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Littoral benthic macroinvertebrate community dynamics in five eutrophic hardwater lakes in north-central Alberta and the influence of $Ca(OH)_2$ applications

by

Karen Ann Yee ©

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **Littoral benthic macroinvertebrate community dynamics in five eutrophic hardwater lakes in north-central Alberta and the influence of $Ca(OH)_2$ applications** submitted by **Karen Ann Yee** in partial fulfillment of the requirements for the degree of **Master of Science in Environmental Biology and Ecology**.

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Dedication

This thesis is dedicated with love to my parents (Harold and May) and to my sisters (Elizabeth, Susan, Leslie, and Linda).

Abstract

Recently, lime ($Ca(OH)_2$ and/or $CaCO_3$) treatment has been used to remediate water quality problems associated with eutrophication in lakes on the Boreal Plain of western Canada. Benthic macroinvertebrates form an important link in aquatic food chains and their high abundance and species diversity makes them valuable organisms to monitor water quality. The objectives of my study were to: (1) evaluate the effect of $Ca(OH)_2$ addition and elevated pH (8-11) on the survival of *Hyalella azteca* and *Chironomus* spp. in laboratory microcosms, and (2) examine the dynamics of benthic macroinvertebrate communities in two eutrophic hardwater lakes before and after $Ca(OH)_2$ treatment relative to three nearby untreated eutrophic lakes, which served as reference lakes.

Four-day laboratory experiments showed that 0 to 300 $g \cdot m^{-2}$ $Ca(OH)_2$ had no detectable effect on the survivorship of *Chironomus* spp., but survivorship of *H. azteca* was reduced at 300 $g \cdot m^{-2}$. $Ca(OH)_2$ dosages that raised pH to ≥ 10 reduced the survival of *H. azteca* by $\geq 50\%$ but did not affect *Chironomus* spp. survival. *In situ* dosages of 225 and 295 $g \cdot m^{-2}$ (74 and 107 $mg \cdot L^{-1}$) $Ca(OH)_2$ did not raise water-column pH above 10 and had no detectable effects on benthic macroinvertebrate densities and biomasses one to two years after treatment, relative to pre-treatment conditions and untreated reference lakes. Canonical correspondence analyses indicate that environmental variables such as pH, water depth, water temperature, and dissolved oxygen, total phosphorus, and magnesium concentrations are important predictors of littoral benthic macroinvertebrate densities in eutrophic hardwater lakes. These environmental variables explained 95 to 99% of the variance in taxonomic composition. However, only 10 to 34 % of the total

taxa variance could be explained by the ordinations, which suggest that other abiotic or biotic factors may be important in influencing community dynamics. By considering the environmental factors that influence littoral benthic macroinvertebrate communities in eutrophic hard waters, lake managers can develop criteria for lake remediation while preventing unwanted impacts on benthic organisms.

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Table of Contents

List of Tables

List of Figures

Chapter 1

1.1. General Introduction

Benthic macroinvertebrates are an essential component of the aquatic food web in lakes. They are an important source of food to fish and waterfowl, help decompose dead plant material (Wetzel 1983), and are useful predictors of fish biomass and yield (Hanson and Leggett 1982). In addition, the diverse species assemblage of benthic macroinvertebrates make them attractive candidates for environmental monitoring and assessment of fresh waters because they offer a range of responses to environmental stresses (Rosenberg and Resh 1993). The use of benthic macroinvertebrates as biological indicators of lake trophic conditions was first proposed by Thienemann (1913). He noted that changes in dissolved oxygen concentrations in German lakes influenced the benthic macroinvertebrate community structure. Also, Brinkhurst (1964) was the first to correlate the trophic status of lakes with the presence of certain types of oligochaetes (aquatic earthworms). Thus, not only are benthic macroinvertebrates important in the food chain of lakes, they are also indicators of water quality conditions.

Since the inception of the Thienemann system over 80 years ago, numerous attempts have been made to determine environmental factors influencing benthic macroinvertebrate community dynamics in the profundal zone of northern-temperate lakes (Hanson and Peters 1984; Rasmussen and Kalff 1987; Dinsmore 1995). Few studies have quantified relationships among littoral benthic fauna and environmental variables; in the two studies that have (Rasmussen and Kalff 1987; Rasmussen 1988), the focus has been on the role of morphometric variables (littoral slope and lake area exposed to waves), water chemistry (calcium and chloride concentrations), and lake trophic status (chlorophyll *a* and total phosphorus concentrations). In particular, these studies found positive relationships between littoral benthic macroinvertebrate biomass and variables indicative of phytoplankton biomass (e.g. chlorophyll *a* concentrations). Because of these relationships, the structure of littoral benthic macroinvertebrate communities is a promising indicator for assessing the effect of lake remediation methods that are intended to reduce total phosphorus concentrations and phytoplankton biomass in eutrophic lakes.

The aim of this study was to evaluate the influence of $Ca(OH)_2$ treatment on littoral benthic macroinvertebrate communities in eutrophic hardwater lakes over a three year period. Since 1983 when lime ($Ca(OH)_2$ and/or $CaCO_3$) was first used to reduce the total phosphorus concentrations and phytoplankton biomass of Frisken Lake, British Columbia (Murphy et al. 1988), lime has been widely used in the restoration of hardwater bodies (e.g. Prepas et al. 1990; Murphy et al. 1990; Babin et al. 1994). However, lime is one of several approaches that have been employed by lake managers to reduce water-column total phosphorus concentrations and phytoplankton biomass of eutrophic hardwater lakes. In this first chapter, I examine the various methods used by managers in lake remediation and discuss these techniques in terms of their possible effect on littoral benthic macroinvertebrates. Prior to predicting possible treatment responses, I examine the interactions of littoral benthic macroinvertebrates with physical, chemical and biotic factors in lakes.

1.2. Environmental factors controlling benthic macroinvertebrate abundance and composition in lakes.

Lake morphometry — The distribution and composition of benthic macroinvertebrates in aquatic systems have been linked strongly to sediment characteristics (McLachlan 1969; Minshall 1984). Species richness and abundance appear to be highest on organically rich substrates, which represents a good food source (Rasmussen and Kalff 1987). Sediment particle size influences the ease of substrate penetration by benthic macroinvertebrates (Wiley 1981) and may also affect respiration (Francis and Kane 1995). Total abundance and species composition of benthic organisms were lowest in sediments of very small particle size (e.g. clay) with little interstitial space for gas exchange; however, *Chironomus* spp. are able to occupy this type of sediment because they can tolerate low dissolved oxygen concentrations and are tube builders (Hopple 1982; Francis and Kane 1995). In addition, the erosion of fine organic-rich sediments during strong waves and currents in steep-sloped areas of a lake (Håkanson 1977) can result in unfavorable conditions for benthic macroinvertebrates (Wolfram

1996). Furthermore, the slower rates of sedimentation in deep compared to shallow lakes may result in much of the food value being lost to water-column oxidation prior to this material being available to benthic animals. Thus, lake characteristics such as the sediment composition, depth, and area exposed to wind currents can influence the accumulation and deposition of fine high quality food source for benthic organisms.

Dissolved oxygen — Dissolved oxygen (DO) in the water column and at the sediment-water interface is essential for aerobic respiration of benthic macroinvertebrates. Unproductive lakes with low hypolimnetic oxygen demand have a diverse benthic macroinvertebrate community of oxygen-sensitive species, whereas eutrophic lakes have a low diversity of specialists (e.g. chironomids) that are tolerant of low DO concentrations (Macan 1961; Jónasson 1978). In eutrophic lakes with minimum DO concentrations < 4 $mg \cdot L^{-1}$, Dinsmore (1995) found that open-water DO concentrations explained 38% of the variance in profundal macroinvertebrates. In these water bodies, the decrease in DO concentrations from high primary productivity during summer stratification can be harmful to profundal macroinvertebrates. Lack of DO replenishment from the surface waters to the profundal zone can result in high mortality because organisms are unable to maintain aerobic metabolic processes. However, organisms (chironomids and tubificids) that are able to maintain oxygen-independent (anaerobic) forms of respiration are able to survive anoxic conditions and therefore are considered tolerant specialists (Davis 1975). These organisms can either maintain a negative Bohr effect and therefore exchange oxygen and waste products against a concentration gradient (Aston 1973), or they can obtain energy by splitting carbohydrates into simpler compounds such as lactic and fatty acids (Hochachka 1980). Interestingly, certain species of chironomids (e.g. *Chironomus gregarius*) produce haemoglobin during the second larval instar, which can act as an oxygen store during periods of anoxia (Panis et al. 1996). On the other hand, oxygen-sensitive species, such as crustaceans and most dipterans, lack these respiratory adaptations and normally have high respiratory requirements (Hamburger and Dall 1990). In eutrophic lakes, macroinvertebrates can exhibit migratory behavior to escape periods of low DO. *Nephalopsis obscura* is known to move into the water column during low oxygen saturation and spends a greater proportion of time near sediments when oxygen is plentiful (Davies and Gates 1991). Yet, the low DO layer in eutrophic lakes can provide a refuge from fish predators for some species of invertebrates such as the larva of *Chaoborus* (Hanazato 1992). However, in oligotrophic lakes, there tends to be a general shift with increased depth from predominantly dipteran fauna to one of largely crustaceans (Hamilton 1971). Presumably, the ability of crustaceans to inhabit the hypolimnion of oligotrophic lakes is due to the low DO demand found there (Hamilton 1971). Therefore, benthic animals that live in eutrophic lakes develop physiological and behavioral responses to periods of hypoxia.

Temperature — Water temperature may directly affect species composition, growth and reproductive activity. Elevated water temperatures as a result of thermal effluent discharge from a power station into Lake Wabamun, Alberta coincided with changes in species composition such that heated areas were dominated by communities of oligochaetes and large *Chironomus* spp., while in unheated areas smaller chironomid species were more abundant (Rasmussen 1982). This shift in species composition may be due to differences in the temperature limits of the various life stages of the species as well as the complete life-cycle of the organism (Rasmussen 1982). Similarly, Reist and Fischer (1987) found that a rise in water temperature from 20 to 25 °C increased developmental rate and reduced the hatching interval in *Chironomus* spp. such as *C. plumosus*, *C. nuditarsis*, and *C. bernensis*. Furthermore, laboratory experiments showed that low temperatures (15 °C) reduced the growth rate and prolonged the development time of *Chaoborus flavicans* early-instar larvae (Hanazato and Yasuno 1989). Moreover, cold deep lakes, like the North basin of Windermere in the English Lake District, are too cold to maintain large communities of oligochaetes (Reynoldson 1990). Hence, increased water temperature enhances the developmental rate and reduces the hatching time of organisms that inhabit both the sediment surface and the water-column (Lutz and Rogers 1991; Giberson and Rosenberg 1992).

Calcium — Calcium is physiologically important for the growth and development of macroinvertebrates (Robertson 1941). Low calcium concentrations inhibit growth in several snail species in the laboratory (Thomas et al. 1974) and calcium carbonate ($CaCO_3$) can account for 80-95% of freshwater molluscan dry weight (Mackie and Flippance 1983). Schumann (1928) reported that certain gammarids (e.g. *Gammarus pulex*) were unable to harden their integuments in natural waters that contained less than 5 $mg \cdot L^{-1}$ calcium, however, in calcium-rich waters (> 20 $mg \cdot L^{-1}$) newly moulted animals were able to harden their integuments within 72 h. Furthermore, the presence of calcium is important to certain species of chironomids and oligochaetes that build calcareous tubes for protection and respiratory purposes (Merritt and Cummins 1984). Moreover, various studies have indicated that the mucous coverings of aquatic organisms probably contain calcium and magnesium compounds (Robertson 1941). In softwater lakes, calcium content often remains well below saturation levels but the amount of calcium utilized by the biota is small in comparison to existing levels so depletion by the biota is unlikely (Wetzel 1983). In hardwater lakes, calcium concentrations undergo marked seasonal dynamics. $CaCO_3$ precipitation often occurs during periods of thermal stratification in hard water supersaturated with $CaCO_3$ (Strong and Eadie 1978; Effler and Driscoll 1985). Therefore, the precipitation of $CaCO_3$ in hardwater lakes reduces the amount of calcium available for uptake by macrobenthos and the deposition of the precipitate may increase bottom fauna numbers by providing additional substrate material for tube building.

Total phosphorus and chlorophyll a — The positive relationship between phytoplankton biomass and total phosphorus concentrations has been well documented in lakes (Schindler 1974). Co-precipitation of phosphorus with $CaCO_3$ has been one of several indirect controls of phytoplankton biomass in eutrophic hard water bodies (Avnimelech 1980; House et al. 1986). This natural process can lead to a shift in phytoplankton species composition toward more edible forms for higher trophic levels (Zhang and Prepas 1996a). Previous studies have positively correlated benthic macroinvertebrate communities with phytoplankton biomass, estimated from chlorophyll *a* concentrations (Dermott et al. 1977; Saether 1979; Rasmussen and Kalff 1987). Spring and autumn diatom blooms provide high quality food, compared to cyanobacterial detritus, for benthic organisms (Jónasson 1964). However, extreme eutrophication can result in reduced dissolved oxygen concentrations in the water column as a result of high photosynthetic respiration, and in sediments because of high bacterial oxygen demand. Thus, changes in phytoplankton production can result in alternatively low and high patterns of biomass among macrobenthos.

pH— The effects of pH on benthic organisms have been extensively documented for acidic waters (Bell 1971; Harvey and McArdle 1986; Stephenson and Mackie 1986). A common conclusion among these authors was lower abundance and diversity of species sensitive to acidic waters (e.g. mayflies, stoneflies, and dragonflies) compared to more tolerant species (e.g. caddisflies) in both the water column and sediments at low pH. In highly productive waters where pH can range between 7 to 10 (Maberley 1996), zooplankton densities decline with increasing pH (Hansen et al. 1991, Beklioglu 1995). However, to my knowledge no information exists on pH effects to benthic macroinvertebrates at pH 7 to 10.

1.3. Lake remediation techniques and the response of benthic macroinvertebrates.

Eutrophication of lakes and man-made water supplies is a serious problem in many parts of North America (Edmondson 1969; Schindler 1974). Unpleasant odours, tastes and the presence of cyanobacterial toxins associated with phytoplankton blooms restrict the use of these waters and can pose serious health hazards to humans and livestock (Kotak et al. 1993; Lam et al. 1995) as well as aquatic biota (Eriksson et al. 1989; Kotak 1995). The well-documented strong relationship between total phosphorus concentrations and phytoplankton standing crop (Schindler 1977) has led to the development of eutrophication control measures such as dredging, water course alterations, and plastic covering of bottom sediments (Ryding and Rast 1989; Murphy et al. 1993) that reduce internal and external phosphorus loads to the water column (Sas 1989).

These techniques, however, require major capital investment and continuous maintenance, are time-consuming, and can have adverse effects on aquatic biota (Cooke et al. 1993). For example, dredging of nutrient-rich sediment from the lake bottom can affect sedimentation rates and detritus distribution by creating steep-sloped areas susceptible to high water turbulence, erosion and sediment transport (Duarte and Kalff 1986). Compared to low-slope areas, these steep shores are less likely to retain fine-organic rich sediments and maintain macrophyte growth, which are important food source (Pinder 1986; Reynoldson 1990) and habitat (Schramm et al. 1987; Beckett and Aartila 1992) for benthic macroinvertebrates. In addition, water course alterations to dilute in-lake nutrient levels with low nutrient content waters can delay developmental rates of benthic macroinvertebrates by reducing temperature conditions (McCall and Tevesz 1982). Although plastic covering of bottom sediments can prevent sediment-water nutrient exchange, they are expensive (Ryding and Rast 1989) and can potentially reduce dissolved oxygen exchange between the water-column and sediment-water interface. There are some organisms that are capable of maintaining oxygen-independent forms of respiration (e.g. chironomids, tubificids) by undergoing anaerobic glycolysis and produce an oxygen debt during emergency situations (Brundin 1951), however, most animals are oxygen-sensitive (e.g. crustaceans and most dipterans) and normally have high respiratory requirements (Hamburger and Dall 1990). Although dredging, water course alterations, and plastic liners are effective in controlling phosphorus concentrations in the water-column, chemical treatments (e.g. aluminum sulfate, lime) are less labour intensive and more cost-effective lake remediation methods.

The addition of aluminum sulfate (alum), a phosphorus precipitating chemical, directly to lakes and reservoirs is an alternative cost-effective measure for nutrient inactivation (Cooke et al. 1986; Welch and Schrieve 1994). At lake pH 6 to 8, aluminum sulfate (alum) undergoes hydrolysis to form aluminum hydroxide ($Al(OH)_3$), which readily adsorbs phosphorus (Maurizi and Poillon 1992). However, alum additions in low or moderate dosages (e.g. Welch and Schrieve 1994) to lakes with poor buffering capacity can result in pH conditions below 6 and the formation of aluminum species such as

$Al(OH)_2^+$ (Entranco 1980; Cooke et al. 1993), which are toxic to numerous aquatic biota (Gostomski 1990; Rosseland et al. 1990). In these water bodies, alum has been added with buffers (e.g. sodium carbonate) to maintain pH between 6 to 8, with either few adverse effects on benthic populations (Jaiswal 1993; Leinenbach 1993) or reduced density and species richness (Smeltzer 1990). During periods of high primary productivity in hardwater lakes, pH > 8 increases the solubility of aluminum (Cooke et al. 1993). Studies on the effects of alum treatment on benthic macroinvertebrates in hardwater lakes have been limited. In a moderately alkaline (120 mg $CaCO_3 \cdot L^{-1}$) Wisconsin lake, the addition of 42 $g \cdot m^{-2}$ (13 $mg \cdot L^{-1}$ Al^{3+}) alum resulted in a more diverse benthic assemblage of dipterans (Narf 1990). In contrast, Moffett (1979) found a decline in species diversity of planktonic microcrustacea two years post-treatment of West Twin Lake (100 to 150 mg $CaCO_3 \cdot L^{-1}$). Nevertheless, alum treatment to hardwater lakes can be harmful to benthic organisms even at pH 6 to 8, particularly if they are exposed to aluminum for prolonged periods of time (Cooke et al. 1993).

Lime treatment ($Ca(OH)_2$ and/or $CaCO_3$) has been used to reduce eutrophication in hardwater lakes and dugouts in western Canada (e.g. Murphy and Prepas 1990; Babin et al. 1994). The primary goal of lime treatment in softwater lakes differs from that of hard waters in that for the former the aim is to increase lake pH to near neutral levels (Nyberg and Thørneløf 1988; Molot et al. 1990; Alenäs et al. 1991). In acidic water bodies, $Ca(OH)_2$ and/or $CaCO_3$ treatments generally result in pH increases of 3-5 units immediately after application (Fordham and Driscoll 1989). In Swedish lakes, increases in benthic macroinvertebrate density and biomass often coincided with these pH increases (Hultberg and Andersson 1982; Raddum et al. 1984; Appelberg 1990). In contrast, lime addition to calcium-saturated hardwater lakes results in calcite ($CaCO_3$) precipitation, the incorporation of phosphorus within the calcite crystal lattice (Ostuki and Wetzel 1972; Effler and Driscoll 1985; Danen-Louwerse et al. 1995), and the co-precipitation of phytoplankton cells (Zhang and Prepas 1996b). Although alkaline water bodies have high buffering capacity, pH increases of 2 or more units can occur following lime application depending upon the dosage applied and the size of the water body (e.g. Prepas et al. 1990; Prepas et al. 1992). However, few data exist on the effects of lime treatment and associated pH excursions on littoral benthic macroinvertebrates in eutrophic hardwater lakes. Yet, lime additions in these lakes are likely to have less adverse effects on aquatic biota than other chemicals used to control phytoplankton biomass (e.g. Reglone A, Simazine, alum) as artificial additions of lime follow similar chemical kinetics as natural lake processes.

1.4 Summary and research objectives

In 1990, a four year project was initiated to evaluate the use of $Ca(OH)_2$ for reducing internal phosphorus recycling and phytoplankton biomass in eutrophic hardwater lakes. Whole-lake $Ca(OH)_2$ applications provided an opportunity to examine the response of littoral macroinvertebrate communities to environmental changes induced by $Ca(OH)_2$ treatment in relation to communities from three nearby reference lakes of similar trophic status. While the effects of $Ca(OH)_2$ treatment on phytoplankton communities have been documented in eutrophic hardwater lakes (Zhang 1996; Zhang and Prepas 1996b), research on biological effects of $Ca(OH)_2$ on benthic fauna has been limited to a single study where the dosage of $Ca(OH)_2$ applied to a hardwater dugout (350 $g{\cdot}m^{-2}$ or 250 $mg{\cdot}L^{-1}$) was over a shorter duration of time than that added to lakes (e.g. Babin et al. 1994), and where pre-treatment densities of macroinvertebrates and pH were not measured (Miskimmin et al. 1995).

My objectives were to: (1) evaluate the effects of 0 to 300 $g{\cdot}m^{-2}$ (required dosage of 0 to 1425 $mg{\cdot}L^{-1}$) of $Ca(OH)_2$ and pH 8 to 11 on the survival of *Chironomus* spp. and *Hyalella azteca* in laboratory bioassays, and (2) compare changes in abundance and biomass of benthic macroinvertebrate communities between two $Ca(OH)_2$-treated and three reference lakes both before and after treatment over a three-year period, in relation to changes in important environmental variables. *Chironomus* spp. and *H. azteca* are two common benthic macroinvertebrates that inhabit the sediment surface or water column of eutrophic hardwater lakes.

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Chapter 2

An evaluation of the influence of lime ($Ca(OH)_2$) treatment on benthic macroinvertebrate communities in eutrophic hardwater lakes.

2.1 Introduction

Eutrophic lakes are common on the boreal plains of western Canada. In Alberta, half the hardwater lakes are eutrophic to hypereutrophic (Mitchell and Prepas 1990) with high internal phosphorus loading from the bottom sediments (Shaw and Prepas 1990). In many of these cases, high total phosphorus concentrations often lead to phytoplankton blooms (Zhang and Prepas 1996a) which can compromise drinking water supplies by releasing toxins to lake water (Kotak et al. 1993). Furthermore, their decomposition can lower dissolved oxygen concentrations below those required by aerobic organisms such as benthic invertebrates (Brinkhurst 1974).

During the past 15 to 20 years, lime ($Ca(OH)_2$ and/or $CaCO_3$) has been used to increase alkalinity and pH of acidified lakes in Canada (Olem et al. 1991). More recently, lime treatment has been tested as a method for lake-wide nutrient inactivation in a hardwater lake in British Columbia (Murphy et al. 1988). Since then, lime has been used extensively as a restoration tool of eutrophic hard waters (Babin et al. 1989; Murphy et al. 1990; Prepas et al. 1990; Babin et al. 1994). Although the impact of lime application on benthic macroinvertebrate communities in softwater bodies has been widely reported (Scheider and Dillon 1976; Olem et al. 1991), the effects on benthic fauna in hard water lakes has received little attention. Benthic macroinvertebrates occupy a key position in the aquatic food web, hence the potential impact of restoration on macroinvertebrate communities is of concern. In addition, benthic macroinvertebrates are valuable indicators of environmental conditions because of their relatively long-lived sedentary nature and their response to environmental changes (Rosenberg and Resh 1993). Therefore, monitoring of benthic macroinvertebrate communities during restoration activities provides useful information on environmental conditions after treatment.

The aim of my research was to assess the response of benthic macroinvertebrates to $Ca(OH)_2$ treatment of eutrophic hardwater lakes. Most whole-lake lime treatments have been conducted in soft-water lakes. Of these, several have examined benthic macroinvertebrate communities and attributed the increase (Raddum et al. 1984; Appelberg 1990) in the numbers of benthic organisms following lime treatment to pH increases associated with the treatment. In the only study to report the effect of lime on benthic macroinvertebrates in hard water, Miskimmin et al. (1995) found fewer numbers of invertebrates in the treated compared to untreated side of a hardwater pond nine weeks following the addition of 350 $g \cdot m^{-2}$ (250 $mg \cdot L^{-1}$) $Ca(OH)_2$ and suggested this reduction in densities of benthic macroinvertebrates was due to pH increases of 2-3 units following $Ca(OH)_2$ treatment. However, their study is limited because pH and pre-treatment benthic macroinvertebrate data were absent.

In the present study, I: (1) evaluated the effect of $Ca(OH)_2$ addition and increased water column pH (up to 11) on the survival of two common macroinvertebrates in laboratory microcosms, and (2) examined the benthic macroinvertebrate communities in two eutrophic hardwater lakes both before and after lime ($Ca(OH)_2$; 225 and 295 $g \cdot m^{-2}$ or 74 and 107 $mg \cdot L^{-1}$) treatment in comparison to three nearby untreated lakes of similar trophic status. $Ca(OH)_2$ additions to hardwater lakes may influence benthic macroinvertebrates through two pathways: (1) phosphate co-precipitation and/or coagulation of phytoplankton cells with calcite may restrict invertebrate movement, feeding, or reproduction at the sediment-water interface, or (2) increases in water-column pH during $Ca(OH)_2$ applications, as a result of the dissociation of hydroxide ions, may influence benthic macroinvertebrate survival. Because of the high buffering capacity of these hardwater lakes (e.g. Prepas et al. 1988; Prepas et al. 1990), pH was expected to remain < 10 during treatment. I hypothesized that at these moderate dosages (225 and 295 $g \cdot m^{-2}$ or 74 and 107 $mg \cdot L^{-1}$) of $Ca(OH)_2$, the presence of a calcite precipitate and pH < 10 would not effect the survival, abundance, or biomass of major benthic macroinvertebrate taxa.

2.2. Materials and Methods

Laboratory Experiments

Three laboratory experiments were performed to determine survivorship of *Hyalella azteca* and *Chironomus* spp. (two common benthic macroinvertebrates found in eutrophic hardwater lakes) after 96-h exposure to: (1) 0, 100, 150, 200, and 300 $g \cdot m^{-2}$ of $Ca(OH)_2$; (2) pH of 8, 9, 10, and 11; or (3) the presence or absence of a floc (200 $g \cdot m^{-2}$ diatomaceous earth) overlying the sediment. Since both taxa are benthic, I used areal loading rates of $Ca(OH)_2$ and DE to represent conditions at the sediment-water interface. The maximum areal dosage of 300 $g \cdot m^{-2}$ $Ca(OH)_2$ used in these laboratory experiments is similar to that applied to Halfmoon Lake, Alberta (Babin et al. 1994). Diatomaceous earth (DE) consists predominantly of silica and is a chemically inert substance that was used to mimic calcite precipitation.

H. azteca and *Chironomus* spp. were collected from Crooked Lake, Alberta (Table 2.1) during the summer of 1994 and 1995. I chose these two organisms for my laboratory experiments because they represented two common macroinvertebrates in hardwater lakes, and occupied different lake strata (i.e. amphipods are found just above the sediment-water interface whereas chironomids are found below the sediment surface). Surface water and bottom sediments were obtained from the deepest site (9 m) of the lake 72 h before each experiment. *H. azteca* and *Chironomus* spp. were collected from the littoral zone and the deepest site with a sweep net and an Ekman grab sampler, respectively, one day prior to each test. In this hardwater lake, chironomids are multi-species assemblages, requiring that mouthparts be slide-mounted for species-level identification (Clifford, 1991), hence, chironomids were identified only to genus (*Chironomus*).

Bioassays were conducted at Meanook Biological Research Station, located 135 km north of Edmonton, Alberta. Small cylindrical microcosms (volume = 2 L, diameter = 11 cm, surface area of bottom = 95 cm^2) with a 3:1 volume ratio of water and sediments (500-μm particle size), respectively, were constructed for the experiments. The chambers were kept at 21°C under a 16:8 h light:dark cycle and gently aerated throughout the tests.

Ten individuals of either *Chironomus* spp. ($\bar{x}$ wet weight per individual = 17.1 ± 0.02 mg) or *H. azteca* ($\bar{x}$ wet weight per individual = 10.03 ± 0.02 mg) were introduced to the microcosms and allowed to acclimate for 24 h before treatment. The number of individuals stocked in each microcosm was similar to mean densities of chironomids (800 ± 160 individuals·m^{-2}) and amphipods (977 ± 209 individuals·m^{-2}) in Crooked Lake during the summer of 1991. In each of the six experiments, five replicate microcosms were established per treatment, and organisms were not fed during the test.

$Ca(OH)_2$ and DE were mixed with 5 mL of lake water to form a slurry, then added to the microcosms slowly and evenly across the water surface to produce a homogeneous layer on the substratum. During application of different $Ca(OH)_2$ dosages, water column pH was regulated with CO_2 gas, such that it did not exceed 10, which is the upper pH level observed during lime application in Alberta lakes (Prepas et al. 1990; Babin et al. 1994). To determine pH effects on survival, one set of microcosms was treated with $Ca(OH)_2$ (200 g·m^{-2}) and a second set of microcosms was treated with NaOH (1.0 mL, 1.0 N) to maintain pH at 8 to 11. In these experiments, test organisms were exposed to water column pH's above that normally found during lime application to hardwater lakes (i.e. pH = 11) to determine the pH range that results in their mortality. In all six experiments, pH was monitored with a portable Beckman Φ 10 pH meter (± 0.01 pH units) at 0, 2, 4, 8, 12, 24, 48, 72, and 96 h after treatment. Conductivity (µohms·cm^{-1}) and dissolved oxygen (mg·L^{-1}) were measured at the sediment-water interface with a Metrohm Herisau E587 meter and microwinkler techniques (Burke 1962), respectively, at the beginning (0 h) and end (96 h) of all experiments.

After 96 h, the contents of each microcosm was passed through a 250-µm mesh sieve to retrieve all organisms. Survivorship was determined by recording the number of live individuals. An organism was considered alive if it moved after being probed gently with forceps. Five percent of the chironomids emerged on day 3, complicating estimates of survival. I captured these individuals and assumed they would have survived to day 4.

Data analyses — For laboratory bioassays, one- and two-factor ANOVA's were used to test the effects of: (1) different dosages of $Ca(OH)_2$, (2) different water column pH's maintained with NaOH and $Ca(OH)_2$, and (3) the presence or absence of a precipitate layer (diatomaceous earth) overlying the sediment at pH 8 and 10, on *H. azteca* and *Chironomus* spp. survival. Differences between treatment means were detected with Scheffe's test (Day and Quinn 1989). To satisfy normality and homogeneity of variance, original data were arcsine square-root transformed (Zar 1984).

Field experiment

Study sites — The five naturally productive study lakes are located in the boreal mixed-wood forest of Alberta (Table 2.1). The three reference (Jenkins, Crooked (south basin), and Baptiste (south basin)) and two treated (Lofty and North Halfmoon) lakes all have summer epilimnetic total phosphorus concentrations > 30 $\mu g \cdot L^{-1}$ (Zhang and Prepas 1996b). North Halfmoon and Lofty lakes were treated once each with 225 and 295 $g \cdot m^{-2}$ (74 and 107 $mg \cdot L^{-1}$) of $Ca(OH)_2$ in June 1991 and July 1992, respectively. $Ca(OH)_2$ was applied as a slurry over the surface water of North Halfmoon Lake from a custom built barge (Babin et al. 1994), however, limited boat launch facilities and poor road access at Lofty Lake required the development of a shore-based distribution system for $Ca(OH)_2$ addition to the lake. At Lofty Lake, the truck-mounted unit mixed $Ca(OH)_2$ with lake water and a boat distributed the slurry over the water surface with a series of booms and nozzle sprayers.

The three untreated lakes were chosen to observe natural variation in benthic macroinvertebrate communities during the study period, while pre- and post-treatment effects were observed in Lofty and North Halfmoon lakes.

Field collections — In all five lakes, benthic macroinvertebrates were collected at three-week intervals between May-August 1991 to 1993. In each lake, samples were taken along three transects at water depths of 1, 3, and 5 m. Two samples were collected with an Ekman grab sampler (15 x 15 x 23 cm) at each water depth for a total of 18 samples per sampling date for each lake. Samples were rinsed through a 500-µm sieve and preserved in 4% formalin solution. Macroinvertebrates were identified to one of six taxonomic groups: Chironomidae, Chaoboridae, Amphipoda, Ceratopogonidae, Oligochaeta, and 'other' (Merritt and Cummins 1984; Clifford 1991). For each taxonomic group, mean density was obtained for the two replicate samples at each water depth within a transect. The mean values for the three depths and transects in each lake were then averaged to give mean densities·m^{-2} per sampling date for each lake. Analysis of 1991 abundance data for the major taxa of each lake indicated no difference between transects, except for chironomids in Jenkins Lake ($P < 0.01$; Appendix A). Hence, in 1992 and 1993, the sorting effort was streamlined by counting duplicate samples from each depth along a single transect.

A modified subsampling procedure (Sebastien et al. 1988) was used to reduce the amount of sample material sorted. Each sample was stirred on a 250-µm sieve and then divided into four equal portions and placed into separate plastic containers with a metal spatula. One subsample and the fine fraction on the sieve were sorted for benthic macroinvertebrates. The total number of individuals per sample was the sum of individuals in the one subsample multiplied by four, plus the number of individuals in the fine fraction. I established that macroinvertebrates were randomly distributed in the subsampler by calculating the index of dispersion for five samples (Wrona et al. 1982; Appendix A).

