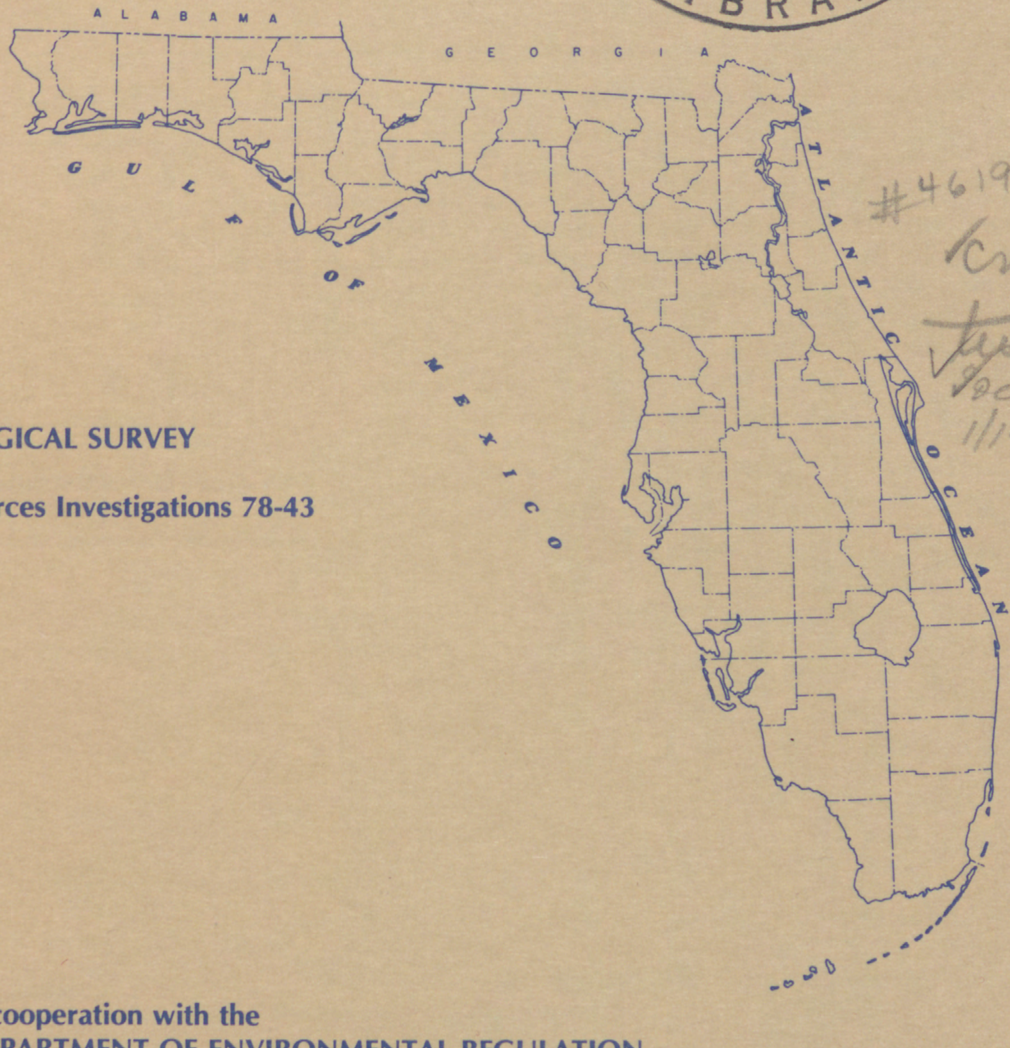
NITROGEN, PHOSPHORUS, ORGANIC CARBON, AND BIOCHEMICAL OXYGEN DEMAND IN FLORIDA SURFACE WATERS, 1972



U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 78-43

Prepared in cooperation with the
FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION
FLORIDA DEPARTMENT OF NATURAL RESOURCES
AND OTHER LOCAL AND FEDERAL AGENCIES

BIBLIOGRAPHIC DATA SHEET	1. Report No.	2.	3. Recipient's Accession No.
4. Title and Subtitle NITROGEN, PHOSPHORUS, ORGANIC CARBON, AND BIOCHEMICAL OXYGEN DEMAND IN FLORIDA SURFACE WATERS, 1972			5. Report Date September 1978 6.
7. Author(s) M. I. Kaufman and J. E. Dysart			8. Performing Organization Rept. No. USGS/WRI 78-43
9. Performing Organization Name and Address U.S. Geological Survey, Water Resources Division 325 John Knox Road, Suite F-240 Tallahassee, Florida 32303			10. Project/Task/Work Unit No. 11. Contract/Grant No.
12. Sponsoring Organization Name and Address U.S. Geological Survey, Water Resources Division 325 John Knox Road, Suite F-240 Tallahassee, Florida 32303			13. Type of Report & Period Covered 14.

15. Supplementary Notes
Prepared in cooperation with the Florida Department of Environmental Regulation, Florida Department of Natural Resources, and other local and Federal agencies

16. Abstracts
Water samples were collected during spring and autumn 1972 from about 100 surface-water sampling sites in Florida. The samples were analyzed for the plant nutrients, nitrogen and phosphorus. In most waters, nitrogen concentrations are less than 2.0 milligrams per liter as nitrogen, and organic nitrogen is dominant. Median total nitrogen concentration for Florida surface waters falls between 1.2 and 2.0 milligrams per liter as nitrogen. In samples from 85 percent of the sites, total nitrogen exceeded 0.6 milligrams per liter. Median total phosphorus concentration as phosphorus for Florida surface waters falls between 0.05 and 0.1 milligrams per liter. The information in the report will form a base useful to agencies concerned with setting concentration limits for nitrogen and phosphorus in industrial and sewage plant outfalls. Consideration should be given the fact that, inasmuch as both elements are common in nature, unrealistic limits could be set, difficult or needless to maintain. Bulk precipitation (rainfall plus dry fallout) can be a major contributor of both nitrogen and phosphorus to a body of surface water.

17. Key Words and Document Analysis. 17a. Descriptors

*Florida, *Nitrogen, *Phosphorus, *Surface waters, Baseline studies, Biochemical oxygen demand, Chemistry of precipitation, nutrients, Water quality standards, Histograms

17b. Identifiers/Open-Ended Terms

Areal water quality, Organic carbon

17c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
No restriction on distribution	UNCLASSIFIED	39
	20. Security Class (This Page) UNCLASSIFIED	22. Price

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1978

UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, Secretary

GEOLOGICAL SURVEY

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SUMMARY AND CONCLUSIONS

In the spring and autumn of 1972 water samples were collected from each of 99 stations in a selected statewide water-quality network. The samples were analyzed for nitrogen and phosphorus. Results showed that organic nitrogen is the dominant nitrogen species in most surface waters, whereas nitrate nitrogen is dominant in many ground waters as evidenced by the high concentrations of nitrate in springs and spring-fed rivers. Total nitrogen concentrations in both surface and ground water are generally less than 2.0 mg/L as N. In water affected by industrial, agricultural or domestic effluents, total nitrogen concentration often exceeds 2.0 mg/L as N and ammonia nitrogen tends to be dominant.

The median total nitrogen concentration in the surface-water samples falls between 1.0 and 2.0 mg/L as N. In samples from more than 85 percent of the stations concentrations of total nitrogen were about 0.6 mg/L or more. In an evaluation of the quality of water from 5 lakes, increased water-quality problems, such as extensive algal blooms, appear to be associated with increased concentrations of total nitrogen.

Concentrations of ammonia and nitrate nitrogen in the surface-water samples generally are very low, emphasizing the rapid uptake by plants and other organisms, or by abiotic chemical processes, such as ion exchange and absorption by clay minerals in soil. In samples from fewer than 6 percent of the stations sampled the concentration of ammonia nitrogen as N was greater than 0.5 mg/L, the limit recommended for public water supply sources (National Academy of Science and National Academy of Engineering, 1973).

In setting concentration limits for nitrogen and phosphorus in industrial and sewage plant outfalls, consideration should be given the fact that both these elements are common in nature. Without a knowledge of their background concentrations in water, unrealistic limits could be set that are difficult or needless to maintain.

Nitrogen is common in nature, and chemical reactions involving this element are cyclic. Lower oxidation forms are oxidized to nitrite and nitrate, which in turn are used by plants through their metabloism to form proteins and other complex nitrogen organics. These products ultimately are subject again to oxidation, and so on.

Phosphorus minerals are a potential source of phosphorus in water in peninsular Florida. There, phosphatic minerals apatite and fluorapatite are widespread in occurrence (Kaufman, 1969a).

Rainfall is a significant source both of nitrogen and phosphorus. About 78 percent of the total nitrogen in water entering the Everglades conservation areas in south Florida and about 90 percent of the total phosphorus, are contributed by rainfall plus dry fallout.

INTRODUCTION

In 1970, the U.S. Geological Survey, as an integral part of its statewide program for the sampling of surface waters in Florida, began to make extensive field and laboratory determinations of physical parameters and inorganic and organic chemical constituents in water at 99 selected network stations. All 99 stations are sampled semiannually, in the spring during normal low flow and in the autumn during normal high flow, to provide information on water quality under extreme--both low and high--flow conditions. This broad, regional approach to data collection provides a useful data base.

The 99-station network includes sampling points on (1) the major stream systems in Florida reflecting differing hydrologic regimes, (2) streams and lakes representing essentially natural conditions, (3) streams and lakes affected by man's activities, (4) streams with high color and organic matter, (5) selected springs reflecting areas of major ground-water discharge, and (6) selected estuaries. Figure 1 shows the locations of the 99 network stations. Table 1 lists each of the 99 stations by name, keying them to figure 1 by means of the map site number.

Dissolved oxygen, pH, temperature, and specific conductance are measured in the field at the time the samples are collected. Nitrogen and phosphorus species, organic-related parameters, trace elements, and major inorganic constituents are determined in the laboratory.

The analyses are published annually in "Water Resources Data for Florida, Part 2, Water Quality Records." A summary of the analyses of nitrogen, phosphorus, trace elements, dissolved solids, BOD, TOC, and turbidity for samples collected in 1970-71 is given by Joyner (1973).

In this report the analyses of nitrogen, phosphorus, organic carbon, and BOD made during the spring and autumn of 1972 are summarized. Although many elements and compounds are required by life forms, nitrogen and phosphorus are considered by many investigators to be the critical or limiting elements for growth of organisms, and thus critical to the eutrophic process. Organic carbon is an index of the organic matter in water. Table 2 lists the determinations made, the laboratory analytical method used, minimum reported quantity, and applicable references for the methods used.

The organic nitrogen as determined by the Kjeldahl method measures the organically bound nitrogen in the trinegative (-3) oxidation state. This includes amino acids, polypeptides, and proteins. The measurement does not account for other organic constituents in different oxidation states (American Public Health Association, 1971).

