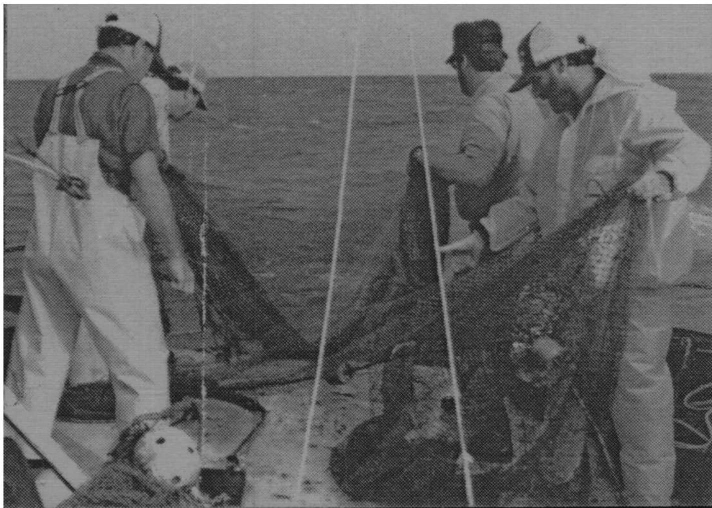


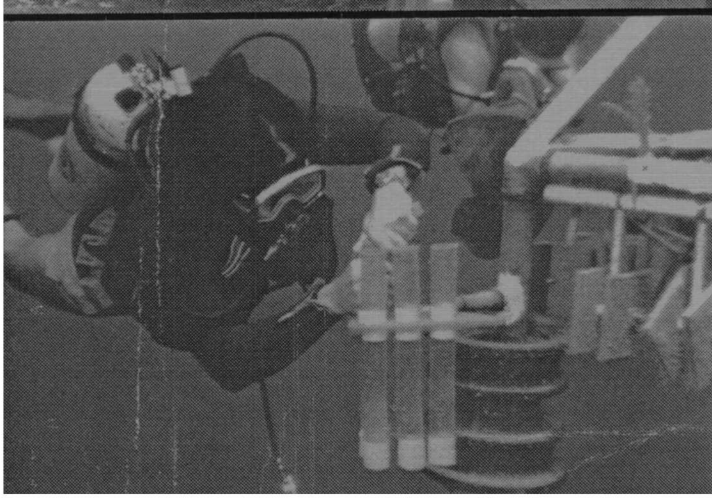

SOUTHWEST FLORIDA SHELF BENTHIC COMMUNITIES STUDY YEAR 4 ANNUAL REPORT

VOLUME I -- EXECUTIVE SUMMARY

Prepared for:

U.S. DEPARTMENT OF THE INTERIOR
MINERALS MANAGEMENT SERVICE
Gulf of Mexico OCS Region
Metairie, Louisiana

Prepared by:

ENVIRONMENTAL SCIENCE AND ENGINEERING, INC.
Gainesville, Florida

and

LGL ECOLOGICAL RESEARCH ASSOCIATES, INC.
Bryan, Texas

Contract No. 14-12-0001-30071

July 1985

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The Southwest Florida Shelf Ecosystems Program began in 1980 and was originally designed as a 3-year, interdisciplinary study of the biogeochemical and seasonal community patterns occurring in the region. The objectives of this study were:

1. To determine the potential impact of outer continental shelf (OCS) oil and gas offshore activities on live-bottom communities;
2. To produce habitat maps which show the location and distribution of bottom substrates; and
3. To classify broadly the biological zonation across and along the shelf, projecting the percent of the area covered by live/reef bottoms and the amount covered by each type of live/reef bottom.

The first 3 years of investigations effectively addressed Objectives 2 and 3. To address Objective 1 effectively, an additional 2-year study ("Southwest Florida Shelf Benthic Communities Study") was designed to investigate the biological and physical processes of the southwest Florida shelf that, in combination with the first 3 years of the study, would provide the information needed to better assess potential impacts of offshore development.

The overall objectives for the Years 4 and 5 study required to investigate biological and physical processes and to provide information needed for impact assessment were defined as follows:

1. Compare and contrast the community structure of both live-bottom and soft-bottom fauna and flora to determine the differences and similarities between them and their dependence on substrate type.
2. Determine and compare the hydrographic structure of the water column and bottom conditions at selected sites within the study area.

3. Determine and compare sedimentary character at selected sites within the study area, and estimate sediment transport.
4. Relate differences in biological communities to hydrographic, sedimentary, and geographic variables.
5. Develop and conduct a research program which will provide essential information on the dynamics of selected "live-bottom" communities and determine the major factors which influence their development, maturation, stability, and seasonal variability.
6. Assemble and synthesize appropriate published and unpublished data with the results of this study, summarizing on a seasonal spatial basis all biological, habitat, and environmental observations and parameters. Relationships between biological and nonbiological factors shall be delineated through illustrations (maps, diagrams, charts, etc.), as well as descriptive text. Appropriate statistical analyses shall be performed to support the interpretations leading to the synthesis and conclusions.
7. Conduct an effective quality assurance and quality control program which ensures that all data acquired are accurate and repeatable within standards normally accepted for each type of observation, measurement, or determination.
8. Assess the need for and determine the type of studies to be conducted in future studies sponsored by Minerals Management Service (MMS) in the eastern Gulf of Mexico.

To address these objectives, a 2-year program (Years 4 and 5 of the overall program) was designed and implemented to provide seasonal data for selected live-bottom stations and supplemental data for soft-bottom stations. This interim, annual report presents only the results of the first year of the study (Year 4 of the program); consequently, the results presented are preliminary since only half of the intended data set has been collected.

The Year 4 field study included four seasonal cruises, with sampling conducted at two sets of stations (Figure 1-1). One set of stations [Group I stations: less than 20-meter (m) water depth] was sampled during fall 1983 and spring 1984, and consisted of the 5 hard-bottom and 5 of the 10 soft-bottom stations that were sampled during the winter 1982-1983 and summer of 1983 (Year 3 study). This sampling essentially completed the seasonal baseline descriptive study of the inshore area.

Ten replicate infauna samples were collected at each of the soft-bottom stations during both cruises. In addition, sediment samples and hydrographic measurements were made at each station to define the soft-bottom habitat. At the five hard-bottom stations, dredging, trawling, underwater television, benthic still photography, sediment sampling, and hydrographic measurements were completed during both cruises.

Five other live-bottom stations, each representing a separate epifaunal community type, were sampled during each of four seasons--fall 1983, winter 1983-1984, spring 1984, and summer 1984. A description of these hard-bottom stations is presented in Table 1-1. These stations are referred to as Group II stations and are at water depths greater than 20 m except for Station 52 (13 m). Station 52 was added to this group to provide one representative shallow water station to this more intensely studied group of stations.

The Group II stations were sampled quarterly during Year 4 and are also scheduled to be sampled quarterly during Year 5. Sampling at these stations consisted of dredging, trawling, underwater television, benthic still photography, sediments, and hydrography. In addition, _in situ_ instrument arrays were installed at these five stations. Each array contained a current meter that measured current speed and direction, temperature, and conductivity; three sets of sediment traps at elevations of 0.5 m, 1.0 m, and 1.5 m above the bottom; and 10 sets of substrate plates that were scheduled to be retrieved at 3-month

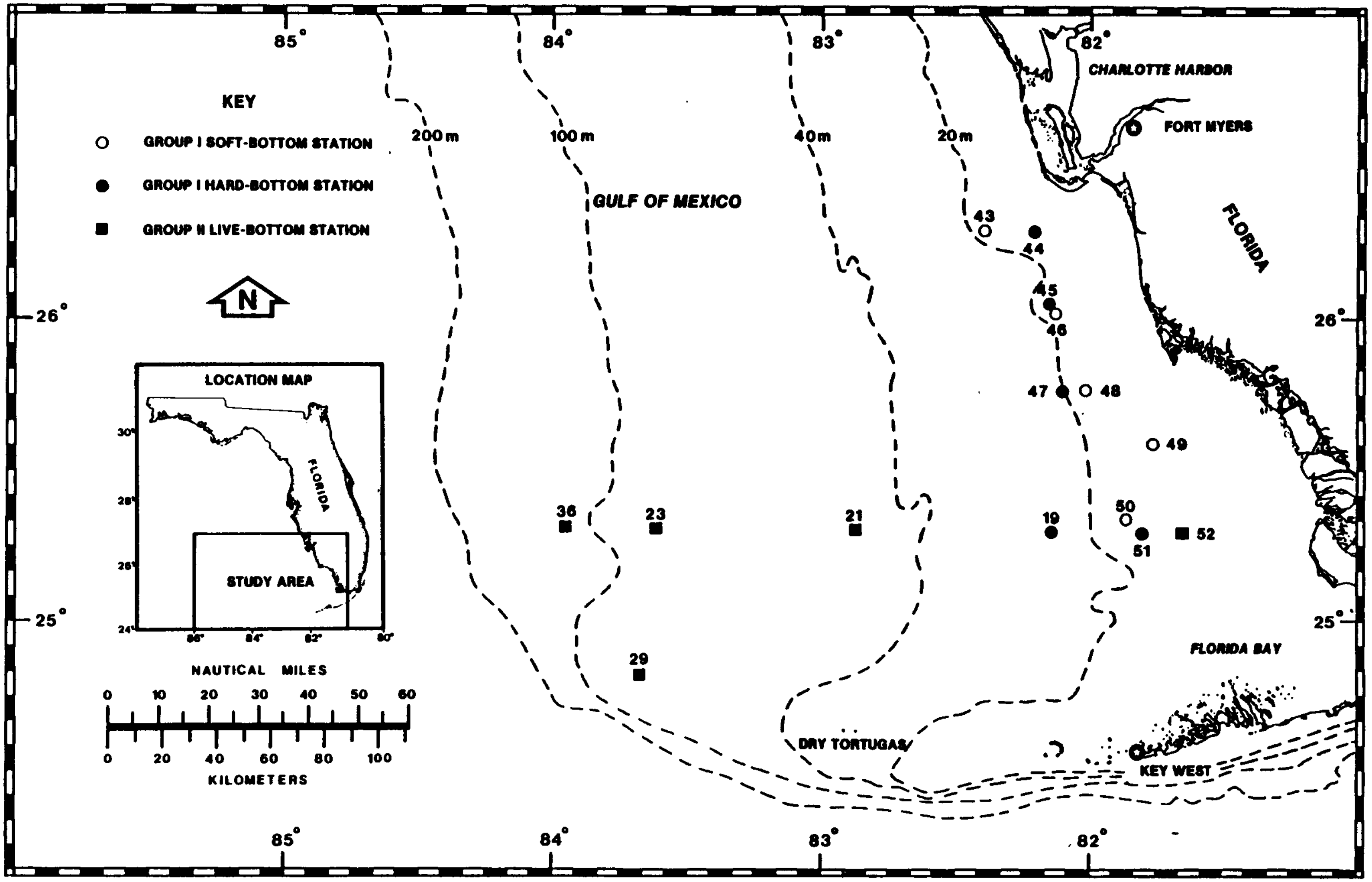


Figure 1-1 STATION LOCATIONS AND INSTRUMENT ARRAY LOCATIONS FOR YEAR 4

Table 1-1. Group II Hard-bottom Stations

Station	Depth (m)	Depth Zone	Substrate	Assemblage
52	13	Inner Shelf	Sand over hard substrate	Soft coral Assemblage I
21	47	Middle Shelf	Sand over hard substrate	Live bottom Assemblage II
23	74	Middle Shelf	Algal nodule layer/sand	Algal nodule assemblage
29	64	Middle Shelf	Algal nodule pavement	*Agaricia* coral plate
36	125	Outer Shelf	Sand over hard substrate	Crinoid assemblage

intervals over the 2-year study. Also, the arrays at Stations 52 and 21 each contained a wave and tide gage and a time-lapse camera to document sediment transport and biological recruitment. These arrays were serviced quarterly and will continue to be maintained during Year 5.

