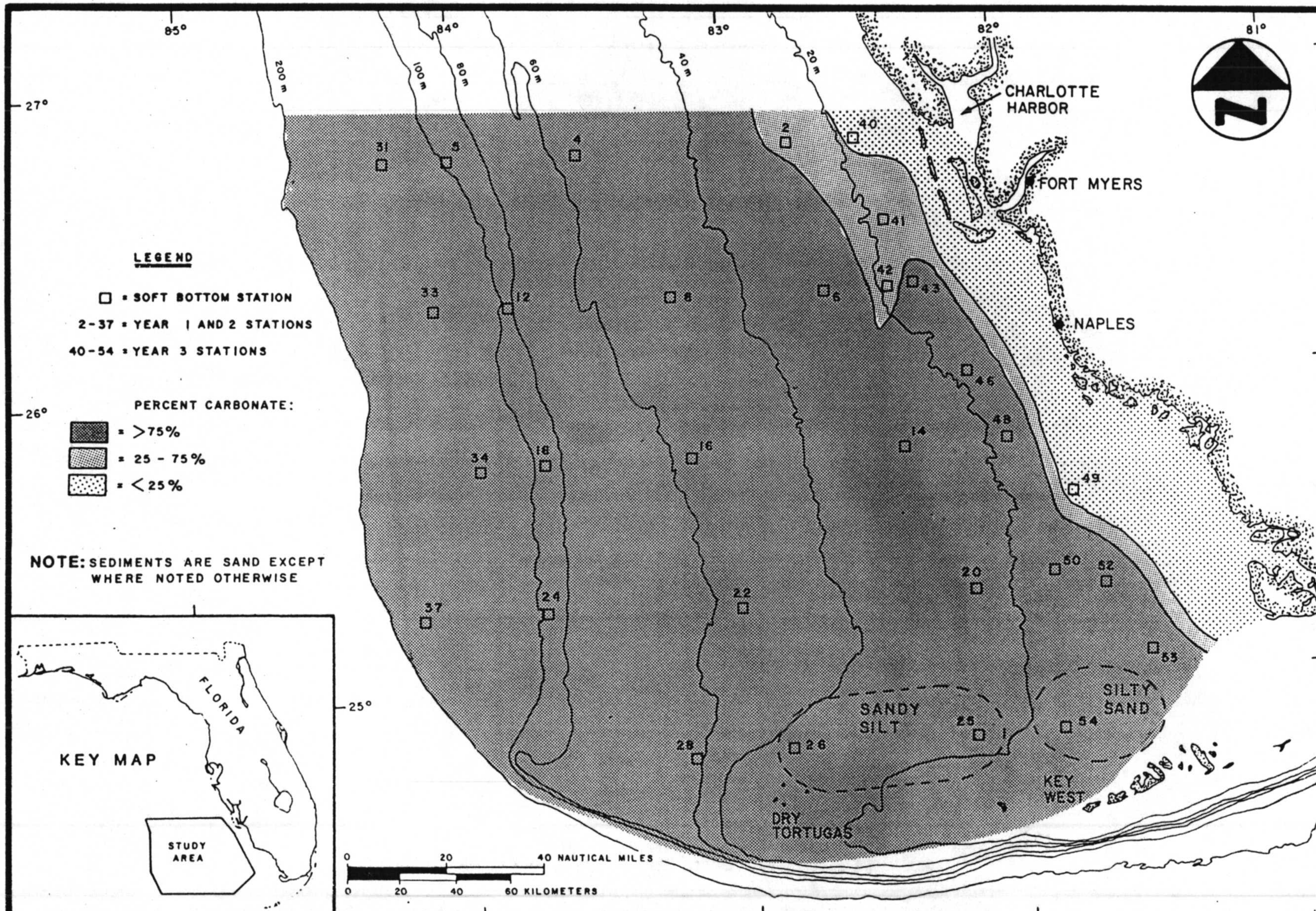


FIGURE 18. SEDIMENT TEXTURE AND CARBONATE CONTOURS BASED ON YEAR 1, 2, AND 3 DATA.

