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A Long-Term Database for Plankton Populations and Nutrient Levels in Prairie Lakes

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ABSTRACT

A database for prairie lake phytoplankton populations, zooplankton populations, physical variables and chemical variables is presented. Samples are taken from two time periods, 1970-1979 and 1988-1997. Six lakes, Pickerel, Enemy Swim, Cochrane, Hendricks, Oak and Bitter were sampled during both time periods. Bluedog lake was sampled only in the earlier time period and Roy, East Oakwood, Tetonkaha, Round, and South Buffalo lakes were only sampled in the later time period.

Water transparency and population numbers of copepods and cladocerans declined in five of the six lakes sampled in both time periods. Chlorophyll a concentrations and Trophic State Index increased in those five lakes, even though total nitrogen concentrations did not change and total phosphorus concentrations actually decreased slightly in three of the five lakes. The lack of increase in nutrients suggests that the decrease in water transparency and increase in trophic state is cause by biological factors, particularly the decline in numbers of the larger cladocerans and copepods which filter the water and increase transparency. The sixth lake, Bitter, experienced greatly increased water tranparency, increased numbers of cladocerans and copepods, decreased Chlorophyll a concentrations, and decreased trophic state after a dramatic rise in water levels that more than doubled the volume of the lake in the mid 1990's.

As the decrease in water tranparency, and increase in Chlorophyll a may result in increased shallowness and decreased future recreational value of the lakes, investigation into reasons for the changes should be of highest priority.

INTRODUCTION

The glacial lakes of South Dakota provide recreation to citizens and habitat for wildlife and fisheries. However, the lakes have experienced growth of algal blooms (eutrophication) resulting in decreased water clarity. Incomplete decomposition of these blooms results in accumulation of black, nutrient-rich sediments, which make the lakes shallower.

Traditionally, eutrophication has been attributed to inputs of nutrients, particularly nitrogen and phosphorus (Vollenweider 1968, Dillon and Rigler 1974, Smith 1982). These nutrients can come from many sources; surface runoff from agriculture, construction, and lakeside lawn fertilization carrying nitrogen and phosphorus, ground water transporting dissolved nitrates and bioicides, leakage of oil and gas and associated trace elements from two-cycle engines on outboard motorboats, and aerial deposition of soil particles as well as particulates and other effluents from industry and power production. The latter may be a source of sulfate which may increase phosphorus release from sediments (Caraco et al 1989. Lamers et al 2002). Iron, manganese, copper and silica are also algal nutrients, and changes in these elements may bring on undesirable algal blooms (Schelske and Stoermer 1972, Goldman et al 1975, Murphy et al 1976, Storch et al 1986, Vymazol 1995).

In addition, many authors have suggested that biological changes within lakes may influence the clarity and quality of the water. Abundance of larger grazing zooplankton is associated with clearer water and less eutrophic conditions (Hrbacek et al 1961, Haney 1973, Haertel 1979, Sommer et al 1986), *Daphnia* is particularly important because of its high filtration rate; at high population densities, the lake water can be filtered several times a day (Haney 1973, Haertel 1979). Conversely, overpopulation of zooplanktivorous fishes results in loss of the larger grazing zooplankton to fish predation and subsequent increase of nuisance algal blooms. Pesticides may also reduce zooplankton populations resulting in algal blooms (Hurlburt et al 1972, Shapiro 1980). Conversely, factors which reduce the overpopulation of zooplanktivorous fishes such as winter kill (De Bernardi and Giussani 1978, Haertel and Jongsma 1982), or ecosystem management to restore the populations of larger predatory fishes (Shapiro et al 1975, Carpenter et al 1985a) may not only increase water clarity but also improve fisheries (Anderson and Weithman 1978).

This paper compiles data taken in other studies conducted on eleven lakes between 1970-1979 and 1988-1997 (hereafter refered to as the 1970's and the 1990's). During both decades nine years of data were collected over a ten year period (Haertel 1976, 1977, 1979, 1996, unpublished data, Thoreson et al 1976, Haertel and Jongsma 1982, Buskerud and Haertel 1992, Haertel and Tucker, 1993, Haertel et al 1995 and Haertel and Troelstrup 1998). Six of the lakes were sampled during both decades, allowing for long-term comparisons. This paper summarizes the midlake, openwater season data base of chemical and physical variables and phytoplankton and zooplankton populations. Littoral zone chemistry and algal populations are reported in Haertel et al (1995), Haertel (1996), and Haertel and Troelstrup (1998). Results of the statistical analyses and discussion of interactions between variables wlll be reported in a later paper.

The objectives of this study are to (1) document changes over time in the six lakes that were sampled in both decades, and (2) provide a data base for comparison with future studies of eastern South Dakota lakes.

DESCRIPTION OF THE LAKES

All of the lakes in this study are associated with glacial moraines dating back to the Wisconsin Stage of the Pleistocene Glaciation. The moraines are found on both the eastern and the western borders of the Prairie Coteau, and vary in age from 13,000 to 14,000 years, as mapped by Flint (1955) and dated by Mickelson et al (1983). Some of the lakes are located in glacial till, and some are located in outwash (Table 1). Older till sites are covered by a layer of yellowish oxidized loess about a meter thick (Flint 1955), which is absent from both the younger till sites and the outwash sites. Lakes situated in the older till which are sufficiently shallow for wave-resuspension of bottom sediments often show a yellowish color on windy days.

A major factor influencing lake ecology is the depth of the lake relative to wind exposure. Lakes which are shallower than the critical depth of the wind-generated waves experience wave resuspension of midlake sediments (Haertel 1976). These lakes will usually have more than sufficient nutrient concentrations to permit midsummer algal blooms (Harrison 1972, Barica 1974, Haertel and Troelstrup 1998). Pickerel and Enemy Swim are the deepest lakes in the study and are located in outwash associated with the older moraines (Table 1). Cochrane and Roy are the next deepest lakes and are located in till associated with the younger moraines. These four lakes are too deep to experience wave-resuspension of midlake sediments. They are not deep enough to experience more than transitory temperature stratification, however, and the water column is mixed throughout the summer season. All of the rest of the lakes in this study may experience resuspension of midlake sediments on windy days. Blue Dog, Hendricks, South Buffalo are located in outwash and may show a greyish-black color on windy days from black bottom deposits. Tetonkaha, Round and Oak are located in older till, and may appear yellowish to green on windy days depending on the amount of algae and sediment resuspension. East Oakwood is on outwash, immediately downstream from till, and intermediate in characteristics.

Both Bitter and Cochrane have no natural outlet at present water levels. Bitter Lake is a saline lake located in outwash, however, it also shows a yellowish color on windy days as sediments transported to it do not leave. Cochrane is naturally less saline than Bitter, and in addition, has an artificial outlet that was constructed in the late 1980's and an artificial inlet from less saline Lake Oliver that was opened up in 1993.

METHODS

Lakes were sampled almost weekly during the open water seasons of 1970-1972 and approximately twice a month during 1974-1979 and 1988. They were sampled from three to five dates a year during 1990-1997. When lakes were sampled only three dates per year they were always sampled at least once in the spring (after icemelt and before June 15). During most years they were also sampled during both early summer (June 15 and July 14) late summer (July 15 through September 5) Sampling during the fall (September 6 through freeze-up) was sporadic. On all dates after 1972, replicate samples were taken of all variables.

Lake Cochrane was sampled 1970-1972, 1975-1979, 1990-1994, and 1997. Hendricks was sampled 1970-1972, 1975, 1978-1979, 1990-1991, and 1994. Oak was sampled 1970, 1978-1979, 1990-1991 and 1994-1997. Pickerel was sampled 1974-1975, 1990-1992, and 1994-1996. Enemy Swim was sampled 1974-1975 and 1990-1994. Bitter was sampled 1974, 1990-1991 and 1995-1996. The following lakes were sampled in only one of the two decades, East Oakwood, 1988 and 1994, Roy, 1995-1996, Blue Dog 1974, Tetonkaha, 1988, Round 1988, and South Buffalo, 1994.

In the deeper lakes, Pickerel, Enemy Swim, Cochrane and Roy, samples were taken just below the surface and about one meter above the bottom using a Van Dorn bottle in the 1970's and a Kemmerer Bottle in the 1990's. However, in 1974, only surface samples were taken. Shallower lakes were sampled just below the surface, except for Hendricks, which was sampled at two depths in 1970-1972.

In all of the lakes, on all dates, water transparency was measured with a Secchi disc. From 1992-1997, it was also measured with a Hach 2001 P or a portable Helege turbidometer. Temperature was measured with a bucket thermometer or a Scout Model probe (Hydrolab Corporation, Austin TX). Station depth was taken with a measured line. Conductivity was measured with an Industrial Instruments Conductivity bridge model RC16B2 in the 1970's and either a LaMotte DA DS or a Scout Model in the 1990's.

During the 1970's the following methods were used for chemical variables (American Public Health Association 1971): Sodium and Potassium (atomic absorbtion), carbonate and bicarbonate (calculated from alkalinity titration), Nitrate plus nitrite nitrogen (brucine), ammonia nitrogen (direct nesslerization), organic nitrogen (total Kjeldahl), total and soluble reactive phosphorus (stannous chloride), oxygen (azide modification of the Winkler technique), silica (heteropoly blue). In addition the following variables were measured monthly during 1970-1972: Manganese and copper (atomic absorbtion), iron (phenanthrolene), calcium (EDTA titrametric) magnesium (EDTA hardness minus calcium), chloride (mercuric nitrate), and sulfate (turbidometric). Chlorophyll a was measured using the Strickland and Parsons (1968) technique (acetone extraction, colorimetric).

During the 1990's the following methods were used for chemical variables (U.S. Environmental Protection Agency 1983): Nitrate plus nitrite nitrogen, 300A ion chromatography and 354.1 colorimetric, ammonia nitrogen, 350.2 colorimetric, nessler reagent, organic nitrogen from total Kjeldahl, 353.3 colorimetric, soluble reactive phosphorus 365.2, colorimetric, ascorbic acid, total phosphorus 365.2 after persulfate digestion, and cations by atomic absorbtion (sodium 273.1, potassium, 258.1, calcium 215.1, magnesium 242.1). Chloride and sulfate were measured using USEPA method 300.6-1 (ion chromatography). Bicarbonate and carbonate were calculated from alkalinity (2320 B, 281). After 1993, the following variables were measured directly in the field: chloride (Hach 8P, silver nitrate), sulfate (Hach DR 100 colorimetric), bicarbonate and carbonate (calculated from alkalinity, Hach AL-DT, sulfuric acid), calcium and magnesium (calculated from hardness, LaMotte PHT-CM-DR). The following variables were always measured directly in the field: Silica (heteropoly blue, Hach SI-5 or SI-7, depending on concentration), iron (Hach IR-21, TPTZ), manganese (Hach MN-PAN). Chlorophyll a was measured by a modification of the Strickland and Parsons technique (1968).

Samples of water for phytoplankton counts were immediately preserved in lugol's solution and counted in a Sedgewick-Rafter cell after settling at least 20 minutes. The one milliliter thickness of the cell enabled focusing up and down through the water column to check for gas vacuole containing bluegreen algae. During the 1970's the Sedgewick-Rafter cell was inverted on a Nikon inverted microscope and random fields were counted at 400x until 100 of most abundant taxon were counted (Lund et al 1958). During 1976-1978, additional counts were made at 100x for larger taxa. During 1988-1997, a compound microscope with a short focal depth lens was used to avoid problems with refraction in inverted cell counting. Cells were counted at 300x in 1988 (three or more random fields) and both 100x and 300x from 1990-1997 (three or more crosswise swipes of the Sedgewick Rafter Cell). During all years a Whipple Disc was used to measure the filament length or colony size of larger bluegreens. Values were then converted to cells by counting average number of cells per square and multiplying by the number of squares covered. Eukaryotic cells were counted individually. Biovolume per cell is reported in Buskerud and Haertel (1992) and Haertel (1996).

During the 1970's zooplankton were collected with a closing-type Clarke-Bumpus sampler with a 153um mesh. During 1970-1972 samples were taken just above the bottom and just below the surface. During 1974-1979, oblique tows were taken. During the 1990's vertical tows were taken using 0.3m aperture conical net with 80um mesh. In some years larger zooplankton including *Leptodora kindtii*, aquatic insects, mites and fish larvae were sampled using oblique tows with a conical net with 1.0 ml mesh. A 1.0 m aperture net was used from 1976-1988, and a 0.3 m aperture net was used 1990-1996. Samples were immediately preserved in 10% formalin (1970-1979) OR 70% ethanol (1988-1997), and counted using a Wild M5 microscope. Aliquots of 1 ml were taken with a Hensen-Stempel pipette until 100 individuals were counted (1970-1972) or 100 individuals of the most abundant species counted (1974-1997).

Weather data shown were taken from the nearest National Weather Service monitoring station to each lake. Seven-day averages (including the day of sampling) are given for rainfall, windstress (Small 1963) and for the 1970's only, solar radiation (William Lytle, personal communication). All variables were tested for normality (SAS 1989), but most were not normally distributed. Thus, medians, maximums and minimums are shown.

TAXONOMIC CONSIDERATIONS

Phytoplankton

Phytoplankton were identified to genus or species, depending on the objectives of the original studies. For many of the plankton, considerable controversy exists as to taxonomy.

Three different identification systems are commonly used for the Cyanophyceae (bluegreen algae), traditional, Drouet and Daily revision (1956), and Rippka et al revision (1979) As the Drouet and Daly revision was taken from extensive field samples and was based on more easily definable and less subjective factors than the traditional classification, it was used in this study (Drouet 1959). However, *Gloeocapsa* was separated from *Anacystis* according to Rippka *et al* (1979). Equivalent genera from the three classifications included the following: *Microcystis* (traditional) = *Anacystis* (Drouet) = *Synechocystis* (Rippka *et al*); and *Aphanothece* (and other genera, traditional) = *Coccochloris* (Drouet) and *Synechococcus* (Rippka *et al*). Because of the difficulty in observing chloroplast structure in very small cells (4 um) under the inverted scope, organisms identified as *Gomphosphaeria* in Haertel (1979) and again encountered in the 1990's were found to be *Botryococcus* and are listed as such in this paper. No *Gomphosphaeria* were encountered in the 1990's. Additional difficulties were present in separating *Aphanizomen* and *Gloeotrichia* and *Anabaena flos-aquae* and *A. spiroides* when only single filaments without heterocysts were present in the water. Finally, Rippka *et al* (1979) consider the different size categories of taxa such as *Synechocystis* (= *Anacystis*) and LPP1 (= *Lyngbya*) as the same species just exposed to better nutrition. However, as at least two distinct size classes of each were consistently present in open water samples in this study, Drouet's 1959 separation into two distinct species was followed.

