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Biological Investigations of the Black Creek Vicinity, Biscayne National Park

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BIOLOGICAL INVESTIGATIONS OF THE BLACK CREEK VICINITY,

BISCAYNE NATIONAL PARK

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NATIONAL PARK SERVICE - Southeast Region

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INTRODUCTION

In 1983, we initiated a series of studies for Biscayne National Park (BNP) (RFP5280-84-22) to determine **(a)** whether there had been a shift in floral composition of the grassbed communities within the Black Creek area of the Park, and if so, **(b)** what might be the factors responsible for the change in floral composition. Specifically, there was concern by BNP staffers that Thalassia was being replaced by Halodule in certain affected areas.

The results of the initial studies under this contract were submitted in two Interim Reports (Appendix A). In summary, the studies showed that there was a shift between these two grass species, with Thalassia dominating the grassbeds south of Military Canal and north of Black Point, and Halodule dominating the intermediate area. The earlier studies also indicated that the shift in grass species was not related to differences in fluxes of nutrients or fresh water from the sediments, nor did grazing pressure by herbivores appear to be a likely factor. Potential factors responsible for the shift in species that were not investigated in the earlier studies include sediment depth and overgrowth by epiphytes.

Under an ammendment to the original contract, in May 1986 we initiated a second study with the following three objectives:

(1) Survey the grassbed communities between Turkey Point and Black Point to locate the northern and southern transition zones between Thalassia- and Halodule-dominated areas.

(2) Measure sediment depths within the areas to see whether lack of sufficient sediment depth might be responsible for limiting the occurrence of Thalassia.

(3) Quantify the amount of epiphytic growth on Thalassia blades throughout the area to address the hypothesis that increased

epiphytic growth within areas with increased nutrient discharge might limit Thalassia growth.

(4) Compare the growth of Thalassia plants transplanted from healthy Thalassia beds to areas of little or no Thalassia cover.

The first objective was addressed by repeating percent-cover transects, similar to those reported on in the first Interim Report (Appendix A), at close latitudinal intervals within the study area. The second objective was addressed by measuring sediment depths within transects done simultaneously with the percent-cover transects. The third objective was addressed in two ways: (1) by attempting to measure the amount of epiphytic growth on blades of Thalassia collected from stations within the area; and (2) by measuring the amount of epiphytic growth on artificial substrates that simulate Thalassia.

MATERIALS AND METHODS

The following field sampling scheme and laboratory procedures were undertaken after consultation with and approval from BNP research personnel. All work in the field took place from June 1986 to early September 1986. The study area was bounded by Turkey Point (25°27.00'N) to the south and extended north past Black Point to 25°33.50'N. The area south of Military Canal, with healthy *Thalassia* beds, was considered the 'control' area . The area around Fender Pt., which the earlier study showed to have a small population of *Thalassia*, was referred to as the 'affected' area. The 'transition' areas were those between the control and affected areas.

Survey of Benthic Flora and Sediment Depth

Loran-C coordinates were used to locate survey lines and station positions. Initially, survey lines were selected at half-minute latitude intervals from 25°29.50'N to 25°28.00' N in order to locate the southern transition zone. Once located, the transition zone was more intensively surveyed to thoroughly define its limits. The same procedure was used from 25°32.50'N to 25°33.50'N to locate and define the northern limits of the affected area.

Each survey line included three stations: inner, middle, and outer. At each station, a 2- x 10-m transect was used to survey bottom cover. The technique used was identical to that used during the earlier study (Appendix A). A quadrat was tossed over the side of the anchored boat and flipped four times in an easterly (offshore) direction to complete the transect. The quadrat was subdivided by crosslines into sixteen 0.25-m^2 areas. The percent of bottom covered by algae, each species of grass, or devoid of plant life ("bare") was estimated in 25% units for each subdivision, and recorded on plastic paper printed with a 4 x 40 grid. Density of growth (thick or sparse) and dominant algal types were also recorded.

A 2- x 6-m transect was used to sample sediment depths. An aluminum probe was pushed into the sediment at each intersection of crosslines to give 25 datum points per quadrat. The depth was recorded to the nearest centimenter on underwater paper printed with a 5 x 15 grid. Surveys of sediment depth and percent-cover were taken simultaneously in parallel transects.

Epiphyte Growth on Thalassia

Samples of Thalassia were collected using corers made from size #6 industrial food cans that had an inner diameter of 15.5 cm. Five stations were selected at regular north/south intervals within the study area and two cores were collected at each station. Two additional stations were added later. Patches of representative Thalassia growth were selected and corers were inserted to approximately 5 cm below the sediment-water interface. After removal to Zip-loc[R] bags, cores were either analyzed immediately or placed in a 5% formaldehyde solution for preservation. Later analysis indicated no appreciable difference in size or degree of epiphytic cover between samples preserved in formaldehyde and those analyzed immediately.

The initial intent was to determine the area of each blade covered by epiphytes. It was soon evident that epiphytic cover was minimal on all samples - usually less than 5% of blade area. Therefore, an alternative protocol was devised to study the differences between the Thalassia plants from the various stations. The parameters measured for each core were: **(a)** number of shoots per core, **(b)** number of blades per shoot, and **(c)** maximum blade length and width per shoot.

Individual shoots of Thalassia containing one or more grass blades per shoot were separated from their rhizomes at the base of the blade. Blade length was then measured from the base to the tip for each individual blade in the shoot. Blades that appeared broken or grazed were included in the "blades-per-shoot" count but were not measured. Blade width was considered to be the width of the longest blade at the region where nonphotosynthetic growth merges into green, photosynthetic tissue. All measurements were made to the nearest millimeter.

Transplantation of Thalassia

A thick Thalassia bed north of Turkey Point was chosen as the site for collecting the cores to be transplanted. Cores were transplanted to three sites: (1) the site of collection (Controls); (2) a station in the transition zone; (3) a station in the affected Halodule zone. The cores were taken as above but a putty knife was used to cut the rhizomes to about 10 cm depth in order to maintain the integrity of the root system. The cores were transferred to 19-liter buckets and transported within an hour to the transplant site.

Four cores per site were transplanted to holes dug 10-20 cm deep in bare areas at each site. Cores were marked with orange flagging tape and the sites were marked with buoys and two-tone, fluorescent-orange cement blocks. Loran-C coordinates were also taken. The cores were collected after 30 days and analyzed as described above for the cores collected in the epiphyte study.

Artificial Substrates

Artificial substrates for a study to compare potential for epiphytic growth between areas (control, transition, and affected) were constructed to resemble Thalassia blades. Twenty five square-centimeter sections of 1.3-cm (0.5-in.) mesh screen were woven with 200 strips of avocado-green plastic flagging tape (1 cm wide x 25 cm long). As the plastic tape was slightly negatively buoyant, the screens were suspended from table-like supports made from 1.3-cm diameter rebar construction rods. The 60-cm-long legs were tapped into the sediment at least 10 cm deep in bare or nearly bare areas. The screens were attached to the tables with cable ties to allow the blades to hang vertically 20-25 cm above the sediment. The blades were free to move in the current and the screen itself is assumed to have caused minimal shading. Four replicate screens were deployed at one station each within the control, transition, and affected areas.

After 2 months, 20 blades per screen were chosen by position with the aid of a random number generator; the blades were carefully cut free at the base and allowed to gently drop into wide-mouth 1-liter bottles. The amount of loose organic flocculus (floc) clinging to the plastic tape was measured by shaking the bottles containing the blades and filtering dislodged material onto preweighed Whatman GF/C filters. The filters were rinsed with distilled water, dried and reweighed. The epiphytes on the blades themselves were preserved in 5% formaldehyde for later analysis. Epiphytes that were growing on the blades were scraped off and combined (20 blades per screen), dried onto preweighed GF/A filters, and reweighed.

Data Analysis

All statistical analysis was performed using a Digital Equipment Corporation VAX computer and the SPSS statistical package (Hull and Nie, 1981).

RESULTS AND DISCUSSION

Distribution of Thalassia and Halodule

The results of the bottom-cover transects are presented in tabular form in Table 1 and graphically in Figure 1. It is clear from Figures 1A and 1B that there is an area between 25° 33' N and 25° 29' N where Thalassia is less than 10% cover and where Halodule is greater than 40% cover. There were no statistically significant differences between the inner, middle, and outer stations along each transect.

The percent cover by mixed assemblages of macroalgae (see Appendix A) was low (less than 20%) at the northern stations, and was generally much higher (40% or greater) along most transects south of 25° 30' N. The percent of the bare bottom was almost the inverse of the pattern for mixed algae, such that 20 to 40% of the bottom was bare north of 25°30' N while generally less than 10% of the bottom was bare at the southern stations.

Sediment Depths

Sediment depths were highly variable within each sample (Table 2) as well as between stations. There were no statistically significant differences between sediment depths of inner, middle, and outer stations nor between that of stations high in Thalassia coverage and low in Thalassia coverage. Figure 2, however, gives the impression that sediment depths were slightly greater in the "affected" area. Given the high variance within each sample, it was difficult to determine statistically whether this perceived difference was real.

Overall, mean sediment depths were generally less than 20 cm even in those areas rich in Thalassia. Many authors have reported that Thalassia requires sediments depths greater than 20 cm for optimal growth (see references in Appendix A: Interim Report).

A Pearson Correlation Coefficient Analysis was performed to test for correlations between sediment depth and the percent cover by the various macrophytes and algae. The resulting probability matrix is presented in Table 3. There was no significant correlation between mean sediment depth and the percent cover of any of the catagories of bottom cover. While the correlation analysis is not strictly applicable to percent data because those data are not independent measures, the correlation matrix does show that the inverse relationship between the percent cover of Thalassia and Halodule is highly significant (p 0.001). There was also a significant inverse correlation between stations with considerable Thalassia coverage and considerable bare area (p 0.005). There was no significant correlation between cover by algae and any of the other categories, or between bare area and any other category of coverage.

Comparison of Thalassia plants Within the Area

Table 4 summarizes the results of the morphometric measurements made on the Thalassia samples that were collected from seven sites within the study area. The cores taken from stations located at 25°29.52' N and 25°29.98' N were from areas with minimal bottom coverage by Thalassia (Figure 1). The latter station had many fewer shoots per core than any of the other stations. Maximum blade length far significantly shorter at that station (p 0.001) and maximum blade width was also narrower than at the other stations (Figures 3a and b). Therefore, these Thalassia plants that were growing just south of the affected area where Thalassia is absent, were smaller and grew less densely than those in "healthy" Thalassia beds.

It should be noted that several stations in the southern transition zone between 25°29.54' N and 25°29.07' N were characterized by Thalassia plants with blades lengths much longer than those in the control zone near Turkey Pt (Figure 3a). The significance of this finding was not clear.

Transplantation Studies

The purpose of the transplantation experiment was to determine whether the absence of Thalassia in the affected zone was due to unfavorable conditions for recruitment to the area or to unfavorable conditions for growth. Because the cycle for growth of individual blades is approximately 30 days, the cores were retrieved for analysis 30 days after transplantation.

Shoot density in the cores retrieved from the station in the affected Halodule area were about half the shoot density of the cores retrieved from the control and transition stations (Table 5). It is unlikely that this result was due to the cores having had a low shoot density initially, since none of the cores taken from the stations in the control area had shoot densities this low. Therefore, it is believed that the low shoot density of the four transplanted cores retrieved from the affected area was due to death of many shoots after transplantation; however, there were no differences between the blade lengths and widths of the surviving shoots and those of the control and transition area cores.

It is very likely that the 30-day deployment period was too short for morphometric changes to occur in the transplanted grasses. The core-transplant study should be repeated with the cores being allowed to remain in their new locations for 90 to 120 days.

Epiphyte Growth on Artificial Substrates

Because the amount of epiphytic growth on natural Thalassia blades was generally small, and the epiphytes were difficult to scrape off without contamination with Thalassia tissue, we were not able to compare quantitatively the amount of epiphytic growth on the blades. We were able, however, to measure the amount of encrusting growth on the artificial grass blades, as well as the amount of floc that settled onto them (Table 6). There were no significant differences between the weights of floc recovered from the blades from the three sites; however, there was 60% more encrusting growth (by weight) on the blades from the Halodule station than from the control and transition stations, and the difference was significant at the p=0.01 level. Therefore, while the epiphyte biomass present at the time of sampling was very low, it is possible that increased epiphytic growth at some time in the past may have been at least in part responsible for the reduction or elimination of the Thalassia population in the affected area.

