FINAL REPORT
OCS Report MMS 95-0005

REPORT TO:

U.S. Department of the Interior
Minerals Management Service
Office of International Activities and Marine Minerals

on

Impacts and Direct Effects of Sand Dredging for Beach Renourishment on the Benthic Organisms and Geology of the West Florida Shelf

Contract Number 14-35-0001-30644

FINAL REPORT

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1.1 INTRODUCTION

The Department of the Interior (DOI) bears the responsibility for managing the development of the submerged lands of the continental shelf seaward of state territorial waters. This federal jurisdiction was first mandated under the 1953 Outer Continental Shelf (OCS) Lands Act (67 Stat. 462). Under this Act the Secretary of the Interior bears direct responsibility for administration of oil, gas, and mineral exploration; for development of the OCS; and for formulation of regulations to meet provisions of the Act. The Bureau of Land Management (BLM) was designated by the Secretary of the Interior to administer leasing of submerged federal lands, and the Geological Survey to supervise production. In May 1982, these functions were centralized under the Minerals Management Service (MMS).

Complementary to the 1953 OCS Lands Act, the National Environmental Policy Act of 1969 requires that MMS use a systematic interdisciplinary approach to plan development which may have an impact on the environment. The Environmental Impact Statements (EIS), Environmental Assessment Teams, data acquisition and analysis, public hearings, and special studies are mechanisms used by MMS to fulfill this requirement.

As an expression of continuing concern about the effect on the environment of man's development of the OCS, the OCS Lands Act Amendments of 1978 were promulgated. These Amendments authorize the Secretary to conduct studies to obtain the information required to predict, assess, and manage the coastal environments of the OCS and those coastal areas that may be affected by mineral mining activities.

To meet its responsibilities the MMS has four priority goals of OCS non-energy minerals leasing: 1. to safeguard the ocean and coastal environments by assuring that OCS mineral activities are environmentally sound and acceptable, 2. to assure that OCS mineral activities are fully coordinated and compatible with other uses of the sea, 3. to provide an effective consultation process for coastal States and the Federal government on offshore minerals, and 4. to evaluate and achieve the potential of the U.S. OCS as a domestic supply source for strategic and other minerals.

To fulfill its environmental protection responsibilities the MMS has used a variety of approaches, primarily related to the OCS oil and gas leasing program. These approaches have included EISs, marine environmental data acquisition and analysis studies, literature surveys, socioeconomic analysis studies, public conferences, and special studies (toxicity trials, modeling of spill trajectories, etc.). With the recent location and evaluation of various OCS hard mineral deposits of potential economic value, there exists the possibility of offshore hard mineral development for various mineral commodities. Therefore, environmental studies are being developed in order to evaluate potential adverse impacts of mineral leasing or development and to identify mitigation measures to minimize these impacts.

1.2 POTENTIAL BIOLOGICAL IMPACTS OF MARINE MINING ACTIVITIES

Environmental disturbance is an important fact of life for shallow water organisms. Storm waves, shifting substrata, longshore currents, temperature variations, and other physical factors, as well as various biological influences (e.g., competition and predation), play an important role in determining the structure and composition of benthic communities (Bowen and Marsh, 1988). Species living in this environment must either be capable of withstanding these influences or of quickly recolonizing locally perturbed areas from which they have previously been extirpated. For most benthic invertebrates, the latter response is more common.

Consequently, most nearshore benthic invertebrates tend to be r-strategists rather than K-strategists, which are more common in deeper, relatively stable areas of the seafloor (Sanders, 1960). According to Odum (1969), r-strategists are characteristically small bodied, short lived, and have high fecundity, efficient dispersal mechanisms, and rapid growth rates. Species possessing these r-selected characteristics are relatively poor biotic competitors and, in the course of succession, are eventually replaced by more competitive K-selected species. The K-strategists are generally larger in size than r-strategists, long lived, and have low fecundity, poor dispersal mechanisms, and slow growth rates. Recolonization of a disturbed area is thus generally initiated by r-strategists. Theoretically, r-selected species change the physical environment so that it can later be occupied by the more K-selected species (Connell and Slatyer, 1977; Rhoads *et al.*, 1977). In unstable or frequently perturbed habitats, however, r-selected species may continue to predominate.

Benthic organisms are commonly monitored because of their intimate contact with the dredged sediments. Organisms living in the immediate vicinity of the dredging and disposal areas either are transported from one site to the other or are buried by the spoils. Also, organisms that feed on suspended and deposited materials in these areas ingest dredged sediments resuspended and redeposited during dredging and spoil disposal.

A second reason for studying benthic organisms stems from their utility as indicator organism. Being less mobile than fish, they are not likely to escape or selectively avoid the affected areas. Their relatively long life-spans make them useful as indicators of past perturbations. Mollusk shell fragments provide a long-term record of changes in birth and death rates (Gordon *et al.*, 1972). Benthic macrofauna are relatively easy to collect and identify in the field. The benthic community makes up a spectrum of species that vary greatly in habitat, modes of feeding, and tolerance of environmental stress (Gordon *et al.*, 1972; Taylor *et al.*, 1970).

A third reason for monitoring benthos is that they provide a crucial link in the detritus-based food chain. They eat organic matter and thus recycle nutrients that otherwise would collect and remain trapped in the sediments. Benthic organisms are food for demersal fish and other predatory aquatic organisms.

Finally, clams, mussels, oysters, scallops and lobsters are important as commercial fishery resources.

Immediate Effects:

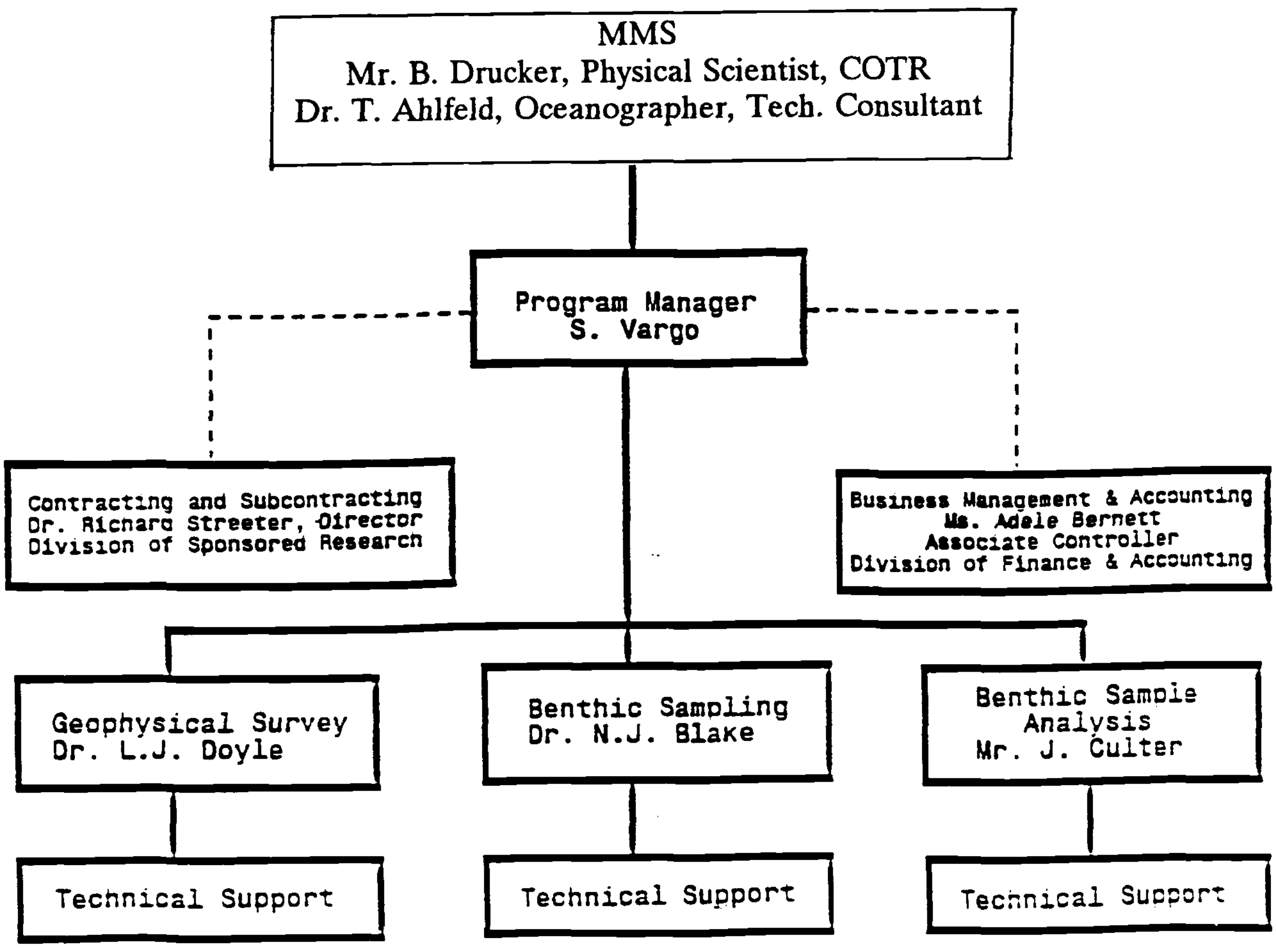
Both Jones (1950) and Scanland (1966) consider "bottom type" as the single-most influential factor for all benthic communities regardless of the physical and chemical characteristics or geographic locations. Both turbidity and sediment deposition rates could affect the substrates, and both could exert their independent influences on filter-feeders and other bottom-dwelling organisms (Collard and D'Asaro, 1973).

Direct burial by spoils discharged in large quantities within the short time interval of spoiling is the most obvious effect on benthic organisms. Sessile or attached animals such as oysters, mussels, and barnacles are killed outright by direct burial (Lunz, 1938, 1942; Wilson, 1950; Brehmer, 1965; Carriker, 1967; Saila *et al.*, 1972; Rose, 1973). In general, when sediments are anoxic, smaller animals are even more vulnerable to burial because they are unable to reach the surface before they suffocate. Small crustaceans respond to oxygen deficiency by increased ventilation and rapidly use up the available dissolved oxygen (DO)(Saila *et al.*, 1972). Some bivalve mollusks, however, can incur an oxygen debt and certain polychaetes can reduce their activity and metabolism when DO levels are low, thus providing a longer time for escape (Nicol, 1967).

Saila *et al.* (1972) showed that *Nephtys incisa*, a large polychaete, and *Mulinia lateralis*, a small filter-feeding bivalve, reached the surface through 21 cm of sediments in the laboratory. *Streblospio benedicti*, a small tube-dwelling polychaete, surfaced through 6 cm of sediments. Bivalves of the genera *Macoma*, *Yoldia*, and *Nucula*, which can move horizontally, would also be expected to escape from spoils deposited upon them (Saila *et al.*, 1972).

Another critical effect of dredging and disposal is habitat destruction resulting from change in the physical and chemical characteristics of the sediments, loss of vegetative cover, filling in of spawning grounds, or change in circulation patterns at the dredge or disposal site (Brehmer, 1965; Chapman, 1968; Cottam, 1968; Marshall, 1968; Taylor *et al.*, 1970; Kaplan *et al.*, 1974). Barnard and Reish (1959) cautioned that dredging in Newport Bay would eliminate the shell fragments from the bottom, leaving behind muddy sand and possibly rendering the habitat no longer suitable for the amphipod *Metaceradocus occidentalis* and the polychaete *Scyphoproctus oculatus*. Saloman *et al.* (1982) described alterations in the physical structure of borrow site substratum in relatively shallow water (18 meters) high energy area. Evidence of post mining sediment alterations included lower sand content, poorer sorting, and a higher organic content. These differences became obscured with time and borrow site sediments were very similar to undisturbed areas after a period of one year. Saloman showed that the fauna of the borrow pits of Panama City, Florida, showed a complete recovery within 9 months to one year. However, samples obtained beyond one year for this same study indicated a lack of complete recovery, which was attributed to inherent spatial variations. Buelow (1968) suggested that sewage sludge dumped at the head of Hudson Canyon might endanger the breeding grounds of lobsters and reduce crab populations. Bruer (1962) reported that oyster populations were destroyed in the northern end of South Bay, Texas, during a shell dredging project. Spoil deposition decreased depth from 1.2m to 0.4m,

Figure 1.5-1. Program Management Plan



cruise plan. He supervised the technical staff collecting and conducting the initial processing of the benthic macroinfaunal samples. In particular, he supervised the collection and analysis of the video tapes of the macro-epibenthic assemblages and the collection and species verification of the epibenthic trawls. He prepared the reports pertinent to this data and in cooperation with Dr. Doyle interpreted the sediment and faunal data.

Benthic Infauna Sample Analysis:

Mr. James K. Culter was responsible for the sorting, biomass determinations, and faunal identification of the benthic samples. He was assisted by four Senior Biologists and one Staff Biologist at Mote Marine Laboratory (MML). He prepared the data in the appropriate data base for submission to MMS and prepared the sections of the report dealing with sample processing and analysis. He coordinated his interpretations with those of Drs. Doyle and Blake. He was the project manager for MML and was the principal liaison with USF/FIO.

1.6 METHODS AND APPROACH

1.6.1 Geophysical Surveys

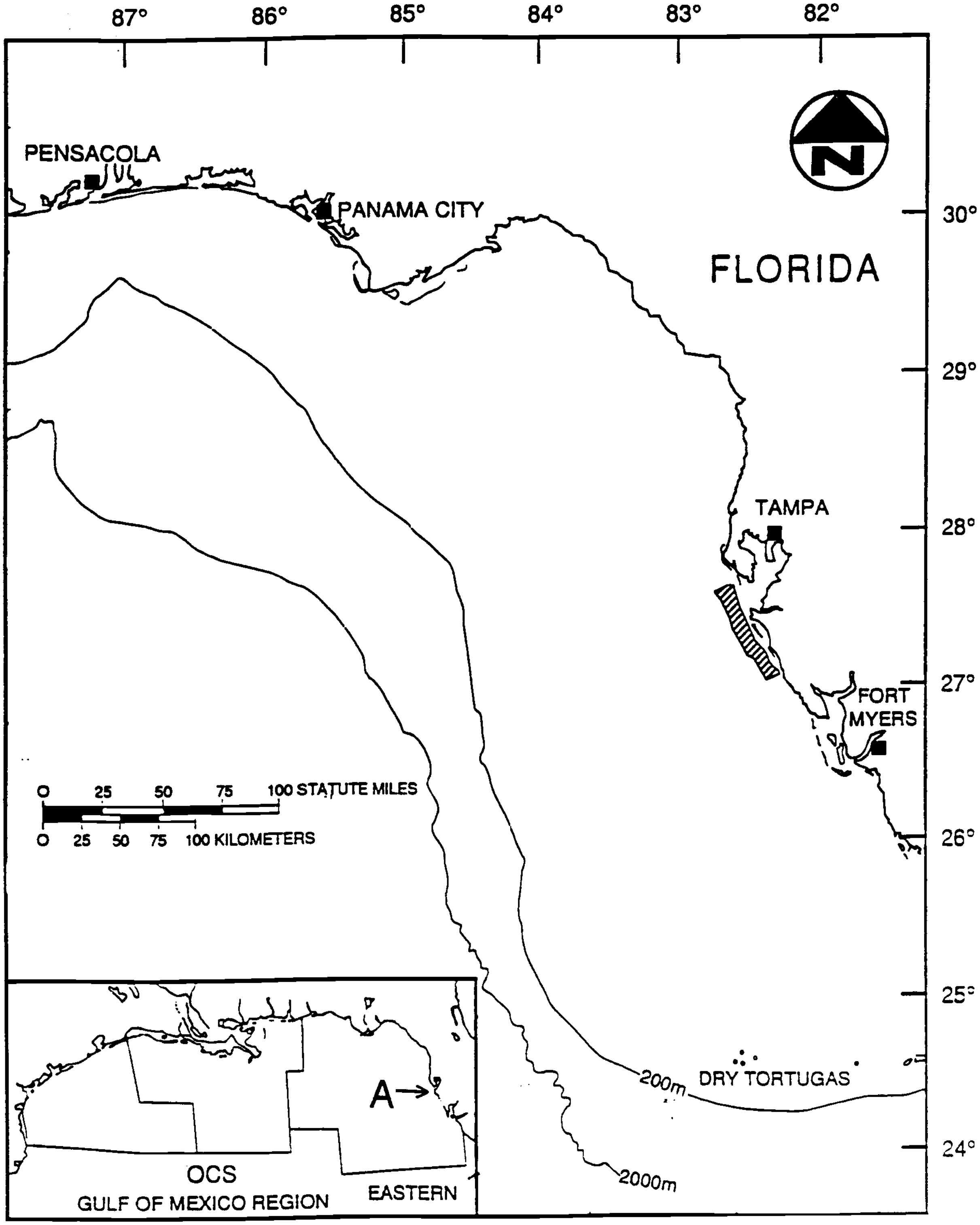
Survey Outline

The sampling program was conducted at each of four sites (Figure 1.6-1) selected after consultation with MMS, the Army Corps of Engineers, principal investigators, and the program manager. The general station locations in latitude and longitude, site designations, and number of samplings are as follows:

Egmont Key	Site I	27°37' N, 82°49'W	1-pre, 3-post
Sarasota	Site II	27°15' N, 82°35'W	3-pre, never dredged
Manasota	Site III	26°29' N, 82°27'W	1-pre, never dredged
Longboat	Site IV	27°14' N, 82°36'W	1-post

Prior to each benthic sampling event a geophysical survey was conducted at each site. A maximum of 12 nautical miles of high resolution seismic reflection profiling, side scan sonar data, and continuous video tape of the bottom was collected simultaneously. Figure 1.6-2 shows the gear array used. Line spacing was as close as possible and depended on the site sizes. Lines were adjusted in surveys following the pre-dredging survey in order to pass over actual dredged areas. Navigation was by LORAN C with fixes marked at 5 minute intervals on the high resolution seismic reflection profiling and side scan sonar surveys and every 10 minutes on the video system. Surveys were conducted at two knots or less (the ROV towing speed was the limiting factor).

Figure 1.6-3 shows the relative position of the four sites and the survey tracks. Figures 1.6-4 to 1.6-12 show the details of all four sampling sites. The positions of each of the benthic box core stations (BC)[each of which had 10 replicate samples taken (A-J)], the geophysical track lines, including TV (solid lines), and finally the locations of the otter trawls (OT) are shown.



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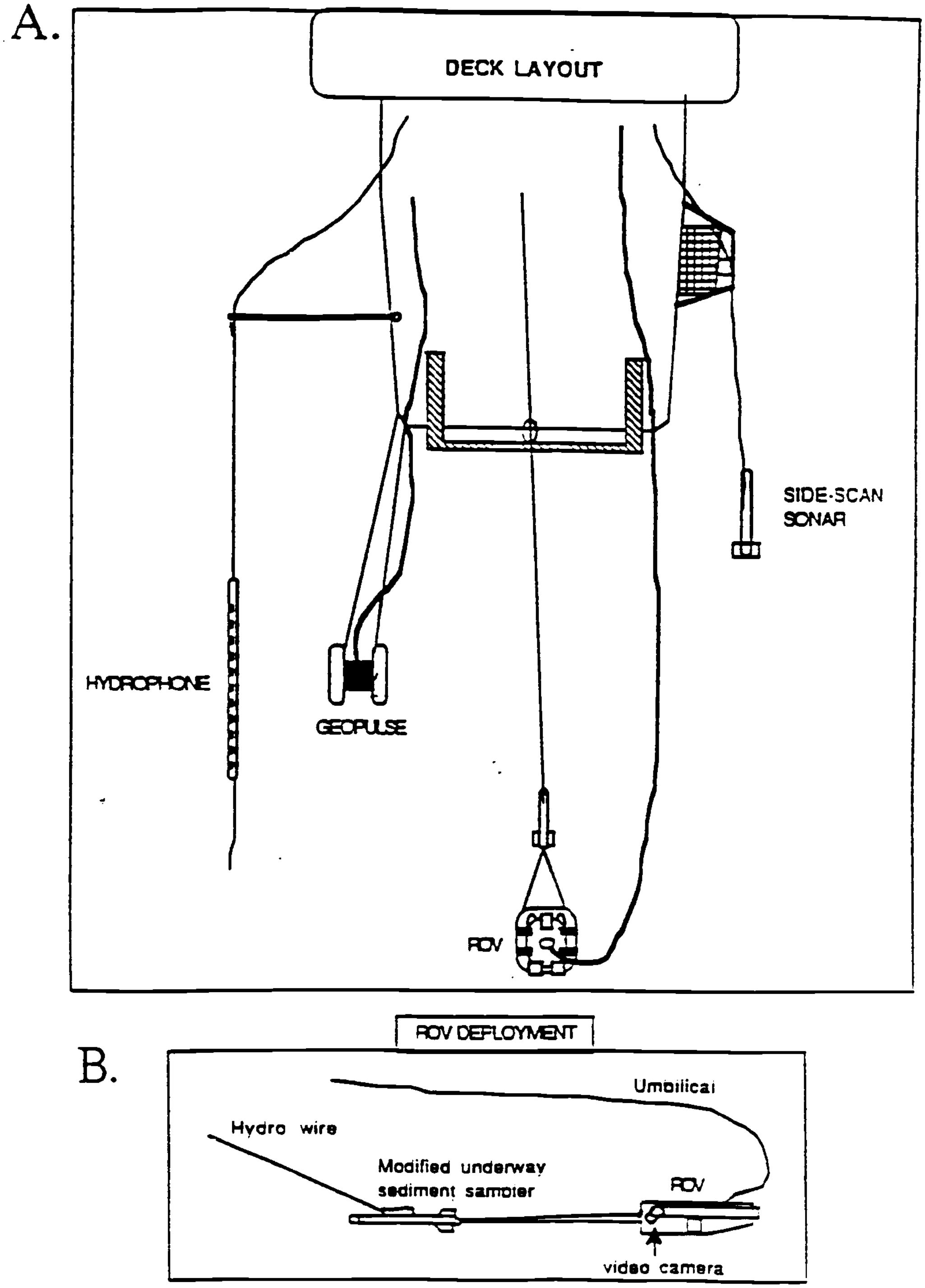
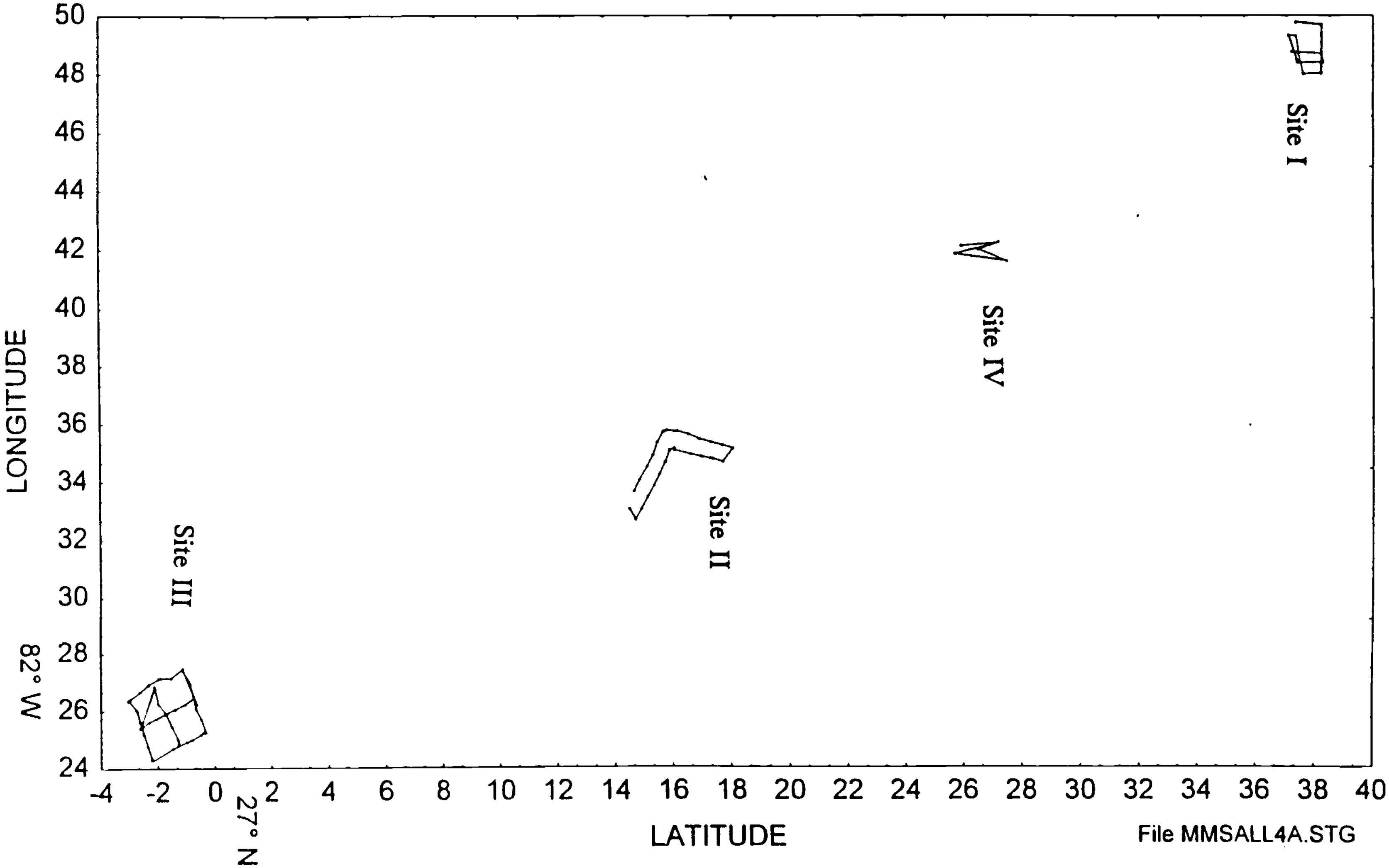


Figure 1.6-2. Towing configuration for geophysical and video surveys A. Geophysical towing system. B. ROV towing system.



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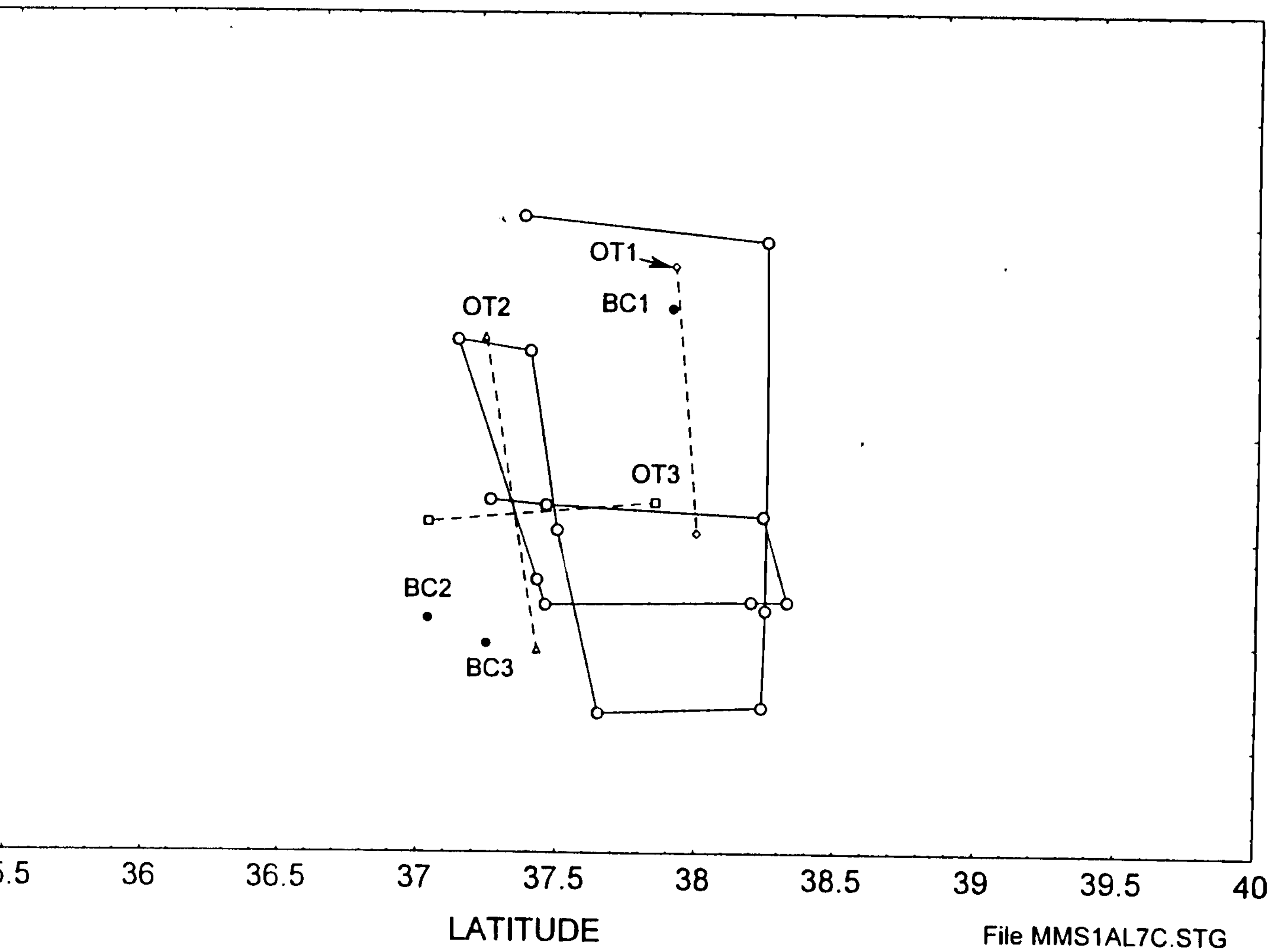


d survey track, Site I, July 1992 and January 1993 ROV track. The geophysical and ROV tracks are as a solid line, otter trawls (OT) as a dashed line, and box coring stations (BC) by a solid dot.

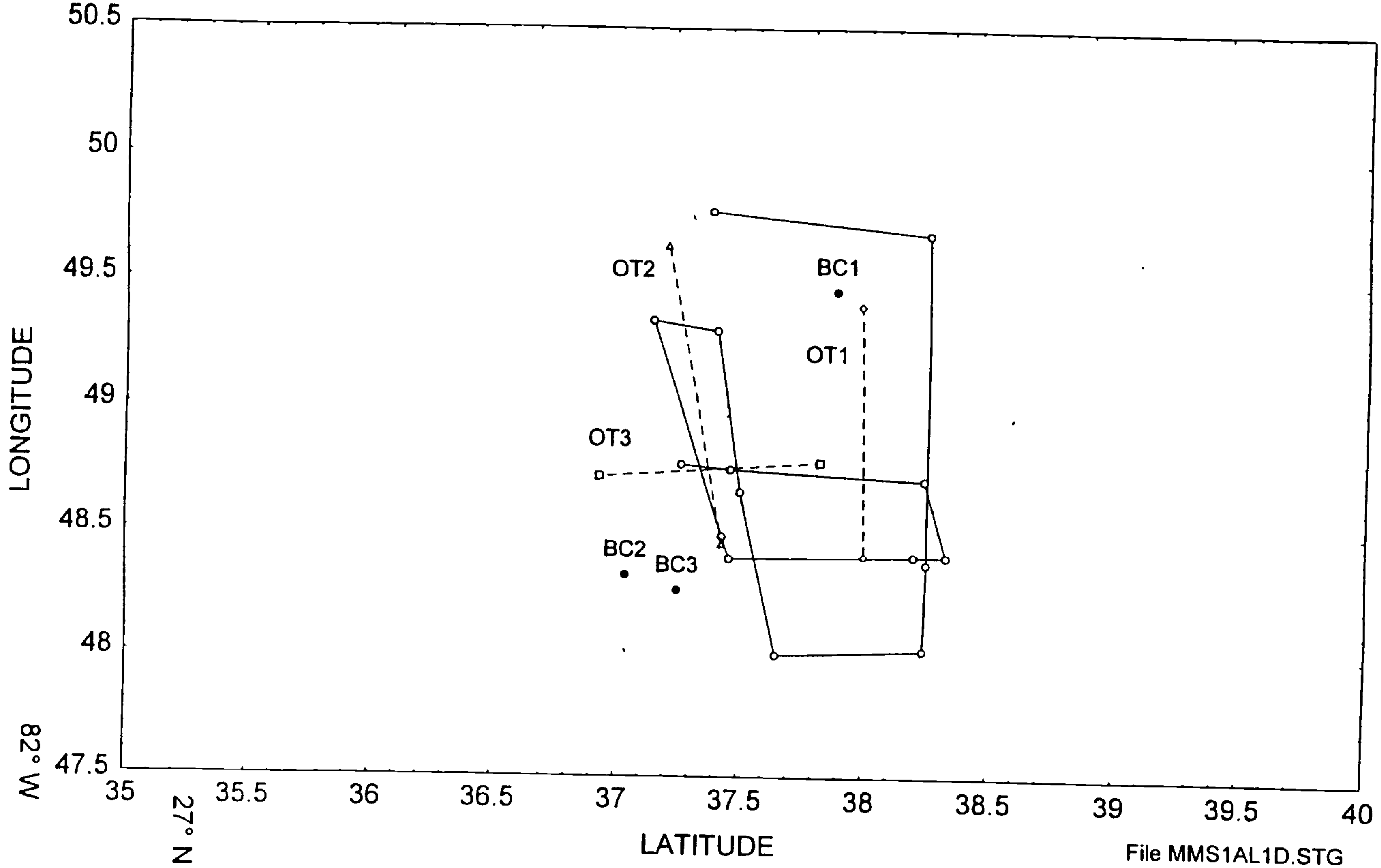
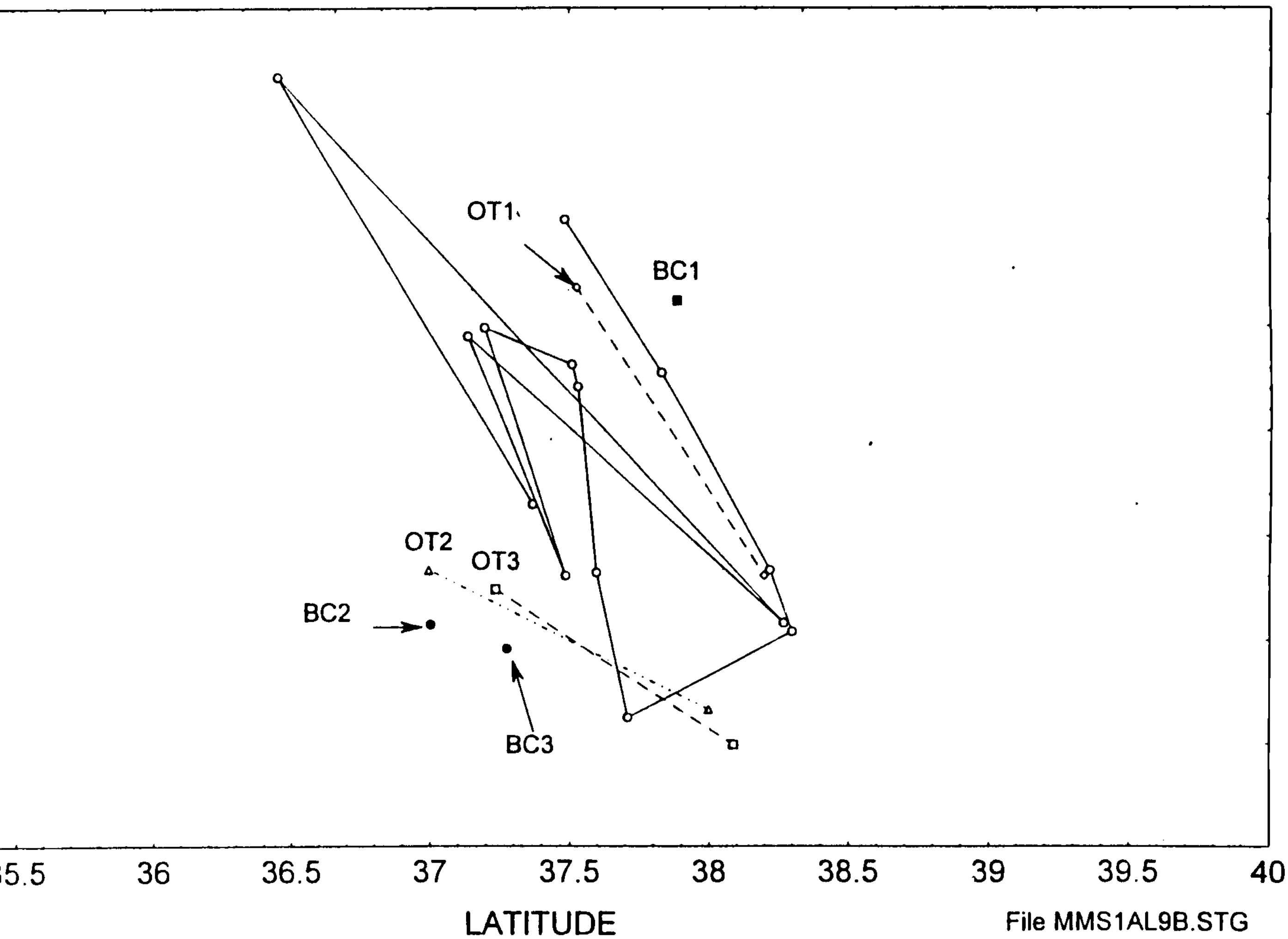


Figure 1.6-5. Detailed survey track, Site I, January 1993. The geophysical and ROV tracks are shown as a solid line, otter trawls (OT) as a dashed line, and box coring stations (BC) by a solid dot.



