ANNEX XII

PLANKTON BASELINE REPORT
FOR THE JAY PROJECT

PLANKTON BASELINE REPORT FOR THE JAY PROJECT

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Appendices

Appendix A Historical Taxa Presence or Absence Summary
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Abbreviations

Abbreviation	Definition
AEMP	Aquatic Effects Monitoring Program
AFDM	ash free dry mass
CCME	Canadian Council of Ministers of the Environment
Diavik Mine	Diavik Diamond Mine
Dominion Diamond	Dominion Diamond Ekati Corporation
DDMI	Diavik Diamond Mines Inc.
Ekati Mine	Ekati Diamond Mine
e.g.,	for example
et al.	and more than one additional author
FF1	far-field 1 area
FF2	far-field 2 area
FFA	far-field reference A area
FFB	far-field reference B area
Golder	Golder Associates Ltd.
i.e.,	that is
n/a	not applicable
No.	number
NWT	Northwest Territories
QA	quality assurance
QC	quality control
RPD	relative percent difference
sp.	species
spp.	multiple species
Project	Jay Project
TN	total nitrogen
TP	total phosphorus
TSI	Trophic State Index
UTM	Universal Transverse Mercator
X	times

Units of Measure

Unit	Definition
%	percent
°C	degrees Celsius
µg/L	micrograms per litre
µm	micrometre
μm^3	cubic micrometre
$\mu m^3/L$	cubic micrometres per litre
cells/L	cells per litre
cm	centimetre
km	kilometre
km^2	square kilometre
m	metre
masl	metres above sea level
mg/m^3	milligrams per cubic metre
mg/L	milligrams per litre
mL	millilitre
m/s	metres per second
org/m^3	organisms per cubic metre

1 INTRODUCTION

1.1 Background and Scope

Dominion Diamond Ekati Corporation (Dominion Diamond) is a Canadian-owned and Northwest Territories (NWT) based mining company that mines, processes, and markets Canadian diamonds from its Ekati Diamond Mine (Ekati Mine). The existing Ekati Mine is located approximately 200 kilometres (km) south of the Arctic Circle and 300 km northeast of Yellowknife, NWT (Map 1.1-1).

Dominion Diamond is proposing to develop the Jay kimberlite pipe (Jay pipe) located beneath Lac du Sauvage. The proposed Jay Project (Project) will be an extension of the Ekati Mine, which is a large, stable, and successful mining operation that has been operating for 16 years. Most of the facilities required to support the development of the Jay pipe and to process the kimberlite currently exist at the Ekati Mine. The Project is located in the southeastern portion of the Ekati claim block approximately 25 km from the main facilities and approximately 7 km to the northeast of the Misery Pit, in the Lac de Gras watershed (Map 1.1-2).

This Plankton Baseline Report describes existing plankton communities in waterbodies within the Lac du Sauvage and Lac de Gras basins. The plankton baseline component is part of a comprehensive baseline program to document the natural and socio-economic environments near the Project. This baseline information will be used for the environmental assessment of Project-related effects on valued components, and will help identify mitigation and protective actions that could be implemented to avoid or reduce potentially adverse effects of the Project on the existing environment.

LEGEND

- JAY PROJECT
- EXISTING MINE OR PROJECT
- ⊙ TERRITORIAL CAPITAL
- ● POPULATED PLACE
- HIGHWAY
- ALL-SEASON ROAD
- WINTER ROAD
- TIBBITT TO CONTWOYTO WINTER ROAD
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- TERRITORIAL/PROVINCIAL BOUNDARY
- TREELINE
- WATERCOURSE
- WATERBODY

150 0 150

SCALE 1:6,000,000 KILOMETRES

REFERENCE

WATER OBTAINED FROM ATLAS OF CANADA
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
PROJECTION: CANADA LAMBERT CONFORMAL CONIC

DOCUMENT

PLANKTON BASELINE REPORT

PROJECT

DOMINION DIAMOND

JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

LOCATION OF THE JAY PROJECT

Golder Associates

PROJECT		13-1328-0041	FILE No. B_JC_Aqua_044_GIS	
DESIGN	CG	24/07/14	SCALE AS SHOWN	REV. 0
GIS	NS	10/09/14	MAP 1.1-1	
CHECK	CG	10/09/14		
REVIEW	SM	10/09/14		

G:\CLIENTS\DOMINION\DDEC Jay and Lynx Projects\13-1328-0041 Jay & Lynx EA\Aquatics\Baseline\Figures\B_JC_Aqua_044_GIS.mxd

LEGEND

▩	EKATI MINE FOOTPRINT
▩	DIAVIK MINE FOOTPRINT
▩	PROPOSED JAY FOOTPRINT
▢	KIMBERLITE PIPE
—	WINTER ROAD
—	TIBBITT TO CONTWOYTO WINTER ROAD
- -	NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
—	ELEVATION CONTOUR (10 m INTERVAL)
≪≪	ESKER
—	WATERCOURSE
■	WATERBODY

REFERENCE

CANVEC © NATURAL RESOURCES CANADA, 2012
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

PLANKTON BASELINE REPORT

3 0 3
SCALE 1:150,000 KILOMETRES

PROJECT
DOMINION DIAMOND™
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

EKATI PROPERTY MAP

Golder Associates

PROJECT		13-1328-0041	FILE No. B_JC_Aqua_048_GIS	
DESIGN	SM	12/08/14	SCALE AS SHOWN	REV 0
GIS	ANK	10/09/14	**MAP 1.1-2**	
CHECK	CG	10/09/14		
REVIEW	SM	10/09/14		

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Plankton is a general term referring to small, usually microscopic organisms that live suspended in the water in lakes. *Phytoplankton* are free-floating photosynthesizing algae and cyanobacteria, which fix large amounts of carbon and form the base of the food web for aquatic animals. *Zooplankton* are the free-floating animal constituent of the plankton, and consist of small crustaceans and rotifers.

For the purpose of this baseline report, the term *phytoplankton* refers to the algal and cyanobacteria component of the plankton community, ranging between 2 and 20 micrometres (µm) in size. Phytoplankton are grouped into the following eight major taxonomic groups:

- Bacillariophyceae (diatoms);
- Chlorophyceae (chlorophytes);
- Chrysophyceae (chrysophytes);
- Cryptophyceae (cryptophytes);
- Cyanobacteria;
- Dinophyceae (dinoflagellates);
- Euglenophyceae (euglenoids); and,
- Xanthophyceae (xanthophytes).

Zooplankton refers to Rotifera (rotifers) and crustaceans, specifically Cladocera (cladocerans or water fleas), Cyclopoida (cyclopoid copepods), and Calanoida (calanoid copepods). Cyclopoid and calanoid copepods are considered separately because of taxonomic and ecological differences. Calanoids are typically herbivorous, feeding on phytoplankton, while cyclopoids are typically omnivorous, feeding on phytoplankton and small zooplankton (Brönmark and Hansson 1998). Additionally, calanoids are almost exclusively pelagic (i.e., open-water), while cyclopoids are dominated by littoral (i.e., near-shore) species, although a few pelagic species of cyclopoids can account for a major component of the plankton community.

Phytoplankton and zooplankton communities can be useful indicators of environmental change, because of their rapid response to changes in nutrients or other substances. The inherent variability in the plankton community poses a challenge for its use as a monitoring tool; therefore, understanding the natural variability of the community under baseline conditions is needed to provide an appropriate reference point before environmental changes occur. Plankton abundance, biomass, and taxonomic composition vary both vertically and horizontally during the open-water period. In addition, seasonal succession and year-to-year variation in the plankton community also contribute to the inherent variability of these communities (Wetzel 2001; Paterson 2002); therefore, estimates of abundance and biomass are sensitive to the number of stations, samples, and the depth of the water column sampled (Findlay and Kling 2001; Paterson 2002).

Trophic status of a waterbody can be evaluated by examining the concentrations of chlorophyll *a*, nutrients, and water transparency. Chlorophyll *a* is the primary photosynthetic pigment in phytoplankton, and is often used as a surrogate measure of phytoplankton biomass and production in lakes (Franklin et al. 2012). The essential nutrients necessary for phytoplankton growth are nitrogen, phosphorus, carbon, and for some groups (e.g., diatoms), silica. The primary nutrient that often limits phytoplankton growth in lakes is phosphorus (Schindler 1974); therefore, phosphorus is also used to establish the trophic status of lakes. Secchi depth (a measure of water transparency) can be used as a coarse surrogate of phytoplankton biomass because, in many waterbodies, Secchi depth is inversely related to phytoplankton biomass (Dodds and Whiles 2010); therefore, Secchi depth is also considered when evaluating trophic status.

The three main classes of trophic status are the following:

- oligotrophic (nutrient-poor, unproductive systems);
- mesotrophic (moderately productive systems); and,
- eutrophic (nutrient-rich, highly productive systems).

Vollenweider (1970) developed a classification scheme for lakes using total phosphorus (TP), total nitrogen (TN), chlorophyll *a*, and Secchi depth. This general classification system is internationally accepted, and is based on an analysis of data from over 200 waterbodies during the international program on eutrophication of the Organization for Economic Cooperation and Development.

The Canadian Council of Ministers of Environment classifies lakes based on TP concentrations and divides the Vollenweider classification system further. This additional subdivision was necessary, because of the considerable variation that exists in Canadian waters (CCME 2004).

Finally, the Trophic State Index (TSI) is also used to measure the trophic status of a lake. The TSI is a numerical index that classifies lakes into a scale from 0 to 100 (Carlson 1977). Each major division (i.e., 10, 20, 30) represents a doubling in algal biomass.

1.2 Objectives

The objectives of the plankton baseline program were to characterize:

- the trophic status of lakes in the baseline study area during open-water conditions;
- plankton communities in lakes in the baseline study area during open-water conditions according to total abundance, total biomass, and community composition; and,
- spatial and seasonal variability in phytoplankton and zooplankton communities, where possible.

The following two approaches were used to meet these objectives:

1) reviewing historical plankton community data from lakes within the study area, using data collected by the Ekati and Diavik mines as part of their baseline or aquatic effects monitoring programs (AEMPs); and,
2) summarizing the results of the 2013 Dominion Diamond plankton baseline program conducted during the open-water sampling period.