Conclusions and Recommendations

This contract is part of an effort by BNP to assess the impact of the canals that drain into southern Biscayne Bay on the nearshore marine communities, especially the seagrass community. We have established that the turtlegrass Thalassia, which dominates most of the grassbeds in Biscayne Bay, is greatly reduced in abundance or absent from the area between 25°32.8'N and 25°29.2'N. In that area Thalassia has been replaced by the eelgrass Halodule. South of that area is a transition zone where Thalassia and Halodule occur together in varying proportions. This southern transition zone extends to approximately 25°28.5'N. The transition zone to the north of the affected area extends to about 25°33.5'N. We have been unable to find any quantitative information on earlier distribution patterns of sea grasses in the bay to determine how long the "affected" area has been in existence.

We found no correlation between the present distribution of Thalassia and sediment depth (this report) nor with nutrient or freshwater seepage out of the sediments (Appendix A). Therefore, it is unlikely that increased sedimentation or groundwater seepage are the environmental factors responsible for the change in macrophyte composition.

We did find, however, lower water-column salinites, higher water-column nutrient concentrations, and more intense water color (brown tanins) in the affected area than in the areas north and south of it (Appendix A). These findings are in agreement with the more extensive set of environmental data collected by BNP over the last decade (R. Curry, BNP, Homestead, FL; per. comm.). The likely source for these nutrient, salinity, and color anomalies is discharge water from the various drainage canals in the area from Military Canal to Fender Point.

Any one of these three anomalies could be responsible for the decline of Thalassia in the area, and it is probable that the synergistic effect of the three factors may be ultimately responsible. Thalassia is known to require high salinity and light levels, while Halodule is tolerant of more euryhaline conditions and lower light levels (see references in Appendix A). Thalassia plants in the northern part of the southern transition zone had shorter and narrower blades and occurred with much lower shoot density (Table 4; Fig. 3), which are indicative of unfavorable environmental conditions. Cores of Thalassia that were transplanted from healthy grassbeds to the affected area decreased in shoot density by about 50% over 30 days (Table 5). A longer time interval following transplantation may have resulted in blade shortening and narrowing. The transplantation experiment should be repeated by BNP with the cores being allowed to remain in their new locations for 90-120 days before retrieval.

Higher nutrient levels in ambient waters can affect Thalassia by promoting the growth of epiphytes that shade the plants. We were not able to quantify the amount of epiphytes on blades of Thalassia that were collected in the study area, because the amount of epiphytes (calcareous algae, forams, a few hyozoans, etc.) was small at the time of collection (less than 5% cover). There was, however, a significantly greater amount of epiphytic growth on the artificial grass blades deployed in the affected area than in the control or transition areas (Table 6). It is possible that at other times of year, or that in the past, epiphyte growth has been severe enough to stress the Thalassia plants in the affected area. One must also consider that we sampled surviving plants, and that heavily encrusted plants might not have survived to be sampled. We recommend that BNP make periodic observations on the amount of epiphytic growth found on Thalassia plants throughout the area of interest.

Summary Recommendations:

(1) To determine whether further deterioration of the Thalassia beds in the Black Creek area is occurring, BNP should establish monitoring stations within the northern and southern transition areas identified in this report.
The technique of measuring percent cover by the major species of seagrass and macroalgae should be adequate for determining whether the affected area is expanding.

(2) Further experimental work should include a repeat of the Thalassia transplantation experiment with a longer monitoring period following transplantation. A secondary benefit from this experiment would be to determine whether the affected area could be successfully repopulated with Thalassia.

(3) Personnel of Biscayne National Park should continue to monitor ambient nutrient concentrations, salinity, and water color in the study area to see whether the area affected by canal discharge is changing.

Acknowledgments

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Reference

Hull, C.H. and N.H. Nie. 1981. SPSS Update 7-9. McGraw-Hill Book Co., New York. 402 pp.

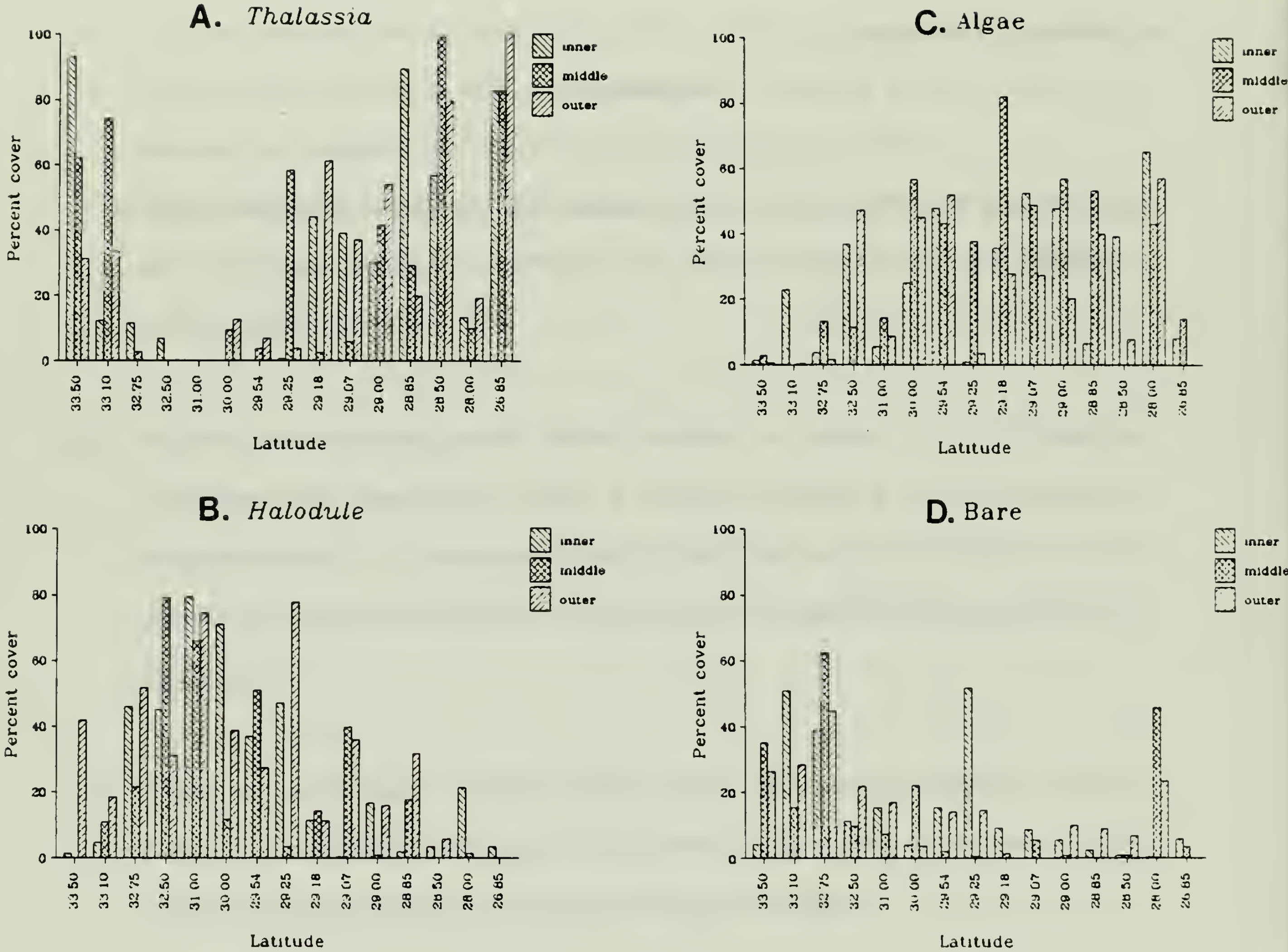

Figure 1. National Park Service Canal Impact Assessment. Percent of the bottom covered by **(A)** Thalassia, **(B)** Halodule, and **(C)** macroalgae, or **(D)** Bare (devoid of sea-grass or macroalgae). See Table 1 for additional information. Latitudes of each station are plotted as minutes of 25^{o} N. Three stations (inner, middle, outer) were taken along each latitude.

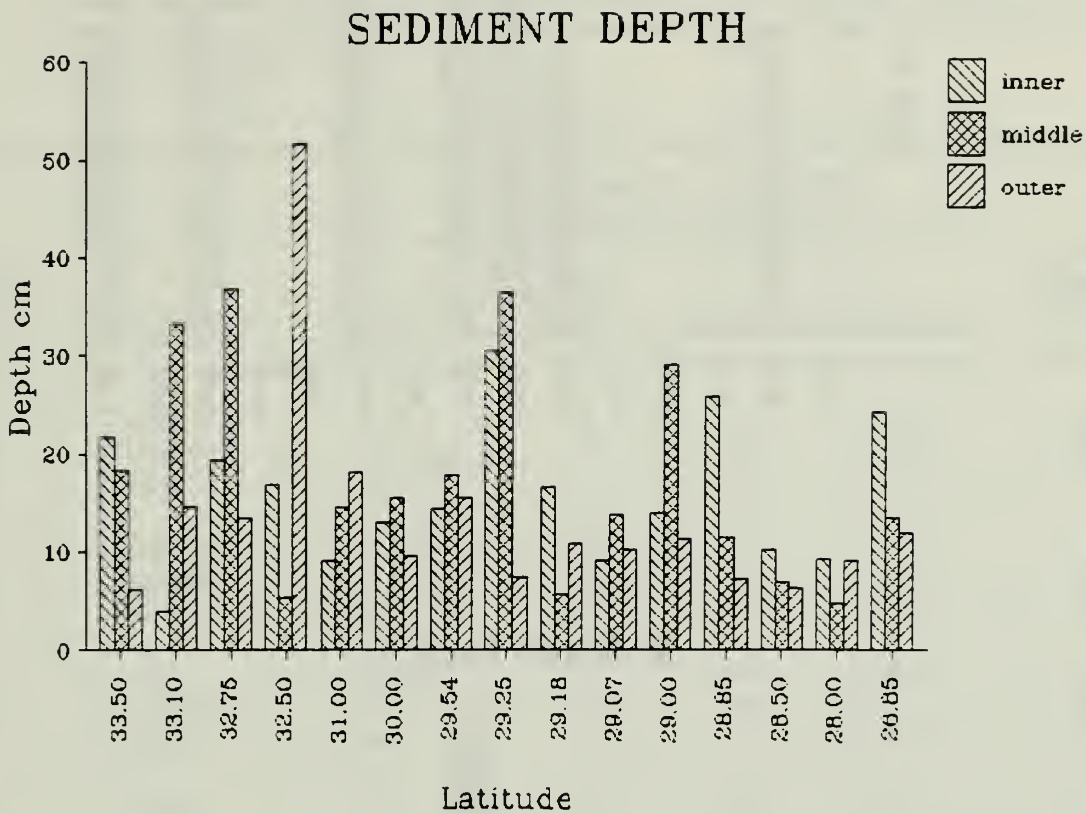

Figure 2. National Park Service Canal Impact Assessment. Mean sediment depths at each of the stations sampled for percent cover by macrophytes (Figure 1). See Table 2 for the descriptive statistics of the sediment data. Latitudes plotted as in Figure 1.