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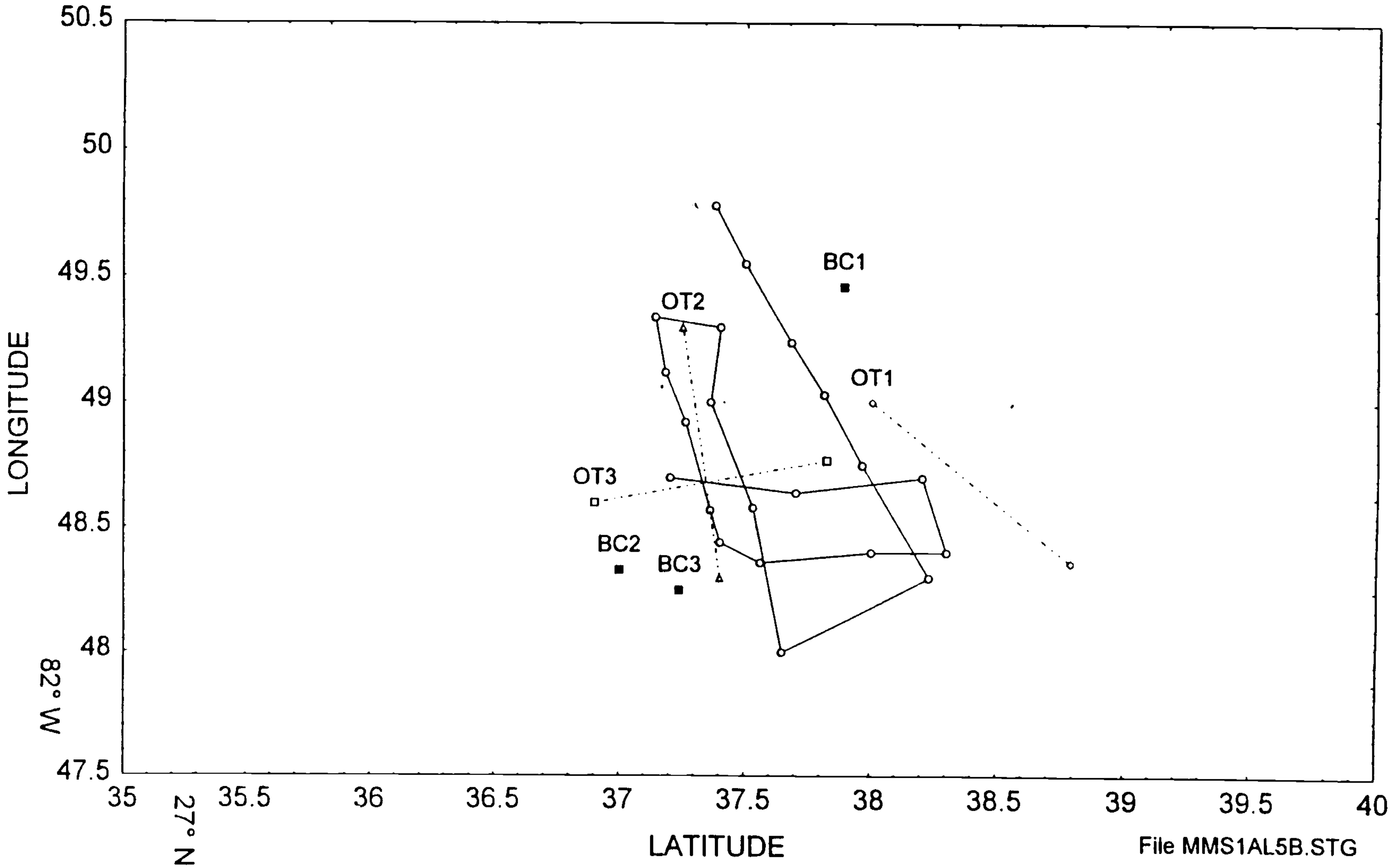
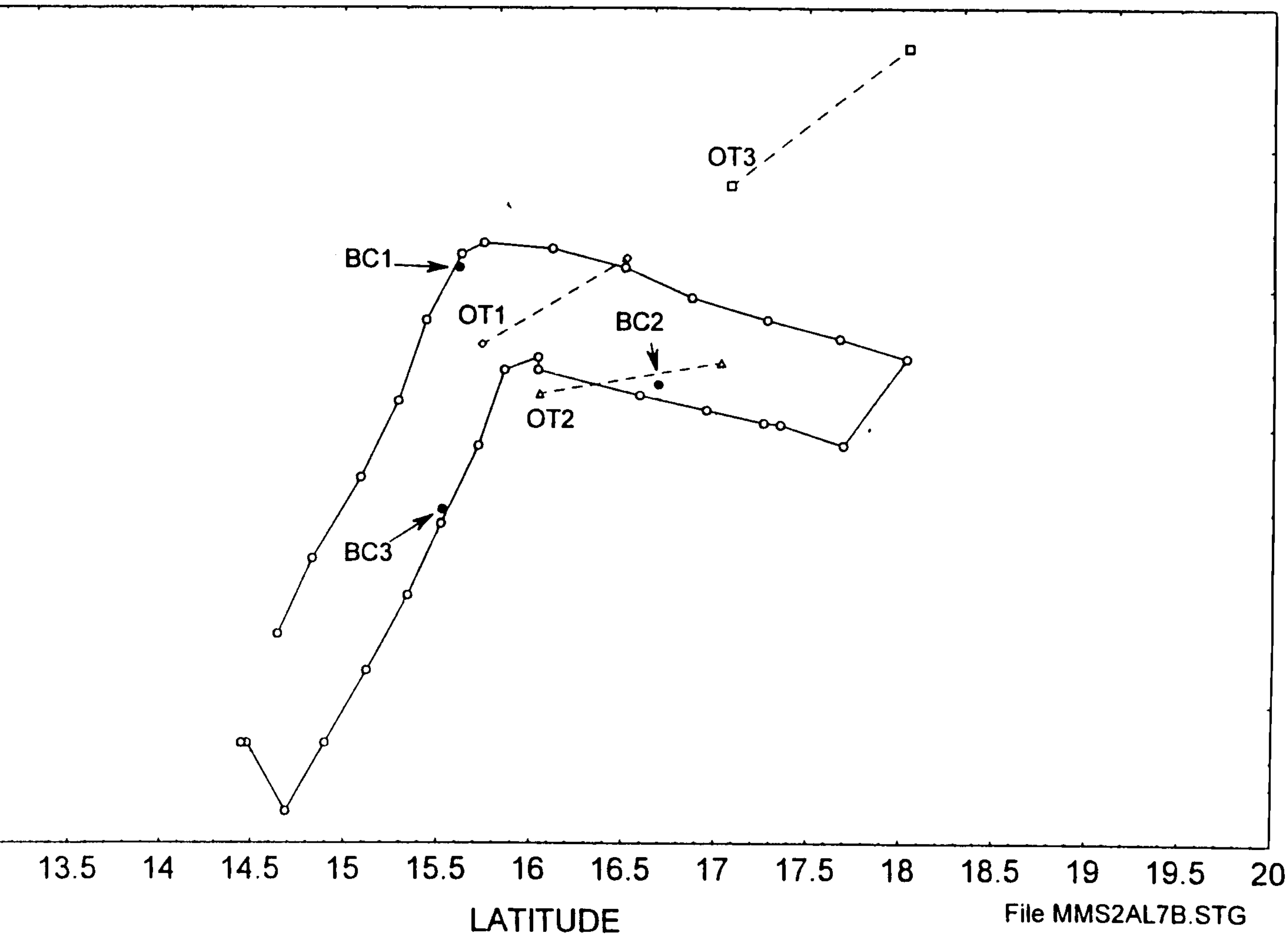


Figure 1.6-7. Detailed survey track, Site I, May 1994. The geophysical and ROV tracks are shown as a solid line, otter trawls (OT) as a dashed line, and box coring stations (BC) by a solid dot.



led survey track, Site II, July 1992. The geophysical and ROV tracks are shown as a solid line, otter (OT) as a dashed line, and box coring stations (BC) by a solid dot.

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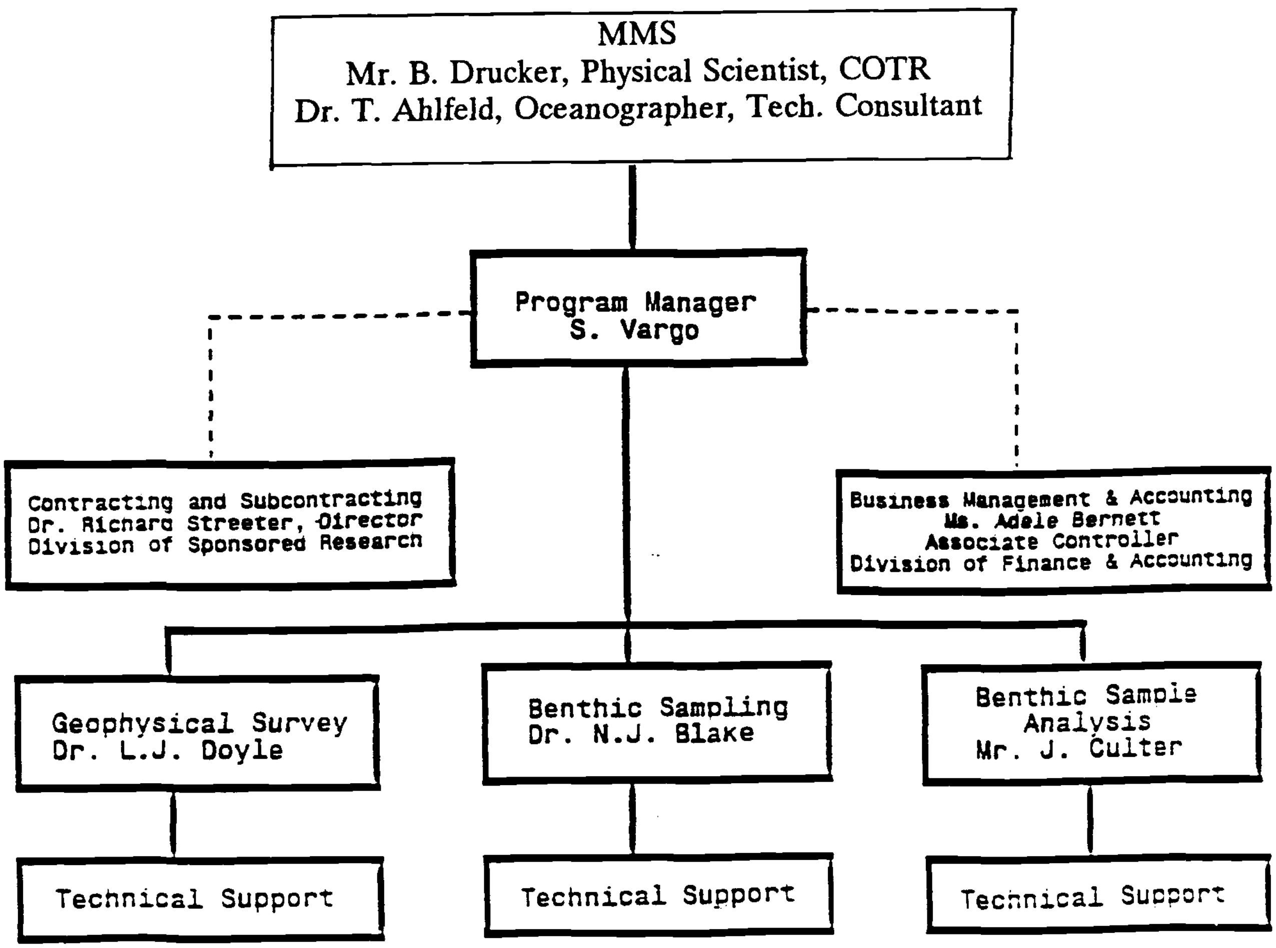

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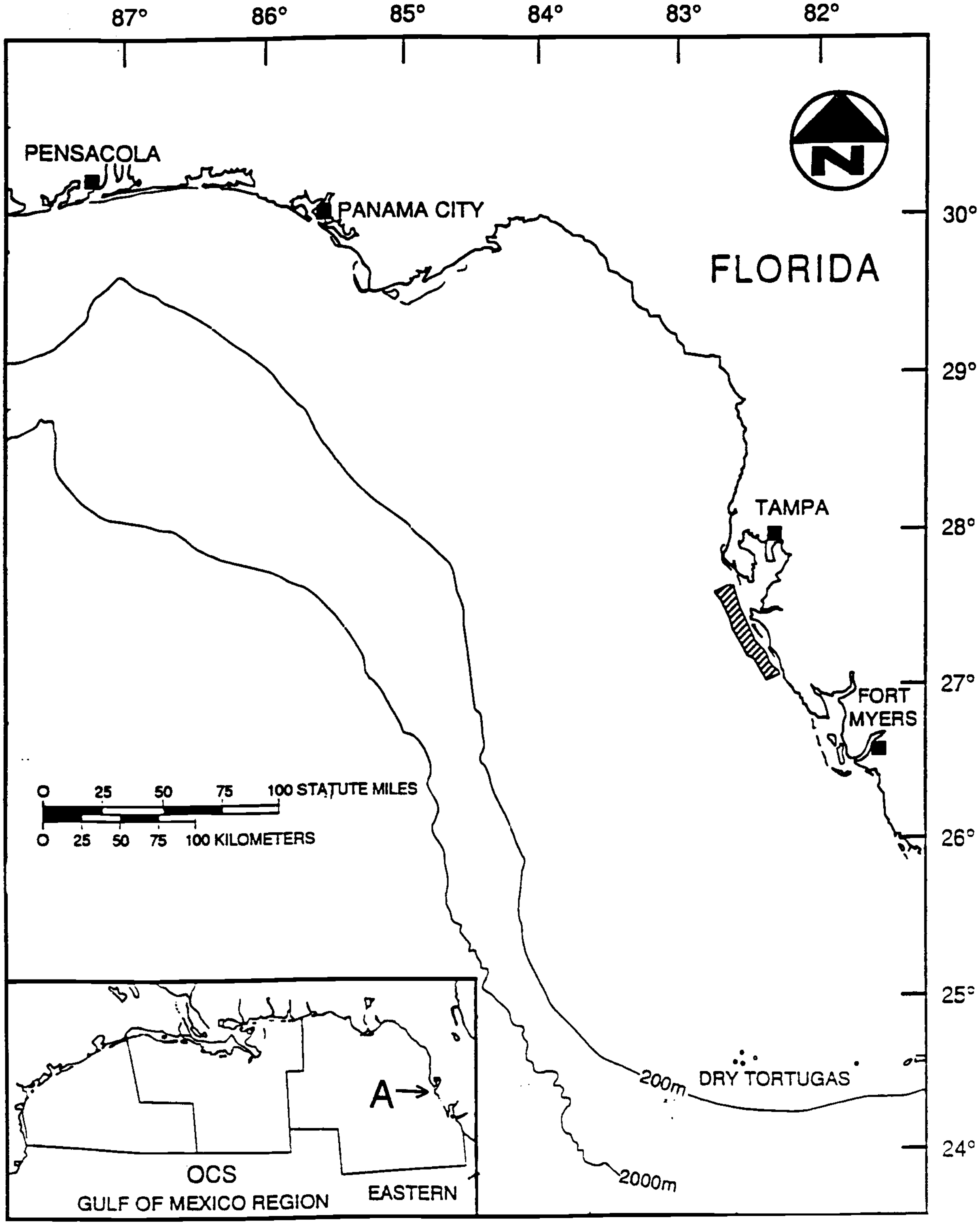

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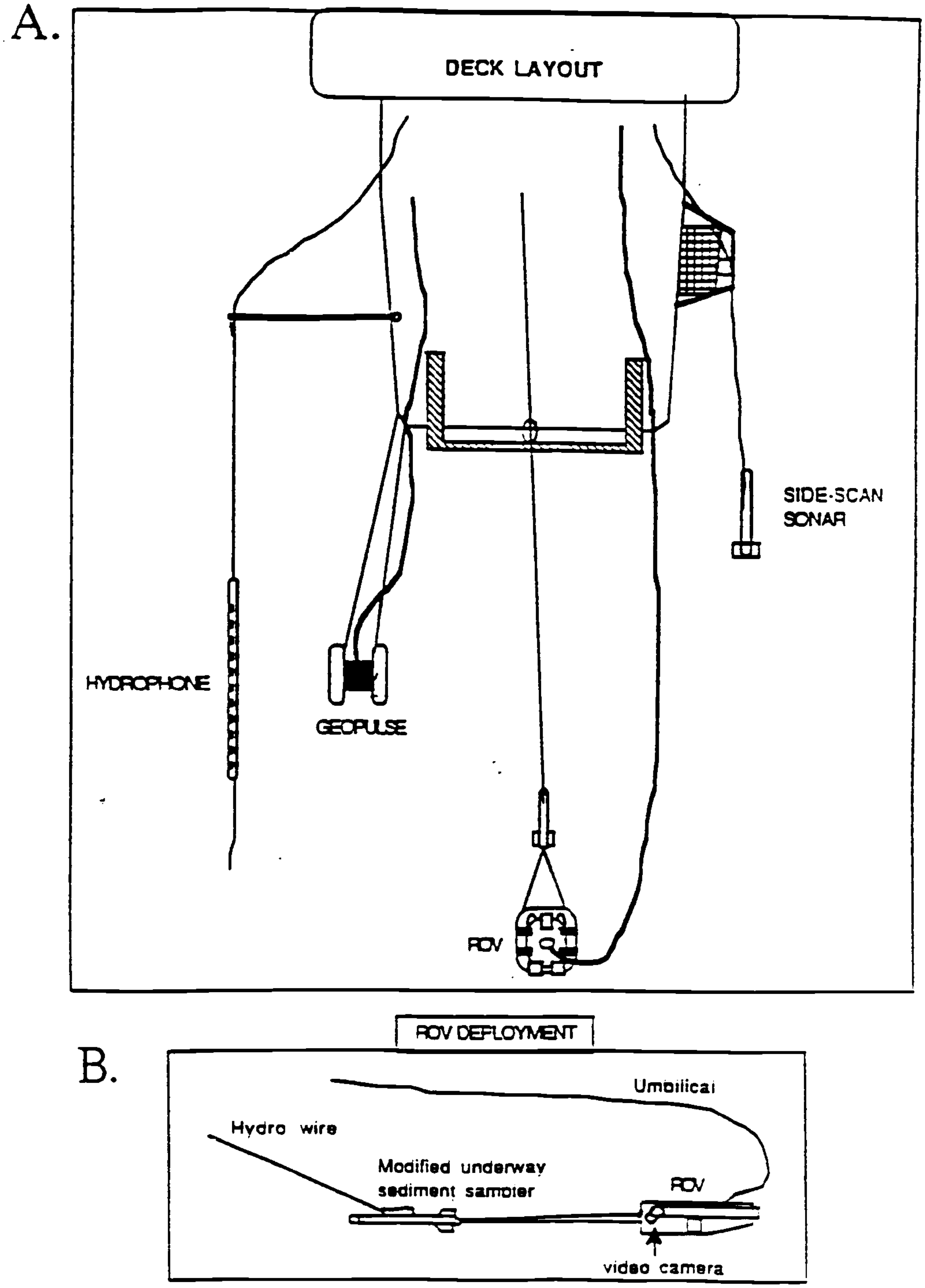

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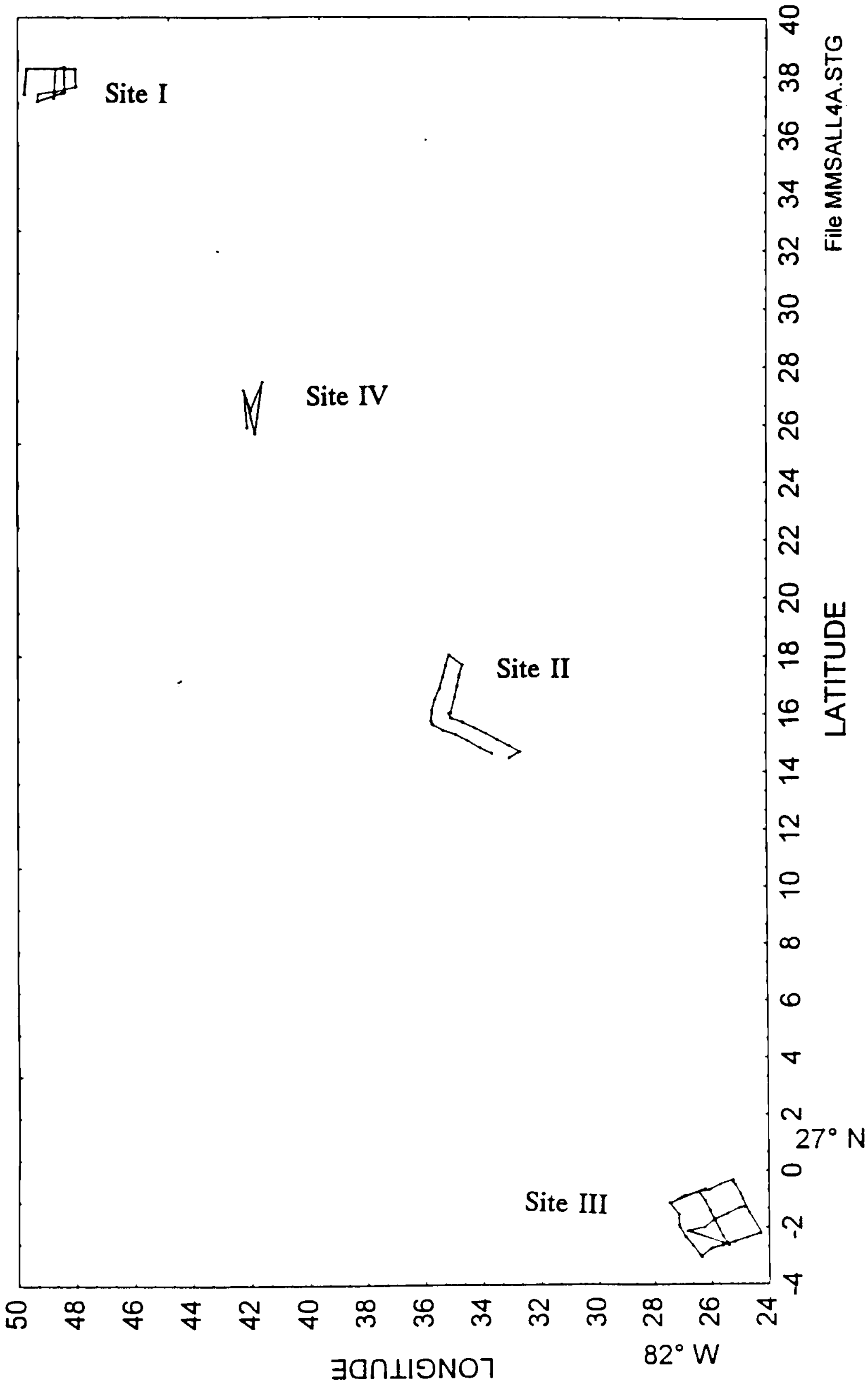

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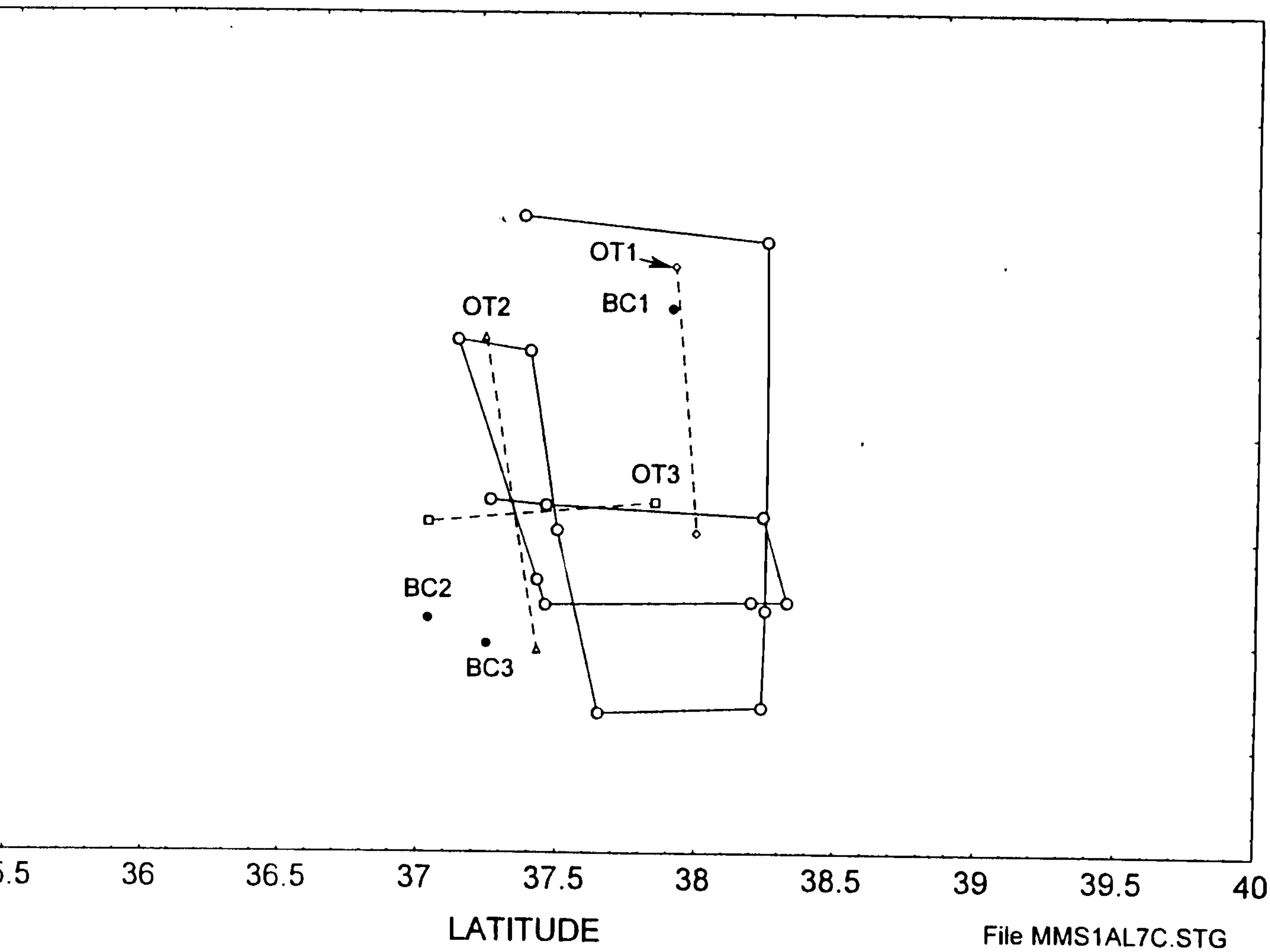

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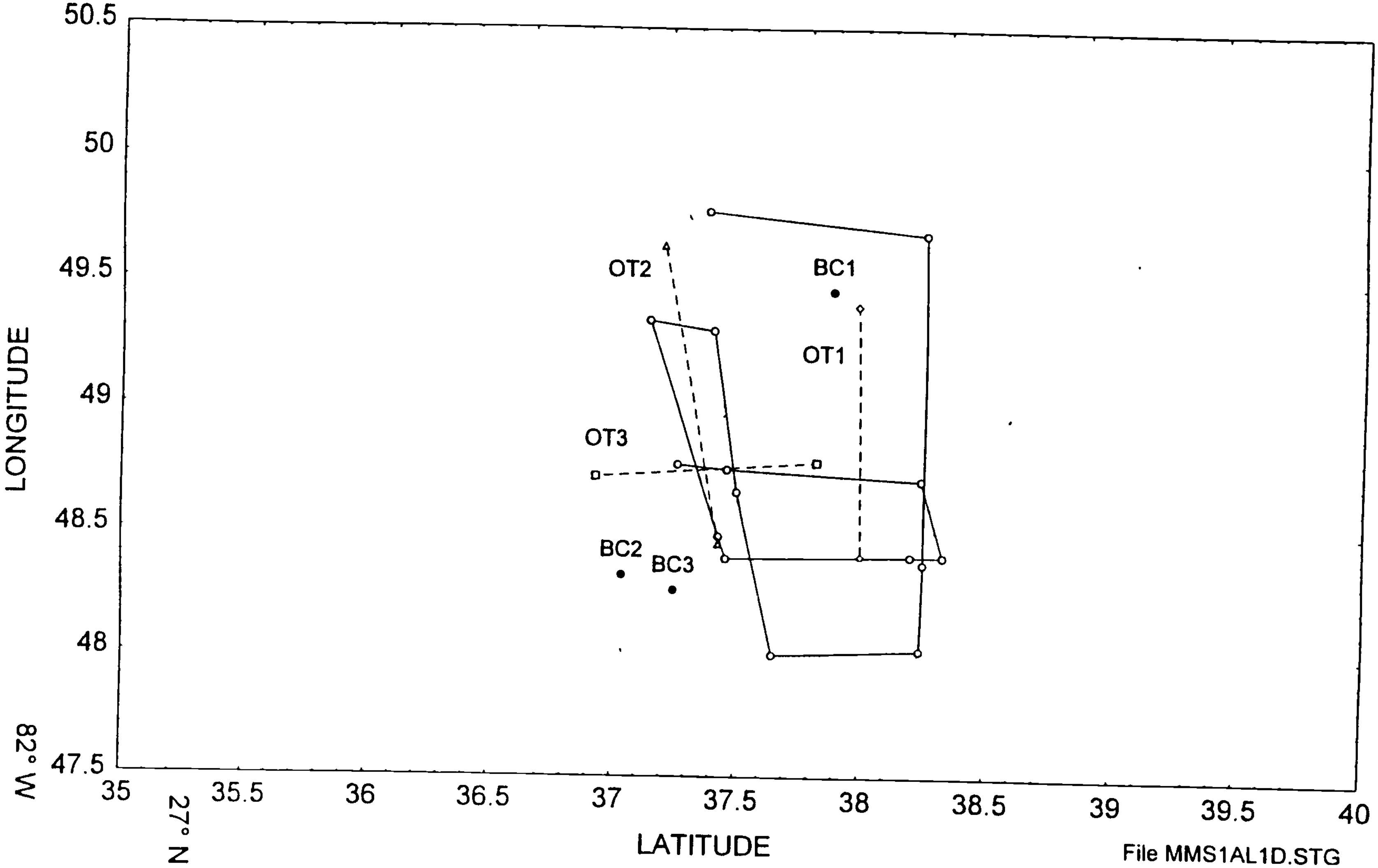
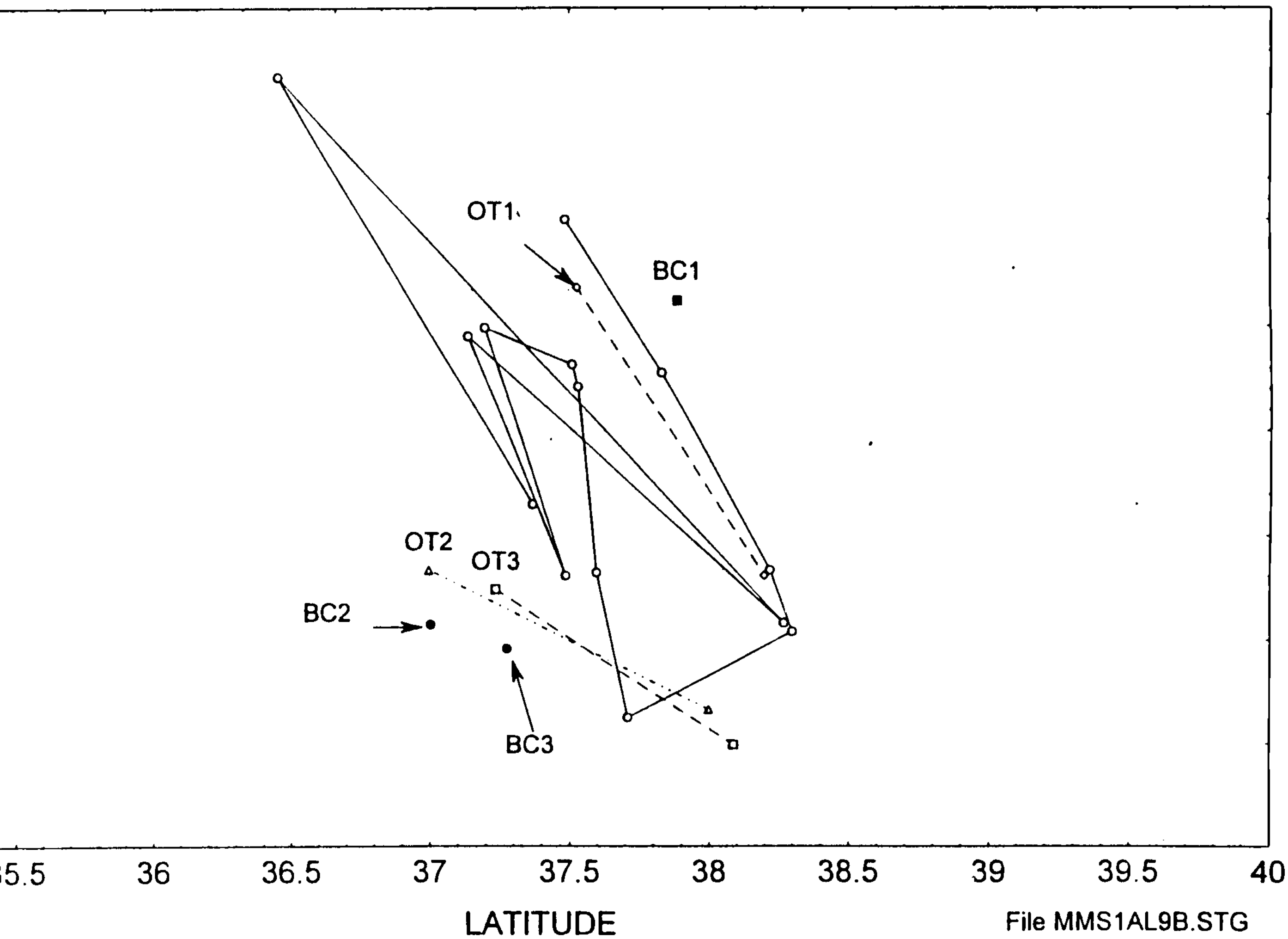


Figure 1.6-5. Detailed survey track, Site I, January 1993. The geophysical and ROV tracks are shown as a solid line, otter trawls (OT) as a dashed line, and box coring stations (BC) by a solid dot.



ed survey track, Site I, September 1993. The geophysical and ROV tracks are shown as a solid line, rawls (OT) as a dashed line, and box coring stations (BC) by a solid dot.

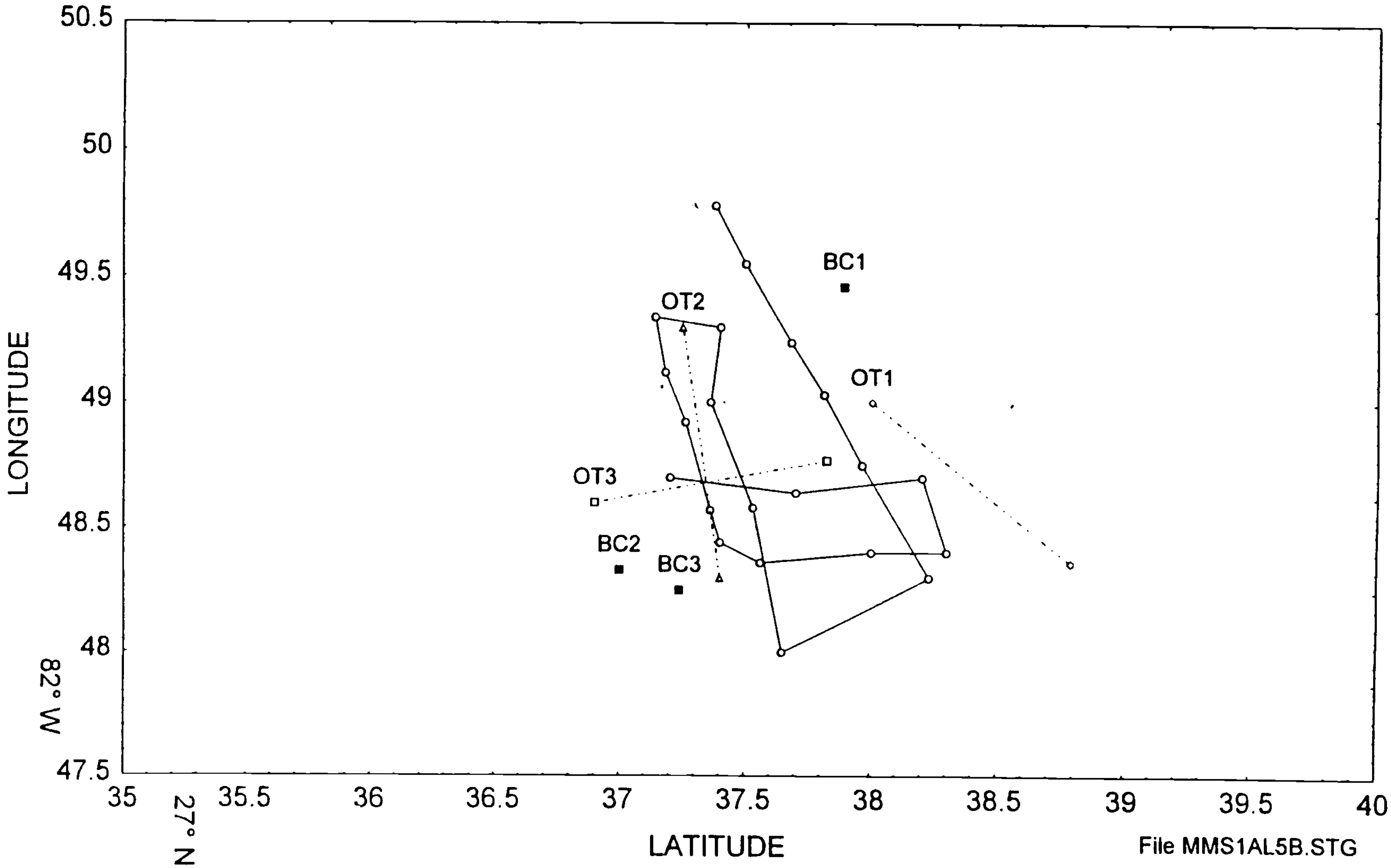
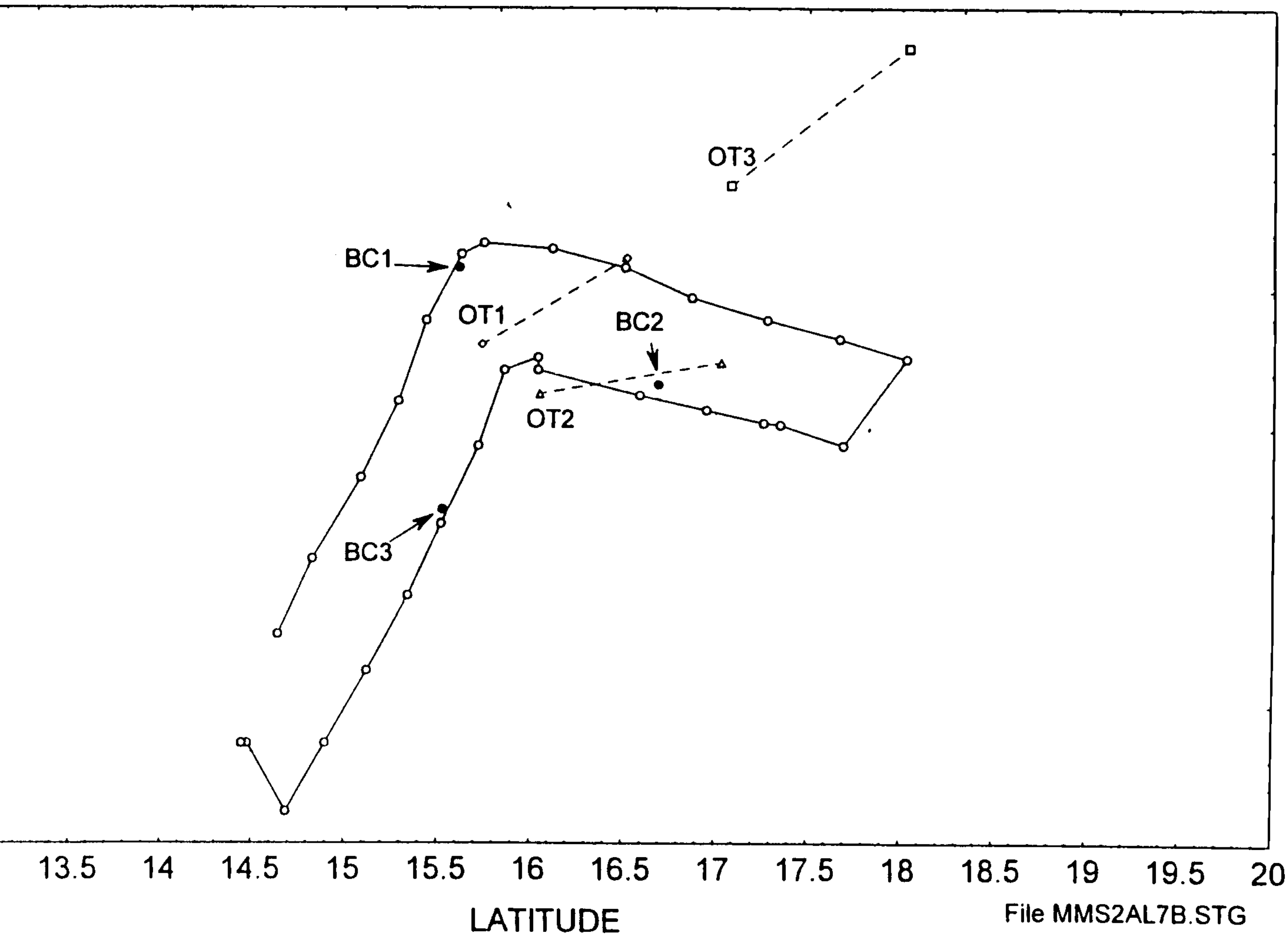


Figure 1.6-7. Detailed survey track, Site I, May 1994. The geophysical and ROV tracks are shown as a solid line, otter trawls (OT) as a dashed line, and box coring stations (BC) by a solid dot.



led survey track, Site II, July 1992. The geophysical and ROV tracks are shown as a solid line, otter (OT) as a dashed line, and box coring stations (BC) by a solid dot.

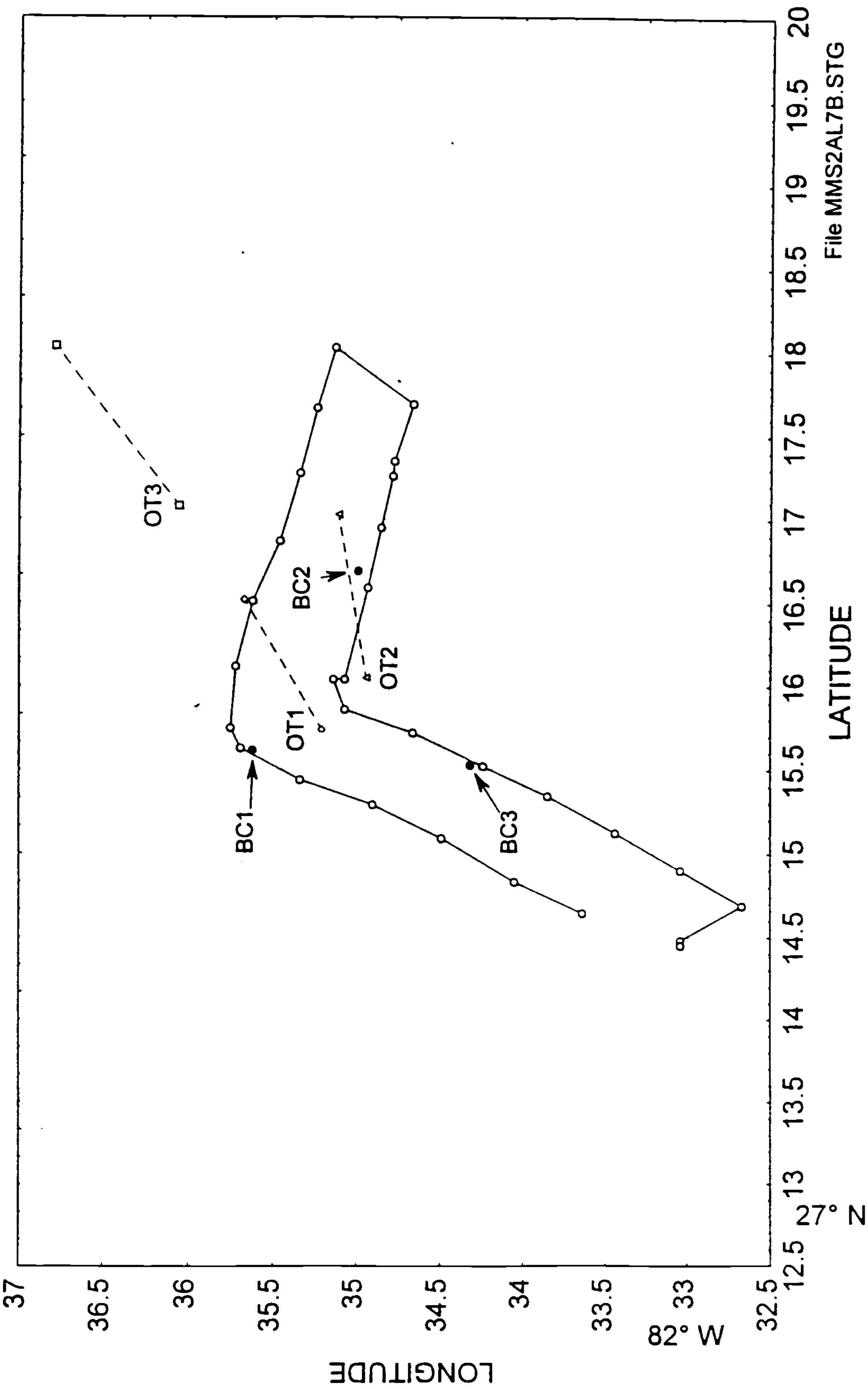


Figure 1.6-8. Detailed survey track, Site II, July 1992. The geophysical and ROV tracks are shown as a solid line, otter trawls (OT) as a dashed line, and box coring stations (BC) by a solid dot.