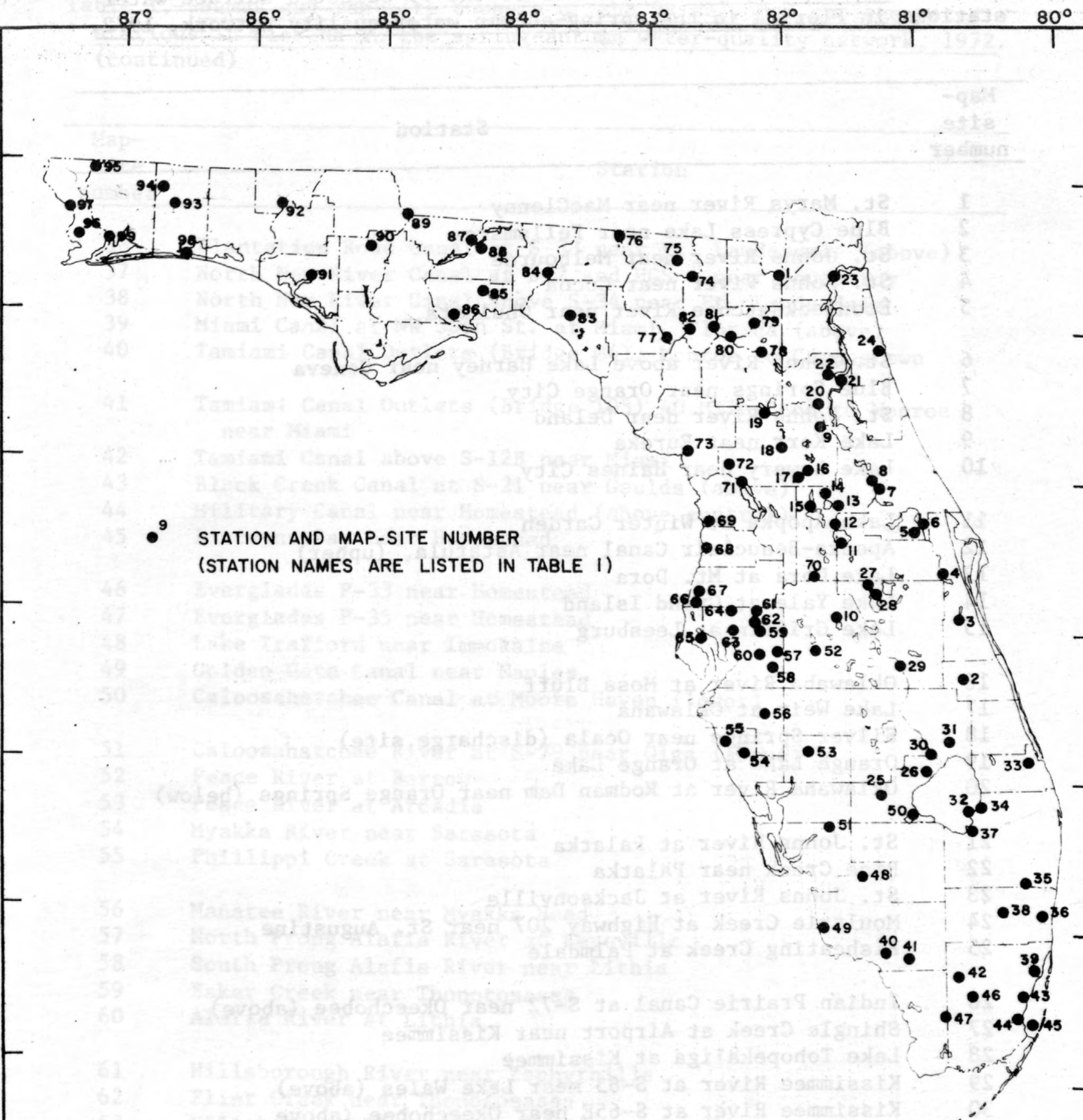

Figure 1.--Location of selected 99 stations in the spring-autumn, 1972, water-quality network.

Table 1.--Names and map-site numbers of the 99 selected surface-water stations in Florida in the spring-autumn water-quality network, 1972.

Map-site number	Station
1	St. Marys River near MacClenny
2	Blue Cypress Lake near Fellsmere
3	St. Johns River near Melbourne
4	St. Johns River near Cocoa
5	Econlockhatchee River near Chuluota
6	St. Johns River above Lake Harney near Geneva
7	Blue Springs near Orange City
8	St. Johns River near Deland
9	Lake Kerr near Eureka
10	Lake Lowery near Haines City
11	Lake Apopka at Winter Garden
12	Apopka-Beauclair Canal near Astatula, (upper)
13	Lake Dora at Mt. Dora
14	Lake Yale at Grand Island
15	Lake Griffin at Leesburg
16	Oklawaha River at Moss Bluff
17	Lake Weir at Oklawaha
18	Silver Springs near Ocala (discharge site)
19	Orange Lake at Orange Lake
20	Oklawaha River at Rodman Dam near Orange Springs (below)
21	St. Johns River at Palatka
22	Rice Creek near Palatka
23	St. Johns River at Jacksonville
24	Moultrie Creek at Highway 207 near St. Augustine
25	Fisheating Creek at Palmdale
26	Indian Prairie Canal at S-72 near Okeechobee (above)
27	Shingle Creek at Airport near Kissimmee
28	Lake Tohopekaliga at Kissimmee
29	Kissimmee River at S-65 near Lake Wales (above)
30	Kissimmee River at S-65E near Okeechobee (above
31	Taylor Creek above Okeechobee
32	Lake Okeechobee at Pahokee, (fishing pier)
33	St. Lucie Canal at Lock near Stuart (above)
34	West Palm Beach Canal at HGS-5 at Canal Point
35	Hillsboro Canal at S-39 near Deerfield Beach (above)

Table 1.--Names and map-site numbers of the 99 selected surface-water stations in Florida in the spring-autumn water-quality network, 1972. (continued)

Map-site number	Station
36	Plantation Road Canal at S-33 near Ft. Lauderdale (above)
37	North New River Canal at S-2 and HGS-4 near South Bay
38	North New River Canal above S-34 near Ft. Lauderdale
39	Miami Canal at NW 36th St. at Miami, Florida (above)
40	Tamiami Canal Outlets (Bridge 84), Monroe to Carnestown
41	Tamiami Canal Outlets (Bridge 105) 40 Mile Bend to Monroe near Miami
42	Tamiami Canal above S-12B near Miami
43	Black Creek Canal at S-21 near Goulds (above)
44	Military Canal near Homestead (above control)
45	Biscayne Bay near Homestead
46	Everglades P-33 near Homestead
47	Everglades P-35 near Homestead
48	Lake Trafford near Immokalee
49	Golden Gate Canal near Naples
50	Caloosahatchee Canal at Moore Haven (lower)
51	Caloosahatchee River at S-79 near Olga (above)
52	Peace River at Bartow
53	Peace River at Arcadia
54	Myakka River near Sarasota
55	Phillippi Creek at Sarasota
56	Manatee River near Myakka Head
57	North Prong Alafia River at Keysville
58	South Prong Alafia River near Lithia
59	Baker Creek near Thonotosassa
60	Alafia River at Lithia
61	Hillsborough River near Zephyrhills
62	Flint Creek near Thonotosassa
63	Hillsborough River at Fowler Ave. near Tampa
64	Lake Magdalene near Lutz
65	Old Tampa Bay at Safety Harbor
66	Anclote River near Elfers
67	Pithlachascotee River near New Port Richey
68	Weekiwachee Springs near Brooksville
69	Chassahowitzka River near Homosassa
70	Withlacoochee River near Eva

Table 1.--Names and map-site numbers of the 99 selected surface-water stations in Florida in the spring-autumn water-quality network, 1972. (continued)

Map-site number	Station
71	Withlacoochee River near Holder
72	Rainbow Springs near Dunnellon
73	Waccasassa River near Gulf Hammock
74	Suwannee River at White Springs
75	Swift Creek at Facil
76	Withlacoochee River near Pinetta
77	Suwannee River at Branford
78	Santa Fe River near Graham
79	New River near Lake Butler
80	Santa Fe River at Worthington Springs
81	Olustee Creek near Providence
82	Ichatucknee Springs near Hildreth
83	Fenholloway River at Foley
84	Aucilla River at Lamont
85	Wakulla Springs near Crawfordville
86	Sopchoppy River near Sopchoppy
87	Ochlockonee River near Havana
88	Lake Jackson near Tallahassee
89	Apalachicola River at Chattahoochee
90	Chipola River near Altha
91	Deer Point Lake near Panama City
92	Choctawhatchee River at Caryville
93	Yellow River at Milligan
94	Blackwater River near Baker
95	Escambia River near Century
96	Elevenmile Creek near Ensley
97	Perdido River at Barrineau
98	Choctawhatchee Bay near Villa Tasso
99	Escambia Bay at I-10 near Pensacola

Table 2.--Methods of determining nitrogen, phosphorus, carbon, and biochemical oxygen demand.

Determinations	Method	Minimum reported quantity	Reference
Organic nitrogen	Digestion, automated indophenol blue	0.01 mg/L (as N)	Environmental Protection Agency (1971)
Ammonia nitrogen	Indophenol blue, automated	.01 mg/L (as N)	Do.
Nitrate nitrogen, total	Automated cadmium reduction-diazotization	.01 mg/L (as N)	Do.
Nitrite nitrogen, total	Automated diazotization	.01 mg/L (as N)	Do.
Phosphorus, total	Persulfate digestion--automated single reagent method	.01 mg/L (as P)	Do.
Total organic carbon	Combustion-infrared spectrophotometry	.1 mg/L (as C)	Goerlitz and Brown (1972)
Biochemical oxygen demand (5-day)	Incubation, titration	.1 mg/L	American Public Health Association (1971)

This report discusses the significance of these constituents in Florida surface waters and compares observed concentrations with water-quality standards and criteria and with apparent natural background levels--levels in existence before man's activities began to have an appreciable impact on the environment. Observed concentrations appreciably greater than apparent natural background levels or exceeding standards and criteria are highlighted.

This regional assessment was carried out as a program of statewide environmental studies in cooperation with the Florida Department of Natural Resources, the Florida Department of Environmental Regulation, and other agencies.

RESULTS AND DISCUSSION

Nitrogen and Phosphorus

Nitrogen and Phosphorus Cycles

Nitrogen and phosphorus are essential nutrients in aquatic ecosystems and in many instances may be the limiting elements in growth of aquatic plants. The two elements are considered to be major contributors to eutrophication of lakes and other water bodies so that an increase in the supply of nitrogen and phosphorus to an aquatic ecosystem can result in accelerated eutrophication. In turn, algal blooms, which usually follow an appreciable increase in nitrogen and phosphorus, may cause a depletion of available dissolved oxygen and further contribute to eutrophication.

Nitrogen is abundant in nature, and in aqueous systems this element may occur as organic nitrogen, ammonia, nitrite, and nitrate nitrogen. As figure 2 depicts, the chemical and biochemical reactions involving nitrogen compounds in aqueous solution are cyclic. The lower oxidation forms are contained in the proteins and other organic constituents found in all organisms. Decomposition of these organisms--through bacterial action--produces amino acids and ammonia. Aerobic conditons and nitrifying bacteria oxidize the decomposition products to nitrite and nitrate, the higher oxidation forms. Through the process of plant metabolism, these forms, nitrite and nitrate, are taken up in the plant to form, once again, proteins and other organic nitrogeneous compounds.

Phosphorus exists in an aqueous environment as ionic phosphate, metallic complexes, and as colloidal material. The most prevalent forms under the pH conditions present in Florida waters or as the $H_2PO_4^{-1}$ and HPO_4^{-2} anions. These, together with any PO_4^{-3} that may be present, are reported as "orthophosphate" and are usually reported in terms of elemental phosphorus (P). The concentration of phosphorus normally is low in surface water since it is readily assimilated by plants (McKee and Wolf, 1963).

