MARYLAND
PORT
ADMINISTRATION

SPARROWS POINT SHORELINE RECLAMATION PROJECT: ASSESSMENT OF BIOLOGICAL PRODUCTIVITY

August 1995

Prepared For
The Maryland Port Administration
MPA Contract # 294904
Prepared By
Maryland Environmental Service

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Parris N. Glendening
Governor

James W. Peck
Director

July 19, 1995

Mr. Bill Lear
Maryland Port Administration
Maritime Center II
2310 Broening Highway
Baltimore, MD 21224

Dear Mr. Lear:

Enclosed for your review is a draft copy of the "Sparrows Point Shoreline Reclamation Project: Assessment of Biological Productivity". The report presents a summary of the biological studies that were undertaken as a result of concerns raised by citizens. Copies of the individual studies are provided as appendices.

If you have any comments, please provide them to me no later than 04 August 1995. This will allow time to incorporate any changes and print the final document by 31 August.

Sincerely,

Michelle Vargo
Project Manager
Environmental Dredging Program

Encl.

cc: Robert Miller, Esq.
Wayne Young
Bob Smith

MARYLAND PORT ADMINISTRATION
OFFICE OF HARBOR DEVELOPMENT
FACSIMILE TRANSMITTAL

TO: MICHELLE VARGO

FAX NO: 974-7236

FROM: BILL LEAR

DATE: 7 AUG 95

There are 2 pages, including this cover sheet. If there are any problems, please call me at (410) 631-1102. My fax number is (410) 631-1057.

Comments/Special Instructions:

MICHELLE -

PLEASE DELETE THE LINE THAT I HAVE NOTED FROM THE SP. PT RECLAMATION REPORT

THANKS
BILL

Please copy to: ____________________

DRAFT

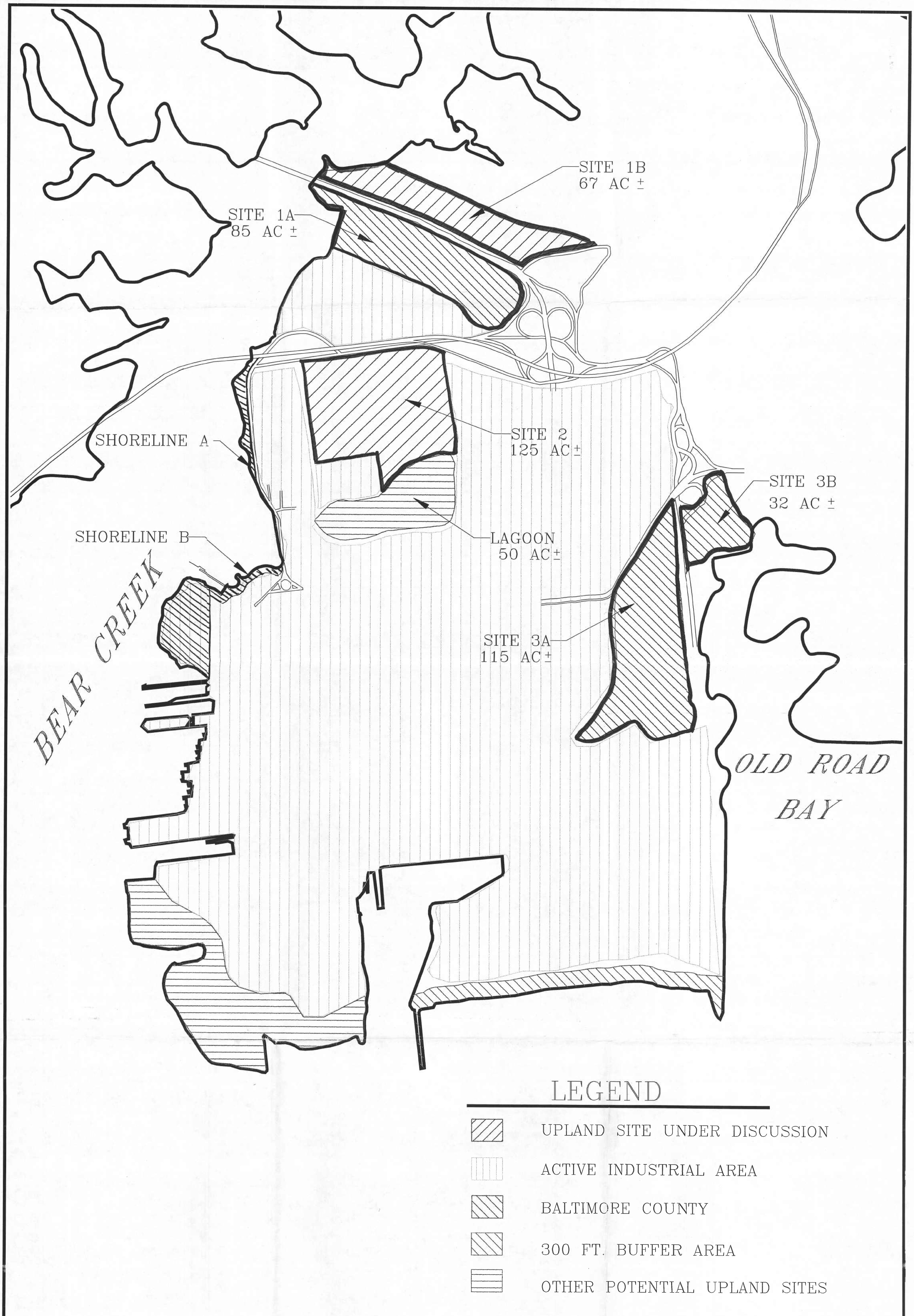
3.0 BACKGROUND

The Sparrows Point Shoreline Reclamation Project was identified through the Dredging Needs and Placement Options Program (DNPOP). The goals of this program were to identify potential dredged material placement sites that could be implemented in the near-term with an emphasis on a balanced approach that included projects utilizing habitat creation and other beneficial use techniques. The Sparrows Point site was selected for further assessment because of its apparent low biological productivity and its suitability for habitat creation using dredged materials.

The proposed project was conceived to serve specific economic and living resources objectives. Economically, the Port of Baltimore would benefit through placement of 10 million cubic yards of dredged material. The natural environment would benefit through the establishment of intertidal and other habitat that would assist in the biological recovery of adjacent open water areas. As a secondary benefit~~,~~ the created habitat~~s~~ would provide a more aesthetically pleasing perspective ~~for persons aboard local vessels, and ships entering Baltimore Harbor,~~ than the industrial shorefront that now exists. The project site is located on the southern end of the Sparrows Point peninsula near the entrance to the Harbor (Figure 1). The project concept consists of approximately 300 acres of constructed intertidal wetland with a 33 acre upland buffer to screen industrial activities along the shoreline. Figure 2 is an artistic interpretation of the proposed project concept.

Meetings were held in May and June of 1993 with local civic groups to brief them on the proposed project and gather community input to the beneficial use of dredged materials at Sparrows Point. The citizens were generally opposed to any encroachment on rivers and embayments in the project vicinity. However, specific opposition to the project stemmed from the local communities perception of the site's existing habitat value. Citizens reported that the site currently supported productive communities of fish, oysters, crabs and submerged aquatic vegetation (SAV).

An investigation of the public's concerns was undertaken to provide a more complete basis for determining the project's suitability. Collection of existing data and field studies were initiated in 1994 to assess the level of biological productivity at the proposed project location. Fish and crab, benthic, microzooplankton and mesozooplankton communities were studied. Table 1 lists the study elements and the reports produced. Investigations were designed to maximize their applicability to future environmental evaluations of the site.



MARYLAND ENVIRONMENTAL SERVICE

SPARROWS POINT LAND USE MAP


SITE 1B
67 AC ±
SITE 1A
85 AC ±
SITE 2
125 AC±
SHORELINE A
SITE 3B
32 AC ±
LAGOON
50 AC±
SHORELINE B
BEAR CREEK
SITE 3A
115 AC±
OLD ROAD
BAY
LEGEND
UPLAND SITE UNDER DISCUSSION
ACTIVE INDUSTRIAL AREA
BALTIMORE COUNTY
300 FT. BUFFER AREA
OTHER POTENTIAL UPLAND SITES
MARYLAND
ENVIRONMENTAL
SERVICE
SPARROWS POINT
LAND USE MAP

Table of Contents

List of Appendices

List of Tables and Figures

1.0 EXECUTIVE SUMMARY

The Sparrows Point Shoreline Reclamation Project was conceived to provide a dredged material placement site which utilizes habitat creation and other beneficial use techniques. This report was prepared in response to community concerns that the water area along the southern shore of Sparrows Point is more biologically productive than perceived by the state agencies. It summarizes several studies conducted to determine the present state of the biological community at the site of the proposed project. The Maryland Environmental Service (MES), under contract to the Maryland Port Administration, managed these studies.

Four studies were conducted to assess the conditions of fish and crab, benthic, microzooplankton, and mesozooplankton communities. Field sampling took place between the Spring and Fall of 1994. Investigations were designed to be applicable to potential future evaluations of the site. The studies are attached to this report in their entirety as appendices.

None of the studies found a unique biological community at the location of the proposed project site. The site of the proposed project was found to have biological productivity that is comparable to other sites sampled in the Baltimore Harbor area. Species composition and conditions were found to be similar among study areas for all biological categories. When the Chesapeake Bay Restoration Goals Index and standard fish habitat productivity measures were applied to some of the data, the Sparrows Point Shoreline Reclamation site was found to be productive to marginally productive.

2.0 INTRODUCTION

This report presents the results of studies conducted to determine the current state of biological productivity at the proposed Sparrows Point Shoreline Reclamation Project site. These studies were undertaken in response to a lack of community support for the project stemming from concerns about the current resource value of the site. The citizens maintained that the proposed location for the project already supported productive aquatic plant and animal communities.

The Maryland Environmental Service (MES), under contract to the Maryland Port Administration (MPA), managed a series of studies to assess existing fish and crab, benthic, microzooplankton and mesozooplankton communities at the proposed site location. This report provides a summary of the information presented in the individual studies. Each of these studies is included in its entirety as appendices to this report.

3.0 BACKGROUND

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Table 1

Sparrows Point Biological Productivity Assessment
Study Elements and Reports

Study Task	Agency	Report Title	Appendix
Fish and Crab Survey	UMCEES	"Sparrows Point Shoreline Reclamation Project: Fish and Crab Survey"	A
Assessment of Benthics	Versar, Inc.	"Assessment of Benthic Community Conditions at a Proposed Wetland Creation Area in the Vicinity of Sparrows Point, Baltimore Harbor"	B
Micro-zooplankton Community Composition	Academy of Natural Sciences	"Microzooplankton Community Composition in the Vicinity of Sparrows Point, Patapsco River, MD"	C
Meso-zooplankton Survey	Versar, Inc.	"Zooplankton Survey Sparrows Point Reclamation Project"	D

4.0 FISH AND CRAB SURVEY

The University of Maryland Center for Environmental and Estuarine Studies (UMCEES), Horn Point Laboratory designed and conducted the fish and crab data collection. Six sampling surveys were conducted between June and October of 1994.

4.1 Investigative Methods

Two sample stations were identified for study: one located within the project area and the other in an ecologically similar area located just west of the project area. Samples were collected by making 5-minute bottom trawls with a 30 ft. otter trawl during six cruises scheduled between 23 June and 18 October of 1994. Two trawl samples were obtained at each station for all cruises. Trawl locations were recorded using GPS. Temperature, salinity and dissolved oxygen were measured at the surface and bottom prior to each trawl. Fish and crabs collected were identified, counted and measured for length.

Analysis of variance (ANOVA) methods were used to analyze the numbers of organisms collected. Length-frequency tables were generated to evaluate sampling station utilization by size. Water quality data was analyzed to identify stratification or other anomalies that may have affected the trawl sampling.

Speciation and abundance data collected from this study were also compared to similar trawl surveys conducted in 1970 (Wiley 1971). Data was used from two stations proximal to the current study and reference locations: one at Old Road Bay and the other at the mouth of Bear Creek.

4.2 Findings

Results of the ANOVA indicated no significant statistical difference between fish and crab abundance at the two sample stations. Species composition was also very similar at both stations with bay anchovy, spot and white perch comprising over 90% of the trawl catch. Tabulation of length-frequency data indicated similar sizes of organisms occurring at both locations. Analysis of water quality data showed generally similar temperature and salinity at both sites however, dissolved oxygen concentration from bottom water samples at the reference site was consistently lower.

Comparisons made between data taken in 1970 and the current study data showed similar population and taxa between the Old Road Bay Station and current data. The Bear Creek station was comparatively poor in terms of speciation and abundance.

5.0 Assessment of Benthic Community Conditions

Versar Inc. collected the data and prepared the report to assess the benthic community conditions at the site. Utilizing Chesapeake Bay Benthic Community Restoration Goals Index (RGI) and comparisons of samples taken at the proposed project location with six other representative locations in Baltimore Harbor allowed evaluation of the habitat value and uniqueness of the project site.

5.1 Investigative Methods

The study was designed to compare the benthic community at the location of the proposed wetland creation and compare it with six other areas in Baltimore Harbor. A Young-modified Van Veen grab and a Wildco box-corer were used to collect grab samples. Table 2 lists the sampling locations and number of sampling sites at each location and collection method. Two samples were collected at each sampling site. Surface and bottom salinity, dissolved oxygen concentration, temperature, Ph and Eh were measured at each sampling site.

Table 2

Benthic Sampling Locations and Methods

Sampling Locations	Number of Sites	Collection Method
Sparrows Point Project Site	9	Young-modified Van Veen grab
Other Sparrows Point	3	Young-modified Van Veen grab
Other Baltimore Harbor	4	Young-modified Van Veen grab
Middle Branch	3	Wildco box-corer
Northwest Branch	3	Young-modified Van Veen grab
Bear Creek	3	Wildco box-corer
Curtis Bay	3	Wildco box-corer

One sample was processed from each of the sampling sites and the benthic organisms preserved for identification, counting and analysis in the laboratory. The other sample was processed to yield two subsamples of surface sediment for grain-size distribution analysis.

Three measures were used to assess the benthic community condition: (1) RGI values, (2) the Shannon-Wiener Diversity Index, and (3) the density of organisms. All three measures are expected to have higher values at sites that are in better condition. ANOVA and Duncan's multiple range statistical methods were used to analyze the data.

5.2 Findings

Samples collected within the proposed project footprint, the Sparrows Point sampling location and the "Other Baltimore Harbor" sampling location met the Chesapeake Bay Benthic Community Restoration Goal. The Restoration Goal Index (RGI) provides a measure with which to assess the condition of benthic communities within the Bay. On an absolute scale from 1 to 5 with a value of 3 or less indicating degraded habitat, the above mentioned locations all had values slightly greater than three. Only one of the twelve other sampling sites met the restoration goal with most of these scoring values less than two, thus indicating severely degraded habitats.

Statistical tests performed on the data indicated no significant difference in the condition of the project site, the Sparrows Point sampling location and the "Other Baltimore Harbor" site. Comparatively for RGI, Shannon-Wiener and abundance analysis, all three of these sites were in the same condition. All other sites were found to be in significantly worse condition.

6.0 MICROZOOPLANKTON COMMUNITY COMPOSITION

The microzooplankton category includes plankton in the sizes between 20 and 202 microns. This group is primarily comprised of rotifers, ciliates, copepod nauplii and various groups of larvae. They are a critical indicator of habitat productivity in that they are a primary food source for higher consumers. The Academy of Natural Sciences, Benedict Estuarine Research Center sampled monthly from May to October of 1994 to gather data about the microzooplankton community at the Sparrows Point project site.

6.1 Investigative Methods

Samples were collected for microzooplankton > 44 microns from six locations at two stations in the Patapsco River on a monthly basis from May through October of 1994. As part of the Chesapeake Bay Monitoring Program, samples were also taken at the Baltimore Harbor sampling station (MWT5.1). For each location, samples were collected by pumping water from five discrete depths through a 44 micron mesh plankton net. Species identification and abundance measurements were completed in the laboratory with samples preserved from the field survey. Only those organisms between 44 and 200 microns in size were included in the data.

6.2 Findings

Trends in microzooplankton densities followed similar patterns except for a dramatic drop in tintinnid population at the Sparrows Point station during July. The populations at the two stations were represented by the same general species composition of rotifers and tintinnids with an "other" category consisting of rotifers, non-loricate ciliates and sarcodinids. Abundance and speciation would vary at the sites presumably as a result of grazing, resurgence and general seasonal trends.

The overall purpose of the study was to measure the productivity and existing habitat value of the site. Microzooplankton population information was used to infer beneficial characteristics of an area for fish habitat. Five hundred organisms per liter is suggested to provide optimal food levels for bay anchovy (Buchanan et al., 1992). Both stations met or exceeded this criteria for most of the summer. In a subsequent study, a more conservative number of 1000 organisms per liter was suggested for optimal food levels (Buchanan et al., 1993). When this standard is applied, optimal levels were only found in August and October at the Sparrows Point site. In general, using 1000 organisms per liter as a test for productivity, the microzooplankton levels found at the stations sampled in the lower Patapsco River for this study were considered to be marginally beneficial for sustaining a bay anchovy population.

7.0 MESOZOOPLANKTON POPULATION

Mesozooplankton, often called copepods, are planktonic invertebrates that range in size from 0.2 to 2 mm in length. As with microzooplankton, they are an important part of the food chain in estuarine ecosystems such as the Chesapeake Bay. The approximately 50 species found in the Bay are a food source for fishes such as bay anchovy, juvenile menhaden, and larval striped bass and white perch. Versar, Inc. collected monthly samples from May to October 1995 to gather information about mesozooplankton population at the Sparrows Point and study reference sites.

7.1 Investigative Methods

Mesozooplankton samples were obtained at the Sparrows Point site and two additional reference stations in the Patapsco River and Upper Bay. Samples were collected by towing a 20 cm bongo net in a stepped oblique fashion. Two replicates were collected at each location. The gear was deployed just above the bottom and was raised in timed progressive steps to sample the entire water column. Species composition and abundance measurements of subsamples of the original sample were performed in the laboratory.

7.2 Findings

The relative abundance of mesozooplankton and trends in composition were similar at the Sparrows Point and Baltimore Harbor stations, although the density was consistently lower at the Sparrows Point station. There was more species diversity at the Upper Bay site probably due to the oligohaline water. All stations collected samples of the copepods *Acartia tonsa*, *Eurytemora affinis*, and *Oithona colcarva*, and the cladoceran, *Moina* sp. A seasonal shift in species dominance was exhibited at all stations from *E. affinis* in colder months to *A. tonsa* in warmer months.

The study found that the mesozooplankton communities at the Sparrows Point site was typical for that area of the Chesapeake Bay. Analysis of data collected from the project site and the reference areas showed similar species composition although total density was lower for the project site.

8.0 CONCLUSIONS

The four studies found the proposed Sparrows Point Shoreline Reclamation Project site to accommodate a typical biological community for locations within Baltimore's Inner Harbor. Although several of the other study areas were more biologically degraded, it was concluded that Sparrows Point does not support a biological community that is unique to the area in any way.

The fish and crab survey found no significant statistical difference between the two study areas. A functioning benthic community was reported in the benthic study. This community is not significantly different from benthic communities in the surrounding Inner Harbor areas. The microzooplankton study concluded that the population at the project site could be considered marginally beneficial using optimal food levels to sustain bay anchovy as a measure. Similar trends in microzooplankton populations were seen at both the project and reference sites. The mesozooplankton study had the same results with similar populations seen at both the project and reference sites.

The studies did not indicate low biological productivity as had been expected. Other comparison areas within Baltimore's Inner Harbor showed similar conditions at all sites indicating a general recovery in the perceived conditions there. The studies did show that although current biological conditions at the site of the proposed project are more productive than anticipated, there remains definite potential for improvement.

Appendix A:

Fish and Crab Survey

University of Maryland
Center of Environmental and Estuarine Studies

Final Report
June 1995

Contract No. 94-07-19
FAS No. 074-30402

Sparrows Point Shoreline Reclamation Project: Fish and Crab Survey

Submitted to

Robert Smith

Maryland Environmental Service
2011 Commerce Park Drive
Annapolis, Maryland 21401

By

Roman V. Jesien

University of Maryland Center for Environmental Estuarine Studies
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Abstract

Fish and crabs were collected near Sparrow's Point, Patapsco River, from 20 June through 18 October 1994 at two locations to document diversity prior to construction of a proposed wetland. The locations, site of proposed construction and a reference site, appeared to be very similar based on comparison of temperature, and salinity data but dissolved oxygen in bottom water was consistently lower at the project area. Mean numbers of fish and invertebrates captured per trawl at the two sites ranged from 128 to 1,725. No differences were detected in numbers captured between the two sites ($P < 0.05$) but more organisms were collected during June, 10 August and September than other times.

A total of 16 species was collected throughout the study. The most abundant species were bay anchovy, spot and white perch which typically comprised over 90% of the organisms collected at both sites. Blue crab, menhaden and striped bass were also frequently collected but were not as abundant. Inspection of length-frequency data indicates that similar sizes of organisms occurred at both locations and that juveniles and young-of-the-year were the most common year classes.

Acknowledgements

This study was a cooperative effort between the University of Maryland System Center for Environmental and Estuarine Studies (UMSCEES) and the Maryland Environmental Service of the Maryland Department of Natural Resources. I am indebted to William Burton, Fred Kelly and Phil Wirth of Versar, Inc., who provided invaluable assistance in logistic and field support. I am especially grateful for the field assistance from Eric Davenport and Ameck Carter of the University of Maryland Eastern Shore, Princess Anne.

Table of Contents

Need

The Maryland Port Administration (MPA) and Maryland Environmental Services (MES) are studying the feasibility of enhancing the shoreline of Sparrow's Point by constructing wetland habitat using dredged material generated from the maintenance of the Baltimore Harbor Approaches. This report describes results of sampling fish and crabs near the project area from June through October 1994.

Project Location

The study area of about 300 acres is located on the north side of the Patapsco River approximately 1.5 miles downstream from the Francis Scott Key Bridge. The Sparrows Point site extends from the shoreline and is bordered by the Sparrows Point Channel on the east, Penwood Channel on the west, and the Brewerton Channel to the south (Figure 1).

Investigation Methods

Two trawl stations were established: one within the project area and another, located west of the project area, that is considered to be ecologically similar (Figure 1). Depth at both trawling locations was 15 to 17 ft, the bottom was muck and no submerged vegetation was observed. During each of six cruises, fish and crabs were collected by making 5-minute bottom trawls using a 30-ft otter trawl (with 1-in stretch-mesh bag and woven liner with 3/8-in diam opening). All organisms were enumerated and length was measured for up to 25 specimens of each species collected. All fish were measured in mm total length (mmTL), and crabs were measured in mm carapace width. Temperature, salinity and dissolved oxygen were measured at the surface and bottom using an Hydrolab Surveyor II prior to each trawl sample. The start and finish points of trawls were recorded using GPS (Magellan NAV 5000 DX). Two trawl samples were obtained at each station such that alternate locations were sampled to allow the areas to recover between samples.

Analysis of trawl catches was conducted with the SAS statistical package (SAS 1982). Analysis of variance was performed on untransformed numbers of organisms per trawl using the general linear model (GLM) procedure, fixed-effects model. Numbers of fish per 10-cm length interval collected at each site was summarized in length-frequency tables to evaluate utilization by size classes.

Results

Water Quality

Mean values (replicates combined) at surface and bottom depths were calculated to investigate potential stratification or anomalies during the investigation (Fig. 2). Temperature and salinity were generally similar at both sites, but dissolved oxygen in bottom water at the study was consistently lower than the reference site.

Water temperature ranged from 16 to 29.8°C during the study and followed a seasonal trend; warmest water during July and coldest water during October (Fig. 2-A). Temperatures at both sites generally tracked each other. Bottom water was typically colder than surface water during June, July and 3 August whereas the opposite was observed, surface water temperatures warmer than bottom water, during September and October at both stations.

Salinity ranged from 2.7 to 14.2 ppt throughout the study and followed a seasonal trend; lowest salinity during summer and highest salinity during September and October (Fig. 2-B). Salinities at both sites generally tracked each other. Salinity was typically higher in bottom water than surface water which is consistent with the circulation pattern in a partially mixed estuary.

Dissolved oxygen (DO) ranged from 2.9 to 10.9 mg/l (Fig. 2-C). DO was higher at the surface at both locations and bottom water DO was consistently lower at Site 1, the project site. At Site 1, DO was consistently less than 5 mg/l and was less than 4.0 mg/l on three of four sampling occasions.

Fish and Crab Abundance

Mean numbers of fish and invertebrates captured per trawl ranged from 128 to 1,725 (Table 1). Results of ANOVA indicated that there was no difference in numbers of organisms collected between the two sites, but that sampling times were significantly different. More organisms were collected during June, 10 August and September than other times (Fig. 4).

Species Composition

A total of 16 species was collected during the study (Table 1). The most abundant species were bay anchovy, spot and white perch which typically comprised over 90% of the organisms collected per trawl. Blue crab, menhaden and striped bass were also frequently collected but were not as abundant. Except for minor exceptions in which single individuals were collected at one site or the other, species composition was very similar at both locations.

Species composition obtained during the present study was compared to trawl surveys conducted in 1970 (Wiley 1971) at the mouth of Bear Creek (west of the reference site) and Old Road Bay (east of the study site) (Table 2). Species composition and numbers of organisms collected were more similar to the Old Road Bay collections than Bear Creek. Samples obtained from Bear Creek appeared to be very poor in terms of abundance and numbers of taxa.

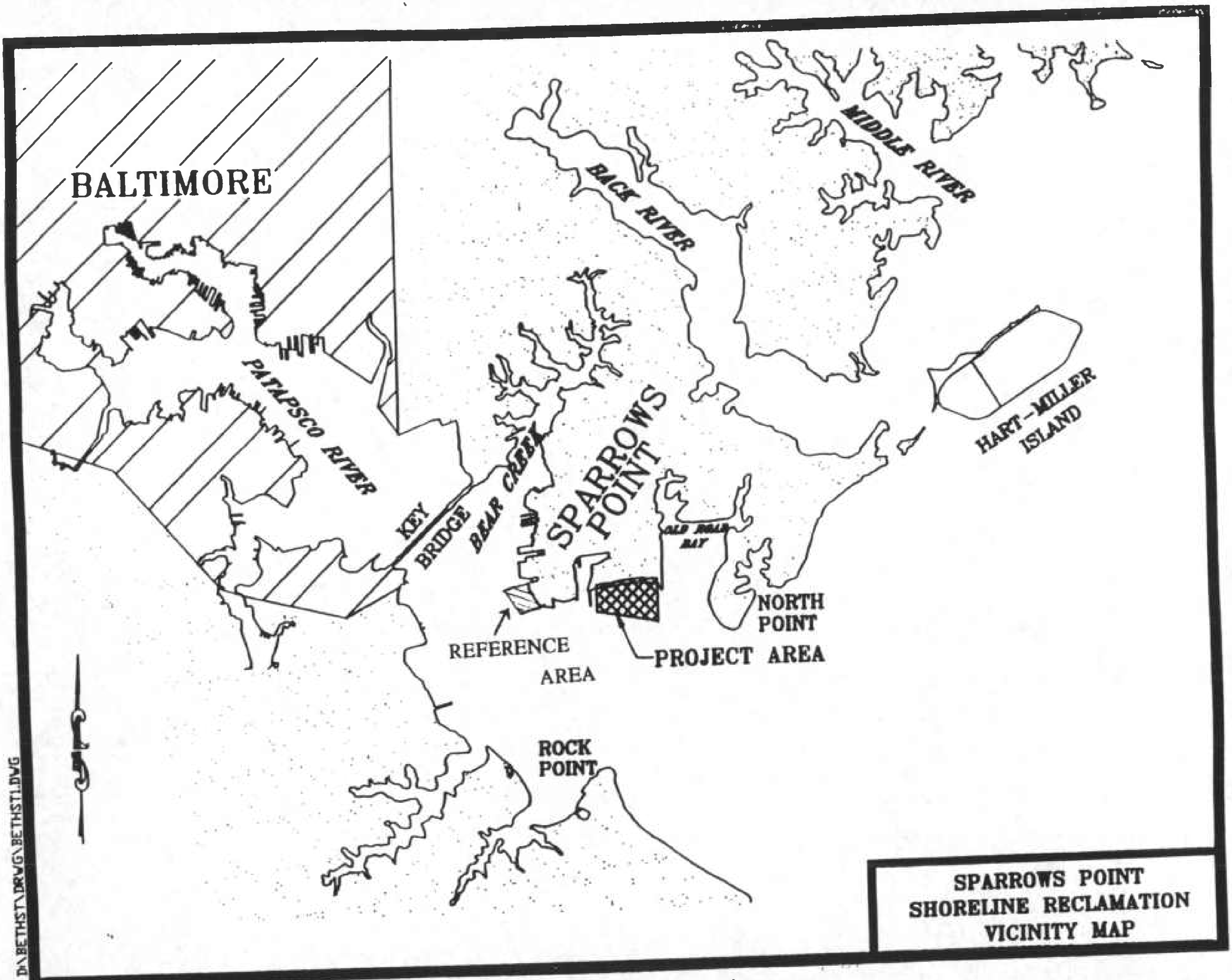
Length-Frequency

Length-frequency data, presented at the number of fish per length intervals, of the most common species, i.e., anchovy, spot, white perch are presented in Tables 2 through 4. Length-frequencies for blue crab and striped bass are included because of their commercial and recreational importance. Inspection of length frequency data indicates that similar sizes of organisms occurred at both locations and that juveniles and young-of-the-year were the most common year classes (Tables 2 - 5).

