COORDINATING COUNCIL
ON THE
RESTORATION OF THE KISSIMMEE RIVER VALLEY
AND
TAYLOR CREEK - NUBBIN SLOUGH BASIN

2600 BLAIR STONE ROAD
TALLAHASSEE, FLORIDA 32301
(904) 488-9830

CHAIRMAN
Victoria J. Tschinkel, Secretary
Department of Environmental Regulation

MEMBERS
Honorable Doyle E. Conner
Commissioner of Agriculture

Dr. Elton J. Gissendanner, Executive Director
Department of Natural Resources

Col. Robert M. Brantly, Executive Director
Game & Fresh Water Fish Commission

Mr. John R. Maloy, Executive Director
South Florida Water Management District

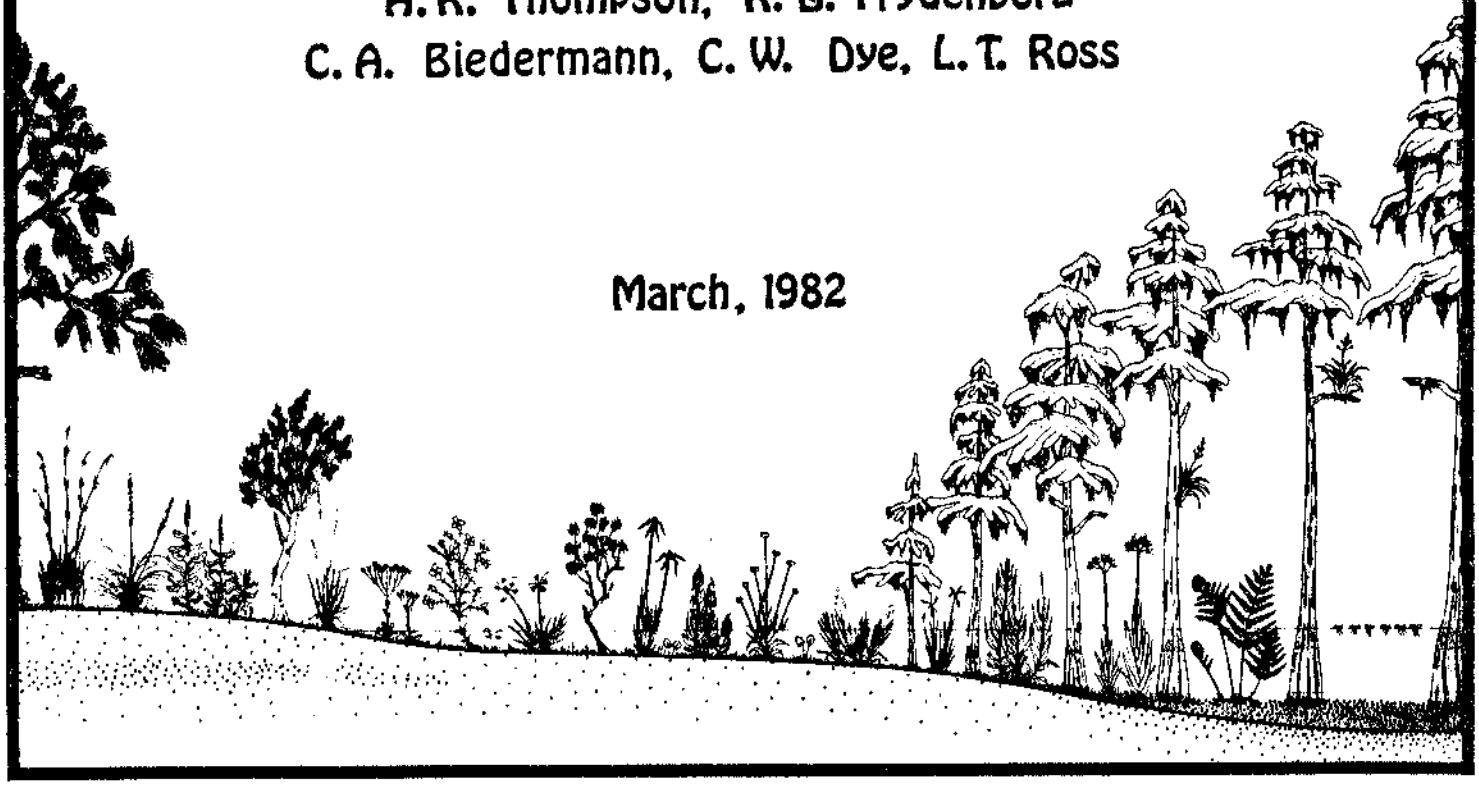
STAFF
Dr. Patrick M. McCaffrey, Director

PHYTOPLANKTON AND PERIPHYTON COMMUNITY DYNAMICS IN DETENTION/RETENTION WETLANDS, KISSIMMEE RIVER BASIN, FLORIDA

FINAL REPORT

A.R. Thompson, R. B. Frydenborg
C.A. Biedermann, C. W. Dye, L.T. Ross

March, 1982



PHYTOPLANKTON AND PERIPHYTON COMMUNITY DYNAMICS IN DETENTION/RETENTION WETLANDS, KISSIMMEE RIVER BASIN, FLORIDA

Final Report

from the

Bureau of Water Analysis

to the

Coordinating Council on the Restoration of the Kissimmee River Valley and Taylor Creek-Nubbin Slough Basin

for the

Upland Detention/Retention Demonstration Project

by

A. R. Thompson
R. B. Frydenborg
C. A. Biedermann
C. W. Dye
L. T. Ross

Biology Section
Bureau of Water Analysis
Florida Department of Environmental Regulation
Tallahassee, Florida

September, 1981

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the South Florida Water Management District Okeechobee Lab staff, including Alan Goldstein and Mary Lou Smith for performing water chemistry analyses, and Ronald Mierau for providing hydrology data. We would also like to thank Pat McCaffrey and Steve Gatewood for providing information on land use patterns at the study sites as well as general coordination.

TABLE OF CONTENTS

	Page
INTRODUCTION	1
SITE DESCRIPTIONS AND STATION LOCATIONS	3
METHODS	11
A. Phytoplankton	11
B. Periphyton	11
C. Algal Assays	12
D. Community Metabolism	12
E. Water Chemistry	12
RESULTS AND DISCUSSION	15
Phytoplankton	15
A. Generic Characterization	15
B. Quantitative Characterization	19
Periphyton	24
A. Generic Characterization	24
B. Quantitative Characterization	26
Water Chemistry	31
Algal Assay	35
Community Metabolism	40
SUMMARY	43
LITERATURE CITED	45
APPENDICES	51

INDEX OF FIGURES AND TABLES

Figure		Page
1.	Armstrong Slough, Ash Slough, and Pitmans Bay Site Location Map	5
2.	Armstrong Slough Site Map	6
3.	Ash Slough Site Map	7
4.	Pitmans Bay Site Map	9
5.	Phytoplankton Percent Composition by Division at Armstrong Slough	16
6.	Phytoplankton Percent Composition by Division at Ash Slough	17
7.	Phytoplankton Percent Composition by Division at Pitmans Bay	18
8.	Average Phytoplankton Biomass Parameters at Armstrong and Ash Sloughs and Pitmans Bay	20
9.	Comparison of Phytoplankton Biomass Parameters at Armstrong Slough, Between Upstream Station M-8 and Downstream Station M-5, Before and After Channel Plug Completion	21
10.	Comparison of Phytoplankton Biomass Parameters at Ash Slough Stations B-4 and B-2	22
11.	Phytoplankton and Periphyton Primary Productivity at Armstrong Slough, Ash Slough, and Pitmans Bay	23
12.	Periphyton Percent Composition by Division at Armstrong Slough	27
13.	Periphyton Percent Composition by Division at Ash Slough	28
14.	Periphyton Percent Composition by Division at Pitmans Bay	29
15.	Average Periphyton Biomass Parameters at Armstrong and Ash Sloughs and Pitmans Bay	30
16.	Comparison of Periphyton Biomass Parameters at Armstrong Slough, Between Upstream Station M-8 and Downstream Station M-5, Before and After Plug Completion	32
17.	Comparison of Periphyton Biomass Parameters at Ash Slough Stations B-4 and B-2	33

Figure — Page

18. Average Nutrient Concentration at Armstrong Slough, Ash Slough, and Pitmans Bay 34

19. Comparison of Nutrient Concentrations at Armstrong Slough, Between Upstream Station M-8 and Downstream Station M-5, Before and After Plug Completion 36

20. Comparison of Nutrient Concentrations at Ash Slough Stations B-4 and B-2 37

21. Algal Assay Results for Armstrong Slough, December, 1980 . . 38

22. Algal Assay Results for Ash Slough, October, 1980 39

23. Community Metabolism at Armstrong Slough, Ash Slough, and Pitmans Bay 41

A-1. Simple Linear Regression Analysis of Top Periphyton Units Counts/mm^2 and Chlorophyll *a* Units (mg/m^2) A-11

A-2. Simple Linear Regression Analysis of Top Periphyton Chlorophyll *a* and Net Organic Weight (g/m^2) A-12

A-3. Simple Linear Regression Analysis of TOP Periphyton Unit Count/mm^2 and Net Organic Weight (g/m^2) A-13

A-4. Simple Linear Regression Analysis of TOP and Bottom Periphyton Unit Counts (algal units/mm^2) A-14

A-5. Simple Linear Regression Analysis of TOP and Bottom Periphyton Chlorophyll *a* Concentration (mg/m^2) A-15

A-6. Simple Linear Regression Analysis of TOP and Bottom Periphyton Non-Organic Weights (g/m^2) A-16

Table — Page

1. Station Description - Armstrong Slough Site 4

2. Station Description - Ash Slough Site 8

3. Station Description - Pitmans Bay Site 10

4. Number of Periphyton Genera Identified in Each Major Algal Division from August 1978 to June 1981 25

A-1. Phytoplankton Genera Found at Armstrong Slough, Ash Slough and Pitmans Bay A-1

INDEX OF FIGURES AND TABLES (Cont.)

Table		Page
A-2.	Periphyton Genera Found at Armstrong Slough, Ash Slough and Pitmans Bay	A-3
A-3.	Epiphytic Periphyton Genera Found on Ash Slough and Armstrong Slough Stations, April 1979	A-5
A-4.	Diatom Species Identified in Study Area	A-17

ABSTRACT

Phytoplankton and periphyton community structure and dynamics were studied in three freshwater wetlands located in the Kissimmee River Valley, Florida. Generic composition and biomass of the algal communities, as well as associated water chemistry were measured. Two areas received runoff from pastures used for beef cattle production, while the third area was unaltered. As a percentage of the total algal population, Cyanophyta dominated all three systems, while Chlorophyta were secondary in abundance. This suggests that nutrient enrichment may have little effect upon the percent composition of algae in subtropical wetlands. One area received heavy nutrient loading. At this location, significantly higher phytoplankton and periphyton biomass levels were found below the site of nutrient input than above the site. Wetland nutrient uptake capabilities were studied in an area where flow characteristics were artificially altered to allow greater retention volume and increased detention time. Although nutrient levels and biomass quantities were lower leaving the wetland after inundation than before inundation, the changes were not statistically significant at the 95% C.L.

INTRODUCTION

South Florida has a long history of water management problems. Two major floods from hurricanes in 1947 and 1948 prompted federal and state governments to embark on a plan in which channelization was used to facilitate land drainage (McCaffrey, 1977). Recently, environmental concerns of degraded water quality due to rapid runoff from land used extensively for beef cattle production have dictated another change in management policies. The Kissimmee Coordinating Council on the Restoration of the Kissimmee River Valley and Taylor Creek-Nubbin Slough Basin was formed to study problem areas and recommend appropriate action. Details of the overall project may be found in the project description by McCaffrey et al. (1978). One of the Kissimmee Coordinating Council's goals is the development of an Upland Detention/Retention Demonstration Project where runoff is routed through natural or man-made wetlands to assess the nutrient uptake capabilities of wetlands. The Biological Section of the Department of Environmental Regulation was contracted to collect and analyze information on the algal communities at three of the Council's demonstration sites: Armstrong Slough, Ash Slough, and Pitmans Bay.

The primary goal of the initial part of this study was a baseline characterization of the algal communities at two shallow subtropical wetlands (Armstrong and Ash Sloughs) that receive nutrient input from agricultural lands. Unlike the algal communities of temperate freshwater wetlands, which have been well described (e.g., Lund, 1965; Hutchinson, 1975; Wetzel, 1975), investigations of the algal communities in shallow (< 2 m deep) subtropical systems have been limited. Community composition and associated biomass levels in temperate wetlands can vary dramatically as a result of extreme changes in physico-chemical parameters such as light, temperature, nutrients, etc., on an annual basis (McCombie, 1953; Moss, 1973; Wetzel, 1975). Florida's climate, however, is fairly constant, and algal assemblages are relatively stable, reflecting the reduced seasonal extremes (Lackey and Lackey, 1967; Brezonik et al., 1978; Biedermann, 1980). Also, much of Florida's agricultural land supports beef cattle production which frequently contributes substantial nutrient loads to aquatic systems. Increased nutrient loading may stimulate overall algal growth and shift community composition so that taxa adapted to nutrient rich water become dominant. Preliminary data from the initial portion of this study were presented in two annual reports (Biedermann et al., 1979; Thompson et al., 1980).

For the later part of the study, we evaluated the capabilities of a wetland to remove nutrients from agricultural runoff. Flow characteristics were altered at Armstrong Slough which allowed greater detention and retention of the water moving through this system. Resulting changes in nutrient concentrations and algal communities at the sites are presented in this report.

Alterations in the structure and relative abundance of various elements of the algal community are among the first symptoms of change in an aquatic habitat (Vollenweider, 1974; Spondniewska, 1978). Therefore, the monitoring of such changes in the phytoplankton and periphyton of the detention/retention sites is a useful tool in evaluating the biological

impact of nutrient retention. Since taxonomic composition of algal communities is related to a community's population dynamics, as manifested by pigment concentrations and changes in organic material (McIntire, 1968), the following objectives were established for this study:

1) Characterization of planktonic algae communities by determination of;

   a) Proportional distribution of phytoplankton genera;

   b) The biomass* distribution of phytoplankton communities with respect to phytosynthetic pigments, ash free dry weights, and total numbers of organisms;

   c) Primary productivity.

2) Characterization of periphytic algal communities by determination of;

   a) The proportional distribution of periphyton genera;

   b) The biomass distribution as measured by photosynthetic pigments, ash free dry weights, and the total number of attached algal organisms; and

   c) Primary productivity.

3) Evaluation of the total community metabolism by monitoring diel variations in free water oxygen.

4) Determination of macronutrients and other water quality parameters.

---

*Note - Biomass is used in reference to phaeopigment correlated chlorophyll-a and ash free dry weight. These are not true mass measurements but rather are indices of biomass (EPA, 1973; Vollenweider, 1974; Wetzel, 1975). Additionally, number of algal organisms is used as a general estimator of biomass, to be used as a range finder for comparisons between stations and sites.

SITE DESCRIPTIONS AND STATION LOCATIONS

The Armstrong Slough site is located on the Latt Maxcy Ranch in Osceola County, just east of the Kissimmee River at the S-65A control structure. This site comprises approximately 120 acres of former tributary flood plain which receives runoff from an approximately 100,000 acre watershed. The site was channelized until April, 1980, when work was completed on a levee and channel plug. The water level was then raised and flow was diverted out of the channel. This re-inundated slough was used to evaluate the potential for the removal of nonpoint source nutrient input. Five sample stations, described in Table 1, were established (Figures 1 and 2). Two stations (M-6 and M-7) were moved due south, into the marsh, when the channel plug was installed.

The Ash Slough site is located on the J.C. Bass Ranch in Okeechobee County, 4 miles north of Basinger. Ash Slough drains through Chandler Slough to the Kissimmee River. It is composed of approximately 15 acres of Pontederia and Panicum marsh. This system receives runoff from 240 acres of ditched, improved pasture that was once a vegetable field but is now used for beef cattle production. This site was used to ascertain the effect of cattle production on a natural marsh system. Four stations were established (Figures 1 and 3), and are described in Table 2.

The Pitmans Bay site is located on the Lykes Brothers Ranch in Highlands County, at the headwaters of Wildcat Slough. This site consists of approximately 320 acres of natural marsh which is composed of Pontederia and Panicum communities with a small bay or "forest" of Sweet Bay and Red Bay trees. There is no channelization or cattle production at or near this site. For this study, Pitmans Bay was considered a natural wetland and was used for comparison with the other systems. Two sampling stations were established in the marsh (Figures 1 and 4) and are described in Table 3.

Table 1. Station Description - Armstrong Slough Site.

Station Number	Location	Water Depth	Bottom Characteristics	Major Aquatic Macrophytes	Comments
M-5	In the stream channel approx. 90 m downstream west of the retention area.	.5-1.5 m	Hard packed sand with a thin overlying layer of organic detritus.	Sparse growth of Panicum, Eleocharis, and Hydrocotyle, along both margins.	Water clear, moderate flow. Cattle crossing nearby.
M-6	In the marsh, 10 m south from channel blockage & approx. 70 m upstream of culverts.	.2-.8 m	Hard packed sand with a thick overlying layer of organic detritus.	Thick growth of Pontederia surrounds this station.	Water clear. Moderate flow.
M-7	In the marsh 40 m south of previous M-7 station, 200 m upstream of M-6.	.2-.6 m	Mat of emersed aquatic plants overlying organic detritus.	Thick growths of Panicum and Pontederia.	Water clear. Little flow.
M-8	In stream channel. Eastern most station upstream of retention area.	1.15-1.3 m	Hard packed sand with thin overlying layer of organic detritus.	Abundant growth of Eichornia sometimes clogs entire channel.	Slow flow. Water turbid, tannin stained.
M-9	In marsh tributary channel upstream of inundated area.	.3-.4 m	Mat of emersed aquatic plants overlying thick muck.	Densely vegetated with Pontederia, Hydrocotyle and Potamogeton.	No observable flow. Station sometimes dry. Turbid, tannin stained water.