Section 2 summarizes the relevant available historical plankton community data from baseline and monitoring programs related to the Ekati Mine AEMP (Rescan 2012; ERM Rescan 2013), the Jay pipe 2006 aquatic baseline study (Rescan 2007), and the Diavik Diamond Mine (Diavik Mine) AEMP (Golder 2011; DDMI 2012, 2013). These data sources were reviewed and relevant data complied to provide regional context for the 2013 data. The historical plankton data review included chlorophyll *a* concentrations as well as phytoplankton and zooplankton community data.

Section 3 describes the methods for the collection and analysis of plankton data in the 2013 baseline program as well as the results of the 2013 plankton sampling program. The 2013 plankton baseline program was conducted to characterize existing plankton communities in lakes in the baseline study area during open-water conditions.

1.3 Study Area

1.3.1 Physical Setting

The Project is situated within the Lac du Sauvage drainage basin, which is a component of the larger Lac de Gras drainage basin (Map 1.3-1). The Lac de Gras drainage basin has moderate topographic relief with a maximum elevation of approximately 500 metres above sea level (masl) and a minimum elevation of approximately 416 masl along the lake shoreline. Lac de Gras, which is immediately downstream of Lac du Sauvage, has a large surface area, provides large inflow storage, and maintains steady outflows. Lac de Gras discharges to the Coppermine River, which drains into the Arctic Ocean at Coronation Gulf.

The Lac de Gras basin is situated in the physiographic region of the Canadian Shield and has land features characteristic of glaciated terrain including crag and lee drumlins, eskers, and kettle lakes. The maze of small lakes, wetlands, and creeks in the basin indicate poorly drained conditions. The total area of these small waterbodies is approximately 1,425 square kilometres (km^2), and the remaining upland area is approximately 2,135 km^2. The upland areas are generally well-drained although periodic ice jams at outlets of small lakes and wetlands increase downstream flood peak discharges and affect the flood characteristics.

The study area lies within the sub-Arctic region of the Canadian Shield, an area of continuous permafrost characterized by typical tundra vegetation. Lichens, mosses, heather, and dwarf shrub species dominate on the higher, well-drained areas, whereas sedges and grasses are more predominant in the poorly drained areas and along creeks and lakeshores.

1.3.2 Historical Plankton Community Study Area

The following lakes and sampling stations were included in the historical review (Map 1.3-1):

- Lac du Sauvage basin: Lac du Sauvage in A basin, Lake B1 (Christine Lake) in B sub-basin, Lake D3 (Counts Lake) in D sub-basin, and Ursula Lake in E sub-basin; and,
- Lac de Gras basin: Lac de Gras, Nanuq Lake, and Vulture Lake.

1.3.3 2013 Plankton Community Baseline Study Area

The 2013 plankton baseline study included the following lakes (Map 1.3-2):

- Lac du Sauvage basin: Lac du Sauvage, Duchess Lake, and Lake Af1, in A sub-basin, and Lake E1 in E sub-basin; and,
- Lac de Gras basin: Paul Lake.

1.3.4 2013 Basic Naming Convention

The Lac du Sauvage basin includes Lac du Sauvage proper, small and direct tributaries to Lac du Sauvage (Basin A), and 11 major tributary sub-basins (Basins B to L). The adjacent Lac de Gras basin includes Lac de Gras proper and Paul Lake. To facilitate the 2013 field program and consistent reporting of results, a naming convention was developed for this large and complex basin for use by all technical disciplines (Hydrology Baseline Report [Annex X], Appendix D – Basin Characteristics).

The convention applied to lake and basin naming is as follows:

- Major sub-basins were identified using a capital letter (i.e., A, B, C…). The local Lac du Sauvage basin was designated as the “A” basin. Tributary basins identified during the basin study were designated as B through L, with the first sub-basin located immediately north of the Lac du Sauvage outlet and the sequence proceeding in a clockwise direction around Lac du Sauvage.
- The local Lac du Sauvage basin was broken into internal sub-basins, designated using an additional lower case letter (i.e., Aa, Ab, Ac…). These lower case letters were designated according to internal basins as identified by the available coarse bathymetry, and the sequence followed the direction generally from southeast basin to northwest.
- Lake names were designated by the basin letter and lake number (i.e., A1, B2, C3…). The sequence started at the terminal lake of each sub-basin and proceeded to the headwater lake on the mainstem of the sub-basin. The sequence then continued from the first branch on the headwater chain, upstream from the sub-basin outlet, then the second branch, and so on. Non-draining lakes were assigned numbers according to the branch that they were closest to.
- Lake names within Lac du Sauvage sub-basins (i.e., Lake Ab1, Lake Ab2, Lake Ab3…) proceeded on a branch-by-branch basis, clockwise through each sub-basin.

Where applicable, lake names in this baseline report also referenced the Ekati lake names consistent with the terminology in historical reports, e.g., Lake B1 (Christine Lake) and Lake B4 (Cujo Lake).

LEGEND

▨ EKATI MINE FOOTPRINT

▨ DIAVIK MINE FOOTPRINT

— WINTER ROAD

— TIBBITT TO CONTWOYTO WINTER ROAD

- - NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD

— ELEVATION CONTOUR (20 m INTERVAL)

— WATERCOURSE

🟦 WATERBODY

● NOT INCLUDED HISTORICAL STATION

● INCLUDED HISTORICAL STATION

REFERENCE

DIAVIK MINE (GOLDER 2013),
EKATI MINE (ERM RESCAN 2013), AND
JAY KIMBERLITE PIPE, EKATI MINE (RESCAN 2007)
NATIONAL TOPOGRAPHIC BASE DATA (NTDB) 1:250,000
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

PLANKTON BASELINE REPORT

5 0 5

SCALE 1:225,000 KILOMETRES

PROJECT

DOMINION DIAMOND™

JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

HISTORICAL PLANKTON COMMUNITY SAMPLING LOCATIONS

Golder Associates

PROJECT		13-1328-0041	FILE No. B_JC_Aqua_017_GIS	
DESIGN	CC	02/04/14	SCALE AS SHOWN	REV 0
GIS	NS	12/09/14	MAP 1.3-1	
CHECK	CG	12/09/14		
REVIEW	SM	12/09/14		

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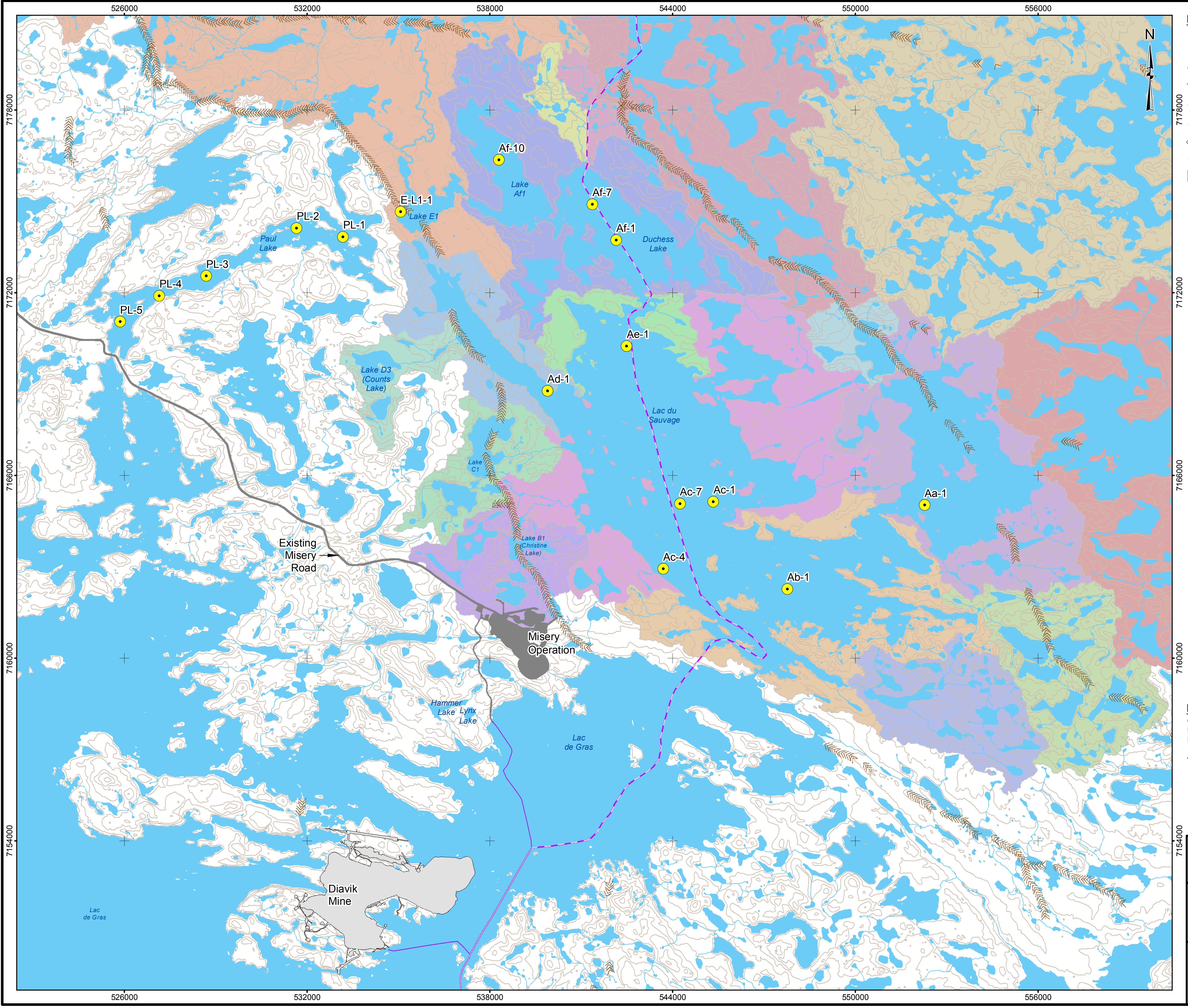