References

SAS 1982. The GLM procedure. In: SAS Users Guide: Statistics. Statistical Analysis System, SAS Institute, Inc., Cary, North Carolina. pp. 139-200.

Wiley, M.L. 1971. Fish, pages 50-91. In A biological study of Baltimore Harbor. Natural Resources Institute, University of Maryland, NRI Ref. No. 71-76.



Fi[redacted]e [redacted]Loc[redacted]on [redacted] th[redacted]tudy site and the reference site.

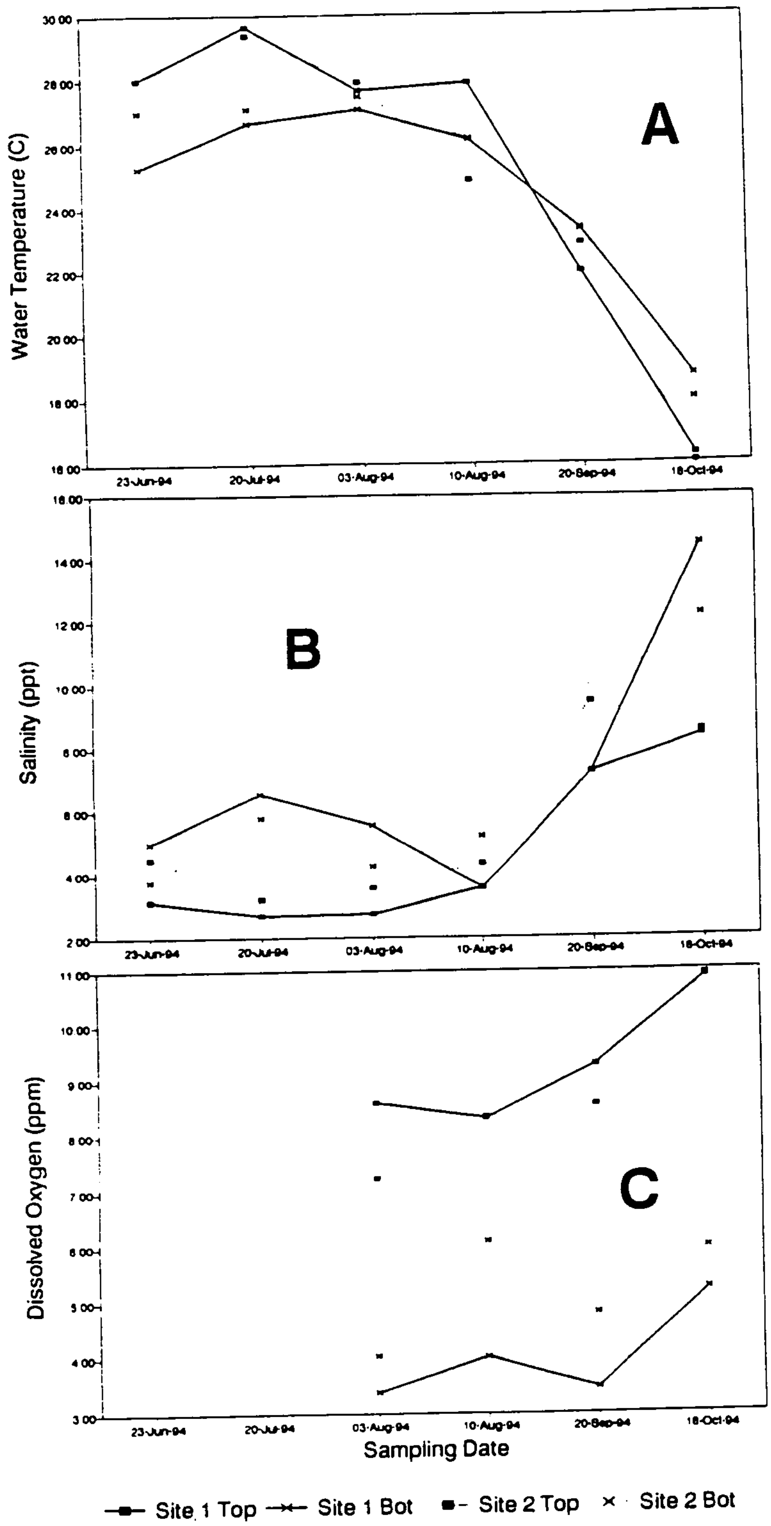


Figure 2. Mean (replicates combined) temperature (A), salinity (B) and dissolved oxygen (C) at surface (Top) and bottom (Bot) depths at the project site (Site 1) and reference site (Site 2). Dissolved oxygen data for 23 June and 20 July is unavailable due to equipment malfunction.

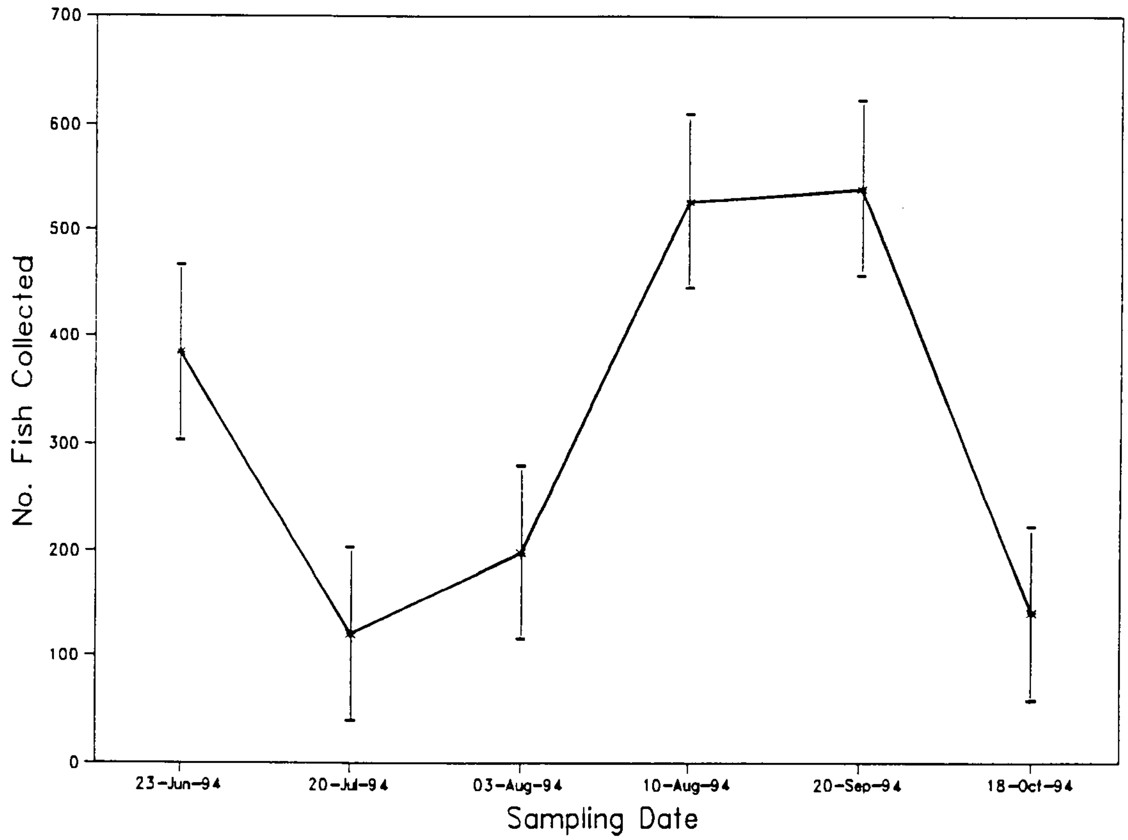


Figure 3. Numbers of fish/invertebrates captured per 5-min trawl. Means in which vertical bars (± 2 se) overlap are not significantly different.

Table 1. Fish and crabs collected at the Sparrow Point location expressed as a percentage of the total number collected. Site 1 represents the Sparrows Point Project Area, Site 2 represents the reference site.

Species	Site	Sampling Date					
		23-Jun	20-Jul	03-Aug	10-Aug	20-Sep	18-Oct
American eel *Anguilla rostrata*	1			0.4			
	2						
Alewife *Alosa pseudoharengus*	1						0.7
	2						
Menhaden *Brevoortia tyrannus*	1		0.8	1.6	0.3		0.7
	2		18.2	1.4	3.1	<0.1	0.4
Bay anchovy *Anchoa mitchilli*	1	4.3	8.6	37.9	76.3	64.7	67.2
	2	.2	30.9	18.0	65.1	85.0	23
Brown bullhead *Ameiurus nebulosus*	1		0.8				
	2		23				
Channel catfish *Ictalurus punctatus*	1	.1			<0.1		
	2	.2	0.3				
Striped bass *Morone saxatilis*	1	1.4	3.1	4.2	0.6		0.3
	2	3.6		1.5	0.8		0.4
White perch *Morone americana*	1	84.7	34.4	16.7	6.3	13.8	26.1
	2	45.6	19.8	41.2	20.0	3.0	62.0
Bluefish *Pomatomus saltatrix*	1						
	2		0.6				
Harvestfish *Peprilus alepidotus*	1						
	2					<0.1	
Spot *Leistomus xanthurus*	1	6.9	49.3	35.6	12.7	19.8	4.5
	2	48.9	33.6	33.4	7.1	10.1	12.8

Species	Site	Sampling Date					
		23-Jun	20-Jul	03-Aug	10-Aug	20-Sep	18-Oct
Croaker *Micropogonias undulatus*	1			0.2			
	2			0.3			
Hogchocker *Trinectes maculatus*	1	1.1					
	2	0.1	0.3				
Blue crab *Callinectes sapidus*	1	1.3	3.1	3.3	3.7	1.6	0.3
	2	1.1		4.4	4.0	1.7	1.6
Mud crab *Rithropanopeus harrisi*	1	1.4					
	2	3.6	<0.1				
Grass shrimp *Palaemonetes sp.*	1						
	2	0.1					
Total Number Species	1	7	7	7	7	4	6
	2	9	8	6	6	7	6
Mean Number Individuals	1	622	128	449	1,503	434	287
	2	917	330	344	607	1,725	274

Table 2. Comparison of species composition obtained in this study with trawl surveys reported in Wiley 1971. Species composition and calculations for mean number per trawl reported in Wiley 1971 were based on catches during June, July and August.

Species	This Study	Bear Creek*	Old Road Bay*
American eel *Anguilla rostrata*	X	X	X
Alewife *Alosa pseudoharengus*	X	X	X
Blueback herring *Alosa aestivalis*			X
Menhaden *Brevoortia tyrannus*	X		
Bay anchovy *Anchoa mitchilli*	X		X
Goldfish *Carassius auratus*		X	
White catfish *Ameiurus catus*			X
Brown bullhead *Ameiurus nebulosus*	X		
Channel catfish *Ictalurus punctatus*	X		
Striped bass *Morone saxatilis*	X	X	X
White perch *Morone americana*	X	X	
Yellow perch *Perca flavescens*			X
Bluefish *Pomatomus saltatrix*	X		
Harvestfish *Peprilus alepidotus*	X		

Species	This Study	Bear Creek*	Old Road Bay*
Spot *Leistomus xanthurus*	X		
Croaker *Micropogonias undulatus*	X		
Hogchocker *Trinectes maculatus*	X		X
Blue crab *Callinectes sapidus*	X	X	X
Mud crab *Rithropanopeus harrisi*	X		
grass shrimp *Palaemonetes sp.*	X		
Total Number Species	16	5	7
Mean Number Individuals	600	140	337

* see Fig. 1 for location.

Table 3. Length-frequency of bay anchovy, represented as number of fish in 10-cm length intervals, collected from Sparrow's Point area at Sites 1 (project area) and Site 2 (reference).

	------Sampling Date and Collection Site------											
	23-Jun	---20-Jul----		---03-Aug---		---10-Aug---		---20-Sep--		---18-Oct---		
mmTL	1	1	2	1	2	1	2	1	2	1	2	mmTL
30					1							30
40			1	2	5	2	5	1	2		2	40
50				9	17	24	22	29	33	23	24	50
60				6	10	13	6	18	13	3	4	60
70	1			2	1	3	2	2	2	1		70
80	5	3	14	26	9	7	12					80
90	18	8	24	6	7	2	4					90
100	2		3	1	1		1					100
110												110
120												120
130	1											130
140												140
Total No	27	11	42	52	51	51	52	50	50	27	30	

Table 4. Length-frequency of white perch, represented as number of fish in 10-cm length intervals, collected from Sparrow's Point area at Sites 1 (project area) and Site 2 (reference).

	---Sampling Date and Collection Site---												
	---23-Jun---		---20-Jul----		---03-Aug---		---10-Aug---		---20-Sep---		---18-Oct---		
mmTL	1	2	1	2	1	2	1	2	1	2	1	2	mmTL
30	6	4											30
40	32	24											40
50	11	15			1	4	1	1					50
60	1	3	1		7	3	10	3		2			60
70			1		1		3		2	4			70
80							2						80
90	1	1											90
100	8	2	5	2	5	1	2	1		2			100
110	20	6	6	6	5	4	4	7	6	3	1	1	110
120	14	6	8	15	9	18	9	4	15	8	3	4	120
130	4	9	6	10	8	13	13	11	6	19	6	15	130
140	1	10	3	7		4	5	4	7	4	13	6	140
150		3	1	5		3	1	3	1		6	9	150
160		1	1			1	1					3	160
170		5			1	1					1	1	170
180		2			1						1	1	180
190	2	3		1	1						1		190
200		1							1		2		200
210		1		2							2	1	210
Total No	100	96	32	48	39	52	51	34	38	42	36	41	

Table 5. Length-frequency of spot, represented as number of fish in 10-cm length intervals, collected from Sparrow's Point area at Sites 1 (project area) and Site 2 (reference).

	Sampling Date and Collection Site												
	23-Jun		20-Jul		03-Aug		10-Aug		20-Sep		18-Oct		
mmTL	1	2	1	2	1	2	1	2	1	2	1	2	mmTL
30		1											30
40							1						40
50	5						1						50
60	9	9											60
70	4	18											70
80	10	10											80
90	2	7		1		1		1					90
100	4	2	6	2	2	2		1					100
110		1	13	8	4	5	3	2		2			110
120		1	12	15	9	10	15	18	2	4		1	120
130			9	17	13	12	11	11	6	23	3	10	130
140			2	6	4	13	12	2	12	13	5	9	140
150			0	2	7	5	7	4	8	3	4	4	150
160			1	1	5	3	1	2	8	4	1		160
170								1		1		1	170
180						1							180
190								1					190
200		1											200
210		1											210
Total No	34	51	43	52	44	52	51	43	36	50	13	25	

Table 6. Length-frequency of blue crab, represented as number of crabs in 10-cm length intervals, collected from Sparrow's Point area at Sites 1 (project area) and Site 2 (reference).

	Sampling Date and Collection Site											
	23-Jun		20-J	03-Aug		10-Aug		20-Sep		18-Oct		
mmTL	1	2	1	1	2	1	2	1	2	1	2	mmTL
10												10
20	3	2										20
30		2										30
40	1					1	1					40
50	1		2	1	1		2					50
60			1			1	1					60
70				2		1	3					70
80				5	3	2	3			1		80
90		1		2	1	8	4					90
100				2	1	4	3		1			100
110				1	1	13	2	1	1			110
120				1	2	8		2	3		1	120
130	1	1			3	5	1		3			130
140	1				2	5		2	5			140
150	1					5	2		5		2	150
160		2			1	1	1	1	4			160
170		1		1		1		1	4			170
180							1		1		1	180
190		1										190
Total No	8	10	3	15	15	55	24	7	27	1	4	

Table 7. Length-frequency of striped bass, represented as number of crabs in 10-cm length intervals, collected from Sparrow's Point area at Sites 1 (project area) and Site 2 (reference).

	Sampling Date and Collection Site									
	23-Jun		20-J	03-Aug		10-Aug		18-Oct		
mmTL	1	2	1	1	2	1	2	1	2	mmTL
40				1						40
50						1				50
60			1	2		1				60
70				2	1	3	2			70
80						2	3			80
90		1			1					90
100	1									100
110		1								110
120	3	1								120
130		3								130
140	2	5			1					140
150		5	1							150
160	1	9	1							160
170	1	3								170
180		1		1	2	1				180
190	1	1	1							190
200		1								200
210										210
220										220
230										230
240									1	240
250								1		250
Total No	9	31	4	6	5	8	5	1	1	

Appendix B:

Assessment of Benthic Community Conditions

Versar, Inc.

ASSESSMENT OF BENTHIC COMMUNITY CONDITION AT A PROPOSED WETLAND CREATION AREA IN THE VICINITY OF SPARROWS POINT, BALTIMORE HARBOR

FINAL REPORT

Prepared for

The Maryland Environmental Service
Maryland Department of Natural Resources
Annapolis, Maryland 21401

and

The Chesapeake Bay and
Watershed Management Administration
Maryland Department of the Environment
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December 1994

FOREWORD

Versar, Inc., prepared this document, *Assessment of Benthic Community Condition at a Proposed Wetland Creation Area in the Vicinity of Sparrows Point, Baltimore Harbor*, at the request of Mr. Robert Smith of the Maryland Environmental Service, Maryland Department of Natural Resources, and Dr. Richard Eskin of the Chesapeake Bay and Watershed Management Administration, Maryland Department of the Environment, under Cooperative Agreement CA-95-07/07-4-30405-3734 between Versar, Inc., and the University of Maryland Center for Environmental and Estuarine Studies. This report compares the condition of the benthic community inhabiting a proposed wetland creation area in the vicinity of Sparrows Point, Baltimore Harbor with the condition of benthic communities inhabiting other areas of Baltimore Harbor.

EXECUTIVE SUMMARY

The Maryland Environmental Service (MES) is evaluating a proposal for creating a wetland in the vicinity of Sparrows Point in Baltimore Harbor. To assist MES, Versar assessed the condition of the bottom habitat in the proposed wetland area by (1) determining if the area meets the relevant Chesapeake Bay Benthic Community Restoration Goal, and (2) comparing the condition of the benthic community in the proposed wetland area with the condition in six other sampling strata representing areas of Baltimore Harbor: Sparrows Point (adjacent to the proposed wetland area), Middle Branch, Bear Creek, Curtis Bay, Northwest Branch, and all other areas of the harbor. These two assessments provide measures of the relative uniqueness or local value of the proposed wetland area within Baltimore Harbor.

The bottom habitat of the proposed wetland area meets the restoration goal, indicating that the area has a heathy, functioning benthic community. The average restoration goals index score, species diversity, and abundance of benthic macroinvertebrates in the proposed wetland area are not significantly different than those values in the adjacent area of Sparrows Point and in the sampling stratum representing other areas of the harbor. Bottom habitats in Middle Branch, Bear Creek, Curtis Bay, and Northwest Branch, however, do not meet the restoration goal and are in significantly worse condition than the proposed wetland area, Sparrows Point adjacent to the wetland area, and other areas of Baltimore Harbor evaluated in this study.

TABLE OF CONTENTS

1.0 INTRODUCTION

This study of benthic macroinvertebrates is one component of an interdisciplinary project to evaluate the potential effects of creating a wetland near Sparrows Point, Baltimore Harbor. The proposed wetland area is under up to 3 m of water and would be filled in with dredged material to create the wetland. The existing bottom habitat will be lost if the proposed wetland is created.

This report describes the condition of the benthic community inhabiting the proposed wetland area at Sparrows Point, Baltimore Harbor. The objective is to assess its condition in comparison with (1) the condition of benthic communities inhabiting other areas of Baltimore Harbor, and (2) the condition expected at relatively unaffected sites in similar habitats in Chesapeake Bay (i.e., Chesapeake Bay Benthic Community Restoration Goals).

Benthic macroinvertebrates (benthos) are organisms that live in estuarine sediments and are large enough to be retained on a 0.5-mm mesh sieve. Benthic macroinvertebrate communities usually include polychaete worms, clams, snail-like mollusks, and shrimp-like crustaceans. Benthic macroinvertebrate communities are good indicators of the condition of bottom habitat in estuaries for several reasons: (1) benthic macroinvertebrates have limited mobility and, therefore, reflect local conditions (Gray 1979); (2) their range of life-spans (months to several years) yields population-level and community-level responses that are observable within a reasonable period of time (Waas 1967); (3) benthic communities respond to many different kinds of stress because they include diverse taxa representing a variety of sizes, modes of reproduction, feeding guilds, life history characteristics, and physiological tolerances to environmental conditions (Gray 1979); (4) benthic macroinvertebrates live in bottom sediments, where exposure to contaminants and oxygen stress is most frequent; (5) benthic communities integrate the varying frequency, duration, and severity of many different kinds of stress over time (Ranasinghe and Holland 1992).

Benthos also are economically and ecologically important. Many benthic organisms, such as oysters and clams, support important commercial and recreational fisheries. Others are a primary source of food for economically and recreationally important fish, crabs, and waterfowl (Homer et al. 1979; Homer and Boynton 1978). Benthos also provide key energy and material linkages in the ecosystem. Suspension feeding bivalve clams and polychaete worms remove suspended material from the water column (Officer et al. 1982); burrowing organisms release nutrients and chemicals trapped in bottom sediments to the water column.

The recent development of the Chesapeake Bay Benthic Community Restoration Goals and the Restoration Goals Index (RGI) enhanced researchers' ability to use the benthic community to assess the condition of bottom habitat in the bay. The Restoration Goals are quantitative statements of the characteristics expected of the benthic community at sites exposed to little environmental stress. The RGI is a measure of how well the restoration goals are being met at a site. The RGI provides an absolute scale (ranging from 1 to 5) for assessing condition and allows comparisons of different kinds of habitats; it provides a benchmark against which to assess the condition of benthic communities in Chesapeake Bay. RGI values less than 3 indicate degraded habitats; values less than 2 indicate severely degraded habitats.

This report is organized into four chapters and two appendices. Chapter 2 presents the field, laboratory, and data analysis methods used to collect, process, and evaluate samples. Chapter 3 presents the results and discusses them. Chapter 4 is a list of the literature cited throughout the report. The appendices present the raw data: Appendix A presents the water quality data; Appendix B presents the bottom condition and benthic species abundance data.

2.0 METHODS

2.1 STUDY DESIGN

This study was designed to compare the benthic community in the proposed wetland area with the communities in six other areas within Baltimore Harbor. The proposed wetland area is north of the Brewerton Channel in the Sparrows Point area of Baltimore Harbor. It was compared with six other strata: (1) the Sparrows Point area south and west of the Brewerton Channel, (2) Curtis Bay, (3) the Middle Branch, (4) the Northwest Branch, (5) Bear Creek, and (6) all remaining areas of the harbor (Figure 2-1). Benthic samples were collected at nine randomly selected sites in the proposed wetland area, three randomly selected sites in each of the first five comparison strata, and four randomly selected sites from the sixth stratum.

2.2 FIELD METHODS

At each sampling site, water quality was measured, and two benthic grab samples were collected. Surface and bottom water salinity, dissolved oxygen concentration, temperature, pH, and eH were measured using a Hydrolab Surveyor II. A Young-modified Van Veen grab was used to collect grab samples at sites in the proposed wetland area, the Northwest Branch, and the remaining harbor strata; a Wildco box-corer was used in the other areas. The Young-modified Van Veen grab samples an area of 0.044 m^2 to a depth of 10 cm; the Wildco box-corer samples an area of 0.022 m^2.

At each sample collection site, one benthic grab sample was processed to preserve benthic macroinvertebrates. It was sieved through a 0.5-mm screen using an elutriative process. Organisms and detritus retained on the screen were transferred to labelled jars and preserved in 10% buffered formalin tinted with rose bengal (a vital stain used to aid with separating organisms from sediment and detritus). Sample volume and penetration depth were measured for all benthic macroinvertebrate samples.

The other benthic grab sample at each collection site was processed to yield two (~20-ml) subsamples of surface sediment for analysis of sediment grain-size distribution. These samples were frozen until they were processed in the laboratory.

2.3 LABORATORY PROCESSING

In the laboratory, all benthic organisms alive at the time of sample collection were sorted from detritus and debris under dissecting microscopes, identified to the lowest practical taxonomic level, and counted. Oligochaetes and chironomids were mounted on slides and identified using a compound microscope.