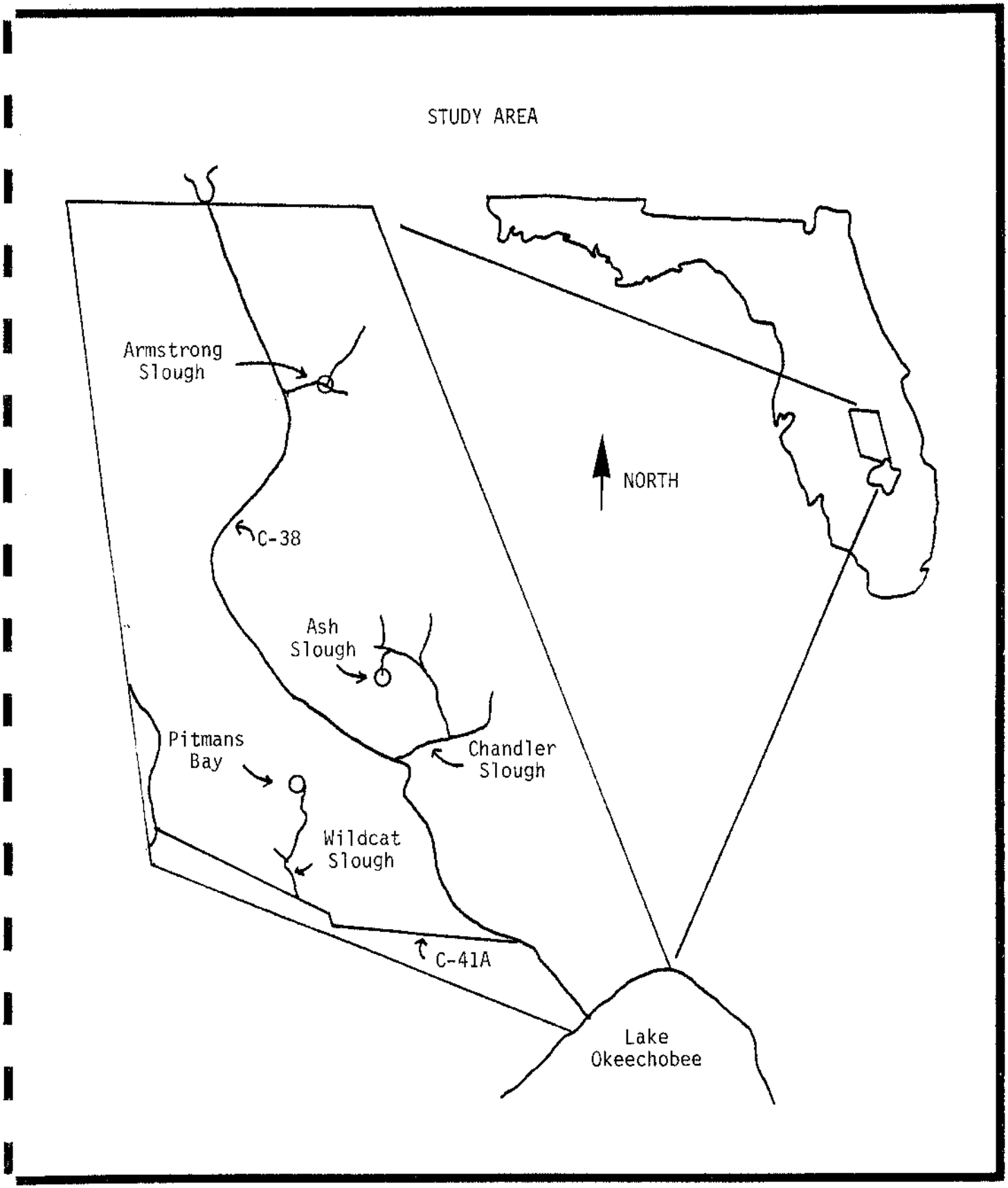


Fig. 1. Armstrong Slough, Ash Slough, and Pitmans Bay Site Location Map

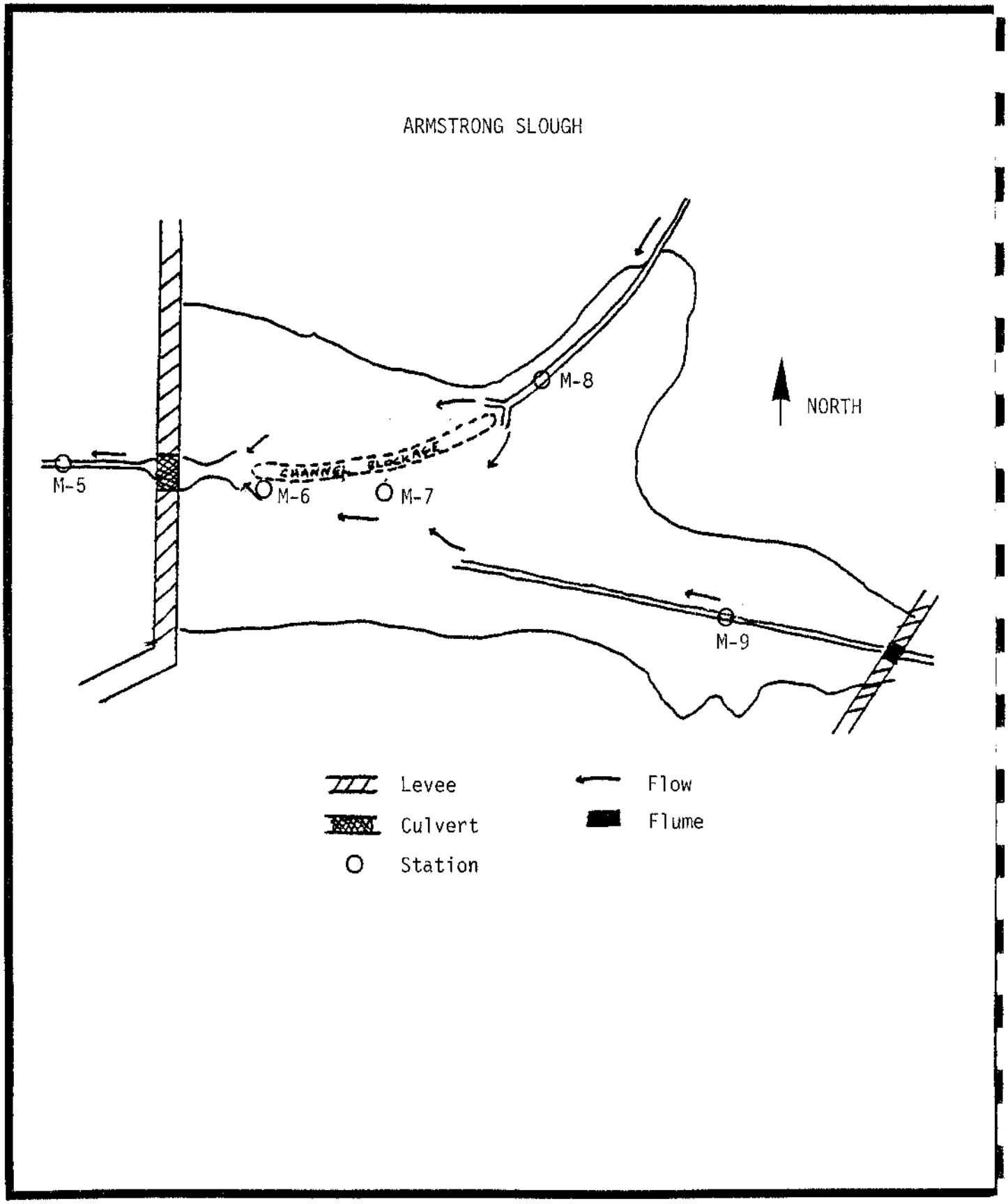


Fig. 2. Armstrong Slough Site Map

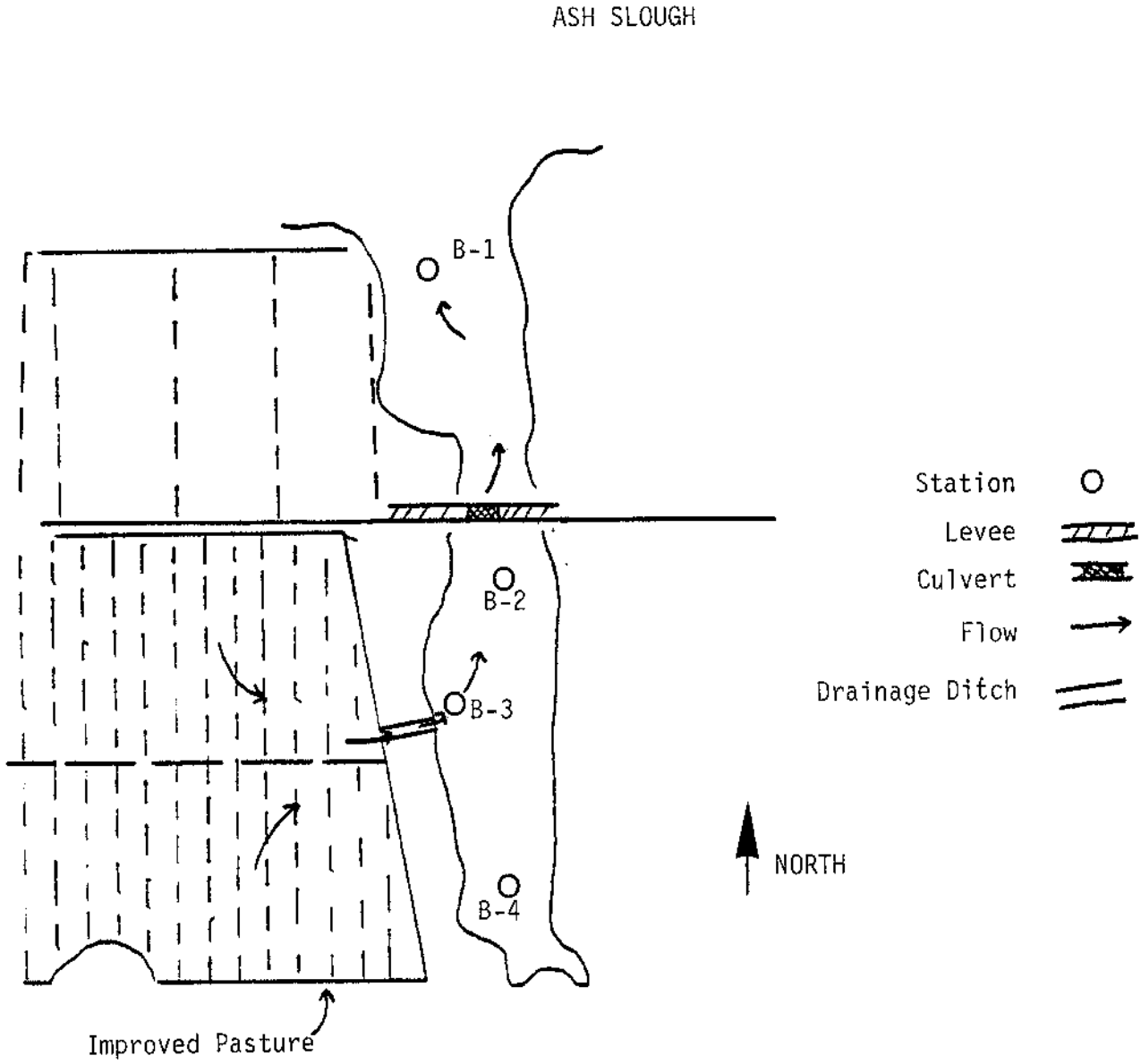


Fig. 3. Ash Slough Site Map

Table 2. Station Description - Ash Slough Site.

Station Number	Location	*Water Depth	Bottom Characteristics	Major Aquatic Macrophytes	Comments
B-1	In a pool north of the existing marsh outfall.	41 - 0 cm	Thick unconsolidated muck.	Patchy growth of Juncus, Pontederia and Polygonum.	No observable flow. This area is apparently used by cattle as a watering hole. The water is tannin stained and turbid.
B-2	In marsh near the outfall.	60 - 0 cm	Thick layer of unconsolidated muck overlying hard packed sand.	Dense growth of Polygonum and Pontederia.	No flow was observed during the sampling period. The water is tannin stained and turbid.
B-3	In marsh adjacent to drainage ditch confluence.	30 - 0 cm	Mat of emersed aquatic plants overlying organic detritus.	Dense growth of Pontederia, Bacopa and Polygonum.	No flow was observed. The water is clear.
B-4	In marsh at its southern perimeter.	46 - 0 cm	Mat of emersed aquatic plants overlying organic detritus.	Dense growth of Nymphoides, Pontederia, Bacopa, and Polygonum.	No flow was observed. The water is clear.

*All stations were completely dry at least once during the sampling period.

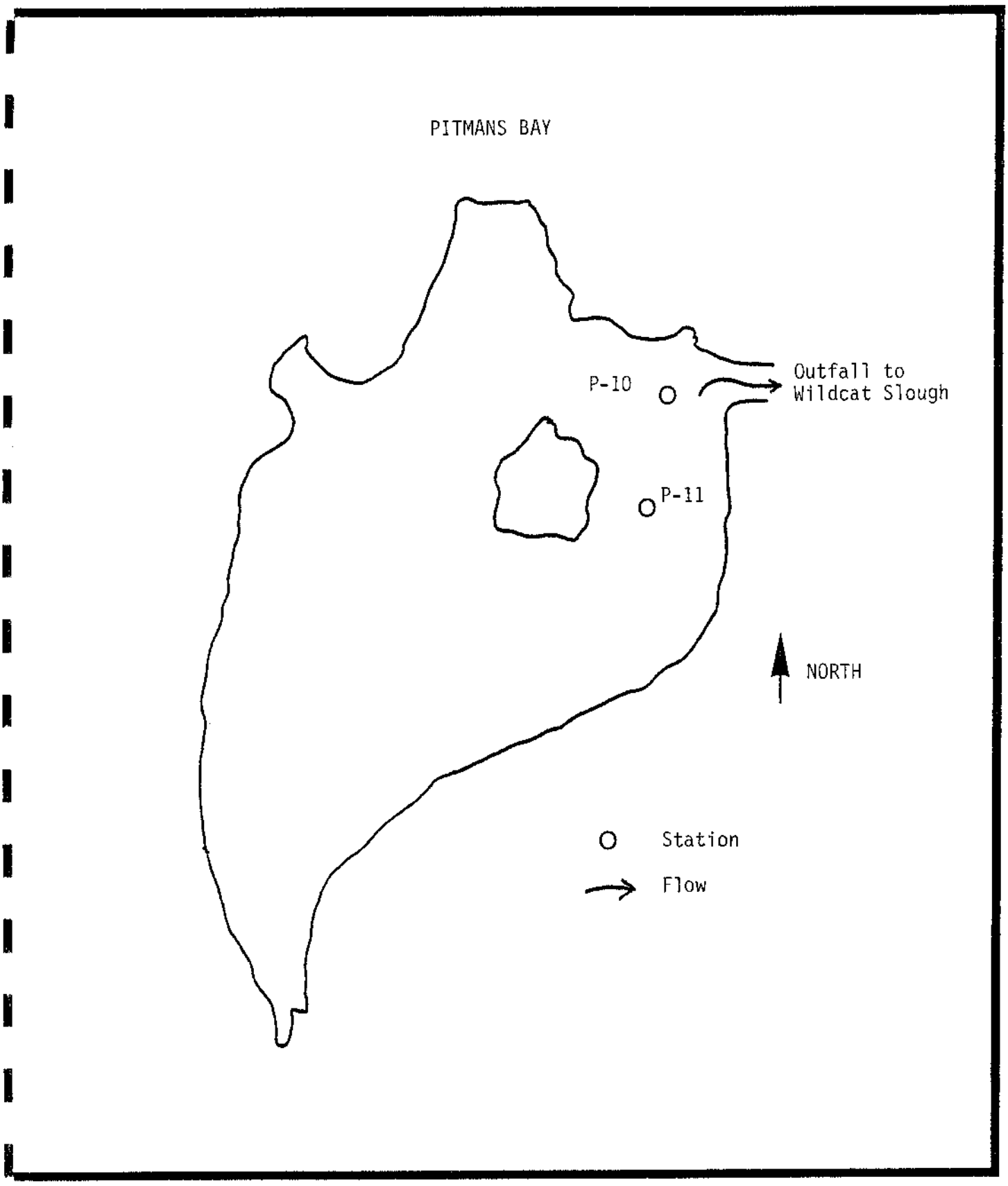


Fig. 4. Pitmans Bay Site Map

Table 3. Station Description - Pitmans Bay Site.

Station Number	Location	Water Depth	Bottom Characteristics	Major Aquatic Macrophytes	Comments
P-10	100 meters west of the outfall in a spot of open water.	50 cm - 0 cm	Thick semi-consolidated muck.	Panicum and Andropogon.	No observable flow, water sometimes turbid.
P-11	250 meters south of P-10, approx. 150 meters from the stand of bay trees.	50 cm - 0 cm	Mat of emerged aquatic plants overlying organic detritus.	Dense growth of Pontederia and Panicum.	No observable flow, water generally clear.

METHODS

Phytoplankton and periphyton samples were collected every other month at Armstrong Slough and Ash Slough from August 1978, to June, 1979, in the first year of study. An identical sampling regime, with the addition of primary productivity experiments and water chemistry collections was instituted for the period from August, 1979 to June, 1981. In August, 1980, and December, 1980, the third site, Pitmans Bay, was sampled in place of Ash Slough.

A. Phytoplankton

Vertical composite samples of the water column were used for phytoplankton identification, proportional counts, ash free dry weights, and pigment concentration determinations. Samples for generic identification, proportional counts, and ash free dry weights were preserved in the field with neutralized formalin (EPA, 1973; APHA, 1976). Generic identification followed Smith (1950) and Prescott (1962, 1970). Ash free dry weight was determined by filtering the samples through pre-ashed 0.45 micron glass fiber filters (Whatman GFA^{R}). The filters were oven dried at 105^{o}C, weighed, ignited at 500^{o}C in a muffle furnace, and reweighed (EPA, 1973; APHA, 1976).

Phytoplankton samples for pigment analysis (chlorophyll-a and phaeophytin) were filtered through 0.45 micron glass fiber filters (Whatman GFC^{R}), air dried, and stored on ice in an opaque desiccator within six hours of collection. Within thirty hours of collection, the filters were macerated with a fluted teflon tissue grinder and extracted in 90% aqueous acetone-magnesiumcarbonate mixture for 18 to 24 hours. Optical density was measured on a Colemen^{R} Model 124 double beam spectrophotometer. Phaeophytin corrected chlorophyll-a values were calculated according to the monochromatic equation of Strickland and Parsons (1972).

Primary productivity was determined at stations B1, B2, M5, M6, and P10 using the light-dark bottle oxygen method (Vollenweider, 1974; APHA, 1976). The dissolved oxygen concentrations were determined using the azide modification of the Winkler method. A surface sample was siphoned into two sets of 300 ml BOD bottles, each set consisting of an initial bottle, a light bottle, and a dark bottle. Initial bottles were immediately fixed while the light and dark bottles were incubated for approximately 2.5 hours at a depth of 15 centimeters before fixing. Incubation typically occurred during the hours of most intense sunlight. Differences in oxygen concentrations between light and dark bottles were determined and converted to mg carbon fixed/m^{3}/hour (APHA, 1976).

B. Periphyton

Samples of attached algal communities were collected on macrophytes for qualitative analysis and on artificial substrates for qualitative and quantitative analysis. Epiphytic algae were obtained in April, 1979, from scraped areas of the dominant macrophytes at Armstrong and Ash Sloughs. Artificial substrates consisted of standard glass microscope slides (25 mm x 75 mm) placed vertically in stainless steel racks. The

slides were incubated in situ for 14 days (Sládeček and Sládečkova, 1964; EPA, 1973). The slides were suspended at depths of 15 cm and 31 cm (referred to as "top" and "bottom", respectively) by anchored floats at the Armstrong site. Artificial substrates were placed at 15cm only, at Ash Slough and Pitmans Bay.

Qualitative analyses of diatoms were made from Armstrong and Ash Sloughs' periphyton samples during the period from August, 1978, to June, 1979. For this procedure, centrifuge-concentrated samples were placed on a heated cover slip with 50% hydrogen peroxide to drive off organic matter. Once dry and cooled, the cover slip was attached with heated mounting media (Hyrax) to a microscope slide. Diatoms were identified at 1000X using Patrick and Reimer (1966) and Weber (1971) as taxonomic references.

Generic identification, proportional counts, and pigment determinations were performed as described above for phytoplankton. Ash free dry weight (organic weight) was determined by scraping the wet incubated microscope slides directly into large tared crucibles which were subsequently oven dried and ashed.

Periphyton primary productivity was determined by the use of the following method: Pairs of replicate light and dark 250 ml Erlenmyer flasks were filled with surface water for which the dissolved oxygen concentration had been determined. A slide with a two-week growth of periphyton was placed in each stoppered flask, then incubated for approximately 2.5 hours at a depth of 15 centimeters between 10:00 am and 2:00 pm. Following the method described in Czaplewski and Parker (1973), initial and final dissolved oxygen concentrations were obtained using a dissolved oxygen meter (Y.S.I. Model 5418) with a self-stirring BOD probe. After correcting for phytoplankton production, differences in dissolved oxygen concentrations were converted to mg C fixed/m^2/hr.

C. Algal Assays

Samples for limiting nutrient assays were collected in October, 1980, December, 1980, and February, 1981, from Armstrong and Ash Sloughs. The limiting nutrient tests followed procedures outlined in Miller et al. (1978) using Selenastrum capricornutum as the test alga.

D. Community Metabolism

Gross community photosynthesis and community respiration was obtained by monitoring the diel change in free water oxygen (Odum and Hoskin, 1958). Replicate samples from five stations (B-1, B-2, M-5, M-6, and P-10) were taken every two hours and siphoned into 300 ml BOD bottles. Dissolved oxygen concentrations were then determined using the azide modification of the Winkler method (APHA, 1976).

E. Water Chemistry

Samples for chemical analysis were collected twice each sampling month. Water samples were iced and kept in the dark until analyzed.

Chemical parameters analyzed were inorganic nitrogen, organic nitrogen, total nitrogen, ortho-phosphorus, total phosphorus, total organic carbon, pH, turbidity, and color. Methods for these tests were outlined in Standard Methods for the Examination of Water and Wastewater (APHA, 1976) and Methods for Chemical Analysis of Water and Wastes (EPA, 1979).

RESULTS AND DISCUSSION

Phytoplankton

A. Generic Characterization

A complete list of the phytoplankton genera identified at the Armstrong Slough, Ash Slough and Pitmans Bay areas is presented in the Appendix (Table A-1). A total of 102 genera were identified. Seventy genera were found at the Armstrong site, including 14 Cyanophyta; 33 Chlorophyta; 19 Chrysophyta (15 were Bacillariophyta - 2 Centrales and 13 Pennales); 3 Euglenophyta; and 1 Pyrrhophyta.

The Ash Slough site yielded 87 genera, mostly the same as those found at Armstrong Slough, including 14 Cyanophyta; 41 Chlorophyta; 22 Chrysophyta (16 were Bacillariophyta - 2 Centrales and 14 Pennales); 1 Cryptophyta; 4 Euglenophyta; and 3 Pyrrhophyta. Although Pitmans Bay was sampled only twice, 56 genera were identified. By division, the algae from this site consisted of 13 Cyanophyta; 29 Chlorophyta; 7 Chrysophyta (of which 4 were pennate and 3 were centric diatoms); 1 Cryptophyta; 3 Euglenophyta; and 3 Pyrrhophyta. Except for 6 genera, all were also found at Armstrong and Ash Sloughs.

Proportional counts indicated that the blue-green algae Microcystis, Chroococcus, Lyngbya, and Gloeothece, and the green algae Gloeocystis and Oocystis were numerically dominant at all three sites. In their evaluation of algae in Florida freshwater systems, Lackey and Lackey (1967) concluded that these and other taxa also identified in this study (such as the blue-green genus Anabaena and the green genera Spirogyra, Mougeotia, Oedogonium, Zygnema, Tetraedron and Scenedesmus were indicative of nutrient enrichment.

The relative abundance of the major taxonomic groups of phytoplankton, expressed as percent composition, is shown in Figure 5 for Armstrong Slough, Figure 6 for Ash Slough, and Figure 7 for Pitmans Bay. All three sites were clearly dominated by cyanophycean genera, which consistently made up 50-90% of the populations at Armstrong and Ash Sloughs, and 70-85% at Pitmans Bay. Chlorophycean genera comprised most of the remainder of the three communities. Although blue-green genera dominated with respect to the number of algal units per milliliter, the green algae generally exhibited more diversity. Dominance of cyanophyte genera has also been noted in other Florida freshwater systems by Lackey and Lackey (1967), Putnam et al. (1972), and Brezonik et al. (1978). There were no upstream-downstream differences noted in the phytoplankton percent composition at any of our study areas.

Although small fluctuations in generic composition occurred from month to month, no well-defined seasonal trends were observed. This is consistent with Wetzel (1975) and Brezonik et al. (1978), who found that the generic composition of algae in Florida lakes, coupled with the relatively stable subtropical climate, prevents the occurrence of prolonged thermal stratification common to temperate regions (Dye et al., 1980). Our data suggest that these climatic and morphometric phenomena may also be responsible for the general stability of the generic composition of the algal populations of these three wetlands as well.