Fresh and dry weight biomass estimates were determined to the nearest 0.1 mg for all individuals within each taxon per sample or subsample. Fresh specimens were unavailable for weighing, therefore change in biomass caused by the preservative was corrected for all subsamples or samples. Preserved weights were converted to fresh weights with a fresh:dry weight ratio of 0.182 (K. Yee, unpubl. data). Fresh and dry weight biomass estimates of all individuals within each taxon per subsample were multiplied by four to obtain the fresh and dry weights of all individuals within each taxon per sample. Mean total biomass (g·m^{-2}) was estimated from May to August of 1991 to 1993. All biomass estimates were determined by weighing samples or subsamples on a Mettler AT261 DeltaRange balance and dry weights were obtained after oven drying at 60°C for 24 h.

For each lake, water samples for 17 environmental variables were collected every two weeks from May to August of 1991 to 1993. Sample preparation procedures are summarized in Table 2.2. Discrete water samples were collected at the deepest site in each lake with an aluminum drop-sleeve water bottle sampler (1.5L, 30 cm in height) at 1- (temperature and light) or 2-m (all other variables) intervals to maximum lake depth. For Baptiste Lake, water chemistry data for 1990 were obtained from Alberta Environment (Water Quality Branch, unpubl. data).

Data analyses — Repeated measures ANOVA were used to examine differences in mean densities$\cdot m^{-2}$ of individual taxa, total mean densities of benthic macroinvertebrates, and total biomass estimates per sampling date between treated and reference lakes. For these analyses, the five lakes were blocked into two categories (treated or reference), and mean densities of macroinvertebrates were from 15 sampling periods over the three year study. In addition, repeated measures ANOVA was used to examine differences in mean densities$\cdot m^{-2}$ of individual taxa and total mean densities of benthic macroinvertebrates between treated and reference lakes at three water depths (1, 3, and 5 m) during the sampling periods immediately before and 21 d after $Ca(OH)_2$ treatment. For this analysis, the five lakes were blocked into two categories (treated or reference), and densities of macroinvertebrates for the three reference lakes obtained up to six days before and 21 d after $Ca(OH)_2$ treatment of North Halfmoon and Lofty lakes in 1991 and 1992, respectively. Paired *t*-tests were used to compare total biomass estimates of benthic macroinvertebrates between years in each lake, and *t*-tests were used to examine differences in water chemistry data immediately before and 21 d after $Ca(OH)_2$ treatment. All statistical analyses were performed with SPSS (1993) and $P = 0.05$.

For each lake, canonical correspondence analysis (CCA) was performed to examine the relationship between benthic macroinvertebrate density and environmental variables. This analysis constructs ordination axes that describe the variation in overall community composition based upon combined effects of environmental variables (Jongman et al. 1987; ter Braak and Prentice 1988). In each lake, prior to CCA: (1)

benthic macroinvertebrate abundance and environmental data were ln(x+1) transformed to correct skewed distributions (Zar 1984), and (2) detrended correspondence analysis (DCA) was performed on abundance data to determine the gradient length of the first ordination axis. For each lake, CCA was determined to be the most appropriate approach to detect patterns in macroinvertebrate taxa groups and taxa group-environment relationships since DCA indicated a wide gradient length (2-3 standard deviations from the mean; ter Braak and Prentice 1988).

CCA and DCA were performed with the computer program CANOCO (version 3.12; ter Braak 1988, 1990). Water depth and all 17 environmental variables shown in Table 2.2 from 1991 to 1993 were included in the initial CCA. Calcium concentrations in North Halfmoon Lake and total dissolved phosphorus (TDP) concentrations in Crooked Lake had high collinearity with other variables (i.e. variance inflation factors > 20, ter Braak 1988); thus, these variables were removed from further CCA in the appropriate lakes. A series of CCA was run on each lake with the forward selection option. Similar to step-wise multiple regression, forward selection was used to find a subset of environmental variables that explains the greatest amount of variance in the macroinvertebrate data about as well as the full set of environmental variables (ter Braak 1990). At each step of the forward selection, the variable added was tested for statistical significance with Monte Carlo permutations (99 unrestricted permutations, $P < 0.05$). Macroinvertebrate taxon points and the arrows of the environmental variables in an ordination biplot reflect the dominant patterns in community composition that can be best explained by environmental variables. The length of the arrow determines the influence of an environmental variable on the macroinvertebrate data (i.e. longer arrow means greater influence). Perpendicular lines drawn from macroinvertebrate taxon points to an arrow determines the relative positions of the taxa group distribution along that environmental axis. In each lake, the significance of the first canonical ordination axis was then tested with Monte Carlo tests (99 unrestricted permutations, $P < 0.05$).

Rasmussen (1988) observed that benthic biomass of lakes located throughout the world were strongly related to chlorophyll *a*, slope, the product of slope and exposure, calcium, and chloride ($r^2 = 0.80$). I tested his relationship to see if it describes the benthic biomass of ten prairie lakes (including the five lakes from this study). Literature data for five Alberta lakes (Appendix B), along with data from my five study lakes and 21 other lakes reported by Rasmussen (1988) were used to examine the relationship between the environmental variables and total biomass of benthic macroinvertebrates in the littoral zone (LZB). LZB was regressed against chlorophyll *a*, littoral slope, the product of slope and exposure, calcium and chloride concentrations for the Alberta lakes data set alone and both data sets (lakes from Alberta and Rasmussen's study) combined. For the five lakes in this study, chlorophyll *a* concentrations were determined from 0 to 2.5 m integrated water samples at four stations in each lake and LZB were calculated for each lake per year as described by Rasmussen (1988). For the other five Alberta lakes, LZB and environmental variables were obtained from Bidgood (1972) and Mitchell and Prepas (1990). In all of the Alberta lakes, bottom slope was obtained from bathymetric maps and lake area exposed to waves was calculated from 1:25 000 maps as described by Rasmussen (1988). Chlorophyll *a*, calcium and chloride concentrations and littoral slope were logarithmically transformed to reduce heteroscedasticity.

2.3 Results

Laboratory bioassays — Survivorship of *Chironomus* spp. over 96 h was not affected by 0 to 300 $g{\cdot}m^{-2}$ $Ca(OH)_2$ (ANOVA, $F = 0.3$, df = 4, 20, $P = 0.86$; Fig. 2.1) at constant pH. Also, over 75 % of *Chironomus* spp. survived for 96 h at all pH levels regardless of whether NaOH or $Ca(OH)_2$ was used to maintain the desired pH ($F = 0.9$, df = 3, 32, $P = 0.46$; Fig. 2.2). The presence of a precipitate layer (diatomaceous earth) did not affect the survival of *Chironomus* spp. ($F = 5.1$, df = 1, 16, $P = 0.05$; Fig. 2.3). Therefore, $Ca(OH)_2$ dosages that maintain pH ≤ 11 did not affect the survival of sediment-dwelling chironomids.

In contrast, *H. azteca* experienced higher mortality at 300 $g{\cdot}m^{-2}$ compared to 0 to 200 $g{\cdot}m^{-2}$ dosages of $Ca(OH)_2$ (Scheffe's test, $P < 0.05$; Fig. 2.1). Also, 50 and 100 % mortality were observed for *H. azteca* at pH 10 and 11, respectively, for both NaOH and

$Ca(OH)_2$ treatments ($F = 79.0$, df = 3, 32, $P < 0.01$; Fig. 2.2). Reduced *H. azteca* survivorship at 300 g·m^{-2} $Ca(OH)_2$ (Fig. 2.1) was associated with a pH of 10 within 24-h of treatment (Fig. 2.4). The presence of a precipitate layer did not affect the survival of *H. azteca* ($F = 0.1$, df = 1, 16, $P = 0.82$; Fig. 2.3). These results indicate that pH $\geq$ 10 at $Ca(OH)_2$ dosage of 300 g·m^{-2} reduced the survival of amphipods.

Benthic macroinvertebrate abundance and biomass — The dominant benthic macroinvertebrate groups differed among years within each study lake (Fig. 2.5). In North Halfmoon Lake, Chironomidae, Amphipoda, and Chaoboridae were the dominant taxa in the treatment year (1991); these three taxonomic groups comprised 85% of total macroinvertebrate density. A year after $Ca(OH)_2$ treatment (1992), Chironomidae and Oligochaeta were the most numerically abundant taxa making up 86% of total macroinvertebrate density. While the relative contribution of Chironomidae remained constant between 1991 and 1992 (44 % of total macroinvertebrate density), the relative contribution of Oligochaeta was 3.5 times higher in 1992 compared to 1991 (42 and 12% of total macroinvertebrate density respectively). However, similar to pre-treatment conditions, Chironomidae, Amphipoda, and Chaoboridae were the most numerically dominant groups two years after treatment (1993). In Lofty Lake, the shift from predominantly Chironomidae to Amphipoda occurred prior to $Ca(OH)_2$ treatment in July 1992, and amphipod numbers remained greater than chironomid numbers one year after treatment (60 and 30 % of the total macroinvertebrate density, respectively; Fig. 2.5). Chironomidae, Amphipoda, and Oligochaeta were the dominant taxa in the reference lakes over the 3-yr study (Fig. 2.5). These three taxa together comprised 81, 85, and 79 % of mean total macroinvertebrate densities in the reference lakes in 1991, 1992, and 1993, respectively. Despite yearly fluctuations in Chironomidae and Amphipoda densities, these two taxa remained numerically dominant two years post- compared to pre-treatment.

There were differences in total densities of littoral benthic macroinvertebrate communities between treated and reference lakes over the entire study period (Fig. 2.5; Table 2.3). Total benthic macroinvertebrate densities were generally one to two times higher in the reference than in treated lakes both before and after $Ca(OH)_2$ treatment (Fig. 2.5; Table 2.3: $F = 8.1$, df = 1, 13, $P = 0.01$). Within a given year, densities of individual taxonomic groups generally peaked in July and August in both treated and reference lakes (Fig. 2.5; Table 2.3, $P < 0.01$). However, different temporal patterns were observed for total densities between treated and reference lakes, largely due to oligochaete densities (Table 2.3: interaction effect). In North Halfmoon Lake, relative densities of oligochaetes increased by three-fold one year post-treatment (1992) compared to the treatment year (1991) but then returned to pre-treatment conditions two years after treatment (Fig. 2.5). In contrast, relative oligochaete densities in Lofty Lake remained unchanged between 1991 and 1993. In the reference lakes, oligochaete densities increased progressively over the three years; in Baptiste Lake, densities of oligochaetes increased by 3-fold from 14 to 42 % of total macroinvertebrate densities in 1991 and 1992, respectively, similar to that observed in North Halfmoon Lake (Fig. 2.5). Therefore, the 3-fold increase in oligochaete densities one year post-treatment in North Halfmoon Lake was likely a natural occurrence rather than due to treatment.

In comparison to densities, total biomass estimates of benthic macroinvertebrates varied within a given year but were similar among years in each lake (Fig. 2.6). In all five lakes, total biomass estimates of benthic macroinvertebrates peaked twice in the summer, in early May and late July, likely due to the presence of large reproducing adults and a new recruitment of young in most macroinvertebrate taxa (pers. observ.). Similar total biomass estimates of benthic macroinvertebrates and temporal patterns were observed between North Halfmoon and Jenkins lakes over the three years (ANOVA, $P > 0.05$; Fig. 2.6). Although total biomass estimates of benthic macroinvertebrates in Lofty Lake were two times higher than in North Halfmoon Lake during all sampling periods, biomass estimates of benthic macroinvertebrates in Lofty Lake were comparable to total biomasses of Crooked and Baptiste lakes (ANOVA, $F = 0.1$, df, 2, 9, $P = 0.9$). Therefore, $Ca(OH)_2$ treatment did not appear to affect total biomass estimates of benthic macroinvertebrates.

Densities of major macroinvertebrate taxa at any given depth did not differ among treated and reference lakes immediately before and 21 d after the application of 225 and 295 g·m^{-2} $Ca(OH)_2$ to North Halfmoon and Lofty lakes, respectively (ANOVA, non-significant depth interactions). In all five lakes, higher chaoborid densities generally occurred at 5-m compared to 1- and 3-m depths, but this pattern was reversed for amphipods and oligochaetes (Table 2.4: depth effect). In the treated lakes, densities of amphipods and chironomids generally did not differ immediately before and 21 d after treatment (Table 2.5); however, densities of oligochaetes and macroinvertebrates in the category 'other' increased 21 d after treatment in North Halfmoon Lake (Table 2.4: time effect). By the next sampling period (42 d after treatment), densities of all major taxa in Lofty and North Halfmoon lakes were similar to that immediately before treatment. In the reference lakes, amphipod, chironomid, oligochaete, and 'other' macroinvertebrate densities generally did not differ immediately before and 21 d after treatment of Lofty Lake, but these densities increased 21 d after treatment of North Halfmoon Lake (Table 2.5). Thus, results indicate that the survival of chironomids and amphipods in the treated lakes were likely unaffected by $Ca(OH)_2$ dosages of 225 g·m^{-2} with pH < 10 (Table 2.6) 21 d after treatment, similar to the results of all 96-h laboratory experiments.

Relationship to environmental variables — For all five lakes, CCA showed that benthic macroinvertebrate community composition (density) was highly correlated with environmental variables; the measured environmental variables explained 95 to 99 % of the variance in the taxa data (Table 2.7). However, the eigenvalues of the first two axes of CCA were quite low (Fig. 2.7), cumulatively explaining 10 to 34 % percentage of the total variance in the taxa (Table 2.7). These results suggest that much of the taxa variance could be related to the measured environmental variables, since Monte Carlo permutations of the first canonical axes were significant ($P = 0.01$). The forward selection criteria determined that pH, water temperature, depth, dissolved oxygen, total phosphorus and magnesium concentrations (Table 2.7) explained the weighted averages of the taxa data almost as well as the original 18 variables for the lakes (water depth and Table 2.2). Except for Baptiste Lake, depth and pH contributed to either axis 1 or 2 in the

CCA of all lakes. Depth and pH were correlated with axis 1 for Lofty, North Halfmoon, and Crooked lakes, whereas magnesium was correlated with axis 2 ($r = 0.2$, 0.4, and 0.4, respectively). In contrast, magnesium ($r = -0.4$) and water depth ($r = 0.3$) were correlated with axis 1 and 2, respectively, for Baptiste Lake. For Jenkins Lake, the length of the depth and pH arrow and their proximity to axis 1 and 2, respectively, indicate that these variables were most strongly correlated with the axes (Fig.2.7). In addition, water temperature and dissolved oxygen concentrations in the water column were important in explaining the variation in macroinvertebrate distribution in Lofty and Crooked lakes, while total phosphorus concentrations were a significant contributor in Lofty, North Halfmoon, and Jenkins lakes. The distribution of benthic macroinvertebrate communities in the treated lakes were correlated with water column pH, water temperature, total phosphorus and magnesium concentrations.

The CCA biplots (Fig. 2.7) support earlier results that chaoborid densities were most abundant at deeper regions of the lakes, whereas amphipods were found in shallower areas of both treated and reference lakes. In addition, most taxa groups appear to be restricted to intermediate pH values (e.g. 8 to 9). However, oligochaete densities appear to be associated with higher magnesium concentrations in the treated compared to reference lakes (Fig. 2.7). In both North Halfmoon and reference lakes, high densities of oligochaetes and 'other' macroinvertebrates 21 d after $Ca(OH)_2$ treatment (Table 2.5) coincided with an increase in water temperature from 15 to 19 °C (Table 2.6, $P < 0.01$). In both treated lakes, densities of amphipods and chironomids did not change 21 d after $Ca(OH)_2$ treatment despite an average pH increase of 0.7 units (Table 2.6, $P < 0.01$); however, water column pH never increased to 10. During the 3-yr study period, pH of treated lakes increased after $Ca(OH)_2$ treatment (Table 2.8, $P < 0.01$). In addition, this pH increase corresponded with elevated total phosphorus concentrations after treatment (Table 2.8, $P < 0.01$). However, increases in pH and total phosphorus concentrations were also observed in the reference lakes ($P < 0.01$). Also, differences in magnesium concentrations were observed immediately before and 21 d after $Ca(OH)_2$ treatment in both treated and reference lakes ($P < 0.05$; Table 2.6). In addition, no distinct grouping of pre- and post-treatment sample points were observed in the CCA biplots for North Halfmoon and Lofty lakes (Fig. 2.7). These results indicate that macroinvertebrate distribution patterns in relation to environmental variables did not change as a result of treatment.

Rasmussen (1988) observed that benthic biomass for lakes located throughout the world was strongly related to chlorophyll *a*, slope, slope x exposure, calcium, and chloride ($r^2 = 0.80$). For the prairie lakes, however, littoral benthic biomass was not correlated with these environmental variables ($r^2 = 0.00$, Fig. 2.8). Littoral benthic biomass for the prairie lakes were often beyond the data range of Rasmussen's study lakes. Moreover, Rasmussen's equation under-estimated littoral benthic biomass of three lakes and over-estimated another three.

2.4 Discussion

The application of $Ca(OH)_2$ to reduce phytoplankton biomass in eutrophic hardwater lakes did not result in significant changes in total biomasses and densities of major benthic macroinvertebrate taxa one to two years post-treatment. In fact, amphipods and chironomids remained numerically dominant in both of the treated lakes before and one to two years after $Ca(OH)_2$ treatment. No long-term studies exist on the response of benthic macroinvertebrates to $Ca(OH)_2$ addition to hardwater lakes. However, studies on the response of benthic macroinvertebrates to $Ca(OH)_2$ and/or $CaCO_3$ addition to acid lakes found increased densities and/or biomass of benthic macroinvertebrates. For example, Raddum et al. (1984) reported increased densities of mayflies, oligochaetes, and chironomids one to two years after 1.1 $kg \cdot m^{-2}$ $CaCO_3$ was applied to softwater Lake S. Boksjø, Sweden. Also, total biomasses of benthic fauna increased two years after CaO or $CaCO_3$ treatment in acidic lakes (Hultberg and Andersson 1982; Appelberg 1990). Increased pH of 3 to 5 units from 5 to 9 in softwater lakes following $CaCO_3$ treatment (Fordham and Driscoll 1989) may provide favorable conditions for acid-sensitive species of benthic macroinvertebrates (e.g. crustaceans, ephemerids) to recolonize (Eriksson et al. 1983; Stephenson and Mackie 1986). Therefore, reduced acid-stressed conditions in softwater lakes compared to highly buffered hardwater lakes following lime ($Ca(OH)_2$ and/or $CaCO_3$) treatment may explain the observed differences in macroinvertebrate densities and biomasses between these water bodies over the study years.

Dosages of 225 and 295 $g \cdot m^{-2}$ (74 and 107 $mg \cdot L^{-1}$), and water-column pH < 10 in hardwater lakes did not change densities of amphipods and chironomids over a short time period (21 d after $Ca(OH)_2$ treatment). Sarkar and Konar (1984) also found that chironomid densities did not change after 90-d exposure to 225 $g \cdot m^{-2}$ (1350 $mg \cdot L^{-1}$) agriculture lime in hardwater ponds, despite sediment pH increases from 7.0 to 8.5 pre- and post-treatment, respectively. In contrast, Miskimmin et al. (1995) inferred that pH increases of 3 or more units (from 8 to 12) were responsible for higher chironomid and lower amphipod densities in the treated compared to untreated side of a hardwater pond (Helbig Pond, Alberta) 9 weeks after 350 $g \cdot m^{-2}$ (250 $mg \cdot L^{-1}$) $Ca(OH)_2$ application. However, interpretation of these findings is limited because pre-treatment densities of invertebrates were not measured and pH was not monitored. In my study, four-day laboratory experiments showed that dosages of ≤ 200 $g \cdot m^{-2}$ with pH below 10 was not harmful to either chironomids or amphipods, but that dosages of 300 $g \cdot m^{-2}$ and pH ≥ 10 decreased amphipod survivorship. These laboratory results corroborate my *in situ* findings where $Ca(OH)_2$ doses that keep pH < 10 do not affect benthic macroinvertebrates. However, extrapolation of laboratory microcosm results to field situations should be made cautiously as the spatial scale of the two systems can affect results (Carpenter 1996). For example, maximum water depths in the two treated lakes were 30-fold greater than in laboratory microcosms and may provide areas of refugia for amphipods even at pH ≥ 10. Nevertheless, laboratory experiments provide controlled conditions in which to test specific predictions and should be complimented by field experiments to account for environmental variability (Verhoef 1996).

While amphipod and chironomid densities *in situ* did not change after $Ca(OH)_2$ treatment, oligochaete and 'other' macroinvertebrate densities increased temporarily in North Halfmoon Lake and this may be due to a 4°C increase in water temperature. The co-precipitation of phytoplankton cells with calcite after $Ca(OH)_2$ treatment (Zhang and

Prepas 1996b) may elevate water-column temperature when phytoplankton cells decompose. In turn, lake sediments absorb a large amount of the heat from the water (Wetzel 1983), which can increase developmental rates of bottom fauna that inhabit the sediments (Oliver 1971, Reynoldson 1987). Reist and Fischer (1987) reported shorter development time and hatching interval in *Chironomus plumosus*, *C. nuditarsis*, and *C. bernensis* when water temperature rose from 20 to 25°C. Since lake water temperature naturally increases during warmer periods of the year (e.g. reference lakes of this study), it is difficult to determine whether the increase in water temperature 21 d after treatment was a natural occurrence or due to treatment. Nevertheless, increased oligochaete densities 21 d after treatment were likely due, at least in part, to heat absorbed at the sediment surface. It is also possible that increased organic material contributed to the temporary increase in oligochaete and 'other' macroinvertebrate densities 21 d after $Ca(OH)_2$ treatment. In the treated lakes, decreased macrophyte biomass one year post-treatment may have provided additional organic material for oligochaetes (P. Chambers, unpubl. data). The deposition and decomposition of phytoplankton cells after $Ca(OH)_2$ treatment may supply desirable food for oligochaetes (Jónasson 1969). Reynoldson (1990) found that higher numbers of oligochaetes (17,380 compared to 167 individuals·m^{-2}) occurred in sediments with high organic content (25.8 to 29.5 % organic content) compared to sediments that contained less (17.1 to 17.8 %) organic matter. Also, the precipitation of calcite may provide additional substrate for tube building (Pinder 1986; Brinkhurst and Jamieson 1971) rather than inhibit movement of invertebrates due to the presence of a floc layer (Lamb and Bailey 1981). In my four-day laboratory experiments I noted no effect of a 0.5 to 1.0 cm thick precipitate layer overlying the sediments on the survival of *Chironomus* spp. and *H. azteca*, two common organisms in hardwater lakes that live in or near the sediments. Thus, $Ca(OH)_2$ treatment may improve sediment conditions for the reproduction and growth of oligochaetes by providing detritus and tube building material.

Chironomids and amphipods are known to move through the water column to emerge and feed, respectively, while chaoborids vertically migrate through the water-column to avoid predation (Merritt and Cummins 1984; Post and Cucin 1984; Pennak 1989). Hence, I expected an increase in water turbidity following $Ca(OH)_2$ application to temporarily disrupt the movement patterns of these three taxa and, consequently, influence their densities at different depths. Although water turbidity was not measured in the treated lakes 21 d after $Ca(OH)_2$ treatment, the densities of these three taxa groups were similar among depths in the treated lakes both before and after $Ca(OH)_2$ application. Therefore, if turbidity increased 21 d after $Ca(OH)_2$ treatment, it did not alter the migratory behavior of benthic macroinvertebrates.

The role of zooplankton as a food source to predacious benthic macroinvertebrates (e.g. *Chaoborus*) is important in fresh waters (Arnott and Vanni 1993). In the treated lakes, higher numbers of predacious macroinvertebrates might be expected to occur 21 d after $Ca(OH)_2$ treatment due to a change in phytoplankton taxonomic composition from cyanobacteria to chrysophytes and cryptophytes (Zhang and Prepas 1996b) and enhanced cladoceran populations < 20 days post-treatment (A. Ghadouani, unpubl. data). However, improved zooplankton food supply did not lead to an increase in chaoborid densities. Instead, chaoborid numbers remained unchanged 21 d after treatment, suggesting other abiotic or biotic factors were probably more important than food supply in influencing chaoborid populations.

The ability of benthic macroinvertebrates to recover from perturbations to their environment may explain the absence of $Ca(OH)_2$ effects (225 and 295 $g \cdot m^{-2}$) on benthic macroinvertebrate densities and biomasses at water-column pH < 10. In northern temperate lakes and ponds, high monthly and yearly fluctuations of benthic macroinvertebrate densities and biomasses are not uncommon (e.g. Hanson 1990; Wen 1992; Dinsmore 1995). For example, in this study, mean population densities of oligochaetes in the south basin of Baptiste Lake, Alberta varied within a given year from 1254 to 12,883 $individuals \cdot m^{-2}$ in early May and late July, respectively, and between years from 123 to 12,883 $individuals \cdot m^{-2}$ in July of 1991 and 1992, respectively. Thus, temporary density changes of benthic macroinvertebrates may be a natural occurrence rather than a response to altered abiotic and biotic conditions from $Ca(OH)_2$ application.

Despite large temporal variability within a single lake, investigators have attempted to model factors controlling benthic macroinvertebrate abundances among lakes (Hanson and Peters 1984; Rasmussen and Kalff 1987), particularly in view of the important role of benthic macroinvertebrates as predictors of fish abundance and indicators of ecosystem health (Hanson and Leggett 1982; Rosenberg and Resh 1993). The results of other literature models are not consistent with my study because most of these empirical relationships have been formulated for profundal rather than littoral benthic fauna. Also, the two studies that do attempt to account for variation in littoral macroinvertebrate biomass were predominantly based on data from softwater oligotrophic systems (Rasmussen 1988; France 1990); hence, the inability of Rasmussen's (1988) model in adequately explain the variation in benthic biomass of lakes in the boreal plains. Their model generally under-estimated the benthic biomass of eutrophic hardwater lakes that are deep and thermally stratify during the summer, which suggests that environmental parameters such as dissolved oxygen concentrations and water temperature may be important correlates of benthic biomass in prairie lakes (Dinsmore 1995). In this study, pH, depth, dissolved oxygen concentrations, water temperature, total phosphorus and magnesium concentrations were important predictors of littoral benthic macroinvertebrate densities. Although these variables accounted for 95 to 99% of the taxa variance, only 10 to 34 % of total taxa variance could be explained by the ordinations. It is possible that the interaction of environmental variables may account for some of the variation in littoral benthic fauna in this study. For example, the interaction of magnesium and calcium concentrations may account for some of the variation in taxa data. In addition, measured environmental data may not reflect the precise environment to which bottom fauna were exposed (i.e. mid-lake compared to sediment-water interface). Furthermore, high temporal variability within a lake makes it difficult to determine the appropriate time to sample for data that is used in developing inter-lake models. Therefore, to determine the influence of $Ca(OH)_2$ treatment on the bottom fauna in eutrophic hardwater lakes, we must understand the basic environmental factors that govern their natural lifecycles.

In summary, dosages of 225 to 295 $g \cdot m^{-2}$ (74 to 107 $mg \cdot L^{-1}$) $Ca(OH)_2$ and water-column pH < 10 had no deleterious effect on littoral zone benthic macroinvertebrate communities over the three year study. I recommend that abiotic and biotic factors controlling benthic macroinvertebrate community dynamics in lakes are part of any evaluation on the potential effects of lake treatments. The more we learn about factors controlling natural variability of macroinvertebrates, the more likely that we can detect subtle impacts of lake treatments/alterations.

Table 2.1. Physical characteristics of the five study lakes.

Characteristic	Treated		Reference		
	Lofty	N. Halfmoon	Jenkins	Crooked[a]	Baptiste[a]
Latitude (N)	54°43.5′	54°04′	54°55′	54°55′	54°45′
Longitude (W)	112°29′	113°21′	113°36′	113°32′	113°33′
Surface area (km^2)	0.7	0.8	1.6	2.4	4.7
Volume (x 10^6 m^3)	1.9	2.4	11.1	4.5	56.5
Mean depth (m)	2.9	3.1	7.4	4.1	11.9
Maximum depth (m)	5.5	6.6	17.2	9.5	27.5

[a] South Basin

Source: E. Prepas and S. Reedyk (unpubl. data)

Table 2.2. Equipment and procedures for analysing 17 environmental variables in the five study lakes. Water samples were collected at the deepest site in each lake at 1- or 2-m intervals to maximum lake depth.

Parameter	Method
Temperature	• Montedoro-Whitney resistance Thermometer model TC-5C (1990-91) Flett thermistor (1991-93)
Light	• Protomatic light meter model 313 (1990-91) LiCor underwater quantum sensor (1991-93)
TP and TDP	• Modified (Prepas and Rigler 1982) potassium persulfate method (Menzel and Corwin 1965)
Dissolved Oxygen	• water samples fixed in the field titrated within 24 h following Winkler dissolved oxygen method (Carpenter 1965)
pH	• Metrohm E588 pH meter within 1 h after sample collection
Conductivity	• Metrohm E587 conductometer within 1 h after sample collection
Total Alkalinity	• potentiometric titration method within 24 h (Environment Canada 1979)
NO_3 and NO_2	• Technicon autoanalyzer within 48 h (Stainton et al. 1977)
NH_4	• Technicon autoanalyzer within 48 h (Solórzano 1969)
Cl, SO_4	• Ion chromatography with Dionex analyzer (APHA et al. 1989)
Ca, Na, K, Mg	• filtered (Whatman GF/C) before analysis on a Perkin-Elmer Model 3030 atomic absorption spectrophotometer (APHA et al. 1989)

Table 2.3. Summary statistics of repeated-measures ANOVA comparing mean benthic macroinvertebrate densities between treated and reference lakes during 15 sampling periods in May to August of 1991 to 1993.

	Lake df = 1, 13		Sampling Period df = 14, 182		Lake x Sampling Period df = 14, 182	
Taxonomic group	MS	*F*	MS	*F*	MS	*F*
Total	21.5	8.1^{*}	6.5	4.8^{**}	3.2	2.3^{**}
Chironomidae	0.6	0.1^{ns}	6.4	2.7^{**}	4.0	1.7^{ns}
Chaoboridae	567.0	19.1^{**}	16.4	6.1^{**}	4.6	1.7^{ns}
Amphipoda	248.5	3.8^{ns}	10.3	2.5^{**}	7.2	1.7^{ns}
Ceratopogonidae	372.5	27.7^{**}	5.6	1.3^{ns}	4.9	1.2^{ns}
Oligochaeta	929.1	53.2^{**}	38.9	14.9^{**}	6.3	2.4^{**}
Other	417.4	30.3^{**}	14.4	5.1^{**}	5.0	1.8^{ns}

^{ns} $P > 0.05$

* $P < 0.05$

** $P < 0.01$

Table 2.4. Summary statistics of repeated-measures ANOVA comparing mean benthic macroinvertebrate densities between treated and reference lakes at water depths of 1, 3, and 5-m immediately before and 21 d after $Ca(OH)_2$ treatment of both North Halfmoon and Lofty lakes.

	Lake df = 1, 45		Depth df = 2, 45		Time df = 1, 45		Lake x Time df = 1, 45	
Taxonomic group	MS	*F*	MS	*F*	MS	*F*	MS	*F*
Total	17.8	5.0^{*}	7.8	2.2^{ns}	0.5	0.3^{ns}	15.4	9.5^{**}
Chironomidae	7.5	1.1^{ns}	3.1	0.4^{ns}	4.4	0.9^{ns}	27.4	5.9^{*}
Chaoboridae	202.5	57.5^{**}	50.6	14.4^{**}	1.3	0.3^{ns}	40.2	10.1^{**}
Amphipoda	85.0	5.7^{*}	66.3	4.4^{*}	1.6	1.0^{ns}	41.5	25.8^{**}
Ceratopogonidae	127.6	16.7^{**}	3.1	0.4^{ns}	5.1	1.2^{ns}	6.0	1.4^{ns}
Oligochaeta	368.4	40.4^{**}	32.8	3.6^{*}	65.0	13.7^{**}	0.5	0.1^{ns}
Other	47.5	4.1^{ns}	8.3	0.7^{ns}	58.9	14.5^{**}	8.5	2.1^{ns}

^{ns} $P > 0.05$
* $P < 0.05$
** $P < 0.01$

Table 2.5. Mean densities (± SE) of major benthic macroinvertebrate taxa in North Halfmoon, Lofty, and reference lakes immediately before and 21 d after $Ca(OH)_2$ treatment in 1991 and 1992. Chir = Chironomidae; Chao = Chaoboridae; Amph = Amphipoda; Cera = Ceratopogonidae; Olig = Oligochaeta; and Oth = all other taxonomic groups.