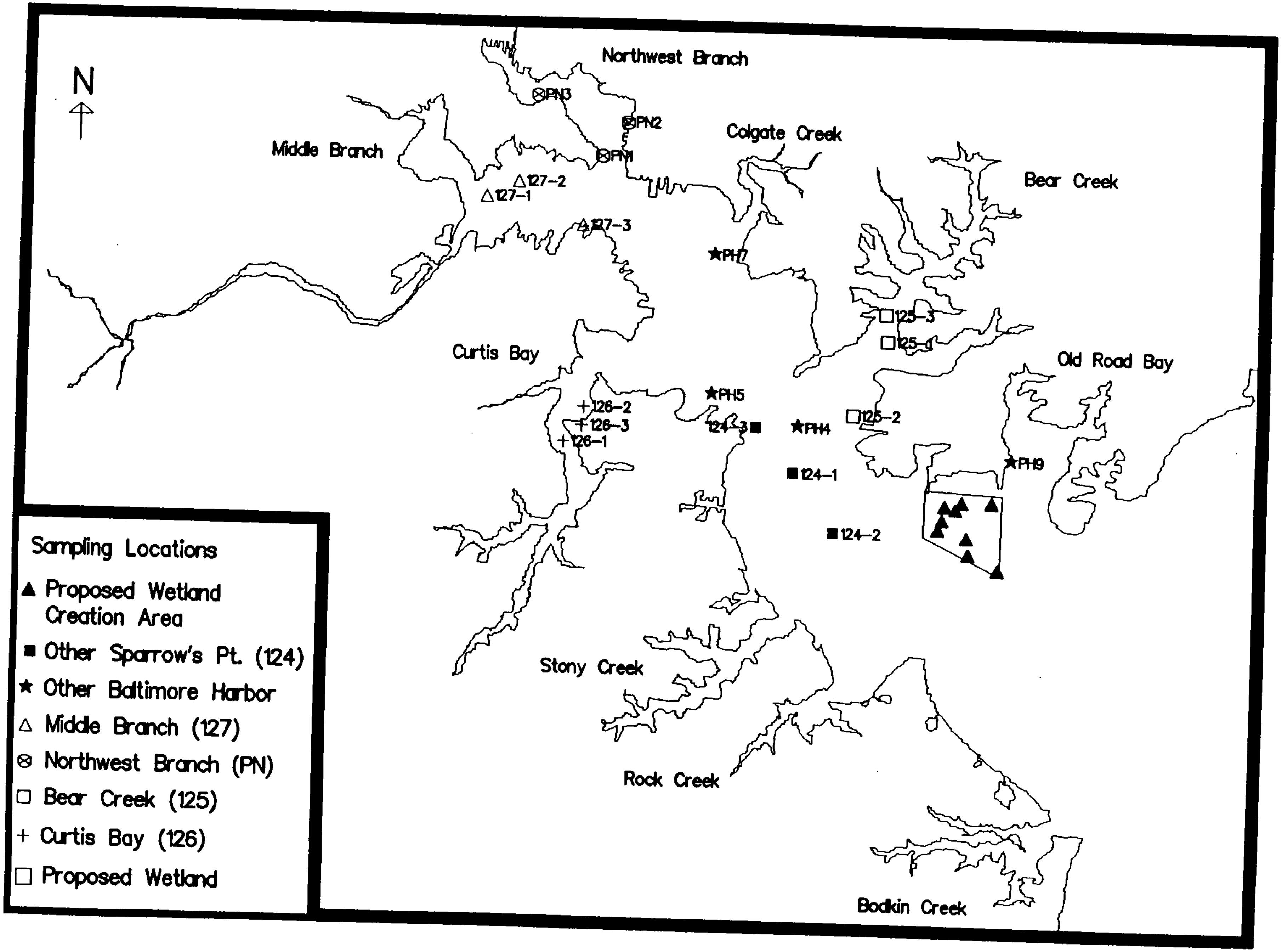

Figure 2-1. Sampling sites for the Sparrows Point wetland creation study

Silt-clay composition by weight was determined for one of the two sediment subsamples collected at each sampling location. The other subsample was archived for quality control/quality assurance (see Scott et al. 1988). Sand and silt-clay particles were separated by wet-sieving through a 63-μm, stainless steel sieve and weighed using the procedures described by Plumb (1981) and Buchanan (1984).

2.4 DATA PREPARATION AND ANALYSIS

All data were key-punched using a double-entry system, verified by custom software that identifies data entry errors such as inappropriate species codes and out-of-range water quality values, and manually verified against data sheets. Any errors were corrected, and all data were rechecked. The data were read into SAS data sets on Versar's VAX/VMS computer system for management, analysis, and storage.

Three measures were used to assess benthic community condition: (1) RGI values, (2) the Shannon-Wiener Diversity Index, and (3) total abundance expressed as number of organisms/m^2. All three measures are expected to have higher values at sites that are in better condition. Analysis of Variance (ANOVA) was used to compare values of these three measures at sites in the proposed wetland area with values at sites in the other six areas. Duncan's multiple range tests were performed to identify differing means.

RGI values were calculated in five steps (see Ranasinghe et al. 1993). First, epifaunal and pelagic organisms were eliminated from the data because: (1) they are not sampled quantitatively by benthic grabs; (2) their exposure to pollution, particularly chemical contaminants in sediments, is different than the exposure experienced by infauna; and (3) the presence of epifauna is most often associated with the presence of shell or structures such as bryozoan colonies, regardless of habitat condition. Second, taxonomy was standardized for use with the RGI. For example, nemerteans were identified and counted collectively as "Phylum Nemertea" for calculating the RGI, even if separate species counts were available in the raw data. Third, values were calculated for the two attributes of the restoration goal for low mesohaline mud habitat for which data were available (the Shannon-Wiener index and the proportion of equilibrium species abundance). Fourth, the Shannon-Wiener index and equilibrium species abundance proportions were scored as 5, 3, or 1 depending on whether the values approximated, deviated slightly from, or deviated strongly from values at the best low mesohaline mud reference sites. Threshold values for the RGI are the 5th and 50th (median) percentile values for the pertinent habitat (Table 2-1). For each of the two available attributes, values below the 50th percentile were scored as 1, values between the 5th and 50th percentiles were scored as 3, and values above the 50th percentile were scored as 5. Finally, RGI values for each site were calculated as the average of the two available attribute scores.

Table 2-1. Attributes of the restoration goal for low mesohaline mud habitat and threshold values used to calculate the Restoration Goals Index (RGI; Ranasinghe et al. 1993). *: Data available for this attribute in this study

Restoration Goal Attribute	5th Percentile	50th Percentile
Shannon-Wiener Diversity Index ($\log_2$)*	2.0	3.0
Biomass (g/m^2)	5	10
Opportunist Biomass (%)	30	10
Equilibrium Species Abundance (%)*	5	15
Taxa > 5 cm below sediment surface (%)	10	40
Biomass > 5 cm below sediment surface (%)	5	80

3.0 RESULTS AND DISCUSSION

Figures 3-1, 3-2, and 3-3 illustrate the relative values of the RGI, Shannon-Wiener index, and benthic macroinvertebrate abundance, respectively, for each sampling site. All samples collected at the proposed wetland area, the Sparrows Point comparison stratum, and the sixth comparison stratum (all other areas of the harbor) met the Chesapeake Bay Benthic Community Restoration Goal. Only one of 12 other sites met the restoration goal.

The analyses of variance and Duncan's multiple range tests for RGI, Shannon-Wiener, and abundance means (Table 3-1) also indicated no significant difference in the condition of the benthic communities at the proposed wetland area, the Sparrows Point comparison stratum, and the sixth comparison stratum. The condition of the communities in these three strata was significantly better than the condition of the communities in Curtis Bay, Middle Branch, Bear Creek, and Northwest Branch.

Table 3-1. Mean values of the RGI, Shannon-Wiener Diversity Index, and macroinvertebrate abundance within each stratum. Means with no common superscript letters are significantly different ($p \leq 0.05$).

Stratum	Restoration Goal Index	Shannon-Wiener Index (log_2)	Abundance (No./m^2)
Proposed Wetland Area	3.33^{a}	2.36^{a}	1871^{ab}
Sparrows Point	3.33^{a}	2.76^{a}	2505^{a}
Middle Branch	2.00^{b}	1.13^{b}	1065^{bcd}
Bear Creek	1.33^{b}	1.04^{b}	435^{cd}
Curtis Bay	1.00^{b}	0.43^{b}	465^{cd}
Northwest Branch	1.00^{b}	0.43^{b}	153^{d}
All Other Areas of Baltimore Harbor	3.25^{a}	2.62^{a}	1621^{abc}

The results indicate that the benthic community at the proposed wetland area is not degraded and that the condition of the proposed wetland area is not unique in Baltimore Harbor. The adjacent area of Sparrows Point and other areas of the harbor are in similar condition. This assessment of the condition of existing habitat in the proposed wetland area should assist the Maryland Environmental Service to evaluate the productivity and usefulness of the habitat that would be lost if a wetland is created.

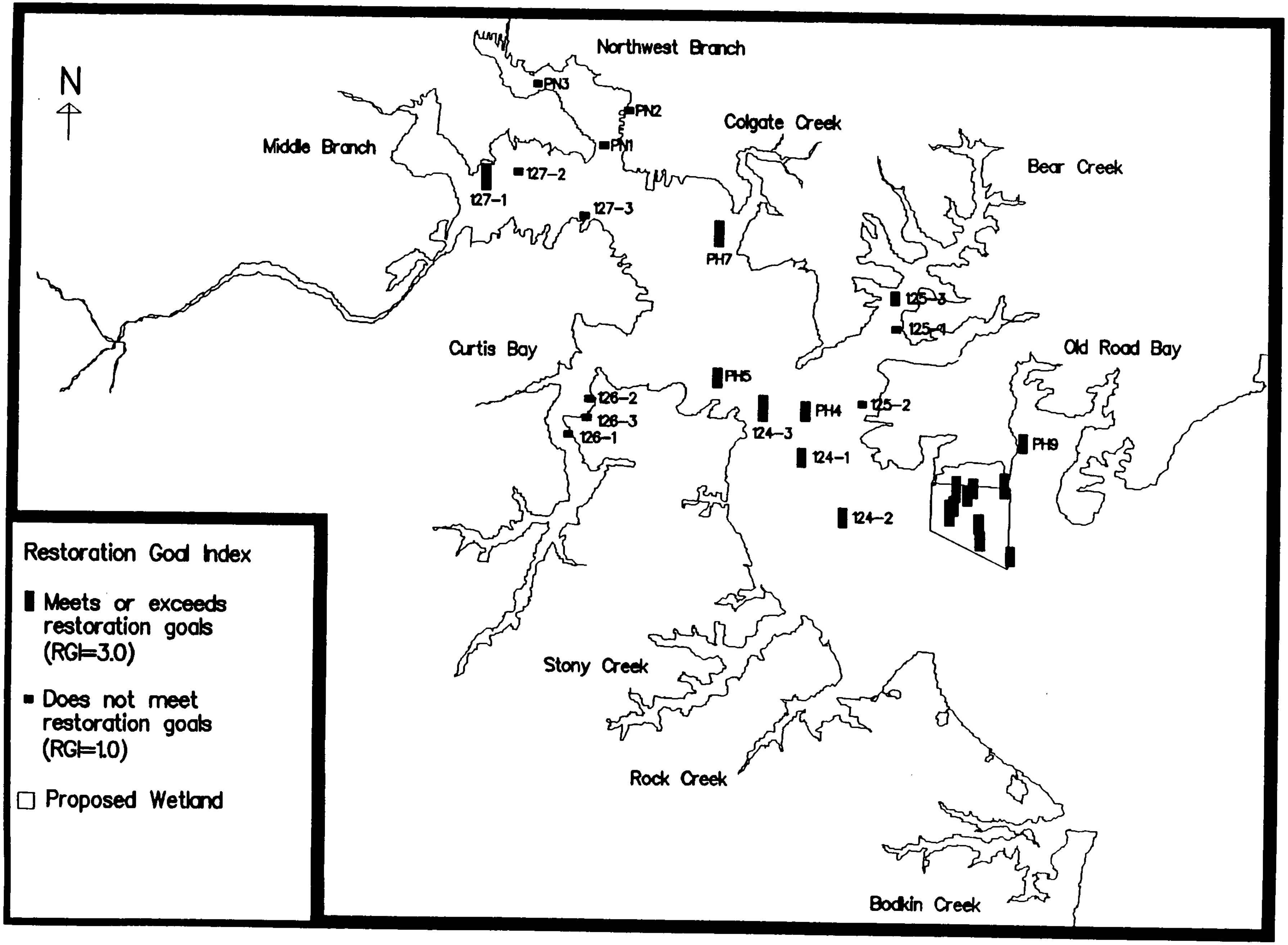

Figure 3-1. RGI values for sites sampled for the Sparrows Point wetland creation study. The height of the bars is proportional to the value.

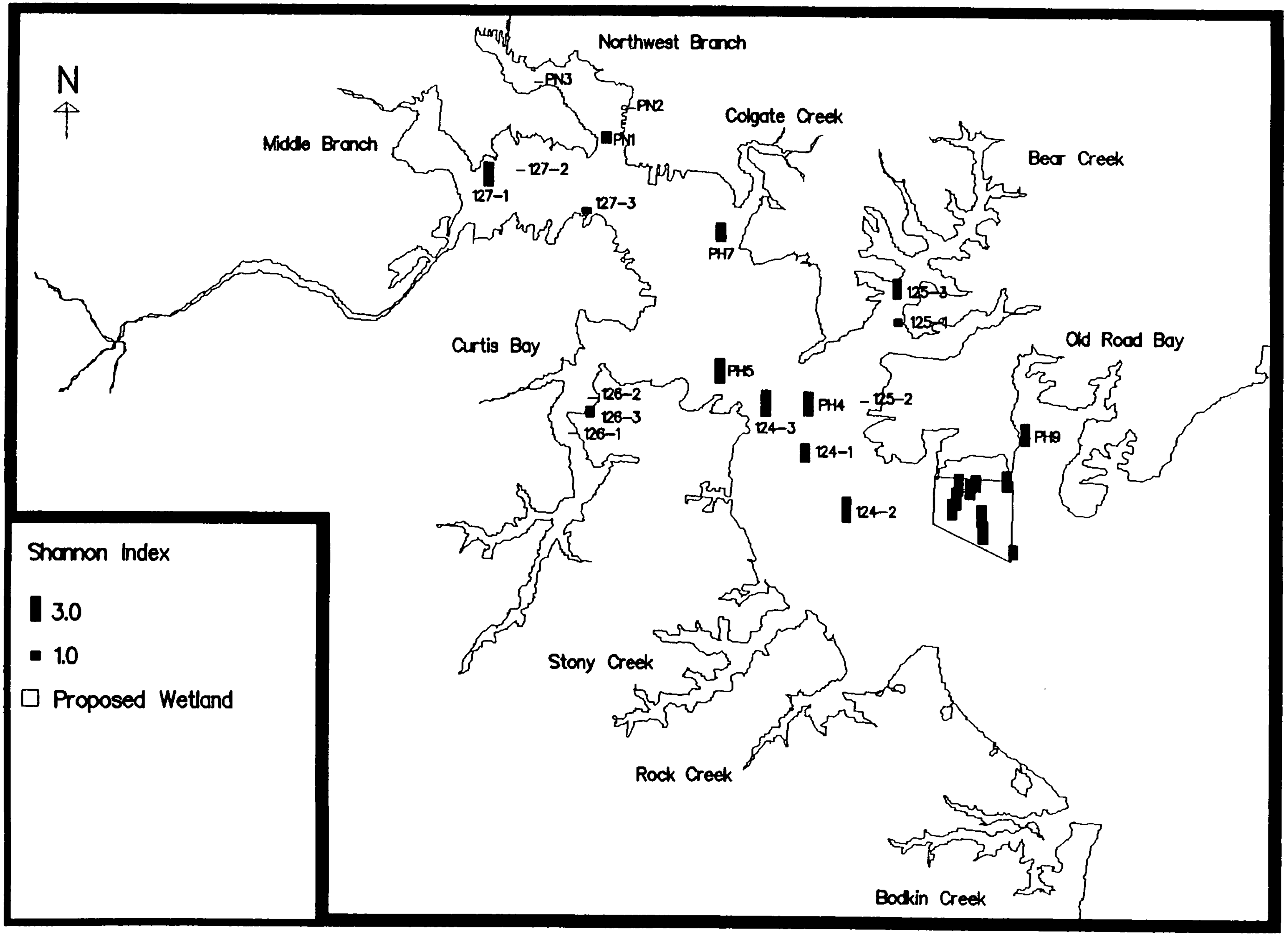

Figure 3-2. Values of the Shannon-Wiener Diversity Index for sites sampled for the Sparrows Point wetland creation study. The height of the bars is proportional to the value

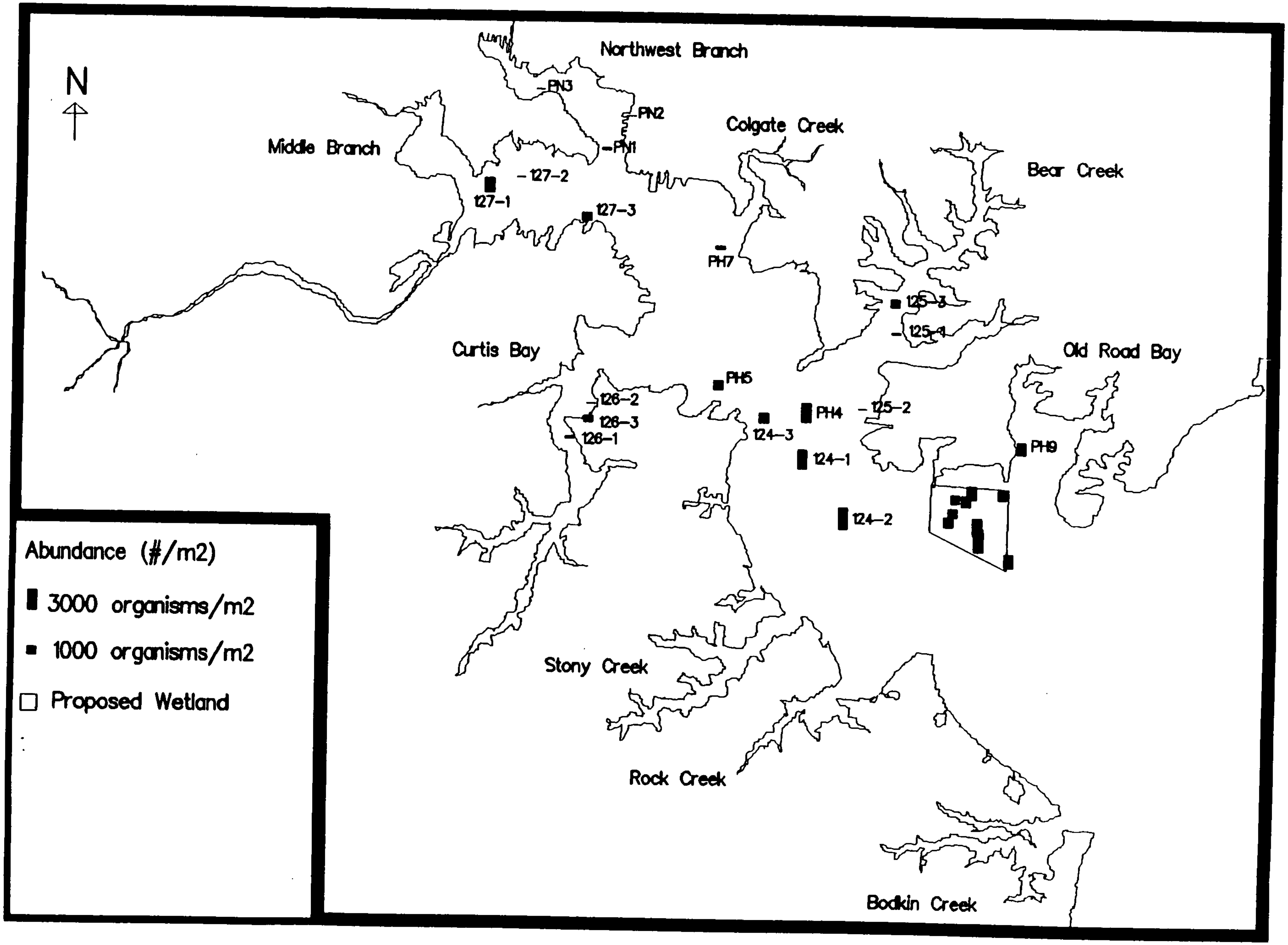

Figure 3-3. Abundance of benthic macroinvertebrates at sites sampled for the Sparrows Point wetland creation study. The height of the bars is proportional to abundance.

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APPENDIX A

WATER QUALITY DATA

WATER COLUMN PARAMETERS, AUGUST 1994 (CRUISE 1:1994/95)

WATER BODY	LOCATION	STRATUM	DEPTH RANGE (ft)	REP	DATE	DEPTH (m)	TEMPERATURE (deg C)	SALINITY (ppt)	CONDUCTIVITY (umhos/cm)	DISSOLVED OXYGEN (mg/L)	PH
Bal.Harbor	Sparrows Point	124	6- 6	01	23AUG94	0.5	24.41	5.00	9690	7.1	7.38
						5.8	24.62	5.50	10380	6.0	7.37
				02	23AUG94	0.5	24.37	5.10	9470	6.9	7.36
						4.1	24.35	5.00	9510	6.7	7.41
				03	23AUG94	0.5	24.37	5.20	9760	6.7	7.29
						1.1	24.38	5.10	9730	6.4	7.31
						2.0	24.40	5.10	9740	6.2	7.31
						3.0	24.40	5.10	9740	6.2	7.31
						4.1	24.39	5.10	9730	6.3	7.31
						5.2	24.44	5.20	9760	6.2	7.30
Bal.Harbor	Bear Creek	125	6- 6	01	23AUG94	0.5	24.10	4.80	8980	6.4	7.35
						3.1	24.16	4.80	9130	6.3	7.37
				02	23AUG94	0.5	24.27	4.80	9300	6.4	7.44
						3.1	24.27	4.90	9300	6.6	7.45
						5.9	24.70	5.20	10020	6.0	7.39
						9.0	25.17	6.50	11890	2.7	7.18
				03	23AUG94	0.5	23.63	4.10	7880	6.9	7.41
						2.0	23.73	4.20	8010	6.0	7.45
Bal.Harbor	Curtis Bay	126	6- 6	01	23AUG94	0.5	24.56	5.50	10150	5.6	7.13
						5.8	24.66	5.50	10360	5.0	7.11
				02	23AUG94	0.5	24.63	5.60	10250	5.6	7.11
						8.6	24.73	5.50	10280	5.0	7.11
				03	23AUG94	0.5	24.23	5.30	10120	6.1	7.13
						0.9	24.23	5.40	10160	5.7	7.17
						2.1	24.22	5.40	10160	5.7	7.17
						2.9	24.24	5.40	10170	5.7	7.18
						3.3	24.19	5.40	10180	5.6	7.18
Bal.Harbor	Middle Branch	127	6- 6	01	22AUG94	0.5	25.06	4.50	8330	7.0	7.52
						2.4	25.26	5.50	10250	6.8	7.46
				02	22AUG94	0.5	25.20	5.20	9760	7.2	7.40
						3.1	25.42	5.60	10340	5.6	7.11
						6.1	25.46	5.70	10650	4.6	7.04
						9.1	25.38	6.20	11530	2.3	7.02
						11.5	25.28	7.40	13030	2.2	7.07

WATER COLUMN PARAMETERS, AUGUST 1994 (CRUISE 1:1994/95)

WATER BODY	LOCATION	STRATUM	DEPTH RANGE (ft)	REP	DATE	DEPTH (m)	TEMPERATURE (deg C)	SALINITY (ppt)	CONDUCTIVITY (umhos/cm)	DISSOLVED OXYGEN (mg/L)	PH
				03	22AUG94	0.5	23.85	1.80	4190	7.2	7.44
						6.1	25.33	5.50	10290	5.1	7.20
Bal.Harbor	Other Bal.Harbor	PH	10-18	04	23AUG94	0.5	24.25	5.30	9630	7.0	7.32
						4.8	24.62	5.20	9950	6.1	7.33
				05	23AUG94	0.5	24.36	5.30	9340	6.6	7.19
						4.6	24.37	4.80	9340	6.4	7.35
				07	22AUG94	0.5	25.38	5.50	10300	6.6	7.05
						5.5	25.40	5.60	10530	6.3	7.16
				09	23AUG94	0.5	24.43	4.50	8510	7.1	7.46
						3.2	24.31	4.50	8740	6.6	7.44
Bal.Harbor	Northwest Branch	PN	14-39	01	22AUG94	0.5	24.96	4.80	9210	6.3	7.20
						4.4	25.43	5.50	10230	5.5	7.17
				02	22AUG94	0.5	25.42	5.50	10300	5.8	7.11
						11.9	25.36	8.00	14360	2.1	7.01
				03	22AUG94	0.5	24.98	3.80	7620	5.9	7.08
						7.6	25.51	6.20	11460	2.3	6.96
Bal.Harbor	Wetlands Creation	PS	12-28	01	23AUG94	0.5	24.08	3.70	7300	7.9	7.60
						7.7	24.90	6.30	11650	5.3	7.35
				02	23AUG94	0.5	24.12	3.90	7750	7.9	7.54
						5.4	24.43	5.10	9660	6.6	7.47
				03	23AUG94	0.5	23.91	4.10	8010	7.5	7.51
						4.5	24.25	4.90	9280	6.8	7.48
				04	23AUG94	0.5	24.27	5.10	9360	7.0	7.47
						5.0	24.41	5.00	9600	6.5	7.44
				05	23AUG94	0.5	24.27	4.80	9230	7.1	7.47
						4.5	24.19	4.90	9380	6.6	7.46
				06	23AUG94	0.5	24.20	4.70	9060	7.8	7.53
						4.1	24.20	4.80	9290	6.7	7.54
				07	23AUG94	0.5	24.20	4.90	9240	7.2	7.46
						4.1	24.21	4.90	9380	6.7	7.48

WATER COLUMN PARAMETERS, AUGUST 1994 (CRUISE 1:1994/95)

WATER BODY	LOCATION	STRATUM	DEPTH RANGE (ft)	REP	DATE	DEPTH (m)	TEMPERATURE (deg C)	SALINITY (ppt)	CONDUCTIVITY (umhos/cm)	DISSOLVED OXYGEN (mg/L)	PH
				08	23AUG94	0.5	24.25	4.70	9020	7.5	7.50
						3.7	24.25	4.80	9280	6.8	7.51
				09	23AUG94	0.5	24.07	4.20	8150	7.4	7.51
						3.8	24.34	5.00	9270	6.2	7.46

APPENDIX B

ABUNDANCE DATA

BOTTOM ENVIRONMENT AND BENTHOS, AUGUST 1994 (CRUISE 1:1994/95)

STRATUM: PS

WATER BODY: Bal.Harbor | LOCATION: Wetlands Creation | STRATUM DEPTH RANGE (ft): 12-28

SAMPLING GEAR: Young Modified Van Veen | SAMPLED AREA (sq.m): 0.043 | HABITAT: Low Mesohaline

BOTTOM ENVIRONMENT

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max
Depth (m)	7.7	5.4	4.5	6.1	1.88	3.8	8.6
Salinity (ppt)	6.30	5.10	4.90	6.53	2.22	4.90	9.70
Temperature (deg C)	24.90	24.43	24.25	31.31	11.69	24.25	48.46
Dissolved Oxygen (mg/L)	5.3	6.6	6.8	8.3	3.50	5.3	13.4
Sediment Silt-Clay (%)	94.88	46.16	63.68	105.5	55.62	46.16	184.8

BENTHOS (Numbers per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Tubificoides sp.	276	1403	782	782.0	470.24	161	1403	41.1
Macoma balthica	1104	184	161	397.6	331.10	161	1104	62.0
Heteromastus filiformis		621	368	354.9	242.99	0	621	80.7
Leptocheirus plumulosus	23	230	644	269.4	190.46	23	644	94.8
Neanthes succinea	92	529	368	262.9	174.59	0	529	108.6
Streblospio benedicti	460	138	46	115.0	156.56	23	460	114.7
Marenzelleria viridis	23	92	46	78.9	62.08	23	184	118.8
Oligochaeta				46.0	121.70	0	322	121.2
Macoma mitchelli			23	23.0	32.53	0	92	122.5
Cyathura polita			23	19.7	42.88	0	115	123.5
Carinoma tremaphorus		46	46	16.4	21.88	0	46	124.4
Littoridinops tenuipes		115		16.4	43.47	0	115	125.2
Polydora cornuta		92		13.1	34.77	0	92	125.9
Rangia cuneata		46		9.9	18.10	0	46	126.4
Hydrobiidae			46	6.6	17.39	0	46	126.8
Overall Abundance	1978	3496	2553	1902.4	852.11	1196	3496	
Number of Species	6	11	11	8.7	1.89	6	11	15

