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DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

QUALITY OF SURFACE WATER ON

SANIBEL ISLAND, FLORIDA, 1976-77

By B. F. McPherson and T. H. O'Donnell

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Prepared in cooperation with
LEE COUNTY
CITY OF SANIBEL, LEE COUNTY, FLORIDA
and the
ISLAND WATER ASSOCIATION

4.8
1.65
$\frac{1.65}{4.8}\frac{N}{100} \approx 34.37$

Tallahassee, Florida

1979

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ABSTRACT

The quality of surface water in parts of the interior of Sanibel Island has been periodically degraded by high concentrations of salt or macronutrients and by low concentrations of dissolved oxygen. In 1976 the chloride concentration of surface water ranged from about 500 milligrams per liter to almost that of seawater, 19,000 milligrams per liter. The highest salinities were during the dry season of 1976 in the Sanibel River near the Tarpon Bay control structure and are attributed to leakage of saline water past the structure. The highest concentrations of macronutrients occurred during the dry season in the eastern reach of the Sanibel River, where concentrations generally exceeded 4.0 milligrams per liter total nitrogen and 0.9 milligrams per liter total phosphorus. Organic nitrogen accounted for about 95 percent of the total nitrogen, and ammonia accounted for most of the remainder. Concentrations of ammonia exceeded 0.1 milligrams per liter in 31 percent of the wet-season samples and 14 percent of the dry-season samples. Nighttime concentrations of ammonia exceeded those in daytime by several orders of magnitude; concentration of dissolved oxygen fluctuated inversely to that of ammonia. The concentration of dissolved oxygen and the magnitude of the day-night fluctuation decreased with depth. In 1976 the median concentration of dissolved oxygen near the surface was 7.5 milligrams per liter in the dry season and 3.5 milligrams per liter in the wet season. Concentrations were lowest in the wet season along an eastern reach of the Sanibel River and in several nearby ponds and canals where near-anaerobic conditions prevailed. The high concentrations of macronutrients and the low concentrations of dissolved oxygen at some surface-water sites are attributed, in part, to urban runoff and sewage effluent that flow directly into the surface water or seep through the shallow water-table aquifer into surface-water bodies.

INTRODUCTION

Sanibel Island is an 18-square mile barrier island off the southwest coast of Florida (fig. 1). The island is composed of low beach ridges, 4 to 7 feet above sea level, freshwater wetlands, mangrove swamps, and salt marsh. The beach ridges roughly parallel the slightly crescent-shaped 13-mile Gulf Coast Beach on the southern side of the island. The freshwater wetlands occur in the interior between beach ridges. The major wetland

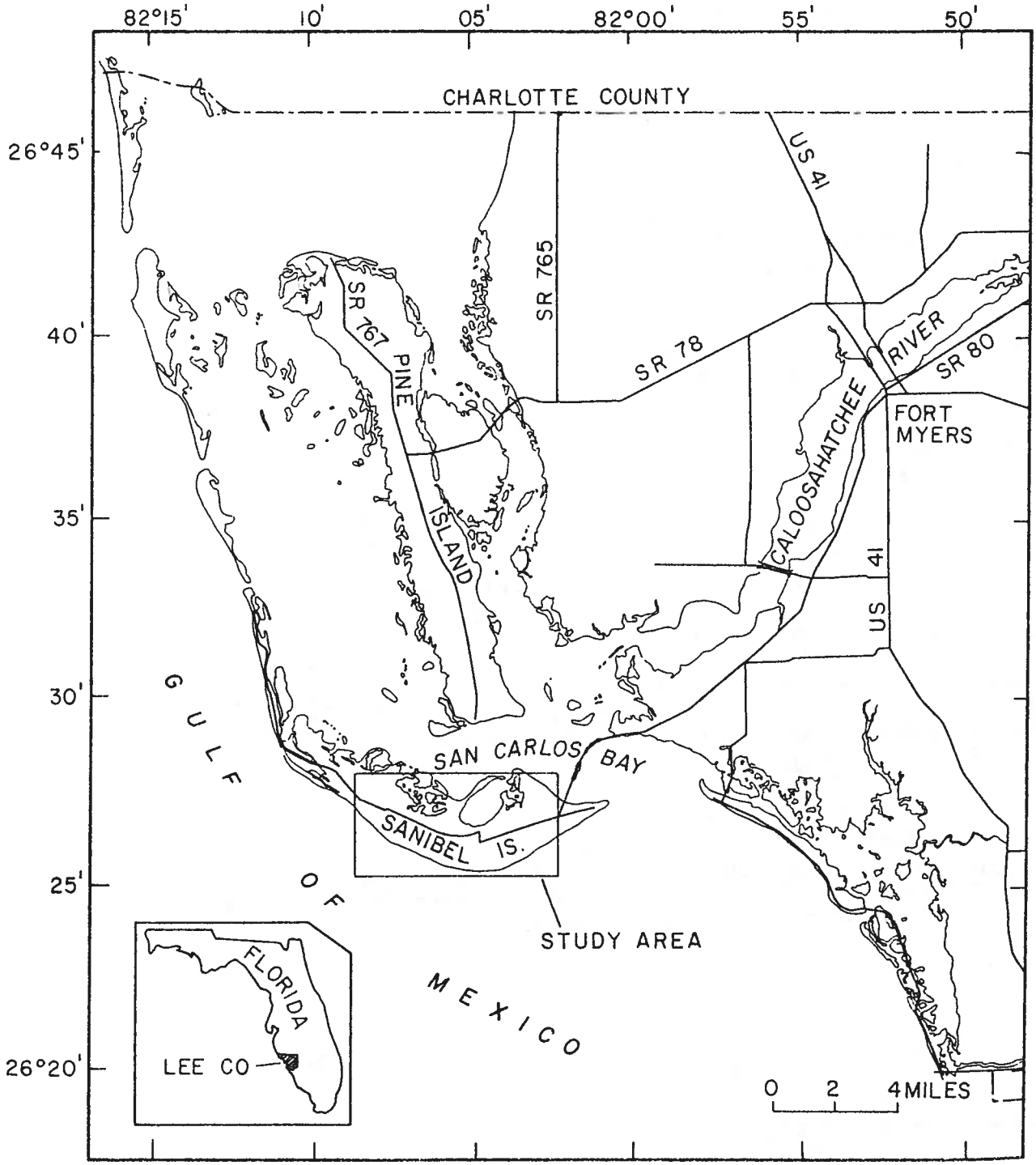

Figure 1.—Western Lee County and location of Sanibel Island

area, commonly referred to as the "Sanibel Slough," drains west and northwest along most of the length of the island. The central drainageway of the slough consists of natural and altered channels of the Sanibel River. The north side of the island is tidally inundated mangrove swamp and salt marsh.

Agricultural development of Sanibel Island began in the late 1800's and continued into the 1920's. Severe hurricanes flooded the island with saltwater and virtually ended farming in 1926 (Clark, 1976).

Substantial residential development and tourism on the island began in the 1950's. Growth accelerated in 1963 after the completion of a causeway to the mainland. In 1974 the Sanibel city government initiated a general moratorium on new building permits (Clark, 1976).

Growth of the resident and tourist population on Sanibel Island was accompanied by the excavation of ponds, lakes, and canals to obtain fill for raising land elevations for home sites, and by the excavation of a network of shallow drainageways in the interior, and the mangrove and salt marshes for mosquito control.

The rapid growth of population on Sanibel Island in recent years has created water-resource problems. Water quality on the island is threatened by saltwater intrusion (Boggess, 1974) and by potential pollution from urban runoff and sewage-pond discharge. Increased saltwater intrusion or pollution in surface waters would alter the aquatic environment in the interior of the island.

Purpose and Scope

The purpose of this investigation was to provide a broader base of information than heretofore available on the water quality in the Sanibel River and ponds and lakes in the interior of Sanibel Island. The investigation was conducted in 1976-77 by the U.S. Geological Survey in cooperation with the city of Sanibel and the Island Water Association.

Earlier reports have indicated that saltwater has intruded into the interior freshwater system (Boggess, 1974), and sewage has polluted ground and surface waters (Clark, 1976). A specific objective of this report was to determine the areal and seasonal extent of saltwater and sewage influences in surface waters. The report includes an areal survey of macronutrients and chloride concentrations in surface water in both the wet and dry seasons in 1976. Concentrations of macronutrients in water indicate the extent of enrichment by sewage, fertilizers, and other sources. Concentrations of chloride indicate the extent of saltwater intrusion. Increased enrichment or greater saltwater intrusion would be detrimental to the island interior ecosystem.

To obtain additional baseline information and to determine seasonal changes in surface-water quality, four sites were selected for more frequent and comprehensive sampling than that made in the wet and dry season areal survey. The objective of sampling the four sites was to describe variability within each of the two aquatic environments. These sites were selected to be representative of two prevalent types of aquatic environment on the island--ponds and the channelized Sanibel River.

SAMPLING SITES

The location of the sampling sites are shown in figure 2, and the latitude-longitude identification numbers of the sites are given in table 1. The dry-season sampling was in April or May 1976; the wet-season sampling was in August or September 1976. Sites 5, 41, 48, and 50 were sampled more frequently.

SOURCES OF WATER

The sources of surface water on Sanibel Island are rainfall, tidal water bodies, and discharge from water-table and artesian aquifers. Tidal water covers much of the northern part of the island and moves inland in storm surges and as seepage past canal control structures. Water from the artesian aquifers moves to the surface through wells or as seepage upward through a confining layer. Artesian water is saline with the exception of a relatively freshwater zone in the Lower Hawthorn Formation (Boggess, 1974). The water-table aquifer, in which the salinity of the water is variable, also contributes seepage to the Sanibel River and other water bodies.

Rainfall

Rainfall on Sanibel Island follows the typical seasonal pattern of south Florida with alternate wet (June-October) and dry seasons, (November-May). Boggess (1974) compared monthly and total rainfall at two sites on Sanibel Island with a site near Fort Meyers, 1971-72. Annual total rainfall near Fort Myers exceeded that at Sanibel by 3 inches in 1971 and by 15 inches in 1972.

At the two sites on Sanibel, annual total rainfall averaged 36 inches for 1976 and and 39 inches at one of the sites for 1977. About 70 percent fell during June-October, and the maximum monthly was in June 1976 and September 1977 (table 2).