Year	Lake	Treatment	Total	Chir	Chao	Amph	Cerat	Olig	Oth
1991	N. Halfmoon	before	1821 (620)	1363 (620)	313 (96)	123 (56)	15 (10)	0 (0)	7 (5)
		after	1769 (751)	644 (225)	89 (35)	0 (0)	22 (9)	960 (545)	54 (19)
	Reference	before	1328 (255)	495 (175)	30 (20)	505 (97)	111 (41)	131 (39)	56 (21)
		after	7926 (2976)	2178 (1069)	111 (81)	1729 (415)	154 (44)	3047 (1765)	707 (286)
1992	Lofty	before	9627 (2728)	2928 (861)	227 (80)	5848 (2075)	10 (8)	333 (201)	281 (59)
		after	6332 (2028)	1931 (631)	155 (40)	3887 (1528)	2 (2)	141 (122)	215 (68)
	Reference	before	21509 (4855)	3864 (1621)	11 (8)	5456 (3247)	820 (347)	9297 (2338)	2060 (748)
		after	25070 (5601)	3379 (819)	320 (219)	7933 (3288)	219 (118)	9219 (2500)	3999 (1400)

Table 2.6. Mean (± SE) pH, water temperature, total phosphorus and magnesium concentrations in North Halfmoon, Lofty, and reference lakes immediately before and 21 d after $Ca(OH)_2$ treatment in 1991 and 1992. Results of *t*-test comparisons are indicated by ns = $P > 0.05$, * = $P < 0.05$, or ** = $P < 0.01$.

Year	Lake	Treatment	pH	Temperature (°C)	Total phosphorus (μg·L⁻¹)	Magnesium (mg·L⁻¹)
1991	N. Halfmoon	before	8.0 (0.0)**	15.4 (2.6)**	61.7 (2.6)ns	24.9 (0.1)*
		after	8.7 (0.0)	19.2 (0.5)	67.3 (5.8)	24.1 (0.3)
	Reference	before	8.1 (0.0)ns	15.0 (0.1)**	32.6 (1.4)ns	12.7 (0.2)**
		after	8.1 (0.1)	19.2 (0.2)	37.2 (2.9)	13.2 (0.2)
1992	Lofty	before	8.5 (0.2)**	18.5 (0.4)ns	70.1 (7.5)*	32.6 (0.1)**
		after	9.3 (0.0)	19.1 (0.3)	50.2 (4.5)	30.0 (0.1)
	Reference	before	8.6 (0.1)ns	19.4 (0.2)ns	45.0 (2.7)ns	16.0 (0.1)**
		after	8.5 (0.1)	19.3 (0.1)	53.6 (6.0)	17.1 (0.2)

Table 2.7. Canonical correspondence analyses of littoral macrobenthos in five eutrophic hardwater lakes. The first two axes of the ordinations explained between 10 to 34 % of the overall variation in benthic macroinvertebrate density data. The ordinations identified three to five environmental variables (pH, depth, magnesium, temperature, and TP) important in explaining 95 to 99% of the taxa data variation. Canonical and correlation coefficients of environmental variables to the first two axes of the ordinations are shown.

Lake	Taxa data	Taxa-environment relationship	Environmental Variables	Canonical Coefficient		Correlation Coefficient	
	First 2 axes	First 2 axes		Axis 1	Axis 2	Axis 1	Axis 2
Lofty	34.2	97.2	pH	-0.5	-0.5	-0.6	-0.2
			Depth	0.6	-0.2	0.6	0.1
			Magnesium	-0.5	0.9	-0.4	0.2
			Temperature	0.1	-0.7	-0.2	-0.2
			TP	-0.2	0.2	0.1	0.1
N. Halfmoon	24.1	95.3	pH	0.4	0.4	0.4	-0.1
			Depth	-0.7	0.7	-0.6	0.2
			Magnesium	0.5	0.9	0.3	0.4
			TP	0.2	-0.5	-0.1	-0.1
Jenkins	9.6	99.3	pH	-0.7	0.7	-0.2	0.3
			Depth	-0.6	-0.4	-0.2	-0.2
			TP	0.6	0.3	0.2	0.2
Crooked	24.6	98.8	pH	0.1	0.2	0.2	0.1
			Depth	-0.9	0.4	-0.7	0.1
			Magnesium	0.1	0.9	0.1	0.4
			Dissolved Oxygen	0.1	0.4	0.4	0.2
Baptiste	13.6	97.1	pH	-0.5	-0.2	-0.4	-0.2
			Depth	0.1	0.7	0.2	0.3
			Magnesium	-0.7	0.6	0.4	0.2

Table 2.8. Mean (± SE) summer (May to August) pH, water temperature, total phosphorus and magnesium concentrations in North Halfmoon and reference lakes before (May 1991 to June 1991) and after (July 1991 to August 1993) $Ca(OH)_2$ treatment in 1991; and in Lofty and reference lakes before (May 1991 to 3 July 1992) and after (16 July 1992 to August 1993) $Ca(OH)_2$ treatment in 1992. Results of *t*-test comparisons are indicated by ns = $P > 0.05$, * = $P < 0.05$, or ** = $P < 0.01$.

Year	Lake	Treatment	pH	Temperature (°C)	Total phosphorus ($\mu g \cdot L^{-1}$)	Magnesium ($mg \cdot L^{-1}$)
1991	N. Halfmoon	before	8.0 (0.0)**	15.4 (0.3)**	65.3 (1.5)**	25.2 (0.2)
		after	8.4 (0.0)	17.8 (0.4)	85.0 (2.9)	27.3 (0.4)
	Reference	before	8.2 (0.0)**	15.7 (0.4)**	41.9 (1.9)*	12.8 (0.1)**
		after	8.4 (0.1)	17.8 (0.2)	49.7 (1.8)	14.7 (0.1)
1992	Lofty	before	8.3 (0.0)**	17.1 (0.3)ns	74.2 (3.3)**	27.9 (0.4)
		after	9.1 (0.1)	17.3 (0.4)	125.9 (18.1)	28.6 (0.3)
	Reference	before	8.3 (0.0)**	16.9 (0.2)ns	45.8 (1.7)ns	13.7 (0.1)**
		after	8.5 (0.1)	16.8 (0.3)	50.7 (2.4)	15.2 (0.2)

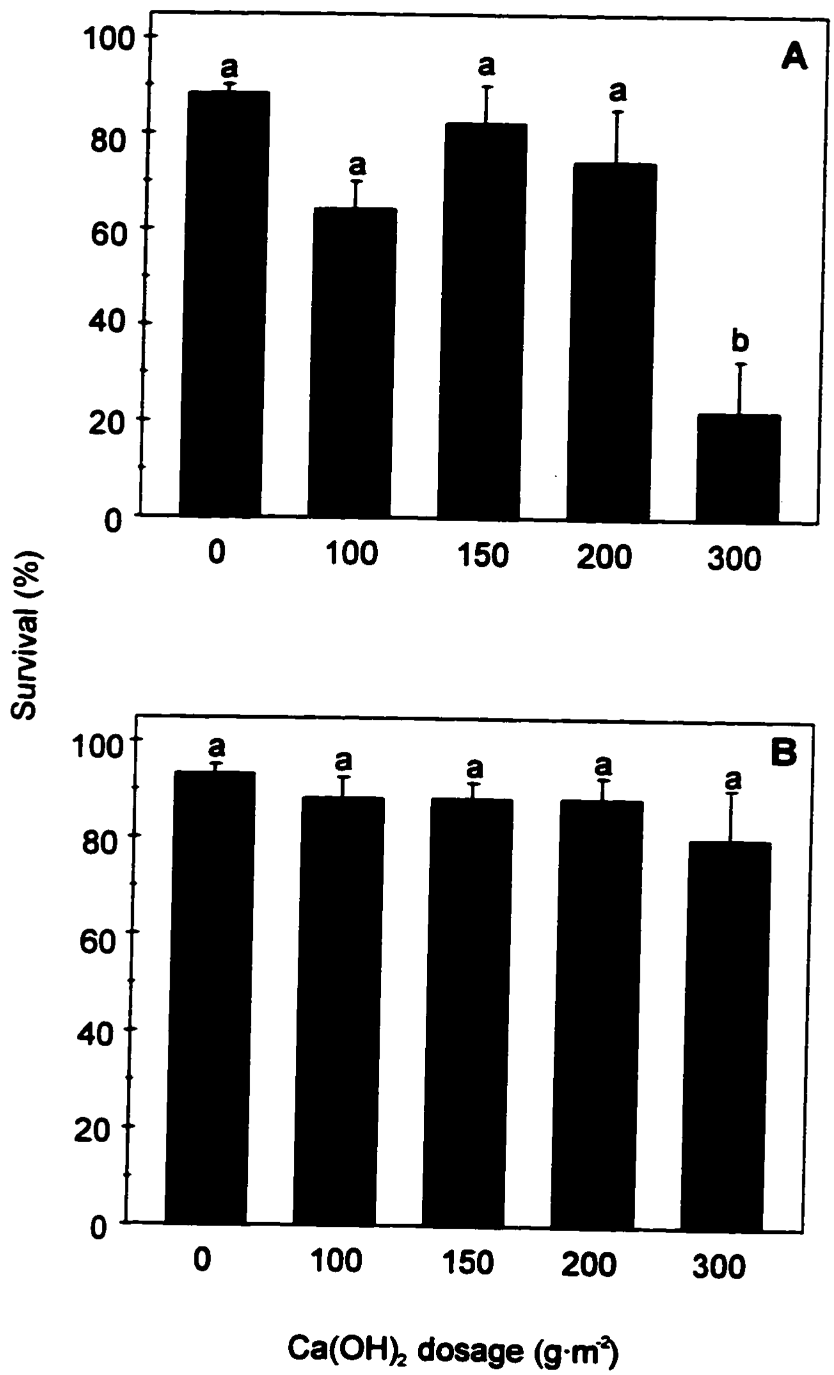

Figure 2.1. Survivorship (± SE) of (A) *Hyalella azteca* and (B) *Chironomus* spp. at four dosages of $Ca(OH)_2$. Histograms sharing the same letter are not different from each other ($P > 0.05$).

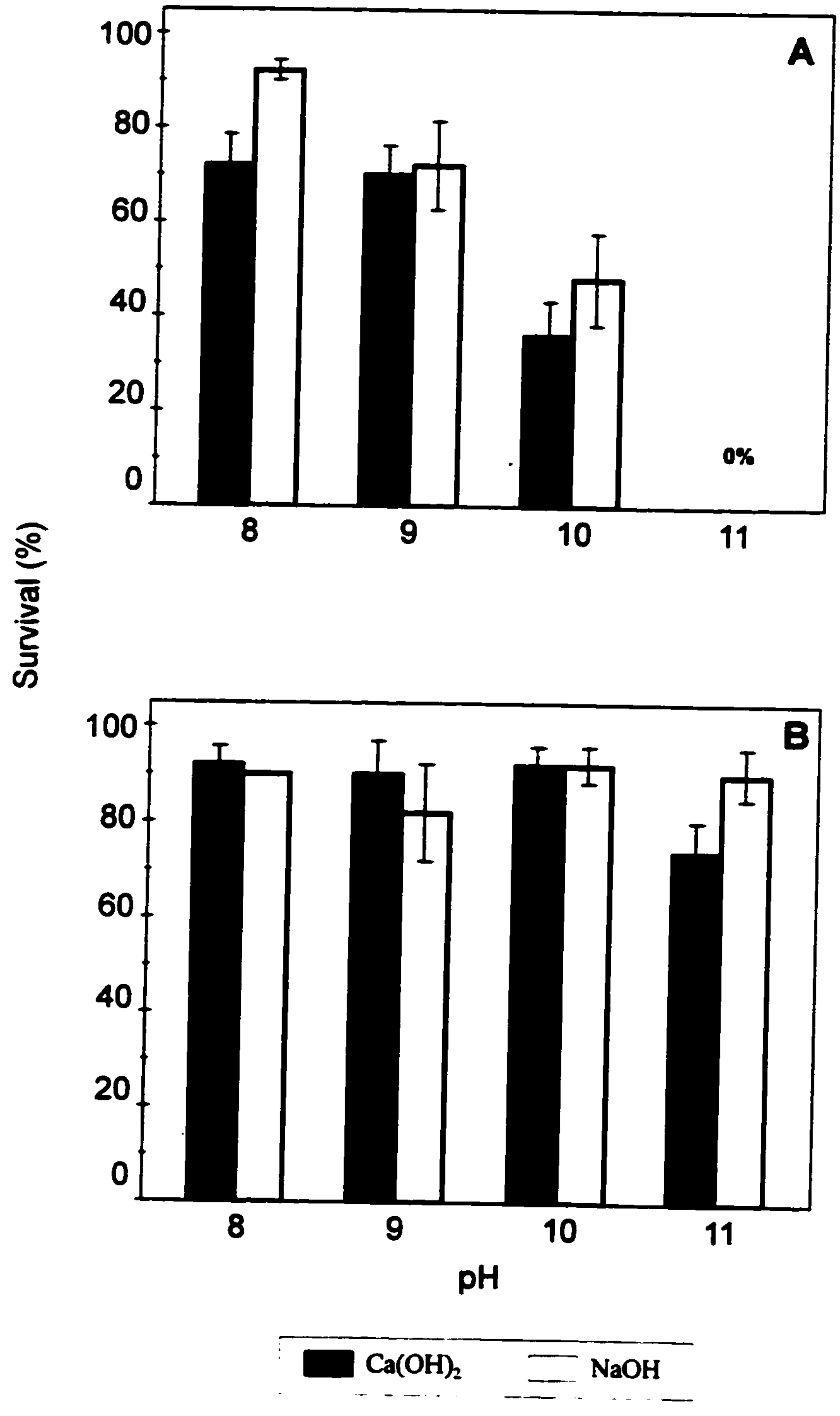

Figure 2.2. Mean (± SE) survival of (A) *Hyalella azteca* and (B) *Chironomus* spp. at four different pH conditions maintained with NaOH or $Ca(OH)_2$.

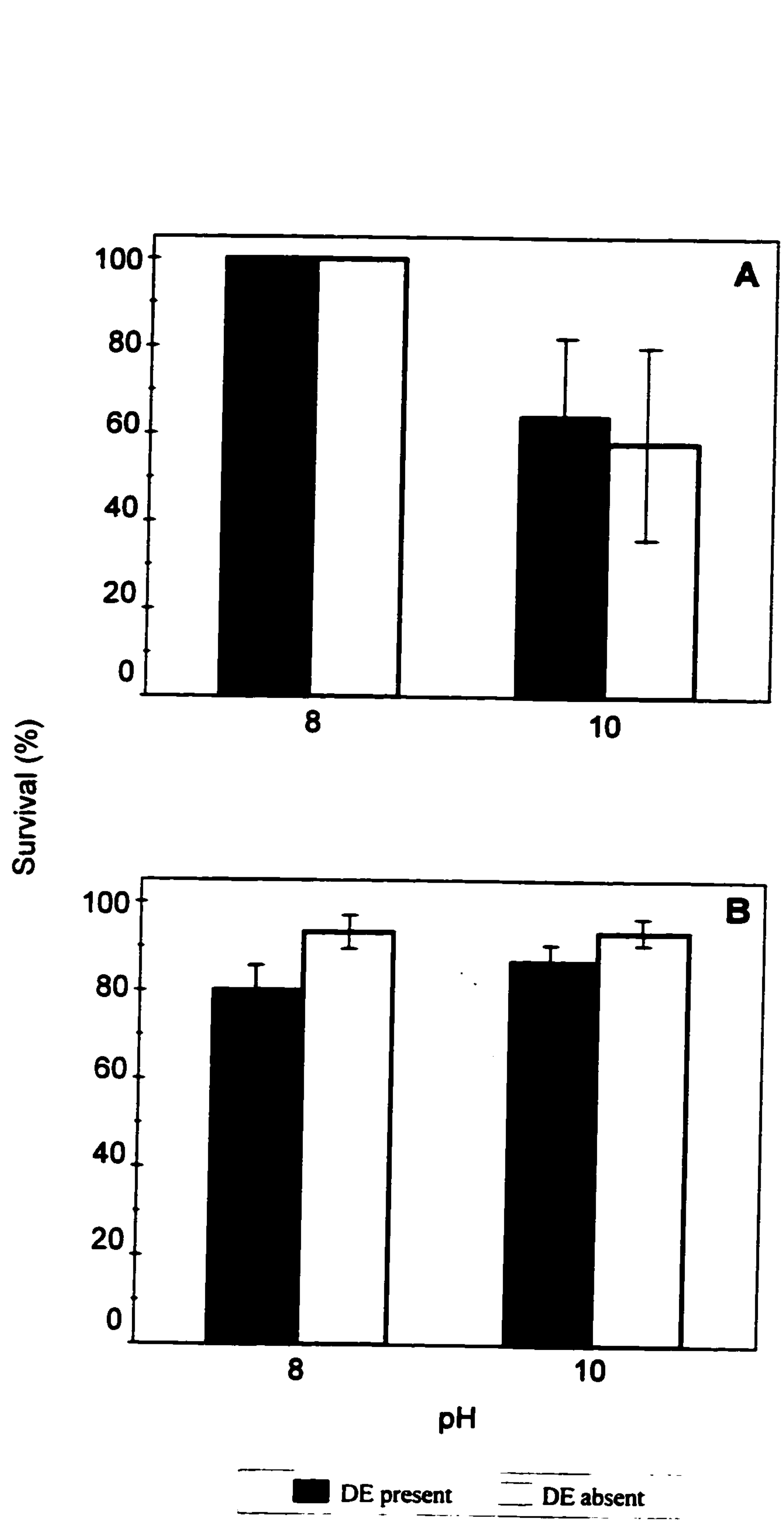

Figure 2.3. Effect of diatomaceous earth (DE) and pH on mean (± SE) survival of (A) *Hyalella azteca* and (B) *Chironomus* spp.

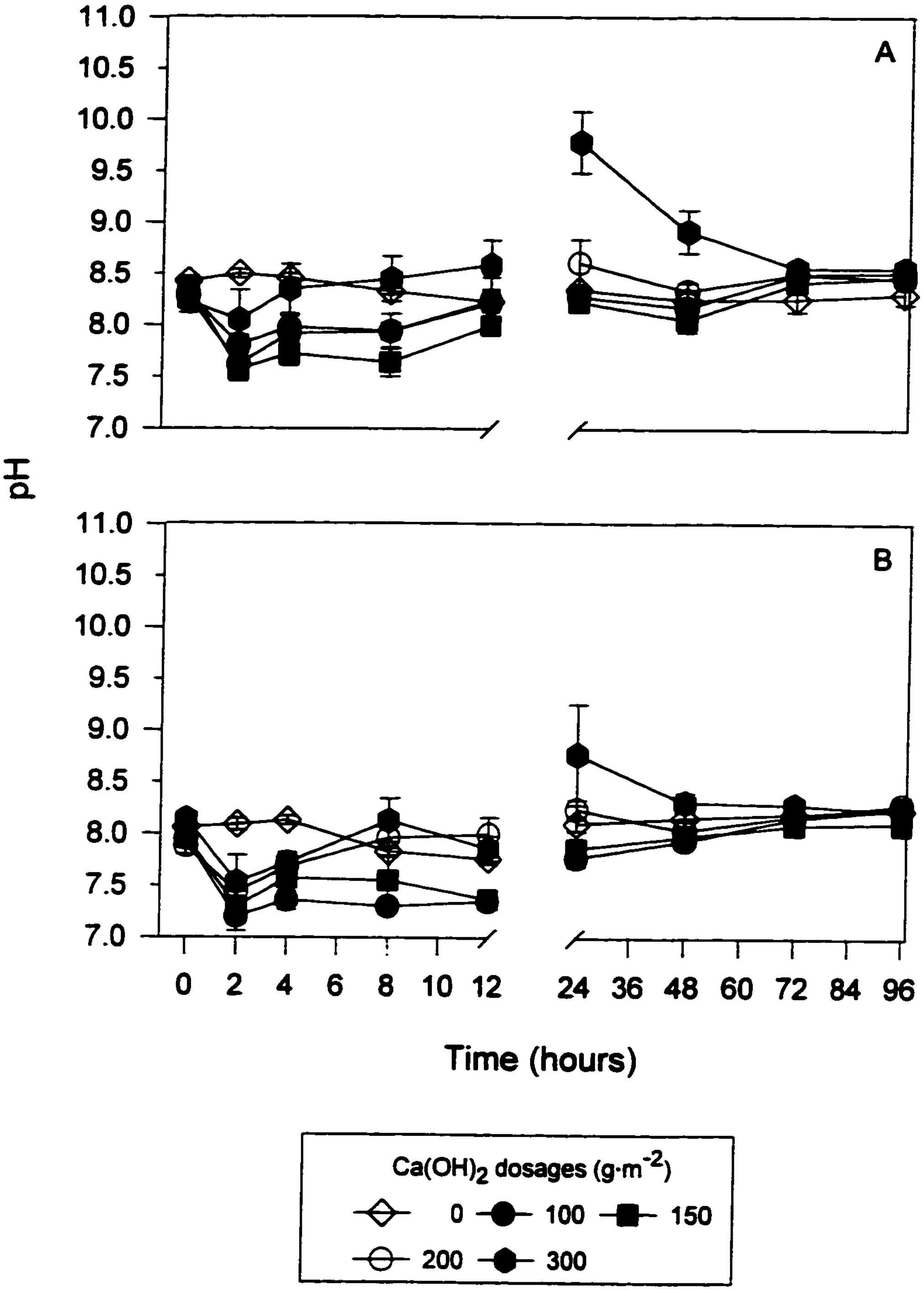

Figure 2.4. Mean (±SE) pH during $Ca(OH)_2$ experiments for (A) *Hyalella azteca* and (B) *Chironomus* spp.

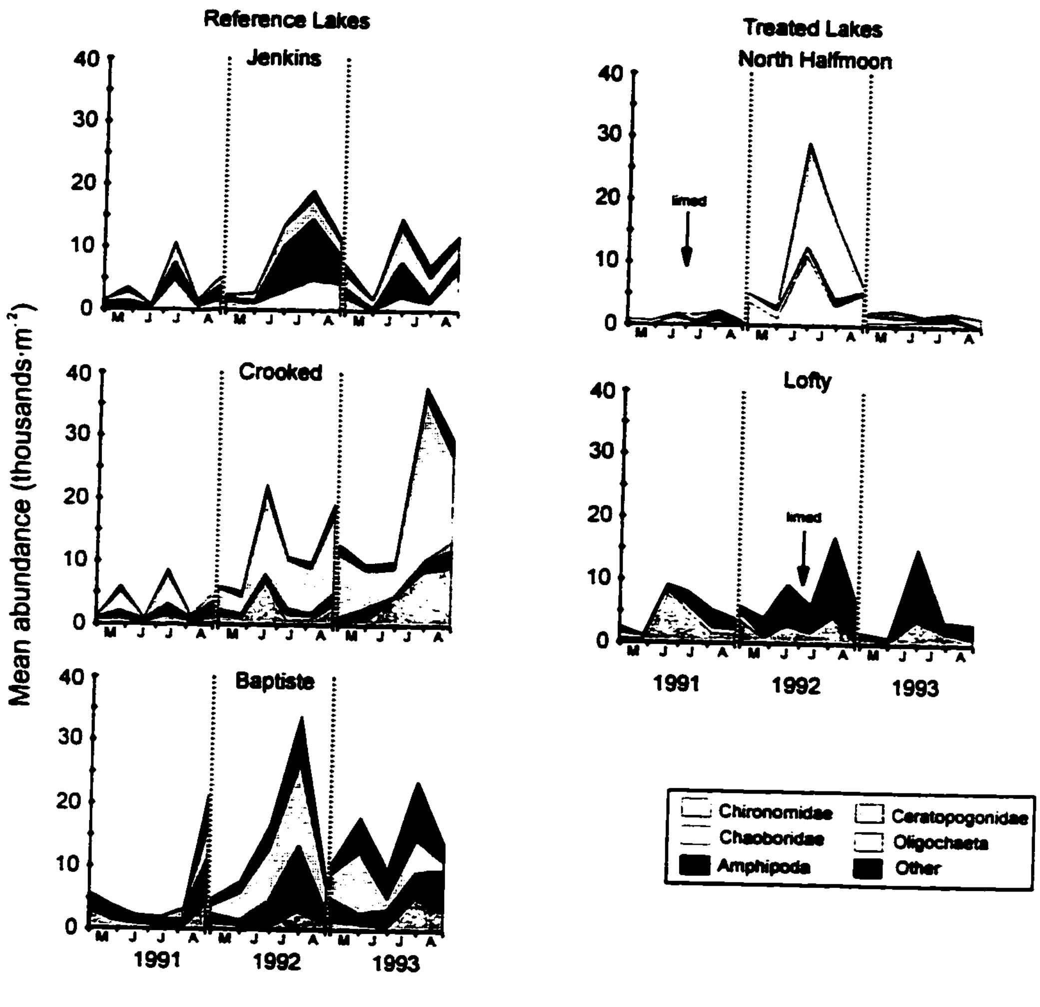

Figure 2.5. Mean abundance (thousands·m^{-2}) of major benthic macroinvertebrate taxa in the reference and treated lakes from 1991-1993. Arrows indicate lime treatment.

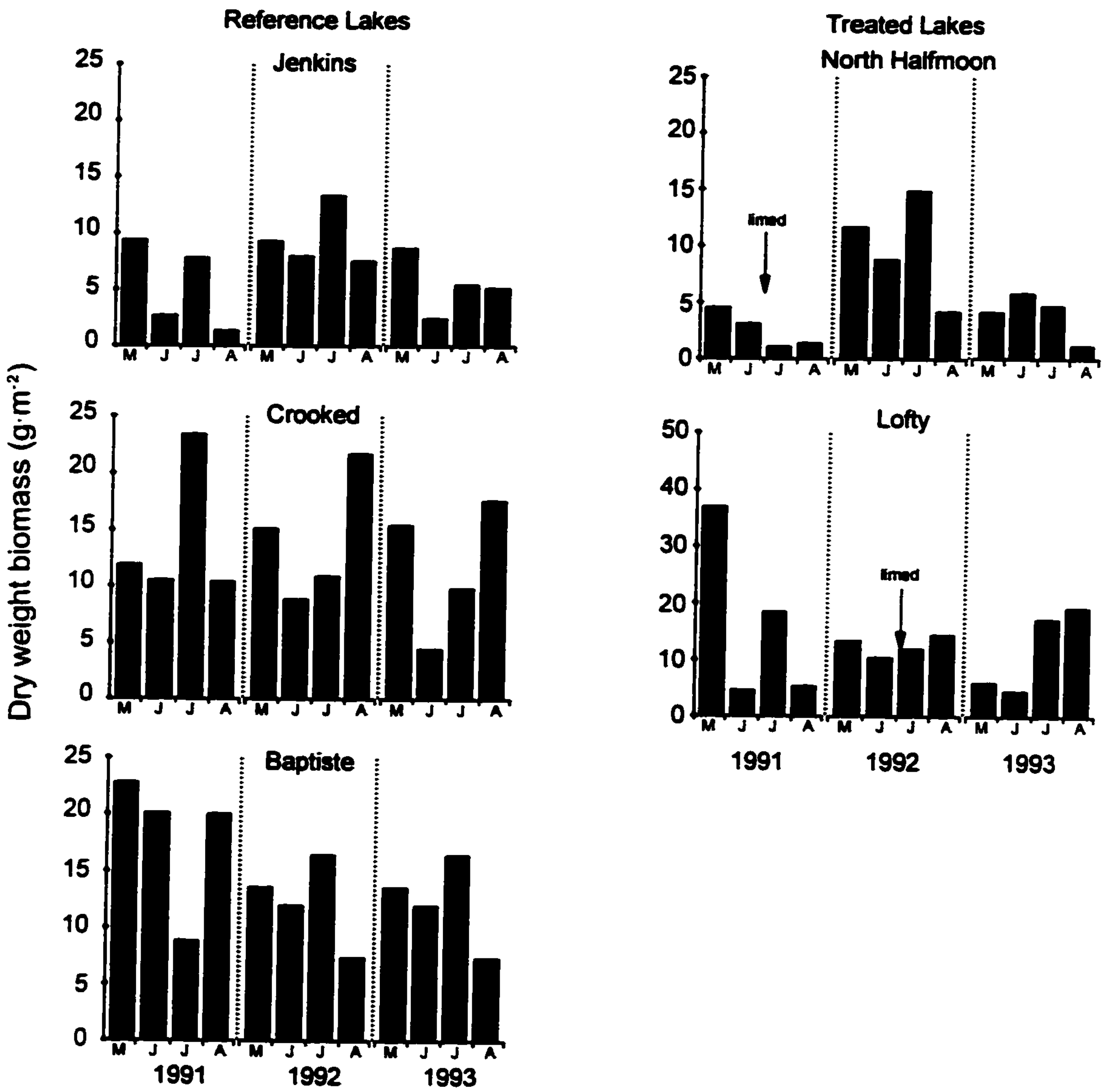

Figure 2.6. Mean dry weight biomass (g·m^{-2}) of total benthic macroinvertebrates in the reference and treated lakes from 1991-1993. Note variation in scale of the vertical axes. Arrows indicate lime treatment.

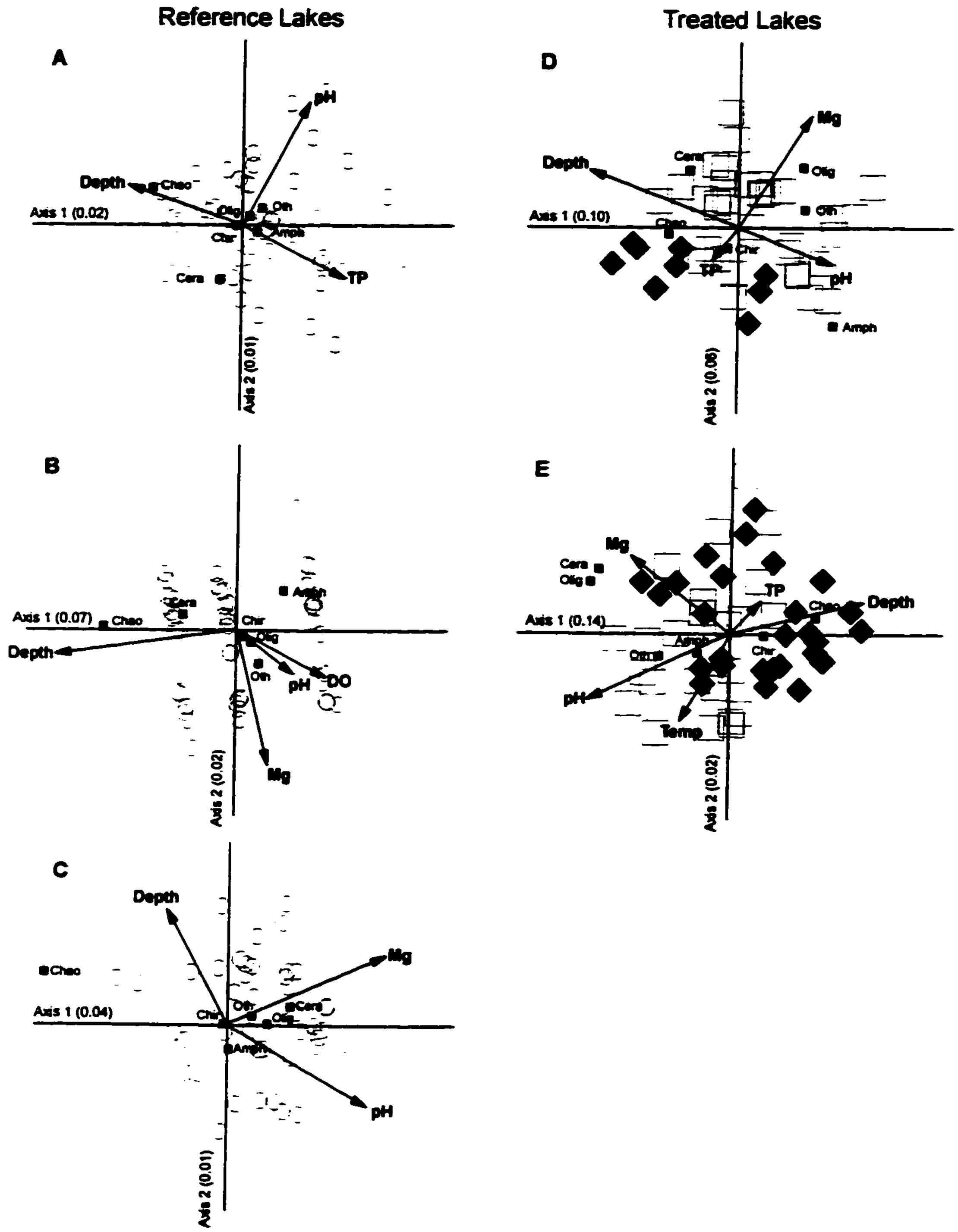

Figure 2.7. Ordinations of taxa by CCA for the five study lakes: A = Jenkins; B = Crooked; C = Baptiste; D = N. Halfmoon; and E = Lofty. Eigenvalues for axes 1 and 2 are shown in parentheses following axes labels. Environmental variables are represented by arrows, taxa by ■; and sample scores by O (reference lakes), ◆ (pre-treatment data), and ⊏ (post-treatment data). TP = total phosphorus; Mg = magnesium; DO = dissolved oxygen; Temp = temperature; Chir = Chironomidae; Chao = Chaoboridae; Amph = Amphipoda; Cera = Ceratopogonidae; Olig = Oligochaeta; Oth = all other taxonomic groups.

