Tidal Potomac Integrative Analysis Project, A Series of Reports on the Water Quality and Living Resources Responses to Management Actions to Reduce Nutrients in the Potomac River Estuary, Final Draft.

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APPENDIX G

VERSAR FINAL REPORT FOR THE MARYLAND DEPARTMENT OF NATURAL RESOURCES TIDEWATER ASSESSMENTS

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VERSAR FINAL REPORT FOR THE
MARYLAND DEPT. NATURAL RESOURCES
TIDEWATER ASSESSMENTS

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5.0 POTOMAC RIVER TRENDS

5.1 INTRODUCTION

Billions of dollars have been spent since the 1960s to improve wastewater treatment facilities (Bennett et al. 1986) and reduce non-point source nutrient inputs to the Potomac river. These efforts have been successful in reducing pollutants entering the river. Total Biological Oxygen Demand from point source loadings decreased by 92% between 1971 and 1985, and phosphorus loadings were reduced by 97% from 1972 to 1985 (Tsai et al., 1991). These changes resulted largely from advanced chemical treatment instituted at the Blue Plains facility in the early 1970s; Blue Plains is the largest treatment facility on the river and accounts for over 77% of its waste water loadings.

Some aspects of Potomac River ambient water quality have improved since the 1970s, particularly in low mesohaline and tidal freshwater habitats. The State of Maryland Department of Natural Resources (DNR) has maintained monthly monitoring of ambient water quality at eight Potomac River stations since 1974 and a ninth since 1984 (Figure 5-1). Phosphorus concentrations have decreased at six, and chlorophyll *a* concentrations have decreased at five of these nine stations (Table 5-1, Skelly et al. in press). Surface chlorophyll *a* concentrations decreased by 25 to 44%. Not all water quality measures have improved, however. Nitrogen concentrations increased significantly at six of the nine stations and dissolved oxygen (DO) concentrations hardly changed at all (Table 5-1). No trend in DO was detected at six of the nine stations. Of the other three, an increasing DO trend was detected at the uppermost tidal freshwater station while decreasing DO trends were detected at two mesohaline stations (Table 5-1).

The water pollution abatement efforts were intended to improve the quality and quantity of living resources in the river and they have been successful in improving the quality of plant populations. The frequency of nuisance blue-green algal (*Microcystis aeruginosa*) blooms has decreased since the early 1980s (Lacouture and Brownlee, 1995). There has also been a resurgence of submersed macrophytes in the river since 1983 (Carter et al. 1986).

The objective of this chapter is to assess whether improvements in living resources further along the food chain, specifically in Potomac River benthic assemblages, have also occurred during this period. The analyses presented here are for data collected at fixed sites analyzed in Chapter 3 (the seven current Potomac fixed sites), but these analyses go beyond those of Chapter 3 in several ways. First, the data record was extended by incorporating compatible historic data collected prior to the initiation of LTB in 1984. Second, Chapter 3 focused on a single indicator, the Benthic Index of Biological Integrity (B-IBI), whereas several assemblage measures and abundance of dominant taxa are analyzed in the present chapter. Finally, spring and summer data are analyzed here; Chapter 3 presented only summer data because the B-IBI has been developed only for summer.

Table 5-1 Trends in selected water quality measures at Maryland Department of Natural Resources Potomac River monitoring stations (from Skelly et al. in press). Results are for 20 years (1974-1994) except Station MLE2.2 (ten years; 1984-1994). *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$; NS: not significant; NR: not reported.