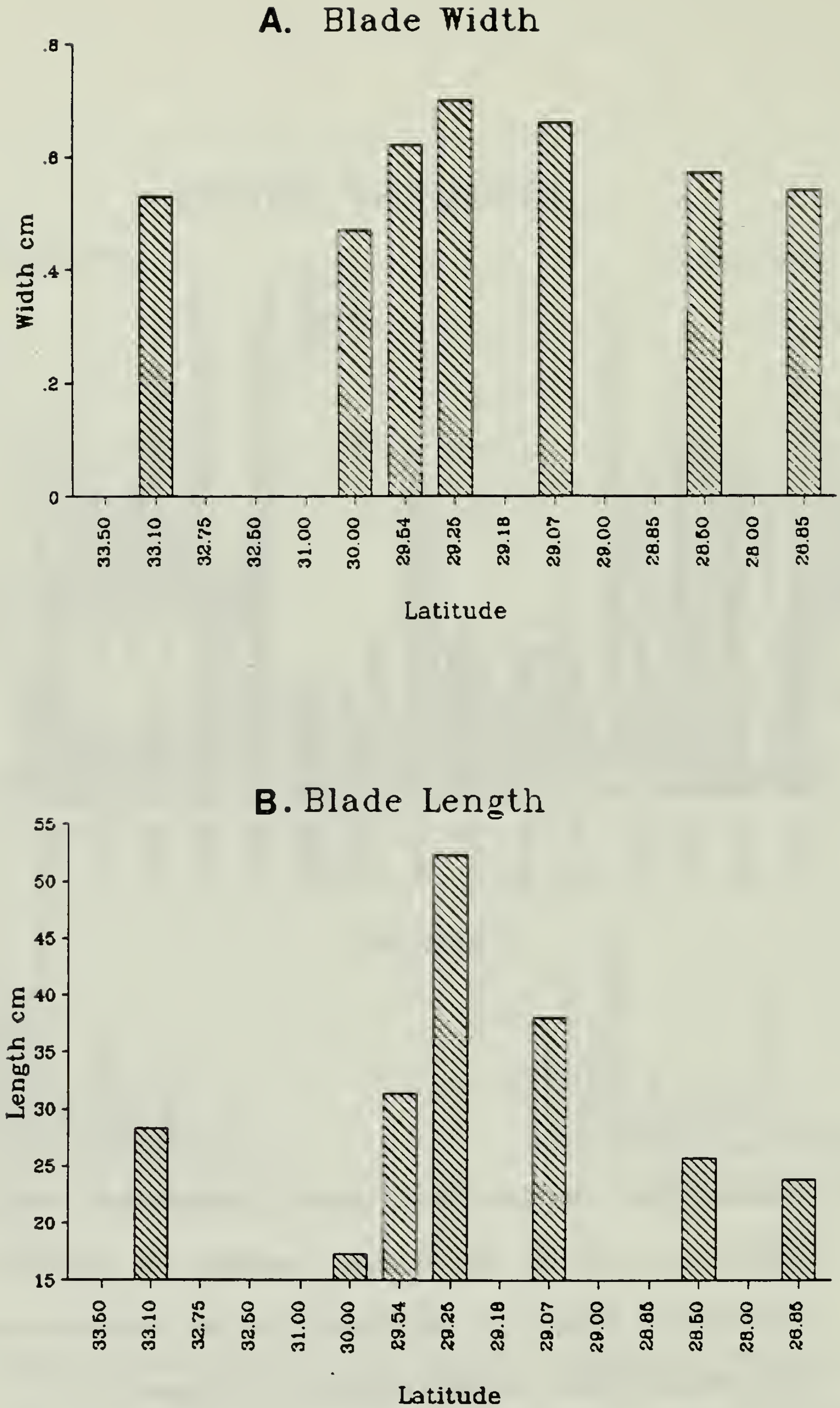

Figure 3. National Park Service Canal Impact Assessment. Mean blade length (A) and blade width (B) in mm for plants of <u>Thalassia</u> sampled with 15-cm diameter corers. See Table 4 for additional information. Latitudes plotted as in Figure 1.

Table 1. National Park Service Canal Impact Assessment. Summary of percent cover by various algal and seagrass types in 2- x 10-m transects, and of mean sediment depth in 2- x 6-m transects. See text for details of how percentages were derived. Descriptive statistics of sediment data can be found in Table 2.

		TYPE OF BOTTOM COVER PERCENT OF TOTAL				
LATITUDE (25°N)	STATION	Bare	Mixed Algae	Halodule	Thalassia	MEAN SEDIMENT DEPTH CM
33.50	inner	4	1	1	93	22
33.50	middle	35	3	0	62	18
33.50	outer	26	1	42	31	6
33.10	inner	51	23	5	12	4
33.10	middle	15	0	11	74	33
33.10	outer	28	0	18	33	15
32.75	inner	39	4	46	12	19
32.75	middle	62	13	23	3	37
32.75	outer	44	2	52	0	14
32.50	inner	11	37	45	7	17
32.50	middle	10	12	79	0	5
32.50	outer	22	47	31	0	52
31.00	inner	15	6	79	0	9
31.00	middle	8	14	66	0	15
31.00	outer	17	9	74	0	18
30.00	inner	4	25	71	0	13
30.00	middle	22	45	39	13	16
30.00	outer	4	45	39	13	10
29.54	inner	15	48	37	0	14
29.54	middle	2	43	51	4	18
29.54	outer	14	52	27	7	15
29.25	inner	52	1	47	1	30
29.25	middle	1	38	3	58	36
29.25	outer	15	3	78	4	7
29.18	inner	9	36	12	44	17
29.18	middle	1	82	14	3	6
29.18	outer	0	28	11	61	11
29.07	inner	9	53	0	39	9
29.07	middle	6	49	40	6	14
29.07	outer	0	27	36	37	10

Table 1 (cont'd.)

LATITUDE (25°N)	STATION	TYPE OF BOTTOM COVER PERCENT OF TOTAL: Bare	Mixed Algae	Halodule	Thalassia	MEAN SEDIMENT DEPTH CM
29.00	inner	6	48	17	30	14
29.00	middle	1	57	1	41	29
29.00	outer	10	20	16	54	11
28.85	inner	3	7	2	89	26
28.85	middle	0	53	18	29	11
28.85	outer	9	40	32	20	7
28.50	inner	1	39	3	57	10
28.50	middle	7	0	0	99	7
28.50	outer	7	8	6	79	6
28.00	inner	0	65	21	13	9
28.00	middle	46	43	1	10	5
28.00	outer	23	57	0	19	9
26.85	inner	6	8	3	83	24
26.85	middle	3	14	0	83	13
26.85	outer	0	0	0	100	12

Table 2. National Park Service Canal Impact Assessment. Summary of sediment depth data taken in 2- x 6-m transects at each station. Sample size was 75 except at 25o26.85'N outer station where it was 25. See text for sampling methods.

LATITUDE (25°N)	STATION	MEAN SEDIMENT DEPTH (CM)	STD. DEV.	RANGE
33.50	inner	22	6	5-35
33.50	middle	18	9	3-44
33.50	outer	6	5	0-22
33.10	inner	4	3	0-14
33.10	middle	33	6	24-55
33.10	outer	15	6	5-45
32.75	inner	19	12	0-55
32.75	middle	37	7	22-55
32.75	outer	14	9	2-51
32.50	inner	17	11	2-55
32.50	middle	5	4	1-20
32.50	outer	52	7	27-55
31.00	inner	9	4	0-20
31.00	middle	14	8	0-35
31.00	outer	18	6	6-36
30.00	inner	13	10	1-48
30.00	middle	16	10	5-55
30.00	outer	10	8	1-44
29.54	inner	14	6	5-40
29.54	middle	18	9	6-50
29.54	outer	15	8	4-46
29.25	inner	30	10	9-55
29.25	middle	36	15	6-55
29.25	outer	7	4	0-18
29.18	inner	17	10	6-55
29.18	middle	6	4	0-17
29.18	outer	11	6	0-30

Table 2. Continued.

LATITUDE (25°N)	STATION	MEAN SEDIMENT DEPTH (CM)	STD. DEV.	RANGE
29.07	inner	9	4	2-19
29.07	middle	14	7	1-38
29.07	outer	10	4	5-25
29.00	inner	14	6	3-36
29.00	middle	29	6	15-43
29.00	outer	11	4	4-25
28.85	inner	26	8	8-46
28.85	middle	11	4	3-22
28.85	outer	7	4	0-22
28.50	inner	10	3	4-18
28.50	middle	7	3	2-17
28.50	outer	6	4	2-21
28.00	inner	9	3	4-18
28.00	middle	5	3	0-17
28.00	outer	9	10	0-55
26.85	inner	24	8	9-53
26.85	middle	13	6	2-36
26.85	outer	12	4	7-20

Table 3. National Park Service Canal Impact Assessment. Probability matrix from a Pearson Correlation-Coefficient Analysis of the percent bottom cover and the sediment depth data from Tables 1 and 2. The purpose of the test was to determine whether there were significant relationships between the abundance of the various floral types and sediment depth. A natural-log transformation was used to normalize the data.

	THALASSIA	HALODULE	ALGAE	BARE	SEDIMENT
THALASSIA	1.000 (0) P = -----	-0.7245 (45) P= 0.000	-0.1692 (45) P = 0.266	-0.4122 (45) P = 0.005	-0.0166 (45) P = 0.914
HALODULE	-0.7245 (45) P = 0.000	1.0000 (0) P = -----	0.0847 (45) P = 0.580	0.2237 (45) P = 0.140	0.0070 (45) P = 0.964
ALGAE	-0.1692 (45) P = 0.266	0.0847 (45) P = 0.580	1.0000 (0) P = ----	-0.2361 (45) P = 0.118	-0.0948 (45) P = 0.536
BARE	-0.4122 (45) P = 0.005	0.2237 (45) P = 0.140	-0.2361 (45) P = 0.118	1.0000 (0) P = ----	0.0718 (45) P = 0.639
SEDIMENT	-0.0166 (45) P = 0.914	0.0070 (45) P = 0.964	-0.0948 (45) P = 0.536	0.0718 (45) P = 0.639	1.0000 (0) P = ----

Table 4. National Park Service Canal Impact Assessment. Morphometric measurements taken from plants of <u>Thalassia</u> collected with a 15.5 cm diameter corer. Blade lengths were not measured for shoots that appeared to be grazed or broken. Values are the means of two cores per station.

		No. of Blades per Shoot		Maximum Blade (cm) Length			Maximum Blade Width		
LATITUDE	SHOOTS PER CORE	MEAN	STD DEV	MEAN	STD DEV	N	MEAN	STD DEV	N
25°26.85	22	2.9	±0.9	23.9	±4.0	36	0.54	±0.09	44
25°28.48	18	2.1	±0.8	25.7	±7.2	36	0.57	±0.09	33
25°29.05	24	2.2	±0.9	38.1	±11.0	48	0.66	±0.11	48
25°29.27	16	2.6	±0.7	52.3	±5.5	31	0.70	±0.07	31
25°29.52	16	3.0	±0.8	31.4	±5.8	31	0.62	±0.07	31
25°29.98	10	2.3	±1.1	17.3	±4.0	20	0.47	±0.09	20
25°33.10	30	2.8	±0.7	28.3	±7.5	47	0.53	±0.11	59

able 5. National Park Service Canal Impact Assessment. Morphometric measurements taken as in Table 4 from cores of Thalassia that had been transplanted from a healthy Thalassia bed to two other sites: a transition site and a site dominated by Halodule. Control cores were those replanted in the same area of collection. Cores were recollected for analysis 30 days after tranplantation. Values are the means of four cores per station.

	SHOOTS PER CORE	No. of Blades per Shoot		Maximum Blade Length			Maximum Blade Width		
		MEAN	STD DEV	MEAN	STD DEV	N	MEAN	STD DEV	N
ONTROL	21	2.2	±0.6	24.1	±7.8	74	0.51	±0.10	85
RANSITION	25	2.2	±0.7	25.9	±9.0	79	0.50	±0.10	100
ALODULE	13	2.1	±0.6	29.1	±8.6	44	0.53	±0.10	52

Table 6. National Park Service Canal Impact Assessment. Summary of data from the artificial substrates. The mean flocculus weight and mean epiphyte weight, in grams dry weight, from the artificial substrate analysis are shown. Flocculus weight is the dry weight of organic matter dislodged from 20 blades of substrate by shaking. The epiphyte weight is the dry weight of epiphytes scraped from those blades. The values represent the means of four samples per site.

