A Partial Checklist of Florida Fresh-Water Algae and Protozoa With Reference to McCloud and Cue Lakes

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Bulletin Series No. 131

FLORIDA ENGINEERING AND INDUSTRIAL EXPERIMENT STATION

COLLEGE OF ENGINEERING • UNIVERSITY OF FLORIDA • GAINESVILLE

WATER RESOURCES RESEARCH CENTER

PUBLICATION No. 3

This research was supported in part by the Office of Water Resources Research, U. S. Department of the Interior, as authorized under the Water Resources Research Act of 1964, Public Law 88-379.

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PREFACE

In 1965 and 1966 the staff of the Phelps Laboratory for Bioenvironmental Research at the University of Florida decided that eutrophication of Florida waters was of prime concern, since intensification of eutrophication easily leads to economic and recreational loss. It was decided that two similar small lakes, Cue and McCloud, known to be oligotrophic should be studied intensively and completely characterized. One of them should be made eutrophic, if possible, by the addition of nutrients such as sewage. The comparative and continuous study of these two is expected to provide useful information on the mechanisms and progress of eutrophication.

These two lakes are isolated, in sandy, scrub-oak terrain and are dependent on surface drainage, but are permanent. Their isolation lends them admirably to instrumentation, and because of this isolation and the cooperation of Mr. and Mrs. Carl Swisher on whose property they are located, are free from outside interference. Detailed studies of these lakes will be presented elsewhere. However this paper is intended to give a general idea of the microbiology of these and similar Florida waters, as a background for biological aspects of the work.

INTRODUCTION

Florida is a land where there are many kinds of fresh water and many kinds of climate. Its waters vary from shallow transient ponds, which may dry up seasonally or only after a protracted rainless spell, to large lakes, some deep, some shallow. There are marsh-bordered lakes and sinkhole ponds with virtually clean margins. There are cypress and gum ponds in deep shade, and spring-fed marshes. Some lakes and ponds are in the midst of urban communities and are frequently eutrophic, others are completely isolated in a pine forest or an open prairie. Flowing waters may originate from surface drainage as small dark-brown streams, or emerge as full-grown rivers of clear water from one of Florida's seventeen first magnitude springs.

Temperatures are always warm enough, even in the western "panhandle" so that field-collecting during any month of the year yields a plentiful harvest. There may be a reduction of microorganism crops in the summer months due to temperatures in excess of 35°C around the margins of the smaller, more shallow bodies of water. Dissolved oxygen is usually high except near the bottom of ponds having a thick peat layer, although many of the springs reach the surface with no dissolved oxygen. Many springs also emerge carrying considerable hydrogen sulfide. The frequent brown water is due to extracted organic acids and quite hard waters are rare, while pH values usually range between 4.5 and 7.5. Since there is usually a distinct rainy season, blooms tend to be prevalent during or just after this season. In waters eutrophic because of human action, blooms may occur at any time.

All these matters make Florida waters an extremely valuable area for the microbiologist. Not too much has been published on areal microbiota (see citations below); hence this listing is proposed to acquaint workers with the abundant flora and fauna.

METHODS

The work began in November of 1952 when surveys of Florida streams were initiated in the then Sanitary Engineering Section, Department of Civil Engineering, now Bioenvironmental Engineering Department, of the University of Florida. In many instances collections were studied in the field using a portable International Clinical Centrifuge capable of carrying four 50-ml conical-ended tubes, and a microscope giving magnifications to 1000 diameters. If samples were brought to the laboratory, they were iced if possible. If it was not possible to drop the temperature by 8 or 10°C, commercial formalin was added at 3 to 5 ml per 100 ml of sample. Wherever it was possible, environmental characteristics of the water were noted.

Living plankton was usually centrifuged at about 2200 rpm for three to five minutes. Catches were calibrated so that numbers per liter could be stated. If an organism occurred once per ml of raw water, it was regarded as common for that particular water. The minimum examined was 6 ml, but often all organisms in 25 ml of water were counted, while those noted once in 100 ml were simply checked off as "present." For benthic samples and aufwuchs, several drops were customarily examined, and with the extraction pipettes used, one ml of material usually equalled about 15 drops, so even here a rough quantitation was possible.

This checklist is not intended as complete, but merely to record the observed species. In some instances only the genus was recognized, as in many of the diatoms. But wherever possible, identification to species was made.

Species identification often was not attempted for many genera, such as the desmids where a voluminous literature exists. Such exceptions are dealt with for each group. At least 10 percent of the organisms encountered could not be included because either a single specimen was seen, or because rapid movement precluded good determination, or because literature was not available. In ctenostomid ciliates movement is almost continuous, and in hypotrichous ciliates determination of the number and groups of cirri depends largely on quietness. Setting a slide aside in a petri dish moist chamber often accomplishes wonders. Nevertheless more species and genera were encountered than are listed here.

ENVIRONMENTS STUDIED

A number of situations in Florida from the Suwannee River to the East Coast and south to the Okeechobee area have been surveyed at various times since 1952.

Early river surveys consisted of visiting a stream at several stations, headwater to mouth, and sampling the stream where currents provided mixing. In some streams interface material was also secured along the banks in quiet stretches. The many thousands of ponds and lakes were largely untouched, unless some special reason existed such as studies of the Orange and Lake County large lakes, studied relative to eutrophication. It was noted that when a body of water was studied repeatedly, the same organisms showed a high degree of recurrence, but that different bodies of water showed certain species which could be termed common, and always a few peculiar to each different pond, lake or stream. The most intensive work has been done on lakes around Melrose, Florida, including the two lakes under study by the Department of Bioenvironmental Engineering at the University of Florida. Cue Lake, near Melrose, has been routinely examined since early 1966, and on March 21, 1967, became subject to routine fertilization. This is an effort to turn this oligotrophic lake into an eutrophic one. McCloud Lake, nearby, is an oligotrophic lake. The present paper reports on 25 samplings of the former and 15 samplings of the latter. We thus will have a "before and after" picture of Cue Lake insofar as its microbiota is concerned. Each sampling represents from two to several samples of plankton, benthic and aufwuchs organisms. These small sinkhole or depression lakes near Melrose have a small surface drainage area, are not spring fed and often are isolated from human influence other than fishermen. Not infrequently they are in pastures, and are fertilized to some extent by cattle droppings and urine, as cattle stand in the shallow margins and eat the grasses, principally Panicum haemotomon, there. The margins also produce good crops of Eriocaulon decangulare, Nymphoides aquaticum and Fuirena scirpoides, while large quantities of Mayacca and Ceratophyllum grow submerged, along with Utricularia. Bonnets (Nuphar) grow in water to 4 ft, and a ring of St. Johnswort (Hypericum cephalanthoides) is usually present at 2- to 4-ft depths. Beyond this is a ring of the grass Leersia, then open water.

The effects of this zonation are seen in rather definite groups of microorganisms. The plankton of the open water shows a few natant species and usually few numbers, but at times a bloom of some species. Thus the Punch Bowl, Location 25, usually has 12-20 species per ml and at times as few as 225 individuals per ml. On December 14, 1964, there were, at the surface, 3200 Peridinium Willei per ml and 192 other organisms of 11 species. Later there were 1000 Peridinium Volzii per ml and 20 organisms of six other species. The open water bottom usually has very few organisms, whether shallow or deep — the Punch Bowl is 46 ft deep.

The shallow margin and the stems of the plants have much larger and more varied populations. There may be in excess of 100 species of algae and protozoa in a single sample of the marginal sediment-water interface, and a population in excess of 5000 per ml of interface material. In McCloud Lake the marginal water often has blooms of Peridinium umbonatum dense enough to color the water, whereas perhaps 100 per ml are found in the open water. There is some evidence that the aufwuchs population is distinctive also. Thus we have not found Micrasterias foliaceum and Frustulia rhomboides except here. Glass slides hung from a dock in Lake Santa Fe at depths of 2 and 3 ft will become populated within 24 to 72 hrs with many species which simply do not appear at all in the plankton, at least in 100 ml samples. Examples are Frustulia rhomboides, Spongomonas uvella, Entosiphon sulcatum and Chaetosporidium.

The organisms listed in Table I were noted from one or more of 35 locations. These were sampled about 300 times, some locations once, others many times. No samples were recorded for 1955 and 1960. Samples were taken during every month of the year, with most of the sampling occurring in November through March. Some seasonal trends were noted, but are not discussed herein since much of the work was not an entire year's study of a single location. The one example of a year's study was Hogtown Creek (Sundaresan, et al, 1965) which was intensively sampled, but the data for which are unavoidably not included herein.