Bacillariophyceae (diatoms) were originally identified according to Smith (1950), Tiffany and Britton (1971) and Patrick and Reimer (1966, 1975). Round et al (1990) changed the names of some of the genera splitting the genus *Melosira* into *Melosira* and *Aulacoseira*. Consequently only when members of that genus were identified to species in the 1970's could they be assigned to either genus. Thus the term *Melosira/Aulacoseira* is used. Similarly Round *et al* reclassified the controversial diatom *Nitzschia closterium* as *Phaeodactylum tricornutum,* a welcome change as triradiate as well as *Nitzschia*-like forms were common in some of the lakes. Finally, as it is difficult to separate the smaller *Nitzschia* from the smaller *Synedra* in a Sedgewick-Rafter cell, the term *Synedra/Nitzschia* was commonly used, and included *Phaeodactylum.*

Chlorophyceae (green algae) were identified according to Prescott (1951) and Tiffany and Britton (1971). Komarkova-Legnerova (1969) split the genus *Ankistrodesmus* into *Ankistrodesmus* for the colonial forms and *Monoraphidium* for the solitary forms. Both forms were present in the 1970's but were not separately counted so the term *Ankistrodesmus/Monoraphidium* is used. *Monoraphidium* was far more abundant in both decades and was the only form encountered in Bitter Lake. *Schroederia* and *Selenastrum* were combined in the counts because neither was abundant, and both had the same shape and size. No attempt was made to separate solitary round green algae into genera. *Chlamydomonas* was abundant in Lake Cochrane, but was frequently in palmelloid stage when preserved in Lugol's, so it was included in the category "unidentified single cells" in this paper. Also, some of the organisms identified as *Tetraedron* were probably Dinoflagellate cysts--both show a positive starch test preserved in Lugol's and are have the same shape and size.

Dinophyceae were identified according to Prescott (1951), and Tiffany and Britton (1971). Flagellates are almost impossible to identify preserved in Lugol's, and thus many are lumped into categories. Among the Dinoflagellates, *Peridinium, Glenodinium*, and *Gymnodinium* were usually lumped, and *Glenodinium,* and *Gymnodinium* were always lumped. Identification of live samples indicated that all three genera were present in Lake Cochrane.

Chrysophytes were identified according to Prescott (1951), Tiffany and Britton (1971) and Patterson and Larson (1991). Lacking live samples for identification, many categories were lumped into the category "unidentified Chrysophyte-like flagellates" These were mostly small solitary organisms (4-5mu), but were occasionally found in colonial palmellas of *Dinobryon*-sized cells. These palmelloid colonies bore superficial resemblance to the green alga *Kirchneriella obesa,* but never showed a positive test for starch. *Ochromonas* and *Paraphysomonas* were not separated in the 1970's because of the difficulty in observing chloroplasts in very small forms under the inverted microscope, so the term *Ochromonas/Paraphysomonas* was used. Mostly *Paraphysomonas* was encountered in the 1990's. The term *"Mallomonas/Rhizochrysis-like"* was used because I suspected that the same organism was appearing in both rhizopodial and flagellated stages. The flagellated stage resembled *Mallomonas acaroides* and the rhizopodial stage resembled *Rhizochrysis.* They were found together, of identical size (approximately 20 um diameter) and golden-brown pigmentation.

Cryptophyceae and Euglenophyceae were identified according to Prescott 1951. Both *Cryptomonas* and *Chroomonas* were present but were lumped in this database because of difficulty of accurate identification of preserved samples in a Sedgewick-Rafter cell. Among the Euglenophytes, only *Trachelomonas* was sufficiently common to separately list, but *Euglena* and *Phacus* were occassionally encountered in the shallower lakes.

Zooplankton

Most zooplankton were identified to genus or species, depending on the objectives of the original studies, using Edmondson (1959). Groups found in the zooplankton tows that were not identified to genus included copepod nauplii, fish larvae, water mites, amphipods, hemipterans, and other insecta with the exception of *Chaoborus* sp.

Rotifers were sampled with too large a mesh size to retain smaller forms in 1970's so estimates for that decade only include the larger forms.

Cladocerans were routinely identified to species as usually only one species of a genus was present. However, multiple species of *Daphnia* could coexist in a lake and were sometimes separately counted. *D. pulex* was not encountered in Lake Hendricks before 1975, but closely related *D. schodleri* was. In 1975, closely related *D. catawba* replaced *D. pulex* in late summer. Neither *D. catawba* nor *D. schodleri* were ever encountered in later years, or at the same time as *D. pulex*. Since there is controversy considering the taxonomy, the three species are lumped in the data tables as *D. pulex**.

All calanoid copepods found were *Diaptomus,* with both a small and a large species found in most lakes, although the larger species was never abundant in the deeper lakes. The small *Diaptomus* in all the lakes except Bitter was *D. siciloides* and the larger species was *D. clavipes*. In Bitter Lake prior to 1995, *D. nevadensis* was the larger species, and the smaller species was *D. connexus*. Lack of adult stages on the few dates sampled made identification of species impossible after the freshening of Bitter Lake in 1995-1996. Cyclopoid copepods were difficult to speciate in early copepodite stages and were lumped except in seasons where only one species was present in the water column, e.g. early spring for *Cyclops bicuspidatus* and late summer for *C. vernalis*. *Mesocyclops leuckarti* and *M. edax* were both present, but the species were not separated in routine counting.

RESULTS

Physical factors

Six of the lakes, Pickerel, Enemy Swim, Cochrane, Hendricks, Oak and Bitter were sampled both in the 1970s and the 1990's, making possible comparisons between decades (Table 2). Cochrane, Hendricks and Oak showed little or no change in maximum station depth measured. Increases in maximum station depths in the 1990's in Pickerel and Enemy Swim occurred partly because stations were selected over the deepest part of the lake in the 1990's as opposed to selection of sites for comparison with remote sensing data in the 1970's (Thoreson et al 1976). Bitter Lake almost doubled in maximum station depth in the 1990's because of rising water levels between 1991 and 1995 that also flooded the surrounding countryside, more than doubling its area. Decreases in median and minimum station depths in Bitter Lake in the 1990's reflected sampling closer to shore on windy days.

In the 1970's, greatest water transparency as measured by Secchi depth was found in Pickerel, followed by Enemy Swim (Table 2). In the 1990's, Enemy Swim and Roy both had greater water transparency than Pickerel. High maximum water transparencies recorded in Hendricks (1978), East Oakwood (1994), and Bitter (1995) coincided with high May or June *Daphnia pulex* populations. During both decades, lowest secchi depth readings were found in Bitter. All of the lakes sampled in both decades, except Bitter, showed a decrease in water transparency between the 1970's and the 1990's. Bitter Lake greatly increased in water transparency after it greatly increased in depth.

Turbidity measurements, taken only after 1991, showed Roy to be least turbid, followed by Cochrane, Enemy Swim and Pickerel (Table 2). High turbidity measurements in Pickerel were found at depth over the deepest part of the lake, even though care was taken not to disturb the bottom sediments. Highest median turbidity was measured in Oak and highest maximum turbidity was measured in Bitter.

Maximum water temperatures recorded (Table 2) never exceeded 28°C in either time period. Minimum water temperatures occurred when sampling immediately after ice-out. Median temperature variation reflected fewer spring and fall samples in some years.

Electrical conductivity (Table 2) was lowest in Enemy Swim, Blue Dog and Pickerel. Hendricks, South Buffalo and Oak were slightly higher, and lakes on the west slope of the Coteau, Roy, Tetonkaha, Round, and East Oakwood, were higher yet. Highest conductivities were found in the lakes with no natural outlet, Cochrane and Bitter. Conductivities in Oak, Hendricks and Cochrane decreased slightly between decades, whereas Enemy Swim and Pickerel increased slightly. Bitter Lake showed a dramatic decrease in conductivity between 1974 and 1995, which probably coincided with the increase in water levels between 1991 and 1995. Conductivity was not measured in Bitter Lake in 1990-1991.

Chemical Factors

Principle cations in Enemy Swim and Pickerel were magnesium and calcium, and bicarbonate was the principle anion (Table 3). Sodium, chloride and sulfate levels were very low especially in Enemy Swim. Bicarbonate levels decreased between the 1970's and the 1990's in both lakes, but because of small sample sizes of other major ions in the 1970's, changes could not be documented. Principle cations in Hendricks and Oak were calcium and magnesium and principle anions were bicarbonate and sulfate. Calcium levels decreased in the 1990's in both lakes. In the 1990's, sulfate and bicarbonate levels decreased in Oak lake, but were not measured in Hendricks. The principle cation in Roy was calcium and the principle anion was sulfate. Magnesium and bicarbonate levels were also high. Only anions were measured in Tetonkaha, East Oakwood, and Round Lakes. Sulfate was the major anion. Bicarbonate levels were lower in those three lakes than all the other lakes in the study. The principle cation in Cochrane was magnesium and the major anion was sulfate. Sodium, potassium and chloride levels were also high. Magnesium and sodium were the major cations and sulfate was the major anion in Bitter Lake in 1975. Potassium and chloride levels were also high. By 1995, levels of all cations and anions except calcium and bicarbonate were almost ten-fold lower. Although only one cation and anion sample is available from Bitter Lake in the 1970's, the change in total cations and anions is supported by the change in conductivity (Table 2).

Total nitrogen levels were lowest in Pickerel and Enemy Swim and highest in Bitter (Table 4). Median levels showed little difference between decades in Pickerel and Enemy Swim, but decreased in the 1990's in Cochrane, Hendricks, Oak and Bitter. Very low levels in Pickerel, Enemy Swim, Cochrane and Hendricks coincided with samples taken immediately after ice-out. High levels recorded in Blue Dog, Hendricks (1970's only), Tetonkaha, East Oakwood, Round and Bitter (1990's only) coincided with blooms of nitrogen-fixing blue-green algae. Nitrate and ammonia were frequently below the limits of detection.

Total phosphorus levels were lowest in Roy and Enemy Swim and highest in Bitter (Table 4). Median levels showed little difference between decades in Enemy Swim and Pickerel but decreased in Cochrane, Hendricks and Bitter, and increased in Oak. Very low levels again coincided with samples taken shortly after ice-out. Maximum levels occured coincident with times of increased runoff or large algal blooms. Soluble reactive phosphorus was frequently below the limits of detection.

Silica levels varied greatly in the lakes with time (Table 5). Lowest median and minimum levels were in Cochrane, Roy and Bitter. Oak showed the highest levels during the 1970's, but the levels were much lower in the 1990's.

Oak and Hendricks were high in iron levels in the 1970's and showed lower levels in the 1990's (Table 5). Iron was frequently below the limits of detection.

Highest manganese levels were found in Cochrane and Bitter lakes in the 1990's (Table 5). Lowest levels were found in Lake Hendricks. Manganese was frequently below the limits of detection, particularly in Lake Hendricks.

Copper was almost never present in detectable levels when measured in Cochrane, Hendricks and Oak (Table 5).

Both median chlorophyll a values and the calculated trophic state index (TSI, Carlson 1977) indicated that the most eutrophic lake was Bitter in the 1970's, and the least eutrophic was Roy. All of the lakes that were shallow enough to have midlake sediments suspended in the water column were hypertrophic (TSI 65 or more) with the exception of Blue Dog, which was borderline. Pickerel, Enemy Swim, Cochrane, Hendricks and Oak increased in both Chlorophyll a and TSI between decades. Bitter decreased.

Dissolved oxygen was always measurable during the open water season except in Lake Cochrane, which could be depleted in the deep water samples (Table 5). Supersaturated levels of oxygen were common during times of algal blooms.

All the lakes had alkaline pH with maximum levels recorded during algal blooms, particularly in Bitter (Table 5).

Weather Variables

Lakes sampled in 1978-1979, Oak, Cochrane, and Hendricks received the greatest amount of wind in the seven days prior to sampling (Table 6). Conversely, rainfall received was much higher in the 1990's for all six lakes sampled in both decades. Highest maximum snow depth was experienced at Lake Cochrane, during the winter of 1993-1994. Solar radiation varied seasonally, but amounts were similar for all seven lakes sampled in the 1970's.

Phytoplankton

Bluegreen algal picoplankton were numerically the most abundant phytoplankton in any of the lakes (Tables 7-15). However, because of their small size, their contribution to the total algal volume in the lake was frequently smaller than the numerically less abundant, but larger bluegreen algae, diatoms, and green algae (Haertel 1996).

Total picoplankton increased between decades in Pickerel and Hendricks, but decreased in Cochrane, Oak and Bitter. Greatest abundance of picoplankton were recorded in the lakes with no outlet, Bitter and Cochrane (Table 7). In 1990-1991, Bitter picoplankton populations were similar to those in 1974 with a median of 22,321.9 cells per microliter and a minimum of 1067.8. At that time all the picoplankters recorded were *Anacystis incerta*. After the increase in water levels by 1995 picoplankton decreased almost a thousand fold to a median of 16.1 and a maximum of 36.2, and *Coccochloris peniocystis* accounted for about 40% of the picoplankters. Lake Cochrane experienced its first picoplankton bloom on June 23, 1971, about two weeks after a cottage owner had bulldozed a hillside into the lake. After that event, picoplankton populations remained high, reaching peak levels September 26, 1976, a year when construction of sediment control dams again resulted in extensive soil erosion into the lake. *C. peniocystis* comprised a larger fraction of the picoplankton in the less eutrophic lakes accounting for about 40% of the median total in Cochrane and about one quarter picoplankton in Enemy Swim, Roy, and South Buffalo and 8% in Pickerel. Median values in most of the more hypertrophic lakes were below the limits of detection.