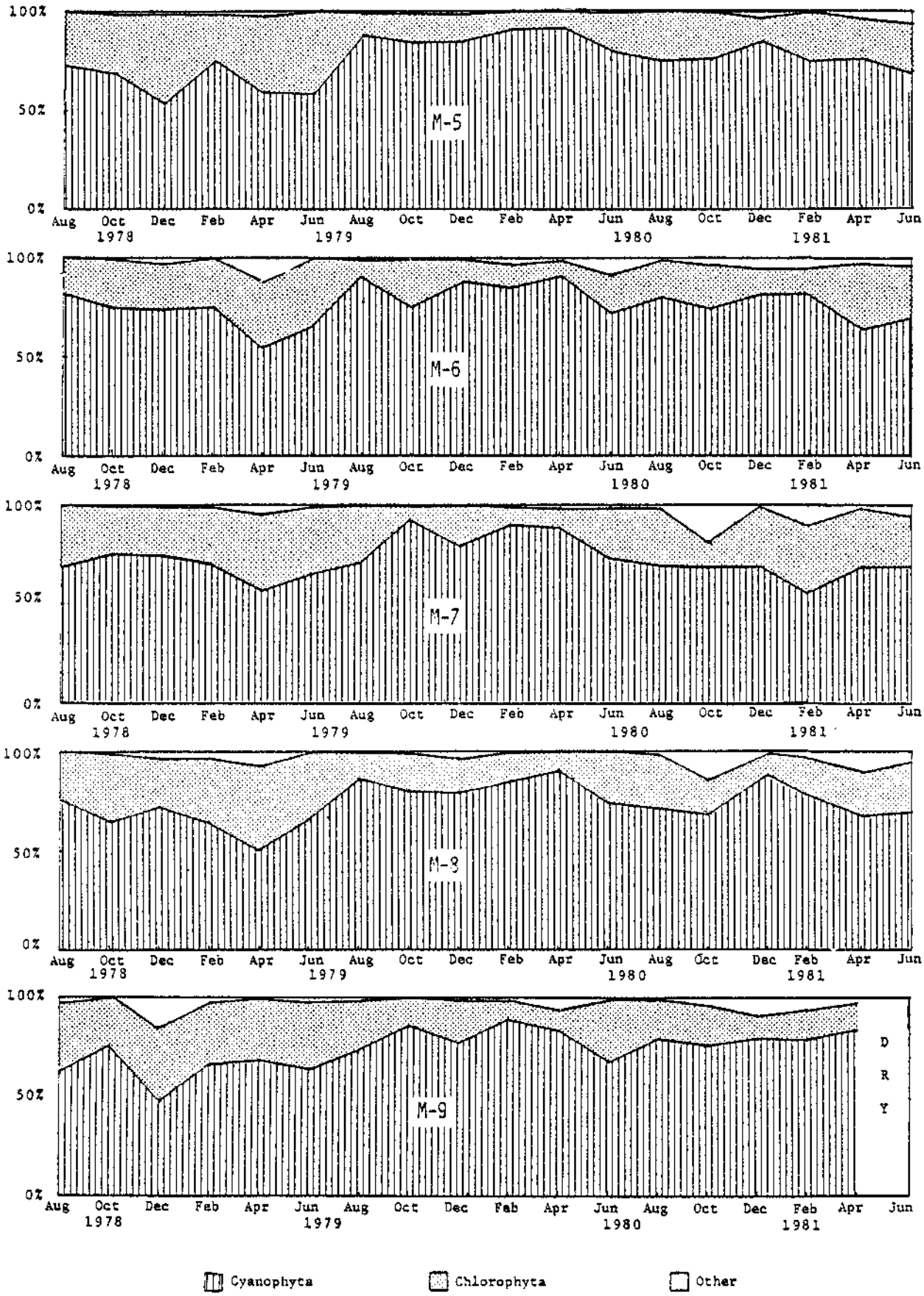


Fig. 5. Phytoplankton Percent Composition by Division at Armstrong Slough

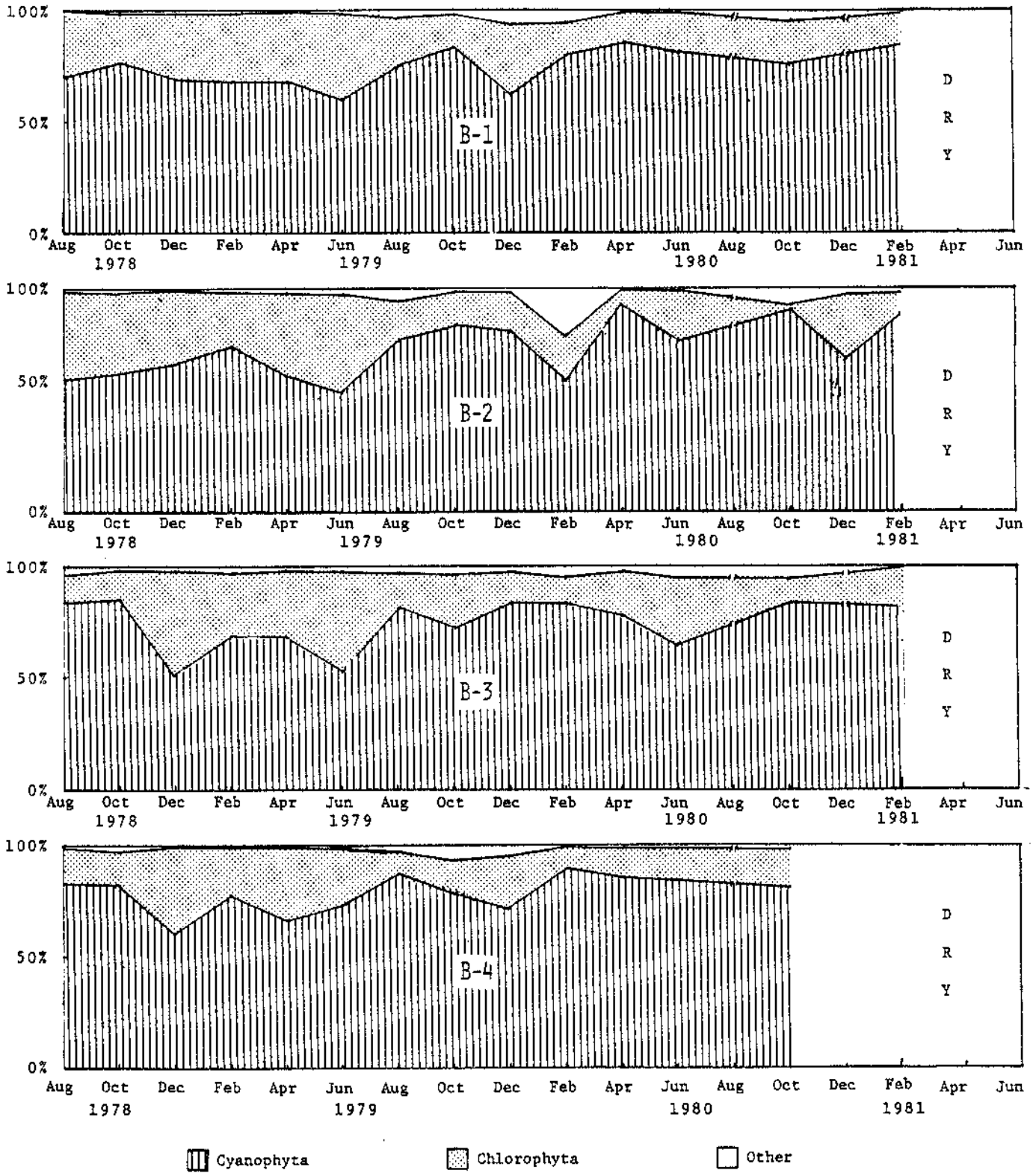


Fig. 6. Phytoplankton Percent Composition by Division at Ash Slough

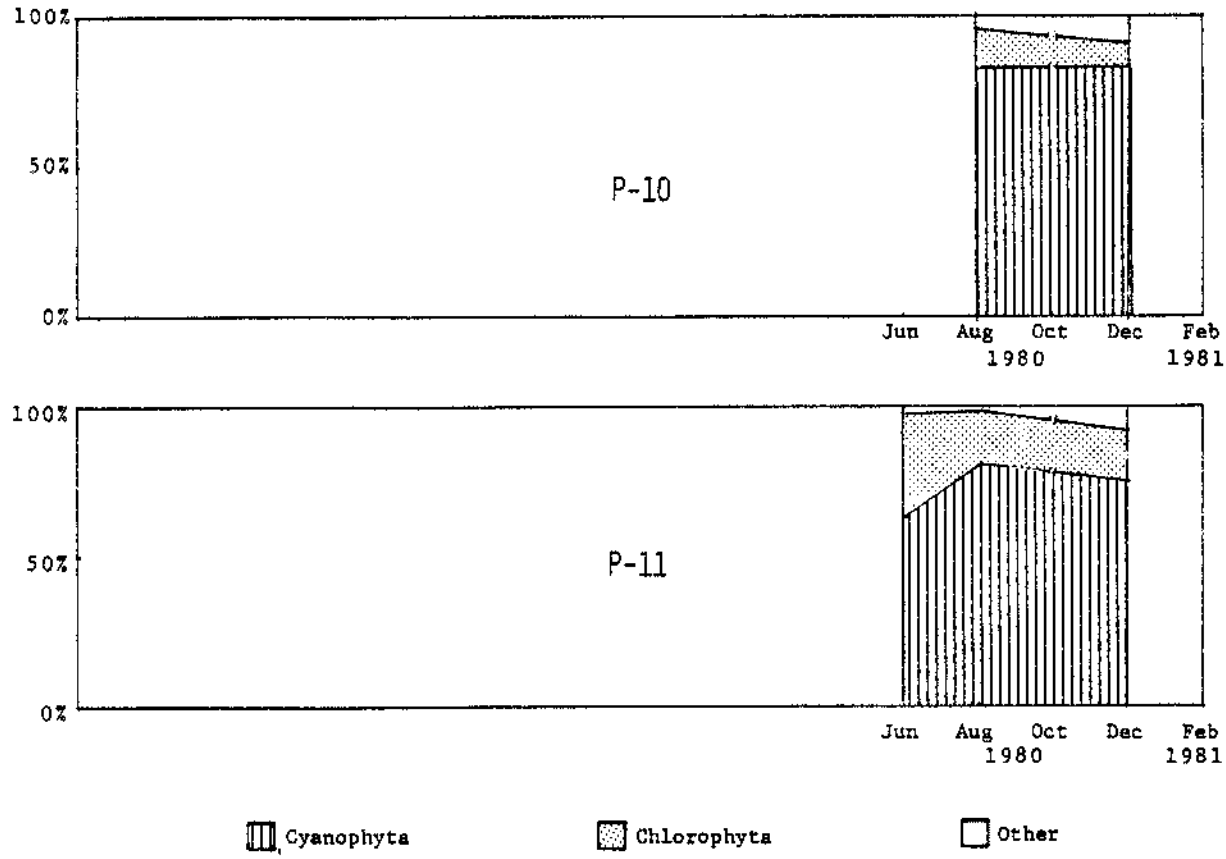


Fig. 7. Phytoplankton Percent Composition by Division at Pitmans Bay

B. Quantitative Characterization

Phytoplankton biomass expressed as phytoplankton proportional counts, chlorophyll a, and sestonic organic weight is presented in Figure 8 for Armstrong Slough, Ash Slough, and Pitmans Bay. At Armstrong Slough, biomass values were stable and displayed no seasonal differences, with highest values occurring the last year of study. Biomass values at Ash Slough varied considerably between sampling periods, but not on a seasonal basis. Though Pitmans Bay was sampled only twice, the phytoplankton values obtained from this site were very similar on both occasions.

Lack of seasonal patterns with regard to both generic composition and phytoplankton biomas parameters suggests that phytoplankton communities were responding to factors other than climate. Water level fluctuation, nutrient concentrations, or biotic interactions may be responsible for such phytoplankton biomass changes in the wetlands.

Comparison of biomass values from the three areas indicates that levels of phytoplankton biomass at Armstrong Slough and Pitmans Bay were similar. T-tests showed, however, that Ash Slough had significantly higher (P's<.05) phytoplankton counts, chlorophyll a and sestonic organic weight than did the other two wetlands. These higher values were likely the result of the higher ambient nutrient concentrations detected at Ash Slough (Figure 8).

Phytoplankton biomass parameters at Armstrong Slough's most upstream station, M-8, are compared with the outfall station M-5, in Figure 9. Prior to plug installation, the statistical means for phytoplankton biomass indicators were slightly higher at M-5 than at M-8. For example, pre-plug means for algal counts and chlorophyll a at M-8 were 180,000 cells/ml and 2.86 mg/m^3 respectively, while algal counts and chlorophyll a values at M-5 were 208,000 cells/ml and 3.41 mg/m^3, respectively. Post-plug mean algal counts and chlorophyll a values for M-8 were 268,660 cells/ml and 9.5 mg/m^3 while those at M-5 were 256,617 cells/ml and 5.3 mg/m^3 respectively. Although the trend of effectively decreasing phytoplankton biomass from input to outfall in the wetland seems genuine, too few post-plug sampling points exist to obtain statistical significance at the 95% confidence level.

Shown in Figure 10 are comparisons of phytoplankton biomass parameters at Ash Slough station B-4, above the pasture outfall, and station B-2, downstream of the pasture outfall. Means for phytoplankton algal counts, chlorophyll a, and ash free dry weights were higher at B-2 than at B-4, although not significantly (p>.05). The data suggest that the higher biomass downstream of the pasture outfall may be the result of the nutrient input associated with cattle grazing activity and run-off from the improved pasture.

Phytoplankton gross primary productivity data for all three sites are presented in Figure 11. Although Armstrong Slough displayed no seasonal trends, the highest productivity values at Ash Slough were found in October for two consecutive years. Whether this is a function of seasonal climatic conditions or some other influence, such as

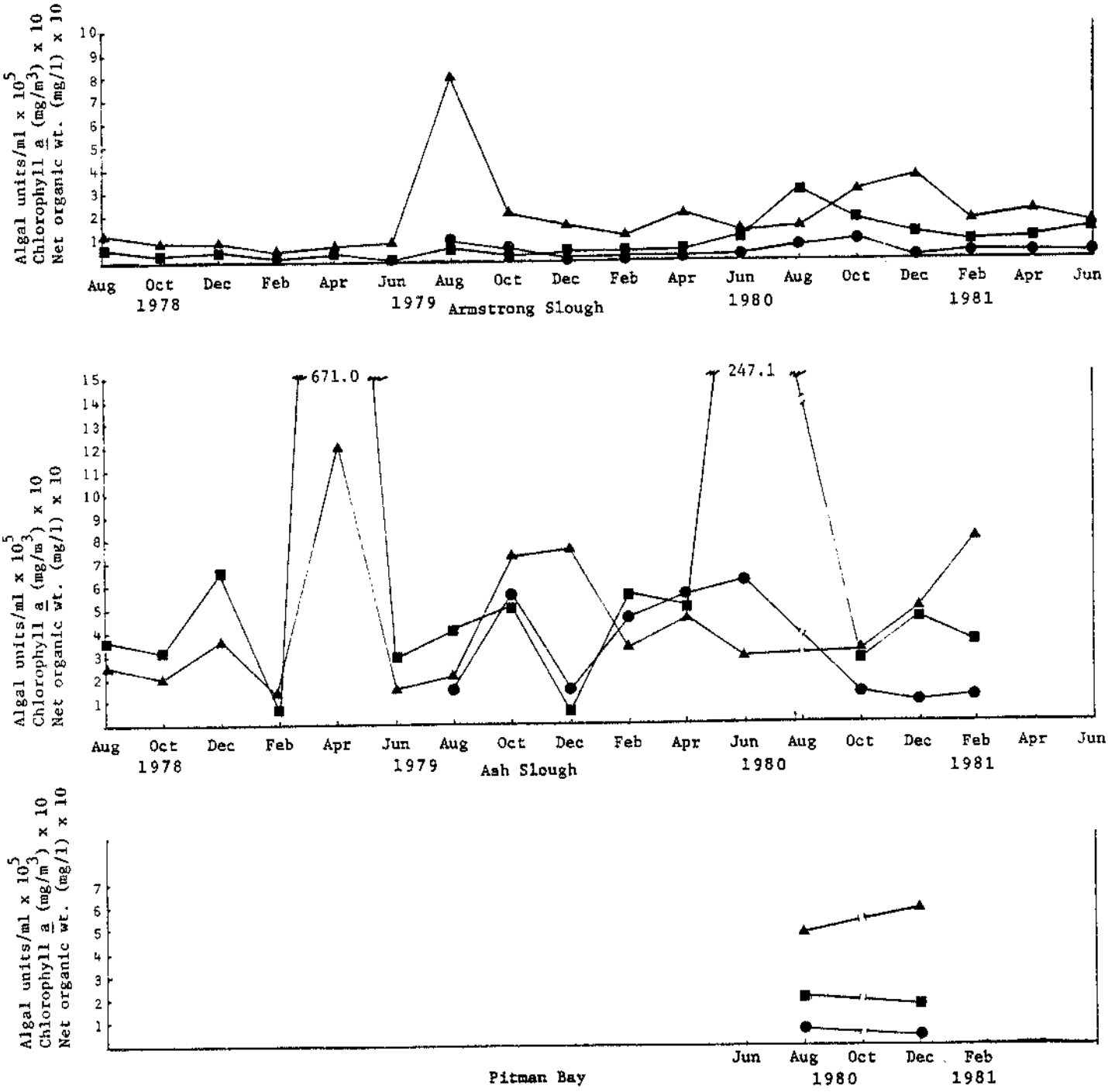


Fig. 8. Average Phytoplankton Biomass Parameters at Armstrong and Ash Sloughs and Pitmans Bay

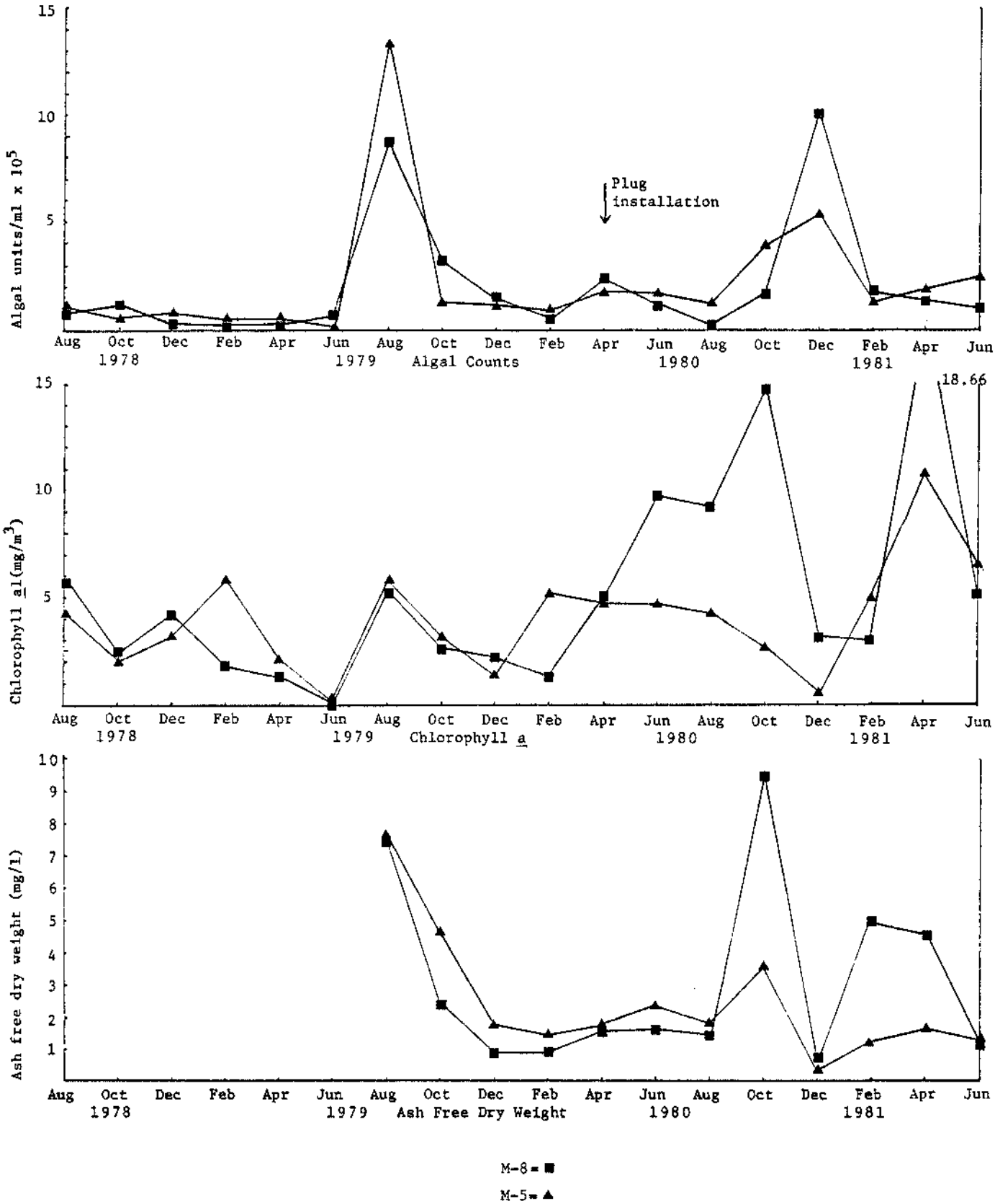


Fig. 9. Comparison of Phytoplankton Biomass Parameters at Armstrong Slough, Between Upstream Station M-8 and Downstream Station M-5, Before and After Channel Plug Completion

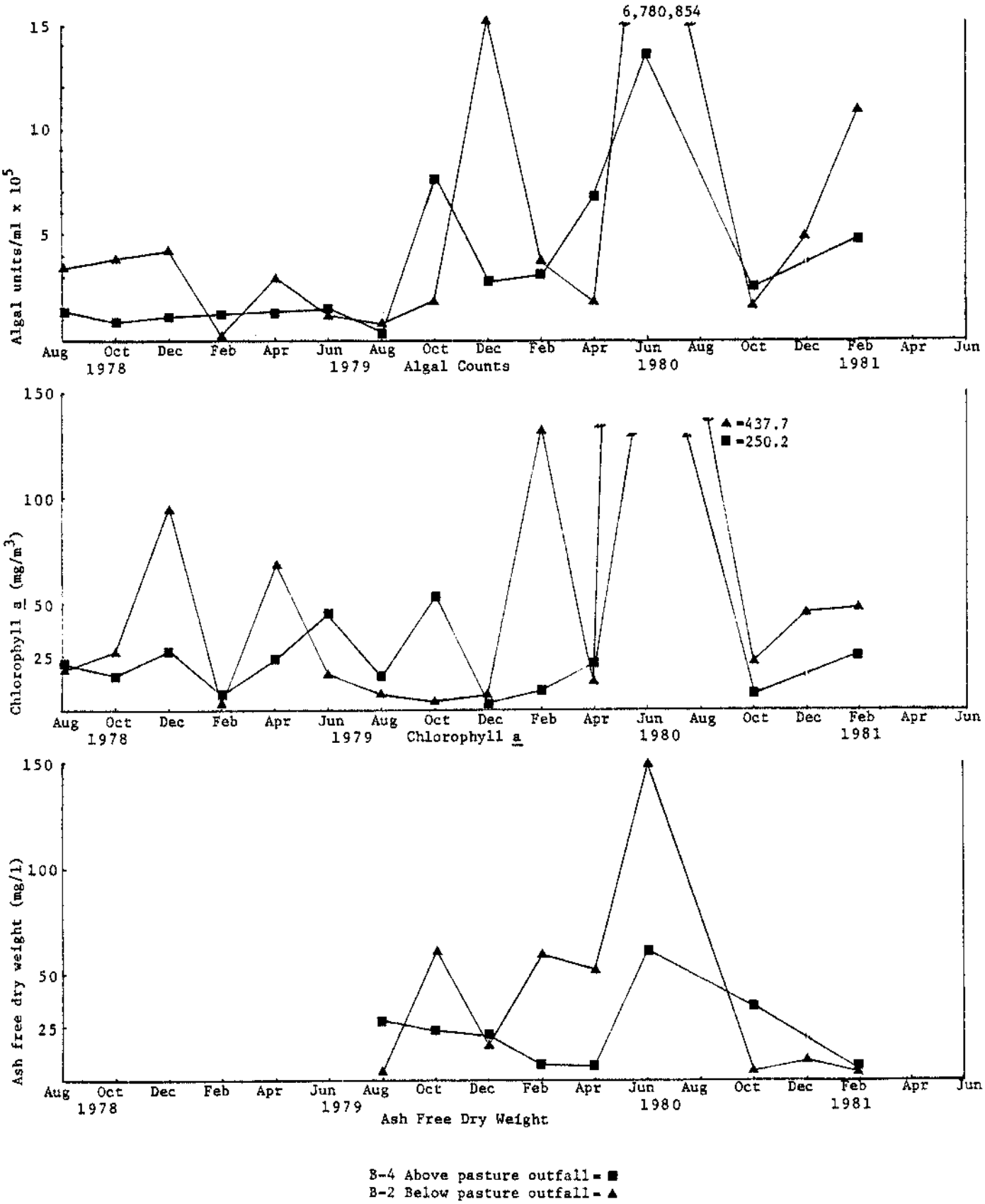
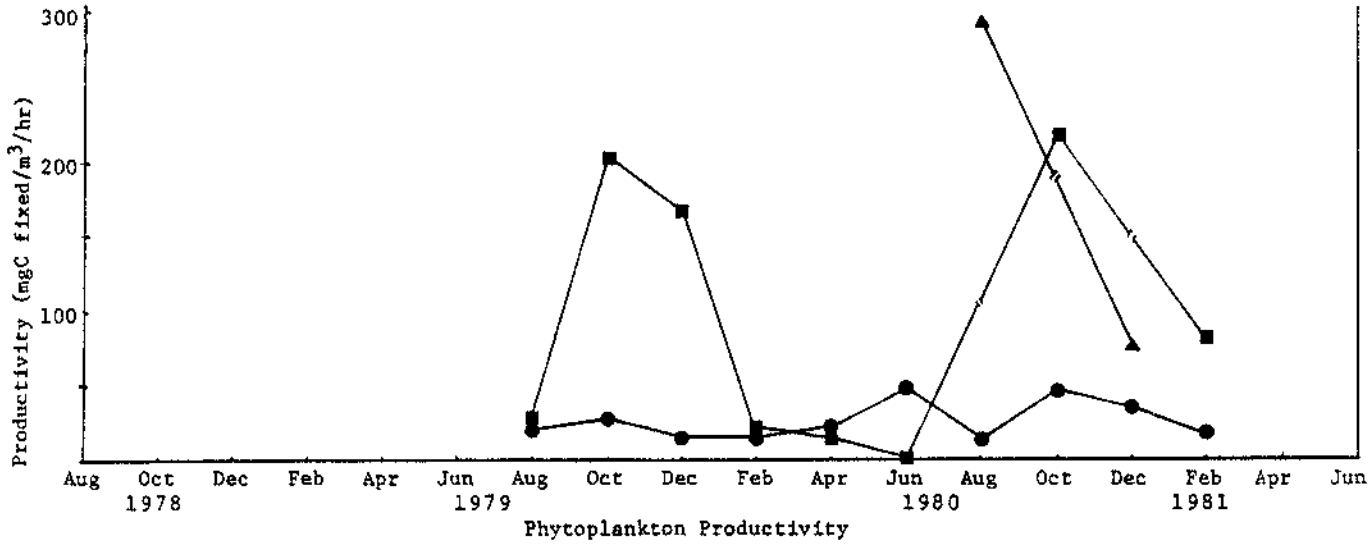
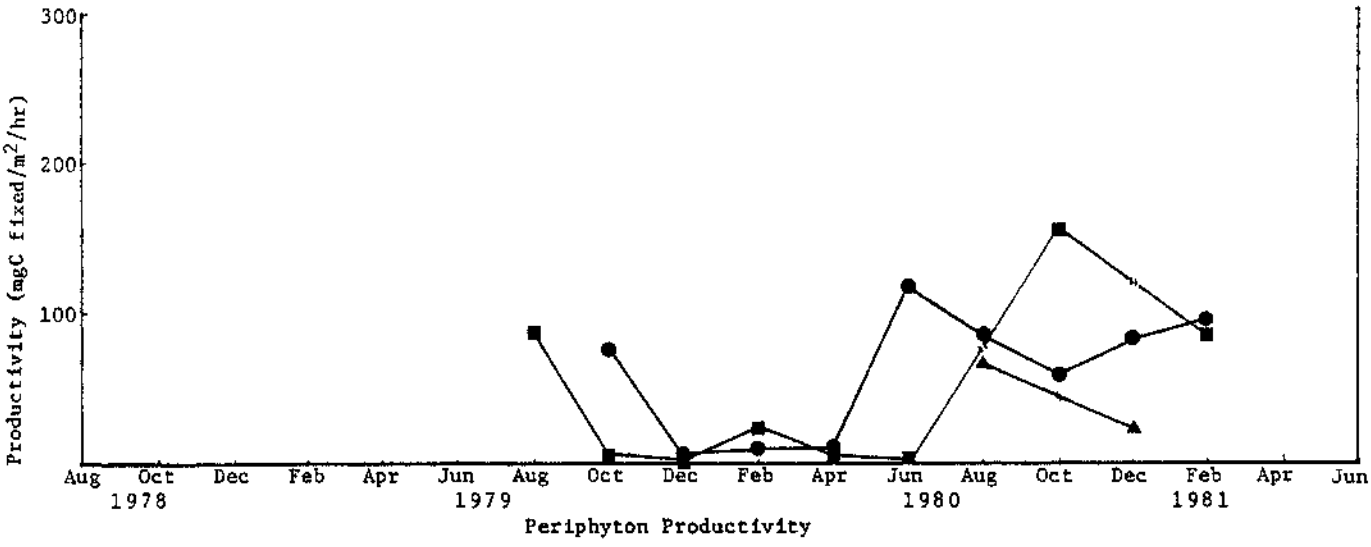


Fig. 10. Comparison of Phytoplankton Biomass Parameters at Ash Slough Stations B-4 and B-2





Armstrong Slough - ●
Ash Slough - ■
Pitman Bay - ▲

Fig. 11. Phytoplankton and Periphyton Primary Productivity at Armstrong Slough, Ash Slough, and Pitmans Bay

fertilization schedules of the surrounding pastures, is unknown. Productivity values at Armstrong Slough ranged from 15 mg C/m^3/hour to 49 mg C/m^3/hour, but were very similar from month to month. In contrast, Ash Slough's productivity exhibited more variability, ranging from 0.00 mg C/m^3/hour to 215 mg C/m^3/hour. Productivity of all three sites was highest at Pitmans Bay in August, 1980 (290 mg C/m^3/hour). The lowest productivity value noted at Pitmans Bay (75 mg C/m^3/hour) was still higher than any noted at Armstrong Slough. Additionally, producitivity at Ash Slough was also higher than at Armstrong Slough on all but two occasions.

Periphyton

A. Generic Characterization

Due to their sedentary nature, periphyton, unlike phytoplankton, are subject to additional environmental influences (Ruttner, 1968). Water levels and movements can influence, considerably, colonization rates and taxonomic composition of periphyton communities (McIntire, 1968, Hutchinson, 1975). Also, although they are usually dominated by diatoms, periphyton communities are generally quite diverse, often containing hundreds of taxa (Sládecková, 1962, Hutchinson, 1975).

A total of 137 different periphyton genera were identified at the three areas. A summary of the numbers of genera identified is presented in Table 4. A strong similarity in both kinds and numbers of taxa was noted between Armstrong Slough and Ash Slough, while fewer genera were identified from Pitmans Bay. Most of the genera found at the study areas were rare forms observed as few as one or two times. Thus, the relatively few genera found at Pitmans Bay may be related to the limited number of samples taken at this site. Chlorophycean genera were found in greatest abundance at all three sites, with over half the number of genera identified belonging to that division.

A list of genera and their relative distribution between the three systems is presented in the Appendix, Table A-2. The dominant genera noted at the three areas, based on proportional counts, included the blue-green algae Microcystis and Chroococcus and the green algae Gloeocystis and Oocystis. Microcystis is a planktonic algae and was the dominant phytoplankton at the study areas. Dominance of the periphyton community by Microcystis can be attributed to settling or entrapment on the slides and macrophytes, unlike true periphytic algae that attach to and colonize substrates (Young, 1945).

