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I. INTRODUCTION

This report is submitted in accordance with Section 5.4.1 of Appendix B to Operating Licenses DPR-31 and DPR-41. It constitutes the Annual Non-Radiological Environmental Monitoring Report Number 15 for the period of January 1, 1981 through December 31, 1981.

II. ABIOTIC MONITORING

A. Thermal (ETS 3.1.1)

Introduction

This monitoring provides circulating cooling water temperature data for the Turkey Point Power Plant intake and discharge.

Materials and Methods

Data were collected continuously at each station by an array of three resistance temperature devices and a Leeds and Northrup Speedomax 250 Chart Recorder. The inlet temperature monitoring system is located at the intake canal of Units 3 and 4. The discharge temperature monitoring system is located at the outlet end of the Lake Warren basin (Figure 1). Data were summarized hourly.

Results and Discussion

A summary of the Units 3 and 4 inlet and Lake Warren outlet mean circulating cooling water temperatures for 1981 are presented in Tables 1 - 12. The maximum inlet and outlet temperatures from 1976 - 1981 by month are presented in Table 13. A comparison of modal temperatures for inlet and outlet appears in Figure 2 and demonstrates the most frequent temperature difference (Δt) across the plant.

Conclusions

Examination of the temperature data obtained during 1981 revealed nothing unusual nor did the results differ notably from previous years.

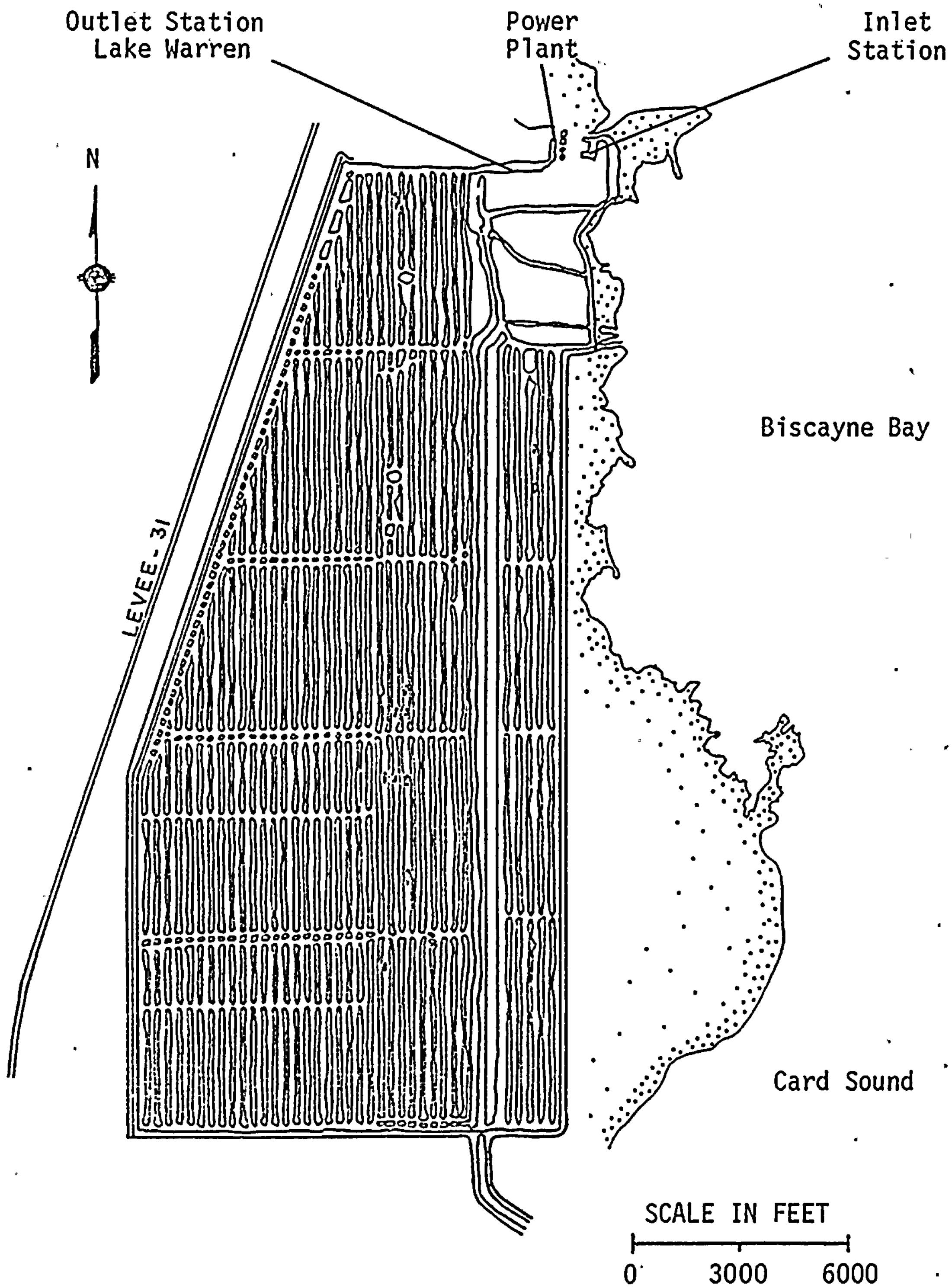


Figure 1. Temperature monitoring stations for the Turkey Point Cooling Canal System, 1981.

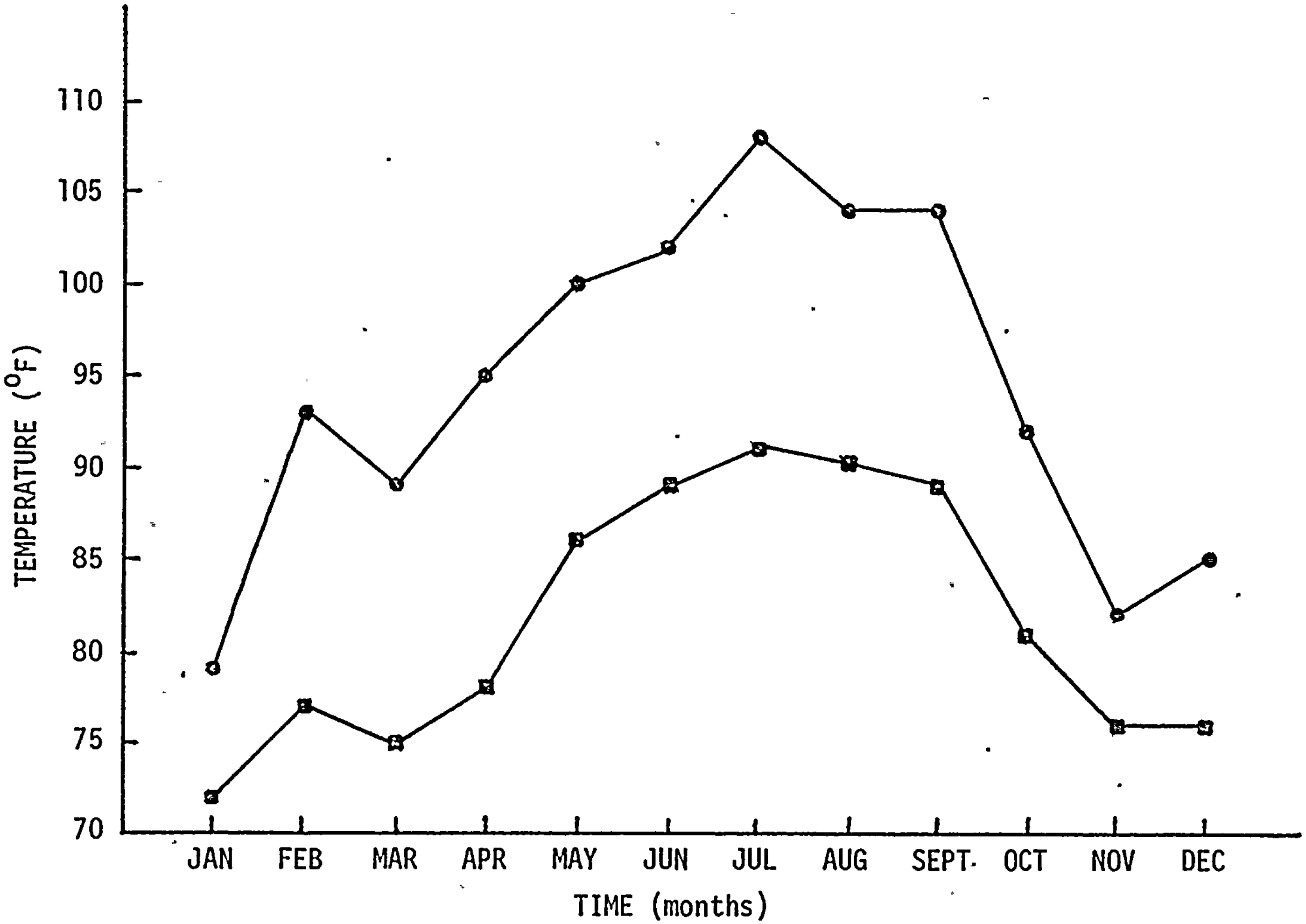


Figure 2. Modal temperatures for inlet (■) and outlet (●) by month, Turkey Point Power Plant, 1981.

Table 1. Time durations and temperatures for Turkey Point Power Plant circulating cooling water, January 1981.

UNITS 3 & 4 INLET			LAKE WARREN OUTLET		
Number of Hours	Temperature (°F)	Time Accumulated (%)	Number of Hours	Temperature (°F)	Time Accumulated (%)
0	80	0.0	0	95	0.0
2	79	0.3	7	94	0.9
13	78	2.0	7	93	1.9
6	77	2.8	4	92	2.4
13	76	4.6	12	91	4.0
33	75	9.0	20	90	6.7
40	74	14.4	23	89	9.8
31	73	18.5	33	88	14.2
91	72	30.8	57	87	21.9
66	71	39.7	51	86	28.8
46	70	45.8	41	85	34.3
49	69	52.4	41	84	39.8
86	68	64.0	41	83	45.3
75	67	74.1	55	82	52.7
40	66	79.4	54	81	59.9
38	65	84.5	45	80	66.0
21	64	87.4	63	79	74.5
24	63	90.6	44	78	80.4
16	62	92.7	27	77	84.0
20	61	95.4	20	76	86.7
6	60	96.2	17	75	89.0
15	59	98.3	11	74	90.5
4	58	98.8	10	73	91.8
3	57	99.2	11	72	93.3

Table 1. (Cont'd) Time durations and temperatures for Turkey Point Power Plant circulating cooling water, January 1981.

UNITS 3 & 4 INLET			LAKE WARREN OUTLET		
Number of Hours	Temperature (°F)	Time Accumulated (%)	Number of Hours	Temperature (°F)	Time Accumulated (%)
6	56	100.0	6	71	94.1
			7	70	95.0
			15	69	97.0
			7	68	98.0
			4	67	98.5
			2	66	98.8
			3	65	99.2
			2	64	99.5
			4	63	100.0

Table 2. Time durations and temperatures for Turkey Point Power Plant circulating cooling water, February 1981.

UNITS 3 & 4 INLET			LAKE WARREN OUTLET		
Number of Hours	Temperature (°F)	Time Accumulated (%)	Number of Hours	Temperature (°F)	Time Accumulated (%)
0	82	0.0	0	97	0.0
5	81	0.7	6	96	0.9
7	80	1.8	22	95	4.2
46	79	8.6	60	94	13.1
98	78	23.2	92	93	26.8
160	77	47.0	82	92	39.0
120	76	64.9	86	91	51.8
63	75	74.3	78	90	63.4
45	74	81.0	81	89	75.4
28	73	85.1	55	88	83.6
10	72	86.6	23	87	87.1
6	71	87.5	3	86	87.5
4	70	88.1	1	85	87.6
16	69	90.5	4	84	88.2
9	68	91.8	20	83	91.2
16	67	94.2	7	82	92.3
23	66	97.6	9	81	93.6
6	65	98.5	21	80	96.7
8	64	99.7	14	79	98.8
2	63	100.0	3	78	99.3
			5	77	100.0

Table 3. Time durations and temperatures for Turkey Point Power Plant circulating cooling water, March 1981.

UNITS 3 & 4 INLET			LAKE WARREN OUTLET		
Number of Hours	Temperature (°F)	Time Accumulated (%)	Number of Hours	Temperature (°F)	Time Accumulated (%)
0	82	0.0	0	97	0.0
14	81	1.9	6	96	0.8
20	80	4.6	7	95	1.7
48	79	11.0	9	94	3.0
43	78	16.8	18	93	5.4
86	77	28.4	29	92	9.3
103	76	42.2	52	91	16.3
111	75	57.1	78	90	26.7
61	74	65.3	85	89	38.2
62	73	73.7	67	88	47.2
63	72	82.1	73	87	57.0
13	71	83.9	47	86	63.3
32	70	88.2	45	85	69.4
62	69	96.5	32	84	73.7
17	68	98.8	27	83	77.3
7	67	99.7	25	82	80.6
2	66	100.0	21	81	83.5
			17	80	85.8
			21	79	88.6
			23	78	91.7
			16	77	93.8
			21	76	96.6
			18	75	99.1
			0	74	99.1
			3	73	99.5
			4	72	100.0

Table 4. Time durations and temperatures for Turkey Point Power Plant circulating cooling water, April 1981.

UNITS 3 & 4 INLET			LAKE WARREN OUTLET		
Number of Hours	Temperature (°F)	Time Accumulated (%)	Number of Hours	Temperature (°F)	Time Accumulated (%)
0	88	0.0	0	102	0.0
15	87	2.1	6	101	0.8
33	86	6.7	15	100	2.9
41	85	12.4	55	99	10.6
57	84	20.3	58	98	18.6
63	83	29.1	74	97	28.9
72	82	39.1	65	96	38.0
69	81	48.7	96	95	51.3
66	80	57.9	76	94	61.9
59	79	66.1	73	93	72.0
107	78	80.9	55	92	79.7
52	77	88.2	51	91	86.8
59	76	96.4	35	90	91.7
19	75	99.0	25	89	95.1
7	74	100.0	9	88	96.4
			3	87	96.8
			3	86	97.2
			2	85	97.5
			4	84	98.1
			2	83	98.3
			8	82	99.4
			0	81	99.4
			1	80	99.6
			3	79	100.0

Table 5. Time durations and temperatures for Turkey Point Power Plant circulating cooling water, May 1981.

UNITS 3 & 4 INLET			LAKE WARREN OUTLET		
Number of Hours	Temperature (^{o}F)	Time Accumulated (%)	Number of Hours	Temperature (^{o}F)	Time Accumulated (%)
0	90	0.0	0	105	0.0
8	89	1.1	11	104	1.5
38	88	6.2	1	103	1.6
67	87	15.2	95	102	14.4
135	86	33.3	40	101	19.8
91	85	45.6	138	100	38.3
90	84	57.7	112	99	53.4
71	83	67.2	46	98	59.5
71	82	76.7	132	97	77.3
89	81	88.7	35	96	82.0
53	80	95.8	70	95	91.4
22	79	98.8	12	94	93.0
9	78	100.0	27	93	96.6
			7	92	97.6
			12	91	99.2
			5	90	99.9
			1	89	100.0

Table 6. Time durations and temperatures for Turkey Point Power Plant circulating cooling water, June 1981.

UNITS 3 & 4 INLET			LAKE WARREN OUTLET		
Number of Hours	Temperature (°F)	Time Accumulated (%)	Number of Hours	Temperature (°F)	Time Accumulated (%)
0	93	0.0	0	110	0.0
6	92	0.8	5	109	0.7
64	91	9.7	13	108	2.5
130	90	27.8	31	107	6.8
150	89	48.6	88	106	19.0
127	88	66.2	38	105	24.3
122	87	83.2	134	104	42.9
55	86	90.8	39	103	48.3
44	85	96.9	166	102	71.4
19	84	99.6	40	101	76.9
2	83	99.9	89	100	89.3
1	82	100.0	56	99	97.1
			8	98	98.2
			7	97	99.2
			4	96	99.7
			2	95	100.0

Table 7. Time durations and temperatures for Turkey Point Power Plant circulating cooling water, July 1981.

UNITS 3 & 4 INLET			LAKE WARREN OUTLET		
Number of Hours	Temperature (°F)	Time Accumulated (%)	Number of Hours	Temperature (°F)	Time Accumulated (%)
0	95	0.0	0	110	0.0
6	94	0.8	22	109	3.0
66	93	9.7	104	108	16.9
105	92	23.8	27	107	20.6
159	91	45.2	87	106	32.3
126	90	62.1	51	105	39.1
80	89	72.8	92	104	51.5
72	88	82.5	29	103	55.4
36	87	87.4	59	102	63.3
39	86	92.6	14	101	65.2
21	85	95.4	71	100	74.7
23	84	98.5	45	99	80.8
2	83	98.8	27	98	84.4
5	82	99.5	46	97	90.6
4	81	100.0	19	96	93.1
			30	95	97.2
			15	94	99.2
			3	93	99.6
			2	92	99.9
			1	91	100.0

Table 8. Time durations and temperatures for Turkey Point Power Plant circulating cooling water, August 1981.

UNITS 3 & 4 INLET			LAKE WARREN OUTLET		
Number of Hours	Temperature (°F)	Time Accumulated (%)	Number of Hours	Temperature (°F)	Time Accumulated (%)
0	94	0.0	0	111	0.0
6	93	0.8	5	110	0.7
36	92	5.6	19	109	3.3
83	91	16.8	26	108	6.8
138	90	35.3	84	107	18.2
108	89	49.9	88	106	30.2
104	88	63.8	66	105	39.1
54	87	71.1	97	104	52.3
35	86	75.8	79	103	63.0
24	85	79.0	62	102	71.5
27	84	82.7	30	101	75.5
30	83	86.7	26	100	79.1
11	82	88.2	41	99	84.6
6	81	89.0	18	98	87.1
23	80	92.1	13	97	88.9
19	79	94.6	16	96	91.0
10	78	96.0	22	95	94.0
30	77	100.0	11	94	95.5
			19	93	98.1
			7	92	99.0
			7	91	100.0

Table 9. Time durations and temperatures for Turkey Point Power Plant circulating cooling water, September 1981.

UNITS 3 & 4 INLET			LAKE WARREN OUTLET		
Number of Hours	Temperature (°F)	Time Accumulated (%)	Number of Hours	Temperature (°F)	Time Accumulated (%)
0	92	0.0	0	109	0.0
21	91	2.9	11	108	1.5
90	90	15.4	48	107	8.2
155	89	36.9	95	106	21.4
124	88	54.2	69	105	31.0
100	87	68.1	108	104	46.0
54	86	75.6	87	103	58.1
26	85	79.2	67	102	67.4
7	84	80.1	42	101	73.2
3	83	80.6	24	100	76.5
21	82	83.5	17	99	78.9
55	81	91.1	29	98	82.9
15	80	93.2	48	97	89.6
20	79	96.0	12	96	91.2
29	78	100.0	22	95	94.3
			31	94	98.6
			5	93	99.3
			5	92	100.0

Table 10. Time durations and temperatures for Turkey Point Power Plant circulating cooling water, October 1981.

UNITS 3 & 4 INLET			LAKE WARREN OUTLET		
Number of Hours	Temperature (°F)	Time Accumulated (%)	Number of Hours	Temperature (°F)	Time Accumulated (%)
0	90	0.0	0	107	0.0
15	89	2.0	1	106	0.1
56	88	9.5	18	105	2.6
55	87	16.9	66	104	11.4
85	86	28.3	37	103	16.4
41	85	33.8	63	102	24.8
27	84	37.4	50	101	31.5
39	83	42.7	49	100	38.1
115	82	58.1	23	99	41.2
133	81	76.0	27	98	44.8
57	80	83.6	14	97	46.7
59	79	91.5	33	96	51.1
53	78	98.7	26	95	54.6
10	77	100.0	27	94	58.3
			34	93	62.8
			74	92	72.8
			72	91	82.4
			56	90	89.9
			29	89	93.8
			23	88	96.9
			4	87	97.4
			19	86	100.0

Table 11. Time durations and temperatures for Turkey Point Power Plant circulating cooling water, November 1981.

UNITS 3 & 4 INLET			LAKE WARREN OUTLET		
Number of Hours	Temperature (°F)	Time Accumulated (%)	Number of Hours	Temperature (°F)	Time Accumulated (%)
0	82	0.0	0	92	0.0
2	81	0.3	4	91	0.6
5	80	1.0	15	90	2.6
40	79	6.5	32	89	7.1
41	78	12.2	38	88	12.4
46	77	18.6	54	87	19.9
105	76	33.2	74	86	30.1
61	75	41.7	63	85	38.9
55	74	49.3	59	84	47.1
48	73	56.0	90	83	59.6
87	72	68.1	109	82	74.7
62	71	76.7	76	81	85.3
87	70	88.7	53	80	92.6
34	69	93.5	37	79	97.8
35	68	98.3	13	78	99.6
12	67	100.0	3	77	100.0

Table 12. Time durations and temperatures for Turkey Point Power Plant circulating cooling water, December 1981.

UNITS 3 & 4 INLET			LAKE WARREN OUTLET		
Number of Hours	Temperature (°F)	Time Accumulated (%)	Number of Hours	Temperature (°F)	Time Accumulated (%)
0	84	0.0	0	100	0.0
4	83	0.5	3	99	0.4
15	82	2.6	15	98	2.4
37	81	7.5	26	97	5.9
31	80	11.7	21	96	8.7
22	79	14.7	16	95	10.9
17	78	16.9	24	94	14.1
30	77	21.0	18	93	16.6
83	76	32.1	8	92	17.6
31	75	36.3	15	91	19.7
24	74	39.5	20	90	22.3
23	73	42.6	13	89	24.1
62	72	50.9	33	88	28.5
42	71	56.6	38	87	33.6
44	70	62.5	37	86	38.6
36	69	67.3	59	85	46.6
19	68	69.9	42	84	52.2
46	67	76.1	30	83	56.3
31	66	80.2	25	82	59.6
25	65	83.6	9	81	60.8
17	64	85.9	16	80	63.0
19	63	88.4	20	79	65.7
15	62	90.5	20	78	68.4
37	61	95.4	55	77	75.8
21	60	98.3	31	76	79.9

Table 12. (Cont'd) Time durations and temperatures for Turkey Point Power Plant circulating cooling water, December 1981.

UNITS 3 & 4 INLET			LAKE WARREN OUTLET		
Number of Hours	Temperature (°F)	Time Accumulated (%)	Number of Hours	Temperature (°F)	Time Accumulated (%)
5	59	98.9	31	75	84.1
8	58	100.0	46	74	90.3
			35	73	95.0
			20	72	97.7
			8	71	98.8
			1	70	98.9
			2	69	99.2
			4	68	99.7
			2	67	100.0

Table 13. Inlet and outlet circulating cooling water temperatures for Turkey Point Power Plant from 1976 through 1981.

MONTH	MAXIMUM INLET TEMPERATURE (^oF)						MAXIMUM OUTLET TEMPERATURE (^oF)					
	1976	1977	1978	1979	1980	1981	1976	1977	1978	1979	1980	1981
January	80	75	78	78	80	79	96	90	91	90	95	94
February	83	82	77	82	84	81	98	99	90	93	100	96
March	86	85	86	81	88	81	102	103	101	94	103	96
April	86	84	87	87	89	87	102	100	101	102	105	101
May	87	91	92	89	89	89	105	105	108	103	105	104
June	90	94	95	92	94	92	106	109	111	108	110	109
July	94	93	96	96	96	94	111	110	111	112	111	109
August	94	94	94	95	95	93	110	111	108	112	110	110
September	92	95	92	91	93	91	108	110	106	107	108	108
October	89	92	91	91	92	89	104	108	104	108	108	106
November	83	84	87	88	87	81	96	100	100	103	101	91
December	83	84	86	83	78	83	97	97	99	95	93	99

B. Chemical Concentrations (ETS 3.1.2)

Introduction

This monitoring provides data for the determination of cooling water quality characteristics and their relative changes in the Turkey Point Cooling Canal System.

Materials and Methods

Monthly grab samples were taken at the discharge side of the plant in Lake Warren (Figure 1) and analyzed for copper, zinc, and chemical oxygen demand (C.O.D.). Copper and zinc were analyzed using a Perkin-Elmer Model 306 Atomic Absorption Spectrophotometer (EPA, 1979). During 1981 lower detection limits were revised and employed in zinc analysis (Section V). The C.O.D. was analyzed using EPA approved methods (Section V).

Weekly grab samples were taken at the same location and analyzed for pH, dissolved oxygen (D.O.) and salinity. Instrumentation included an Orion Model 401 Ion Analyzer, a Yellow Springs Instrument Polarographic Probe/Oxygen Meter and an American Optical T/C Refractometer respectively.

Results

The results of the 1981 chemical monitoring program for copper, zinc, C.O.D., pH, D.O. and salinity are given in Table 1.

The quantities of bulk chemicals used in the operation of Units 3 and 4 are reported in Tables 2 and 3.

<u>Discussion</u>

The lower limit of detection for copper is 0.02 mg/l. The values for copper have remained below 0.02 mg/l since June 1976. Zinc data are compared with data from 1977 through 1980 in Figure 2. The linearity breaks of zinc values seen in 1981 were the results of reevaluations of instrument capability pertaining to lower detection limits. These comparisons demonstrate that no unusual levels of copper or zinc were observed during 1981. The C.O.D. data for 1979 through 1981 are presented in Figure 3. Values reported for 1981 were within the historical ranges (FPL, 1979 and 1980).

The 1981 pH values ranged from 7.9 - 8.2 with an average value of 8.1. Average pH values have steadily increased from 7.9 in 1975 to 8.1 in 1981. Dissolved oxygen continued to fluctuate inversely with power plant loading (i.e. electrical generation per unit time). The yearly average salinity decreased from 42.1 o/oo in 1980 to 38.6 o/oo in 1981. This decrease was due to two periods of heavy rainfall during August and September which have temporarily suppressed the long term upward trend (Table 1, Zooplankton Section).

The chemical quantities listed in Tables 2 and 3 are based on power plant bulk chemical usage. The assumption is that ultimately

the chemicals were added in some form to the circulating cooling water system. Most of the chemicals were used for water treatment processes necessary to produce high quality water for steam production. Only estimates of chemicals discharged to the canal system can be made since treatment processes of sedimentation, neutralization and precipitation are carried out before the wastewater is discharged.

Conclusions

Copper levels continue to be below detectable limits. Zinc levels were below detectable limits during 1981. C.O.D. levels continue to fluctuate in a range considered to be of questionable reliability for testing in saline waters (EPA, 1979 Method 410.3). There appears to be no measurable effect, on cooling system water quality, of the chemicals assumed in this report to be added to the open circulating cooling water during plant operations.

Although in lesser quantities than from Units 3 and 4, two adjacent fossil units also discharged similar water treatment related chemicals to the canal system.

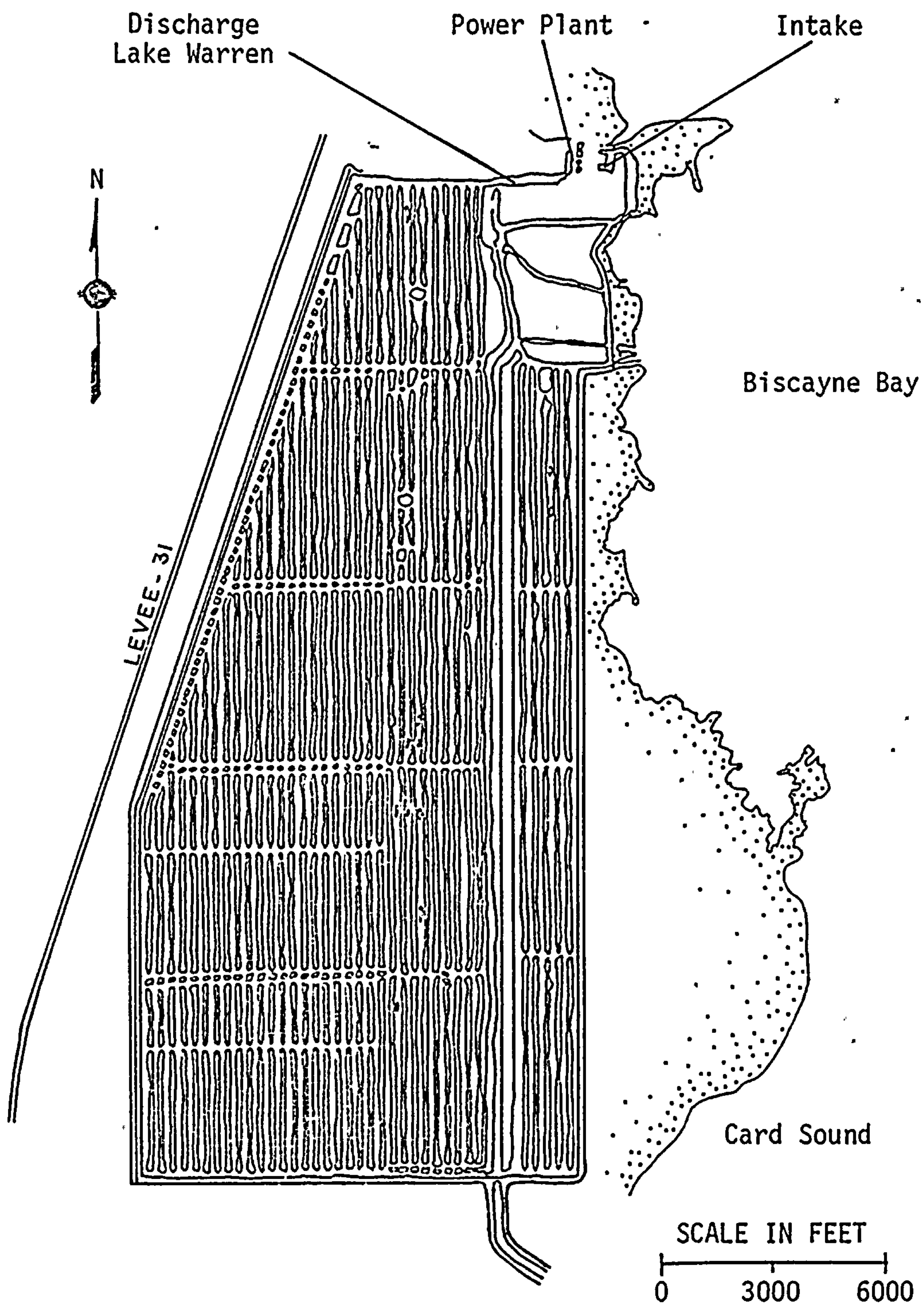


Figure 1. The location of the discharge chemical sampling point at Turkey·Point Power Plant, 1981.

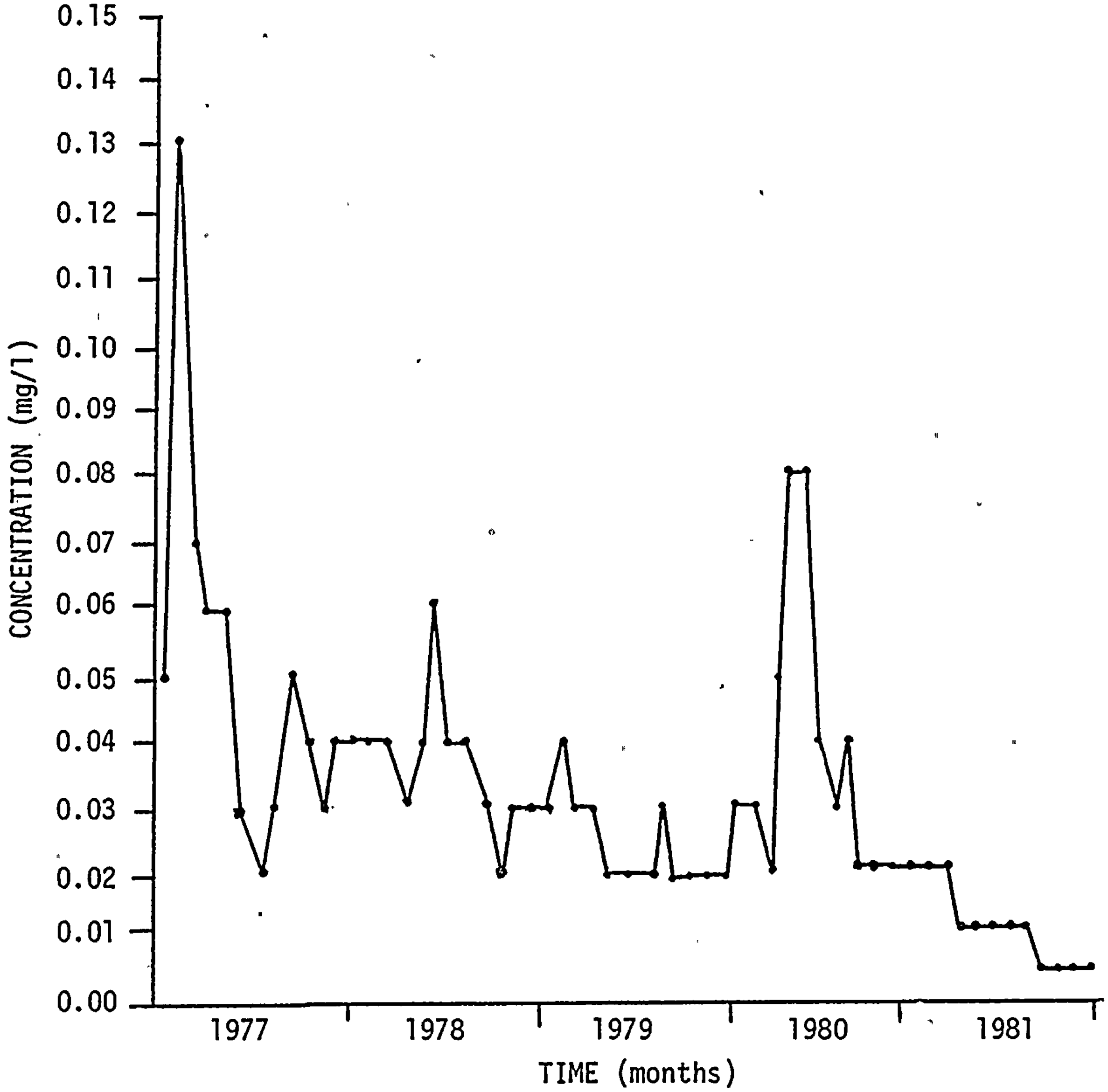


Figure 2. Monthly zinc values at the outlet of Lake Warren, Turkey Point Power Plant, 1977-1981.

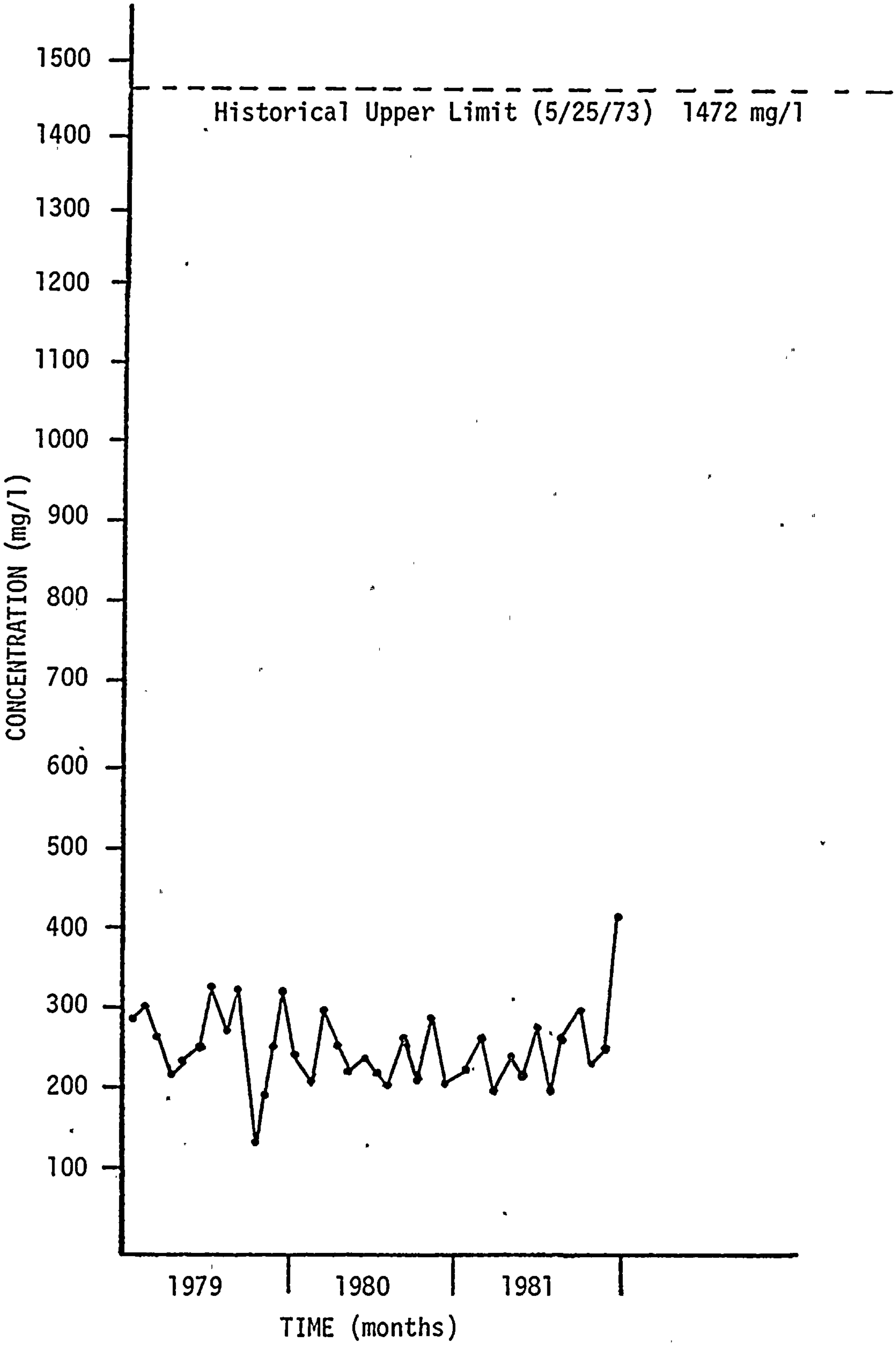


Figure 3. Monthly C.O.D. values at the outlet of Lake Warren, Turkey Point Power Plant, 1979-1981.

Table 1. Values of selected chemical parameters monitored at the outlet of Lake Warren, Turkey Point Power Plant, 1981.

MONTHLY				WEEKLY			
DATE	C.O.D. (mg/l)	Cu (mg/l)	Zn (mg/l)	DATE	pH (std. units)	D.O. (mg/l)	Salinity (o/oo)
Jan.	219	<0.02	<0.02	01/08	8.2	4.8	40.0
				01/15	8.0	5.4	40.0
				01/22	7.9	4.6	40.0
				01/29	7.9	4.7	40.0
Feb.	261	<0.02	<0.02	02/05	8.0	5.8	41.0
				02/12	8.0	4.4	42.0
				02/19	7.9	4.8	41.0
				02/26	8.0	5.0	42.0
Mar.	197	<0.02	<0.02	03/05	8.1	4.2	42.0
				03/12	8.1	4.1	42.0
				03/19	8.1	4.2	42.0
				03/26	8.1	4.9	44.0
Apr.	236	<0.02	<0.01	04/02	8.0	5.0	44.0
				04/09	8.2	5.8	44.0
				04/16	8.0	4.6	44.0
				04/23	8.0	5.0	44.0
				04/30	8.0	4.1	44.0
May	222	<0.02	<0.01	05/07	8.1	4.0	44.0
				05/14	8.1	4.0	44.0
				05/21	8.0	4.0	45.0
				05/28	8.0	3.7	41.0
Jun.	276	<0.02	<0.01	06/04	8.2	3.8	42.0
				06/11	8.1	2.0	42.0
				06/18	8.1	4.2	44.0
				06/25	8.0	4.7	43.0
Jul.	202	<0.02	<0.01	07/02	8.0	4.8	43.0
				07/09	8.1	5.0	44.0
				07/15	8.1	5.0	45.0
				07/23	8.0	4.3	46.0
				07/30	8.0	4.7	46.0
Aug.	266	<0.02	<0.01	08/06	8.0	4.1	45.0
				08/13	8.1	3.7	46.0
				08/20	8.1	4.1	33.0
				08/27	8.1	3.1	35.0
Sep.	302	<0.02	<0.005	09/03	8.1	3.6	36.0
				09/10	8.0	4.0	36.0
				09/17	8.1	3.8	37.0
				09/24	8.2	3.9	35.0

Table 1. (Cont'd) Values of selected chemical parameters monitored at the outlet of Lake Warren, Turkey Point Power Plant, 1981.

MONTHLY				WEEKLY			
DATE	C.O.D. (mg/l)	Cu (mg/l)	Zn (mg/l)	DATE	pH (std. units)	D.O. (mg/l)	Salinity (o/oo)
Oct	234	<0.02	<0.005	10/01	7.9	4.7	27.0
				10/08	8.1	4.0	29.0
				10/15	8.1	4.9	28.0
				10/22	8.2	4.6	30.0
				10/29	8.2	4.2	30.0
Nov.	254	<0.02	<0.005	11/05	8.2	4.8	29.0
				11/12	8.1	4.8	29.0
				11/19	8.1	5.3	30.0
				11/25	8.0	6.0	30.0
Dec.	413	<0.02	<0.005	12/03	8.1	4.8	30.0
				12/10	8.1	6.0	31.0
				12/17	8.1	4.8	31.0
				12/24	8.1	5.6	32.0
				12/31	8.0	4.0	33.0

Table 2. Chemical usage during operations of the Turkey Point Power Plant Units 3 & 4 January through June, 1981.

CHEMICALS[a]	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE
Amerfloc 275[b]	29	23	26	21	14	15
Ammonium Hydroxide (58%)	0	0	0	30	0	0
Bentonite Clay	1,710	1,303	1,462	1,322	840	1,224
Boric Acid	10,361	1,701	0	4,390	5,270	1,834
Chlorine	0	0	0	0	0	0
Concentrated Sodium Hydroxide (50%)	85,109	76,369	72,375	59,443	47,710	51,627
Concentrated Sulfuric Acid (93%)	101,322	110,324	118,300	75,417	57,489	68,298
HTH - Calcium Hypochlorite	0	0	0	0	0	0
Hydrated Lime	25,402	19,839	5,855	26,518	12,880	14,696
Hydrazine (35%)	0	0	26	708	27	0
Potassium Chromate	50	67	75	25	0	16
Potassium Dichromate	0	8	0	10	0	9
Soda Ash	0	0	0	0	0	0
Sodium Chloride	0	0	0	0	0	0
Sodium Hexametaphosphate	0	8	0	14	0	0

[a] All values in pounds.
[b] Trade name for a coagulant aid.

Table 3. Chemical usage during operations of the Turkey Point Power Plant Units 3 & 4 July through December, 1981.

CHEMICALS[a]	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Amerfloc 275[b]	17	20	17	12	2	19
Ammonium Hydroxide (58%)	0	0	0	0	117	0
Bentonite Clay	1,043	1,152	997	661	108	1,226
Boric Acid	6,160	2,742	2,384	3,150	7,348	4,780
Chlorine	0	0	0	0	0	0
Concentrated Sodium Hydroxide (50%)	39,837	52,252	40,262	23,612	7,784	3,502
Concentrated Sulfuric Acid (93%)	53,095	49,467	40,051	41,291	7,670	4,262
HTH - Calcium Hypochlorite	0	0	0	0	0	0
Hydrated Lime	15,875	17,600	15,470	10,227	1,658	18,461
Hydrazine (35%)	0	0	0	0	568	0
Potassium Chromate	75	55	37	70	25	25
Potassium Dichromate	5	5	21	0	16	15
Soda Ash	0	0	0	0	0	0
Sodium Chloride	0	0	0	0	0	0
Sodium Hexametaphosphate	3	2	10	0	7	4

[a]All values in pounds.
[b]Trade name for a coagulant aid.

III. BIOTIC MONITORING

A. AQUATIC ENVIRONMENT

1. Plankton (ETS 4.1.1.1.1)

a. Zooplankton

(1) physical data

Introduction

This monitoring serves "to compare the physical parameters of the water in the Turkey Point Cooling Canal System with those in the adjacent lagoon (Biscayne Bay/Card Sound) and determine the ability of the cooling canal system to support biological life" (ETS 4.1.1.1).

Materials and Methods

Physical data were collected quarterly during plankton sampling at various stations in the Turkey Point Cooling Canal System and southern Biscayne Bay/Card Sound hereafter referred to as the canal system and the bay respectively (Figures 1 and 2).

Water temperature was measured using a Yellow Springs Instruments (Y.S.I.) Telethermometer with an accuracy of $\pm$ 0.15^{o}C and a readability of 0.2^{o}C. Salinities were determined using an American Optical T/C Refractometer with an accuracy of 0.10 o/oo and a readability of 0.5 o/oo. Dissolved oxygen (D.O.) was measured using a Y.S.I. Polarographic Probe and Oxygen Meter. The accuracy of this instrument was 0.20 mg/l with instrument readability of 0.1 mg/l. All instruments were calibrated before sampling and all measurements were made in the top meter of the water column.

Results

Results of the physical data for 1981 can be found in Table 1 (canal system) and Table 2 (bay) at the end of the Zooplankton Organism Section.

The temperatures in the canal system for 1981 ranged from 42.0 to 24.0^{o}C with a mean of 29.2^{o}C. The maximum reading was recorded at Station F.1 nearest the power plant discharge. Temperatures in the bay for 1981 ranged from 32.5 to 21.0^{o}C with a mean of 26.2^{o}C. The mean temperature for the canal system was 3.0^{o}C higher than the bay temperature.

The salinity in the canal system for 1981 ranged from 46.0 to 26.0 o/oo, with a mean of 39.9 o/oo. There was an average decrease of 1.8 o/oo in salinity in the canal system from 1980 to 1981. The lowest salinity in the canal system was 26.0 o/oo and occurred at Station WF.2. The salinity in the bay for 1981 ranged from 41.0 to 19.5 o/oo, with a mean of 33.5 o/oo. The average salinity in the canal system was 6.4 o/oo higher than the bay.

The D.O. in the canal system for 1981 ranged from 8.3 to 3.0 mg/l with a mean of 5.3 mg/l. In the bay, D.O. ranged from 8.1 to 5.2 mg/l with a mean of 6.8 mg/l.

Discussion

Temperatures in both the canal system and the bay were within ranges observed for previous years (Tables 1 and 2). The maximum bay temperature was typical of the deeper waters of the bay area but did not reflect the higher temperatures known to occur on the tidal flats due to solar heating.

The decrease of 1.8 o/oo in the mean salinity of the canal system from 1980 - 1981 was due to two periods of heavy precipitation (Table 1). The low salinity value at Station WF.2 was a result of back pumping of the Interceptor Ditch into the canal system. Salinities in the bay were also lower than previously noted. This was also attributed to the aforementioned precipitation and the subsequent heavy discharges from the South Florida Water Management District flood control canals.

Dissolved oxygen levels in the canal system were generally lower than those in the bay (Tables 1 and 2). This is due to the decrease in oxygen solubility with increases in temperature and salinity. The level of dissolved oxygen in the water column is of fundamental importance to the biota, although response of individual species or a group of species may be highly variable (Perkins, 1974). Although lower than the bay levels, the D.O. levels in the canal system were sufficient to support the established biota.

There was no notable difference exhibited between physical data for the bay during 1981 and that obtained during baseline bay monitoring (Bader and Roessler, 1972).

Conclusions

Temperature and dissolved oxygen levels in both canal and bay are not significantly different from previous years (1975-1980). The variation of salinity from the previously established pattern is the result of two brief periods of heavy rainfall.

The physical data do not indicate conditions restrictive to biological life in the canal system with the exception of the circulating cooling water discharge area. The discharge area is species selective as a result of elevated and fluctuating temperatures.

No significant changes in physical parameters were observed in the bay as a result of power plant operation.

a. Zooplankton

(2) nutrient data

Introduction

This program compares the chemical parameters of the water in the Turkey Point Cooling Canal System with those in the adjacent lagoon (Biscayne Bay/Card Sound) and determines the ability of the cooling system to support biological life (ETS 4.1.1.1).

Materials and Methods

Samples were collected quarterly at 12 sample points within the Turkey Point Cooling Canal System and five control points in southern Biscayne Bay/Card Sound hereafter referred to as the canal system and the bay respectively (Figures 1 and 2).

Acid washed, clear glass containers with ground glass stoppers were used for the ammonia samples, with five milliliters of phenol/ethanol solution added as the preservative. Acid washed, dark glass containers with ground glass stoppers were used for the other nutrient samples with 0.5 milliliters of 0.2N mercuric chloride added as the preservative.

All analyses were performed with either a Beckman DU-2 Spectrophotometer or a Technicon (CS-M-6) Autoanalyzer. Nitrite, nitrate and inorganic phosphate were determined by Technicon Methodology modified by Klaus Grasshoff. Ammonia was determined

using the Phenol-Hypochlorite Method and total phosphate was measured using the EPA Method (1979). Data were reported in milligrams per liter.

Results

Results for nutrient data for 1981 can be found in Table 1 (canal system) and Table 2 (bay) at the end of the Zooplankton Organism Section.

Ammonia

Ammonia (NH_3) values in the canal system ranged from 0.218 to 0.044 mg/l with a mean of 0.089 mg/l. At the bay control stations the maximum value was 0.074 mg/l and the minimum value was 0.005 mg/l with an average value of 0.045 mg/l. The highest ammonia values in the canal system were found at Station WF.2 while those in the bay occurred at Station Y-2.

Nitrite

Nitrite (NO_2) values in the canal system ranged from 0.041 to 0.001 mg/l with a mean of 0.010 mg/l. At the bay control stations values ranged from 0.009 to <0.000 mg/l with a mean of 0.004 mg/l. The average canal value was approximately three times the average bay control value. The highest nitrite values for the canal system were found at Station E3.2 while the maximum values for the bay were

Nitrate

Nitrate (NO_3) values in the canal system ranged from 1.612 to 0.016 mg/l. Values at the bay control stations ranged from 0.322 to 0.012 mg/l. The average values for the canal system and the bay were 0.547 mg/l and 0.098 mg/l respectively. Peak values occurred at Station RC.2 in the canal system and Station 12 in the bay.

Inorganic Phosphate

Inorganic phosphate (IPO_4) values in the canal system ranged from 0.024 to <0.002 mg/l. The bay control stations values ranged from 0.028 to <0.002 mg/l. The mean value for the canal system was 0.008 mg/l; the bay mean value was 0.009 mg/l. Highest values of inorganic phosphate in the canal system occurred at Station WF.2, while those in the bay occurred at Stations R-3 and 28.

Total Phosphate

Total phosphate (TPO_4) values in the canal system ranged from 0.057 to 0.004 mg/l with a mean of 0.029 mg/l. The bay control stations values ranged from 0.050 to 0.006 mg/l. The highest values occurred at Stations WF.2 in the canal system and Station Y-2 in the bay.

Discussion

The mean ammonia value for 1981 in the canal system was greater than those noted for the past three years (1978-1980). The mean

ammonia value for 1981 in the bay was greater than those previously encountered from 1976-1980. The elevated ammonia values of canal system Station WF.2 were again the result of back pumping the Interceptor Ditch into the canal system.

Nitrites in the canal system continued the established decreasing trend (FPL, 1978-1980). Nitrites in the bay decreased from 1980, but the decrease was slight and the overall trend (FPL, 1973-1980) is best described as variable.

Nitrates in both the bay and the canal system increased significantly relative to 1980 values.

By comparison, nutrient values for the bay and the canal system are similar to values obtained in Card Sound during the baseline studies (Bader, 1969; Tabb & Roessler, 1970; Bader & Roessler, 1971; Bader & Roessler, 1972; Segar, 1971).

Conclusions

Generally, nutrient levels in the canal system are higher than levels in the bay. The decreasing trend of nitrite values observed in the canal system in previous years is repeated in 1981. No trends are apparent in the other nutrient parameters monitored. The chemical data does not indicate conditions restrictive to biological life in the canal system.

A. Zooplankton

(3) organisms

Introduction

This report qualitatively and quantitatively assesses the major groups of planktonic consumers present in the cooling canal system and the adjacent lagoon (Biscayne Bay/Card Sound) in order "to follow biological succession and determine the biological stability of the system" (ETS 4.1.1.1).

Materials and Methods

Plankton samples were collected quarterly at stations in the Turkey Point Cooling Canal System and southern Biscayne Bay/Card Sound hereafter referred to as the canal system and the bay respectively (Figures 1 and 2). A 5 inch diameter Clarke-Bumpus sampling apparatus with a number 10 mesh (158 micron) net and bucket was used to impinge zooplankters. Plankton tows were performed in the top meter of the water column at speeds of 1 to 3 knots. Each tow lasted 5 minutes in the canal system and 3 minutes in the bay. Zooplankton densities were obtained using the Lackey Drop Method (APHA, 1975) and the volume of water sampled.

Biomass was determined using a volume displacement technique (UNESCO, 1974; Yentsch and Hebard, 1957) and was expressed in terms of volume of water displaced. The method proved acceptable for bay samples, however, it was not sensitive enough to determine the very low biomasses known to occur in the canal system and was subject to

interference due to particulate matter.

Zooplankton organisms were divided into the following six categories: Copepods, Gastropods, Bivalve Larvae, Copepod Nauplii, Cirriped Nauplii, and Other Plankton.

Biological stability of the canal system was assessed by comparing the mean (1976-1981) percent of the combined gastropod and copepod fractions of the canal system to that of the bay. Means were computed separately for the canal system and bay using the following equations.

$$X_{FY} = X_{GY} + X_{CY}$$

$$X_T = \sum_{Y=1}^{Z} X_{FY}$$

$$\overline{X}_F = \frac{X_T}{Z}$$

Where: X_{GY} = The percent of total plankton represented by gastropods in a specific year.

X_{CY} = The percent of total plankton represented by copepods in a specific year.

X_{FY} = The percent of total plankton represented by both copepods and gastropods (copepod/gastropod fraction) in a specific year.

Z = Number of years in data base.

X_T = Sum of all X_{FY} in data base.

$\overline{X}_F$ = The mean percent of total plankton represented by the copepod/gastropod fraction over all years in the data base.

Results

Zooplankton organism data for 1976 through 1981 can be found in Table 3 (canal system) and Table 4 (bay).

Copepods

The 1981 mean copepod densities were 0.187 organisms per liter in the canal system and 6.392 organisms per liter in the bay. The percent of the total plankton population represented by copepods was 67 percent in the canal system and 54 percent in the bay.

Gastropods

The 1981 mean planktonic gastropod densities were 0.065 organisms per liter in the canal system and 4.551 organisms per liter in the bay. The percentage of the total plankton population represented by gastropods was 23 percent in the canal system and 39 percent in the bay.

Bivalve Larvae

The 1981 mean bivalve larvae densities were 0.007 organisms per liter in the canal system and 0.218 organisms per liter in the bay. The percent of the total plankton represented by bivalve larvae was 2.5 percent in the canal system and 1.8 percent in the bay.

Copepod Nauplii

The 1981 mean copepod nauplii concentrations were 0.009 organisms per liter in the canal system and 0.131 organisms per liter in the bay.

The percent of the total population represented by copepod nauplii was 3.2 percent in the canal system and 1.1 percent in the bay.

Cirriped Nauplii

No cirriped nauplii were noted in the canal system during 1981. The 1981 mean concentration of cirriped nauplii in the bay was 0.034 organisms per liter. This represented 0.3 percent of the total plankton population.

Other Plankton

The 1981 mean densities of the other plankton were 0.02 organisms per liter in the canal system and 0.445 organisms per liter in the bay. The percentage of the total plankton represented by other plankton was 8.0 percent in the canal system and 3.8 percent in the bay.

Total Plankton

The 1981 mean densitites of the total plankton population were 0.281 organisms per liter in the canal system and 11.744 organisms per liter in the bay.

Zooplankton Biomass

The zooplankton biomass in the canal system for 1981 could not be measured due to interferences mentioned previously. The mean zooplankton biomass value of bay sample was 0.95×10^{-2} ml/m^3 for 1981. Biomass values for the four quarters were 1.33×10^{-2} ml/m^3, 0.78×10^{-2} ml/m^3, 0.58×10^{-2} ml/m^3, and 1.10×10^{-2} ml/m^3.

Discussion

Copepods

The mean copepod concentration in the canal system increased from 49 percent of the total plankton population in 1980 to 66.5 percent of the total plankton population in 1981. The mean copepod concentration in the bay decreased from 79.2 percent of the total plankton population in 1980 to 54.4 percent this year. This reversed the increasing bay to canal system copepod ratios observed in the past six years. This reversal is attributed to the increased density of gastropods in the bay in 1981. The mean copepod densities in the canal system and the bay have remained constant.

Gastropods

Gastropods in the canal system comprised a slightly smaller percentage of the total plankton population in 1981 than they did in 1980. Bay gastropod concentrations in 1981 were up 500 percent over 1980. This was the first time in 6 years that the bay had a higher percentage of gastropods than the canal system.

Bivalve Larvae

Thermal exclusion of these larvae during initial open mode use of the bay water for condenser cooling (1968-1972) and subsequent inadequate adult base populations is the most likely cause for the low mean density values for the canal system. Although 1981 bivalve increased 250 percent over 1980 values, the concentrations have never exceeded 3 percent of the total canal system plankton population in the past six years.

The 1981 bivalve densities in the bay increased 151 percent over 1980 values. This group was the second least abundant zooplankter and continued to comprise only 1.0 - 2.0 percent of the total bay plankton since 1976.

Copepod Nauplii

Copepod nauplii were found in the canal system during the first, second, and fourth quarters of 1981 although occurrences were sporadic and densities low.

Copepod nauplii continued to be collected in very low concentrations in the bay. Copepod nauplii densities and percentages in both the canal system and the bay have not changed notably in six years.

Cirriped Nauplii

Cirriped nauplii were not found in the canal system in 1981. This supported the data from the previous year in which cirriped nauplii were observed in low and sporadic density levels.

Cirriped nauplii were collected in very low concentrations in the bay as they have been in the past.

Both cirriped and copepod nauplii are too small to be adequately sampled by a #10 mesh (158 micron) net, therefore the concentrations reported are not considered representative of actual population densities.

Other Plankton

This category of zooplankters includes the fish larvae, zoea and megalops of various crustaceans, cladocerans, ostracods, chaetognaths, tunicate larvae, polychaete larvae, echinopluteii, bipinnaria, and medusae.

The difference in density levels between the bay and canal system dropped considerably during 1981. The bay density was 20 times higher than the canal system density for 1981 and was 28 times higher for 1980. This was due to a 22 percent increase in other plankton in the canal system and a 13 percent decrease in the other plankton density in the bay.

Densities of other plankton in the canal system have steadily decreased from 1976-1979. Since then they seem to have leveled off. This is most likely a reflection of the absence of all the aforementioned other plankton with the exception of polychaete larvae.