2.0 PHYSICAL CHARACTERIZATION

2.1 GROUP I SOFT-BOTTOM STATIONS

Stations 43, 46, 48, 49, and 50 were the soft-bottom stations sampled during Year 4. All of these stations are inner and middle shelf sand bottom assemblages with sand bottom substrates. Generally, the macrofauna are motile, and the density is usually less than one individual per square meter. There may be some sessile epifauna, but these are the exception because of the highly mobile nature of the sand bottom. This sand bottom designation includes unconsolidated sediments (ranging in average size from sand to silt) possibly overlying a hard substrate (e.g., limestone). The sand bottom possesses a variety of morphological and transient features such as sand waves, ripples, and bioturbated areas. These sands may also be covered with varying amounts of algae. It should be noted that this bottom type can vary both spatially and temporally; that sediment grain size and chemical characteristics can vary; and that virtually all of the morphological features are the result of dynamic forces and are, therefore, transient. The stations covered about 1° in latitude starting near Charlotte Harbor and extended south about 60 nautical miles (nm).

Group I soft-bottom stations ranged in depth from 11 m (Station 49) to 16 to 18 m (Stations 43, 46, 48, and 50). Sediment grain size of these stations [median phi size (MdØ)] ranged from medium sand to fine sand, with Stations 43 (MdØ = 1.6) and 48 (MdØ = 1.2) having medium sands and Stations 46 (MdØ = 2.2), 49 (MdØ = 2.5), and 50 (MdØ = 2.5) having fine sand substrates. Chemically, sediments at Stations 43, 46, 48, and 50 were similar, with organic carbon content ranging from 2.3 to 3.0 percent and calcium carbonate ($CaCO_3$) content ranging from 78 to 92.4 percent. Station 49 was dissimilar to the other four stations and had low organic carbon content (0.9 percent) and low $CaCO_3$ content (22.9 percent).

Group I soft-bottom stations were hydrographically similar (Table 2-1). Near-bottom salinities at Group I soft-bottom stations ranged from a low of 34.56 parts per thousand (‰) to a high of 35.81 ‰. The lowest salinity was recorded at Station 49 and was the only salinity value below 35 ‰. The pH was consistent over all stations and ranged from 7.83 to 7.85. Waters were oxygen rich, with percent saturation over both collection episodes of 98 to 125 percent. Dissolved oxygen (DO) concentrations over the two trips ranged from 6.5 to 8.69 milligrams per liter (mg/L) with lower DO values observed in December 1983 at all stations when compared with May 1984.

2.2 GROUP I HARD-BOTTOM STATIONS

Hydrographically, Group I hard-bottom stations were similar to Group I soft-bottom stations. Bottom depths ranged from 13 m to 23 m. Salinity ranged from 35.08 ‰ to 36.46 ‰, DO from 6.5 mg/L to 8.78 mg/L, with the higher DO concentrations measured during May 1984. DO saturation showed oxygen-rich waters, with saturation ranging from 98 to 125 percent. The pH was relatively constant and ranged from 7.82 to 7.88.

Sediments at these stations ranged from coarse sand to fine sand, representing a thin veneer of mobile sediments covering rock substrate. The coarsest sands were found at Station 44 (MdØ = 0.9), and the bottom was predominantly sand with patches of hard bottom. Coarse sands were also found at Stations 45 (MdØ = 1.0) and 19 (MdØ = 1.2). At Station 19, sand was the predominant bottom type, while at Station 45, hard-bottom predominated over sand. Fine sands predominated at Stations 47 (MdØ = 2.2) and 51 (MdØ = 2.6). Sand waves were evident at these two stations.

Chemically, Group I hard-bottom stations were similar to Group I soft-bottom stations. The organic carbon content of the sediments ranged from 1.2 to 2.9 percent, and the $CaCO_3$ content ranged from 87.2 to 93.1 percent.

Table 2-1. Summary of Near-Bottom Hydrographic Characteristics for Year 4, Group I and II Stations

Station Number	Salinity (‰)	Temperature (°C)	Sigma-t	DO (mg/L)	DO Saturation (%)	Transmis-sivity (%)	pH	Average Current Speed (cm/s)	Speed >40 cm/s (%)
43*	35.08-35.17	22.74-26.46	23.04-24.09	6.70-7.25	101-102	101-103	7.83	—	—
46*	35.34-35.86	23.51-26.05	23.29-24.46	6.70	101	81-101	7.83	—	—
48*	35.38-35.81	23.37-26.20	23.29-24.46	6.50-8.69	98-125	99-103	7.83	—	—
49*	34.56-35.43	22.93-27.26	22.33-24.30	6.90-7.16	102-106	90-96	7.85	—	—
50*	35.40-35.66	23.43-26.68	23.15-24.33	6.90-7.23	104-105	90-102	7.84	—	—
44**	35.08-35.22	23.19-26.56	22.94-24.07	6.90-8.78	104-125	98-102	7.83	—	—
45**	35.31-35.88	23.65-26.12	23.25-24.44	6.50-6.97	98-100	92-108	7.82	—	—
47**	35.59-35.92	23.61-25.94	23.52-24.48	6.70	101	88-107	7.86	—	—
51**	35.36-35.70	23.62-26.72	23.10-24.30	6.50-7.55	99-109	89-100	7.87	—	—
19**	35.92-36.46	23.94-25.17	24.00-24.79	7.00-7.02	103-104	92-97	7.88	—	—
52***	35.14-35.78	17.00-30.56	22.03-25.13	6.27-7.26	96-106	67-100	7.82-8.58	27.5	19.7
21***	36.14-36.31	20.32-25.29	24.15-25.62	6.35-9.44	95-128	89-98	7.94-8.56	13.3	0.6
23***	36.11-36.67	17.50-23.30	25.87-26.24	6.11-6.40	82-85	82-95	7.92-8.66	22.1	9.5
29***	36.11-36.64	17.85-23.90	24.94-25.92	6.40-8.59	87-114	95-100	7.94-8.64	24.5	14.1
36***	36.13-36.42	15.00-23.85	—	4.35-5.50	88-106	—	—	22.1	14.2

*Group I Soft-Bottom Stations (ranges based on a maximum of two observations).
**Group I Hard-Bottom Stations (ranges based on a maximum of two observations).
***Group II Live-Bottom Station (ranges based on maximum of four observations; temperatures at all stations, but Station 21 augmented with continuous temperature data from current meters).

2.3 GROUP II LIVE-BOTTOM STATIONS

Each Group II live-bottom station represented a different biological assemblage and bottom type. Station 52, located 48 kilometers (km) offshore and in 13 m of water, was the easternmost and shallowest Group II station. The sediment was coarse (MdØ = 0.6) sand, with $CaCO_3$ content equal to 92.6 percent and organic carbon content of 1.9 percent. The near-bottom salinity ranged from 35.14 to 35.78 ‰, and temperature ranged from 17.00° to 30.56°C. DO ranged from 6.27 to 7.26 mg/L, with saturation values from 96 to 106 percent. The pH ranged from 7.82 to 8.58. The average current speed was 27.5 centimeters per second (cm/s), and 19.7 percent of the time current speeds exceeded 40 cm/s (the speed at which sediment transport would occur for sand).

Station 21 was 133 km from land in 45 m of water. The bottom substrate was thin sand over hard substrate. Sand waves with wave lengths of approximately 1 m were measured. The sands had an MdØ of 1.6 with a $CaCO_3$ content of 91.2 percent and an organic carbon content of 2.6 percent. Because of the loss of an instrument array, hydrographic data at this station were not as complete as at other Group II stations. Salinity ranged from 36.14 ‰ to 36.31 ‰; DO ranged from 6.35 mg/L to 9.44 mg/L with saturation values of 95 to 108 percent. The pH varied from 7.82 to 8.58. During 3 months of current meter operation, average currents of 13.3 cm/s were measured, with currents greater than 40 cm/s recorded 0.6 percent of the time.

Station 23 was located 194 km from land in approximately 70 m of water. The bottom type was predominantly algal nodules over sand with depressions. The depressions ranged from 5 to 30 m in diameter and from 2 to 3 m deep, and were oriented along a north-northeast to south-southwest axis. The algal nodule layer accounted for 93 to 100 percent of the bottom. The northwest corner of the study area was nearly bare sand. The sands were skewed toward finer material with a MdØ equal to 2.4. $CaCO_3$ content equaled 95.3 percent, and organic carbon equaled 2.9 percent. Near-bottom salinity ranged from 36.11 ‰ to 36.67 ‰; DO ranged from 6.11 mg/L to 6.40 mg/L, with saturation values of 82 to 85 percent. The pH ranged from 7.92 to 8.66. Nine months of current meter data indicated an average current speed of 22.09 cm/s, with currents greater than 40 cm/s occurring 9.5 percent of the time.

Station 29 was 229 km from land with an average water depth of 60 m. The bottom was entirely covered with an algal nodule pavement with Agaricia accumulations (Woodward Clyde Consultants and Continental Shelf Associates, Inc., 1984). Only minor amounts of bare sand (<1 percent) were reported, and no signs of ripples or bioturbation were observed. Near-bottom salinity ranged from 36.11 to 36.64 ‰, DO ranged from 6.40 to 8.59 mg/L, and saturation values ranged from 87 to 114 percent. The pH varied from 7.94 to 8.64. Current data from the first three quarters indicated average current speeds of 24.5 cm/s, with speeds greater than 40 cm/s occurring 14.1 percent of the time.

Station 36 was located 219 km from land with an average depth of 126 m. The predominant bottom type was sand bottom/soft bottom (59 to 76 percent) with lesser coverages (24 to 40 percent) of thin sand over hard substrate (Woodward Clyde Consultants/Continental Shelf Associates, Inc., 1984). Sand ripples and depressions were observed as bottom features. The sands were coarse (MdØ = 0.7) with a $CaCO_3$ content of 94.4 percent and an organic carbon content of 2.9 percent. Near-bottom salinity ranged from 36.13 to 36.42 ‰, and DO ranged from 4.35 to 5.50 mg/L, with saturation values of 88 to 106 percent. The average current speed was 22.09 cm/s, with a current exceeding 40 cm/s approximately 14.2 percent of the time.

3.0 BENTHIC COMMUNITY DISTRIBUTION AND STRUCTURE

The following section provides biological site descriptions of the 5 soft-bottom and 10 hard-bottom stations studied in Year 4. The soft-bottom station descriptions were developed from samples collected during two seasons where 10 replicate infaunal samples were collected at each of the 5 stations. The five shallow water Group I stations were also occupied during two seasons with biological sampling, including dredging, trawling, underwater television, and still photography. The five Group II hard-bottom stations were sampled during all four seasons, and each station included an *in situ* array to provide additional time-continuous data.