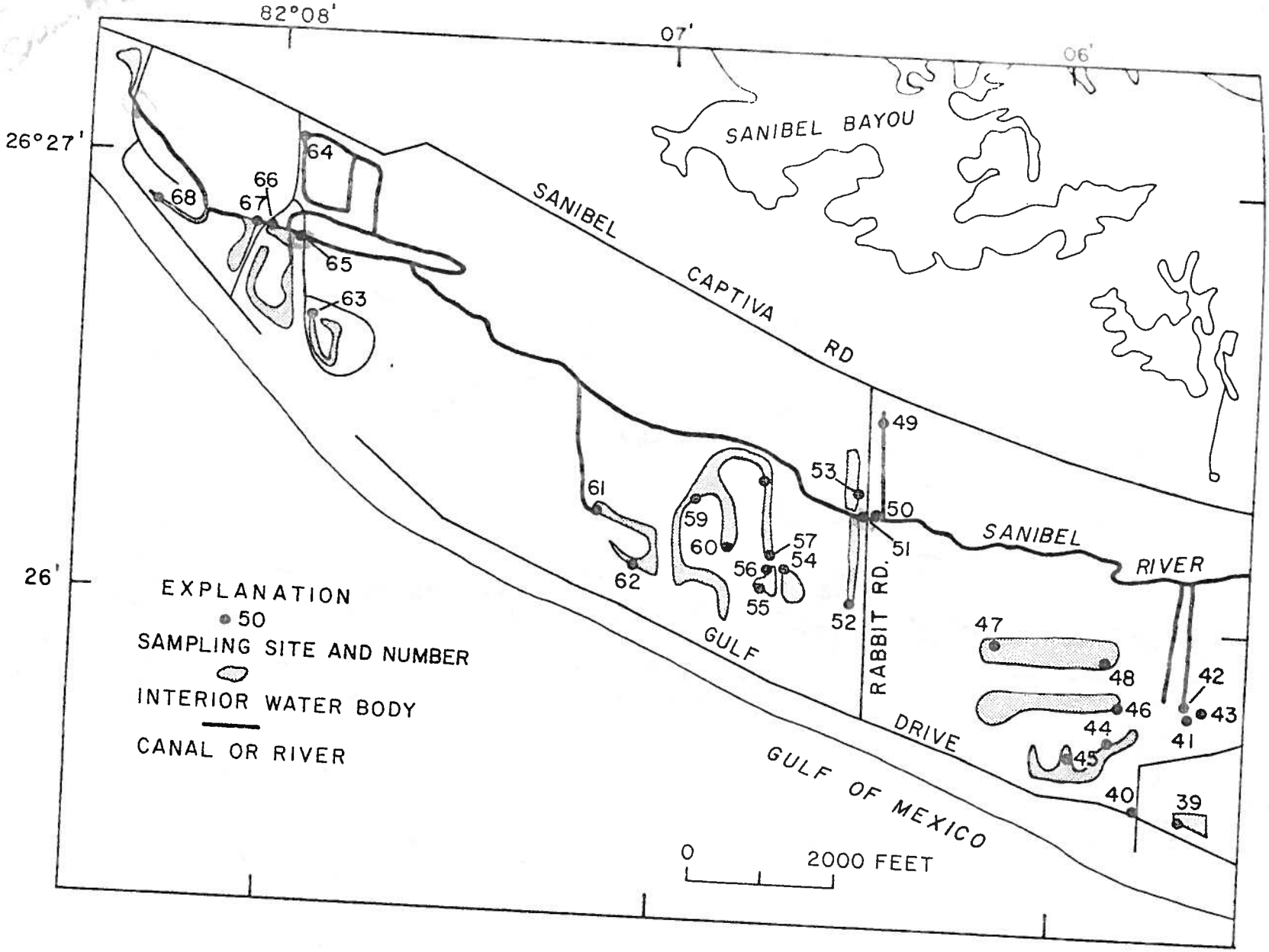

Figure 2.—Location of water-quality sampling sites

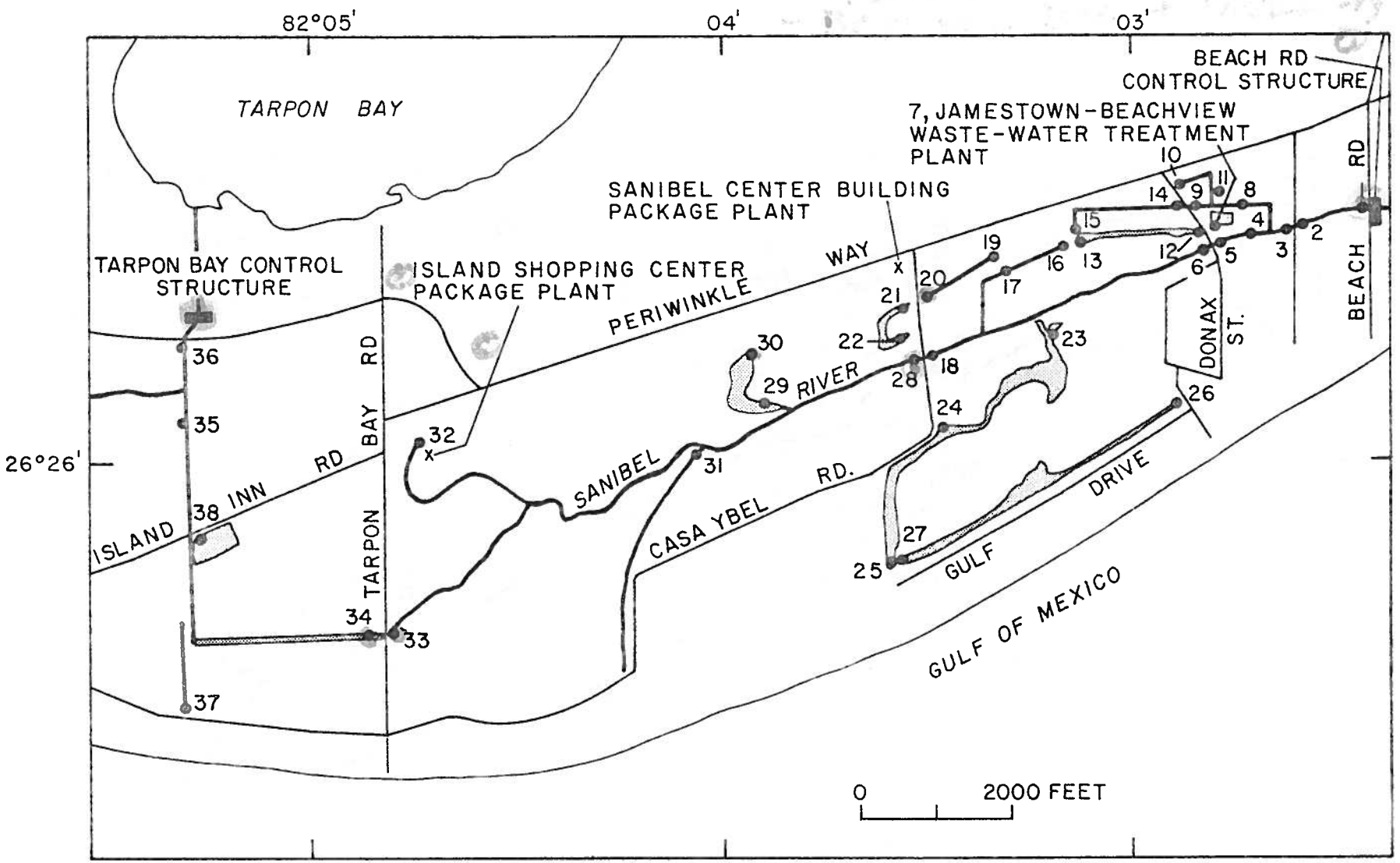

Figure 2.--Location of water-quality sampling sites (Cont'd)

Table 1.--Surface-water quality site numbers and latitude-longitude identification numbers

Site	Latitude-longtiude identification number
1	262633082022500
2	262631082023500
3	262631082023600
4	262632082024200
5	262628082024700
6	262628082024701
7	262632082034700
8	262636082024500
9	262636082025200
10	262637082025300
11	262637082024700
12	262631082025000
13	262629082030700
14	262636082025300
15	262632082030800
16	262629082031000
17	262625082031800
18	262613082033000
19	262631082031900
20	262622082033000
21	262622082033200
22	262617082033300
23	262618082031200
24	262604082032800
25	262544082033201
26	262607082025400
27	262544082033200
28	262613082033001
29	262608082035400
30	262614082035600
31	262557082041400
32	262603082044500
33	262532082044900
34	262538082045200
35	262605082051700
36	262616082051800
37	262528082051800
38	262550082051700
39	262535082054200
40	262537082054800
41	262549082054000
42	262551082054001
43	262550082053800
44	262546082055200
45	262545082060100
46	262551082055300

Table 1.--Surface-water quality site numbers and latitude-longitude identification numbers (Cont'd)

Site	Latitude-longtiude identification number
47	262558082060900
48	262557082055200
49	262627082062800
50	262615082062700
51	262615082063000
52	262603082063100
53	262617082063100
54	262607082064100
55	262604082064600
56	262607082064400
57	262609082064400
58	262619082064500
59	262616082065500
60	262605082064900
61	262614082071000
62	262607082070400
63	262642082075400
64	262703082075700
65	262654082075700
66	262651082080200
67	262651082080300
68	262653082081900

Table 2.--Monthly rainfall totals, in inches, from two stations on Sanibel Island, 1976-77

	J	F	M	A	M	J	J	A	S	O	N	D	Total
Station 1 (Mario Hutton) 1976	0.26	1.86	0.09	0.93	2.94	7.88	4.01	6.29	5.86	4.26	1.66	2.39	38.43
Station 2 (Post Office) 1976	0.22	1.67	.03	.76	2.81	6.75	4.78	4.03	4.38	3.78	1.95	2.73	33.89
Station 1 1977	4.98	.24	.03	.23	1.19	3.78	5.12	7.53	10.71	.28	2.60	2.02	38.71

Ground Water

The predominantly sand water-table aquifer extends from near the land surface to depths of about 10 to 20 feet. Below the water-table aquifer, low permeability strata of predominantly silt and clay retard the movement of water downward from the water-table aquifer or upward from a saline artesian aquifer. The salinity of the water in the water-table aquifer is highly variable, but tends to be higher in areas of low elevation along the north half of the island than in the interior upland areas. Over most of the island, water salinity increases with depth (Boggess, 1974). Saline water from the shallow artesian aquifer enters surface water by upward leakage during low stages of the ponds and canals. Improperly sealed wells or test holes which tap saline water zones also discharge saline water at the surface (Boggess, 1974).

SURFACE-WATER DRAINAGE

The interior of Sanibel Island is composed of parallel systems of low beach ridges separated by swales. Some of the swales interconnect to form the meandering Sanibel Slough, a seasonally inundated wetland. Before drainage alterations on the island, the slough contained several poorly defined channels, now the Sanibel River (fig. 3). Flow occurred in the slough and river only after extended periods of heavy rainfall. At these times freshwater flowed from the interior over a distance of several miles and discharged to the Gulf of Mexico or Pine Island Sound at one or more of four locations (Tabb and others, 1976).

Man has altered the historic drainage pattern of Sanibel Island by dredging and modifying the original river channels and by excavating numerous drainage ditches, canals, ponds, and lakes. In the interior the main purpose of the excavation has been to obtain fill material for raising the altitude of adjacent land, usually for building residential developments. In tidal areas excavation has been for mosquito control or navigation.

The Sanibel River (1978) extends from the vicinity of Site 68 in the west to the control structure at Beach Road near the eastern end of the island (fig. 2), a distance of about 8 miles. The width of the channel varies from less than 10 feet to more than 50 feet, depending on the extent of modification by dredging. The bottom of the river channel is at or slightly below sea level.

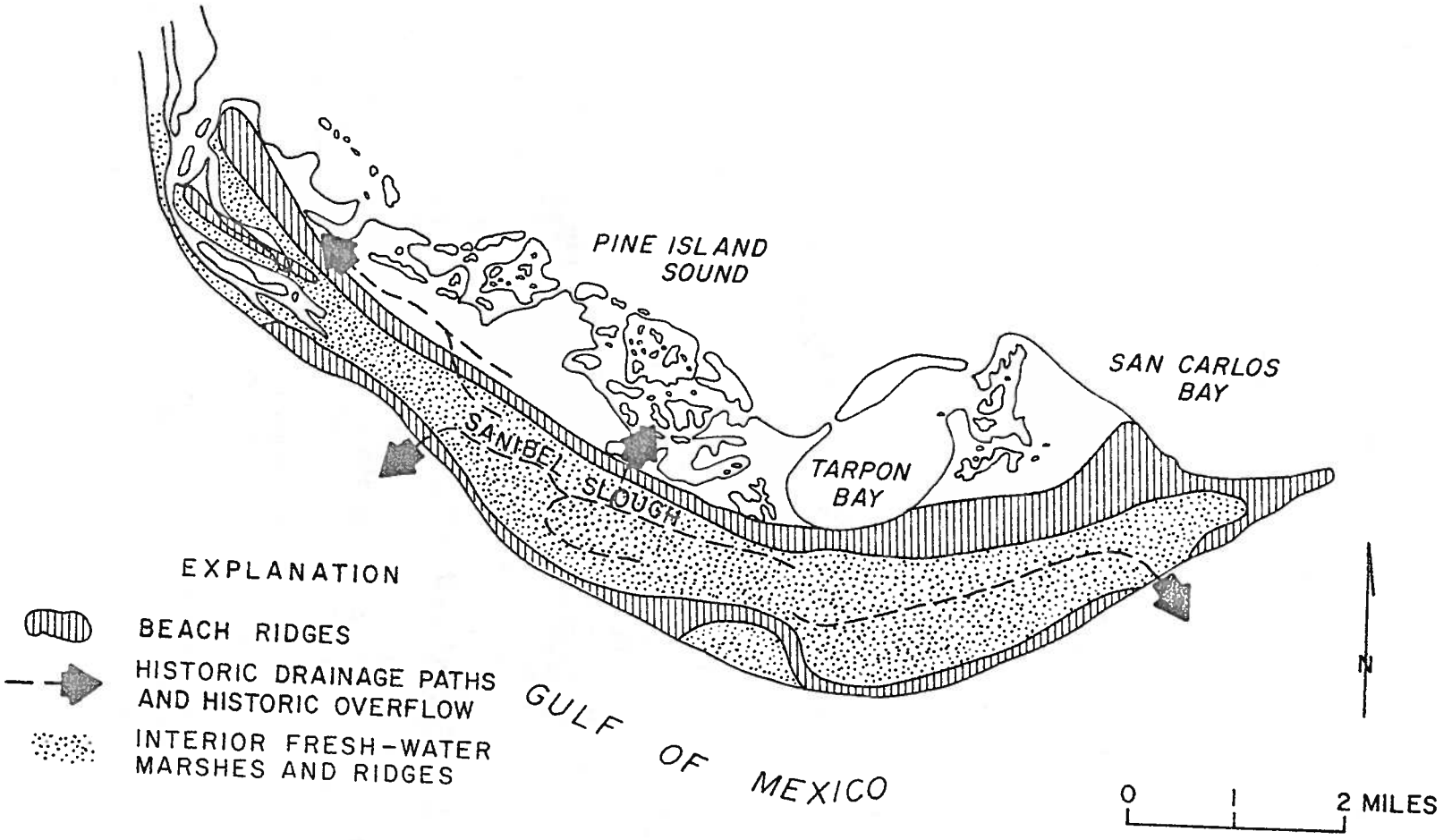

Figure 3.—Sanibel Island showing historic drainage patterns (modified from Tabb and others, 1976)

The Sanibel River is connected at road crossings by culverts, some of which have bottoms several feet above the river bed. During the dry seasons the roads and other impediments may impound water and segment the river. During wet seasons water flows through the culverts toward the control structures at Tarpon Bay or Beach Road (fig. 2). Because of the low hydraulic gradient, water may flow toward either control structure.

Water flows from the river to the bay only after heavy rainfall and then only for a relatively short time. Boggess (1974) estimated that about 500 Mgal flowed through the Tarpon Bay control structure and 100 Mgal through the Beach Road structures after heavy rainfall in September 1971.

SURFACE-WATER CHLORIDE CONCENTRATIONS

The salinity of the surface water is one of the most important factors in determining the kind of aquatic ecosystem that will exist in the island interior. Increased salinity is undesirable because it will alter the aquatic environment, eliminate plants and animals that are intolerant of high salinities, and cause problems for residents that use this water.

The concentrations of chloride can be used as an indicator of surface-water salinity. In 1976 the chloride concentrations at 24 surface-water sites in the interior of Sanibel Island ranged from about 500 mg/L to slightly less than 19,000 mg/L, the concentration of chloride in seawater (fig. 4). Maximum concentrations occurred during the dry season and indicate inflow of saline tidal water or upward movement of water from artesian aquifers. Chloride concentrations were highest in the Sanibel River at sites 35 and 36 near the Tarpon Bay control structure. Concentrations at site 36 ranged from less than 5,000 mg/L in late summer to nearly 19,000 mg/L in May 1976. 5 - 19 ppm

The high chloride concentrations at sites 35 and 36 in the spring of 1976 are attributable to leakage of saline water from Tarpon Bay through and over the wood boards in the control structure. The relatively high salinity at other sites on the Sanibel River during the dry season is also attributable, in part, to leakage of this control structure.