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LEGEND

EKATI MINE FOOTPRINT
DIAVIK MINE FOOTPRINT
WINTER ROAD
TIBBITT TO CONTWOYTO WINTER ROAD
NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
ELEVATION CONTOUR (10 m INTERVAL)
ESKER
WATERCOURSE
WATERBODY
● PLANKTON STATION

BASIN

▨	Aa
▨	Ab
▨	Ac
▨	Ad
▨	Ae
▨	Af
▨	B
▨	C
▨	D
▨	E
▨	F
▨	F2
▨	G
▨	H
▨	I
▨	J
▨	K
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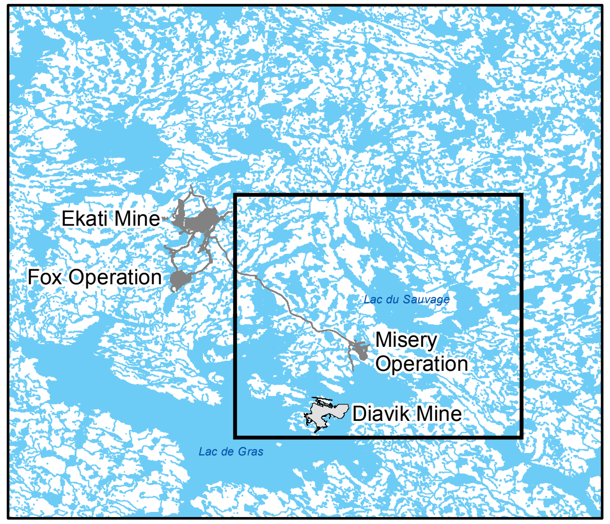


REFERENCE

CANVEC © NATURAL RESOURCES CANADA, 2012
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

PLANKTON BASELINE REPORT

2.5 0 2.5
SCALE 1:125,000 KILOMETRES

PROJECT
DOMINION DIAMOND™

JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

PLANKTON COMMUNITY SAMPLING LOCATIONS, 2013

Golder Associates

PROJECT		13-1328-0041	FILE No. B_JC_Aqua_038_GIS	
DESIGN	KMH	29/04/14	SCALE AS SHOWN	REV 0
GIS	NS	10/09/14		
CHECK	CG	10/09/14		
REVIEW	SM	10/09/14		

MAP 1.3-2

2 HISTORICAL PLANKTON COMMUNITY REVIEW

2.1 Historical Data Sources

The historical plankton data included in this review were obtained from the following sources:

- baseline and long-term AEMP data from 1995 to 2012 for the Ekati Mine (Rescan 2012; ERM Rescan 2013);
- baseline data from the 2006 baseline program for the proposed development of the Jay pipe as part of the Ekati Mine (Rescan 2007); and,
- baseline and long-term AEMP data from 1997 to 2012 for the Diavik Mine (Golder 2011; DDMI 2012, 2013).

For the purpose of this historical data summary, data from sampling stations located in areas exposed to treated effluent were excluded, regardless of whether mine-related effects have been observed. For each program, however, there were exceptions to this exclusion approach, as follows:

- **Ekati Mine:** Phytoplankton and zooplankton assemblages have been altered in lakes downstream of the Long Lake Containment Facility (ERM Rescan 2013). Two sampling stations, S2 and S3, are situated at the northern end of Lac de Gras, downstream of the Long Lake Containment Facility (Map 1.3-1). A change in the relative phytoplankton composition based on abundance has been observed at Station S2, specifically, a decrease in the proportion of cyanobacteria and an increase in the proportion of diatoms (ERM Rescan 2013). Despite recently documented changes in the phytoplankton community at Station S2, data from both Lac de Gras stations were retained in this historical summary because they are useful for describing current conditions at the northern end of Lac de Gras.
- **Jay Pipe Baseline:** Christine Lake (Lake B1) was included in the 2006 Jay pipe baseline program and was reported to have higher concentrations of sulphate, total dissolved solids, chloride, potassium, aluminum, copper, and nickel, which was possibly due to its location downstream of the discharge from the Ekati Mine King Pond Settling Facility (Rescan 2007). Despite the potential project-related effects, the data from Christine Lake were retained in this historical summary because they provided additional seasonal information on a regional basis.
- **Diavik Mine:** The far-field 2 (FF2) area in Lac de Gras is considered an exposure area, because there is uncertainty related to the contribution of inflowing water from Lac du Sauvage relative to treated effluent from the Diavik Mine (Golder 2011). The data from the FF2 area are important for characterizing the current and historical conditions in this area of potential cumulative effects.

2.2 Methods

2.2.1 Diavik Mine Baseline and Aquatic Effects Monitoring Program

2.2.1.1 Sampling Locations and Timing

The Diavik Mine is located on an island in Lac de Gras (Map 1.3-1), approximately 300 km northeast of Yellowknife in the NWT and approximately 200 km south of the Arctic Circle. The Diavik Mine baseline program and current AEMP stations that are included in this historical review are located in Lac de Gras (Map 1.3-1). The 1997 baseline data were only available for the far-field reference A (FFA) area, because baseline data were not collected from the other far-field reference areas currently monitored as part of the AEMP (Golder 2011). Diavik Mine AEMP data were reported for the FF2 area as well as the far-field/reference FF1, FFA, and FFB areas.

The Diavik Mine plankton baseline program was completed in 1997 and consisted of monthly sampling, in late spring (July), summer (August), and fall (September). The current AEMP plankton programs occurred between 2007 and 2011, with samples collected monthly in late spring (July), summer (August), and fall (September). In 2012, plankton community sampling decreased to once per open-water season (late August/early September); however, phytoplankton community data from 2012 were not available when this report was prepared.

2.2.1.2 Summary of Field and Laboratory Methods

Detailed field and laboratory methods for the Diavik Mine AEMP plankton program are presented in the appendices to the 2012 AEMP Annual Report (DDMI 2013). Sampling methods relevant to this historical review are summarized in Table 2.2-1.

2.2.2 Ekati Mine Baseline and Aquatic Effects Monitoring Program Data

2.2.2.1 Sampling Locations and Timing

The Ekati Mine is located approximately 20 km north of Lac de Gras (Map 1.3-1). The Ekati Mine baseline program and AEMP evaluated plankton communities in lakes in the Lac du Sauvage basin (Lac du Sauvage and Counts Lake) and the Lac de Gras basin (Lac de Gras and Vulture Lake). Counts Lake (Lake D3) is a reference lake situated southeast of the Ekati camp, halfway between the Ekati camp and Misery Pit (ERM Rescan 2013). The nearest source of potential mine influence is the Misery Haul Road, which is approximately 5 km from Counts Lake at its closest point (ERM Rescan 2013). In addition, Nanuq Lake was included in the historical summary. This lake is located within the northeast corner of the Ekati claim block, just beyond the Lac de Gras basin boundary in the Coppermine River Basin, and is approximately 26 km from the nearest possible mine influence (ERM Rescan 2013). For the purposes of this historical review, Nanuq Lake was included in the Lac de Gras basin lakes.

Baseline data for the Ekati Mine include data collected in 1996 (includes only phytoplankton from Vulture Lake) and 1997 (all lakes); sampling was completed in August only. Zooplankton biomass (as ash free dry mass [AFDM]) data collection did not begin until 1998. The Ekati Mine AEMP has been operating since 1998 and data from the AEMP plankton program were available from 1998 until 2012. Plankton sampling began in Lac du Sauvage in 2000. The AEMP plankton program in all lakes included in this historical review occurs annually during the summer (August) sampling period.

2.2.2.2 Summary of Field and Laboratory Methods

Detailed field and laboratory methods for the Ekati Mine AEMP plankton program are presented in the 2012 Ekati Mine AEMP report (ERM Rescan 2013). Sampling methods relevant to this historical review are summarized in Table 2.2-1.

2.2.3 Ekati Mine Jay Pipe Aquatic Baseline Data

2.2.3.1 Sampling Locations and Timing

The Jay pipe is located under the southeast region of Lac du Sauvage (Map 1.3-2). The Jay pipe aquatic baseline program occurred in 2006 and was the first year of a proposed two-year baseline monitoring program to support an environmental assessment and a future AEMP development (Rescan 2007). As part of the 2006 baseline program, 12 stations were sampled in Lac du Sauvage, including LDS1, which was sampled as part of the Ekati Mine AEMP (Rescan 2007; ERM Rescan 2013; Map 1.3-1). In addition, one station was sampled in Christine Lake (Lake B1, Lac du Sauvage basin), which is within the Ekati exposure area. Baseline plankton data were also collected from three plankton sampling stations in Ursula Lake, which is a large lake located completely within the Ekati claim block, but outside of the Ekati zone of influence (Rescan 2007).

The Jay pipe aquatic baseline program included three open-water sampling periods in 2006 (i.e., late spring [July], summer [August], and fall [September]) for chlorophyll *a*, phytoplankton, and zooplankton. This was the only monitoring program related to the Ekati Mine that encompassed the open-water season rather than only summer conditions.

2.2.3.2 Summary of Field and Laboratory Methods

Detailed field and laboratory methods for the Jay pipe aquatic baseline program are presented in the *Ekati Mine 2006 Jay Pipe Aquatic Baseline* (Rescan 2007). Sampling methods relevant to this historical review are summarized in Table 2.2-1.

