WATER, SEDIMENT, AND BIOLOGICAL MONITORING FOR AN ONGOING FEASIBILITY STUDY OF THE NEW JERSEY INTRACOASTAL WATERWAY, NEW JERSEY

Prepared for

U.S. Army Corps of Engineers
Philadelphia District
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390

Prepared by

Craig M. Bruce
Ward Slacum
Lisa Scott

Contract No. DACW61-00-D-0009
Delivery Order No. 38

Versar, Inc.
9200 Rumsey Road
Columbia, MD 21045

Prepared under the Supervision of
William H Burton
Principal Investigator

November 2002

ABSTRACT

In the fall of 2002 the U.S. Army Corps of Engineers, Philadelphia Distinct, conducted sampling to evaluate potential environmental effects of maintenance dredging in New Jersey's Intracoastal Waterway. Sediment samples collected with a vibracore were taken from 26 stations within the waterway in an area ranging from Little Egg Inlet to the Cape May Canal. Sediments were analyzed for organic, and inorganic contaminant concentrations and compared to New Jersey Department of Environmental Protection soil cleanup standards. Three stations in Great Bay were also tested for PCBs using high resolution, congener specific analytical methods. To predict contaminant concentrations that may be released to surface waters during dredging, elutriate tests were conducted on the material and compared to New Jersey water quality standards. Biological (benthic invertebrates and fish) and water quality monitoring was conducted in two dredged holes and a manmade channel (Meadow Cut) through a marsh to evaluate current ecological conditions and to determine if filling the holes and/or the cut with dredge material would restore and improve estuarine habitat.

Chemical analysis of the sediment samples suggested that the likelihood of adverse environmental effects from maintenance dredging operation is low. Only beryllium was observed in bulk sediment concentrations over the New Jersey soil clean levels for residential and non-residential areas. The only other metal observed in concentrations over New Jersey soil cleanup criteria was chromium that was over the lower of the two non-residential criteria promulgated by the state (20 mg/kg). Among the three stations included in the high resolution PCB testing, the sum of congeners was an order of magnitude lower that New Jersey soil clean up criteria and generally below levels considered unsafe for aquatic biota. While elutriate tests with the sediments resulted in a few metals concentrations over New Jersey's surface water criteria, there was no consistent pattern among the sampling stations suggesting that there is no widespread contamination of one element throughout the study area. None of the organic compounds detected in elutriate testing were over New Jersey surface water criteria.

Benthic invertebrate sampling in the deep areas of two holes examined for this study revealed that this habitat was azoic at the time of sampling as no organisms were found in any sample. Improving benthic conditions were observed at intermediate depths while the best conditions were seen in the shallowest habitats. Water quality measurements taken during this study suggest that these areas are anoxic/hypoxic for long periods of time, which in turn is lethal to the bottom dwelling organisms. The benthic community within Meadow Cut displayed similar characteristics to surrounding reference communities. The data from this study suggest that partially filling the holes but not the man-made Meadow Cut would result in improved estuarine habitat. Fish surveys with gill nets and trawls indicated that fish used the dredge areas as much as the associated reference sites. However, the majority of the catch was larger mobile species such as bluefish and weakfish and were either transient species or may have come from the edges of the holes.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The New Jersey Intracoastal Waterway (NJIWW) is 117 miles long, extending from the Manasquan River to the Delaware Bay, and is a federally maintained navigation project used by commercial and recreational vessels. The NJIWW is composed of extensive channels, bays, and inlets, which create a complex estuarine system. A series of canals exists within the NJIWW along the bayward side of the barrier islands. The U.S. Army Corps of Engineers (USACE) is responsible for maintaining navigability of many U.S. coastal waterways, including the NJIWW under jurisdiction of the USACE, Philadelphia District. Maintenance dredging has been ongoing for several decades, accounting for the removal of many millions of cubic yards of sediment. This dredge material has been placed in numerous upland and overboard disposal sites, many located in or adjacent to environmentally sensitive areas within the shallow bays, waterways, and wetlands along the NJIWW.

Dredging of sediments raises several issues of environmental concern. These concerns include potential environmental risks of deposition of contaminated sediments in upland and overboard disposal sites and potential water quality impacts during dredging operations. For dredging operations that use upland disposal sites, sediment and water is pumped through a pipeline into a series of confined disposal facilities (CDF) along the NJIWW. After settling, excess water is discharged back into the surface waters of the estuary. The disruption of sediment during this process can mobilize contaminants, potentially releasing them into surface waters.

An alternate disposal method being considered by the Philadelphia District is the partial filling of dredged holes created by historical sand mining operations. Dredged holes in the bar-built estuaries along the New Jersey coast are unnatural features, many of which can contain poor water quality (in bottom waters) and reduced benthic invertebrate secondary productivity (due to anaerobic sediments). Recent studies conducted by the Philadelphia District in Barnegat Bay New Jersey suggested that partial filling of dredged holes could increase benthic productivity and provide better habitat for fish communities (Scott and Kelley 1999).

The purpose of this study was to evaluate the contaminant levels in the sediments of the IWW and assess the potential for impacts of maintenance dredging operations to aquatic resources and people in the vicinity of the proposed dredging and disposal areas. Given that dredged holes were being considered as a potential beneficial use of dredged material, evaluating the ecological and water quality conditions within two dredged holes being considered for potential filling and a man made channel cut near Margate, New Jersey was an additional objective of this study.

To address the potential environmental risks of dredging in the NJIWW, sediment cores were collected in the navigational channel and analyzed for bulk concentration of semivolatile organic compounds (SVOCs), pesticides, PCB's, and inorganics. Additionally, standard and modified elutriate tests were conducted on the sediment samples to estimate the potential concentration of contaminants that may be released into surface waters. In the dredged holes and the Meadow Cut near Margate New Jersey benthic invertebrate, fish, and water quality sampling was conducted to evaluate the current ecological conditions of these three potential disposal sites. These data were needed to assess the feasibility of partially filling the holes with dredge material.

2.0 METHODS

2.1 SEDIMENT CONTAMINANT TESTING

Field

The sampling design and analysis plan for this project was developed in consultation with the New Jersey Department of Environmental Protection (NJDEP) and followed recommended field and analytical methods as summarized in The Management and Regulation of Dredging Activities and Dredged Material in New Jersey's Tidal Waters, October 1997."

Twenty-five sediment cores from the NJIWW were collected with a 4-inch diameter vibracore in October 2002. At the Meadow Cut near Margate City and the fifty-foot deep Hole 34 near Atlantic City and the twenty eight foot deep Hole 35 near Corson Inlet three composite sediment samples were collected with a 0.044-m2 stainless steel, Young grab sampler. The locations of the cores were positioned according to maintenance plans where the USACE predicts most of the dredging for the IWW will occur (Figure 2-1 and Figure 2-2, Table 2-1). The vibracore tube was lined with a flexible plastic tube to eliminate cross-contamination and to allow for the sediment core to be removed for sectioning, inspection, and subsampling. Target core depths at each station were about two feet. If penetration refusal occurred (due to hard-packed clay), a second core was attempted beside the original sample location. In the event that penetration refusal occurred with the second core, the longest core of the two attempted at the station was selected for compositing. Upon retrieval, each sediment core was inspected for grain size stratification to determine if distinct strata greater than two feet in depth existed. Station locations were recorded using a Differential Global Positioning System and coring logs were maintained for each sample (see Appendix B).

Surface water was collected for use in the standard and modified elutriate tests in clean glass jars. In addition, a background surface water sample was collected in near Station 25 near the Cape May Canal and analyzed for the same contaminant suite in order to provide a measure of background reference surface water concentrations. A summary of which stations received standard and modified elutriate testing is also presented in Table 2-1.

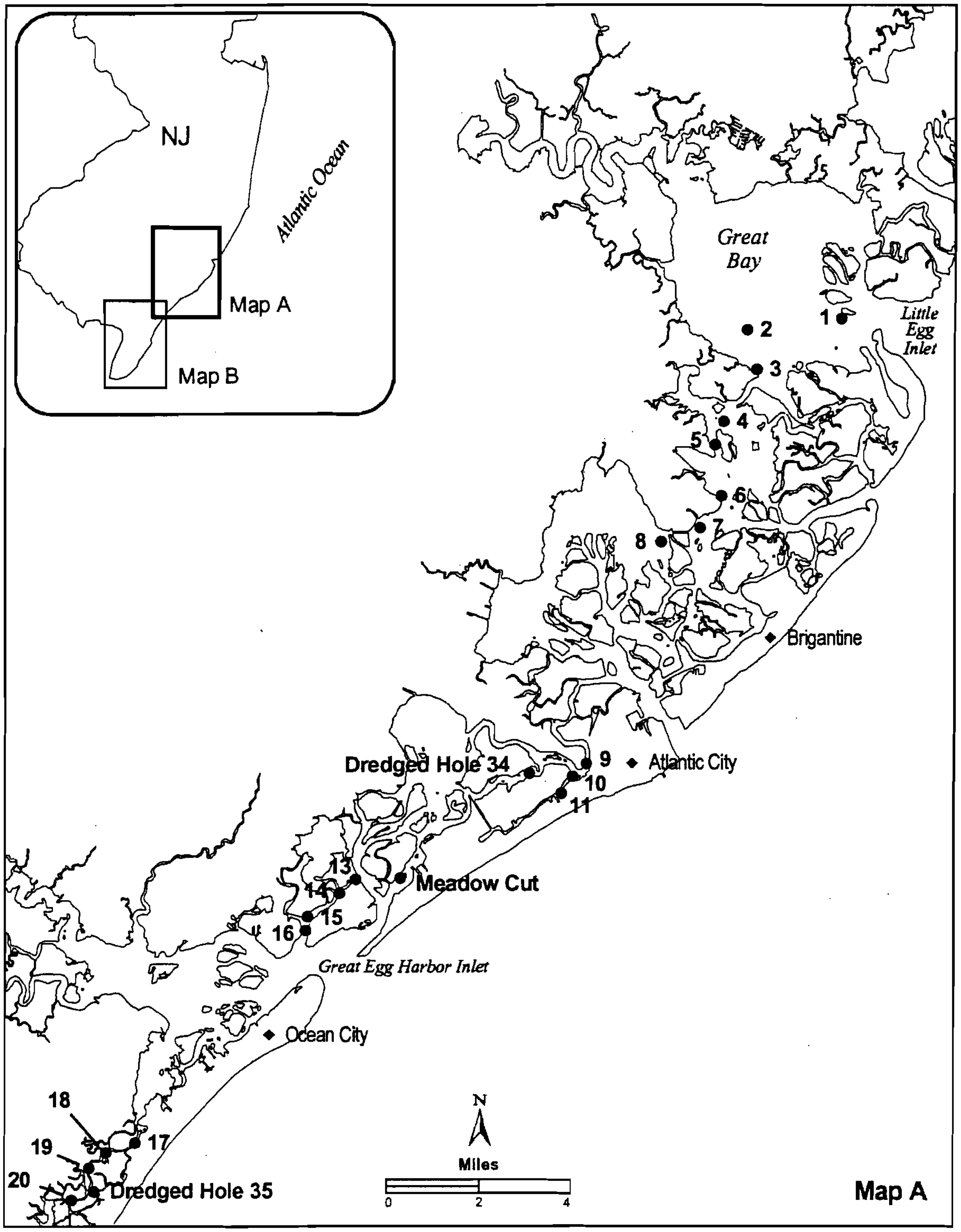

Figure 2-1. Map A. Study area map and location of the sediment cores collected from the northern reaches of NJIWW in October 2002.

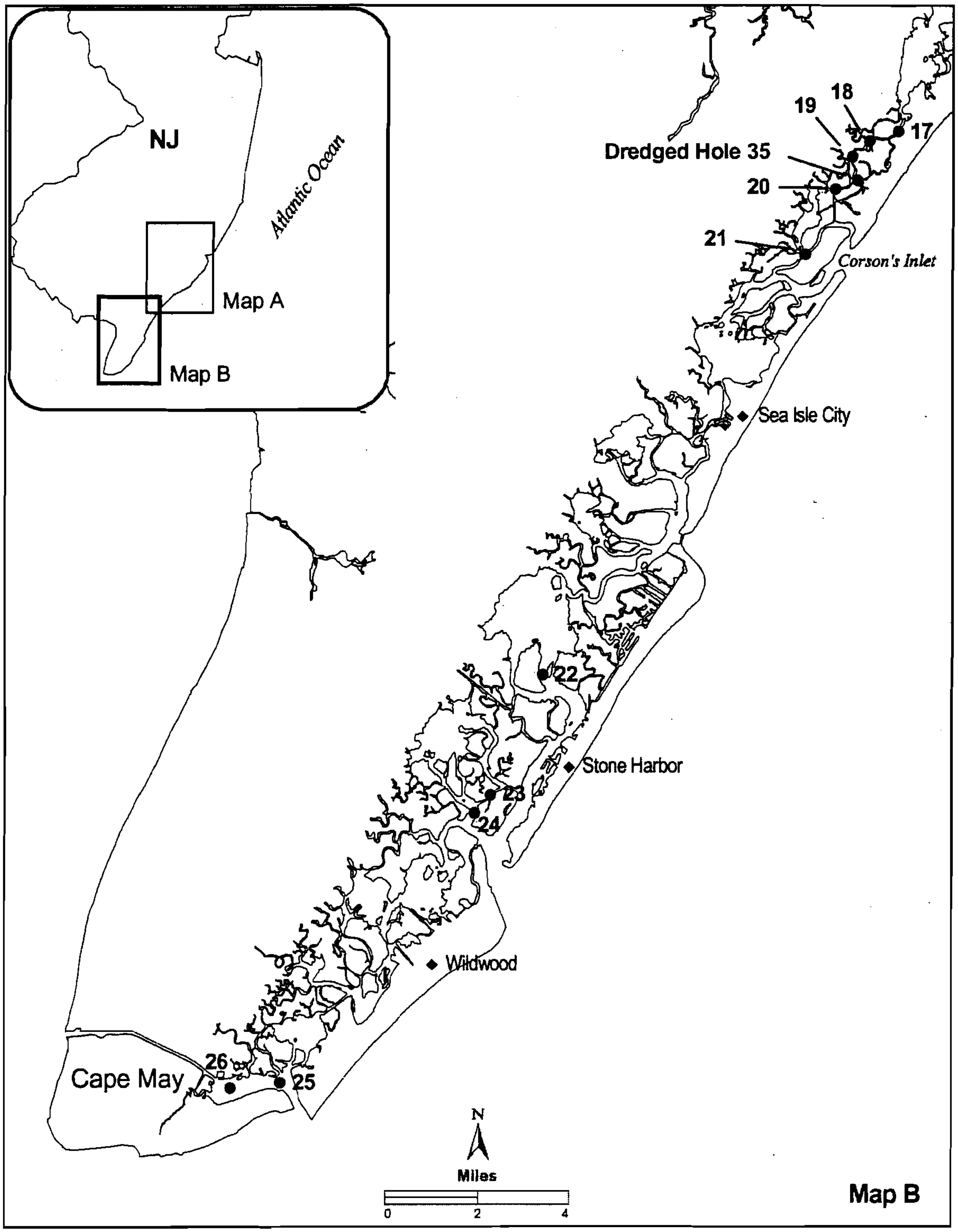

Figure 2-2. Map B. Study area map and location of the sediment cores collected from the southern reaches of NJIWW in October 2002.

Table 2-1. NJIWW sampling station locations				
Station (Elutriate Test Type)	Latitude		Longitude	
	Degrees	Decimal Minutes	Degrees	Decimal Minutes
1 (Standard)	39	30.133	7	20.617
2 (Standard)	39	29.932	74	22.887
3 (Standard)	39	29.194	74	22.555
4 (Standard)	39	28.216	74	23.437
5 (Standard)	39	27.781	74	23.646
6 (Standard)	39	26.818	74	23.496
7 (Standard)	39	26.219	74	24.020
8 (Modified)	39	25.962	74	24.958
9 (Standard)	39	21.809	74	26.767
10 (Standard)	39	21.572	74	27.106
11 (Standard)	39	21.259	74	27.383
13 (Standard)	39	19.650	74	32.374
14 (Modified)	39	19.378	74	32.766
15 (Modified)	39	18.951	74	33.539
16 (Modified)	39	18.686	74	33.580
17 (Modified)	39	14.712	74	37.757
18 (Modified)	39	14.531	74	38.462
19 (Modified)	39	14.241	74	38.881
20 (Modified)	39	13.650	74	39.300
21 (Modified)	39	12.442	74	40.035
22 (Modified)	39	06.646	74	46.316
23 (Modified)	39	02.423	74	47.586
24 (Modified)	39	02.083	74	47.983
25 (Modified)	38	57.082	74	52.640
26 (Modified)	38	56.988	74	53.846
Back Ground Water	38	57.090	74	52.650
Dredged Hole 34 (Modified)	39	21.628	74	28.167
Meadow Cut (Standard)	39	19.667	74	31.300
Dredged Hole 35 (Modified) (Modified)	30	13.808	74	38.754

Nov 2002

Laboratory

Sample containers were promptly shipped following collection to the contract laboratories performing chemical analysis. Blue Marsh Laboratories in Douglassville, PA performed all chemical analyses, except high-resolution PCBs. Blue Marsh used USEPA method 8270 for SVOCs, 8081 for pesticides, 6020 for Tributyltin, 6010 and 200.7 for inorganics, method 335.3 and 9010 for cyanide, and method 245.1 and 7471 for mercury, as specified in the Scope of Work (Table 2-2 and Table 2-3).