However most of the organisms were abundant throughout the year. Chrysophyceae tended to be most abundant in the spring. Dinoflagellata were also most abundant in the spring, but blooms have been recorded in any month. The largest numbers of green Euglenophyceae have been found in the fall, winter and spring, rather than the summer. Lake marginal temperatures become very high in June through

September which may account for this, since some very large crops of Euglena have been noted in flowing water during the summer.

Diatoms, except small naviculoid forms, have been few in these predominantly soft waters. The same is true of some other groups and of some species. However, it is difficult to record an organism as common or rare, because for most of the listed species we do not know the optimum environmental characteristics. Thus Micrasterias foliaceum might be deemed rare, but the studies herein have neglected the aufwuchs population, and our only records for this species are from such situations, the first in 1966. Attheya zachariasi is a diatom very easy to overlook, until the first one is seen, but a very large number of samples have been examined in which it might occur, and we believe it to be rare in Florida.

GROUPS STUDIED

Table I illustrates the number of species and/or genera recognized in more than 300 samplings from 35 locations. No specific listing of locations is given because many of the situations have local names not on a map, and because the material presented is intended as background for the intensive study of both McCloud and Cue Lakes.

This is a large species list, but will be greatly expanded as Florida waters are more intensively studied. There seem to be few studies of this sort at the present time. Nielsen, Nielsen and Madsen, and Brannon studied certain groups of blue-green algae, publishing their findings in the Quarterly Journal of the Florida Academy of Science between 1950 and 1955. Scott and Gronblad (1957) studied the desmids, and Whitford (1956) has some lists of algae. We know of virtually no papers listing Florida protozoa. Because Florida faces so many problems of water supply, lake eutrophication, and water resources conservation, it is hoped this list will be useful and that it will be expanded.

SULFUR BACTERIA

Table II is a list of the sulfur accumulating bacteria found in the fresh waters of Florida. Members of this group are usually recognized by morphology and since many species have not been cultivated in the laboratory, intensive work within the group might well increase the number of recorded species, and certainly frequency of occurrence. Lackey, et al (1965) have considered their general occurrence and ecology and find them more common in Florida in marine than fresh water. However Florida contains an enormous number of sulfur springs and wells, and these waters develop heavy white carpets of Beggiatoales as they emerge from the ground. The organisms die out quickly down the run as it becomes well aerated. Other than in these locations these species are rarely found in quantity.

These organisms in Table II need little comment. It is apparent that Beggiatoa alba is the most frequently occurring of the filamentous sulfur bacteria. Most of these bacteria occur in the sediment-water interface, even the Thiorhodaceae, and intensive study of such situations would probably add most of the species listed by Winogradsky (1949), Ellis (1952) and Bergey (1957) to this group. The importance of these organisms has been discussed by Lackey et al (1965).

In McCloud and Cue Lakes their occurrence is sparse.

BLUE-GREEN ALGAE

Most Florida waters show blue-green algae by following the sampling procedures outlined. The smallest numbers of species and individuals are in the humic acid-containing waters which are often oligotrophic. However Lake Santa Fe, oligotrophic and slightly acid, pH 6.0 - 7.2, bloomed three times in 1967, twice with Anabaena bornetiana and once with Aphanizomenon. Cue and McCloud Lakes have not shown a bloom of blue greens yet, although McCloud had large numbers of small colonies of Merismopedia punctata for a short period. Actually the most species of blue greens have occurred in polluted lakes (Apopka, Carleton, Beauclair, Eustis, Griffin) and rivers (Peace at Bartow), and these have the largest blue-green populations also. The five lakes have at present permanent, pea-soup blooms top to bottom, which have greatly decreased both species and number of other organisms, algae to fish. The dominant blue green is not the same in all. It may be Microcystis aeruginosa, M. incerta, Chroococcus limneticus or an Anabaena.

The listing in the table uses principally the taxonomy of Smith (1950). There is some disagreement as to the correct names for various genera, but to follow Drouet and Daily (1956) for example, would require dried specimens, not feasible when a few examples are seen in a mixed collection of living organisms. Many of the filamentous blue greens are difficult or impossible to trace to species when they occur in small numbers as in McCloud and Cue Lakes. These lakes have not had a large blue-green population during the study except for Merismopedia punctata which seems persistent there. Nevertheless the interface and the attaching forms show a good species representation (19 and 29 respectively in Table III). Rare species are Gleochaete Witrockiana and Nostochopsis lobatus. Seventeen other species were found only once in all the samples examined.

Neither the quantity nor number of species suggests that either McCloud or Cue is other than an oligotrophic lake. It will be interesting to see if enrichment shows up earliest in the blue-green algae, and what species increase.

CHLOROPHYCEAE

Filamentous Chlorophyceae have been comparatively sparse in the locations studied. Spirogyra species have been most common, then Mougeotia (2 species), Sirogonium floridanum, Oedogonium spp. and a few others, at least three not identifiable by us. Pleurodiscus has been found once. Zygnema has been rare, and Hydrodictyon has been noted only from the Peace River.

Nonfilamentous genera, including Mesotaeniaceae and Desmidiaceae have been much more common as shown by Table IV. Many desmids have been identified only to genus, because variability in this group is so great as to require study by a specialist. Micrasterias foliaceum, identified by Dr. Hannah Croasdale, was found only in McCloud and Cue Lakes. Coelastrum Chodati, not seen by us outside Florida, is often so pale that its trophic condition is doubtful. The nonfilamentous genera and species are rather widespread, but a few have been restricted as to location where found. Also there were few which could not be classified, and which occurred so frequently they might be new species.

Table IV shows the occurrence of the species found. The most striking thing about these organisms is not the large number of species found (167) but that about one third (52) were found only once. One might infer that they were scarce. However they might be quite numerous when and where found. Micrasterias foliaceum has occurred in long chains of cells in the two Melrose lakes; it is an abundant desmid there. Perhaps examination of the growths on the attached aquatic plants in other lakes would show a wider Florida occurrence of this desmid. However this has been done in Lake Santa Fe without finding the species. It has not occurred on numerous glass slides suspended in the lake. Bulbochaete sp. has been found at a single location — slides suspended in Lake Santa Fe. But every time slides have been withdrawn for examination, this alga has been present.

The list of green algae in Table IV is a long one. But these collections, in the hands of a specialist in green algae, would have produced many more species of such forms as desmids, Oocystis, Scenedesmus, Tetraedron, and others. None of these have been present as great blooms, but in some abundance when they were found. No great mats or masses of filamentous species were discovered, such as the massive growths of Spirogyra occasionally noted in other lakes and ponds. The impression that we have gained in these studies is that for most of these waters, the algae are growing on a modest nutrient budget which allows a large number of species to be present, but not dense populations.

VOLVOCALES

These flagellated green algae have been very scarce in McCloud and Cue Lakes, and the total number of species in Florida waters has been as shown in Table V. Chlamydomonas has been widespread, but species identification has been very limited for this and Carteria. Massive blooms have been composed of Chlamydomonas, Eudorina, Gonium, Pandorina and Pteromonas. These have been confined to a pond on the University campus which probably received small quantities of organic wastes, and to ponds and pools receiving cattle droppings. Phacotus lenticularis has been abundant in Lakes Apopka, Dora, Eustis and Griffin, the chain of highly eutrophic lakes in central Florida. It has been present every time the lake waters were examined, but reported only a very few times, because most of the examinations of these lake waters were not complete but only for the purpose of determining dominant and blooming species, invariably blue-green algae.

There were no unidentifiable Volvocales noted, although Cephalomonas, Dysmorphococcus, Pleodorina californica and the fresh-water species of Pyramidomonas have been uncommon in our experience. An interesting note is that some of the Pteromonas populations have shown wide variations, so that it might be questioned as to whether species erection in this genus has been carried too far.

The Volvocales that have been found in McCloud and Cue Lakes indicate a low content of soluble organic matter there. Here again any rise in organic matter should be reflected in a rise in populations of Volvocales. It may be that a very low seeding of the few species encountered may sharply restrict such a rise.

EUGLENOPHYCEAE

The Euglenophyceae are usually readily divisible into green (chlorophyll containing) and colorless genera and species. A few, such as Euglena acus, E. quartana and Hyalophacus ocellata readily secondarily lose their chlorophyll, in a rich organic environment, but most of the genera are sharply separated into green or colorless categories. This characteristic almost separates the group into swimming and creeping species, for the green forms need the light, and the colorless ones exist in its absence. This does not sharply separate them into autotrophic and heterotrophic groups for there is abundant evidence that many of those containing chlorophyll utilize dissolved organic matter, while various species (Peranema trichophorum for example) ingest solid materials. And both groups synthesize paramylum.