BOTTOM ENVIRONMENT AND BENTHOS, AUGUST 1994 (CRUISE 1:1994/95)

WATER BODY: Bal.Harbor
SAMPLING GEAR: Young Modified Van Veen
STRATUM: PS
LOCATION: Wetlands Creation
SAMPLED AREA (sq.m): 0.043
STRATUM DEPTH RANGE (ft): 12-28
HABITAT: Low Mesohaline

BOTTOM ENVIRONMENT

	Rep 4	Rep 5	Rep 6	Mean	Std.Dev	Min	Max
Depth (m)	5.0	4.5	4.1	4.8	1.23	3.7	7.7
Salinity (ppt)	5.00	4.90	4.80	5.08	0.47	4.80	6.30
Temperature (deg C)	24.41	24.19	24.20	24.35	0.22	24.19	24.90
Dissolved Oxygen (mg/L)	6.5	6.6	6.7	6.5	0.46	5.3	6.8
Sediment Silt-Clay (%)	81.76	89.71	92.58	82.05	16.52	46.16	94.88

BENTHOS (Numbers per sq. meter)

	Rep 4	Rep 5	Rep 6	Mean	Std.Dev	Min	Max	Cum %
Tubificoides sp.	161	437	667	608.2	460.30	0	1403	32.4
Macoma balthica	276	92	207	309.2	304.50	92	1104	48.9
Heteromastus filiformis	414	276	345	276.0	192.43	0	621	63.6
Leptocheirus plumulosus	253	138	184	209.6	176.83	23	644	74.8
Neanthes succinea	299	138	115	204.4	163.63	0	529	85.7
Streblospio benedicti	46	23	23	89.4	143.84	23	460	90.5
Marenzelleria viridis	23	115	69	61.3	32.53	23	115	93.7
Oligochaeta				35.8	107.33	0	322	95.6
Macoma mitchelli		23		17.9	29.94	0	92	96.6
Cyathura polita				15.3	38.14	0	115	97.4
Carinoma tremaphorus		23		12.8	20.28	0	46	98.1
Littoridinops tenuipes				12.8	38.33	0	115	98.8
Polydora cornuta				10.2	30.67	0	92	99.3
Rangia cuneata				7.7	16.26	0	46	99.7
Hydrobiidae				5.1	15.33	0	46	100.0
Overall Abundance	1472	1265	1610	1875.8	744.85	1196	3496	
Number of Species	7	9	7	8.3	1.80	6	11	15

BOTTOM ENVIRONMENT AND BENTHOS, AUGUST 1994 (CRUISE 1:1994/95)

	STRATUM: PS	
WATER BODY: Bal.Harbor	LOCATION: Wetlands Creation	STRATUM DEPTH RANGE (ft): 12-28
SAMPLING GEAR: Young Modified Van Veen	SAMPLED AREA (sq.m): 0.043	HABITAT: Low Mesohaline

BOTTOM ENVIRONMENT

	Rep 7	Rep 8	Rep 9	Mean	Std.Dev	Min	Max
Depth (m)	4.1	3.7	3.8	4.8	1.23	3.7	7.7
Salinity (ppt)	4.90	4.80	5.00	5.08	0.47	4.80	6.30
Temperature (deg C)	24.21	24.25	24.34	24.35	0.22	24.19	24.90
Dissolved Oxygen (mg/L)	6.7	6.8	6.2	6.5	0.46	5.3	6.8
Sediment Silt-Clay (%)	93.03	91.79	84.86	82.05	16.52	46.16	94.88

BENTHOS (Numbers per sq. meter)

	Rep 7	Rep 8	Rep 9	Mean	Std.Dev	Min	Max	Cum %
Tubificoides sp.		1173	575	608.2	460.30	0	1403	32.4
Macoma balthica	207	299	253	309.2	304.50	92	1104	48.9
Heteromastus filiformis	276	115	69	276.0	192.43	0	621	63.6
Leptocheirus plumulosus	161	92	161	209.6	176.83	23	644	74.8
Neanthes succinea	138	161		204.4	163.63	0	529	85.7
Streblospio benedicti	23	23	23	89.4	143.84	23	460	90.5
Marenzelleria viridis	46	92	46	61.3	32.53	23	115	93.7
Oligochaeta	322			35.8	107.33	0	322	95.6
Macoma mitchelli	23		92	17.9	29.94	0	92	96.6
Cyathura polita			115	15.3	38.14	0	115	97.4
Carinoma tremaphorus				12.8	20.28	0	46	98.1
Littoridinops tenuipes				12.8	38.33	0	115	98.8
Polydora cornuta				10.2	30.67	0	92	99.3
Rangia cuneata			23	7.7	16.26	0	46	99.7
Hydrobiidae				5.1	15.33	0	46	100.0
Overall Abundance	1196	1955	1357	1875.8	744.85	1196	3496	
Number of Species	8	7	9	8.3	1.80	6	11	15

BOTTOM ENVIRONMENT AND BENTHOS, AUGUST 1994 (CRUISE 1:1994/95)

WATER BODY: Bal.Harbor
SAMPLING GEAR: WildCo Box Corer
STRATUM: 124
LOCATION: Sparrows Point
SAMPLED AREA (sq.m): 0.022
STRATUM DEPTH RANGE (ft): 6- 6
HABITAT: Low Mesohaline

BOTTOM ENVIRONMENT

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max
Depth (m)	5.8	4.1	5.2	5.0	0.86	4.1	5.8
Salinity (ppt)	5.50	5.00	5.20	5.23	0.25	5.00	5.50
Temperature (deg C)	24.62	24.35	24.44	24.47	0.14	24.35	24.62
Dissolved Oxygen (mg/L)	6.0	6.7	6.2	6.3	0.38	6.0	6.7
Sediment Silt-Clay (%)	70.61	74.80	70.73	72.05	2.39	70.61	74.80

BENTHOS (Numbers per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Leptocheirus plumulosus	1035	630	180	615.0	427.70	180	1035	24.6
Heteromastus filiformis	135	855	315	435.0	374.70	135	855	41.9
Littoridinops tenuipes	1035	135		390.0	562.65	0	1035	57.5
Neanthes succinea	360	405	270	345.0	68.74	270	405	71.3
Marenzelleria viridis		315	135	150.0	158.03	0	315	77.2
Macoma balthica	180	45	135	120.0	68.74	45	180	82.0
Polydora cornuta		360		120.0	207.85	0	360	86.8
Macoma mitchelli	45	90	90	75.0	25.98	45	90	89.8
Streblospio benedicti		90	135	75.0	68.74	0	135	92.8
Tubificoides sp.		135	90	75.0	68.74	0	135	95.8
Rangia cuneata	45	90		45.0	45.00	0	90	97.6
Carinoma tremaphorus		45	45	30.0	25.98	0	45	98.8
Hypereteone heteropoda	45		45	30.0	25.98	0	45	100.0
Overall Abundance	2880	3195	1440	2505.0	935.67	1440	3195	
Number of Species	8	12	10	10.0	2.00	8	12	13

BOTTOM ENVIRONMENT AND BENTHOS, AUGUST 1994 (CRUISE 1:1994/95)

WATER BODY: Bal.Harbor
SAMPLING GEAR: WildCo Box Corer
STRATUM: 127
LOCATION: Middle Branch
SAMPLED AREA (sq.m): 0.022
STRATUM DEPTH RANGE (ft): 6- 6
HABITAT: Low Mesohaline

BOTTOM ENVIRONMENT

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max
Depth (m)	2.4	11.5	6.1	6.7	4.58	2.4	11.5
Salinity (ppt)	5.50	7.40	5.50	6.13	1.10	5.50	7.40
Temperature (deg C)	25.26	25.28	25.33	25.29	0.04	25.26	25.33
Dissolved Oxygen (mg/L)	6.8	2.2	5.1	4.7	2.37	2.2	6.8
Sediment Silt-Clay (%)	53.01	71.16	87.49	70.55	17.25	53.01	87.49

BENTHOS (Numbers per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Streblospio benedicti			900	300.0	519.62	0	900	23.8
Macoma mitchelli	720			240.0	415.69	0	720	42.9
Edotea triloba	540			180.0	311.77	0	540	57.1
Marenzelleria viridis	315			105.0	181.87	0	315	65.5
Cyathura polita	270			90.0	155.88	0	270	72.6
Rangia cuneata	225			75.0	129.90	0	225	78.6
Heteromastus filiformis	180			60.0	103.92	0	180	83.3
Macoma balthica	180			60.0	103.92	0	180	88.1
Tubificoides sp.			180	60.0	103.92	0	180	92.9
Littoridinops tenuipes	135			45.0	77.94	0	135	96.4
Carinoma tremaphorus	45			15.0	25.98	0	45	97.6
Leptocheirus plumulosus	45			15.0	25.98	0	45	98.8
Mytilopsis leucophaeta	45			15.0	25.98	0	45	100.0
Overall Abundance	2700	0	1080	1260.0	1358.97	0	2700	
Number of Species	11	0	2	4.3	5.86	0	11	13

BOTTOM ENVIRONMENT AND BENTHOS, AUGUST 1994 (CRUISE 1:1994/95)

WATER BODY: Bal.Harbor
SAMPLING GEAR: WildCo Box Corer

STRATUM: 125
LOCATION: Bear Creek
SAMPLED AREA (sq.m): 0.022

STRATUM DEPTH RANGE (ft): 6- 6
HABITAT: Low Mesohaline

BOTTOM ENVIRONMENT

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max
Depth (m)	3.1	9.0	2.0	4.7	3.76	2.0	9.0
Salinity (ppt)	4.80	6.50	4.20	5.17	1.19	4.20	6.50
Temperature (deg C)	24.16	25.17	23.73	24.35	0.74	23.73	25.17
Dissolved Oxygen (mg/L)	6.3	2.7	6.0	5.0	2.00	2.7	6.3
Sediment Silt-Clay (%)	77.56	89.00	62.54	76.37	13.27	62.54	89.00

BENTHOS

(Numbers per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Streblospio benedicti	135		315	150.0	158.03	0	315	33.3
Imm. Tubificid w/o Cap. Chaete	45		225	90.0	119.06	0	225	53.3
Tubificoides sp.			270	90.0	155.88	0	270	73.3
Tanypus sp.			225	75.0	129.90	0	225	90.0
Hobsonia florida			45	15.0	25.98	0	45	93.3
Littoridinops tenuipes			45	15.0	25.98	0	45	96.7
Mytilopsis leucophaeta		45		15.0	25.98	0	45	100.0
Overall Abundance	180	45	1125	450.0	588.45	45	1125	
Number of Species	2	1	6	3.0	2.65	1	6	7

BOTTOM ENVIRONMENT AND BENTHOS, AUGUST 1994 (CRUISE 1:1994/95)

WATER BODY: Bal.Harbor
SAMPLING GEAR: WildCo Box Corer

STRATUM: 126
LOCATION: Curtis Bay
SAMPLED AREA (sq.m): 0.022

STRATUM DEPTH RANGE (ft): 6- 6
HABITAT: Low Mesohaline

BOTTOM ENVIRONMENT

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max
Depth (m)	5.8	8.6	3.3	5.9	2.65	3.3	8.6
Salinity (ppt)	5.50	5.50	5.40	5.47	0.06	5.40	5.50
Temperature (deg C)	24.66	24.73	24.19	24.53	0.29	24.19	24.73
Dissolved Oxygen (mg/L)	5.0	5.0	5.6	5.2	0.33	5.0	5.6
Sediment Silt-Clay (%)	85.23	86.87	78.61	83.57	4.37	78.61	86.87

BENTHOS (Numbers per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Streblospio benedicti	360		585	315.0	295.08	0	585	65.6
Tubificoides sp.			315	105.0	181.87	0	315	87.5
Neanthes succinea			90	30.0	51.96	0	90	93.8
Littoridinops tenuipes		45		15.0	25.98	0	45	96.9
Palaemonetes sp.	45			15.0	25.98	0	45	100.0
Overall Abundance	405	45	990	480.0	476.94	45	990	
Number of Species	2	1	3	2.0	1.00	1	3	5

BOTTOM ENVIRONMENT AND BENTHOS, AUGUST 1994 (CRUISE 1:1994/95)

WATER BODY: Bal.Harbor
SAMPLING GEAR: Young Modified Van Veen

STRATUM: PN
LOCATION: Northwest Branch
SAMPLED AREA (sq.m): 0.043

STRATUM DEPTH RANGE (ft): 14-39
HABITAT: Low Mesohaline

BOTTOM ENVIRONMENT

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max
Depth (m)	4.4	11.9	7.6	8.0	3.76	4.4	11.9
Salinity (ppt)	5.50	8.00	6.20	6.57	1.29	5.50	8.00
Temperature (deg C)	25.43	25.36	25.51	25.43	0.08	25.36	25.51
Dissolved Oxygen (mg/L)	5.5	2.1	2.3	3.3	1.88	2.1	5.5
Sediment Silt-Clay (%)	39.55	85.65	81.58	68.93	25.52	39.55	85.65

BENTHOS (Numbers per sq. meter)

	Rep 1	Rep 2	Rep 3	Mean	Std.Dev	Min	Max	Cum %
Streblospio benedicti	253			84.3	146.07	0	253	55.0
Tubificoides sp.	69	46	23	46.0	23.00	23	69	85.0
Neanthes succinea	69			23.0	39.84	0	69	100.0
Overall Abundance	391	46	23	153.3	206.15	23	391	
Number of Species	3	1	1	1.7	1.15	1	3	3

BOTTOM ENVIRONMENT AND BENTHOS, AUGUST 1994 (CRUISE 1:1994/95)

WATER BODY: Bal.Harbor
SAMPLING GEAR: Young Modified Van Veen
STRATUM: PH
LOCATION: Other Bal. Harbor
SAMPLED AREA (sq.m): 0.043
STRATUM DEPTH RANGE (ft): 10-18
HABITAT: Low Mesohaline

BOTTOM ENVIRONMENT

	REP 4	Rep 5	Rep 7	Rep 9	Mean	Std.Dev	Min	Max
Depth (m)	4.8	4.6	5.5	3.2	4.5	0.96	3.2	5.5
Salinity (ppt)	5.20	4.80	5.60	4.50	5.03	0.48	4.50	5.60
Temperature (deg C)	24.62	24.37	25.40	24.31	24.68	0.50	24.31	25.40
Dissolved Oxygen (mg/L)	6.1	6.4	6.3	6.6	6.3	0.22	6.1	6.6
Sediment Silt-Clay (%)	62.80	86.90	88.92	66.45	76.27	13.55	62.80	88.92

BENTHOS (Numbers per sq. meter)

	REP 4	Rep 5	Rep 7	Rep 9	Mean	Std.Dev	Min	Max	Cum %
Heteromastus filiformis	966	207	115	736	506.0	411.01	115	966	31.2
Tubificoides sp.	483	230	69	345	281.8	175.54	69	483	48.6
Macoma balthica	345	161	161	230	224.3	86.82	161	345	62.4
Leptocheirus plumulosus	322	253		161	184.0	139.27	0	322	73.8
Neanthes succinea	184	230	23	138	143.8	88.83	23	230	82.6
Marenzelleria viridis	276	115	23	69	120.8	110.10	23	276	90.1
Macoma mitchelli	161		23	92	69.0	72.73	0	161	94.3
Streblospio benedicti	46	69		46	40.3	28.94	0	69	96.8
Carinoma tremaphorus	23	23		46	23.0	18.78	0	46	98.2
Littoridinops tenuipes	69				17.3	34.50	0	69	99.3
Imm. Tubificid w/ Cap. Chaete		23			5.8	11.50	0	23	99.6
Rangia cuneata		23			5.8	11.50	0	23	100.0
Overall Abundance	2875	1334	414	1863	1621.5	1027.99	414	2875	
Number of Species	10	10	6	9	8.8	1.89	6	10	12

Appendix C:

Microzooplankton Community Composition

The Academy of Natural Sciences
Benedict Estuarine Research Center

Microzooplankton Community Composition in the Vicinity of Sparrow's Point, Patapsco River, MD

Submitted by:

Stella G. Brownlee
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November 30, 1994

Introduction

Microzooplankton are the animal plankton that are between 20 and 202 μm in size and are composed primarily of the following groups: rotifers, ciliates, copepod nauplii and various groups of larvae. This zooplankton group is a critical link between primary producers and higher consumers such as forage fish and first feeding larval stages of predatory fish (white perch and striped bass). This report summarizes a comparison of the microzooplankton taxa and abundances at two stations in the Patapsco River.

Methods

An area between Sparrow's Point and Brewerton Channel was sampled monthly from May-October, 1994 for > 44 μm microzooplankton. The six samples were collected by pumping water from 5 discrete depths through a 44 μm mesh plankton net. The contents of the net were rinsed into a jar and preserved with buffered formalin to a final concentration of 2.5% formalin. As part of the Chesapeake Bay Monitoring Program, microzooplankton samples were also taken at the Baltimore Harbor sampling station MWT5.1 (east of Hawkins Point and in the middle of Brewerton Channel) on the same day. These samples were composited from 5 depths sampled above the pycnocline. The fixed samples were concentrated and 1 ml subsamples were decanted into a Sedgwick-Rafter counting cell and examined at 100X using a Leitz-Laborlux compound microscope. Species identification was made using the NODC species code. Only those organisms between 44 and 200 μm in size are included in the data.

The raw count data sets are provided in Appendix I. Tables 1 and 2 give total microzooplankton and individual densities for Sparrow's's Point and the reference station. The physical data for both stations are included in Table 3.

Results

A comparison of total microzooplankton densities for both stations is presented in Figure 1. Because the depth of the surface mixed layer at reference station MWT5.1 was not the same as the depth of Sparrow's Point, the microzooplankton densities are also integrated over the water column in Figure 2. Total microzooplankton densities for Sparrow's Point were consistently higher than noted for the reference station in June, August and October (Figure 1). In July, Sparrow's Point microzooplankton densities were only 57% of those at the reference station. In May and September, the densities of the organisms at both sites were within 30% and 10% of each other, respectively. When the densities are normalized in regard to sampling depths, the integrated densities are very similar between the 2 stations with the exceptions of the July and August samplings.

Figure 3 compares copepod nauplii numbers at both sites. The copepod nauplii densities at Sparrow's Point were higher than those of the reference station in June, August and September.

Rotifer densities at both sites showed no pattern except for the highest numbers occurring in August (Figure 4). Brachionus plicatilis and a small Synchaeta species made the greatest contributions to rotifer numbers at Sparrow's Point in August while the same Brachionus species and Synchaeta bicornis, a common summer species, were found at the reference site. Again, a small Synchaeta species appeared at both stations in October.

Tintinnid numbers were higher at Sparrow's Point (Figure 5) except in July and when overall numbers were low in September and May. At Sparrow's Point, Tintinnopsis fimbriata and T.meuneri (grouped together because of similarities in lorica shape) were abundant throughout the entire sampling period except in the low density months of July and September. The same Tintinnopsis group was also found at low densities throughout the study at the reference station.

Figures 6 through 11 compare the 2 stations for the various taxonomic groups by month. In June, August and October when highest total densities of organisms were noted at Sparrow's Point, densities for each group were also consistently higher. Microzooplankton densities for the reference station were higher than densities of organisms at Sparrow's Point for three observations, rotifers in May, tintinnids in September and all groups in July. The total densities of microzooplankton varied between the 2 stations over the course of the study with Sparrow's Point having higher numbers of individuals in 3 of the 6 months. The populations at the 2 stations were represented by the same general species composition of rotifers and tintinnids. Densities of organisms in the "other" category, composed of larvae, non-loricate ciliates and sarcodinids were relatively low for both stations except in August at Sparrow's Point. At this time, pelecypod larvae numbers were high but contributed only a small percentage to total population densities.

Discussion

The overall trend in total microzooplankton densities at both stations over the course of the study would have followed remarkably similar patterns if the tintinnid population had not dropped so dramatically in July at the Sparrow's Point station. A similar decline in tintinnid numbers was also seen at the reference station in 1985. Rotifer densities at both stations peaked in August and declined in September, perhaps reflecting grazing by planktivorous fish and copepods. The decline in copepod numbers in the fall could account for the resurgence of the rotifer population in October. The corresponding increase in copepod nauplii numbers in June could be a result of the high numbers of adults found earlier in the year. A second increase in nauplii numbers at Sparrow's Point in August, a shallow station, probably reflected larger contributions of benthic harpacticoid copepods, typical of benthic communities in the Bay.

The data collected in the present study provide some of the information currently used in the development of habitat characteristics beneficial to high fish production. For example, Buchanan et al. (1992) have proposed that rotifer and nauplii densities exceeding 500/L provide optimal food levels for bay anchovy populations. As noted in Figure 12, this level is met or exceeded for both stations during most of the summer. However, a more conservative estimate of 1000 individuals/L, an equivalent biomass to the level of copepod biomass required as optimal food levels in another analysis (Buchanan et al., 1993), was only found in August and October at the Sparrow's Point site. Thus, the microzooplankton levels found in the lower Patapsco River estuary in summer can be considered as marginally beneficial for sustaining a bay anchovy population.

References

Buchanan, C., R.S. Birdsong, K.G. Sellner, F. Jacobs, and S.E. Bieber. 1992. Chesapeake Bay Zooplankton Monitoring: Report on a Workshop held in Easton, Maryland, September 23-24,1991. ICPRB, Rockville, MD. 53pp.

Buchanan, C., R.W. Alden, R.S. Birdsong, F. Jacobs, and K.G. Sellner. 1993. Development of Zooplankton Community Environmental Indicators for Chesapeake Bay: Report on the Project's Results through June, 1993. ICPRB, Rockville, MD. 122pp.

Table 1. Comparison of total and integrated microzooplankton densities, Sparrow's Point and reference station MWT5.1. SPPT=Sparrow's Point, MWT5.1=reference station, SPDEP=depth of water column at Sparrow's Point, MWTDEP=depth of surface mixed layer at reference station, SPINT=integrated densities at Sparrow's Point, MWTINT=integrated densities at reference station.

MONTH	SPPT #/L	MWT5.1 #/L	SPDEP M	MWTDE M	SPINT 10E6/M2	MWTINT 10E6/M2
MAY	185.5	263.6	4.3	4.0	0.80	1.05
JUNE	1194.7	589.8	4.3	7.0	5.14	4.13
JULY	564.4	997.0	4.0	5.0	2.26	4.99
AUG	2966.9	1192.8	4.5	5.0	13.35	5.96
SEPT	322.6	294.9	4.5	4.0	1.45	1.18
OCT	2276.8	1077.3	4.5	7.0	10.25	7.54

Table 2. Comparison of microzooplankton densities by group, Sparrow's Point and reference station MWT5.1. STA=station name, SPPT=Sparrow's Point, MWT5.1=reference station, TIN=loricate ciliate group tintinnids, ROT=rotifers, NAUP=copepod nauplii, OTHER=sarcodinids+non-loricate ciliates+larvae.

MONTH	STA	TIN #/L	ROT #/L	NAUP #/L	OTHER #/L	TOTAL #/L
MAY	SPPT	7.0	78.0	92.5	8.0	185.5
MAY	MWT5.1	4.9	161.1	86.1	11.5	263.6
JUNE	SPPT	503.8	155.6	505.7	29.6	1194.7
JUNE	MWT5.1	86.6	86.6	386.1	30.4	589.7
JULY	SPPT	139.4	210.8	190.9	23.1	564.2
JULY	MWT5.1	201.0	423.0	322.0	51.0	997.0
AUG	SPPT	420.0	1999.2	376.3	171.4	2966.9
AUG	MWT5.1	232.3	714.1	228.3	18.2	1192.9
SEPT	SPPT	40.3	79.4	173.9	29.0	322.6
SEPT	MWT5.1	90.9	57.6	116.2	30.3	295.0
OCT	SPPT	1013.0	1210.9	36.5	16.4	2276.8
OCT	MWT5.1	333.7	644.8	83.4	15.4	1077.3

TABLE 3. PHYSICAL DATA - SPARROW'S POINT AND REFERENCE STATION MWT5.1

	MAY		JUN		JUL		AUG		SEP		OCT	
	T	B	T	B	T	B	T	B	T	B	T	B
SPARROW'S PT												
DEPTH (m)	0.5	4.3	0.5	4.3	0.5	4.0	0	0	0.5	4.5	0.5	4.5
SAL (ppt)	2.7	6.0	4.5	5.2	3.2	4.0	0	0	8.1	10.9	9.2	11.8
TEMP (c)	21.2	16.5	25.8	23.6	28.9	27.7	0	0	25.3	23.1	17.9	18.6
D.O. (mg/l)	12.9	6.9	10.6	4.2	11.4	5.6	0	0	10.8	1.0	14.4	5.8
REFERENCE STATION MWT5.1												
DEPTH (m)	0.5	4.0	0.5	7.0	0.5	5.0	0.5	5.0	0.5	4.0	0.5	7.0
SAL (ppt)	3.3	4.3	4.6	5.2	5.2	5.6	5.2	5.6	8.8	9.4	11.0	12.3
TEMP (c)	21.5	18.4	25.3	23.2	25.6	25.7	25.6	25.7	24.4	23.2	19.1	19.1
DO (mg/l)	12.7	9.9	10.1	5.2	8.1	6.8	8.1	6.8	12.7	7.1	11.9	4.8

NO DATA AVAILABLE = 0
T=TOP OF MIXED SURFACE LAYER
B=BOTTOM OF MIXED SURFACE LAYER

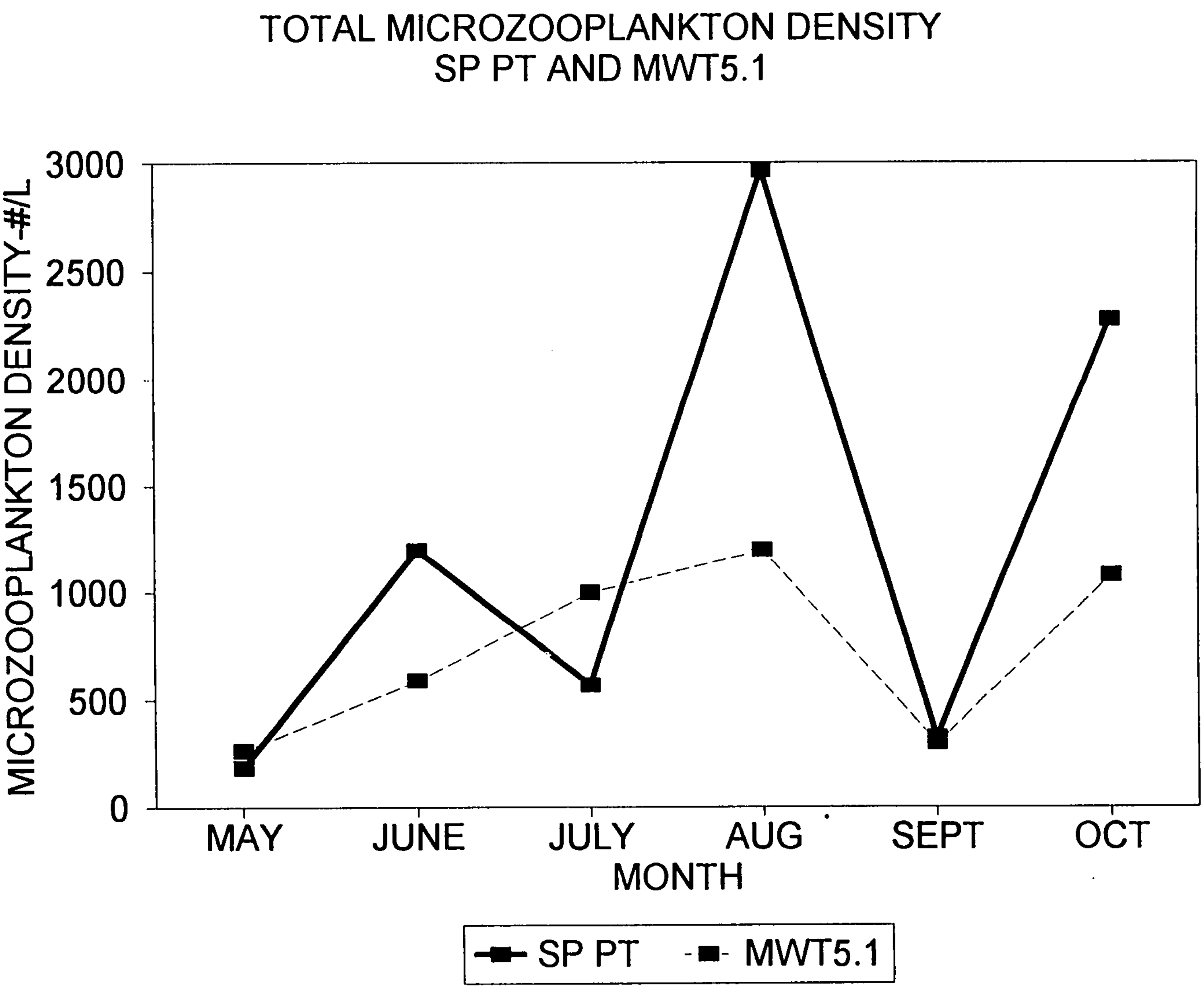

Figure 1: Monthly total microzooplankton densities (#/L) for Sparrow's Point and reference station MWT5.1 for May, 1994-October, 1994. Abbreviations are SP PT=Sparrow's Point, MWT5.1=reference station.