Anacystis cyanea was the only larger chroococcalean taxon abundant in the lakes. Like *A. incerta,* it was most abundant in Bitter and Cochrane. It decreased in abundance between the 1970's and 1990's in Cochrane (Table 7). In 1990-1991, Bitter populations were similar to 1974 with a median of 3487.8 and a minimum of 19.1. By 1995-1996 populations had decreased one hundred fold with a median of 8.2 and a maximum of 65.0.

Lyngbya spp. were the most abundant filamentous, non-nitrogen fixing bluegreens in these lakes, with largest populations in Tetonkaha, Round, East Oakwood and Oak Lakes (Table 8). *Lyngbya* spp. increased between decades in Pickerel, Enemy Swim, Oak and Bitter and decreased in Cochrane and Hendricks. *L. contorta* was more abundant in Cochrane, Bitter, Pickerel and Oak (1970's), and *L. versicolor* was more abundant in Enemy Swim, Roy, Tetonkaha, Round, East Oakwood and Oak (1990's). *L. birgei* was recorded in small numbers only in Roy, Enemy Swim, and Pickerel Lakes. *Oscillatoria* sp. was abundant in Tetonkaha, East Oakwood, and Round.

Aphanizomenon holsatica was the most abundant nitrogen-fixing bluegreen alga in most of the lakes. It was most abundant in Bitter (after the rise in water levels), East Oakwood, Hendricks, Tetonkaha, Round, Oak (1990's only) and Bluedog (Table 9). It was not recorded from Oak prior to 1990 or from Bitter prior to 1995. *Cylindrospermum musicola,* was present in all of the above lakes except Hendricks and Bluedog, and was the most abundant nitrogen-fixing alga in Oak. It may have been present in Oak in late summer

1978, but was not counted separately from *L. versicolor* (Table 8). *Gloeotrichia echinulata* was recorded from Blue Dog lake on August 23, 1974, when *Aphanizomenon* was absent. However, that was the only date *Gloeotrichia* was present in Blue Dog, and *Aphanizomen* was very abundant both 18 days before and 18 days later. *Anabaena* spp. were present in all of the lakes, reaching greatest abundance in Tetonkaha, Round and East Oakwood. *Anabaena* spp. were also abundant in Pickerel, Hendricks and Oak, and increased in abundance between decades in all three lakes. *A. circinalis* and *A. flos-aquae* were recorded from all of the lakes, and *A. spiroides* only from Enemy Swim. *Nodularia* was most abundant in Bitter, and frequently present in Cochrane. It was recorded from Oak Lake in 1997.

Heterocysts, which indicate nitrogen fixation, were separately counted in the 1990's only (Table 10). The largest numbers of *Aphanizomen* heterocysts were recorded in Bitter and Hendricks, and the largest number of *Cylindrospermum* heterocysts were recorded in Oak. *Nodularia* heterocysts were abundant in Bitter, and *Anabaena* spp. heterocysts in Pickerel and Oak.

Centric diatoms were most abundant in Oak (Table 11) where silica levels were also highest (Table 5). *Cyclotella* spp. were widely distributed. *C. meneghiniana* was present in Pickerel and Enemy Swim and both *C. glomerata* and *C. melosiroides* in Cochrane and Oak. A very small (4-5um) unidentified *Cyclotella* formed early spring blooms in Hendricks. *Cyclotella* spp. were most abundant in Hendricks, Oak (1970's), and Bitter (1990-1991). Cyclotella spp. showed a decrease between decades in Pickerel, Enemy Swim, Cochrane and Oak, but increased in Hendricks and Bitter. *Stephanodiscus niagarae* was widely distributed but abundant only in Hendricks, where it decreased between decades. *Melosira/Aulacoseira* were most abundant in Oak, Tetonkaha, Round and East Oakwood. *Melosira* was identified in Bitter lake only after the rise in water levels (1995-1996). *Chaetoceras,* a marine genus, was abundant in the two lakes with higher salinities, Bitter (1970's and 1990-1991) and Cochrane.

The most abundant and widely distributed pennate diatoms were *Synedra/Nitzschia* spp., *Asterionella formosa* and *Fragilaria crotonensis* (Table 12). Included in the *Synedra/Nitzschia* category was *Phaeodactylum tricornutum,* which was most abundant in Bitter Lake prior to the rise in water levels in the 1990's. Not separately counted in Bitter in the 1970's was a very small *Cymbella* sp. which was abundant when *P. tricornutum* was abundant. It was also abundant in 1990-1991. *N. holsatica* was abundant in Cochrane, and *N. acicularis/S. acus* were abundant in Oak (1970's) *S. ulna* was abundant only in the 1970's in Hendricks, Oak and Cochrane. *Asterionella* was abundant in Pickerel, Enemy Swim, Roy, and Oak (1970's) in the spring. It was present in Bitter only after the rise in water levels. *Fragilaria* was widely distributed and abundant in Oak (1970's), Pickerel, and Enemy Swim. *Navicula* spp. were abundant in the 1970's in Cochrane and Oak. *Entomoneis* sp. was present in Cochrane, Oak, Hendricks and Enemy Swim.

Green algae were most abundant in Bitter Lake before the rise in water levels where the most abundant genus was *Monoraphidium* (Table 13). In Bitter (1995-1996), *Monoraphidium* levels decreased to a median of 0 and a maximum of 0.33. *Monoraphidium* was widely distributed but much less abundant in the other lakes. The less widely distributed *Crucigenia quadrata* was abundant in Cochrane from 1976-1978, during and after the construction of the sediment control dams, and in Oak in 1979, after severe winter fishkill. *Oocystis, Pediastrum* and *Scenedesmus* spp. were widely distributed. They were abundant in Round Lake after an intentional fish kill. They were also abundant in Tetonkaha which was connected to Round Lake, and in Oak in 1978-1979 after natural winter fish kills. Their abundance in Cochrane in the 1970's may have indicated summer fish kill. One was recorded from that lake in 1984 (David German, personal communication) and bottom water oxygen concentrations were sometimes below the limit of detection (Table 5). *Oocystis* was most abundant in the two lakes of highest salinity, Cochrane and Bitter prior to the rise in water levels. *Scenedesmus* was abundant in Pickerel (1990's only). *Chlamydomonas* sp. was present in Cochrane but was frequently in palmella stage and included in the category "unidentified single cells." Unidentified single cells were abundant in Oak after the fish kills in 1978-1979. *Shroederia/Selenastrum, Closteriopsis,* and desmids (*Closterium, Cosmarium,* and *Staurastrum*) were widely distributed, but not abundant.

Botryococcus braunii was widely distributed and most abundant in Oak, Tetonkaha, East Oakwood, Cochrane and Round (Table 13). It decreased between decades in Oak, Cochrane, and Enemy Swim and increased in Pickerel, Hendricks and Bitter.

Flagellates

The most abundant category of flagellates found were very small forms (4-5um long) that were assigned to the category "unidentified Chrysophyta-like" (Table 14). In most cases these lacked chloroplasts. These were very abundant in the spring after winters of heavy snow cover, particularly in the 1990's in Pickerel, Enemy Swim, Cochrane and Oak, and in the 1970's in Oak, Cochrane, and Bitter. *Paraphysomonas* was usually present in smaller numbers at the same time. *Dinobryon sertularia* was more common in the less eutrophic lakes, particularly Enemy Swim. *Mallomonas* and *Mallomonas*-like forms were most abundant in Bitter (1990-1991) and Tetonkaha.

Among dinoflagellates, only *Ceratium hirundinella* was routinely identified to species as other genera were difficult to separate in routine counting. Dinoflagellates were most abundant in Lake Cochrane (Table 15). Occasional empty shells were identified as *Peridinium bipes* and *Glenodinium quadridans*. *Gymnodinium* sp. was identified from live samples. Dinoflagellates were also abundant in Tetonhaka, East Oakwood, Round and Oak, and *Ceratium* was frequently present in Pickeral and Enemy Swim.

Euglenophytes were most abundant in Tetonkaha, East Oakwood, and Bitter (Table 15). *Trachelomonas* spp. were the only frequently encountered form in all of the lakes except Bitter, where *Phacus* sp. was present in 1990.

Zooplankton

Larger numbers of rotifers were collected in the 1990's than in the 1970's in all lakes except Enemy Swim (Table 16). This may have been partially an artifact of sampling with a smaller mesh size in the 1990's. Rotifers were not present in samples from Bitter until 1995-1996, after the rise in water levels, and were never abundant. Rotifers were most abundant in Tetonkaha, East Oakwood, Round, Oak and Cochrane. All of those lakes are located in till (Table 1) or just downstream from till (East Oakwood). *Polyarthra* sp., *Filinia longiseta* and *Brachionus* spp. were widely distributed and abundant in the above lakes. *B. plicatilus* was identified in Cochrane in the 1970's and *B. calyciflorus* in the 1990's. However, *Brachionus* was not identified to species on all dates, or in other lakes. *Keratella* spp. were widely distributed and abundant in the above five lakes and in Enemy Swim (1970's) and Hendricks (1990's). *Asplanchna priodonta* was widely distributed and abundant in the above five lakes and in Pickerel (1970's). *Trichocerca* sp. was widely distributed but not abundant. *Kellicotia* sp. and *Synchaeta* sp. were less widely distributed but abundant in Pickerel (1990's) and Hendricks (1990's), respectively. *Platyias quadricornis* was most abundant in South Buffalo.

Daphnia spp. showed a substantial decline in abundance between decades in Pickerel, Cochrane, Hendricks and Oak, and a slight decline in Enemy Swim (Table 17). The *D. pulex* group was the abundant spring form in all of the lakes except Oak, where *D. parvula* was more abundant and Cochrane, where *D. rosea* was more abundant. *D. pulex* and *rosea* were both abundant in spring in Enemy Swim. *D. galeata* commonly became more abundant in midsummer in all of the lakes except Hendricks and Bitter. *D. similus* (subgenus *Ctenodaphnia*) was abundant in Bitter until the rise in water levels, after which it was replaced by *D. pulex*. Although large daphnids were frequently most abundant in the lakes located in outwash (Table 1), smaller-bodied cladocerans were more abundant in the lakes located in till or immediately downstream from till. *Ceriodaphnia lacustris* was more abundant in Cochrane and *Bosmina longirostris* (often associated with *Diaphanosoma birgei*), was more abundant in Oak, Tetonkaha, Round and East Oakwood. *Ceriodaphnia* declined between decades in Cochrane, and *Diaphanosoma* and *Bosmina* declined between decades in Pickerel, Enemy Swim, Cochrane and Oak. The latter two genera increased between decades in Hendricks. *Chydorus sphaericus* was widely distributed, and often associated with *Aphanizomenon.* It increased between decades in Pickerel, Enemy Swim, and Oak, but decreased in Cochrane and Hendricks. The predatory *Leptodora kindtii* was collected in small numbers from Pickerel, Enemy Swim, Roy and South Buffalo.

Diaptomus spp. showed a decline in numbers between decades in Pickerel, Enemy Swim, Cochrane, Hendricks and Oak (Table 18). *D. nevadensis* increased in Bitter between 1974 and 1990-1991 to a median value of 98.5 individuals per liter, but decreased after the rise in water levels by 1995-1996 to a median value of 0.7 and a maximum value of 5.0. The smaller *Diaptomus* present in Bitter showed little change in numbers between time periods. Cyclopoid copepods also showed a decline in numbers between decades in Pickerel, Enemy Swim, Cochrane, Hendricks, and Oak. *Cyclops bicuspidatus* was the species present in all the lakes in the fall and spring, and was usually replaced in mid-summer by *C. vernalis.* In Pickerel, Enemy Swim and Cochrane, *Mesocyclops* spp. were also present with *M. leuckarti* very abundant in Pickerel in 1975, and *M. edax* present in small numbers in Enemy Swim and Cochrane. After the severe winterkill year of 1978 (Haertel and Jongsma 1980), *C. bicuspidatus* was the only cyclopoid present all summer long in Oak and Hendricks which winterkilled, However, it was replaced by *C. vernalis* in Cochrane which did not winterkill. Copepod nauplii decreased between decades in Pickerel, Enemy Swim and Cochrane and increased in Hendricks, Oak and Bitter. Because the net mesh size used in the 1970's was too large to catch the smaller nauplii, the increase in the latter three lakes may be partially due to sampling gear used.

Ostracods were frequently present in the plankton tows in Pickerel, Enemy Swim, Roy, South Buffalo and Bitter, but were infrequent in the midlake plankton of the southern lakes (Table 18). However, they were abundant in the littoral zones of Lake Cochrane (Haertel, unpublished). They were more abundant in Bitter after the rise in water levels, the maximum number per liter recorded in 1990-1991 was only 0.76.

Abundant planktivorous fish taxa collected in the lakes included Yellow Perch larvae (*Perca flavescens)* in Lake Cochrane and Fathead Minnow (*Pimopheles promelas)* adults and larvae in Oak, Tetonkaha, East Oakwood and Round (Table 19). Fish larvae were never present in plankton tows from Hendricks, Roy or Bitter.

Water mites (Hydracarina) were most abundant in Oak, where three different unidentified taxa were present (Table 19). They were also abundant in Roy and Bitter.

Brine Shrimp (*Artemia* sp.) were abundant in Bitter in the spring, before 1995 (Table 19). They were not collected after the rise in water levels.

Amphipods were collected in small numbers in midlake plankton tows in many of the lakes and were abundant in Bitter after the rise in water levels (Table 19). They were not collected from Bitter before 1995.

Hemipterans, mostly Corixidae, were abundant in Hendricks and in Bitter, before the rise in water levels (Table 19). After the rise in water levels, numbers were two orders of magnitude lower.

Chaoborus sp. (*C. punctipennis* in Cochrane, German and Haertel 1979) was present in plankton tows from all of the lakes except Pickerel, South Buffalo, Hendricks, and East Oakwood (Table 19).

Other Insecta included mostly Diptera larvae other than *Chaoborus*. These were most abundant in Hendricks and Bitter, both before and after the rise in water levels (Table 19).