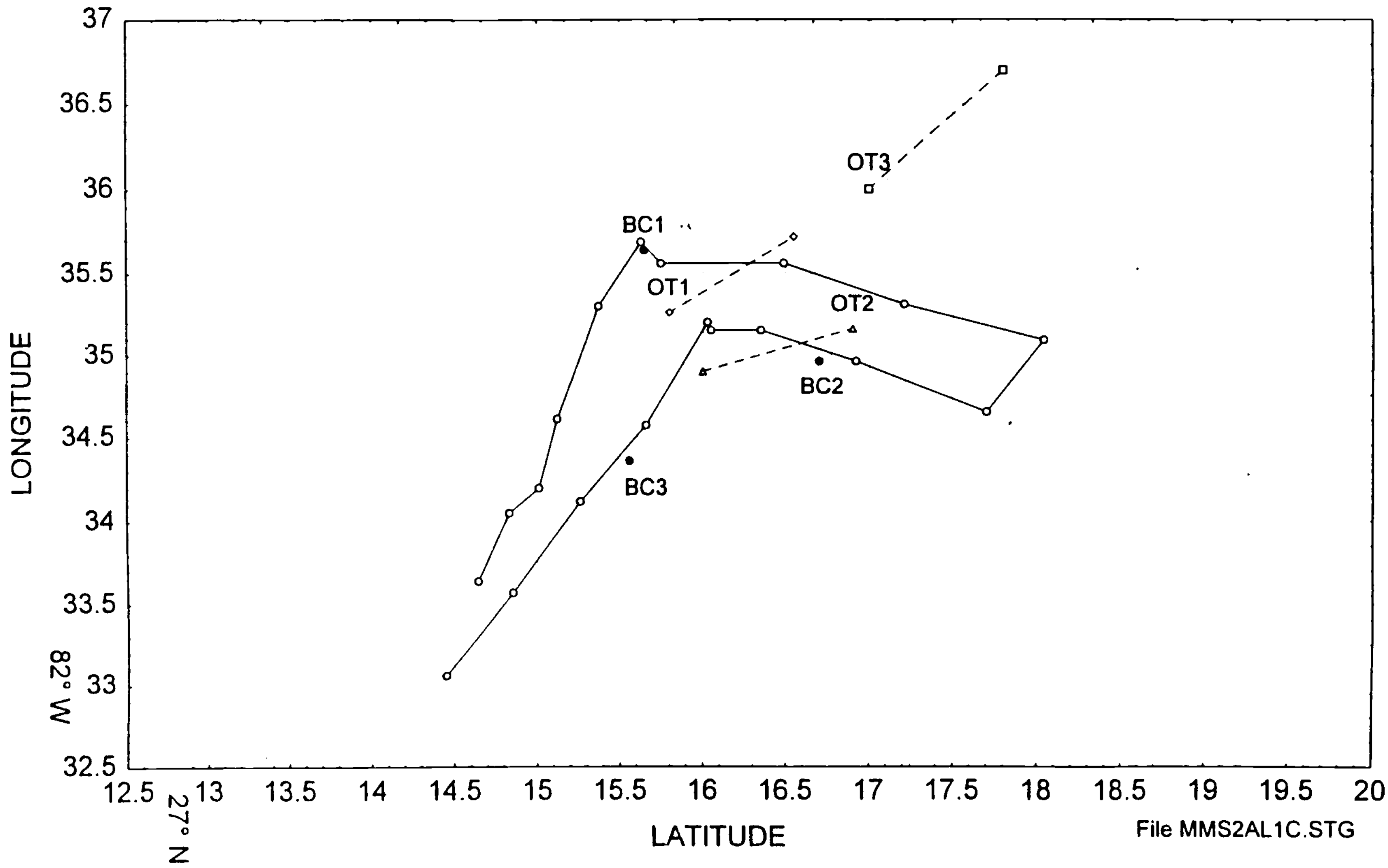


Figure 1.6-9. Detailed survey track, Site II, January 1993. The geophysical and ROV tracks are shown as a solid line, otter trawls (OT) as a dashed line, and box coring stations (BC) by a solid dot.

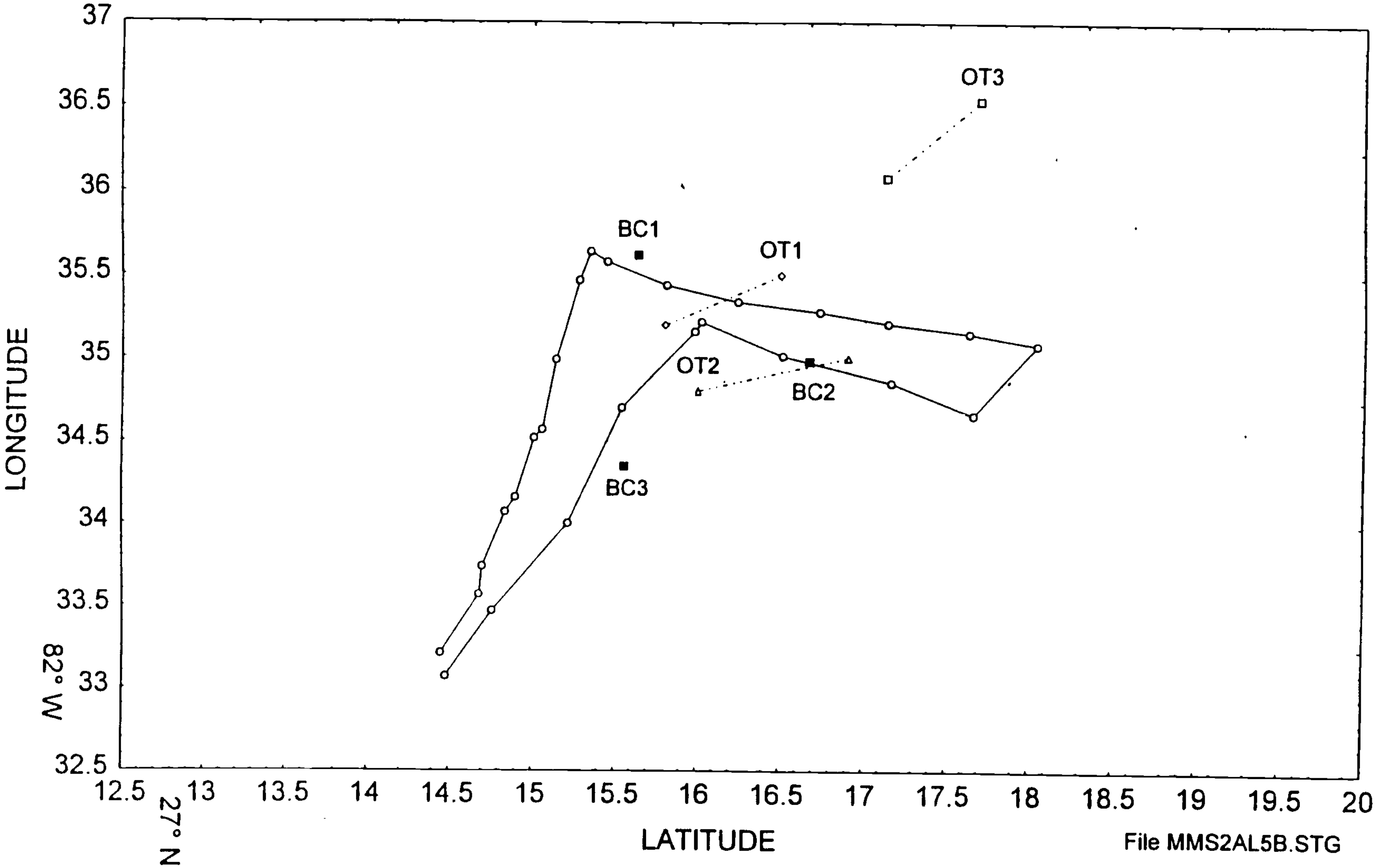


Figure 1.6-10. Detailed survey track, Site II, May 1994. The geophysical and ROV tracks are shown as a solid line, otter trawls (OT) as a dashed line, and box coring stations (BC) by a solid dot.

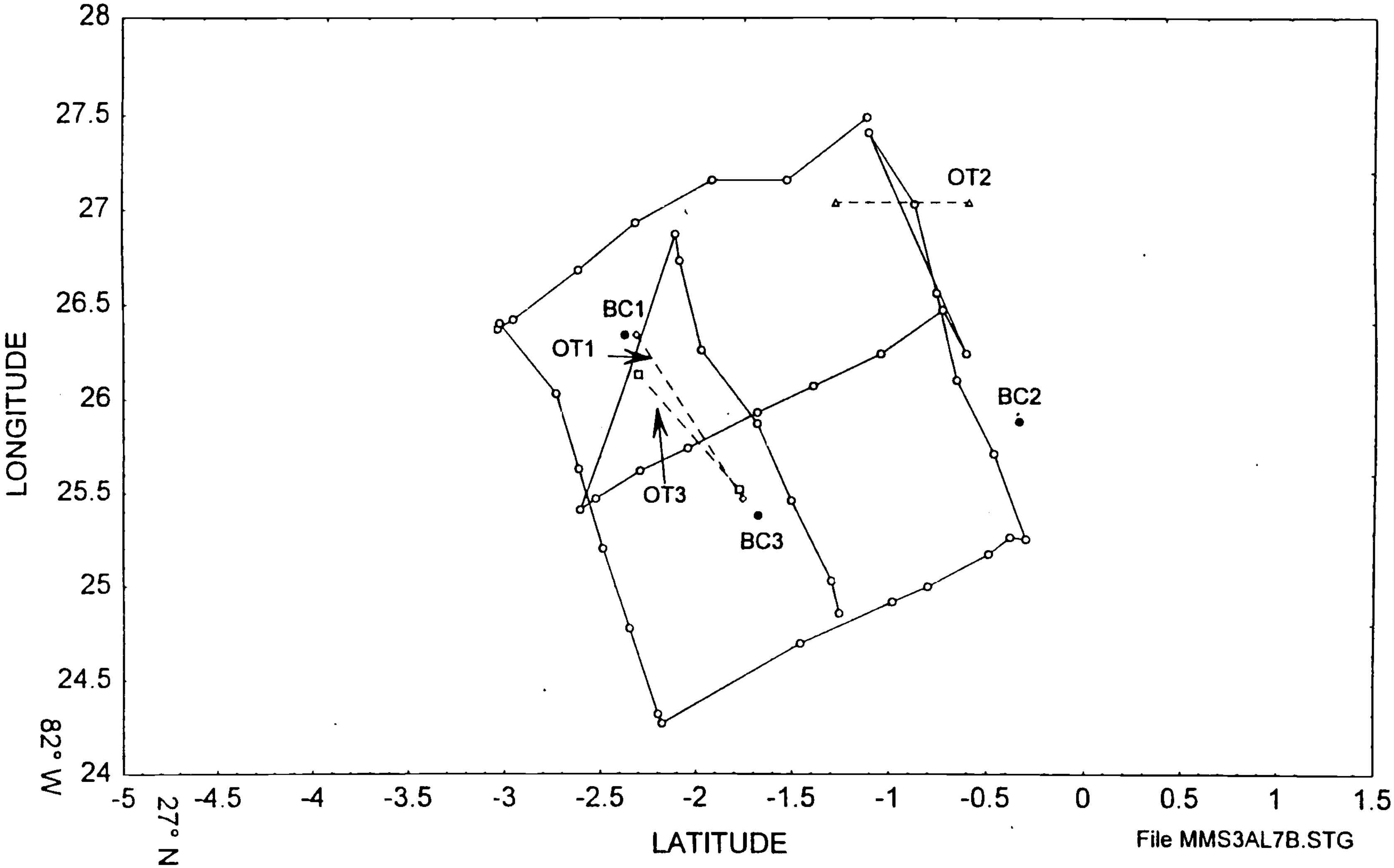


Figure 1.6-11. Detailed survey track, Site III, July 1992. The geophysical and ROV tracks are shown as a solid line, otter trawls (OT) as a dashed line, and box coring stations (BC) by a solid dot.

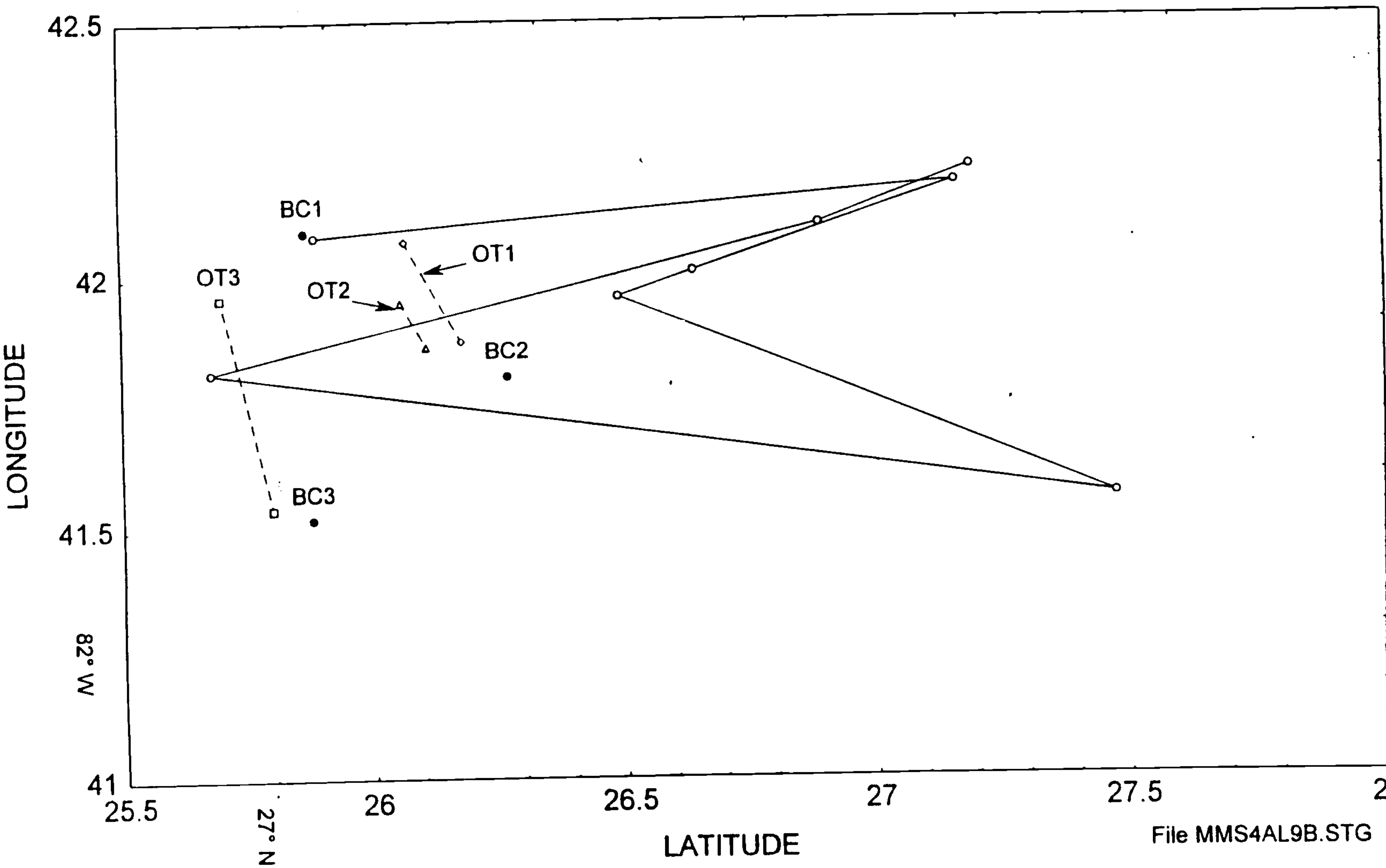


Figure 1.6-12. Detailed survey track, Site IV, September 1993. The geophysical and ROV tracks are shown as a solid line, otter trawls (OT) as a dashed line, and box coring stations (BC) by a solid dot.

High Resolution Seismic Reflection Profiling

Seismic reflection data was collected using an ORE Geopulse profiling system consisting of an ORE power supply, acoustic source, 20 element hydrophone array, receiver/filter/amplifier, and an EPC 1650 graphic recorder. The seismic profiles were recorded using a 62 ms sweep with band pass filters typically set for 700-3000 Hz. Prior experience has shown that these settings are optimal for the west Florida shelf, but of course, were adjusted during the survey in order to optimize the records. The raw unfiltered analog signal was recorded on magnetic tape.

Side Scan Sonar Survey

Side scan sonar records were obtained using an EG&G model 260 Sea Floor Mapping System with automatic slant range correction. Sonographs were typically recorded with a horizontal range of 75 m on a side (150 m total swath). Processed digital data was recorded on magnetic tape as well as on paper record.

1.6.2 Benthic Community Survey

Video Camera System

A video camera mounted on a PHANTOM 500 ROV was towed a few feet above the bottom behind a torpedo-like weight (Figure 1.6-2) that helps maintain depth control. The system was remotely flown from the vessel laboratory. Video camera output was recorded on VCR tape. Observations of bottom type and biology were logged in real time aboard ship every 10 minutes or as specific features or changes in bottom type or epibenthos were encountered. A LORAN fix was taken at the time of each log entry. Dr. Norman Blake, who served as Chief Scientist on all cruises, was responsible for on-board video observations. On-board video observations of epibenthos included the presence of dominant epifaunal species such as bottom fish, crabs, sponges, corals, and shellfish as well as major attached and rolling algae.

After each video camera/side scan/seismic site survey, three trawls were taken for epibenthic species verification using a 30 foot otter trawl. The location of each 20 minute trawl was determined by the chief-scientist and depended upon the on-board observations with the video camera. The individuals collected in each trawl sample were counted and representative individuals were preserved and returned to the laboratory for analysis to the lowest practical taxon.

Precision Depth Recorder

PDR records were obtained using a Furuno Model FE881 depth recorder with a hull mounted transducer.

Box Coring Program

The benthic infaunal and sediment sampling programs were conducted at each of four sites. All four sites were off the West coast of Florida between Egmont Key and Venice. A total of three stations at each site (two in the dredge area and one outside) were sampled by box corer. The control station was outside the dredge area and one mile removed from the limits of the disposal area, but in a sediment environment similar to the dredge area. Although an attempt was made for the first sampling period to be prior to any dredging operation and the remaining three periods after dredging, this did not prove practical for all four locations.

1. On-Board Processing

Quantitative benthic samples were collected using a box corer. Figure 1.6-13 shows the box corer on deck prior to deployment. Completely rigged it weighs about 2,000 pounds and obviously can only be used in small seas. Figures 1.6-14 to 1.6-15 show how the box corer is deployed, while Figures 1.6-16 and 1.6-17 show two box cores on deck prior to subsampling for sediment and infauna analyses. Each box core removed a sediment plug measuring 21.3 cm x 30.5 cm in surface dimensions with a maximum depth of penetration of 32 cm. The box corer gives a relatively undisturbed sample, both surficially and stratigraphically. Note the ripple marks on the surface of the sample in Figure 1.6-16 and the worms in place on the surface of the sample shown in Figure 1.6-17. Nine replicate cores were collected at each station (A-I). (An additional replicate (J) was collected, archived and maintained as a backup). Previous sampling in the area has shown that nine cores are required to obtain a statistically valid description of the benthic macroinfauna (Culter, personal comm.)

After each box core was brought on board, it was catalogued and labelled with the appropriate sample number. Salient visual characteristics, including color, texture, stratigraphy, and conspicuous epibiota, were recorded. Figure 1.6-18 shows the initial biological screening of a sample.

Sediment Samples

Each box core was sub-sampled with a 5 cm diameter coring device to the depth of core penetration. The resultant samples were placed in clearly labelled containers for later sediment analyses.

Infauna Samples

After a 5 cm subsample was extracted for sediment analysis, the top 15 cm of sediment remaining in each box core was removed for faunal processing. The sample was placed in a 50 gallon drum mounted on a swivel and frame and subjected to a gentle stream of running seawater. As the can filled with water, the sample was gently stirred to bring the soft-bodied organisms out of the sediment. The water was then poured through a spout in the can chute onto a 500μ mesh screen.

The material from the sieve was rinsed into a pre-labelled plastic quart jar with filtered seawater. (A matching internal label was placed in the jar). A buffered formalin and rose bengal solution was then added to the jar to bring the final formalin concentration to ten percent. The sediment left in the can (along with the remaining fauna) was transferred to prelabelled cotton bags and placed in a drum of 15% magnesium chloride for fifteen minutes to relax the organisms. Finally, the bags were transferred to a drum of 10% formalin. After each cruise, all infaunal samples were

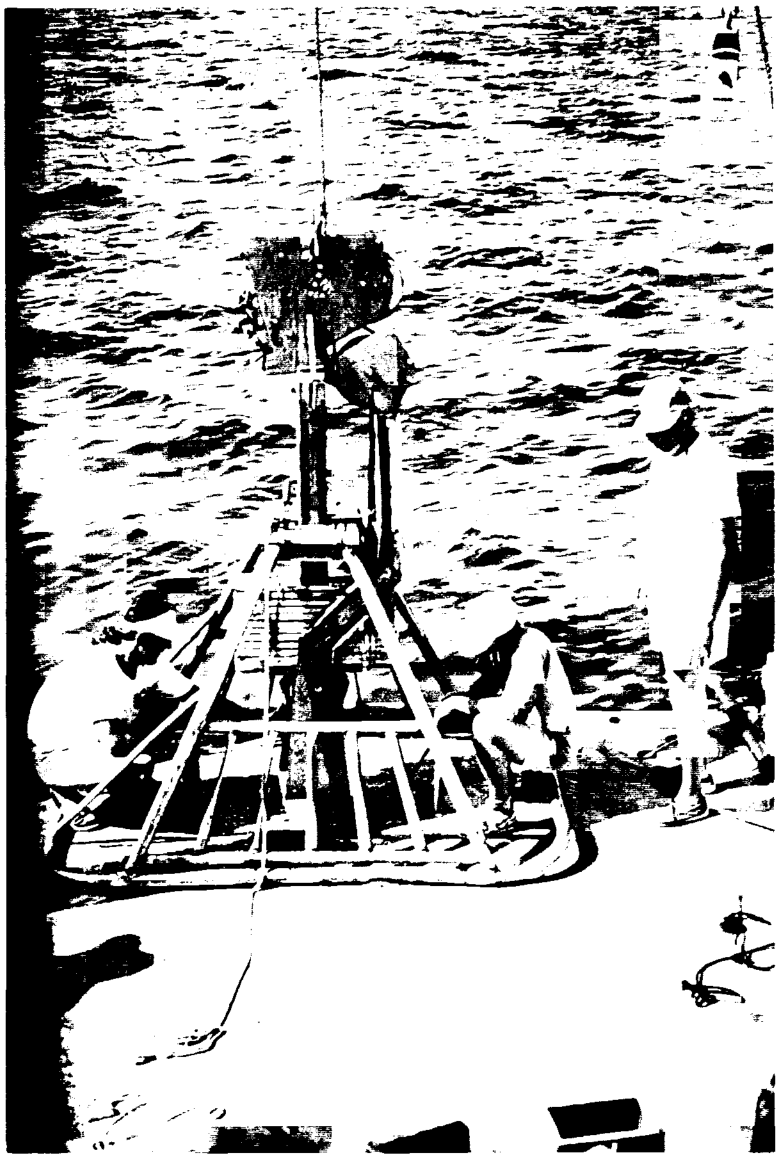


Figure 1.6-13. Final preparation of the box corer prior to deployment.

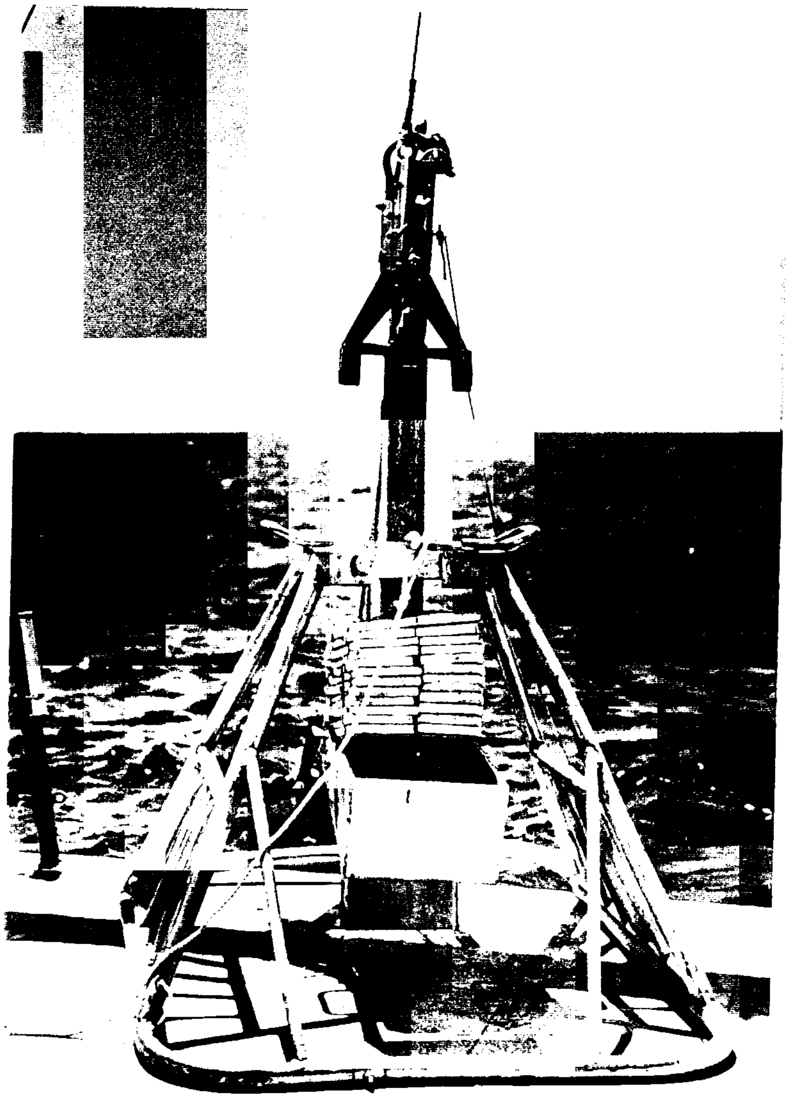


Figure 1.6-14. Box corer on deck and ready for deployment.

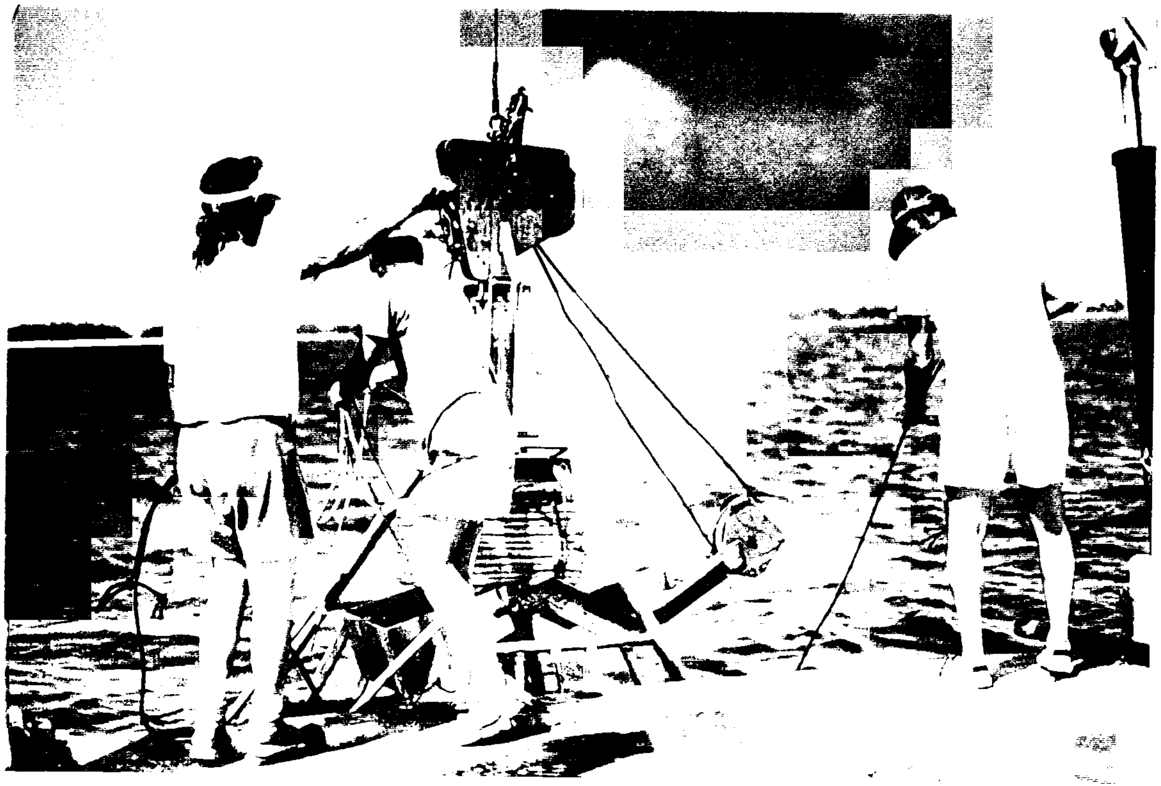


Figure 1.6-15. Deployment of the box corer.

Figure 1.6-16. Box core on deck showing ripple marks on its surface.

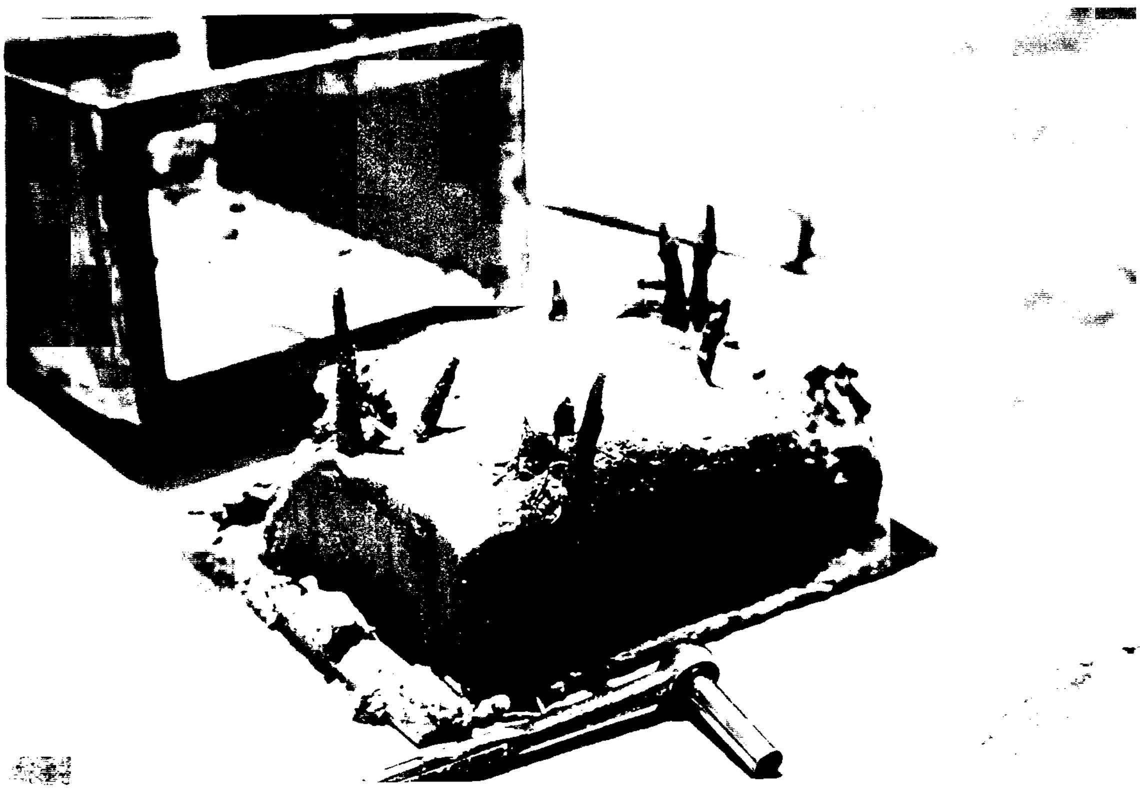


Figure 1.6-17. Box core on deck with worm tubes.

Figure 1.6-18. Initial benthic sample processing.

inventoried (each sample recorded on custody sheets) and transported to Mote Marine Laboratory.

2. Laboratory Analyses

Sediment Analyses

As part of the framework portion of the study to determine recolonization after dredging, the standard sedimentary parameters of grain size, carbonate content, and organic content were determined for each of the ten samples at each station for each sampling period. Samples were taken from the box cores with a stainless steel scoop. Figures 1.6-16 and 1.6-17 show one of the box core samples on deck. Notice that worm tubes protrude from the sediment. Box coring is the best method to obtain undisturbed samples. Figure 1.6-16 shows that even surface ripple marks are preserved. Only the top 15 cm was collected for sediment analyses, since that is the depth to which organism samples were taken. Sediment samples were analyzed for texture, carbonate content, and total organic carbon.

Grain size (texture) was measured by the standard technique of sieving an aliquot through sieves nested at 1 ϕ intervals ; that is -1 ϕ (2mm), 0 ϕ (1mm), 1 ϕ (500 microns), 2 ϕ (250 microns), 3 ϕ (125 microns), 4 ϕ (62 microns), and pan (< 62 microns) in the method of Folk, 1980. This whole range is considered to be the sand sized fraction. For Site I, the only one in which we have sampling before, during and after dredging, measurements of all ten replicate samples were combined at each of the three stations and histograms were constructed for comparison of sampling periods.

Carbonate content was determined by acidifying a weighed aliquot with 10% HCl, dissolving the carbonate minerals, drying the sample and re-weighing. Organic content was determined by combustion of a carbonate free subsample.

Infauna Analyses

After 48 hours, samples were transferred to 70% isopropyl alcohol and stored until processing. Samples were first rough sorted to major categories (annelids, crustaceans, molluscs, echinoderms, hemichordates and miscellaneous) and then identified to the lowest practical taxonomic level, which for most fauna was either the species or genus level.

Wet weight biomass (g) was measured for each major taxonomic group. Wet weights were obtained by pouring the sample into a small sieve (250 micron mesh) which separated the specimens from the preservative. The samples were rinsed with tap water to remove excess isopropyl alcohol. Specimens were blotted dry, placed in a small aluminum pan and weighed to the nearest mg.

Epibenthic Sampling

Upon return to the laboratory, the video tapes were reduced to a slower speed and the species verified (Dr. N. Blake) with the samples collected with the otter trawl. The results of this analysis were used in conjunction with the video tape to describe the epibenthic assemblages that were observed during each survey of each site.

Geophysical Data Reduction and Products

Sequence boundaries at each site were mapped from the high resolution seismic reflection data. Isopach maps of the sequences present, including the sand body to be mined, were constructed for each sampling period. Side scan sonographs were analyzed for topographic changes, bedform character, and sediment textural variation. Seismic and side scan records were correlated with bathymetry as determined by PDR records and with the observations taken from the video data.

General Macroinfaunal and Epibenthic Data Analysis

Species were coded for computer entry utilizing National Oceanographic Data Center (NODC) numeric coding system. All computer entries were 100% verified for accuracy and completeness prior to analysis. Mote Marine Laboratory analyzed the collected macroinfaunal data utilizing accepted statistical procedures. Emphasis was on statistical parameters that numerically defined species composition and relative abundance and that showed whether or not correlations existed between combinations of substratum characteristics (such as grain size) and faunal characteristics. Analysis of the data included the following when appropriate:

(1) Species diversity
(2) Species evenness
(3) Species richness
(4) Definition of community assemblages based on classification and ordination analysis procedures, such as cluster analysis.
(5) Association of assemblages with substratum variables by discriminate multivariate analysis.
(6) Analysis of distribution of fauna by species and numbers among major faunal groups. The loss of a particular type of organism (example amphipods) representing a particular functional morphology, is often indicative of an alteration of the habitat structure.

Data analysis was conducted with Mote Marine Laboratory developed SuperCalc 5.0 spreadsheet software and BioStat II, community analysis software (Pimentel and Smith, 1993)

Representative epibenthic samples from the trawl were identified to the lowest practical taxon. Combined with the counts from the trawl this provided data on numerical abundance of epibenthic species in the sampling area.

Infaunal Data Analyses

Each sample collected within each area was treated as a replicate. These data were tested for homogeneity of variance and normality. Data sets used for comparisons consisted of species richness (total taxa) and total individuals for each taxa. These data sets were tested for normality (*Kolmogorov-Smirnov* test) and homogeneity of variance (*Levene* Median test) using SigmaStat™ software (Jandel Scientific, 1992). Data sets that passed the tests for normality and homogeneity of variance were tested for spatial and temporal differences utilizing a one-way ANOVA and the *Student-Newman-Kuels* method of pairwise comparisons to identify significantly different groups. Data sets that did not pass the tests for normality and homogeneity of variance were analyzed utilizing the non-parametric statistic, *Kruskal-Wallis* one-way ANOVA by ranks (Siegel, 1956).

Stewart-Oaten *et al.* (1986) described a rationale for the evaluation of environmental impact assessment based upon the magnitude of variation between control and affected areas before and after impact. Description of the environment to be affected must include estimates of the variances of the sample means of the relevant variables, for it is only against this variation that impacts can be detected (Underwood, 1992).

One objective of the pre-dredging sampling was to define natural pre-impact or baseline levels of variation throughout all areas. The baseline variations were then utilized as a comparative measure for post-dredging impact variations of community parameters, with the control stations continuing to serve as a guide for "natural" variations.

The level of natural variation in species composition and faunal abundance can serve as a measure of stress in marine communities. Warwick and Clarke (1993) examined variability in species diversity (H') and species abundances for meiobenthos, macrobenthos, coral reefs and reef fish. A clear log-log relationship was found between the variance and the mean abundance for all species. The slope of the log-log regression increased significantly between control and impacted sites. Additionally, the variability in macrobenthic species diversity (H') tended to increase with increasing levels of perturbation.

Standard descriptive community parameters were calculated for each sample. These parameters are:

<u>Faunal density</u> was calculated as the number of organisms per square meter of substratum by the formula: **FD = i/a** where "i" is the total number of individuals collected at a station, and "a" is the total area sampled, in square meters.

<u>Wet weight biomass</u> was obtained for each abundant species or taxonomic group.

<u>Species richness</u> was calculated as the number of identifiable taxa present for each sample and each area (total species for 10 samples).

<u>Species diversity</u> was calculated as the Shannon Index (Shannon and Weaver, 1972) using the formula:

$$H' = -\sum_{i=1}^{s}(p_i)(\log p_i)$$

where s = total number of species for the sample and p_i = the proportion of total individuals for the i^{th} species. The index was calculated using various log bases ($\log_{10}$, $\log_2$, ln) to enable comparisons to other data sets.

The Shannon Index has been strongly criticized by several authors (Hurlbert, 1971; Goodman, 1975; Patten, 1968; Washington, 1984) as to the biological meaning of the index. An increase or decrease in H' does not necessarily indicate an improvement or decline in the quality of a benthic community. Environmental impact assessments must take into consideration the natural state of the community under consideration. Caution should be used when interpreting values of H'as related to impact assessments.