Adequate cataloging of Florida Euglenophyceae would require that both water and benthic habitats be equally examined. Table VI shows the species found thus far in Florida, with a general use of such technique. However in benthic material there is far more chance to miss an organism, or be unable to identify it because of debris interference. Huber-Pestalozzi (1955) lists 572 green species and 222 colorless species. In Table VI, 58 of the 161 species belong to the colorless genera, and it is believed that this latter group will show a much greater addition of species than the green forms. There are evidently considerable numbers of colorless species for which we do not have adequate descriptive material, as shown by the work of Skuja (1956) and Christen (1962), while the interface of salt water sediments has a rich collection, many unidentifiable at present.

Since both groups are regarded as common to well-fertilized or mildly polluted waters, the recognition of 91 species in McCloud and Cue Lakes needs comment. In McCloud Lake, 13 green species and 24 colorless species, most of which use soluble organic matter, have been found. In Cue, more intensively studied to date, the numbers were 28 green and 24 colorless species. But in all other situations 103 green species and 58 colorless species were recorded. The answer is that many of the other situations were eutrophic. Often they had blooms, always of green species such as Cryptoglena pigra, Euglena deses, E. pisciformis, E. velata, E. clara, Lepocinclis ovum, Phacus Stokesii and Trachelomonas volvocina. It is the total numbers of green Euglenophyceae which are most useful in determining the eutrophic condition of a body of water, and in these two lakes there has not been even a semblance of a bloom of these observed thus far. The criterion is not absolute — Euglena mutabilis will bloom in unpolluted water, and E. polymorpha will bloom in an isolated cedar swamp. Also, given a good rich organic medium, Entosiphon sulcatum, Astasia Klebsii, Peranema trichophorum and other colorless species are produced in dense cultures in the laboratory. But the numbers and kinds of colorless Euglenophyceae can offer some very useful criteria concerning the two experimental lakes. At present, they mark these lakes as oligotrophic.

There were few Euglenophyceae which were unusual or rare. Heteronema nebulosum, H. spirale and H. trispira were seen by us for the first time. Previous records for Khawkinea ocellata were from brackish water. Some of the Phacus records were also firsts for us. It is evident that finding the ones on this list is largely a matter of careful examination of those found in the open water, and careful search of the sediment-water interface of Florida waters.

XANTHOPHYCEAE

It is probable that species of this group have been overlooked in these Florida studies, considering the large number of species described in Die Susswasserflora and elsewhere. Nevertheless the ones listed in Table VII are distinctive enough so that their much greater occurrence in field material is at best dubious. Possibly members of the group have hard water optima, for Ohio Valley waters have yielded more. However they have been rather common in Cape Cod ponds and lakes.

Only one has occurred in bloom proportions in these studies. A single red bloom covering a few hundred square feet in Lake Beauclaire in 1967 proved to be Botryococcus Braunii. Otherwise it and the remaining seven species have occurred in very small numbers.

CRYPTOPHYCEAE

These are represented by a small group of species, but probably have a wider and more frequent occurrence than any other. Table VIII shows the occurrence of the determined species in Florida fresh waters. Chilomonas paramecium and Cyathomonas truncata vary little and are easily recognized, although size variation in the latter may be as much as 300 percent. But species of Chroomonas, Cryptomonas and Rhodomonas vary widely. It seems that Chroomonas Nordstetii and C. setoniensis are distinct species, but in a good population of the genus there are other species, or variation in both size and morphology is common. The matter might be settled by the number and arrangement of the trichites around the buccal groove, but in ecological work this is not feasible.

Cryptomonas is much the same. Probably erosa and ovata are good species, but others are frequently encountered which vary in size, morphology and color. A red Cryptomonas is much more common in the winter months, but aside from its color shows no difference from erosa, unless its cytology is different. Rhodomonas is not as frequent in fresh water as in salt, where it is often a dominant. But when numbers are high, variation in shapes from a rounded oval to an acutely pointed form, and from 6 microns to 20 microns in length are common.

Cryptophyceae are so frequent in occurrence, and so often abundant that they convey little information as to the quality of water in which they are found.

CHRYSOPHYCEAE

These organisms are sparingly represented in Florida waters, and in fact are more numerous in numbers and species in Florida salt waters. Some of the genera in Table IX are probably represented by more species than we have been able to determine, despite the papers of Conrad (1926), Pascher (1940) and others. This is true of Chromulina, Dinobryon, Mallomonas, and Ochromonas, and there are probably many sessile and palmelloid forms which we have overlooked. Unless they occur in large numbers, many motile Chrysophyceae are difficult to identify, especially those of small size.

While occurrence as indicated in Table IX is restricted as to locations in which a given species occurs, it is usually found in that station repeatedly. Thus Phaeoplaca thallosa has been found only in Lake Santa Fe, but practically any time a slide is withdrawn from the lake, it has been colonized by this species. It is probable that many Chrysophyceae are quite selective in environmental requirements. Mallomonas akrokomos which is common in the Ohio Basin, we have not found in Florida. In Cue and McCloud Lakes Chromulina, Chrysococcus, Mallomonas and Synura have shown a strong tendency to recur, and at times stratify either in the top layer, or close to the bottom.

CHLOROMONADIDA

The chloromonads are still a very poorly known group, and with the exception of Gonyostomum semen and Merotricha capitata are seldom recorded in lists of species. Both of these are widespread in Florida waters, and are frequent in McCloud and Cue Lakes. In addition, a small intermediate sized, rounded Gonyostomum occurs with some frequency, while there are certain colorless forms, which could be Reckertia or Thaumatomastix species, found principally in estuarine waters, but also in our fresh waters. Since we are uncertain as to their genus they are not recorded in Table X. Nevertheless four of the more rare chloromonads have been found in the state, and the two common ones recur frequently in McCloud and Cue Lakes.

DINOFLAGELLATA

Dinoflagellates are of frequent occurrence in many Florida lakes and McCloud and Cue, as shown by Table XI, are no exception. Moreover, both these lakes have shown blooms, i.e., 500 or more individuals per ml, of Peridinium umbonatum, which sometimes colors the shallow inshore water brown. Table XI will probably be a major but not a complete recording of Florida species, and especially for the two experimental lakes, but will be expanded as those species which occur very sparingly are found. At present 30 of the 42 species have been noted from a single occurrence. Some of these, notably Diplopsalis roseum, Gonyaulax triacantha and Massartia rotundata, have occurred freely in salt-water samples, but all three are distinctive for identification, and they may represent relict populations in areas that in recent geologic times have been submerged by the seas.

Numbers of dinoflagellates have been fairly high in these lakes and ponds. Thus Cue had 20, McCloud 14 out of 42. Likewise their tendency to recur is high. Notable in this respect are Ceratium curvirostre, Gymnodinium fusca, Peridinium umbonatum and P. wisconiense.

Records exist for several kinds which are not included here because their generic status is not satisfactorily determined (because the basis for this study has been ecological, rather than taxonomic). One, tentatively named Gymnodinium unispinosum is definitely new, and is a constant inhabitant of Cue Lake.

BACILLARIEAE (DIATOMS)

The diatoms of the area are probably represented by more species than any of the other groups. While Table XII lists only 75 species, the genera Amphiprora, Cocconeis, Cyclotella, Gyrosigma, Navicula, Synedra, and Tabellaria probably include many species which could be determined only from cleaned, mounted preparations, not possible in a study of this sort. In many ways it seems unfortunate that standard works on diatoms, such as those of Hendy (1964) and Patrick and Reimer (1966), do not include more aids to the identification of living diatoms, to help the field worker. Some species lend themselves admirably to this, such as Attheya Zachariasi, Frustulia rhomboides or Melosira varians. It is fortunate that diatoms all seem much alike physiologically, hence the total species can be lumped together to some extent, to seek their connotation in a given situation whose physicochemical characteristics are known. Nevertheless this does not explain why we may have huge blooms of Asterionella formosa or Fragilaria crotonensis often to the virtual exclusion, or at least the absence in abundance, of other diatom species.

Nowhere in Florida have we seen huge blooms of diatoms such as Cyclotella Meneghiana or Fragilaria crotonensis which have occurred in other waters. On the contrary diatoms tend to be much less in number in Florida waters, and particularly in Lakes McCloud and Cue. The 9 and 14 species which have been found in these two lakes include only the genus Navicula which might materially augment the number of species. Therefore some reason for their lack must be sought. Diatoms must use silicate, whereas other plankton algae do not. A low silicate value in McCloud and Cue Lakes therefore might help to account for low numbers there, without influencing the numbers of other organisms, unless diatoms were a prime food for certain animal species. Such is the case for certain species of the ciliate genus Strombidium, whose occurrence in Cue Lake compares favorably with that of other ciliates.