High resolution PCB testing was conducted at Stations 1, 2, and 3 in the northern range of the study area (Figure 2-1). Paradigm Laboratory, in Wilmington North Carolina, conducted high-resolution PCB analysis using draft method 1668 (Table 2-4). The PCB analysis allowed for the identification of individual PCB congeners through the use of high-resolution gas chromatography (HRGC)/ high-resolution mass spectrometry (HRMS).

Standard and Modified elutriate tests to predict contaminant concentrations in open water disposal an in upland disposal site discharge water were conducted for dissolved concentrations of SVOCs, pesticides, and inorganics following procedures outlined in Palermo (1985), as required by NJDEP.

Sediment grain-size analysis was performed according to ASTM Method D422-63 for each core sample and sediment samples for benthic invertebrate community composition in the dredged holes and Meadow Cut. Sieve sizes ranged from 4.25 mm (U.S. Standard Sieve No. 4) to 63 mm (U.S. Standard Sieve No. 230). Total organic content (TOC) was measured by weight loss upon ignition at 500EC for 4 hours.

Table 2-2. Laboratory methods for inorganic analysis of bulk sediment and elutriate for cores collected from NJIWW in October 2002.

Parameter	Solid Samples		Aqueous Samples	
	Analytical Method	Detection Limit (mg/kg dry weight)	Analytical Method	Detection Limit (mg/L)
Antimony	6010B	0.02	200.7	0.02
Arsenic	6010B	0.02	200.7	0.05
Beryllium	6010B	0.005	200.7	0.005
Cadmium	6010B	0.005	200.7	0.005
Chromium	6010B	0.005	200.7	0.005
Copper	6010B	0.005	200.7	0.005
Cyanide	9010B	0.25	335.2	0.005
Lead	6010B	0.02	200.7	0.003
Mercury	7471A	0.0002	245.1	0.0002
Nickel	6010B	0.005	200.7	0.005
Selenium	6010B	0.02	200.7	0.005
Silver	6010B	0.005	200.7	0.001
Thallium	6010B	0.02	200.7	0.005
Tributyltin	6090	0.001	6090	0.001
Zinc	6010B	0.005	200.7	0.003

Table 2-3. Laboratory methods for organic analysis of bulk sediment and elutriate for cores collected from the NJIWW in October 2002

Parameter	Aqueous Samples		Solid Samples	
	Analytical Method	MDL	Analytical Method	MDL
Pesticides				
4,4'-DDD	8081A	0.04 ppb	8081A	5.0 ppb
4,4'-DDE	8081A	0.04 ppb	8081A	5.0 ppb
4,4'-DDT	8081A	0.04 ppb	8081A	5.0 ppb
Aldrin	8081A	0.04 ppb	8081A	5.0 ppb
alpha-BHC	8081A	0.04 ppb	8081A	5.0 ppb
beta-BHC	8081A	0.04 ppb	8081A	5.0 ppb
Chlordane, technical	8081A	0.17 ppb	8081A	51.0 ppb
delta-BHC	8081A	0.04 ppb	8081A	5.0 ppb
Dieldrin	8081A	0.04 ppb	8081A	5.0 ppb
Endosulfan I	8081A	0.04 ppb	8081A	5.0 ppb
Endosulfan II	8081A	0.04 ppb	8081A	5.0 ppb
Endosulfan sulfate	8081A	0.04 ppb	8081A	5.0 ppb
Endrin	8081A	0.04 ppb	8081A	5.0 ppb
Endrin aldehyde	8081A	0.04 ppb	8081A	5.0 ppb
gamma-BHC (Lindane)	8081A	0.04 ppb	8081A	5.0 ppb
Heptachlor	8081A	0.04 ppb	8081A	5.0 ppb
Heptachlor epoxide	8081A	0.04 ppb	8081A	5.0 ppb
Toxaphene	8081A	0.09 ppb	8081A	51.0 ppb
SVOC				
1,2,4-Trichlorobenzene	8270C	0.2 ppb	8270C	25.0 ppb
1,2-Dichlorobenzene	8270C	0.2 ppb	8270C	25.0 ppb
1,2-Diphenylhydrazine	8270C	0.2 ppb	8270C	25.0 ppb
1,3-Dichlorobenzene	8270C	0.2 ppb	8270C	25.0 ppb
1,4-Dichlorobenzene	8270C	0.2 ppb	8270C	25.0 ppb
2,4,6-Trichlorophenol	8270C	0.2 ppb	8270C	25.0 ppb
2,4-Dichlorophenol	8270C	0.2 ppb	8270C	25.0 ppb
2,4-Dimethylphenol	8270C	0.2 ppb	8270C	25.0 ppb
2,4-Dinitrophenol	8270C	0.2 ppb	8270C	25.0 ppb
2,4-Dinitrotoluene	8270C	0.2 ppb	8270C	25.0 ppb
2,6-Dinitrotoluene	8270C	0.2 ppb	8270C	25.0 ppb
2-Chloronaphthalene	8270C	0.2 ppb	8270C	25.0 ppb
2-Chlorophenol	8270C	0.2 ppb	8270C	25.0 ppb
2-Methyl-4,6-Dinitrophenol	8270C	0.2 ppb	8270C	25.0 ppb
2-Nitrophenol	8270C	0.2 ppb	8270C	25.0 ppb
3,3'-Dichlorobenzidine	8270C	0.2 ppb	8270C	25.0 ppb
4-Bromophenyl-phenylether	8270C	0.2 ppb	8270C	25.0 ppb
4-Chloro-3-methylphenol	8270C	0.2 ppb	8270C	25.0 ppb
4-Chlorophenyl-phenylether	8270C	0.2 ppb	8270C	25.0 ppb
4-Nitrophenol	8270C	0.2 ppb	8270C	25.0 ppb
Acenaphthene	8270C	0.2 ppb	8270C	25.0 ppb

Table 2-3. (Continued)				
	Aqueous Samples		Solid Samples	
Parameter	Analytical Method	MDL	Analytical Method	MDL
Acenaphthylene	8270C	0.2 ppb	8270C	25.0 ppb
Anthracene	8270C	0.2 ppb	8270C	25.0 ppb
Benzidine	8270C	0.2 ppb	8270C	25.0 ppb
Benzo(a)anthracene	8270C	0.2 ppb	8270C	25.0 ppb
Benzo(a)pyrene	8270C	0.2 ppb	8270C	25.0 ppb
Benzo(b)fluoranthene	8270C	0.2 ppb	8270C	25.0 ppb
Benzo(ghi)perylene	8270C	0.2 ppb	8270C	25.0 ppb
Benzo(k)fluoranthene	8270C	0.2 ppb	8270C	25.0 ppb
bis(2-Chloroethoxy)methane	8270C	0.2 ppb	8270C	25.0 ppb
bis(2-Chloroethyl)ether	8270C	0.2 ppb	8270C	25.0 ppb
bis(2-Chloroisopropyl)ether	8270C	0.2 ppb	8270C	25.0 ppb
bis(2-Ethylhexyl)phthalate	8270C	0.2 ppb	8270C	25.0 ppb
Butylbenzylphthalate	8270C	0.2 ppb	8270C	25.0 ppb
Chrysene	8270C	0.2 ppb	8270C	25.0 ppb
Dibenzo(a,h))anthracene	8270C	0.2 ppb	8270C	25.0 ppb
Diethylphthalate	8270C	0.2 ppb	8270C	25.0 ppb
Dimethylphthalate	8270C	0.2 ppb	8270C	25.0 ppb
Di-n-butylphthalate	8270C	0.2 ppb	8270C	25.0 ppb
DI-n-octylphthalate	8270C	0.2 ppb	8270C	25.0 ppb
Dioxin (2,3,7,8-TCDD)	8270C	0.2 ppb	8270C	25.0 ppb
Fluoranthene	8270C	0.2 ppb	8270C	25.0 ppb
Fluorene	8270C	0.2 ppb	8270C	25.0 ppb
Hexachloro-1,3-butadiene	8270C	0.2 ppb	8270C	25.0 ppb
Hexachlorobenzene	8270C	0.2 ppb	8270C	25.0 ppb
Hexachlorocyclopentadiene	8270C	0.2 ppb	8270C	25.0 ppb
Hexachloroethane	8270C	0.2 ppb	8270C	25.0 ppb
Indeno(1,2,3-cd)pyrene	8270C	0.2 ppb	8270C	25.0 ppb
Isophorone	8270C	0.2 ppb	8270C	25.0 ppb
Naphthalene	8270C	0.2 ppb	8270C	25.0 ppb
Nitrobenzene	8270C	0.2 ppb	8270C	25.0 ppb
N-Nitrosodimethylamine	8270C	0.2 ppb	8270C	25.0 ppb
N-Nitroso-Di-N-Propylamine	8270C	0.2 ppb	8270C	25.0 ppb
N-Nitrosodiphenylamine	8270C	0.2 ppb	8270C	25.0 ppb
Pentachlorophenol	8270C	0.2 ppb	8270C	25.0 ppb
Phenanthrene	8270C	0.2 ppb	8270C	25.0 ppb
Phenol	8270C	0.2 ppb	8270C	25.0 ppb
Pyrene	8270C	0.2 ppb	8270C	25.0 ppb

Table 2-4. Analyte list, methods, and detection limits for high-resolution PCB congener specific bulk sediment analysis for the NJIWW study (pg/g)					
Analyte	Detection Limit	Method	Analyte	Detection Limit	Method
1-MoCB	208	1668A	(48)-TeCB	208	1668A
(2)-MoCB	208	1668A	44,47,(65)-TeCB	208	1668A
3-MoCB	208	1668A	(59,62,75)-TeCB	208	1668A
(4)-DiCB	208	1668A	42-TeCB	208	1668A
(10)-DiCB	208	1668A	(41)-TeCB	208	1668A
(9)-DiCB	208	1668A	(40,71)-TeCB	208	1668A
(7)-DiCB	208	1668A	64-TeCB	208	1668A
(6)-DiCB	208	1668A	(72)-TeCB	208	1668A
(5)-DiCB	208	1668A	(68)-TeCB	208	1668A
8-DiCB	208	1668A	(57)-TeCB	208	1668A
(14)-DiCB	208	1668A	(58)-TeCB	208	1668A
(11)-DiCB	208	1668A	(67)-TeCB	208	1668A
(12,13)-DiCB	208	1668A	(63)-TeCB	208	1668A
15-DiCB	208	1668A	(61),70,74,(76)-TeCB	208	1668A
(19)-TrCB	208	1668A	66-TeCB	208	1668A
18,(30)-TrCB	208	1668A	(55)-TeCB	208	1668A
(17)-TrCB	208	1668A	56-TeCB	208	1668A
(27)-TrCB	208	1668A	60-TeCB	208	1668A
(24)-TrCB	208	1668A	80-TeCB	208	1668A
(16)-TrCB	208	1668A	(79)-TeCB	208	1668A
(32)-TrCB	208	1668A	(78)-TeCB	208	1668A
(34)-TrCB	208	1668A	81-TeCB	208	1668A
(23)-TrCB	208	1668A	77-TeCB	208	1668A
(26,29)-TrCB	208	1668A	(104)-PeCB	208	1668A
(25)-TrCB	208	1668A	(96)-PeCB	208	1668A
31-TrCB	208	1668A	(103)-PeCB	208	1668A
(20),28-TrCB	208	1668A	(94)-PeCB	208	1668A
(21),33-TrCB	208	1668A	95-PeCB	208	1668A
22-TrCB	208	1668A	(93,100)-PeCB	208	1668A
(36)-TrCB	208	1668A	(98,102)-PeCB	208	1668A
(39)-TrCB	208	1668A	(88),91-PeCB	208	1668A
(38)-TrCB	208	1668A	84-PeCB	208	1668A
(35)-TrCB	208	1668A	(89)-PeCB	208	1668A
37-TrCB	208	1668A	(121)-PeCB	208	1668A
(54)-TeCB	208	1668A	92-PeCB	208	1668A
(50,53)-TeCB	208	1668A	90,101,(113)-PeCB	208	1668A
(45,51)-TeCB	208	1668A	(83)-PeCB	208	1668A
(46)-TeCB	208	1668A	99-PeCB	208	1668A
52-TeCB	208	1668A	(112)-PeCB	208	1668A
(73)-TeCB	208	1668A	86,87,97,(108),119,(125)-PeCB	208	1668A
(43)-TeCB	208	1668A	(117)-PeCB	208	1668A
49,(69)-TeCB	208	1668A	(85,116)-PeCB	208	1668A

Table 2-4. (Continued)					
Analyte	Detection Limit	Method	Analyte	Detection Limit	Method
110-PeCB	208	1668A	158-HxCB	208	1668A
115-PeCB	208	1668A	128,166-HxCB	208	1668A
82-PeCB	208	1668A	(159)-HxCB	208	1668A
(111)-PeCB	208	1668A	(162)-HxCB	208	1668A
120-PeCB	208	1668A	167-HxCB	208	1668A
(107,124)-PeCB	208	1668A	156,157-HxCB	208	1668A
(109)-PeCB	208	1668A	169-HxCB	208	1668A
123-PeCB	208	1668A	(188)-HpCB	208	1668A
(106)-PeCB	208	1668A	179-HpCB	208	1668A
118-PeCB	208	1668A	184-HpCB	208	1668A
(122)-PeCB	208	1668A	(176)-HpCB	208	1668A
114-PeCB	208	1668A	(186)-HpCB	208	1668A
105-PeCB	208	1668A	178-HpCB	208	1668A
127-PeCB	208	1668A	(175)-HpCB	208	1668A
126-PeCB	208	1668A	187-HpCB	208	1668A
(155)-HxCB	208	1668A	(182)-HpCB	208	1668A
(152)-HxCB	208	1668A	183,185-HpCB	208	1668A
(150)-HxCB	208	1668A	174-HpCB	208	1668A
136-HxCB	208	1668A	177-HpCB	208	1668A
(145)-HxCB	208	1668A	(181)-HpCB	208	1668A
(148)-HxCB	208	1668A	171,(173)-HpCB	208	1668A
135,151-HxCB	208	1668A	(172)-HpCB	208	1668A
(154)-HxCB	208	1668A	(192)-HpCB	208	1668A
(144)-HxCB	208	1668A	180,(193)-HpCB	208	1668A
(147),149-HxCB	208	1668A	191-HpCB	208	1668A
(134)-HxCB	208	1668A	170-HpCB	208	1668A
(143)-HxCB	208	1668A	190-HpCB	208	1668A
(139,140)-HxCB	208	1668A	189-HpCB	208	1668A
(131)-HxCB	208	1668A	202-OcCB	208	1668A
(142)-HxCB	208	1668A	201-OcCB	208	1668A
132-HxCB	208	1668A	(204)-OcCB	208	1668A
(133)-HxCB	208	1668A	(197,200)-OcCB	208	1668A
(165)-HxCB	208	1668A	198,199-OcCB	208	1668A
146-HxCB	208	1668A	196-OcCB	208	1668A
(161)-HxCB	208	1668A	203-OcCB	208	1668A
153,168-HxCB	208	1668A	195-OcCB	208	1668A
141-HxCB	208	1668A	194-OcCB	208	1668A
(130)-HxCB	208	1668A	205-OcCB	208	1668A
137-HxCB	208	1668A	208-NoCB	208	1668A
(164)-HxCB	208	1668A	207-NoCB	208	1668A
(129),138,(163)-HxCB	208	1668A	206-NoCB	208	1668A
(160)-HxCB	208	1668A	209-DeCB	208	1668A

2.2 BIOLOGICAL AND WATER QUALITY TESTING IN DREDGED HOLES AND MEADOW CUT

Benthic Field

Benthic macroinvertebrates were collected from 2 holes (Hole 34 and Hole 35) and a man-made channel (Meadow Cut) in the late summer (third week of September 2002) to evaluate benthic community conditions during a period when dissolved oxygen stress was expected to be the highest (Figures 2-3 through and 2-5). Dredged Hole 34 was 50 feet deep while dredged Hole 35 near Carson Inlet was 28 feet deep. Within each hole three depth strata (shallow, middle, and deep) were sampled to determine if benthic community characteristics were affected by depth. A reference site near each hole was sampled to estimate the benthic community characteristics that occur naturally in the shallow waters of the IWW. Three replicate samples were taken within each depth strata and at the reference area for a total of 12 samples for each hole. Additionally, three replicate samples were collected from within Meadow Cut site, to determine if the benthic community within this man-made channel was different from natural conditions.

Benthic samples were collected with a 0.044-m^2 stainless steel Young grab sampler. If the grab did not penetrate the bottom sediment to at least 6-cm, a new sample was taken. The benthic samples were sieved in the field using a 0.5-mm mesh screen. The material retained on the screen was bottled and preserved in a 10% buffered formalin solution stained with rose bengal. The sediment samples were frozen until processed in the laboratory.

Benthic Laboratory Methods

Samples were re-sieved in the laboratory using a 0.5mm standard laboratory sieve. Benthic organisms were sorted from debris using a dissecting microscope, identified to the lowest practical taxonomic category, and counted. Quality control/quality assurance methods employed by the lab assured a high level of precision for processed samples. Once identified, organisms were grouped according to the lowest taxonomic level to determine taxon specific ash-free dry weight (AFDW) biomass. AFDW biomass procedures include drying each taxon to a constant weight at 60 °C, burning them in a muffle furnace at 500 °C for 4 hours, and weighing the ash remains. Each taxon was weighed to the nearest 0.0001 gram. AFDW provides a measure of the carbon available to higher trophic levels.

When completing taxonomic identifications in the laboratory, some organisms cannot be completely identified to the species level, particularly if they are immature/ juveniles or in poor shape. For these cases, the taxonomist makes a note in the database when such an organism should not be considered a separate taxon when tallying total number of taxa. All species summaries presented in this report account for these taxonomic identification notations.