Table 2.2-1 Summary of Historical Plankton Studies in the Jay Pipe Study Area

Component	Waterbody	Project	Years	Number of Sampling Periods	Sampling Depth and Type	Mesh Size and Net Diameter	Source
Phytoplankton and Chlorophyll *a*	Lac de Gras(a)	Diavik Mine Baseline Program	1997	Three open-water (late spring , summer, and fall)	10 m depth-integrated, single sample	n/a	Golder 2011
	Lac de Gras	Diavik Mine AEMP	2003 to 2011	Three open-water (late spring, summer, and fall)	10 m depth-integrated, composite sample	n/a	Golder 2011; DDMI 2012
	Lac de Gras	Diavik Mine AEMP	2012(b)	One open-water (summer only)	10 m depth-integrated, composite sample	n/a	DDMI 2013
	Counts Lake (Lake D3), Lac de Gras, Vulture Lake, and Nanuq Lake	Ekati Mine Baseline	1996(c) and 1997	One open-water (summer only)	Surface grab at 1 m below the surface, triplicate samples	n/a	Rescan 2012; ERM Rescan 2013
	Counts Lake, Lac de Gras, Vulture Lake, and Nanuq Lake	Ekati Mine AEMP	1998 to 2012	One open-water (summer only)	Surface grab at 1 m below the surface, triplicate samples	n/a	Rescan 2012, 2013
	Lac du Sauvage (2000)	Ekati Mine AEMP	2000 to 2012	One open-water (summer only)	Surface grab at 1 m below the surface, triplicate samples	n/a	Rescan 2012, 2013
	Lac du Sauvage, Christine Lake (Lake B1), Ursula Lake	Jay Pipe Aquatic Baseline Program	2006	Three open-water (late spring, summer, and fall)	Surface grab at 1 m below the surface, triplicate samples	n/a	Rescan 2007
Zooplankton	Lac de Gras(a)	Diavik Mine Baseline Program	1997	Three open-water (late spring , summer, and fall)	Vertical hauls at 1 m above bottom, single sample	75 µm, 0.3 m	Golder 2011
	Lac de Gras	AEMP	2003 to 2011	Three open-water (late spring, summer, and fall)	Vertical hauls at 1 m above bottom, composite sample	75 µm, 0.3 m	Golder 2011; DDMI 2012
	Lac de Gras	Diavik Mine AEMP	2012	One open-water (summer only)	Vertical hauls at 1 m above bottom, composite sample	75 µm, 0.3 m	DDMI 2013
	Counts Lake (Lake D3), Lac de Gras, Vulture Lake, and Nanuq Lake	Ekati Mine Baseline	1996(c) and 1997	One open-water (summer only)	Vertical haul nets at 1 to 2 m above bottom	118 µm, 0.3 m	Rescan 2012; ERM Rescan 2013
	Counts Lake, Lac de Gras, Vulture Lake, and Nanuq Lake	Ekati Mine AEMP	1998 to 2012	One open-water (summer only)	Vertical hauls at 1 to 2 m above bottom, triplicate samples	118 µm, 0.3 m	Rescan 2012; ERM Rescan 2013
	Lac du Sauvage (2000)	Ekati Mine AEMP	2000 to 2012	One open-water (summer only)	Vertical hauls at 1 to 2 m above bottom, triplicate samples	118 µm, 0.3 m	Rescan 2012; ERM Rescan 2013
	Lac du Sauvage Christine Lake (Lake B1), Ursula Lake	Jay Pipe Aquatic Baseline Program	2006	Three open-water (late spring, summer, and fall)	Vertical hauls at 1 to 2 m above bottom, triplicate samples	118 µm, 0.3 m	Rescan 2007

a) Includes only the far-field reference 2 area (FF2 area).

b) Includes only chlorophyll *a* concentrations because phytoplankton taxonomic results were not available at the time of this report.

c) Includes only Vulture Lake.

µm = micrometre; m = metre; AEMP = Aquatic Effects Monitoring Program; n/a = not applicable.

2.2.4 Data Assessment Approach

The development of this historical review entailed a review and synthesis of a large amount of chlorophyll *a* and plankton community data from three separate programs. In addition to compiling these data, the review required additional data analyses using publicly available data.

Direct comparisons of data among programs are limited by the following differences in sampling designs:

- timing and frequency of sampling: the Diavik Mine baseline and AEMP, and the Jay pipe aquatic baseline study collected data over three open-water sampling periods, while data for the Ekati Mine AEMP were collected during a single open-water sampling period (i.e., August);
- zooplankton mesh size (i.e., 75 µm [micrometres] for the Diavik Mine AEMP versus 118 µm for the Jay pipe aquatic baseline and Ekati Mine AEMP); and,
- sampling depth and type of sample collected for phytoplankton and chlorophyll *a* (i.e., 10 metre [m] depth-integrated sample for Diavik Mine AEMP versus 1 m grab sample for Jay pipe aquatic baseline and Ekati Mine AEMP).

Due to these differences among programs, comparisons presented in this report are qualitative and restricted to a high level, as follows:

- Chlorophyll *a* concentrations were qualitatively assessed within each lake. In addition, chlorophyll *a* concentrations were compared to trophic status classifications based on Wetzel (2001).
- For phytoplankton, a qualitative assessment of total abundance, total biomass (where available), taxonomic richness, and the relative proportion of abundance and biomass (where available) was completed for each waterbody. Phytoplankton abundance and biomass data were divided into groups based on taxonomic results as follows: cyanobacteria; chlorophytes; chrysophytes; diatoms; and “others” including cryptophytes, dinoflagellates, euglenoids, and unidentified taxa. For data related to the Jay pipe aquatic baseline, seasonal variability was evaluated by examining total biomass and the biomasses of each major phytoplankton group.
- For zooplankton, a qualitative assessment of total abundance, total biomass, taxonomic richness, and relative proportion of abundance was completed for each waterbody. Zooplankton abundance and biomass data were divided into groups based on taxonomic results as follows: cladocerans; calanoid copepods; cyclopoid copepods; and rotifers. For data related to the Jay pipe aquatic baseline, seasonal variability was evaluated by examining total biomass and the biomass of each major zooplankton group.

2.3 Results

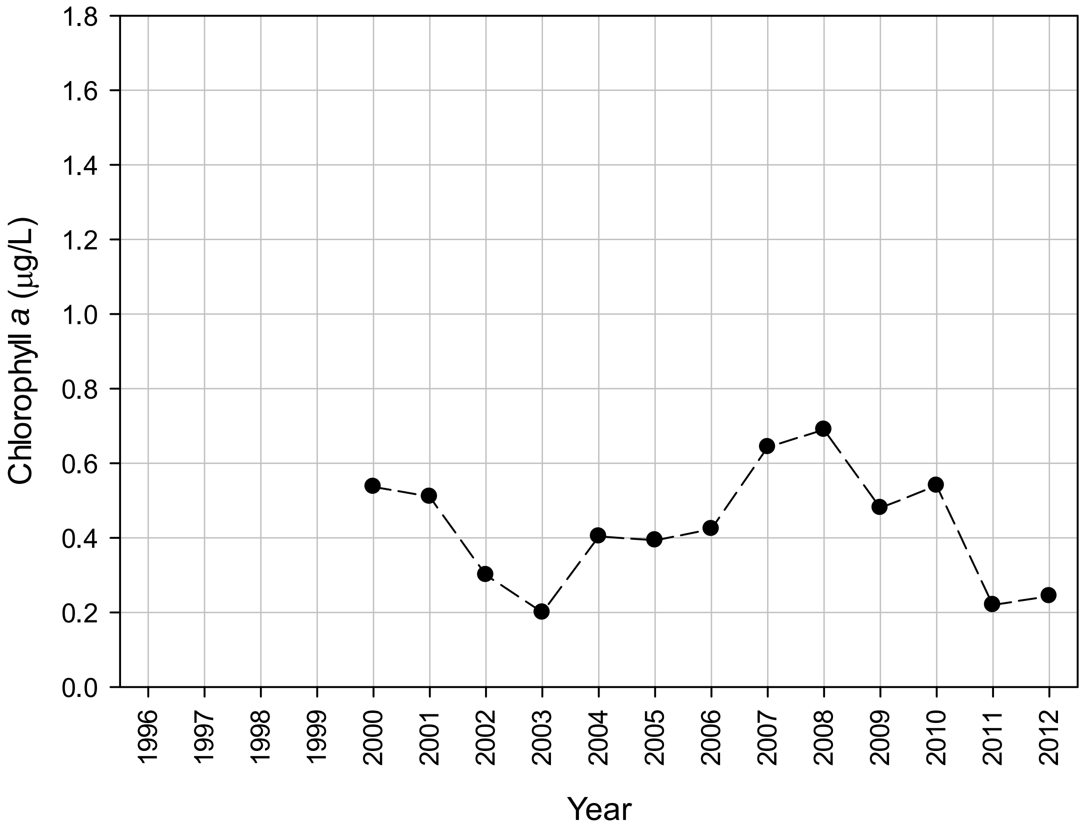
2.3.1 Lac du Sauvage Basin

2.3.1.1 Lac du Sauvage, 2000 to 2012

2.3.1.1.1 Chlorophyll a

Summer chlorophyll *a* concentrations at Station LDS1 in Lac du Sauvage exhibited variability between 2000 and 2012 (Figure 2.3-1). Chlorophyll *a* concentrations at LDS1 ranged between 0.20 micrograms per litre (µg/L) (2003) and 0.69 µg/L (2008). Peak chlorophyll *a* concentrations were observed in 2008, followed by a decline in concentrations to near the detection limit of 0.20 µg/L in 2011. These chlorophyll *a* concentrations in Lac du Sauvage were consistent with a trophic status classification of oligotrophic (Wetzel 2001).

Figure 2.3-1 Summer Chlorophyll *a* Concentrations in Lac du Sauvage, 2000 to 2012



Source: ERM Rescan (2013).

µg/L = micrograms per litre.