3.1 GROUP I SOFT-BOTTOM STATIONS

A total of 414 taxa was identified in the macroinvertebrate data set. Of these, 344 were identified to the genus or species level, with 212 of these identified to the species level. Polychaete taxa were the most numerous and represented 223 of the total taxa. Crustaceans were the next most numerous group with 117 taxa, 52 of which were gammarid amphipods. Fifty-four taxa were molluscs, with 23 gastropods, 25 bivalves, 5 scaphopods, and 1 polyplacophoran. Echinoderms were represented by seven taxa. The remaining 13 taxa were *Phoronis architecta*, *Glottidia pyramidata*, *Branchiostoma caribaeum*, oligochaetes, bryozoa, sipunculids, priapulids, pycnogonids, turbellarians, rhynchocoels, demospongiae, and hydrozoa.

The taxonomic composition of the individual stations followed the same pattern as the overall infaunal collection. Polychaetes accounted for the greatest number of taxa at each station, with crustaceans ranked second and molluscs ranked third. The crustacean component of the station communities was dominated by gammaridean amphipods.

Infaunal Abundance, Diversity, Richness, and Evenness--The estimated mean density of individuals per square meter (#/m^2) across the five stations sampled in December 1983 and again in May 1984 ranged from a low of 3245/m^2 at Station 43 in December 1983 to a high of 15 821/m^2 at Station 50 in May 1984. Estimated mean densities were generally higher in May than in December, with only Station 49 having a lower mean density in the second sampling effort.

The Shannon-Weaver diversity index for all stations was high. In December 1983, the index ranged from a low of 4.91 at Station 48 to a high of 5.76 at Station 43 (Table 3-1). In May 1984, the Shannon-Weaver diversity index ranged from 4.71 at Station 49 to 5.39 at Station 50. Diversity was slightly higher in December 1983 collections than in May 1984 collections, due primarily to the higher numbers of taxa recorded in the December 1983 collections. The high diversity index values resulted from both the high species richness values and the high evenness values. At each station the great majority of the taxa were present in approximately equal numbers, with most taxa represented by only a few individuals equalling small percentages of the total collections. Over all stations, the number of taxa which were equal to less than 1 percent of the total individuals at a station ranged from 73.5 percent to 87.1 percent of the number of taxa at a station. The number of taxa which was equal to or greater than 10 percent of the total individuals at a station ranged from only 0.8 percent to 1.9 percent of the number of taxa at a station (Table 3-2).

Diversity, richness, and evenness are all conservative estimates because all taxa could not be identified to the species level. Some of these taxa which were identified only to genus or a higher taxonomic level will be represented by more than one species, particularly groups such as oligochaetes, ostracods, and rhynchocoels.

Of the 344 taxa which were identified to the genus or species level, 50 occurred at 5 or more stations out of 10 (5 stations sampled two times,

Table 3-1. Shannon-Weaver Diversity, Margalef's Species Richness, and Pielou's Evenness Values for Benthic Infauna

Station	Diversity (H')	Richness (J)	Evenness (E)
December 1983			
43	5.76	14.22	0.84
46	5.20	13.70	0.75
48	4.91	12.78	0.72
49	5.13	12.94	0.75
50	5.09	13.73	0.73
May 1984			
43	5.19	11.79	0.77
46	4.87	11.27	0.73
48	4.82	11.32	0.72
49	4.71	9.22	0.74
50	5.40	15.82	0.74

Table 3-2. Total Number of Taxa, Number of Taxa by Density Percentage Categories, and Percentage Composition

	Station									
	43		46		48		49		50	
	# taxa	%	# taxa	%	# taxa	%	# taxa	%	# taxa	%
December 1983										
Total number taxa	116	100	120	100	110	100	118	100	124	100
Number taxa <1%	97	83.6	101	84.2	93	84.5	101	85.6	108	87.1
Number taxa 1-5%	16	13.8	16	13.3	14	12.7	12	10.2	12	9.7
Number taxa >5-<10%	2	1.7	2	1.7	2	1.8	4	3.4	2	1.6
Number taxa ≥10%	1	0.9	1	0.8	1	0.9	1	0.8	2	1.6
May 1984										
Total number taxa	108	100	102	100	106	100	83	100	154	100
Number taxa <1%	84	77.8	83	81.4	89	83.9	61	73.5	131	85.1
Number taxa 1-5%	19	17.6	14	13.7	11	10.4	16	19.3	20	13.0
Number taxa >5-<10%	4	3.7	3	2.9	4	3.8	5	6.0	1	0.6
Number taxa ≥10%	1	0.9	2	1.9	2	1.9	1	1.2	2	1.3

Table 3-3). Cluster analysis was performed using 400 binary variables and a second time using 86 numeric variables. The numeric variables were those 86 infaunal taxa which were equal to or greater than 0.9 percent of the total density at any station. Normal cluster analysis performed using binary and numeric data produced similar results. In the binary case, all stations were 0.619 dissimilar (0.381 similar), and in the numeric case all stations were 0.459 dissimilar (0.541 similar, Figure 3-1). In both cases, Station 49 was the only station which linked with itself before linking with another station.

The results of both the binary classification and the numerical classification showed that the level of dissimilarity of soft-bottom infaunal communities was relatively low, or conversely, the similarity between stations was relatively high. This is not unexpected because the stations were all located within a narrow range of depths and a narrow range of sediment types. The station depths ranged from 11 to 18 m. The fact that Station 49 was the only station which clustered with itself in both classification strategies may be due to the depth of the station and to sediment chemistry. Station 49 was the shallowest station (11 m), whereas the remaining four stations were between 16 and 18 m deep. Station 49 was also chemically different from the remaining stations in that sediments were low in $CaCO_3$ (22.9 percent) and organic carbon (0.9 percent). No clustering of stations was readily apparent by sediment grain size. All stations were predominantly sand size sediments ranging from medium sand to fine sand, with medium sand stations clustering with fine sand stations. There was also no readily apparent clustering of stations by sampling season.

Taxa which may be considered characteristic of the majority of stations were *Branchiostoma caribaeum*, *Ampelisca* spp., *Cyclaspis* spp. (predominantly *Cyclaspis* sp. A), *Axiothella mucosa*, *Mediomastus californiensis*, *Synchelidium americanum*, Sabellidae spp. (subfamily Fabricinuae), *Armandia maculata*, *Exogone dispar*, *Metharpinia floridana*, *Photis macromanus*, *Polygordius* sp., *Xenanthura brevitelson*,

Table 3-3. Genera and Species Which Occurred in Five or More Station Collections

Acanthohaustorius sp. A (A)*	*Leptochela serratorbita* (D)
Acuminodeutopus naglei (A)	*Leptochelia* sp. A (T)
Aglaophamus verrilli (P)	*Listriella barnardi* (A)
Ampelisca spp. (A)	*Lucifer faxoni* (D)
Ampelisca agassizi (A)	*Lumbrineris verrilli* (P)
Anchialina typica (M)	*Magelona pettiboneae* (P)
Aoridae genus B. (A)	*Mediomastus californiensis* (P)
Argissa hamatipes (A)	*Metharpinia floridana* (A)
Aricidea spp. (P)	*Minuspio* sp. (P)
Armandia maculata (P)	*Myriochele* spp. (P)
Axiothella mucosa (P)	*Nephtys simoni* (P)
Branchiostoma caribaeum (Cp)	*Olivella minuta* (G)
Calyptraea centralis (G)	*Onuphis nebulosa* (P)
Campyclaspis spp. (C)	*Owenia* sp. A (P)
Cerapus sp. A (A)	*Oxyurostylis smithi* (C)
Chione spp. (B)	*Paraprionospio pinnata* (P)
Cirrophorus spp. (P)	*Photis macromanus* (A)
Cumella spp. (C)	*Polygordius* sp. (P)
Cyclaspis spp. (C)	*Prionospio cristata* (P)
Cyclaspis cf. *unicornis* (C)	*Processa hemphilli* (D)
Eudeuenopus honduranus (A)	*Serpula* spp. (P)
Exogone dispar (P)	*Synchelidium americanum* (A)
Garosyrrhoe sp. A (A)	*Synelmis* sp. B (P)
Gouldia cerina (B)	*Tellina* spp. (B)
Kalliapseudes sp. A (T)	*Xananthura brevitelson* (I)

*Key:
A = Amphipoda.
B = Bivalvia.
C = Cumacea.
P = Polychaeta.
T = Tanaidacea.
I = Isopoda.
D = Decapoda.
M = Mysidacea.
Cp = Cephalochordata.

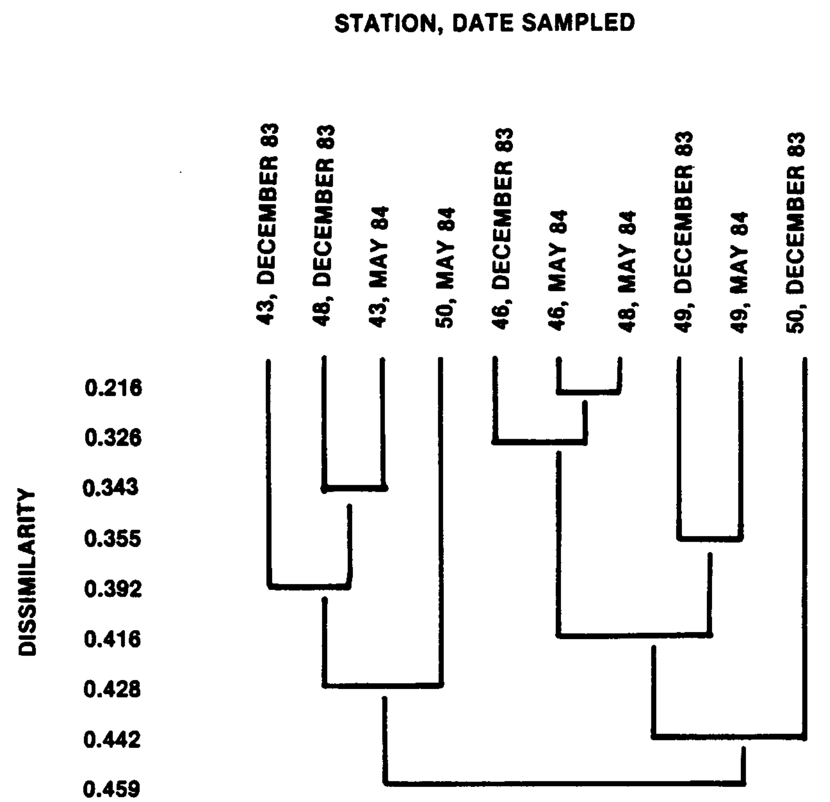


Figure 3-1 DENDROGRAM PRODUCED BY NORMAL CLUSTER ANALYSIS OF 86 NUMERICALLY DOMINANT INFAUNAL TAXA

Oxyurostylis smithi, *Paraprionospio pinnata*, *Prionospio cristata*, *Cyclaspis unicornis*, Aoridae genus B, *Eudeuenopus honduranus*, *Lumbrineris verrilli*, *Minuspio* sp., *Cirrophorus* spp., *Aricidea* spp., and *Tellina* spp.

Although cluster analyses did not show an apparent grouping of stations by collection date, some individual taxa did have distributions which showed differences between the two collection dates. *Leptochelia* sp. A, *Glottidia pyramidata*, *Synelmis* sp. B, *Aspseudes propinquus*, and *Minuspio* sp. were more common in December 1983 while *Spio pettiboneae*, *Paraprionospio pinnata*, *Monoculodes nyei*, and *Mysidopsis furca* were more common during May 1984.