DISCUSSION

Decreased water transparency and increased Chlorophyll a and resultant TSI point to a decline in water quality between decades in Pickerel, Enemy Swim, Cochrane, Hendricks and Oak. However, the nutrients normally associated with increases in trophic state, nitrogen and phosphorus, have not increased, except for phosphorus in Oak. In three of the other four lakes, phosphorus levels actually decreased slightly, possibly suggesting less erosional inputs in the 1990's than in the 1970's. The lack of increase in nutrients, indicates that the increase in chlorophyll and decrease in water tranparency is a result of biological changes rather than chemical (Hrbacek 1961, Shapiro 1975, Carpenter et al 1985a). Numbers of copepods and cladocerans, have decreased in all of the above lakes. The decline in water transparency may be a response to a decline in filtering of the water by the larger zooplankters, particularly *Daphnia* spp. as zooplankton filtration has been shown to be closely correlated with water transparency (Haney 1973, Haertel 1979, Sommer et al 1986) The simultaneous decline in *Diaptomus,* which, like *Daphnia*, is heavily preyed on by zooplanktivorous fishes, suggests that increased fish predation may be a cause of the decline in larger zooplankton. Increased sport fishing removal of game fish, which prey on zooplanktivorous fishes, may be responsible for an increase in zooplanktivorous fishes and subsequent decline in abundance of larger zooplankton and thus water transparency. Improved sport fishing technology and intensity could contribute to increased game fish removal. At the same time, numbers of rotifers appear to have increased, a common change when competition and predation from larger copepods and cladocerans is decreased by fish predation (Carpenter et al 1985b). Severe winter fish kills in two of the lakes, Hendricks (1978) and Oak (1979) and resultant increases in water clarity and decreases in bluegreen algal populations (Haertel and Jongsma 1982) document the importance of predation by zooplanktivorous fishes. Although those winterkills could have been responsible for the higher water transparencies in the 1970's in those two lakes, Pickerel. Enemy Swim and Cochrane did not winterkill, and also showed much higher water tranparencies in the 1970's.

Increased pesticide usage could also contribute to decreased copepod and cladoceran populations and subsequent water transparency (Hurlburt et al 1972, Shapiro 1980). Pesticide levels have not been studied in the lakes.

Bitter is the only lake showing an increase in water transparency and increases in zooplankton between decades, and in Bitter, the drastic increase in water level and decrease in salinity may be solely responsible for the changes.

Nutrient levels and and zooplankton predation may also influence which algal taxa are present. Different algae are limited by different nutrients; for example, limitation in silica may cause diatoms to be replaced by less beneficial bluegreens (Schelske and Stoermer 1972) even at levels where silica is measurable in the water. Both silica and centric and pennate diatom medians decreased between decades in Cochrane, Hendricks and Oak. Many other nutrients were commonly below the limits of detection, including available forms of nitrogen and phosphorus, total iron, manganese and copper. Any of these nutrients may have selectively limited the growth of some algae. Changes in concentrations of major ions may also influence algal population dynamics. Nutrient bioassay experiments (1993) found enhanced Chlorophyll a with addition of silica in Cochrane and chloride in Enemy Swim (Christine Kraft, personal communication).

Geologic position also influences species composition. Lakes located in till or immediately downstream from till, Oak, Tetonkaha, East Oakwood, and Round had abundant rotifers, *Diaphanosoma, Bosmina, Aulacoseira* spp., *Oocystis, Pediastrum* spp., *Lyngbya* spp., *Cylindrospermum, Anabaena* spp. and *Aphanizomenon.* Among these lakes, Oak lake had unusually high species diversity, also having abundant *Cyclotella, Stephanodiscus, Nitzschia/Synedra* spp., *Botryococcus, Crucigenia, Sphaerocystis*, and *Closterium.*

In lakes located in outwash, *Daphnia* spp. and *Aphanizomen* were abundant frequently accompanied by *Chydorus sphaericus.* Among these lakes, Enemy Swim had the unusually high diversity, also having three species of *Anabaena, Gloeotrichia echinulata, Anacystis* spp., *Coccochloris, Lyngbya* spp., *Melosira/Aulacoseira, Asterionella formosa, Fragilaria crotonensis, Oocystis, Pediastrum* spp., *Dinobryon sertularia, Bosmina* and *Diaphanosoma.*

Lack of an outlet in Cochrane and Bitter resulted in more salt tolerant biotas. The bluegreens *Anacystis* spp. *Nodularia,* the diatom *Chaetoceras* and the green alga *Oocystis* were characteristic of both lakes. Dinoflagellates, the diatom *Nitchia holsatica,* the rotifer *Brachionus plicatilis* and the cladoceran *Ceriodaphnia lacustris* were most abundant in Cochrane. In the slightly saline Tetonkaha, East Oakwood and Round, dinoflagellates, *Ceriodaphnia* and *Brachionus* sp. were also abundant. In Bitter, prior to the rise in water levels, *Phaeodactylum tricornutum, Cymbella sp., Monoraphidium* sp, and a zooplankton community similar to that found in saline lakes in Saskatchewan (Hammer and Hurlbert 1992), including the brine shrimp *Artemia,* the cladoceran *D. similis,* and the copepods *D. Nevadensis* and *connexus* were abundant. After the rise in water levels, less salt-tolerant forms, particularly *Aphanozomenon holsatica* and *D. pulex,* became abundant.

CONCLUSIONS

This study presents a data base for water transparency, nitrogen and phosphorus levels, and zooplankton and phytoplankton populations for six prairie lakes in two different time periods, and for one time period in five other lakes. It presents a data base in two time periods for silica, iron, sodium, magnesium and calcium and bicarbonate in several lakes, and a data base for only one time period for manganese, copper, potassium, sulfur and chloride. More study of trace elements and major ions is needed to document what changes are taking place.

Location in outwash or till, as well as the presence or absence of a natural outlet influence the biota present. The most diverse lake located in outwash is Enemy Swim, and the most diverse lake located in till is Oak. These lakes deserve special protection for their scientific value.

Extensive comparisons of water transparency, water chemistry and cladoceran and copepod populations have documented an alarming decrease in water clarity and larger zooplankton, and an increase in Chlorophyll a, even though nitrogen and phosphorus levels have not increased. As these changes threaten the future recreational value of the prairie lakes, investigation into the reasons for the cladoceran and copepod declines should be of highest priority.

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Table 1. Lake characteristics.

Lake	Pickerel	Enemy Swim	Cochrane	Roy	Blue Dog	South Buffalo	Hendricks	Tetonkaha	East Oakwood	Round	Oak	Bitter
Depth (m)												
Mean	4.9	4.9	3.4	3.3	1.9	18	1.5	1.8	1.5	1.2	1.1	
Maximum	13.2	7.9	8.2	5.6	2.4	3.7	3.0	3.0	2.7	1.8	2.0	
Surface area (km^2)	3.6	8.8	1.5	6.9	6.1	7.2	6.3	4.1	3.8	0.2	1.6	13.1
Geologic Site	Outwash	Outwash	Till, No Outlet	Till	Outwash	Outwash	Outwash	Till	Outwash	Till	Till	Outwash, No Outlet
Approximate Age (yrs)	14,000	14,000	13,000	13,000	14,000	13,000	14,000	14,000	14,000	14,000	14,000	14,000
Side of Prairie Coteau	East	East	East	West	East	East	East	West	West	West	East	East
Latitude (N)	45°30'	45°26'	44°42'	45°42'	45°21'	45°37'	44°29'	44°26'	44°26'	44°26'	44°31'	45°17'
Longitude (W)	97°16'	97°16'	96°28'	97°26'	97°17'	97°16'	96°27'	96°59'	96°58'	96°59'	96°32'	97°17'

Notes: Lake depths and surface areas are taken from South Dakota Department of Game, Fish and Parks maps except for Oak Lake which was mapped by Connelly and Troelstrup (2001), and Bitter Lake, which has not been mapped. Bitter Lake surface area is taken from the U.S. Geological Survey Topographic map and was representative of conditions in 1974 and 1990-1991. Bitter Lake surface area had more than doubled by 1995-1996. Geologic site and age are from Flint 1995 and Mickelson et al., 1983. Tetonkaha, East Oakwood and Round Lake are all part of the Oakwood Lakes system.

Table 2. Measured physical variables.

Lake	Pickerel		Enemy Swim		Cochrane		Roy	Blue Dog	Buffalo	Hendricks		Tetonkaha	East Oakwood	Round	Oak		Bitter	
Time Period	**74-75**	**90-96**	**74-75**	**90-94**	**70-79**	**90-97**	**95-96**	**74**	**94**	**70-79**	**90-94**	**88**	**88-94**	**88**	**70-79**	**90-97**	**74**	**90-96**
No. Yrs. Sampled	2	5	2	5	9	6	2	1	1	6	3	1	2	1	3	6	1	4
Station Depth (m)																		
Median	7.2	7.8	5.1	6.5	6.0	6.0	6.0	1.9	3.7	2.7	2.8	1.9	2.3	1.7	2.0	1.8	1.3	0.7
Minimum	7.0	1.0	3.7	3.5	1.0	3.0	5.4	1.4	2.2	1.0	2.3	1.0	0.7	1.4	1.0	1.5	1.0	0.5
Maximum	7.4	12.0	6.8	8.1	8.0	8.0	6.0	2.0	4.5	3.2	3.3	3.2	2.7	2.3	2.0	2.0	1.3	2.5
N	82	86	116	108	493	114	24	61	6	219	33	128	30	22	56	46	66	36
Secchi Depth (m)																		
Median	1.7	1.1	1.6	1.3	1.2	1.1	2.3	0.4	1.5	0.5	0.4	0.3	0.4	0.3	0.5	0.3	0.01	0.10
Minimum	1.0	0.8	0.7	0.5	0.6	0.6	0.9	0.1	1.2	0.2	0.3	0.1	0.1	0.1	0.2	0.1	0.01	0.05
Maximum	5.4	3.0	3.0	4.3	3.6	2.2	3.5	1.0	2.0	2.8	1.0	0.9	2.6	0.6	1.0	1.0	0.20	1.90
N	80	86	116	108	493	114	24	61	6	219	33	128	30	22	51	46	63	36
Turbidity (ntu)																		
Median		7.6		3.7		3.6	2.9		6.2		24.5		8.0			35.9		9.3
Minimum		2.1		0.9		1.4	0.6		1.8		17.8		1.9			6.5		1.8
Maximum		20.5		12.0		11.4	8.1		7.9		30.1		83.5			156.0		178.0
N		34		54		60	20		6		6		6			20		10
Temperature (°C)																		
Median	19.0	21.0	19.0	19.0	20.0	19.0	22.0	18.0	20.0	22.0	21.0	23.5	23.0	25.0	18.5	21.0	15.0	20.0
Minimum	7.0	7.0	6.0	8.0	0.0	10.0	7.0	8.0	13.0	0	9.0	3.0	2.5	3.0	5.0	9.0	8.0	7.0
Maximum	25.0	24.0	25.0	23.0	27.0	28.0	24.0	24.0	24.0	28.0	26.0	28.0	26.0	26.0	26.0	26.0	24.0	28.0
N	80	86	122	108	501	114	24	61	6	222	33	104	26	22	56	46	65	36
Conductivity (µS)																		
Median	398	480	330	398	2873	2312	1200	371	636	695	628	1425	1299		575	520	12,300	3875
Minimum	318	275	250	232	389	1768	825	305	488	244	600	1383	1250	1475	537	340	9800	2400
Maximum	470	612	710	528	3111	3231	1460	440	648	850	720	1484	1410	1493	662	608	19,000	4650
N	42	36	82	58	168	66	24	61	6	135	6	12	6	2	15	22	63	12

Notes: Underscored lakes were sampled in two time periods. Measured lake depths are sometimes deeper than maximum depths mapped by the S. D. Department of Game, Fish & Parks (Table 1). The discrepancy is caused by fluctuating water levels.

Table 3. Measured Cation and Anion Concentration (mg.1-4).

	Pickerel		Enemy Swim		Cochrane		Roy	Blue Dog	Hendricks		Tetonkaha	East Oakwood	Round	Oak		Bitter	
Time Period	75	90-96	75	90-96	70-79	90-97	95-96	74	70-79	90-91	88	88	88	70-79	90-97	75	95-96
Sodium																	
Median	8	6	8	8	102	103	26		7					9	6	4200	375
Minimum	8	6	8	8	7	51	18		2					5	5		330
Maximum	8	32	4	8	249	14	24		112					14	16		560
N	4*	24	4*	8*	143	14	24		112					14	16	1*	12
Potassium																	
Median	7	5	9	7	50	54	20		11					13	4	900	92
Minimum	6	4	8	7	4	53	15		1					6	4		80
Maximum	7	5	10	7	105	54	24		23					13	5		108
N	4*	24	4*	8*	108	8*	24		97					5*	12	1*	12
Magnesium																	
Median	44	46	50	49	338	425	92		28	54				44	49	5000	520
Minimum	44	32	49	35	274	420	76		1	40				38	7		410
Maximum	44	77	50	85	380	430	107		91	95				48	66		570
N	4*	24	4*	50	59	8*	24		48	27				5*	36	1*	12
Calcium																	
Median	47	32	30	30	96	90	158		96	60				74	36	24	73
Minimum	46	16	29	16	80	85	117		82	25				73	13		29
Maximum	47	64	30	40	216	93	192		73					82	56		124
N	4*	64	4*	56	59	14	16		48	27				5*	36	1*	10
Chloride																	
Median	4	5	4	4	15	22	30		5		15	14	16	6	6	931	128
Minimum	3	3	4	4	12	21	15		2		11	9	13	3	3		110
Maximum	4	10	4	4	38	22	60		10		18	20	20	10	10		225
N	4*	24	4*	8*	59	8*	24		48		101	18	18	5*	12	1*	12
Sulfate																	
Median	77	78	33	26	1315	1924	400		135		560	486	559	130	120	21,350	3400
Minimum	75	60	33	26	1065	1881	250		96		444	395	450	117	80		1900
Maximum	78	160	33	27	2095	1948	460		188		680	580	680	136	158		4600
N	4*	24	4*	8*	59	8*	24		48		102	18	18	5*	12	1*	12
Bicarbonate																	
Median	249	191	264	235	272	252	253	248	193		136	167	114	219	183	980	404
Minimum	224	152	236	232	88	248	210	224	48		68	89	93	124	145	702	250
Maximum	280	250	296	236	1028	256	300	267	263		208	196	162	259	212	1388	448
N	78	24	118	8*	467	8*	24	62	218		128	24	22	37	12	63	12

Notes: Underscored lakes were sampled in two time periods. Carbonate was rarely present in measurable concentrations. Its weight was added to Bicarbonate on the few dates it was detected. *Data available from only 1 or 2 dates.