It seems hardly possible that nitrates or orthophosphate or both are limiting, because some of the situations where they were practically lacking have had enough NO_3 and PO_4 to support good crops. The Peace River with NO_3 between 0.05 ppm and 0.13 ppm and PO_4 between 0.034 ppm and 0.041 ppm is an example. Table XIII shows these and other relationships in the Punch Bowl, which is practically lacking in diatoms, although it occasionally supports blooms of dinoflagellates. It would appear from these analyses alone that humic acid, lowering the pH, and producing soft water, might be the answer. In support of this, diatoms are completely lacking in the peat-water interface in McCloud, Cue, and other Florida lakes. Until we have some additional answers, there is little to tell us what a paucity or an abundance of diatoms indicates as to water quality. Finding such salt-water diatoms as Actinoptychus undulatus or Terpsinoe americana in Florida fresh waters only complicates the question.

RHODOPHYCEAE

The only red algae found in these surveys was Auoudinella violacea which occurred twice, once in Lake Alice and once in the Econlockhatchee River.

MICROSCOPIC ALGAE AS A WHOLE

The algae listed above comprise a very large number of species, most of them from soft waters or those of very slight hardness; from clean and polluted situations, and from oligotrophic and eutrophic conditions. The question may well be asked how it is possible for oligotrophic lakes to have as many species (162 and 204) as are accorded to McCloud and Cue Lakes in Table I. There are several answers.

Almost all of these algae are autotrophic. This is true of all those containing chlorophyll. The colorless Euglenophyceae and Dinoflagellata are mostly heterotrophic, in that they absorb dissolved organic nutrients. A few (Ochromonas, Peranema, several dinoflagellates) can and often do, ingest solid food, and are holozoic. But many chlorophyll bearers also use, sometimes require, organic solubles. Very few are like Chlorella which will grow in distilled water. If the above list of algae is separated into those found in open water and those from the interface, the former group is much the smaller. In other words they occur where little disintegration of particulate matter takes place. Most solids settle to the bottom and decompose at the sediment-water interface. Studies of comparative bacterial numbers in the water column and vertically in bottom cores reveal the greatest concentration of bacteria in the top few millimeters of sediment. Therefore not only are PO_4, NO_3, SO_4 and other inorganic substances liberated at this point, but also intermediate organic solubles. Algae at this interface are therefore in the best position to acquire their nutrient needs, to grow and to reproduce. They also exert an effect in preventing diffusion into the upper waters, thereby reducing amounts available nearer the surface.

Many unicellular organisms, including algae as large as desmids, are able to make hydrostatic adjustments, to move up or down and from place to place. It has been mentioned that the peat-water interface in these lakes is virtually devoid of algae and protozoa, which seem to be confined to the marginal areas where the bottom is usually sediment. This peat-water interface in deeper water is often so flocculent that sinking organisms settle into it and die. It has a much reduced light; it releases very small quantities of nutrients since the peat or humus is largely cellulosic material; it is where pH drops suddenly (see Table XIII), and it is low in dissolved oxygen. None of these is conducive to high microbiotic populations. Some of these conditions apply also to the aufwuchs. Organisms attached to the upper stems of grass and plants growing in deep water are conceivably not in the best position to receive the nutrients being processed at the sediment-water interface. The aufwuchs population is intermediate between open water and marginal bottom in number of species.

It appears that oligotrophic waters, if properly surveyed, will show a large number of species, but that numbers of individuals are usually quite low.

PROTOZOA

The colorless holozoic organisms are in large measure dependent on bacterial food. Presumably, oligotrophic waters receive small contributions of organic matter, or else the organic matter is unbalanced in that it may consist largely of cellulosic material such as dead leaves of pine and cypress, or a variety of dead leaves which tend to slow decomposition. Consequently, lakes such as McCloud and Cue have smaller and less productive (of nutrients) bacterial populations, and are themselves less food for protozoa. These two lakes get few pine and no cypress leaves, but an abundance of shrub, oak, and grass leaves, as well as some cattle droppings. Nevertheless the same distribution of protozoa occurs, as shown above for algae. There are few protozoa in the open water, more in the growth attached to the stems of aquatic plants, a moiety in the shallow marginal areas, and very few species or numbers in the sediment interface in deep water.

ZOOFLAGELLATA

Table XIV, listing the species of Zooflagellata, could probably be materially expanded if proper studies of all genera, such as Bodo could be made. The total number of species, 69, includes all major groups. As expected McCloud and Cue have few species and few numbers and except for Bodo, Monosiga and Oicomonas, little tendency to recur. The zooflagellates probably represent the group which will respond most quickly to any eutrophication, after the bacteria. Any increase in bacterial numbers should quickly be followed by an increase in zooflagellates.

Taxonomically, Table XIV lists several species that are new to us, and that are probably records for Florida. All species in Table XIV are well documented in the literature, however, and we have no records of possible new species.

RHIZOPODA

A surprisingly large species list of Rhizopoda is given in Table XV, and they are shown to be widespread in distribution. Next to the diatoms this is the most difficult group to work with, despite the descriptions of Penard (1902) and Deflandre (1959); for a limited number, Cash and Wailes (1905-21) is ample. A very large number of rhizopods, especially Heliozoa, have been seen time after time, but have been impossible to classify, so either the number in Table XV is too small; recurrence and occurrence is greater than indicated; or these Florida waters have a considerable number of new species. Numbers have never been high for any one occurrence, but there is a high percentage of the total species recorded for both McCloud and Cue. Most of them have been found in the marginal interface for these two lakes. Species for which these are our first records are: Acanthocystis rubella, Amphizonella violacea, Astrodisculus radians, Awerintzia cyclostoma, Cienkowskya mereschkowskyi, Diaphorodon mobile, Frenzelina reniformis, Microcometes paludosus, Phryganella nidulus and Pompholyxophrys punicea. Their frequent occurrence, large size, and relative abundance in the marginal debris probably indicates a larger role than usually assumed for Amoeba spp., Arcella mitrata and Difflugia spp. in McCloud and Cue. However the primary interest in the rhizopods is the unexpectedly large number of species.

CILIATA

Using the procedures outlined, a large variety of ciliates have been found in these studies. Table XVI shows a total of 194 species or genera, and the species list could have been materially increased by better determination in some groups — Hypotrichida, for example. Most of these determinations follow the monograph of Kahl (1930-35), but a few follow definitions by Noland (1959), Borror (1963), or Calkins (1902). We regard Cyclotrichium meuneri and Dallasia frontata as valid species which Kahl does not, and there are other instances such as this.

Some of these ciliates frequently occur in open water. Such are Halteria grandinella, Codonella cratera, Mesodinium pulex, Strombidium spp. and Cyclidium spp. Others occur most frequently in the more nearly anaerobic bottom regions and include Caenomorpha medusula, the Ctenostomata generally, and Metopus. Some are sessile as Cothurnia and Vorticella spp., while others such as Uronema and Pleuronema are positively thigmotactic.

Most of them appear to be widespread, but 71 species were recorded from a single location. Hastatella radians was found only in Orange Lake. It is sufficiently large and distinctive so that it would not easily be overlooked if it occurred as frequently as once in 100 ml in other situations. The same is true of Vorticella planctonica.

McCloud and Cue Lakes had 50 and 81 recorded species respectively, and their lists will certainly be augmented. But 26 percent and 42 percent, respectively, of the total species list indicate these lakes support a large and wide variety, albeit low numbers, of ciliates. Some of these have been found elsewhere in marine waters, and the ciliates seem to be next to the colorless Euglenophyceae in ability to live under such a wide range of pH and salts concentration.

Numbers of ciliates in Cue and McCloud are almost certainly attributable to the numbers of bacteria which serve as food. Their distribution, principally in the marginal sediment water interface, further points to this region as the one where most active organic decomposition is taking place. It will be interesting to see if either open water or bottom dwelling ciliate increases take place in the middle of Cue where fertilizing material is added. As long as this is inorganic (NO_3, PO_4), no material ciliate increase is anticipated. But, if settled raw sewage is added, there should be a ciliate increase.