Concentrations of chloride were lowest along the eastern reach of the Sanibel River from site 1, near the Beach Road control structure, to site 5 (fig. 4). Concentrations remained less than 1,000 mg/L, except at site 1 during the dry season when they reached about 1,200 mg/L. The slightly higher salinity at

Divide by 1,000 PPM to PPT

PPT to PPM multiply 1,000

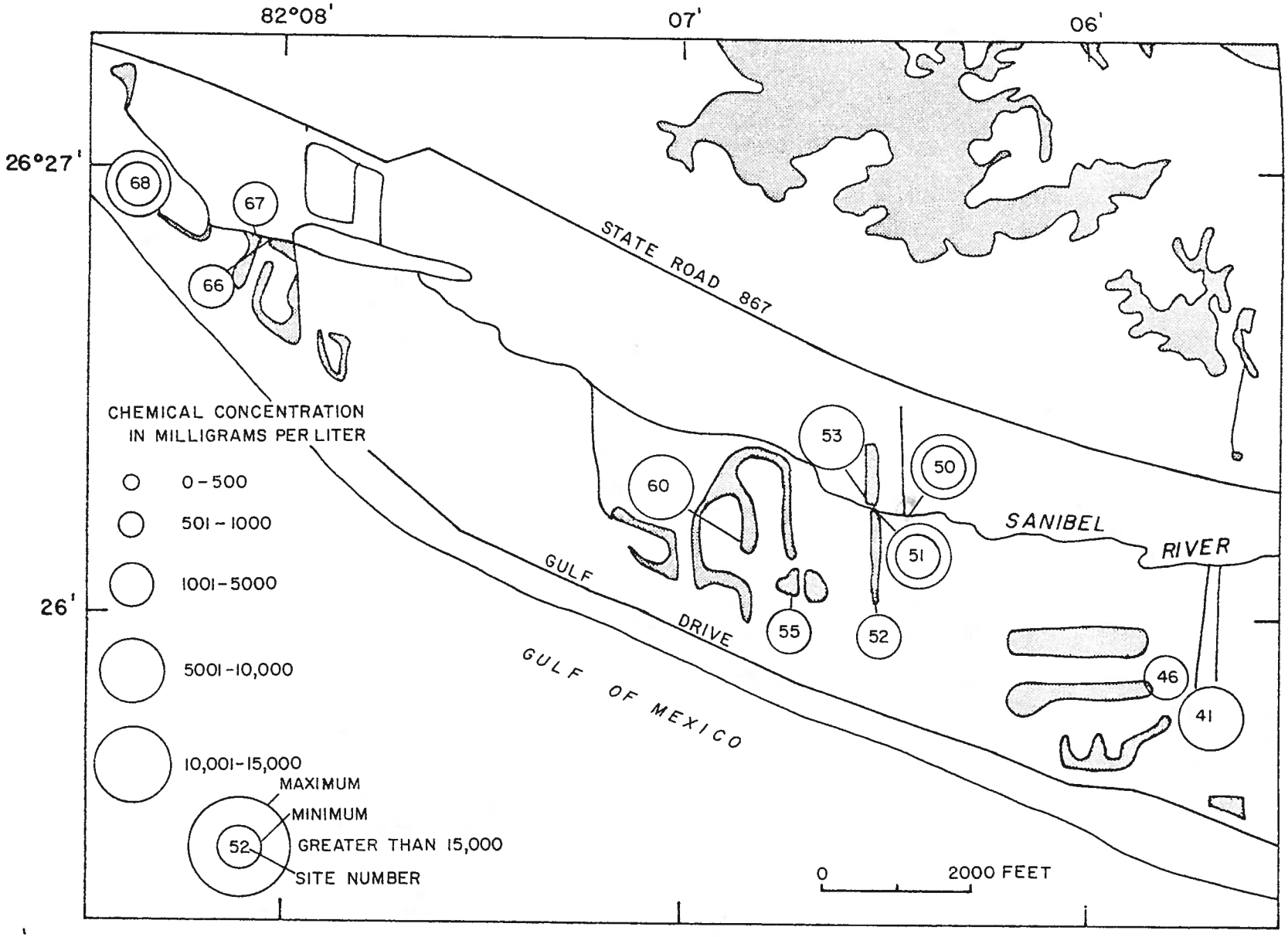

Figure 4.—Maximum and minimum (inner circle) concentrations of chloride in 1976

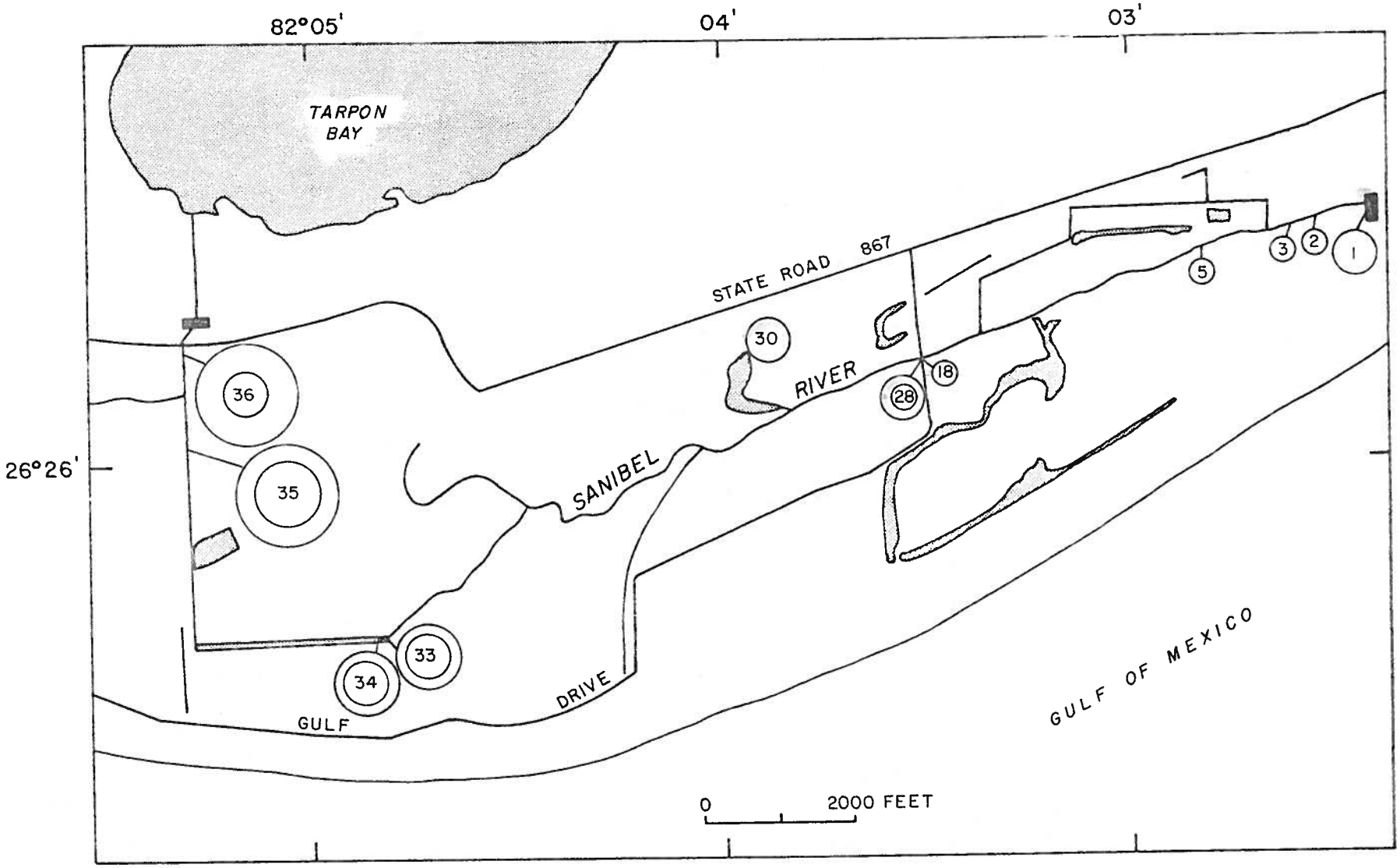

Figure 4.--Maximum and minimum (inner circle) concentrations of chloride in 1976 (Cont'd)

site 1 is probably a result of leakage around the nearby control structure at Beach Road. Seasonal changes in chloride concentrations along this reach of the river ranged from about 500 to 1,200 mg/L. The low salinities along this reach of the river in 1976-77 compared with the high salinities near Tarpon Bay control structure is attributable to the better construction of the Beach Road control structure, which largely retards tidal inflow.

AREAL AND SEASONAL DISTRIBUTION OF MACRONUTRIENTS

The concentrations of nitrogen, phosphorus, carbon, and dissolved oxygen in surface waters were measured during the wet and dry seasons of 1976 (tables 3 and 4). Median concentrations are listed in table 5.

Total organic nitrogen (TON) accounted for about 95 percent of the total nitrogen. Median concentrations of TON were 3.7 mg/L during the dry season and 2.9 mg/L during the wet season. TON exceeded 4.0 mg/L in 33 percent of dry-season samples and 14 percent of the wet-season samples. Most sites on the Sanibel River had TON concentrations exceeding 4.0 mg/L during the dry season.

Ammonia was the second most abundant form of nitrogen. Median total concentrations were 0.04 mg/L in the wet season and 0.03 mg/L in the dry season (table 5). Thirty-one percent of the wet-season samples and 14 percent of the dry-season samples had values that exceeded 0.1 mg/L. The highest concentrations in both and wet dry seasons were at site 32 (2.2 and 2.4 mg/L), and on the Sanibel River at sites 28 and 31 (1.4 and 1.7 mg/L) in the dry season.

Nitrate and nitrite were the least abundant forms of nitrogen. Median total concentrations were 0.0 to 0.11 mg/L (table 5). About 55 percent of the samples had no detectable nitrate. The sewage pond at site 7 had concentrations of 0.23 mg/L nitrite and 13 mg/L nitrate.

Median concentrations of total phosphorus were 0.05 to 0.06 mg/L, about half of which was orthophosphate (table 5). At some sites where concentrations were high, orthophosphate accounted for most or all of the phosphorus. The highest concentrations, for example, were at site 32 with 8.2 and 13.0 mg/L phosphorus of which all was orthophosphate. Concentrations of total phosphorus equaled or exceeded 1.0 mg/L in 15 percent of the samples. Concentrations exceeded this value in the reach of the Sanibel River between site 1 at the Beach Road control structure and site 6, and at sites 7, 8, 9, and 32.

Table 3.--Concentrations of total organic nitrogen (TON), total NH_3 as N, total NO_3 as N, total NO_2 as N, total phosphorus as P, total orthophosphate as P, and total organic carbon (TOC) in 1976: Wet (W) and Dry (D) season

[Values in milligrams per liter]

Site	Season	TON	NH_3	NO_3	NO_2	Total P	Ortho P	TOC
1	D	5.8	0.02	0.04	0.01	2.4	2.0	22
	W	2.5	.02	.01	.02	2.0	1.9	32
2	D	4.4	.04	.00	.01	2.7	2.1	25
	W	3.5	.56	.00	.02	2.8	2.4	35
3	D	4.6	.02	.03	.01	2.6	2.1	15
	W	3.9	.98	.00	.03	2.8	2.6	39
4	D	5.9	.03	.00	.01	2.6	1.9	—
	W	3.9	.58	.01	.02	2.8	2.6	26
5	D	4.7	.04	.03	.01	2.7	2.1	--
	W	4.3	.37	.02	.04	3.2	3.2	—
6	D	3.2	.04	.00	.01	2.1	1.5	—
	W	4.3	.04	.01	.01	.18	.05	—
7	D	2.2	.70	13.0	.23	7.5	7.5	12
	W	1.6	.78	9.8	.25	5.8	5.8	11
8	D	3.1	.08	.01	.01	1.3	1.0	—
	W	—	—	--	--	—	--	--
9	D	2.5	.03	.01	.00	1.0	.70	—
	W	—	--	--	--	—	—	--
10	D	5.5	.06	.00	.01	.41	.31	12
	W	2.6	.12	.00	.02	.15	.05	31
11	D	6.2	.04	.00	.01	.06	.03	35
	W	2.0	.02	.00	.01	.03	.03	25
12	D	3.4	.06	.00	.01	.08	.03	—
	W	5.0	.01	.00	.01	.71	.29	44
13	D	2.7	.02	.00	.01	.06	.03	—
	W	5.5	.24	.00	.01	.27	.03	39

Table 5.--Concentrations of total organic nitrogen (TON), total NH_3 as N, total NO_3 as N, total NO_2 as N, total phosphorus as P, total orthophosphate as P, and total organic carbon (TOC) in 1976: Wet (W) and Dry (D) season (Cont'd)

[Values in milligrams per liter]