Table 4. Measured nitrogen, phosphorus and chlorophyll a concentrations, and calculated trophic state index.

Lake	Pickerel		Enemy Swim		Cochrane		Roy	Blue Dog	Hendricks		Tetonkaha	East Oakwood	Round	Oak		Bitter	
Time Period	**74-75**	**94-96**	**74-75**	**92-94**	**70-79**	**92-97**	**95-96**		**70-79**	**94**	**88**	**88-94**	**88**	**70-79**	**94-97**	**74**	**95-96**
Total Nitrogen (mg.l-1)																	
Median	0.75	0.75	0.80	0.76	1.49	1.34	1.20	0.84	1.91	1.17	3.34	2.78	3.50	2.26	1.69	8.71	3.20
Minimum	0.11	0.34	0.01	0.53	0.07	0.98	1.03	0.19	0.21	0.94	1.30	1.10	2.04	1.42	0.20	5.42	2.29
Maximum	1.07	1.51	2.33	1.25	4.16	1.71	2.61	8.02	17.19	1.26	7.71	6.51	6.66	4.32	3.20	16.46	42.92
N	74	36	118	60	465	66	24	61	218	6	128	24	22	41	22	63	12
Nitrate-Nitrogen (mg.l-1)																	
Median	.020	.010	.020	.001	.000	.028	.040	.040	.090	.080	.083	.073	0.073	.080	.010	.1501	.0900
Minimum	.000	.000	.000	.000	.000	.000	.010	.000	.000	.040	.011	.012	0.024	.000	.000	.080	.010
Maximum	.200	.171	.100	.121	.400	.140	1.390	0.200	1.060	.270	.202	.161	0.171	1.120	.700	.3600	1.190
N	78	36	118	60	465	66	24	61	218	6	128	24	22	41	22	63	12
Ammonia-nitrogen (mg.l-1)																	
Median	.000		.000	.000	.000	.000		.000	.120		.005	.030	.040	.300		.000	
Minimum	.000		.000	.000	.000	.000		.000	.120		.005	.030	.000	.300		.000	
Maximum	.130		.430	.175	1.200	.000		.180	1.900		2.670	3.080	3.140	1.200		.040	
N	78		118	24	445	24		61	218		128	24	22	26		63	
Total Phosphorus (mg.l-1)																	
Median	.035	.037	.030	.026	.050	.036	.025	.060	.220	.108	.160	.105	.140	.095	.110	.470	.250
Minimum	.000	.010	.010	.017	.000	.014	.020	.040	.091	.072	.050	.050	.080	.020	.058	.260	.080
Maximum	.130	.140	.180	.228	.200	.056	.040	.290	.368	.139	.390	.210	.230	.300	.370	.940	2.770
N	78	36	118	60	297	66	24	61	78	6	128	24	22	26	22	63	12
Soluble Reactive Phosphorus (mg.1-1)																	
Median	.000		.000	.004	.010	.007		.010	.165		.010	.010	.010	.010		.110	
Minimum	.000		.000	.000	.000	.001		.000	.000		.000	.000	.000	.000		.040	
Maximum	.060		.030	.008	.410	.016		.030	.410		.040	.030	.020	.090		.440	
N	78		118	24	465	24		61	218		128	24	22	41		63	
Chlorophyll a (µg.l-1)																	
Median	11.3	15.2	8.2	14.9	11.8	22.4	6.6	10.1	25.3					25.3	39.9	106.5	20.6
Minimum	0.0	8.2	1.4	2.1	0.0	2.3	2.6	3.4	0.0					0.0	13.6	38.3	4.4
Maximum	30.3	29.4	24.1	42.7	43.7	56.9	15.2	778.8	365.1					109.5	141.5	271.3	97.4
N	78	24	109	37	456	32	24	61	216					55	16	63	12
Trophic State Index																	
Median	52.8	56.2	52.3	54.1	57.2	58.5	49.2	64.4	69.8	74.3	75.3	74.5		67.4	72.0	93.3	72.4

Notes: 0.000, 0.0 = below detection limit. Underscored lakes were sampled in two time periods. The Trophic State Index (TSI, Carlson 1977) is calculated as the average of the Chlorophyll a TSI, total phosphorus TSI and Secchi Depth TSI, except for Round '88 and Hendricks '94 where only TP and secchi data were used. 1988 Chlorophyll a TSI values for Tetonkaha and East Oakwood are from German *et al* 1991. The variables shown in this table were not measured in Buffalo Lake.

Table 5. Measured silica, iron, manganese, and oxygen concentrations, and pH measured.

	Pickerel	Enemy Swim	Cochrane		Roy	South Buffalo	Hendricks		Tetonkaha	East Oakwood	Round	Oak		Bitter
Time Period	**94-96**	**92-94**	**70-79**	**92-97**	**95-96**	**94**	**70-79**	**94**	**88**	**88-94**	**88**	**70-79**	**94-97**	**95-96**
Silica (mg.l-1)														
Median	6.8	15.0	6.1	8.0	9.0	13.4	17.1	14.6		17.3		19.8	11.5	6.3
Minimum	0.6	7.0	0.2	0.2	0.0	9.7	0.8	5.5		16.0		13.9	0.0	0.1
Maximum	12.0	19.0	20.0	12.0	14.0	16.0	41.2	18.0		19.0		30.0	26.0	10.0
N	38	48	432	62	24	6	182	6		6		41	22	12
Iron (mg.l-1)														
Median	.055	.035	.050	.030	.040	.025	.130	.058		.030		.190	.120	.085
Minimum	.000	.000	.000	.000	.020	.020	.000	.045		.004		.070	.010	.000
Maximum	1.000	.100	.910	.195	.250	.050	.930	.120		.040		.260	1.000	.800
N	38	40	59	54	24	6	48	6		6		5*	22	12
Manganese (mg.l-1)														
Median	.050		.000	.190	.050		.000					.000	.100	.175
Minimum	.000		.000	.030	.000		.000					.000	.050	.000
Maximum	.500		.150	.260	.150		.050					.100	.250	.300
N	24		59	6	24		48					5*	16	12
Copper (mg.l-1)														
Median			0.00				0.00					0.00		
Maximum			0.20				0.20					0.00		
N			60				47					5*		
Dissolved Oxygen (mg.l-1)														
Median		8.7	7.5	9.2			7.6		9.2	9.3	8.8	8.3		
Minimum		6.9	0.0	7.0			4.1		6.7	7.2	6.9	6.0		
Maximum		10.7	10.5	10.0			18.2		14.6	14.4	11.0	9.9		
N		32	171	24			138		92	18	16	15		
pH														
Median	8.0	8.1	8.6	8.2	8.3	8.4	8.6	7.9	9.1	8.6	9.4	8.5	8.0	8.5
Minimum	7.5	7.6	8.1	7.7	7.8	8.0	7.6	6.6	8.2	7.9	8.6	7.6	7.4	8.0
Maximum	8.5	8.9	9.0	9.0	8.4	8.5	9.3	9.0	10.0	9.6	9.7	8.7	8.7	11.0
N	84	106	164	109	24	6	132	33	58	14	10	15	46	36

Notes: 0.00, 0.0 = below detection limit. Underscored lakes were sampled in two time periods. *Data available from only 2 dates.

Table 6. Weather conditions prior to sampling dates.

	Pickerel		Enemy Swim		Cochrane		Roy	Blue Dog	Buffalo	Hendricks		Tetonkaha	East Oakwood	Round	Oak		Bitter	
Years	**74-75**	**90-96**	**74-75**	**90-94**	**70-79**	**90-97**	**95-96**	**74**	**94**	**70-79**	**90-94**	**88**	**88-94**	**88**	**70-79**	**90-97**	**74**	**95-96**
Wind Stress																		
Median	0.026	0.024	0.026	0.038	0.086	0.036	0.033	0.024	0.010	0.078	0.013	0.021	0.020	0.017	0.174	0.020	0.026	0.025
Minimum	0.018	0.008	0.001	0.008	0.003	0.008	0.023	0.018	0.008	0.003	0.007	0.009	0.009	0.009	0.017	0.007	0.018	0.008
Maximum	0.050	0.059	0.050	0.104	0.414	0.106	0.051	0.031	0.043	0.414	0.070	0.043	0.043	0.043	0.414	0.059	0.050	0.059
N	21	17	21	17	93	19	6	11	3	64	11	12	15	11	23	19	12	14
Rainfall																		
Median	10	206	10	193	90	224	93	1	25	60	104	213	213	64	50	122	10	239
Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	300	1885	300	767	1000	1290	213	61	1885	700	1077	485	1168	191	960	1052	60	767
N	21	17	21	17	94	19	6	11	3	64	11	12	15	11	23	19	12	14
Snow Depth																		
Median		9		8	19	14		13	32	14	10	18		18	16	10	13	9
Minimum	13	4	13	4	14	7	22			9	4		18		14	4		4
Maximum	17	32	17	32	33	61	24			23	29		29		20	30		20
N	2	5	2	5	8	6	2	1	1	6	3	1	2	1	3	6	1	4
Solar Radiation																		
Median	469		463		467			496		466					457		489	
Minimum	325		325		116			325		119					218		325	
Maximum	620		620		828			620		574					581		620	
N	10	0	12	0	94	0	0	11	0	61	0	0	0	0	23	0	10	0

Notes: Rainfall is the total received (cm) during the day of sampling and 6 days prior. Solar Radiation (Langleys) and Wind Stress is the average of the day of sampling and 6 days prior. Wind Stress = 1.1 x 10^{-6} w^2 where w = windspeed in $cm{\cdot}sec^{-1}$ (Small, 1963). Snow depth is the average maximum monthly depth during the months of Nov. - Apr. of the prior winter. Solar radiation was measured in Brookings, SD (William Lytle, personal communication). Other variables were taken from the nearest National Weather Service monitoring station.

Table 7. Abundance of non-filamentous Cyanophyceae (cell·1^{-4}) measured in the study lakes.

Lake	Pickerel		Enemy Swim		Cochrane		Roy	Blue Dog	South Buffalo	Hendricks		Teton-kaha	East Oakwood	Round	Oak			Bitter
Time Period	**74-75**	**90-96**	**74-75**	**90-94**	**70-79**	**90-97**	**95-96**	**74**	**94**	**70-79**	**90-94**	**88**	**88-94**	**88**	**78-79**	**90-97**	**74**	**90-96**
N	47	86	48	108	458	108	24	23	6	211	33	157	40	32	40	46	11	36
Chroococcales:																		
Coccochloris peniocystis																		
Median		8.8		23.5	1.1	54.6	4.2		37.9	0	0	0	0	0	0	9.5		0
Minimum		0		0	0	5.7	0		0	0	0	0	0	0	0	0		0
Maximum		286.7		109.2	372.5	216.5	14.6		125.8	0	65.5	3.9	6.1	0.9	1.8	289.6		26.1
N					285					157					19			
Anacystis incerta																		
Median		109.4		65.9	1055.3	80.7	12.8		164.9	0	351.0	24.9	13.2	44.6	8364.3	585.9		95,57.9
Minimum		3.3		2.6	0	15.3	6.4		92.7	0	31.5	0	0	0	162.6	33.8		4.8
Maximum		531.4		646.2	20,195.9	402.9	46.9		287.6	289.5	2268.4	261.7	199.5	299.3	11,830.7	4190.3		53,371.5
N					285					157					19			
Total picoplankton																		
Median	79.9	125.7	98.0	92.3	965.5	139.0	19.0	75.6	209.0	0	351.0	24.9	34.3	44.6	3898.1	586.2	21,274.3	10,105.0
Minimum	3.7	5.3	8.8	9.1	0.2	41.2	8.7	34.0	112.6	0	31.5	0	0	0	162.6	44.8	2552.4	8.2
Maximum	244.5	713.6	403.0	690.9	20,614.9	492.8	60.4	189.0	439.4	289.5	2268.4	261.9	199.5	299.3	15,779.9	4414.0	76,594.6	68,155.5
Anacystis cyanea																		
Median	4.4	0.2	4.1	0.9	26.3	8.0	1.2	0	2.8	0	0.7	64.5	39.8	41.9	6.6	8.8	1655.3	206.7
Minimum	0	0	0	0	0	0	0.2	0	1.1	0	0	0.9	0	15.4	0	0	180.8	0.3
Maximum	18.1	15.4	33.1	90.9	1358.5	27.2	2.9	73.1	4.2	13.0	29.3	613.9	200.4	212.1	140.9	387.9	4643.1	3587.8
Gloeocapsa sp.																		
Median		0		0	0	0	0		0		0		0		0	0		0
Maximum		0.1		0.2	12.9	1.8	0		0.1		0		0		10.0	0.6		0
N				60	340	60					6							
Total Chroococcales																		
Median	59.8	125.8	93.0	85.7	1027.1	153.8	19.5	76.33	211.4	0	325.8	99.7	39.4	134.4	3920.9	602.7	16,697.1	10,168.6
Minimum	3.7	8.1	6.4	9.5	0.2	42.2	9.8	20.6	114.6	0	35.9	3.3	2.4	48.4	175.7	35.5	2519.6	8.9
Maximum	244.5	713.6	406.6	665.4	20,778.0	504.9	62.8	219.9	442.7	289.5	2272.4	619.8	287.6	340.1	15,779.4	4464.5	83,196.2	68,956.7
N	77		118					60									57	
Chaemisiphonales																		
Stichosiphon sp.																		
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0	0.2	0.1	0.2	2.7	0.0	0.4	0	0	0.0	0.1	0.7	0	0	0	1.0		0.2

Notes: Underscored lakes were sampled in two time periods. Minimum values measured are 0 when not given. 0 = none measured, 0.0 = less than 0.05 measured. Sample size (N) is the number given at the top of each column, if not otherwise specified.