	MEAN FLOCCULUS WT		MEAN EPIPHYTE WT	
SITE	MEAN	STD DEV	MEAN	STD DEV
CONTROL	0.11245	±0.02705	0.37465	±0.12407
TRANSITION	0.11180	±0.02708	0.35998	±0.03108
HALODULE	0.09988	±0.03668	0.58028	±0.08841

APPENDIX A

INTERIM REPORT

National Park Service
Biscayne National Park

CANAL IMPACT ASSESSMENT: BLACK CREEK VICINITY SURFACE SEDIMENT AND PORE-WATER CHEMISTRY

INTRODUCTION

The benthic community of the western half of Biscayne Bay is dominated by grassbeds. The predominant grass throughout the portions of the bay falling within the Biscayne National Park (BNP) is Thalassia testudinum. In certain areas within BNP, however, there are undocumented observations that the Thalassia has been dying out and/or is being replaced by other marine macrophytes and algae. Suggested causes for the changes, if such have occurred, include: (a) increased discharge from the freshwater canals into Biscayne Bay, and (b) seepage of groundwater from the underlying freshwater lens, up through the porous limestone substrate into the bay (Kohout and Kolpinski, 1967). Either of these sources of freshwater might carry with them pollutants leached from nearby landfills or agricultural areas.

The studies reported here, conducted under contract with the National Park Service, had the following objectives:

(a) To search for indications of groundwater seepage within the purportedly affected area and in sites north and south of it;

(b) To measure the rates of flux of nutrients and organic pollutants from the benthic sediments; and

(c) To compare the benthic floral communities within those areas in order to determine whether there are, at this point in time, significant differences between the biotic communities.

SAMPLING SITES

A total of 18 stations was selected arranged into 6 east-west transects of 3 stations each (Inner, Middle, Outer). Nine of the stations formed a 3x3 grid within the area located between Moody and Military Canals, which is the suspected affected area. Three stations were located along an onshore/offshore transect in the area north of Black Point, which is north of the affected area. The remaining six stations formed two onshore/offshore-oriented transects within the area between the Florida City Canal and Turkey Point, a control area south of the affected area.

METHODS

The following field sampling scheme and laboratory procedures conform to the specifications outlined in RFP 5280-84-22. Any modification that were made were undertaken only after consultation and with approval from Biscayne National Park research personnel.

FIELD METHODS

1. Sediment and Water Samples:

At each station a 7.6 cm diameter corer was inserted into the sediments down to 15 - 20 cm depth. We originally hoped to obtain longer cores but we were unable to find sites with greater sediment depth. The sites were selected so as to have as little grass or algal cover as possible to minimize effects by the plants on the nutrient flux measurements. Brown-glass, incubation chambers were placed over each corer and gently pushed 3 - 5 cm into the sediment. The incubation chambers and corers were left in place for 24 hours. Water samples were taken at the beginning (from the immediate vicinity of the chambers), at the end of the incubation period (from within the chambers and also from the immediate vicinity outside of them) for determinations of salinity, ammonium, nitrate, phosphate, and dissolved organic pesticides and herbicides (the latter to be reported on separately). The cores were then recovered and returned to the laboratory for further processing.

The water samples were collected in acid-cleaned syringes and kept in a cooler on ice during transportation to the laboratory for processing. Nutrient analyses were done within 24 hours of collection. Extraction of pore-water from the cores was done at the same day of collection.

Additional water samples were collected at each site for the measurement of surface salinity (A/O Goldberg refractometer), and surface and bottom temperatures were measured with a hand-held thermometer.

2. Biological Characterization:

At each of the six middle stations, one transect (2 x 10 m) was surveyed to determine the percent coverage by each of the dominant algal or grass types and the percent of barren bottom. A 2- by 2-m quadrat was tossed at random from the anchored boat to initiate the transect; the quadrat was then flipped four times in an easterly direction to complete the transect. The quadrat was subdivided into 16x0.25-m^2 areas, and the species of grass or macroalgae dominating each subarea was recorded on underwater paper printed with a 4 x 40 grid pattern. The dominant benthic floral types were photographed with a Nikonos V underwater camera to document the different types of bottom cover. To quantify the differences in plant/algal biomass between these different bottom types, three large (0.06 m^2)

cores were taken from each station, one from each of the three most common benthic associations. At some stations where there were only two dominant benthic community types, the most common one was sampled twice. The samples were washed with a 0.5-mm mesh screen and fixed with 5% formalin and rose bengal for later sorting. Plant/algal materials were separated by species, dried and weighed (or counted for some macroalgae). Macrofauna living within or on macrophytes or algae were also sorted, counted and identified to family level or genus where possible.

LABORATORY METHODS

3. Core Subsampling:

Cores were transported to the Rosenstiel School of Marine and Atmospheric Science in the vertical position inside of buckets filled with seawater to minimize disturbance to the pore-water structure. Once in the laboratory the cores were extruded and subsampled. The top 1 cm of core was preserved in 4% formalin and later examined for macrophyte rhizomes and macroalgal components. Four 2-cm sections, taken from 1-3 cm, 3-5 cm, and two additional sections spaced evenly down the remainder of the core (depending on its length), were centrifuged at 12,000 x g for 15 minutes to separate the pore-waters from the solids. The pore-waters were recovered and analyzed for nutrients (see below) and organics (separate report by E. Corcoran).

4. Nutrient Analysis:

Overlying water and pore-water samples were analyzed for nitrate + nitrite and ammonium concentrations using an automated wet-chemistry system. The $NO_3 + NO_2$ method used was the standard Technicon AutoAnalyzer method: the ammonium method was a high-sensitivity modification (Szmant-Froelich, unpublished) of the automated phenol-hypochlorite method of Slawyk and MacIssac (1972). Phosphate concentrations were measured with the manual method of Strickland and Parsons (1972). Because of the limited amount of sample available, pore-waters were diluted 1:25 for the nitrogen analyses and 1:5 for the phosphate analyses.

RESULTS

Ambient Temperature, Salinity and Nutrients

Table 1 summarizes the environmental data collected during the three sampling periods. Temperatures and salinities were, in general, highly variable within the bay at any given time depending on proximity to canals, tides, winds, etc., and also from day-to-day depending on rainfall, tides, cold fronts, etc. On the days we sampled there were many stations that had stratified water columns inspite of the shallow depths (2 meters), but others that did not. Most of the stratification was due to salinity, with the surface layer being 2-4 o/oo less saline than the bottom layer. Along each transect, there was a general trend for the outer stations to have slightly higher salinities, but no similar trend existed for temperatures. Salinities were generally lower at the stations within the supposed affected area, especially the Military Canal ones, but water temperatures were 1-3^{o}C warmer within the affected area.

The ambient nutrient concentrations (= Table 1, "initial") also indicated differences in water quality between the control and the affected areas. Ammonium, but especially nitrate, levels were 2 to 20 times higher at all of the affected stations. Ammonium was also slightly elevated at the North Turkey Point stations. Along each transect within the affected area, there was a general trend for ammonium and nitrate concentrations to decrease towards the offshore stations. Phosphate concentrations were generally low at all stations.

Pore-water Nutrients

Table 2 summarizes the concentrations of nutrients measured in the pore-waters extracted from the cores. Figures 1 - 6 illustrate the pore-water concentration profiles. Phosphate concentrations are low and variable, sometimes exhibiting an increase down-core. Nitrate concentrations were from very low to nondetectable as would be expected for anoxic sediments. (Eh and oxygen profiles were not measured in these cores, but the sediments were distinctly black with a strong smell of H_2S). Neither of these nutrients will be discussed further.

Ammonium concentrations ranged from 17 to over 500 uM, but were generally in the 100- to 200- uM range. A variety of different profiles were exhibited. Most increased in concentration rapidly over the first few centimeters, then continued to increase more gradually down-core. Several, however, after the initial increase, showed a decrease in concentration down-core. There was no distinctive north - south or east - west trend in profile patterns or concentration ranges. In general, most of the inner stations reached concentrations of about 100 ± 50 uM within a few centimeters down-core. The two northernmost middle stations had the highest concentrations (400 uM at North Black Point and 500 uM at Moody Canal), but the rest, except for North Turkey Point (200-300 uM, had concentrations lower than 150 uM. The outer stations had concentrations of about 100 uM, except for Moody Canal and North Turkey Point where concentrations reached 200 uM.

Nutrient Fluxes

The rate at which a nutrient fluxes out of the sediment is a function of the concentration gradient between the pore-waters and the overlying water modified by many other factors including sediment porosity (ϕ), tortuosity, and bioturbation. Flux rates can be measured directly, by placing a chamber over the area of interest, or estimated based on the nutrient's concentration profile and sediment characteristics. In this study we attempted both approaches, and the measured and calculated fluxes for each station and summarized in Table 3.

The measured rates were based on the change in concentration of the nutrient within the incubation chamber adjusted for the period of the incubation, the volume of the chamber, and the sediment surface area within the chamber. The calculated fluxes were based on the method of Berner (1980), using the peak concentration from the initial linear portion of each pore-water profile (Figures 1 -6) as the high end-member of the concentration gradient, and the initial incubation nutrient measurement (Table 1) as the lower end-member, and assuming no bioturbation within the chamber. Simplified, the relationships in Berner (1980) estimate the flux rate (J) as:

$$J = \phi D_s \frac{dC}{dx}$$

where: D_s is the molecular diffusion coefficient in sediment estimated as: $D_s = \phi D$ and D is the diffusion coefficient in water and DC is the concentration change over distance dx. We did not measure porosity directly, but assumed a value of 0.5 based on measurements of porosity on similar appearing sediments worked with elsewhere. The use of values for porosity of 0.6 or 0.7 (more "watery" sediments) would have yielded flux rates 50% and 100% higher, respectively. The calculated flux rates were generally a bit higher than the measured ones, but were often in close agreement.

In general, both the measured and calculated fluxes of ammonium and phosphate were low in comparison with those reported for other nearshore estuarine areas. This agrees with the fact that pore-water nutrient concentrations were also lower than those other areas. Nitrate concentrations were nearly always undetectable in the pore-waters, and thus calculated fluxes were not estimated. Measured fluxes of nitrate may have been the result of nitrification of ammonium, either within the top centimeter of sediment or within the incubation chambers, during the incubation period.

There were no distinct or consistent differences in flux rates between control and affected areas but the Moody Canal stations differed from the rest in that measured fluxes (Table 3, columns A) showed uptake, rather than release, of ammonium and nitrate by the sediments. Calculated fluxes for these Moody Canal stations, however, were not significantly different from those of the other stations. The three North Turkey Point stations, and the outer South Turkey Point station had significantly higher measured (but not always calculated) fluxes of ammonium than those of the other stations. However, there were no significant differences in their nitrate or phosphate fluxes.

<u>Groundwater Flux</u>

Changes in salinity inside the incubation chambers could result from low or high salinity water seeping up through the sediment enclosed within the chamber, or by equilibration with seawater outside of the chamber ("leaky" exchange) if the salinity of the exterior seawater changed during the incubation period. Table 4 compares the measured changes in salinity inside and outside of each incubation chamber. Groundwater seepage would be expected to cause a decrease in salinity within the chamber greater than any decrease that might occur outside. "Leaking" of the chambers would be evidenced by changes in salinity inside the chamber always following the same trend as those outside, while nonexchange and nonseepage would be indicated by no change occurring inside the chamber in spite of large changes occurring outside.

Ambient salinities either remained the same (two cases) or increased. There were 4 cases of a total of 17 (one chamber station was lost) of salinity decreases greater than 2°/oo inside of Chambers that might indicate ground water seepage (Military and North Turkey Point, inner and middle stations). There were 10 cases where there was either no change inside the chamber, or a change of only 1°/oo (readability of refractometer) that might indicate no groundwater seepage and no exchange/leakage of the chambers with the outside. In the remaining three cases salinities inside of the chambers increased, but unfortunately there were no estimates of outside ambient salinity change for two of these. These three chambers probably leaked and were influenced by salinity increases occurring outside the chambers.

Macrophyte - Macroalgal Percent Cover and Biomass

The two macrophytes found within the study areas were Thalassia and Halodule. In addition, there were several common species of macroalgae, of which the most abundant was Laurencia. The percent of the bottom dominated by each of the easily recognizable species at each station is presented in Table 5. All areas had variable and sometimes large amounts of bottom covered by what we termed "mixed algae" (mostly Laurencia), with no consistent north - south or affected area/control area differences. There were, however, definite distributional patterns for the macrophytes. The two southern control stations were dominated by areas of thick Thalassia and mixtures of macroalgae, but no Halodule was present. Percent cover by Thalassia decreased northward to a minimum in the Fender Point area. It was also in low abundance in the northern control station north of Black Point. There was a pocket of higher percent cover by Thalassia in the Moody Canal area. As Thalassia decreased in percent cover, Halodule increased in percent cover; Halodule was most abundant in the Moody Canal area. The southern stations also had some coverage by the macroalgae Halimeda and Sargassum, which were uncommon in the more northern stations. The northern stations had a higher percentage of bare substrate, and of substrate covered by accumulations of dead grasses (mostly Halodule).