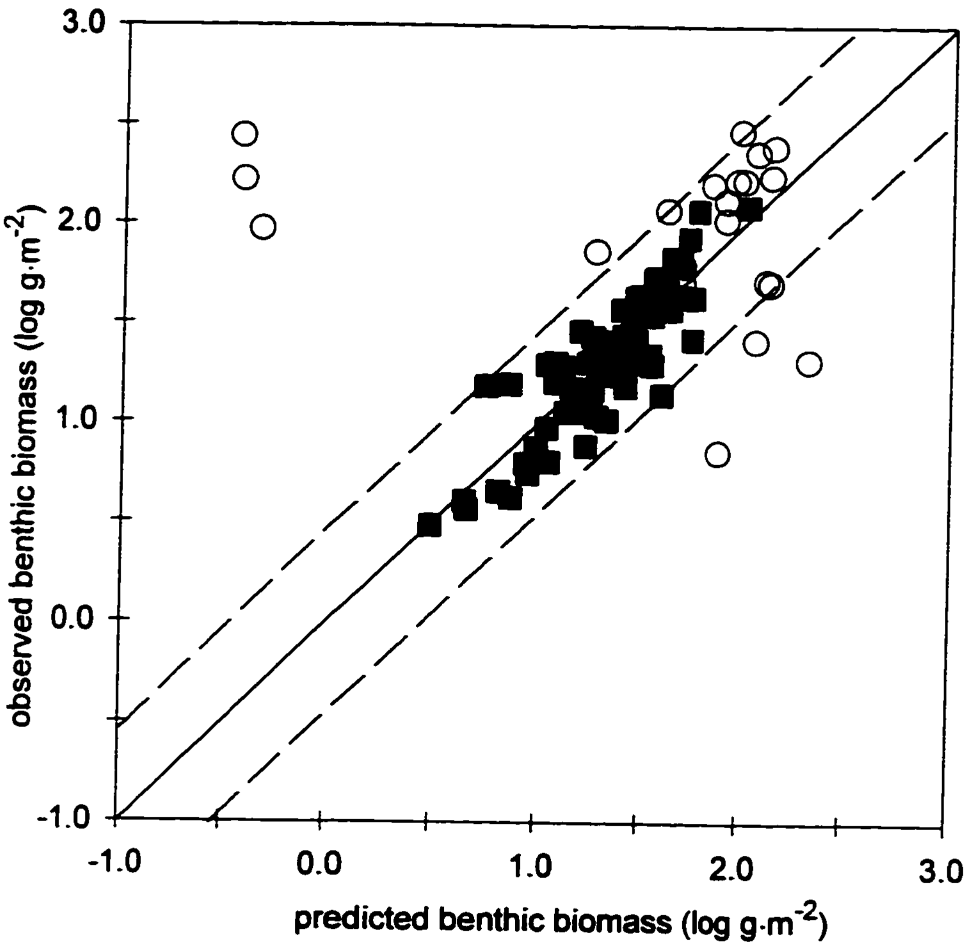

Figure 2.8. Observed and predicted littoral benthic biomass (LZB) from lakes located in Alberta (O; this study) and around the world (■; Rasmussen 1988). The regression line and 95% confidence intervals are from Rasmussen (1988) and do not include the Alberta lakes.

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Chapter 3

3.1 General Discussion and Conclusions

Dosages of 225 and 295 $g{\cdot}m^{-2}$ (74 and 107 $mg{\cdot}L^{-1}$) $Ca(OH)_2$ to two eutrophic hardwater lakes had no detectable effect on benthic macroinvertebrate densities and biomass one to two years after treatment compared to pre-treatment conditions or untreated reference lakes. However, *a posterior* power analyses of my data indicated low statistical power (< 50 %), suggesting that natural processes in lakes and ponds may obscure smaller impacts of $Ca(OH)_2$ treatment. High interannual variability in benthic macroinvertebrate communities were observed in the three reference lakes. Other field studies have also reported low statistical power due to complex ecosystem dynamics (e.g. Barnthouse et al. 1983; Toft and Shea 1983). These results emphasize the importance of understanding physical, chemical, and biological responses of benthic fauna under natural conditions prior to whole-lake manipulations. Previous research has shown the importance of littoral slope, exposure to waves, calcium, chloride and chlorophyll *a* concentrations in determining benthic macroinvertebrate biomass in the littoral zone of lakes on a world-wide scale, however, my study indicates other factors are likely also important for lakes in the boreal plains. Hence, it is important to investigate the relationship between benthic macroinvertebrate communities and environmental variables on a local scale, prior to predicting possible treatment effects from lake remediation. However, the absence of an effect on benthic macroinvertebrate densities in my study were similar to findings by Sakar and Konar (1984) who found that the addition of 225 $g{\cdot}m^{-2}$ agriculture lime to hardwater ponds in Kalyani, India did not effect densities of benthic organisms pre- and 90-d post-treatment.

Laboratory experiments corroborated findings of my field results in that dosages ≤ 200 $g{\cdot}m^{-2}$ had no impact on the survival of *Chironomus* spp. and *Hyalella azteca* when pH < 10. *Chironomus* spp. survival remained unaffected by water-column pH up to 11 and 300 $g{\cdot}m^{-2}$ $Ca(OH)_2$ in laboratory microcosms, however, at this dosage *H. azteca* survivorship was 25% when pH = 10. The discrepancies between field and laboratory experiments in the response of *H. azteca* to moderate $Ca(OH)_2$ dosages (295 or 300 $g{\cdot}m^{-2}$)

were likely because pH increased to ≥ 10 in the laboratory but not in the field experiments. Although much is known about the ecological impact of water pH 7 to 10 on zooplankton communities both *in situ* and in laboratory conditions (Bogatova 1962; Ivanova and Klekowski 1972; O'Brien and DeNoyelles 1972; Hansen et al. 1991), the effects of water column pH 7 to 10 on benthic macroinvertebrates has received little attention. Interestingly, both amphipods and cladocerans have similar habitat and respiratory characteristics that may explain their increased mortality at pH ≥ 10: both organisms are found in the water column and possess gills that function in gas exchange. In my study, increased water-column pH (≥ 10) may have damaged amphipod gills, depressed filtering rates (Ivanova and Klekowski 1972) or altered their internal ionic balance, as was suggested by Cameron and Mangum (1983) for crustaceans.

Caution should be exercised when laboratory results are extrapolated to the field, as the spatial and the temporal scale of the two experiments differ (Carpenter 1996). In my study, microcosms prevented emigration by benthic macroinvertebrates and thus likely increased their exposure to pH excursions during $Ca(OH)_2$ treatment compared to lakes and ponds. The greater water-column depth *in situ* compared to the laboratory may also provide areas of refugia for organisms that migrate between the sediment and water column (e.g. amphipods). Carpenter (1996) and others (Jaeffee 1996; Lawton 1996) noted other drawbacks to the utility of microcosms such as the neglect of community dynamics and over-simplification from the full complexity of nature. Yet, I support the view of Kareiva (1994) and Drake et al. (1996) that laboratory experiments are necessary exploratory tools because they are cost-effective, can be adequately replicated, and are efficient at isolating and quantifying processes which would be difficult to elucidate under field conditions. In my study, laboratory bioassays provided useful predictions about appropriate $Ca(OH)_2$ dosages to apply to lakes and ponds when complimented with field studies.

My study showed that $Ca(OH)_2$ dosages of 225 and 295 $g \cdot m^{-2}$ (74 and 107 $mg \cdot L^{-1}$) in two eutrophic hardwater lakes had no detectable deleterious effects on benthic macroinvertebrate biomass and density when water-column pH < 10. However, despite the high buffering capacity of hard waters, dosages of 300 $g \cdot m^{-2}$ (1425 $mg \cdot L^{-1}$) $Ca(OH)_2$ have the potential to raise pH ≥ 10. This increase in pH may reduce densities of benthic macroinvertebrates. Where maintenance of benthic macroinvertebrate community structure is a concern, lake managers should apply dosages of $Ca(OH)_2$ that maintain pH < 10. In hardwater lakes pH is unlikely to increase above 10, except in extremely small water bodies. It takes several days to apply $Ca(OH)_2$ to most hardwater lakes based on current technology and thus pH is unlikely to rise above 10. By considering the environmental factors that influence littoral benthic macroinvertebrate communities in eutrophic hard waters, lake managers can develop criteria for lake remediation while preventing unwanted impacts on benthic organisms.

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Chapter 4

Appendices

Appendix A:

Statisical analysis of subsampling methods for macroinvertebrate abundance.

Table A1. Summary statistics (*F*-values) of one-way ANOVAs comparing mean macroinvertebrate abundance between transects within each study lake in 1991. total = all taxa pooled; chir = chironomids; chao = chaoborids; amph = amphipods; cerolioth = ceratopogonids, oligochaetes, and all other taxa.

Taxonomic Group	Lofty (df = 2, 62)	N. Halfmoon (df = 2, 76)	Jenkins (df = 2, 52)	Crooked (df = 2, 59)	Baptiste (df = 2, 48)
total	0.6	0.4	6.4*	0.0	4.6
chir	1.9	0.6	8.6*	0.0	2.1
chao	0.1	0.8	0.2	0.7	1.8
amph	0.6	0.4	0.1	2.0	0.2
cerolioth	0.2	0.4	4.1	0.1	0.9

* Bonferroni-adjusted probability, $P < 0.05$

Table A2. Index of dispersion ($I_{df=(n-1)} = \chi^2_{df=(n-1), \alpha=0.05} = \frac{s^2(n-1)}{\bar{x}}$) and subsample counts for total macroinvertebrates in five random samples from the study lakes. $\chi^2_{(df=3)} = 7.82$.

Sample number	1	2	3	4	total	I
1	21	24	25	29	99	1.3
2	9	17	13	8	47	4.3
3	26	35	31	30	122	1.3
4	22	54	52	46	174	15.0*
5	43	34	39	48	164	2.5

* $P < 0.05$

Appendix B:

Littoral benthic macroinvertebrate biomass and water chemistry from Alberta lakes used in multiple regression analysis.

Table B1. Mean environmental variables and littoral benthic biomass (LZB) for ten Alberta lakes used in multiple regression analysis. [*] = data obtained from this study (1991 to 1993); [$] = data obtained from Bidgood (1972) and Mitchell and Prepas (1990). Bottom slope and area exposed to waves were determined with bathymetric maps as described by Rasmussen (1988).

Lake	Maximum Depth (m)	Slope (%)	Exposure (km^2)	Calcium (mg/L)	Chloride (mg/L)	Chlorophyll *a* (µg/L)	LZB (g/m^2)
Jenkins[*]	17.2	3.7	1.30	31.3	1.8	10.6	61.6
Jenkins[*]	17.2	3.7	1.30	28.7	1.6	6.5	116.7
Jenkins[*]	17.2	3.7	1.30	28.4	1.9	12.3	50.0
Crooked[*]	9.5	2.3	0.10	33.5	2.2	12.9	293.7
Crooked[*]	9.5	2.3	0.10	29.4	0.6	15.8	243.7
Crooked[*]	9.5	2.3	0.10	28.7	1.9	12.1	166.5
Baptiste[*]	27.5	19.0	2.30	32.7	2.0	11.0	273.7
Baptiste[*]	27.5	19.0	2.30	34.9	1.9	18.3	92.7
Baptiste[*]	27.5	19.0	2.30	29.7	2.1	13.5	166.7
Lofty[*]	5.5	4.8	0.17	29.6	1.7	13.4	133.0
Lofty[*]	5.5	4.8	0.17	24.0	2.0	12.7	156.9
Lofty[*]	5.5	4.8	0.17	26.3	1.9	44.4	228.7
N. Halfmoon[*]	6.6	0.6	0.09	23.6	2.3	17.6	25.9
N. Halfmoon[*]	6.6	0.6	0.09	28.1	2.0	19.9	173.8
N. Halfmoon[*]	6.6	0.6	0.09	27.2	2.2	22.5	49.9
Sturgeon[$] (main basin)	9.5	1.0	17.80	15.0	1.0	45.2	71.7
Sturgeon[$] (west basin)	3.0	0.1	1.50	15.0	1.0	38.8	20.6
Eagle[$]	4.9	0.3	3.20	29.0	30.0	39.5	105.3
Reesor[$]	5.5	6.0	0.37	28.0	1.0	14.0	7.0
Buck[$]	12.2	1.5	0.20	23.0	2.0	18.1	166.0
Pigeon[$]	9.1	0.7	0.40	26.0	1.0	12.8	51.4

Appendix C:

Benthic macroinvertebrate densities in treated and reference lakes from 1991-1993.

Table C1. Number of individuals per Ekman grab (15 x 15 x 23 cm) of major taxa in the five study lakes from 1991 to 1993. Lofty = 1; North Halfmoon = 2; Jenkins = 3; Crooked = 4; and Baptiste = 5.

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
1	91	5	13	A	1	12	1	16	0	0	2	31
1	91	5	13	A	1	5	6	175	0	0	0	186
1	91	5	13	A	3	13	4	0	0	5	0	22
1	91	5	13	A	3	11	27	3	0	0	0	41
1	91	5	13	A	5	1	28	0	0	0	0	29
1	91	5	13	A	5	10	40	2	0	0	0	52
1	91	5	13	B	1	5	0	0	0	0	0	5
1	91	5	13	B	1	24	6	90	0	0	0	120
1	91	5	13	B	3	27	11	9	0	0	1	48
1	91	5	13	B	3	22	9	10	0	0	4	45
1	91	5	13	B	5	33	17	19	0	0	0	69
1	91	5	13	B	5	0	24	12	0	0	0	36
1	91	5	13	B	5	19	23	0	0	0	0	42
1	91	5	13	C	1	48	43	92	0	0	6	189
1	91	5	13	C	1	31	0	0	0	0	0	31
1	91	5	13	C	3	9	28	0	0	0	0	37
1	91	5	13	C	5	14	41	0	0	0	0	55
1	91	5	13	DEEP	5.5	0	51	0	0	0	0	51
1	91	5	13	DEEP	5.5	0	52	3	0	0	0	55
1	91	6	3	A	3	1	5	0	0	0	0	6
1	91	6	3	A	5	11	11	0	0	0	0	22
1	91	6	3	B	1	12	0	6	0	0	0	18
1	91	6	3	B	3	12	6	0	0	0	1	19
1	91	6	3	B	5	14	9	0	0	0	0	23
1	91	6	3	C	1	56	3	27	0	0	0	86
1	91	6	3	C	3	14	8	0	0	0	0	22
1	91	6	3	C	3	5	1	0	0	0	0	6
1	91	6	3	C	3	18	14	10	0	0	0	42
1	91	6	3	C	5	1	48	3	0	0	0	52
1	91	6	3	C	5	5	12	0	0	0	6	23
1	91	6	17	A	3	208	3	3	0	0	0	214

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
1	91	6	17	A	5	0	1	0	0	0	0	1
1	91	6	17	B	1	24	1	13	0	0	0	38
1	91	6	17	B	3	57	17	9	0	0	0	83
1	91	6	17	B	3	205	6	10	0	0	0	221
1	91	6	17	B	5	911	7	0	0	0	0	918
1	91	6	17	C	1	17	2	19	0	0	2	40
1	91	6	17	C	3	299	12	6	0	0	0	317
1	91	6	17	C	5	12	6	0	0	0	0	18
1	91	7	8	A	1	63	0	130	0	0	0	193
1	91	7	8	A	3	64	11	0	1	0	0	76
1	91	7	8	A	5	0	30	0	0	0	0	30
1	91	7	8	B	1	29	8	27	0	0	0	64
1	91	7	8	B	3	291	32	48	0	1	0	372
1	91	7	8	B	5	0	43	0	0	0	3	46
1	91	7	8	C	1	123	0	71	0	0	0	194
1	91	7	8	C	1	202	5	101	0	0	0	308
1	91	7	8	C	3	210	22	182	0	0	4	418
1	91	7	8	C	5	3	26	0	0	0	1	30
1	91	7	8	C	5	359	5	7	0	0	1	372
1	91	7	31	A	1	102	21	297	0	0	10	430
1	91	7	31	A	5	11	33	5	0	0	0	49
1	91	7	31	B	1	3	14	70	0	0	4	91
1	91	7	31	B	3	51	13	18	1	0	1	84
1	91	7	31	B	3	26	49	9	1	0	0	85
1	91	7	31	C	1	24	6	39	0	0	3	72
1	91	7	31	C	3	52	7	6	0	0	1	66
1	91	7	31	C	3	68	15	25	0	0	2	110
1	91	7	31	C	5	19	17	3	0	0	0	39
1	91	7	31	DEEP	5.5	6	45	3	0	0	0	54
1	91	7	31	DEEP	5.5	1	14	3	0	0	0	18
1	91	8	19	A	1	8	9	65	0	0	1	83

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
1	91	8	19	A	3	32	17	1	0	0	1	51
1	91	8	19	A	5	49	33	0	0	0	0	82
1	91	8	19	B	1	32	4	80	0	0	5	121
1	91	8	19	B	3	70	10	157	0	0	0	237
1	91	8	19	B	5	24	32	0	0	0	0	56
1	91	8	19	C	3	22	1	2	0	0	2	27
1	91	8	19	C	5	34	34	0	0	0	0	68
1	91	8	19	DEEP	5.5	2	58	0	0	0	0	60
1	91	8	19	DEEP	5.5	0	33	0	0	0	1	34
2	91	5	13	A	1	17	0	0	0	0	0	17
2	91	5	13	A	3	3	52	0	1	0	1	57
2	91	5	13	A	5	4	21	0	0	0	0	25
2	91	5	13	B	1	25	0	0	0	0	0	25
2	91	5	13	B	3	2	0	0	0	0	0	2
2	91	5	13	B	5	3	3	0	0	0	0	6
2	91	5	13	C	1	20	0	0	0	0	0	20
2	91	5	13	C	3	3	6	0	0	0	0	9
2	91	5	13	C	5	2	16	0	0	0	0	18
2	91	5	13	DEEP	6	3	17	0	4	0	0	24
2	91	6	3	A	1	4	0	27	0	0	3	34
2	91	6	3	A	1	7	1	0	0	2	1	11
2	91	6	3	A	3	0	0	0	1	0	1	2
2	91	6	3	A	3	5	7	0	0	0	0	12
2	91	6	3	A	5	3	13	0	0	0	0	16
2	91	6	3	B	1	0	0	0	0	0	0	0
2	91	6	3	B	1	0	0	0	0	1	0	1
2	91	6	3	B	3	1	0	0	0	0	0	1
2	91	6	3	B	5	2	29	0	2	0	0	33
2	91	6	3	B	5	0	54	0	2	0	0	56
2	91	6	3	C	1	4	1	0	0	1	0	6
2	91	6	3	C	1	0	1	0	0	0	0	1

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
2	91	6	3	C	1	1	7	0	0	0	0	8
2	91	6	3	C	3	2	3	0	0	0	0	5
2	91	6	3	C	5	1	52	0	1	0	0	54
2	91	6	17	A	1	5	2	0	0	0	0	7
2	91	6	17	A	3	7	0	0	0	0	0	7
2	91	6	17	A	3	13	8	0	0	0	2	23
2	91	6	17	A	5	2	19	0	2	0	0	23
2	91	6	17	B	1	16	5	1	0	0	0	22
2	91	6	17	B	1	24	1	13	0	0	0	38
2	91	6	17	B	3	57	17	9	0	0	0	83
2	91	6	17	B	3	205	6	10	0	0	0	221
2	91	6	17	B	3	2	0	0	0	0	0	2
2	91	6	17	B	5	14	18	0	0	0	0	32
2	91	6	17	B	5	2	25	0	2	0	0	29
2	91	6	17	B	5	10	7	0	0	0	0	17
2	91	6	17	C	1	17	1	19	0	0	0	37
2	91	6	17	C	1	9	0	0	0	0	1	10
2	91	6	17	C	3	299	12	6	0	0	0	317
2	91	6	17	C	3	29	2	0	1	0	0	32
2	91	6	17	C	3	25	0	0	0	0	0	25
2	91	6	17	C	5	12	6	0	0	0	0	18
2	91	7	8	A	1	29	0	0	1	10	2	42
2	91	7	8	A	3	39	6	0	0	79	1	125
2	91	7	8	A	5	1	0	0	1	1	1	4
2	91	7	8	B	1	12	0	0	0	8	0	20
2	91	7	8	B	1	5	0	0	2	6	0	13
2	91	7	8	B	3	20	3	0	0	1	2	26
2	91	7	8	B	5	2	9	0	3	2	0	16
2	91	7	8	B	5	2	1	0	0	1	0	4
2	91	7	8	C	1	30	1	0	0	93	4	128
2	91	7	8	C	3	0	0	0	0	0	0	0

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
2	91	7	8	C	5	1	3	0	0	2	1	7
2	91	7	8	DEEP	0	0	0	0	0	0	0	0
2	91	7	31	A	1	3	0	0	0	0	0	3
2	91	7	31	A	1	104	2	297	0	0	10	413
2	91	7	31	A	1	0	0	0	0	0	0	0
2	91	7	31	A	3	0	0	0	0	0	0	0
2	91	7	31	A	5	11	3	5	0	0	0	19
2	91	7	31	A	5	2	12	0	0	0	0	14
2	91	7	31	B	1	3	14	70	0	0	4	91
2	91	7	31	B	3	51	13	18	1	0	1	84
2	91	7	31	B	3	4	0	0	0	0	0	4
2	91	7	31	B	3	26	57	9	1	0	0	93
2	91	7	31	C	1	24	6	39	0	0	3	72
2	91	7	31	C	1	0	0	0	0	0	0	0
2	91	7	31	C	3	4	3	0	0	0	0	7
2	91	7	31	C	3	68	15	25	0	0	2	110
2	91	7	31	C	3	52	7	6	0	0	1	66
2	91	7	31	C	5	19	17	3	0	0	0	39
2	91	7	31	C	5	4	8	0	0	0	0	12
2	91	7	31	C	5	14	5	0	1	0	0	20
2	91	7	31	DEEP	5.5	1	14	3	0	0	0	18
2	91	7	31	DEEP	5.5	6	45	3	0	0	0	54
2	91	7	31	DEEP	5.5	2	91	0	3	0	0	96
2	91	8	19	A	1	0	0	0	0	0	0	0
2	91	8	19	A	3	9	0	0	0	0	0	9
2	91	8	19	A	5	4	21	0	0	0	0	25
2	91	8	19	B	1	1	5	0	0	0	0	6
2	91	8	19	B	3	2	26	0	0	0	0	28
2	91	8	19	C	1	18	0	0	0	0	0	18
2	91	8	19	C	3	2	0	0	0	0	0	2
2	91	8	19	C	5	27	13	0	0	0	0	40

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
2	91	8	19	DEEP	5.5	0	20	0	1	0	0	21
2	91	8	19	DEEP	5.5	0	19	0	0	0	0	19
3	91	5	14	A	1	0	0	28	0	5	1	34
3	91	5	14	A	3	20	0	27	1	11	3	62
3	91	5	14	A	5	0	0	15	0	3	3	21
3	91	5	14	A	7	15	2	2	12	0	0	31
3	91	5	14	B	3	16	0	2	0	0	0	18
3	91	5	14	B	5	14	0	8	3	7	1	33
3	91	5	14	B	7	30	1	1	0	1	0	33
3	91	6	4	A	5	0	0	0	0	1	0	1
3	91	6	4	A	5	27	0	7	1	6	0	41
3	91	6	4	A	7	46	1	2	3	8	3	63
3	91	6	4	B	3	5	8	0	0	8	1	22
3	91	6	4	B	5	17	0	10	3	47	81	158
3	91	6	4	B	9	17	0	0	1	1	12	31
3	91	6	4	C	1	14	0	54	4	37	4	113
3	91	6	4	C	3	13	0	14	5	98	12	142
3	91	6	4	C	5	12	16	0	9	3	34	74
3	91	6	4	C	6	17	4	0	0	4	2	27
3	91	6	4	DEEP	15	2	13	0	1	1	0	17
3	91	6	4	DEEP	15	12	56	0	0	3	0	71
3	91	6	18	A	3	0	0	6	1	3	0	10
3	91	6	18	A	3	0	0	10	0	2	0	12
3	91	6	18	A	5	1	0	0	2	1	1	5
3	91	6	18	A	5	1	0	6	2	4	1	14
3	91	6	18	A	7	27	0	2	1	6	0	36
3	91	6	18	B	5	16	0	9	2	9	3	39
3	91	6	18	C	1	2	0	4	0	2	0	8
3	91	6	18	C	5	16	0	0	12	3	0	31
3	91	6	18	DEEP	13	3	12	0	0	1	0	16
3	91	6	18	DEEP	13	4	13	0	0	1	0	18

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
3	91	7	9	A	3	5	1	1	11	7	1	26
3	91	7	9	A	3	79	0	248	1	176	25	529
3	91	7	9	A	5	5	0	3	0	6	0	14
3	91	7	9	B	5	37	0	7	9	71	6	130
3	91	7	9	B	5	25	7	2	1	0	3	38
3	91	7	9	C	1	17	0	418	1	3	3	442
3	91	7	9	C	1	462	0	23	13	81	131	710
3	91	7	9	C	1	862	0	37	9	524	52	1484
3	91	7	9	C	3	139	0	12	12	5	18	186
3	91	7	9	C	5	5	35	0	0	2	1	43
3	91	7	9	DEEP	12.5	5	27	0	0	3	0	35
3	91	8	1	A	1	18	0	44	0	0	1	63
3	91	8	1	A	3	1	0	3	0	0	0	4
3	91	8	1	A	5	5	11	2	0	0	0	18
3	91	8	1	B	1	21	0	5	0	1	3	30
3	91	8	1	B	3	5	1	3	0	3	1	13
3	91	8	1	B	5	10	0	1	0	0	0	11
3	91	8	1	B	5	45	3	33	1	18	0	100
3	91	8	1	C	1	18	0	1	38	22	0	79
3	91	8	1	C	3	3	1	21	5	2	5	37
3	91	8	1	C	5	11	0	12	3	14	0	40
3	91	8	1	DEEP	14.5	3	49	0	2	0	0	54
3	91	8	1	DEEP	14.5	4	50	0	0	1	0	55
3	91	8	20	A	3	4	2	21	0	32	0	59
3	91	8	20	A	5	3	19	0	1	0	0	23
3	91	8	20	A	5	5	40	0	3	0	1	49
3	91	8	20	A	7	8	37	0	0	6	1	52
3	91	8	20	B	1	21	0	331	5	35	30	422
3	91	8	20	B	3	35	0	2	0	44	14	95
3	91	8	20	B	5	11	0	0	0	14	2	27
3	91	8	20	C	1	4	0	11	1	46	3	65

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
3	91	8	20	C	3	101	4	6	4	23	16	154
3	91	8	20	C	5	133	0	1	0	7	0	141
3	91	8	20	DEEP	14	1	18	0	0	2	0	21
4	91	5	14	A	1	12	0	10	1	3	1	27
4	91	5	14	A	3	30	3	0	16	1	2	52
4	91	5	14	A	5	73	13	0	17	8	0	111
4	91	5	14	B	1	3	0	11	0	3	0	17
4	91	5	14	B	3	3	0	8	0	1	0	12
4	91	5	14	B	5	0	0	10	3	0	1	14
4	91	5	14	C	1	0	0	0	0	2	0	2
4	91	5	14	C	3	2	0	0	0	1	0	3
4	91	5	14	C	5	30	2	4	0	1	0	37
4	91	5	14	DEEP	7	65	38	0	0	15	0	118
4	91	5	14	DEEP	7	58	101	0	0	26	1	186
4	91	6	4	A	5	72	10	3	7	172	4	268
4	91	6	4	B	1	25	1	58	1	61	16	162
4	91	6	4	B	3	1	0	2	0	15	0	18
4	91	6	4	B	5	21	1	1	8	80	78	189
4	91	6	4	C	1	2	0	3	1	62	14	82
4	91	6	4	C	5	8	0	0	35	13	21	77
4	91	6	4	C	5	24	93	0	0	57	1	175
4	91	6	4	DEEP	9	34	90	0	0	38	3	165
4	91	6	4	DEEP	9	21	95	0	1	61	1	179
4	91	6	18	A	1	0	0	10	0	2	0	12
4	91	6	18	A	3	0	0	0	0	0	1	1
4	91	6	18	A	5	24	2	0	6	13	0	45
4	91	6	18	A	5	60	8	8	6	19	0	101
4	91	6	18	B	1	1	0	5	1	4	0	11
4	91	6	18	B	3	3	0	14	0	2	0	19
4	91	6	18	B	5	11	1	17	13	4	0	46
4	91	6	18	C	1	0	0	9	1	2	6	18

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
4	91	6	18	C	3	0	0	6	1	0	0	7
4	91	6	18	C	5	11	7	14	7	4	1	44
4	91	6	18	DEEP	9	18	44	0	1	10	1	74
4	91	6	18	DEEP	9	17	37	0	0	0	0	54
4	91	7	9	A	1	0	0	0	0	5	0	5
4	91	7	9	A	1	44	0	121	4	1	2	172
4	91	7	9	A	1	4	0	4	3	58	4	73
4	91	7	9	A	3	7	1	12	16	80	4	120
4	91	7	9	A	3	0	1	33	3	1	1	39
4	91	7	9	A	5	35	8	42	7	48	2	142
4	91	7	9	A	5	59	2	27	7	19	0	114
4	91	7	9	B	1	3	0	47	0	11	0	61
4	91	7	9	B	3	45	0	32	15	5	4	101
4	91	7	9	B	5	28	1	9	2	31	29	100
4	91	7	9	C	1	176	0	54	0	757	101	1088
4	91	7	9	C	3	4	1	124	9	113	181	432
4	91	7	9	C	3	8	0	20	4	12	2	46
4	91	7	9	C	3	13	1	0	3	4	1	22
4	91	7	9	C	5	2	0	6	6	9	1	24
4	91	7	9	DEEP	8	32	34	0	0	44	0	110
4	91	7	9	DEEP	8	29	29	0	0	51	0	109
4	91	8	1	A	1	0	0	0	8	0	2	10
4	91	8	1	A	3	0	0	0	2	0	1	3
4	91	8	1	A	5	39	5	12	3	0	4	63
4	91	8	1	A	5	47	3	43	3	5	0	101
4	91	8	1	A	7	4	2	0	0	2	0	8
4	91	8	1	B	3	1	1	0	0	0	0	2
4	91	8	1	B	5	30	1	21	2	20	0	74
4	91	8	1	C	1	4	0	26	0	1	2	33
4	91	8	1	C	3	2	1	28	2	2	0	35
4	91	8	1	C	5	6	1	8	0	10	0	25

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
4	91	8	1	C	5	33	9	5	7	18	0	72
4	91	8	1	DEEP	8.5	4	97	0	0	13	0	114
4	91	8	1	DEEP	8.5	3	123	0	0	23	0	149
4	91	8	20	A	1	3	0	187	2	70	0	262
4	91	8	20	A	3	1	0	7	4	0	1	13
4	91	8	20	A	5	40	64	1	15	22	0	142
4	91	8	20	B	1	0	1	46	0	11	0	58
4	91	8	20	B	3	2	0	104	1	102	2	211
4	91	8	20	B	5	9	26	15	18	4	0	72
4	91	8	20	C	1	7	0	123	1	30	6	167
4	91	8	20	C	3	1	5	10	0	0	0	16
4	91	8	20	C	3	6	5	13	7	2	0	33
4	91	8	20	C	5	10	51	3	18	25	0	107
4	91	8	20	DEEP	8	6	76	4	0	43	0	129
4	91	8	20	DEEP	8	13	92	5	0	39	0	149
5	91	5	15	A	3	3	0	44	0	33	0	80
5	91	5	15	A	3	4	0	53	0	7	7	71
5	91	5	15	A	5	16	0	33	0	0	1	50
5	91	5	15	B	5	186	3	41	10	2	18	260
5	91	5	15	B	8.5	200	7	13	0	31	5	256
5	91	5	15	C	3	73	0	10	0	4	1	88
5	91	5	15	C	3	9	0	37	0	0	4	50
5	91	5	15	C	5	104	0	88	2	1	13	208
5	91	5	15	DEEP	17	2	149	1	0	1	0	153
5	91	6	5	A	1	33	0	21	1	16	10	81
5	91	6	5	A	3	18	0	43	0	1	4	66
5	91	6	5	A	3	5	0	2	0	3	3	13
5	91	6	5	B	1	13	0	98	0	3	5	119
5	91	6	5	B	3	77	0	57	1	1	5	141
5	91	6	5	B	5	28	2	21	1	0	0	52
5	91	6	5	B	5	91	4	26	0	1	8	130