Table 8. Measured abundance of non-heterocystous, filamentous Cyanophyceae (Oscillatorineae, cells·ml^{-1}).

Lake	Pickerel		Enemy Swim		Cochrane		Roy	Blue Dog	South Buffalo	Hendricks		Tetonkaha	East Oakwood	Round	Oak		Bitter	
Time Period	**74-75**	**90-96**	**74-75**	**90-94**	**70-79**	**90-97**	**95-96**	**74**	**94**	**70-79**	**90-94**	**88**	**88-94**	**88**	**78-79**	**90-97**	**74**	**90-96**
N	77	86	48	108	458	108	24	23	6	211	33	157	40	32	40	46	11	36
Lyngbya spp.																		
Median	0	0.5	0	0.9	6.3	4.2	3.0	0.5	0.5	0	0	645.9	251.7	829.3	63.3	9.3	0	0
Maximum	1.9	30.7	40.3	220.6	1120.0	551.6	157.4	0	3.4	34.4	1.9	8833.8	3778.5	5498.6	322.5	1372.5	0	992.3
L. contorta																		
Median		0		0	6.3	3.3	0		0.2	0	0	85.7	39.7	26.9	50.5	2.8		0
Maximum		30.7		9.3	1120.0	551.6	2.6		0.7	34.3	1.9	2632.6	1596.5	646.6	3201.0	119.8		992.3
N					539					45								
L. versicolor																		
Median		0		0.3	0	0	2.2		0	0	0	465.5	51.3	750.5	4.6	3.4		0
Maximum		10.8		212.1	0	10.3	157.4		2.7	12.8	1.8	6201.2	3723.9	5327.2	735.2	1363.4		2.3
N					539					45								
L. birgei																		
Median		0		0	0	0	0		0	0	0	0	0	0	0	0		0
Maximum		1.7		4.0	0	0	24.4		0	0	0	0	0	0	0	0		0
Oscillatoria sp.																		
Median	0	0	0	0	0	0	0		0	0	0	43.1	50.7	49.8	0	0		0
Maximum	0	0	0	0	27.5	3.2	0		0	0.1	0	1809.8	615.4	252.4	2.0	46.8		0
Spirulina sp.																		
Median	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0		0
Maximum	0	0	0	0	0	0.0	0		0	0	0	65.7	197.2	0	0	0		6.3
Total Oscillatorineae																		
Median	0	0.5	0	0.9	6.3	4.4	3.0	0	0.5	0	0	892.4	156.1	859.9	54.1	8.2	0	0
Maximum	1.9	30.7	40.3	220.6	1120.0	551.6	157.4	0	3.4	34.4	1.9	8920.1	3982.6	5628.0	322.5	1375.7	0	992.3

Notes: Underscored lakes were sampled in two time periods. Minimum values measured are 0 when not given. 0 = none measured, 0.0 = less than 0.05 measured. Sample size (N) is the number given at the top of each column, if not otherwise specified.

Table 9. Measured abundance of heterocystous Cyanophyceae (Nostochinaeae, (cells·ml^{-4}).

	Pickerel		Enemy Swim		Cochrane		Roy	Blue Dog	South Buffalo	Hendricks		Tetonkaha	East Oakwood	Round	Oak		Bitter	
Time Period	**74-75**	**90-96**	**74-75**	**90-94**	**70-79**	**90-97**	**95-96**	**74**	**94**	**70-79**	**90-94**	**88**	**88-94**	**88**	**78-79**	**90-97**	**74**	**90-96**
N	47	86	48	108	458	108	24	22	6	211	33	157	40	32	40	46	11	36
Anabaena spp.																		
Median	0.3	0.2	0.1	0	0	0	0	1.0	0	0	0	0	0	0	0	1.5	0	0
Maximum	7.1	91.0	4.9	5.8	12.6	0.1	5.2	9.8	0.7	30.9	91.0	351.6	137.4	163.9	21.1	68.3	0	8.7
N	77		118					60									57	
A. circinalis																		
Median		0	0.1	0	0	0	0		0	0	0				0	0		0
Maximum		3.2	0.9	3.1	12.6	0.1	0.5		0	21.6	0				0	39.1		0.8
N			36							81								
*A. flos-aquae**																		
Median		0	0	0	0	0	0		0	0	0				0	0.5		0
Maximum		89.9	1.9	5.0	1.6	0.1	5.2		0.7	11.4	91.0				21.1	29.2		8.7
N			36							81								
Aphanizomenon holsatica																		
Median	0	0	0	0	0	0	0	15.5	0	21.5	2.3	208.2	131.1	137.5	0	5.0	0	0
Maximum	48.8	35.1	32.6	4.9	9.6	2.9	38.6	106.4	0	1894.7	1666.6	1856.4	7065.2	1360.1	0	227.5	0	14,560
N	77		118					60									57	
Cylindrospermum musicola																		
Median	0	0	0	0	0	0	0	0	0	0	0	62.7	10.8	39.8		10.4	0	0
Maximum	0	0	0	0	0	0	0	0	0	0	0	1662.1	1037.9	1115.1		900.7	0	139.9
Nodularia Harveyensis																		
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0	0	0	0	0.1	3.3	0	0	0	0	0	0	0	0	0	0.4	0	222.6
Gleotrichia echinulata																		
Medium	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	7.0	4.3	16.1	4.3	0	0.1	9.0	162.3	0	0	0	0	0	0	0	0.9	0	0
Total Nostochineae																		
Medium	0.4	1.6	0.5	0.1	0	0	0	0	0	25.9	45.6	419.5	346.1	333.4	0	20.3	0	0
Minimum	48.8	91.0	33.1	5.8	12.6	3.5	43.8	162.3	0.7	1894.7	1666.6	2353.1	7065.2	2466.4	21.1	907.0	0	14,560

Notes: Underscored lakes were sampled in two time periods. Minimum values measured are 0 when not given. 0 = none measured, 0.0 = less than 0.05 measured. Sample size (N) is the number given at the top of each column, if not otherwise specified. Small numbers of *Anabaena spiroides* in Lake Enemy Swim were included with the count of *A. flos-aqua as* they could not be separated when heterocysts and akinetes were not present.

Table 10. Measured abundance of Heterocysts (cells·ml^{-1}).

Lake	Pickerel	Enemy Swim	Cochrane	Roy	Hendricks	Oak	Bitter
Time Period	**90-96**	**90-94**	**90-97**	**95-96**	**90-94**	**90-97**	**90-96**
N	86	108	108	24	33	46	36
Anabaena circinalis							
Median	0	0	0	0	0	0	0
Maximum	0.1	0.1	0	0.0	0	2.6	0.8
A. flos-aqua							
Median	0	0	0	0	0	0	0
Maximum	3.1	0.2	0.0	0.1	0.1	0.3	0
Aphanizomenon holsatica							
Median	0	0	0	0	0.1	0	0
Maximum	0.2	0	0.0	0.4	10.5	2.5	114.6
Cylindrospermum musicola							
Median	0	0	0	0	0	0	0
Maximum	0	0	0	0	0	28.2	19.1
Nodularia harveyensis							
Median	0	0	0	0	0	0	0
Maximum	0	0	0.1	0	0	0.0	12.7
Gloeotrichia echinulata							
Median	0	0	0	0	0	0	0
Maximum	0.1	0	0.1	0	0	0.1	0
Total heterocysts							
Median	0	0	0	0	0.1	0.0	0
Maximum	3.2	0.2	0.1	0.5	10.5	28.2	114.6

Notes: Underscored lakes were sampled in two time periods. Minimum values measured are 0 when not given. 0 = none measured, 0.0 = less than 0.05 measured.

Table 11. Measured abundance of Centric Diatoms (Centrales, no$\cdot$ml^{-4}).

Lake	Pickerel		Enemy Swim		Cochrane		Roy	Blue Dog	South Buffalo	Hendricks		Tetonkaha	East Oakwood	Round	Oak		Bitter	
Time Period	**74-75**	**90-96**	**74-75**	**90-94**	**70-79**	**90-97**	**95-96**	**74**	**94**	**70-79**	**90-94**	**88**	**88-94**	**88**	**70-79**	**90-97**	**74**	**90-96**
N	47	86	48	108	458	108	24	22	6	211	33	157	40	32	40	46	11	36
Cyclotella spp.																		
Median	0.14	0	0	0.01	0.11	0.03	0	0	0.03	0	0.04	0	0	0	2.68	0.10	0	0
Maximum	3.50	0.43	1.42	0.80	7.60	0.95	0.03	0.13	0.04	29.00	69.64	0	0.01	0	22.23	1.51	0	31.81
Stephanodiscus niagarae																		
Median	0	0.03	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0	0
Maximum	0.31	0.24	0.11	0	1.02	1.02	0.02	0.06	0	2.25	0.16	1.32	1.43	0.66	4.23	4.07	0	6.36
Melosira/Aulacoseira spp.																		
Median	0.22	0.11	0.43	0	0	0	0.18	0	0.03	0	0	6.50	2.91	2.91	0.05	0.17	0	0
Maximum	2.29	2.24	1.69	1.87	1.53	0.25	2.40	0.12	0.39	0.19	2.26	70.52	37.42	41.16	142.25	277.68	0	0.17
M. Varians																		
Median		0		0	0	0	0		0		0				0	0		0
Maximum		1.60		0.96	0	0	0.25		0		2.26				0.01	6.24		0.17
N					162										21			
Aulacoseira spp.																		
Median		0		0	0	0	0.14		0.03		0				0	0.05		0
Maximum		22.3		1.27	0.64	0.25	2.40		0.39		0.02				8.58	9.39		0
N					162										21			
Chaetoceras elmorei																		
Median	0	0	0	0	0.07	0.03	0	0	0	0	0	0	0		0	0	0	0
Maximum	0	0	0	0.31	8.87	0.57	0	0	0	0	0	0	0		0	0	10.86	82.70
Total centrales																		
Median	0.15	0.17	0.48	0.17	0.60	0.11	0.18	0	0.07	0.11	0.06	6.50	3.24	3.58	4.13	0.67	0	0
Minimum	0	0	0.03	0	0	0	0	0	0.02	0	0	0	0	0	8	0	0	0
Maximum	3.60	2.30	1.71	1.89	11.63	0.95	2.40	0.18	0.42	29.00	69.64	70.52	37.42	41.16	147.88	279.40	10.86	89.06

Notes: Underscored lakes were sampled in two time periods. Minimum values measured are 0 when not given. 0 = none measured, 0.0 = less than 0.005 measured. Sample size (N) is the number given at the top of each column, if not otherwise specified.

Table 12. Measured abundance of Pennate Diatoms (Pennales, no·ml-4).

Lake	Pickerel		Enemy Swim		Cochrane		Roy	Blue Dog	South Buffalo	Hendricks		Teton-kaha	East Oakwood	Round	Oak		Bitter	
Time Period	**74-75**	**90-96**	**74-75**	**90-94**	**70-79**	**90-97**	**95-96**	**74**	**94**	**70-79**	**90-94**	**88**	**88-94**	**88**	**70-79**	**90-97**	**74**	**90-96**
N	36	86	48	108	458	108	24	22	6	211	33	157	40	32	40	46	11	36
Asterionella formosa																		
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	8.58	19.39	3.23	6.90	0.85	0.77	3.84	0.26	0	0.02	0.93	0	0	0	3.07	0.05	0	0.68
N	77		118					60									57	
Fragilaria crotonensis																		
Median	0.19	0.04	0.29	0.29	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0
Maximum	9.62	5.27	2.16	6.40	8.19	0.17	1.38	0.19	0.27	1.40	0.43	3.95	2.71	1.73	33.80	3.25	0	0.17
N	77		118					60									57	
Tabellaria fenestrata																		
Median	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0		0
Mcaximum	0	0	0	0	1.80	0	0.01		0	0.76	0	0	0	0	0.46	0.01		0
Synedra/Nitzchia spp.																		
Median	0	0	0	0.01	0	0.03	0		0.04	0	0	0	0	0	1.55	0.09		19.26
Maximum	2.85	1.81	0.77	1.35	4.34	5.03	0.21		0.10	1.78	0.06	12.18	3.86	4.50	45.06	3.52		566.16
N	36																	
S. ulna																		
Median		0		0	0	0	0		0	0	0				0	0		0
Maximum		0.04		0.04	1.09	0.09	0		0.02	1.78	0.01				13.00	0.08		0
N					279													
N. acicularis / S. acus																		
Median		0		0	0	0	0		0.01	0	0				0	0		0
Maximum		0.13		0.13	0.01	0.31	0.21		0.03	0.35	0.03				16.90	0.60		0.12
N					73													
N. holsatica																		
Median		0		0	0	0	0		0	0	0				0	0		
Maximum		1.81		1.33	3.38	4.95	0		0.03	0	0.04				0	0.21		
N					260													
Phaeodactylum tricornutum																		
Median		0		0	0	0	0		0.01	0	0				0	0		19.26
Maximum		0.13		0.21	4.08	0.13	0.03		0.08	0.18	0				27.36	0.49		566.12
Navicula spp																		
Median		0		0	0	0	0		0	0	0				0	0		0
Maximum		0		0.40	3.38	0.08	0.02		0	0.14	0				6.89	0.01		0
Entomoneis sp																		
Median	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0		0
Maximum	0	0	0	0.01	0.99	0.07	0		0	0.01	0.50	0	0	0	0.63	0.05		0
Total Pennales																		
Median	0.07	0.25	0.49	0.63	0.11	0.08	0.22	0	0.19	0	0	0.63	0.44	0.27	4.33	0.19	28.00	566.45
Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.60	0
Maximum	3.15	20.57	4.39	12.89	13.33	10.05	5.10	0.64	0.58	3.56	1.00	12.18	4.07	5.54	80.47	3.93	99.90	1164.12
N	77		118					60									57	

Notes: Underscored lakes were sampled in two time periods. Minimum values measured are 0 when not given. 0 = none measured, 0.00 = less than 0.005 measured. Sample size (N) is the number given at the top of each column, if not otherwise specified. *Synedra/Nitzschia* spp. also includes *Phaeodactylum tricornutum* which was originally identified as *Nitzschia closteriun*.

Table 13. Measured abundance of green algae (Chlorophyceae) and *Botryococcus braunii* ($no \cdot ml^{-1}$).