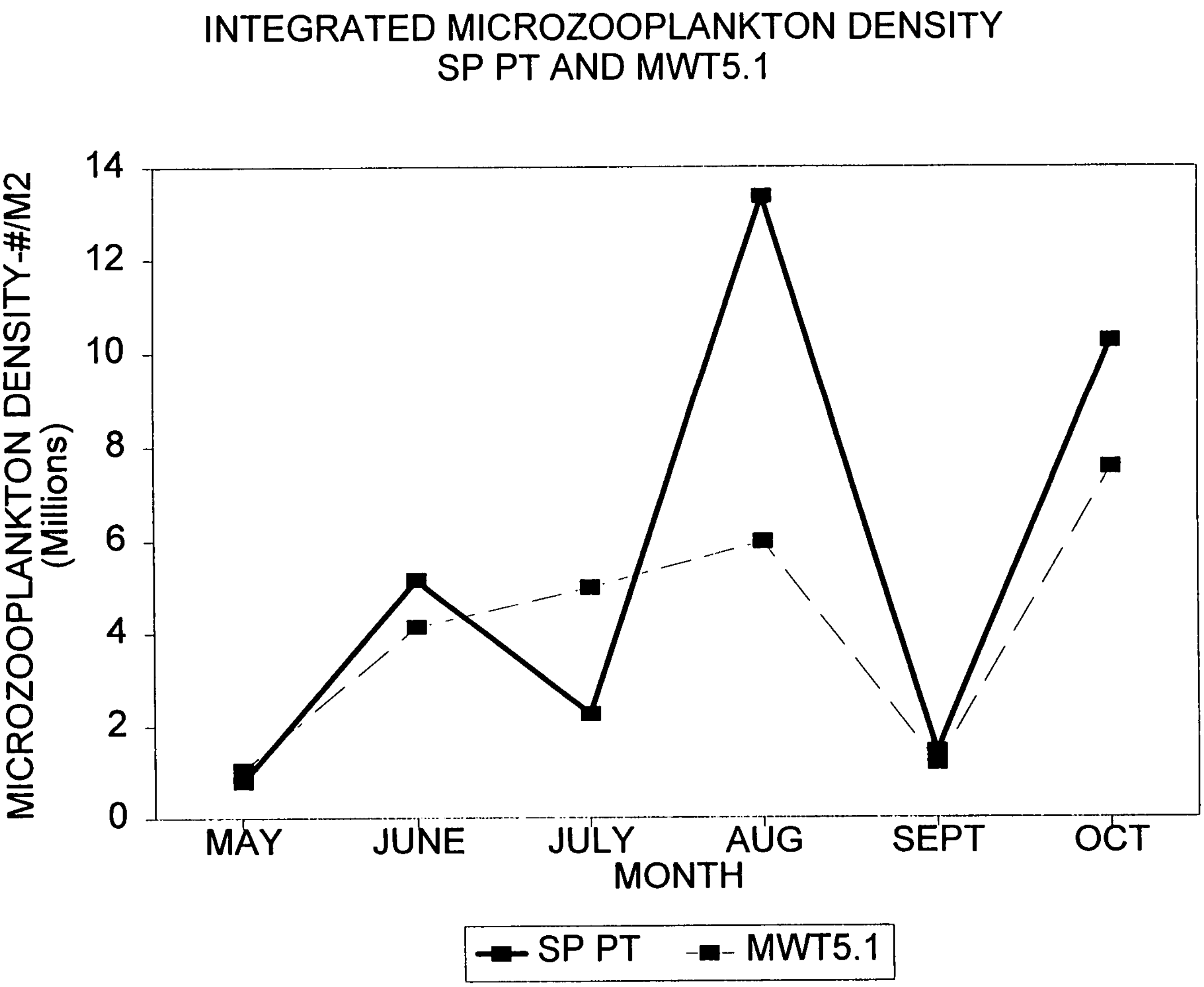

Figure 2: Monthly total microzooplankton densities (#/m^2) for Sparrow's Point and reference station MWT5.1 for May, 1994-October, 1994. Abbreviations are SP PT=Sparrow's Point, MWT5.1=reference station.

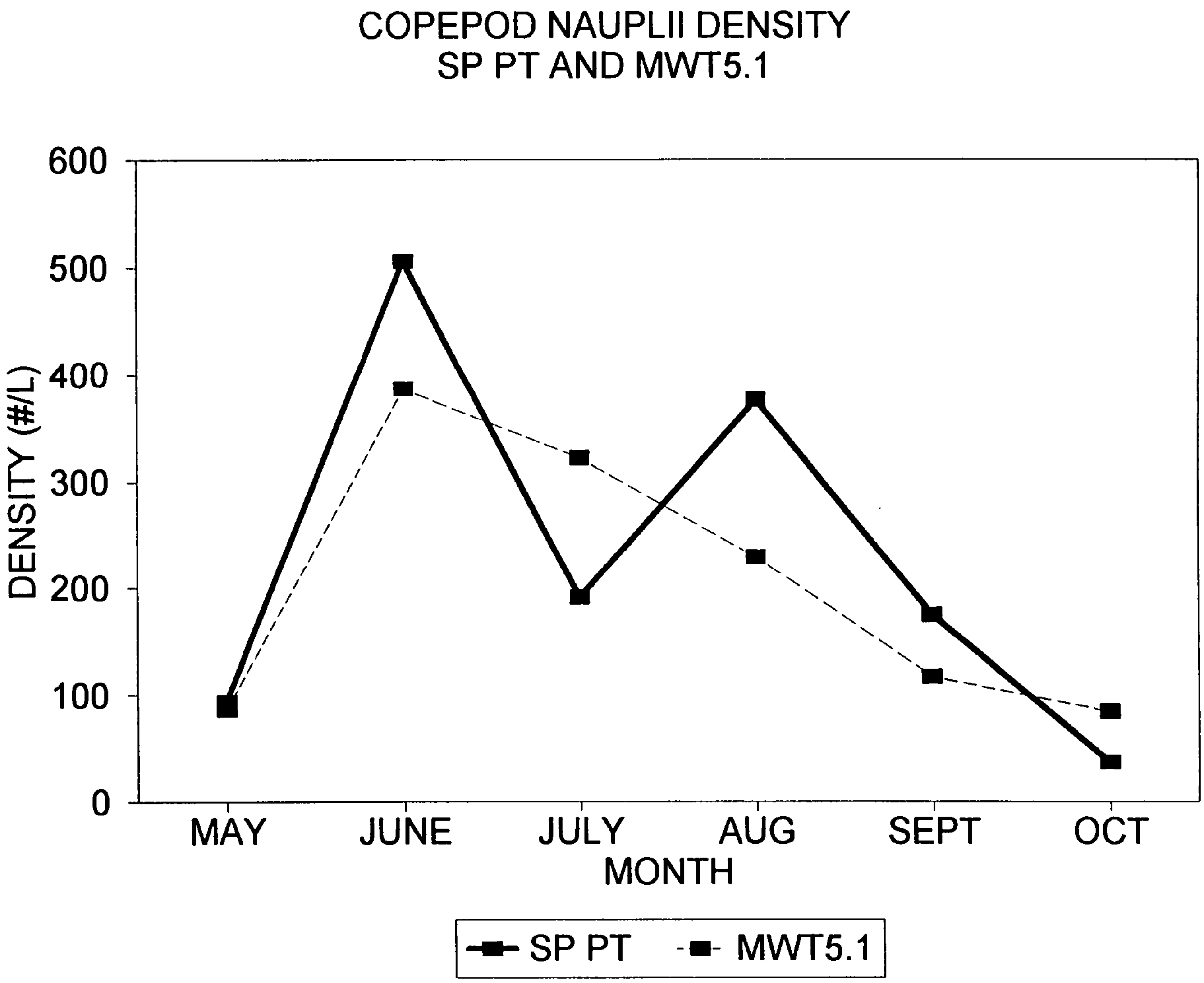

Figure 3: Monthly total copepod nauplii densities (#/L) for Sparrow's Point and reference station MWT5.1 for May, 1994-October, 1994. Abbreviations are: SP PT=Sparrow's Point, MWT5.1=reference station.

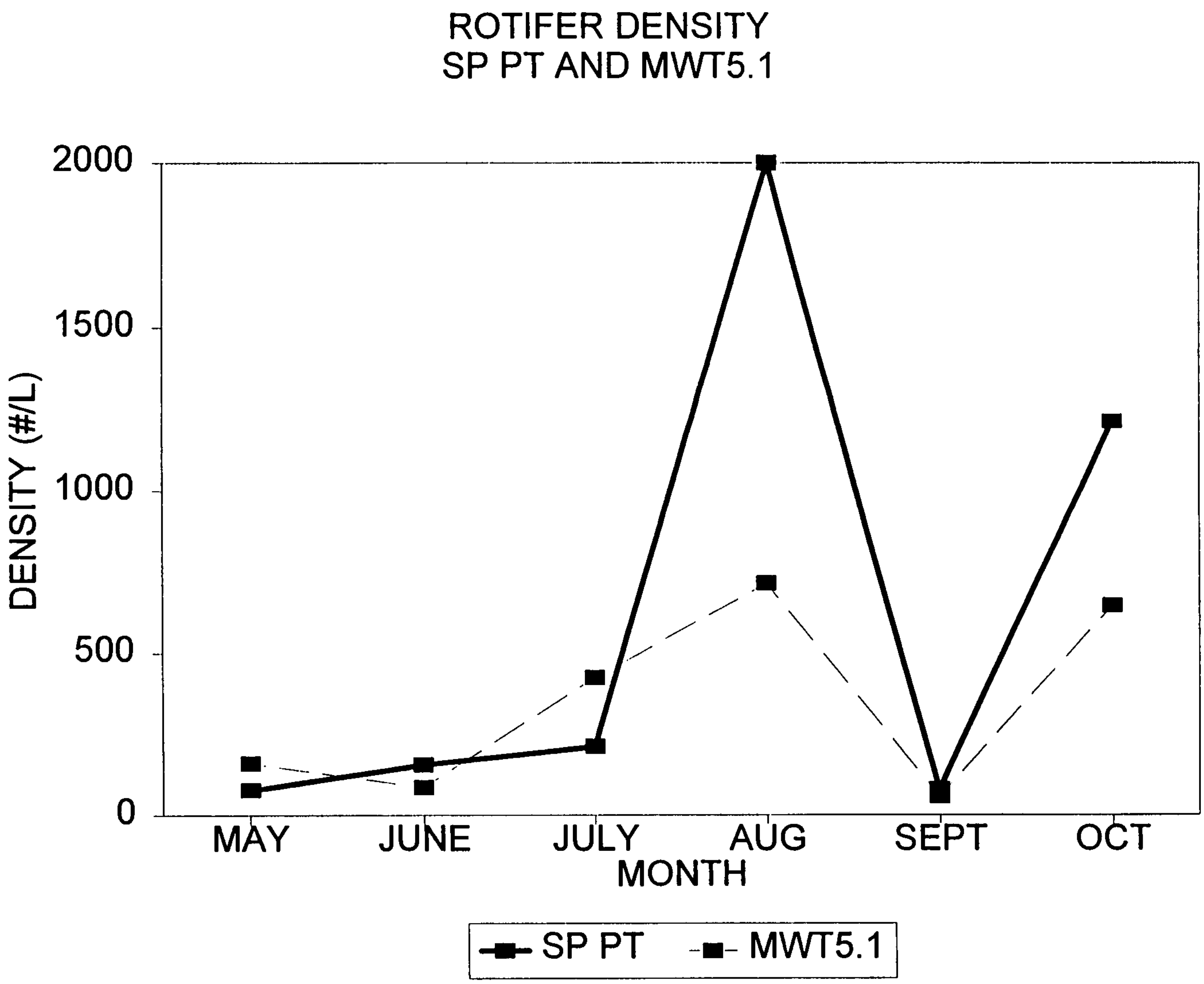

Figure 4: Monthly total rotifer densities (#/L) for Sparrow's Point and reference station MWT5.1 for May, 1994-October, 1994. Abbreviations are: SP PT=Sparrow's Point, MWT5.1=reference station.

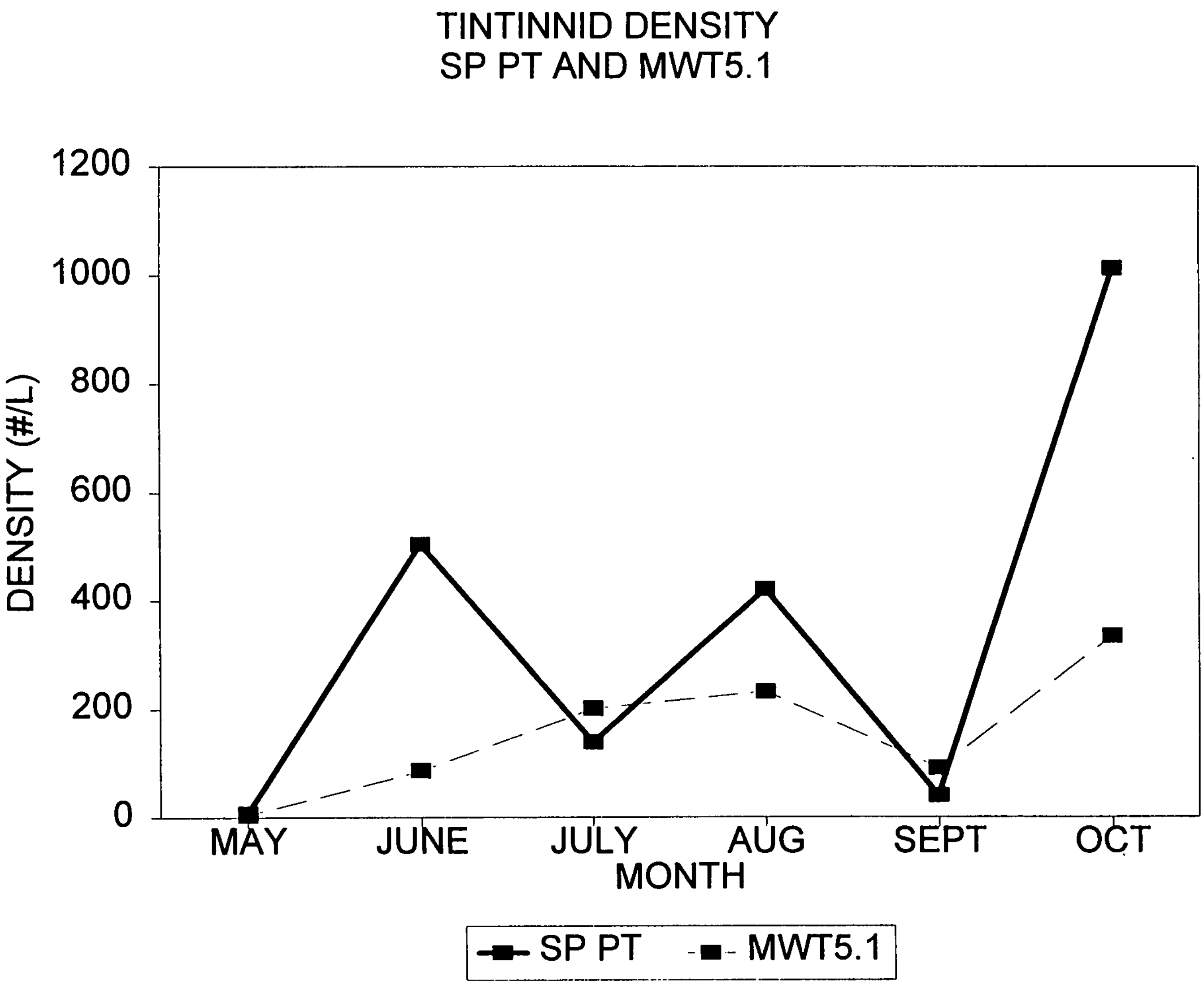

Figure 5: Monthly total tintinnid densities (#/L) for Sparrow's Point and reference station MWT5.1 for May, 1994-October, 1994. Abbreviations are: SP PT=Sparrow's Point, MWT5.1=reference station.

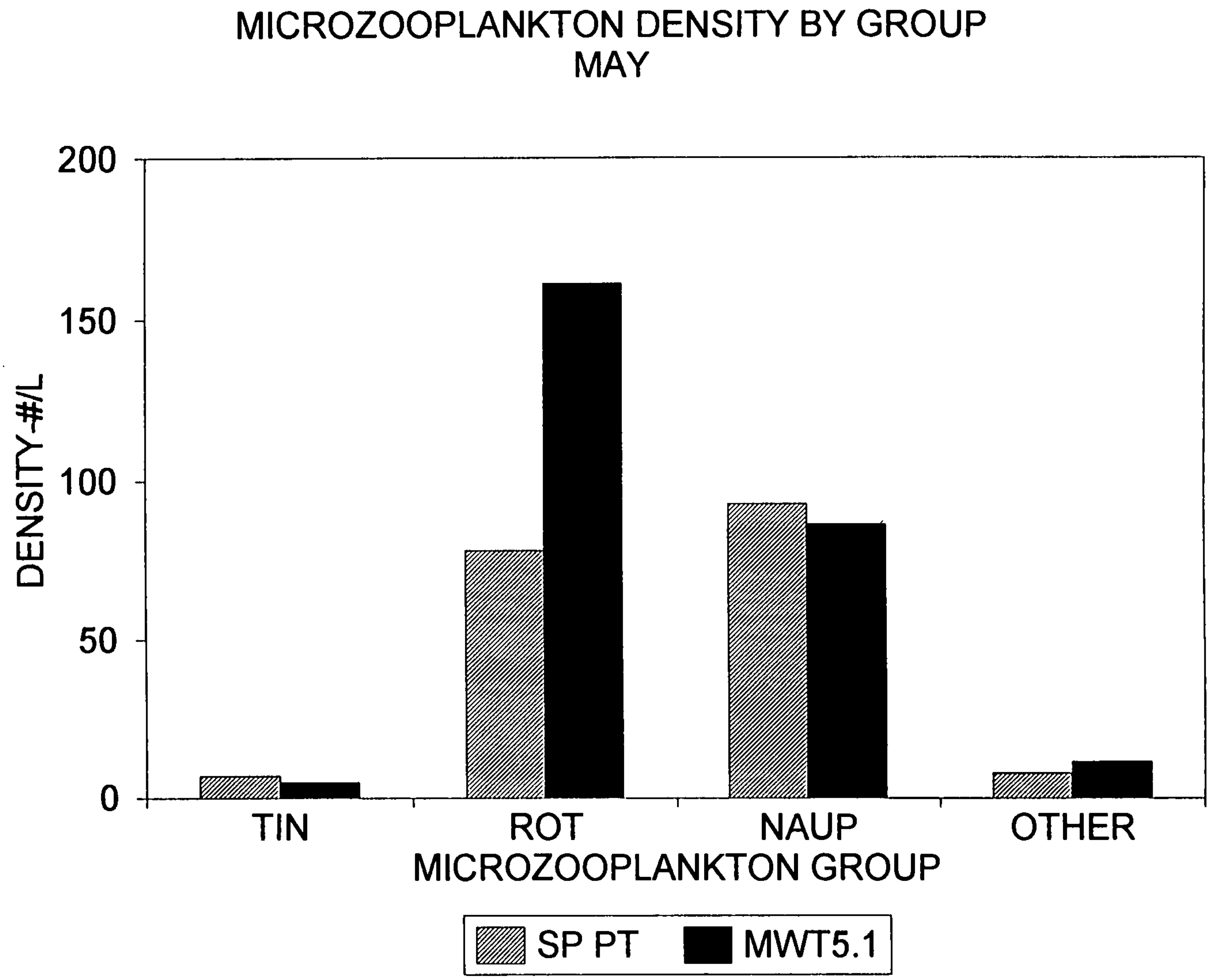

Figure 6: Microzooplankton densities (#/L) by taxonomic group for Sparrow's Point and reference station MWT5.1 for May, 1994. Abbreviations are: SP PT=Sparrow's Point, MWT5.1=reference station, TIN=tintinnids, ROT=rotifers, NAUP=copepod nauplii, OTHER=non-loricate ciliates+larvae+sarcodinids.

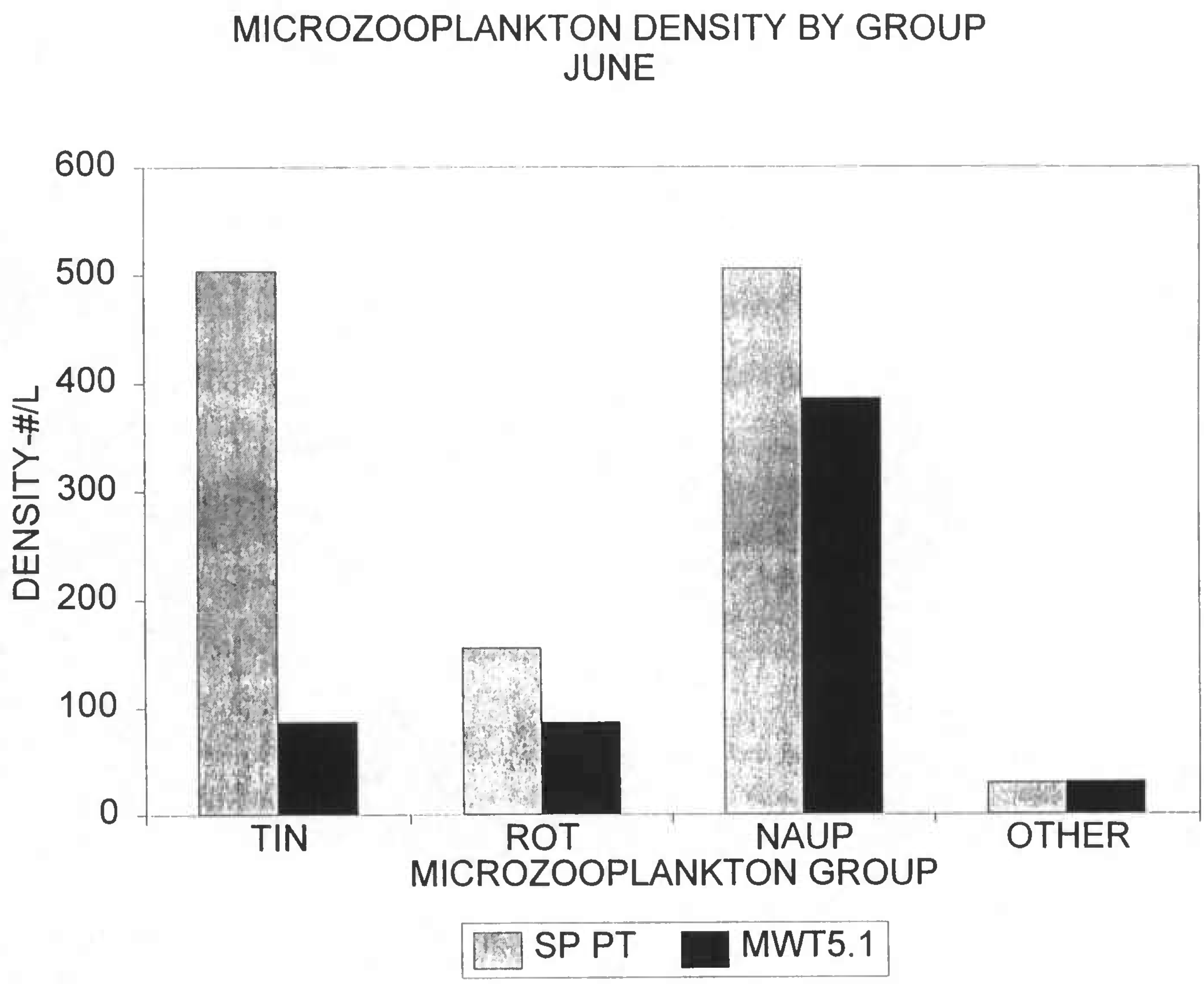

Figure 7: Microzooplankton densities (#/L) by taxonomic group for Sparrow's Point and reference station MWT5.1 for June, 1994. Abbreviations are: SP PT=Sparrow's Point, MWT5.1=reference station, TIN=tintinnids, ROT=rotifers, NAUP=copepod nauplii, OTHER=non-loricate ciliates+larvae+sarcodinids.