Unlike the phytoplankton, periphyton communities exhibited larger populations of filamentous and desmid green species as well as diatoms. Many of the genera identified in the current study were also noted in previous studies conducted by Browder and Brown (1979) in the Florida Everglades and by Zafar (1966) in fish ponds in Hyderabad, India. Both of these sites were nutrient enriched, the former by nonpoint source residential runoff and the latter by fertilizer, applied for experimental purposes.

Table 4. Number of Periphyton Genera Identified in Each Major Algal Division from August 1978 to June 1981.

Taxa	Armstrong Slough	Ash Slough	Pitmans Bay
Cyanophyta	24	17	10
Chlorophyta	67	56	22
Chrysophyta	9	7	4
Sub-Division Bacillariophyta:			
Order Centrales	2	2	0
Order Pennales	17	15	4
Cryptophyta	1	0	0
Euglenophyta	4	2	1
Pyrrhophyta	1	0	1
TOTAL	125	99	42

The similarity in dominant genera between Armstrong and Ash Sloughs, which are influenced by cattle production, and Pitmans Bay, which is unaffected, suggests that nutrient enrichment may have a limited effect upon the dominant periphyton genera in areas where blue-green algae are prevalent. No difference in generic occurrence or dominance was noted at Armstrong Slough after the water level was raised and the channel plug installed.

To ensure an accurate characterization of the attached algal community, the predominant macrophytes at each station of Armstrong and Ash Sloughs were collected and generic identification of the epiphyton performed during spring of 1979. A list of taxa identified, including the macrophytes on which they occurred, is presented in Table A-3 of the Appendix. A majority of the taxa were found on both the artificial and natural substrates that were analyzed from both sites. This similarity in periphytic colonization on vegetative and artificial substrates has been noted by a large number of authors (reviewed by Sládečkova, 1962; Hutchinson, 1975).

Although diatoms were not found in numbers as large as in many other periphyton studies (e.g., Patrick and Reimer, 1966), they are important indicator organisms. Table A-4 of the Appendix lists the diatom species identified from samples taken in the first year of study at

Armstrong and Ash Sloughs. The most common diatoms at both sites were Eunotia pectinalis, Gomphonema augustatum, two species of Navicula, and two species of Nitzschia. These genera have been found to be characteristic of eutrophic waters (Patrick, 1945). Also, many of the genera found, such as Achnathes, Cocconeis, Cymbella, Gomphonema are rheophils. These are diatoms that are able to secrete a gelatinous stalk or mass which allows them to survive periodic desiccation (Godwald, 1937).

Data on the relative abundance of the major taxonomic divisions are presented in Figures 12, 13, and 14 for Armstrong Slough, Ash Slough and Pitmans Bay, respectively. A strong similarity exists between the phytoplankton and periphyton communities at the three areas, in that blue-green genera are dominant throughout the year with green genera following in abundance. Genera from other divisions were more prevalent in the periphyton than the phytoplankton. Channel stations at Armstrong Slough (Figure 12) experienced spring increases in diatom populations and concurrent decreases in blue-green populations. Alteration of the flow characteristics had no noticeable effect on community composition. Additionally, community composition data at Ash Slough (Figure 13) did not exhibit any seasonal trends. Stations located below the pasture outfall (B1, B2, and B3) were similar in generic composition to the station above the outfall (B4). This suggests that nutrient additions may have little effect on the algal community composition in this area. The community composition at Pitmans Bay (Figure 14) is similar to the other two sloughs. Again, this suggests that nutrient loading may not alter community composition in systems where blue-green genera are dominant.

B. Quantitative Characterization

Periphyton biomass estimates which were made during this study include algal counts, phaeophytin corrected chlorophyll a, and ash free dry weight determinations. Linear regressions performed on these data (see Appendix Figures A-5, A-6, and A-7) indicate highly significant positive correlations ($r's > .37$, $p's < .001$) among the three parameters. Positive correlations between chlorophyll and other biomass estimates were also found by Kurasawa (1959), Grzenda and Brehmer (1960), Wetzel (1963), and Cushing (1967). Additionally, highly significant positive correlations ($r's > .61$, $p's < .001$) were found between top and bottom periphyton biomass parameters indicating analogous trends in growth. However, a T-test comparing individual parameters showed that top samples were statistically greater ($p < .001$ in all three tests) in periphyton biomass than bottom samples, which suggests light limitation.

Periphyton biomass seasonal trends for the three areas are shown in Figure 15. Biomass estimates for the three types of analyses are plotted as an average for the water column and as an average for all stations. Periphyton biomass at Armstrong Slough (Figure 15), before the flow alteration in April, 1980, increased in the winter and was lowest in the summer. A T-test of seasonally grouped biomass parameters confirmed this observation ($p's < .05$). However, after channel plug installation, periphyton biomass remained relatively constant on a seasonal basis. Biomass levels at Ash Slough fluctuated between seasons and years with highest values occurring in the third year of study, although only a few samples

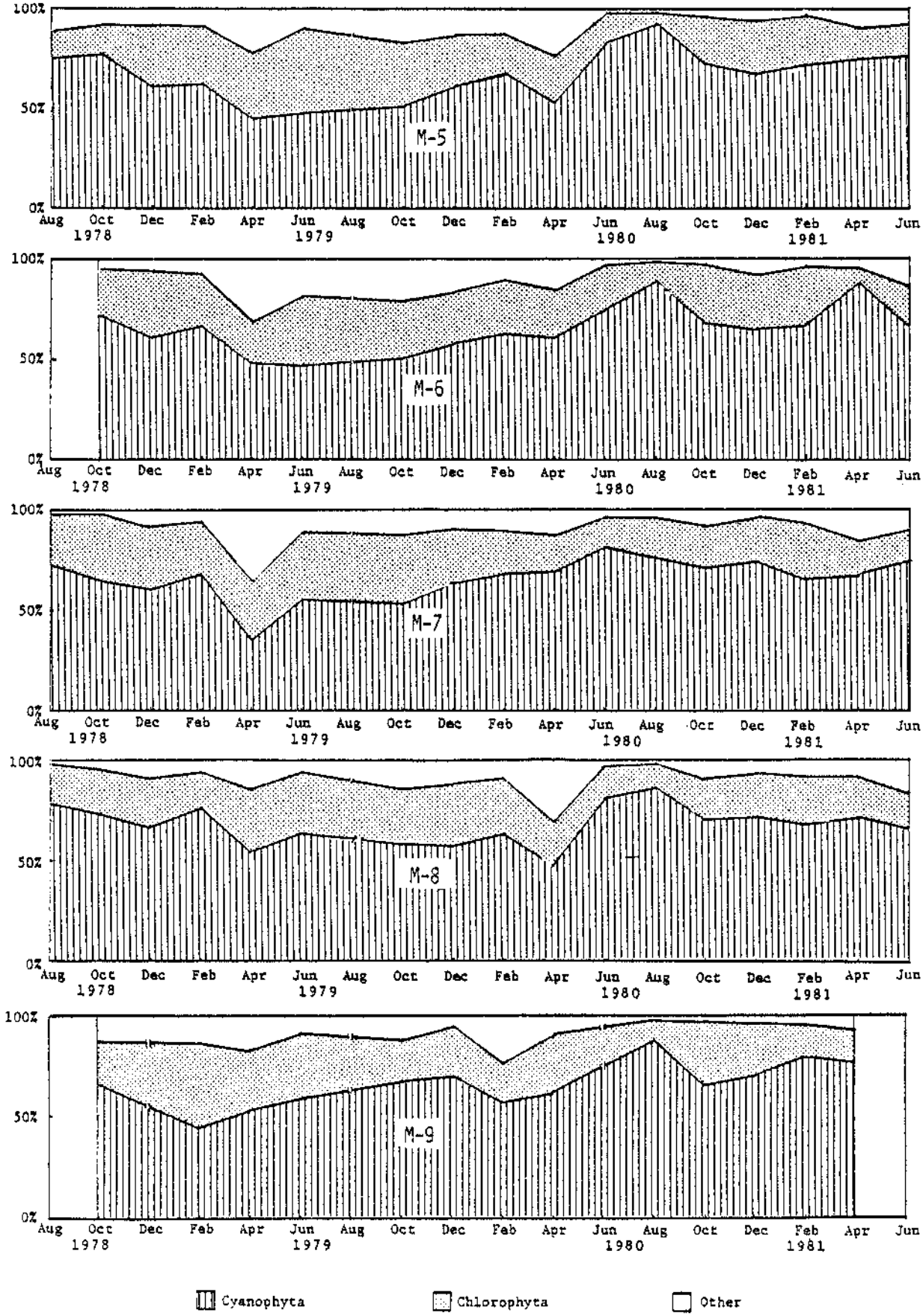


Fig. 12. Periphyton Percent Composition by Division at Armstrong Slough

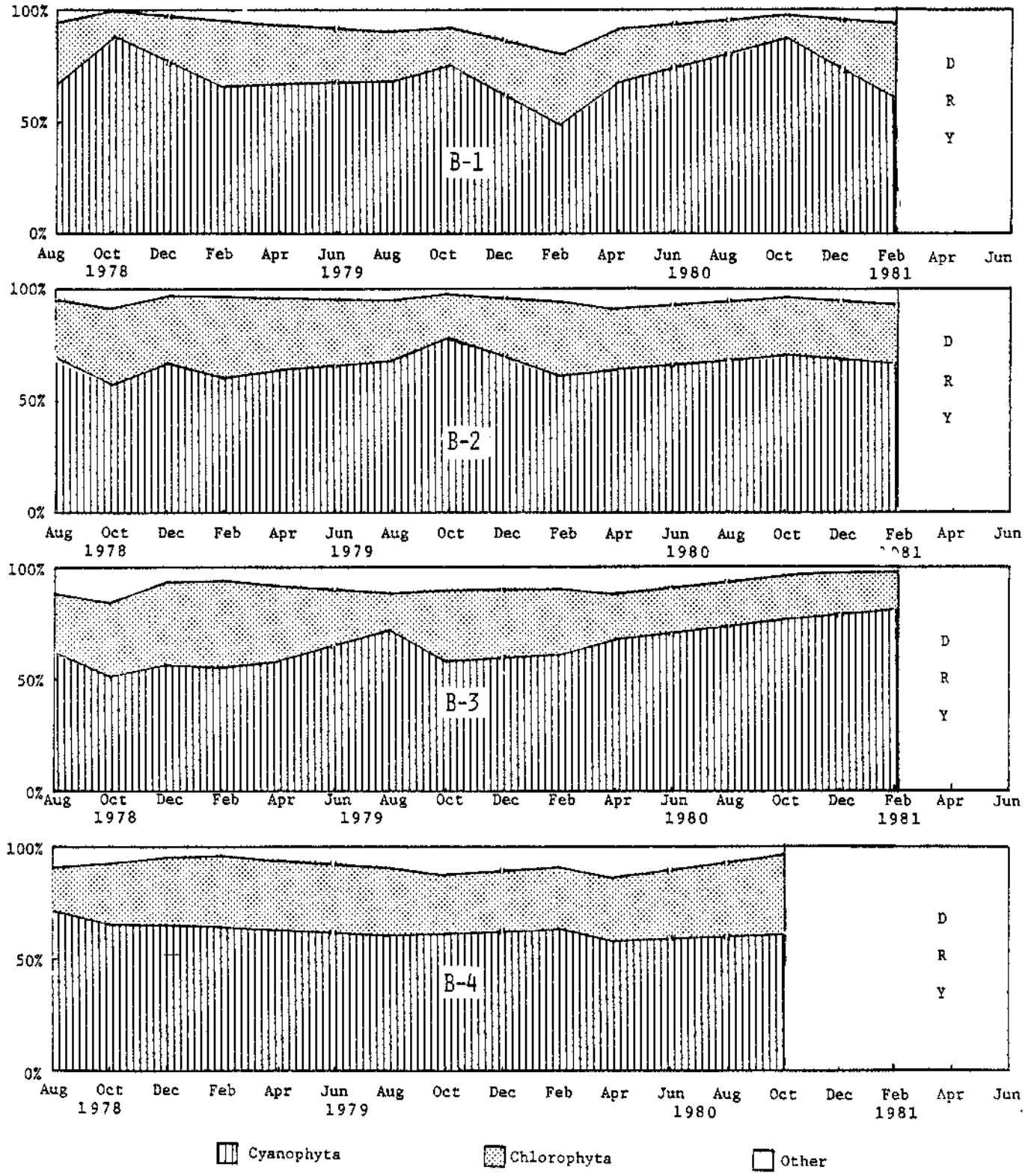


Fig. 13. Periphyton Percent Composition by Division at Ash Slough

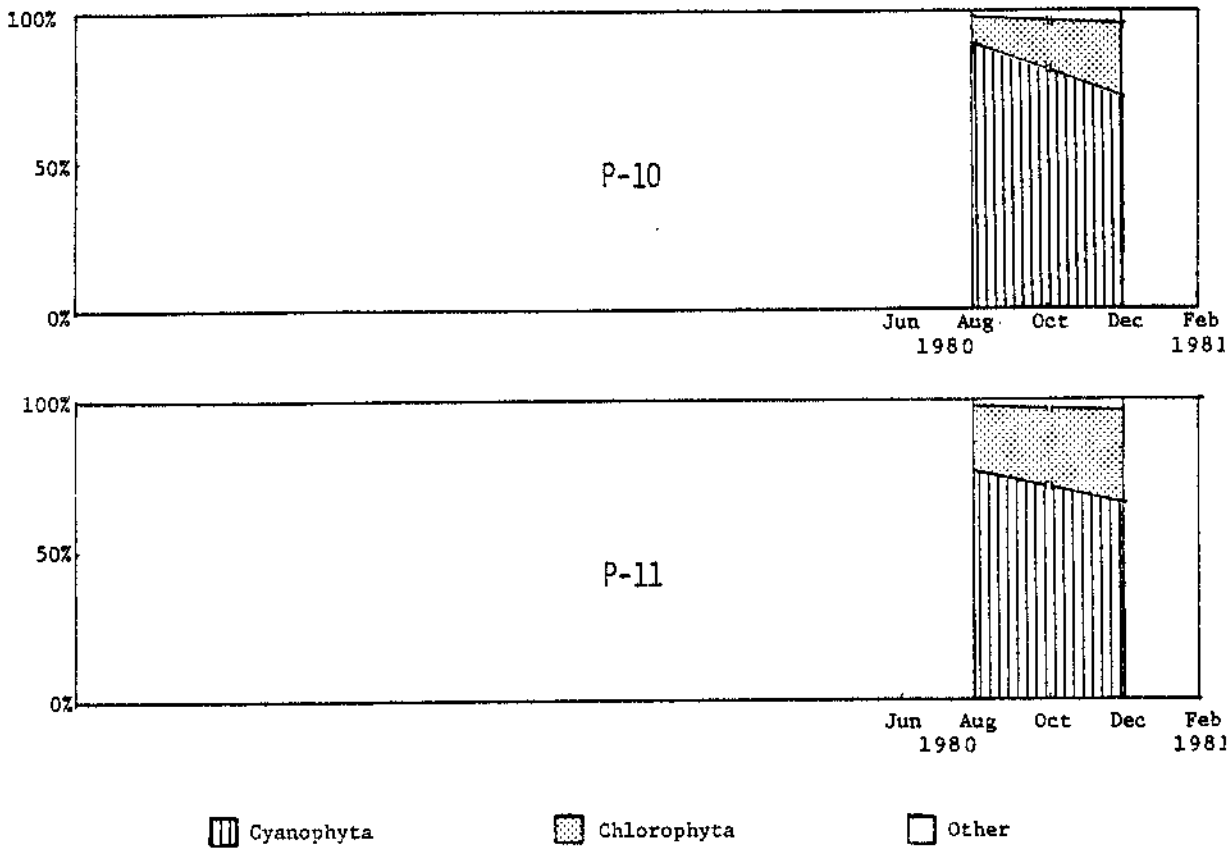


Fig. 14. Periphyton Percent Composition by Division at Pitmans Bay

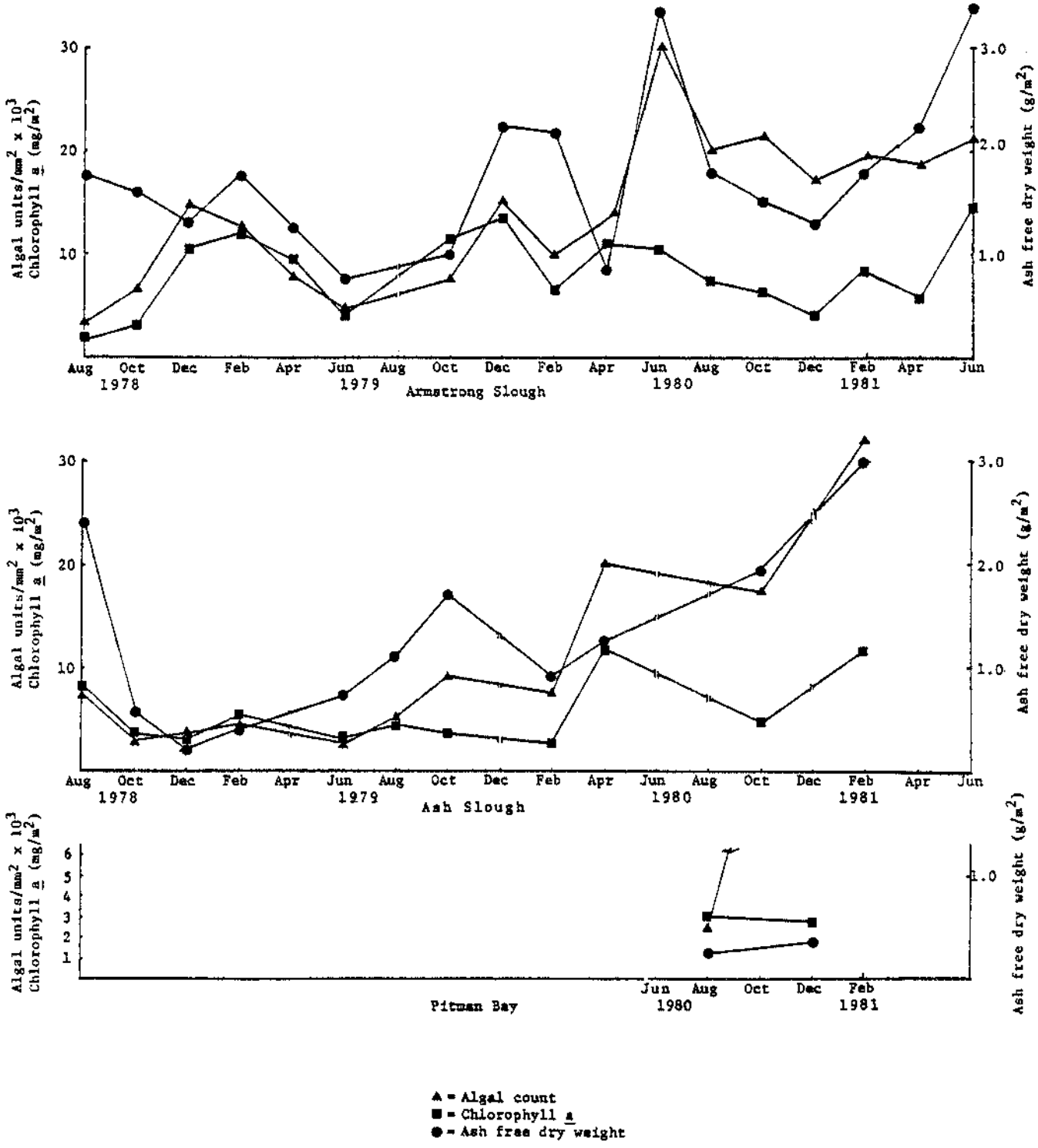


Fig. 15. Average Periphyton Biomass Parameters at Armstrong and Ash Sloughs and Pitmans Bay

were collected that year. Periphyton biomass levels at Pitmans Bay were similar to levels in the other systems, for the two months the Bay was sampled. Spring biomass maxima, as suggested in the literature (Wetzel, 1975), were not noted in this study, perhaps due to the relatively stable year-round temperatures and longer periods of sunlight available in Florida (Brezonik et al., 1969).

Comparisons of periphyton biomass among stations in Armstrong Slough were made to evaluate the community reaction to the altered flow regime. Figure 16 presents a comparison of periphyton biomass parameters for the upstream station M-8 and outfall station M-5, averaged through the water column. Changes in the biomass at M-5 after plug installation, were not evident. Although chlorophyll a levels were lower at M-5 than at M-8 for five sampling months after plug installation, the difference in mean values were not statistically significant (at the 95% level), based on a T-test.

Intra-area comparisons at Ash Slough were made to assess the effect of pasture land outfall on periphyton biomass. Biomass parameters for station B-4 above the outfall and station B-2 below the outfall are presented in Figure 17. Although the number of samplings was limited at this area due to frequent dry conditions, the amount of periphyton was greater below the outfall. A T-test of the means showed that the differences between B-4 and B-2, for algal counts and ash free dry weights, were statistically significant at the 95% confidence level.

Periphyton biomass was significantly higher at Armstrong Slough than at Ash Slough based on a one-tailed T-test ($p's<.05$). Differing flow and water level regimes between Armstrong Slough and Ash Slough probably account for the observed difference. Increasing flow rates which result in concurrent increases in periphyton biomass are well documented (Ho, 1967; McIntire, 1968; Moore, 1977; Palmer, 1977; Rickert et al., 1977) and our data suggest similar conclusions for the communities in our study. However, some generalities can be made. No seasonal trends were evident at either Armstrong or Ash Slough. Also, production rates at Pitmans Bay were lower than the other areas for the two times the rates were determined. Interestingly, productivity at Armstrong Slough increased after plug installation (April, 1980) and stayed high for the remaining five sampling months. Most likely, this is related to the different flow regime (increased contact area) created by plug installation.

Water Chemistry

Algal growth is related to, and dependent upon, the chemical constituents of the water column (Eyster, 1964). Of greatest concern are the concentrations of major nutrients, primarily forms of nitrogen and phosphorus, since they are most often limiting to algal growth and consequently have the largest effect on algal biomass and productivity (Fuhs, 1969; Thomas, 1969; Miller and Maloney, 1971; Specht, 1975).