Equitability is considered a component of diversity in that it provides an idea about the evenness of species distribution at a site. Usually, a positive correlation exists between diversity and equitability i.e., a high equitability would indicate a high diversity and probably a "healthy condition" of the fauna. Reduction of equitability almost always occurs with an increase in oligomixity. Pielou's (1966) method of measuring equitability is most widely used. The computational formula is:

$$J' = \frac{H'}{\log_e S}$$

where e = 2.30, H' = value for Shannon Index, and S = total number of species for a sample.

Margalef's index assumes a theoretical relationship between the number of individuals (N) and the number of species (S) in a sample and is expressed as:

$$M.I. = \frac{S - 1}{\log_e N} \quad \text{(Margalef, 1958)}$$

Faunal similarity analysis: A number of coefficients for measuring faunal similarities are available (Whittaker, 1967; Lie and Kelly, 1970; Sanders, 1960; Bray and Curtis, 1957; Field and MacFarlane, 1968; Morisita, 1959). However, most of the available coefficients consider only the number and rank of common species and not the distribution of individuals. The Bray-Curtis Index (Bray and Curtis, 1957), which takes into consideration both the number of species in common and the number of individuals shared, was used in the current study. The index has a range from 0 to 1, with 0

representing identical faunal composition. The computational formula for the index is:

$$B = \frac{\sum_{i=1}^{s} |X_{ij} - X_{ik}|}{\sum_{i=1}^{s} (X_{ij} + X_{ik})}$$

where B = Bray-Curtis measure of dissimilarity; X_{ij} = individuals for the *i*th species in the *j*th sample; X_{ik} = individuals for the *i*th species in the *k*th sample and *s* = the number of species over all samples. The index is relatively free from sample size effects. The results of the faunal similarity analyses are presented as a trellis diagram and as a dendrogram cluster graph. The use of this analysis in environmental studies is invaluable, since differences in community structure between stations can be inferred. From the clusters (or groupings) of similar stations, statements on the extent of environmental impact can be made.

The Bray-Curtis Index was calculated for all pair-wise combinations of stations and dates. The pair-wise combinations of the index were then used as input for the cluster analysis.

Faunal distribution among taxonomic groups was calculated as the relative percentage of species and individuals comprising major faunal groups, such as; polychaetes, oligochaetes, bivalves, gastropods, decapods, amphipods, cumaceans, etc. The change in proportion of a particular type of organism (for example, amphipods) representing a particular functional morphology, may be indicative of an alteration of the habitat structure. This study was compared to historical surveys and to post-dredging data to determine differences in taxonomic distributions.

Agglomerative Hierarchical Cluster Analysis was conducted utilizing the Czekanowski's Index as the matrix of association coefficients. The agglomerative technique starts by linking the highest similarity pairs and then proceed to the next highest in order. Hierarchical refers to the tree-like branching form of the output. The group average sorting technique was utilized as the clustering method (Sneath and Sokal, 1973), where the similarity between a sample and an existing cluster equals the arithmetic mean of similarities between the sample and all the members of the cluster (Krebs, 1989).

Similarity and cluster analyses were conducted using BioStat II® Software (Pimentel and Smith, 1993).

Reference Collections

Mote Marine Laboratory and the University of South Florida maintain an invertebrate museum collection. Any species collected by this study, not currently contained in the collection, were verified and added to the archive.

Chapter 2

2.1 BASELINE INFORMATION

The bottom topography at all the sampling sites is essentially a flat, sand sheet with no consolidated substrate or hard-bottom communities observed. Turbidity made observations difficult during dredging at Site I but dredged holes could be observed from the clamshell dredge used at this location. Small sand waves reflect the current activity in the area and this current activity also occasionally caused an increase in turbidity.

2.2 ENVIRONMENTAL CONDITIONS AT THE STUDY SITES

The sites studied in this survey all lie in the innermost portion of the west Florida Continental Shelf. Water depths ranged from 5-6 m at all sites with the exception of the ship channel off Egmont Key (Site I) where depths were 10-15 m. Doyle and Sparks (1980) have described the geology and sediments of this continental margin. The west Florida margin, like the peninsula itself is made up of about 5 kilometers of carbonate rocks intercalated with evaporites which have been deposited more or less continuously since Jurassic Time. Most of the west Florida continental shelf is veneered with a surficial sand sheet of relatively coarse carbonate sands composed predominantly of mollusk fragments. However, the Florida Peninsula is covered with a number of Tertiary quartz sand terrace deposits brought south by long shore currents from the Appalachian Province during higher stands of sea level. The inner 10 miles or so of the west Florida continental shelf is also veneered with this quartz sand mixed with varying amounts of carbonates. Quartz sand also composes the majority of the west Florida beaches. Rivers that drain into the west Florida margin are small and slow flowing with little capacity to carry suspended sand sized material. In fact, they carry a very small suspended load of any size. What the rivers do bring down is trapped in estuaries or lagoons behind barrier islands. The beaches are therefore sediment poor and somewhat ephemeral. It is therefore probable that the only new material being added to the inner west Florida system is carbonate.

The quartz sand band is thin and sand sources for beach renourishment, the dredging of the west Florida Margin that led to the inception of this project, are rare. Most sources are found in the ebb tidal deltas that lie offshore associated with either active or closed inlets in the barrier island system. The largest of these is the giant feature at the mouth of Tampa Bay where the Egmont Key site (Site I) is located. The only new sand coming into the system is from the erosion of headlands or from retreat of the dunes along the barrier islands. Many of the narrow barrier islands along the study area coast have been undergoing erosion and exhibit the bluff formation characteristic of a retreating coast.

2.3 DREDGING TECHNIQUES EMPLOYED AT THE EGMONT KEY AND LONGBOAT KEY SITES

It should be noted that the dredging techniques and equipment employed at the two study sites that were dredged were quite different. These differences may be responsible for some of the observed differences in seafloor impacts

At the Egmont Key site (Site I), a clamshell dredge was used to excavate the sand deposits which were then placed in a hopper barge for transport into shallower waters. Clamshell dredges use buckets (sizes 1-8 cubic meters) which are mechanically activated to "bite into" the seabed to remove material (typically for low-cost/low-volume mining close to shore). Material may then be loaded into its own hopper or onto a separate barge. Resulting small pits usually leave an irregular seafloor topography and turbidity plumes throughout the water column are common (Groat *et al.*, 1993).

At the Longboat Key site (Site IV), Bean Dredging Corporation's Beachbuilder was employed. The Beachbuilder is a dustpan dredge. It has a wide, flat head designed to skim thin layers of sand from the bottom and uses high-pressure jets of seawater to loosen sand in a wide, shallow path. Because the dustpan dredge removes a much thinner layer of sand than a conventional dredge, it tends to leave some of the substrate intact (Taylor, 1993).

Chapter 3

3.1 SEDIMENT AND GEOPHYSICAL RESULTS

Sediment Analyses

Grain size (texture) was measured by the standard technique of sieving an aliquot through sieves nested at 1 ϕ intervals; that is -1 ϕ (2mm), 0 ϕ (1mm), 1 ϕ (500 μ), 2 ϕ (250 μ), 3 ϕ (125 μ), 4 ϕ (62 μ), and pan (< 62 μ) in the method of Folk, 1980. This whole range is considered to be the sand sized fraction. For Site I, the only one in which we have before, during and after dredging sampling, measurements of all ten replicate samples were combined at each of the three stations and histograms were constructed for comparison of sampling periods. These are shown as Figures 3.1-1 to 3.1-5. Appendix A is the source data for these histograms.

Figures 3.1-1 to 3.1-3 show that there is no significant difference in texture through time. At Stations I-1 and I-3 the majority of the particles are concentrated in the 2-3 ϕ (250-125 μ) size class with a strong secondary concentration in the 3-4 ϕ (125-62 μ) size range. These sizes are commonly described as fine sand and very fine sand, respectively. Station I-2 shows an anomalous concentration in the coarse sand range 0-1 ϕ (1 mm-500 μ) in the 01/93 sampling as well as more sediment in the coarser fractions as well. Station I-2 generally shows more variation between sampling periods as well.

Normally it would be expected that a newly created depression in relatively shallow water such as at the Egmont Key site (Site I), where waves and current affect the bottom, would begin to be filled immediately with sediment moved by these forces around the inner portion of the shelf. Normally depressions are thought to be sinks for fine grained sediments (finer than sand sized) first. Apparently that is not the case here. A plausible explanation may be found by examining Figures 3.1-1 to 3.1-6. There is only a tiny finer than sand sized fraction present in the inner west Florida shelf surficial sand sheet. There is simply virtually no fine fraction with which to fill the depression.

The sediment on the inner few miles of the west Florida shelf is dominantly fine to very fine quartz sand, thus the heavy concentration in the 2-4 ϕ size fractions. However, there is a second important component, calcium carbonate, composed mostly of molluscan shell fragments. These make up the coarser size fractions. In some places they can be quite concentrated and their distribution is patchy and can vary even within a station wide area. Station I-2 has a higher carbonate content that accounts for its variability.

Figures 3.1-4 to 3.1-6 show the within station variability for stations I-3-09-3, II-2-54, and II-1-072. Examination of the within station variability for Station 3-1-09-3 (Figure 3.1-4) shows the expected concentrations in the 2-3 ϕ and 3-4 ϕ size fractions. It also shows that when the coarser carbonate fractions increase there is a concomitant decrease in the finer quartz sand fractions. Figure 3.1-5 and 3.1-6 show the between station variability of two stations at Site II. Table 3.1-1 shows the carbonate content for these two stations for the same sampling periods. Station II-2-054, composed predominantly of quartz sand shows heavy concentrations in the 2 to 4 ϕ size ranges

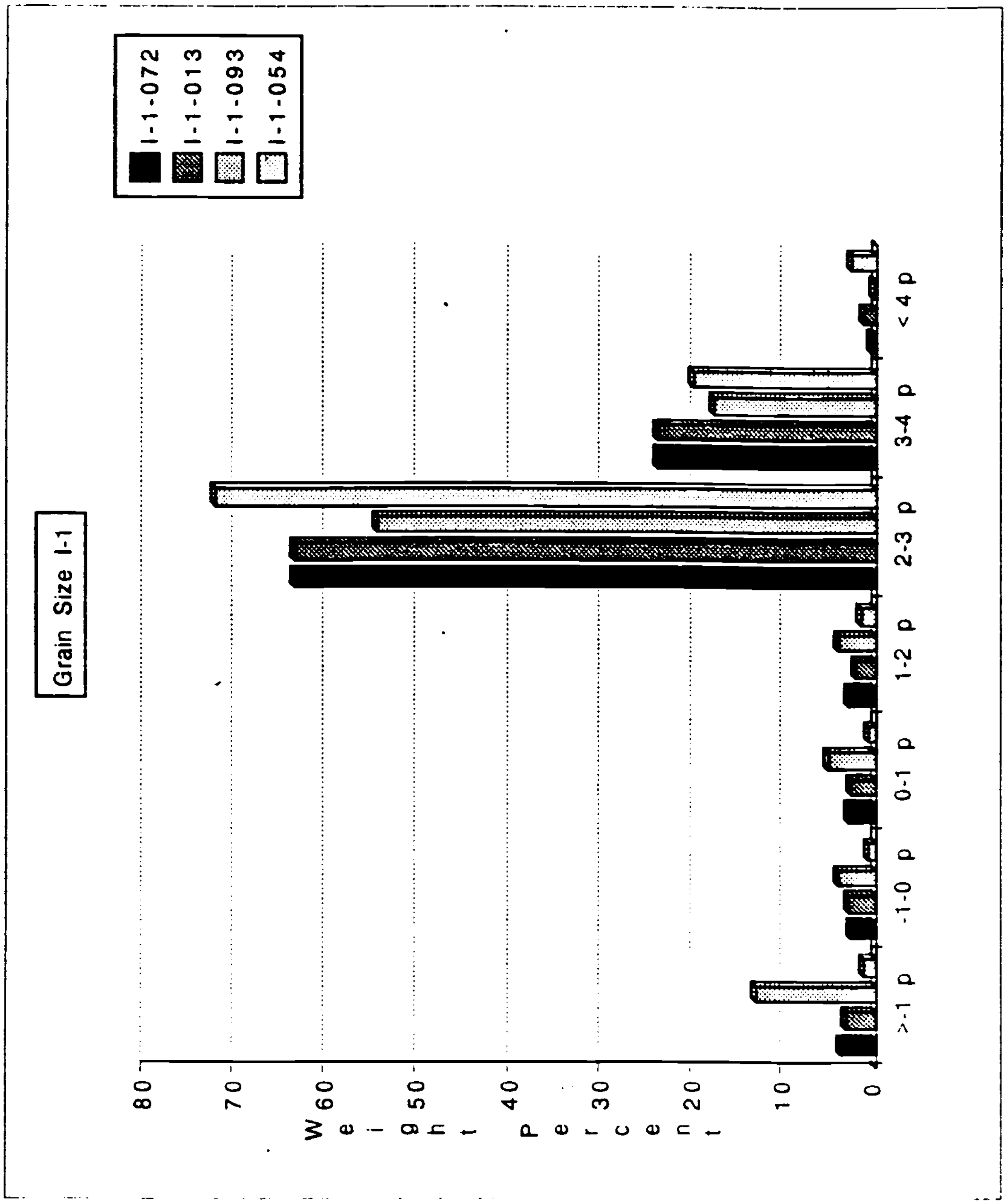


Figure 3.1-1. Sediment grain size distribution, Site I, Station 1.

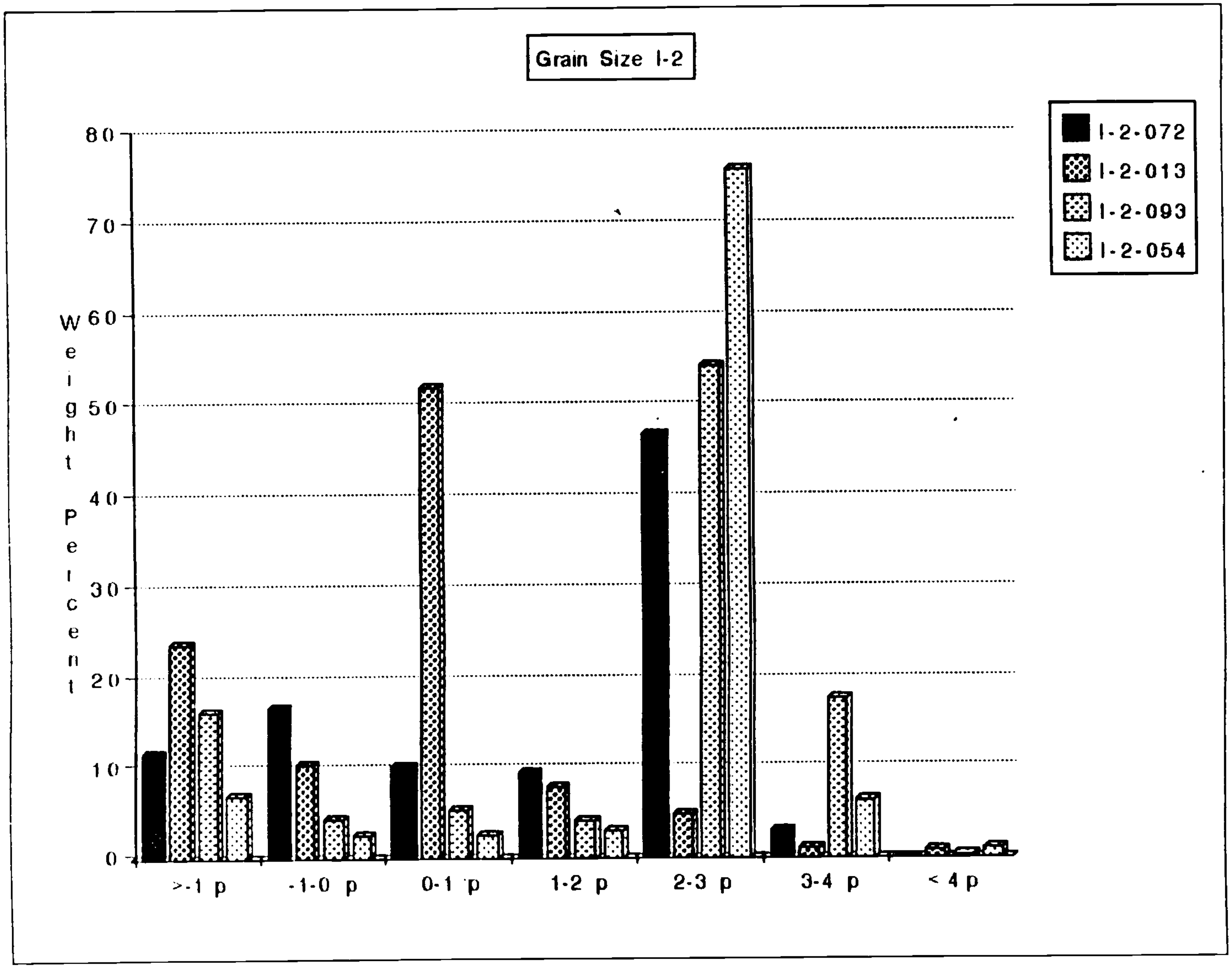


Figure 3.1-2. Sediment grain size distribution, Site I, Station 2.

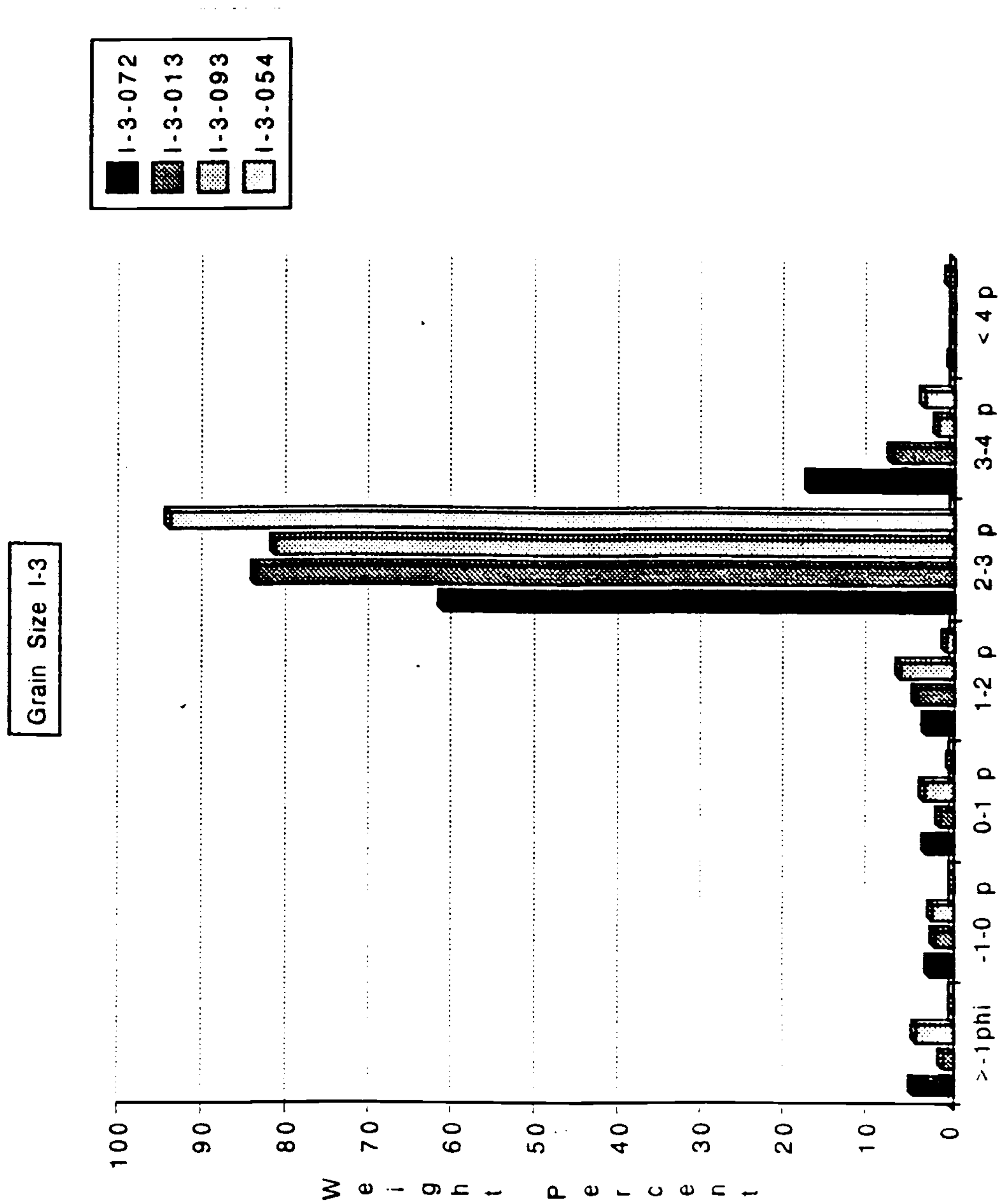


Figure 3.1-3. Sediment grain size distribution, Site I, Station 3.

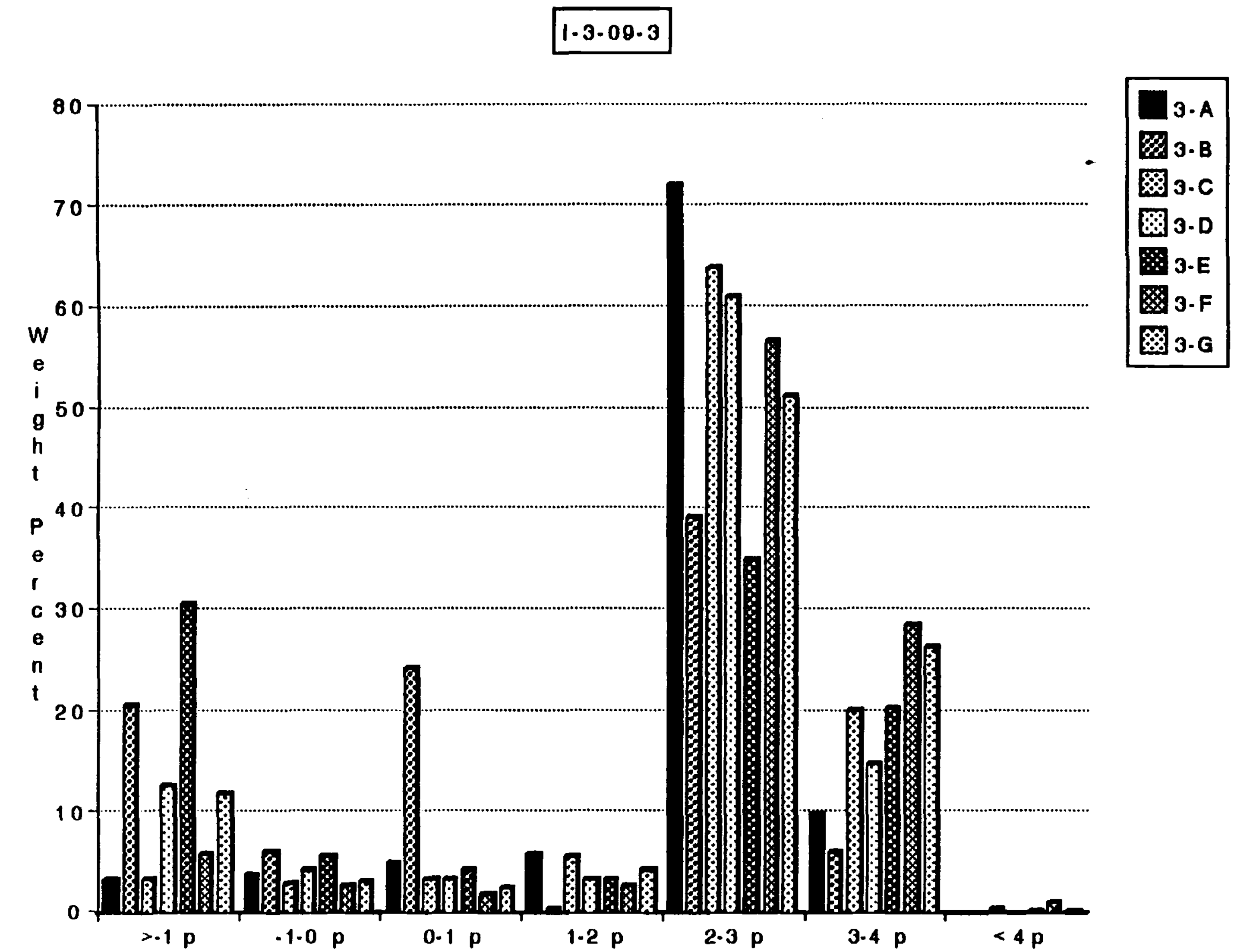


Figure 3.1-4. Sediment grain size distribution for subsamples A-G, Site I, Station 3, September 1993.

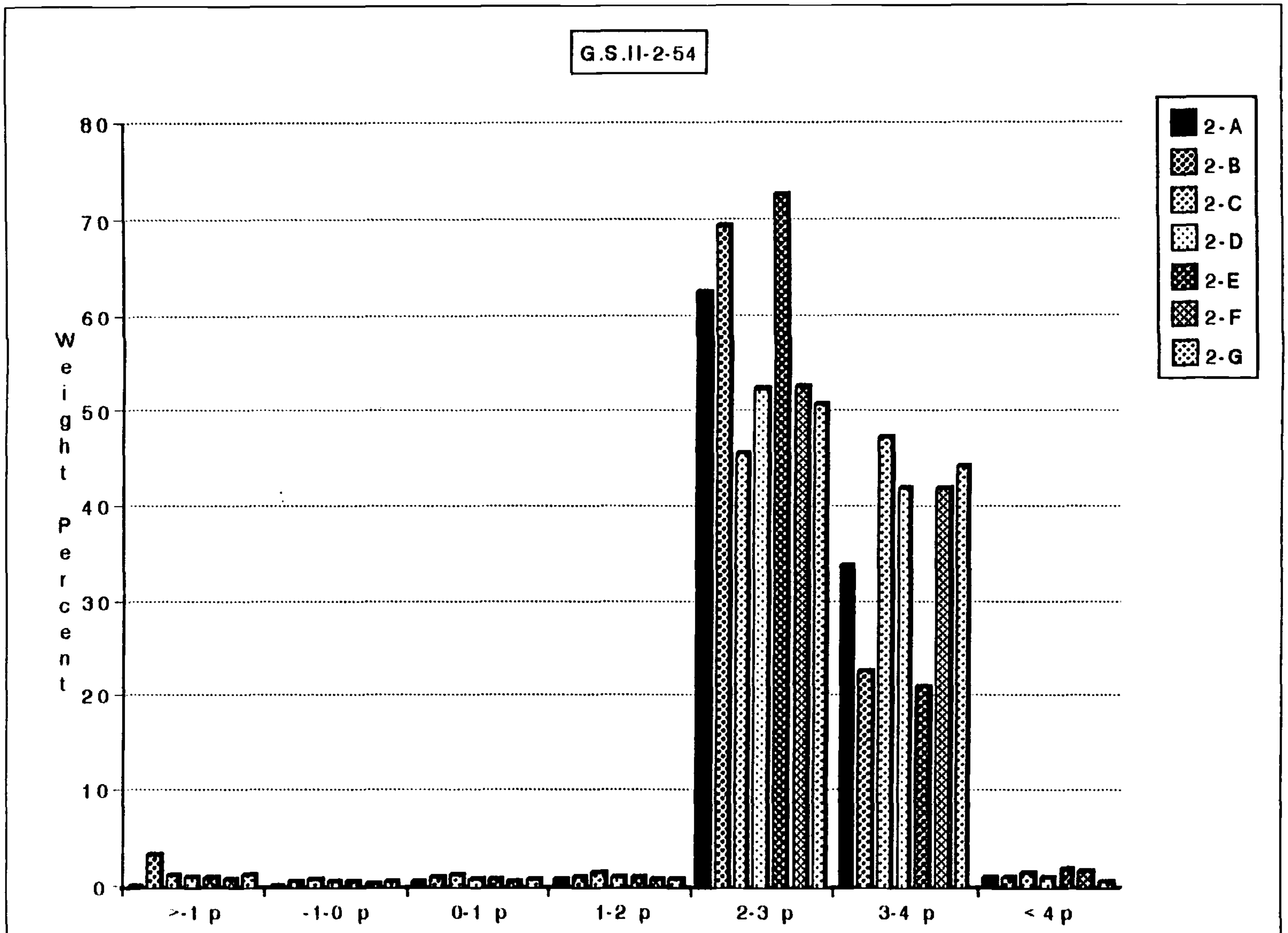


Figure 3.1-5. Sediment grain size distribution for subsamples A-G, Site II, Station 2, May 1994.

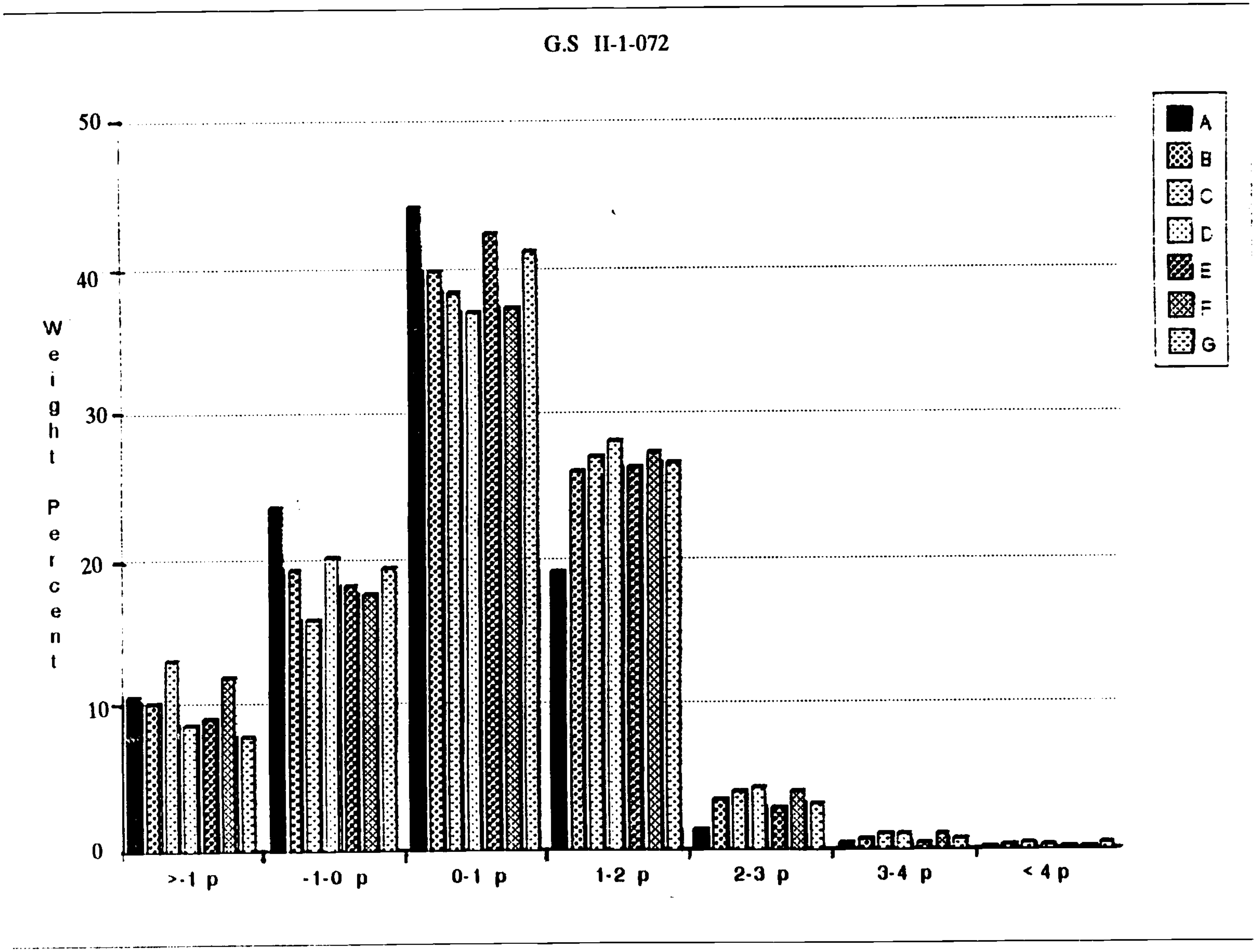


Figure 3.1-6. Sediment grain size distribution for subsamples A-G, Site II, Station 1, July 1992.

while Station II-1-072 has a coarser distribution, reflecting high carbonate content.

TABLE 3.1-1
Weight Percent CaCO3

Subsample	Site/Location/Date II-2-054	Site/Location/Date II-1-072
A	12.0	82.5
B	12.8	87.6
C	15.6	77.3
D	13.9	84.6
E	17.3	86.3
F	10.4	82.5
G	11.4	80.8
H	11.2	87.3
I	14.7	89.9
J	16.6	78.2

Carbonate content was determined by acidifying a weighed aliquot with 10% HCl, dissolving the carbonate minerals, drying the sample and re-weighing. Organic content was determined by combustion of a carbonate free subsample. Data for all stations is in Appendix B.

Geophysical Results

The geophysical surveys provided a framework for the benthic sampling. Several techniques were used - side scan sonar, high resolution seismic profiling, and precision depth recording. Precision depth recording (PDR) of bathymetry provided the most useful data. Should such a study be undertaken again, it would be wise to dispense with the high resolution seismic profiling and side scan sonar work and concentrate on repeating with precise navigation a complete bathymetric survey of the excavation. The pre-dredge survey of the Egmont Key site (Site I) was used as data by Mr. David Duncan in his Master's thesis. Figure 3.1-7 (after Duncan 1993) shows the seismic stratigraphy and structure North to South across the main ship channel and the Egmont study area. The Tampa Bay ebb tidal delta is the largest on the peninsular west coast of Florida. It was formed by sand transported by the long shore currents being swept seaward by the ebb tidal currents flowing out of Tampa Bay around Egmont Key.

Bathymetry turned out to be by far and away the most sensitive geophysical tool. A pre-dredging example of Site I, the only one that was dredged, is shown in Figure 3.1-8. Note the vertical exaggeration. Figure 3.1-9 (post-dredging) shows the primary lasting effect of the dredging; that is the excavation itself. Even as late as 1994, after several storm and frontal system seasons, the excavation is clearly visible. It is clear that

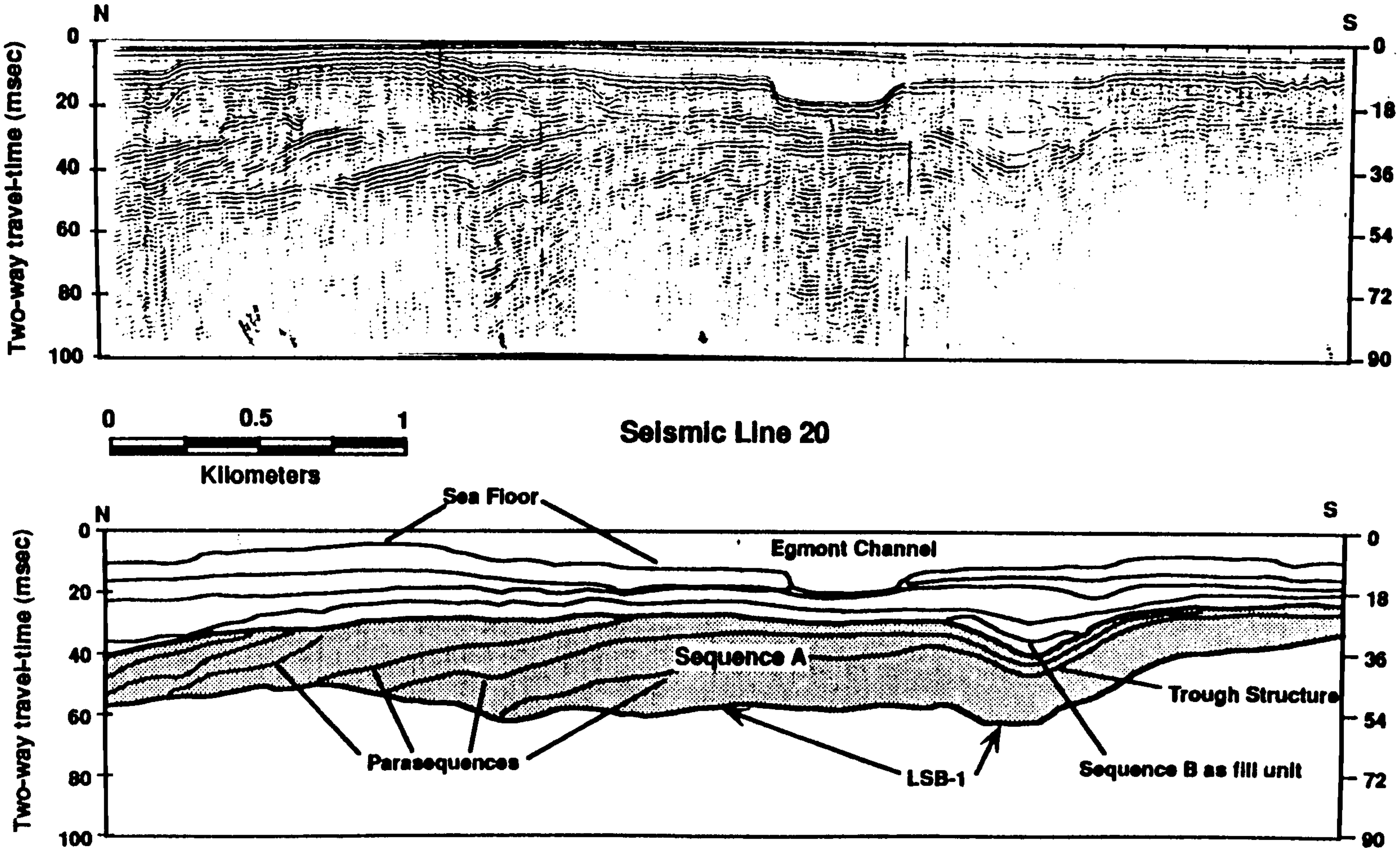


Figure 3.1-7. Seismic profile of Site I, Egmont Key showing parasequences. The shadded area covers Sequence A. Trough structure is evident to the south of Egmont Channel (after Duncan 1993).

the excavation was below local wave base and that even in this shallow system sediment supply is insufficient to quickly hide the dredge scar.

Figure 3.1-10 shows the post-dredging bathymetry at the Longboat Key site. No pre-dredge data is available for this site. However perusal of adjacent areas at this site suggests that a smooth sea floor is the norm along this portion of the coast. Clearly dredging activity has caused an irregular topography but the pronounced dredge scar visible at Egmont Key (Site I) is not present.

Longboat Key was dredged with a dustpan dredge which is different from the clam-shell bucket dredge used off Egmont Key. As discussed in Section 2.3, a dustpan dredge skims thin layers of sand from the bottom using high-pressure jets of seawater. Comparison of the post-dredging profiles from both locations does not reveal major differences in bathymetric profile. While at first glance at Figure 3.1-10, the Longboat Key site may appear to be more irregular, much of that appearance is due to the very greater vertical exaggeration (see Figure 3.1-10 vertical scale 6 feet; horizontal scale 1 mile). A diver on the bottom site would not be impressed by the bottom undulations at either site although the actual dredged excavation would be more visible at Egmont Key (Site I).

3.2 EPIBENTHIC RESULTS

Although epibenthic surveys were done extensively on the outer continental shelf of the eastern gulf of Mexico in the early 1970's as part of baseline surveys conducted by the Bureau of Land Management, little to no information exists for the epibenthos of the nearshore, subtidal, sand environment. The epibenthos of this area are highly patchy and mobile. In addition they are often nocturnal and may dig into the sediment during the daylight hours. Because of these factors, the epibenthic surveys of this study were qualitative and relied upon the use of otter trawls and a towed, underwater video.

Trawls

Table 3.2-1 shows a list by abundance of all the invertebrate and vertebrate taxa collected at each sampling site and at each station for the four sampling periods. A total of 41 different taxa were observed during the study, a low species richness reflecting the constancy of the habitat in this area. The crab, *Portunus gibbesii,* and the sand dollar, *Mellita tenuis* were by far the most dominant species present during the study. Although both species were absent from Site II during the May, 1994 sampling, this site had not been dredged as planned by the Army Corps of Engineers. The shrimp, *Penaeus duorarum* a predominantly nocturnal species, was a distant third and showed great variability between samples.

Tables 3.2-2 through 3.2-9 list the species collected by number of individuals for each trawl and the location of each trawl. Although an attempt was made to make each trawl location constant, current and wind conditions would not make this possible. However, *Portunus gibbesii* and *Mellita tenuis* remained the dominant epibenthic species throughout the course of the study at both dredged and undredged locations.