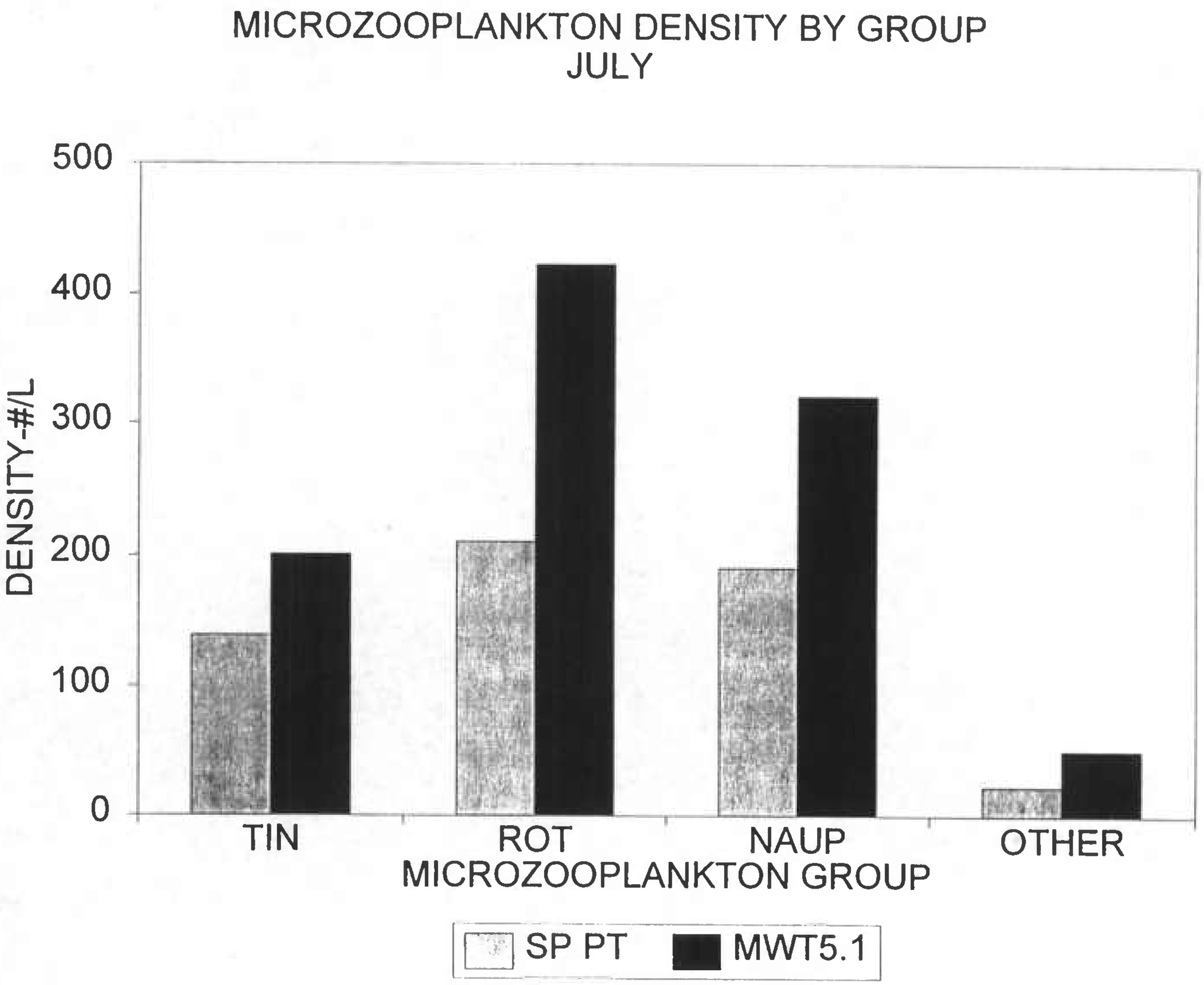

Figure 8: Microzooplankton densities (#/L) by taxonomic group for Sparrow's Point and reference station MWT5.1 for July, 1994. Abbreviations are: SP PT=Sparrow's Point, MWT5.1=reference station, TIN=tintinnids, ROT=rotifers, NAUP=copepod nauplii, OTHER=non-loricate ciliates+larvae+sarcodinids.

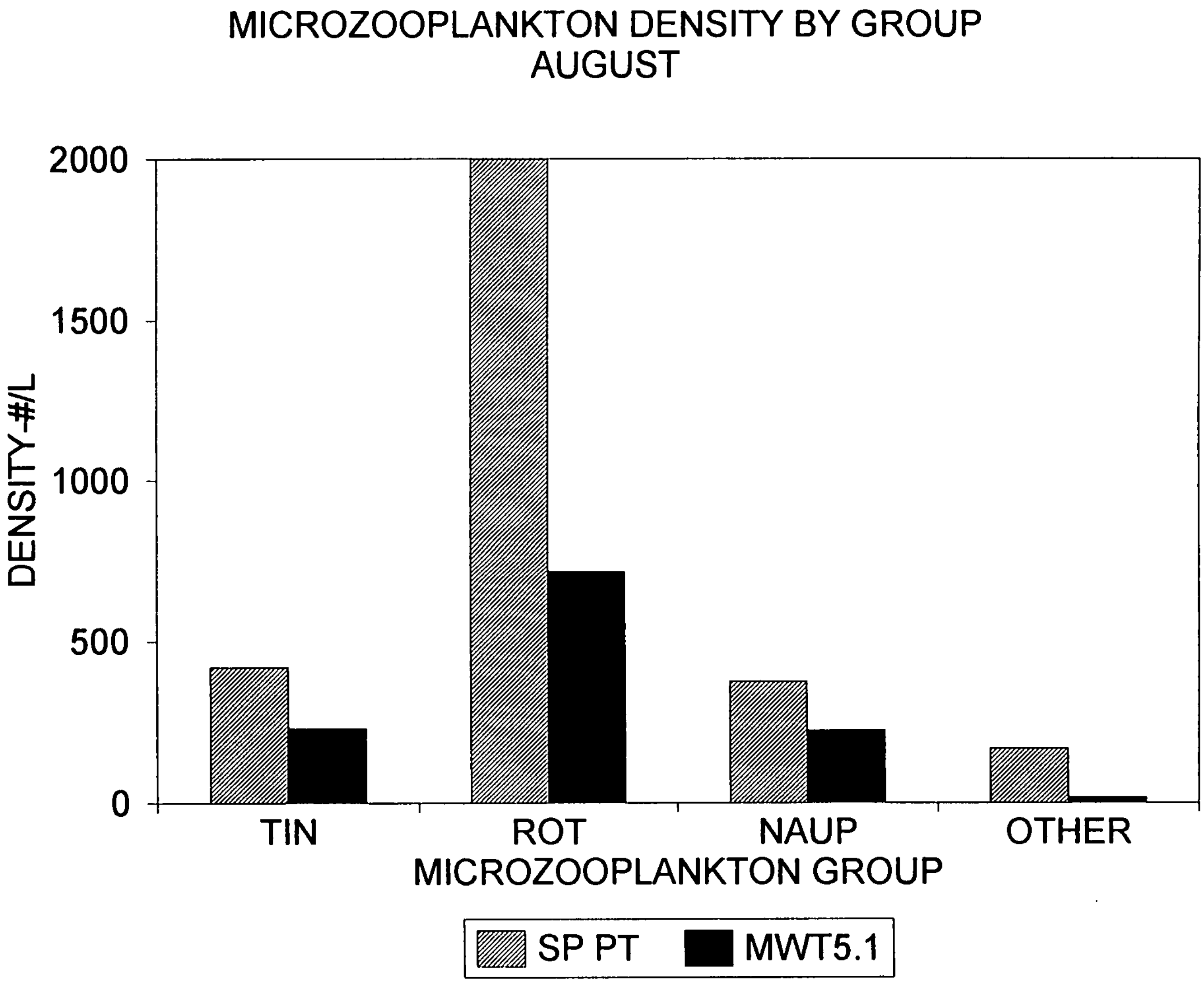

Figure 9: Microzooplankton densities (#/L) by taxonomic group for Sparrow's Point and reference station MWT5.1 for August, 1994. Abbreviations are: SP PT=Sparrow's Point, MWT5.1=reference station, TIN=tintinnids, ROT=rotifers, NAUP=copepod nauplii, OTHER=non-loricate ciliates+larvae+sarcodinids.

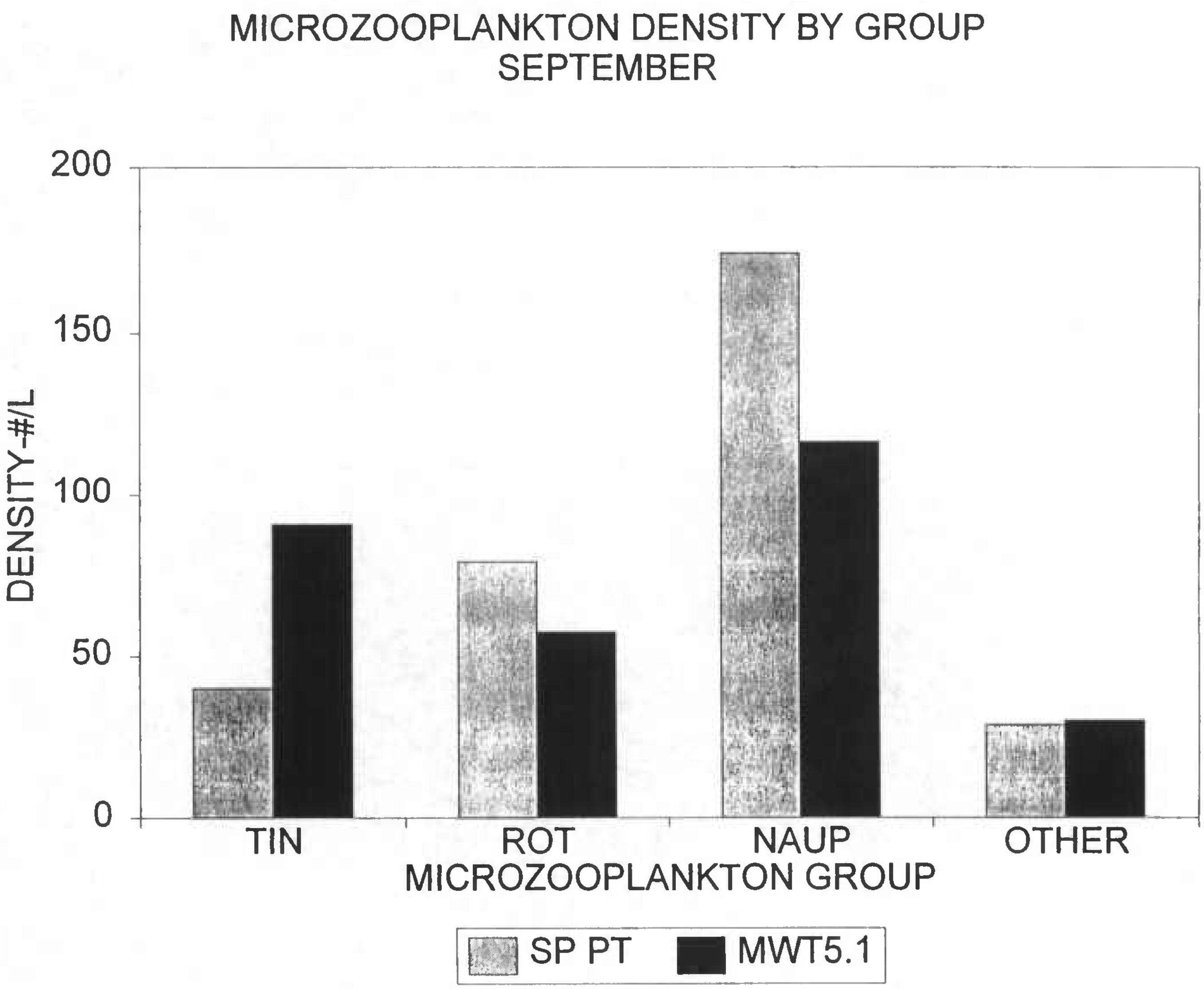

Figure 10: Microzooplankton densities (#/L) by taxonomic group for Sparrow's Point and reference station MWT5.1 for September, 1994. Abbreviations are: SP PT=Sparrow's Point, MWT5.1=reference station, TIN=tintinnids, ROT=rotifers, NAUP=copepod nauplii, OTHER=non-loricate ciliates+larvae+sarcodinids.

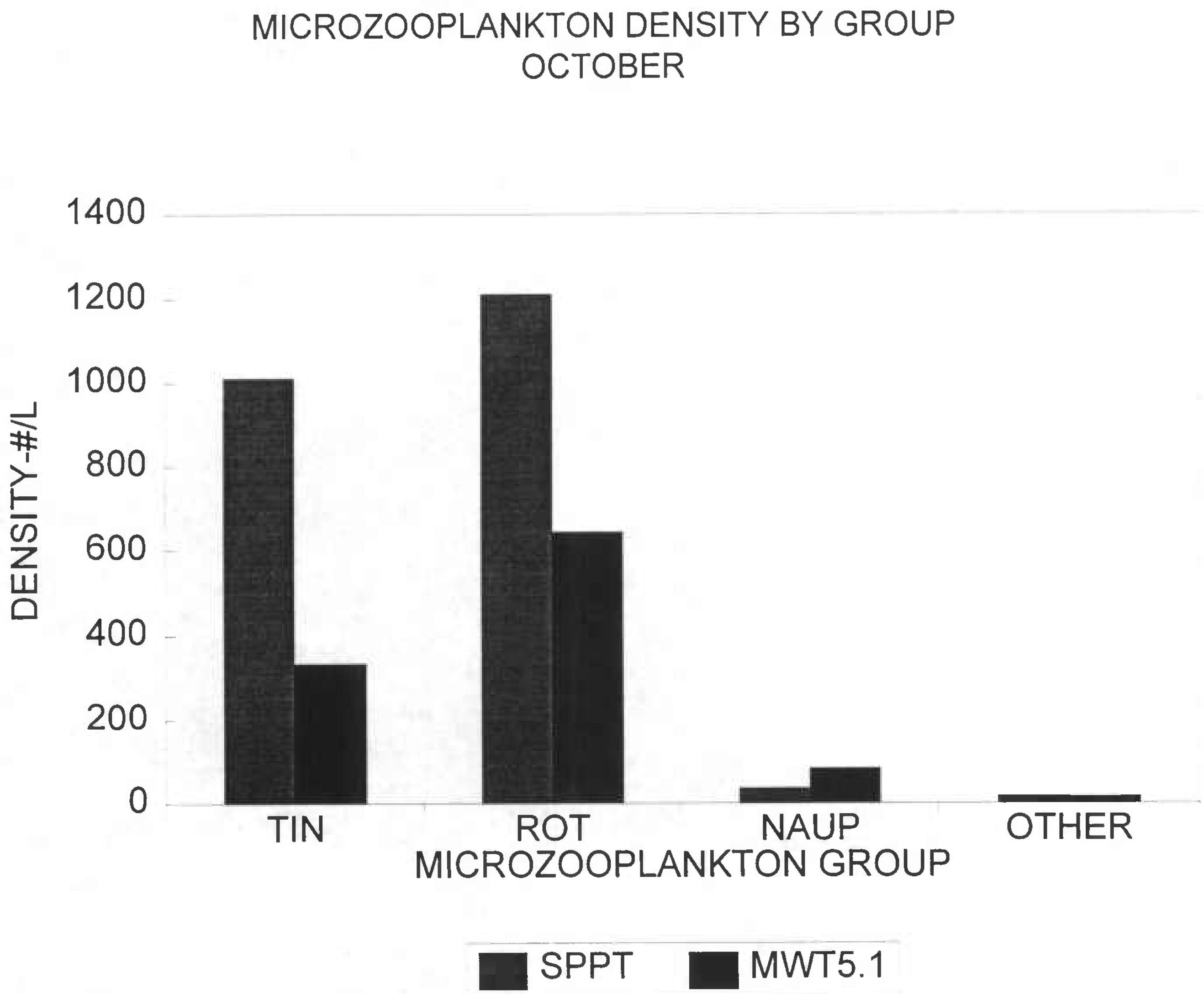

Figure 11: Microzooplankton densities (#/L) by taxonomic group for Sparrow's Point and reference station MWT5.1 for October, 1994. Abbreviations are: SP PT=Sparrow's Point, MWT5.1=reference station, TIN=tintinnids, ROT=rotifers, NAUP=copepod nauplii, OTHER=non-loricate ciliates+larvae+sarcodinids.

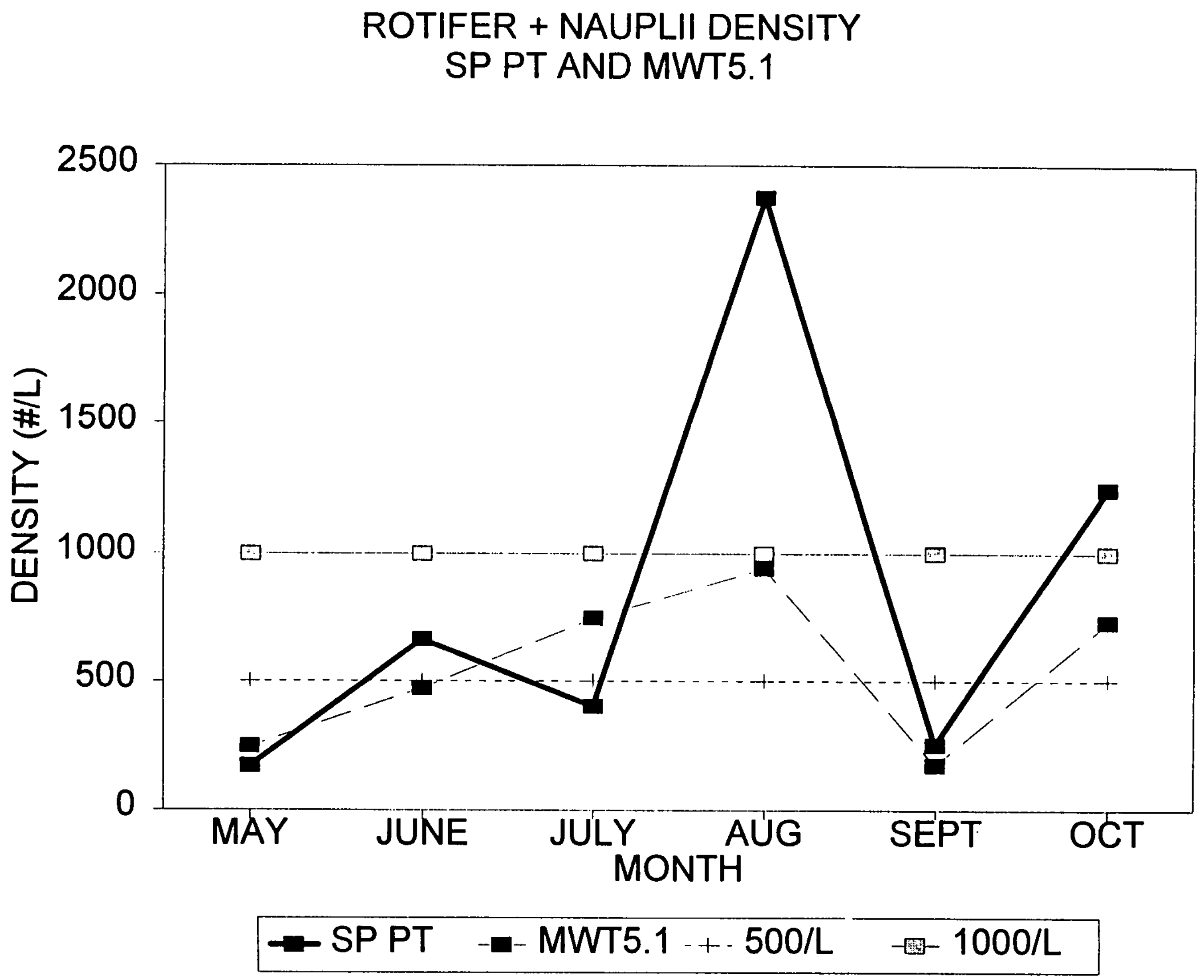

Figure 12: Monthly total rotifer+copepod densities (#/L) for Sparrow's Point and reference station MWT5.1. Abbreviations are: SP PT=Sparrow's Point, MWT5.1=reference station. Superimposed lines at 500 and 1000/L represent minimal food levels required for bay anchovies (see text).

Appendix I

Explanation of Raw Data Sets

The raw count data sets are provided in individual data files. The names of the files include the sampling trip number, a zero, and the station number followed by a W for Sparrow's Point samples or a T for reference station samples. The extension for the counts is DAT and for the recount is QA. The trip numbers are 179, 180, 182, 184, 186, and 188 for May through October. The same station number was used for both sampling sites since the data entry program only recognizes those stations used in the regular monitoring program. The data set lists the initials of the counter, number of different taxa counted, serial number, station abbreviation, date sampled, W for Sparrow's Point or T for reference station, numbers of liters filtered through the net, and number of milliliters in the final concentrated volume of the sample. This header information is followed by the NODC code, organism or group name, number counted and number of milliliters counted for that organism. The printed data sheets include the same information along with a normalized count (#/L) for each different organism counted and the entire sample. A summary table providing total numbers by taxonomic group is given at the bottom of the page.

179036 MWT5.1 940525 MZP W SPARROW'S POINT

MICROZOOPLANKTON > 44 UM

NUMBER OF LITERS FILTERED	100.0
CONCENTRATE VOLUME (ML)	50.0

SPECIES CODE	SPECIES NAME	RAW CNT	#MLS CNTD	NORM CNT (#/L)
6117000000001	COPEPOD NAUPLII	185	1.00	92.50
4506130200003	SYNCHAETA SPP. S-SMALL	132	1.00	66.00
4506010402000	BRACHIONUS CALYCIFLORUS	15	1.00	7.50
3540020123003	TINTINNOPSIS FIMBRIATA-MEUNIERI GRP	10	1.00	5.00
3512000000000	CILIOPHORA-UNIDED CILIATE	9	1.00	4.50
5500000000001	PELECYPODA-LARVAE	6	1.00	3.00
4506130200001	SYNCHAETA SPP. L-LARGE	3	1.00	1.50
3540020105000	TINTINNOPSIS DADAYI	2	1.00	1.00
3540020133000	TINTINNOPSIS SUBACUTA	2	1.00	1.00
4506010405000	BRACHIONUS URCEOLARIS	2	1.00	1.00
4506130200010	SYNCHAETA BICORNIS	1	1.00	0.50
4500000000000	ROTIFERA-UNIDED ROTIFER	1	1.00	0.50
4506130200010	SYNCHAETA BICORNIS	1	1.00	0.50
3448000000000	FORAMINIFERIDA	1	1.00	0.50
4506010406000	BRACHIONUS ANGULARIS	1	1.00	0.50
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MICROZOOPLANKTON >44UM RAW COUNT FOR ENTIRE SAMPLE 371

MICROZOOPLANKTON >44UM (#/L) FOR ENTIRE SAMPLE 185.50

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TOTALS BY TAXONOMIC GROUP

CODE#	TAXONOMIC GROUP	TOTAL #/L	%OF SAMPLE TOTAL
3540	TINTINNIDS	7.00	4
4500-4599	ROTIFERS	78.00	42
6117-6120	COPEPOD NAUPLII	92.50	50
3438-3448	SARCODINIDS	0.50	0
3512-3545	NON-LORICATE CILIATES	4.50	2
5500000000001	PELECYPOD LARVAE	3.00	2
	OTHER	0.00	0

179036 MWT5.1 940525 MZP T

MICROZOOPLANKTON > 44 UM

NUMBER OF LITERS FILTERED 100.0
CONCENTRATE VOLUME (ML) 41.0

SPECIES CODE	SPECIES NAME	RAW CNT	#MLS CNTD	NORM CNT (#/L)
4506130200003	SYNCHAETA SPP. S-SMALL	297	1.00	121.77
6117000000001	COPEPOD NAUPLII	210	1.00	86.10
4506010402000	BRACHIONUS CALYCIFLORUS	73	1.00	29.93
3512000000000	CILIOPHORA-UNIDED CILIATE	24	1.00	9.84
3540020123003	TINTINNOPSIS FIMBRIATA-MEUNIERI GRP	11	1.00	4.51
4506010405000	BRACHIONUS URCEOLARIS	10	1.00	4.10
4506130200010	SYNCHAETA BICORNIS	6	1.00	2.46
5500000000001	PELECYPODA-LARVAE	2	1.00	0.82
4506010406000	BRACHIONUS ANGULARIS	2	1.00	0.82
4500000000000	ROTIFERA-UNIDED ROTIFER	2	1.00	0.82
4506130200002	SYNCHAETA SPP. M-MEDIUM	1	1.00	0.41
3442010000000	DIFFLUGIIDAE	1	1.00	0.41
4506010106000	KERATELLA VALGA	1	1.00	0.41
4[illegible]00000000000	NEMATODA	1	1.00	0.41
4506010103000	KERATELLA COCHLEARIS	1	1.00	0.41
3540010100050	TINTINNIDIUM SP.-LARGE	1	1.00	0.41
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MICROZOOPLANKTON >44UM RAW COUNT FOR ENTIRE SAMPLE 643

MICROZOOPLANKTON >44UM (#/L) FOR ENTIRE SAMPLE 263.63

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TOTALS BY TAXONOMIC GROUP

[illegible] CODE#	TAXONOMIC GROUP	TOTAL #/L	%OF SAMPLE TOTAL
3540	TINTINNIDS	4.92	2
4500-4599	ROTIFERS	161.13	61
6117-6120	COPEPOD NAUPLII	86.10	33
[illegible]438-3448	SARCODINIDS	0.41	0
[illegible]512-3545	NON-LORICATE CILIATES	9.84	4
5500000000001	PELECYPOD LARVAE	0.82	0
	OTHER	0.41	0

180036 MWT5.1 940614 MZP W SPARROW'S POINT

MICROZOOPLANKTON > 44 UM

NUMBER OF LITERS FILTERED	100.0
CONCENTRATE VOLUME (ML)	47.0

SPECIES CODE	SPECIES NAME	RAW CNT	#MLS CNTD	NORM CNT (#/L)
6117000000001	COPEPOD NAUPLII	538	0.50	505.72
3540020123003	TINTINNOPSIS FIMBRIATA-MEUNIERI GRP	536	0.50	503.84
4506130200003	SYNCHAETA SPP. S-SMALL	159	0.50	149.46
5000000000001	PELECYPODA-LARVAE	54	1.00	25.38
4506130200010	SYNCHAETA BICORNIS	11	1.00	5.17
3512000000000	CILIOPHORA-UNIDED CILIATE	9	1.00	4.23
4506010401000	BRACHIONUS PLICATILIS	1	1.00	0.47
4506010406000	BRACHIONUS ANGULARIS	1	1.00	0.47
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MICROZOOPLANKTON >44UM RAW COUNT FOR ENTIRE SAMPLE 1309

MICROZOOPLANKTON >44UM (#/L) FOR ENTIRE SAMPLE 1194.74

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TOTALS BY TAXONOMIC GROUP

CODE#	TAXONOMIC GROUP	TOTAL #/L	%OF SAMPLE TOTAL
3540	TINTINNIDS	503.84	42
4500-4599	ROTIFERS	155.57	13
6117-6120	COPEPOD NAUPLII	505.72	42
3438-3448	SARCODINIDS	0.00	0
3512-3545	NON-LORICATE CILIATES	4.23	0
5000000000001	PELECYPOD LARVAE	25.38	2
	OTHER	0.00	0

100036 MWT5.1 940614 MZP T

MICROZOOPLANKTON > 44 UM

NUMBER OF LITERS FILTERED	100.0
CONCENTRATE VOLUME (ML)	76.0

SPECIES CODE	SPECIES NAME	RAW CNT	#MLS CNTD	NORM CNT (#/L)
6117000000001	COPEPOD NAUPLII	254	0.50	386.08
3540020123003	TINTINNOPSIS FIMBRIATA-MEUNIERI GRP	114	1.00	86.64
4506130200003	SYNCHAETA SPP. S-SMALL	103	1.00	78.28
5300000000001	PELECYPODA-LARVAE	39	1.00	29.64
4506130200010	SYNCHAETA BICORNIS	7	1.00	5.32
4506130200002	SYNCHAETA SPP. M-MEDIUM	3	1.00	2.28
4506010405000	BRACHIONUS URCEOLARIS	1	1.00	0.76
5100000000001	GASTROPODA-LARVAE	1	1.00	0.76
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MICROZOOPLANKTON >44UM RAW COUNT FOR ENTIRE SAMPLE 522

MICROZOOPLANKTON >44UM (#/L) FOR ENTIRE SAMPLE 589.76

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TOTALS BY TAXONOMIC GROUP

CODE#	TAXONOMIC GROUP	TOTAL #/L	%OF SAMPLE TOTAL
3540	TINTINNIDS	86.64	15
4500-4599	ROTIFERS	86.64	15
6117-6120	COPEPOD NAUPLII	386.08	65
3438-3448	SARCODINIDS	0.00	0
3512-3545	NON-LORICATE CILIATES	0.00	0
5300000000001	PELECYPOD LARVAE	29.64	5
	OTHER	0.76	0