Seasonal fluctuations in water column concentrations of nitrogen and phosphorus for all three study areas are presented in Figure 18. Low to moderate levels of nitrogen and phosphorus were noted at Armstrong

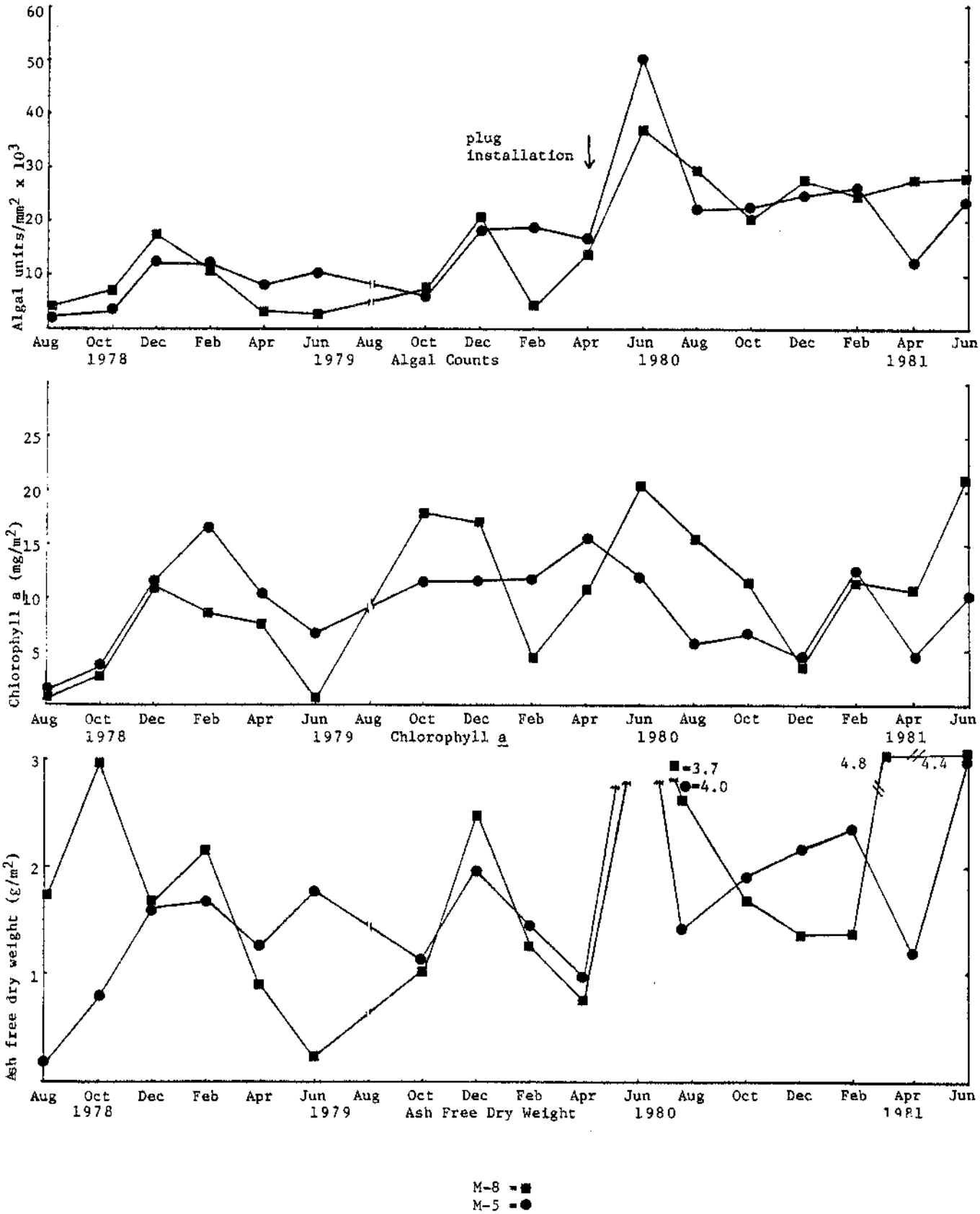
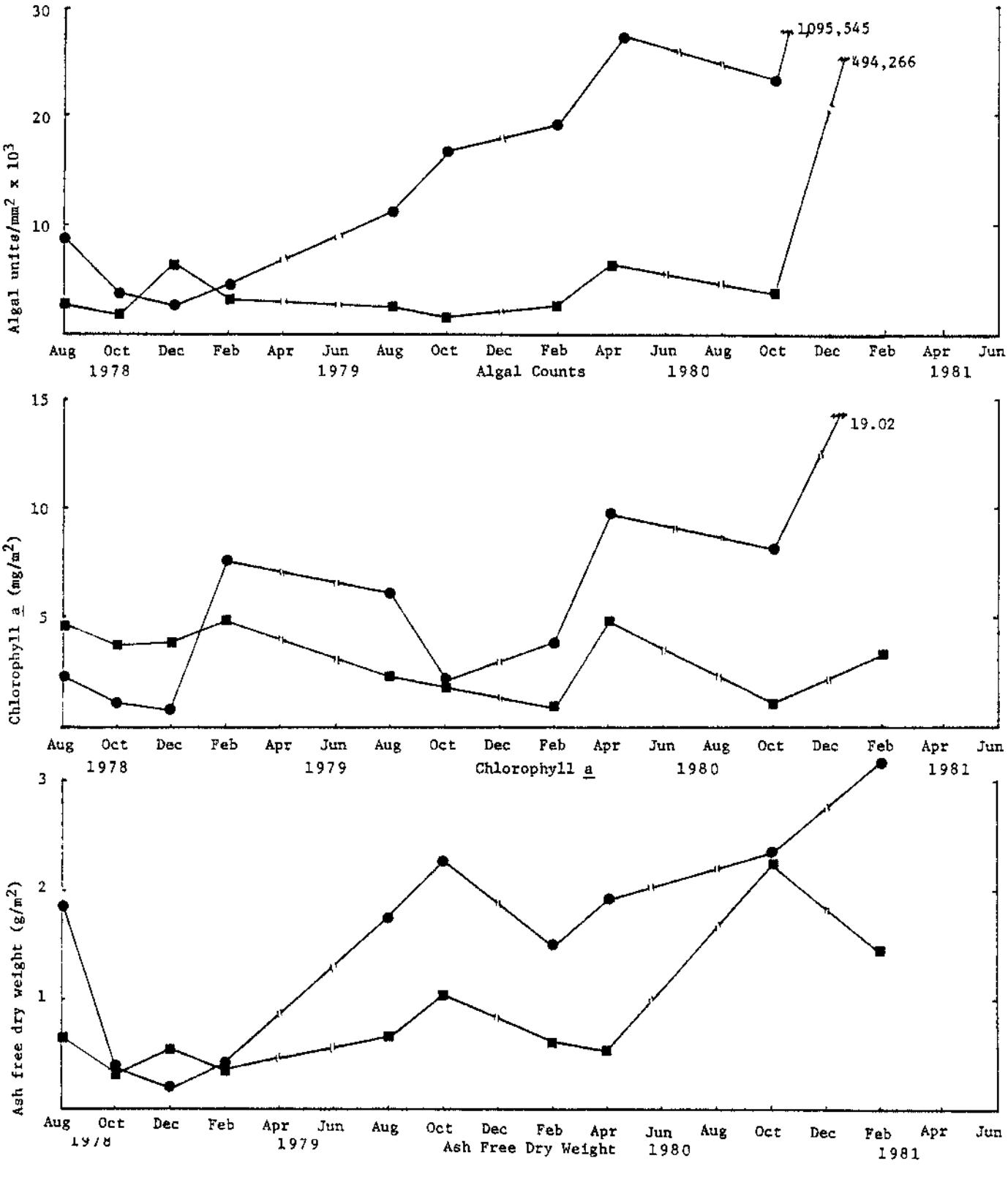


Fig. 16. Comparison of Periphyton Biomass Parameters at Armstrong Slough, Between Upstream Station M-8 and Downstream Station M-5, Before and After Plug Completion



B-4 above pasture outfall = ■
B-2 below pasture outfall = ●

Fig. 17. Comparison of Periphyton Biomass Parameters at Ash Slough Stations B-4 and B-2

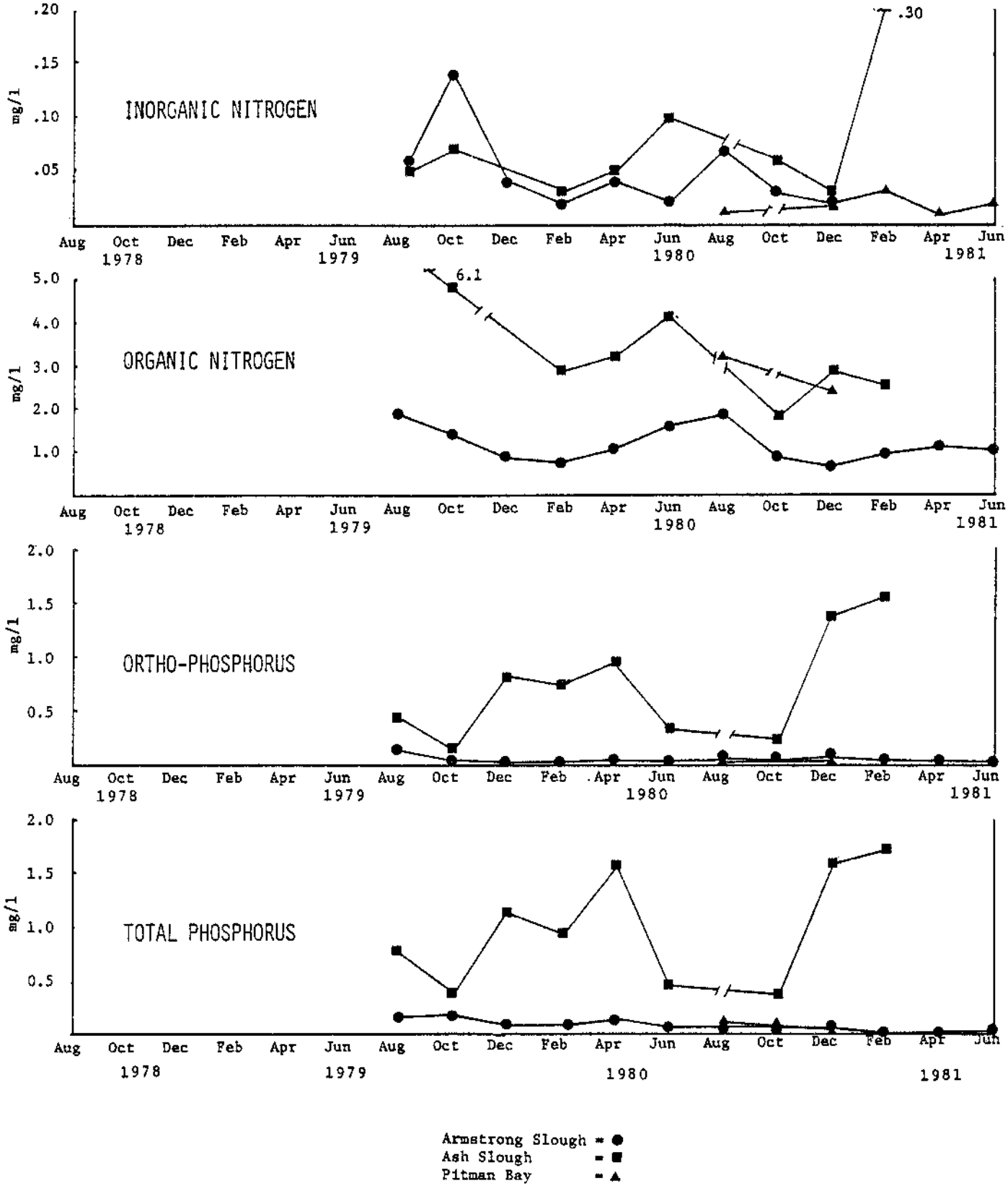


Fig. 18. Average Nutrient Concentration at Armstrong Slough, Ash Slough, and Pitmans Bay

Slough, and changes in concentrations between samplings were minimal. Concentrations of ortho-phosphate, total phosphorus, and total nitrogen were high at Ash Slough and large fluctuations in concentrations were frequently noted between samplings. Inorganic nitrogen levels were relatively low and the percentage of ortho to total phosphorus was high. Other investigators have found similar results in areas used for beef cattle production (Filip and Middlebrooks, 1976; Mudrock and Capobianco, 1979; Goldstein et al., 1980; and Ulevich, 1980). Concentrations of phosphorus and inorganic nitrogen at Pitmans Bay were consistently low.

Figure 19 shows the major forms of nitrogen and phosphorus for stations M-8 (upstream) and M-5 (outfall) at Armstrong Slough (note the expanded scale). Before plug installation, the variations in nutrient concentrations at M-5 fell slightly and then remained constant whereas nutrient concentrations entering the system at M-8 continued to fluctuate.

Comparisons of nutrient concentrations, at Ash Slough, above (B-4) and below (B-2) the pasture outfall respectively, are presented in Figure 20. Means of inorganic and organic nitrogen values were higher at station B-2 than at B-4, although the difference was not statistically significant. However, means of ortho and total phosphorus concentrations were approximately thirty times greater below the outfall (B-2) and the difference, based on a T-test, was highly significant ($p<.01$). This suggests that cattle grazing and the associated runoff contributes significant amounts of nutrients to the Ash Slough system.

Algal Assay

Concentrations of nitrogen and/or phosphorus are the most common algal growth limiting factors (Fuhs, 1969; Weiss, 1970; Miller and Maloney, 1971; Schindler, 1971; Hannan et al., 1973; Miller et al., 1974; Karlgren and Ljungstrom, 1975). Generally, natural freshwater algae are phosphorus limited (Shapiro, 1970; Schelske and Stroemer, 1972; Stumm and Stumm-Zollinger, 1972). However, water subjected to nutrient enrichment will often shift towards nitrogen limitation (Gerloff and Skoog, 1957; Lange, 1971; Hannan et al., 1973). Much of the artificial enrichment in central Florida waters comes from cattle production and the attendant animal waste that contributes high levels of both organic and inorganic phsophorus (Davis and Marshall, 1975; Filip and Middlebrook, 1976; Dye and Jones, 1978).

Algal assays were performed to identify the growth limiting nutrient(s) at out study sties. Figure 21 presents the results of an assay, performed in December, 1980, on samples taken from Armstrong Slough. These results are typical of the other assays we performed using water from this site, and indicate a nitrogen-phosphorus co-limitation. This category of nutrient limitation indicates moderate nutrient enrichment (Miller et al., 1978).

Figure 22 presents October, 1980, algal assay results from Ash Slough which are representative of other assay results from this site. This area was strongly nitrogen limited. This result is not surprising since concentrations of bioavailable nitrogen were low at this site while

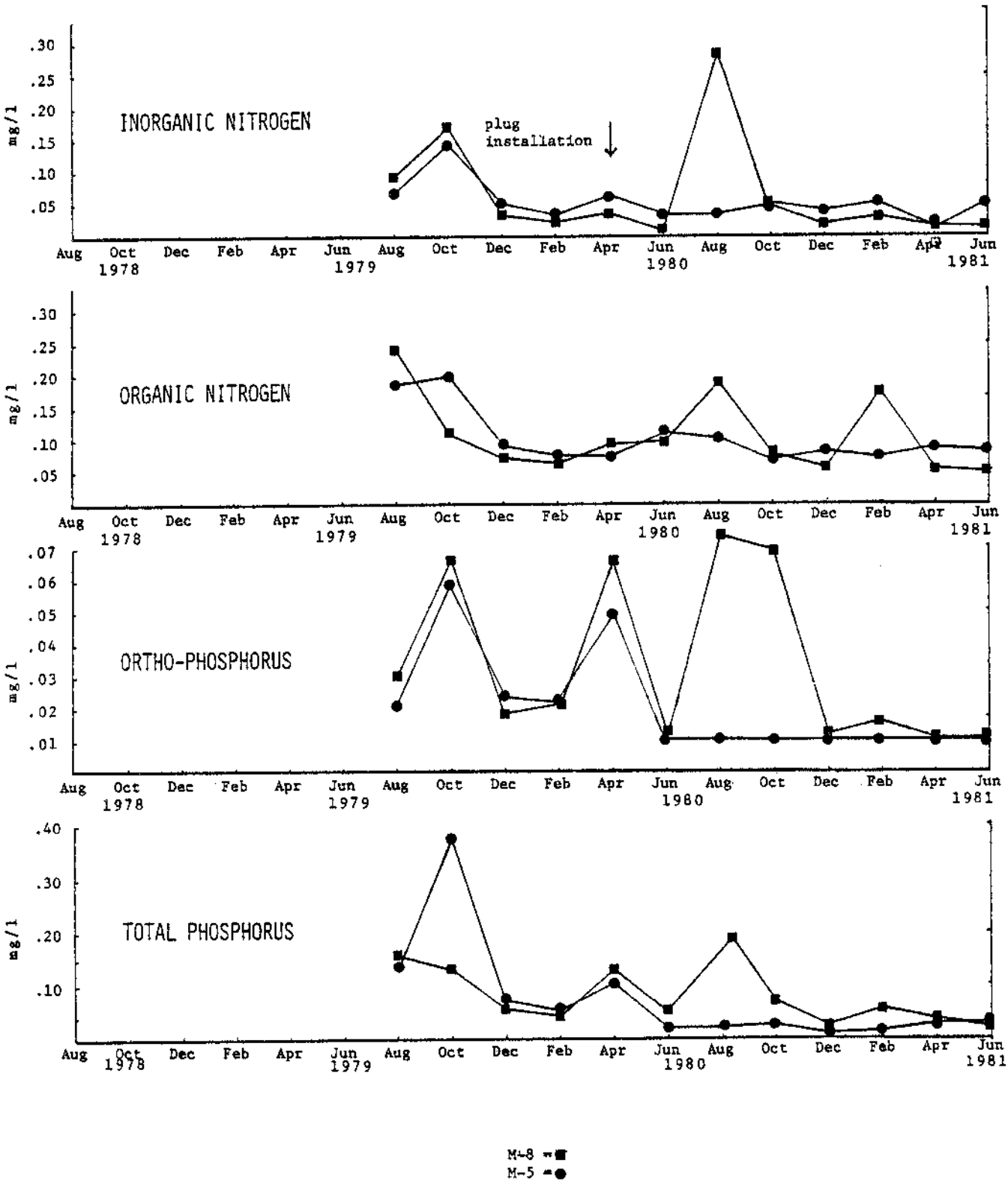


Fig. 19. Comparison of Nutrient Concentrations at Armstrong Slough, Between Upstream Station M-8 and Downstream Station M-5, Before and After Plug Completion

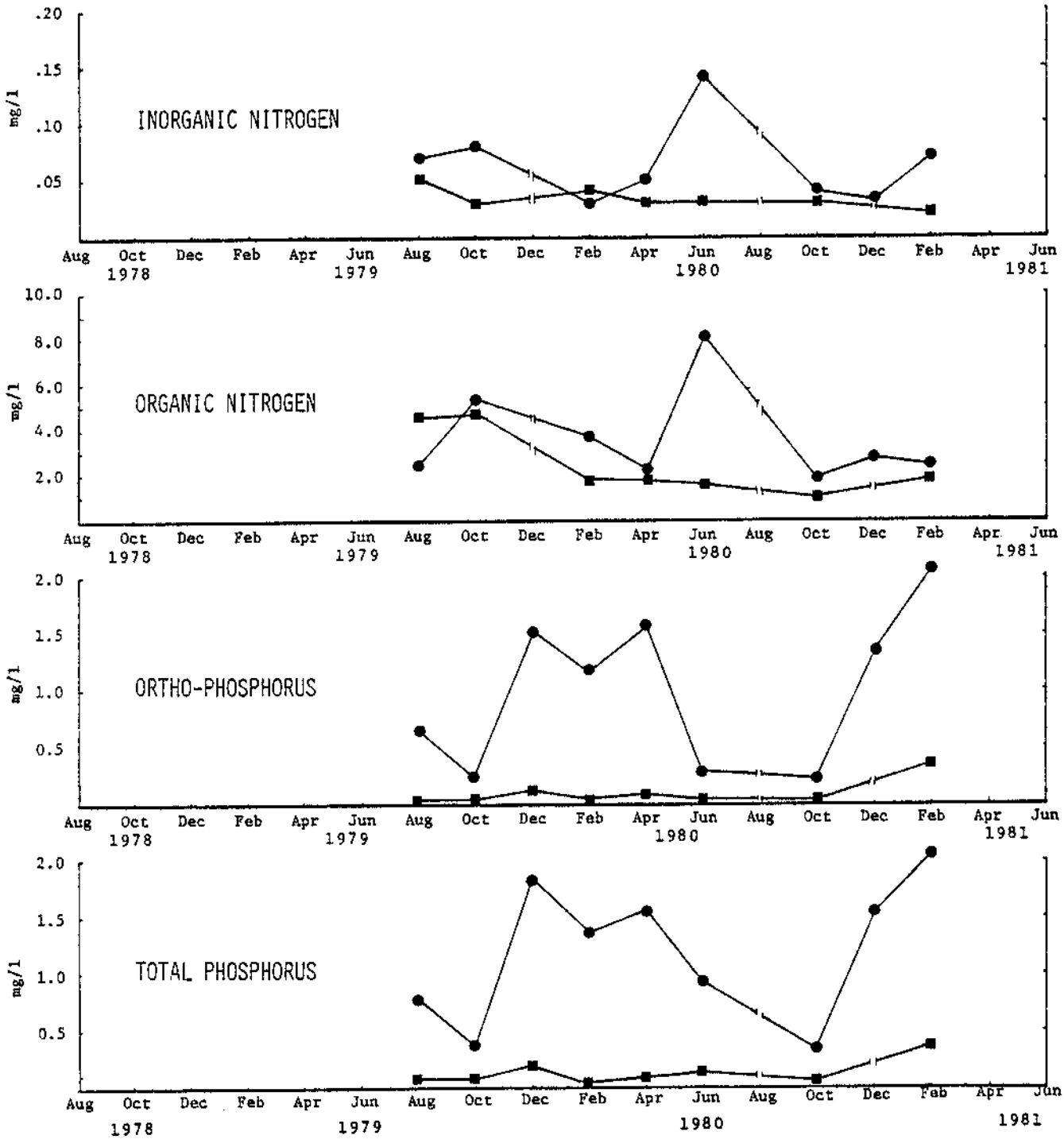


Fig. 20. Comparison of Nutrient Concentrations at Ash Slough Stations B-4 and B-2

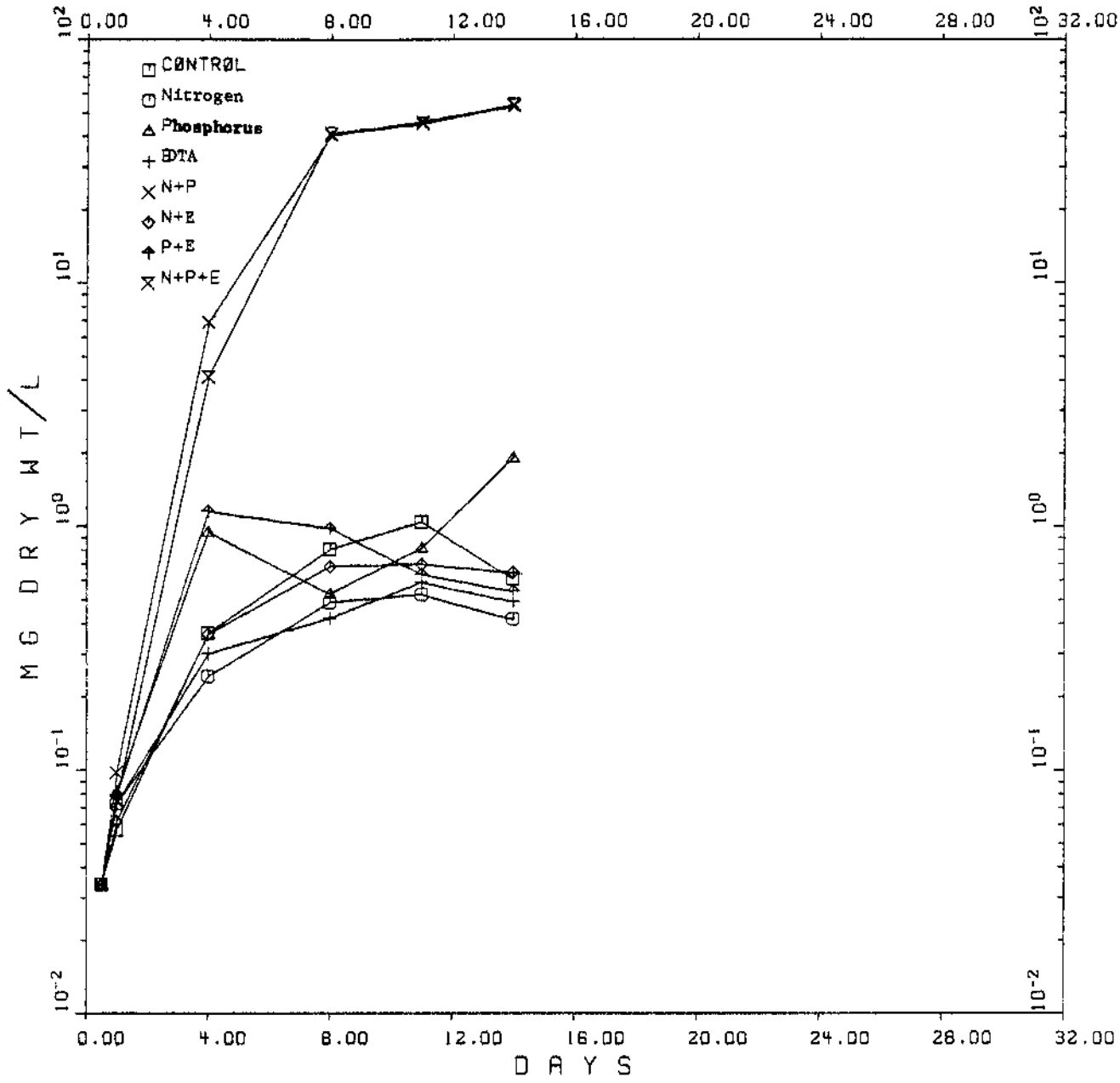


Fig. 21. Algal Assay Results for Armstrong Slough, December, 1980

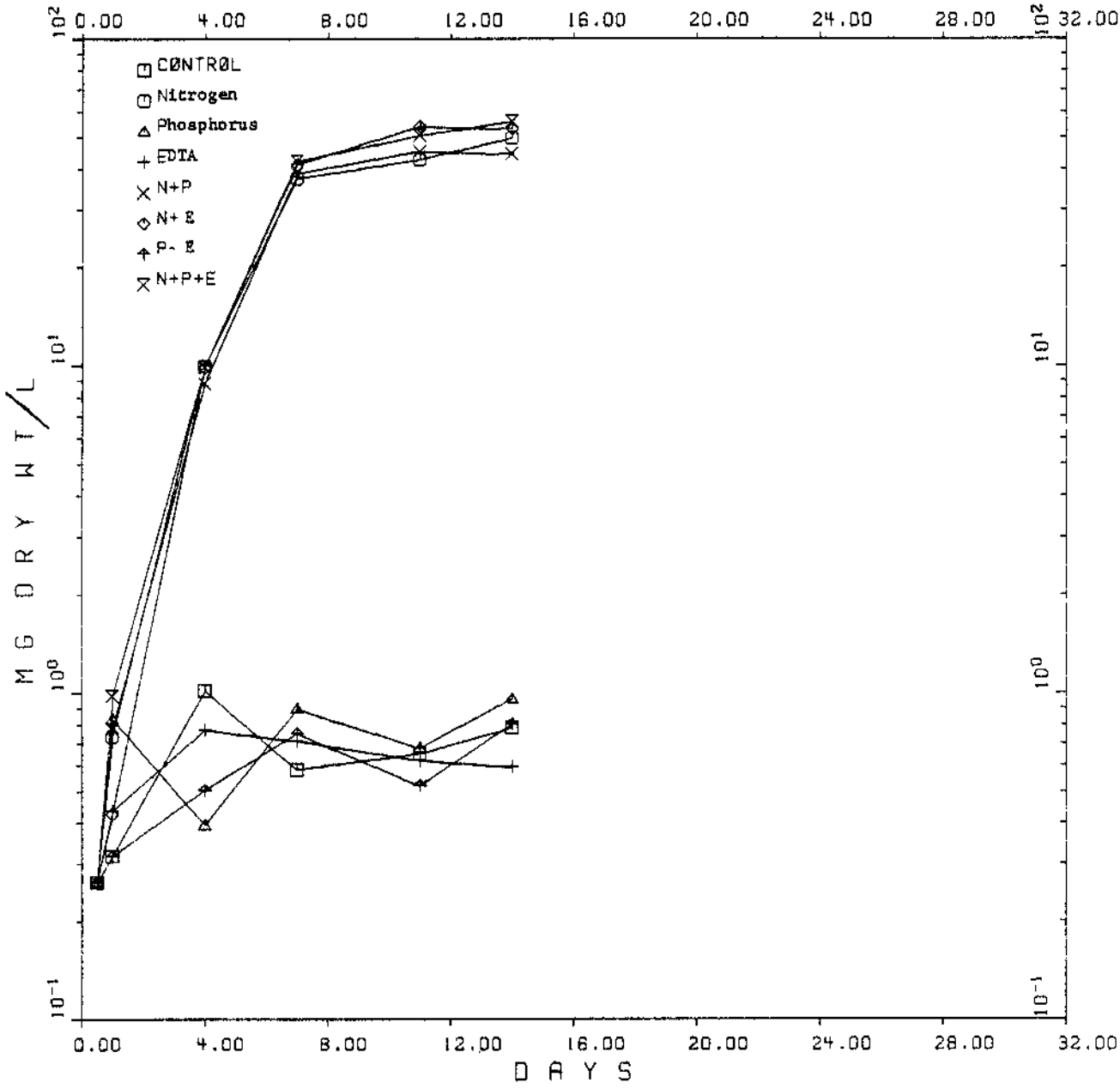


Fig. 22. Algal Assay Results for Ash Slough, October, 1980

ortho-phosphorus concentrations were very high. These data suggest that algal growth at Ash Slough is being significantly affected by the agricultural practices (i.e., cattle production) in this area.