Total Plankton

Zooplankton concentrations in the canal system were consistently lower than those found in the bay. The total bay plankton density increased 76 percent over the 1980 bay value and was 42 times higher than the canal system concentration. Total plankton densities observed in the canal system increased 45 percent over the 1980 value. The

bay to canal system ratio of the total plankton continued on its increasing trend due to the higher than normal concentration of plankton noted in the bay during 1981.

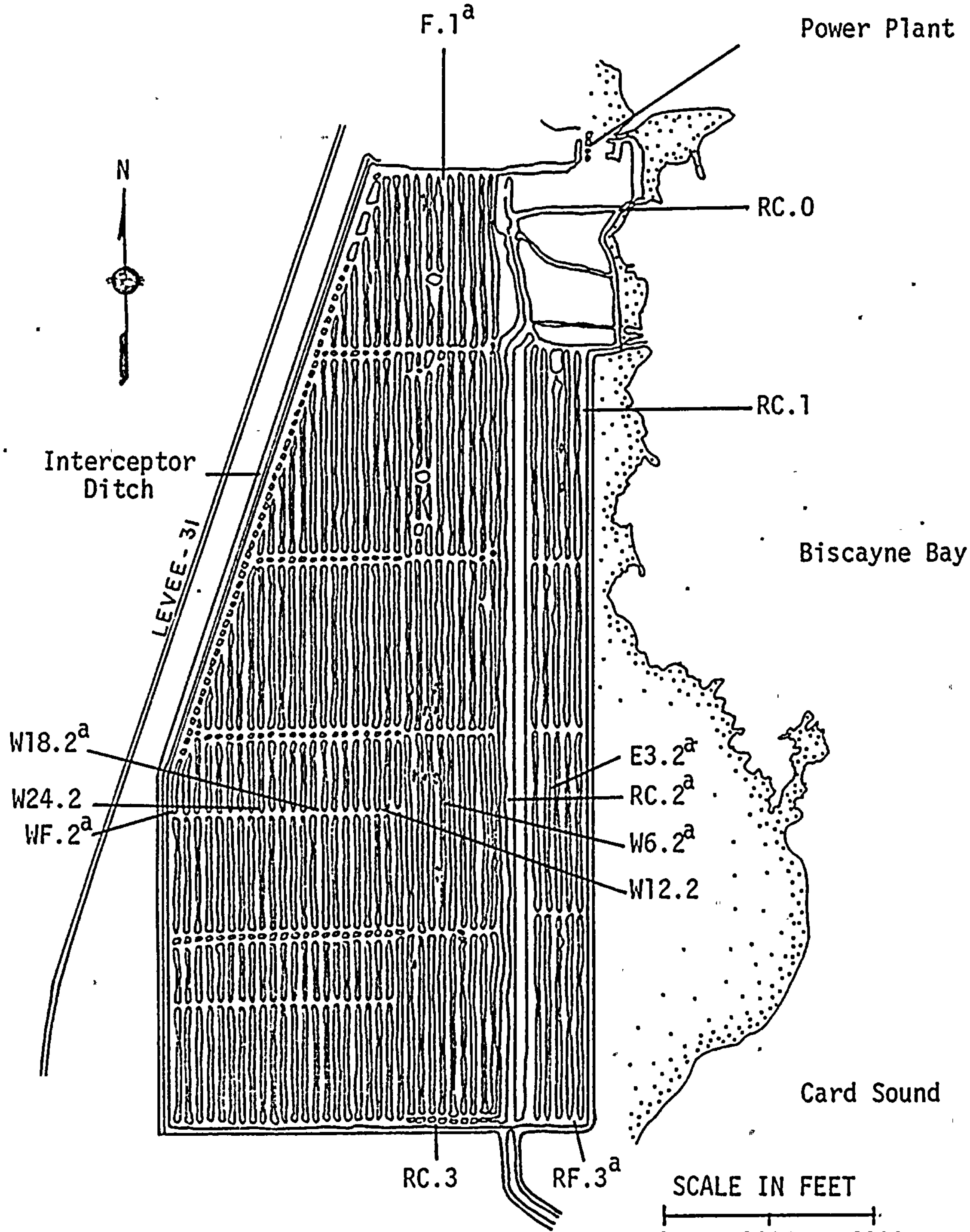
The total bay plankton density was 76 percent higher than 1980 and 20 percent higher than the previously reported record mean value. The previously reported record mean value occurred in 1979, corresponding to the passage of Hurricane David. The record mean value for 1981 is most likely due to the effect of Tropical Storm Dennis which occurred in late August. Coastal run off and storm flood gate inflow as a result of "Dennis" released large amounts of nitrogen and phosphorous into the nutrient cycles. Fourth quarter nutrient data agree with this supposition since values are notably higher than during other sampling periods.

The gastropod/copepod fraction over a number of years was used as an index of stability. The canal system compared favorably to the bay. The mean gastropod/copepod fraction for the canal system was 87.0 with a standard deviation of 5.0 while the bay was 90.4 with a standard deviation of 2.2.

Data for 1981 were not comparable to the pre-operational data because of the different methods of collection and quantification that were employed i.e. different plankton net sizes, equipment types, and taxonomic categories.

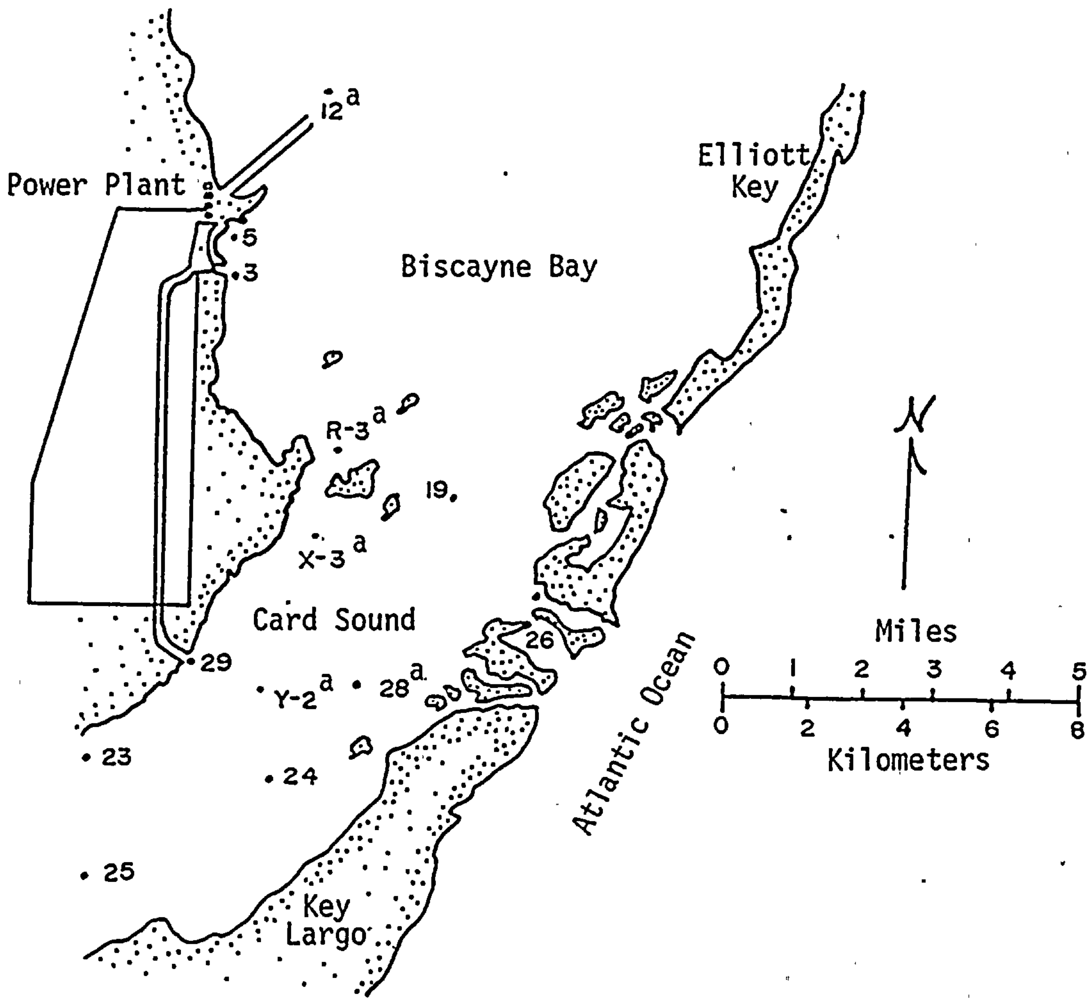
Conclusions

The canal system zooplankter populations show limited variations and have densities and diversities similar to previous reporting periods and hence apparently normal for this environment. The canal system seems to be a stable environment when compared to the bay.



[a]Zooplankton stations.

Figure 1. Physical, nutrient and zooplankton sample stations in the Turkey Point Cooling Canal System, 1981.



[a]Indicates nutrient sample stations.

Figure 2. Physical, nutrient and zooplankton sample stations in Biscayne Bay/Card Sound for the Turkey Point Power Plant, 1981.

Table 1. Composite physical and nutrient data for years 1976 through 1981 showing the maximum, minimum and mean for all plankton stations in the Turkey Point Cooling Canal System.

PARAMETERS		1976	1977	1978	1979	1980	1981
	Max.	41.6	40.0	42.5	44.0	42.7	42.0
Temperature -	Mean	28.3	29.2	29.2	29.8	29.7	29.2
(^oC)	Min.	18.5	19.2	18.0	24.0	21.5	24.0
	Max.	40.0	41.5	43.5	46.0	45.0	46.0
Salinity -	Mean	36.6	37.7	37.3	40.8	41.7	39.9
(o/oo)	Min.	26.0	28.5	29.5	36.5	38.0	26.0
Dissolved	Max.	8.4	7.4	6.4	7.9	8.1	8.3
Oxygen -	Mean	5.4	4.8	5.0	5.3	5.0	5.3
(mg/l)	Min.	4.1	2.6	3.3	3.2	2.2	3.0
	Max.	0.463	0.284	0.208	0.169	0.104	0.218
NH_3 -	Mean	0.072	0.093	0.049	0.068	0.047	0.089
(mg/l)	Min.	0.012	0.015	0.008	0.011	0.000	0.044
	Max.	0.060	0.055	0.041	0.029	0.023	0.041
NO_2 -	Mean	0.028	0.025	0.019	0.016	0.013	0.010
(mg/l)	Min.	0.010	0.004	0.005	0.002	0.000	0.001
	Max.	0.960	0.769	1.373	1.649	0.596	1.612
NO_3 -	Mean	0.474	0.287	0.476	0.553	0.217	0.547
(mg/l)	Min.	0.042	0.007	0.040	0.009	0.002	0.016
	Max.	0.048	0.143	0.033	0.019	0.017	0.024
IPO_4 -	Mean	0.026	0.021	0.017	0.008	0.010	0.008
(mg/l)	Min.	0.008	0.010	0.007	0.000	0.002	0.000
	Max.	0.098	0.098	0.072	0.064	0.079	0.057
TPO_4 -	Mean	0.058	0.049	0.048	0.036	0.043	0.029
(mg/l)	Min.	0.019	0.011	0.029	0.009	0.010	0.004

Table 2. Composite physical and nutrient data for years 1976 through 1981 showing the maximum, minimum and mean for all plankton stations in Biscayne Bay/Card Sound.

PARAMETERS		1976	1977	1978	1979	1980	1981
	Max.	32.4	32.1	31.9	32.7	32.0	32.5
Temperature -	Mean	26.0	26.2	25.7	25.7	26.2	26.2
(°C)	Min.	17.5	18.7	15.5	19.9	19.5	21.0
	Max.	40.0	38.0	38.5	41.5	38.0	41.0
Salinity -	Mean	35.2	33.5	33.7	34.3	33.6	33.5
(o/oo)	Min.	21.0	28.0	24.0	21.5	25.0	19.5
Dissolved	Max.	8.8	8.3	7.8	9.2	7.5	8.1
Oxygen -	Mean	6.8	5.6	5.6	6.0	5.9	6.8
(mg/l)	Min.	5.0	3.3	3.6	4.4	4.1	5.2
	Max.	0.044	0.098	0.134	0.059	0.061	0.074
NH_3 -	Mean	0.022	0.032	0.028	0.025	0.034	0.045
(mg/l)	Min.	0.007	0.004	0.004	0.007	0.014	0.005
	Max.	0.028	0.009	0.023	0.018	0.012	0.009
NO_2 -	Mean	0.005	0.003	0.004	0.007	0.005	0.004
(mg/l)	Min.	0.001	0.000	0.000	0.002	0.000	0.000
	Max.	0.164	0.112	0.527	0.237	0.233	0.322
NO_3 -	Mean	0.052	0.034	0.085	0.103	0.057	0.098
(mg/l)	Min.	0.002	0.001	0.009	0.022	0.003	0.012
	Max.	0.019	0.019	0.011	0.025	0.024	0.028
IPO_4 -	Mean	0.007	0.007	0.007	0.008	0.007	0.009
(mg/l)	Min.	0.002	0.002	0.002	0.000	0.000	0.000
	Max.	0.055	0.151	0.021	0.066	0.091	0.050
TPO_4 -	Mean	0.016	0.017	0.012	0.027	0.032	0.025
(mg/l)	Min.	0.006	0.004	0.006	0.009	0.002	0.006

Table 3. Composite zooplankton data for years 1976 through 1981 showing the maximum, minimum and mean for all stations in the Turkey Point Cooling Canal System.

ORGANISMS[a]		1976	1977	1978	1979	1980	1981
Copepods	Max.	0.630	0.440	0.682	0.560	0.533	0.626
	- Mean	0.100	0.096	0.148	0.136	0.095	0.187
	Min.	0.000	0.000	0.008	0.000	0.000	0.021
Gastropods	Max.	2.530	3.380	0.325	6.550	0.827	0.580
	- Mean	0.064	0.153	0.036	0.302	0.076	0.065
	Min.	0.000	0.000	0.000	0.000	0.000	0.000
Bivalves	Max.	0.000	0.040	0.010	0.022	0.026	0.103
	- Mean	0.000	0.001	0.000	0.001	0.002	0.007
	Min.	0.000	0.000	0.000	0.000	0.000	0.000
Copepod Nauplii	Max.	0.010	0.220	0.060	0.011	0.026	0.118
	- Mean	0.001	0.007	0.006	0.001	0.002	0.009
	Min.	0.000	0.000	0.000	0.000	0.000	0.000
Cirriped Nauplii	Max.	0.240	0.020	0.030	0.010	0.009	0.000
	- Mean	0.004	0.002	0.005	0.001	0.000	0.000
	Min.	0.000	0.000	0.000	0.000	0.000	0.000
Other Plankton	Max.	0.680	0.620	0.120	0.240	0.086	0.335
	- Mean	0.049	0.036	0.017	0.027	0.018	0.022
	Min.	0.000	0.000	0.000	0.000	0.000	0.000
Total Plankton	Max.	2.610	3.490	0.844	6.990	0.943	0.738
	- Mean	0.210	0.291	0.210	0.472	0.194	0.281
	Min.	0.000	0.010	0.008	0.000	0.012	0.031

[a]All values in organisms per liter.

Table 4. Composite zooplankton data for years 1976 through 1981 showing the maximum, minimum and mean for all stations in Biscayne Bay/Card Sound.

ORGANISMS[a]		1976	1977	1978	1979	1980	1981
Copepods	Max.	15.050	17.090	27.360	18.320	11.890	23.396
	Mean	3.075	3.799	5.341	7.200	5.269	6.392
	Min.	0.030	0.050	0.026	0.060	0.288	0.263
Gastropods	Max.	6.290	10.540	7.029	17.890	3.500	74.208
	Mean	0.396	0.576	0.849	1.569	0.682	4.551
	Min.	0.000	0.000	0.000	0.000	0.000	0.000
Bivalves	Max.	0.370	1.670	2.667	0.450	1.316	1.649
	Mean	0.027	0.074	0.129	0.102	0.087	0.218
	Min.	0.000	0.000	0.000	0.000	0.000	0.000
Copepod Nauplii	Max.	0.280	0.083	1.500	0.217	0.862	0.967
	Mean	0.030	0.111	0.139	0.067	0.097	0.131
	Min.	0.000	0.000	0.000	0.000	0.000	0.000
Cirriped Nauplii	Max.	1.000	0.490	0.264	0.240	0.234	0.532
	Mean	0.652	0.046	0.016	0.027	0.011	0.034
	Min.	0.000	0.000	0.000	0.000	0.000	0.000
Other Plankton	Max.	1.330	5.190	2.584	4.800	2.145	1.393
	Mean	0.204	0.409	0.309	0.849	0.509	0.445
	Min.	0.000	0.000	0.000	0.012	0.000	0.000
Total Plankton	Max.	18.980	24.350	35.820	41.630	16.680	86.998
	Mean	3.790	5.030	6.727	9.808	6.655	11.744
	Min.	0.040	0.150	0.039	0.080	0.418	0.405

[a]All values in organisms per liter.

b. Phytoplankton

(1) chlorophyll a, biomass, and primary productivity

Introduction

Chlorophyll a is used to estimate phytoplankton biomass and primary productivity. Chlorophyll is a pigment contained in the chloroplasts of plant cells, the function of which is to absorb radiant energy which is then used by the plant to manufacture food. The chlorophyll discussed in this report is extracted from marine phytoplankton.

Materials and Methods

Chlorophyll a, biomass, and primary productivity were determined quarterly at 13 stations. Eight of these stations were located in the Turkey Point Cooling Canal System and five were located in the Biscayne Bay/Card Sound area hereafter referred to as the canal system and the bay respectively (Figures 1 and 2).

Chlorophyll a

Chlorophyll a determinations were made using the Trichromatic Method[1] (ASTM, 1980; APHA, 1975). Two each, one liter samples were

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[1]The Trichromatic method of analysis was used to determine the chlorophyll a content of a quality control sample from the Environmental Protection Agency's Cincinnati monitoring and support laboratory. Values obtained were within 4.7 percent of the reference value for the sample. This is within the acceptable limit of 10 percent set by the EPA for this method of analysis.

taken at each of the 13 stations and concentrated using Whatman GF/C glass fiber filters. Pigments were extracted from the concentrated samples by homogenizing the impinged sample with a tissue grinder, steeping in an aqueous acetone solution, and decanting the supernatant. Optical density of the extracts was determined using a Beckman 25 UV-Visible Light Spectrophotometer with a 5 centimeter path length.

Biomass

"Chlorophyll a constitutes approximately 1 to 2 percent of the dry weight of organic material in all planktonic algae and is therefore the preferred indicator for algal biomass estimates. By assuming that chlorophyll a constitutes, on the average, 1.5 percent of the dry weight organic matter (ashfree weight) of the algae, one can estimate the algal biomass by multiplying the chlorophyll a content by a factor of 67" (APHA, 1975).

Primary Productivity

Primary productivity was estimated by using chlorophyll a values, surface solar radiation values and extinction coefficients in equations derived by Ryther and Yentsch (1957). Surface radiation values were taken at a nearby coastal meteorological facility. A table by Ryther and Yentsch (1957) showed the relationship between total daily surface radiation and daily relative photosynthesis beneath a unit of sea surface. Extinction coefficients were calculated

in the canal system using Secchi Disc measurements. Due to the shallowness and water clarity, it was not possible to obtain Secchi Disc readings at sample stations in the bay. Consequently, an estimated extinction coefficient of 0.15/m was used (see Ryther and Yentsch, 1957, Figure 1).

Results

The mean chlorophyll a values, biomass, and primary productivity for the canal system and the bay for 1981 are shown in Table 1.

Discussion

"The chlorophyll of the euphotic zone fluctuates as a function of available nutrients, predation, and conditions favoring high turnover rates" (Odum, 1975).

Chlorophyll a

The mean chlorophyll a value in the canal system 0.36 mg/m^3 in 1978, 0.43 mg/m^3 in 1979, 0.63 mg/m^3 in 1980 and 0.53 mg/m^3 in 1981. The mean chlorophyll a value in the bay was 0.20 mg/m^3 in 1978, 0.16 mg/m^3 in 1979-1980 and 0.47 mg/m^3 in 1981 (Figure 3).

The highest values for chlorophyll a in the canal system and the bay occurred during quarters with long photoperiods and/or high nutrient values. The elevated chlorophyll a values in the canal system were attributed primarily to its high phytoplankton levels as

a result of the higher nutrient levels. Nutrient levels, in general, were three times greater in the canal system than in the bay.

There appeared to be a limited amount of nutrients in Biscayne Bay and Card Sound, with most of them probably being utilized by the macrophytes or otherwise tied-up in biogeochemical cycles.

The 1981 chlorophyll a values for both the canal system and the bay fell within the range of baseline values for Biscayne Bay as determined by Bader and Roessler (1972).

Biomass

The average biomass value in the canal system was 22.08 mg/m^3 in 1978, 28.61 mg/m^3 in 1979, 41.88 mg/m^3 in 1980, and 35.77 mg/m^3 in 1981. The bay value was 12.97 mg/m^3 in 1978, 11.04 mg/m^3 in 1979, 10.62 mg/m^3 in 1980, and 31.48 mg/m^3 in 1981 (Figure 4).

Biomass values were higher in the canal system than the bay. This was expected since biomass values are a function of the chlorophyll a. These data cannot be validly compared with the Bader and Roessler (1972) baseline biomass data since different analytical methods were employed.

Primary Productivity

The mean primary productivity value for the canal system was 0.055 gC/(m^2·day) in 1978, 0.057 gC/(m^2·day) in 1979, 0.063 gC/(m^2·day) in 1980 and 0.048 gC/(m^2·day) in 1981. The mean primary productivity value of the bay was 0.147 gC/(m^2·day) in 1978, 0.084 gC/(m^2·day) in 1979, 0.082 gC/(m^2·day) in 1980 and 0.242 gC/(m^2·day) in 1981 (Figure 5).

Primary productivity estimates have remained consistently greater in the bay than in the canal system. Higher productivity estimates in the bay were attributed to greater light penetration. Greater light attenuation in the canal system is thought to be the result of high tannin and lignin concentrations which produce color and organic debris which produce turbidity. Color and turbidity are expected by-products of impoundment. The lowest primary production estimates were recorded in the canal system at stations where water velocities were relatively high. No comparisons between the baseline and present primary productivity estimates could be made due to the differences in the methodologies employed.

Bader and Roessler (1972) observed that rain causes nutrient rich run-off to enter the bay. The nutrient load causes a buildup of phytoplankton and benthic flora during the early summer. The highest primary productivity estimates during 1981 in the bay occurred in the fourth quarter. This increase was correlated with

the effects of Tropical Storm Dennis which occurred in late August. The resulting agricultural run-off caused significantly higher nutrient values, with a resultant buildup of phytoplankton and chlorophyll a.

Conclusions

Chlorophyll a and biomass values are higher in the cooling canals than the bay. This is attributed to the higher nutrient levels in the cooling canal system. The primary productivity values of the bay are greater than those of the cooling canal system. This difference is caused by the disparity in light penetration between the two systems.

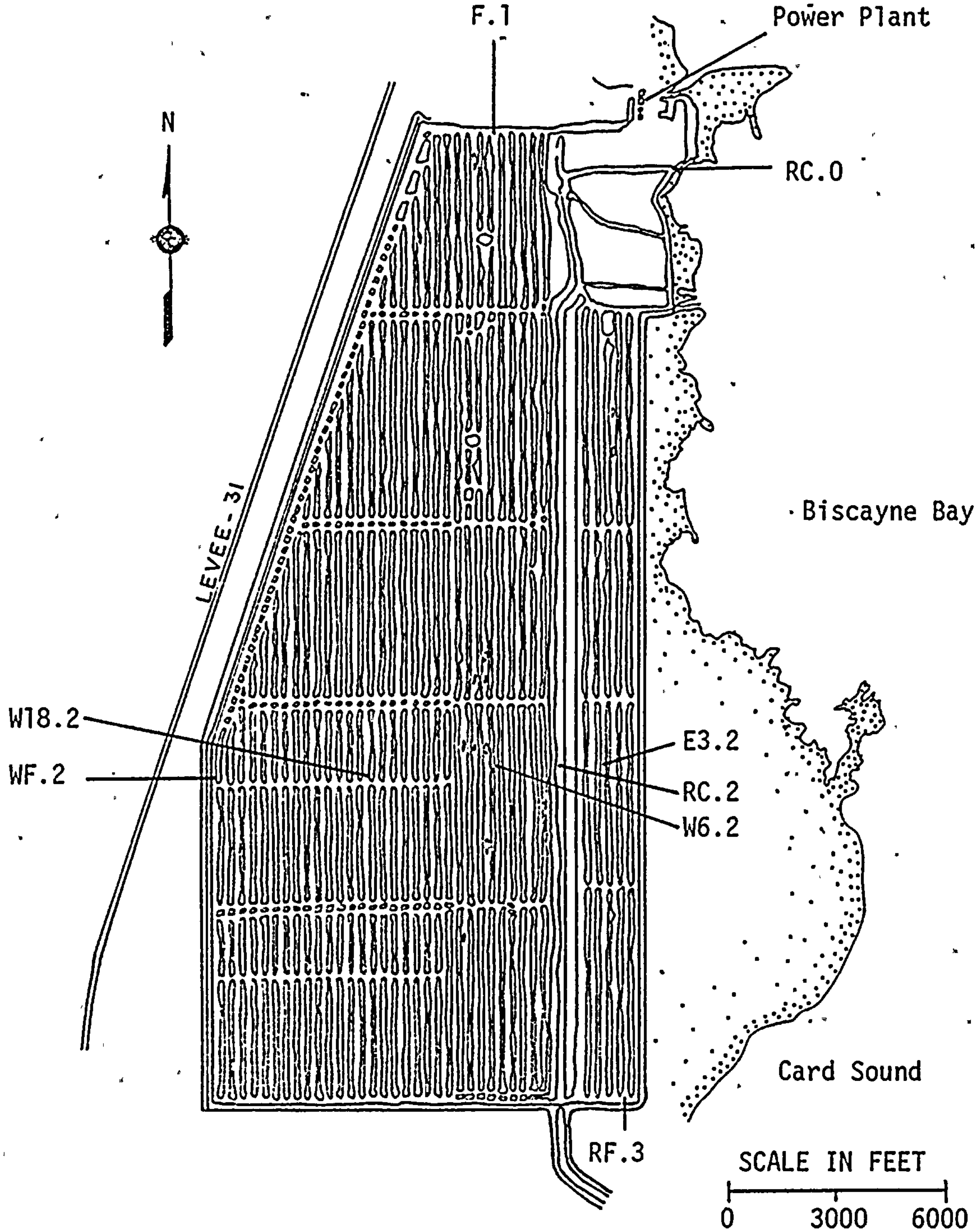


Figure 1. Chlorophyll a sample stations in the Turkey Point Cooling Canal System, 1981.

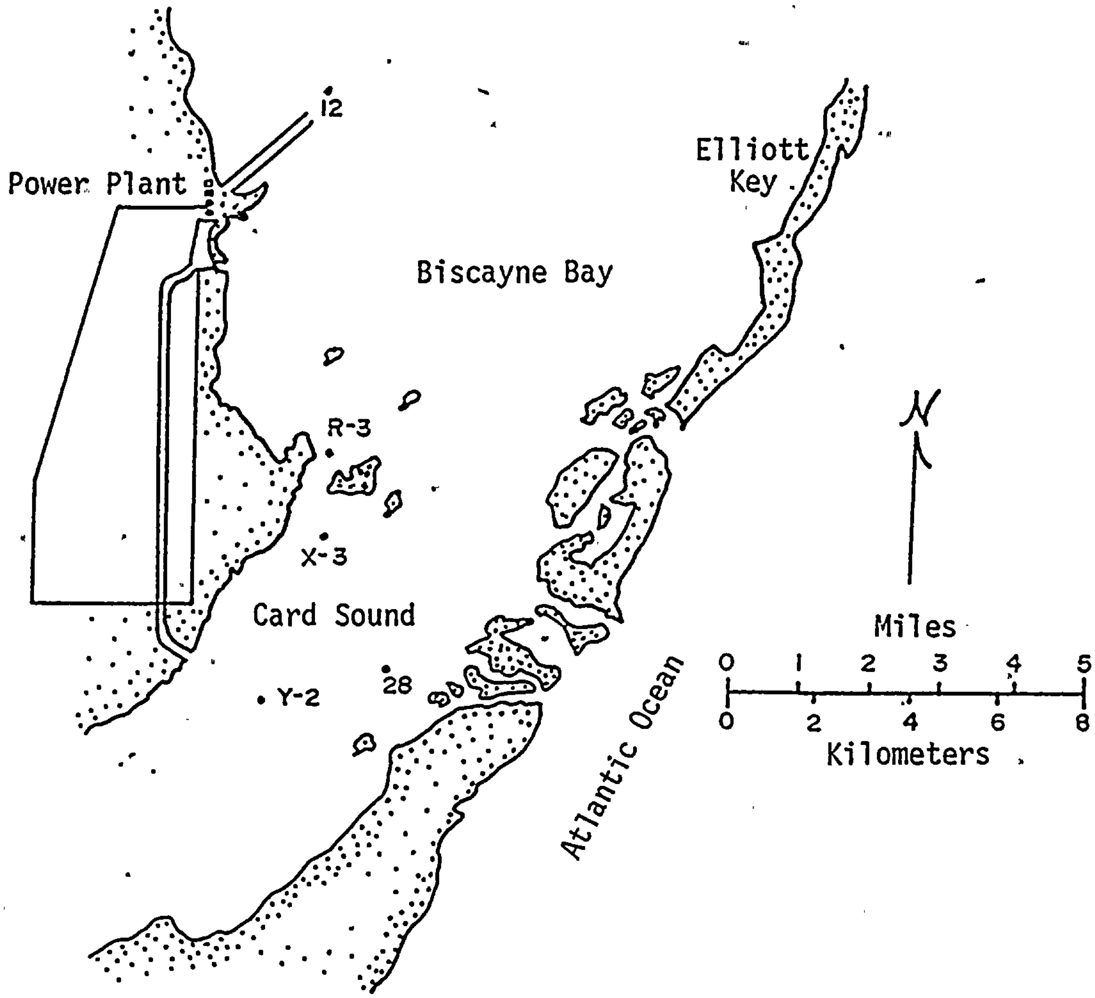


Figure 2. Chlorophyll a sample stations in Biscayne Bay and Card Sound associated with the Turkey Point Cooling Canal System, 1981.

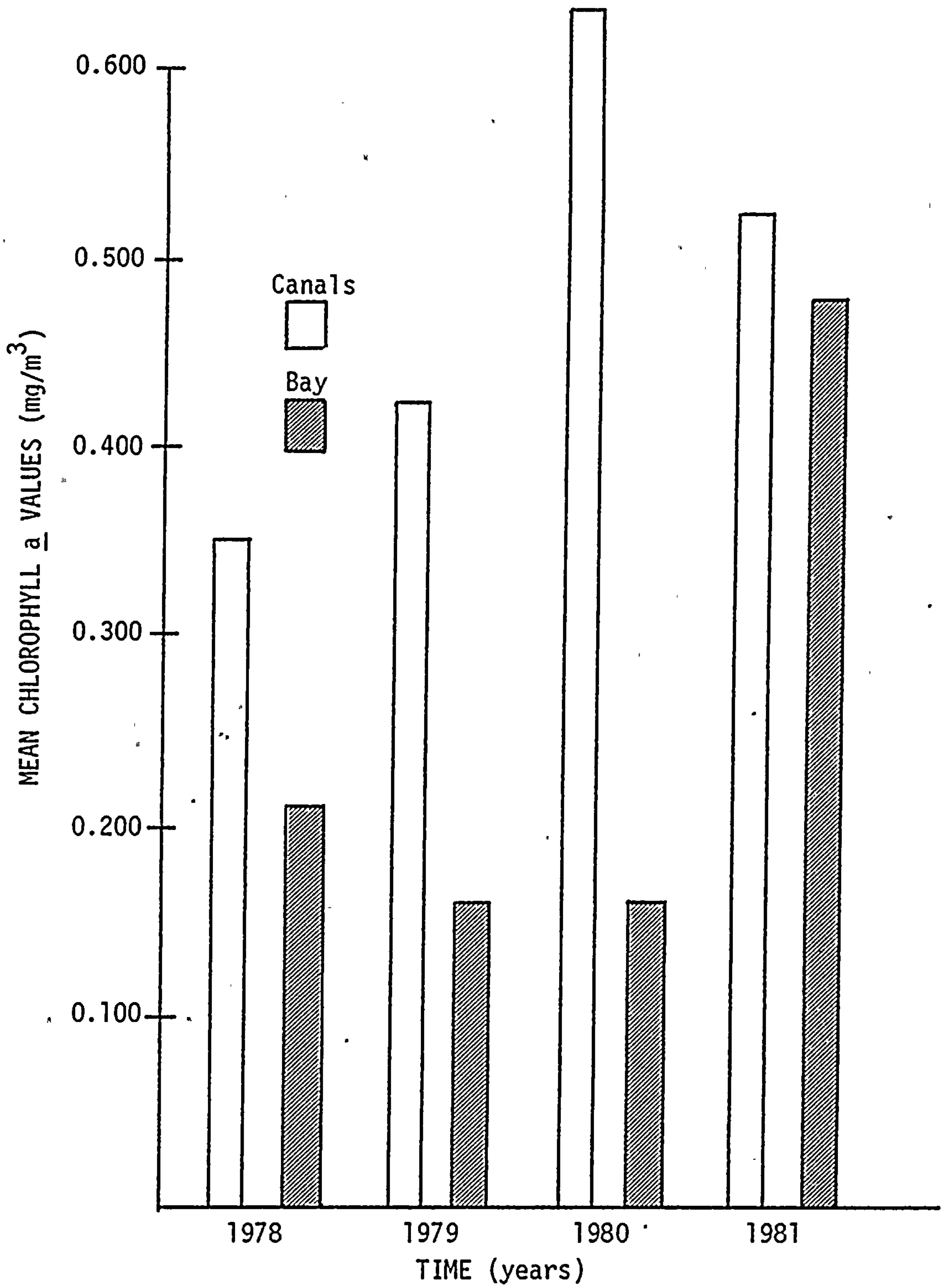


Figure 3. A comparison of mean chlorophyll a values for all stations in the Turkey Point Cooling Canal System and Biscayne Bay/Card Sound, 1978-1981.

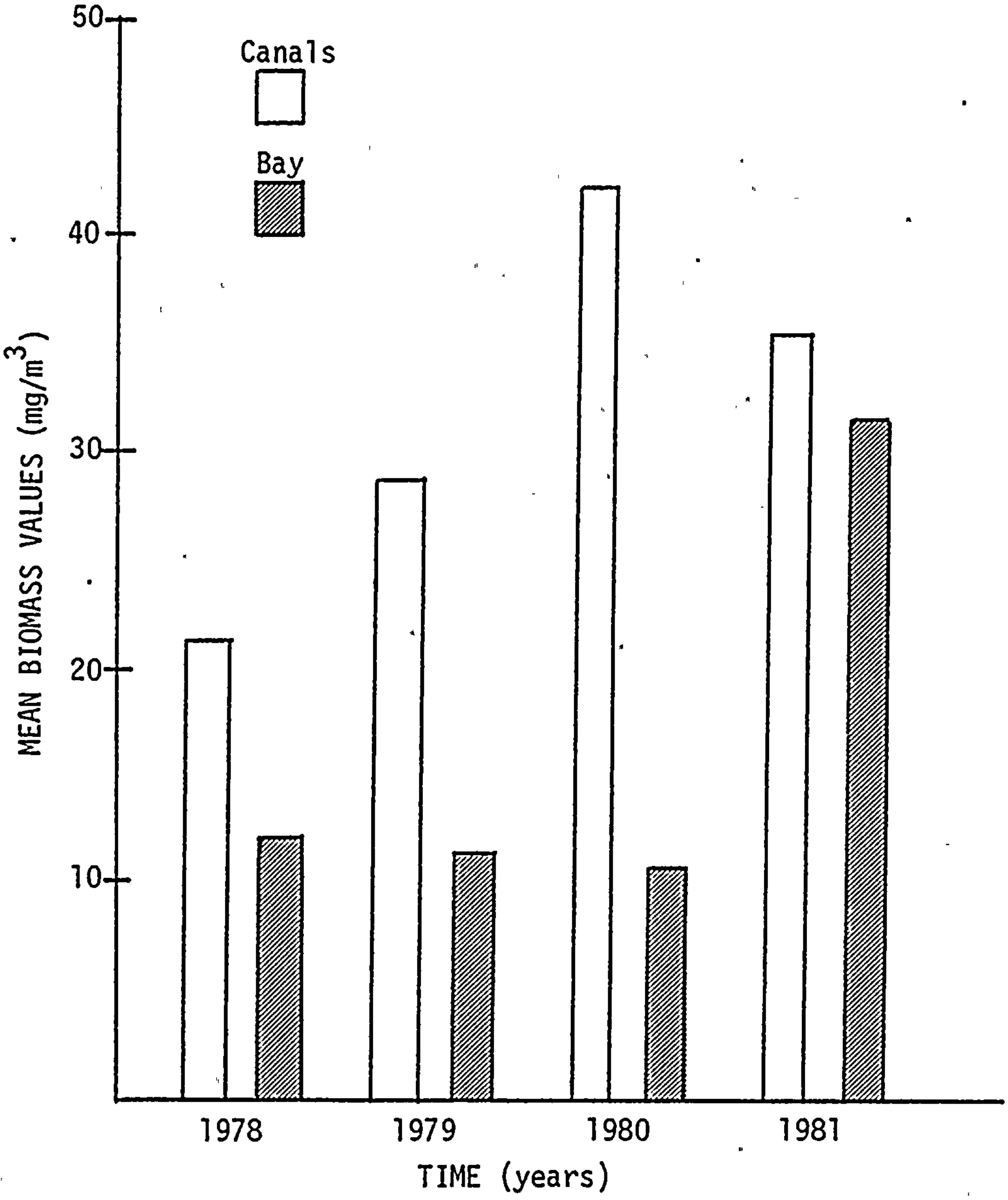


Figure 4. A comparison of mean biomass values for all stations in the Turkey Point Cooling Canal System and Biscayne Bay/Card Sound, 1978-1981.

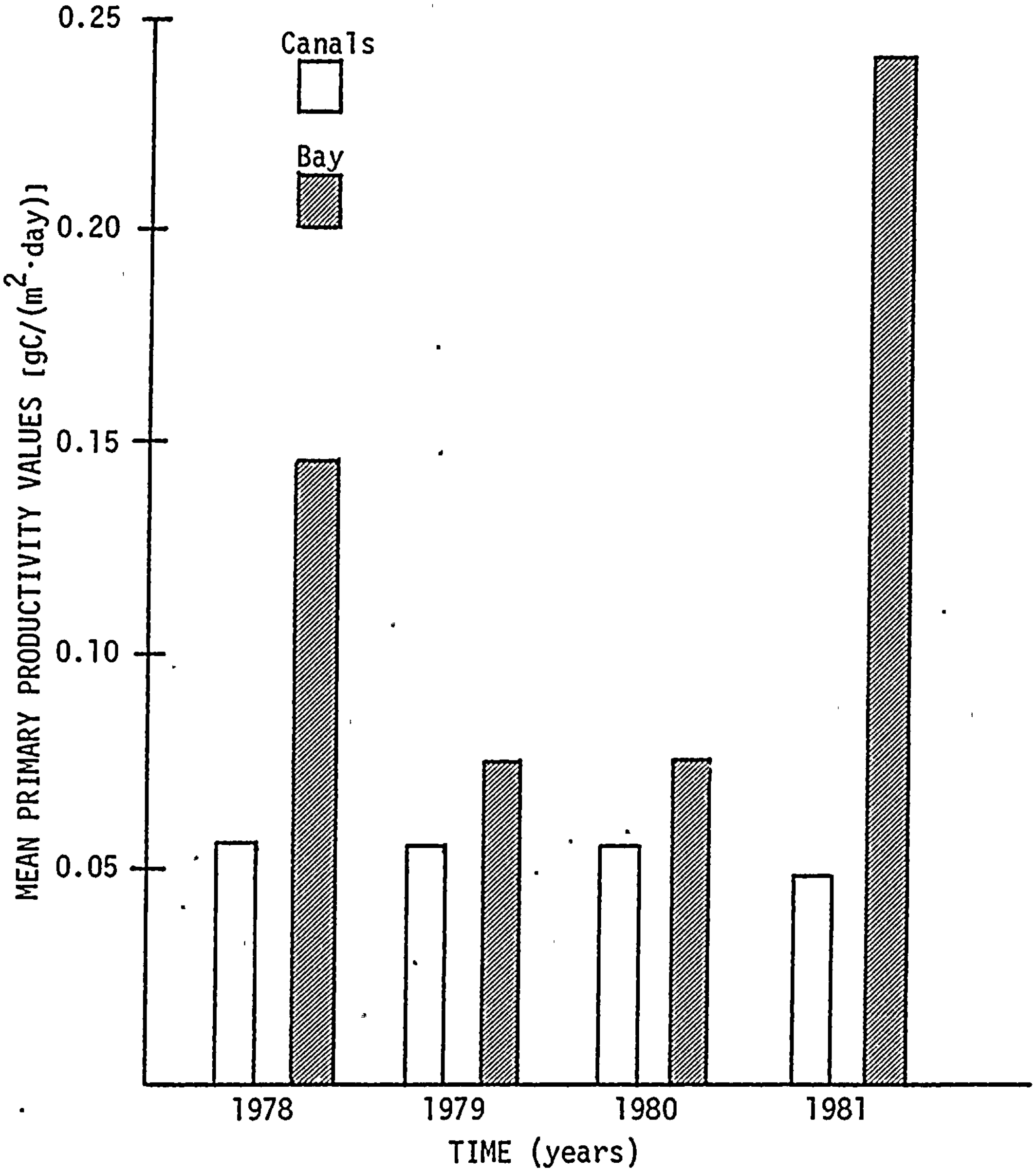


Figure 5. A comparison of mean primary productivity for all stations in the Turkey Point Cooling Canal System and Biscayne Bay/Card Sound, 1978-1981.

Table 1. Mean chlorophyll a, biomass and primary productivity values for the Turkey Point Cooling Canal System and Biscayne Bay/Card Sound for 1981.

DATA PERIOD	CHLOROPHYLL a (mg/m^3)		BIOMASS (mg/m^3)		PRIMARY PRODUCTIVITY [$gC/(m^2 \cdot day)$]	
	Canals	Bay	Canals	Bay	Canals	Bay
First Quarter (February)	0.62	0.18	41.59	11.87	0.050	0.091
Second Quarter (May)	0.64	0.12	42.86	7.98	0.053	0.062
Third Quarter (July)	0.41	0.21	27.49	13.86	0.043	0.107
Fourth Quarter (November)	0.46	1.38	31.14	92.20	0.044	0.713
Yearly Mean	0.53	0.47	35.77	31.48	0.048	0.242

b. Phytoplankton

(2) organisms

Introduction

This report compares phytoplankton populations occurring in the Turkey Point Cooling Canal System and adjacent lagoon (Biscayne Bay/ Card Sound) with those of previous reports (FPL, 1973-1980) in order to follow biological succession and biological stability of the system.

Materials and Methods

Samples were collected in the top meter of the water column quarterly (February, May, August and November) at 12 stations in the Turkey Point Cooling Canal System and 13 stations in Biscayne Bay/ Card Sound hereafter referred to as the canal system and the bay (Figures 1 and 2). These samples were reduced in volume, sedimented, preserved in 5% formalin and examined for species and abundance of organisms. Procedures were as in the previous reports (FPL, 1977).

Because the traditional method of preserving samples (5% formalin) occasionally caused erroneous identification of diatoms at the species level, many diatoms were identified only to genus. This is based upon the understanding, widely accepted by aquatic biologists, that relatively few diatoms can be determined to species level without clearing. Since the methods employed did not permit clearing, only those diatoms with distinctive outline features could be accurately

identified. The method thus permits identification of most diatoms to genus, and a few to species.

Results

A total of 103 organisms were identified in the canal system, including 32 considered common and relatively abundant, and 33 of sporadic occurrence. A total of 134 organisms were identified in the bay, including 43 common and relatively abundant species, and 31 others of sporadic occurrence. Most of these organisms were recorded in previous studies in comparable numbers. Counts of the principal organisms appear in Tables 1 and 2 for the canal system and bay respectively.

The diversity of the phytoplankton populations (Table 3) is expressed as the number of genera identified in the different groups. The principal taxomonic groups, counts of organisms by month and group for both the canal system and bay are listed in Table 4. It also gives total counts for the year by group and total counts by month.

Diatoms represented the largest component of the phytoplankton in both the canal system and the bay. Diatoms were generally at least twice as abundant in the canal system as in the bay.

Discussion

Considerable fluctuation in populations occurred seasonally in both the canal system and the bay. Most organisms or groups of organisms have appeared in previous years and have often been represented by large populations. The most conspicuous canal system population peaks were those of Rhodomonas sp. and Cryptomonas sp. in November, Cyclotella sp. in February and May, and Naviculoid diatoms in February and August. Lesser population peaks occurred in the bay during November i.e. Cyclotella sp. and Exuviaella spp.

The population totals listed for specific groups (Table 4) are essentially similar to those for 1980. The seasonal fluctuations were well within the limits which can be expected for phytoplankton populations.

Increased bay populations were observed in November due to the higher concentrations of principal phytoplankton nutrients (Plankton Nutrients, Table 2, Section III A.1.a). This was attributed to the excessive rainfall and subsequent run-off which occurred in August and September.

Conclusions

The majority of the phytoplankton organisms and groups show no major changes in numbers or diversity and hence provide evidence for biological stability of the canal system. Most of these organisms

were observed in previous years. The fact that certain organisms present in the bay do not regularly occur in the canal system has been documented in a previous report (FPL, 1979). This is to be expected in view of the detrital sedimentation and higher temperatures of the canal system producing a lower species diversity and greater number of organisms. Thus, the phytoplankton populations do not suggest any marked changes from conditions existing in the canal system prior to this report period.

The proportion existing between the different taxonomic groupings of phytoplankton is comparable for both canal system and bay. The canal system populations parallel those observed in previous reports (FPL, 1979-1981) and represent populations which are apparently normal for canal system environment.

When compared to sampling periods of previous years, no marked trends were observed during 1981.

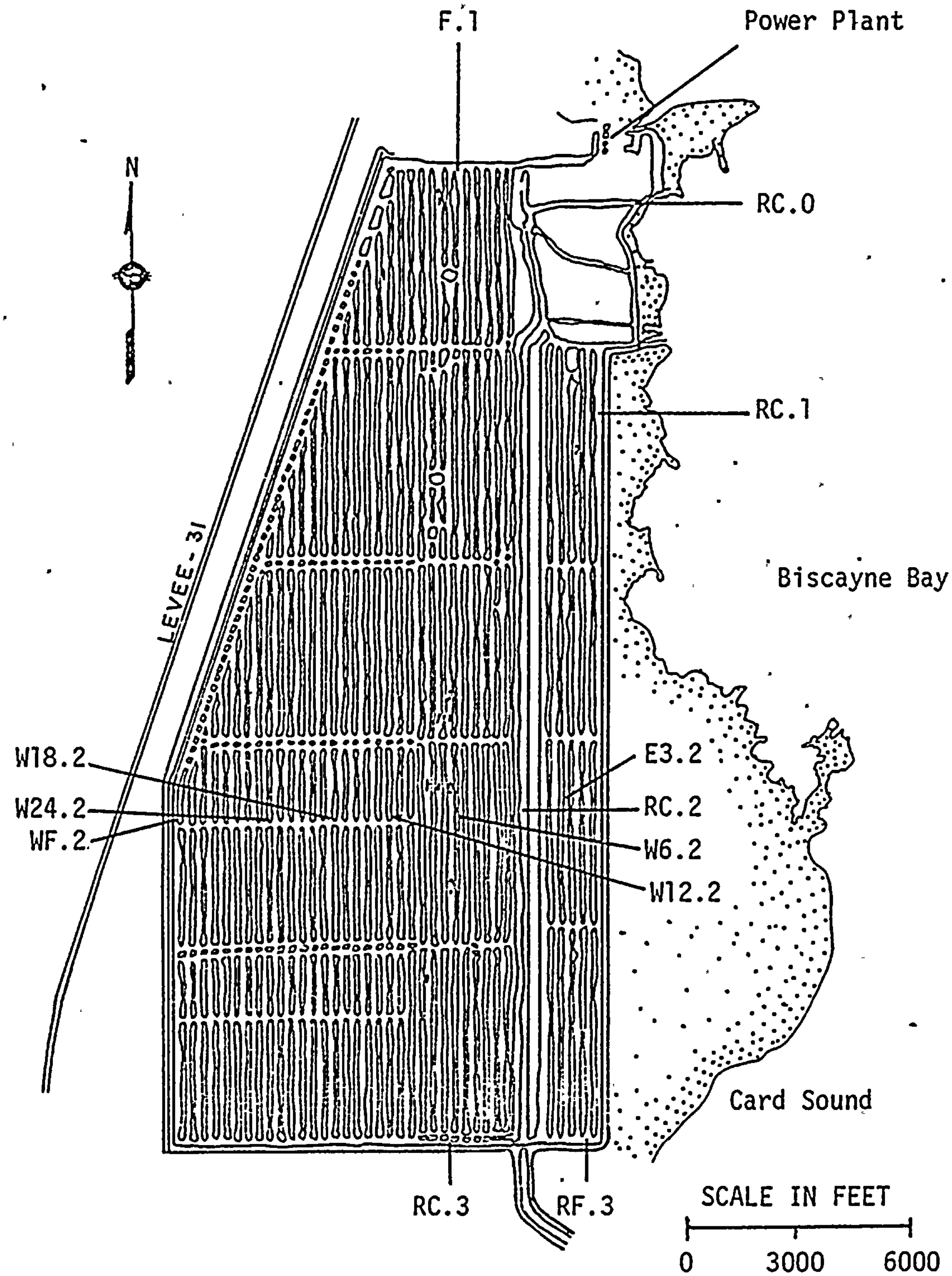


Figure 1. Phytoplankton sample stations in the Turkey Point Cooling Canal System, 1981.

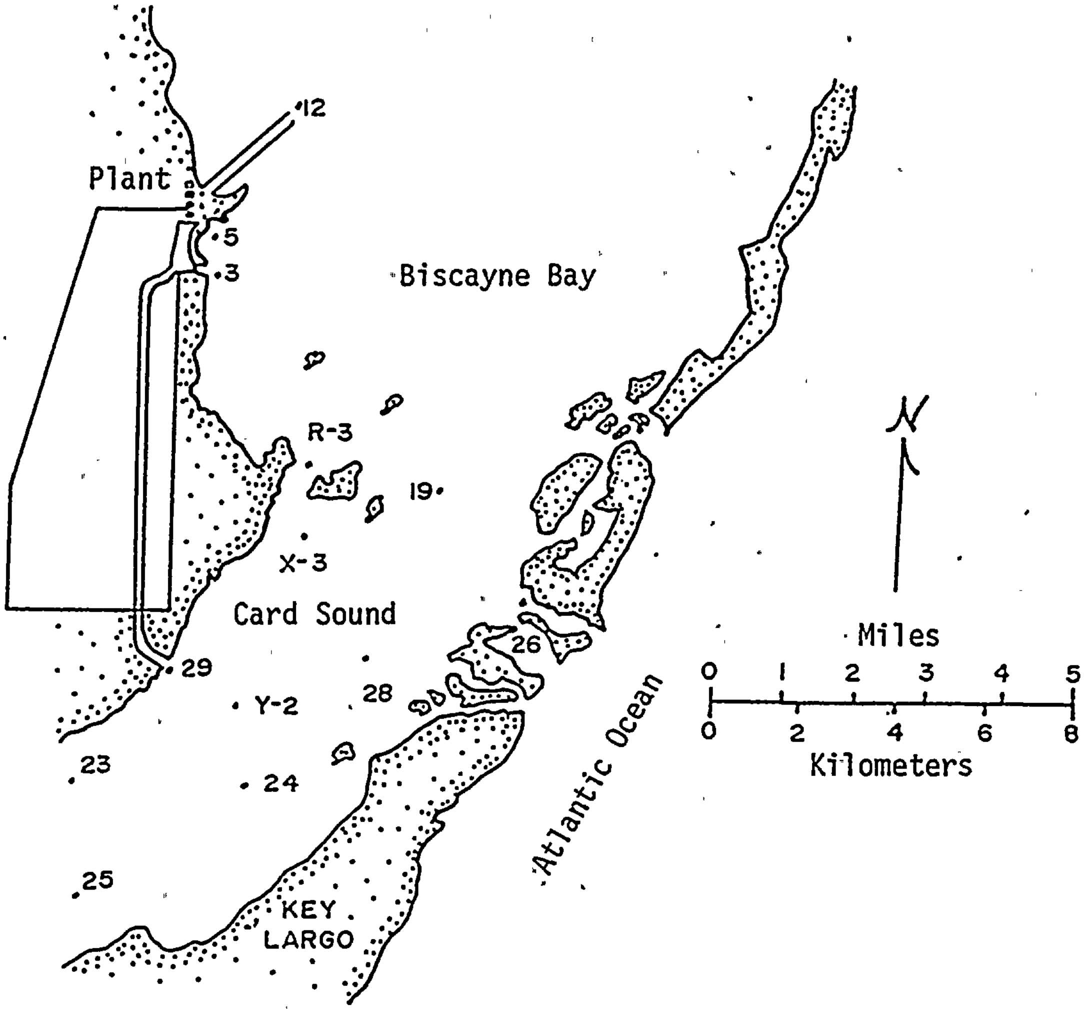


Figure 2. Phytoplankton sample stations in Biscayne Bay and Card Sound adjacent to the Turkey Point Cooling Canal System, 1981.

Table 1. Counts of the principal plankton organisms found in the Turkey Point Cooling Canal System, 1981.

ORGANISMS	FEBRUARY a	FEBRUARY b	MAY a	MAY b	AUGUST a	AUGUST b	NOVEMBER a	NOVEMBER b
Sulfur organisms								
Beggiatoa sp.	5	92	10	509	10	2016	5	107
B. arachnoidea	-	-	-	-	-	-	2	30
B. mirabilis	2	6	-	-	-	-	-	-
B. uniguttata	-	-	-	-	-	-	1	15
Macromonas sp.	-	-	1	3	-	-	-	-
Blue-green algae								
Anabaena sp.	2	45	4	390	9	960	4	210
Anacystis sp.	-	-	3	270	3	60	2	75
Aphanocapsa sp.	-	-	1	45	3	135	-	-
Arthrospira jenneri	-	-	1	60	3	105	2	33
Chroococcus gigantea	7	141	5	770	11	766	1	3
Chroococcus sp.	4	120	6	370	7	585	3	93
Gloeocapsa sp.	-	-	2	105	-	-	-	-
Gomphosphaeria aponina	-	-	4	150	10	628	2	45
Johannesbaptistia sp.	-	-	2	150	6	181	1	15
Lyngbya sp.	-	-	-	-	1	3	1	60
Merismopedia sp.	-	-	3	120	7	330	-	-
Oscillatoria sp. (3-5μ)	7	270	-	-	12	1440	5	180
Oscillatoria sp. (9-12μ)	5	132	-	-	12	737	-	-
Oscillatoria sp. (over 12μ)	6	106	-	-	8	306	5	96
Schizothrix calcicola	7	600	-	-	9	840	8	440
Spirulina major	-	-	-	-	5	243	1	3
S. minor	2	18	-	-	9	480	1	513

Table 1. (Cont'd) Counts of the principal plankton organisms found in the Turkey Point Cooling Canal System, 1981.

ORGANISMS	FEBRUARY		MAY		AUGUST		NOVEMBER	
	a	b	a	b	a	b	a	b
Green algae								
<u>Chlamydomonas</u> sp.	4	360	8	285	5	420	-	-
<u>Pediastrum</u> sp.	1	3	-	-	-	-	-	-
<u>Pyramidomonas grossi</u>	1	60	3	75	-	-	2	390
Euglenoids								
<u>Euglena acus</u>	-	-	1	45	-	-	-	-
<u>Eutreptia hirudoidea</u>	1	30	-	-	2	33	5	133
<u>E. viridis</u>	8	399	6	315	4	123	12	1836
<u>Trachelomonas</u> sp.	2	45	-	-	1	30	1	60
<u>Bodo</u> sp.	-	-	1	30	-	-	-	-
Unidentified Euglenoids	4	180	2	30	3	105	-	-
Cryptomonads								
<u>Cryptomonas</u> sp.	12	1556	8	1170	11	1485	12	18 510
<u>Rhodomonas</u> sp.	12	3318	4	345	8	450	12	59 430
Flagellates (<u>incertae sedis</u>)	10	2190	12	4290	12	5530	12	13 190
Dinoflagellates								
<u>Amphidinium</u> sp.	11	1500	11	960	8	840	11	405
<u>Amphidinium acuta</u>	-	-	-	-	1	3	-	-
<u>Exuviaella baltica</u>	3	135	7	330	6	495	5	208
<u>E. marina</u>	2	6	5	136	5	81	-	-
<u>E. minor</u>	-	-	2	30	-	-	-	-
<u>E. oblonga</u>	12	1203	10	1095	9	340	9	290

Table 1. Counts of the principal plankton organisms found in the Turkey Point Cooling (Cont'd) Canal System, 1981.

ORGANISMS	FEBRUARY		MAY		AUGUST		NOVEMBER	
	a	b	a	b	a	b	a	b
Dinoflagellates (cont'd)								
Gymnodinium albulum	5	30	2	45	8	525	7	540
G. breve	-	-	1	15	-	-	-	-
G. foliaceum	8	765	1	30	6	420	3	450
G. spendens	-	-	-	-	-	-	3	9
G. pingue	-	-	1	30	-	-	6	305
Gymnodinium (small) Unk.	12	1350	12	2505	9	2130	10	11 055
Gymnodinium (large) Unk.	10	1200	3	225	8	3780	9	7500
Peridinium brevipes	-	-	1	15	-	-	-	-
P. hirobis	1	30	-	-	-	-	8	378
P. triquetra	-	-	1	30	-	-	-	-
P. trochoideum	7	510	-	-	2	45	9	2490
Peridinium sp.	11	1650	10	1590	6	315	10	2160
Peridiniopsis rotundata	-	-	2	45	-	-	4	63
Prorocentrum micans	-	-	-	-	1	30	1	30
Protoceratium reticulatum	2	6	4	105	-	-	1	3
Pyrocystis sp.	-	-	1	30	1	10	-	-
Pyrodinium bahamiense	-	-	-	-	2	18	1	6
Unidentified Dinoflagellates	12	5540	11	3575	11	5535	12	4305
Diatoms								
Amphiprora alata	9	573	8	810	6	403	6	555
A. minuta	11	1140	6	155	10	2145	5	555
A. paludosa	-	-	3	75	2	180	1	60
A. sp.	-	-	5	150	-	-	-	-

Table 1. (Cont'd) Counts of the principal plankton organisms found in the Turkey Point Cooling Canal System, 1981.