The biomasses (grams dry weight) of the two grasses and of Laurencia for each of the three large can-cores collected at each station are tabulated in Table 6. The proportions of the total biomass of each sample made up of each species are tabulated in Table 7. As explained above, the three cores per station were not replicates, but were taken to characterize, biomass-wise the three dominant types of floral bottom cover. These were generally: (1) Thalassia, (2) Halodule, and (3) mixed algae (mostly Laurencia). Table 6 shows that areas covered by Thalassia had standing crops 2 - 4 times higher than those covered by the other two plant types.

Off of North Black Point all three types were present. Although areas covered by Thalassia were only a small percent of the total (Table 5) they had a biomass similar to those from Turkey Point stations. Overall, however, this control area had a lower average standing crop than the southern control area.

Off of Moody Canal, there was some Thalassia present, but the standing crop of the sample dominated by this species was only one-half of that of samples from the control stations, and it contained an appreciable amount of Halodule. The remaining two samples contained almost pure Halodule. There were no samples of mixed algae because this floral type was not common at this station (Table 5). Because Halodule stands had a standing crop of only 25 - 30% of Thalassia stands, the overall standing crop in this area was relatively low.

Fender Point also had very low percent coverage by Thalassia. Two of the core samples were dominated by mixed algae and Halodule, respectively, and the third by the calcerous green alga Penicillus and the green alga Batophora (Table 8). The overall standing crop was also low at this station (Table 6).

Off of Military Canal significant areas were covered with each of the three main bottom types. The Thalassia samples had a biomass similar to that of the Turkey Point stations, but much of the bottom in this area was covered by lower biomass Halodule and mixed algae. As a result, the overall standing crop was higher than that of the other two "affected" stations but lower than that of the adjacent control stations.

The two Turkey Point control stations were characterized by an almost total absence of Halodule. The three samples at each station had similar biomasses of Laurencia, and differed mostly in the amount of Thalassia they contained. The samples dominated by Laurencia had lower total biomasses than those dominated by this alga at other stations (Table 6); however, these samples contained large numbers of Penicillus and Batophora (Table 8) which were low in biomass but effectively covered the substrate. These Thalassia-dominated stations has the highest overall standing crops.

Table 8 summarizes the abundances, in terms of biomass or numbers, of the less-abundant macroalgae found in the core samples. Two species (Sargassum and Halimeda) were only found at the southern stations, and another one, Batophora, was most abundant south of Military Canal. Pencillus, while present throughout, was most abundant in the northern and southern control areas.

Macrofauna

While the emphasis of the biological sampling was on the floral communities, some macrofauna (retained on a 0.5 mm sieve) was recovered from the large core samples (Table 9). There were no differences in the number of taxa collected at each station, but this is not a fair comparison since most of the animals were not identified to the species level. Most of the taxa were found in only a few of the samples, so it is difficult to determine whether there were differences in distribution between areas. Among the few groups that occurred more widely or in large numbers were the following: The mussel Brachidontes was most common in samples with Thalassia or Laurencia, and therefore we found few of them in the Moody Canal or Fender Point samples which were dominated by Halodule. The same is true for the gammarid amphipods, which were also in lower abundance in the North Black Point samples. The idoteid and spaeromatid isopods, on the other hand, were much more abundant in the North Black Point and in the affected area samples, possibly because they may feed heavily on Halodule detritus and associated microbial films. The nereid polychaetes were more abundant in the Moody and Military Canal samples, possibly indicating greater siltation in these two areas.

CONCLUSIONS AND RECOMMENDATIONS

The results of the biological sampling quantitatively confirm that there are large differences in the composition of the benthic macrophyte and macroalgae communities between the southern control stations and stations within the affected area. The results also suggest that these differences extend northward into the Black Creek area, which was supposed to be a northern control site.

The major difference between the control and affected areas is that the seagrass Thalassia dominates the former, while Halodule dominates the latter. The Black Point and Military Canal areas can be considered transition zones with both grasses coexisting at the present time. There is no way to determine from the present study how long these differences have existed, nor whether there are progressive changes taking place at this time in the transition areas.

Neither is there any indication that these biological differences are related in any way to nutrient conditions in the sediments. Nutrient concentrations and fluxes of nutrients out of the Biscayne Bay sediments were generally higher than those of typical turtlegrass beds (McRoy and McMillan, 1977; S. Williams, pers. comm. and unpubl. data). Thalassia beds have high nutrient demands and are generally considered to be nutrient limited (McRoy and McMillan, 1977). Fertilization studies have shown that increased nutrient input to nutrient-poor sediments favors Thalassia over other seagrasses and macroalgae (Williams, in press). Therefore, seepage of nutrient-rich groundwater would be expected to favor Thalassia rather than be responsible for a shift from Thalassia to Halodule. This is supported by the fact that the highest rates of nutrient flux were measured at the Turkey Point stations, which also had the densest stands of Thalassia.

Recent studies by Williams (in press) of the process of recolonization by seagrasses of denuded areas have shown that there is a succession in recolonization beginning with macroalgae, followed by Halodule, then Syringodium (when present), and concluding with Thalassia, which parallels the enrichment of the sediments with organic material and nutrients. It is possible that what is being seen now in the affected area is the recolonization of the Moody Canal and Fender Point area after a major die-off of previously healthy Thalassia beds. The die-off could have been caused by a major episode of extremely high or low temperatures or of lowered salinity, or by a longer-term deterioration of the marine environment in the area. This deterioration is likely caused by increased color, lower salinity, and higher nutrients in the water column that were in turn caused by increased discharges from the canals. High nutrients in the water column differs from nutrient enrichment in the sediments in that the former would favor the growth of epiphytic algae that could smother Thalassia but not Halodule. In general, Halodule is much more tolerant of lower light and salinity and of extremes in temperature (den Hartog, 1977, McRoy and McMillan, 1977). Kohout and Kolipinski (1967) found a transition from Halodule nearshore to Thalassia further offshore of the Cutler area (north of our Black Creek stations) which they attributed to the influence of groundwater seepage close to shore. Another factor that may intervene is sediment depth. Thalassia requires a greater sediment depth than macroalgae and Halodule, and thus, variations in sediment depth between areas may determine the relative abundances of these two species of macrophytes.

In view of these data and observations and because of the lack of historical data on the distribution of seagrasses within these areas for comparison, I recommend that rather than repeat the nutrient-flux measurements, which were nondiagnostic the first time around, that any further efforts of this project be spent on collecting more biological samples with the following objectives:

1) Determine with great accuracy the boundaries of the transition zones between Thalassia- and Halodule-dominated macrophytic communities;

2) Compare ranges of sediment depths in the three areas (control, transition, affected);

3) Compare the primary productivity of Thalassia- and Halodule-dominated areas, since the standing crops of the two seagrass types differ so much.

4) Establish stations within the core of the affected area and in the transition zones that can be monitored by BNP personnel over a period of years to determine the direction of any changes in community structure that may still be taking place.

I also recommend that BNP undertake a low-altitude, aerial photographic study of portions of these areas to determine how much change is taking place in the denuded areas of bottom. It was obvious that bare areas were more common in the affected and northern control areas than in the southern control areas. Such a study would be difficult or impossible to conduct from a small boat because of the problems associated with relocating specific patches.

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Table 1. Summary of temperatures, salinities, and nutrient concentrations measured during the periods when NPS Canal Assessment benthic flux studies were conducted. Temperatures and salinities were measured in surface bucket samples. Bottom temperature and salinity measurements were made within 30 cm of the bottom. Nutrient samples were taken from within the flux chambers. I = measurements made at time flux chambers were set up. F = measurements made at termination of flux period.

Date	Station	Temperature				Salinity (o/oo)				Nutrients (uM)					
		Surface		Bottom		Surface		Bottom		Ammonium		Nitrate		Phosphate	
		I	F	I	F	I	F	I	F	I	F	I	F	I	F
11/16/84	North Black Pt.														
	Inner	21.5	-	21.0	-	32	-	32	32	0.48	1.37	0.19	0.20	0.05	0.13
	Middle	21.0	21.5	20.5	-	31	32	31	32	0.58	2.15	0.19	0.20	0.04	0.18
	Outer	21.0	-	-	-	32	-	30	32	0.53	0.93	0.20	0.21	0.04	0.04
	Fender Pt.														
	Inner	23.5	-	22.0	-	25	-	25	(-lost)	1.64	-	4.40	-	0.18	-
	Middle	23.0	-	22.0	-	22	-	25	30	1.32	6.30	4.74	6.41	0.04	0.20
	Outer	22.0	-	21.0	-	25	-	27	26	1.21	3.00	2.08	2.06	0.01	0.18
11/19/84	Military Canal														
	Inner	24.5	-	23.8	24.5	20	24	24	22	1.76	5.17	1.28	6.80	0.04	0.30
	Middle	24.0	-	24.0	24.5	21	25	24	22	1.80	5.52	6.45	8.92	0.05	0.20
	Outer	24.0	-	24.0	24.5	22	25	24	24	1.05	4.97	1.53	4.98	0.06	0.09
	South Turkey Point														
	Inner	23.0	-	23.2	24.0	24	27	24	24	0.35	1.35	0.53	0.32	0.03	0.18
	Middle	23.0	-	23.0	24.0	25	28	26	25	0.44	1.40	0.63	0.95	0.01	0.14
	Outer	23.0	-	23.0	24.0	26	27	27	26	0.36	17.52	0.47	0.41	0.03	0.26
11/30/84	Moody Canal														
	Inner	25.0	-	24.0	24.2	24	29	26	28	2.96	1.48	5.08	0.41	0.05	0.23
	Middle	24.5	-	24.0	24.0	24	30	27	28	5.87	3.23	3.46	1.76	0.17	0.11
	Outer	24.7	-	23.7	24.0	25	31	28	28	1.85	1.79	2.45	0.31	0.05	0.06
	North Turkey Pt.														
	Inner	22.5	-	23.5	25.0	25	26	28	25	1.12	15.90	0.23	2.96	0.02	0.10
	Middle	22.5	-	23.0	24.8	26	26	29	26	1.11	17.42	0.73	1.30	0.12	0.15
	Outer	22.8	-	23.3	24.5	25	27	28	27	1.39	11.97	0.37	1.20	0.14	0.10

Table 2. Summary of pore-water nutrient concentrations (μM) measured in cores taken from within benthic, nutrient flux chambers during the NPS Canal Assessment Project. Stations are listed in order of location from north to south within the study area. Depths are depths down-core.