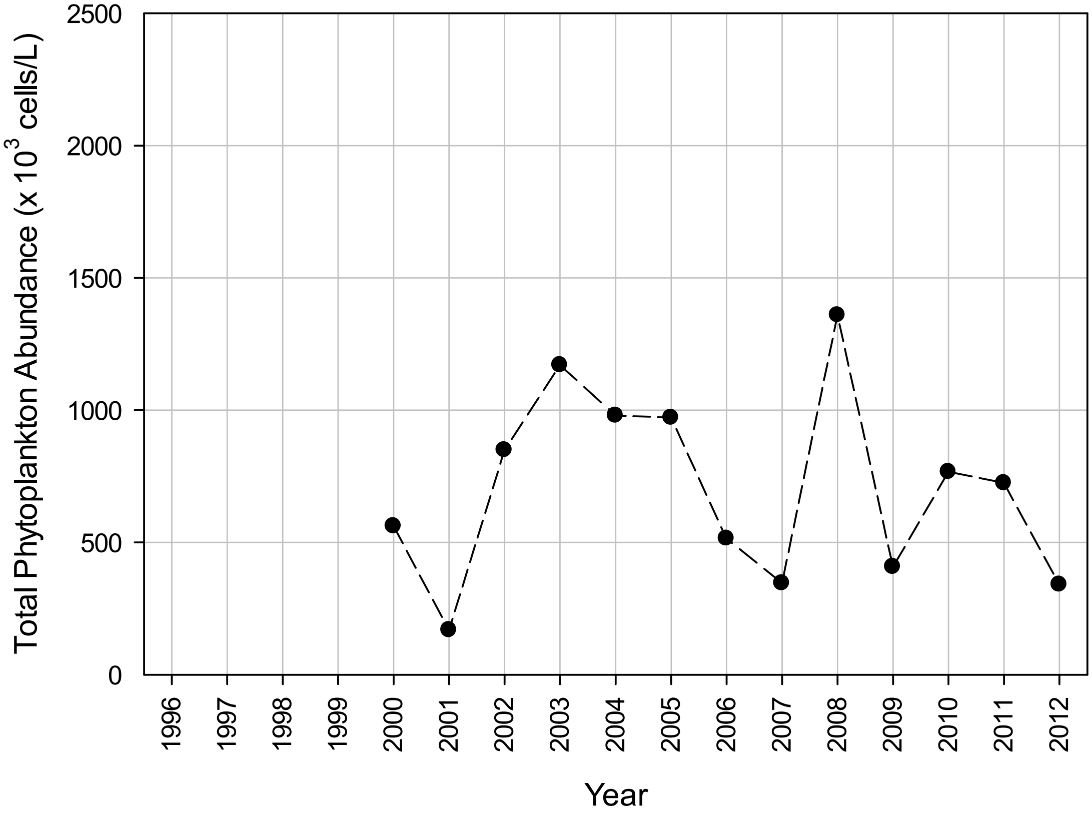
During the first year of the Jay pipe aquatic baseline data collection in 2006, mean open-water chlorophyll *a* concentrations at the majority of the twelve stations sampled in Lac du Sauvage ranged between 0.46 µg/L and 0.64 µg/L (Rescan 2007). Mean open-water chlorophyll *a* concentration was higher (1.08 milligrams per litre [mg/L]) at one station (LDS8; Rescan 2007).

2.3.1.1.2 Phytoplankton

Abundance

Summer total phytoplankton abundance at Station LDS1 in Lac du Sauvage was highly variable between 2000 and 2012, with no distinct temporal trend (Figure 2.3-2). Total phytoplankton abundance ranged from a minimum of 168,333 cells per litre (cells/L) (2001) to a maximum of 1,358,000 cells/L (2008).

Figure 2.3-2 Summer Total Phytoplankton Abundance in Lac du Sauvage, 2000 to 2012



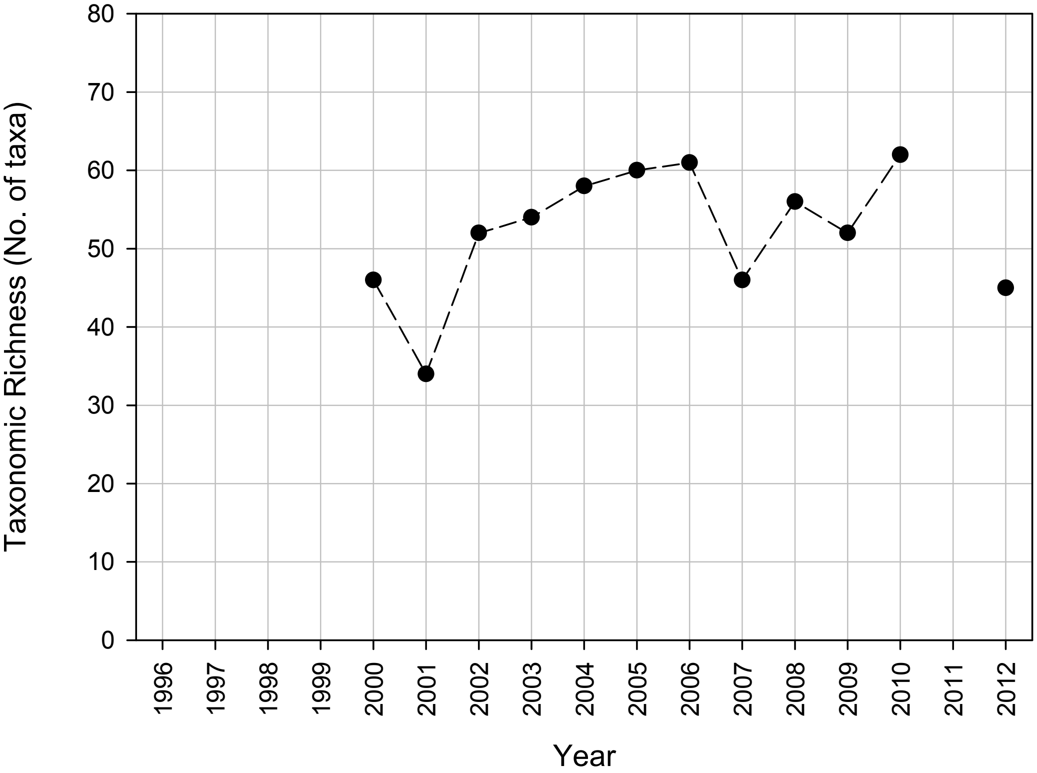
Source: ERM Rescan (2013).
cells/L = cells per litre.; x = times.

The 2006 seasonal data indicated that the lowest total phytoplankton abundance was generally observed in the late spring, and peak values occurred in either the summer or fall (Rescan 2007). Total phytoplankton abundance ranged from a minimum of 426,067 cells/L to a maximum of 1,195,600 cells/L (Rescan 2007). No spatial trend in total phytoplankton abundance was evident in 2006.

Community Composition

Between 2000 and 2012, phytoplankton total taxonomic richness at Station LDS1 ranged between 34 and 62 taxa (Figure 2.3-3). In general, variability in taxonomic richness was relatively low over time, with the exception of 2001 (34 taxa). Overall, the taxa present at Station LDS1 were relatively consistent over time (Historical Taxa Presence or Absence Summary [Appendix A], Table A-1).

Figure 2.3-3 Summer Total Phytoplankton Taxonomic Richness in Lac du Sauvage, 2000 to 2012



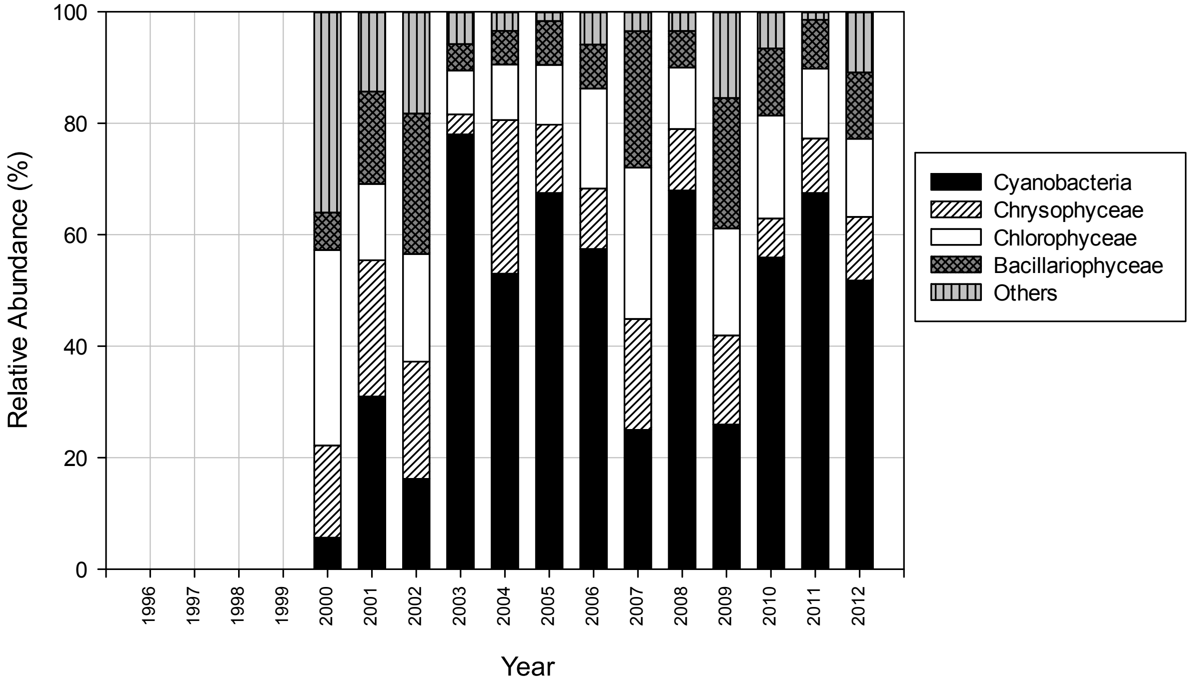
Source: ERM Rescan (2013).

No. = number.

A total of 78 taxa were identified among the twelve stations sampled in Lac du Sauvage during the 2006 open-water season (Appendix A, Table A-2). The open-water phytoplankton community was consistently dominated by two taxa of cyanobacteria, *Anabaena* species (sp.) and *Lyngbya limnetica* (Rescan 2007). Both cyanobacteria taxa were also present in Lac du Sauvage during most years sampled as part of the Ekati Mine AEMP (Appendix A, Table A-2).

The open-water phytoplankton community (based on abundance) at Station LDS1 was typically dominated by cyanobacteria (Figure 2.3-4). In 2000, chlorophytes and “others” (primarily cryptophytes, 21 percent [%]) co-dominated the open-water phytoplankton community at 35% and 36%, respectively. In 2002, 2007, and 2009, the open-water phytoplankton community consisted of approximately equal proportions of cyanobacteria, chlorophytes, chrysophytes, and diatoms.

