EPA

United States Environmental Protection Agency

Region 4

345 Courtland Street

Atlanta, Georgia 30365

FINAL
ENVIRONMENTAL IMPACT STATEMENT

for

the Designation of an

Ocean Dredged Material Disposal Site

Located Offshore

Miami, Florida

August, 1995

FINAL ENVIRONMENTAL IMPACT STATEMENT FOR DESIGNATION OF AN OCEAN DREDGED MATERIAL DISPOSAL SITE LOCATED OFF MIAMI, FLORIDA

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1.00 SUMMARY

1.01 Major conclusions and findings. Investigations were conducted of the interim-designated ocean dredged material disposal site (ODMDS) and of environmental amenities considered to be within its zone of influence. Physical, chemical, and biological characteristics and their interactive effects were measured. The probable dispersion fate of dredged materials that might be dumped at the site was modeled. All information was compared with relevant provisions of Section 103 of the Marine Protection, Research and Sanctuaries Act of 1972 (MPRSA),as amended. The conclusion is that the interim-designated site is suitable for designation for disposal of dredged material. The site meets all evaluation criteria for use as an ocean dredged material disposal site.

1.02 Areas of controversy. At this time, three areas of controversy have been identified. The State of Florida believes that all ODMDSs should, by rule, be restricted to prohibit the disposal of beach quality sand. In addition, the State of Florida believes that the Miami ODMDS should be restricted to "prohibit the disposal of material with a grain size less than .025 mm and material constituted by more than 10 percent fine grained material." There is also concern regarding the disposal of dredged material from the Miami River in the Miami ODMDS.

1.03 Issues to be resolved. No issues remain unresolved. The issues of 1) prohibition of beach quality sand disposal and 2) prohibition of fine-grained material have been resolved. Their resolution is discussed within this EIS and in the response to comments. Dredged material from the Miami River has not been determined to be suitable for ocean disposal. Only dredged material suitable for ocean disposal will be disposed in the Miami ODMDS. The suitability of dredged material for ocean disposal must be verified by the Corps of Engineers and agreed to by EPA prior to disposal.

1.04 Relationship of alternatives to environmental protection statutes, executive orders, and other requirements. Table 1 presents the status of the alternatives with environmental requirements.

2.00 PURPOSE AND NEED FOR ACTION

2.01 National Environmental Policy Act. The National Environmental Policy Act (NEPA) of 1969, as amended, requires that an Environmental Impact Statement (EIS) be prepared for major federal actions that may significantly affect the quality of the human environment. A major purpose of this EIS is to fulfill the NEPA requirements of two federal agencies. First,

Table 1

Relationship of alternatives to environmental requirements

	NO ACTION	CANDIDATE SITE
FEDERAL STATUTES		
Archeological and Historic Preservation Act, as amended, 16 USC 469, et seq. PL 93-291	F/C*	F/C
Clean Air Act, as amended, 42 USC 1857h-7, et seq. PL 91-604	F/C	F/C
Clean Water Act, as amended, (Federal Water Pollution Control Act) 33 USC 1251, et seq. PL 92-500	F/C	F/C
Coastal Barrier Resources Act, 16 USC 3501 et seq. PL 97-348	N/A**	N/A
Coastal Zone Management Act, as amended, 16 USC 1451, et seq. PL 92-583	F/C	F/C
Endangered Species Act, as amended, 16 USC 1531, et seq. PL 93-205	F/C	F/C
Estuary Protection Act, 16 USC 1221, et seq. PL 90-454	N/A	N/A
Federal Water Project Recreation Act, as amended, 16 USC 460-1(12), et seq. PL 89-72	F/C	F/C
Fish and Wildlife Coordination Act, as amended, 16 USC 661, et seq. PL 85-624	N/A	F/C
Land and Water Conservation Fund Act, as amended, 16 USC 4601-4601-11, et seq. PL 88-578	F/C	F/C
Marine Mammal Protection Act 16 USC 1361, et seq. PL 92-522	F/C	F/C
Marine Protection, Research and Sanctuaries Act, 33 USC 1401, et seq. PL 92-532	F/C	F/C
National Historic Preservation Act, as amended, 16 USC 470a, et seq. PL 89-655	F/C	F/C
National Environmental Policy Act, as amended, 42 USC 4321, et seq. PL 91-190	F/C	F/C
River and Harbor Act, 33 USC 401, et seq.	F/C	F/C
Watershed Protection and Flood Prevention Act, 16 USC 1001, et seq. PL 83-566	N/A	N/A
Wild and Scenic Rivers Act, as amended, 16 USC 1271, et seq. PL 90-542	N/A	N/A
EXECUTIVE ORDERS		
Floodplain Management (EO 11988)	N/A	N/A
Protection of Wetlands (EO 11990)	N/A	N/A
Protection and Enhancement of Environmental Quality (EO 11514, as amended EO 11991)	F/C	F/C
Protection and Enhancement of the Cultural Environment (EO 11593)	N/A	N/A
Federal Compliance with Pollution Control Standards	F/C	F/C
STATE POLICIES		
Florida Coastal Management Program	F/C	F/C

NOTES: For each item listed enter one of the following:
* F/C Full Compliance. Having met all requirements of the statute, EO, or other environmental requirements in the current stage of planning (either pre or post authorization).
** N/A. Not applicable

this EIS carries out the U.S. Environmental Protection Agency's (EPA) policy to prepare voluntary EIS's (30 FR 16186 [May 7, 1984]) as part of the designation process of an Ocean Dredged Material Disposal Site (ODMDS) under Section 102 of the MPRSA. Second, it will satisfy the U.S. Army Corps of Engineers (COE) need for NEPA documentation relating to ocean disposal site suitability for permitting under Section 103 of the MPRSA.

2.02 Marine Protection, Research, and Sanctuaries Act. The dumping of all types of materials into ocean waters is regulated by the MPRSA. Section 102 of the MPRSA authorizes the EPA to designate sites for ocean disposal pursuant to criteria established in this section. EPA's site designation does not by itself authorize any dredging or on-site dumping of dredged material. EPA Ocean Dumping Regulations (40 CFR 220-229) establish procedures and criteria for selection and management of ocean disposal sites and evaluation of permits. Section 103 of the MPRSA authorizes the COE to issue permits for the transportation of dredged material for the purpose of disposal into ocean waters. The purpose of the action is to comply with the provisions of the MPRSA and 40 CFR 220-229 by providing the information required to evaluate the suitability of the proposed site for designation as an ocean disposal site as well as providing information about the site as a viable disposal option required in the COE permitting process. Section 103 evaluation of the dredged material proposed for disposal will still be needed.

2.03 Other needs. The Miami Port Authority and other local interests have requested the COE to provide increased depths in the existing Federal Miami Harbor Project and locally constructed channels to obtain transportation cost savings. Of immediate need is an offshore site for offshore disposal of 5 million cubic yards of material currently being dredged for the Miami Harbor deepening project. An ODMDS could also be used for disposal of material from maintenance dredging of that portion of the Atlantic Intracoastal Waterway (AIWW) in the vicinity of Miami Harbor. However, any proposed material would need a Section 103 evaluation and EPA concurrence prior to ocean disposal.

3.00 ALTERNATIVES

3.01 Non-ocean alternatives. Alternatives to ocean disposal may include upland disposal within the port area, disposal in Biscayne Bay, and beach disposal. Upland disposal in the intensively developed Port of Miami - Biscayne Bay area has not been found feasible. The Port of Miami itself is built partially on fill in Biscayne Bay. Undeveloped areas within cost-effective haul distances are environmentally valuable in their own right.

3.02 Almost all inshore waters of the Biscayne Bay area are part of the Biscayne Bay Aquatic Preserve (see Figure 5). The waters of the southern portion of Biscayne Bay, now included in the Aquatic Preserve, are to be incorporated, along with some offshore waters, into the Biscayne National Park in the near future. The Florida Department of Environmental Regulation (DER) has afforded the waters of these areas special protection as Outstanding Florida Waters. This effectively removes virtually all of the Biscayne Bay area from consideration for disposal of dredged material.

3.03 The use of suitable dredged material for beach disposal is usually the preferred disposal alternative for all dredging projects. Consequently, the placement of beach quality material in the Miami ODMDS is subject to agreement between the State of Florida and the US Army Corps of Engineers as described in a dredged material disposal plan. Suitable rock might be placed in nearshore waters. These options are feasible only where a substantial quantity of the desired type of material is separable from silt or other undesirable material.

3.04 Maintenance dredging of Miami Harbor has been performed four recorded times: In 1957, 1960, 1968, and 1985. Each time, dredged material was disposed in the ocean, about one nautical mile (nmi) west of the candidate site.

3.05 The COE has been authorized to deepen Miami Harbor. For that project, environmental and economic analyses were performed and an EIS was prepared. The COE examined and documented the feasibility of each of the above-described disposal options and found none to be feasible. However, the COE agreed to make further analyses during preconstruction engineering and design of the project to determine whether rock dredged from the channels might be separable for use in creating nearshore marine habitat.

3.06. Alternative sites on the continental shelf. In the Miami nearshore area, hardgrounds supporting coral and algal communities are concentrated on the continental shelf. Disposal operations on the shelf could adversely impact this reef habitat. Because the shelf is narrow, about 3.3 nmi (6 km) off Government Cut, the transport of dredged materials for disposal beyond the shelf is both practical and economically feasible. Therefore, alternative sites on the continental shelf are not desirable.

3.07 Designated interim site (candidate site). The preferred alternative considered in this document is the final designation of an ODMDS. This site is an area of approximately one square nautical mile with the following corner coordinates: 25~45'30"N, 80~03'54"W; 25~45'30"N, 80~02'50"W; 25~44'30"N, 80~02'50"W;

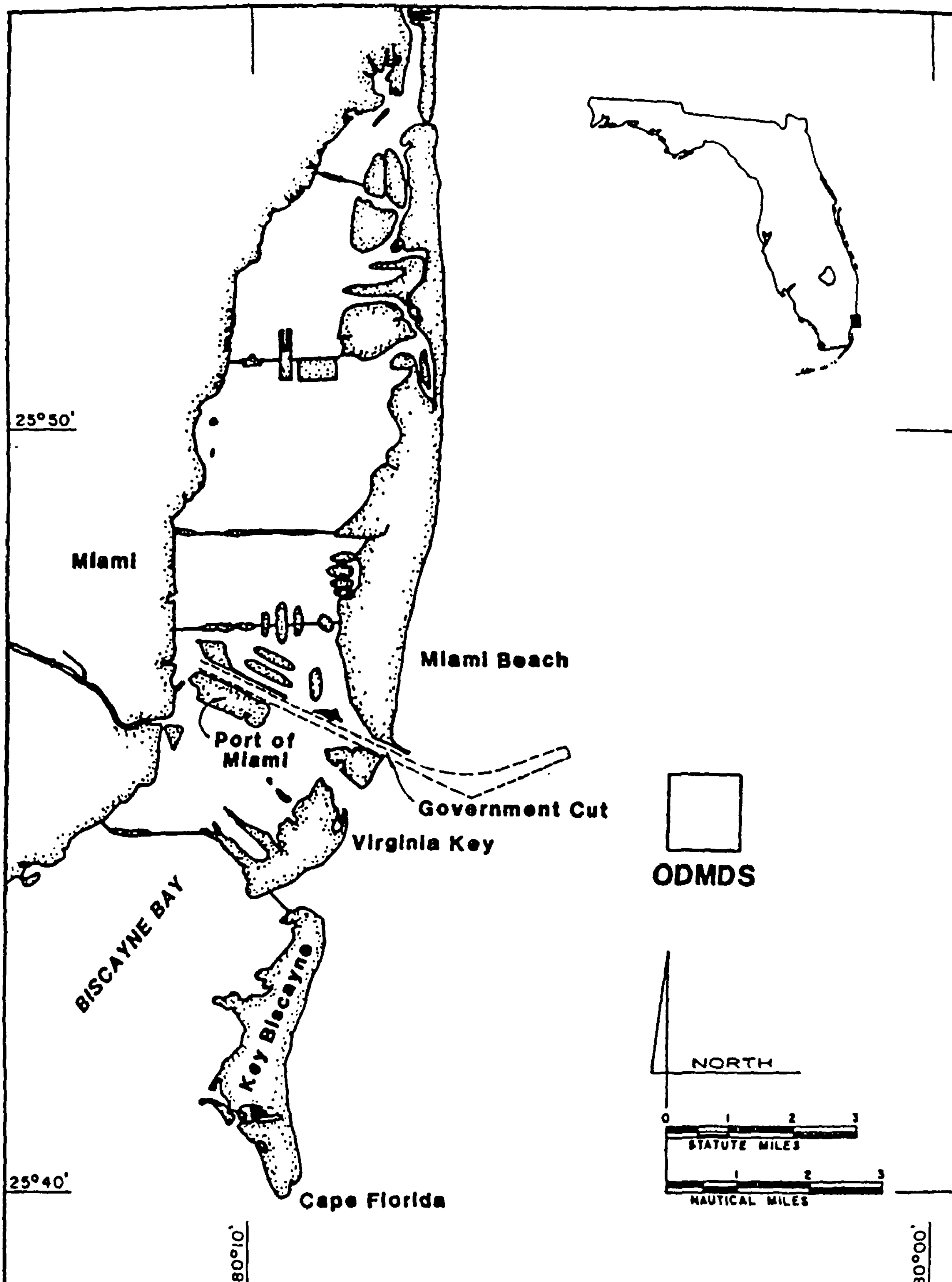

FIGURE 1

GENERAL LOCATION MAP

Ocean Dredged Material Disposal Site Miami, Florida

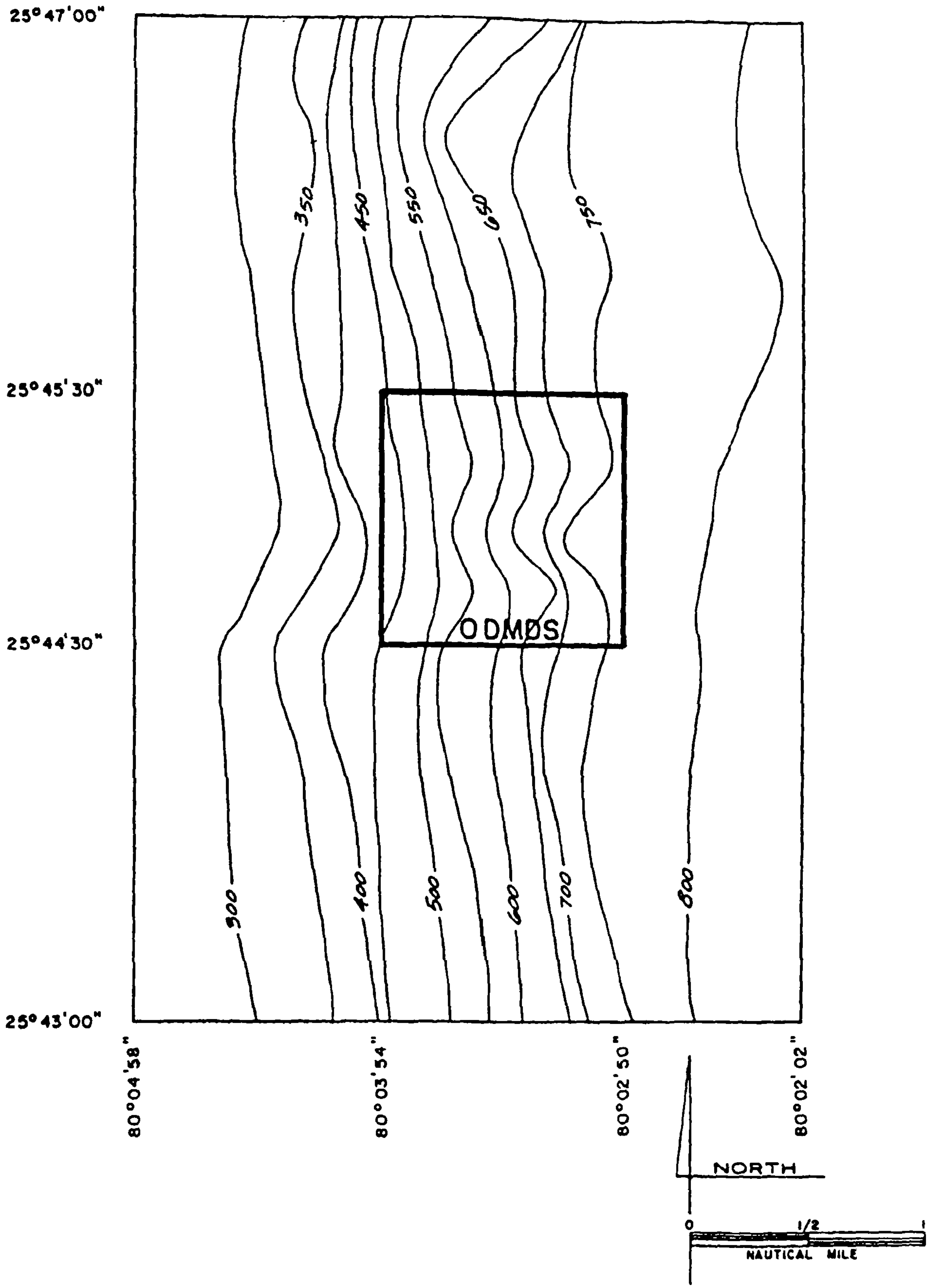

FIGURE 2

BATHYMETRIC MAP

Ocean Dredged Material Disposal Site Miami, Florida

25-44'30"N, 80-03'54"W. The site is centered at: 25°45'00"N and 80°03'22"W. This site is considered suitable in terms of practicality and economic feasibility. Sections 228.5 and 228.6 of EPA's Ocean Dumping Regulations and Criteria 40 CFR establish criteria for the evaluation of ocean disposal sites. The extent to which the candidate site meets these criteria is addressed in Section 5.00 (Environmental Effects) of this document.

3.08 Alternative sites beyond the continental shelf. The center of the Gulf Stream lies about 15 nmiles offshore of Miami (Section 4.00). Dumping in the center of the Gulf Stream was considered, but the enormous task and expense of monitoring disposal under such conditions caused sufficient concern to eliminate that option.

3.09 No action. Under the "no action" alternative, the interim site would not receive final designation and the Miami area would have no EPA-designated ODMDS.

3.10 Proposed action. The proposed action is to designate the interim ODMDS as a permanent dredged material disposal site. The site will be managed and monitored according to the approved Site Management and Monitoring Plan (SMMP).

4.00 AFFECTED ENVIRONMENT

4.01 Introduction. This chapter describes the environmental characteristics of the area that may be affected by the disposal of dredged materials at the proposed Miami ODMDS. A general location map of the area is presented as Figure 1. The information contained in this chapter was drawn from previous surveys, interviews with local regulatory agency personnel, individuals knowledgeable about the area, and from a survey of the disposal site environment conducted in January 1986, by Conservation Consultants, Inc., (CCI) and described in Appendix A, and from a dispersion characteristic evaluation by the U.S. Army Corps of Engineers Waterways Experiment Station (WES) presented in Appendix B.

4.02 Geological characteristics. The proposed Miami ODMDS is situated on the continental slope. Depths at the site range from about 427 to 785 feet (130 to 239 m). The depth at the center of the site is approximately 625 feet (191 m). The average declivity of the slope at the ODMDS is approximately 325 feet (100 m) per nautical mile (1.85 km). A bathymetric map of the area is presented as Figure 2.

4.03 A January 1986 survey (Appendix A) found surficial sediments in the proposed ODMDS vicinity to be comprised primarily of very fine sands and coarse silt. Sediments are well sorted and relatively uniform throughout the area. An underwater video survey conducted at the same time visually confirmed this.

4.04 Tides and currents. Over most continental shelves, circulation is primarily governed by tides and winds. Off the southeast coast of Florida, circulation is also strongly influenced by the nearby Florida Current. The Florida Current is that portion of the Gulf Stream system that connects the Loop Current in the Gulf of Mexico to the Gulf Stream as it proceeds through the Straits of Florida and into the open Atlantic Ocean (Lee, et al., 1977). The degree of coastal influence exerted by this current is quite variable and reflects the dynamic nature of the Gulf Stream system.

4.05 The Florida Current influences coastal circulation on the southeast Florida Shelf in two ways, depending on the degree of intrusion of this current over the continental shelf (EPA, 1973). When the western edge of the Florida Current is over the shelf, the current draws the coastal waters north, though velocities may be considerably reduced due to bottom friction. When the western edge of the Florida Current is seaward of the continental shelf, cyclonic spin-off eddies are formed. These eddies with an average diameter of 10 to 30 km, are carried north, but cyclonic currents inside the eddies may control local current patterns. Meanders of the Florida Current and eddy formation may be mutually related to atmospheric forces (Lee, et al., 1977).

4.06 Following their formation, spin-off eddies travel northward along the continental margin at speeds ranging from 20 to 50 cm/sec. At these rates, it generally takes less than one day for an eddy to pass a fixed point (Lee, et al., 1977). Eddies occur on the average of once per week and can be recognized as disruptions of prevailing temperature and salinity fields and of local current patterns (Lee and Mayer, 1977). These cyclonic eddies play an important role in coastal exchange processes, removing coastal water and replacing it with waters from the Florida Current.

4.07 The proposed Miami ODMDS lies near the western edge of the Florida Current. Horizontal meanders result in fluctuations of about 2.6 nmi (4.8 km) in the location of the western edge of the current that, on the average, lies 3.2 nmi (5.9 km) east of Virginia Key (EPA, 1973). The center of the proposed ODMDS is located 4.7 nmi (8.7 km) east of Virginia Key.

4.08 Ocean currents in the vicinity of the proposed site are generally along the north-south axis. The predominant direction of flow is to the north. Current speeds are highest in surface waters, decreasing to near zero at the bottom. Mean current speeds in surface waters at the candidate site range from a low of 62 cm/sec in the winter to about 95 cm/sec in the spring and summer (Lee et al., 1977). Maximum surface currents are about 150 cm/sec to the north and 50 cm/sec to the south (Lee and Mooers, 1977). Current speeds are lower and north-south reversals are more common in near-bottom waters. Lee and Mooers (1977) report a mean northerly flow in near-bottom waters in the proposed ODMDS vicinity of 3.5 cm/sec, with maximum flows of 27 cm/sec to the north and 23 cm/sec to the south.

4.09 Tidal currents in the proposed disposal site vicinity are also directed along the north-south axis. Measurements taken in approximately 175 meters water depth show semi-diurnal tides with amplitudes ranging from 10 to 20 cm/sec in near-bottom (10 meters above the bottom) waters (Lee and Mooers, 1977).

4.10 <u>Water temperature</u>. EPA (1973) reports surface water temperatures for the coastal region off Miami ranging from a low of 19~C in February to a high of 30~C in July. Over the continental shelf the water column is generally well mixed from mid-August to late April. Thermal stratification begins to appear in April and continues through mid-August. EPA (1973) reports vertical temperature variation in the summer of up to 11~C at the 90 ft. (27 m) depth contour.

4.11 Lee and Mooers (1977) report annual mean water temperatures for the offshore area in the proposed disposal site vicinity ranging from 26~C at the surface, to 21~C at 100 m (328 ft.), and approaching 10~C at a depth of 200 m (656 ft.). These authors also cite Brooks (1975) who reports two years of temperature data collected from a station located about 5.5 nmi (10 km) south of the proposed ODMDS in waters of a similar depth (689 ft.; 210 m). Mean seasonal surface water temperatures varied from 24 to 29~C, while bottom waters ranged from 7.9 to 13.5~C. Seasonal surface-to-bottom thermal gradients ranged from about 14~ to 18~C. Lowest bottom water temperatures appear to occur in the summer in the proposed disposal site vicinity (Lee and Mooers, 1977). This phenomenon is thought to reflect both the seasonal wind-induced upwelling of cooler waters over the slope and the increased volume transport of the Florida Current in the summer.

4.12 A January 1986 survey of the proposed disposal site vicinity (Appendix A) found waters to be generally isothermal to a depth of 220 ft. (67 m). Temperatures recorded during this survey ranged from 22.3 to 23.3~C., but the survey did not reach the reported winter pycnocline depth of 325 feet.

4.13 Salinity gradients. Salinity in the proposed disposal area ranges from approximately 33 to 37 parts per thousand (ppt) and averages about 35.6 ppt (EPA, 1973). Subsurface core waters of the Florida Current generally range from 36.2 to 36.6 ppt (CH2M Hill, 1985). Surface waters of the Florida Current occasionally exhibit reduced salinities as a result of the entrainment of fresh water from the Mississippi River system by the Gulf Loop Current during periods of increased river flow (U.S. Department of the Interior {DOI}, 1977).

4.14 A January 1986 survey of the proposed ODMDS vicinity (Appendix A) recorded salinities ranging from 35.5 to 36.8 ppt. No vertical salinity stratification was apparent in the upper 220 ft. (67 m) of the water column. Only minor salinity gradients are expected to occur in the area.

4.15 The density of seawater in the proposed disposal site vicinity, based on average salinity and temperature values, averages 1.024 grams per cubic centimeter (gms/cc) (EPA, 1973). The average depth of the pycnocline varies seasonally from approximately 60 ft. (18 m) in the summer to about 150 ft. (46 m) in the winter (Marble and Mowell, 1971; in EPA, 1973). An EPA (1973) winter reconnaissance survey found the pycnocline off Miami at a depth of about 325 ft. (99 m). Densities recorded during this EPA survey ranged from 1.0236 gms/cc at the surface to 1.0260 gms/cc to a depth of 380 ft. (116 m).

4.16 Physical and chemical characteristics. Chemical and physico-chemical water quality parameters that are relevant to this ODMDS evaluation include dissolved oxygen (DO), suspended solids, turbidity, trace metals, pesticides, polychlorinated biphenyls (PCBs), and high molecular weight (HMW) hydrocarbons.

4.17 Waters in the vicinity of the disposal site are believed to be well oxygenated throughout the year. The DOI (1977) reports average surface DO concentrations of between 6 and 7.2 ppm for waters of the southeast Atlantic coast shelf and slope. Studies conducted at inshore locations in the general area have found DO levels to be near saturation throughout the year (Smith et al., 1950; Voss and Voss, 1955).

4.18 EPA (1973) reports DO concentrations averaging about 6.8 ppm and ranging from 91 to 105 percent of saturation for a winter survey conducted on the continental shelf off Dade County. Little DO variation was observed in the upper portion of the water column. A survey conducted at the proposed ODMDS in January, 1986 (Appendix A) measured DO concentrations ranging from 7.9 to 8.5 ppm. No vertical stratification was observed in the upper 220 ft. (67 m) of the water column. Site waters during this 1986 survey were supersaturated (115 to 121 percent) with oxygen.

4.19 Suspended solids concentrations measured in surface and bottom waters of the disposal area in January 1986 (Appendix A) ranged from 11 mg/l to less than 5 mg/l. No horizontal or vertical patterns of distribution were noted.

4.20 Turbidity is defined as the optical property of a sample which causes light to be scattered and absorbed rather than transmitted in straight lines. Turbidity is commonly measured with a nephelometer, which measures scattered light, and is reported in NTUs (nephelometric turbidity units). Turbidity samples were collected from surface and bottom waters at stations in the ODMDS vicinity in January, 1986 (see Appendix A). Turbidity values ranged from 4 to 9 NTU. Turbidity levels were comparable throughout the area and no consistent differences between surface and bottom waters were found.

4.21 In January 1986, water quality samples were collected from surface and near-bottom waters in the proposed Miami ODMDS vicinity to determine ambient concentrations of selected contaminants. Specific groups of compounds analyzed included trace metals, pesticides, pesticide derivatives, PCBs, and HMW hydrocarbons. The results of these analyses are summarized below and are detailed in Appendix A.

4.22 Mercury, cadmium, and lead were the trace metals selected for analysis. Cadmium was not found at detectable levels in surface waters, but was detected in near-bottom waters at two of seven water quality sampling stations in the disposal site area. Lead was only present at detectable levels in one of seven surface water samples collected from the area. Mercury was not detected in either surface or near-bottom water samples.

4.23 Levels of pesticides, pesticide derivatives, PCBs, and HMW hydrocarbons were below analytical detection limits in all surface and near-bottom water samples collected from the area.

4.24 Sediment quality samples from the proposed ODMDS vicinity were collected in December 1985 and analyzed to determine concentrations of selected trace metals, pesticides, pesticide derivatives, PCBs, HMW hydrocarbons, total organic carbon (TOC), and oil and grease. The results of these analyses are summarized below and are detailed in Appendix A.

4.25 Ambient concentrations of the trace metals (mercury, cadmium, and lead) are low in area sediments. No chlorinated hydrocarbon pesticides, pesticide derivatives, or PCBs were detected.

4.26 Concentrations of HMW hydrocarbons in the sediment samples varied considerably. Lowest levels were found at stations located north (downstream) of the ODMDS. Highest total HMW hydrocarbon concentrations were measured in sediments collected from stations located within and south (upstream) of the ODMDS. In general, component HMW hydrocarbon fractions exhibited no definitive spatial trends. Highest unresolved hydrocarbon concentrations were measured in sediment samples collected from stations within the proposed disposal site.

4.27 Oil and grease concentrations in area sediments ranged from 12 to 41 ug/g. No apparent pattern of distribution was noted.

4.28 TOC concentrations in area sediments ranged from 11 to 18 mg/g. No trends in the distribution of TOC concentrations over the area were observed.

4.29 Biological characteristics. The biological communities addressed in this section are the benthic macroinfauna, benthic meiofauna, epibenthic invertebrates, and fish. Species of special concern which may utilize the proposed ODMDS vicinity are also addressed. Biota restricted to the benthic environment are of principal concern in disposal site investigations. Disposal impacts on planktonic communities are generally considered to be temporary, while larger, motile organisms (nekton) are able to avoid disposal operations and localized areas of poor water quality.

4.30 The benthic macroinfauna of the study area are dominated by polychaete worms and amphipod crustaceans. Results from a January 1986 survey (Appendix A) of the candidate site vicinity found that polychaetes accounted for 37 percent, and amphipods 33 percent of total benthic community numbers. Molluscs and nematodes were also common and comprised 14 percent and 9 percent of the area's macroinfaunal assemblage, respectively.

4.31 The amphipod family Ampeliscidae was the most abundant macroinvertebrate family represented in samples from the proposed ODMDS vicinity (Appendix A). Polychaete families characteristic of the area included Cirratulidae, Spionidae, Orbiniidae, and Ampharetidae. Molluscs belonging to the families Thyasiridae and Nuculidae were also common in the area.

4.32. The most abundant species at most sites in the disposal area was found to be the tube-dwelling amphipod, Ampelisca agassizi. This species is abundant on and characteristic of the upper continental slope off the southeastern U.S. (Boesch, 1977; in EPA, 1983).

4.33 Faunal similarity indices indicate that the benthic community throughout the proposed ODMDS vicinity is relatively similar in composition. Cluster analyses did not reveal differences between stations in the proposed ODMDS and those located upstream and downstream. Faunal dissimilarities attributed to depth were observed. These dissimilarities, however, were not apparent over the range of depths encountered at the disposal site.

4.34 The meiofauna of the proposed ODMDS vicinity are described from a survey conducted in January 1986 and reported in Appendix A. Nematode worms were found to dominate the meiofaunal assemblage of the area. Nematodes accounted for 94 percent of the meiofauna collected from the proposed ODMDS vicinity. Harpacticoid copepods, larval polychaetes, and turbellarians, while common, were never abundant.

4.35 Nematodes typically dominate the marine meiobenthos. Pequegnat et al. (1981) observe that, in most marine sediments, nematode worms account for 90 percent or more of the meiofaunal community.

4.36 Epibenthic invertebrates were collected by trawl from the disposal site vicinity in January 1986 (Appendix A). The most abundant invertebrates collected from the area were pink shrimp (Penaeus duorarum) and the lobster-like, galatheid crustacean (Munida irrasa). Other invertebrates represented in trawl samples were Jonah crabs (Cancer borealis), rock crabs (Cancer irroratus), spider crabs (Nibilia antilocapra), portunid crabs (Portunus spinicarpus and Ovalipes sp.), squid (Rossia tenera), and hermit crabs (Paguridae sp.).

4.37 Demersal fish were collected in a January 1986 survey of the ODMDS vicinity (Appendix A). The most abundant fish at all trawl stations in the area was the largescale tonguefish (Symphurus minor). Other fish species frequently represented in samples include the longspine scorpionfish (Pontinus longispinus), freckled skate (Raja lentignosa), horned searobin (Bellator militaris), and spotted hake (Urophycis regius).

4.38 The distribution of fish over the area appears to be variable and may be related to depth. Fish density was highest at the shallowest of the sampling sites and decreased with increasing station depth.

4.39 Threatened or endangered species. Marine species classified by the U.S. Fish and Wildlife Service (FWS) and/or

National Marine Fisheries Service (NMFS) as endangered or threatened and found in shore or coastal waters off Miami are listed in Table 2.

4.40 This EIS will serve as a Biological Assessment for purposes of Section 7 of the Endangered Species Act coordination. Site designation of the Miami ODMDS will not, and use of this site is not expected to adversely impact any threatened or endangered species. In a letter dated October 14, 1994, the National Marine Fisheries Service determined that populations of endangered/threatened species under their purview would not be adversely affected by the designation and use of the proposed ODMDS. A copy of the letter is included Section 7.03 of this document.

Table 2. Species of the Miami ODMDS Area Classified as Endangered or Threatened by Federal Agencies.

Common Name	Scientific Name	Status
REPTILES		
Green turtle	Chelonia mydas	T
Hawksbill turtle	Eretmochelys imbricata	E
Kemp's ridley turtle	Lepidochelys kempii	E
Leatherback turtle	Dermochelys coriacea	E
Loggerhead turtle	Caretta caretta	T
MAMMALS		
West Indian manatee	Trichechus manatus	E
Finback whale	Balaenoptera physalus	E
Humpback whale	Megaptera novaeangliae	E
Right whale	Eubalaena glacialis	E
Sei whale	Balaenoptera borealis	E
Sperm whale	Physeter macrocephalus (catodon)	E

Legend: E = Endangered
T = Threatened

4.41 Commercial fisheries. The proposed Miami ODMDS does not support significant commercial fishery resources. While pelagic species may utilize the area, heaviest commercial fishing pressure is concentrated in inshore waters or at offshore natural and artificial reefs.

4.42 Bait shrimp and mullet are the principal commercial species taken from inshore waters (Heald, 1970). Major species taken in offshore waters are red snapper, yellowtail snapper, groupers, king mackerel, spanish mackerel, and spiny lobster.

4.43 While commercial shrimping is not conducted in the proposed ODMDS vicinity, the inshore waters of Biscayne Bay have been identified as a nursery area for pink shrimp (Bielsa et al., 1983). A January 1986 survey of the disposal area (Appendix A), found pink shrimp to be relatively common at one trawl station within the proposed ODMDS. Greatest concentrations of pink shrimp occur inshore of the proposed disposal site at depths of less than 144 ft. (44 m) (Kutkuhn, 1962, in Bielsa et al., 1983). Shrimp are most common in deeper waters in the winter. Pink shrimp utilization of the disposal area is not expected to be high and is probably restricted to the winter. Depths at the candidate site exceed the maximum depths of occurrence previously reported for this species (Bureau of Commercial Fisheries, 1962; in Bielsa et al., 1983).

4.44 Recreational fishing. Like the commercial fishery, recreational fishing in the waters off Dade County is concentrated inshore or at offshore natural and artificial reefs. The natural reef areas are shown in Figure 3. The artificial reefs are shown on Figure 4 and described in Table 3. The candidate disposal site is not located in or near areas used for recreational fishing.

4.45 Other recreation. Dade County's waters support a wide variety of recreational activities. Fishing has been addressed previously in this document. Coastal waters are also used for swimming, skiing, sailing, boating, surfing, skin diving, and SCUBA diving. Few of these activities occur in, and none is restricted to, the proposed ODMDS.

4.46 Shipping. The proposed Miami ODMDS is located just to the south and approximately 1.3 nmi (2.4 km) seaward of the entrance channel to the Port of Miami through Government Cut. While there are no designated shipping lanes beyond the entrance channel, the general area experiences heavy commercial shipping traffic.

4.47 Military usage. While the Atlantic Ocean off Miami may be used by the United States armed forces for training, testing, and research activities, the proposed ODMDS does not lie within any designated fleet operating area as identified by the DOI (1977).

4.48 Mineral resources. There are no known mineral resources in the proposed Miami ODMDS vicinity.

4.49 Underwater video narrative. A video survey of the proposed Miami Harbor Ocean Dredged Material Disposal Site (ODMDS) was done on January 25 and 26, 1986. Depths at the site ranged from about 400 feet on the western (shoreward) edge to nearly 800 feet on the eastern (seaward) edge. Approximately 18 hours (9 2-hour videos) of film were used to record the survey. Four transects were run, one on the shoreward edge of the site (V-1), one approximately in the middle of the site (V-2), one on the eastern edge (V-3) and one beginning in the southwest corner and ending at the northeast corner (V-4). The video was continuous along each transect.

4.50 The tapes show that the entire disposal area exhibits a consistent pattern, regardless of depth. Much of the bottom appears to be covered by a fine, silty material, easily put into suspension by the actions of organisms startled into movement by the video equipment. No evidence of hard bottom was seen in any part of the proposed site. The area is sparsely populated by burrowing organisms, sea urchins, crabs, shrimp, small demersal fishes and other invertebrates. There is no visible plant life growing on the bottom and the energy base of this community is apparently sedimentary.

5.00 ENVIRONMENTAL EFFECTS

5.01 Introduction. Criteria promulgated in 40 CFR, Sections 228.5 and 228.6, deal with the evaluation of ocean disposal locations and requirements for effective management to prevent unreasonable degradation of the marine environment. These criteria have been used as the basis of an environmental assessment of impacts at the candidate site. Criteria in 40 CFR 228.5 are titled "General criteria for the selection of sites," and those in 228.6 are titled "Specific criteria for site selection". Evaluation of the proposed Miami ODMDS utilized the literature base, interviews, and baseline data collected at the site (CCI, 1985) to assess compliance with both the general and the specific criteria of 40 CFR. Table 4 summarizes the application of the specific criteria to the site. Each of the general and specific criteria is addressed in this section as it relates to the site's suitability as a disposal site.

5.02 Geographical position, depth of water, bottom topography and distance from coast [40 CFR 228.6(a)1]. The proposed Miami interim ODMDS is approximately a one square nautical mile area with the following corner coordinates:

(NW)	25~45'30" N 80~03'54" W	(NE)	25~45'30" N 80~02'50" W
(SW)	25~44'30" N 80~03'54" W	(SE)	25~44'30" N 80~02'50" W

The center coordinates are: 25°45'00"N and 80°03'22"W. The general location of the candidate site is shown on Figure 1. The shoreward boundary of the disposal site is located approximately 3.6 nmi (6.7 km) from shore.

5.03 The proposed ODMDS is situated on the continental slope. Depths at the site range from about 427 to 785 ft (130 to 239 m). The average declivity of the slope at the ODMDS is approximately 325 ft (100 m) per nautical mile (1.85 km).

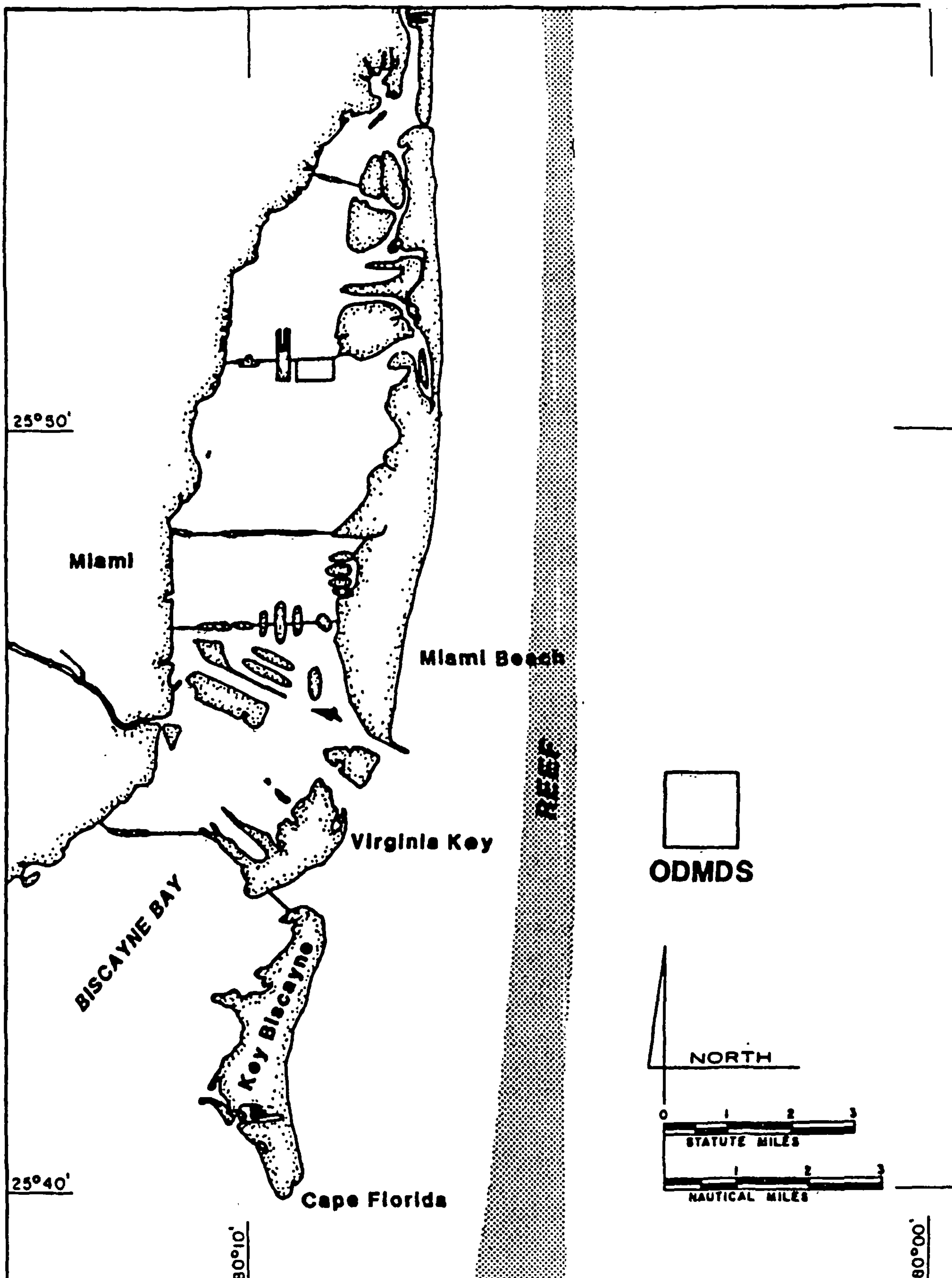

FIGURE 3

NATURAL REEF AREAS

Ocean Dredged Material Disposal Site Miami, Florida

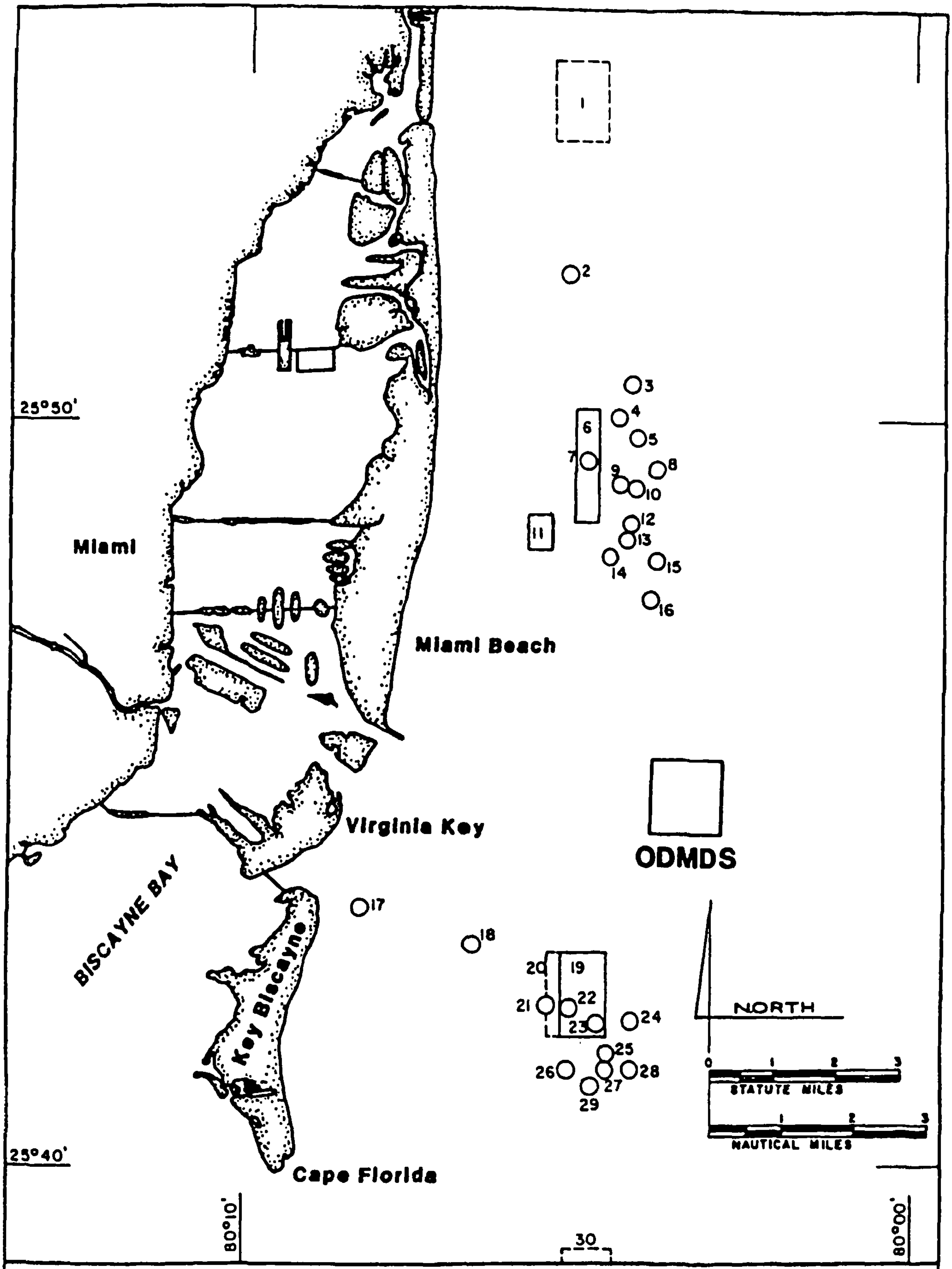

FIGURE 4

PROPOSED SITES
ACTIVE SITES

ARTIFICIAL REEF SITES

Ocean Dredged Material Disposal Site Miami, Florida

Tat   Artificial Reef Sites in the Proposed Miami ODMDS Vicinity.

Fig. No.		Year	Latitude (N)	Longitude (W)	Depth (Ft.)	Composition	Reference**
1	Proposed	----	25°54'00"*	80°05'00"*	50-450	------	3
2	Crane Boom	1947	25°54'00"	80°05'00"	70-85	Crane Boom	2
3	Fireboat	1973	25°50'31"	80°04'02"	222	Steel Tug	2
4	Mine Sweeper	1971	25°50'01"	80°04'14"	180	Minesweeper	2
5	Lotus	1971	25°49'54"	80°04'00"	216	Coast Guard Tender	2
6	Pflueger Site	----	25°49'30"*	80°04'54"*	75-225	Unspecified	3
7	No Name	----	25°49'34"	80°04'54"	125-250	Metal, Concrete, Ships	1
7	Hopper Barge	1971	25°49'34"	80°04'54"	234	175' Metal Barge	4
7	San Rapael	1980	25°49'34"	80°04'54"	330	200' Steel Freighter	4
7	Ostwind	1989	25°49'34"	80°04'54"	275-	80' Steel Hull	4
8	Walka Q	1980	25°49'22"	80°03'50"	282	Steel Freighter	2
9	Pimellons	1971	25°49'06"	80°04'11"	135	Steel Ferry	2
10	West End	1973	25°49'05"	80°04'01"	228	Landing Craft	2
11	Billy's Barge	1987	25°48'42"	80°05'40"	48	100' Barge	3
11	Anchorage Reef	1987	25°48'42"	80°05'40"	45	6 Concrete 90' Girders	4
						& 1120 tons Concrete Pipe	4
11	Cote Reef	1990	25°48'42"	80°05'40"	45	Concrete/Tanks	4
11	Coquina	1987	25°48'42"	80°05'40"	44	55' Steel Cargo Ship	4
11	Miss Karline	1989	25°48'42"	80°05'40"	51	85' Steel Ship	4
11	Shamrock	1985	25°48'42"	80°05'40"	44	120' Steel LCT	4
11	LandsEnd, Mary Ann	1984	25°48'42"	80°05'40"	46	2 vessels	4
11	Pyramid Reef	1988	25°48'42"	80°05'40"	50	19 Radio Antenna	4
11	Esjoo	1987	25°48'42"	80°05'40"	51	70' Steel Cargo Ship	4
11	Patricia	1990	25°48'42"	80°05'40"	53	65' Steel Tug	4
11	Leon's Barge	1988	25°48'42"	80°05'40"	50	100' Barge	4
11	John Koppin Mem.	1986	25°48'42"	80°05'40"	45	75' Steel Barge, concrete	4
12	LCI	1969	25°48'42"	80°04'03"	202	Landing Craft	2
13	Pipes	1978	25°48'33"	80°04'02"	204	Scrap Steel, Rubble	2
14	Deep Freeze	1976	25°48'21"	80°04'23"	120	Transport Vessel	2
15	Dry Dock	1978	25°48'19"	80°03'43"	330	Pontoon Dock	2
16	Hopper Barge	1970	25°47'18"	80°03'54"	234	Metal Barge	2
17	Bear Cut	----	25°43'30"	80°08'05"	6-10	Barge	2
18	No Name	----	25°43'00"	80°06'30"	21	Autos	1
19	Key Biscayne Site	----	25°42'30"*	80°05'00"*	75-350*	Unspecified	3
20	Proposed	----	25°42'30"*	80°05'20"*	50-75*	------	3
21	Biscayne Wreck	1976	25°42'08"	80°05'17"	55	Freighter	2
22	Shrimp Drift-Boats	1981	25°42'09"	80°05'10"	55-100	Vessels	2
23	No Name	----	25°42'04"	80°04'24"	220	Concrete Rubble	1
24	Dade County Reef	1977	25°42'00"	80°04'06"	220	Concrete Rubble	2
25	Arida	1982	25°41'43"	80°04'24"	90	Steel Vessel	2
26	Orion	1981	25°41'26"	80°05'03"	95-100	Steel Tug	2
26	Belzona One	1990	25°42'04"	80°05'21"	68	85' Steel Tug	4
26	Mystic Isle	1986	25°42'04"	80°05'21"	185	103' Steel Ferry	4
26	Rio Miami	1989	25°42'04"	80°05'21"	67	105' Steel Tug	4
26	Miracle Express	1987	25°42'04"	80°05'21"	55	100' Steel Freighter	4
26	Key Biscayne Reef	1986	25°42'04"	80°05'21"	135	850 Tons of Bridge Girders	4
26	Sarah Jane, Drift Boats	1981	25°42'04"	80°05'21"	100	7 vessels (4 wood, 3 steel)	4
26	South Seas	1983	25°42'04"	80°05'21"	73	175' Steel Yacht	4
26	Grouper Site	1987	25°42'04"	80°05'21"	35	50 Modules	4
26	Proteus	1985	25°42'04"	80°05'21"	72	220' Steel Freighter	4
26	Sheri-Lynn	1987	25°42'04"	80°05'21"	96	235' Ship	4
26	Dade County Reef	1977	25°42'04"	80°05'21"	220	Concrete Rubble	4
26	Belcher Barge #27	1985	25°42'04"	80°05'21"	58	195' Steel Barge	4
26	Big Lou	1989	25°42'04"	80°05'21"	55	36' Steel Hull	4
27	Lakeland	1982	25°41'29"	80°04'23"	126-140	Steel Ship, Midwater Reefs	2
28	Star Trek	1982	25°41'28"	80°04'01"	205-210	Steel Ship, Midwater Reefs	2
29	Cement Mixer	1982	25°41'05"	80°04'47"	75-88	Twenty Cement Mixer Bowls	2
30	Proposed	----	25°37'00"*	80°05'00"*	60-350*	------	3

* Approximate locations and depths (from charts).

** 1. Florida Sea Grant. 1979. Recreational use reefs in Florida, artificial and natural. Sea Grant Advisory Bulletin MAP-9. Florida Sea Grant.

2. Aska, D.Y. and D.W. Pybas. 1983. Atlas of artificial reefs in Florida. Sea Grant Advisory Bulletin MAP-30. Florida Sea Grant.
3. Metropolitan Dade County Department of Environmental Resources Management. No date. Artificial reef program Metropolitan Dade County.
4. Florida Sea Grant. 1991. Atlas of Artificial Reefs in Florida - 4th Ed.

5.04 Location in relation to breeding, spawning, nursery, feeding or passage areas of living resources in adult or juvenile phases [40 CFR 228.6(a)2]. The most active breeding and nursery areas are located in inshore waters, along adjacent beaches, or in nearshore reef areas. While breeding, spawning, and feeding activities may take place near the proposed ODMDS, these activities are not believed to be confined to, or concentrated in, this area.

5.05 While many marine species pass through the proposed ODMDS, passage is not geographically restricted to this area. The probability of significant impact from dredged material disposal is directly related to the motility of these organisms.

5.06 Location in relation to beaches and other amenity areas [40 CFR 228.6(a)3]. Beaches and inshore resources are outside the area to be affected by disposal in the proposed ODMDS. These amenities areas lie approximately 3.6 nmi (6.7 km) inshore of the designated disposal site.

5.07 Several protected areas, shown in Figure 5, lie inshore of the candidate disposal site. The Biscayne Bay Aquatic Preserve encompasses almost all of the inshore waters in the area. The waters of the southern portion of Biscayne Bay as well as some offshore waters are expected to be incorporated into Biscayne National Park in the near future. The Bill Baggs Cape Florida State Recreational Area is located on the southern tip of Key Biscayne. The Florida Department of Environmental Regulation (FDER) has afforded the waters associated with each of these areas special protection as Outstanding Florida Waters.

5.08 Both natural and artificial reef sites are found in the proposed Miami ODMDS vicinity. Natural hardground reefs occur primarily at depths ranging from 20 to 100 ft (6 to 30m). The seaward extent of the natural reef zone in the area lies approximately 1.3 nmi (2.4 km) inshore of the west side of the interim disposal site. Two concentrations of artificial reef sites are also located in the area. One group of artificial reef sites is located about 3.3 nmi (6.1 km) north and slightly inshore of the proposed ODMDS and another cluster of sites is located 1.7 nmi (3.2 km) south and inshore of the proposed disposal site.

5.09 Types and quantities of waste to be disposed of, and proposed methods of release, including methods of packing the waste, if any (40 CFR 228.6(a)4). The only material to be disposed in the ODMDS will be dredged material that complies with EPA Ocean Dumping Regulations (40 CFR 220-229). The site is expected to be used for routine maintenance of the authorized Federal channels and the Miami Harbor deepening project. It is estimated that 5 million cubic yards of material will be disposed from the deepening project.

5.10 Feasibility of surveillance and monitoring (40 CFR 228.6(a)(5)). Bottom contours in the area can be monitored through bathymetric survey methods. Monitoring of the proposed Miami ODMDS is discussed further in the Site Management and Monitoring Plan (SMMP) provided in Appendix C. This SMMP is intended to be flexible and may be modified by the responsible agency for cause.

5.11 Dispersal, horizontal transport, and vertical mixing characteristics of the area, including prevailing current direction and velocity, if any (40 CFR 228.6(a)6). Circulation off the southeast coast of Florida is primarily influenced by the Florida Current. The Florida Current is that portion of the Gulf Stream system which connects the Loop Current of the Gulf of Mexico to the Gulf Stream as it proceeds through the Straits of Florida and into the open Atlantic Ocean (Lee et al., 1977). The proposed Miami ODMDS lies near the western edge of the Florida Current.

5.12 The Florida Current is a highly variable and dynamic current system. Horizontal meanders result in fluctuations of about 2.6 nmi (4.8 km) in the location of the western edge of the current which, on the average, lies 3.2 nmi (5.9 km) east of Virginia Key (EPA, 1973). In addition to horizontal meandering, spin-off eddies are frequently formed along the western boundary of the Florida Current. These cyclonic eddies occur on an average of once per week, travel north at speeds ranging from 20 to 50 cm/sec, and result in internal currents that are directed to the west, south, and east. Other factors contributing to the variability of the Florida Current include tides, winds, and seasonal variations in the volume of water transported in the Gulf Stream system.

5.13 Currents in the proposed ODMDS vicinity are strongly directed along the north-south axis. The predominant direction of flow is to the north. Current speeds are highest in surface waters, decreasing to near zero at the bottom. Mean current speeds in surface waters at the site range from a low of 62 cm/sec in winter to about 95 cm/sec in the spring and summer (Lee et al., 1977). Maximum surface water currents range from about 150 cm/sec to the north to 50 cm/sec to the south (Lee and Mooers, 1977). Speeds are lower and north-south reversals more common near the bottom. Lee and Mooers (1977) report a mean northerly flow in near-bottom waters near the proposed ODMDS of 3.5 cm/sec, with maximum flows of 27 cm/sec to the north and 23 cm/sec to the south.

5.14 Tidal currents in the proposed disposal site vicinity are also directed along the north-south axis. Measurements taken in approximately 175 m water depth show semi-diurnal tides with amplitudes ranging from 10 to 20 cm/sec in near-bottom (10 m above the bottom) waters (Lee and Mooers, 1977).

5.15 In a response to a request by the Jacksonville District, the Army Corps of Engineers Waterways Experiment Station (WES) performed a technical study of the Gulf Stream meanders, frontal

Table 4

Summary of the Specific Criteria as Applied to the Interim Designated (Candidate) Site

Criteria as Listed in 40 CFR 228.6(a)	Interim Designated (Candidate) Site
1. Geographical position, depth of water, bottom topography and distance from coast.	See Figures 1 and 2. Depths at the site range from about 427 to 785 ft (130 to 239 m). The site is located on the steepest part of the continental slope, with a declivity of about 325 ft (100 m) per nautical mile (1.85 km). The site lies about 3.6 nmi (6.7 km) from shore.
2. Location in relation to breeding, spawning, nursery, feeding, or passage areas of living resources in adult or juvenile phases.	None concentrated in or restricted to the interim disposal site. Most breeding, spawning, nursery, and feeding activities take place in coastal waters or at reef areas located shoreward of the site. Passage through the proposed ODMDS is not geographically restricted.
3. Location in relation to beaches and other amenity areas.	The interim site is located approximately 3.6 nmi (7.4 km) from coastal beaches and protected inshore waters. The natural reef zone lies about 1.3 nmi (2.4 km) inshore of the site. Artificial reef sites are located about 3.3 nmi (6.1 km) to the north (downcurrent) and about 1.7 nmi (3.2 km) to the south (upcurrent) of the disposal site.
4. Types and quantities of waste proposed to be disposed of, and proposed methods of release, including methods of packing the waste if any.	The only material to be disposed in the ODMDS will be dredged material that complies with the EPA Ocean Dumping Regulations (40 CFR 220-229).

Table 4 (continued)

Summary of the Specific Criteria as Applied to the Interim Designated (Candidate) Site

Criteria as Listed in 40 CFR 228.6(a)	Interim Designated (Candidate) Site
5. Feasibility of surveillance and monitoring.	A Site Management and Monitoring Plan has been developed for the Miami ODMDS and is included in this EIS as Appendix C.
6. Dispersal, horizontal transport, and vertical mixing characteristics of the area, including prevailing current direction and velocity, if any.	Prevailing currents parallel the coast and are generally oriented along a north-south axis. Northerly flow predominates. Mean surface currents range from 62 to 95 cm/sec with maximum velocities of about 150 cm/sec. Current speeds are lower and current reversals more common in near-bottom waters. Mean velocities of 3.5 cm/sec and maximum velocities of 27 cm/sec have been reported for near-bottom waters in the area (see text). A pycnocline occurs in site waters throughout the year at reported depths ranging from about 60 ft in the summer to 325 ft in the winter. Dredged material dispersion studies conducted by the Corps for both short and long-term fate of material disposed at the proposed site indicate little possibility of disposed material affecting near-shore reefs.
7. Existence and effects current and previous discharges and dumping in the area (including cumulative effects)	The only use of this site was in April 1990. Monitoring during dumping activities verified the current model results. No adverse impacts were found.

Table 4 (continued)

Summary of the Specific Criteria as Applied to the Interim Designated (Candidate) Site

Criteria as Listed in 40 CFR 228.6(a)	Interim Designated (Candidate) Site
8. Interference with shipping, fishing, recreation, mineral extraction, fish and shellfish culture, areas of special scientific importance, and other legitimate uses of the ocean.	No significant interference is anticipated. Closest fishing sites are located 1.3 nmi (2.4 km) inshore, 3.3 nmi (6.1 km) to the north, and 1.7 nmi (3.2 km) to the south of the designated interim site.
9. The existing water quality and ecology of the site as determined by available data, or by trend assessment or baseline surveys.	Water quality at the site is influenced by inshore discharges, oceanic intrusions, and periodic upwelling. The location of the Florida Current determines whether site waters are predominantly coastal or oceanic. The site supports a benthic and epibenthic fauna characteristic of the continental slope habitat.
10. Potential for the development of nuisance species in the disposal site.	No evidence of undesirable organisms at the site noted. Disposal should not recruit or promote the development of nuisance species.
11. Existence at or in close proximity to the site of any significant natural or cultural features of historical importance.	No known features.

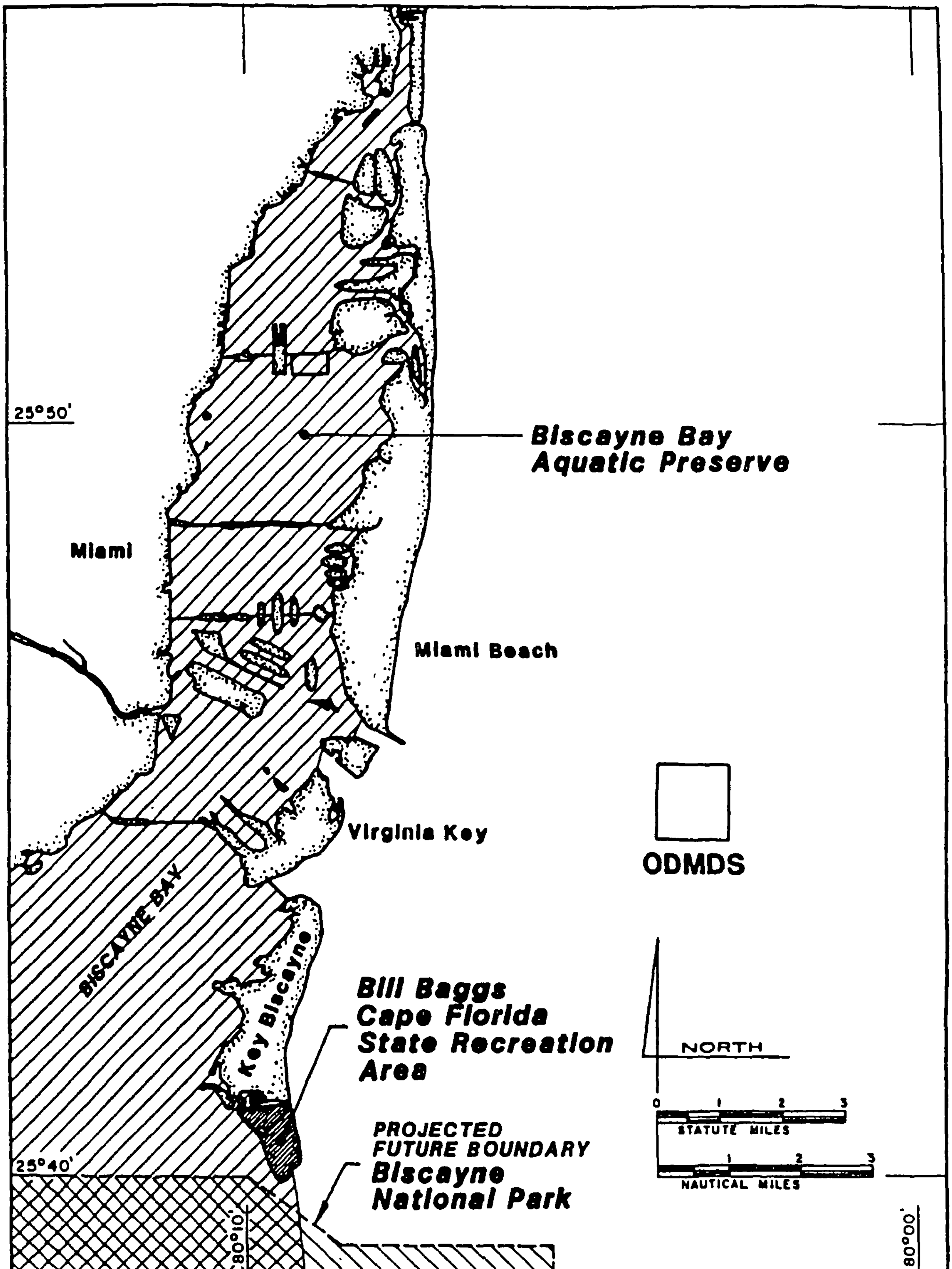

FIGURE 5

PARK AND PRESERVE AREAS

Ocean Dredged Material Disposal Site Miami, Florida

eddies and prevailing tides and currents off the east coast of Florida with respect to the potential for reef siltation by disposed dredged material originating from the proposed Miami ODMDS (Appendix B). A numerical modeling approach was used for estimating both the short-term and long-term fate of dredged material disposed at the proposed ODMDS. The modeling of the short-term dumping operation was performed by the Disposal from an Instantaneous Dump (DIFID) model. Long-term simulations, using a newly developed coupled hydrodynamic/sediment transport model, employed depth-averaged velocity fields to determine whether non-storm related currents are capable of transporting sediments outside of the proposed ODMDS over long periods of time. The effects of storm erosion were separately modeled by simulating the passage of a storm surge over the site. For the short-term study, the dredged material was initially assumed to be 90 percent sand (fine to medium) and 10 percent silt and clay. A second modeling run was made using a 90 percent silt and clay fraction and a 10 percent sand fraction. This proportion is quite similar to that of dregded material from Miami Harbor recently tested preparatory to maintenance dredging. A second study (see Appendix E) was undertaken as a cooperative effort between Rosenstiel School of Marine and Atmospheric Science (RSMAS) of the University of Miami, Atlantic Oceanographic and Meteorogical Laboratory of the National Oceanic and Atmospheric Administration and WES. This study included the following: 1) a verification of the Short Term FATE (STFATE) model (a revised version of the DIFID model) using field collected water samples; 2) a model run using ambient conditions provided by RSMAS; and 3) an analysis of the potential resuspension and transport of bottom sediment at the site.

5.16 Short-term modeling results. Short-term modeling results of both the 90 percent sand- 10 percent silt-clay and 90 percent silt clay-10 percent sand show that most of the material from the disposal load settles into a mound within several hours after initial release from the dredge. The silt and clay portion of the disposal load creates a suspension cloud or turbidity plume that is transported by ambient currents. This cloud increases in size and decreases in concentration with distance from the point of disposal. The concentration of the suspended sediment cloud was computed at specific depths for each simulation. The modeling results for all three short-term modeling efforts indicate concentrations of suspended materials, at the time they reach the reefs, to be at or below 10 mg/l above ambient levels.

5.17 Long-term modeling results. The long-term modeling efforts were conducted to determine whether a disposal mound is stable over long periods of time. In the first study, two types of simulations were conducted. A long duration simulation of a specified mound configuration was conducted. A 3-month simulation showed no erosion of a mound in 600 feet of water. Additional shorter duration simulations were made in order to investigate storm-related transport of material from the mound onto the reefs. A 24-hour sustained storm surge simulation showed that essentially no material was transported as a result of the surge. The second study investigated the potential for moving material other than uniformly graded, non-cohesive sediments by calculating shear stress values on the mound and in the surrounding area. Under normal environmental conditions, shear stress values at the ODMDS are low, and little movement is anticipated for either cohesive or non-cohesive material. During storm events, the shear stress values increase by an order of magnitude. However, the shear stress on the dredged material disposal mound increases by less than 2 dynes/cm^2 above the shear stress of the surrounding area. When subjected to storms, material is anticipated to move from the mound for short periods of time but large dispersion of the mound is not predicted. For the proposed Miami ODMDS, simulations show that local velocity fields are simply not adequate to move material in 600 feet or more of water. Both the short-term disposal and long-term erosion simulations of sediment transport as a function of local velocity fields indicate little possibility of affecting reefs as a direct result of use of the disposal site.

5.18 Existence and effects of current and previous discharges and dumping in the area (including cumulative effects) [40 CFR 228.6(a)7]. The existing EPA interim-designated ODMDS was first used for dredged material disposal in April 1990. Required maintenance dredging of Miami Harbor is relatively infrequent and has occurred four times since 1957; 80,000 cy in 1957; 80,000 in 1960; 210,000 in 1968; and 15,000 in 1985. Materials generated by these maintenance dredging operations were placed approximately one nautical mile (nmi) shoreward of the proposed site. No records of ocean disposal prior to 1955 are available for this area. No incidents of adverse impacts from these disposal actions are known.

5.19 Two additional disposal areas are indicated on navigational charts for the area (National Oceanic and Atmospheric Administration (NOAA), 1985). These are located adjacent to and to either side of the Miami Harbor entrance channel and inshore of the site previously used. No record of the use of either site has been found.

5.20 Interference with shipping, fishing, recreation, mineral extraction, desalination, fish and shellfish culture, areas of special scientific importance, and other legitimate uses of the ocean [40 CFR 228.6(a)8]. The proposed ODMDS is located just south of the entrance channel to the Port of Miami, an area of heavy commercial shipping traffic. Most traffic passes to the north of the proposed disposal area. The infrequent use of this site should not significantly disrupt either commercial shipping or recreational boating.

5.21 Commercial and recreational fishing activity is concentrated in inshore and nearshore waters or at offshore natural and artificial reefs. The proposed ODMDS lies about 3.6 nmi (6.7 km) from shore and 1.3 nmi (2.4 km) seaward of the natural reef line (see Figure 3). Artificial reef sites are located approximately 3.3 nmi (6.1 km) north (downstream) and 1.7 nmi (3.2 km) south (upstream) of the designated disposal area (see Figure 4). DIFID model results and NOAA/WES plume monitoring show no likely effects to these resources from using the proposed ODMDS.

5.22 No mineral extraction, desalination, or mariculture activities occur in the immediate area. Recreational and scientific resources are present throughout the area but are not geographically limited to the proposed Miami ODMDS or nearby waters.

5.23 Existing water quality and ecology of the site as determined by available data or by trend assessment or baseline surveys [40 CFR 228.6(a)9]. Water quality at the proposed ODMDS is variable and is influenced by discharges from inshore systems, frequent oceanic intrusions, and periodic upwelling. The proposed disposal site lies on the continental slope in an area traversed by the western edge of the Florida Current. The location of the western edge of the current determines to a large extent whether waters at the site are predominantly coastal or oceanic. Frequent intrusions or eddies of the Florida Current transport oceanic waters over the continental shelf in the proposed ODMDS vicinity. Periodic upwelling/ downwelling events associated with wind stress also influence waters in the area (Lee and Moores, 1977).

5.24 Surface and bottom water samples collected from the proposed disposal site vicinity in January 1986 (Appendix A) did not contain measurable concentrations of pesticides, pesticide derivatives, mercury, PCBs, or HMW hydrocarbons. Cadmium was detected in near bottom waters at two of the seven stations sampled. Lead was found in surface water collected at one station.

5.25 Potential for the development or recruitment of nuisance species in the proposed disposal site [40 CFR 228.6(a)10]. The disposal of dredged materials should not attract or promote the development of nuisance species. No pre-disposal nuisance organisms were identified in a January 1986 (Appendix A) survey of the proposed disposal site and none has been reported to occur at previously utilized disposal sites in the vicinity.

5.26 Existence at or in close proximity to the site of any significant natural or cultural features of historical importance [40 CFR 228.6(a)11]. No natural or cultural features of historical importance are known to occur at or in close proximity to the site. No such features were noted in a video survey of the proposed disposal area conducted by Conservation Consultants, Inc. in January 1986.

5.27 The dumping of materials into the ocean will be permitted only at sites or in areas selected to minimize the interference of disposal activities with other activities in the marine environment, particularly avoiding areas of existing fisheries or shellfisheries, and regions of heavy commercial or recreational navigation [40 CFR 228.5(a)]. The proposed Miami ODMDS does not support an active commercial or recreational fishery. Fishery and shellfishery resources are not concentrated in, restricted to, or dependent upon the interim disposal site vicinity.

5.28 There are no specially designated shipping lanes in the proposed disposal site vicinity. The candidate ODMDS is located seaward and slightly south of Government Cut, the entrance channel to the Port of Miami, and is in an area of heavy commercial shipping traffic. However, it is not anticipated that future, intermittent use of the site would result in a level of activity that would significantly disrupt shipping.

5.29 Locations and boundaries of disposal sites will be so chosen that temporary perturbations in water quality or other environmental conditions during initial mixing caused by disposal operations anywhere within the site can be expected to be reduced to normal ambient seawater levels or to undetectable contaminant concentrations or effects before reaching any beach, shoreline, marine sanctuary, or known geographically limited fishery or shellfishery [40 CFR 228.5(b)]. Any temporary perturbations in water quality resulting from disposal operations would be reduced to ambient or undetectable levels within a short distance of the release point (see para. 5.15). Prevailing currents at this site are to the north and parallel the coast. The proposed ODMDS lies about 3.6 nmi nautical miles (6.7 km) from the nearest landfall, and 1.3 nmi from the nearest reef. At this location, the likelihood of impacts to nearshore amenities and protected areas is small. In addition, provisions in the Site Management and Monitoring Plan restrict disposal to prevent any residual disposal plume from reaching the nearest reef. The proposed disposal site does not lie in the vicinity of geographically limited fishery or shellfishery resources.

5.30 If, at any time during or after disposal site evaluation studies, it is determined that existing disposal sites presently approved on an interim basis for ocean dumping do not meet the criteria for site selection set forth in 228.5 and 228.6, the use of such sites will be terminated as soon as alternate disposal sites can be designated [40 CFR 228.5(c)]. The proposed site meets the cited criteria.

5.31 The sizes of ocean disposal sites will be limited in order to localize for identification and control any immediate adverse impacts and permit the implementation of effective monitoring and surveillance programs to prevent adverse long-range impacts. The size, configuration, and location of any disposal site will be determined as part of the disposal site evaluation or designation study [40 CFR 228.5(d)]. A limited area of about one square nautical mile has been proposed as the ODMDS. Bottom contours in the area can be monitored through bathymetric survey methods. Monitoring of the proposed Miami ODMDS is discussed further in the SMMP provided in Appendix C. This SMMP is intended to be flexible and may be modified by the responsible agency for cause.

5.32 <u>EPA will, wherever feasible, designate ocean dumping sites beyond the edge of the continental shelf and other such sites that have been historically used [40 CFR 228.5(e)]</u>. The candidate site is located beyond the edge of the continental shelf. Historically used sites are on the shelf, but their proximity to environmental amenities makes their use environmentally questionable.

5.33 <u>Relationship between short-term uses and long-term productivity</u>. Use of the proposed ODMDS in the manner described should have no effect on long-term productivity.

5.34 The disposal of dredged materials at the proposed Miami ODMDS would not result in significant long-term water quality degradation. Water quality impacts of concern with regard to dredged material disposal include those associated with increased turbidity, decreased dissolved oxygen levels, and the release of sediment-bound contaminants such as heavy metals, nutrients, and hydrocarbons, including pesticides and PCBs. Generally, contaminants bound in sediments are not released under conditions normally occurring at open water disposal sites (Burks and Engler, 1978; Saucier, 1978). Most potential contaminants remain sorbed on sediments or are readily scavenged from the water column by particulate matter and metal oxides and precipitated. In addition, only material meeting ocean disposal criteria will be disposed at the site.

5.35 Increased turbidity resulting from dredged material disposal is generally short-term and transient (Windom, 1976). Elevated turbidity levels occur during dredged material disposal, but decrease rapidly as suspended sediments settle or disperse. Some increases in turbidity could occur at the pycnocline.

5.36 Temporary decreases in dissolved oxygen would occur during disposal. Given the depth of the well-mixed portion of the water column at the proposed ODMDS, significant off-site impacts are not expected and on-site impacts should be of short duration.

5.37 Nutrients bound in sediments would be released to the water column during disposal. Soluble phosphorus would be temporarily released but would be rapidly scavenged from the water column (Burks and Engler, 1978). Soluble nitrogen compounds, particularly ammonia, would also be released during disposal. Ammonia, which is toxic in high concentrations, should be rapidly reduced below harmful concentrations by dilution (Burks and Engler, 1978).

5.38 The potential for water quality impacts resulting from the release of trace metals is minor. Most heavy metals are poorly soluble and are readily sorbed by suspended matter and precipitated (Windom, 1976; Burks and Engler, 1978). Hydrocarbons, such as pesticides and PCBs, are generally poorly water soluble. These substances generally remain sorbed on sediments and are not released during disposal (Windom, 1976; Burkes and Engler, 1978).

5.39 The disposal of uncontaminated sediments in compliance with EPA's Ocean Dumping Regulations and Criteria (40 CFR 220-229) would not be expected to result in sediment quality degradation. Periodic bioassay testing (toxicity/bioaccumulation) of proposed dredged material is required to ensure compliance.

5.40 Impacts of dredged material disposal upon organisms in the water column are difficult to assess but are generally considered to be minimal and temporary (Pequegnat et al., 1981). Most motile organisms (nekton) can avoid disposal operations and localized areas of poor water quality. Nonmotile (planktonic) organisms such as phytoplankton, zooplankton, and ichthyoplankton entrained within the disposal plume would be directly affected. The impacts of disposal on these organisms is difficult to assess in light of the high natural variability of planktonic communities. Significant long-term impacts are not anticipated.

5.41 Sedentary and slow-moving benthic and epibenthic biota could be impacted both directly and indirectly by dredged material disposal. Direct impacts would result from the smothering of bottom-dwelling organisms under varying depths of dredge material. These impacts would result in the loss of some of the disposal site biota and the resultant alteration of benthic community structure. The high reproductive potential of most benthic infauna should re-establish pre-disposal conditions rapidly unless sediment characteristics are significantly different.

5.42 Direct impacts would occur at the specific sites of disposal. Recolonization from both the vertical migration of resident infaunal species and the recruitment of species from nearby areas would occur rapidly after completion of disposal operations.

5.43 Irreversible or Irretrievable Commitments of resources. Resources irreversibly or irretrievably committed through use of the proposed site will include: (1) loss of fuel for the dredges to transport any dredged material to the site; (2) loss of some potentially recyclable material (i.e., sand for land fill); and (3) loss of some benthic organisms that will be smothered during disposal operations.

6.00 The following chart presents the list of preparers.

The following people were primarily responsible for the preparation of this document.

Name	Discipline/Expertise	Experience	Project Role
Mr. Rea Boothby	Ecologist	21 years EIS studies	EIS Facilitator
Mr. Elmar Kurzdach		20 years NEPA Review	NEPA Supervisor
Mr. William T. Marsh	Environmental Assessment Aquatic Ecology, Coastal Systems	Staff Scientist, Environmental Science and Engineering, Inc.; 2 years Staff Scientist, Jones, Edmunds & Assoc. Inc.; 5 years Vice President, TAI Environmental Services Inc.; 3 years Senior Staff Scientist/ Division Manager, Conservation Consultants, Inc.; 1 year	Project Manager, Principal Investigator, ODMDS Site Study
Mr. William T. Hamilton	Environmental Assessment	President, Conservation Consultants, Inc.; 17 years	Project Advisor, ODMDS Study
Mr. Lawrence J. Swanson	Fisheries Resources, Aquatic Biology	Staff Scientist, Conservation Consultants, Inc.; 13 years Research Assistant, University of Miami; 1 year	Field Team Coordination, Fish and Epibenthic Invertebrate Taxonomy
Ms. Dorothy S. Morse	Chemistry	Soil Chemist, University of Florida; 3 years Laboratory Supervisory, Utility Service Associates, Inc.; 4 years Chemist, Manatee County Pollution Control; 1 year Chief Chemist, Conservation Consultants, Inc.; 8 years	Laboratory Supervisor, Granulometry
Ms. Sherrie A Leman	Analytical Chemistry	Staff Chemist, Conservation Consultants Inc.; 3 years Laboratory Technician, Manatee County Utilities; 2 years	Granulometry
Dr. Norm Scheffner		Waterways Experiment Station	Evaluation of Dispersion Characteristics
Mr. Gary W. Collins	Environmental Scientist	Oceanographic studies; 15 years	EPA Miami ODMDS Manager 1988-1992
Mr. Robert B. Howard	Supervisory Engineer	22 years in EPA programs	Ocean Disposal Program Manager
Mr. Chris McArthur	Environmental Engineer	Transport Processes	EPA Miami ODMDS Manager
Mr. Glenn Schuster	Environmental Engineer	16 years in Water Quality	EIS Facilitor

7.00 PUBLIC INVOLVEMENT.

7.01 This EIS, in either draft of final form or both, has been coordinated with the following agencies, groups and individuals:

<u>Federal</u>

Advisory Council on Historic Preservation
Council on Environmental Quality
Department of Agriculture
  Forest Service
  Soil Conservation Service
Department of Commerce
  National Oceanic and Atmospheric Administration
    National Marine Fisheries Service
    National Ocean Survey
    Office of Coastal Zone Management
    Altantic Oceanographic and Meteorological Laboratory
Department of Defense
  Pentagon
  Department of the Air Force
  Department of the Army
    Corps of Engineers
  Department of the Navy
Department of Energy
Department of Health and Human Services
Department of Housing and Urban Development
Department of Interior
  Bureau of Mines
  Fish and Wildlife Service
  Geological Survey
  Minerals Management Service
  National Park Service
Department of Transportation
  Coast Guard
    Seventh District, Miami, FL
  Federal Aviation Administration
  Federal Highway Administration
  Maritime Administration
Economic Development Administration
Environmental Government Affairs
Federal Emergency Management Administration
Federal Maritime Commission
Federal Power Commission
Food and Drug Administration
General Services Administration
National Science Foundation
U.S. Senate
  Honorable Bob Graham
  Honorable Connie Mack
U.S. House of Representatives
  Honorable Dante Fascell
  Honorable Ileana Ros-Lehtinen

State

Florida Senate
Honorable Lincoln Diaz-Balart
Honorable Jack Gordon
Honorable Carrie Mack
Honorable Gwen Margolis
Florida House of Representatives
Honorable Elaine Bloom
Honorable Michael Friedman
Honorable Susan Guber
Honorable Alberto Gutman
Honorable Luis Morse
Honorable Jefferson Reaves
Florida Department of Environmental Regulation
Florida Department of Natural Resources
Office of the Governor
Governor of Florida
State of Florida A-95 Clearing House

Local

Dade County
Chairman of County Commissioners
Metropolitan Dade County Environmental Resources Management
Metropolitan Dade County Planning Department
Mayor of Miami
Miami Herald, The
Port of Miami
Miami River Coordinating Committee
Miami River Dredging Coalition

Organizations and Individuals

Alert Citizens Tri-City Alliance
Atlantic States Marine Fisheries Commission
Audubon Society of the Everglades
Center of Action - Endangered Species
Clean Ocean Action
Coalition to Cease Ocean Dumping
Conservation Consultants, Inc
Continental Shelf Associates
Florida Atlantic University
Ecology Action of Hollywood
Florida Audubon Society
Florida Coalition for Clean Water
Florida Conservation Foundation
Florida Institute of Technology
Florida Keys Audubon Society
Florida League of Anglers
Florida Sport Fishing Association
Florida Wildlife Federation
Friends of the Everglades

Organizations and Individuals Cont'd

Harbor Branch Oceanographic Institute
International Women's Fishing Association
Isaak Walton League of America
League of Women Voters
Miami-Dade Community College
Miami Women's Club
National Audubon Society
National Wildlife Federation
Natural Resources Defense Council
Nature Conservancy
Nova University
Oceanic Society
Organized Fishermen of Florida
Rosenstiel School of Marine and Atmospheric Science - University of Miami
Sierra Club
South Atlantic Fishery Management Council
Survive
Tropical Audubon Society
Thomas Nehrig

7.02 Coordination with the National Marine Fisheries Service as required by Section 7 of the Endangered Species Act of 1973 has been concluded. In a letter dated October 14, 1994, (see 7.03) the National Marine Fisheries Service determined that populations of endangered/threatened species under their purview would not be adversely affected by the designation and use of the proposed ODMDS. Should additional information become available concerning possible impacts or should the activity be modified, additional consultation would be requested.

7.03 Responses to Comments. The Notice of Availability of the Draft EIS was published in the Federal Register on September 7, 1990 and the public comment period closed on December 7, 1990. A total of 13 comment letters were received during the public review period. All the comment letters are included on the following pages along with responses to the comments. The comment numbers in the left margin of the comment letter correspond to the response numbers on the pages immediately following the comment letter.

Florida Department of Environmental Regulatic

Twin Towers Office Bldg. • 2600 Blair Stone Road • Tallahassee, Florida 32399-2400

Bob Martinez, Governor Dale Twachtmann, Secretary John Shearer, Assistant Secretary

January 5, 1991

Mr. Wesley Crum, Chief
Wetlands and Coastal Programs Section
United States Environmental Protection Agency
Region IV
345 Courtland Street, Northwest
Atlanta, Georgia 30365

RE: Draft Environmental Impact Statement For Designation of an Ocean Dredged Material Disposal Site Located Offshore Miami, Florida

SAI: FL9009110358C

Dear Mr. Crum:

The State of Florida has completed its review of the referenced document in accordance with the National Environmental Policy Act and the Florida Coastal Management Program. The proposals in the Draft Environmental Impact Statement (DEIS) could affect natural and artificial reefs in state waters and the loss of beach quality sand.

The Department of Environmental Regulation (DER), as the lead coastal agency pursuant to section 306(c) of the federal Coastal Zone Management Act, 16 U.S.C. section 1456(c), and section 380.22, Florida Statutes, hereby notifies the Region IV Environmental Protection Agency, that the State of Florida cannot support the findings described in the Draft Environmental Impact Statement. The State's position is based on inconsistencies with the following specific provisions of the Florida Coastal Management Program: Sections 403.021, .031, .061, .062, and .918; 161.142; 370.025, .114, Florida Statutes. State agency concerns are explained in detail in the enclosed correspondence.

In order for the State to reconsider its findings, EPA will need to relocate the ODMDS site approximately three nautical miles to the east of its present location. If this is not possible, the State requests restrictions on the designation which prohibit the deposition of material with a grain size less than .025 mm and material constituted by more than 10 percent fine grained material. These restrictions must be adopted by rule. In addition, the model used to calculate the potential transport o. fine grain material in a westerly direction must be correctly run using the correct velocities for the water column and these results published in the Final Environmental Impact Statement.

Under either of the two ODMDS proposed locations, the following language must be added into the EIS and rule: "No beach quality sand that can be placed on proximate beaches consistent with existing federal, state and local requirements may be placed in the Miami Harbor Ocean Dredged Material Disposal Site."

In accordance with 15 CFR 930.42(c), a copy of this letter has been sent to the U.S. Department of Commerce, National Ocean and Atmospheric Administration, Office of Ocean and Coastal Resource Management. Mediation by the Secretary, U.S. Department of Commerce, may be sought pursuant to 15 CFR 930, subpart G for serious disagreements between the State and a federal agency taking direct action governed by 15 CFR 930, subpart C. We request a responce to this letter and to the specific comments in the enclosed correspondence.

Sincerely,

Dale Twachtmann
Secretary

DT/dh

Enclosures

cc: A. J. Salem, Jacksonville District, Corps of Engineers
Tom Gardner, Department of Natural Resources
Russell Nelson, Marine Fisheries Commission
Tom Pelham, Department of Community Affairs
Estus Whitfield, Executive Office of the Governor
Timothy R. E. Keeney, Director, NOAA, Ocean and Coastal Resource Management

STATE OF FLORIDA
DEPARTMENT OF NATURAL RESOURCES

Marjory Stoneman Douglas Building • 3900 Commonwealth Boulevard • Tallahassee, Florida 32399
Tom Gardner, Executive Director

January 3, 1991

Ms. Karen MacFarland, Director
State Clearinghouse
Office of Planning and Budgeting
Executive Office of the Governor
The Capitol
Tallahassee, Florida 32399-0001

Dear Ms. MacFarland:

SAI No. FL9009110358C, Draft EIS for Designation of the Miami Harbor Ocean Dredged Material Disposal Site (ODMDS)

The Department of Natural Resources has completed review of the Draft Environmental Impact Statement for the above referenced project and the additional information provided at a joint meeting of the applicant (U.S. Environmental Protection Agency), the U.S. Army Corps of Engineers, and the state agencies involved in the review process. The draft document proposes the unconditional designation of a new site offshore of Miami Harbor for the placemen of materials obtained from dredging projects anticipated in the Miami area. The site, while located offshore of the territorial waters of Florida, is sufficiently close to the natural resources of the state to merit careful review under the Florida Coastal Management Program.

The Department does not concur with the proposed designation of the site pursuant to Chapters 161 and 370 of our approved program. Specifically, the draft does not include a prohibition for the placement of any material suitable for beach placement in the
1 ODMDS. The Department's position on the importance of beach quality material was detailed in an objection to a similar proposed site designation offshore of Canaveral Harbor. Our comments on this site designation are the same and will not be reiterated here for the sake of brevity. The EPA is well aware of the Department's concerns. In addition, there remains considerable disagreement on the part of expert physical oceanographers with many years of experience working in the Miami area in researching the Gulf Stream current and the occurrence of frontal eddies as to the ultimate fate
2 of any material placed in the proposed ODMDS. The draft does not adequately address these expert's concerns nor the Department's concerns regarding the movement of silt and clay sized particles out of the disposal area and onto the environmentally sensitive hardbottoms and coral reefs which are as close as 1.3 nm to the west

(2) of the proposed site. The turbidity generated from a typical disposal event could be prolonged over a number of months and materials placed in the water column could be transported for many miles under the most severe cases. The Department is working actively to protect coral reef tracts in this area and other areas of the State and any activity which has the potential to negatively impact reefs must be opposed until adequate assurance has been provided that no negative impact will occur.

In summary, the Department does not concur that the proposed site designation is consistent with our authorities pursuant to Sections 161.142, 370.025, and 370.114, Florida Statutes. The applicant can make the proposed designation consistent by moving the ODMDS further offshore to maximize the distance that material would have to travel before encountering hardbottoms and to increase the influence of the Gulf Stream in distributing the material over a large area. We suggest a minimum of 3 additional nautical miles offshore. In addition, the following language should be added to the EIS and the rule designating the site: No beach quality sand that can be placed on proximate beaches consistent with existing federal, state, and local requirements may be placed in the Miami Harbor Ocean Dredged Material Disposal Site.

Thank you for the opportunity to provide our position on this proposal. If you have any questions, please contact David W. Arnold at (904)488-2955.

Sincerely,

Tom Gardner

Tom Gardner
Executive Director

cc: Bob Howard, EPA, Atlanta
Col. Bruce Malson, USACE-Jacksonville
Dale Twachtmann, DER
Pam McVety, Div. of Marine Resources

Florida Department of Environmental Regulation

Twin Towers Office Bldg. • 2600 Blair Stone Road • Tallahassee, Florida 32399-2400

December 17, 1990

Ms. Karen MacFarland, Director
Florida State Clearinghouse
Office of Planning and Budgeting
Executive Office of the Governor
The Capitol
Tallahassee, Florida 32399-0001

Dear Ms. MacFarland:

Re: Draft Environmental Impact Statement,
Miami Ocean Dredged Material Disposal Site
Designation, SAI FL 90--0358C

We have reviewed the referenced document and met with the Corps and EPA to discuss the proposed designation. Our specific comments on the document are enclosed. We request that the document be revised to address these comments and to correct the identified errors or omissions.

The central issue surrounding this designation is the suitability of its location. The site is 1.5 - 2 nmi from natural reefs and hard ground areas to the west and 2 - 5 nmi from several artificial reefs to the north. Under ambient conditions, flow through this site is influenced by the Florida current directed to the north toward the artificial reefs. Under frequent circumstances which occur during the passage of frontal eddies spinning off of the Florida current, a strong westerly flow toward the natural reefs results.

The DEIS includes modeling results for predominantly coarse and predominantly fine material disposal events under conditions estimated for westerly flow. The influence of the Florida current axis was not considered in the dispersion analysis. Under the westerly flow scenarios, the model concludes that no significant quantities of sediment will be transported toward the reef tract. However, certain of the current velocity assumptions used in these runs were flamed and therefore produced incorrect transport projections. Using correct velocity figures, transpor of fine grained material to the reef tract by an onshore eddy would occur. Transport to the artificial reef sites by the Florida current will occur also. We request that the model be run again using correct velocities and include these results in the final EIS.

We have previously concurred with the use of this site for coarse grained material which settles rapidly. We believe there is limited potential for this material to be transported to the reef areas. Therefore, we can agree with the use of this site for such material. However, it is likely that fine grained material would be deposited on adjacent live bottom and natural and artificial reef sites. Such deposition can severely impair biological activity and ultimately cause mortality of the benthic organisms in these areas. Subtropical marine habitat is generally intolerant of excessive sedimentation and should not be subjected to such an impact.

We disagree with the proposed designation based on the availability of the site for the disposal of fine grained material. The probable damage to adjacent marine resources is inconsistent with the following specific provisions of the DER's authorities in the Florida Coastal Management Program: Sections 403.021, .031, .061, .062, and .918 Florida Statutes.

As an alternative, we recommend the EPA include language in the FEIS which is formally adopted by rule to restrict the use of this site to coarse grained material as defined by a grain size of > .025 mm and < 10% fines.

We would be pleased to discuss these issues with EPA and the Corps as needed. If you have any questions, please contact Lynn Griffin at 904-488-0130.

Sincerely,

Mark Latch
Deputy Director
Division of Water Management

ML/clw

cc: Scott Benyon

Enclosure

For Routing To Other Than The Addressee

To	Location
To	Location
To	Location
From	Date

State of Florida
DEPARTMENT OF ENVIRONMENTAL REGULATION

Interoffice Memorandum

TO: Mark Latch

FROM: Lynn Griffin

DATE: December 20, 1990

SUBJECT: Comments on the Draft Environmental Impact Statement for the Miami Ocean Dredged Material Disposal Site Designation

---

I have reviewed the referenced document and offer the following comments:

1.02 and 1.03: These sections should acknowledge the considerable public concern as well as the state's reservations for this designation. The controversy has primarily focused on whether the Miami River sediments should be dumped in this site, but there is some opposition to any designation of a site in such close promimity to reefs and other hard bottom areas. It is inaccurate to state that no controversy exists or that there are no unresolved issues.

2.03: Since the Corps has applied for permits to maintenance dredge the Miami River and to dispose of the material in the proposed Miami ODMDS, this project should be identified in this discussion. If EPA has determined that Miami River material will not be suitable for disposal in this site, this should be explained.

3.04: The previous dumping history is new information. The DEIS should include more details regarding volume and type of material disposed, bathymetric changes and biological information of the previously used site, particularly for the 1985 disposal. Disposal 1 mile west of the ODMDS places the dump site in state waters which means the dumping required state permits. Permitting information such as the permit number, conditions, and monitoring requirements and results should have been included in the DEIS.

3.08: Please explain what "additional variables" would preclude a move further offshore.

4.50: As we have stated repeatedly in the past, the state should have been consulted on the video survey design and then should have been presented the survey for review. Survey transects should have been run in an east - west direction and extended to the west to document the proximity and type of hard bottom. Transects should also have been run through the area used for disposal in 1985.

5.10: Why isn't sediment mapping a feasible monitoring option at this site?

5.16: This discussion should be revised to reconcile the points raised by Dr. Thomas Lee regarding the inappropriate depth - averaged velocity figures used in the model. Also, a model run of a worst case scenario for the artificial reef sites to the north should be completed using Gulf Stream currents.

5.17: According to oceanographic researchers, evidence of bottom scour is quite pronounced in this area. Were there any literature surveys or consultations with local scientific experts to ensure that the simulations were based on solid assumptions of bottom current velocities?

5.18: What is the basis for the statement that there were no adverse impacts from the 1985 disposal to the west of the ODMDS. Monitoring reports and field investigations of existing conditions should be included in the DEIS.