Fish Survey

To evaluate the potential fish habitat value of the dredge areas (Dredge Hole 34, 35, and Meadow cut; Figure 2-3, Figure 2-4, and Figure 2-5), otter trawling and gill netting was conducted late September 2002. Replicate fish trawls using a 5-meter (16 foot) otter trawl were towed in each designated dredge area and a nearby reference area established for each site. Reference sites were considered to be representative of the surrounding available habitat, and were located adjacent to each study area. Trawls were conducted such that each tow was in a straight line across the deepest part of each dredge area. Tow depths varied from 40 to 50 feet in Hole 34, 20 to 27 feet in Hole 35, and 5 to 6 feet in the Meadow cut. Reference areas tow depths were from 4 to 5 feet, 8 to 9 feet, and 7 to 10 feet for Holes 34, 35, and the Meadow cut reference stations, respectively. All trawls were towed into the current for 5 minutes at a speed of 2 to 3 knots. The otter trawl body was made up of 1-inch stretch mesh with quarter inch mesh cod end line. Experimental gill nets with three mesh sizes (2, 4, and 6 inches) were deployed overnight (15-17 hours) in each dredge hole and their respective reference area. Gill nets were not deployed in Meadow Cut because of the shallowness of the channel and the heavy use of the cut by area boaters. Gill nets were fished on the bottom and in the deepest part of the dredge areas. All fish collected in each gear type were identified to species, measured, and counted. Up to 25 randomly selected specimens of each species in each dredge area and each gear type were measured to the nearest millimeter (mm).

Water Quality Testing

The physical and chemical conditions within dredge Hole 34, 35, Meadow Cut and associated reference sites were tested to determine if poor water quality exists. During the benthic survey temperature, dissolved oxygen, salinity, turbidity, pH, and conductivity were measured with a calibrated YSI 6600 water quality meter. Surface and bottom water quality measurements in the dredge holes were taken at shallow, middle, and deep sites, coinciding with benthic survey samples. At sites where total depth was less than 6 feet, only mid water column measurements were taken. Water quality was measured at each site and a reference. Surface and bottom water samples were also collected and tested for hydrogen sulfide concentrations. Additionally, two YSI units were deployed for 48 hours in each of the two dredge holes to monitor diel changes in water quality. These units were anchored one-meter off the bottom and were set to record physical and chemical parameters at half-hour intervals.

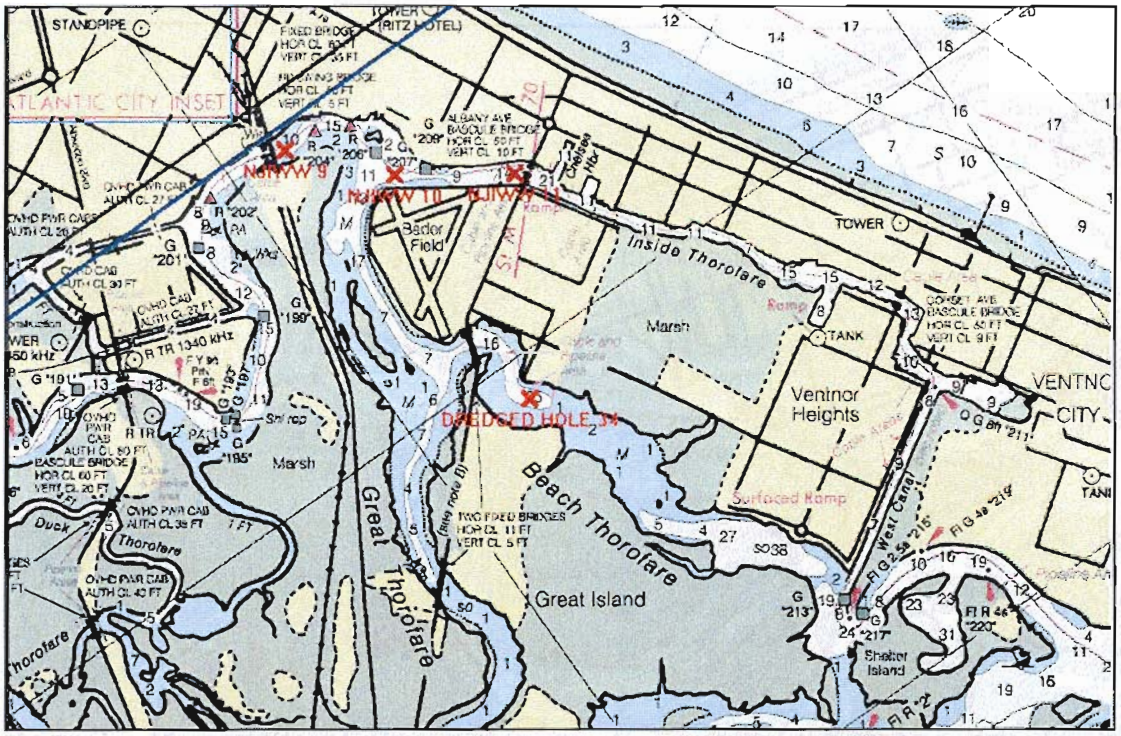

Figure 2-3. Location and bathymetry of Dredged Hole 34 located near Atlantic City, New Jersey.

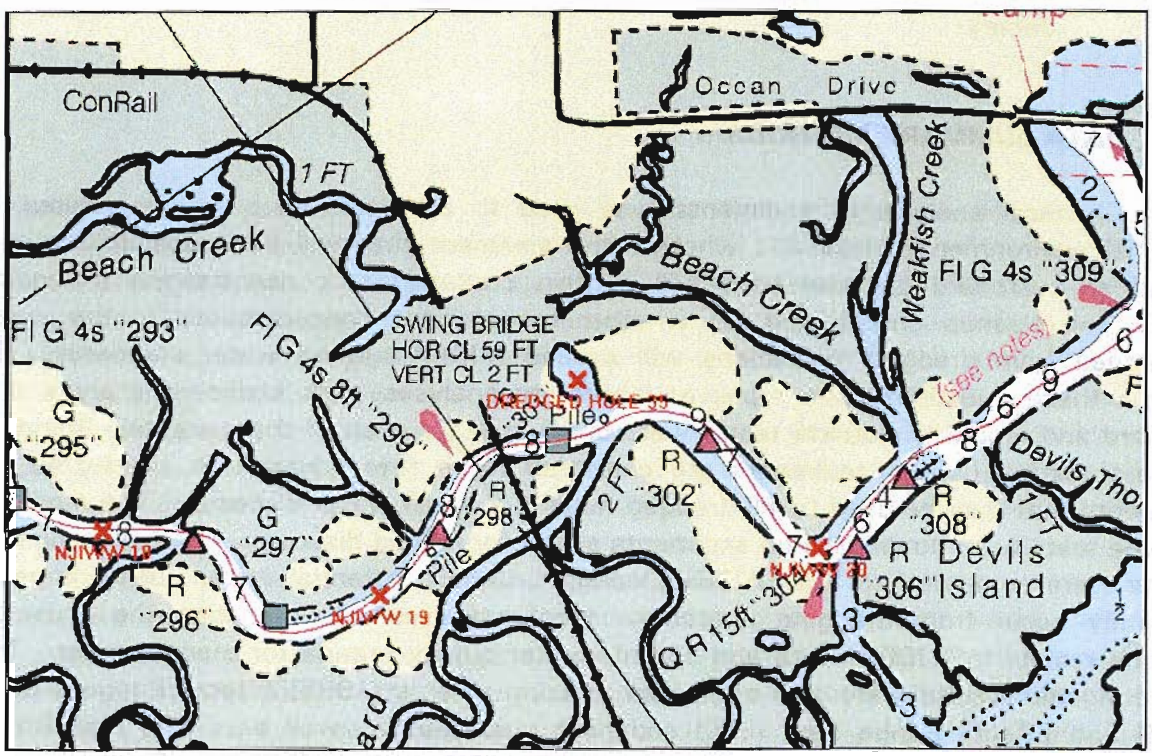

Figure 2-4. Location and bathymetry of Dredged Hole 35 located near Corson Inlet, north of Strathmere, New Jersey

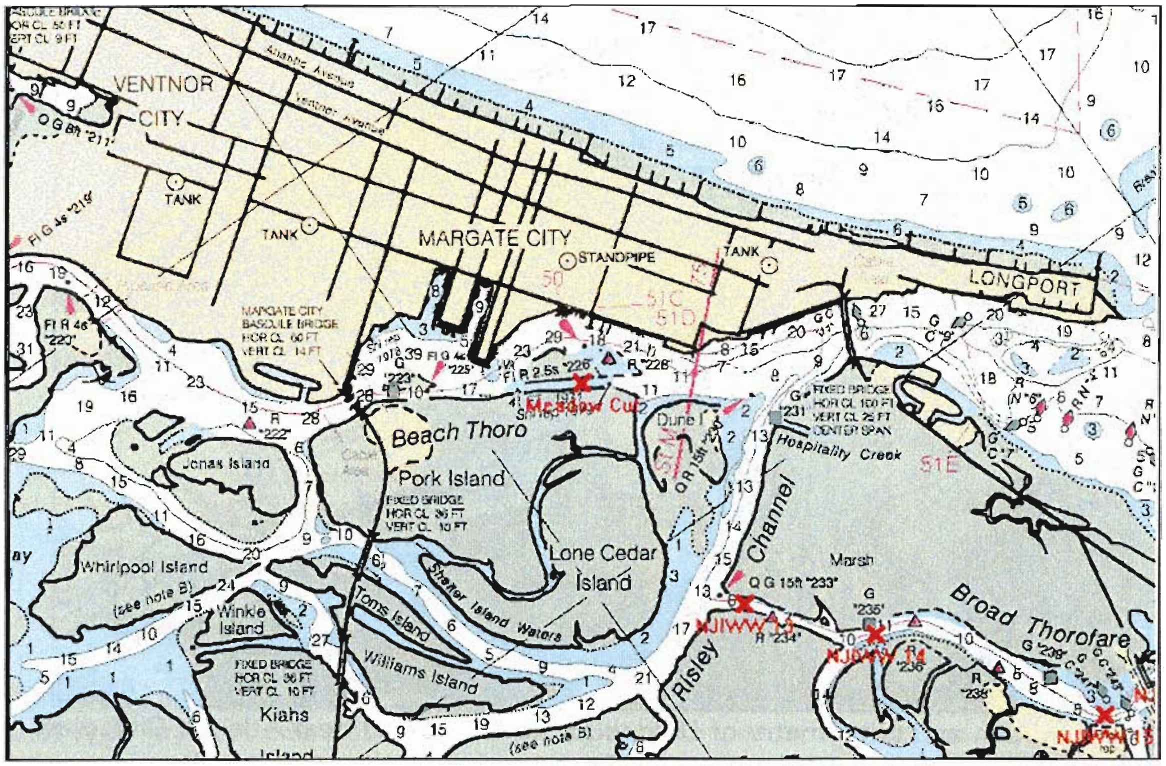

Figure 2-5. Location and bathymetry of Meadow Cut located west of Margate, New Jersey.

2.3 DATA SUMMARY METHODS

Chemical analysis of sediments was used to address two questions related to potential environmental risks: (1) whether the sediment that will be deposited into the upland or overboard disposal sites will contain contaminant concentrations exceeding NJDEP soil cleanup criteria and (2) whether contaminant concentrations in the water discharged from dredging operations will exceed NJDEP surface water standards. To address these questions, two types of laboratory analyses, bulk sediment analysis and standard and modified elutriate tests, were conducted for each of the samples. Standard elutriate testing (where sediments are elutriated for a few hours) was conducted for sediments that may be used to fill dredged holes (i.e. open water disposal). The modified elutriate tests were conducted on sediments slated for upland disposal. The bulk sediment results were compared to NJDEP Soil Cleanup Criteria. Potential water quality impacts that may occur from dredging operations were assessed by comparing the sediment elutriate results to NJDEP acute and chronic water quality criteria for marine water. The PCB congener results were also compared to Long et al.'s (1995) Effects Range Median (ERM) and Effects Range Low (ERL) sediment guidelines as well as EPA's Risk Based Concentrations (RBC) for residential and non-residential area and Delaware Department of Natural Resources and Environmental Control (DNREC) sediment guidance value for the protection of human health.

For the benthic community analysis data summaries are presented comparing various parameters (e.g., total abundance, biomass, and diversity) and the top 10 species collected from each depth strata and nearby reference area. These summaries were conducted only on benthic species classified as infauna. Epifaunal organisms were identified and counted in the laboratory, but were summarized separately and were excluded from statistical analyses because they are not sampled quantitatively with the Young grab.

An ANOVA was performed comparing various benthic infaunal community parameters at each depth sampled at each hole to the nearby reference area. Another ANOVA was preformed comparing the same benthic community parameters at Meadow Cut to the two reference areas collected near Holes 34 and 35.

Three measures of benthic community condition were assessed: abundance, biomass, and diversity. Several abundance and biomass parameters were calculated for the total infaunal community and for three major taxonomic groups: amphipods, polychaetes, and bivalves. Benthic community diversity was measured in three ways: (1) number of taxa (i.e., taxa richness), (2) Shannon-Wiener Diversity Index, which includes measures of taxa richness and evenness (the higher the number the greater the diversity); and (3) Simpson's Dominance Index (scaled from 0 to 1, with 1 being the highest possible diversity), which calculates the probability of randomly selecting two organisms that are different taxa (Shannon and Weaver 1949, Krebs 1978).

The formula for the calculation of the Shannon-Wiener Index is:

$$H = -\sum_{i=1}^{s} (p_i)(\log_2 p_i)$$

where

H = index of species diversity
S = number of species
p_i = proportion of total sample belonging to ith species

The formula for the calculation of the Simpson's Dominance Index is:

$$D = 1 - \sum_{i-1}^{2} (p_i)^2$$

where

D = Simpson's index of diversity
p_i = proportion of individuals of species i in the community.

The fish survey results are summarized and presented in tabular form for each site and gear type. Summary tables include all species collected and the total counts for each species. Species comparisons were made between dredge areas and the reference sites. The discreet physical and chemical water quality measurements are summarized for each site and presented in a table. Dissolved oxygen (DO) measurements collected by the two anchored YSI units in dredge Holes 34 and 35 are presented graphically by date and time.

3.0 RESULTS AND DISCUSSION

3.1 SEDIMENT CONTAMINATION

3.1.1 Bulk Sediment Testing

Metals and Organics

To assess the potential risks to sediment-associated biota from sediment contamination in the NJIWW, sediment contaminant concentrations (presented electronically in Appendix A) were compared to the NJDEP Residential Direct Contact Soil Cleanup Criteria (residential) and Non-residential Direct Contact Soil Cleanup Criteria (non-residential). Beryllium was present at concentrations exceeding both the residential and non-residential criteria at seven locations (Table 3-1). It should be noted that the NJDEP beryllium soil cleanup criterion is based on an inhalation exposure pathway and is among the lowest metals criteria published by the state. Also samples with detectable levels of beryllium were confined to Stations 1 through 14 all of which are north of Ocean City, New Jersey suggesting that there may be some geological explanation for the detections (Figure 2-1). Total chromium was present at concentrations exceeding the non-residential for chromium VI at seven locations (Table 3-1). To be conservative total chromium concentrations were compared to the lower chromium VI soil cleanup criteria (if there was any chromium VI present in the sediments, it would be a smaller percentage of the total chromium). In addition, the total chromium levels were only over the lowest value for non-residential soils published by NJDEP (20 mg/kg), and this value was established to protect humans with dermatitis from an allergic reaction. Total chromium concentrations measured in the IWW sediment were all below the higher NJDEP criteria (Table 3-1).

Only fifteen SVOC organic contaminants out of 76 organic compounds tested were detected in the sediment samples (Table 3-2). Stations 1, 2, 8, and 24 had no organics detected. None of the sediment organic contaminant concentrations exceeded NJDEP's residential and non-residential soil cleanup criteria. Bis(2-ethylhexyl)phthalate was detected in many of the samples, but this contaminant is a common field and laboratory contaminant, as it is a plasticizer, found in many types of field and lab equipment, including ziplock bags. Thus, this is not believed to reflect site contamination.

Polychlorinated Biphenyls

PCB congeners were detected in all three northern samples (Stations 1, 2, and 3) that were included in the PCB tests (Table 3-3). Out of 168 possible congeners, 128 were not detected in any of the samples. The remaining 40 were detected in at least one

Table 3-1. Inorganic results of NJIWW bulk sediment testing. Concentrations are presented in mg/kg dry weight.