Community Metabolism

Community metabolism experiments quantify the oxygen production and utilization of the aquatic community, including both producer and consumer organisms. Gross community phytosynthesis and production/respiration ratios for the three sites are presented in Figure 23. Armstrong Slough exhibited the greatest production, ranging from 11.79g O_2/m^2/day in February, 1980, to 81.65g O_2/m^2/day in August, 1980. Production values were generally lower in the winter months. Production increased after plug installation, with monthly values being about twice the amount noted in the previous year. The P/R ratio suggested that the site was autotrophic (i.e., P/R>1), indicating that organic matter was being produced faster than it was being used (Odum, 1956; Odum and Wilson, 1962).

Gross photoshnthesis values at Ash Slough ranged from 2.26g O_2/m^2/day to 39.41g O_2/m^2/day. Seasonal production trends at Ash Slough were similar to Armstrong Slough in that generally lower values were noted in winter months. The production/respiration ratio, for three of the seven samplings, was below 1, which indicated that organic matter was being concentrated. Many other aquatic systems with a continual input of organic matter also behave in a similar fashion (Odum, 1956). The pasture runoff into this system may be altering the production characteristics to fluctuate between autotrophy and heterotrophy.

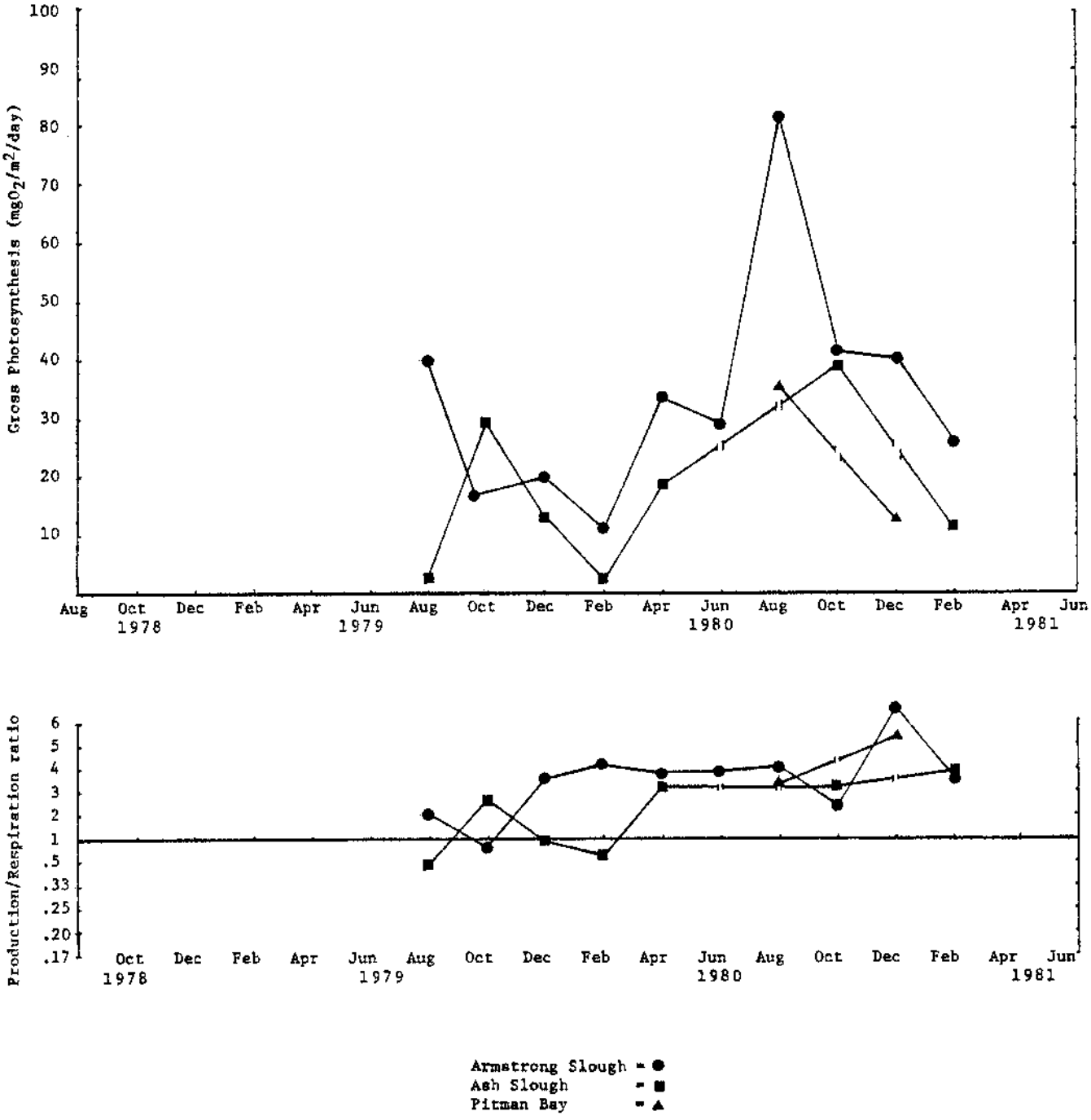


Fig. 23. Community Metabolism at Armstrong Slough, Ash Slough, and Pitmans Bay

SUMMARY

The goals of our study were to collect and analyze data on phytoplankton and periphyton generic composition and biomass variations of three south Florida freshwater wetlands to: 1) characterize the phytoplankton and periphyton communities in subtropical wetlands; 2) determine any effects nutrient loading has on these algal populations; and 3) evaluate the response of the algal communities to the creation of a detention/retention wetland, which was designed to remove nutrients from agricultural runoff.

Two of the study areas were marshes. One area, Ash Slough, receives heavy nutrient loading from an extensively ditched improved pasture used for intensive beef cattle production (1 cow per 2-3 acres), while the other marsh, Pitmans Bay, is relatively unaffected by agricultural practices. The third study area, Armstrong Slough, was a channelized stream running through a former tributary floodplain. The channel was blocked and the Slough re-inundated in April, 1979. Data was gathered for the two years prior to channel plug installation at Armstrong Slough, and approximately one year of data was collected after re-inundation. The slough receives low to moderate levels of nutrient loading from adjacent pasture lands and upstream citrus beds.

The generic composition of the phytoplankton and periphyton communities at the three study areas was similar. The individual genera identified at each site, as well as those genera found in the largest numbers, were analogous among the wetlands locations. Additionally, percent composition by division was similar among the sites, in that Cyanophyta dominated all systems on an annual basis, while Chlorophyta comprised nearly all the remainder of the phytoplankton and periphyton communities. The uniform community composition among sites that receive differing nutrient loadings, suggests that increasing nutrients may not substantially affect the generic composition of subtropical wetlands already dominated on an annual basis by blue-green algae.

Large variations in algal biomass were noted at Ash Slough. Levels of phytoplankton and periphyton biomass, nutrients, and productivity underwent large fluctuations between samplings. These changes were not seasonal, but were related to transient periods of pasture runoff. The runoff increased the concentrations of nitrogen and phosphorus (particularly phosphorus) which stimulated algal growth. Higher mean algal biomass values were observed at stations below the pasture outfall. Algal assay data identified nitrogen as the growth limiting nutrient at this site. Nitrogen limitation indicates that this site is considerably influenced by runoff from the high density beef cattle pasture.

Algal biomass levels at Pitmans Bay were not significantly lower than those at the other systems which received nutrient loading. Concentrations of reactive forms of nitrogen and phosphorus were low, although concentrations of the organic forms of these nutrients were similar to those found at the other two sites. Apparently, all the available nutrients are utilized by the algal communities at Pitmans Bay, resulting in biomass levels that were comparable to the other systems, although slightly lower.

Phytoplankton biomass values at Armstrong Slough remained relatively constant, annually, until the slough was re-inundated, when biomass and primary productivity values increased marginally. Initially, periphyton biomass parameters displayed a seasonal trend of increased growth during winter which decreased in the summer. After the plug was completed, periphyton biomass and periphyton primary productivity increased and thereafter remained constant. Intra-area comparisons of algal biomass and water chemistry at the influent and outfall stations, showed changes associated with the slough's re-inundation. Mean nitrogen and phosphorus levels were reduced at the outfall station after plug installation and no longer paralleled nutrient concentrations entering the slough. Additionally, mean values of phytoplankton biomass leaving the slough were greater before re-inundation; after reflooding, biomass mean values leaving the slough were lower than entering. All the changes in algal biomass and productivity associated with re-inundation at Armstrong Slough were not statistically significant (at the 95% confidence level), probably because only 7 sets of samples were collected after the plug installation.

LITERATURE CITED

American Public Health Association. 1976. Standard Methods for Examination of Water and Wastewater. 14th ed. 1193 pp.

Biedermann, C.A. 1980. Phytoplankton Population Dynamics in Lake Apopka and the Upper Oklawaha Chain of Lakes. Master's Thesis. University of Florida, Gainesville, FL. 78pp.

Biedermann, C.A., A.R. Thompson., C.W. Dye and L.T. Ross. 1980. Phytoplankton and Periphyton Community Dynamics in the Kissimmee River Basin. (First annual report to the Coordinating Council on the Restoration of the Kissimmee River Valley and Taylor Creek-Nubbin Slough Basin. 57pp.

Brezonik, P.L., W.H. Morgan, E.E. Shannon and H.D. Putnam. 1969. Eutrophication Factors in North Florida Lakes. Florida Engineering and Industrial Experimental Station. Bulletin No. 134. 101pp.

Brezonik, P.L., D.D. Pollman, T.L. Crisman, J.N. Allison and J.L. Fox. 1978. Limnological Studies in Lake Apopka and the Oklawaha Chain of Lakes, 1. Water Quality in 1977. Department of Env. Eng. Sci., University of Florida, Gainesville, FL. Report No. ENV-07-78-01 for Florida Department of Environmental Regulation, Tallahassee. 238pp.

Browder, J.A. and M. Brown. 1979. Working Paper Submitted to the Dade County Planning Department. Section I. Baseline Technical Studies Subsection I. Biological Data Collection, Task 3: Quantitative Baseline Study of Periphyton. University of Miami. 32pp.

Cushing, C.E. 1967. Periphyton Productivity and Radionuclids Accumulation in the Columbia River, Washington, U.S.A. Hydrobiologia 29: 125-139.

Czaplewski, R.L. and M. Parker. 1973. Use of BOD Oxygen Probe for Estimating Primary Productivity. Limnol. and Oceanog. 18: 152-154.

Davis, F.E. and M.L. Marshall. 1975. Chemical and Biological Investigations of Lake Okeechobee, January 1973 to June 1974. Interim Rept. Tech. Publ. #75-1. Cen. S. Fla. Flood Contr. Dist.

Dye, C.W. and D.A. Jones. 1978. A Review of Eutrophication, Nutrient Regulation, and Impacts of Nutrients on Water Quality. Florida Department of Environmental Regulation Tech. Series. 3(1)1-34.

Dye, C.W., D.A. Jones, L.T. Ross and J.L. Gernert. 1980. Diel Variations of Selected Physio-Chemical Parameters in Lake Kissimmee, Florida. Hydrobiologia 71: 51-60.

Eyster, C. 1964. Micronutrient Requirements for Green Plants, Especially Algae. In D.F. Jackson (ed.) Algae and Man, Plenum Press, New York. Pp. 86-119.

Filip, D.S. and E.J. Middlebrooks. 1976. Eutrophication Potential of Dairy Cattle Waste Runoff. Water Research 10: 89-93.

Fuhs, G.W. 1969. Phosphorus Limited Growth of Plankton Diatoms. Verh. Int. Ver. Limnol. 17: 784-786.

Gerloff, G.C. and F. Skoog. 1957. Nitrogen as a Limiting Factor for the Growth of Microcystis aerieginosa in Southern Wisconsin Labs. Ecology 38(4): 5560-5561.

Godward, M. 1937. An Ecological and Taxonomic Investigation of Littoral Algal Flora of Lake Windermere. J. Ecology 25: 496-568.

Goldstein, A.L., T.K. Mac Vicar, R.L. Mierau, M.L. Smith and R.J. Ulevich. 1980. Upland Detention/Retention Demonstration Project: Semi-Annual Report to the Coordinating Council on the Restoration of the Kissimmee River Valley and Taylor Creek/Nubbin Slough Basin. SFWMD. RPC/FSD - 199 480 5c, 263 pp.

Goldstein, A.L. and R.J. Ulevich. 1980. Upland Detention/Retention Demonstration Project. Annual Report to the Coordinating Council on the Restoration of the Kissimmee Valley and Taylor Creek/Nubbin Slough Basin. 119pp.

Grzenda, A.R. and M.L. Brehmer. 1960. A Quantitative Method for the Collection and Measurement of Stream Periphyton. Limnol. and Oceanog. 5: 190-194.

Hannan, H.H., W.C. Young and J.J. Mayhew. 1973. Nitrogen and Phosphorus in a Stretch of the Guadalupe River, Texas, With Five Main-Stream Impoundments. Hydrobiologia 43(3): 419-441.

Ho, Sinn-Chye. 1967. Periphyton Production in a Tropical Lowland Stream Polluted by Inorganic Sediments and Organic Wastes. Arch. Hydrobiol. 77(4): 458-474.

Hornberger, G.M., M.G. Kelly and B.J. Crosby. 1977. Water Research 11: 65-69.

Hutchinson, E.G. 1975. A Treatise on Limnology, Vol. III Limnological Botany. John Wiley and Sons, Inc., New York. 660pp.

Karlgren, L. and K. Ljungstrom. 1975. Nutrient Budgets for the Inner Archipelago of Stockholm. J. Wat Poll. Contr. Fed. 47(4): 823-933.

Kurasawa, H. 1959. Chlorophyll Content in Sessile Algal Community of a Japanese Mountain River. Bot. Mag. Tokyo 73: 228-235.

Lackey, J.B. and E.W. Lackey. 1967. A Partial Checklist of Florida Freshwater Algae and Protozoa With Reference to McCloud and Cue Lakes. Water Resources Research Center, Pub. No. 3. University of Florida, Gainesville, FL. 28p.

Lange, W. 1971. Limiting Nutrient Elements in Filtered Lake Erie Water. Water Research 5(11): 1031-1048.

Lund, J.W.G. 1965. The Ecology of the Freshwater Phytoplankton. Biol. Rev. 40: 231.

McCaffrey, P.M. 1977. The Kissimmee River: Progress in New Directions. Florida Environmental and Urban Issues 5(2): 1-4.

McCaffrey, P.M., J.M. Ruddell, M.A. Drew, S.E. Gatewood, F. Howard and J.S. Lyons. 1978. Second Annual Report to the Florida Legislature. Coordinating Council on the Restoration of the Kissimmee River Valley and Taylor Creek-Nubbin Slough Basin. 40pp.

McIntire, C.D. 1968. Structural Characteristics of Benthal Algal Communities in Laboratory Streams. Ecology 49(3): 520-537.

Miller, W.E. and T.E. Maloney. 1971. Effects of Secondary and Tertiary Wastewater Effluents on Algal Growth in a Lake River System. J. Wat. Poll. Contr. Fed. 43: 2361-2365.

Miller, W.E., T.E. Maloney and J.C. Greene. 1974. Algal Productivity in 49 Lake Waters as Determined by Algal Assays. Water Research 8: 667-679.

Miller, W.E., J.C. Greene and T. Shiroyama. 1975. Applications of Algal Assays to Define the Effects of Wastewater Effluents Upon Algal Growth in Multiple Use River Systems. In: Middlebrooks, D.A. Falkenborg and T.A. Maloney (eds.), Biostimulation and Nutrient Assessment. Ann Arbor Sci. Pp.77-92.

Moore, J.W. 1977. Seasonal Succession of Algae in an Eutrophic Stream in Southern England. Hydrobiologia 53(2): 181-192.

Moss, B. 1973. Diversity in Fresh-Water Phytoplankton. Amer. Midland Naturalist 90(2): 341-355.

Mudrock, A. and J.A. Capobianco. 1979. Effects of Treated Effluent on a Natural Marsh. J. Wat. Poll. Contr. Fed. 51: 2243-2256.

Odum, H.T. 1956. Primary Production in Flowing Waters. Limnol. and Oceanog. 1: 102-117.

Odum, H.T. and C.M. Hoskin. 1958. Comparative Studies on the Metabolism of Marine Waters. Publ. Inst. Marine Sci. Texas 5: 16-46.

Odum, H.T. and R.F. Wilson. 1962. Further Studies on the Reaeration and Metabolism of Texas Bays, 1958-1960. Publ. Inst. Marine Sci. Texas 8: 23-55.

Palmer, C.M. 1977. Algae and Water Pollution, an Illustrated Manual on the Identification, Significance and Control of Algae in Water Supplies and in Polluted Waters. R.L. Lewis (ed.) U.S. E.P.A., EPA 600 19-77-036. 123pp.

Patrick, R. 1945. A Taxonomic and Ecological Study of Some Diatoms From Ponco Plateau and Adjacent Regions. Farlowia 2(2): 143-214.

Patrick, R. and C.W. Reimer. 1966. The Diatoms of the United States. Monog. Nat. Sci. Philadelphia, Number 13. 688pp.

Prescott, G.W. 1962. Algae of the Western Great Lakes Area. W.C. Brown Co. Publishers, Dubuque, Iowa. 977pp.

Prescott, G.W. 1970. The Freshwater Algae. W.C. Brown Co. Dubuque, Iowa. 348pp.

Putnam, H.D., P.L. Brezonik and E.E. Shannon. 1972. Eutrophication Factors in North Central Florida Lakes. Water Pollution Control Research Series Project #16010 DON E.P.A. 141pp.

Rickert, D.A., R.R. Petersen, S.W. McKenzie, W.G. Hines and S.A. Wille. 1977. Algal Conditions and the Potential for Future Algal Problems in the Willamette River, Oregon. Geological Survey Circular 715-G. 39pp.

Ruttner, F. 1968. Fundamentals of Limnology. University of Toronto Press. Toronto, Canada. 295pp.

Ryther, J.H. and W.M. Dunstan. 1971. Nitrogen, Phosphorus, and Eutrophication in the Coastal Marine Environment. Science 171(3975): 1008-1013.

Schelske, C. and E.F. Stoermer. 1972. Phosphorus, Silica, and Eutrophication of Lake Michigan. In G.E. Likens (ed.), Nutrients and Eutrophication: The Limiting Nutrient Controversy. Limnol. Oceanogr. Spec. Sympos. 1. Pp. 157-171.

Schindler, D.W. 1971. Carbon, Nitrogen and Phosphorus and Eutrophication of Freshwater Lakes. J. Phycol. 7: 321-329.

Shapiro, J. 1970. A Statement on Phosphorus. J. Wat. Poll. Contr. Fed. 42(5): 772-775.

Sládeček, V. and A. Sládečkova. 1964 Determination of Periphyton Production by Means of Glass Slide Method. Hydrobiologia. 23: 125-128.

Sládečkova, A. 1962. Limnological Investigation Methods of the Periphyton ("Aufwuchs") Community. Bot. Review 28(2): 286-350.

Smith, M. 1950. The Freshwater Algae of the United States. McGraw-Hill Book Co., Inc., New York. 719pp.

Specht, D.T. 1975. Seasonal Variation of Algal Biomass Potential and Nutrient Limitation in Yaguina Bay, Oregon. Presented at: Biostim. and Nutrient Assess. Sympos., Utah St. Univ., Logan, Utah. Pp. 149-174.

Spodniewska, I. 1978. Phytoplankton as the Indicator of Lake Eutrophication, I. Summer Situation in 34 Masurian Lakes in 1973. Ekologia Polaska. V. 26(1): 53-70.

Strickland, J.H. and T.R. Parsons. 1972. A Practical Handbook of Seawater Analysis. 2nd Edition. Fish Res. Bd. Can. 310pp.

Stumm, W. and E. Stumm-Zollinger. 1972. The Role of Phosphorus in Eutrophication. In R. Mitchell (ed.), Water Pollution Microbiology. Wiley-Interscience, New York. Pp. 11-42.

Thomas, W.H. 1969. Phytoplankton Nutrient Enrichment Experiments Off Baja, California and in the Eastern Equatorial Pacific Ocean. J. Fish. Res. Bd. Can. 26: 1133-1145.

Thompson, A.R., R.B. Frydenborg, C.A. Biedermann, C.W. Dye and L.T. Ross. 1981. Phytoplankton and Periphyton Community Dynamics of Detention/Retention Wetlands. Annual Report to the Coordinating Council on the Restoration of the Kissimmee River Valley and Taylor Creek/Nubbin Slough Basin. 60pp.

U.S. Environmental Protection Agency. 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020.

U.S. Environmental Protection Agency. 1973. Biological Field and Laboratory Methods. EPA-670/4-73-001.

Vollenweider, R.A. (ed.). 1974. A Manual on Methods for Measuring Production in Aquatic Environments, IBP Handbook No. 12, Blackwell Scientific Publications, Oxford. 225pp.

Weber, C.I. 1971. A Guide to the Common Diatoms at Water Pollution Surveillance System Stations. U.S.E.P.A., Cincinnati, Ohio. 101pp.

Weiss, C.M. 1970. The Relative Significance of Phosphorus and Nitrogen as Algal Nutrients. ESE Publ. No. 240, Wat. Resour. Res. Inst., University of North Carolina.

Wetzel, R.G. 1963. Primary Productivity of Periphyton. Nature, Lond. 197: 1025-1027.

Wetzel, R.G. 1975. Limnology. W.B. Saunders Company. Philadelphia. 743pp.

Young, O.W. 1945. A Limnological Investigation of Periphyton in Douglass Lake, Michigan. Trans. Amer. Microsc. Soc. 64:1-20.

Zafar, A.R. 1966. On the Ecology of Algae in Certain Fish Ponds of Hyderabad, India. III. The Periodicity. Hydrobiologia. Pp. 96-112.

APPENDICES

Table A-1. Phytoplankton Genera Found at Armstrong Slough, Ash Slough and Pitmans Bay.