5.25: Where is it reported that nuisance species are not present in previously utilized disposal sites in the vicinity? As stated above, pre v. post site surveys and monitoring of previously used sites should have been performed and should have been included in the DEIS. If they do not exist they should not be used as a basis for conclusions that there will be no effects from use of the ODMDS.

Appendix A, figure A-2: Had the state been consulted in developing the survey design, a grid pattern of sampling stations would have been recommended for the ODMDS. A transect of stations to the west should have been included to document the proximity and biological characteristics of hard bottoms and to evaluate the effects of previous disposal operations.

Appendix B, p. 47: Neither the proposed designation nor the Site Management and Monitoring Program includes a restriction on the dumping location. Therefore, a central release point is not a worst case factor. The release point can be at the western edge of the site as presently proposed. The model should be rerun using a starting point for the plume 0.5 nmi closer to shore.

Figures 2.2 - 2.5: These sediment cloud plots are illegible and should be reproduced one to a page in the DEIS.

Figures 2.7, 2.9, 2.11, 2.13 and 3.6: These figures are also illegible.

The copies of the DEIS provided to the state did not include the last part of Appendix B which addressed transport from the Miami site. Everything after page 69 was omitted.

Appendix C

Part II C: Due to unresolved concern for transport of fine material to adjacent hard bottom communities and artificial reef areas, the SMMP should include a restriction on the type of material which can be eligible for disposal in the site. Essentially, a grain size and percent fines limit should be stipulated in the designation rule. We propose limits of > .025 mm grain size and < 10% fines.

Part II E: Due to substantial opinion that even coarser grained material may be transported, the dump station location should be specified. The station should be located in the southeast portion of the site to allow the greatest distance from areas of biological concern.

Parts III A and B: Considering the concern for adjacent hard bottom areas, a monitoring program consisting only of bathymetry seems inadequate. Sediment mapping, discharge plume monitoring and monitoring in amenity areas should be included.

Part III C: The NOAA plume tracking study took place because the state made numerous requests to monitor the Miami Harbor maintenance dredging disposal which took place earlier this year. The reason we wanted the disposal monitored was to verify the DIFID. model predictions so that this information could be considered when we evaluated the proposal to designate the site. For this information not to be included in the DEIS is a significant omission. The DEIS should be revised to include the results and analysis of this information.

Responses
Florida Department of Environmental Regulation

Letter dated January 5, 1991:

The comments in this letter are a summary of comments explained in detail in enclosed internal letters and memorandums. These comments will therefore be addressed through addressing the detailed comments of the enclosed correspondence.

Letter dated January 3, 1991:

1. The disposition of any significant quantities of beach compatible sand from future projects will be determined during permitting activities for any such projects. It is expected that the State of Florida will exercise its authority and responsibility, regarding beach nourishment, to the full extent during any future permitting activities. Utilization of any significant quantities of beach compatible dredged material for beach nourishment is strongly encouraged and supported by EPA. Disposal of coarser material should be planned to allow the material to be placed so that it will be within or accessible to the sand-sharing system, to the maximum extent practical, and following the provisions of the Clean Water Act. Additional language has been added to Section 3.03 of the Final EIS addressing the use of suitable dredged material for beach disposal.

2. Since the completion of the Draft EIS, additional work has been conducted in addressing the concerns regarding transport of fine grained material towards environmentally sensitive areas. A joint field data collection project was conducted in April 1990 by the Atlantic Oceanographic and Meteorological Laboratory (AOML) of the National Oceanic and Atmospheric Administration, Jacksonville District of the Corps of Engineers (SAJ), and the Coastal Engineering Research Center (CERC) at the Army Corps of Engineers Waterways Experiment Station. The project monitored the spatial and temporal variations in suspended sediment load that occur during disposal using acoustic technology. Data from this study was used in verification and calibration of the CERC transport model. Additional modelling was then conducted by CERC utilizing environmental parameters provided by the Rosenstiel School of Marine and Atmospheric Science (RSMAS) of the University of Miami. The modelling concluded that the dispersion of the material will reduce concentrations to within background levels before moving sufficiently westerly to reach the coral reefs and that even in the maximum westerly flow, the coral reefs are not anticipated to be effected. Reports on both the field data collection effort and the modelling are included in the Final EIS as Appendices.

   As an added precaution, the current Site Management and Monitoring Plan requires a real-time current monitoring program to be in place during disposal until the effect of disposal during eddy currents is better understood. The program will prohibit disposal of dredged material during certain current conditions. The monitoring program is discussed in detain in the Site Management and Monitoring Plan, Appendix C of the Final EIS.

Letter dated December 17, 1990:

1. Additional modelling was conducted by CERC utilizing environmental parameters provided by the Rosenstiel School of Marine and Atmospheric Science (RSMAS) of the University of Miami. The modelling concluded that the dispersion of the material will reduce concentrations to within background levels before moving sufficiently westerly to reach the coral reefs and that even in the maximum westerly flow, the coral reefs are not anticipated to be effected. Reports on both the field data collection effort and the modelling are included in the Final EIS as Appendices.

   As an added precaution, the current Site Management and Monitoring Plan requires a real-time current monitoring program to be in place during disposal until the effect of disposal during eddy currents is better understood. The program will prohibit disposal of dredged material during certain current conditions. The monitoring program is discussed in detain in the Site Management and Monitoring Plan, Appendix C of the Final EIS.

Memorandum dated December 20, 1990:

1. Section 1.02 and 1.03 have been changed.

2. Placement of material from the Miami River in the ODMDS is not planned at this time. Other options for disposal of this material are being investigated. EPA has not been asked to make a determination regarding the suitability of the Miami River sediments for ocean disposal.

3. There is no additional information available regarding the previous dumping history.

4. Additional variables includes the enormous task and expense of monitoring disposal under conditions at the Gulf Stream (depth and current velocity). Section 3.08 has been changed to reflect this.

5. As a member of the Site Management and Monitoring Plan (SMMP) team, the State of Florida will be a participating partner and will be consulted on future monitoring plans. The survey transects were selected to document resources that would receive direct deposition due to disposal. The issue of indirect deposition due to shore directed current events has since been realized. The current direction/magnitude monitoring plan discussed in the SMMP should ensure that any resources that were not documented to the west of the site are protected. If the proximity and type of hard bottom again become of concern in the future due to a change in the monitoring plan, the SMMP team wil again address this issue. A detailed survey of any resources in the 1985 site would have no bering on the current Miami ODMDS.

6. The depth of the Miami ODMDS is beyond the current range of the sediment mapping technology.

7. This section has been revised and an additional study was conducted using ambient currents provided by the Rosenstiel School of Marine and Atmospheric Sciences at the University of Miami.

8. The Corps is now monitoring the site and will continue to do so for the foreseeable future. Evidence of such scouring should be disclosed by the monitoring.

9. See comment 3 above.

10. The focus of this EIS is the suitability of a site for disposal of dredged material. A literature search was conducted and found no reports of the development of nuisance species in the area. The development of nuisance species has not been reported at other ocean dredged material disposal sites in Florida where post-disposal biological surveys have been conducted. It is not feasible to conduct a search for nuisance species at all the old disposal sites.

11. See response to item 5.

12. The Site Management and Monitoring Plan has been revised to restrict the disposal location.

13, 14, & 15. These problems were addressed in the revised study and report done by WES.

16. A management and monitoring program described in the Site Management and Monitoring Plan (Appendix C) has been initiated to ensure that fine grained material is not transported towards the reef and hardbottom areas.

17. The current Site Management and Monitoring Plan specifies disposal within a 500 foot radius of the center of the site to additionally ensure protection of live bottom communities outside of the site and to contain the disposal mound within the site during periods of strong currents in all directions.

18. Plume monitoring and methods for tracking sediment movement have been added to the Site Management and Monitoring Plan. Options for monitoring in amenity areas are also included.

19. The EIS has been revised to include the results from the plume tracking study. The related reports: "Miami Harbor Dredged Material Disposal Project;" "Miami Harbor Dredged Material Disposal Project: Total Suspended Solids Measurements;" and "Evaluation of the Miami Ocean Dredged Material Disposal Site (ODMDS)" are attached as Appendices F, G, and E, respectively.

UNIVERSITY OF MIAMI

Ref: TNL/62:jg

October 30, 1990

Mr. Wesley Crum, Chief
Wetlands and Coastal Programs Section
U. S. Environmental Protection Agency
345 Courtland Street NE
Atlanta, GA 30365

Dear Mr. Crum:

I have reviewed the draft Environmental Impact Statement (EIS) for designation of an ocean dredged material disposal site located offshore Miami, FL, and I disagree with the conclusion that the interim-designated site is suitable for disposal of dredged material from the dredging of Government Cut. The designated site is located much too close to natural and artificial reefs and should be relocated at least an additional 3 nautical miles (nm) offshore. My reasons for this follow:

1) The draft EIS contains a large number of errors, especially Part I (pages 12-40). The most serious error is in determining the vertically average velocity to use in the short-simulation of disposal operations. On page 21, section 24, it is stated that "The site evaluation approach is inherently conservative in that a constant, maximum-valued, reef-directed velocity is selected as a boundary condition for sediment transport calculations." However this is not the case, for the method used consisted of selecting the minimum east-west velocity profile and the minimum north-south velocity profile to calculate the maximum, reef-directed, vertical averaged velocity. To properly compute a "maximum, reef-directed velocity" would require the minimum east-west velocity (maximum shoreward directed velocity) to be combined with the maximum north-south velocity, not the minimum north-south velocity. This is especially important since the disposal site is located 3.3 nm south and slightly offshore of a group of artificial reef sites. The velocity profiles used to compute the maximum reef-directed velocity are shown in Fig. 1.9 and Table 1.5. The effect of this error is particularly glaring in Fig. 1.13 and Table 1.6, which show the distribution of the computed maximum vertical average velocity vectors and the velocity components. What strikes you in this figure is the lack of a Gulf Stream. The currents shown at the 24 ft water depth site are stronger than at the 258 ft or 834 ft sites or near 1000 ft, where there should occur a strong Gulf Stream axis. This is an obvious error and the maximum reef-directed velocities should be recomputed using minimum u and maximum v profiles, then used to rerun the short-term and long-term simulations to estimate the impact on the nearby live and artificial reefs.

2) The disposal site chosen is located only 1.3 nm offshore of the live reef line off Miami and 3.3 nm upstream of artificial reefs. Using the EIS chosen value for the maximum reef-directed vertical average velocity of 2.79 ft/sec (85 cm/sec) toward 320 degrees indicates that the sediment plume resulting from the dredge disposal will reach the reef in only 1.8 hours. Using the fall velocities for sand and silt/clay from

Rosenstiel School of Marine and Atmospheric Science
Division of Meteorology and Physical Oceanography
4600 Rickenbacker Causeway
Miami, Florida 33149-1098

Table 2.2 indicates that it takes 2.4 hours for sand to be deposited on the bottom in a water depth of 400 ft and 43.4 hours for silt/clay deposition. The depth of the reefs range from about 20 ft to 150 ft, which will require about .3 to .8 hours for sand deposition and 5 to 15 hours for silt/clay. Therefore the silt/clay plume will extend over the live reef line causing increased sedimentation and higher levels of turbidity.

3) The artificial reefs are almost directly downstream from the disposal site. If we use a more reasonable downstream (northward) maximum current of about 100 cm/sec (3.28 ft/sec) then the sediment plume will reach the artificial reefs in only 1.6 hours and sand, as well as silt/clay size particles, will still be in suspension for deposition on the reefs.

4) Frontal eddies are a common feature of the local oceanography of this region, having a frequency of about one per week. During the passage of these eddies the total water column at the disposal site can undergo westward currents for several hours' duration. Using a realistic velocity of 50 cm/sec (1.64 ft/sec) would require only 1.3 hours for the sediment plume to travel the 1.3 nm to the live coral reefs. I feel this presents a serious hazard for the nearby live and artificial reefs. It is just one more stress that the reefs are threatened by and an unnecessary one at that, for there are suitable alternative disposal sites nearby. A reasonable solution is to shift the discharge site further offshore, increasing the distance from the reefs and decreasing the possibility for harmful impact from short-term or long-term consequences of the dredge disposal. A minimum offshore shift of 3 nm would increase the travel time to the reef to about 4.3 hours from onshore eddy-induced flow. Shifting the disposal site further offshore would also increase the distance from the ship conjested entrance to Government Cut and Miami Harbor, providing greater safety for ship traffic.

5) Any dredged materials that are suitable for beach nourishment should be used for that purpose. The repeated dredging of Government Cut with deep water disposal is removing sediment from the littoral environment, i.e., a loss from the beach that will contribute to long-term beach erosion and the need for expensive beach renourishment programs. There may also be reuse alternatives available for the rock material.

Thank you for the opportunity to review this draft EIS.

Sincerely,

Thomas N. Lee

Dr. Thomas N. Lee
Research Professor
Rosenstiel School of Marine and Atmospheric Science
University of Miami

cc: Randall L. Armstrong
Dr. Ken Echternacht
Lynn F. Griffin
Walt Kolb
Sally Turner

Responses
University of Miami
Dr. Thomas N. Lee

1. The velocity data used in the original modeling did incorporate the presence of the Gulf Stream. The input velocity data set was developed through analysis and combination of data from approximately 60 published and unpublished sources. The composite data set was generalized in such a way as to maximize the effect of the westward component, thereby maximizing the potential threat to the shoreward reef. The objective was to simulate the possible action of the frontal eddies of Gulf Stream "loop currents" that appear with approximate 1- to 2-week period. The terminology "loop current" was not used in this section of the draft EIS and for that reason some misunderstanding of the calculation strategy may occur.

   Use of maximum westward-directed velocity component and minimum-to-typical north component is considered appropriate because this procedure maximized the potential residency time for dredged material in the water column to reach or stay in the area of the shoreward coral reefs. If a large northward component were to be employed in the calculations, the material would be swept out of the area. In fact, this situation of rapid northward sweeping of material is the normal transport mode in the region and was quantitatively observed in all eight dredged material plumes th were tracked in a field monitoring project conducted at the Mi ODMDS by the Jacksonville District during April 23-27, 1990, in cooperation with WES and Dr. John Proni of the Atlantic Oceanographic and Meteorological Laboratory, National Oceanic and Atmospheric Administration, Miami, Florida.

   An additional study has also been conducted using ambient currents provided by the Rosenstiel School of Marine and Atmospheric Sciences at the University of Miami. The results of this study are included in this EIS in Appendix E.

2. In a dredged material placement operation such as at the Miami ODMDS, it is known that the vast majority of the material falls to the bottom in a so-called "convective descent" phase. Basically, the material falls collectively at the speed of a large object, not as individual particles. This was verified conclusively for relatively deep water at the Miami ODMDS during the aforementioned monitoring operation. The only material remaining in the water column, that comprises the visible surface plume that will move with the current, consists of very fine particles that do have a low settling velocity as described in the letter. The convective descent of the vast majority of material and transport of the remaining suspended material are accounted for in the numerical model used in the simulations.

   However, the results presented in the WES report for the short term modelling are off by six orders of magnitude (too low). The WES values were reported in units of mg/l, but were actually unitless and representative of a solids volumetric ratio. The WES values should therefore be multiplied by the density of the solids to obtain concentration values in units of mg/l. The values in the report have not been corrected for this EIS because the additional short-term transport modeling presented in Appendix E supersedes the previous results.

3. Material that remains suspended in the water column to disperse laterally does not penetrate the picnocline (density surface) normally located at about 80-m depth in the region of the ODMDS. A rhodamine tracer dye study confirmed that this cloud of extremely low concentration (See comments above) would be dispersed to near background levels if it were directed towards the deep water artificial fish haven located northwest of the dump site.

4. The response to this comment, in this regard, are discussed in items 1 and 3 above. The calculations took account of the eddies as a "worst-case" situation, and it was found that the material did not arrive at the sensitive areas of concern. The Site Management and Monitoring Plan further ensures that material will not arrive at the sensitive areas of concern.

5. The disposition of any significant quantities of beach compatible sand from future projects will be determined during permitting activities for any such projects. It is expected that the State of Florida will exercise its authority and responsibility, regarding beach nourishment, to the full extent during any future permitting activities. Utilization of any significant quantities of beach compatible dredged material for beach nourishment is strongly encouraged and supported by EPA. Disposal of coarser material should be planned to allow the material to be placed so that it will be within or accessible to the sand-sharing system, to the maximum extent practical, and following the provisions of the Clean Water Act. Additional language has been added to Section 3.03 of the Final EIS addressing the use of suitable dredged material for beach disposal.

UNIVERSITY OF MIAMI

3 DECEMBER 1990

Mr. Wesley Crum, Chief
Wetlands and Coastal Programs Section
U.S. Environmental Protection Agency
345 Courtland Street NE
Atlanta, GA 30365

Dear Mr. Crum,

I am writing comments in response to a draft Environmental Impact Statement for designation of an ocean dredged material disposal site located offshore Miami, Florida. It is my understanding that the dredging will involve first removal of 'clean ocean dredged material' and then later 'contaminated ocean dredged material' (the later from the Miami River). I will address these two materials separately.

A. CLEAN OCEAN DREDGED MATERIAL

1. Any clean material that is dredged from Biscayne Bay should be redeposited within Biscayne Bay so as to shallow the number of deep dredged holes and trenches in northern and north-central Biscayne Bay that are not necessary for navigation.

> Between 1900 and 1960, extensive dredging took place in northern Biscayne Bay both along its margins and on the Bay interior (see Harlem, 1976). The purpose of much of this dredging was to obtain fill to create land for development of for causeways. These dredged areas vary from 9 to 25 feet in depth. There were also dredging activities for navigation, but these account for only a small percentage of the artificially deepened bottom of northern Biscayne Bay.
>
> In the early 1980's, I undertook a study to ascertain the causes for high sustained turbidity level in northern Biscayne Bay (Wanless et al., 1984). The answer was that, areas greater than 8 to 10' in depth are not receiving sufficient light to develop an effective benthic community of seagrass, algal mat or hardbottom organisms. The turbidity remains high in the absence of these bottom-stabilizing and water-filtering organisms. Areas of northern Biscayne Bay that are slightly shallower (<7'), have moderate to dense

Rosenstiel School of Marine and Atmospheric Science
Division of Marine Geology and Geophysics
4600 Rickenbacker Causeway
Miami, Florida 33149-1098

benthic communities that are actively stabilizing the bottom and actively filtering particulate materials form the water column.

The solution to improving the water clarity and quality and enhancing the benthic communities of northern Biscayne Bay is **to fill in those deeper dredged areas that are not necessary for navigation to a depth where there is sufficient light for beneficial benthic communities to re-establish.** This would mean shallowing all non-navigation channels to less than 6 feet and shallowing intracoastal waterway and dock access channels to less than 7-10 feet depth.

Dade County has made efforts in this direction but have been hampered by the lack of fill material. This harbor deepening project will provide the unique opportunity to greatly enhance the environmental quality of northern and north-central Biscayne Bay. As deepening and expansion of the Miami Harbor channels are not an enhancement of the environmental quality of Biscayne Bay, I should expect that all concerned will welcome the opportunity to disposed of the clean fill in a manner that will enhance the quality of Biscayne Bay.

B. CONTAMINATED OCEAN DREDGED MATERIAL

1. Bottom material dredged from the Miami River or other areas of the harbor system that are contaminated should not be dumped offshore. The Florida Current episodically generates extremely strong bottom currents that will rework any deposited mound of sediment.

I have made several observation transects of the bottom of the Straits of Florida by submersible from 450' to 150' depth. In the zone from 450' to 200', there is usually a soft sediment bottom which has conical mounds of sediment 0.5' to 1.5' in height. These are produced by excavating burrowers. The age of the mounds could be ascertained by the degree of algal stabilization. Only the very fresh mounds were cones. All older mounds were deformed and flattened and deformed by northward sediment movement. There are episodic strong bottom currents to the north caused by flow of the Florida Current. (Strong southward currents have also been observed by some sedimentologists). These bottom currents will move the coarser sediment along the bottom but will resuspend the finer sediment and transport it great distances. Drs. John van Leer and Tom Lee (of Meteorology and Physical Oceanography at RSMAS) can give you a good idea as to the transport directions and durations.

During the series of submarine dives with which I was involved, other trips encountered sufficient northward bottom currents to resuspend bottom sediment and obscure vision.

Very simply the slope seaward of southeast Florida's shelf is a dynamic high energy system and must not be used for dumping contaminated materials. They will be recycled elsewhere by episodic erosion and transportation. As contaminants are mainly associated with the very fine particulates, it is the contaminants that will be most widely distributed.

2. The bottom environments at 400' depth are valuable marine environments.

At 400' depth off Miami, the bottom has sufficient light for there to be primary productivity. The bottom has a good algal mat cover and there are a variety of macro benthos. I do not think it is wise of necessary to smother these bottoms with dredged material, and it is very unwise to place contaminated fill on these environments. There is certainly a major ocean community that interacts with this bottom environment.

3. Contaminated ocean dredged material is a hazardous waste.

The contamination of the sediment at the bottom of the Miami River must be treated in the same manner as any dump site. If it is a hazardous waste, it should be removed, concentrated and transported to a suitable disposal site as with any other hazardous waste site. Throwing hazardous waste in the ocean is not a suitable solution. When one realizes how interactive the proposed dump site is with important coastal and marine communities, this ocean dumping solution is intolerable.

I look forward to working with the County, the Port Authority, the involved State of Florida agencies, the Environmental Protection Agency, the Corps of Engineers, and those contracted to the transfer of dredge material to assure that this is an environmental opportunity and enhancement.

Sincerely yours,

Harold R. Wanless
Associate Professor

References:

Harlem, P.H., 1979. Aerial Photographic Interpretation of the Historical Changes in Northern Biscayne Bay, Florida: 1925-1976. M.S. Thesis, University of Miami, 152p. (also University of Miami Sea Grant Tech. Bull. No. 40, 151p.).

Wanless, H.R., D. Cottrell, R. Parkinson, and E. Burton, 1984. Sources and Circulation of Turbidity, Biscayne Bay Florida. Final Report to Sea Grant and Dade County, 499p.

cc: Commissioner Harvey Ruvin, Dade County
Dr. B. Rosendahl, Dean, RSMAS
Dr. Ken Echternacht, DERM
Mr. Huber Parsons, Miami River Coordinating Comm.

Responses
University of Miami
Harold R. Wanless

1. The question of beneficial use of dredged material from Miami Harbor and other areas and the bay were addressed in the Miami Harbor Channel, Florida, Design Memorandum dated October 1991. The conclusion of the study was that the cost of producing rock material suitable for disposal in the bay was prohibitive; therefore, this option was dropped from further consideration.

2. Before any material can be placed within the ODMDS, it must be evaluated and shown to be acceptable for ocean disposal in accordance with ocean dumping regulations (40 CFR 227.13). Certain portions of the sediments proposed to be dredged from the Miami River have been found to be unsuitable for ocean disposal. Transport of material disposed at the ODMDS has been addressed in the Final EIS, Site Management and Monitoring Plan and in the reports included as Appendices B and E.

STATE OF FLORIDA
DEPARTMENT OF COMMUNITY AFFAIRS

2740 CENTERVIEW DRIVE • TALLAHASSEE, FLORIDA 32399-2100

LAWTON CHILES
Governor

LINDA LOOMIS SHELLEY
Secretary

September 6, 1994

Mr. Wesley Crum
Chief, Coastal Programs Section
WOWB-WMD
U.S. Environmental Protection Agency
345 Courtland Street, NE
Atlanta, Georgia 30365

RE: Miami Ocean Dredged Material Disposal Site Designation
SAI: FL9009110358C

Dear Mr. Crum:

Pursuant to Presidential Executive Order 12372, Gubernatorial Executive Order 93-194, the Coastal Zone Management Act, 16 U.S.C. §§ 1451-1464, as amended, and the National Environmental Policy Act, 42 U.S.C. §§ 4321, 4331-4335, 4341-4347, as amended, the State of Florida hereby acknowledges the resolution of the concerns initially identified by the state following its 1991 review of the proposed Miami Ocean Dredged Material Disposal Site (Miami ODMS).

Based on the enclosed comments provided by the Department of Environmental Regulation (DEP), the state hereby withdraws its 1991 objection to the designation of the proposed Miami ODMS. As a result of the project modifications and agreements referenced by the DEP, the state has determined that, as modified, the proposed Miami ODMS is consistent with the Florida Coastal Management Program.

In closing, the state wishes to express its appreciation for the efforts made to resolve this matter.

Very truly yours,

Mary Anne McNeill

Linda Loomis Shelley
Secretary

LLS/jr
CC: Virginia Wetherell, Department of Environmental Protection
Lynn Griffin, Department of Environmental Protection
Estus Whitfield, Executive Office of the Governor

FLORIDA

Department of
Environmental Protection

Lawton Chiles
Governor

Marjory Stoneman Douglas Building
3900 Commonwealth Boulevard
Tallahassee, Florida 32399-3000

Virginia B. Wetherell
Secretary

August 1, 1994

Estus Whitfield
Executive Office of the Governor
Office of Planning and Budgeting
The Capitol
Tallahassee, Florida 32399-0001

Dear Mr. Whitfield:

Re: Miami Ocean Dredged Material Disposal Site Designation
SAI FL9009110358C

In 1991, the state reviewed a draft environmental impact statement for the designation of an ocean dredged material disposal site offshore of Miami. The Departments of Environmental Regulation and Natural Resources disagreed with this designation under the federal consistency provisions of the Florida Coastal Management Program. The bases of these objections were 1)that the offshore site could be used for the disposal of beach quality material and 2)the potential for fine sediments to be transported to reef and hard ground habitat approximately 1 nmi downcurrent of the disposal site. The first issue has been resolved since EPA has agreed to place certain stipulations on site designations which require beach quality material to be preferentially disposed for beneficial uses. The second issue, however, has been the subject of continuing discussion since 1991.

Based on its modeling results, the Corps of Engineers did not agree that dredged material would be transported far enough to impact nearby amenity areas. However, physical oceanographers from DER and the University of Miami, Rosenstiel School of Marine and Atmospheric Sciences (RSMAS), concluded that such transport was likely during the passage of frontal eddies which periodically spin off of the Gulf Stream and move onshore. After consulting with RSMAS, the Corps reevaluated the probable transport of material to be disposed at the proposed site and issued a report of its findings. This report was reviewed and discussed at a meeting last September between the Corps, EPA, RSMAS, DEP and NOAA's Atlantic Oceanographic and Meterological Laboratory. The result of this meeting was that there still was not agreement among technical experts on the assumptions or results of the Corps' model. Because of this, the Corps suggested that a current monitoring program be developed instead of continuing further predictive modeling efforts. The development of that monitoring plan has been the subject of a number of meetings over the last several months. Most recently, all parties met with representatives of the Port of Miami on July 27.

The purpose of this letter is to inform you of the status of this matter and the agreements which have been reached to resolve the previous objections to the designation of the offshore disposal site. The Corps has agreed to develop and implement a program to detect real-time current data during dredging and disposal operations. The objective of the program is to ensure that disposal of fine sediments will not coincide with the presence of onshore currents. This monitoring will be a part of the EPA's site management and monitoring plan for this site.

The Corps is consulting with NOAA and RSMAS to develop the technical protocols for implementing this monitoring program. These protocols will specify the conditions and time periods for restricting disposal. These details will be included as conditions of a modification to the Port's wetland resource permit and water quality certification for this project. The permit modification can be issued as soon as these protocols are submitted and approved by the Department. To meet the dredging contract schedule demands of the Port of Miami, the Corps and the Department have committed to issuing this permit modification by August 31, 1994.

Based on the agreements and implementation time schedule described above, the Department can at this time remove its previous objection to the designation of this site. Accordingly, we agree that the proposed designation of the Miami ODMDS is consistent with the Department's statutory authorities in the Florida Coastal Management Program. The EPA should be notified as soon as possible that the state's objections to this designation have been removed.

If there are any questions concerning these comments, please contact Lynn Griffin at 487-2231.

Sincerely,

Kirby B. Green for
Virginia B. Wetherell
Secretary

VBW/l
cc: Kirby Green, DEP
Pam McVety, DEP
Jeremy Craft, DEP
Ray Keough, Port of Miami
Richard Bonner, USACE
John Proni, NOAA/AOML
Kevin Leaman, RSMAS
Wesley Crum, EPA

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Office of the Chief Scientist
Washington, D.C 20230

October 4, 1990

Mr. Wesley Crum
U.S. EPA
Region IV
345 Courtland Street, NE
Atlanta, Georgia 30365

Dear Mr. Crum:

Enclosed are comments to the Draft Environmental Impact Statement for Designation of an Ocen Dredged Material Disposal Site Located Offshore Miami, Florida. We hope our comments will assist you. Thank you for giving us an opportunity to review the document.

Sincerely,

David Cottingham
Director
Ecology and Environmental
Conservation Office

Enclosure

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL OCEAN SERVICE
OFFICE OF CHARTING AND GEODETIC SERVICES
ROCKVILLE, MARYLAND 20852

SEP 26 1990

MEMORANDUM FOR: David Cottingham
Ecology and Environmental Conservation Office
Office of the Chief Scientist

FROM: Rear Admiral Wesley V. Hull, NOAA
Director, Charting and Geodetic Services

SUBJECT: DEIS 9009.02 - Designation of an Ocean Dredged Material Disposal Site Located Offshore of Miami, Florida

The subject statement has been reviewed within the areas of Charting and Geodetic Services' (C&GS) responsibility and expertise and in terms of the impact of the proposed actions on C&GS activities and projects. Since safety of navigation is one of C&GS' primary missions, this proposal was examined with that in mind and any other impact this activity may have on C&GS activities and projects. The feasibility report and environmental impact statement referenced in this DEIS for the Miami Harbor deepening project also were reviewed.

C&GS considers the maintenance and improvement of navigation channels to be an extremely important and worthwhile effort and encourages such activities. Although it is never desirable to place materials in the ocean in the vicinity of ports and harbors, C&GS concurs with the designation of the referenced offshore site as the best alternative. This site is covered on NOS nautical charts 11465 and 11466 and will continue to be shown as appropriate. The effects upon navigation in the vicinity are expected to be of minimal consequence.

Questions about this response should be directed to the Mapping and Charting Branch, N/CG22x2, WSC1, Room 804, Nautical Charting Division, 6001 Executive Boulevard, NOAA, Rockville, Maryland 20852, telephone 301-443-8742.

cc:
N/CG1x11 - Taylor
N/CG17 - Spencer
N/CG22x2 - Frey

SEP 28 1990

RECEIVED
EC

Gary

U.S. Department of Transportation
United States Coast Guard

Commandant
United States Coast Guard

Washington, D.C. 20593-0001
Staff Symbol: G-MEP-1
Phone: (202) 267-0504

16004

12 OCT 1990

Mr. Wesley B. Crum
Chief
Wetlands and Coastal Programs Section
U.S. Environmental Protection Agency
Region IV
345 Courtland Street
Atlanta, Georgia 30365

Dear Mr. Crum:

We have reviewed the Draft Environmental Impact Statement (DEIS) for designation of an Ocean Dredged Material Disposal Site located offshore Miami, Florida. Based on information presently available, we have no objections to the DEIS. However, the Coast Guard is currently conducting a study of Florida vessel traffic to determine whether other vessel routing measures such as traffic separation schemes are needed. The study is scheduled to be completed by May 1991. This will determine if further comments are in order regarding the DEIS.

Thank you for providing the opportunity to review the DEIS for designation of an Ocean Dredged Material Disposal Site located offshore Miami, Florida.

Sincerely,

T G Balunis

T. G. BALUNIS
Commander, U.S. Coast Guard
Chief, Prevention Enforcement
and Standards Branch
Marine Environmental Protection Division
By direction of the Commandant

General Services Administration
401 West Peachtree Street
Atlanta, GA 30365

SEP 11 1990

Mr. Wesley Crum, Chief
Wetlands and Coastal Programs Section
U.S. Environmental Protection Agency
345 Courtland Street, NE
Atlanta, GA 30365

Re: Draft Environmental Impact Statement (EIS) for
Designation of an Ocean Dredged Material Disposal Site
Located Offshore Miami, Florida

Dear Mr. Crum:

The Safety and Environmental Management Branch (4PMS) has reviewed the submitted draft EIS. The proposed actions will not affect General Services Administration (GSA) operations in the area. GSA has no comment on the submitted draft.

If you have questions, please contact Gerald Hust, Chief, Safety and Environmental Management Branch on 331-3125.

Sincerely,

Thomas E. Davis
Assistant Regional Administrator
Public Buildings Service

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

ATLANTA REGIONAL OFFICE, REGION IV
Richard B. Russell Federal Building
75 Spring Street, S.W.
Atlanta, Georgia 30303-3388 11 936

September 14, 1990

Mr. Heinz Mueller
EIS Project Officer
United States Environmental
Protection Agency, Region IV
345 Courtland Street, N.E.
Atlanta, Georgia 30365

Dear Mr. Mueller:

This refers to your transmittal of the Draft Environmental Impact Statement (DEIS) for Designation of An Ocean Dredged Material Disposal Site located offshore Miami, Florida.

Our review indicates there will be no significant adverse impact on any HUD programs as a result of this action.

Thank you for the opportunity to review and comment on the proposed project.

Very sincerely yours,

for Harry Walker

Ivar O. Iverson
Regional Environmental Officer
Office of Community Planning
and Development

DEPARTMENT OF THE AIR FORCE
REGIONAL CIVIL ENGINEER, EASTERN REGION (HQ AFESC)
77 FORSYTH STREET, SW, SUITE 291
ATLANTA, GEORGIA 30335-6801

REPLY TO ATTN OF: ROV

5 September 1990

SUBJECT: Air Force Review of the Draft Environmental Impact Statement for Designation of an Ocean Dredged Material Disposal Site (ODMDS) Located Offshore Miami, FL

TO: U.S.EPA Region IV
Attn: Mr Wesley Crum, Chief
Wetlands and Coastal Programs Section
345 Courtland Street NE
Atlanta GA 30365

As the Air Force single point of contact for environmental matters in the eastern United States, we have reviewed the Draft Environmental Impact Statement (DEIS) for the ODMDS and find that implementation of the proposal will not affect Air Force operations in the site area. Thank you for the opportunity to review this DEIS. Our point of contact is Mr George Dodson at telephone number 331-5313/6776.

ANTHONY E. FONTANA III, Capt, USAF
Deputy Chief
Environmental Planning Division

1 Atch
DEIS

cc: HQ USAF/LEEV wo Atch

Gary

FLORIDA DEPARTMENT OF STATE
Jim Smith
Secretary of State
DIVISION OF HISTORICAL RESOURCES
R.A. Gray Building
500 South Bronough
Tallahassee, Florida 32399-0250
Director's Office (904) 488-1480
Telecopier Number (FAX) (904) 488-3353

September 13, 1990

Wesley Crum, Chief
Wetlands and Coastal Program Section
U. S. Environmental Protection Agency
Region IV
345 Courtland Street, N.E.
Atlanta, Georgia 30365

In Reply Refer To:
Susan M. Herring
Historic Sites Specialist
(904) 487-2333
Project File No. 902710

RE: Cultural Resource Assessment Request
Draft Environmental Impact Statement for Designation of an Ocean Dredged Material Disposal Site Located Offshore Miami, Florida
Dade County, Florida

Dear Mr. Crum:

In accordance with the procedures contained in 36 C.F.R., Part 800 ("Protection of Historic Properties"), we have reviewed the above referenced project(s) for possible impact to archaeological and historical sites or properties listed, or eligible for listing, in the National Register of Historic Places. The authority for this procedure is the National Historic Preservation Act of 1966 (Public Law 89-665), as amended.

We have reviewed the above referenced Environmental Impact Statement and find it to be complete and sufficient. Thus, it is the opinion of this agency that project activities will have noeffect on any archaeological or historic sites or properties listed, or eligible for listing, in the National Register of Historic Places, or otherwise of national, state, regional, or local significance. The project is consistent with the historic preservation aspects of Florida's coastal zone program, and may proceed without further involvement with this agency.

If you have any questions concerning our comments, please do not hesitate to contact us. Your interest in protecting Florida's archaeological and historic resources is appreciated.

Sincerely,

George W. Percy, Director
Division of Historical Resources
and
State Historic Preservation Officer

GWP/smh

UNITED ST. .S DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
9721 Executive Center Drive N.
St. Petersburg, FL 33702

October 14, 1994 F/SEO13:JEB

Mr. Wesley B. Crum
Chief, Coastal Programs Section
Region IV
Environmental Protection Agency
345 Courtland Street
Atlanta, GA 30365

Dear Mr. Crum:

This responds to your request for consultation on the proposed designation of the Miami Ocean Dredged Material Disposal Site (ODMDS) located approximately 4 nautical miles offshore east-southeast of Government Cut at the entrance to Miami Harbor, Dade County, Florida. A biological assessment (BA), in the form of a draft environmental impact statement, was transmitted to us pursuant to Section 7 of the Endangered Species Act of 1973 (ESA).

We have review the BA and have determined that populations of endangered/threatened species under our purview would not be adversely affected by the designation and use of the proposed site, centered at 25°45'00"N and 80°03'22"W, as an ODMDS. Also, we believe the Site Management and Monitoring Plan, summarized in the draft State of Florida permit conditions for the Port of Miami Water Quality Permit, is appropriate for this project and contributes to our determination.

This concludes consultation responsibilities under Section 7 of the ESA. However, consultation should be reinitiated if new information reveals impacts of the identified activity that may affect listed species or their critical habitat, a new species is listed, the identified activity is subsequently modified, or critical habitat is determined that may be affected by the proposed activity.

If you have any questions please contact Jeffrey Brown, Fishery Biologist, at (813) 570-5312.

Sincerely,

Andrew J. Kemmerer
Regional Director

cc: F/PR2
F/SER2

Gr 7

United States Department of the Interior

TAKE PRIDE IN AMERICA

OFFICE OF THE SECRETARY
Office of Environmental Affairs
Richard B. Russell Federal Building
75 Spring Street, S.W.
Atlanta, Georgia 30303

OCT 1 8 1990

ER 90/822

Mr. Wesley Crum
Wetlands and Goastal Program Section
U.S. Environmental Protection Agency
345 Courtland Street, NE.
Atlanta, Georgia 30365

Dear Mr. Crum:

The Department of the Interior (Department) has reviewed your Draft Environmental Impact Statement for Designation of an Ocean Dredged Material Disposal Site located offshore of Miami, Florida, and have the following comments.

The Fish and Wildlife Service has recommended that the dredged material disposal site not be located closer than 1/2 mile from the nearest known live coral reef. Apparently, the proposed site is in very deep water and about 1 1/2 miles from any reef. The biological sampling in the deepwater site (400 to 800 feet) indicates the site will recover rapidly, since no hardbottom was found in the disposal area.

Your study of the proposed site for preparation of this draft statement is comprehensive and well done. The statement could be improved if it had appended results of monitoring past dumping for Miami Harbor in the previously used site. This would have helped indicate whether there would be any problems expected for resources of concern to the Department. However, the depth and distance away from priority resources are sufficient to remove any concerns from the Department.

Thank you for the opportunity to comment on this statement.

Sincerely yours,

James H. Lee

James H. Lee
Regional Environmental Officer

Responses

State of Florida
Department of Community Affairs
September 6, 1994

United States Department of Commerce
Office of the Chief Scientist

United States Department of Commerce
National Ocean Service

United States Coast Guard

General Services Administration

U.S. Department of Housing and Urban Development

Department of the Air Force

Florida Department of State
Division of Historical Resources

United States Department of Commerce
National Marine Fisheries Service

Comments in these letters are appreciated, but do not warrant a response.

United States Department of the Interior

OFFICE OF THE SECRETARY
Office of Environmental Affairs
Richard B. Russell Federal Building
75 Spring Street, S.W.
Atlanta, Georgia 30303

November 27, 1990

ER-90/822

Mr. Wesley Crum
Wetlands and Coastal Program Section
U.S. Environmental Protection Agency
345 Courtland St., NE
Atlanta, GA 30365

Dear Mr. Crum:

On October 18, 1990, we submitted comments concerning the Draft Environmental Impact Statement (DEIS) for Designation of an Ocean Dredged Material Disposal Site located offshore of Miami, FL. Since that time we have received additional information and offer the following supplemental comments.

We are concerned that the site may not be suitable for the disposal of very fine sized, highly polluted sediment obtained from dredging the Miami River and harbor. During events of strong onshore breezes upwelling events occur that could possibly entrain the deposited sediments and transport the sediments onto the reef platform, potentially having an adverse impact to the coral reefs of Biscayne National Park, and distribute them along the Florida coastal platform.

The DEIS addresses the environmental impacts of the disposal site for dredged material from the Miami River and harbor, but does not discuss the types of material to be dredged or methods of transport to the disposal site. Of concern is the design and method of operation of the barges presently used in dredging operations. Also of concern is the dewatering of the dredged material during transit to the disposal site. Any dewatering should occur only in the river behind the sediment screens or over the disposal site.

Thank you for the opportunity to make these additional comments.

Sincerely,

James H. Lee

James H. Lee
Regional Environmental Officer

Responses
United States Department of the Interior
Office of the Secretary

Letter dated October 18, 1990

1. No additional information regarding disposal at the previous disposal site is available.

Letter dated November 27, 1990

1. Before any material can be placed within the ODMDS, it must be evaluated and shown to be acceptable for ocean disposal in accordance with ocean dumping regulations (40 CFR 227.13). Certain portions of the sediments proposed to be dredged from the Miami River have been found to be unsuitable for ocean disposal. Transport of material disposed at the ODMDS has been addressed in the Final EIS, Site Management and Monitoring Plan and in the reports included as Appendices B and E.

2. Discussion on project specific types of materials to be dredged, methods of transport and possible dewatering of dredged material will be done on an individual project-by-project basis.

SIERRA CLUB

Miami Group

Post Office Box 43-0741 • South Miami, Florida 33243-0741

Mr. Wesley Crum, Chief
Wetlands and Coastal Programs Sections
U.S. Environmental Protection Agency
Region IV
345 Courtland Street, NE
Atlanta Georgia 30365

October 17th, 1990

Dear Mr. Crum,

We are enclosing comments and an assessment done on the Environmental Impact Statement of an Ocean Dredged Material Disposal Site Located Offshore Miami, Florida, by Tom Davenport, Ph.D.. The Sierra Club-Conservation Committee is fortunate to have Dr. Davenport as a member because of his expertise in this area. His scientific background is in Biochemistry, Oceanography and Plant Physiology. His training includes ecological surveys of benthic communities in the Gulf of Mexico and he is an avid diver who is familiar with the local benthic communities, sediments and currents as well.

The Conservation Committee feels, after a report on his review of the E.I.S., that this study is indeed misleading, erroneous and inadequate. Of particular importance here is the proximity to valuable coral reef habitat and the fact that Miami River sediments, which have been considered to have many hazardous "hot spots", have been proposed for disposal at this site. This assessment, however, invalidates this site for any sediment disposal due to the following comments and subsequent assessment by Dr. Davenport.

The model itself is inadequate, first of all, in that the edge of the Gulfstream fluctuates westward much more than stated. Also, the large macro-events studied up and down the Florida coast and across to the Bahamas, have little or nothing to do with this very specific coastal area. The stations are too far displaced and not applicable to near-shore conditions of drag, eddys, etc.. There was also only one area tested shoreward of the proposed site -- in 300' of water. This is not relevant to the areas of concern, namely the coral reef community, and none of those significant organisms were even tested. Furthermore, the composition of the sediments were said at the beginning of the E.I.S. to be 90% clay, which is closer to the actual composition for maintenance work, yet the numbers were all based on 10% clay. Finally, current velocities were averaged from the surface to the bottom which cuts the stronger, more significant surface currents in half, thereby doubling the distance of sediment carrying to the reef. In every example, the U.S. Army Corps gives the best case scenario, mixed with statistically slanted figures to arrive at the conclusion that they want.

The living reef off South Florida, is currently showing heavy signs of stress and siltation, especially north of the Government Cut area. We are now on the verge of losing this sensitive ecosystem. Therefore, we strongly urge you to consider these comments and assessment of the E.I.S. and reject this site for disposal. It is our belief that if sediments are non-hazardous, that a land-based or an ocean siting much further out be proposed. Either way, this study does little towards a representative or conclusive plan.

We are also forwarding copies of other studies which support these findings

SIERRA
CLUB

Miami Group

Post Office Box 43-0741 ● South Miami, Florida 33243-0741

and hope that they can assist you in you responsible evaluation.

Sincerely,

Lee F. Emerson

Lee F. Emerson, Sierra Club
Conservation Committee

cc; John Renfrow, Director D.E.R.M
Fred Calder, Fl. Dept. of Environmental Regulation
Scott Benyon, Fl. Dept. of Environmental Regulation
Dick Townsend, Tropical Audubon Society-Coastal Committee
Lloyd Miller, Isaac Walton League
Susan Berryman, Wilderness Society
Bonnie Barnes, Friends of the Oleta River
Alex Atone, American Littoral Society

recycled paper

ASSESSMENT OF AN ENVIRONMENTAL IMPACT STATEMENT FOR DESIGNATION OF AN OCEAN DREDGED MATERIAL DISPOSAL SITE LOCATED OFFSHORE MIAMI, FLORIDA

A draft version of an "Environmental Impact Statement for Designation of an Ocean Dredged Material Dumping Site Located Offshore Miami, Florida" has been submitted to the U.S. Environmental Protection Agency by the U.S. Army Corps of Engineers. In behalf of the Sierra Club of Miami, I had the opportunity to read this document in its entirety. It consists of a 39-page summary; Appendix A, which is a detailed report of the results of a January, 1986 environmental survey of the physical, chemical and biological characteristics of the bottom and waters within and adjacent to the disposal site; and Appendix B, which is an April 1989 evaluation of a computer-simulated model of dispersal characteristics of dumped dredge material.

The overall conclusion of this document is that the environmental impact of periodic disposal of dredged material, obtained from Miami Harbor maintenance and improvement projects, at the proposed, permanent, dump site will be minimal. It is my opinion that this conclusion is based on inadequate, non-existent, and misleading information. Several important statements are inconsistent with information presented in other sections of the document. Moreover, a number of important considerations, especially regarding the potential impact on adjacent inshore coral reefs and potential environmentally-sensitive areas located on the continental shelf, have been ignored or given cursory attention in the report. I am also concerned about the lack of a proposal to monitor the impact of suspended sediment drifting into these areas and the lack of remedies which would be considered in the event that the physiology of organisms residing on the shelf are adversely affected. Some of these concerns are indicated below.

Biological Considerations

The Sierra Club's primary concern is the potentially adverse environmental impact of man's activities on the sensitive biology of ecologically important organisms. Appendix A describes the diverse range of benthic organisms residing within the dump site and in areas of similar bottom characteristics north and south of the site. It is assumed that extensive disruption of the biota in the dump site will occur. I accept the conclusion that the dump site itself is not a particularly unique area requiring preservation. Moreover, it is correctly assumed that, barring any toxological problems associated with the spoils, new communities will form in the disturbed areas.

Only one sampling was conducted shoreward of the site at station M-5. This station is located only 0.5 miles west of the proposed dump site in 300 ft of water. It is characterized by a bottom structure and biota that are substantially different from those found at the site and at stations north and south of the site. No further attempt was made to document the locations, extent, or present condition of reef complexes or other communities typical of the shoreward continental shelf which would be adversely affected by periodic drift of silty clay material into these areas. No information on the possible impact of chronic sediment deposition on sediment and filter feeding organisms residing in the shoreward areas are mentioned. Moreover, there is no plan to monitor the detrimental or beneficial impact on these environmentally sensitive areas if dumping at the proposed site is approved

There is a substantial body of literature describing the detrimental effects of fine, suspended sediment on coral and other sediment and filter feeders. Portions of only a few of the available articles are attached. Considering that sensitive reef complexes extend north and south of a location 1.3 miles west of the dump site, the potential for massive destruction of this environment is a real possibility. Studies of the effects of dredge spoils when constructing a harbor in Dubai have shown that reefs located 2 miles from a similar dump site with less ocean current pressure than experienced in Miami were totally destroyed (Dr. T. Bright, personal communication).

Sediment-carrying Current Considerations

Contrary to the statement in paragraph (p) 3.08, the average western edge of the Florida Current is located one mile shoreward of the proposed dump site and meanders 2.6 miles east or west depending upon a number of factors discussed in the report. This places the dump site in a highly dynamic area in which cylonic eddy currents occur. These currents at the dump site and surrounding areas are unpredictable in both vector and velocity as they are swept northward by the Florida Current.

The model of sediment deposition (Appendix B) consists of two parts: 1, the potential to displace fine suspended particles to adjacent environmentally sensitive reefs following each dumping event, 2, the potential to move the settled mound during storm conditions. I cannot argue with the methodologies used to model mound movement on the bottom. It is not likely to be substantially disturbed once in place. The model presenting a hypothetical, worst-case scenario of shoreward-moving currents which might carry clay particles to reef areas concerns me greatly. Most of the information presented has little bearing on the question of local eddy currents which would impact the environmentally sensitive areas along the continental shelf. Several unrealistic assumptions are made in formulating the model.

1. Background data providing current direction and velocities at one sampling station in the area were obtained from only one 1977 study. Although the current direction was toward the NW, it was erroneously assumed that the

current is always in that direction and would thus displace the location of sensitive reefs 3 mile from the dump site rather than 1.3 when eddy currents sweep the plume shoreward. More importantly, depth averaged velocities were used. This not realistic since the highest velocities occur in the upper half of the water column. Velocities at and near the bottom approach zero, thus reducing the velocities to be considered by up to one half.

2. A model using only 10% clay material was considered. I found no results in the text regarding an evaluation of 90% clay as is indicated in the summary. It is my understanding that most spoils would contain greater than 10% clay and approach 90% in maintenance dredgings. The 10% model clearly demonstrates that the turbid plume would travel 3 miles under the conditions specified. Considering the potential for variable current vectors, the probable doubling of current velocities in the upper half of the water column than those modeled, and the likelihood of higher amounts of suspended particles contributing to a sediment plume, I would argue that the potential for serious detrimental impact is far greater than is suggested by this inadequate study.

Conclusion

In the interest of protecting the quality of our near shore environment, I urge the EPA to consider the lack of meaningful information presented in this study. Designation of a disposal site should be postponed until realistic surveys of eddy currents, surveys of floral and fuanal communities on the continental shelf adjacent to the site, and a realistic assessment of the probable impact of recurring plumes of fine sediment on the local filter and sediment feeders can be addressed. It should also include means of monitoring sedimentation rates in these environmentally sensitive areas prior to and after the start of dumping.

Recommendations

1. Consider a dumping site several miles further into the Florida Current, such as near Station C (see page 24 -26 of Appendix B) so that the possibility of encountering eddy currents is reduced to nil.

2. Consider deposition of spoils directly on the bottom, beyond the influence of upper level currents. This could be accomplished by either a closed-bucket system lowered into place or a shunting flume system mounted on an anchored barge as is currently practiced for dumping drill muds from off-shore drilling platforms in the Gulf of Mexico.

Both possibilities would resolve numerous problems associated with dumping of spoils along the coasts of Florida.

T.L Davenport, Ph.D
Sierra Club, Conservation Committee

Responses
Sierra Club Miami Group

The general concerns expressed by the Miami Group in their letter dated October 17th, 1990 will be addressed by responding to the specific comments of their attached assessment by Dr. Tom Davenport.

1. Station M-5 was sampled as part of the benthic infaunal characterization. It is well documented that this type of community changes substantially as one moves shoreward and the corresponding depths shallow and bottom sediments change. The one station sampled (M-5) confirms that such a change occurs very near the proposed site.

2. The Site Management and Monitoring Plan has addressed this issue. See Appendix C.

3. The Site Management and Monitoring Plan has addressed this concern. See Appendix C.

4 & 5. Additional field studies and modeling have addressed these concerns (Appendices E, F, and G). The model was applied for a strong easterly current without a northern current component and using ambient currents provided by the Rosenstiel School of Marine and Atmospheric Sciences at the University of Miami. The results of this study are included in this EIS in Appendix E. In addition, management requirements have been implemented as described in the Site Management and Monitoring Plan (Appendix C) to restrict disposal during specific current events.

6. Additional modelling was conducted with varying dredged material characteristics. Results are presented in Appendices B and E.

7. Use of a site several miles further offshore is not economically feasible.

8. Deposition of dredged material directly on the bottom is not feasible at the depths at the site.

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APPENDIX A

Environmental Survey in the Vicinity of
An Ocean Dredged
Material Disposal Site
Miami Harbor, Florida

December, 1985

CONSERVATION CONSULTANTS, INC.
Environmental Scientists and Engineers
Post Office Box 35
Palmetto, Florida 33561

APPENDIX A

CONTENTS

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APPENDIX A

This report details the methods and results of an environmental survey of the Miami Harbor interim Ocean Dredged Material Disposal Site (ODMDS) vicinity. This survey was conducted by Conservation Consultants, Inc. (CCI) on January 22 through 29, 1986.

A.1 METHODS

A.1.1 Location of Study Area and Sampling Locations

The Miami Harbor interim ODMDS is a one square nautical mile area with the following corner coordinates:

(NW)	25°45'30" N 80°03'54" W	(NE)	25°45'30" N 80°02'50" W
(SW)	25°44'30" N 80°03'54" W	(SE)	25°44'30" N 80°02'50" W

The general location of the ODMDS is shown in Figure A-1. Nine sampling stations were located in the Miami Harbor study area. The relationship of these stations to the designated interim ODMDS is shown in Figure A-2. The location and the type of sampling conducted at each of these stations is given in Table A-1.

A.1.2 Physical and Geological Characteristics

A.1.2.1 Bathymetry

A bathymetric survey was conducted along ten transects in the Miami Harbor ODMDS study area. Each of these transects was

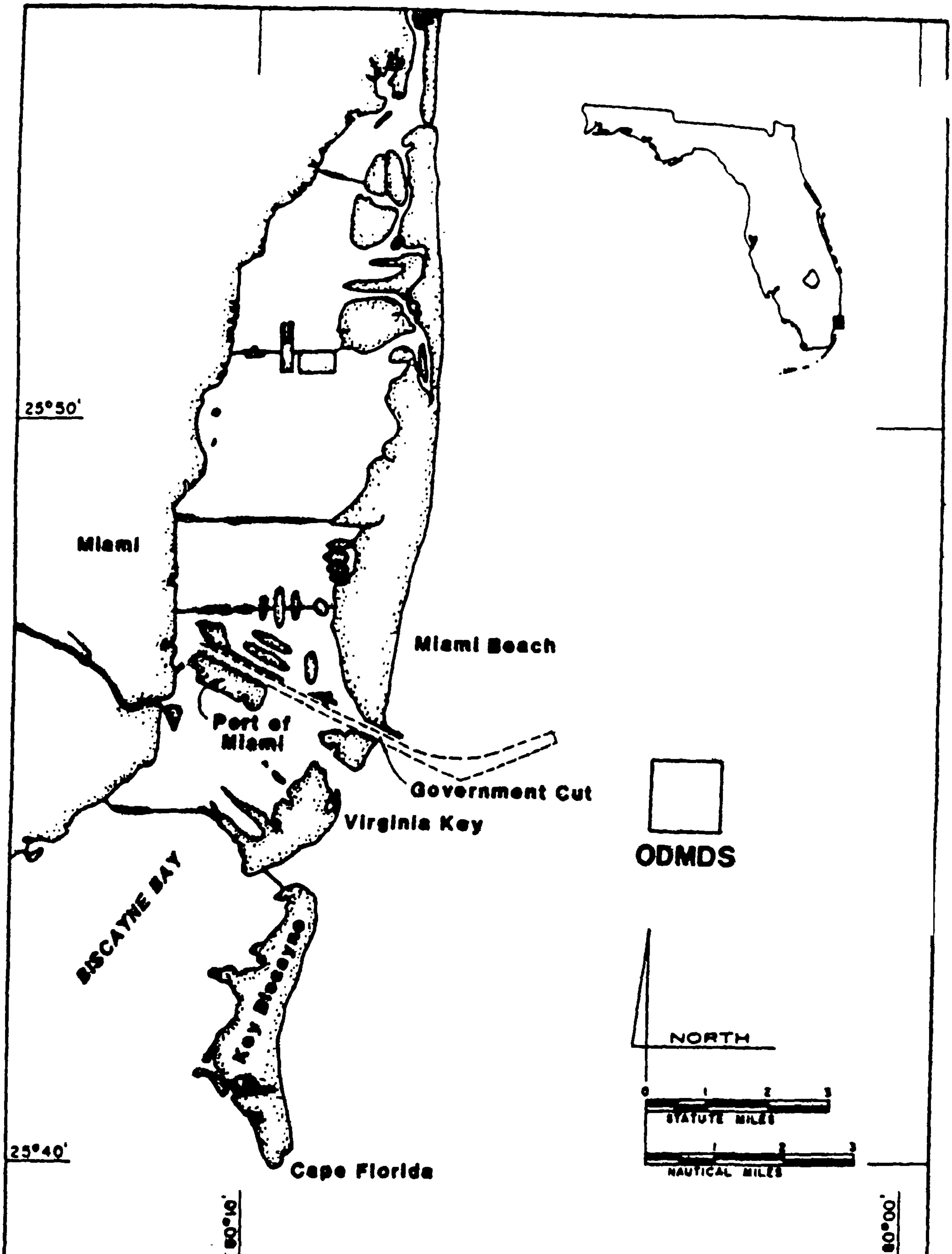
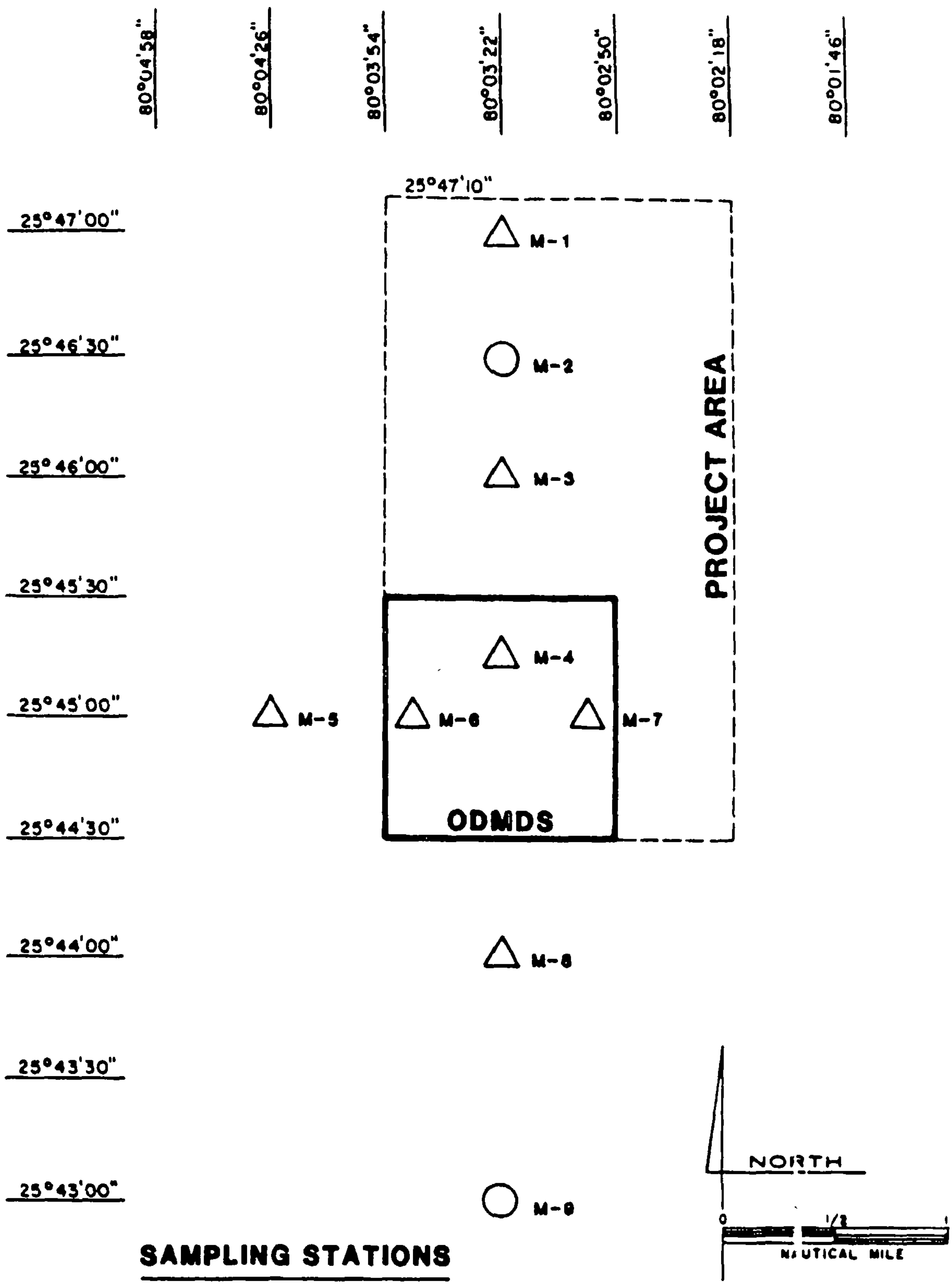


FIGURE A-1

GENERAL LOCATION MAP

Ocean Dredged Material Disposal Site Miami, Florida



SAMPLING STATIONS

○ **Sediments/Benthos**

△ **Sediments/Benthos and Water Quality**

FIGURE A-2

SAMPLING STATION LOCATIONS

Ocean Dredged Material Disposal Site Miami, Florida

Table A-1. Station Locations and Types of Samples Collected from the Miami Harbor ODMDS Study Area.

Station No.	Latitude (N)	Longitude (W)	Samples Collected
M-1	25°47'00"	80°03'22"	Sediments Benthic Invertebrates Water Quality Trawl
M-2	25°46'30"	80°03'22"	Sediments Benthic Invertebrates
M-3	25°46'00"	80°03'22"	Sediments Benthic Invertebrates Water Quality
M-4	25°45'15"	80°03'22"	Sediments Benthic Invertebrates Water Quality Trawl
M-5	25°45'00"	80°04'26"	Sediments Benthic Invertebrates Water Quality
M-6	25°45'00"	80°03'46"	Sediments Benthic Invertebrates Water Quality Trawl
M-7	25°45'00"	80°02'58"	Sediments Benthic Invertebrates Water Quality
M-8	25°44'00"	80°03'22"	Sediments Benthic Invertebrates Water Quality
M-9	25°43'00"	80°03'22"	Sediments Benthic Invertebrates Trawl

approximately two nautical miles (3.7 km) in length and oriented in an east-west direction. Transects were established to run between 80°02'18" and 80°04'26" west longitude at the following latitudes.

Transect No.	Latitude (N)
M-T1	25°47'00"
M-T2	25°46'30"
M-T3	25°46'00"
M-T4	25°45'30"
M-T5	25°45'15"
M-T6	25°45'00"
M-T7	25°44'45"
M-T8	25°44'30"
M-T9	25°44'00"
M-T10	25°43'00"

M-T1, M-T2, and M-T3 were located approximately 1.5, 1.0 and 0.5 nautical miles north of the ODMDS, respectively. Transect M-T1 crossed sampling Station M-1, while M-T2 crossed Station M-2 and M-T3 traversed Station M-3. Transects M-T9 and M-T10 were established about 0.5 and 1.5 nautical miles south of the disposal site, respectively. Transect M-T9 crossed sampling Station M-8, and M-T10 crossed Station M-9. The remaining six transects traversed the ODMDS. Transect M-T6 crossed Stations M-5, M-6, and M-7 and M-T5 crossed Station M-4. Each of the ten transects extended approximately 0.5 nautical mile (0.9 km) beyond both the east and west boundaries of the ODMDS.

Depths were measured using a Gifft 4000T receiver/recorder linked to a 3.5 KHz transducer which was mounted in a towfish and trailed from the survey vessel.

A.1.2.2 Hydrography

Hydrographic profiles were taken at each of the seven water quality stations. At each station, measurements of temperature, salinity, and dissolved oxygen were taken at 20 ft (6.1 m) intervals from the surface to a depth of 220 ft (67 m). Temperature and dissolved oxygen measurements were made with a Hydrolab TPD-2 temperature/dissolved oxygen meter. Salinities were measured with a Hydrolab 4021 temperature/conductivity meter. Meters were calibrated both before and after measurements were taken.

Total suspended solids and turbidity levels were measured in waters collected from 30 ft (91.5 m) below the surface and from approximately 6.5 ft (2 m) off the bottom at each of the seven designated water quality stations. Analytical methods are given in Table A-2.

A.1.2.3 Granulometry

Sediment samples were collected from each of the nine sediment sampling stations with a ponar grab sampler. Subsamples of the relatively undisturbed grab samples were taken with 3 cm (i.d.) Plexiglass coring tubes for granulometric analyses. These tubes were pushed into the sediment, sealed top and bottom with rubber stoppers, and then removed. The top ten centimeters of each core was then extruded into a labeled plastic bottle and transported to the laboratory for analysis.

Table A-2. Methods of Chemical Analysis of Water, Sediment, and Tissue Samples.

Parameter	Sample Type	Preservation	Analytical Methods
Cadmium	Water	Nitric Acid	Atomic Absorption Spectrophotometry/Graphite Furnace
	Sediment	Chilled	Atomic Absorption Spectrophotometry/Graphite Furnace
	Tissue	Chilled	Atomic Absorption Spectrophotometry/Graphite Furnace
Lead	Water	Nitric Acid	Atomic Absorption Spectrophotometry/Graphite Furnace
	Sediment	Chilled	Atomic Absorption Spectrophotometry/Graphite Furnace
	Tissue	Chilled	Atomic Absorption Spectrophotometry/Graphite Furnace
Mercury	Water	Nitric Acid	Atomic Absorption Spectrophotometry/Cold Vapor
	Sediment	Chilled	Atomic Absorption Spectrophotometry/Cold Vapor
	Tissue	Chilled	Atomic Absorption Spectrophotometry/Cold Vapor
Chlorinated Hydrocarbons (PCBs and Pesticides)	Water	Chilled	Gas Chromatography/Electron Capure Detector
	Sediment	Chilled	Gas Chromatography/Electron Capure Detector
	Tissue	Chilled	Gas Chromatography/Electron Capure Detector
HMW Hydrocarbons	Water	Chilled	Gas Chromatography/Flame Ionization Detector
	Sediment	Chilled	Gas Chromatography/Flame Ionization Detector
	Tissue	Chilled	Gas Chromatography/Flame Ionization Detector
Total Suspended Solids	Water	Chilled	Gravimetric
Total Organic Carbon	Sediment	Chilled	Wet Combustion/Infrared Detector
Oil and Grease	Sediment	Chilled	Soxhlet Extraction (hexane)
Turbidity	Water	Chilled	Nephelometry

NOTE 1. Analytical methods followed those outlined in Pequegnat (1981) U.S. Army Waterways Experiment Station, Technical Report EL-81-1; Procedural Guide for Designation Surveys of Ocean Dredged Material Disposal Sites.

NOTE 2. PCBs = Polychlorinated Biphenyls.
HMW = High Molecular Weight.

Grain size determinations generally followed the procedures outlined by Pequegnat et al. (1981) in U.S. Army Waterways Experiment Station Technical Report EL-81-1; Procedural Guide for Designation Surveys of Ocean Dredged Material Disposal Sites. Samples were first wet sieved through a 62 um sieve, using a 5 g/l sodium hexametaphosphate dispersant, to separate the sand-shell fraction from the silt-clay fraction. The sand-shell fraction then underwent grain size analysis by sieving, while pipette analysis was used to quantify the silt-clay fraction. A Tyler Sieve Shaker (Model R-X24) and nested 8-inch brass sieves with mesh sizes of 2.0, 1.0, 0.5, 0.25, 0.177, 0.12, and 0.06 mm were used to conduct the sieve analysis.

A.1.3 Chemical Characteristics

A.1.3.1 Water Quality

Grab samples for chemical analysis were collected with a non-contaminating Kemmerer-type sampler from 33 ft (10 m) below the surface and from approximately 6.5 ft (2 m) off the bottom at each of seven designated water quality sampling stations. Methods of preservation and analysis are summarized in Table A-2.

A.1.3.2 Sediment Chemistry

Sediment samples for chemical analysis were taken with a ponar grab sampler. Well-mixed composite samples were collected from each station for analysis. Upon collection, sediment samples were placed in labeled glass jars and kept on ice until delivered to the laboratory.

Two methods were used for the extraction of sediment samples, as recommended by Pequegnat et al. (1981). Seven of the nine samples collected were treated by seawater elutriation and two by 0.1 N HCl partial extraction. Methods used for the chemical analysis of the seawater and acid elutriates are given in Table A-2.

A.1.4 Biological Characteristics

A.1.4.1 Benthic Macroinvertebrates

Benthic macroinvertebrates were sampled by ponar dredge at nine stations in the Miami Harbor ODMDS study area. The ponar dredge samples 0.054 square meters of sediment surface. Five samples, representing 0.27 square meters of bottom surface, were taken at each station.

Upon collection, samples were fixed in a ten percent solution of buffered Formalin to which a stain, rose bengal (200 mg/l), had been added. This stain concentrates in animal tissues and facilitates the effective recovery of organisms for analysis.

In the laboratory, samples were sieved through a 500 u mesh and re-preserved in a 70 percent solution of isopropyl alcohol. The sieved samples were then sorted under a dissecting microscope to recover all benthic organisms. All samples were cross-checked to ensure the efficiency of sample processing.

Following sorting, identifications and counts were made under a dissecting microscope. Representative specimens have been preserved in a reference collection.

A.1.4.2 Meiofauna

Two meiofauna samples were collected at each of the nine benthic sampling stations in the Miami Harbor ODMDS study area. Meiofauna samples were taken by coring sediments collected by ponar dredge with a 3 cm (1.2 in) i.d. Plexiglass coring tube. The coring tube was then capped at both ends, removed from the sediment, and the top 20 cm (7.87 in) of material extruded into a labeled sample container. Meiofauna samples were preserved in a 5 percent solution of buffered Formalin to which a stain, rose bengal (200 mg/l), had been added.

In the laboratory, meiofaunal samples were first sieved through a 500 u mesh screen to remove representatives of the macrobenthos. The remaining material was passed through a 64 u sieve, and the portion retained sorted to remove meiofauna. All counts and identifications were made under a binocular dissecting microscope at a magnification of 25 X.

A.1.4.3 Macroepifauna

Macroepifauna were collected by trawl at four sites in the study area. Two 15 minute tows with a 10 ft. (3.1 m) trawl were made at each site. All trawls were made from north to south, against the current, at an estimated bottom speed of one to two knots. The wet weight biomass of each sample was determined immediately after trawl retrieval with a Hanson (Model 600) spring scale. Following biomass determination, organisms were counted and identified to the extent possible in the field. Those organisms which were selected for tissue analyses were removed at this time, identified, weighed, and placed on ice. All other organisms were preserved in a 10 percent Formalin solution. Upon return to the laboratory, taxonomic verifications were made and all samples were placed in storage.

A.1.4.4 Tissue Analyses

Tissues for chemical analysis were taken from macroepifaunal organisms collected by trawl as described in Section A.1.4.3. Following collection, fish and crabs selected for analysis were frozen and transported in a chilled state to the laboratory for analysis.

Whole fish and crabs were analyzed for constituents listed in Table A-2. Edible shrimp tissues were analyzed for trace metals only using the methods of analysis given in Table A-2.

A.2 Results and Discussion

A.2.1 Physical and Geological Characteristics

A.2.1.1 Bathymetry

The Miami Harbor ODMDS is situated on the Continental Slope, approximately 4 nmi (7.4 km) east of the Port of Miami. Depths at the designated interim disposal site range from about 427 to 785 ft (130 to 239 m). The average declivity of the Slope at the interim ODMDS is approximately 325 ft (100 m) per nautical mile (1.85 km). A bathymetric map of the ODMDS vicinity is presented as Figure A-3. Depths at each of the nine sampling stations established in the Miami Harbor ODMDS vicinity are given in Table A-3.

A.2.1.2 Hydrography

Hydrographic profiles were made at each of the seven water quality stations established in the study area. Temperature, salinity, and dissolved oxygen were measured at 20 ft (6.1 m) intervals through the upper 220 ft (67 m) of the water column. Results of these measurements are presented in Table A-4.

Temperature

Temperatures measured during this survey ranged from 22.3 to 23.3°C. These temperatures are comparable to winter temperatures previously reported for the area. The Environmental Protection Agency (EPA, 1973) reports temperatures in the

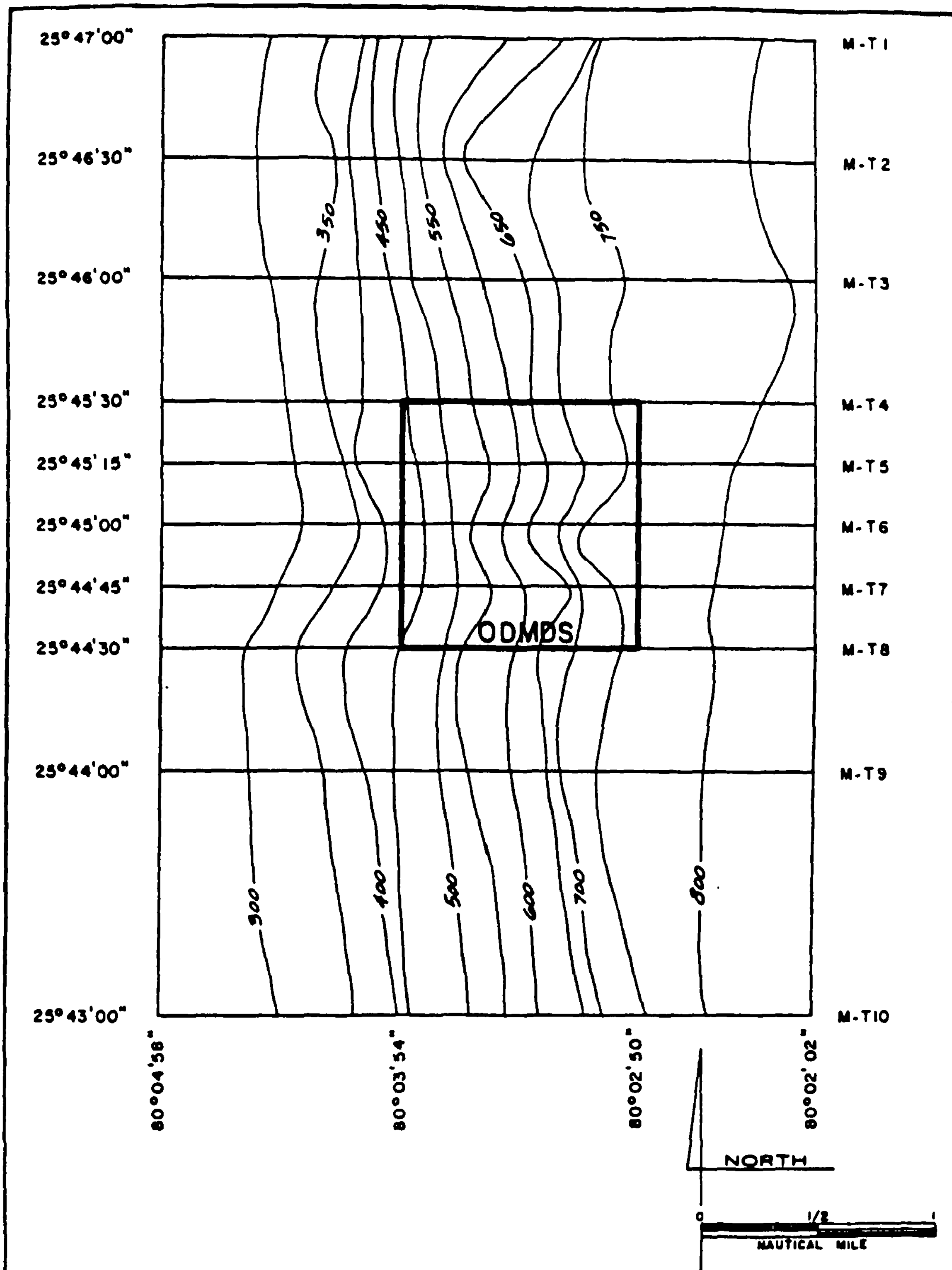


FIGURE A-3

BATHYMETRIC MAP

Ocean Dredged Material Disposal Site Miami, Florida

Table A-3. Water Depths at Stations in the Miami Harbor ODMDS Study Area.

Station	Depth ft.	Depth m
M-1	615	187
M-2	708	216
M-3	644	196
M-4	600	183
M-5	282	86
M-6	452	138
M-7	770	235
M-8	625	190
M-9	574	175

Table A-4. Temperature, Salinity, and Dissolved Oxygen Profiles Taken at Stations in the Miami Harbor ODMDS Vicinity; January 29, 1986.

Station	Time	Depth (Ft)	Temperature (°C)	Salinity (ppt)	Dissolved Oxygen (ppm)	Dissolved Oxygen % Saturation
M-1	0840	0	23.0	36.2	8.1	117
		20	23.0	36.3	8.2	118
		40	23.0	36.4	8.0	115
		60	23.1	36.5	8.0	115
		80	23.3	36.5	8.0	115
		100	23.1	36.8	7.9	114
		120	23.0	36.4	8.3	120
		140	22.9	36.4	8.3	120
		160	22.9	36.5	8.3	120
		180	22.7	36.6	8.3	120
		200	22.8	36.6	8.3	120
		220	22.8	36.6	8.3	120
M-3	0915	0	22.6	35.9	8.3	118
		20	22.4	35.9	8.5	121
		40	22.6	35.9	8.3	118
		60	22.6	35.8	8.2	117
		80	22.7	35.8	8.3	118
		100	22.7	35.8	8.3	118
		120	22.6	35.9	8.3	118
		140	22.6	35.9	8.2	117
		160	22.6	36.0	8.1	116
		180	22.6	35.9	8.1	116
		200	22.6	35.9	8.1	116
		220	22.5	36.1	8.2	117
M-4	1001	0	22.5	35.7	8.2	116
		20	22.5	35.6	8.1	115
		40	22.6	35.7	8.2	116
		60	22.6	35.8	8.1	115
		80	22.6	35.7	8.3	118
		100	22.6	35.7	8.3	118
		120	22.6	35.6	8.2	116
		140	22.6	35.7	8.3	118
		160	22.6	35.7	8.3	118
		180	22.5	35.7	8.2	116
		200	22.5	35.7	8.2	116
		220	22.5	35.7	8.2	116

Table A-4. (Continued)

Station	Time	Depth (Ft)	Temperature (°C)	Salinity (ppt)	Dissolved Oxygen (ppm)	Dissolved Oxygen % Saturation
M-5	1045	0	22.5	35.7	8.3	118
		20	22.6	35.7	8.3	118
		40	22.6	35.6	8.2	116
		60	22.7	35.6	8.1	115
		80	22.6	35.7	8.2	116
		100	22.5	35.7	8.2	116
		120	22.5	35.7	8.2	116
		140	22.3	35.7	8.2	116
		160	22.3	35.7	8.2	116
		180	22.3	35.7	8.2	116
		200	22.3	35.7	8.2	116
		220	22.4	35.7	8.2	116
M-6	1111	0	22.6	35.5	8.3	118
		20	22.7	35.7	8.3	118
		40	22.7	36.0	8.3	118
		60	22.7	36.1	8.3	118
		80	22.7	35.9	8.3	118
		100	22.6	35.7	8.2	116
		120	22.6	35.7	8.2	116
		140	22.6	35.7	8.2	116
		160	22.6	35.7	8.2	116
		180	22.6	35.7	8.2	116
		200	22.5	35.7	8.2	116
		220	22.5	35.7	8.2	116
M-7	1145	0	22.8	35.7	8.4	119
		20	22.7	35.7	8.3	118
		40	22.7	35.7	8.3	118
		60	22.6	35.7	8.2	116
		80	22.6	35.7	8.2	116
		100	22.6	35.7	8.2	116
		120	22.5	35.7	8.1	115
		140	22.5	35.7	8.1	115
		160	22.5	35.7	8.1	115
		180	22.6	35.7	8.2	116
		200	22.7	35.7	8.2	116
		220	22.4	35.7	8.2	116

Table A-4. (Continued)

Station	Time	Depth (Ft)	Temperature (°C)	Salinity (ppt)	Dissolved Oxygen (ppm)	Dissolved Oxygen % Saturation
M-8	1232	0	22.9	35.5	8.2	117
		20	22.8	35.7	8.2	117
		40	22.8	35.9	8.1	115
		60	22.8	35.9	8.1	116
		80	22.8	35.9	8.1	116
		100	22.8	36.2	8.1	116
		120	22.7	36.2	8.1	116
		140	22.7	36.4	8.0	115
		160	22.7	36.5	8.1	117
		180	22.7	36.5	8.0	115
		200	22.7	36.6	8.1	117
		220	22.7	36.5	8.1	117

ODMDS vicinity ranging from a low of around 23°C in February to over 29°C in July.

No evidence of thermal stratification was noted. Temperatures measured from the surface to a depth of 220 ft (67 m) did not vary by more than 0.5°C.

Salinity

Salinities measured in the upper water column during this January 1986 survey ranged from 35.5 to 36.8 parts per thousand (ppt). Similar salinities have previously been reported for the area (EPA, 1973).

Little variation in salinity with depth was observed. Salinity in the upper 220 ft (67 m) of the water column generally varied less than 1 ppt. Salinities of near-bottom waters (Table A-9) were also in the 35 to 36 ppt range.

Dissolved Oxygen

Dissolved oxygen (DO) concentrations measured in study area waters on January 29, 1986 ranged from 7.9 to 8.5 ppm and were consistently above saturation. Little variation in DO concentrations between stations or with depth was noted.

Total Suspended Solids

Total suspended solids (TSS) samples were collected from near-surface and near-bottom waters at each of the seven water quality stations. Results of TSS analyses are presented in

Table A-5. TSS concentrations were generally low, ranging from below detection (5 mg/l) to 11 mg/l. Values were below detection in ten of the fourteen samples taken.

Turbidity

Turbidity is defined as the optical property of a sample which causes light to be scattered and absorbed rather than transmitted in straight lines. Turbidity is commonly measured with a nephelometer, which measures scattered light, and is reported in NTUs (nephelometric turbidity units). Turbidity samples were collected from near-surface and near-bottom waters at each of the seven designated water quality stations. Results of these analyses are given in Table A-5.

Turbidity levels ranged between 4 and 9 NTU. No consistent differences or trends were noted between levels in near-surface and near-bottom waters or in the distribution of values between stations.

A.2.1.3 Granulometry

The grain size distributions of surficial sediments collected in the study area are presented in Table A-6. Mean grain sizes, modes, and inclusive standard deviations, calculated for the sediments collected from each station are given in Table A-7.

Surficial sediments in the Miami Harbor interim ODMDS vicinity are primarily comprised of very fine sands and coarse silt.

Table A-5. Total Suspended Solids Concentrations and Turbidity Levels Measured at Stations in the Miami Harbor ODMDS Vicinity.

Station	Position	Depth (Ft.)	Total Suspended Solids (mg/l)	Turbidity (NTU)
M-1	Surface	33	<5	5
	Bottom	608	<5	4
M-3	Surface	33	<5	5
	Bottom	637	<5	6
M-4	Surface	33	5.7	4
	Bottom	593	<5	4
M-5	Surface	33	<5	4
	Bottom	275	5.8	6
M-6	Surface	33	<5	5
	Bottom	445	<5	4
M-7	Surface	33	11	9
	Bottom	763	<5	5
M-8	Surface	33	<5	5
	Bottom	618	6.2	6

Table A-6. Grain Size Distribution of Sediments Collected from the Miami Harbor ODMDS Vicinity.

Station	Percent Composition Shell (≤ -1 ∅)	Coarse sands (-1 to 1 ∅)	Medium sands (1 to 2 ∅)	Fine sands (2 to 4 ∅)	Silt (4 to 8 ∅)	Clay (≥ 8 ∅)
M-1	<1	<1	<1	61	38	0
M-2	<1	<1	<1	74	25	0
M-3	<1	1	2	75	22	0
M-4	0	1	1	73	25	0
M-5	1	5	7	64	9	14
M-6	0	1	1	70	28	0
M-7	<1	1	2	73	24	0
M-8	0	1	2	73	24	0
M-9	<1	3	1	69	27	0

Table A-7. Granulometric Characteristics of Sediments Collected from the Miami Harbor ODMDS Vicinity.

Station	Mean (phi, ø)	Mode (phi, ø)	Inclusive Standard Deviation (phi, ø)
M-1	4.0	4.0	0.6
M-2	3.8	4.0	0.4
M-3	3.8	4.0	0.4
M-4	3.8	4.0	0.4
M-5	4.2	4.0	2.3
M-6	3.8	4.0	0.4
M-7	3.8	4.0	0.4
M-8	3.8	4.0	0.4
M-9	3.8	4.0	0.4

Sediment composition was generally uniform at most stations in the ODMDS area. The greatest differences in sediment composition were found at M-5, the sampling station located farthest inshore. Sediments at M-5 contained more clay, coarser sands, and less silt than sediments collected from the other station in the study area.

Inclusive graphic standard deviations were calculated as a measure of the uniformity or sorting of sediments. Values for this statistic generally range from 0.35 phi for well-sorted sediments to 4.00 phi for poorly sorted, non-uniform sediments (Pequegnat et al., 1981). Surficial sediments at most stations in the study area were well sorted, with inclusive standard deviation values of 0.4 and 0.6. Sediments at Station M-5 were less well sorted and had a inclusive standard deviation value of 2.3.

A.2.2 Chemical Characteristics

A.2.2.1 Water Quality

Water samples for chemical analysis were collected from approximately 33 ft (10 m) below the surface and 6.5 ft (2 m) above the bottom at Stations M-1, M-3, M-4, M-5, M-6, M-7, and M-8. Samples were analyzed for a number of potential contaminants, including selected trace metals, pesticides and pesticide derivatives, polychlorinated biphenyls (PCBs), and high molecular weight (HMW) hydrocarbons. Salinity was also measured as an indicator of stratification (discussed previously in Section A.2.1.2). Specific parameters measured and results of analyses of near-surface and near-bottom waters are presented in Tables A-8, and A-9, respectively.

Trace metals analyzed in water samples were mercury, cadmium, and lead. Mercury was not detected. Cadmium was present in near-bottom waters collected from Stations M-4 and M-5. Lead was only detected in one near-surface water sample collected from Station M-6.

Levels of pesticides, pesticide derivatives, PCBs, and HMW hydrocarbons were below analytical detection limits in all near-surface and near-bottom waters sampled.

A.2.2.2 Sediment Chemistry

Sediments were collected from each station for chemical analysis. Constituents analyzed were selected trace metals, pesticides, polychlorinated biphenyls (PCBs), high molecular weight (HMW) hydrocarbons, total organic carbon, and oil and grease. Metals were extracted from sediments collected from Stations M-1, M-2, M-3, M-5, M-6, M-7 and M-9 by seawater elutriation. Weak acid (0.1 N HCl) leaching was used to extract metals from sediments collected from M-4 and M-8. Results of sediment chemistry analyses are presented in Table A-10.

Concentrations of metals in sediments were below analytical detection limits in all seawater elutriates. Mercury,

Table A-8. Results of Chemical Analyses of Near Surface Waters Collected from the Miami Harbor ODMDS Vicinity.

PARAMETER	Station M-1	M-3	M-4	M-5	M-6	M-7	M-8
Trace Metals							
Mercury, ppb	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cadmium, ppb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Lead, ppb	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	<0.5
Pesticides							
Alpha-BHC, ppb	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Gamma-BHC, ppb	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Heptachlor, ppb	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Beta-BHC, ppb	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Aldrin, ppb	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009
Heptachlor Epoxide, ppb	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
4,4'-DDE, ppb	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.04
4,4'-DDD, ppb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
4,4'-DDT, ppb	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
o,p'-DDD, ppb	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
o,p'-DDT, ppb	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chlordane, ppb	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dieldrin, ppb	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Endrin, ppb	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Total PCBs as Archlor 1254, ppb	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
High Molecular Weight Hydrocarbons							
Volume of sample extracted, ml	1500	1500	1500	1500	1500	1500	1500
Weight of extractables, ppm	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Aliphatics and aromatics, ppb	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Resolved hydrocarbons, ppb	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Unresolved hydrocarbons, ppb	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sum of n-alkanes, ppb	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sum of even n-alkanes, ppb	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sum of odd n-alkanes, ppb	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Salinity, ppt	36	36	36	35	36	36	35

Table A-9. Results of Chemical Analyses of Near Bottom Waters Collected from the Miami Harbor ODMDS Vicinity.

	Station						
PARAMETER	M-1	M-3	M-4	M-5	M-6	M-7	M-8
Trace Metals							
Mercury, ppb	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cadmium, ppb	<0.05	<0.05	0.07	0.06	<0.05	<0.05	<0.05
Lead, ppb	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Pesticides							
Alpha-BHC, ppb	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Gamma-BHC, ppb	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006	<0.006
Heptachlor, ppb	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Beta-BHC, ppb	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Aldrin, ppb	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009	<0.009
Heptachlor Epoxide, ppb	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
4,4'-DDE, ppb	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.04
4,4'-DDD, ppb	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
4,4'-DDT, ppb	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
o,p'-DDD, ppb	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
o,p'-DDT, ppb	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Chlordane, ppb	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Dieldrin, ppb	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Endrin, ppb	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Total PCBs as Archlor 1254, ppb	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
High Molecular Weight Hydrocarbons							
Volume of sample extracted, ml	1500	1500	1500	1500	1500	1500	1500
Weight of extractables, ppm	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Aliphatics and aromatics, ppb	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Resolved hydrocarbons, ppb	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Unresolved hydrocarbons, ppb	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sum of n-alkanes, ppb	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sum of even n-alkanes, ppb	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sum of odd n-alkanes, ppb	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Salinity, ppt	35	36	35	36	35	35	35

Table A-10. Results of Chemical Analyses of Sediments Collected from the Miami Harbor ODMDS Vicinity.

PARAMETER	Station M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-8	M-9
<u>Trace Metals</u>									
Mercury (in seawater elutriate),* ug/l	<0.05	<0.05	<0 05	---	<0.05	<0.05	<0.05	---	<0.05
Cadmium (in seawater elutriate), ug/l	<0.5	<0.5	<0.5	---	<0.5	<0 5	<0.5	---	<0.5
Lead (in seawater elutriate), ug/l	<0.2	<0.2	<0.2	---	<0.2	<0.2	<0.2	---	<0.2
Mercury (in acid leachate),** ug/g, dry	---	---	---	<0.03	---	---	---	0.03	---
Cadmium (in acid leachate), ug/g, dry	---	---	---	0.14	---	---	---	0.18	---
Lead (in acid leachate), ug/g, dry	---	---	---	1.7	---	---	---	2 2	---
<u>Pesticides</u>									
Alpha-BHC, ug/kg	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Gamma-BHC, ug/kg	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
Heptachlor, ug/kg	<0.08	<0.08	<0 08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Beta-BHC, ug/kg	<0.3	<0.3	<0.3	<0 3	<0.3	<0.3	<0.3	<0.3	<0.3
Aldrin, ug/kg	<0.1	<0.1	<0 1	<0.1	<0 1	<0.1	<0.1	<0.1	<0.1
Heptachlor Epoxide, ug/kg	<0.1	<0 1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
4,4'-DDE, ug/kg	<0.2	<0 2	<0.2	<0.2	<0 2	<0.2	<0.2	<0.2	<0.2
4,4'-DDD, ug/kg	<0.4	<0.4	<0.4	<0 4	<0.4	<0.4	<0.4	<0.4	<0.4
4,4'-DDT, ug/kg	<0.4	<0.4	<0.4	<0 4	<0.4	<0.4	<0 4	<0.4	<0.4
o,p'-DDD, ug/kg	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
o,p'-DDT, ug/kg	<0 5	<0 5	<0.5	<0 5	<0.5	<0.5	<0.5	<0.5	<0.5
Chlordane, ug/kg	<0.7	<0.7	<0.7	<0.7	<0 7	<0.7	<0.7	<0.7	<0.7
Dieldrin, ug/kg	<0.2	<0.2	<0 2	<0 2	<0 2	<0 2	<0.2	<0.2	<0 2
Endrin, ug/kg	<0.3	<0 3	<0.3	<0 3	<0 3	<0.3	<0 3	<0.3	<0.3
<u>Total PCBs as Archlor 1254</u>, ug/kg	<3 0	<3 0	<3.0	<3 0	<3 0	<3 0	<3 0	<3 0	<3 0

Table A-10. (Continued)

PARAMETER	Station M-1	M-2	M-3	M-4	M-5	M-6	M-7	M-8	M-9
<u>High Molecular Weight Hydrocarbons</u>									
Wet weight of sample extracted, g	250	250	250	250	250	250	250	250	250
Dry weight of sample extracted, g	130	118	108	133	135	128	150	115	133
Percent dry weight of wet weight	52	47	43	53	54	51	60	46	53
Weight of extractables, ppm, dry	49	37	39	180	52	68	48	160	82
Aliphatics and aromatics, ppm, dry	0.09	0.12	0.09	0.12	0 08	0.13	0.07	0.14	0.10
Resolved hydrocarbons, ppm, dry	0.27	0.43	0.28	0.32	0.31	0.29	0.21	0.21	0.23
Unresolved hydrocarbons, ppm, dry	0.13	0.13	0.15	0.10	0.21	0.32	0.38	0.14	0.23
Sum of n-alkanes, ppm, dry	0.06	0.02	0.04	0.03	0.07	0.06	0.03	0.05	0.03
Sum of even n-alkanes, ppm, dry	0.03	0.01	0.03	0.02	0.05	0.05	0.02	0.04	0.02
Sum of odd n-alkanes, ppm, dry	0.03	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01
Unresolved hydrocarbons/resolved hydrocarbons	0.48	0.30	0.54	0.31	0.68	1.1	1.8	0.67	1.0
Odd n-alkanes/even n-alkanes	1.0	1.0	0.33	0.50	0.40	0.20	0.50	0.25	0.50
<u>Oil and grease</u>, ug/g	12	24	21	14	32	41	27	27	30
<u>Total organic carbon</u>, mg/g	13	18	17	17	11	14	16	16	18

*Seawater elutriation conducted in accordance with Environmental Protection Agency/Corps of Engineers Technical Report EPA/CE-81-1: Sediment:water ratio of 1:4 (vol/vol).

**Acid extraction with 0.1 N HCl in accordance with Pequegnat et al. (1981); Corps of Engineers Technical Report EL-81-1.

cadmium, and lead concentrations were comparable in acid leachates of sediments from M-4 and M-8.

No chlorinated hydrocarbon pesticides, pesticide derivatives, or PCBs were detected in sediments collected from the study area.

Sediment concentrations of total high molecular weight (HMW) hydrocarbons exhibited a considerable range. Lowest levels were found at stations located north (downstream) of the ODMDS. Highest concentrations were measured in sediments collected from Station M-4, located within the ODMDS, and from Station M-8, located south (upstream) of the ODMDS. In general, component HMW hydrocarbon fractions exhibited no definitive spatial trends. Highest unresolved hydrocarbon concentrations were measured in sediments collected from Stations M-6 and M-7, within the designated interim disposal site.

Oil and grease concentrations in study area sediments ranged from 12 to 41 ug/g. The highest oil and grease concentration was measured in sediments from M-6, within the designated disposal area. Low concentrations were found at Station M-1, downstream of the ODMDS, and Station M-4, near the center of the ODMDS. No distinct pattern of distribution was apparent.

Total organic carbon (TOC) concentrations ranged from 11 to 18 mg/g. No trends in the distribution of TOC concentrations over the study area were observed.

A.2.3 Biological Characteristics

A.2.3.1 Benthic Macroinvertebrates

About 9,000 organisms representing approximately 200 individual taxa were inventoried from collections made in the Miami Harbor interim ODMDS study area. A listing of the benthic macroinvertebrate taxa identified is given in Appendix B, Table B-1. The composition, abundance, and diversity of macroinvertebrates collected in each sample taken from the nine stations in the study area are presented in Appendix B, Table B-2 through Table B-10.

The mean abundance, total number of taxa, and Shannon-Weaver diversity of benthic macroinvertebrates collected from each station are presented in Table A-11. Mean densities ranged from a low of 1,852 organisms/m^2 at Station M-2 to 6,041 organisms/m^2 at Station M-3. The mean density of benthic macroinfauna, averaged over all stations in the study area, was 3,753 organisms/m^2.

The interim ODMDS and the surrounding area supports a diverse assemblage of benthic macroinvertebrates. The number of individual taxa represented at stations in the study area ranged from 61 at Station M-2 to 88 at Station M-3 and primarily reflects the relative numbers of organisms encountered in samples. Shannon-Weaver diversities were high, ranging from a value of 3.38 at Station M-1 to 4.66 at

Table A-11. Mean Abundance and Diversity of Benthic Macroinvertebrates Collected from Stations in the Miami Harbor ODMDS Vicinity.