	Station											
	1	2	3	4	5	6	7	8	9	10	Residential	Non-residential
Antimony	13.978	5.325	2.506	ND	ND	ND	ND	ND	ND	ND	14	340
Arsenic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	20	20
Beryllium	1.335	1.464	**2.976**	**3.81**	1.788	1.469	**2.289**	**2.282**	1.443	**3.975**	2	2
Cadmium	2.76	3.595	5.326	7.43	3.277	2.448	3.863	4.564	2.501	8.13	39	100
Chromium [a]	8.636	12.248	19.737	**29.721**	9.981	7.834	12.446	14.453	7.502	**38.303**	240 [b] 270 [c]	6100 [b] 20 [c]
Copper	1.781	4.393	7.675	9.907	2.235	3.06	2.432	2.155	7.502	19.874	600	600
Cyanide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1100	21000
Lead	1.157	3.195	8.145	11.622	1.192	3.427	1.574	1.521	11.926	25.837	400	600
Mercury	0.09	0.08	0.26	0.21	ND	0.05	0.02	ND	0.19	0.25	14	270
Nickel	3.116	3.595	5.796	7.621	4.32	3.305	4.435	5.325	3.27	9.395	250	2400
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	63	3100
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	110	4100
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	2
Tributyltin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NL	NL
Zinc	ND	ND	1.88	3.429	ND	ND	ND	ND	15.581	22.946	1500	1500

	Station											
	11	Meadow Cut	13	14	15	16	17	18	19	20	Residential	Non-residential
Antimony	ND	ND	ND	ND	ND	ND	ND	ND	5.586	ND	14	340
Arsenic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	20	20
Beryllium	**5.521**	1.001	**2.607**	1.068	ND	ND	ND	ND	ND	ND	2	2
Cadmium	11.042	1.877	5.069	1.943	0.532	0.572	6.145	6.655	4.68	1.349	39	100
Chromium [a]	**43.478**	7.633	**21.143**	6.41	1.702	2.515	**32.093**	**24.771**	19.627	6.859	240 [b] 270 [c]	6100 [b] 20 [c]
Copper	29.446	1.502	7.386	1.651	1.17	1.601	31.182	16.637	14.947	9.67	600	600
Cyanide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1100	21000
Lead	36.347	3.003	8.979	2.72	0.532	0.572	15.477	2.958	4.831	2.474	400	600
Mercury	0.28	0.06	0.16	0.03	ND	ND	0.14	0.02	0.07	0.02	14	270
Nickel	11.042	2.878	5.938	2.525	0.957	1.143	9.332	8.319	6.643	2.361	250	2400
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	63	3100
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	110	4100
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	2
Tributyltin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NL	NL
Zinc	32.896	ND	4.2	1.068	1.489	ND	9.377	5.86	4.922	3.429	1500	1500

Table 3-1. (Continued)

	Station									
	21	22	23	24	25	26	34	35	Residential	Non-residential
Antimony	ND	ND	ND	ND	ND	4.628	ND	ND	14	340
Arsenic	ND	ND	ND	ND	ND	ND	ND	ND	20	20
Beryllium	ND	ND	ND	ND	ND	ND	ND	ND	2	2
Cadmium	6.316	5.968	2.852	1.084	2.1	6.82	11.944	8.058	39	100
Chromium [a]	**27.12**	**29.199**	9.743	4.696	8.958	**30.934**	**44.704**	**40.624**	240 [b] 270 [c]	6100 [b] 20 [c]
Copper	17.461	11.296	3.089	8.429	13.017	27.037	16.039	38.274	600	600
Cyanide	ND	ND	ND	ND	ND	ND	ND	ND	1100	21000
Lead	2.229	10.656	3.683	1.927	3.919	12.666	21.158	16.115	400	600
Mercury	ND	0.16	0.04	0.04	0.06	0.08	0.06	0.03	14	270
Nickel	9.659	8.525	3.208	2.167	3.499	9.499	12.626	13.094	250	2400
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	63	3100
Silver	ND	ND	ND	ND	ND	ND	ND	ND	110	4100
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	2	2
Tributyltin	ND	ND	ND	ND	ND	ND	ND	ND	NL	NL
Zinc	5.628	3.836	3.66	2.95	4.115	9.183	3.754	12.758	1500	1500

NL - Not listed

[a] The lower of the soil cleanup criteria for chromium III and chromium VI were used – chromium VI was lower under these conditions.

[b] Criterion based on the inhalation exposure pathway.

[c] Site specific determination required for SCC for the allergic contact dermatitis exposure pathway.

< - not detected

Bold type indicates sample exceeds NJDEP Non-residential.

Shaded cells indicate sample exceeds NJDEP Residential

Table 3-2. Organic results of NJIWW bulk sediment testing. Concentrations are presented in mg/kg dry weight.

	Station											
	1	2	3	4	5	6	7	8	9	10	Residential	Non-residential
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3400	10000
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.090	10000	10000
Benzo(a)anthracene	ND	ND	0.055	0.046	ND	ND	0.045	ND	0.107	0.271	0.9	4
Benzo(a)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	0.126	0.199	NL	NL
Benzo(b)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	0.171	0.221	0.9	4
Benzo(ghi)perylene	ND	ND	ND	ND	ND	ND	ND	ND	0.053	0.113	NL	NL
Benzo(k)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.163	0.9	4
bis(2-Ethylhexyl)phthalate	ND	ND	0.175	0.078	0.053	0.095	ND	ND	0.058	0.201	49	210
Chrysene	ND	ND	0.042	ND	ND	ND	ND	ND	0.108	0.231	9	40
Di-n-butylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5700	10000
Fluoranthene	ND	ND	0.07	ND	ND	ND	0.068	ND	ND	0.53	2300	10000
Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.9	4
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	230	4200
Phenanthrene	ND	ND	0.043	ND	ND	ND	0.042	ND	ND	0.243	NL	NL
Pyrene	ND	ND	0.056	ND	ND	ND	0.045	ND	ND	0.464	1700	10000
	Station											
	11	Meadow Cut	13	14	15	16	17	18	19	20	Residential	Non-residential
Acenaphthene	ND	ND	ND	ND	ND	0.032	ND	ND	ND	ND	3400	10000
Anthracene	0.159	ND	ND	ND	ND	ND	ND	ND	ND	ND	10000	10000
Benzo(a)anthracene	0.378	ND	0.061	ND	ND	ND	ND	ND	ND	ND	0.9	4
Benzo(a)pyrene	0.284	ND	ND	ND	ND	ND	ND	ND	ND	ND	NL	NL
Benzo(b)fluoranthene	0.329	ND	0.041	ND	ND	ND	ND	ND	ND	ND	0.9	4
Benzo(ghi)perylene	0.162	ND	ND	ND	ND	ND	ND	ND	ND	ND	NL	NL
Benzo(k)fluoranthene	0.334	ND	0.037	ND	ND	ND	ND	ND	ND	ND	0.9	4
bis(2-Ethylhexyl)phthalate	0.435	0.049	0.125	0.028	0.075	0.026	0.084	0.095	0.05	0.047	49	210
Chrysene	0.442	ND	0.067	0.039	ND	ND	ND	ND	0.063	0.033	9	40
Di-n-butylphthalate	0.063	ND	ND	ND	0.133	ND	ND	ND	ND	ND	5700	10000
Fluoranthene	1.127	ND	0.122	ND	0.027	ND	0.074	0.055	ND	ND	2300	10000
Indeno(1,2,3-cd)pyrene	0.165	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.9	4
Naphthalene	0.072	ND	ND	ND	ND	ND	ND	ND	ND	ND	230	4200
Phenanthrene	0.274	ND	0.059	ND	ND	ND	0.048	ND	ND	ND	NL	NL
Pyrene	0.082	ND	0.081	ND	0.04	0.116	0.067	ND	ND	ND	1700	10000

Table 3-2. (Continued)

	Station									
	21	22	23	24	25	26	34	35	Residential	Non-residential
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	3400	10000
Anthracene	ND	ND	ND	ND	ND	0.127	ND	ND	10000	10000
Benzo(a)anthracene	ND	ND	ND	ND	ND	0.173	ND	ND	0.9	4
Benzo(a)pyrene	ND	ND	ND	ND	ND	0.109	ND	ND	NL	NL
Benzo(b)fluoranthene	ND	ND	ND	ND	ND	0.118	ND	ND	0.9	4
Benzo(ghi)perylene	ND	ND	ND	ND	ND	ND	ND	ND	NL	NL
Benzo(k)fluoranthene	ND	ND	ND	ND	ND	0.079	ND	ND	0.9	4
bis(2-Ethylhexyl)phthalate	ND	0.094	0.065	ND	0.05	0.114	0.146	0.147	49	210
Chrysene	0.044	0.07	0.032	ND	ND	0.107	0.09	ND	9	40
Di-n-butylphthalate	ND	ND	ND	ND	ND	ND	ND	ND	5700	10000
Fluoranthene	ND	0.085	ND	ND	0.051	0.372	0.126	0.08	2300	10000
Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	0.9	4
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	230	4200
Phenanthrene	ND	0.05	ND	ND	0.042	0.1	0.097	0.081	NL	NL
Pyrene	ND	0.049	ND	ND	0.032	0.171	0.08	ND	1700	10000

RDCSCC = Residential Direct Contact Soil Cleanup Criteria
NRDCSCC = Non- Residential Direct Contact Soil Criteria
[a] The lower of the soil cleanup criteria for chromium III and chromium VI were used – chromium VI was lower under these conditions.
NL - No NJDEP Criteria is listed.
< - not detected
Bold type indicates sample exceeds NJDEP NRDCSCC.
Shaded cells indicate sample exceeds NJDEP RDCDCC.

Table 3-3. High resolution PCB analytical results for detected analytes in the NJIWW (pg/g)			
Analyte	Station		
	1	2	3
(2)-MoCB	ND	ND	363
8-DiCB	ND	346	783
(11)-DiCB	B 834	B 1360	B 2590
15-DiCB	ND	404	1860
(17)-TrCB	ND	ND	424
18,(30)-TrCB	B 263	B 483	B 964
(20),28-TrCB	B 512	B 1120	B 3290
(21),33-TrCB	B 301	B 525	B 905
22-TrCB	B 221	B 405	B 814
(25)-TrCB	ND	ND	450
(26,29)-TrCB	ND	ND	652
31-TrCB	B 397	B 805	B 2360
(32)-TrCB	ND	ND	393
37-TrCB	223	525	1510
(40,71)-TeCB	ND	ND	490
42-TeCB	ND	ND	382
44,47,(65)-TeCB	B 267	B 508	B 1230
49,(69)-TeCB	ND	321	951
52-TeCB	B 278	B 529	B 1080
56-TeCB	ND	258	752
(61),70,74,(76)-TeCB	B 374	B 760	B 2110
64-TeCB	ND	ND	395
66-TeCB	B 229	B 549	B 1860
77-TeCB	ND	ND	439
90,101,(113)-PeCB	B 212	B 416	B 1490
95-PeCB	ND	300	651
99-PeCB	ND	ND	1280
105-PeCB	ND	ND	523
110-PeCB	B 258	B 466	B 1550
118-PeCB	ND	408	1770
(129),138,(163)-HxCB	208	430	1760
132-HxCB	ND	ND	331
135,151-HxCB	ND	ND	588
146-HxCB	ND	ND	400
(147),149-HxCB	ND	316	1390
153,168-HxCB	ND	371	1870
170-HpCB	ND	ND	370
180,(193)-HpCB	ND	ND	891
187-HpCB	ND	ND	924
198,199-OcCB	ND	ND	412
Sum of Congeners	4577	11605	43247

B - detections also found in the method blank
ERL -22,700 pg/g
ERM - 180,000 pg/g
DNREC 38,800 pg/g
EPA Risk Based Level Residential - 1,600,000 pg/g
EPA Risk Based Level Non-residential - 41,000,000 pg/g

sample each, at levels ranging from 208 to 3,290 pg/g (Table 3-3). Of the four non-ortho coplanar PCB congeners (77-TeCB, 81-TeCB, 126 PeCB, and 169 HxCB), 77-TeCB was detected at Station 3 at a concentration of 439 pg/g. Non-ortho coplanar PCBs are generally considered the most toxic form of PCBs. Total PCB concentrations (sum of congeners, using 0 for non-detects) were 4,577, 11,605, and 43,247 pg/g for Stations 1, 2, and 3 respectively (4.577 x 10^{-3} to 43.247 x 10^{-3} mg/kg). The highest sum of congener at Station 3 was and order of magnitude lower than lowest New Jersey soil cleanup criterion for PCBs (490,000 pg/g for residential soils). Furthermore, the sum of congeners for the sediments at Stations 1 and 2 were well below the ERL sediment guidelines value of 22,700 pg/g. However, concentrations at Station 3 were higher, but below the ERM guideline of 180,000 pg/g. The Effects Range Low (ERL) is that level at which adverse effects to marine biota were observed in 10% of the studies reviewed by NOAA (Long et al. 1995) while the Effects Range Median (ERM) is the level at which 50% of the studies reported an effect.

The data at the low levels of detection reported by the analytical laboratory have high levels of uncertainty due to routine laboratory method error. The laboratory report shows detections of 12 PCB congeners in the method blanks at levels similar to those found in the samples (Table 3-3). USEPA guidance for data usability (USEPA 1994a,b) proscribes that organic compounds detected in site samples at levels less than ten times greater than levels detected in method blanks should not be considered detections. None of the these samples had PCBs detected in concentrations greater than 10 times the detections observed in the method blank. Therefore, if this PCB analysis followed USEPA guidance total PCB concentrations without these 12 congeners would be 431, 3,679, and 23,004 pg/g for Station 1, 2, and 3 respectively (0.431 x 10^{-3} to 23.004 x 10^{-3} mg/kg). While this guidance was not followed for the purposes of this report, the results suggest that PCB concentrations are much lower than those summarized in Table 3-3, and would be at levels at or below the ERL of 22,700 pg/g.

Bulk Sediment Comparison Between 1999 and 2002 Sampling

The inorganic bulk sediment data developed for the current 2002 sampling in the New Jersey IWW were compared to a similar study conducted by the UASCE in 1999 (Farrar and Burton 1999) to evaluate whether contaminant levels changed appreciably between study periods. The 1999 sampling was conducted at a different set of stations but within the same general north-south geographic range of the IWW. In addition, the 32 cores collected in 1999 were combined to form 18 composite samples for analytical analysis, while each core was analyzed individually in the present 2002 study. Comparisons of the average concentrations for the metals in common with both studies (using a value of 0 for non-detects) suggest that contaminant concentrations observed in 2002 were, for the most part, similar to those observed in 1999 (Figure 3-1). Two notable exceptions were lead and zinc that had much higher average concentrations in 2002 relative to the 1999 composite samples. Averaged among all stations lead concentrations were over 20 mg/kg in 2002 but less than 10 mg/kg in the 1999 study. Similarly, zinc concentrations averaged nearly 60 mg/kg in 2002 but only 5 mg/kg in 1999. Another major difference between the 1999 and 2002 sediment sampling was noted for mercury. In 1999 the average mercury concentration among the 18 composite samples was 0.476 mg/kg but only 0.086 mg/kg among the samples taken in 2002. One station in 1999 which has not composited (Station 10; IWW Composite #9) had a mercury concentration of 2.04 mg/kg. The nearest two stations in the 2002 sampling was Station 18 and 19 that had mercury concentrations of 0.02 and 0.07 mg/kg, respectively. The same method, detection limits, and analytical laboratory was used in both studies. The reasons for these differences are unclear but the results suggest that heavily metals are not distributed evenly throughout the coastal estuary. In addition, given that the samples were not taken at the same stations and one study composited samples while that other did not, these data should be viewed with caution.

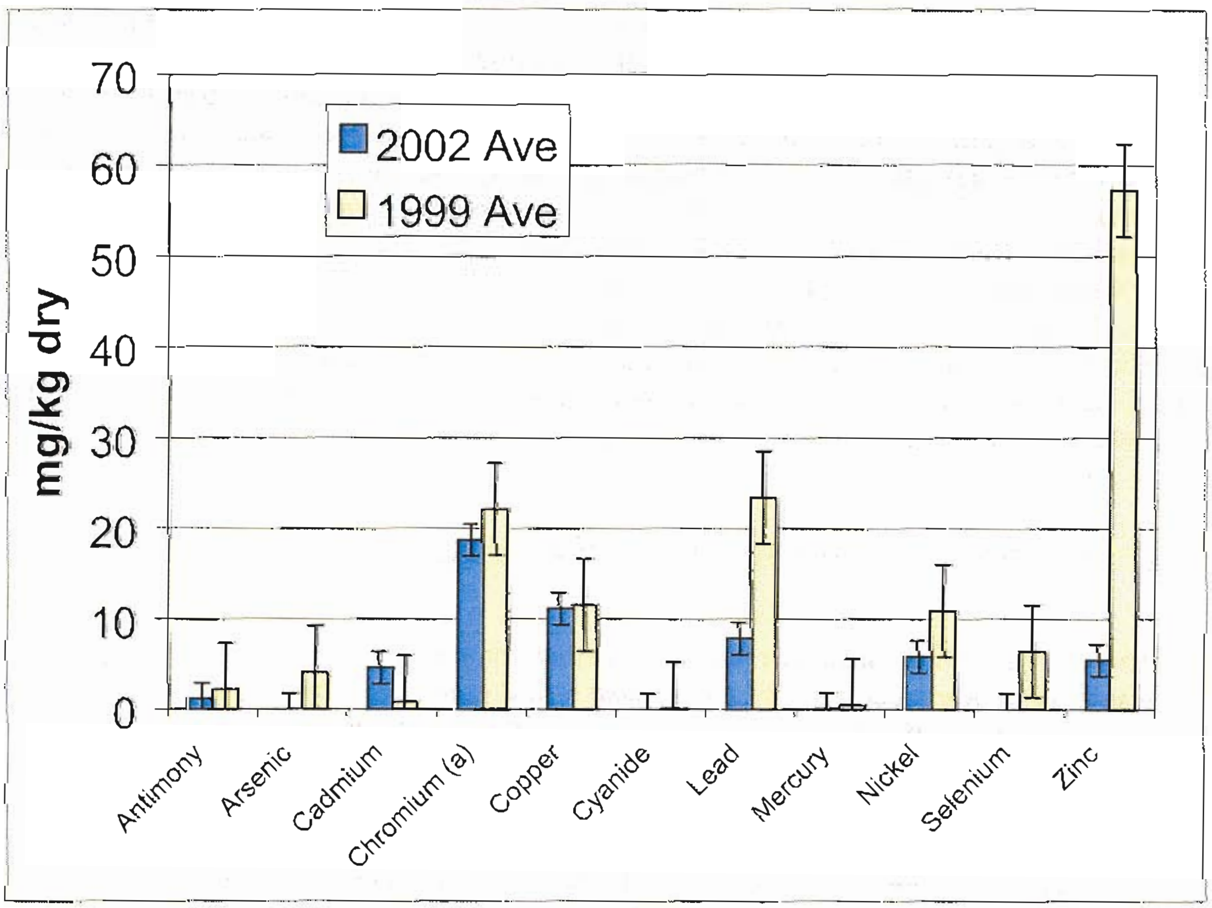

Figure 3-1. Comparison of average sediment metals concentration (mg/kg) between the 2002 sampling and sediment levels reported in the New Jersey IWW in 1999.