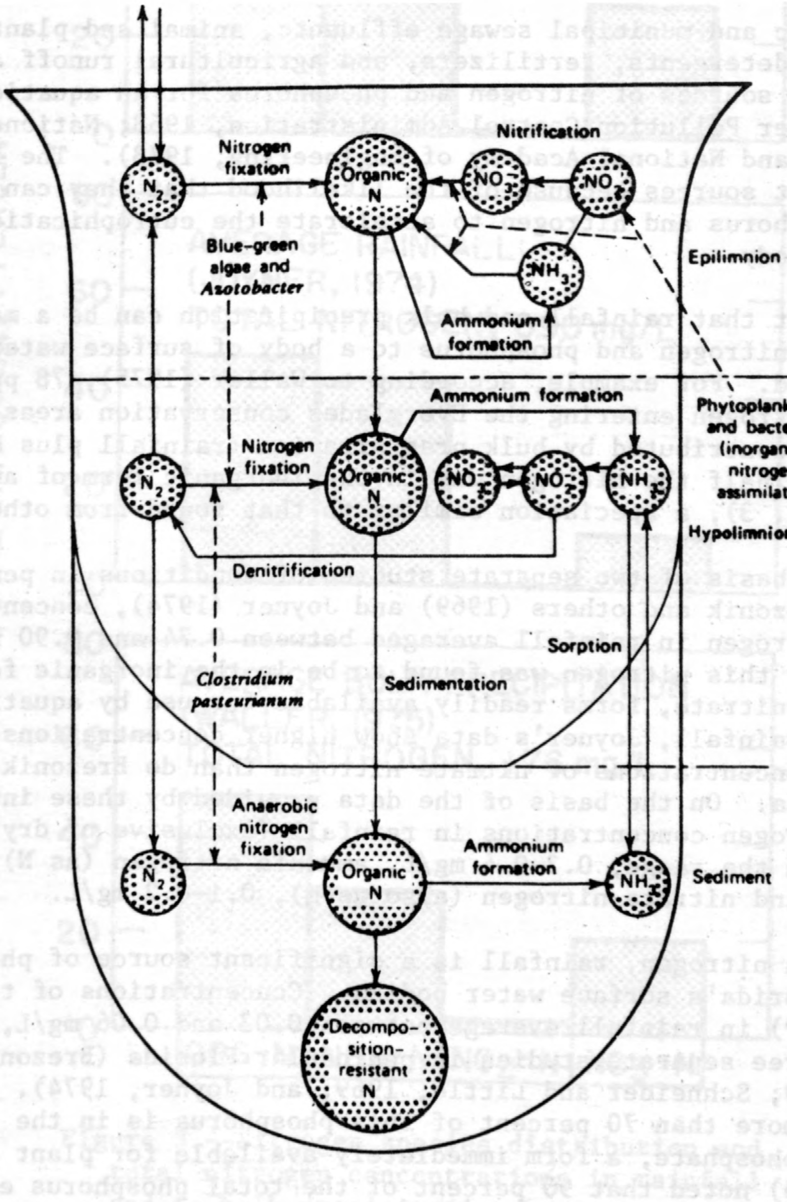

Figure 2.--Nitrogen cycle reactions in an idealized stratified lake (from Brezonik, 1972, fig. 2).

The minerals apatite and fluorapatite, widespread in phosphatic sediments in peninsular Florida (Kaufman, 1969a), are a potential source of phosphorus, although the phosphorus--in the form in which it occurs in these minerals--is not very soluble in water. Also phosphates are one of the end products of the decomposition of organic materials. Except where phosphate rock is mined and concentrated for phosphatic fertilizer or other products, phosphorus concentrations are low in Florida's surface waters.

Domestic and municipal sewage effluents, animal and plant processing wastes, detergents, fertilizers, and agricultural runoff are some of the other sources of nitrogen and phosphorus for an aquatic system (Federal Water Pollution Control Administration, 1968; National Academy of Sciences and National Academy of Engineering, 1973). The foregoing are important sources because of the likelihood that they can contribute enough phosphorus and nitrogen to accelerate the eutrophication process of a water body.

The fact that rainfall and bulk precipitation can be a major contributor of nitrogen and phosphorus to a body of surface water should be considered. For example, according to Waller (1975), 78 percent of the total nitrogen entering the Everglades conservation areas in south Florida was contributed by bulk precipitation (rainfall plus dry fallout). About half the nitrogen was in the inorganic form of ammonia and nitrate (fig. 3), a speciation similar to that found from other studies.

On the basis of two separate studies of conditions in peninsular Florida, Brezonik and others (1969) and Joyner (1974), concentrations of total nitrogen in rainfall averaged between 0.74 and 0.90 mg/L. More than half of this nitrogen was found to be in the inorganic forms ammonia and nitrate, forms readily available for use by aquatic vegetation. For rainfall, Joyner's data show higher concentrations of ammonia and lower concentrations of nitrate nitrogen than do Brezonik's and Waller's data. On the basis of the data provided by these investigators, organic nitrogen concentrations in rainfall (exclusive of dry fallout) are about in the range, 0.3-0.4 mg/L, ammonia nitrogen (as N), 0.21-0.38 mg/L; and nitrate nitrogen (also as N), 0.1-0.2 mg/L.

As with nitrogen, rainfall is a significant source of phosphorus input to Florida's surface water bodies. Concentrations of total phosphorus (as P) in rainfall average between 0.03 and 0.06 mg/L, on the basis of three separate studies in peninsular Florida (Brezonik and others, 1969; Schneider and Little, 1969; and Joyner, 1974). As reported by Joyner, more than 70 percent of this phosphorus is in the inorganic form, orthophosphate, a form immediately available for plant growth. Waller (1975) noted that 90 percent of the total phosphorus entering the conservation areas was contributed by bulk precipitation, and of this 90 percent, nearly all was as orthophosphate.

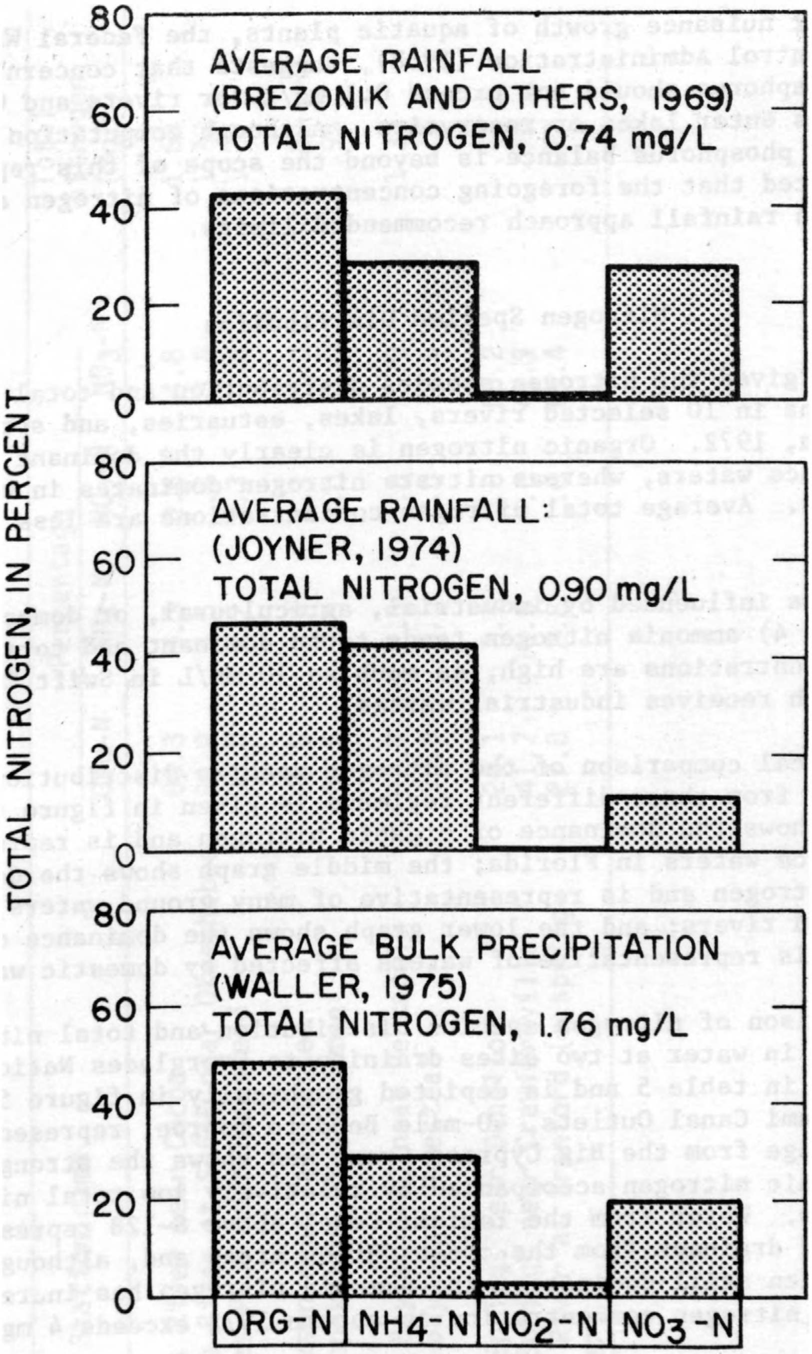

Figure 3.--Nitrogen species distribution and total nitrogen concentrations in rainfall and in bulk precipitation.

To limit nuisance growth of aquatic plants, the Federal Water Pollution Control Administration (1968), suggests that concerntrations of total phosphorus should not exceed 0.1 mg/L for rivers and 0.05 mg/L where streams enter lakes or reservoirs. Although computation of a nitrogen and phosphorus balance is beyond the scope of this report, it should be noted that the foregoing concentrations of nitrogen and phosphorus in rainfall approach recommended limits.

Nitrogen Species Distribution

Table 3 gives the nitrogen species distribution and total nitrogen concentrations in 10 selected rivers, lakes, estuaries, and springs during autumn, 1972. Organic nitrogen is clearly the dominant species in most surface waters, whereas nitrate nitrogen dominates in many ground waters. Average total nitrogen concentrations are less than 2.0 mg/L.

In waters influenced by industrial, agricultural, or domestic wastes (table 4) ammonia nitrogen tends to be dominant and total nitrogen concentrations are high, as much as 10 mg/L in Swift Creek at Facil which receives industrial wastes.

A graphical comparison of the nitrogen species distribution in surface water from three different regimens is given in figure 4. The upper graph shows the dominance of organic nitrogen and is representative of most surface waters in Florida; the middle graph shows the dominance of nitrate nitrogen and is representative of many ground waters, springs, and spring-fed rivers; and the lower graph shows the dominance of ammonia nitrogen and is representative of waters affected by domestic wastes.

A comparison of nitrogen species distribution and total nitrogen concentration in water at two sites draining to Everglades National Park is given in table 5 and is depicted graphically in figure 5. Water from the Tamiami Canal Outlets, 40-mile Bend to Monroe, represents natural drainage from the Big Cypress Swamp and shows the strong dominance of organic nitrogen accompanied by relatively low total nitrogen concentrations. Water from the Tamiami Canal above S-12B represents man-influenced drainage from the conservation areas and, although organic nitrogen still dominates, the ammonia nitrogen has increased and the total nitrogen concentration in autumn 1972 exceeds 4 mg/L.

Organic Nitrogen

As noted by Joyner (1973), organic nitrogen is present in all surface waters as the result of inflow of nitrogenous products and normal biological activity in the water body. Organic nitrogen is important in aquatic biological activity because it is a potential source of nitrogen for both plant and animal life. Sewage and industrial effluents often

Table 3.--Nitrogen species distribution and total nitrogen concentration in water from selected rivers, lakes, springs, and estuaries; autumn 1972.