ORGANISMS	FEBRUARY a	FEBRUARY b	MAY a	MAY b	AUGUST a	AUGUST b	NOVEMBER a	NOVEMBER b
Diatoms (cont'd)								
Amphora sp.	7	480	12	1028	12	6195	8	735
Campylosira cymbelliformis	1	30	1	180	5	285	-	-
Chaetoceras sp.	1	30	4	195	6	255	6	255
Campylostylus striatus	2	33	3	55	9	7971	-	-
Cocconeis sp.	12	5730	11	2715	12	3460	7	2250
Coscinodiscus concinnus	-	-	-	-	-	-	1	10
Cyclotella sp.	12	48 750	12	22 365	6	525	8	1155
Cymbella sp.	2	90	8	450	5	350	2	150
Fragilaria sp.	-	-	4	195	6	630	8	570
Grammatophora sp.	-	-	1	15	2	60	-	-
Gyrosigma balticum	2	33	-	-	4	81	-	-
Licmophora sp.	8	208	3	153	8	551	7	261
L. flabellata	4	72	8	314	-	-	-	-
Navicula amphibola	4	120	8	645	4	513	2	45
Unidentified Naviculoids	12	33 750	12	15 870	12	24 650	12	4440
Nitzschia acicularis	9	1740	6	795	-	-	-	-
N. closterium	7	285	3	270	11	720	8	840
N. longissima	11	2175	8	1080	6	1250	9	1431
N. paxillifer	1	15	-	-	-	-	-	-
N. rigida	6	300	1	180	-	-	5	25
N. sigma	-	-	-	-	4	72	-	-
N. sigmoidea	-	-	-	-	-	-	1	3
Nitzschia sp.	11	1530	11	4425	11	5400	10	930
Pinnularia sp.	-	-	-	-	2	90	-	-

Table 1. (Cont'd) Counts of the principal plankton organisms found in the Turkey Point Cooling Canal System, 1981.

ORGANISMS	FEBRUARY a	FEBRUARY b	MAY a	MAY b	AUGUST a	AUGUST b	NOVEMBER a	NOVEMBER b
Diatoms (cont'd)								
Pleurosigma brebissonii	6	315	8	570	11	2910	2	60
P. elongatum	7	111	5	103	12	13 680	8	342
Striatella sp.	1	30	-	-	1	3	-	-
Surirella sp.	-	-	-	-	3	75	1	30
Synedra acicularis	-	-	3	105	-	-	-	-
S. crystallina	5	330	3	78	2	36	2	63
S. laevigata	-	-	-	-	1	30	-	-
S. fulgens	4	315	1	30	12	6540	3	75
Synedra sp.	4	105	12	900	3	120	7	345
Tabellaria sp.	4	78	-	-	10	3780	3	75
Thalassiosira sp.	1	30	-	-	-	-	2	45
Unidentified Diatoms	6	780	10	345	9	690	4	210
Ciliates								
Askenasia sp.	1	15	-	-	-	-	-	-
Cymatocylis sp.	-	-	-	-	-	-	11	133
Favella panamensis	1	10	-	-	-	-	-	-
Favella sp.	-	-	-	-	-	-	1	3
Helicostomella sp.	-	-	1	3	-	-	-	-
Metacylis sp.	1	3	-	-	-	-	-	-
Orthodon sp.	-	-	-	-	-	-	1	3
Strombidium conicum	-	-	-	-	-	-	6	675
Strombidium sp.	-	-	-	-	-	-	1	3
Tintinnopsis wailesi	-	-	-	-	-	-	6	210

Table 1. Counts of the principal plankton organisms found in the Turkey Point Cooling
(Cont'd) Canal System, 1981.

ORGANISMS	FEBRUARY		MAY		AUGUST		NOVEMBER	
	a	b	a	b	a	b	a	b
Ciliates (cont'd)								
T. tubulosoides	2	45	7	660	-	-	-	-
Tintinnopsis sp.	-	-	1	30	-	-	12	18
Unidentified Ciliates	3	90	9	891	9	375	11	3810
Rhizopoda								
Amoeba sp.	-	-	-	-	-	-	1	3
Metazoa								
Polychaetes	1	3	-	-	-	-	-	-
Copepods	9	266	8	199	5	129	-	-
Unidentified Larvae	2	45	2	36	-	-	2	150
Nematodes	1	30	1	15	8	76	4	51
Gastropods	-	-	3	76	10	86	-	-
Crab larvae	-	-	-	-	2	10	10	148
Rotifers	-	-	1	6	1	6	-	-
Bivalves	-	-	1	3	12	309	5	90
Eggs	6	114	2	40	2	33	1	15
Cells (*incertae sedis*)	12	4080	12	4620	11	3750	11	4530

[a] Number of stations at which it occurred.
[b] Total number of organisms or colonies per 0.5 liter.

Table 2. Counts of the principal plankton organisms found in Biscayne Bay/Card Sound, 1981.

ORGANISMS	FEBRUARY		MAY		AUGUST		NOVEMBER	
	a	b	a	b	a	b	a	b
Sulfur organisms								
Beggiatoa spp.	3	63	-	-	5	390	5	528
Macromonas sp.	-	-	1	3	1	3	-	-
Blue-green algae								
Anabaena sp.	3	150	3	48	9	300	7	240
Anacystis sp.	1	30	-	-	-	-	-	-
Aphanocapsa sp.	1	30	3	60	3	105	3	60
Arthrospira jenneri	1	3	1	15	5	78	4	255
Chroococcus gigantea	3	90	3	60	3	90	1	30
Chroococcus sp.	4	180	10	315	8	220	5	270
Coelosphaerium sp.	-	-	1	15	-	-	-	-
Eucapsis sp.	-	-	-	-	-	-	9	3570
Gloeocapsa sp.	-	-	-	-	-	-	3	75
Gomphosphaeria aponina	4	156	11	315	8	195	3	48
Johannesbaptistia sp.	6	300	12	375	7	276	7	143
Lyngbya sp.	-	-	-	-	-	-	1	3
Merismopedia sp.	5	165	2	45	-	-	4	195
Microcystis sp.	1	30	-	-	-	-	-	-
Oscillatoria sp. (3-5μ)	2	60	-	-	3	39	6	1185
Oscillatoria sp. (9-12μ)	5	69	-	-	7	135	8	186
Oscillatoria sp. (over 12μ)	1	30	-	-	2	33	4	46
Schizothrix calcicola	7	315	-	-	7	270	4	90
Spirulina major	-	-	1	30	5	243	-	-
S. minor	3	75	-	-	9	480	4	90

Table 2. (Cont'd) Counts of the principal plankton organisms found in Biscayne Bay/Card Sound, 1981.

ORGANISMS	FEBRUARY		MAY		AUGUST		NOVEMBER	
	a	b	a	b	a	b	a	b
Green algae								
Chlamydomonas sp.	-	-	4	225	7	535	2	120
Dunaliella salina	-	-	-	-	-	-	1	300
Pandorina sp.	-	-	1	15	-	-	-	-
Pediastrum sp.	-	-	-	-	1	3	-	-
Pyramidomonas grossi	3	90	6	210	2	90	9	715
Euglenoids								
Cylindromonas sp.	-	-	3	240	-	-	-	-
Euglena acus	-	-	3	90	1	30	-	-
Eutreptia hirudoidea	-	-	-	-	1	15	5	715
E. viridis	-	-	4	105	-	-	3	16
Trachelomonas sp.	1	30	3	120	-	-	-	-
Bodo sp.	2	60	-	-	-	-	-	-
Peranema sp.	-	-	1	3	-	-	-	-
Unidentified Euglenoids	1	90	11	1965	8	395	5	360
Silicoflagellates								
Dictyocha fibula	-	-	-	-	2	120	7	570
Cryptomonads								
Cryptomonas sp.	2	180	5	150	-	-	12	2525
Rhodomonas sp.	2	330	10	2105	8	2010	13	21 335
Flagellates (*incertae sedis*)	13	17 430	13	5610	13	10 680	13	50 280

Table 2. Counts of the principal plankton organisms found in Biscayne Bay/Card Sound,
(Cont'd) 1981.

ORGANISMS	FEBRUARY a	FEBRUARY b	MAY a	MAY b	AUGUST a	AUGUST b	NOVEMBER a	NOVEMBER b
Dinoflagellates								
Amphidinium acuta	-	-	-	-	-	-	1	5
Amphidinium sp.	2	360	12	1050	12	1550	13	3300
Ceratium furca	1	6	9	386	11	614	10	3334
C. fusus	-	-	1	3	2	60	6	390
Dinophysis sp.	-	-	-	-	1	30	2	60
Exuviaella baltica	11	1320	5	240	12	655	13	19 470
E. marina	3	19	8	196	3	27	-	-
E. oblonga	13	1639	8	345	12	658	8	691
Gonyaulax digitale	-	-	-	-	1	30	-	-
Gonyaulax sp.	2	60	-	-	5	195	2	18
Gymnodinium albulum	1	30	-	-	4	300	5	1050
G. auratum	1	30	-	-	-	-	-	-
G. breve	1	30	-	-	-	-	1	60
G. foliaceum	3	150	6	105	4	210	-	-
G. lachryma	-	-	-	-	1	3	2	9
G. spendens	1	3	-	-	8	113	2	63
G. pingue	1	90	1	30	10	705	13	2295
Gymnodinium (small) Unk.	13	6300	13	2895	13	4770	13	7020
Gymnodinium (large) Unk.	4	1500	3	90	8	390	9	1515
Peridinium conicum	-	-	-	-	1	30	-	-
P. depressum	-	-	2	30	5	79	-	-
P. divergens	1	30	-	-	5	225	7	38
P. globulus	-	-	-	-	1	30	-	-
P. hirobis	2	60	3	60	7	180	4	105

Table 2. Counts of the principal plankton organisms found in Biscayne Bay/Card Sound, (Cont'd) 1981.

ORGANISMS	FEBRUARY		MAY		AUGUST		NOVEMBER	
	a	b	a	b	a	b	a	b
Dinoflagellates (cont'd)								
P. triquetra	7	330	-	-	4	330	-	-
P. trochoideum	10	1170	5	225	12	1305	7	405
P. pentagonum	-	-	-	-	1	30	-	-
Peridinium sp.	13	2790	13	1380	11	2580	9	4125
Peridiniopsis rotundata	1	30	2	30	3	195	11	4845
Prorocentrum gracile	2	6	-	-	2	45	6	114
P. micans	4	93	-	-	5	135	9	4843
P. triangulatum	-	-	-	-	-	-	1	30
Protoceratium reticulatum	6	160	7	165	10	247	9	412
Pyrocystis sp.	5	99	4	125	13	4019	3	9
Pyrodinium bahamiense	1	32	3	60	10	370	6	474
Unidentified Dinoflagellates	13	6220	13	5355	13	10 170	13	11 235
Diatoms								
Amphiprora alata	3	105	2	45	5	63	4	570
A. minuta	7	690	1	60	7	270	-	-
A. paludosa	3	90	1	15	2	90	-	-
Amphiprora sp.	-	-	5	120	1	60	-	-
Amphora commutata	-	-	-	-	3	240	1	480
A. ocellata	3	150	3	75	2	75	4	165
Amphora sp.	10	1206	6	240	9	795	9	570
Biddulphia sp.	1	3	-	-	-	-	-	-
Campylosira cymbelliformis	2	60	1	15	-	-	2	45
Chaetoceras sp.	1	30	5	675	2	63	3	135
Campylostylus striatus	-	-	1	15	-	-	1	15

Table 2. Counts of the principal plankton organisms found in Biscayne Bay/Card Sound,
(Cont'd) 1981.

ORGANISMS	FEBRUARY		MAY		AUGUST		NOVEMBER	
	a	b	a	b	a	b	a	b
Diatoms (cont'd)								
Cocconeis sp.	12	2280	13	720	10	570	10	1705
Coscinodiscus concinnus	-	-	-	-	1	30	10	511
Cyclotella sp.	13	3040	9	555	11	1696	13	17 025
Cymbella sp.	5	270	8	210	4	150	1	30
Fragilaria sp.	-	-	5	420	7	255	2	90
Licmophora sp.	11	1900	3	90	3	255	6	186
L. flabellata	8	213	8	579	2	45	-	-
L. grandis	2	123	2	195	1	3	3	63
Navicula amphibola	8	423	8	345	11	825	9	615
N. pandura	2	33	1	15	2	63	-	-
N. scopulorum	2	63	-	-	-	-	1	60
Unidentified Naviduloids	13	11 400	13	7650	13	9930	12	6690
Nitzschia acicularis	8	960	11	630	-	-	-	-
N. closterium	6	300	3	135	9	210	2	45
N. longissima	10	840	7	240	12	8910	5	690
N. rigida	2	120	1	30	-	-	4	180
N. sigma	1	30	-	-	2	18	-	-
N. sigmoidea	1	60	-	-	1	60	1	30
Nitzschia sp.	13	2790	11	1050	13	2280	11	1034
Pinnularia sp.	-	-	-	-	-	-	1	15
Pleurosigma brebissonii	1	30	-	-	-	-	1	30
P. elongatum	9	226	-	-	5	69	4	1110
Striatella sp.	6	243	-	-	6	2623	1	30
Surirella sp.	6	111	2	45	3	75	2	30

Table 2. Counts of the principal plankton organisms found in Biscayne Bay/Card Sound, (Cont'd) 1981.

ORGANISMS	FEBRUARY a	FEBRUARY b	MAY a	MAY b	AUGUST a	AUGUST b	NOVEMBER a	NOVEMBER b
Diatoms (cont'd)								
Synedra acicicularis	-	-	4	225	4	630	-	-
S. affinis	-	-	2	45	-	-	-	-
S. crystallina	2	6	5	139	4	36	2	9
S. laevigata	-	-	-	-	2	120	-	-
S. fulgens	1	6	2	30	1	15	4	225
S. undulata	-	-	2	30	2	18	-	-
Synedra sp.	8	660	9	800	9	2025	6	495
Tabellaria sp.	7	660	-	-	8	660	3	135
Thalassiosira sp.	1	30	-	-	-	-	4	13 350
Unidentified Diatoms	11	843	9	510	10	1170	3	285
Ciliates								
Askenasia sp.	-	-	1	30	-	-	-	-
Favella panamensis	1	13	-	-	7	61	-	-
Metacylis corbula	1	15	-	-	3	40	-	-
M. juergensenii	5	118	1	60	9	318	7	173
Metacylis sp.	2	60	-	-	2	40	-	-
Parafavella sp.	1	3	-	-	1	15	-	-
Salpingella sp.	1	6	-	-	-	-	-	-
Strobilidium sp.	3	150	-	-	2	60	-	-
Strombidium conicum	2	4	4	75	8	483	5	603
Strombidium sp.	4	270	3	105	5	360	5	723
Tintinnus apertus	1	3	-	-	8	269	-	-
T. tenue	-	-	-	-	1	3	-	-

Table 2. (Cont'd) Counts of the principal plankton organisms found in Biscayne Bay/Card Sound, 1981.

ORGANISMS	FEBRUARY a	FEBRUARY b	MAY a	MAY b	AUGUST a	AUGUST b	NOVEMBER a	NOVEMBER b
Ciliates (cont'd)								
Tintinnopsis everta	-	-	-	-	-	-	1	3
T. wailesi	3	45	1	3	4	67	3	21
T. tubulosoides	10	955	1	75	3	190	8	448
T. sp.	2	63	1	6	1	60	4	108
Unidentified Ciliates	9	1500	13	1703	12	2460	12	4680
Rhizopoda								
Rhabdosphaera sp.	-	-	2	135	-	-	-	-
Metazoa								
Trematodes	-	-	-	-	1	3	-	-
Polychaetes	-	-	-	-	1	3	-	-
Copepods	13	627	9	238	11	441	9	439
Unidentified Larvae	3	42	2	18	5	45	7	127
Nematodes	3	36	-	-	2	9	2	16
Gastropods	4	112	1	30	3	12	7	60
Crab larvae	-	-	-	-	-	-	7	156
Bivalves	3	12	2	6	6	101	10	143
Eggs	9	214	-	-	4	78	4	78
Cells (*incertae sedis*)	13	5940	13	11 160	13	6150	10	1431

[a]Number of stations at which it occurred.
[b]Total number of organisms or colonies per 0.5 liter.

Table 3. Diversity of the respective groups of plankton found in the Turkey Point Cooling Canal System and Biscayne Bay/Card Sound, 1980-1981.

GROUPS	1978		1979		1980		1981	
	Canals	Bay	Canals	Bay	Canals	Bay	Canals	Bay
Sulfur organisms	1	1	2	1	1	1	5	2
Blue-green algae	22	20	25	18	18	17	15	18
Green algae	5	6	4	5	3	3	3	5
Euglenoids	5	6	5	4	4	5	6	8
Silicoflagellates	1	1	0	1	1	1	0	1
Cryptophytes	3	3	3	2	2	2	2	2
Flagellates (Incertae sedis)	1	1	1	1	1	1	1	1
Dinoflagellates	22	31	16	33	23	40	22	34
Diatoms	56	70	59	60	48	58	40	45
Ciliates	10	21	6	23	11	23	14	22
Rhizopoda	1	1	1	1	1	1	1	1
Total	127	161	122	149	113	152	109	139

Table 4. Counts by taxonomic group of planktonic organisms monitored in the Turkey Point Cooling Canal System and Biscayne Bay/Card Sound, 1981.

GROUPS	FEB.		MAY		AUG.		NOV.		SUB-TOTALS		TOTAL
	Canals	Bay	Canals	Bay	Canals	Bay	Canals	Bay	Canals	Bay	By Group
Blue-greens	1432[a]	1683	2430	1278	7799	2464	1766	6486	13,427	11,911	25,338
Dinoflagellátes	13,925	22,557	10,821	12,770	14,567	30,280	30,197	65,915	69,510	131,522	201,032
Diatoms	99,178	29,994	54,251	15,948	83,650	34,367	15,515	46,648	252,594	126,957	379,551
Ciliates	163	3205	1584	2057	375	4426	4855	6759	6977	16,447	23,424
Flagellates[b]	2190	17,430	4290	5610	5530	10,680	13,190	50,280	25,200	84,000	109,200
Cryptomonads	4874	510	1515	2255	1935	2010	77,940	23,860	86,264	28,635	114,899
Sub-totals	121,762	75,379	74,891	39.918	113,856	84,227	143,463	199,948	453,972	399,472	
Total[c]	197,141		114,809		198,083		343,411				853,444 (Grand Total)

[a]Population totals are expressed in terms of organisms per 0.5 liters.
[b]*Incertae sedis*
[c]By month - Canals and Bay combined.

2. Fish (ETS 4.1.1.1.2)

Introduction

Populations of fish within the Turkey Point Cooling Canal System were isolated from Biscayne Bay and adjacent offshore habitats, hereafter referred to as the canal system and the bay, when the canal system was closed off from the bay in February 1973.

This study characterizes and documents population changes that occur in the fish fauna within the canal system. To place these changes in perspective, the canal system fish data is compared to that of the bay (Nugent, 1970).

Materials and Methods

Fish were collected monthly at the ten stations in the canal system to determine the species present, their relative abundance, life history stages, biomass, and size. Species that demonstrated a variety of life history stages were considered to be reproducing and established in the canal system, while those represented only by adults were not considered to be reproducing and are expected to be lost through natural attrition over time.

Stations 1 and 8 were relatively deepwater (6 m) areas located near the plant intake and discharge, respectively (Figure 1). Water depth at Stations 2 and 4 ranged from 1 to 6 m. Water depth at Stations 3, 5, 6, and 7 averaged less than 1 m. Stations 9 and 10 were in a backwater area and small pond, respectively, adjacent to the

canal system proper. Water depth at these two stations was less than 0.6 m.

Collections were made by nylon gill nets and minnow traps. Each gill net was 30 m in length by 1.8 m in depth and consisted of three 10 m panels of 25, 38, and 51-m^2 mesh sewn end to end. The gill nets were set perpendicular to shore in water depth of 1 to 2.5 m. The minnow traps were of the double funnel type and measured 406 mm long by 229 mm in diameter. These traps were constructed of 6.4 mm^2 galvanized mesh. The traps were set near the edges of the canals at water depths of from 30 cm to 50 cm.

The sampling method at each station was determined primarily by the water depth at the sampling site. Gill nets were set at Stations 1, 2, 4, and 8; the minnow traps were set at Stations 1 through 10. One gill net and/or two minnow traps were fished for one 24-hour period per station per month.

All specimens collected were identified to species whenever possible, counted, measured to the nearest millimeter, and weighed to the nearest gram. Fish were measured from the tip of the snout to the caudal peduncle (standard length). Fish nomenclature was in accordance with Bohlke and Chaplin (1968).

Results

A total of 16 species of fish represented by 6446 individuals

was collected in the canal system during 1981 (Table 1). The majority of these individuals were small forage fish collected by minnow traps.

The killifish family (Cyprinodontidae) comprised 94.6 percent of the total number of fish collected in 1981. The goldspotted killifish and sheepshead minnow were the predominant species found with 3579 and 2521 individuals respectively (Table 1). Other members of this family collected were the rainwater and gulf killifish. Killifish were generally less than 65 mm in length, and because of their small size, made up only 24.6 percent of the total biomass of the fish collected.

The livebearer family (Poeciliidae) was represented by the sailfin molly. Livebearers comprised 2.4 percent of the total number of fish collected during 1981 and, due to their small size, made up only 0.8 percent of the total fish biomass (Table 1).

The balance of the fish collected in 1981 comprised only 3.0 percent of the total number but accounted for 74.6 percent of the total biomass. The collection of a relatively few large individuals such as bonefish, barracuda, and snapper accounted for most of the biomass (Table 1).

Discussion

Actively reproducing populations of killifish and livebearers within the canal system were evidenced by the occurrence of juveniles as

well as adults (Table 1) and the continued abundance of these fish over past years (Table 2). Although not as abundant as the killifish, crested gobies and gulf toadfish were also collected as juveniles and adults and are considered established in the canal system. No juvenile silver jenny or mojarras were collected during 1981.

Redfin needlefish were frequently observed in the canal system and are considered established. However, they were generally not collected because of the sampling methods employed. Needlefish are becoming a prominent predator in the canal system as populations of nonreproducing predatory species are reduced by natural attrition.

The remainder of the species found did not appear to be reproducing in the canal system as indicated by both an absence of juveniles and a decline in number collected (Table 2). The species that were not reproducing within the canal system generally spawn at sea. These fish (i.e. barracuda, bonefish, and crevelle jack) have pelagic eggs and larvae which develop offshore. Confinement to the inshore canals was not conducive to spawning and development of eggs and larvae.

Changes which occurred in fish populations in the canal system were reflected in the data when plotted as catch per unit effort (C.P.U.E.). The minnow trap C.P.U.E., indicative of populations of the small forage species, increased after the first year of the study and decreased slightly over subsequent years. The minnow trap C.P.U.E.

for 1981 was similar to that of past years after an unusually high C.P.U.E. in 1980 (Figure 2). The large expanse of generally shallow water provided an ideal habitat for forage fish. This and the decrease in the number of predatory species is considered the cause for their established populations. The gill net C.P.U.E., indicative of populations of larger fish, decreased substantially after the 1975 study and continued its slow decrease through 1981.

Eighty species of fish were collected by trawling in southern Biscayne Bay and Card Sound during the baseline survey for the Turkey Point Plant (Bader and Roessler, 1971). This can be compared to 42 species collected in the canal system for 1974 through 1978 by Applied Biology, Inc. and 27 species collected in 1979-1981 by Florida Power & Light/Land Utilization. Although the different collection methods between the baseline survey and later surveys may have accounted for some of the difference in the number of species, it appears that many species found in the bay simply did not enter the canal system during the brief period the canal system was open to the bay.

The surveys conducted by Nugent (1970) with gill nets and fish traps in the immediate vicinity of the power plant resulted in a collection of 51 species of fish. These studies were conducted in tidal creeks and other nearshore areas so that the species found were more representative of those collected in the canal system (Table 3). Nevertheless, Nugent also found more species than were found in the canal system. This is a further indication that certain fish species

in the area may not have entered the canal system before it was closed off from the bay in 1973.

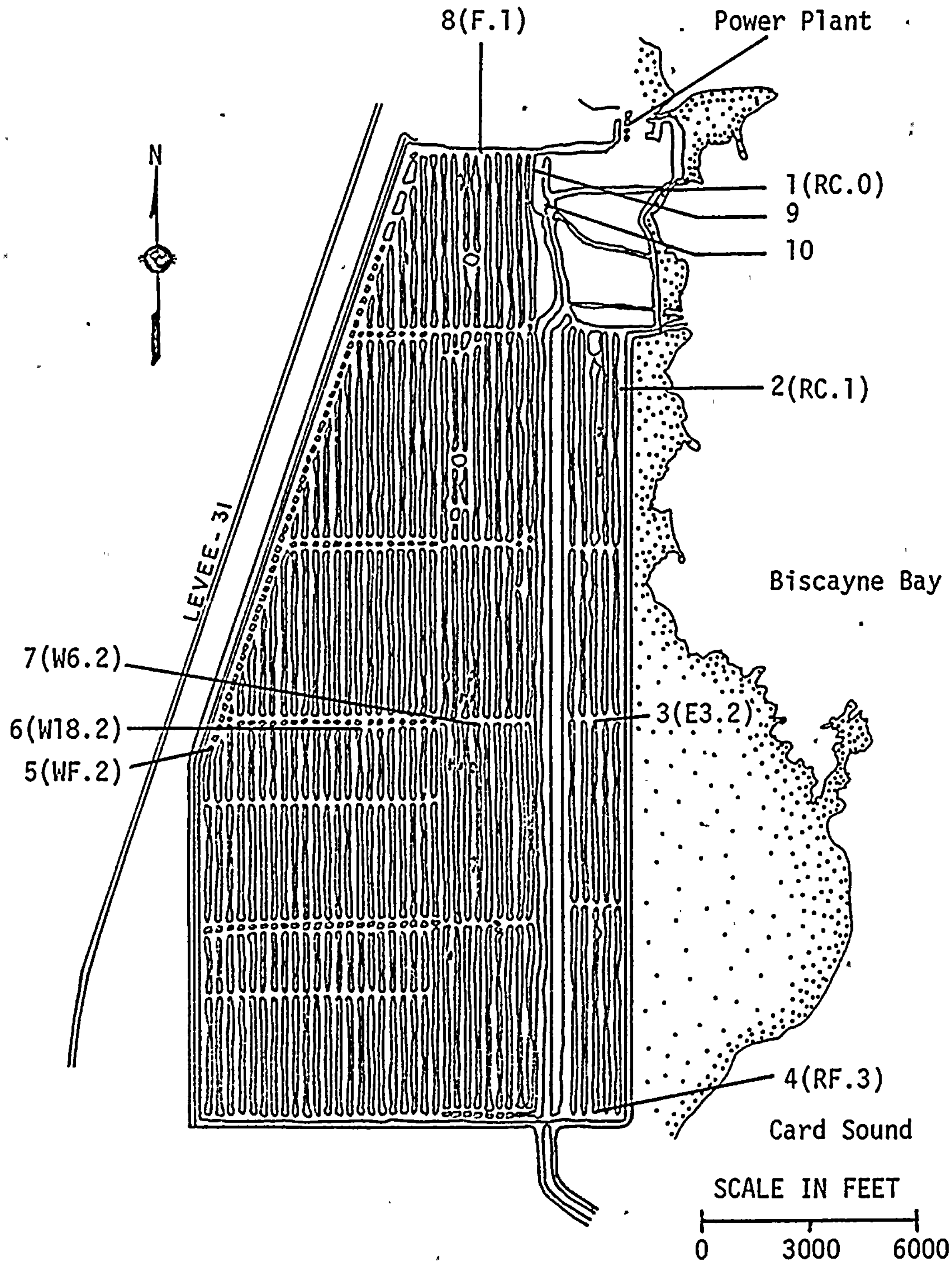
In general, studies conducted since 1979 have shown that the fish which became isolated in the canals were primarily the common, and often abundant species found by Nugent outside the canal system. The few species collected from 1974 through 1978 by A.B.I., which were not found by Nugent (Table 3), were mainly small fish collected by minnow traps, a method which Nugent did not use.

Conclusions

Populations of fish within the Turkey Point Cooling Canal System became isolated from Biscayne Bay, Card Sound, and adjacent offshore habitats when the canal system was closed off in February 1973. Certain species, particularly forage fish in the killifish and livebearer families, have adapted relatively well in the canal system. Other fish, such as snappers, grunts and barracuda, are not able to reproduce within the canals and their numbers have been reduced through natural attrition. Many of these species are predators which may, at least in part, account for the continued abundance of the forage fish.

Study comparisons indicate that several species found in the bay and sound adjacent to the canal system did not enter when the canal system was open. All fish found within the canals are members of

species which were common or abundant outside the canal system in adjacent waters.



[a]Plankton station numbers in association with fish stations are indicated by ( ).

Figure 1. Fish sampling station locations, Turkey Point Cooling Canal System, 1981.

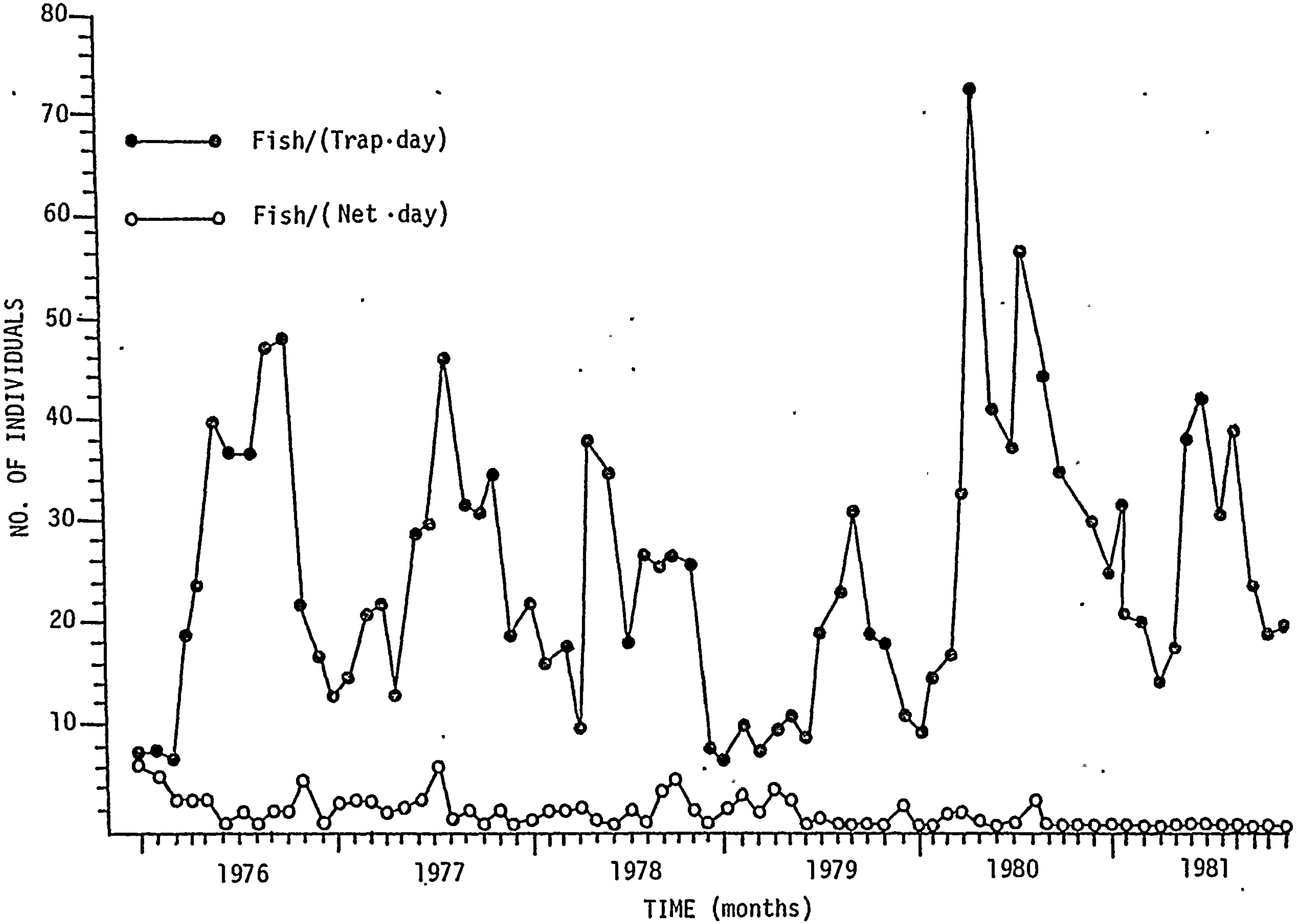


Figure 2. Minnow trap and gill net catch per unit effort in Turkey Point Cooling Canal System, 1976-1981.

Table 1. Fish collected within the Turkey Point Cooling Canal System, 1981.

COMMON NAME	SCIENTIFIC NAME	NUMBER OF INDIVIDUALS	RANGE OF LENGTHS (mm)	TOTAL WEIGHT (g)	% COMPOSITION BY (NO.)	% COMPOSITION BY (WT.)
Goldspotted Killifish	*Floridichthys carpio*[a]	3579	15-65	5333.2	55.5	14.9
Sheepshead Minnow	*Cyprinodon variegatus*[a]	2521	17-53	3348.2	39.1	9.4
Sailfin Molly	*Poecilia latipinna*[a]	153	22-70	298.7	2.4	0.8
Crested Goby	*Lophogobius cyprinoides*[a]	81	32-81	469.5	1.2	1.3
Yellowfin Mojarra	*Gerres cinereus*	34	146-250	7415.0	0.5	20.7
Gulf Toadfish	*Opsanus beta*[a]	26	71-198	623.9	0.4	1.7
Rainwater Killifish	*Lucania parva*[a]	16	21-35	9.6	0.3	≤.1
Gulf Killifish	*Fundulus grandis*[a]	13	47-97	115.9	0.2	0.3
Tidewater Silverside	*Menidia beryllina*	7	39-48	7.4	≤.1	≤.1
Bonefish	*Albula vulpes*	4	480-580	10400.0	≤.1	29.1
Pike Killifish	*Belonesox belizanus*	4	60-117	37.8	≤.1	≤.1
Gray Snapper	*Lutjanus griseus*	3	263-480	3418.6	≤.1	9.6
Silver Jenny	*Eucinostomus gula*	2	207-230	543.9	≤.1	1.5
Great Barracuda	*Sphyraena barracuda*	1	680	2381.4	≤.1	6.7
Atlantic Needlefish	*Strongylura marina*	1	232	22.4	≤.1	≤.1
Ladyfish	*Elops saurus*	1	530	1360.8	≤.1	3.8

[a]Species which are reproducing in the canal system.

Table 2. Fish collected within the Turkey Point Cooling Canal System, 1977-1981.

COMMON NAME[a]	SCIENTIFIC NAME	NUMBER OF INDIVIDUALS PER YEAR 1977[b]	1978[b]	1979[c]	1980[c]	1981
Goldspotted Killifish	*Floridichthys carpio*[d]	3392	3233	1984	3153	3579
Sheepshead Minnow	*Cyprinodon variegatus*[d]	2207	1212	1091	4672	2521
Sailfin Molly	*Poecilia latipinna*[d]	762	173	48	228	153
Crested Goby	*Lophogobius cyprinoides*[d]	53	73	154	204	81
Yellowfin Mojarra	*Gerres cinereus*	59	29	58	87	34
Gulf Toadfish	*Opsanus beta*[d]	8	6	13	23	26
Rainwater Killifish	*Lucania parva*[d]	7	13	10	6	16
Gulf Killifish	*Fundulus grandis*[d]	13	2	0	7	13
Tidewater Silverside	*Menidia beryllina*	8	1	3	0	7
Bonefish	*Albula vulpes*	11	8	6	3	4
Pike Killifish	*Belonesox belizanus*[d]	3	15	0	0	4
Gray Snapper	*Lutjanus griseus*	9	4	9	8	3
Silver Jenny	*Eucinostomus gula*	14	21	44	8	2
Great Barracuda	*Sphyraena barracuda*	4	6	8	7	1
Atlantic Needlefish	*Strongylura marina*	0	0	0	1	1
Ladyfish	*Elops saurus*	0	0	0	0	1
Mosquitofish	*Gambusia affinis*	0	0	0	2	0
Spotfin Mojarra	*Eucinostomus argenteus*	2	13	3	1	0
Drum	SCIAENIDAE	0	0	0	1	0
Marsh Killifish	*Fundulus confluentus*[d,e]	12	4	1	1	0
Striped Mojarra	*Eugerees plumieri*	2	1	3	0	0
Schoolmaster	*Lutjanus apodus*	10	4	2	0	0
Sharksucker	*Echeneis naucrates*	0	0	2	0	0
Bluestriped Grunt	*Haemulon sciurus*	4	2	1	0	0
Crevalle Jack	*Caranx hippos*[e]	1	1	1	0	0
Sailors Choice	*Haemulon parrai*	1	0	1	0	0
Atlantic Spadefish	*Chaetodipterus faber*[e]	0	0	1	0	0
Snook	*Centropomus undecimalis*	1	4	0	0	0

Table 2. Fish collected within the Turkey Point Cooling Canal System, 1977-1981. (Cont'd)

COMMON NAME[a]	SCIENTIFIC NAME	NUMBER OF INDIVIDUALS PER YEAR				
		1977[b]	1978[b]	1979[c]	1980[c]	1981
Sea Catfish	Arius felis	1	4	0	0	0
Redfin Needlefish	Strongylura notata[d,e]	2	2	0	0	0
Pinfish	Lagodon rhomboides	0	1	0	0	0
Hardhead Silverside	Atherinomorus stipes	4	1	0	0	0
Striped Mullet	Mugil cephalus[e]	20	0	0	0	0
Lined Seahorse	Hippocampus erectus	0	0	0	0	0
Permit	Trachinotus falcatus	0	0	0	0	0
Sheepshead	Archosargus probatocephalus	1	0	0	0	0
Fat Sleeper	Dormitator maculatus	1	0	0	0	0
Total fishes		6612	4829	3443	8412	6443

[a]Ranked from most abundant to least abundant, based on 1981 collections.
[b]F.P.L., 1973-1978
[c]F.P.L., 1979-1981
[d]Species which are reproducing in the canal system.
[e]Observed, but not collected during 1981.

Table 3. Species of fish collected in the Turkey Point Cooling Canal System, tidal creeks, and near shore areas around the Turkey Point Power Plant.

COMMON NAME	SCIENTIFIC NAME	NUGENT AUG. 1968 THRU JAN. 1970	A.B.I.[a] DEC. 1974 THRU DEC. 1978	FPL/LU[b] JAN. 1979 THRU DEC. 1981
Atlantic Needlefish	Strongylura marina	X	X	X
Atlantic Spadefish	Chaetodipterus faber	X	X	X
Bandtail Puffer	Sphoeroides spengleri	X	---	---
Banner Goby	Microgobius microlepis	---	X	X
Barbfish	Scorpaena brasiliensis	X	---	---
Black Drum	Pogonias cromis	X	---	---
Bonefish	Albula vulpes	---	X	X
Blue Runner	Caranx crysos	X	X	X
Blue Striped Grunt	Haemulon sciurus	X	X	X
Bull Shark	Carcharhinus leucas	X	---	---
Checkered Puffer	Sphoeroides testudineus	X	X	X
Crested Goby	Lophogobius cyprinoides	X	X	X
Crevalle Jack	Caranx hippos	X	X	X
Fantail Mullet	Mugil trichodon	X	---	---
Fat Sleeper	Dormitator maculatus	---	X	---
Fat Snook	Centropomus parallelus	X	---	---
Goby	Gobionellus sp.	---	X	X
Goldspotted Killifish	Floridichthys carpio	---	X	X
Gray (Mangrove) Snapper	Lutjanus griseus	X	X	X
Gray Triggerfish	Balistes capriscus	X	---	---
Great Barracuda	Sphyraena barracuda	X	X	X
Gulf Flounder	Paralichthys albigutta	X	---	---
Gulf Killifish	Fundulus grandis	---	X	X
Gulf Kingfish	Menticirrhus lottoralis	---	X	X
Gulf Toadfish	Opsanus beta	X	X	X
Hardhead Silverside	Atherinomorus stipes	---	X	X

Table 3. (Cont'd) Species of fish collected in the Turkey Point Cooling Canal System, tidal creeks, and near shore areas around the Turkey Point Power Plant.

COMMON NAME	SCIENTIFIC NAME	NUGENT AUG. 1968 THRU JAN. 1970	A.B.I.[a] DEC. 1974 THRU DEC. 1978	FPL/LU[b] JAN. 1979 THRU DEC. 1981
Jewfish	Epinephelus itajara	X	---	---
Ladyfish	Elops saurus	X	X	X
Lane Snapper	Lutjanus synagris	X	---	---
Lemon Shark	Negaprion brevirostris	X	---	---
Lined Seahorse	Hippocampus erectus	---	X	X
Lookdown	Selene vomer	X	X	X
Margate	Haemulon album	X	---	---
Marsh Killifish	Fundulus confluentus	---	X	X
Mosquitofish	Gambusia affinis	X	---	X
Mummichog	Fundulus heteroclitus	X	---	---
Nurse Shark	Ginglymostoma cirratum	X	---	---
Permit	Trachinotus falcatus	X	X	X
Pike Killifish	Belonesox belizanus	---	X	X
Pinfish	Lagodon rhomboides	X	X	X
Pipefish	Syngnathus sp.	---	X	X
Rainwater Killifish	Lucania parva	---	X	X
Redfin Needlefish	Strongylura notata	---	X	X
Remora	Remora remora	X	---	X
Sailfin Molly	Poecilia latipinna	X	X	X
Sailors Choice	Haemulon parrai	X	X	X
Sargassum Fish	Histrio histrio	X	---	---
Scrawled Cowfish	Lactophrys quadricornis	X	---	---
Schoolmaster	Lutjanus apodus	X	X	X
Sea Catfish	Arius felis	X	X	X
Sharksucker	Echenesis naucrates	---	X	X
Sheepshead	Archosargus probatocephalus	X	X	X

Table 3. (Cont'd) Species of fish collected in the Turkey Point Cooling Canal System, tidal creeks, and near shore areas around the Turkey Point Power Plant.

COMMON NAME	SCIENTIFIC NAME	NUGENT AUG. 1968 THRU JAN. 1970	A.B.I.[a] DEC. 1974 THRU DEC. 1978	FPL/LU[b] JAN. 1979 THRU DEC. 1981
Sheepshead Minnow	Cyprinodon variegatus	X	X	X
Shortnose Gar	Lepisosteus platyrhineus	X	---	---
Silver Jenny	Eucinostomus gula	X	X	X
Snook	Centropomus undecimalis	X	X	X
Southern Stingray	Dasyatis americana	X	---	---
Spot	Leiostomus xanthurus	X	---	---
Spotfin Mojarra	Eucinostomus argenteus	X	X	X
Spotted Seatrout	Cynoscion nebulosus	X	---	---
Striped Mojarra	Eugerees plumieri	X	X	X
Striped Mullet	Mugil cephalus	X	X	X
Tarpon	Megalops atlantica	X	---	X
Tarpon Snook	Centropomus pectinatus	X	---	---
Tidewater Silverside	Menidia beryllina	---	X	X
Tripletail	Lobotes surinamensis	X	---	---
White Mullet	Mugil curema	X	---	---
Yellowfin Mojarra	Gerres cinereus	X	X	X

[a]FPL, 1974-1978
[b]FPL, 1979-1981

3. Benthos (ETS 4.1.1.1.3)

a. Characteristics of the Sediments

Introduction

This study of the characteristics of the sediments is designed to determine the pH, salinity and temperature and to monitor selected nutrients in the interstitial (pore) water and sediments of the Turkey Point Cooling Canal System. To assess potential biological changes resulting from operation of the Turkey Point Plant, results of sediment analysis from samples collected in the cooling canal system are compared with data from samples collected at three control areas outside of the canals.

From September 1970 through May 1971, preoperational chemical data were collected in Biscayne Bay and Card Sound (RSMAS, 1971, 1972). These studies differed from the existing operational monitoring program in many aspects (Table 1). Nevertheless, operational monitoring data can be compared with relevant preoperational data to evaluate the long term impact of the Turkey Point Plant on the water and sediments in and adjacent to the cooling canal system.

The Turkey Point Canal System is potentially oxygen poor because the heated water from the power plant discharge is not mixed with adjacent Biscayne Bay waters. Additionally, the canal system is located in the subtropics that are characterized by the high production of organic material. Evidence of anoxic conditions, if present, would be observed first in the interstitial water of the sediment-water interface.

Various chemicals used in Turkey Point Plant operations (Section II.B - Table 1 and 2) are considered in evaluating the results of the chemistry program (Tables 2 through 12).

Materials and Methods

Samples containing a combination of water and sediment were collected monthly at eight canal stations and three bay stations (Figure 1). Sediment and interstitial water samples were collected in cylindrical polypropylene cores approximately 5 cm in diameter and 45 cm in length. All samples were placed in an ice chest and kept at 4°C until analyzed. Samples were then homogenized, filtered and analyzed for the following soluble nutrients: sulfate, nitrate, nitrite, ammonium and orthophosphate. Standard analytical methods (Table 13) were used to perform all chemical analyses. Sediment from the core samples collected at canal and bay stations also was analyzed for insoluble sulfide content. A portion of each of these samples was acidified to convert insoluble sulfide to hydrogen sulfide, which was then distilled into a trapping solution of zinc acetate and analyzed spectrophotometrically.

Water samples to be analyzed for the presence of sulfite and sulfide were collected in 250-ml screwcap polyethylene bottles containing 0.5 ml of zinc acetate (2N). Because these ions are susceptible to oxidation, the bottles were filled to overflowing to avoid excessive exposure to oxygen that would be contained in an airspace. To prevent the deleterious effects of oxygenation, these samples were kept at 4°C and analyzed without filtration.

The pH of sediment samples was measured with a standard Corning Model 10 pH meter. Salinity was measured with a Yellow Springs Instrument (YSI) Model 33 salinity-conductivity-temperature (S-C-T) meter. Temperature was measured in the field using a YSI Model 42 single channel temperature meter.

Results and Discussion

pH

The pH of marine and estuarine waters is a measure of the acid-base equilibrium of dissolved components. pH is important in aquatic chemical and biological systems because 1) changes in pH affect dissociation of weak acids and bases, 2) the degree of dissociation affects the toxicity of many compounds, 3) pH affects the solubility of metals from suspended solids and bottom sediments, and 4) changes in pH directly influence physiological changes in marine organisms.

The pH values of the cooling canal system sediments ranged from 7.2 to 8.6. Measurements for Biscayne Bay stations ranged from 7.7 to 9.4 (Tables 2 and 14). These values are close to the narrow range of 6.8 to 8.2 found for most marine porewaters (Goldberg, 1974). Comparison of the past year's average values (Table 15) shows very small variations among canal stations (7.6 to 8.1) and Biscayne Bay stations (8.4 to 8.5). The pH range of the canal stations was apparently not affected by the additions of various chemicals to the circulating cooling water system.

Salinity

Salinity is a measure of the salt content of water. Marine organisms vary in their ability to tolerate salinity changes. In deep water and open sea where salinity ranges from only 34 to 36 ppt, animals are sensitive to relatively small salinity changes. In the coastal regions and estuaries where wide salinity variations may occur, organisms adapted to these habitats are more tolerant of salinity changes.

During 1981, the salinity of the sediments ranged from 1.5 to 40.0 ppt at Biscayne Bay stations and from 18.0 to 46.0 ppt in the Turkey Point canal system (Tables 3 and 14). The value of 1.5 ppt measured in Biscayne Bay during October 1981 was unusually low; values of 8.0 and 9.0 also were recorded at other Biscayne Bay stations during October. High rainfall at this time may account for the temporary decrease in salinity. In 1980, these ranges were from 8.2 to 35.8 ppt for Biscayne Bay stations and from 21.0 to 39.0 ppt for the Turkey Point canal system (FPL, 1981). The average yearly sediment salinity at the adjacent Biscayne Bay sampling stations was 29.6 ppt in 1977, 22.2 ppt in 1978, 22.5 ppt in 1979, 23.9 ppt in 1980, and 23.4 ppt in 1981. The average yearly sediment salinity in the canal system was 38.4 ppt in 1977, 30.4 ppt in 1978, 29.3 ppt in 1979, 31.3 ppt in 1980, and 30.5 ppt in 1981.

There was no increase in sediment salinity from 1980 to 1981 in the canal system, although values were higher in the canals than at control stations in Biscayne Bay. Seasonal variations in salinity were also noted with high values generally occurring in May and low salinity values

occurring in October or November (Table 3). Because the heaviest rainfall of 1981 occurred in August and September, it is likely that the low salinity in October and November resulted from rainfall in the Turkey Point area.

Temperature

Temperature is important to biological systems because high temperatures decrease dissolved oxygen levels, increase the rates of chemical reactions, and give false temperature cues to aquatic life. If temperatures are high enough, lethal temperature limits may be exceeded. These factors affect not only the fish, benthic organisms and aquatic plants but also the bacterial populations living in the sediment.

Temperatures in the Turkey Point Canal System reflected the thermal discharge from the power plant and solar heating of the canals. Temperatures ranged from 11.1 to 29.6°C at control stations in Biscayne Bay and from 12.4 to 42.5°C in the cooling canals (Tables 4 and 14). In 1980, temperatures ranged from 10.2 to 30.3°C at the Biscayne Bay stations and 13.0 to 43.0°C in the canal system (FPL, 1981). Biscayne Bay stations had lower yearly average temperatures than canal stations (Table 16). The highest average temperature (33.8°C) was recorded at canal Station 8, lower temperatures were found at Stations 5, 6, and 7 (27.9 to 28.4°C), and the lowest readings were at Stations 1, 2, 3 and 4 (24.6 to 26.4°C). This gradient followed the path of the water in the canal system. Warm water discharged from the plant enters the canal system close to Station 8, moves through the canal system in a circular fashion,

and re-enters the plant at Station 1. Temperatures observed at Station 8 were in a range that could exclude some biota occurring in the other parts of the Turkey Point canal system (Roessler and Tabb, 1974).

Sulfur

Sulfur occurs in a number of forms in marine water but only sulfate and sulfide are of major importance. Both forms are present in the waters of anoxic sediments, with sulfate usually the most abundant. Bacteria can reduce sulfate to sulfide. This reduction can take place in the water column if oxygen is not available, but more frequently, sulfate reduction occurs in the underlying sediment. Dissolved sulfides are to a large extent precipitated to form sulfide minerals. Sulfite can also be present in the marine environment where the redox process (sulfate-sulfide conversion) is active. Because the Turkey Point canal network is a closed system, it is a potentially anoxic environment in which sulfide could build up within the sediment through depletion of available sulfate.

During 1981, the sulfate concentration ranged from 1569 to 4841 ppm in the cooling canals and from 887 to 3519 ppm at Biscayne Bay stations (Table 15). In 1980, these values ranged from 2115 to 3611 ppm in the cooling canals and from 959 to 3215 ppm at Biscayne Bay stations (Table 15). The average yearly sulfate concentration in the canal waters was about 36 percent higher than in Biscayne Bay samples (2212 ppm; Table 16). The average yearly sulfate concentration in the canal waters decreased from 3095 ppm in 1980 to 3018 ppm in 1981. In Biscayne Bay it

decreased from 2311 ppm in 1980 to 2212 ppm in 1981. There was no difference in the average yearly sulfate concentrations at the canal stations.

Soluble sulfite values in 1981 ranged from <2.0 to 23.0 ppm in the cooling canals and from <2.0 to 15.0 ppm at Biscayne Bay stations (Table 6). In 1980, sulfite levels were generally below the 0.02 ppm detection limit. Values of 3.0 to 23.0 ppm were observed during the winter and spring of 1981, but after June, nearly all sulfite values were at or below detectable limits of the method employed.

During 1981, levels of soluble sulfide (Table 7) were generally below the detectable limit of 0.05 ppm for the analytical method used. Similarly low levels were observed in 1980.

Insoluble sulfide values in the cooling canals ranged from <0.05 to 14.31 μg/g wet weight of soil and in Biscayne Bay from 0.10 to 3.38 μg/g wet weight of soil (Table 8). The yearly average value of insoluble sulfide at canal stations was 1.49 μg/g in 1981 as compared to 1.56 μg/g wet weight of soil in 1980. At Biscayne Bay stations, the yearly average value was 0.94 μg/g in 1981 as compared to 0.79 μg/g wet weight of soil in 1980. These findings indicate that sediments in the Turkey Point Canal System are not anoxic.

Nitrogen

Nitrogen occurs in a number of different forms in marine waters. The principal ones are NO_3 (nitrate), NO_2 (nitrite), N_2 (dissolved nitro-

gen gas) and NH_4^+ (ammonium). Under the conditions existing in the porewaters of anoxic marine sediments, the principal species are N_2 and NH_4^+ (Thorstenson, 1970). A lack of nitrate and nitrite is caused by rapid bacterial reduction to N_2 and NH_4^+. Nitrate, nitrite and ammonium were analyzed in the interstitial water of Turkey Point Cooling Canal samples.

During 1981, nitrate concentrations ranged from 0.014 to 0.914 ppm in the cooling canals and from <0.001 to 0.367 ppm at Biscayne Bay control stations (Tables 9 and 14). In 1980, these ranges were very similar: 0.003 to 0.746 ppm in the cooling canals and 0.004 to 0.404 ppm for the Biscayne Bay stations (Table 15). The 1981 yearly average values were very close for all cooling canal stations but higher than for Biscayne Bay stations (Table 16). Comparison with Biscayne Bay stations and 1980 values indicates that during 1981 there was no depletion of nitrate that might indicate anoxic conditions in the cooling canals.

During 1981, nitrite concentrations ranged from 0.002 to 0.046 ppm in the cooling canals and from 0.002 to 0.033 ppm for the Biscayne Bay stations (Tables 10 and 14). In 1980, these ranges were similar, <0.001 to 0.084 in the cooling canals and <0.001 to 0.070 ppm for the Biscayne Bay stations. The yearly average value for canal stations was 0.010 ppm and 0.008 ppm for Biscayne Bay stations. This constancy in nitrite concentrations indicates that during 1981 there was no depletion of nitrite in the cooling canals due to anoxic conditions.

Ammonium values found in the Turkey Point Canal System during 1981 ranged from <0.01 to 6.66 ppm (Tables 11 and 14). These values were lower than the control stations' values, which ranged from 0.28 to 10.00 ppm. Ammonium values were especially high at the Biscayne Bay stations in March. In 1980, the range of ammonium values at the cooling canals (0.10 to 6.02 ppm) were higher than the range of values at the Biscayne Bay stations (0.08 to 1.74 ppm). The 1981 yearly average value was 1.18 ppm for the canal stations and 2.25 ppm for Biscayne Bay stations (Table 16). Yearly average values were 0.74 ppm ammonium at the canal stations and 0.53 ppm at the Biscayne Bay stations in 1980. This increase in ammonium concentrations is one parameter indicating that conditions may be becoming anoxic at the sediment/water interface both in the cooling canals and at the Biscayne Bay sampling stations.

Phosphorus

The most stable and dominant form of dissolved phosphorus in marine sediments is orthophosphate (Kester and Pytkowicz, 1967). Dissolved orthophosphate levels in oxygen-containing sediments are similar to values for the overlying water. By contrast, phosphate levels increase in anoxic sediments (Brooks et al., 1968) with ammonium and, to a lesser extent, sulfide.

During 1981, orthophosphate values in interstitial waters ranged from <0.01 to 0.55 ppm in the cooling canals (Tables 12 and 15) and from <0.01 to 0.10 ppm at the control stations in Biscayne Bay. In 1980, orthophosphate values ranged from <0.01 to 0.15 ppm in the cooling canals

and from <0.01 to 0.08 ppm for the Biscayne Bay stations. Yearly average values in 1981 were 0.02 ppm in the cooling canals and 0.01 ppm at the Biscayne Bay stations (Table 16). From 1980 to 1981, there was no increase in orthophosphate concentrations in the interstitial waters of the cooling canals. This trend indicates that the sediments were not anoxic.

Comparison With Preoperational Data

Parameters monitored, analytical methods and sampling locations differed between the preoperational studies (RSMAS, 1971, 1972) and the operational study (Table 1). However, the values for the same parameters were in similar ranges. The pH range of 7.0 to 7.8 found in Card Sound sediments in 1970-71 is slightly lower than the pH ranges found during 1981 (Table 15). The salinity of Biscayne Bay/Card Sound water during the 1970-71 sampling was slightly higher (27.3 to 44.4 ppt) than that of sediments in Biscayne Bay control stations in 1981 (1.5 to 40.0 ppt). This difference probably was caused by the rainfall pattern during this time. The range of nitrate values (<0.001 to 0.023 ppm) found during the preoperational study was lower than that found in 1981 (<0.001 to 0.367). Differences in preservation and analysis methods used in these studies could account for this discrepancy. Nitrite and orthophosphate values were in the same range during the 1970-71 and 1981 monitoring.

Conclusion

In the cooling canals, salinity, temperature, sulfate and nitrate values of sediment samples are higher than in Biscayne Bay. Temperatures of the cooling canal sediments are influenced by plant operations as shown by the decrease in temperature at stations farther from the plant discharge. Salinity and sulfate values are influenced by outside factors such as water evaporation and rainfall.

Anoxic conditions result when ammonium, sulfide and phosphate concentrations increase. For the cooling canals, ammonium values in 1981 are 45 percent higher than in 1980, in Biscayne Bay ammonium values increased 325 percent since last year. These results suggest that environmental conditions such as drought may have had a greater impact on sediments in Biscayne Bay than in the cooling canals. Sulfide and orthophosphate values are similar to those of previous years at control and canal stations. The slightly higher nitrate values in the cooling canals show that there is no depletion of nitrate due to anoxic conditions. All other parameters are in the same range as values from control stations.

Comparisons of 1981 data with those of the preoperational study indicate that no detectable impact on physical or chemical parameters has resulted from plant operation.