3.1.2 Elutriate Testing

The potential for releasing contaminants from the sediment to the water column during dredging operations were evaluated by comparing the results of the standard and modified elutriate tests to NJDEP acute and chronic water quality criteria for marine water. Most of the exceedances observed in the testing were for chronic quality criteria while fewer instances of acute criteria occurred. Because maintenance dredging operations are relatively short in duration, use of the chronic criteria to evaluate effects on aquatic biota may be overly conservative.

Three of the inorganics detected in at least one sample do not have screening criteria: antimony, beryllium, and thallium (Table 3-4). One of the water samples (Station 1) had detected concentrations of arsenic exceeding the acute and chronic marine criteria. Cadmium exceeded the chronic marine criteria in at Station 2, 4, and 24, and both the chronic and acute marine criteria at Station 3. Copper exceeded the chronic marine criteria at Station 5 and 25 and the acute marine criteria at Station 5. Lead exceeded the chronic marine criteria at 12 sites (Stations 1, 2, 4, 11, Meadow Cut, 13, 19, 21, 22, 24, 26, and Hole 35). Nickel exceeded the chronic marine criteria at 13 sites (Stations 1, 2, 4, 5, 6, 7, 9, 10, 13, 20, 21, 25, and Hole 35), additionally Stations 2, 6 and Hole 35 exceeded the acute marine criteria. Selenium exceeded the chronic marine criteria at Station 20. Silver exceeded the acute marine criteria at Station 3. The only organic compounds detected in elutriate water samples were bis(2-ethylhexyl)phthalate, chrysene, diethylphthalate, and di-n-butylthalate and none of these organic analytes have water quality criteria (Table 3-5). No organics were detected in background water sample collected in Cape May Canal.

3.2 BIOLOGICAL AND WATER QUALITY MONITORING

3.2.1 Water Quality

Water quality measurements were taken at three dredge areas (Dredge Hole 34, 35, and Meadow Cut) and three reference sites on September 25^{th} and 26^{th}, 2002. All data is summarized and presented in Table 3-6. Surface water measurements for each dredge area were generally good and typical of marine estuarine environments. The lowest surface DO reading of 6.6 mg/l (Table 3-6) was found in dredge Hole 34, all other areas exhibited DO's above 7.0 mg/l. For all sites except dredge Hole 34, bottom DO was similar to surface DO indicating uniform mixing and generally good water quality conditions. In dredge Hole 34 the bottom water DO was almost anoxic and measured 0.56 mg/l. Very low DO was also measured in the anchored YSI unit (see below). Not only did the DO drop from the surface to bottom, significantly lower temperatures were also observed indicating stratification of the water column (Table 3-6).

Table 3-4. Dissolved inorganic elutriate concentrations in the NJIWW samples (mg/L).

	Station											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Acute**	**Chronic**
Antimony	ND	ND	ND	ND	ND	ND	ND	ND	0.17	ND	NL	NL
Arsenic	**0.368**	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.069	0.036
Beryllium	ND	0.01	ND	ND	ND	ND	ND	ND	ND	0.01	NL	NL
Cadmium	ND	**0.01**	**0.05**	**0.01**	ND	ND	ND	ND	ND	ND	0.042	0.0093
Chromium	0.03	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.1	0.05
Copper	ND	ND	ND	ND	**0.3**	ND	ND	ND	ND	ND	0.0024	0.0024
Cyanide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.001	0.001
Lead	**0.03**	**0.04**	ND	**0.11**	ND	ND	ND	ND	ND	ND	0.21	0.0081
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0018	0.00025
Nickel	**0.06**	**0.13**	ND	**0.02**	**0.06**	**0.08**	**0.07**	ND	**0.06**	**0.02**	0.074	0.0082
Selenium	ND	ND	ND	ND	ND	ND	0.06	ND	ND	ND	0.29	0.071
Silver	ND	ND	**0.94**	ND	ND	ND	ND	ND	ND	ND	0.0019	NL
Thallium	0.22	ND	ND	ND	ND	ND	ND	ND	ND	ND	NL	NL
Tributyltin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NL	NL
Zinc	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.9	0.081
	Station											
	11	**Meadow Cut**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**Acute**	**Chronic**
Antimony	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NL	NL
Arsenic	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.069	0.036
Beryllium	ND	ND	0.02	ND	ND	ND	ND	ND	ND	ND	NL	NL
Cadmium	ND	ND	ND	ND	**0.01**	ND	ND	ND	ND	ND	0.042	0.0093
Chromium	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.1	0.05
Copper	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0024	0.0024
Cyanide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.001	0.001
Lead	**0.05**	**0.05**	**0.14**	ND	ND	ND	ND	ND	**0.06**	ND	0.21	0.0081
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0018	0.00025
Nickel	ND	ND	**0.09**	ND	ND	ND	ND	ND	ND	**0.02**	0.074	0.0082
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	**0.09**	0.29	0.071
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0019	NL
Thallium	ND	ND	ND	0.08	ND	ND	ND	ND	ND	0.07	NL	NL
Tributyltin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NL	NL
Zinc	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.9	0.081

Table 3-4. (Continued)

	Station									Acute	Chronic
	21	22	23	24	25	26	Hole 34	Hole 35	Background water		
Antimony	ND	ND	ND	ND	ND	ND	ND	ND	ND	NL	NL
Arsenic	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.069	0.036
Beryllium	ND	ND	ND	ND	ND	0.05	ND	ND	ND	NL	NL
Cadmium	ND	ND	ND	**0.02**	ND	ND	ND	ND	ND	0.042	0.0093
Chromium	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.1	0.05
Copper	ND	ND	ND	ND	**0.01**	ND	ND	ND	ND	0.0024	0.0024
Cyanide	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.001	0.001
Lead	**0.06**	**0.05**	ND	**0.04**	ND	**0.05**	ND	**0.05**	ND	0.21	0.0081
Mercury	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0018	0.00025
Nickel	**0.02**	ND	ND	ND	**0.02**	ND	ND	**0.08**	ND	0.074	0.0082
Selenium	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.29	0.071
Silver	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0019	NL
Thallium	ND	ND	ND	ND	ND	ND	ND	ND	ND	NL	NL
Tributyltin	ND	ND	ND	ND	ND	ND	ND	ND	ND	NL	NL
Zinc	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.9	0.081

ND - Not detected
NL - Not Listed
Bold type indicates sample exceeds NJDEP Chronic Marine Criteria.
Shaded cells indicate sample exceeds NJDEP Acute Marine Criteria.

Table 3-5. Dissolved organic elutriate concentrations detected in the NJIWW samples (ug/L).

	Station											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Acute**	**Chronic**
bis(2-Ethylhexyl)phthalate	ND	243.6	2	ND	5.4	18.9	ND	ND	16	2.3	NL	NL
Chrysene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NL	NL
Diethylphthalate	ND	0.3	ND	ND	ND	ND	0.5	ND	ND	ND	NL	NL
Di-n-butylphthalate	ND	ND	ND	0.4	0.5	ND	ND	ND	ND	ND	NL	NL
	Station											
	11	**Meadow Cut**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**Acute**	**Chronic**
bis(2-Ethylhexyl)phthalate	ND	1	ND	ND	ND	ND	ND	0.5	ND	ND	NL	NL
Chrysene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NL	NL
Diethylphthalate	ND	ND	ND	ND	0.3	ND	ND	ND	ND	ND	NL	NL
Di-n-butylphthalate	ND	ND	ND	ND	0.2	0.4	ND	ND	ND	ND	NL	NL
	Station											
	21	**22**	**23**	**24**	**25**	**26**	**Hole 34**	**Hole 35**	**Background water**		**Acute**	**Chronic**
bis(2-Ethylhexyl)phthalate	ND	0.5	ND	9.6	5.2	ND	ND	ND	ND		NL	NL
Chrysene	ND	ND	ND	ND	ND	ND	0.3	ND	ND		NL	NL
Diethylphthalate	ND	ND	ND	ND	ND	ND	ND	0.3	ND		NL	NL
Di-n-butylphthalate	ND	ND	ND	ND	ND	0.3	ND	ND	ND		NL	NL

ND - Not detected
NL - Not Listed

Table 3-6. Physical/chemical characteristics observed among the dredged holes, Meadow Cut and each reference site on September 25-26, 2002

Station type	Depth (feet)	DO (mg/L)	Temp (°C)	pH	Conductivity (mS/cm)	Salinity (ppt)	Turbidity (NTU)
Hole 34							
Reference	3.0	7.63	23.34	7.60	48.48	31.66	4.3
Shallow	3.0	6.62	23.29	7.28	48.38	31.58	6.8
Middle	2.0	6.84	23.30	7.34	48.37	31.58	6.6
Middle	25.0	5.57	22.91	7.29	48.48	31.66	12.0
Deep	2.0	6.67	23.28	7.49	48.39	31.59	5.5
Deep	49.0	0.56	17.50	7.03	47.22	30.77	0.1
Hole 35							
Reference	2.0	7.10	22.57	7.48	49.32	32.28	36.4
Reference	7.0	6.99	22.61	7.45	49.32	32.29	47.1
Shallow	2.0	7.30	22.54	7.59	49.16	32.16	10.8
Shallow	10.0	7.03	22.50	7.56	49.15	32.12	10.0
Middle	2.0	7.27	22.44	7.58	49.13	32.15	6.9
Middle	16.0	7.05	22.46	7.12	49.16	32.17	7.3
Deep	2.0	7.97	22.47	7.64	49.12	32.14	6.1
Deep	25.0	7.28	22.43	7.60	49.14	32.16	9.0
Meadow Cut							
Shallow	3.0	7.68	21.25	7.68	48.86	31.97	14.4
Reference	2.0	7.80	21.41	7.61	48.87	31.96	11.4
Reference	7.0	7.60	21.38	7.58	48.87	31.97	21.2

In addition to surface and bottom water quality measurements, 2 YSI water quality meters were anchored 1-meter off the bottom in dredged Holes 34 and 35. These units were deployed to continuously monitor bottom water conditions in the holes (and Figure 3-2 and Figure 3-3). Both holes were monitored for approximately a 48-hour time period. The YSI meter in the deeper of the two holes (Hole 34) measured poor dissolved oxygen conditions the entire time it was deployed (Figure 3-2). The average DO was 1.7±1.52 mg/l, with a low of 0.2 mg/l and a high of 4.0 mg/l. For the first 28 hours of monitoring the DO did not rise above 1.0 mg/l, thereafter it rose to 4.0 mg/l in 5 hours. This sharp increase in DO could be attributed to a significant wind and rain event that occurred on the 2nd and 3rd day of deployment, had this not occurred it is believed that DO would have stayed below 1.0 mg/l. In dredge Hole 35 DO concentrations were much higher than Hole 34, with an average of 5.7±1.03 mg/l, low of 4.1 mg/l, and high of 7.4 mg/l (Figure 3-3). This hole exhibited the same trend as Hole 34 with nearly a 2.0 mg/l increase in DO over 5 hours. It is believed that this general increase in DO was from the same weather event that increased DO in Hole 34. Although the increase in DO for both stations are hours apart, it would have taken longer for mixing to occur in the deeper Hole 34 and this could account for the lag.

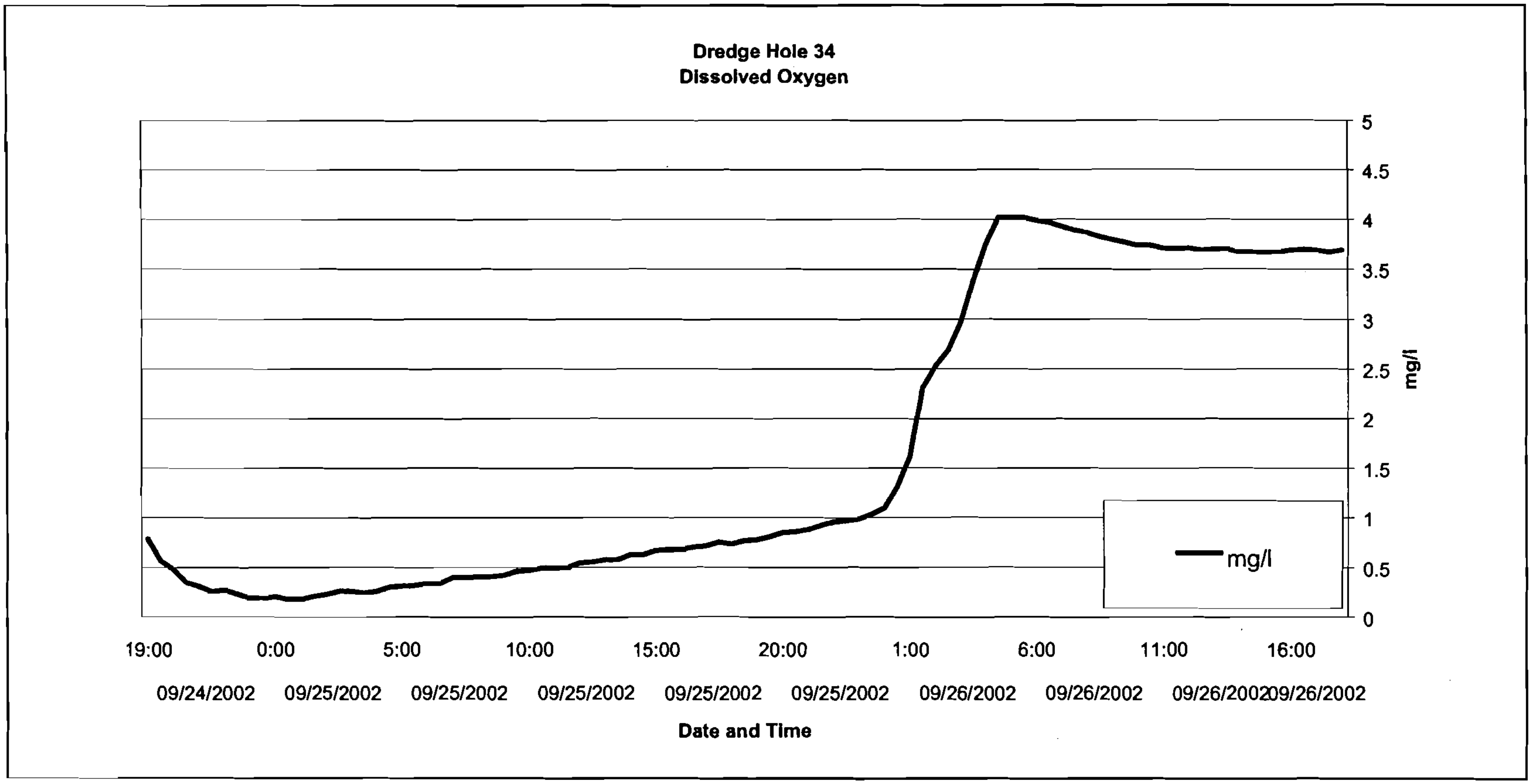

Figure 3-2. Hourly dissolved oxygen concentrations monitored one-meter from the bottom of dredge Hole 34 from September 24-26, 2002.