Station	Abundance ($Organisms/m^2$)*	Number of Taxa**	Shannon-Weaver Diversity**
M-1	4054 ± 2169	70	3.38
M-2	1852 ± 1031	61	4.24
M-3	6041 ± 2701	88	4.11
M-4	2779 ± 1201	72	4.13
M-5	3324 ± 1089	73	4.66
M-6	3278 ± 1656	69	3.85
M-7	5867 ± 1065	79	3.42
M-8	4044 ± 2865	74	3.80
M-9	2536 ± 1554	66	4.08

*Value given is the mean ± one standard deviation of the five samples taken at each station.

**Calculated based on data composited from the five samples taken at each station.

Station M-5. Values in this range are generally considered characteristic of stable environments.

No patterns were apparent in the distribution of macroinfaunal densities or diversities over the study area. While the depths of the stations sampled ranged approximately 488 ft. (149 m), no trends in quantitative community descriptors with depth were observed.

The composition of the benthic macroinfauna, by major taxonomic group, is given in Table A-12. Polychaete worms and amphipod crustaceans were co-dominants in the study area. Polychaetes were the dominant group at four stations, while amphipods were dominant at five stations. Polychaetes accounted for 37 percent of the area's macroinfaunal assemblage and were most abundant at Station M-3 and least abundant at Station M-4. Amphipods comprised 33 percent of the macroinfaunal community. Amphipod densities were lowest at the shallowest station (M-5) and highest at the deepest station (M-7).

Molluscs and nematodes were also well represented at all stations. Molluscs accounted for 14 percent of the benthic macroinvertebrate community and were evenly distributed over the study area. Nematodes comprised 9 percent of the macrobenthos.

Table A-13 presents rankings of the most abundant benthic macroinvertebrates present at each station, and in the overall

Table A-12. Benthic Macroinvertebrate Composition; By Major Group

Station	Polychaetes	Amphipods	Molluscs	Nematodes	Others
M-1	24	51	11	8	6
M-2	36	31	13	12	8
M-3	39	29	10	15	7
M-4	30	38	17	6	9
M-5	62	4	19	5	10
M-6	36	42	10	6	6
M-7	25	53	8	7	7
M-8	27	43	15	8	7
M-9	51	6	20	17	6
Average	37	33	14	9	7

Table A-13. Benthic Macroinvertebrate Taxa of the Miami Harbor ODMDS Vicinity, Ranked in Order of Abundance.

	Taxon* Rank				
Station	1	2	3	4	5
M-1	Ampeliscidae	Nematoda	Paraonidae	Nuculidae	Cirratulidae
M-2	Ampeliscidae	Nematoda	Spionidae	Lumbrineridae	Cirratulidae
M-3	Ampeliscidae	Nematoda	Cirratulidae	Orbiniidae	Spionidae
M-4	Ampeliscidae	Thyasiridae	Nematoda	Cossuridae	Ampharetidae
M-5	Spionidae	Orbiniidae	Cirratulidae	Paraonidae	Capitellidae
M-6	Ampeliscidae	Cirratulidae	Orbiniidae	Nematoda	Spionidae
M-7	Ampeliscidae	Nematoda	Spionidae	Cirratulidae	Nuculidae
M-8	Ampeliscidae	Nematoda	Orbiniidae	Nuculidae	Ampharetidae
M-9	Cirratulidae	Nematoda	Ampharetidae	Thyasiridae	Paraonidae
Overall	Ampeliscidae	Nematoda	Cirratulidae	Spionidae	Orbiniidae

*Ranked by taxonomic family or by next lowest practical taxonomic level.

study area. Rankings were made at the family level or at the next lowest level to which the organisms were identified. The most abundant family overall, and at seven of the nine stations sampled, was Ampeliscidae. This amphipod family accounted for almost one-third of the macroinvertebrates collected from the disposal site vicinity. The nematodes, representing several families, were ranked second in overall abundance followed by the polychaete families Cirratulidae, Spionidae, and Orbiniidae. Other locally abundant taxa included the pelecypod mollusc families, Nuculidae and Thyasiridae, and the polychaete families, Paraonidae, Lumbrineridae, Cossuridae, Capitellidae, and Ampharetidae.

The most abundant macroinfaunal species in the disposal site vicinity was Ampelisca agassizi, a tube-dwelling amphipod. This species has previously been reported as an abundant species characteristic of the upper Continental Slope off the southeastern U.S. (Boesch, 1977; in EPA, 1983). A. agassizi accounted for almost all of the amphipods encountered in samples from the Miami Harbor interim ODMDS vicinity. This species was the dominant infaunal species at all stations except M-5 and M-9.

A trophic classification of the most abundant benthic macroinvertebrate taxa of the study area is presented in Table A-14. Deposit feeding taxa were dominant at all stations.

Three similarity indices were used to aid in the classification and evaluation of the benthic macroinfauna collected at

Table A-14. Trophic Classification of Major Benthic Macroinvertebrate Taxa Collected from the Miami Harbor Interim ODMDS Vicinity.

Phylum	Class/Order	Family	Trophic Guild	Trophic Type
Annelida	Polychaeta	Ampharetidae	SDT	SDF
Annelida	Polychaeta	Capitellidae	SMX	NSDF
Annelida	Polychaeta	Cirratulidae	SDT	SDF
Annelida	Polychaeta	Cossuridae	BDT	SDF
Annelida	Polychaeta	Lumbrineridae	CMJ	C
Annelida	Polychaeta	Nephtyidae	CMJ	C
Annelida	Polychaeta	Orbiniidae	SDT	SDF,SF
Annelida	Polychaeta	Paraonidae	SDT	SDF
Annelida	Polychaeta	Spionidae	SDT	SDF
Arthropoda	Amphipoda	Ampeliscidae	SDX	SDF,SF
Arthropoda	Cumacea	Leuconidae	SMX	SF
Aschelminthes	Nematoda	---	SMX	NSDF
Mollusca	Pelecypoda	Nuculidae	FSX	SF
Mollusca	Pelecypoda	Thyasiridae	FSX	SF

Trophic Guild Codes:
Feeding Preference: S - Surface deposit; B - Subsurface deposit; C - Carnivore; F - Filter feeder
Mobility: M - Motile; D - Discreetly motile; S - Sessile;
Feeding Structures: J - Jaws; T - Tentacles; X - Miscellaneous.

Trophic Type Codes: C - Carnivore; O - Omnivore; SF - Suspension feeder;
SDF - Selective deposit feeder;
NSDF - Non-selective deposit feeder.

stations in the Miami Harbor interim ODMDS vicinity. Indices used were the Morisita Index, Bray-Curtis Index, and a simple matching index. The Morisita and Bray-Curtis indices are quantitative and take into account both the occurrence and the abundance of organisms. The simple matching index is qualitative and is based solely on the presence of common species in samples compared.

Cluster analyses were based on the above determinations of faunal similarity. Results of cluster analyses based on the Morisita Index, Bray-Curtis Index, and simple matching are presented in Figures A-4, A-5, and A-6, respectively.

Cluster analyses based on the quantitative similarity indices yielded similar results. Both the Morisita Index and the Bray-Curtis Index clustered Stations M-3, M-4, M-6, M-7, M-8, and M-9 as a major group. These indices also paired the northernmost Stations, M-1 and M-2. The Morisita Index also associated this pair with the largest station cluster at a relatively high similarity level. Both indices identified the shallow water station, M-5, as a distinct outlier.

Results of clustering based on presence/absence agreed well with results of the quantitative similarity analyses. Simple matching also identified Station M-5 as an outlier and paired Stations M-1 and M-2. The largest cluster, including the remaining six stations, exhibited a higher degree of internal differentiation than was indicated by the quantitative indices.

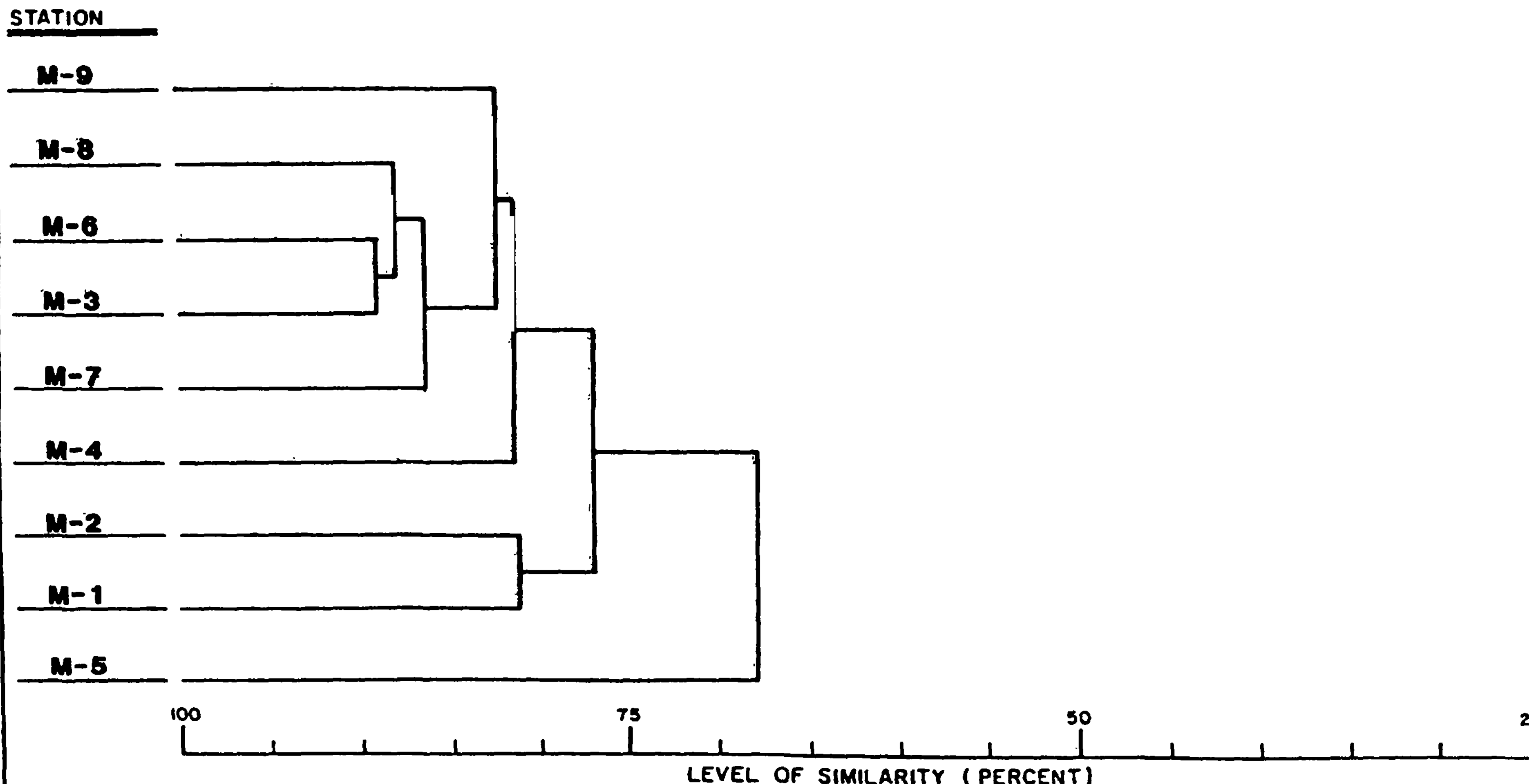


FIGURE A-4

CLUSTER DENDOGRAM SHOWING STATION ASSOCIATIONS BASED ON BENTHIC MACROINVERTEBRATE SIMILARITY AS DETERMINED USING THE MORISITA INDEX

Ocean Dredged Material Disposal Site Miami, Florida

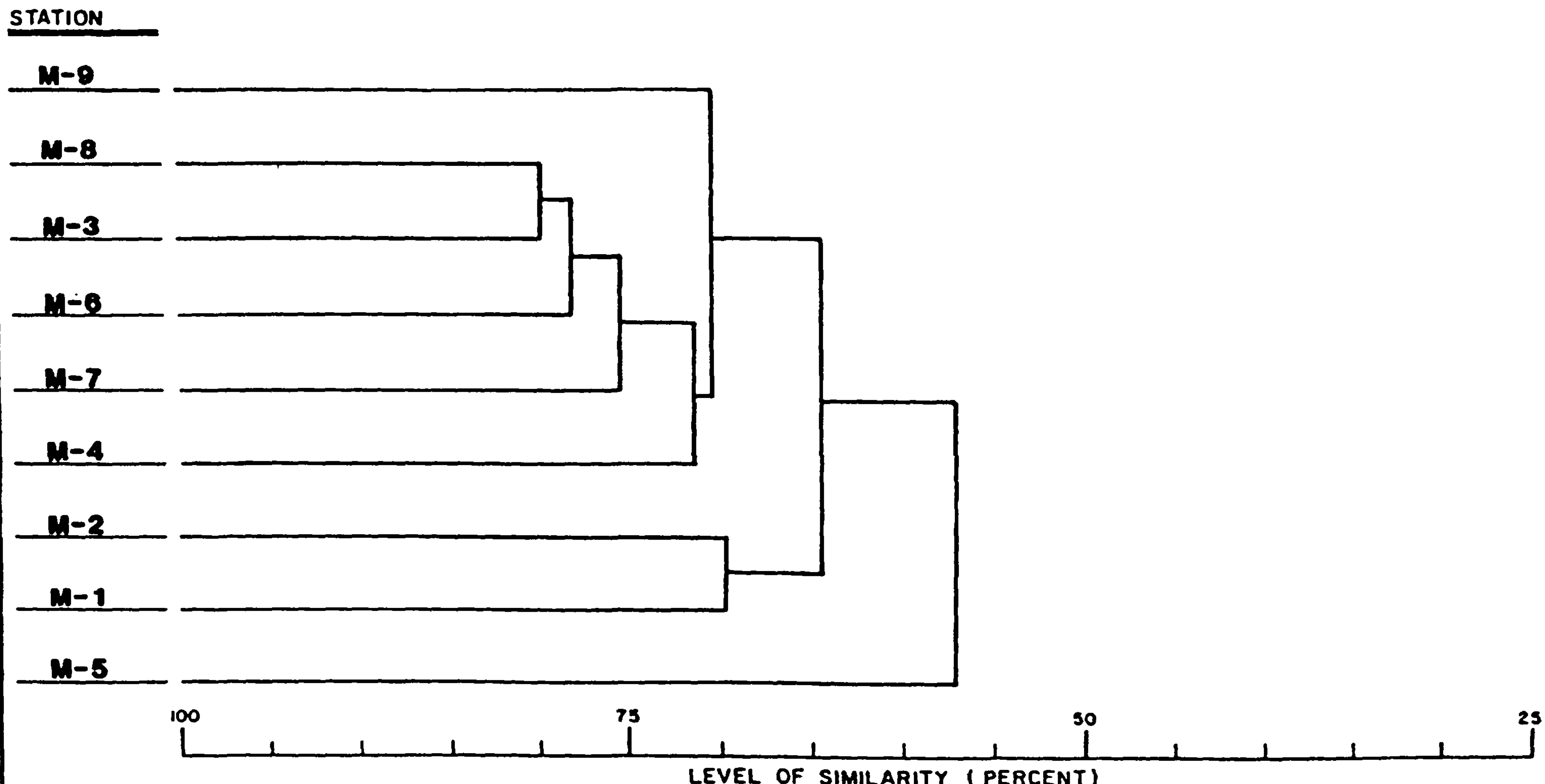


FIGURE A-5

CLUSTER DENDOGRAM SHOWING STATION ASSOCIATIONS BASED ON BENTHIC MACROINVERTEBRATE SIMILARITY AS DETERMINED USING THE BRAY-CURTIS INDEX

Ocean Dredged Material Disposal Site Miami, Florida

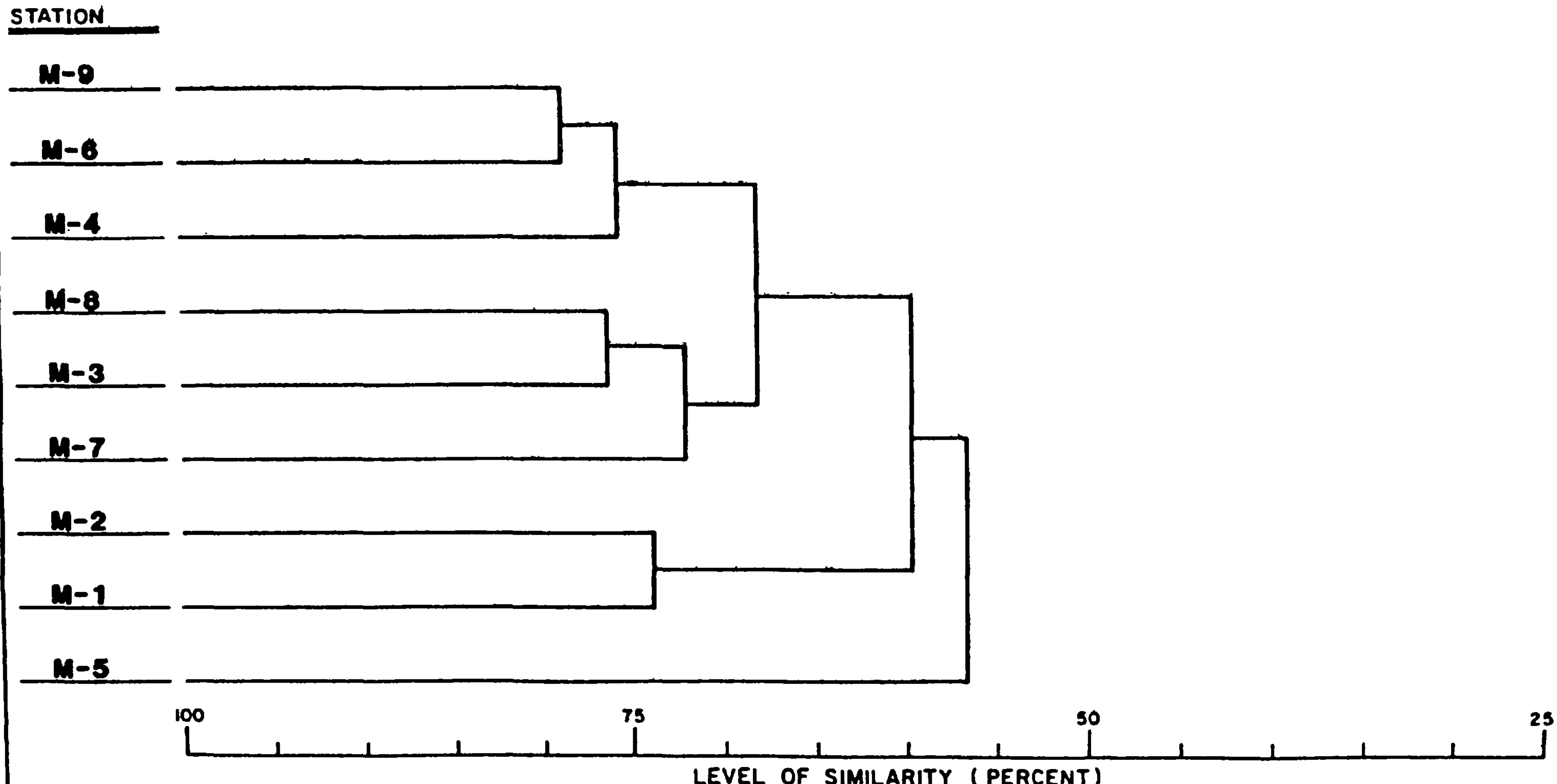


FIGURE A-6

CLUSTER DENDOGRAM SHOWING STATION ASSOCIATIONS BASED ON BENTHIC MACROINVERTEBRATE SIMILARITY AS DETERMINED BY SIMPLE MATCHING (PRESENCE/ABSENCE)

Ocean Dredged Material Disposal Site Miami, Florida

Based on the results of this survey of benthic macroinvertebrates of the Miami Harbor interim ODMDS vicinity, the following observations can be made.

1. Polychaete worms and amphipod crustaceans co-dominate the benthic macroinfauna of the area numerically.

2. The interim disposal site vicinity supports a diverse macroinvertebrate community.

3. A relatively high degree of similarity was found between most of the stations in the study area. Greatest faunal differences are attributed to depth.

A.2.3.2 Meiofauna

The composition, abundance, and diversity of meiofauna collected from the study area is presented in Table A-15. Analysis of the meiofauna samples revealed several anomalies apparently introduced through sampling. It is felt that during the extended period required to retrieve the sampling dredge from the depths worked, substantial sediment disruption occurred in some samples. As a result, surficial sediments were not always obtained in meiofaunal subsamples. This was apparently the case at Stations M-6, M-7, and M-9 where very few meiofauna were found in samples. Data from these stations have not been reported.

Nematodes comprised the overwhelming majority of the meiofauna collected. Pequegnat et al (1981) note that in most marine

Table A-15. Meiofauna Collected from Stations in the Miami Harbor ODMDS Vicinity.

Phylum Class Subclass Order	Station/Replicate/Abundance*											
	M-1		M-2		M-3		M-4		M-5		M-8	
	A	B	A	B	A	B	A	B	A	B	A	B
Platyhelminthes												
Turbellaria	1	1	4	2	3	5	6	9	12	2	1	1
Nematoda	188	363	278	115	85	118	238	533	290	200	129	181
Gastrotricha										1		
Kinorhyncha									2			
Priapulida										1		
Annelida												
Polychaeta		4	9	1	4	7	1	12	13	11		3
Arthropoda												
Crustacea (larvae)												1
Copepoda												
Harpaticoida			1	4	4	5	1	4	33	10		3
Cyclopoida	1		1				1					
Arachnida												
Acarina							1					
Total Sample Abundance (No./Sample)	190	368	293	122	96	135	248	558	350	225	130	189
Mean Station Abundance	279		208		116		403		288		160	
Shannon-Weaver Diversity	0.11		0.39		0.72		0.33		0.86		0.24	

sediments, nematode worms account for 90 percent or more of the meiofauna community. In samples from stations in the Miami Harbor ODMDS vicinity, nematodes accounted for 94 percent of the meiofaunal assemblage. Harpacticoid copepods, larval polychaete worms, and turbellarians were common but never abundant in samples.

Meiofauna diversity was quite low, reflecting the degree of nematode dominance. Shannon-Weaver diversities, calculated for each station, ranged from 0.11 to 0.86.

A.2.3.3 Macroepifauna

Fish

Table A-16 lists the fish collected in replicate 15-minute tows at Stations M-1, M-4, M-6, and M-9. A total of 459 individuals representing 20 species were collected.

The abundance of demersal fishes, the number of taxa represented, and the diversity of fish species calculated for each station is presented in Table A-17. The fish fauna was most abundant and diverse at Station M-6, within the ODMDS. The lowest number of fish and the fewest taxa were captured in trawls at Station M-4, also within the ODMDS. Fish diversity, as determined by the Shannon-Weaver Index, was lowest at Station M-1, located to the north of the designated disposal area.

Table A-16. Fish Collected by Trawl from the Miami Harbor ODMDS Vicinity.

Station	Trawl (No.)*	Scientific Name	Common Name	Number
M-1	(1)	Bellator militaris	Horned searobin	5
		Raja lentiginosa	Freckled skate	1
		Symphurus minor	Largescale tonguefish	14
	(2)	Bellator militaris	Horned searobin	1
		Chlorophthalmus agassizi	Shortnose greeneye	2
		Pontinus longispinis	Longspine scorpionfish	1
		Symphurus minor	Largescale tonguefish	24
		Urophycis regius	Spotted hake	1
M-4	(1)	Bellator militaris	Horned searobin	1
		Chlorophthalmus agassizi	Shortnose greeneye	3
		Pontinus longispinus	Longspine scorpionfish	1
		Symphurus minor	Largescale tonguefish	10
	(2)	Symphurus minor	Largescale tonguefish	1
M-6	(1)	Ancylopsetta quadrocellata	Ocellated flounder	1
		Antennarius sp.	Frogfish	1
		Antigonia sp.	Boarfish	5
		Bellator militaris	Horned searobin	6
		Callionymus sp.	Dragonet	4
		Lepophidium sp.	Cusk-eel	7
		Ogcocephalus sp.	Batfish	18
		Paraconger caudilimbatus	Margintail conger	5
		Pontinus longispinus	Longspine scorpionfish	1
		Prionotus stearnsi	Shortwing searobin	13
		Raja lentiginosa	Freckled skate	1
		Scorpaena calcarata	Smoothhead scorpionfish	1
		Scorpaenidae sp.	Scorpionfish	1
		Symphurus minor	Largescale tonguefish	115
		Urophycis regius	Spotted hake	1
	(2)	Callionymus sp.	Dragonet	1
		Lepophidium sp.	Cusk-eel	3
		Paraconger caudilimbatus	Margintail conger	3
		Pontinus longispinus	Longspine scorpionfish	10
		Raja lentiginosa	Freckled skate	4
		Symphurus minor	Largescale tonguefish	54

Table A-16. (Continued)

Station	Trawl (No.)	Scientific Name	Common Name	Number
M-9	(1)	Antigonia capros	Deepbody boarfish	1
		Macrorhamphosus sp.	Snipefish	1
		Paraconger caudilimbatus	Margintail conger	3
		Pontinus longispinus	Longspine scorpionfish	5
		Rhechias vicinus	Moray eel	1
		Raja lentiginosa	Freckled skate	8
		Symphurus minor	Largescale tonguefish	55
		Urophycis regius	Spotted hake	7
	(2)	Lepophidium sp.	Cusk-eel	1
		Ogcocephalus sp.	Batfish	1
		Paralichthys albigutta	Gulf flounder	1
		Pontinus longispinus	Longspine scorpionfish	1
		Raja lentiginosa	Freckled skate	10
		Symphurus minor	Largescale tonguefish	40
		Urophycis regius	Spotted hake	4

*Two 15 minute replicate tows were taken at each trawl station.

Table A-17. Abundance and Diversity of Fish Collected at Trawl Stations in the Miami Harbor ODMDS Vicinity.

Station	Abundance	Number of Taxa	Shannon-Weaver Diversity
M-1	49	6	1.19
M-4	16	4	1.32
M-6	255	15	2.04
M-9	139	11	1.67

Station M-6 is the shallowest of the sites sampled by trawl, at an approximate depth of 450 ft (137 m). Depths at the other trawl sites are similar, ranging from about 574 ft (175 m) at Station M-9, to 600 ft (183 m) at Station M-4, to 615 ft (187 m) at Station M-1. Results of this survey, though cursory, suggest that fish density and diversity may be greatest at shallowest sites within the study area. This may reflect differences in food availability with depth. Food materials and organic substrate transported from coastal waters would be most available to biota inhabiting inshore portions of the study area.

The most abundant fish present in all collections, throughout the study area, was the largescale tonguefish (Symphurus minor). The species accounted for 68 percent of all fish collected. Other fish which were frequently present in samples include the longspine scorpionfish (Pontinus longispinus), freckled skate (Raja lentignosa), horned searobin (Bellator militaris), and spotted hake (Urophycis regius).

Epibenthic Invertebrates

Epibenthic invertebrates collected from the Miami Harbor ODMDS are listed in Table A-18. Replicate tows at the four designated trawl stations resulted in the collection of 845 individuals representing 9 species. Species collected included pink shrimp (Penaeus duorarum), the lobster-like, galatheid crustacean, Munida irrasa, rock crabs (Cancer

Table A-18. Epibenthic Invertebrates Collected by Trawl from the Miami Harbor ODMDS Vicinity.

Station	Trawl (No.)	Scientific Name	Common Name	Number
M-1	(1)	*Munida irrasa*	Galatheid crustacean	48
		Nibilia antilocapra	Spider crab	1
		Portunus spinicarpus	Portunid crab	6
	(2)	*Cancer borealis*	Jonah crab	1
		Cancer irroratus	Rock crab	3
		Munida irrasa	Galatheid crustacean	4
		Portunus spinicarpus	Portunid crab	1
M-4	(1)	*Cancer irroratus*	Rock crab	2
		Nibilia antilocapra	Spider crab	1
		Portunus spinicarpus	Portunid crab	1
		Rossia tenera	Squid	2
	(2)	*Penaeus duorarum*	Pink shrimp	4
M-6	(1)	*Nibilia antilocapra*	Spider crab	1
		Penaeus duorarum	Pink shrimp	281
		Rossia tenera	Squid	1
	(2)	*Cancer borealis*	Jonah crab	3
		Munida irrasa	Galatheid crustacean	10
		Nibilia antilocapra	Spider crab	1
		Ovalipes sp.	Portunid crab	1
		Penaeus duorarum	Pink shrimp	4
M-9	(1)	*Paguridae* sp.	Hermit crab	2
		Rossia tenera	Squid	1
	(2)	*Cancer borealis*	Jonah crab	2
		Nibilia antilocapra	Spider crab	1
		Penaeus duorarum	Pink shrimp	2
		Portunus spinicarpus	Portunid crab	2

irroratus), Jonah crabs (Cancer borealis), spider crabs (Nibilia antilocapra), portunid crabs (Portunus spinicarpus and Ovalipes sp.), hermit crabs (Paguridae sp.), and squid (Rossia tenera).

Considerable variation in the distribution of invertebrate species over the study area was observed. Pink shrimp were locally dominant at Station M-6. The crustacean, Munida irrasa, was relatively common at Stations M-1 and M-6 but not present in collections from M-4 or M-9.

Epibenthic Biomass

Table A-19 gives the total wet weight biomass of all fish and invertebrates collected in each trawl sample.

A.2.3.4 Tissue Analyses

Fish

Results of the chemical analysis of fish tissues collected from the Miami Harbor ODMDS are presented in Table A-20. Species selected for analysis are those which are thought to be "residential" and/or common to the area. Residential organisms are those which spend much or all of their time in a specific environment. Species selected for analysis were the freckled skate (Raja lentignosa), longspine scorpionfish (Pontinus longispinis), largescale tonguefish (Symphurus minor), and spotted hake (Urophycis regius). Because disposal activities have not occurred at the Miami site, data obtained

Table A-19. Total Wet Weight Biomass of Fish and Epibenthic Invertebrates Collected by Trawl from Stations in the Miami Harbor ODMDS Vicinity.

Station	Trawl Number*	Wet Weight Biomass (kg)
M-1	1	2.27
	2	2.04
M-4	1	2.72
	2	0.09
M-6	1	2.04
	2	1.63
M-9	1	0.73
	2	1.54

*Two 15 minute replicate tows were taken at each trawl station.

Table A-20 Results of Chemical Analyses of Fish Tissues Collected from the Miami Harbor ODMDS Vicinity

PARAMETER*	Station	M-1	M-4	M-6	M-9	M-9
	Scientific Name	*Raja lentiginosa*	*Pontinus longispinis*	*Symphurus minor*	*Symphurus minor*	*Urophycis regius*
	Common Name	Freckled skate	Longspine scorpionfish	Largescale tonguefish	Largescale tonguefish	Spotted hake
Trace Metals						
Mercury ug/g		0.03	0.10	<0.03	0.06	0.20
Cadmium ug/g		0.100	0.007	0.170	0.043	0.008
Lead ug/g		0.09	<0.07	0.12	0.09	<0.06
Pesticides						
Alpha-BHC, ug/kg		<0.02	<0.03	<0.03	<0.02	<0.02
Gamma-BBC, ug/kg		<0.03	<0.04	<0.04	<0.03	<0.03
Heptachlor, ug/kg		<0.04	<0.05	<0.05	<0.04	<0.04
Beta-BHC, ug/kg		<0.1	<0.2	<0.2	<0.2	<0.2
Aldrin, ug/kg		<0.05	<0.08	<0.08	<0.06	<0.06
Heptachlor Epoxide, ug/kg		<0.06	<0.08	<0.08	<0.07	<0.07
4,4'-DDE, ug/kg		<0.1	<0.3	<0.2	<0.1	<0.1
4,4'-DDD, ug/kg		<0.2	<0.3	<0.3	<0.2	<0.2
4,4'-DDT, ug/kg		<0.2	<0.3	<0.3	<0.2	<0.2
o,p'-DDD, ug/kg		<0.2	<0.3	<0.3	<0.2	<0.2
o,p'-DDT, ug/kg		<0.2	<0.3	<0.3	<0.3	<0.3
Chlordane, ug/kg		<0.3	<0.5	<0.4	<0.4	<0.4
Dieldrin, ug/kg		<0.1	<0.1	<0.1	<0.1	<0.1
Endrin, ug/kg		<0.1	<0.2	<0.2	<0.1	<0.1
Total PCBs as Archlor 1254**, ug/kg		46	46	24	29	22
High Molecular Weight Hydrocarbons						
Weight of sample extracted, g		100	100	100	100	100
Weight of extractables, ppm		2400	2200	1100	1600	1800
Aliphatics and aromatics, ppm		0.03	0.09	0.10	0.04	0.08
Resolved hydrocarbons, ppm		0.11	0.12	0.21	0.31	0.21
Unresolved hydrocarbons, ppm		0.11	0.05	0.24	0.09	0.08

Table A-20 (Continued)

Station	M-1	M-4	M-6	M-9	M-9
Scientific Name	*Raja lentiginosa*	*Pontinus longispinis*	*Symphurus minor*	*Symphurus minor*	*Urophycis regius*
PARAMETER* Common Name	Freckled skate	Longspine scorpionfish	Largescale tonguefish	Largescale tonguefish	Spotted hake
High Molecular Weight Hydrocarbons (Cont)					
Sum of n-alkanes, ppm	0.02	0.04	0 03	0 04	0.04
Sum of even n-alkanes, ppm	0.02	0 03	0.02	0 03	0.02
Sum of odd n-alkanes, ppm	<0.01	0 01	0.01	0 01	0 02
Unresolved hydrocarbons/resolved hydrocarbons	1.0	0 42	1 1	0 29	0 38
Odd n-alkanes/even n-alkanes	N/A***	0.33	0.5	0 33	1.0

*All values expressed on a wet weight basis

**PCBs = Polychlorinated biphenyls

***Ratio cannot be calculated (one parameter not detected) serve primarily to aid in the establishment of baseline conditions.

Each of the fish tissue samples was analyzed for mercury, cadmium, and lead. Mercury concentrations ranged from below detection (0.03 ug/g) to 0.20 ug/g and were highest in spotted hake and lowest in tonguefish. Cadmium concentrations ranged from 0.007 ug/g in scorpionfish to 0.170 ug/g in tonguefish. Lead levels were below detection (0.07 ug/g) in scorpionfish and hake tissues and measured up to 0.12 ug/g in tonguefish.

Chlorinated hydrocarbon pesticides and pesticide derivatives were not detected in the tissues of any of the fish selected for analysis.

Polychlorinated biphenyls (PCBs) ranged in concentration from 22 ug/kg in hake to a level of 46 ug/kg in skate and scorpionfish tissues.

Total high molecular weight (HMW) hydrocarbon levels were highest in skate tissues. While total extractable HMW hydrocarbon levels were lowest in a tonguefish sample from Station M-6, this sample yielded highest concentrations of those component fractions potentially indicative of anthropogenic contamination.

<u>Invertebrates</u>

Results of the chemical analysis of invertebrate tissues collected from the study area are presented in Table A-21.

Table A-21 Results of Chemical Analyses of Epibenthic Invertebrate Tissues Collected from the Miami Harbor ODMDS Vicinity

PARAMETER* — Station / Scientific Name / Common Name	M-1 *Cancer irroratus* Rock Crab	M-4 *Cancer irroratus* Rock Crab	M-6 *Libinia antilocapra* Spider crab	M-6 *Penaeus duorarum* Pink Shrimp
Trace Metals				
Mercury ug/g	0.40	0.30	0.30	0.13
Cadmium ug/g	0.170	0.031	0.092	0.070
Lead ug/g	<0.04	<0.05	<0.04	0.32
Pesticides				
Alpha-BHC, ug/kg	<0.2	<0.03	<0.03	----
Gamma-BHC, ug/kg	<0.03	<0.04	<0.04	----
Heptachlor, ug/kg	<0.04	<0.05	<0.05	----
Beta-BHC, ug/kg	<0.1	<0.2	<0.2	----
Aldrin, ug/kg	<0.05	<0.08	<0.06	----
Heptachlor Epoxide, ug/kg	<0.06	<0.08	<0.08	----
4,4'-DDE, ug/kg	<0.1	<0.3	<0.2	----
4,4'-DDD, ug/kg	<0.2	<0.3	<0.3	----
4,4'-DDT, ug/kg	<0.2	<0.3	<0.3	----
o,p'-DDD, ug/kg	<0.2	<0.3	<0.3	----
o,p'-DDT, ug/kg	<0.2	<0.3	<0.3	----
Chlordane, ug/kg	<0.3	<0.5	<0.4	----
Dieldrin, ug/kg	<0.1	<0.1	<0.1	----
Endrin, ug/kg	<0.1	<0.2	<0.2	----
Total PCBs as Archlor 1254**, ug/kg	40	38	18	----
High Molecular Weight Hydrocarbons				
Weight of sample extracted, g	100	100	100	----
Weight of extractables, ppm	2400	1800	2100	----
Aliphatics and aromatics, ppm	0.05	0.09	0.04	----
Resolved hydrocarbons, ppm	0.15	0.31	0.25	----
Unresolved hydrocarbons, ppm	0.04	0.07	0.17	----

Table A-21 (Continued)

PARAMETER*	Station / Scientific Name / Common Name	M-1 *Cancer irroratus* Rock Crab	M-4 *Cancer irroratus* Rock Crab	M-6 *Nibilia antilocapra* Spider crab	M-6 *Penaeus duorarum* Pink Shrimp
High Molecular Weight Hydrocarbons (Cont)					
Sum of n-alkanes, ppm		0 03	0 02	0 02	----
Sum of even n-alkanes, ppm		0 03	0 01	0 02	----
Sum of odd n-alkanes, ppm		<0.01	0.01	<0.01	----
Unresolved hydrocarbons/resolved hydrocarbons		0 27	0 23	0 68	----
Odd n-alkanes/even n-alkanes		N/A***	1 0	N/A	----

*All values expressed on a wet weight basis

**PCBs = Polychlorinated biphenyls

***Ratio cannot be calculated (one parameter not detected)

---- Analyses not performed

Benthic Macroinfauna Collected from the Miami Harbor ODMDS Vicinity, December, 1985

Table B-1. Benthic Macroinvertebrates Collected from Stations in the Miami Harbor Interim ODMDS Vicinity.

Phylum / Class / Subclass / Order / Family / *Genus species*
Protista
Foraminifera
Porifera
Unidentified sp. A
Unidentified sp. B
Cnidaria
Anthozoa
Actiniaria
Hydrozoa
Rhynchocoela
Aschelminthes
Nematoda
Mollusca
Aplacophora
Gastropoda
Atlantidae
Columbellidae
Glycymeridae
Haminoeidae
Marginellidae
Granulina ovuliformis
Retusidae
Rissoidae
Trochidae
Turridae
Pelecypoda
Cuspidariidae
Limacinidae
Limacina inflata
Lucinidae
Anodontia alba
Nuculanidae
Nuculidae
Semelidae
Tellinidae
Thyasiridae
Volrulella persimilis
Scaphopoda
Dentaliidae
Siphonodentaliidae

Table B-1. (Continued)

Phylum	Class	Subclass	Order	Family	Genus species
				Veneridae	
				Vitrinellidae	
	Cephalopoda				
				Sepiolidae	
Annelida					
	Oligochaeta				
	Polychaeta				
				Ampharetidae	
					Isolda pulchella
					Isolda sp.
				Amphinomidae	
				Capitellidae	
					Notomastus sp.
				Cirratulidae	
				Cossuridae	
				Dorvilleidae	
				Flabelligeridae	
					Pherusa sp.
				Glyceridae	
				Goniadidae	
					Goniada maculata
					Goniada sp.
				Hesionidae	
				Lumbrineridae	
					Lumbrineris brevipes
					Lumbrineris sp.
				Magelonidae	
					Aglaomphus sp.
					Magelona sp.
				Maldanidae	
				Nephtyidae	
					Nephtys picta
					Nephtys squamosa
					Nephtys sp.
				Nereidae	
				Onuphidae	
				Opheliidae	
					Ophelina cylindricaudata
					Ophelina sp.
				Orbiniidae	

Table B-1. (Continued)

Phylum	Class	Subclass	Order	Family	Genus species
				Oweniidae	
					Myriochele sp
				Paraonidae	
					Aricidea sp.
				Pectinariidae	
				Phyllodocidae	
					Phyllodoce sp.
				Sabellidae	
				Spionidae	
					Paraprionospio sp.
					Prionospio steenstrupi
					Prionospio sp.
				Syllidae	
				Terebellidae	
Sipuncula					
				Golfingiidae	
					Golfingia sp.
				Nymphonidae	
					Nymphon sp.
Arthropoda					
	Crustacea				
		Cephalocarida			
				Hutchinsoniellidae	
					Hutchinsoniella macraca
					Natantia sp.
		Malacostraca			
			Amphipoda		
				Aeginellidae	
					Mayerella sp.
				Ampeliscidae	
					Ameplisca agassizi
					Ampelisca c.f. *verrilli*
					Ampelisca sp. A
					Ampelisca sp. B
					Haploops sp. A
					Haploops sp. B
					Haploops spp.
				Amphilochidae	
					Unidentified sp. A

Table B-1. (Continued)

- Phylum
  - Class
    - Subclass
      - Order
        - Family
          - Genus species

- Aoridae
  - *Unicola serrata*
  - *Unicola* sp.
- Eusiridae
  - *Eusirus* sp.
- Gammaridae
- Hyperiidae
  - *Lestrigonus bengalensis*
  - *Lestrigonus schizogenos*
- Ischyroceridae
  - *Ericthonias* sp.
- Lysianassidae
  - *Hippomedon* sp.
- Oedicerotidae
  - *Monoculodes* sp.
  - *Pontocrates* sp.
  - Unidentified sp. A
  - Unidentified sp. B
  - Unidentified sp. C
- Paradaliscidae
- Paramphithoidae
  - *Epimeria* sp.
- Photidae
  - Unidentified sp. A
- Phoxocephalidae
  - *Harpinia*sp. A
  - *Harpinia* sp. B
  - *Harpinia* sp. C
  - *Harpinia* spp.
  - *Metharpina floridana*
  - *Paraphoxus* sp.
- Phrosinidae
  - *Primmo johnsoni*
- Podoceridae
  - *Dulichia* sp.
- Scinidae
  - *Scinia* sp.
- Stegocephalidae
  - *Stegocephaloides* sp.
- Stenothoidae
  - *Parametopella* sp.

Table B-1. (Continued)

Phylum
  Class
    Subclass
      Order
        Family
          Genus species

- Synopiidae
  - *Syrrhoe* sp.
- Caridean shrimp
- Cumacea
  - Bodotriidae
    - *Cyclaspis* sp.
  - Diastylidae
    - *Diastylis* sp.
    - *Leptystylis* sp.
    - Unidentified genus A
  - Leuconidae
    - *Eudorella* sp.
    - *Leucon* sp.
  - Nannastacidae
    - *Campylaspis* sp. A
    - *Campylaspis* sp. B
    - *Cumella* sp. A
    - *Cumella* sp. B
    - *Procampylaspis* sp.
- Decapoda
  - Alpheidae
    - *Alpheus floridanus*
    - *Automate evermanni*
  - Dorippidae
    - *Clythocerus* sp.
  - Euphausiidae
    - *Euphausia* sp.
  - Paguridae
  - Pandalidae
    - *Pontomus parvulus*
  - Parapaguridae
    - *Parapagurus* sp.
  - Pasiphaeidae
    - *Leptochela papulata*
    - *Leptochela* sp.
  - Penaeidae
    - *Trachypenaeus* sp.
  - Processidae
    - *Processa* sp.
  - Sergestidae

Table B-1. (Continued)

Phylum
- Class
  - Subclass
    - Order
      - Family
        - *Genus species*

- Isopoda
  - Anthuridae
    - *Ptilanthura tricarinata*
    - *Xenanthura brevitelson*
    - Unidentified genus A
  - Cirolanidae
    - *Conilera cylindracea*
  - Desmosomidae
    - *Desmosoma* sp.
  - Gnathiidae
    - *Gnathia* sp.
- Mysidacea
    - *Pseudomma* sp.
- Tanaidacea
  - Apsendidae
    - *Aspeudes* sp.
  - Leptognathiidae
    - *Leptognathia* sp.
    - *Typhlotanais* sp.
  - Paratanaidae
  - Pseudoltanaidae
    - *Pseudotanais* sp.
  - Sphyrapidae
    - *Sphyrapus* sp.

Ostracoda
- Myodocopida
  - Asteropidae
  - Halocyprididae
    - Unidentified genus A
    - Unidentified genus B
    - Unidentified genus C
  - Philomedidae
    - *Harbansus paucichelatus*
    - Unidentified genus A
  - Unidentified family A
- Podocopida
  - Cytherellidae
  - Paracyprididae
  - Rutidermatidae
    - *Rutiderma* sp.

Table B-1. (Continued)

Phylum / Class / Subclass / Order / Family / Genus species
Sariellidae
Sarsiella sp.
Pycnogonida
Ammotheidae
Heterofragilia sp.
Nymphonidae
Nymphon sp.
Echinodermata
Ophiuroidea
Amphiuridae
Amphiura sp.
Amphioplus sp.
Ophiuridae
Chordata
Cephalochordata
Branchiostoma sp.
Urochordata
Ascidiacea

Table B-2. Macroinfauna Collected at Station M-1, Miami Harbor Interim ODMDS Study Area.

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m^2) 1	2	3	4	5	Mean Abundance (Organisms/m^2)
Protista						
Foraminifera		19				4
Cnidaria						
Anthozoa						
Actiniaria		210				42
Rhynchocoela	19		19	19		11
Aschelminthes						
Nematoda	115	421	134	229	650	310
Mollusca						
Aplacophora		19			19	8
Gastropoda						
Columbellidae		57	19			15
Haminoeidae		19		19		8
Rissoidae		19				4
Turridae		38				8
Pelecypoda						
Cuspidariidae			19	38	38	19
Nuculanidae		19			19	8
Nuculidae		76	593	287	76	206
Thyasiridae	96	268		115	229	142
Scaphopoda						
Dentaliidae	19	38	19	19	38	27
Siphonodentaliidae		18	37		37	18
Annelida						
Oligochaeta	57					11
Polychaeta						
Ampharetidae					19	4
Isolda pulchella		191	57	57	76	76
Capitellidae	19			38		11
Notomastus sp.	19					4
Cirratulida	96	478	38	57	249	184
Dorvilleidae		19			19	8
Flabelligeridae						
Pherusa sp.			38	38		15
Goniadidae						
Goniada maculata	38	19			19	15
Lumbrineridae	96			19		23
Lumbrineris brevipes				19		4
Lumbrineris sp.	38	57		19	76	38

Table B-2. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m²) 1	2	3	4	5	Mean Abundance (Organisms/m²)
Magelonidae						
Magelona		38				8
Maldanidae		38		57		19
Nephtyidae						
Nephtys picta	57	38				19
Nephtys squamosa			38	19		11
Nephtys sp.	38			19	19	15
Onuphidae				38		8
Opheliidae				38		8
Ophelina cylindricaudata	19	19			38	15
Ophelina sp.			57			11
Orbiniidae			38	268		61
Oweniidae						
Myriochele sp.				19		4
Paraonidae						
Aricidea sp.	96	631	115	134	249	245
Spionidae	57				57	23
Prionospio steenstrupi					19	4
Prionospio sp.	96	210	191	153	96	149
Sipuncula			19			4
Golfingiidae						
Golfingia sp.					19	4
Arthropoda						
Crustacea						
Malacostraca						
Amphipoda						
Ampeliscidae						
Ampelisca agassizi	38	3442	3021	2887	516	1981
Ampelisca cf. *verrilli*	19					4
Haploops sp. B			19			4
Aoridae						
Unciola serrata					19	4
Oedicerotidae		19				4
Unidentified sp. A				19		4
Unidentified sp. B			38			8
Phoxocephalidae					19	4
Harpinia sp. A				19		4
Harpinia sp. B			19			4
Synopiidae						
Syrrhoe sp.	38		38	57		27

Table B-2. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m²) 1	2	3	4	5	Mean Abundance (Organisms/m²)
Cumacea						
Diastylidae						
Diastylis sp. A	19	19				8
Leuconidae						
Eudorella sp. A			115	57		34
Leucon sp. A			19	19		8
Nannastacidae	19			19		8
Campylaspis sp. A	19					4
Campylaspis sp. B				19		4
Procampylaspis sp.A		19				4
Decapoda						
Parapaguridae						
Parapagurus sp.			19			4
Pasiphaeidae						
Leptochela sp.		19				4
Isopoda						
Cirolanidae						
Conilera cyclindracea				19		4
Gnathiidae						
Gnathia sp.		153		19		34
Mysidacea						
Mysidae						
Pseudomma sp.	38					8
Tanaidacea						
Leptognathiidae						
Typhlotanais sp.			19			4
Sphyrapidae						
Sphyrapus sp.		19		19		8
Echinodermata						
Ophiuridae	19	96	19	57		38
Totals	1184	6746	4758	4928	2616	4054
Number of Species	25	32	26	35	24	70
Shannon-Weaver Diversity	4.34	2.92	2.27	2.79	3.53	3.38

Table B-3. Macroinfauna Collected at Station M-2, Miami Harbor Interim ODMDS Study Area.

Phylum / Class / Subclass / Order / Family / Genus Species	Replicate/(Organisms/m²) 1	2	3	4	5	Mean Abundance (Organisms/m²)
Cnidaria						
Hydrozoa	19	19				8
Porifera						
Unidentified sp. B	76	115		38	19	50
Aschelminthes						
Nematoda	57	38	402	497	96	218
Mollusca						
Aplacophora			19			4
Gastropoda						
Columbellidae			19	19		8
Marginellidae				19		4
Rissoidae	19			38		11
Trochidae		38				8
Unidentified spp.				19		4
Turridae		19				4
Pelecypoda						
Cuspidariidae				57		11
Nuculidae	19	38	96	153		61
Nuculanidae					19	4
Thyasiridae	134	38	115	76	134	99
Scaphopoda			19			4
Dentaliidae					57	11
Siphonodentaliidae			19			4
Annelida						
Polychaeta						
Ampharetidae						
Isolda pulchella	19	38	38	172		53
Capitellidae		19		19	57	19
Cirratulidae	191	115		210	38	111
Flabelligeridae			38			8
Glyceridae					19	4
Goniadidae						
Goniada sp.		38	38			15
Lumbrineridae						
Lumbrineris brevipes				76		15
Lumbrineris sp.	96	191	19	57	134	99
Magelonidae						
Magelona sp.		19		38		4
Maldanidae			19	19	19	11

Table B-3. (Continued)

Phylum / Class / Subclass / Order / Family / Genus Species	Replicate/(Organisms/m²) 1	2	3	4	5	Mean Abundance (Organisms/m²)
Nephtyidae	19	19			38	15
Nephtys sp.	19	57	19	19	115	46
Onuphidae				38		8
Opheliidae						
Ophelina sp.	38	76				23
Orbiniidae					19	4
Paraonidae						
Aricidea sp.	76	76	134	172	76	107
Spionidae						
Paraprionospio sp.	38					8
Prionospio sp.	76	57	172	249	19	115
Arthropoda						
Crustacea						
Malacastraca						
Amphipoda						
Ampeliscidae						
Ampelisca agassizi	153	19	1358	994		505
Amphilochidae			19			4
Lysianassidae		19				4
Hippomedon sp.	19					4
Phoxocephalidae			19	19		8
Harpinia sp. A			38			8
Harpinia sp. B		19		57		15
Oedicerotidae		38			19	11
Unidentified sp. A		19			19	8
Unidentified sp. C		38				8
Synopiidae					19	4
Syrrhoe sp.	19					4
Caridean shrimp				19		4
Cumacea						
Bodotriidae		19				4
Diastylidae			19			4
Diastylis sp.			19	19		8
Leuconidae						
Eudorella sp.			76	38		23
Nannastacidae		19		19		8
Campylaspis sp. B		19				4
Procampylaspis sp.			19			4
Decapoda						
Pasiphaeidae						
Leptochela sp.	19					4

Table B-3. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m^2) 1	2	3	4	5	Mean Abundance (Organisms/m^2)
Euphausiacea						
Euphausiidae						
Euphausia sp.				19		4
Mysidacea						
Mysidae						
Pseudomma sp.		19				4
Echinodermata						
Amphiuridae						
Amphiura sp.				19		4
Ophiuridae			38			8
Totals	1163	1238	2733	3188	935	1852
Number of Species	21	23	23	29	19	62
Shannon-Weaver Diversity	3.91	4.39	2.82	3.63	3.82	4.24

Table B-4. Macroinfauna Collected at Station M-3, Miami Harbor Interim ODMDS Study Area.

Phylum / Class / Subclass / Order / Family / Genus Species	Replicate/(Organisms/m^2) 1	2	3	4	5	Mean Abundance (Organisms/m^2)
Cnidaria						
Hydrozoa			19	19		8
Porifera						
Unidentified sp. A		19				4
Unidentified sp. B		19			19	8
Aschelminthes						
Nematoda	631	841	1033	994	1109	922
Mollusca						
Gastropoda						
Columbellidae	76	38	19	76		42
Glycymeridae	38					8
Haminoeidae				19		4
Marginellidae						
Granulina ovuliformis		19				4
Rissoidae					38	8
Trochidae				38		8
Turridae		19				4
Pelecypoda						
Cuspidariidae	38					8
Nuculidae	210	134	344	76	76	168
Nuculanidae	19				33	11
Tellinidae						
Thyasiridae						
Volrulella persimilis	191	306	172	268	287	245
Scaphopoda						
Dentaliidae	76	19	38	38	96	53
Siphonodentaliidae		57			19	15
Annelida						
Oligochaeta	38	57		19		23
Polychaeta						
Ampharetidae	38	134	229	57	19	95
Isolda sp.		402	229		172	161
Isolda pulchella	153			325		96
Capitellidae	96	38	38	38		42
Cirratulidae	325	956	363	899	440	597
Dorvilleidae	19			134		31
Flabelligeridae		19				4
Goniadidae	57		19	19		19
Glyceridae				38	19	11
Hesionidae			19			4

Table B-4. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m²) 1	2	3	4	5	Mean Abundance (Organisms/m²)
Lumbrineridae		96	115		57	54
Lumbrineris sp.	76			57		27
Magelonidae					19	4
Magelona sp.	19	19				8
Maldanidae	38	38	38			23
Nephtyidae		76	57		76	42
Nephtys sp.	57			76		27
Onuphidae	19				38	11
Opheliidae					19	4
Ophelina sp.				38		8
Orbiniidae	210	535	937	344	440	493
Paraonidae						
Aricidae sp.	210	191	535	287	134	271
Phyllodocidae						
Phyllodoce sp.	19					4
Polynoidae			19			4
Spionidae		38				8
Prionospio sp.	210	287	459	249	363	314
Syllidae	19	19	57			19
Terebellidae				19		4
Sipuncula						
Golfingiidae	19	19				8
Arthropoda						
Crustacea						
Malacostraca						
Amphipoda						
Aeginellidae						
Mayerella sp.	19				19	8
Ampeliscidae						
Ampelisca agassizi	19	4321	3212	191	191	1587
Aoridae						
Unciola serrata		19				4
Unciola sp.			19			4
Gammaridae	19					4
Hyperiidae						
Lestrigonus bengalensis			19	19	19	11
Lysianassidae					19	4
Hippomedon sp.	19		38	38	19	23
Oedicerotidae	19			19	19	11
Pontocrates sp.		19				4
Unidentified sp. A			19	19		8

Table B-4. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m²)					Mean Abundance (Organisms/m²)
	1	2	3	4	5	
Paradaliscidae		19			19	8
Phoxocephalidae						
Harpinia sp. A		38	19	19	38	23
Harpinia sp. B	19	19	38	38	96	42
Harpinia sp. C		19	19			8
Harpinia sp.		19	38			11
Stegocephalidae						
Stegocephaloides sp.				19		4
Synopiidae						
Syrrhoe sp.	38	19		19		15
Cumacea						
Diastylidae						
Diastylis sp.	19	19		19		11
Leuconidae						
Eudorella sp.	57	19	115	57	57	61
Nannastacidae						
Campylaspis sp. B	19		19	76	19	27
Decapoda						
Paguridae		19				4
Pasiphaeidae					19	4
Sergestidae				19		4
Isopoda						
Cirolanidae						
Conilera cylindracea			19	19		8
Desmosomidae						
Desmosoma sp.		19				4
Gnathiidae						
Gnathia sp.		38	38	38	19	27
Tanaidacea						
Apseudidae						
Apseudes sp.	57					11
Leptognathiidae						
Leptognathia sp.	19					4
Paratanaidae	76	76			19	34
Pseudotanaidae						
Pseudotanais sp.			19			4
Sphyrapidae						
Sphyrapus sp.	19	19	57			19

Table B-4. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m^2) 1	2	3	4	5	Mean Abundance (Organisms/m^2)
Ostracoda						
Myodocopida						
Asteropidae		19				4
Halocyprididae						
Euconchoecia sp.				38		8
Philomedidae						
Harbansus paucichelatus		38	38	19		19
Unidentified genus A		19				4
Podocopida						
Cytherellidae					19	4
Unidentified family A		19				4
Echinodermata						
Ophiuroidea			96	38		27
Ophiuridae	76	38	38			30
Amphiuridae		19				4
Totals	3395	9248	8599	4831	4069	6041
Number of Species	41	48	38	41	35	88
Shannon-Weaver Diversity	4.51	3.20	3.44	4.10	3.86	4.11

Table B-5. Macroinfauna Collected at Station M-4, Miami Harbor Interim ODMDS Study Area.

Phylum / Class / Subclass / Order / Family / Genus Species	Replicate/(Organisms/m²) 1	2	3	4	5	Mean Abundance (Organisms/m²)
Porifera						
Unidentified sp. B	172					34
Rhynchocoela		38		38		15
Aschelminthes						
Nematoda	191	363	76	115	153	180
Mollusca						
Aplacophora	19					
Gastropoda						
Columbellidae			96	19		
Epitoniidae		19				4
Haminoeidae		19		38		11
Rissoidae			19			4
Trochidae	38					8
Turridae	19					4
Pelecypoda						
Cuspidariidae	19			19		8
Nuculidae		115	19	249	191	115
Nuculanidae		19				4
Solemyacidae		76				15
Thyasiridae	115	631	134	268	134	256
Scaphopoda						
Dentaliidae		19	76			19
Siphonodentaliidae		19		19		8
Annelida						
Oligochaeta		38		38		15
Polychaeta						
Ampharetidae				38	38	15
Isolda pulchella		363	57	76	134	126
Isolda sp.	96					19
Capitellidae		115	38	19		34
Cirratulidae	96		115	76	325	122
Cossuridae		784				157
Goniadidae	19	19				8
Lumbrineridae		57				11
Lumbrineris sp.	115		38	38		38
Maldanidae		19		38		11
Nephtyidae		38	19			11
Nephtys sp.	57			38	19	23
Onuphidae		19				4
Orbiniidae	38	96	57	191	76	92

Table B-5. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m²) 1	2	3	4	5	Mean Abundance (Organisms/m²)
Paraonidae		57				11
Aricidea sp.	19		19		76	23
Spionidae		153				31
Prionospio sp.	57		134	153	96	88
Syllidae			19	38		11
Arthropoda						
Crustacea						
Cephalocarida						
Hutchinsoniellidae						
Hutchinsoniella macraca			19			4
Natantia sp.		19				4
Malacostraca						
Amphipoda						
Aeginellidae						
Mayerella sp.		19				4
Ampeliscidae				19		4
Ampelisca agassizi	76	593	210	1644	2199	944
Haploops sp. B				19		4
Aoridae						
Unicola serrata		19			19	8
Unicola sp.	19					.4
Gammaridae			38			8
Lysianassidae		19				4
Hippomedon sp.			19			4
Oedicerotidae	19				19	8
Monoculodes sp.	19					4
Unidentified sp. A	19					4
Pardaliscidae	19					4
Photidae				19		4
Phoxocephalidae						
Harpinia sp. A					19	4
Harpinia sp. B	19				19	8
Harpinia spp.					19	4
Metharpinia floridana	19					4
Stenothoidae						
Parametopella sp.	19		19			8
Synopiidae						
Syrrhoe sp.		19	19		19	11

Table B-5. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m²) 1	2	3	4	5	Mean Abundance (Organisms/m²)
Cumacea						
Bodotriidae						
Cyclaspis sp.				19		4
Diastylidae						
Diastylis sp. A	19	19	76			23
Leptystylis sp.					19	4
Leuconidae						
Eudorella sp.	76	38	76	57	38	57
Nannastacidae						
Campylaspis sp. B	38		19	38		19
Isopoda						
Cirolanidae						
Conilera cylindracea		19		19		8
Gnathiidae						
Gnathia sp.		19		38	19	15
Tanaidacea						
Paratanaidae		19				4
Ostracoda						
Myodocopida						
Halocyprididae						
Unidentified genus A	19					4
Unidentified genus B	38					8
Sipuncula					19	4
Echinodermata						
Ophiuroidea						
Amphiuridae				19		4
Ophiuridae	19			19		8
Totals	1507	3859	1430	3418	3650	2779
Number of Species	30	32	25	30	21	72
Shannon-Weaver Diversity	4.41	3.73	4.20	3.19	2.42	4.13

Table B-6. Macroinfauna Collected at Station M-5, Miami Harbor Interim ODMDS Study Area.

Phylum / Class / Subclass / Order / Family / Genus Species	Replicate/(Organisms/m^2) 1	2	3	4	5	Mean Abundance (Organisms/m^2)
Cnidaria						
Hydrozoa	19	19		19	19	15
Porifera						
Unidentified sp. B		76	57			27
Rhynochocoela		19	19			8
Aschelminthes						
Nematoda	134	306	153	96	172	172
Mollusca						
Aplacophora		19				4
Gastropoda						
Epitoniidae						
Haminoeidae	19				19	8
Retusidae			19			4
Pelecypoda						
Cuspidariidae						
Lucinidae	57		153			42
Nuculidae	115	57		96	344	122
Semelidae				57		11
Abra aequalis					19	4
Abra gequa		19				4
Limacina inflata		19				4
Solemyacidae	210	191	96		402	180
Tellinidae	19	57	76	76	57	57
Thyasiridae	19	115		19	210	73
Scaphopoda						
Dentaliidae	57	57	134		76	65
Siphonodentaliidae	153		57		38	50
Annelida						
Oligochaeta	76	57	96	76	57	72
Polychaeta						
Ampharetidae	38	268	38	57	210	122
Amphinomidae	19		57			15
Capitellidae	612	38	210	38	19	183
Cirratulidae	115	459	229	172	631	321
Dorvilleidae	57	38		19		23
Glyceridae	19		19		57	19
Goniadidae	38	96		38	96	54
Hesionidae	19					4
Lumbrineridae				19		4
Lumbrineris sp.	19	38	19		96	34

Table B-6. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m²) 1	2	3	4	5	Mean Abundance (Organisms/m²)
Magelonidae						
Magelona sp.		19				4
Maldanidae					38	8
Nephtyidae				19	57	15
Aglaomphus sp.	19	19	38			15
Nereidae			19			4
Opheliidae					19	4
Ophelina sp.			19			4
Onuphidae	19	76		57	57	42
Diopatra sp.			19			4
Orbiniidae	191	746	325	363	535	432
Paraonidae						
Aricidea sp.	76	516	115	191	268	233
Pectinariidae		19				4
Phyllodocidae		19		19		8
Polynoidae	57	76	115		57	61
Sabellidae	19					4
Spionidae						
Prionospio sp.	249	899	516	229	306	440
Syllidae	19					4
Terebellidae			19			4
Sipuncula	38					8
Arthropoda						
Malacostraca						
Amphipoda						
Ampeliscidae						
Ampelisca agassizi	19	134	115	96	134	100
Ampelisca sp. A		38	19	19		15
Aoridae						
Unicola sp.		19	57			15
Hyperiidae						
Lestrigonus bengalensis					19	4
Podoceridae						
Dulichia sp.				19		4
Synopiidae					19	4
Cumacea						
Nannastacidae						
Campylaspis sp. A	19					4
Campylaspis sp. B			19			4
Cumella sp. A		19				4

Table B-6. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m²) 1	2	3	4	5	Mean Abundance (Organisms/m²)
Decapoda						
Alpheidae						
Alpheus floridanus			19			4
Automate evermanni				19		4
Pandalidae						
Pontomus parvulus					19	4
Penaeidae						
Trachypenaeus sp.			19			4
Isopoda						
Anthuridae						
Ptilanthura tricarinata		19		19		8
Xenanthura brevitelson	19					4
Ostracoda						
Myodrocopida						
Halocyprididae			38			8
Philomedidae			38			8
Harbansus paucichelatus			38			8
Rutidermatidae						
Rutiderma sp.			57			11
Sarsiellidae						
Sarsiella sp.		19				4
Echinodermata						
Ophiuroidea	57	19		115	38	46
Amphiuridae		19				4
Amphioplus sp.					38	8
Ophiuridae	38		172			42
Chordata						
Branchiostoma sp.		19				4
Totals	2653	4642	3208	1947	4126	3324
Number of Species	34	37	36	25	31	73
Shannon-Weaver Diversity	4.22	4.00	4.49	4.02	4.15	4.66

Table B-7. Macroinfauna Collected at Station M-6, Miami Harbor Interim ODMDS Study Area.

Phylum / Class / Subclass / Order / Family / Genus Species	Replicate/(Organisms/m^2) 1	2	3	4	5	Mean Abundance (Organisms/m^2)
Cnidaria						
Anthozoa						
Actiniaria sp.			19			4
Hydrozoa	19	19		19		11
Rhynchocoela			38			8
Aschelminthes						
Nematoda	38	229	287	249	210	203
Mollusca						
Aplacophora			19			4
Cephalopoda						
Sepiolidae			19			4
Gastropoda						
Columbellidae		38			19	11
Haminoeidae			19			4
Retusidae						
Rissoidae				19	19	8
Pelecypoda						
Cuspidariidae				19	76	19
Lucinidae		38				8
Nuculidae		134		287	57	96
Nuculanidae		76				15
Semelidae	19					4
Tellinidae						
Thyasiridae	19	57	229	38	306	130
Scaphopoda						
Dentaliidae			38	19		11
Siphonodentaliidae				19	38	11
Annelida						
Oligochaeta	19		19			8
Polychaeta						
Ampharetidae				38	57	19
Isolda pulchella	19	440				92
Isolda sp.				134	134	54
Capitellidae	38	38	76	57		42
Chaedtopteridae	19					4
Cirratulidae	191	803	153	268	153	314
Dorvilleidae				19	19	8
Glyceridae	76					15
Goniadidae		19	19	38	19	19

Table B-7. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m²) 1	2	3	4	5	Mean Abundance (Organisms/m²)
Lumbrineridae		57	76			27
Lumbrineris sp.	210			96	57	73
Magelonidae						
Magelona sp.			19			4
Maldanidae		19				4
Nephtyidae			19	38	38	19
Nephtys sp.	57	96				31
Opheliidae				19		4
Ophelina sp.	76					15
Orbiniidae	96	115	306	229	287	207
Paraonidae						
Aricidea sp.	57	19	76	38	19	42
Pisionidae			19			4
Polytnoidae					19	4
Sabellidae		19				4
Spionidae		19				4
Prionospio sp.	134	19	287	306	96	168
Sipuncula	19					4
Arthropoda						
Crustacea						
Cephalocarida						
Hutchinsoniellidae						
Hutchinsoniella macraca					19	4
Malacostraca						
Cumacea						
Nannastacidae	19					4
Campylaspis sp. B		19			19	8
Diastylidae						
Diastylis sp.		19	19		38	15
Leuconidae						
Eudorella sp.		57	19	19	57	30
Isopoda						
Gnathiidae						
Gnathia sp.	19		19	19	19	15
Cirolanidae						
Conilera cylindracea			19	38	19	15
Amphipoda						
Aeginellidae						
Mayerella sp.		19				4

Table B-7. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m^2) 1	2	3	4	5	Mean Abundance (Organisms/m^2)
Ampeliscidae						
Ampelisca agassizi	2027			3920	402	1270
Ampelisca sp.			19			4
Aoridae						
Unciola sp.		19				4
Eusiridae						
Eusirus sp.	38					8
Lysianassidae		19				4
Hippomedon sp.	19			19		8
Oedicerotidae		19	38		38	19
Unidentified sp. A	19	19	19	19		15
Paramphithoidae						
Epimeria sp.		19				4
Paradaliscidae				19		4
Phoxocephalidae						
Paraphoxus sp.	19					4
Synopiidae		19				4
Syrrhoe sp.	19	76			38	27
Decapoda						
Pasiphaeidae						
Leptochela papulata	19				38	11
Processidae						
Processa sp.					19	4
Tanaidacea						
Paratanaidae			19	38		11
Ostracoda						
Podocopida						
Paracyprididae			19			4
Echinodermata						
Ophiuroidea						
Ophiuridae		76	19	57	38	38
Totals	3285	2672	1927	6097	2367	3278
Number of Species	25	33	28	29	30	69
Shannon-Weaver Diversity	2.50	3.81	3.90	2.37	4.13	3.85

Table B-8. Macroinfauna Collected at Station M-7, Miami Harbor Interim ODMDS Study Area.

Phylum / Class / Subclass / Order / Family / Genus Species	Replicate/(Organisms/m²) 1	2	3	4	5	Mean Abundance (Organisms/m²)
Cnidaria						
Hydrozoa	19			19		8
Rhynchocoela		19	19	19		11
Aschelminthes						
Nematoda	497	363	746	134	363	421
Mollusca						
Gastropoda						
Columbellidae	19			19	38	15
Epitoniidae						
Haminoeidae	19	19	19			11
Marginellidae						
Granulina ovuliformis						
Retusidae						
Turridae	19				19	8
Pelecypoda						
Cuspidariidae	19	19	76	38	76	46
Lucinidae					38	8
Nuculidae	172	249	268	287	249	245
Nuculanidae	19				19	8
Solemyacidae						
Thyasiridae						
Volrulella persimilis	96	76	210	172		111
Scaphopoda						
Dentaliidae			19		38	11
Siphonodentaliidae			19			4
Annelida						
Oligochaeta		38	38	57	57	38
Polychaeta						
Ampharetidae	191	19	76	19	57	72
Isolda pulchella		115	38			31
Isolda sp.	19				325	69
Capitellidae	19	76		115	172	76
Cirratulidae	96	325	191	134	803	310
Dorvilleidae				38		8
Flabelligeridae				19		4
Goniadidae					19	4
Glyceridae			38			8
Hesionidae		19				4
Lumbrineridae	38				19	11
Lumbrineris sp.		19	19	57	38	27

Table B-8. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m^2) 1	2	3	4	5	Mean Abundance (Organisms/m^2)
Magelonidae	19					4
Maldanidae	76	38	19	19		30
Nephtyidae						
Nephtys sp.				19	96	23
Nereidae				19		4
Onuphidae		38	19	57	19	27
Opheliidae	38		19			11
Orbiniidae	134	134	382	96	115	172
Paraonidae						
Aricidea sp.	115	115	153	191	19	119
Polynoidae				19		4
Sabellidae				19		4
Spionidae				19		4
Prionospio sp.	306	306	382	402	153	310
Paraprionospio sp.				19		4
Syllidae		229		363	19	122
Sipuncula		19	19			8
Arthropoda						
Crustacea						
Malacostraca						
Amphipoda						
Ampeliscidae						
Ampelisca agassizi	2141	2524	3939	2467	3556	2925
Ampelisca cf. *verrilli*			19	76		19
Ampelisca sp. B			76			15
Hapoops sp. A		19				4
Hapoops spp.					38	8
Aoridae						
Unciola serrata	57					11
Hyperiidae						
Lestrigonus bengalensis	19				19	8
Ischyroceridae						
Ericthonius sp.				38		8
Lysianassidae		19				4
Oedicerotidae	57		19		19	19
Unidentified sp. A					19	4
Pardaliscidae		19		19	19	11
Photidae					57	11

Table B-8. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m^2)					Mean Abundance (Organisms/m^2)
	1	2	3	4	5	
Phoxocephalidae (dam.)		19				4
Harpinia sp. A		38				8
Harpinia spp.	38		19			11
Paraphoxus sp.	19					4
Stegocehalidae						
Stegocephaloides sp.				19	19	8
Synopiidae						
Syrrhoe sp.	19	57				15
Cumacea						
Bodotriidae						
Cyclaspis sp. A				19		4
Diastylidae						
Diastylis sp.	19					4
Unidentified genus A	19					4
Leuconidae						
Eudorella sp.	38	76	19	76	134	69
Leucon sp.				19	19	8
Nannastacidae						
Campylaspis sp. B	57	57	38	38		38
Isopoda						
Anthuridae	19					4
Cirolanidae						
Conilera cylindracea	19			38	19	15
Desmosomidae						
Desmosoma sp.	38	38				15
Gnathiidae						
Gnathia sp.	38	19	19	96	96	54
Mysidiacea					19	4
Tanaidacea						
Apseudidae						
Apseudes sp.		57				11
Paratanaidae	38	38	19	19	38	30
Sphyrapidae						
Sphyrapus sp.	38	19			19	15
Ostracoda					19	4
Pycnogonida						
Nymphonidae						
Nymphon sp.				19		4

Table B-8. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m²) 1	2	3	4	5	Mean Abundance (Organisms/m²)
Echinodermata						
Ophiuroidea				57		11
Amphiuridae	19		57	19	19	23
Ophiuridae	76		57		57	38
Totals	4698	5234	7050	5388	6936	5867
Number of Species	39	34	32	41	41	79
Shannon-Weaver Diversity	3.41	3.22	2.69	3.45	3.07	3.42

Table B-9. Macroinfauna Collected at Station M-8, Miami Harbor Interim ODMDS Study Area.

Phylum / Class / Subclass / Order / Family / Genus Species	Replicate/(Organisms/m²)					Mean Abundance (Organisms/m²)
	1	2	3	4	5	
Cnidaria						
Hydrozoa					19	4
Porifera						
Unidentified sp. A		96		38	115	50
Rhynchocoela			19			4
Aschelminthes						
Nematoda	76	172	344	134	860	317
Mollusca						
Cephalopoda						
Sepiolidae						
Gastropoda						
Columbellidae		19	19	38	115	38
Glycymeridae				19		4
Haminoeidae				19	19	8
Marginellidae						
Granulina ovuliformis						
Retusidae				19		4
Rissoidae			19		38	11
Pelecypoda						
Cuspidariidae			19			4
Nuculidae	38	96	344	631	134	249
Nuculanidae	38	38				15
Limacinidae						
Limacina inflata	19	19				8
Lucinidae					210	42
Semelidae						
Thyasiridae	38	172	191		96	99
Volrulella persimilis				172		34
Veneridae		57				11
Scaphopoda						
Dentaliidae			19		153	34
Siphonodentaliidae		38	38	38	57	34
Annelida						
Polychaeta				57		11
Ampharetidae			76	57		27
Isolda pulchella		19		172	497	138
Isolda sp.			153			31
Capitellidae			57	134	38	46
Cirratulidae	287	96	96	172	325	195
Glyceridae	38				19	11

Table B-9. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m²) 1	2	3	4	5	Mean Abundance (Organisms/m²)
Goniadidae	19					4
Lumbrineridae						
Lumbrineris sp.	19	134	19		38	42
Magelonidae						
Magelona sp.			19			4
Maldanidae				19		4
Nephtyidae			19		76	19
Nephtys sp.	38	76		19		27
Onuphidae			19			4
Opheliidae			19			4
Ophelina sp.		57		19		15
Orbiniidae	76	57	631	631	76	294
Paraonidae						
Aricidea sp.	19	38	57	38	134	57
Spionidae					19	4
Prionospio sp.	38	134	287	229	38	145
Syllidae				38		8
Sipuncula						
Golfingiidae		19				4
Arthropoda						
Crustacea						
Malacostraca						
Amphipoda						
Aeginellidae						
Mayerella sp.					19	4
Ampeliscidae						
Ampelisca agassizi	38	306	3499	4379	38	1652
Haploops sp. B			38			8
Aoridae						
Unciola serrata			19			4
Gammaridae					19	4
Hyperiidae						
Lestrigonus bengalensis		19				4
Lysianassidae						
Hippomedon sp.		19	19	38		15
Oedicerotidae		19		19		8
Unidentified sp. A					19	4
Paradaliscidae	19					4
Phoxocephalidae						
Harpinia sp. B		38	19	38	57	30
Harpinia sp.			19			4

Table B-9. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m²) 1	2	3	4	5	Mean Abundance (Organisms/m²)
Synopiidae						
Syrrhoe sp.				57	19	15
Cumacea						
Leuconidae						
Eudorella sp.		76	76		19	34
Nannastacidae						
Campylaspis sp. A					19	4
Campylaspis sp. B		19		19		8
Cumella sp. B	19					4
Procampylaspis sp.		19	19	38		15
Isopoda						
Cirolanidae						
Conilera cylindracea			38			8
Gnathiidae						
Gnathia sp.			57	57	19	27
Tanaidacea						
Leptognathiidae						
Leptognathia sp.			19			4
Paratanaidae				19	38	11
Sphyrapidae						
Sphyrapus sp.	19					4
Ostracoda						
Myodocopida						
Asteropidae					38	8
Philomedidae						
Harbansus paucichelatus			115			23
Podocopida						
Cytherellidae				19	19	8
Paracyprididae				19	19	8
Ophiuroidea						
Amphiuridae				19		4
Ophiuridae	57		38	38	38	34
Pycnogonida						
Ammotheidae						
Heterofragilia sp.				19		4

Table B-9. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m^2) 1	2	3	4	5	Mean Abundance (Organisms/m^2)
Chordata						
Ascidiacea						
Unidentified juvenile				19		4
Totals	914	1852	6439	7528	3456	4044
Number of Species	19	26	34	37	35	74
Shannon-Weaver Diversity	3.64	4.19	2.83	2.69	4.05	3.80

Table B-10. Macroinfauna Collected at Station M-9, Miami Harbor Interim ODMDS Study Area.

Phylum / Class / Subclass / Order / Family / Genus Species	Replicate/(Organisms/m²) 1	2	3	4	5	Mean Abundance (Organisms/m²)
Cnidaria						
Anthozoa						
Actiniaria					19	4
Rhynchocoela	19					4
Aschelminthes						
Nematoda	841	401	19	96	860	443
Mollusca						
Aplacophora	19	19		19		11
Cephalopoda						
Sepiolidae						
Gastropoda						
Atlantidae		19				4
Columbellidae	76	57		38		34
Glycymeridae	19					4
Haminoeidae		38			19	11
Retusidae						
Rissoidae				38	19	11
Pelecypoda						
Cuspidariidae		134	38	38		42
Nuculidae				38	96	27
Limacinidae						
Limacina inflata					19	4
Lucinidae				38		8
Anodontia alba					19	4
Thyasiridae	363	765	38	19	268	291
Veneridae		38				8
Vitrinellidae	38		19		19	15
Scaphopoda						
Dentaliidae	19	38		19	57	27
Siphonodentaliidae		38		19		11
Annelida						
Oligochaeta		57				11
Polychaeta						
Ampharetidae					19	4
Capitellidae		37				11
Cirratulidae	1128	669	38	57	937	566
Glyceridae					19	4
Goniadidae			19	19		8
Lumbrineridae		38				8
Lumbrineris sp.	57		96	19		34

Table B-10. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m²) 1	2	3	4	5	Mean Abundance (Organisms/m²)
Maldanidae	19			19		8
Opheliidae						
Ophelina sp.	19				38	11
Orbiniidae	115	57	19	96	19	61
Paraonidae						
Aricidea sp.	96	19		19	325	92
Phyllodocidae						
Phyllodoce sp.	19					4
Pilargiidae					19	4
Spionidae		19				4
Prionospio sp.	134	96		76	115	84
Sipuncula		38				8
Golfingiidae						
Arthropoda						
Crustacea						
Malacostraca						
Amphipoda						
Ampeliscidae						
Ampelisca agassizi	76	38		57		34
Hyperiidae						
Lestrigonus bengalensis					19	4
Lestrigonus schizogenos					19	4
Lysianassidae						
Hippomedon sp.		19				4
Oedicerotidae		38	76			23
Unidentified sp. A	38	38				15
Unidentified sp. B	19		19		19	11
Unidentified sp. C					19	4
Pardaliscidae	57				38	19
Phoxocephalidae						
Harpinia sp. B	19	38	19		19	19
Phrosinidae						
Primno johnsoni					19	4
Scinidae						
Scinia sp.					19	4
Synopiidae						
Syrrhoe sp.					19	4
Cumacea						
Diastylidae						
Diastylis sp.	19	38				11

Table B-10. (Continued)

Phylum Class Subclass Order Family Genus Species	Replicate/(Organisms/m^2) 1	2	3	4	5	Mean Abundance (Organisms/m^2)
Leuconidae						
Eudorella sp.	38	19		57		23
Nannastacidae						
Campylaspis sp. B	19		19			8
Decapoda						
Dorippidae						
Clythocerus sp.		19				4
Isopoda						
Gnathiidae						
Gnathia sp.	19					4
Tanaidacea						
Paratanaidae		19		19	19	11
Ostracoda						
Myodocopida						
Halocyprididae						
Unidentified genus A		19				4
Unidentified genus C	19					4
Philomedidae					19	4
Harbansus paucichelatus		19				4
Sarsiellidae						
Sarsiella sp.			19			4
Podocopida						
Paracyprididae					19	4
Echinodermata						
Ophiuroidea	57			19	19	19
Ophiuridae		19				4
Totals	3820	3570	553	1144	3573	2536
Number of Species	29	33	14	23	34	66
Shannon-Weaver Diversity	3.38	3.78	3.44	3.97	3.51	4.08

APPENDIX B

EVALUATION OF THE DISPERSION CHARACTERISTICS OF THE MIAMI AND FORT PIERCE DREDGED MATERIAL SITES

PREFACE

This Appendix contains the report by Scheffner and Swain of the Coastal Engineering Research Center and a supplementary letter by Scheffner presenting results for a sediment distribution representative of sediment from Miami Harbor The report contains results for a sediment distribution representative of the Miami Channel.

Since the completion of the both the report and supplementary letter, it was discovered that incorrect units for the suspended sediment concentrations were presented. Concentrations were given in mg/l whereas the concentrations were actually volummetric void ratios. To convert the volummetric void ratios to concentrations, the values must be multiplied by the particle density (2 65g/cc) The values in Figures 2 6 and 2 10 and Tables 2 4 and 2.5 of the report and the table in the supplementary letter need to be multiplied by 2 65x10^6 to represent concentrations in mg/l Table 2.4 and the table in the supplementary letter are reproduced with modified values below

Table 2.4 (modified)

Summary of Computed Suspended Silt and Clay Concentration
(Concentration in mg/l above ambient)

Depth (ft)	Elapsed Time (sec) / Approximate Distance from Dredge (Miles): 1500 / 0.8	3000 / 1 6	4500 / 2.3	6000 / 3.2
200	0.000000318	1 7755	4 505	2.65
250	0 018815	11.395	6.625	2.438
300	14.575	23.055	5 83	1.749
350	151.05	15 37	2.915	1.007
400	39 75	6 36	1.8285	0.689

Summary of Computed Maximum Suspended Silt and Clay Concentration
(Concentration in mg/l above ambient)

Depth (ft)	Elapsed Time (sec) / Approximate Distance from Dredge (Miles): 1500 / 0 8	3000 / 1 6	4500 / 2 3	6000 / 3 2
200	0 0000053	9 01	20 405	10 865
250	0 17755	53	29 15	10 335
300	87 45	103 35	24 91	7.42
350	715 5	68 9	13 515	4 24
400	193 45	26 5	7 95	2 915

EVALUATION OF THE DISPERSION CHARACTERISTICS OF THE MIAMI AND FORT PIERCE DREDGED MATERIAL DISPOSAL SITES

by

Norman W. Scheffner

and

Abhimanyu Swain

Coastal Engineering Research Center

April 1989

Final Report

Prepared for
US Army Engineer District, Jacksonville
Jacksonville, Florida 32232-0019

PREFACE

This report describes a comprehensive approach for evaluating the environmental suitability of proposed open water disposal sites for dredged material. Two proposed Florida disposal sites are evaluated in this investigation, one off the coast of Miami and one off the coast of Fort Pierce. The purpose of the evaluation is to determine whether either site poses a contamination threat to sensitive nearshore coral reefs. Two criteria are necessary of a site if it is to be approved as environmentally acceptable. The first is concerned with the immediate effects of the disposal operation, material from the descending plume of sediments can not contaminate areas outside the designated disposal site. This short-term phase analysis represents several minutes to several hours following the initial release of material from the dredge. The second phase of investigation determines whether material deposited within the disposal site can be eroded and subsequently transported out of the site by either local current fields or by storm conditions. This long-term phase examines mound stability for periods of time up to one year following the disposal operation.

A two-phase numerical modeling methodology was selected for this investigation. The approach utilizes the Disposal From an Instantaneous Dump (DIFID) model for calculating the short-term fate and a coupled hydrodynamic/sediment transport model for computing the long-term fate of the disposed material. The project was authorized and funded by the US Army Engineer District, Jacksonville (SAJ), under the project management of Mr. Ronald Tapp and Ms. Elizabeth Rhodes and under the general direction of Mr. A. J. Salem.

Much of the prototype data required for numerical model input were provided by or extracted from research publications of Dr. T. N. Lee, School of Marine and Atmospheric Science, Division of Meteorology and Physical Oceanography, University of Miami, Florida. Supplementary velocity measurement data were also obtained from other sources. The study was conducted at the US Army Engineer Waterways Experiment Station's (WES) Coastal Engineering Research Center (CERC). The numerical investigation was completed, and this report prepared by Drs. Norman W. Scheffner and A. Swain.

Providing general supervision were Dr. James R. Houston and Mr. Charles C. Calhoun, Jr., Chief and Assistant Chief, respectively, CERC; direct supervision

the project was provided by Mr H. L. Butler, Chief of the Research Division, and Mr. Bruce A. Ebersole, Chief of the Coastal Processes Branch of the Research Division. Commander and Director of WES during the course of this study and the preparation and publication of this report was COL Dwayne G. Lee, CE. Technical Director was Dr. Robert. W. Whalin.

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INTRODUCTION

Background and Objective

1. Dredging of estuaries, bays, harbors, and coastal inlets in the United States is often required in order to maintain minimum navigation depths. The selection of an environmentally acceptable disposal site for this dredged material requires some means of predicting the effects of the disposal operation on the coastal and inland water environment. One means of prediction is the utilization of numerical models capable of simulating the short- and long-term diffusion and transport of dredged material from the disposal site.

2. The Corps of Engineers have become increasingly active in the area of maintenance dredging of harbor channels and coastal inlets. The designation of acceptable disposal sites for this material is, however, becoming increasingly difficult. Open water disposal sites are often selected as a means of minimizing any adverse effects resulting from the disposal of material in the vicinity of the dredging operation. This approach is acceptable if the designated site is far enough removed from any environmentally sensitive area that material at the site will remain at the site and not represent a possible source of contamination.

3. The Planning Division, US Army Engineer District, Jacksonville (SAJ), is preparing an Environmental Impact Statement (EIS) for submission to the US Environmental Protection Agency (EPA). The purpose of the EIS is to evaluate the environmental impact of dredged material disposed at the proposed Ocean Dredged Material Disposal Sites (ODMDS) offshore of Miami and Fort Pierce, Florida. The location and bathymetries of these sites are shown in Figures 1.1 and 1.2.

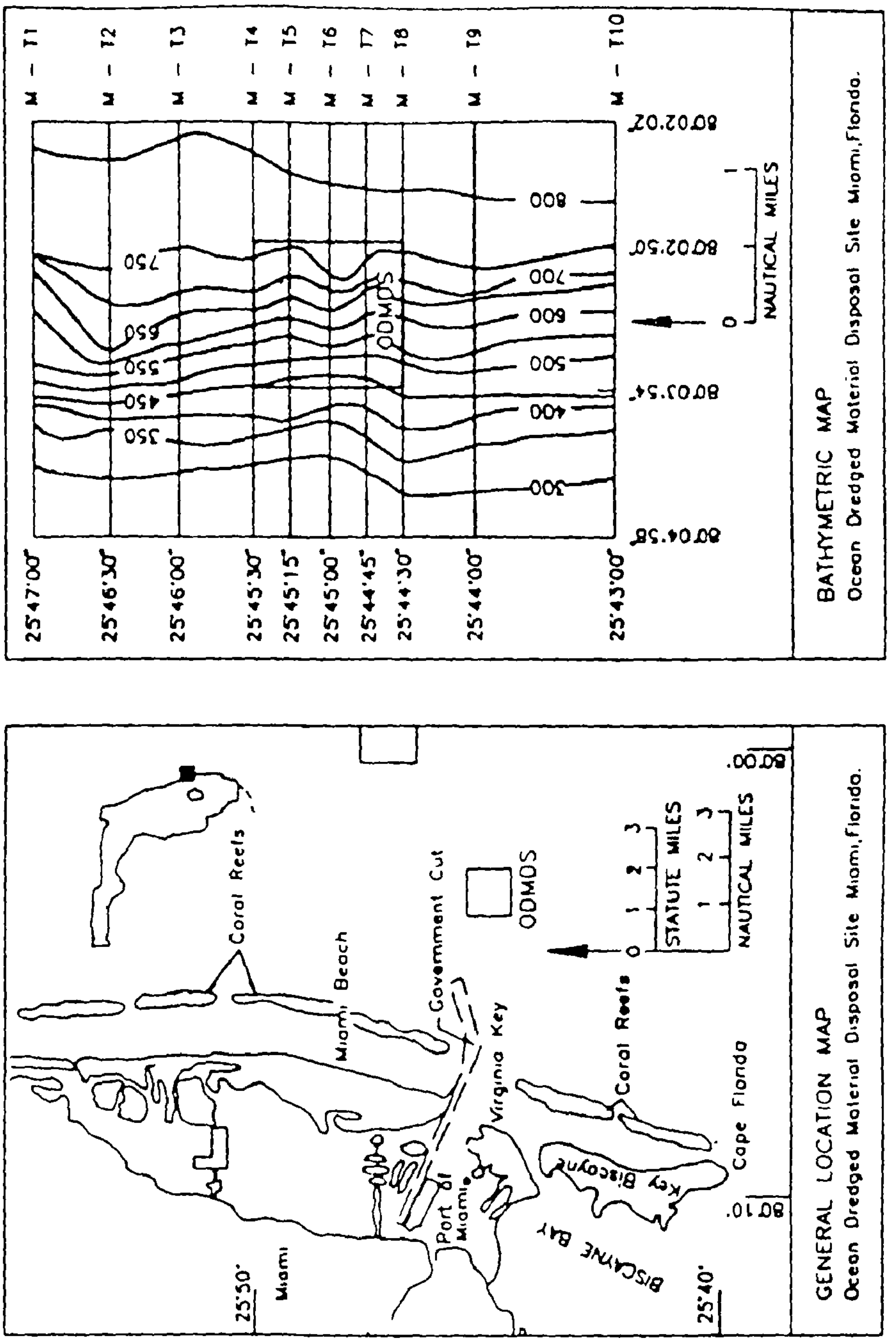
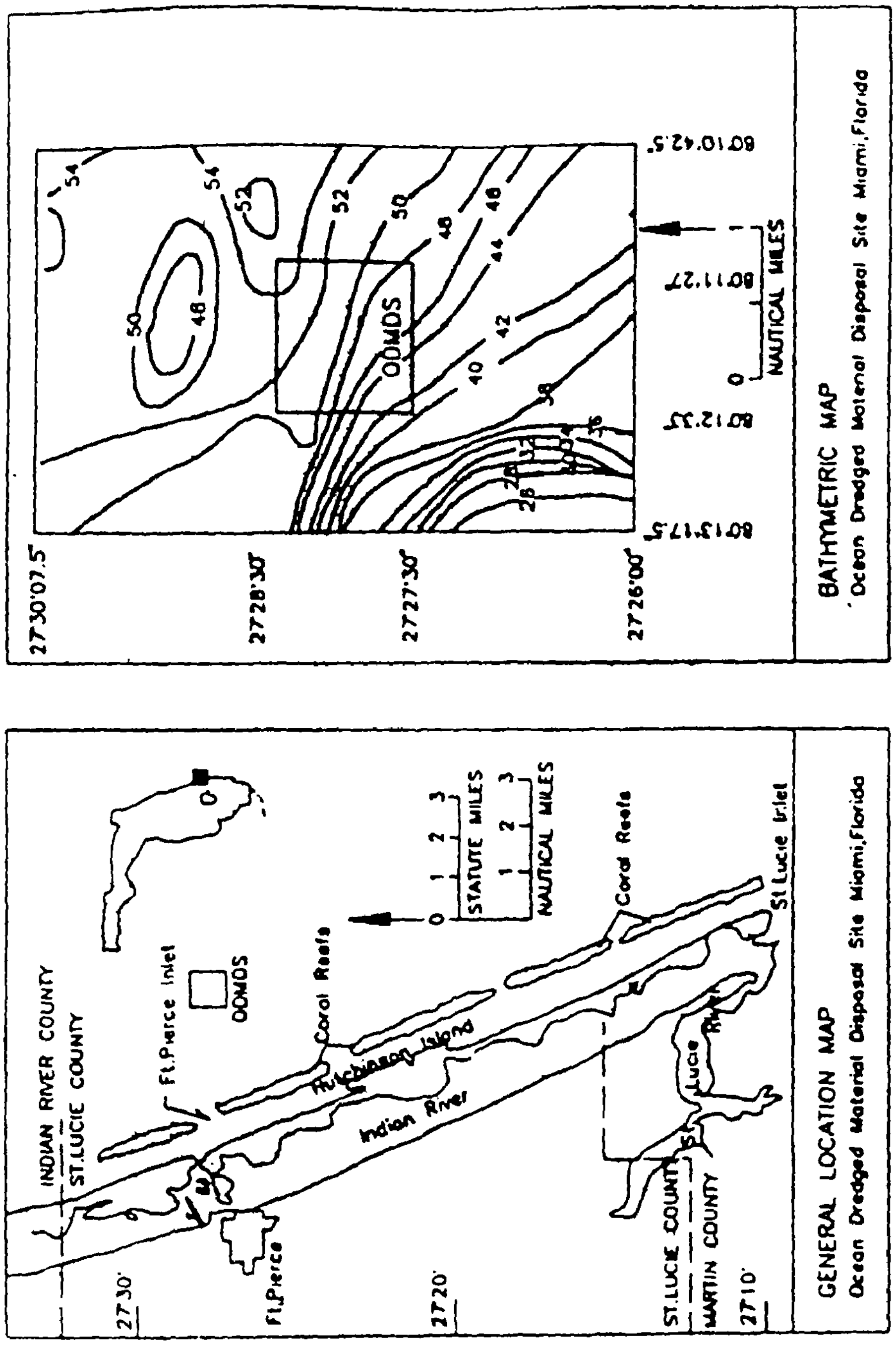


Figure 1.1. Location of ODMDS, bathymetry map, and coral reefs for the Miami Site



Figures 1.2. Location of ODMDS, bathymetry map, and coral reefs for the Fort Pierce site

4. The EPA has expressed a concern regarding the fate of the disposed materials at both proposed ODMDS. It is feared that discharged sediments frc either disposal site may be carried by the Gulf Stream and its spin-off eddie onto sensitive shore-parallel coral reefs located approximately 1 mile offshore of the barrier islands. In addition to sediment transported by eddies and ambient currents, the possibility of resuspension and subsequent transpor of material from the disposal site during storm events is also an expressed concern.

5. The SAJ requested the US Army Engineer Waterways Experiment Station's (WES) Coastal Engineering Research Center (CERC) to perform a technical study of the Gulf Stream, the spin-off eddies, and other relevant environmental forces, with respect to the potentials for reef contamination b dredged material originating from either proposed ODMDS. The CERC was first requested to study the acceptability of the proposed sites offshore of Miami and Fort Pierce. If these sites are not found to be environmentally acceptable, the first acceptable offshore location which does not pose a contamination threat to the reefs should be identified.

6. A preliminary technical review was performed by the CERC (MFR, 9 February 1988) of the available literature provided by SAJ (Memorandum, 4 December 1987). The review concluded that a detailed disposal site evaluation should be performed in order to determine whether velocities in the Gulf Stream and its spin-off eddies are sufficient in magnitude to transport disposed material from the proposed ODMDS onto the coral reefs.

7. The study reported here uses a numerical modeling approach for estimating both short-term and long-term fate of dredged material disposed at a proposed ODMDS. The modeling of the short-term dumping operation is performed by the Disposal From an Instantaneous Dump (DIFID) model (Johnson et al. 1988). Long-term simulations, using a newly developed coupled hydrodynamic/sediment transport model (Scheffner 1981), use depth averaged velocity fields to determine whether non-storm related currents are capable o transporting sediments outside of the designated ODMDS over long periods of time following the initial deposition. The effects of storm erosion are separately examined with the model by simulating the passage of a storm surge over the site.