Map site number	Station name	Percentage				Total nitrogen (mg/L)
		Org-N	NH_4-N	NO_2-N	NO_3-N	
4	St. Johns River near Cocoa	89.3	5.3	0.6	4.8	1.68
30	Kissimmee River at S-65E near Okeechobee	90.9	4.5	.8	3.8	1.32
47	Everglades P-35 near Homestead	93.0	4.7	2.3	.0	1.29
88	Lake Jackson near Tallahassee	95.5	3.4	1.1	.0	.89
28	Lake Tohopekaliga at Kissimmee	90.5	9.5	.0	.0	.95
99	Escambia Bay at I-10 near Pensacola	97.7	2.3	.0	.0	1.33
45	Biscayne Bay near Homestead	90.9	6.5	.0	2.6	.77
72	Rainbow Springs near Dunellon	26.1	8.7	.0	65.2	.46
85	Wakulla Springs near Crawfordville	41.7	16.6	.0	41.7	.72
77	Suwannee River at Branford (a spring-fed river).	27.8	2.8	.0	69.4	.72

Table 4.--Nitrogen species distribution and total nitrogen concentration in selected waters affected by industrial, agricultural, or domestic wastes, 1972.

Map-site number	Date of collection (1972)	Station	Percentage				Total nitrogen (mg/L)
			Organic nitrogen	Ammonia nitrogen	Nitrite nitrogen	Nitrate nitrogen	
75	August 23 (autumn)	Swift Creek at Facil	4.4	34.2	0.5	61.0	8.2
5	April 12 (spring)	Econlockhatchee River near Chuluota	35.7	13.6	5.2	45.5	3.08
36	August 29 (autumn)	Plantation Road Canal at S-33 near Ft. Lauderdale	35.2	63.0	1.0	0.8	3.97
11	September 7 (autumn)	Lake Apopka at Winter Garden	94.7	5.1	0.2	0.0	4.75

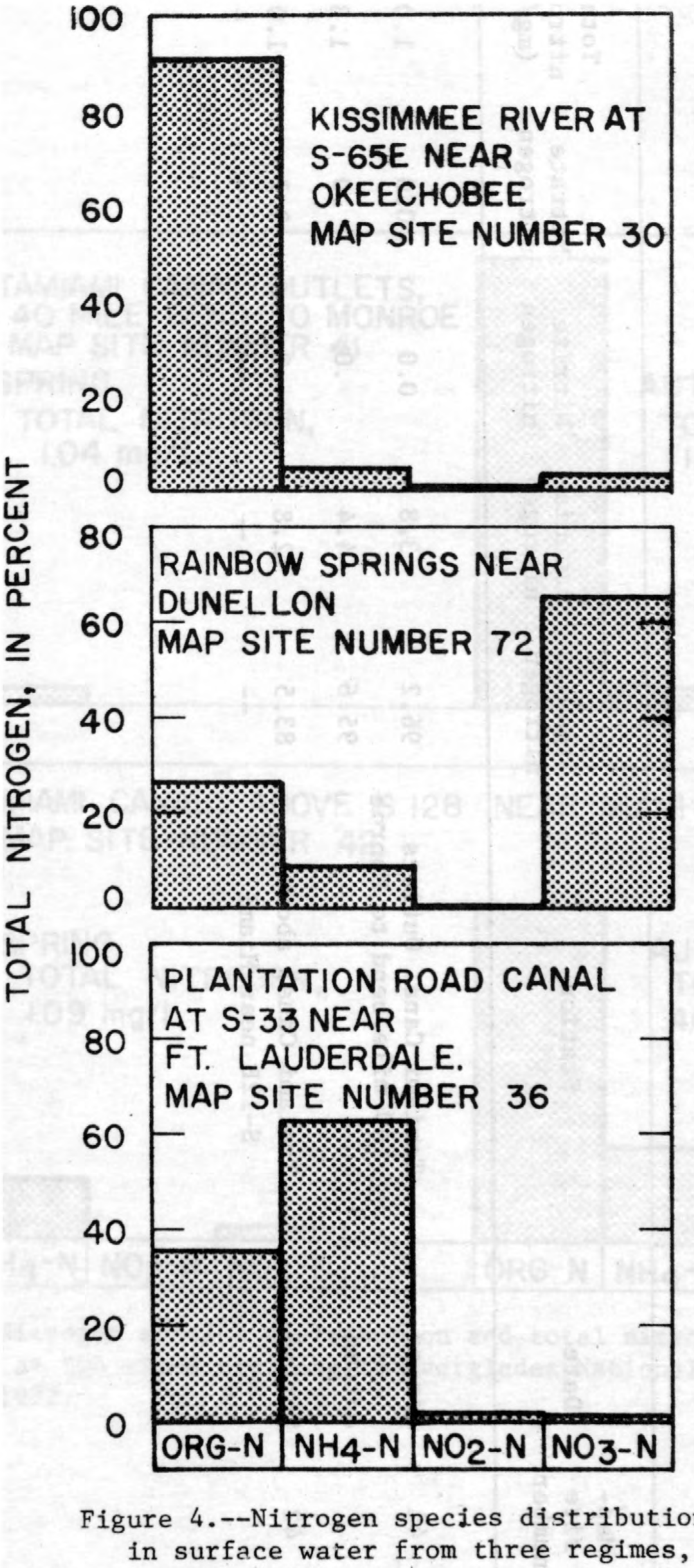

Figure 4.--Nitrogen species distribution in surface water from three regimes, autumn 1972.

Table 5.--Comparison of nitrogen species distribution and total nitrogen concentration in water from two canals draining to Everglades National Park. (On the basis of one sample collected from each site in spring 1972 and one collected from one site in autumn, 1972).

Map-site number	Date	Station	Organic nitrogen	Ammonia nitrogen	Nitrite nitrogen	Nitrate nitrogen	Total nitrogen (mg/L)
41	Spring	Tamiami Canal Outlets 40-mile bend to Monroe	96.2	3.8	0.0	0.0	1.04
	Autumn		95.6	4.4	.0	.0	1.36
42	Spring	Tamiami Canal above S-12B near Miami	83.5	12.8	.0	3.7	1.09
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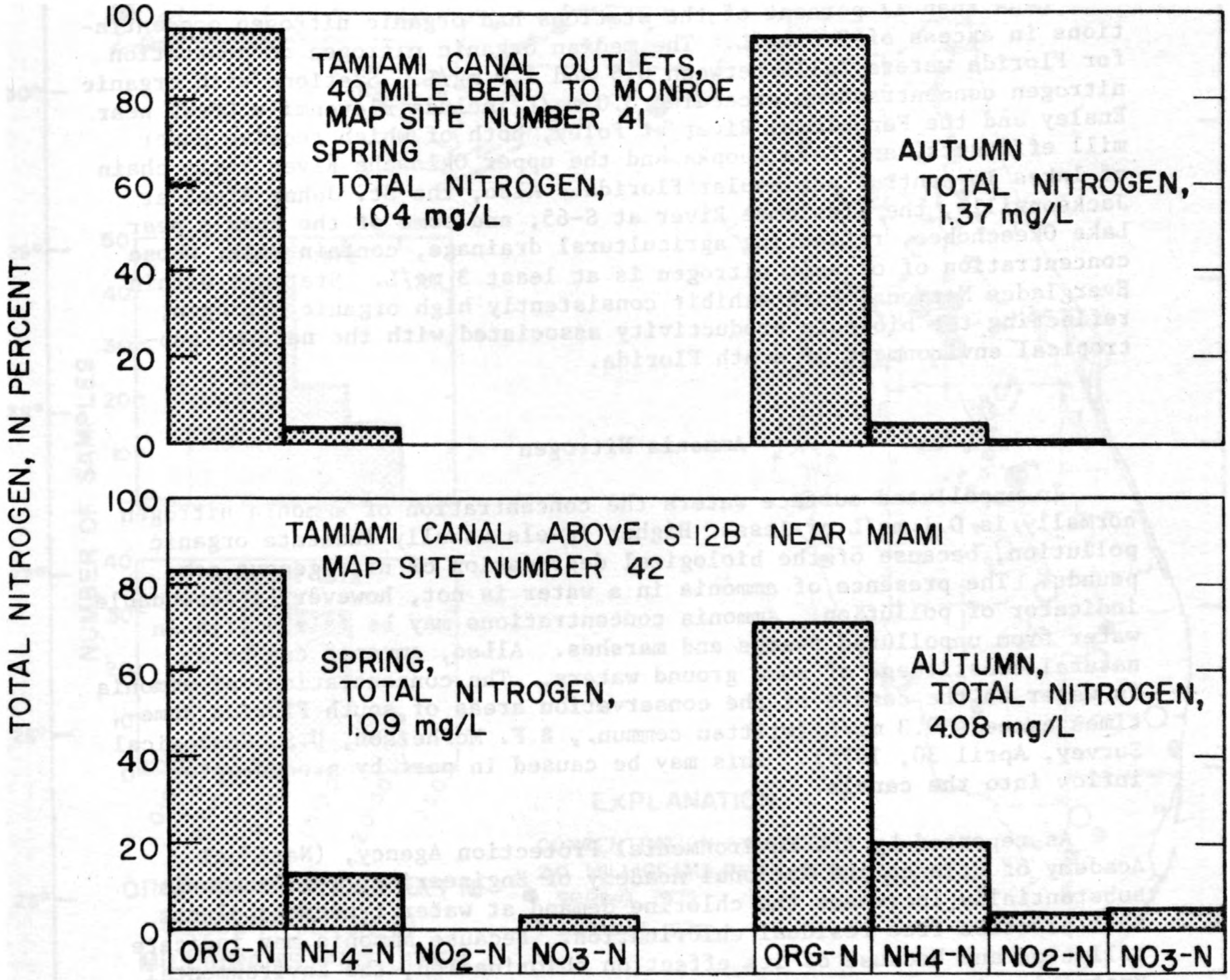

Figure 5.--Nitrogen species distribution and total nitrogen concentrations in water at two sites draining to Everglades National Park, spring-autumn, 1972.

contain high organic nitrogen concentrations. Thus an increase in organic nitrogen concentration might be an indicator of pollution.

The distribution of organic nitrogen concentrations exceeding 2.0 mg/L during spring and autumn of 1972 are shown in figure 6. The frequency distribution of all nitrogen species concentrations are shown by histogram inserts.

Less than 17 percent of the stations had organic nitrogen concentrations in excess of 2.0 mg/L. The median organic nitrogen concentration for Florida waters falls between 0.5 and 1.0 mg/L. Stations with organic nitrogen concentrations exceeding 3.0 mg/L include Elevenmile Creek near Ensley and the Fenholoway River at Foley, both of which receive paper mill effluents, and Lake Apopka and the upper Oklawaha River basin chain of lakes in central peninsular Florida. Also, the St. Johns River at Jacksonville, the Kissimmee River at S-65, and some of the canals near Lake Okeechobee, reflecting agricultural drainage, contain water whose concentration of organic nitrogen is at least 3 mg/L. Stations within Everglades National Park exhibit consistently high organic nitrogen, reflecting the biologic productivity associated with the natural subtropical environment of south Florida.

Ammonia Nitrogen

In unpolluted surface waters the concentration of ammonia nitrogen normally is 0.1 mg/L or less. Higher levels usually indicate organic pollution, because of the biological degradation of nitrogenous compounds. The presence of ammonia in a water is not, however, a dependable indicator of pollution: ammonia concentrations may be fairly high in water from unpolluted swamps and marshes. AlLso, ammonia can be a natural constituent of some ground waters. The concentrations of ammonia in water in the canals of the conservation areas of south Florida sometimes exceeds 0.3 mg/L (written commun., B.F. McPherson, U.S. Geological Survey, April 30, 1975). This may be caused in part by ground-water inflow into the canals.