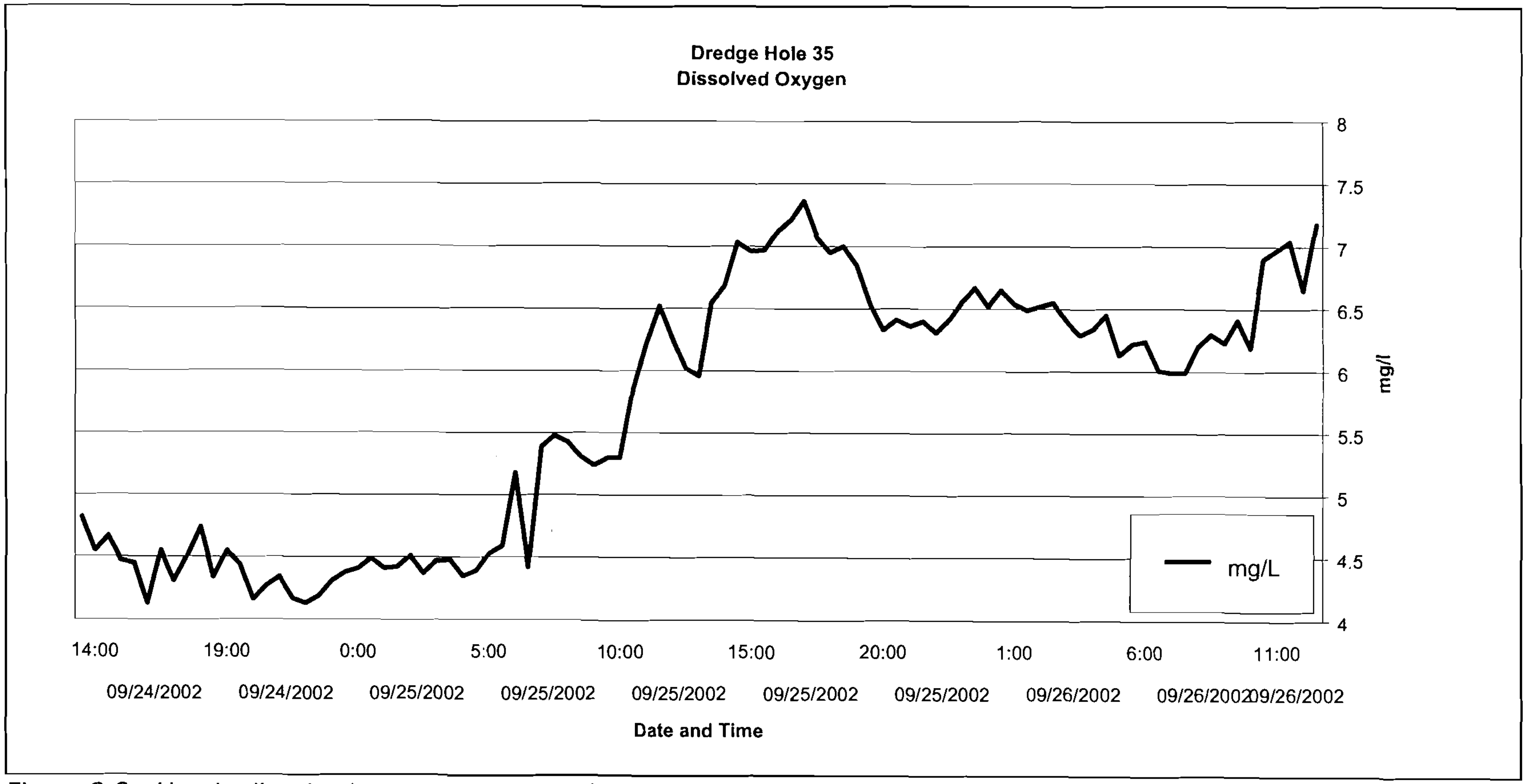

Figure 3-3. Hourly dissolved oxygen concentrations monitored one-meter from the bottom of dredge Hole 35 from September 24-26, 2002.

Surface and bottom water grab samples were collected at both dredge holes to test for hydrogen sulfide concentrations. Hydrogen sulfide was detected in both holes in the surface and bottom samples. Hydrogen sulfide concentrations in Hole 34 were 0.8 mg/l at the surface and 0.03 mg/l on the bottom. Concentrations for Hole 35 were 0.03 mg/l at the surface and 0.8 mg/l on the bottom.

3.2.2 Sediment

The grain size analysis testing on the cores and Young Grab sampling in the dredged holes and Meadow Cut revealed that the sediments in the study area were comprised of a mixture of sands and silts. In general, samples with higher silt/clay content had a higher percentage of organic carbon (Table 3-7). Composite surface grabs collected in dredged Holes 34 and 35 were over 80% silt/clay and had among the highest concentration of carbon as would be expected in these unnaturally deep holes. The relative percentages of silt, sand, and total organic carbon did not exhibit any obvious latitudinal gradient that may help explain the beryllium detections noted in the northern most stations (1-14) relative to the southernmost stations (14-26). Grain size curves for each sediment sample are presented in Appendix E.

3.2.3 Benthic Invertebrates

The community composition of each hole and surrounding shallow reference areas were similar to each other, however, depth differences were clearly apparent. In general, annelids, specifically polychaete worms dominated the benthic community in the reference areas and within the holes (Table 3-8 and Table 3-9). The numerically dominant polychaetes included *Streblospio benedicti* at all the sampling sites, and *Scolotoma tenuis* at the reference area for Hole 34 (Table 3-8). Oligochaete worms were also a numerical dominant within the Meadow Cut area and the shallow depth of Hole 34 (Table 3-8). The quahog hard clam, *Mercenaria mercenaria,* was one of the dominant taxa at the reference station for Hole 35, the shallow area of Hole 35, and within Meadow Cut (Table 3-9).

The majority of the epifaunal species collected from the sampling area were crustaceans (Table 3-10). Amphipod crustaceans were the numerically dominant epifaunal taxa collected. No epifauna organisms were collected from the mid or deep areas of either hole sampled (Table 3-10).

No benthic organisms were collected from the deep area of either Hole 34 or Hole 35 (Figure 3-4 and Figure 3-5). As a result, all of the benthic parameters examined were significantly lower in the deep area of each hole compared to the respective reference area (Table 3-11 and Table 3-12).

Table 3-7. Summary of physical characteristics of the sediment samples taken from the vibracores and surface grabs samples taken with the Young Grab in the dredged holes and Meadow Cut.

Station	Silt/clay (%)	Sand (%)	TOC (%)
1	10.95	89.05	0.80
2	19.45	80.55	2.32
3	30.86	69.14	3.84
4	55.00	45.00	5.26
5	21.00	79.00	1.77
6	11.68	88.32	1.21
7	11.78	88.22	1.61
8	48.05	51.95	2.20
9	9.76	90.24	2.22
10	62.34	37.66	7.57
11	75.13	24.87	7.71
13	22.91	77.09	4.05
14	4.06	95.94	1.00
15	1.92	98.08	0.40
16	0.95	99.05	0.27
17	83.08	16.92	6.83
18	71.80	28.20	5.20
19	16.07	83.93	2.65
20	4.48	95.52	0.71
21	67.07	32.93	8.75
22	36.04	63.96	5.53
23	28.56	71.44	4.61
24	8.85	91.15	1.60
25	4.68	95.32	1.19
26	74.17	25.83	8.18
Hole 34	81.13	18.87	8.56
Hole 35	86.55	13.45	8.98
Meadow Cut	3.10	96.90	0.90

Table 3-8. Mean abundance (#/m^2) of the 10 most abundant benthic infauna taxa at each of the depths sampled at Hole 34 and at Meadow Cut

Taxonomic Group	Taxon Name	Reference	Shallow	Middle	Deep	Meadow Cut
Annelida : Polychaeta	*Apoprionospio pygmaea*	393.94	0.00	0.00	0.00	7.58
	Exogone dispar	7.58	0.00	0.00	0.00	136.36
	Glycera americana	7.58	0.00	0.00	0.00	174.24
	Glycinde solitaria	477.27	30.30	90.91	0.00	75.76
	Heteromastus filiformis	128.79	45.45	0.00	0.00	37.88
	Leitoscoloplos spp.	386.36	30.30	7.58	0.00	60.61
	Mediomastus ambiseta	151.51	0.00	22.73	0.00	106.06
	Nereididae	0.00	45.45	0.00	0.00	7.58
	Orbiniidae	37.88	53.03	0.00	0.00	0.00
	Paraprionospio pinnata	90.91	53.03	401.51	0.00	0.00
	Phyllodoce arenae	0.00	7.58	0.00	0.00	106.06
	Platynereis dumerilii	45.45	53.03	7.58	0.00	7.58
	Scoletoma tenuis	1106.06	0.00	0.00	0.00	409.09
	Spiochaetopterus costarum	151.51	0.00	0.00	0.00	0.00
	Streblospio benedicti	2696.96	174.24	2613.63	0.00	2613.63
Annelida : Oligochaeta	Oligochaeta	303.03	939.39	53.03	0.00	4984.83
Mollusca : Bivalvia	*Macoma tenta*	0.00	0.00	0.00	0.00	204.54
	Mercenaria mercenaria	68.18	53.03	15.15	0.00	583.33
	Tellina agilis	37.88	0.00	7.58	0.00	977.27
Crustacea : Cumacea	*Leucon americanus*	0.00	0.00	22.73	0.00	0.00
Crustacea : Amphipoda	*Listriella barnardi*	431.82	0.00	0.00	0.00	0.00
	Ampelisca abdita	60.61	7.58	272.73	0.00	30.30

Table 3-9. Mean abundance (#/m^2) of the 10 most abundant benthic infauna taxa at each of the depths sampled at Hole 35

Taxonomic Group	Taxon Name	Reference	Shallow	Middle	Deep
Annelida : Polychaeta	*Capitella capitata* complex	189.39	848.48	0.00	0.00
	Cirratulidae	219.70	0.00	0.00	0.00
	Eteone heteropoda	0.00	75.76	0.00	0.00
	Glycinde solitaria	196.97	22.73	0.00	0.00
	Mediomastus ambiseta	303.03	22.73	37.88	0.00
	Neanthes succinea	0.00	257.57	0.00	0.00
	Polydora cornuta	0.00	37.88	0.00	0.00
	Scoletoma tenuis	204.54	0.00	0.00	0.00
	Streblospio benedicti	4037.87	9825.73	7.58	0.00
Annelida : Oligochaeta	Oligochaeta	863.63	60.61	45.45	0.00
Mollusca : Bivalvia	*Mercenaria mercenaria*	1265.15	106.06	0.00	0.00
	Tellina agilis	893.94	22.73	0.00	0.00
Crustacea : Amphipoda	*Lysianopsis alba*	257.57	0.00	0.00	0.00

Table 3-10. Abundance of epifauna organisms collected from all sites/depths sampled for this study. No epifauna organisms were collected if a site/depth is not listed in this table.

Taxonomic Category	Taxon Name	Reference 34	Hole 34 Shallow	Reference 35	Hole 35 Shallow	Meadow Cut
Platyhelminthes:Turbellaria	Turbellaria	0	0	7.58	0	0
Annelida : Polychaeta	*Hydroides dianthus*	15.15	0	0	0	0
	Lepidonotus sublevis	0	0	0	0	7.58
	Polynoidae	0	0	0	0	7.58
	Proceraea cornuta	0	0	7.58	0	0
	Sabellaria vulgaris	0	0	7.58	0	0
Mollusca : Gastropoda	*Astyris lunata*	0	0	166.68	0	45.45
	Crepidula convexa	37.88	136.36	53.03	0	0
	Crepidula plana	0	0	37.88	0	30.30
	Gastropoda	0	0	7.58	0	0
Mollusca : Polyplacophora	Polyplacophora	0	0	0	0	7.58
Crustacea : Isopoda	*Edotea triloba*	0	0	0	7.58	0
	Erichsonella filiformis	7.58	7.58	0	0	128.79
	Erichsonella spp.	0	7.58	0	0	0
	Synidotea laticauda	0	0	0	7.58	0
Crustacea : Amphipoda	*Ampithoe valida*	0	0	0	0	15.15
	Apocorophium acutum	0	0	0	0	7.58
	Batea catharinensis	30.30	0	128.79	0	30.30
	Caprella penantis	45.45	0	22.73	0	75.76
	Cerapus tubularis	0	0	0	0	15.15
	Cymadusa compta	15.15	7.58	0	0	0
	Elasmopus laevis	60.61	0	90.91	0	371.21
	Ericthonius brasiliensis	0	0	0	0	90.91
	Melita nitida	0	0	30.30	0	0
	Microdeutopus gryllotalpa	106.06	15.15	0	0	75.76

Table 3-10. (Continued)

Taxonomic Category	Taxon Name	Reference 34	Hole 34 Shallow	Reference 35	Hole 35 Shallow	Meadow Cut
Crustacea : Mysidacea	Mysidae	15.15	0	0	0	0
	Heteromysis formosa	0	0	53.03	0	0
Crustacea: Decapoda	*Libinia* spp.	0	0	0	0	7.58
	Pagurus lonicarpus	0	0	0	0	15.15
	Pagurus pollicaris	0	0	0	0	7.58
	Majidae	0	0	0	0	22.73
	Libinia emarginata	0	0	7.58	0	0
	Portunidae	22.73	0	0	0	0
	Xanthidae	0	0	60.61	0	7.58
Chordata:Ascidiacea	Ascidiacea	7.58	83.33	0	0	22.73
Number of Epifauna taxa		11	6	14	2	20

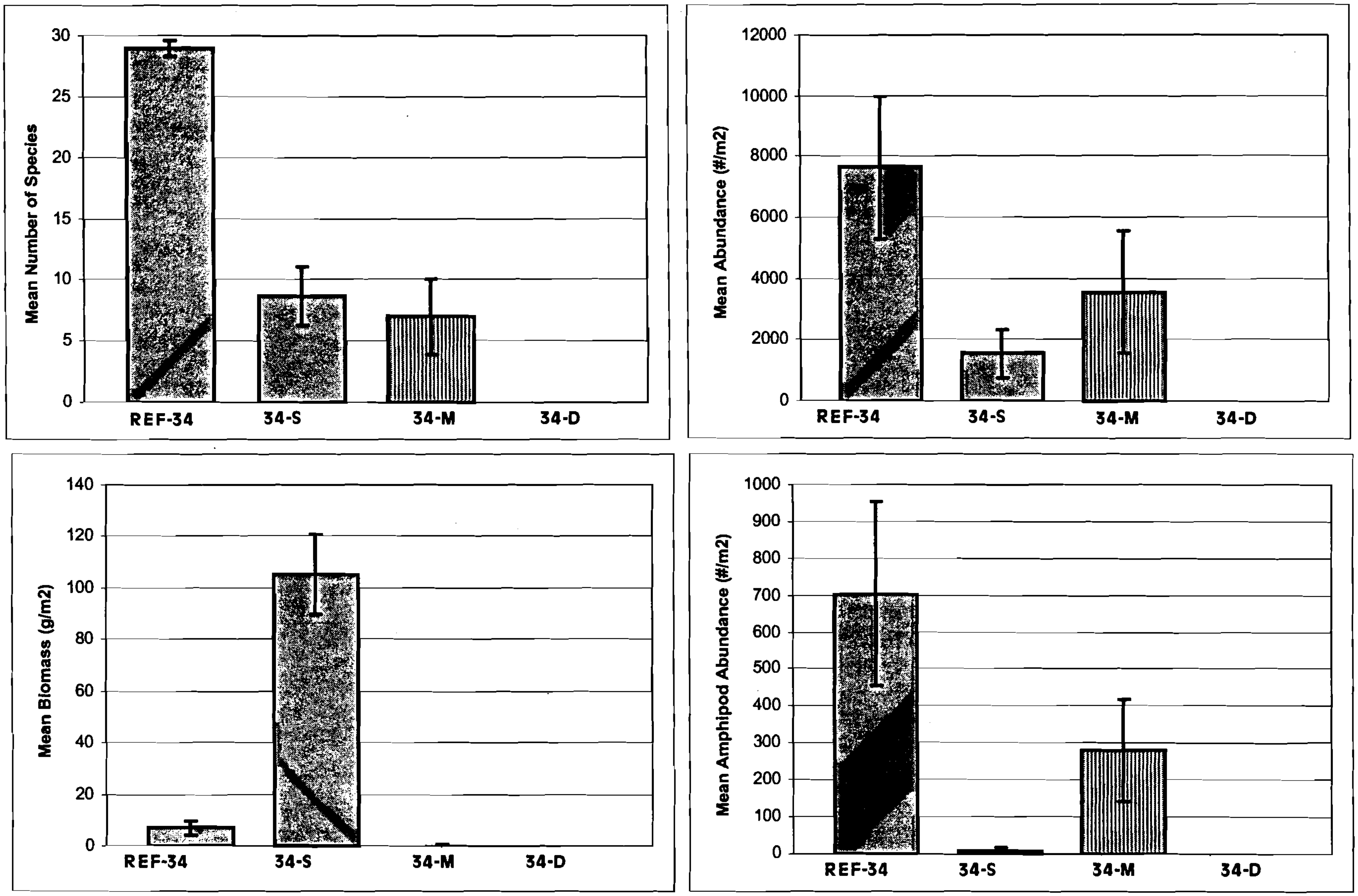

Figure 3-4. Mean number of species, total abundance, total biomass, and amphipod abundance observed in benthic collections taken at three deeps (deep, mid, and shallow) in Hole 34 and relative to a nearby reference site.