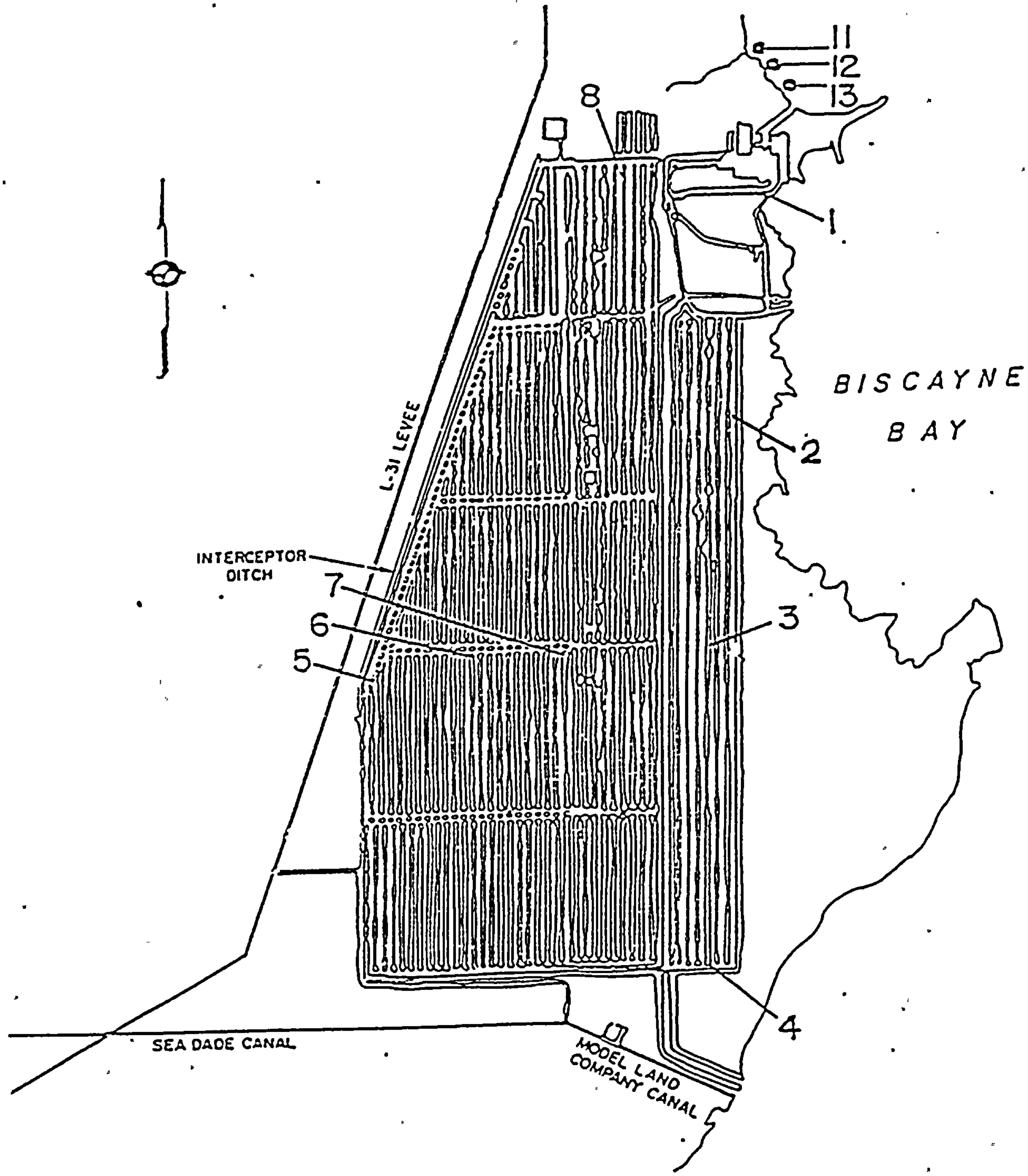


Figure 1. Chemistry sampling locations, Turkey Point Plant, 1981.

Table 1. Parameters measured during the preoperational studies and 1981 operational study at the Turkey Point Plant Site.

PARAMETER	PREOPERATIONAL STUDIES[a] 1970-1971		OPERATIONAL STUDY 1981		
	Water	Sediment	Interstitial water	Water	Sediment
Alkalinity	X				
Ammonium			X		
Dissolved inorganic carbon	X				
Dissolved organic carbon	X	X			
Dissolved oxygen	X				
Nitrate	X		X		
Nitrite	X		X		
pH		X			X
Orthophosphate	X		X		
Radioactivity	X	X			
Salinity	X			X	
Silica	X				
Sulfate			X		
Sulfide				X	X
Sulfite				X	
Temperature	X	X			
Trace metals	X	X			

[a] RSMAS, 1971, 1972.

Table 2. pH of sediments at stations in the Turkey Point Canals and Biscayne Bay during 1981.

MONTHS	STATION LOCATION AND NUMBER										
	Turkey Point Canal System								Biscayne Bay		
	1	2	3	4	5	6	7	8	11	12	13
Jan.	7.7	7.4	7.6	7.8	7.8	7.9	7.7	7.8	8.2	7.7	7.7
Feb.	8.2	7.5	8.1	8.1	8.1	8.1	7.8	8.0	8.8	8.2	8.8
Mar.	7.9	7.2	7.8	7.6	7.8	7.7	7.8	7.8	8.1	8.1	8.1
Apr.	8.5	7.8	8.1	8.5	8.1	8.0	8.3	8.3	8.7	8.4	8.8
May	7.8	7.2	7.9	7.7	8.0	8.0	7.9	8.1	8.8	8.2	8.5
Jun.	7.5	7.7	7.7	7.8	8.0	7.9	7.7	7.9	8.2	8.0	8.3
Jul.	8.5	8.3	7.9	7.8	8.2	8.4	8.1	8.2	8.6	8.6	8.7
Aug.	8.0	7.6	8.3	8.3	8.3	8.6	8.3	8.4	9.4	9.2	9.0
Sep.	7.5	7.9	7.8	7.8	8.1	8.2	8.0	7.9	8.4	8.2	8.8
Oct.	7.9	7.6	7.9	7.6	7.9	8.0	8.1	8.0	8.6	8.8	7.8
Nov.	8.3	7.5	7.9	7.9	8.1	8.2	7.8	8.0	8.4	8.3	8.3
Dec.	7.7	7.6	8.0	8.0	8.0	8.3	8.2	7.9	8.1	8.5	8.3

Table 3. Salinity (ppt) of sediments at stations in the Turkey Point Canals and Biscayne Bay during 1981.

MONTHS	STATION LOCATION AND NUMBER										
	Turkey Point Canal System								Biscayne Bay		
	1	2	3	4	5	6	7	8	11	12	13
Jan.	31.5	31.0	31.0	31.0	30.5	31.0	31.0	31.0	21.0	21.5	21.0
Feb.	28.8	27.5	27.5	27.5	27.0	28.5	28.0	28.5	16.8	16.3	17.5
Mar.	30.1	30.2	28.7	29.5	27.0	30.4	30.8	28.2	20.8	20.5	21.1
Apr.	27.5	24.8	26.5	26.5	24.8	25.4	26.3	26.2	22.2	22.2	21.4
May	44.0[a]	44.0	46.0	44.0	38.0	44.0	44.0	44.0	40.0	38.0	38.0
Jun.	33.0	33.0	34.0	33.0	32.0	35.0	35.0	33.0	26.0	27.0	28.0
Jul.	37.0	40.0	44.0	44.0	42.0	44.0	46.0	44.0	40.0	37.0	37.0
Aug.	38.0	37.0	38.0	34.0	39.0	39.0	39.0	38.0	35.0	32.0	37.0
Sep.	32.0	30.0	30.0	32.0	32.0	32.0	32.0	32.0	22.0	20.0	20.0
Oct.	19.0	23.0	22.0	19.0	19.0	22.0	23.0	18.0	1.5	9.0	8.0
Nov.	22.0	21.0	21.0	20.0	21.0	21.0	20.0	22.0	17.0	19.0	18.0
Dec.	21.0	22.0	23.0	22.0	21.0	20.0	22.0	20.0	16.0	16.0	17.0

[a]Salinity readings to whole numbers after April 1981.

Table 4. Temperature (°C) of sediment surface at stations in the Turkey Point Canals and Biscayne Bay during 1981.

MONTHS	STATION LOCATION AND NUMBER										
	Turkey Point Canal System								Biscayne Bay		
	1	2	3	4	5	6	7	8	11	12	13
Jan.	20.2	19.8	12.4	12.8	21.6	19.2	19.9	28.2	11.2	11.3	11.1
Feb.	25.0	24.5	23.2	24.8	27.9	27.1	26.7	32.2	22.0	21.9	21.9
Mar.	23.1	25.0	22.0	22.8	27.5	26.2	26.9	31.0	21.3	21.0	20.8
Apr.	25.9	25.9	25.2	25.0	28.1	28.0	28.7	33.6	23.7	24.1	24.2
May	26.0	27.0	24.8	26.0	27.8	28.2	29.9	34.2	25.8	26.0	27.0
Jun.	30.4	30.0	28.9	29.0	30.8	31.8	31.8	38.4	27.0	27.2	28.3
Jul.	33.0	32.7	31.5	33.7	34.2	34.6	34.8	42.5	29.0	29.1	29.6
Aug.	30.2	30.0	28.7	29.9	32.3	32.5	32.3	37.9	27.3	27.3	27.3
Sep.	32.5	32.2	31.2	31.9	35.0	33.2	33.9	40.0	29.0	29.0	29.2
Oct.	28.2	29.1	28.2	29.0	31.4	30.2	30.5	36.8	25.8	26.2	26.4
Nov.	22.2	22.0	22.0	22.2	24.1	23.1	23.2	27.2	21.0	21.0	21.0
Dec.	18.1	19.0	17.3	19.2	20.0	20.2	21.2	23.5	16.8	16.3	16.5

Table 5. Analysis of soluble sulfate (ppm) at stations in the Turkey Point Canals and Biscayne Bay during 1981.

MONTHS	STATION LOCATION AND NUMBER										
	Turkey Point Canal System								Biscayne Bay		
	1	2	3	4	5	6	7	8	11	12	13
Jan.	4841	4749	3972	4051	3735	3833	3975	4270	2259	2930	2673
Feb.	3190	3237	2962	3277	3056	3157	3354	3197	1900	1868	1801
Mar.	3366	3070	3211	3022	2573	3173	3060	3137	2176	1889	1264
Apr.	3298	2945	2923	3169	2978	2959	3257	3281	2762	2505	2604
May	3384	3337	3324	3203	2666	3134	3095	3342	2628	2724	2757
Jun.	3203	3366	3117	3141	3080	3146	2843	3285	2989	2786	2717
Jul.	4065	3873	3984	4095	4021	4076	4021	4384	2977	3519	3473
Aug.	3347	3073	3015	3121	3260	3389	3126	3260	2811	2720	3047
Sep.	2832	2850	2501	2422	2438	2893	2689	2955	1750	1678	1589
Oct.	2405	2379	2601	2145	1569	2231	2282	2533	1194	1109	887
Nov.	2029	2160	2144	2191	2128	2318	2214	2201	1559	1635	1710
Dec.	2076	2165	2368	2140	1654	2246	2055	2018	1598	1578	1569

Table 6. Analysis results of soluble sulfite (ppm) at stations in the Turkey Point Canals and Biscayne Bay during 1981.

MONTHS	STATION LOCATION AND NUMBER										
	Turkey Point Canal System								Biscayne Bay		
	1	2	3	4	5	6	7	8	11	12	13
Jan.	17.0	15.0	14.0	11.0	16.0	14.0	23.0	13.0	10.0	11.0	15.0
Feb.	8.0	7.0	8.0	8.0	10.0	11.0	8.0	9.0	9.0	9.0	9.0
Mar.	8.0	14.0	12.0	9.0	9.0	10.0	11.0	9.0	8.0	11.0	9.0
Apr.	7.0	8.0	7.0	8.0	9.0	8.0	8.0	8.0	7.0	8.0	7.0
May	8.0	12.0	7.0	3.0	4.0	5.0	5.0	4.0	4.0	3.0	3.0
Jun.	2.0	2.0	3.0	3.0	2.0	2.0	<2.0	3.0	2.0	2.0	2.0
Jul.	<2.0[a]	<2.0	10.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Aug.	<2.0	<2.0	3.0	<2.0	2.0	3.0	<2.0	2.0	2.0	2.0	2.0
Sep.	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Oct.	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.0	<2.0	2.0
Nov.	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Dec.	<2.0	<2.0	<2.0	2.0	2.0	<2.0	<2.0	2.0	<2.0	<2.0	<2.0

[a]Previous reports cited <0.1 ppm as the detection limit for soluble sulfite but that limit can be obtained only when other elements do not obscure the reading. A detection limit of <2.0 ppm is cited in APHA (1980).

Table 7. Analysis results of soluble sulfide (ppm) at stations in the Turkey Point Canals and Biscayne Bay during 1981.

MONTHS	STATION LOCATION AND NUMBER										
	Turkey Point Canal System								Biscayne Bay		
	1	2	3	4	5	6	7	8	11	12	13
Jan.	<0.05[a]	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Feb.	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mar.	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Apr.	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
May	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Jun.	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Jul.	<0.05	<0.05	0.26	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Aug.	<0.05	<0.05	0.97	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Sep.	<0.05	<0.05	0.08	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Oct.	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.06
Nov.	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Dec.	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

[a]Detection limit is 0.05 ppm.

Table 8. Analysis results of insoluble sulfide (µg/g wet weight sediment) at stations in the Turkey Point Canals and Biscayne Bay during 1981.

MONTHS	STATION LOCATION AND NUMBER										
	Turkey Point Canal System								Biscayne Bay		
	1	2	3	4	5	6	7	8	11	12	13
Jan.	5.92	<0.05[a]	2.32	0.40	<0.05	0.39	0.33	<0.05	1.49	1.01	0.51
Feb.	3.84	0.10	0.21	5.51	0.06	0.20	1.12	3.58	1.54	0.37	0.14
Mar.	5.44	0.07	0.13	0.22	0.09	0.05	0.08	0.05	1.96	0.16	0.54
Apr.	1.40	2.20	0.43	0.25	1.59	0.56	1.56	0.13	1.78	3.32	0.52
May	0.10	0.05	0.36	0.37	0.22	0.10	4.33	0.14	0.20	3.38	1.01
Jun.	0.57	<0.05	3.07	7.32	1.39	0.17	0.11	0.06	1.84	0.95	0.17
Jul.	0.08	1.56	4.24	0.31	3.97	4.60	0.11	0.82	0.10	1.55	0.34
Aug.	4.36	0.39	1.64	0.02	0.52	1.30	0.87	0.77	0.24	0.22	0.13
Sep.	14.31	0.13	8.32	<0.05	2.73	5.84	5.65	2.03	1.91	1.05	0.86
Oct.	3.79	0.36	0.16	0.10	<0.05	0.15	<0.05	0.49	1.02	0.21	0.27
Nov.	12.71	0.52	0.20	0.39	<0.05	0.11	0.06	<0.05	0.72	1.38	0.40
Dec.	0.62	0.22	0.09	0.06	0.41	0.47	0.10	0.92	0.20	1.25	1.04

[a]Detection limit is 0.05.

Table 9. Analysis results of soluble nitrate (ppm) at stations in the Turkey Point Canals and Biscayne Bay during 1981.

MONTHS	STATION LOCATION AND NUMBER										
	Turkey Point Canal System								Biscayne Bay		
	1	2	3	4	5	6	7	8	11	12	13
Jan.	0.057	0.206	0.104	0.067	0.104	0.198	0.117	0.174	0.045	0.044	0.038
Feb.	0.052	0.042	0.035	0.057	0.062	0.070	0.052	0.077	0.033	0.060	<0.001[a]
Mar.	0.044	0.018	0.109	0.017	0.017	0.017	0.019	0.020	0.013	<0.001	<0.001
Apr.	0.082	0.049	0.059	0.042	0.026	0.025	0.037	0.036	0.086	0.043	<0.001
May	0.118	0.102	0.082	0.080	0.110	0.103	0.108	0.081	0.114	0.102	0.167
Jun.	0.210	0.009	0.026	0.014	0.032	0.021	0.026	0.047	0.053	0.019	0.049
Jul.	0.091	0.054	0.035	0.041	0.087	0.057	0.046	0.037	0.102	0.051	0.054
Aug.	0.086	0.066	0.140	0.104	0.070	0.064	0.073	0.127	0.056	0.122	0.052
Sep.	0.062	0.232	0.083	0.196	0.102	0.234	0.145	0.119	0.023	0.079	0.367
Oct.	0.062	0.132	0.914	0.333	0.058	0.111	0.137	0.201	0.026	0.052	0.095
Nov.	0.031	0.082	0.099	0.082	0.046	0.078	0.045	0.086	0.107	0.167	0.098
Dec.	0.316	0.393	0.329	0.227	0.294	0.268	0.267	0.285	0.264	0.179	0.217

[a]Detection limit is 0.001.

Table 10. Analysis results of soluble nitrite (ppm) at stations in the Turkey Point Canals and Biscayne Bay during 1981.

MONTHS	STATION LOCATION AND NUMBER										
	Turkey Point Canal System								Biscayne Bay		
	1	2	3	4	5	6	7	8	11	12	13
Jan.	0.005	0.021	0.006	0.007	0.007	0.010	0.005	0.010	0.005	0.003	0.003
Feb.	0.006	0.006	0.004	0.009	0.008	0.008	0.006	0.008	0.004	0.004	0.033
Mar.	0.006	0.006	0.023	0.007	0.005	0.007	0.007	0.005	0.007	0.019	0.016
Apr.	0.003	0.004	0.006	0.005	0.004	0.005	0.005	0.005	0.004	0.005	0.005
May	0.010	0.012	0.011	0.013	0.010	0.011	0.011	0.012	0.011	0.010	0.012
Jun.	0.003	0.003	0.002	0.003	0.005	0.002	0.002	0.005	0.003	0.002	0.002
Jul.	0.005	0.005	0.004	0.006	0.005	0.006	0.005	0.006	0.006	0.004	0.005
Aug.	0.004	0.007	0.005	0.007	0.005	0.004	0.005	0.006	0.003	0.003	0.004
Sep.	0.027	0.028	0.011	0.011	0.018	0.021	0.015	0.017	0.010	0.004	0.019
Oct.	0.011	0.017	0.017	0.046	0.012	0.015	0.024	0.032	0.004	0.006	0.003
Nov.	0.008	0.015	0.021	0.015	0.010	0.013	0.029	0.011	0.007	0.023	0.014
Dec.	0.009	0.011	0.014	0.005	0.012	0.009	0.008	0.015	0.011	0.004	0.006

Table 11. Analysis results of soluble ammonium (ppm) at stations in the Turkey Point Canals and Biscayne Bay during 1981.

MONTHS	STATION LOCATION AND NUMBER										
	Turkey Point Canal System								Biscayne Bay		
	1	2	3	4	5	6	7	8	11	12	13
Jan.	0.98	0.19	2.03	0.62	0.27	0.15	1.95	0.21	2.02	0.80	1.03
Feb.	0.61	0.58	0.81	0.47	0.38	1.11	1.13	1.25	1.56	2.16	2.58
Mar.	1.06	1.04	0.93	0.82	0.56	0.32	5.39	0.46	4.69	10.00	9.38
Apr.	1.04	0.65	4.63	0.61	0.39	0.49	0.35	0.32	1.06	4.04	0.92
May	0.96	0.26	0.06	0.14	0.07	<0.01[a]	0.33	0.08	1.97	0.56	0.28
Jun.	1.11	1.11	1.46	1.01	0.90	1.39	2.67	0.05	1.48	1.63	0.33
Jul.	0.59	0.48	1.08	0.34	0.42	0.10	0.63	0.38	0.91	0.42	0.35
Aug.	1.28	1.38	6.66	0.43	0.62	0.40	1.62	0.53	1.16	1.22	0.81
Sep.	3.04	1.48	3.04	5.90	1.79	0.96	1.04	1.15	0.92	1.73	2.50
Oct.	2.71	2.32	2.00	1.04	1.14	1.33	1.38	1.57	3.17	3.17	3.43
Nov.	2.09	1.04	0.57	0.96	0.57	0.57	0.68	0.61	1.23	3.97	2.78
Dec.	3.43	1.32	1.79	0.50	0.93	0.97	1.09	3.43	4.13	1.71	0.70

[a]Detection limit is 0.01.

Table 12. Analysis results of soluble orthophosphate (ppm) at stations in the Turkey Point Canals and Biscayne Bay during 1981.

MONTHS	STATION LOCATION AND NUMBER										
	Turkey Point Canal System								Biscayne Bay		
	1	2	3	4	5	6	7	8	11	12	13
Jan.	<0.01[a]	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Feb.	<0.01	0.01	<0.01	0.05	0.02	<0.01	<0.01	<0.01	0.07	0.01	0.10
Mar.	0.04	0.02	0.06	0.02	0.05	0.12	0.01	0.01	0.01	0.02	0.03
Apr.	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
May	0.03	<0.01	0.06	<0.01	<0.01	0.01	0.01	<0.01	ND[b]	<0.01	<0.01
Jun.	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Jul.	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Aug.	0.02	0.02	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sep.	0.55	0.02	0.03	0.03	0.02	0.02	0.02	0.01	<0.01	0.03	0.02
Oct.	0.02	0.01	0.03	0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
Nov.	0.02	0.02	<0.01	0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01
Dec.	0.01	0.01	<0.01	<0.01	0.02	<0.01	<0.01	0.02	0.08	<0.01	<0.01

[a]Detection limit is 0.01.

[b]ND-no data.

Table 13. Methods for chemical analysis of sediment and interstitial water at the Turkey Point Plant during 1981.

PARAMETER	METHOD	REFERENCE
Sulfate	turbidimetric (barium sulfate)	APHA, 15th edition, 1980, p. 493
Sulfite	titrimetric (iodide-iodate)	APHA, 15th edition, 1980, p. 509
Sulfide	spectrophotometric (p-phenylenediamine)	Strickland and Parsons, 1972, p. 41
Nitrate nitrogen	cadmium reduction method	APHA, 15th edition, 1980, p. 434
Nitrite nitrogen	spectrophotometric (diazotization)	APHA, 15th edition, 1980, p. 434
Ammonia nitrogen	spectrophotometric (phenol-hypochlorite)	Strickland and Parsons, 1972, p. 87
Orthophosphate	spectrophotometric (ascorbic acid)	APHA, 15th edition, 1980 p. 481

Table 14. Ranges of selected physical and chemical parameters at stations in the Turkey Point Canals and Biscayne Bay.

STATION[a]	pH	SALINITY (ppt)	TEMPERATURE (°C)	SOLUBLE SULFATE (ppm)	SOLUBLE NITRATE (ppm)	SOLUBLE NITRITE (ppm)	SOLUBLE AMMONIUM (ppm)	SOLUBLE ORTHOPHOSPHATE (ppm)
1	7.5-8.5	19.0-44.0	18.1-33.0	2029-4841	0.031-0.316	0.003-0.027	0.59-3.43	<0.01-0.55
2	7.2-8.3	21.0-44.0	19.0-32.7	2160-4749	0.009-0.393	0.003-0.028	0.19-2.32	<0.01-0.02
3	7.6-8.3	21.0-46.0	12.4-31.5	2144-3984	0.026-0.914	0.002-0.023	0.06-6.66	<0.01-0.06
4	7.6-8.5	19.0-44.0	12.8-33.7	2140-4095	0.014-0.333	0.003-0.046	0.14-5.90	<0.01-0.05
5	7.8-8.3	19.0-42.0	20.0-35.0	1569-4021	0.017-0.294	0.004-0.018	0.07-1.79	<0.01-0.05
6	7.7-8.6	20.0-44.0	19.2-34.6	2231-4076	0.017-0.268	0.002-0.021	<0.01-1.39	<0.01-0.12
7	7.7-8.3	20.0-46.0	19.9-34.8	2055-4021	0.019-0.267	0.002-0.029	0.33-5.39	<0.01-0.02
8	7.8-8.4	18.0-44.0	23.5-42.5	2018-4384	0.020-0.285	0.005-0.032	0.05-3.43	<0.01-0.02
11	8.1-9.4	1.5-40.0	11.2-29.0	1194-2989	0.013-0.264	0.003-0.011	0.91-4.69	<0.01-0.08
12	7.7-9.2	9.0-38.0	11.3-29.1	1109-3519	<0.001-0.179	0.002-0.023	0.42-10.00	<0.01-0.03
13	7.7-9.0	8.0-38.0	11.1-29.6	887-3473	<0.001-0.367	0.002-0.033	0.28-9.38	<0.01-0.10

[a]Stations 1-8 are in the Turkey Point Cooling Canal System; Stations 11-13 are in Biscayne Bay.

Table 15. Ranges for selected parameters recorded at stations in Biscayne Bay/Card Sound (preoperational studies) and in the Turkey Point Canals and Biscayne Bay (operational studies).

PARAMETER	PREOPERATIONAL STUDIES[a]	OPERATIONAL STUDIES[b]				
	1970-1971	1977	1978	1979	1980	1981
pH (pH units)	7.0-7.8	7.4-8.5 (8.0-8.7)[c]	7.2-8.7 (7.4-8.4)	7.6-8.9 (7.8-8.9)	7.0-8.3 (7.2-8.3)	7.2-8.6 (7.7-9.4)
Salinity (ppt)	27.3-44.4	35.00-54.54 (23.69-35.54)	22.0-43.1 (11.6-37.7)	18.3-48.0 (14.0-31.5)	21.0-39.0 (8.2-35.8)	18.0-46.0 (1.5-40.0)
Temperature (C°)	-[d]	11.1-39.9 (19.1-33.0)	15.8-39.5 (18.5-33.9)	17.5-44.0 (10.0-37.0)	13.0-43.0 (10.2-30.3)	12.4-42.5 (11.1-29.6)
Soluble sulfate (ppm)	-[d]	2100-3818 (733-3448)	360-3950 (180-3100)	2399-3450 (1521-3120)	2115-3611 (959-3215)	1569-4841 (887-3519)
Soluble nitrate (ppm)	<0.001-0.023	0.014-0.460 (0.007-0.240)	0.002-0.346 (0.005-0.253)	<0.001-2.712 (<0.001-0.341)	0.003-0.746 (0.004-0.404)	0.014-0.914 (<0.001-0.367)
Soluble nitrite (ppm)	<0.001-0.003	<0.001-0.017 (0.001-0.010)	<0.001-0.024 (<0.001-0.012)	<0.001-0.028 (<0.001-0.014)	<0.001-0.084 (<0.001-0.070)	0.002-0.046 (0.002-0.033)
Soluble ammonium (ppm)	-[d]	0.01-0.98 (<0.01-0.69)	<0.01-1.91 (0.24-1.78)	0.02-0.97 (0.09-1.00)	0.10-6.02 (0.08-1.74)	<0.01- 6.66 (0.28-10.00)
Soluble orthophosphate (ppm)	<0.01-0.10	<0.01-0.13 (<0.01-0.04)	<0.01-0.24 (<0.01-0.17)	<0.01-0.90 (<0.01-0.24)	<0.01-0.15 (<0.01-0.08)	<0.01-0.55 (<0.01-0.10)

[a]RSMAS, 1971, 1972.

[b]FPL, 1977-1980.

[c]Biscayne Bay values in parenthesis.

[d]No adequate data.

Table 16. Yearly average values for selected physical and chemical parameters at stations in the Turkey Point Canals and Biscayne Bay during 1981.

STATION[a]	pH	SALINITY (ppt)	TEMPERATURE (°C)	SOLUBLE SULFATE (ppm)	SOLUBLE NITRATE (ppm)	SOLUBLE NITRITE (ppm)	SOLUBLE AMMONIUM (ppm)	SOLUBLE ORTHOPHOSPHATE (ppm)[b]
1	8.0	30.3	26.2	3070	0.101	0.008	1.58	0.06
2	7.6	30.3	26.4	3100	0.115	0.011	0.99	0.01
3	7.9	31.0	24.6	3010	0.168	0.010	2.09	0.02
4	7.9	30.2	25.5	2998	0.105	0.011	1.07	0.01
5	8.0	29.4	28.4	2763	0.084	0.008	0.67	0.01
6	8.1	31.0	27.9	3046	0.104	0.009	0.65	0.01
7	8.0	31.4	28.3	2998	0.089	0.010	1.52	<0.01
8	8.0	30.4	33.8	3155	0.108	0.011	0.84	<0.01
11	8.5	23.2	23.3	2217	0.077	0.006	2.03	0.01
12	8.4	23.2	23.4	2245	0.077	0.007	2.62	0.01
13	8.4	23.7	23.6	2174	0.095	0.010	2.09	0.01

[a]Stations 1-8 are in the Turkey Point Cooling Canal System; Stations 11-13 are in Biscayne Bay.

[b]To calculate yearly means for orthophosphate, the value <0.01 ppm was considered equal to 0.

b. Benthic Organisms

Introduction

This report documents trends in the benthic macroinvertebrate populations of the Turkey Point Plant Cooling Canal System. This unique marine habitat is analyzed to determine the benthic species present and their relative abundances. A further objective of the study is to assess the impact of power plant operation on the cooling canal system environment since operation began and to compare the canal habitat to the adjacent lagoonal ecosystem, which was monitored during 3 years of baseline study (Bader and Roessler, 1972).

Benthic macroinvertebrates are animals large enough to be seen by the unaided eye and retained by a U.S. Standard No. 30 sieve (0.595-mm mesh; EPA, 1973). They live at least part of their life cycles within or upon suitable substrata. Benthic macroinvertebrates are sensitive to external stress due to their limited mobility and relatively long life span. As a result, benthic communities exhibit characteristics that are a function of environmental conditions in the recent past. Benthic communities reflect the effects of temperature, salinity, depth, current, substrate, and chemical and organic pollutants. In addition, benthic macroinvertebrates are important members of the food web as prey for many species of the water column (EPA, 1973).

Materials and Methods

Benthic macroinvertebrates were collected and analyzed using methods and materials recommended by Holme and McIntyre (1971), EPA (1973), NESP (1975) and APHA (1980).

Turkey Point Cooling Canal System substrates were sampled with an Ekman grab. The sample was washed through a No. 30 mesh sieve to remove fine sediment and detritus. All material retained on the sieve was preserved in a 1:1 mixture of Eosin B and Biebrich Scarlet stains in a 1:1000 concentration of 5-percent formalin (Williams, 1974). Preserved samples were placed in labeled containers and taken to the laboratory where they were hand sorted and the specimens identified to the lowest practicable taxon. Temperature, salinity and dissolved oxygen measurements were made concurrently with each biotic sampling.

In May and October of 1981, three replicate grab samples were taken at each of 11 sampling stations (Figure 1). Three control stations have been established in Biscayne Bay north of the plant site. Control Station 1 is located on shallow flats just offshore. Control Station 2 is at the mouth of a small creek, and Control Station 3 is some distance up this same creek. The control stations were sampled for the first time in May 1979.

Prior to 1980, reliable sampling at canal Station RC.0 was hindered by the rocky substratum that prevented penetration and proper closure of the grab. In 1980, this station was relocated several hundred feet

closer to the plant intake. Former benthic Station RC.2, even though not specifically associated with plankton Station RC.1 (Section III.A.1.a -Figure 1), sampled the same key cut canal. In 1980, station designation RC.2 (Figure 1) in this report was transferred to plankton Station RC.1.

Biomass analyses of the samples were made on an ash-free dry weight basis. Whole samples were dried at 105°C for 4 hours, then weighed to the nearest milligram on a Mettler H32 analytical balance (EPA, 1973). Biomass per square meter and density per square meter were calculated by taking the sum of the results of the three replicate samples and multiplying by the appropriate factor.

The Shannon-Wiener index of diversity and the equitability component were also computed from the data. Diversity indices are additional tools for measuring the environmental quality and the effect of induced stress on the structure of a macroinvertebrate community. Use of these indices is based on the generally observed phenomenon that undisturbed environments support communities having relatively few species with large numbers of individuals and large numbers of species represented by only a few individuals. Many forms of stress tend to reduce diversity by making the environment unsuitable for some species or by giving other species a competitive advantage.

Species diversity has two components: the number of species (species richness) and the distribution of individuals among the species (species evenness). The inclusion of this latter component renders the diversity index independent of sample size.

The Shannon-Wiener index of diversity (H'; Lloyd et. al., 1968) calculates mean diversity and is recommended by the EPA (1973):

$$H' = \frac{C}{N}(N \log_{10} N - \Sigma n_i \log_{10} n_i)$$

where: C = 3.321928 (converts base 10 log to base 2),

N = Total number of individuals,

n_i = Total number of individuals of the ith species.

Mean diversity as previously calculated is affected by both species richness and evenness and can range from 0 to 3.321928 log N.

Equitability, the distribution of individuals among the species present, is computed by:

$$e = \frac{s'}{s}$$

where: s = Number of taxa in the sample,

s' = Hypothetical maximum number of taxa in the sample based on a table devised by Lloyd and Ghelardi (1964).

Data from EPA biologists (EPA, 1973) have shown that diversity indices in unpolluted waters are generally greater than 3.0 and are usually less than 1.0 in polluted waters. Equitability levels below 0.5 have not been encountered in waters known to be free of oxygen-demanding wastes. In such waters, equitability usually ranges from 0.6 to 0.8, while equitability in polluted waters is generally 0.0 to 0.3.

The number of species found at each station was analyzed using Sorensen's (1948) index of similarity:

$$\text{Similarity (\%)} = \frac{2C}{a + b} \times 100$$

where: C = Number of species common to the two stations being compared,

a = Number of species at the first station,

b = Number of species at the second station.

Results and Discussion

Benthic macroinvertebrates collected in the Turkey Point Plant area were representatives of four main groups: polychaete worms, molluscs (snails and bivalves), crustaceans and a miscellaneous group of diverse organisms that were present irregularly and in small numbers (Tables 1-11). The canals were characterized by higher temperatures and salinities than were the control areas (Table 12).

Canal Stations

In 1981, the density of macroinvertebrates sampled in the canals varied considerably from station to station, ranging from 230 individuals/m^2 (Station F.1 in October; Table 8) to 24,368/m^2 (Station E3.2 in May; Table 3). This wide range in density illustrates the highly variable nature of the canal system infauna. Macrobenthos density was higher in the spring than in the fall, and conformed to a fairly regular pattern of high spring density/low fall density noted over the past 7 years (Figure 2). The mean density of all stations combined was

8358/m^2 in May and 4449/m^2 in October (Table 13). The May density was similar to high values recorded in 1979 and 1980. The October density was similar to those of earlier years, being much lower than the figure recorded for October 1980.

Mean biomass in the canals was 9.143 g/m^2 in May and 5.310 g/m^2 in October (Table 13). The May value was high compared to earlier monitoring studies (being surpassed only by the very high value in April 1980). The October mean was the highest fall biomass estimate to date in the canals. The 1981 figures conformed to the trend of higher spring biomass and lower fall biomass that have been observed in every year of the study except 1979 (Figure 3). Biomass values ranged from 1.48 g/m^2 (Station RC.0 in October; Table 5) to 45.60 g/m^2 (Station RF.3 in May; Table 4). Most of the wide biomass variation was caused by the occurrence of larger specimens such as molluscs or brittle stars. Generally, however, the benthic fauna was composed of individuals of small size.

The mean index of diversity in the canals was 3.23 in May and 3.00 in October. Both of these values were high when compared to previous monitoring data (the May value was exceeded only by that for April 1980, and the October value was the highest fall diversity ever observed in the canal studies; Figure 4). However, these mean values were lower than those usually observed for marine communities, which typically show values over 3.5 (Bader and Roessler, 1971, 1972; Holme and McIntyre, 1971). In 1981, diversity indices ranged from 1.50 (Station F.1 in October; Table 8) to 4.09 (Station RC.1 in October, Table 2).

As indicated, macroinvertebrate density, biomass and diversity were generally higher at the canal stations during 1980 and 1981 than in previous years (Figures 2, 3 and 4). These increases were partially caused by inclusion in 1980 and 1981 of data from the previously unsampled Stations RC.0 and RC.1, which usually have denser and more diverse benthic communities than the other canal stations. In the 1980 Turkey Point Plant report (FPL, 1981), mean density, biomass and diversity data were compared for the stations common to both the 1979 and 1980 monitoring studies (RC.0 and RC.1 were excluded), and this showed that the inclusion of RC.0 and RC.1 data exerted a general increasing effect on mean density, little or no effect on mean biomass, and a large increasing effect on diversity (FPL, 1981).

Control Stations

Control station density was as highly variable as that of the canal stations, ranging from 6092 individuals/m^2 (Control Station 1 in May; Table 9) to 87,155/m^2 (Control Station 2 in May; Table 10). Overall mean densities were 36,600/m^2 in May and 21,188/m^2 in October (Table 14; Figure 2). The annual mean density of 28,894/m^2 was much higher than the annual mean density of 6404/m^2 at the canal stations.

Biomass values at the control stations ranged from 0.50 g/m^2 (Control Station 3 in October, Table 11) to 6.07 g/m^2 (Control Station 2 in May; Table 10). Mean biomass was 3.90 g/m^2 in May and 2.85 g/m^2 in October (Table 14; Figure 3). The annual mean biomass during 1981 at the control stations was 3.38 g/m^2 compared to 7.23 g/m^2 for the canal sta-

tions. The canal mean annual biomass was more than twice the value for the control stations. In contrast, the values were approximately equal in 1980, while in 1979, the control biomass was twice that of the canals, the reverse of the situation in 1981 (FPL, 1981; Table 14). Much of the wide variation in biomass values can be attributed to the sporadic occurrence of larger specimens of molluscs, echinoderms or brittle stars.

Control station diversity ranged from 2.08 (Control Station 1 in October, Table 9) to 5.50 (Control Station 2 in May, Table 10). Mean control station diversity was 4.70 in May and 2.88 in October (Table 14, Figure 4), the highest and lowest mean control station diversity indices to date. The mean annual diversity for the control stations was 3.79, while that of the canal stations was 3.11.

Biomass, density and diversity at the control stations were generally higher in May than in October 1981, a trend observed for biomass and diversity at the control stations in 1980. This contrasts with the trend observed for biomass, density and diversity in 1979 (and density in 1980), where the fall values were generally higher than those observed in the spring. The 1980 and 1981 data indicate that biomass, density and diversity variation at the control stations follows a pattern similar to that of the canal stations (with high values in spring and low values in the fall).

Comparison of Station Groups

The trellis diagram (Figure 5) resulting from the use of Sorensen's index of community similarity illustrates that the Turkey Point benthic sampling stations can be divided into four groups for comparative purposes: east stations (RC.0, RC.1, E3.2 and RF.3), west stations (WF.2, W18.2 and W6.2), discharge (F.1) and control stations (C-1, C-2 and C-3). The data for these groups from 1975 to 1981 were compared statistically using t-tests at the P=0.05 level. Analysis of the biomass data showed that while the biomass values for the east stations were significantly higher than those for the west stations, there were no significant differences between the biomass figures for the other groups. Density showed no significant difference between the east and control groups, although both of these groups had significantly higher density than the west group, and all three of these groups had significantly denser populations than the discharge station. All groups were significantly different in diversity. The control group had the highest diversity, followed by the east group, the west group and the discharge group, respectively.

Biomass, density and diversity data were checked for correlation with the dissolved oxygen, salinity and temperature data by calculating correlation coefficients on a station-by-station basis. Relatively strong negative correlations between density and temperature and diversity and temperature were indicated. No consistent relationship could be found between biomass and temperature. Neither dissolved oxygen concentration nor salinity showed consistent correlation with either density, diversity or biomass.

The relationship between temperature, density and diversity could be seen clearly when the annual means of these parameters were calculated for the station groups (Table 15). These data reflect the fact that the discharge station (F.1) is closest to the plant's thermal outfall, the west station group (WF.2, W18.2 and W6.2) is the second closest, the east group (RC.0, RC.1, E3.2 and RF.3) is the farthest canal station group from the thermal effluent, while the control stations are essentially unaffected by the heated water (Figure 1). Many researchers have stated that the faunas of subtropical and tropical areas still thrive at or near their upper incipient lethal temperatures (Mayer, 1914; Gunter, 1957; Naylor, 1965; Bader and Roessler, 1972). Additional heat increases, even relatively small ones, may create stresses that are intolerable. Though the canal salinity averaged 35.7 ppt and the average salinity of the control stations was 28.2 ppt, salinity and dissolved oxygen showed no consistent relationships with the station groups.

Community Composition

As in the past years of monitoring, the canal stations were dominated by polychaetes (Figure 6). The numerically important species of polychaetes are limited to a few types. They were primarily burrowing, sedentary, detritus feeding, or filter feeding species. The bottom substrate of the canals, which is composed of fibrous peat and mud mixed with shell debris, is an environment to which these worms are well adapted.

Polychaetes are known to be more tolerant of wide variations in environmental conditions than are most other marine organisms. Several studies have shown that polychaetes are among the only organisms able to survive the effects of thermal outfalls (Markowski, 1960; Warinner and Brehmer, 1965, 1966). Studies in southern California have reported polychaetes surviving in heavily polluted areas with restricted circulation (Reish, 1956, 1959). Bandy et al., (1965) reported that polychaetes outnumbered other groups 8 to 1 at an ocean sewage outfall. From the preceding studies, polychaetes appear to be the group of organisms most tolerant of elevated temperature and salinity, restricted circulation, and highly organic substrates that are characteristic of the Turkey Point Cooling Canal System.

Compared to the canal stations, the control stations showed a slightly better balance between the major macroinvertebrate groups (Figure 6). Polychaetes were 40 percent of the macroinvertebrate fauna at the control stations as opposed to 65 percent of the canal stations organisms. These numbers were lower than those for 1980 (control stations with 69 percent polychaetes, canal stations with 78 percent). The control station macroinvertebrates exhibited a wider degree of niche differentiation (utilization of different feeding and habitat preferences) than did those of the canal stations.

Control Station 3 was the only control station with a mud and peat substrate similar to that in the canals. Control Station 1 has a sand/calcareous algae substrate, while Control Station 2 has a

sand/peat/seagrass substrate. Because its substrate is similar to that of the canals, the community structure of Control Station 3 was more like that of the canal stations than like the other control stations.

Comparison with Previous Studies

Some species found in both baseline and operational studies were recruited originally from the adjacent Biscayne Bay and Card Sound estuarine ecosystems. In studies of these adjacent ecosystems 266 species of epifaunal macroinvertebrates, including molluscs, large crustaceans, sponges and echinoderms were sampled by trawling (Bader, 1969; Tabb and Roessler, 1970; Bader and Roessler, 1971 and 1972). This large number of species does not include infaunal organisms such as polychaete worms and small crustaceans that comprise the bulk of the species in the canal system. Many more species could be found in Biscayne Bay or in Card Sound if these infaunal forms were included in faunal surveys. Differing sampling methodologies, thermal regimes and substrates limited the applicability of these studies to the present monitoring study.

Conclusion

During 1981, no significant changes in the macroinvertebrate fauna of the Turkey Point Canal System are observed when the data are compared to the data from previous years of monitoring. Biomass, density and diversity values observed in 1981 are among the highest ever encountered in the canals. Though there are some deviations, the data from the past seven years indicate a fairly regular pattern of higher biomass, density and diversity in spring alternating with lower biomass, density and diversity in the fall.

When compared to control stations, the canal macroinvertebrate fauna had lower density, higher biomass and statistically significantly lower diversity. The diversity trend is probably the result of 1) a lack of means of recruitment of new species to the canal system, 2) the higher temperature and salinity of the canals, and 3) the general unsuitability of the canal substrate for animals other than polychaete worms.

The benthic macroinvertebrate community of the canal system has many species, but only those burrowing, sedentary, detritus feeding and filter feeding species that are adapted to living in the thick fibrous peat substrate (such as many polychaete worms) can be expected to have significantly large populations. The relatively harsh environment and the restricted fauna of the canals makes the canal macroinvertebrate populations subject to wide and sometimes irregular variations in biomass, density and diversity.

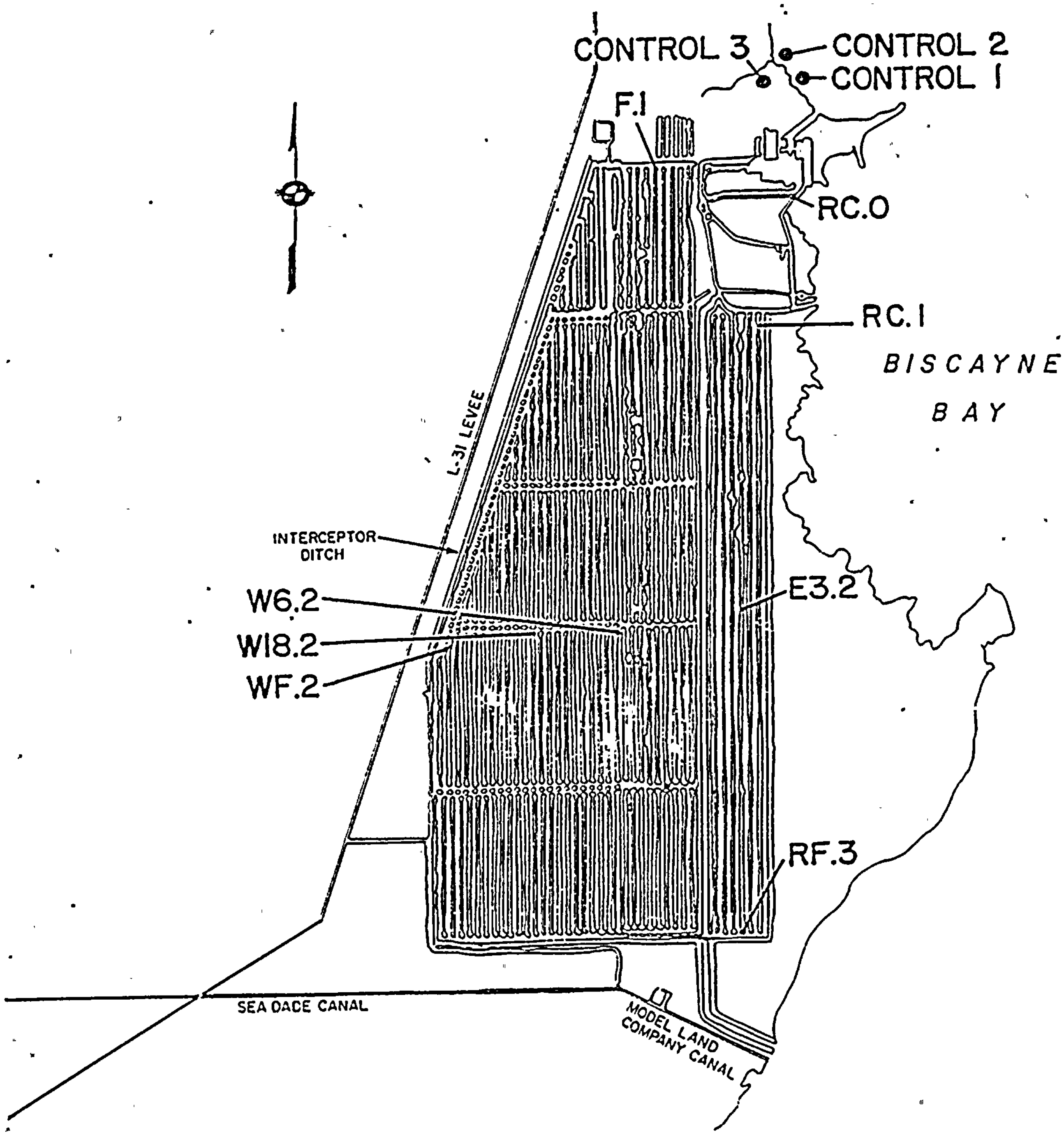


Figure 1. Benthic macroinvertebrate sampling station locations, Turkey Point site, 1981.

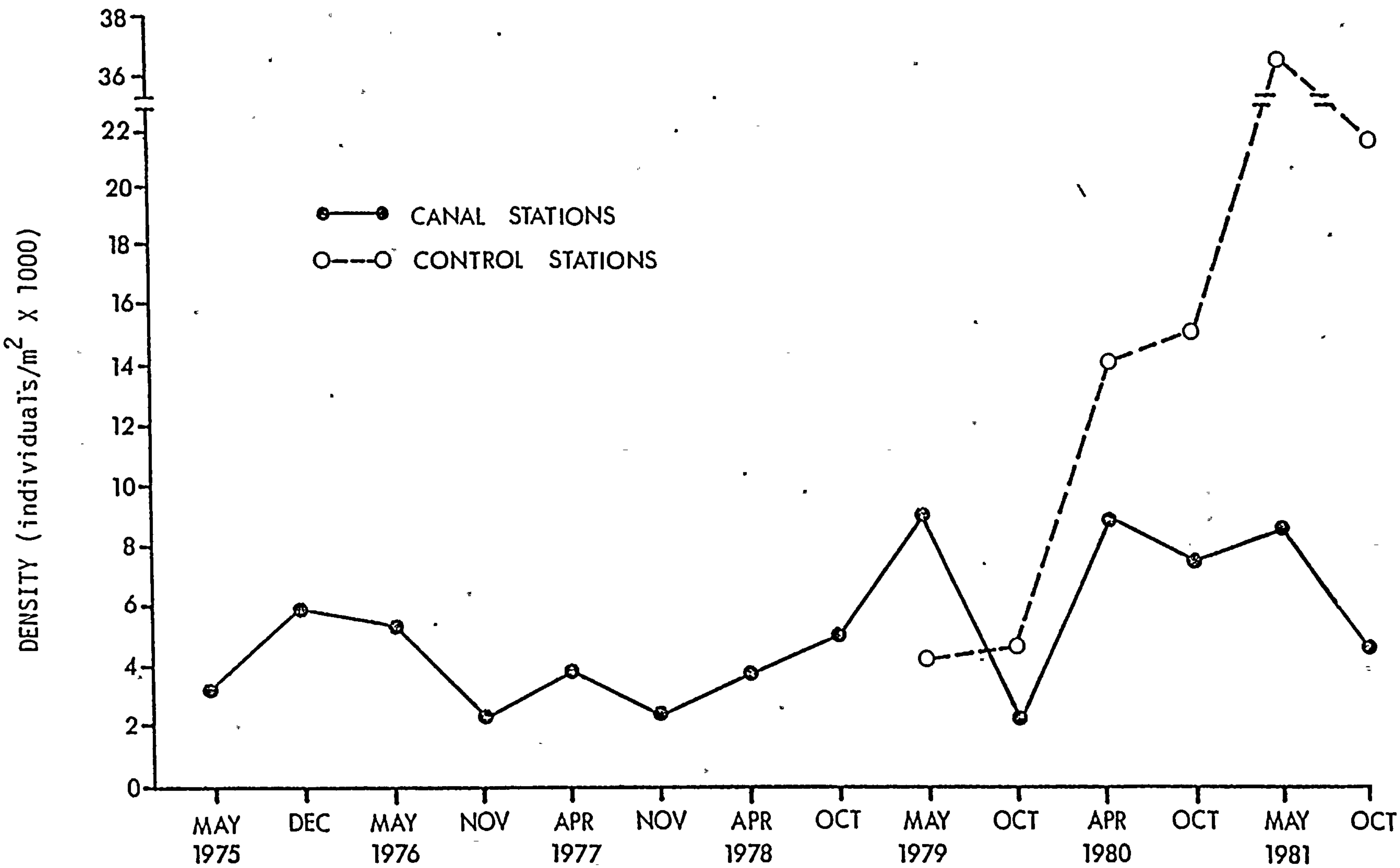


Figure 2. Mean number of benthic macroinvertebrates per square meter (all sampling stations combined), Turkey Point Plant, 1975-1981.

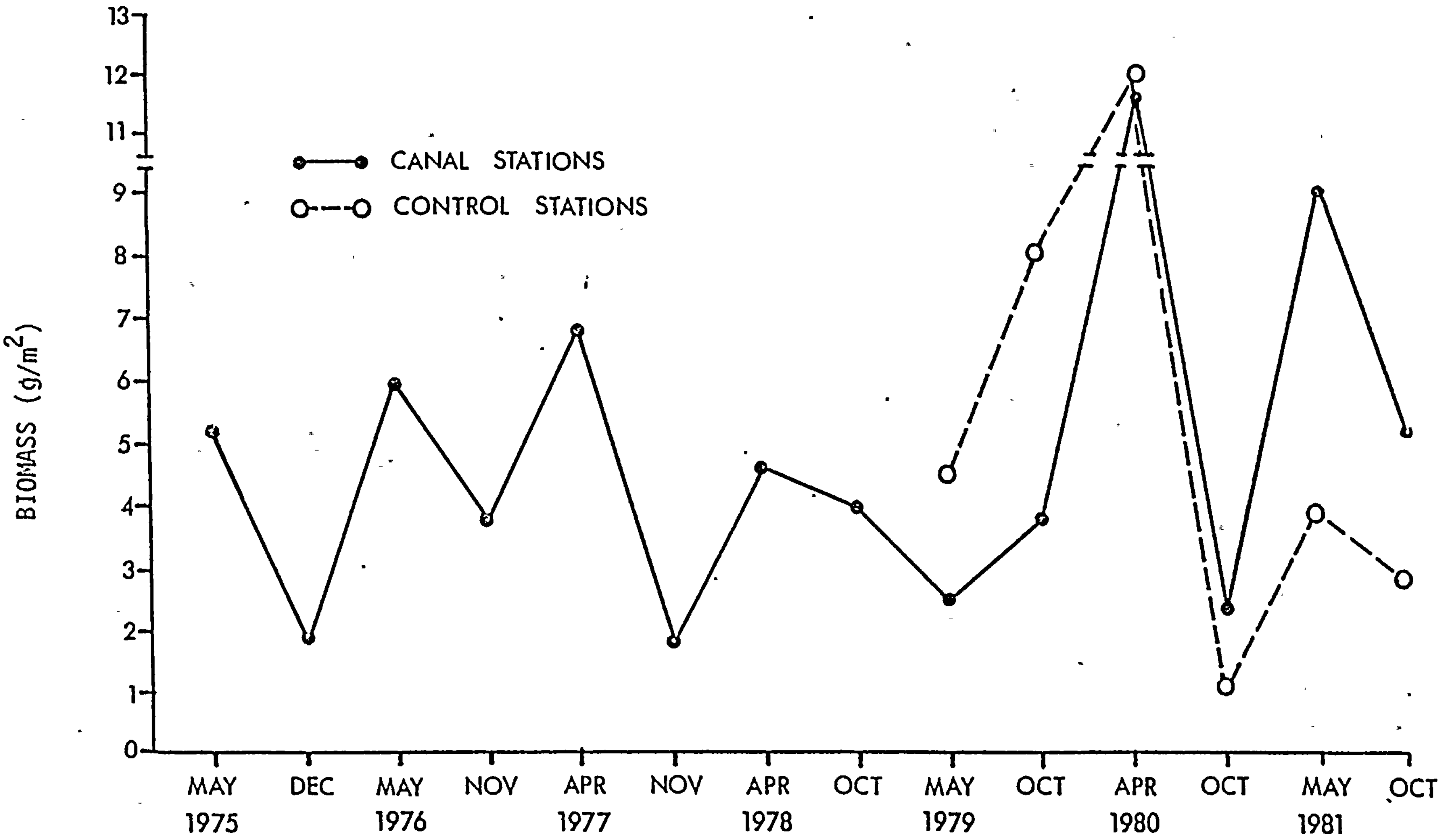


Figure 3. Mean benthic macroinvertebrate biomass per square meter (all sampling stationscbmbined), Turkey Point Plant, 1975-1981.

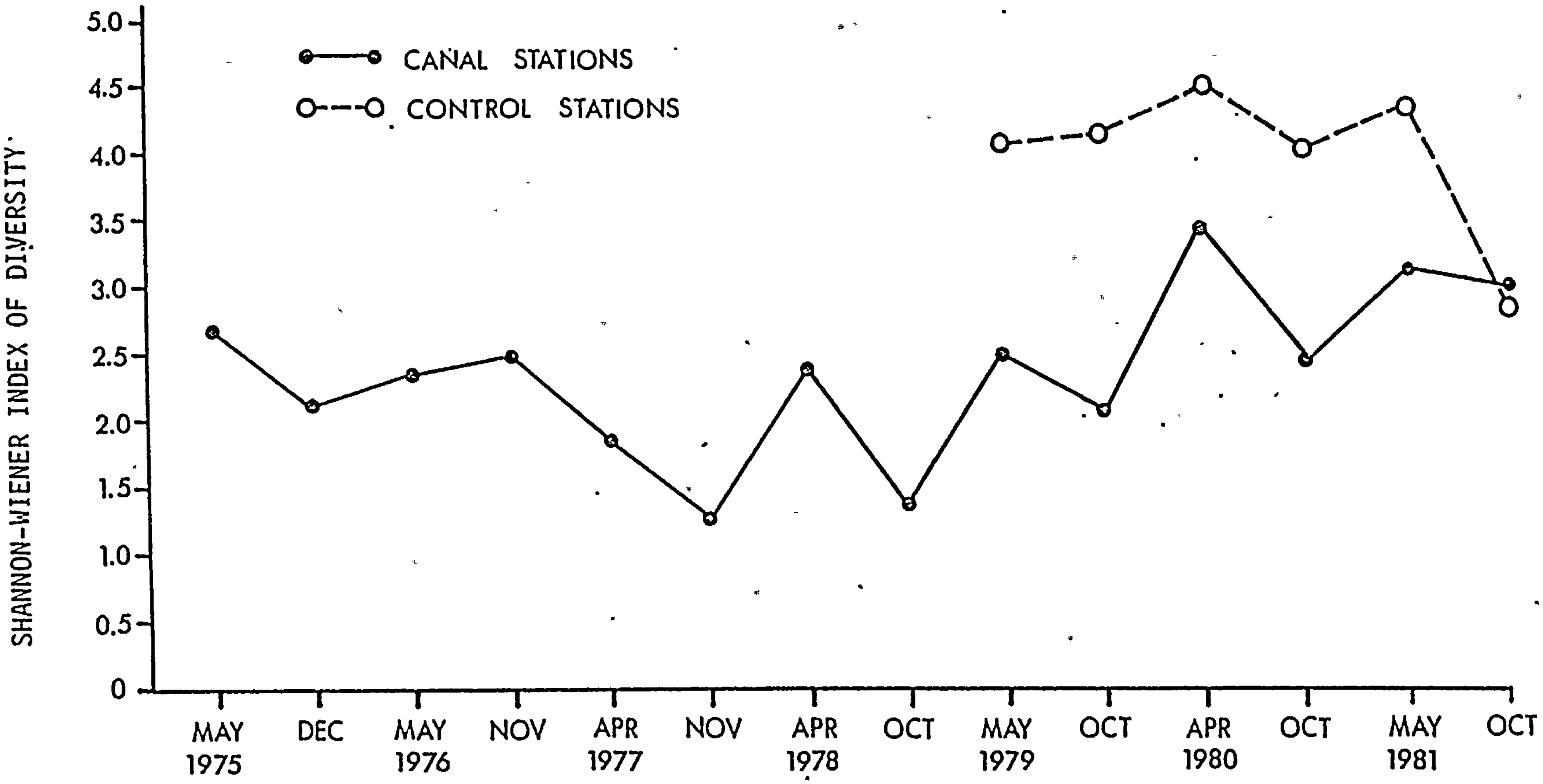


Figure 4. Mean benthic macroinvertebrate species diversity (all sampling stations combined), Turkey Point Plant, 1975-1981.

Station	RC.0	RC.1	E3.2	RF.3	WF.2	W18.2	W6.2	F1	C1	C2	C3
RC.0		31.0	60.0	23.3	12.0	15.7	11.5	4.7	25.6	22.0	24.2
RC.1			38.2	38.6	15.8	20.5	33.3	12.9	33.3	21.1	37.0
E3.2				38.0	16.7	23.0	35.5	11.3	27.3	34.5	36.8
RF.3					16.3	24.0	31.4	4.8	33.8	27.0	25.0
WF.2						51.6	43.8	26.1	27.6	11.1	13.0
W18.2							54.6	16.7	20.4	16.6	11.8
W6.2								16.0	20.0	15.1	12.5
F1									11.8	7.3	5.1
C1										41.9	29.7
C2											33.8
C3											

TURKEY POINT STATION SIMILARITY
MAY 1981

76–100% STRONG SIMILARITY

51–75% MODERATE SIMILARITY

26–50% FAIR SIMILARITY

0–25% WEAK SIMILARITY

Station	RC.0	RC.1	E3.2	RF.3	WF.2	W18.2	W6.2	F1	C1	C2	C3
RC.0		20.3	11.1	17.5	11.8	17.1	5.9	7.7	11.4	6.0	21.1
RC.1			40.8	55.0	0.0	12.5	12.8	5.1	12.5	20.0	23.5
E3.2				38.3	8.3	16.0	25.0	12.5	0.0	3.5	7.1
RF.3					8.9	17.4	13.3	0.0	13.0	25.6	20.4
WF.2						52.2	45.5	14.3	43.5	14.6	5.4
W18.2							43.5	0.0	25.0	7.1	7.4
W6.2								14.3	26.1	7.3	15.4
F1									13.3	4.3	0.0
C1										28.6	22.2
C2											30.5
C3											

TURKEY POINT STATION SIMILARITY
OCTOBER 1981

Figure 5. Trellis diagrams showing percentages of species similarity between sampling stations, Turkey Point Plant, 1981.