Habitat	Station	Total Nitrogen	Total Phosphorus	Chlorophyll *a*	Bottom Dissolved Oxygen Concentration
Tidal Freshwater	XFB2470	37% ***	-29% ***	NS	39% **
	XFB1433	32% ***	-29% ***	NS	NS
	XEA6596	42% ***	-29% ***	-27% **	NS
	XEA1840	46% ***	-60% ***	-43% ***	-33% **
Oligohaline	XDA4238	NS	-36% ***	-25% ***	NS
	XDA1177	18% *	-22% **	-34% ***	NS
Low Mesohaline	XDB3321	30% ***	NS	-44% *	NS
	XDC1707	NS	NR	NS	-31% **
High Mesohaline	MLE2.2	NS	NR	NS	NS

5.2 METHODS

Data from the seven LTB fixed sites in the Potomac (Figure 5-2, Table 2-1) were used to test for trends in benthic condition in order to analyze them for trends. Six of the seven stations had been sampled prior to initiation of LTB in 1984 as part of DNR's Power Plant Siting Program (Table 5-2). Those data, which commenced in 1981, were added to the LTB data base for these analyses. No pre-LTB data were available for tidal freshwater Station 36. Sample collection and laboratory processing techniques for the added data were the same as for LTB (Table 5-2); they are described in detail in Chapter 2.

Table 5-2. Habitat, sampling period, and sampling devices used at the seven LTB fixed stations located in the Potomac River. Mud > 40%, sand < 40% silt/clay sized particles.

Habitat	Station	Depth (m)	Sampling Period	Sampling Device
Tidal Freshwater Mud	36	3	July 1984 to August 1995	Hand-operated box corer: July 1984 to September 1989 Wildco box-corer: October 1989 to August 1995
Oligohaline Mud	40	8	July 1981 to August 1995	Petite ponar grab: July 1981 to June 1989 Wildco box-corer: July 1989 to August 1995
Mesohaline Sand	43	2	July 1981 to August 1995	Hand-operated box corer: July 1981 to August 1995
	47	2	July 1981 to August 1995	Hand-operated box corer: July 1981 to August 1995
	51	2	July 1981 to August 1995	Hand-operated box corer: July 1981 to August 1995
Low Mesohaline Mud	44	14	July 1981 to August 1995	Petite ponar grab: July 1981 to June 1989 Wildco box-corer: July 1989 to August 1995
High Mesohaline Mud	52	11	July 1981 to August 1995	Petite ponar grab: July 1981 to June 1989 Wildco box-corer: July 1989 to August 1995

5.3 RESULTS

5.3.1 Sediment Carbon Content

Sediment carbon content decreased significantly at six of the seven stations over the study period (Table 5-3). At mesohaline sand Stations 43,47 and 51, sediment carbon content declined from values always above 0.5% and often in the 1-2% range in the early 1980s, to values which were always below 0.5% in the late 1980s and 1990s (Figure 5-3). At the three mud stations furthest up the river (tidal freshwater Station 36, oligohaline Station 40, and low mesohaline mud Station 44) sediment carbon values decreased from highs over 3% in the early 1980s to values consistently from 2-2.5% in the late 1980s and 1990s (Figure 5-4). The highest median rate of decline, 1% every five years, was observed at Station 36, which was farthest up the river, in spite of its shorter, ten year, data record. Only high mesohaline mud Station 52, which was farthest down the river, displayed no significant carbon content trend.

Table 5-3. Median annual rate of change (Sen 1968) and results of van Belle and Hughes (1984) trend test on sediment carbon content. Results are for spring and summer combined trends. *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$.

Habitat	Station	Median rate of carbon content change (%/year) and trend analysis result
Tidal freshwater	36	-0.20 **
Oligohaline	40	-0.06 *
Mesohaline sand	43	-0.13 ***
	47	-0.19 ***
	51	0.10 ***
Low mesohaline mud	44	-0.15 ***
High mesohaline mud	52	-0.03