As reported by the Environmental Protection Agency, (National Academy of Science and National Academy of Engineering, 1973) ammonia substantially increases the chlorine demand at water treatment plants that practice free residual chlorination. Because ammonia may indicate pollution and because of its effect on chlorination, the Environmental Protection Agency recommends that ammonia nitrogen in public water supply sources not exceed 0.5 mg/L. The World Health Organization European Drinking Water Standards (1961) set a limit of 0.5 mg/L for ammonia nitrogen (McKee and Wolf, 1963).

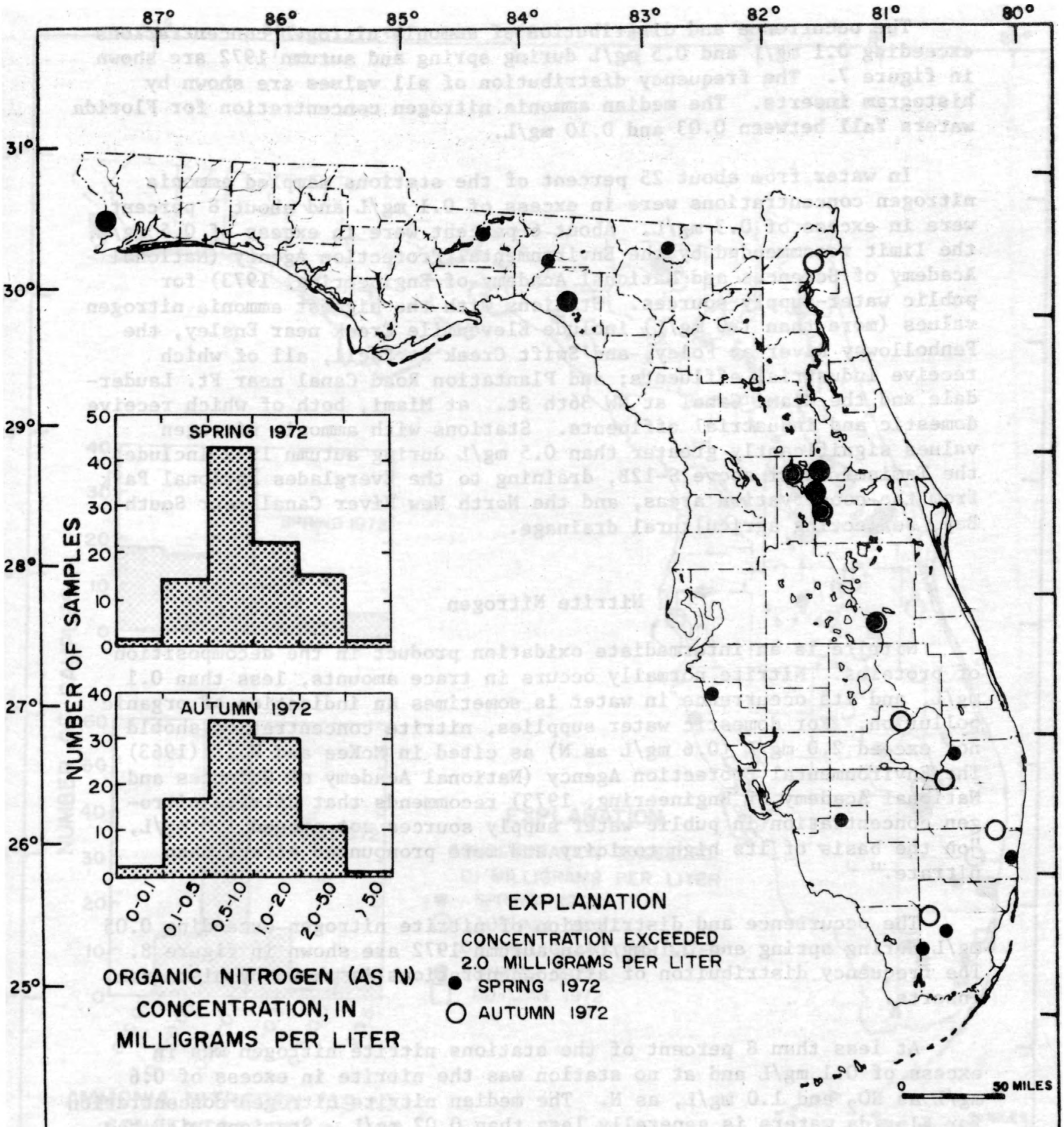

Figure 6.--Locations of stations where organic nitrogen (as N) exceeded 2.0 mg/L in spring and autumn 1972.

The occurrence and distribution of ammonia nitrogen concentrations exceeding 0.1 mg/L and 0.5 mg/L during spring and autumn 1972 are shown in figure 7. The frequency distribution of all values are shown by histogram inserts. The median ammonia nitrogen concentration for Florida waters fall between 0.03 and 0.10 mg/L.

In water from about 25 percent of the stations sampled ammonia nitrogen concentrations were in excess of 0.1 mg/L and about 8 percent were in excess of 0.3 mg/L. About 6 percent were in excess of 0.5 mg/L, the limit recommended by the Environmental Protection Agency (National Academy of Sciences and National Academy of Engineering, 1973) for public water-supply sources. Stations with the highest ammonia nitrogen values (more than 1.0 mg/L) include Elevenmile Creek near Ensley, the Fenholloway River at Foley, and Swift Creek at Facil, all of which receive industrial effluents; and Plantation Road Canal near Ft. Lauderdale and the Miami Canal at NW 36th St. at Miami, both of which receive domestic and industrial effluents. Stations with ammonia nitrogen values significantly greater than 0.5 mg/L during autumn 1972 include the Tamiami Canal above S-12B, draining to the Everglades National Park from the conservation areas, and the North New River Canal near South Bay, reflecting agricultural drainage.

Nitrite Nitrogen

Nitrite is an intermediate oxidation product in the decomposition of proteins. Nitrite normally occurs in trace amounts, less than 0.1 mg/L, and its occurrence in water is sometimes an indication of organic pollution. For domestic water supplies, nitrite concentration should not exceed 2.0 mg/L (0.6 mg/L as N) as cited in McKee and Wolf (1963). The Environmental Protection Agency (National Academy of Sciences and National Academy of Engineering, 1973) recommends that nitrite nitrogen concentration in public water supply sources not exceed 1.0 mg/L, "on the basis of its high toxicity and more pronounced effect than nitrate."

The occurrence and distribution of nitrite nitrogen exceeding 0.05 mg/L during spring and 0.1 mg/L in autumn 1972 are shown in figure 8. The frequency distribituon of all concentrations is shown by histogram inserts.

At less than 8 percent of the stations nitrite nitrogen was in excess of 0.1 mg/L and at no station was the nitrite in excess of 0.6 mg/L as NO_2 and 1.0 mg/L, as N. The median nitrite nitrogen concentration for Florida waters is generally less than 0.02 mg/L. Stations with the highest nitrite nitrogen concentrations (more than 0.2 mg/L) include Elevenmile Creek near Ensley and Swift Creek at Facil, both of which receive industrial effluents, and the Sopchoppy River near Sopchoppy.

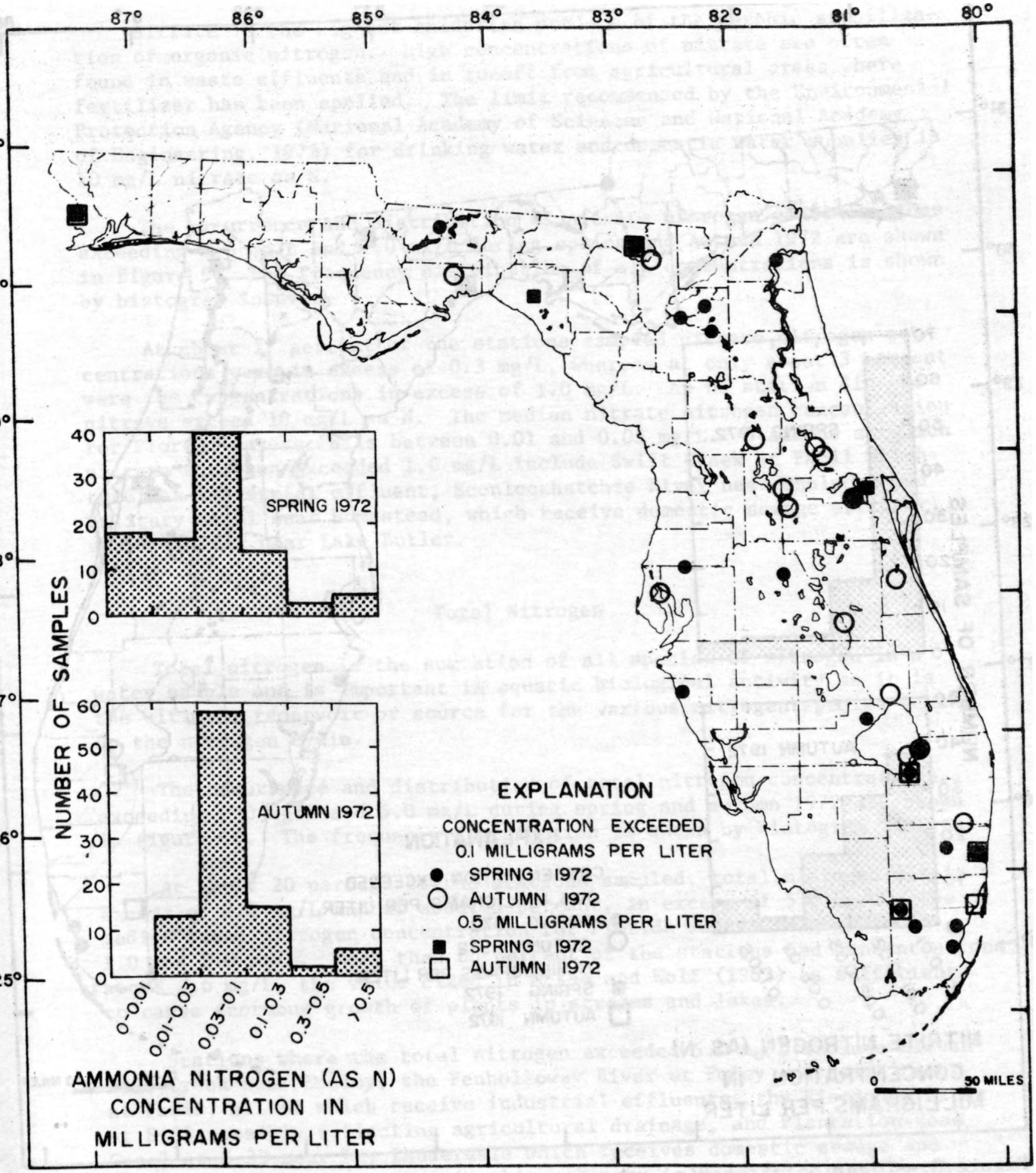

Figure 7.--Location of stations where ammonia nitrogen (as N) exceeded 0.1 and 0.5 mg/L in spring and autumn 1972.