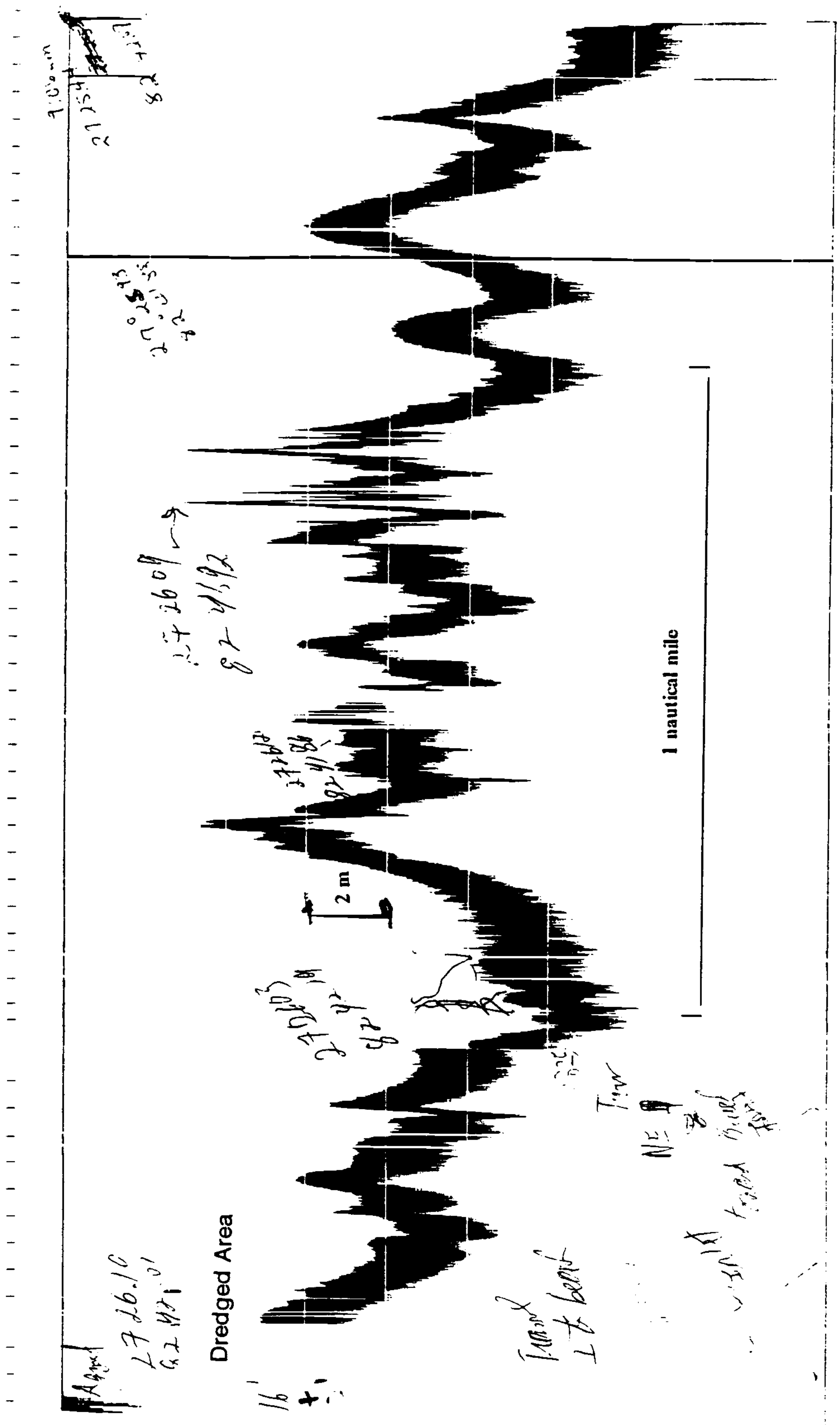


Figure 3.1-10. Bathmetry at Site IV, Longboat Key, September 1993, post-dredging.

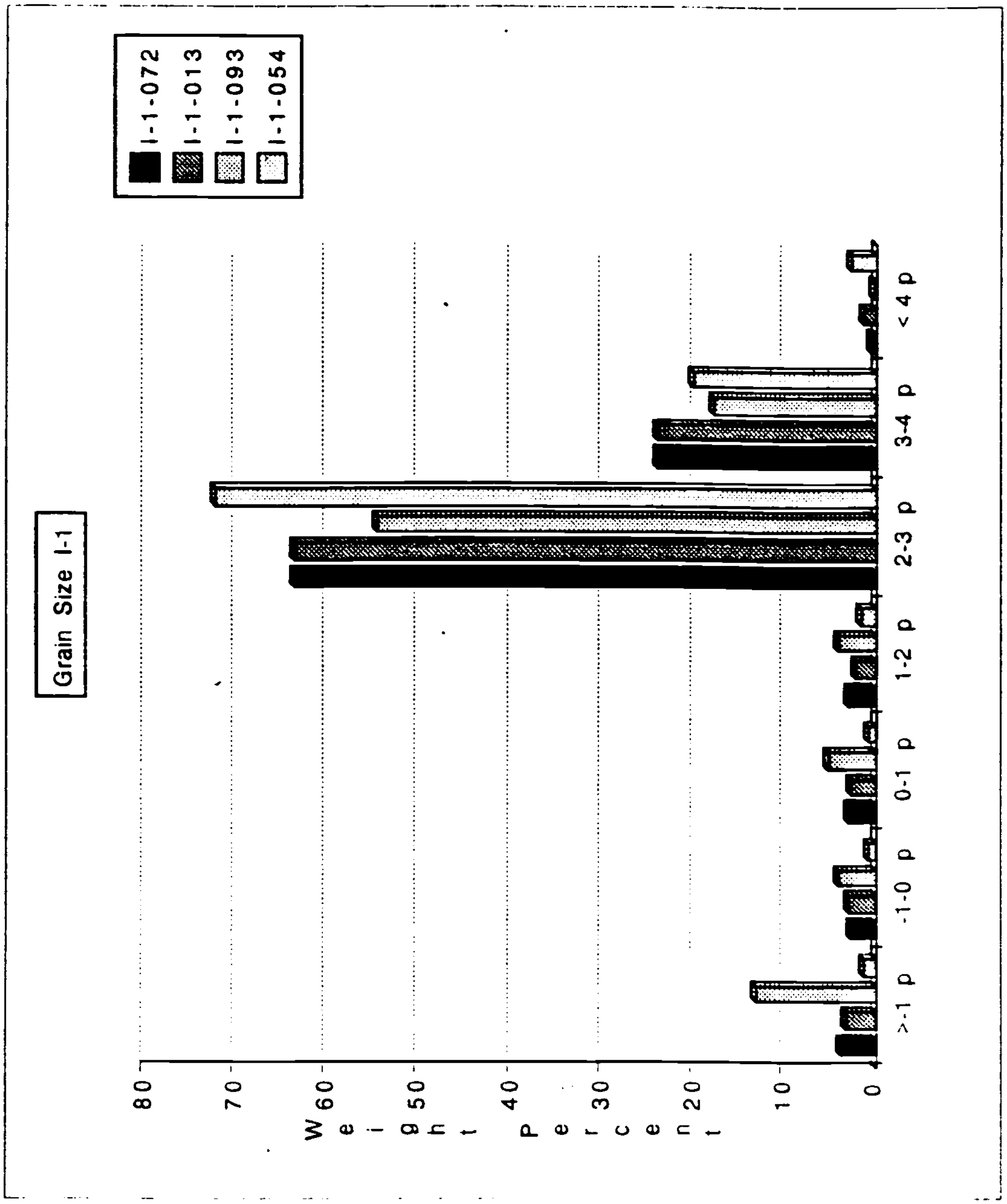


Figure 3.1-1. Sediment grain size distribution, Site I, Station 1.

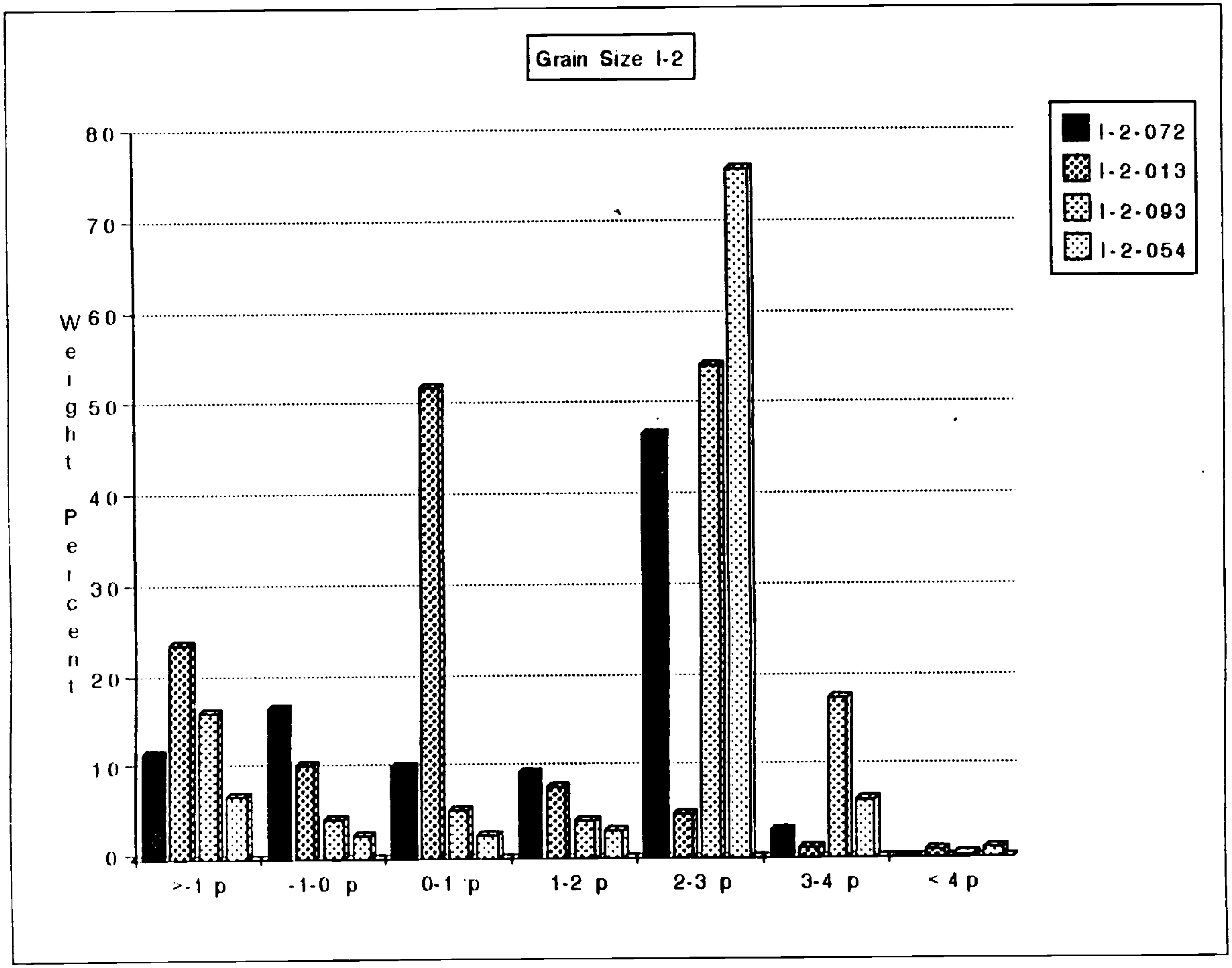


Figure 3.1-2. Sediment grain size distribution, Site I, Station 2.

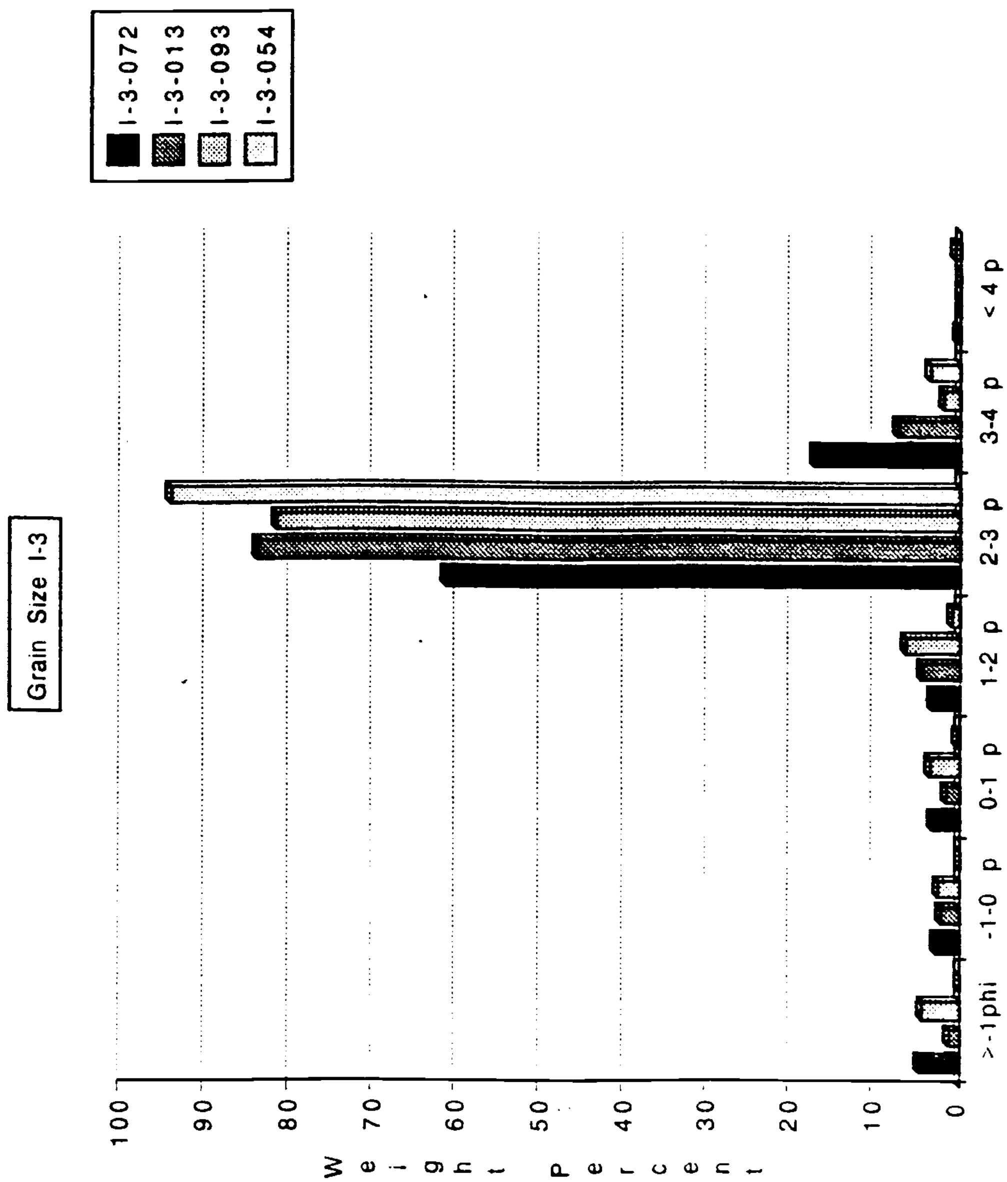


Figure 3.1-3. Sediment grain size distribution, Site I, Station 3.

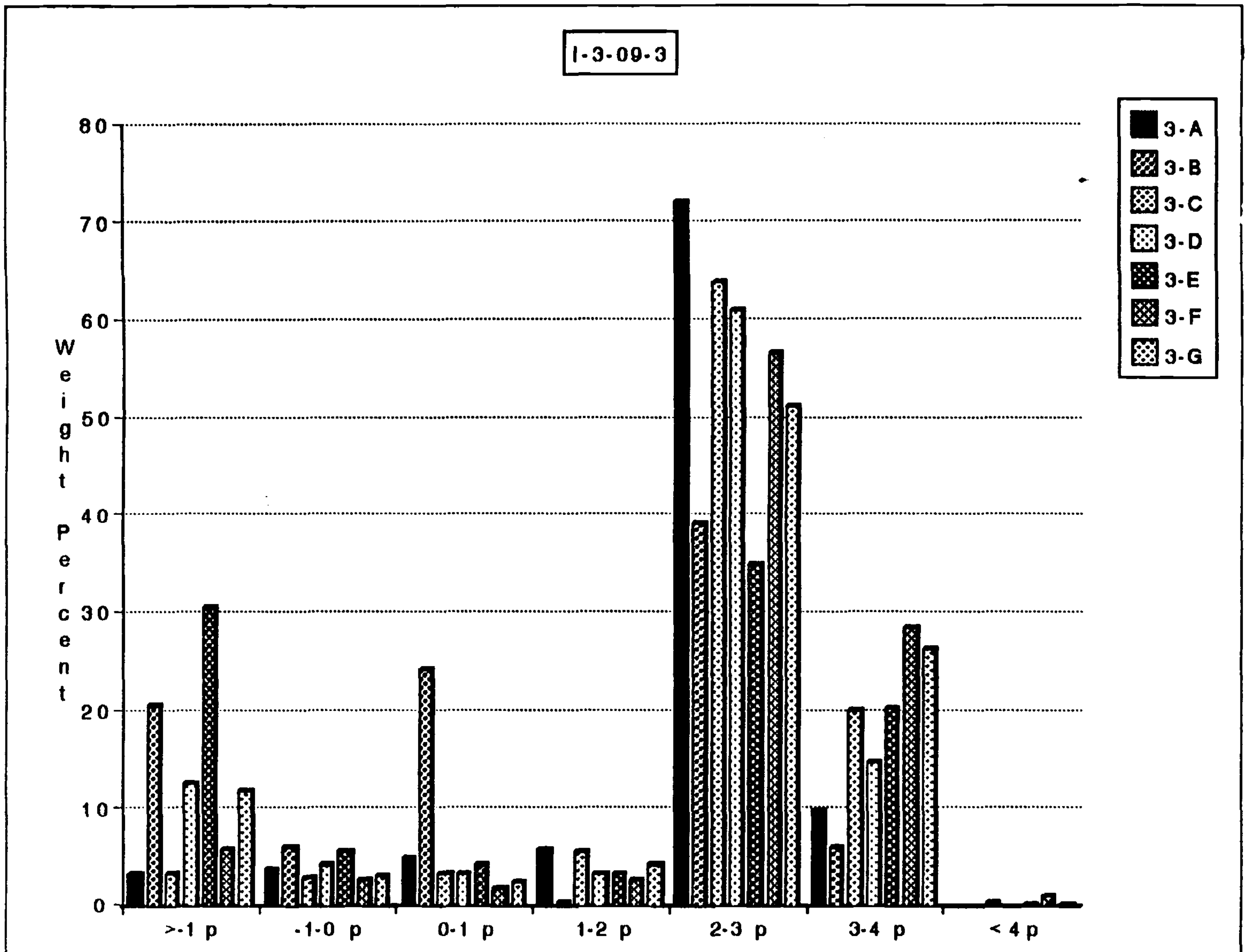


Figure 3.1-4. Sediment grain size distribution for subsamples A-G, Site I, Station 3, September 1993.

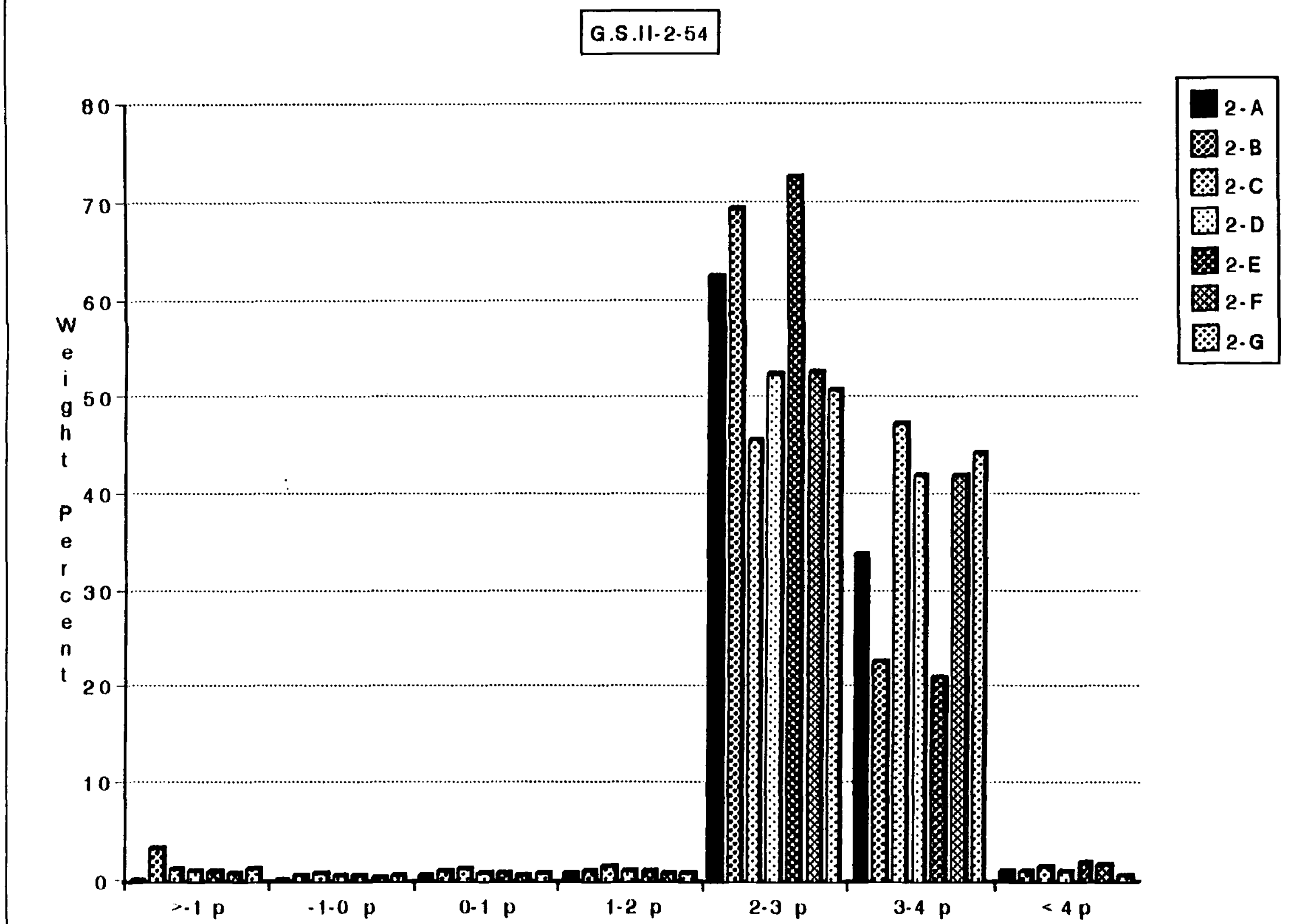


Figure 3.1-5. Sediment grain size distribution for subsamples A-G, Site II, Station 2, May 1994.

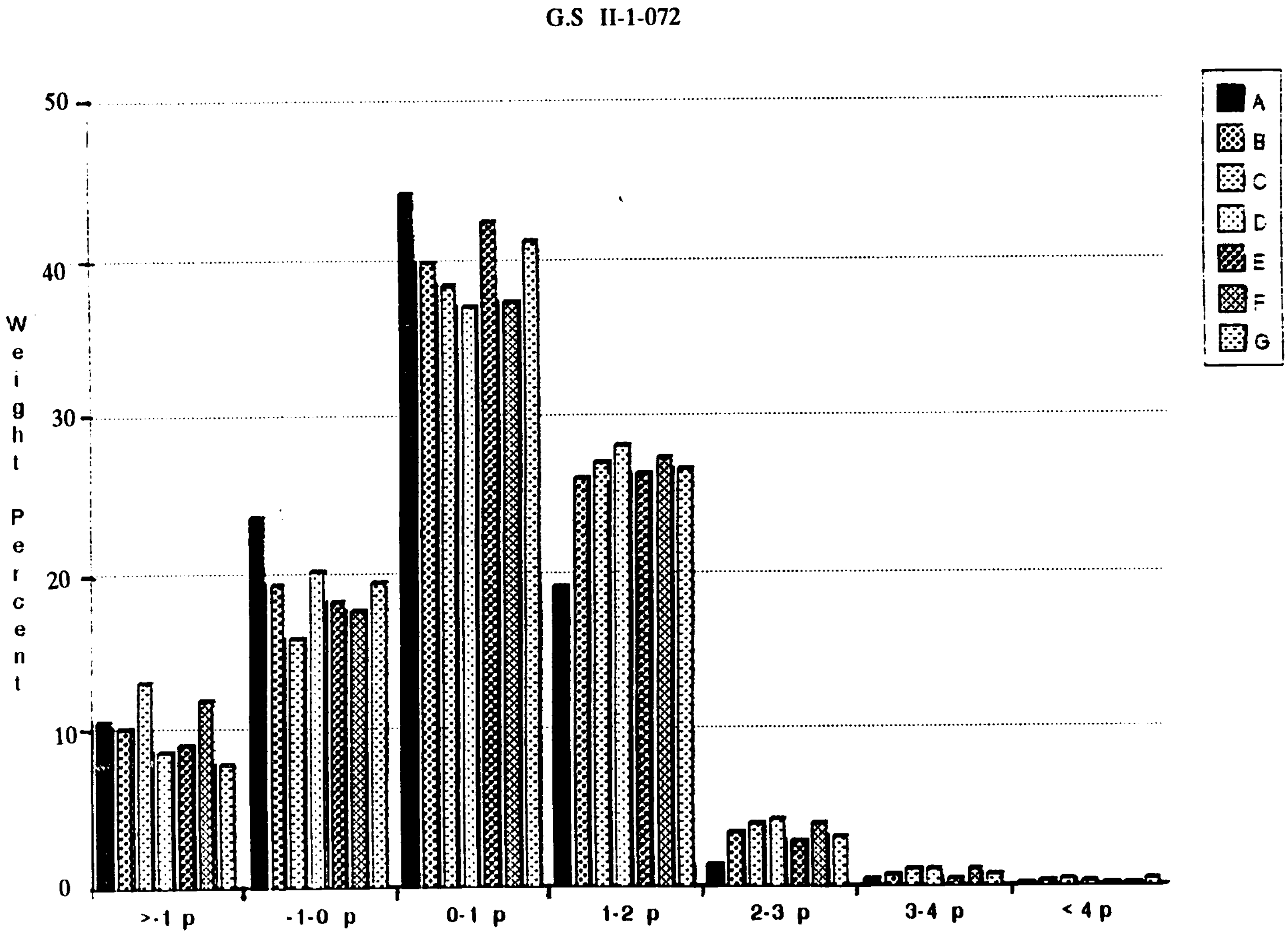


Figure 3.1-6. Sediment grain size distribution for subsamples A-G, Site II, Station 1, July 1992.

while Station II-1-072 has a coarser distribution, reflecting high carbonate content.

TABLE 3.1-1
Weight Percent CaCO3

Subsample	Site/Location/Date II-2-054	Site/Location/Date II-1-072
A	12.0	82.5
B	12.8	87.6
C	15.6	77.3
D	13.9	84.6
E	17.3	86.3
F	10.4	82.5
G	11.4	80.8
H	11.2	87.3
I	14.7	89.9
J	16.6	78.2

Carbonate content was determined by acidifying a weighed aliquot with 10% HCl, dissolving the carbonate minerals, drying the sample and re-weighing. Organic content was determined by combustion of a carbonate free subsample. Data for all stations is in Appendix B.

Geophysical Results

The geophysical surveys provided a framework for the benthic sampling. Several techniques were used - side scan sonar, high resolution seismic profiling, and precision depth recording. Precision depth recording (PDR) of bathymetry provided the most useful data. Should such a study be undertaken again, it would be wise to dispense with the high resolution seismic profiling and side scan sonar work and concentrate on repeating with precise navigation a complete bathymetric survey of the excavation. The pre-dredge survey of the Egmont Key site (Site I) was used as data by Mr. David Duncan in his Master's thesis. Figure 3.1-7 (after Duncan 1993) shows the seismic stratigraphy and structure North to South across the main ship channel and the Egmont study area. The Tampa Bay ebb tidal delta is the largest on the peninsular west coast of Florida. It was formed by sand transported by the long shore currents being swept seaward by the ebb tidal currents flowing out of Tampa Bay around Egmont Key.

Bathymetry turned out to be by far and away the most sensitive geophysical tool. A pre-dredging example of Site I, the only one that was dredged, is shown in Figure 3.1-8. Note the vertical exaggeration. Figure 3.1-9 (post-dredging) shows the primary lasting effect of the dredging; that is the excavation itself. Even as late as 1994, after several storm and frontal system seasons, the excavation is clearly visible. It is clear that

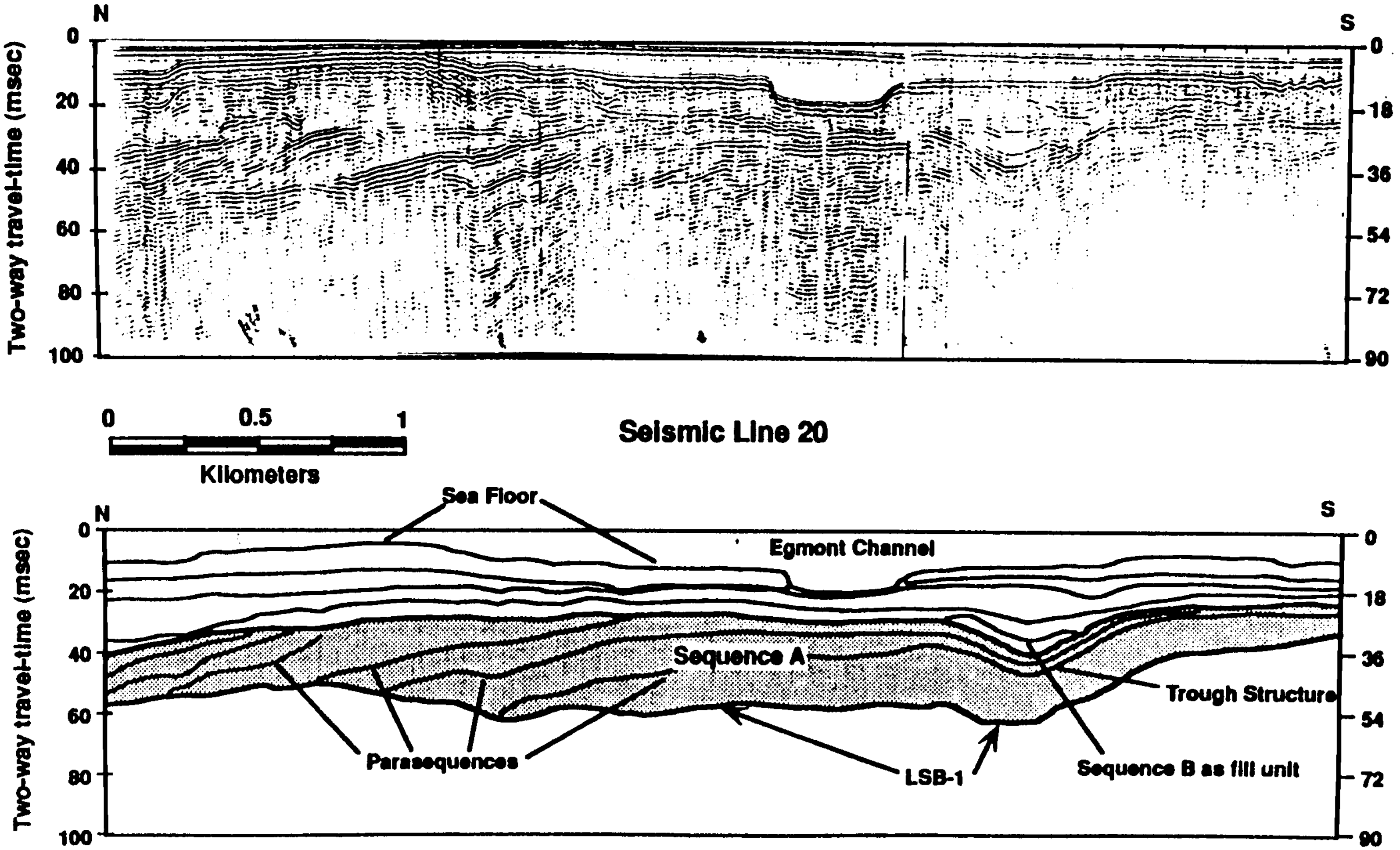


Figure 3.1-7. Seismic profile of Site I, Egmont Key showing parasequences. The shadded area covers Sequence A. Trough structure is evident to the south of Egmont Channel (after Duncan 1993).

the excavation was below local wave base and that even in this shallow system sediment supply is insufficient to quickly hide the dredge scar.

Figure 3.1-10 shows the post-dredging bathymetry at the Longboat Key site. No pre-dredge data is available for this site. However perusal of adjacent areas at this site suggests that a smooth sea floor is the norm along this portion of the coast. Clearly dredging activity has caused an irregular topography but the pronounced dredge scar visible at Egmont Key (Site I) is not present.

Longboat Key was dredged with a dustpan dredge which is different from the clam-shell bucket dredge used off Egmont Key. As discussed in Section 2.3, a dustpan dredge skims thin layers of sand from the bottom using high-pressure jets of seawater. Comparison of the post-dredging profiles from both locations does not reveal major differences in bathymetric profile. While at first glance at Figure 3.1-10, the Longboat Key site may appear to be more irregular, much of that appearance is due to the very greater vertical exaggeration (see Figure 3.1-10 vertical scale 6 feet; horizontal scale 1 mile). A diver on the bottom site would not be impressed by the bottom undulations at either site although the actual dredged excavation would be more visible at Egmont Key (Site I).

3.2 EPIBENTHIC RESULTS

Although epibenthic surveys were done extensively on the outer continental shelf of the eastern gulf of Mexico in the early 1970's as part of baseline surveys conducted by the Bureau of Land Management, little to no information exists for the epibenthos of the nearshore, subtidal, sand environment. The epibenthos of this area are highly patchy and mobile. In addition they are often nocturnal and may dig into the sediment during the daylight hours. Because of these factors, the epibenthic surveys of this study were qualitative and relied upon the use of otter trawls and a towed, underwater video.

<u>Trawls</u>

Table 3.2-1 shows a list by abundance of all the invertebrate and vertebrate taxa collected at each sampling site and at each station for the four sampling periods. A total of 41 different taxa were observed during the study, a low species richness reflecting the constancy of the habitat in this area. The crab, *Portunus gibbesii,* and the sand dollar, *Mellita tenuis* were by far the most dominant species present during the study. Although both species were absent from Site II during the May, 1994 sampling, this site had not been dredged as planned by the Army Corps of Engineers. The shrimp, *Penaeus duorarum* a predominantly nocturnal species, was a distant third and showed great variability between samples.

Tables 3.2-2 through 3.2-9 list the species collected by number of individuals for each trawl and the location of each trawl. Although an attempt was made to make each trawl location constant, current and wind conditions would not make this possible. However, *Portunus gibbesii* and *Mellita tenuis* remained the dominant epibenthic species throughout the course of the study at both dredged and undredged locations.

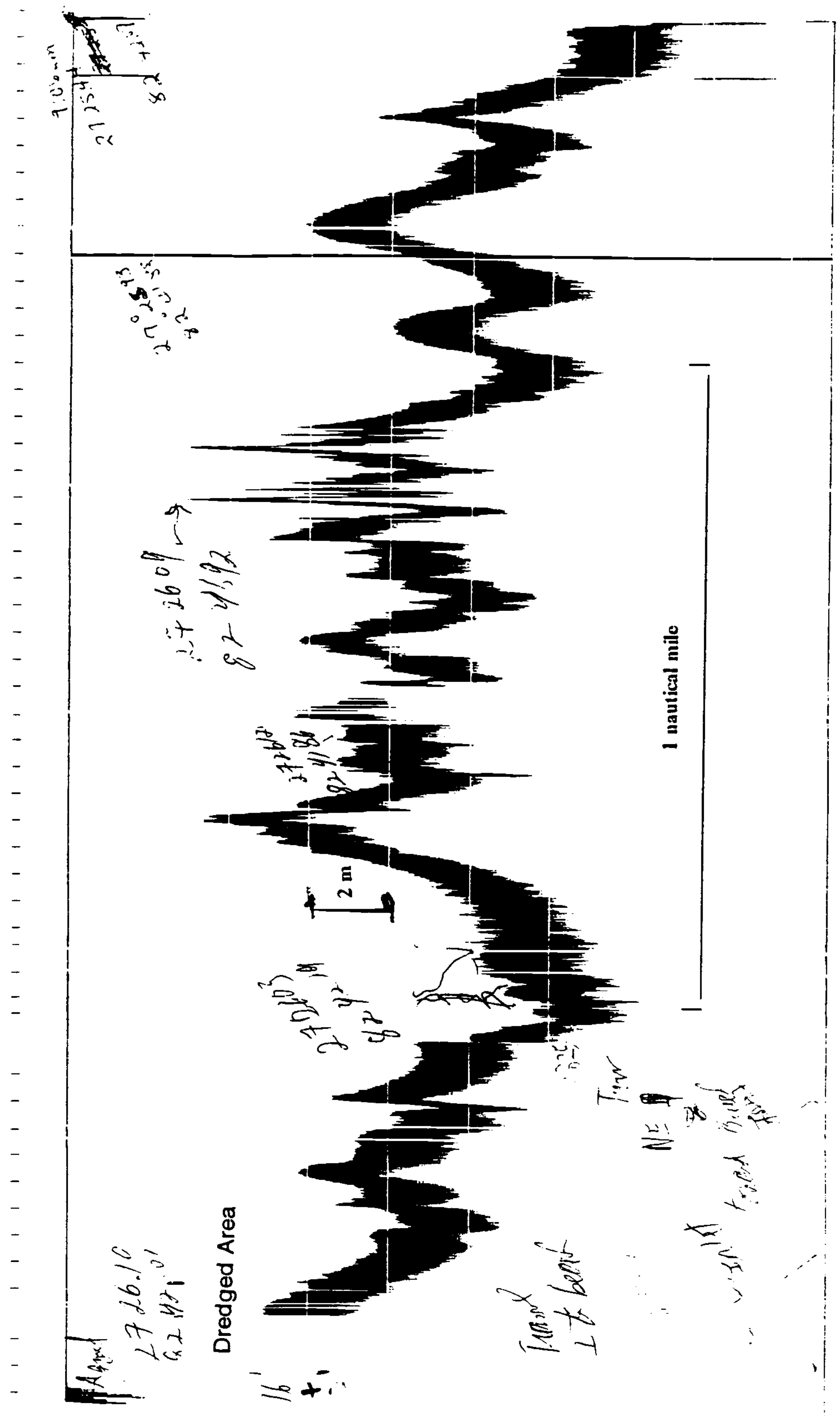


Figure 3.1-10. Bathmetry at Site IV, Longboat Key, September 1993, post-dredging.