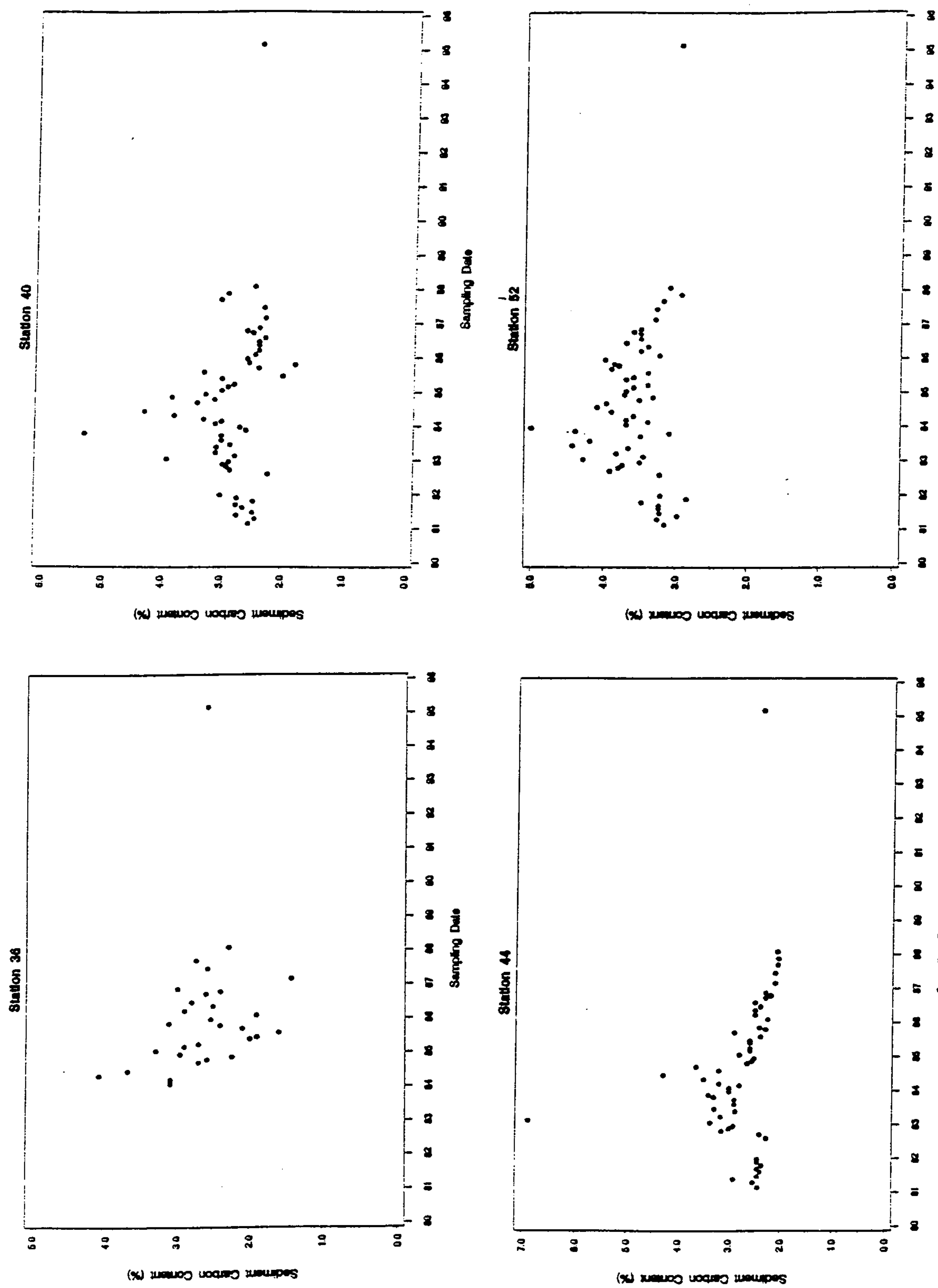

Figure 5-4. Sediment carbon content at tidal freshwater Station 36, oligohaline Station 40, low mesohaline mud Station 44, and high mesohaline mud Station 52

Table 5-5. Median annual rate of change (Sen 1968) and results of van Belle and Hughes (1984) trend test on benthic assemblage measures. Results are for spring and summer combined trends. +: $p < 0.1$; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$; N/A: Not applicable.