The organisms listed herein constitute a wide spectrum of algae and protozoa. This is rather a long list considering that not too great a variety of waters have been sampled. Nevertheless, from these same waters, as more workers study them, the list will grow. Some of these species have been recognized in bays and estuaries — waters of varying degrees of salinity — from Florida and elsewhere. What this all amounts to is to emphasize that most, possibly all, of these organisms are cosmopolitan. Many of them do not cross broad ecological boundaries, as between fresh and salt water or between oxygen-saturated and oxygen-depleted water. But many of them cross narrow boundaries, and each species has an optimum set of conditions under which it attains maximum numbers. It is useful to recognize the species we see, and by correlating numbers of individuals with known conditions, we may reach conclusions as to the meaning of large numbers either of taxonomic species or physiologically grouped species. It is hoped that this list will constitute a background against which further study may develop.

TABLE I

Number of Species and Genera Found to Date in McCloud Lake, Cue Lake and Other Florida Fresh Waters

Organism group	McCloud	Cue	Others	All Species
Algae				
Sulfur bacteria	3	16	21	22
Cyanophyta, blue-green algae	19	29	56	61
Chlorophyceae, nonmotile green algae	56	67	156	167
Volvocales, motile green algae	3	6	40	40
Euglenophyceae	37	54	151	161
Xanthophyceae	1	2	9	10
Chrysophyceae	12	17	31	34
Cryptophyceae	6	7	10	10
Chloromonadida	2	2	8	8
Dinoflagellata	14	20	38	42
Bacillarieae, diatoms	9	14	75	75
Rhodophyceae			1	1
Total algae	162	204	596	631
Protozoa				
Zooflagellata	17	24	67	69
Rhizopoda	37	38	77	93
Ciliata	50	81	171	194
Total protozoa	104	143	315	356
Total algae and protozoa	266	377	911	987

TABLE II

Occurrence of Species of Sulfur-Accumulating Bacteria in Florida Fresh Waters

Organism	McCloud	Cue	Others
Achromatium oxaliferum	2	4	8
Amoebobacter roseus			2
Amoebobacter sp.			1
Beggiatoa alba	1	6	14
Beggiatoa arachnoidea			4
Beggiatoa leptomitiformis	1	2	5
Beggiatoa minima		2	5
Chromatium Okeni			5
Chromatium sp.			2
Lamprocystis roseopersicina			1
Macromonas bipunctata		1	2
Macromonas mobilis			2
Thiocapsa floridana			1
Thiocapsa roseopersicina			1
Thiodictyon elegans			2
Thiopedia rosea			2

TABLE II (Continued)

Organism	McCloud	Cue	Others
Thiopedia sp.		1	
Thiopolycoccus ruber			1
Thiosarcina rosea			2
Thiospirillum jenense			2
Thiothrix nivea			4
Thiovulum rotans			2
Total no. species in	3	6	21
Total no. species found, 22			

TABLE III

Occurrence of Species of Blue-Green Algae in Florida Fresh Waters

Organism	McCloud	Cue	Others
Anabaena Bornetiana	3	11	16
Anabaena circinalis		2	9
Anabaena Lemmermanni			1
Anabaena spiroides		1	1
Anabaena sp.			18
Anabaeniopsis Elenkinii	1	3	9
Anacystis sp.		2	
Aphanizomenon flos aquae			6
Aphanocapsa pulchra		2	6
Aphanocapsa sp.			2
Aphanothece stagnina		2	3
Arthrospira Jenneri			1
Aulasira implexa	1	1	1
Borzia trilocularis	2		1
Calothrix sp.			1
Chroococcus limnetica			5
Chroococcus planctonica	3	1	6
Chroococcus turgidus		1	6
Chroococcus sp.			1
Coelosphaerium Kuetzingianum		2	2
Coelosphaerium Nagelianum			1
Coelosphaerium sp.			1
Eucapsis alpina			5
Gleocapsa magma	5	1	8
Gleocapsa sp.			5
Gleochaete Witrockiana			2
Gleothece sp.	2	4	6
Gomphosphaera aponina			2
Gomphosphaera lacustris		1	9
Hapalosiphon pumillus	3	6	13
Holopedium irregulare			1
Lyngbya contorta			13
Lyngbya majuscula	1	2	3
Lyngbya sp.	3	1	11
Merismopedia elegans			2
Merismopedia glauca	1		13
Merismopedia punctata	7	9	4
Merismopedia tenuissima			1
Merismopedia sp.			10
Microcoleus sp.		2	6
Microcystis aeruginosa	2	2	17
Microcystis incerta			21
Nodularia spumigena			2
Nostoc sp.			1
Nostocopsis lobatus			1
Oscillatoria chlorina		1	1
Oscillatoria princeps		1	2
Oscillatoria sp.	3	10	32
Phormidium inundatum			1
Phormidium tenue	1	3	7
Phormidium sp.			1
Pleurocapsa fluviatilis		1	
Schizothrix sp.	2	1	
Scytonema sp.	1	2	1
Spirulina major			2
Spirulina sp.			2
Stigonema turfaceum	2	1	

TABLE III (Continued)

Organism	McCloud	Cue	Others
Symploca sp.		1	
Synechococcus aeruginosa	1		1
Tolypothrix sp.			1
Total no. species in	19	29	56
Total no. species found, 61			

TABLE IV

Occurrence of Species of Nonmotile Chlorophyceae in Florida Fresh Waters

Organism	McCloud	Cue	Others
Actinastrum Hantschii			7
Ankistrodesmus contorta			2
Ankistrodesmus falcatus	2	7	22
Ankistrodesmus mirable	-		7
Ankistrodesmus spiralis		1	12
Ankistrodesmus tumidus			2
Aphanochaete repens			1
Arthrodesmus spp.	2	5	8
Asterococcus limneticus	1		
Binuclearia eriensis			1
Bulbochaete sp.			1
Chaetopeltis orbicularis			1
Chaetophora incrassata			1
Chaetosphaeridium globosum		1	1
Characium spp.	1	2	1
Chlorella spp.	3	5	8
Chodatella Wratislawiensis			1
Cladophora sp.			2
Closteridium lunula	2	4	2
Closteriopsis longissima	1	2	9
Closterium acerosum			1
Closterium acicularis			2
Closterium lunula			1
Closterium minuta			1
Closterium setaceum	1	4	6
Closterium strigosum			1
Closterium venus			1
Closterium sp.	3	16	31
Coelastrum cambricum		3	12
Coelastrum Chodati	1	3	2
Coelastrum microporum		2	10
Coelastrum proboscideum		1	4
Coelastrum reticulatum			2
Coelastrum sp.			1
Coleochaete scutata			1
Coronastrum acicularis			1
Cosmarium spp.	4	15	28
Cosmocladium constrictum			1
Crucigenia apiculata			8
Crucigenia rectangularis			2
Crucigenia tetrapedia			17
Crucigenia sp.			1
Cylindrocystis spp.	5	8	8
Dactylothece confluens		1	
Desmidium Baileyi		6	2
Desmidium Grevillei	1	1	
Dicranochaete reniformis	1	1	1
Dictyosphaerium Ehrenbergianum			4
Dictyosphaerium Naegelianum			2
Dictyosphaerium pulchellum	2	2	18
Dictyosphaerium sp.			3
Dimorphococcus lunatus			5

TABLE V (Continued)

Organism	McCloud	Cue	Others
Heteromastix sp.			4
Labomonas rostrata			5
Mesostigma viridis			3
Pandorina morum		2	11
Pedinomonas major			1
Pedinomonas minor		1	3
Pedinopera granulosus			2
Phacotus lenticularis			5
Platymonas elliptica			1
Pleodorina californica			1
Polytoma sp.			1
Pteromonas angulosa			10
Pteromonas sp.		1	6
Pyramidomonas sp.			2
Scourfieldia complanata			2
Spermatozopsis exultans			3
Sphaerellopsis sp.			1
Thoracomonas phacotoides			1
Uroglenopsis americana			1
Volvox globator			1
Wislouchiella planctonica			1
Total no. species in	3	6	40