Lake	Pickerel		Enemy Swim		Cochrane		Roy	Blue Dog	South Buffalo	Hendricks		Teton-kaha	East Oakwood	Round	Oak		Bitter	
Time Period	**74-75**	**90-96**	**74-75**	**90-94**	**70-74**	**90-97**	**95-96**	**74**	**94**	**70-79**	**90-94**	**88**	**88-94**	**88**	**70-79**	**90-97**	**74**	**95**
N	47	86	48	108	458	108	24	22	6	211	33	157	40	32	40	46	11	36
Sphaerocystis schroeteri																		
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0	0.22	0	0.80	70.60	0.57	1.91	0	0.22	2.64	0.09	0	0	0	50.70	1.11	0	0
Crucigenia quadrata																		
Median	0	0	0	0	0.16	0.06	0	0	0	0	0	0	0	0	1.86	0	0	0
Maximum	0	0.20	0	1.23	289.58	14.24	0	0	0	10.03	0	0	0	0	161.21	2.35	0	0.16
Oocystis spp.																		
Median	0	0	0	0.12	0	0.05	0	0	0.12	0	0	0	0	0	0	0.03	0	0
Maximum	0.46	0.59	0.62	0.97	24.70	1.71	0	0.18	0.33	0.37	0.03	27.61	1.80	33.63	10.81	1.84	47.66	165.39
Pediastrum spp.																		
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.16	0.12	0	0
Maximum	9.89	0.71	14.16	1.33	9.26	0.48	0.85	1.73	0.24	0.70	0.43	80.88	18.91	207.98	72.43	2.40	0	0.28
P. boryanum																		
Median		0		0	0	0	0		0	0	0				0	0		0
Maximum		0.71		0.63	7.63	0.48	0.85		0.24	0.70	0.43				72.43	0.64		0
N					216					175								
P. duplex																		
Median		0		0	0	0	0		0	0	0				0	0		0
Maximum		0.61		1.33	1.07	0.43	0.19		0	0.52	0				42.25	2.21		0.28
N					216					175								
Scenedesmus spp.																		
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0.11	15.91	0.18	0.55	7.32	0.27	0	0	0.04	1.59	0	0.73	0.07	26.05	8.43	0.20	0	0
Schroederia/Selenastrum spp.																		
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0	0.01	0.07	0.04	0.02	2.57	0	0	0	9.58	0.01	2.88	0.94	0.35	0	0.01	7.52	0
Ankistrodesmus/Monoraphidium spp.																		
Median	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	91.57	6.53
Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.64	0
Maximum	0.38	0.08	0.12	0.14	2.77	0.57	0.01	0.22	0.01	5.90	0.22	2.39	5.84	1.83	0	0.55	246.98	547.07

Table 13 continued. Measured abundance of green algae (Chlorophyceae) and *Botryococcus braunii* (no·ml^{-1}).

Lake	Pickerel		Enemy Swim		Cochrane		Roy	Blue Dog	South Buffalo	Hendricks		Teton-kaha	East Oakwood	Round	Oak		Bitter	
Time Period	**74-75**	**90-96**	**74-75**	**90-94**	**70-74**	**90-97**	**95-96**	**74**	**94**	**70-79**	**90-94**	**88**	**88-94**	**88**	**70-79**	**90-97**	**74**	**95**
N	47	86	48	108	458	108	24	22	6	211	33	157	40	32	40	46	11	36
Tetraedron																		
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0	0	0	0.01	2.25	0	0	0	0	0.08	0	0	0	0	0	0.03	0	0
Closteriopsis sp.																		
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.02	0	0
Maximum	0	0.03	0	0.01	0	0	0	0	0	0	0.13	1.41	0.39	1.01	2.82	1.69	0	6.36
Closterium spp.																		
Median	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0
Maximum	0.19	0.10	0.03	0.01	0.10	0	0.19	0	0	0.03	0	0	0	0	8.45	0.35	0	0.08
Cosmarium spp.																		
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0	0.05	0.02	0.07	1.42	0.21	0.01	0	0.06	0.00	0	0	0	0.37	1.12	0.02	0	0
Staurastrum																		
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0	0.03	0	0.02	0	0	0.04	0	0	0.03	0.03	0.66	0.68	0.69	0.07	0.18	0	0
Unidentified single cells																		
Median	0	0	0	0	0	0	0	0	0	0	0	0.66	0.22	0.66	0.75	0	0	0
Maximum	0	0.08	0.08	0.87	22.72	2.01	0	0.01	0.17	0	0.08	4.60	3.59	3.95	41.05	0.47	0	0
Total Chlorophyceae																		
Median	0.12	0.09	0	0.34	3.42	0.54	0.04	0.04	0.26	0	0.01	1.97	1.26	1	28.23	0.97	108.64	6.5
Minimum	0	0	0	0	0	0	0	0	0.03	0	0	0	0	0	0	0.02	1.64	0
Maximum	9.89	16.06	14.22	3.32	294.40	14.35	1.91	1.73	0.48	10.03	0.52	83.80	22.49	244.95	176.81	4.35	259.54	712.5
Botryococcus braunii																		
Median	0	0.64	0	1.61	18.92	4.79	0	0	4.01	0	0	12.57	2.66	41.49	2.5	1.14	0	0
Maximum	9.30	28.81	93.60	19.21	344.77	31.42	0.39	0	6.97	0.91	7.84	1936.01	355.59	248.92	5910.52	79.40	0	2.73

Notes: Underscored lakes were sampled in two time periods. Minimum values measured are 0 when not given. 0 = none measured, 0.00 = less than 0.005 measured. Sample size (N) is the number given at the top of each column, if not otherwise specified.

Table 14. Measured abundance of Chrysophyta-like flagellates (no·ml^{-1}).

Lake	Pickerel		Enemy Swim		Cochrane		Roy	Blue Dog	South Buffalo	Hendricks		Teton-kaha	East Oakwood	Round	Oak		Bitter	
Time Period	**74-75**	**90-96**	**74-75**	**90-94**	**70-79**	**90-97**	**95-96**	**74**	**94**	**70-79**	**90-94**	**88**	**88-94**	**88**	**78-79**	**90-97**	**74**	**90-96**
N	47	86	48	108	458	108	24	22	6	211	33	157	40	32	40	46	11	36
Ochromonas/Paraphysomonas																		
Median	0	0	0	0	0	0	0	0	0.01	0	0.01	0	0	0	0	0	0	0
Maximum	0	0.36	0.47	0.50	1.04	0.19	0.13	0.33	0.12	0.34	0.26	1.01	1.00	0	0	1.75	0	0
Dinobryon sertularia																		
Median	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0.17	0.56	0.55	0.62	0.03	1.70	0.33	0.16	0.04	0	0.05	0	0	0	0	0.48	0	0
D. calciformus																		
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0.00	0	0	0	0	0.01	0	0.09	0	0	0	0	0	0	0	0	4.91	0
Mallomonas/Rhizo-chrysis-like																		
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0.02	0.08	0.02	0.10	0.35	0.05	0	0.06	0	0	0.05	3.63	0.08	0.80	0.01	0.02	0	6.36
Unidentified Chrysophyte-like																		
Median	0.02	0	0	0	0	0	0	0	0.06	0	0	0	0	0	0.13	0	5.32	0
Minimum	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0.41	0
Maximum	2.00	37.55	0.08	22.45	11.93	14.44	0	0.85	3.27	1.28	2.90	4.93	2.19	0.55	25.62	33.27	15.43	37.55
Total Chrysophyta-like																		
Median	0.04	0.05	0.04	0.02	0	0	0	0.05	0.16	0	0.03	0	0	0	0.13	0.03	5.32	0
Minimum	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0.41	0
Maximum	0.62	37.67	0.65	22.49	11.93	16.23	0.33	0.85	3.27	1.28	3.19	5.40	2.19	0.80	25.62	33.46	15.43	6.36

Notes: Underscored lakes were sampled in two time periods. Minimum values measured are 0 when not given. 0 = none measured. Sample size (N) is the number given at the top of each column, if not otherwise specified.

Table 15. Measured abundance of Dinoflagellates (Dinophyceae), Cryptophyceae) and Euglenophytes (Euglenophyceae ($no \cdot ml^{-1}$).

Lake	Pickerel		Enemy Swim		Cochrane		Roy	Blue Dog	South Buffalo	Hendricks		Teton-kaha	East Oakwood	Round	Oak		Bitter	
Time Period	**74-75**	**90-96**	**74-75**	**90-94**	**70-79**	**90-97**	**95-96**	**74**	**94**	**70-79**	**90-94**	**88**	**88**	**88**	**70-79**	**90-97**	**74**	**90-96**
N	47	86	48	108	458	108	24	22	6	211	33	157	40	32	40	46	11	36
Peridinium/ Glenedinium/ Gymnodinium spp.																		
Median	0	0	0	0	0	0.05	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0.02	0.03	0.01	0.13	2.24	1.16	0.30	0	0.10	0.10	0.12	1.32	0.60	0.66	0.34	0.41	0	0.02
Peridinium sp.																		
Median		0			0	0	0	0				0	0	0		0		0
Maximum		0.03			2.24	0.28	0.15	0				0.73	0.60	0.66		0.22		0
N		24			206	6										16		12
Glenodinium/ Gymnodinium spp.																		
Median		0			0	0	0	0				0	0	0		0		0
Maximum		0			1.29	0.03	0.15	0				1.32	0	0.66		0.05		0.02
N		24			206	6										16		12
Ceratium hirundinella																		
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0.10	0.21	0.17	0.04	0.35	0.04	0.01	0	0	0	0.02	0.66	0.66	0.44	0	0.01	0	0
Total Dinophyceae																		
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0.10	0.22	0.17	0.13	2.24	1.17	0.30	0	0.10	0.10	0.12	1.32	0.66	0.66	0.34	0.41	0	0.02
Total Cryptophyceae																		
Median	0	0.03	0	0.01	0	0.03	0.13	0	0.15	0	0.01	3.51	1.53	2.07	0	0.05	0	0
Minimum	0	0	0	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0	0
Maximum	13.09	1.67	1.43	0.27	1.63	0.56	0.99	0	0.48	4.41	0.40	64.55	78.17	45.15	0	0.29	0	0.59
Trachelomonas spp.																		
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0	0	0	0.04	0	0.02	0	0	0	0.64	0.02	5.40	5.38	0.73	0	0.08	0	0
Total Euglenophyta																		
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0
Maximum	0	0.01	0	0.04	0.04	0.03	0.01	0	0.07	0.64	0.02	5.40	5.38	0.73	0.02	0.10	0	6.36

Notes: Underscored lakes were sampled in two time periods. Minimum values measured are 0 when not given. 0 = none measured, 0.00 = less than 0.005 measured. Sample size (N) is the number given at the top of each column, if not otherwise specified.

Table 16. Measured abundance of Rotifers (Rotifera, $no{\cdot}ml^{-4}$).

Lake	Pickerel		Enemy Swim		Cochrane		Roy	South Buffalo	Hendricks		Teton-kana	East Oakwood	Round	Oak		Bitter	
Time Period	**74-75**	**90-96**	**74-75**	**90-94**	**70-79**	**90-97**	**95-96**	**94**	**70-79**	**90-94**	**88**	**88-94**	**88**	**70-79**	**90-97**	**74**	**90**
N	39	42	34	54	344	66	12	6	167	33	158	41	33	40	46	23	36
Filinia longiseta																	
Median	0	0	0	0.1	0	7.5	0	0	0	0	5.0	2.0	13.7	0	0	0	0
Maximum	2.1	9.9	62.9	10.4	550.0	78.6	0.5	1.3	8.5	1.7	579.4	447.9	571.2	6.5	81.4	0	21.6
Asplanchna sp.																	
Median	0.1	0.0	0.8	2.9	1.8	1.1	0.3	5.0	0	0	1.8	2.6	2.6	9.2	4.0	0	0
Minimum	0	0	0	0	0	0	0	1.4	0	0	0	0	0	0	0	0	0
Maximum	190.3	10.0	17.1	37.2	322.2	57.0	4.3	14.2	38.6	5.7	72.2	145.7	78.6	369.0	91.9	0	59.0
Brachionus spp.																	
Median	0	0	0	0	0	1.1	0	1.9	0	0	8.8	3.1	24.5	0.1	0	0	0
Maximum	0	1.0	0	1.4	110.0	1285.4	0	4.3	93.1	1.4	942.6	589.4	1311.8	8.3	25.6	0	0
Keratella spp.																	
Median	0	7.5	1.0	3.2	0	2.4	2.2	18.4	0	63.1	6.3	5.0	5.8	0	13.1	0	0.5
Minimum	0	0	0	0	0	0	1.1	12.1	0	0.6	0	0	0	0	0	0	0
Maximum	19.9	37.2	108.3	50.0	281.8	194.5	6.3	48.6	63.3	312.3	3561.6	4243.6	1532.4	12.9	838.0	0	43.9
K. quadrata																	
Median	0	0.2	0	0		1.9			0	1.2					0		
Maximum	11.0	1.4	2.7	1.4		194.5			15.8	165.0					7.1		
N		9	17	35		56			9	27					28		
K. cochlearis																	
Median	0	16.5	0	2.9		0			0	22.8					2.7		
Minimum	0	5.0	0	0		0			0	0					0		
Maximum	12.7	28.7	14.2	37.2		7.6			0.9	224.4					838.0		
N		9	17	35		56			9	27					28		
Kellicotia longispina																	
Median		0		0		0	0	0		0	0	0	0		0		0
Maximum		70.2		0		0	81.1	0		0	4.8	0	0		274.3		0.4
Platyias quadricornis																	
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0	0	0	0.2	0.5	14.1	0	29.1	0	0	0	0	0	0	20.0	0	0
Polyarthra sp.																	
Median		0		0		0	0	1.2		0	5.3	0	0		0		0
Maximum		20.6		63.8		0	0	11.3		24.5	10,129.3	2752.9	523.8		111.8		0

Table 16 continued. Measured abundance of Rotifers (Rotifera, no·ml^{-4}).