	Tidal Freshwater Habitat	Oligohaline Habitat	Mesohaline Sand Habitat			Low Mesohaline Mud Habitat	High Mesohaline Mud Habitat
Measures	Station 36	Station 40	low Station 43	low Station 47	high Station 51	Station 44	Station 52
Benthic Index of Biotic Integrity	N/A	-0.03	-0.03 *	-0.03 +	0.00	0.03	-0.04 *
Number of Taxa (#/sample)	0.00	0.17 +	0.08 *	0.33 +	0.24 **	0.22 ***	0.00
Total Abundance (#/m^2)	-220.00	-30.91	0.00	204.44 *	104.76 *	30.85	8.76
Suspension Feeder Abundance (#/m^2)	-191.11 *	-2.00	12.44 *	15.00 +	3.64	0.00	0.00
Interface Feeder Abundance (#/m^2)	0.00	10.15	18.89	106.67 +	86.11 *	37.44 *	13.08
Deep Deposit Feeder Abundance (#/m^2)	-48.18	-13.33 ***	25.11 *	45.33	-5.71	0.85	0.00
Pollution-Sensitive Taxon Abundance (#/m^2)	0.00	-8.28	-1.94	56.67	10.00 +	0.91	0.00
Pollution-Tolerant Taxon Abundance (#/m^2)	0.00	0.00 *	1.44	0.00	12.22	8.89	3.15
Total Biomass (g/m^2)	-9.90	-0.08	4.32 +	3.32	-0.26	0.01	0.00
Mollusc Biomass (g/m^2)	-9.99	-0.07 *	3.67	2.71	0.02	0.00	0.00