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
5	91	6	5	C	1	11	0	42	0	1	2	56
5	91	6	5	C	3	57	2	54	0	6	1	120
5	91	6	5	C	5	15	0	11	0	11	7	44
5	91	6	5	DEEP	16	4	117	0	0	0	0	121
5	91	6	5	DEEP	16	0	49	0	0	0	0	49
5	91	6	5	DEEP	18	1	94	0	0	0	0	95
5	91	6	19	A	1	3	0	14	1	1	0	19
5	91	6	19	A	3	5	0	27	1	2	1	36
5	91	6	19	A	7	54	18	0	0	22	0	94
5	91	6	19	B	1	3	0	37	0	10	5	55
5	91	6	19	B	3	51	0	11	0	0	6	68
5	91	6	19	B	5	50	0	36	0	0	5	91
5	91	6	19	C	1	2	0	7	0	6	1	16
5	91	6	19	C	3	0	0	25	0	0	0	25
5	91	6	19	C	5	32	1	51	0	0	8	92
5	91	6	19	DEEP	18	4	8	0	0	0	0	12
5	91	7	10	A	1	1	0	37	0	6	7	51
5	91	7	10	A	3	0	0	10	0	5	0	15
5	91	7	10	A	5	7	2	0	0	7	0	16
5	91	7	10	B	3	1	0	37	0	2	2	42
5	91	7	10	B	5	71	1	19	0	0	9	100
5	91	7	10	B	7	67	1	0	0	18	0	86
5	91	7	10	C	3	0	0	51	0	2	2	55
5	91	7	10	DEEP	22	2	4	0	0	0	0	6
5	91	7	30	A	1	1	0	5	0	10	2	18
5	91	7	30	A	3	0	0	51	0	6	1	58
5	91	7	30	A	5	3	0	4	0	1	3	11
5	91	7	30	B	1	0	0	0	331	1	0	332
5	91	7	30	B	3	1	0	136	0	2	1	140
5	91	7	30	B	5	12	0	4	0	0	0	16
5	91	7	30	C	1	2	0	16	0	2	0	20

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
5	91	7	30	C	3	5	0	47	0	2	0	54
5	91	7	30	C	5	36	0	0	0	1	0	37
5	91	7	30	C	5	37	0	0	0	1	0	38
5	91	7	30	DEEP	17	0	3	0	0	0	0	3
5	91	8	20	A	3	38	1	21	17	35	77	189
5	91	8	20	A	5	20	0	65	18	59	59	221
5	91	8	20	B	1	23	0	114	0	81	51	269
5	91	8	20	B	3	470	0	63	4	8	182	727
5	91	8	20	B	5	22	1	1	3	11	147	185
5	91	8	20	C	1	50	0	547	16	478	357	1448
5	91	8	20	C	3	57	0	228	0	37	42	364
1	92	5	12	A	1	13	0	36	0	1	4	54
1	92	5	12	A	1	16	2	47	0	6	3	74
1	92	5	12	A	3	22	32	24	1	1	7	87
1	92	5	12	A	3	49	5	15	0	1	3	73
1	92	5	12	B	1	450	63	25	0	5	3	546
1	92	5	12	B	1	539	58	36	0	4	13	650
1	92	5	12	B	3	11	23	4	0	0	0	38
1	92	5	12	B	3	8	22	9	0	0	2	41
1	92	5	12	B	5	0	73	0	0	0	1	74
1	92	5	12	B	5	4	72	1	0	0	0	77
1	92	5	12	C	1	11	1	29	2	7	17	67
1	92	5	12	C	1	13	3	33	0	12	3	64
1	92	5	12	C	3	17	12	15	0	0	4	48
1	92	5	12	C	3	26	11	8	0	0	4	49
1	92	6	8	A	1	3	1	41	1	0	1	47
1	92	6	8	A	1	2	0	114	0	0	6	122
1	92	6	8	A	3	28	3	15	1	3	0	50
1	92	6	8	A	3	33	5	22	0	0	1	61
1	92	6	8	A	5	2	10	1	0	0	0	13
1	92	6	8	A	5	6	3	3	0	3	0	15

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
1	92	6	8	B	1	7	0	44	0	6	0	57
1	92	6	8	B	1	14	8	79	5	21	4	131
1	92	6	8	B	3	10	6	7	0	0	0	23
1	92	6	8	B	3	14	7	10	0	2	1	34
1	92	6	8	B	5	0	11	0	0	0	0	11
1	92	6	8	B	5	1	10	0	0	0	0	11
1	92	6	8	C	1	53	0	248	0	9	9	319
1	92	6	8	C	1	67	0	423	0	9	30	529
1	92	6	8	C	1	75	0	210	0	22	38	345
1	92	6	8	C	3	98	11	68	0	0	0	177
1	92	6	8	C	3	115	8	3	0	0	0	126
1	92	6	8	C	5	0	15	0	0	0	0	15
1	92	6	8	C	5	0	29	0	0	0	0	29
1	92	6	8	DEEP	6.5	3	9	0	1	0	0	13
1	92	6	8	DEEP	6.5	0	13	0	0	0	0	13
1	92	7	3	A	1	9	1	248	1	75	12	346
1	92	7	3	A	1	9	0	84	0	3	11	107
1	92	7	3	A	3	17	20	32	1	2	6	78
1	92	7	3	A	3	238	10	309	2	7	9	575
1	92	7	3	A	5	50	16	11	0	0	4	81
1	92	7	3	A	5	72	11	26	0	0	6	115
1	92	7	3	B	1	18	0	59	0	0	1	78
1	92	7	3	B	1	29	0	137	0	0	17	183
1	92	7	3	B	3	7	0	68	0	1	14	90
1	92	7	3	B	3	6	3	54	0	0	8	71
1	92	7	3	B	5	144	1	71	0	4	2	222
1	92	7	3	B	5	46	7	21	0	0	1	75
1	92	7	3	C	1	133	4	157	0	0	9	303
1	92	7	3	C	1	117	4	774	0	42	0	937
1	92	7	3	C	3	113	4	134	0	1	7	259
1	92	7	3	C	3	176	4	178	0	0	7	365

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
1	92	7	3	C	5	3	2	1	0	0	0	6
1	92	7	3	C	5	0	5	7	0	0	0	12
1	92	7	3	DEEP	7	0	0	1	0	0	0	1
1	92	7	3	DEEP	7	0	1	0	0	0	1	2
1	92	7	16	A	1	72	0	337	1	18	7	435
1	92	7	16	A	1	52	0	228	0	32	12	324
1	92	7	16	A	3	3	1	51	0	0	2	57
1	92	7	16	A	3	58	8	21	0	0	4	91
1	92	7	16	A	5	39	4	3	0	0	2	48
1	92	7	16	A	5	70	9	8	0	0	1	88
1	92	7	16	B	1	23	2	259	0	4	6	294
1	92	7	16	B	1	6	1	91	0	0	1	99
1	92	7	16	B	3	13	0	12	0	0	12	37
1	92	7	16	B	3	15	3	65	0	1	7	91
1	92	7	16	B	5	63	8	9	0	0	2	82
1	92	7	16	B	5	16	4	3	0	0	0	23
1	92	7	16	C	1	209	0	294	0	1	21	525
1	92	7	16	C	1	83	0	101	0	1	5	190
1	92	7	16	C	3	12	5	27	0	0	2	46
1	92	7	16	C	3	32	6	63	0	0	2	103
1	92	7	16	C	5	8	3	3	0	0	1	15
1	92	7	16	C	5	9	9	1	0	0	0	19
1	92	7	16	DEEP	5.5	8	6	5	0	0	2	21
1	92	7	16	DEEP	5.5	20	0	3	0	0	2	25
1	92	7	31	A	1	0	0	933	0	0	20	953
1	92	7	31	A	1	0	0	752	0	4	8	764
1	92	7	31	A	3	3	2	86	0	0	2	93
1	92	7	31	A	3	3	5	54	0	0	2	64
1	92	7	31	A	5	3	4	1	0	0	0	8
1	92	7	31	A	5	4	9	15	0	0	4	32
1	92	7	31	C	1	382	1	216	0	0	9	608

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
1	92	8	19	A	1	2	0	154	1	0	14	171
1	92	8	19	A	1	12	0	464	0	4	12	492
1	92	8	19	A	3	3	1	78	0	0	1	83
1	92	8	19	A	3	1	0	149	0	0	1	151
1	92	8	19	A	5	26	0	3	0	0	0	29
1	92	8	19	A	5	51	0	4	0	0	4	59
2	92	5	11	A	3	18	11	0	0	9	0	38
2	92	5	11	A	5	26	140	0	1	0	0	167
2	92	5	11	B	3	4	4	0	0	1	0	9
2	92	5	11	B	3	15	1	2	0	5	1	24
2	92	5	11	B	5	18	39	0	2	0	1	60
2	92	5	11	B	5	13	27	0	1	0	0	41
2	92	5	11	B	6	17	33	0	1	2	0	53
2	92	5	11	B	6	26	62	0	0	0	1	89
2	92	5	11	C	2	404	1	0	0	1	2	408
2	92	5	11	C	3	8	7	0	0	3	2	20
2	92	5	11	C	3	225	0	0	0	0	4	229
2	92	5	11	C	5	23	25	0	0	0	3	51
2	92	5	11	C	5	5	3	0	0	1	1	10
2	92	5	11	C	5	27	15	0	2	0	0	44
2	92	6	2	A	1	4	0	0	0	0	4	8
2	92	6	2	A	1	64	4	4	0	16	12	100
2	92	6	2	A	3	60	17	0	1	40	1	119
2	92	6	2	A	3	20	5	0	1	16	0	42
2	92	6	2	A	5	5	26	0	0	0	1	32
2	92	6	2	A	5	28	33	0	0	8	1	70
2	92	6	2	B	5	6	91	0	0	3	0	100
2	92	6	2	C	1	45	1	22	1	0	2	71
2	92	6	2	DEEP	6	8	91	0	0	9	0	108
2	92	7	3	A	1	560	4	4	0	541	8	1117
2	92	7	3	A	1	0	0	0	0	0	0	0

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
2	92	7	3	A	3	299	16	21	8	782	62	1188
2	92	7	3	A	5	186	48	0	0	17	0	251
2	92	7	28	A	1	52	8	72	0	24	0	156
2	92	7	28	A	1	118	0	34	0	1081	16	1249
2	92	7	28	A	3	49	14	0	1	201	0	265
2	92	7	28	A	5	99	12	0	0	65	0	176
2	92	7	28	A	5	66	5	0	0	76	0	147
2	92	8	20	A	1	298	0	4	0	22	10	334
2	92	8	20	A	1	204	0	16	4	8	24	256
2	92	8	20	A	3	17	0	0	0	0	0	17
2	92	8	20	A	3	72	0	0	0	16	8	96
2	92	8	20	A	5	51	24	0	0	29	0	104
3	92	5	23	B	3	8	0	5	1	4	4	22
3	92	5	23	C	1	27	0	48	1	11	2	89
3	92	5	23	C	1	41	0	68	0	32	4	145
3	92	5	23	C	1	17	0	11	0	2	0	30
3	92	5	23	C	3	47	0	9	1	4	1	62
3	92	5	23	C	3	58	0	8	3	6	3	78
3	92	5	23	C	5	39	0	3	0	1	1	44
3	92	5	23	C	5	58	0	1	1	2	0	62
3	92	5	23	DEEP	16	0	96	0	0	3	1	100
3	92	6	7	A	1	61	0	15	7	99	6	188
3	92	6	7	A	1	47	1	36	3	139	5	231
3	92	6	7	A	3	30	0	0	0	8	19	57
3	92	6	7	A	3	3	1	0	1	1	0	6
3	92	6	7	A	5	4	1	0	0	2	1	8
3	92	6	7	A	5	0	0	0	0	0	1	1
3	92	6	7	A	5	8	1	0	1	17	2	29
3	92	6	7	B	1	12	2	33	18	5	5	75
3	92	6	7	B	1	2	0	0	1	16	5	24
3	92	6	7	B	1	10	0	5	0	7	4	26

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
3	92	6	7	B	3	2	1	1	1	0	3	8
3	92	6	7	B	3	11	0	7	1	27	5	51
3	92	6	7	B	5	14	7	0	4	18	0	43
3	92	6	7	B	5	14	1	1	1	6	0	23
3	92	6	7	C	1	86	0	4	1	31	24	146
3	92	6	7	C	1	70	0	3	1	20	9	103
3	92	6	7	C	3	63	1	7	19	45	0	135
3	92	6	7	C	3	27	0	4	2	14	5	52
3	92	6	7	C	5	10	4	0	0	3	2	19
3	92	6	7	C	5	11	1	1	3	13	0	29
3	92	6	7	DEEP	14	2	76	0	0	1	0	79
3	92	6	7	DEEP	14	0	1	0	0	0	0	1
3	92	6	7	DEEP	14	5	97	0	0	17	0	119
3	92	7	2	A	1	124	0	1038	65	125	20	1372
3	92	7	2	A	3	16	0	4	0	21	2	43
3	92	7	2	A	5	106	0	9	1	34	1	151
3	92	7	2	A	5	43	0	3	1	1	0	48
3	92	7	2	B	1	101	0	142	5	57	1	306
3	92	7	2	B	3	150	1	88	5	50	2	296
3	92	7	2	B	5	63	0	36	1	54	1	155
3	92	7	2	C	1	18	0	58	4	39	18	137
3	92	7	2	C	1	38	0	41	3	57	6	145
3	92	7	2	C	3	8	0	0	3	3	13	27
3	92	7	2	C	3	43	0	0	3	11	22	79
3	92	7	2	C	5	70	0	32	11	385	7	505
3	92	7	2	C	5	16	0	37	1	84	1	139
3	92	7	2	DEEP	17	7	15	1	0	54	0	77
3	92	7	2	DEEP	17	43	31	0	0	116	0	190
3	92	7	28	A	1	93	0	858	0	114	28	1093
3	92	7	28	A	1	483	1	867	1	178	105	1635
3	92	7	28	A	3	104	0	64	0	96	80	344

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
3	92	7	28	A	3	136	0	44	0	72	92	344
3	92	7	28	A	5	46	1	6	0	37	4	94
3	92	7	28	A	5	101	0	67	0	45	8	221
3	92	7	28	B	3	41	0	98	3	35	9	186
3	92	7	28	C	5	34	1	38	1	50	3	127
3	92	7	28	DEEP	17	3	39	0	0	1	1	44
3	92	8	22	A	1	15	0	43	0	29	6	93
3	92	8	22	A	1	32	0	112	0	56	8	208
3	92	8	22	A	3	118	0	33	0	36	25	212
3	92	8	22	A	3	376	0	136	0	86	96	694
3	92	8	22	A	5	227	4	76	0	156	20	483
3	92	8	22	A	5	56	0	18	0	27	2	103
3	92	8	22	B	5	17	0	175	0	12	5	209
3	92	8	22	C	1	68	0	111	4	20	1	204
3	92	8	22	DEEP	17	0	60	0	0	40	0	100
4	92	5	13	A	1	200	0	4	0	388	32	624
4	92	5	13	A	1	25	0	0	1	57	4	87
4	92	5	13	A	3	0	0	0	24	48	8	80
4	92	5	13	A	3	2	0	4	17	21	16	60
4	92	5	13	A	5	34	4	1	21	93	1	154
4	92	5	13	A	5	44	2	3	14	118	11	192
4	92	5	13	B	3	0	5	7	9	9	2	32
4	92	5	13	C	1	25	0	39	0	5	3	72
4	92	5	13	DEEP	9	61	68	2	0	71	2	204
4	92	6	7	A	1	40	0	0	1	38	28	107
4	92	6	7	A	1	69	0	4	4	40	12	129
4	92	6	7	A	3	6	1	0	1	3	4	15
4	92	6	7	A	3	24	4	0	43	151	97	319
4	92	6	7	A	5	28	6	16	17	87	10	164
4	92	6	7	B	1	1	0	1	0	42	0	44
4	92	7	1	A	1	758	0	0	0	695	0	1453

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
4	92	7	1	A	1	288	0	4	0	189	0	481
4	92	7	1	A	3	144	0	1	102	645	80	972
4	92	7	1	A	5	92	2	0	15	377	21	507
4	92	7	1	A	5	84	3	0	26	226	15	354
4	92	7	1	B	3	26	0	6	0	9	86	127
4	92	7	1	C	1	9	0	10	0	36	1	56
4	92	7	1	DEEP	14	194	42	1	6	108	5	356
4	92	7	14	A	1	9	0	20	0	46	36	111
4	92	7	14	A	1	32	0	4	0	33	0	69
4	92	7	14	A	3	15	53	13	27	208	33	349
4	92	7	14	A	3	48	24	8	44	1069	36	1229
4	92	7	14	A	5	55	96	0	2	211	4	368
4	92	7	14	A	5	15	25	0	0	53	0	93
4	92	7	14	B	1	2	0	29	0	50	5	86
4	92	7	14	C	3	3	0	30	0	2	2	37
4	92	7	14	DEEP	9.5	4	4	0	0	6	0	14
4	92	7	28	A	1	3	0	2	9	62	5	81
4	92	7	28	A	1	30	0	8	12	207	44	301
4	92	7	28	A	3	15	4	0	47	642	38	746
4	92	7	28	A	3	17	2	0	27	334	23	403
4	92	7	28	A	5	55	34	0	2	94	5	190
4	92	7	28	A	5	64	70	0	5	137	2	278
4	92	7	28	B	3	13	0	1	0	25	45	84
4	92	7	28	C	5	8	0	0	4	28	12	52
4	92	7	28	DEEP	9	17	28	0	0	10	4	59
4	92	7	28	DEEP	9	39	33	0	4	27	4	107
4	92	8	23	A	1	4	0	100	0	68	32	204
4	92	8	23	A	1	0	0	28	32	88	76	224
4	92	8	23	A	3	24	0	8	20	5	0	57
4	92	8	23	A	3	16	0	12	12	88	8	136
4	92	8	23	A	5	10	0	1	107	976	29	1123

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
4	92	8	23	A	5	9	0	0	36	1427	28	1500
4	92	8	23	B	3	24	0	4	3	35	104	170
4	92	8	23	C	1	314	0	24	2	40	25	405
4	92	8	23	DEEP	10	2	7	0	0	21	1	31
5	92	5	12	A	3	5	0	23	0	5	2	35
5	92	5	12	A	3	54	0	68	9	59	87	277
5	92	5	12	A	5	22	0	4	10	22	14	72
5	92	5	12	A	5	28	0	4	2	27	7	68
5	92	6	9	A	1	11	0	30	8	195	108	352
5	92	6	9	A	1	18	1	56	3	134	30	242
5	92	6	9	A	3	18	0	3	4	132	32	189
5	92	6	9	A	3	3	0	8	0	5	24	40
5	92	6	9	A	5	32	0	16	0	105	46	199
5	92	6	9	A	5	6	0	3	1	18	11	39
5	92	7	2	A	1	8	0	235	4	272	89	608
5	92	7	2	A	1	8	0	102	12	485	235	842
5	92	7	2	A	3	3	0	20	4	49	17	93
5	92	7	2	A	3	27	0	180	19	137	50	413
5	92	7	2	A	5	0	0	0	13	66	67	146
5	92	7	2	A	5	10	0	10	7	86	65	178
5	92	7	30	A	1	107	0	443	14	529	240	1333
5	92	7	30	A	1	94	0	671	2	246	149	1162
5	92	7	30	A	3	75	0	108	12	146	74	415
5	92	7	30	A	3	34	0	166	0	236	90	526
5	92	7	30	A	5	29	0	0	0	549	430	1008
5	92	7	30	A	5	83	0	2	0	35	53	173
5	92	8	18	A	1	20	0	125	0	29	24	198
5	92	8	18	A	1	7	0	104	0	4	16	131
5	92	8	18	A	3	3	0	18	0	7	0	28
5	92	8	18	A	3	9	0	28	2	44	3	86
5	92	8	18	A	5	39	0	5	0	155	51	250

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
5	92	8	18	A	5	74	0	6	5	245	101	431
1	93	5	11	A	1	23	2	16	3	2	3	49
1	93	5	11	A	1	16	0	33	2	3	2	56
1	93	5	11	A	3	39	0	2	0	1	0	42
1	93	5	11	A	3	64	3	5	0	0	0	72
1	93	5	11	A	5	22	1	0	0	0	0	23
1	93	5	11	A	5	29	1	3	1	0	0	34
1	93	6	8	A	1	4	0	20	1	35	21	81
1	93	6	8	A	1	0	0	6	0	0	0	6
1	93	6	8	A	3	25	0	0	0	0	3	28
1	93	6	8	A	3	26	0	2	0	0	1	29
1	93	6	8	A	5	6	0	0	0	0	0	6
1	93	6	8	A	5	12	0	0	0	0	0	12
1	93	7	6	A	1	52	0	627	5	44	11	739
1	93	7	6	A	1	175	0	823	0	5	13	1016
1	93	7	6	A	3	172	4	5	0	0	1	182
1	93	7	6	A	3	92	2	13	0	0	1	108
1	93	7	6	A	5	19	0	6	0	0	1	26
1	93	7	6	A	5	20	1	1	0	1	1	24
1	93	7	28	A	1	12	0	174	0	16	21	223
1	93	7	28	A	1	1	0	0	0	0	0	1
1	93	7	28	A	3	147	0	3	0	0	0	150
1	93	7	28	A	3	108	1	5	0	0	0	114
1	93	7	28	A	5	6	4	10	0	1	0	21
1	93	7	28	A	5	4	2	3	0	0	0	9
1	93	8	19	A	1	7	0	155	0	0	3	165
1	93	8	19	A	1	0	0	133	0	0	0	133
1	93	8	19	A	3	58	2	1	0	0	0	61
1	93	8	19	A	3	86	3	4	0	0	0	93
1	93	8	19	A	5	0	5	2	0	0	0	7
1	93	8	19	A	5	0	1	5	0	0	0	6

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
2	93	5	14	A	1	8	8	0	4	0	4	24
2	93	5	14	A	1	0	0	8	0	0	0	8
2	93	5	14	A	3	12	52	0	0	8	4	76
2	93	5	14	A	3	16	16	0	0	0	0	32
2	93	5	14	A	5	32	45	0	3	19	1	100
2	93	5	14	A	5	28	22	0	3	26	0	79
2	93	6	11	A	1.6	13	2	0	69	49	32	165
2	93	6	11	A	1.6	8	0	0	0	0	4	12
2	93	6	11	A	3	3	4	0	0	1	1	9
2	93	6	11	A	3	37	12	0	4	4	0	57
2	93	6	11	A	5	14	53	0	3	9	1	80
2	93	6	11	A	5	8	33	0	0	1	1	43
2	93	7	8	A	2.5	22	9	0	0	4	0	35
2	93	7	8	A	2.6	26	1	0	0	0	4	31
2	93	7	8	A	3	19	4	0	0	10	4	37
2	93	7	8	A	5	37	11	0	2	10	1	61
2	93	7	8	A	5	20	13	0	0	3	3	39
2	93	8	4	A	1	12	0	76	4	4	12	108
2	93	8	4	A	1	72	0	0	4	20	12	108
2	93	8	4	A	3	37	4	0	0	2	1	44
2	93	8	4	A	3	19	4	0	0	0	2	25
2	93	8	4	A	5	16	8	0	2	1	2	29
2	93	8	4	A	5	3	2	0	0	0	0	5
2	93	8	18	A	1	0	0	0	0	0	0	0
2	93	8	18	A	1	0	0	0	0	201	0	201
2	93	8	18	A	3	0	0	0	0	2	0	2
2	93	8	18	A	3	0	0	0	0	1	0	1
2	93	8	18	A	5	0	0	0	0	0	0	0
2	93	8	18	A	5	1	0	1	0	0	0	2
3	93	5	13	A	1	8	0	15	0	21	5	49
3	93	5	13	A	1	2	0	36	1	4	6	49

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
3	93	5	13	A	3	52	0	24	24	84	104	288
3	93	5	13	A	3	56	0	20	16	105	49	246
3	93	5	13	A	5	44	4	16	0	8	8	80
3	93	5	13	A	5	148	16	36	8	48	49	305
3	93	6	7	A	1	8	0	20	12	136	9	185
3	93	6	7	A	1	0	1	1	0	0	2	4
3	93	6	7	A	3	24	0	0	0	17	20	61
3	93	6	7	A	3	4	0	0	0	14	9	27
3	93	6	7	A	5	0	0	0	0	0	0	0
3	93	6	7	A	5	0	0	6	1	5	0	12
3	93	7	27	A	1	28	0	49	0	114	65	256
3	93	7	27	A	1	0	0	92	0	80	172	344
3	93	7	27	A	3	0	0	0	0	13	9	22
3	93	7	27	A	3	38	0	0	0	69	4	111
3	93	7	27	A	5	91	0	1	0	90	10	192
3	93	7	27	A	5	24	0	0	0	44	0	68
3	93	7	9	A	1	97	0	296	4	302	57	756
3	93	7	9	A	1	61	4	422	4	44	60	595
3	93	7	9	A	3	8	0	0	0	126	26	160
3	93	7	9	A	3	32	0	5	0	46	32	115
3	93	7	9	A	5	36	0	16	0	65	24	141
3	93	7	9	A	5	21	5	0	0	77	12	115
3	93	7	9	A	5	113	16	16	4	160	40	349
3	93	8	20	A	1	7	0	76	0	40	69	192
3	93	8	20	A	1	44	0	128	18	24	8	222
3	93	8	20	A	3	507	0	36	0	93	36	672
3	93	8	20	A	3	225	0	8	0	32	53	318
3	93	8	20	A	5	100	32	0	0	88	8	228
3	93	8	20	A	5	0	0	0	0	32	0	32
4	93	5	10	A	1	8	0	12	0	52	0	72
4	93	5	10	A	1	8	0	0	0	84	8	100

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
4	93	5	10	B	1	38	0	8	0	321	119	486
4	93	5	10	A	3	16	0	4	4	108	4	136
4	93	5	10	A	5	44	10	1	40	840	58	993
4	93	5	10	A	5	1	9	0	10	89	11	120
4	93	5	10	C	5	0	2	2	6	177	18	205
4	93	6	9	A	1	46	0	158	2	229	34	469
4	93	6	9	A	3	8	0	8	4	72	20	112
4	93	6	9	A	3	11	0	3	5	66	8	93
4	93	6	9	A	5	56	0	0	16	268	12	352
4	93	6	9	A	5	24	0	0	8	188	32	252
4	93	6	9	B	1	1	0	36	0	0	0	37
4	93	6	9	C	5	8	0	0	4	146	34	192
4	93	7	5	B	3	12	0	8	0	84	40	144
4	93	7	5	B	3	24	0	8	0	132	116	280
4	93	7	5	B	5	28	0	0	0	24	0	52
4	93	7	5	B	5	28	0	4	8	48	4	92
4	93	7	5	B	1	203	0	0	0	149	25	377
4	93	7	5	B	1	78	0	1	0	140	10	229
4	93	7	5	C	3.6	230	0	0	0	95	12	337
4	93	7	5	DEEP	9.3	11	44	0	7	133	1	196
4	93	7	26	A	1	444	0	60	0	2320	91	2915
4	93	7	26	A	1	550	0	137	0	324	104	1115
4	93	7	26	A	3	116	0	0	1	683	8	808
4	93	7	26	A	3	30	0	0	8	28	4	70
4	93	7	26	A	5	15	0	1	9	103	15	147
4	93	7	26	A	5	8	4	0	8	48	42	118
4	93	8	16	A	1	240	12	140	4	28	32	444
4	93	8	16	A	1	220	0	232	48	65	101	666
4	93	8	16	A	3	377	0	0	0	232	164	773
4	93	8	16	A	3	417	0	0	60	506	80	1063
4	93	8	16	A	5	9	1	0	45	645	10	710

Table C1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Chironomidae	Chaoboridae	Amphipoda	Ceratopogonidae	Oligochaeta	Other	Total
4	93	8	16	A	5	14	1	0	34	318	11	378
5	93	5	12	A	1	9	0	192	1	188	45	435
5	93	5	12	A	1	13	0	128	0	102	57	300
5	93	5	12	A	3	20	0	45	0	72	22	159
5	93	5	12	A	3	28	0	97	15	76	67	283
5	93	5	12	A	5	94	0	8	1	45	32	180
5	93	5	12	A	5	35	0	8	0	61	17	121
5	93	6	10	A	1	25	0	56	8	325	263	677
5	93	6	10	A	1	5	0	9	0	51	15	80
5	93	6	10	A	3	21	0	60	0	67	95	243
5	93	6	10	A	3	80	0	68	12	828	328	1316
5	93	6	10	A	5	7	0	6	0	2	7	22
5	93	6	10	A	5	14	0	20	0	34	53	121
5	93	7	7	A	1	5	0	55	1	71	300	432
5	93	7	7	A	1	7	0	152	0	2	200	361
5	93	7	7	A	3	6	0	37	7	11	41	102
5	93	7	7	A	3	43	0	17	10	60	52	182
5	93	7	7	A	5	6	0	30	2	47	19	104
5	93	7	7	A	5	4	0	82	6	39	19	150
5	93	7	29	A	1	477	0	126	0	0	4	607
5	93	7	29	A	1	67	0	20	0	7	12	106
5	93	7	29	A	3	29	0	248	6	330	426	1039
5	93	7	29	A	3	23	0	92	6	265	743	1129
5	93	7	29	A	5	44	0	20	9	53	48	174
5	93	7	29	A	5	82	0	20	8	45	48	203
5	93	8	17	A	1	31	0	417	4	52	65	569
5	93	8	17	A	1	47	0	219	1	28	111	406
5	93	8	17	A	3	127	0	12	8	38	71	256
5	93	8	17	A	3	23	0	14	5	70	7	119
5	93	8	17	A	5	36	0	10	5	19	31	101
5	93	8	17	A	5	144	0	207	20	20	106	497

Appendix D:

Benthic macroinvertebrate biomass estimates in treated and reference lakes from 1991-1993.

Table D1. Biomass estimates of major benthic macroinvertebrate taxa in the five study lakes from 1991 to 1993. Lakes: Lofty = 1; North Halfmoon = 2; Jenkins = 3; Crooked = 4; and Baptiste = 5. Taxa: Amph = Amphipoda; Chao = Chaoboridae; Cerat = Ceratopogonidae; Chir = Chironomidae; Olig = Oligochaeta; and Oth = 'other' taxa.