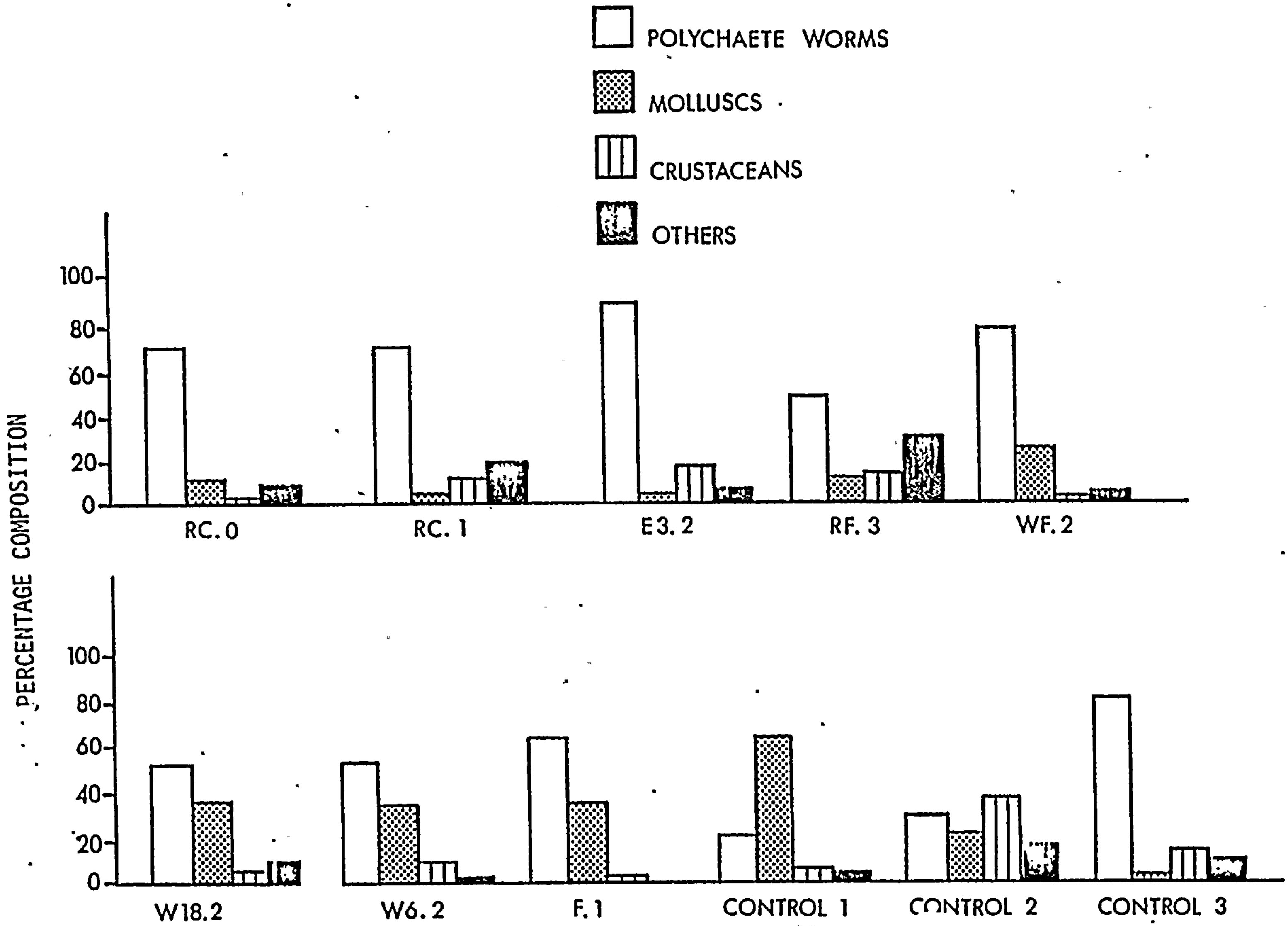


Figure 6. Structure of the benthic macroinvertebrate community by station, Turkey Point Plant, 1981.

Table 1. Results of benthic macroinvertebrate sampling at Station RC.0 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES May	SUM OF 3 REPLICATES October
Class Polychaeta (worms)		
Aricidea taylori	80	8
Armandia maculata	4	-
Cirratulidae (damaged)	16	4
Cirriformia filigera	12	-
Cirrophorus lyriformis	12	12
Exogone arenosa	68	24
Fabricia sp.	384	96
Flabelligeridae sp. A	16	12
Heteromastus filiformis	12	-
Naineris laevigata	-	4
Neridae (juvenile)	-	4
Nereis acuminata	4	12
Notomastus latericeus	4	-
Paraonides lyra	60	24
Pista palmata	-	4
Polycirrus sp. A	8	-
Polydora socialis	76	-
Pseudopolydora antennata	4	-
Prionospio heterobranchia texana	4	-
Sabella melanostigma	20	44
Schistomeringos rudolphi	12	-
Terebellides stroemii	56	-
Tubificidae sp.	4	-
Typosyllis sp. A	4	4
Typosyllis sp. B	-	4
Class Gastropoda (snails)		
Odostomia sp. C	4	-
Rissoina cancellata	-	4
Vermicularia knorri	264	-
Class Pelecypoda (bivalves)		
Carditamera floridana	4	-
Chione cancellata	-	8
Codakia orbiculata	-	20
Lucina nassuala	4	-
Tellidora cristata	4	4
unidentified damaged specimen	4	-
unidentified species A	12	
Veneridae sp. A (juvenile)	4	-

Table 1. (cont'd) Results of benthic macroinvertebrate sampling at Station RC.0 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES	
	May	October
Class Scyphozoa (jellyfish)	4	-
Class Ascidiacea (sea squirts)	4	-
Class Anthozoa (sea anenomes)		
Anenome sp.	8	-
unidentified specimen	-	8
Phylum Nematoda (roundworms)	28	-
Phylum Nemertinea (proboscis worms)	60	20
Total individuals	1268	332
Total biomass (g)	0.1360	0.1032
Density (no./m^2)	18,218	4,770
Biomass (g/m^2)	1.954	1.483
Index of diversity	3.54	3.70
Equitability	0.48	0.81

Table 2. Results of benthic macroinvertebrate sampling at Station RC.1 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES	
	May	October
Class Polychaeta (worms)		
Armandia maculata	-	12
Branchiomma nigromaculata	-	16
Capitella capitata	-	160
Caulleriella alata	4	-
Ceratonereis mirabilis	-	16
Cirriformia filigera	12	-
Exogone dispar	4	-
Fabricia sp.	12	12
Haplosyllis sponicola	-	4
Naineris laevigata	68	32
Naineris setosa	20	-
Nematonereis sp. A	-	4
Nereis acuminata	-	84
Ophryotrocha puerilis	-	8
Paraonides lyra	140	-
Prionospio heterobranchia texana	44	4
Sabella melanostigma	-	4
Schistomeringos rudolphi	60	-
Spirorbis corrugatus	4	4
Syllis cornuta	16	-
Terebellidae (damaged)	-	4
Tubificidae	8	124
Typosyllis annularis	-	12
Typosyllis sp. A	12	84
Typosyllis sp. B	40	16
Typosyllis sp. C	4	-
Typosyllis sp. (damaged)	-	4
Class Gastropoda (snails)		
Balcis conoidea	-	4
Bulla striata	-	20
Cerithium muscarum	-	12
Haminoea antillarum	-	4
H. succinea	8	-
Modulus modulus	-	8
Prunum apicinum	-	16
P. lavalleeanum	4	4
Class Pelycypoda (bivalves)		
Opisthobranchia sp. B	4	-
Tellina sp. (juvenile)	-	4
Class Crustacea (copepods)		
Harpacticoida sp.	-	76

Table 2. (cont'd) Results of benthic macroinvertebrate sampling at Station RC.1 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES	
	May	October
Class Crustacea (isopods, amphipods, tanaids)		
Asellota sp.	4	-
Cymodusa spp.	-	12
Gitanopsis tortugae	-	8
Grandidierella bonnieroides	-	4
Hargeria rapax	-	16
Class Holothuroidea (sea cucumbers)		
Leptosynapta sp.	24	-
Synaptula hydriformis	28	24
Thyonella gemmata	-	12
Class Anthozoa (sea anemones)	-	4
Phylum Nematoda (roundworms)	16	124
Phylum Nemertinea (proboscis worms)	44	-
Total individuals	580	956
Total biomass (g)	0.2884	0.8736
Density (no./m^2)	8,333	13,735
Biomass (g/m^2)	4.140	12.550
Index of diversity	3.75	4.09
Equitability	0.85	0.69

Table 3. Results of benthic macroinvertebrate sampling at Station E3.2 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES May	SUM OF 3 REPLICATES October
Class Polychaeta (worms)		
Armandia maculata	-	4
Aricidea taylori	8	-
Branchiomma nigromaculata	8	-
Capitella capitata	-	16
Ceratonereis mirabilis	-	4
C. singularis	4	-
Cirratulidae (damaged)	4	-
Cirriformia filigera	8	-
Cirrophorus lyriformis	8	-
Exogone verugera	220	4
Fabricia sp.	180	-
Laeonereis culveri	12	4
Naineris laevigata	448	16
Paraonides lyra	20	-
Prionospio heterobranchia texana	4	24
Sabella melanostigma	8	-
Schistomeringos rudolphi	-	4
Scyphoproctus sp. A	24	-
Sphaerosyllis sp. B	12	-
Spirorbis corrugatus	12	-
Terebella rubra	4	-
Trichobranchus glacialis	24	-
Typosyllis annularis	124	4
Typosyllis hyalina	36	-
Typosyllis sp. A	56	64
Typosyllis sp. B	40	12
Typosyllis sp. D	16	-
Class Gastropoda (snails)		
Haminoea antillarum	-	16
Haminoea sp. (juvenile)	8	-
Odostomia sp. C	4	-
Prunum apicinum	4	-
P. lavalleeanum	4	-
Class Pelycypoda (bivalves)		
Veneridae sp. A	4	-
Class Crustacea (copepods and isopods)		
Copepoda sp.	68	-
Asellota sp.	84	-
Cymodoce faxoni	4	-

Table 3. (cont'd) Results of benthic macroinvertebrate sampling at Station E3.2 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES	
	May	October
Class crustacea (amphipods and shrimp)		
Cymadusa compta	20	-
Cymodusa sp.	40	-
Elasmopus levis	64	-
E. rapax	4	-
Elasmopus sp.	20	-
Grandidierella bonnieroides	4	-
Thor sp.	4	-
Class Ophiuroidea (brittle stars)		
Amphioplus abditus	4	-
Amphiuridae sp.	16	-
Class Holothuroidea (sea cucumbers)		
Synaptula hydriformis	4	96
Class Ascidiacea (sea squirts)	4	-
Class Anthozoa (sea anemones)		
Anemone sp.	8	-
Phylum Nematoda (round worms)	8	-
Phylum Nemertinea (proboscis worms)	36	-
Total individuals	1696	268
Total biomass (g)	0.4148	0.1468
Density (no./m^2)	4,368	3,850
Biomass (g/m^2)	5.960	2.110
Index of diversity	4.02	2.81
Equitability	0.53	0.75

Table 4. Results of benthic macroinvertebrate sampling at Station RF.3 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES	
	May	October
Class Polychaeta (worms)		
Armandia maculata	4	4
Branchiomma nigromaculata	4	68
Ceratonereis mirabilis	-	4
C. singularis	4	-
Exogone verugera	4	16
Fabricia sp.	52	64
Naineris laevigata	-	20
Prionospio heterobranchia texana	216	8
Streblosoma hartmanae	-	4
Spiorbis corrugatus	4	272
Terebellidae (damaged)	-	8
Terebellides stroemii	4	-
Typosyllis annularis	-	44
Typosyllis sp. A	4	28
Typosyllis sp. B	48	84
Typosyllis sp. C	-	4
Class Gastropoda (snails)		
Bulla striata	-	12
Cerithium muscarum	-	4
Cylindrobulla beauii	4	-
Haminoea succina	4	-
Modulus modulus	64	16
Phyllaplysia smarada	20	-
Prunum lavalleeanum	8	12
unidentified damaged specimen	4	4
Class Pelycypoda (bivalves)		
Lyonsia floridana	4	-
Class Crustacea (tanaids, isopods, amphipods, shrimp)		
Hargeria rapax	-	8
Asellota sp.	40	-
Cymadoce faxoni	-	56
Erichsonella filiformis	4	-
Cymodusa sp.	32	24
Elasmopus pocillimanus	4	-
Elasmopus rapax	-	8
Elasmopus sp.	8	16
Gitanopsis tortugae	4	8
Grandiderella bonnieroides	-	4
Thor	-	4

Table 4. (cont'd) Results of benthic macroinvertebrate sampling at Station RF.3 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES	
	May	October
Class Pantopoda (sea spiders)		
Achelia sawayai	8	-
Ammothella rugulosa ?	4	8
Anoplodactylus pectinus	4	-
Class Ophiuroidea (brittle stars)	4	-
Class Holothuroidea (sea cucumbers)		
Holothuroidea	-	4
Synaptulla hydriformis	180	116
Thyonella gemmata	16	4
Phylum Porifera (sponges)	4	-
Phylum Cnidaria (jellyfish)	4	-
Class Ascidacea (sea squirts)	-	112
Class Anthozoa (sea anemones)	-	4
Anemone sp.	4	-
Phylum Nematoda (round worms)	12	-
Phylum Nemertinea (proboscis worms)	44	12
Total individuals	828	1064
Total biomass (g)	3.1736	0.3748
Density (no./m2)	11,897	15,287
Biomass (g/m2)	45.598	5.385
Index of diversity	3.64	3.91
Equitability	0.53	0.64

Table 5. Results of benthic macroinvertebrate sampling at Station WF.2 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES	
	May	October
Class Polychaeta (worms)		
<u>Aricidea philbinae</u>	-	8
<u>A. taylori</u>	-	8
<u>Capitella capitata</u>	4	-
<u>Ceratonereis mirabilis</u>	12	-
<u>C. singularis</u>	4	-
<u>Haploscoloplos foliosus</u>	20	12
<u>Lanicides toboquille</u>	12	-
<u>Laeonereis culveri</u>	136	296
<u>Marphysa sanguinea</u>	12	-
<u>Polydora</u> sp.	4	-
<u>Prionospio heterobranchia texana</u>	20	-
Spionidae (damaged)	12	-
<u>Typosyllis</u> sp. A	32	-
Class Gastropoda (snails)		
<u>Batillaria minima</u>	12	4
<u>Cylichnella canaliculata</u>	-	56
Class Pelycypoda (bivalves)		
<u>Lyonsia floridana</u>	-	4
<u>Polymesoda maritima</u>	-	108
<u>Tivela floridana</u>	8	16
Class Crustacea (tanaids and isopods)		
<u>Hargeria rapax</u>	4	-
<u>Cymadoce faxoni</u>	-	4
Phylum Nemertinea (proboscis worms)	8	4
Total individuals	300	520
Total biomass (g)	0.2016	0.3936
Density (no./m^2)	4,310	7.471
Biomass (g/m^2)	2.897	5.655
Index of diversity	2.92	1.96
Equitability	0.71	0.46

Table 6. Results of benthic macroinvertebrate sampling at Station W18.2 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES May	SUM OF 3 REPLICATES October
Class Polychaeta (worms)		
Aricidea philbinae	12	4
A. taylori	4	8
Branchiomma nigromaculata	4	-
Ceratonereis mirabilis	20	4
Haploscoloplos foliosis	4	-
Lanicides toboquille	12	-
Laeonereis culveri	32	-
Prionospio heterobranchia texana	68	-
Typosyllis sp. A	100	12
Typosyllis sp. B	12	-
Class Gastropoda (snails)		
Bulla striata	12	-
Cerithium lutosum	-	12
C. eburneum	-	16
Cylichnella canaliculata	8	36
Class Pelycypoda (bivalves)		
Lyonsia floridana	4	-
Polymesoda maritima	-	24
Tivela floridana	108	4
Class Crustacea (ostracods)		
Haplocytheridea ? sp. A	8	24
Class Holothuroidea (sea cucumbers)		
Thyonella gemmata	-	4
Phylum Nemertines (proboscis worms)	20	28
Total individuals	428	176
Total biomass (g)	0.4128	0.8032
Density (no./m2)	6,149	2,529
Biomass (g/m2)	5.931	11.540
Index of diversity	3.15	3.22
Equitability	0.79	1.10

Table 7. Results of benthic macroinvertebrate sampling at Station W6.2 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES	
	May	October
Class Polychaeta (worms)		
Branchiomma nigromaculata	4	-
Caulleriella killariensis	4	-
Ceratonereis mirabilis	12	-
C. singularis	8	-
Haploscoloplos foliosis	-	12
Laeonereis culveri	4	12
Naineris laevigata	4	-
Prionospio heterobranchia texana	4	8
Terebella rubra	20	-
Typosyllis annularis	4	-
Typosyllis sp. A	200	4
Typosyllis sp. B	8	-
Class Gastropoda (snails)		
Batillaria minima	-	4
Cerithidae (damaged)	4	-
Cerithium lutosum	-	52
Cylichnella canaliculata	-	8
Haminoea succinea	4	-
Class Pelycypoda (bivalves)		
Polymesoda maritima	-	60
Tivela floridana	52	-
Transennella conradina	-	12
Class Crustacea (ostracods and amphipods)		
Haplocytheridea sp. A	12	24
Cymadusa sp.	4	-
Gitanopsis tortugae	-	4
Phylum Nemertinea (proboscis worms)	12	-
Total individuals	360	200
Total biomass (g)	0.2860	0.2592
Density (no./m^2)	5,172	2,874
Biomass (g/m^2)	4.109	3.724
Index of diversity	2.49	2.83
Equitability	0.45	0.90

Table 8. Results of benthic macroinvertebrate sampling at Station F.1 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES	
	May	October
Class Polychaeta (worms)		
Capitella capitata	-	4
Ceratonereis mirabilis	4	-
Ceratonereis sp. (damaged)	4	-
Cirrophorus lyriformis	-	4
Eunicidae	4	-
Typosyllis sp. A	52	-
Typosyllis sp. C	8	-
Class Gastropoda (snails)		
Batillaria minima	12	8
Cerithium lutosum	24	-
Class Crustacea (copepods)		
Copepoda	4	-
Total individuals	112	16
Total biomass (g)	0.1776	0.1536
Density (no./m^2)	1,609	230
Biomass (g/m^2)	2.552	2.207
Index of diversity	2.29	1.50
Equitability	0.83	1.19

Table 9. Results of benthic macroinvertebrate sampling at Control Station 1 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES May	SUM OF 3 REPLICATES October
Class Polychaeta (worms)		
Aricidea philbinae	4	-
Armandia maculata	8	-
Axiothella mucosa	40	-
Capitella capitata	8	-
C. jonesi	4	-
Ceratonereis mirabilis	16	-
Chone sp.	20	-
Exogone dispar	4	-
Fabricia sp.	48	24
Maldanidae (damaged)	16	-
Nereis (Neanthes) acuminata	8	-
Notomastus latericeus	8	-
Platynereis dumerilii	4	-
Prionospio heterobranchia texana	12	-
Schistomeringos rudolphi	4	-
Spirorbis corrugatus	12	-
Typosyllis hyalina	4	-
Typosyllis sp. A	16	-
Typosyllis sp. B	4	-
Typosyllis sp. D	8	-
Class Gastropoda (snails)		
Batillaria minima	-	4
Caecum pulchellum	-	20
Cerithidae (juvenile)	4	-
Cerithium muscarum	-	8
Crepidula sp. A	8	-
Cylichnella canaliculata	-	72
Fargoa ? laevigata	4	-
Granulina ovuliformis	4	-
Modulus modulus	4	-
Prunum lavalleeanum	8	8
Rissoina catesbyana	4	-
Class Pelycypoda (bivalves)		
Anomalocardia auberiana	-	72
Branchidontes domingensis	8	-
Lyonsia floridana	-	16
Parastarte triquetra	-	512
Polymesoda maritima	-	4
Tellina (Eurytellina) sp. (juvenile)	-	172
T. tampaensis (juvenile)	4	-

Table 9. (cont'd) Results of benthic macroinvertebrate sampling at Control Station 1 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES May	SUM OF 3 REPLICATES October
Class Polyplacophora (chitons)		
Chaetopleura apiculata	4	-
Ischnochiton papillosus	4	-
Class Crustacea (tanaids, isopods, amphipods)		
Hargeria rapax	16	-
Kalliapseudes sp. A	4	-
Cymodoce faxoni	4	-
Erichsonella filiformis	8	-
Cymodusa sp.	8	-
Elasmopus levis	24	-
Lysianopsis alba	4	-
Class Insecta (midges)		
Chironomidae	28	-
Class Holothuroidea (sea cucumbers)		
Leptosynapta sp.	8	-
Class Anthozoa (sea anemones)		
Anemone sp.	4	-
Phylum Nematoda (round worms)	8	-
Phylum Nemertinea (proboscis worms)	4	4
Total individuals	424	916
Total biomass (g)	0.068	0.1032
Density (no./m2)	6,092	13,161
Biomass (g/m2)	0.977	1.483
Index of diversity	4.95	2.08
Equitability	1.07	0.47

Table 10. Results of benthic macroinvertebrate sampling at Control Station 2 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES	
Species	May	October
Class Polychaeta (worms)		
Arabella mutans	4	-
Aricidea philbanae	4	-
A. taylori	4	-
Armandia maculata	52	-
Axiothella mucosa	4	-
Brania clavata	84	-
Capitella capitata	16	56
C. jonesi	8	-
Caulleriella alata	20	-
C. killariensis	4	-
Ceratonereis mirabilis	20	-
Chone sp.	388	-
Chrysopetalum sp. A	4	-
Cirratulidae (damaged)	8	-
Eunicidae	4	-
Exogone arenosa	4	-
E. verugera	276	-
Fabricia sp.	280	-
Gyptis brevipalpa	4	-
Haploscoloplos foliosis	4	-
Haploscoloplos sp.	-	4
Haplosyllis spongicola	132	-
Lanicides toboquille	36	-
Maldanidae sp. (damaged or juvenile)	8	-
Naineris laevigata	52	-
Nereidae (damaged)	4	-
Nereis (neanthes) acuminata	48	-
Nematonereis sp.	20	-
Notomastus latericeus	28	-
Odontosyllis fulgurans	4	-
Parahesione luteola	-	4
Paraonides lyra	68	48
Platynereis dumerilii	16	-
Podarke obscura	8	-
Polydora ligni	40	-
P. websteri	-	52
Prionospio heterobranchia texana	160	-
Proscoloplos sp. A	4	-
Schistomeringos rudolphi	120	-
Scyphoproctus sp. A	24	-
Sphaerosyllis sp. A	4	-
Sphaerosyllis sp. B	4	-
Spirorbis corrugatus	40	8

Table 10. (cont'd) Results of benthic macroinvertebrate sampling at Control Station 2 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES May	SUM OF 3 REPLICATES October
Class Polychaeta (continued)		
Streblosoma hartmanae	24	-
Tharyx annulosus	4	8
Tharyx cf. setigera	4	-
Tubificidae sp.	20	-
Tubificoides (Peloscolex) sp.	8	-
Typosyllis annularis	48	-
Typosyllis sp. A	104	-
Typosyllis sp. B	52	-
Typosyllis sp. C	4	-
Typosyllis sp. E	4	-
Class Gastropoda (snails)		
Alvania auberiana	4	-
Bittium varium	4	-
Bulla striata	28	-
Caecum pulchellum	640	36
Cerithidae (damaged)	4	-
Cerithium muscarum	-	4
Costoanachis catenata	-	8
Crepidula maculosa	12	-
C. plana	-	4
Cylichnella canaliculata	4	4
Cylindrobulla beauii	12	-
Dentimargo aureocincta	24	-
Gastropoda sp. A	4	-
Gastropoda (damaged)	8	-
Geukensia demissa	-	12
Haminoea antillarum	8	-
Meioceras nitidium	108	-
Modulus modulus	8	8
Odostomia ? (juvenile)	4	-
Odostomia sp. C	8	-
Phyllaplysia smarada	4	-
Polycera sp. B	4	-
Prunum apicinum	24	-
P. lavalleeanum	12	-
Rissoina catesbyana	60	-
Turbinidae sp. A	12	-
Turbonilla (chemitzia) sp. A	4	-
Triptychus niveus	4	-
Vitrinella floridana	4	40
Vitrinellidae (damaged)	4	-

Table 10. (cont'd) Results of benthic macroinvertebrate sampling at Control Station 2 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES	
	May	October
Class Pelecypoda (bivalves)		
Amygdalum papyrium	-	40
Anomalocardia auberiana	-	36
Branchidontes domingensis	100	-
Branchidontes sp.	-	116
Carditamera floridana	28	-
Gouldea cerina	-	8
Lyonsia floridana	-	8
Lyonsia spp. (damaged)	4	-
Mytilidae (juvenile)	8	128
Mytilopsis leucophaeta ?	-	44
Ostreidae (juvenile)	-	4
Parastarte triquetra	-	4
Pelecypoda (damaged)	-	4
Pitar fulminatus	4	-
Pteria sp. (juvenile)	-	4
Sportellidae sp. A	-	16
Tellina sp. (juvenile)	-	192
Class Polyplacophora (chitons)		
Chaetopleura apiculata	4	-
Ischnochiton papillosus	168	-
Class Crustacea (ostracods, copepods, cumaceans, caprelids, tanaids, isopods, amphipods)		
Haplocytheridea ? sp. A	4	-
Copepoda	92	-
Cumacea sp. A	8	-
Paracaprella tenuis	256	-
Hargeria rapax	-	512
Kalliapseudes sp.	12	-
Pagurapseudes sp. A	16	-
Tanais sp.	4	-
Apanthura magnifica	8	-
Erichsonella filiformis	20	32
Cymodoce faxoni	64	4
Paracerceis sp.	28	-
Amphipoda	52	-
Amphithoe sp.	-	12
Aoridae	4	-
Cymodusa comptu	-	144
Cymodusa spp.	32	536

Table 10. (cont'd) Results of benthic macroinvertebrate sampling at Control Station 2 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES May	SUM OF 3 REPLICATES October
Elasmopus levis	28	-
E. pocillimanus	-	12
E. floridana	8	-
Elasmopus sp.	16	-
Class Crustacea (amphipods, shrimp, barnacles crabs)		
Gitanopsis tortugae	72	392
Grandidierella bonnieroides	4	472
Lembos sp.	4	-
Lysianopsis alba	124	-
Melita appendiculata	92	-
M. elongata	-	4
Melita spp.	-	16
Melitidae	44	12
Caridea	24	-
Thor floridanus	8	-
Thor sp.	12	-
Balanus sp.	4	-
Brachyiura	-	4
Class Insecta (midges)		
Chironomidae	52	20
Class Pantopoda sea spiders)		
Achelia sawayai	24	-
Anoplodactylus pectinus	40	-
Anoplodactylus sp.	8	-
Callipallene brevirostris	4	-
Class Ophiuroidea (brittle stars)		
Amphioplus abditus	4	-
A. thrombodes	4	-
Amphiuridae	8	-
Ophiactis sp.	64	-
Class Holothuroidea (sea cucumbers)		
Leptosynapta sp.	84	-
Synaptidae	32	-
Synaptula hydriformis	526	-
Class Ascidacea (sea squirts)	4	-

Table 10. (cont'd) Results of benthic macroinvertebrate sampling at Control Station 2 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES	
	May	October
Class Anthozoa (sea anemones)		
Anenome sp.	8	-
Phylum Nematoda (round worms)	364	-
Phylum Nemertinea (proboscis worms)	172	4
Phylum Platyhelmenthes (flatworms)	8	4
Phylum Sipuncula (sipunculan worms)	4	-
Phylum Chaetognatha (arrow worms)	4	-
Total individuals	6066	3080
Total biomass (g)	0.4224	0.3392
Density (no./m^2)	87,155	44,253
Biomass (g/m^2)	6.069	4.874
Index of diversity	5.50	3.81
Equitability	0.53	0.46

Table 11. Results of benthic macroinvertebrate sampling at Control Station 3 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES May	SUM OF 3 REPLICATES October
Class Polychaeta (worms)		
Brania clavata	4	-
Capitella capitata	4	-
C. jonesi	4	-
Cirratulidae (damaged)	36	-
Cirratulus sp. A	8	-
Exogone verugera	36	-
Fabricia sp.	280	20
Glyptis brevipalpa	-	4
Laonereis culveri	-	20
Naineris laevigata	4	-
Nereidae (juvenile)	-	4
Paraonides lyra	212	68
Polydora ligni	4	-
Prionospio heterobranchia texana	96	-
Schistomoringos rudolphi	4	-
Sphaerosyllis sp. A	24	-
Sphaerosyllis sp. B	4	-
Spirorbis corrugatus	20	-
Trichobranchus glacialis	12	-
Tubificidae sp.	116	172
Tubificoides (Peloscolex)	24	4
Typosyllis sp. B	4	-
Class Pelycypoda (bivalves)		
Tellina sp. (juvenile)	-	4
Class Crustacea (ostracods, cumaceans, copepods, caprelids, tanaids, amphipods, snapping shrimp)		
Parasterope pollex	4	-
Sarsiella zostericola	28	-
Cumacea sp. A	4	-
Copepoda	16	-
Paracaprella tenuis	4	-
Hargeria rapax	-	8
Gitanopsis tortugae	4	20
Grandidierella bonnieroides	20	76
Melita elongata	-	4
Melita spp.	-	8
Rudilemboides naglei	8	-
Alpheus sp.	4	-
Class Insecta (midges)		
Chironomidae	-	4

Table 11. (cont'd) Results of benthic macroinvertebrate sampling at Control Station 3 at the Turkey Point Plant during 1981.

ORGANISMS	SUM OF 3 REPLICATES	
	May	October
Phylum Nematoda (round worms)	116	-
Phylum Nemertinea (proboscis worms)	32	12
Phylum Sipuncula (sipanculan worms)	16	-
Total individuals	1152	428
Total biomass (g)	0.3244	0.0348
Density (no./m2)	16,552	6,149
Biomass (g/m/m2)	4.661	0.500
Index of diversity	3.64	2.75
Equitability	0.58	0.62

Table 12. Physical data recorded during benthic sampling at the Turkey Point Plant during 1981.

STATION	MONTH	TEMPERATURE (°C)	SALINITY (ppt)	DISSOLVED OXYGEN (ppm)
RC.0	May	29.2	45.0	3.6
	October	29.8	28.0	4.6
RC.1	May	30.1	45.0	10.4
	October	29.6	28.0	5.9
E3.2	May	28.8	46.0	5.7
	October	27.8	26.0	6.0
RF.3	May	28.1	45.0	4.7
	October	28.2	27.0	5.3
WF.2	May	29.3	37.0	4.8
	October	32.0	26.0	4.6
W18.2	May	30.5	45.0	3.0
	October	30.9	27.0	5.7
W6.2	May	30.4	46.0	4.0
	October	31.0	27.0	6.0
F.1	May	36.0	45.0	4.2
	October	38.0	28.0	4.7
Control 1	May	25.1	41.0	6.4
	October	25.0	15.0	3.3
Control 2	May	24.9	42.0	3.3
	October	25.8	14.0	4.4
Control 3	May	25.1	43.0	3.8
	October	25.9	14.0	2.6

Table 13. Comparison of the mean density, biomass and diversity of the Turkey Point Canal Stations.

DATE	DENSITY (no./m^2)	BIOMASS (g/m^2)	DIVERSITY
1980			
April	9575	11.56	3.36
October	8858	2.34	2.39
1981			
April	8358	9.14	3.23
October	4449	5.31	3.00

Table 14. Comparison of the mean density, biomass and diversity of the Turkey Point Canal Stations.

DATE	DENSITY (no./m2)	BIOMASS (g/m2)	DIVERSITY
1980			
April	14,377	12.05	4.47
October	16,640	1.04	4.10
1981			
April	36,600	3.90	4.70
October	21,188	2.85	2.88

Table 15. Correlation coefficients of biomass, density and diversity vs. dissolved oxygen, salinity and temperature for benthic macroinvertebrate at the Turkey Point Plant in 1981.

PARAMETERS	MONTH	TEMPERATURE (°C)	SALINITY (ppt)	DISSOLVED OXYGEN (ppm)
Density ($no./m^2$)	May	-0.50	-0.09	-0.25
	October	-0.52	-0.56*	-0.17
Diversity	May	-0.80*	-0.22	0.15
	October	-0.43	0.07	0.33
Biomass (g/m^2)	May	-0.09	0.20	-0.05
	October	0.14	0.38	0.56*

*Statistically significant correlation at the P=0.05 levels.

Table 16. Annual means of temperature, density and diversity for the macroinvertebrate station groups at the Turkey Point Plant in 1981.

STATION GROUP	TEMPERATURE (°C)	DENSITY (no./m^2)	DIVERSITY
Control	25.30	28,894	4.58
East	28.95	12,557	3.68
West	30.68	4,751	2.76
Discharge	37.00	920	1.90

4. Recovery in the Grand Canal Discharge Area (ETS 4.1.1.1.4)

Introduction

This study documents the recovery of the marine flora in the Grand Canal Discharge Area. Grand Canal discharged into Biscayne Bay from 1967 to 1973. Area damage was a result of thermal, scouring, and turbidity effects of the effluent.

Materials and Methods

A qualitative and quantitative study of the revegetation of the Grand Canal Discharge Area (Figure 1) was conducted on a semi-annual basis. This study employed three methods to map and evaluate the recovery of seagrasses and macroalga. A combination of aerial and plane table surveys, *in situ* density determinations, and *in situ* transect surveys constituted the study.

Method 1 - Aerial and Plane Table Surveys

The revegetation of the affected Grand Canal Discharge Area was assessed using aerial photographs taken from an altitude of 2000 feet. The scale of the photograph was determined by measuring known reference points on Turtle Point. Tracings of the different floral populations were made from the photographs. A plane table survey using a Keuffel and Esser paragon conventional expedition alidade and a fiberglass Philadelphia rod was carried out to determine, in acres, the affected area and compare it to the baseline data of Thorhaug (Bader and Roessler, 1972).

Method 2 - Quadrat Stations

Quantitative measurements of seagrass and algal densities were made by counting and identifying the vegetation at six stations of one square meter each. Stations X-1, X-2, X-3, and X-4 are permanently located 100, 200, 400, and 600 feet east of the mouth of the former discharge canal respectively. Station X-2N is located approximately 200 feet north northeast of X-2. Station X-2S is located approximately 200 feet south southeast of X-2.

Method 3 - Transects

Three east-west transects and two north-south transects, represented by dotted lines in Figures 2 and 3, were surveyed to to determine the different floral zones in the affected area. Relative abundance, sediment depths, general conditions, and macroalga present were also determined during this survey. The surveys primarily served to "ground truth" the aerial photographs.

Results

June 1981

The analysis of the aerial photograph and transect swim indicated four community zones in the previously affected area (Figure 2). Listed in order from west to east were a *Halodule wrightii* community, a mixed *Thalassia testudinum* and *H. wrightii* community, a *T. testudinum* community, and a *T. testudinum* community with large patches of *Syringodium filiforme*.

Results of the quadrat density analysis are summarized in Table 1. *Halodule wrightii* was dominant at Stations X-1 and X-2S. *Syringodium filiforme* was dominant at X-2N. *Thalassia testudinum* was dominant at Stations X-2, X-3, and X-4. These results correspond roughly to seagrass zones determined from the aerial photographs and the transect swim.

October 1981

The October photograph and transect swim showed four zones. A zone of macroalgae dominance occurred around the mouths of Grand Canal and the tidal creek. A large zone of blue-green algae and detrital mat was noted to the north of Station X-2. Zones of *T. testudinum*, *H. wrightii* mixed dominance were recorded from Stations X-2 to X-3. *Thalassia testudinum* was dominant at tation X-3. *Syringodium filiforme* decreased from X-4 to the east.

A zone of mixed dominance was recorded in the area north of the tidal creek and an additional zone occurred south of the mouth of Grand Canal.

The results of the October quadrat density analysis are summarized in Table 2. *Thalassia testudinum* was dominant at all six stations.

Annual

The alidade analysis revealed a total affected area of 0.21 acres (Figure 4). This roughly corresponds to the velocity scarp (canal drop off) visible in the aerial photographs. The alidade figures for 1981 show that more than half the 1980 denuded area has been recovered by marine flora.

Discussion

June 1981

The vegetation in the area of X-1 was composed of sparse H. wrightii with some T. testudinum present. Macroalga were very abundant to the west of X-1 in the vicinity of the former discharge canal drop off. Caulerpa prolifera was the most abundant algae. Also present in the area were species of Acetabularia, Laurencia, Halimeda, and Dictyota.

The west to east zonation patterns encountered during the north transect swim were a H. wrightii zone, a zone of mixed dominance, and a T. testudinum zone. Rhizophora mangle radicles and Avicennia germinan seedlings were recorded as were species of Halimeda, Caulerpa, Penicillus, Acetabularia, and Batophora.

The west to east zonation patterns encountered during the south transect swim were a mixed dominance zone and a T. testudinum zone. Species of Halimeda, Caulerpa, Penicillus, Udotea, Acetabularia, Laurencia, and Rhipocephalus were present.

October 1981

The vegetation in the area of X-1 was extremely sparse. The macroalgae Caulerpa prolifera was the dominant plant in the Grand Canal mouth area. Thalassia testudinum and H. wrightii were present but were very sparse. Other macroalgae noted were species of Penicillus and Caulerpa mexicana.

The northern transect swim traversed three marine floral communities. The west to east zonation patterns were a Caulerpa prolifera zone, a detrital and blue-green algal mat zone, and a T. testudinum. Various species of green macroalgae were noted during the transect swim.

The southern transect swim traversed four zones. The west to east zonation patterns were a mixed dominance zone, a detrital and blue-green algal mat zone, a zone of mixed dominance, and a T. testudinum zone. The macroalga encountered were species of Halimeda, Penicillus, Caulerpa, Udotea, Digenia, Anadyomene, and Acetabularia.

The sediments in the vicinity of all stations except X-1 were greater than six inches deep and composed of Thalassia blades, algae, mangrove leaves, and animal remains (crustacean cuticle, molluscan shells, etc). The scoured area of the velocity scarp was covered with one to two inches of fine organic silt.

Thorhaug (Bader and Roessler, 1972) reported that areas of decreased sediment depth were unable to sustain large populations of T. testudinum due to its extensive root and rhizome system, but major macroalga flourished under these conditions. This might explain the dense macroalga population and the lack of seagrasses at the immediate mouth of Grand Canal Discharge Canal.

The extensive detrital and blue-green algal mat zone reported during the October survey may have been caused by the effects of Tropical Storm Dennis which dropped 11.53 inches of precipitation on south Florida (Homestead Air Force Base Weather Service Data). The salinity in Biscayne Bay/Card Sound prior to Dennis was 38 o/oo. Approximately one month after the storm, salinities in the low 30's were recorded and in October the salinity reached 18 o/oo (FP&L unpublished data). Temperatures in the low to mid 80's were recorded for the waters of Card Sound during this period (FP&L unpublished data). Conover (1954) reported that some benthic marine plants have a decreased tolerance for low salinity and high temperatures. Also, the opening of flood gates and the high winds of the tropical storm caused extremely turbid conditions in Biscayne Bay. Visibility was six inches or less during the October survey. Thorhaug (Bader and Roessler, 1972) reported that wave action and turbidity were factors adversely affecting local distribution of seagrasses and macroalgae.

In general, all stations exhibited a seasonal fluctuation of grass and macroalgal densities with lower densities occurring during

the summer months. The densities of all stations, except X-1, appeared essentially the same as those found in the baseline report (Bader and Roessler, 1972). However, they were not directly comparable since the units of enumeration used in these studies differed. The present study used fascicles (sheaths of blades) per square meter while the baseline study used blades per square meter as an indication of density.

Conclusions

The previously affected area has revegetated and supports a seagrass macroalgae community very similar to the community described in the baseline studies (Bader and Roessler, 1972). The large denuded area recorded for October is most likely due to the effects of Tropical Storm Dennis. The non-recovered area (0.21 acres) at the mouth of the former discharge canal will continue to recover at a slow rate and will not support a floral community of densities similar to adjacent areas until a stable sediment base becomes established.

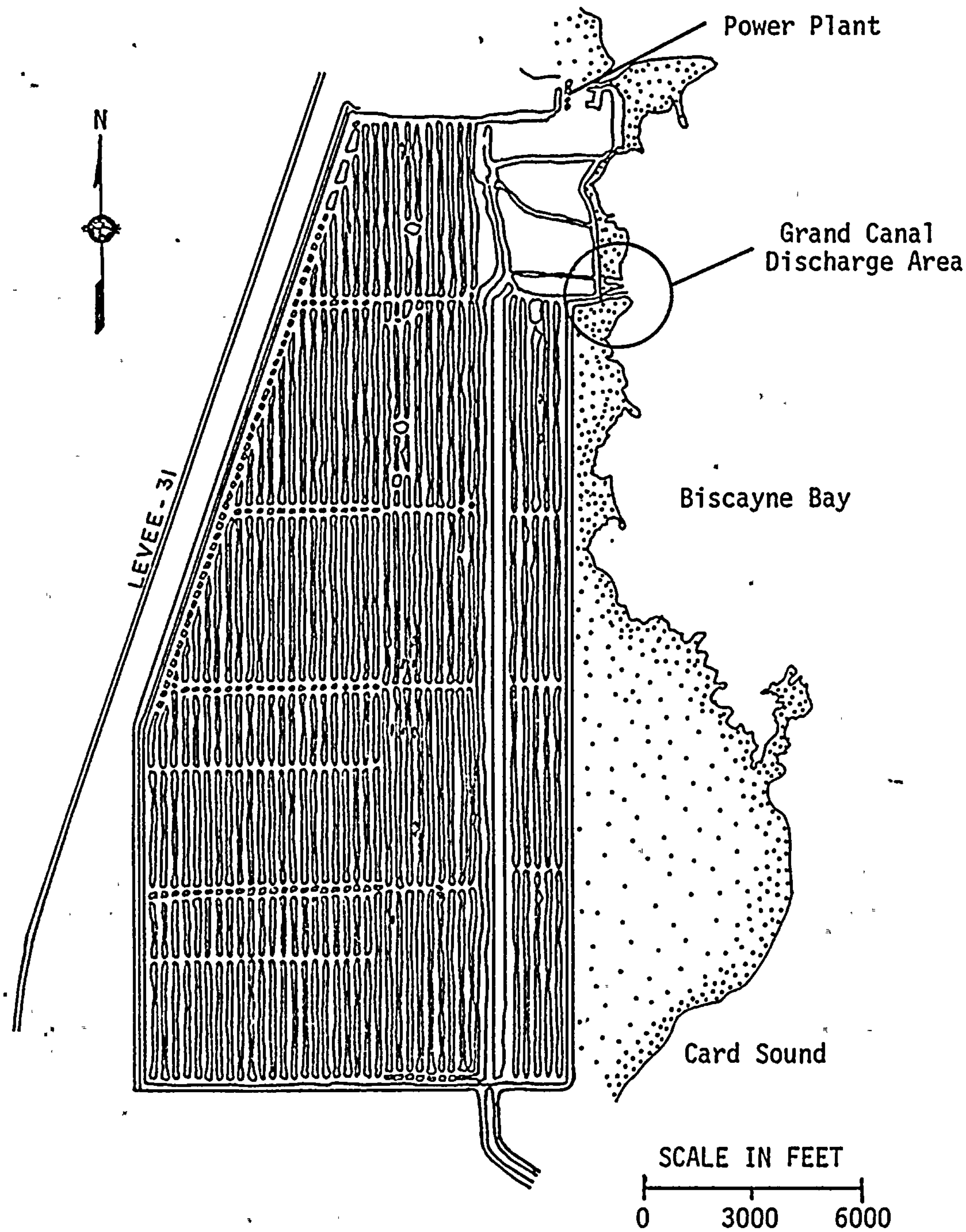


Figure 1. Location of Turkey Point Power Plant Grand Canal Discharge, closed in February 1973.

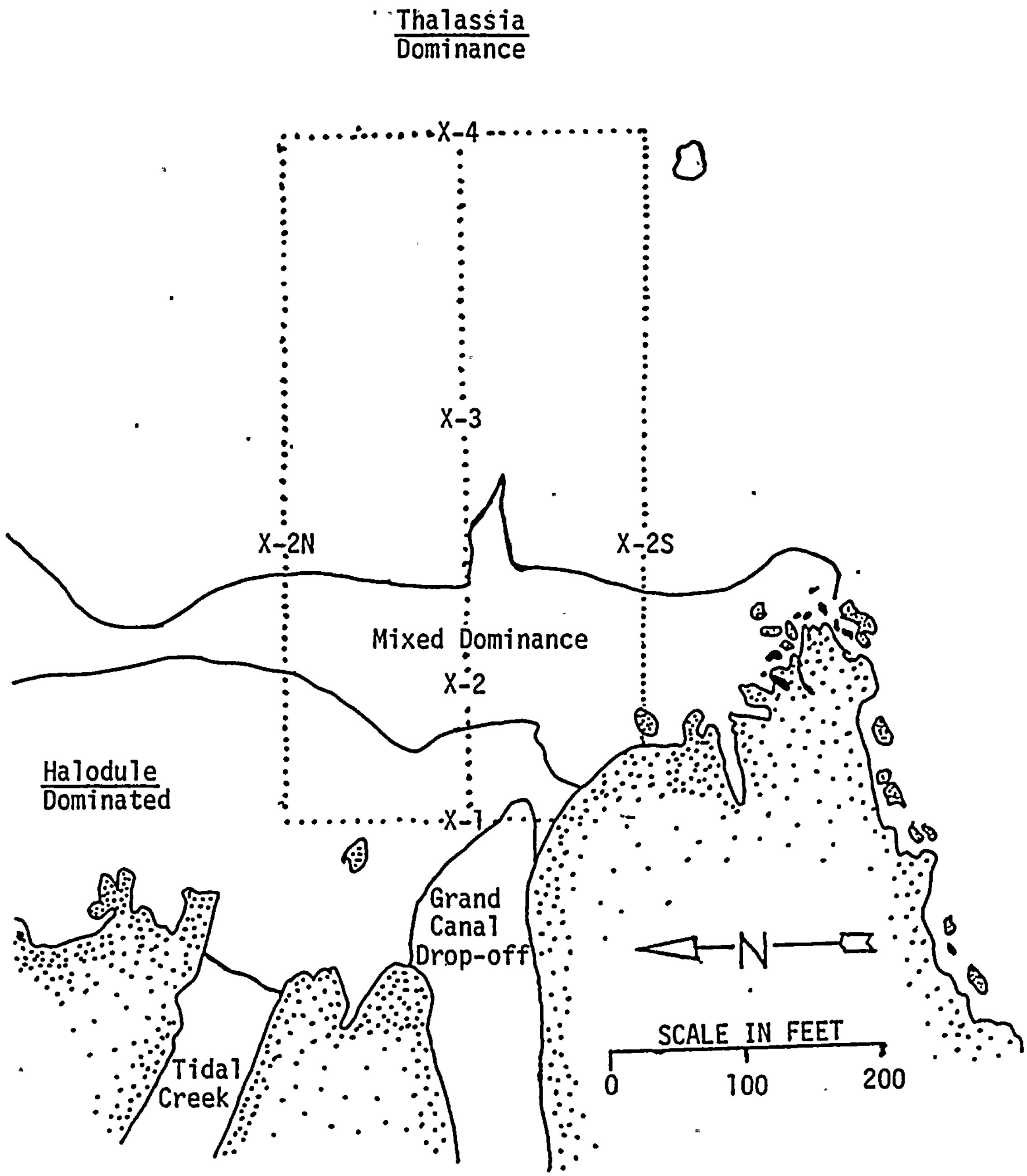


Figure 2. Tracing of Aerial Photograph of previously affected area at Turkey Point Power Plant, Grand Canal Discharge, June 1981.

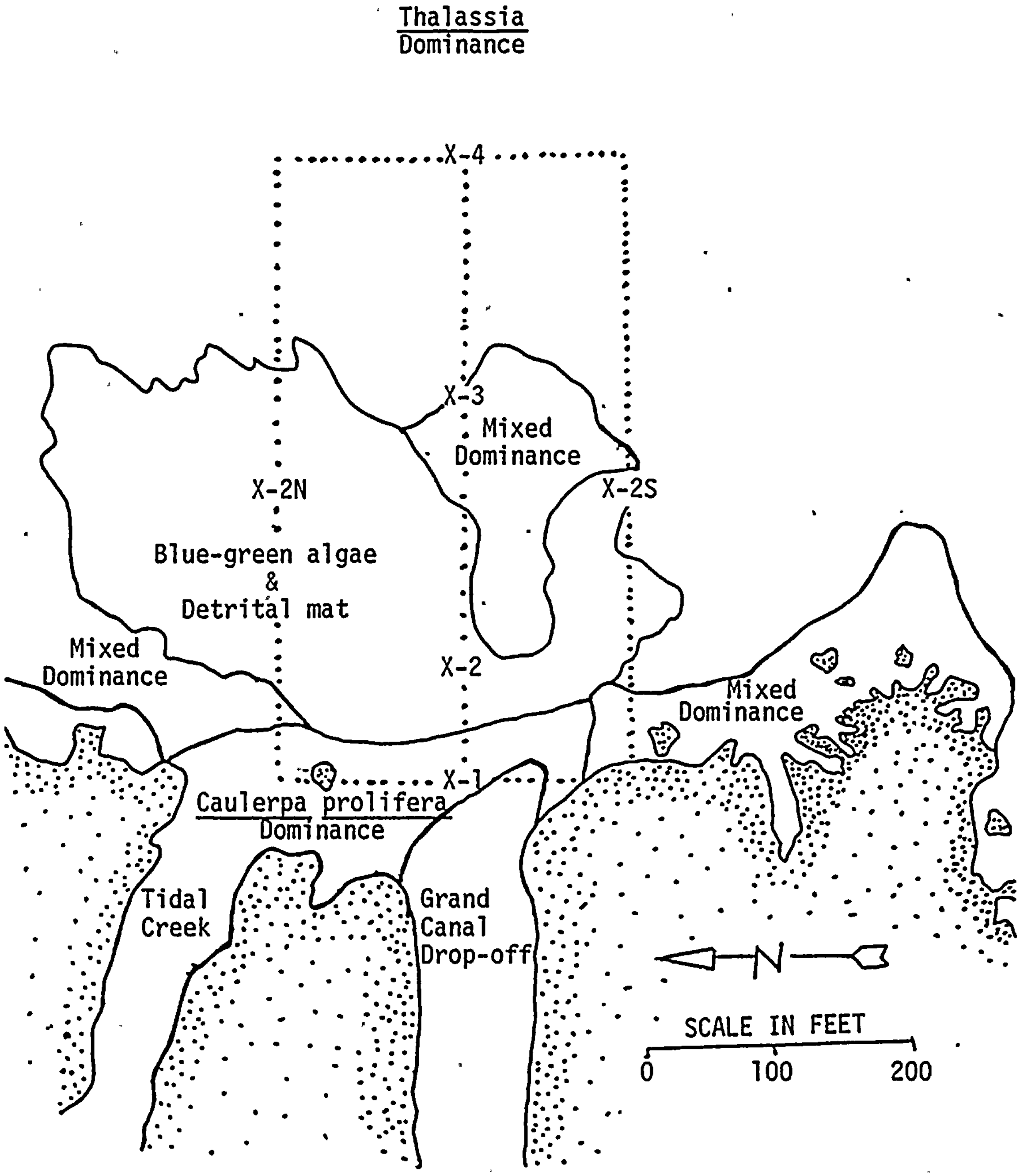


Figure 3. Tracing of Aerial Photograph of previously affected area at Turkey Point Power Plant, Grand Canal Discharge, October 1981.

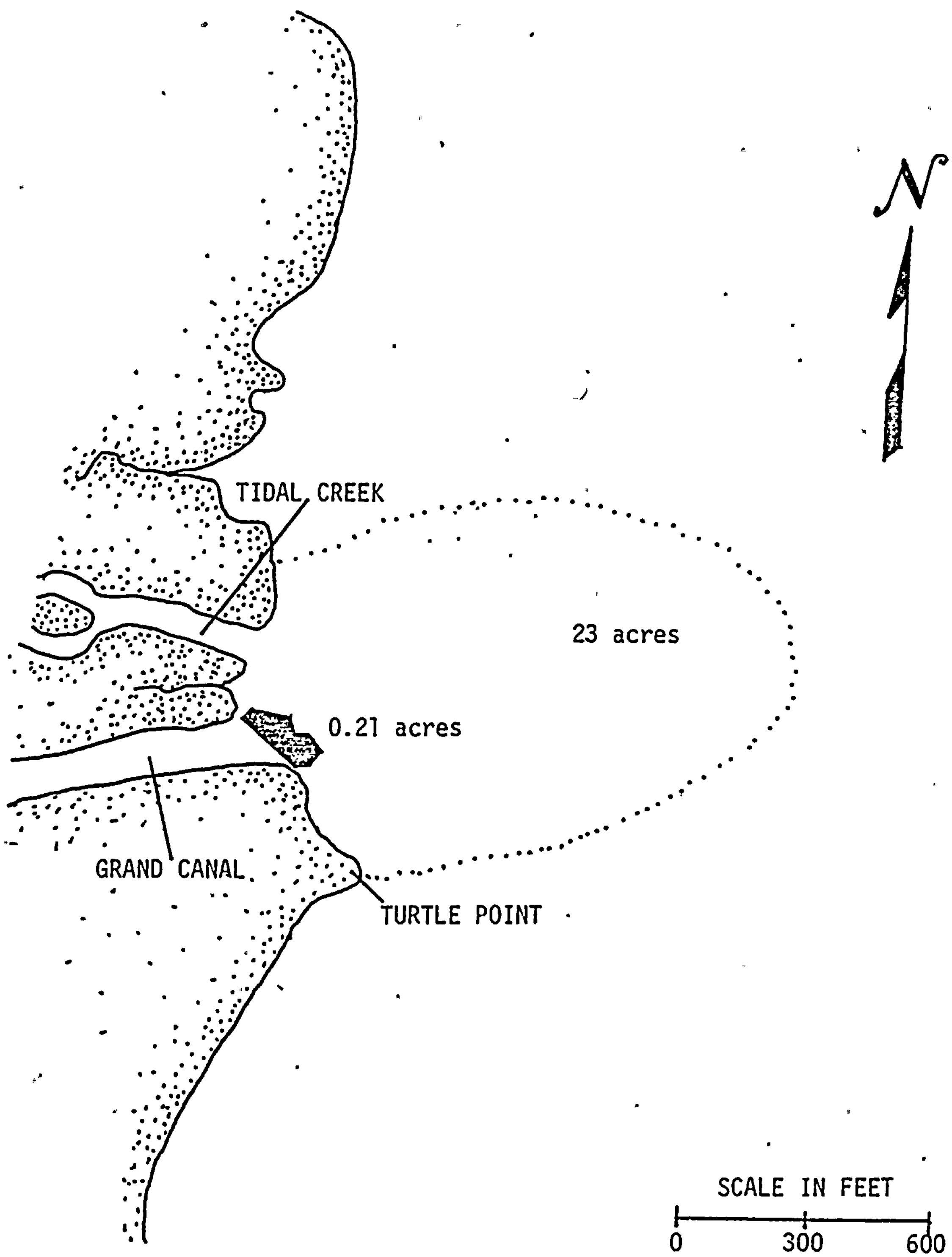


Figure 4. Comparison of plane table surveys of previously affected Turkey Point Power Plant Grand Canal Discharge Area after Thorhaug, October 1971 (dotted line) and Florida Power & Light, June 1981 (blackened area).

Table 1. Quadrat Study of the marine flora at the Turkey Point Plant Grand Canal Discharge, June 1981.

FLORA	QUADRATS					
	X-1	X-2	X-3	X-4	X-2N	X-2S
ANGIOSPERMS:						
Halodule wrightii[a]	148	---	---	---	---	388
Thalassia testudinum[a]	76	116	532	576	448	344
Syringodium filiforme[a]	---	---	---	516	480	---
CHLOROPHYTA:						
Acetabularia sp.	b	---	b	b	b	b
Anadyomene stellata	---	---	b	---	---	---
Avrainvillea nigricans[c]	---	---	---	---	---	---
Batophora oerstedi	---	b	b	b	b	b
Caulerpa sp.	b	b	b	b	b	b
Halimeda sp.	b	---	b	---	b	b
Penicillus sp.	---	b	---	---	---	---
Rhipocephalus sp.	---	---	b	---	---	b
Udotea sp.	---	---	---	b	---	b
PHAEOPHYTA:						
Dictyota sp.[c]	---	---	---	---	---	---
RHODOPHYTA:						
Digenia sp.[c]	---	---	---	---	---	---
Laurencia sp.	---	---	---	---	---	b
OTHERS:						
Rhizophora mangle[c]	---	---	---	---	---	---

[a] Number of fascicles/m^2.
[b] Present
[c] Present in previous years.

Table 2. Quadrat Study of the marine flora at the Turkey Point Plant Grand Canal Discharge, October 1981.

FLORA	QUADRATS					
	X-1	X-2	X-3	X-4	X-2N	X-2S
ANGIOSPERMS:						
Halodule wrightii[a]	96	104	124	184	---	100
Thalassia testudinum[a]	124	156	596	820	288	120
Syringodium filiforme[a]	---	---	---	140	---	---
CHLOROPHYTA:						
Acetabularia sp.	---	---	---	---	b	---
Anadyomene stellata[c]	---	---	---	---	---	---
Avrainvillea nigricans[c]	---	---	---	---	---	---
Batophora oerstedi	---	---	---	---	b	---
Caulerpa sp.	b	---	b	---	---	---
Halimeda sp.	---	---	b	---	---	b
Penicillus sp.[c]	---	---	---	---	---	---
Rhipocephalus sp.[c]	---	---	---	---	---	---
PHAEOPHYTA:						
Dictyota sp.[c]	---	---	---	---	---	---
RHODOPHYTA:						
Digenia sp.[c]	---	---	---	---	---	---
Laurencia sp.[c]	---	---	---	---	---	---
OTHERS:						
Rhizophora mangle[c]	---	---	---	---	---	---

[a] Number of fascicles/m^2.
[b] Present
[c] Present in previous years.