Armstrong Slough	Ash Slough	Pitmans Bay
	DIVISION Cyanophyta	
Anabaena	Anabaena	Anabaena
Anabaenopsis		Anabaenopsis
Aphanocapsa		Aphanocapsa
Aphanothece	Aphanothece	Aphanothece
		Arthrospira
		Calothrix
Chroococcus	Chroococcus	Chroococcus
Gloeothece	Gloeothece	Gloeothece
Gomphosphaeria	Gomphosphaeria	
Lyngbya	Lyngbya	Lyngbya
Merismopedia	Merismopedia	
Microcystis	Microcystis	Microcystis
Oscillatoria	Oscillatoria	
Raphidiopsis	Raphidiopsis	Raphidiopsis
Rhabdoderma	Rhabdoderma	Rhabdoderma
	Schizothrix	
Spirulina	Spirulina	Spirulina
	Trichodesmium	
	DIVISION Chlorophyta	
Ankistrodesmus	Ankistrodesmus	Ankistrodesmus
	Characium	Characium
Chlamydomonas	Chlamydomonas	Chlamydomonas
Chlorella	Chlorella	Chlorella
Chlorococcum	Chlorococcum	Chlorococcum
	Chlorosarcinopsis	
Closteriopsis	Closteriopsis	
Closterium	Closterium	Closterium
	Coelastrum	
Coleochaete		
Cosmarium	Cosmarium	Cosmarium
Crucigenia	Crucigenia	Crucigenia
Desmidium	Desmidium	Desmidium
Dictyosphaerium	Dictyosphaerium	Dictyosphaerium
	Dimorphococcus	Dimorphococcus
	Eremosphaera	Eremosphaera
	Euastridium	
	Euastrum	Euastrum
Eudorina		
Gloeocystis	Gloeocystis	Gloeocystis
		Golenkinia
		Haematococcus
Kirchneriella	Kirchneriella	Kirchneriella
Micrasterias		
Microspora	Microspora	
Mougeotia	Mougeotia	Mougeotia
	Nephrocytium	Nephrocytium
	Oedogonium	
Oocystis	Oocystis	Oocystis
Pediastrum	Pediastrum	Pediastrum
	Peridinium	
	Phymatodocis	
Pleurotaenium		
	Quadrigula	Quadrigula
Radiococcus	Radiococcus	
Rhizoclonium	Rhizoclonium	
Scenedesmus	Scenedesmus	Scenedesmus
Selenastrum	Selenastrum	
	Sorastrum	
Sphaerocystis	Sphaerocystis	
	Sphaerozosma	Sphaerozosma
Spondylosium		
Staurastrum	Staurastrum	Staurastrum
Tetradesmus	Tetradesmus	Tetradesmus
Tetraedron	Tetraedron	Tetraedron
Treubaria		
Trochiscia	Trochiscia	
Ulothrix	Ulothrix	
		Vaucheria
Zygnema		Zygnema
	DIVISION Chrysophyta	
	Botryococcus	
Characiopsis	Characiopsis	Characiopsis
Dinobryon		
	Mallomonas	
Ophiocytium	Ophiocytium	Ophiocytium
Peroniella	Peroniella	Peroniella
	Synura	
	SUB-DIVISION Bacillariophyta	
	ORDER Centrales	
Cyclotella	Cyclotella	
Melosira		
	Neidum	

Table A-1. (Cont.)

Armstrong Slough	Ash Slough	Pitmans Bay	Armstrong Slough	Ash Slough	Pitmans Bay
	SUB-DIVISION Bacillariophyta (Cont.)				
	ORDER Pennales				
	Anomoeoneis				
		Asterionella			
Cocconeis	Cocconeis				
Cymbella	Cymbella				
Eunotia	Eunotia				
Fragilaria	Fragilaria				
Gomphonema	Gomphonema				
Navicula	Navicula	Navicula			
Nitzschia	Nitzschia				
Pinnularia	Pinnularia	Pinnularia			
Rhopalodia	Rhopalodia				
Stauroneis	Stauroneis	Stauroneis			
Surirella	Surirella				
Synedra	Synedra				
Tabellaria	Tabellaria				
	DIVISION Cryptophyta				
	Cryptomonas	Crytomonas			
	DIVISION Euglenophyta				
Euglena	Euglena				
Lepocinclis	Lepocinclis	Lepocinclis			
	Phacus	Phacus			
Trachelomonas	Trachelomonas	Trachelomonas			
	DIVISION Pyrrhophyta				
	Gonyaulax	Gonyaulax			
Hemidinium	Hemidinium	Hemidinium			
	Peridinium	Peridinium			

Table A-2. Periphyton Genera Found at Armstrong Slough, Ash Slough and Pitmans Bay.

Armstrong Slough	Ash Slough	Pitmans Bay
	DIVISION Cyanophyta	
Anabaena	Anabaena	Anabaena
	Anabaenopsis	
Aphanocapsa	Aphanocapsa	
Aphanothece	Aphanothece	
Borzia		
Calothrix		
Chamaesiphon	Chamaesiphon	
Chroococcus	Chroococcus	Chroococcus
Gloeocapsa		Gloeocapsa
Gloeothece	Gloeothece	Gloeothece
Lyngbya	Lyngbya	Lyngbya
Merismopedia	Merismopedia	
	Microchaete	
Microcystis	Microcystis	Microcystis
Nodularia		
Nostoc		
	Nostochopsis	
Oscillatoria	Oscillatoria	Oscillatoria
Phormidium		
Plectonema		
Rhabdoderma	Rhabdoderma	Rhabdoderma
Raphidiopsis	Raphidiopsis	Raphidiopsis
Rivularia		
Schizothrix		
Scytonema	Scytonema	
Spirulina	Spirulina	Spirulina
	DIVISION Chlorophyta	
Actinastrum		
Ankistrodesmus	Ankistrodesmus	Ankistrodesmus
Arthrodesmus		
Binuclearia		
Bulbochaete		
Chaetophora		
Characium	Characium	Characium
Chlamydomonas	Chlamydomonas	Chlamydomonas
Chlorella	Chlorella	
Chlorococcum	Chlorococcum	
	Chlorophysema	
Chlorosarcinopsis	Chlorosarcinopsis	
Cladophora	Cladophora	
Closteriopsis	Closteriopsis	
Closterium	Closterium	Closterium
Coelastrum	Coelastrum	

Armstrong Slough	Ash Slough	Pitmans Bay
	DIVISION Chlorophyta (Cont.)	
Coleochaete	Coleochaete	
Cosmarium	Cosmarium	Cosmarium
Crucigenia	Crucigenia	Crucigenia
Cylindrocapsa	Cylindrocapsa	
Desmidium	Desmidium	
Desmococcus	Desmococcus	
Dictyosphaerium	Dictyosphaerium	
Dimorphococcus	Dimorphococcus	
Dysmorphococcus		
		Elakothrix
	Eremosphaera	
Euastrum	Euastrum	Euastrum
Geminella		Geminella
Genicularia	Genicularia	
Gloeocystis	Gloeocystis	Gloeocystis
Golenkinia	Golenkinia	
Gonatozygon	Gonatozygon	
Gongrosira		
Groenbladia	Groenbladia	
Heterococcus		
Hyalotheca		
Kentrosphaera	Kentrosphaera	
Kirchneriella	Kirchneriella	Kirchneriella
Micrasterias	Micrasterias	
Mougeotia	Mougeotia	Mougeotia
Nephrocytium		
		Netrium
Oedogonium	Oedogonium	Oedogonium
Oocystis	Oocystis	Oocystis
Palmodictyon		
Pandorina		
Pediastrum	Pediastrum	
	Pleurotaenium	Pleurotaenium
Protoderma	Protoderma	
Quadrigula	Quadrigula	Quadrigula
	Radiococcus	
Radiofilum	Radiofilum	Radiofilum
Rhizocolonium	Rhizocolonium	Rhizocolonium
Scenedesmus	Scenedesmus	Scenedesmus
Selenastrum	Selenastrum	
	Sorastrum	
Sphaerellopsis		
Sphaerocystis	Sphaerocystis	
Sphaeroplea		
Spirogyra		

Table A-2. (Cont.)

Armstrong Slough	Ash Slough	Pitmans Bay	Armstrong Slough	Ash Slough	Pitmans Bay
	DIVISION Chlorophyta (Cont.)			ORDER Pennales (Cont.)	
Spondylosium	Spondylosium		Navicula	Navicula	Navicula
Staurastrum	Staurastrum	Staurastrum	Nedium		
	Stichococcus		Nitzchia	Nitzchia	
Stigeocolonium	Stigeocolonium	Stigeocolonium	Pinnularia	Pinnularia	
Temnogametum			Rhopalodia	Rhopalodia	
Tetraëdron	Tetradaëdron	Tetradaëdron	Stauroneis	Stauroneis	
Tetraspora	Tetraspora		Surirella	Surirella	
Truebaria			Synedra	Synedra	Synedra
Trochiscia	Trochisia		Tabellaria	Tabellaria	
Ulothrix	Ulothrix				
Ulvella	Ulvella			DIVISION Cryptophyta	
Vaucheria					
Westella			Cryptomonas		
Zygnema	Zygnema				
				DIVISION Euglenophyta	
	DIVISION Chrysophyta				
			Euglena	Euglena	
Botryococcus	Botryococcus		Lepocinclis		
Characiopsis	Characiopsis	Characiopsis	Phacus		
Chlorellidiopsis			Trachelomonas	Trachelomonas	Trachelomonas
Dinobryon					
Heterococcus	Heterococcus			DIVISION Pyrrhophyta	
Mallomonas	Mallomonas				
		Mischococcus			Gonyaulax
Ophiocytium	Ophiocytium	Ophiocytium	Peridinium		
Peroniella	Peroniella	Peroniella			
Stripitococcus	Stripitococcus				
	SUB-DIVISION Bacillariophyta				
	ORDER Centrales				
Cyclotella	Cyclotella				
Melosira	Melosira				
	ORDER Pennales				
Anomoeoneis	Anomoeoneis				
Asterionella	Asterionella				
Cocconeis	Cocconeis				
Cymbella	Cymbella				
Eunotia	Eunotia				
Fragilaria	Fragilaria				
Gomphonema	Gomphonema				
Gyrosigma					

Table A-3. Epiphytic Periphyton Genera Found on Ash Slough and Armstrong Slough Stations, April 1979.

ASH SLOUGH

Station B-1

DIVISION Cyanophyta

0*	Chamaesiphon	0	Merismopedia
0	Chroococcus	0	Microcystis
0	Gomphosphaeria	0	Raphidiopsis
0	Lyngbya	0	Spirulina

DIVISION Chlorophyta

0	Ankistrodesmus	0	Oocystis
0	Chlorococcum	0	Radiococcus
0	Coleochaete	0	Scenedesmus
0	Desmococcus	0	Selenastrum
0	Gloeocystis	0	Sphaerocystis
0	Golenkinia	0	Spirogyra
0	Gonatozygon	0	Tetraëdron
0	Lagarheimia	0	Trochiscia

DIVISION Pyrrhophyta

0	Peridinium

DIVISION Chrysophyta

0	Ophiocytium

SUB-PHYLUM Bacillariophyta

ORDER Pennales

0	Synedra	0	Tabellaria

DIVISION Euglenophyta

0	Phacus

Station B-2

DIVISION Cyanophyta

P	Anabaena	P 0	Lyngbya
0	Aphanothece	P 0	Merismopedia

ASH SLOUGH

Station B-2

DIVISION Cyanophyta (Cont.)

P	Calothrix	P 0	Microcystis
P 0	Chroococcus		

DIVISION Chlorophyta

P	Ankistrodesmus	P 0	Mougeotia
P	Characium	P 0	Oocystis
P	Chlorococcum	0	Radiococcus
P	Cosmarium	P	Rhizocolonium
P	Crucigenia	P 0	Scenedesmus
P	Euastrum	P	Spondylosium
P 0	Gloeocystis	P 0	Tetraëdron
P 0	Gonatozygon	P	Trochiscia
0	Kirchneriella	P 0	Ulothrix
P	Lagarheimia		

DIVISION Chrysophyta

P	Ophiocytium

SUB-PHYLUM Bacillariophyta

ORDER Pennales

P	Cocconeis	P	Rhopalodia
P	Gomphonema	P 0	Synedra
P 0	Navicula		

DIVISION Euglenophyta

P	Phacus

Station B-3

DIVISION Cyanophyta

B	Anabaena	B	Calothrix
B	Aphanocapsa	B P 0	Chroococcus
0	Aphanothece	B P 0	Lyngbya
B	Borzia	B P 0	Microcystis

*Substrates: 0 = Pontederia P = Potamogeton B = Bacopa N = Nymphoides

Table A-3. (Cont.)

ASH SLOUGH

Station B-3

DIVISION Chlorophyta

	B	Ankistrodesmus	P	O	B	Oocystis
O		Apatococcus			B	Pediastrum
O		Characium			B	Quadrigula
P	O	B Chlorococcum			B	Radiofilum
	B	Chlorosarcinopsis	P		B	Rhizocolonium
P	O	B Coleochaete	P		B	Scenedesmus
	B	Cosmarium	P		B	Selenastrum
P	O	Crucigenia			B	Sphaerocystis
	B	Euastrum	P		B	Spondylosium
P	O	B Gloeocystis			B	Staurastrum
	O	B Gonatozygon	P		B	Stigeocolonium
P	O	B Kirchneriella	P	O	B	Tetraëdron
P		Lagarheimia	P	O	B	Trochiscia
	B	Mougeotia	P		B	Ulothrix

DIVISION Chrysophyta

	B	Botryococcus		O	Heterococcus
P	B	Characiopsis	P	B	Ophiocytium

SUB-PHYLUM Bacillariophyta

ORDER Centrales

	B	Cyclotella

ORDER Pennales

P	B	Cocconeis	P	B	Rhopalodia
	B	Cymbella		B	Stauroneis
P	B	Gomphonema	P	B	Synedra
P	B	Navicula		B	Tabellaria
	B	Nitzschia			

DIVISION Euglenophyta

P		Euglena		B	Trachelomonas
	B	Phacus			

ASH SLOUGH

Station B-4

DIVISION Cyanophyta

B	O	N Anabaena		O		Gloeothece
		N Aphanocapsa	B	O	N	Lyngbya
B	O	N Aphanothece	B	O		Merismopedia
		N Borzia	B	O	N	Microcystis
B		Calothrix	B			Scytonema
B	O	N Chroococcus	B	O		Spirulina
B		Entophysalis				

DIVISION Chlorophyta

		N Ankistrodesmus			N	Quadrigula
B		N Characium			N	Radiococcus
B	O	N Chlorococcum	B	O	N	Rhizocolonium
B		N Cosmarium			N	Scenedesmus
		N Crucigenia	B	O	N	Selenastrum
	O	Dictyosphaerium			N	Sphaerocystis
B		N Eremosphaera			N	Spinocosmarium
B	O	Euastrum		O	N	Spondylosium
B	O	N Gloeocystis			N	Staurastrum
B		N Kirchneriella		O		Stigeoclonium
B	O	Mougeotia	B		N	Tetraëdron
B	O	N Oocystis	B	O	N	Trochiscia
B	O	Phymatodocis	B			Ulothrix
			B			Zygnema

DIVISION Chrysophyta

B		Characiopsis	B		N Ophiocytium
B		Mallomonas			

SUB-PHYLUM Bacillariophyta

ORDER Pennales

B		N Cocconeis	B		N	Nitzschia
		N Eunotia	B		N	Pinnularia
B		N Gomphonema	B	O	N	Rhopalodia
	O	N Navicula	B	O	N	Synedra

*Substrates: O = Pontederia P = Potamogeton B = Bacopa N = Nymphoides

Table A-3. (Cont.)

ASH SLOUGH

Station B-4

DIVISION Cryptophyta

O	N	Cryptomonas	

DIVISION Euglenophyta

B	O	N	Phacus	N	Trachelomonas

ARMSTRONG SLOUGH

Station M-5

DIVISION Cyanophyta

A		M	Anabaena			M	Gomphosphaeria
	E		Borzia	A	E	M	Lyngbya
A	E	M	Calothrix	A	E	M	Microcystis
	E		Chamaesiphon		E		Nostoc
A	E	M	Chroococcus			M	Oscillatoria

DIVISION Chlorophyta

		M	Binuclearia	A	E	M	Mougeotia
A	E	M	Characium	A	E	M	Oocystis
		M	Chlorococcum	A	E	M	Rhizocolonium
A		M	Coleochaete	A		M	Scenedesmus
A			Cosmarium	A		M	Selenastrum
	E	M	Crucigenia	A	E	M	Spondylosium
A		M	Desmidium	A			Staurastrum
A		M	Dictyosphaerium			M	Stigeoclonium
A	E	M	Euastrum	A		M	Tetraëdron
A	E	M	Gloeocystis	A	E	M	Trochiscia
A		M	Gonatozygon	A	E	M	Ulothrix
A			Kirchneriella		E		Zygnema

DIVISION Chrysophyta

A	E	M	Characiopsis		E	M	Ophiocytium
		M	Heterococcus				

ARMSTRONG SLOUGH

Station M-5 (Cont.)

SUB-PHYLUM Bacillariophyta

ORDER Centrales

A			Cyclotella

ORDER Pennales

A		M	Anomoeoneis		A	E	M	Nitzschia
		M	Asterionella				M	Pinnularia
		M	Cocconeis		A		M	Stauroneis
A	E		Cymbella				M	Synedra
A			Gomphonema		A		M	Tabellaria
A		M	Navicula					

DIVISION Euglenophyta

		M	Euglena

Station M-6

DIVISION Cyanophyta

B	A	E		Anabaena	B	A	E	M	Lyngbya
B	A		M	Aphanothece	B	A		M	Microcystis
B				Calothrix	B				Oscillatoria
B	A	E	M	Chroococcus	B				Scytonema

DIVISION Chlorophyta

	A			Ankistrodesmus	B				Oedogonium
B			M	Characium	B	A	E	M	Oocystis
B	A			Chlorococcum	B	A			Phymatodocis
	A			Chlorosarcinopsis	B		E		Rhizocolonium
B	A	E	M	Coleochaete	B	A	E		Scenedesmus
			M	Cosmarium	B	A		M	Selenastrum
			M	Crucigenia	B			M	Spondylosium
B			M	Euastrum	B	A	E	M	Stigeoclonium
B	A	E	M	Gloeocystis	B			M	Tetraëdron
	A			Gonatozygon	B	A	E	M	Trochiscia
B			M	Kirchneriella	B	A	E		Ulothrix
B	A	E		Mougeotia					

*Substrates: E = Eleocharis A = Polygonum M = Panicum B = Bacopa O = Pontederia N = Nymphoides

Table A-3. (Cont.)

ARMSTRONG SLOUGH

Station M-6

DIVISION Chrysophyta

B	A	E	M	Characiopsis		A			Mallomonas
B	A			Heterococcus		B	E	M	Ophiocytium

SUB-PHYLUM Bacillariophyta

ORDER Centrales

B		E		Cyclotella		A			Melosira

ORDER Pennales

B				Anomoeoneis		B	A		Pinnularia
	A	E		Cocconeis		B			Rhopalodia
	A			Eunotia		B	A	E	M Stauroneis
	A	E	M	Gomphonema		B	A		M Synedra
B	A	E	M	Navicula		B			M Tabellaria
B	A	E	M	Nitzschia					

DIVISION Euglenophyta

B				Phacus

Station M-7

DIVISION Cyanophyta

H			M	Anabaena		H	E	M	Chroococcus
H	E		M	Aphanocapsa		H	E	M	Lyngbya
			M	Aphanothece		H	E	M	Microcystis
H				Borzia		H			Oscillatoria
H			M	Calothrix		H			Spirulina
H				Chamaesiphon					

DIVISION Chlorophyta

			M	Ankistrodesmus		H		M	Oocystis
H			M	Characium		H			Rhizocolonium
H			M	Chlorococcum		H		M	Scenedesmus
H				Chlorosarcinopsis		H	E	M	Selenastrum
H				Coleochaete		H			Sphaerocystis
			M	Dictyosphaerium		H	E	M	Spondylosium

ARMSTRONG SLOUGH

Station M-7

DIVISION Chlorophyta (Cont.)

H				Euastrum		H			Staurastrum
H	E		M	Gloeocystis		H			Stigeoclonium
H			M	Kirchneriella		H	E	M	Tetraëdron
H				Oedogonium		H		M	Trochiscia
H	E			Ulothrix					

DIVISION Chrysophyta

		E	M	Characiopsis		H			Ophiocytium
H				Heterococcus					

SUB-PHYLUM Bacillariophyta

ORDER Pennales

H				Cocconeis		H	E	M	Nitzschia
H				Cymbella		H		M	Stauroneis
		M		Fragilaria		H		M	Synedra
H				Gomphonema		H			Tabellaria
H	E	M		Navicula					

DIVISION Euglenophyta

H				Phacus

Station M-8

DIVISION Cyanophyta

			M	Chamaesiphon		E	P	M	B Microcystis
E	P	M	B	Chroococcus				B	Spirulina
E	P	M	B	Lyngbya					

DIVISION Chlorophyta

		M	B	Ankistrodesmus				B	Oedogonium
P	M	B		Characium		E	P	M	B Oocystis
P	M	B		Chlorococcum				M	B Phymatodocis
	M	B		Chlorosarcinopsis			P	M	Quadrigula
	M			Closterium				M	B Rhizocolonium
E		B		Coleochaete			P	M	B Scenedesmus

*Substrates: E = Eleocharis A = Polygonum M = Panicum B = Bacopa H = Hydrocotyl P = Potamogeton

Table A-3. (Cont.)

ARMSTRONG SLOUGH

Station M-8

DIVISION Chlorophyta (Cont.)

	M B	Cosmarium		B	Selenastrum
	M B	Desmidium	P M B		Spondylosium
	B	Euastrum	P M		Staurastrum
E P M		Gloeocystis	P M B		Trochiscia
P M		Kirchneriella		B	Ulothrix
	M	Mougeotia			

DIVISION Chrysophyta

E P M B		Characiopsis		B	Ophiocytium
P M		Heterococcus			

SUB-PHYLUM Bacillariophyta

ORDER Centrales

P M B		Cyclotella		B	Melosira

ORDER Pennales

P M		Anomoeoneis		B	Nitzschia
	M	Cocconeis	P		Pinnularia
	B	Cymbella	E P M B		Stauroneis
	B	Fragilaria	P M B		Synedra
	M B	Gomphonema		B	Tabellaria
	M B	Navicula			

Station M-9

DIVISION Cyanophyta

E A B		Anabaena		A	Gloeothece
	A	Aphanocapsa	E A B		Lyngbya
	A	Aphanothece	E A B		Microcystis
	B	Aphanozominon		A	Nodularia
	B	Borzia		A B	Rhapidiopsis
E	B	Calothrix		B	Spirulina
	A B	Chroococcus			

ARMSTRONG SLOUGH

Station M-9

DIVISION Chlorophyta

E A B		Ankistrodesmus		A B	Kirchneriella
	B	Binuclearia	E		Mougeotia
E A		Chaetosphaeridium		B	Mycanthococcus
E A		Characium	E A B		Oocystis
	B	Chlamydomonas		A	Pediastrum
E A B		Chlorococcum	E A B		Rhizocolonium
	A B	Chlorosarcinopsis	E A B		Scenedesmus
	A	Coelastrum	E A B		Selenastrum
E	B	Coleochaete	E A		Sphaerocystis
E	B	Cosmarium	E		Spirogyra
	B	Desmidium	E A B		Spondylosium
E	B	Dictyosphaerium		A B	Tetraëdron
	A	Eremosphaera	E A B		Trochiscia
	B	Euastrum	E A B		Ulothrix
E A B		Gloeocystis	E		Zygnema

DIVISION Chrysophyta

E A B		Characiopsis	E	B	Mallomonas
	A	Botryococcus	E A B		Ophiocytium
	B	Heterococcus			

SUB-PHYLUM Bacillariophyta

ORDER Centrales

	A	Cyclotella			

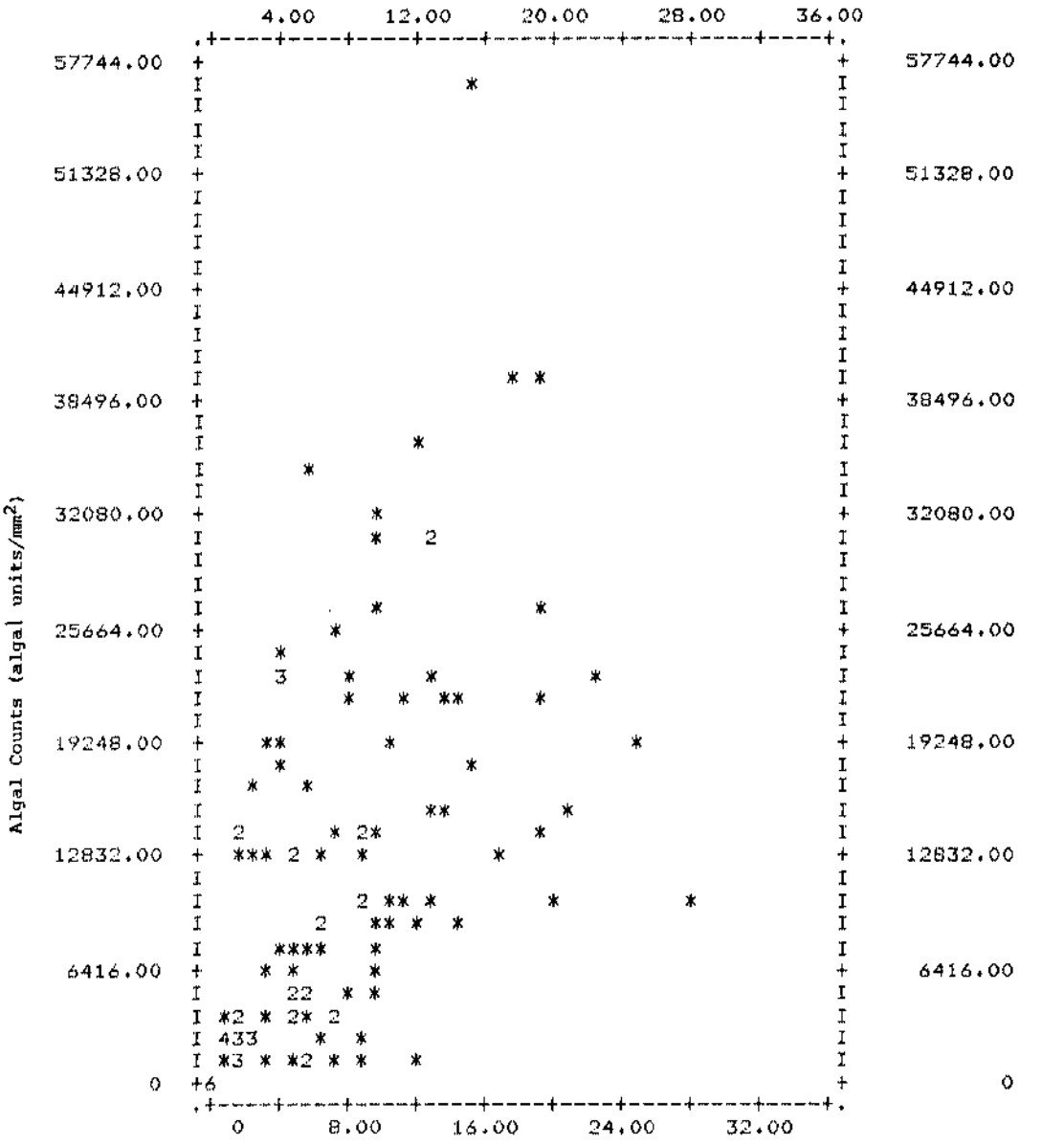
ORDER Pennales

	B	Cocconeis		B	Pinnularia
	A B	Cymbella	E A B		Synedra
E	B	Navicula		A	Tabellaria
E A		Nitzschia			