TABLE 3.2-1

Combined species list in order of prevalence and which trawls the species was found in for all four MMS cruises
X= present O = absent

		07/13–15/92			01/19–21/93		09/08–09/93		05/24–25/94	
		Site I	Site II	Site III	Site I	Site II	Site I	Site IV	Site I	Site II
Species	**Number**	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
Portunus gibbesii	>1424	X X X	X X X	X X X	X X X	X X O	X X X	X X X	X X O	O O O
Mellita tenuis	>1157	O X X	O X O	O O O	O X X	O O O	O X X	O X X	O X X	O O O
Penaeus duorarum	129	O O O	O O O	O O O	X O X	X X O	X X X	O O O	O O O	O O O
Penaeus sp.	2	O O O	O O O	X O O	O O O	O O O	O O O	O O O	O O O	O O O
Anadara transversa	90	O O O	X O O	X X X	O O O	X O X	O O O	O O O	O O O	O O O
Portunus spinimanus	75	X X O	O X X	O O O	X X X	O X O	X X X	X O O	O O O	O O O
Arenaeus cribrarius	55	O X X	O O O	O O O	X X X	O O O	X X X	X O O	O O O	X O O
Penaeus aztecus	52	O O O	O O O	O O O	X X X	X X O	O O O	O O O	O O O	O O O
Pagurus impressus	42	O O O	O O X	O O X	O O O	X O O	O O O	O O O	O O O	O O O
Squilla empusa	36	O O O	O O O	O O O	X X X	O O O	X X X	O O O	O O O	O O O
Luidia clathrata	32	X X X	O X O	O O O	X O X	O O X	X O X	X O X	O X O	O O O
Lytechinus variegatus	30	X X O	O X O	X O O	O X O	X O X	O O O	O O O	O O O	X O O
Argopecten gibbus	25	O O O	O O O	X O X	O O O	O O O	O O O	O O O	O O O	X O O
Callinectes sapidus	15	O X X	O X O	X O O	O O O	O O O	X X X	O X O	O O O	O X O
Diadema sp.	7	O O O	O O O	X O X	O O O	O O O	O O O	O O O	O O O	O O O
Menippe mercenaria	6	O O O	O X X	O O O	O O O	O O O	O O X	O O O	O O O	O O O
Menippe mercenaria juvenile	1	O O O	O O O	O O O	O O O	O O O	O O O	O O O	O O O	X O O
Ophioderma cinereum	4	O O O	O O O	O O O	O O O	X X X	O O O	O O O	O O O	O O O
Ophioderma sp.	2	O O O	O O X	O O X	O O O	O O O	O O O	O O O	O O O	O O O
Astropecten comptus	3	X O X	O O O	O O O	O O O	O O O	O O O	O O O	O O O	O O O
Callinectes similis	3	O O O	O O O	O O X	O O O	O O O	O O O	X X O	O O O	O O O
Echinaster modestus	3	O O O	O O O	X O X	O O O	O O O	O O O	O O O	O O O	O O O
Pteria colymbus	3	O O O	O O O	O O X	O O O	O O O	O O O	O O O	O O O	O O O
Strombus alatus	3	X O O	O O O	X O O	O O O	O O O	O O O	O O O	O O O	O O O
Astropecten duplicatus	2	O O O	O O O	O O O	O O O	O O O	O O X	O X O	O O O	O O O
Calappa flammea	2	O O O	O O X	O O O	O X O	O O O	O O O	O O O	O O O	O O O
Hepatus epheliticus	2	O O O	O O O	O O O	O O X	O O O	O O O	O O O	O O O	X O O
Libinia dubia	2	O O O	O X O	O O O	O X O	O O O	O O O	O O O	O O O	O O O
Persephona punctata aquilonaris	2	O O O	O O O	O O O	O X O	O O O	O O O	O O O	O O O	O O O
Podochela riisei	2	O O O	O O O	O O X	O O O	O O O	O O O	O O O	O O O	O O O
Synaptula hydriformis	2	O O O	O O O	O O O	O O O	O O O	O O O	O X O	O O O	O O O
Botrylloides sp.	1	O O O	O O O	O O O	O O O	O O O	O O O	O X O	O O O	O O O

		07/13–15/92			01/19–21/93		09/08–09/93		05/24–25/94	
		Site I	Site II	Site III	Site I	Site II	Site I	Site IV	Site I	Site II
Species	**Number**	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3	1 2 3
Hepatus pudibundus juvenile	1	O O O	O O O	O O O	O O O	X O O	O O O	O O O	O O O	O O O
Hippocampus sp.	1	O O O	O O O	X O O	O O O	O O O	O O O	O O O	O O O	O O O
Holothuria princeps	1	O O O	O O O	O O O	O X O	O O O	O O O	O O O	O O O	O O O
Holothuria sp.	1	O O O	O O O	X O O	O O O	O O O	O O O	O O O	O O O	O O O
Luidia alternata	1	O O O	X O O	O O O	O O O	O O O	O O O	O O O	O O O	O O O
Panopeus herbstii juvenile	1	O O O	O O O	O O O	O O O	O O O	O O O	O O X	O O O	O O O
Pleuroploca gigantea juvenile	1	O O O	O O O	O O X	O O O	O O O	O O O	O O O	O O O	O O O
Podochela sidneyi	1	O O O	X O O	O O O	O O O	O O O	O O O	O O O	O O O	O O O
Polynices duplicatus	1	O O O	O O O	O O O	O X O	O O O	O O O	O O O	O O O	O O O
Portunus ordwayi juvenile	1	O O O	O O O	O O X	O O O	O O O	O O O	O O O	O O O	O O O

TABLE 3.2-2

Species List for Trawls Made on MMS Cruise 07/13-16/92 R/V Suncoaster

Site I Trawl 1 — 07/16/92 — 0654 27°37.92'N 82°49.40'W; 0711 27°38.00'N 82°48.65'W

Species	Number
Portunus gibbesii	>100
Luidia clathrata	2
Lytechinus variegatus	2
Astropecten comptus	1
Portunus spinimaneus	1
Strombus alatus	1

Site I Trawl 2 — 07/16/92 — 0729 27°37.43'N 82°48.23'W; 0750 27°37.24'N 82°49.35'W

Species	Number
Portunus gibbesii	>100
Mellita quinquesperforata	>50
Luidia clathrata	5
Callinectes sapidus	4
Lytechinus variegatus	2
Arenaeus cribrarius	1
Portunus spinimaneus	1

Site I Trawl 3 — 07/16/92 — 0818 27°37.85'N 82°48.76'W; 0840 27°37.04'N 82°48.69'W

Species	Number
Portunus gibbesii	>200
Mellita quinquesperforata	20
Astropecten comptus	2
Luidia clathrata	2
Arenaeus cribrarius	1
Callinectes sapidus	1

Site II Trawl 1 — 07/15/92 — 1931 27°15.74'N 82°35.21'W; 1950 27°16.52'N 82°35.67'W

Species	Number
Anadara transversa	20
Portunus gibbesii	6
Luidia alternata	1
Podochela sidneyi	1

Site II Trawl 2 07/15/92 1850 27°17.03'N 82°35.11'W
1911 27°16.05'N 82°34.94'W

Species	Number
Portunus gibbesii	35
Mellita quinquesperforata	27
Lytechinus variegatus	6
Menippe mercenaria	4
Callinectes sapidus	2
Luidia clathrata	2
Portunus spinimaneus	2
Libinia dubia	1

Site II Trawl 3 07/15/92 2000 27°17.08'N 82°36.06'W
2020 27°18.04'N 82°36.79'W

Species	Number
Portunus gibbesii	18
Portunus spinimaneus	8
Calappa flamea	1
Menippe mercenaria	1
Ophioderma sp.	1
Pagurus impressus	1

Site III Trawl 1 07/14/92 2245 26°57.68'N 82°26.34'W
2310 26°58.24'N 82°25.47'W

Species	Number
Argopecten gibbus	23
Anadara transversa	17
Diadema sp.	5
Portunus gibbesii	4
Callinectes sapidus	3
Lytechinus variegatus	3
Penaeus sp.	2
Strombus alatus	2
Echinaster modestus	1
Hippocampus sp.	1
Holothuria sp.	1

Site III Trawl 2 07/15/92 0044 26°59.41'N 82°27.04'W
0106 26°58.72'N 82°27.04'W

Species	Number
Anadara transversa	30
Portunus gibbesii	1

Site III Trawl 3 07/14/92 2335 26°58.22'N 82°25.52'W
2350 26°57.69'N 82°26.13'W

Species	Number
Pagurus impressus	40
Anadara transversa	14
Pteria colymbus	3
Diadema sp.	2
Echinaster modestus	2
Podochela riisei	2
Argopecten gibbus	1
Callinectes similis	1
Ophioderma sp.	1
Pleuroploca gigantea juvenile	1
Portunus gibbesii	1
Portunus ordwayi juvenile	1

TABLE 3.2-3

Combined species list in order of prevalence and which trawls the species was found in

MMS Cruise 07/13 - 16/92 R/V Suncoaster

Species	Number	Site I 1	Site I 2	Site I 3	Site II 1	Site II 2	Site II 3	Site III 1	Site III 2	Site III 3
Portunus gibbesii	>465	X	X	X	X	X	X	X	X	X
Mellita quinquesperforata	>97					X	X	X		
Anadara transversa	81				X			X	X	X
Pagurus impressus	41						X			X
Argopecten gibbus	24							X		X
Lytechinus variegatus	13	X	X			X		X		
Portunus spinimaneus	12	X	X		X	X				
Luidia clathrata	11	X	X	X	X					
Callinectes sapidus	10		X	X	X			X		
Diadema sp.	7							X		X
Menippe mercenaria	5					X	X			
Astropecten comptus	3	X		X						
Echinaster modestus	3							X		X
Pteria colymbus	3									X
Strombus alatus	3	X						X		
Arenaeus cribrarius	2		X	X						
Ophioderma sp.	2						X			X
Penaeus sp.	2							X		
Podochela riisei	2									X
Calappa flamea	1						X			
Callinectes similis	1									X
Portunus ordwayi juvenile	1									X
Hippocampus sp.	1							X		
Holothuria sp.	1							X		
Libinia dubia	1					X				
Luidia alternata	1				X					
Pleuroploca gigantea juvenile	1									X
Podochela sidneyi	1				X					

TABLE 3.2-4

Species List for Trawls Made on MMS Cruise 01/19–21/93 R/V Suncoaster

Site I Trawl 1 01/19/93 — 2140 27°37.98'N 82°49.40'W; 0711 27°38.00'N 82°48.40'W

Species	Number
Portunus gibbesii	150
Penaeus duorarum	12
Squilla empusa	12
Penaeus aztecus	5
Luidia clathrata	2
Arenaeus cribrarius	1
Portunus spinimanus	1

Site I Trawl 2 01/19/93 — 2237 27°37.43'N 82°48.45'W; 2257 27°37.20'N 82°49.64'W

Species	Number
Mellita tenuis	372
Portunus gibbesii	24
Penaeus aztecus	18
Squilla empusa	7
Portunus spinimanus	4
Arenaeus cribrarius	2
Persephona punctata aquilonaris	2
Calappa flammea	1
Holothuria princeps	1
Libinia dubia	1
Lytechinus variegatus	1
Polynices duplicatus	1

Site I Trawl 3 01/19/93 — 2335 27°37.82'N 82°48.78'W; 2355 27°36.93'N 82°48.72'W

Species	Number
Mellita tenuis	226
Portunus gibbesii	88
Penaeus aztecus	23
Squilla empusa	6
Penaeus duorarum	3
Portunus spinimanus	3
Arenaeus cribrarius	1
Hepatus epheliticus	1
Luidia clathrata	1

Site II Trawl 1 01/20/93 0705 27°15.80'N 82°35.26'W
0720 27°16.55'N 82°35.72'W

Species	**Number**
Lytechinus variegatus	14
Anadara transversa	6
Portunus gibbesii	6
Penaeus aztecus	2
Penaeus duorarum	2
Hepatus pudibundus juvenile	1
Ophioderma cinereum	1
Pagarus impressus	1

Site II Trawl 2 01/20/93 0735 27°16.90'N 82°35.16'W
1950 27°16.00'N 82°34.90'W

Species	**Number**
Penaeus aztecus	4
Penaeus duorarum	4
Ophioderma cinereum	1
Portunus gibbesii	1
Portunus spinimanus	1

Site II Trawl 3 01/20/93 0845 27°17.00'N 82°36.00'W
0905 27°17.80'N 82°36.70'W

Species	**Number**
Anadara transversa	3
Ophioderma cinereum	2
Luidia clathrata	1
Lytechinus variegatus	1

TABLE 3.2-5

Combined species list in order of prevalence and which trawls the species was found in

MMS Cruise 01/19 - 21/93 R/V Suncoaster

Species	**Number**	**Site I** 1	**Site I** 2	**Site I** 3	**Site II** 1	**Site II** 2	**Site II** 3
Mellita tenuis	598		X	X			
Portunus gibbesii	269	X	X	X	X	X	
Penaeus aztecus	52	X	X	X	X	X	
Squilla empusa	25	X	X	X			
Penaeus duorarum	21	X		X	X	X	
Lytechinus variegatus	16		X		X		X
Anadara transversa	9				X		X
Portunus spinimanus	9	X	X	X		X	
Arenaeus cribrarius	4	X	X	X			
Luidia clathrata	4	X		X			X
Ophioderma cinereum	4				X	X	X
Persephona punctata aquilonaris	2		X				
Calappa flammea	1		X				
Hepatus epheliticus	1			X			
Hepatus pudibundus juvenile	1				X		
Holothuria princeps	1		X				
Libinia dubia	1		X				
Pagarus impressus	1				X		
Polynices duplicatus	1		X				

TABLE 3.2-6

Species List for Trawls Made on MMS Cruise 09/08–09/93 R/V Suncoaster

Site I Trawl 1 | 09/08/93 | 2239 27°37.53'N 82°49.51'W
2259 27°38.20'N 82°48.48'W

Species	Number
Portunus gibbesii	339
Penaeus duorarum	57
Portunus spinimanus	25
Arenaeus cribrarius	12
Squilla empusa	3
Luidia clathrata	2
Callinectes sapidus	1

Site I Trawl 2 | 09/08/93 | 2321 27°38.02'N 82°48.00'W
2343 27°37.14'N 82°46.68'W

Species	Number
Portunus gibbesii	207
Penaeus duorarum	30
Arenaeus cribrarius	23
Mellita tenuis	21
Portunus spinimanus	15
Squilla empusa	5
Callinectes sapidus	1

Site I Trawl 3 | 09/09/93 | 0038 27°38.09'N 82°47.87'W
0058 27°37.24'N 82°48.43'W

Species	Number
Portunus gibbesii	122
Penaeus duorarum	21
Luidia clathrata	12
Mellita tenuis	10
Portunus spinimanus	9
Arenaeus cribrarius	8
Squilla empusa	3
Astropecten duplicatus	1
Callinectes sapidus	1
Menippe mercenaria	1

Site IV Trawl 1 09/09/93 0812 27°26.18'N 82°41.87'W
0821 27°26.07'N 82°42.07'W

Species	Number
Portunus spinimanus	5
Arenaeus cribrarius	4
Portunus gibbesii	3
Callinectes similis	1
Luidia clathrata	1

Site IV Trawl 2 09/09/93 0834 27°26.06'N 82°41.95'W
0839 27°26.11'N 82°41.86'W

Species	Number
Portunus gibbesii	2
Synaptula hydriformis	2
Astropecten duplicatus	1
Botrylloides sp.	1
Callinectes sapidus	1
Callinectes similis	1
Mellita tenuis	1

Site IV Trawl 3 09/09/93 0922 27°25.80'N 82°41.54'W
0933 27°25.70'N 82°41.96'W

Species	Number
Mellita tenuis	359
Luidia clathrata	1
Panopeus herbstii juvenile	1
Portunus gibbesii	1

TABLE 3.2-7

Combined species list in order of prevalence and which trawls the species was found in

MMS Cruise 09/08 - 09/93 R/V Suncoaster

Species	Number	Site I 1	Site I 2	Site I 3	Site IV 1	Site IV 2	Site IV 3
Portunus gibbesii	674	X	X	X	X	X	X
Mellita tenuis	391		X	X		X	X
Penaeus duorarum	108	X	X	X			
Portunus spinimanus	54	X	X	X	X		
Arenaeus cribrarius	47	X	X	X	X		
Luidia clathrata	16	X		X	X		X
Squilla empusa	11	X	X	X			
Callinectes sapidus	4	X	X	X		X	
Astropecten duplicatus	2			X		X	
Callinectes similis	2				X	X	
Synaptula hydriformis	2					X	
Botrylloides sp.	1					X	
Menippe mercenaria	1			X			
Panopeus herbstii juvenile	1						X

TABLE 3.2-8

Species List for Trawls Made on MMS Cruise 05/24–25/94 R/V Suncoaster

Site I Trawl 1 05/25/94 — 0702 27°38.00'N 82°47.00'W; 0735 27°38.98'N 82°47.35'W

Species	Number
Portunus gibbesii	10

Site I Trawl 2 05/25/94 — 0807 27°37.59'N 82°47.40'W; 0829 27°37.41'N 82°48.23'W

Species	Number
Mellita tenuis	21
Portunus gibbesii	6
Luidia clathrata	1

Site I Trawl 3 05/25/94 — 0846 27°37.87'N 82°47.68'W; 0903 27°37.19'N 82°47.58'W

Species	Number
Mellita tenuis	50

Site II Trawl 1 05/24/94 — 2243 27°16.15'N 82°34.25'W; 2301 27°16.58'N 82°34.45'W

Species	Number
Arenaeus cribrarius	2
Argopecten gibbus	1
Hepatus epheliticus	1
Lytechinus variegatus	1
Menippe mercenaria juvenile	1

Site II Trawl 2 05/24/94 — 2330 27°17.00'N 82°34.20'W; 2350 27°16.32'N 82°33.87'W

Species	Number
Callinectes sapidus	1

Site II Trawl 3 05/25/94 — 0035 27°17.135'N 82°36.085'W; 0055 27°16.15'N 82°34.92'W

Species	Number
NOTHING	

TABLE 3.2-9

Combined species list in order of prevalence and which trawls the species was found in

MMS Cruise 05/24 - 25/94 R/V Suncoaster

		Site I			Site II		
Species	**Number**	1	2	3	1	2	3
Mellita tenuis	71		X	X			
Portunus gibbesii	16	X	X				
Arenaeus cribrarius	2				X		
Argopecten gibbus	1				X		
Callinectes sapidus	1					X	
Hepatus epheliticus	1				X		
Luidia clathrata	1		X				
Lytechinus variegatus	1				X		
Menippe mercenaria juvenile	1				X		

The smallest number of epibenthic species and the smallest number of individuals were collected on the last cruise in May, 1994 (Table 3.2-8 and 9). This probably reflects seasonal changes and not a result of dredging since on this date only Sites I and II were sampled and only Site I had been dredged.

Underwater Video

Underwater video was recorded over each transect at each location for each sampling cruise. This represents a total of approximately 120 hours of video recorded during the course of the study. There was little variability observed between locations or between sampling dates.

Observations of flora and fauna were rare. The flora observed was unattached, drifting macroalgae and not seagrass. Occasional worm tubes belonging to the infaunal species, *Diopatra cuprea*, were observed protruding above the sediment and an occasional portunid crab was observed swimming away from the light. These observations reflect the constancy of this very dynamic sand habitat and the low epibenthic diversity of the area.

3.3 INFAUNAL COMMUNITY RESULTS

Stewart-Oaten *et al.* (1986) described a rationale for the evaluation of environmental impact assessment based upon the magnitude of variation between control and affected areas before and after impact. Description of the environment to be affected must include estimates of the variances of the sample means of the relevant variables, for it is only against this variation that impacts can be detected (Underwood, 1992).

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The level of natural variation in species composition and faunal abundance can serve as a measure of stress in marine communities. Warwick and Clarke (1993) examined variability in species diversity (H') and species abundances for meiobenthos, macrobenthos, coral reefs and reef fish. A clear log-log relationship was found between the variance and the mean abundance for all species. The slope of the log-log regression increased significantly between control and impacted sites. Additionally, the variability in macrobenthic species diversity (H') tended to increase with increasing levels of perturbation.

Overall results are presented and discussed first on an areawide basis prior to dredging and second, on a site by site basis according to site specific dredging schedules. Each site had its own dredging design and schedule. As it turned out, Egmont Key was dredged in the Fall of 1992 and Longboat Key was dredged in the Summer of 1993. Both the Sarasota and Manasota Key sites were not dredged during the time frame of this study. A comparison of community parameters among sites prior to dredging will also be presented.

Species saturation curves are generally constructed to determine the appropriate number of replicate samples for any given benthic study. This analysis considers the number of new species added to the total number of species with each additional replicate sample collected. After a certain number of samples, the contribution of new taxa to total taxa drops off. When the percent of new taxa falls below some predetermined number (generally 5%) then a sufficient number of replicates have been collected to describe faunal composition. A species saturation curve for the present study is shown in Figure 3.3-1.

Total number of taxa and individuals (and percent of total taxa and individuals) for each major faunal group are presented in Table 3.3-1. A total of 620 taxa and 52,295 individuals were identified during the study. Annelids (segmented worms) contributed 44 and 49 percent of the taxa and individuals, respectively. Molluscan fauna represented 22% of the taxa and 29% of the total fauna, while arthropods comprised 27% of the taxa and 11% of the individuals. These three taxonomic groups represented 93% of the taxa and 89% of all fauna.

Pre-Dredging Faunal Community Conditions

Three of the four study sites were sampled in July, 1992, prior to the commencement of any dredging activity. These three sites were: Egmont Key, Sarasota, and Manasota Key. This section summarizes spatial patterns in community parameters among all sites in order to describe the general conditions of the benthic faunal communities prior to dredging.

A statistical summary of faunal parameters for all stations sampled in July, 1992 is presented as part of Table 3.3-2. Manasota Key had the highest mean number of taxa per station (142 ± 29 taxa), followed by Sarasota (101 ± 9) and Egmont Key (77 ± 26). The difference in number of taxa between Manasota Key and Egmont Key was statistically significant ($p < 0.05$). Manasota Key also had the highest mean number of individuals per square meter (3635 ± 1175). Sarasota and Egmont Key had similar faunal abundance, with mean numbers of individuals per square meter of 1832 ± 812 and 2296 ± 1030, respectively. None of the differences in mean number of individuals per square meter were statistically different ($p = 0.05$).

Manasota Key had the highest species diversity (Shannon Index) among the three stations (3.67), followed by Sarasota (3.19) and Egmont Key (2.47). There was a statistically significant difference ($p < 0.05$) in Shannon Index between Manasota Key and Egmont Key. Equitability (a measure of the evenness of species distribution) was highest at Manasota Key (0.743 ± 0.12), followed by Sarasota (0.697 ± 0.09) and Egmont Key (0.573 ± 0.12). There were no statistical differences in equitability among stations. Usually, a positive relationship exists between diversity and equitability i.e., a high equitability would indicate a high diversity and probably a "healthy condition" of the fauna. This was evident among all stations during July 1992, where there was a

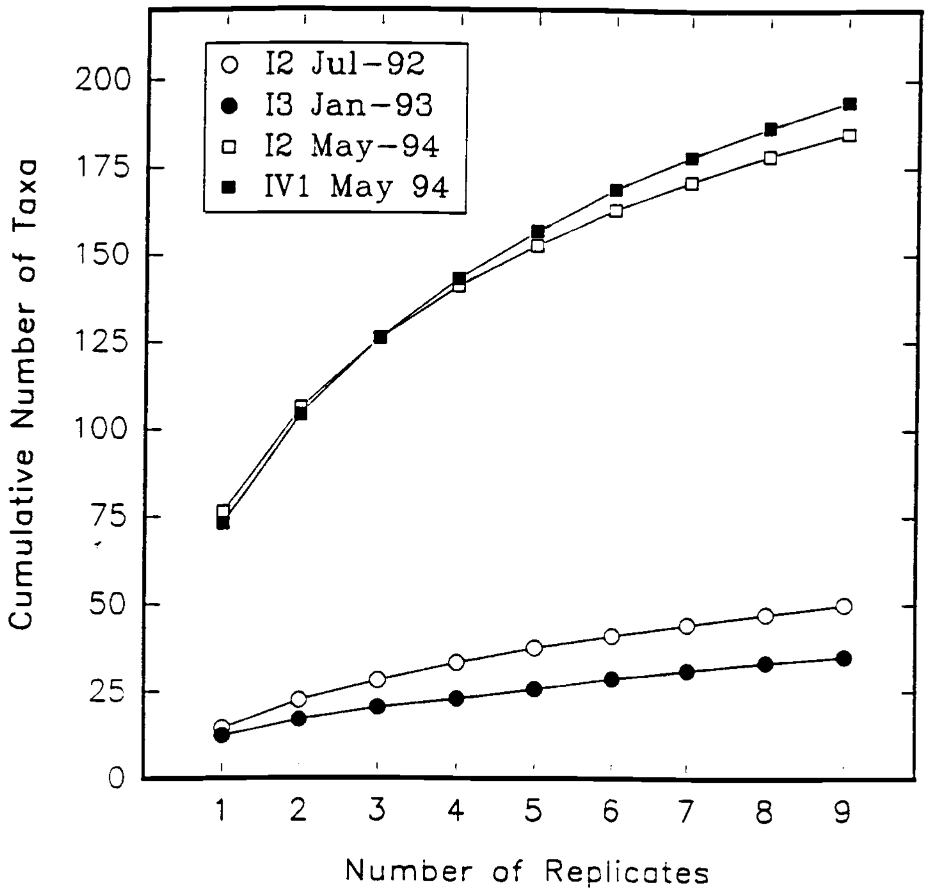

Figure 3.3-1. Species saturation curves for four station-data combinations.

Table 3.3-1. Total number of taxa and individuals (and percent of total taxa and individuals) for each major faunal group.

Station:	All	Total Taxa	620
Date:	All	Total Indivduals	52295

Faunal Group	Number of Taxa	Percent of Taxa	Number of Individuals	Percent of Individuals
NEMERTEA	7	1.13	1911	3.65
ANNELIDA-Total	271	43.71	25379	48.53
Polychaeta	267	43.06	21727	41.55
Oligochaeta	2	.32	3630	6.94
Misc. Annelids	2	.32	22	.04
MOLLUSCA-Total	135	21.77	15078	28.83
Gastropoda	66	10.65	3679	7.04
Bivalvia	65	10.48	11394	21.79
Misc. Molluscs	4	.65	5	.01
ARTHROPODA-Total	169	27.26	5992	11.46
Mysidacea	5	.81	27	.05
Cumacea	9	1.45	620	1.19
Tanaidacea	6	.97	52	.10
Isopoda	13	2.10	175	.33
Amphipoda	78	12.58	3441	6.58
Decapoda	52	8.39	1667	3.19
Insecta	2	.32	5	.01
Misc Arthropods	4	.65	5	.01
ECHINODERMATA	21	3.39	939	1.80
HEMICHORDATA	2	.32	87	.17
VERTEBRATA	1	.16	5	.01
MISCELLANEOUS	14	2.26	2904	5.55
TOTAL	620	100.00	52295	100.00

Table 3.3-2. Benthic fauna parameters: Statistical summary for each station and date.

Date	Station	No. of Taxa	Number of Individuals	Individuals per m2	Shannon logE	Shannon log10	Shannon log2	Pielou	Margalef	Simpson	Gin
Jul-92	IC	99	1830	3129	3.14	1.36	4.53	.68	13.05	.082	.91
Jul-92	ID	49	670	1145	2.33	1.01	3.36	.60	7.38	.184	.81
Jul-92	ID	84	1529	2614	1.94	.84	2.80	.44	11.32	.415	.58
Jul-92	IID	92	588	1005	3.56	1.55	5.14	.79	14.27	.053	.94
Jul-92	IID	101	1537	2628	2.84	1.23	4.10	.62	13.63	.186	.81
Jul-92	IIC	110	1090	1863	3.18	1.38	4.58	.68	15.58	.147	.85
Jul-92	IIID	121	1336	2284	3.65	1.59	5.27	.76	16.67	.056	.94
Jul-92	IIIC	176	2458	4202	4.02	1.75	5.80	.78	22.42	.031	.96
Jul-92	IIID	131	2585	4419	3.34	1.45	4.82	.69	16.54	.068	.93
Jan-93	IC	94	1553	2655	3.07	1.33	4.42	.67	12.66	.094	.90
Jan-93	ID	109	1170	2000	3.12	1.36	4.51	.67	15.29	.132	.86
Jan-93	ID	35	558	954	1.98	.86	2.86	.56	5.38	.294	.70
Jan-93	IID	166	1233	2108	4.45	1.93	6.42	.87	23.18	.017	.98
Jan-93	IID	114	1516	2592	3.56	1.55	5.14	.75	15.43	.055	.94
Jan-93	IIC	131	1433	2450	3.98	1.73	5.74	.82	17.89	.030	.97
Sep-93	IC	120	3249	5555	3.13	1.36	4.52	.65	14.72	.084	.91
Sep-93	ID	142	1547	2645	3.59	1.56	5.18	.72	19.20	.067	.93
Sep-93	ID	62	453	774	3.02	1.31	4.35	.73	9.97	.090	.91
Sep-93	IVD	100	726	1241	3.78	1.64	5.46	.82	15.03	.038	.96
Oct-93	IVD	91	3730	6377	2.43	1.06	3.50	.54	10.94	.191	.80
Oct-93	IVC	98	1200	2052	3.43	1.49	4.94	.75	13.68	.059	.94
May-94	IC	124	3600	6155	3.19	1.39	4.61	.66	15.02	.082	.91
May-94	ID	184	4347	7432	3.72	1.62	5.37	.71	21.84	.052	.94
May-94	ID	81	2359	4033	1.69	.73	2.44	.38	10.30	.485	.51
May-94	IID	193	3517	6013	3.60	1.56	5.20	.68	23.51	.081	.91
May-94	IID	159	3582	6124	3.66	1.59	5.28	.72	19.31	.053	.94
May-94	IIC	133	2899	4956	3.51	1.53	5.07	.72	16.56	.059	.94

significant positive relationship ($p < 0.001$; $r = 0.953$) between species diversity and equitability (Figure 3.3-2).

A breakdown of individuals into major faunal groups (phyla) is presented in Table 3.3-3. The major groups are further subdivided phylogenetically into classes and orders. The percent of individuals in each major faunal group is presented in Table 3.3-4. Annelids comprised approximately 50% of the total fauna at all sites. At two stations (one Sarasota and one Manasota Key), oligochaetes contributed over 10% of the total fauna. The contribution by molluscs varied greatly within and between sites. Molluscs varied from 14 individuals (2.1 %) at one Egmont Key station to 1125 individuals (73.6%) at another Egmont Key station. This fluctuation in molluscan fauna was due to differences in the distribution of the bivalve, *Parvilucina multilineata*. Gastropods were slightly more abundant at Manasota Key with respect to the other two sites. Arthropods were consistent in abundance at all sites, contributing between five and ten percent of the total fauna. Amphipods and decapods were the most abundant arthropods. Echinoderms were rare at Egmont Key, while they represented one to three percent of the fauna at Sarasota and Manasota Key. Finally, miscellaneous taxa, dominated by the lancelet *Branchiostomma*, showed high variability within each site, ranging from 0.2 to 17.8% of the fauna at any given station.

The composition of fauna during pre-dredging sampling shows slight differences among stations in dominant taxa (Table 3.3-5). A composite species list for all stations can be found in Appendix C. Tubificid oligochaetes were the dominant taxon at Manasota Key, followed by the lancelet *Branchiostomma* sp. and the polychaete *Prionospio cristata*. The bivalve, *Parvilucina multilineata*, was dominant at Egmont Key and Sarasota during this period. Other differences in species composition among the three stations include: higher relative abundance of the polychaete *Aglaophamus verrilli* at Sarasota and Manasota Key; higher relative abundance of *Mooreonuphis nebulosa*, *Isolda pulchella*, *Goniadides carolinae*, and *Aricidea* cf. *suecica* (polychaetes), *Anadara transversa* (bivalve), at Manasota Key; and a high percentage of the gastropod *Ceacum bipartitum* at Egmont Key (Table 3.3-6). Biomass for the major faunal groups is shown in Table 3.3-7.

Overall, faunal richness and abundance at each of the three borrow sites indicate healthy, diverse infaunal communities along the west Florida coastal zone.

Egmont Key

Egmont Key was sampled four times during this study. This included a pre-dredging sampling (July, 1992), one sampling during dredging activities (January, 1993) and two post-dredging sampling events (September, 1993 and May, 1994, respectively). This section discusses the temporal trends in faunal community response to dredging at Egmont Key. It will also look at differences over time among the two dredged and one control stations as determined by two-way analysis of variance.

Site IV Trawl 1 09/09/93 0812 27°26.18'N 82°41.87'W
0821 27°26.07'N 82°42.07'W

Species	Number
Portunus spinimanus	5
Arenaeus cribrarius	4
Portunus gibbesii	3
Callinectes similis	1
Luidia clathrata	1

Site IV Trawl 2 09/09/93 0834 27°26.06'N 82°41.95'W
0839 27°26.11'N 82°41.86'W

Species	Number
Portunus gibbesii	2
Synaptula hydriformis	2
Astropecten duplicatus	1
Botrylloides sp.	1
Callinectes sapidus	1
Callinectes similis	1
Mellita tenuis	1

Site IV Trawl 3 09/09/93 0922 27°25.80'N 82°41.54'W
0933 27°25.70'N 82°41.96'W

Species	Number
Mellita tenuis	359
Luidia clathrata	1
Panopeus herbstii juvenile	1
Portunus gibbesii	1

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Combined species list in order of prevalence and which trawls the species was found in

MMS Cruise 09/08 - 09/93 R/V Suncoaster

Species	Number	Site I 1	Site I 2	Site I 3	Site IV 1	Site IV 2	Site IV 3
Portunus gibbesii	674	X	X	X	X	X	X
Mellita tenuis	391		X	X		X	X
Penaeus duorarum	108	X	X	X			
Portunus spinimanus	54	X	X	X	X		
Arenaeus cribrarius	47	X	X	X	X		
Luidia clathrata	16	X		X	X		X
Squilla empusa	11	X	X	X			
Callinectes sapidus	4	X	X	X		X	
Astropecten duplicatus	2			X		X	
Callinectes similis	2				X	X	
Synaptula hydriformis	2					X	
Botrylloides sp.	1					X	
Menippe mercenaria	1			X			
Panopeus herbstii juvenile	1						X

TABLE 3.2-8

Species List for Trawls Made on MMS Cruise 05/24–25/94 R/V Suncoaster

Site I Trawl 1 05/25/94 0702 27°38.00'N 82°47.00'W
0735 27°38.98'N 82°47.35'W

Species	Number
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Species	Number
NOTHING	

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		Site I			**Site II**		
Species	**Number**	**1**	**2**	**3**	**1**	**2**	**3**
Mellita tenuis	71		X	X			
Portunus gibbesii	16	X	X				
Arenaeus cribrarius	2				X		
Argopecten gibbus	1				X		
Callinectes sapidus	1					X	
Hepatus epheliticus	1				X		
Luidia clathrata	1		X				
Lytechinus variegatus	1				X		
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The smallest number of epibenthic species and the smallest number of individuals were collected on the last cruise in May, 1994 (Table 3.2-8 and 9). This probably reflects seasonal changes and not a result of dredging since on this date only Sites I and II were sampled and only Site I had been dredged.

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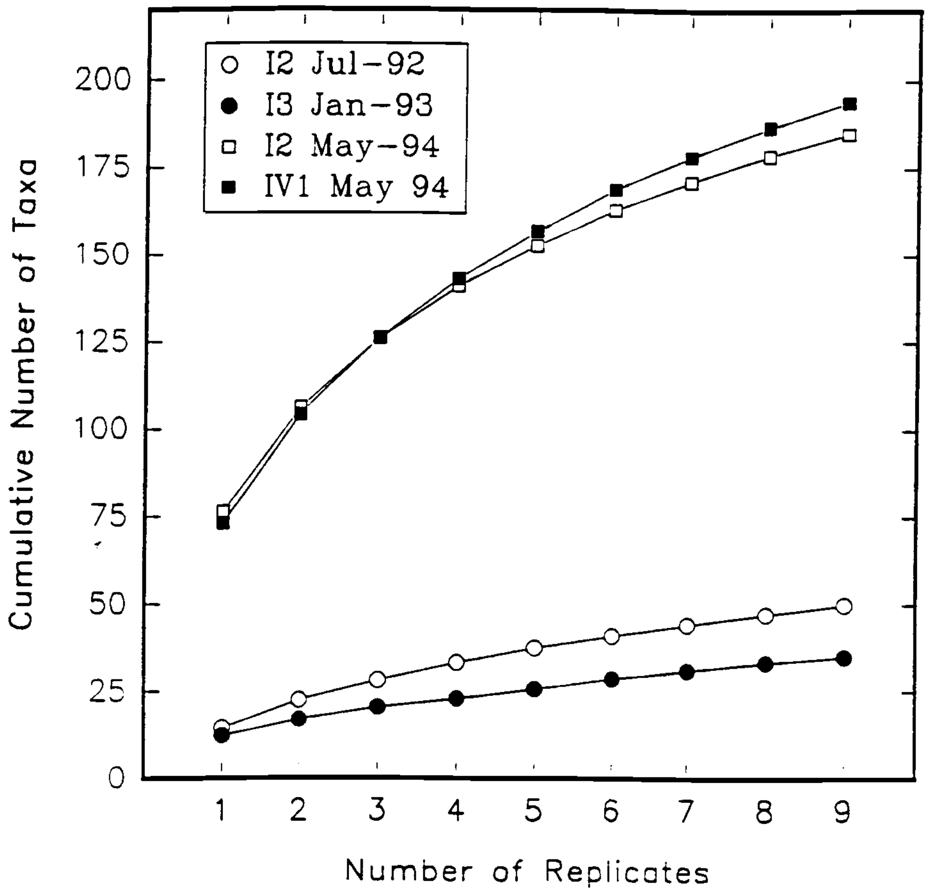

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Date: All Total Indivduals 52295

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Decapoda	52	8.39	1667	3.19
Insecta	2	.32	5	.01
Misc Arthropods	4	.65	5	.01
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HEMICHORDATA	2	.32	87	.17
VERTEBRATA	1	.16	5	.01
MISCELLANEOUS	14	2.26	2904	5.55
TOTAL	620	100.00	52295	100.00

Table 3.3-2. Benthic fauna parameters: Statistical summary for each station and date.

Date	Station	No. of Taxa	Number of Individuals	Individuals per m2	Shannon logE	Shannon log10	Shannon log2	Pielou	Margalef	Simpson	Gin
Jul-92	IC	99	1830	3129	3.14	1.36	4.53	.68	13.05	.082	.91
Jul-92	ID	49	670	1145	2.33	1.01	3.36	.60	7.38	.184	.81
Jul-92	ID	84	1529	2614	1.94	.84	2.80	.44	11.32	.415	.58
Jul-92	IID	92	588	1005	3.56	1.55	5.14	.79	14.27	.053	.94
Jul-92	IID	101	1537	2628	2.84	1.23	4.10	.62	13.63	.186	.81
Jul-92	IIC	110	1090	1863	3.18	1.38	4.58	.68	15.58	.147	.85
Jul-92	IIID	121	1336	2284	3.65	1.59	5.27	.76	16.67	.056	.94
Jul-92	IIIC	176	2458	4202	4.02	1.75	5.80	.78	22.42	.031	.96
Jul-92	IIID	131	2585	4419	3.34	1.45	4.82	.69	16.54	.068	.93
Jan-93	IC	94	1553	2655	3.07	1.33	4.42	.67	12.66	.094	.90
Jan-93	ID	109	1170	2000	3.12	1.36	4.51	.67	15.29	.132	.86
Jan-93	ID	35	558	954	1.98	.86	2.86	.56	5.38	.294	.70
Jan-93	IID	166	1233	2108	4.45	1.93	6.42	.87	23.18	.017	.98
Jan-93	IID	114	1516	2592	3.56	1.55	5.14	.75	15.43	.055	.94
Jan-93	IIC	131	1433	2450	3.98	1.73	5.74	.82	17.89	.030	.97
Sep-93	IC	120	3249	5555	3.13	1.36	4.52	.65	14.72	.084	.91
Sep-93	ID	142	1547	2645	3.59	1.56	5.18	.72	19.20	.067	.93
Sep-93	ID	62	453	774	3.02	1.31	4.35	.73	9.97	.090	.91
Sep-93	IVD	100	726	1241	3.78	1.64	5.46	.82	15.03	.038	.96
Oct-93	IVD	91	3730	6377	2.43	1.06	3.50	.54	10.94	.191	.80
Oct-93	IVC	98	1200	2052	3.43	1.49	4.94	.75	13.68	.059	.94
May-94	IC	124	3600	6155	3.19	1.39	4.61	.66	15.02	.082	.91
May-94	ID	184	4347	7432	3.72	1.62	5.37	.71	21.84	.052	.94
May-94	ID	81	2359	4033	1.69	.73	2.44	.38	10.30	.485	.51
May-94	IID	193	3517	6013	3.60	1.56	5.20	.68	23.51	.081	.91
May-94	IID	159	3582	6124	3.66	1.59	5.28	.72	19.31	.053	.94
May-94	IIC	133	2899	4956	3.51	1.53	5.07	.72	16.56	.059	.94

significant positive relationship ($p < 0.001$; $r = 0.953$) between species diversity and equitability (Figure 3.3-2).

A breakdown of individuals into major faunal groups (phyla) is presented in Table 3.3-3. The major groups are further subdivided phylogenetically into classes and orders. The percent of individuals in each major faunal group is presented in Table 3.3-4. Annelids comprised approximately 50% of the total fauna at all sites. At two stations (one Sarasota and one Manasota Key), oligochaetes contributed over 10% of the total fauna. The contribution by molluscs varied greatly within and between sites. Molluscs varied from 14 individuals (2.1 %) at one Egmont Key station to 1125 individuals (73.6%) at another Egmont Key station. This fluctuation in molluscan fauna was due to differences in the distribution of the bivalve, *Parvilucina multilineata*. Gastropods were slightly more abundant at Manasota Key with respect to the other two sites. Arthropods were consistent in abundance at all sites, contributing between five and ten percent of the total fauna. Amphipods and decapods were the most abundant arthropods. Echinoderms were rare at Egmont Key, while they represented one to three percent of the fauna at Sarasota and Manasota Key. Finally, miscellaneous taxa, dominated by the lancelet *Branchiostomma*, showed high variability within each site, ranging from 0.2 to 17.8% of the fauna at any given station.

The composition of fauna during pre-dredging sampling shows slight differences among stations in dominant taxa (Table 3.3-5). A composite species list for all stations can be found in Appendix C. Tubificid oligochaetes were the dominant taxon at Manasota Key, followed by the lancelet *Branchiostomma* sp. and the polychaete *Prionospio cristata*. The bivalve, *Parvilucina multilineata*, was dominant at Egmont Key and Sarasota during this period. Other differences in species composition among the three stations include: higher relative abundance of the polychaete *Aglaophamus verrilli* at Sarasota and Manasota Key; higher relative abundance of *Mooreonuphis nebulosa*, *Isolda pulchella*, *Goniadides carolinae*, and *Aricidea* cf. *suecica* (polychaetes), *Anadara transversa* (bivalve), at Manasota Key; and a high percentage of the gastropod *Ceacum bipartitum* at Egmont Key (Table 3.3-6). Biomass for the major faunal groups is shown in Table 3.3-7.

Overall, faunal richness and abundance at each of the three borrow sites indicate healthy, diverse infaunal communities along the west Florida coastal zone.