5. Grasses and Macrophyton Invasion/Revegetation (ETS 4.2.2.2)

Introduction

Grasses and macrophyton can have potentially detrimental effects on the thermal and hydraulic efficiency of the Turkey Point Cooling Canal System, hereafter referred to as the canal system. This study qualitatively assesses the diversity and extent of seagrasses and macroalga within the canal system in order to monitor changes in populations which might effect power plant operations.

Materials and Methods

Identification and quantification of seagrasses and macrophyton were made during a yearly survey and periodically in conjunction with other monitoring programs in the canal system.

Results

Thirty-five genera of seagrasses and macrophyton were identified in the canal system during 1981 (Table 1) compared to fifteen for 1980, twelve for 1979 and eleven reported during the baseline study (Bader & Roessler, 1972). Concentrations of these plants were scattered throughout the canal system with the most dense assemblages in the southwest corner and the eastern return canals (Figure 1).

The effectiveness of the "drag bar", a means of clearing the canals of aquatic weeds (FPL, 1980), was determined this year. The results obtained employing this method were very similar to the results

obtained using the rotary cutting head or "rotavation" (FPL, 1980). One year after these two methods were employed the densities of Ruppia maritima (commonly known as widgeon grass, ditch grass or sea tassle) were approximately the same as the control canal. In addition, the seagrass was more uniformly distributed in the test canal than the control canal.

In addition to the previously colonized canals this year R. maritima was found in heavy concentrations in the eastern canals and the south ends of western canals 7 through 16.

Discussion

Ruppia maritima continued to be the seagrass of primary importance in the canal system (FPL, 1979-1980). It is no longer confined to the southwest canals and was observed in very heavy concentrations in the eastern return canals and many western canals formerly not colonized. The dramatic increase in this species was thought to be due to the inefficient entrainment techniques used during the "rotavation" and "drag bar" experiments. This grass grew to lengths of 4 to 8 feet and seasonally became encrusted with heavy epiphytic growth. The length of the grass and the epiphytic encrustations combined to severely impede water flow in the affected canals.

The apparently large increase in the number of macroalga over previous years was not significant. This increase was primarily due to an effort made this year to collect rarely occurring specimens and to enumerate to the species level alga previously listed only to genera.

Also found in the canal system were the marine angiosperms Halodule wrightii (formerly known as Diplanthera wrightii), shoalgrass; Halophila englemanni, no common name; Thalassia testudinum, turtle grass; and Syringodium filiforme, manatee grass. The northernmost sections of the eastern return canals continued to represent the area with the heaviest growth of the latter two grasses.

Halodule wrightii was particularly well represented by stands on both east and west sides. Due to the finite growth habit of its fascicles, this species was thought to be of little consequence in restricting water movement. However, in dense stands or on rocky substrates, this species' runners, which are normally attached to the substrate by holdfasts, overlapped each other in such a way that the holdfasts did not reach or penetrate the substrate. This resulted in long floating strands that obstructed water flow in a manner similar to R. maritima.

Syringodium filiforme and T. testudinum showed no significant changes in abundance since last year. Halophila englemanni was fairly common on the east side of the canal system.

Various red and brown alga continued to be found along the rocky shoreline of most of the canals (Table 1). Dasya sp. grew predominantly in the winter months on rocks in the shallower canals and was associated with high water velocity. Laurencia spp. were

observed scattered throughout the canal system. The brown algae, *Sargassum filipendula*, increased in the eastern return canals over last year. However, densities were still extremely low and this fucale was considered to be of little consequence to the marine ecology and flow characteristics of the canal system. In greater densities this aglae has the potential of becoming a major flow inhibitor.

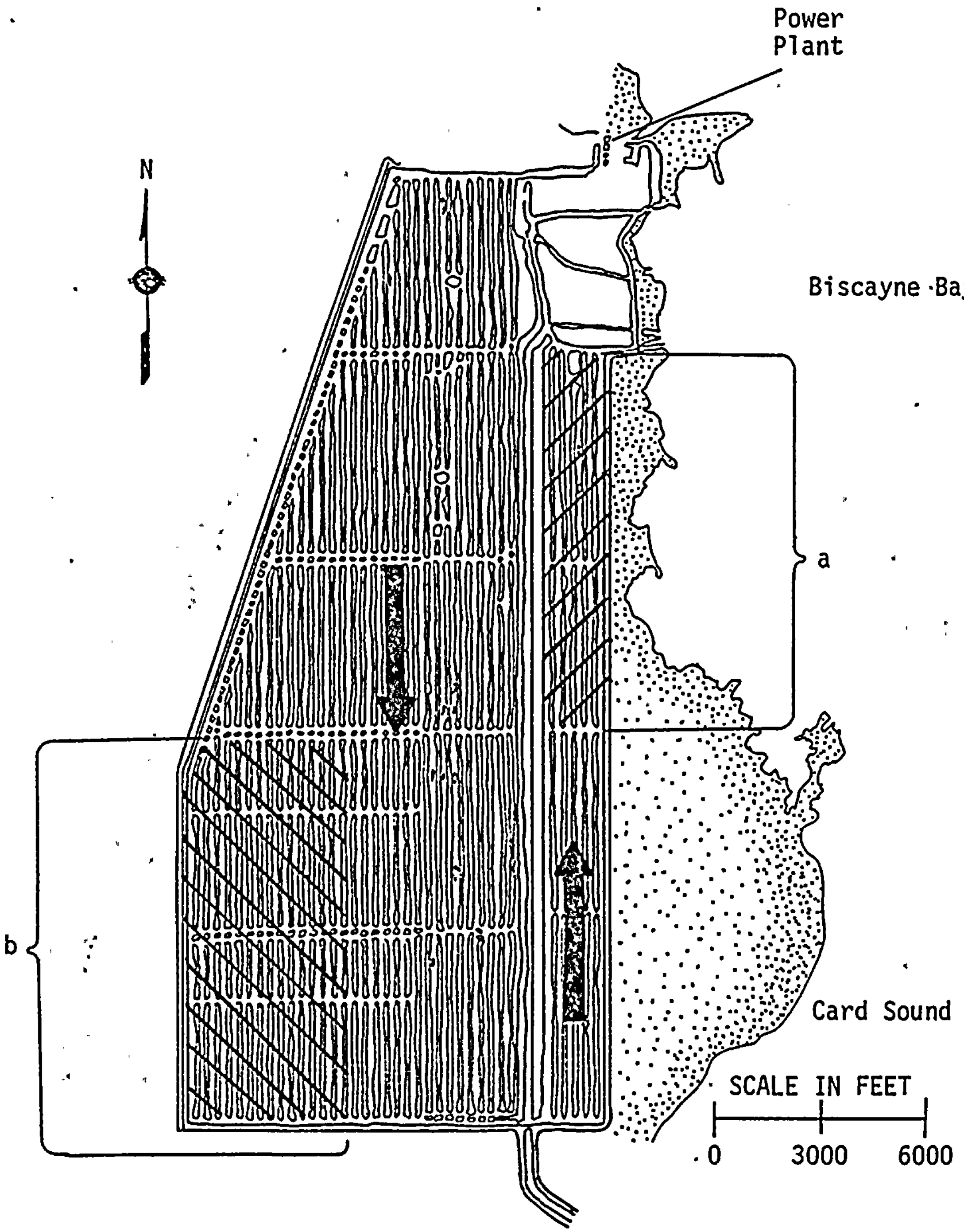
There was substantial green algal growth on solid substrates throughout the system. *Halimeda* spp. were observed on rocks throughout the southern end of the western canals and in the rocky shallows of the eastern return canals. *Penicillus* spp. were prominent in the northeastern canals. *Caulerpa mexicana* occurred in varying densities systemwide. Several other species of caulerpa were also present. *Batophora oerstedi*, *Acetabularia crenulata*, *A. farlowii*, and *Anadyomene stellata* were found as epiphytes on a variety of stable substrates in shallow water.

Sixteen genera were identified in the canal system that were not reported during the baseline study (Bader and Roessler, 1972; Table 1). The baseline study does not appear to be representative of the present floral community of either the canal system or Biscayne Bay/ Card Sound.

Conclusions

In the eastern return canals *R. maritima* has increased significantly and shares dominance of the area with the macroalga. *H. wrightii*

and *R. maritima* continue to dominate the southwest corner of the system on alternating seasonal cycles and will continue to spread rapidly until an effective method of control can be found. The continuing spread and concentration of these seagrasses will reduce the thermal and hydraulic efficiency of the canal system.



[a]Macroalga dominance, seagrasses present to lesser extent.

[b]Area dominated by Ruppia maritima and Halodule wrightii.

Figure 1. Grasses and macrophyton orientation in the Turkey Point Cooling Canal System, 1981.

Table 1. Comparison of macrophyton and seagrasses identified during the baseline study with those in the Turkey Point Cooling Canal System, 1979-1981.

SCIENTIFIC NAME	BASELINE[a] 1972	1979	1980	1981
ANGIOSPERMS				
Halodule wrightii[b]	X	X	X	X
Halophila englemanni	---	---	X	X
Ruppia maritima	---	X	X	X
Syringodium filiforme	---	X	X	X
Thalassia testudinum	X	X	X	X
CHLOROPHYTA				
Acetabularia crenulata	X	X	X	X
Acetabularia farlowii	---	---	---	X
Avrainvillea sp.	X	---	---	---
Anadyomene stellata	---	---	X	X
Batophora oerstedi	X	X	X	X
Caulerpa spp.	X	X	X	c
Caulerpa lanuginosa	---	---	---	X
Caulerpa mexicana	---	---	---	X
Caulerpa prolifera	---	---	---	X
Cladophora crispula	---	---	---	X
Cladophora gracilis	---	---	---	X
Cladophoropsis membranacea	---	---	---	X
Derbesia vaucheriaeformis	---	---	---	X
Halimeda spp.	X	X	X	c
Halimeda incrassata	---	---	---	X
Halimeda tuna	---	---	---	X
Penicillus spp.	X	X	X	c
Penicillus capitatus	---	---	---	X
Penicillus dumetosus	---	---	---	X
Penicillus lamourouxii	---	---	---	X
Rhipocephalus spp.	X	---	X	---
Udotea sp.	X	---	---	---

Table 1. (Cont'd) Comparison of macrophyton and seagrasses identified during the baseline study with those in the Turkey Point Cooling Canal System, 1979-1981.

SCIENTIFIC NAME	BASELINE[a] 1972	1979	1980	1981
CHLOROPHYTA (Cont'd)				
Udotea conglutinata	---	---	---	X
Udotea flabellum	---	---	---	X
PHAEOPHYTA				
Sargassum sp.	---	X	X	c
Sargassum filipendula	---	---	---	X
RHODOPHYTA				
Acanthophora muscoides	---	---	---	X
Acanthophora spicifera	---	---	---	X
Centroceras clavulatum	---	---	---	X
Dasya sp.	---	X	X	X
Dasya pedicillata	---	---	---	X
Digenia simplex	---	---	---	X
Jania rubens	---	---	---	X
Laurencia sp.	X	X	X	c
Laurencia intricata	---	---	---	X
Laurencia papillosa	---	---	---	X
Lophosiphonia saccorhiza	---	---	---	X
Polysiphonia subtillissima	---	---	---	X
Spyridia filamentosa	---	---	---	X

[a] Bader & Roessler, 1972.
[b] Formerly named *Diplanthera wrightii*.
[c] Refer to second paragraph of discussion.

6. GROUNDWATER PROGRAM (ETS 4.1.1.2)

A summary report entitled Groundwater Monitoring Program, Turkey Point, Florida, prepared by Florida Power & Light Company's consultant Dames & Moore, for period July 1, 1981 through June 30, 1982 will be forwarded to NRC by August 30, 1982.

B. TERRESTRIAL ENVIRONMENT

1. Revegetation of Cooling Canal Banks (ETS 4.2.1)

a. Natural Revegetation

Introduction

This study measures the density of the floristic species and their rate of recolonization on the spoil berms created by constructing the cooling canals.

Materials and Methods

Data were gathered semi-annually from six stations located within the Turkey Point Cooling Canal System (Figure 1). One 10 meter by 10 meter quadrat was permanently staked out at each of the six stations on the canal system spoil berms. Two meter by 10 meter quadrats, established along the shoreline at each of the six stations, were monitored to estimate *Rhizophora mangle* growth and reinvasion rates. Tabulated data were presented as number of individuals with the exception of *Casuarina equisetifolia* and *Conocarpus erectus*. Only individuals greater than 3 feet for *C. equisetifolia* and greater than 1 foot for *C. erectus* were reported.

Results

Changes in the number of individuals of all species observed at the six stations since 1976 are listed in Tables 1-6. *Rhizophora mangle* growth and reinvasion rates are presented in Table 7. The common and scientific names of all species identified

since the start of the natural vegetation program in 1975 can be found in Table 8.

Discussion

Station 105S

During 1981 the small vegetation at this station continued to increase in density. Distichilis spicata, Mikania scandens, and Eupatorium capillifolium all exhibited significant increases in density. Two new species, Borrichia frutescens and Melothria pendula, appeared in small numbers. Schinus terebinthifolius which had disappeared from this station in 1980 reappeared during 1981.

Station 204N

During 1981 C. equisetifolia continued to decline as in 1980. Solanum donianum experienced a moderate increase in density during the year. Borrichia frutescens appeared at this station for the first time since January 1976.

Station 310N

Rhizophora mangle, C. equisetifolia and Cladium jamaicensis all exhibited declines in population due to the vegetation control program. Andropogon glomeratus appeared for the first time at this station. All other species remained at approximately the same density level.

Station 323S

This station showed a major decrease in density in all but two of the species present. Conocarpus erectus increased through seedling recruitment by 10 adults. Solanum donianum maintained its high density levels.

Station 408M

Pteris vittata, S. donianum, E. capillifolium and A. glomeratus all showed major increases in density during 1981. Two new species, M. scandens and Trema floridana were identified. Casuarina equisetifolia continued to decline but at a lesser rate than in 1980.

Station 505N

The small vegetation continued to spread within this station. Borrichia frutescens, Aster tenuifolius, and A. glomeratus exhibited the largest density increases. Sabatia stellaris, M. scandens and Rhabdadenia biflora were new species which appeared during 1981.

Two of the six shoreline quadrats (Table 7) showed changes in the adult population of R. mangle. Station 204N experienced the death of its only adult and the population at Station 405M decreased by 4 adults. The adult population for all other stations remained unchanged.

The R. mangle seedling population of Station 408M was the only station to show an increase. The populations of Stations

105S, 204N, and 505N all decreased while Stations 310N and 323S remained unchanged.

Discussion

A vegetation control program has been underway for over two years. This program was designed to control vegetation over 3 feet in height which inhibit wind flow across the waters surface thereby reducing cooling canal efficiency.

Casuarina equisetifolia and S. terebinthifolius are two of the primary target species of the vegetative control program. Both of these trees are undesirable exotic species which have invaded and outcompeted the natural vegetation of south Florida. All six monitoring stations have received herbicide applications. Four of these six stations showed a substantial decrease in the C. equisetifolia populations.

The decrease in large tree species has had a dramatic effect on most small species. Significant increases in D. spicata, A. glomeratus, S. donianum, A. tenuifolius and numerous other species were observed in 1981 as well as in 1980. These increases in previously declining species can be attributed primarily to the vegetation control program, which targeted the woody species of the canopy. Where aerial application was utilized in areas of dense concentration of these large species, little or no herbicide reached the ground. The large species died while the smaller under story

plants were relatively unaffected. The small plants, previously shaded by the large species, receive increased light and nutrient resources and have proliferated accordingly. In conjunction with the above physical selectivity, the herbicide combinations used in the control program were chemically selective for woody species.

Conocarpus erectus was present at all stations. The adult population increased at four stations, decreased at one and remained unchanged at one. Seedlings were too numerous to count at Stations 505N, 323S, and 105S.

The higher elevation caused by berm construction has allowed sufficient edaphic changes to permit non-mangrove community species such as Baccharis halimifolia, Passiflora suberosa and several new species (Tables 1-6) to progressively invade from the western upland side of the canal system.

Comparison with available pre-operational vegetation data is inappropriate since construction of the canal system has disrupted the indigenous topography and vegetative communities in areas within the system. Areas south and west of the system are dealt with in another section of this report (Section III.B.2).

Distichilis spicata, remained the primary ground cover on the western berms (1-7) and continued to spread westward.

This grass grew well even on marl soils and should serve as excellent hurricane protection for the berms. Increases in this species occurred at stations where C. equisetifolia was absent.

Although saw grass, C. jamaicensis, only occurred at three stations, systemwide it was still considered an important ground cover and erosion inhibitor.

Conclusions

Soil type continues to be the apparent factor determining vegetation density. Casuarina equisetifolia and C. erectus dominate the peat and muck soils of the old tidal creeks and hammock areas, while salt grass and saw grass dominate the marl barrens. Casuarina equisetifolia reduces the species richness and the diversity in areas where it dominates. The vegetation control program has been effective in substantially decreasing the dominance of C. equisetifolia which in turn has allowed for greater species diversity. The increased elevations resulting from berm construction have allowed upland species to invade the western areas of the canal system.

The total number of C. erectus has increased sharply when compared to 1980. The increase results from the recruitment of seedlings into the adult population. This is not surprising since three stations had numerous seedlings in 1980. This increase in the adult population is expected to continue during 1982.

The rates of revegetation of *D. spicata* and *C. jamaicensis* is expected to increase as a result of a reduction in competition from the large *C. equisetifolia*.

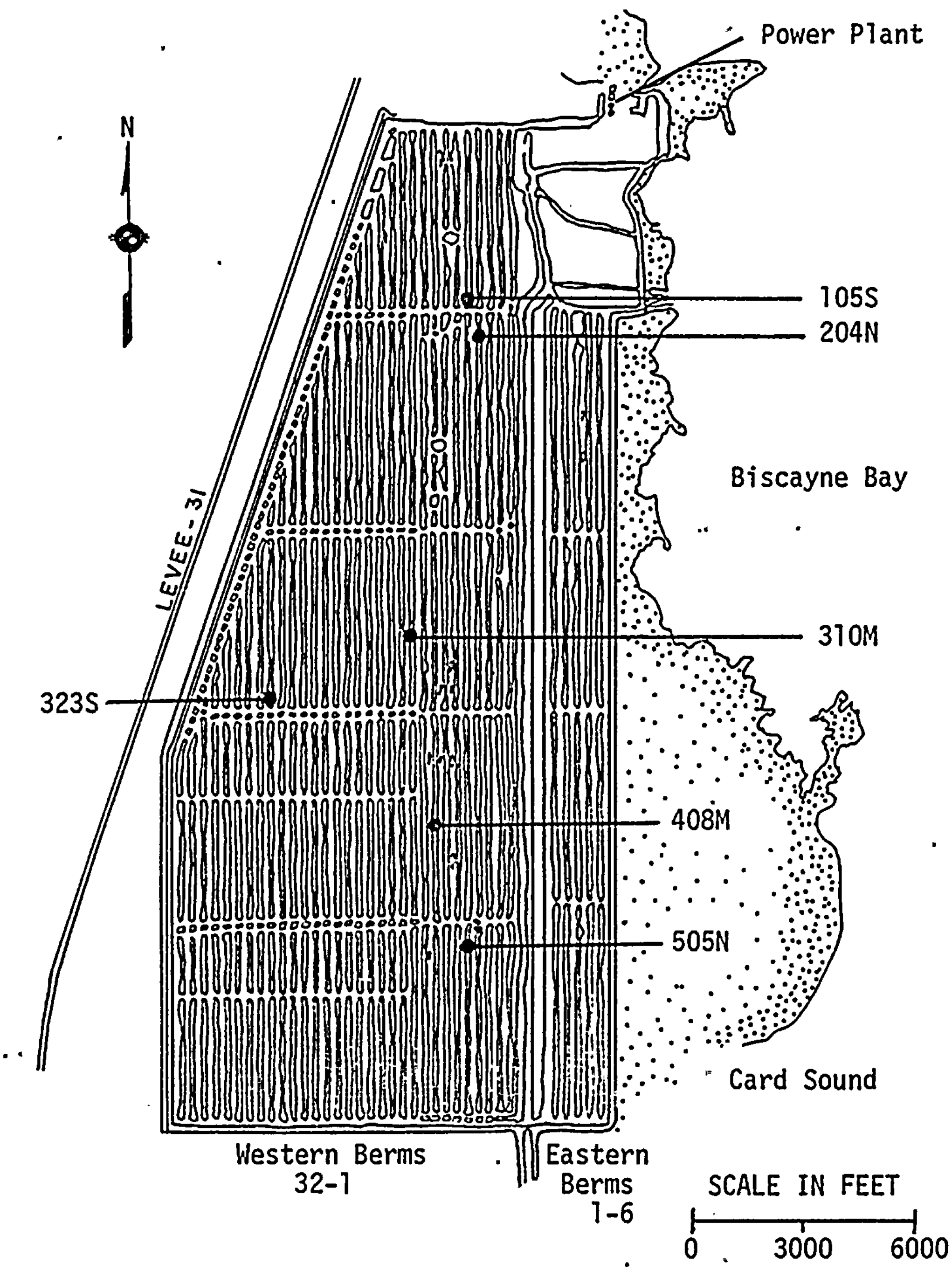


Figure 1. Natural revegetation stations at the Turkey Point Cooling Canal System 1981.

Table 1. Number of individuals per 10 x 10m revegetation quadrat at Station 105S in the Turkey Point Cooling Canal System, 1976-1981.

SCIENTIFIC NAME	1976				1977				1978				1979			1980		1981	
	Jan.	Apr.	Jul.	Oct.	Jan.	Apr.	Jul.	Oct.	Jan.	Apr.	Jul.	Oct.	Jan.	May	Nov.	May	Nov.	May	Nov.
Rhizophora mangle	7	7	6	7	5	4	7	7	7	7	7	7	7	7	7	7	7	7	4
Laguncularia racemosa	7	9	6	6	6	5	7	8	8	8	8	8	8	8	10	10	10	7	7
Conocarpus erectus	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	9
Distichilis spicata[a]	4	7	8	10	9	9	18	15	20	22	30	35	35	35	46	40	35	70	80
Juncus roemerianus	49	19	18	26	19	30	47	30	33	25	15	5	5	5	6	5	4	2	2
Solanum donianum										1	1	2	2	2	15	14	20	10	14
Erechtites hieracifolia												2	2	2	0	0	0	0	0
Baccharis halimifolia												1	3	3	3	4	4	12	12
Eupatorium capillifolium												3	3	3	2	2	0	84	27
Schinus terebinthifolius															2	3	0	11	6
Andropogon glomeratus															1	1	3	1	1
Mikania scandens															1	3	1	9	b
Casuarina equisetifolia																	1	2	1
Borrichia frutescens																		3	0
Melothria pendula																			1

[a]Denotes coverage in m^2.
[b]Too numerous to count.

Table 2. Number of individuals per 10 x 10m revegetation quadrat at Station 204N in the Turkey Point Cooling Canal System, 1976-1981.

SCIENTIFIC NAME	1976				1977				1978				1979			1980		1981	
	Jan.	Apr.	Jul.	Oct.	Jan.	Apr.	Jul.	Oct.	Jan.	Apr.	Jul.	Oct.	Jan.	May	Nov.	May	Nov.	May	Nov.
Baccharis halimifolia	3	1	0	0	0	11	18	23	42	35	40	40	50	50	13	8	0	1	1
Conocarpus erectus	11	11	0	1	2	3	2	2	2	2	2	2	2	2	2	2	1	2	2
Casuarina equisetifolia	20	0	0	8	10	13	31	31	32	30	30	36	37	40	37	38	24	9	8
Acrostichum danaeifolium	3	1	0	4	2	3	4	4	5	5	5	2	2	2	0	0	0	0	0
Eupatorium capillifolium	0	0	0	0	0	0	2	2	2	2	2	0	0	0	0	0	0	0	0
Borrichia frutescens	50	16	30	24	21	43	43	45	4	0	0	0	0	0	0	0	0	0	0
Rhabdadenia biflora	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	1
Sonchus oleraceus	0	0	0	0	0	1	0	0	5	0	0	0	0	0	0	0	1	0	0
Solanum nigrescens				1	2	1	0	0	3	3	3	0	0	0	0	0	0	0	0
Solanum donianum					1	4	1	1	10[a]	10[a]	10[a]	2	2	2	2	1	9	29	32
Chamaesyce mesembryanthemifolia					1	0	0	6	4	1	0	1	2	2	0	0	0	0	0
Pluchea rosea						29	25	40	50	20	0	0	0	0	0	0	0	0	0
Sarcostemma clausa							1	1	1	2	3	10[a]	15[a]	15[a]	90[a]	90[a]	2	1	0
Mikania scandens							2	2	2	25[a]	50[a]	50[a]	40[a]	40[a]	3	0	95[a]	87[a]	95[a]
Physalis angulata								1	1	0	0	0	0	0	1	0	0	0	0
Thelysteris normalis								1	1	4	3	2	2	2	0	0	0	0	0
Aster tenuifolius									3	0	0	0	0	0	0	0	0	0	0
Phytolacca rigida									4	5	7	9	1	1	5	3	0	0	0
Erechtites hieracifolia									5	30	25	0	0	0	0	0	3	0	0
Schinus terebinthifolius												1	1	1	1	0	0	0	0
Melothria pendula															3	6	50[a]	50[a]	35[a]
Lantana camara															1	2	1	0	1
Passiflora suberosa															1	1	1	0	1

[a]Denotes coverage in m^2.
[b]Too numerous to count.

Table 3. Number of individuals per 10 x 10m revegetation quadrat at Station 310N in the Turkey Point Cooling Canal System, 1976-1981.

SCIENTIFIC NAME	1976				1977				1978				1979			1980		1981	
	Jan.	Apr.	Jul.	Oct.	Jan.	Apr.	Jul.	Oct.	Jan.	Apr.	Jul.	Oct.	Jan.	May	Nov.	May	Nov.	May	Nov.
Rhizophora mangle	7	6	7	9	9	8	10	11	12	13	13	13	13	13	10	10	6	0	0
Casuarina equisetifolia	10	37	37	42	37	39	42	44	46	48	43	43	43	45	45	58	25	19	8
Cladium jamaicensis	510	b	b	600	620	600	9[a]	12[a]	14[a]	15[a]	14[a]	15[a]	15[a]	15[a]	13[a]	15[a]	35	41	16
Distichlis spicata	6	5	4	6	4	4	8	8	12	12	12	10	9	9	1	1	8	8	8
Baccharis halimifolia	0	0	1	0	0	0	1	2	2	2	2	2	2	2	1	1	0	4	0
Melanthera parvifolia[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sonchus oleraceus[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Conocarpus erectus	3	3	2	4	4	6	5	6	8	8	8	8	8	8	1	2	1	1	1
Rhabdadenia biflora			1	1	1	1	1	1	1	1	1	1	1	1	1	0	2	2	3
Laguncularia racemosa				1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0
Acrostichum danaeifolium				1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Thelysteris normalis					2	4	1	0	0	0	0	0	0	0	0	0	0	0	0
Schinus terebinthifolius						2	0	0	0	0	0	0	0	0	0	0	0	0	0
Solanum donianum												2	2	2	0	0	0	2	1
Sporobolus virginicus															6	0	0	0	0
Aster tenuifolius															1	0	0	1	1
Mikania scandens																	12	20	5
Andropogon glomeratus																		1	1

[a]Denotes coverage in m^2.
[b]Too numerous to count.
[c]Found previous to 1976.

Table 4. Number of individuals per 10 x 10m revegetation quadrat at Station 323S in the Turkey Point Cooling Canal System, 1976-1981.

SCIENTIFIC NAME	1976 Jan.	1976 Apr.	1976 Jul.	1976 Oct.	1977 Jan.	1977 Apr.	1977 Jul.	1977 Oct.	1978 Jan.	1978 Apr.	1978 Jul.	1978 Oct.	1979 Jan.	1979 May	1979 Nov.	1980 May	1980 Nov.	1981 May	1981 Nov.
Conocarpus erectus	9	5	11	15	18	19	18	19	22	23	23	24	24	24	20	26	20	20	30
Casuarina equisetifolia	9	8	12	9	12	18	17	18[a]	19[a]	19[a]	19[a]	19[a]	19[a]	33[a]	37[a]	55[a]	65[a]	65[a]	23[a]
Cladium jamaicensis	370	500	700	875	376	b	b	35[a]	35[a]	50[a]	65[a]	65[a]	65[a]	65[a]	65[a]	65[a]	65[a]	65[a]	25[a]
Juncus roemerianus	35	43	61	65	82	102[a]	74	65	32	39	20	14	14	14	0	0	0	0	0
Solanum donianum	13	7	11	16	40	9[a]	38	61	73	89	89	104	107	163	160	149	169	b	b
Ipomoea sagittata	9	6	5	7	0	11	1	1	0	0	0	0	0	0	0	0	0	0	0
Pluchea rosea	23	15	31	b	0	57	3	8	5	0	2	0	0	0	0	0	0	0	0
Eupatorium capillifolium	17	10	6	6	6	0	4	9	8	8	8	0	0	0	0	0	0	0	0
Aster tenuifolius	0	0	0	0	8	19	0	0	5	0	0	0	0	0	0	0	0	0	0
Sabatia stellaris		26	32	4	0	7	0	0	0	0	0	0	0	0	0	0	0	0	0
Schinus terebinthifolia		1	1	1	1	1	1	1	2	2	2	1	1	1	1	2	1	3	0
Acrostichum danaeifolium		2	2	4	18	13	1	3	3	3	3	3	3	3	3	4	3	2	2
Baccharis helimifolia		1	1	9	20	17	15	19	24	20	22	22	22	23	4	3	1	1	0
Passiflora suberosa		1	1	1	1	1	1	1	1	1	1	4	4	2	4	3	3	0	1
Andropogon glomeratus					1	2	0	0	2	0	2	0	0	0	0	0	0	0	0
Trema floridana							1	1	0	0	0	1	1	0	0	0	0	0	0
Mikania scandens															5	0	1	0	1
Borrichia frutescens															1	0	0	0	0

[a]Denotes coverage in m^2.
[b]Too numerous to count.

Table 5. Number of individuals per 10 x 10m revegetation quadrat at Station 408M in the Turkey Point Cooling Canal System, 1976-1981.

SCIENTIFIC NAME	1976				1977				1978				1979			1980		1981	
	Jan.	Apr.	Jul.	Oct.	Jan.	Apr.	Jul.	Oct.	Jan.	Apr.	Jul.	Oct.	Jan.	May	Nov.	May	Nov.	May	Nov.
Conocarpus erectus	2	1	2	5	5	8	7	7	7	7	7	7	7	7	12	8	3	2	2
Casuarina equisetifolia	3	10	18	61	32	85	79	130	139	140	140	140	145	150	155	162	11	3	3
Cladium jamaicensis	13	18	14	14	3	16	10	11	14	13	12	12	12	12	10	7	5	5	6
Distichilis spicata[a]	.5	.5	1	2	2	4	5	5	9	9	9	9	9	9	9	9	12	12	12
Rhizophora mangle[c]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sabatia stellaris		4	9	0	0	1	1	1	1	0	4	0	0	0	0	4	1	21	0
Pteris vittata		2	9	11	33	47	40	42	50	40	30	20	18	16	4	0	32	b	85
Thelysteris normalis		1	7	10	9	6	7	6	8	7	4	4	4	4	2	9	24	14	12
Baccharis halimifolia		1	1	1	1	2	1	1	3	3	3	0	0	0	0	3	5	5	4
Solanum donianum			1	2	2	0	2	1	1	1	1	1	0	0	0	0	0	57	37
Acrostichum danaeifolium					6	5	0	2	2	2	2	2	2	2	0	0	40	26	11
Sonchus oleraceus					1	2	1	1	1	1	1	1	1	1	0	0	0	0	0
Eupatorium capillifolium								3	3	4	6	4	6	6	0	0	11	b	b
Andropogon glomeratus								8	6	0	14	50	50	50	2[a]	1[a]	8	b	b
Pluchea rosea								2	2	1	1	1	1	1	0	0	43	10	0
Salix caroliniana																	3	1	1
Aster tenuifolius																	1	0	3
Vallesia antillana																	1	0	0
Trema floridana																		57	37
Mikania scandens																		8	8

[a]Denotes coverage in m^2.
[b]Too numerous to count.
[c]Found previous to 1976.

Table 6. Number of individuals per 10 x 10m revegetation quadrat at Station 505N in the Turkey Point Cooling Canal System, 1976-1981.

SCIENTIFIC NAME	1976				1977				1978				1979			1980		1981	
	Jan.	Apr.	Jul.	Oct.	Jan.	Apr.	Jul.	Oct.	Jan.	Apr.	Jul.	Oct.	Jan.	May	Nov.	May	Nov.	May	Nov.
Conocarpus erectus	5	5	7	6	5	5	5	5	5	4	4	4	4	4	4	4	4	4	6
Borrichia frutescens	40	4	3	4	5	5	5	5	7	8	12	13	13	13	40	38	47	128	82
Distichilis spicata[a]	0	0	0	.3	.5	.3	.5	1	2	2	2	2	2	2	4	6	10	25	16
Casuarina equisetifolia													1	1	1	0	0	0	2
Aster tenuifolius															39	84	120	b	b
Baccharis halimifolia															3	1	8	3	3
Andropogon glomeratus																1	1	10	23
Sabattia stellaris																		1	0
Mikania scandens																		10	7
Rhabdadenia biflora																		1	1

[a]Denotes coverage in m^2.
[b]Too numerous to count.

Table 7. Number of *Rhizophora mangle* per 2 x 10m quadrat at stations in the Turkey Point Cooling Canal System, 1979-1981.

STATIONS	1979 JAN.	1979 MAY	1979 NOV.	1980 MAY	1980 NOV.	1981 MAY	1981 NOV.
105S							
Mature[b]	2	2	2	2	2	2	2
Seedlings[c]	7	7	4	3	3	0	0
204N							
Mature	1	1	1	1	1	0	0
Seedlings	12	12	16	14	7	5	3
310N							
Mature	2	2	2	2	2	2	2
Seedlings	7	7	0	0	0	1	0
323S							
Mature	0	0	0	0	0	0	0
Seedlings	0	0	0	0	0	0	0
408M							
Mature	0	10	10	14	7	6	3
Seedlings	0	48	53	27	2	0	4
505N							
Mature	6	a	7	14	15	16	15
Seedlings	15	a	11	5	4	0	0

[a] No data taken
[b] Adults, woody trunk and prop roots, greater than 1 foot in height.
[c] No prop roots, green radicle, less than 1 foot in height.

Table 8. Historical list of species identified in the Turkey Point Natural Revegetation Program, 1975-1981.

SCIENTIFIC NAME	COMMON NAME
Acrostichum danaeaefolium	Leather Fern (Mangrove Fern)
Andropogon glomeratus	Beard Grass
Aster tenuifolius	Saltmarsh Aster
Baccharis halimifolia	Saltbush (Groundsel)
Borrichia frutescens	Sea Oxeye (Oxeye Daisy, Sea Daisies)
Casuarina equisetifolia	Australian Pine
Chamaesyce mesembryanthemifolia	Spurge
Cladium jamaicensis	Sawgrass
Conocarpus erectus	Buttonwood
Distichilis spicata	Saltgrass
Echites sp.	Devil's Potatoe
Eleocharis sp.	Club Rush (Spike Rush)
Erechtites hieracifolia	Fireweed (Burnweed)
Eupatorium capillifolium	Dog Fennel
Fuirena sp.	Umbrella Grass
Ipomoea sagittata	Glades Morning Glory
Juncus roemerianus	Black Rush (Needle Rush)
Laguncularia racemosa	White Mangrove
Lantana camara	Lantana
Melanthera aspera	Rohrb
Melothria pendula	Creeping Cucumber
Mikania scandens	Climbing Hempweed (Hempvine)
Passiflora suberosa	Corky-Stemmed Passion Flower
Physalis angulata	Ground Cherries
Phytolacca rigida	Pokeweed (Inkberry)
Pluchea rosea	Marsh Fleabane
Pteris vittata	Brake Fern
Rhabdadenia biflora	Mangrove Rubber Vine
Rhizophora mangle	Red Mangrove

Table 8. (Cont'd) Historical list of species identified in the Turkey Point Natural Revegetation Program, 1975-1981.

SCIENTIFIC NAME	COMMON NAME
Sabatia stellaris	Marsh Pink
Salix caroliniana	Coastal Plains Willow
Sarcostemma clausa	White Vine
Schinus terebinthifolius	Brazilian Pepper
Sesuvium portulacastrum	Sea Purslane
Sida rubromarginata	Mallow Family
Solanum donianum	Blodgett's Potatoe
Solanum nigrescens	Black-Nightshade
Solidago stricta	Golden Rod
Sonchus oleraceus	Sow Thistle
Sporobolus virginicus	Virginia Dropseed
Thelypteris sp.	Schmidel
Trema floridana	Florida Trema (Nettle Tree)
Vallesia antillana	Oleander

b. Soil Chemistry (ETS 4.2.1.1)

Introduction

This program monitors selected chemical parameters and their changes over time for three elevations of the spoil banks i.e. berms in the Turkey Point Cooling Canal System.

Materials and Methods

One hundred fifty nine samples were collected on a semi-annual basis at 53 sample sites that represented all major soil types throughout the canal system (Figure 1). Samples were taken from each of three berm levels at a depth of 12 inches using a JMC Backsaver Coring Device. They were placed in "Whirl Paks" for transportation to the laboratory. Samples were separated by type and replicates were mixed to create a composite sample representing the soil type and elevation. East side samples were mixed according to elevation only i.e. "ET" equals all east side top elevations.

Composite samples were analyzed for pH, nitrogen, phosphorous, potassium, calcium, chloride, and conductivity (Tables 1 and 2). The pH was measured using a glass electrode; potassium and calcium were determined using a Beckman DU-2 Flame Photometer (APHA, 1975). Nitrogen was determined using the Brucine Method (APHA, 1975). Phosphorous was determined using the Stannous Chloride Method (APHA, 1975). Chloride was determined using a silver nitrate titration (APHA, 1975). Conductivity was determined using a modified

Wheatstone Bridge (APHA, 1975). The resulting data were analyzed statistically using the P7D program of U.C.L.A. Biomedical Program Series P.

Results

Nutrient data for all sample sites for May and November are listed on Tables 1 and 2. The ranges of the nutrient values and the sample sites having the highest nutrient values can be found on Table 3.

Discussion

The pH exhibited a highly significant variance ($\alpha=0.01$) within successive years and soil types. It was lowest at stations with organic substrates and at middle elevations. The high pH values were found in the marl substrates, areas of sparse vegetation and low elevations. The highest value occurred during May in sample 4 WT (Table 3). The pH values were more alkaline than the range cited as optimal for plant growth (Hartmann & Kester, 1975).

Nitrogen values also exhibited highly significant variance ($\alpha=0.01$) within successive years and soil types. Values ranged from 2.0 - 180.0 mg/kg. This was similar to the 1980 range of 0.1 - 110 mg/kg (FPL, 1980). Generally the lowest nitrogen values were obtained at low elevations.

Phosphorous values were not significantly different ($\alpha=0.05$) by soil type but exhibited a highly significant difference ($\alpha=0.01$) from year to year. The yearly variations are apparent in the following ranges 0.1 - 10.0 mg/kg, 1981; 0.1 - 6.0 mg/kg, 1980; and 0.1 - 2.0 mg/kg, 1979. Phosphorous values were unaffected by sample elevations. The highest recorded phosphorous value occurred during November in sample 9 WT (Table 3). Phosphorous was generally present in very small quantities, due to the very high calcium levels (Black, 1968).

Potassium values were not significantly different ($\alpha=0.05$) by soil type. They did, however, have a highly significant difference ($\alpha=0.01$) by year. This year's potassium values correlated well with both chloride and conductivity having correlation coefficients (r) of 0.91 and 0.95 respectively. However, the historical correlations (using all data points 1975-1981) between potassium and chloride and potassium and conductivity were only fair with correlation coefficients of 0.73 and 0.82. The highest potassium value was noted in May in sample EL (Table 3). The levels of potassium for the berms were within the historical ranges for this geographic area (Black, 1968).

Calcium values showed no significant variance ($\alpha=0.05$) as a function of time from 1975 through 1981, however this parameter exhibited highly significant variance, ($\alpha=0.01$) by soil type. In May the highest value was observed in sample EL while in November the highest value was noted in 7 WT (Table 3).

Chloride levels showed significant variance by year (α=0.05) but no significant difference by soil type. Generally, the higher chloride levels were observed at the lowest elevations (Tables 1 and 2) which were in contact with the water.

Conductivity followed chloride very closely in terms of yearly and soil type comparisons. Again the general pattern was higher conductivities at the lowest elevations. Tables 1 and 2 present data for the dry and wet seasons respectively. Generally, the values for parameters decreased during the wet season and increased in the dry season. The exception to this trend was phosphorous.

Conclusions

The pH, nitrogen, phosphorous, potassium, chloride and conductivity vary significantly from year to year (FPL, 1975-1981). Calcium shows no significant variations, and hence is temporally stable.

The pH, nitrogen and calcium vary significantly by soil type while phosphorous, potassium, chloride and conductivity exhibit no such variation.

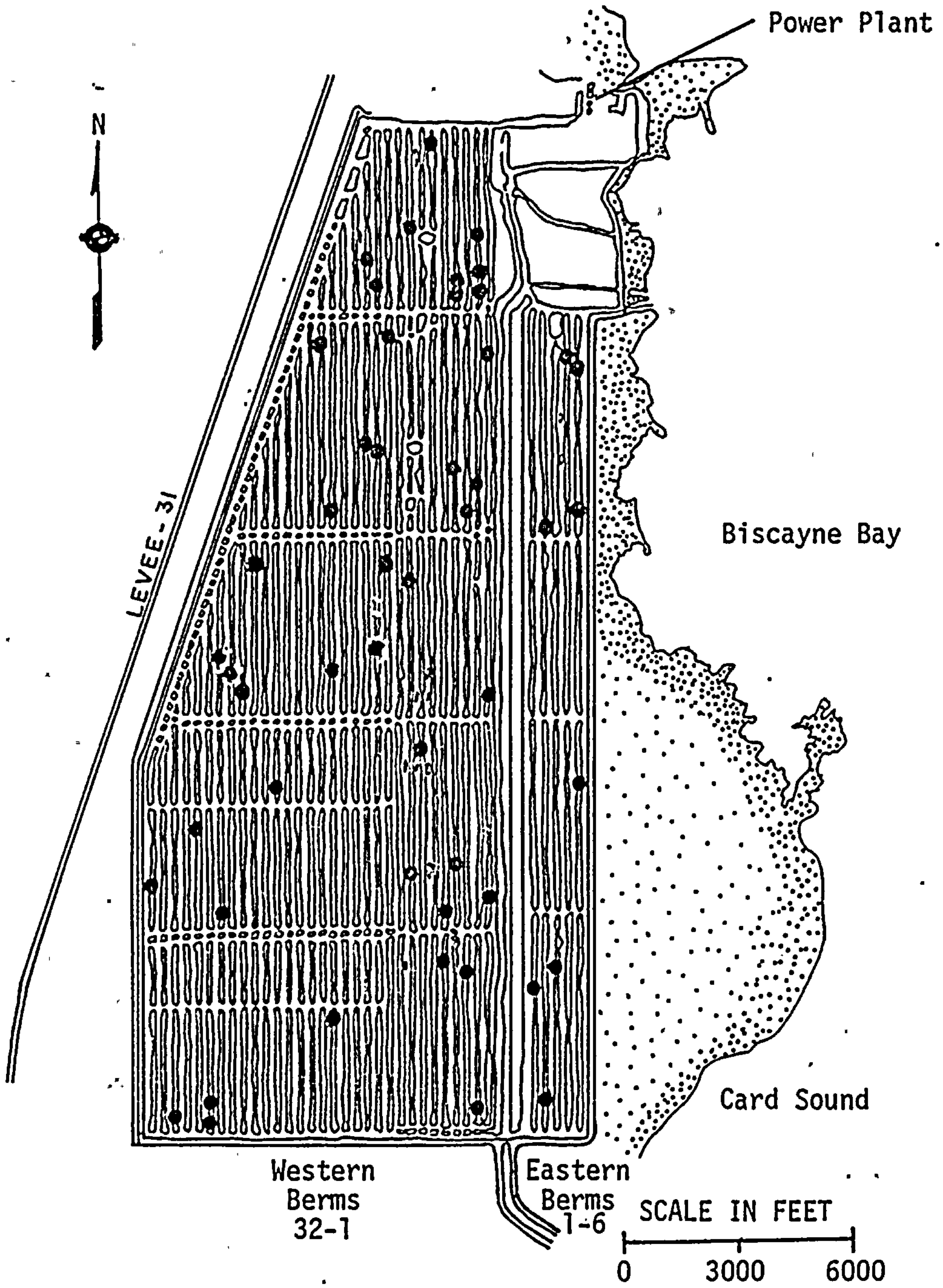


Figure 1. Soil Chemistry samples sites (•) in the Turkey Point Cooling Canal System 1981.

Table 1. Chemical summary of soils for Turkey Point Cooling Canal System berms during May 1981.

SAMPLE SITES[a]	pH	NO_3[b]	P[b]	K[b]	Ca[b]	Cl[b]	Cond.[c]
1 WT	7.8	39	0.5	17	900	1500	240
WM	7.7	35	1.0	37	1000	1700	260
WL	8.0	15	0.3	540	1400	52,500	1800
2 WT	7.7	31	0.1	9	600	1650	150
WM	7.6	60	<0.1	25	900	2000	320
WL	7.8	23	1.0	238	900	23,500	1200
3 WT	8.0	42	0.3	82	550	5100	600
WM	8.0	23	0.2	40	200	2000	280
WL	8.1	23	0.1	190	550	31,000	800
4 WT	8.3	41	<0.1	59	450	3700	420
WM	8.0	65	1.0	120	400	4250	600
WL	8.1	75	0.1	500	650	28,000	1500
5 WT	8.1	100	<0.1	53	700	4300	400
WM	7.9	38	<0.1	59	350	3650	450
WL	8.2	5	0.3	325	650	35,500	1350
6 WT	8.1	27	1.0	17	450	3600	240
WM	7.9	27	0.3	13	250	1400	170
WL	8.1	31	1.0	300	950	37,000	1200
7 WT	8.0	37	<0.1	13	600	2600	200
WM	7.9	26	<0.1	27	550	3500	240
WL	8.1	24	<0.1	325	800	42,000	1400
8 WT	8.0	50	1.0	30	550	3300	300
WM	8.0	22	1.0	42	500	2500	280
WL	8.2	8	1.0	500	650	49,500	1800
9 WT	8.1	35	<0.1	17	250	2000	200
WM	8.1	31	0.2	22	300	2000	220
WL	8.2	8	0.2	307	600	26,250	900
ET	7.7	46	0.1	56	2000	4100	325
EM	7.7	48	<0.1	100	2000	7000	500
EL	7.6	60	0.3	630	4500	30,000	1250

[a] 1-4, sample site based on composition i.e. black organic, organic, mucky-marl and marl respectively.
5-9, sample site based on vegt. density i.e. none, heavy, medium, light and areas initially covered by grass.
"W" and "E", samples taken on the west and east sides of system respectively.
"T", "M", and "L", samples taken at three levels, top, middle and one foot above water level.
[b] All these values in mg/kg.
[c] Conductivity in MHOS X 10^{-5}.

Table 2. Chemical summary of soils for Turkey Point Cooling Canal System berms during November 1981.

SAMPLE SITES[a]	pH[b]	NO_3[b]	P[b]	K[b]	Ca[b]	Cl[b]	Cond.[c]
1 WT	7.2	54	<0.1	12	1300	440	123
WM	7.1	180	6.0	26	900	1300	250
WL	7.6	4	6.0	276	500	12,500	1000
2 WT	7.4	36	4.0	22	800	500	127
WM	7.0	18	2.0	22	1800	400	215
WL	7.9	6	2.0	124	500	8700	480
3 WT	7.5	78	2.0	30	300	1500	250
WM	7.1	82	2.0	54	500	620	290
WL	7.7	2	4.0	136	600	9000	550
4 WT	7.5	92	0.6	60	700	2200	325
WM	7.2	34	0.6	54	300	3600	350
WL	8.0	26	0.1	124	300	8900	520
5 WT	7.7	52	2.0	18	200	1000	163
WM	7.3	28	0.6	34	300	2400	310
WL	8.0	8	2.0	106	500	7500	440
6 WT	7.6	12	6.0	12	400	340	101
WM	7.4	21	2.0	12	300	250	97
WL	7.8	2	6.0	142	500	8800	480
7 WT	7.4	23	<0.1	18	2100	460	150
WM	7.3	95	6.0	30	800	1400	208
WL	7.9	2	1.0	106	600	760	490
8 WT	7.5	30	2.0	22	200	1500	170
WM	7.5	40	8.0	34	300	1600	260
WL	7.9	14	4.0	172	600	9800	590
9 WT	7.8	30	10.0	30	100	350	55
WM	7.7	14	6.0	16	100	740	103
WL	8.1	4	2.0	112	300	7800	470
ET	7.6	44	2.0	30	500	1500	212
EM	7.6	32	4.0	30	800	1100	152
ET	7.6	4	4.0	130	500	7500	440

[a] 1-4, sample site based on composition i.e. black organic, organic, mucky-marl and marl respectively.
5-9, sample site based on vegt. density i.e. none, heavy, medium, light and areas initially covered by grass.
"W" and "E", samples taken on the west and east sides of system respectively.
"T", "M", and "L", samples taken at three levels, top, middle and one foot above water level.
[b] All these values in mg/kg.
[c] Conductivity in MHOS X 10^{-5}.

Table 3. The ranges of soil nutrient values and the sample site with the highest nutrient value for the Turkey Point Cooling Canal System, 1981.

MAY			NOVEMBER		
NUTRIENT	RANGE	SAMPLE SITE WITH HIGHEST VALUE	NUTRIENT	RANGE	SAMPLE SITE WITH HIGHEST VALUE
pH	7.6-8.3	4WT	pH	7.1-8.1	9WL
Nitrate[a]	5.0-100	5WT	Nitrate[a]	2.0-180	1WM
Phosphorous[a]	<0.1-1.0	1WM,2WL,4WM, 6WT,6WL,8WT, 8WM,8WL	Phosphorous[a]	<0.1-10.0	9WT
Potassium[a]	9-630	WEL	Potassium[a]	12-276	1WL
Calcium[a]	1400-52,500	WEL	Calcium[a]	100-2100	7WT
Chloride[a]		1WL	Chloride[a]	250-12,500	1WL

[a]Values in mg/kg.

c. Soil Erosion (ETS 4.2.1.1)

Introduction

Soil erosion data are collected and quantified to determine canal bank i.e. berm erosion rates due collectively to soil oxidation, precipitation, and wind.

"Erosion, in its physical aspects, is simply the accomplishment of a certain amount of work in tearing apart and transporting soil material" (Stallings, 1957). It is important since it can cause sedimentation in the cooling canals thus reducing the thermal and hydraulic efficiency of the Turkey Point Cooling Canal System.

Materials and Methods

Soil erosion data were collected semi-annually at two stations in the canal system (Figure 1). Station 502N is located at the north end of Section 5, on berm 2 and Station 530N is located at the north end of Section 5, on berm 30. The most common soil type in the canal system is mucky-marl, therefore, both stations were placed in areas with predominantly that edaphic characteristic. At each station, four pipes were driven vertically through the berms and into the underlying rock to serve as permanent reference points. A stainless steel "averaging cross" was placed horizontally on each of the pipes. It was oriented to magnetic north and the distance from the tips of the cross to the berm surface was then measured. Comparing these measurements over time yields the berm erosion rates.

Results

An average berm erosion of 0.010 feet occurred during the dry season and 0.027 feet during the wet season for a total average erosion of 0.037 feet in 1981. Rainfall for the dry season and wet season was 7.49 inches and 28.78 inches respectively (Table 1).

Discussion

Data for 1981 showed the general pattern of erosion by season (Table 1), i.e. deposition or little erosion during the dry season and higher erosion during the wet season.

Rainfall and erosion were very weakly correlated (r=0.54). When the rainfall versus erosion correlation was examined considering seasonal components, the correlation coefficients were 0.04 and 0.69 for the wet and dry seasons respectively. These low correlation coefficients indicate that rainfall was not the sole agent responsible for erosion of the berms. Other factors such as degree of wind gustiness, duration of critical wind velocities, soil densities, soil moisture content, rainfall frequency and rainfall intensity act in concert to erode the berms. General pattern reversals such as those that occurred in 1978 and 1979 should not be considered uncommon and were manifestations of significant changes in the patterns or magnitudes of eroding agents other than rainfall.

The berm erosion for 1981 was 0.037 feet. This value was similar to all years except 1976.

No comparison to baseline data can be made since preoperational data for erosion do not exist.

Conclusions

During 1981 the cooling canal berm erosion rate did not differ significantly from historical data (1976-1980). No increase in erosion rate can be expected to occur other than that due to the intrinsic seasonal fluctuation apparent in the historical data (FPL, 1976-1980).

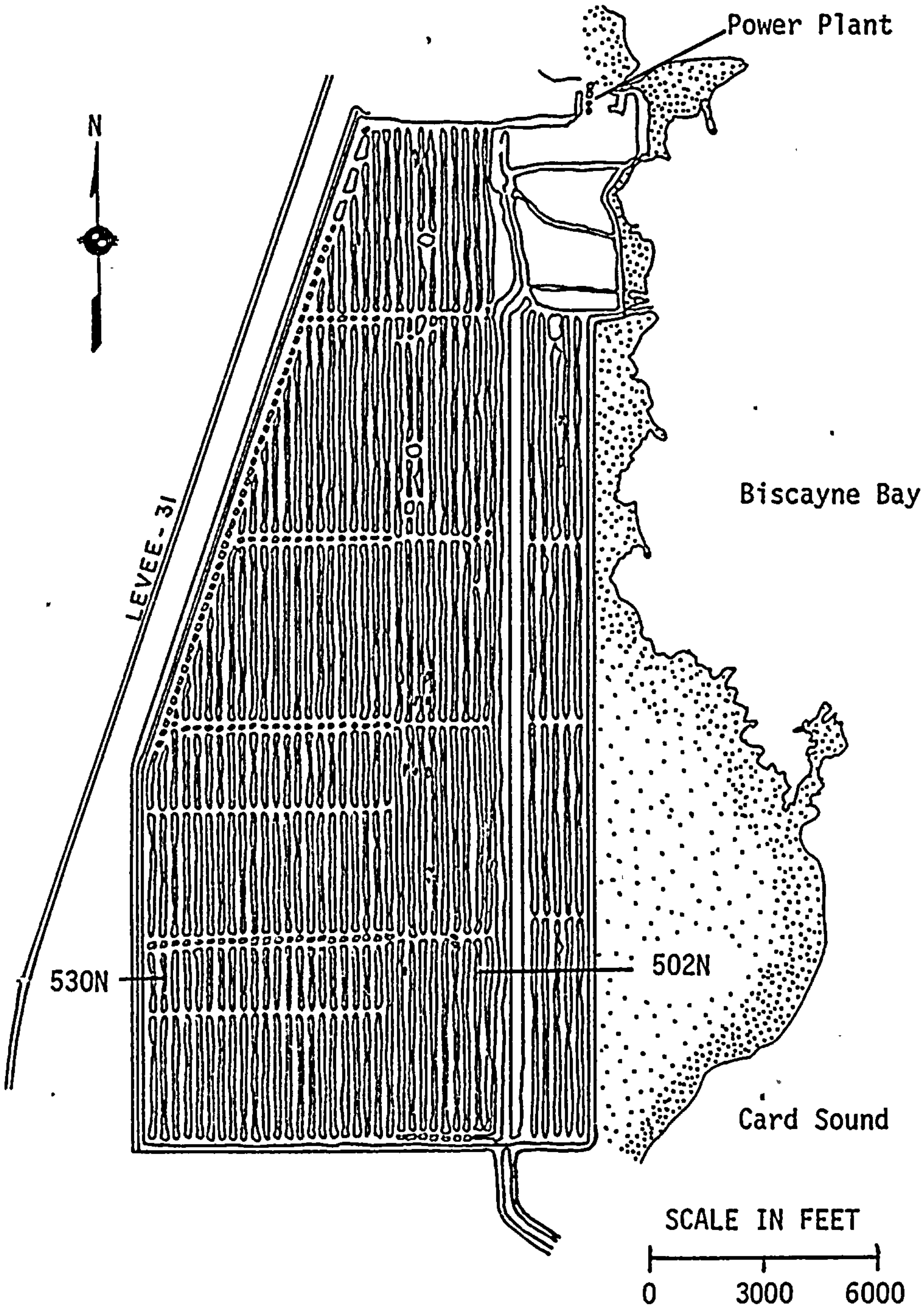


Figure 1. Soil erosion stations at the Turkey Point Cooling Canal System, 1981.

Table 1. Rainfall, average erosion and erosion rate per quarter in the Turkey Point Cooling Canal System, 1976-1981.

YEAR	QUARTER	RAINFALL (inches)	AVERAGE EROSION (feet)[a]	EROSION PER INCH OF RAINFALL [(feet)·10^{-4}]
1976	1	5.80	+0.035	
	2	21.76	-0.005	
	3	18.78	-0.032	
	4	5.39	-0.004	
	Total	51.73	-0.006	-1.16
1977	1	4.81	+0.001	
	2	22.16	+0.057[b]	
	3	23.56	-0.093[b]	
	4	12.66	-0.016	
	Total	63.19	-0.051	-8.07
1978	1	10.20	-0.008	
	2	12.92	-0.007	
	3	25.42	-0.014	
	4	4.11	-0.018	
	Total	52.65	-0.047	-8.93
1979	1	----	----	
	2	10.62	-0.034	
	3	----	----	
	4	22.75	-0.012	
	Total	33.37	-0.046	-13.78
1980	1	----	----	
	2	12.44	+0.008	
	3	----	----	
	4	30.84	-0.042	
	Total	43.28	-0.034	-7.85
1981	1	----	----	
	2	7.49	-0.010	
	3	----	----	
	4	28.78	-0.027	
	Total	36.27	-0.037	-10.20

[a] Erosion is denoted by (-), and deposition by (+).
[b] An error was made in the 1977, 2nd quarter measurements indicating relatively high deposition. The 3rd quarter measurements were correct, but compensated for the 2nd quarter by indicating greater than normal erosion. The yearly average follows the norm.

d. Faunal Survey (ETS 4.2.1.1)

Introduction

This section furnishes a qualitative assessment of the fauna (birds, mammals, reptiles, and amphibians) found in association with the Turkey Point Cooling Canal System and compares it with the fauna of the surrounding area (ABI, 1978b). The study area encompasses 6,800 acres of land needed for the cooling canal system, selected coastline, associated canals and 28 acres for plant site (Figure 1).

Materials and Methods

Most faunal estimates were made by visual observation during routine monitoring. Some non-destructive sampling was carried out on reptiles and amphibians. Captured organisms were released after identification. Mammal abundance was estimated from visual observation, road kills and natural deaths. Due to the opportunistic nature of the program, it is quite likely that some species inhabiting the study area were not observed and therefore the data constitute a conservative estimate of faunal populations.