DIVISION Euglenophyta

	A	Phacus		B	Trachelomonas

*Substrates: E = Eleocharis A = Polygonum M = Panicum B = Bacopa P = Potamogeton

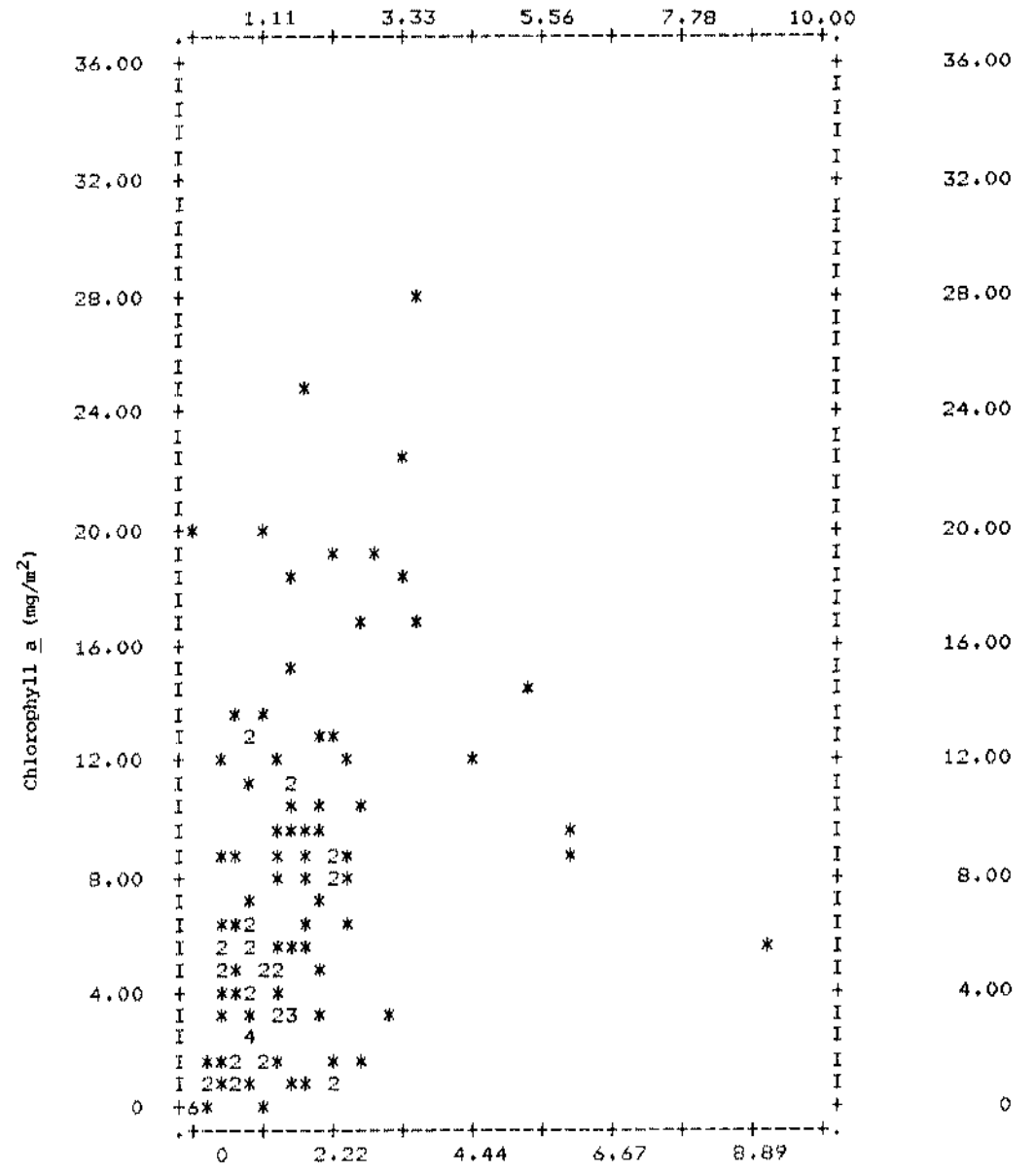


STATISTICS..

CORRELATION (R) -	.50799	R SQUARED -	.2580
SIGNIFICANCE R -	.00001	STD ERR OF EST -	9251.0408
INTERCEPT (A) -	5697.55383	STD ERROR OF A -	1394.4450
SIGNIFICANCE A -	.00008	SLOPE (B) -	914.2531
STD ERROR OF B -	145.83238	SIGNIFICANCE B -	.0000

PLOTTED VALUES - 115 EXCLUDED VALUES - 0 MISSING VALUES - 22

Fig. A-1. Simple Linear Regression Analysis of Top Periphyton Units Counts/mm² and Chlorophyll a Units (mg/m²)

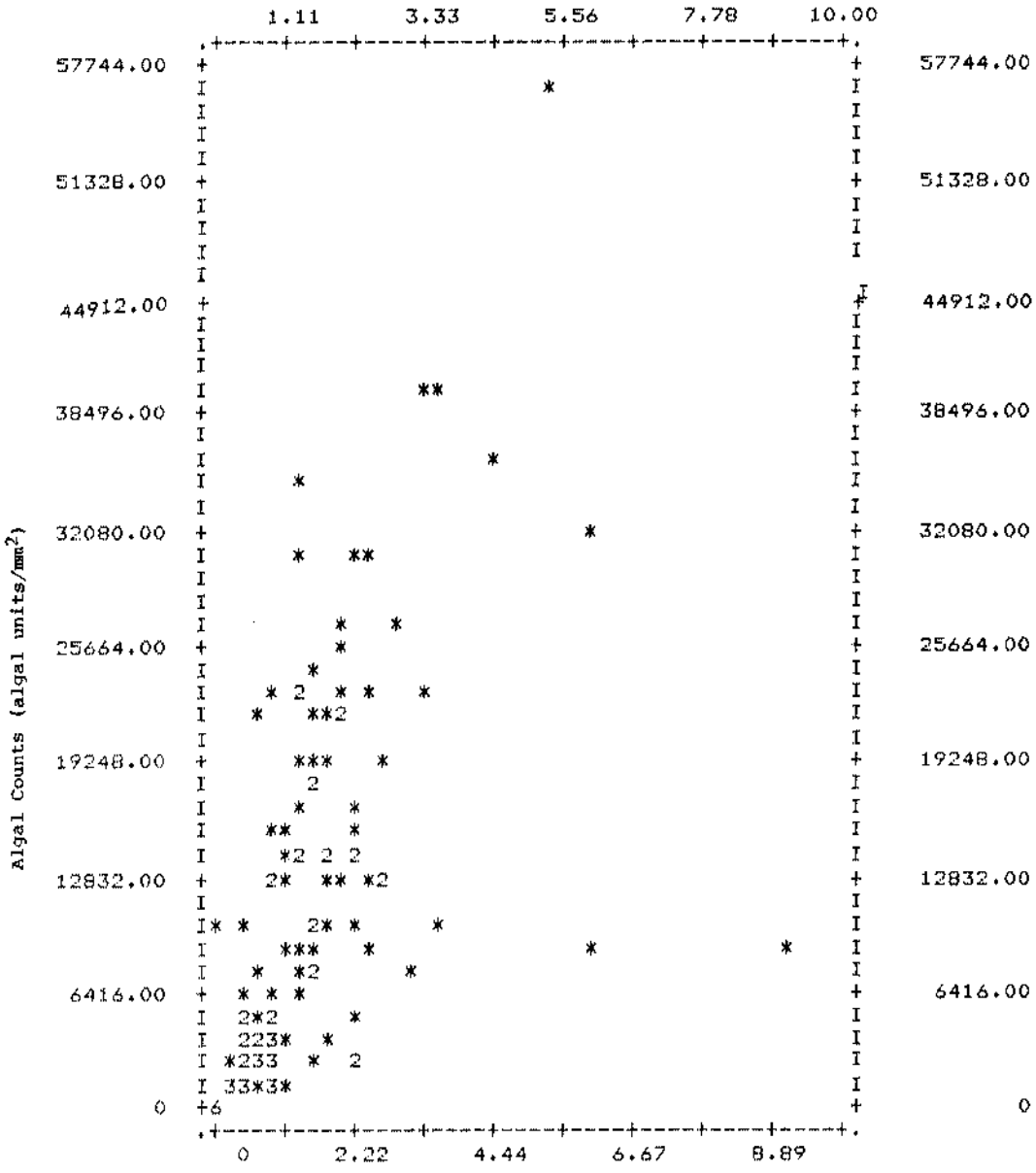


STATISTICS..

CORRELATION (R) =	.37485	R SQUARED =	.14051
SIGNIFICANCE R =	.00003	STD ERR OF EST =	5.54028
INTERCEPT (A) =	4.87505	STD ERROR OF A =	.78820
SIGNIFICANCE A =	.00001	SLOPE (B) =	1.66902
STD ERROR OF B =	.38661	SIGNIFICANCE B =	.00003

PLOTTED VALUES = 116 EXCLUDED VALUES = 0 MISSING VALUES = 21

Fig. A-2. Simple Linear Regression Analysis of Top Periphyton Chlorophyll a and Net Organic Weight (g/m^2)

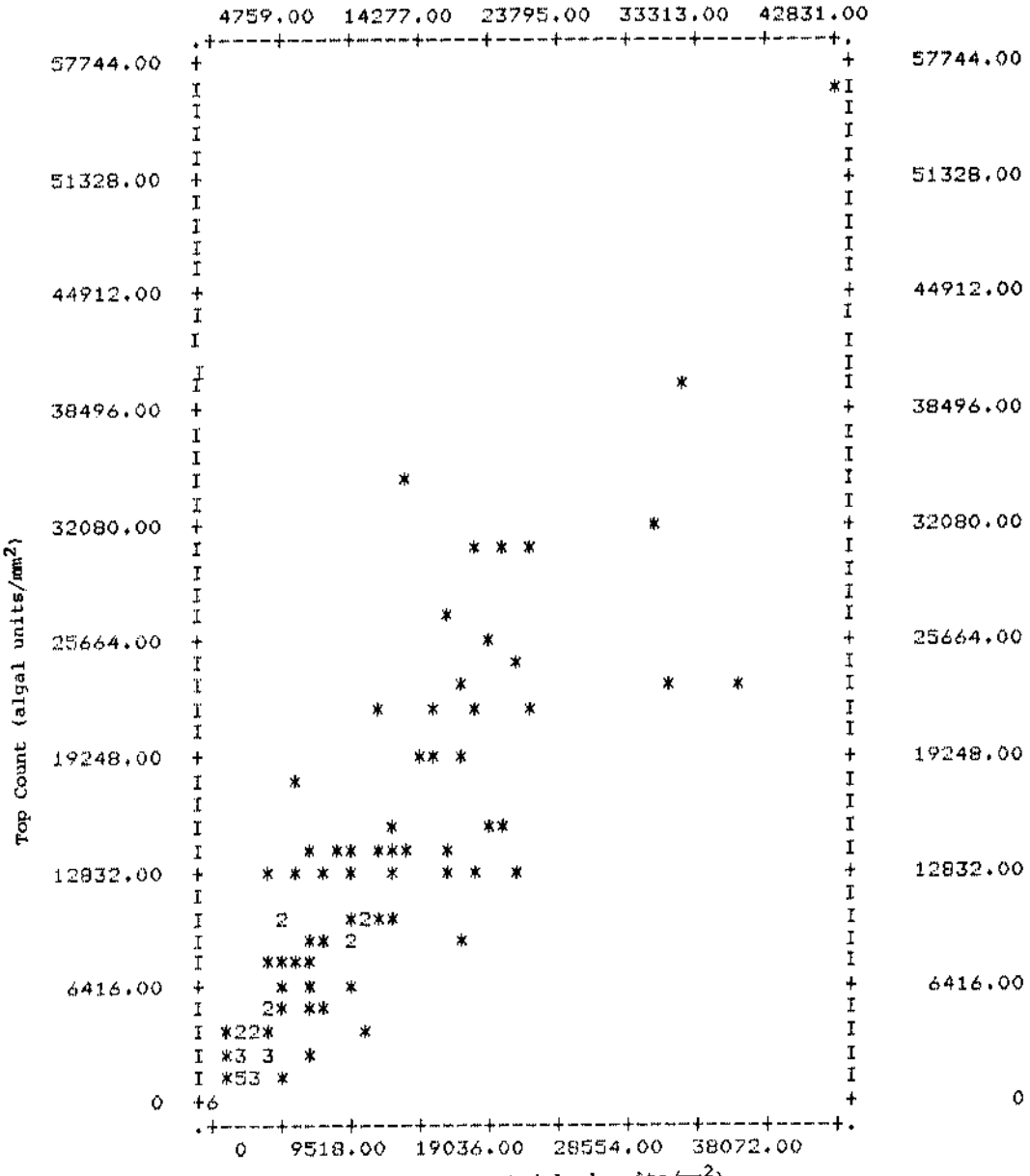


STATISTICS..

CORRELATION (R)-	.53422	R SQUARED -	.28540
SIGNIFICANCE R -	.00001	STD ERR OF EST -	9079.00262
INTERCEPT (A) -	5976.89624	STD ERROR OF A -	1295.68058
SIGNIFICANCE A -	.00001	SLOPE (B) -	4257.37813
STD ERROR OF B -	633.74050	SIGNIFICANCE B -	.00001

PLOTTED VALUES - 115 EXCLUDED VALUES - 0 MISSING VALUES - 22

Fig. A-3. Simple Linear Regression Analysis of TOP Periphyton Unit Count/mm² and Net Organic Weight (g/m²)

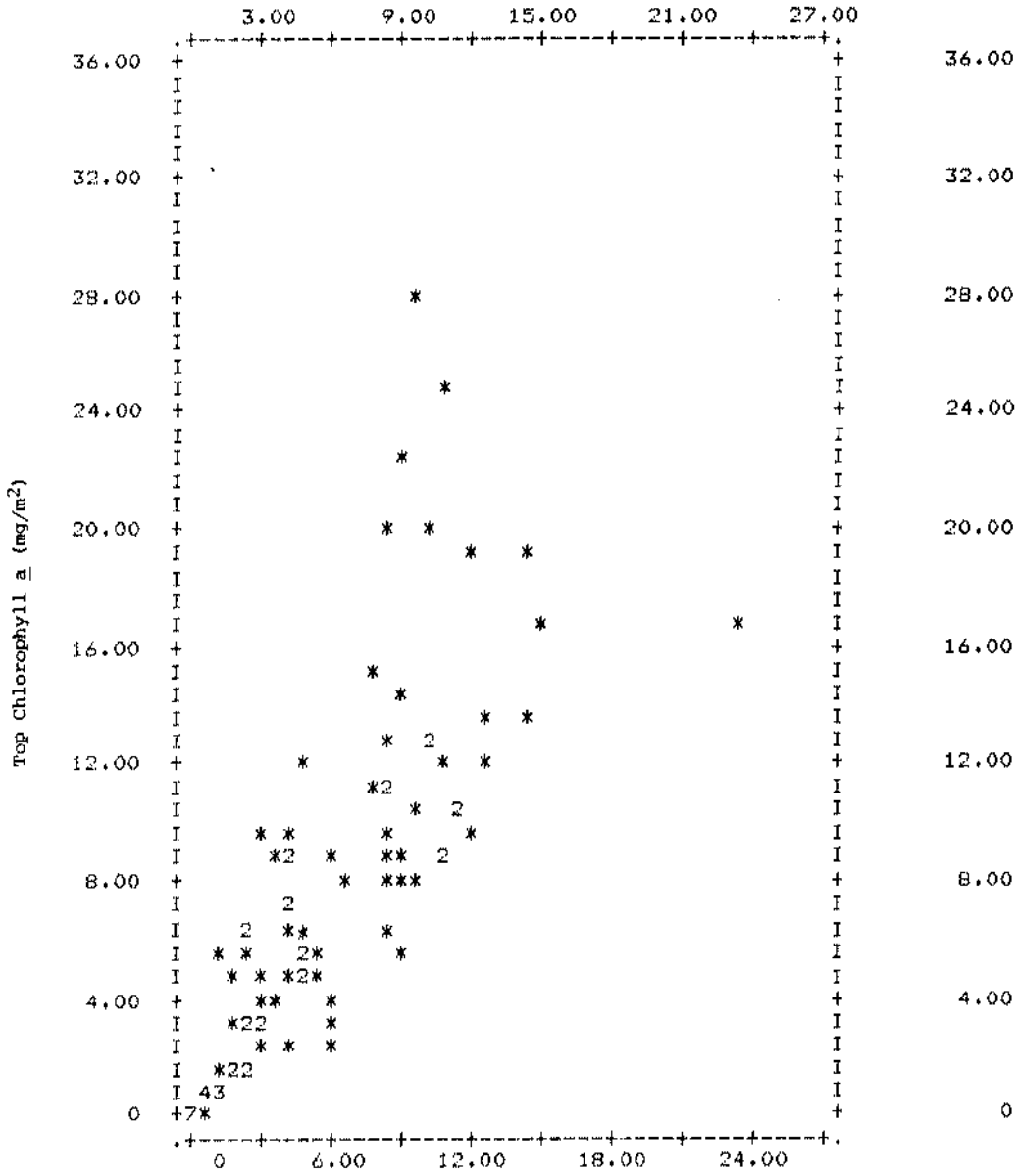


STATISTICS..

CORRELATION (R)-	.87128	R SQUARED -	.75914
SIGNIFICANCE R -	.00001	STD ERR OF EST -	5154.90859
INTERCEPT (A) -	1677.82158	STD ERROR OF A -	805.47996
SIGNIFICANCE A -	.04003	SLOPE (B) -	1.05560
STD ERROR OF B -	.06199	SIGNIFICANCE B -	.00001

PLOTTED VALUES - 94 EXCLUDED VALUES - 0 MISSING VALUES - 43

Fig. A-4. Simple Linear Regression Analysis of TOP and Bottom Periphyton Unit Counts (algal units/mm²)

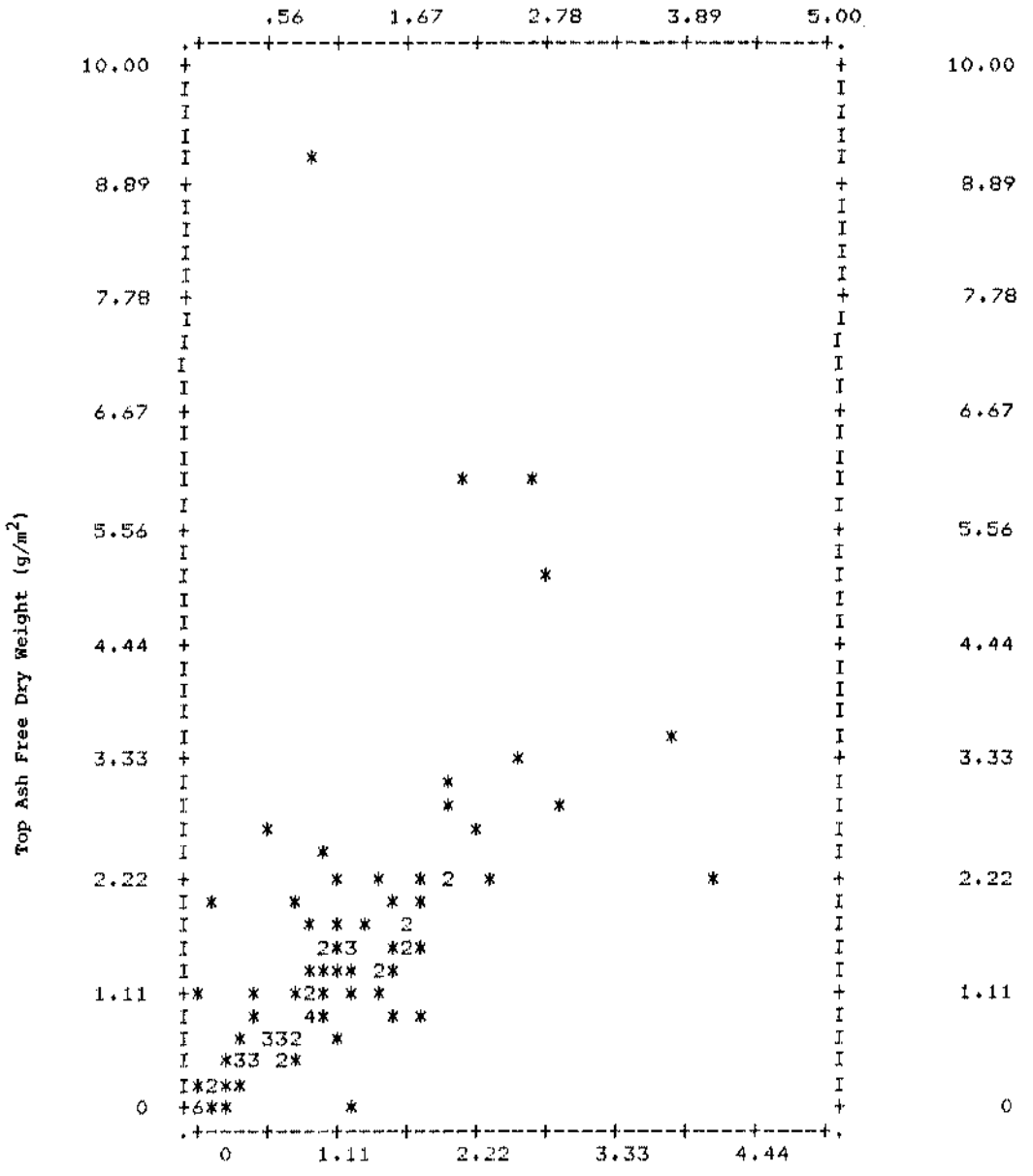


STATISTICS..

CORRELATION (R) -	.78385	R SQUARED -	.61443
SIGNIFICANCE R -	.00001	STD ERR OF EST -	3.81121
INTERCEPT (A) -	1.60177	STD ERROR OF A -	.65426
SIGNIFICANCE A -	.01630	SLOPE (B) -	1.07790
STD ERROR OF B -	.09001	SIGNIFICANCE B -	.00001

PLOTTED VALUES - 92 EXCLUDED VALUES - 0 MISSING VALUES - 45

Fig. A-5. Simple Linear Regression Analysis of TOP and Bottom Periphyton Chlorophyll a Concentration (mg/m^2)



STATISTICS..

CORRELATION (R) -	.60514	R SQUARED -	.36619
SIGNIFICANCE R -	.00001	STD ERR OF EST -	1.12653
INTERCEPT (A) -	.39919	STD ERROR OF A -	.19162
SIGNIFICANCE A -	.03998	SLOPE (B) -	1.04441
STD ERROR OF B -	.14248	SIGNIFICANCE B -	.00001

PLOTTED VALUES - 95 EXCLUDED VALUES - 0 MISSING VALUES - 42

Fig. A-6. Simple Linear Regression Analysis of TOP and Bottom Periphyton Non-Organic Weights (g/m^2)

Table A-4. Diatom Species Identified in Study Area.

Achnanthes lanceolata Grun.
Anomoeoneis sp.
Asterionella sp.
Caloneis vetricosa Meist.
Cocconeis scutellum Ehr.
C. placentula Ehr.
Cyclotella sp.
Cymbella prostrata Cl.
C. sp.
Eunotia pectinalis Rabh.
E. sp.
E. sp. M
Fragilaria brevistriata Grun.
Frustulia rhomboides DeT.
Gomphonema angustatum Rabh.
G. sp.
Melosira ambigua O. Mull.
M. sp. R
M. sp.
Navicula capitata Ross
N. confervacea Grun.
N. peregrina Kutz.
N. pupula Kutz.
N. radiosa Grun.
N. rhynchocephala Kutz.
N. sp.
Neidium sp.
Nitzschia filiformis Hust.
Nit. palea W.Sm.
Nit. sigma W.Sm.
Nit. sp. W
Pinnularia biceps Greg.
P. gibba Ehr.
P. microstauron Ehr.
P. subcapitata Grun.
P. sp.
Rhopalodia gibberula Ehr.
Stauroneis crucicula Grun.
S. phoenicenteron Ehr.
S. sp. A
S. sp.
Surirella angustata Kutz.
Sur. striatula Trup.
Synedra actinastroides Lemm.
Syn. acus Kutz.
Syn. tabulata Kutz.
Syn. ulna Kutz.
Syn. sp.
Tabellaria sp.