Egmont Key

Egmont Key was sampled four times during this study. This included a pre-dredging sampling (July, 1992), one sampling during dredging activities (January, 1993) and two post-dredging sampling events (September, 1993 and May, 1994, respectively). This section discusses the temporal trends in faunal community response to dredging at Egmont Key. It will also look at differences over time among the two dredged and one control stations as determined by two-way analysis of variance.

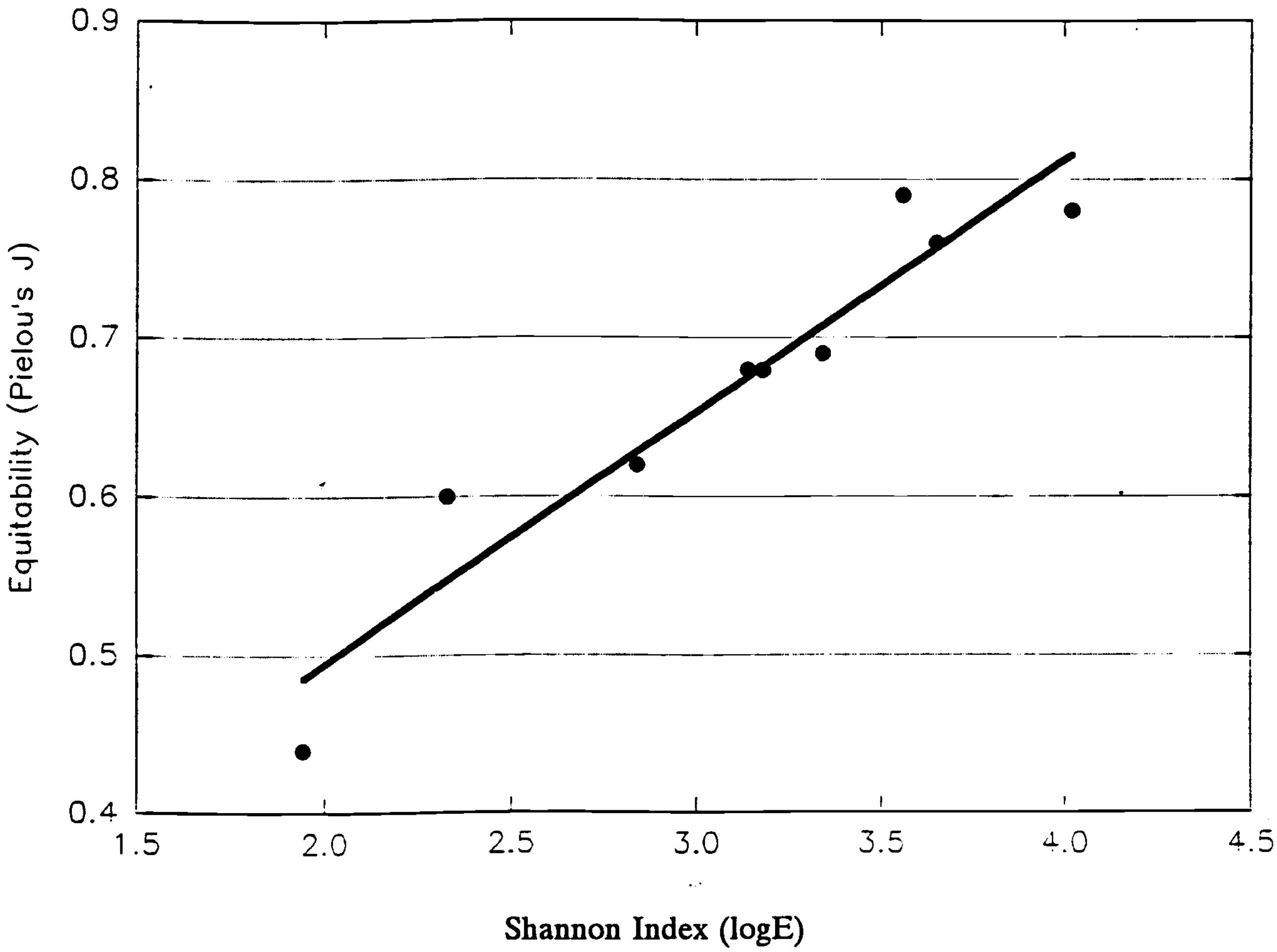


Figure 3.3-2. Linear regression of equitability (Pielou's J) and Shannon Index for all stations during July, 1992 ($p<0.001$, $r=0.953$).

Table 3.3-3. Total number of individuals in each major faunal group for each station and date.

Faunal Group	IC Jul-92	ID Jul-92	ID Jul-92	IID Jul-92	IID Jul-92	IIC Jul-92	IIID Jul-92	IIIC Jul-92	IIID Jul-92	IC Jan-93	ID Jan-93	ID Jan-93	IID Jan-93	IID Jan-93	IIC Jan-93	IC Sep-93	ID Sep-93	ID Sep-93	IVD Sep-93	IVD Oct-93	IVC Oct-93	IC May-94	ID May-94	ID May-94	IID May-94	IID May-94	IIC May-94
NEMERTEA	89	1	23	1	47	31	11	33	4	166	71	20	21	62	47	201	92	66	42	17	54	114	133	98	76	254	137
ANNELIDA-Total	1080	470	316	366	539	427	899	1407	1056	787	483	55	710	668	727	2083	948	104	323	446	320	2131	2446	226	2594	1805	1963
Polychaeta	886	468	314	282	514	420	647	1285	962	456	354	55	710	668	727	1841	634	96	320	446	320	1878	1769	216	1745	1796	1918
Oligochaeta	194	0	2	83	25	7	252	122	91	331	127	0	0	0	0	242	305	8	3	0	0	253	677	10	845	9	44
Misc. Annelids	0	2	0	1	0	0	0	0	3	0	2	0	0	0	0	0	9	0	0	0	0	0	0	0	4	0	1
MOLLUSCA-Total	599	14	1125	51	837	488	241	880	661	551	465	360	195	472	373	513	280	176	148	775	234	1179	1077	1779	341	895	369
Gastropoda	308	7	46	8	79	13	100	100	483	107	1	4	16	3	15	20	39	15	97	512	67	418	113	122	36	702	248
Bivalvia	290	7	1079	42	758	475	141	779	177	444	464	356	178	469	358	493	241	161	51	263	167	761	964	1657	305	193	121
Misc. Molluscs	1	0	0	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ARTHROPODA-Total	52	74	61	52	89	127	70	108	317	43	121	76	257	278	245	426	137	83	172	950	351	161	589	142	381	347	283
Mysidacea	1	0	0	0	1	0	2	1	1	0	1	0	1	0	0	11	1	1	0	0	0	0	1	1	2	1	1
Cumacea	2	18	20	0	24	15	4	19	30	28	39	3	17	43	10	173	11	3	3	12	9	17	87	2	7	6	18
Tanaidacea	0	0	0	0	0	0	0	1	0	0	3	0	15	0	1	0	3	0	1	0	0	5	4	0	11	3	5
Isopoda	1	26	0	1	11	8	2	3	15	1	1	1	1	10	2	5	10	1	5	34	16	9	1	1	10	0	0
Amphipoda	16	17	16	15	45	54	32	32	166	13	77	72	190	217	193	213	82	69	25	822	263	90	363	45	161	96	57
Decapoda	32	13	25	35	8	50	30	51	103	1	0	0	33	8	39	22	29	9	138	82	63	40	133	93	187	241	202
Insecta	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0

0

Misc Arthropods	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0
ECHINODERMATA	2	0	1	22	11	10	20	20	88	2	8	8	16	3	3	2	41	1	21	44	118	6	22	88	50	202	130
HEMICHORDATA	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	0	5	3	1	0	0	6	0	66	2
VERTEBRATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2
MISCELLANEOUS	8	111	3	96	14	7	95	10	459	4	22	39	34	31	37	23	49	23	15	1495	122	9	80	20	75	10	13
TOTAL	1830	670	1529	588	1537	1090	1336	2458	2585	1553	1170	558	1233	1516	1433	3249	1547	453	726	3730	1200	3600	4347	2359	3517	3582	2899

Table 3.3-4. Percent of individuals in each major faunal group for each station and date.

Faunal Group	IC Jul -92	ID Jul -92	ID Jul -92	IID Jul -92	IID Jul -92	IIC Jul -92	III D Jul -92	III C Jul -92	III D Jul -92	IC Jan -93	ID Jan -93	ID Jan -93	IID Jan -93	IID Jan -93	IIC Jan -93	IC Sep -93	ID Sep -93	ID Sep -93	IVD Sep -93	IVD Oct -93	IVC Oct -93	IC May -94	ID May -94	ID May -94	IID May -94	IID May -94	IIC May -94
NEMERTEA	4.9	.1	1.5	.2	3.1	2.8	.8	1.3	.2	10.7	6.1	3.6	1.7	4.1	3.3	6.2	5.9	14.6	5.8	.5	4.5	3.2	3.1	4.2	2.2	7.1	4.7
ANNELIDA-Total	59.0	70.1	20.7	62.2	35.1	39.2	67.3	57.2	40.9	50.7	41.3	9.9	57.6	44.1	50.7	64.1	61.3	23.0	44.5	12.0	26.7	59.2	56.3	9.6	73.8	50.4	67.7
Polychaeta	48.4	69.9	20.5	48.0	33.4	38.5	48.4	52.3	37.2	29.4	30.3	9.9	57.6	44.1	50.7	56.7	41.0	21.2	44.1	12.0	26.7	52.2	40.7	9.2	49.6	50.1	66.2
Oligochaeta	10.6	.0	.1	14.1	1.6	.6	18.9	5.0	3.5	21.3	10.9	.0	.0	.0	.0	7.4	19.7	1.8	.4	.0	.0	7.0	15.6	.4	24.0	.3	1.5
Misc. Annelids	.0	.3	.0	.2	.0	.0	.0	.0	.1	.0	.2	.0	.0	.0	.0	.0	.6	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0
MOLLUSCA-Total	32.7	2.1	73.6	8.7	54.5	44.8	18.0	35.8	25.6	35.5	39.7	64.5	15.8	31.1	26.0	15.8	18.1	38.9	20.4	20.8	19.5	32.8	24.8	75.4	9.7	25.0	12.7
Gastropoda	16.8	1.0	3.0	1.4	5.1	1.2	7.5	4.1	18.7	6.9	.1	.7	1.3	.2	1.0	.6	2.5	3.3	13.4	13.7	5.6	11.6	2.6	5.2	1.0	19.6	8.6
Bivalvia	15.8	1.0	70.6	7.1	49.3	43.6	10.6	31.7	6.8	28.6	39.7	63.8	14.4	30.9	25.0	15.2	15.6	35.5	7.0	7.1	13.9	21.1	22.2	70.2	8.7	5.4	4.2
Misc. Molluscs	.1	.0	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
ARTHROPODA-Total	2.8	11.0	4.0	8.8	5.8	11.7	5.2	4.4	12.3	2.8	10.3	13.6	20.8	18.3	17.1	13.1	8.9	18.3	23.7	25.5	29.3	4.5	13.5	6.0	10.8	9.7	9.8
Mysidacea	.1	.0	.0	.0	.1	.0	.1	.0	.0	.0	.1	.0	.1	.0	.0	.3	.1	.2	.0	.0	.0	.0	.0	.0	.1	.0	.0
Cumacea	.1	2.7	1.3	.0	1.6	1.4	.3	.8	1.2	1.8	3.3	.5	1.4	2.8	.7	5.3	.7	.7	.4	.3	.8	.5	2.0	.1	.2	.2	.6
Tanaidacea	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.3	.0	1.2	.0	.1	.0	.2	.0	.1	.0	.0	.1	.1	.0	.3	.1	.2
Isopoda	.1	3.9	.0	.2	.7	.7	.1	.1	.6	.1	.1	.2	.1	.7	.1	.2	.6	.2	.7	.9	1.3	.3	.0	.0	.3	.0	.0
Amphipoda	.9	2.5	1.0	2.6	2.9	5.0	2.4	1.3	6.4	.8	6.6	12.9	15.4	14.3	13.5	6.6	5.3	15.2	3.4	22.0	21.9	2.5	8.4	1.9	4.6	2.7	2.0
Decapoda	1.7	1.9	1.6	6.0	.5	4.6	2.2	2.1	4.0	.1	.0	.0	2.7	.5	2.7	.7	1.9	2.0	19.0	2.2	5.3	1.1	3.1	3.9	5.3	6.7	7.0
Insecta	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.0	.0
Misc Arthropods	.0	.0	.0	.2	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
ECHINODERMATA	.1	.0	.1	3.7	.7	.9	1.5	.8	3.4	.1	.7	1.4	1.3	.2	.2	.1	2.7	.2	2.9	1.2	9.8	.2	.5	3.7	1.4	5.6	4.5

HEMICHORDATA	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.1	.0	.0	.0	.7	.1	.1	.0	.0	.3	.0	1.8	.1
VERTEBRATA	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1	.1
MISCELLANEOUS	.4	16.6	.2	16.3	.9	.6	7.1	.4	17.8	.3	1.9	7.0	2.8	2.0	2.6	.7	3.2	5.1	2.1	40.1	10.2	.3	1.8	.8	2.1	.3	.4
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table 3.3-5. Total number of taxa in each major faunal group for each station and date.

Faunal Group	IC Jul -92	ID Jul -92	ID Jul -92	IID Jul -92	IID Jul -92	IIC Jul -92	III D Jul -92	III C Jul -92	III D Jul -92	IC Jan -93	ID Jan -93	ID Jan -93	IID Jan -93	IID Jan -93	IIC Jan -93	IC Sep -93	ID Sep -93	ID Sep -93	IVD Sep -93	IVD Oct -93	IVC Oct -93	IC May -94	ID May -94	ID May -94	IID May -94	IID May -94	IIC May -94
NEMERTEA	4	1	4	1	4	4	4	4	3	4	4	3	5	3	3	4	4	3	2	2	4	4	4	3	4	4	5
ANNELIDA-Total	54	23	44	49	50	55	62	77	51	45	67	15	81	59	64	61	78	28	48	38	38	60	88	34	107	89	72
Polychaeta	53	22	43	46	48	54	61	75	48	44	65	15	81	59	64	59	75	27	47	38	38	59	87	33	104	87	70
Oligochaeta	1	0	1	2	2	1	1	2	2	1	1	0	0	0	0	2	2	1	1	0	0	1	1	1	2	2	1
Misc. Annelids	0	1	0	1	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1
MOLLUSCA-Total	22	8	20	17	24	20	27	54	34	23	15	7	26	18	26	20	22	12	16	16	13	28	40	20	32	30	19
Gastropoda	13	4	12	5	13	7	15	24	15	10	1	3	10	2	9	7	9	8	9	11	8	15	19	13	13	16	8
Bivalvia	8	4	8	11	11	13	12	29	18	13	14	4	15	16	17	13	13	4	7	5	5	13	21	7	19	14	11
Misc. Molluscs	1	0	0	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ARTHROPODA-Total	16	15	13	19	14	23	19	35	34	16	16	6	43	26	29	28	27	15	25	26	29	25	40	16	41	24	24
Mysidacea	1	0	0	0	1	0	1	1	1	0	1	0	1	0	0	1	1	1	0	0	0	0	1	1	1	1	1
Cumacea	1	2	2	0	2	1	2	3	3	4	4	2	3	4	2	5	3	1	2	5	6	2	3	2	2	2	2
Tanaidacea	0	0	0	0	0	0	0	1	0	0	2	0	2	0	1	0	1	0	1	0	0	1	2	0	3	1	1

Isopoda	1	2	0	1	1	2	2	2	3	1	1	1	1	2	2	4	2	1	2	2	2	3	1	1	2	0	0
Amphipoda	6	8	5	6	7	13	10	11	18	10	8	3	23	14	19	14	11	7	9	10	13	12	17	7	17	14	12
Decapoda	7	3	6	11	3	7	4	16	7	1	0	0	13	6	5	3	8	5	11	9	8	7	16	5	14	6	8
Insecta	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Misc Arthropods	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
ECHINODERMATA	2	0	1	1	3	3	4	1	3	2	2	2	3	1	1	1	6	1	4	3	6	4	6	4	4	6	7
HEMICHORDATA	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	1	1	1	0	0	1	0	1	1
VERTEBRATA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
MISCELLANEOUS	1	2	2	5	6	5	5	5	6	4	5	2	8	6	7	5	5	3	4	5	7	3	6	3	5	4	4
TOTAL	99	49	84	92	101	110	121	176	131	94	109	35	166	114	131	120	142	62	100	91	98	124	184	81	193	159	133

Table 3.3-6. Percent of taxa in each major faunal group for each station and date.

Faunal Group	IC Jul -92	ID Jul -92	ID Jul -92	IID Jul -92	IID Jul -92	IIC Jul -92	IIID Jul -92	IIIC Jul -92	IIID Jul -92	IC Jan -93	ID Jan -93	ID Jan -93	IID Jan -93	IID Jan -93	IIC Jan -93	IC Sep -93	ID Sep -93	ID Sep -93	IVD Sep -93	IVD Oct -93	IVC Oct -93	IC May -94	ID May -94	ID May -94	IID May -94	IID May -94	IIC May -94
NEMERTEA	4.0	2.0	4.8	1.1	4.0	3.6	3.3	2.3	2.3	4.3	3.7	8.6	3.0	2.6	2.3	3.3	2.8	4.8	2.0	2.2	4.1	3.2	2.2	3.7	2.1	2.5	3.8
ANNELIDA-Total	54.5	46.9	52.4	53.3	49.5	50.0	51.2	43.8	38.9	47.9	61.5	42.9	48.8	51.8	48.9	50.8	54.9	45.2	48.0	41.8	38.8	48.4	47.8	42.0	55.4	56.0	54.1
Polychaeta	53.5	44.9	51.2	50.0	47.5	49.1	50.4	42.6	36.6	46.8	59.6	42.9	48.8	51.8	48.9	49.2	52.8	43.5	47.0	41.8	38.8	47.6	47.3	40.7	53.9	54.7	52.6
Oligochaeta	1.0	0.0	1.2	2.2	2.0	0.9	0.8	1.1	1.5	1.1	0.9	0.0	0.0	0.0	0.0	1.7	1.4	1.6	1.0	0.0	0.0	0.8	0.5	1.2	1.0	1.3	0.8
Misc. Annelids	0.0	2.0	0.0	1.1	0.0	0.0	0.0	0.0	0.8	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.8
MOLLUSCA-Total	22.2	16.3	23.8	18.5	23.8	18.2	22.3	30.7	26.0	24.5	13.8	20.0	15.7	15.8	19.8	16.7	15.5	19.4	16.0	17.6	13.3	22.6	21.7	24.7	16.6	18.9	14.3
Gastropoda	13.1	8.2	14.3	5.4	12.9	6.4	12.4	13.6	11.5	10.6	0.9	8.6	6.0	1.8	6.9	5.8	6.3	12.9	9.0	12.1	8.2	12.1	10.3	16.0	6.7	10.1	6.0
Bivalvia	8.1	8.2	9.5	12.0	10.9	11.8	9.9	16.5	13.7	13.8	12.8	11.4	9.0	14.0	13.0	10.8	9.2	6.5	7.0	5.5	5.1	10.5	11.4	8.6	9.8	8.8	8.3
Misc. Molluscs	1.0	0.0	0.0	1.1	0.0	0.0	0.0	0.6	0.8	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ARTHROPODA-Total	16.2	30.6	15.5	20.7	13.9	20.9	15.7	19.9	26.0	17.0	14.7	17.1	25.9	22.8	22.1	23.3	19.0	24.2	25.0	28.6	29.6	20.2	21.7	19.8	21.2	15.1	18.0
Mysidacea	1.0	0.0	0.0	0.0	1.0	0.0	0.8	0.6	0.8	0.0	0.9	0.0	0.6	0.0	0.0	0.8	0.7	1.6	0.0	0.0	0.0	0.0	0.5	1.2	0.5	0.6	0.8
Cumacea	1.0	4.1	2.4	0.0	2.0	0.9	1.7	1.7	2.3	4.3	3.7	5.7	1.8	3.5	1.5	4.2	2.1	1.6	2.0	5.5	6.1	1.6	1.6	2.5	1.0	1.3	1.5
Tanaidacea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	1.8	0.0	1.2	0.0	0.8	0.0	0.7	0.0	1.0	0.0	0.0	0.8	1.1	0.0	1.6	0.6	0.8
Isopoda	1.0	4.1	0.0	1.1	1.0	1.8	1.7	1.1	2.3	1.1	0.9	2.9	0.6	1.8	1.5	3.3	1.4	1.6	2.0	2.2	2.0	2.4	0.5	1.2	1.0	0.0	0.0
Amphipoda	6.1	16.3	6.0	6.5	6.9	11.8	8.3	6.3	13.7	10.6	7.3	8.6	13.9	12.3	14.5	11.7	7.7	11.3	9.0	11.0	13.3	9.7	9.2	8.6	8.8	8.8	9.0
Decapoda	7.1	6.1	7.1	12.0	3.0	6.4	3.3	9.1	5.3	1.1	0.0	0.0	7.8	5.3	3.8	2.5	5.6	8.1	11.0	9.9	8.2	5.6	8.7	6.2	7.3	3.8	6.0
Insecta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
Misc Arthropods	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ECHINODERMATA	2.0	0.0	1.2	1.1	3.0	2.7	3.3	0.6	2.3	2.1	1.8	5.7	1.8	0.9	0.8	0.8	4.2	1.6	4.0	3.3	6.1	3.2	3.3	4.9	2.1	3.8	5.3
HEMICHORDATA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.8	0.8	0.0	0.0	1.0	1.1	1.0	0.0	0.0	1.2	0.0	0.6	0.8
VERTEBRATA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.8

MISCELLANEOUS	1.0	4.1	2.4	5.4	5.9	4.5	4.1	2.8	4.6	4.3	4.6	5.7	4.8	5.3	5.3	4.2	3.5	4.8	4.0	5.5	7.1	2.4	3.3	3.7	2.6	2.5	3.0
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Table 3.3-7. Wet weight biomass (g) for each major faunal group for each station and date.

		Annelida	Mollusca	Arthropoda	Echinodermata	Miscellaneous	Total
Jul-92	IC	5.029	4.587	0.061	0.047	0.578	10.300
Jul-92	ID	1.430	4.621	0.029	0.000	2.473	8.554
Jul-92	ID	2.952	11.610	0.036	0.919	0.351	15.867
Jul-92	IID	5.410	11.144	2.546	0.043	4.849	23.992
Jul-92	IID	8.869	15.579	0.933	0.163	0.812	26.356
Jul-92	IIC	21.316	30.854	5.849	2.324	1.176	61.519
Jul-92	IIID	5.171	1.341	0.124	0.488	0.826	7.950
Jul-92	IIIC	9.893	357.138	0.788	0.639	0.423	368.882
Jul-92	IIID	3.549	4.943	0.338	1.344	10.898	21.072
Jan-93	IC	7.019	0.639	0.010	0.683	0.635	8.985
Jan-93	ID	13.406	1.542	0.050	31.633	0.588	47.219
Jan-93	ID	0.642	0.549	0.057	0.134	1.573	2.955
Jan-93	IID	21.633	122.747	3.926	2.188	4.385	154.880
Jan-93	IID	11.624	69.387	0.973	0.150	3.252	85.386
Jan-93	IIC	45.110	10.310	9.267	3.249	4.347	72.283
Sep-93	IC	4.935	0.166	0.142	0.000	0.441	5.684
Sep-93	ID	18.830	0.880	0.088	2.828	6.091	28.718
Sep-93	ID	0.550	1.456	0.050	0.000	0.591	2.647
Sep-93	IVD	7.119	0.359	0.209	1.905	3.846	13.438
Sep-93	IVD	2.554	0.606	0.881	1.398	29.572	35.010
Sep-93	IVC	3.005	2.154	0.277	117.852	7.135	130.422
May-94	IC	4.223	3.805	0.073	24.292	0.608	33.000
May-94	ID	51.631	15.813	1.288	38.133	1.646	108.511
May-94	ID	1.208	1.540	0.032	15.992	1.287	20.060
May-94	IID	8.318	34.806	1.137	1.808	22.934	69.003
May-94	IID	4.445	1.609	0.157	11.307	1.343	18.859
May-94	IIC	3.516	0.738	0.244	59.149	4.681	68.328

Faunal Abundance, Richness and Diversity. Figure 3.3-3 shows temporal trends in number of taxa and number of individuals at each site. The first three panels summarize trends at Egmont Key (Site I). Temporal trends in species diversity (Shannon's H') and equitability (Pielou's J') are found in Figure 3.3-4. These data are also presented in Table 3.3-2. Temporal responses in number of taxa and faunal abundance (individuals/square meter) were distinct for each station at this site. The control station (I-C) experienced a slight decrease in both parameters shortly after dredging operations were completed (between July, 1993 and January, 1994). One of the two dredged stations (I-D2) showed a much more drastic decline in number of taxa and individuals during this same period. From January to September, 1993, station I-C experienced a substantial increase in both parameters, while the aforementioned dredged station (I-D2) underwent an increase in number of taxa, but a decrease in faunal density. By the end of the study, station I-D2 had not recovered to faunal levels experienced by the control station. The other dredged station (I-D1), however, showed no apparent declines in faunal parameters associated with dredging activities. This station showed a continual increase in both faunal diversity and abundance. At the end of the study, station I-D1 had far more taxa present and more individuals than either of the other stations at the Egmont Key site.

Species diversity and equitability at Egmont Key were fairly constant at the control station (Figure 3.3-4). These parameters showed wide fluctuations at station I-D2, especially during postdredging sampling events. The other dredged station (I-D1), which had lower diversity and equitability values prior to dredging, showed a continual increase in these parameters until the end of the study.

A two-way analysis of variance (ANOVA) was performed on all station and date combinations to look at the interaction between these two variables. The test was designed to detect differences in mean number of taxa and faunal density. Although there are inherent inaccuracies associated with applying analysis of variance to replicate benthic samples through space and time, the test will allow us to determine if there is an appreciable interaction between stations and sampling dates. If there is, then it makes it inappropriate to discuss differences between control and dredged stations at any one time as statistically significant. In any case, there was a significant ($p < 0.001$) interaction effect between sampling time and station at the Egmont Key site. This effect can be seen in Figure 3.3-5, where temporal trends in number of taxa and faunal density behaved differently at each of the three stations over time. This makes it impossible to attribute any of the observed changes to the effects of dredging alone. This finding, along with the observed differences in response of the two dredged stations, does not allow for an accurate analysis of dredging effects at Egmont Key. However, a look at changes in faunal composition at these stations should help pinpoint which species were mainly responsible for the observed community oscillations.

Faunal Composition. Total number and percent of individuals in each major faunal group for Egmont Key stations are found in Tables 3.3-3 and 3.3-4, respectively. Annelids contributed the lowest percent of total fauna throughout the study at the second dredge station (I-D2). Typically, annelids constituted 20% or less of the total fauna

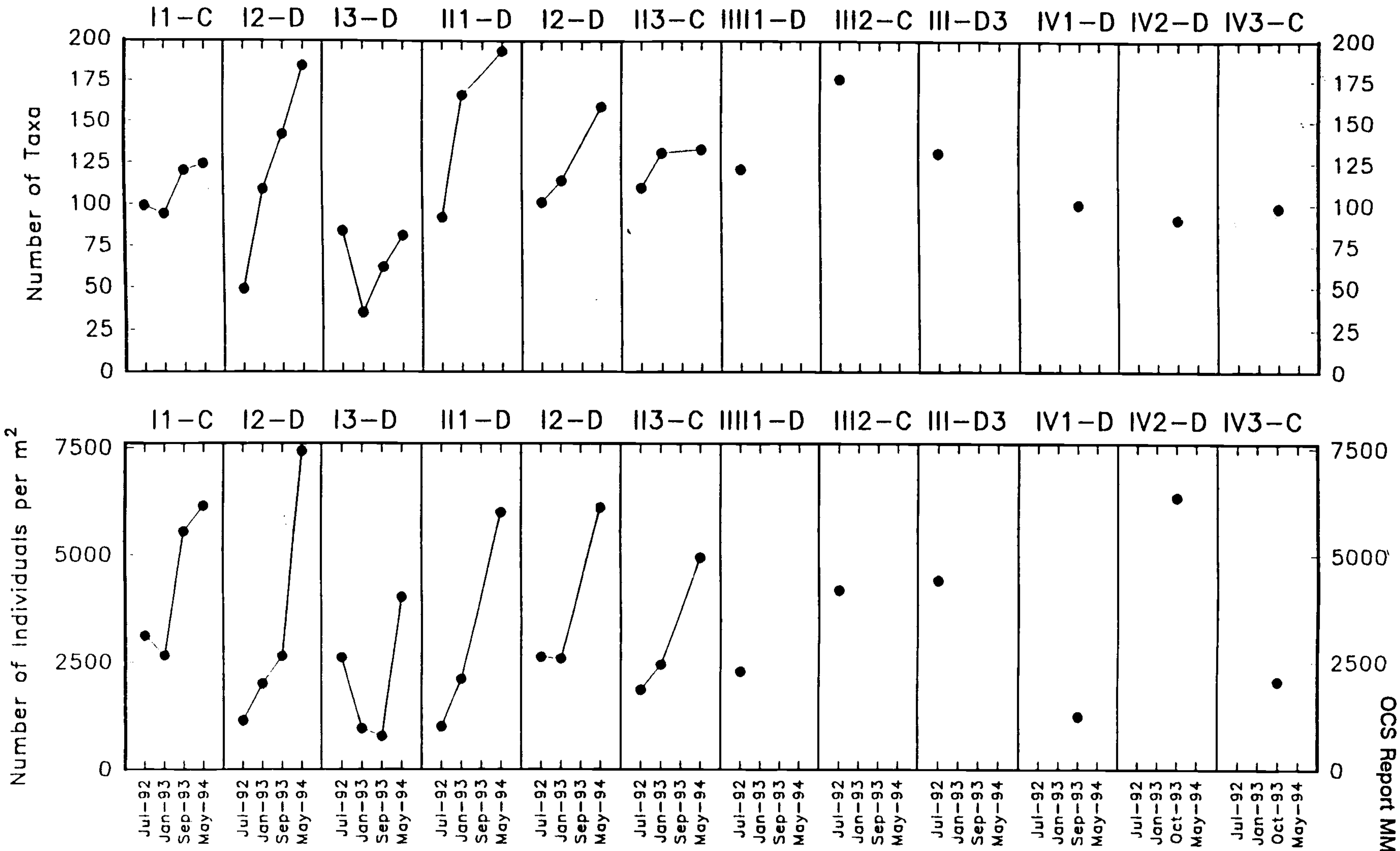


Figure 3.3-3 Temporal trends in number of taxa (top) and number of individuals (bottom) at each site. I = Egmont Key; II = Sarasota; III = Manasota Key; IV = Longboat Key. (C = control; D = dredged).

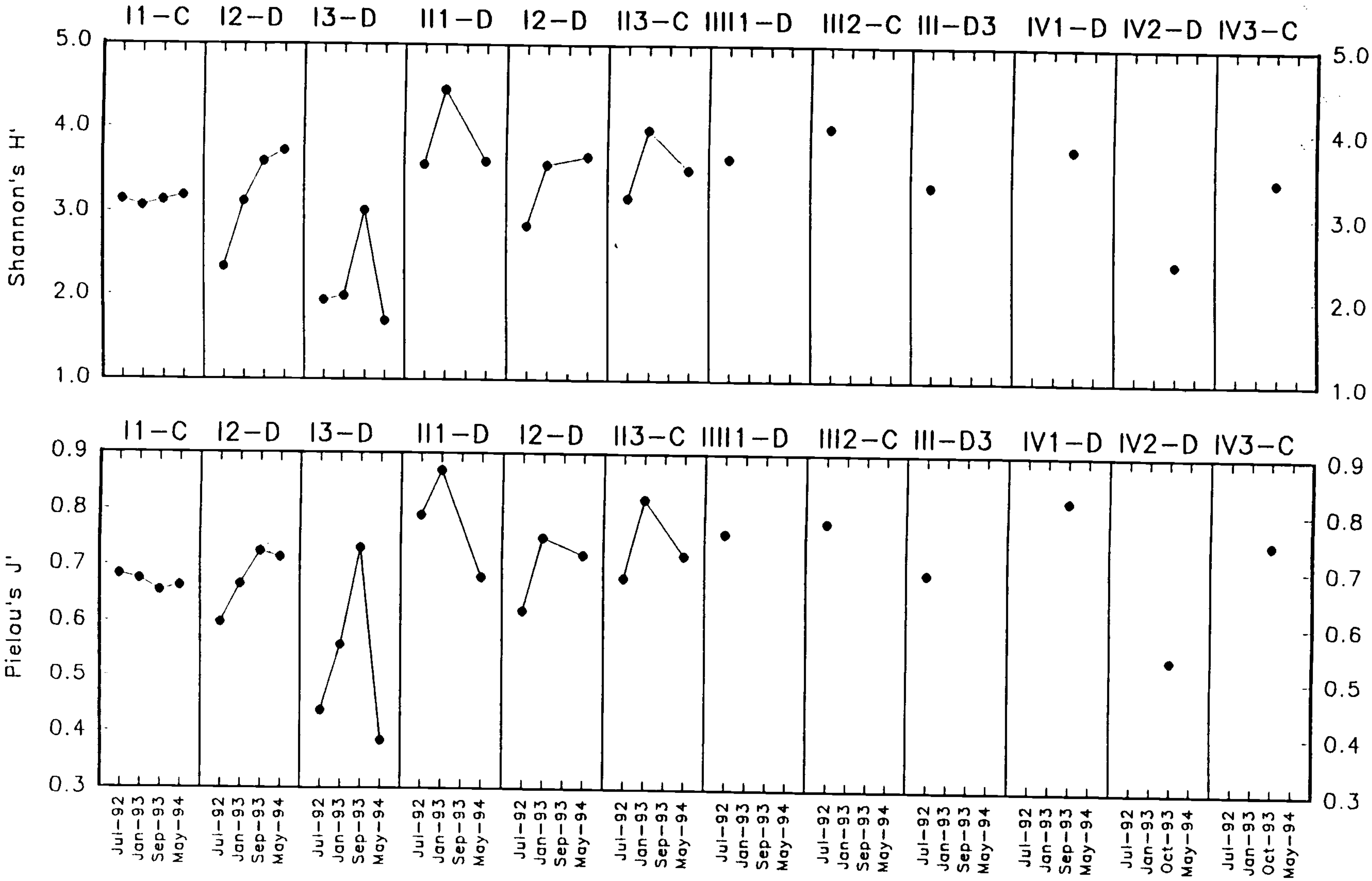


Figure 3.3-4. Temporal trends in species diversity (Shannon's H) and equitability (Pielou's J) at each site. I = Egmont Key; II = Sarasota; III = Manasota Key; IV = Longboat Key. (C = control; D = dredged).

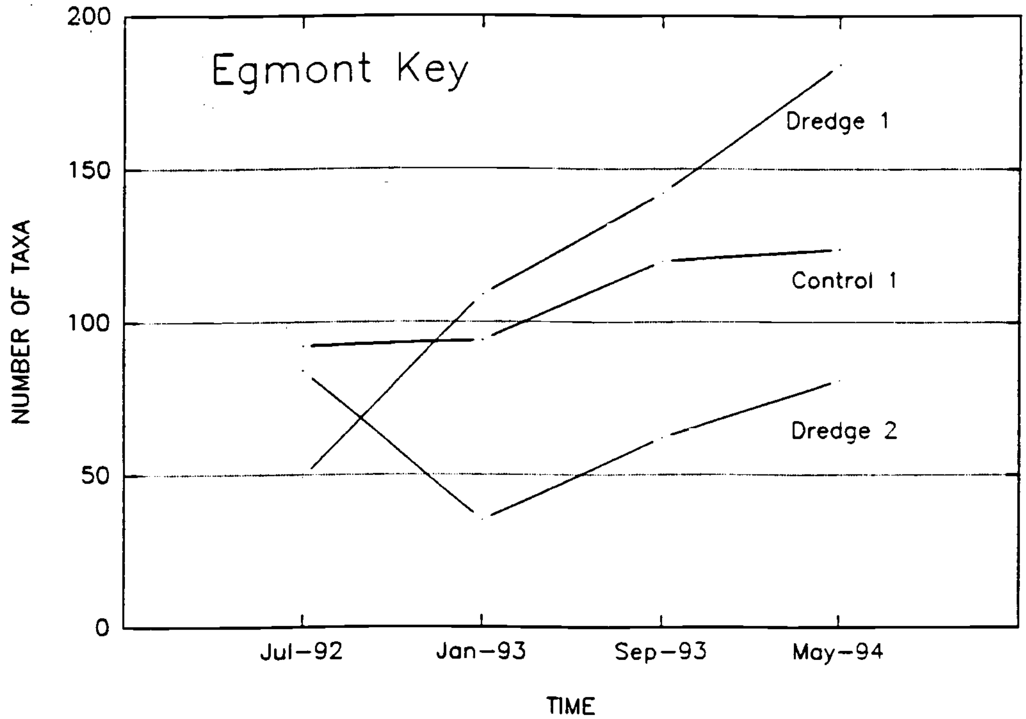
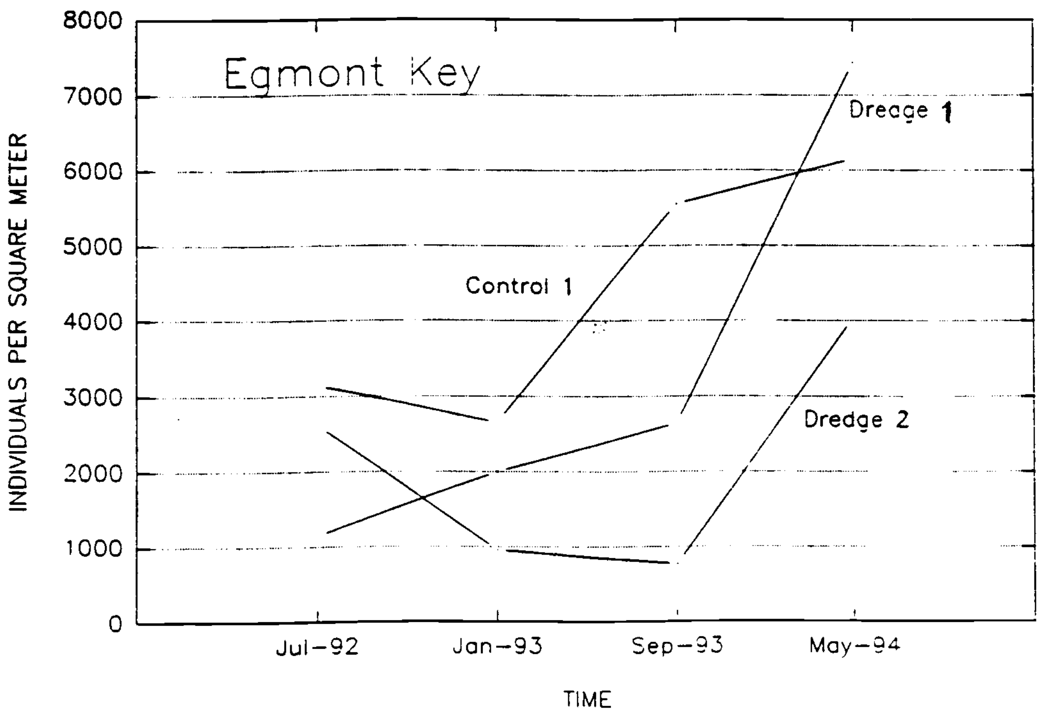


Figure 3.3-5. Temporal trends in number of taxa (top) and individuals per square meter (bottom) at Egmont Key.



(compared to roughly 60% at the other two stations) at station I-D2 throughout the study. This was countered by a substantially higher percent of molluscs at station I-D2 compared to the other two stations (70% to 25%, respectively). This difference in the composition of the fauna at station I-D2 compared to the other two stations at Egmont Key could play an important role in the ability of fauna to recolonize the second dredge site. This is due to differences in the reproductive and dispersal potential between polychaetes and molluscs.

Differences in total and percent of taxa in major taxonomic groups among the three Egmont Key stations were less evident (Tables 3.3-5 and 3.3-6). While the total number of annelid and molluscan taxa at the second dredge station were lowest, the percent of total taxa for annelids and molluscs among all stations were similar. This indicates that, although overall faunal conditions were poorest at the second dredge station, the number of taxa were in proportion to the number of individuals present. In other words, the fauna were not limited to a few taxa, but rather were spread among a number of taxa comparable to the other two stations.