Station	Depth (cm)	Pore-water Nutrient Concentrations		
		NH_4	NO_3	PO_4
North Black Pt. Inner	-1	96	0.03	2.04
	-3	108	0.03	1.68
	-7	111	0.03	2.16
	-9	112	0.03	2.22
North Black Pt. Middle	-1	117	n.d.	1.20
	-3	293	n.d.	1.56
	-7	346	n.d.	3.06
	-11	400	n.d.	1.86
North Black Pt. Outer	-1	75	n.d.	1.32
	-3	113	n.d.	1.20
	-9	92	n.d.	0.96
	-15	62	n.d.	1.02
Moody Canal Inner	-1	63	n.d.	0.66
	-3	81	n.d.	0.48
	-9	81	n.d.	1.14
	-13	25	n.d.	1.26
Moody Canal Middle	-1	508	n.d.	1.38
	-3	265	n.d.	0.78
	-9	98	n.d.	2.10
	-15	17	n.d.	0.84
Moody Canal Outer	-1	165	n.d.	0.90
	-3	216	n.d.	1.68
	-5	161	n.d.	1.14
	-9	152	n.d.	1.08
Fender Pt. Inner	***			
Fender Pt. Middle	-1	68	2.5	0.30
	-3	132	5.4	2.88
	-7	128	2.5	2.22
	-10	135	0.5	6.18
Fender Pt. Outer	-1	68	n.d.	0.30
	-3	62	n.d.	0.30
	-11	38	n.d.	0.66
	-19	95	n.d.	1.20

*** Station was lost

Table 2 (continued)

Station	Depth (cm)	Pore-water Nutrient Concentrations		
		NH_4	NO_3	PO_4
Military Canal Inner	-1	96	1.5	1.10
	-3	120	1.8	2.35
	-9	131	0.8	3.30
	-17	159	1.5	2.25
Military Canal Middle	-1	109	n.d.	0.85
	-3	165	n.d.	1.40
	-7	92	n.d.	0.80
	-13	79	n.d.	0.55
Military Canal Outer	-1	81	n.d.	0.40
	-3	85	n.d.	0.80
	-11	115	n.d.	0.55
	-17	143	n.d.	0.60
North Turkey Pt. Inner	-1	136	n.d.	2.64
	-3	160	n.d.	1.68
	-9	89	n.d.	1.68
	-15	146	n.d.	-
North Turkey Pt. Middle	-1	245	n.d.	3.16
	-3	201	n.d.	1.50
	-7	162	n.d.	1.32
	-13	206	n.d.	2.94
North Turkey Pt. Outer	-1	81	n.d.	1.38
	-3	88	n.d.	1.50
	-9	163	n.d.	2.16
	-15	236	n.d.	4.80
South Turkey Pt. Inner	-2	123	3.5	1.80
	-4	80	3.3	0.95
	-11	39	2.0	0.45
	-16	32	2.0	0.40
South Turkey Pt. Middle	-1	83	2.0	0.25
	-3	112	2.8	0.75
	-9	78	1.8	0.80
	-13	96	1.5	0.70
South Turkey Pt. Outer	-2	77	n.d.	0.40
	-4	98	n.d.	2.15
	-8	168	n.d.	0.70
	-12	141	n.d.	0.85

Table 3. Nutrient flux rates out of Biscayne Bay sediments.

A. Flux rates measured with brown-glass benthic chambers (3- liter volume; 511-cm^2 surface area) over 24 periods.

B. Flux rates calculated from the concentration gradients between surface waters and pore-waters assuming a porosity (o) of 0.5. (See text for details of calculations). Nitrate fluxes were not estimated by this method. Values in ug-at$\cdot m^{-2}\cdot h^{-1}$.

	AMMONIUM						PHOSPHATE						NITRATE		
	Inner		Middle		Outer		Inner		Middle		Outer		Inner	Middle	Outer
	A	B	A	B	A	B	A	B	A	B	A	B	A	A	A
North Black Pt.	2.08	8.48	3.94	12.92	0.98	4.97	0.19	0.29	0.34	0.17	0.00	0.19	0.02	0.02	0.02
Moody Canal	-3.84	5.26	-6.86	11.45	-0.15	14.41	0.47	0.06	-0.16	0.18	0.03	0.12	-12.13	-4.42	-5.52
Fender Pt.	--	--	12.39	5.77	4.45	5.90	--	--	0.40	0.21	0.42	0.06	--	-4.15	-0.05
Military Canal	8.65	8.32	9.37	7.21	9.90	7.06	0.66	0.17	0.38	0.10	0.08	0.05	14.00	6.22	8.71
North Turkey Pt.	34.70	11.91	38.82	21.54	26.22	7.03	0.19	0.39	0.07	0.05	-0.10	0.18	6.41	1.36	2.06
South Turkey Pt.	2.46	7.22	2.35	7.29	41.97	4.51	0.37	0.10	0.32	0.04	0.56	0.12	0.52	0.78	-0.15

Table 4. Change in salinity within benthic flux chambers as compared to changes in salinity in ambient seawater near the bottom. Values in ‰.

Stations	Inner		Middle		Outer	
	Inside Chamber	Outside	Inside Chamber	Outside	Inside Chamber	Outside
North Black Pt.	0	-	+1	0	+2	-
Moody Canal	+2	+5	+1	+6	0	+6
Fender Pt.	lost	-	+5	-	-1	-
Military Canal	-2	+4	-2	+4	0	+3
North Turkey Pt.	-3	+1	-3	0	-1	+2
South Turkey Pt.	0	+3	-1	+3	-1	+1

Table 5. Summary of percent cover by various algal and seagrass types in 2-m x 10-m transects surveyed during the NPS Canal Asses project. For details on how percentages were derived, see methods section of the report. Values in parentheses for North Black Point station were from a second, smaller 2-m x 6-m transect.

	STATIONS					
Type of Grass or Algae	N. Black Point	Moody Canal	Fender Point	Military Canal	N. Turkey Point	S. Turkey Po
Thalassia	6(13)	20	4	21	32	41
Halodule	26(30)	60	21	29	-	-
Mixed algae*	20(35)	10	64	23	37	52
Halimeda	-	-	-	-	2	4
Penicillus	35(22)	-	-	-	21	-
Acetabularia	-	-	-	-	1	-
Batophora	-	-	-	19	2	-
Sargassum	-	-	-	-	4	2
Dead grasses	-	5	-	6	-	-
Barren	13(0)	5	11	-	1	0

*Mostly Laurencia, but also includes Penicillus, Halimeda, Acetabularia and Batophora when those were not sufficiently abundant to be listed separately.

Table 6. Biomass of major plant/algal species collected with large-can cores (0.06 m^2) during NPS Canal Assessment Study. Three samples were taken at each station from three representative floral types. Values are g dry wt.• 0.06 m^{-2}.

	Thalassia		Halodule				
Site/Sample	rhizomes, stalks	blades	rhizomes, stalks	blades	Laurencia	Total plant dry weight per sample	Percent of total of all stations
North Black Pt.							
1	50.6	33.3	0.4	0.1	0.2	84.5	10.99%
2	11.2	0.3	0.1	0.1	26.7	38.3	4.98%
3	1.1	0.1	10.2	1.8	4.0	17.2	2.24%
Moody Canal							
1	1.7	0.5	11.6	2.3	0.1	16.1	2.09%
2	0.0	0.0	17.3	4.6	0.0	21.9	2.85%
3	16.1	11.4	14.0	3.3	0.0	44.8	5.83%
Fender Pt.							
1	4.0	0.0	0.4	0.4	32.3	37.1	4.83%
2	0.0	0.1	13.2	4.0	0.1	17.2	2.24%
3	0.0	0.0	0.9	0.6	0.1	1.6	0.21%
Military Canal							
1	39.2	21.4	3.5	1.3	8.1	73.5	9.56%
2	10.4	6.0	13.9	6.1	0.1	36.4	4.74%
3	0.0	0.0	0.1	1.8	39.4	41.2	5.36%
North Turkey Pt.							
1	32.6	16.1	0.0	0.0	13.4	62.1	8.08%
2	46.8	23.0	0.1	0.1	8.4	78.2	10.17%
3	3.4	2.2	1.3	0.2	13.5	20.6	2.68%
South Turkey Pt.							
1	1.0	5.9	0.0	0.0	14.2	21.1	2.74%
2	40.6	23.2	0.1	0.1	11.8	75.6	9.83%
3	49.8	18.3	0.0	0.0	13.2	81.3	10.58%
Total for all samples:	308.5	161.7	86.8	26.4	185.3	768.7	
% of total plant dry weight:	40.13%	21.04%	11.29%	3.43%	24.11%		

Table 7. Percent of total floral biomass in each sample made up of each of the three dominant plant/algal species.

Site Sample	Thalassia	Halodule	Laurencia
North Black Pt.			
1	99.3	0.5	0.2
2	30.0	0.3	69.7
3	7.0	69.8	23.3
Moody Canal			
1	13.7	86.3	0.0
2	0.0	100.0	0.0
3	61.4	38.6	0.0
Fender Pt.			
1	10.8	2.2	87.1
2	0.0	100.0	0.0
3	0.0	93.8	6.3
Military Canal			
1	82.5	6.5	11.0
2	45.0	55.0	0.0
3	0.0	4.4	95.6
North Turkey Pt.			
1	78.4	0.0	21.6
2	89.3	0.0	10.7
3	27.2	7.3	65.5
South Turkey Pt.			
1	32.3	0.0	67.3
2	84.4	0.0	15.6
3	84.8	0.0	16.2

able 8. Biomass or numbers of individuals of smaller or less abundant algal species found in the can cores. Values are in g dry wt.• 0.06 m-2 or number of stalks (#).

te Sample	Sargassum	Halimeda	Penicillus (#)	Batophora (#)	Anadyomene (#)
orth Black Pt.					
2	0.0	0.0	0	0	1
3	0.0	0.0	40	0	0
oody Canal					
1	0.0	0.0	0	7	0
ender Pt.					
1	0.1	0.0	0	19	0
2	0.0	0.0	0	3	0
3	0.0	0.0	67	55	0
ilitary Canal					
3	0.0	0.0	0	326	0
orth Turkey Pt.					
1	0.0	0.0	4	8	0
2	0.0	0.1	32	2	3
3	0.0	4.9	36	234	1
outh Turkey Pt.					
1	0.2	0.1	0	226	7
2	4.1	0.0	7	2	1
3	0.0	4.2	13	123	31

Table 9. Summary of numbers of fauna collected in large (0.06-m^2) can cores taken during November and December 1985 during NPS Canal Assessment study. Three cores were taken at each station, from three representative floral types (see Table 6 for data on grasses and algae in each sample).

Taxon	North Black Pt.			Moody Canal			Fender pt.			Military Canal			North Turkey Pt.			South Turkey Pt.		
Core #	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
FISHES																		
Gobiosoma								2										
Opsanus		1										1						1
Syngnathus	1						1								1			
? fish larvae					1					2		1				1		
MOLLUSCS																		
Amygdalum				5	1	3				2	3							
Anomalocardia				2		3		2	4		3							
Arcidae			3															
Brachidontes	5	95	3				15		1	23	2	27	25	20	10	19	8	1
Busycon eggs					1													
Cerithium	2										1		2	7			1	1
Chione				1							2		4			1		
Cylindrobulla			2						1				3	3	4	2	2	
Lucinidae													4					
Melongenidae										1	1							
Nertina (dead)		2		2		1	1											
Polyplacophora													5	3			4	1
Tagelus					2	2												
Tellina	1						4	4		4	3		1					
Turbo						1												
ARTHROPODS																		
Cleantis		1																
Edotea								1										
Idoteidae		5	4	1	5	2	16	22	1	3	1	3			4			
Sphaeromatidae		5	3	13	21	13	29	3	6	7	11	18	1		6		3	1
Diastylidae				1				1	4									
Gammaroidea	31	197	27	47	54	27	69	21	29	174	138	79	131	238	92	394	274	224
Hippolyte		4		1		1	5	1			2		4	4	4	9	20	2
Leptochelia		2		3		1												
Paguridae			2	1									1	3	6	2	1	
Parantanaidae									25				1		2		4	
Penaeidae				1														
Portunidae	1				1													
Xanthidae						1												
POLYCHAETES																		
Arabellidae																		
Arenicola					2	1	1				1	1		1	1	1		1
Eunicidae	6	2	4										12		1		2	2
Maldanidae			2								2						1	
Nereidae	3	7	9	104	24	25	12	59	48	8	9	3	9	10	24	22	12	6
Sabellidae		2	1			1			1									
Sipuncula	1					1			1	1				1		3		
Terebellidae		7	1	1		1										1	1	1
Unid. Worm					1	1				2	5	1	2	1	1		4	2
ECHINODERMS																		
Asteroidea														1				
Ophiuroidea	1																	

FIGURE 1. Pore water nutrient profiles for North Black Point Stations.