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight ($g \cdot m^{-2}$)	Dry Weight ($g \cdot m^{-2}$)
1	91	5	13	A	1	Amph	49.69	0.19
1	91	5	13	C	1	Amph	55.35	1.73
1	91	5	13	A	1	Chao	3.28	1.21
1	91	5	13	C	1	Chao	8.87	0.19
1	91	5	13	A	1	Chir	1.47	0.24
1	91	5	13	A	1	Chir	1.29	0.40
1	91	5	13	C	1	Chir	8.45	0.37
1	91	5	13	C	1	Chir	5.23	0.69
1	91	5	13	A	1	Olig + Oth	3.99	0.47
1	91	5	13	C	1	Olig + Oth	0.00	0.00
1	91	5	13	A	3	Amph	1.19	0.23
1	91	5	13	C	3	Amph	19.92	5.40
1	91	5	13	A	3	Cerat	2.62	0.52
1	91	5	13	A	3	Chao	8.32	1.26
1	91	5	13	C	3	Chao	4.09	0.86
1	91	5	13	C	3	Chao	8.54	1.19
1	91	5	13	A	3	Chir	6.78	0.60
1	91	5	13	A	3	Chir	7.63	0.19
1	91	5	13	C	3	Chir	8.01	0.94
1	91	5	13	A	3	Olig + Oth	63.29	25.93
1	91	5	13	A	5	Amph	2.37	0.00
1	91	5	13	C	5	Amph	8.13	4.69
1	91	5	13	A	5	Chao	12.24	1.21
1	91	5	13	A	5	Chao	6.27	0.49
1	91	5	13	A	5	Chao	10.65	0.70
1	91	5	13	C	5	Chao	11.94	0.82
1	91	5	13	A	5	Chir	0.80	0.68
1	91	5	13	A	5	Chir	4.08	0.13
1	91	5	13	C	5	Chir	5.14	0.62
1	91	5	13	C	5	Olig + Oth	0.21	0.00
1	91	6	3	C	1	Amph	21.57	0.08
1	91	6	3	C	1	Chao	1.44	0.52
1	91	6	3	C	1	Chir	6.53	0.66
1	91	6	3	C	1	Olig + Oth	0.05	0.00
1	91	6	3	A	3	Chao	3.14	1.77
1	91	6	3	C	3	Chao	0.70	0.12
1	91	6	3	C	3	Chao	2.78	0.08
1	91	6	3	C	3	Chir	10.02	0.58
1	91	6	3	C	3	Chir	2.75	0.33
1	91	6	3	A	5	Chao	3.60	0.30
1	91	6	3	C	5	Chao	4.59	0.45
1	91	6	3	A	5	Chir	8.84	0.33
1	91	6	3	C	5	Chir	4.22	0.59
1	91	6	3	C	5	Olig + Oth	13.23	1.26
1	91	6	17	C	1	Amph	8.60	0.28
1	91	6	17	C	1	Chao	0.97	0.27
1	91	6	17	C	1	Chir	1.44	0.36

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight (g·m⁻²)	Dry Weight (g·m⁻²)
1	91	6	17	C	1	Olig + Oth	0.68	0.10
1	91	6	17	A	3	Amph	2.51	0.27
1	91	6	17	C	3	Amph	2.37	0.25
1	91	6	17	C	3	Chao	1.12	0.61
1	91	6	17	A	3	Chir	49.33	0.08
1	91	6	17	C	3	Chir	68.05	0.19
1	91	6	17	A	3	Olig + Oth	0.05	0.05
1	91	6	17	C	5	Chao	3.57	0.02
1	91	6	17	C	5	Chir	6.93	2.53
1	91	7	8	A	1	Amph	7.10	3.37
1	91	7	8	C	1	Amph	8.48	0.65
1	91	7	8	C	1	Chao	0.21	0.20
1	91	7	8	A	1	Chir	2.14	0.11
1	91	7	8	C	1	Chir	5.43	0.31
1	91	7	8	C	1	Chir	5.28	6.64
1	91	7	8	A	1	Olig + Oth	3.20	0.21
1	91	7	8	C	1	Olig + Oth	17.16	1.21
1	91	7	8	C	1	Olig + Oth	0.00	0.00
1	91	7	8	C	3	Amph	1.48	0.57
1	91	7	8	C	3	Amph	68.02	0.07
1	91	7	8	A	3	Chao	2.65	0.88
1	91	7	8	C	3	Chao	1.08	0.00
1	91	7	8	A	3	Chir	48.89	0.34
1	91	7	8	C	3	Chir	0.94	6.05
1	91	7	8	C	3	Chir	68.90	0.05
1	91	7	8	A	3	Olig + Oth	21.88	2.15
1	91	7	8	C	3	Olig + Oth	94.78	16.69
1	91	7	8	C	5	Amph	8.34	4.81
1	91	7	8	C	5	Amph	24.62	0.61
1	91	7	8	A	5	Chao	4.07	0.03
1	91	7	8	C	5	Chao	3.67	0.09
1	91	7	8	C	5	Chao	0.82	0.27
1	91	7	8	C	5	Chir	120.36	3.40
1	91	7	8	C	5	Chir	4.39	0.22
1	91	7	8	C	5	Olig + Oth	3.04	0.21
1	91	7	31	A	1	Amph	95.15	0.68
1	91	7	31	C	1	Amph	22.90	0.91
1	91	7	31	A	1	Chao	0.47	0.49
1	91	7	31	C	1	Chao	2.52	0.29
1	91	7	31	A	1	Chir	25.98	0.38
1	91	7	31	C	1	Chir	31.33	1.23
1	91	7	31	A	1	Olig + Oth	1.73	0.10
1	91	7	31	C	1	Olig + Oth	0.94	0.10
1	91	7	31	C	3	Amph	14.42	2.30
1	91	7	31	C	3	Amph	6.51	1.60
1	91	7	31	C	3	Chao	2.28	0.02
1	91	7	31	C	3	Chao	1.99	0.00
1	91	7	31	C	3	Chir	30.23	4.99
1	91	7	31	C	3	Chir	74.53	0.65
1	91	7	31	C	3	Olig + Oth	1.78	0.10

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight ($g \cdot m^{-2}$)	Dry Weight ($g \cdot m^{-2}$)
1	91	7	31	C	3	Olig + Oth	19.84	2.05
1	91	7	31	A	5	Amph	11.18	9.21
1	91	7	31	C	5	Amph	4.68	0.39
1	91	7	31	A	5	Chao	5.95	0.40
1	91	7	31	C	5	Chao	3.70	0.38
1	91	7	31	A	5	Chir	12.49	2.12
1	91	7	31	C	5	Chir	10.35	0.34
1	91	7	31	C	5	Olig + Oth	2.78	0.21
1	91	8	19	A	1	Amph	1.31	0.05
1	91	8	19	A	3	Amph	0.26	1.90
1	91	8	19	A	3	Chao	2.73	0.23
1	91	8	19	C	3	Chao	0.47	0.60
1	91	8	19	A	3	Chir	21.20	0.60
1	91	8	19	C	3	Chir	14.27	0.86
1	91	8	19	A	3	Olig + Oth	3.67	0.31
1	91	8	19	C	3	Olig + Oth	48.70	2.20
1	91	8	19	A	5	Chao	6.46	0.28
1	91	8	19	C	5	Chao	8.71	0.00
1	91	8	19	A	5	Chir	8.61	0.55
1	91	8	19	C	5	Chir	18.53	0.97
1	92	5	12	A	1	Amph	22.36	4.88
1	92	5	12	A	1	Amph	39.15	2.36
1	92	5	12	C	1	Amph	21.73	2.94
1	92	5	12	C	1	Amph	25.98	2.26
1	92	5	12	A	1	Chao	1.21	1.42
1	92	5	12	C	1	Chao	4.78	0.68
1	92	5	12	C	1	Chao	1.36	0.58
1	92	5	12	A	1	Chir	2.15	0.47
1	92	5	12	C	1	Chir	2.57	0.84
1	92	5	12	C	1	Chir	1.42	1.00
1	92	5	12	A	1	Olig + Oth	48.91	5.25
1	92	5	12	A	1	Olig + Oth	1.26	0.05
1	92	5	12	A	3	Amph	17.69	2.36
1	92	5	12	A	3	Amph	20.00	0.55
1	92	5	12	A	3	Cerat	10.97	0.68
1	92	5	12	A	3	Chao	13.91	0.94
1	92	5	12	A	3	Chao	1.84	0.52
1	92	5	12	C	3	Chao	4.51	0.63
1	92	5	12	C	3	Chao	4.04	0.73
1	92	5	12	A	3	Chir	10.65	0.73
1	92	5	12	A	3	Chir	3.78	0.63
1	92	5	12	C	3	Chir	5.09	0.68
1	92	5	12	C	3	Chir	3.83	1.42
1	92	5	12	A	3	Olig + Oth	0.05	0.00
1	92	5	12	A	3	Olig + Oth	0.47	0.10
1	92	5	12	A	3	Olig + Oth	0.21	0.00
1	92	5	12	C	5	Amph	15.17	2.41
1	92	5	12	C	5	Amph	4.99	1.89
1	92	6	8	A	1	Amph	11.65	0.50
1	92	6	8	A	1	Amph	30.44	0.06

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight ($g \cdot m^{-2}$)	Dry Weight ($g \cdot m^{-2}$)
1	92	6	8	A	1	Cerat	0.05	0.00
1	92	6	8	A	1	Chao	0.37	0.26
1	92	6	8	A	1	Chir	1.05	0.00
1	92	6	8	A	1	Chir	0.58	0.47
1	92	6	8	A	1	Olig + Oth	1.42	0.10
1	92	6	8	A	1	Olig + Oth	0.10	0.05
1	92	6	8	A	3	Amph	15.01	0.01
1	92	6	8	A	3	Amph	5.41	2.91
1	92	6	8	C	3	Amph	32.33	3.40
1	92	6	8	C	3	Amph	4.78	3.19
1	92	6	8	A	3	Cerat	0.05	0.00
1	92	6	8	A	3	Chao	1.84	0.03
1	92	6	8	A	3	Chao	0.94	0.10
1	92	6	8	C	3	Chao	4.51	0.30
1	92	6	8	C	3	Chao	3.10	0.88
1	92	6	8	A	3	Chir	6.72	0.34
1	92	6	8	A	3	Chir	3.99	0.09
1	92	6	8	C	3	Chir	15.11	1.03
1	92	6	8	C	3	Chir	14.48	0.07
1	92	6	8	A	3	Olig + Oth	18.63	1.89
1	92	6	8	A	5	Amph	0.89	1.41
1	92	6	8	A	5	Amph	0.84	0.68
1	92	6	8	C	5	Amph	36.58	1.12
1	92	6	8	A	5	Chao	0.94	0.38
1	92	6	8	A	5	Chao	2.94	0.11
1	92	6	8	C	5	Chao	10.81	0.18
1	92	6	8	C	5	Chao	5.67	0.44
1	92	6	8	A	5	Chir	1.42	0.51
1	92	6	8	A	5	Chir	1.89	0.09
1	92	6	8	C	5	Chir	8.61	0.91
1	92	6	8	A	5	Olig + Oth	0.26	0.00
1	92	6	8	A	5	Olig + Oth	47.97	5.25
1	92	7	3	A	1	Amph	99.92	7.14
1	92	7	3	A	1	Amph	1.52	0.16
1	92	7	3	A	1	Cerat	1.47	0.00
1	92	7	3	A	1	Chao	46.18	3.15
1	92	7	3	A	1	Chao	0.21	0.00
1	92	7	3	A	1	Chir	0.68	0.00
1	92	7	3	A	1	Chir	0.00	0.00
1	92	7	3	A	1	Olig + Oth	0.05	0.00
1	92	7	3	A	1	Olig + Oth	15.53	1.26
1	92	7	3	A	3	Amph	65.08	0.88
1	92	7	3	A	3	Amph	13.33	6.86
1	92	7	3	C	3	Amph	37.16	0.07
1	92	7	3	C	3	Amph	23.93	2.35
1	92	7	3	A	3	Cerat	0.31	0.05
1	92	7	3	A	3	Cerat	4.93	0.58
1	92	7	3	A	3	Chao	2.47	0.19
1	92	7	3	A	3	Chao	3.36	0.23
1	92	7	3	C	3	Chao	1.15	0.09

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight (g·m^{-2})	Dry Weight (g·m^{-2})
I	92	7	3	C	3	Chao	2.31	0.04
I	92	7	3	A	3	Chir	9.50	1.30
I	92	7	3	A	3	Chir	1.57	0.14
I	92	7	3	C	3	Chir	3.46	0.04
I	92	7	3	C	3	Chir	5.09	0.19
I	92	7	3	A	3	Olig + Oth	0.63	0.16
I	92	7	3	A	3	Olig + Oth	0.21	0.00
I	92	7	3	A	5	Amph	10.92	0.97
I	92	7	3	A	5	Amph	3.20	1.24
I	92	7	3	C	5	Amph	0.89	0.19
I	92	7	3	C	5	Amph	3.73	1.61
I	92	7	3	A	5	Chao	2.36	0.25
I	92	7	3	A	5	Chao	2.62	0.14
I	92	7	3	C	5	Chao	0.89	0.09
I	92	7	3	C	5	Chao	1.47	0.04
I	92	7	3	A	5	Chir	21.57	0.82
I	92	7	3	A	5	Chir	24.98	0.09
I	92	7	3	C	5	Chir	0.84	1.56
I	92	7	3	A	5	Olig + Oth	1.00	0.16
I	92	7	3	A	5	Olig + Oth	1.31	0.10
I	92	7	3	A	5	Olig + Oth	0.05	0.05
I	92	7	16	A	1	Amph	60.67	0.17
I	92	7	16	A	1	Amph	0.42	0.00
I	92	7	16	C	1	Amph	48.33	0.31
I	92	7	16	C	1	Amph	16.79	3.37
I	92	7	16	A	1	Cerat	1.00	0.10
I	92	7	16	A	1	Chao	0.21	0.00
I	92	7	16	A	1	Chir	0.63	0.00
I	92	7	16	A	1	Chir	1.10	0.10
I	92	7	16	C	1	Chir	7.03	0.37
I	92	7	16	C	1	Chir	3.25	0.49
I	92	7	16	A	1	Olig + Oth	8.97	0.84
I	92	7	16	C	1	Olig + Oth	0.16	0.00
I	92	7	16	C	1	Olig + Oth	0.89	0.16
I	92	7	16	A	3	Amph	3.99	1.01
I	92	7	16	A	3	Amph	12.49	0.25
I	92	7	16	C	3	Amph	4.51	0.10
I	92	7	16	C	3	Amph	17.06	1.64
I	92	7	16	A	3	Chao	0.42	0.10
I	92	7	16	A	3	Chao	2.41	0.07
I	92	7	16	C	3	Chao	1.47	0.07
I	92	7	16	C	3	Chao	1.73	0.16
I	92	7	16	A	3	Chir	3.31	1.38
I	92	7	16	A	3	Chir	26.56	0.17
I	92	7	16	C	3	Chir	8.29	0.75
I	92	7	16	C	3	Chir	14.22	0.59
I	92	7	16	A	3	Olig + Oth	0.31	0.00
I	92	7	16	A	3	Olig + Oth	0.21	0.00
I	92	7	16	C	3	Olig + Oth	1.78	0.16
I	92	7	16	C	3	Olig + Oth	0.10	0.00

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight ($g \cdot m^{-2}$)	Dry Weight ($g \cdot m^{-2}$)
I	92	7	16	A	5	Amph	3.73	0.44
I	92	7	16	A	5	Amph	1.78	0.44
I	92	7	16	C	5	Amph	1.99	0.89
I	92	7	16	C	5	Amph	1.00	5.11
I	92	7	16	A	5	Chao	1.73	0.00
I	92	7	16	A	5	Chao	3.20	0.12
I	92	7	16	C	5	Chao	1.99	0.10
I	92	7	16	C	5	Chao	1.78	0.16
I	92	7	16	A	5	Chir	31.70	0.23
I	92	7	16	A	5	Chir	18.16	1.91
I	92	7	16	C	5	Chir	6.19	1.59
I	92	7	16	C	5	Chir	6.72	0.37
I	92	7	16	A	5	Olig + Oth	0.05	0.00
I	92	7	16	C	5	Olig + Oth	0.10	0.05
I	92	7	31	A	1	Amph	255.27	13.85
I	92	7	31	A	1	Amph	190.61	10.08
I	92	7	31	A	1	Chir	0.00	0.00
I	92	7	31	A	1	Olig + Oth	86.28	9.03
I	92	7	31	A	1	Olig + Oth	1.47	0.42
I	92	7	31	A	3	Amph	0.00	0.00
I	92	7	31	A	3	Amph	5.35	0.31
I	92	7	31	A	3	Chao	10.81	0.52
I	92	7	31	A	3	Chao	0.00	0.00
I	92	7	31	A	3	Chir	0.73	0.05
I	92	7	31	A	3	Chir	0.47	0.05
I	92	7	31	A	3	Olig + Oth	0.58	0.05
I	92	7	31	A	3	Olig + Oth	0.00	0.00
I	92	7	31	A	5	Amph	2.62	0.16
I	92	7	31	A	5	Amph	0.63	0.00
I	92	7	31	A	5	Amph	3.04	0.26
I	92	7	31	A	5	Chao	12.28	0.58
I	92	7	31	A	5	Chao	0.10	0.00
I	92	7	31	A	5	Chir	1.31	0.05
I	92	7	31	A	5	Chir	2.94	0.16
I	92	7	31	A	5	Olig + Oth	0.58	0.00
I	92	8	19	A	1	Amph	55.00	3.57
I	92	8	19	A	1	Amph	116.93	6.72
I	92	8	19	A	1	Cerat	0.21	0.00
I	92	8	19	A	1	Chir	0.63	0.21
I	92	8	19	A	1	Olig + Oth	17.84	3.57
I	92	8	19	A	1	Olig + Oth	31.49	4.41
I	92	8	19	A	3	Amph	41.98	2.31
I	92	8	19	A	3	Amph	0.16	0.00
I	92	8	19	A	3	Chao	2.52	0.21
I	92	8	19	A	3	Chir	0.63	0.05
I	92	8	19	A	3	Chir	101.29	3.83
I	92	8	19	A	3	Olig + Oth	29.23	1.68
I	92	8	19	A	3	Olig + Oth	0.10	0.00
I	92	8	19	A	5	Amph	0.00	0.00
I	92	8	19	A	5	Cerat	12.44	0.42

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight (g·m⁻²)	Dry Weight (g·m⁻²)
1	92	8	19	A	5	Chir	3.78	0.31
1	92	8	19	A	5	Chir	6.04	0.42
1	92	8	19	A	5	Olig + Oth	0.42	0.05
1	93	5	11	A	1	Amph	19.84	0.94
1	93	5	11	A	1	Amph	7.50	0.58
1	93	5	11	A	1	Cerat	1.31	0.05
1	93	5	11	A	1	Cerat	1.21	0.05
1	93	5	11	A	1	Chao	2.20	0.16
1	93	5	11	A	1	Chir	36.05	2.26
1	93	5	11	A	1	Chir	0.94	0.16
1	93	5	11	A	1	Olig + Oth	0.31	0.00
1	93	5	11	A	1	Olig + Oth	0.79	0.05
1	93	5	11	A	3	Amph	62.71	2.52
1	93	5	11	A	3	Chir	0.05	0.00
1	93	5	11	A	3	Olig + Oth	0.94	0.10
1	93	5	11	A	5	Amph	0.42	0.05
1	93	5	11	A	5	Chao	12.86	0.89
1	93	5	11	A	5	Chao	17.90	1.05
1	93	5	11	A	5	Chir	0.52	0.05
1	93	5	11	A	5	Chir	0.89	0.10
1	93	6	8	A	1	Amph	0.05	0.05
1	93	6	8	A	1	Amph	31.44	3.52
1	93	6	8	A	1	Cerat	3.04	0.16
1	93	6	8	A	1	Chir	13.54	0.89
1	93	6	8	A	1	Olig + Oth	0.05	0.00
1	93	6	8	A	3	Chir	2.52	0.16
1	93	6	8	A	3	Olig + Oth	20.05	1.15
1	93	6	8	A	5	Amph	0.94	0.10
1	93	6	8	A	5	Chir	3.31	0.16
1	93	6	8	A	5	Chir	4.30	0.16
1	93	6	8	A	5	Olig + Oth	0.84	0.05
1	93	7	6	A	1	Amph	169.83	8.40
1	93	7	6	A	1	Amph	224.20	10.50
1	93	7	6	A	1	Cerat	0.42	0.00
1	93	7	6	A	1	Chir	3.57	0.63
1	93	7	6	A	1	Chir	1.05	0.21
1	93	7	6	A	1	Olig + Oth	5.88	0.63
1	93	7	6	A	1	Olig + Oth	3.99	0.42
1	93	7	6	A	1	Olig + Oth	0.26	0.05
1	93	7	6	A	3	Amph	0.89	0.05
1	93	7	6	A	3	Amph	0.21	0.05
1	93	7	6	A	3	Chao	0.73	0.10
1	93	7	6	A	3	Chao	190.19	7.50
1	93	7	6	A	3	Chir	5.20	0.26
1	93	7	6	A	3	Chir	0.00	0.05
1	93	7	6	A	3	Olig + Oth	1.00	0.00
1	93	7	6	A	3	Olig + Oth	82.18	3.41
1	93	7	6	A	5	Amph	2.57	0.16
1	93	7	6	A	5	Amph	6.19	0.26
1	93	7	6	A	5	Chao	17.21	0.68

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight (g·m^{-2})	Dry Weight (g·m^{-2})
1	93	7	6	A	5	Chir	51.33	2.89
1	93	7	6	A	5	Chir	0.73	0.00
1	93	7	6	A	5	Olig + Oth	42.25	2.89
1	93	7	28	A	1	Amph	95.10	6.51
1	93	7	28	A	1	Chir	0.21	0.00
1	93	7	28	A	1	Chir	0.21	0.21
1	93	7	28	A	1	Olig + Oth	0.63	0.42
1	93	7	28	A	3	Amph	3.99	0.26
1	93	7	28	A	3	Amph	132.30	5.56
1	93	7	28	A	3	Chir	132.67	4.41
1	93	7	28	A	3	Chir	0.16	0.10
1	93	7	28	A	5	Amph	0.26	0.05
1	93	7	28	A	5	Amph	3.94	0.21
1	93	7	28	A	5	Chao	5.88	0.21
1	93	7	28	A	5	Chao	11.07	0.68
1	93	7	28	A	5	Chir	2.83	0.16
1	93	7	28	A	5	Chir	1.31	0.05
1	93	7	28	A	5	Olig + Oth	7.08	0.37
1	93	8	19	A	1	Amph	245.19	13.23
1	93	8	19	A	1	Amph	8.71	0.47
1	93	8	19	A	1	Chir	140.49	7.29
1	93	8	19	A	1	Olig + Oth	0.42	0.00
1	93	8	19	A	3	Amph	1.73	0.05
1	93	8	19	A	3	Amph	83.76	2.36
1	93	8	19	A	3	Chao	0.73	0.05
1	93	8	19	A	3	Chao	61.30	3.31
1	93	8	19	A	3	Chir	0.52	0.05
1	93	8	19	A	3	Chir	3.20	0.21
1	93	8	19	A	5	Amph	99.35	3.73
1	93	8	19	A	5	Amph	0.16	0.00
1	93	8	19	A	5	Chao	3.57	0.26
1	93	8	19	A	5	Chao	2.57	0.10
2	91	5	13	A	1	Amph	0.05	0.58
2	91	5	13	A	3	Cerat	1.26	0.26
2	91	5	13	A	3	Chao	32.85	0.47
2	91	5	13	C	3	Chao	1.89	1.10
2	91	5	13	A	5	Chao	8.82	0.42
2	91	5	13	C	5	Chao	20.21	0.05
2	91	5	13	C	5	Chao	5.88	1.52
2	91	5	13	C	5	Chao	16.27	0.00
2	91	5	13	A	1	Chir	1.00	0.00
2	91	5	13	C	1	Chir	0.73	0.47
2	91	5	13	A	3	Chir	7.14	0.10
2	91	5	13	C	3	Chir	1.73	0.00
2	91	5	13	A	5	Chir	5.51	0.58
2	91	5	13	C	5	Chir	0.58	0.10
2	91	5	13	C	5	Chir	0.68	0.05
2	91	5	13	C	5	Chir	1.00	0.05
2	91	5	13	C	5	Olig	0.26	0.00
2	91	5	13	A	3	Olig + Oth	3.52	1.89

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight (g·m^{-2})	Dry Weight (g·m^{-2})
2	91	6	3	A	1	Amph	15.74	0.21
2	91	6	3	A	1	Cerat	0.05	0.05
2	91	6	3	C	5	Cerat	0.16	0.10
2	91	6	3	A	1	Chao	0.00	1.26
2	91	6	3	C	1	Chao	0.05	0.00
2	91	6	3	C	1	Chao	1.26	0.00
2	91	6	3	C	1	Chao	1.42	0.00
2	91	6	3	A	3	Chao	0.16	0.00
2	91	6	3	C	3	Chao	0.84	0.00
2	91	6	3	A	5	Chao	3.73	0.10
2	91	6	3	C	5	Chao	20.89	0.00
2	91	6	3	A	1	Chir	0.05	0.00
2	91	6	3	A	1	Chir	0.31	0.00
2	91	6	3	A	3	Chir	0.26	0.16
2	91	6	3	C	3	Chir	0.21	1.73
2	91	6	3	A	5	Chir	2.99	0.31
2	91	6	3	C	5	Chir	1.99	0.00
2	91	6	3	C	1	Olig	0.26	0.00
2	91	6	3	A	1	Olig + Oth	0.05	5.51
2	91	6	3	A	1	Olig + Oth	0.00	0.05
2	91	6	3	C	1	Olig + Oth	47.81	0.05
2	91	6	17	C	3	Cerat	0.79	0.00
2	91	6	17	A	3	Chao	1.21	0.05
2	91	6	17	C	3	Chao	1.36	0.10
2	91	6	17	A	5	Chao	0.05	2.20
2	91	6	17	C	1	Chir	1.36	0.00
2	91	6	17	A	3	Chir	0.52	0.21
2	91	6	17	A	3	Chir	0.10	0.10
2	91	6	17	C	3	Chir	2.73	0.00
2	91	6	17	C	3	Chir	0.52	0.00
2	91	6	17	C	3	Chir	8.87	0.05
2	91	6	17	A	5	Chir	0.21	0.05
2	91	6	17	C	3	Olig	1.47	0.37
2	91	6	17	C	1	Olig + Oth	0.05	0.26
2	91	6	17	A	3	Olig + Oth	2.26	0.05
2	91	6	17	A	3	Olig + Oth	21.78	0.26
2	91	7	8	A	5	Cerat	0.26	0.10
2	91	7	8	C	1	Chao	1.61	0.37
2	91	7	8	A	3	Chao	2.05	0.10
2	91	7	8	C	3	Chao	1.57	0.09
2	91	7	8	A	5	Chao	0.37	0.00
2	91	7	8	C	1	Chir	1.68	0.05
2	91	7	8	A	3	Chir	0.52	0.05
2	91	7	8	A	1	Olig + Oth	0.94	0.05
2	91	7	8	C	1	Olig + Oth	0.26	0.05
2	91	7	8	C	1	Olig + Oth	0.00	0.05
2	91	7	8	C	1	Olig + Oth	0.16	0.00
2	91	7	8	A	3	Olig + Oth	1.15	0.16
2	91	7	8	A	5	Olig + Oth	0.42	0.16
2	91	7	8	C	5	Olig + Oth	0.10	0.05

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight ($g \cdot m^{-2}$)	Dry Weight ($g \cdot m^{-2}$)
2	91	7	31	C	3	Cerat	0.52	0.00
2	91	7	31	C	5	Cerat	0.16	0.00
2	91	7	31	C	3	Chao	1.42	0.26
2	91	7	31	A	5	Chao	1.21	0.00
2	91	7	31	C	5	Chao	3.25	0.21
2	91	7	31	C	5	Chao	3.41	0.10
2	91	7	31	A	1	Chir	0.00	0.00
2	91	7	31	A	1	Chir	0.10	0.05
2	91	7	31	C	3	Chir	6.98	0.16
2	91	7	31	A	5	Chir	0.79	0.00
2	91	7	31	C	5	Chir	12.96	0.42
2	91	7	31	C	5	Chir	4.57	0.63
2	91	7	31	C	5	Olig + Oth	0.05	0.16
2	91	7	31	C	1	Oth	0.26	0.00
2	91	8	19	C	5	Cerat	0.10	0.05
2	91	8	19	C	1	Chao	0.79	0.21
2	91	8	19	A	5	Chao	2.10	0.10
2	91	8	19	C	5	Chao	2.94	0.21
2	91	8	19	C	1	Chir	2.94	0.63
2	91	8	19	A	3	Chir	4.15	0.10
2	91	8	19	C	3	Chir	1.78	0.16
2	91	8	19	A	5	Chir	0.31	0.16
2	91	8	19	C	5	Chir	14.75	0.05
2	91	8	19	A	1	Olig + Oth	1.31	0.05
2	92	5	11	C	1	Chao	0.00	0.00
2	92	5	11	C	1	Chir	158.65	0.00
2	92	5	11	C	1	Olig + Oth	1.00	7.87
2	92	5	11	B	3	Amph	21.10	0.00
2	92	5	11	B	3	Chao	0.00	0.26
2	92	5	11	B	3	Chao	0.16	0.05
2	92	5	11	B	3	Chir	2.31	0.00
2	92	5	11	B	3	Chir	0.68	0.05
2	92	5	11	B	3	Olig + Oth	0.42	1.10
2	92	5	11	B	3	Olig + Oth	0.00	0.05
2	92	5	11	B	5	Cerat	0.26	0.52
2	92	5	11	C	5	Cerat	0.31	0.31
2	92	5	11	B	5	Chao	5.98	2.26
2	92	5	11	C	5	Chao	3.41	2.83
2	92	5	11	B	5	Chir	31.54	0.00
2	92	5	11	C	5	Chir	60.83	0.05
2	92	6	2	A	1	Amph	50.59	2.10
2	92	6	2	A	1	Chao	0.42	0.00
2	92	6	2	A	1	Chir	1.68	0.00
2	92	6	2	A	1	Chir	9.24	1.05
2	92	6	2	A	1	Olig + Oth	1.05	0.00
2	92	6	2	A	1	Olig + Oth	10.71	1.47
2	92	6	2	A	3	Cerat	0.00	0.00
2	92	6	2	A	3	Cerat	0.05	0.00
2	92	6	2	A	3	Chao	3.46	0.31
2	92	6	2	A	3	Chao	1.47	0.42

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight ($g \cdot m^{-2}$)	Dry Weight ($g \cdot m^{-2}$)
2	92	6	2	A	3	Chir	27.92	1.68
2	92	6	2	A	3	Chir	21.83	1.10
2	92	6	2	A	3	Olig + Oth	4.62	0.21
2	92	6	2	A	3	Olig + Oth	0.84	0.10
2	92	6	2	A	5	Chao	10.29	0.84
2	92	6	2	A	5	Chao	13.02	1.05
2	92	6	2	A	5	Chir	67.18	3.15
2	92	6	2	A	5	Chir	20.78	1.47
2	92	6	2	A	5	Olig + Oth	2.31	0.21
2	92	7	3	A	1	Amph	0.63	0.00
2	92	7	3	B	1	Amph	108.53	5.46
2	92	7	3	A	1	Chao	0.63	0.00
2	92	7	3	B	1	Chao	0.21	0.00
2	92	7	3	A	1	Chir	49.75	2.10
2	92	7	3	B	1	Chir	43.87	5.88
2	92	7	3	A	1	Olig + Oth	23.93	0.84
2	92	7	3	B	1	Olig + Oth	62.77	7.35
2	92	7	3	A	3	Amph	1.63	0.16
2	92	7	3	A	3	Amph	1.26	0.21
2	92	7	3	A	3	Cerat	0.00	0.00
2	92	7	3	A	3	Cerat	2.73	0.42
2	92	7	3	A	3	Chao	1.36	0.10
2	92	7	3	A	3	Chao	3.57	0.21
2	92	7	3	A	3	Chir	25.19	1.42
2	92	7	3	A	3	Olig + Oth	3.99	0.21
2	92	7	3	A	3	Olig + Oth	35.32	2.36
2	92	7	3	A	5	Amph	0.10	0.00
2	92	7	3	A	5	Chao	17.42	1.26
2	92	7	3	A	5	Chir	132.04	5.04
2	92	7	3	A	5	Chir	2.99	0.10
2	92	7	3	A	5	Olig + Oth	0.00	0.00
2	92	7	28	A	1	Amph	102.65	6.09
2	92	7	28	A	1	Amph	15.95	1.26
2	92	7	28	A	1	Chao	0.21	0.21
2	92	7	28	A	1	Chir	4.41	0.42
2	92	7	28	A	1	Chir	0.63	0.21
2	92	7	28	A	1	Olig + Oth	33.17	1.05
2	92	7	28	A	1	Olig + Oth	0.00	0.00
2	92	7	28	A	3	Amph	0.16	0.00
2	92	7	28	A	3	Cerat	0.10	0.00
2	92	7	28	A	3	Cerat	0.84	0.21
2	92	7	28	A	3	Chao	0.21	0.10
2	92	7	28	A	3	Chao	1.84	0.16
2	92	7	28	A	3	Chir	14.12	2.05
2	92	7	28	A	3	Chir	55.52	2.41
2	92	7	28	A	3	Olig + Oth	5.72	0.37
2	92	7	28	A	3	Olig + Oth	11.49	0.52
2	92	7	28	A	5	Chao	2.10	0.21
2	92	7	28	A	5	Chao	3.57	0.42
2	92	7	28	A	5	Chir	58.78	2.52

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight ($g \cdot m^{-2}$)	Dry Weight ($g \cdot m^{-2}$)
2	92	7	28	A	5	Chir	34.64	4.62
2	92	7	28	A	5	Olig + Oth	0.84	0.00
2	92	7	28	A	5	Olig + Oth	2.10	0.00
2	92	8	20	A	1	Amph	18.47	1.47
2	92	8	20	A	1	Amph	0.00	0.00
2	92	8	20	A	1	Cerat	0.21	0.00
2	92	8	20	A	1	Chir	0.42	0.21
2	92	8	20	A	1	Chir	9.24	0.63
2	92	8	20	A	1	Olig + Oth	0.21	0.21
2	92	8	20	A	1	Olig + Oth	0.42	0.21
2	92	8	20	A	3	Chir	1.47	0.00
2	92	8	20	A	3	Chir	5.88	0.21
2	92	8	20	A	3	Olig + Oth	1.26	0.21
2	92	8	20	A	5	Chao	2.10	0.16
2	92	8	20	A	5	Chir	60.72	2.36
2	92	8	20	A	5	Olig + Oth	0.37	0.00
2	93	5	14	A	1	Chao	1.68	0.00
2	93	5	14	A	1	Chir	1.05	0.00
2	93	5	14	A	1	Olig + Oth	0.21	0.00
2	93	5	14	A	1	Amph	2.73	0.21
2	93	5	14	A	1	Cerat	0.63	0.00
2	93	5	14	A	3	Chao	1.89	0.00
2	93	5	14	A	3	Chir	1.89	0.00
2	93	5	14	A	3	Olig + Oth	0.21	0.00
2	93	5	14	A	3	Chao	1.68	0.42
2	93	5	14	A	3	Chir	2.94	0.21
2	93	5	14	A	5	Olig + Oth	0.63	0.16
2	93	5	14	A	5	Olig + Oth	0.16	0.10
2	93	5	14	A	5	Chir	26.29	2.05
2	93	5	14	A	5	Chao	3.31	0.37
2	93	5	14	A	5	Chir	43.19	3.10
2	93	5	14	A	5	Chao	9.60	0.63
2	93	5	14	A	5	Cerat	1.05	0.37
2	93	6	11	A	1	Chir	1.05	0.00
2	93	6	11	A	1	Olig + Oth	0.21	0.00
2	93	6	11	A	1	Olig + Oth	1.89	0.10
2	93	6	11	A	1	Cerat	2.99	0.37
2	93	6	11	A	1	Chao	0.05	0.00
2	93	6	11	A	1	Chir	0.73	0.05
2	93	6	11	A	3	Olig + Oth	53.01	7.45
2	93	6	11	A	3	Chao	0.52	0.05
2	93	6	11	A	3	Cerat	1.89	0.21
2	93	6	11	A	3	Chao	0.63	0.00
2	93	6	11	A	3	Olig + Oth	0.42	0.00
2	93	6	11	A	3	Chir	0.16	0.00
2	93	6	11	A	3	Chir	6.30	0.21
2	93	6	11	A	5	Chir	13.38	1.05
2	93	6	11	A	5	Chao	13.54	0.79
2	93	6	11	A	5	Cerat	0.10	0.00
2	93	6	11	A	5	Olig + Oth	0.21	0.00