Figure 2.3-4 Summer Relative Phytoplankton Abundance in Lac du Sauvage, 2000 to 2012



Source: ERM Rescan (2013).
% = percent.

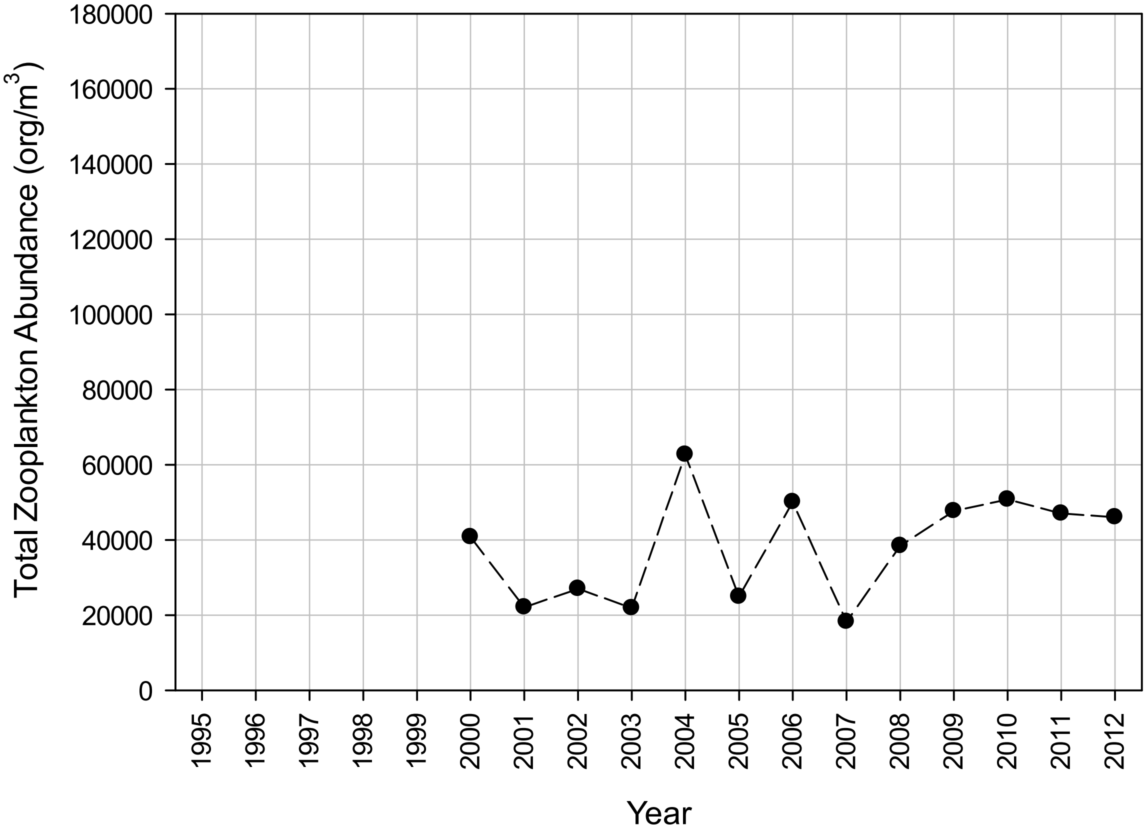
In 2006, seasonal variation in phytoplankton community composition (based on abundance) was observed in the Jay pipe aquatic baseline study area (Rescan 2007). Cyanobacteria consistently dominated the phytoplankton community, but the relative proportion of this major taxonomic group increased from late spring (28% to 56%) to open-water (54% to 78%) and fall (48% to 68%). Chlorophytes were consistently sub-dominant in the phytoplankton community and the proportion, based on abundance, of this major taxonomic group remained relatively consistent between late spring (14% to 30%), open-water (10% to 26%), and fall (17% to 30%). The relative proportions of chrysophytes were highest in the late spring (16% to 33%) compared to open-water (4% to 11%) or fall (3% to 5%). With a few exceptions, diatoms accounted for less than or equal to 10% of the phytoplankton community (based on abundance).

2.3.1.1.3 Zooplankton

Abundance and Biomass

Summer total zooplankton abundance at Station LDS1 in Lac du Sauvage was variable over the years, although zooplankton abundances were relatively stable from 2009 to 2012 (Figure 2.3-5). The minimum summer total zooplankton abundance of 18,171 organisms per cubic metre (org/m^3) was observed in 2007, and the maximum of 62,687 org/m^3 was observed in 2004. Since 2009, total zooplankton abundance was approximately 47,000 org/m^3, which is comparable to the zooplankton abundance of 40,734 org/m^3 observed in 2000.

Figure 2.3-5 Summer Total Zooplankton Abundance in Lac du Sauvage, 2000 to 2012

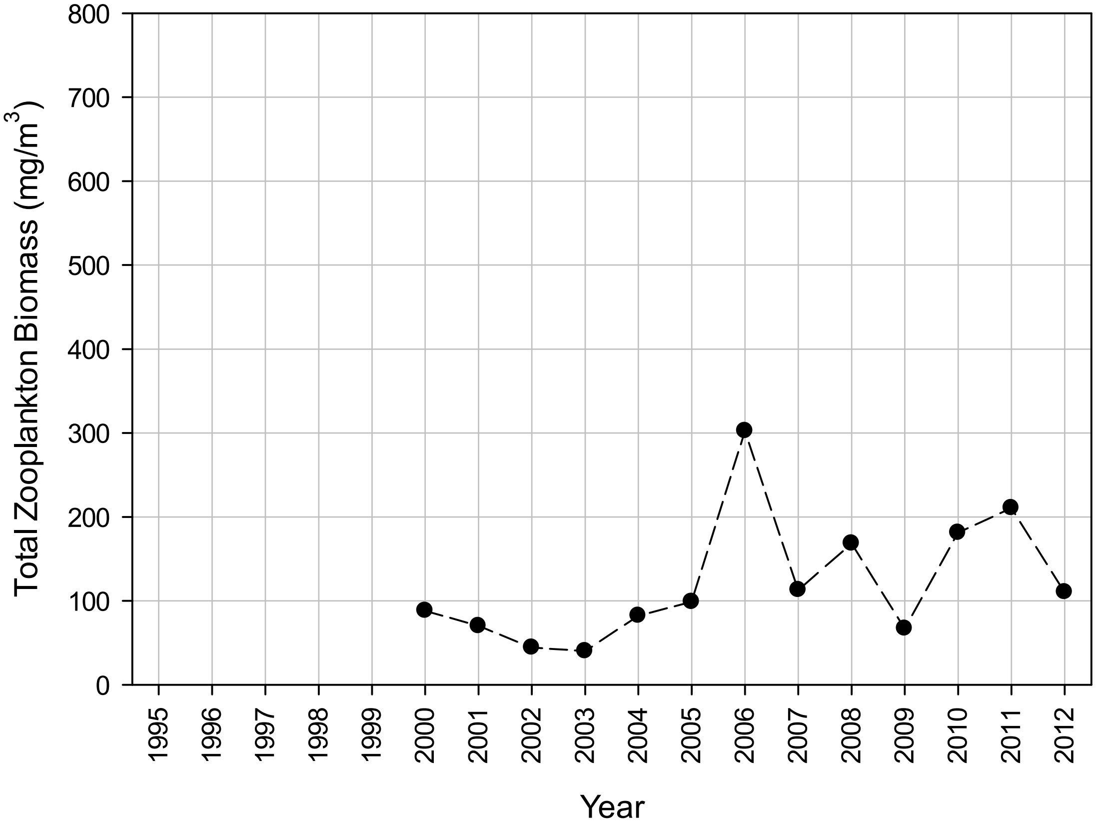


Source: ERM Rescan (2013).
org/m^3 = organisms per cubic metre.

In 2006, total zooplankton abundance was highly variable throughout the open-water season, ranging from 11,353 to 87,858 org/m^3 in late spring, 1,998 to 193,979 org/m^3 in summer, and 14,034 to 85,102 org/m^3 in fall (Rescan 2007). There were no distinct seasonal or spatial trends observed in total zooplankton abundance values beyond Station LDS2 consistently having the lowest total zooplankton abundance compared to other sampling stations (Rescan 2007).

In general, summer total zooplankton biomass has increased at Station LDS1 since the first year of sampling in 2000, although there was year-to-year variability (Figure 2.3-6). Total biomass ranged from a minimum of 40 milligrams per cubic metre (mg/m^3) (2003) to a maximum of 302 mg/m^3 (2006).

Figure 2.3-6 Summer Total Zooplankton Biomass in Lac du Sauvage, 2000 to 2012



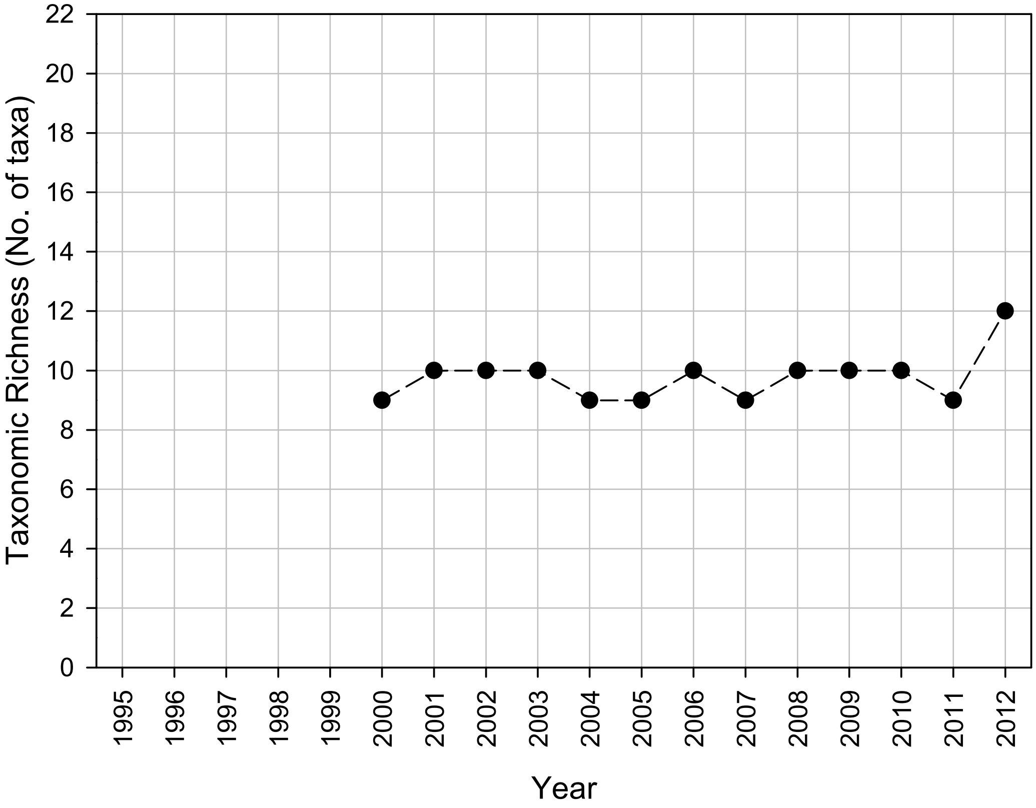
Source: ERM Rescan (2013).
mg/m^3 = milligrams per cubic metre.