Scope of Report

8. The purpose of this study is to evaluate the dispersion characteristics of the proposed disposal sites offshore of Miami and Fort Pierce. These two sites were selected as representative of the two primary environments found off the east coast of Florida. The first is typified by the proposed Miami site at which the bathymetry is complex, the water is deep (greater than 500 ft), and the site is directly influenced by the Gulf Stream and its spin-off eddies. Due to the close proximity of the Gulf Stream to the disposal site, it is feared that disposed sediments may be carried onto the coral reefs by spin-off eddies shed by the Gulf Stream.

9. In contrast to the Miami site, the Fort Pierce disposal site is removed from the direct effects of the Gulf Stream, is situated on a broad, gently sloping shelf, and is located in shallow water (less than 75 ft). This ODMDS has a small cross-sectional area of flow compared to that of the Miami site. A comparison of the site characteristics of both the Miami and Fort Pierce ODMDS is given in Table 1.1.

10. This investigation will classify each of the proposed disposal sites as either dispersive of non-dispersive according to whether the local current fields are capable of transporting material from the disposal site onto the reef area. This approach requires documenting the local velocities at each site in order to identify a reef-directed component which may be attributed to the Gulf Stream. This component will be used to compute a sediment transport rate and direction for use in evaluating the possibility of disposal site related reef contamination. The following section represents the result of an extensive literature review which begins with a description of the Gulf Stream and its major characteristics. This portion of the review is included to verify that shoreward directed spinoff eddies do exist and should be investigated as a possible source of sediment transport. This background documentation will be followed by a quantification of velocity magnitudes and directions which are shown to be representative of each site. These velocities will then be used as model input for the short- and long-term stability analyses of Parts II and III.

Table 1.1

Disposal Site Characteristics for Miami and Fort Pierce

Characteristics	Miami	Fort Pierce
Water depth	Greater than 500 ft	Less than 75 ft
Bottom slope	Steep (0.02-0.05)	Mild (0.001-0.002)
Topography	Complex (nonlinear)	Simple (linear)
Terrace	Miami Terrace confined to a 2 mile offshore zone	No terrace zone
Flow cross-section of ODMDS	About 3,168,000 sq ft	About 294,000 sq ft
Continental Margin	Wide	Narrow
Continental	Contains inner, mid, and and outer shelf with sharp shelf break.	Contains inner shelf only
Direction of Velocity	Westerly and northerly	Northerly
Magnitude of velocities:		
westerly	0.15-1.5ft/sec	0.05-0.5ft/sec
northerly	0.7-3.5ft/sec	0.20-1.5ft/sec
Average axis of Gulf Stream	15 miles offshore	80 miles offshore
Coastal currents are primarily driven by	Gulf Stream	Wind and tidal forcing
Gulf Stream Effects	Present	Free
Dredged materials	90% sand (fine to medium)	90% sand (fine to medium)
	10% clay	10% clay

PART I: LITERATURE REVIEW

The Gulf Stream

11. The objective of the literature review is to identify the primary characteristics of the Gulf Stream and quantify its basic structure, magnitude, and limits of influence along the south and southeast coast of the United States. A brief summary of the origin and dynamics of the Gulf Stream is presented in this section as a preliminary background for the present ODMDS selection study as well as for future site selection studies. The terms Gulf Stream or stream are used throughout this section of the report to refer to the entire current system off the south and east coast of the United States, including the Florida Current.

12. Figure 1.3 presents a schematic diagram of the dominant currents and current induced secondary circulation patterns off the east coast of the United States. The origin of the Gulf Stream begins as the Atlantic and North Equatorial Current systems combine with the South Equatorial and Guyana Current systems. This combined flow discharges through the Caribbean Sea and Yucatan Channel into the southeastern portion of the Gulf of Mexico. Because the waters are colder than the surrounding Gulf of Mexico, a density differential is created which results in a deflection of the current from the Gulf of Mexico toward the Straights of Florida. This density driven flow is most pronounced during winter months. During this time, the current is often sharply deflected from the Yucatan Channel through the Straights of Florida as shown in Figure 1.3. However, the loop current can extend well into the Gulf of Mexico during the summer months (Leipper 1967). Regardless of the specific path, the current enters the Straights of Florida in nearly the same temperature, salinity, and density as when it entered the Caribbean Sea (Lee, et al. 1977).

13. The dynamics of the Gulf Stream are driven by the large tides of the Caribbean Sea which dominate the smaller tides of the Gulf of Mexico. These large tides force water through the long channel between the Florida Peninsula and the islands of Cuba and the Bahamas, developing a water level differential of about 2/3 ft (Stommel 1965) between the Gulf of Mexico and

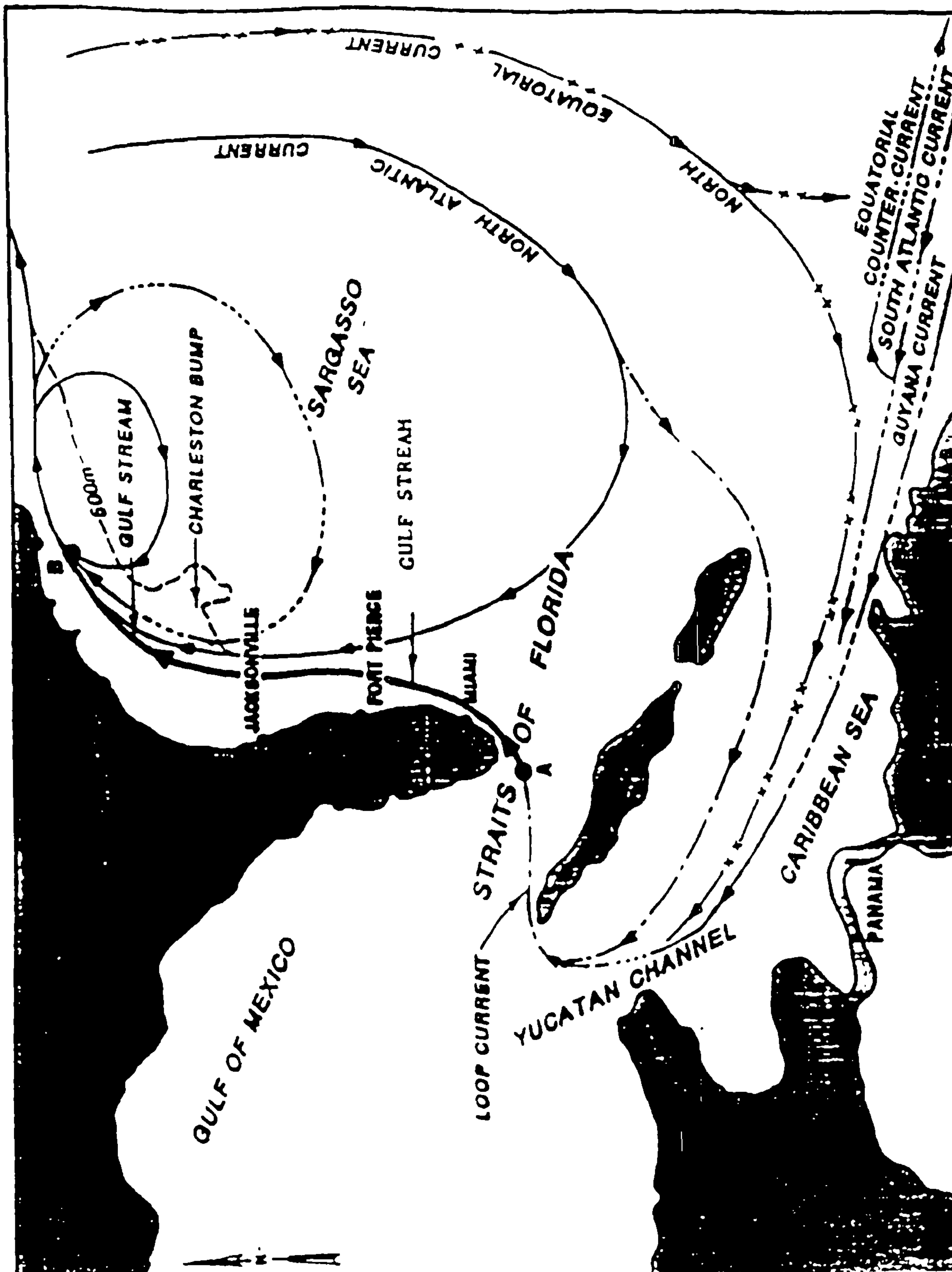


Figure 1.3. A schematic diagram of the origin of the Gulf Stream Current (after Sverdrup, Johnson, Flemming, and Stommel 1965)

the Atlantic Ocean. As the current flows through the Straights of Florida toward Miami, the axis of flow makes an abrupt 90 degree turn to the north and enters the continental shelf channel. The approximate point of deflection is indicated as position A in Figure 1.3. The cross-sectional area occupied by the stream undergoes a change from approximately 90 miles wide and 1 mile deep at Key West to approximately 50 miles wide and 0.5 miles deep in the vicinity of Miami. This reduction in flow area causes an increase in stream velocity with an accompanying decrease in free surface water level between Key West and Miami.

14. The Gulf Stream continues along the south and southeast coast of the United States as shown in Figure 1.3. It is seen that the stream hugs the continental shelf from the deep water region offshore of Miami, north to shallow water depths of less than 100 m at Cape Canaveral. Beyond Cape Canaveral, the stream is diverted into deeper water in the vicinity of the Charleston bump (Brooks and Bane, 1978; Legeckis 1979), a topography anomaly in the continental shelf slope between the 200 and 600 m isobaths. North of the bump, the stream moves back onshore into waters of about 300 m. This onshore shift of the current is primarily due to a steady increase in bottom slope north of Charleston. This increasing slope, coupled with ridge and trough bottom features, prevalent strong northwest winds, and baroclinic instabilities cause the stream to subsequently deflect off the continental shelf and become confined to a path between the 300 m and 400 m isobaths. Position B in Figure 1.3 indicates the approximate location of the offshore point of deflection.

15. The lateral extent of the width of the stream about its average axis is shown in Figure 1.4. This figure, obtained from the National Oceanic and Atmospheric Administration's (NOAA) field station at Miami and reproduced in the Journal of Geophysical Research (1983) represents satellite imagery of the Sea Surface Temperature (SST) structure of the Gulf Stream. The figure demonstrates the variability in width of influence of the Gulf Stream about its mean axis. The following section will investigate the spatial and temporal characteristics of the Gulf Stream.

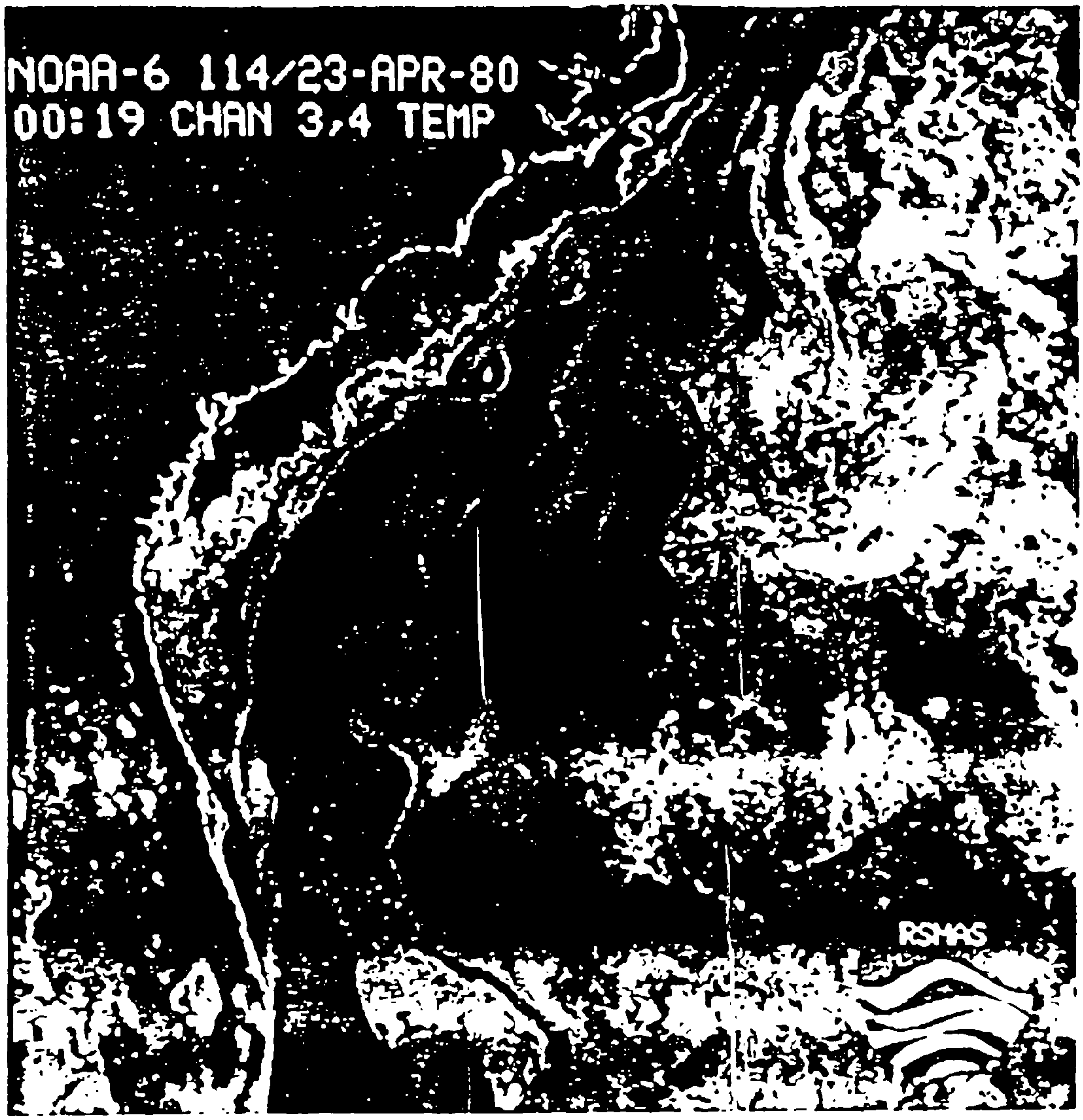


Figure 1.4 Satellite-derived path of the Gulf Stream (NOAA 1983)

Gulf Stream Meanders

16. The Gulf Stream is a high velocity thermal current which flows along the outer continental shelf. The time-dependent structure of the stream is a function of a combination of forces including the current distribution, bottom topography, wind stress, entrainment of fluid from below the free surface, and rotational forces developed due to the rotation of the earth. The constantly changing spatial and temporal structure of the stream has been widely studied and documented in the literature. Although an attempt to quantify these dynamics are beyond the scope of this report, many of the references used in this literature review to document the characteristics of the Gulf Stream have been included in the list of references. Since this report is intended to determine whether the Gulf Stream can adversely affect either of the two proposed disposal sites, this section begins with a description of commonly observed features which may directly impact either ODMDS.

17. The high velocity main body of the Gulf Stream propagates in wave like patterns referred to as meanders. The dynamic features are a result of forces such as shearing instabilities of the stream, geostrophic imbalances, the transfer of kinetic energy to the mean flow, the passage of cold fronts, the random passage of wind events, etc. Although the mean axis of the stream propagates to the north, these forcings can produce localized undulations about the mean axis which can locally flow either upstream (southerly), downstream (northerly), onshore or offshore.

18. Many documenting measurements quantifying the spatial variation of meanders have been reported. Duing (1975) obtained 2 weeks of current profile measurements off the coast of Miami and identified a current meander with a 4-6 day period which was propagating to the north at approximately 45 cm/sec with a wave length of nearly 200 km. Duing's data showed that when the axis of the Gulf Stream was displaced offshore, southerly flows occurred over portions of the Miami terrace. Conversely, when the axis of the stream was displaced onshore, flows over the terrace were directed to the north. Thermal gradients can be used to measure the primary features of meanders as they grow in size or become skewed. Lee and Moore (1977), for example, have correlated the distribution of meanders with the propagation of SST derived isotherms.

19. Meanders of the stream are commonly observed between Jupiter Inlet and Cape Hatteras where the stream enters the wide continental shelf region after passing through the topographic constriction formed by the Florida coast and the Little Bahama bank. This discharge of water from a confined to an unconfined area results in meanders in the stream axis which are no longer primarily controlled by the continental shelf bathymetry (Lee et al 1981) but are strongly influenced by weather patterns, long waves from the deep sea, tidal forcing, and local wind fields Northeast of Cape Hatteras, the Gulf Stream moves beyond our area of interest into deep water where they are no longer controlled by continental shelf bathymetry.

20. The meandering process is well illustrated in an example presented by Bane and Brooks (1979) and Bane (1983), shown in Figures 1.5 and 1 6. In Figure 1.5, a 64-week period of SST data are used to show the shoreward and seaward envelope of occupation of the Gulf Stream in relation to the location of the time-averaged mean axis shown by the dashed line. Figures 1.6 uses quarter-period (16-week) incremental plots of the axis to illustrates how two typical meanders (labeled A and B) occupy the shaded limits of the stream as they propagate northward. Table 1.2 lists the basic dimensions of meanders typical of those documented along the south and southeast coasts of Florida.

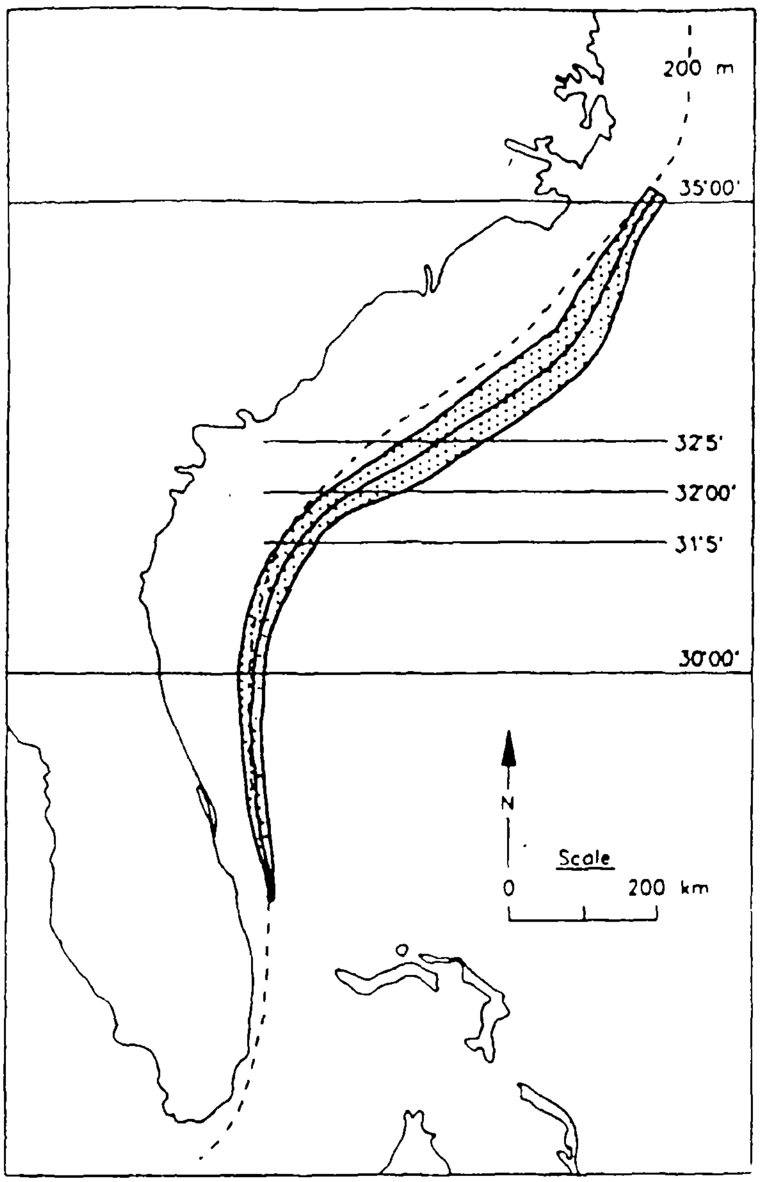


Figure 1.5. Mean position and meander deviation of the Gulf Stream surface (Bane and Brooks 1979)

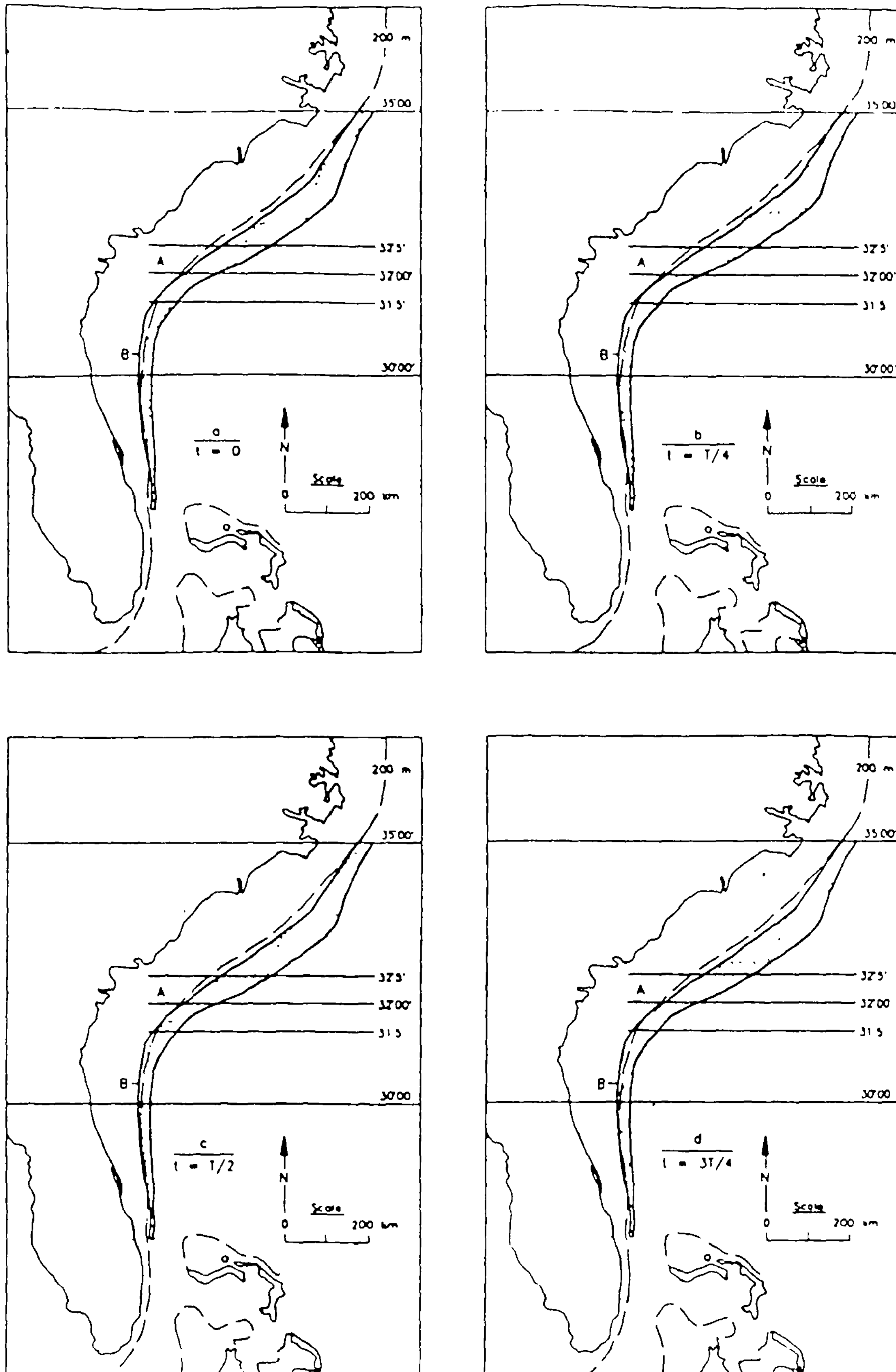


Figure 1.6. Example of the propagation of Gulf Stream meanders at quarter-period snapshots (Bane 1983)

Table 1.2

Basic Dimensions of the Gulf Stream Meanders

Features	Dimensions
Wave length (longitudinal)	90 - 260 km
Lateral displacement (east-west)	1 - 100 km
Average velocity of propagation	47 cm/sec
Maximum downstream current speed recorded	134 cm/sec

Results of this investigation have shown that much of the Continental Shelf area south of Cape Hatteras is subject to the direct influence of the Gulf Stream. Nearshore areas can also be affected by the Gulf Stream even though the area in question may not be directly impacted by the envelope of meanders. The following section will address Gulf Stream eddies in order quantify their potential impact on the proposed Miami and Fort Pierce disposal sites.

Spin-off Eddies

21. The movement of the Gulf Stream through the continental shelf often creates rotational patterns which propagate away from the main body of the Stream. These patterns generally represent unstable meanders which have become detached from the main body of the stream. This can occur if the meander becomes too pronounced or deviates too far from the main axis of flow, in which case, detachment into the low velocity ambient current can be caused by topography anomalies, wind fields, or barotropic instabilities. These detached secondary currents are referred to as spin-off eddies and are commonly observed in the shallow slope and terrace waters (40-80 m) off the coast of Florida. The following sections describe some of their basic characteristics.

22. Richardson (1985) identifies three distinct zones of the Gulf Stream. These are the clockwise rotating onshore eddy, the axis or main body of the Stream, and the counterclockwise rotating offshore eddy. The high velocity axis of the Gulf Stream acts as a barrier separating the onshore and offshore regions. Depending on the environmental conditions, detached onshore eddies can propagate to the north, shoreward, or to the south with short-lived

periods ranging from 2 days to 2 weeks. Eddy diameters range from 10 to 30 k and can extend from the surface to a depth of approximately 200 m (Lee and Mayer 1977). Detached eddies have been observed to propagate with surface velocities ranging from 20 to 100 cm/sec

23. The above sections of this report have documented the dynamic properties of the Gulf Stream and its spin-off eddies. The data presented indicate that, at times, the Gulf Stream does generate, or contribute to, shoreward directed velocity fields which may affect either or both of the proposed disposal sites. The effects can be compounded when coupled with shoreward-directed flood tide conditions. The magnitude of this total shoreward directed velocity field will be determined from the available data such that a boundary condition velocity field for each ODMDS can be defined as input to the short- and long-term sediment transport calculations. The following sections describe the selection of a maximum shoreward-directed velocity for each of the designated sites based on available prototype data.

Prototype Velocity Data

24. The site designation approach utilizes sediment transport theory and numerical modeling techniques to determine possible magnitudes of erosion and/or transport of sediment from a specified disposal site. The computations are based on a specific depth and background velocity field for each site which will be documented to be representative of the location. The site evaluation approach is inherently conservative in that a constant, maximum-valued, reef-directed velocity is selected as a boundary condition for sediment transport calculations. In reality, the velocity field is continuously fluctuating as a function of tides, wind fields, waves, the Gulf Stream, etc.; therefore, no single representative value is truly descriptive of any location. Also, two measuring periods would yield two different values; however, when the length of data is sufficiently long, the two computations should not vary significantly in magnitude. Data which cover sufficiently long periods of time to satisfy these criteria will be used in determining appropriate boundary conditions.

25. Since maximum values are to be selected, the degree of accuracy achieved by this approach is considered adequate as a basis for reliable

predictions of the dispersion characteristics of a disposal site. If it can be shown, for example, that the prototype velocity in 500 ft of water never exceeds 30 cm/sec (or 40, or 50) and that a velocity magnitude of 100 cm/sec is necessary for initiating and transporting sediment transport at that depth, then the data are adequate to show that the site under investigation is non-dispersive and will not represent a source of contamination. Severe storm conditions are not included in this analysis since it is assumed that disposal operations would be discontinued during storm events.

26. A large data base of published current meter data was identified which was acceptable for quantifying the velocity patterns off the eastern coast of Florida. Data included measurements at multiple depths in the water column for various mooring string sites extending from south of Miami to north of Fort Pierce and from less than 1 km to more than 100 km offshore. Although the spatial distribution of data is sparse in its coverage of the disposal site locations, the data base is adequate for determining a velocity field which is representative of each survey area and can be used to evaluate the transport potential of each disposal site. In the present context, adequacy refers to data which covers a sufficient length of time and number of vertical locations within the water column, that a reliable depth-averaged velocity can be computed.

27. Multiple sources of acceptable velocity data were located for application in the present Miami and Fort Pierce disposal site study. The following sections will use this data, in addition to other available data, to develop a spatially consistent data base of depth averaged velocity vectors. The intent of this multiple station analysis and inter-comparison is to develop velocity vectors which are consistent with surrounding data and are, therefore, truly representative of the area.

Depth Averaged Velocity

28. The site designation approach computes short-term and long-term potentials for sediment transport as a function of a site-specific, depth-averaged velocity field. The depth averaged condition was selected for two reasons. First, due to the limited time available for this study, a representative velocity field had to be defined from existing data. Available data

was sufficient for determining a maximum shore-directed, depth-averaged current but was not adequate in either duration or distribution to define any meaningful vertical velocity distribution trend. Secondly, an "average" vertical distribution probably does not exist, since the vertical velocity structure shows a continuously changing current gradient due to variations in the wave fields, salinity gradients, thermoclines, and Gulf Stream meanders. Also, attempting to compute site-specific sediment movement as a function of a three-dimensional velocity distribution is not feasible. For these reasons, a depth-averaged current was selected for input to both the DIFID and long-term sediment models. The computation of the selected velocity field is described in the following sections.

29. Two examples data sources are used here to demonstrate the computation of a shoreward-directed depth-averaged velocity field. Both sources of data are reported by Lee, Brooks, and Duing (1977). The Miami data was collected as a portion of the SYNOPS 71 (Synoptic Observations of Profiles in the Straights) project. The research vessels Calanus (C), Humble (H), Pillsbury (P), and Gerda (G) simultaneously collected 16 days of vertical profiles of horizontal velocities. These measurements were taken every 3 hours at the four locations between Miami and Bimini shown in Figure 1.7. Ship-deployed measurement stations for the Fort Pierce area are shown in Figure 1.8. These reported data are based on the analysis of multiple data sets, collected at each of the data collection stations over a period of approximately 5.5 years.

30. Velocity measurements for the Miami transects are based on Profiling Current Meter data (PCM). The data were reduced to u (+ to the east) and v (+ to the north) velocity components and then averaged over 5 m depth intervals. Details of the deployment can be found in Lee, Brooks, and Duing 1977, Duing and Johnson 1972 and Duing 1973. Figure 1.9 displays three types of velocity profiles which were constructed from the velocity time series data records for mooring sites C, H, P, and G. These represent the measured maximum, minimum, and mean velocity. The depth averaged value is also indicated in the figure. The minimum u velocity (negative referring to westward) and corresponding v component were used to compute the shore-directed depth-averaged velocity vector indicated by the dotted line.

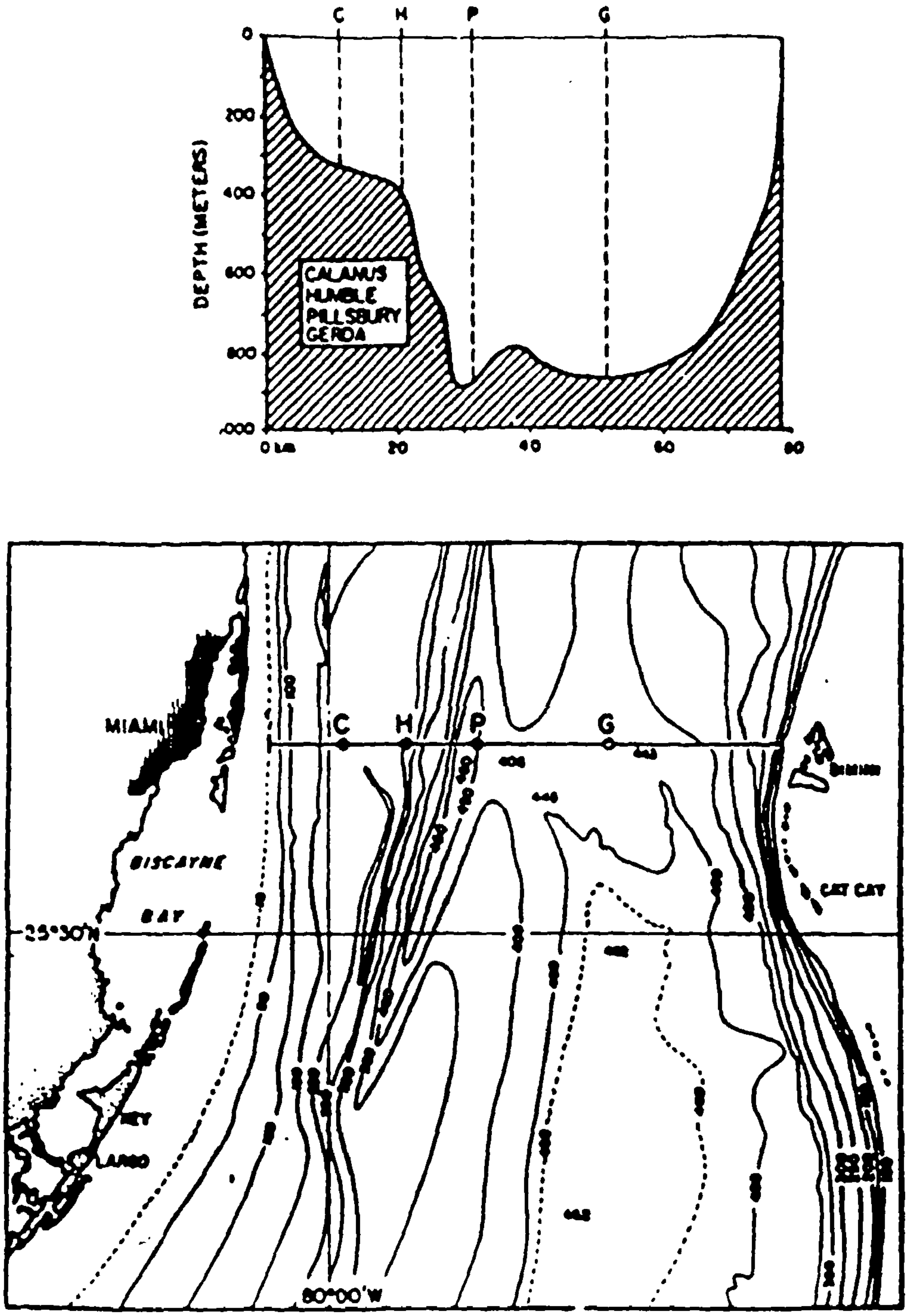


Figure 1 7. Current meter locations for Miami (Lee, Brooks, and Duing 1977)

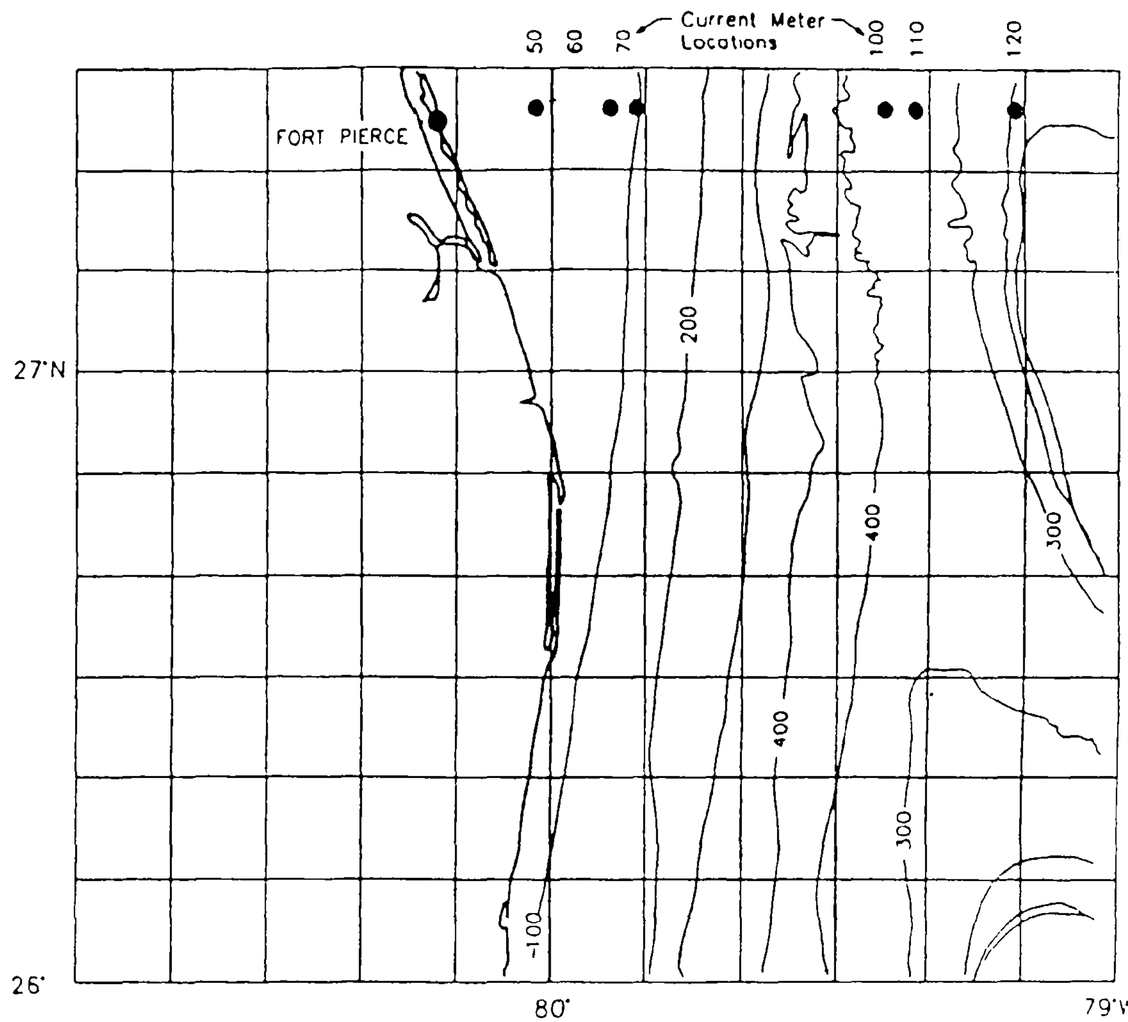


Figure 1 8. Current meter locations for Fort Pierce
(Lee, Brooks, and Duing 1977)

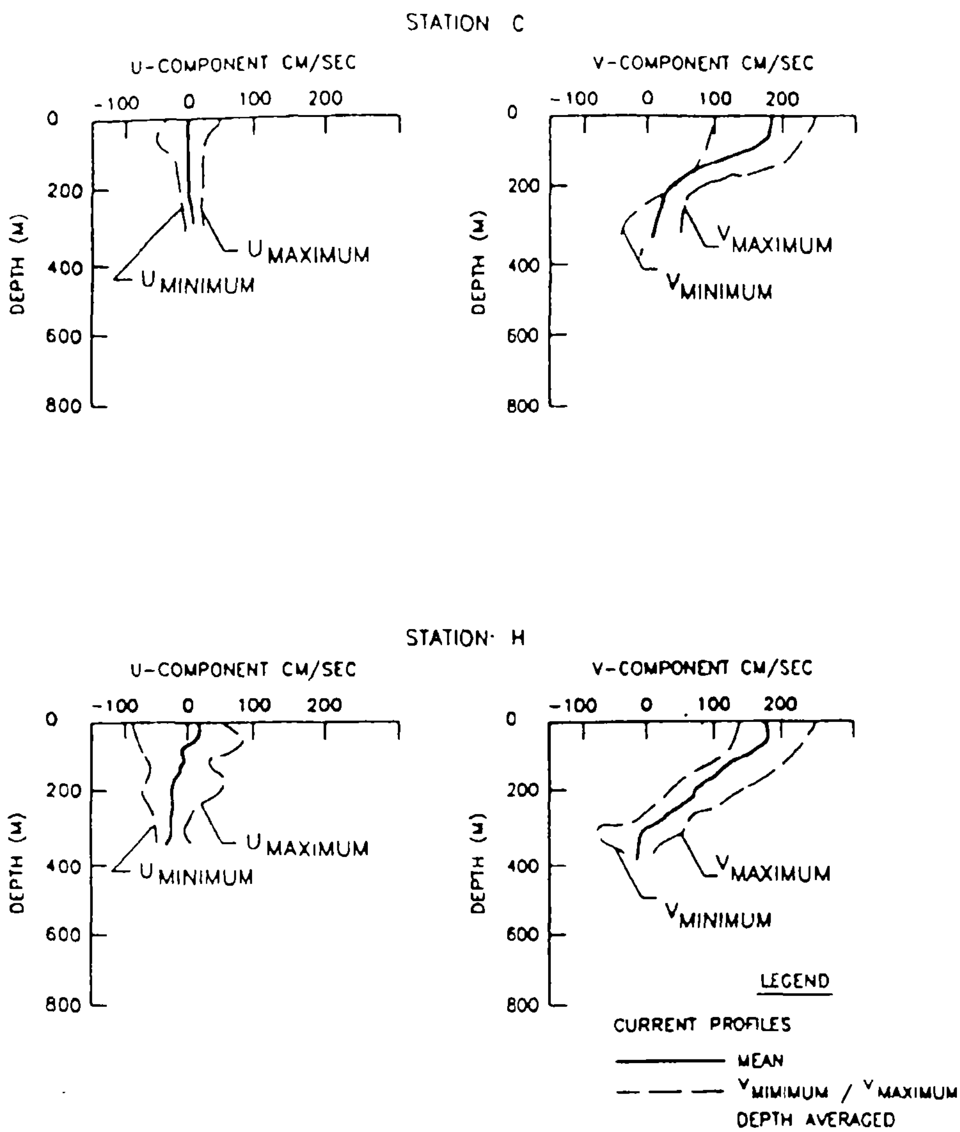


Figure 1 9. Measured velocity profiles offshore of Miami

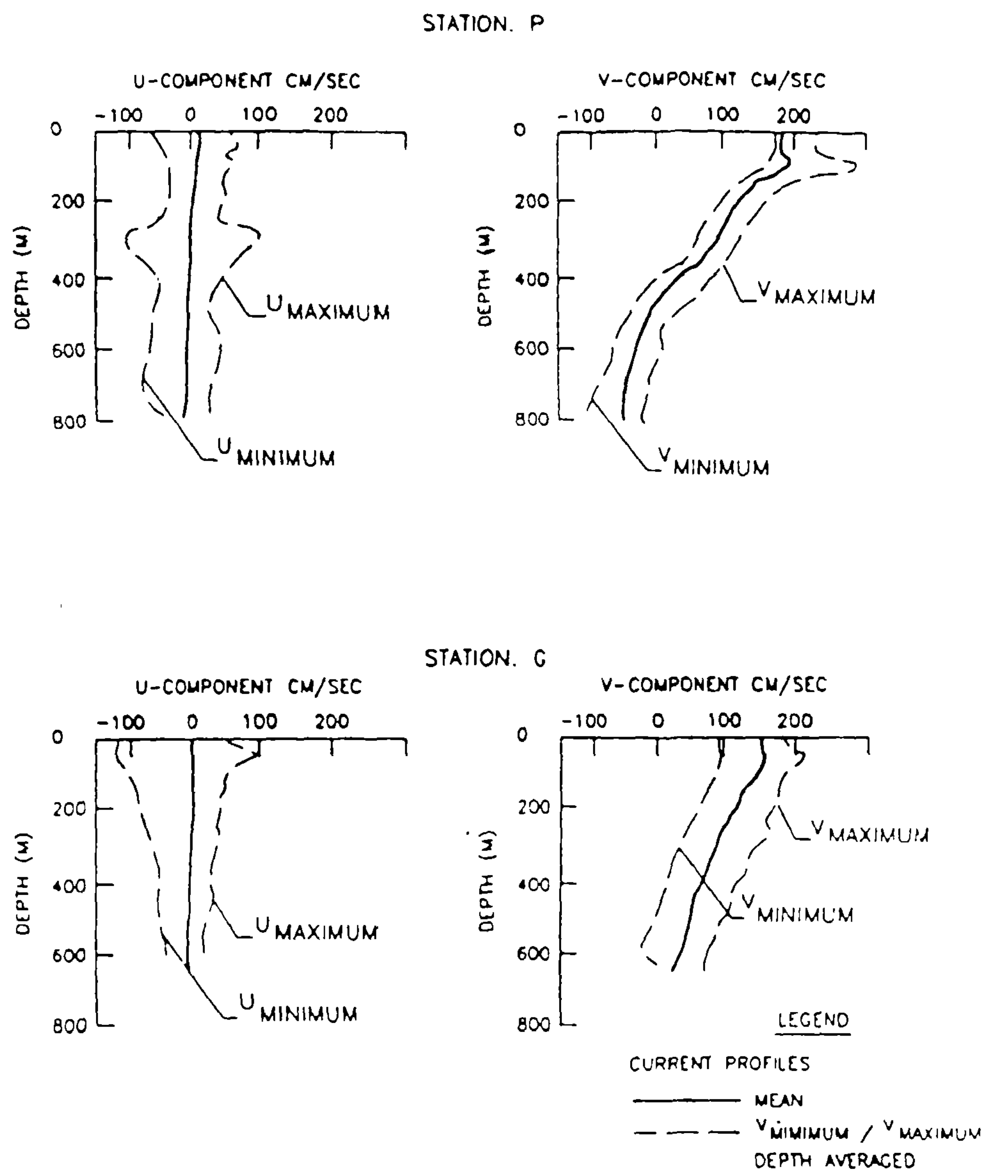
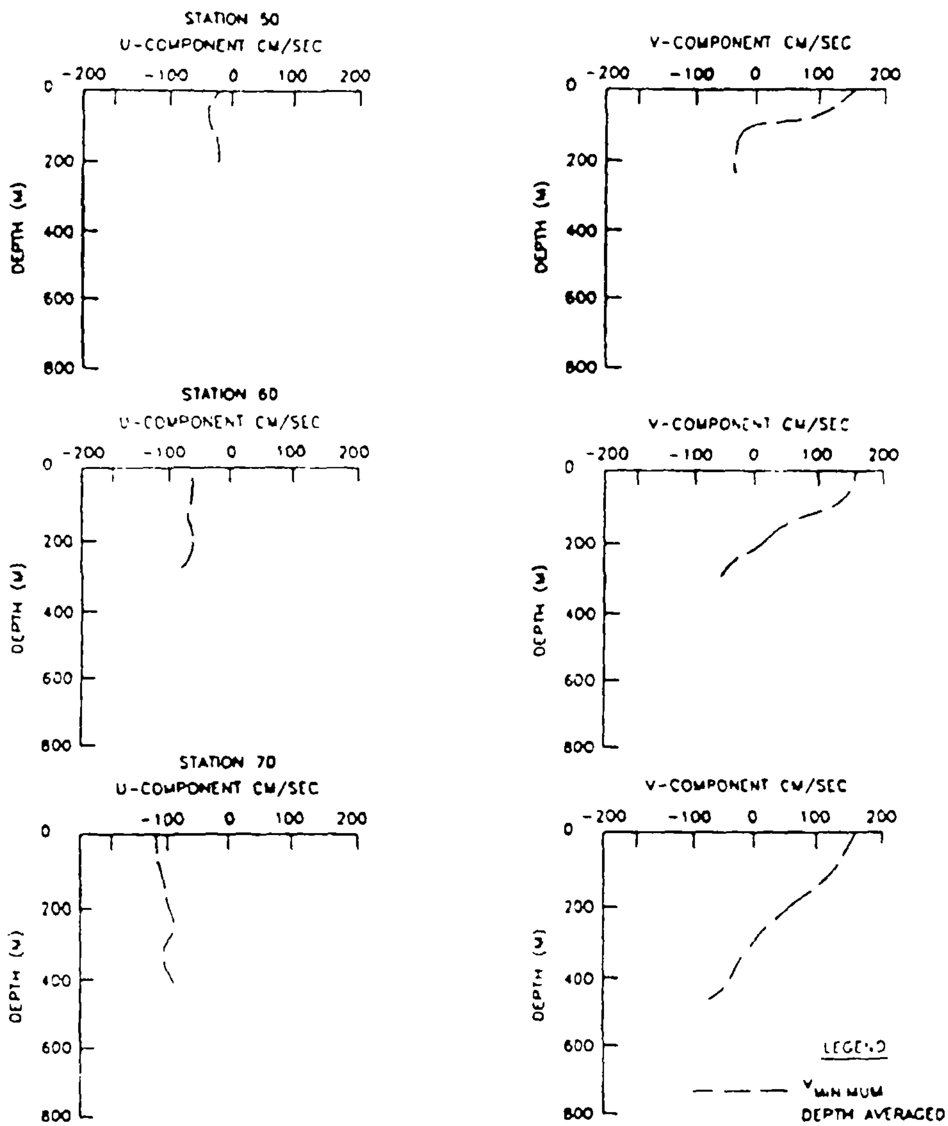


Figure 1 9. (Continued)

31. The Dropsonde data collection method was used to measure the velocity distribution for the Fort Pierce transects shown in Figure 1.8. This technique involves the deployment of multiple Dropsonde instruments which record the vertical distribution of the horizontal velocity field as the instrument descends through the water column. A cubic spline function is then used to compute a vertically averaged velocity vector at 50-m increments throughout the water column. The data set for Fort Pierce is based on 18 days of Dropsonde deployment (Lee, Brooks, and Duing 1977). Details of the measurement technique are reported in Richardson and Schmitz 1965. The minimum (westerly) u, corresponding v, and computed depth averaged values for each of the Fort Pierce stations are shown in Figure 1.10.



Figures 1.10. Measured velocity profiles offshore of Fort Pierce

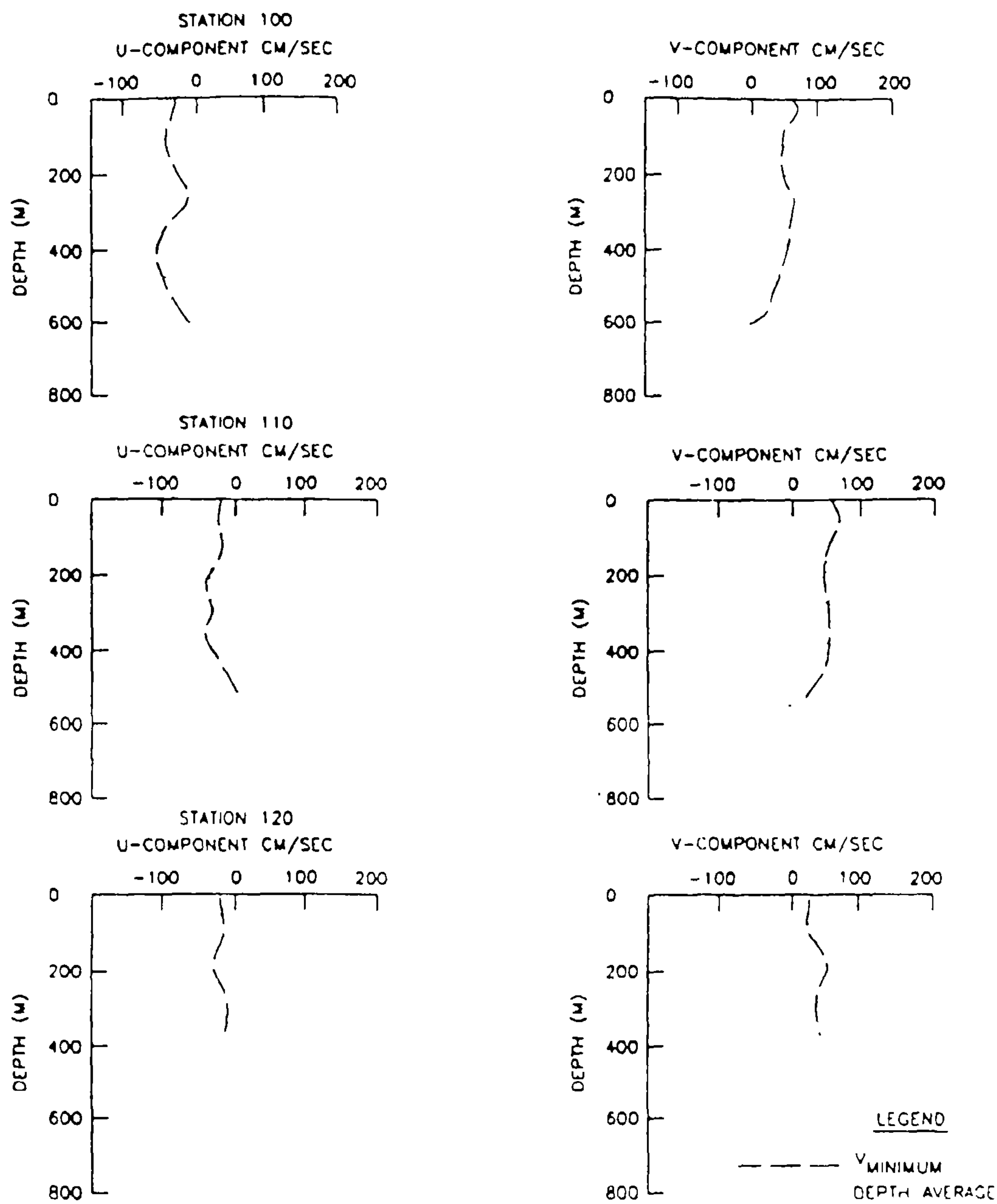


Figure 1.10 (Continued)

32. Available current meter data for all additional locations between Miami and Fort Pierce were similarly analyzed. The purpose was to demonstrate a spatial consistency in depth averaged velocities in order to show that the velocities assigned to each proposed site are representative of their respective locations. Table 1.5 identifies the current meter stations, coordinates, and depth-averaged u and v velocity components for all gage locations identified in the literature review.

Table 1.5

Current Meter Locations and Depth Averaged Velocities

Current Meter Stations	Latitude (North)	Longitude (West)	Eastward Velocity cm/sec	Northward Velocity cm/sec	Vector cm/sec	Direction (from north) degs
Lee, Brooks, and Duing 1977 Miami(Spring)						
10	25 32.0	80 3.0	17.5	55.5	58.2	342
20	25 31.0	80 0.0	12.2	45.3	46.9	345
30	25 32.0	79 57.1	7.1	66.8	67.2	354
40	25 32.0	79 54.1	8.2	59.7	60.3	352
50	25 32.0	79 51.1	22.6	26.9	35.2	320
60	25 32.0	79 48.1	21.2	50.8	55.0	337
70	25 32.0	79 42.1	12.5	54.9	56.3	347
80	25 32.0	79 36.2	21.3	43.5	48.4	334
90	25 32.0	79 30.2	19.1	34.2	39.2	330
100	25 32.2	79 24.2	20.4	23.4	31.1	319
110	25 32.2	79 21.2	22.7	26.3	34.8	319
120	25 32.2	79 19.5	24.5	20.9	32.2	310
130	25 32.2	79 17.1	35.3	20.4	40.8	300
Lee, Brooks, and Duing 1977 Miami						
C	25 45.0	79 59.0	25.6	20.4	49.3	343
H	25 45.0	79 52.5	29.3	44.7	53.4	327
P	25 45.0	79 47.0	21.2	50.8	55.0	337
G	25 45.0	79 36.0	24.0	58.8	63.5	328
10	25 44.5	80 3.0	14.5	47.0	49.3	343
20	25 44.5	80 0.0	25.6	20.4	32.8	309
30	25 44.5	79 57.0	29.0	5.3	29.4	280
40	25 44.5	79 54.0	31.4	14.0	34.4	294
50	35 44.5	79 51.1	29.3	44.7	53.4	327
60	25 44.5	79 48.1	25.2	12.4	28.1	296
70	25 44.5	79 42.1	26.3	57.1	63.0	335
80	25 44.5	79 36.1	24.0	58.8	63.5	338
90	25 44.5	79 30.1	23.4	35.8	42 8	327
100	25 44.5	79 19.4	13.5	26.8	30.0	333
100	25 44.5	79 27.1	15.2	38.9	41.8	339

110	25 44.5	79 24.1	12.1	43.3	45.0	344
120	25 44.5	79 21.2	16.2	43.5	46.4	340
130	25 44.5	79 19.4	13.5	26.8	30.0	333
Lee, Brooks, and Duing 1977 Miami Bal Harbor						
10	25 51.0	80 5.7	21.0	46.0	50.6	335
20	25 51.0	80 4.5	18.0	46.0	76.2	346
30	25 51.0	80 1.6	21.5	28.8	35.9	323
40	25 51.0	79 58.6	32.6	3.8	32.8	276
50	25 51.0	79 56.1	30.5	1.8	30.6	275
60	25 51.0	79 53.6	37.8	43.0	57.3	319
70	25 51.0	79 51.1	36.2	64.0	73.5	330
80	25 51.0	79 47.4	29.4	24.1	38.0	309
90	25 51.0	79 41.0	21.1	44.8	49.5	335
100	25 34.6	79 34.6	19.6	44.0	48.2	336
110	25 51.0	79 28.3	10.1	33.0	34.5	343
120	25 51.0	79 21.2	12.1	14.0	14.8	305
130	25 51.0	79 17.8	12.3	6.0	13.7	296
Lee, Brooks, and Duing 1977 Near Miami						
R	25 50.7	80 05.0	31.0	72.4	78.9	337
R2	25 50.9	80 4.3	34.8	79.0	86.3	334
R3	25 51.0	80 3.3	29.1	10.5	30.9	290
R5	25 51.1	79 57.3	41.2	20.4	45.0	296
R6	25 51.1	79 51.1	52.4	17.5	55.3	289
N1	25 51.2	79 47.4	25.1	55.0	60.5	336
N2	25 50.9	79 22.0	5.0	5.0	7.1	315
R7	25 34.5	80 04.0	26.2	57.4	63.1	336
R9	26 8.9	80 3.7	18.2	55.5	58.4	342
R10	26 23.0	80 1.8	28.7	55.4	62.4	333
Lee, Brooks and Duing 1977 Fort Pierce						
40	27 26.0	79 53.7	21.3	78.0	80.8	345
50	27 26.0	79 50.7	12.6	31.0	33.5	338
60	27 26.0	79 47.6	32.5	69.8	77.0	335
70	27 26.0	79 44.6	17.6	86.4	88.2	349
80	27 26.0	79 38.5	7.7	100.0	100.2	356
90	27 26.0	79 32.5	10.4	74.5	75.2	352
100	27 26.0	79 26.4	28.5	48.8	56.5	330
110	27 26.0	79 20.3	29.0	49.5	57.4	330
Leaman and Vertes 1982 Near Jupiter Inlet						
1	27 01	79 52	11.8	91.2	92.0	353
2	27 01	79 48	7.9	103.6	103.9	355
3	27 01	79 42	2.9	106.8	106.9	359
4	27 01	79 38	27.9	96.2	100.4	344
5	27 01	79 31	2.3	79.8	78.9	358
6	27 01	79 25	11.8	65.0	66.0	350
7	27 01	79 18	11.1	70.0	70.9	351
8	27 01	79 12	10.5	45.4	46.7	347

Richardson, Schmitz, and Niiler 1969 Cape Kennedy						
Sec 5	28 20	80 06	16.2	33.5	37.2	334
	28 20	79 58.5	19.0	51.8	55.2	339
	28 20	79 52.5	16.3	75.0	77.0	348
	28 20	79 33	18.0	80.7	82.0	347
	28 20	79 07	31.7	33.5	46.1	317
Lee et al 1986 Ponce De Leon Inlet						
1	26 58.0	79 56.8	17.2	58.2	60.6	344
2	27 29.9	79 59.1	19.9	75.1	77.7	345
3	28 00.2	79 59.8	19.2	22.1	29.0	345
4	28 58.2	80 39.2	5.7	44.8	45.0	353
5	29 00.7	80 21.7	15.1	44.6	47.0	341
6	29 00.0	80 08.2	25.5	52.9	58.7	334
7	29 00.2	80 02.2	23.5	35.4	42.5	327
8	29 03.9	79 50.9	11.7	39.3	41.0	344
9	29 00.2	79 00.2	27.1	11.1	29.3	293
10	29 00.1	79 07.5	16.8	20.4	26.1	320
11	30 00.6	80 16.3	20.7	53.4	57.3	339
Lee and Atkinson 1983 Near St. Augustine Inlet						
4	29 10.0	80 10.0	20.0	6.0	20.9	287
5	29 30.0	80 30.0	14.0	14.0	19.8	315
6	29 30.0	80 20.0	12.0	75.0	76.0	351
9	30 00.0	80 30.0	30.0	28.1	41.1	313
10	30 00.0	80 20.0	35.0	75.0	82.8	345
12	30 40.0	80 15.0	18.0	10.0	20.6	300
15	30 50.0	80 10.0	10.0	8.0	12.8	307
25	32 30.0	78 30.0	30.0	15.1	33.5	297
Lee and Waddel 1983						
A	30 00.0	80 15.0	20.2	31.4	37.3	327
B	30 00.0	79 40.0	32.2	1.2	32.3	270
C	30 00.0	79 20.0	19.6	5.4	20.4	286
D	30 00.0	78 10.0	20.4	26.6	33.5	323
E	30 00.0	77 00.0	26.0	34.4	43.6	323
Williams and Lee 1987						
A1	28 35.8	80 31.2	5.2	60.3	60.5	355
A2	28 37.9	80 21.2	14.3	46.3	48.5	343
B1	29 53.6	81 14.9	2.8	12.0	12.3	347
B2	29 57.8	81 1.2	4.2	34.0	34.3	353
C1	31 1.1	81 16.6	5.6	15.0	20.0	340
C2	30 57.2	80 56.1	4.9	31.5	31.9	351

33. The velocity data presented in Table 1.5 are shown in vector form in Figure 1.11 for the lower east coast (Miami to Fort Pierce) and Figure 1.1 for the upper east coast. At Miami the mainstream vectors are directed towar the shore due to the combined effects of a complex bathymetry and the approximate 90 degree northerly deflection of the Gulf Stream at Miami. Flow is generally directed to the north at Jupiter Inlet and Fort Pierce, as demonstrated by the vectors at these two locations. This uniform orientation is partially due to the fact that the offshore topography at Jupiter Inlet and Fort Pierce is smooth and mild in gradient across the entire continental shelf (Lee and Atkinson 1983). In addition to the mild bathymetry and shallow water depth, the area is relatively free from the direct influence of the Gulf Stream.

34. The velocity data presented in Table 1.5 and shown in Figures 1.11 and 1.12 were analyzed to produce summary velocity vectors at 2 mile intervals across transects offshore of Miami and Fort Pierce. The proposed disposal site locations are each located approximately 4 miles offshore. Tables 1.6 and 1.7 present these vector data along with the corresponding distance offshore, water depth, and bottom slope. The results presented in Tables 6 and 7 are shown in vector form in Figures 1.13 and 1.14.

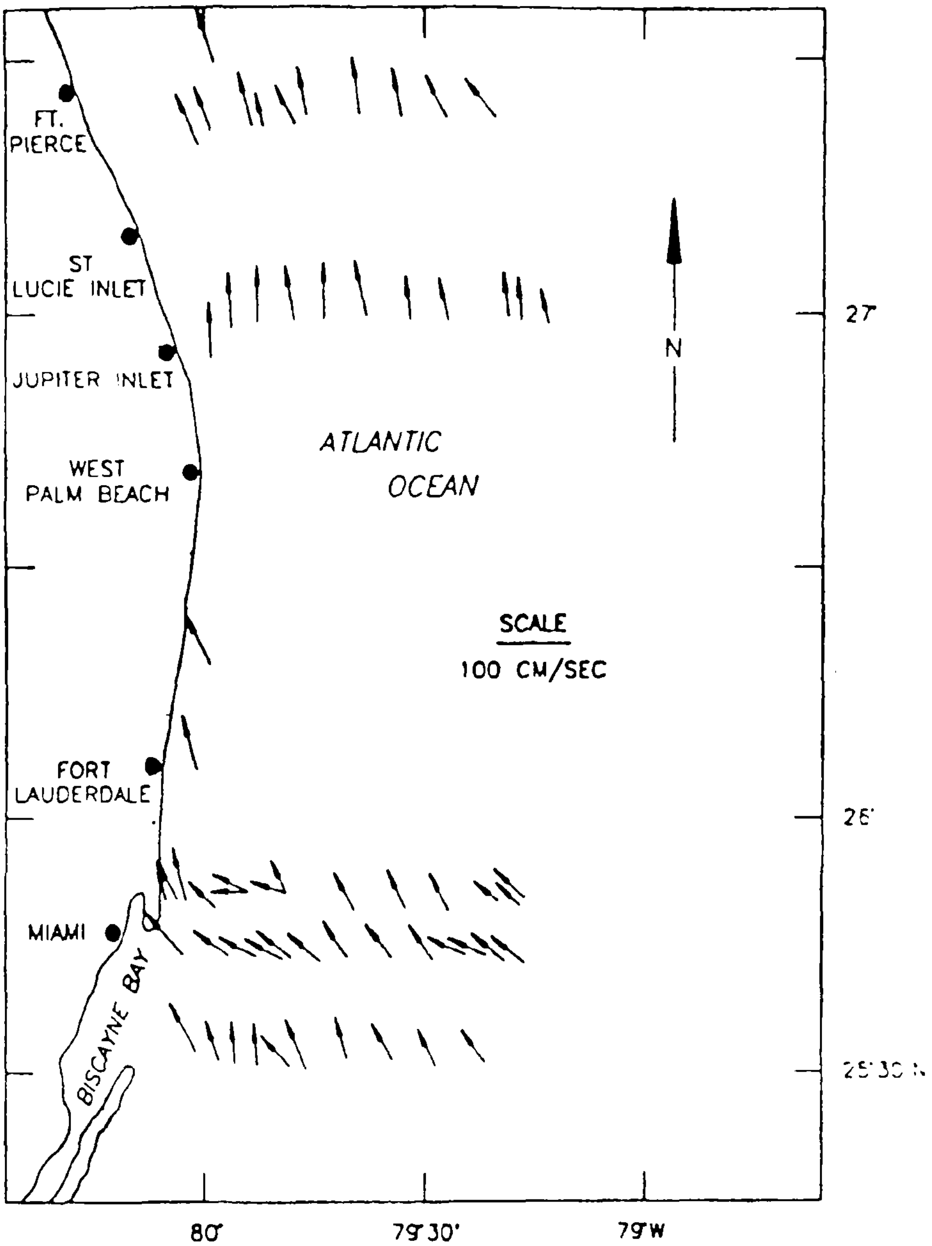


Figure 1.11. Depth-averaged current vectors from Miami to Fort Pierce

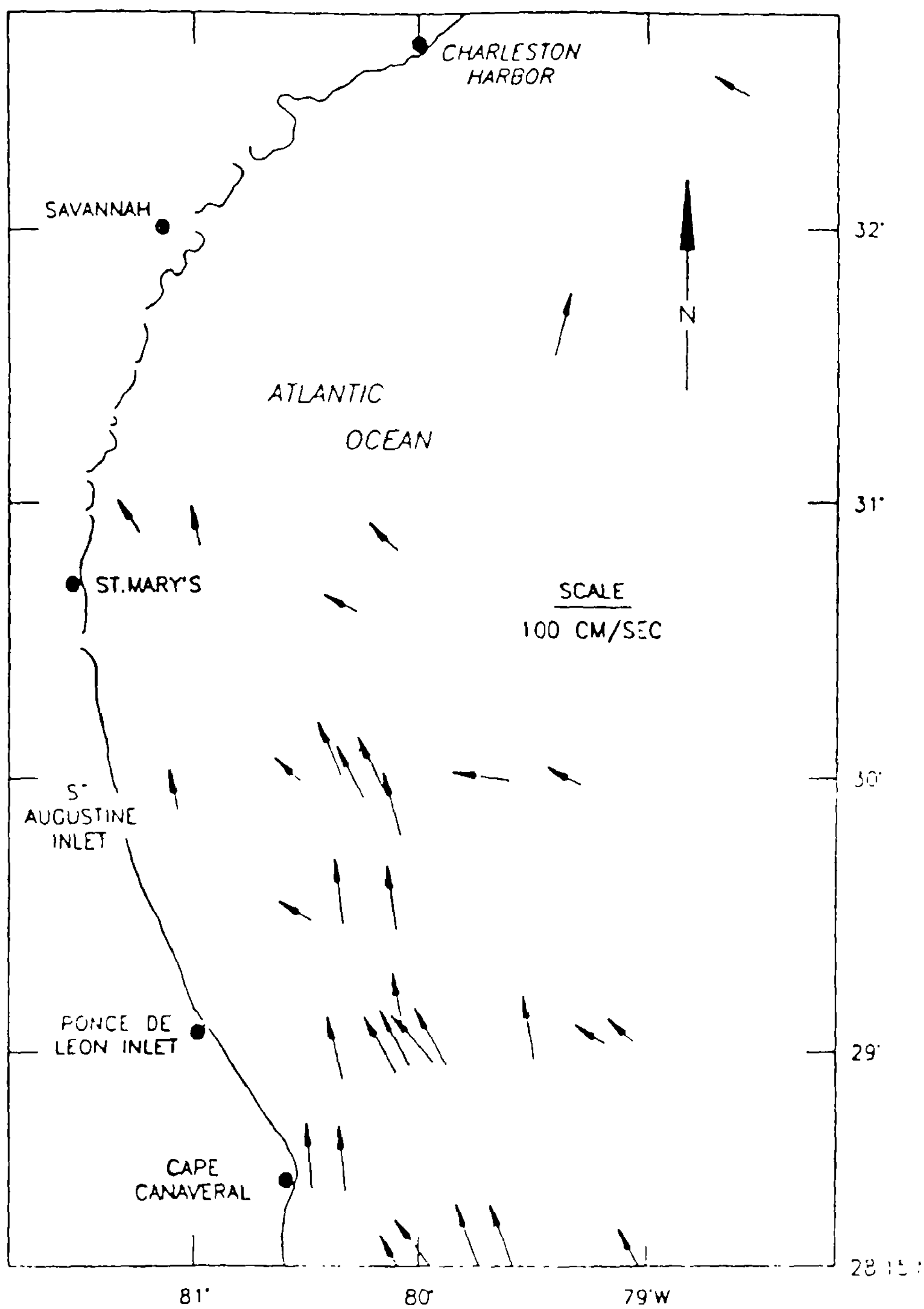


Figure 1.12. Depth-averaged current vectors north of Fort Pierce

Table 1.6

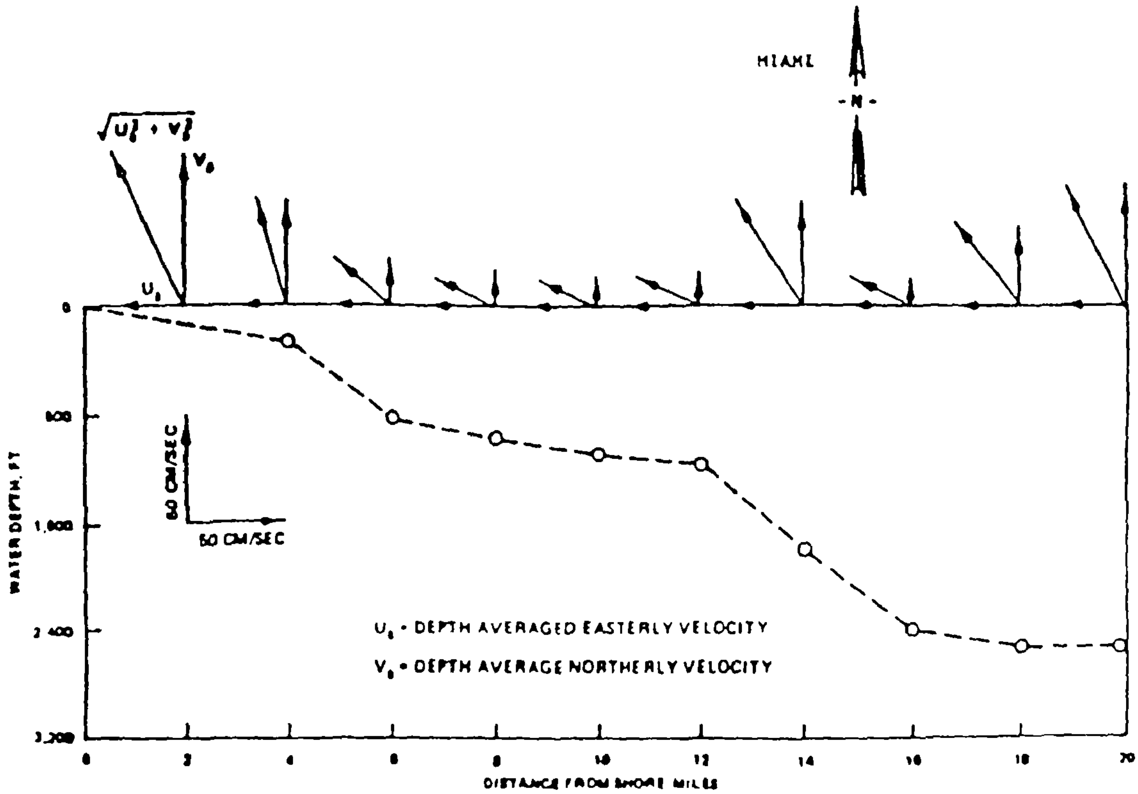
Velocity Distribution Offshore of Miami

Distance miles	Depth ft	Slope	U cm/sec	V cm/sec	Magnitude cm/sec	Direction Degrees "N"	Remark
2	24	0.0222	34.4	71.9	79.7	335.	Too shallow to dump
4	258	0.0222	14.4	47.0	49.3	343.	
6	834	0.0545	25.6	20.4	32.8	309.	
8	960	0.0119	27.3	12.9	30.2	295.	
10	1092	0.0125	30.2	9.7	31.7	288.	
12	1152	0.0057	31.4	14 0	34.4	294.	
14	1800	0.0670	29.3	44.7	53.4	327.	
16	2400	0.0568	25.2	12.4	28.1	296.	
18	2562	0.0153	26.3	34.8	43.6	323.	
20	2568	0.0006	26.2	57.1	63.0	335.	

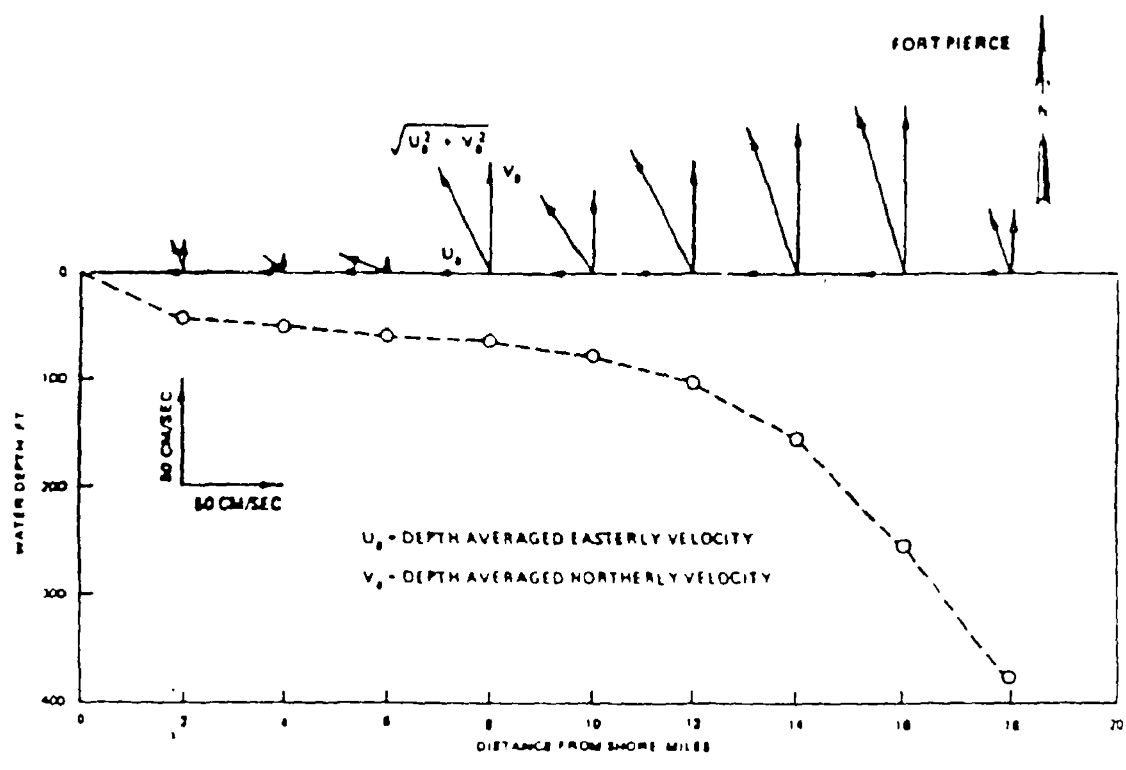
Table 1.7

Velocity Distribution Offshore of Fort Pierce

Distance miles	Depth ft	Slope	U cm/sec	V cm/sec	Magnitude cm/sec	Direction Degrees "N"	Remark
2	32	0.0021	5.6	15.0	16.0	340.	Too shallow to dump
4	43	0.0010	10.0	8.0	12.8	308.	
6	50	0.0009	20.0	6.0	20.9	287.	
8	60	0 0009	25.5	52.9	58.7	334.	
10	63	0.0003	23.5	35.4	42.5	326.	
12	77	0.0013	28.7	55.4	62.4	333.	
14	102	0.0024	25.0	66.7	71.2	339.	
16	155	0.0050	21.3	78.0	80.85	345.	
18	255	0.0095	12.6	31.0	33.5	338.	
20	376	0.0115	32.5	69.8	77.0	335.	



Figures 1.13. Velocity vector distribution offshore of Miami



Figures 1.14 Velocity vector distribution offshore of Fort Pierce

Velocity Field Input Data

35. The short-term DIFID model and the long-term sediment transport model require a velocity field boundary condition for each site in order to calculate sediment transport. The velocity fields for driving the long-term simulations were based on an approximate average of the 2, 4, 6, and 8 mile offshore values for the Miami and Fort Pierce data shown in Tables 1.6 and 1.7. Values of 50 cm/sec (1.64 ft/sec) for Miami and 30 cm/sec (0.98 ft/sec) for Fort Pierce were used. In order to account for short-term velocity fluctuations about the selected long-term values, the approximate maximum of the inner 8-mile values shown in Tables 1.6 and 1.7 were selected for the short-term simulations. Values of 85 cm/sec (2.79 ft/sec) and 60 cm/sec (1.97 ft/sec) were adopted for the Miami and Fort Pierce sites. The corresponding angles of orientation (measured clockwise from true north) for the velocity vectors are approximately 320 and 317 degrees for Miami and Fort Pierce.

36. The depth averaged non-storm related velocity field approach for analyzing the stability of each proposed ODMDS was used to analyze sediment dispersion during dumping and to investigate long-term erosion resulting from normal meteorological conditions. However, storm-induced erosion of an existing mound may initiate sediment transport which may adversely impact the reefs when normal long-term conditions would not. For this reason, a storm-related velocity field was selected for simulation with the long-term model.

37. Peak velocities for a storm event were based on prototype observations during hurricane David. Smith (1982) investigated the influence of this hurricane on the continental shelf waters off south Florida north of Fort Pierce Inlet. On 3 September 1979 hurricane David passed over an inner and middle shelf prototype data collection area near Fort Pierce, producing a record water level at the Fort Pierce inlet. Bottom pressure fluctuations recorded on the inner shelf indicated a storm surge of approximately 3 ft above the normal high water mark with a corresponding current of over 2.7 ft/sec. Based on these prototype velocity data, a numerical model input velocity of 6 ft/sec for Miami and 4 ft/sec for Fort Pierce were used in the long-term sediment transport model to simulate storm effects at the respective sites.

Upwelling and Downwelling

38. All prototype velocity data obtained in the literature review represent horizontal velocities and all numerical modeling efforts are depth averaged; therefore, vertical transport of sediments are not addressed in the present approach. This section of the report briefly investigates the occurrences of upwelling and downwelling in the vicinity of the Gulf Stream as a possible source of transport of dredged material from the disposal site onto the reefs. During upwelling, the deep waters are brought into the euphotic zone (water depth less than 50 m) along the outer continental shelf (Lee et al 1981). The intent of this section is to determine whether these vertical currents are adequate to erode and transport sediment.

39. The precise origin of upwelling and downwelling appears unclear; however, it is suspected that they are a response to the movement of the Gulf Stream (Smith 1983). Upwelling and downwelling events have been observed in the vicinity of meander crests (Brooks and Bane, 1983) and have been correlated with wind stress forcings which contribute to the formation of meanders. Green (1944) documented an upwelling event off Daytona Beach which was associated with southerly winds during July and August. Brooks and Mooers (1977) investigated the relationship between wind fields and upwelling and downwelling offshore of Miami. They concluded that southerly winds cause upwelling while northerly winds produce downwelling on both side of the Stream axis. The purpose of this section is to review the available literature and document the magnitude of the vertical velocity w associated with an upwelling event in order to assess its potential for transporting sediment.

40. Lee and Atkinson (1983) documented upwelling velocities associated with a frontal eddy to be on the order of 0.01 cm/sec based on the measured movement of an isotherm associated with an upwelling event. They also estimated w by using vorticity conservation principles and calculated a value of 0.014 cm/sec. Osgood et al. (1987) used surface floats and current meter data to compute a value of 0.048 cm/sec for a time series of data from a documented event. A summary of reported upwelling velocity magnitudes reported by Osgood et al. (1987), is shown in Table 1.8.

Table 1.8

Summary of Upwelling Related Velocity Calculations
(Osgood et al. 1987)

Researchers	Method of Calculation	Depth of Calculation (m)	w cm/sec
Lee and Atkinson (1983)	tracking an isotherm	50	0.010
Lee and Atkinson (1983)	vorticity conservation	50	0.014
Chew et al (1985)	tracking an isotherm	28-45	0.010
Chew et al (1985)	thermal wind balance	200	0.100
Rossby et al. (1985)	Rafos floats	500	0.100
Levine et al. (1986)	Swallow float	400	0.080
Osgood et al. (1987)	Heat equation	219	0.048

41. The results of this brief examination indicate that vertical velocities during an upwelling event are on the order of 0.1 cm/sec. As a sediment transporting mechanism, velocities of this magnitude are not considered significant with respect to horizontal velocities on the order of 30 to 40 cm/sec. Any possible transport by these vertical velocities would be insignificant in comparison to sediment transported by the horizontal velocity field. The following sections will, therefore, address sediment transport as a function of only the horizontal velocity fields previously described.

PART II: THE SHORT-TERM SIMULATION OF DISPOSAL OPERATIONS

42. Section II of this report investigates the short-term fate (less than a day) of dredged material at the proposed Miami and Fort Pierce disposal sites. The analysis approach will determine whether the combined effects of the local topography at the site and the depth-averaged velocity field developed in Section I, impact the effectiveness of the dredged material disposal operation. Can the dredged material be physically placed within the designated ODMDS limits as the material descends through the water column to the ocean floor or are the local currents of sufficient magnitude to transport material from the disposal vessel onto sensitive coral reefs? If the dredged material can not be confined within the designated ODMDS limits, then an alternate site further offshore should be evaluated for site designation.

43. The short-term site evaluation phase is made by numerically modeling the disposal operation using the DIFID numerical model. Theory and background of the model are reported in Johnson and Holliday (1978), Johnson (1987), and Johnson, Trawle, and Adamec (1988). The model computes the time history of a single disposal operation from the time the dredged material is released from the barge until it reaches equilibrium on the ocean floor. The DIFID model separates the dumping operation into three distinct phases. In the first phase, material released from the bin is assumed to form a hemispherically shaped cloud which descends through the water column under the influence of gravity. This phase is called the convective descent phase. In shallow water, such as the Fort Pierce site, this can be completed within a few seconds of the initial dump. In deep water, such as the Miami site, this time can be greater than 3 minutes. The increased descent time is due to both the greater depth and to a corresponding loss of momentum of the released material as it travels through the water column.

44. The cloud of material continues to descend through the water column until it either impacts the bottom or has reached a stable point of neutral buoyancy. In either case, the horizontal spreading of material marks the end of the descent phase and beginning of the dynamic collapse phase. If the disposal load is primarily composed of non-cohesive material, this phase may simply represent a settling and consolidation of the sediment into a mound; however, if the load contains cohesive sediment, a combination of buoyancy an

suspension may occur in which the cloud of suspended sediment may be transported a considerable distance from the point of disposal.

45. When the rate of horizontal spreading in the dynamic collapse phase becomes less than the spreading rate due to turbulent diffusion, the material begins the final transport-diffusion phase. The termination of this phase marks the end of the short-term investigation. The resulting post-disposal sediment mound represents the initial boundary condition for the long-term transport computations to be described in Section III. An idealization of all three phases of the short-term disposal are shown in Figure 2.1

Input Data Requirement

46. The DIFID model requires site-specific input data in order to quantitatively predict the short-term fate of sediment released during a disposal operation. Input data include the characteristics of the dredge, a description of the local environment to include the local depth and velocity field, and a knowledge of the characteristics of the dredged material. In addition, certain modeling parameters and coefficients must be specified. A brief description of these input parameters is presented here.

47. The primary goal of the short-term modeling effort is to determine whether disposed material could be transported from the disposal site onto the reefs. Since the potential for reef contamination increases with increasing volumes of material in the water column, a conservative approach was adopted in which a large capacity dredge was specified for model simulation. The selected dimensions shown in Table 2.1 are representative of the largest instantaneous dumping type dredge anticipated by SAJ (Tapp, 1988) to be involved with the Miami and Fort Pierce dredging operation. A dredge of these dimensions was, therefore, used for both the Miami and Fort Pierce simulations.

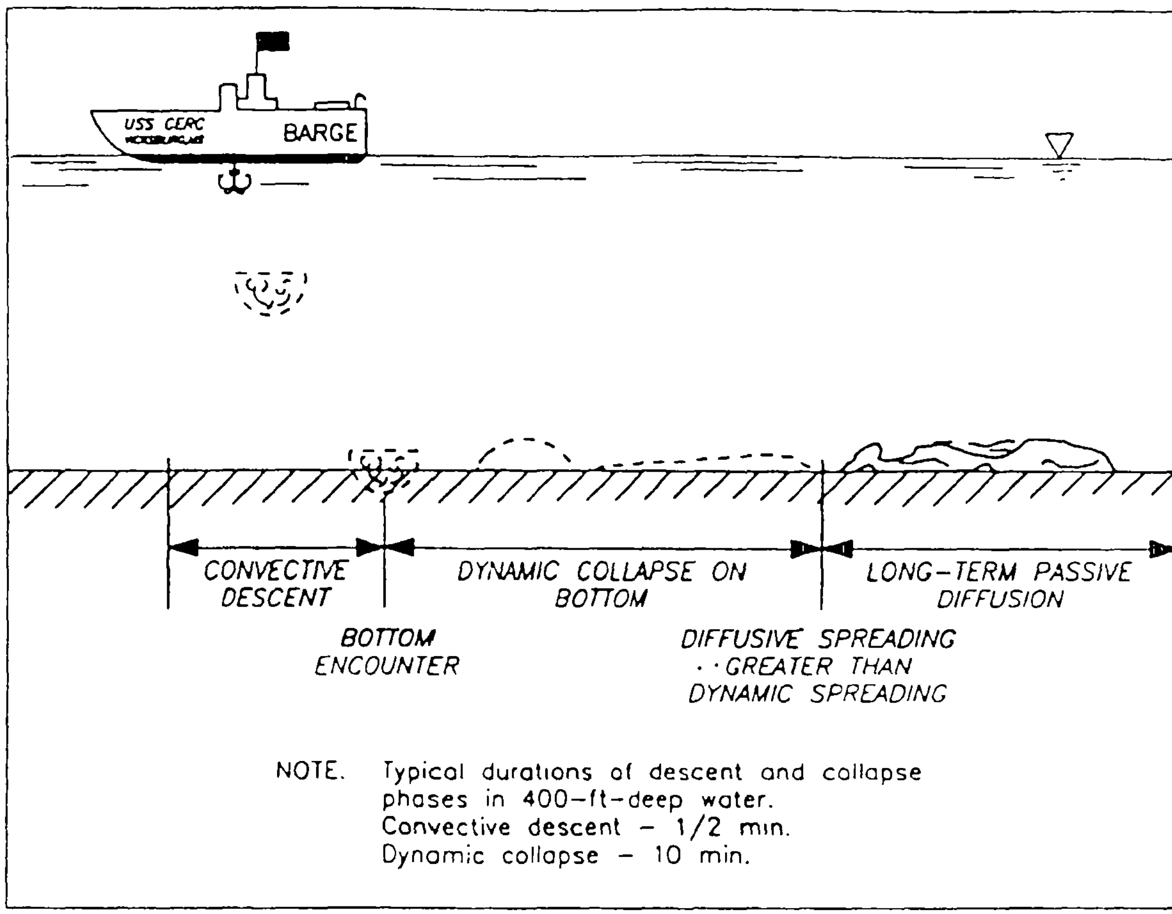


Figure 2.1. Computational phases of the DIFID model (from Brandsma and Divorky, 1976)

Table 2.1

Instantaneous Dredge Capacities and Dimensions

Overall length	236 ft
Beam length	53 ft
Depth of container	21 ft
Opening width of bin	12 ft
Unloaded draft of vessel	3.9 ft
Loaded draft of vessel	19.7 ft
Volume	4000 cu yds
Capacity	5400 tons

The location maps shown in Figures 1.1 and 1.2 show the disposal site environment for Miami and Fort Pierce.

48. The Miami site is located in deep water with bathymetry contours between approximately 400 and 750 ft. A depth of 400 feet, corresponding to the shoreward limit of the designated site, with a bottom slope of 0.0658 was specified for the simulations. An examination of bathymetry at the Fort Pierce site indicates that the water depth varies between approximately 40 and 54 ft.

49. The DIFID model computes the convective descent of a cloud of sediment from the bottom of the loaded dredge through the water column. In order to properly model the descent phase, the total water depth must be greater than the loaded draft of the dredge plus the computed radius of the released sediment cloud. The specified dredge dimensions used for both site simulations required a minimum of 60 ft of depth. The shallower depth at Fort Pierce produced unstable results because the sediment cloud corresponding to the 4000 cu yd load did not have a chance to complete the convective descent stage. The choice of utilizing the 60 ft depth for the Fort Pierce simulations was selected over the option of specifying a smaller capacity dredge. This is not a severe assumption considering that depths of almost 55 ft are representative of that site. A bottom slope of 0.0 was specified.

50 Depth-averaged velocities of 2 79 ft/sec (85 cm/sec) for the Miami site and 1 97 ft/sec (60 cm/sec) for the Fort Pierce site were selected as input to

the DIFID model. The angles of orientation of the velocity vectors for the Miami and Fort Pierce sites is 320 and 317 degrees, measured clockwise from magnetic north. The simulations performed in this section are relative to this axis.

51. Additional input required for the DIFID model include specifying the composition of the material in the dredge. Normally, the dredged materi is composed of a solid fraction (rock, sand, clay, etc.) and a fluid component. Each component must be defined according to its respective density, concentration by volume (component percentage of total load volume) fall velocity, and voids ratio (volume of water to volume of solids ratio). In addition, the in-barge percent distribution of solids must be specified. The selection of material densities, fall velocities, and void ratios for bo the Miami and Fort Pierce sites was based on information obtained from SAJ (Tapp 1988), from a recent DIFID application in Mobile Bay (Reese 1988), and from numerous DIFID applications reported by Johnson and Holliday (1978). Tl selected composition of the disposal load used for both sites is shown in Table 2.2

Table 2.2

Characterization of Dredged Material for Miami and Fort Pierce

Description	Density g/cc	Volumetric ratio	Fall Velocity ft/sec	Voids Ratio	Cohesive (1 or 0)
SAND	2.650	0.6300	0.04660	0.00	0
SIL-CLAY	2.650	0.0700	0.00256	1.00	1
WATER	1.023	0.3000	0.00		

52. The concentration percentages of the total load are based on an assumed solids content of 70 percent by volume of the material in the barge. Sieve analyses received from SAJ (Tapp 1988) showed medium well graded sand (non-cohesive) was representative of at least 90 percent of the solids in the load (90% of 70% - 63%). Cohesive silts and clays were specified for the remaining 10 percent of solids A bulk density of 2.16 gm/cc and an aggregat

void ratio of 1.4 was specified for both sites to compute the final thickness of the composite mound.

53. There are numerous model parameters in addition to the internal model coefficients required as input to the DIFID model. Grid resolution and time step parameters were selected to best represent each disposal site. The internal model coefficients recommended by Johnson and Holliday (1978) and used by Reese (1988) were used for both site simulations. The parameters and coefficients used are shown in Table 2.3.

Table 2.3

Input Data Related to Disposal Operation for the Miami and Fort Pierce ODMDS

Variables	Miami	Fort Pierce
Grid size (ft)	200	200
Number of cells:		
cross-shore direction	105	105
Alongshore direction	28	28
Time step (sec)	100	100
Duration of simulation (sec)	6000*	10800
Ambient velocity (ft/sec)	2.79	1.97
Ambient density (gm/cc)	1.023	1.023
DINCR1	1.0	1.0
DINCR2	1.0	1.0
Entrainment coefficient ALAPHO	0.200*	0.235
BETA	0.0	0.0
CM	1.0	1.0
Drag coefficient for sphere, CD	0.5	0.5
GAMA	0.25	0.25
Drag coefficient for elliptic cylinder, CDRAG	1 0	1 0

CFRIC	0.01	0.01
CD3	0.10	0.10
CD4	1.00	1.00
Entrainment due to cloud collapse, ALPHAC	0.0010	0.0010
Bottom friction, FRICTN	0.0100	0.0100
ALAMDA	0.005	0.005
Vertical diffusion coefficient, AKYO	0.0100	0.0100

* Adjustments in value from those of Fort Pierce were required for the deeper depths of the Miami site.

Method and Procedure for Short-Term Model Simulations

54. The objective of the short-term simulations was to determine whether dredged material could be effectively placed within the limits of the designated disposal sites under the action of a realistic localized velocity field. Of particular interest was whether the settling material (primarily sand) or the suspended sediment cloud (silts and clays) could be transported from the dredge onto the reef area. Data received from SAJ (Tapp, 1988) and shown in Figures 1.1 and 1.2 indicated that the reef areas are located a minimum of approximately 1.5 miles due west of the shoreward edge or 2.0 miles from the center of either ODMDS. If the average release point is considered to be at the center of the designated site, an effective distance between the disposal site and the nearest reef of approximately 3.0 miles is computed from the angle of orientation of the velocity vector. In order to investigate these far field effects, the model grid dimensions were specified to be 105 cells in the flow direction by 28 cells in the transverse direction. The grid spacing of 200 ft produces an effective modeling area of 1 mile by 4 miles The disposal release point was selected at approximately 0 4 miles (grid cell 10) from the upstream boundary

55. The approach taken to investigate the possibility of reef contamination was to determine both the depth and extent of deposition and the sediment plume concentration impact produced by a single disposal load under the maximum, reef-directed, non-storm condition likely to be encountered during a dumping operation. Two parameters were of interest. First, the total deposition pattern was computed to indicate the maximum distance from the dredge at which measurable (above 0.01 ft) deposition could be expected. This maximum excursion distance provides an indication of the spatial extent of direct deposition of material on the bottom.

56. The second measure of impact, and the primary parameter of interest to this study, quantifies the movement and concentration of the moving cloud of suspended sediments. As the cloud is transported from the dredge by the ambient currents, it grows larger (diffuses) and, correspondingly, less concentrated. The second phase of investigation looks at the change in time of the location and concentration of this cloud of sediment as it is diffused and transported toward the reef area. An example of transport and diffusion of the cloud is shown in Figures 2.2, 2.3, 2.4, and 2.5 in which the horizontal distribution of the suspended sediment concentration of the silt-clay cloud is shown at the 200 ft level (below the surface) for the Miami simulation. With the release point assumemed to be at the center of the disposal site (specified as cell 10, the nearest reef is located at approximately grid cell number 89. The 1500, 3000, 4500, and 6000 sec snapshots shows the increase in size and corresponding decrease in concentration of the settling cloud as it is transported toward the reef area.

57. Results of the concentration computation are used to produce a concentration (in ppt or mg/l above ambient conditions) versus distance relationship along the axis of the grid at five discrete depths for four specified time periods (i.e., along the axis of symmetry at grid N = 14 of Figures 2.2-2.5). Quarter-point times were selected to show results at the 1/4, 1/2, 3/4 and final point of any specified time period following the initial release of material from the barge. The following sections present the results of these simulations for the Miami and Fort Pierce sites.