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight ($g \cdot m^{-2}$)	Dry Weight ($g \cdot m^{-2}$)
2	93	6	11	A	5	Chir	1.63	0.10
2	93	6	11	A	5	Chao	12.02	0.58
2	93	6	11	A	5	Olig + Oth	0.21	0.05
2	93	7	8	A	1	Olig + Oth	0.00	0.00
2	93	7	8	A	1	Chir	0.21	0.00
2	93	7	8	A	1	Chir	3.99	0.21
2	93	7	8	A	1	Chao	0.42	0.21
2	93	7	8	A	1	Chao	0.21	0.00
2	93	7	8	A	1	Olig + Oth	0.00	0.00
2	93	7	8	A	3	Chao	0.05	0.00
2	93	7	8	A	3	Chir	11.13	0.42
2	93	7	8	A	3	Olig + Oth	0.42	0.00
2	93	7	8	A	5	Olig + Oth	78.41	4.93
2	93	7	8	A	5	Cerat	0.42	0.10
2	93	7	8	A	5	Chao	1.89	0.21
2	93	7	8	A	5	Chir	17.53	1.26
2	93	7	8	A	5	Olig + Oth	5.35	0.63
2	93	7	8	A	5	Chao	1.15	0.10
2	93	7	8	A	5	Chir	12.33	0.73
2	93	8	4	A	1	Chir	0.84	0.21
2	93	8	4	A	1	Olig + Oth	0.00	0.00
2	93	8	4	A	1	Cerat	0.84	0.21
2	93	8	4	A	1	Amph	2.52	0.21
2	93	8	4	A	1	Cerat	0.42	0.21
2	93	8	4	A	1	Chir	0.00	0.00
2	93	8	4	A	1	Olig + Oth	0.00	0.00
2	93	8	4	A	3	Chir	16.43	0.73
2	93	8	4	A	3	Chao	0.05	0.00
2	93	8	4	A	3	Olig + Oth	0.10	0.00
2	93	8	4	A	3	Olig + Oth	0.10	0.00
2	93	8	4	A	3	Chir	5.51	0.21
2	93	8	4	A	3	Chao	0.10	0.00
2	93	8	4	A	5	Chir	0.63	0.00
2	93	8	4	A	5	Chao	0.47	0.05
2	93	8	4	A	5	Chir	8.45	0.26
2	93	8	4	A	5	Olig + Oth	0.00	0.00
2	93	8	4	A	5	Chao	0.52	0.05
2	93	8	4	A	5	Cerat	0.00	0.05
2	93	8	18	A	1	Olig + Oth	10.71	1.05
2	93	8	18	A	3	Chir	0.00	0.00
2	93	8	18	A	5	Chir	0.00	0.00
2	93	8	18	A	5	Amph	0.16	0.05
2	93	8	18	A	5	Olig + Oth	0.00	0.00
3	91	5	14	A	1	Amph	13.23	1.15
3	91	5	14	A	1	Olig + Oth	4.88	0.63
3	91	5	14	A	3	Amph	8.87	0.73
3	91	5	14	A	3	Cerat	0.26	0.05
3	91	5	14	A	3	Chir	6.82	0.63
3	91	5	14	A	3	Olig + Oth	38.68	3.73
3	91	5	14	A	5	Amph	8.87	0.79

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight (g·m⁻²)	Dry Weight (g·m⁻²)
3	91	5	14	A	5	Chir	0.16	0.00
3	91	5	14	A	5	Olig + Oth	8.61	1.63
3	91	6	18	C	1	Amph	1.36	0.16
3	91	6	18	C	1	Olig + Oth	1.73	0.10
3	91	6	18	A	3	Amph	5.83	0.52
3	91	6	18	A	3	Amph	2.52	0.21
3	91	6	18	A	3	Cerat	0.05	0.00
3	91	6	18	A	3	Cerat	0.10	0.00
3	91	6	18	A	3	Olig + Oth	3.46	0.21
3	91	6	18	A	3	Olig + Oth	0.21	0.00
3	91	6	18	A	3	Olig + Oth	4.41	0.84
3	91	6	18	A	5	Amph	2.73	0.21
3	91	6	18	A	5	Cerat	0.73	0.16
3	91	6	18	A	5	Chir	0.37	0.00
3	91	6	18	A	5	Chir	2.52	0.26
3	91	6	18	A	5	Olig + Oth	10.13	1.15
3	91	7	9	C	1	Amph	9.66	0.84
3	91	7	9	C	1	Amph	8.82	0.63
3	91	7	9	C	1	Cerat	0.21	0.21
3	91	7	9	C	1	Cerat	1.26	0.00
3	91	7	9	C	1	Chir	36.74	2.10
3	91	7	9	C	1	Chir	35.69	2.73
3	91	7	9	C	1	Olig + Oth	30.86	2.94
3	91	7	9	C	1	Olig + Oth	30.44	1.26
3	91	7	9	C	3	Amph	1.78	0.16
3	91	7	9	C	3	Cerat	1.89	0.37
3	91	7	9	C	3	Chir	11.76	0.63
3	91	7	9	C	3	Olig + Oth	16.74	0.68
3	91	7	9	C	5	Chao	6.25	0.42
3	91	7	9	C	5	Chir	1.63	0.16
3	91	7	9	C	5	Olig + Oth	0.37	0.00
3	91	8	1	C	1	Amph	0.05	0.00
3	91	8	1	C	1	Amph	5.35	0.47
3	91	8	1	C	1	Cerat	0.21	0.05
3	91	8	1	C	1	Cerat	4.72	0.47
3	91	8	1	C	1	Chir	0.21	0.05
3	91	8	1	C	1	Chir	1.57	0.16
3	91	8	1	C	1	Olig + Oth	3.62	0.37
3	91	8	1	C	1	Olig + Oth	6.19	0.47
3	91	8	1	C	5	Amph	1.52	0.21
3	91	8	1	C	5	Cerat	0.21	0.05
3	91	8	1	C	5	Chir	0.37	0.10
3	91	8	1	C	5	Olig + Oth	4.15	0.21
3	91	8	20	C	1	Amph	0.10	0.05
3	91	8	20	C	1	Cerat	0.05	0.00
3	91	8	20	C	1	Chir	0.00	0.00
3	91	8	20	C	1	Olig + Oth	4.57	0.47
3	91	8	20	C	1	Olig + Oth	0.16	0.05
3	91	8	20	C	1	Olig + Oth	0.00	0.00
3	91	8	20	C	3	Amph	0.79	0.05

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight (g·m^{-2})	Dry Weight (g·m^{-2})
3	91	8	20	C	3	Amph	0.00	0.00
3	91	8	20	C	3	Cerat	0.21	0.05
3	91	8	20	C	3	Chao	0.00	0.00
3	91	8	20	C	3	Chir	0.84	0.16
3	91	8	20	C	3	Chir	2.47	0.21
3	91	8	20	C	3	Olig + Oth	0.00	0.00
3	91	8	20	C	3	Olig + Oth	10.29	0.84
3	92	5	23	C	1	Amph	52.69	3.99
3	92	5	23	C	1	Amph	23.51	1.89
3	92	5	23	C	3	Amph	9.03	0.84
3	92	5	23	C	3	Amph	4.99	0.42
3	92	5	23	C	5	Amph	0.16	0.00
3	92	5	23	C	5	Amph	1.31	0.21
3	92	5	23	C	3	Cerat	0.00	0.00
3	92	5	23	C	3	Cerat	1.26	0.00
3	92	5	23	C	5	Cerat	0.31	0.10
3	92	5	23	C	1	Chir	2.94	0.42
3	92	5	23	C	1	Chir	3.99	0.42
3	92	5	23	C	3	Chir	38.42	3.99
3	92	5	23	C	3	Chir	16.95	1.36
3	92	5	23	C	5	Chir	19.79	1.52
3	92	5	23	C	5	Chir	7.92	0.73
3	92	5	23	C	1	Olig + Oth	0.21	0.00
3	92	5	23	C	1	Olig + Oth	13.85	1.26
3	92	5	23	C	3	Olig + Oth	1.00	0.10
3	92	5	23	C	3	Olig + Oth	7.77	1.05
3	92	5	23	C	5	Olig + Oth	0.00	0.00
3	92	5	23	C	5	Olig + Oth	0.10	0.10
3	92	6	7	A	1	Amph	11.97	0.79
3	92	6	7	A	1	Amph	33.59	2.36
3	92	6	7	A	1	Cerat	0.37	0.16
3	92	6	7	A	1	Cerat	0.10	0.05
3	92	6	7	A	5	Cerat	0.00	0.00
3	92	6	7	A	1	Chao	0.21	0.00
3	92	6	7	A	5	Chao	0.10	0.00
3	92	6	7	A	5	Chao	0.10	0.05
3	92	6	7	A	1	Chir	16.11	1.36
3	92	6	7	A	1	Chir	23.72	1.99
3	92	6	7	A	3	Chir	29.28	1.42
3	92	6	7	A	5	Chir	1.63	0.21
3	92	6	7	A	5	Chir	4.57	0.52
3	92	6	7	A	1	Olig + Oth	18.26	2.26
3	92	6	7	A	1	Olig + Oth	18.53	2.10
3	92	6	7	A	3	Olig + Oth	20.42	1.05
3	92	6	7	A	3	Olig + Oth	0.73	0.00
3	92	6	7	A	5	Olig + Oth	0.10	0.05
3	92	6	7	A	5	Olig + Oth	0.00	0.00
3	92	6	7	A	5	Olig + Oth	0.47	0.10
3	92	7	2	C	1	Amph	2.89	0.26
3	92	7	2	C	1	Amph	12.60	1.05

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight (g·m^{-2})	Dry Weight (g·m^{-2})
3	92	7	2	A	3	Amph	2.52	0.00
3	92	7	2	C	5	Amph	9.76	0.73
3	92	7	2	C	5	Amph	4.25	0.42
3	92	7	2	C	1	Cerat	0.21	0.05
3	92	7	2	C	1	Cerat	0.21	0.05
3	92	7	2	C	3	Cerat	0.52	0.10
3	92	7	2	C	3	Cerat	0.63	0.10
3	92	7	2	C	5	Cerat	0.05	0.00
3	92	7	2	C	5	Cerat	0.94	0.31
3	92	7	2	C	1	Chir	1.10	0.16
3	92	7	2	C	1	Chir	0.05	0.05
3	92	7	2	A	3	Chir	3.36	0.21
3	92	7	2	C	3	Chir	15.01	1.10
3	92	7	2	C	3	Chir	0.68	0.10
3	92	7	2	C	5	Chir	0.73	0.10
3	92	7	2	C	5	Chir	15.69	1.05
3	92	7	2	C	1	Olig	13.70	0.89
3	92	7	2	C	1	Olig + Oth	11.34	0.94
3	92	7	2	A	3	Olig + Oth	13.49	0.79
3	92	7	2	C	3	Olig + Oth	16.69	1.89
3	92	7	2	C	3	Olig + Oth	9.39	1.00
3	92	7	2	C	5	Olig + Oth	49.80	2.68
3	92	7	2	C	5	Olig + Oth	19.68	0.89
3	92	7	2	C	1	Oth	9.29	0.94
3	92	7	28	A	1	Amph	141.91	8.03
3	92	7	28	A	1	Amph	171.30	8.82
3	92	7	28	A	3	Amph	1.47	0.42
3	92	7	28	A	3	Amph	2.73	0.21
3	92	7	28	A	5	Amph	0.00	0.00
3	92	7	28	A	5	Amph	14.06	1.26
3	92	7	28	A	1	Cerat	0.00	0.00
3	92	7	28	A	1	Chao	0.21	0.05
3	92	7	28	A	5	Chao	0.00	0.00
3	92	7	28	A	1	Chir	3.78	0.42
3	92	7	28	A	3	Chir	2.31	0.63
3	92	7	28	A	3	Chir	6.30	0.21
3	92	7	28	A	5	Chir	4.41	1.05
3	92	7	28	A	5	Chir	22.04	2.10
3	92	7	28	A	1	Olig + Oth	67.81	4.93
3	92	7	28	A	1	Olig + Oth	23.30	1.89
3	92	7	28	A	3	Olig + Oth	22.25	2.52
3	92	7	28	A	3	Olig + Oth	58.78	4.20
3	92	7	28	A	5	Olig + Oth	14.90	0.63
3	92	7	28	A	5	Olig + Oth	9.24	1.26
3	92	8	22	A	1	Amph	4.62	0.84
3	92	8	22	A	1	Amph	4.51	0.47
3	92	8	22	A	3	Amph	18.84	1.21
3	92	8	22	A	3	Amph	1.89	0.21
3	92	8	22	A	5	Amph	8.82	0.84
3	92	8	22	A	5	Amph	1.68	0.16

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight ($g \cdot m^{-2}$)	Dry Weight ($g \cdot m^{-2}$)
3	92	8	22	A	5	Chao	0.10	0.00
3	92	8	22	A	1	Chir	0.00	0.00
3	92	8	22	A	1	Chir	0.00	0.00
3	92	8	22	A	3	Chir	24.19	1.68
3	92	8	22	A	3	Chir	3.36	0.63
3	92	8	22	A	5	Chir	3.04	0.37
3	92	8	22	A	5	Chir	12.81	1.05
3	92	8	22	A	1	Olig + Oth	0.21	0.21
3	92	8	22	A	1	Olig + Oth	0.68	0.21
3	92	8	22	A	3	Olig + Oth	38.63	5.25
3	92	8	22	A	3	Olig + Oth	3.15	1.05
3	92	8	22	A	5	Olig + Oth	4.62	0.63
3	92	8	22	A	5	Olig + Oth	1.26	0.21
3	92	8	22	A	5	Olig + Oth	4.62	0.42
3	93	5	13	A	1	Amph	20.62	1.78
3	93	5	13	A	1	Amph	7.24	0.58
3	93	5	13	A	3	Amph	5.88	0.63
3	93	5	13	A	3	Amph	5.04	0.63
3	93	5	13	A	5	Amph	0.00	0.00
3	93	5	13	A	5	Amph	6.09	0.42
3	93	5	13	A	1	Cerat	0.05	0.05
3	93	5	13	A	3	Cerat	0.00	0.00
3	93	5	13	A	3	Cerat	0.42	0.21
3	93	5	13	A	5	Cerat	9.45	0.84
3	93	5	13	A	5	Chao	2.73	0.21
3	93	5	13	A	5	Chao	1.89	0.00
3	93	5	13	A	1	Chir	0.21	0.05
3	93	5	13	A	1	Chir	0.37	0.05
3	93	5	13	A	3	Chir	5.46	1.05
3	93	5	13	A	3	Chir	2.73	0.63
3	93	5	13	A	5	Chir	1.47	0.21
3	93	5	13	A	5	Chir	49.12	5.46
3	93	5	13	A	1	Olig + Oth	1.94	0.21
3	93	5	13	A	1	Olig + Oth	0.05	0.05
3	93	5	13	A	3	Olig + Oth	8.82	1.05
3	93	5	13	A	3	Olig + Oth	4.62	1.05
3	93	5	13	A	5	Olig + Oth	0.21	0.21
3	93	5	13	A	5	Olig + Oth	8.82	1.05
3	93	6	7	A	1	Amph	11.34	1.26
3	93	6	7	A	5	Amph	1.84	0.21
3	93	6	7	A	1	Cerat	0.00	0.00
3	93	6	7	A	5	Cerat	0.00	0.00
3	93	6	7	A	1	Chir	0.00	0.00
3	93	6	7	A	3	Chir	3.57	0.42
3	93	6	7	A	3	Chir	0.84	0.21
3	93	6	7	A	1	Olig + Oth	3.57	0.63
3	93	6	7	A	3	Olig + Oth	0.00	0.00
3	93	6	7	A	3	Olig + Oth	0.42	0.00
3	93	6	7	A	5	Olig + Oth	0.00	0.00
3	93	7	9	A	1	Amph	3.57	0.21

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight (g·m-2)	Dry Weight (g·m-2)
3	93	7	9	A	1	Amph	31.28	2.31
3	93	7	9	A	1	Amph	7.35	1.05
3	93	7	9	A	3	Amph	0.21	0.00
3	93	7	9	A	5	Amph	5.88	0.63
3	93	7	9	A	1	Cerat	0.00	0.00
3	93	7	9	A	1	Cerat	0.00	0.00
3	93	7	9	A	1	Cerat	0.21	0.00
3	93	7	9	A	1	Chao	0.42	0.00
3	93	7	9	A	1	Chao	0.84	0.21
3	93	7	9	A	5	Chao	0.00	0.00
3	93	7	9	A	1	Chir	0.21	0.00
3	93	7	9	A	1	Chir	5.88	0.84
3	93	7	9	A	1	Chir	0.42	0.21
3	93	7	9	A	3	Chir	0.00	0.00
3	93	7	9	A	3	Chir	0.63	0.21
3	93	7	9	A	5	Chir	1.47	0.00
3	93	7	9	A	5	Chir	4.62	0.42
3	93	7	9	A	1	Olig + Oth	13.65	1.26
3	93	7	9	A	1	Olig + Oth	19.94	2.10
3	93	7	9	A	1	Olig + Oth	3.36	0.00
3	93	7	9	A	3	Olig + Oth	67.60	9.45
3	93	7	9	A	3	Olig + Oth	11.76	0.84
3	93	7	9	A	5	Olig + Oth	5.88	0.63
3	93	7	9	A	5	Olig + Oth	0.63	0.21
3	93	7	27	A	1	Amph	2.94	0.63
3	93	7	27	A	1	Amph	5.67	0.21
3	93	7	27	A	5	Amph	0.21	0.00
3	93	7	27	A	1	Chir	1.05	0.00
3	93	7	27	A	1	Chir	0.63	0.00
3	93	7	27	A	5	Chir	0.21	0.00
3	93	7	27	A	5	Chir	7.77	0.84
3	93	7	27	A	1	Olig + Oth	1.05	0.21
3	93	7	27	A	1	Olig + Oth	11.34	0.84
3	93	7	27	A	3	Olig + Oth	4.41	0.21
3	93	7	27	A	3	Olig + Oth	0.00	0.00
3	93	7	27	A	5	Olig + Oth	2.94	0.42
3	93	7	27	A	5	Olig + Oth	0.21	0.00
3	93	8	20	B	1	Amph	9.45	1.26
3	93	8	20	B	1	Amph	7.56	1.05
3	93	8	20	A	3	Amph	0.21	0.00
3	93	8	20	A	3	Amph	4.20	0.63
3	93	8	20	B	1	Cerat	0.21	0.00
3	93	8	20	A	5	Chao	4.41	0.00
3	93	8	20	B	1	Chir	0.42	0.00
3	93	8	20	B	1	Chir	0.21	0.00
3	93	8	20	A	3	Chir	10.50	1.26
3	93	8	20	A	3	Chir	24.77	1.89
3	93	8	20	A	5	Chir	0.63	0.00
3	93	8	20	B	1	Olig + Oth	11.76	1.26
3	93	8	20	B	1	Olig + Oth	1.89	0.21

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight (g·m^{-2})	Dry Weight (g·m^{-2})
3	93	8	20	A	3	Olig + Oth	17.63	1.47
3	93	8	20	A	3	Olig + Oth	5.25	0.63
3	93	8	20	A	5	Olig + Oth	3.78	0.42
3	93	8	20	A	5	Olig + Oth	0.21	0.21
4	91	5	14	B	1	Amph	20.36	1.05
4	91	5	14	B	1	Chir	1.21	0.05
4	91	5	14	B	1	Olig + Oth	1.36	0.05
4	91	5	14	C	1	Olig + Oth	0.63	0.00
4	91	5	14	B	3	Amph	42.77	1.99
4	91	5	14	A	3	Cerat	4.46	0.73
4	91	5	14	A	3	Chao	0.84	0.05
4	91	5	14	A	3	Chir	40.31	2.68
4	91	5	14	A	3	Olig + Oth	1.57	0.10
4	91	5	14	B	3	Olig + Oth	9.39	0.31
4	91	5	14	B	5	Amph	74.68	3.36
4	91	5	14	C	5	Amph	1.57	0.10
4	91	5	14	A	5	Cerat	8.76	1.42
4	91	5	14	B	5	Cerat	0.94	0.21
4	91	5	14	A	5	Chao	11.86	0.31
4	91	5	14	C	5	Chao	1.31	0.05
4	91	5	14	A	5	Chir	82.71	3.94
4	91	5	14	C	5	Chir	6.67	0.58
4	91	5	14	A	5	Olig + Oth	3.94	0.21
4	91	5	14	B	5	Olig + Oth	0.58	0.05
4	91	5	14	C	5	Olig + Oth	0.05	0.00
4	91	6	4	B	1	Amph	231.13	8.66
4	91	6	4	C	1	Amph	1.31	0.00
4	91	6	4	B	1	Cerat	0.05	0.00
4	91	6	4	C	1	Cerat	2.52	0.05
4	91	6	4	B	1	Chao	0.89	0.05
4	91	6	4	B	1	Chir	14.43	0.47
4	91	6	4	C	1	Chir	3.57	0.00
4	91	6	4	B	1	Olig + Oth	47.39	2.99
4	91	6	4	C	1	Olig + Oth	5.14	0.31
4	91	6	4	A	3	Amph	8.45	0.26
4	91	6	4	C	3	Amph	56.05	1.89
4	91	6	4	A	3	Cerat	3.83	0.52
4	91	6	4	C	3	Cerat	5.67	0.63
4	91	6	4	C	3	Cerat	0.47	0.16
4	91	6	4	A	3	Chao	0.42	0.00
4	91	6	4	C	3	Chao	0.31	0.00
4	91	6	4	A	3	Chir	13.33	0.63
4	91	6	4	C	3	Chir	32.54	1.94
4	91	6	4	C	3	Chir	0.21	0.00
4	91	6	4	A	3	Olig + Oth	4.25	0.16
4	91	6	4	C	3	Olig + Oth	2.68	0.16
4	91	6	4	C	3	Olig + Oth	15.95	1.26
4	91	6	4	A	5	Amph	13.96	0.63
4	91	6	4	B	5	Amph	1.21	0.05
4	91	6	4	A	5	Cerat	1.68	0.26

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight ($g \cdot m^{-2}$)	Dry Weight ($g \cdot m^{-2}$)
4	91	6	4	B	5	Cerat	1.21	0.10
4	91	6	4	A	5	Chao	3.83	0.26
4	91	6	4	B	5	Chao	0.52	0.05
4	91	6	4	A	5	Chir	146.21	6.40
4	91	6	4	B	5	Chir	66.60	3.46
4	91	6	4	B	5	Olig	6.19	0.10
4	91	6	4	A	5	Olig + Oth	18.47	0.58
4	91	6	18	A	1	Amph	27.81	1.26
4	91	6	18	C	1	Amph	10.76	0.58
4	91	6	18	C	1	Cerat	0.52	0.10
4	91	6	18	A	1	Olig + Oth	0.31	0.05
4	91	6	18	C	1	Olig + Oth	5.04	0.42
4	91	6	18	B	3	Amph	13.44	0.31
4	91	6	18	C	3	Amph	23.77	0.89
4	91	6	18	C	3	Cerat	0.52	0.10
4	91	6	18	B	3	Chir	1.36	0.05
4	91	6	18	B	3	Olig + Oth	0.58	0.05
4	91	6	18	C	3	Olig + Oth	0.05	0.00
4	91	6	18	B	5	Amph	28.34	1.68
4	91	6	18	C	5	Amph	1.57	0.10
4	91	6	18	B	5	Cerat	4.41	0.42
4	91	6	18	C	5	Cerat	1.63	0.16
4	91	6	18	B	5	Chao	1.21	0.00
4	91	6	18	C	5	Chao	3.20	0.16
4	91	6	18	B	5	Chir	43.56	1.99
4	91	6	18	C	5	Chir	62.29	2.89
4	91	6	18	B	5	Olig + Oth	2.99	0.10
4	91	6	18	C	5	Olig + Oth	1.31	0.05
4	91	7	9	A	1	Amph	6.56	0.31
4	91	7	9	C	1	Amph	25.19	1.26
4	91	7	9	A	1	Cerat	1.05	0.05
4	91	7	9	A	1	Chir	0.47	0.00
4	91	7	9	C	1	Chir	52.27	1.68
4	91	7	9	A	1	Olig + Oth	9.92	0.37
4	91	7	9	C	1	Olig + Oth	480.72	19.31
4	91	7	9	A	3	Amph	79.61	3.99
4	91	7	9	C	3	Amph	7.56	0.21
4	91	7	9	A	3	Cerat	0.84	0.00
4	91	7	9	C	3	Cerat	12.39	0.21
4	91	7	9	A	3	Chao	0.63	0.00
4	91	7	9	C	3	Chir	18.05	0.00
4	91	7	9	A	3	Olig + Oth	0.52	0.00
4	91	7	9	C	3	Olig + Oth	5.04	0.00
4	91	7	9	B	5	Amph	12.23	0.52
4	91	7	9	C	5	Amph	42.40	4.57
4	91	7	9	B	5	Cerat	0.21	0.05
4	91	7	9	C	5	Cerat	1.26	0.16
4	91	7	9	B	5	Chao	0.84	0.00
4	91	7	9	C	5	Chao	0.37	0.00
4	91	7	9	B	5	Chir	123.70	10.29

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight ($g \cdot m^{-2}$)	Dry Weight ($g \cdot m^{-2}$)
4	91	7	9	C	5	Chir	51.38	3.25
4	91	7	9	B	5	Olig + Oth	4.93	0.21
4	91	7	9	C	5	Olig + Oth	6.77	0.21
4	91	8	1	C	1	Amph	10.34	0.37
4	91	8	1	A	1	Cerat	1.99	0.16
4	91	8	1	C	1	Chir	0.94	0.00
4	91	8	1	A	1	Olig + Oth	5.46	0.26
4	91	8	1	C	1	Olig + Oth	52.17	3.67
4	91	8	1	C	3	Amph	18.21	0.84
4	91	8	1	C	3	Cerat	0.84	0.05
4	91	8	1	B	3	Chao	0.63	0.00
4	91	8	1	C	3	Chao	1.47	0.00
4	91	8	1	B	3	Chir	4.15	0.21
4	91	8	1	C	3	Chir	0.47	0.05
4	91	8	1	C	3	Olig + Oth	1.99	0.05
4	91	8	1	A	5	Amph	13.44	0.58
4	91	8	1	A	5	Amph	51.90	2.52
4	91	8	1	A	5	Cerat	2.10	0.10
4	91	8	1	A	5	Cerat	1.31	0.16
4	91	8	1	A	5	Chao	0.52	0.00
4	91	8	1	A	5	Chao	1.52	0.05
4	91	8	1	A	5	Chir	132.57	4.67
4	91	8	1	A	5	Chir	118.82	4.25
4	91	8	1	A	5	Olig + Oth	1.63	0.05
4	91	8	1	A	5	Olig + Oth	1.68	0.05
4	91	8	20	A	1	Amph	183.11	7.45
4	91	8	20	C	1	Amph	63.50	2.73
4	91	8	20	A	1	Cerat	1.31	0.00
4	91	8	20	A	1	Chir	1.78	0.05
4	91	8	20	C	1	Chir	1.68	0.05
4	91	8	20	A	1	Olig + Oth	12.02	0.42
4	91	8	20	C	1	Olig + Oth	12.39	1.00
4	91	8	20	C	3	Amph	22.67	1.10
4	91	8	20	C	3	Amph	9.87	0.42
4	91	8	20	C	3	Cerat	4.09	0.21
4	91	8	20	C	3	Chao	2.15	0.05
4	91	8	20	C	3	Chao	0.00	0.10
4	91	8	20	C	3	Chir	23.20	0.79
4	91	8	20	C	3	Chir	1.36	0.05
4	91	8	20	C	3	Olig + Oth	10.34	0.79
4	91	8	20	A	5	Amph	2.15	0.10
4	91	8	20	C	5	Amph	3.20	0.21
4	91	8	20	A	5	Cerat	5.09	0.52
4	91	8	20	C	5	Cerat	3.36	0.37
4	91	8	20	A	5	Chao	14.96	0.47
4	91	8	20	C	5	Chao	10.29	0.26
4	91	8	20	A	5	Chir	145.63	5.14
4	91	8	20	C	5	Chir	27.60	1.05
4	91	8	20	A	5	Olig + Oth	5.98	0.10
4	91	8	20	C	5	Olig + Oth	12.75	0.21

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight (g·m^{-2})	Dry Weight (g·m^{-2})
4	92	5	13	A	1	Amph	1.68	0.00
4	92	5	13	C	1	Amph	9.13	1.26
4	92	5	13	A	1	Cerat	0.52	0.10
4	92	5	13	A	1	Chir	4.62	0.37
4	92	5	13	A	1	Chir	50.17	3.15
4	92	5	13	C	1	Chir	1.78	0.16
4	92	5	13	C	1	Olig	0.05	0.00
4	92	5	13	A	1	Olig + Oth	8.97	0.21
4	92	5	13	A	1	Olig + Oth	16.37	0.84
4	92	5	13	C	1	Oth	0.42	0.05
4	92	5	13	A	3	Amph	15.32	1.05
4	92	5	13	B	3	Amph	92.79	5.25
4	92	5	13	A	3	Cerat	3.15	0.63
4	92	5	13	A	3	Cerat	1.47	0.21
4	92	5	13	B	3	Cerat	5.25	0.84
4	92	5	13	B	3	Chao	6.30	0.63
4	92	5	13	B	3	Olig	4.20	0.42
4	92	5	13	A	3	Olig + Oth	13.02	0.84
4	92	5	13	A	3	Olig + Oth	6.72	1.26
4	92	5	13	B	3	Olig + Oth	1.68	0.21
4	92	5	13	A	5	Amph	2.89	0.31
4	92	5	13	A	5	Amph	3.88	0.37
4	92	5	13	A	5	Cerat	2.26	0.31
4	92	5	13	A	5	Cerat	4.78	0.73
4	92	5	13	A	5	Chao	1.10	0.16
4	92	5	13	A	5	Chao	0.68	0.05
4	92	5	13	A	5	Chir	79.56	6.04
4	92	5	13	A	5	Chir	69.64	5.51
4	92	5	13	A	5	Olig	3.62	0.26
4	92	5	13	A	5	Olig + Oth	60.67	1.47
4	92	6	7	A	1	Amph	33.59	1.68
4	92	6	7	B	1	Amph	2.31	0.21
4	92	6	7	A	1	Cerat	0.42	0.00
4	92	6	7	A	1	Cerat	0.63	0.00
4	92	6	7	A	1	Chir	0.42	0.21
4	92	6	7	A	1	Chir	1.47	0.21
4	92	6	7	B	1	Chir	0.42	0.00
4	92	6	7	B	1	Olig	2.52	0.42
4	92	6	7	A	1	Olig + Oth	32.75	2.10
4	92	6	7	A	1	Olig + Oth	5.67	0.00
4	92	6	7	C	3	Amph	15.95	1.00
4	92	6	7	A	3	Cerat	2.31	0.42
4	92	6	7	A	3	Cerat	0.52	0.10
4	92	6	7	A	3	Chao	1.26	0.00
4	92	6	7	A	3	Chao	0.26	0.05
4	92	6	7	A	3	Chir	0.10	0.00
4	92	6	7	A	3	Chir	0.00	0.00
4	92	6	7	C	3	Chir	0.00	0.00
4	92	6	7	C	3	Olig	0.89	0.10
4	92	6	7	A	3	Olig + Oth	2.99	0.05

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight ($g \cdot m^{-2}$)	Dry Weight ($g \cdot m^{-2}$)
4	92	6	7	A	3	Olig + Oth	15.11	1.89
4	92	6	7	C	3	Oth	0.16	0.10
4	92	6	7	A	5	Amph	1.15	0.10
4	92	6	7	A	5	Amph	0.84	0.10
4	92	6	7	A	5	Cerat	4.99	0.63
4	92	6	7	A	5	Cerat	2.94	0.47
4	92	6	7	A	5	Chao	1.57	0.21
4	92	6	7	A	5	Chao	7.29	0.47
4	92	6	7	A	5	Chir	61.87	5.62
4	92	6	7	A	5	Chir	26.71	1.31
4	92	6	7	A	5	Olig	17.06	0.37
4	92	6	7	A	5	Olig + Oth	6.19	0.26
4	92	6	7	A	5	Oth	0.84	0.21
4	92	7	1	A	1	Amph	0.84	0.05
4	92	7	1	C	1	Amph	1.68	0.31
4	92	7	1	A	1	Chir	117.98	8.40
4	92	7	1	A	1	Chir	6.67	0.63
4	92	7	1	C	1	Chir	0.16	0.05
4	92	7	1	C	1	Olig	0.52	0.05
4	92	7	1	A	1	Olig + Oth	3.15	0.21
4	92	7	1	A	1	Olig + Oth	49.75	2.52
4	92	7	1	C	1	Oth	0.05	0.00
4	92	7	1	A	3	Amph	0.00	0.00
4	92	7	1	B	3	Amph	1.89	0.16
4	92	7	1	A	3	Cerat	4.20	0.63
4	92	7	1	A	3	Cerat	8.19	1.26
4	92	7	1	A	3	Chir	14.06	0.84
4	92	7	1	A	3	Chir	21.83	1.26
4	92	7	1	B	3	Chir	0.84	0.10
4	92	7	1	B	3	Olig	0.10	0.00
4	92	7	1	A	3	Olig + Oth	1.05	0.21
4	92	7	1	A	3	Olig + Oth	27.92	1.26
4	92	7	1	A	3	Olig + Oth	33.80	1.05
4	92	7	1	A	5	Cerat	0.31	0.10
4	92	7	1	A	5	Cerat	2.20	0.47
4	92	7	1	A	5	Chao	0.26	0.10
4	92	7	1	A	5	Chao	0.00	0.00
4	92	7	1	A	5	Chir	141.96	7.87
4	92	7	1	A	5	Chir	120.02	7.24
4	92	7	1	A	5	Olig	14.06	0.58
4	92	7	1	A	5	Olig + Oth	44.35	1.26
4	92	7	1	A	5	Oth	4.51	0.31
4	92	7	14	A	1	Amph	1.05	0.21
4	92	7	14	A	1	Amph	10.92	0.42
4	92	7	14	A	1	Chir	2.10	0.21
4	92	7	14	A	1	Chir	0.21	0.00
4	92	7	14	A	1	Olig + Oth	16.37	0.84
4	92	7	14	A	1	Olig + Oth	16.37	0.42
4	92	7	14	A	3	Amph	5.51	0.26
4	92	7	14	A	3	Amph	11.34	0.63