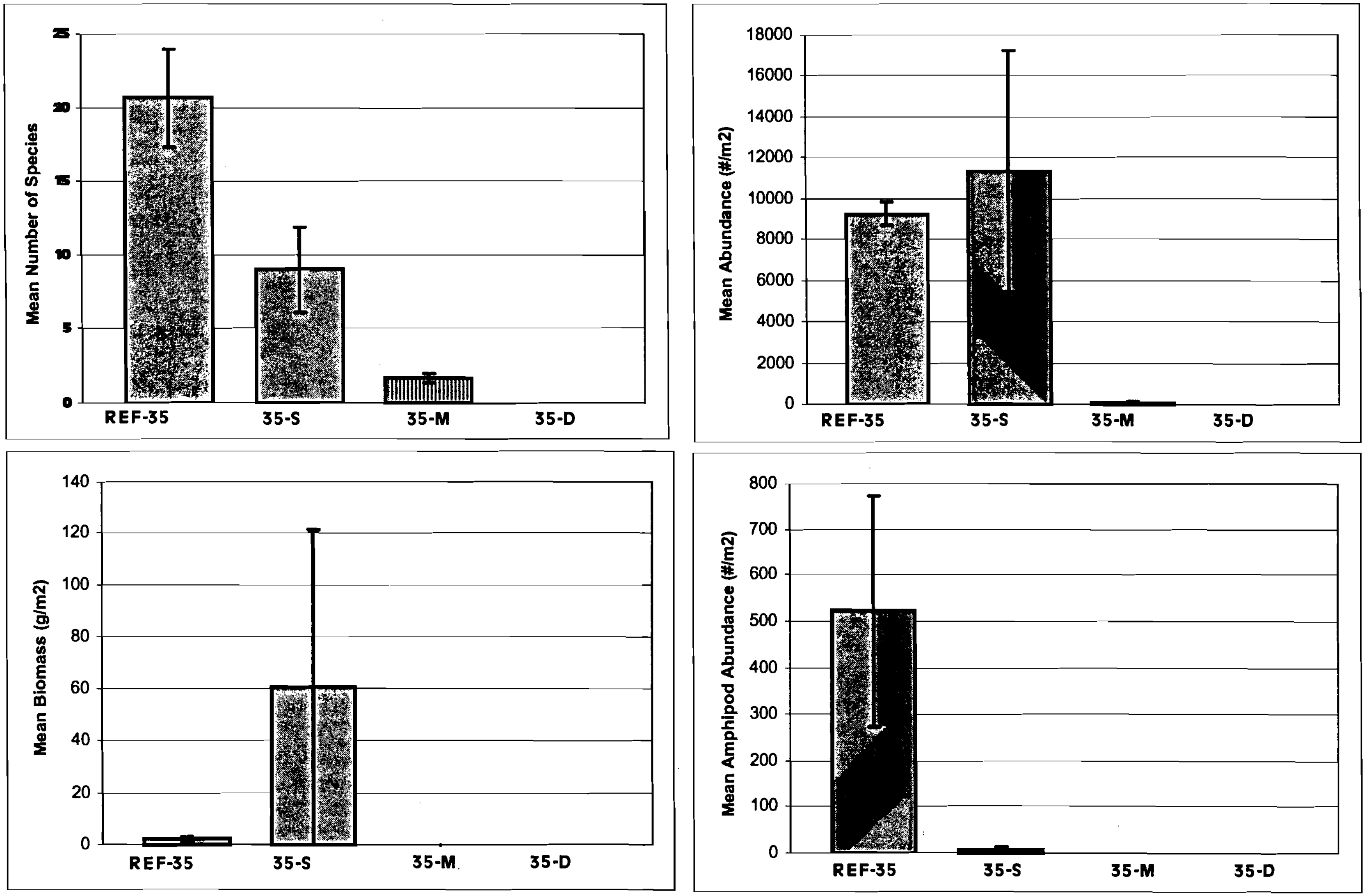

Figure 3-5. Mean number of species, total abundance, total biomass, and amphipod abundance observed in benthic collections taken at three deeps (deep, mid, and shallow) in Hole 34 and relative to a nearby reference site.

Table 3-11. Summary of benthic infauna community parameters at Hole 34 and the near-by reference area. Standard error of estimate is in parenthesis. Means with the same letter are not significantly different as indicated by Duncan's Multiple Range Test.

Parameter	Reference	Shallow	Middle	Deep
Total number of taxa	46	16	14	0
Mean Number of Taxa (#/Sample)	29.0 (A) (0.58)	8.67 (A,B) (2.40)	7.00 (B) (3.06)	0.00 (C) (0.00)
Mean Shannon-Wiener Index	3.50 (A) (0.47)	2.04 (A,B) (0.32)	0.96 (B,C) (0.49)	0.00 (C) (0.00)
Mean Simpson's Dominance Index	0.82 (A) (0.09)	0.64 (A,B) (0.10)	0.30 (B,C) (0.15)	0.00 (C) (0.00)
Mean Total Abundance (#/m^2)	7651.49 (A) (2346.61)	1545.45 (A) (769.71)	3537.87 (A) (1995.40)	0.00 (B) (0.00)
Mean Amphipod Abundance (#/m^2)	704.54 (A) (249.31)	7.58 (B) (7.58)	280.30 (A) (139.07)	0.00 (B) (0.00)
Mean Bivalve Abundance (#/m^2)	204.54 (A) (57.20)	53.03 (A,B) (20.04)	30.30 (B) (20.04)	0.00 (C) (0.00)
Mean Polychaete Abundance (#/m^2)	6363.62 (A) (2308.83)	545.45 (A) (255.45)	3151.51 (A) (1817.34)	0.00 (B) (0.00)
Mean Total AFDW Biomass (g/m^2)	6.94 (B) (2.86)	105.26 (A) (15.75)	0.20 (C) (0.11)	0.00 (C) (0.00)
Mean Amphipod AFDW Biomass (g/m^2)	0.03 (A) (0.01)	0.00 (B) (0.00)	0.02 (A,B) (0.01)	0.00 (B) (0.00)
Mean Bivalve AFDW Biomass (g/m^2)	1.07 (B) (0.50)	105.06 (A) (15.78)	0.00 (C) (0.00)	0.00 (C) (0.00)
Mean Polychaete AFDW Biomass (g/m^2)	3.89 (A) (0.51)	0.17 (B) (0.05)	0.18 (B) (1.10)	0.00 (B) (0.00)

Table 3-12. Summary of benthic infauna community parameters at Hole 35 and the near-by reference area. Standard error of estimate is in parenthesis. Means with the same letter are not significantly different as indicated by Duncan's Multiple Range Test.

Parameter	Reference	Shallow	Middle	Deep
Total number of taxa	36	17	3	0
Mean Number of Taxa (#/Sample)	20.67 (A) (3.28)	9.00 (B) (2.89)	1.67 (C) (0.33)	0.00 (D) (0.00)
Mean Shannon-Wiener Index	2.77 (A) (0.22)	0.97 (B) (0.19)	0.53 (B) (0.29)	0.00 (C) (0.00)
Mean Simpson's Dominance Index	0.75 (A) (0.04)	0.33 (B) (0.10)	0.25 (B,C) (0.14)	0.00 (C) (0.00)
Mean Total Abundance (#/m^2)	9257.55 (A) (552.72)	11333.30 (A) (5914.20)	90.91 (B) (34.72)	0.00 (C) (0.00)
Mean Amphipod Abundance (#/m^2)	522.73 (A) (250.34)	7.58 (B) (7.58)	0.00 (B) (0.00)	0.00 (B) (0.00)
Mean Bivalve Abundance (#/m^2)	2242.42 (A) (590.52)	128.79 (B) (87.37)	0.00 (C) (0.00)	0.00 (C) (0.00)
Mean Polychaete Abundance (#/m^2)	5515.13 (A) (696.47)	11128.75 (A) (5796.44)	45.45 (B) (13.12)	0.00 (C) (0.00)
Mean Total AFDW Biomass (g/m^2)	2.16 (A) (1.00)	60.93 (A) (60.67)	0.00 (A) (0.00)	0.00 (A) (0.00)
Mean Amphipod AFDW Biomass (g/m^2)	0.07 (A) (0.03)	0.00 (B) (0.00)	0.00 (B) (0.00)	0.00 (B) (0.00)
Mean Bivalve AFDW Biomass (g/m^2)	1.13 (A) (0.96)	60.42 (A) (60.42)	0.00 (A) (0.00)	0.00 (A) (0.00)
Mean Polychaete AFDW Biomass (g/m^2)	0.85 (A) (0.21)	0.51 (A,B) (0.28)	0.00 (B) (0.00)	0.00 (B) (0.00)

Diversity

Only 3 taxa were collected from the mid depths of Hole 35, which resulted in a significantly lower mean number of taxa than both the reference and shallow area of Hole 35 (Table 3-12; Figure 3-5). The mean number of taxa collected from the shallow depths of Hole 35 was also significantly lower than the nearby reference area (Table 3-12). Shannon-Wiener and Simpson's Dominance Indices were significantly lower at the shallow and mid depths of Hole 35 than at the nearby reference (Table 3-12).

More taxa were collected from the mid depths of Hole 34 than Hole 35 but the mean number of taxa collected from this area was significantly lower than the reference area (Table 3-11; Figure 3-4). Both diversity indices at the mid depths of Hole 34 were also significantly lower than at the nearby reference area (Table 3-11). None of the three measures of diversity at the shallow depths of Hole 34 were significantly different than the reference area (Table 3-11).

The mean number of benthic taxa collected from Meadow Cut was not significantly different from either of the 2 reference areas (Table 3-13; Figure 3-6). Neither of the diversity indices examined was significantly different between Meadow Cut and the reference areas (Table 3-13).

Abundance

Mean abundance of benthic organisms at the mid depths of Hole 35 was extremely depressed (Figure 3-5), and was significantly lower than both the reference and shallow areas (Table 3-12). As a result, all of the mean abundances of the major taxonomic groups examined (amphipods, polychaetes, and bivalves) were significantly lower in the mid depth of Hole 35 than both the shallow depth and the reference areas (Table 3-12). Amphipods, which are major prey for the resident fish populations of the area, were not present in any of the samples collected from the mid depth of Hole 35 (Figure 3-5).

The shallow area of Hole 35 had a higher mean abundance than the nearby reference area but the difference was not significant (Figure 3-5; Table 3-12). *Streblospio benedicti*, a small opportunistic polychaete worm, was the major contributor to the high abundance in the shallow depths of Hole 35 (Table 3-9). Because the abundance of this worm was patchy within the shallow area, neither the mean total abundance or the mean polychaete abundance were significantly higher than the reference area due to the high standard error of the mean (Table 3-12; Figure 3-5). Mean abundances of amphipods and bivalves were significantly lower in the shallows of Hole 35 than at the nearby reference area (Table 3-12).

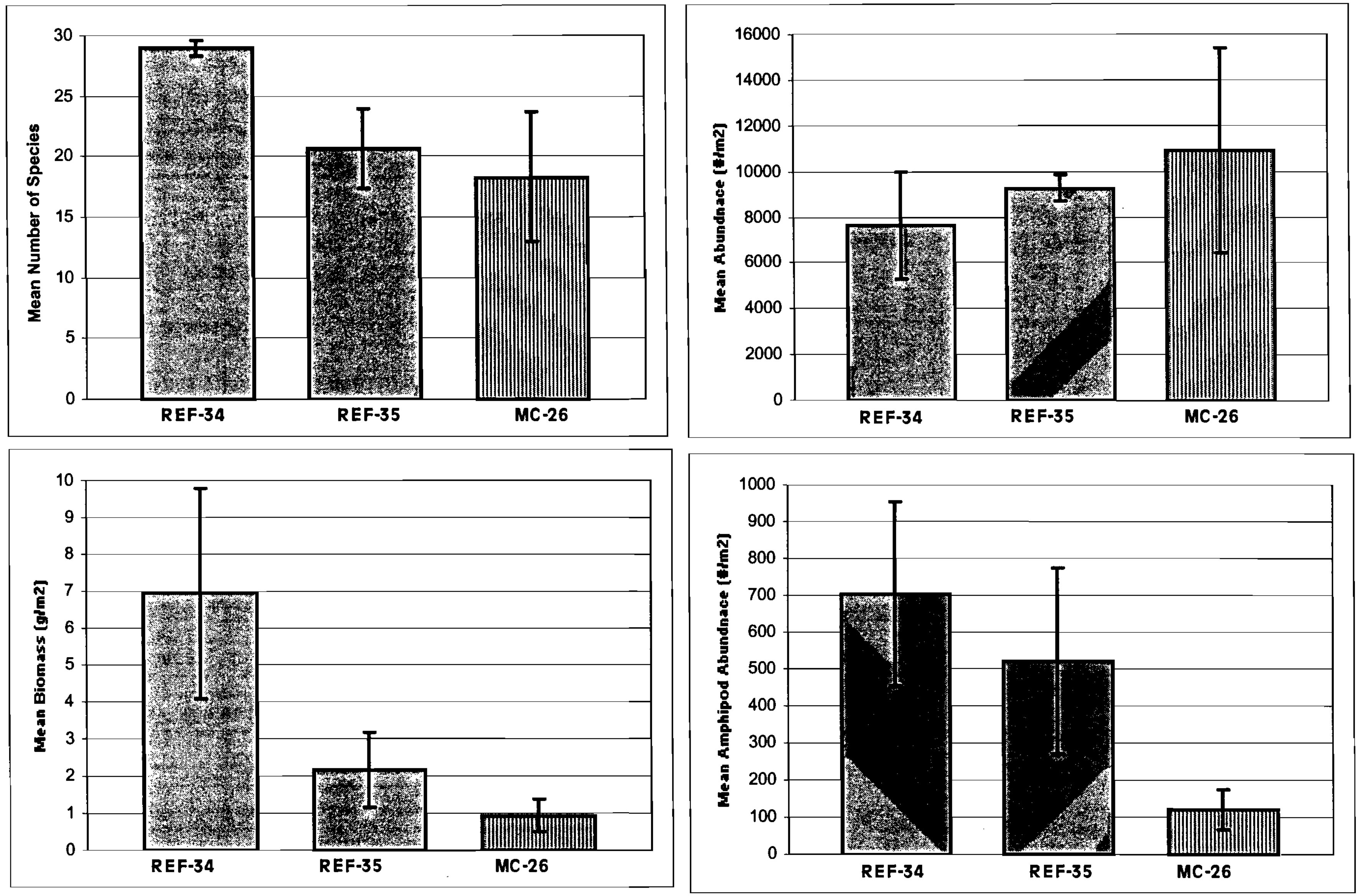

Figure 3-6. Mean number of species, total abundance, total biomass, and amphipod abundance observed in benthic collections taken in the Meadow Cut relative to the reference sites for Holes 34 and 35.

Table 3-13. Summary of benthic infauna community parameters at Meadow Cut and reference areas. Standard error of estimate is in parenthesis. Means with the same letter are not significantly different as indicated by Duncan's Multiple Range Test.

Parameter	Meadow Cut	Reference 35	Reference 34
Total number of taxa	34	36	46
Mean Number of Taxa (#/Sample)	18.33 [A] (5.36)	20.67 [A] (3.28)	29.00 [A] (0.58)
Mean Shannon-Wiener Index	2.32 [A] (0.22)	2.77 [A] (0.22)	3.50 [A] (0.47)
Mean Simpson's Dominance Index	0.70 [A] (0.02)	0.75 [A] (0.04)	0.82 [A] (0.09)
Mean Total Abundance (#/m^2)	10909.06 [A] (4455.48)	9257.55 [A] (552.72)	7651.49 [A] (2346.61)
Mean Amphipod Abundance (#/m^2)	121.21 [A] (53.03)	522.73 [A] (250.34)	704.54 [A] (249.31)
Mean Bivalve Abundance (#/m^2)	1825.75 [A] (662.91)	2242.42 [A] (590.52)	204.54 [B] (57.20)
Mean Polychaete Abundance (#/m^2)	3893.93 [A] (1734.05)	5515.13 [A] (696.47)	6363.62 [A] (2308.83)
Mean Total AFDW Biomass (g/m^2)	0.93 [B] (0.45)	2.16 [A,B] (1.00)	6.94 [A] (2.86)
Mean Amphipod AFDW Biomass (g/m^2)	0.01 [A] (0.00)	0.07 [A] (0.03)	0.03 [A] (0.01)
Mean Bivalve AFDW Biomass (g/m^2)	0.32 [A] (0.17)	1.13 [A] (0.96)	1.07 [A] (0.50)
Mean Polychaete AFDW Biomass (g/m^2)	0.49 [A] (0.25)	0.85 [A] (0.21)	3.89 [A] (0.51)

The mean benthic abundance at the mid depths of Hole 34 was not as low as in Hole 35 (Figure 3-4) and was not significantly lower than the nearby reference or shallow areas (Table 3-11). In fact, the mean abundance of benthos collected from the mid depth of Hole 34 was higher (but not significantly so) than the mean abundance from the shallow depth (Figure 3-4). As in the shallow area of Hole 35, *Streblospio benedicti*, the small opportunistic polychaete worm, was the major contributor to the higher abundance in the mid depth of Hole 34 (Table 3-8). As a result, mean polychaete abundance was not significantly different between the mid depth of Hole 34 and the nearby reference area (Table 3-11). Amphipod abundance at the mid depths of Hole 34 was lower than the reference area but the difference was not significant (Table 3-11 and Figure 3-4). The mean number of bivalves collected from the mid depths of Hole 34 was significantly lower than the reference area (Table 3-11).

The shallow area of Hole 34 had a lower mean abundance than the mid area and the reference area but the difference was not significant due to a high standard error of the mean (Figure 3-4 and Table 3-11. However, the amphipod abundance in the shallow area of Hole 34 was significantly lower than both the reference area and mid depth area (Figure 3-4; Table 3-11). Again due to a high standard error of the mean, both the mean polychaete and bivalve abundance parameters were not significantly lower at the shallow area compared to the nearby reference area (Table 3-11).

Meadow Cut had a higher mean abundance of benthic organisms than both of the reference areas but the difference was not significant (Table 3-13; Figure 3-6). None of the major taxonomic groups examined within Meadow Cut were significantly lower than the reference site (Table 3-13). In fact the mean bivalve abundance at Meadow Cut was significantly higher than at the reference near Hole 34.

Biomass

Mean total biomass collected from the shallow area of Hole 35 was dominated by the presence of a few large (2 or 3 year old) quahog clams, *Mercenaria mercenaria* collected in the second replicate (Appendix D). As a result, the mean total biomass for the shallow area of Hole 35 was about 61 g/m^2 (Figure 3-5). However, the variance around this mean was almost as high so that no significant difference in biomass was detected between the reference area, the shallow, or the mid depth region of Hole 35 (Figure 3-5; Table 3-12).

Mean total biomass in the mid depths of Hole 35 was substantially lower than in the shallow and reference areas of Hole 35 (Table 3-12). This is not surprising since so few organisms were collected in the three samples taken from the mid depths of this hole.

As at Hole 35, several large (up to 5 year old) quahog clams, *Mercenaria mercenaria* were collected from all three samples collected from the shallow depths of Hole 34

(Appendix D). Since all three samples contained these large clams, the variance around the mean was low so that the shallow area had significantly higher total and bivalve biomass than the other areas examined (Table 3-11). *Mercenaria mercenaria,* were also collected from the nearby reference area, however, all of them were new recruits and did not contribute substantially to total biomass (Appendix D).