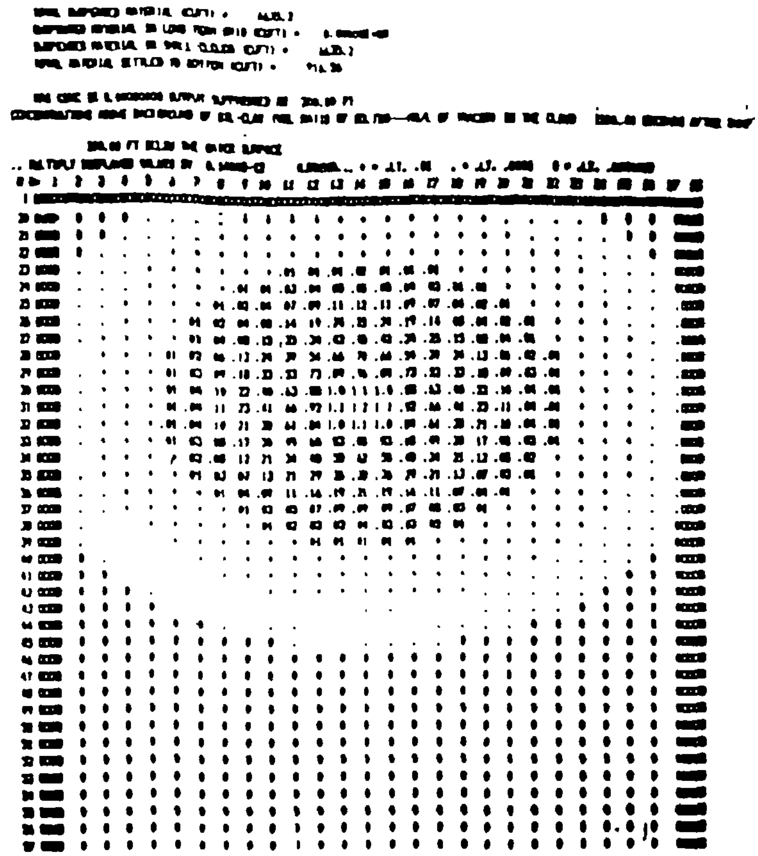


Figure 2.2. Suspended sediment cloud at 200 ft deep at 1500 sec after dump

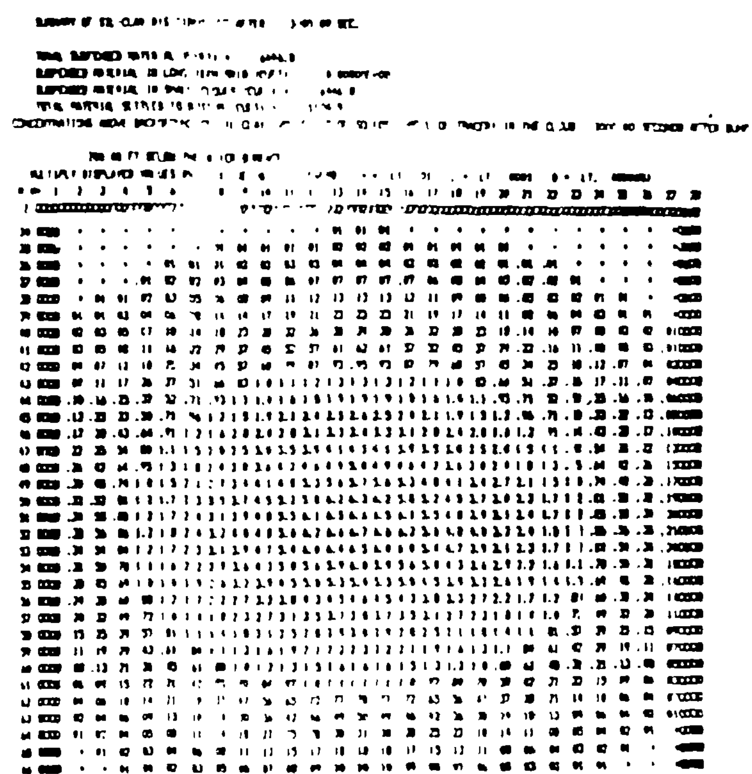


Figure 2.3. Suspended sediment cloud at 200 ft deep at 3000 sec after dump

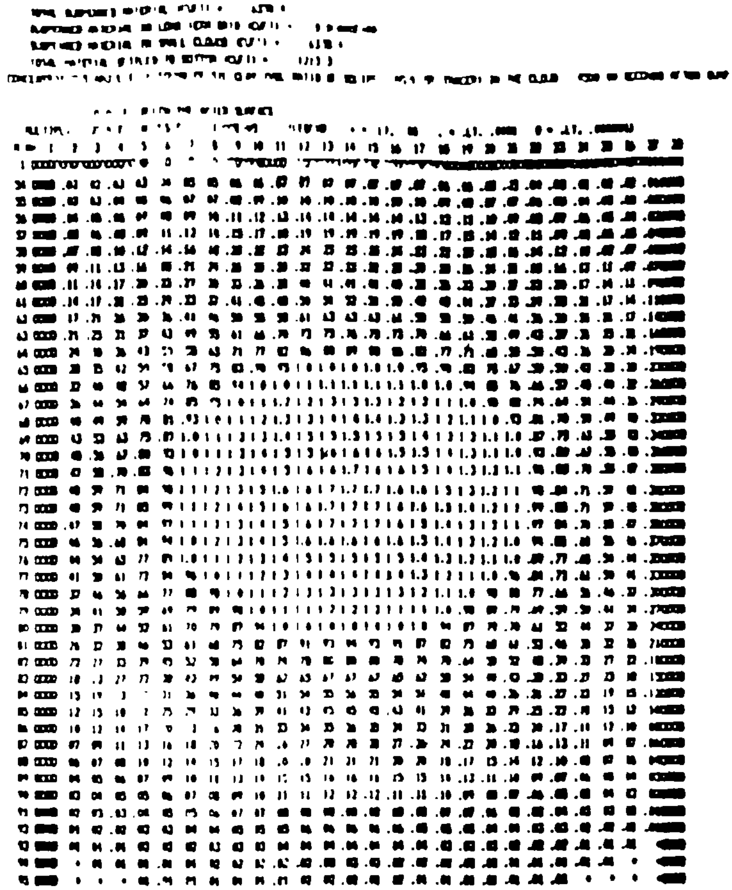


Figure 2.4. Suspended sediment cloud at 200 ft deep at 4500 sec after dump

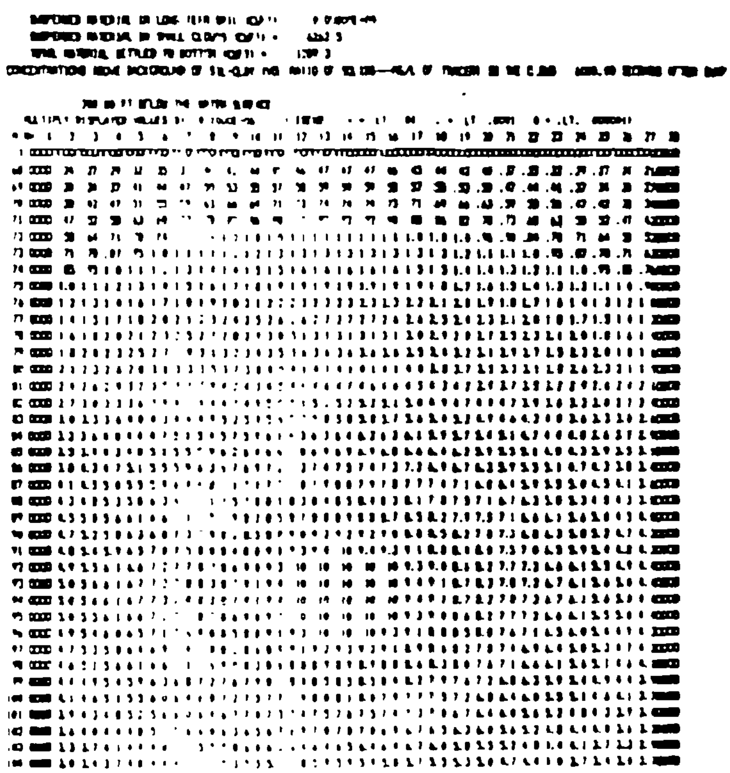


Figure 2.5 Suspended sediment cloud at 200 ft deep at 6000 sec after dump

Miami Disposal Site

58. Results of the sediment concentration computation for Miami are shown in Figure 2.6. The disposal release point is located at approximately mile 0.4 and the reef at approximately mile 3.5. Note that these figures represent distance-concentration plots at the quarter-point times along the reef-directed cloud axis. The uppermost graph of Figure 2.6, for example, summarizes the data presented in Figures 2.2 through 2.5. The depths of 200, 250, 300, 350, and 400 ft were used in order to present an overall representation of the numerical results. For example, at 1500 sec after the initial dump, simulations of the disposal operation shows concentrations of suspended silt and clay at the 200 ft depth to be 10^{-12} ppm. Results demonstrate that the descent phase of the hemispherically shaped cloud passes through the water rapidly leaving little sediment in the upper water column. The examples presented in Figure 2.6 indicate that a point of maximum concentration is reached at a depth of approximately 350 ft and that a concentration decrease is seen both above and below this point. This relationship of maximum concentration is maintained for each quarter point as the cloud disperses. All results indicate a decreasing concentration in both time after disposal and distance from the release point as shown in the summary Table 2.4.

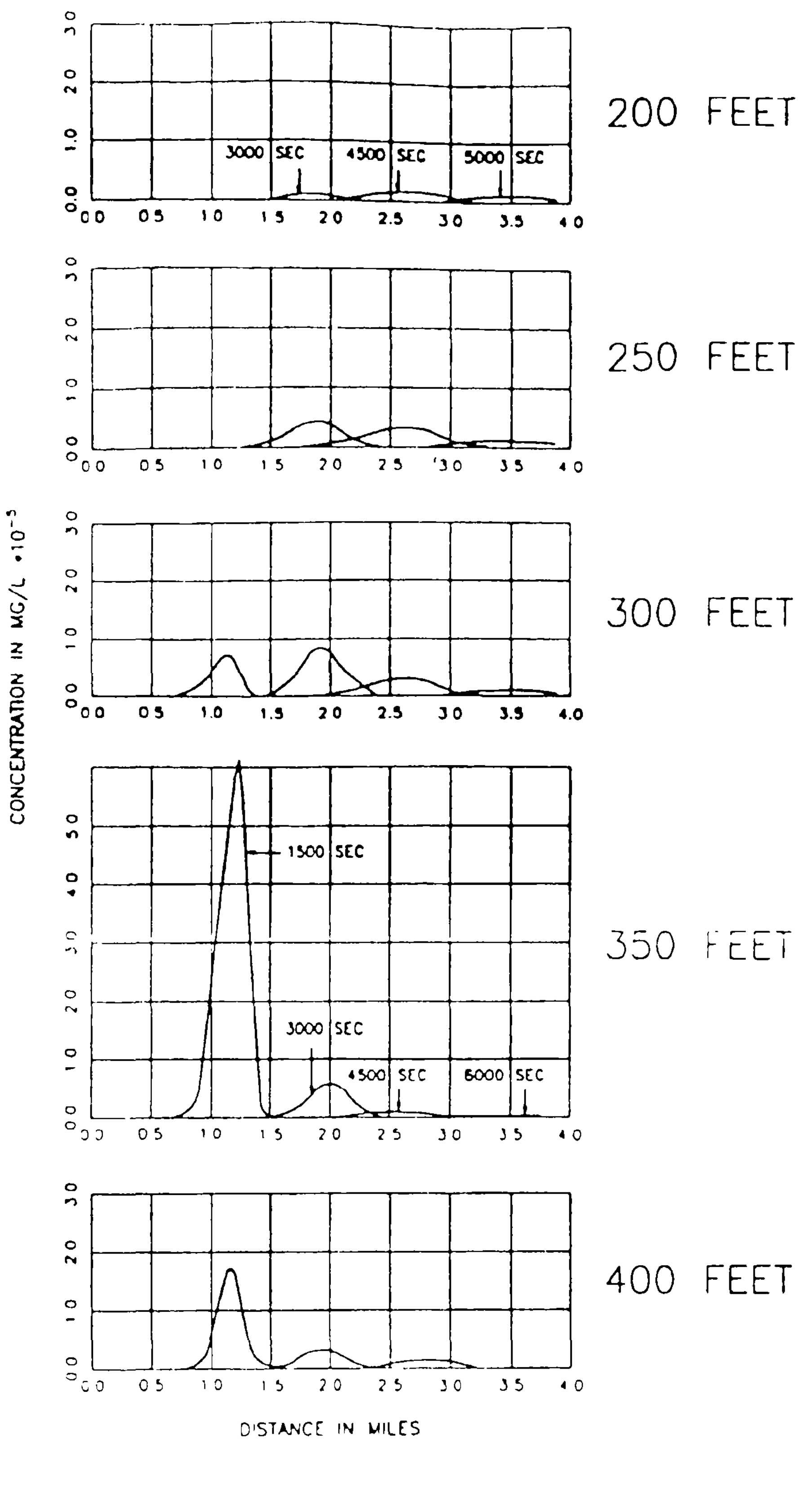


Figure 2 6 Time-concentration for Miami at 200, 250, 300, 350, and 400 ft

Table 2.4

Summary of Computed Maximum Suspended Silt and Clay Concentration

(Concentration in mg/l above ambient)

Depth (ft)	Elapsed Time (sec)/Approximate Distance from Dredge (Miles) 1500 0.8	3000 1.6	4500 2.3	6000 3.2
200	1.2×10^{-13}	6.7×10^{-7}	1.7×10^{-6}	1.0×10^{-6}
250	7.1×10^{-9}	4.3×10^{-6}	2.5×10^{-6}	9.2×10^{-7}
300	5.5×10^{-6}	8.7×10^{-6}	2.2×10^{-6}	6.6×10^{-7}
350	5.7×10^{-5}	5.8×10^{-6}	1.1×10^{-6}	3.8×10^{-7}
400	1.5×10^{-5}	2.4×10^{-6}	6.9×10^{-7}	2.6×10^{-7}

59. A plot of the total sediment deposition versus distance along the axis of the disposal grid is shown in Figure 2.7. A three-dimensional view of the resulting disposal pattern is shown in Figure 2.8 with the corresponding contour plot shown in Figure 2.9. The stable material mound is composed primarily of the sand portion of the disposal load and will be the subject of the long-term disposal simulations described in Section III.

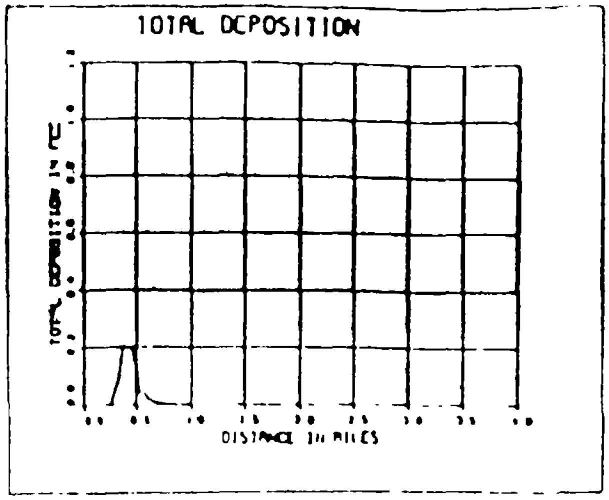


Figure 2.7. Deposition pattern for the Miami site

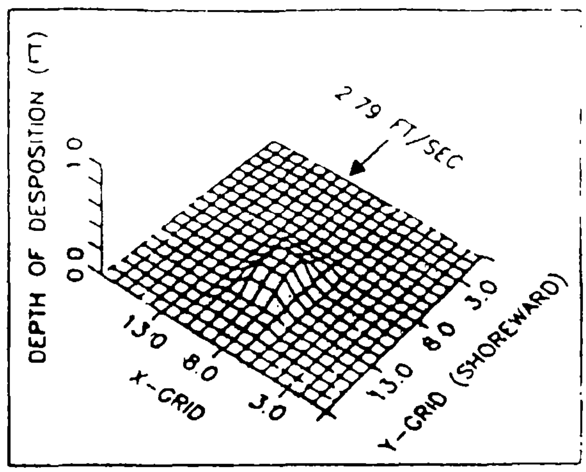


Figure 2 8 Three-dimensional view of the Miami site disposal mound

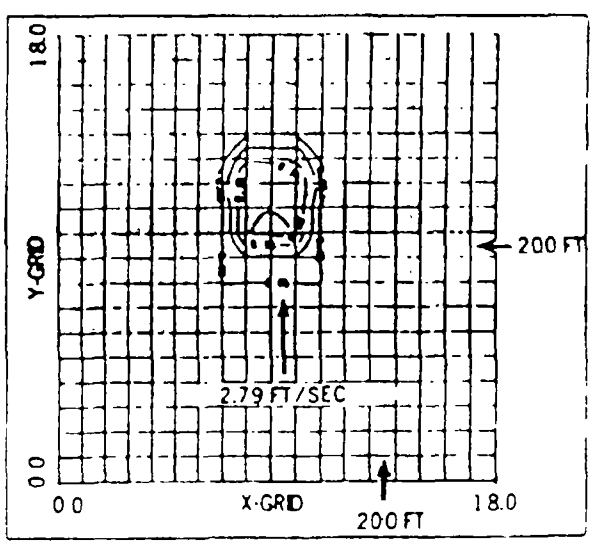


Figure 2 9 Contour plot of the deposition pattern for the Miami site

Fort Pierce Disposal Site

60. Results of the sediment concentration computation for the Fort Pierce site are shown in Figure 2.10. Depths of 10, 20, 30, 40, and 50 ft were specified in the simulation. Note that because of the shallow depth, sediment remains in suspension throughout the water column. Also, the figures show the depth of maximum concentration to be located at approximately the 30 ft depth. A trend, similar to that shown in the Miami simulations, of decreasing concentration with increasing distance and time is seen. This trend can be seen in the concentration summary Table 2.5.

61. A plot of the total deposition in ft versus distance along the axis of the disposal grid is shown in Figure 2.11. Three-dimensional results of the disposal mound are shown in Figure 2.12 with the corresponding contour plot shown in Figure 2.13. Due to the shallow water depths and relatively low velocities, the stable mound can be seen to be conical in shape.

Table 2.5

Summary of Computed Maximum Suspended Sediment Concentration

(Concentration in mg/l above ambient)

Depth (ft)	Time (sec)/Approximate Distance from Dredge (Miles) 2700 1.0	5400 2.0	8100 3.0	10800 4.0
10	1.2x10-5	2.4x10-6	7.8x10-7	*
20	2.3x10-5	4.4x10-6	1.4x10-6	*
30	2.8x10-5	5.5x10-6	1.7x10-6	*
40	2.3x10-5	4.4x10-6	1.4x10-6	*
50	1.2x10-5	2.4x10-6	7.8x10-7	*

* Results at the 10800 sec were below the computationa. threshold of the model, hence, no values are reported.

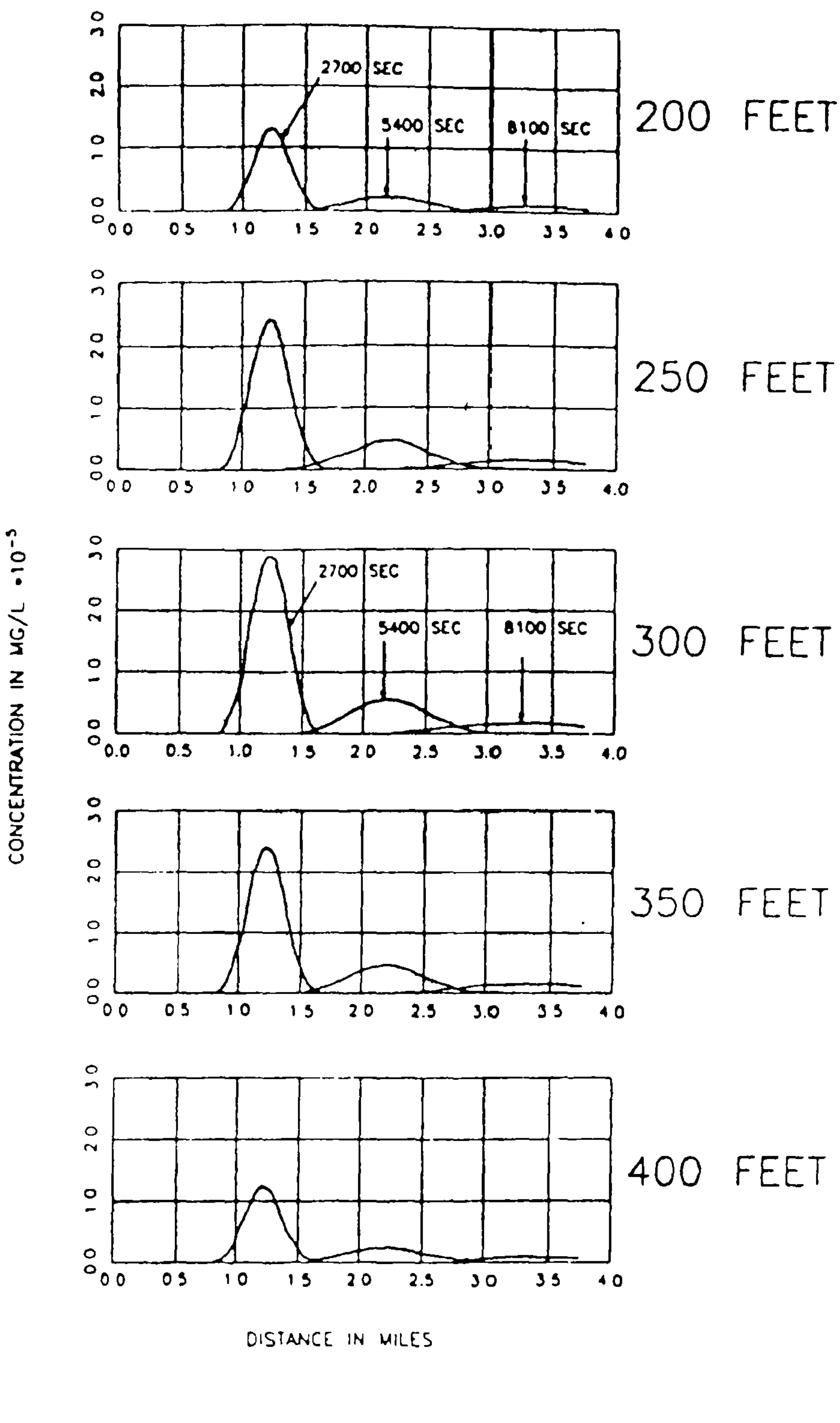


Figure 2 10 Time-concentration for Fort Pierce at 10, 20, 30, 40, and 50 ft

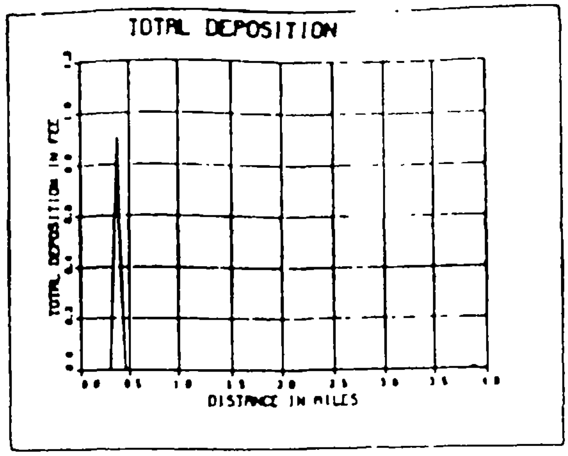


Figure 2.11. Deposition pattern for the Fort Pierce site

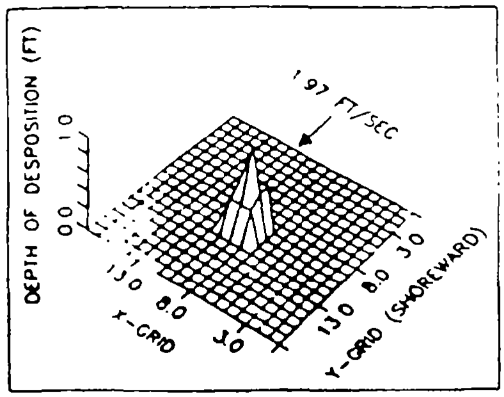


Figure 2.12 Three-dimensional view of the Fort Pierce site disposal mound

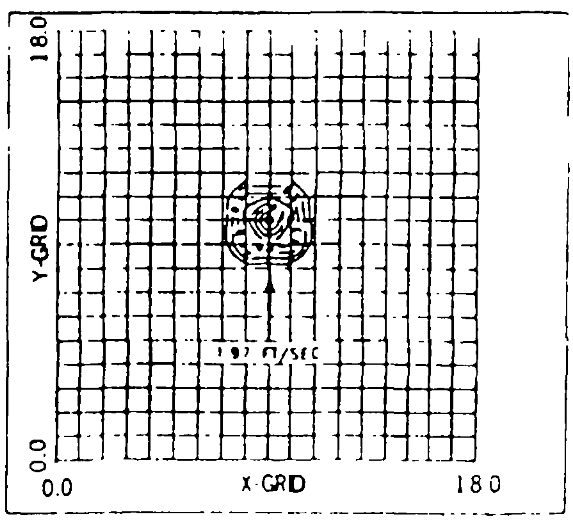


Figure 2.13. Contour plot of the deposition pattern for the Fort Pierce site

PART III: THE SIMULATION OF LONG-TERM DISPOSAL FATE

62. The final task of the evaluation study investigates the long-term fate of disposed material in open water. This analysis will concentrate on classifying the disposal sites as either dispersive or non-dispersive based on whether the local velocity field is adequate to erode and transport material from the mound onto the coral reefs. Transport simulations will be made for periods of time ranging from a day to a year. This phase of the project differs from Phase II in that the short-term investigation determined whether the material could be effectively placed within a designated site during the dumping process when material descends through the water column and collapses on the ocean bottom. The long-term analysis assumes that the material has been successfully deposited on the bottom and has assumed a stable mound configuration. Whether the mound is dispersive or non-dispersive now depends on whether the local current field is capable of resuspending and transporting material such that the mound deformes and is moved from its initial position. Changes in the computed sediment transport patterns are used to compute these changes in location and configuration. For example, as material is eroded from the higher velocity regions near the top of the mound and deposited in areas of lower velocity in the lee of the mound, the shape, orientation, and center of mass of the mound change.

63. The long-term analysis will consist of two approaches. The first will utilize the long-term velocity field developed in Section I of this report to determine whether these velocities are sufficient in magnitude to suspend and transport bottom sediments from an existing disposal mound of a specified initial configuration. The second phase will simulate the passage of a storm surge over the mound. Both approaches will use a sediment transport model to compute non-cohesive sediment transport and the associated bathymetric change as a result of a time varying velocity field around the mound. A brief description of the modeling approach follows.

Sediment Transport

64. Empirical relationships for computing sediment transport as a primary function of ambient water velocity, depth, and sediment grain size were reported by Ackers and White (1973). These relationships were subsequently modified by Swart (1976) to reflect an increase in sediment transport when a wave field is superimposed on the ambient current field. This additional transport reflects the fact that additional sediments are suspended by wave induced bottom orbital velocities. These additional sediments in the water column are available for transport by the localized velocity field. Details of an application of the combined Ackers-White and Swart modification methodology were reported by Vemulakonda et al. (1987) in which computed erosion and deposition volumes were shown to adequately reproduce measured bathymetric changes computed from periodic maintenance dredging surveys in the entrance channel of St Marys Inlet, Florida.

65. Prior to computing long-term simulations, a sensitivity test of the transport predictions was performed for the local conditions at the proposed Miami and Fort Pierce disposal locations. The goal of this testing was to determine threshold velocities needed to initiate sediment movement at each site under the localized environmental conditions of depth and wave field. Sediment transport curves were prepared for each site for a velocity range of 0.0 to 4.0 ft/sec and for a sediment diameter size of 0.1 mm to 0.2 mm in increments of .02 mm. These curves are shown in Figures 3.1 and 3.2.

66. Approximations for wave height and period used in the generation of Figures 3.1 and 3.2 were determined from the Wave Information Study (WIS) 20-yr hindcast data base (Jensen, 1983). Figures 3.3 and 3.4 represent a reproduction of the wave summary statistics for WIS Stations 163 (for the Miami site) and 153 (for the Fort Pierce site). Note that the wave heights and periods selected are representative of larger than average wave conditions; hence the transport rates used in this analysis will be conservative. Average depths of 600 ft for Miami and 50 ft for Fort Pierce were selected from Figures 1.2 and 1.3 to represent depths at the center of the designated sites.

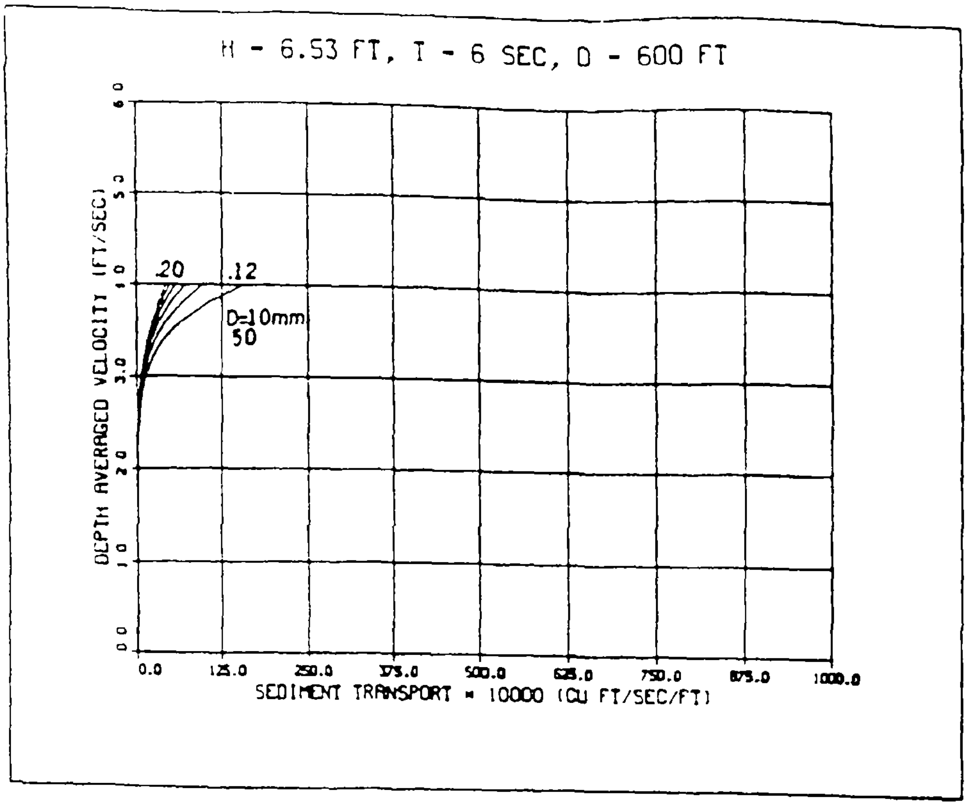


Figure 3.1. Sediment transport vs velocity - Miami disposal site

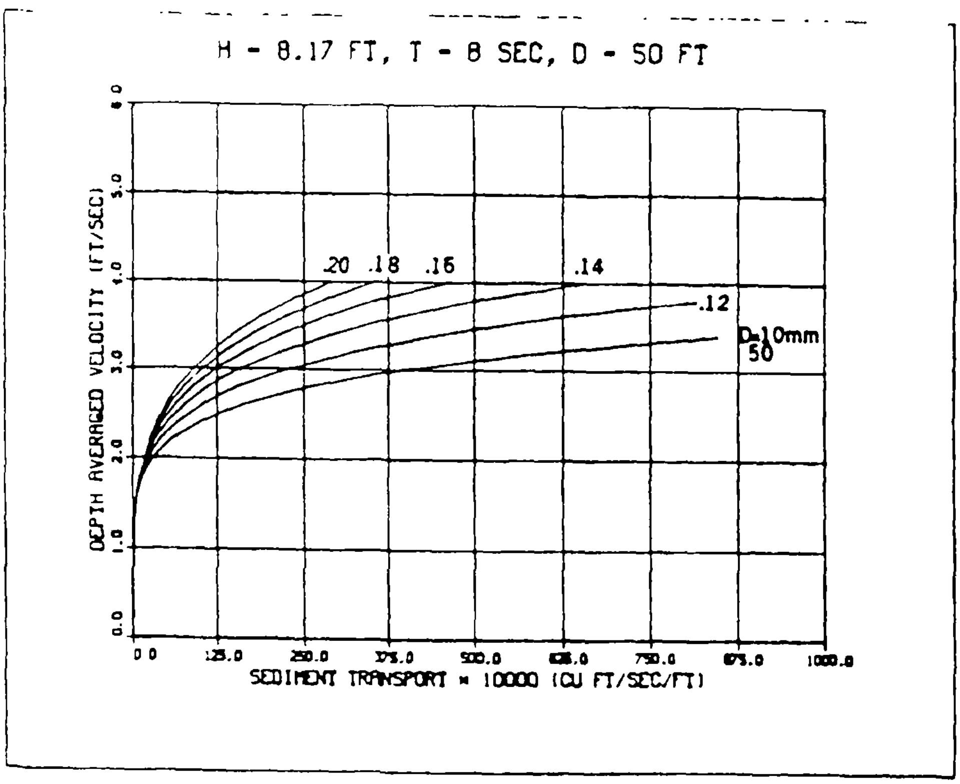


Figure 3.2. Sediment transport vs velocity - Fort Pierce disposal site

STATION 163 20 YEARS FOR ALL DIRECTIONS
SHORELINE ANGLE = 6.0 DEGREES AZIMUTH
WATER DEPTH = 10.00 METRES
PERCENT OCCURRENCE(X100) OF HEIGHT AND PERIOD FOR ALL DIRECTIONS

HEIGHT(METRES)	PERIOD(SECONDS) 0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-LONGER	TOTAL
0. - 0.49	1863	1953	388	294	127	241	156	56	160	97	5355
0.50 - 0.99	.	706	1898	414	75	35	4	.	1	1	3134
1.00 - 1.49	.	.	23	708	183	50	9	.	.	.	972
1.50 - 1.99	.	.	.	16	130	61	10	1	.	.	218
2.00 - 2.49	.	.	.	.	41	50	5	2	.	.	98
2.50 - 2.99	.	.	.	.	.	2	.	.	.	.	2
3.00 - 3.49	.	.	.	.	.	.	.	.	.	.	0
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	1863	2659	2309	1432	555	439	184	59	161	98	

AVE HS(M) = 0.53 LARGEST HS(M) = 2.91 TOTAL CASES = 58440

Figure 3.3. WIS station 163 wave characteristic summary for the Miami site

STATION 153 20 YEARS FOR ALL DIRECTIONS
SHORELINE ANGLE = 339.0 DEGREES AZIMUTH
WATER DEPTH = 10.00 METRES
PERCENT OCCURRENCE(X100) OF HEIGHT AND PERIOD FOR ALL DIRECTIONS

HEIGHT(METRES)	PERIOD(SECONDS) 0.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-LONGER	TOTAL
0. - 0.49	644	904	234	149	290	416	311	179	116	173	3416
0.50 - 0.99	.	535	1171	357	59	369	348	417	282	432	3971
1.00 - 1.49	.	.	230	485	104	174	153	103	55	264	1568
1.50 - 1.99	.	.	.	86	205	150	65	28	10	80	624
2.00 - 2.49	.	.	.	.	59	203	45	8	6	16	337
2.50 - 2.99	.	.	.	.	.	22	24	2	.	6	54
3.00 - 3.49	.	.	.	.	.	.	6	.	.	3	9
3.50 - 3.99	.	.	.	.	.	.	.	.	.	.	0
4.00 - 4.49	.	.	.	.	.	.	.	.	.	.	0
4.50 - 4.99	.	.	.	.	.	.	.	.	.	.	0
5.00 - GREATER	.	.	.	.	.	.	.	.	.	.	0
TOTAL	644	1439	1635	1077	717	1334	952	737	469	974	

AVE HS(M) = 0.78 LARGEST HS(M) = 3.61 TOTAL CASES = 58440

Figure 3.4. WIS station 153 wave characteristic summary for the Fort Pierce site

67. Depth-averaged non-storm velocity fields were shown in Section I of this report to be approximately 1.64 ft/sec (50 cm/sec) for the Miami site and 0.98 ft/sec (30 cm/sec) for the Fort Pierce site. Results shown in Figures 3.1 and 3.2 indicate that these velocities are marginally adequate to transport sediment; however, locally elevated velocity vectors in the vicinity of the mound crest may be adequate to transport sediment from the mound. The following section will address the velocity field distribution as the ambient current field flows over the mound.

Velocity Field Distribution

68. The sediment transport modeling approach is based on an accurate velocity distribution around the mound. A steady state numerical model was developed specifically for this purpose. The model, based on the simplified equations of motion and the continuity equation, computes a velocity distribution around a mound of specified dimensions as a result of a constant imposed "upstream" velocity field boundary condition. A sample computation is shown in Figure 3.5 in which the depth averaged velocity vectors can be seen to increase in magnitude and change orientation as the velocity field is influenced by the presence of the disposal mound.

69. A sediment transport rate corresponding to each vector is computed for the entire numerical grid in order to yield a spatial transport distribution. This distribution is input to a non-cohesive sediment continuity model which computes bathymetric changes as a result of transport gradients. When more sediment enters a computational cell than exits the cell, deposition will occur. Conversely, when more leave than enter, erosion will be shown. No net change occurs for a uniform flow field in which equal amounts of sediment enter and leave a cell. When the velocity field is below the local transport threshold value (such as those shown in Figures 3.1 and 3.2), no transport occurs and no net erosion or deposition results.

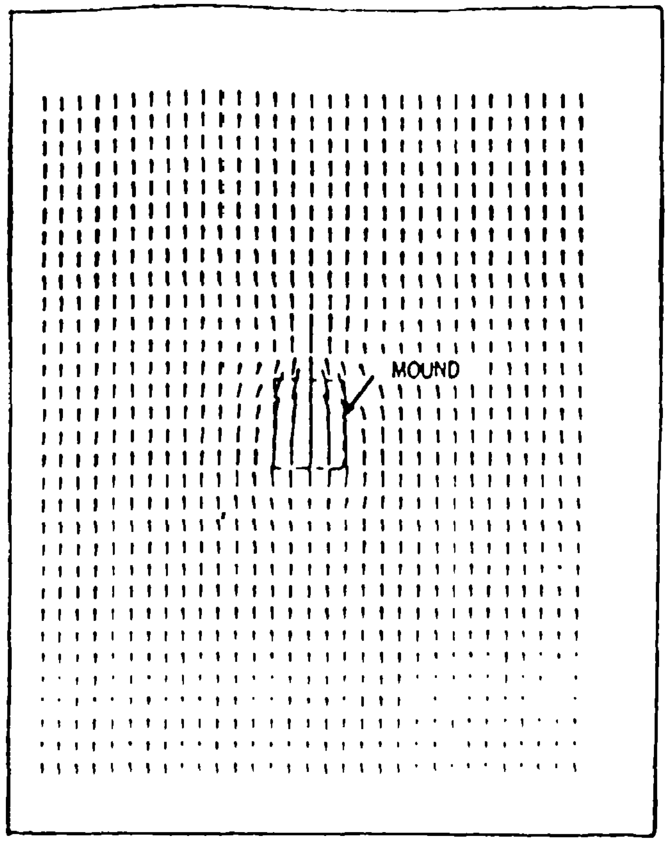


Figure 3.5. Velocity vectors around an idealized disposal mound

70. Velocity field simulation computations are updated at a 3-hr time step to reflect the changing shape of the mound. As the transport patterns adjust in response to the time-varying velocity field, material is transported from regions of high velocity and deposited in regions of low velocity. This process will continue until either the velocities fall below the threshold value required to transport sediment or the mound reaches an equilibrium condition in which equal amounts of sediment enter and leave a computational cell. In the latter scenario, the mound has dispersed to the point that the identity of the mound has been lost and it no longer effects the current regime.

71. Erosion and deposition patterns associated with the changing shape of the disposal mound are also computed at every 3-hr time step. These computations indicate the time variation in depth of sediment deposition versus distance from the mound. The distance at which zero depth changes occur will indicate the first location from the mound at which no mound material has been deposited; hence, the maximum radius of mound influence on the environment If material from the mound is deposited beyond a designated

point, i.e., on the reefs, then the disposal site can be considered dispersive. For the present study, the critical distance of excursion is the distance from the disposal mound to the reefs.

72. Two simulations will be used to determine whether the presence of the mound poses a potential threat to the coral reef area. The first is a long-term simulation in which the mean non-storm velocity field and wave condition for each site is continually subjected to the mound. Simulations are performed to determine either an excursion rate of the mound in feet per day or to demonstrate that a point of equilibrium has been reached and the mound ceases to move. The second is to simulate a storm related event and compute the total excursion associated with that storm. This simulation will utilize a sustained storm driven velocity surge for a duration of 24 hours, a time scale typical of a hurricane event. If either the long-term average velocities or the high intensity storm induced velocities can be shown to be of sufficient magnitude to transport material from the mound onto the reef areas, it can be concluded that the site is potentially dispersive with respect to long-term events, and that alternate disposal areas further offshore should be investigated.

Sediment Transport Due to Non-Storm Velocity Fields

73. The results shown in Figures 3.1 and 3.2 indicate that sediment transport is initiated at velocity threshold values of approximately 1.0 ft/sec and 2.0 ft/sec for the Fort Pierce and Miami sites respectively. Although the observed ambient velocities at both sites are below these critical values (0.98 and 1.64 ft/sec), the effect of the mound on the velocity distribution may result in elevated velocities on the mound which are sufficient in magnitude to erode and transport material. In addition to the velocity magnitude, model input includes the specification of a single sediment size.

74. Although Figures 3.1 and 3.2 show that the mean sediment diameter is not a critical parameter when the velocity magnitude is near the sediment transport threshold, a sediment size of 0.2 mm was selected for all simulations. The specification of a fine-grained non-cohesive sediment for both sites provides a threshold evaluation of the onset of mound erosion since

fine grained materials are eroded before coarse grained materials are. Results obtained from SAJ (Tapp, 1988) indicate average specific gravities of materials which will be disposed of at the Miami and Fort Pierce sites to be 2.78 and 2.70 respectively, indicative of quartz sand. A typical grain size analysis of a sample obtained from the Fort Pierce harbor is shown in Figure 3.6. The report classifies the material as "poorly graded sand (SP)." In view of this classification, a fine sand specification will provide an estimate of maximum erosion potential. The analysis further indicates a D50 diameter of approximately 3 mm; therefore, the use of a 0.2 mm material in the transport computations serves two functions. It provides a threshold indication of fine material transport, and it provides an indication of fine grain mound transport; as such, it yields a "worst case" prediction of sediment erosion from the mound.

75. A test mound measuring 250 ft square and 10 ft high was used as the design mound configuration for both simulations. A mound of this dimension would contain a volume of approximately 20,000 cubic yards. Although idealized, this configuration will provide an indication of mound stability. The following sections will address the long-term and storm event analysis.

Fort Pierce

76. The proposed disposal site offshore of Fort Pierce (Figure 1.1) is located in shallow water, with an average depth of only approximately 50 ft. A wave with a height of 8.17 ft (2.49 m) and period of 8 seconds was used to indicate a rough, but non-storm, sea state. Results of Section I indicate this area to be outside of the direct influence of the Gulf Stream; therefore, depth averaged velocities are relatively low, on the order of 0.98 ft/sec (30 cm/sec). This velocity represents a maximum, non-storm, depth-averaged velocity field and does not represent a sustained flow field; therefore, long-term simulations using this velocity field represent a highly conservative condition. In reality, the velocity field at this location is primarily a function of tidal forcing and wind induced flow and is not necessarily directed toward the reefs. However, long-term simulations were made using this maximum velocity in order to determine the maximum possible rate of mound erosion and migration.

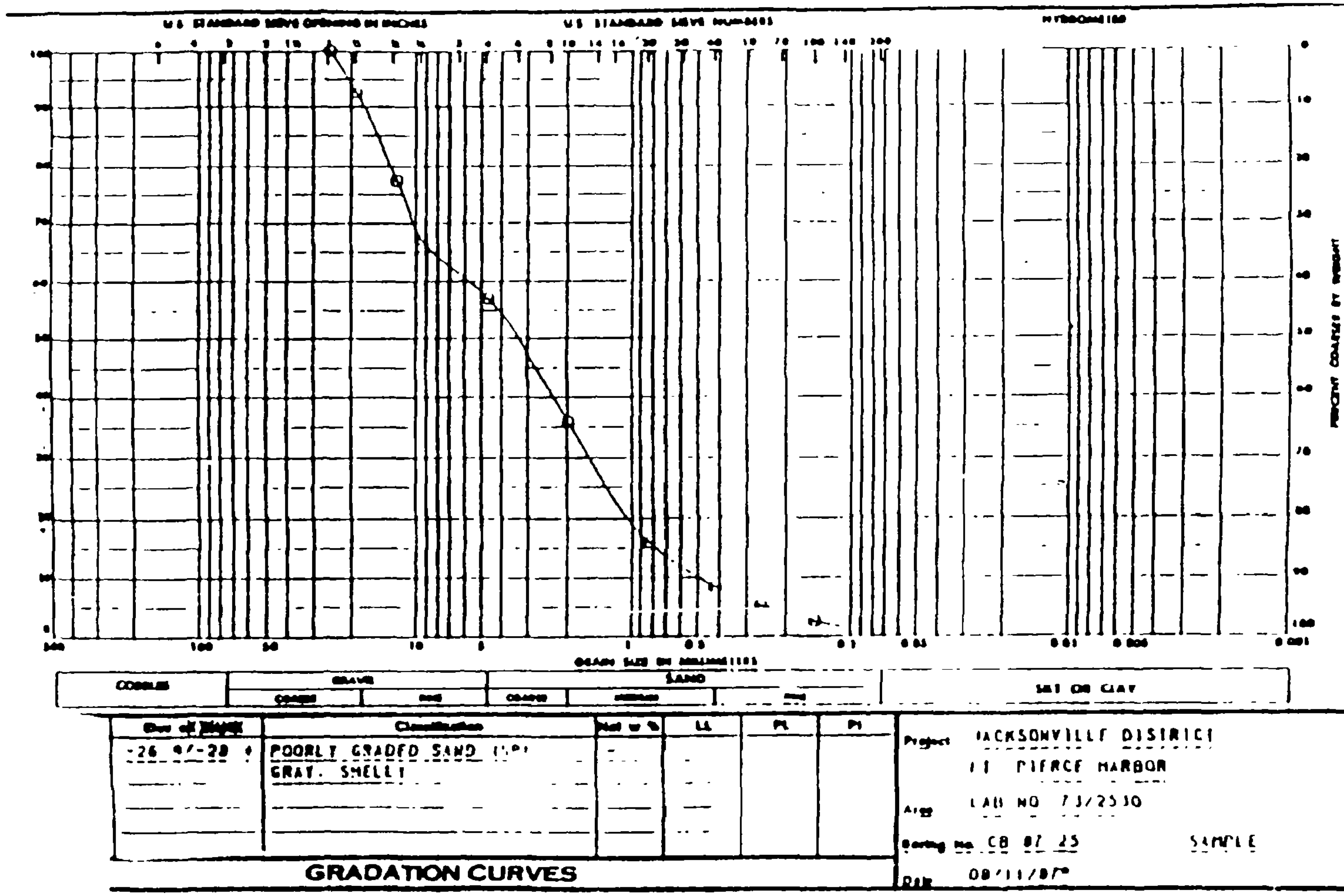


Figure 3 6 Gradation curve of Fort Pierce sediment

77. A 1-year simulation of the idealized mound at the Fort Pierce site was made. Results indicate that material from the mound migrated a total distance of 600 ft in 6 months of sustained maximum current. At this point, the outer edge of the mound reached the computational boundary. The approximate center of mass of the mound migrated approximately 700 ft during the 1 year simulation. During this time, the shape of the mound became elongated, and a scour hole developed in front of the mound. Figures 3.7, 3.8, and 3.9 show the initial configuration, the mid-simulation shape, and the configuration at the end of the simulation. Figure 3.10 presents the monthly change of shape through a central cross-section of the mound. The rate of excursion of the leading edge of the mound is approximately 3 ft per day. Center of mass migration is less than 2.0 ft per day. At either rate, a migration onto the reef area would require in excess of 10 years. During this time, the mound would realistically erode and disperse in many directions, resulting in a lower, less dispersive profile.

78. In order to investigate the erosion producing capability of a storm event, a hypothetical hurricane was constructed with a sustained 24-hour depth-averaged surge velocity of 4 ft/sec. The initial mound configuration is identical to that shown in Figure 3.7. The final mound shape at the end of the storm event is shown in Figure 3.11. Cross-sectional profiles at 6-hr intervals are shown in Figure 3.12. Results indicate that the maximum radius of transport resulting in deposition of more than 0.1 ft to be approximately 500 ft The corresponding mound crest migration is 350 ft.

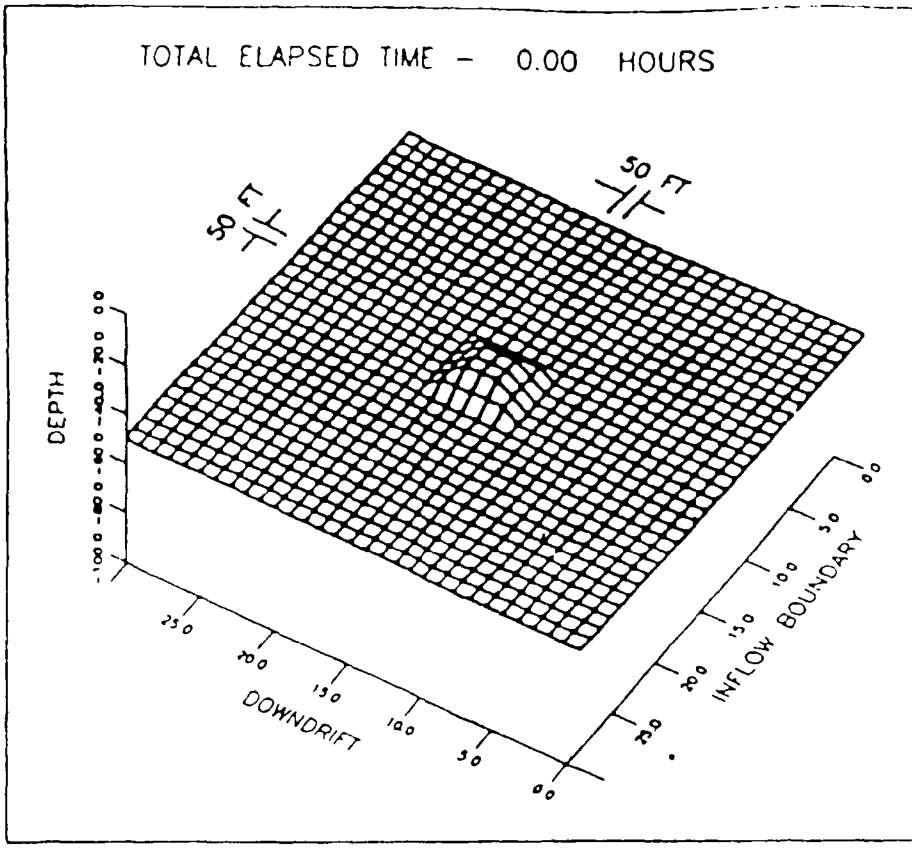


Figure 3.7. Initial mound configuration for Fort Pierce

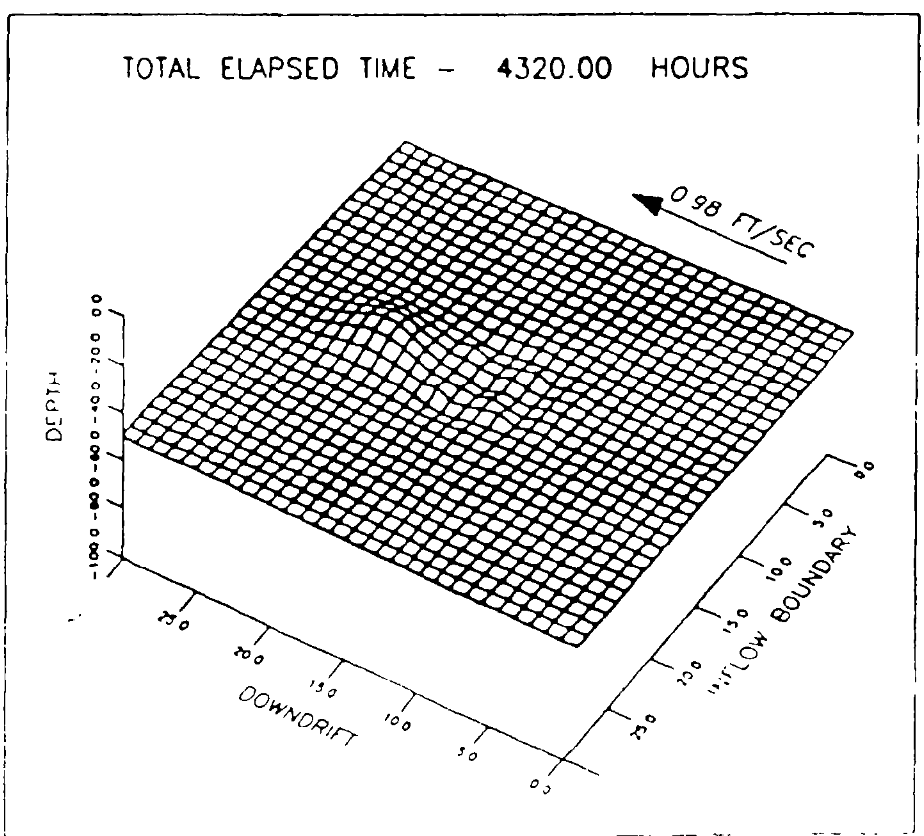


Figure 3.8 Fort Pierce mound configuration at 6 months

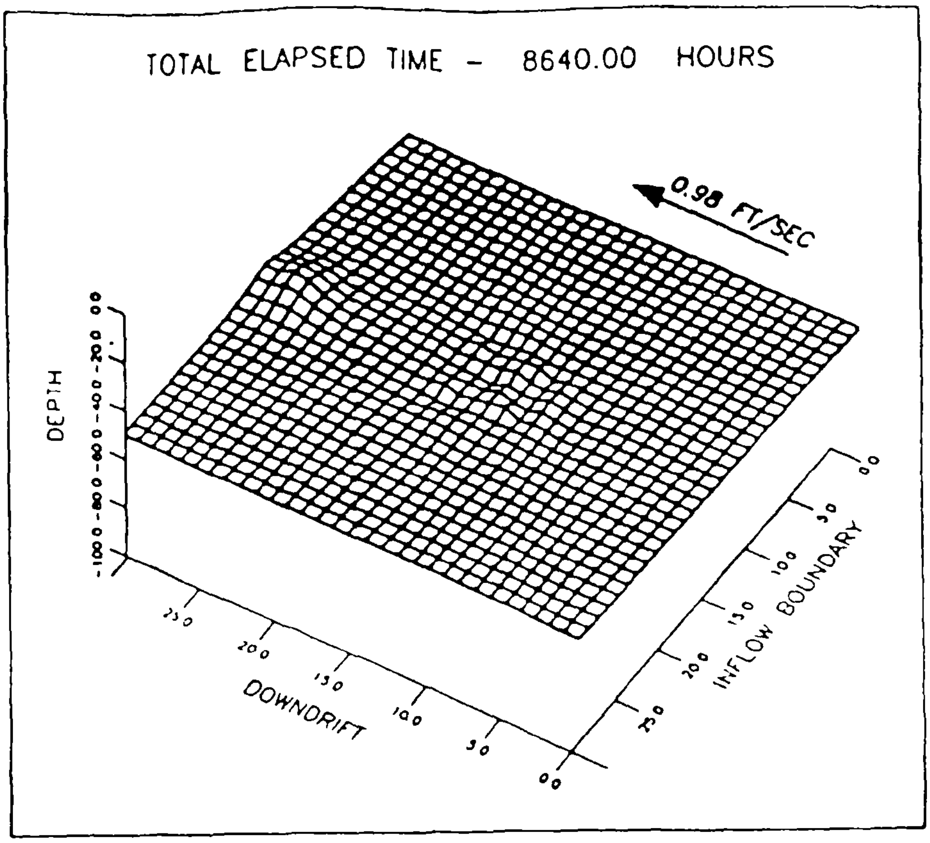


Figure 3.9. Final Fort Pierce mound configuration at 12 months

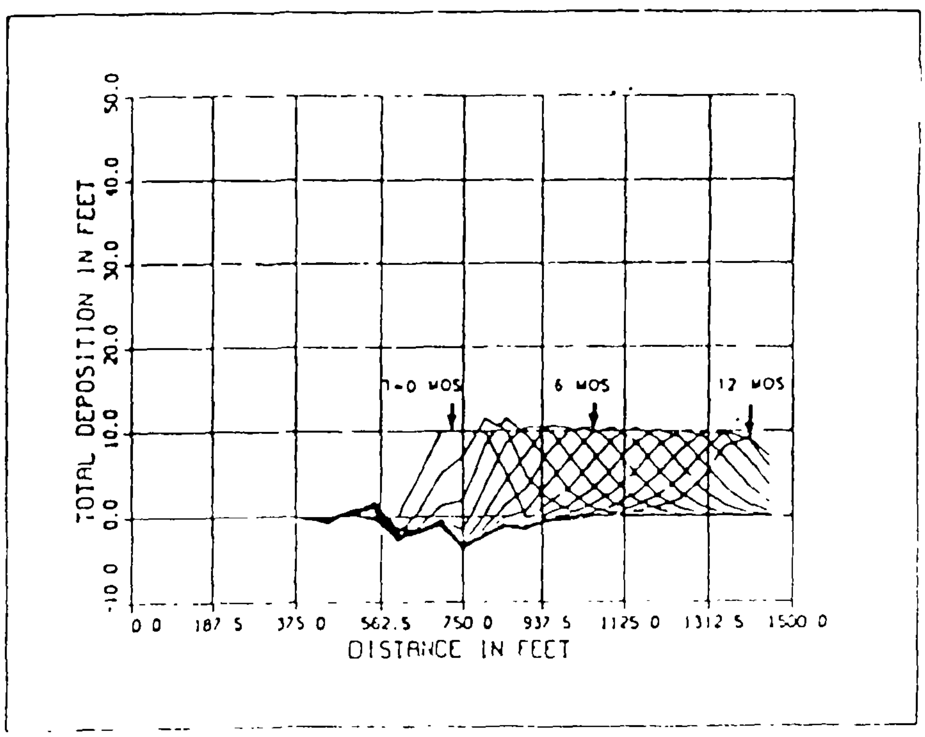


Figure 3 10 Time history of long-term erosion of the Fort Pierce mound

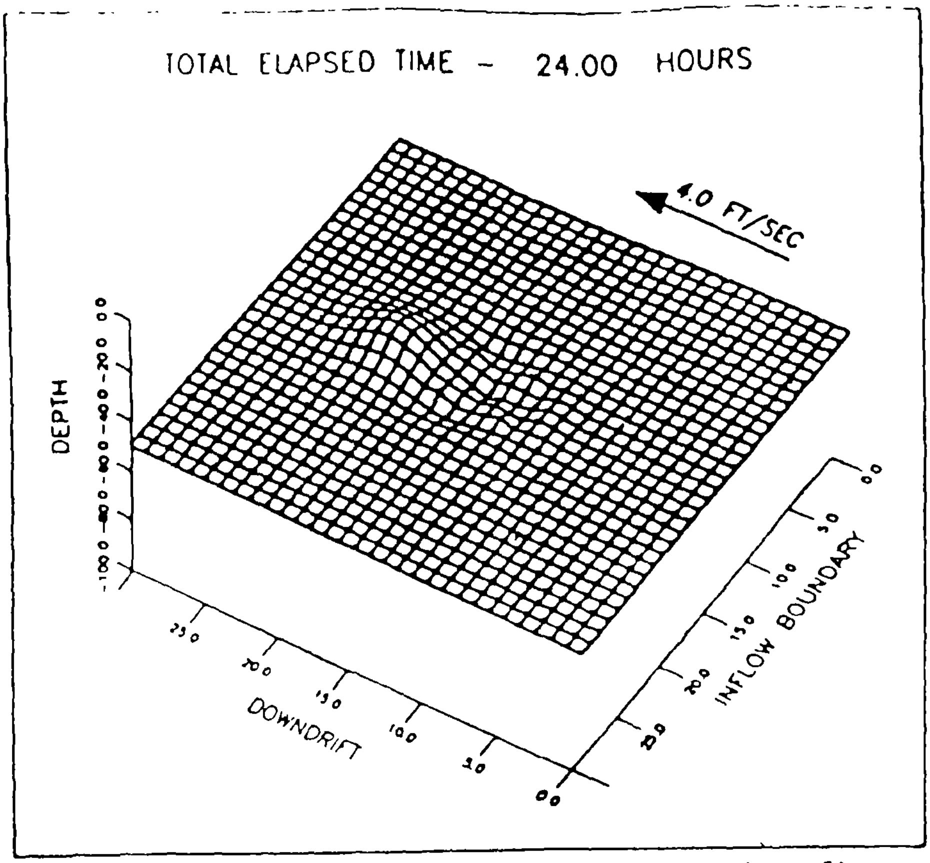


Figure 3.11. Final (24 hr) Fort Pierce storm mound configuration

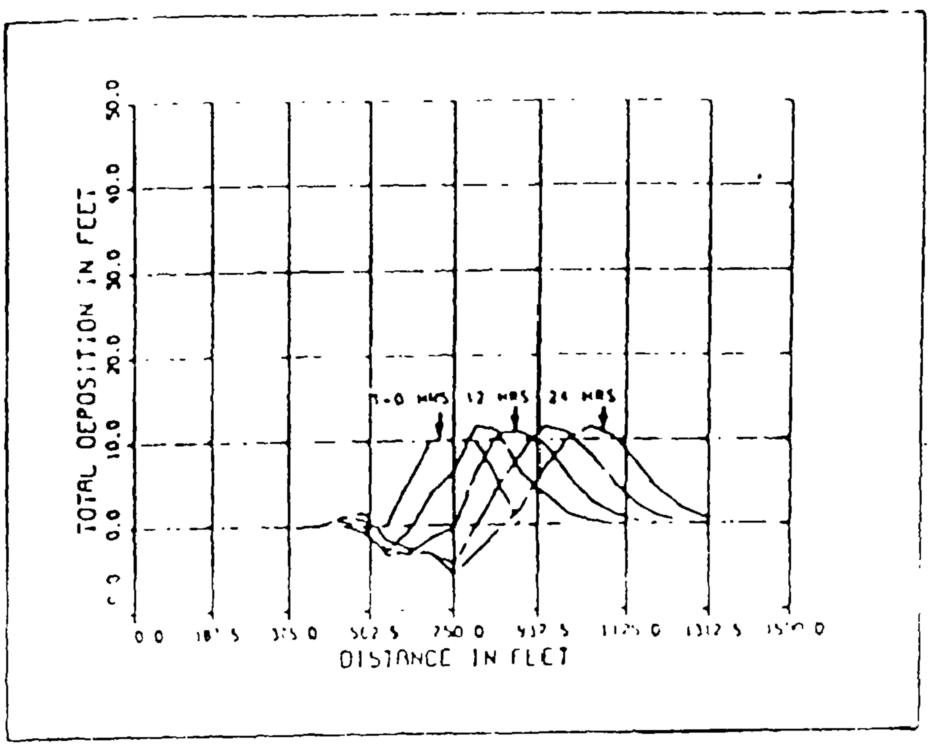


Figure 3 12 Time history of storm erosion of Fort Pierce mound

Miami

79. The proposed disposal site for Miami is located at a depth of approximately 600 ft with a corresponding maximum velocity field of approximately 1.64 ft/sec (50 cm/sec). A 3-month simulation of the idealized mound, using a wave height of 6.53 ft (1.99 m) and period of 6 secs, was performed. The initial and final mound configuration and the evolution of the mound with time, shown on Figures 3.13, 3.14, and 3.15, indicate no transport or erosion. The result that the velocity field is not adequate to either suspend or transport material at a depth of 600 ft is not surprising in view of the threshold values shown in Figure 3.1.

80. A storm event for the Miami site was assumed to have a sustained velocity of 6.0 ft.sec for 24 hours. The post-storm mound configuration is shown in Figure 3.16. The corresponding time changes of the cross-section at 6-hr intervals is shown in Figure 3.17. As can be seen in the figures, a mound located in 600 ft of water is little effected by velocities of a magnitude realistically representative of the disposal site offshore of Miami.

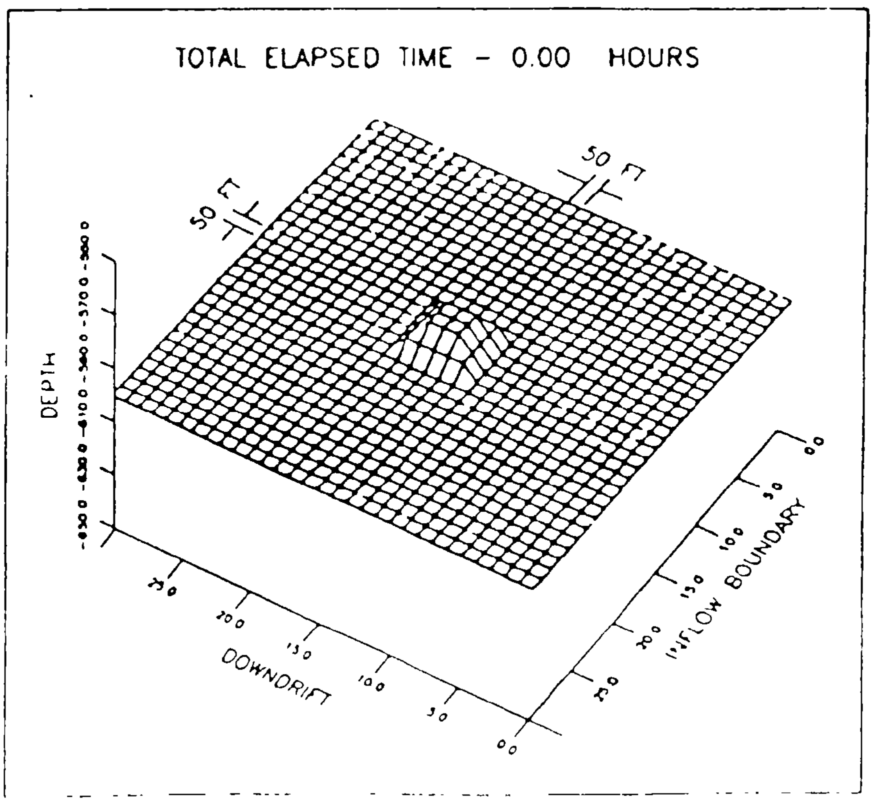


Figure 3 13 Initial mound configuration for Miami

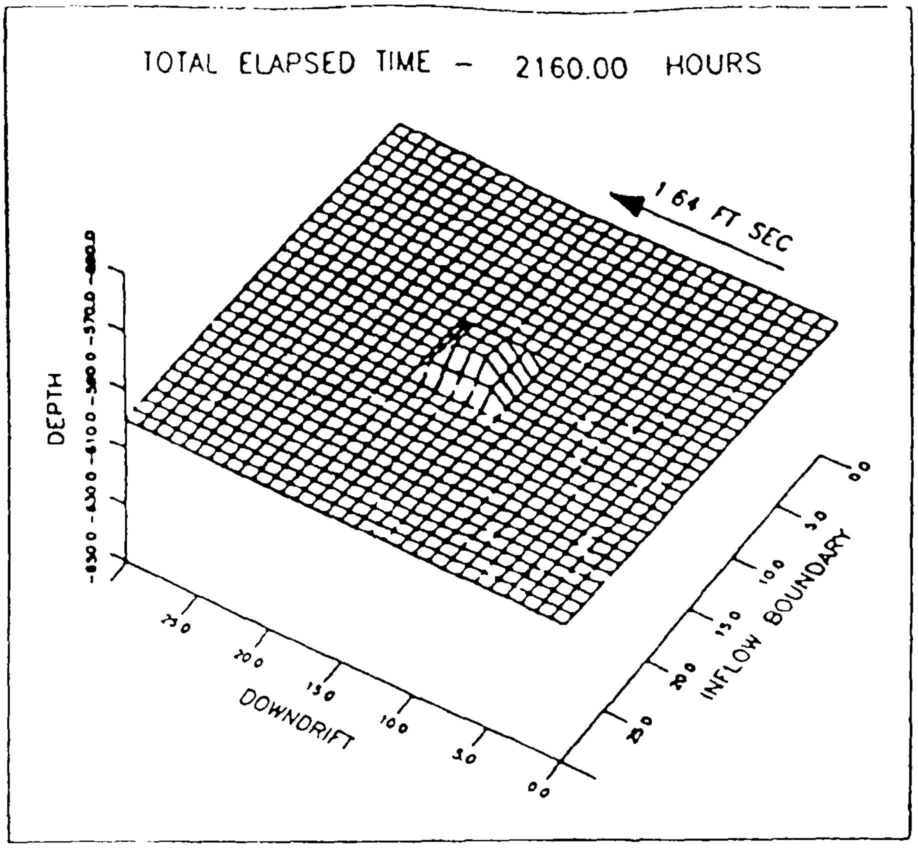


Figure 3 14. Final Miami mound configuration at 3 months

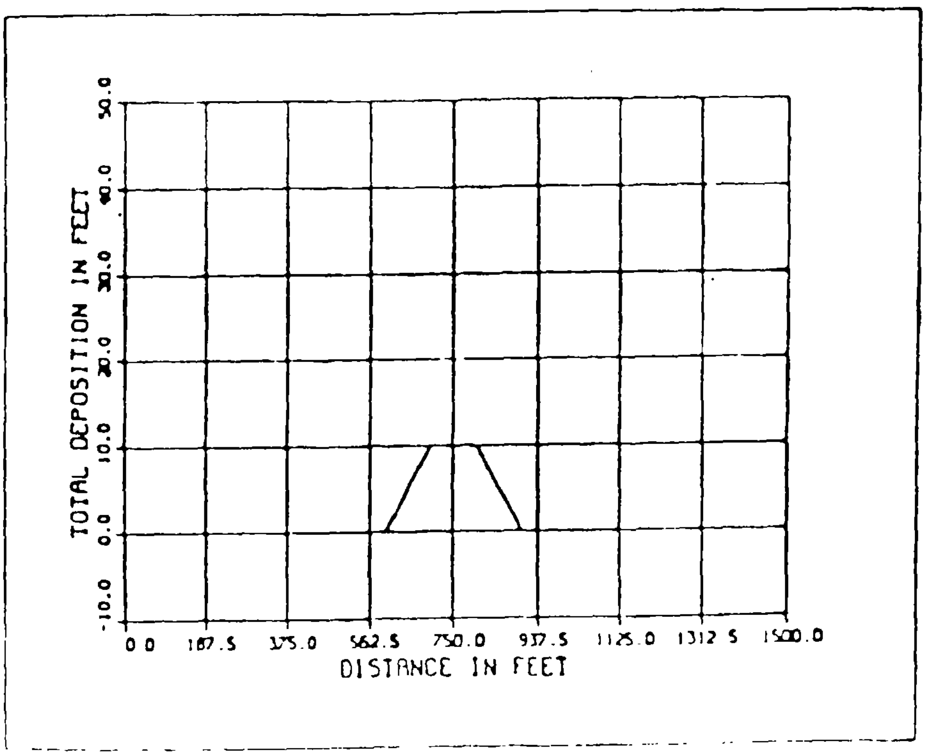


Figure 3 15 Time history of long-term erosion of the Miami mound

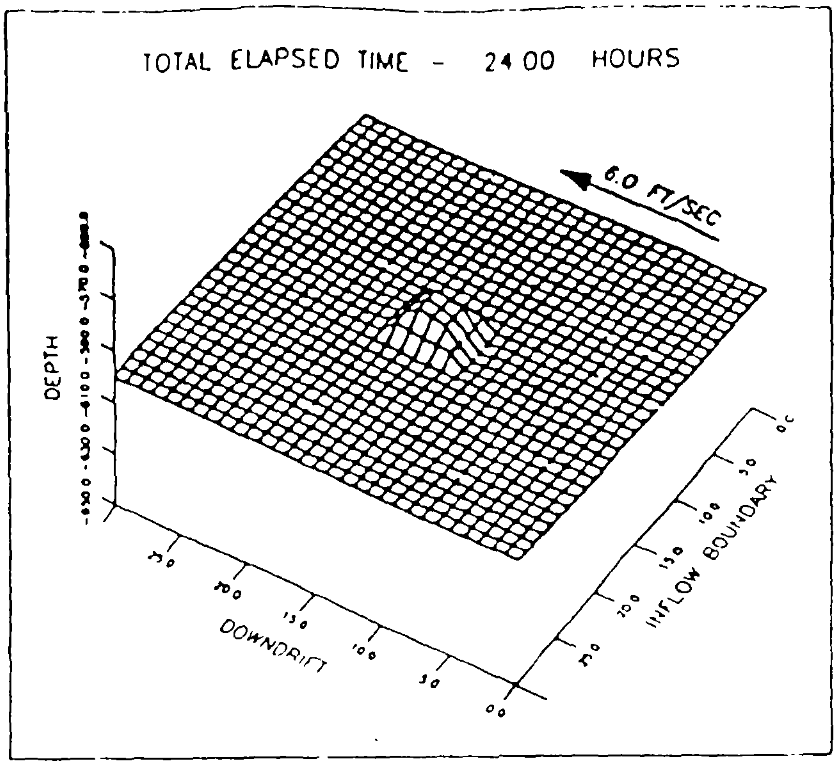


Figure 3.16. Final (24 hr) Fort Pierce storm mound configuration

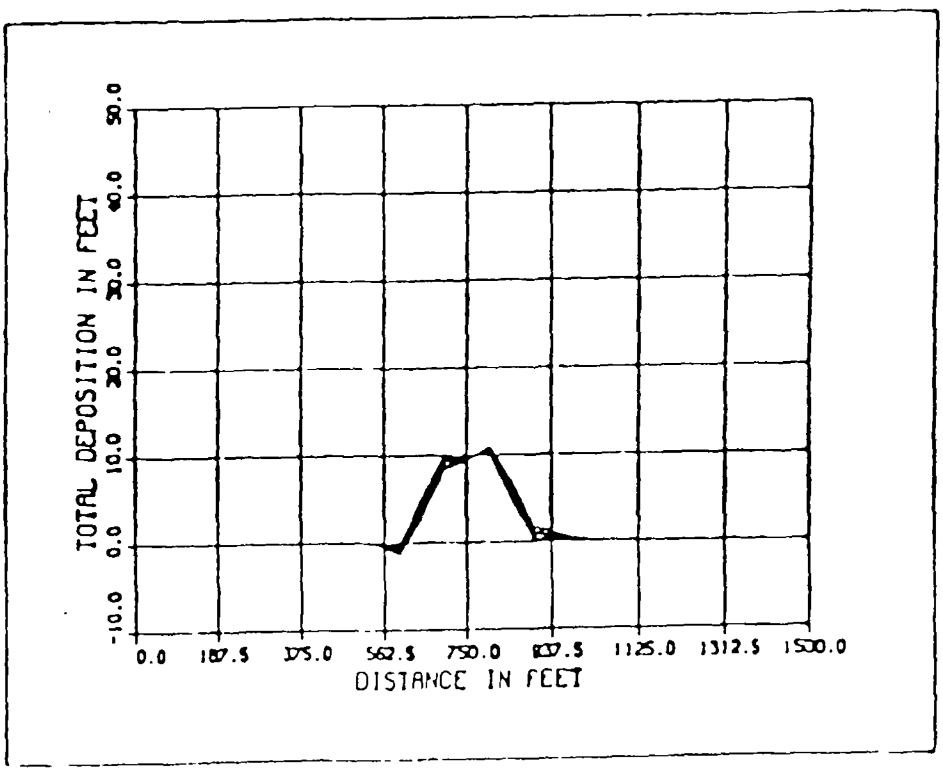


Figure 3 17 Time history of storm erosion of Miami mound

PART IV: CONCLUSION

81. The purpose of this investigation is to determine whether sediment from the proposed Miami and Fort Pierce disposal sites could be transported onto the sensitive near-shore coral reefs. Numerical modeling techniques were utilized to answer these questions. The approach taken was first to review the available literature and document the magnitude of velocities which are representative of each site. The question of reef contamination was then addressed in a two-phase modeling approach. In the short-term analysis, the actual disposal operation was modeled to determine whether material from the descending sediment plume could be carried in suspension by the ambient velocity field onto the reefs before settling into the disposal site. The long-term investigation computes sediment transport and the associated erosion and deposition of the disposal mound as a function of the local velocity field. Results of the study indicate that neither the Miami nor the Fort Pierce site pose an environmental threat to the reef areas. These results are briefly summarized below.

82. The first level of investigation requires the defining of a non-storm velocity field for both proposed disposal sites. Existing velocity records were extensively examined to quantify a depth-averaged velocity field which would represent the most severe reef-directed currents. The approach is based on the assumption that shore parallel or offshore directed velocities present no environmental threat to the reefs but that a worst case condition of maximum shoreward directed velocities could possibly effect the reef areas. The review of data showed that a maximum depth-averaged, velocity of 0.97 ft/sec (30 cm/sec) and 1.64 ft/sec (50 cm/sec) was representative of the Fort Pierce and Miami sites. In order to simulate a more extreme condition, larger values of 2.79 ft/sec (85 cm/sec) for Miami and 1.97 ft/sec (60 cm/sec) for Fort Pierce were selected for the short-term simulation phase.

83. The short-term modeling of the disposal operation shows that most of the material from the disposal load settles into a mound within several hours after the initial release of sediment from the dredge. Model results indicate the maximum distance from the barge showing deposition in excess of 0.01 ft was 1600 ft for Miami and 400 ft for Fort Pierce The silt and clay portion of the disposal load creates a suspension cloud or turbidity plume

which is transported toward the reefs by the specified ambient currents. This cloud increases in size and decreases in concentration with distance from the point of disposal. The concentration of the suspended sediment cloud was computed at five specified depths for each site simulation. Results at the conclusion of the simulation indicate maximum concentrations above background levels at the reef (taken to be approximately 3 miles from the disposal area) to be 0.00000089 mg/l at a depth of 200 feet for the Miami site. This value corresponds to an elapsed time of 1.66 hours after the initial sediment release. At 2.25 hours after disposal, a maximum concentration of 0.0000017 mg/l at a depth of 30 ft was computed for the Fort Pierce site. As shown, both values are less than one part per million. The short-term modeling efforts, therefore, indicate that the local ambient velocity fields are not adequate in magnitude to transport any significant amount of material from the dumping operation onto the reef area.

84. The long-term modeling effort was conducted to determine whether a disposal mound is stable over long periods of time. Two types of simulations were conducted. A long duration simulation of a specified mound configuration was conducted for each site using a reef directed non-storm depth-averaged velocity field of 0.97 ft/sec (30 cm/sec) and 1.64 ft/sec (50 cm/sec) for the Fort Pierce and Miami sites. Results of these simulations show that the local velocity field at Miami is below the threshold value required for eroding and transporting material, i.e., a 3-month simulation showed no erosion of a mound located in 600 ft of water. The mound at Fort Pierce was shown to erode, deform, and migrate at a rate of approximately 2-3 ft/day. These results were based on a 1-year simulation in which the centroid of the mound moved approximately 700 ft. Additional shorter duration simulations were made for each site in order to investigate storm related transport of material from the mound onto the reefs. A 24-hour sustained storm surge velocity of 4.0 ft/sec for Fort Pierce and 6.0 ft/sec for Miami was input to the long-term sediment transport model. Results for the Fort Pierce simulation show that material was moved a maximum distance of approximately 550 ft in 24 hours. The Miami simulation showed that essentially no material was transported as a result of the surge Conclusions of the long-term simulation indicate that sediment will be transported from the Fort Pierce site during both ambient and storm conditions, but that the rate of movement should not effect the reef system.

For the proposed Miami site, simulations show that local velocity fields are simply not adequate to move material in 600 ft of water.

85. The simulation approach taken in this study involves the specification of a local velocity field directed to maximize the transport of material from the disposal site onto the sensitive reef area. Numerical simulations are used to evaluate whether this velocity field is adequate to contaminate the coral reef with dredged material. The disposal operation and the disposal mound are modeled as a potential source of contamination. Both the short-term disposal and long-term erosion simulations of sediment transport as a function of local velocity fields indicate little possibility of reef contamination as a direct result of either proposed Miami or Fort Pierce disposal sites.

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DEPARTMENT OF THE ARMY
WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS
3909 HALLS FERRY ROAD
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REPLY TO ATTENTION OF

December 19, 1989

Coastal Processes Branch
Research Division

Mr. Gerald Atmar
U.S. Army Engineer District, Jacksonville
ATTN: CESAJ-PD-ES
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Atmar:

As a result of the Miami disposal site designation meeting in Tallahassee, Florida, on December 12, 1989, I have repeated the short-term modeling simulations for the proposed disposal site using a sediment distribution more representative of sediment from Miami Harbor. Based on the gradation curve data received from SAJ, I have specified the barge load distribution to be 90% silt-clay and 10% sand. A value of 30% solids by volume was selected to reflect the high percentage of fine materials. All other coefficients in the simulation were maintained at the values reported in the October 1989 preliminary draft report. Results of the new simulation are shown below.

Summary of Computed Maximum Suspended Silt-Clay Concentrations
(Concentration in mg/l above ambient conditions)

Depth	Elapsed Time (sec)/ Approximate Distance from Dredge (miles)			
	1500	3000	4500	6000
ft	0.8	1.6	2.3	3.2
200	2.0×10^{-12}	3.4×10^{-6}	7.7×10^{-6}	4.1×10^{-6}
250	6.7×10^{-8}	2.0×10^{-5}	1.1×10^{-5}	3.9×10^{-6}
300	3.3×10^{-5}	3.9×10^{-5}	9.4×10^{-6}	2.8×10^{-6}
350	2.7×10^{-4}	2.6×10^{-5}	5.1×10^{-6}	1.6×10^{-6}
400	7.3×10^{-5}	1.0×10^{-5}	3.0×10^{-6}	1.1×10^{-6}

Results shown in the draft report were based on a sediment distribution of 90% sand and 10% silt, with a corresponding solids concentration of 70%. Results based on Miami harbor sediment samples indicate that the maximum concentrations reported in the draft report should be increased by a factor of approximately four to five to be representative of Miami Harbor sediment. For example, if the reefs were considered to be 1.6 miles West of the disposal point, and the velocity field was assumed to be due West, the computed maximum concentration shown in Table 2.4 of the draft report should be increased from 0.0000087 mg/l to 0.000039 mg/l. Since these computed concentrations are not significantly greater than those originally reported, the conclusions stated in the draft report should remain valid.

If you have any questions concerning these results or the input used in their calculation, please give me a call at 601-634-3220.

Sincerely,

Norman W. Scheffner

Norman W. Scheffner, PhD
Research Division
Coastal Engineering Research Center

APPENDIX C

MIAMI ODMDS

SITE MANAGEMENT AND MONITORING PLAN

MIAMI ODMDS

Site Management and Monitoring Plan

Introduction. It is the responsibility of EPA under the Marine Protection, Research, and Sanctuaries Act (MPRSA) of 1972 to manage and monitor each of the Ocean Dredged Material Disposal Sites (ODMDSs) designated by the EPA pursuant to Section 102 of MPRSA. As part of this responsibility, a management and monitoring plan has been developed to specifically address the deposition of dredged material into the Miami ODMDS.

Site Management and Monitoring Team. An interagency Site Management and Monitoring team, consisting of representatives of EPA, COE, State of Florida, NOAA-AOML, University of Miami, and the Port of Miami has been established to review and comment on all Miami ODMDS management and monitoring activities. Other agencies will be asked to participate where appropriate. This SMMP team will evaluate existing monitoring data, the type of proposed disposal (i.e., O&M vs. construction), the type of material (i.e., sand vs. mud), location of placement within the ODMDS and quantity of proposed material. This team will make recommendations to the responsible agency on appropriate monitoring techniques, level of monitoring, significance of results and potential management options.

SITE MANAGEMENT

Section 228.3 of the Ocean Dumping Regulations (40 CFR 228.3) defines ODMDS site management as "..regulating times, rates, and methods of disposal and quantities and types of materials disposed of; developing and maintaining effective ambient monitoring programs for the site; conducting disposal site evaluation studies; and recommending modifications in site use and/or designation." The plan may be modified if it is determined that such changes are warranted as a result of information obtained during the monitoring process.

Management Objectives. There are three primary objectives in the management of each ODMDS. These are:

- o Protection of the marine environment;
- o Beneficial use of dredged material whenever practical; and
- o Documentation of disposal activities at the ODMDS.

The following sections provide the framework for meeting these objectives to the extent possible.

Material volumes. The Miami ODMDS was first used in April, 1990 for disposal of maintenance material. Because routine maintenance dredging is sporadic, the next expected disposal at the proposed ODMDS should be the newly authorized deepening of the Federal Miami Harbor Project. Approximately five million cubic yards is expected to be disposed within the ODMDS from this project. Subsequent maintenance dredging should not occur until 2000.

TABLE: Volumes Disposed and Estimated Volumes of Material to be Disposed at Miami Site

Completion Date	Type of Action	Volume (cubic yards)	Composition
1990	Maintenance	225,000	silt/clay
1995	U.S. Coast Guard Basin	3,000	sand/gravel
1995	NOAA Restoration	300	limerock rubble
1996	Deepening Proj.	5,000,000	sand/silt/ clay/rubble
2000	Maintenance	250,000	silt/clay

Because the site is located in deep water (427 to 785 ft.), no restrictions are presently placed on disposal volumes. Disposal of unrestricted volumes is dependent upon results from future monitoring surveys.

Material suitability. Two basic sources of material are expected to be placed at the site, i.e. construction or new work dredged material and maintenance dredged material. These sediments will consist of mixtures of silt, clay and sand, in varying percentages.

The disposition of any significant quantities of beach compatible sand from future projects will be determined during permitting activities for any such projects. It is expected that the State of Florida will exercise its authority and responsibility, regarding beach nourishment, to the full extent during any future permitting activities. Utilization of any significant quantities of beach compatible dredged material for beach nourishment is strongly encouraged and supported by EPA where environmentally acceptable. Disposal of coarser material should be planned to allow the material to be placed so that it will be within or accessible to the sand-sharing system, to the maximum extent practical, and following the provisions of the Clean Water Act.

In addition, the suitability of dredged material for ocean disposal must be verified by the COE and agreed to by EPA prior to disposal. Verification will be valid for three years from the time last verified with the option of a two year extension. Verification will involve: 1) a case-specific evaluation against the exclusion criteria (40 CFR 227.13(b)), 2) a determination of the necessity for bioassay (toxicity and bioaccumulation) testing for non-excluded material based on the potential for contamination of the sediment since last tested, and 3) carrying out the testing and determining that the non-excluded, tested material is suitable for ocean disposal.

Documentation of verification will be completed prior to use of the site. Documentation for material suitability for dredging events proposed for ocean disposal more than 5 years since last verified will be a new 103 evaluation and public notice. Documentation for material suitability for dredging events proposed for ocean disposal less than 5 years but more than 3 years since last verified will be an exchange of letters between the COE and EPA.

Should EPA conclude that reasonable potential exists for contamination to have occurred, acceptable testing will be completed prior to use of the site. Testing procedures to be used will be those delineated in the 1991 EPA/COE Dredged Material Testing Manual and 1992 Regional Implementation Manual. This includes how dredging operations will be subdivided into project segments for sampling and analysis. Only material determined to be suitable through the verification process by the COE and EPA will be placed at the designated ocean disposal site.

Time of disposal. At present no restrictions have been determined to be necessary for disposal related to seasonal variations in ocean current or biotic activity. If new information indicates that endangered or threatened species are being adversely impacted, seasonal restrictions may be incurred.

The disposal of dredged material with a median grain size of less than 0.125 mm and material with a composition consisting of greater than 10% fine grained material (grain size of less than 0.074mm) by weight will be halted at the Miami ODMDS during periods of onshore current events. An approved real-time current monitoring program must be implemented by the user prior to disposal to ensure that fine grained sediments disposed at the Miami ODMDS are not transported to area reefs and hardbottoms.

Disposal Technique. No specific disposal technique is required for this site. Dredged material will be placed within a 500 foot radius of the center of site to additionally ensure protection of live bottom communities outside of the site and to contain the majority of the disposal mound and plume within the ODMDS boundaries during periods of strong currents.

SITE MONITORING

The MPRSA establishes the need for including a monitoring program as part of the Site Management Plan. Site monitoring is conducted to ensure the environmental integrity of a disposal site and the areas surrounding the site and to verify compliance with the site designation criteria, any special management conditions, and with permit requirements. Monitoring programs should be flexible, cost effective, and based on scientifically sound procedures and methods to meet site-specific monitoring needs. A monitoring program should have the ability to detect environmental change and assist in determining regulatory and permit compliance. The intent of the program is to provide the following:

(1) Information indicating whether the disposal activities are occurring in compliance with the permit and site restrictions; and/or

(2) Information concerning the short-term and long-term environmental impacts of the disposal; and/or

(3) Information indicating the short-term and long-term fate of materials disposed of in the marine environment.

The main purpose of a disposal site monitoring program is to determine whether dredged material site management practices, including disposal operations, at the site need to be changed to avoid significant adverse impacts.

Baseline Monitoring. The results of investigations presented in the designation EIS will serve as a general pre-disposal characterization of the ODMDS and nearby vicinity (see EIS Appendix A). Site specific investigations included: *1985 Environmental Survey in the Vicinity of An Ocean Dredged Material Disposal Site, Miami Harbor, Florida*; and *1986 Miami Harbor Interim Ocean Dredged Material Disposal Site Video Survey*.

A bathymetric survey will be conducted by the COE or site user not more than 60 days prior to the dredging cycle or project disposal. The surveys will be taken along lines spaced at 500 foot intervals or less and be of sufficient length to adequately cover the disposal area. Accuracy of the surveys will be ± 0.5 feet. These surveys will be referenced to the appropriate datum and corrected for tide conditions at the time of survey.

Disposal Monitoring. For all disposal activities, the dredging contractor will be required to prepare and operate under an approved electronic verification plan for all disposal operations. As part of this plan, the contractor will provide an automated system that will track (1 to 5 minute intervals) the horizontal location and draft condition (vertical) of the disposal vessel from the point of dredging to the disposal area, and return to the point of dredging. Required digital data for each load are as follows:

(a) Date;

(b) Time;

(c) Vessel Name;

(d) Dump Number;

(e) Map Number on which dump is plotted (if appropriate);

(f) Beginning and ending coordinates of the dredging area for each load;

(g) Actual location at points of initiation and completion of disposal event and the compass heading at the beginning of each dump;

(h) Description of material disposed, e.g., rock, sand, silt, or clay;

(i) Volume of material disposed; and

(j) Disposal technique used.

As a precaution to protect marine mammals as well as sea turtles during disposal operations, a bow observer will be stationed on vessels participating in disposal activities.

As a follow-up to the baseline bathymetric survey, the COE or other site user will conduct a bathymetric survey within 30 days after disposal. The number of transects required will be the same as in the baseline survey. The user will be required to prepare daily reports of operations and submit to the COE a monthly report of operations for each month or partial month's work. The user is also required to notify the COE and EPA within 24 hours of becoming aware of a violation of the permit and/or contract conditions during disposal operations.

Material Tracking. Based on the type and volume of material disposed, various monitoring surveys may be used to determine if and where the disposed material is moving.

The primary concern regarding use of the Miami ODMDS is the potential for adverse impact on nearshore reefs due to short and long-term transport of dredged material from the ODMDS and subsequent sedimentation and/or light attenuation. The management requirements discussed previously have been adopted to minimize this potential. To further quantify the potential of impact, the Site Management and Monitoring Team has decided to focus monitoring efforts on analysis of the transport mechanisms at the ODMDS.

The Site Management and Monitoring Team has identified two major monitoring objectives: 1) Assess intensity and frequency of disposal plumes reaching nearshore reefs, 2) Assess the potential for long-term transport of dredged material towards critical habitats. Additional objectives may be added as new information is obtained from the current monitoring system and from the studies described below.

Objective 1

Field studies will be conducted during the current Miami Harbor Deepening Project to quantify disposal plume concentrations during onshore current events due to Florida Current Spinoff Eddies. Data collected from these field studies will be used to calibrate computer models for at least two separate current regimes (eddy present and eddy absent) for assessing the intensity and frequency of disposal plumes reaching nearshore reefs. Results from the computer modelling will be examined with respect to potential impact on the reef communities. Based on the expected impact, the real-time current monitoring management requirement can be modified or discontinued. The monitoring plan for this objective is currently under development.

Objective 2

Field studies will be conducted to quantify bottom currents and dredged material resuspension at the Miami ODMDS. Data collected from these field studies will be used in calibrating computer models for assessing the potential for long-term transport of dredged material towards critical habitats. Should the modelling indicate that significant quantities of dredged material will reach critical habitats, management techniques will be examined or the ODMDS will be relocated. The monitoring plan for this objective is currently under development.

Reporting and Data Formatting. Disposal summary reports should be provided by the COE to EPA within 45 days after project completion. These should consist of dates of disposal, volume of disposal, approximate location of disposal and pre- and post-disposal bathymetric survey results in both hard copy and electronic formats. Other disposal data should be available upon request. In addition, EPA should be notified of ODMDS use 15 days prior to dredging cycle or project disposal.

A brief report on the real-time monitoring results should be provided to SMMP team members by the permittee within 45 days after project completion. This report should include: number of times disposal was delayed due to restricted current conditions; the date, time and duration of each delay; any operational or logistical inconsistencies or complications in conducting this program; and any conclusions or recommendations.

Material tracking, disposal effects monitoring and any other data collected should be provided to SMMP team members and federal and state agencies as appropriate. Data will be provided to other interested parties requesting such data to the extent possible. Data will be provided for all surveys in a report generated by the action agency. The report should indicate how the survey relates to the SMMP and previous surveys at the Miami ODMDS and should provide data interpretations, conclusions, and recommendations, and should project the next phase of the SMMP.

Modification of ODMDS SMMP. The SMMP will be modified on an as needed basis. Should the results of the monitoring surveys indicate that continuing use of the ODMDS would lead to unacceptable impacts, then either the ODMDS Management Plan will be modified to alleviate the impacts, or the location of the ODMDS would be modified. In addition, should the results of the monitoring surveys indicate that specific management practices are not needed, then the SMMP would be modified. The SMMP will be reviewed and revised if appropriate at a minimum of every ten years.

APPENDIX D

MIAMI OCEAN DREDGED MATERIAL DISPOSAL SITE DESIGNATION

FLORIDA COASTAL ZONE MANAGEMENT PROGRAM

CONSISTENCY EVALUATION

Submitted by:

U.S. Environmental Protection Agency

Region IV

August 1995

I. INTRODUCTION

The U.S. Environmental Protection Agency (EPA), in cooperation with the U.S. Army Corps of Engineers (COE), has prepared an Environmental Impact statement (EIS) titled "Environmental Impact Statement For Designation of a Miami, Florida Ocean Dredged Material Disposal Site." This EIS evaluates the environmental conditions relevant to the designation of an ocean disposal site offshore Miami, Florida. Additionally, the EIS evaluates the proposed Miami site according to the eleven environmental criteria required for site designations under 40 CFR 228.6 (Ocean Dumping Regulations).

The site proposed for final designation is the Miami site that received an EPA interim designation (40 CFR 228.12) and was used for dredged material disposal for the first time in April 1990. The total area of the proposed site is 1 square nautical mile (nmi). The western boundary of this site is located 3.6 nmi east of Virginia Key, Florida in the Atlantic Ocean. Since April 1990, approximately 300,000 cubic yards of dredged material have been disposed at the interim site.

The site designation is needed in this area to provide an ocean disposal option for dredging projects in the area. Potential sources of the dredged material are Government Cut, the Port of Miami channels and turning basins, and the Miami Harbor Deepening Project. It should be emphasized that final designation of the interim Miami site does not by itself authorize any dredging or on-site disposal of dredged material. EPA and the COE must conduct an environmental review of each proposed ocean disposal project. That review ensures that there is a demonstrated need for ocean disposal and that the material proposed for disposal meets the requirements for dredged material given in the Ocean Dumping Regulations.

II. THE FLORIDA COASTAL ZONE MANAGEMENT PROGRAM (CZMP)

There are eight Florida statutes relating to ocean disposal site designations. This assessment discusses how the referenced EIS for the Miami site designation will meet the CZMP objectives to protect coastal resources while allowing multiple use of coastal areas. Consult the EIS for further data and information.