The high macroinfauna community diversity, richness, and evenness; the moderate densities; and taxonomic compositions of the five shallow water sampling stations were consistent with results of previous studies conducted on the southwest Florida shelf and other United States coastal areas (Woodward Clyde Consultants/Continental Shelf Associates, Inc., 1983; Woodward Clyde Consultants/Continental Shelf Associates, Inc. Year II; EPA, 1982a; EPA, 1982b; Maurer *et al*., 1976; Maurer and Leathem, 1981; Knox, 1977).

3.2 LIVE-BOTTOM STATIONS

Since the live-bottom stations were selected to span a range of different habitat types identified in previous programs, major differences were expected between the communities of the Florida shelf. Such differences were found, but there were also many similarities, as discussed in the following paragraphs. The sampling intensities within gear types differed slightly during Year 4 from station to station, both as a result of program design and of unexpected events such as heavy weather and equipment failure. For this reason, statistical comparisons were made primarily with presence/absence data which are less sensitive to unequal sampling. The gear types that were used were dredges, trawls, and underwater television.

3.2.1 BENTHIC INVERTEBRATES

Many of the stations had major benthic habitat-forming organisms in common. For instance, all stations had sponges large enough to see on the underwater television. Two species of sponges, *Ircinia campana* and *I. strobilina*, were identified in videotapes from each station, except for Station 36. Scleractinian corals were collected by the triangular dredge at all of the stations except 51 and 19, and gorgonians at all stations except 51 and 21. However, scleractinians were seen with the underwater television at Station 51--though not collected with the dredge--and gorgonians were seen in videotapes of Stations 51 and 21. This confirms that these stations were similar in many respects. It also emphasizes the importance of sampling the same community with a variety of gear types.

Five of the stations (44, 45, 47, 51, and 52) span a depth range of only 6 m, lying in shallow water along isobaths between 14 and 20 m deep. All of these stations are approximately the same distance offshore and fall within the Inner Shelf region running north to south along the Florida coast. The next five stations proceeding westward spanned the depth range from 24 m to 125 m. These were Station 19, 24 m deep, and still within the Inner Shelf; Group II Stations 21, 29, and 23 (Middle Shelf); and Station 36 (Outer Shelf). It would be reasonable to expect that all of the Inner Shelf stations (shallow stations) might have had similar shallow water biota. Major differences, however, were expected with increasing depth between the remaining Group II stations.

The Inner Shelf stations had much in common. The habitat most frequently encountered at these stations was fairly low relief, with occasional patches of hard substrate which cropped up amid plains of unconsolidated sediment. However, at Station 19, higher profile reef rock was observed with the underwater television. The sediment at the other shallow stations sometimes covered everything except large sponges and gorgonians. These organisms are long-lived and slow-growing, and can only settle and survive when attached to hard substrate. Wherever they are observed, it can therefore be inferred that there must be hard substrate beneath a thin veneer of sediment. It can also be inferred that the sand moves and periodically exposes the hard substrate, because various sizes of these taxa were observed, suggesting ongoing recruitment.

The five shallow stations appeared to be similar to one another in benthic species composition for many taxonomic groups. Underwater television samples for all cruises showed a natural grouping of gorgonians at Stations 52, 44, 51, 45, 47, and 19, and a distinct break between Station 19 (24 m) and Station 21 (47 m). The same faunal break between Station 19 and Station 21 was also clearly visible for asteroids, with only a single taxon noted for the deeper stations, and holothuroids. Stations 19 and 51 (toward the southern end of the study area) were particularly poor for scleractinians and gorgonians, as well as depauperate for many other groups of organisms.

Triangular dredge presence/absence data for all cruises together also suggested that there was a definable, Inner Shelf, shallow water benthic community held in common by the shallow stations. Each of the major taxa observed can be conveniently divided into three categories: (1) taxa found exclusively at shallow stations; (2) taxa found exclusively at deeper stations (21, 29, 23, and 36); and (3) taxa held in common between Inner Shelf, Middle Shelf, and Outer Shelf stations.

The results provided in Table 3-4 indicate how habitat-specific major taxa fell within large-scale station groupings. Percentages should not, strictly speaking, be compared, since there were six stations in the Inner Shelf and only four stations in the Outer/Middle Shelf category. It can be seen that some groups of taxa were more habitat-specific than others. Four of 10 major taxa had more species restricted to the Middle/Outer Shelf stations than to the Inner Shelf stations.

However, considering just those restricted species, in 9 of 10 major taxa, higher percentages of restricted species were shared within the

Table 3-4. Distribution of Invertebrates and Plants in Inner Versus Middle and Outer Shelf Regions, Based on Triangular Dredge Samples

		Biogeographic Region			
		Inner Shelf		Middle/Outer Shelf	
	Number of Species	Restricted (%)	Spread (%)	Restricted (%)	Spread (%)
Invertebrates					
Zoantharia	27	19	60	48	8
Alcyonaria	29	83	33	17	20
Bivalvia	40	70	50	20	0
Gastropoda	46	48	36	28	8
Brachyura	56	48	27	36	33
Anomura	12	42	60	33	60
Caridea	14	43	17	21	0
Asteroidea	19	26	40	58	18
Ophiuroidea	26	15	25	62	13
Echinoidea	15	7	100	60	22
Plants					
Chlorophyceae	15	73	55	27	50
Phaeophyceae	13	38	20	46	17
Rhodophyceae	44	70	16	16	0

Note: "% Restricted" indicates the percentage of species in that group that were found only within that region; "% Spread" indicates the percentage of those taxa restricted to each region that were found at more than one station within that region.

Inner Shelf region between two or more stations than within the Middle/ Outer Shelf region. In other words, there was far more overlap (similarity) between Inner Shelf stations in terms of benthic species presence/absence than between Middle/Outer Shelf stations. For example, half of the 28 bivalves found exclusively at Inner Shelf stations were collected from more than one of these stations, whereas not one of the eight bivalves collected exclusively at Middle/Outer Shelf stations was taken from more than one station.

The major habitat-forming organisms differed considerably between the four deepest live-bottom stations. Station 21 (47 m) was mainly a sponge community on low-profile sandy bottom. Station 29 (66 m) was dominated by scleractinian corals, primarily Agaricia spp., with rocky patches projecting above the substrate, along with the large green alga Anadyomene menziesii. Station 23 (75 m) was a bed of algal nodules and rubble, with many sponges and smaller invertebrates (e.g., abalones) in the interstices, and Anadyomene menziesii. Station 36 was fairly low-profile, but dominated by two species of comatulid crinoids.

Some invertebrates were very widespread between stations. Ophiuroids were particulary notable in this regard. The angular brittle star, Ophiothrix angulata, was collected with the triangular dredge at 9 of the 10 stations, and several other species (O. savignyi and Ophioderma brevispina can be described as ubiquitous. Nonetheless, only 2 of the 16 ophiuroids collected exclusively at Middle/Outer Shelf stations were found at more than one station.

An overview of stations from the standpoint of major groups of taxa is presented in Figures 3-2 and 3-3. Figure 3-2 depicts the results of a nodal constancy analysis per Boesch (1977) on presence/absence data for invertebrates collected with triangular dredge at the shallow live-bottom stations, and also presents the same information for all stations sampled four times. Figure 3-3 shows the key to graphics showing nodal constancy and nodal fidelity. Figure 3-4 presents nodal fidelity analyses for two sets of stations.

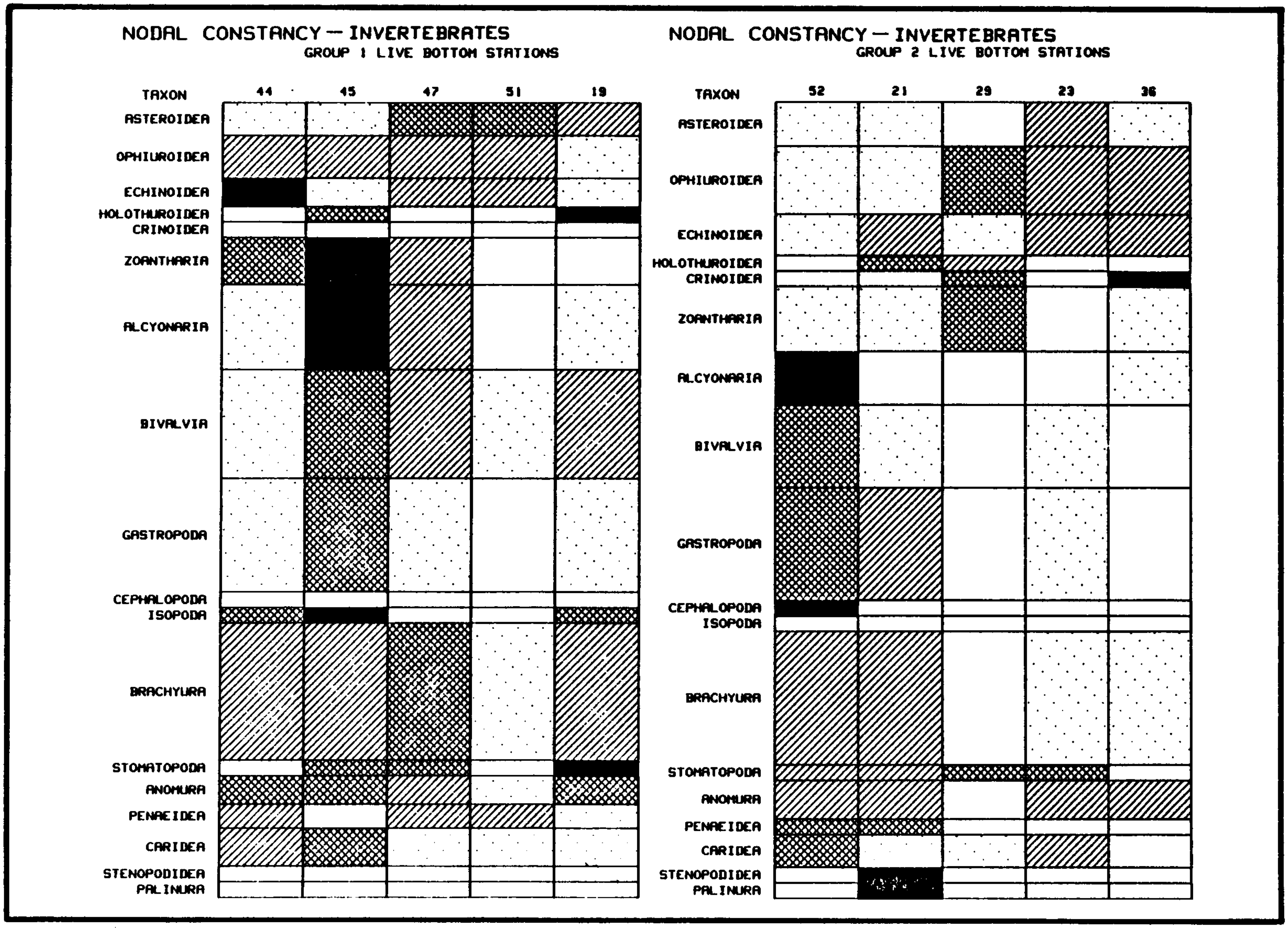


Figure 3-2 NODAL CONSTANCY FOR GROUP I AND II LIVE—BOTTOM STATIONS

NOTE: SEE FIGURE 3-3 FOR A DESCRIPTION OF THE KEY.