In 2006, total zooplankton biomass was highly variable throughout the open-water season, ranging from 9 to 197 mg/m^3 in late spring, 22 to 405 mg/m^3 in summer, and 9 to 549 mg/m^3 in fall (Rescan 2007). No distinct seasonal or spatial trends were observed in total zooplankton biomass values beyond Station LDS2 consistently having the lowest total zooplankton biomass compared to other sampling stations (Rescan 2007).

Community Composition

Zooplankton taxonomic richness at Station LDS1 in Lac du Sauvage has ranged from 9 to 12 taxa (Figure 2.3-7; Appendix A, Table A-3). Overall, there has been little variation in zooplankton taxonomic richness between 2000 and 2012.

Figure 2.3-7 Summer Total Zooplankton Taxonomic Richness in Lac du Sauvage, 2000 to 2012

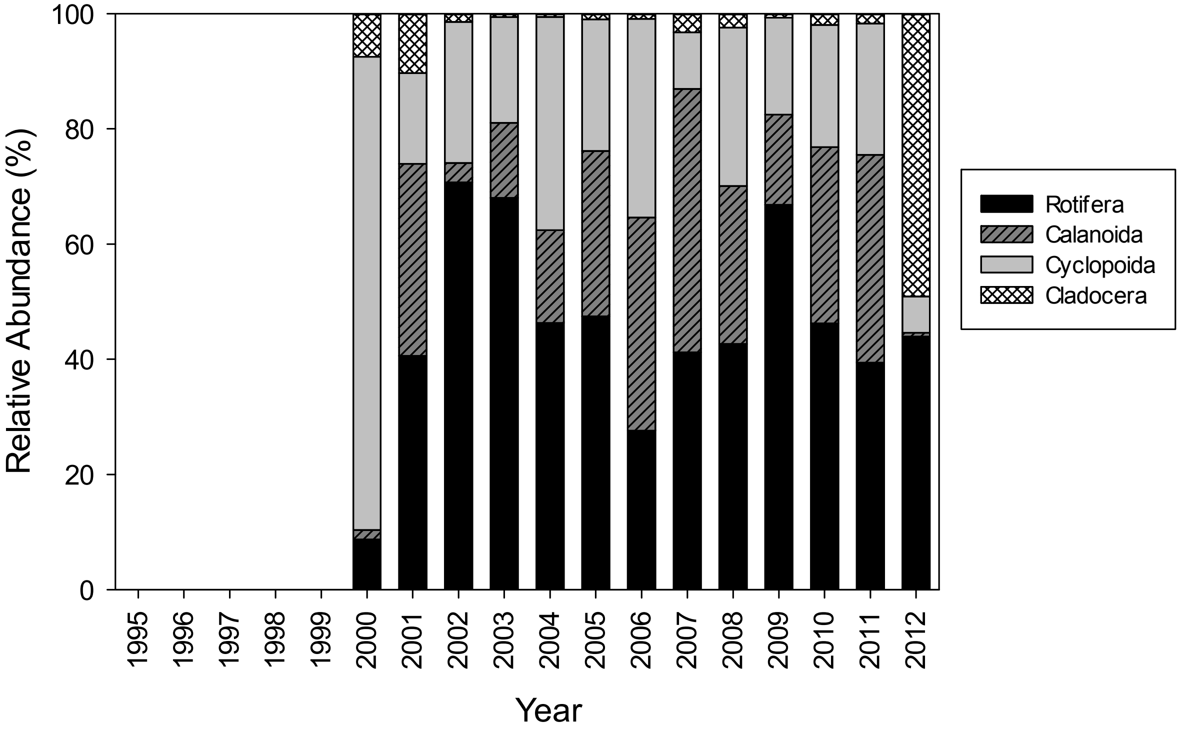


Source: ERM Rescan (2013).
No. = number.

In total, 14 zooplankton taxa were identified in Lac du Sauvage in 2006 (Rescan 2007). Two rotifer taxa, *Kellicottia longispina* and *Conochilus* sp., and three calanoid copepod taxa, *Leptodiaptomus* sp., *Heterocope* sp., and *Epischura* sp., were identified at every station in 2006 (Appendix A, Table A-4).

The zooplankton community (based on relative abundance) in Lac du Sauvage was typically co-dominated by rotifers and copepods (calanoid and cyclopoid; Figure 2.3-8). In 2000, cyclopoid copepods accounted for 82% of the open-water zooplankton community. In general, cladocerans were present in low numbers (less than 10%) with the exception of 2012, when this group accounted for 49% of the zooplankton community.

Figure 2.3-8 Summer Relative Zooplankton Abundance in Lac du Sauvage, 2000 to 2012



Source: ERM Rescan (2013).
% = percent.

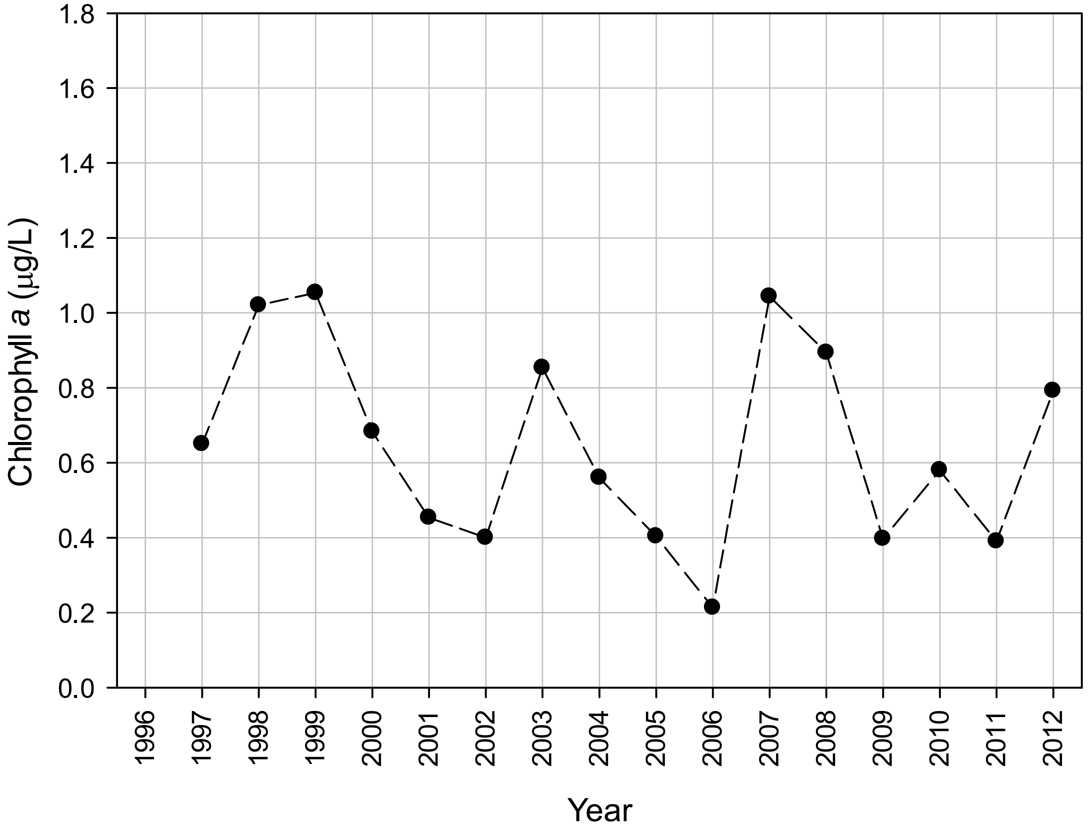
In 2006, while there was seasonal variation in the relative proportions of the major zooplankton taxonomic groups (based on abundance), overall the zooplankton community remained consistently co-dominated by copepods (calanoid and cyclopoid) and rotifers (Rescan 2007). The relative proportion of cladocerans increased from less than or equal to 2% in the late spring and summer, to up to 10% in the fall.

2.3.1.2 Counts Lake (Lake D3), 1997 to 2012

2.3.1.2.1 Chlorophyll a

Counts Lake (Lake D3) summer chlorophyll *a* concentrations were variable between 1997 and 2012 (Figure 2.3-9). Chlorophyll *a* concentrations in this lake ranged from a minimum of 0.21 µg/L (2006) to a maximum of 1.05 µg/L (1999). Overall, mean summer chlorophyll *a* concentrations fluctuated within the oligotrophic range (Wetzel 2001).