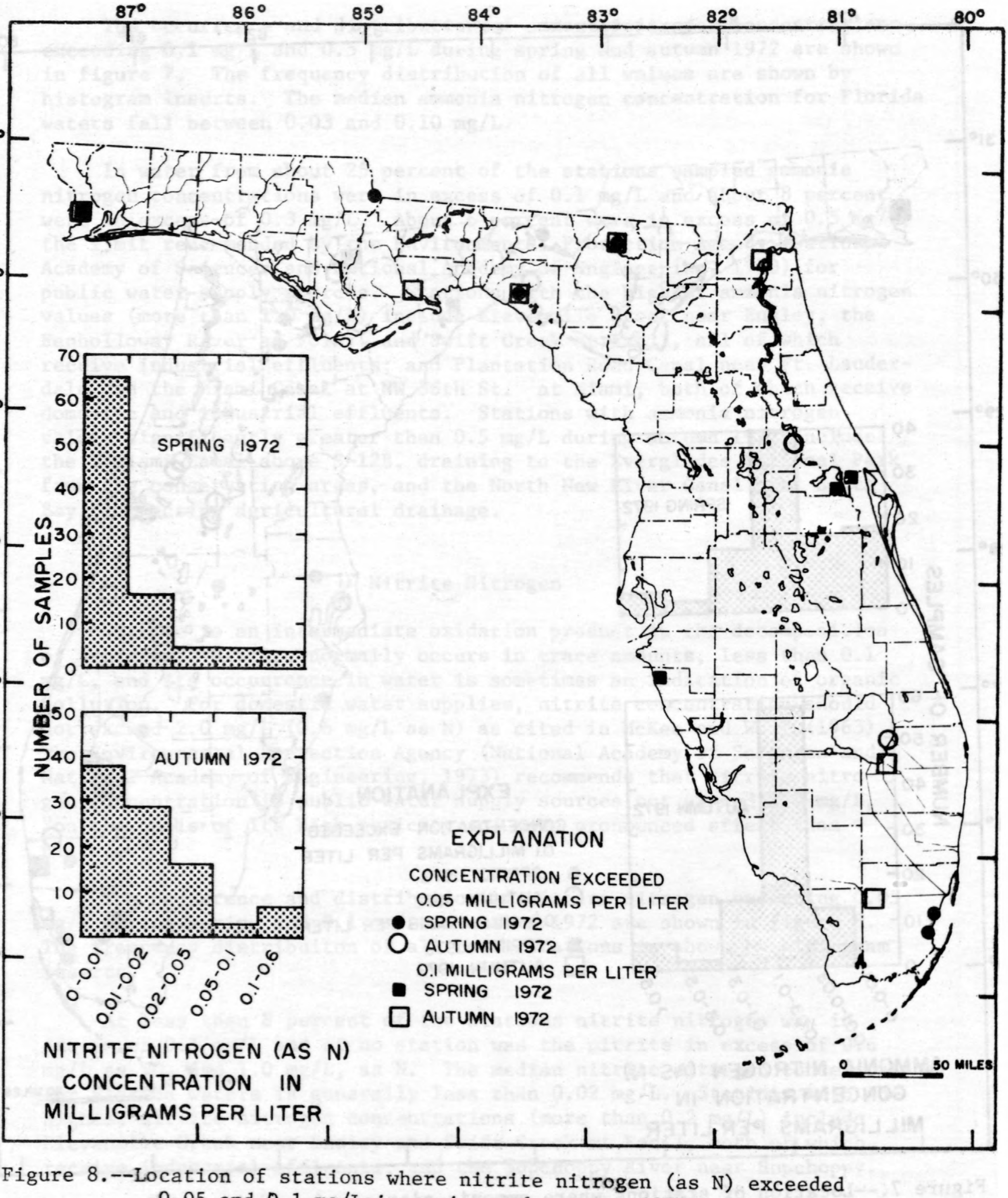

Figure 8.--Location of stations where nitrite nitrogen (as N) exceeded 0.05 and 0.1 mg/L in spring and autumn 1972.

Nitrate Nitrogen

Nitrate is the highest oxidation product of the aerobic stabilization of organic nitrogen. High concentrations of nitrate are often found in waste effluents and in runoff from agricultural areas where fertilizer has been applied. The limit recommended by the Environmental Protection Agency (National Academy of Sciences and National Academy of Engineering, 1973) for drinking water and domestic water supplies is 10 mg/L nitrate as N.

The occurrence and distribution of nitrate nitrogen concentrations exceeding 0.3 mg/L and 1.0 mg/L during spring and autumn 1972 are shown in figure 9. The frequency distribution of all concentrations is shown by histogram inserts.

At about 17 percent of the stations sampled nitrate nitrogen concentrations were in excess of 0.3 mg/L, whereas at only about 3 percent were the concentrations in excess of 1.0 mg/L. At no station did the nitrate exceed 10 mg/L as N. The median nitrate nitrogen concentration for Florida waters falls between 0.01 and 0.05 mg/L. Stations at which nitrate nitrogen exceeded 1.0 mg/L include Swift Creek at Facil which receives industrial effluent, Econlockhatchee River near Chuluota and Military Canal near Homestead, which receive domestic sewage effluent, and New River near Lake Butler.

Total Nitrogen

Total nitrogen is the summation of all species of nitrogen in a water sample and is important in aquatic biological activity as it is the ultimate reservoir or source for the various nitrogen species making up the nitrogen cycle.

The occurrence and distribution of total nitrogen concentrations exceeding 2.0 mg/L and 5.0 mg/L during spring and autumn 1972 are shown in figure 10. The frequency distribution is shown by histogram inserts.

At about 20 percent of the stations sampled, total nitrogen was in excess of 2.0 mg/L and at about 5 percent, in excess of 5.0 mg/L. The median total nitrogen concentration for Florida waters falls between 1.0 and 2.0 mg/L. More than 85 percent of the stations had concentrations above 0.6 mg/L, the value cited in McKee and Wolf (1963) as sufficient to cause enormous growth of plants in streams and lakes.

Stations where the total nitrogen exceeded 5.0 mg/L include Elevenmile Creek near Ensley, the Fenholloway River at Foley and Swift Creek at Facil, all of which receive industrial effluents, the Kissimmee River at S-65 possibly reflecting agricultural drainage, and Plantation Road Canal at S-33 near Ft. Lauderdale which receives domestic sewage and industrial effluents. Also in this category is Everglades P-35, within Everglades National Park, presumably due in part to high aquatic biologic productivity associated with the natural subtropical environment of south Florida.

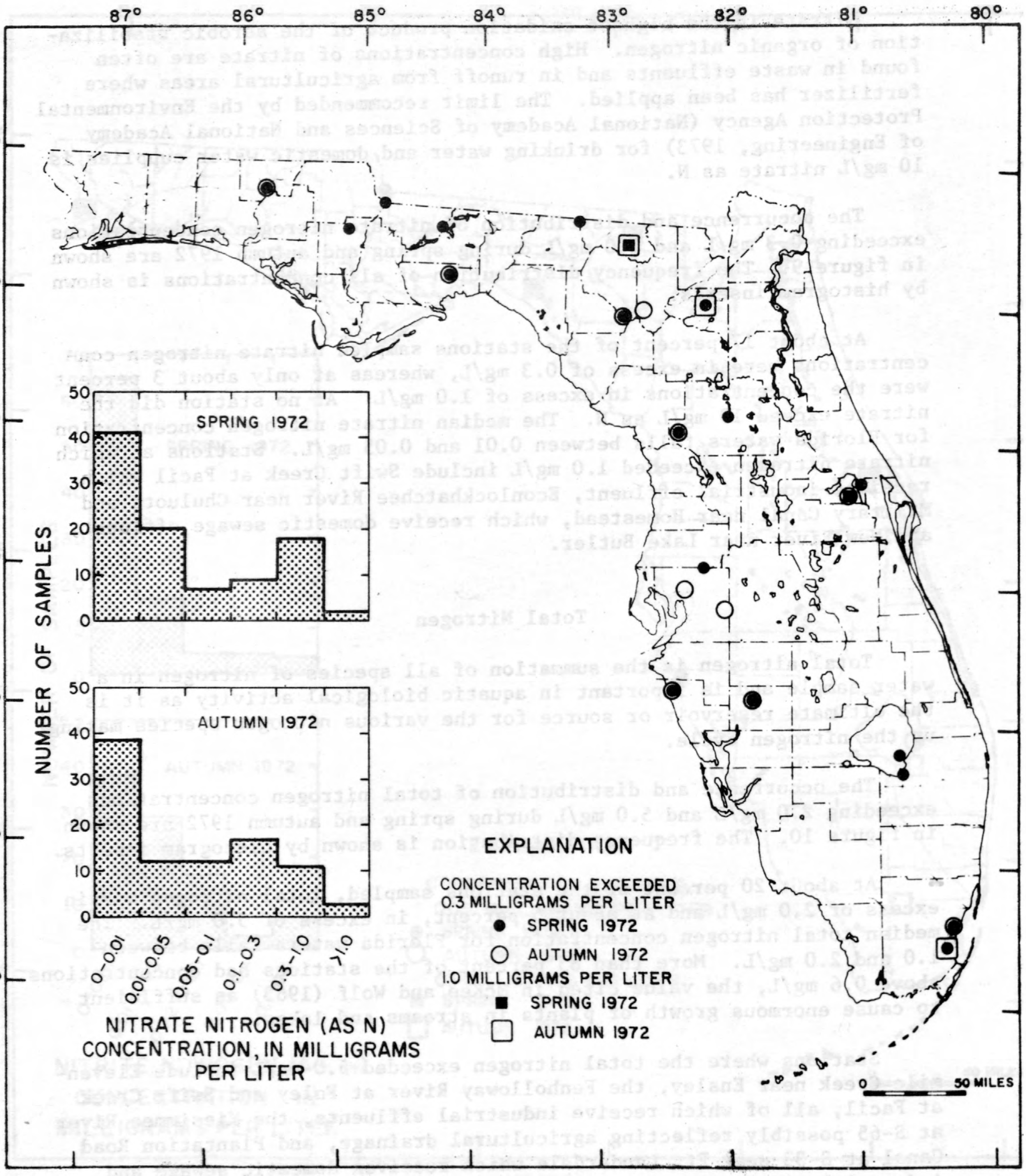

Figure 9.--Location of stations where nitrate nitrogen (as N) exceeded 0.3 and 1.0 mg/L in spring and autumn 1972.