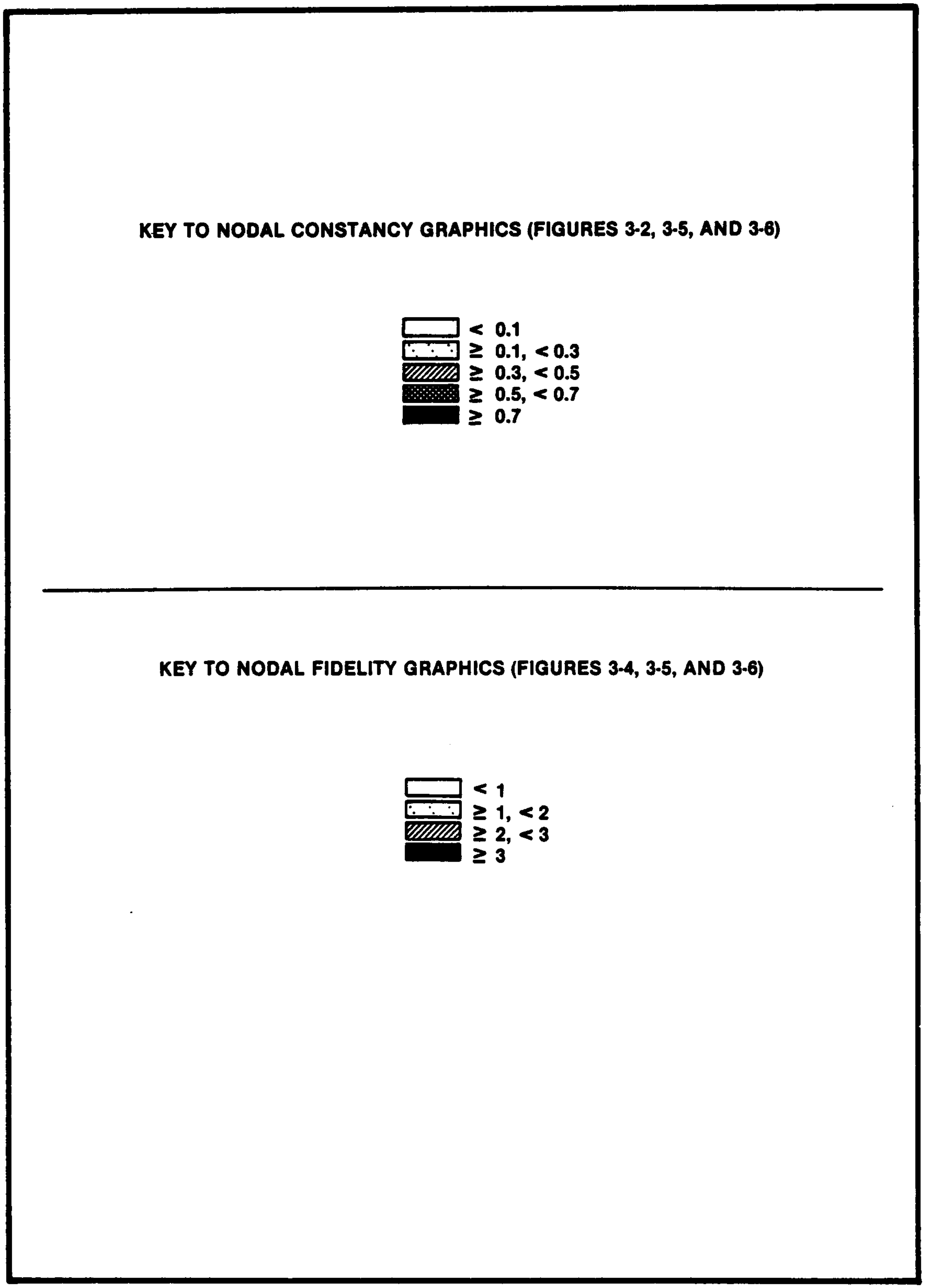


Figure 3-3 KEY TO NODAL CONSTANCY AND NODAL FIDELITY GRAPHICS

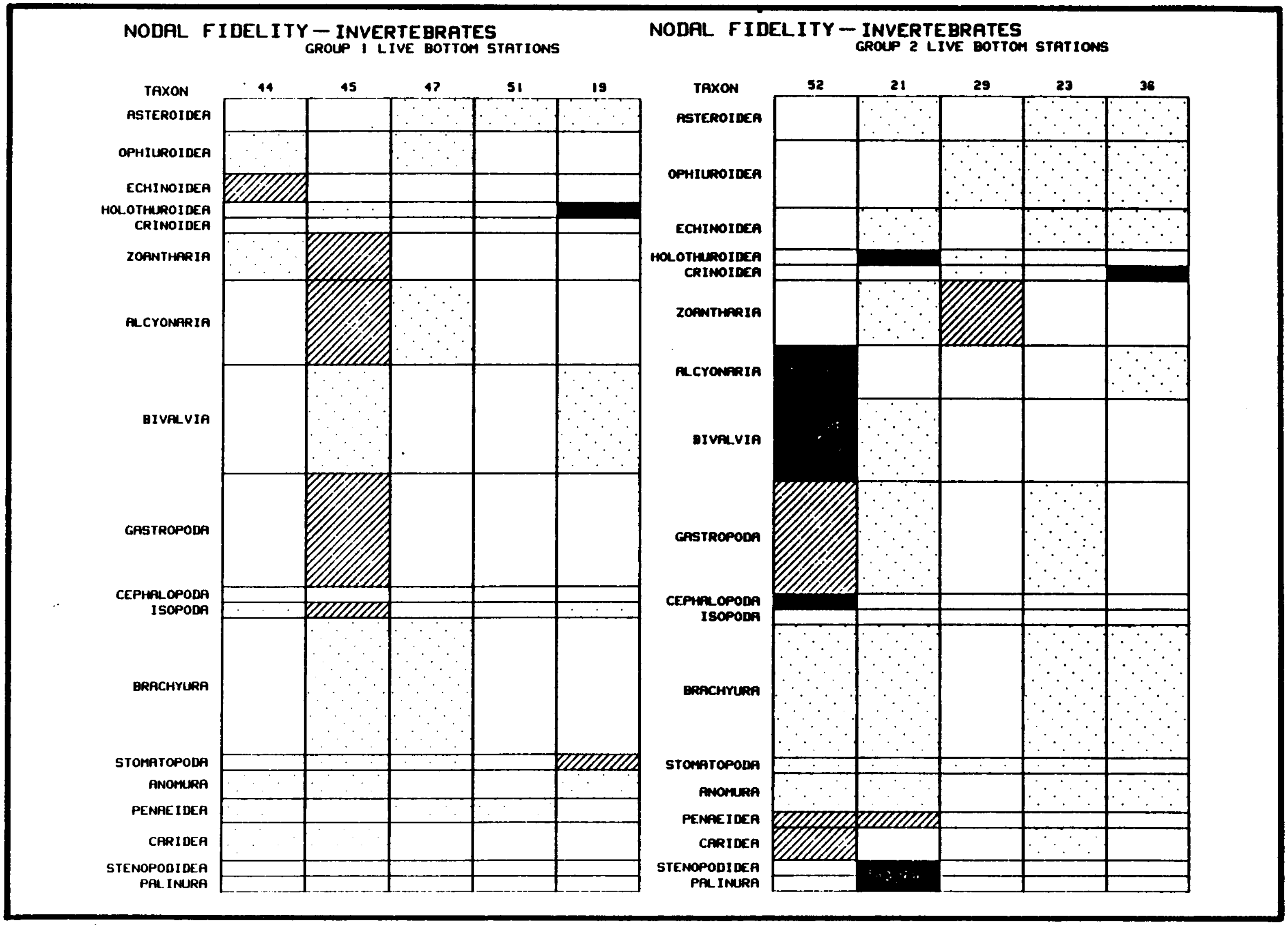


Figure 3-4 NODAL FIDELITY FOR GROUP I AND II LIVE— BOTTOM STATIONS

NOTE: SEE FIGURE 3-3 FOR A DESCRIPTION OF THE KEY.

Constancy is the ratio between the number of taxa (within each group) collected at that station to the total number of taxa within the group. High constancy values are one indication of the quality or suitability of a given environment for members of a particular taxon. The better or more suitable the environment for those species, the higher the proportion of possible species that will be there. Where the number of taxa within a group is small, it is possible to achieve very high constancy values with just a few appearances at one station, since the analysis uses only presence/absence data. For this reason, major groups of taxa which include only several species are de-emphasized in this discussion.

The height of each bar in the nodal constancy chart corresponds to the number of taxa identified with each major taxonomic group listed at left. The darkness of each bar beneath the stations listed across the top of the figure indicates constancy. Fully darkened boxes indicate that 70 percent or more of the taxa within a group were found at those particular stations, i.e., very high constancy. Cross-hatched boxes indicate high constancy, 50 percent or greater; lined boxes, moderate constancy, 30 percent or greater; dots, low constancy, 10 percent or greater; and blanks, very low constancy, less than 10 percent.

Figure 3-2 reveals high or very high nodal constancy at some shallow stations for several large groups of taxa such as Zoantharia, which includes the scleractinian corals (Station 44 and 45); Alcyonaria, the gorgonians (Station 45); gastropods (Station 45); brachyurans (Station 47); and Asteroidea, the sea stars (Stations 47 and 51). Among Group II stations (Figure 3-2), very high or high constancy values were found for scleractinians (Station 29), gorgonians (Station 52), bivalves and gastropods (Station 52), and several smaller groups at various stations.

Nodal fidelity is the ratio between constancy for a given major taxon at a particular station to overall constancy for taxon. Positive ratios are shown with dots (low fidelity, ratio = one or greater), lines (moderate fidelity, two or greater), or solid boxes (high fidelity, three or greater), while negative ratios are blanks. Fidelity indices thus reflect specificity in habitat selection. Figure 3-4 shows that four large groups of taxa were fairly specific in choice of habitat within shallow stations, but that most taxa were widely spread between stations. Scleractinians, gorgonians, and gastropods all showed moderate fidelity to Station 45; echinoids had moderate fidelity to Station 46. Among Group II stations, many taxa had high fidelity values, indicating strong habitat preferences. For example, gorgonians, bivalves, and gastropods had high or moderate fidelity to Station 52; scleractinians showed moderate fidelity to Station 29. Brachyurans, ophiuroids, echinoids, and asteroids, which were extremely numerous at most stations, showed low fidelity values, demonstrating that these taxa as a whole have broad habitat requirements.

3.2.2 BENTHIC ALGAE

Among the green algae, Chlorophyceae, there were no species held in common between Inner Shelf and Middle/Outer Shelf stations. There were 15 taxa collected by triangular dredge; 4 of these were present only at deeper stations, and the remainder only at shallower stations. The most spectacular large species, Anadyomene menziesii, was collected only at Stations 29 and 23.

There was more overlap among the brown algae, Phaeophyceae. Two species were held in common, and Dictyota bartayresii was collected at five stations, more than any other alga. However, there were clearly defined Inner Shelf and deep-water suites of species.

The red algae, Rhodophyceae, had the longest species list and a distinct pattern of station specificity, with lower percentages of species shared between stations than either of the other two groups of algae. Only 5 of the 31 species collected exclusively at Inner Shelf stations were shared between two or more of those stations, and none of the seven species collected exclusively at Middle/Outer Shelf stations was present at more than one station.