Site	Season	TON	NH_3	NO_3	NO_2	Total P	Ortho P	TOC
14	D	4.1	0.19	0.00	0.01	0.07	0.04	13
	W	3.8	.18	.00	.02	.18	.09	--
15	D	5.2	.03	.00	.02	.07	.07	60
	W	3.4	.09	.02	.01	.09	.03	47
16	D	2.6	.02	.00	.01	.04	.04	34
	W	3.2	.02	.00	.01	.08	.05	26
17	D	2.6	.02	.00	.01	.04	.04	—
	W	1.9	.04	.00	.01	.06	.02	27
18	D	—	—	--	--	--	--	50
	W	2.0	.03	.00	.01	.08	.03	26
19	D	7.4	1.5	.00	.01	.51	.36	125
	W	4.3	.49	.00	.02	.34	.19	65
20	D	4.0	.17	.00	.02	.34	.20	97
	W	2.9	.06	.01	.01	.07	.03	49
21	D	4.5	.02	.00	.01	.04	.02	—
	W	2.0	.04	.01	.01	.04	.03	93
22	D	2.6	.03	.00	.01	.04	.03	39
	W	2.4	.04	.01	.01	.06	.03	34
23	D	2.4	.02	.00	.01	.05	.02	26
	W	1.8	.11	.00	.01	.05	.03	23
24	D	2.9	.02	.00	.01	.04	.04	—
	W	2.0	.01	.00	.01	.04	.03	26
25	D	2.3	.02	.00	.01	.03	.02	23
	W	1.8	.01	.01	.01	.03	.03	29
26	D	1.2	.05	.08	.01	.03	.02	--
	W	4.7	.07	.00	.01	.05	.02	17

Table 3.—Concentrations of total organic nitrogen (TON), total NH_3 as N, total NO_3 as N, total NO_2 as N, total phosphorus as P, total orthophosphate as P, and total organic carbon (TOC) in 1976: Wet (W) and Dry (D) season (Cont'd)

[Values in milligrams per liter]

Site	Season	TON	NH_3	NO_3	NO_2	Total P	Ortho P	TOC
27	D	1.7	0.02	0.00	0.01	0.04	0.02	37
	W	1.2	.02	.00	.00	.02	.01	33
28	D	8.5	1.4	.00	.03	.25	.14	100
	W	2.3	.01	.21	.02	.08	.04	36
29	D	2.8	.03	.10	.01	.04	.03	—
	W	—	—	—	—	—	—	—
30	D	2.9	.19	.05	.01	.04	.02	22
	W	2.4	.02	.00	.01	.05	.03	51
31	D	9.2	1.7	.01	.03	.23	.09	142
	W	1.9	.03	.01	.01	.06	.02	23
32	D	5.6	2.2	.02	.02	13.0	13.0	107
	W	4.5	2.4	.01	.01	8.2	8.2	58
34	D	2.5	.04	.00	.00	.03	.02	19
	W	1.8	.01	.01	.01	.04	.03	14
36	D	2.0	.08	.00	.01	.41	.26	43
	W	2.2	.04	.01	.01	.05	.02	41
37	D	1.8	.04	.00	.01	.06	.02	—
	W	1.7	.61	.01	.02	.02	.11	47
38	D	2.5	.02	.00	.01	.03	.01	33
	W	1.9	.01	.00	.01	.02	.01	25
39	D	1.8	.02	.00	.01	.04	.02	—
	W	3.3	.01	.01	.01	.08	.04	128
40	D	2.0	.12	.01	.02	.15	.05	—
	W	2.3	.04	.01	.01	.25	.11	45
41	D	2.4	.09	.00	.01	.08	.02	37
	W	1.8	.18	.07	.04	.01	.00	33

Table 3.--Concentrations of total organic nitrogen (TON), total NH_3 as N, total NO_3 as N, total NO_2 as N, total phosphorus as P, total orthophosphate as P, and total organic carbon (TOC) in 1976: Wet (W) and Dry (D) season (Cont'd)

[Values in milligrams per liter]

Site	Season	TON	NH_3	NO_3	NO_2	Total P	Ortho P	TOC
42	D	2.8	0.06	0.00	0.01	0.09	0.02	—
	W	2.0	.05	.03	.02	.04	.03	—
43	D	4.5	.04	.00	.02	.05	.05	—
	W	2.2	.08	.00	.01	.04	.02	34
44	D	1.9	.02	.00	.01	.03	.02	22
	W	1.8	.03	.01	.01	.02	.02	23
45	D	2.8	.02	.00	.01	.04	.02	—
	W	1.8	.02	.01	.01	.02	.02	24
46	D	1.8	.05	.00	.01	.03	.03	31
	W	2.4	.02	.01	.01	.03	.03	32
47	D	5.8	.05	.00	.02	.07	.07	—
	W	—	—	—	—	—	—	—
48	D	5.4	.03	.00	.02	.08	.07	81
	W	5.2	.05	.00	.02	.06	.06	71
49	D	2.2	.01	.01	.01	.06	.02	—
	W	—	—	—	—	—	—	—
50	D	2.5	.01	.01	.01	.06	.02	32
	W	3.4	.01	.00	.01	.04	.02	35
51	D	8.7	.08	.00	.01	.16	.09	88
	W	1.9	.04	.00	.01	.04	.02	35
52	D	7.3	.01	.01	.01	.09	.02	94
	W	4.0	.02	.00	.01	.07	.05	78
53	D	5.6	.03	.00	.01	.04	.03	81
	W	3.6	.05	.00	.01	.03	.02	54
54	D	2.6	.02	.01	.00	.03	.01	42
	W	2.4	.02	.01	.01	.02	.02	46

Table 3.--Concentrations of total organic nitrogen (TON), total NH_3 as N, total NO_3 as N, total NO_2 as N, total phosphorus as P, total orthophosphate as P, and total organic carbon (TOC) in 1976: Wet (W) and Dry (D) season (Cont'd)

[Values in milligrams per liter]

Site	Season	TON	NH_3	NO_3	NO_2	Total P	Ortho P	TOC
55	D	2.4	0.02	0.01	0.00	0.03	0.01	46
	W	1.9	.04	.01	.01	.04	.03	54
56	D	2.2	.02	.01	.00	.03	.01	--
	W	3.2	.02	.01	.02	.04	.04	68
57	D	4.6	.03	.00	.01	.02	.00	—
	W	3.8	.42	.01	.01	.03	.03	71
58	D	3.6	.02	.01	.00	.01	.01	--
	W	3.8	.38	.01	.01	.03	.03	—
59	D	3.5	.03	.00	.00	.01	.00	—
	W	3.6	.26	.01	.01	.02	.02	—
60	D	3.3	.03	.01	.00	.01	.01	42
	W	3.5	.12	.00	.01	.03	.01	59
61	D	1.6	.02	.01	.00	.02	.00	19
	W	1.4	.06	.00	.01	.04	.01	22
62	D	1.8	.02	.02	.01	.02	.00	19
	W	1.2	.04	.00	.01	.09	.01	23
63	D	5.4	.02	.00	.02	.05	—	93
	W	3.4	.02	.01	.01	.03	.03	50
64	D	—	--	--	--	--	--	--
	W	2.8	.03	.01	.01	.04	.02	52
65	D	4.0	.02	.00	.02	.08	.07	51
	W	2.4	.03	.01	.01	.03	.02	31
66	D	3.8	.02	.00	.02	.10	.06	—
	W	—	--	--	--	--	--	--
67	D	1.8	.02	.02	.01	.02	.00	28
	W	2.4	.28	.01	.01	.05	.03	27
68	D	3.2	.02	.00	.01	.12	.09	29
	W	1.5	.05	.01	.01	.03	.01	--

Table 4.--Concentrations of dissolved oxygen in the wet (W) and dry (D) seasons, 1976

[Values in milligrams per liter]

Site	Season	Time	DO	Site	Season	Time	DO
1	D	1030	1.3	16	D	1300	11.4
	W	—	--		W	—	--
2	D	1100	5.3	17	D	0930	7.1
	W	1130	2.4		W	1145	2.2
3	D	—	--	18	D	--	—
	W	1130	1.2		W	1515	2.8
4	D	—	--	19	D	1000	0.7
	W	—	--		W	1300	0.2
5	D	1430	9.7	20	D	1420	0.2
	W	1000	3.0		W	1235	0.6
6	D	1220	5.0	21	D	1400	6.4
	W	—	--		W	1310	0.6
7	D	1120	3.9	22	D	1220	5.6
	W	1200	4.5		W	1120	2.0
8	D	—	--	23	D	1430	9.3
	W	—	--		W	1300	3.6
9	D	1230	7.3	24	D	1300	8.5
	W	—	--		W	1400	4.8
10	D	1300	0.8	25	D	1200	6.3
	W	—	--		W	—	--
11	D	1400	11.4	26	D	1230	9.3
	W	1340	2.0		W	—	--
12	D	1220	2.6	27	D	1220	7.1
	W	—	--		W	1500	5.4
13	D	1345	10.8	28	D	1320	4.1
	W	—	--		W	1410	2.4
14	D	1200	10.0	29	D	1300	7.4
	W	1215	2.0		W	—	—
15	D	1415	8.9	30	D	1315	4.1
	W	—	--		W	1515	4.1

Table 4.—Concentrations of dissolved oxygen in the wet (W) and dry (D) seasons, 1976 (Cont'd)

[Values in milligrams per liter]

Site	Season	Time	DO	Site	Season	Time	DO
31	D	1400	8.5	46	D	1330	6.9
	W	1015	1.4		W	—	--
32	D	1120	0.4	47	D	1430	8.0
	W	1330	0.2		W	—	--
33	D	1040	2.6	48	D	1445	6.9
	W	—	—		W	1640	8.6
34	D	1020	2.4	49	D	1315	9.4
	W	1535	9.5		W	—	--
35	D	—	—	50	D	1300	7.1
	W	—	—		W	1600	1.9
36	D	1100	1.5	51	D	1200	12.5
	W	1300	3.2		W	1400	5.1
37	D	1325	7.4	52	D	1330	7.2
	W	1425	2.6		W	—	--
38	D	1140	6.6	53	D	1345	8.1
	W	1400	5.6		W	—	--
39	D	1340	8.8	54	D	1435	7.8
	W	1500	5.4		W	1710	7.8
40	D	1300	8.8	55	D	1130	5.6
	W	1530	9.5		W	1440	6.0
41	D	1200	3.1	56	D	1420	9.5
	W	1645	2.5		W	1650	7.2
42	D	1230	9.0	57	D	1410	7.9
	W	1715	6.1		W	1630	2.5
43	D	1245	9.3	58	D	1345	7.1
	W	1730	3.9		W	1615	5.5
44	D	—	—	59	D	1335	8.6
	W	—	--		W	1545	5.5
45	D	1400	5.8	60	D	1335	8.6
	W	1205	4.7		W	1545	5.5

Table 4.—Concentrations of dissolved oxygen in the wet (W) and dry (D) seasons, 1976 (Cont'd)

[Values in milligrams per liter]

Site	Season	Time	DO	Site	Season	Time	DO
61	D	1200	6.5	65	D	1200	10.6
	W	—	--		W	1745	6.3
62	D	1230	4.8	66	D	—	--
	W	1345	2.7		W	—	—
63	D	1305	8.6	67	D	1345	5.8
	W	—	--		W	1345	1.8
64	D	—	--	68	D	1000	3.5
	W	1300	1.3		W	1825	4.5

Table 5.--Median concentrations of nitrogen, phosphorus, and carbon at sites 1-68 on Sanibel Island, 1976 wet and dry seasons

[Values in milligrams per liter]

Total orthophosphate		Total phosphorus	
Dry	Wet	Dry	Wet
0.03 (63)*	0.03 (60)	.06 (64)	.05 (60)

Total organic nitrogen		Total NH_3 as N	
Dry	Wet	Dry	Wet
3.7 (64)	2.9 (59)	0.03 (65)	0.04 (59)

Total NO_2 as N		Total NO_3 as N	
Dry	Wet	Dry	Wet
0.01 (64)	0.01 (60)	0.0 (65)	0.01 (59)

Total organic carbon		Dissolved oxygen	
Dry	Wet	Dry	Wet
35 (40)	35 (53)	7.5 (60)	3.5 (44)

*Number of samples.

The relatively high concentrations of organic nitrogen and total phosphorus at some sites on Sanibel exceed those reported for highly eutrophic water bodies in other areas of Florida. For example, the water in Lake Apopka in central Florida, which is considered highly eutrophic, had concentrations of organic nitrogen that averaged 3.8 mg/L and total phosphorus that averaged 0.24 mg/L (Brezonik and others, 1969).

Sewage-treatment ponds, package sewage-treatment plant effluents, and septic tanks are the potential sources of the high concentrations of nitrogen and phosphorus in Sanibel surface water. The Jamestown-Beachview Wastewater Treatment Plant on the eastern end of the island has two retention ponds (site 7) near the Sanibel River. These ponds contain water with exceedingly high concentrations of soluble nitrate and orthophosphate. The reach of the river near the treatment ponds contained water with some of the highest nutrient concentrations on the island. The Island Shopping Center sewage-treatment package plant is about 50 feet north of the pond at site 32 which had the maximum concentrations of phosphorus. The Sanibel Center Buildings sewage-treatment package plant is near sites 19 and 20, and effluent from the plant may explain the relatively high nutrient and low dissolved-oxygen concentrations at these sites.

Concentrations of total organic carbon in the surface water of Sanibel ranged from 11 to 142 mg/L. The lowest value was in a sewage treatment pond, site 7, and the highest was in the Sanibel River at site 31. In the wet season at site 31, however, the concentration was only 23 mg/L. The median concentration of total organic carbon was 35 mg/L in both the wet and dry seasons (table 5).

Concentrations of dissolved oxygen in the upper surface waters of Sanibel measured, in most cases, near midday and ranged from near zero to 12.5 mg/L with median concentrations of 7.5 mg/L in the dry season, and 3.5 mg/L in the wet season of 1976 (table 5). Concentrations were low (2.2 mg/L average) in the eastern reach of the Sanibel River between sites 2 and 31 in the wet season and near zero at several nearby sites (19, 20, and 32) during the wet and dry seasons.