Total no. species found, 40

TABLE VI

Occurrence of Euglenophyceae in Florida Fresh Waters

Organism	McCloud	Cue	Others
Anisonema acinus			1
Anisonema dubium			1
Anisonema emarginatum			2
Anisonema grande			1
Anisonema orbicularis			1
Anisonema ovale	2	2	11
Anisonema praegnans			2
Anisonema variable		1	1
Astasia Harrisii			1
Astasia Klebsii	1	5	7
Astasia longa	1	1	1
Astasia praecompleta			1
Astasia torta	1	2	2
Astasia sp.			5
Colacium arbuscula		1	
Cryptoglena pigra			16
Dinema grisoleum	1		2
Dinema litorale	1		1
Distigma proteus	3	1	5
Entosiphon obliquum			1
Entosiphon sulcatum	3	2	15
Entosiphon sp.			1
Euglena acus		3	14
Euglena adherens			1
Euglena agilis			5
Euglena centralis			1
Euglena clara			4
Euglena deses	2		10
Euglena Ehrenbergii		1	6
Euglena fusca		4	7
Euglena gracilis		1	8
Euglena haematodes			2
Euglena minima			1
Euglena minuta		1	
Euglena mutabilis	3	7	7
Euglena oxyuris		1	9
Euglena pisciformis	1	3	15
Euglena polymorpha			8
Euglena quartana		1	
Euglena sanguinea			5
Euglena sciotensis			7
Euglena spirogyra		5	6
Euglena splendens			1
Euglena sub-Ehrenbergii			1

TABLE VI (Continued)

Organism	McCloud	Cue	Others
Euglena tripteris			6
Euglena velata			11
Euglena vermiformis			1
Euglena viridis	2	6	17
Euglena sp.	3	10	27
Eutreptia sp.			2
Eutreptiella sp.			1
Heteronema acus	3	5	5
Heteronema Klebsii			1
Heteronema nebulosum			1
Heteronema spirale			1
Heteronema trispira			1
Heteronema sp.			1
Hyalophacus ocellata		3	
Khawkinea ocellata	1	1	
Lepocinclis Butschlii			2
Lepocinclis fusiformis		1	2
Lepocinclis Marssoni			3
Lepocinclis ovum			14
Lepocinclis teres			1
Lepocinclis texta			11
Lepocinclis cymbiformis			3
Lepocinclis sp.	1		2
Menoidium falcatum		1	1
Menoidium gracile	2		7
Menoidium incurvum		3	5
Menoidium sp.			2
Notosolenus apocamptus	3	7	9
Notosolenus orbicularis			1
Notosolenus sinuatus			1
Peranema aspera			1
Peranema ovalis			2
Peranema trichophorum	2	9	16
Petalomonas abscissa			1
Petalomonas carinata	2	2	5
Petalomonas gigas			1
Petalomonas mediocanellata	1	1	2
Petalomonas praegnans	1	2	
Petalomonas pusilla		1	1
Petalomonas quadrilineata	1		
Petalomonas Steinii	1	1	1
Petalomonas tricarinata			1
Petalomonas sp.	1	3	2
Phacus aenigmaticus			4
Phacus anacoleus			2
Phacus asymmetrica			1
Phacus brachykentron			1
Phacus brevicaudatus			2
Phacus caudatatus			1
Phacus circularis			1
Phacus Dangeardii			1
Phacus glaber			1
Phacus helicoides			1
Phacus hispida v. elongata			1
Phacus hispidula			6
Phacus longicauda		3	9
Phacus longicauda v. insecta			1
Phacus Morii			1
Phacus parvulus			1
Phacus pleuronectes	1	1	7
Phacus pusillus			6
Phacus pyrum			16
Phacus Raciborski			1
Phacus Stokesii			8
Phacus suecicus		2	5
Phacus tortus	1		7
Phacus triqueter		1	15
Phacus sp.	1		11
Pleotia marina			1
Rhabdomonas incurva			1
Rhabdomonas sp.	1	4	1
Scytomonas pusilla	1	2	2
Sphenomonas australis	1		

TABLE VI (Continued)

Organism	McCloud	Cue	Others
Sphenomonas quadrangularis			2
Sphenomonas quadrangularis v. cruciformis	1	1	1
Sphenomonas teres	1	7	6
Strombomonas acuminata			1
Strombomonas Deflandrei			1
Strombomonas urceolata			1
Strombomonas sp.			3
Trachelomonas abrupta			1
Trachelomonas armata			4
Trachelomonas australis			2
Trachelomonas crebea			1
Trachelomonas cylindrica		5	9
Trachelomonas cylindrica v. hispida		1	
Trachelomonas cylindrica v. punctata			1
Trachelomonas Dybowski		1	
Trachelomonas euchlora		2	6
Trachelomonas eurystoma			1
Trachelomonas Raciborski			1
Trachelomonas granulosa			1
Trachelomonas hispida	2	6	16
Trachelomonas hispida v. duplex			3
Trachelomonas lismorensis			2
Trachelomonas megalacantha			1
Trachelomonas oblonga			3
Trachelomonas oblonga v. attenuata			1
Trachelomonas obovata	1	6	10
Trachelomonas ovalis			2
Trachelomonas ovata		3	1
Trachelomonas pulchra			1
Trachelomonas punctata		1	3
Trachelomonas pusilla			1
Trachelomonas rotunda	1	1	
Trachelomonas rugulosa			1
Trachelomonas scabra			1
Trachelomonas Skvortzowiana			1
Trachelomonas sydneyensis			1
Trachelomonas urceolata			5
Trachelomonas verrucosa			1
Trachelomonas volvocina	1	6	32
Trachelomonas Zingeri			1
Trachelomonas zorensis			1
Trachelomonas sp.		3	15
Tropidoscyphus octocostatus			5
Urceolus cyclostomus			1
Urceolus sabulosus			3
Total no. species in	37	54	151
Total no. species found, 161			

TABLE VII

Occurrence of Xanthophyceae
in Florida Fresh Waters

Organism	McCloud	Cue	Others
Botryococcus Braunii		4	4
Bumilleria sicula			2
Centritractus belonophorus	1		7
Desmatractum bipyramidatum			4

TABLE VII (Continued)

Organism	McCloud	Cue	Others
Desmatractum elongatum			2
Ophiocytium capitatum			1
Peroniella planctonica		1	2
Tribonema sp.	1	2	
Total no. species in	2	3	8
Total no. species found, 9			

TABLE VIII

Occurrence of Cryptophyceae
in Florida Fresh Waters

Organism	McCloud	Cue	Others
Chilomonas paramecium	1	2	9
Chroomonas Nordstetii			2
Chroomonas spp.	2	3	10
Cryptomonas erosa	8	17	31
Cryptomonas ovata	2	8	11
Cryptomonas sp.	1	1	21
Cyathomonas truncata	3	2	13
Rhodomonas lacustris		3	8
Rhodomonas sp.			7
Total no. species in	6	7	9
Total no. species found, 9			

TABLE IX

Occurrence of Chrysophyceae
in Florida Fresh Waters

Organism	McCloud	Cue	Others
Chlorodesmus hispidus	2		2
Chromulina globosa			2
Chromulina ovalis	3	8	7
Chromulina Pascheri			1
Chromulina sp.			3
Chrysamoeba radians	1	1	3
Chrysocapsa planctonica	2		1
Chrysochromulina parva		1	3
Chrysochromulina sp.			3
Chrysococcus cordiformis	5	7	7
Chrysococcus major			3
Chrysococcus reticulata			1
Chrysococcus rufescens	3	4	18
Chrysococcus sp.			5
Chrysopyxis bipes	1	1	
Chrysostephanosphaera globulifera	1	1	
Dinobryon sertularia	6	13	14
Dinobryon sp.			4
Hymenomonas roseola		1	2
Mallomonas caudata		2	
Mallomonas sp.	6	10	30
Ochromonas Pascheri		1	1
Ochromonas sociabilis			1
Ochromonas variabilis			1
Ochromonas sp.		1	1
Phaeoplaca thallosa			1
Phaeothamnion confervicola			1
Rhizochrysis limnetica			1
Synura uvella	3	13	21
Uroglena americana		1	3
Total no. species in	12	17	31
Total no. species found, 34			

TABLE X

Occurrence of Chloromonadids
in Florida Fresh Waters

Organism	McCloud	Cue	Others
Gonyostomum depressum			1

TABLE X (Continued)

Organism	McCloud	Cue	Others
Gonyostomum semen	3	14	9
Gonyostomum sp.		2	4
Merotricha capitata	4	13	4
Thaumatomastix setifera			1
Trentonia flagellata			1
Vacuolaria virescens			2
Total no. species in	2	3	7
Total no. species found, 7			