182036 MWT5.1 940712 MZP W SPARROW'S POINT

MICROZOOPLANKTON > 44 UM

NUMBER OF LITERS FILTERED	50.0
CONCENTRATE VOLUME (ML)	83.0

SPECIES CODE	SPECIES NAME	RAW CNT	#MLS CNTD	NORM CNT (#/L)
6117000000001	COPEPOD NAUPLII	115	1.00	190.90
3540020123003	TINTINNOPSIS FIMBRIATA-MEUNIERI GRP	78	1.00	129.48
4506010401000	BRACHIONUS PLICATILIS	46	1.00	76.36
4506130200003	SYNCHAETA SPP. S-SMALL	42	1.00	69.72
4506010406000	BRACHIONUS ANGULARIS	16	1.00	26.56
4506130200010	SYNCHAETA BICORNIS	13	1.00	21.58
5500000000001	PELECYPODA-LARVAE	9	1.00	14.94
3540020133000	TINTINNOPSIS SUBACUTA	6	1.00	9.96
4506010402000	BRACHIONUS CALYCIFLORUS	6	1.00	9.96
3512000000000	CILIOPHORA-UNIDED CILIATE	5	1.00	8.30
4500000000000	ROTIFERA-UNIDED ROTIFER	2	1.00	3.32
4507050100000	FILINIA SP.	1	1.00	1.66
4506010106000	KERATELLA VALGA	1	1.00	1.66
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MICROZOOPLANKTON >44UM RAW COUNT FOR ENTIRE SAMPLE 340

MICROZOOPLANKTON >44UM (#/L) FOR ENTIRE SAMPLE 564.40

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TOTALS BY TAXONOMIC GROUP

CODE#	TAXONOMIC GROUP	TOTAL #/L	%OF SAMPLE TOTAL
3540	TINTINNIDS	139.44	25
4500-4599	ROTIFERS	210.82	37
6117-6120	COPEPOD NAUPLII	190.90	34
3438-3448	SARCODINIDS	0.00	0
3512-3545	NON-LORICATE CILIATES	8.30	1
5500000000001	PELECYPOD LARVAE	14.94	3
	OTHER	0.00	0

182036 MWT5.1 940712 MZP T

MICROZOOPLANKTON > 44 UM

NUMBER OF LITERS FILTERED	100.0
CONCENTRATE VOLUME (ML)	100.0

SPECIES CODE	SPECIES NAME	RAW CNT	#MLS CNTD	NORM CNT (#/L)
6117000000001	COPEPOD NAUPLII	161	0.50	322.00
4506010401000	BRACHIONUS PLICATILIS	154	0.50	308.00
3540020123003	TINTINNOPSIS FIMBRIATA-MEUNIERI GRP	89	0.50	178.00
4506130200003	SYNCHAETA SPP. S-SMALL	45	1.00	45.00
3512000000000	CILIOPHORA-UNIDED CILIATE	31	1.00	31.00
4506130200010	SYNCHAETA BICORNIS	27	1.00	27.00
3540020133000	TINTINNOPSIS SUBACUTA	23	1.00	23.00
4506010406000	BRACHIONUS ANGULARIS	23	1.00	23.00
4506070100000	TRICHOCERCA SP.	18	1.00	18.00
5500000000001	PELECYPODA-LARVAE	12	1.00	12.00
5100000000001	GASTROPODA-LARVAE	6	1.00	6.00
3516010100000	DIDINIUM SP.	2	1.00	2.00
4507050102000	FILINIA BRACHIATA	1	1.00	1.00
4500000000000	ROTIFERA-UNIDED ROTIFER	1	1.00	1.00
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MICROZOOPLANKTON >44UM RAW COUNT FOR ENTIRE SAMPLE 593

MICROZOOPLANKTON >44UM (#/L) FOR ENTIRE SAMPLE 997.00

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TOTALS BY TAXONOMIC GROUP

CODE#	TAXONOMIC GROUP	TOTAL #/L	%OF SAMPLE TOTAL
3540	TINTINNIDS	201.00	20
4500-4599	ROTIFERS	423.00	42
6117-6120	COPEPOD NAUPLII	322.00	32
3438-3448	SARCODINIDS	0.00	0
3512-3545	NON-LORICATE CILIATES	33.00	3
5500000000001	PELECYPOD LARVAE	12.00	1
	OTHER	6.00	1

184036 MWT5.1 940816 MZP W SPARROW'S POINT

MICROZOOPLANKTON > 44 UM

NUMBER OF LITERS FILTERED	50.0
CONCENTRATE VOLUME (ML)	84.0

SPECIES CODE	SPECIES NAME	RAW CNT	#MLS CNTD	NORM CNT (#/L)
4506010401000	BRACHIONUS PLICATILIS	277	0.50	930.72
4506130200003	SYNCHAETA SPP. S-SMALL	253	0.50	850.08
3540020123003	TINTINNOPSIS FIMBRIATA-MEUNIERI GRP	125	0.50	420.00
6117000000001	COPEPOD NAUPLII	112	0.50	376.32
4506130200010	SYNCHAETA BICORNIS	98	1.00	164.64
5500000000001	PELECYPODA-LARVAE	61	1.00	102.48
3512000000000	CILIOPHORA-UNIDED CILIATE	41	1.00	68.88
4506070100000	TRICHOCERCA SP.	27	1.00	45.36
4500000000000	ROTIFERA-UNIDED ROTIFER	4	1.00	6.72
4506010406000	BRACHIONUS ANGULARIS	1	1.00	1.68
		-----	------	----------

MICROZOOPLANKTON >44UM RAW COUNT FOR ENTIRE SAMPLE 999

MICROZOOPLANKTON >44UM (#/L) FOR ENTIRE SAMPLE 2966.88

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TOTALS BY TAXONOMIC GROUP

CODE#	TAXONOMIC GROUP	TOTAL #/L	%OF SAMPLE TOTAL
3540	TINTINNIDS	420.00	14
4500-4599	ROTIFERS	1999.20	67
6117-6120	COPEPOD NAUPLII	376.32	13
3438-3448	SARCODINIDS	0.00	0
3512-3545	NON-LORICATE CILIATES	68.88	2
5500000000001	PELECYPOD LARVAE	102.48	3
	OTHER	0.00	0

184036 MWT5.1 940816 MZP T

MICROZOOPLANKTON > 44 UM

NUMBER OF LITERS FILTERED	100.0
CONCENTRATE VOLUME (ML)	101.0

SPECIES CODE	SPECIES NAME	RAW CNT	#MLS CNTD	NORM CNT (#/L)
4506130200010	SYNCHAETA BICORNIS	153	0.50	309.06
4506010401000	BRACHIONUS PLICATILIS	146	0.50	294.92
3540020123003	TINTINNOPSIS FIMBRIATA-MEUNIERI GRP	115	0.50	232.30
6117000000001	COPEPOD NAUPLII	113	0.50	228.26
4506130200003	SYNCHAETA SPP. S-SMALL	101	1.00	102.01
5500000000001	PELECYPODA-LARVAE	11	1.00	11.11
3512000000000	CILIOPHORA-UNIDED CILIATE	6	1.00	6.06
4500000000000	ROTIFERA-UNIDED ROTIFER	3	1.00	3.03
4506010103020	KERATELLA COCHLEARIS COCHLEARIS	2	1.00	2.02
4506130300000	POLYARTHRA SP.	2	1.00	2.02
[illegible]100000000001	GASTROPODA-LARVAE	1	1.00	1.01
4507050100000	FILINIA SP.	1	1.00	1.01
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MICROZOOPLANKTON >44UM RAW COUNT FOR ENTIRE SAMPLE 654

MICROZOOPLANKTON >44UM (#/L) FOR ENTIRE SAMPLE 1192.81

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TOTALS BY TAXONOMIC GROUP

CODE#	TAXONOMIC GROUP	TOTAL #/L	%OF SAMPLE TOTAL
3540	TINTINNIDS	232.30	19
4500-4599	ROTIFERS	714.07	60
6117-6120	COPEPOD NAUPLII	228.26	19
3438-3448	SARCODINIDS	0.00	0
3512-3545	NON-LORICATE CILIATES	6.06	1
5500000000001	PELECYPOD LARVAE	11.11	1
	OTHER	1.01	0

186036 MWT5.1 940913 MZP W SPARROW'S POINT

MICROZOOPLANKTON > 44 UM

NUMBER OF LITERS FILTERED 50.0
CONCENTRATE VOLUME (ML) 63.0

SPECIES CODE	SPECIES NAME	RAW CNT	#MLS CNTD	NORM CNT (#/L)
6117000000001	COPEPOD NAUPLII	138	1.00	173.88
4506010401000	BRACHIONUS PLICATILIS	37	1.00	46.62
3540010100050	TINTINNIDIUM SP.-LARGE	22	1.00	27.72
4506130200003	SYNCHAETA SPP. S-SMALL	17	1.00	21.42
5500000000001	PELECYPODA-LARVAE	14	1.00	17.64
3540020123003	TINTINNOPSIS FIMBRIATA-MEUNIERI GRP	10	1.00	12.60
4506130200010	SYNCHAETA BICORNIS	7	1.00	8.82
3512000000000	CILIOPHORA-UNIDED CILIATE	7	1.00	8.82
4506130200002	SYNCHAETA SPP. M-MEDIUM	2	1.00	2.52
0000000000001	UNIDED LARVAE	1	1.00	1.26
3516010100000	DIDINIUM SP.	1	1.00	1.26
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MICROZOOPLANKTON >44UM RAW COUNT FOR ENTIRE SAMPLE 256

MICROZOOPLANKTON >44UM (#/L) FOR ENTIRE SAMPLE 322.56
****

TOTALS BY TAXONOMIC GROUP

CODE#	TAXONOMIC GROUP	TOTAL #/L	%OF SAMPLE TOTAL
3540	TINTINNIDS	40.32	13
4500-4599	ROTIFERS	79.38	25
6117-6120	COPEPOD NAUPLII	173.88	54
3438-3448	SARCODINIDS	0.00	0
3512-3545	NON-LORICATE CILIATES	10.08	3
5500000000001	PELECYPOD LARVAE	17.64	5
	OTHER	1.26	0

1[illegible]6036 MWT5.1 940913 MZP T

MICROZOOPLANKTON > 44 UM

NUMBER OF LITERS FILTERED	100.0
CONCENTRATE VOLUME (ML)	101.0

SPECIES CODE	SPECIES NAME	RAW CNT	#MLS CNTD	NORM CNT (#/L)
6117000000001	COPEPOD NAUPLII	115	1.00	116.15
3540010100050	TINTINNIDIUM SP.-LARGE	87	1.00	87.87
4506130200010	SYNCHAETA BICORNIS	20	1.00	20.20
4506130200003	SYNCHAETA SPP. S-SMALL	18	1.00	18.18
4506010401000	BRACHIONUS PLICATILIS	14	1.00	14.14
5500000000001	PELECYPODA-LARVAE	10	1.00	10.10
3512000000000	CILIOPHORA-UNIDED CILIATE	9	1.00	9.09
4506130200002	SYNCHAETA SPP. M-MEDIUM	4	1.00	4.04
3545010000000	EUPLOTIDAE	4	1.00	4.04
[illegible]000000000001	UNIDED LARVAE	4	1.00	4.04
3540020123003	TINTINNOPSIS FIMBRIATA-MEUNIERI GRP	3	1.00	3.03
3516010100000	DIDINIUM SP.	3	1.00	3.03
4506130200001	SYNCHAETA SPP. L-LARGE	1	1.00	1.01
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MICROZOOPLANKTON >44UM RAW COUNT FOR ENTIRE SAMPLE 292

MICROZOOPLANKTON >44UM (#/L) FOR ENTIRE SAMPLE 294.92

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TOTALS BY TAXONOMIC GROUP

CODE#	TAXONOMIC GROUP	TOTAL #/L	%OF SAMPLE TOTAL
3540	TINTINNIDS	90.90	31
4500-4599	ROTIFERS	57.57	20
6117-6120	COPEPOD NAUPLII	116.15	39
3438-3448	SARCODINIDS	0.00	0
3512-3545	NON-LORICATE CILIATES	16.16	5
5500000000001	PELECYPOD LARVAE	10.10	3
	OTHER	4.04	1

188036 MWT5.1 941012 MZP W SPARROW'S POINT

MICROZOOPLANKTON > 44 UM

NUMBER OF LITERS FILTERED	50.0
CONCENTRATE VOLUME (ML)	63.0

SPECIES CODE	SPECIES NAME	RAW CNT	#MLS CNTD	NORM CNT (#/L)
4506130200003	SYNCHAETA SPP. S-SMALL	232	0.25	1169.28
3540020123003	TINTINNOPSIS FIMBRIATA-MEUNIERI GRP	109	0.25	549.36
3540010100050	TINTINNIDIUM SP.-LARGE	92	0.25	463.68
6117000000001	COPEPOD NAUPLII	29	1.00	36.54
4506130200010	SYNCHAETA BICORNIS	21	1.00	26.46
4506130200001	SYNCHAETA SPP. L-LARGE	11	1.00	13.86
3512000000000	CILIOPHORA-UNIDED CILIATE	6	1.00	7.56
5500000000001	PELECYPODA-LARVAE	5	1.00	6.30
3516010100000	DIDINIUM SP.	2	1.00	2.52
4506070100000	TRICHOCERCA SP.	1	1.00	1.26
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MICROZOOPLANKTON >44UM RAW COUNT FOR ENTIRE SAMPLE 508

MICROZOOPLANKTON >44UM (#/L) FOR ENTIRE SAMPLE 2276.82

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TOTALS BY TAXONOMIC GROUP

CODE#	TAXONOMIC GROUP	TOTAL #/L	%OF SAMPLE TOTAL
3540	TINTINNIDS	1013.04	44
4500-4599	ROTIFERS	1210.86	53
6117-6120	COPEPOD NAUPLII	36.54	2
3438-3448	SARCODINIDS	0.00	0
3512-3545	NON-LORICATE CILIATES	10.08	0
5500000000001	PELECYPOD LARVAE	6.30	0
	OTHER	0.00	0

188036 MWT5.1 941012 MZP T

MICROZOOPLANKTON > 44 UM

NUMBER OF LITERS FILTERED 100.0
CONCENTRATE VOLUME (ML) 81.0

SPECIES CODE	SPECIES NAME	RAW CNT	#MLS CNTD	NORM CNT (#/L)
4506130200003	SYNCHAETA SPP. S-SMALL	379	0.50	613.98
3540020123003	TINTINNOPSIS FIMBRIATA-MEUNIERI GRP	194	0.50	314.28
6117000000001	COPEPOD NAUPLII	103	1.00	83.43
3540010100050	TINTINNIDIUM SP.-LARGE	24	1.00	19.44
4506130200010	SYNCHAETA BICORNIS	19	1.00	15.39
3516010100000	DIDINIUM SP.	8	1.00	6.48
4506130200002	SYNCHAETA SPP. M-MEDIUM	7	1.00	5.67
3512000000000	CILIOPHORA-UNIDED CILIATE	6	1.00	4.86
4506130200001	SYNCHAETA SPP. L-LARGE	5	1.00	4.05
4506010103020	KERATELLA COCHLEARIS COCHLEARIS	4	1.00	3.24
0000000000001	UNIDED LARVAE	3	1.00	2.43
5500000000001	PELECYPODA-LARVAE	2	1.00	1.62
4500000000000	ROTIFERA-UNIDED ROTIFER	2	1.00	1.62
4506010401000	BRACHIONUS PLICATILIS	1	1.00	0.81
		-----	------	----------

MICROZOOPLANKTON >44UM RAW COUNT FOR ENTIRE SAMPLE 757

MICROZOOPLANKTON >44UM (#/L) FOR ENTIRE SAMPLE 1077.30
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TOTALS BY TAXONOMIC GROUP

CODE#	TAXONOMIC GROUP	TOTAL #/L	%OF SAMPLE TOTAL
3540	TINTINNIDS	333.72	31
4500-4599	ROTIFERS	644.76	60
6117-6120	COPEPOD NAUPLII	83.43	8
3438-3448	SARCODINIDS	0.00	0
3512-3545	NON-LORICATE CILIATES	11.34	1
5500000000001	PELECYPOD LARVAE	1.62	0
	OTHER	2.43	0

188036 MWT5.1 941012 MZP W SPARROW'S POINT

MICROZOOPLANKTON > 44 UM

NUMBER OF LITERS FILTERED	50.0
CONCENTRATE VOLUME (ML)	63.0

SPECIES CODE	SPECIES NAME	RAW CNT	#MLS CNTD	NORM CNT (#/L)
4506130200003	SYNCHAETA SPP. S-SMALL	232	0.25	1169.28
3540020123003	TINTINNOPSIS FIMBRIATA-MEUNIERI GRP	109	0.25	549.36
3540010100050	TINTINNIDIUM SP.-LARGE	92	0.25	463.68
6117000000001	COPEPOD NAUPLII	29	1.00	36.54
4506130200010	SYNCHAETA BICORNIS	21	1.00	26.46
4506130200001	SYNCHAETA SPP. L-LARGE	11	1.00	13.86
3512000000000	CILIOPHORA-UNIDED CILIATE	6	1.00	7.56
5500000000001	PELECYPODA-LARVAE	5	1.00	6.30
3516010100000	DIDINIUM SP.	2	1.00	2.52
4506070100000	TRICHOCERCA SP.	1	1.00	1.26
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MICROZOOPLANKTON >44UM RAW COUNT FOR ENTIRE SAMPLE 508

MICROZOOPLANKTON >44UM (#/L) FOR ENTIRE SAMPLE 2276.82

****

TOTALS BY TAXONOMIC GROUP

CODE#	TAXONOMIC GROUP	TOTAL #/L	%OF SAMPLE TOTAL
3540	TINTINNIDS	1013.04	44
4500-4599	ROTIFERS	1210.86	53
6117-6120	COPEPOD NAUPLII	36.54	2
3438-3448	SARCODINIDS	0.00	0
3512-3545	NON-LORICATE CILIATES	10.08	0
5500000000001	PELECYPOD LARVAE	6.30	0
	OTHER	0.00	0

Appendix D:

Mesozooplankton Population

Versar, Inc.

ZOOPLANKTON SURVEY

SPARROWS POINT SHORELINE

RECLAMATION PROJECT

Prepared for

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December 1994

FOREWORD

This report was prepared by Versar, Inc, with funding from the Maryland Port Administration and Maryland Environmental Services under the direction of Richard Eskin of the Maryland Department of the Environment (MDE). Sampling support, reference station information, and long-term trends in zooplankton abundance were supplied by the Maryland Department of Environment through the Chesapeake Bay Monitoring Program.

TABLE OF CONTENTS

1.0 INTRODUCTION

The Maryland Port Administration (MPA) and Maryland Environmental Service (MES) are investigating the feasibility of placing dredged materials along the shoreline of Sparrows Point just west of Old Roads Bay. The proposed project involves constructing wetland habitat using material dredged from the approach channels to Baltimore Harbor. MES initiated a series of studies to characterize the current condition and biological productivity of the proposed site and compare the living resources inhabiting the project waters with those inhabiting nearby reference stations that are monitored routinely by the Chesapeake Bay Water Quality Monitoring Program. This report presents the results of five months of monitoring of the mesozooplankton community at the proposed wetland creation site.

Mesozooplankton are planktonic invertebrates that are an important link in the food chain in estuarine ecosystems. These tiny crustaceans, often called copepods, range in size from 0.2 mm to about 2 mm in length. Many scientists consider mesozooplankton to be the most abundant multicelled organisms on Earth. Copepods proliferate throughout the Chesapeake Bay, where there are about 50 species. In estuarine (brackish) water, however, only a few species make up 95% of the average population. Copepods generally are free swimming and typically are filter feeders capable of consuming large quantities of phytoplankton (microscopic plants) and organic detritus from the water column. Mesozooplankton populations constitute a primary source of food for fishes such as bay anchovy and are important food sources for larval fish such as striped bass, white perch, and juvenile menhaden.

This study was conducted to characterize the species composition and abundances of the mesozooplankton populations within the proposed area of the Sparrows Point reclamation project and to provide a baseline of environmental information for evaluating the potential effect of the proposed project.

2.0 METHODS

Mesozooplankton were collected monthly at a station (SP01.0) the Sparrows Point reclamation site (Fig. 2-1) between May and October 1994 (Table 2-1). Data from two additional reference stations, MDE's Chesapeake Bay monitoring stations MWT5.1 (near the Key Bridge) and main bay station MCB2.2, also were sampled to compare the composition of the zooplankton community at the project site with the communities of the Patapsco River and upper bay.

Table 2-1. Collection dates for mesozooplankton samples from the Sparrows Point, Baltimore Harbor, and upper bay stations, May through October 1994

Station	May	Jun	Jul	Aug	Sep	Oct
Sparrows Point (SPO1.0)	25	14	12	16	13	12
Baltimore Harbor (MWT5.1)	25	14	12	16	13	12
Main Bay (MCB2.2)	31	15	13	17	14	13

Mesozooplankton samples were obtained by towing a 20-cm bongo net (202-μ mesh net) in a stepped oblique fashion. Two replicates were collected. The entire water column was sampled by deploying the gear just above the bottom and raising the net in timed progressive steps; the duration of the tow was typically five minutes. The actual volume of water filtered through each net was calculated using a General Oceanics flowmeter mounted in the mouth of one side of the bongo net. Ancillary data, including dissolved oxygen concentration, conductivity (salinity), temperature, pH, and Secchi disk depth, were collected at each station.

Laboratory processing procedures for taxonomic analysis included counting and identifying zooplankton in subsamples of the original sample. Subsamples were taken using a Hensen-Stempel pipette, and a hierarchical counting technique was employed to obtain reliable density estimates for dominant and less abundant species. This procedure consisted of first counting at least 60 individuals of the dominant forms (e.g., *Acartia tonsa*) in a small subsample (usually 1 to 2 ml); then all species that had counts less than 60 in the 1 to 2 ml subsample were counted in subsequent subsamples of 5 and 10 ml. Appropriate calculations were made to express counts for each species as estimates per cubic meter of water sampled (#s/m^3).

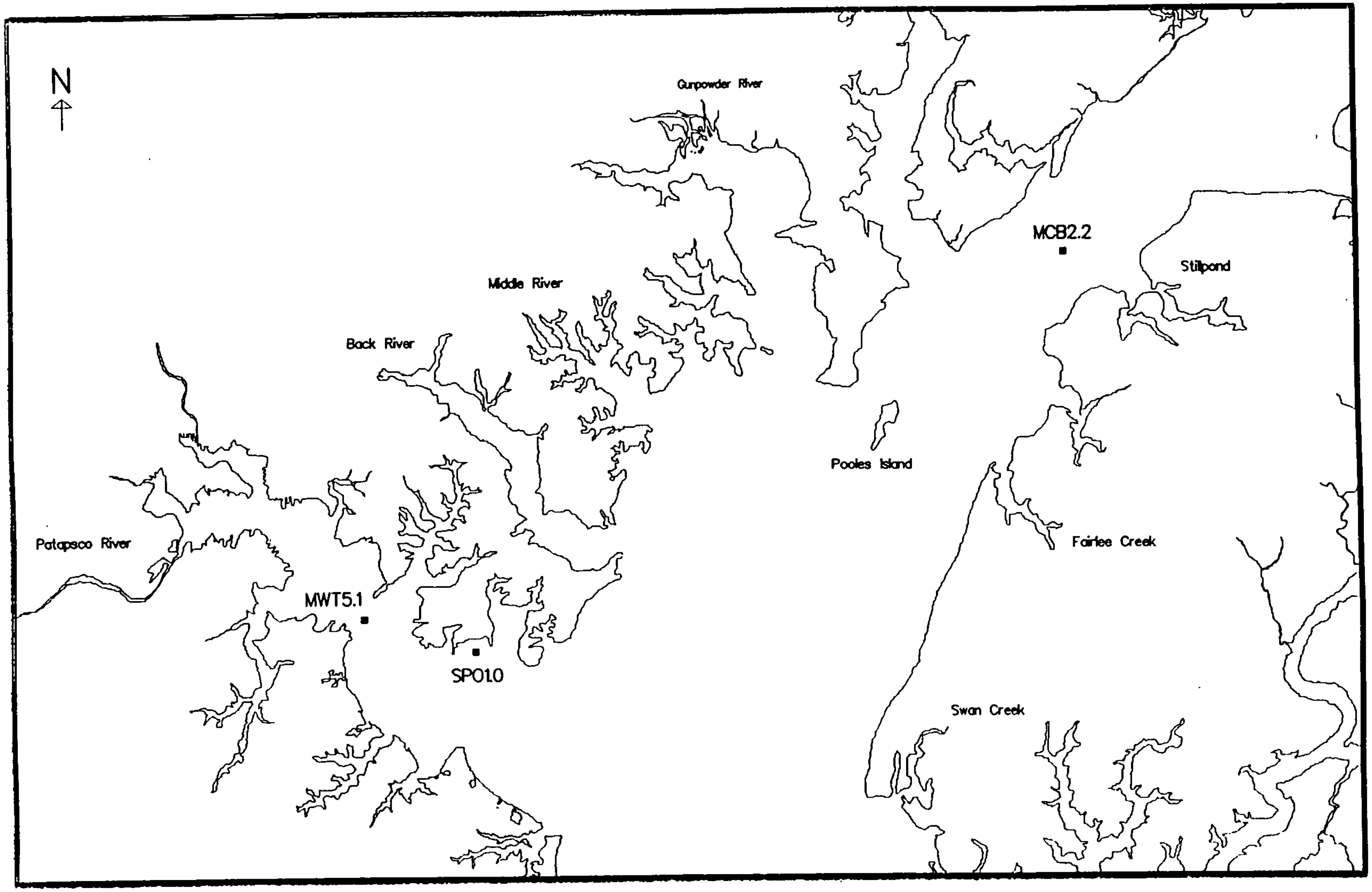

Figure 2-1. Sampling locations and station designations for the Sparrows Point Reclamation Project zooplankton survey

3.0 RESULTS AND DISCUSSION

3.1 SPECIES COLLECTED

Table 3-1 lists all species collected at the three stations sampled during the study period. Many species were common to all three stations and are prevalent throughout the oligohaline (0.5-5 ppt salinity) and mesohaline (5-18 ppt salinity) regions of the Chesapeake Bay. Samples from all three stations contained the calanoid copepods *Acartia tonsa* and *Eurytemora affinis*, and the cyclopoid copepod *Oithona colcarva*. All stations also had the parasitic copepod *Ergasilus* sp., harpactacoids, ostracods, polychaete larvae, and barnacle and copepod nauplii. One cladoceran, *Moina* sp., was found in all regions sampled. The oligohaline station, MCB2.2, exhibited greater diversity throughout the study period and included many examples of freshwater species. The only species found at both the Sparrows Point and Baltimore Harbor stations but not at the upper bay station was the saltwater cladoceran *Podon polyphemoides*.

Total species counts for the study period illustrate the greater diversity at the oligohaline upper bay station. The Sparrows Point station, with 16 species, and the Baltimore Harbor station, with 13 species, were more similar in species count and composition than the upper bay station, at which 27 species were found throughout the study period.