Low dissolved-oxygen concentrations in surface waters of Sanibel can be attributed to low photosynthetic oxygen production by aquatic plants during the day, high bacterial oxygen consumption, or both. The low concentrations in the wet season, particularly along the Sanibel River, may be due to the increased seasonal water flow. Flow would tend to flush phytoplankton population out of the river system, whereas in the dry season, stagnant conditions would favor a buildup of the phytoplankton

populations. Attached plants are another source of dissolved oxygen, but are restricted in distribution by the type of bottom substrate and the amount of light that reaches it. On Sanibel, attached, submerged plants are generally confined to shallow-water areas because high turbidity and color of the water greatly reduce light penetration and limit photosynthesis. Floating mats of aquatic plants also greatly reduce light penetration. The near-anaerobic conditions at several sites on Sanibel are probably caused by high bacterial respiration that is associated with large nutrient loads. For example, at site 32 (pond) which had less than 0.5 mg/L dissolved oxygen, total phosphorus averaged 11 mg/L and total nitrogen averaged 7.3 mg/L.

Overall the concentrations of macronutrients and dissolved oxygen in the interior of Sanibel Island indicate that surface waters are not widely polluted by organic material. Flushing by tides and rainfall and high biological productivity probably maintain relatively low concentrations of macronutrients and aerobic conditions during much of the year. However, some exceptions to this are evident. In these places the high concentrations of macronutrients and low concentrations of dissolved oxygen are attributable, in part, to urban runoff and sewage effluent that may flow directly into the surface waters or seep through the shallow water-table aquifer into surface-water bodies.

WATER QUALITY AT SELECTED SITES

Four of the sites sampled in the 1976 areal survey in the wet and dry seasons were selected for further monitoring at different depths and for additional parameters. These were sites 5 and 50 on the Sanibel River and sites 41 and 48 at borrow ponds (fig. 2). At these sites macronutrients and other selected parameters were sampled every 2 to 4 months over 19 months of 1976-77. In addition, measurements were made over a 24-hour period (diel) on May 23-24, 1977.

Site 5

The Sanibel River at Donax Street (site 5) is a sluggish, shallow water body about 45 feet wide. Concentrations of chloride ranged from about 600 to 1,200 mg/L during 1976-77. Boggess (1974) reported that as a result of dewatering and subsequent pumping of high-salinity water into the river, chloride concentrations at site 5 were 11,000 mg/L on June 20, 1970. By October 1970 the concentrations had dissipated to less than 2,000 mg/L, as a result of rainfall during the period and of discharge at the Beach Road control structure. Concentrations of chloride remained above 1,000 mg/L in 1971-72 but were mostly below this level after mid-1973 (fig. 5).

Figure 5.--Chloride concentrations at site 5, Sanibel River, 1971-77

The concentrations of total nitrogen at site 5 in 1976-77 ranged from 2.1 to 8.7 mg/L and averaged 4.8 mg/L (table 6). About 70 percent of the total was organic nitrogen. The organic nitrogen was almost entirely ammonia, which averaged 1.3 mg/L. Concentrations of total nitrogen increased in early summer of 1977, largely as a result of increased concentrations of ammonia (fig. 6). The high ammonia concentrations coincided with anaerobic conditions throughout the water column.

Concentrations of total phosphorus ranged from 0.26 to 3.2 mg/L and averaged 1.8 mg/L (table 6). Most of the total was orthophosphate. Concentrations of phosphorus tended to be higher in late spring and summer of both 1976 and 1977 than in the winter (fig. 6).

The source of the relatively high concentrations of nitrogen and phosphorus at site 5 is probably a sewage treatment pond about 100 feet to the north. Concentrations of total nitrogen in the pond were 16.1 mg/L on May 24, 1976, and 12.5 mg/L on June 22, 1976; about 80 percent was nitrate. Concentrations of total phosphorus on these dates were 7.5 mg/L and 5.8 mg/L, all of which was orthophosphate. Dissolved orthophosphate and nitrate could be transported by ground-water flow from the pond to the river. Nitrate, under anaerobic conditions, would be reduced to ammonia.

Concentrations of dissolved oxygen, nitrate and nitrite, ammonia, orthophosphate, and total phosphorus were measured periodically over 24 hours (diel) on May 23-24, 1977, but showed no significant trends (fig. 7). Concentrations of dissolved oxygen remained below 0.5 mg/L indicating near-anaerobic conditions. Ammonia concentrations remained at about 5 mg/L, and orthophosphate and total phosphorus concentrations were both slightly more than 2.0 mg/L. Concentrations of nitrate and nitrite ranged between 0.0 and 0.02 mg/L.

Site 50

Site 50 at Rabbit Road on the Sanibel River is about 4 miles west of site 5 and about 1.3 miles west of the Tarpon Bay control structure. The river at site 50 is more saline that at site 5. Concentrations of chloride showed marked seasonal fluctuations ranging generally from about 2,000 mg/L in the wet season to more than 6,000 mg/L during the dry season (fig. 8). Boggess (1974) points out that the salinity in this reach of the river in 1971-72 was increased by leakage of saltwater through and over the Tarpon Bay control structure and by pumpage of saline water into the river.

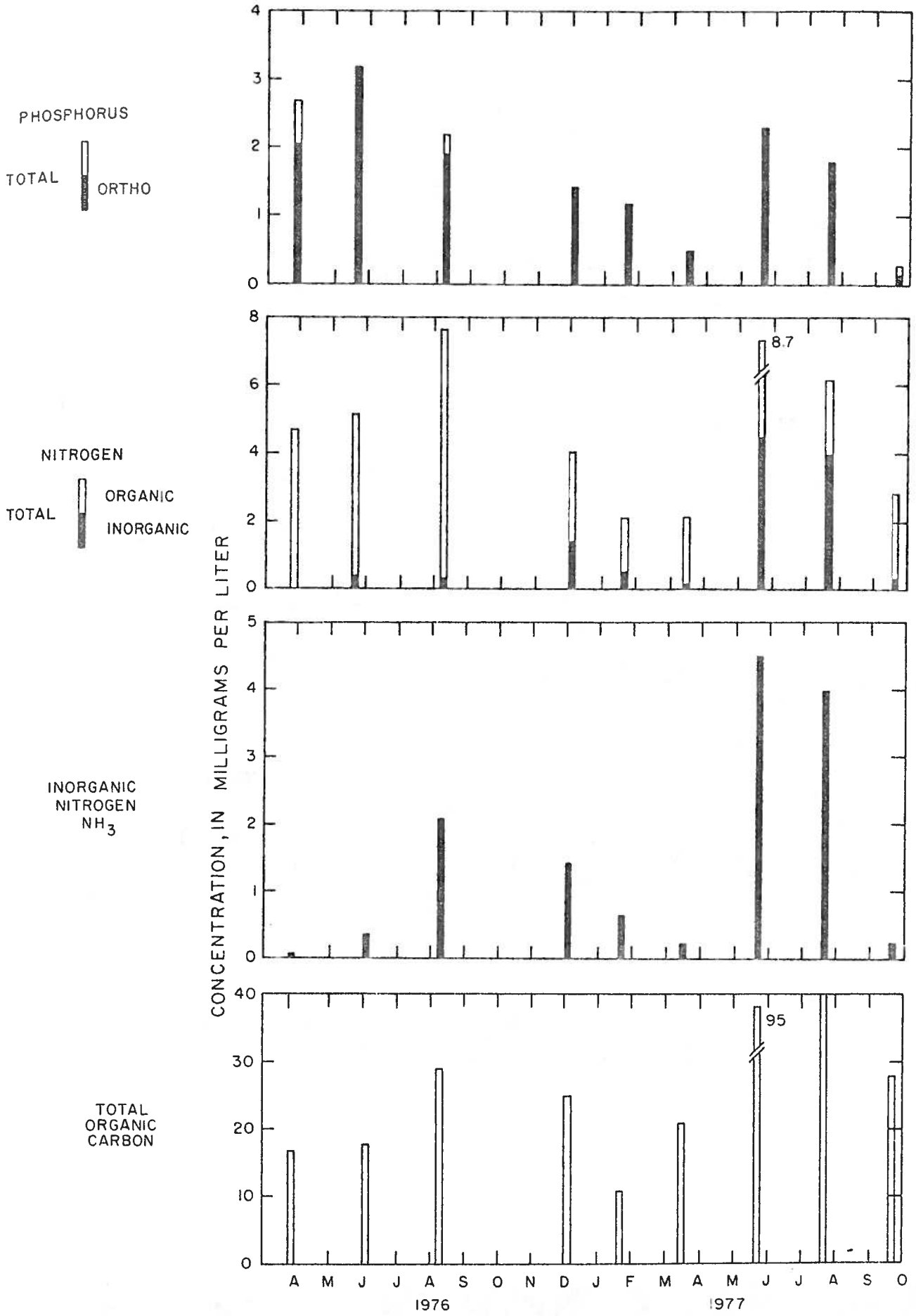

Figure 6.--Concentrations of macronutrients near the surface at site 5, Sanibel River, 1976-77

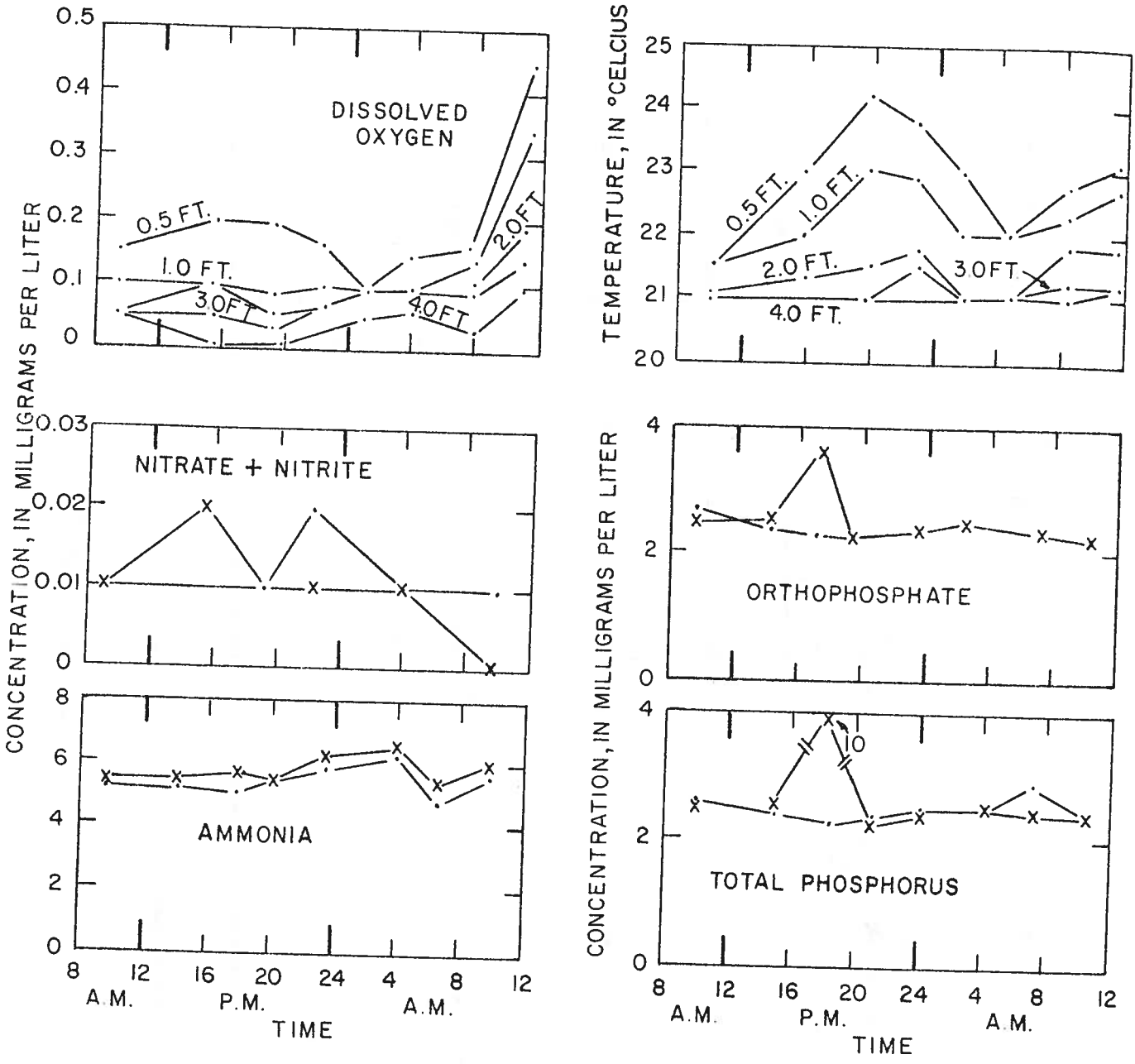

Figure 7.—Concentrations of dissolved oxygen, total nitrate plus nitrite, total ammonia, total orthophosphate, total phosphorus, and water temperature at site 5 over 24 hours, May 23-24, 1977

Figure 8.—Chloride concentrations at site 50, Sanibel River, 1971-77

Table 6.--Mean concentrations of macronutrients and other selected parameters at site 5, Sanibel River at Donax Street, 1976-77, (sampled in upper foot)

[Values in milligrams per liter unless otherwise indicated]

	Number of analyses	Range	Mean
Total nitrogen	9	2.1 - 8.7	4.8
Total organic nitrogen	9	1.5 - 7.5	3.5
Total NH_3 as N	9	0.04 - 4.6	1.3
Total NO_2 as N	9	.00 - .03	.01
Total NO_3 as N	9	.00 - .03	.01
Total phosphorus as P	9	.26 - 3.2	1.8
Total orthophosphate as P	9	.14 - 3.2	1.6
Total organic carbon	9	11 - 95	40
Specific conductance (umho/cm at 25°C)	14	2450 - 3830	3281
Dissolved oxygen	10	0 - 9.7	3.6
BOD	6	3.1 - 10.1	6.3
Transparency, secchi disk, (ft)	5	1.1 - 2.5	1.8
Turbidity (JTU)	11	5 - 35	15.8

The concentrations of nitrogen, phosphorus, and carbon compounds at site 50 in 1976-77 are shown in figure 9. Concentrations of total nitrogen ranged from 2.1 to 4.2 mg/L and averaged 3.0 mg/L. About 90 percent was organic nitrogen, and about 10 percent was ammonia. Nitrate and nitrite made up the remaining small amount of inorganic nitrogen with an average concentration of 0.02 mg/L for each. Concentrations of total phosphorus ranged from 0.03 to 0.21 mg/L and averaged 0.09 mg/L of which about 60 percent was orthophosphate. Total organic carbon concentrations averaged 38 mg/L (table 7).