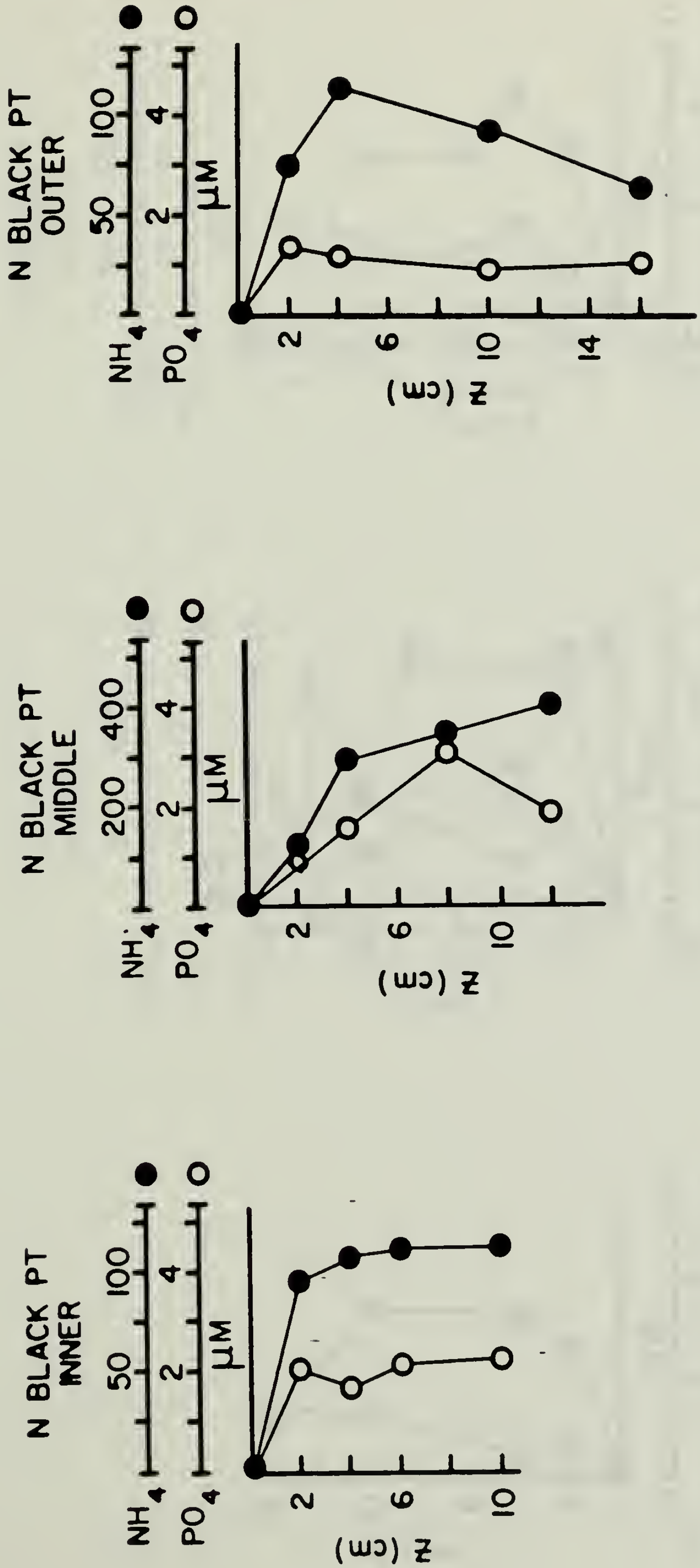


FIGURE 2. Pore water nutrient profiles for Moody Canal stations.

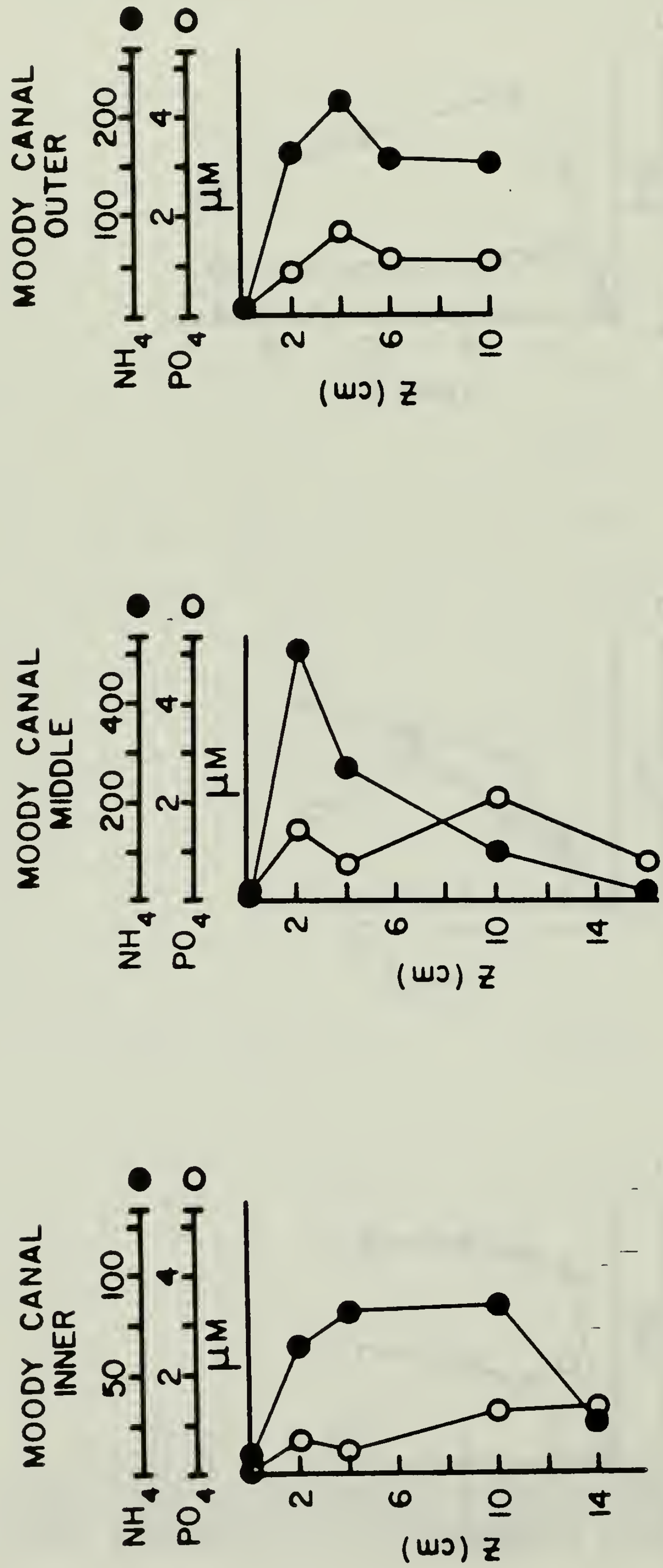


FIGURE 3. Pore water nutrient profiles for the Fender Point stations.

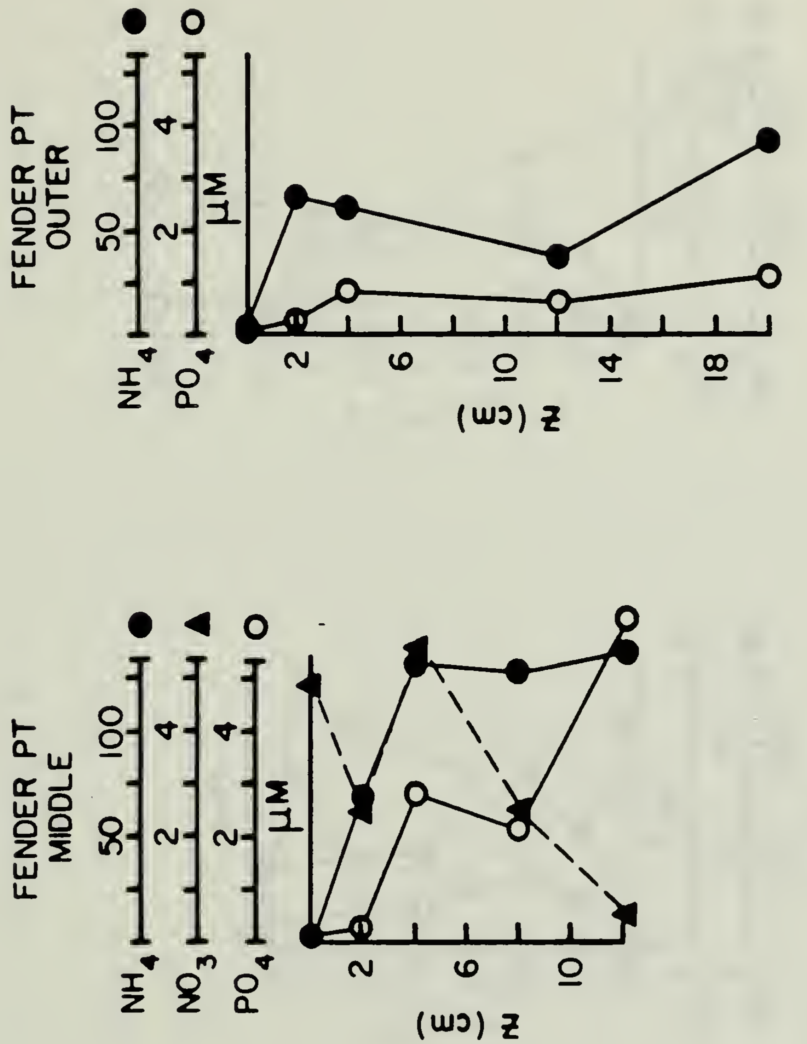


FIGURE 4. Pore water nutrient profiles for the Military Canal stations.

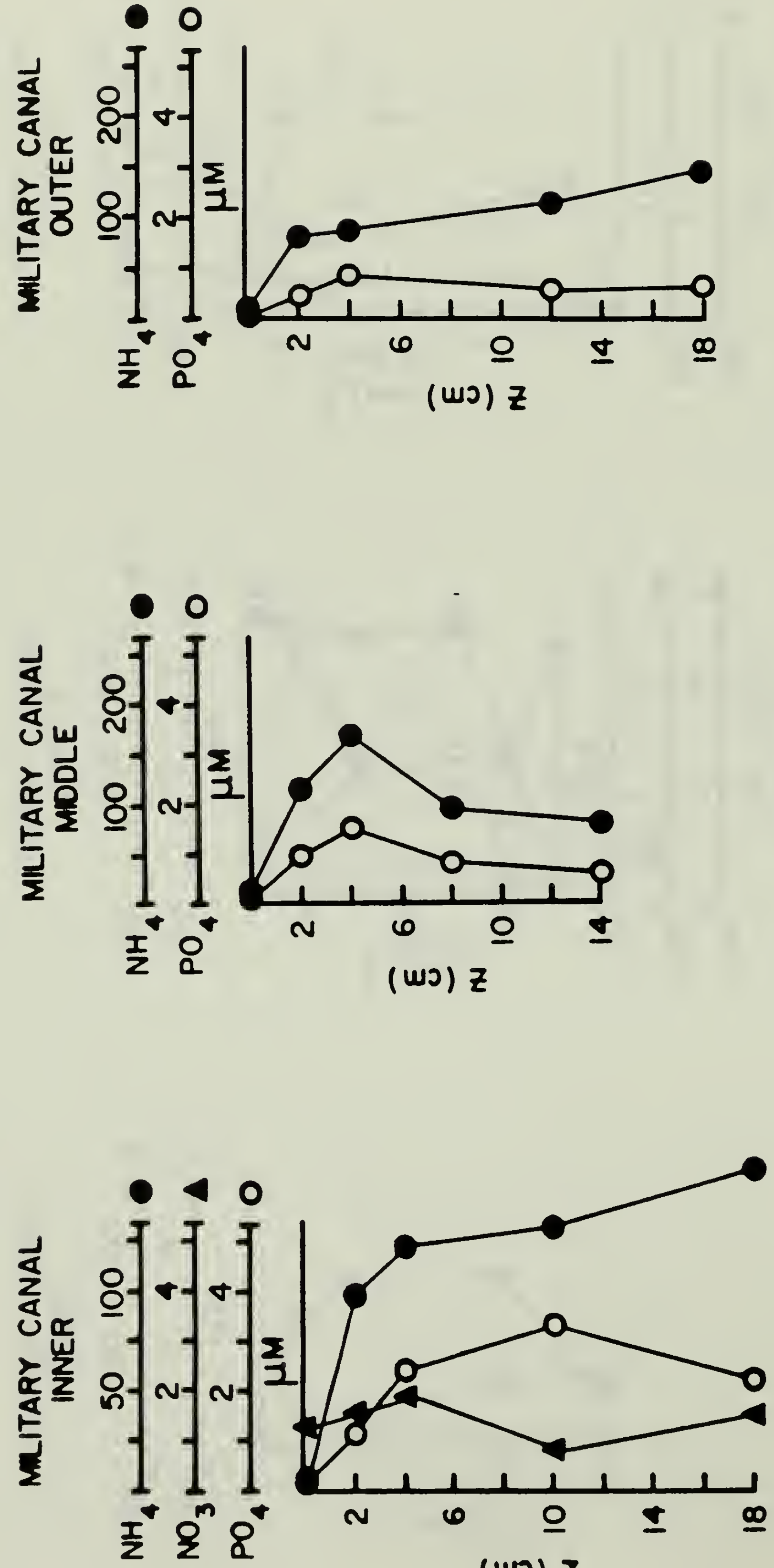


FIGURE 5. Pore water nutrient concentrations for the North Turkey Point stations.