Results

One hundred five avian species (Table 1), 18 reptilian species (Table 2), 5 amphibian species (Table 2) and 7 mammalian species (Table 3) were observed in the study area during 1981. Among the observed species were: the southern bald eagle, the wood stork, the

american crocodile, the eastern indigo snake, the bobcat, and the manatee.

Fifty avian species, 13 species of reptiles and amphibians, and 6 species of mammals were common to both the surrounding area (ABI, 1978) and the study area (Tables 4, 5 and 6).

The 1981 population estimate for crocodiles observed in the study area was 18 to 21 individuals (Table 7). Crocodile nesting was discovered and 30 hatchlings were observed..

Discussion

Table 1 is a list of 105 avian species sighted in the study area for 1981. A total of 65 avian species were sighted during 1980. The birds occurred either as permanent residents, regular or casual visitors, or visitors that appeared only during migration.

The least tern was common during the months of April through August. As in previous years, this species found the spoil banks a suitable nesting ground. Nests were observed and young birds were commonly found on the spoil banks.

A total of 18 reptiles and five amphibians were observed in the study area (Table 2) as compared to only 10 reptiles and one amphibian in 1980 and 8 reptiles and one amphibian in 1979. All reptiles and amphibians were considered permanent residents of the study area.

The 1981 crocodile population estimate was 18 to 21 individuals, as compared to 14 individuals in 1980.

Two hatches were discovered on berm 26. The first took place on July 9, and resulted in the capture of 27 hatchlings. The second hatch occurred on August 6 and three hatchlings were captured. All of the hatchlings were measured, weighed, marked, and released. After Tropical Storm Dennis in mid-August only three hatchlings were observed. It is believed that the high waters left by the tropical storm may have resulted in the death of some of the 1981 hatchlings (Metcalf & Eddy Inc. unpublished data).

Nocturnal monitoring indicated that the marsh rabbit and racoon were quite common. A total of 7 species of mammals were identified in 1981, compared to 8 in 1980 and 6 in 1979.

Data for the surrounding area (ABI, 1978) was compared to the fauna of the study area (Tables 4, 5 and 6). A total of 76 bird species, 18 species of reptiles and amphibians, and 10 species of mammals were observed in the surrounding area in 1978. During 1981 fifty species of birds, 13 species of reptiles and amphibians and 6 species of mammals were common to both areas.

Conclusions

The increase in the total number of bird species sighted from 1980-1981 is not considered significant. It is primarily due to a more intensive monitoring program.

Both crocodile and alligator populations appear to have increased since 1980. However, the numbers of reptiles, amphibians, and mammals do not differ notably from 1980 or 1979.

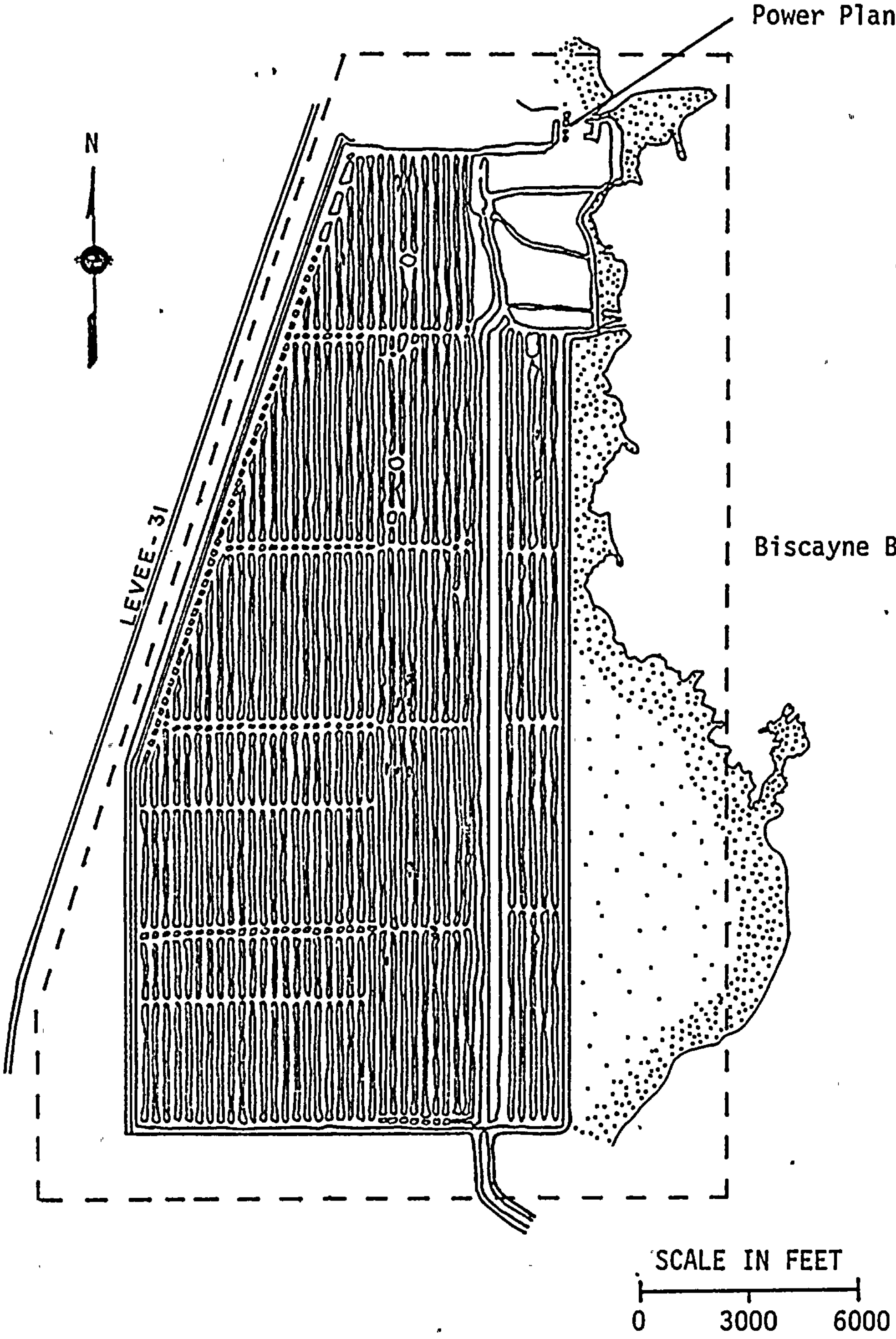


Figure 1. Faunal study area (outline) for Turkey Point Cooling Canal System,1981.

Table 1. A list of birds observed in the Turkey Point Study Area, 1981.

COMMON NAME	SCIENTIFIC NAME[a]	RELATIVE ABUNDANCE[b]	SEASON OF OCCURRENCE
American Bittern	Botaurus lentiginosus	Rare	Transient
American Black Duck	Anas rubripes	Very Rare	Accidental
American Coot	Fulica americana	Uncommon	Permanent
American Kestrel	Falco sparverius paulus	Fairly Common	Winter
Anhinga	Anhinga anhinga leucogaster	Rare	Permanent
Bald Eagle	Haliaeetus leucocephalus	Rare	Permanent
Belted Kingfisher	Megaceryle alcyon alcyon	Common	Winter
Black-bellied Plover	Pluvialis squatarola	Uncommon	Winter
Black-crowned Night Heron	Nycticorax nycticorax hoactli	Uncommon	Winter
Black-necked Stilt	Himantopus mexicanus	Uncommon	Summer
Black Scoter	Melanitta nigra nigra	Very Rare	Winter
Black Skimmer	Rynchops nigra	Common	Winter
Black Vulture	Coragyps atratus	Common	Permanent
Blue-gray Gnatcatcher	Polioptila caerulea caerulea	Rare	Permanent
Boat-tailed Grackle	Cassidix mexicanus	Fairly Common	Permanent
Bob-white	Colinus virginianus	Rare	Permanent
Bonapartes Gull	Larus philadelphia	Very Rare	Winter
Brown Pelican	Pelecanus occidentalis carolinensis	Common	Permanent
Cape May Warbler	Dendroica tigrina	Rare	Winter
Cat Bird	Dumetella carolinensis	Very Rare	Winter

Table 1. A list of birds observed in the Turkey Point Study Area, 1981. (Cont'd)

COMMON NAME	SCIENTIFIC NAME[a]	RELATIVE ABUNDANCE[b]	SEASON OF OCCURRENCE
Cardinal	Richmondena cardinalis	Fairly Common	Permanent
Caspian Tern	Sterna caspia	Common	Winter
Cattle Egret	Bubulcus ibis	Fairly Common	Permanent
Clapper Rail	Rallus longirostris	Very Rare	Permanent
Common Crow	Corvus brachyrhynchos	Fairly Common	Permanent
Common Egret	Casmerodius albus egretta	Common	Permanent
Common Flicker	Colaptes auratus	Fairly Common	Permanent
Common Gallinule	Gallinula chloropus cachinnans	Very Rare	Permanent
Common Grackle	Quiscalus quiscula	Fairly Common	Permanent
Common Loon	Gavia immer	Rare	Winter
Common Nighthawk	Chorheiles minor	Common	Summer
Common Snipe	Capella gallinago	Very Rare	Winter
Common Starling	Sturnus vulgaris vulgaris	Common	Permanent
Common Tern	Sterna hirundo hirundo	Fairly Common	Winter
Double-crested Cormorant	Phalacrocorox auritus	Common	Permanent
Dunlin	Calidris alpina	Uncommon	Winter
Eastern Kingbird	Tyrannus tyrannus	Very Rare	Summer
Eastern Phoebe	Sayornis phoebe	Rare	Winter
Gray Kingbird	Tyrannus dominicensis dominicensis	Uncommon	Summer
Great Blue Heron	Ardea herodias	Common	Permanent

Table 1. A list of birds observed in the Turkey Point Study Area, 1981. (Cont'd)

COMMON NAME	SCIENTIFIC NAME[a]	RELATIVE ABUNDANCE[b]	SEASON OF OCCURRENCE
Great White Heron	Ardea occidentalis occidentalis	Uncommon	Permanent
Green Heron	Butorides virescens virescens	Common	Permanent
Ground Dove	Columbigallina passerina passerina	Common	Permanent
Gull-billed Tern	Gelochelidon nilotica aranea	Rare	Casual
Herring Gull	Larus argentatus	Fairly Common	Winter
Hooded Merganser	Lophodytes cucullatus	Rare	Winter
House Sparrow	Passer domesticus domesticus	Fairly Common	Permanent
Killdeer	Charadrius vociferus vociferus	Fairly Common	Winter
Laughing Gull	Larus atricilla	Common	Permanent
Least Flycatcher	Empidonax minimus	Very Rare	Accidental
Least Sandpiper	Erolia minutilla	Fairly Common	Winter
Least Tern	Sterna albifrons	Common	Summer
Lesser Yellowlegs	Tringa flavipes	Uncommon	Winter
Little Blue Heron	Florida caerulea coerulea	Common	Permanent
Long Billed Curlew	Numenius americanus	Common	Winter
Louisiana Heron	Hydranassa tricolor ruficollis	Common	Permanent
Magnificent Frigatebird	Fregata magnificens rothschildi	Uncommon	Permanent
Mallard Duck	Anas platyrhynchos platyrhynchos	Uncommon	Permanent
Marsh Hawk	Circus cyaneus hudsonius	Uncommon	Winter
Mockingbird	Mimus polyglottos polyglottos	Fairly Common	Permanent

Table 1. A list of birds observed in the Turkey Point Study Area, 1981. (Cont'd)

COMMON NAME	SCIENTIFIC NAME[a]	RELATIVE ABUNDANCE[b]	SEASON OF OCCURRENCE
Mottled Duck	Anas fulvigula	Common	Permanent
Mourning Dove	Zenaidura macroura	Common	Permanent
Osprey	Pandion haliaetus carolinensis	Common	Permanent
Palm Warbler	Dendroica palmarum	Fairly Common	Winter
Painted Bunting	Passerina ciris ciris	Very Rare	Winter
Pied-billed Grebe	Podilymbus podiceps podiceps	Common	Winter
Pileated Woodpecker	Dryocopus pileatus	Very Rare	Permanent
Piping Plover	Charadrius melodus	Uncommon	Winter
Purple Martin	Progne subis subis	Rare	Transient
Red-bellied Woodpecker	Melanerpes carolinus	Uncommon	Permanent
Red-breasted Merganser	Mergus serrator	Rare	Winter
Reddish Egret	Dichromanassa rufescens rufescens	Fairly Common	Summer
Red Knot	Calidris canutus rufus	Very Rare	Winter
Red-shouldered Hawk	Buteo lineatus	Uncommon	Permanent
Red-tailed Hawk	Buteo jamaicensis	Rare	Permanent
Red-winged Blackbird	Agelaius phoeniceus	Fairly Common	Permanent
Ring-billed Gull	Larus delawarensis	Common	Winter
Robin	Turdus migratorius	Very Rare	Winter
Rock Dove	Columba livia	Rare	Permanent
Roseate Spoonbill	Ajaia ajaja	Common	Winter

Table 1. A list of birds observed in the Turkey Point Study Area, 1981. (Cont'd)

COMMON NAME	SCIENTIFIC NAME[a]	RELATIVE ABUNDANCE[b]	SEASON OF OCCURRENCE
Royal Tern	Sterna maxima	Common	Winter
Ruddy Turnstone	Aernaria interpres morinella	Common	Summer
Rufous-sided Towhee	Pipilo erythrophthalmus	Very Rare	Permanent
Sanderling	Calidris alba	Common	Winter
Scrub Jay	Aphelocoma coerulescens coerulescens	Very Rare	Permanent
Semipalmated Plover	Charadrius hiaticula semipalmatus	Common	Winter
Semipalmated Sandpiper	Calidris pusillus	Fairly Common	Transient
Sharp-shinned Hawk	Accipiter striatus	Common	Winter
Short-billed Dowitcher	Limnodromus scolopaceus	Common	Winter
Snowy Egret	Leucophoyx thula thula	Common	Permanent
Solitary Sandpiper	Tringa solitaria	Rare	Winter
Sooty Tern	Sterna fuscata	Very Rare	Accidental
Spotted Sandpiper	Actitis macularia	Uncommon	Winter
Summer Tanager	Piranga rubra	Rare	Casual
Swallow-tailed Kite	Elanoides forticatus forficatus	Very Rare	Permanent
Tree Swallow	Iridoprocne bicolor	Common	Winter
Turkey Vulture	Cathartes aura	Common	Permanent
White-crowned Pigeon	Columba leucocephala	Rare	Summer
White Ibis	Guara alba	Common	Permanent
White Pelican	Pelecanus erythrorhynchos	Fairly Common	Winter

Table 1. A list of birds observed in the Turkey Point Study Area, 1981. (Cont'd)

COMMON NAME	SCIENTIFIC NAME[a]	RELATIVE ABUNDANCE[b]	SEASON OF OCCURRENCE
Willet	Catoptrophorus semipalmatus	Rare	Winter
Wilson's Plover	Charadrius wilsonia wilsonia	Uncommon	Permanent
Wood Ibis	Mycteria americana	Fairly Common	Winter
Yellow-crowned Night Heron	Nyctanassa violacea	Uncommon	Permanent
Yellow-throated Vireo	Vireo flavifrons	Very Rare	Winter

[a]Binomial Nomenclature by American Ornithologists Union.
[b]Very rare = 1 sighting; Rare = 2-5 sightings; Uncommon = 6-20 sightings; Fairly common = 21-50 sightings; Common = 51 and more sightings.

Table 2. A list of reptiles and amphibians observed in the Turkey Point Study Area for 1981.

COMMON NAME	SCIENTIFIC NAME[a]	PREFERRED HABITAT
Reptiles		
American Alligator	Alligator mississippiensis	Fresh or brackish water
American Crocodile	Crocodylus acutus	Salt or brackish water
Atlantic Loggerhead Turtle	Caretta caretta caretta	Tropical and subtropical Atlantic
Brown Anole	Anolis sagrei	On ground near shrubs
Eastern Diamond Back Rattlesnake	Crotalus adamanteus	Dry thickets
Eastern Garter Snake	Thamnophis sirtalis sirtalis	Marshes woodlands, and drainage ditches
Eastern Indigo Snake	Drymarchon corais couperi	Near thickets of dense vegetation
Florida Red-bellied Turkey	Chrysemys nelsoni	Fresh or brackish water
Florida Soft Shell Turtle	Trionyx ferox	Fresh water
Green Anole	Anolis carolinensis carolinensis	Shrubs and vines
Mangrove Water Snake	Natrix fasciata compressicauda	Salt or brackish water
Mediterranean Gecko	Hemidactylus turcicus turcicus	Associated with man
Red Rat Snake	Elaphe guttata guttata	Rocky hillsides
Snapping Turtle	Chelydra serpentina	Fresh or brackish water
Southern Black Racer	Coluber constrictor priapus	Low vegetation
Southeastern Fivelined Skink	Eumeces inexpectatus	On spoil banks
Striped Swamp Snake	Liodytes alleni	Shallow water, dense vegetation

Table 2. (Cont'd) A list of reptiles and amphibians observed in the Turkey Point Study Area for 1981.

COMMON NAME	SCIENTIFIC NAME[a]	PREFERRED HABITAT
Amphibians		
Cuban Tree Frog	Hyla septentrionalis	Wet, moist environments
Green Tree Frog	Hyla conerea	Swamps, borders of lakes and streams
Florida Cricket Frog	Acris gryllus dorsalis	Swamps, ponds
Southern Leopard Frog	Rana utricularia	Fresh or brackish water
Southern Toad	Bufo terrestris	Sandy areas

[a]Binomial nomenclature by Conant, 1975.

Table 3. A list of mammals observed in the Turkey Point Study Area for 1981.

COMMON NAME	SCIENTIFIC NAME[a]	PREFERRED HABITAT
Bobcat	*Lynx rufus*	Swamps
Domestic Cat	*Felis domestica*	Associated with man
Marsh Rabbit	*Sylvilagus palustris*	Berms, swamps, and hammocks
Manatee	*Trichechus manatus*	Shallow, protected, coastal waters
Opossum	*Didelphis marsupialis*	Woodland, along streams
Raccoon	*Procyon lotor*	Along berms
Whitetail Deer	*Odocoileus viginianus*	Forest and swamps

[a] Binomial nomenclature by Burt, et al., 1976.

Table 4. A comparison of the bird species identified in the Turkey Point Study Area, 1979-1981, to those of the Surrounding Area.

COMMON NAME	SURROUNDING AREA[a]	1979	1980	1981
American Bittern	X	-	X	X
American Coot	-	X	X	X
American Goldfinch	X	-	-	-
American Kestrel	X	X	X	X
American Redstart	X	-	-	-
Anhinga	X	-	X	X
Bald Eagle	X	X	X	X
Barn Owl	-	X	-	-
Barn Swallow	X	X	X	-
Belted Kingfisher	X	X	X	X
Black-bellied Plover	X	-	-	X
Black-crowned Night Heron	X	-	-	X
Black Duck	-	-	-	X
Black-necked Stilt	-	-	X	X
Black Scoter	-	-	-	X
Black Skimmer	X	-	X	X
Black Vulture	-	X	-	X
Black-poll Warbler	X	-	-	-
Black-whiskered Vireo	X	-	-	-
Blue-gray Gnatcatcher	X	-	X	X
Blue Jay	X	-	-	-
Blue-winged Teal	-	-	X	-
Boat-tailed Grackle	X	X	X	X
Bobolink	X	-	-	-
Bob-white	-	-	X	X
Bonapartes Gull	-	-	-	X
Broadwinged Hawk	-	X	-	-
Brown Pelican	X	X	X	X
Cape May Warbler	-	X	-	X
Cardinal	X	X	X	X
Caspian Tern	X	X	-	X
Cat Bird	-	-	-	X
Cattle Egret	X	X	X	X
Cedar Waxwing	X	-	-	-
Chuck-will's Widow	X	-	-	-
Clapper Rail	X	-	-	X
Common Crow	-	X	X	X
Common Egret	X	X	X	X
Common Flicker[b]	X	X	-	X
Common Gallinule	-	-	-	X
Common Grackle	X	-	X	X
Common Loon	-	-	-	X
Common Nighthawk	X	X	X	X
Common Snipe	X	-	-	X

Table 4. (Cont'd) A comparison of the bird species identified in the Turkey Point Study Area, 1979-1981, to those of the Surrounding.

COMMON NAME	SURROUNDING AREA[a]	1979	1980	1981
Common Starling	-	X	X	X
Common Tern	-	X	-	X
Double-crested Cormorant	X	X	X	X
Downy Woodpecker	X	-	-	-
Dunlin	-	-	-	X
Eastern Kingbird	-	-	-	X
Eastern Meadowlark	X	-	-	-
Eastern Phoebe	X	-	-	X
Glossy Ibis	X	-	-	-
Gray Kingbird	X	-	-	X
Great Blue Heron	X	X	X	X
Great White Heron	-	X	X	X
Green Heron	X	X	X	X
Ground Dove	-	X	X	X
Gull-billed Tern	-	-	-	X
Herring Gull	X	X	X	X
Hooded Merganser	-	X	X	X
House Sparrow	-	X	X	X
House Wren	X	-	-	-
Killdeer	X	X	X	X
Laughing Gull	X	X	X	X
Least Flycatcher	-	-	-	X
Least Sandpiper	-	X	X	X
Least Tern	X	X	X	X
Lesser Yellowlegs	X	-	-	X
Little Blue Heron	X	X	X	X
Long Billed Curlew	-	-	-	X
Louisiana Heron	X	X	X	X
Magnificent Frigatebird	X	X	X	X
Mallard Duck	-	-	-	X
Marsh Hawk	-	X	X	X
Merlin (Pigeon Hawk)	X	-	-	-
Mockingbird	X	X	X	X
Mottled Duck	-	X	X	X
Mourning Dove	X	X	-	X
Northern Waterthrush	X	-	-	-
Osprey	X	X	X	X
Painted Bunting	-	-	X	X
Palm Warbler	X	-	-	X
Peregrine Falcon	X	-	-	-
Pied-billed Grebe	X	X	X	X
Pileated Woodpecker	-	-	-	X
Pine Warbler	-	-	-	-
Piping Plover	-	-	-	X

Table 4. (Cont'd) A comparison of the bird species identified in the Turkey Point Study Area, 1979-1981, to those of the Surrounding Area.

COMMON NAME	SURROUNDING AREA[a]	1979	1980	1981
Prairie Warbler	X	-	-	-
Purple Martin	-	-	-	X
Red-bellied Woodpecker	X	X	-	X
Red-breasted Merganser	X	X	-	X
Reddish Egret	X	X	X	X
Red-headed Woodpecker	-	-	X	-
Red Knot	-	-	-	X
Red-shouldered Hawk	X	-	X	X
Red-tailed Hawk	-	X	-	X
Red-winged Blackbird	X	X	X	X
Ring-billed Gull	X	X	X	X
Robin	-	-	X	X
Rock Dove	-	X	-	X
Roseate Spoonbill	X	X	X	X
Royal Tern	X	X	-	X
Ruddy Turnstone	-	-	X	X
Rufous-sided Towhee	-	-	-	X
Sanderling	X	-	X	X
Savannah Sparrow	-	-	-	-
Screech Owl	X	-	-	-
Scrub Jay	-	-	-	X
Semipalmated Plover	-	X	X	X
Semipalmated Sandpiper	-	-	-	X
Sharp-shinned Hawk	X	-	-	X
Short-billed Dowitcher	-	-	X	X
Smooth-billed Ani	-	-	X	-
Snowy Egret	X	X	X	X
Solitary Sandpiper	-	-	-	X
Sooty Tern	-	-	-	X
Spotted Sandpiper	-	X	-	X
Summer Tanager	-	-	-	X
Swallow-tailed Kite	-	-	X	X
Tree Swallow	X	X	X	X
Turkey Vulture	X	X	X	X
White-crowned Pigeon	-	-	-	X
White-eyed Vireo	X	-	X	-
White Ibis	X	X	X	X
White Pelican	X	-	X	X
Willet	X	X	X	X
Wilson's Plover	-	-	-	X
Wood Duck	X	-	-	-
Wood Ibis	-	X	X	X
Wurdemann's Heron	-	-	X	-
Yellowthroat	X	-	-	-

Table 4. (Cont'd) A comparison of the bird species identified in the Turkey Point Study Area, 1979-1981, to those of the Surrounding Area.

COMMON NAME	SURROUNDING AREA[a]	1979	1980	1981
Yellow-bellied Sapsucker	X	X	-	-
Yellow-billed Cuckoo	-	X	-	-
Yellow-crowned Night Heron	X	X	X	X
Yellow-rumped Warbler	X	-	-	-
Yellow-throated Vireo	-	-	-	X
Yellow Warbler	X	-	-	-

[a] ABI, 1978

[b] In previous years the Common Flicker was referred to as the Yellow-shafted Flicker within the Turkey Point Study Area. This has now been changed to the Common Flicker since both the Red-shafted and Yellow-shafted Flicker are now considered to be the same species by the American Ornithologists Union.

Table 5. A comparison of the amphibian and reptilian species in the Turkey Point Study Area, 1979-1981, to those of the Surrounding Area.

COMMON NAME	SURROUNDING AREA[a]	1979	1980	1981
American Alligator	X	X	X	X
American Crocodile	X	X	X	X
Atlantic Green Turtle	-	X	-	-
Atlantic Loggerhead Turtle	-	-	X	X
Bahaman Bark Anole	X	-	-	-
Brown Anole	-	X	X	X
Corn Snake	X	X	-	X
Cuban Tree Frog	X	X	-	X
Eastern Diamondback Rattlesnake	X	X	X	X
Eastern Garter Snake	X	X	-	X
Eastern Indigo Snake	X	X	X	X
Everglades Racer Snake	X	-	-	-
Florida Cricket Frog	X	-	-	X
Florida King Snake	-	X	-	-
Florida Red-bellied	-	-	-	X
Florida Softshell Turtle	X	X	-	X
Florida Water Snake	X	-	-	-
Green Anole	X	X	X	X
Green House Frog	X	-	-	-
Green Tree Frog	X	-	X	X
Key West Anole	X	-	-	-
Mangrove Water Snake	X	X	X	X
Mediterranean Gecko	-	-	-	X
Mud Snake	-	X	X	-
Pig Frog	X	-	-	-
Reef Gecko	X	-	-	-
Southeastern Five-lined Skink	-	X	X	X
Southern Black Racer	-	-	-	X

Table 5. (Cont'd) A comparison of the amphibian and reptilian species in the Turkey Point Study Area, 1979-1981, to those of the Surrounding Area.

COMMON NAME	SURROUNDING AREA[a]	1979	1980	1981
Southern Leopard Frog	X	-	-	X
Southern Painted Turtle	-	X	-	-
Southern Ringneck Snake	-	X	-	-
Southern Toad	-	X	-	X
Striped Swamp Snake	-	-	-	X
Yellow Rat Snake	-	X	-	-

[a]ABI, 1978

Table 6. A comparison of the mammalian species in the Turkey Point Study Area, 1979-1981, to those of the Surrounding Area.

COMMON NAME	SURROUNDING AREA[a]	1979	1980	1981
Black Rat	X	X	-	-
Bobcat	X	X	X	X
Cotton Rat	X	-	-	-
Dolphin	X	-	-	-
Domestic Cat	X	X	X	X
Domestic Dog	X	X	X	-
House Mouse	X	-	-	-
Manatee	X	-	X	X
Marsh Rabbit	X	X	X	X
Opossum	-	-	-	X
Raccoon	X	X	X	X
Rice Rat	X	-	X	-
Whitetail Deer	X	-	X	X

[a]ABI, 1978

Table 7. Crocodile observations in the Turkey Point Study Area for 1981.

TAGGED ANIMALS

NUMBER OF INDIVIDUALS	SIZE RANGE (FEET)	MATURITY
1	3 - 4	Juvenile
3	5 - 6	Sub Adult
2	8 1/2 - 9	Adult
1	12 1/2 - 13	Adult

UNTAGGED ANIMALS

NUMBER OF INDIVIDUALS	SIZE RANGE (FEET)	MATURITY
2 or 3	3 - 4	Juvenile
1	4 - 5	Sub Adult
2 to 4	5 - 6	Sub Adult
2	6 - 7	Adult
3	8 - 9	Adult
1	11 - 12	Adult

2. Sampling of Soil and Vegetation West and South of the Cooling Canal System (ETS 4.2.2.3)

a. Soil Study

Introduction

The soil study is conducted to measure nitrite and nitrate levels in soils to the west and south of the Turkey Point Plant Cooling Canal System. These data define soil nitrogen levels in areas of natural vegetation relatively unaffected by the Turkey Point Plant and canals.

Materials and Methods

Soil samples were taken from the midpoint of Transects 1, 3, 5, 7 and 9 (Figure 1). A small core of several grams was taken after removal of the top 3 cm of soil. A second sample was taken 30 cm below the first. All samples were preserved on ice and sent to the laboratory. An acidified sodium chloride extraction procedure was used for nitrite and nitrate analyses (Jackson, 1958). Nitrate was reduced to nitrite in a cadmium column and the nitrite was analyzed using the diazotization method (APHA, 1980).

Nitrite and nitrate values were reported as nitrogen in micrograms per gram of dry weight of sample (Table 1).

Results

Nitrite levels in 1981 are about the same as levels in 1980. The range of nitrite at different sampling points is 0.38 to 6.11

μg/g dry soil in 1981 (Table 1) as compared with a range of 0.31 to 6.83 μg/g dry soil in 1980 (FPL, 1981). Nitrate levels are much lower this year and ranged from 1.56 to 10.93 μg/g dry soil in 1981 as compared with a range of 5.17 to 103.17 μg/g dry soil in 1980. The highest nitrite and nitrate values are present at a depth of 33 cm in the middle of Transect 5.

Discussion

Most soil nitrogen is found in organic matter that is decomposed by soil microorganisms into ammonium compounds. This nitrogen is first oxidized to nitrite and then to nitrate. The two oxidation changes are called nitrification. These microbiological transformations are influenced profoundly by soil conditions. When soil is cold, waterlogged, or excessively acid, nitrification progresses slowly. The most favorable conditions for nitrification are 1) adequate soil aeration, 2) temperatures from 27 to 32°C, 3) moderate soil moisture, and 4) an abundance of exchangeable bases (Brady, 1974).

The major soil type found west and south of the Turkey Point cooling canal system is highly organic peat. Organic soils are characterized by a high calcium oxide content and, therefore, an abundance of exchangeable bases even though the soils are often acidic. In the presence of a high hydrogen ion concentration, more nitrate accumulation takes place than in mineral soils. Consequently, the nitrite and nitrate values found in the 1981 soil

samples probably reflect this accumulation. As in previous years, nitrite and nitrate values are greater in the grasssland (Transects 1, 3 and 5) where greater soil aeration may have occurred than in the mangrove swamp (Transects 7 and 9) where standing water can be expected year round.

Conclusion

The combination of edaphic characteristics and environmental factors that influence the nitrification process accounts for the high variability found in soil nitrite and nitrate concentrations. No evidence suggests that this natural variability is affected by operation of the Turkey Point Plant.

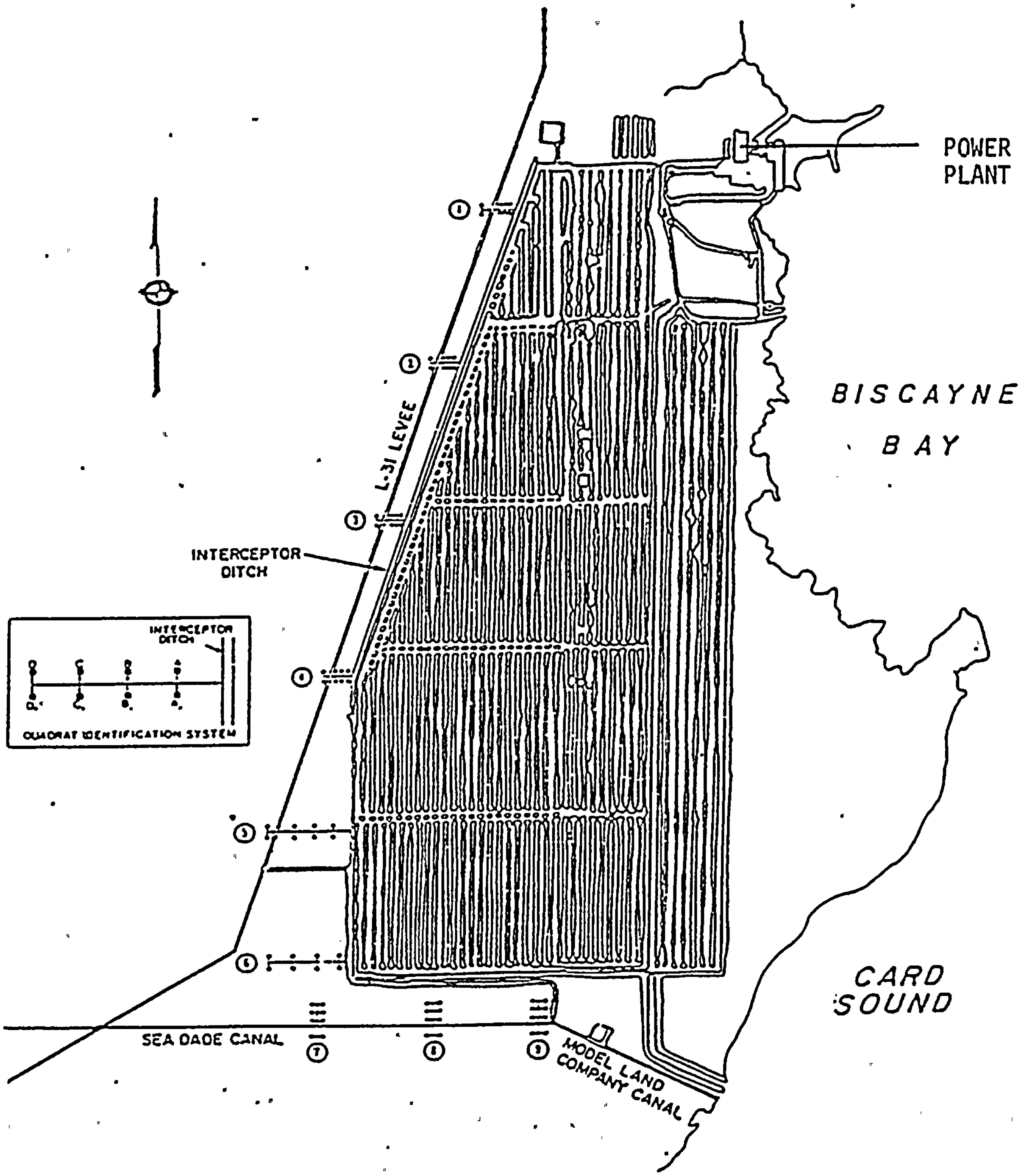


Figure 1. Vegetation transects, Turkey Point Plant, 1981. Soil samples were collected from Transects 1, 3, 5, 7 and 9.

Table 1. Laboratory analysis of 10 soil samples from the Turkey Point Site during 1981.

TRANSECT (number)	SOIL DEPTH (cm)	NITRITE NITROGEN (µg/g dry soil)	NITRATE NITROGEN (µg/g dry soil)
1	3	0.64	2.45
	33	1.30	4.23
3	3	0.51	1.74
	33	0.71	4.19
5	3	1.11	3.28
	33	6.11	10.93
7	3	0.74	2.15
	33	0.79	1.56
9	3	0.75	2.10
	33	0.38	2.01

b. Vegetation Study (ETS 4.2.2.3)

Introduction

The salinity regime resulting from land elevation is a major factor that determines the composition and distribution of plant communities along southeast Florida's coast. The interaction of tidal waters and freshwater runoff from rain creates a salinity gradient that ranges from salt water along the coast to fresh water inland. Following this gradient, the mangrove swamps that fringe shallow marine bays give way to buttonwood tree islands, salt marshes and eventually inland freshwater wetlands dominated by saw grass.

The climate and topography of this area strongly influence the interaction of tidal waters and freshwater runoff that produce the salinity gradient. Runoff varies seasonally with rainfall. About 152 cm of rain falls in the area annually, primarily from May through November. During this wet season, groundwater is near the surface. During the dry season (December through April), when groundwater levels are low, infiltration of surface water is greater and freshwater runoff is reduced. The slight slope of the land, approximately 1.8 cm per 100 m, causes fresh water from inland regions to drain southeastward into Card Sound (Figure 1).

The natural equilibrium between freshwater runoff and tidal waters has been altered in recent years by the construction of

Canal L-31 west of the Turkey Point Plant, the Sea Dade and Model Land Canals south of the site, and the Turkey Point Plant Cooling Canal System. The natural southeasterly flow of runoff and groundwater from inland regions has been diverted towards these canals and away from the plant communities located south and west of the Turkey Point system (Figure 1). The purpose of this continuing study is to identify the long-term operational impacts of the Turkey Point Plant Cooling Canal System on vegetation located south and west of the system.

Materials and Methods

Study Design

The vegetation near the cooling canal system was classified into three plant community types for sampling and data analysis. These categories were 1) the saline mangrove swamp south of the system, 2) the brackish grassland of saw grass, salt rush and salt grass to the west, and 3) mangrove and buttonwood tree islands within the grasslands. Each of these communities was sampled to identify potential impacts of the canal system on vegetation composition and biomass.

The specific location of sampling stations within each community was determined by the interpretation of aerial photos. Sampling transects were chosen to provide equal sampling in each of the major vegetation communities on the site.

The study design assumes that impacts on vegetation attributable to the cooling canal system will decrease with distance from the system. Sample quadrat locations were selected along transects that originated adjacent to the cooling canal and extended into the surrounding vegetation west and south of the system. Thus, by comparing the composition and biomass of vegetation adjacent to and farther away from the canal system, changes attributable to operation of the Turkey Point Plant Cooling Canal System can be readily observed.

Field Methods

Quantitative data have been collected along nine transects once during each dry season since 1975. The 1981 sampling was conducted in early November.

Transects 1 through 6 run east to west perpendicular to and west of the cooling canals (Figure 1). These transects were selected so that three intersect tree islands and three intersect grasslands. Transects 7 through 9 run north-south perpendicular to the southern border of the canal system and intersect mangrove communities.

Four sampling points were established at predetermined intervals along each transect to identify canal system effects on vegetation with distance from the canal. At each sampling point, two 5 x 5-m (25-m^2) quadrats were located on opposite sides of the

transect line as shown in the insert of Figure 1. Thus, for the grassland community (Transects 1, 3 and 5), quadrats A and A' represent vegetation adjacent to the canal system and quadrats D and D' represent vegetation farthest away from the system. This sampling design yields six replicate quadrats per community and distance from the canal system.

Statistical Methods

The statistical approach used to detect impacts of cooling canal system operation on the vegetation answered the following questions:

1. Is there a change in composition and/or biomass of vegetation communities that is greater adjacent to the canal system and less farther away from the system,
2. Is the change greater this year than in previous years,
3. Are both of the above true; that is, does the change increase with time and is it greatest adjacent to the canal system?

If the answer to any one of these questions is affirmative, it may be concluded that canal system impact has occurred. If the associated null hypotheses are accepted according to the data, no effects can be attributed to the canal system.

Composition was estimated by frequency. Frequency is defined as the number of quadrats in which a species occurred divided by the total number of quadrats sampled. The resulting values estimate the probability of finding at least one individual of the spe-

cies in one quadrat. Analysis of frequencies with G as the test criterion (Sokal and Rohlf, 1969) was used to detect changes in species composition.

Biomass was estimated by a volume-density index developed for this study. This index estimates the volume (height x radius^2) and weighs it by the density of individuals within the volume (Figure 2). This method is analagous to traditional measures of yield and was derived from Goodall's vector space approach to community analyses (Greig-Smith, 1964). It shares the advantage of the traditional measures in that it can be determined easily in the field and has the further advantage of allowing comparisons of species with different growth forms. Multivariate analysis of variance (SAS, 1979) with the F-ratio as the test criterion was used to detect changes in biomass. Because biomass data are strongly skewed and biomass changes exponentially due to the rate of plant growth, the data were transformed by taking natural logarithms of the values (Sokal and Rohlf, 1969).

Whenever the hypotheses tested were proven to be true with 95 percent confidence (P=0.05), the results were designated as "(statistically) significant". The independent variables for the analyses are 1) distance from the cooling canal system and 2) calendar year in which the data were collected. The dependent variables are 1) frequencies of each species and 2) volume density index for each common species.

The critical tests of the hypotheses determined not only statistical significance, as defined above, but also the ecological significance to the ecosystem (Collier et al., 1973). The indices were chosen because they allow an examination of the individual species' contributions to overall community effects. If a community effect was detected, then individual species were examined to identify the ecological significance of the change in the community.

Although the statistical design was constructed to detect changes attributable to the canal system, the study design can also detect impacts from other events. Correct interpretation of the data requires identification of the manner in which vegetation would be affected by different causes.

Comparison With Baseline Data

The data collected in this continuing study were compared with Turkey Point baseline data collected east of the present study area prior to cooling canal construction in 1972 (FPL, 1978a). Additional baseline data were collected from the South Dade site, southeast of the present study area, in 1974 (FPL, 1978b).

Results and Discussion

Plant Species at Turkey Point

A total of 186 plant species (Table 1) have been observed in the Turkey Point and South Dade studies. Fifteen species were present in all studies and in 1981, 29 species had frequencies greater than or equal to 5 percent. In the 1981 study, 67 species were observed. This value is not significantly different from the average (64 species) for all studies.

From 1974 through 1976, a decreasing number of new species was observed each year (Figure 3). In a stable plant community this would be expected because a smaller number of the uncommon species would be discovered with each year's sampling effort. In 1977, however, the number of new species increased, suggesting a change in the previously stable plant communities. The major cause of this change was a killing freeze that occurred in January 1977 (FPL, 1978). After the 1977 sampling year, the number of species observed for the first time again steadily decreased through 1980. This phenomenon indicates that the composition of species at Turkey Point reached a new, post-freeze stability through 1980.

In 1981, seven new species were observed for the first time (Figure 3; Table 1). Four of the new species were found in fire-impacted Quadrats 2D2, 4D1 and 4D2 (Figure 4; Benedict, 1981). The probable cause of this increase in new species was revegetation after brush fires swept through areas west of the cooling canal

system in March. These fires destroyed quadrat location markers at 4D1 and 4D2 and three of four corners were destroyed at Quadrat 2D1. All three quadrats were reset as close as possible to their original locations.

Community Composition, 1981 Study

Overall community composition in 1981 was not significantly different from community composition in 1980 but was significantly different from that of the pre-freeze years (1975-1976; G=65.50, $P \leq 0.05$) as expected. Impacts from the freeze of January 1977 have been noted in previous studies (FPL, 1979, 1980, 1981). Community composition in 1981 also was significantly different from that of two post-freeze years (1978 and 1979; G=52.2 and 48.0, respectively, $P \leq 0.05$). To identify the ecological implications of these results, the contribution of each common species to the overall difference between 1981 and these years was examined.

First, the frequency of occurrence of common species was calculated to detect differences between 1981 and the pre-freeze years (Table 2). Common species are defined as those present in 1981 at frequencies greater than 5 percent. Of these 29 common species, 13 showed significant differences in frequency between 1981 and 1975-1976. Twelve species have increased in frequency (aster, glades morning glory, salt grass, clubrush, schoenus, climbing hempvine, groundsel, Brazilian pepper, St. John's wort, loosetrife, mermaid weed and white indigo berry) and one (leather

fern) decreased in frequency since the freeze. For many of these species, an abrupt change in frequency took place between 1976 and 1977 (Figure 5) and the impact of that change is still evident in statistical tests comparing 1981 data with those preceding the freeze (1975-1976).

Ecological causes for the changes in species' frequency can be inferred by examining frequency changes observed immediately after the freeze. Between 1976 and 1977, 10 predominately salt-tolerant herbaceous and woody species increased in frequency (white mangrove, aster, glades morning glory, salt grass, clubrush, schoenus, groundsel, sea daisy, Brazilian pepper and St. John's wort; Table 2). These species apparently benefited from the effects of the freeze by expanding their distributions. Perhaps their ability to recover quickly might have given these plants a competitive advantage over their neighbors. In contrast, other species such as red mangrove, blechnum fern, leather fern and cabbage palm were adversely affected by the freeze as shown by their sharply reduced frequencies in 1977. Most of these species are slowly returning to pre-freeze frequencies. As we have seen, however, the frequency of leather fern in 1981 still is significantly lower than in pre-freeze years. Freeze effects therefore account for some but not all of the discrepancy between overall community composition in 1981 compared with previous years.

Secondly, differences were examined in the frequency of occurrence of common species between 1981 and two post-freeze years (1978 and 1979; Table 2). Five species have increased significantly in frequency since 1978 and 1979 (glades morning glory, climbing hempvine, St. John's wort, loosestrife and red bay). In each case, these species had frequencies of less than 5 percent in 1978 or 1979 and increased to greater than 5 percent in 1981. Successional changes can account for the increase in these species over the post-freeze years. Since 1977, only seven species (glades morning glory, rush, schoenus, climbing hempvine, fleabane, loosestrife and muscadine grape) have shown greater than a 5 percent net increase in frequency with time.

Although there were no statistically significant changes in community composition from 1980 to 1981, the frequency of one species increased significantly (loosestrife) and three others increased sharply (glades morning glory, climbing hempvine and fleabane) over the past year. These increases most likely reflect successional changes in community composition. Only red mangrove showed reduction in frequency between 1980 and 1981. This change occurred because a fire in March 1981 destroyed red mangroves in Transect 2.

These results show that no ecologically significant change in overall community composition has occurred since the freeze. Species' frequencies appear stable with the exception of some

increases resulting from natural succession. Although there have been some changes in species frequency over time, these changes reflect impacts from the freeze of January 1977 or slight increases probably resulting from succession. No impacts attributable to the cooling canal system are evident.

Community Composition, Comparison With Baseline

The community composition for 1981 was significantly different from the community composition for both the 1972 Turkey Point Baseline Study (FPL, 1978a) and the 1974 South Dade Baseline Study (FPL, 1978b; $G=24.16$ and 36.58, respectively, $P \leq 0.05$).

To determine the ecological implications of these results, the contribution of common species to the differences observed between the operational monitoring data and the baseline data were examined (Table 3). Generally, species that showed significant frequency differences between studies had greater frequencies in 1981 than in either baseline study. Species characteristic of the saw grass prairie and associated hammocks (saw grass, buttonwood, white mangrove and poisonwood) had greater frequencies in the 1981 study than in the baseline data. However, more salt-tolerant species, such as red mangrove and salt grass, had higher frequencies in one or the other baseline study than in the 1981 operational monitoring study. Red mangrove was reduced because of the March 1981 fire. Frequencies of all other species were fairly constant from 1972 to 1981, indicating that differences were not increasing over time (FPL, 1979, 1980, 1981).

Therefore, the significant differences observed in community composition between the baseline studies (FPL, 1978a, 1978b) and the 1981 study cannot be attributed to the cooling canal system. The observed differences in frequency are probably due to differences in sampling locations among the studies. The Turkey Point operational monitoring study stations are further from the shoreline than those of either the Turkey Point Baseline Study or the South Dade Baseline Study.

Biomass, 1981 Study

Analysis of biomass for 1981 is valuable for the information it conveys in detecting long-term trends. Vegetation volume-density indices by transect for 1981 are presented in Tables 4 through 6. Biomass data from 1981 then were combined with all of the previous data for the 12 most common species (annual mean frequencies greater than 10 percent; Table 1) and used for the long-term analysis.

Biomass, Long-Term Analysis

Biomasses of the 12 common species were examined to detect changes occurring over time and changes occurring with distance from the cooling canal system. If the biomass of a species differed significantly with time or distance, the overall biomass for that year or quadrat was examined. A species' biomass in each of the three vegetation communities--grassland, tree island and

mangrove--was discussed when this information revealed ecological reasons for its abundance or decline.

Five species showed significant biomass differences among years (Table 7). Four of these species, saw grass, buttonwood, red mangrove, and leather fern, decreased in biomass by a factor of 10 between 1976 and 1977 (Figure 5). Since the freeze, all of these species have exhibited varying degrees of biomass recovery. When data from each vegetation community were combined, biomass of saw grass, red mangrove and leather fern increased in 1981 to levels that were not significantly different from those of one or the other pre-freeze years (1975 or 1976). Although the biomass of buttonwood increased from 1980 to 1981, 1981 biomass was still significantly lower than in pre-freeze years. The fifth species, aster, was rare prior to 1977 but has now become established and is maintaining a low biomass.

In the tree island vegetation community, red mangrove and buttonwood appear to be competitors. Both species increased from relatively low biomass in 1975 to much greater biomass in 1976 (Figure 6). They also both decreased after the freeze and retained low biomass through 1978. By 1979, red mangrove biomass increased in tree island communities then decreased slightly in 1980 and buttonwood remained about the same during 1979 and 1980. Red mangrove biomass in 1981, however, decreased to the low 1975 pre-freeze biomass. In contrast, buttonwood biomass increased in 1981 to the

high 1976 level. Ecological reasons for these changes in the tree island communities are, first, that the March 1981 fire scorched and destroyed red mangroves in several tree island quadrats. Second, buttonwood responded to the effects of the freeze by producing many-stemmed shrubs after its top branches were killed. This probably increases its biomass and may be giving buttonwood a competitive edge in the tree islands where both species coexist. Future studies will show whether red mangrove replaces itself, buttonwood increases its biomass or new woody species invade as the burned quadrats recover.

For each of the five species that exhibited a statistically significant change in biomass over the years 1975 to 1981, the most abrupt change occurred between pre-freeze 1976 and post-freeze 1977. Therefore, the observed changes in biomass primarily reflect the impact of the freeze and, to a lesser extent, the effects of local fire and natural succession. Because there has been no consistent annual change in biomass overall, evidence suggests that the cooling canal system has had no significant impact on vegetation biomass over time.

Biomass of five of the common species showed significant differences with distance from the canal system (Table 7). These species were saw grass, buttonwood, rush, leather fern and Australian pine (Figure 6). Biomass for saw grass, buttonwood and rush was higher at quadrats close to the canal system (A,B and C) than

farther away (D). Biomass for leather fern and Australian pine also was significantly higher close to the canal system (Quadrats A and. B) than at quadrats farther away (C and D). Because biomass at the D quadrats was significantly lower in all cases and because D quadrats are the only ones located either west of Canal L-31 (Transects 1 through 5; Figure 1) or south of the Sea Dade Canal (Transects 7 through 9), it is likely that effects are attributable to these canals.

Each of the species that showed significant differences in biomass with distance from the cooling canal system has specific ecological requirements. Therefore, the response of each species to environmental variables is different and it is difficult to determine specifically how proximity to the canal system may have resulted in biomass changes. Ecological needs of each species are discussed briefly.

Saw grass, buttonwood and rush did not differ significantly in distribution of biomass within the area likely to be affected by the cooling canal system (Quadrats A through C). Saw grass biomass in the most seaward portions of the mangrove community (D quadrats) was naturally low because brackish water there limits growth of this freshwater species (Long and Lakela, 1971). Buttonwood is a species commonly found in less brackish inland areas and rush is a fresh- and salt water tolerant species usually found on salt flats (Craighead, 1971).

Leather fern and Australian pine decreased in biomass with distance from the cooling canal even when biomass at D quadrats was not taken into consideration. Leather fern is a salt-tolerant species common to brackish coastal hammocks. Australian pine grows well on disturbed land such as spoil berms but cannot colonize mangrove communities or wetlands that are flooded most of the year (Craighead, 1971).

A consistent increase or consistent decrease in biomass with distance from the cooling canal system would indicate an impact on vegetation. No ecologically consistent pattern is evident, however. For example, biomass of salt-tolerant species is not always greater adjacent to the cooling canals, nor is biomass of freshwater species always greater away from the system. Therefore, evidence suggests that no impact on the biomass of vegetation can be attributed to the Turkey Point canals. It does appear, however, that statistically significant differences in biomass at the farthest quadrats (D) result from proximity to Canal L-31, the Sea Dade or Model Land Canals where the interception of freshwater run-off may cause different ecological conditions from those east and north of these canals.

Conclusion

A total of 186 plant species have been observed in all of the Turkey Point (FPL, 1976, 1977, 1978c, 1979, 1980, 1981) and South Dade Studies (ABI, 1978a, 1978b). Examination of the number of

species observed for the first time each year revealed that there have been no major changes in the species list since the change that occurred between December 1976 and December 1977, following the freeze of January 1977.

Community composition showed a significant change attributable to the freeze of 1977. There was evidence in the 1981 study that both freshwater and salt-tolerant species had increased in frequency since that natural event. However, salt-tolerant species seem to have recovered more quickly than salt-intolerant ones. Successional changes account for the increase in frequency of some less-common species during the years since the freeze.

Community composition in the 1981 operational monitoring study was significantly different from both the 1972 Turkey Point baseline data (ABI, 1978a) and from the 1974 South Dade baseline data (ABI, 1978b). Baseline data showed higher frequencies for salt-tolerant species and lower frequencies for salt-intolerant species than did the operational monitoring data. Differences in sampling locations in the studies probably accounted for the observed differences.

Two general trends in vegetation biomass are evident. First, the biomass of five common species differed significantly among years. These differences reflect the impact of the freeze of 1977, the localized effects of a fire in March 1981, and overall natural

succession. Secondly, the biomass of five common species decreased significantly with distance from the Turkey Point canal system. These results probably reflect the impact of canals outside the cooling canal system (Canal L-31, Sea Dade and Model Land Company Canals) as well as differences in the ecological requirements of those species. Evidence suggests that the cooling canal system has had no clear impact on the biomass of species at Turkey Point.

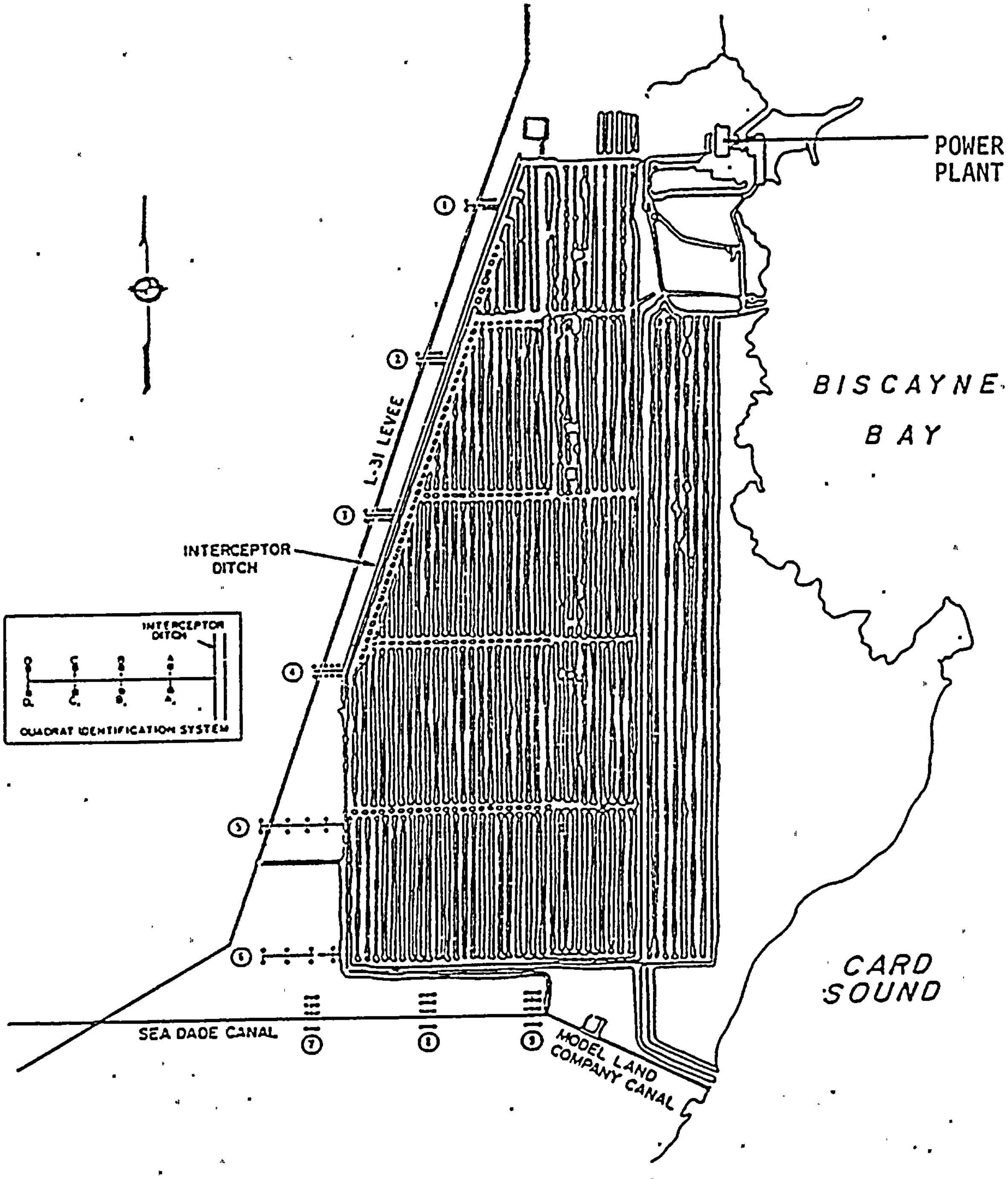


Figure 1. Location of vegetation sampling transects, Turkey Point site, 1981.

Example 1. Saw grass (*Cladium* sp.)

where: *Cladium* index = $\frac{NHR^2}{A}$

N = Number of graminoid plants;

H = Average height per plant, in centimeters = $\frac{\text{Total WH}}{T}$,

WH = Weighted height per plant, in centimeters = PC,

P = Number of plants per clump,

C = Clump height,

T = Total number of plants measured;

R = Radius per plant, in centimeters (gathered, compressed and measured at widest point) = $\frac{D}{2}$;

D = Average diameter per plant, in centimeters = $\frac{D'}{T'}$

D' = Total diameter of all measured plants,

T = Total number of plants measured.

sample	N = 240	R = 1.592
values	H = 142.2	A = 1.0

Cladium Index = $\frac{(240)(142.2)(1.59)^2}{1.0}$ = 86,002.56

Figure 2a. Examples of volume-density index calculations of a graminoid and woody plant species, Turkey Point Plant, 1981.

<u>Example 2.</u> Woody shrub (<u>Conocarpus</u>)

<u>Conocarpus</u> index = NHR^2

where: N = Number of shrubs of similar dimensions (seedlings measured separately);

H = Average shrub height, in centimeters = $\frac{H'}{N'}$,

H' = Total height of all measured shrubs,

N' = Total number of shrubs measured;

R = Radius per shrub, in centimeter = $\frac{D}{2}$

D = Average diameter per shrub, in centimeters = $\frac{D'}{N'}$

D' = Total diameter of all measured shrubs,

N' = Total number of shrubs measured.

sample values

N = 1.0

H = 365.8

R = 6.45^2

<u>Conocarpus</u> Index = $(1.0)(365.8)(6.45)^2$ = 15,218.19

Figure 2b. Examples of volume-density index calculations of a graminoid and woody plant species, Turkey Point Plant, 1981.