Mean total biomass in the mid depths of Hole 34 was significantly lower than both the shallow and reference areas (Figure 3-4; Table 3-11). Of the major taxonomic groups examined, amphipod biomass was not significantly lower than the reference, but both bivalve and polychaete biomass was significantly lower than the reference at Hole 34 (Table 3-11).

Mean total biomass at Meadow Cut was not significantly different than Hole 35 reference area but was lower than the reference area of Hole 34 (Figure 3-6). The major difference in total biomass between these two areas was the presence of several large gastropod snails (*Ilyanassa obsoleta*) at replicate 3 of Hole 34 reference area which led to a higher mean biomass for this area (Appendix D). No significant differences were detected between Meadow Cut and the 2 reference areas for mean biomass of amphipods, polychaetes, or bivalves (Table 3-13).

Benthic Summary

The deep area of both holes examined for benthic invertebrate community composition and abundance for this study was azoic. No benthic organisms were collected in any of the samples collected from the deep areas of each hole (Table 3-11 and Table 3-12). The benthic communities collected from the mid depths of each hole varied in health. The mid depths of Hole 35 contained very few taxa and biomass (Table 3-12), whereas the mid depths of Hole 34 contained some high numbers of opportunistic organisms, specifically the polychaete worm, *Streblospio benedicti* (Table 3-8). Overall, however, the mid depths of Hole 34 contained fewer taxa, had lower diversity indices, and less total biomass than the nearby reference area (Table 3-11). The shallow areas of both holes examined were generally similar to the reference area in terms of number of taxa, diversity, abundance, and biomass (Table 3-11 and Table 3-12). However, several large quahog clams, *Mercenaria mercenaria*, were collected from this area but not from the reference area. No major differences were detected in any of the benthic parameters examined from Meadow Cut compared to the two reference areas (Table 3-13).

3.2.4 Fisheries Sampling

3.2.4.1 Gill Nets

Experimental gill nets were set overnight in both dredge holes and reference sites to assess potential fish usage (Table 3-14). Fish collected from dredge Hole 34 and its reference site showed similar species composition. A total of 4 species were collected in dredge Hole 34, and 6 species at the reference, with more total fish collected at the reference site (27) than in the dredge hole (14). Bluefish and smooth dogfish dominated the catch at both sites (Table 3-14). Species composition for reference 35 could not be accurately assessed due to predation of fish in the net by crabs; therefore no comparisons to dredge Hole 35 will be made. A total of 5 species were collected at dredge Hole 35, with the bulk of the catch being large bluefish and weakfish. A total of 7 different species were collected in the gill net survey. Invertebrates collected in the gill net survey included: green crabs, spider crabs, and mantis shrimp (Table 3-14).

Table 3-14. Fish collected in experimental gill nets set overnight in dredge Hole 34, 35, and each respective reference site.

	Total Collected	Average Length mm)
Hole 34		
Bluefish (*Pomatomus saltatrix*)	3	346
Atlantic menhaden (*Brevoortia tyrannus*)	2	347
Smooth dogfish (*Mustelus canis*)	8	530
Spot (*Leiostomus xanthurus*)	1	180
Hole 34 Reference		
Black sea bass (*Centropristis striata*)	2	163
Bluefish (*Pomatomus saltatrix*)	3	289
Mantis shrimp (*Stomatopoda spp.*)	1	n/a
Atlantic menhaden (*Brevoortia tyrannus*)	1	347
Scup (*Stenotomus chrysops*)	1	160
Smooth dogfish (*Mustelus canis*)	18	537
Spot (*Leiostomus xanthurus*)	1	192
Hole 35		
Black sea bass (*Centropristis striata*)	3	184
Bluefish (*Pomatomus saltatrix*)	17	329
Gizzard Shad (*Dorosoma cepedianum*)	1	495
Spot (*Leiostomus xanthurus*)	1	148
Weakfish (*Cynoscion regalis*)	9	434
Hole 35 Reference		
Black sea bass (*Centropristis striata*)	3	188
Green crab (*Carcinus Maenas*)	6	62
Spider Crab (*Libinia Emarginata*)	47	54
Weakfish (*Cynoscion regalis*)	2	n/a

3.2.4.2 Trawls

The trawl survey revealed similar species composition between dredge areas and reference sites (Tables 3-15 and 3-17). A total of 17 species were collected in the trawl survey, bay anchovy being the most common and most abundant. Trawls in dredge Hole 34 collected 5 species of fish comprising 6 individuals, compared to one summer flounder, and one fourspined stickle back collected at the reference area (Table 3-15). Trawls done in dredge Hole 35 and its reference collected the most individuals from any area in the survey (Table 3-16). Sampling at these sites collected a total of 266 individuals between them due to large numbers of bay anchovies found in all the trawls. Also present at several sites in the survey, were invertebrate species including: blue crab, grass shrimp, mud crab, green crab, hermit crab, and purple sea urchin. Species composition at the Meadow Cut and reference was by far the most diverse between the dredge areas (Table 3-17). These sites produced unique species such as, bluespotted cornet fish, northern pipefish, and northern puffers. Seven species of fish were collected at both the Meadow Cut and Meadow Cut reference.

Table 3-15. Fish and shellfish collected in a 16 foot otter trawl towed through dredge Hole 34 and reference site 34.

	Total Collected	Average Length (mm)
Hole 34		
Trawl 1		
Grass shrimp (*Paleomonettes vulgaris*)	8	n/a
Tautog (*Tautoga onitis*)	2	168
Trawl 2		
Atlantic Croaker (*Micropogonias undulates*)	1	22
Blue Crab (*Callinectes sapidus*)	6	91
Fourspine stickleback (*Apeltes quadracus*)	1	31
Naked goby (*Gobiosoma bosc*)	1	29
Summer flounder (*Paralicthys dentatus*)	1	235
Hole 34 Reference		
Trawl 1		
Blue Crab (*Callinectes sapidus*)	4	65
Grass shrimp (*Paleomonettes vulgaris*)	5	n/a
Trawl 2		
Blue Crab (*Callinectes sapidus*)	4	28
Mud crab (*Xanthidae spp.*)	3	12
Grass shrimp (*Paleomonettes vulgaris*)	25	n/a
Fourspine stickleback (*Apeltes quadracus*)	1	36
Summer flounder (*Paralicthys dentatus*)	1	319

Table 3-16. Fish and shellfish collected in a 16 foot otter trawl towed through dredge Hole 35 and reference site 35.

	Total Collected	Average Length (mm)
Hole 35		
Trawl 1		
Bay anchovy (*Anchoa mitchilli*)	24	52
Trawl 2		
Atlantic Croaker (*Micropogonias undulates*)	1	47
Atlantic Silverside (*Menidia menidia*)	1	83
Bay anchovy (*Anchoa mitchilli*)	99	53
Scup (*Stenotomus chrysops*)	3	151
Silver Jenny (*Eucinostomus gula*)	1	52
Hole 35 Reference		
Trawl 1		
Bay anchovy (*Anchoa mitchilli*)	97	59
Blue Crab (*Callinectes sapidus*)	1	141
Scup (*Stenotomus chrysops*)	7	155
Summer flounder (*Paralicthys dentatus*)	2	355
Trawl 2		
Bay anchovy (*Anchoa mitchilli*)	25	66
Blue Crab (*Callinectes sapidus*)	1	144
Green crab (*Carcinus Maenas*)	1	66
Purple sea urchin (*Arbacia punctulata*)	1	n/a
Scup (*Stenotomus chrysops*)	4	224

Table 3-17. Fish and shellfish collected in a 16 foot otter trawl towed through Meadow Cut and Meadow Cut reference.

	Total Collected	Average Length (mm)
Meadow Cut		
Trawl 1		
Bay anchovy (*Anchoa mitchilli*)	24	57
Northern Puffer (*Sphoeroides maculates*)	2	218
Scup (*Stenotomus chrysops*)	1	190
Striped anchovy (*Anchoa hepsetus*)	2	84
Tautog (*Tautoga onitis*)	1	352
Trawl 2		
Black sea bass (*Centropristis striata*)	1	72
Blue Crab (*Callinectes sapidus*)	2	133
Bluespotted cornetfish (*Fistularia tabacaria*)	1	472
Northern Puffer (*Sphoeroides maculates*)	4	208
Meadow Cut Reference		
Trawl 1		
Bay anchovy (*Anchoa mitchilli*)	2	63
Northern pipefish (*Syngnathus fuscus*)	1	204
Striped anchovy (*Anchoa hepsetus*)	1	84
Winter flounder (*Pleuronectes americanus*)	1	236
Trawl 2		
Bay anchovy (*Anchoa mitchilli*)	1	74
Bluespotted cornetfish (*Fistularia tabacaria*)	1	302
Hermit crab (*Diogenidae spp.*)	2	n/a
Northern Puffer (*Sphoeroides maculates*)	1	200
Smooth butterfly ray (*Gymnura micrura*)	1	800
Striped anchovy (*Anchoa hepsetus*)	1	80

4.0 CONCLUSIONS

4.1 CONTAMINANTS

Chemical analysis of sediment collected from the NJIWW in October 2002 suggests that the likelihood of adverse environmental effects from the scheduled dredging operation is low. Only beryllium was observed in bulk sediment concentrations over the New Jersey soil clean levels for residential and non-residential areas from 7 of the 28 stations included in the study. All seven stations with beryllium levels exceeding the 2 mg/kg were only slightly over the criteria and only the northern stations (Stations 1 through 14) had beryllium detections. It should also be noted the New Jersey soil cleanup proposed criteria for beryllium is based on natural background levels which can vary from site to site. Average beryllium concentration among the northern sites was 2.5 mg/kg and only 1.1 mg/kg if all stations are used and non-detects were treated as 0. The only other metal observed in concentrations over New Jersey soil cleanup criteria was chromium that was over the 20 mg/kg non-residential criteria. This site specific criterion is based on preventing an allergic reaction to humans suffering from dermatitis. All other concentration of total chromium was below chromium VI's standard criteria for both residential and non-residential use (Table 3-1). None of the few organic compounds detected in the sediment samples were above soil screening levels. Among the three stations included in the high resolution PCB testing (northern Stations 1, 2, and 3) the sum of congeners was an order of magnitude lower that New Jersey soil clean up criteria and generally below levels considered unsafe for aquatic biota (i.e., ERL and ERM).

While elutriate tests with the sediments resulted in a few metals concentrations over New Jersey's surface water criteria, there was no consistent pattern of exceedances among the sampling stations suggesting that there is no widespread contamination of any one element throughout the study area. In general, the elutriate testing indicated that the metals released from the dredging operations will result in concentrations that are protective of aquatic resources. In addition, there was no obvious difference in the metals released in sediments slated for upland disposal (modified elutriate testing) relative to those that maybe placed in the dredged holes or Meadow Cut sites (Table 3-4). None of the organic compound detected in elutriate testing were over New Jersey surface water criteria (Table 3-5).

4.2 WATER QUALITY AND BIOLOGICAL CHARACTERIZATION

The information collected from discreet and continuous monitoring of water quality in the dredge holes indicate that poor water quality occurs at the bottom of both holes. This is most likely due to the depth of the holes in relation to the surrounding environment creating poor circulation. Dredge Hole 34 is over 50 feet deep with very steep banks, which rise to less than 7 feet deep in the more natural and adjacent environment. This undoubtedly creates a sink in which organic material can enter, but won't be flushed out. When this occurs, bacterial decomposition of organic material depletes all available oxygen, which is not replaced by flushing. The fact that DO's of less than 1 mg/l were recorded in the dredge hole indicated that this is indeed occurring (Figure 3-2). This is also corroborated by several direct field observations, where benthic samples reeked of hydrogen sulfide and large quantities of detritus where collected in the otter trawl. Similar findings occurred in the study of dredge holes in Barnegat Bay, NJ (Scott and Kelley 1999).

Although the DO in dredge Hole 35 was not as poor as Hole 34, DO's of 4.0 mg/l (Table 3-7; Figure 3-3) is probably a barrier to many aquatic species. This hole exhibits the same characteristics of Hole 34, where depths dramatically drop from 3 feet to 28 feet. Water measurements collected at the Meadow Cut suggest good water quality, and based on the depth in relation to the surrounding environment this area is most likely better flushed relative to Hole 35 and would therefore have fewer water quality problems.

Benthic invertebrate sampling in the deep areas of both holes examined for this study revealed that this habitat was azoic at the time of sampling as no organisms were found in any sample. These areas most likely support a minimal benthic community during other times of the year when bottom water dissolved oxygen levels increase to higher levels (i.e., late fall through early spring). Water quality measurements taken during this study suggest that these areas are anoxic/hypoxic for long periods of time, which in turn is lethal to the bottom dwelling organisms. Part of the reason for these anoxic conditions can be explained by circulation patterns within the holes. Circulation within the IWW is driven to some degree by wind. The depths occurring within the holes limit the amount of wind driven circulation. As a result, the holes become a sink for fine silts/clays and organic material. A previous study conducted by Versar in Barnegat Bay (Scott and Kelly 1999) found that the deep depths of holes in the bay contained high amounts of organic material including decaying plant material. The sediment collected as part of the benthic samples contained large volumes of decaying plant material such as sea grasses, and the sediments from the depths of these holes smelled of hydrogen sulfide.

The mid depths of the holes showed some level of depressed benthic community in terms of lower abundance, diversity, and biomass compared to the nearby reference area. The benthic community at the mid depths of Hole 35 was extremely depressed, whereas at Hole 34, many small opportunistic organisms were found (i.e., *Streblospio benedicti*). Results from the study conducted at holes in Barnegat Bay suggested that there was a strong relationship between depth within the hole and the benthic community condition (Scott and Kelly 1999). As depths increased within the holes all three measures of benthic condition (abundance, diversity, and biomass) increased.

The shallow areas of the holes were also somewhat different from the reference areas, however, these differences were not always in the form of a depression. Numerous large quahog clams, *Mercenaria mercenaria*, were collected from the shallow areas of both holes. These clams were several years old and dominated the total biomass when present. Scott and Kelly (1999) also reported that several large quahog clams were collected from the shallow and mid depths of the holes sampled in Barnegat Bay.

The benthic community within Meadow Cut displayed similar characteristics to surrounding reference communities. No apparent differences in benthic abundance, diversity, and biomass were evident. The depths of the stations sampled in Meadow Cut were, on average, no different than those sampled in the reference areas. The data from this study suggest that filling parts of the man-made channel would not result in improved benthic community condition.

The benthic data suggest that filling the holes to a more natural condition within the IWW would be beneficial to the benthic community. However, filling them to a mid depth level may be beneficial in two ways. The benthic community should support higher levels of abundance, diversity, and biomass as excursions of hypoxic/anoxic waters from the deep regions of the hole are reduced or eliminated. But maintaining some depth contours instead of filling the holes to a level plain could be beneficial to resident fish populations that use deeper areas as refuge.

Scott and Kelly (1999) suggested in the Barnegat Bay study that some uncertainty existed as to the circulation patterns that may result from filling the holes to only a mid depth. Circulation within the newly filled holes may still cause the mid depths to be a sink for organic material. If this is the case, the benthic community could be affected by periodic episodes of low dissolved oxygen events. These events, however, will most likely not be as extensive and prolonged as currently occurring in the deep areas of Holes 34 and 35. Therefore, the benthic community of a partially filled hole should not exhibit the azoic conditions currently occurring in Holes 34 and 35 and should provide additional food resources to resident benthic feeding fish species. Additional biological studies of areas that currently occur in the IWW at the mid depths proposed for this study could help evaluate the potential benefit of filling Holes 34 and 35.

The information collected from the fish survey indicates that fish are indeed using the dredge areas as much as the associated reference sites. This is not surprising because poor water quality conditions were found to occur only at the bottom of both holes and good water quality was found at the Meadow Cut. The Meadow Cut area is good quality fish habitat. However, in the case of the two dredge holes, the fish data may be somewhat misleading. Although every attempt was made to focus the trawling effort on the deepest portion of the holes, it was impossible not to trawl portions of the edge at both sites; therefore fish collected in this gear could have been from the edges and not necessarily the bottom. Looking at the gill net data for the dredge holes reveals that the majority of the catch is larger mobile species such as bluefish and weakfish (Table 3-13). Observations by field personnel indicated that heavy predation of baitfish was occurring at the surface during the survey. In light of this, it is believed that most of the fish collected in the two holes were either transient species or may have come from the edges.

5.0 REFERENCES

Farrar, J. and W. Burton. 1999. Water and sediment quality monitoring for an ongoing feasibility study of the New Jersey Intracoastal Waterway, New Jersey. Prepared for U.S. Army Corp of Engineers, Philadelphia District, by Versar, Inc., Columbia, MD.

Krebs, C.J. 1978. Ecology: The Experimental Analysis of Distribution and Abundance. New York: Harper and Row.

Long, E.R., D.D. Macdonald, S.L. Smith, and F.D. Calder. 1995. Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments. Env. Manage. 19(1):81-97.

Scott, L. and F. Kelley. 1999. Biological sampling for dredged holes in Barnegat Bay, Ocean County, NJ. Prepared for U.S. Army Corp of Engineers, Philadelphia District, by Versar, Inc., Columbia, MD.

Shannon, C.E., and W. Weaver. 1949. The Mathematical Theory of Communication. Urbana: University of Illinois Press.

USEPA. 1994a. Contract Laboratory Program National Functional Guidelines for Organic Data Review. February 1994.

USEPA. 1994b., Region III Modifications to the National Functional Guidelines for Organic Data Review. September 1994.