3.2.3 FISHES

The most detailed information on fish distribution was provided by trawl hauls, since nearly every individual collected could be identified to the species level. During Year 4, 98 species of fishes belonging to 36 families were collected. The most common species overall were (in decreasing order of abundance) the blackear bass, Serranus atrobranchus (average = 6.6 individuals per trawl); the offshore lizardfish, Synodus poeyi (4.5 individuals); the tattler grouper, Serranus phoebe (4.3 individuals); the shortwing searobin, Prionotus stearnsi (1.8 individuals); and the horned whiff, Citharichthys cornutus (1.4 individuals). However, since species composition differed so much between stations, overall density averages for most species are not particularly meaningful. Station-by-station summaries are more revealing.

The station with the highest average catch per haul was Station 36 (193.6 individuals), followed by Station 23 (66.3 individuals), and Station 52 (56.3 individuals). The poorest catches were made at Station 19 (14 individuals), Station 44 (11 individuals), Station 51 (8 individuals), and Station 29 (5 individuals).

Although the taxonomic resolution provided by underwater television surveys was not as high as that offered by trawl collection, the area surveyed was much greater, and an excellent overview of fish distribution was obtained.

Several families of fishes censused with underwater television were restricted in their distributions, either to deeper water (e.g., the bigeyes, Priacanthidae; the bonnetmouths, Emmelichthyidae; and the squirrel fishes, Holocentridae) or to the shallow water environment of the Inner Shelf (e.g., the snappers, Lutjanidae, and the grunts, Haemulidae). For example, the grunts, Haemulon plumieri and

H. aurolineatum, and the gray snapper, Lutjanus synagris, were seen at all Group I stations and at Station 52, but at none of the deeper stations. Similarly, all four taxa of lizard fishes, Synodontidae, were seen at Station 36, the deepest station; although three of them were sighted at other stations, only at Station 36 did they all co-occur.

Most families, however, included at least a few representatives that were observed at many stations, as well as both species seen mainly on the Inner Shelf or in the Middle and Outer Shelf regions. For example, the groupers, Serranidae, included a high proportion of widespread species. The red grouper, Epinephelus morio, was observed at 8 of 10 stations. Within the same family, the tattler grouper, Serranus phoebe, was seen only at the Middle/Outer Shelf stations (21, 29, 23, and 36). No station had fewer than two species of serranids observed by the television, and stations averaged over four species. Stations 29 and 23 had eight and seven species of groupers (respectively) recorded on the underwater television system. The porgies (Sparidae), butterfly fish (Chaetodontidae), trunkfish (Ostraciodontidae), and the jacks (Carangidae) also included ubiquitous species.

As in the underwater television observations, some taxa collected in trawls were ubiquitous over broad depth ranges, such as the sand diver, Synodus intermedius (eight stations); the fringed filefish, Monacanthus ciliatus (six stations); and the blackedge moray, Gymnothorax nigromarginatus (four stations).

Other families showed clear zonation of species. Clear examples in the trawl data can be seen for the porgies, Sparidae, and for the groupers, Serranidae. Many taxa seemed to lie on either side of an apparent faunal break between Stations 19 and 21. Examples of widespread species--present at three or more stations--mainly found on the Inner Shelf included the white grunt, Haemulon plumieri; the tomtate, Haemulon aurolineatum; the scrawled cowfish, Lactophrys quadricornis; the gray snapper, Lutjanus griseus; and the red grouper, Epinephelus morio.

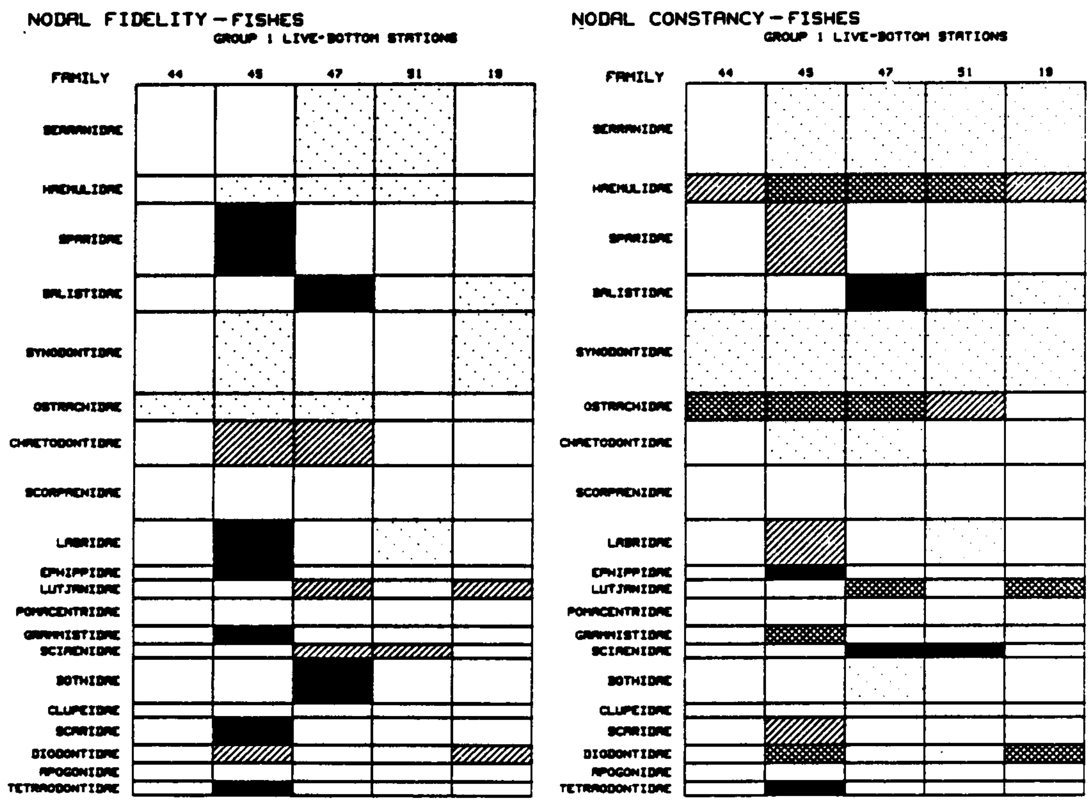
Other taxa were found exclusively or nearly so on the deeper side of Station 19, such as the lefteye flounders, Bothidae; the scorpion fishes, Scorpaenidae; and the damselfishes, Pomacentridae.

Nodal constancy and nodal fidelity analyses were performed for fishes collected by trawling at shallow stations and Group II stations. Figure 3-5 shows constancy and fidelity for families of fishes at the shallow stations, based on presence/absence data. Families showing high or very high constancy included the grunts, Haemulidae, at Stations 45, 47, and 51; the trigger fish, Balistidae, at Station 47; and the trunkfish, Ostracidae, at Stations 44, 45, and 47. Of these, only the Balistidae showed high fidelity.

Several large families were notable for their lack of both constancy and fidelity, indicating scattered distributions or absences by most members of the family within the shallow stations. These included the groupers, Serrandiae; the lizard fishes, Synodontidae; the butterfly fishes, Chaetodontidae; and the scorpion fishes, Scorpaenidae. High fidelity was observed for several families, including the porgies, Sparidae, and the Wrasses, Labridae, at Station 45; and the trigger fishes, Balistidae, and lefteye flounders, Bothidae, at Station 47.

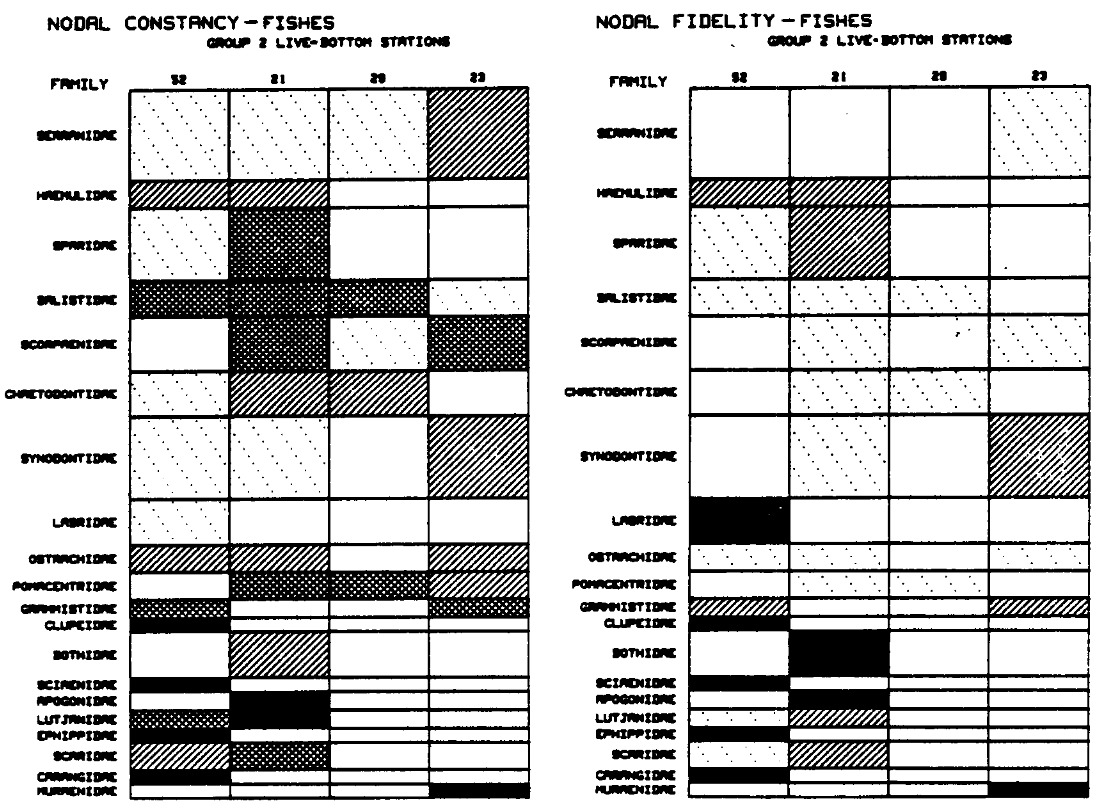
Figure 3-6 illustrates nodal constancy and fidelity for families of fishes at Group II stations. Larger families showing high or very high constancy at Group II stations included the porgies, Sparidae, at Station 21; the trigger fishes, Balistidae, at Stations 52, 21, and 29; and the scorpion fishes, Scorpaenidae, at Stations 21 and 23. Of these, only the wrasses showed high fidelity at Station 52.

A qualitative comparison of stations can be derived by simply noting the number of families within each station showing very high or high constancy, and high or moderate fidelity values (Table 3-5). This comparison provides an indirect indication of how "desirable" or



NOTE: SEE FIGURE 3-3 FOR A DESCRIPTION OF THE KEY.

Figure 3-5 NODAL CONSTANCY AND FIDELITY FOR GROUP I LIVE-BOTTOM STATIONS



NOTE: SEE FIGURE 3-3 FOR A DESCRIPTION OF THE KEY.

Figure 3-6 NODAL CONSTANCY AND FIDELITY FOR GROUP II LIVE-BOTTOM STATIONS

Table 3-5. Comparison of Stations Based Upon Nodal Constancy and Fidelity Analyses for Fishes Collected by Trawling

	Station								
	Group I					Group II			
	44	45	47	51	19	52	21	29	23
Constancy									
Very High	0	2	2	1	0	4	2	0	1
High	1	4	3	1	2	3	5	2	2
TOTAL	1	6	7	2	2	7	7	2	3
Fidelity									
High	0	6	2	0	0	5	2	0	1
Moderate	0	2	3	1	2	2	4	0	2
TOTAL	0	8	5	1	2	7	6	0	3

suitable each station is compared to other stations within the same group. The results suggest that on a relative scale, within the shallow stations Stations 44, 51, and 19 were less "desirable" than Stations 45 and 47 to most families of fishes. Similarly, within Group II, species collected from Stations 29 and 23 showed lower constancy and fidelity, i.e., specificity, than did those from the shallower stations, 52 and 21, which could be considered more "desirable" or suitable for many families.