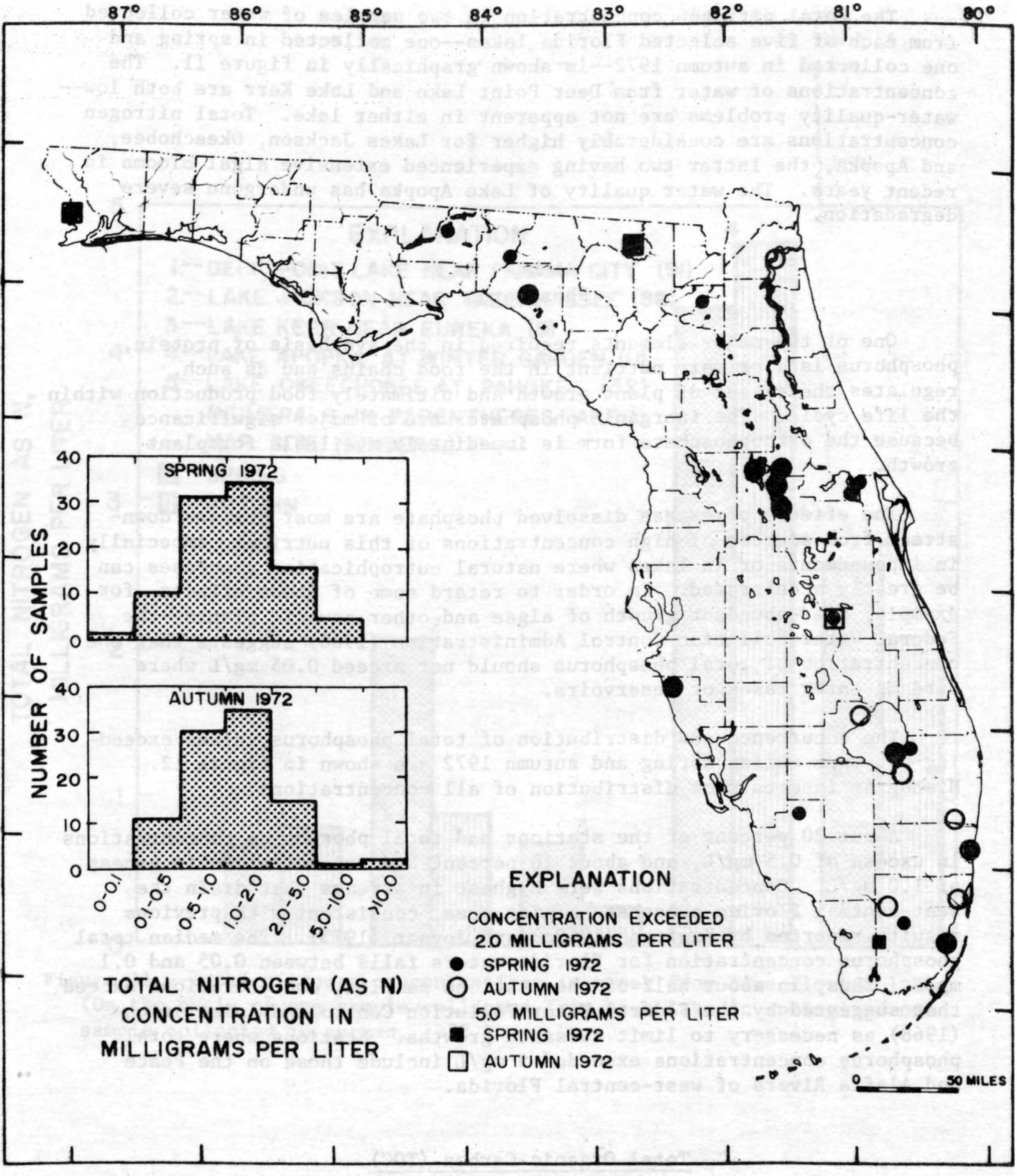

Figure 10.--Location of stations where total nitrogen (as N) exceeded 2.0 and 5.0 mg/L in spring and autumn 1972.

The total nitrogen concentration in two samples of water collected from each of five selected Florida lakes--one collected in spring and one collected in autumn 1972--is shown graphically in figure 11. The concentrations of water from Deer Point Lake and Lake Kerr are both low--water-quality problems are not apparent in either lake. Total nitrogen concentrations are considerably higher for Lakes Jackson, Okeechobee, and Apopka, the latter two having experienced extensive algal blooms in recent years. The water quality of Lake Apopka has undergone severe degradation.

Phosphorus

One of the major elements required in the synthesis of protein, phosphorus is a primary nutrient in the food chains and as such, regulates the extent of plant growth and ultimately food production within the life cycle. The inorganic phosphates are of major significance because the orthophosphate form is immediately available for plant growth.

The effects of excess dissolved phosphate are most serious downstream from sources of high concentrations of this nutrient, expecially in impoundments or in lakes where natural eutrophication processes can be greatly accelerated. In order to retard some of these effects--for example, over-abundant growth of algae and other aquatic plants--the Federal Water Pollution Control Administration (1968) suggests that the concentration of total phosphorus should not exceed 0.05 mg/L where streams enter lakes or reservoirs.

The occurrence and distribution of total phosphorus values exceeding 0.5 mg/L during spring and autumn 1972 are shown in figure 12. Histogram inserts show distribution of all concentrations.

About 20 percent of the stations had total phosphorus concentrations in excess of 0.5 mg/L, and about 10 percent had concentration in excess of 1.0 mg/L. Concentrations were highest in streams that drain the west-central Florida phosphate mining area, consistent with previous results reported by Kaufman (1969a) and Joyner (1973). The median total phosphorus concentration for Florida waters falls between 0.05 and 0.1 mg/L. Thus, in about half of the stations sampled, concentrations exceed that suggested by the Federal Water Pollution Control Administration (1968) as necessary to limit nuisance growths. Stations where total phosphorus concentrations exceeded 5 mg/L include those on the Peace and Alafia Rivers of west-central Florida.

Total Organic Carbon (TOC)

Total organic carbon is a measure of the quantity of organic matter in water, both dissolved and particulate. Bacterial oxidation of organic

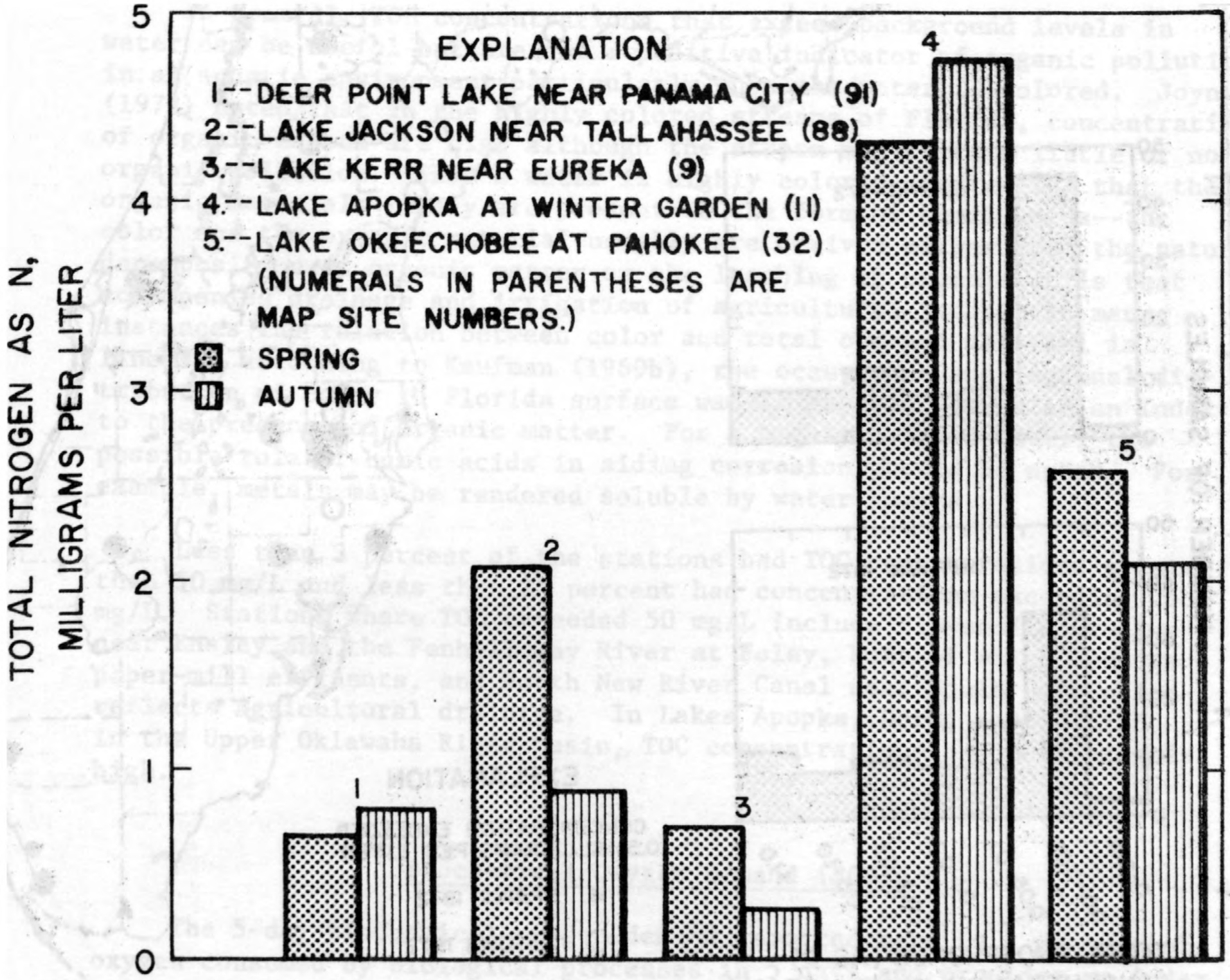

Figure 11.--Total nitrogen concentrations in water from five Florida lakes. (On the basis of one sample collected from each lake in spring and one sample collected in autumn, 1972.)

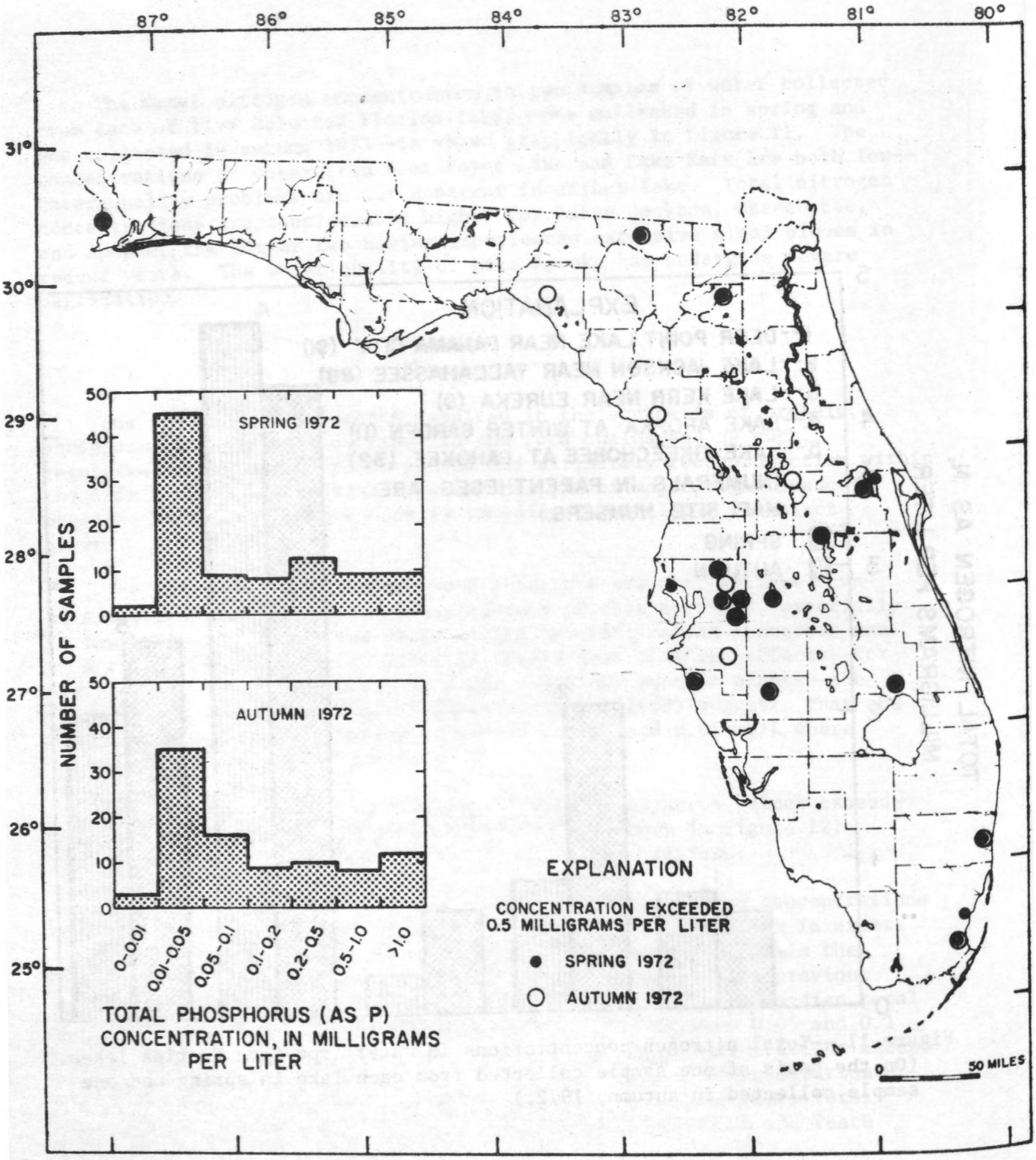

Figure 12.--Location of stations where total phosphorus (as P) exceeded 0.5 mg/L in spring and autumn 1972.

carbon is a principal source of carbon dioxide in aquatic systems. The increased availability of inorganic carbon as carbon dioxide or bicarbonate may stimulate algal growth. Further, organic material may act as a chelator, making iron and other trace metals more available for use by microorganisms. The occurrence and distribution of TOC exceeding 25 mg/L in spring and 50 mg/L in autumn 1972 are shown in figure 13. Histogram inserts show the distribution of the concentrations.