Although the EIS serves a dual role of NEPA documentation for site designation and COE permitting under Section 103 of the Marine Protection, Research, and Sanctuaries Act (MPRSA) of 1972, as amended (see Section 2.01 of EIS), this CZMP consistency evaluation is only relevant for site designation. Therefore, COE permitting actions will need a separate CZMP consistency evaluation.

A. Chapter 161: Beach and Shore Preservation

The intent of Chapter 161 is the protection of thousands of miles of Florida's coastline by regulating construction activities near and within these areas. The Miami site designation will, by itself, require no new construction and therefore no related support activities will be subject to the construction regulations in this chapter

The western boundary of the Miami ODMDS is located 3.6 nmi from Virginia Key, the nearest beach and shore-related amenity. Sediment transport in the vicinity of the site is driven mainly by the Florida Current. However, eddy currents associated with the Florida Current have been shown to occur within this area. Modelling, which has been compared to field studies, has indicated that these frontal eddies should not result in significant transport of dredged material toward the shore. In addition, provisions have been established in the Site Management and Monitoring Plan to ensure that transport does not occur toward the shore. In the event that significant accumulation of the dredged material towards any amenity is evident, use of the site can be modified or terminated by EPA.

B. Chapter 253: State Lands

This chapter addresses the responsibilities of the State Board of Trustees in managing the State sovereign lands by issuing leases, easements, rights of way, or other forms of consent for those wishing to use State lands, including State submerged lands.

Since the Miami site is not within State waters, Chapter 253 is not relevant.

C. Chapter 258: State Parks and Preserves

Figure 5 in the EIS locates the Parks and Preserves in the vicinity of the proposed Miami site. As similarly discussed in Section A above, the distance from these areas to the proposed site should prevent any impacts to these areas from use of the site.

D. Chapter 267: Historic Preservation

There are no known features of historical importance in the vicinity of the proposed site, and therefore it is unlikely that the proposed site designation will result in any impact to these areas. The bottom video survey of the ODMDS did not reveal any new such areas.

E. Chapter 288: Commercial Development and Capital Improvements; Industrial Siting Act

The final designation of the Miami site provides an environmentally acceptable ocean location for the disposal of dredged material that meets the Ocean Dumping Criteria. If ocean disposal is selected as the most feasible option for a dredged material disposal project, this site designation ensures that an ocean disposal option is available in the area. Therefore, the designation removes one barrier to free and advantageous flow of commerce in the area in that dredging projects and their associated navigational benefits cannot be halted due to the lack of an acceptable ocean disposal site.

The Industrial Siting Act is not applicable to this proposed site designation.

F. Chapter 370: Saltwater Fisheries

Chapter 370 ensures the preservation, management and protection of saltwater fisheries and other marine life. Most commercial and recreational fishing activity in the Miami vicinity is concentrated in inshore and nearshore waters. No natural hardbottom areas are known to occur in proximity to the proposed site. The nearest fisheries area is located about 1.3 nmi from the site. In short, the Miami site does not represent a unique habitat for any of the important commercial or recreational fisheries. Use of the site will smother the non-motile or slow moving benthic organisms at the site. However, the ability of these organisms to recolonize in similar sediments renders this impact short-term and insignificant. Should the disposed material differ in grain-size, other benthic organisms would likely colonize the area. The EIS served as the Biological Assessment from which the National Marine Fisheries Service (NMFS) determined that populations of endangered/threatened species under their purview would not be adversely affected by the designation and use of the ODMDS (See FEIS section 7.03).

G. Chapter 376: Pollutant Discharge Prevention and Removal

Possible effects associated with the use of this site are local mounding, temporary increases in turbidity and the smothering of benthic organisms. The effect on the benthos should be minor as discussed in Section F above. The great depths at the site will ensure that any mounding does not become a hazard to navigation. Turbidities resulting from use of the site will be temporary. Any suspended sediments remaining in the water column will be diluted and dispersed so that the long term effect would not be greater than ambient suspended solids concentrations. This is supported by the results of dispersion modelling, which has been compared to field studies and has indicated that these frontal eddies should not result in significant transport of dredged material toward the shore. In addition, provisions have been established in the Site Management and Monitoring Plan to ensure that transport does not occur toward the shore.

Any material proposed for ocean disposal must meet the criteria given in 40 CFR Part 227 (Ocean Dumping Criteria). EPA and the COE will continue to monitor the site as long as it is used to detect movement of the material and any associated impacts. The Site Management and Monitoring Plan (SMMP) for the Miami ODMDS is included in the EIS (see Appendix C).

H. Chapter 403: Environmental Control

The principle concerns raised in this chapter are similar to those addressed in many of the chapters discussed above: pollution control, waste disposal and dredging.

The COE and EPA will evaluate all federal dredged material disposal projects in accordance with the EPA criteria given in the Ocean Dumping Regulations (40 CFR Sections 220-229), the COE regulations (33 CFR 209.120 and 209.145), and any state requirements. The COE will also issue permits to private dredged material disposal projects after review under the same regulations. EPA has the right to disapprove any ocean disposal project if, in its judgement, all provisions of the MPRSA and associated implementing regulations have not been met.

III. CONCLUSIONS

Based on the information presented in the EIS and the above summary, EPA concludes that the proposed designation of the Miami ODMDS is consistent with the Florida CZMP to the extent feasible.

APPENDIX E

EVALUATION OF THE
MIAMI OCEAN DREDGED MATERIAL DISPOSAL SITE (ODMDS)

Evaluation of the Miami Ocean Dredged Material Disposal Site (ODMDS)

Introduction

1. Limited capacity in existing disposal sites for dredged material in the Miami, Florida area combined with the planned deepening of the Miami Harbor creates a need to designate an environmentally acceptable, adequately sized, and economically feasible offshore Ocean Dredged Material Disposal Site (ODMDS). In December 1987, the US Army Engineer District, Jacksonville (SAJ) requested assistance from the US Army Engineer Waterways Experiment Station's Coastal Engineering Research Center (CERC) to perform a site designation investigation of the proposed ODMDS offshore of Miami, see Figure 1a. Figure 1b shows the bathymetry at the proposed ODMDS. The purpose of the study was to determine the acceptability of the site with respect to the potential effects of the dredging operation on live coral reef areas located shoreward of the ODMDS. Specifically, the question was whether material from the ODMDS could be transported from the disposal site and deposited onto coral reefs located along the adjacent coast.

2. Conclusions of the study were reported by Scheffner and Swain (1989) and indicated that the proposed disposal site did not pose a threat to the live reef areas. These conclusions were based on numerical model simulations of: 1) the short-term (Johnson et al. 1988) fate and transport of material in the water column from the disposal site to the reef and 2) a long-term (Scheffner 1989) simulation of the erosion and transport from a non-cohesive disposal mound located in the ODMDS. Because data were not available for validation of the short-term modeling results, no quantitative verification of the results were presented in the initial report. Additionally, the long-term transport was limited to non-cohesive material of a single, uniform grain size.

3. Although the numerical approach adopted for the study represented the state-of-the-art in disposal site analysis, the lack of model verification to prototype measurements has resulted in a reluctance to accept the conclusion that the disposal site will not adversely impact the coral reefs. As a result of these concerns, the proposed ODMDS designation request may not be approved by the Florida State Department of Environmental Resources (DER). Although these concerns are valid, the amount of data necessary for such a verification has never been available and such data collection effort was not planned as a component of the original study. However, an acceptable and cost effective ODMDS must be located and approved in the near future; otherwise, SAJ dredging activities in the Miami area will have to be terminated.

4. At the time that the numerical model tests were run, the technology was not available to monitor the spatial and temporal variations that occur during the disposal of dredged material. However, during a field data collection activity in Mobile, Alabama (Kraus 1991), it was shown that such measurements could be accurately taken acoustically. This acoustic technology along with conventional sampling techniques were used to monitor the proposed Miami ODMDS (Proni et al. 1991 and Tsai et al. 1992) in a joint field data collection project performed by the Atlantic Oceanographic and Meteorological Laboratory (AOML) of the National Oceanic and Atmospheric Administration, SAJ, and CERC.

5. In response to a recent request by SAJ, a cooperative effort between Rosenstiel School of Marine and Atmospheric Science (RSMAS) of the University of Miami, AOML, and CERC has been undertaken. RSMAS provided data describing the environmental conditions at the study site. AOML analyzed field data, and CERC utilized predictive numerical models to characterize movement of suspended material and bottom sediments at the ODMDS. This memorandum describes the use of theory and field measurements to address all reservations concerning the conclusions reached by the original numerical modeling investigation and provides predictions based on the most recent model versions. The following three sections summarize findings with respect to: 1) analyzing water samples and developing a theoretically based and field calibrated acoustic backscatter versus sediment concentration curve, 2) running of the Short Term FATE (STFATE) model with hydrodynamic data specified according to the field conditions which occurred during monitoring and are representative of the site, and 3) performing an analysis of the potential resuspension and transport of bottom sediment at the site.

Field Measurements

6. The primary concern of the DER is founded on the lack of verification of the numerical model predictions of suspended sediment concentrations at the reef area. The 1990-91 field data collection project at Miami produced the data capable of providing quantitative verification of the numerical model predictions. The field monitoring was comprised of three phases. During the first field monitoring project, which was conducted from 24 to 26 April 1990, conductivity, temperature, current, and total suspended solids (TSS) concentration measurements were obtained. Water samples were gathered with a water sampling arrangement utilizing a towed body in which the entrance port of a pumping system was mounted at a depth between 3 and 8 meters below the ocean surface. This is the only portion of the water column from which water samples were obtained. On 28 August 1990, a second field collection exercise was conducted, in which Rhodamine dye was introduced into the hopper of the dredge while enroute to the disposal site. After disposal, the residual plume was monitored using NOAA's Acoustic Concentration Profiler. Water samples were drawn from the residual plume and analyzed for the presence of dye with a Turner Fluorometer. No dredged material discharges occurred during the third monitoring period, 26-28 June 1991, due to dredging contractors scheduling. This effort was undertaken to gather background water samples only.

7. It is desirable to compare acoustical measures of TSS with conventional water samples in order to obtain an empirical calibration of the relationship between acoustic backscatter intensity and suspended material for each particular dredged material and disposal site. However, the 20kHz system, used in phase one of the field exercise, has a certain zone (several meters adjacent to the transducer face), over which the data becomes saturated from immediate return. Because of the method of the pumped sampling and limitations of the acoustical data at locations where water samples were collected, a calibration of the acoustical data to field measurements is difficult.

Sample Analysis

8. Despite the inability to perform an acoustic calibration to field data, it was determined that analyzing the existing samples would provide valuable information regarding the residual plume

left after dredged material discharge. Tsai et al. (1992) determined that, although the bulk of the discharged material descends as a viscous mass, a small portion, perhaps in the form of individual fines, remains within the water column.

9. TSS concentrations were determined by AOML from pumped samples (Proni et al. 1993) taken from residual plumes as they moved along a nearly straight path to the North-Northeast. Values for all samples of dredged material discharges plotted against time are shown in Figure 2. Data from three of the discharges have been selected and included in Figure 3 to obtain a smoother estimate of dilution with time (or distance) from the discharge. A curve can be fit to the data to give an estimate of the normalized dilution with time or distance for discharges occurring within the designated site. From Figure 3, a dilution factor of 0.1 occurs 20 minutes after discharge. For example, an initial concentration of 80 mg/ℓ (no bottle samples exceeded a concentration of 80 mg/ℓ) would diminish to 8 mg/ℓ after 20 minutes or at a distance of 600 m from the point of discharge (current speed assumed to be 50 cm/s). The dilution factor decreases to approximately 0.05 at 45 minutes. The concentration in the example becomes 4 mg/ℓ at a distance of 1350 m. The maximum background concentration measured in June 1991 was 3.1 mg/ℓ. Therefore, the TSS concentration of dredged material will not impact the coral reefs a distance of about 3 miles (≈ 5000 m) from the ODMDS with concentrations in excess of background levels.

Acoustic Calibration

10. Because it was not possible to perform an acoustic calibration to TSS samples taken in the field, an alternate method had to be devised to produce concentration data which would be used to determine if the Short Term FATE (STFATE) model was producing concentration values within an order of magnitude of those obtained in the field. It was determined that the environmental conditions (i.e. grain size, cohesiveness, salinity) at the disposal site could be adequately represented in the conversion from acoustic backscatter to concentration by acoustical theory calibrated to field data. The acoustical theory used in the conversion has been elucidated by Thevenot and Kraus (1993). The concentration ratio between a scattering volume and a volume of known concentration is given by

$$C = 10^{(K + aS_v)} \tag{1}$$

where a = 0.1 according to theory, and K is a site specific constant.

11. The coefficients a and K are typically determined empirically through fitting to field data. Because field data corresponding to acoustic backscatter measurements are not available, the theoretical value 0.1 is used for a. Bottom grab samples taken at the Miami dredging operations were found to be similar to the material disposed during the Mobile, Alabama field data collection project. Therefore, it was determine that the same value for K (6.78) would be used in this study. Figure 4 (from Ogushwitz 1992) shows a comparison of data taken from two acoustic instruments at Mobile, Alabama, the best fit to the data greater than 10 mg/ℓ, and the theoretical backscatter versus concentration relationship. This figure shows that the best fit line deviates only slightly from the theoretical line for concentration values greater than 10 mg/ℓ. Converting

the Miami acoustical measurements using the above theory will provide estimated concentration within an order of magnitude for concentrations ranging from 10 to 1000 mg/ℓ (Ogushwitz 1992).

Short Term Fate Analysis

12. In order to run STFATE, four types of input data are required. The first two types of input data pertain to the ambient conditions at the disposal site. Specifically, a density profile of the water column is required as well as an indication of the current velocities at the site. Because Scheffner and Swain (1989) were criticized for using depth averaged velocities, the velocity profile option of STFATE was selected. Input is also required regarding the material to be disposed and the dimensions and velocity of the disposal vessel.

Verification to Prototype Data

13. The primary concern expressed by the DER regarding the Scheffner and Swain (1989) study was that the STFATE model was not verified to prototype data. Therefore, an initial set of STFATE runs were made with the input parameters which coincided with a dredged material discharge operation monitored on 26 April 1990 (Proni et al 1991). Although several disposal operations were monitored, the disposal associated with the highest quality acoustic data was selected for verification of the STFATE model due to limited time to complete the study. Density stratification information that occurred at the time of the disposal was derived from measurements of conductivity, temperature, and depth taken during the monitoring project. An Acoustic Doppler Current Profiler obtained current profiles, and these data were used as input to STFATE. Grain size information was obtained from a bottom grab sample taken from the channel being dredged. The final input required are the dimensions of the vessel and its speed during disposal. Estimates of the dimensions of a typical disposal vessel were the same as used in Scheffner and Swain (1989). The speed of the vessel at disposal was estimated based on observations of the disposal operations.

14. After all of the required input information was obtained, vertical contours of TSS concentration were developed for the STFATE simulations and compared to concentration measured with acoustic techniques. The acoustic backscatter was converted to concentration using the relationship discussed above. The residual plume was followed during the acoustic monitoring by visual observation of the surface plume, thus the vertical concentration profiles from the STFATE model were taken at the highest concentration for the least depth of calculation and were consistent throughout the water column.' Six passes were made through the discharge plume, covering the period between disposal and 25 minutes after disposal. Because each pass through the plume took over 150 sec, the spatial distribution shown in the acoustic transects may vary from the snapshot of the water column developed to represent the STFATE model output. However, this difference was considered to be well less than an order of magnitude. Because data was previously unavailable to verify the spatial and temporal distribution of concentration results of such models, this data represents the first comprehensive data set which is spatially adequate for verifying the STFATE model.

15. Figure 5 shows acoustical measurements of the water column taken over a period of 0 to 150 sec after the disposal of dredged material. Contour intervals representing one half order of magnitude illustrate the TSS in the water column, ranging from .1 to 1000 mg/ℓ. The period shown in Figure 5 includes the convective descent phase, 0 to 42 sec after discharge according to model results, and dynamic collapse phase, 42 to 177 sec after discharge, of the material's descent in the water column. During these two phases of the discharge, the model results illustrate a single cloud of material falling through the water column with decreasing density, similar to the field data (Figure 5).

16. Figure 6 shows acoustic measurements of TSS concentration taken 150 to 300 sec after the discharge of dredged material. Two distinct clouds of material can be seen, one in the upper water column and one in the lower water column, both with maximum concentrations exceeding 1000 mg/ℓ. During this phase of material descent model results were converted to vertical profiles of TSS concentration to facilitate comparison to prototype data. Scales on figures showing model results are arbitrary (i.e., 0 does not represent the point of discharge). The figure is centered around the maximum concentration of the plume, and the scale is based on the plume extent. Figure 7 illustrates model results at 240 sec after discharge at which time the center of the plume is approximately 90 m north (to the right on Fig 7) of the discharge location. Contour lines represent the TSS concentration of dredged material in the water column and are given in orders of magnitude, i.e., .1, 1, 10, 100, 1000 mg/ℓ. Similar to the prototype data shown in Figure 6, Figure 7 shows two clouds of material with maximum concentration exceeding 1000 mg/ℓ, one at approximately 30 meter depth and another near the ocean floor.

17. Figures 8 and 9 show the TSS concentration measurements taken in the field and the TSS concentration from model simulation, respectively. The field data was collected during the period from 570 to 720 sec after disposal of dredged material. The simulated data shown in Figure 9 represents a snapshot of the water column 600 sec after discharge. Disposal occurred 360 m east (to the right in Fig 9) and 450 m south (out of the page) of the center of the plume, about 575 m total distance from the location of discharge to the center of the plume. In both plots, a cloud of material with concentrations exceeding 100 mg/ℓ can be seen suspended in the water column. Except for minor differences, e.g. the numerical simulation predicts that the cloud of material to be deeper in the water column than observed in the field data, the simulated concentrations seem to be an accurate account of the fate of the disposed dredged material.

18. Figure 10, the TSS concentration measured in the field from 930 to 1080 sec after disposal, shows a cloud of material comparable to that seen in Figure 8, with maximum concentrations in Figure 10 lower (100 mg/ℓ) than those found in Figure 8 (1000 mg/ℓ). Similarly, Figure 11, the TSS concentration in the water column from model simulations at 1000 sec after disposal (about 985 m from the discharge point), shows a cloud of material comparable to Figure 9, with lower maximum concentrations (10 mg/ℓ as compared to 100 mg/ℓ). When the field data (Figure 10) are compared to simulated data (Figure 11) 1000 sec after disposal, each illustrate a cloud of suspended material with concentrations greater than 10 mg/ℓ. A significant portion of the cloud exceeds 100 mg/ℓ in the field data; however, concentrations do not exceed 35 mg/ℓ in the simulated data.

19. In Figures 9 and 11, the simulated plume descends deeper in the water column than shown in the field data, Figures 8 and 10. The simulated plume is effected by the density gradient which occurs at an approximate 105 m depth causing the plume to remain in suspension above this depth. Another density gradient was measured at 43 m, and the field data indicate that material is trapped at this depth. The difference in the plume depth in the model results and field data during 570 to 1080 sec after disposal are due to the lack of sensitivity of the STFATE model to a change in density occurring at a depth of 43 m. The material shown in the field data to be trapped at the surface has been effected by a similar density stratification occurring at a depth of 23 m. The density profile described has been documented by Proni et al (1991). Stripping of the material from the barge, which has been added to subsequent versions of STFATE, may also attribute to this difference in field data and simulated results.

20. Figure 12 illustrates the TSS concentration in the water column from the field measurements taken 1350 to 1500 sec after dredged material discharge. Figure 13 shows the TSS concentration calculated 1400 sec after disposal for the simulation. These data were taken between two plumes of higher concentration about 550 m from the location of discharge. This appears to coincide with monitoring procedures. Both figures show similar distributions of TSS concentration below 60 m with maximum concentrations exceeding 1 mg/ℓ. The simulation computed concentrations in the center of the plume are in excess of 10 mg/ℓ but the field data indicate lower concentrations.

21. Figures 5 through 13 illustrate that the STFATE model provides reasonably accurate predictions of the fate of dredged material from the time of disposal to 25 minutes after the discharge in that the simulated spatial distributions of material are similar to the actual spatial distribution with concentrations within an order of magnitude. The spatial distributions of material from field and simulated data cannot be compared at precisely equivalent times because the acoustic technology used to obtain the field measurements required 150 sec to pass through the dredged material residual plume. The simulated data are reported as a snapshot of the water column at a single time providing a more intuitive insight into the material dispersion. Other differences regarding the comparison of field and simulated data include assumptions made regarding the disposal vessel and discharged material. Samples of dredged material were taken and are being analyzed but the bulk density could not be included as input in the short time frame allowed for this study. The results show that the simulation is predicting the convection and advection of material up to 25 minutes after disposal to the degree required for the present study (within an order of magnitude for concentration measurements taken in mg/ℓ).

Prediction of Plume Movement

22. For the purpose of predicting the long term diffusion of dredged material and to determine if material will reach the coral reefs, environmental conditions pertaining to velocity and density stratification of the water column at the study site were provided by RSMAS. Information which was not provided by RSMAS included parameters related to dredged material and vessel dimensions, therefore, this input remained the same as that used for the verification of the STFATE model. The depth, which must remain constant if a velocity profile is used, was selected to be 750 ft. If the slope were included, it is reasoned that material would settle to the bottom more quickly than simulated, decreasing the amount of material remaining in suspension.

This represents the maximum depth of the disposal site, and it was reasoned that the deeper the dredged material had to fall the more likely it was to be trapped in suspension. The velocity distribution used as input into STFATE for the purpose of predicting dredged material movement originated from Lee et al (1977). The mean velocities, which included northerly velocities of 175 cm/sec at the surface and 43 cm/sec mid-depth in the water column and westerly currents of 5.4 cm/sec at the surface and 1.9 cm/sec near the bottom, were used. These data were obtained in June 1971 and are representative of the summer conditions when most material is discharged.

23. Measurements of temperature and salinity were taken from Roemmich and Wunsch (1985) and were converted to density with the equation

$$\rho = \frac{P}{\alpha + 0.698P}$$

where

ρ = density (g/cc)
$P = 5890 + 38T - 0.375T^2 + 3S$
$\alpha = 1779.5 + 11.25T - 0.0745T^2 - (3.8 + 0.01T)S$
T = temperature (°C)
S = salinity (ppt).

These data were collected in September, 1981 and do not represent the density during the summer months. Summer temperatures presented by RSMAS were not adequate (not sufficiently deep) to describe the density profile. The data described were input into STFATE and represent average conditions encountered at the site.

24. Results of the sediment concentration computation for Miami are shown in Figure 14. The disposal release point is located at the origin, and the distance is the absolute distance from the disposal site to the residual plume. The depths of 27.4 m (90 ft), 54.9 m (180 ft), 82.3 m (270 ft), 109.7 m (360 ft), and 135.6 m (445 ft) were used in order to present an overall representation of the numerical results. For example, at 3000 sec after the initial dump, simulations of the disposal operation shows concentrations of suspended silt and clay at the 27.4 m (90 ft) depth to be 5.5 mg/ℓ. Results illustrate a decreasing amount of material suspended in the water with time. The simulated TSS concentration simulated falls below the maximum background concentration measured in June 1991 (3.1 mg/ℓ) after 9000 sec at all depths.

25. It may seem unacceptable to incur concentrations twice the background level for periods of almost 2 hours in an area of coral reefs (i.e., 6.5 mg/ℓ, at time 6000 sec, at depth 54.9 m). However, the plume can be shown to move almost due north for over 2.5 hours, not reaching the reefs with concentration levels below background levels. The path of the simulated TSS concentrations is illustrated in Figure 15, with squares representing points along its path. The "X" is the location of the disposal, assumed to be in the center of the disposal site.

26. In the August 1990 field study, acoustical methods were combined with adding a tracer to the material to follow the residual plume. The plume was monitored for 1.5 hours using this method

and was found to move due north. After the tracer could no longer be detected, the reef areas were monitored, and no tracer was detected. The circles, shown in Figure 15, represent the results of the dye study conducted by SAJ and AOML in August 1990. Filled circles indicate dye was detected and open circles indicate no dye detected. The simulated path of the dredged material is almost identical to the actual path of dredged material in August, 1990.

27. The question can then be asked if the coral reefs are effected at times of maximum westerly currents. The same conditions as above were run with the maximum westerly currents reported by Lee et al (1977) (57 cm/sec at the surface and 16 cm/sec near the bottom), and the residual plume reached the coral reefs at approximately 1.7 hr (see asterisk in Figure 15). The maximum concentration predicted near the coral reefs at this time was computed to be 0.02 mg/ℓ. During the verification runs, a maximum westerly current speed of 66.8 cm/sec was input at the mid depth of the profile, which exceeds the velocity reported by Lee et al (1977) (57 cm/sec). The resulting location of the residual plume after approximately 17 minutes is shown as a triangle in Figure 15. The maximum TSS concentration was found to be greater than 10 mg/ℓ by both simulation and prototype data. However, the maximum concentration decreases to below 1 mg/ℓ in about 23 minutes. The material is not anticipated to reach the coral reefs before 40 minutes.

Long Term Fate Analysis

28. The final task of the study investigates the long-term fate of disposed material. Scheffner and Swain (1989) determined the Miami ODMDS to be non-dispersive, i.e. the velocities at the site were not sufficient to move significant amounts of the dredged material on the bottom. Empirical relationships for computing sediment transport as a primary function of ambient water velocity, depth, and sediment grain size were reported by Ackers and White (1973). These relationships were subsequently modified (Swart 1976) to reflect an increase in sediment transport when a wave field is superimposed on the ambient current field. The Long Term FATE (LTFATE) model uses the Swart (1976) modification to compute sediment transport at the dredged material disposal site. The model has been verified to prototype data by Scheffner (1991) and was shown to be a viable approach to providing quantitative predictions of disposal site stability. The program was modified to output the shear stress based on the equation taken from Ackers and White (1973).

29. The present investigation involves determining the potential for moving material other than uniformly graded, non-cohesive sediments. This question is addressed by calculating shear stress values on the mound and in the surrounding area that can be used to determine the effect on any dredged material. The difference between shear stress values on the mound and the surrounding area provides an indication of the normal movement and the increase caused by the disposal mound.

Non-Storm Conditions

30. In order to run LTFATE to determine long term mound evolution, two types of input data are required, wave data characteristics at the site and time series of tidal elevations and velocities. The wave height, period and direction data were taken from the 20-year Wave Information Study (WIS) Revised Atlantic Coast Hindcast (Hubertz, et al 1993) database This

database was processed through a wave simulation procedure, developed by Borgman and Scheffner (1991), that generates waves statistically similar to those known to occur at the site, i.e., preserving seasonality, directionality, distribution, sequencing, etc. The advantage of the procedure is that the simulated data reflect the trends of the entire 20-year database, not merely one specific event. The tidal database is composed of tidal harmonic constituents which can be used to simulate a tidal time series at the disposal site. The constituents are based on a 6-month simulated tidal time series computed by a long-wave hydrodynamic finite element model (Luettich et al. 1992). A residual current velocity of 50 cm/sec to the west was used because this was determined to be an approximate threshold value for the initiation of sediment movement by Scheffner and Swain (1989).

31. As in the Scheffner and Swain (1989) study, the Miami ODMDS was found to be non-dispersive. The shear stress values were determined as an indication of the potential of material resuspension. For non-storm conditions, the shear stress ranged from 2.54 to 3.64 dynes/cm^2, throughout the simulated domain. As shown in Figure 16, the critical shear stress for cohesive dredged material for field data illustrated by Teeter and Pankow (1989) was found to be 2.5 dynes/cm^2. This value is conservative because the typical critical shear stress value is given to be 5.0 dynes/cm^2 (Teeter and Pankow 1989). A difference of 0.14 dynes/cm^2 (3.64-3.50) is shown to be the difference between the shear stress on the disposal mound and that of the surrounding area. This variability in shear stress represents the maximum difference between the values on the dredged material mound and the surrounding area. The minimum difference was shown to be 0.10 dynes/cm^2 when the surrounding shear stress was 2.54 dynes/cm^2. If the critical value for shear stress is taken from Figure 16, the entire simulated domain is in the significant erosion range. If the typical value of 0.5 dynes/cm^2 is used, the entire simulated domain is below the significant erosion range. In either case, the mound has little consequence to the amount of sediment moved.

Storm Conditions

32. A storm event for the Miami site was assumed to have a sustained velocity of 6.0 ft/sec for 24 hours. The findings of this study agree with those of Scheffner and Swain (1989), in which the mound located in 600 ft of water is little effected by the velocities of a magnitude realistically representative of the disposal site offshore of Miami. The shear stress increased by an order of magnitude over non-storm conditions, ranging from 38.9 to 45.9 dynes/cm^2. The maximum difference in shear stress between the dredged material mound and the surrounding area is 1.8 dynes/cm^2. The increase in shear stress to due the presence of the dredged material mound is only 5% of the shear stress of the surrounding area. This increased in shear stress is anticipated to have little impact on the sediment movement in the area.

Summary and Conclusions

33. Background conditions and dredged material plumes were monitored offshore of Miami, Florida as a cooperative effort between SAJ, AOML, and CERC on three occasions, and the data were subsequently analyzed to determine the validity of numerical simulation methods used in

predicting the fate of dredged material. The objective was to determine if dredged material would reach coral reefs located shoreward of the Miami ODMDS.

34. Field samples taken in April 1990 and June 1991 were analyzed for TSS concentration by AOML. The dredged material plume was found to decrease in concentration to the level of background measurements in approximately 45 minutes. During that time, the plume may move about 1500 m but not nearly the 5000 m necessary for the material to reach the sensitive coral reefs.

35. Acoustic backscatter measurements were used to verify the residual plume concentrations predicted by the STFATE model. Acoustic theory was used to convert backscatter intensity to TSS concentrations. The simulated concentrations accurately predicted the acoustic field measurements to within an order of magnitude. After being verified, the STFATE model was run with input provided by RSMAS. The results indicate that the disposal site is dominated by northerly flows produced by the Gulf Stream Current. Thus, the material generally moves in a northerly direction as verified by field data collect in August 1990. The dispersion of the material will reduce concentrations to within background levels before moving sufficiently westerly to reach the coral reefs. Even in the maximum westerly flow, the coral reefs are not anticipated to be effected.

36. Under normal environmental conditions, shear stress values at the ODMDS are low, and little movement is anticipated for either cohesive or non-cohesive material. During storm events, the shear stress values increase by an order of magnitude. However, the shear stress on the dredged material disposal mound increases by less than 2 dynes/cm^2 above the shear stress of the surrounding area. When subjected to storms, material is anticipated to move from the mound for short periods of time but large dispersion of the mound is not predicted, therefore the material is not expected to effect the coral reefs.

37. Amongst the data collected during three field monitoring studies and two numerical model prediction studies, no evidence has been found to indicate that dredged material will migrate on to coral reefs. The predominant current velocities are toward the north-northeast, away from the sensitive areas. Even in the maximum anticipated westerly currents, the dredged material is shown in field data to disperse to well within the limits of background concentrations in approximately half the time it would take to reach the reefs. The model predictions have not been fully verified to prototype data in the upper few meters of the water column (results are illustrated beginning at 30 meters), however, field data collected and analyzed by AOML indicate that concentrations in the upper 3 to 8 m of the water column decrease to just above background levels in the minimum time required to reach the reefs. Therefore, the discharge of dredged material at the placement site is not predicted to cause an increase in naturally occurring concentration of TSS on the coral reefs located shoreward of the Miami ODMDS.

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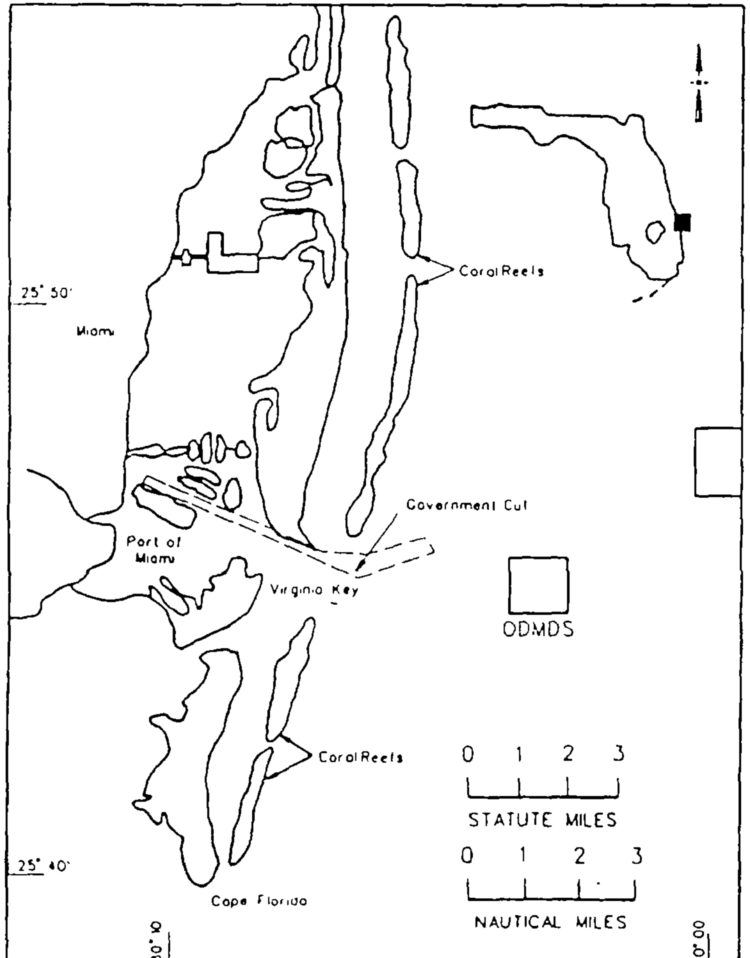
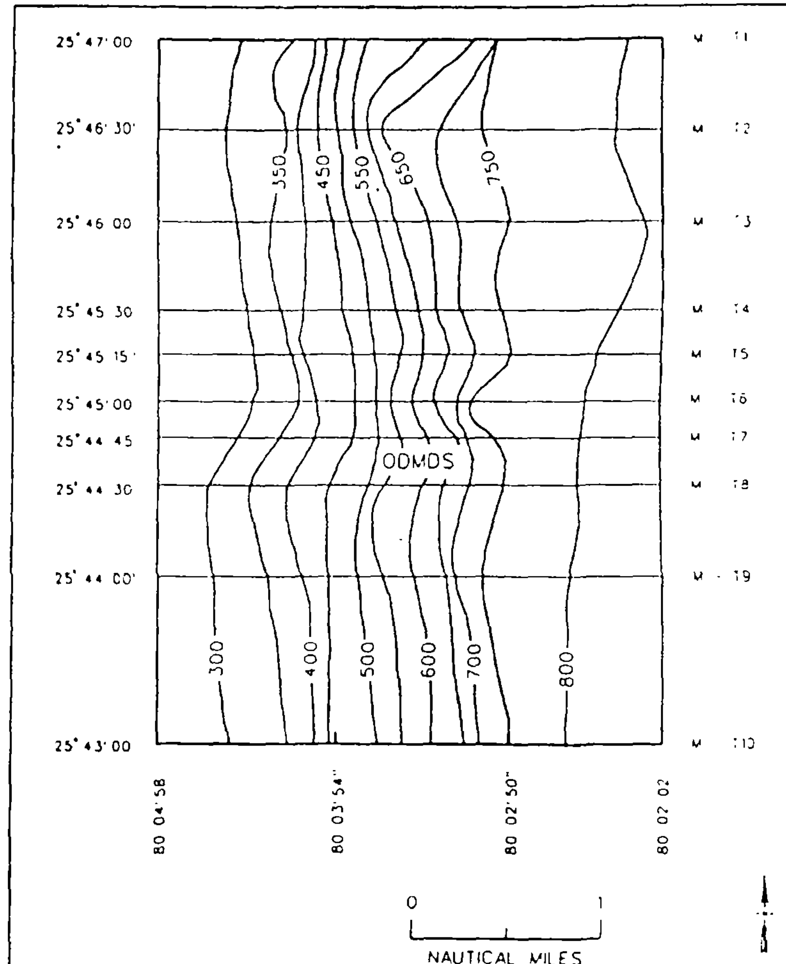


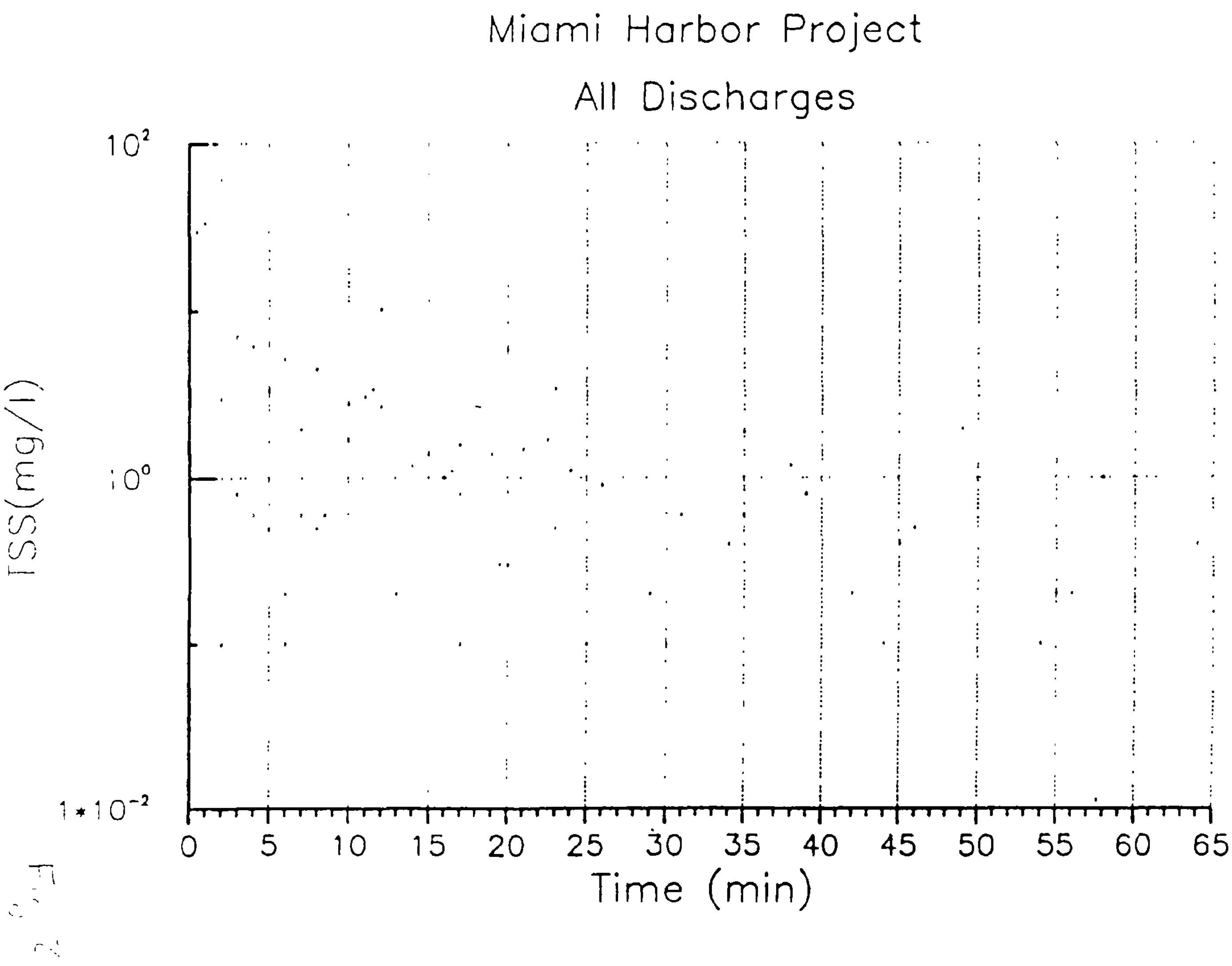
GENERAL LOCATION MAP

Ocean Dredged Material Disposal Site Miami, Florida

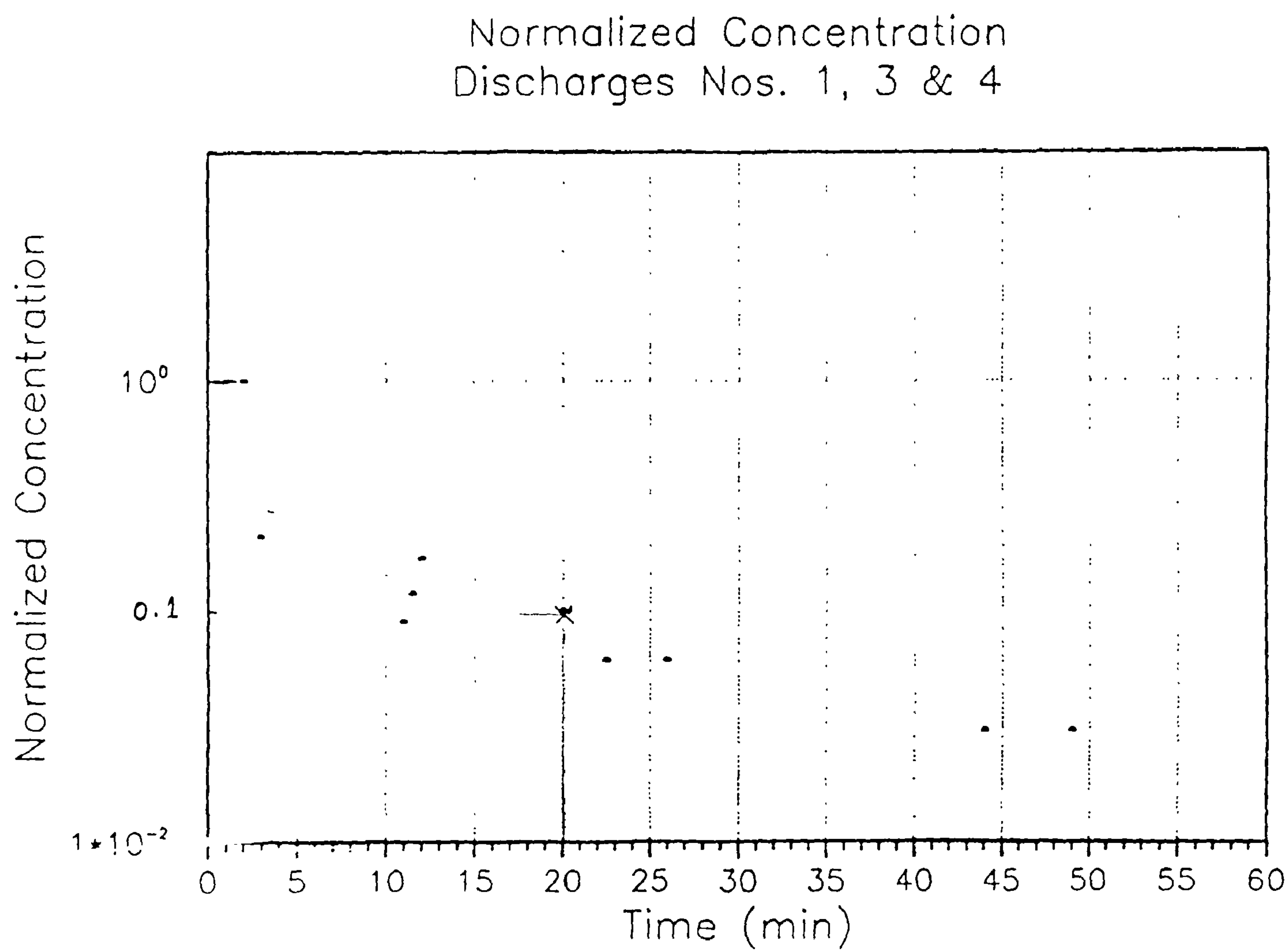


BATHYMETRIC MAP

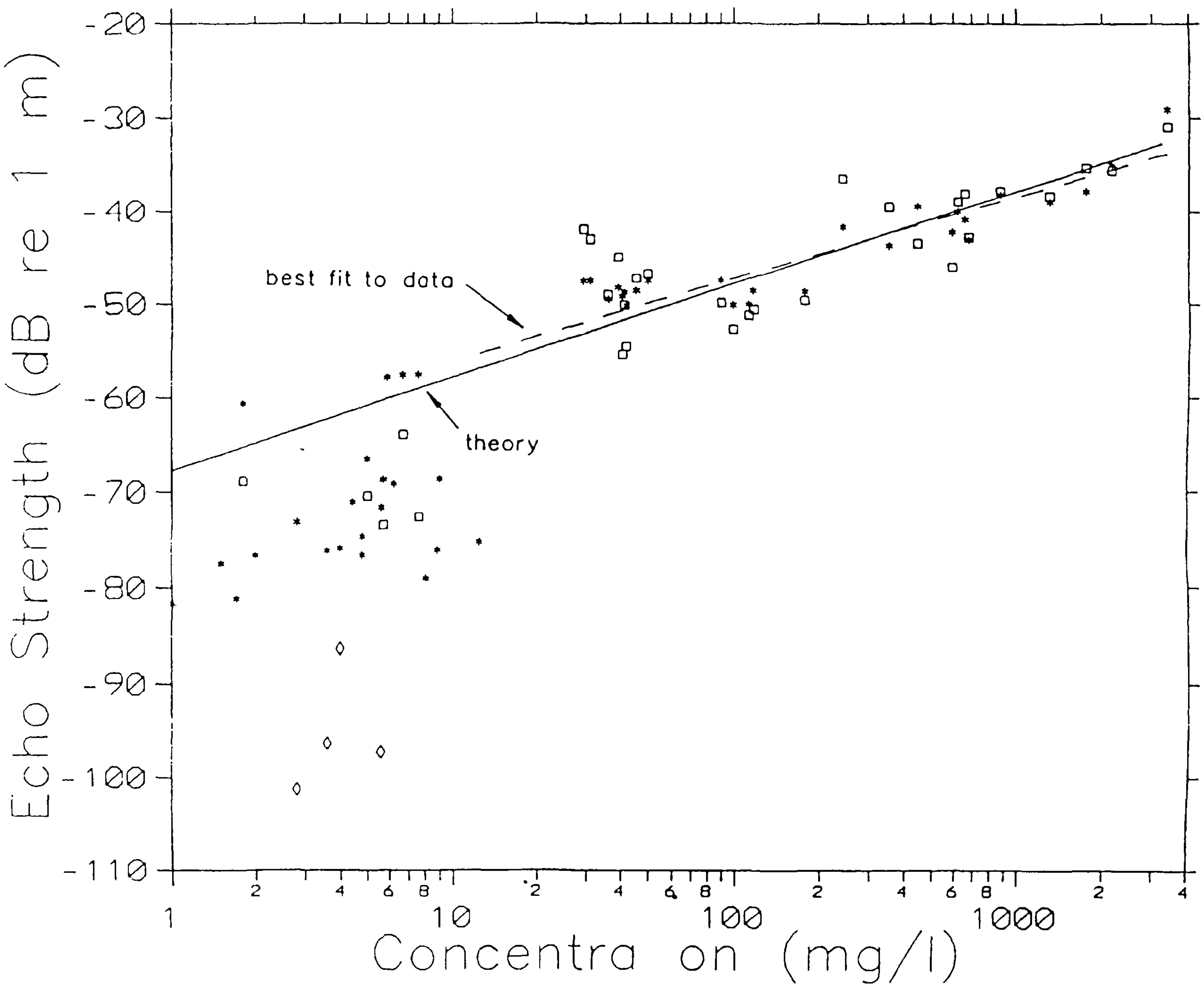
Ocean Dredged Material Disposal Site Miami, Florida



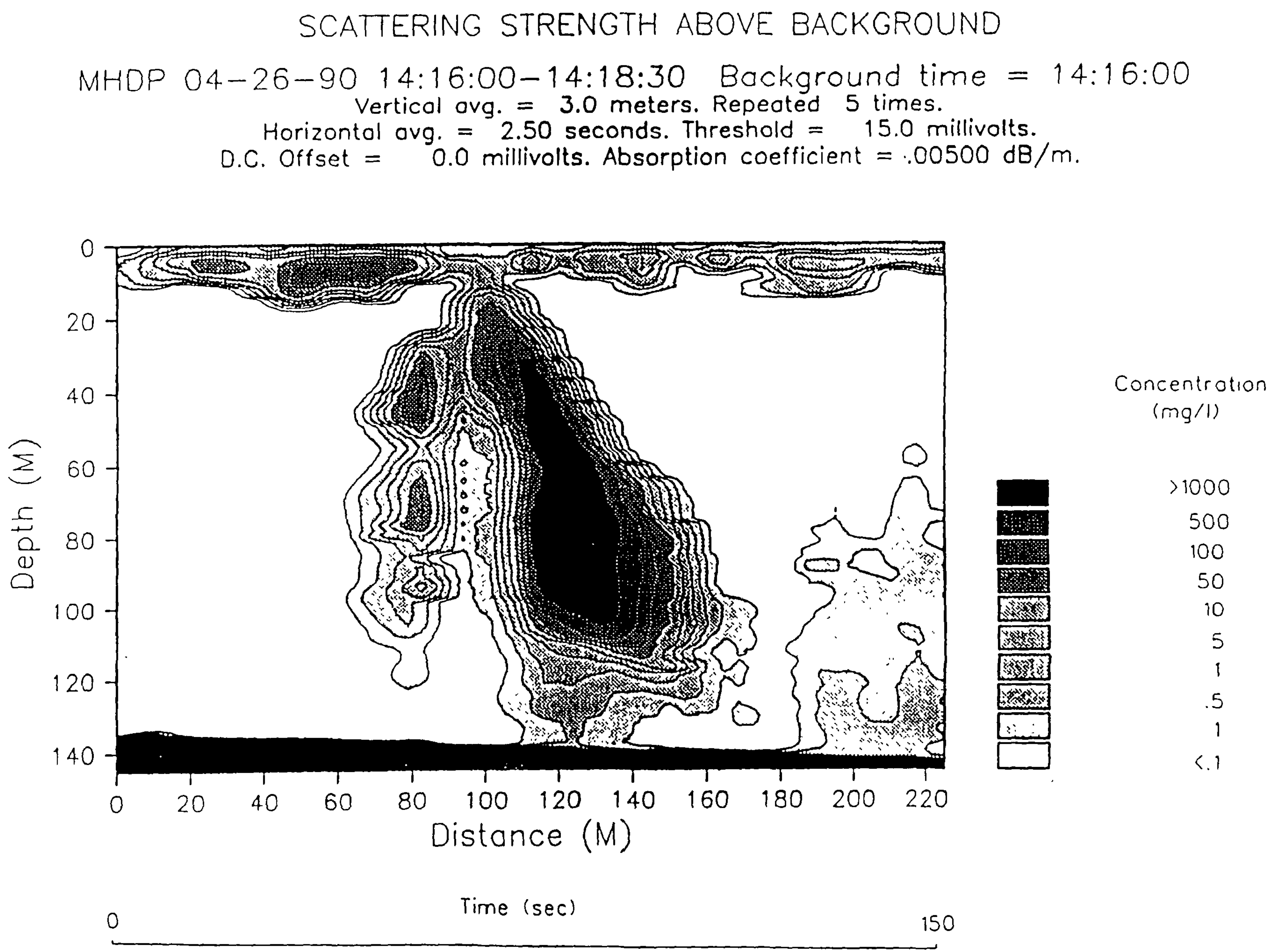
Miami Harbor Project
All Discharges
TSS(mg/l)
10²
10⁰
1*10⁻²
0
5
10
15
20
25
30
35
40
45
50
55
60
65
Time (min)



Normalized Concentration
Discharges Nos. 1, 3 & 4
Normalized Concentration
10⁰
0.1
1*10⁻²
0
5
10
15
20
25
30
35
40
45
50
55
60
Time (min)



-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
Echo Strength (dB re 1 m)
best fit to data
theory
1
2
4
6
8
10
2
4
6
8
100
2
4
6
8
1000
2
4
Concentra on (mg/l)



SCATTERING STRENGTH ABOVE BACKGROUND
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Vertical avg. = 3.0 meters. Repeated 5 times.
Horizontal avg. = 2.50 seconds. Threshold = 15.0 millivolts.
D.C. Offset = 0.0 millivolts. Absorption coefficient = .00500 dB/m.
Depth (M)
0
20
40
60
80
100
120
140
Distance (M)
0
20
40
60
80
100
120
140
160
180
200
220
Concentration (mg/l)
>1000
500
100
50
10
5
1
.5
1
<.1
Time (sec)
0
150

SCATTERING STRENGTH ABOVE BACKGROUND

MHDP 04-26-90 14:18:30-14:21:00 Background time = 14:16:00

Vertical avg. = 3.0 meters. Repeated 5 times.

Horizontal avg. = 2.50 seconds. Threshold = 15.0 millivolts.

D.C. Offset = 0.0 millivolts. Absorption coefficient = .00500 dB/m.

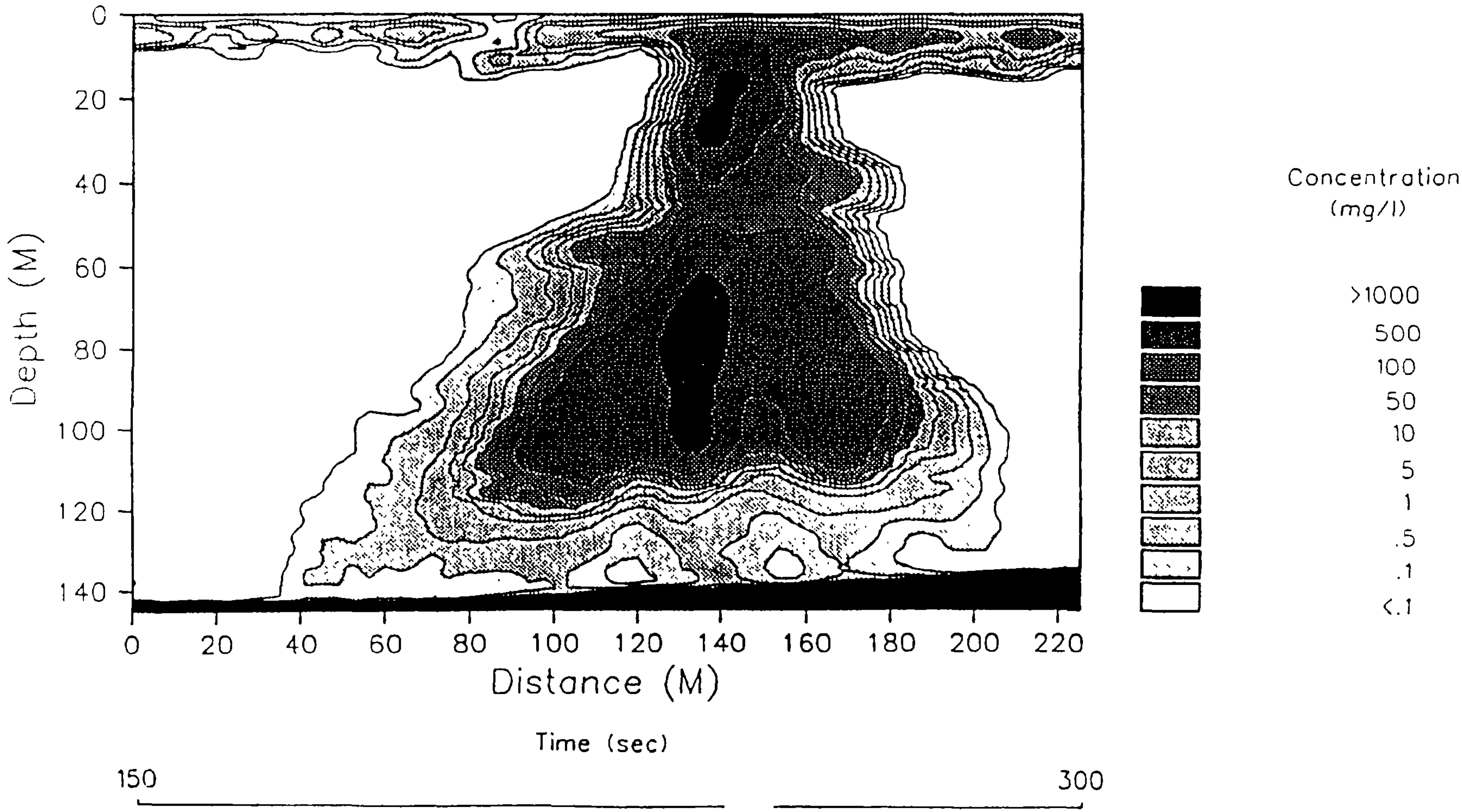
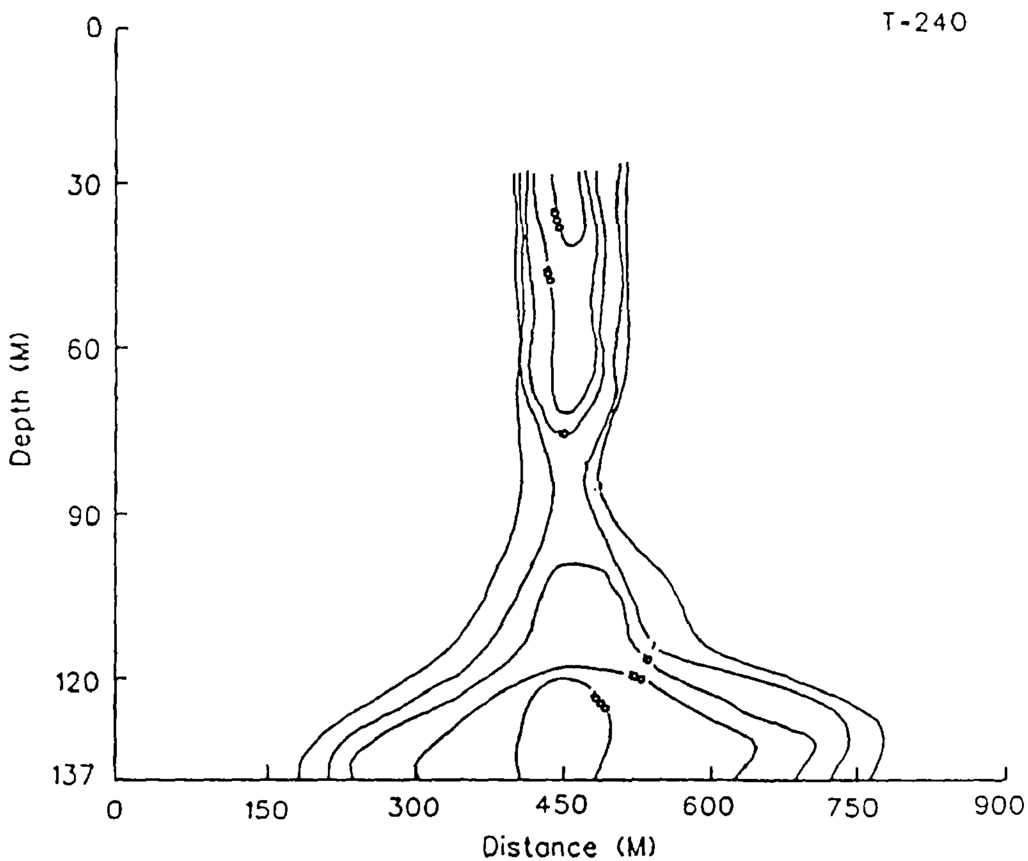


Fig 6


T-240
Depth (M)
0
30
60
90
120
137
0
150
300
450
600
750
900
Distance (M)

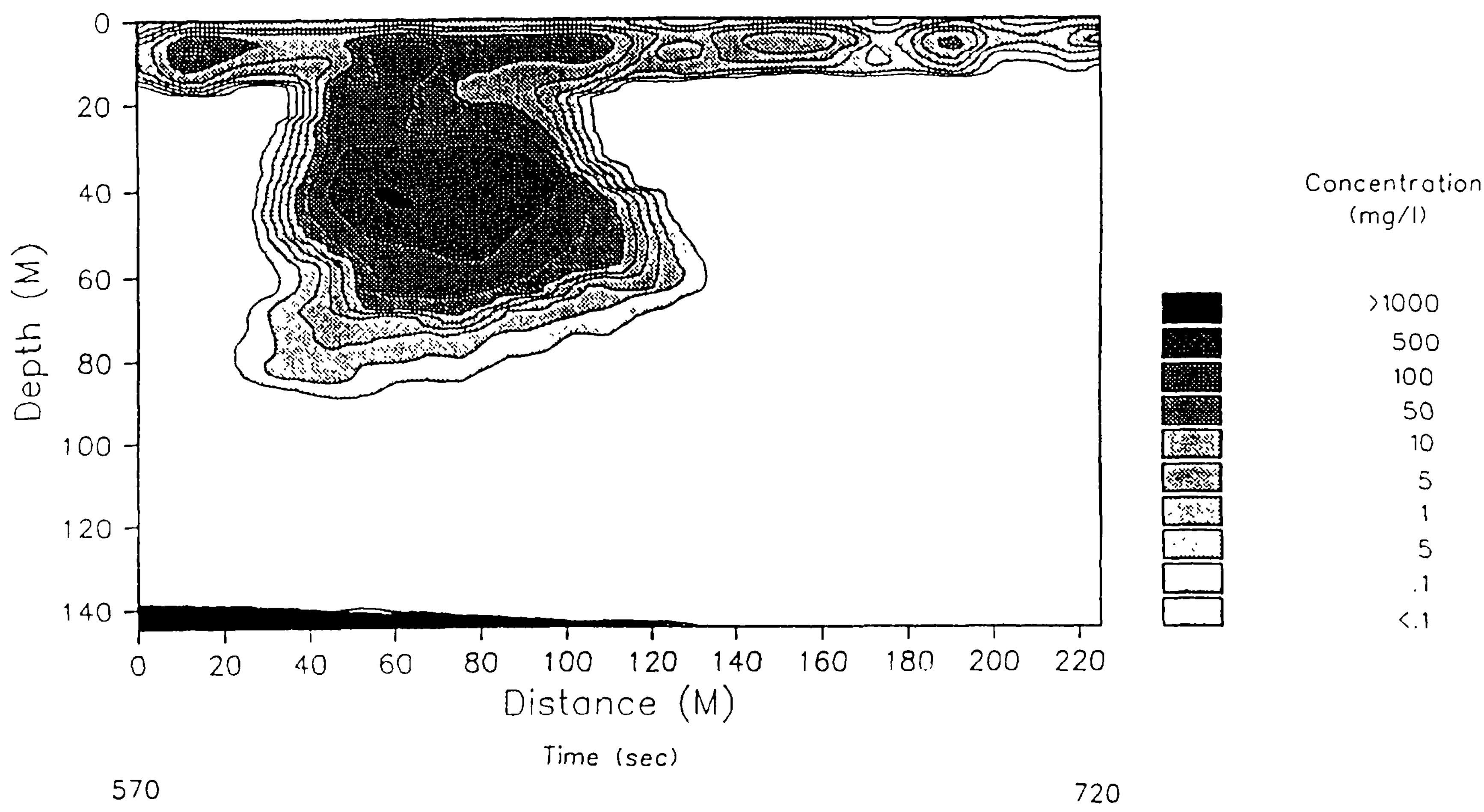
SCATTERING STRENGTH ABOVE BACKGROUND

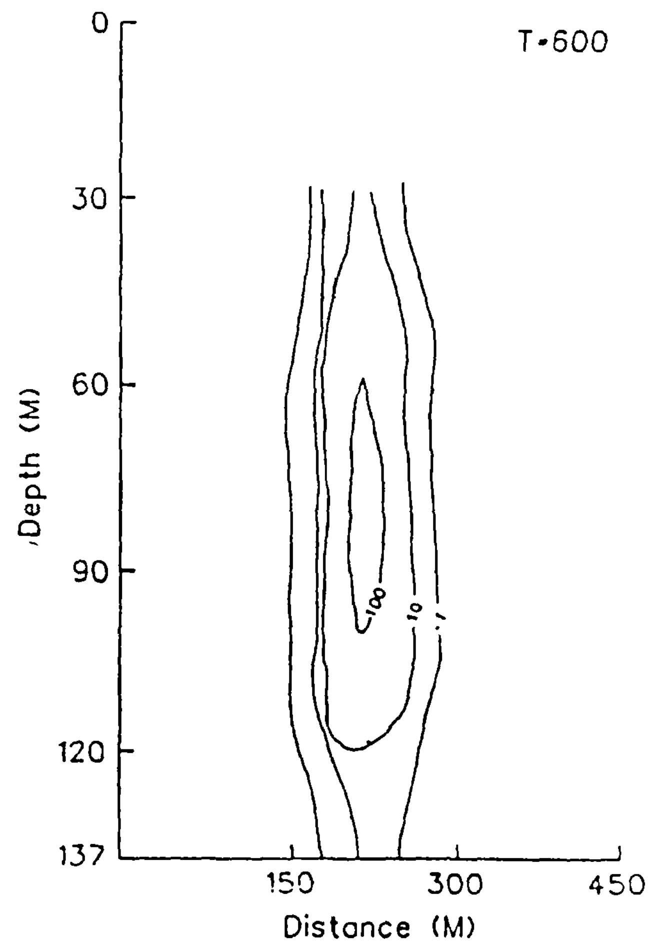
MHDP 04-26-90 14:25:30-14:28:00 Background time = 14:16:00

Vertical avg. = 3.0 meters. Repeated 5 times.

Horizontal avg. = 2.50 seconds. Threshold = 15.0 millivolts.

D.C. Offset = 0.0 millivolts. Absorption coefficient = .00500 dB/m.





T-600
0
30
60
90
120
137
Depth (M)
150
300
450
Distance (M)
100
10
1

SCATTERING STRENGTH ABOVE BACKGROUND

MHDP 04-26-90 14:31:30-14:34:00 Background time = 14:16:00

Vertical avg. = 3.0 meters. Repeated 5 times.

Horizontal avg. = 2.50 seconds. Threshold = 15.0 millivolts.

D.C. Offset = 0.0 millivolts. Absorption coefficient = .00500 dB/m.

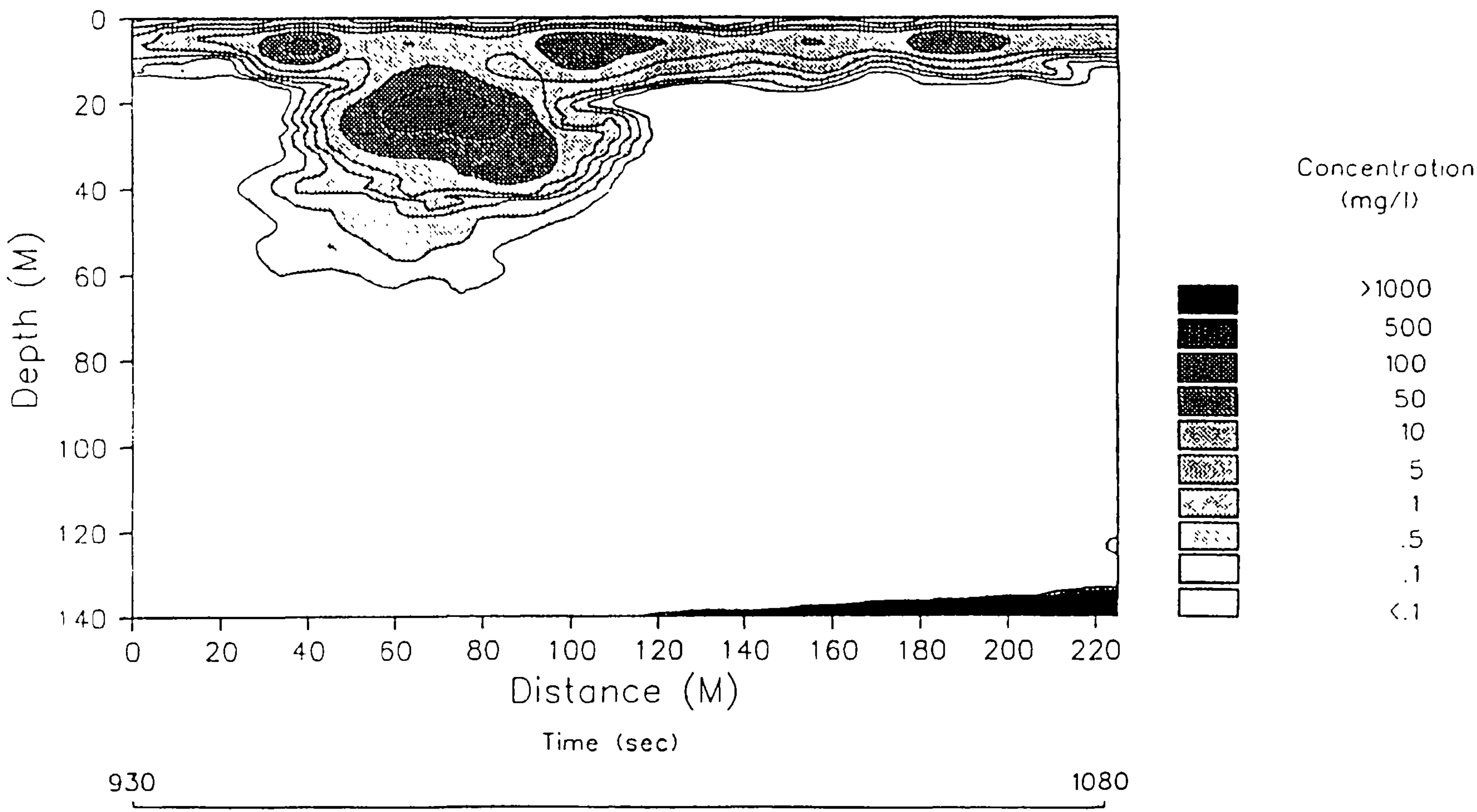
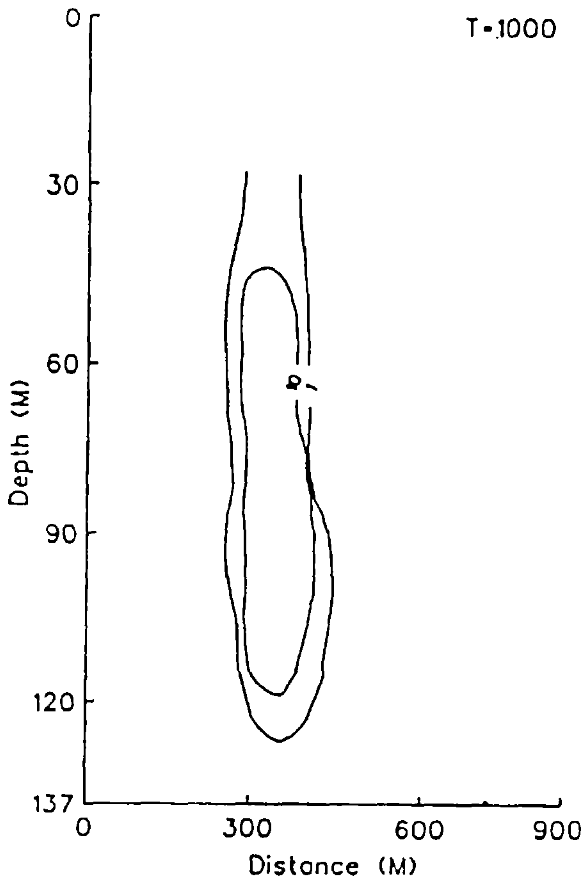


Fig 10


T=1000
Depth (M)
0
30
60
90
120
137
0
300
600
900
Distance (M)

SCATTERING STRENGTH ABOVE BACKGROUND

MHDP 04-26-90 14:38:30-14:41:00 Background time = 14:16:00

Vertical avg. = 3.0 meters. Repeated 5 times.

Horizontal avg. = 2.50 seconds. Threshold = 15.0 millivolts.

D.C. Offset = 0.0 millivolts. Absorption coefficient = .00500 dB/m.

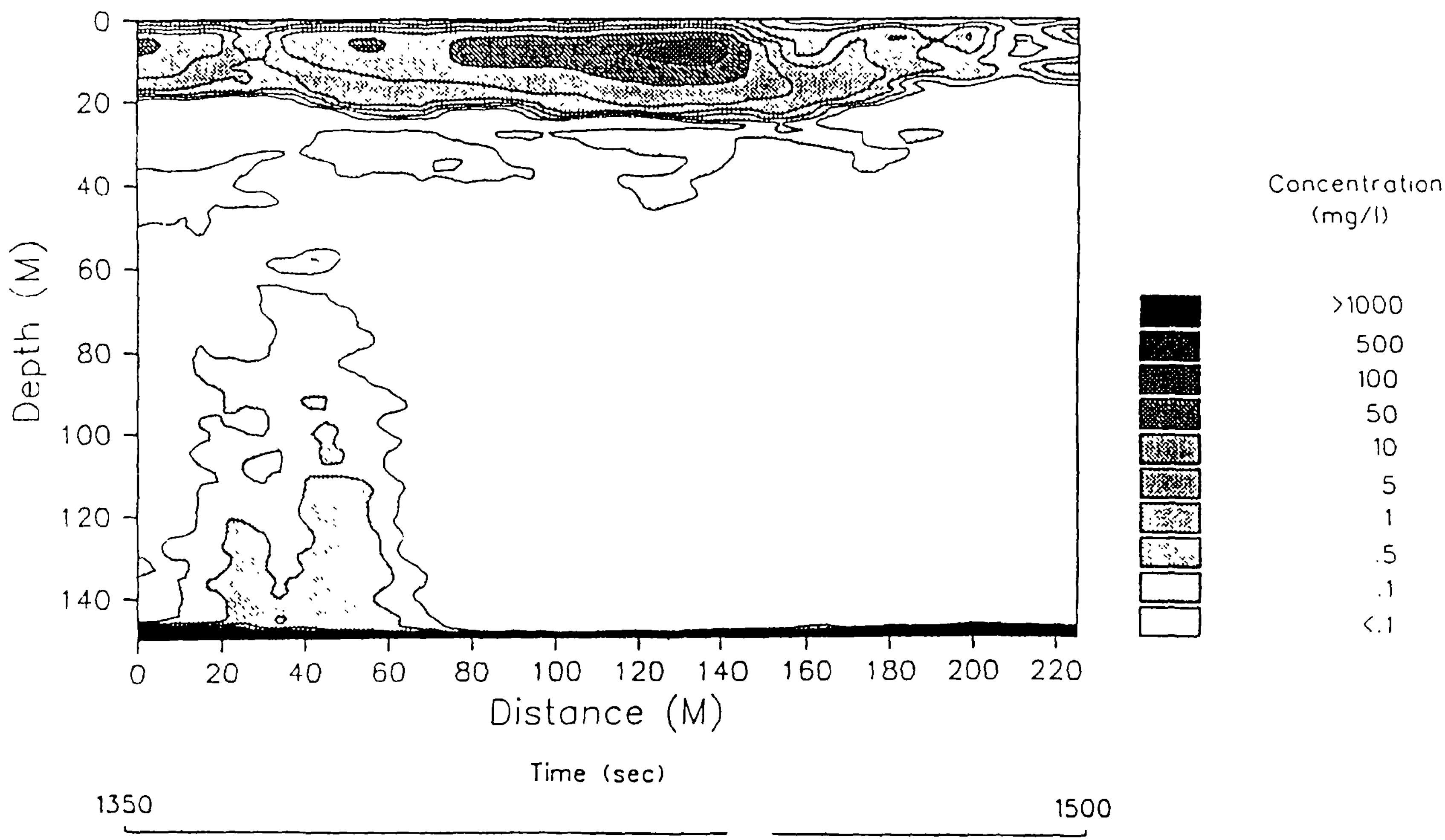
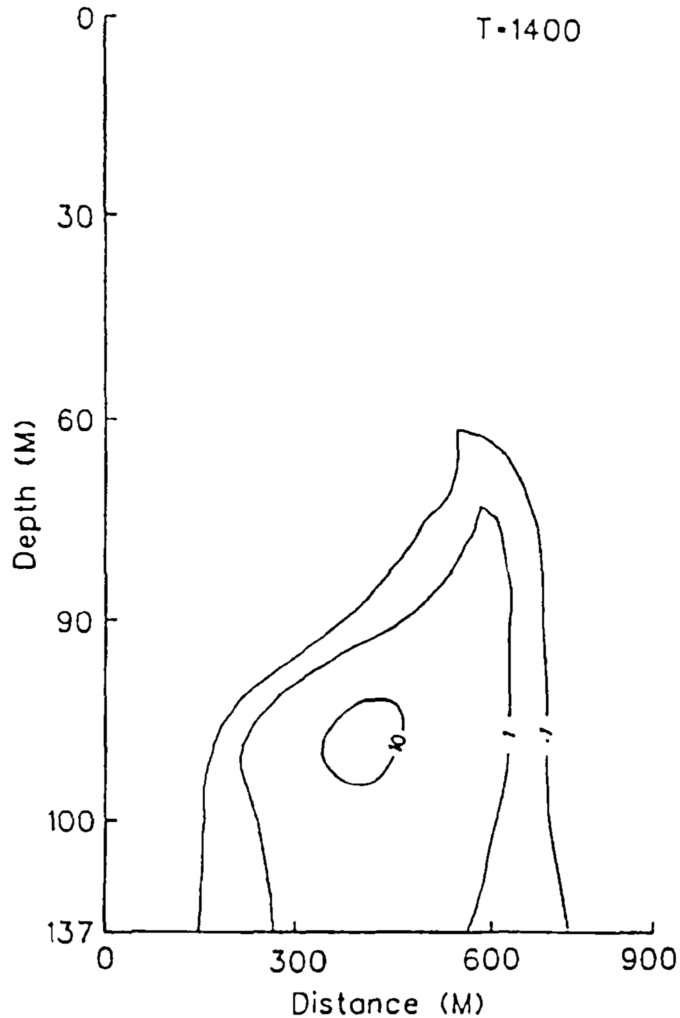
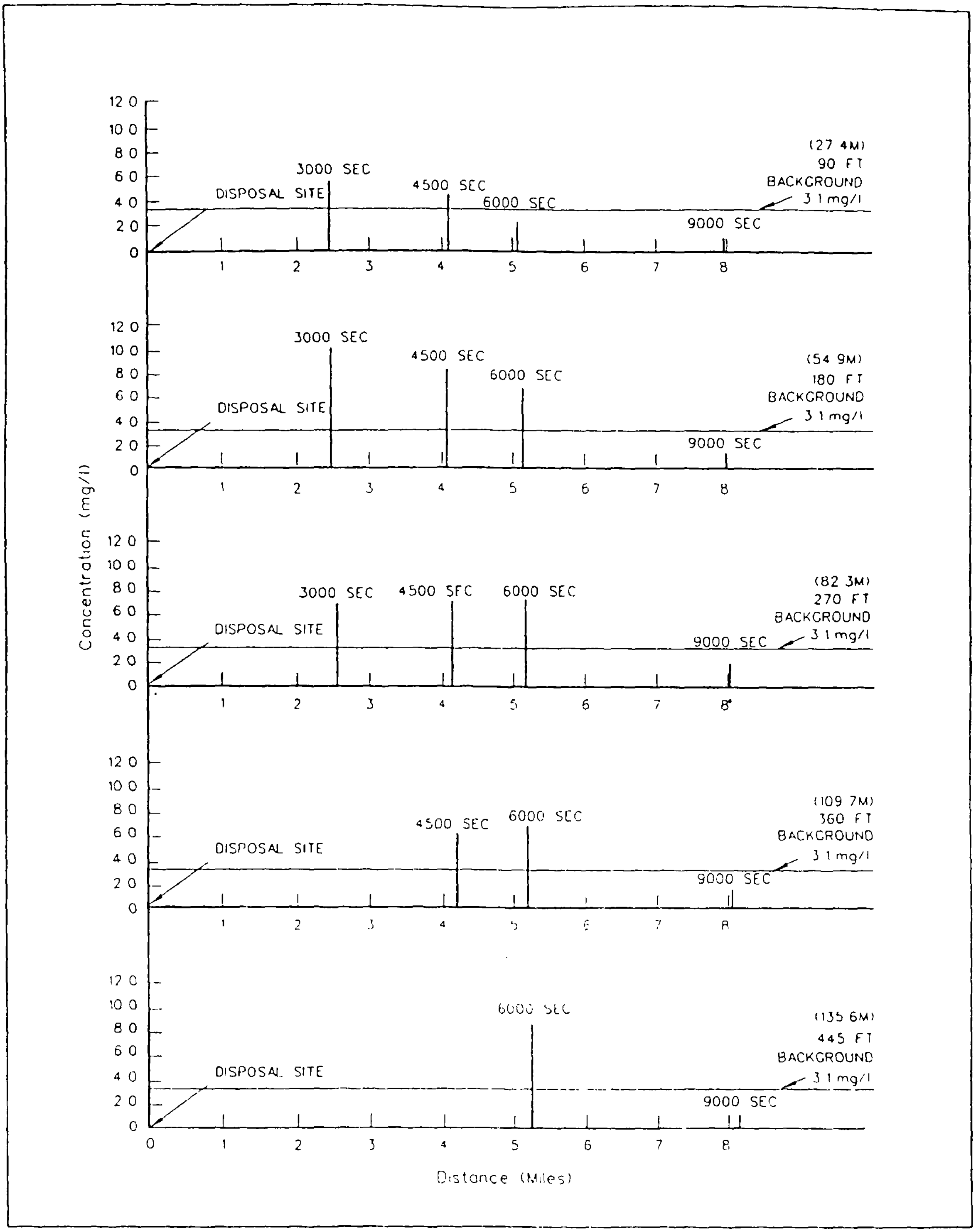
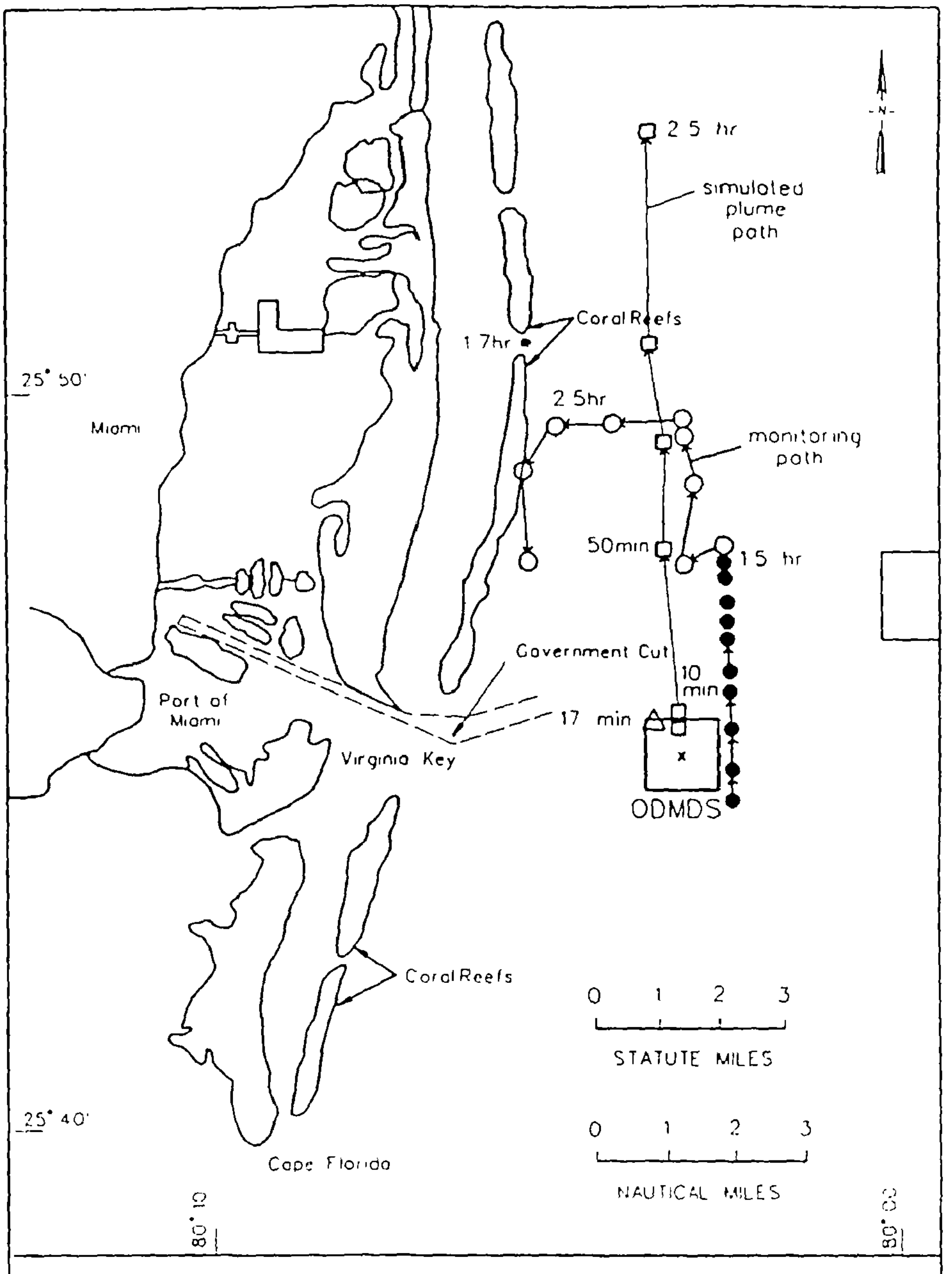


Fig 12


T-1400
0
30
60
90
100
137
Depth (M)
0
300
600
900
Distance (M)
10
1
1

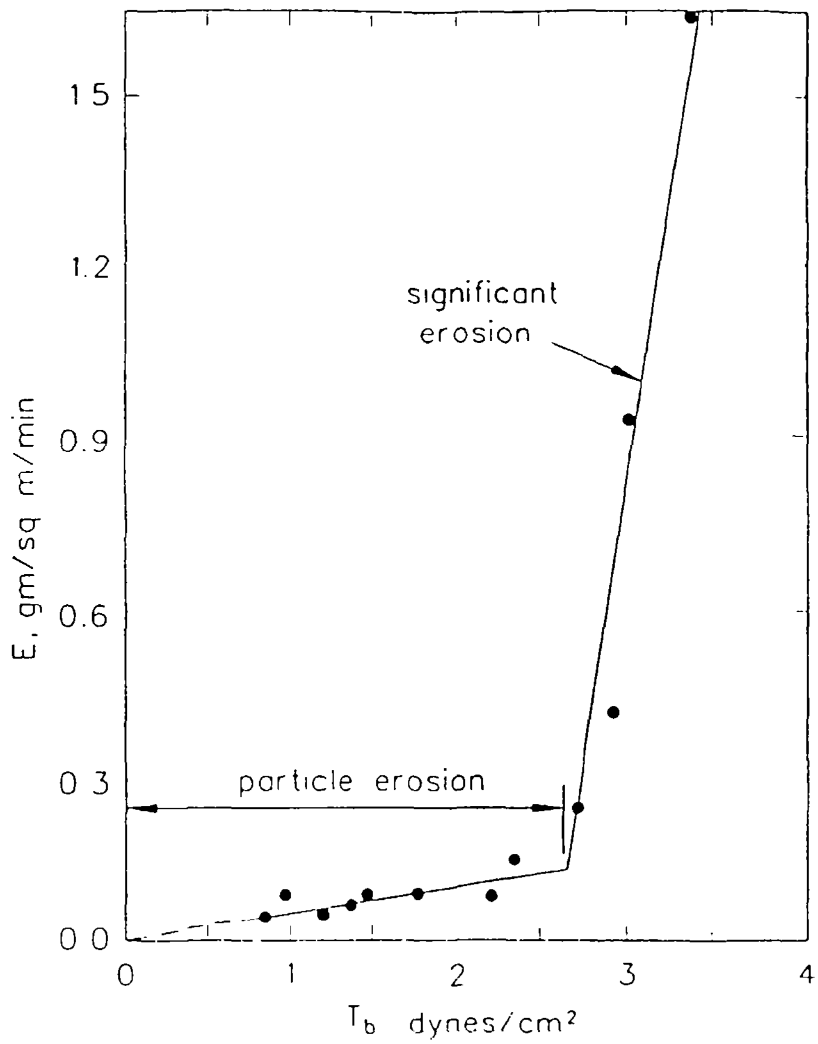

Concentration (mg/l)
Distance (Miles)
3000 SEC
4500 SEC
6000 SEC
9000 SEC
DISPOSAL SITE
(27 4M)
90 FT
BACKGROUND
3 1 mg/l
(54 9M)
180 FT
(82 3M)
270 FT
(109 7M)
360 FT
(135 6M)
445 FT



PATH OF RESIDUAL PLUME

Ocean Dredged Material Disposal Site Miami, Florida

Fig 15



1.5
1.2
0.9
0.6
0.3
0.0
E, gm/sq m/min
significant
erosion
particle erosion
0
1
2
3
4
τ_b dynes/cm²

Fig 16

APPENDIX F

MIAMI HARBOR DREDGED MATERIAL DISPOSAL PROJECT

MIAMI HARBOR DREDGED MATERIAL DISPOSAL PROJECT

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June 1991

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FIGURE CAPTIONS

FIGURE CAPTIONS (continued)

I. INTRODUCTION

There are only limited upland disposal sites of dredged material in the Miami, Florida area and the recently planned deepening of the Miami Harbor creates a need to designate by the U.S. Environmental Protection Agency (EPA) an environmentally acceptable, adequately sized and economically feasible offshore Ocean Dredged Material Disposal Site (ODMDS) for the greater Miami, Florida area (EPA, 1990). Two independent studies were carried out to comply with the Marine Protection, Research, and Sanctuaries Act (MPRSA) of 1972. Physical, chemical and biological characteristics and their interactive effects were measured (Conservation Consultants, Inc., 1985) and the probable dispersion fate of dredged materials that might be dumped at the site was modeled (Scheffner and Swain, 1989). The Draft Environmental Impact Statement of EPA (EPA, 1990) concluded that the interim-designated site, about five nautical miles offshore from Government Cut at Port of Miami and shown in Fig. 1, is suitable for designation for disposal of dredged material.

Both natural and artificial reefs are found in the proposed Miami ODMDS vicinity. The seaward extent of the natural reef zone in the area lies approximately 2.4 km inshore of the west side of the interim disposal site (Fig. 1). Two concentrations of artificial reef sites are also located in the area, one group about 6 km north and slightly inshore and the other about 3 km south and inshore of the proposed disposal site (Fig. 1). There are concerns about the potential contamination of these reef areas due to the proposed disposal of up to 6 million cubic yards of material from the Miami Harbor deepening project. One of the major reasons is that the proposed ODMDS is situated on the continental slope where the ocean circulation is strongly influenced by the nearby Florida Current. The Florida Current is that portion of the Gulf Stream system that connects the Loop Current in the Gulf of Mexico to the Gulf Stream

Miami Ocean Dredged Material Disposal Site

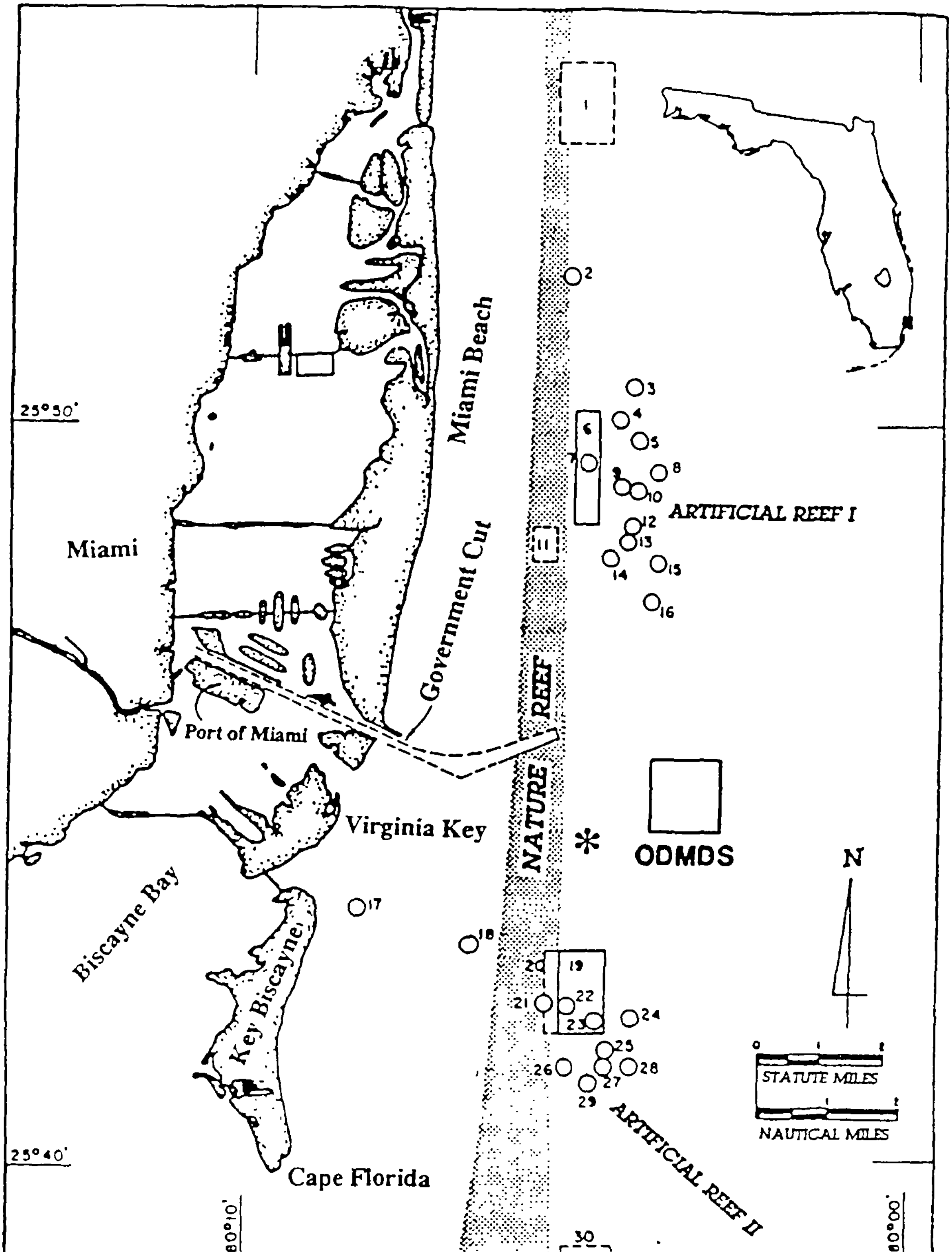

Fig. 1. Location map of Miami ODMDS. Insert at the upper right corner indicates the location of the map in Florida. Circles and squares represent active artificial reefs, except dotted squares are proposed artificial reefs.

as the flow proceeds through the Straits of Florida and into the open Atlantic Ocean (Lee et al., 1977). When the western edge of the Florida Current is over the continental shelf, the current draws the coastal waters north with it. When the western edge is seaward of the shelf, cyclonic spin-off eddies are formed. Following their formation, spin-off eddies travel northward along the continental margin at speeds ranging from 20 to 50 cm/sec. Eddies occur on the average of once per week and can be recognized as disruptions of prevailing temperature and salinity fields and of local current patterns (Lee and Mayer, 1977). These cyclonic eddies play an important role in coastal exchange processes, removing coastal water and replacing it with water from the Florida Current.

Because the designated Miami ODMDS lies near the western edge of the Florida Current and the mean current can be greater than 100 cm/sec in the spring and summer, transport, dispersion and mixing of dredged material dumped in this area could be affected greatly by physical processes associated with the Florida Current. Therefore, a monitoring study of dredged materials from the turning basin area, Port of Miami, that were dumped in the designated Miami ODMDS was undertaken during the period of April 24 to April 26, 1990. A second phase of study took place between June 26 and June 28, 1990. One major objective of the study is to identify and monitor environmentally significant physical processes at the ODMDS site, which would change the fate of dredged materials dumped at the site. One of those significant quantities is the maximum reef-directed shoreward current that would transport dumped material to the coral reef area. Another objective is to compare the in-situ measurements and observations with results of a numerical modeling study (Scheffner and Swain, 1990).

The Ocean Acoustic Division (OAD) of the Atlantic Oceanographic and Meteorological Laboratory (AOML), a component of NOAA (National Oceanic and Atmospheric Administration), has been at the forefront of the analysis and technology required for understanding coastal ocean processes and their influence on the dispersion of material discharged into the open ocean. During the last 15 years, OAD has applied this acoustic remote sensing technique to study ocean disposal of different materials at various environments and locations. Among these studies were sewage sludge in New York Bight (Proni et al., 1976), river bottom dredged material in Lake Ontario (Proni et al., 1977), pharmaceutical wastes off Puerto Rico, drilling muds from an oil rig in the Gulf of Mexico (Trefey and Proni, 1983), dredged material in New York Bight (Tsai, 1984; Tsai and Proni, 1985), and more recently dredged material in Mobile Bay. Results from these studies have provided good evidence that acoustic remote sensing can be very useful for studying waste disposal in the ocean.