TABLE XI

Occurrence of Dinoflagellata in Florida Fresh Waters

Organism	McCloud	Cue	Others
Ceratium cornutum		1	2
Ceratium curvirostre	4	11	2
Ceratium hirundinella			8
Cochlodinium sp.			1
Cystodinium sp.			1
Diplopsalis roseum			1
Glenodinium cinctum			1
Glenodinium Elpatiewski		1	
Glenodinium foliaceum		2	3
Glenodinium gymnodinium			6
Glenodinium neglectum			2
Glenodinium sp.		1	2
Gonyaulax apiculata		1	1
Gonyaulax palustre			1
Gonyaulax polygramma			1
Gonyaulax triacatha			1
Gonyaulax sp.			4
Gymnodinium aeruginosa	1	1	8
Gymnodinium fusca	2	9	6
Gymnodinium oculatum			2
Gymnodinium pygmaeum	1		
Gymnodinium vorticella		1	1
Gymnodinium unispinosum p. n.	1	9	4
Gymnodinium sp.	6	11	21
Hemidinium nasutum	3	2	6
Massartia rotundata			1
Massartia sp.	1	2	9
Peridinium cinctum	1		
Peridinium inconspicuum		2	1
Peridinium marchicum		1	
Peridinium pygmaeum			1
Peridinium quadridens			4
Peridinium tabulatum			1
Peridinium trochoideum			1
Peridinium umbonatum	7	11	7
Peridinium Volzii	2	3	4
Peridinium Willei	1		3
Peridinium wisconiense	3	5	3
Peridinium sp.	2	7	15
Protodinium sp.		1	1
Tetragonidium sp.			1
Total no. species in	14	20	38
Total no species found, 42			

TABLE XII

Occurrence of Diatoms in Florida Fresh Waters

Organism	McCloud	Cue	Others
Acnanthes coarctata			1
Actinoptychus undulatus		1	1
Amphiprora sp.			8
Amphora ovalis			4
Asterionella formosa	6	2	8
Asterionella gracillma			2
Attheya Zachariasi			5
Biddulphia sp.			1

TABLE XII (Continued)

Organism	McCloud	Cue	Others
Caloneis sp.			2
Campylosira sp.			2
Cocconeis pediculus			1
Cocconeis placentula			3
Cocconeis sp.			12
Coscinodiscus lacustris		1	6
Cyclotella catenella			1
Cyclotella Meneghianiana			2
Cyclotella spp.	1	2	36
Cymbella sp.			3
Denticula sp. (thermalis?)			3
Detonula sp.			4
Diatoma hiemale			1
Diploneis sp.			2
Epithemia sp.			1
Eunotia arcus			2
Eunotia spp.	1		4
Fragilaria capuchina			1
Fragilaria construens			8
Fragilaria crotonensis			3
Fragilaria nitzschii			1
Fragilaria sp.	1	2	8
Frustulia rhomboides	2	1	3
Gomphonema olivaceum			4
Gomphonema sp.			4
Gyrosigma nicobarium			1
Gyrosigma spp.			11
Licmophora abbreviata			1
Melosira borreya			1
Melosira distans			1
Melosira granulata	1		31
Melosira monilata		2	1
Melosira sulcata			2
Melosira varians		2	13
Meridion circulare			1
Navicula viridis			4
Navicula spp.	6	15	49
Neidium sp.			5
Nitzschia acicularis			1
Nitzschia closterium			13
Nitzschia longissima			1
Nitzschia paradoxa			4
Nitzschia recta			1
Nitzschia sigmoidea			3
Nitzschia scalaris			3
Nitzschia sp.			1
Pinnularia viridis		1	8
Pleurosigma formosa			7
Rhizosolenia eriensis			6
Rhopalodia sp.			2
Stauroneis sp.			1
Stephanodiscus niagarae			1
Surirella spp.		1	13
Synedra actinastroides			25
Synedra acus			5
Synedra acutissimum			3
Synedra capitata			13
Synedra princeps			1
Synedra ulna	1	4	34
Synedra sp.			11
Tabellaria fenestrata		1	8
Tabellaria flocculosa	1	7	8
Tabellaria spp.			9
Terpsinoe americana			4
Thalassiosira sp.			2
Tropidoneis sp.			1
Total no. species in	9	14	75

Total no. species found, 75

TABLE XIII

Some Environmental Factors in the Punch Bowl Lake

Nitrate and Phosphate in ppm

Sampling depth	Surface	10 ft	20 ft	30 ft	40 ft (bottom)
Temperature	60°F	59°F	59°F	59°F	59°F
Five day BOD	1.37ppm				
NO_3	0.44	0.62	0.62	0.44	0.48
PO_4 Total, no sediment	0.045	0.098	0.037	0.048	0.048
PO_4 Total, stirred	0.527	0.098	0.037	0.061	0.048
PO_4 Inorganic	0.029	0.008	0.012	0.030	0.018
pH	7.4-5.5	5.5	5.6	5.6	5.7

TABLE XIV

Occurrence of Zooflagellata in Florida Fresh Waters

Organism	McCloud	Cue	Others
Amastigomonas de brunyei			1
Amphimonas globosa			1
Anthophysa vegetans			8
Bicoeca lacustris	2	1	12
Bicoeca mediterranea			1
Bicoeca sp.			1
Bodo agilis	1	6	9
Bodo angustus			1
Bodo caudatus			2
Bodo elongatus	1		
Bodo glissans			1
Bodo globosus	1	2	5
Bodo minimus		1	3
Bodo ovata			1
Bodo sp.	3	3	8
Bodopsis godboldi			3
Cercobodo crassicauda			1
Cercobodo sp.		1	5
Codomonas annulata			1
Codonosiga botrytis	1		4
Codonosiga sp.			1
Collodictyon triciliatum			11
Hexamitus inflatus		1	2
Histiona aroides*		1	1
Kephyrion ovum			2
Lagynion ampulla	1	3	5
Mastigamoeba lacustris			1
Mastigamoeba setosa		1	1
Mastigamoeba sp.	1		
Mastigella polymastix			1
Mastigella sp.			2
Mastigina setosa			1
Monas coronifera			4
Monas granulifera			1
Monas socialis		1	4
Monas vestita			1
Monas vulgaris			1
Monas sp.	1	4	9
Monosiga ovata	3	5	9

*Colorless chrysomonad.

TABLE XIV (Continued)

Organism	McCloud	Cue	Others
Monosiga sp.			1
Multicilia lacustris		2	
Oicomonas ocellata	1		1
Oicomonas socialis		1	3
Oicomonas termo	1	9	15
Paraphysomonas vestita			2
Phalansterium digitatium			1
Phanerobia pelophila			1
Phyllomitus amylophagus			1
Pleuromonas jaculans	1		7
Poteriodendron petiolatum		1	4
Rhipidodendron splendidum	1	4	7
Rynchobodo nasuta			1
Salpingoeca gracile			1
Salpingoeca lagenula			1
Salpingoeca marssoni			1
Salpingoeca vaginicola		1	1
Salpingoeca sp.			1
Siphomonas Fritschii			1
Spharoeca volvox	1	1	2
Spriochaeta plicatilis			2
Spirochaeta sp.		1	3
Spiromonas angusta	1	3	3
Spongomonas uvella	3	2	5
Sterromonas formicina			3
Stomatochone infundibuliformis			1
Tetramitus pyriformis			1
Trepomonas rotans		1	3
Urophagus sp.			1
Total no. species in	17	24	68

Total no. species found, 69

TABLE XV

Species of Rhizopods Occurring in Florida Fresh Waters

Organism	McCloud	Cue	Others
Acanthocystis aculeata	3	4	5
Acanthocystis infestans			1
Acanthocystis rubella			1
Acanthocystis sp.			1
Actinosphaerium eichorni	1		3
Actinophrys sol	1	3	4
Amoeba dubia			2
Amoeba proteus			3
Amoeba radiosa		2	5
Amoeba striata		1	1
Amoeba villosa			3
Amoeba vespertilio	3	4	8
Amoeba sp.	1	5	8
Amphitrema wrightianum	1		
Amphizonella violacea			1
Arachnula impatiens	1		
Arcella angulosa			1
Arcella dentata	1	2	9
Arcella discoides	1	3	9
Arcella mitrata	5	4	4
Arcella pentagonum	1		
Arcella vulgaris		6	14
Astrodisculus radians			1
Awerintzia cyclostoma		1	
Campascus sp.			1
Centropyxis aculeata	1		1
Chaos chaos		2	1
Chlamydophrys stercorea	1		
Chlamydophrys sp.	1		
Cienkowskya mereschkowskyi			1
Clothrulina elegans	1		3
Cochlopodium bilimbosum	1	4	6

TABLE XV (Continued)