Underwater television surveying appeared to sample some taxonomic groups not easily collected by trawling at some stations. However, many species observed on the underwater television were collected in the trawl as shown in Table 3-6. Since the 3-dimensional area surveyed by television (as opposed to trawls) would be difficult or impossible to compare quantitatively, only general statements as to the capabilities of both gears can be made. The area sampled by each trawl was probably much less than a tenth of the area sampled by underwater television, and the trawl sampled only those fishes on or near the bottom, whereas the television observed fish much higher in the water column but could not census cryptic fauna.

At 7 of 10 stations, far more taxa were identified in television samples though some could only be identified to the genus level. Many species observed in videotapes were never collected by trawling. Examples include most of the jacks, Carangidae; the porkfish, Anisotremus virginicus; half the butterfly fishes, Chaetodontidae; half the damselfishes, Pomacentridae; and many groupers, Serranidae. On the other hand, the trawl collected some benthic or cryptic species never seen by the underwater television, such as the soapfishes, Rypticus maculatus and R. bistrispinus, and the blackedge moray, Gymnothorax nigromarginatus.

Table 3-6. Comparison of Number of Individual Taxa of Fishes Observed on Underwater Television Versus Number Collected by Trawling (Stations are in Order of Increasing Depth)

	Station									
	52	44	51	45	47	19	21	29	23	36
Number of Taxa (underwater television)	32	17	29	25	15	36	26	33	32	13
Number of Taxa (trawl)	17	3	8	17	16	10	32	9	19	33

4.0 PHYSICAL DYNAMICS

Based on Year 4 results, it appears the wind-driven currents, tidal currents, and surface wave-induced bottom orbital velocities operate in concert to resuspend and transport significant quantities of sediment in the study area. Further, it appears that routinely recurring weather patterns do not cause significant quantities of sediment resuspension and transport at depths exceeding 50 m. These conclusions are based on the following interpretations of the Year 4 data.

Substantial quantities of sediment were trapped (resuspended) only at Station 52 at a depth of 13 m. A minor amount of sediment was trapped during the fall at Station 21 at a depth of 45 m. There was no evidence of sediment resuspension at Stations 23, 29, and 36 in depths of 70 m, 60 m, and 126 m, respectively. Thus, to identify the mechanisms responsible for sediment transport, the first task is to identify the difference between Station 52 and the other stations. Obviously, it is the shallowest, and surface waves will generate higher bottom orbital velocities in shallower waters. Resultant current vectors (net drift) are greater at the deep water stations than at 52. Although net drift is a good indication of the ability of current to transport suspended sediments, extreme currents are required to resuspend sediments initially. The lower net drift at Station 52 reflects the dominant contribution of oscillating tidal flow. Average current speeds at Station 52 are slightly higher than at Stations 23, 29, and 36 because of the strong tidal currents at Station 52 as illustrated in Figure 4-1. The most important statistic, however, is the frequency of current speeds exceeding 60 cm/s. These data are illustrated in Figure 4-2, which shows that extreme bottom currents capable of resuspending sediments were much more prevalent at Station 52 in the winter and spring than at any other station in any other season. Winter and spring were also the seasons when the greatest quantities of suspended sediments were trapped at Station 52. The frequency of currents

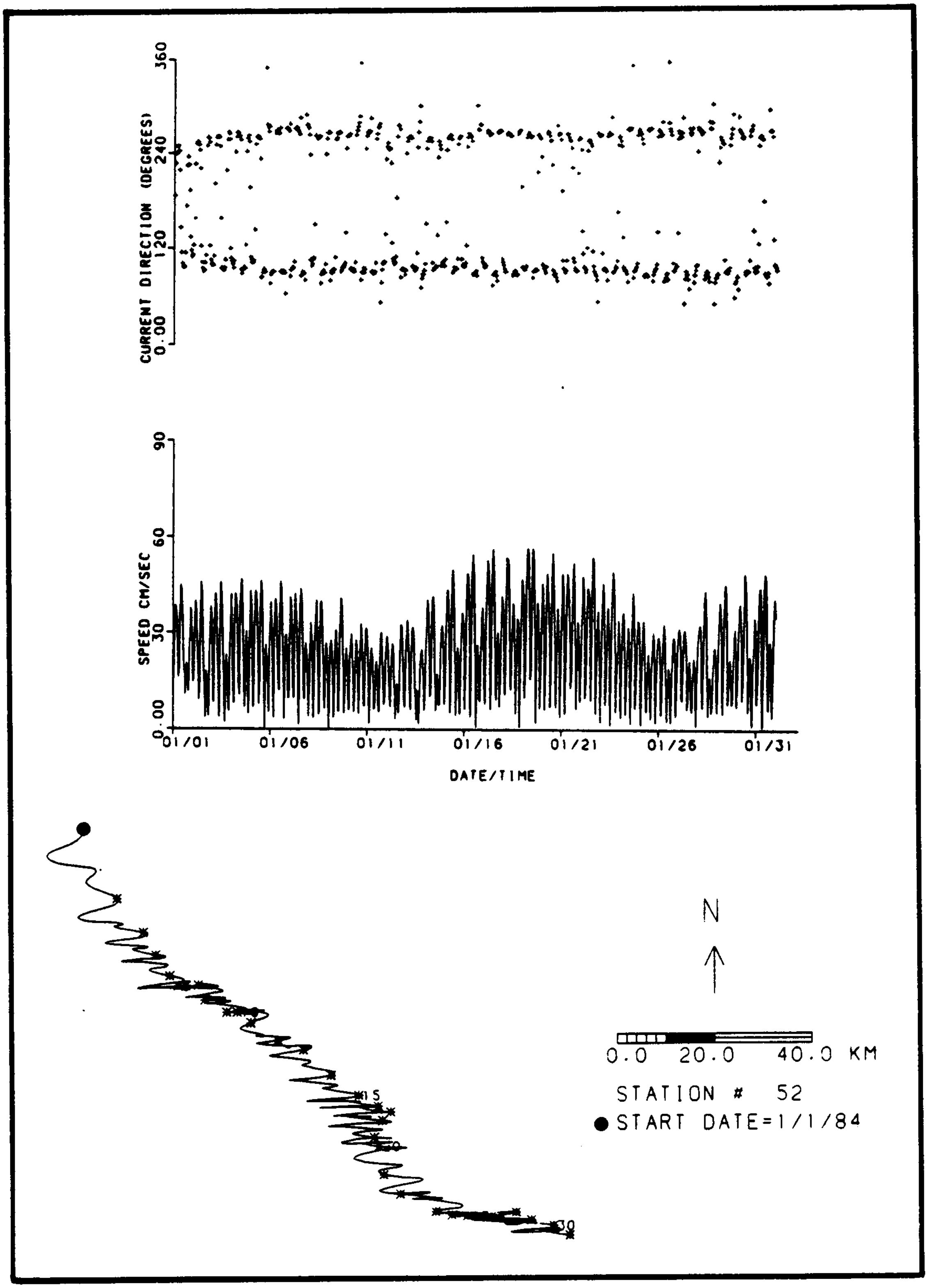


Figure 4-1 **STATION 52 CURRENT SPEED, DIRECTION AND PROGRESSIVE VECTOR PLOTS - JANUARY 1984**

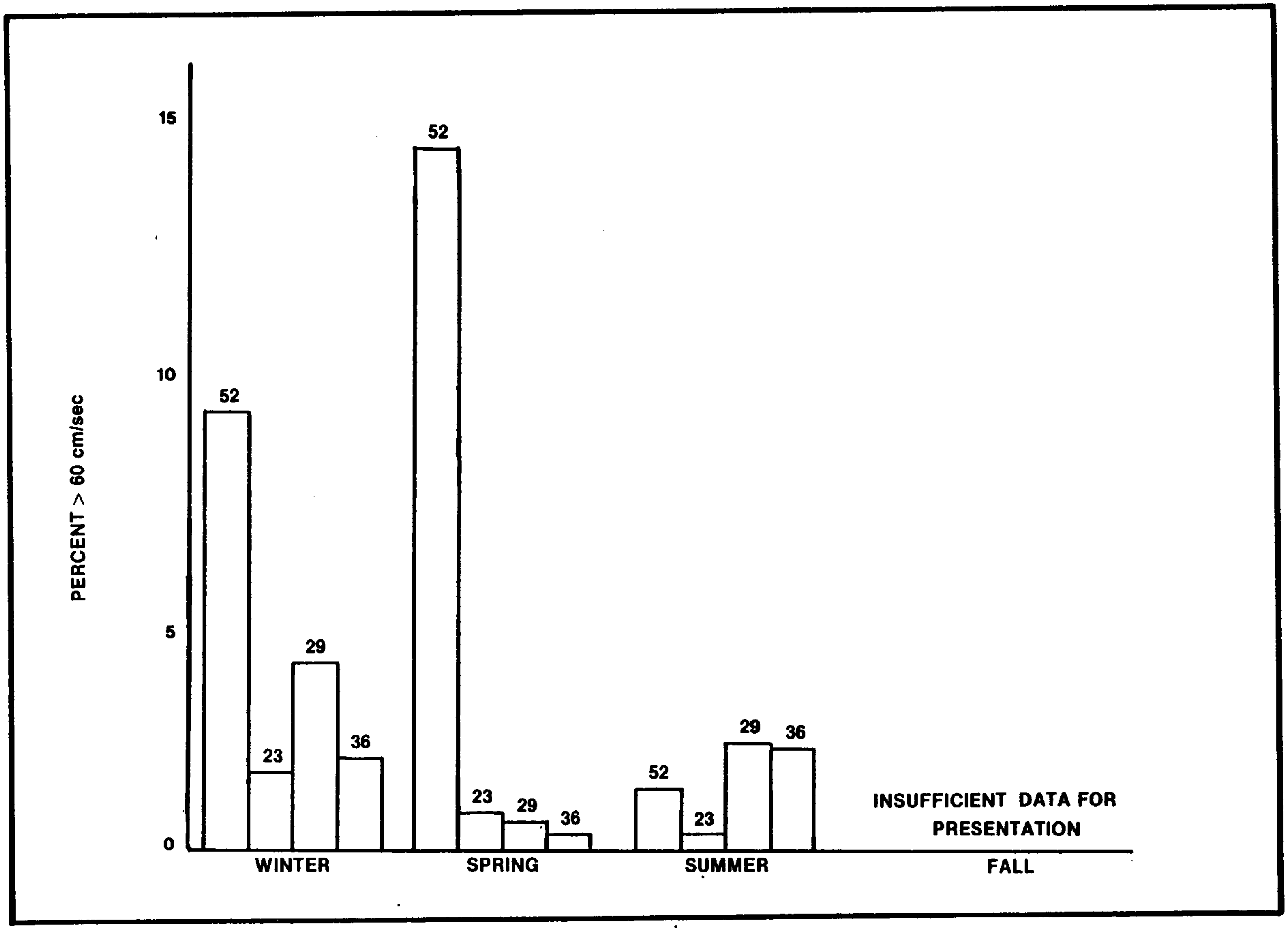


Figure 4-2 FREQUENCY OF EXTREME BOTTOM CURRENTS

exceeding 60 cm/s at each station is closely correlated with the quantity of sediments trapped (r = 0.83, significant at 99 percent confidence). Nonetheless, extreme currents alone explain only about two-thirds of the variability in trapped sediment mass. For example, in the fall, currents at Station 52 never exceeded 60 cm/s, and the frequency of currents in excess of 40 cm/s was lower than observed during the summer at that station (0.4 percent in fall versus 11 percent during the summer), yet the mass of trapped sediments was more than three times greater in the fall than in the summer. As another example, currents during the winter at Station 29 exceeded 60 cm/s 3.7 percent of the time, more frequently than observed at Station 52 in either the summer or fall, yet negligible amounts of sediments were trapped at Station 29 in comparison with Station 52.