The Miami Harbor Dredging Material Dumping Study is a joint project of the U.S. Army Engineer District, Jacksonville and the Coastal Engineering Research Center (CERC) of the U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Mississippi, and was conducted by OAD/AOML of NOAA, Miami. The plume concentration of discharged material and current velocity were monitored continuously to depths as great as 160 m and are believed to provide the first reliable measurements of sediment plume dynamics over such depths in the open ocean. The data and observations for all dredged material placement operations during this project indicate that the waste plume moved toward the north to north-east, that is northward and away from sensitive coral reef areas of concern. The results also support predictions from previous numerical modeling and certain conclusions reached in the EPA Draft EIS. The procedures followed and results obtained are expected to provide information on other ODMDS's managed by the Jacksonville District.

II. FIELD OPERATION

The entire operation took place in two phases, Phase I from April 24 to 26, 1990 and Phase II from June 26 to 28, 1990. During Phase I, eight dumps of dredged material from the Miami Harbor turning basin area were carried out, and the waste plumes were monitored continuously with an Acoustic Concentration Profiler (ACP) of OAD/AOML and an Acoustic Doppler Current Profiler (ADCP) of RDI (RD Instruments, Inc.). The ADCP was not used during the Phase II because it was not available during that time. There were no dumps monitored during Phase II because the contracted dredging operation was unexpectedly finished early. During both phases, CTD (Conductivity-Temperature-Depth) stations were taken using a Seabird CTD profiler, and water/sediment samples were collected continuously from a towed pump sampler when the ship was underway. Sediment samples were collected from the dredging vessel with a sediment grab sampler during Phase I.

The ADCP was mounted at the port side of the monitoring vessel (Sea Explorer), opposite to the towed transducer of the ACP. The ADCP transmits short acoustic pulses along narrow beams at a known, fixed frequency (150 MHz). It listens to and processes the echoes from successive volumes (depth cells or 'bins) along the beams to determine how much the frequency has changed. The difference in frequency between transmitted and reflected sound is proportional to the relative velocity between the ADCP and the particles in the water that do the reflecting (backscattering). This frequency shift results from the Doppler effect. The ADCP uses an autocovariance method to compute the mean value or first moment of the Doppler frequency, and from this computed first moment of frequency, velocity of the scatterers is determined. However, the current at each depth cell is assumed to be the same for all beams (the homogeneous velocity assumption). The ADCP also provides echo amplitude as a byproduct of the AGC (Automatic Gain Control) circuits. This echo amplitude estimates backscatter intensity and is comparable with the acoustic intensity measurement from ACP. Backscattering cross sections derived from both the ADCP echo amplitude and the ACP acoustic intensity can be used to estimate the particulate concentrations of suspended wastes in the water column and to compare with particle concentrations derived from bottle samples.

The ACP has five major components as a system (Fig. 2). (1) It has transducers mounted in a streamlined towbody, aiming vertically downward and towed on the starboard side of the ship at a nearly constant depth of about 1 m below the water surface. The two transducers have acoustic frequencies of 20 kHz and 200 kHz. (2) The ACP uses a Datasonic model DFT-210 dual channel acoustic transceiver with several features not found in standard acoustic transceivers. It provides digital control of transmitter output pulse and receiver gain characteristics to allow accurate measurement of target echo levels. A precision low noise preamplifier is incorporated within the receiver to extend the system dynamic range and to allow measurement of very low backscattering levels. The DFT-210 also offers multiple receiver outputs and interfaces for simultaneous recording and display. (3) Two Raytheon TDU-850 digital chart recorders were used to record echographs from the DFT-210, one for 20 kHz signals and the other for 200 kHz. The TDU-850 is a thermal display unit which generates hard copy of true gray shades at high speed and with high resolution, producing near photographic quality. It features a universal interface that transfers data rapidly and relies on synchronization of clock and data signals to transfer the image in a

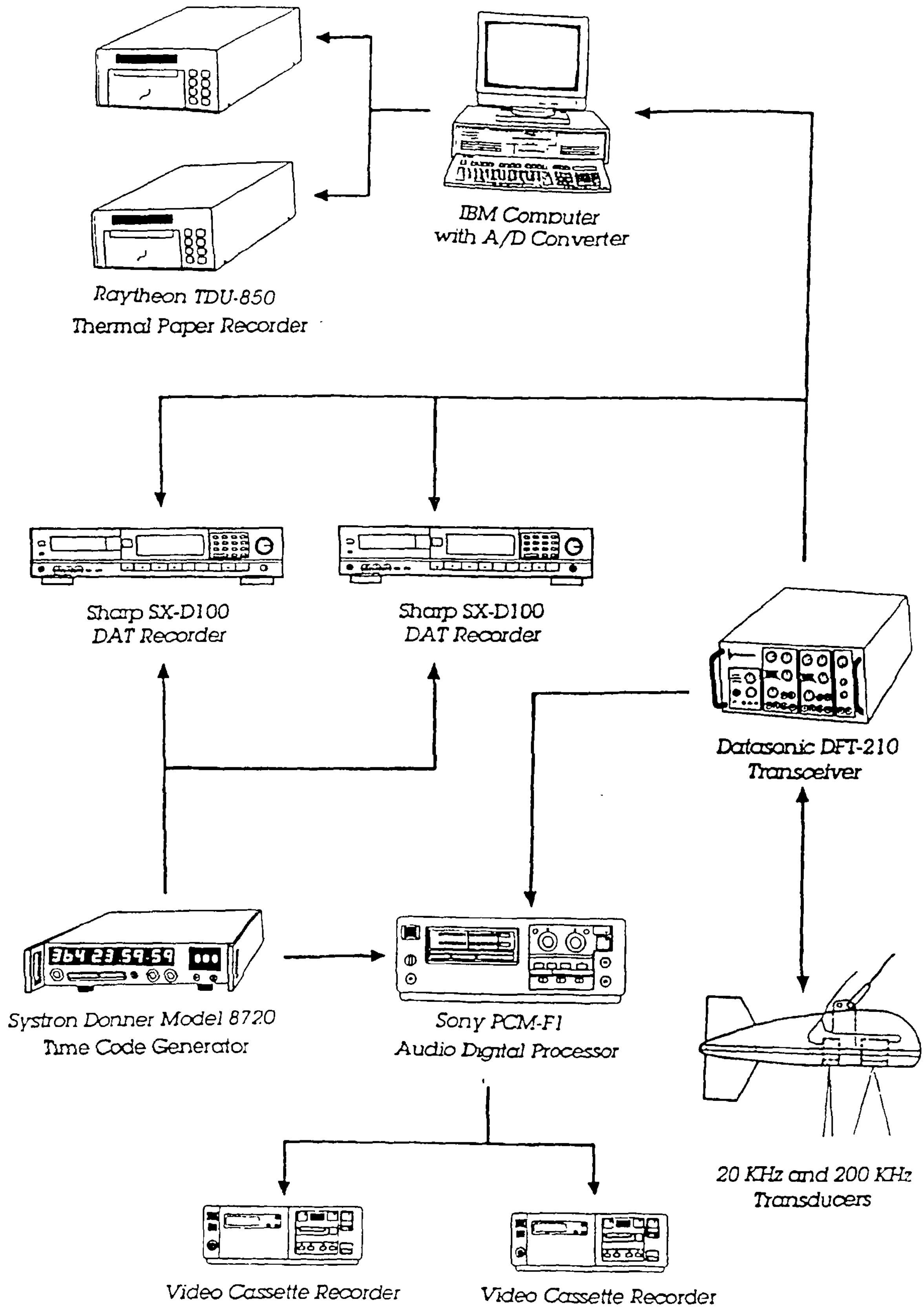

Fig. 2. Signal flow chart of acoustic concentration profiler system.

raster scan format. (4) Both receiver outputs from the 20 kHz and 200 kHz transducers were also recorded respectively onto two Sharp SX-D100 digital audio tape (DAT) recorders with IRIG-B time code generated from a Systron Donner Model 8720 time code generator. The recorded outputs were processed later to obtain the acoustic back-scattering strength from which the waste concentration is derived. (5) The receiver outputs were recorded separately on two standard VHS video cassette tapes using a Sony PCM-F1 Audio Digital Processor. These VHS tapes serve as backup and have the same data as those on the DAT.

There were eight dumps in total for the entire operation. Before each dump and between successive dumps, the Sea Explorer monitored the water column to obtain background concentrations of suspended materials and ambient currents in the area using the ACP and ADCP on board the vessel. Ambient density and salinity were measured by taking CTD stations at the previous dumping spots that were determined from the ship track records. There were six CTD stations in Phase I and 50 stations in Phase II. CTD stations taken during Phase II were not based on the actual dumping location because no dumping took place in Phase II. Sediment samples were collected directly from the dredging vessel Atchafalaya for each dump. The dumping would occur for most of the dumps when Atchafalaya had just made the turn to head shoreward. Both the ADCP and ACP were set ready to operate upon the approach of Atchafalaya and the Sea Explorer proceeded to make the transects immediately after the dumping commenced. The Sea Explorer would track the waste plume for several transects until the ACP could not detect the plume any more. It usually took about 40 minutes since the release. During each transect, water samples were taken by a towed V-fin with a pump that pumps water continuously through a hose to the deck of the moving ship. The water sampling took place at approximately constant depth by maintaining constant ship speed, and collecting samples only during the time when transects were in the plume. During the first two-day operation, ship positions were automatically logged with a computer and displayed in real time to assist monitoring. A drift buoy was to be deployed to mark the spot of each dump but was never used. However, the surface features of the waste plume were visible up to 30 minutes and were helpful in tracking the plume. All ship tracks are presented in Appendix A for reference.

III. DATA ANALYSIS

The primary data obtained from the Phase I were the ACP data recorded on the DAT and VHS tapes and the ADCP data stored on computer diskettes. In addition, water samples and sediment samples were collected during Phase I. However, no detailed analysis has been done with the water samples and the sediment samples. Grain size distributions are available from analysis of samples taken in 1988. CTD data were obtained in Phases I and II and made up the major portion of data collected in Phase II. CTD stations are summarized in Table 1 for Phase I and in Tables 2-1, 2-2 and 2-3 for Phase II. Station locations are presented on page B1-2 of Appendix B1 and page B2-2 of Appendix B2. For Phase II, station locations are separated into three sections for the three days and listed on pages B2-4, 19, and 38. All temperature, salinity, and density profiles for both phases were plotted for each station as shown in Appendices B1 and B2. All observational data and results of analysis are described below.

Water Depths

The Miami ODMDS is situated on the continental slope with depths ranging from 425 to 785 feet, or 130 to 240 m (Fig. 3). The depth at the

Table 1

CTD stations and temperature, density and salinity gradients for Phase I

CTD No.	Date	Time	Temperature Gradients (deg C/m)		Density Gradients (gm/cc/m)		Salinity Gradient (ppt/m)
			Overall	Middle	Overall	Middle	Overall
1	04/24/90	10:49:30	-0.107	-0.055 -0.275	0.023	0.014 0.064	0.011
2		13:16:30	-0.108	-0.107	0.025	0.019	0.017
3		18:17:00	-0.109	-0.068	0.023	0.019	0.018
4	04/25/90	11:12:00	-0.127	-0.081	0.030	0.019	0.029
5		15:59:00	-0.124	-0.130	0.030	0.027	0.018
6	04/26/90	09:29:00	-0.138	-0.100	0.028	0.027	0.017

Table 2-1

CTD stations and temperature, density and salinity gradients for June 26, 1990 of Phase II

CTD No.	Date	Time	Temperature Gradients (deg C/m)		Density Gradients (gm/cc/m)		Salinity Gradient (ppt/m)
			Overall	Middle	Overall	Middle	Overall
1	06/26/90	10:12:00	-0.135	-0.195	0.038	0.058	0.002
3		12:34:20	-0.106	-0.155	0.027	0.036	0.006
4		13:25:13	-0.112	-0.155	0.032	0.044	0.008
5		14:21:50	-0.103	-0.147	0.025	0.043	0.008
6		15:18:30	-0.103	-0.162	0.026	0.039	0.005
7		16:04:44	-0.104	-0.201	0.024	0.056	0.009
8		16:59:23	-0.098	-0.227	0.022	0.071	0.012
9		18:18:00	-0.105	-0.332	0.026	0.126	0.014

Table 2-2

CTD stations and temperature, density and salinity gradients for June 27, 1990 of Phase II

CTD No.	Date	Time	Temperature Gradients (deg C/m)		Density Gradients (gm/cc/m)		Salinity Gradient (ppt/m)
			Overall	Middle	Overall	Middle	Overall
17	06/27/90	00:47:14	-0.113	-0.320	0.028	0.096	0.012
18		01:50:43	-0.109	-0.285	0.024	0.085	0.010
19		03:39:23	-0.088	-0.098	0.018	0.026	0.010
20		10:50:57	-0.137	-0.365	0.035	0.115	0.010
21		11:25:13	-0.124	-0.133	0.030	0.039	0.008
22		12:39:16	-0.101	-0.140	0.023	0.033	0.010
23		14:10:02	-0.105	-0.222	0.025	0.066	0.007
24		14:50:13	-0.132	-0.660	0.038	0.210	0.002
28		16:36:39	-0.113	-0.214	0.026	0.062	0.008
29		17:46:03	-0.118	-0.199	0.028	0.059	0.007
30		19:31:08	-0.119	-0.216	0.027	0.062	0.008
31		20:25:12		-0.332		0.098	
32		22:14:20	-0.111	-0.288	0.025	0.092	0.015

Table 2-3

CTD stations and temperature, density and salinity gradients for June 28, 1990 of Phase II

CTD No.	Date	Time	Temperature Gradients (deg C/m)		Density Gradients (gm/cc/m)		Salinity Gradient (ppt/m)
			Overall	Middle	Overall	Middle	Overall
33	06/28/90	00:04:15	-0.119	-0.314	0.029	0.088	0.006
34		01:03:26	-0.112	-0.157	0.026	0.042	0.006
35		02:49:02	-0.132	-0.185	0.031	0.055	0.006
37		05:02:39	-0.093	-0.143	0.018	0.033	0.010
38		06:52:58	-0.119	-0.268	0.027	0.070	0.006
39		07:43:14		-0.413		0.133	
42		15:05:34		-0.354		0.099	

Miami Ocean Dredged Material Disposal Site

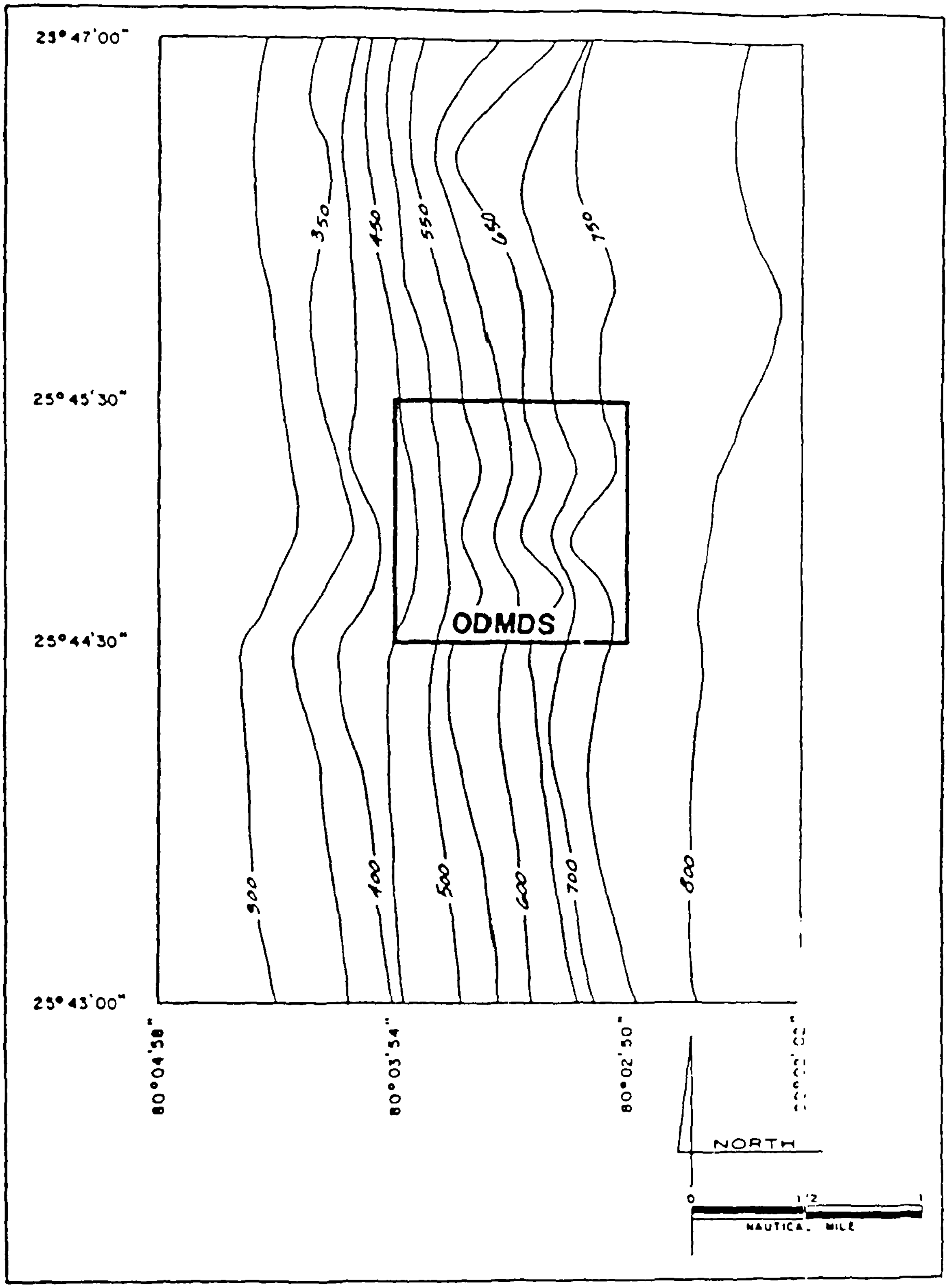

Fig. 3. Bathymetric map in the vicinity of the Miami ODMDS; water depth in feet.

center of the site is approximately 625 feet (191 m). The average declivity of the slope at the ODMDS is approximately 325 feet (100 m) per nautical mile (1.85 km). The eight dumps during Phase I took place at locations with depths varying from 120 m to 170 m.

Temperature Profiles

The temperature profiles indicate a well mixed surface layer of 25°C temperature for the three-day period of Phase I (Fig. 4). There are strong gradients below 50 m depth and extend possibly all the way to the ocean bottom. The surface temperature varies only about 0.5 degree a day. Temperature gradients differ significantly from time to time and day to day, however. This temperature difference creates important variations in density stratification (Fig. 5) because the salinities do not change significantly (Fig. 6). One temperature profile at the time 10:49:30 on April 24, 1990 shows a distinguishable second gradient at the intermediate water of small depth region between 35 and 65 m. There also exists a slight gradient instead of constant temperature in the surface layer for April 25, 1990 at 11:12:00. On April 24 at 10:49:30, the temperature profile indicates a four layer structure with different gradients.

Temperatures in June show stronger gradients, but in general there is a shallower mixed layer near the surface. In fact, six profiles on June 26, three on June 27 and one on June 28 show no mixed layer near the surface. In contrast, two mixed layers were observed at 06:52:58 on June 28. Daily differences seem to be small when temperature profiles were grouped together and plotted in the same graphs for similar depths. All individual temperatures for each station with their salinity and density profiles are included in Appendix B1 for Phase I and Appendix B-2 for Phase II.

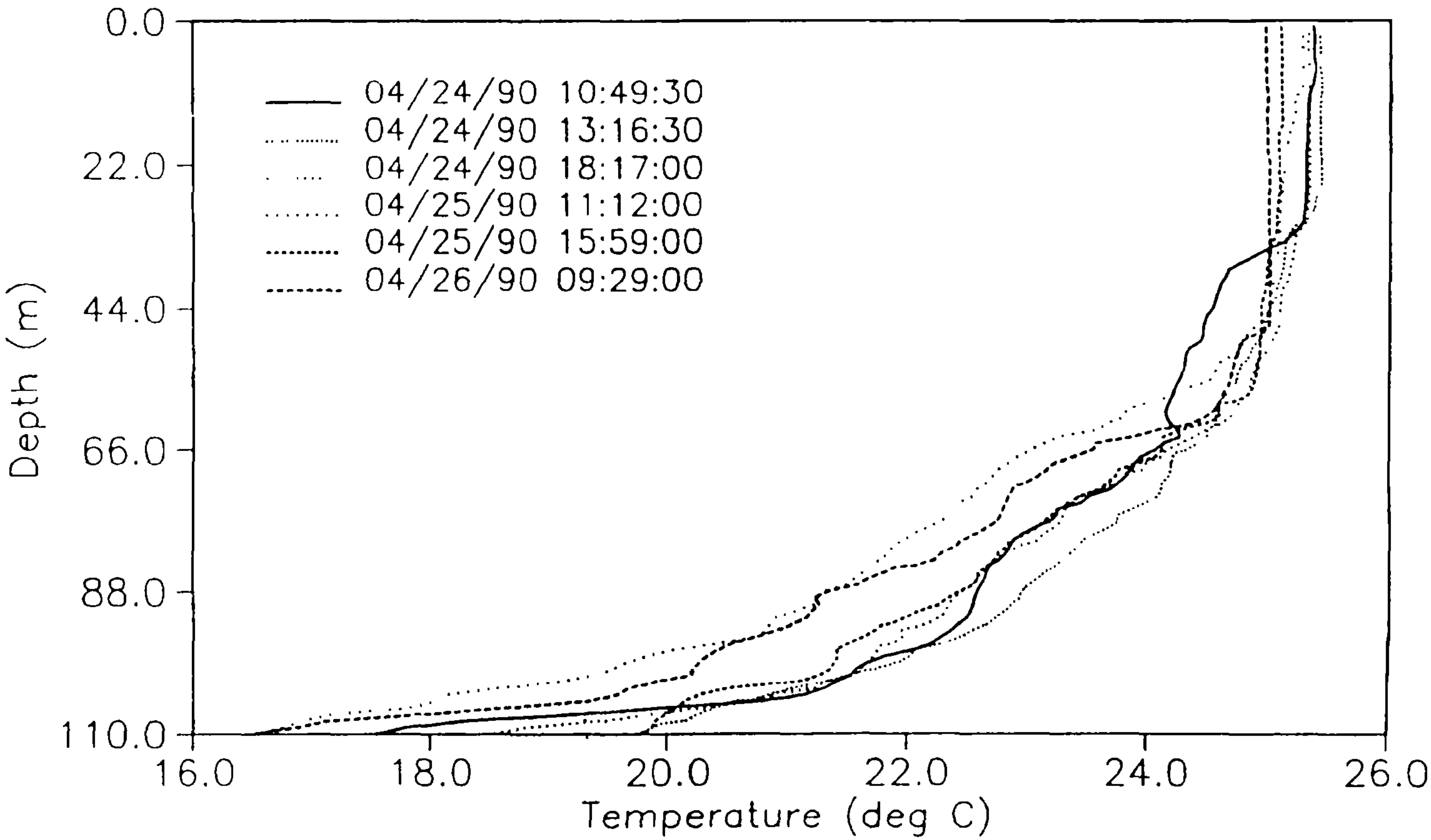

Fig. 4. Temperature profiles from six CTD stations of Phase I.

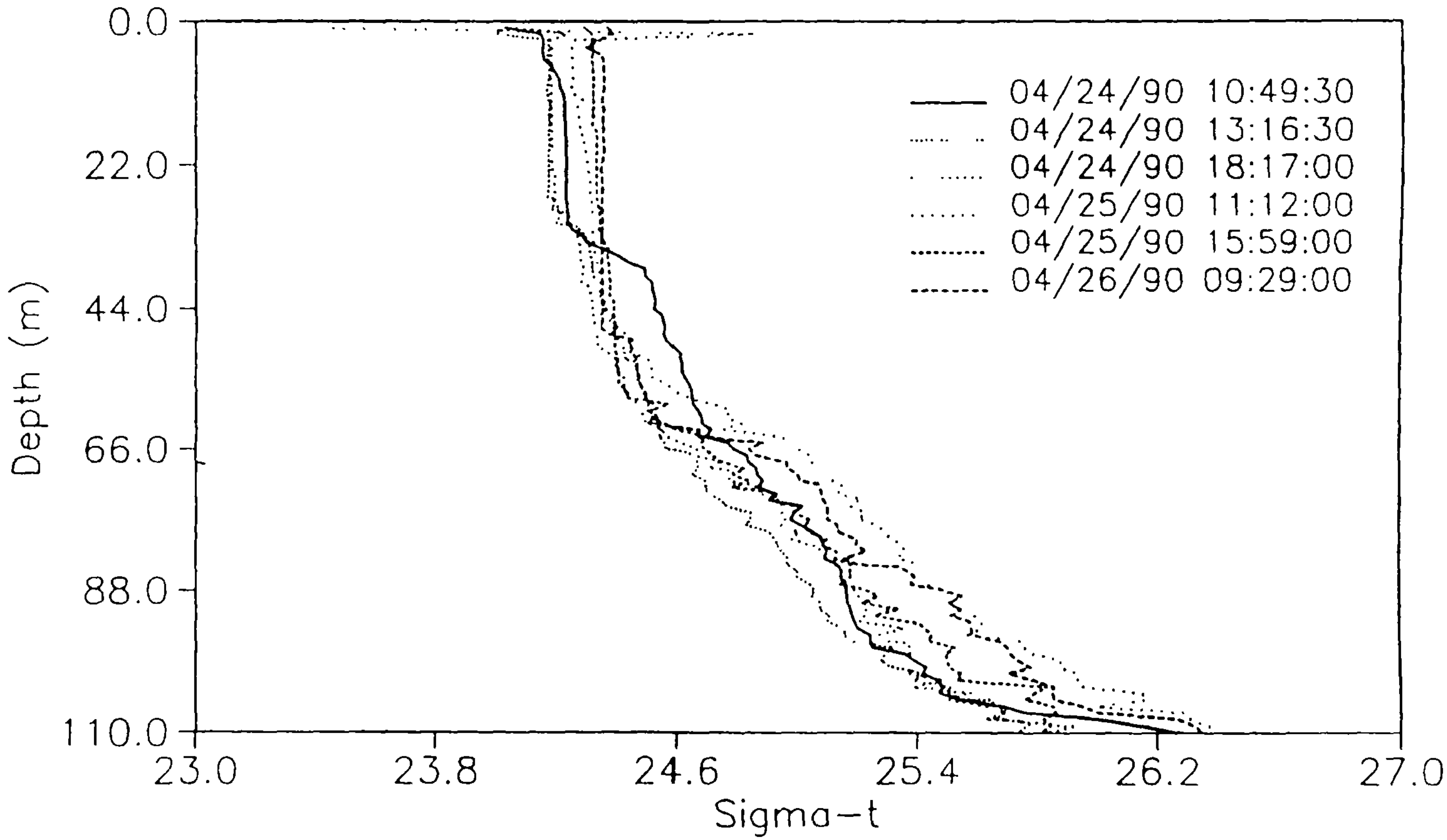

Fig. 5. Density profiles from six CTD stations of Phase I.

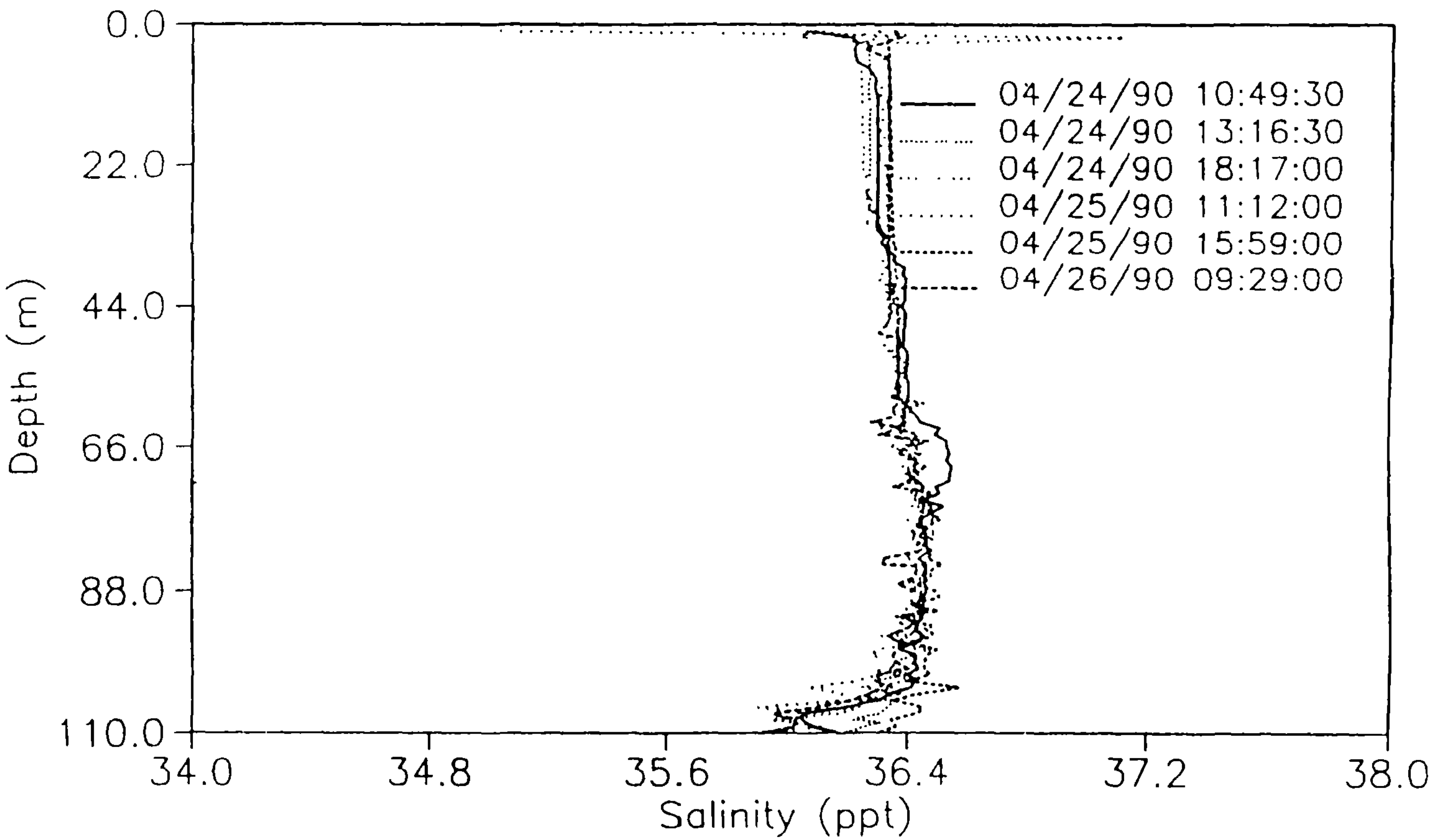

Fig. 6. Salinity profiles from six CTD stations of Phase I.

The observed temperature gradients are listed in Table 1 for Phase I and in Tables 2-1, 2-2, and 2-3 for Phase II. The maximum overall gradient is about -0.138°C per meter depth for Phase I (April 26 at 09:29:00, page B1-7) and -0.137°C for Phase II (June 27 at 10:50:57, page B2-24). However, the temperature profile observed on April 24 shows double gradients at 10:49:30 (page B1-3). In fact, there exist more than two gradients at different depths for this station. The middle water temperature gradient is always greater than that of deeper water. Most of the June profiles also show these double gradients. Three profiles on June 27 (12:39:16, 14:10:02 and 14:50:13 on pages B2-26, 27, and 28 respectively) and four on June 28 (05:02:39, 06:52:58, 07:43:14 and 15:05:34 on pages B2-43, 44, 45 and 46 respectively) have more than two gradients.

Maximum temperatures always occur at the surface and range from 25°C in April to about 29°C in June. These observations are in the ranges of annual mean reported by Lee and Mooers (1977) and EPA (1990).

Density Stratification

Density profiles also show gradients at all times and days and are strongly associated with the temperature variation. Whenever there is a constant temperature layer near the surface, there is a constant density layer in the same depth range. Whenever there are temperature gradients, there are density gradients within the same depth range. The multiple layer structure at 10:49:30 on April 24 also appears in the density profile. The double mixed layer in temperature at 06:52:58 on June 28 also appears in density. Clearly the density variations largely follow the temperature variations.

Observed density ranges from 1.024 gm/cc to 1.027 gm/cc in April. In June, the surface density was about 1.023 gm/cc or smaller, and densities near the bottom can be larger than 1.027 gm/cc because of the deeper water at some of the stations. These values agrees fairly with the report by EPA (1990). Density gradients are shown in Tables 1 and 2-1, 2-2, 2-3 for overall depths and the middle water column. The middle water column gradients in general are greater than those in deeper water near the bottom just as in the case of temperature. The maximum overall density gradient is 0.038 gm/cc/m at 10:12:00 on June 26 (page B2-5).

Salinity Measurements

Salinity at the dump site was fairly constant through all depths except at the deep water below 100 m for Phase I (Fig. 6). Salinity fluctuates vigorously in deep water with apparent local variations at different times and locations. The salinity profile generally increases slightly with depth from the surface and begins to decrease at about the thermocline depth. The surface salinity is about 36.3 ppt, and maximum salinity can be as much as 36.6. The lower salinity near-bottom water can reach as low as 35.6 in April (Phase I). One profile on April 24 at 10:49:30 (page B1-3) shows a rapid increase and decrease within 10 m depth, and indicates a salt finger.

In June, the salinity generally remains constant to some depth, increases very slightly to a certain maximum, and then decreases rapidly to the bottom with strong gradient. It reached 35.0 ppt at 240 m depth (June 27, at 03:39:23, page B2-23). In some cases, salinity near the surface and the bottom appear to be constant at different times, but it varies significantly in the middle water column (June 27 from 01:50:43 to 22:14:20 and June 28 from 02:49:02 to 15:05:34). One profile from June 28 at 06:52:58 (page B2-44) shows distinguishing features from the others. It indicates a rapid increase in salinity and then decreases with a strong gradient. The maximum salinity gradient occurred at 11:12:00 on April 25 with value of 0.029 ppt/m (page B1-6).

Current Velocity

The current profiles from the ADCP provide very good information on the current structure at the Miami ODMDS. However, ADCP data were available only for Phase I, and there are no current measurements during Phase II.

An initial sample interval of two minutes was selected for the first day of Phase I. The primary objective of the current measurements was to determine the water column ambient current profile and, in particular, the vertical shear, i.e., the change of horizontal current with depth at the time of discharge and during the subsequent tracking period. Since the tracking ship crosses a plume in about 15-30 sec, it was not anticipated that the ADCP should provide data on plume-related currents. Furthermore, since the key assumption of spatial homogeneity of currents in different beam "look" directions for the JANUS geometry is clearly violated for dredged material discharge plumes, it is unrealistic to expect reliable horizontal current data for plume traverses. However, once the initial transient currents generated by the falling plume material have been reduced or eliminated and the "quasi-equilibrium" plume condition has been reached, then reliable current data may be gathered during (residual) plume traverses.

Nevertheless, it was decided to reduce the ADCP sample intervals to 30 seconds to evaluate ADCP plume-related current data. The sample intervals were reduced to 30 seconds for the second and third days. The processed current profiles are presented in Appendices C1, C2 and C3.

Appendix C1 presents horizontal (north and east) and vertical current components with AGC (Automatic Gain Control) amplitude at fixed depths for all transects of each dump. When the ship was inside the plume judging from the acoustic profiles, the current components are represented by different symbols. Those current measurements outside the tracked plume are represented by a star (*) symbol. Whenever a question mark (?) appears, it indicates the current data at that depth were invalid and are placed there for continuity of the time series. For each transect at a fixed depth, two plots were presented to indicate the current direction and its speed.

Appendix C2 presents current measurements as a function of depth at different times either from the center position of each transect or from all positions within one transect for each dump. The time indicated in the plots is the guide to tell whether it is a collection of all center positions of the transects or a collection of all measurements within the plume. In most of the cases, the north component keeps constant to the thermocline depth and then decreases with depth, and sometimes reverses direction in deep water. The maximum north component can be as high as 150 cm/sec. The east component mostly fluctuates between +20 cm/sec to -20 cm/sec, with the maximum value sometimes reaching 60 cm/sec. The vertical component fluctuates as the east component does, but with a smaller maximum value.

Appendix C3 presents five current measurements at fixed depths for each transect of all dumps. Based on the ship track, the plots were rearranged such that the directions of transects are the same from west to east when several transects were plotted together. No consistent pattern was observed. Four consecutive current measurements for each transect of all dumps are also plotted and shown to indicate the change of current within the plume.

The ADCP also provides an echo amplitude signal that represents the concentration of suspended material in the water column. Appendix C4 shows time series of echo amplitudes that were observed at fixed depths and corrected for spherical spreading during Phase I. The depth intervals are between 10 m and 130 m with a 20 m increment for the eight depths in each plot. Generally, the top curve is for a 10 m depth and the bottom curve is for 130 m depth.

The ADCP current profiles were processed with programs developed in NOAA/AOML that are similar to programs provided by R&D Instruments. The transmit pulse and bin length is 4 m for 150 kHz frequency. The data were averaged over 30 seconds which consists of 9 individual pings. The standard deviations of north and east current are 19.7 cm/sec and 18.5 cm/sec respectively (Atle Lohrmann, personal communication). They include the variance introduced by ship motion (pitch and roll) and the variation in the current field over the survey area as well as the instrument noise. The standard deviation of the vertical current measurements is 9.5 cm/sec which includes the instrument noise and the variation introduced by the ship motion. Variances of both east current component and vertical component are almost as large as the magnitudes themselves.

Dredged Materials

The disposed material was dredged from the turning basin of Miami Harbor shown as a star in Fig. 7. Sediment samples and field data were collected from this basin area on December 12, 1988 and again on April 19, 1989. The 1988 sample stations were labeled MHTB-1 to MHTB-3 and shown as * in the lower left corner insert of Fig. 7. The gradation curves for 1988 data are shown in Fig. 8 for all three stations. An individual curve of each station is presented in Appendix D along with corresponding suspended sediment-time curves for test specimens of

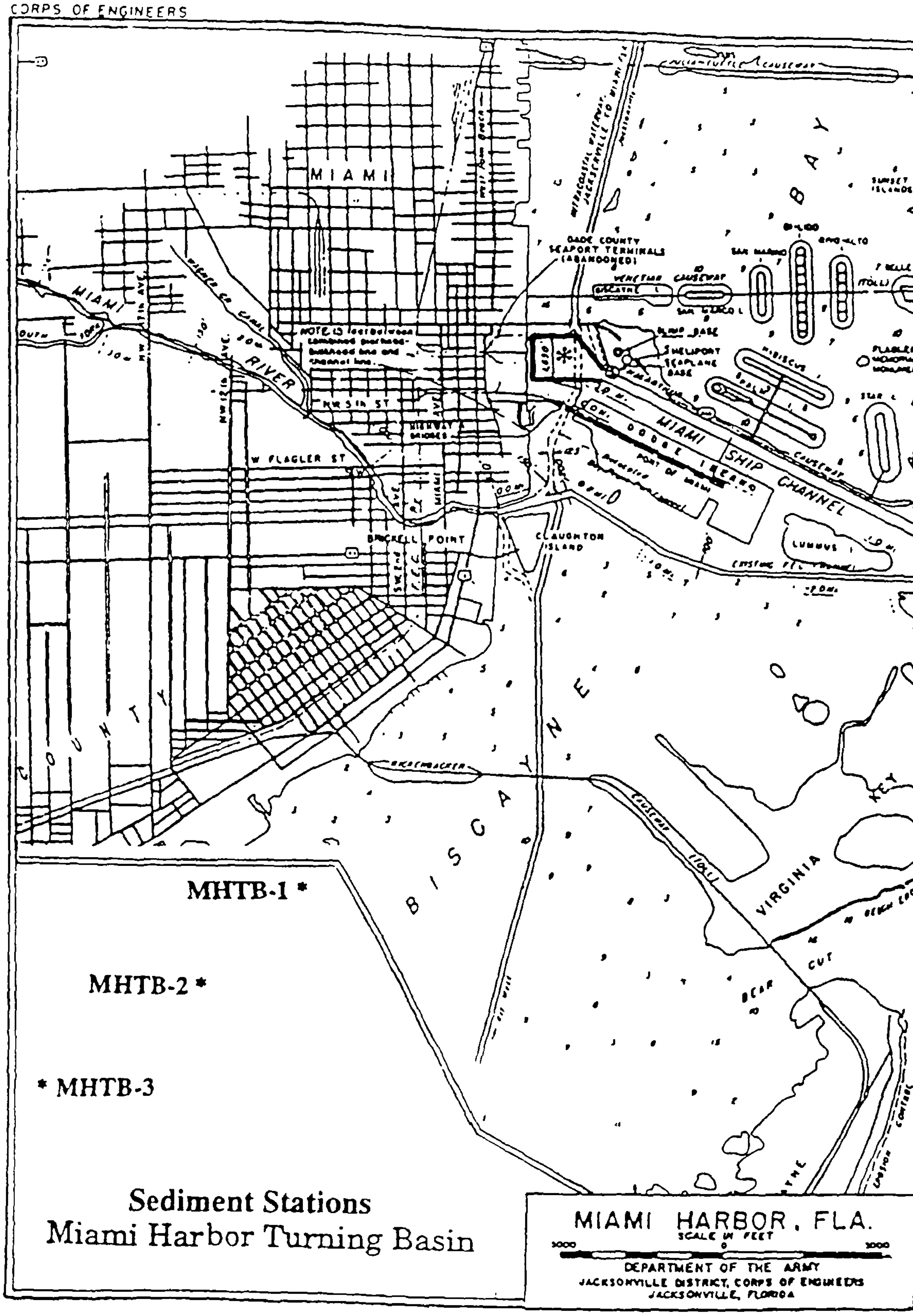

Fig. 7. Location map of the Miami Harbor. The turning basin is indicated as a * at the end of the Miami Ship Channel. The insert at the lower left corner shows the three sediment stations.

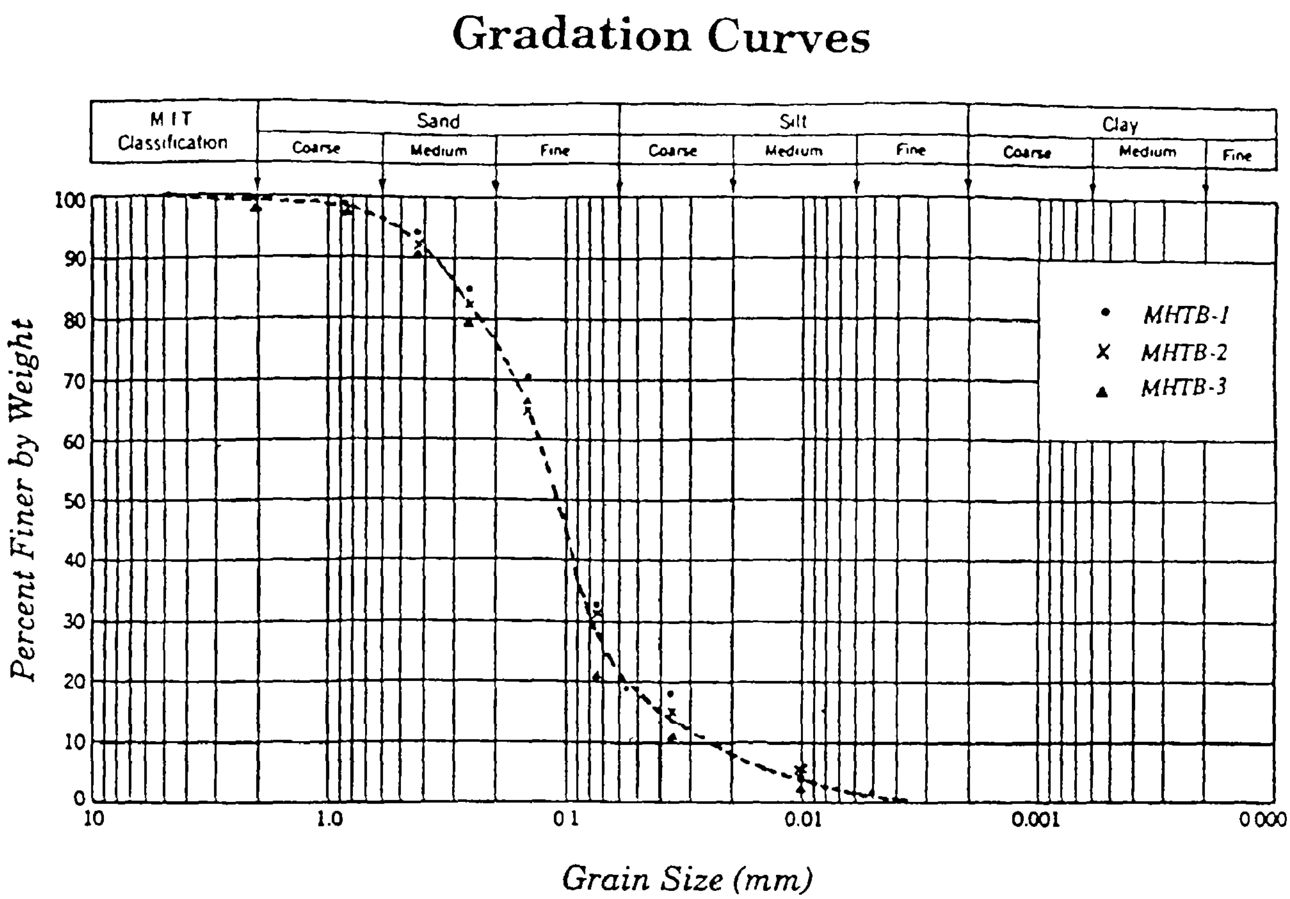

Fig. 8. Gradation curves of particle-size distribution for the three sediment stations in the Miami Harbor Turning Basin.

50 gms/liter and 100 gms/liter. The most common materials are coarse silt and fine to medium sand.

Acoustic Profiles

There were two types of acoustic data recording. One type was recorded on Raytheon thermal paper recorder, which was also displayed in real time during the field study. Portions of these acoustic echograms are shown in Appendix E1, which correspond to transects of the eight dumps during a three-day period. The vertical coordinates are depth in meters and have different depth scales for different dumps. The horizontal coordinates show hour and minute. Except the first dump on April 24, 1991 (page E1-2), all time scales shown represent a 21 minute time period, and have a horizontal distance of 1890 m when the ship speed was taken to be constant at 3 knots for all transects.

The other type of acoustic data was recorded on DAT tapes. These data represent the same data as the first type, but can provide more detailed plume structure when processed numerically to extract the acoustic backscattering intensity from the data. The acoustic intensity is considered to be proportional to the particulate concentration (Tsai, 1984), and contour plots of equal intensity levels will provide the detected sediment plume field for each transect. These contour plots are shown in Appendix E2. The concentration levels are shown in db and equivalent to backscattering strength which is proportional to the logarithm of acoustic intensity. The actual processing is summarized in the following.

The recorded acoustic signal on DAT represents the root mean square voltage V in integer format at the output of the receiver. This 10-kHz double side band signal was filtered to remove 60-cycle noise and to provide anti-aliasing protection for analog demodulation. Output from the demodulator was further filtered and amplified for input to a 12-bit analog to digital (A/D) converter interfaced to an IBM compatible personal computer (PC). The voltage at the input of the A/D converter is proportional to the root mean square plane wave sound pressure P at a reference location 1 m from the face of the acoustic transducer, that is,

$$20\text{Log}(V) = RR + RL + G$$

where RR is the receiving response of the transducer given in decibels referenced to 1 volt per micropascal (db/1V/1uPa), G is the overall system gain in db, and RL is the reverberation level given by

$$RL = 20\text{Log}(P).$$

For a cloud of particulate scatterers such as a sediment plume, the reverberation level is given by

$$RL = SL - 20\text{Log}(r) - 2ar + S + 10\text{Log}(ctb/2),$$

where SL is the source level (db/uPa/V), r is range in meters, a is absorption coefficient in db/m, S is the volume scattering strength in db, c is speed of sound in the water and is taken to be 1500 m/sec, t is transmitted pulse duration in sec, and b is equivalent solid angle of a uniform beam containing the same integrated power as the actual transmitted beam and is given in steradians. Therefore, the volume scattering strength is

$$S = 20\text{Log}(V) - RR - G - SL + 20\text{Log}(r) + 2ar - 10\text{Log}(ctb/2).$$

These scattering strengths represent the waste concentrations observed in the water column, and are plotted in constant levels as contours shown in Appendix E2.

The horizontal axis of those contour plots is distance in meters which is calculated from time of transect by the ship velocity of 3 knots. One of the important observations is the waste materials near the ocean bottom at the first few transects. It is proved that the material does reach the bottom and acoustic imaging is useful to provide information for tracking wastes even in strong current and deep water. During the first or two transects of each dump, it appears to indicate that acoustic signals were blocked by the bubbles generated during the dumping process. It occurred in the Mobile Bay Project too.

Appendix E3 shows time series of acoustic backscattering strength at fixed depth for Phase I. Each plot represents waste concentration at one fixed depth for one particular dump. Each peak of the time series is the observed plume and its peak value provides the maximum waste concentration during that particular transect. The distance obtained by multiplying time by tracking ship speed gives the plume width at that time.

Appendix E4 is an illusion of detailed plume structure at fixed depth for a particular transect. The plume width increases with depth to some point and stays unchanged or even decreases thereafter in most cases. The plume width also increases with time as indicated by transects at later times. However, the peak value or maximum concentration decreases both with depth and time in general.

IV. DISCUSSION

A central question in the present study is whether the discharged material remained within the designed site boundaries. The present study encompassed a grand total of six days, April 24 through 26, 1990, and June 26 through 28, 1990. Discharge events occurred in the period of April 24 through April 26, 1990, so that observations on discharged material remaining within the site are restricted to this 72-hour period. Generally speaking, there are two time frames regarding escape of material from the designed site: a short term time frame, e.g., a few hours or so and a larger term time frame extending over days and beyond.

Model results have indicated that the vast bulk of the discharged material should fall directly to the bottom and that a gradually diminishing quantity of material should remain within the water column. The material that remains within the water column for some period of time is expected to be "fine" material, i.e., of small size, and of low concentration. In the early stage of a dredging operation, the material dredged may contain much "fines" whereas as the operation continues a lesser quantity of fines may result.

Consider the sequence of plume transects presented in Fig. 9. The first transect, shown in Fig. 9(a), was taken less than one minute after initiation of discharge. Acoustic returns are obtained from throughout the water column to the bottom. Thus a portion, most likely the largest portion, of discharge material falls rapidly to the bottom. A portion of the material remains within the water column as a wispy cloud. This portion was tracked not only for the discharge shown in Fig. 9(b) to (d), but for each discharge in the entire study.

It may be readily discerned from these data that the width of the discharged plume increases with depth. This increase in width with depth is due to the entrainment process. An entrainment coefficient, a, may be estimated directly from the acoustical data. To see this, Brandsma and Divoky (1976) that the entrainment, E, may be expressed as

$$E = Aa\ (\vec{v} - \vec{v}_a)$$

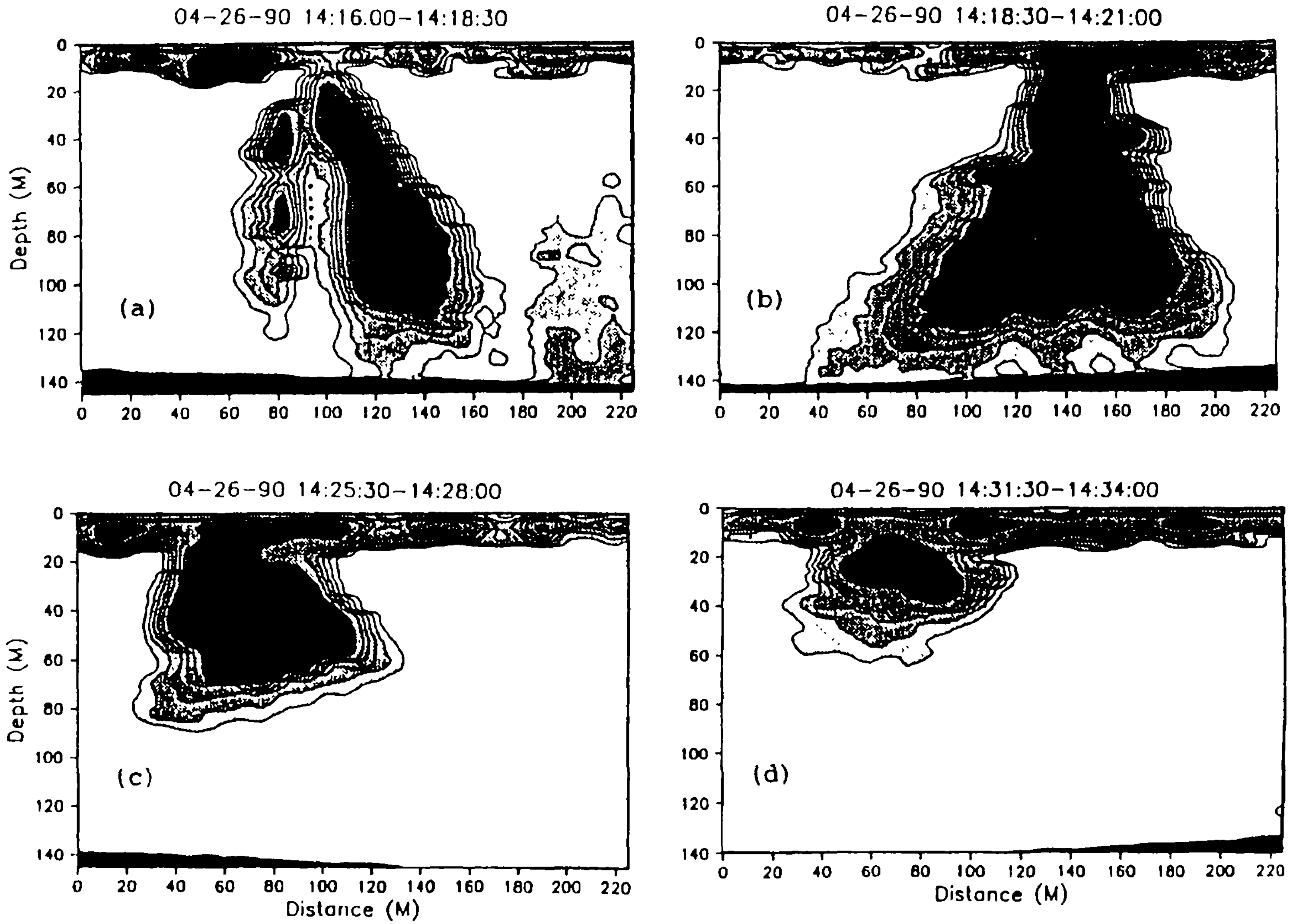

Fig. 9. Acoustic iso-concentration contours of one dump on April 26, 1990, corresponding to four transect at different times. The gap in concentration indicated in (a) at 90 to 100 m distance is attributed to acoustic absorption at the frequency of 20 kHz by a cloud of bubbles in the water near the surface.

where A = area of hemispherical dump volume,

a = entrainment coefficient,

$\vec{v}$ = vector velocity of discharged material,

$\vec{v}_a$ = vector velocity of ambient water.

For $\vec{v} >> \vec{v}_a$

$$dV/dt = aA(dz/dt)$$

where V = volume of hemispheric discharge. Then,

$$a = (1/A)(dV/dz),$$

and for a hemispheric radius, r,

$$V = (2/3)\ \pi r^3,$$

$$A = 2\pi r^2$$

so that

$$a = dr/dz.$$

Thus, by measuring the coordinates, i.e., depth and distance, of an iso-backscatter contour at two different depths, the value of a may be estimated. For example, from Fig. 10, for the iso-concentration line marking the outer boundary of the plume, i.e., scattering strength above background equals -70 decibels, at 20 m depth, a horizontal coordinate of 118 m is indicated while at 50 m depth, a horizontal coordinate of 138 m is indicated. Thus,

$$a = dr/dz = (138-118)/(50-20) = 0.67.$$

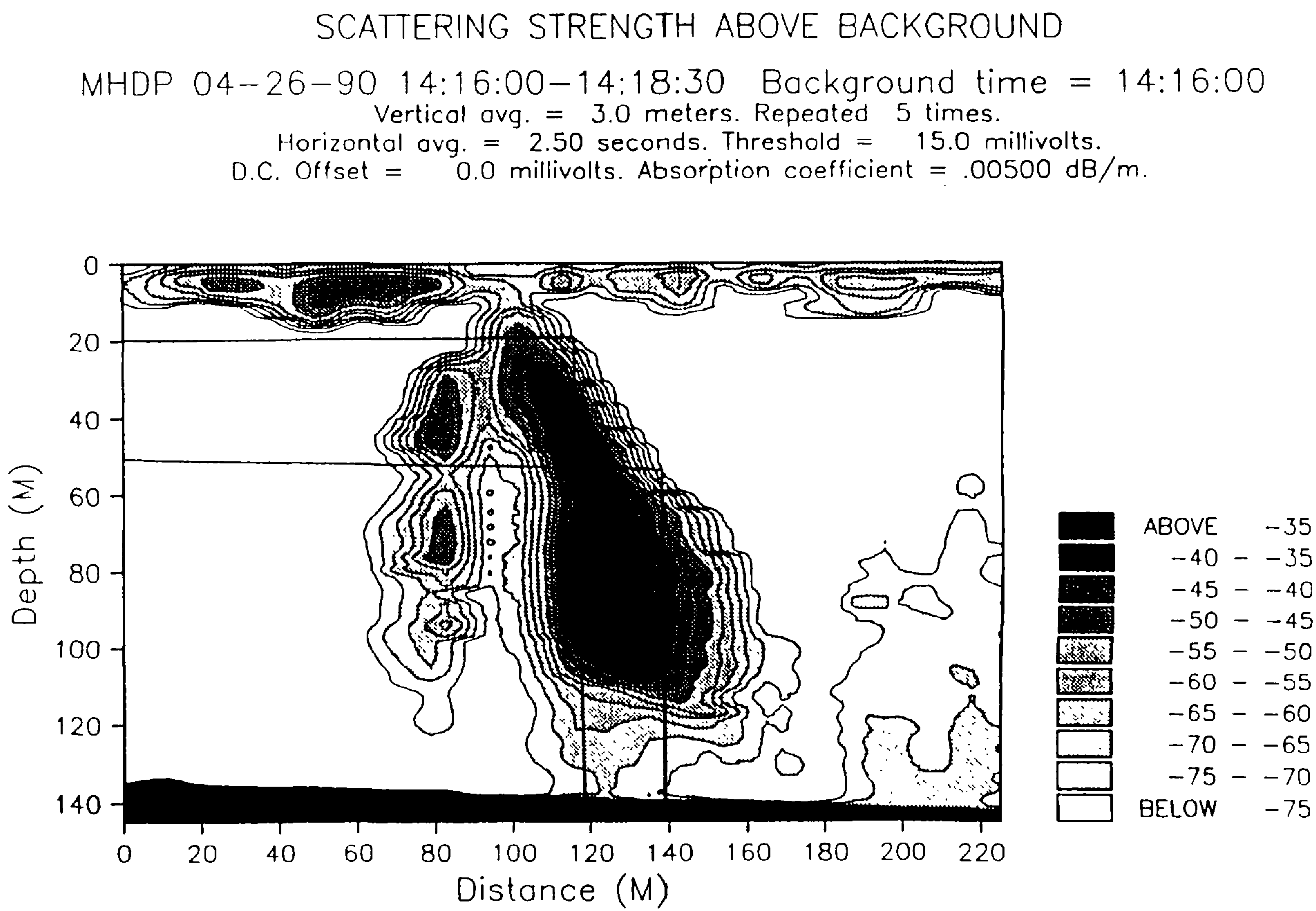

Fig. 10. Acoustic iso-concentration contours of the first transect of Fig. 9, showing the method to calculate the entrainment coefficients. The backscattering strength levels shown in Figs. 9 and 10 are in decibels and represent particulate concentrations of suspended mat als in the water column.

for a given discharge plume, two estimates for a may be made: a plume ingress estimate and a plume egress estimate. Depending on the circumstances of the discharge and time of transect, both or neither estimates may be made. For Fig. 10, the egress estimate appears superior to the ingress estimate. Nevertheless, in the 25 m to 50 m depth interval, an ingress estimate for a of 0.57 was obtained.

Estimates of a have been made for various discharges in the present study; these estimates are summarized in Table 3. In selecting the depth interval for estimation of a, some care with regard to the water column vertical density structures and current structure must be given. From the density profile shown in Fig. 11, it may be seen that the upper 50 m or so of the water column are well mixed with little structure in the density profile. At about 55 m depth, a density step occurs and structure appears within the water column. A change in the slope of the iso-backscattering contour line occurs there, thus leading to a different estimate for a in that depth region.

The wispy clouds of material which remain within the water column gradually diminish in density or concentration as time goes by; within the first 20 minutes the concentration of material within the water column and below the 50 m depth horizon diminishes by about four orders of magnitude. Note that this concentration reduction is measured relative to the concentration which existed within the water column about two minutes after discharge. The reduction of water column concentration with time is illustrated in Figs. 12 and 13 for a discharge on April 26, 1990 and in Fig. 14.

Various processes affect the cloud of discharged material remaining within the water column. One of these processes is the advection of the material by ambient water currents. Our concern is principally with the horizontal advection of the material; ambient vertical currents were in

Table 3

Entrainment Coefficients calculated from acoustic profiles. The ingress and egress depths are water depths used to calculate the the Entrainment Coefficients.

Dump	Date	Time Interval	Ingress		Egress	
			Estimate	Depth	Estimate	Depth
2	04/24/90	16:13:30-16:15:30	0.74	50 m	0.80	80 m
5	04/25/90	14:37:00-14:39:30	0.78	50 m	0.50	30 m
7	04/26/90	11:29:30-11:31:30	0.53	60 m	0.83	40 m
8	04/26/90	14:16:30-14:18:00	0.57	50 m	0.67	60 m
Average			0.66		0.70	
Standard Deviation			0.11		0.13	

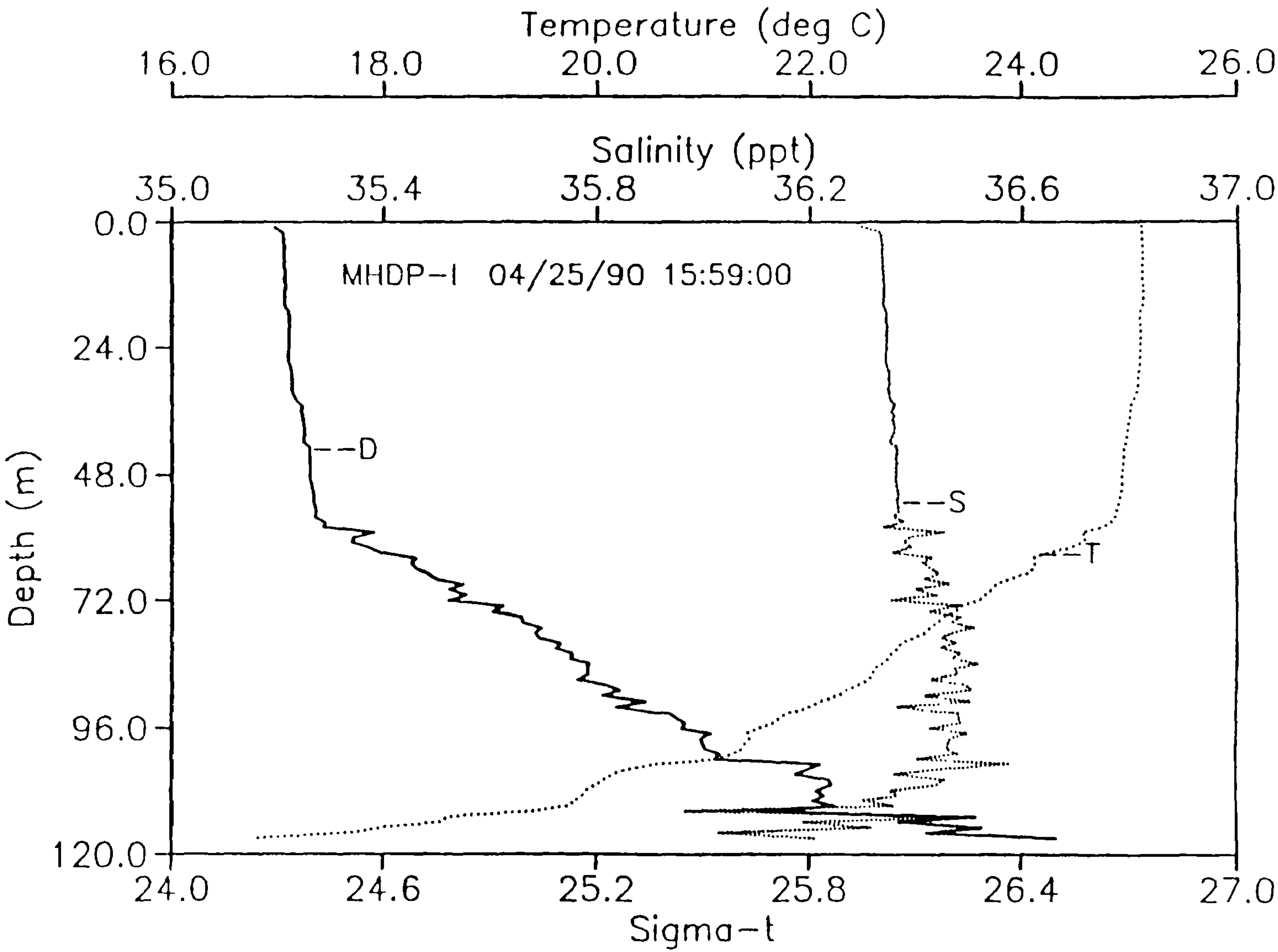

Fig. 11. Temperature, salinity and density profiles at 15:59:00 on April 25, 1990 during Phase I.

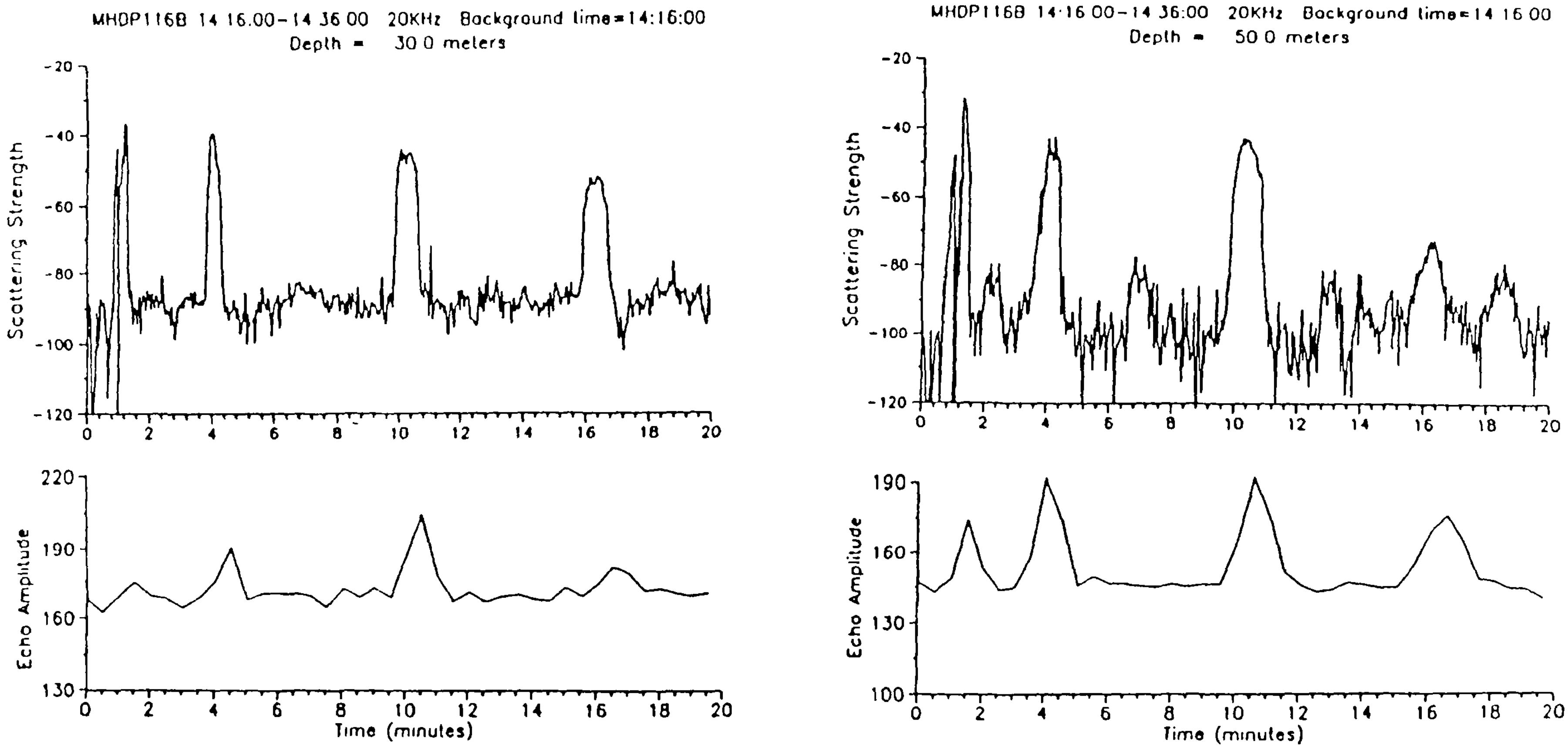

Fig. 12. Comparison between acoustic scattering strength from ACP and echo amplitude from ADCP at 30 m and 50 m. Top: from ACP; bottom: from ADCP.

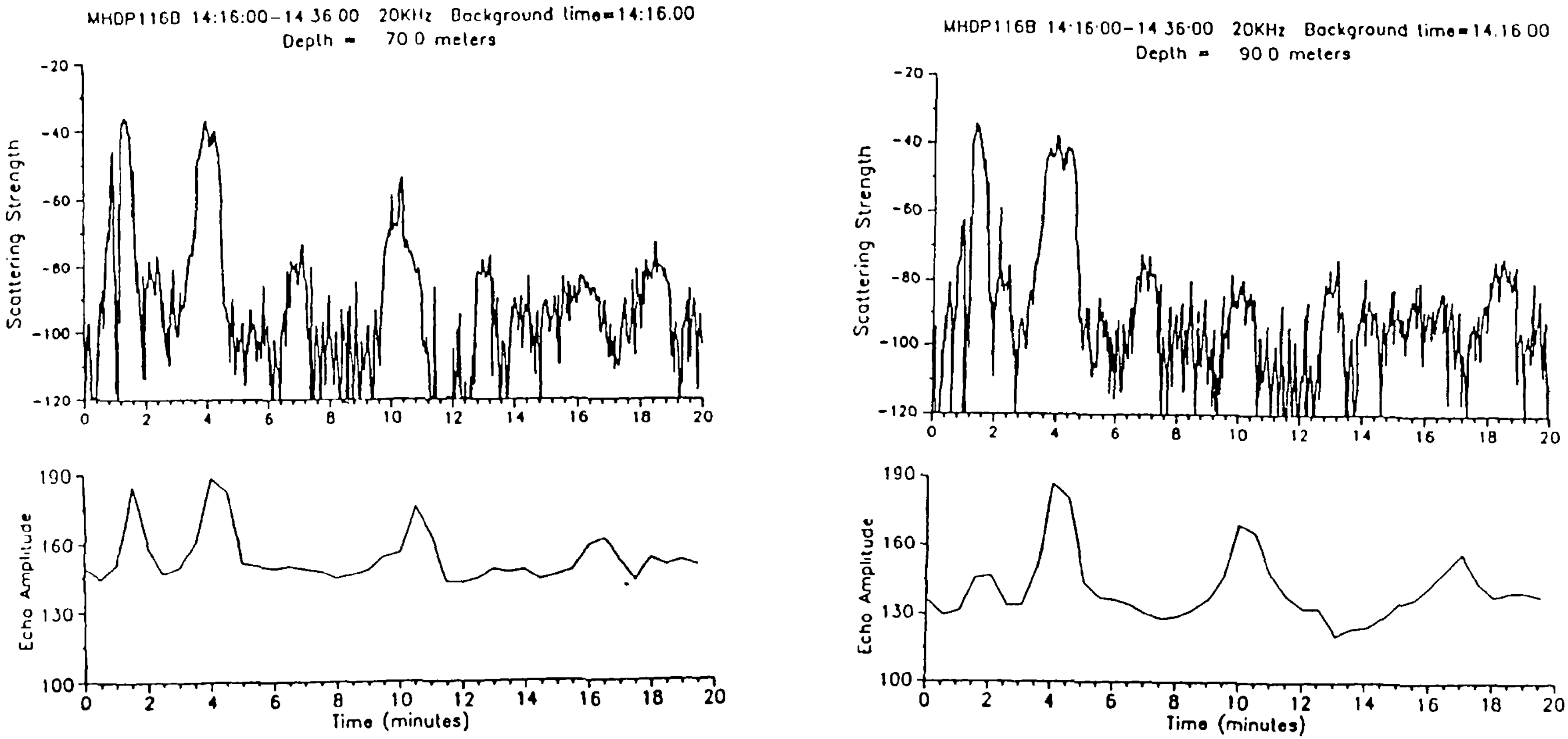

Fig. 13. Comparison between acoustic scattering strength from ACP and echo amplitude from ADCP at 70 m and 90 m. Top: from ACP; bottom: from ADCP.

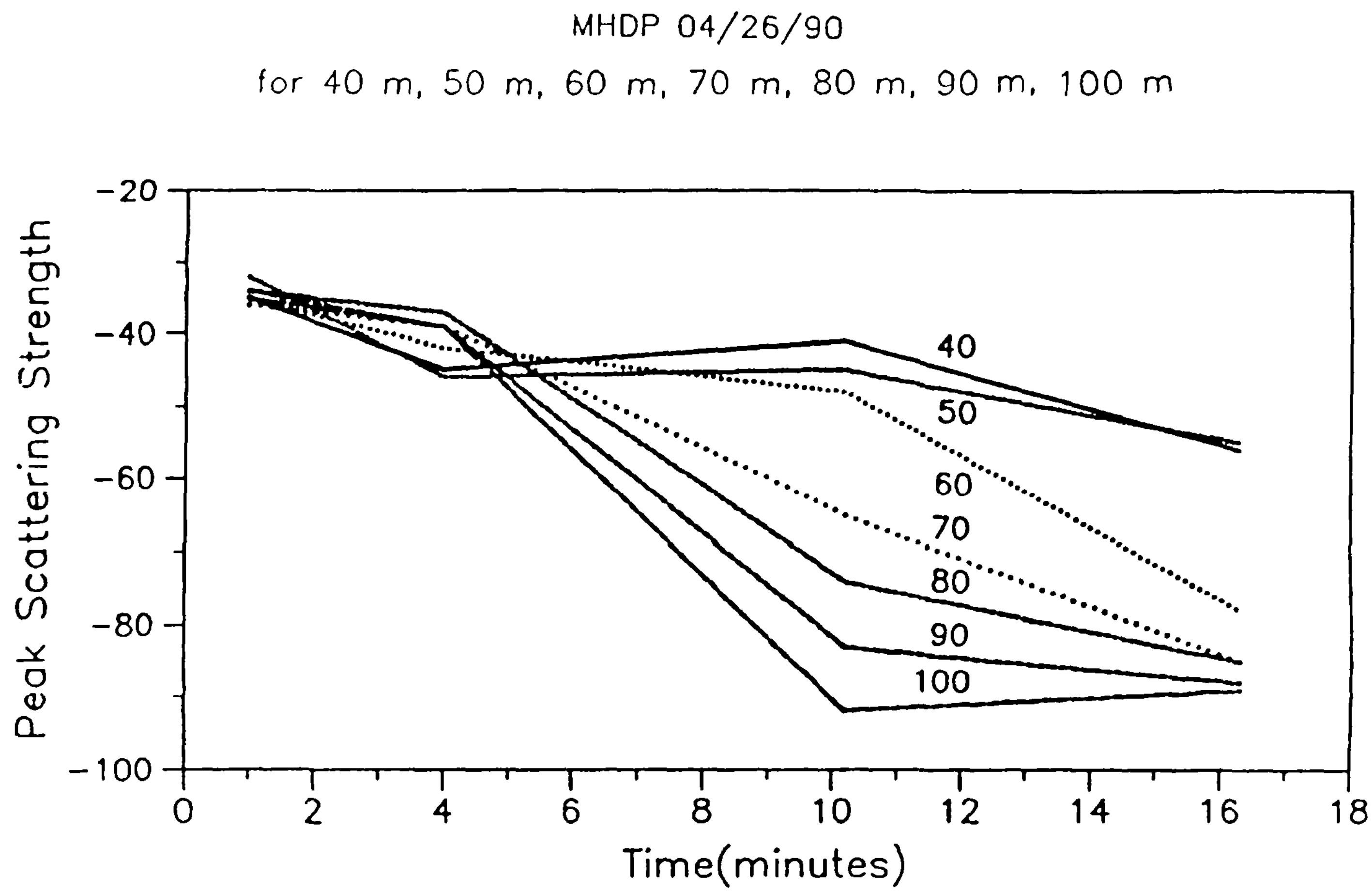

Fig. 14. Peak concentration as function of time at six fixed depths for April 26, 1990 during Phase I.

general quite small during the exercise. A key question is the existence of vertical shear within the water column and its effect in displacing the upper portion of water column material vs. the deeper portion of water column material. There are two different components of data which bear on this issue; the first is the acoustic Doppler measurements of the north and east directed components of the ambient current as a function of depth, and the second is the relative displacement of the centroid of cloud concentration as a function of depth as determined from acoustic backscattered measurements.

An estimate of the difference in the horizontal current v_h at two different depths in the water column z_1 and z_2 can be made directly from the backscatter amplitude information. The AGC amplitude will be used to compare with Doppler estimates. For depths z_1 and z_2, one can write

$$[v_h (z_2)-v_h (z_1)]t = r(z_2)-r(z_1$$

where t equals the time from initial discharge to the time of plume observation, and r(z) is the range from coordinate origin (cyclindrical coordinates) at the time of plume observation.

From Fig. 15, we see that the maximum time difference between peak concentrations encounters at any two depths in the water column is approximately 30 seconds. Thus, for a ship speed of 1.5 m/sec,

$$r(z_2)-r(z_1) < 45 \text{ m} = 4500 \text{ cm}.$$

Then

$$v_h(z_2)-v_h(z_1) < 4500/t$$

Now t = 18 minutes = 1080 seconds, so

$$v_h(z_2)-v_1(z_1) < 4.3 \text{ cm/sec}.$$

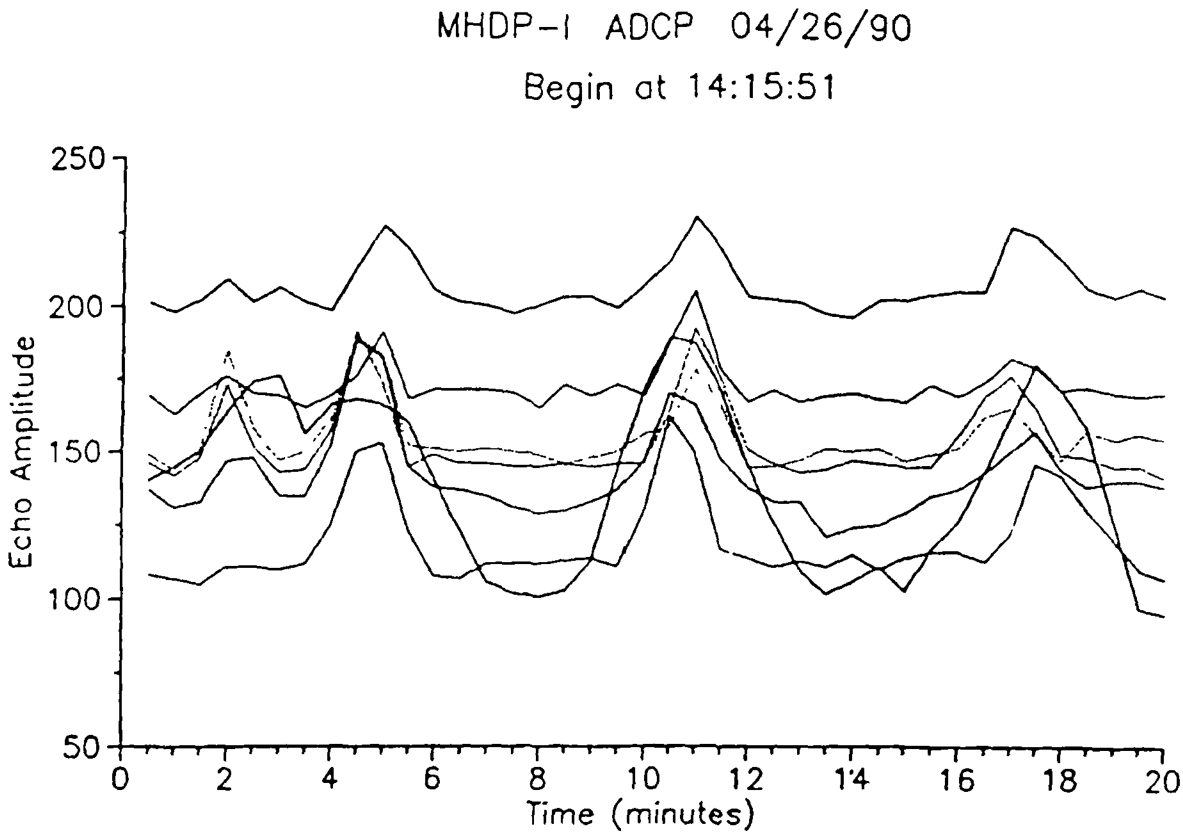

Fig. 15. Time series of echo amplitudes at seven fixed depths from 10 m (top) to 130 m (bottom) for April 26, 1990 during Phase I.

How does the Doppler estimate compare with the proceeding result? From Fig. 16, we note that there is much variability in the estimate of horizontal (north) velocity from the ADCP. If the first two plume transects are disregarded, the remaining transects indicate very little vertical shear to be present with an uncertainty greater than the AGC-derived limit.

In each of the discharge events, a portion of the discharged material was observed to remain in the upper portion of the water column. This material remaining in the upper part of the water column exists as a wispy cloud having undergone a reduction in concentration in excess of three orders of magnitude from the original concentration which existed immediately after discharge. The material below 50 m depth in the water column has undergone an even greater reduction in concentration.

A series of plume crossings was carried out for approximately one-half hour after discharge. The locations and time of these plume crossings for each of the discharges is shown on pages A2 to A6 of Appendix A. We see that for each discharge the motion of the material remaining in the upper portion of the water column is generally in a north-northeast direction. The discharges occurred over a three-day period and available ship tracks resulting from an approximately 48 hour period consistently indicated a generally north-northest movement of the residual plume material. The discharge site is sufficiently far at sea that tidal current influences are expected to be minimal.

V. RESULTS

(1) Acoustical detection and mapping of dredged material discharge plume within the entire water column and impacting the ocean bottom, have been made for the interim Miami ODMDS located at the western edge of the Florida Current (Gulf Stream). These detections and complete

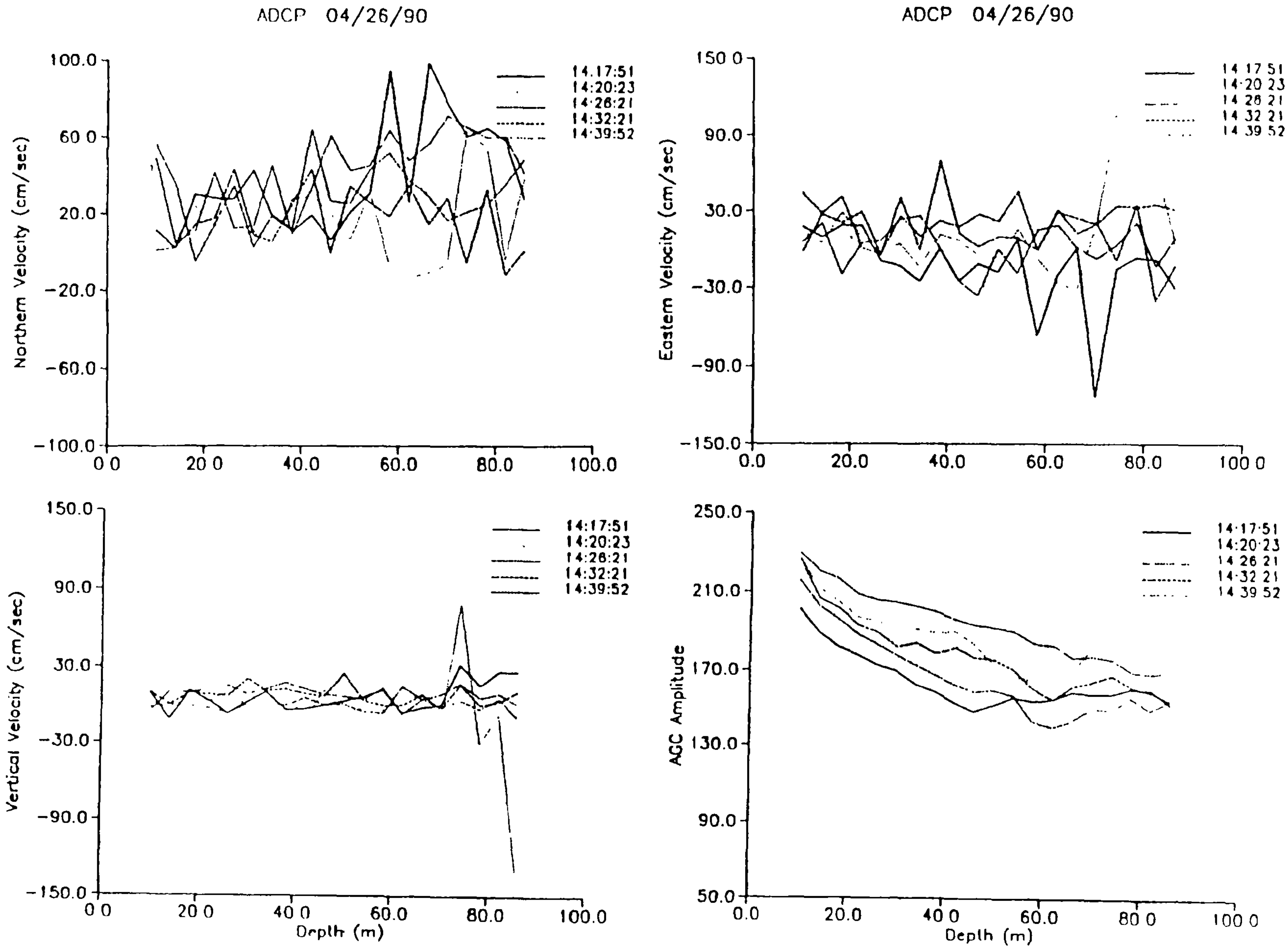

Fig. 16. Current profiles for the five transects of the second dump on April 26, 1990 during Phase I.

mappings have been achieved at the deepest dredged material site (typically 140 m depth) studied to date.

(2) A high concentration central portion of the discharge descended quickly and directly to the bottom. This central portion descended with a speed of 2 m per second or greater.

(3) The deep water discharge plumes observed in this study displayed the major generic features observed in shallow water discharge plumes, namely lateral growth through entrainment, rapid descend of a central core, impact with the bottom and formation of an expanding bottom surge and rapid decrease of water column concentration residual with time.

(4) Of the residual material left in the water column, that material below about 50 m depth underwent approximately a four order of magnitude reduction in concentration in one-half hour while that remaining in the upper portion of water column underwent approximately a three order of magnitude reduction in concentration.

(5) Over the time period during which the residual material remaining within the water column from various discharges was detected and tracked, about 48 hours, the general movement was towards the north-northeast. Vertical current shear did not separate the top and bottom portions of the plume in most cases of the observations.

VI. CONCLUSIONS AND COMMENTARY

The key conclusion is that the material discharged , except for a low concentration residual remaining within the water column, reached bottom within the designated site boundaries. A total of eight discharge plumes were detected and tracked for a period of about one-half hour on average; for the three day time period during which the discharge occurred, the resulting plumes were observed to be transported in a north to northeast direction.

A very interesting point regarding the knowledge gained on discharged plume behavior during the course of the present three day study is this: while it is a valid criticism that only a very limited sample of ambient current conditions were obtained during the course of the study, and that the ambient current field may undergo significant changes in both magnitude and direction over the course of a year thereby significantly affecting the transport of any residual plume material left within the water column, the same may not be said of the ambient density profile. That is to say, so long as the physical structure and constitution of the dredged material being discharged remains essentially the same, it may be expected that the changes which occur over the course of a year in the ambient water column density structure will not significantly alter the main discharge features, as listed in section V, item 3, observed in the present study.

The principal basis for this conjecture is that a very rapid convective descent of a central core plume discharge portion is oberved to occur. The discharge material descends at a much higher rate than would be expected on the basis of individual particulate settling velocities, thereby indicating a cohesive body structure in the central plume. This descent is so rapid that any variations which may be expected to occur in the water column density profile over the course of a year will not significantly affect the descent.

The effects of water column density structure are, however, of significance in affecting both the formation and longer-term fate of the water column residual plume. It is this residual plume which is most strongly affected by both ambient current and density water column profiles.

Not addressed in the present study is the issue of resuspension of material deposited on the ocean's bottom. To address this question, near-bottom current data is required and observation of resuspension events, if any.

VII. ACKNOWLEDGMENTS

The help and assistance in planning and execution of the present study of Mr. Mark Skarbek of the Jacksonville District and of Dr. Nick Krause of the Waterways Experiment Station are hereby gratefully acknowledged. The expert electronic assistance of Charles A. Lauter is appreciated.

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APPENDIX G

MIAMI HARBOR DREDGED MATERIAL DISPOSAL PROJECT.
TOTAL SUSPENDED SOLIDS MEASUREMENTS

MIAMI HARBOR DREDGE MATERIAL DISPOSAL PROJECT:

Total Suspended Solids Measurements

John R. Proni, Jules F. Craynock, John J. Tsai

A Report to the
U.S. Army Corps of Engineers

National Oceanic & Atmospheric Administration
Atlantic Oceanographic and Meteorological Laboratory
4301 Rickenbacker Causeway
Miami, Florida 33145

April 16, 1993

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I. INTRODUCTION

In April 1990, a field data collection project was undertaken to investigate the short-term fate of dredged material discharged in the designated Miami Ocean Dredged Material Disposal Site (ODMDS) before dredging of the Miami River and the Miami Harbor Turning Basin begins. A discussion of this project is presented in reference one and two. As part of the study, series of water column samples of total suspended material was obtained. Later, in June 1991, a second project was carried out in order to obtain an expanded series of background water column suspended material values.

II. PROCEDURE

Sediment plumes resulting from eight placement operations, occurring in the period April 24 to April 26, 1990, of dredged material were sampled and monitored acoustically. A test discharge, for logistics evaluation, was conducted in the morning of April 24th. Water column sediment sampling was guided by acoustical systems employed, in particular by the Acoustic Concentration Profiler or ACP, and by visual surface detections of subsequent-to-discharge plumes. Before each discharge, and between successive discharges, the surveying vessel *Seaward Explorer* monitored the water column to obtain background concentrations of suspended material and ambient currents in the area using the ACP and ADCP on board the surveying vessel. Ambient density and salinity were measured by taking CTD casts at locations of previous discharge that were determined from ship track records. Sediment samples were collected directly from the dredging vessel *Atchafalaya* for each discharge. Discharge occurred when the

Atchafalaya began to turn to return shoreward. The ACP was set ready to operate upon the approach of *Atchafalaya*, and the *Seaward Explorer* proceeded to make the transects immediately after the dumping commenced. The *Seaward Explorer* tracked the sediment plume for several transects until the concentration of suspended material could no longer be detected by the ACP. This reduction in concentration usually took about 60 minutes after the release. During each transect, water samples were collected by a towed V-Fin with a pump that discharged water continuously via a hose to the deck of the *Seaward Explorer*. The water sampling took place at approximately constant depth by maintaining constant ship speed, and only during the periods when transects crossed the plume. Ship position was determined using LORAN and GPS and was automatically logged with a computer and displayed in real time to assist monitoring. Surface features of the sediment plume were visible up to 60 minutes after discharge and were helpful in tracking the plume.

III. DATA PRESENTATION AND ANALYSIS

(A) Presentation

Three data sets for each discharge are presented: (i) acoustical data including the first several transects for each discharge (ii) track data for each discharge and (iii) water bottle sample data for each discharge.

Discharge One

The first discharge of the study occurred at about 16:14 on April 24, 1990. In Figure 1 the acoustical data are shown from the first five passes over the discharge plume. The *Seaward Explorer* first encountered the discharge plume between 16:14 and 16:15. Other encounters shown in Figure 1 occurred at about 16:17, 16:19,16:21 and 16:26. In Figure 2 the ship track for this discharge event is shown. Plume encounters were made at various times subsequent to the first few minutes following the discharge event shown in Figure 1. These encounters are marked by various symbols on the ship's track. For example, the encounter at 16:40 is marked by a hexagon, the encounter at 16:45 with a triangle and so on. The small stars are time marks. In Table I, the concentrations of particulate matter, measured in mg/liter, for the sample stations shown in Figure 2 are given. The sample concentration values are plotted against time after discharge in Figure 3.

Discharge Two

The second discharge occurred at about 09:37 on April 25, 1990. In Figure 4 the acoustical data from the first five passes over the discharge are shown. The track data for discharge two are shown in Figure 5. The suspended particulate values measured are given in Table II and plotted in Figure 6.

Discharge Three

Discharge three occurred at 12:04 on April 25, 1990. The acoustical data for the first six passes over this discharge are shown in Figures 7 and 8. Extensive absorption by bubbles is seen in the first pass over this discharge. Some residual bubble absorption is seen in the second pass over the discharge and no discernable absorption is seen in any of the subsequent plume encounters The track data for discharge three are shown in Figure 9. The suspended particulate values measured during discharge three are shown in Figure 10.

Discharge Four

Discharge four occurred at about 14:37:30 on April 25, 1990. The acoustical data for the various transects over this discharge are presented in Figure 11. The corresponding ships track is presented in Figure 12. The corresponding total suspended material data is presented in Figure 13.

Discharge Five

Discharge five occurred at about 17:49 on April 25, 1990. The acoustical data for the various transects over the discharge are presented in Figure 14. The corresponding ship track and total suspended solids (TSS) data are presented in Figures 15 and 16, respectively.

Discharge Six

Discharge six occurred at about 11:30 on April 26, 1990. No track data was available for this discharge. The acoustical data for the various transects over the discharge are presented in Figure 17. The corresponding TSS data is presented in Figure 18.

Discharge Seven

Discharge seven occurred at about 14:16 on April 26, 1990. No track data was available for this discharge. The acoustical data for the various transects over the discharge are presented in Figure 19 The corresponding TSS data is presented in Figure 20.

June 1991 Background Samples

Additional Background TSS Measurements were obtained by NOAA/OAD and US Army Corps of Engineers personnel aboard the S/V *Sable* on June 27 and 28, 1991. These data are presented in the appendix. Sampling transects were conducted through Government Cut and north and south along the predominant offshore reef line. Water samples for TSS analysis were collected using a small V-Fin pump sampler deployed from the side of the S/V *Sable*. Simultaneous CTD casts were conducted utilizing a Seabird CTD system. Pumped samples were analyzed for turbidity with a HACH portable turbidimeter. Offshore fixes were determined via LORAN-C, samples sites A, B, C within Government Cut were determined by shore sightings. Table A-1 and Table A-2 summarize the TSS/turbidity measurements. Charts 1, 2, and 3 indicate sampling positions as well as a detailed depiction of the Government Cut positions. CTD cast data are included for each of the stations completed within the two days. On both days of operations sample stations were conducted during an outgoing tide. Ship traffic during the sampling period through Government Cut was relatively light and seas were calm.

(B) Analysis

As discussed in reference one, during the disposal operation a quantity of the dredged material discharged remains suspended for some period of time within the water column. Although the bulk of the discharged material is thought to descend as a cohesive mass, a small portion of the, perhaps in the form of individual fines, are thought to remain within the water column. Entrainment processes, which are known to occur within such discharges, could play a key role in the formation of the residual cloud of material within the water column. Once the residual cloud is formed, the cloud then drifts with the ambient current with continued settling and dispersion of the cloud material.