In general, TOC concentrations that exceed background levels in water can be useful but are not a positive indicator of organic pollution in an aquatic environment particularly when the water is colored. Joyner (1973) noted that in the highly colored streams of Florida, concentrations of organic carbon are high although the stream may contain little or no organic pollution. When a water is highly colored--indicating that the organic materials likely are present in the form of humic acids--the color and the organic material usually are derived either from the natural decomposition of organic matter or the leaching of organic soils that accompanies drainage and irrigation of agricultural lands. In many instances the relation between color and total organic material is linear: according to Kaufman (1969b), the occurrence and regional distribution of color in Florida surface waters may also serve as an index to the presence of organic matter. For a highly colored water, the possible role of humic acids in aiding corrosion should be noted. For example, metals may be rendered soluble by water humics.

Less than 3 percent of the stations had TOC concentrations greater than 50 mg/L and less than 15 percent had concentrations exceeding 25 mg/L. Stations where TOC exceeded 50 mg/L include Elevenmile Creek near Ensley and the Fenholloway River at Foley, both of which receive paper-mill effluents, and North New River Canal near South Bay, which reflects agricultural drainage. In Lakes Apopka, Dora, and Griffin, in the Upper Oklawaha River basin, TOC concentrations are consistently high.

Biochemical Oxygen Demand (BOD)

The 5-day biochemical oxygen demand reported here is a measure of oxygen consumed by biological processes in 5 days and provides an index of the degree of organic pollution. This test is used to determine the relative requirements of oxygen by wastewater, effluents, and polluted waters. High BOD concentrations may be related to depletion of dissolved oxygen in an aquatic environment.

The utilization of oxygen in a stream or lake is generally a biological process. In an unpolluted stream, oxygen consumption is governed by aerobic organisms. These organisms may be adversely affected in a stream where organic pollutants increase oxygen demand.

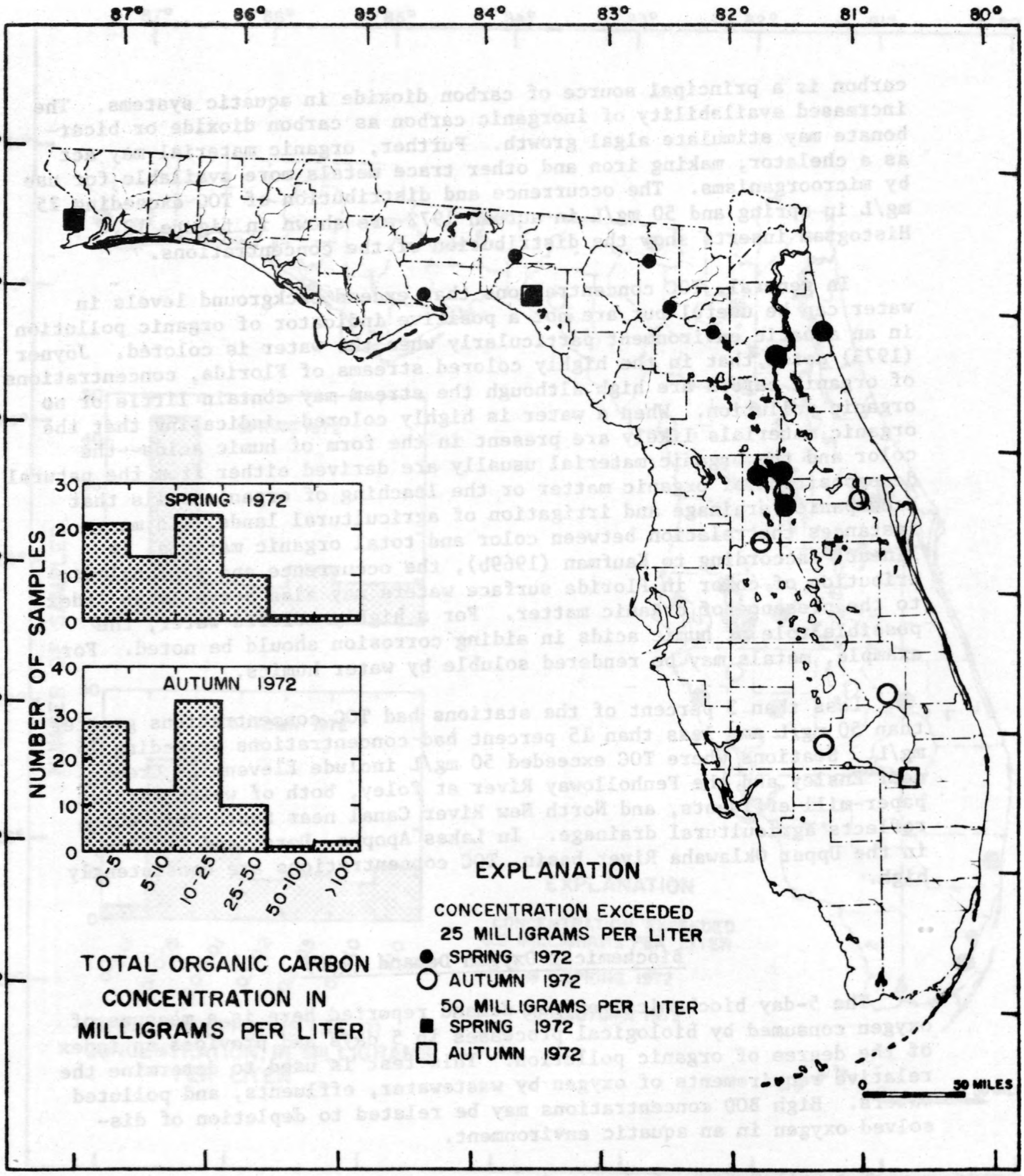

Figure 13.--Location of stations where total organic carbon exceeded 25 and 50 mg/L in spring and autumn 1972.

Joyner (1973) noted that BOD concentrations in excess of 100 mg/L may be found in raw sewage, whereas in unpolluted water BOD is usually less than 1.0 mg/L. McKee and Wolf (1963) suggest that in a slow, sluggish stream, BOD in excess of 5 mg/L might indicate harmful conditions for aerobic organisms. As a note of caution in evaluating of BOD concentrations it should be pointed out that the laboratory environment does not effectively duplicate stream conditions such as temperature, sunlight, and biological population (American Public Health Association, 1971).

The occurrence and distribution of BOD exceeding 5.0 mg/L during spring and fall 1972 are shown in figure 14. The distribution of all concentrations is shown by histogram inserts.

Less than 10 percent of the stations had BOD's in excess of 5.0 mg/L. The median BOD for Florida waters falls between 1.0 and 2.0 mg/L. Stations with the highest BOD's (exceeding 10 mg/L) include Elevenmile Creek near Ensley, Fenholloway River at Foley, and Rice Creek near Palatka, all of which receive paper-mill effluent. Lake Apopka and Dora in the upper Oklawaha River basin exhibit consistently high BOD concentrations.

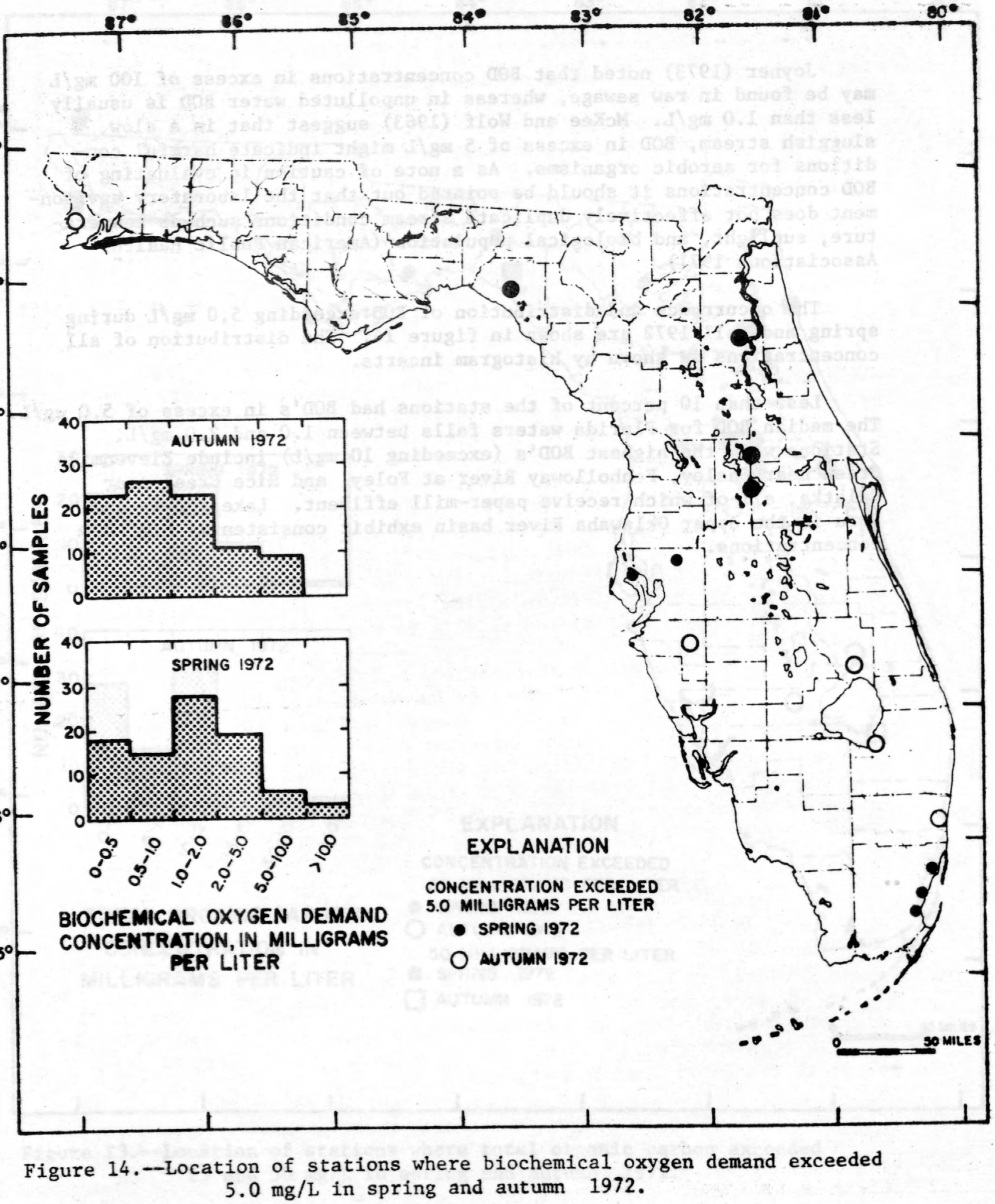

Figure 14.--Location of stations where biochemical oxygen demand exceeded 5.0 mg/L in spring and autumn 1972.

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