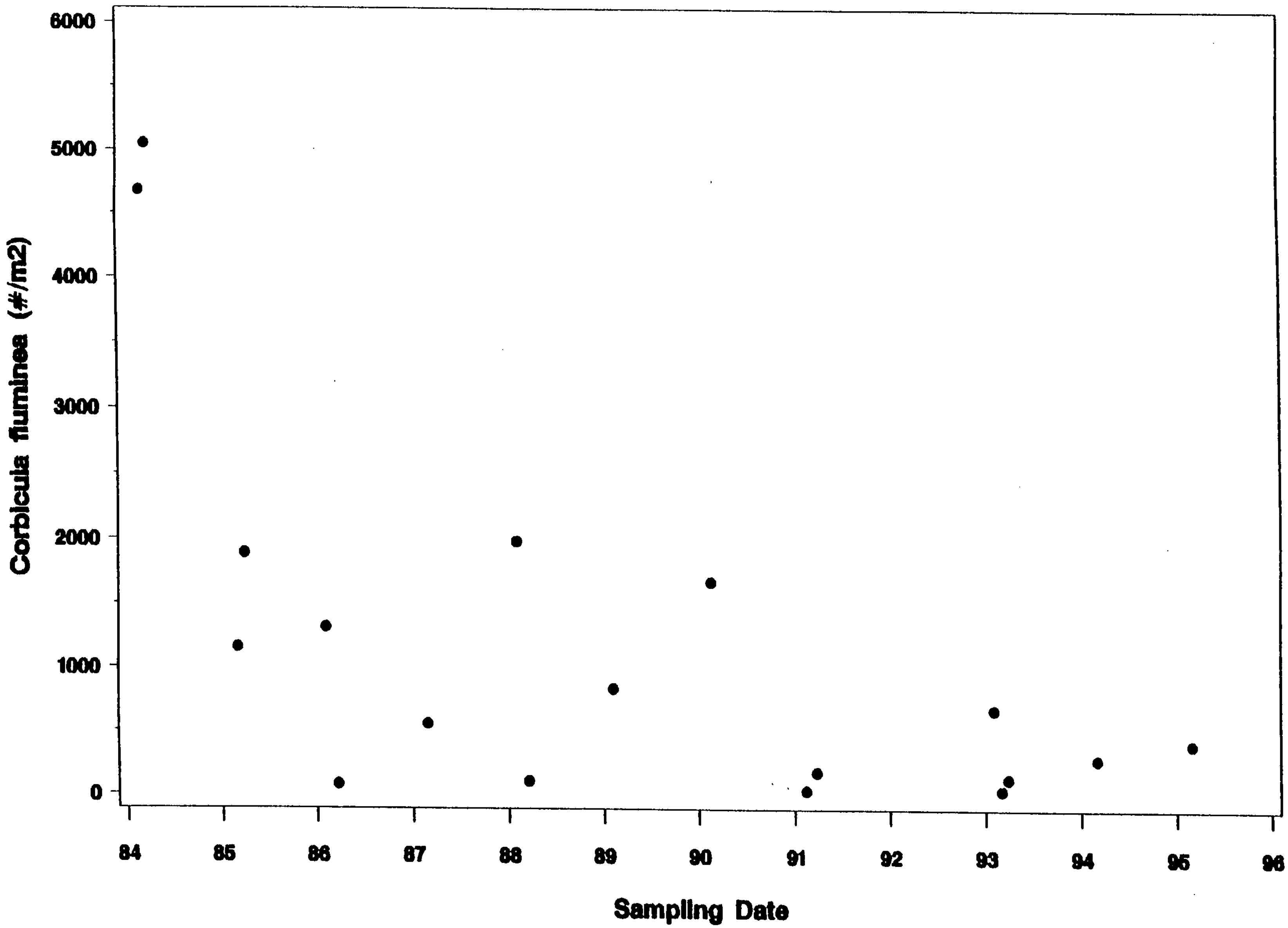

Figure 5-5. Summer abundance of *Corbicula fluminea* at Station 36

were among the ten abundance dominants at all three stations and together accounted for 67.7%, 75.4%, and 75.3% of the total abundance, respectively (Tables 5-7, 5-8, and 5-9). Stations 43 and 47 had identical abundance dominant lists, the other four taxa being the low salinity species *Rangia cuneata* and *Cyathura polita* and the omnivorous *Neanthes succinea* and *Laeonereis culveri*. At Station 51 the other dominants were higher salinity taxa.

Table 5-7. Median annual rate of change (Sen 1968) and results of van Belle and Hughes (1984) trend test on abundances of the ten most abundant taxa at mesohaline sand Station 43. Results are for spring and summer combined trends. +: $p < 0.1$; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$.

Taxon	Feeding Guild [a]	Contribution to Total Abundance (1981-1995)	Trend
Marenzelleria viridis	Interface	42.2	-14.44
Heteromastus filiformis	Deep Deposit	16.5	21.82 +
Leptocheirus plumulosus	Interface	9.3	6.67
Rangia cuneata	Suspension	5.0	14.00 ***
Macoma mitchelli	Suspension	4.7	14.44 **
Laeonereis culveri	Carnivore/Omnivore	4.8	-0.07
Cyathura polita	Carnivore/Omnivore	4.0	0.77
Streblospio benedicti	Interface	2.4	1.67
Neanthes succinea	Carnivore/Omnivore	1.9	1.11
Macoma balthica	Interface	1.9	-3.64 +

Significant increasing trends in the number of taxa per sample were detected at all three stations (Table 5-5). On average, a taxon would be added to each sample every 12 years at Station 43, every three years at Station 47, and every four years at Station 51. Significant decreasing trends in B-IBI were detected at Stations 43 and 47, although at a low rate. In 1995, Stations 43 and 47 met the Restoration Goals, although Station 51 did not.

Increasing trends in benthic abundance were detected at all three stations; they were statistically significant at Stations 47 and 51 (Table 5-5). Strong, significant, increasing trends in interface feeder abundance were detected at Stations 47 and 51, although increasing trends were

Table 5-9. Median annual rate of change (Sen 1968) and results of van Belle and Hughes (1984) trend test on abundances of the ten most abundant taxa at mesohaline sand Station 51. Results are for spring and summer combined trends. +: $p < 0.1$; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$.