During 1976-77 the concentration of dissolved oxygen ranged between 0.5 and 18.2 mg/L and averaged 6.0 mg/L (table 7). The minimum concentration occurred on September 22, 1977, (0.5 mg/L at the surface at 1000 hours) and coincided with the minimum specific conductance (2,600 umhos/cm) and maximum BOD (9.6 mg/L). The maximum concentration of dissolved oxygen (18.2 mg/L) was measured on May 22, 1977 at 1720 hours during the diel measurement.

Diel measurements of dissolved oxygen, and nitrogen and phosphorus compounds on May 23-24, 1977 are shown in figure 10. Concentrations of dissolved oxygen increased to maximum values in late afternoon and declined to minimum values in early morning. The dissolved oxygen concentration and the ammonia of diel fluctuation decreased with depth so that at 6 feet, concentrations remained at about 4 mg/L throughout the 24 hours. At 7 feet, which was just off the bottom, concentrations approached zero.

The concentration of ammonia nitrogen fluctuated inversely to dissolved oxygen over the 24-hour period. The concentration of ammonia was lowest during the afternoon of May 23, 1977, and highest in the early morning of May 24, 1977. Other nitrogen and phosphorus compounds showed no obvious diel trends (fig. 10).

Comparison between sites 5 and 50 on the Sanibel River

Water-quality characteristics differed substantially at sites 5 an 50. Site 5 was periodically characterized by low concentrations of dissolved oxygen, and by high concentrations of nutrients and BOD. Anaerobic conditions occurred periodically at site 5. The average concentration of dissolved oxygen at site 50 was twice that at site 5 (table 8). Ammonia nitrogen and phosphorus concentrations were orders of magnitude higher at site 5 than site 50. Average BOD at site 5 was about twice that at site 50 (table 8). The transparency of water was much greater at site 50 than at site 5. The secchi disk could be seen at site 50 at a depth 3 times that at site 5. Also, turbidity was almost 4 times greater at site 5 than at site 50 (table 8). Low water transparency restricts photosynthesis to all but the uppermost part of a water column.

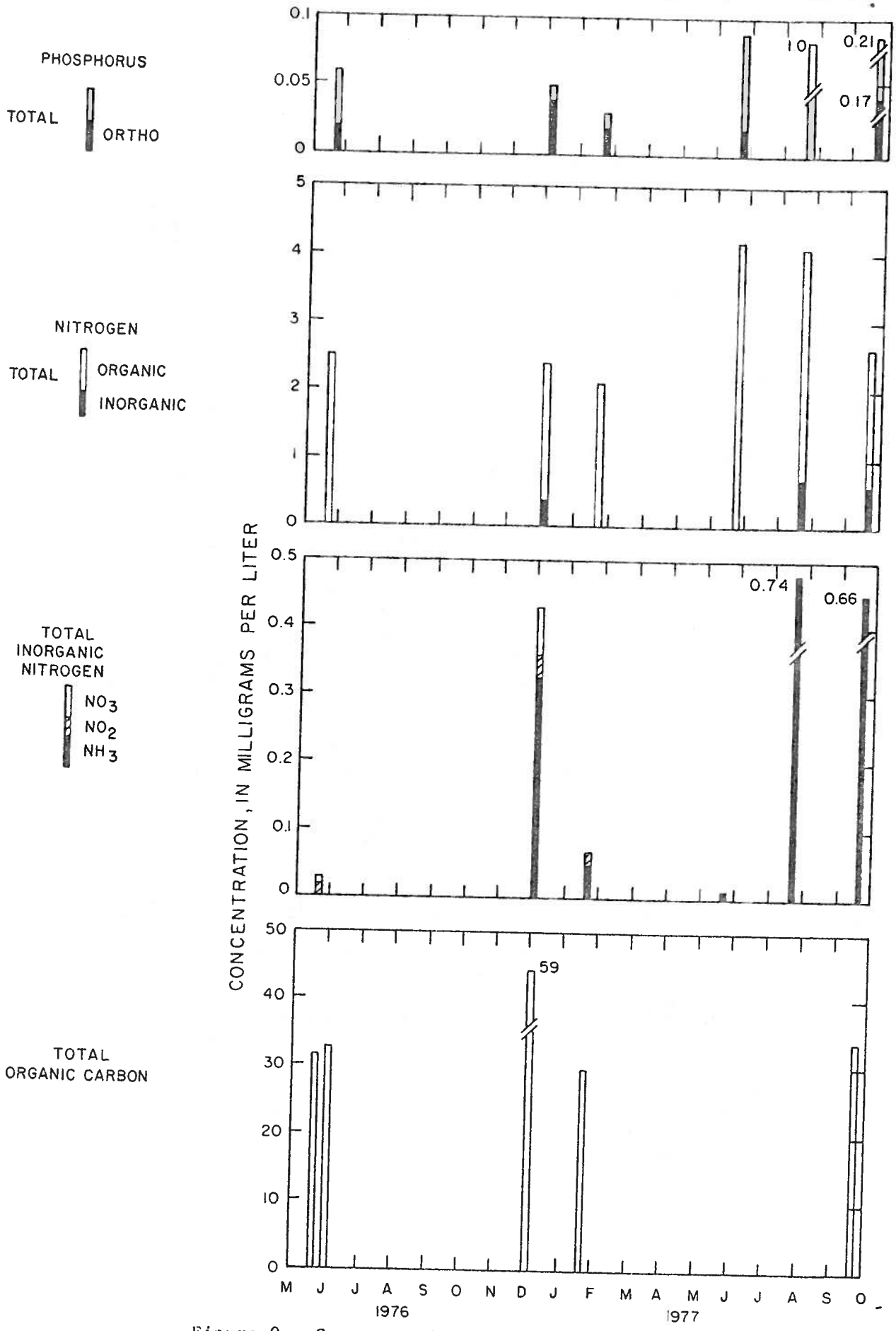

Figure 9.—Concentrations of macronutrients near the surface at site 50, 1976-77

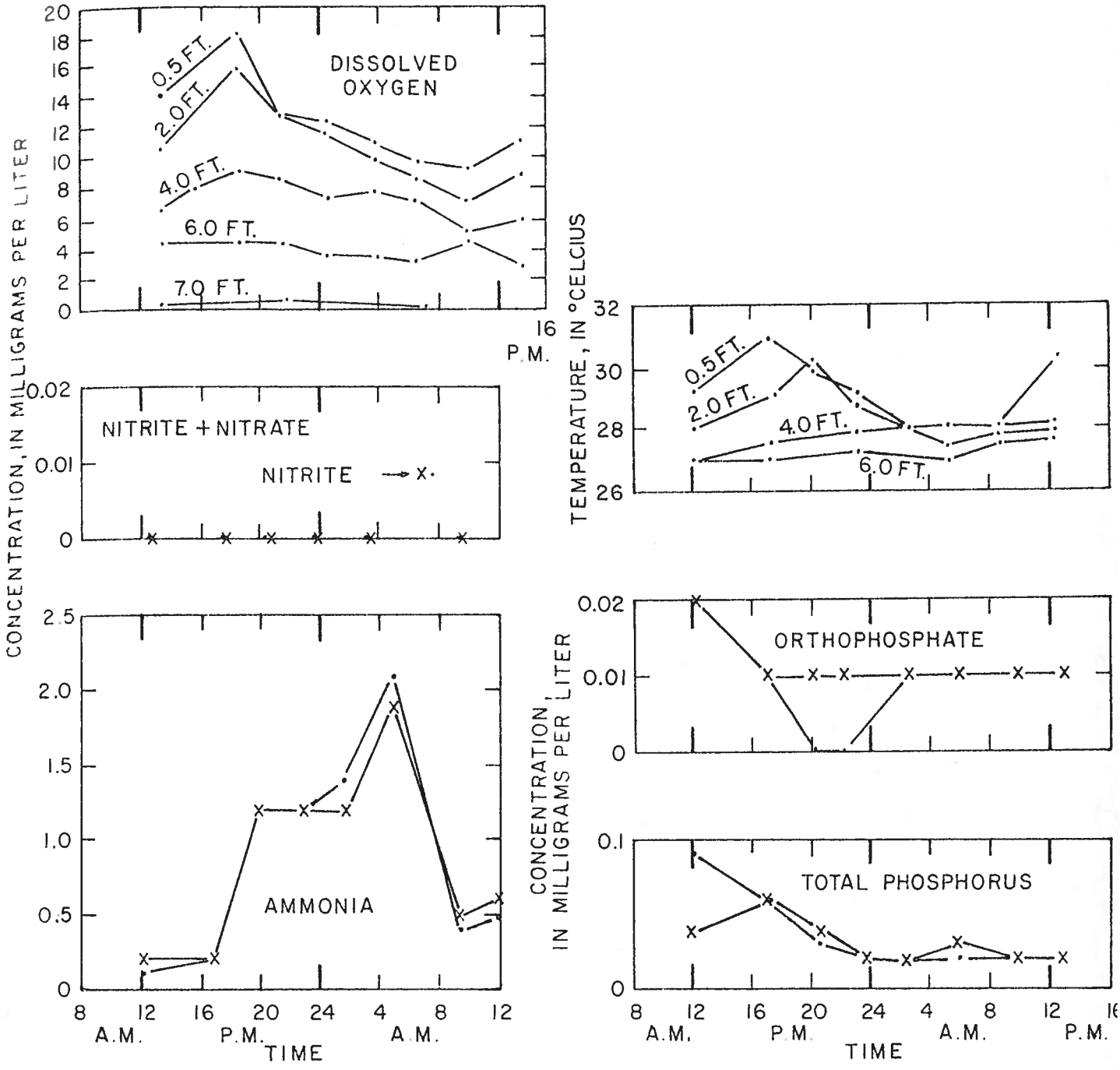

Figure 10.--Concentrations of dissolved oxygen, total nitrate plus nitrite, total ammonia, total orthophosphate, total phosphorus, and water temperature at site 50 over 24 hours, May 23-24, 1977

Table 7.--Mean concentration of macronutrients and other selected parameters at site 50, Sanibel River at Rabbit Road, 1976-77, (sampled in upper foot)

[Values in milligrams per liter unless otherwise indicated]

	Number of analyses	Range	Mean
Total nitrogen	6	2.1 - 4.2	3.0
Total organic nitrogen	6	2.0 - 4.2	2.7
Total NH_3 as N	6	.01 - .74	0.3
Total NO_2 as N	6	.00 - .03	.02
Total NO_3 as N	6	.00 - .07	.02
Total phosphorus as P	6	.03 - .21	.09
Total orthophosphorus as P	6	.02 - .17	.05
Total organic carbon	5	32 - 59	38
Specific conductance (umho/cm at 25°C)	4	2600 - 17,000	11,275
Dissolved oxygen	8	0.5 - 18.2	6.0
BOD	6	0.1 - 9.6	3.3
Transparency, secchi disk (ft)	5	2.5 - 7.2	5.2
Turbidity (JTU)	9	2 - 8	4.1

Table 8.--Average values for selected water-quality parameters 1976-77, and the range of values, May 23-24, 1977 at sites 5 and 50 on the Sanibel River (sampled in upper foot)

[Values in milligrams per liter unless otherwise indicated]

	Average 1976-77	
	Site 5	Site 50
Temperature, (°C)	23.6	25.7
Specific conductance (umho/cm)	3281	11,275
Dissolved oxygen (DO)	3.6	6.0
Turbidity (JTU)	15.8	4.1
Total organic nitrogen	3.5	2.7
Total organic carbon	40	38
Total NH_3 as N	1.3	0.3
Total phosphorus	1.8	.09
Total orthophosphate	1.6	.05
BOD	6.3	3.3
Transparency, secchi disk, (ft)	1.8	5.2

	Range for 24 hours, May 23-24, 1977	
Near surface	Site 5	Site 50
Temperature, (°C)	22.5 - 25.2	28 - 31
DO	0.1 - .4	9.0 - 18.2
pH	7.2 - 7.6	8.6 - 9.0
Near bottom		
Temperature, (°C)	22.0 - 24.0	27 - 28
DO	0.0 - .1	.2 - .6
pH	6.8 - 7.4	8.2 - 8

Diel fluctuations in dissolved oxygen indicated a greater productivity at site 50 than at site 5 on May 23-24, 1977. In the upper 2 feet of water, net daily production, as estimated by the diel oxygen curve method (Greeson and others, 1977), was 9.3 g/m^3 of oxygen per day at site 50 compared with near zero production at site 5.

Average water temperature was 2°C lower at site 5 than at site 50, and on May 23-24, 1977 was 5 to 6°C lower (table 8). The lower temperature at site 5 may indicate greater contributions of cool ground-water, a shading effect from trees and duckweed, or a combined effect of inflow, shading, and other factors.