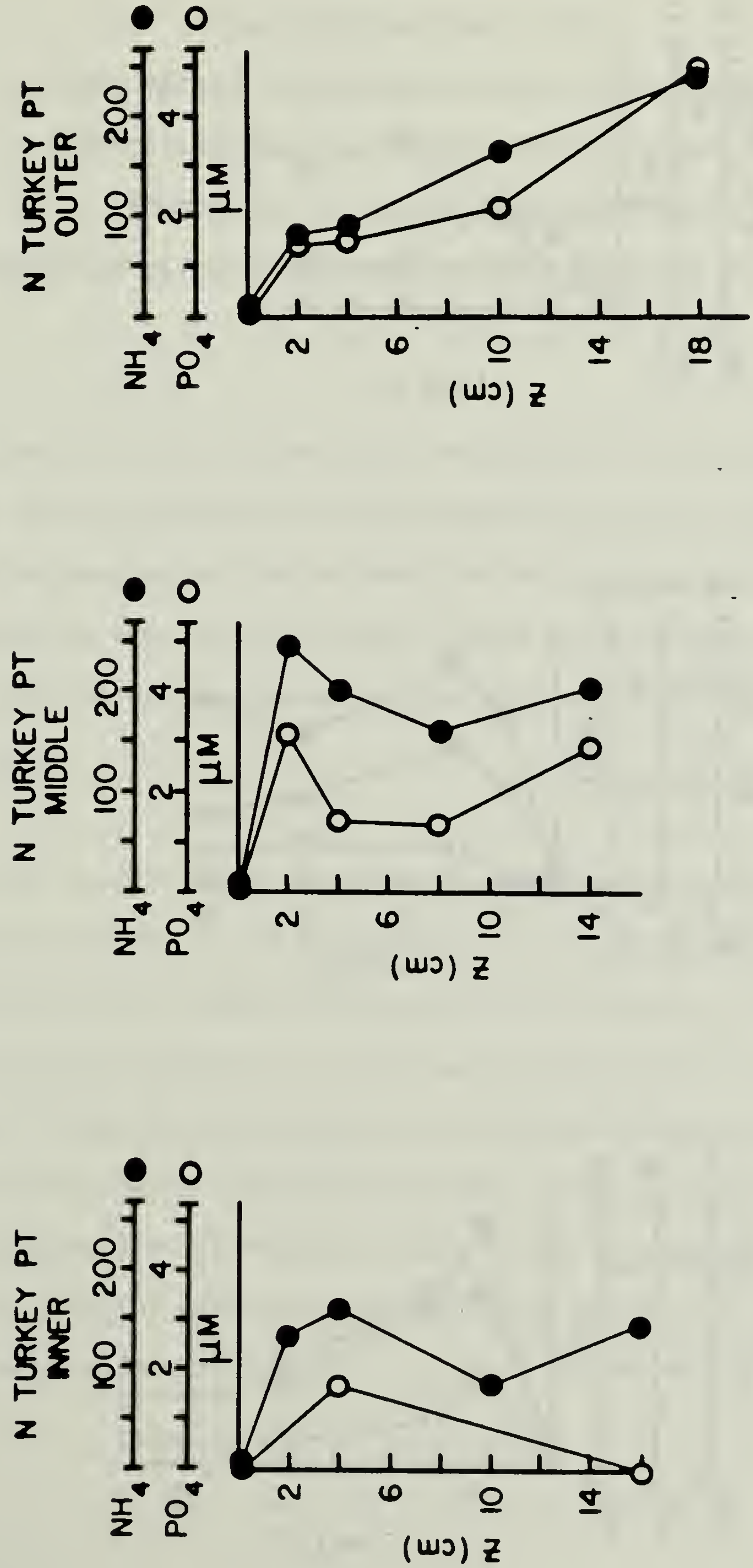
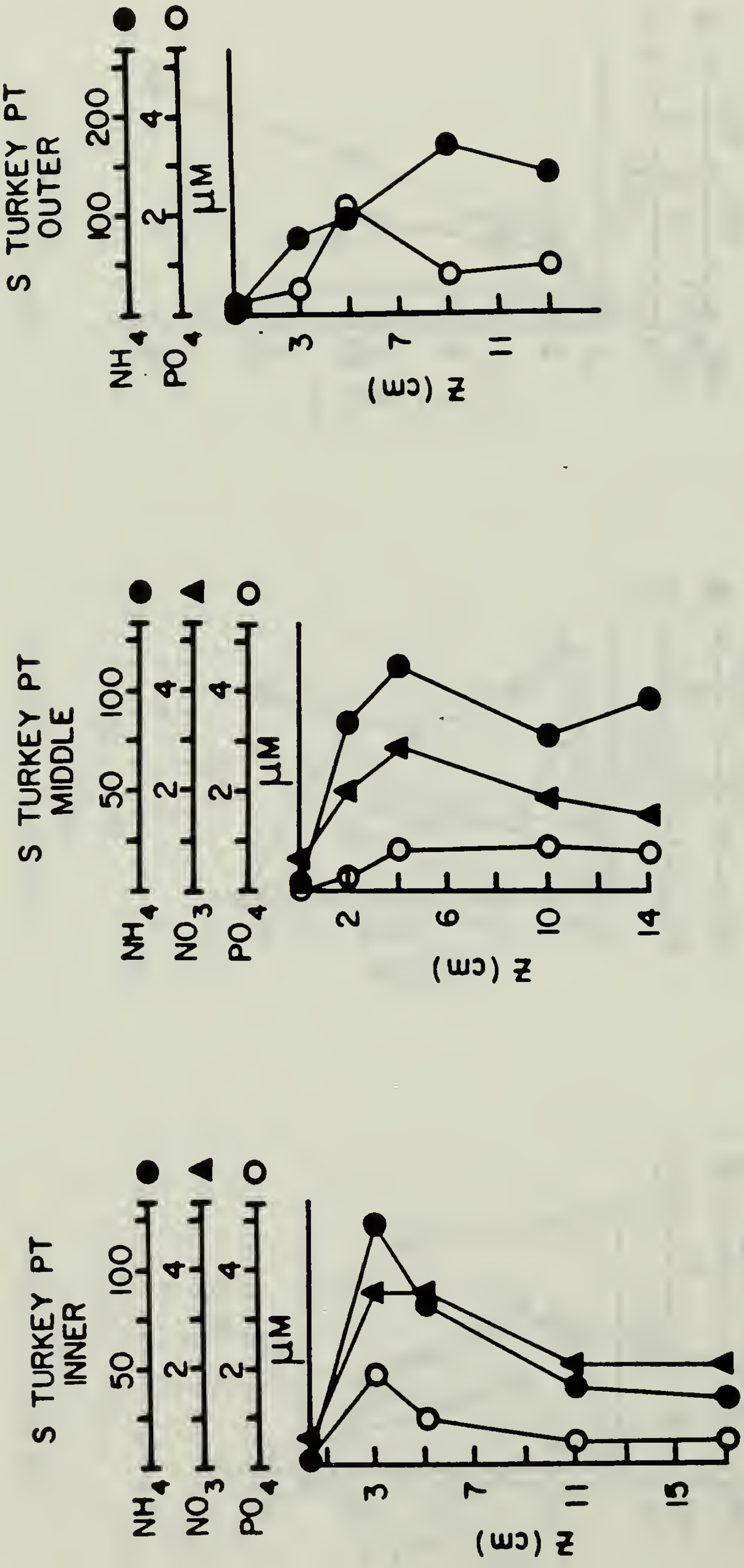


FIGURE 6. Pore water nutrient profiles for the South Turkey Point stations.



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CANAL IMPACT ASSESSMENT: BLACK CREEK VICINITY

SURFACE SEDIMENT AND PORE-WATER CHEMISTRY

REPORT NO. 2: CAGING EXPERIMENTS -

COMPARISON OF PLANT COVERAGE BETWEEN JANUARY AND APRIL 1985

Six cages, 2-m x 2-m in size, were constructed of PVC pipe and 1.3-cm mesh wire cloth. They were deployed in late December 1984 at the midtransect station at each of the six stations (see Interim Report for details about station locations). The cages were placed over large "bare" spots (devoid of macrophytes) as the purpose of the experiment was to determine whether the bare spots were a result of grazing by fishes or turtles.

The areas enclosed within the cages were photographed in mid-January 1985 and again in mid-April 1985. On the second date we found that two of the cages (Moody Canal and Fender Point sites) had been destroyed by boaters. A 0.33-m x 0.33-m quadrat was used to divide the area within each cage into nine, 0.11-m^2 sections for photography. Photographs were taken with a Nikonos 5 underwater camera with either a 28-mm or 35-mm lens, and an underwater strobe. Appended to this report are slides of the photographs taken of each cage (nine per cage; six stations in January, four in April). The following discussion will be limited to the four cages that were photographed twice.

NORTH BLACK POINT:

In January, *Halodule* and "mixed algae" were present in approximately equal amounts at the North Black Point station. *Acetabularia* and *Thalassia* were less abundant at that time. In general, there was a relatively thin coverage of plant material with sediment being visible in all nine of the squares. Over 50% of the enclosed area were barren. The water was clear with a greenish-yellow tint.

When the caged area was rephotographed in April, *Acetabularia* had became more abundant, with mixed *Thalassia* and *Halodule* covering much of the quadrat. Most of the *Thalassia* and *Halodule* blades appeared to be covered with a thin layer of silt. Some of this material might have been dead or uprooted seagrass that had washed into the caged quadrat during high tide and subsequently become trapped within the cage and settled onto the bottom. There was slightly less barren area present in April than in January, possibly because of the aforementioned detrital covering. The water clarity was fair with a yellowish tint at North Black Point during the April sampling.

MILITARY CANAL

Halodule was the most abundant type of vegetation present at this station in both January and April. *Thalassia* and "mixed algae" were approximately equivalent in coverage and second in abundance in January. *Thalassia* was less abundant in April, however, with an *Acetabularia* "mixed algae" combination being second in abundance during this latter sampling period. Also, a *Batophora* population was present in January that was not apparent in April. The area enclosed within the cage appeared to be more barren in April (about 5% bare spots) than it was in January (5% bare spots). Fair water clarity was present during both sampling periods, with a brownish tint to the water in January and a more yellowish tint in April.

NORTH TURKEY POINT:

The plant coverage within the North Turkey Point cage showed little to no detectable change between January and April. The growth was thick at this station with no bare spots observed within the quadrat. Thalassia was dominant, with "mixed algae" interspersed throughout. The only apparent differences in coverage between the two sampling periods was that Penicillus was present within the cage in January but not in April. Also, there may have been slightly more "mixed algae" present in April than in January. The water clarity was good in January and fair in April with water color changing from a slightly greenish tint in January to a yellowish tint in April.

SOUTH TURKEY POINT:

While North Turkey Point showed very little apparent difference in plant coverage between January and April, the South Turkey Point station did change considerably between the two sampling periods. "Mixed algae" and Thalassia were present in approximately equivalent amounts in January with about 50% of the quadrat area bare at that time. In April there was a more complete coverage of Thalassia, with Acetabularia and "mixed algae" interspersed throughout the quadrat. There was much less bare area at the latter sampling date with less than 5% of the area covered by the cage considered as barren. The water clarity was good during both sampling periods with the water tinted green in January and yellow in April.

CONCLUSION:

Unfortunately, the two cages with in the "affected" area were destroyed. It does not appear that there were significant changes in plant coverage within the surviving cages over the sampling period. The cages appear to trap detrital Halodule, which could have a critical effect on the plant communities within them. We recommend this part of the study be discontinued.

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environment and cultural value of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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