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight (g·m⁻²)	Dry Weight (g·m⁻²)
4	92	7	14	A	3	Cerat	2.94	0.42
4	92	7	14	A	3	Cerat	6.72	0.79
4	92	7	14	A	3	Chao	3.99	0.21
4	92	7	14	A	3	Chao	1.26	0.05
4	92	7	14	A	3	Chir	22.46	1.47
4	92	7	14	A	3	Chir	24.14	0.84
4	92	7	14	A	3	Olig + Oth	81.35	1.84
4	92	7	14	A	3	Olig + Oth	23.72	1.05
4	92	7	14	A	5	Cerat	0.16	0.00
4	92	7	14	A	5	Chao	4.15	0.16
4	92	7	14	A	5	Chao	10.97	0.31
4	92	7	14	A	5	Chir	0.00	0.00
4	92	7	14	A	5	Chir	30.65	1.89
4	92	7	14	A	5	Olig	9.45	1.05
4	92	7	14	A	5	Olig + Oth	28.92	1.31
4	92	7	28	A	1	Amph	7.56	0.63
4	92	7	28	A	1	Amph	1.57	0.10
4	92	7	28	A	1	Cerat	0.84	0.21
4	92	7	28	A	1	Cerat	0.73	0.47
4	92	7	28	A	1	Chir	4.62	0.21
4	92	7	28	A	1	Chir	2.89	0.73
4	92	7	28	A	1	Olig	3.99	0.05
4	92	7	28	A	1	Olig + Oth	7.35	0.21
4	92	7	28	A	1	Oth	1.10	0.00
4	92	7	28	A	3	Cerat	22.46	2.73
4	92	7	28	A	3	Cerat	3.99	0.42
4	92	7	28	A	3	Chao	0.37	0.05
4	92	7	28	A	3	Chao	2.52	0.00
4	92	7	28	A	3	Chir	30.28	1.99
4	92	7	28	A	3	Chir	19.52	1.05
4	92	7	28	A	3	Olig + Oth	21.94	1.63
4	92	7	28	A	3	Olig + Oth	74.52	3.36
4	92	7	28	A	5	Cerat	0.16	0.00
4	92	7	28	A	5	Cerat	0.47	0.05
4	92	7	28	A	5	Chao	18.21	0.47
4	92	7	28	A	5	Chao	6.87	0.21
4	92	7	28	A	5	Chir	48.86	2.47
4	92	7	28	A	5	Chir	33.06	1.10
4	92	7	28	A	5	Olig + Oth	15.32	0.47
4	92	7	28	A	5	Olig + Oth	24.09	1.15
4	92	8	23	A	1	Amph	48.70	2.10
4	92	8	23	A	1	Amph	188.93	10.08
4	92	8	23	A	1	Cerat	3.36	0.42
4	92	8	23	A	1	Chir	0.00	0.00
4	92	8	23	A	1	Olig + Oth	46.39	0.21
4	92	8	23	A	1	Olig + Oth	119.24	5.04
4	92	8	23	A	3	Amph	7.77	0.42
4	92	8	23	A	3	Amph	20.36	0.84
4	92	8	23	A	3	Cerat	3.99	0.63
4	92	8	23	A	3	Cerat	2.10	0.42

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight (g·m⁻²)	Dry Weight (g·m⁻²)
4	92	8	23	A	3	Chir	0.84	0.21
4	92	8	23	A	3	Chir	0.00	0.00
4	92	8	23	A	3	Olig + Oth	57.73	5.67
4	92	8	23	A	3	Olig + Oth	20.99	1.26
4	92	8	23	A	5	Amph	0.21	0.05
4	92	8	23	A	5	Cerat	2.89	1.05
4	92	8	23	A	5	Cerat	17.32	3.83
4	92	8	23	A	5	Chir	3.41	0.26
4	92	8	23	A	5	Chir	0.26	0.10
4	92	8	23	A	5	Olig	41.46	1.36
4	92	8	23	A	5	Olig + Oth	280.88	8.82
4	92	8	23	A	5	Oth	0.00	0.00
4	93	5	10	A	1	Amph	23.93	1.26
4	93	5	10	B	1	Amph	24.19	1.26
4	93	5	10	A	3	Amph	3.78	0.42
4	93	5	10	A	3	Amph	6.09	0.00
4	93	5	10	A	5	Amph	7.66	0.16
4	93	5	10	A	5	Amph	0.26	0.00
4	93	5	10	C	5	Amph	10.34	0.31
4	93	5	10	A	3	Cerat	25.61	5.25
4	93	5	10	A	3	Cerat	1.89	0.21
4	93	5	10	A	5	Cerat	11.28	1.00
4	93	5	10	A	5	Cerat	1.31	0.26
4	93	5	10	C	5	Cerat	1.31	0.16
4	93	5	10	A	5	Chao	3.46	0.21
4	93	5	10	A	5	Chao	2.99	0.31
4	93	5	10	C	5	Chao	0.31	0.00
4	93	5	10	A	1	Chir	0.21	0.00
4	93	5	10	A	1	Chir	0.00	0.00
4	93	5	10	B	1	Chir	4.04	0.73
4	93	5	10	A	3	Chir	3.78	1.26
4	93	5	10	A	3	Chir	1.26	0.21
4	93	5	10	A	5	Chir	3.73	0.21
4	93	5	10	A	5	Chir	0.26	0.05
4	93	5	10	A	1	Olig	2.52	0.21
4	93	5	10	B	1	Olig	27.29	2.83
4	93	5	10	A	3	Olig	31.07	3.57
4	93	5	10	C	5	Olig	22.09	0.94
4	93	5	10	A	1	Olig + Oth	0.42	0.21
4	93	5	10	A	3	Olig + Oth	69.06	9.87
4	93	5	10	A	5	Olig + Oth	48.12	1.78
4	93	5	10	A	5	Olig + Oth	23.35	0.58
4	93	5	10	B	1	Oth	0.63	0.05
4	93	5	10	A	3	Oth	10.50	0.63
4	93	5	10	C	5	Oth	0.47	0.10
4	93	6	9	B	1	Amph	11.81	0.89
4	93	6	9	B	1	Amph	5.30	0.47
4	93	6	9	A	3	Amph	0.05	0.00
4	93	6	9	A	3	Amph	4.83	0.42
4	93	6	9	B	1	Cerat	0.89	0.16

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight ($g \cdot m^{-2}$)	Dry Weight ($g \cdot m^{-2}$)
4	93	6	9	A	3	Cerat	1.73	0.37
4	93	6	9	A	3	Cerat	1.47	0.21
4	93	6	9	A	5	Cerat	0.42	0.21
4	93	6	9	A	5	Cerat	1.47	0.21
4	93	6	9	A	5	Cerat	1.68	0.21
4	93	6	9	B	1	Chir	3.78	0.26
4	93	6	9	B	1	Chir	0.05	0.05
4	93	6	9	A	3	Chir	3.78	0.84
4	93	6	9	A	3	Chir	5.67	0.26
4	93	6	9	A	5	Chir	7.98	0.42
4	93	6	9	A	5	Chir	21.83	0.84
4	93	6	9	A	5	Chir	3.78	0.00
4	93	6	9	A	5	Olig	38.42	2.10
4	93	6	9	B	1	Olig + Oth	13.65	0.58
4	93	6	9	A	3	Olig + Oth	8.19	0.00
4	93	6	9	A	5	Olig + Oth	25.40	0.42
4	93	6	9	A	5	Olig + Oth	15.95	0.84
4	93	6	9	A	3	Oth	1.52	0.10
4	93	6	9	A	3	Oth	0.21	0.00
4	93	7	5	B	1	Amph	0.05	0.00
4	93	7	5	B	3	Amph	0.21	0.21
4	93	7	5	B	3	Amph	0.00	0.00
4	93	7	5	B	5	Amph	0.00	0.00
4	93	7	5	B	5	Cerat	0.42	0.00
4	93	7	5	B	1	Chir	10.18	0.79
4	93	7	5	B	1	Chir	25.40	1.68
4	93	7	5	B	3	Chir	0.00	0.00
4	93	7	5	B	3	Chir	0.00	0.00
4	93	7	5	C	3	Chir	45.55	1.89
4	93	7	5	B	5	Chir	1.05	0.21
4	93	7	5	B	5	Chir	0.84	0.21
4	93	7	5	C	3	Olig	12.18	0.84
4	93	7	5	B	1	Olig + Oth	12.60	0.21
4	93	7	5	B	1	Olig + Oth	40.52	0.84
4	93	7	5	B	3	Olig + Oth	0.63	0.21
4	93	7	5	B	3	Olig + Oth	1.26	0.00
4	93	7	5	B	3	Olig + Oth	0.84	0.21
4	93	7	5	B	5	Olig + Oth	0.21	0.21
4	93	7	5	C	3	Oth	2.31	0.00
4	93	7	26	B	1	Amph	53.53	3.36
4	93	7	26	A	3	Amph	4.62	0.63
4	93	7	26	A	5	Amph	0.00	0.00
4	93	7	26	B	1	Cerat	1.47	0.21
4	93	7	26	A	3	Cerat	1.26	0.42
4	93	7	26	A	5	Cerat	0.89	0.16
4	93	7	26	A	5	Cerat	1.26	0.21
4	93	7	26	A	5	Chao	0.26	0.00
4	93	7	26	A	5	Chao	2.31	0.42
4	93	7	26	B	1	Chir	118.82	7.56
4	93	7	26	B	1	Chir	2.73	0.21

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight ($g \cdot m^{-2}$)	Dry Weight ($g \cdot m^{-2}$)
4	93	7	26	A	3	Chir	8.82	0.63
4	93	7	26	A	3	Chir	142.75	8.19
4	93	7	26	A	5	Chir	0.21	0.21
4	93	7	26	A	5	Chir	7.45	0.47
4	93	7	26	B	1	Olig + Oth	83.55	0.63
4	93	7	26	B	1	Olig + Oth	2.31	0.00
4	93	7	26	A	3	Olig + Oth	116.30	3.57
4	93	7	26	A	3	Olig + Oth	13.23	0.84
4	93	7	26	A	5	Olig + Oth	8.40	0.16
4	93	7	26	A	5	Olig + Oth	0.84	0.21
4	93	8	16	A	1	Amph	58.15	3.78
4	93	8	16	A	1	Amph	64.66	5.46
4	93	8	16	A	1	Cerat	0.21	0.00
4	93	8	16	A	1	Cerat	0.00	0.00
4	93	8	16	A	3	Cerat	6.30	0.84
4	93	8	16	A	5	Cerat	4.04	0.37
4	93	8	16	A	5	Cerat	7.98	1.21
4	93	8	16	A	5	Chao	0.00	0.00
4	93	8	16	A	5	Chao	0.31	0.00
4	93	8	16	A	1	Chir	4.83	0.21
4	93	8	16	A	1	Chir	1.89	0.00
4	93	8	16	A	3	Chir	20.57	1.05
4	93	8	16	A	3	Chir	41.56	1.89
4	93	8	16	A	5	Chir	14.38	1.26
4	93	8	16	A	5	Chir	0.94	0.05
4	93	8	16	A	1	Olig + Oth	120.50	13.23
4	93	8	16	A	1	Olig + Oth	3.57	0.42
4	93	8	16	A	3	Olig + Oth	5.67	0.21
4	93	8	16	A	3	Olig + Oth	48.07	1.89
4	93	8	16	A	5	Olig + Oth	44.82	1.57
4	93	8	16	A	5	Olig + Oth	26.71	0.84
5	91	5	15	A	3	Amph	95.62	5.62
5	91	5	15	C	3	Amph	49.96	3.36
5	91	5	15	A	3	Chir	1.68	0.05
5	91	5	15	C	3	Chir	1.94	0.21
5	91	5	15	A	3	Olig + Oth	38.36	3.41
5	91	5	15	C	3	Olig + Oth	3.67	0.26
5	91	5	15	B	5	Amph	20.31	1.00
5	91	5	15	C	5	Amph	38.42	2.31
5	91	5	15	B	5	Cerat	1.84	0.26
5	91	5	15	C	5	Cerat	5.98	0.05
5	91	5	15	B	5	Chao	0.84	0.05
5	91	5	15	C	5	Chao	2.52	0.05
5	91	5	15	B	5	Chir	215.17	13.75
5	91	5	15	C	5	Chir	123.22	10.76
5	91	5	15	B	5	Olig + Oth	11.81	0.73
5	91	5	15	C	5	Olig + Oth	23.67	3.62
5	91	6	5	B	1	Amph	79.30	4.41
5	91	6	5	C	1	Amph	47.39	2.68
5	91	6	5	B	1	Cerat	0.31	0.00

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight ($g \cdot m^{-2}$)	Dry Weight ($g \cdot m^{-2}$)
5	91	6	5	B	1	Chir	1.78	0.21
5	91	6	5	C	1	Chir	1.10	0.10
5	91	6	5	B	1	Olig + Oth	27.19	1.99
5	91	6	5	C	1	Olig + Oth	7.45	0.63
5	91	6	5	B	3	Amph	48.54	2.57
5	91	6	5	C	3	Amph	34.53	2.31
5	91	6	5	B	3	Cerat	0.84	0.00
5	91	6	5	C	3	Cerat	0.16	0.05
5	91	6	5	C	3	Chao	0.89	0.05
5	91	6	5	B	3	Chir	107.80	10.60
5	91	6	5	C	3	Chir	36.26	2.78
5	91	6	5	B	3	Olig + Oth	30.75	2.73
5	91	6	5	C	3	Olig + Oth	3.04	0.31
5	91	6	5	B	5	Amph	11.39	0.68
5	91	6	5	B	5	Chao	1.00	0.16
5	91	6	5	B	5	Chir	124.22	8.92
5	91	6	5	B	5	Olig + Oth	4.99	0.31
5	91	6	19	A	1	Amph	7.45	0.37
5	91	6	19	B	1	Amph	38.00	1.84
5	91	6	19	A	1	CERTA	0.10	0.05
5	91	6	19	A	1	Chir	3.04	0.21
5	91	6	19	B	1	Chir	0.89	0.10
5	91	6	19	A	1	Olig + Oth	0.31	0.00
5	91	6	19	B	1	Olig + Oth	20.31	1.21
5	91	6	19	A	3	Amph	15.64	0.52
5	91	6	19	B	3	Amph	5.88	0.31
5	91	6	19	A	3	Cerat	7.35	0.00
5	91	6	19	B	3	Cerat	1.15	0.00
5	91	6	19	A	3	Chir	4.62	0.47
5	91	6	19	B	3	Chir	53.90	6.82
5	91	6	19	A	3	Olig + Oth	13.23	1.05
5	91	6	19	B	3	Olig + Oth	10.55	1.00
5	91	6	19	B	5	Amph	43.87	1.68
5	91	6	19	C	5	Amph	38.47	1.47
5	91	6	19	B	5	Chir	114.93	7.87
5	91	6	19	C	5	Chir	24.93	1.63
5	91	6	19	B	5	Olig + Oth	20.00	1.52
5	91	6	19	C	5	Olig + Oth	4.88	0.47
5	91	7	10	A	1	Amph	18.37	0.79
5	91	7	10	A	1	Chir	5.56	0.00
5	91	7	10	A	1	Olig + Oth	13.33	1.15
5	91	7	10	A	3	Amph	3.52	0.16
5	91	7	10	B	3	Amph	20.21	1.05
5	91	7	10	B	3	Chir	0.79	0.05
5	91	7	10	A	3	Olig + Oth	0.63	0.05
5	91	7	10	B	3	Olig + Oth	23.30	2.20
5	91	7	10	B	5	Amph	9.24	0.37
5	91	7	10	A	5	Chao	0.68	0.00
5	91	7	10	A	5	Chir	7.87	0.26
5	91	7	10	B	5	Chir	174.92	12.02

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight ($g \cdot m^{-2}$)	Dry Weight ($g \cdot m^{-2}$)
5	91	7	10	A	5	Olig + Oth	3.62	0.10
5	91	7	10	B	5	Olig + Oth	14.54	0.79
5	91	7	30	C	1	Amph	10.92	0.63
5	91	7	30	C	1	Olig + Oth	0.52	0.05
5	91	7	30	C	3	Amph	27.50	1.10
5	91	7	30	C	3	Chir	2.73	0.21
5	91	7	30	C	3	Olig + Oth	1.00	0.16
5	91	7	30	C	5	Chir	1.00	0.10
5	91	7	30	C	5	Chir	128.26	9.03
5	91	7	30	C	5	Chir	61.77	4.78
5	91	7	30	C	5	Olig + Oth	0.26	0.00
5	91	7	30	C	5	Olig + Oth	1.94	0.26
5	91	8	20	B	1	Amph	66.76	3.78
5	91	8	20	C	1	Amph	91.74	6.51
5	91	8	20	C	1	Cerat	0.21	0.21
5	91	8	20	B	1	Chir	0.21	0.00
5	91	8	20	C	1	Chir	1.05	0.21
5	91	8	20	A	1	Olig + Oth	191.24	10.50
5	91	8	20	A	3	Amph	0.16	0.10
5	91	8	20	C	3	Amph	104.75	4.41
5	91	8	20	A	3	Cerat	0.05	0.00
5	91	8	20	A	3	Chao	0.05	0.05
5	91	8	20	A	3	Chir	0.10	0.10
5	91	8	20	C	3	Chir	0.00	0.00
5	91	8	20	A	3	Olig + Oth	2.73	0.26
5	91	8	20	A	3	Olig + Oth	8.82	0.63
5	91	8	20	A	5	Amph	4.15	0.31
5	91	8	20	B	5	Amph	0.00	0.00
5	91	8	20	A	5	Cerat	0.05	0.05
5	91	8	20	B	5	Cerat	0.05	0.00
5	91	8	20	B	5	Chao	0.05	0.00
5	91	8	20	A	5	Chir	0.26	0.05
5	91	8	20	B	5	Chir	26.56	1.47
5	91	8	20	A	5	Olig + Oth	6.56	0.16
5	91	8	20	A	5	Olig + Oth	7.40	0.42
5	92	5	12	A	3	Amph	18.42	1.68
5	92	5	12	A	3	Amph	7.98	0.52
5	92	5	12	A	3	Cerat	0.05	0.00
5	92	5	12	A	3	Chir	5.67	0.84
5	92	5	12	A	3	Chir	0.94	0.16
5	92	5	12	A	3	Olig + Oth	0.21	0.05
5	92	5	12	A	3	Olig + Oth	4.20	0.52
5	92	5	12	A	5	Amph	0.73	0.10
5	92	5	12	A	5	Amph	1.10	0.10
5	92	5	12	A	5	Cerat	0.00	0.00
5	92	5	12	A	5	Cerat	0.10	0.05
5	92	5	12	A	5	Chir	4.46	0.52
5	92	5	12	A	5	Chir	7.82	1.00
5	92	5	12	A	5	Olig + Oth	4.30	0.42
5	92	5	12	A	5	Olig + Oth	2.20	0.16

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight (g·m^{-2})	Dry Weight (g·m^{-2})
5	92	6	9	A	1	Amph	24.30	2.41
5	92	6	9	A	1	Amph	15.06	1.31
5	92	6	9	A	1	Cerat	0.16	0.00
5	92	6	9	A	1	Cerat	0.00	0.00
5	92	6	9	A	1	Chao	0.21	0.00
5	92	6	9	A	1	Chir	0.89	0.16
5	92	6	9	A	1	Chir	1.31	0.26
5	92	6	9	A	1	Olig + Oth	40.04	3.88
5	92	6	9	A	1	Olig + Oth	18.32	1.78
5	92	6	9	A	3	Amph	4.09	0.42
5	92	6	9	A	3	Amph	4.36	0.31
5	92	6	9	A	3	Cerat	0.05	0.00
5	92	6	9	A	3	Chir	0.37	0.00
5	92	6	9	A	3	Chir	2.62	0.37
5	92	6	9	A	3	Olig + Oth	28.02	1.52
5	92	6	9	A	3	Olig + Oth	4.67	0.37
5	92	6	9	A	5	Amph	2.15	0.16
5	92	6	9	A	5	Amph	7.35	0.42
5	92	6	9	A	5	Cerat	0.00	0.00
5	92	6	9	A	5	Chir	5.88	0.63
5	92	6	9	A	5	Chir	1.99	0.37
5	92	6	9	A	5	Olig + Oth	7.77	0.42
5	92	6	9	A	5	Olig + Oth	2.52	0.37
5	92	7	2	A	1	Amph	43.45	2.94
5	92	7	2	A	1	Cerat	0.00	0.00
5	92	7	2	A	1	Cerat	0.00	0.00
5	92	7	2	A	1	Chir	0.21	0.00
5	92	7	2	A	1	Olig + Oth	99.71	11.76
5	92	7	2	A	1	Olig + Oth	71.58	4.62
5	92	7	2	A	3	Amph	33.38	2.31
5	92	7	2	A	3	Amph	5.98	0.48
5	92	7	2	A	3	Cerat	0.42	0.00
5	92	7	2	A	3	Cerat	0.00	0.00
5	92	7	2	A	3	Chir	0.63	0.00
5	92	7	2	A	3	Chir	0.10	0.00
5	92	7	2	A	3	Olig + Oth	6.40	0.84
5	92	7	2	A	3	Olig + Oth	19.94	2.31
5	92	7	2	A	5	Amph	2.47	0.26
5	92	7	2	A	5	Cerat	6.14	0.47
5	92	7	2	A	5	Cerat	0.84	0.00
5	92	7	2	A	5	Chir	1.21	0.26
5	92	7	2	A	5	Olig + Oth	7.24	0.47
5	92	7	2	A	5	Olig + Oth	1.05	0.42
5	92	7	30	A	1	Amph	83.97	4.41
5	92	7	30	A	1	Amph	1.68	0.21
5	92	7	30	A	1	Amph	110.63	7.98
5	92	7	30	A	1	Cerat	0.21	0.21
5	92	7	30	A	1	Cerat	0.00	0.00
5	92	7	30	A	1	Chir	0.00	0.00
5	92	7	30	A	1	Chir	3.36	0.42

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight (g·m⁻²)	Dry Weight (g·m⁻²)
5	92	7	30	A	1	Olig + Oth	69.69	5.04
5	92	7	30	A	1	Olig + Oth	29.39	2.52
5	92	7	30	A	3	Amph	18.26	1.26
5	92	7	30	A	3	Cerat	0.21	0.00
5	92	7	30	A	3	Chir	1.26	0.21
5	92	7	30	A	3	Chir	0.42	0.21
5	92	7	30	A	3	Olig + Oth	60.46	5.46
5	92	7	30	A	3	Olig + Oth	22.46	1.05
5	92	7	30	A	5	Amph	0.84	0.00
5	92	7	30	A	5	Chir	1.47	0.00
5	92	7	30	A	5	Chir	0.42	0.00
5	92	7	30	A	5	Chir	0.26	0.05
5	92	7	30	A	5	Olig + Oth	17.42	1.47
5	92	7	30	A	5	Olig + Oth	23.09	0.63
5	92	8	18	A	1	Amph	26.77	1.63
5	92	8	18	A	1	Amph	26.71	1.73
5	92	8	18	A	1	Chir	0.26	0.00
5	92	8	18	A	1	Chir	0.68	0.05
5	92	8	18	A	1	Olig + Oth	0.47	0.21
5	92	8	18	A	1	Olig + Oth	0.94	0.21
5	92	8	18	A	3	Amph	3.99	0.26
5	92	8	18	A	3	Amph	1.52	0.05
5	92	8	18	A	3	Cerat	0.00	0.00
5	92	8	18	A	3	Chir	0.05	0.00
5	92	8	18	A	3	Chir	0.05	0.00
5	92	8	18	A	3	Olig + Oth	0.00	0.00
5	92	8	18	A	3	Olig + Oth	0.63	0.10
5	92	8	18	A	5	Amph	0.31	0.05
5	92	8	18	A	5	Amph	0.58	0.10
5	92	8	18	A	5	Cerat	0.58	0.00
5	92	8	18	A	5	Chir	1.94	0.26
5	92	8	18	A	5	Chir	1.63	0.21
5	92	8	18	A	5	Olig + Oth	60.35	5.14
5	92	8	18	A	5	Olig + Oth	9.34	1.10
5	93	5	12	A	1	Amph	92.10	4.46
5	93	5	12	A	1	Amph	78.14	4.78
5	93	5	12	A	1	Cerat	0.00	0.00
5	93	5	12	A	1	Chir	0.37	0.10
5	93	5	12	A	1	Chir	0.21	0.05
5	93	5	12	A	1	Olig + Oth	13.12	1.78
5	93	5	12	A	1	Olig + Oth	15.48	1.68
5	93	5	12	A	3	Amph	49.49	2.78
5	93	5	12	A	3	Amph	36.58	2.20
5	93	5	12	A	3	Cerat	0.16	0.05
5	93	5	12	A	3	Chir	7.50	1.00
5	93	5	12	A	3	Chir	4.09	0.73
5	93	5	12	A	3	Olig + Oth	4.51	0.73
5	93	5	12	A	3	Olig + Oth	7.50	0.89
5	93	5	12	A	5	Amph	2.47	0.16
5	93	5	12	A	5	Amph	1.78	0.00

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight ($g \cdot m^{-2}$)	Dry Weight ($g \cdot m^{-2}$)
5	93	5	12	A	5	Cerat	0.10	0.00
5	93	5	12	A	5	Chir	7.35	0.68
5	93	5	12	A	5	Chir	21.94	2.26
5	93	5	12	A	5	Olig + Oth	12.39	2.41
5	93	5	12	A	5	Olig + Oth	1.52	0.26
5	93	6	10	A	1	Amph	4.20	0.26
5	93	6	10	A	1	Amph	11.55	1.05
5	93	6	10	A	1	Cerat	0.00	0.00
5	93	6	10	A	1	Chir	8.61	0.84
5	93	6	10	A	1	Chir	3.67	0.58
5	93	6	10	A	1	Olig + Oth	8.29	0.52
5	93	6	10	A	1	Olig + Oth	38.63	3.15
5	93	6	10	A	3	Amph	13.70	0.68
5	93	6	10	A	3	Amph	19.73	1.05
5	93	6	10	A	3	Cerat	0.84	0.21
5	93	6	10	A	3	Chir	45.97	5.04
5	93	6	10	A	3	Chir	5.09	0.47
5	93	6	10	A	3	Olig + Oth	1.47	0.05
5	93	6	10	A	3	Olig + Oth	77.88	3.15
5	93	6	10	A	5	Amph	1.42	0.10
5	93	6	10	A	5	Amph	100.29	5.35
5	93	6	10	A	5	Chir	2.15	0.10
5	93	6	10	A	5	Chir	8.13	0.42
5	93	6	10	A	5	Olig + Oth	0.00	0.00
5	93	6	10	A	5	Olig + Oth	9.97	0.63
5	93	7	7	A	1	Amph	54.74	2.68
5	93	7	7	A	1	Amph	41.77	1.68
5	93	7	7	A	1	Cerat	0.21	0.00
5	93	7	7	A	1	Chir	1.05	0.21
5	93	7	7	A	1	Chir	0.42	0.05
5	93	7	7	A	1	Olig + Oth	83.34	6.51
5	93	7	7	A	1	Olig + Oth	12.49	1.00
5	93	7	7	A	3	Amph	9.66	0.42
5	93	7	7	A	3	Amph	12.70	0.58
5	93	7	7	A	3	Cerat	0.21	0.00
5	93	7	7	A	3	Cerat	0.21	0.00
5	93	7	7	A	3	Chir	0.00	0.00
5	93	7	7	A	3	Chir	1.26	0.21
5	93	7	7	A	3	Olig + Oth	59.41	4.20
5	93	7	7	A	3	Olig + Oth	1.94	0.79
5	93	7	7	A	5	Amph	9.24	0.63
5	93	7	7	A	5	Amph	12.81	1.05
5	93	7	7	A	5	Cerat	0.21	0.00
5	93	7	7	A	5	Cerat	0.42	0.21
5	93	7	7	A	5	Chir	3.57	0.84
5	93	7	7	A	5	Chir	0.21	0.00
5	93	7	7	A	5	Olig + Oth	2.31	0.21
5	93	7	7	A	5	Olig + Oth	30.23	4.41
5	93	7	29	A	1	Amph	1.68	0.21
5	93	7	29	A	1	Amph	9.29	0.73

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight ($g \cdot m^{-2}$)	Dry Weight ($g \cdot m^{-2}$)
5	93	7	29	A	1	Chir	1.89	0.42
5	93	7	29	A	1	Chir	1.57	0.21
5	93	7	29	A	1	Olig	0.21	0.21
5	93	7	29	A	1	Oth	0.31	0.05
5	93	7	29	A	1	Oth	0.21	0.00
5	93	7	29	A	3	Amph	36.11	2.31
5	93	7	29	A	3	Amph	71.16	3.78
5	93	7	29	A	3	Cerat	0.21	0.21
5	93	7	29	A	3	Cerat	0.21	0.00
5	93	7	29	A	3	Chir	0.42	0.21
5	93	7	29	A	3	Chir	0.00	0.00
5	93	7	29	A	3	Olig	42.40	2.94
5	93	7	29	A	3	Olig	51.85	4.62
5	93	7	29	A	3	Oth	128.05	11.34
5	93	7	29	A	3	Oth	126.58	10.08
5	93	7	29	A	5	Amph	5.46	0.42
5	93	7	29	A	5	Amph	11.34	0.42
5	93	7	29	A	5	Cerat	0.42	0.00
5	93	7	29	A	5	Chir	4.41	0.63
5	93	7	29	A	5	Chir	4.83	0.42
5	93	7	29	A	5	Olig	5.04	0.42
5	93	7	29	A	5	Olig	0.21	0.00
5	93	7	29	A	5	Oth	0.00	0.00
5	93	7	29	A	5	Oth	2.73	0.21
5	93	8	17	A	1	Amph	40.99	2.57
5	93	8	17	A	1	Amph	78.56	5.51
5	93	8	17	A	1	Cerat	0.05	0.00
5	93	8	17	A	1	Cerat	0.05	0.00
5	93	8	17	A	1	Chir	2.31	0.31
5	93	8	17	A	1	Chir	1.15	0.16
5	93	8	17	A	1	Olig	0.94	0.16
5	93	8	17	A	1	Olig	4.83	0.31
5	93	8	17	A	1	Oth	14.22	1.05
5	93	8	17	A	1	Oth	5.25	0.26
5	93	8	17	A	3	Amph	0.79	0.10
5	93	8	17	A	3	Amph	0.42	0.00
5	93	8	17	A	3	Cerat	0.21	0.00
5	93	8	17	A	3	Cerat	0.05	0.00
5	93	8	17	A	3	Chir	2.10	0.42
5	93	8	17	A	3	Chir	0.16	0.00
5	93	8	17	A	3	Olig	0.42	0.21
5	93	8	17	A	3	Olig	4.51	0.52
5	93	8	17	A	3	Oth	1.89	0.00
5	93	8	17	A	3	Oth	0.42	0.05
5	93	8	17	A	5	Amph	9.03	0.63
5	93	8	17	A	5	Amph	7.50	0.52
5	93	8	17	A	5	Cerat	0.21	0.21
5	93	8	17	A	5	Cerat	0.00	0.00
5	93	8	17	A	5	Chir	2.52	0.63
5	93	8	17	A	5	Chir	0.79	0.10

Table D1. (continued)

Lake	Year	Month	Day	Transect	Depth (m)	Taxa	Fresh Weight ($g \cdot m^{-2}$)	Dry Weight ($g \cdot m^{-2}$)
5	93	8	17	A	5	Olig	0.21	0.00
5	93	8	17	A	5	Olig	1.68	0.21
5	93	8	17	A	5	Oth	9.18	0.73
5	93	8	17	A	5	Oth	0.84	0.00