The average specific conductance was about 4 times higher at site 50 than at site 5 (table 8). The salinity at site 5 was about 6 percent that of seawater compared with 28 percent at site 50.

Duckweed covered the surface at site 5, but was absent at site 50, probably because of the high salinity at site 50. Chamberlain (1960) recorded duckweed in Florida over a chloride range of 47 to 181 mg/L. At site 5, however, duckweed flourished in water with chloride concentrations that exceeded 600 mg/L.

The poor water-quality conditions at site 5 can be attributed to high nutrient input, little flushing or dilution, and low submerged biological production. Although the mat of duckweed at site 5 utilized nutrients from the water, the mat also contributed to the poor water quality by reducing light penetration and photosynthesis in water beneath it.

Site 41

Site 41 is at a borrow pond near Poinciana Circle (fig. 2). The 1-acre pond, which was dug in the late 1960's, has a maximum depth of about 10.6 feet. It is connected to the Sanibel River by an 1,800-foot shallow ditch.

The water in the borrow pond at site 41 is brackish. Specific conductance near the surface in 1976-77, ranged from 8,600 to 21,500 umhos/cm at 25°C and averaged 16,630 umhos (table 9). This corresponds to an average salinity of about 34 percent of seawater. The brackish water is partly attributable to saline-water intrusion from the Sanibel River through the shallow connecting ditch. Boggess (1974) reported that on June 18-19, 1972, high tides topped the Tarpon Bay control structure and spread saline water inland through the Sanibel River and into its secondary drainageways. Chloride concentrations at the bottom of the pond at that time increased from less than 2,000 mg/L to more than 12,000 mg/L. Salinity decreased after June but remained well above pre-June levels (Boggess, 1974).

Table 9.—Mean concentrations of macronutrients and other parameters at site 41, 1976-77 (sampled in upper foot)

[Values in milligrams per liter unless otherwise indicated]

	Number of analyses	Range	Mean
Total nitrogen as N	9	1.7 - 3.0	2.3
Total organic nitrogen	9	1.7 - 2.2	2.0
Total NO_3 as N	9	.0 - 1.0	.29
Total NO_2 as N	9	.01 - .05	.02
Total NO_3 as N	9	.0 - .07	.02
Total phosphorus as P	9	.01 - .15	.06
Total orthophosphate as P	9	.00 - .12	.04
Total organic carbon	6	23 - 37	30
Specific conductance, (umho/cm at 25°C)	7	8600 - 21,500	16,629
Dissolved oxygen	9	0.8 - 7.9	4.0
BOD	4	0.3 - 2.2	1.2
Transparency, secchi disk, (ft)	6	3.6 - 9.2	6.7
Turbidity (JTU)	11	1 - 8	4.4

The concentrations of nitrogen, phosphorus, and carbon compounds in the upper 1 foot at site 41 in 1976-77 are shown in figure 11. Concentrations of total nitrogen ranged from 1.7 to 3.0 mg/L and averaged 2.3 mg/L. Eighty-seven percent was organic nitrogen; 13 percent was ammonia. Concentrations of nitrate and nitrite averaged 0.02 mg/L each. Concentrations of total phosphorus ranged from 0.01 to 0.15 mg/L and averaged 0.6 mg/L of which about 66 percent was orthophosphate (table 9).

The concentrations of nitrogen and phosphorus compounds were measured every few hours over a 24-hour period on May 23-24, 1977. No obvious diel trends were evident for nitrate and orthophosphate, which averaged about 0.02 mg/L, or for total phosphorus, which averaged about 0.05 mg/L. However, high concentrations coincided with low concentrations of dissolved oxygen.

Over the 24-hour period, the concentration of dissolved oxygen near the surface ranged from 7.9 mg/L in late afternoon to about 4 mg/L in early morning. Concentrations decreased with depth. At 9 feet the dissolved oxygen was about 3 mg/L and changed little over the 24-hour period (fig. 12). During 1976-77 concentrations of dissolved oxygen ranged from 0.8 to 7.9 mg/L and averaged 4.0 mg/L (table 9).

Site 48

Site 48 is at the east end of an elongated borrow pond, North Lake Murex (fig. 2). The 15-acre pond was dug in 1974-75 and has a maximum depth of about 10 feet.

Water in the borrow pond is brackish. Specific conductance averaged 16,317 umhos/cm at 25°C (table 10), which corresponds to a salinity of about 34 percent that of seawater. The brackish water is largely attributable to upward movement of saline water from the lower part of the water-table aquifer that occurred during and after excavation of the pond and to upward leakage from the shallow saline artesian aquifer.

The concentrations of nitrogen, phosphorus, and carbon compounds at site 48 are shown in figure 13. Concentrations of total nitrogen ranged from 1.0 to 6.5 mg/L and averaged 5.2 mg/L, most of which was organic nitrogen. Ammonia, which averaged 0.21 mg/L in concentration with highest values in July and September 1977, constituted most of the inorganic nitrogen. Total phosphorus, which was almost entirely orthophosphate, had an average concentration of 0.05 mg/L (table 10).

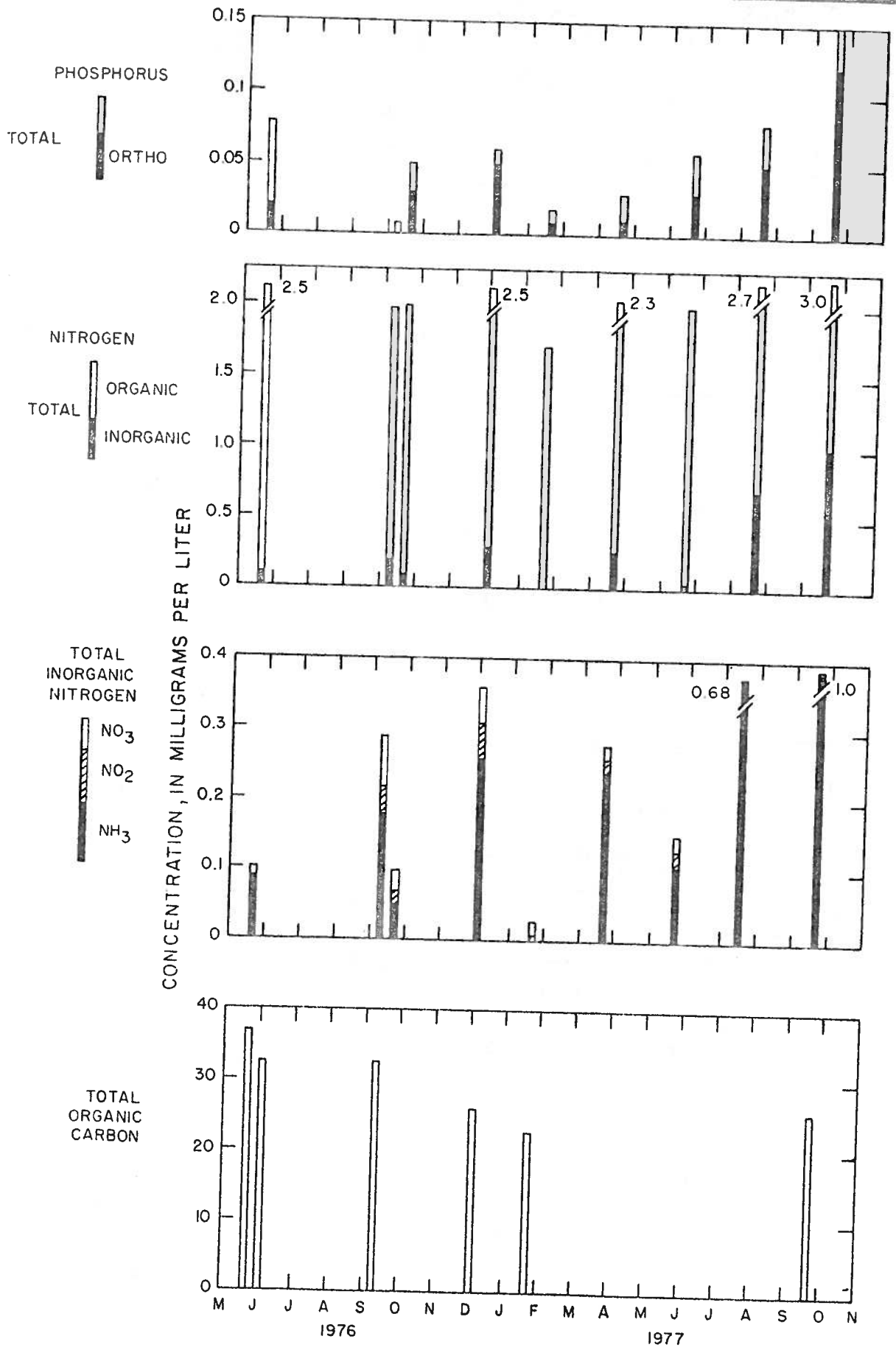

Figure 11.—Concentrations of macronutrients near the surface

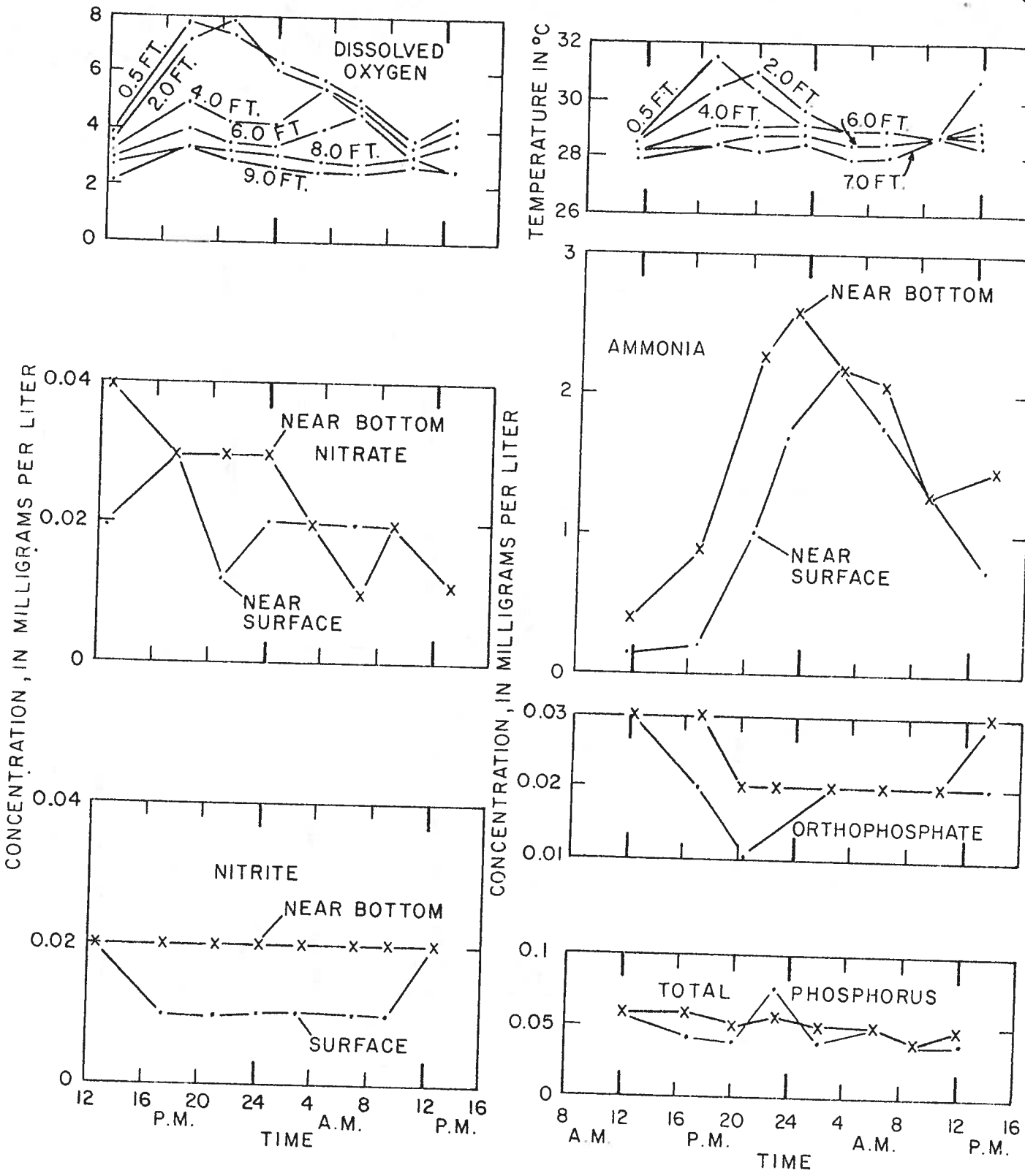

Figure 12.--Graph showing concentrations of dissolved oxygen, total nitrate plus nitrite, total ammonia, total orthophosphate, total phosphorus, and water temperature at site 41 for 24 hours, May 23-24, 1977