Taxon	Feeding Guild (a)	Contribution to Total Abundance (1981-1995)	Trend
Heteromastus filiformis	Deep Deposit	27.4	-2.50
Streblospio benedicti	Interface	16.6	5.69
Macoma mitchelli	Suspension	15.7	31.87 *
Marenzelleria viridis	Interface	11.3	3.33
Micrura leidyi	Carnivore/Omnivore	3.0	0.00
Lepidactylus dytiscus	Interface	2.6	3.33 ***
Mulinia lateralis	Suspension	2.3	0.00
Leptocheirus plumulosus	Interface	2.3	0.00
Carinoma tremaphoros	Carnivore/Omnivore	2.0	5.93 ***
Macoma balthica	Interface	2.0	0.00

5.3.5 Low Mesohaline Mud (Station 44) Benthos

The assemblage encountered at the low mesohaline mud station was quite similar to the mesohaline sand assemblage. It shared all six of the top ten abundance dominants that were common among the three mesohaline sand stations (Table 5-10).

A significant increasing trend in number of taxa per sample, was detected with the increase equal to about one taxon every 4.5 years detected (Table 5-5). No significant trend in B-IBI was present. Station 44 did not meet the Restoration Goals in 1995.

No significant trend in total abundance was detected, and an increasing trend in interface feeder abundance was the only significant abundance trend detected. However, all the abundance measure rates of change were in a positive direction.

Significant increasing trends were observed for five of the ten most abundant taxa (Table 5-10). However, the median rates of change were insignificant.

Table 5-11. Median annual rate of change (Sen 1968) and results of van Belle and Hughes (1984) trend test on abundances of the seven most abundant taxa at high mesohaline mud Station 52. Results are for spring and summer combined trends. +: $p < 0.1$; *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$.

Taxon	Feeding Guild	Contribution to Total Abundance (1981-1995)	Trend
Streblospio benedicti	Interface	82.4	14.55
Mulinia lateralis	Suspension	3.8	0.00
Neanthes succinea	Carnivore/Omnivore	3.6	0.00
Hypereteone heteropoda	Carnivore/Omnivore	2.2	0.00
Paraprionospio pinnata	Interface	1.5	0.00
Macoma mitchelli	Suspension	1.2	0.00
Heteromastus filiformis	Deep Deposit	1.0	0.00 +

No trend in number of taxa per sample was detected (Table 5-5). A decreasing trend in B-IBI was detected and Station 52 failed the Restoration Goal. On the scale used to classify Baywide random samples (Chapter 2), it was classified as severely degraded.

No significant trends in total abundance, or feeding guild or pollution sensitive or pollution indicative taxon abundance (Table 5-5) were detected. The median rates of change were also insignificant. Similarly, no significant dominant taxon abundance trends (Table 5-11) or biomass trends (Table 5-5) of any magnitude were detected.

5.4 DISCUSSION

Measurable improvements in water quality of the Potomac River have been documented by several researchers. One of the major water quality improvements has been a reduction in chlorophyll *a* concentrations. Reduction in chlorophyll *a* in the water column can affect benthic habitats in at least two ways. First, the amount of decaying matter reaching the bottom may decrease sediment carbon concentrations. Second, a decline in organic matter may reduce metabolism and increase oxygen concentrations. Improvements in bottom water dissolved oxygen concentrations have not been reported, but the results of our trend analysis on sediment carbon concentrations show significant decreases at six of the seven stations.

enough, or did not cross a significant enough threshold, to effect a benthic response. Benthos at many of the sites were meeting Restoration Goals prior to the carbon decline and hypoxic stress was apparent at the sites that were not. While the effects of high carbon concentrations on benthos are well documented, the thresholds at which benthic response begins to occur is not.

Sediment carbon concentration is a potentially important mechanism linking nutrient reduction efforts in Chesapeake Bay with living resources. It is also potentially useful as an integrator of nutrient reduction efforts since it is less temporally variable than water column nutrient or chlorophyll *a* measures. The probability based element of LTB provides a robust mechanism for measuring the effectiveness of nutrient controls in reducing bay-wide sediment carbon concentrations. Future LTB efforts will investigate the relationship between carbon levels and benthic response to better define relevant carbon thresholds for interpreting trends in benthic data and which can serve as a means for establishing management goals in nutrient reduction efforts.