Organism	McCloud	Cue	Others
Cochlopodium setosa		1	
Cochlopodium vinctum			1
Cochlopodium sp.	1		1
Cucurbitella mespiliformis	1		
Cyphoderia ampulla			3
Diaphorodon mobile		1	
Difflugia acuminata	1	4	5
Difflugia corona	2	4	
Difflugia lebes	3	6	9
Difflugia lobostoma			2
Difflugia oblonga			1
Difflugia pyriformis	3	6	5
Difflugia sp.	1		2
Diplophrys archeri		2	6
Eleorhanis oculea		1	
Euglypha alvcotata	1		5
Euglypha ciliata			1
Frenzelina reniformis			1
Gocevia binucleata			2
Gromia fluviatilis	1		3
Hartmanella hyalina			4
Heleopera sp.			1
Heterophrys myriapoda		2	6
Heterophrys sp.			2
Lecythium hyalinum	1	1	
Leptochlamys ampulla		1	1
Lesquereusia spiralis			1
Microcometes paludosus			1
Microgromia sp.			3
Nebela collaris			4
Nuclearia delicatula	1	1	7
Nuclearia lateritia			1
Nuclearia sp.			4
Paulinella chromatophora			3
Pelomyxa palustris	1	2	4
Pelomyxa villosa			1
Pelomyxa sp.			1
Penardia cometa			1
Phryganella nidulus		1	1
Phryganella sp.	1		1
Pompholyxophrys sp.			1
Pseudodifflugia fulva			1
Pseudodifflugia gracilis			2
Pseudodifflugia sp.	2	1	2
Pyxidicula operculata			3
Raphidiocystis simplex	1		
Raphidiophrys elegans		1	2
Raphidiophrys pallida		2	2
Raphidiophrys viridis	1		
Trinema lineare	1	2	9
Vahlkampfia albida		1	8
Vahlkampfia gigas		1	
Vahlkampfia guttula		2	4
Vahlkampfia limax	1	3	8
Vahlkampfia sp.			1
Vampyrella lateritia	2	2	5
Wagnerella borealis			1
Total no. species in	37	38	77
Total no. species found, 93			

TABLE XVI

The Occurrence of Ciliates
in Florida Fresh Waters

Organism	McCloud	Cue	Others
Acineta sp.		1	2
Actinobolina radians			3
Amphisia multiseta			1
Amphileptus claparedi			1
Askenasia faurei		1	3
Aspidisca costata	3	4	11
Aspidisca hexeris		1	
Aspidisca lynceus			4
Aspidisca turrita	3	4	1

TABLE XVI (Continued)

Organism	McCloud	Cue	Others
Aspidisca sp.			2
Atopodinium fibulatum			1
Balanonema biceps	2		
Blepharisma undulans			1
Bursaria truncatella			1
Bursaridium difficile	1		1
Caenomorpha medusula		1	1
Carchesium polypinum			4
Carchesium sp.			1
Chaenea teres			1
Chaenea vorax			1
Chaenea sp.		1	1
Chilodonella cucullulus			1
Chilodonella piscatoris			2
Chilodonella uncinata	3	6	13
Chilodonella sp.			1
Chilodontopsis vorax			1
Cinetochilum margaritaceum	2	8	18
Cinetochilum marinum	1	2	4
Climacostomum virens			1
Codonella cratera			8
Coleps caudatus			1
Coleps hirtus		7	18
Coleps saprophyticus			1
Coleps sp.			6
Colpoda aspera			1
Colpoda inflata			1
Colpoda sp.		2	1
Cothurnia sp.		1	3
Cristigera phoenix	2	5	
Cristigera setosa			1
Cristigera sp.			1
Cyclidiopsis sp.		2	1
Cyclidium glaucoma			9
Cyclidium saltans p. n.		2	3
Cyclidium sp.	4	6	21
Cyclotrichium meuneri			1
Cyrtolophosis mucicola	1	1	6
Dallasia frontata			1
Didinium nasutum			2
Dileptus anser	2	4	4
Dileptus gigas	1	1	
Discomorpha pectinata		1	
Drepanomonas dentata	1		
Drepanomonas revoluta		5	3
Drepanomonas sp.			4
Dysteria procera			1
Dysteria sp.	1	2	3
Enchelyodon sulcatus			1
Enchelyodon sp.		1	
Enchelyomorpha vermicularis			1
Enchelys vestita		1	
Epalxis striata		1	1
Ephelota sp.		1	1
Epiclintes ambiguus		1	
Epistylis sp.		2	4
Espejoia mucicola	2		
Espejoia sp.			1
Euplotes carinatus		1	1
Euplotes sp.			6
Frontonia acuminata		1	
Frontonia atra	1		
Frontonia leucas	4	7	13
Gastronauta membranaceus	2		
Glaucoma scintillans			3
Halteria grandinella	2	7	24
Hastatella radians			1
Hastatella sp.			3
Hemiophrys maleagris			1
Hemiophrys sp.	2	3	3
Holophrya discolor			1
Holophrya sp.	1	3	6
Holosticha sp.			3
Lacrymaria olor		1	1
Lacrymaria pupula		1	1

TABLE XVI (Continued)

Organism	McCloud	Cue	Others
Lembadion bullinum		6	6
Lembus fusiformis			1
Lembus pusillus		1	
Lembus sp.			1
Lionotus cygnus		1	2
Lionotus fasciola		3	9
Lionotus obtusus			1
Lionotus vesiculosus			1
Lionotus sp.			2
Loxocephalus granulosus	1		2
Loxocephalus luridus	2	4	3
Loxodes magnus		3	1
Loxodes undulatus			1
Loxophyllum meleagris			1
Loxophyllum rostratum			2
Mesodinium cinctum	1	1	1
Mesodinium pulex	2	2	18
Metacystis truncata	1		1
Metacystis sp.		1	3
Metopus es	1	4	2
Metopus spiralis			1
Microthorax glaber	1	1	
Microthorax pusillus	1		
Monodinium balbiani			3
Mylestoma uncinata		1	
Nannophrya truncata			2
Nassula aurea			2
Nassula sp.			5
Opercularia sp.			3
Ophrydium crassicaule		1	1
Ophrydium versatile		3	7
Ophrydium sp.			1
Oxytricha chlorelligera		3	
Oxytricha discocephalus		1	
Oxytricha pelionella	1	2	5
Oxytricha sp.	1	3	8
Parablepharisma pellitus		1	
Paradileptus musculus			1
Paradileptus robustus			1
Paramecium bursaria		1	1
Paramecium caudatum	1	2	9
Paramecium trichium			2
Paramecium sp.			3
Paruroleptus piscis			1
Perispira sp.			1
Pithothorax processus			1
Placus luciae			1
Platycola sp.			1
Platynema sociale			1
Pleuronema chrysalis		4	3
Pleurotrichia lanceolata			1
Podophrya sp.		1	1
Prorodon ovum			1
Prorodon sp.	3	5	5
Pyxicola striata			1
Remanella rugosa		3	6
Saprodinium dentatum			1
Saprodinium putrinum			1
Saprodinium sp.		3	2
Sonderia schizostoma			1
Spathidium spathula			1
Spirostomum ambiguum		1	1
Spirostomum loxodes			1
Spirostomum minus			1
Spirostomum teres	2	6	6
Spirostomum sp.			1
Stentor coeruleus	2	1	3
Stentor mülleri		1	
Stentor polymorphus	1	6	4
Stentor roeseli			1
Stentor sp.			3
Stichotricha secunda			3
Strobilidium humile	1	8	15
Strobilidium sp.			9
Strombidium spp.	2	5	16
Stylonychia mytilus	1	2	1

TABLE XVI (Continued)

Organism	McCloud	Cue	Others
Stylonychia pustulata		4	7
Tetrahymena sp.	2		2
Thuricola sp.			1
Tintinnidium fluviatile			7
Tintinnidium primitivum			6
Tintinnopsis cylindrata			2
Tintinnopsis minuta			3
Trachelius ovum	1		2
Trachelocerca oblonga			1
Trachelocerca phoenicopterus	1		3
Trachelophyllum brachypharynx		1	
Trochilia dubia	1	1	
Urocentrum turbo		2	5
Uroleptus holsatica			1
Uroleptus muscorum			1
Uroleptus piscis		1	3
Uroleptus rattulus	1	1	2
Uroleptus sp.			1
Uronema marinum	1		3
Urotricha farcta	3	7	22
Vaginicola ampulla			1
Vaginicola crystallina			1
Vaginicola sp.			1
Vorticella campanula		2	5
Vorticella citrina	1		1
Vorticella convallaria			1
Vorticella microstoma			4
Vorticella monilata			1
Vorticella planctonica			2
Vorticella sp.	4	5	25
Zoothamnium sp.			1
Total no. species in	50	81	171
Total no. species found, 194			

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