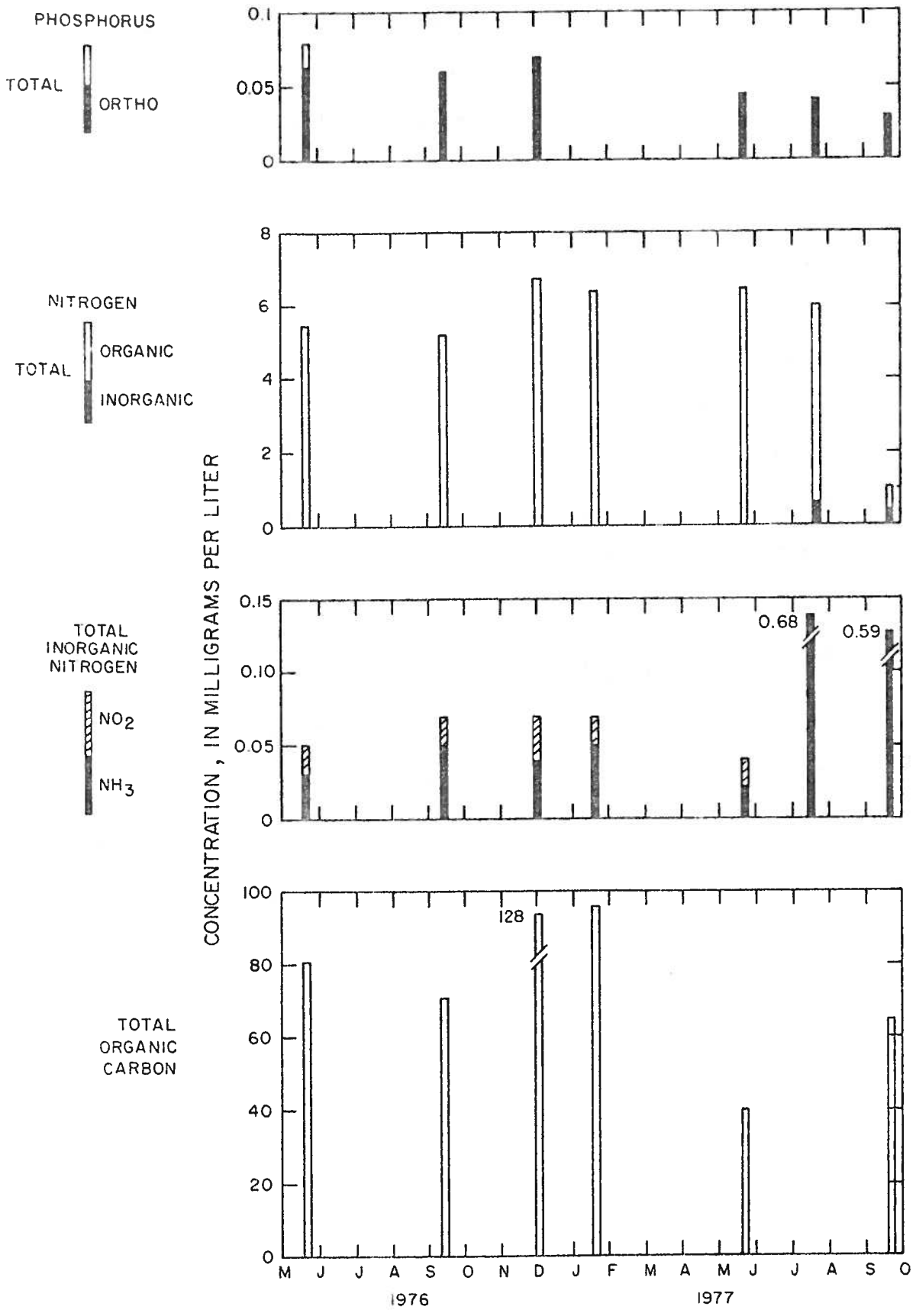

Figure 13.--Concentrations of macronutrients near the surface at site 48, 1976-77

Table 10.--Mean concentrations of macronutrients and other parameters at site 48, 1976-77 (sampled in in upper foot)

[Values in milligrams per liter unless otherwise indicated]

	Number of analyses	Range	Mean
Total nitrogen as N	7	1.0 - 6.5	5.2
Total organic nitrogen as N	7	.39 - 6.5	5.1
Total NH_3 as N	7	.02 - .68	.21
Total NO_2 as N	7	.00 - .02	.00
Total NO_3 as N	7	.00 - .01	.00
Total phosphorus as P	6	.03 - .08	.05
Total orthophosphate as P	6	.03 - .07	.05
Total organic carbon	6	59 - 128	83
Specific conductance, (umho/cm at 25°C)	6	13,800 - 17,800	16,317
Dissolved oxygen	8	5.6 - 9.6	7.5
BOD	6	1.4 - 7.6	5.0
Transparency, secchi disk, (ft)	5	.4 - 1.1	0.7
Turbidity (JTU)	10	6 - 20	13.5

The concentrations of nitrogen and phosphorus compounds over a 24-hour period are shown in figure 14. Only ammonia concentrations showed diel fluctuations. Concentrations increased at night in both surface and deep water (8 feet). Concentrations at 8 feet were slightly higher than those near the surface. The diel fluctuation in ammonia was the reverse of the fluctuation in dissolved oxygen concentration.

Concentrations of dissolved oxygen near the water surface reached 9.6 mg/L in the late afternoon of May 23, 1977 and then declined to about 6 mg/L in the early morning of May 24 (fig. 14). Dissolved oxygen concentrations decreased with depth--at 9.5 feet concentrations ranged from about 6 mg/L to 2 mg/L. The average dissolved oxygen concentration in 1976-77 was 7.5 mg/L (table 10).

Comparison between sites 41 and 48

Water-quality characteristics differed substantially at borrow pond sites 41 and 48. Site 48 was characterized by relatively higher concentrations of organic nitrogen, organic carbon, dissolved oxygen, and BOD, and during the diel period, May 23-24, 1977, by slightly lower temperatures and higher pH (table 11). Site 41 was characterized by high water transparency and low turbidity. The average depth the secchi disk could be seen at site 41 was 6.7 feet compared with 0.7 foot at site 48. Also, average turbidity was about 3 times greater at site 48 than at site 41 (table 11).

Diel fluctuations in dissolved oxygen indicated that net daytime production and night respiration were greater at site 41 than at site 48 on May 23-24, 1977 (table 12). The higher rates of production and respiration at site 41 are probably due to a more abundant submerged vegetation and to greater water transparency. The pond at site 41 has submerged or emergent macroscopic plants (such as cattail, Typha sp.) around much of its littoral zone, whereas the pond at site 48 is virtually devoid of macroscopic aquatic plants. The absence of macroscopic plants in the pond at site 48 in 1976-77 is due to its recent (1973-74) excavation. Macroscopic plants at site 41 have had a longer period to become established and have been favored by a greater water transparency and a more extensive shallow zone than at the pond at site 48.

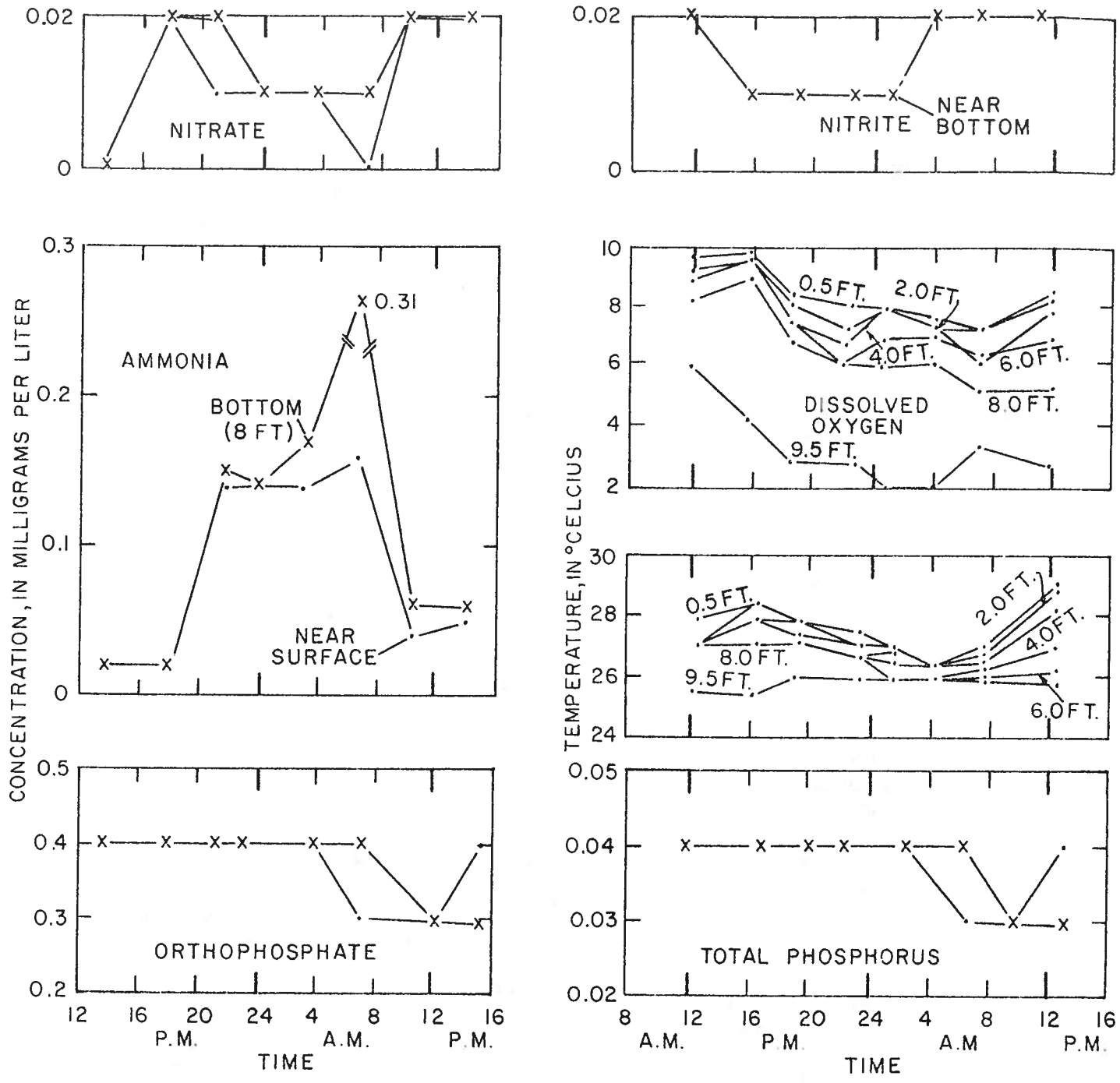

Figure 14.--Concentrations of dissolved oxygen, total nitrate plus nitrite, total ammonia, total orthophosphate, total phosphorus, and water temperature at site 48, May 23-24, 1977

Table 11.--Average values for selected water-quality parameters, 1976-77, and the range of values, May 23-24, 1977, at sites 41 and 48 (sampled in upper foot)

[Values in milligrams per liter unless otherwise indicated]

	Averages, 1976-77	
	Site 41	Site 48
Specific conductance, (umho/cm at 25°C)	16,629	16,317
Dissolved oxygen (DO)	4.0	7.5
Turbidity (JTU)	4.4	13.5
Organic nitrogen	2.0	5.1
Organic carbon	30	83
Total NH_3 as N	.29	.21
Total phosphorus	.06	.05
Total orthophosphate	.04	.05
BOD	1.2	5.0
Transparency, secchi disk, (ft)	6.7	.7
	Diel range, May 23-24, 1977	
Near Surface		
Temperature, (°C)	29.0 - 31.5	26.5 - 28.5
DO	3.9 - 7.9	7.6 - 9.6
pH	7.9 - 8.2	8.6 - 8.9
Near bottom		
Temperature, (°C)	28.2 - 28.5	25.5 - 27.0
DO	2.0 - 2.6	2.0 - 6.0
pH	7.6 - 8.1	8.5 - 8.9

Residential development and tourism on Sanibel Island, particularly after the 1940's, have resulted in an accelerated modification of freshwater drainage patterns and water quality. Growth on the island was accompanied by the excavation of ponds, lakes, and canals to obtain fill for construction and the excavation of shallow-drainage ditches for mosquito control. The quality of surface water in parts of the island interior has been periodically degraded by high concentrations of salt or macronutrients and by low concentrations of dissolved oxygen.

In 1976 the salinity of surface water on the interior of Sanibel Island ranged from about 500 mg/L chloride to slightly less than 19,000 mg/L, the concentration in seawater. The highest salinities occurred during the dry season in the Sanibel River near the Tarpon Bay control structure and are attributable to leakage of saline water past the structure

Overall the concentrations of macronutrients and dissolved oxygen in the interior of Sanibel Island indicate that surface waters are not widely polluted by organic material. Some exceptions to this are evident, however, and in these places high concentrations of macronutrients and low concentrations of dissolved oxygen are attributable, in part, to urban runoff and sewage effluent that flows directly into the surface waters or seeps through the shallow water-table aquifer into surface-water bodies.

The highest concentrations of macronutrients in 1976 were along the eastern reach of the Sanibel River during the dry season. Most sites along this reach had concentrations of total nitrogen that exceeded 4.0 mg/L, and concentrations of total phosphorus had exceeded 0.9 mg/L. Organic nitrogen accounted for about 95 percent of the total nitrogen, and ammonia accounted for most of the remainder. Concentrations of ammonia exceeded 0.1 mg/L in 31 percent of the wet-season samples and 14 percent of the dry-season samples. About half the total phosphorus was orthophosphate. At sites where concentrations were high, orthophosphate accounted for most or all the total.

The concentrations of dissolved oxygen varied depending on time of day, depth, season, and other factors. Concentrations, measured near the surface mostly during mid-day or afternoon, ranged from near zero to 12.5 mg/L. The median concentrations were 7.5 mg/L in the 1976 dry season and 3.5 mg/L in the 1976 wet season. Concentrations were low (2.2 mg/L, average) along the eastern reach of the Sanibel River in the wet season and near zero at several nearby sites during both seasons. Concentrations of dissolved oxygen tended to increase during the night and with depth below the surface. Over a 24-hour (diel) cycle on May 23-24, 1977, concentrations fluctuated several milligrams per liter at three sites but remained nearly anaerobic at site 5.

Concentrations of ammonia tended to increase at night and with depth. Over a 24-hour cycle, concentrations changed by several orders of magnitude at three sites.

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