Several species contributed to the high faunal density at the control station during July, 1992. Tubificid oligochaetes, *Prionospio cristata* (polychaete) and *Caecum bipartitum* (gastropod) were found almost exclusively at the control station, while the bivalve, *Parvilucina multilineata* was much more plentiful at the second dredge station. During January, 1993, faunal abundance dropped off noticeably at the second dredge station because of the absence of this bivalve. The higher total abundance at the control site was partly due to tubificid oligochaetes and nemerteans. Other significant species at the control station include *Cylichnella bidentata*, *Caecum bipartitum*, *Mediomastus* spp., *Prionospio pygmaea*, and *Aricidea* cf. *suecica*. *Caecum johnsoni* and *Acteocina* sp. were found exclusively at the first dredge station, while *Myriowenia* sp. was present only at the second dredge station. A number of species contributed to the large increase in faunal abundance at the control station during September, 1993. These species were: *Parvilucina multilineata*, *Prionospio cristata*, *Prionospio pygmaea*, *Nemertean* sp. B, *Cyclaspis* cf. *varians*, and *Paraprionospio pinnata*. These species are all surface-deposit feeding organisms (three are polychaetes in the family Spionidae). This suggests a stable surface with a sufficient organic component to support such a diverse and abundant fauna. The dredged stations may have had a disturbed surface which prevented the early colonization of these stations. By May, 1994, the distribution of species between the control and the dredge stations revealed some interesting distinctions. The second dredge station, which had depressed faunal abundance throughout the study, had a large abundance of the bivalve *Tellina* sp. This species represented 70% of the fauna at this station (no other species contributed more than 4% to the total fauna). This disparity in species distribution led to the low species diversity and equitability at this station during May, 1994. The other two stations (control and first dredge station) had several dominant species, although this dominance was distinct for each station. *Parvilucina multilineata*, *Prionospio cristata*, *Cylichnella bidentata* (gastropod), and *Spiophanes bombyx* (polychaete) were abundant at the control station. *Branchiostomma* sp., *Prionospio perkinsi*, *Mooreonuphis nebulosa*, *Carazziella hobsonae*, and *Erichthonius brasiliensis* were specifically dominant at the first dredge station.

Overall diversity and equitability at these two stations was high, reflecting the abundant and diverse species composition.

An interesting shift in faunal composition was observed at the second dredge station (I-D2). Bivalves contributed a much greater percent of the fauna at this station than the other two (Table 3.3-4). Before dredging, the bivalve *Parvilucina multilineata* represented 64% of the total fauna. The next two sampling periods (immediately post dredging) revealed very low faunal abundance with no clear dominance by any organism. By May 1994, the bivalve *Tellina* sp. comprised 69% of the fauna. This clear shift in species composition was not observed at the other two stations.

This slow recolonization by bivalves has been demonstrated in other studies. Bowen and Marsh (1988) found that periodic molluscan settlement in a Delray Beach, Florida borrow site was in most cases followed by nearly complete mortality. The authors did not speculate on the cause of this mortality but only noted that no adults were found. Oliver *et al.* (1977) reported similar molluscan mortality in a study of dredged material disposed at various depths in Monterey Bay, California. Simon and Dauer (1977) also noted the slow appearance of molluscs in a disturbed area in Tampa Bay. The authors surmised that the phenomenon may be related to their more limited dispersal abilities and reproductive seasonality. The cause of the sharp decline in *Parvilucina multilineata* at the second dredge station combined with the slow, but steady increase in *Tellina* sp. may reflect these inherent patterns of recolonization exhibited by molluscs.

Faunal Similarity. Distinctions in faunal composition among Egmont Key stations are also reflected in faunal similarity values (Figure 3.3-6). Not surprisingly, only two combinations showed moderate similarity, and they were temporal similarities at the same station. The first dredge station (I-D1) showed moderate similarity between January, 1993 and September, 1993, while the control station showed moderate similarity between September, 1993 and May, 1994. When a presence/absence data transform was performed, several more Egmont Key station combinations showed moderate similarity through space and time (Figure 3.3-7). Moderate similarity occurred between: dredge station two and control station, July, 1992; control station, July, 1992 and January, 1993; and control station, January, 1993 and dredge station two, July, 1992. All other station-date combinations showed low to very low faunal similarity. These faunal relationships among stations are also displayed as dendrograms in Figures 3.3-8 and 3.3-9 and a trellis diagram in Figure 3.3-10.

In summary, each station at the Egmont Key site underwent different temporal patterns in benthic community composition. The two dredged stations responded quite differently from each other, making data interpretation difficult. Most of the difficulty involves the distinct contrast in faunal community response between the two dredged stations. In general, the control station exhibited less variable temporal trends, while the two dredged stations showed widely fluctuating and contrary faunal responses.

		IC Jul-92	ID Jul-92	ID Jul-92	IID Jul-92	IID Jul-92	IIC Jul-92	IIID Jul-92	IIIC Jul-92	IIID Jul-92	IC Jan-93	ID Jan-93	ID Jan-93	IID Jan-93	IID Jan-93	IIC Jan-93	IC Sep-93	ID Sep-93	ID Sep-93	IVD Sep-93	IVD Oct-93	IVC Oct-93	IC May-94	ID May-94	ID May-94	IID May-94	IID May-94	IIC May-94
IC	Jul-92		...	...	...	---	---	---	...	...	---	...	...	...	...	...	---	...	...	...	...	...	---	...	...	...	...	...
ID	Jul-92	.942		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
ID	Jul-92	.720	.924		...	+++	---	...	...	...	...	...	...	...	---	...	...	...	...	...	...	...	...	...	...	...	...	...
IID	Jul-92	.853	.724	.943		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
IID	Jul-92	.665	.909	.395	.883		+++	...	---	...	...	...	...	...	---	---	...	...	...	...	...	...	...	...	...	...	...	...
IIC	Jul-92	.664	.925	.547	.864	.385		...	---	...	...	...	...	...	---	---	...	...	...	...	...	...	...	...	...	...	...	...
IIID	Jul-92	.606	.887	.825	.731	.718	.749		---	...	---	---	...	...	...	---	...	---	...	...	...	...	...	...	...	...	...	...
IIIC	Jul-92	.705	.950	.773	.816	.680	.685	.627		...	...	...	...	---	...	---	...	...	...	...	...	...	...	---	...	...	...	...
IIID	Jul-92	.821	.884	.950	.828	.902	.909	.817	.869		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
IC	Jan-93	.628	.939	.817	.882	.717	.803	.599	.777	.898		---	...	...	---	...	---	---	...	...	...	...	---	---	...	...	...	...
ID	Jan-93	.822	.899	.865	.802	.784	.844	.683	.772	.839	.565		---	...	---	...	...	+++	---	...	...	...	...	---	...	...	...	...
ID	Jan-93	.961	.868	.906	.918	.854	.951	.861	.947	.927	.712	.512		...	...	...	...	...	---	...	...	...	...	...	...	...	...	...
IID	Jan-93	.806	.932	.863	.800	.778	.728	.736	.677	.888	.822	.772	.938		---	+++	...	...	...	...	...	...	...	...	...	...	...	...
IID	Jan-93	.763	.931	.697	.899	.637	.663	.777	.709	.926	.663	.648	.741	.653		---	---	...	...	...	...	...	---	...	...	...	...	...
IIC	Jan-93	.749	.939	.776	.859	.677	.595	.692	.577	.921	.767	.785	.902	.497	.514		...	...	...	...	...	...	...	...	...	...	...	...
IC	Sep-93	.605	.960	.785	.907	.751	.794	.748	.733	.827	.645	.754	.864	.852	.624	.749		---	...	...	...	...	+++	---	...	...	...	...
ID	Sep-93	.728	.919	.859	.774	.813	.854	.567	.747	.813	.599	.488	.705	.800	.725	.794	.670		---	...	...	---	...	---	...	...	...	...
ID	Sep-93	.918	.926	.886	.885	.849	.886	.844	.895	.915	.811	.641	.630	.893	.831	.848	.861	.656		...	...	---	...	...	...	...	...	...
IVD	Sep-93	.829	.927	.817	.872	.769	.805	.788	.861	.927	.833	.808	.873	.767	.745	.794	.848	.720	.735		...	---	...	...	...	...	...	...
IVD	Oct-93	.934	.912	.941	.930	.923	.959	.907	.936	.711	.875	.825	.819	.937	.868	.937	.881	.807	.874	.883		...	...	...	...	...	...	...
IVC	Oct-93	.879	.828	.857	.847	.806	.886	.787	.896	.817	.806	.731	.732	.883	.792	.855	.846	.696	.685	.681	.712		...	...	...	...	...	...
IC	May-94	.604	.983	.799	.922	.757	.803	.724	.774	.854	.609	.717	.840	.884	.692	.820	.395	.715	.883	.834	.868	.853		---	...	...	...	...
ID	May-94	.805	.967	.857	.906	.816	.830	.726	.674	.870	.697	.674	.859	.805	.706	.724	.687	.625	.888	.858	.870	.856	.642		...	---	...	...
ID	May-94	.918	.976	.929	.969	.908	.947	.911	.939	.959	.808	.708	.761	.941	.837	.930	.868	.788	.836	.876	.869	.821	.799	.806		...	...	...
IID	May-94	.872	.930	.951	.834	.938	.925	.794	.819	.825	.814	.821	.950	.837	.887	.868	.826	.715	.905	.898	.943	.903	.838	.661	.916		...	...
IID	May-94	.854	.976	.862	.953	.833	.869	.812	.792	.951	.851	.883	.962	.817	.754	.758	.813	.819	.899	.763	.927	.820	.703	.769	.872	.752		+++
IIC	May-94	.823	.972	.870	.921	.805	.850	.806	.806	.937	.811	.842	.951	.792	.709	.709	.795	.799	.892	.766	.927	.830	.713	.729	.889	.753	.352	

... Very Low Similarity --- Low Similarity +++ Moderate Similarity

Figure 3.3-6. Trellis diagram of Bray-Curtis faunal similarity values for each station and date based on group-averaged sorting.

		IC Jul-92	ID Jul-92	I3D Jul-92	IID Jul-92	IID Jul-92	IIC Jul-92	IIID Jul-92	IIIC Jul-92	IIID Jul-92	IC Jan-92	ID Jan-93	ID Jan-93	IID Jan-93	IID Jan-93	IIC Jan-93	IC Sep-93	ID Sep-93	ID Sep-93	IVD Sep-93	IVD Oct-93	IVC Oct-93	IC May-94	ID May-94	ID May-94	IID May-94	IID May-94	IIC May-94
IC	Jul-92		---	+++	---	---	---	---	---	---	+++	---	...	---	---	---	---	---	---	---	---	...	---	---	...	...	---	---
ID	Jul-92	.667		---	---	---	---	---	...	---	---	---	---	...	...	...	...	...	---	...	...	...	...	...	...	...	...	...
ID	Jul-92	.376	.618		---	+++	---	---	---	---	+++	---	...	---	---	---	---	---	...	---	---	---	---	---	...	...	---	---
IID	Jul-92	.617	.608	.642		---	---	---	---	---	...	---	...	---	---	---	...	---	...	---	...	...	---	---	...	---	---	---
IID	Jul-92	.520	.610	.421	.574		+++	+++	---	---	---	---	...	---	---	---	---	---	...	---	---	---	---	---	...	...	---	---
IIC	Jul-92	.600	.637	.531	.606	.393		+++	+++	---	---	---	...	+++	+++	+++	---	---	---	---	...	---	---	---	...	...	---	---
IIID	Jul-92	.500	.690	.533	.594	.474	.444		+++	+++	---	---	...	---	---	---	---	---	---	---	...	---	---	---	---	---	---	---
IIIC	Jul-92	.558	.752	.588	.591	.521	.462	.460		---	---	---	...	+++	+++	+++	---	---	...	---	...	...	---	---	...	---	---	---
IIID	Jul-92	.615	.663	.609	.559	.538	.508	.488	.548		---	---	...	---	---	---	---	---	...	---	---	---	---	---	...	---	---	---
IC	Jan-93	.467	.697	.481	.755	.538	.571	.589	.594	.651		---	...	---	---	---	---	---	...	---	...	---	---	---	...	...	---	---
ID	Jan-93	.629	.663	.633	.675	.589	.536	.564	.566	.582	.502		---	---	---	---	---	+++	---	---	...	---	---	---	...	---	---	---
ID	Jan-93	.778	.694	.736	.859	.727	.766	.723	.858	.763	.708	.655		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
IID	Jan-93	.575	.743	.630	.594	.596	.496	.541	.448	.550	.627	.525	.823		+++	+++	---	---	...	---	...	...	---	---	...	---	---	---
IID	Jan-93	.579	.732	.590	.643	.514	.438	.513	.483	.556	.560	.500	.812	.418		+++	---	---	...	---	---	---	---	---	...	---	---	---
IIC	Jan-93	.554	.727	.543	.628	.536	.449	.533	.443	.596	.561	.523	.798	.375	.344		---	---	...	---	...	---	---	---	...	---	---	---
IC	Sep-93	.563	.793	.581	.714	.570	.590	.613	.580	.628	.534	.607	.811	.610	.529	.603		+++	...	---	---	---	+++	---	...	---	---	---
ID	Sep-93	.584	.720	.602	.588	.606	.600	.562	.546	.570	.624	.492	.751	.566	.583	.583	.482		---	---	---	---	---	---	---	---	---	---
ID	Sep-93	.675	.690	.737	.761	.706	.693	.695	.769	.750	.727	.693	.703	.795	.778	.749	.716	.630		---	---	---	...	...	...	...	...	---
IVD	Sep-93	.561	.742	.560	.677	.550	.572	.607	.609	.649	.600	.647	.757	.612	.589	.538	.555	.506	.602		---	+++	---	---	---	---	---	---
IVD	Oct-93	.685	.728	.683	.737	.692	.710	.701	.758	.662	.719	.710	.727	.751	.697	.713	.656	.555	.644	.545		+++	---	---	---	...	---	---
IVC	Oct-93	.710	.707	.648	.730	.611	.631	.645	.731	.643	.653	.622	.718	.731	.665	.683	.619	.564	.607	.491	.402		---	---	---	...	---	---
IC	May-94	.545	.839	.571	.687	.596	.641	.597	.613	.651	.580	.675	.836	.658	.622	.650	.492	.584	.737	.581	.647	.645		---	---	---	+++	+++
ID	May-94	.649	.796	.653	.691	.654	.620	.618	.546	.624	.686	.614	.827	.598	.619	.610	.618	.516	.769	.593	.688	.699	.521		---	---	+++	---
ID	May-94	.735	.771	.713	.793	.730	.728	.688	.767	.712	.739	.717	.724	.775	.733	.757	.746	.697	.701	.688	.618	.638	.678	.684		...	---	---
IID	May-94	.707	.779	.736	.638	.738	.704	.679	.546	.591	.792	.684	.878	.580	.662	.621	.679	.605	.800	.666	.725	.754	.648	.509	.731		---	---
IID	May-94	.562	.790	.610	.676	.614	.622	.577	.548	.646	.663	.622	.867	.549	.547	.522	.563	.548	.717	.525	.650	.640	.486	.490	.585	.537		+++
IIC	May-94	.545	.792	.598	.664	.603	.597	.626	.586	.670	.614	.597	.833	.568	.587	.511	.564	.569	.688	.529	.635	.633	.486	.541	.598	.517	.311	

... Very Low Similarity --- Low Similarity +++ Moderate Similarity

Figure 3.3-7. Trellis diagram of Bray-Curtis faunal similarity values for each station and date. (Presence/absence transform).

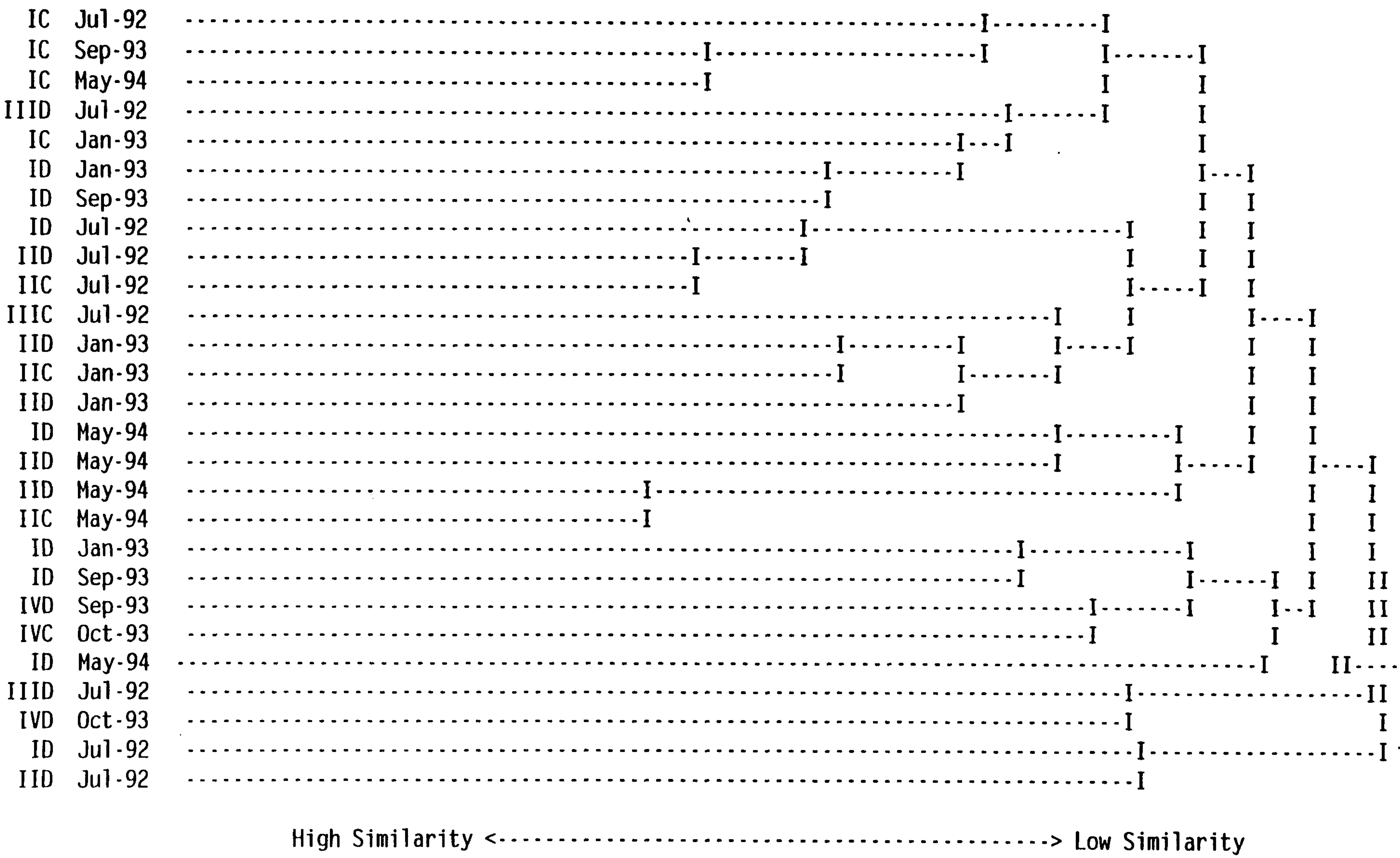


Figure 3.3-8. Dendrogram of Bray-Curtis similarity for each station and date based on group-averaged sorting.

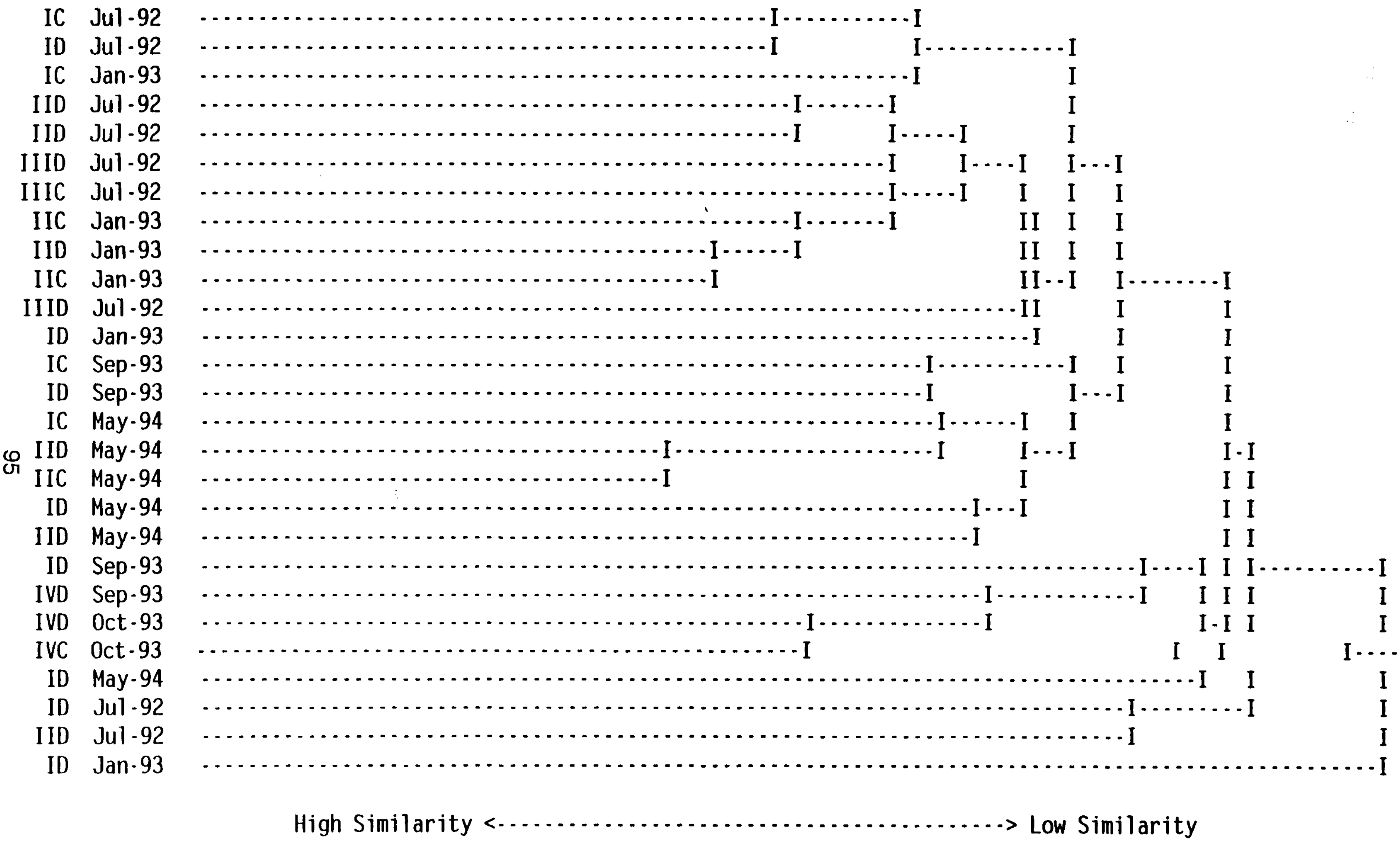


Figure 3.3-9. Dendrogram of Bray-Curtis similarity for each station and date. (Presence/absence transform).

	I1 Jul	I2 Jul	I3 Jul	II1 Jul	II2 Jul	II3 Jul	III1 Jul	III2 Jul	III3 Jul	I1 Jan	I2 Jan	I3 Jan	II1 Jan	II2 Jan	II3 Jan	I1 Sep	I2 Sep	I3 Sep	IV1 Sep	IV2 Oct	IV3 Oct	I1 May	I2 May	I3 May	IV1 May	IV2 May	IV3 May
I1 Jul		...	■	---	+++	---	■	■	---	+++	---	...	■	---	+++	+++	+++	...	---	---	...	+++	+++	...	---	■	+++
I2 Jul	25		...	...	...	...	...	...	---	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
I3 Jul	58	26		---	+++	+++	+++	+++	---	+++	---	...	+++	---	+++	---	+++	...	---	...	---	---	+++	...	---	+++	---
II1 Jul	37	28	32		---	---	---	+++	+++	...	---	...	+++	---	---	---	+++	...	---	...	...	---	---	...	+++	---	---
II2 Jul	49	30	55	42		■	■	■	+++	+++	---	...	+++	+++	+++	+++	+++	...	+++	---	---	+++	+++	...	---	+++	+++
II3 Jul	42	29	46	40	65		■	■	■	---	+++	...	■	■	■	+++	+++	...	+++	...	---	---	■	...	---	+++	+++
III1 Jul	56	27	49	44	60	65		■	■	---	+++	...	■	■	■	+++	■	...	---	---	---	+++	■	---	+++	■	+++
III2 Jul	61	28	54	55	67	77	81		■	+++	■	...	■	■	■	■	■	...	+++	---	---	■	■	...	■	■	■
III3 Jul	45	31	43	50	55	60	66	70		---	+++	...	■	+++	+++	+++	■	...	---	---	---	---	■	---	■	+++	---
I1 Jan	52	22	47	23	46	44	45	55	40		+++	...	+++	---	+++	+++	---	...	---	...	---	+++	---	...	...	---	---
I2 Jan	39	27	36	33	44	51	51	62	51	51		...	■	+++	■	---	■	...	---	...	---	---	■	...	+++	+++	+++
I3 Jan	15	13	16	9	19	17	22	15	20	19	25		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
II1 Jan	57	28	47	53	55	70	67	95	68	48	65	18		■	■	■	■	...	+++	---	---	+++	■	...	■	■	■
II2 Jan	45	22	41	37	53	63	58	75	55	45	55	14	81		■	+++	+++	...	---	---	---	---	■	...	+++	■	+++
II3 Jan	52	25	50	42	55	67	60	86	54	49	57	17	93	80		+++	■	...	+++	---	---	---	■	...	■	■	■
I1 Sep	49	18	44	31	49	48	48	63	48	50	45	15	56	55	50		■	...	+++	---	---	■	■	...	+++	■	■
I2 Sep	52	28	47	50	50	52	60	74	61	45	65	23	68	54	58	70		---	■	+++	+++	■	■	---	■	■	■
I3 Sep	27	18	20	19	25	27	29	28	25	22	27	15	24	20	25	27	40		---	...	---	...	...	...	...	---	---
IV1 Sep	45	20	42	32	47	46	45	55	42	39	37	17	52	44	54	50	62	34		+++	+++	+++	■	...	+++	■	■
IV2 Oct	31	20	29	25	31	30	33	33	39	27	30	18	33	32	33	38	55	29	46		■	---	---	---	---	---	---
IV3 Oct	30	23	34	27	41	40	41	38	43	34	40	20	36	36	37	43	55	34	53	61		---	---	---	---	+++	---
I1 May	51	14	45	34	46	42	50	58	45	46	38	13	50	45	45	63	57	25	48	39	41		■	---	■	■	■
I2 May	50	24	47	43	50	56	59	82	60	43	56	19	70	56	61	58	80	29	58	44	43	74		---	■	■	■
I3 May	24	15	24	18	25	26	32	30	31	23	27	16	28	26	26	26	35	22	29	34	34	33	42		---	+++	---
IV1 May	43	27	37	52	39	45	51	84	67	30	48	14	76	52	62	51	68	26	50	40	37	56	93	37		■	■
IV2 May	57	22	48	41	51	51	60	76	52	43	51	13	74	62	70	62	70	32	63	45	48	73	88	50	82		■
IV3 May	53	19	44	38	47	49	48	64	44	44	49	14	65	51	65	56	61	31	56	42	44	66	73	43	79	101	

... 0-30 Taxa (1st Quartile 30 Taxa)
--- 31-45 Taxa (Median 45 Taxa)
+++ 46-55 Taxa (3rd Quartile 55 Taxa)
■ >55 Taxa

Figure 3.3-10. Trellis diagram showing number of taxa in common for each pair of stations and dates.

Sarasota

The Sarasota site was sampled on three occasions: July, 1992, January, 1993 and May, 1994. This site was not dredged during the course of the project, so this site can serve as an illustration of natural temporal trends in community parameters. These trends can then be compared to trends from Egmont Key to delineate impacts associated with dredging at Egmont Key.

Faunal Abundance, Richness and Diversity. Temporal trends in number of taxa and number of individuals per square meter at Sarasota (Area II) are found in Figure 3.3-3. Temporal trends in species diversity (Shannon's H') and equitability (Pielou's J') are found in Figure 3.3-4. These data are also presented in Table 3.3-1.

Both number of taxa and number of individuals per square meter increased through time at the Sarasota site. This trend was evident at all three stations. Species richness was similar at all three stations in July, 1992, ranging from 92 to 110 taxa (mean = 101). By January , 1993, mean species richness increased to 137 taxa. The station with the least number of taxa in July (II-D1) had the most taxa in January, an increase from 92 to 166 taxa. This station showed a less dramatic increase in the number of individuals. Species diversity at Sarasota was highest in January, 1993. This is due to a substantial increase in species richness coupled with only a slight increase in faunal density from July, 1992 to January, 1993. By May, 1994, there was a further increase in species richness and a large increase in faunal density. This resulted in a decrease in species diversity from January, 1993 to May, 1994.

Faunal Composition. The relatively low faunal abundance at station II-D1 compared to the other two stations during July, 1992 was due to the absence of several dominant species at this station, most notably the bivalve *Parvilucina multilineata* and the polychaete *Aglaophamus verrilli*, which were numerous at the other two stations. By January, 1993, these two species were no longer dominant. They were replaced by tubificid oligochaetes and a suite of lesser dominant taxa, all of which were equally abundant at all three stations. Consequently, faunal density was similar among all sites by January, 1993. Between January, 1993 and May, 1994, there was more than a twofold increase in faunal density, from a mean of 2,383 individuals per square meter in January, 1993 to 5,698 individuals per square meter by May, 1994. An increase in the abundance of a variety of organisms contributed to this overall rise in faunal density.

Faunal Similarity. Faunal similarity values for Sarasota stations can be found in Figure 3.3-6 (trellis diagram) and Figure 3.3-8 (dendrogram). Figures 3.3-7 and 3.3-9 display faunal similarity values as trellis and dendrogram diagrams, respectively, for presence/absence data transformations. Stations II-C and II-D showed moderate similarity during July, 1992 and May, 1994 for both normal and transformed data. These stations were the most similar in faunal composition of any station-date combinations for the entire study. All other Sarasota station comparisons showed low similarity.

This pattern of change in faunal communities at Sarasota is consistent with models of temporal variability in natural systems (Maurer *et al.*, 1993; Rakocinski *et al.*, 1991; Boesch *et al.*, 1976). Faunal density and diversity from estuarine systems showed peaks during spring and early summer (Leverone *et al.*, 1991; Mahoney and Livingston, 1982; Boesch *et al.*, 1976). Differences in population-based parameters (e.g., density and diversity) through space and time are often quite variable (Osenberg *et al.*, 1994). This variable pattern in faunal density and species diversity was also observed at the Sarasota site during the present study.

Longboat Key

The Longboat Key site was sampled once (a six month post-dredging event in September, 1993) during the present study. However, an independent Mote Marine Laboratory study was conducted within the proposed borrow site during June, 1991. Despite differences in sample size and sampling frequency between the two studies, results from the MML study can be used to make qualitative observations and comparisons of faunal composition at this site. Also keep in mind that there was over a two year difference between the two sampling events, rendering any temporal relationships between the two studies inappropriate.

A composite species list of fauna from the MML Longboat Key study is presented as Table 3.3-8. No analysis on faunal abundance, species richness, diversity and equitability are available for this study. A total of fifty species were found in this limited study. The dominant species during the 1991 MML study were the lancelet, *Branchiostomma* sp. (comprising 65% of the total fauna), followed by, in decreasing abundance: *Tellina* sp. (bivalve), *Spio pettiboneae* (polychaete), *Rhepoxynius epistomus* (amphipod), *Olivella floralia* (gastropod), and *Myodocopa* sp. E (ostracod). The top ten species constituted 90% of the total fauna, which indicates a relatively high level of oligomixity. This may, however, be a reflection of the limited sampling effort during this study. A more comprehensive study might have revealed a higher degree of diversity and equitability.

Branchiostomma sp. was also the dominant species at Longboat Key during the present study. This species was followed by *Actiocina caniliculata* (gastropod), *Tellina* sp. (bivalve) and *Rhepoxynius epistomus* (amphipod). Several other species were relatively abundant during the present study. These species include: *Eudevenopus honduranus*, *Acanthohaustorius uncinus*, and *Paraonis fulgens* (polychaete).

These cursory comparisons between the two studies suggest a consistency in faunal composition over time at this site. The dominant fauna present are characteristic of well sorted sandy environments typical of the nearshore coastal environment. Because of the relative similarity in fauna between the two studies, it appears that any effects of dredging at the Longboat Key borrow site were minimal.

Table 3.3-8. Composite species list. Number of individuals for each taxa from Mote Marine Laboratory beach renourishment study, 1991. Longboat Key borrow site, pre-dredging sampling.

Taxa	NODC	BS1-1 1	BS1-1 2	BS1-1 3	BS1-1 Total	BS1-2 1	BS1-2 2	BS1-2 3	BS1-2 Total	Overall Total
Branchiostoma floridae	8500010102	99	29	15	143	195	133	170	498	641
Tellina	55153102	10	9	4	23	14	12	17	43	66
Spio pettiboneae	5001430706	2	0	1	3	16	13	11	40	43
Rhepoxynius epistomus	6169421501	5	14	2	21	7	4	2	13	34
Olivella floralia	5105100108	1	3	7	11	7	7	5	19	30
Myodocopa sp. E	6111000095	10	0	0	10	5	5	4	14	24
Eudevenopus honduranus	6169422101	6	2	1	9	1	3	4	8	17
Prionospio cristata	5001430510	0	0	0	0	3	3	10	16	16
Nemertea	43	2	0	3	5	1	2	2	5	10
Acanthohaustorius pansus	6169220608	3	5	1	9	0	0	1	1	10
Mellita tenuis	8155040101	0	1	2	3	3	1	2	6	9
Paraonis fulgens	5001410302	0	1	0	1	0	2	5	7	8
Dispio uncinata	5001431901	3	2	1	6	0	2	0	2	8
Spisula solidissima	5515250102	0	2	0	2	3	2	1	6	8
Cyclaspis sp. G	6154090293	1	1	0	2	0	3	2	5	7
Armandia maculata	5001580204	0	0	0	0	1	2	1	4	4
Podocopa sp. H	6113000092	0	0	0	0	2	1	1	4	4
Goniada littorea	5001280205	0	1	2	3	0	0	0	0	3
Natica	51037602	0	1	0	1	1	0	1	2	3
Sigambra tentaculata	5001220201	0	2	0	2	0	0	0	0	2
Nephtys picta	5001250117	0	1	0	1	0	0	1	1	2
Prionospio pygmaea	5001430507	2	0	0	2	0	0	0	0	2
Magelona riojai	5001440107	0	1	1	2	0	0	0	0	2
Parvilucina multilineata	5515010102	0	0	0	0	0	0	2	2	2
Asteropterygion sp. A	6111031499	0	0	0	0	0	0	2	2	2
Apanthura magnifica	6160012001	0	0	0	0	0	1	1	2	2
Batea catharinensis	6169100101	2	0	0	2	0	0	0	0	2
Monoculodes edwardsi	6169370820	0	1	1	2	0	0	0	0	2
Lucifer faxoni	6177020201	0	0	0	0	0	0	2	2	2
Processa hemphilli	6179170101	0	0	1	1	0	0	1	1	2
Athenaria	3759	0	0	0	0	0	1	0	1	1
Cerebratulus lacteus	4303020209	1	0	0	1	0	0	0	0	1
Hypereteone lactea	5001130208	0	0	0	0	1	0	0	1	1

Taxa	NODC	BS1-1 1	BS1-1 2	BS1-1 3	BS1-1 Total	BS1-2 1	BS1-2 2	BS1-2 3	BS1-2 Total	Overall Total
Onuphis eremita oculata	500129010701	0	0	0	0	0	1	0	1	1
Spionidae	500143	0	0	0	0	1	0	0	1	1
Armandia agilis	5001580203	1	0	0	1	0	0	0	0	1
Capitellidae	500160	0	0	0	0	1	0	0	1	1
Loimia medusa	5001682001	0	0	0	0	0	1	0	1	1
Chone cf. *americana*	5001700107CF	0	0	0	0	1	0	0	1	1
Gastropoda	51	0	0	0	0	1	0	0	1	1
Bivalvia	55	0	0	0	0	0	0	1	1	1
Eusarsiella spinosa	6111040414	1	0	0	1	0	0	0	0	1
Podocopa sp. A	6113000099	0	0	1	1	0	0	0	0	1
Cyclaspis sp. E	6154090295	0	0	0	0	0	1	0	1	1
Edotea triloba	6162020703	0	0	1	1	0	0	0	0	1
Glottidia pyramidata	8002010101	0	0	0	0	1	0	0	1	1
Ophiophragmus wurdemani	8129030603	0	0	1	1	0	0	0	0	1
Micropholis atra	8129031201	1	0	0	1	0	0	0	0	1
Enteropneusta	8201	0	0	0	0	0	0	1	1	1
Ascidiacea	8401	0	0	1	1	0	0	0	0	1

Manasota Key

Manasota Key was sampled during July, 1992. Faunal conditions at this site have been previously discussed in the section "Pre-Dredging Faunal Community Conditions". These results are briefly reiterated here. Manasota Key had the highest mean number of taxa per station (142 ± 29 taxa). The difference in number of taxa between Manasota Key and Egmont Key was statistically significant ($p < 0.05$). Manasota Key also had the highest mean number of individuals per square meter (3635 ± 1175). Manasota Key also had the highest species diversity (Shannon Index) during July (3.67). There was a statistically significant difference ($p < 0.05$) in Shannon Index between Manasota Key and Egmont Key. Equitability (a measure of the evenness of species distribution) was highest at Manasota Key (0.743 ± 0.12). There were no statistical differences in equitability among stations. These findings indicate that Manasota Key sustained a rich and diverse fauna during the present study.

The results support the contention of Osenberg *et al.* (1994) in that relatively few of the population parameters provide adequate power given the time constraints of the study. This indicates that greater emphasis should be placed on individual-based parameters in field assessments of environmental impacts. It will be critical to develop and test predictive models that link these impacts with effects on populations. In order to provide accurate descriptions of temporal variability in the soft-bottom communities of estuaries and coastal embayments, low bias and highly precise estimates from each sampling occasion are required.

Chapter 4

4.1 SUMMARY AND CONCLUSIONS

The objectives of this study were to assess the possible impacts of sand dredging on the benthic communities, both epifaunal and infaunal, and the possible changes to the geology and topography as a result of the dredging operations. To achieve these objectives geophysical and benthic surveys were conducted.

The geophysical surveys included precision depth recording, high resolution seismic reflection profiling, side scan sonar, and box coring for sediment samples. The precision depth recording was the most useful geophysical data collected due to the persistent nature of the excavation left by the dredging operation. On the last cruise in 1994, almost 2 years after dredging and after several storm and frontal system periods the excavation at the Egmont Key Site (Site I) was still clearly visible. It is clear that the excavation was below the local wave base and that even in this shallow system sediment supply is insufficient to quickly hide the dredge scar. There was no significant difference in sediment grain size at Site I comparing pre- and post dredging samples. However, grain size determinations did offer an explanation why wave and current action did not fill the depressions created by the dredging operation with finer grain sediments. The reason for this is that the finer than sand fraction of the sediments is very small for the inner west Florida shelf surficial sand sheet. Therefore, there is no fine fraction to fill the depressions. The variation in the coarser grain sizes is explained by increased amounts of calcium carbonate composed primarily of shell fragments.

The epifaunal community was surveyed by otter trawl and video camera. The epibenthos sampled by otter trawl displayed some seasonal variability. *Portunus gibbesii* and *Mellita tenuis* were the dominant species at both the dredged and undredged sites. There was no detectable difference between pre- and post-dredging at Site I. The underwater video also showed little variability between sites or sampling dates and observations of flora and fauna were rare except for an occasional portunid crab or surface tubes of infaunal species. This reflects the constancy of this very dynamic sand habitat and the low epibenthic diversity.

The infauna was sampled by box corer. The infauna at all sites was much more abundant than the epibenthic fauna. A between site comparison of species richness and diversity pre-dredging indicated healthy, diverse infaunal communities typical of the west Florida coastal zone. There was some variation in the dominant taxa between sites.

As Egmont Key (Site I) was the only site with pre- and post-dredging sampling occurring during the period of study, the infauna analysis focused on this location. Each station at this site underwent different temporal patterns in benthic community composition. Compounding the difficulty of interpreting the data is the observation that the two stations in the dredged area responded quite differently from each other. In general, the control station exhibited much less temporal variability. Therefore, it was not possible to attribute differences between stations solely to dredging.

Temporal natural trends in infauna community parameters were determined from the three sampling dates at the Sarasota site (Site II), which was not dredged. Faunal density and diversity showed peaks in spring and early summer, although there was considerable variability in the pattern.

The Longboat Key site (Site IV) was only sampled post-dredging during this study. Comparison with data from other areas indicates a consistency in faunal composition over time at this site, with infauna exhibiting characteristics common to a well sorted sandy environment typical of the nearshore coastal zone. Because of this consistency, it appears that any effects of dredging at the Longboat Key site were minimal. No dredge hole or pits were observed in the geophysical records. Overall the analysis of the infauna samples indicated that relatively few of the population parameters provided adequate power to detect dredging impacts given the time and spatial constraints of the study. Greater emphasis should be placed on individual-based parameters in field assessments of environmental impacts.

In conclusion, the only demonstrable impact of the dredging from this study was the physical alteration of the bottom topography which persisted almost two years after dredging activities using a clamshell dredge ceased at the Egmont Key site (Site I). There were no observable physical alterations at the Longboat Key site (Site IV) where a dustpan dredge was used.

Chapter 5

5.1 LITERATURE CITED

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