Lake	Pickerel		Enemy Swim		Cochrane		Roy	South Buffalo	Hendricks		Teton-kana	East Oakwood	Round	Oak		Bitter	
Time Period	**74-75**	**90-96**	**74-75**	**90-94**	**70-79**	**90-97**	**95-96**	**94**	**70-79**	**90-94**	**88**	**88-94**	**88**	**70-79**	**90-97**	**74**	**90**
Synchaeta sp.																	
Median		0		0		0	0	0		0	0	0	0		0		0
Maximum		0		0		0	0	0		290.4	0	4.0	0		25.5		0
Trichocerca sp.																	
Median		0		0		0	0	0		0	0	0	0		0		0
Maximum		4.1		0.6		1.7	0	16.5		0	84.4	79.2	15.6		45.7		0
Total Rotifers																	
Median	0.0	15.0	3.9	3.8	2.7	48.6	3.8	41.2	0	63.1	152.3	103.0	147.9	9.9	66.0	0	5.0
Minimum	0	0	0	0	0	0.3	2.3	22.0	0	1.7	0	0	0	0	0	0	0
Maximum	200.4	722.0	108.3	41.6	725.0	1363.2	87.4	53.7	199.3	312.3	10,238.5	4332.0	2484.3	369.0	1676.1	0	62.7

Notes: Zooplankton were sampled with a 153 μm mesh in 1970-79 and a 80 μm mesh in 1990-97, so smaller genera and taxa were more reliably retained in 1990-97.

Table 17. Measured abundance of Cladocerans (Cladocera, $no \cdot ml^{-4}$).

	Pickerel		Enemy Swim		Cochrane		Roy	South Buffalo	Hendricks		Teton-kaha	East Oakwood	Round	Oak		Bitter	
Time Period	**74-75**	**90-96**	**74-75**	**90-94**	**70-79**	**90-97**	**95-96**	**74**	**70-79**	**90-94**	**88**	**88-94**	**88**	**70-79**	**90-97**	**74**	**90-96**
N	39	42	31	54	334	66	12	6	167	33	158	41	33	40	46	23	36
Daphnia (subgenus *Ctenodaphnia*) spp.																	
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.2	1.8
Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0	20.9	224.4
Daphnia spp																	
Median	7.6	4.7	4.1	3.2	1.6	1.2	26.9	0.2	45.9	18.2	2.9	1.9	5.9	0.1	4.2	0	0
Minimum	0	0	0	0	0	0	6.3	0	4.3	0	0	0	0	0	0	0	0
Maximum	364.5	25.0	94.8	85.5	1152.1	73.1	42.9	21.3	734.7	378.4	149.1	104.0	184.2	1709.5	171.4	0	871.3
*D. pulex**																	
Median	0	0.5		0.7	0	0	26.9		45.8	20.7	0	0	0	0	0		0
Minimum	0	0		0	0	0	3.1		4.3	0	0	0	0	0	0		0
Maximum	175.1	25.0		19.0	0.8	0	42.9		734.7	378.4	145.2	79.2	184.2	17.2	14.4		871.3
N	18	36		48	315	60				27		35					
D. galeata																	
Median	1.4	1.4		0.6	0.1	0	0		0	0	0	0	0	0	0		0
Maximum	182.3	22.4		77.8	85.8	36.5	3.1		0	0	87.3	39.8	60.1	31.0	7.1		0
N	18	36		48	315	60				27		35					
D. rosea																	
Median	0	0		7.2	0.5	0	0		0	0	0	0	0	0	0		0
Maximum	0	0		42.3	1152.1	36.5	0		45.5	76.9	3.1	0	0	10.0	31.8		0
N	18	36		48	315	60				27		35					
D. parvula																	
Median	0	0		0	0	0	0		0	0	0	0	0	0	3.5		0
Maximum	0	0		0	0	0	0		0	0	11.6	2.7	0.7	1709.5	169.7		3.1
Ceriodaphnia lacustris																	
Median	0	0	0	0	35.4	21.2	0	0	0	0	0	0	0	0	0	0	0
Maximum	0	0.6	0	0	2011.1	184.2	0	0	29.0	0	95.0	165.0	238.7	11.9	36.1	0	0
Diaphanosoma birgei																	
Median	0	0	0	0.2	0	0	0	0	0	0	6.6	2.0	5.7	18.6	2.1	0	0
Maximum	25.8	19.7	27.0	14.8	2.8	0	8.0	0.5	46.9	126.4	161.4	112.9	70.1	808.0	137.3	0	0

Table 17 continued. Measured abundance of Cladocerans (Cladocera, no·ml^{-4}).

	Pickerel		Enemy Swim		Cochrane		Roy	South Buffalo	Hendricks		Teton-kaha	East Oakwood	Round	Oak		Bitter	
Time Period	**74-75**	**90-96**	**74-75**	**90-94**	**70-79**	**90-97**	**95-96**	**74**	**70-79**	**90-94**	**88**	**88-94**	**88**	**70-79**	**90-97**	**74**	**90-96**
Bosmina longirostris																	
Median	0	0	0.7	0.1	0	0	0	23.8	0	0	61.0	48.6	94.0	9.4	69.3	0	0
Minimum	0	0	0	0	0	0	0	3.1	0	0	0	0	0	0	0	0	0
Maximum	0.9	3.0	15.7	12.0	16.8	2.1	3.7	72.3	6.3	16.0	1431.6	719.1	943.4	3040.0	821.5	0.2	27.0
Chydorus sphaericus																	
Median	0.1	0.1	0.8	0.0	0	0	0		5.3	0	0	0	0	0	0	0	0
Maximum	8.4	12.0	5.3	6.1	13.9	4.4	0		328.7	0.1	0	0	0	0.1	54.3	0	0
Leptodora kindtii																	
Median	0	0.0	0	0.0	0	0	0	0.0	0	0	0	0	0	0	0	0	0
Maximum	2.6	0.5	6.7	0.7	0	0	0.0	0.1	0	0	0	0	0	0	0	0	0
Total Cladocera																	
Median	8.4	7.6	10.3	8.5	38.4	41.0	27.2	25.0	63.4	30.4	108.5	100.3	178.2	29.9	106.6	1.2	12.0
Minimum	0	0.7	0.4	0.4	0	0.1	16.9	3.6	7.3	1.5	0	0	5.2	0.1	0.8	0	0
Maximum	364.5	26.6	101.8	94.3	2100.0	197.6	42.9	93.6	1092.4	498.6	1468.8	966.6	1018.7	387.2	950.5	20.9	871.3

Notes: Underscored lakes were sampled in two time periods. Minimum values measured are 0 when not given. 0 = none measured, 0.0 = less than 0.05 measured. Sample size (N) is the number given at the top of each column, if not otherwise specified. *D. pulex** includes *D. schodleri* from Lake Hendricks (1970-1972, only) and *D. catawba* from Lake Hendricks (1975, only). *D.*

Table 18. Measured abundance of Copepods (Copepoda) and Ostracods (Ostrocoda, $no \cdot ml^{-4}$).

	Pickerel		Enemy Swim		Cochrane		Roy	South Buffalo	Hendricks		Teton-kaha	East Oakwood	Round	Oak		Bitter	
Time Period	**74-75**	**90-96**	**74-75**	**90-96**	**74-75**	**90-97**	**95-96**	**74**	**70-79**	**90-91**	**88**	**88**	**88**	**70-79**	**90-97**	**74**	**90-96**
N	39	42	34	54	334	66	12	6	163	33	158	41	33	40	46	23	36
Diaptomus spp.																	
Median	13.3	10.2	18.1	11.0	21.7	22.2	13.3	1.4	20.3	25.8	20.4	14.9	21.9	12.2	44.6	26.0	72.7
Minimum	0	0	0.4	0	0.2	0.2	1.1	0	0	0	0	0	0	0	0.9	3.7	0
Maximum	324.8	29.6	237.5	61.7	616.7	98.1	58.5	2.8	1027.5	186.7	114.6	84.5	94.9	671.2	232.6	88.7	758.1
D. siciloides /D. connexus																	
Median	13.3	10.2	18.1	11.0	21.5	22.2	13.3	1.4	17.1	20.1	20.4	14.9	21.9	20.5	43.1	24.7	41.0
Minimum	0	0	0.4	0	0	0.2	1.1	0	0	0	0	0	0	0	0.9	0	0
Maximum	324.8	29.6	237.5	61.7	616.7	98.1	58.5	2.8	1020.0	186.7	114.6	84.5	94.9	613.5	232.6	84.7	150.9
D. clavipes /D. nevadensis																	
Median	0	0	0	0	0	0	0	0	2.0	0	0	0	0	0	0	2.5	10.7
Minimum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0
Maximum	0.7	0	0	0	1.6	0.0	0	0	77.1	27.7	0	0	0	63.2	32.8	7.6	607.3
Total Cyclopoida																	
Median	17.5	7.8	19.3	7.4	8.2	9.5	16.2	1.9	7.9	3.5	106.1	86.3	152.0	57.9	27.2	0	0
Minimum	0.5	1.4	2.4	0	0	0	8.6	0.5	0	0	0	2.8	14.7	0.0	1.1	0	0
Maximum	103.4	65.4	302.0	93.0	221.4	181.1	39.0	49.6	456.8	226.3	1030.4	400.2	1028.7	586.6	133.4	0.1	26.9
Cyclops bicuspidatus																	
Median	0	0		0.5	0	0	8.0		6.1	0	0	0	0	73.2	0		0
Minimum	0	0		0	0	0	0		0	0	0	0	0	2.4	0		0
Maximum	45.6	65.4		93.0	1.3	181.1	39.0		85.3	9.7	1030.4	389.0	1028.7	510.9	133.4		5.7
N	16	31		48	21	45			30	15		35		20	31		
C. vernalis																	
Median	0	0.7		0.0	1.8	3.3	4.8		0	0.7	39.3	29.0	26.7	0	14.5		0
Maximum	3.5	11.9		28.3	9.7	38.5	15.8		32.5	28.3	344.0	347.2	273.0	0	126.2		27.0
N	16	31		48	21	45			30	15		35		20	31		
Mesocyclops spp.																	
Median	3.5	0		0	0	0	0		0	0	0	0	0	0	0		0
Maximum	56.2	8.6		11.1	0	5.7	0		0	0	0	0	0	0	0		0
N	18	31		48	21	45			30	15		35		20	31		
Total nauplii																	
Median	14.5	11.1	18.4	12.2	5.0	24.7	26.9	7.8	5.3	49.5	240.4	103.1	255.3	9.4	64.7	0.1	36.2
Minimum	0	1.4	0.3	0	0	0	19.5	5.7	0	0	0	9.9	18.4	0	0	0	0
Maximum	143.9	44.7	178.7	90.2	360.7	163.2	35.7	8.5	158.9	448.1	1495.6	775.4	925.0	222.6	398.9	55.4	350.8
Total Copepoda																	
Median	46.2	30.2	71.0	28.6	42.2	63.6	60.5	10.9	44.7	89.6	408.0	326.0	460.4	82.0	141.4	26.0	93.5
Minimum	5.0	4.1	4.4	4.6	0.4	12.0	46.3	6.8	1.4	2.0	0	49.1	44.5	2.1	14.6	3.7	0
Maximum	486.2	103.0	612.5	193.9	788.9	392.7	105.5	65.2	1080.0	681.2	2017.2	1157.6	1235.7	952.0	619.9	88.7	1108.9
Total Ostracoda																	
Median	0	0.24	0	0.34	0	0	0	3.15	0	0	0	0	0	0	0	0	0
Maximum	24.49	4.65	4.67	34.3	1.45	0.75	7.44	6.22	4.55	4.72	0	2.02	0	0	0	0	5.83

Notes: Underscored lakes were sampled in two time periods. Minimum values measured are 0 when not given. 0 = none measured, 0.0 = less than 0.05 measured. Sample size (N) is the number given at the top of each column, if not otherwise specified. *Diaptomus, connexus* and *Nevadensis* were only found in Bitter Lake, and were the only *Diaptomus* species found there prior to the rise in water levels in the mid 1990s.

Table 19. Larger organisms caught in horizontal plankton tows (individuals per m³).

	Pickerel	Enemy Swim	Cochrane		Roy	Buffalo	Hendricks		Tetonkaha	East Oakwood	Round	Oak		Bitter	
Years	**90-96**	**90-94**	**76-79**	**90-96**	**95-96**	**94**	**78-79**	**90-94**	**88**	**88-94**	**88**	**78-79**	**90-96**	**74**	**90-96**
N	42	54	97	60	12	6	37	33	156	41	33	24	42	23	36
Fish Larvae/Minnows															
Median	0	0	0.54	0	0	0	0	0	0.01	0.06	0	*	0.20		0
Maximum	0.27	0.30	8.00	35.17	0	0.71	0	0	6.82	4.24	0.08	*	8.51		0
Hydracarina															
Median	0	0	0	0	7.68	0.48	0	0	0	0	0	2.24	0.48		0
Maximum	4.95	1.67	0.50	9.00	15.56	1.41	1.02	1.06	0	3.71	0	99.99	159.04		13.48
Artemia sp.															
Median	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0	5.08	43.68
Amphipoda															
Median	0	0	0	0	0	0	0	0	0	0	0	0	0		0
Maximum	0	0.26	0	0.13	0	0.71	0	0	0.01	0	0	0	0		229.74
Hemiptera															
Median	0	0	0	0	0	0	0	0	0.01	0	0	0	0		11.14
Maximum	0.35	0.71	0	0.02	0	0	*	4.24	1.39	0.11	0.10	0	1.41		334.7
Chaoborus															
Median	0	0	0	0	0	0	0	0	0	0	0	0.19	0		0
Maximum	0	4.24	0.67	3.39	0.71	0	0	0	0.17	0	0.04	2.52	2.13		22.09
Other Insecta															
Median	0	0	0	0	0	0.17	0	0	0	0	0	0	0		0.99
Maximum	0.71	2.27	0	1.41	14.10	2.12	460.50	2.13	0.01	1.59	0	0.02	86.52		82.26

Notes: Underscored lakes were sampled in two time periods. Hemiptera in Hendricks and fish larvae in Oak (1978-1979) were abundant but were not counted. *The estimate for *Artemia* (Bitter Lake, 1974) was taken from Clarke-Bumpus zooplankton tows.