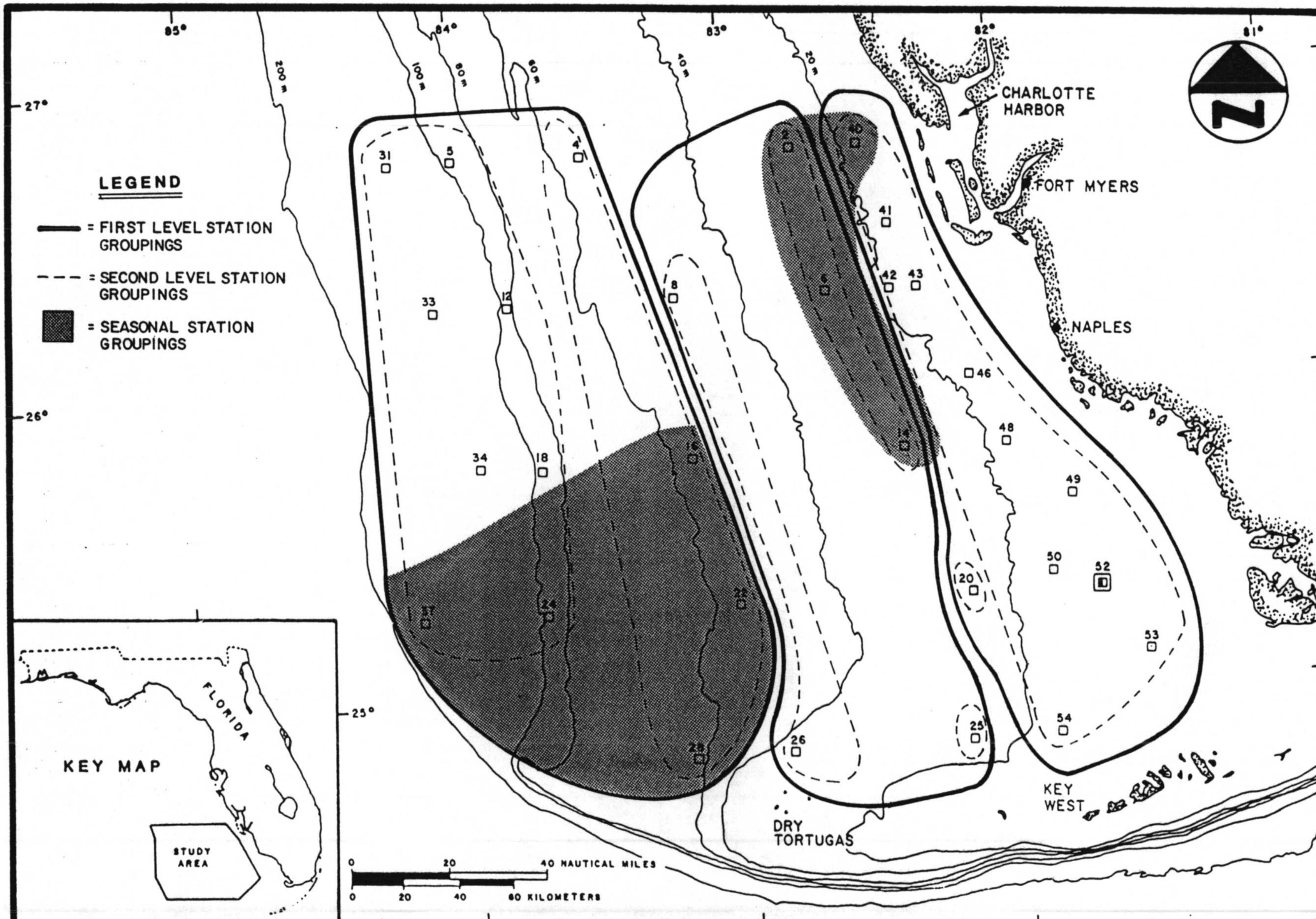


FIGURE 19. CLUSTER ANALYSIS RESULTS FOR YEAR 1, 2, AND 3 INFAUNAL DATA.

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