Thus, it appears that wave-generated bottom orbital velocities are responsible for some fraction of the sediment resuspension. Wave-generated currents are apparently a secondary contributing factor, since bottom orbital velocities are somewhat less than the flows observed by the current meters. Wave-induced bottom orbital velocities exceeding 40 cm/s occur 1 to 6 percent of the time at Station 52, while currents exceeding 40 cm/s occurred 25 percent of the time in Year 4. Currents in excess of 60 cm/s occurred 6.5 percent of the time at Station 52 during Year 4 (14 percent during the spring), while bottom orbital velocities exceeding 60 cm/s occur less than 6 percent of the time. Nonetheless, they are important contributing factors since the current meters recorded high speeds, in excess of 60 cm/s, at both deep and shallow stations, but only the shallowest station (52) experienced significant sediment resuspension.

ESE's data support the findings of Cooper (1982), in that Station 52 net drift was to the southeast and was stronger in winter and spring than in the summer. Since Cooper's results indicate that net drift in the vicinity of Station 52 is predominantly wind driven, then wind-driven currents are an important driving force for sediment transport on the shallow inner shelf. The tidal ellipse at Station 52 is strongly dominated by an east-west major axis reinforcing the southeast wind-driven net flow on the flood tide. Cooper's model also indicates a strong vertical, wind-driven, shear in this region and shear-generated turbulence will enhance sediment resuspension. Wave-generated orbital velocities further enhance the bottom shear stress which ultimately drives sediment resuspension and transport.

On a theoretical basis, the intrusions of the Loop Current bring strong enough currents to the outer shelf to initiate sediment transport. The sediment trap data, however, showed no significant sediment resuspension as a result of these events. This provides further evidence that wave action is an important contributing factor in sediment resuspension on the inner shelf.

5.0 CONCLUSIONS AND RECOMMENDATIONS

This Year 4 Annual Report is essentially a progress report being submitted midway in an ongoing 2-year study to present current information collected on the Southwest Florida OCS. Consequently, final conclusions and potential impact assessments will not be formulated until the data set is complete. However, from the descriptive biological and physical data presented, it is possible to summarize the results to date, present potential areas of concern, and recommend modifications in the focus of certain tasks within the program.

The natural variability of suspended solids, sediment characteristics, and sediment transport is important in assessing stresses on the existing communities and assessing potential impacts of additional stress that may be imposed by introducing drilling muds and cuttings to the environment. The natural sediment at the hard-bottom stations consists of a thin layer of sand over hard substrate. The sand is about 90 percent $CaCO_3$ with no clay minerals present. The $CaCO_3$ consists of both aragonite and calcite, which indicates it is derived from shell fragments and from the limestone bedrock. Even though the sediments consist of 98 percent sand-sized particles, the suspended sediments were 90 percent silt and clay size, indicating the wave and current energy at the shallow station (Station 52) was sufficient to resuspend smaller particles but not sufficient to readily resuspend and transport sand-sized particles.

Wave action and currents at the shallow station were very active in resuspending and transporting sediments. Periods of near-zero visibility resulting from suspended sediments loads were recorded by time-lapse camera. The sediment traps indicated an average of up to 1,000 metric tons per square kilometer per day ($t/km^2/d$) were resuspended to a height of 0.5 m during the most active winter months. This can be compared to a typical drilling rig discharge of mud and cuttings of about 10 metric tons per day (t/d). This sediment resuspension and subsequent deposition were very episodic as indicated by layering in the sediment traps and intermittent periods of high turbidity apparent on the time-lapse camera. In fact, as much as 40 percent of the sedimentation that occurred during the 3-month winter period may have occurred during one storm. No bedload transport in the form of moving ripple marks was observed on the time-lapse camera.

Sediment resuspension at the shallow (13 m) station was due in part to the strong tidal currrents that occurred there. However, currents of equal magnitude occurred occasionally at the deepest station (125 m) and yet no sediment resuspension occurred. Consequently, the addition of the wave energy that was able to penetrate to the bottom at the shallow station was sufficient in conjunction with the currents to produce the velocities needed for the sediment transport observed in shallow water. It was estimated that wave orbital velocities at the bottom for the shallow station exceeded 40 cm/s between 1 and 6 percent of the time. Since almost no wave energy could penetrate to 125 m or even to depths greater than 50 m, little sediment resuspension occurred at the deeper stations.

Once the sediments were resuspended at the shallow station, the net currents indicated the sediment would drift to the southeast toward Florida Bay. The currents in this area were dominated by a strong east-west tidal current, but the net drift was to the southeast during all seasons. Any contaminant entering the water column in this area would be greatly dispersed by the tides, but the center of mass would still propagate to the southeast. It cannot be determined if a potential contaminant would reach Florida Bay, but since the literature search conducted indicated a paucity of data for Florida Bay, a study of its resources and circulation patterns may be justified. One mitigating factor for this area, however, does exist. Even though the net currents are to the southeast, the prevailing winds are generally from the east (as recorded at Key West). This would tend to keep any surface contaminant away from Florida Bay.

Several other characteristics of the currents were apparent in the current meter data. The tides were the dominant periodic component at all stations. The tidal energy varied from a dominant semidiurnal component with nearly all energy in the east-west direction in the shallow water to a mixed tide with nearly circular tidal ellipses in the deeper water. As mentioned previously, the net flow in shallow water was consistently to the southeast. The net flow at the deeper stations varied between seasons with frequent reversals in flows. Obvious intrusions of the Loop Current were apparent in the records from the deeper stations, and some evidence existed that the influence may have reached Station 21 at a depth of 47 m. Loop Current intrusions were recognized in the data as temperature increases of 3° to 5°C and resulted in strong currents to the north. Since the Loop Current flows to the south, these observed currents were either reverse eddies at the edge of the Loop Current or reverse bottom flows beneath the Loop Current. Subsequent analysis of Year 5 data will concentrate on better defining the extent of the Loop Current effects and its charcteristics at these Florida OCS stations. Since the highest currents observed at the deeper stations occurred during Loop Current intrusions, it is possible that subsequent intrusions may cause sediment resuspensions and transport and possibly subject the deep water biological communities to stresses resulting from suspended solids that were not observed during Year 4. If such events occur, subsequent current meter data and sediment trap results will document the occurrence.

The biological data collected during all four seasons of sampling identified a diversity of taxa varying from a very dense epifaunal, hard-bottom community in shallow water to a sparse crinoid assemblage at the shelf break in 125 m of water. The communities are very complex as illustrated by earlier studies that identified over 100 species of sponges in shallow water stations. The lush shallow-water communities, however, are subject to extreme variabilities in suspended sediment concentrations as well as considerable temperature changes over the year. Since the communities are flourishing under these conditions, it is possible they may be more resistant to disruptive activities than communities in less turbid areas. Communities in depths greater than 50 m are not naturally subjected to periods of high suspended solids (according to 1 year of sediment trap data) and, although they may be resistant, it has not been observed as with the shallow stations.

The shallow water station also exhibited much faster recruitment than the deeper stations. After 1 year, the fouling plates and most of the array structure were completely covered by the fouling community. In contrast, Station 36 at a depth of 125 m had minimal growth consisting primarily of hydroids. This, of course, implies that communities damaged in shallow water may recover more quickly (at least for some species) than those damaged in deeper water.

Most of the biological data, including the underwater television, trawls, fouling plates, and time-lapse camera data, will not be subjected to detailed statistical analysis and comparison to physical parameters for this mid-study annual report. However, a discussion is warranted on the adequacy on the methods and modifications that will be implemented during Year 5 to better meet the objectives of the program.

The underwater television data have provided the detailed information in sufficient quantity to document community characteristics. Only station descriptions were provided from the underwater television data for this report, but once the 2-year data base is complete, seasonal changes, habitat relationships to fish and other motile communities, and responses to physical parameters will be identified. This information will enhance the chances for meaningful impact assessment of offshore development. Consequently, underwater television work is being continued during Year 5.

The dredge sampling to collect representative epifaunal species proved to be effective. More sample was collected than could possibly be processed within the scope of the contract. Consequently, since sufficient voucher specimens were collected dredge sampling was eliminated during Year 5 at stations that were sampled during Year 4. New stations that were established during Year 5, however, will be sampled to collect voucher specimens. Trawl sampling will continue at all stations during Year 5.

The fouling plate studies originally designed for 2 years will continue. Since the data are proving important in documenting highly variable recruitment rates (generally as a function of depth), additional plates will be installed at new stations established during Year 5. The greatest weakness of the plates is that they are susceptible to damage from large fish that occupy the arrays, and many of them were lost during Year 4, particularly at Station 52.

One of the most useful biological sample devices proved to be the time-lapse cameras. They were originally installed to monitor sediment transport but are proving to be valuable in documenting fish behavior around platform structures. Only two time-lapse cameras were installed on a trial basis during Year 4 to investigate their utility. Two things were learned: (1) they obtained valuable biological and physical data that could be obtained in no other way, and (2) they are difficult to maintain. Much of the time-lapse camera data were lost during Year 4 primarily from a lost array and from damage by large fish and turtles that took up residency in the arrays. However, because the time-lapse camera data collected proved to be valuable, seven time-lapse cameras will be installed and maintained at various depths during Year 5.

The time-lapse camera data presented in this report identified several patterns of fish habits around the array structure. The greatly expanded data base for Year 5 will allow for better observation of these patterns and should allow for documentation of hourly, daily, and seasonal changes in fish activity and recruitment around an artificial structure. The expanded data base may also allow for comparison with physical parameters to determine if structure recruitment or abandonment is caused by currents, tides, or storm activity. It may also help determine if there is some hierarchy established among fish species within a reef structure. This type of information should prove valuable in assessing the effects of offshore structures on fish communities.

In conjunction with the time-lapse cameras, the instrumented arrays proved to be most effective in collecting continuous data. Consequently, the number of arrays will be expanded from five to eight during Year 5, and all but the deep water station (125 m) will be equipped with time-lapse cameras. Considerable equipment was lost during Year 4 from vandalism and fishermen. The array presumably was dragged from the area because it could not be found with the underwater television. As a result of relatively high instrument loss, three backup arrays have been provided for the Year 5 program.

Other recommendations that have been implemented for Year 5 include:

1. Establishment of underwater video and side-scan sonar transects in potentially sensitive areas around the Dry Tortugas,
2. Investigation of a deep hole identified by the Florida Department of Natural Resources,
3. Collection and preservation for 5 years of 100 fish samples that can be used for baseline contaminant levels if required, and
4. Seasonal monitoring of an established transect using a hand-held video system to identify small changes in sedimentation and epifaunal community structure.

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The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil and other mineral resources. The MMS **Minerals Revenue Management** meets its responsibilities by ensuring the efficient, timely and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.