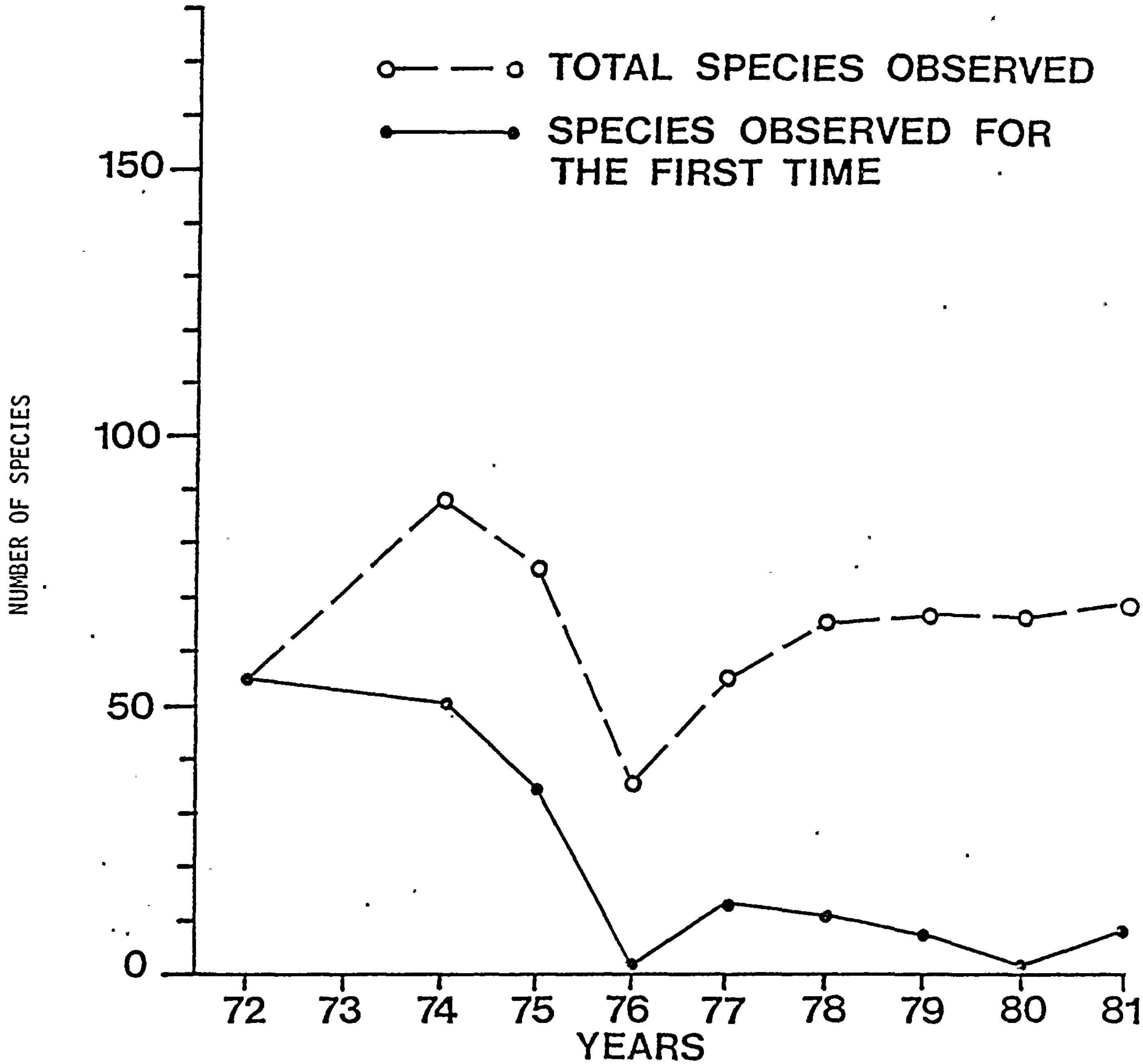


Figure 3. Number of plant species observed, Turkey Point Plant, 1973-1981.

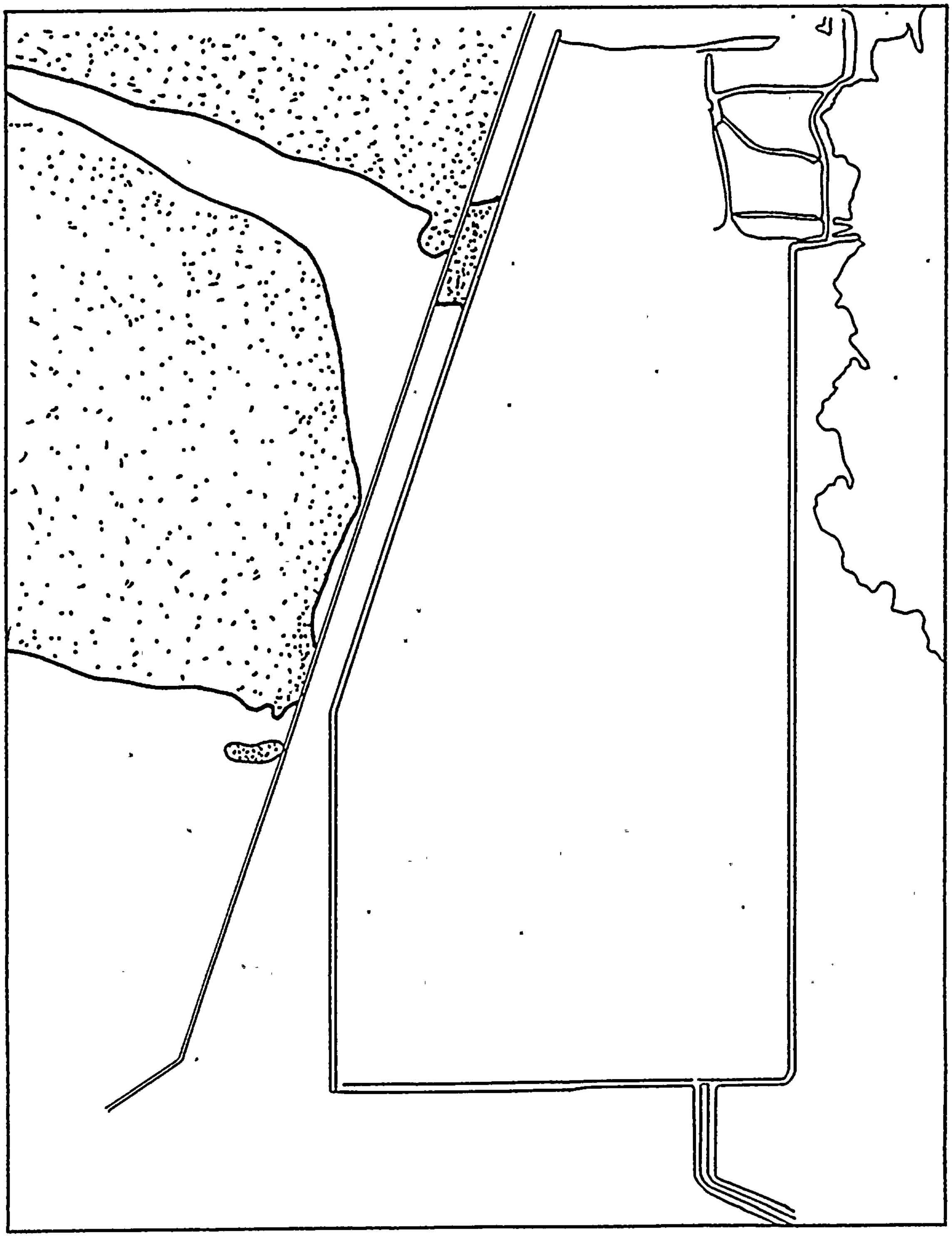
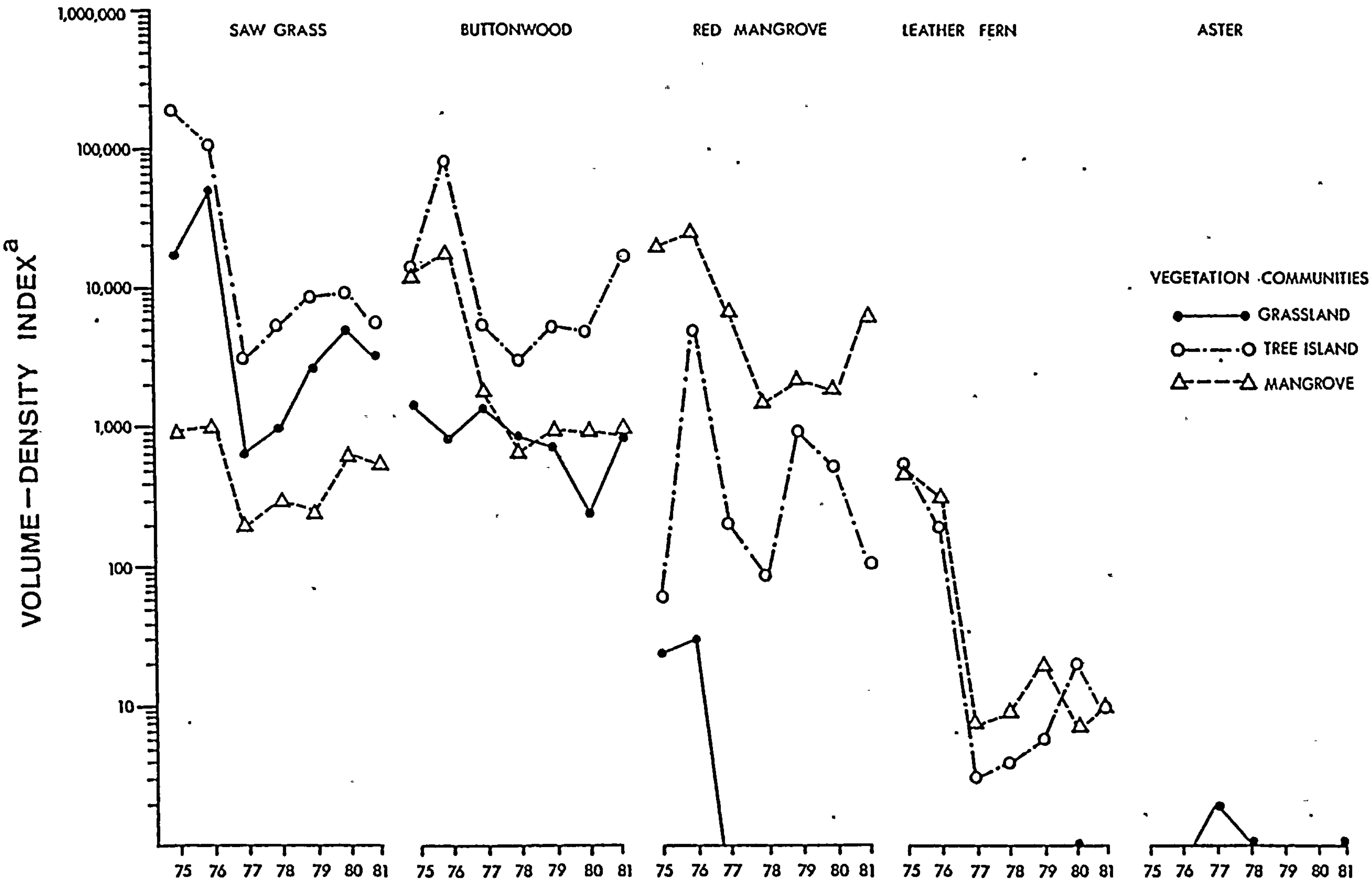
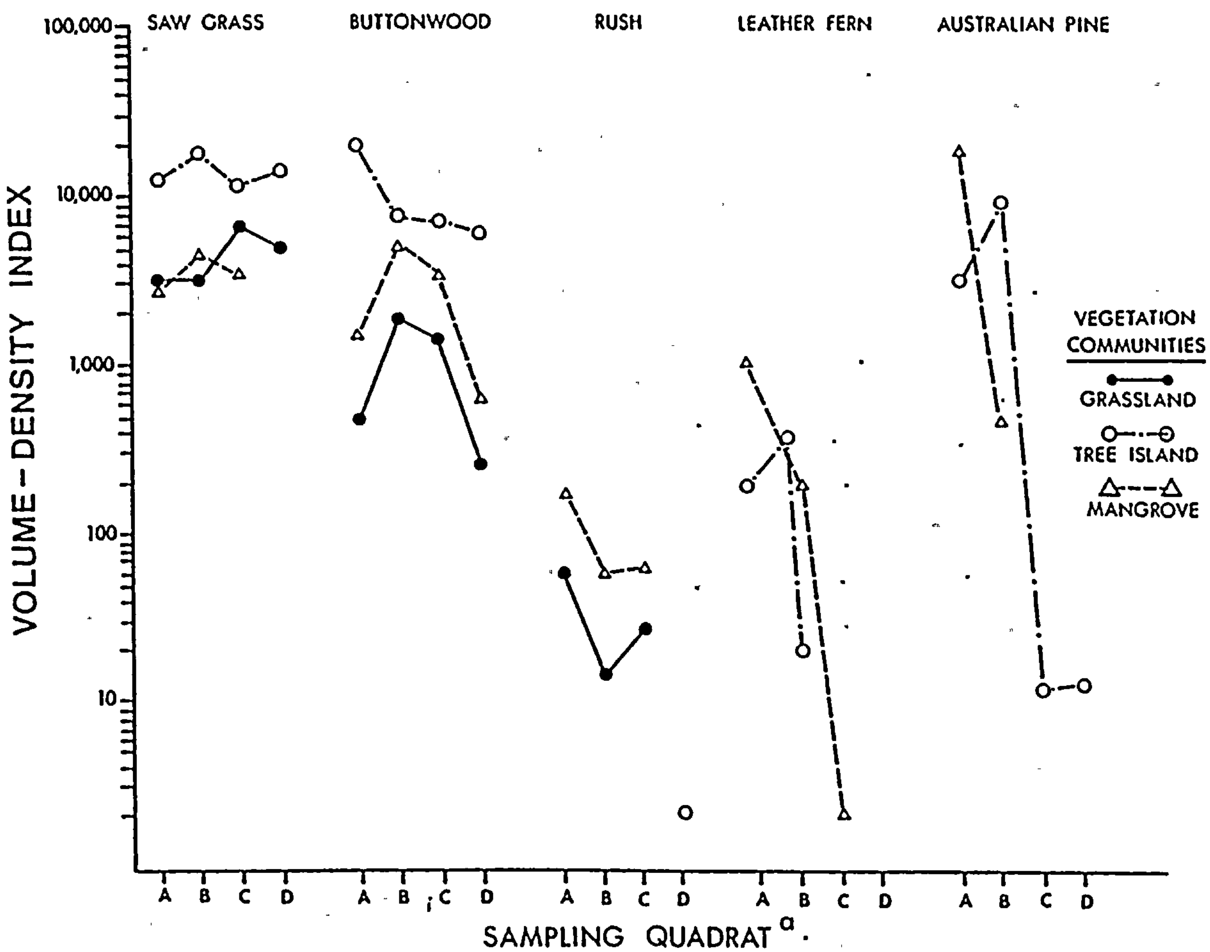


Figure 4. Location and extent of burned areas near the Turkey Point Cooling Canal System. March 1981. Stippled areas are 70 - 100 percent burned.



[a]Values are the geometric mean of the index for each community per year.

Figure 5. Comparison of average biomass for selected species, Turkey Point Plant, 1975-1981.



[a]Sampling quadrats A through D represent sampling points of increasing distance from the cooling canal system; A is adjacent to the cooling canal, D is farthest from it (see Vegetation Figure 1).

Figure 6. Comparison of average biomass for selected species with increasing distances form the cooling canal system, Turkey Point Plant, 1975-1981.

Table 1. Plant species observed and frequency of occurrence at the Turkey Point Plant during 1972-1981.

SPECIES	COMMON NAME	FREQUENCY (%) 1972[a]	1974[b]	1975[c]	1976[c]	1977[c]	1978[c]	1979[c]	1980[c]	1981[c]	Mean
Acrostichum aureum	Leather fern	15.9	10.0	30.6	18.1	6.9	12.5	11.1	12.5	8.3	14.0
Agalinis sp.	False foxglove	2.4	-	-	-	-	-	-	-	-	0.3
Annona glabra	Pond apple	3.7	3.3	1.4	1.4	-	-	-	1.4	-	1.2
Ardisia escallonoides	Marlberry	-	-	-	-	4.2	-	-	-	-	0.5
Asclepias sp.	Milkweed	3.7	0.5	-	-	-	-	-	-	-	0.5
Aster sp.	Aster	-	0.5	-	-	30.6	29.2	27.8	29.2	30.6	16.4
Aster tenuifolius v. aphyllus	Aster	-	-	1.4	-	-	-	-	-	-	0.2
Avicennia germinans (Avicennia nitida)[d]	Black mangrove	-	5.2	1.4	-	4.2	-	2.8	2.8	2.8	2.1
Baccharis sp.	Groundsel, saltbush	-	-	4.2	-	11.1	4.2	-	1.4	-	2.3
B. angustifolia	False willow	1.2	7.1	1.4	-	-	5.6	4.2	5.6	4.2	3.3
B. dioica	Groundsel	-	-	-	-	-	-	1.4	-	-	0.2
B. glomeruliflora	Groundsel tree	-	-	-	-	-	4.2	4.2	2.8	5.6	1.9
B. halimifolia	Groundsel	12.2	6.2	1.4	-	-	2.8	8.3	4.2	1.4	4.1
Bacopa monnieri	Water hyssop	-	-	1.4	-	-	-	-	-	-	0.2
Batis maritima	Saltwort	-	4.3	1.4	-	-	-	-	-	-	0.6
Blechnum serrulatum	Blechnum fern	9.8	5.2	23.6	15.3	6.9	8.3	5.6	9.7	11.1	10.6
Borrichia arborescens	Sea oxeye daisy	-	1.4	-	-	-	1.4	-	-	-	0.3
B. frutescens	Sea daisy	6.1	16.2	2.8	2.8	12.5	12.5	9.7	12.5	8.3	9.3
Bucida spinosa	Spiny bucida	-	-	1.4	-	-	-	-	-	-	0.2
Bulbostylis stenophylla[e]	(no common name)	-	-	-	-	-	-	-	-	1.4	0.2
Cakile fusiformis	Sea rockets	-	-	-	-	1.4	-	-	-	-	0.2
Calopogon sp.	Grass pink	-	0.5	-	-	-	-	-	-	-	0.1
Calyptranthes pallens	Pale lidflower	-	-	1.4	-	-	-	-	-	-	0.2
Cassytha filiformis	Love vine, dodder	-	-	1.4	-	-	-	2.8	5.6	1.4	1.2
Casuarina equisetifolia	Australian pine	12.2	5.7	13.9	12.5	8.3	12.5	9.7	9.7	11.1	10.6
Celtis laevigata	Hackberry	-	-	1.4	-	-	-	-	-	-	0.2
Cephalanthus occidentalis	Buttonbush	-	4.8	-	1.4	1.4	-	-	-	-	0.8
Chamaesyce sp.	Spurge	-	-	-	-	-	1.4	-	-	-	0.2
Chiococca alba	Snowberry	4.9	5.2	5.6	-	4.2	-	5.6	1.4	4.2	3.5
Chloris sp.	Finger grass	-	0.5	-	-	-	-	-	-	-	0.1
Chrysobalanus icaco	Coco palm	1.2	1.9	4.2	6.9	-	4.2	-	-	-	2.0
Cladium jamaicensis (Mariscus jamaicensis)	Saw grass	74.4	44.3	83.3	80.6	81.9	86.1	84.7	83.3	84.7	78.1
Coccothrinax argentata	Silver palm	-	-	1.4	-	-	-	-	-	-	0.2
Cocos nucifera	Coconut palm	1.2	-	-	-	-	-	-	-	-	0.1
Colubrina elliptica (Colubrina reclinata)	Nakedwood	2.4	-	-	-	-	-	-	-	-	0.3
Conocarpus erecta	Buttonwood	65.9	30.5	77.8	76.4	70.8	77.8	73.6	70.8	69.4	68.1
Crinum americanum	String lily	-	2.4	1.4	1.4	-	-	-	-	-	0.6
Cuscuta sp.	Dodder	1.2	2.4	-	-	-	1.4	-	-	-	0.6
Cuscuta americana	Dodder	-	0.5	-	-	-	-	-	-	-	0.1
Cyanchum palustre	Vine milkweed	-	2.4	-	-	-	-	-	-	-	0.3
CYPERACEAE	Sedge	-	-	-	-	1.4	1.4	-	-	-	0.3
Dalbergia amerimnon (Dalbergia brownii)	(no common name)[f]	-	1.4	-	-	-	-	-	-	-	0.2

Table 1. Plant species observed and frequency of occurrence at the Turkey Point Plant during 1972-1981. (cont'd).

SPECIES	COMMON NAME	FREQUENCY (%)									
		1972[a]	1974[b]	1975[c]	1976[c]	1977[c]	1978[c]	1979[c]	1980[c]	1981[c]	Mean
D. ecastophyllum	(no common name)	-	-	-	1.4	-	-	-	-	-	0.2
Damirino sp.	(no common name)	-	-	-	-	-	-	1.4	1.4	-	0.3
Dichromena floridensis	(no common name)	-	-	-	-	-	1.4	-	1.4	-	0.3
Dipholis salicifolia	Bustic	-	-	1.4	1.4	4.2	1.4	1.4	2.8	1.4	1.6
Distichilis spicata	Salt grass	20.7	49.0	4.2	5.6	18.1	18.1	19.4	18.0	18.1	19.0
Eleocharis sp.	Clubrush, spikerush	1.2	1.0	-	-	-	-	-	-	-	0.2
Eleocharis cellulosa	Clubrush, spikerush	1.2	-	1.4	4.2	12.5	12.5	13.9	11.1	15.3	8.0
Eleusine indica	Yard grass	-	1.0	-	-	-	-	-	-	-	0.1
Encyclia tampensis	Butterfly orchid	-	-	1.4	-	-	-	-	-	-	0.2
Eugenia sp.	(no common name)	-	-	-	-	-	-	1.4	-	-	0.2
E. axillaris	White stopper	2.4	-	1.4	2.8	1.4	-	-	-	-	0.9
E. confusa	Ironwood	-	-	-	-	-	2.8	-	-	-	0.3
E. foetida[e]	Stopper	-	-	-	-	-	-	-	-	2.8	0.3
E. myrtoides	Spanish stopper	2.4	-	-	-	-	1.4	1.4	4.2	-	1.0
Eulophia alta	Wild coco	-	-	1.4	-	-	-	-	-	-	0.2
Eupatorium capillifolium	Dog fennel	-	7.1	1.4	-	1.4	5.6	1.4	-	2.8	2.2
Ficus aurea	Strangler fig	-	-	2.8	-	-	-	-	-	-	0.3
F. citrifolia	Wild banyan tree	3.7	3.8	1.4	1.4	-	-	-	-	-	1.1
Fimbristylis sp.	Sedge	-	-	1.4	-	2.8	-	-	-	-	0.5
Flaveria sp.	(no common name)	-	-	-	-	-	-	1.4	1.4	-	0.3
Forestiera segregata	Florida privet	-	-	-	-	2.8	-	1.4	1.4	1.4	0.8
Fuirena sp.	Umbrella grass	1.2	0.5	-	-	-	-	-	-	-	0.2
F. scirpoidea	Umbrella grass	1.2	3.3	-	-	1.4	-	1.4	-	-	0.8
Galium hispidulum	Bedstraw	-	-	1.4	-	-	-	-	-	-	0.2
G. obtusum	Bedstraw	-	-	-	-	-	-	1.4	2.8	1.4	0.6
Habenaria sp.	Orchid	-	-	-	-	-	-	-	1.4	1.4	0.3
Hydrocotyle umbellata	Marsh pennywort	-	3.3	-	-	-	-	-	-	-	0.4
Hypericum sp.	St. John's wort	-	-	-	-	6.9	6.9	-	2.8	6.9	2.6
Ilex cassine	Dahoon holly	6.1	5.2	4.2	5.6	2.8	1.4	1.4	4.2	2.8	3.7
Ipomoea sp.	Morning glory	2.4	-	-	-	-	-	-	-	-	-
I. sagittata	Glades morning glory	-	4.3	5.6	-	8.3	20.8	1.4	9.7	20.8	7.9
Jacquemontia curtissii	(no common name)	-	-	-	-	2.8	-	2.8	2.8	4.2	1.4
J. reclinata	(no common name)	-	-	-	-	-	4.2	-	-	-	0.5
Juncus roemerianus	Rush	15.9	17.6	22.2	13.9	13.9	19.4	22.2	19.4	19.4	16.7
Kosteletzkya virginica	Salt marsh willow	-	0.5	-	-	-	-	-	-	-	0.1
Lachnanthes caroliniana	Red root	-	0.5	-	-	-	-	-	-	-	0.1
Laguncularia racemosa	White mangrove	9.8	34.8	23.6	30.6	41.7	33.3	29.2	29.2	33.3	29.5
Lantana involucrata	Lantana	-	0.5	-	1.4	2.8	2.8	1.4	1.4	1.4	1.3
L. microcephala	Lantana	-	-	-	-	-	-	1.4	1.4	1.4	4.7
Lippia nodiflora	Capeweed	-	1.0	-	-	-	-	-	-	-	0.1
Ludwigia sp.	(no common name)	-	-	-	-	-	-	1.4	5.6	4.2	1.2
L. microcarpa	Water purslane	-	-	1.4	-	-	-	-	-	-	0.2
L. peruviana	Primrose willow	-	1.0	-	-	-	-	-	-	-	0.1
L. repens	Water purslane	-	-	-	-	-	5.6	4.2	4.2	1.4	1.7
Lycium carolinianum	Christmas berry	-	-	2.8	2.8	-	-	-	-	-	0.6
Lythrum alatum	Loosestrife	-	-	-	-	-	-	1.4	1.4	6.9	1.1

Table 1. Plant species observed and frequency of occurrence at the Turkey Point Plant during 1972-1981. (cont'd).

SPECIES	COMMON NAME	FREQUENCY (%)									
		1972[a]	1974[b]	1975[c]	1976[c]	1977[c]	1978[c]	1979[c]	1980[c]	1981[c]	Mean
Magnolia virginiana	Sweet bay, swamp bay	-	3.8	2.8	-	2.8	1.4	1.4	2.8	-	1.7
Maytenus phyllanthoides[e]	Molina	-	-	-	-	-	-	-	-	2.8	0.3
Metopium toxiferum	Poisonwood	4.9	1.9	2.8	4.2	8.3	8.3	8.3	9.7	8.3	6.3
Mikania batatifolia	Hemp vine	-	-	1.4	-	-	5.6	-	1.4	-	0.9
M. scandens	Climbing hempvine	4.9	4.8	-	-	1.4	1.4	1.4	6.9	12.5	3.7
Myrica cerifera	Wax myrtle	4.9	5.2	5.6	9.7	6.9	6.9	5.6	6.9	8.3	6.7
Myrsine guianensis (Rapanea guianensis)	Myrsine	4.9	5.7	4.2	5.6	5.6	8.3	6.9	8.3	8.3	5.9
Nectandra coriacea	Lancewood	-	-	1.4	-	-	-	-	-	-	0.2
Nephrolepis biserrata	Boston fern	-	-	2.8	-	-	-	-	-	-	0.3
N. exaltata	Boston fern	-	0.5	-	-	-	-	-	-	-	0.06
Osmunda cinnamonea	Royal fern	-	0.5	-	-	-	-	-	-	-	0.06
O. regalis v. spectabilis	Royal fern	-	2.4	1.4	-	-	-	-	-	-	0.4
Panicum sp.	Panic grass	-	-	1.4	-	-	-	-	-	-	0.2
Panicum portoricense[e]	Panic grass	-	-	-	-	-	-	-	-	1.4	0.2
P. dichotomum	Panic grass	-	-	-	-	-	-	1.4	-	-	0.2
Parthenocissus quinquefolia	Virginia creeper	4.9	4.8	1.4	-	-	-	-	-	-	1.2
Paspalum sp.	(no common name)	-	3.3	-	-	-	-	-	-	-	0.4
Passiflora suberosa	Corky-stemmed passion flower	-	-	-	-	1.4	1.4	-	-	-	0.3
Peltandra virginica	(no common name)	-	2.4	-	-	-	-	-	-	-	0.3
Penstemon sp.	Beardtongue	-	0.5	-	-	-	-	-	-	-	0.1
Persea borbonia	Red bay	4.9	-	5.6	5.6	4.2	1.4	1.4	4.2	6.9	3.8
P. palustris	Swamp bay	-	3.3	-	-	-	-	-	-	1.4	0.5
Phlebodium sp.	Golden polypody	-	-	-	-	-	1.4	1.4	1.4	1.4	0.6
P. aureum	Golden polypody	4.9	-	1.4	-	-	-	-	-	-	0.7
Phyllanthus	(no common name)	-	-	-	-	-	-	1.4	1.4	2.8	0.6
Pinguicula pumila	Butterwort	-	-	-	-	1.4	1.4	-	1.4	-	0.5
Pisonia sp.	Cockspur	-	-	-	-	2.8	-	-	-	-	0.3
P. aculeata	Devil's claw	-	-	2.8	-	-	-	-	-	-	0.3
P. discolor (Torrubia longifolia)	Blolly, beef tree	1.2	-	-	-	-	4.2	1.4	2.8	4.2	1.5
Pithecellobium unguis-cati	Catclaw	1.2	-	-	-	-	-	-	-	-	0.1
Pluchea purpurascens	Camphorweed	2.4	-	1.4	1.4	1.4	-	-	-	-	0.7
P. rosea	Marsh fleabane	-	6.2	-	-	-	1.4	-	-	8.3	1.8
Polygala sp.	Milkwort	-	0.5	-	-	-	-	-	-	-	0.1
Polygala cruciata	Milkwort	-	-	-	-	1.4	-	-	-	-	0.2
P. grandiflora	Milkwort	-	1.4	1.4	-	-	-	-	-	-	0.3
Polygonum sp.	Knotweed, smartweed	-	1.0	-	-	-	-	-	-	-	0.1
Pontederia lanceolata	Pickerelweed	-	0.5	-	1.4	-	-	-	-	-	0.2
Proserpinaca sp.	Mermaid weed	-	-	-	-	1.4	4.2	2.8	-	-	0.9
P. palustris	Swamp mermaid	-	4.3	-	-	-	-	1.4	4.2	5.6	1.7
Psilotum nudum	Whisk fern	-	-	1.4	-	-	-	-	-	-	0.2
Psychotria ligustrifolia	Wild coffee	-	-	-	-	-	-	1.4	-	2.8	0.5
Pteris vittata	Brake fern	-	-	1.4	-	-	-	1.4	1.4	-	0.5

Table 1. Plant species observed and frequency of occurrence at the Turkey Point Plant during 1972-1981. (cont'd).

SPECIES	COMMON NAME	Frequency (%)									
		1972[a]	1974[b]	1975[c]	1976[c]	1977[c]	1978[c]	1979[c]	1980[c]	1981[c]	Mean
Randia aculeata	White indigoberry	-	0.5	-	-	1.4	4.2	2.8	2.8	5.6	1.9
Rhexia sp.	Meadow beauty	1.2	0.5	-	-	-	-	-	-	-	0.1
R. mariana	Meadow beauty	-	-	-	-	-	1.4	1.4	-	-	0.3
Rhizophora mangle	Red mangrove	50.0	46.2	36.1	50.0	29.2	31.9	33.3	37.5	27.8	38.0
Rhus sp.	Sumac	-	-	-	-	-	1.4	-	-	-	0.2
Rhynchospora sp.	Beak rush	-	-	1.4	-	-	-	-	-	-	0.2
Sabal palmetto	Cabbage palm	13.4	4.3	23.6	12.5	8.3	9.7	8.3	8.3	6.9	10.6
Sabatia sp.	Marsh pink	4.9	1.0	-	-	-	-	-	-	-	0.7
S. grandiflora	Marsh pink	-	-	-	-	1.4	-	1.4	-	1.4	0.5
Salicornia virginica (Salicornia perrenis)	Perennial glasswort	-	8.6	1.4	-	1.4	2.8	2.8	1.4	2.8	2.4
Salix caroliniana	Coastal plain willow	-	2.9	1.4	-	-	1.4	1.4	1.4	1.4	1.1
Samolus ebracteatus	Water pimpernel	-	-	1.4	-	1.4	-	-	-	-	0.3
Sarcostemma clausa	White vine	-	-	1.4	-	-	-	-	-	-	0.2
Schinus terebinthifolius	Brazilian pepper	6.1	5.7	1.4	-	6.9	5.6	6.9	6.9	8.3	5.2
Schoenus nigricans	(no common name)	-	1.0	-	-	6.9	6.9	8.3	8.3	12.5	4.9
Serenoa repens	Saw palmetto	1.2	1.0	-	1.4	-	-	-	-	-	0.4
Sesuvium maritimum	Sea purslane	-	-	5.6	4.2	-	-	-	-	-	1.1
S. portulacastrum	Sea purslane	1.2	6.2	-	-	-	-	-	-	-	0.8
Setaria geniculata[e]	Foxtail grass	-	-	-	-	-	-	-	-	1.4	0.2
Setaria sp.	Foxtail grass	-	0.5	-	-	-	-	-	-	-	0.1
Smilax sp.	Briar	3.7	-	-	-	-	-	-	-	-	0.4
S. auriculata	Earleaf briar	-	-	1.4	-	-	-	-	-	-	0.2
S. bona-nox	Green briar	-	0.5	-	-	-	-	-	-	-	0.1
S. laurifolia	Bamboo vine	-	1.4	-	-	-	-	-	-	-	0.2
Solanum blodgettii	Nightshade	-	-	20.8	13.9	19.4	20.8	18.1	18.1	18.1	14.4
S. erianthum (Solanum verbascifolium)	Potato tree	13.4	8.1	-	-	-	-	-	-	-	2.4
Solidago microcephala	Goldenrod	-	-	-	-	-	1.4	-	-	-	0.2
S. tortifolia	Goldenrod	-	-	-	-	1.4	-	-	-	-	0.2
Sophora tomentosa	Necklace pod	-	0.5	1.4	-	-	-	-	-	-	0.2
Sporobolus virginicus[e]	Brown dropseed	-	-	-	-	-	-	-	-	1.4	0.2
Stenandrium sp. (Gerardia sp.)	(no common name)	1.2	-	-	-	-	-	-	-	-	0.2
Suriana maritima	Bay cedar	-	0.5	-	-	-	-	-	-	-	0.1
Swietenia mahagoni	West Indian mahogany	1.2	0.5	-	2.8	2.8	2.8.	2.8	2.8	2.8	2.1
Talinum sp.	Flame flowers	-	-	-	-	1.4	-	-	-	-	0.2
T. paniculatum	Flame flower	-	2.4	-	-	-	-	1.4	-	-	0.4
Thelypteris sp.	(no common name)	1.2	-	-	-	-	2.8	2.8	2.8	1.4	1.2
T. augescens	(no common name)	-	-	1.4	-	-	-	-	-	-	0.2
Tillandsia balbisiana	Air plant	-	0.5	-	-	-	-	-	-	-	0.1
T. circinata	Air plant	-	-	-	-	2.8	4.2	1.4	2.8	1.4	1.4
T. fasciculata	Air plant	-	-	1.4	-	-	-	-	-	-	0.2
T. flexuosa	Twisted air plant	-	-	1.4	2.8	2.8	4.2	-	-	-	1.2
T. utriculata	Air plant	2.4	-	-	-	-	-	-	-	-	0.3
T. valenzuelana	Soft-leaf air plant	-	-	1.4	-	-	-	-	-	-	0.2

Table 1. Plant species observed and frequency of occurrence at the Turkey Point Plant during 1972-1981. (cont'd).

SPECIES	COMMON NAME	FREQUENCY (%)									
		1972[a]	1974[b]	1975[c]	1976[c]	1977[c]	1978[c]	1979[c]	1980[c]	1981[c]	Mean
Toxicodendron radicans	Poison ivy	6.1	7.1	1.4	-	-	2.8	1.4	2.8	4.2	2.9
Trema lamarkiana	West Indian trema	7.3	2.9	1.4	1.4	-	-	-	-	-	1.4
T. micrantha	Florida trema	4.9	2.9	-	-	-	1.4	1.4	2.8	2.8	1.5
Typha sp.	Cattail	-	-	-	2.8	1.4	2.8	2.8	2.8	2.8	1.7
T. domingInensis	Southern cattail	-	0.5	-	-	-	-	-	-	-	0.1
Utricularia sp.[e]	Bladderwort	-	-	-	-	-	-	-	-	1.4	0.2
Vanilla inodora	Scentless vanilla	-	0.5	-	-	-	-	-	-	-	0.1
Verbena bonariensis	Vervain	-	1.9	-	-	-	-	-	-	-	0.2
Vitis rotundifolia	Muscadine grass	2.4	5.7	1.4	-	-	4.2	2.8	4.2	5.6	2.9
Vittaria lineata	Shoestring fern	3.7	-	1.4	-	-	1.4	-	1.4	1.4	1.0
Xyris sp.	Yellow-eyed grass	-	-	-	-	-	1.4	1.4	2.8	-	6.2
X. brevifolia	Yellow-eyed grass	-	-	-	-	-	4.2	-	1.4	-	0.6
Zanthoxylum fagara	Wild lime	-	0.5	-	-	-	-	-	-	-	0.1
TOTAL NUMBER OF SPECIES OBSERVED ANNUALLY		56	88	76	36	56	66	67	66	67	
CUMULATIVE NUMBER OF SPECIES OBSERVED		56	105	138	140	155	167	177	179	186	

[a]Turkey Point site prior to construction of the cooling canal system (ABI, 1978a.)

[b]South Dade site adjacent to the cooling canal system (ABI, 1978b.)

[c]Turkey Point site, annual operational monitoring (FPL, 1976, 1977, 1978, 1979, 1980.)

[d]The name in parentheses is a synonym for the species preceeding it in the list, according to Long and Lakela (1971). These synonyms appear in some of the cited references.

[e]New species found in 1981.

[f]Long and Lakela (1971) do not give common names for these uncommon species.

Table 2. Comparisons of yearly frequency data at the Turkey Point Plant from 1975 to 1981.

COMMON NAMES	SCIENTIFIC NAMES	FREQUENCIES (%)					
		1975-1976[a]	1977[b]	1978[b]	1979[b]	1980[b]	1981[b]
Saw grass	Cladium	81.9	81.9	86.1	84.7	83.3	84.7
Buttonwood	Conocarpus	80.5	70.8	77.8	73.6	70.8	69.4
White mangrove	Laguncularia	27.1	41.7	33.3	29.2	29.2	33.3
Aster	Aster	0.7*	30.6	29.2	27.8	29.2	30.6
Red mangrove	Rhizophora	43.7	29.2	31.9	33.3	37.5	27.8
Glades morning glory	Ipomoea	2.8*	8.3*	20.8	1.4*	9.7	20.8
Rush	Juncus	18.0	13.9	19.4	22.2	19.4	19.4
Nightshade	Solanum	17.3	19.4	20.8	18.1	18.1	18.1
Salt grass	Distichilis	4.9*	18.1	18.1	19.4	18.0	18.1
Clubrush	Eleocharis	2.1*	12.5	12.5	13.9	11.1	15.3
Schoenus	Schoenus	0.0*	6.9	6.9	8.3	8.3	12.5
Climbing hempvine	Mikania	0.0*	1.4*	1.4*	1.4*	6.9	12.5
Groundsel	Baccharis spp.	3.5*	11.1	16.8	18.1	14.0	11.2
Blechnum fern	Blechnum	19.4	6.9	8.3	5.6	9.7	11.1
Australian pine	Casuarina	13.2	8.3	12.5	9.7	9.7	11.1
Leather fern	Acrostichum	24.3*	6.9	12.5	11.1	12.5	8.3
Sea daisy	Borrichia	2.8	12.5	12.5	9.7	12.5	8.3
Poisonwood	Metopium	3.5	8.3	8.3	8.3	9.7	8.3
Myrsine	Myrsine	4.9	5.6	8.3	6.9	8.3	8.3
Wax myrtle	Myrica	7.6	6.9	6.9	5.6	6.9	8.3
Brazilian pepper	Schinus	0.7*	6.9	5.6	6.9	6.9	8.3
Fleabane	Pluchea spp.	1.4	1.4	1.4	0.0	0.0	8.3
Cabbage palm	Sabal	18.0	8.3	9.7	8.3	8.3	6.9
St. John's wort	Hypericum	0.0*	6.9	6.9	0.0*	2.7	6.9

Table 2. (cont'd) Comparisons of yearly frequency data at the Turkey Point Plant from 1975 to 1981.

COMMON NAMES	SCIENTIFIC NAMES	FREQUENCIES (%)					
		1975-1976[a]	1977[b]	1978[b]	1979[b]	1980[b]	1981[b]
Loosestrife	Lythrum	0.0*	0.0*	0.0*	1.4*	1.4*	6.9
Red bay	Persea	5.6	4.2	1.4*	1.4*	4.2	6.9
Mermaid weed	Proserpinaca spp.	0.0*	1.4	4.2	4.2	4.2	5.6
White indigo berry	Randia	0.0*	1.4	4.2	2.8	2.8	5.6
Muscadine grape	Vitis	1.4	0.0	4.2	2.8	4.2	5.6

[a]Pre-freeze years.

[b]Post-freeze years.

*Significant difference from 1981 frequencies (G-test, $P \leq 0.05$).

Table 3. Comparisons of 1981 operational monitoring and baseline frequencies at the Turkey Point Plant during 1972, 1974 and 1981.

COMMON NAMES	SCIENTIFIC NAMES	FREQUENCIES (%)			G-TEST	
		1972[a]	1974[b]	1981	1981-1974	1981-1972
Saw grass	Cladium	74.4	44.3	84.7	9.2*	0.4
Buttonwood	Conocarpus	65.1	30.5	69.4	5.6*	0.1*
Red mangrove	Rhizophora	50.0	46.2	27.8	1.6	4.6
White mangrove	Laguncularia	9.8	34.8	33.3	0.0	4.9*
Rush	Juncus	15.9	17.6	19.4	0.0	0.2
Salt grass	Distichilis	0.7	49.0	18.1	5.2*	6.1*
Leather fern	Acrostichum	15.9	10.0	8.3	0.1	2.0
Australian pine	Casuarina	12.2	5.7	11.1	0.7	0.0
Sea daisy	Borrichia	6.1	16.2	8.3	2.0	0.2
Cabbage palm	Sabal	13.4	4.3	6.9	0.3	1.8
Poisonwood	Metopium	4.9	1.9	8.3	4.0*	0.2
Brazilian pepper	Schinus	6.1	5.7	8.3	0.2	0.2
Blechnum fern	Blechnum	9.8	5.2	11.1	2.2	0.1

[a]Turkey Point baseline data (ABI, 1978a).

[b]South Dade baseline data (ABI, 1978b).

*Significant at $P \leq 0.05$.

Table 4. Volume-density index of grassland transects at the Turkey Point Canal System during 1981.

SPECIES	TRANSECT	QUADRATS							
		A1	A2	B1	B2	C1	C2	D1	D2
<u>Cladium jamaicensis</u>	1	13	449	1,271	0	722	3,105	3,013	8,326
	3	3,333	6,200	2,341	3	4,521	4,100	3,300	4,227
	5	2,741	5,087	3,767	3,283	3,109	1,755	2,876	15,480
<u>Conocarpus erecta</u>	1	0	382	4,058	72	304	6,851	485	61
	3	0	0	413	574	0	200	0	0
	5	8,748	0	815	6,217	703	0	304	0
<u>Juncus roemerianus</u>	1	166	212	36	228	219	2	0	3
	3	0	0	0	0	11	62	0	0
	5	0	0	0	0	0	0	0	0
<u>Aster</u> sp.	1	0	0	6	0	0	1	4	<1
	3	0	0	1	0	0	1	0	0
	5	3	0	3	7	4	0	4	1
<u>Distichlis spicata</u>	1	0	0	<1	28	0	0	0	0
	3	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0
<u>Eleocharis cellulosa</u>	1	242	160	41	16	31	36	77	37
	3	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	19	29

Table 4. Volume-density index of grassland transects at the Turkey Point Canal System during (cont'd). 1981.

SPECIES	TRANSECT	Quadrats							
		A1	A2	B1	B2	C1	C2	D1	D2
Typha sp.	1	0	0	0	0	705	367	0	0
	3	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0
Ipomoea sagittata	1	0	0	0	0	0	0	0	0
	3	0	0	36	3	0	0	0	0
	5	0	0	<1	0	0	0	<1	0
Rhizophora mangle	1	0	0	0	76	0	0	0	0
	3	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0

Table 5. Volume-density index of tree island transects at the Turkey Point Canal System during 1981.

SPECIES	TRANSECT	QUADRATS							
		A1	A2	B1	B2	C1	C2	D1	D2
Cladium jamaicensis	2	4,469	2,025	3,222	10,135	8,183	11,385	3,632	7,862
	4	3,564	4,279	4,919	37,673	626	6,450	2,079	2,578
	6	12,214	8,484	4,961	7,238	381	26	2,704	3,417
Conocarpus erecta	2	1,081	113,490	2,867	4,038	26,942	3,050	2,864	2,492
	4	43,173	7,725	21,113	35,435	828	57,960	1,755	5,271
	6	107	545	24,255	194	0	346,199	3,723	191
Rhizophora mangle	2	0	0	0	7,949	0	1,558	0	0
	4	854	3,102	0	0	0	0	0	0
	6	0	9,943	0	0	0	0	0	0
Laguncularia racemosa	2	14	1,552	0	173	12,674	12,920	240	0
	4	0	0	0	0	86,400	399	0	0
	6	0	0	2,739	0	0	0	0	0
Solanum blodgettii	2	0	0	0	0	0	42	0	0
	4	0	5	0	0	813	97	4,048	185
	6	50	0	186	0	156	33	0	61
Acrostichum aureum	2	0	0	0	0	0	0	0	0
	4	0	0	0	1,581	0	4,084	0	0
	6	0	0	1,331	0	0	0	0	0
Sparobolus virginicus	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	11
	6	0	0	0	0	0	0	0	0

Table 5. (cont'd) Volume-density index of tree island transects at the Turkey Point Canal System during 1981.

SPECIES	TRANSECT	A1	A2	B1	B2	C1	C2	D1	D2
Aster sp.	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	2
	6	0	0	0	0	0	0	0	0
Blechnum serrulatum	2	0	0	0	0	0	0	0	0
	4	12	0	0	0	3,421	614	440	0
	6	470	535	0	0	5	525	0	0
Sabal palmetto	2	0	0	0	0	0	0	0	0
	4	0	0	0	100,238	259,200	0	0	0
	6	78,400	0	46963	0	14,700	0	0	0
Casurina equisetifolia	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	261	0
	6	0	80,928	0	336,824	0	5	22	0
Metopium toxiferum	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	1	0	0	1	250	11,941	17,502	20,662
Myrsine guianensis	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	873	450	0	0	15,088	53	740	558
Maytenus phyllanthoides	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	2,430	361

Table 5. Volume-density index of tree island transects at the Turkey Point Canal System
(cont'd) during 1981.

SPECIES	TRANSECT	QUADRATS							
		A1	A2	B1	B2	C1	C2	D1	D2
Schinus terebinthifolius	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	111	2	0	0
	6	0	0	2,696	0	22	1,719	0	0
Myrica cerifera	2	0	0	0	0	0	0	0	0
	4	0	45	0	0	0	0	201	0
	6	0	7,261	0	0	6	0	477	2,388
Baccharis spp.	2	0	0	4	0	0	0	0	0
	4	0	0	<1	0	89	2,609	0	162
	6	0	0	0	0	0	0	0	0
Chiococca alba	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	31	24	1
Ludwigia spp.	2	0	0	0	0	0	0	0	2
	4	0	0	0	0	8	0	5	<1
	6	0	0	0	0	0	0	0	0
Proserpinaca palustris	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	28	0	2	0
	6	0	0	0	0	0	<1	0	16
Setaria geneculata	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	1
	6	0	0	0	0	0	0	0	0

Table 5. Volume-density index of tree island transects at the Turkey Point Canal System (cont'd) during 1981.

SPECIES	TRANSECT	QUADRATS							
		A1	A2	B1	B2	C1	C2	D1	D2
Swietenia mahagoni	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	127,294	18,670	0	0
Thelypteris sp.	2	0	0	0	0	0	0	0	0
	4	0	0	<1	0	0	0	0	0
	6	0	0	0	0	0	0	0	0
Dipholis salicifolia	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0
Eugenia spp.	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	27	27	327
Ilex cassine	2	0	0	0	0	0	0	612	0
	4	0	0	0	0	0	0	0	0
	6	0	4	0	0	0	0	0	0
Lantana involucrata	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	281
Eupatorium capillifolium	2	0	0	0	0	0	0	0	<1
	4	0	0	0	0	0	0	0	29
	6	0	0	0	0	0	0	0	0

Table 5. Volume-density index of tree island transects at the Turkey Point Canal System (cont'd) during 1981.

SPECIES	TRANSECT	QUADRATS							
		A1	A2	B1	B2	C1	C2	D1	D2
Mikania scandens	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	36	<1	0	<1
	6	<1	0	0	0	0	0	<1	<1
Phlebodium sp.	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	<1	0	0	0
Salix caroliniana	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	1,125	0	0	0
Bulbostylis stenophylla	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	376	0
Trema micrantha	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	128	0	0	<1
Galium obtusum	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	<1	0
Persea borbonia	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	675	4,124	0	2

Table 5. (cont'd) Volume-density index of tree island transects at the Turkey Point Canal System during 1981.

SPECIES	TRANSECT	QUADRATS							
		A1	A2	B1	B2	C1	C2	D1	D2
Lantana microcephala	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	15	0
Randia aculeata	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	2,793	289	33	40
	6	0	0	0	0	0	0	0	0
Pisonia discolor	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	<1	0	0	<1
Rhus sp.	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	<1	0	0	0	0	4	0	0
Pluchea rosea	2	0	0	0	0	0	0	0	20
	4	0	0	0	0	0	2	107	14
	6	0	0	0	0	0	0	5	0
Annona glabra	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0
Ipomoea sagittata	2	0	2	0	0	0	0	0	0
	4	<1	<1	<1	0	0	0	<1	0
	6	0	0	0	0	0	0	0	0

Table 5. Volume-density index of tree island transects at the Turkey Point Canal System (cont'd) during 1981.

SPECIES	TRANSECT	QUADRATS							
		A1	A2	B1	B2	C1	C2	D1	D2
Vitis rotundifolia	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	<1	<1	<1	<1
Habenaria sp.	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	<1	0	0	0
Lythrum alatum	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0
Cassytha filiformis	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	0	0	0
Vittaria lineata	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	<1	0	0	0
Hypericum sp.	2	0	<1	0	0	0	0	0	0
	4	0	0	0	0	0	3	0	0
	6	0	0	0	0	0	0	0	1
Psychotria ligustrifolia	2	0	0	0	0	0	0	0	0
	4	0	0	0	0	0	0	0	0
	6	0	0	0	0	0	28,927	0	0

Table 6. Volume-density index of mangrove transects at the Turkey Point Canal System during 1981.

SPECIES	TRANSECT	QUADRATS							
		A1	A2	B1	B2	C1	C2	D1	D2
Cladium jamaicensis	7	5,830	2,083	6,348	3,030	3,555	3,962	0	65
	8	3,917	3,824	1,230	5,287	1,830	917	0	0
	9	0	0	0	0	15	0	0	0
Conocarpus erecta	7	0	1,042	0	876	707	770	225	65
	8	1,948	1,725	20,054	12,497	7,499	9,224	0	0
	9	0	0	380	179	3,145	2,573	0	0
Rhizophora mangle	7	0	0	0	0	0	0	0	0
	8	0	12	5,240	0	0	1,603	199	677
	9	45,182	11,583	15,521	17,461	2,895	23,110	4,659	9,186
Laguncularia racemosa	7	0	0	0	0	0	8	94	49
	8	0	0	366	5,449	0	1,688	3,421	3,429
	9	5,015	1,876	59	0	0	45	335	555
Solanum blodgettii	7	0	0	0	0	0	0	0	0
	8	0	0	46	435	0	0	0	0
	9	0	0	0	0	0	0	0	0
Juncus roemerianus	7	0	0	0	0	0	0	0	0
	8	159	451	34	0	233	0	0	0
	9	0	0	0	0	0	7	0	0

Table 6. Volume-density index of mangrove transects at the Turkey Point Canal System (cont'd) during 1981.

SPECIES	TRANSECT	QUADRATS							
		A1	A2	B1	B2	C1	C2	D1	D2
Acrostichum aureum	7	0	0	0	0	0	0	0	0
	8	0	0	0	440	0	0	0	0
	9	25,609	0	0	0	0	0	0	0
Aster sp.	7	0	5	1	0	1	4	0	0
	8	<1	0	0	0	0	0	0	0
	9	0	0	<1	0	0	0	0	0
Casurina equisetifolia	7	0	0	0	0	0	0	0	0
	8	14,456	99,225	0	57,600	0	0	0	0
	9	0	0	0	0	0	0	0	0
Distichilis spicata	7	0	0	0	0	0	0	139	104
	8	0	0	0	0	0	0	69	67
	9	0	30	10	6	16	34	58	57
Borrichia frutescens	7	0	0	0	0	0	0	2	19
	8	0	0	0	0	0	0	0	0
	9	0	0	4	0	16	6	0	0
Schoenus nigricans	7	0	0	0	0	0	0	0	0
	8	0	23	0	0	0	63	0	0
	9	0	9,957	.75	9	132	205	0	<1

Table 6. Volume-density index of mangrove transects at the Turkey Point Canal System (cont'd) during 1981.

SPECIES	TRANSECT	QUADRATS							
		A1	A2	B1	B2	C1	C2	D1	D2
Avicennia germinans	7	0	0	0	0	0	0	286	96
	8	0	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0
Salicornia virginica	7	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	67	2
	9	0	0	0	0	0	0	0	0
Ipomoea sagittata	7	2	0	0	0	13	<1	0	0
	8	5	0	0	0	0	0	0	0
	9	0	0	0	0	0	0	0	0
Hypericum sp.	7	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	1	0	0
	9	0	0	0	0	0	0	0	0
Schinus terebinthifolius	7	0	0	0	0	0	0	0	0
	8	0	0	3	0	0	0	0	0
	9	0	0	0	0	0	0	0	0
Eleocharis cellulosa	7	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	2
	9	0	0	0	0	0	0	0	0

Table 7. Analysis of variance for long-term changes in biomass of the 12 most common species at the Turkey Point Plant during 1975-1981.

SPECIES	SCIENTIFIC NAMES	F-RATIO		
		Years[b]	Distance[c]	Year x distance
Saw grass	Cladium	3.42*	6.75*	0.23
Buttonwood	Conocarpus	6.59*	6.35*	1.44
Red mangrove	Rhizophora	4.90*	2.37	0.83
White mangrove	Languncularia	1.40	0.57	0.97
Nightshade	Solanum	0.99	1.21	0.42
Rush	Juncus	1.61	5.56*	0.45
Leather fern	Acrostichum	2.51*	8.81*	0.75
Aster	Aster	3.50*	2.25	0.84
Blechnum fern	Blechnum	1.80	3.08	0.39
Cabbage palm	Sabal	2.09	1.25	1.00
Australian pine	Casuarina	0.18	13.05*	0.76
Salt grass	Distichilis	1.45	2.83	0.22
Degrees of freedom		6	3	18

*Significant at $P \leq 0.05$.

[a]Analysis of variance indicates a change in biomass but does not give the direction of the change over time or with distance. That information is obtained by examination of each species (see text).

[b]A significant value (*) indicates a change in biomass from 1975 to 1981.

[c]A significant value (*) indicates a change in biomass between vegetation adjacent to the cooling canal system and that farther away from the system.

3. Annual Aerial Photograph Analyses (ETS 4.2.2.1)

The 1981 Turkey Point study aerial photograph taken in November 1981 showed healthy and vigorous vegetative growth to the east, south and west of the canal system. Since the aerial photograph of last year (taken February 1981), no change was evident in the cover and vigor of either mangrove swamps to the east and south of the canal system or the fresh-water saw grass marshes to the west.

In March 1981, brush fires swept through much of the sawgrass marshes and tree islands west of the canal system (Figure 4, Section 4.2.2.3). Because of rapid revegetation, fire impact on vegetation was no longer evident in the November 1981 aerial photograph. For example, a comparison of burned marsh areas west and north of the cooling canal system with unaffected areas west and south, showed no distinct color variations indicative of differences in vegetation growth or cover. On the other hand, the area immediately adjacent to both Canal L-31 and the Turkey Point system appeared darker blue than that further west along most of the canal system length. This was probably due to high water that reflects dark blue on color infrared film. In general, the growth condition of sawgrass marshes did not change between 1980 and 1981 as indicated by low infrared reflectance on both photgraphs. The light to dark pink colors of tree islands and strands signified healthy and vigorous vegetative growth.

Infrared reflectance remained low along several canal banks in the middle of the northern half of the cooling canal system. This suggested continued decreased productivity of the exotic Australian pines growing on the spoil berms. To prevent invasion of natural vegetation by this exotic species, Australian pines inside the canal system have been treated with herbicides. No significant changes were evident in canal embankment vegetation between 1980 and 1981.

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V. CHANGES IN SURVEY PROCEDURES (ETS 5.4.1 (3))

Chemical Concentrations (ETS 3.1.2)

The lower limit of detection for zinc was changed from 0.02 mg/l in 1980 to 0.005 mg/l in 1981 following "detectable limit evaluations" conducted by the Power Resources Test Laboratory.

The chemical oxygen demand methodology was changed from Standard Methods Procedure 508 (APHA, 1976) to the E.P.A. Approved Hach Microdigestion Procedure.

Revegetation of the Cooling Canal Banks (ETS 4.2)

b. Soil Chemistry

The soil sample collection method was changed in November 1981 from a geotome to a 1 1/4" X 18" JMC sampling tube and N-3 backsaver handle. The depth of sample collection was not changed.

d. Faunal Survey

The common name, Yellow Shafted Flicker, has been changed to the Common Flicker; the binomial name remains the same. This change is in accordance with the American Ornithologists Union (A.O.U.).

VI. STUDIES NOT REQUIRED BY THE ETS (5.4.1.(4))

A. AMERICAN CROCODILE STUDIES-SITE MANAGEMENT PROGRAM

Site Management Program for the endangered American Crocodile, _Crocodylus acutus_, at the Turkey Point Power Plant Site draft report, February 1982

B. AMERICAN CROCODILE STUDIES-POPULATION STUDIES

The population of the American Crocodile, _Crocodylus acutus_ (Reptilia, Crocodilidae) at the Turkey Point Power Plant Site - Annual Report, January 1982

C. HEAVY METALS BIOACCUMULATION STUDIES

Heavy metals bioaccumulation in Turkey Point Cooling Canal System from a vertebrate organism and an invertebrate organism

VII. VIOLATIONS OF THE ETS (ETS 5.4.1(5))

No violations of the ETS occurred during 1981 at the Turkey Point Plant relative to the cooling canal system operation.