In the present study, samples of the residual cloud material were gathered using a pumping system to fill water bottles aboard ship. The nozzle of the hose used in the pumping system is attached to a V-Fin device which was towed about 1 meter below the ocean's surface. It took about 30 seconds to fill a bottle, so with a ship's speed typically being one to two knots, or 0.5 m/sec to 1.0 m/sec, water is included in the sample gathered over a 15 to 30 meter distance. This has the effect of smoothing peak concentration values in cloud volumes of size less than about 30 meters. This smoothing effect is more pronounced in the earlier portion of residual water column material tracking than in later portions, say three or so minutes after discharge, as the material has dispersed or spread out in space and has become more homogeneous through mixing.

Consider the TSS data displayed in Figure 10 for discharge number three. This data displays a series of peaks of diminishing order in time, i.e. 61 mg/l, 10.2 mg/l, 5.8 mg/l, 1.9 mg/l and 2.0 mg/l, separated by a set of relatively low concentration sample values. This data is interpreted in the following way: the sampling device more accurately passed through higher concentration regions of the cloud (at the towing depth of the V-fin) to obtain the afore-listed concentration peaks and in between those peaks did not so accurately target or pass through high concentration regions of the cloud. Inasmuch as it is always a question in sampling of material discharged in the ocean as to whether the sampling device was indeed within the volume of material to be sampled, it is noted that the basic confirmation for proper space-time sampling was achieved using acoustical devices. In addition to acoustical detection of residual water column material a visible ocean surface signature (a milk-like coloring) was available. The acoustical systems show the subsurface distribution of material corresponding to a particular surface detection

TSS values for all discharges plotted against time are shown in Figure 21. A background concentration estimate may be obtained from the lowest of the TSS values shown in Table I, as such values presumably are obtained from complete or partial "misses' in sampling of the residual plume. A second background concentration estimate may be made from the data gathered on June 27 and 28, 1991 and displayed in Table II assuming, of course, that data gathered on those dates are also applicable for April 1990. Using the data from Table II gathered at those points proximate to the designated discharge area (stations 1,2,3,5,6 and 7 for Jun 27, 1991 and station 6 for June 28, 1991 a background value of about 0.5 mg/l is obtained. Using in-between-peak low values from discharge 2 for example, a background value of about 0.2 mg/l is obtained. As discussed earlier, many of the values are judged to be gathered at locations somewhat separated from cloud regions of highest concentration. Data from three of the discharges have been selected and included in Figure 22 to obtain a smoother estimate of dilution with time (or distance) from the discharge. Figure 22 has been constructed by normalizing the data for three discharges, i.e discharges one, three and four, by the largest (i.e. initial) value recorded for each discharge respectively. From among these three discharges local maximum values, i.e. values higher than at least one preceding value were selected and plotted. An estimated fit curve has been drawn to give a crude estimate of the normalized dilution with time or distance for discharges occurring within the designated site. Thus, for example, an initial concentration of 80 mg/l would diminish to 8 mg/l after one-half hour or at a distance of 900 meters from the point of discharge (current speed assumed is 100 cm/sec).

In reference one, a very crude estimate was made of the quantity of material residing within the residual water column cloud about 20 minutes after discharge. The main drawbacks of that were the delineation of the geometric dimensions of the plume of material within the water column and the lack of TSS measurements for a calibration of the acoustical system. The geometric delineation issue is still not resolved so that the assumption made in reference one, namely that the geometric delineation is provided by the plume delineation beginning one to two meters below the ocean's surface, is still required. The TSS measurements discussed in this document were obtained in the upper few meters of the water column. The assumption made in reference one is that an average TSS of about 10 mg/l is present in the residual cloud. If it is assumed that the near-surface TSS data values are typical of the subsurface cloud as a whole, the 10 mg/l assumed in reference one appears to be reasonable perhaps even conservative. Retaining the 10 mg/l estimate a very crude estimate that about 0.6% of the total solid material discharged remains within the water column about 20 minutes after discharge.

SUMMARY

Total suspended material (TSS) samples were obtained for a number of dredged material discharges at the Miami Ocean Dredged Material discharge site. Initial TSS values gathered in the upper few meters of the water column, approximately one minute after discharged, ranged from about 34 mg/l to 77 mg/l. A residual plume of dredged material remained within the water column. The plume was tracked for about forty-five minutes to one-hour and TSS samples obtained. About one-half hour after discharge plume concentration was observed to have a value of about a few mg/l. The general direction of movement of the residual plume cloud was North-Northeast.

ACKNOWLEDGEMENTS

The assistance and support of Dr. Nick Kraus and Michelle Thevenot, of the U.S. Army Corps of Engineers Waterways Experiment Station, is greatly appreciated. The support and field participation of Mr. Mark Skarbek of the Jacksonville District U.S. Army Corps of Engineers is also greatly appreciated.

REFERENCE

1. Tsai, J.J., Proni, J.R., Dammann, W.P., and Kraus, N.C., (1992), *Dredged Material Disposal at the Edge of the Florida Current*, Chemistry and Ecology 6, pp. 169-187.

2. Proni, J.R., Tsai, J.J., and Dammann, W.P., (1991), *Miami Harbor Dredged Material Disposal Project*, A report to the U.S. Army Corps of Engineers.

LIST OF FIGURES

TABLE I

Total Water Column Suspended Material

Discharge #	TSS (mg/l)	Time Since Discharge	Discharge #	TSS (mg/l)	Time Since Discharge	Discharge #	TSS (mg/l)	Time Since Discharge
TEST 13:57	77.4	01:00	No. 2 09:37	0.0	00:00	No. 3 12:04	61.0	02:00
				0.6	03:00		0.6	04:00
No. 1	33.6	01:00		2.7	12:00		0.2	06:00
	7.0	03:00		0.2	13:00		2.0	07:00
	0.1	06:00		1.6	17:00		1.7	10:00
	0.5	08:00		0.3	20:00		10.2	12:00
	3.1	11:00		0.5	23:00		1.0	16:00
				0.1	30:00		1.4	19:00
				0.4	34:00		5.8	20:00
				0.0	38:00		1.1	24:00
				0.2	42:00		0.2	29:00
				0.5	46:00		1.9	35:00
				0.2	55:00		0.8	39:00
				0.2	56:00		2.0	49:00

TABLE I continued

Total Water Column Suspended Material

Discharge #	TSS (mg/l)	Time Since Discharge		Discharge #	TSS (mg/l)	Time Since Discharge		Discharge #	TSS (mg/l)	Time Since Discharge
No. 4	29.5	00:30		No. 5	3.0	02:00		No. 6	0.1	00:00
	0.6	08:30			2.0	04:00			0.1	02:00
	3.4	11:30			3.3	05:00			0.5	05:00
	1.1	16:30			5.1	06:00			4.5	08:00
	0.3	19:30			0.6	07:00			1.2	14:00
	1.7	22:30							0.1	17:00
									0.8	20:00
									0.9	26:00
									0.6	31:00
									1.2	38:00
									0.4	45:00

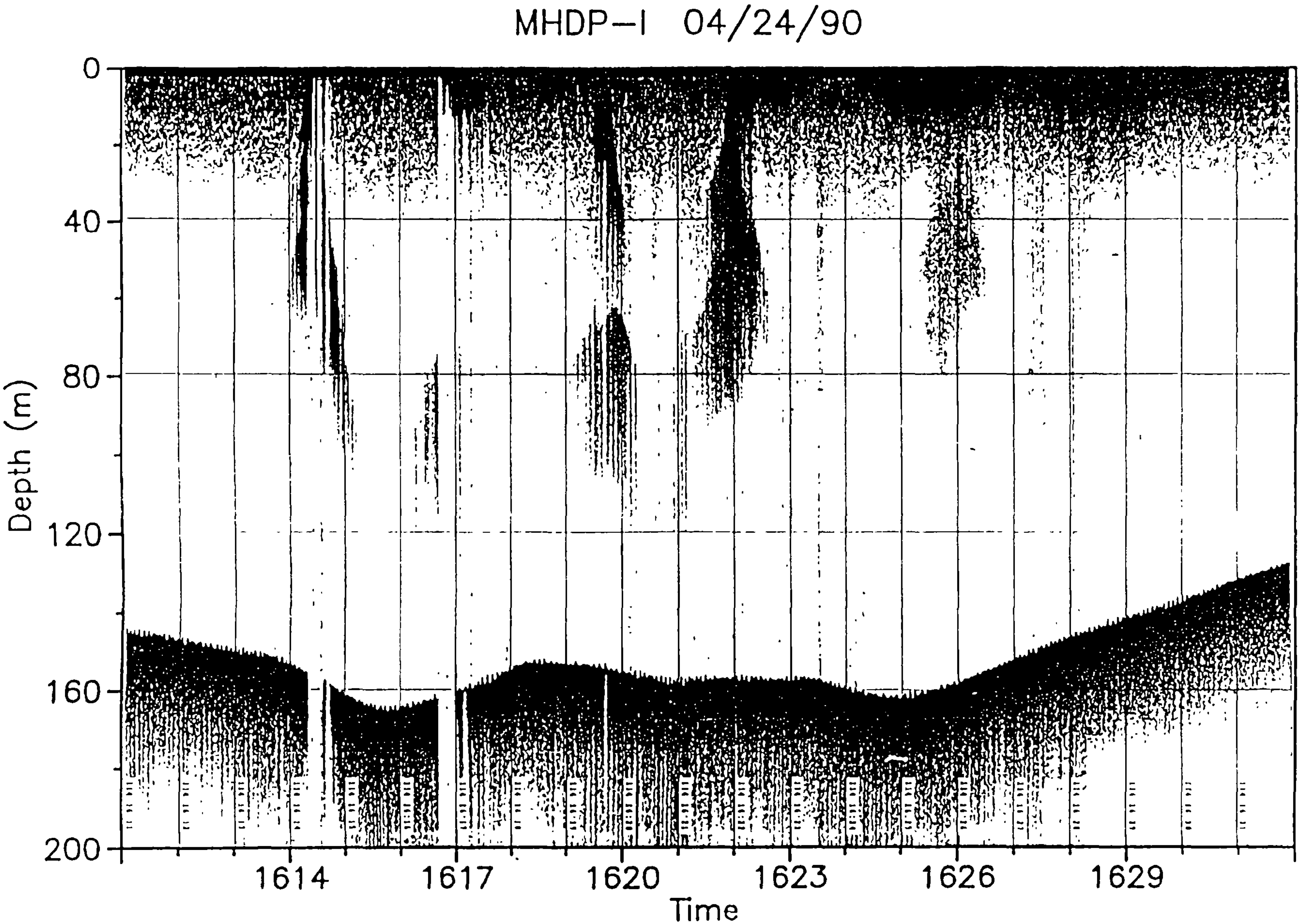
TSS is measured in milligrams per liter
Time is measured in minutes and seconds

TABLE I continued

Total Water Column Suspended Material

Discharge #	TSS (mg/l)	Time Since Discharge
No. 7	6.1	04:00
	2.8	10:00
	1.4	15:00
	0.8	17:00
	1.5	21:00
	3.4	23:00
	0.1	25:00
	0.6	35:00
	0.1	44:00
	0.1	54:00
	1.0	58:00
	0.4	64:00

TSS is measured in milligrams
Time is measured in minutes and seconds



MHDP-I 04/24/90
0
40
80
120
160
200
Depth (m)
1614
1617
1620
1623
1626
1629
Time

Figure 1

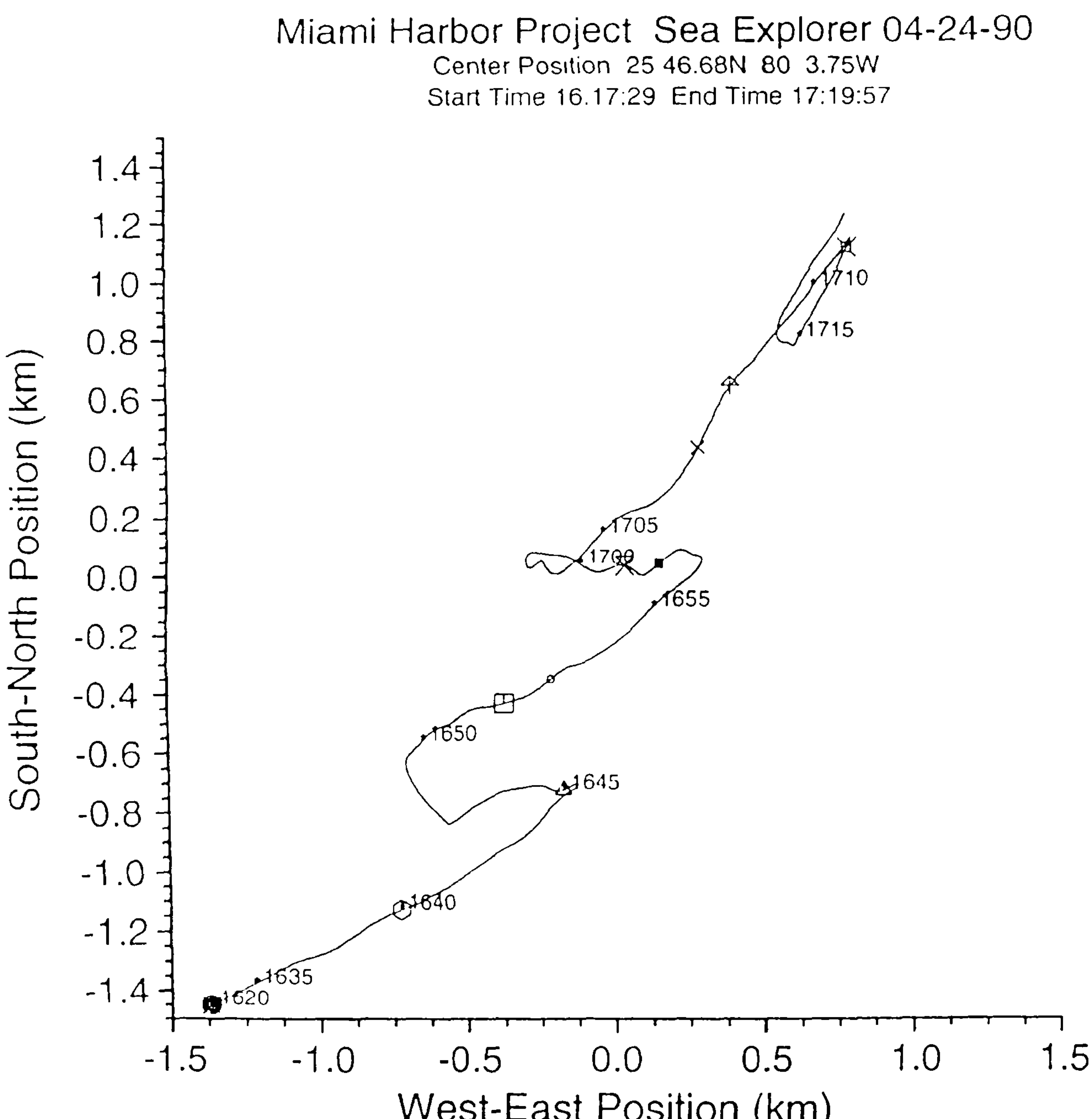
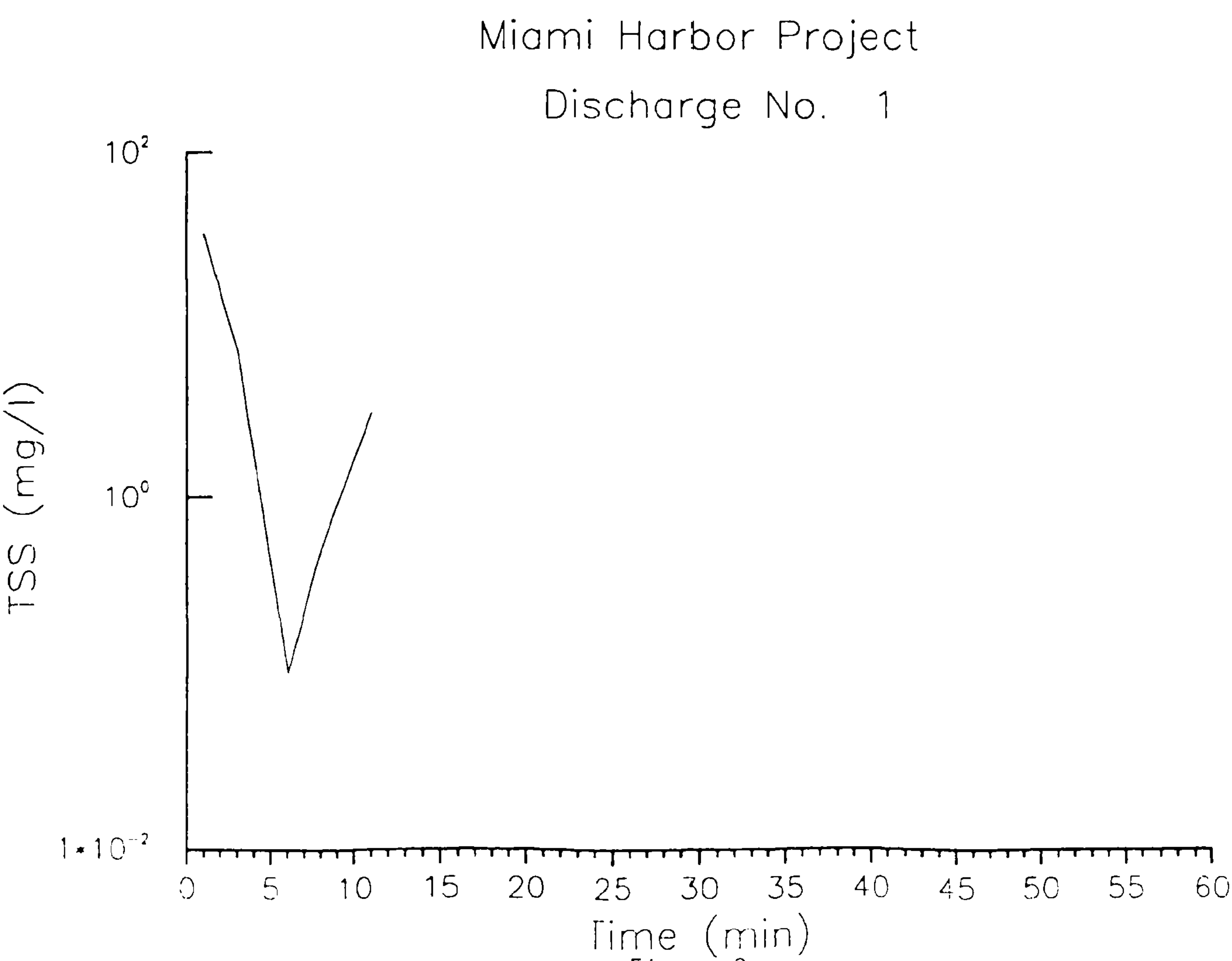
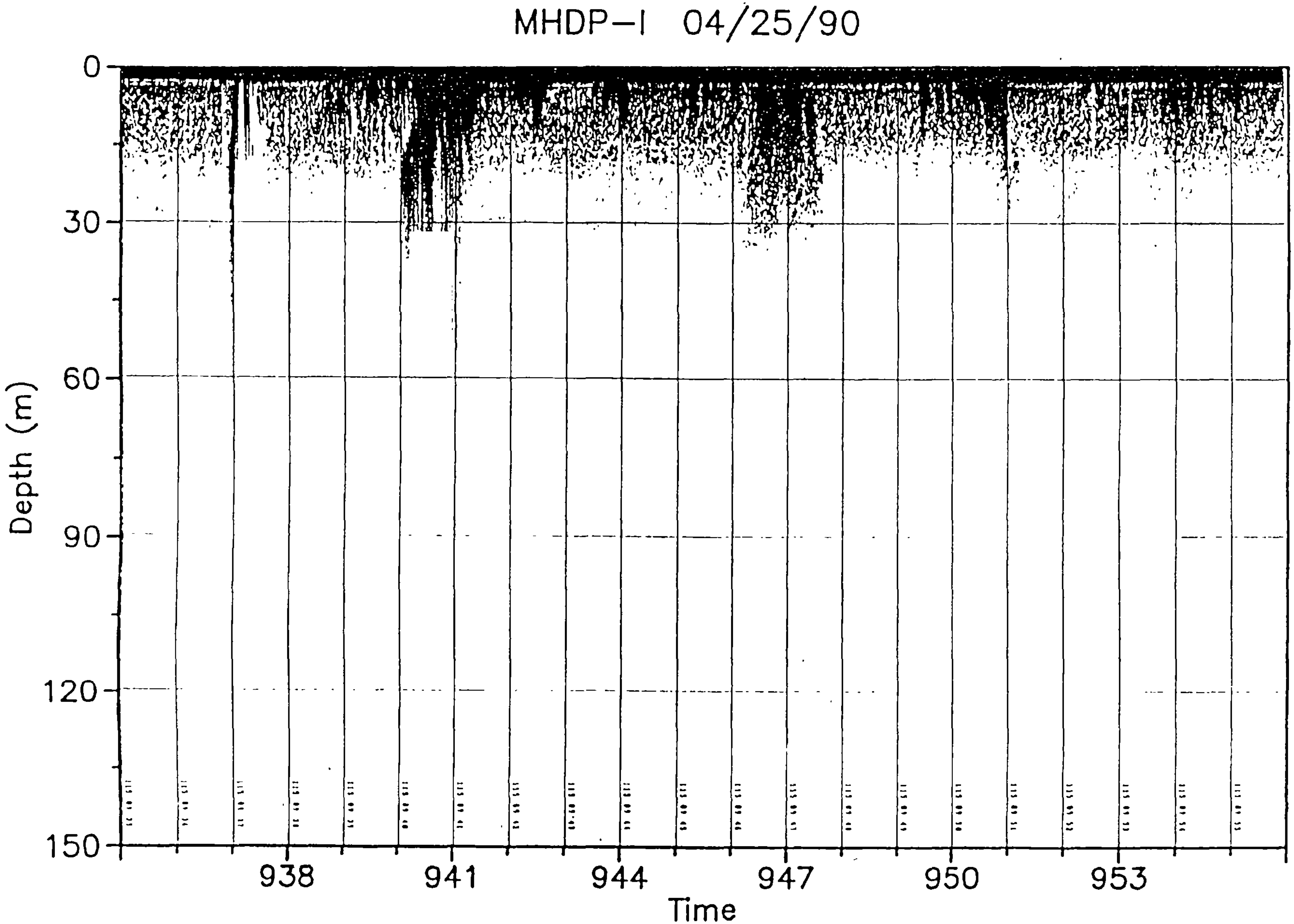

Miami Harbor Project Sea Explorer 04-24-90
Center Position 25 46.68N 80 3.75W
Start Time 16.17:29 End Time 17:19:57
South-North Position (km)
West-East Position (km)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
1710
1715
1705
1700
1655
1650
1645
1640
1635
1620

Figure 2



Miami Harbor Project
Discharge No. 1
10^2
10^0
$1*10^{-2}$
TSS (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
Time (min)

Figure 3



MHDP-I 04/25/90
Depth (m)
0
30
60
90
120
150
938
941
944
947
950
953
Time

Figure 4

Miami Harbor Project Sea Explorer 04-25-90
Center Position 25 45.79N 80 3.63W
Start Time 09:30:01 End Time 10:39:59

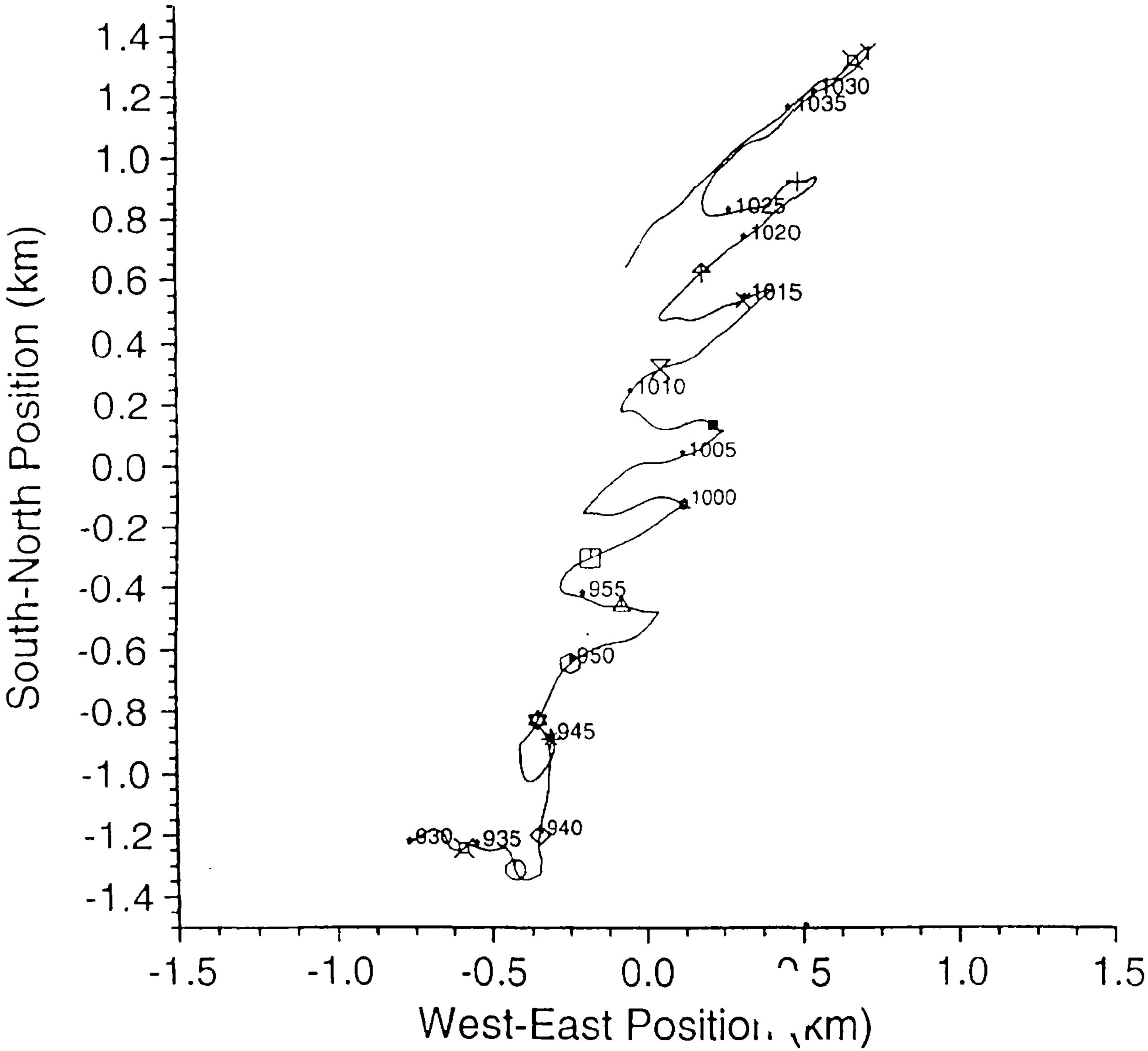
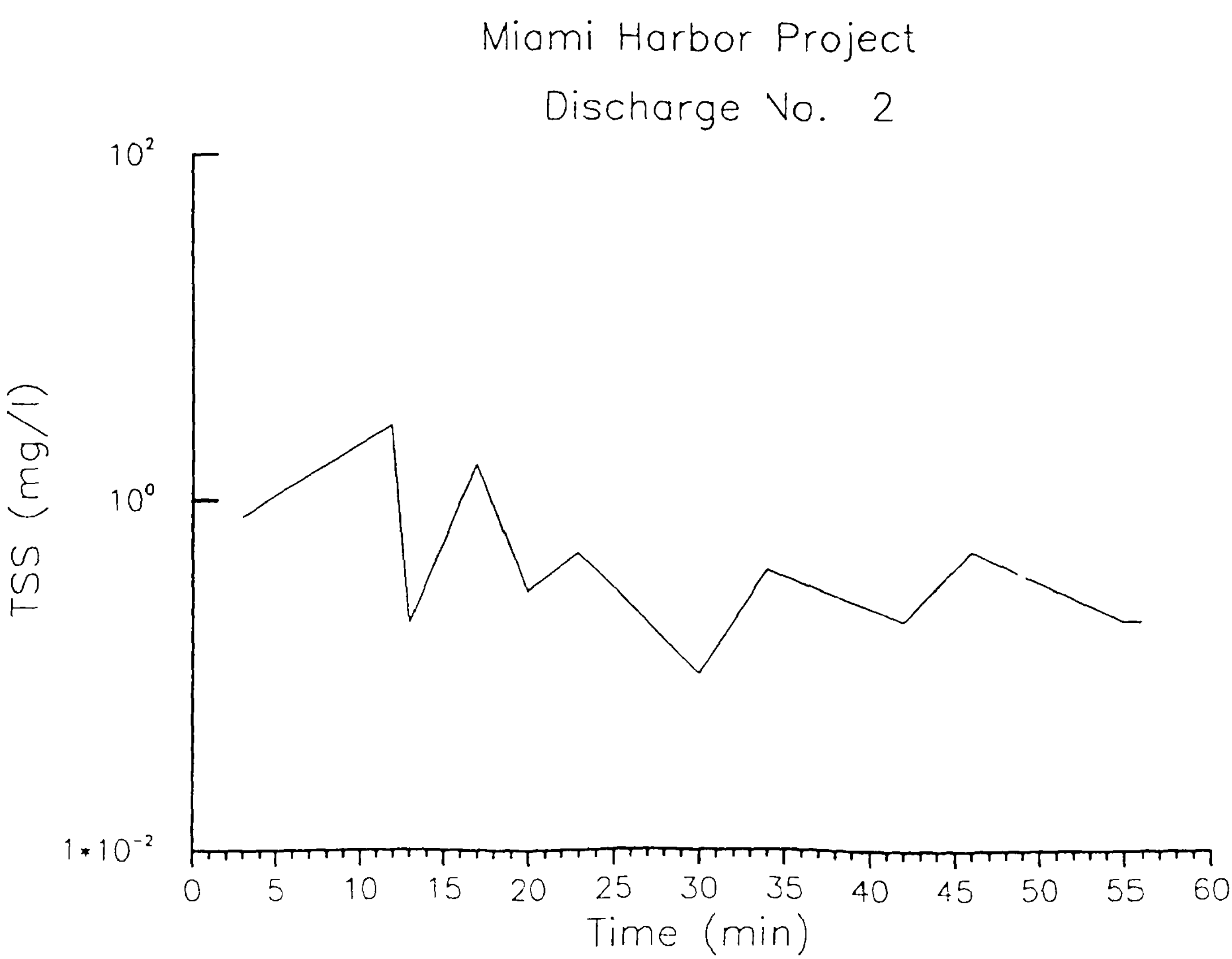
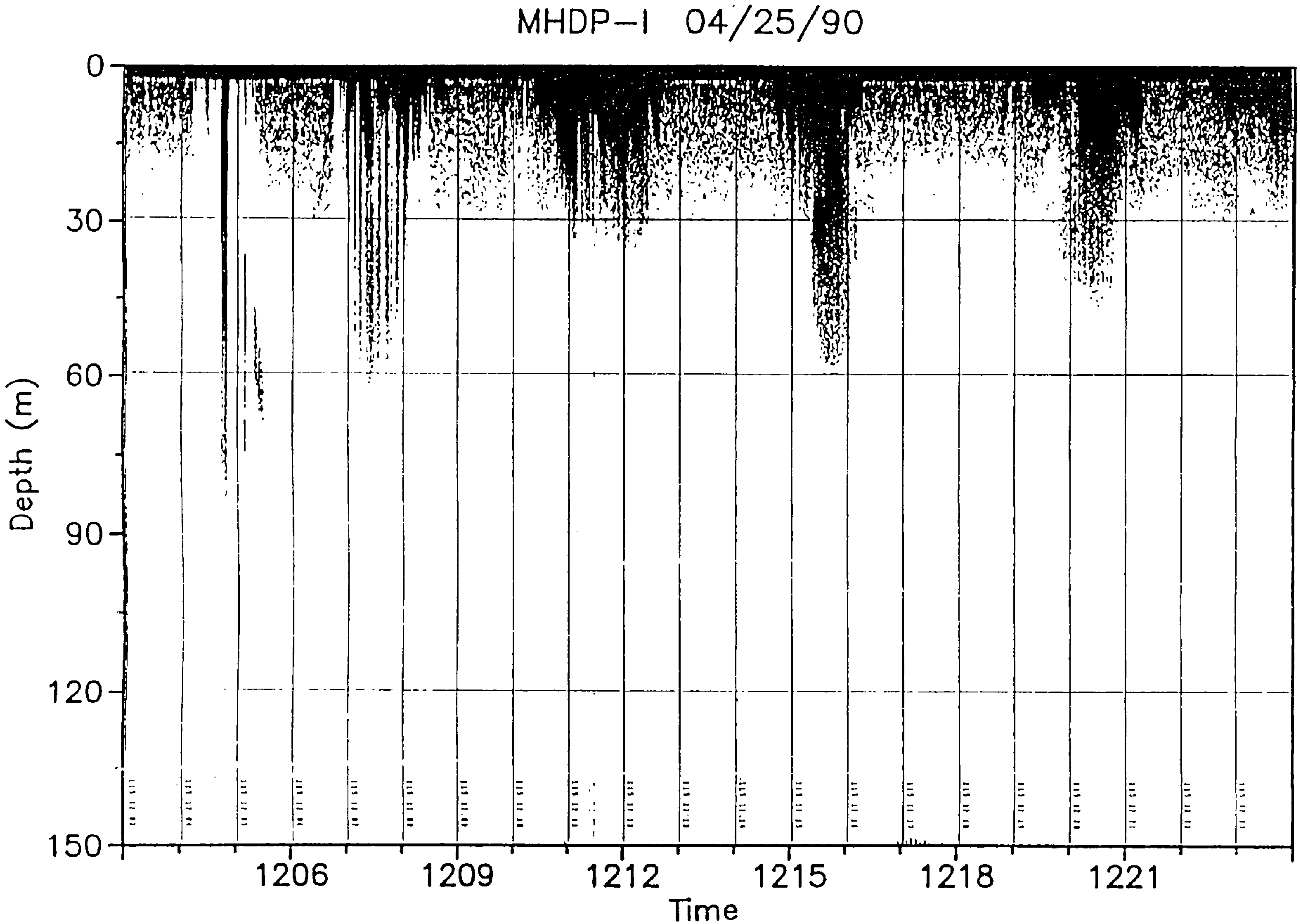


Figure 5


Miami Harbor Project
Discharge No. 2
TSS (mg/l)
10²
10⁰
1*10⁻²
0
5
10
15
20
25
30
35
40
45
50
55
60
Time (min)
Figure 6



MHDP-I 04/25/90
Depth (m)
0
30
60
90
120
150
1206
1209
1212
1215
1218
1221
Time

Figure 7

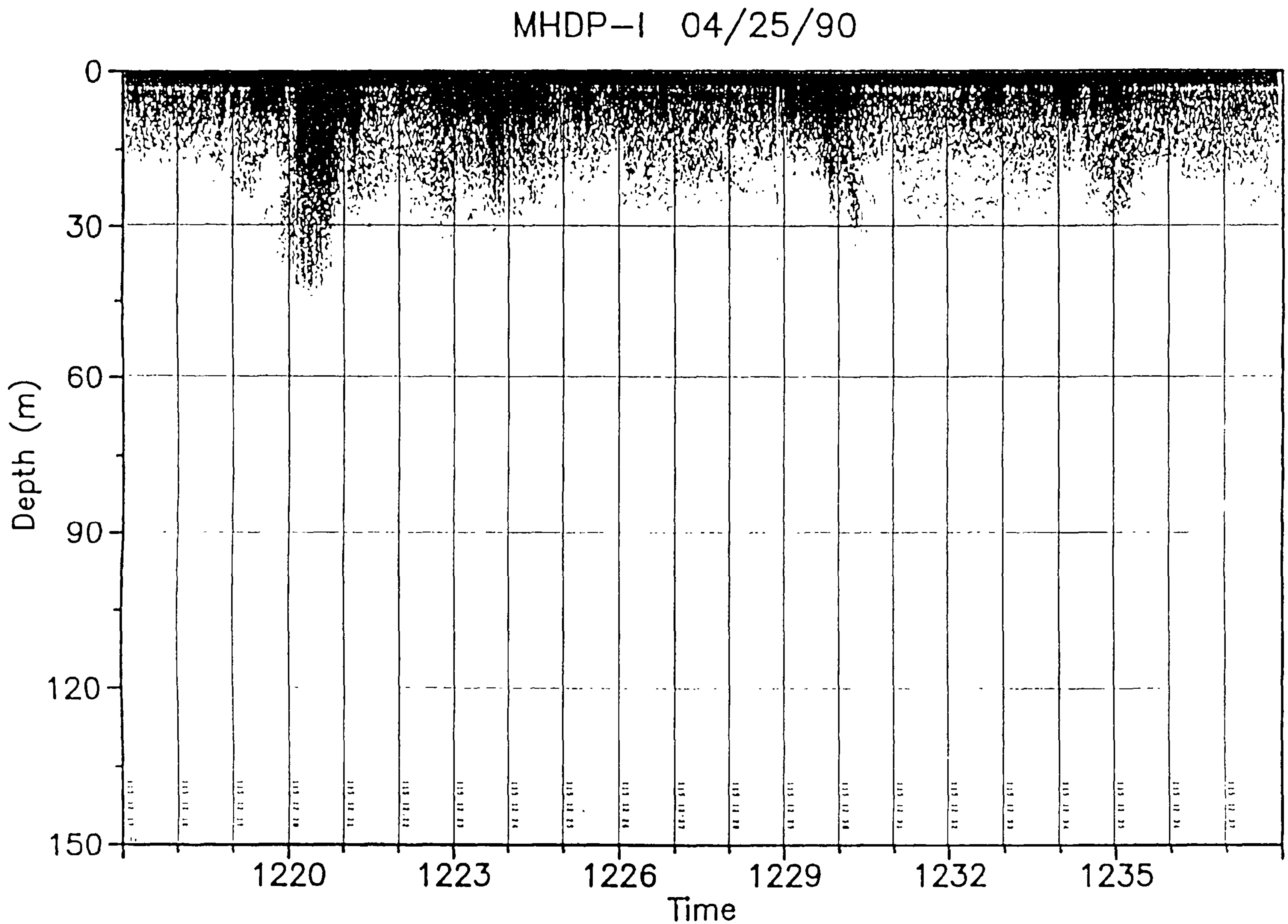

MHDP-I 04/25/90
Depth (m)
0
30
60
90
120
150
1220
1223
1226
1229
1232
1235
Time

Figure 8

Miami Harbor Project Sea Explorer 04-25-90

Center Position 25 46.00N 80 3.64W

Start Time 12:05:02 End Time 12:59:59

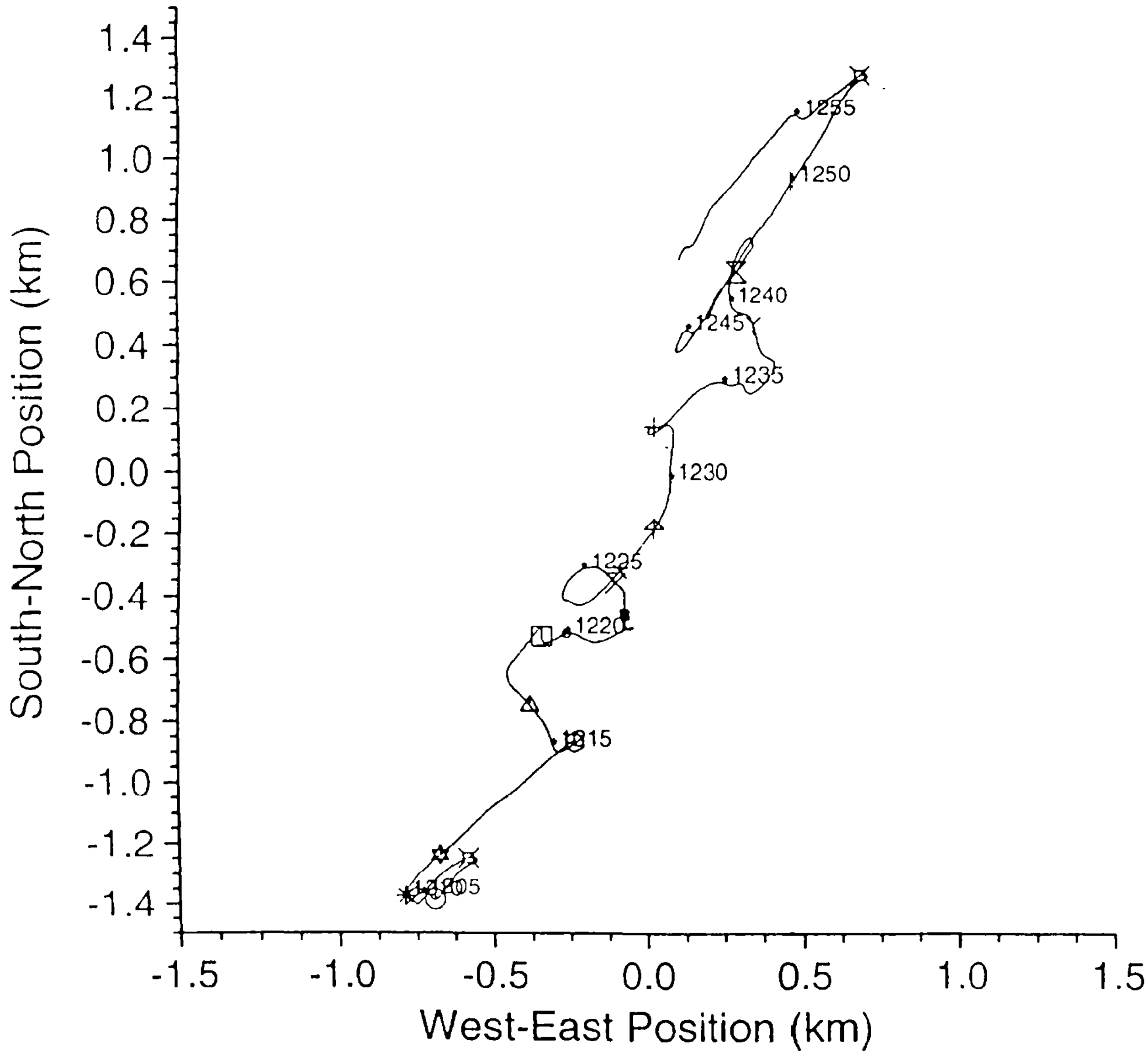
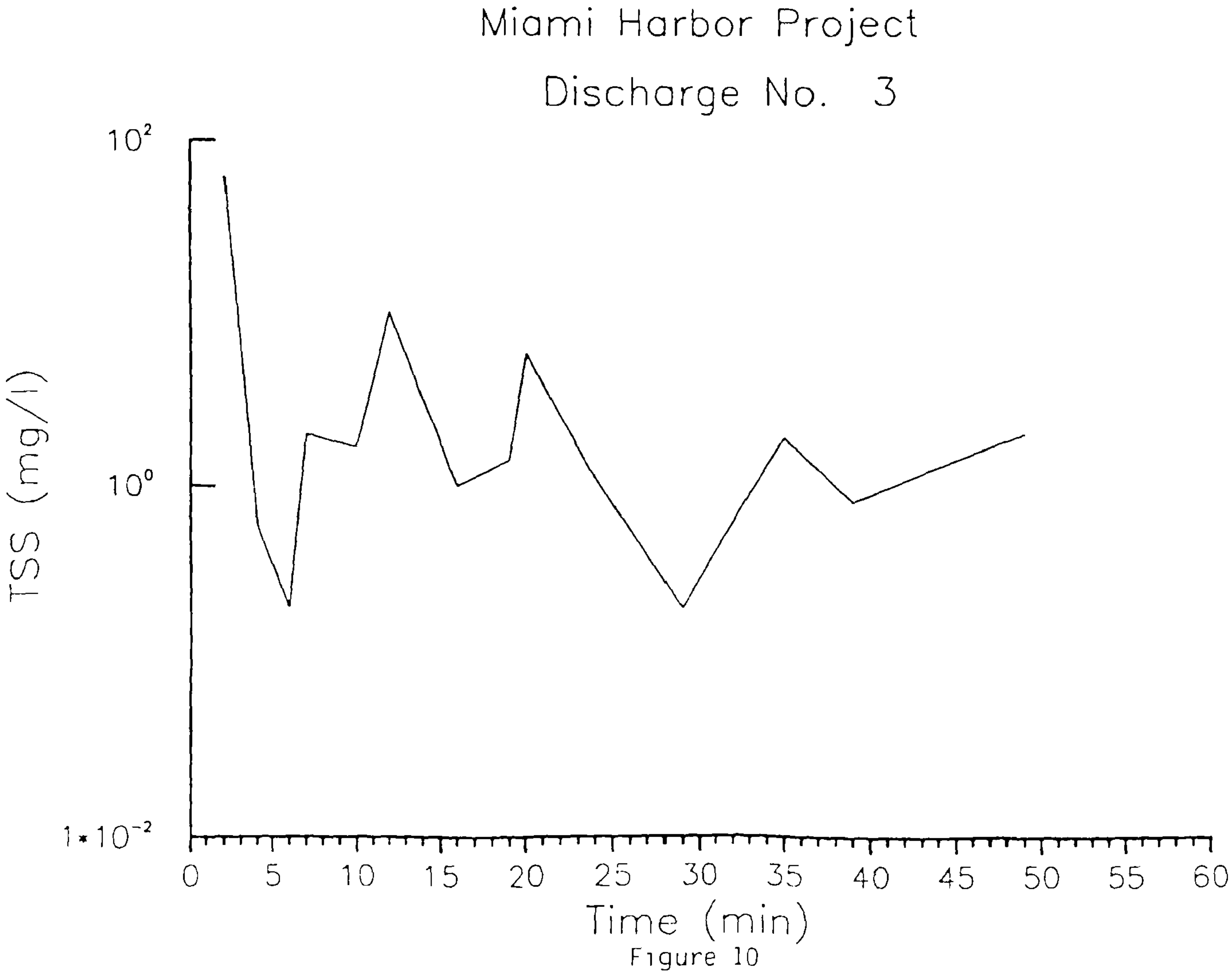


Figure 9


Miami Harbor Project
Discharge No. 3
10²
10⁰
1*10⁻²
TSS (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
Time (min)
Figure 10

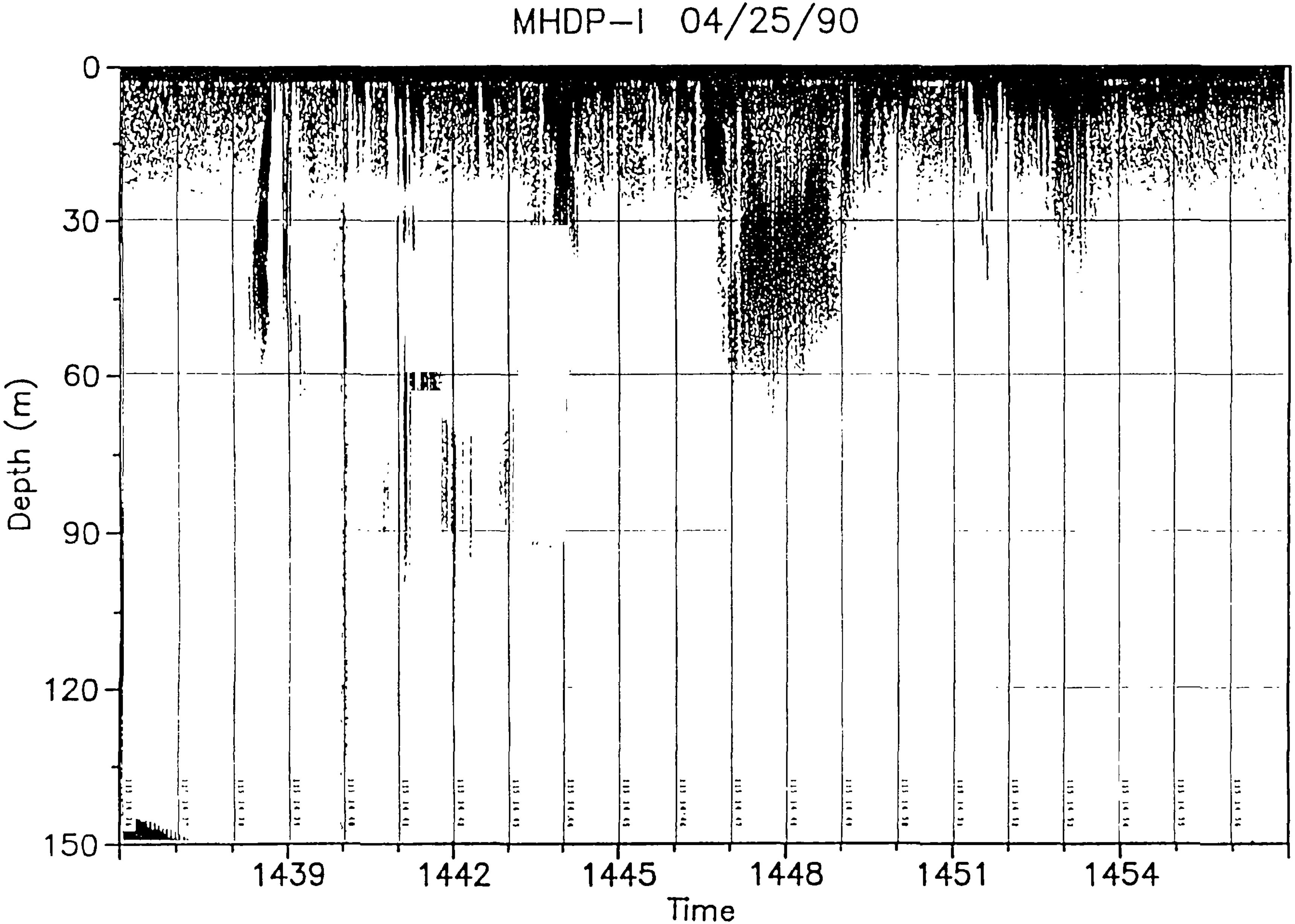
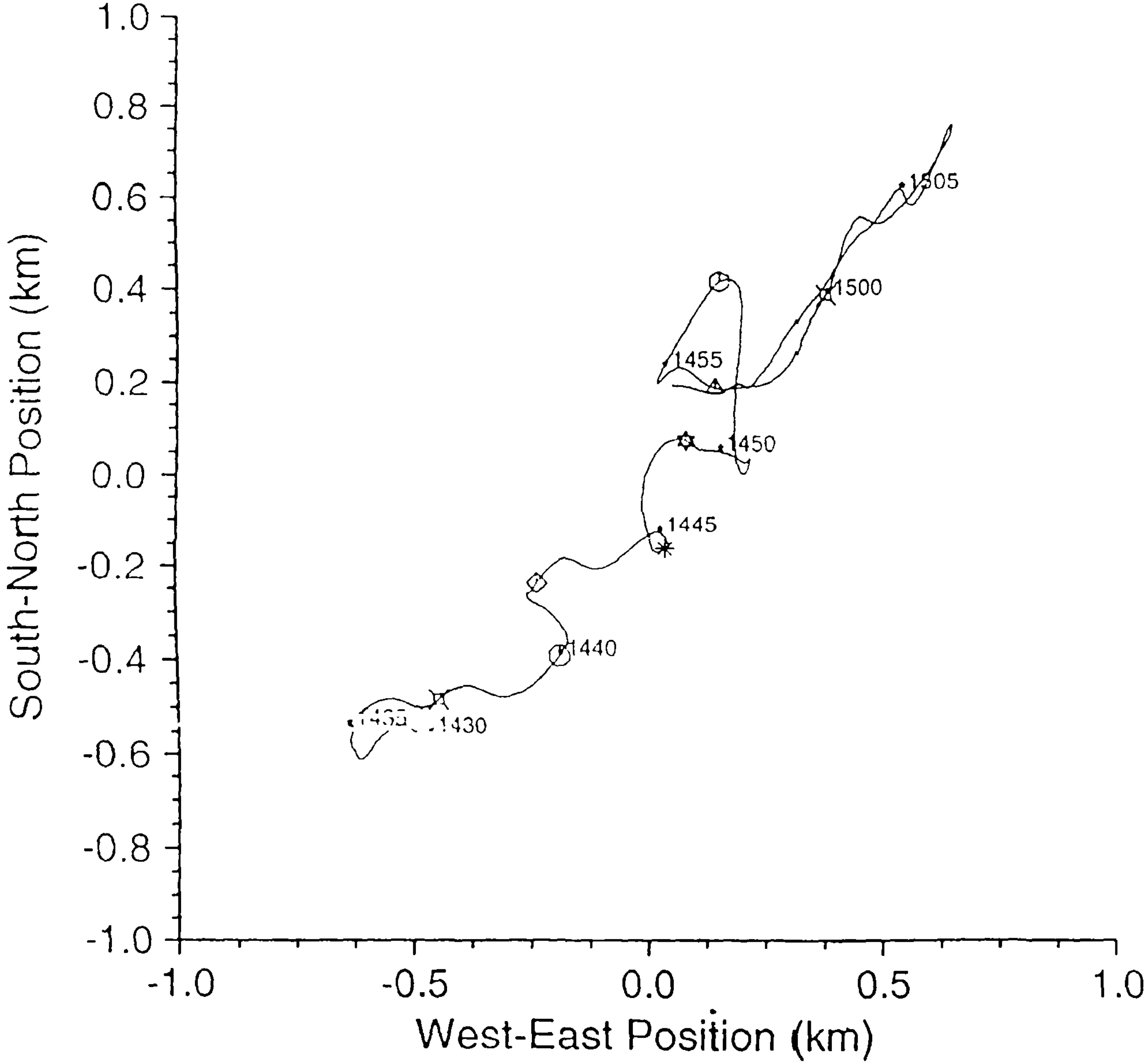
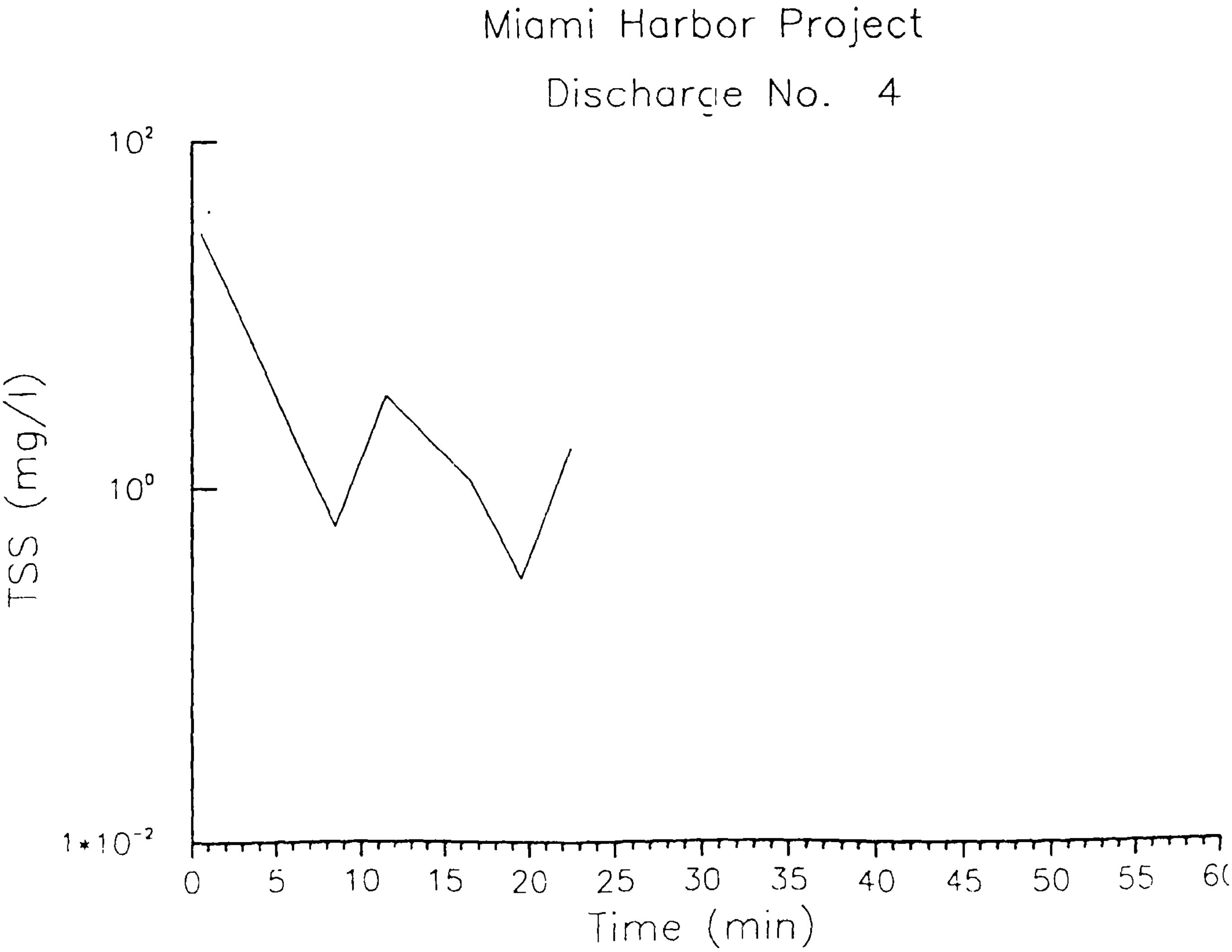

MHDP-I 04/25/90
Depth (m)
0
30
60
90
120
150
1439
1442
1445
1448
1451
1454
Time

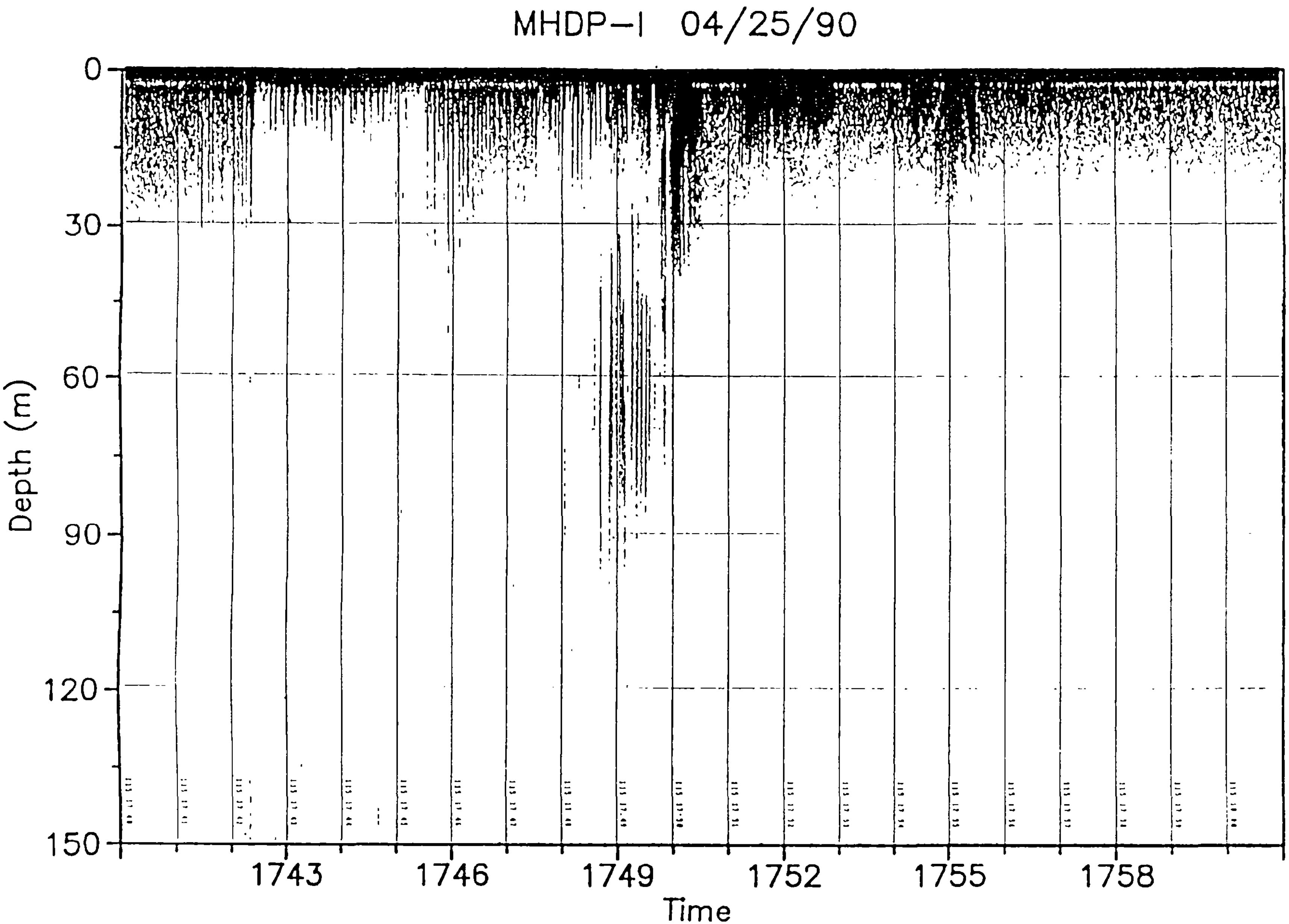
Figure 11

Figure 12

Miami Harbor Project Sea Explorer 04-25-90
Center Position 25 45.44N 80 3.51W
Start Time 14:30:00 End Time 15:09:57




Miami Harbor Project
Discharge No. 4
TSS (mg/l)
10²
10⁰
1*10⁻²
0 5 10 15 20 25 30 35 40 45 50 55 60
Time (min)
Figure 13



MHDP-I 04/25/90
Depth (m)
0
30
60
90
120
150
1743
1746
1749
1752
1755
1758
Time

Figure 14

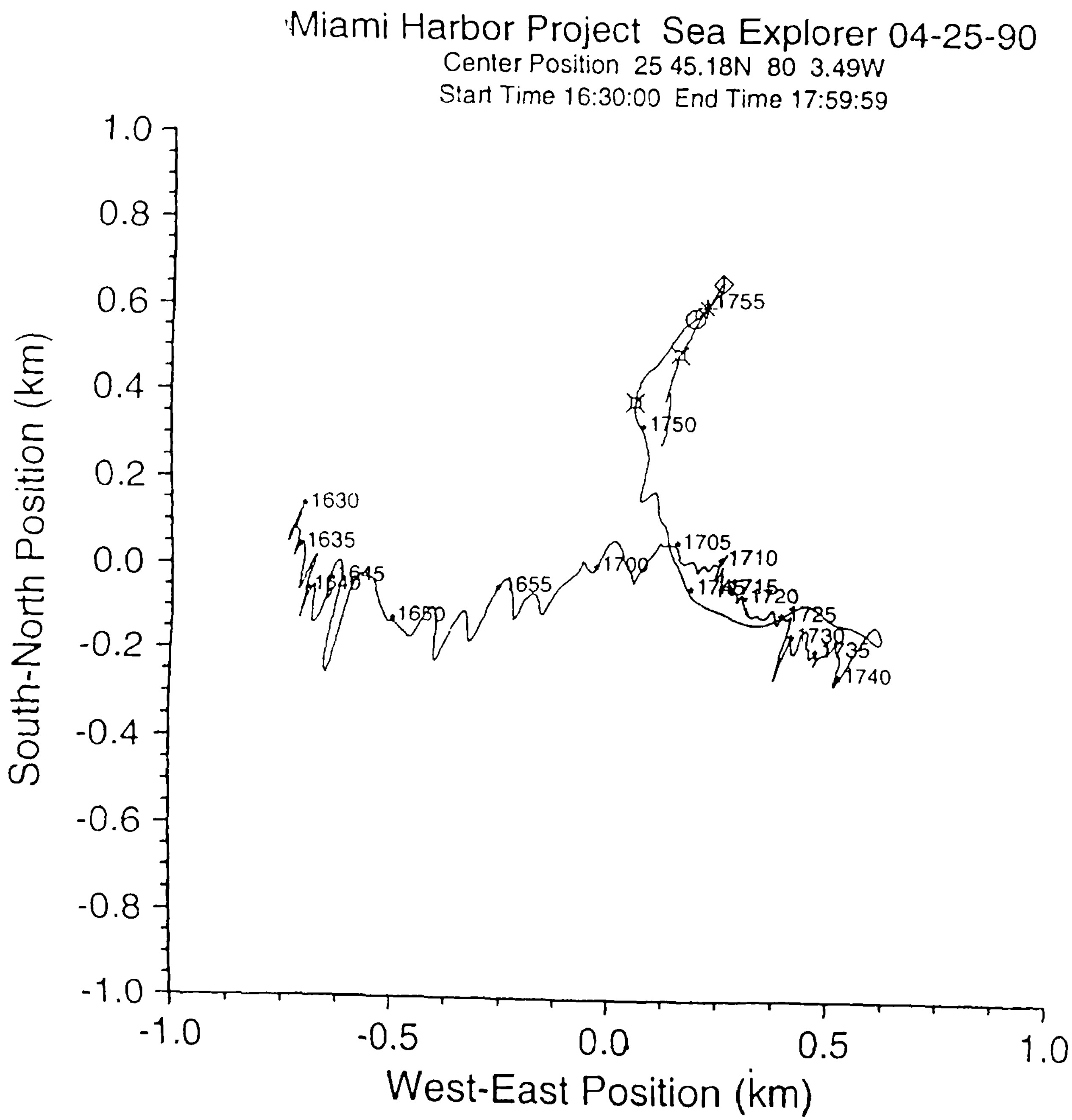
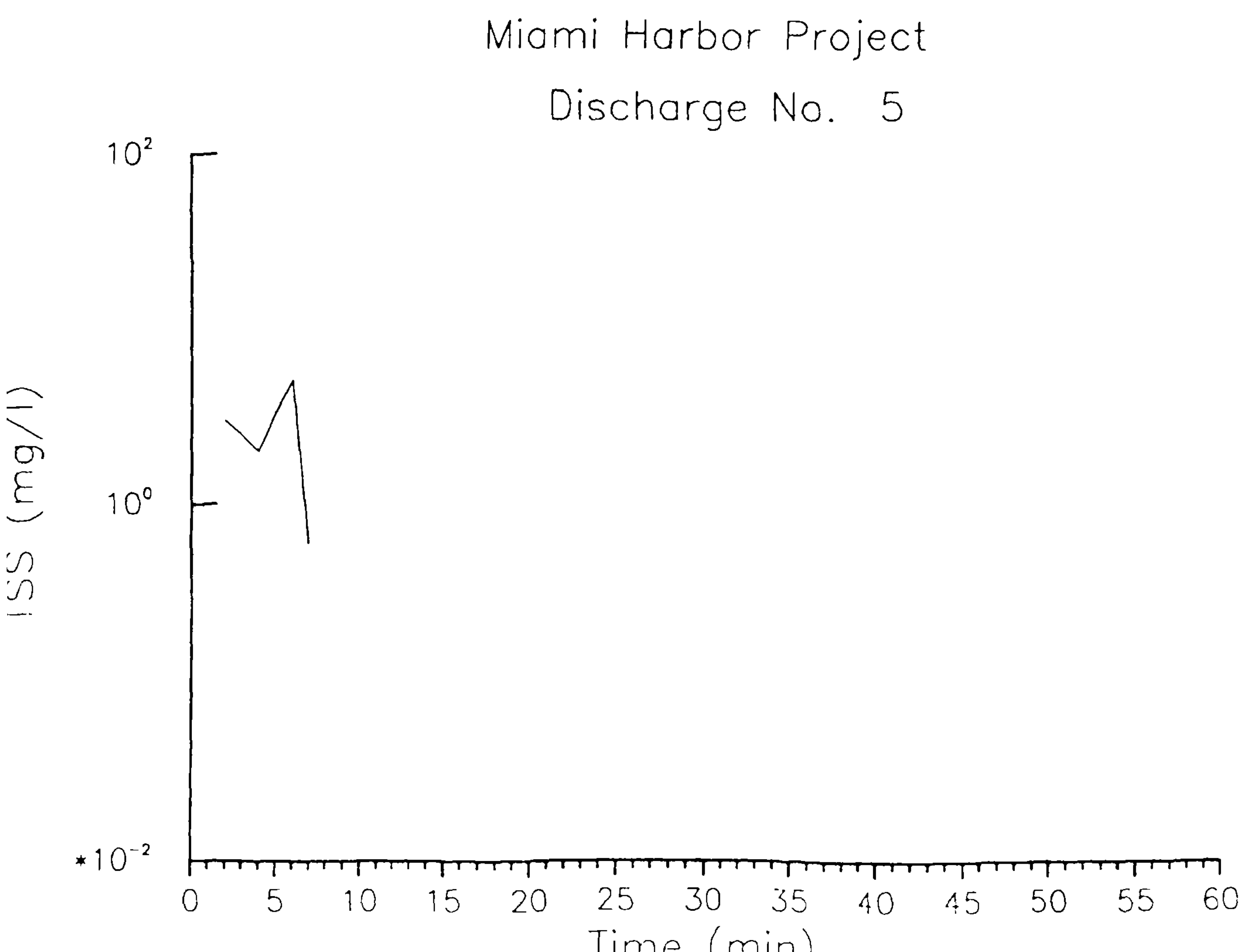
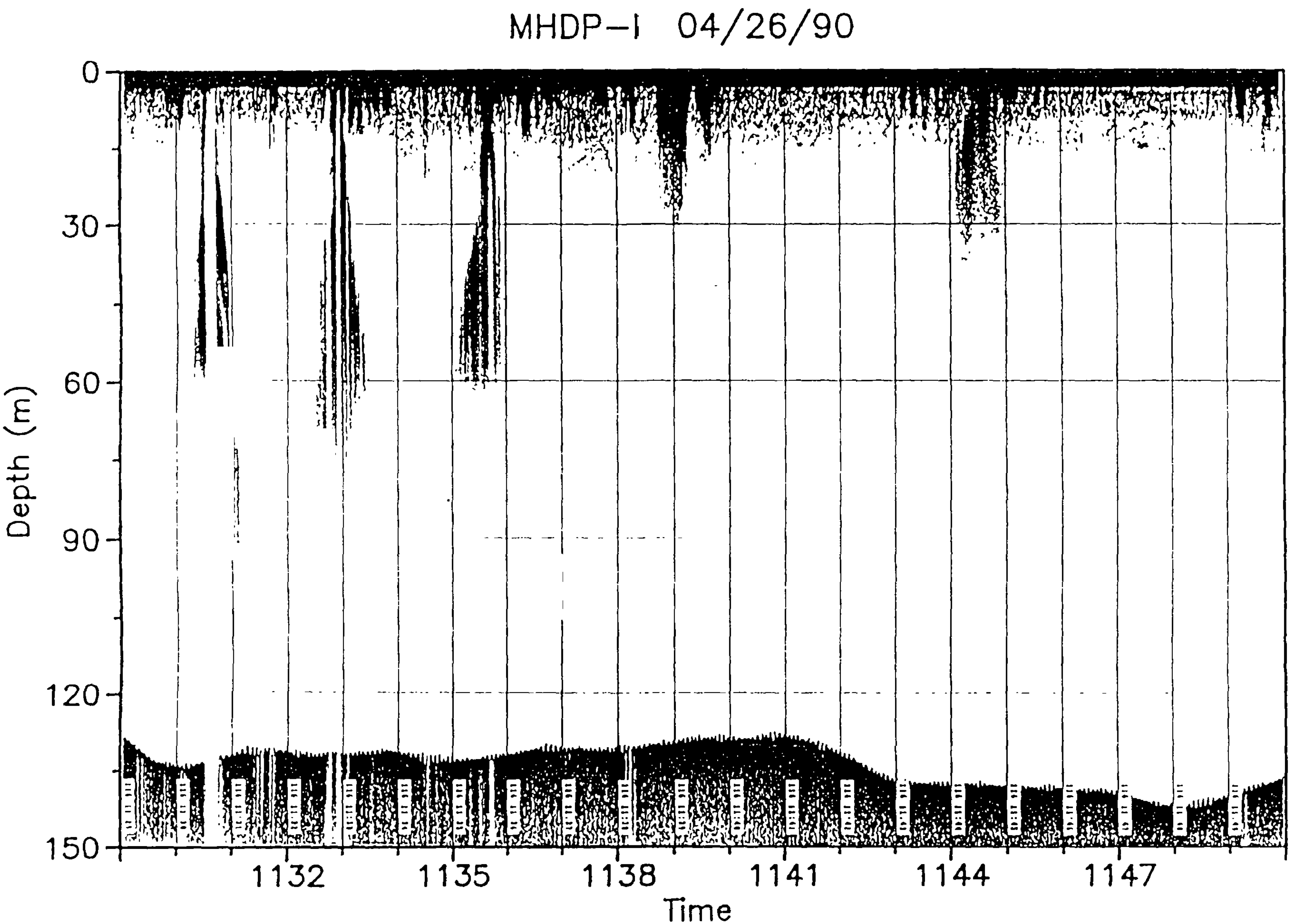

Miami Harbor Project Sea Explorer 04-25-90
Center Position 25 45.18N 80 3.49W
Start Time 16:30:00 End Time 17:59:59
South-North Position (km)
West-East Position (km)
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.0
-0.5
0.0
0.5
1.0
1630
1635
1645
1650
1655
1700
1705
1710
1715
1720
1725
1730
1735
1740
1750
1755

Figure 15


Miami Harbor Project
Discharge No. 5
10^2
10^0
$*10^{-2}$
ISS (mg/l)
0
5
10
15
20
25
30
35
40
45
50
55
60
Time (min)
Figure 16



MHDP-I 04/26/90
Depth (m)
0
30
60
90
120
150
1132
1135
1138
1141
1144
1147
Time

Figure 17

Miami Harbor Project

Discharge No. 6

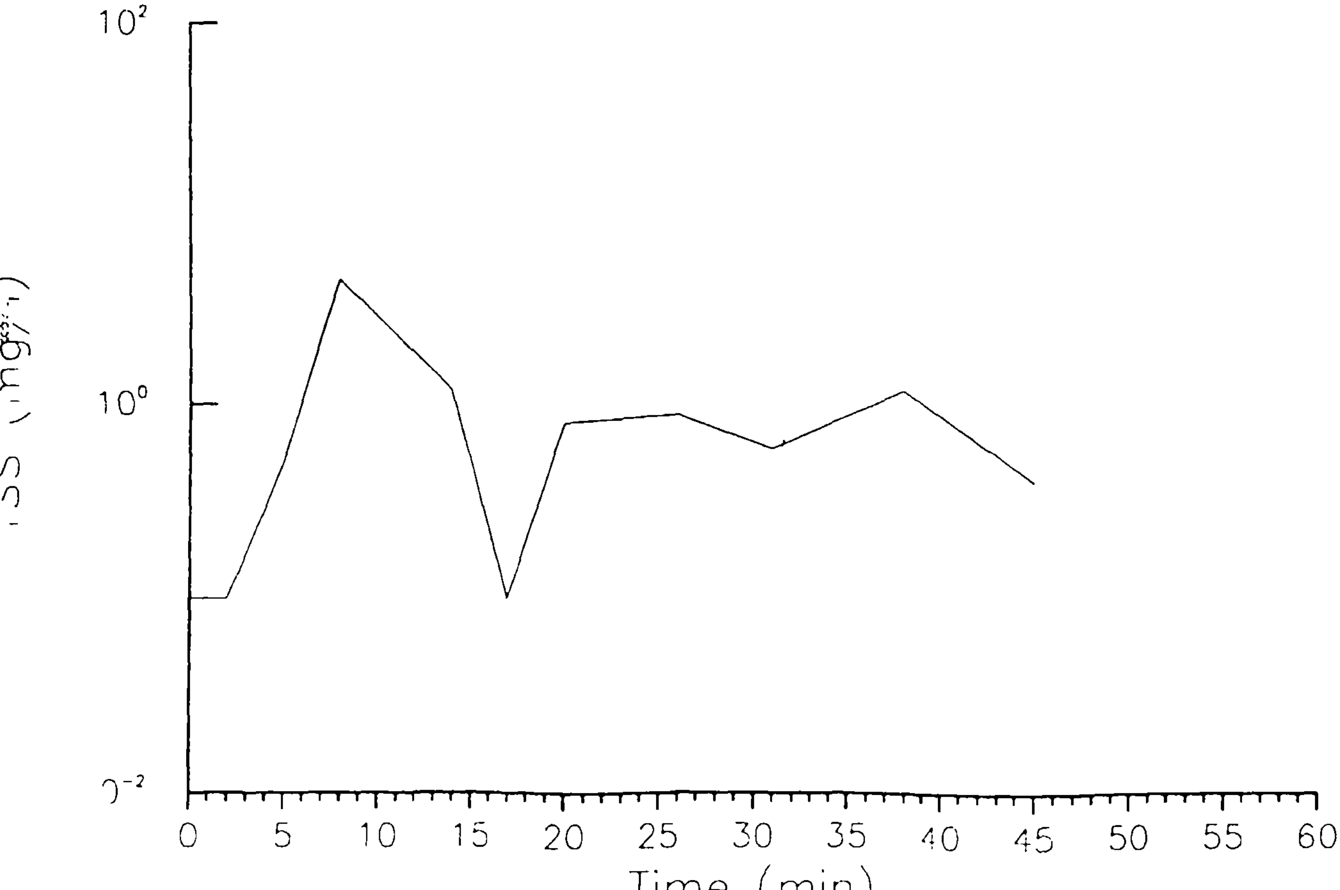


Figure 18

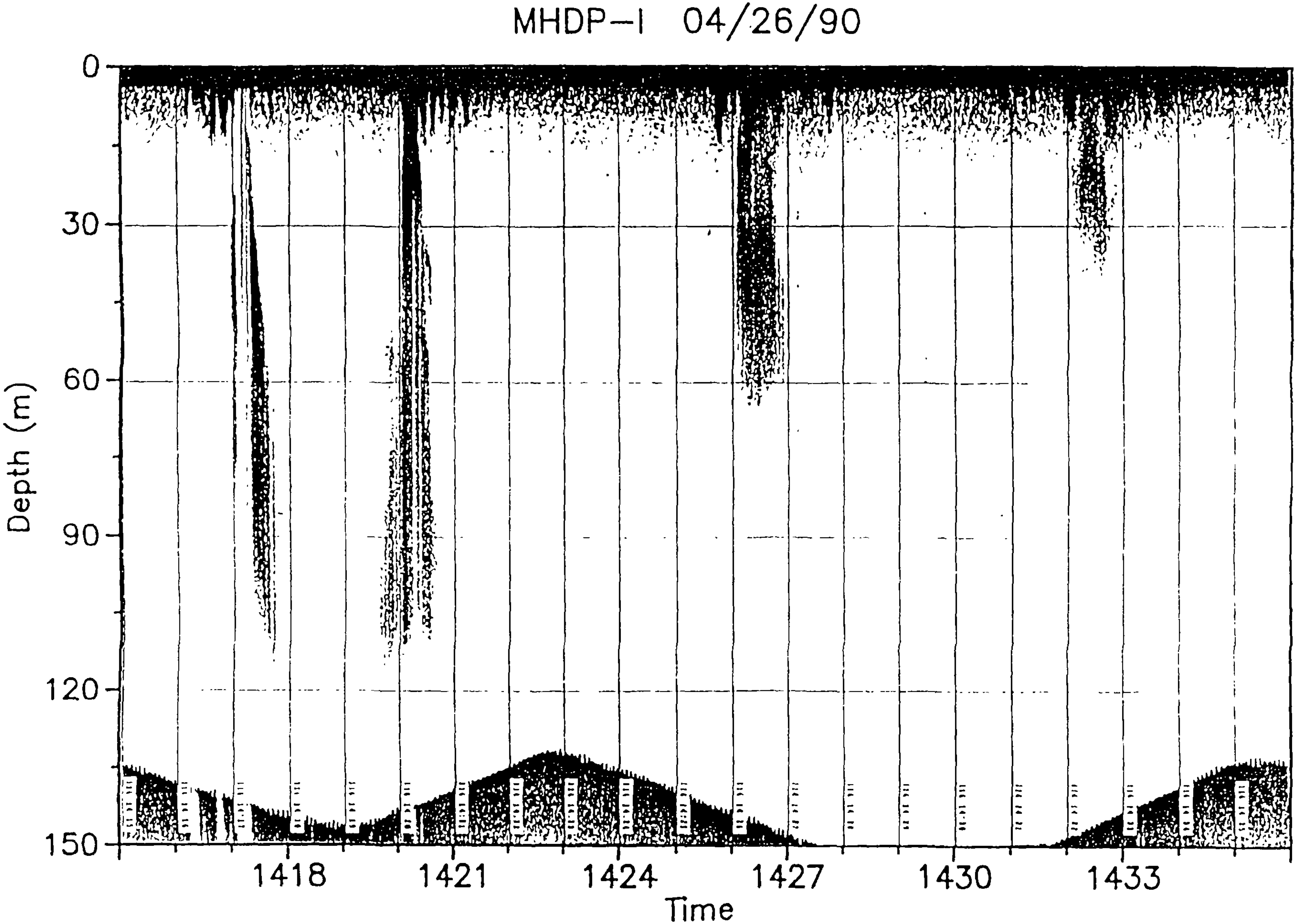
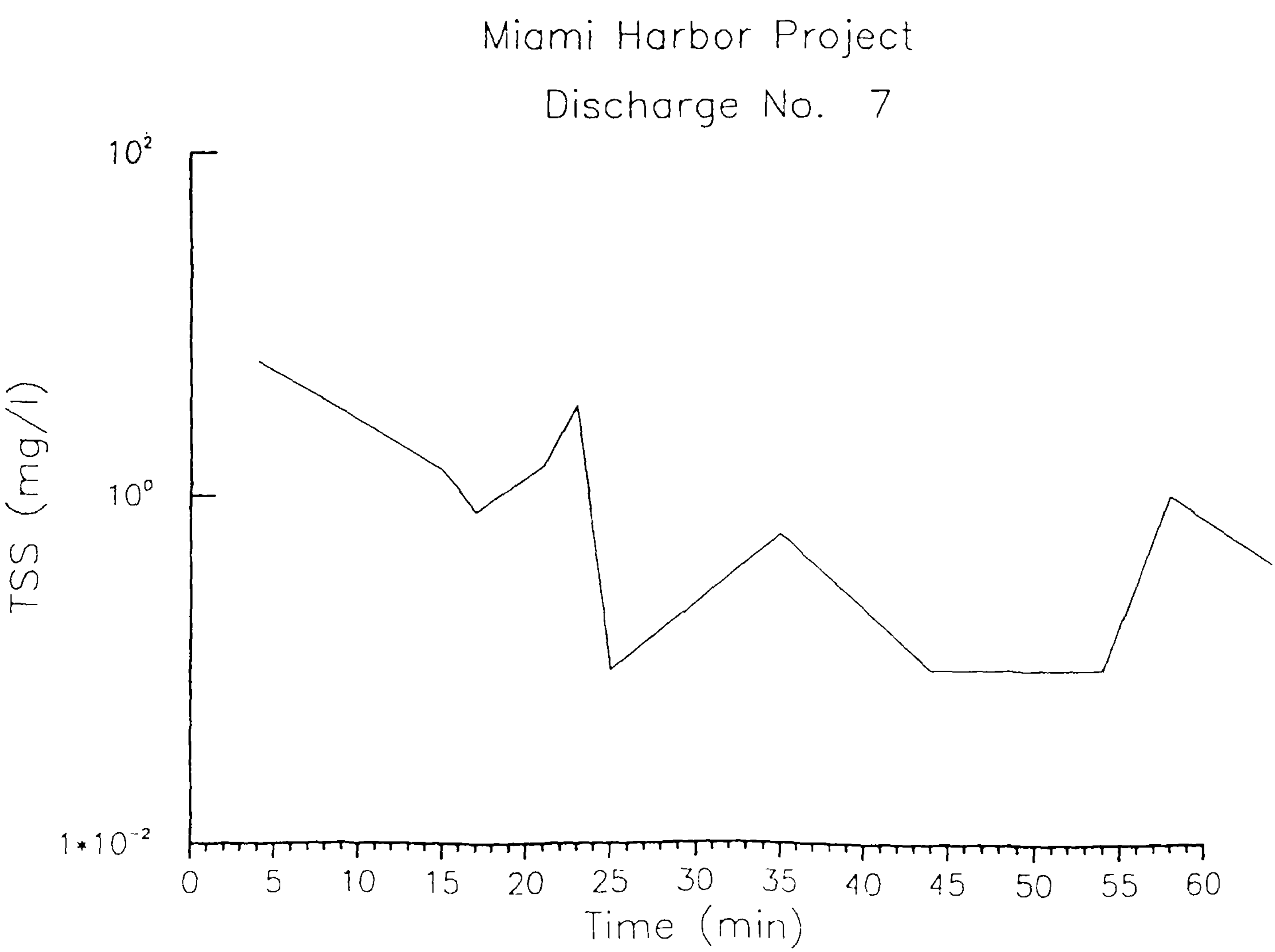
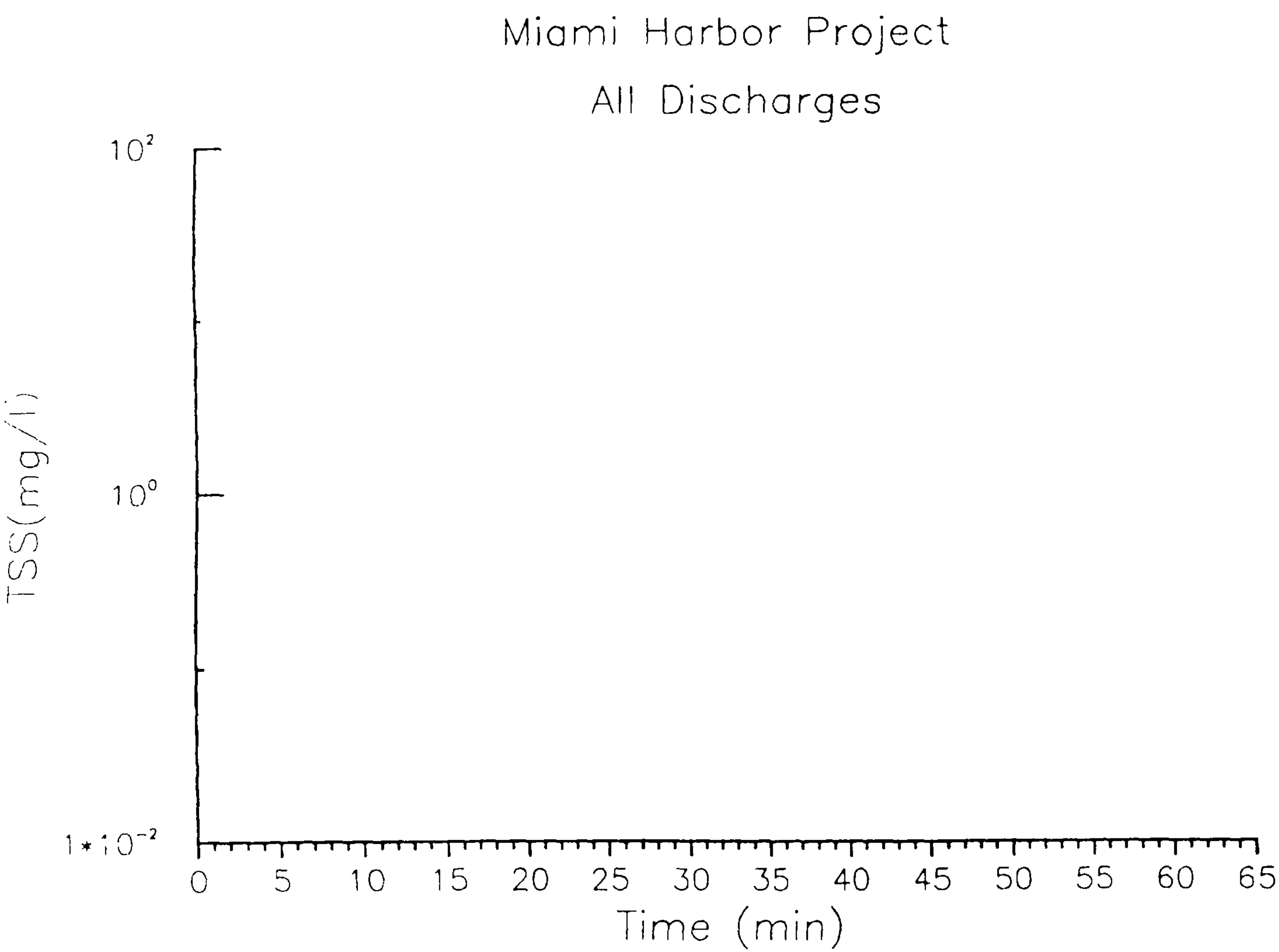

MHDP-I 04/26/90
Depth (m)
0
30
60
90
120
150
1418
1421
1424
1427
1430
1433
Time

Figure 19



Miami Harbor Project
Discharge No. 7
TSS (mg/l)
10^2
10^0
$1*10^{-2}$
0
5
10
15
20
25
30
35
40
45
50
55
60
Time (min)

Figure 20


Miami Harbor Project
All Discharges
10^2
10^0
$1*10^{-2}$
TSS(mg/l)
0 5 10 15 20 25 30 35 40 45 50 55 60 65
Time (min)

Normalized Concentration
Discharges Nos. 1, 3 & 4

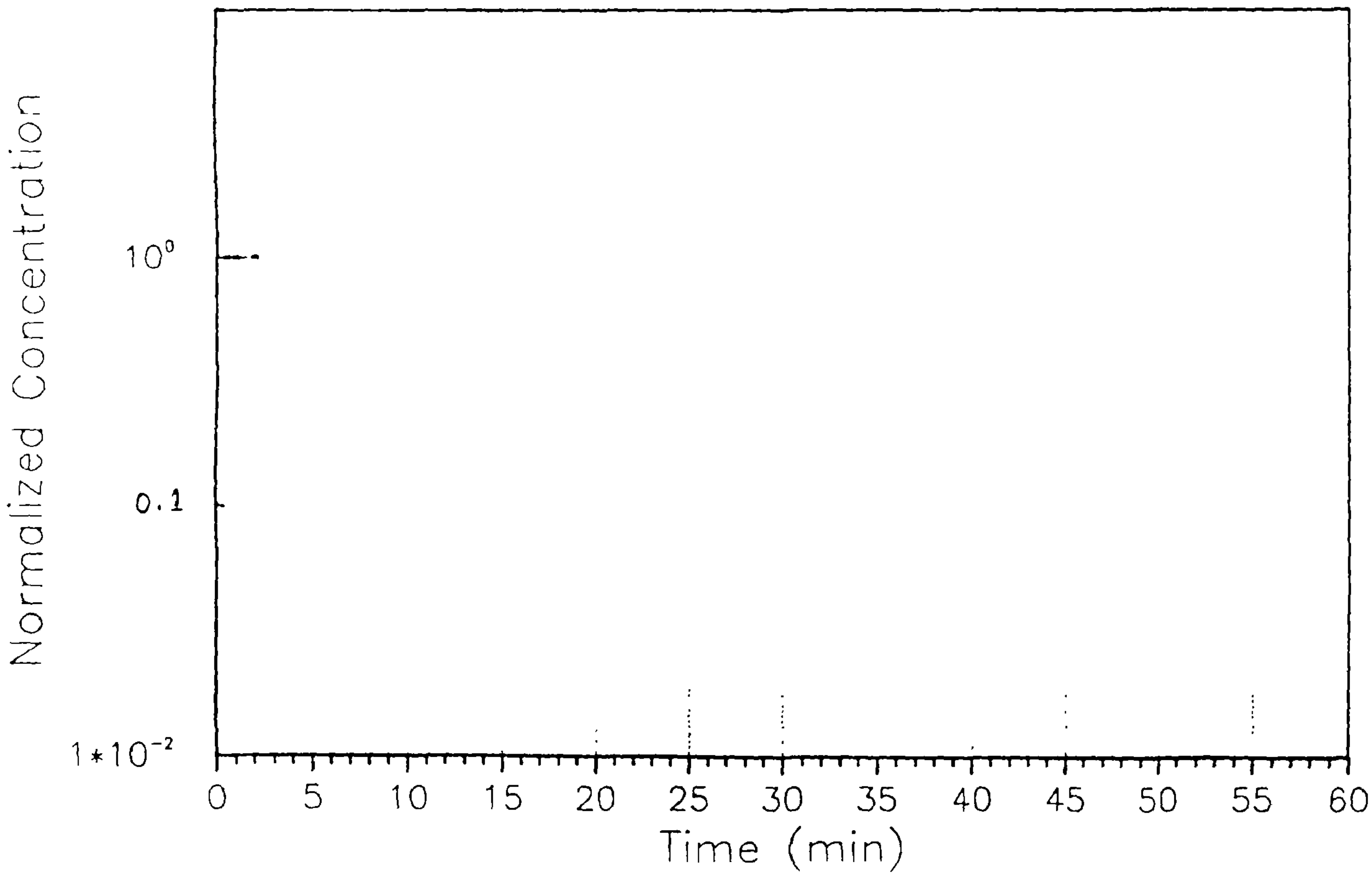


Figure 22

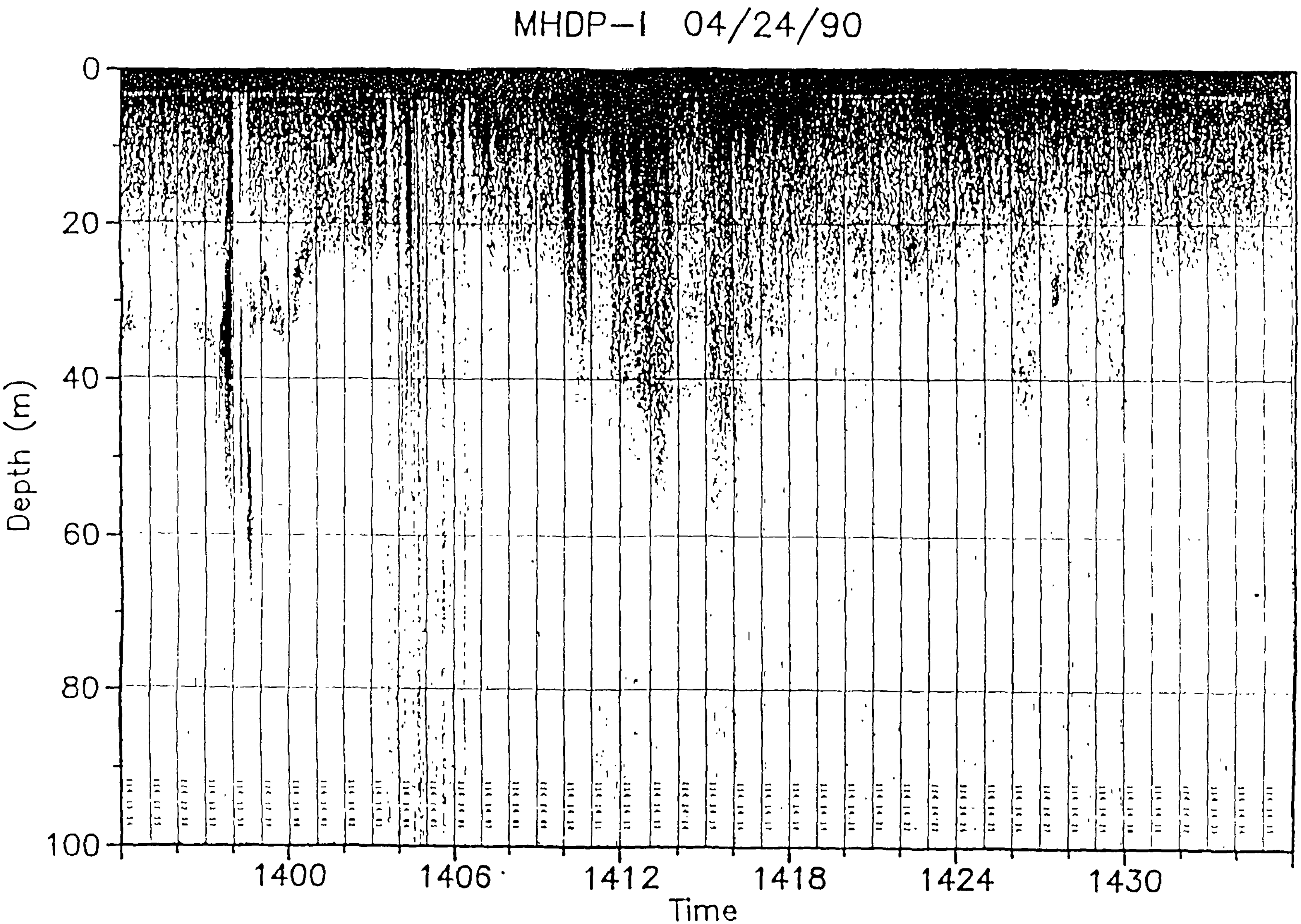


Figure 23
Test Discharge