3.2 SPATIAL DIFFERENCES IN SPECIES COMPOSITION

Salinity controls the distribution of estuarine species, primarily because of physiological processes and the osmotic stress caused by the salt content of the water (Reid 1961). Some organisms have a wide tolerance for changes in salinity and are found in many salinity zones. Others have a limited ability to withstand salinity changes and, therefore, may be restricted to one salinity zone (e.g., fresh or marine). Salinities can vary even at fixed sampling sites because of tidal state, freshwater input, and current regimes at the time of sampling. Table 3-2 shows the mean salinity measured during each sampling event. The upper bay station, MCB2.2, is influenced strongly by the freshwater flows from the Susquehanna River and was either fresh or oligohaline throughout the study. The Sparrows Point and Baltimore Harbor stations were more similar in salinity ranges, but the Sparrows Point site was consistently a lower salinity environment. The spatial distribution of the zooplankton communities probably was influenced by these salinity characteristics.

The relative species composition at the three stations differed throughout the study period (Figure 3-1). The Sparrows Point and Baltimore Harbor stations, both located on the Patapsco River, showed similar species compositions. The copepod *Acartia tonsa* was the dominant species in these areas (over 90% at both stations). At the Sparrows Point station cladocerans constituted a large portion of the community. The consistently lower salinity (Table 3-2) at this station may have provided a more suitable habitat for cladocerans. The oligohaline station, MCB2.2, had slightly greater numbers of the calanoid *Eurytemora affinis*

Table 3-1. List of species at the Sparrows Point, Baltimore Harbor, and upper bay stations, May through October 1994			
Species	**Sparrows Point**	**Baltimore Harbor**	**Upper Bay**
Acartia tonsa	X	X	X
Barnacle nauplii	X	X	X
Bosmina longirostris	X		X
Ceriodaphnia lacustris			X
Ceriodaphnia quadrangula	X		X
Copepod nauplii	X	X	X
Cyclops bicuspidatus	X		X
Cyclops sp.			X
Cyclops spp.			X
Cyclops varicans		X	
Cyclops vernalis			X
Daphnia sp.			X
Diaphanosoma sp.	X		X
Diaptomus sp.			X
Ergasilus sp.	X	X	X
Eurytemora affinis	X	X	X
Halicyclops magnaceps			X
Halicyclops sp.			X
Harpacticoida	X	X	X
Hemicyclops sp.		X	
Ilyocryptus spinifer			X
Latona setifera			X
Mesocyclops edax			X
Moina spp.	X	X	X
Oithona colcarva	X	X	X
Ostracoda	X	X	X
Paracyclops sp.			X
Podon polyphemoides	X	X	
Polychaete larvae	X	X	X
Pseudocalanus minutus	X		
Sida crystallina			X
Total Species	**16**	**13**	**27**

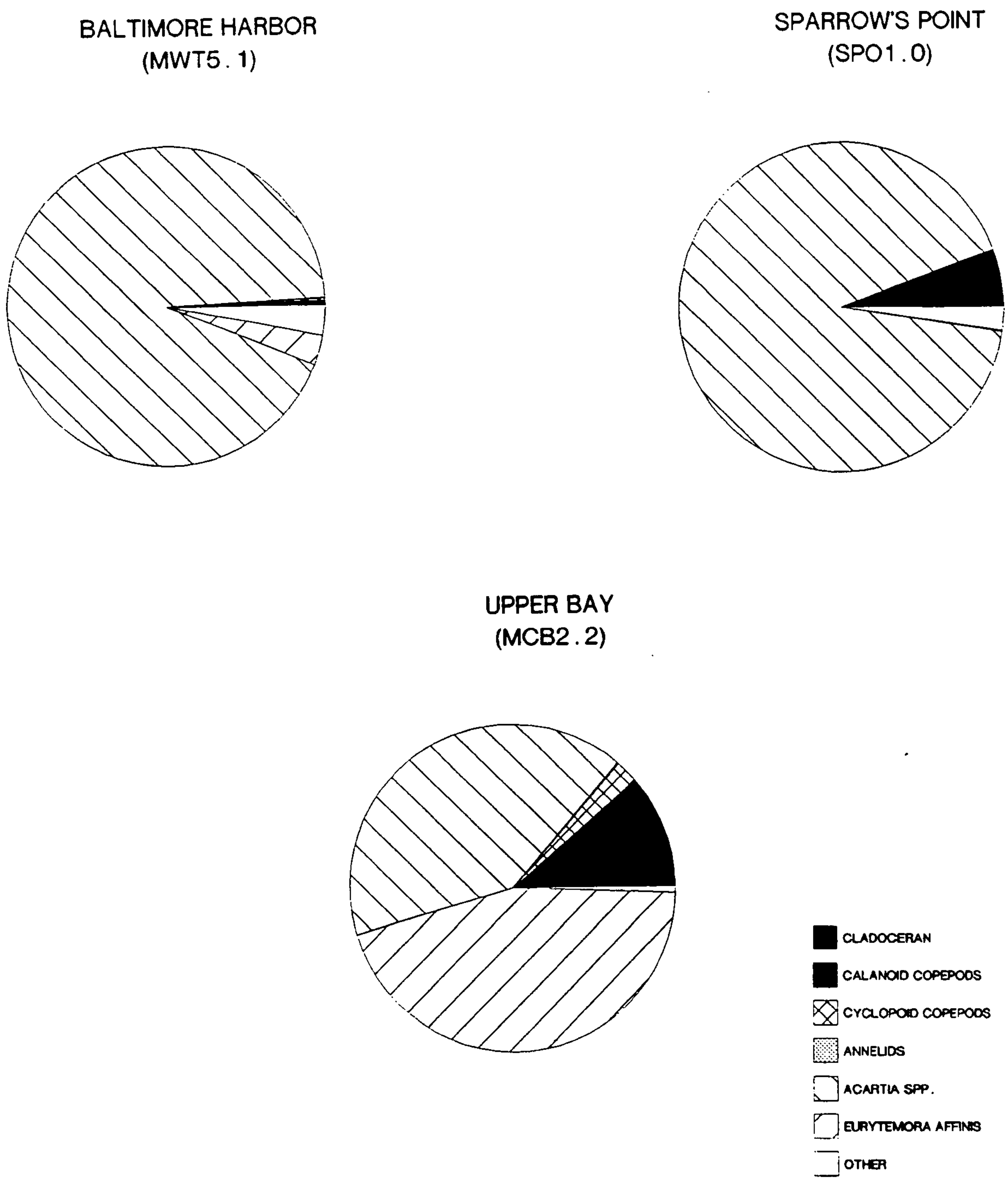

Figure 3-1 Percent composition by species group at the Sparrows Point, Baltimore Harbor, and upper bay stations, May through October 1994

than of *Acartia tonsa* during the study period. *Acartia tonsa*, however, was still a major constituent (41%) of the community at this station. The cladoceran population was even more prevalent at the upper bay station than at the Sparrows Point station, as expected in a lower salinity environment.

Table 3-2. Mean salinities (ppt) at the Sparrows Point, Baltimore Harbor, and upper bay stations, May through October 1994

Station	May	Jun	Jul	Aug	Sep	Oct
Sparrows Point (SPO1.0)	5.03	4.8	3.5	*	9.37	10.07
Baltimore Harbor (MWT5.1)	7.15	5.6	6.84	7.54	12.06	12.84
Upper Bay (MCB2.2)	3.43	0.0	0.0	0.87	3.3	4.13

* Salinity data not available.

3.3 TEMPORAL DIFFERENCES IN SPECIES COMPOSITION

Zooplankton in the Chesapeake Bay exhibit seasonal shifts in abundance because of various factors including changes in temperature and salinity (MDE 1992). The six-month study encompassed a major transitional phase from spring to summer. A shift in dominance from *E. affinis* in colder months to *A. tonsa* in warmer months is historically most evident in oligohaline habitats (MDE 1992). As seen in Figure 3-2, *E. affinis* was the dominant species at the oligohaline station, MCB2.2, during the first half of the sampling period but was replaced by *A. tonsa* during August. The trends in the composition of the zooplankton community at the Sparrows Point station were similar to trends at the Baltimore Harbor station. *A. tonsa* was the dominant species throughout the study. *E. affinis* was found at both the Sparrows Point and Baltimore Harbor stations during May, and the relative abundance of cladocerans reached a minor peak during July.

Although the relative abundances were similar at the Sparrows Point and Baltimore Harbor sta2tions, the total densities were dissimilar (Fig. 3-3). The densities at the Sparrows Point station were consistently lower than at either of the other study sites. The mean total densities (numbers per cubic meter) throughout the study period were 2, 579, 11, 905, and 21, 681/m^3 at the Sparrows Point, Baltimore Harbor, and upper bay stations, respectively.

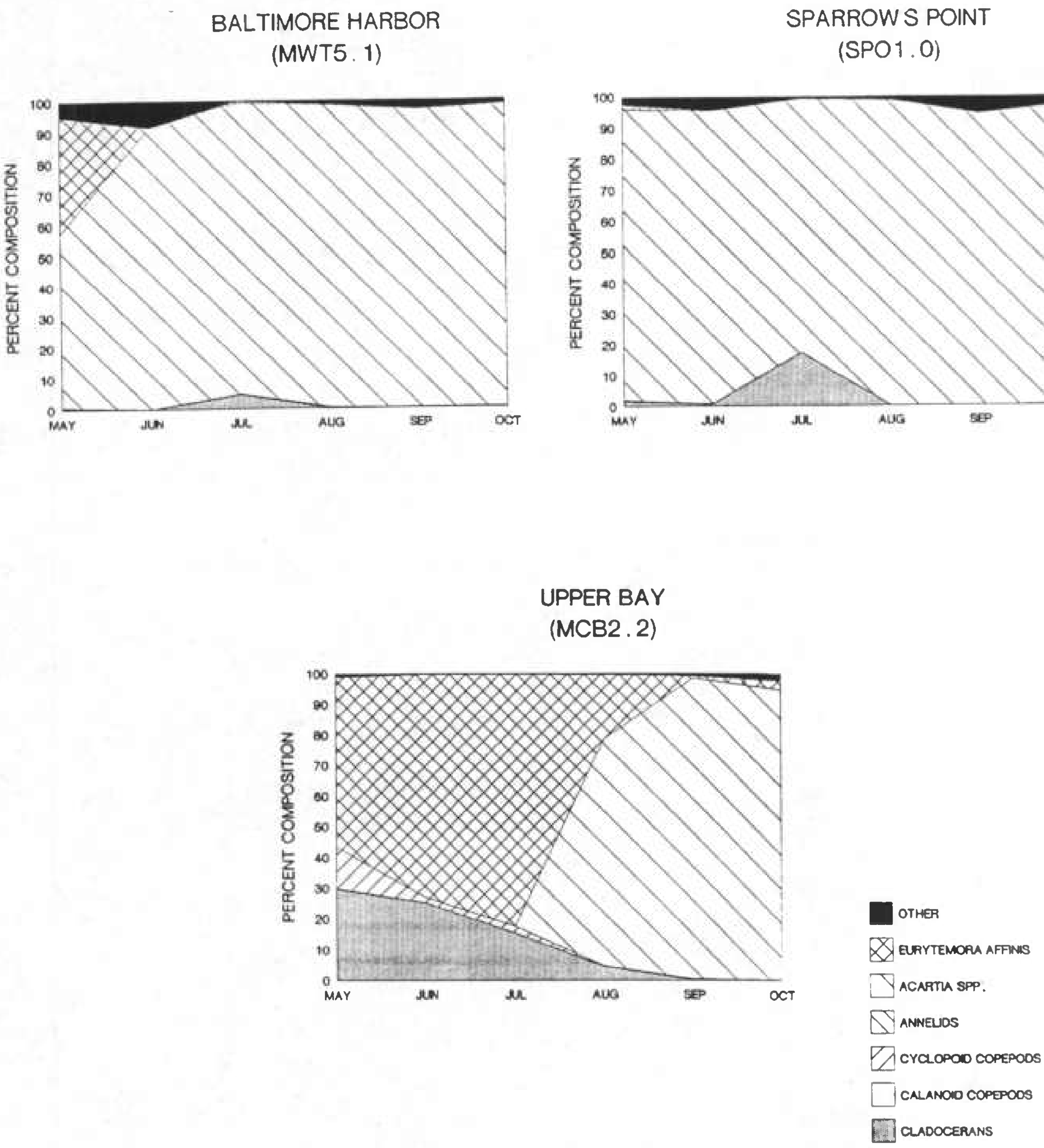

Figure 3-2. Monthly changes in percent composition of zooplankton species groups at the Sparrows Point, Baltimore Harbor, and upper bay stations, May through October 1994

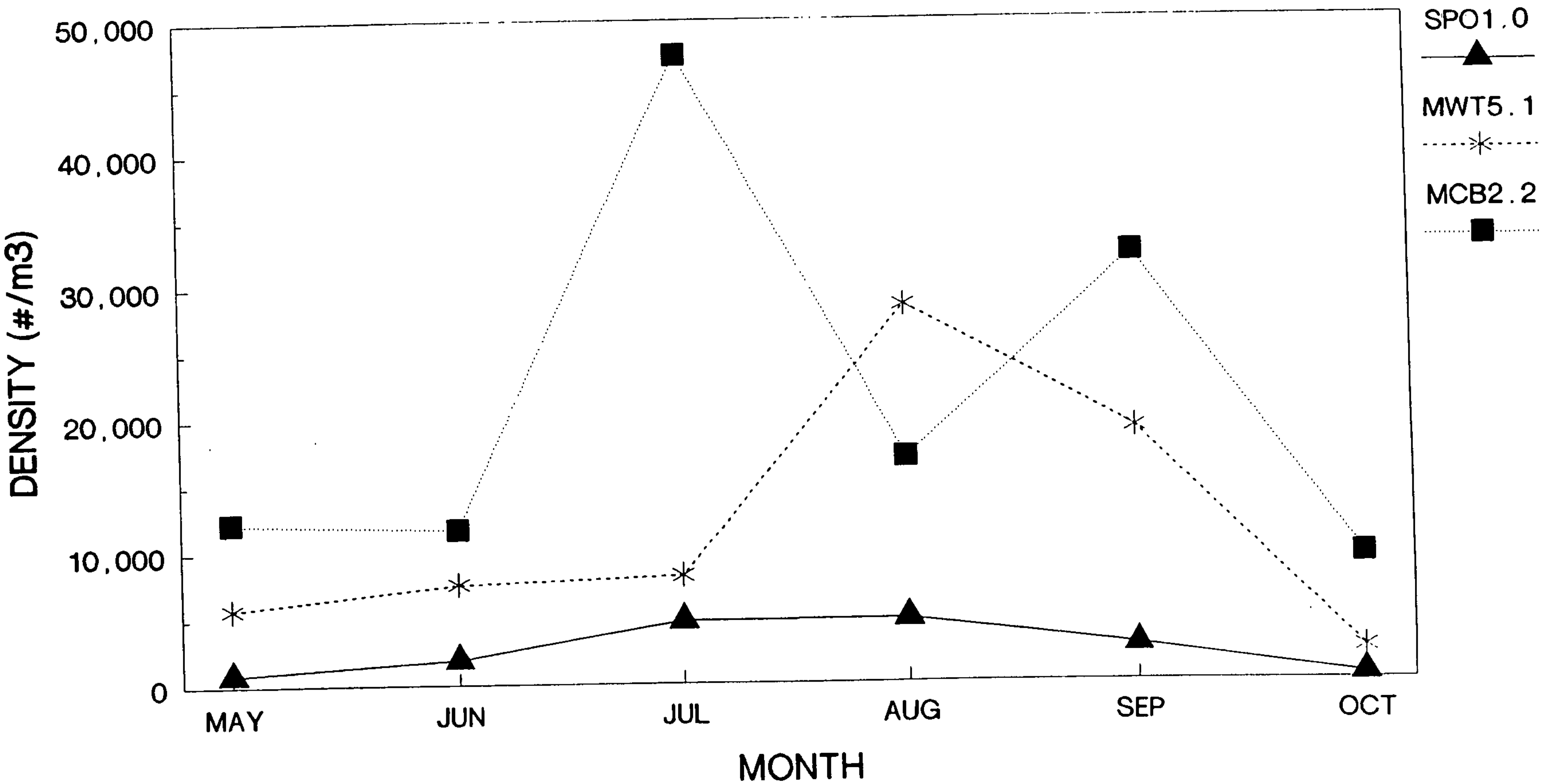

Figure 3-3 Mean total zooplankton densities (#s/m³) at the Sparrows Point (SP1.0), Baltimore Harbor (MWT5.1), and upper bay (MCB2.2) stations, May through October 1994

3.4 SUMMARY

The mesozooplankton communities at the proposed project site are typical for this region of the Chesapeake Bay. The species composition at the Sparrows Point site is very similar to the composition at the nearby Baltimore Harbor station. Although the total density at the Sparrows Point site was lower than the densities at other stations, the population characteristics at the project site are not unique relative to reference areas within the Patapsco River and the upper bay.

4.0 REFERENCES

MDE (Maryland Department of Environment). 1992. Chesapeake Bay Water Quality Monitoring Program Mesozooplankton Component. Volume 1: Text. Prepared by Versar, Inc., Columbia, Maryland.

Reid, G.K. 1961. Ecology of Inland Waters and Estuaries. New York: D. Van Nostrand Company.

APPENDIX

Appendix Table 1. Summary of May 1994 species composition and abundance at the Sparrows Point, Baltimore Harbor, and upper bay stations

		MEAN NUMBER PER CUBIC METER	PERCENT COMPOSITION	CUMULATIVE PERCENT
SPARROWS POINT	SPO1.0			
Acartia tonsa		811.4	94.97	94.97
Ergasilus sp.		16.8	1.97	96.94
Ceriodaphnia quadrangula		13.4	1.57	98.51
Copepod nauplii		4.4	0.51	99.02
Eurytemora affinis		2.7	0.32	99.34
Bosmina longirostris		1.2	0.14	99.49
Pseudocalanus minutus		1.2	0.14	99.63
Ostracoda		1.2	0.14	99.78
Barnacle nauplii		1.2	0.14	99.92
Cyclops bicuspidatus		0.7	0.08	100.00
TOTALS		854.39		
BALTIMORE HARBOR	MWT5.1			
Acartia tonsa		3269.8	56.69	56.69
Eurytemora affinis		2176.1	37.73	94.43
Barnacle nauplii		265.5	4.60	99.03
Polychaete larvae		30.9	0.54	99.56
Copepod nauplii		12.7	0.22	99.78
Ergasilus sp.		10.5	0.18	99.97
Harpacticoida		2.0	0.03	100.00
TOTALS		5767.31		
MAIN BAY	MCB2.2			
Eurytemora affinis		6749.1	55.27	55.27
Moina spp.		2231.4	18.27	73.54
Cyclops vernalis		1089.5	8.92	82.46
Bosmina longirostris		845.9	6.93	89.39
Daphnia sp.		540.9	4.43	93.82
Cyclops bicuspidatus		526.6	4.31	98.13
Harpacticoida		105.3	0.86	98.99
Ergasilus sp.		50.8	0.42	99.41
Halicyclops magnaceps		18.1	0.15	99.55
Paracyclops sp.		14.5	0.12	99.67
Diaptomus sp.		14.5	0.12	99.79
Acartia tonsa		7.3	0.06	99.85
Halicyclops sp.		7.3	0.06	99.91
Ostracoda		7.3	0.06	99.97
Diaphanosoma sp.		3.6	0.03	100.00
TOTALS		12212.15		

Appendix Table 2. Summary of June 1994 species composition and abundance at the Sparrows Point, Baltimore Harbor, and upper bay stations

		MEAN NUMBER PER CUBIC METER	PERCENT COMPOSITION	CUMULATIVE PERCENT
SPARROWS POINT	SP01.0			
Acartia tonsa		1795.2	94.79	94.79
Barnacle nauplii		55.6	2.93	97.73
Copepod nauplii		24.9	1.31	99.04
Podon polyphemoides		11.5	0.61	99.65
Ostracoda		3.8	0.20	99.85
Ergasilus sp.		1.9	0.10	99.95
Harpacticoida		1.0	0.05	100.00
TOTALS		1893.88		
ALSO OBSERVED				
Ceriodaphnia quadrangula				
BALTIMORE HARBOR	MWT5.1			
Acartia tonsa		6909.7	91.21	91.21
Barnacle nauplii		611.5	8.07	99.28
Copepod nauplii		28.1	0.37	99.66
Ostracoda		16.1	0.21	99.87
Harpacticoida		8.0	0.11	99.97
Podon polyphemoides		2.0	0.03	100.00
TOTALS		7575.39		
ALSO OBSERVED				
Oithona colcarva				
MAIN BAY	MCB2.2			
Eurytemora affinis		8539.3	72.90	72.90
Daphnia sp.		1710.0	14.60	87.50
Bosmina longirostris		853.4	7.29	94.78
Diaphanosoma sp.		239.1	2.04	96.82
Cyclops vernalis		176.6	1.51	98.33
Moina spp.		148.6	1.27	99.60
Cyclops bicuspidatus		10.5	0.09	99.69
Harpacticoida		10.3	0.09	99.78
Ceriodaphnia lacustris		5.3	0.04	99.82
Ergasilus sp.		5.3	0.04	99.87
Copepod nauplii		5.3	0.04	99.91
Cyclops spp.		5.3	0.04	99.96
Acartia tonsa		5.1	0.04	100.00
TOTALS		11714.04		

Appendix Table 3. Summary of July 1994 species composition and abundance at the Sparrows Point, Baltimore Harbor, and upper bay stations

		MEAN NUMBER PER CUBIC METER	PERCENT COMPOSITION	CUMULATIVE PERCENT
SPARROWS POINT	SPO1.0			
Acartia tonsa		3899.4	82.07	82.07
Moina spp.		821.0	17.28	99.36
Copepod nauplii		12.9	0.27	99.63
Barnacle nauplii		12.7	0.27	99.89
Diaphanosoma sp.		2.5	0.05	99.95
Eurytemora affinis		2.5	0.05	100.00
TOTALS		4751.08		
ALSO OBSERVED				
Harpacticoida				
BALTIMORE HARBOR	MWT5.1			
Acartia tonsa		7708.1	94.43	94.43
Moina spp.		378.4	4.64	99.06
Barnacle nauplii		24.8	0.30	99.37
Copepod nauplii		23.2	0.28	99.65
Ostracoda		18.1	0.22	99.88
Polychaete larvae		5.1	0.06	99.94
Hemicyclops sp.		5.1	0.06	100.00
TOTALS		8162.82		
ALSO OBSERVED				
Harpacticoida				
MAIN BAY	MCB2.2			
Eurytemora affinis		38988.8	82.33	82.33
Diaphanosoma sp.		4323.7	9.13	91.46
Bosmina longirostris		2707.6	5.72	97.17
Cyclops vernalis		784.4	1.66	98.83
Mesocyclops edax		161.6	0.34	99.17
Halicyclops magnaceps		126.7	0.27	99.44
Moina spp.		115.6	0.24	99.68
Daphnia		46.2	0.10	99.78
Harpacticoida		46.1	0.10	99.88
Ilyocryptus spinifer		23.0	0.05	99.93
Latona setifera		11.6	0.02	99.95
Ergasilus sp.		11.6	0.02	99.98
Ceriodaphnia quadrangula		11.5	0.02	100.00
TOTALS		47358.46		
ALSO OBSERVED				
Polychaete larvae				
Copepod nauplii				

Appendix Table 4. Summary of August 1994 species composition and abundance at the Sparrows Point, Baltimore Harbor, and upper bay stations

		MEAN NUMBER PER CUBIC METER	PERCENT COMPOSITION	CUMULATIVE PERCENT
SPARROWS POINT	SP01.0			
Acartia tonsa		4732.1	98.62	98.62
Copepod nauplii		49.8	1.04	99.65
Barnacle nauplii		13.0	0.27	99.93
Polychaete larvae		3.6	0.07	100.00
TOTALS		4798.55		
ALSO OBSERVED				
Ostracoda				
BALTIMORE HARBOR	MWT5.1			
Acartia tonsa		27839.2	98.03	98.03
Barnacle nauplii		352.0	1.24	99.27
Cyclops varicans		118.9	0.42	99.69
Copepod nauplii		88.6	0.31	100.00
TOTALS		28398.60		
ALSO OBSERVED				
Ostracoda				
Harpacticoida				
MAIN BAY	MCB2.2			
Acartia tonsa		12522.9	74.00	74.00
Eurytemora affinis		3568.2	21.09	95.09
Bosmina longirostris		481.5	2.85	97.93
Diaphanosoma sp.		178.1	1.05	98.99
Moina spp.		101.6	0.60	99.59
Ergasilus sp.		15.8	0.09	99.68
Harpacticoida		9.3	0.05	99.74
Polychaete larvae		9.3	0.05	99.79
Barnacle nauplii		9.3	0.05	99.84
Sida crystallina		6.6	0.04	99.88
Copepod nauplii		6.6	0.04	99.92
Ostracoda		6.6	0.04	99.96
Cyclops sp.		6.6	0.04	100.00
TOTALS		16922.27		

Appendix Table 5. Summary of September 1994 species composition and abundance at the Sparrows Point, Baltimore Harbor, and upper bay stations

		MEAN NUMBER PER CUBIC METER	PERCENT COMPOSITION	CUMULATIVE PERCENT
SPARROWS POINT	SPO1.0			
Acartia tonsa		2566.1	94.25	94.25
Barnacle nauplii		143.3	5.26	99.52
Copepod nauplii		7.9	0.29	99.81
Harpacticoida		5.3	0.19	100.00
TOTALS		2722.63		
BALTIMORE HARBOR	MWT5.1			
Acartia tonsa		18418.9	96.63	96.63
Barnacle nauplii		561.3	2.95	99.58
Copepod nauplii		29.8	0.16	99.74
Ostracoda		27.8	0.15	99.88
Polychaete larvae		17.5	0.09	99.97
Oithona colcarva		5.2	0.03	100.00
TOTALS		19060.52		
MAIN BAY	MCB2.2			
Acartia tonsa		31672.8	97.91	97.91
Eurytemora affinis		274.8	0.85	98.76
Barnacle nauplii		199.9	0.62	99.37
Polychaete larvae		117.2	0.36	99.74
Copepod nauplii		51.9	0.16	99.90
Bosmina longirostris		25.9	0.08	99.98
Diaphanosoma sp.		7.7	0.02	100.00
TOTALS		32350.22		

ALSO OBSERVED

Harpacticoida

Appendix Table 6. Summary of October 1994 species composition and abundance at the Sparrows Point, Baltimore Harbor, and upper bay stations

		MEAN NUMBER PER CUBIC METER	PERCENT COMPOSITION	CUMULATIVE PERCENT
SPARROWS POINT	SPO1.0			
Acartia tonsa		421.4	97.13	97.13
Barnacle nauplii		7.9	1.83	98.96
Copepod nauplii		3.2	0.74	99.70
Ostracoda		0.6	0.15	99.85
Oithona colcarva		0.3	0.08	99.92
Polychaete larvae		0.3	0.08	100.00
TOTALS		433.90		
BALTIMORE HARBOR	MWT5.1			
Acartia tonsa		2375.4	97.85	97.85
Barnacle nauplii		22.6	0.93	98.78
Copepod nauplii		15.3	0.63	99.41
Oithona colcarva		7.2	0.30	99.71
Ostracoda		5.3	0.22	99.93
Eurytemora affinis		0.8	0.03	99.97
Polychaete larvae		0.8	0.03	100.00
TOTALS		2427.65		
ALSO OBSERVED				
Ergasilus sp.				
MAIN BAY	MCB2.2			
Acartia tonsa		8946.4	94.36	94.36
Eurytemora affinis		281.6	2.97	97.33
Barnacle nauplii		194.8	2.05	99.39
Polychaete larvae		38.6	0.41	99.80
Oithona colcarva		7.7	0.08	99.88
Copepod nauplii		7.7	0.08	99.96
Ostracoda		4.0	0.04	100.00
TOTALS		9480.74		