Figure 2.3-9 Summer Chlorophyll *a* Concentrations in Counts Lake, 1997 to 2012



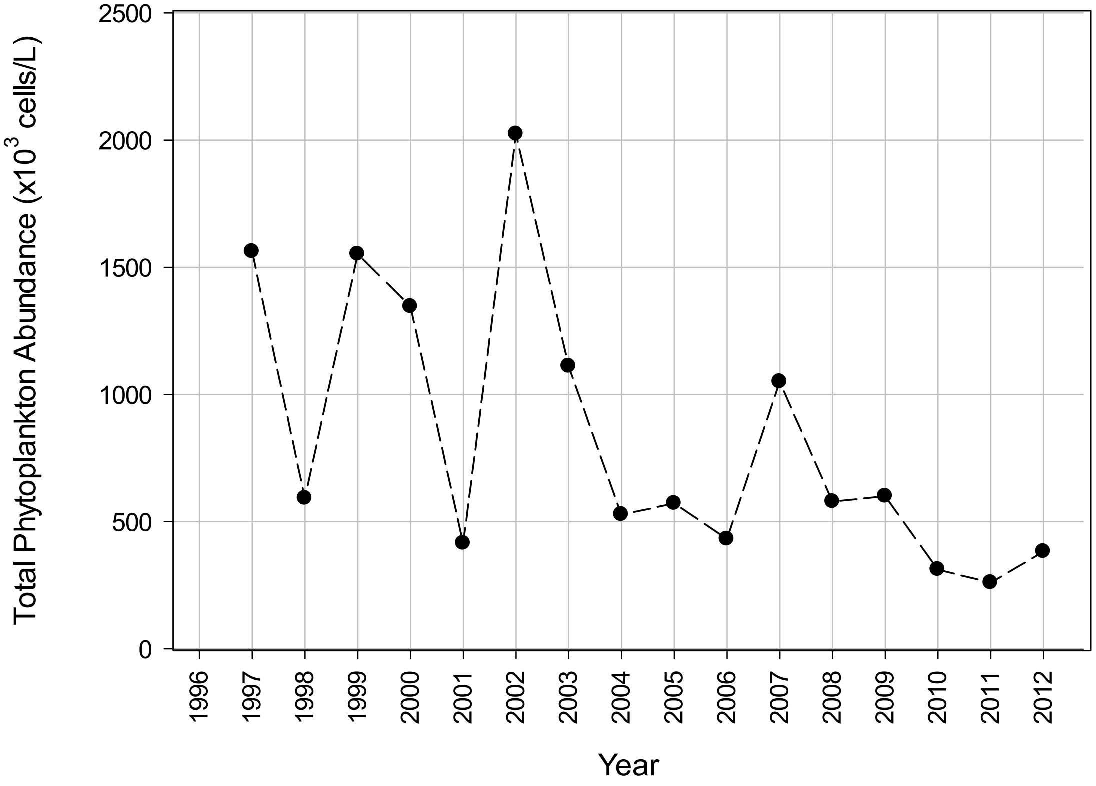
Source: ERM Rescan (2013).
µg/L = micrograms per litre.

2.3.1.2.2 Phytoplankton Community

Abundance

Summer total phytoplankton abundance in Counts Lake was variable, although this variability appears to be less pronounced since 2004 (Figure 2.3-10). In 1997, total phytoplankton abundance was 1,561,150 cells/L in the summer. The highest total phytoplankton abundance was observed in 2002 (2,023,383 cells/L). Thereafter, summer total phytoplankton abundance declined and has remained below 400,000 cells/L since 2010.

Figure 2.3-10 Summer Total Phytoplankton Abundance in Counts Lake, 1997 to 2012

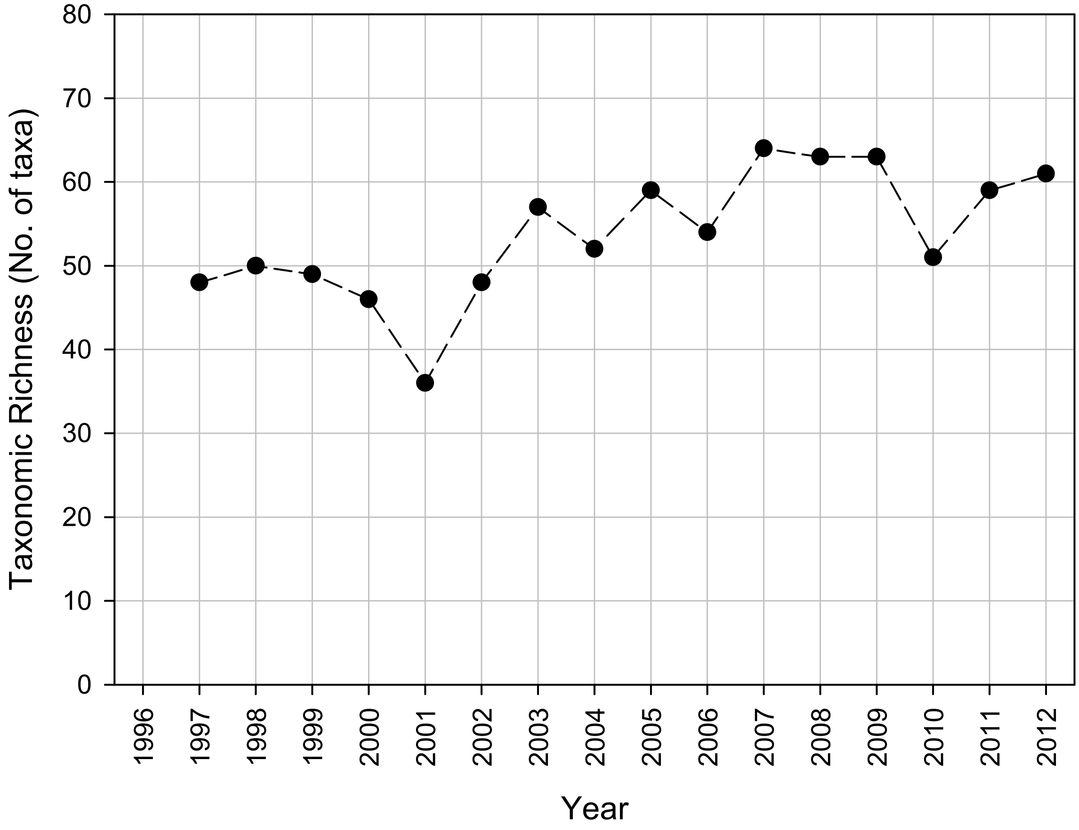


Source: ERM Rescan (2013).
cells/L = cells per litre; x = times.

Community Composition

Between 1997 and 2001, total phytoplankton taxonomic richness in Counts Lake decreased to the lowest richness of 36 taxa in 2001 (Figure 2.3-11). Since 2001, total phytoplankton taxonomic richness exhibited an increasing trend, which peaked at approximately 63 taxa between 2007 and 2009. In 2010, a slight decrease to 51 taxa was observed, but total phytoplankton taxonomic richness again approached peak values in 2011 (59 taxa) and 2012 (61 taxa; Appendix A, Table A-5).

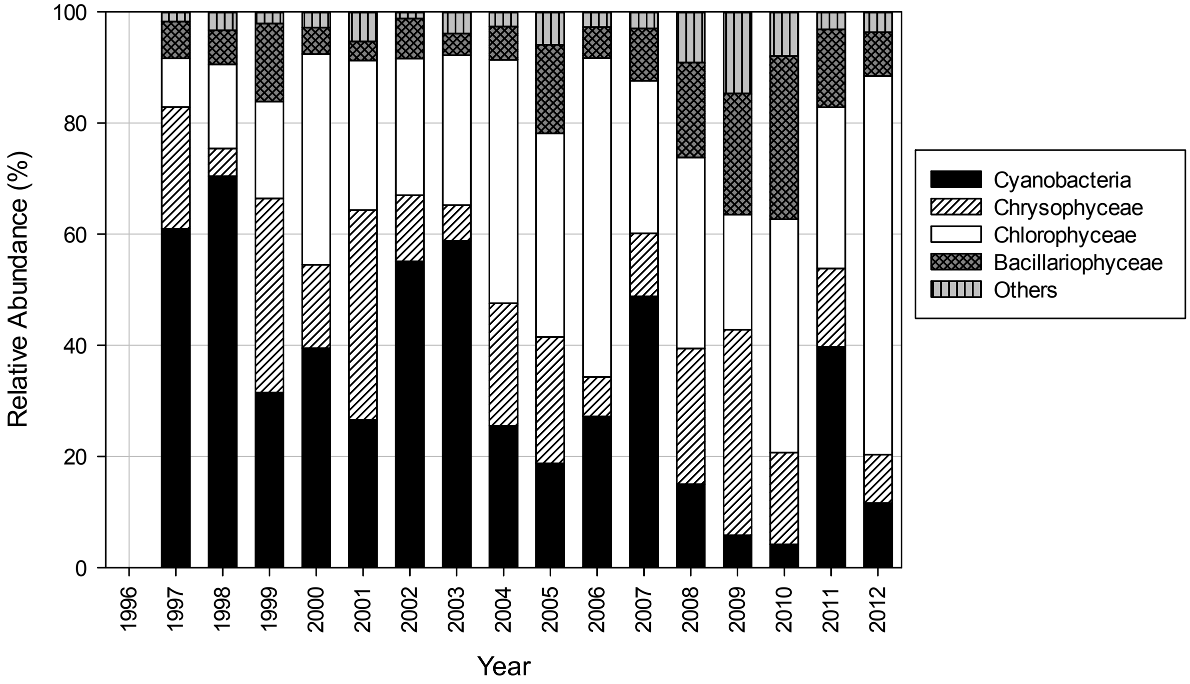
Figure 2.3-11 Summer Total Phytoplankton Taxonomic Richness in Counts Lake, 1997 to 2012



Source: ERM Rescan (2013).
No. = number.

The composition of the phytoplankton community (based on abundance) in Counts Lake has been inconsistent over time (Figure 2.3-12). In most years, cyanobacteria accounted for more than 20% of the community composition and occasionally reached proportions of 50% to 70%. The proportion of chlorophytes in Counts Lake has increased since 1997 (9%), with the highest proportion of chlorophytes recorded in 2012 (68%). Chrysophytes accounted for more than 20% of the community composition in 7 of the 16 years that Counts Lake was sampled. Diatoms typically contributed a relatively low proportion of the phytoplankton community, and accounted for more than 20% of the community composition on only two occasions (2009 and 2010).

Figure 2.3-12 Summer Relative Phytoplankton Abundance in Counts Lake, 1997 to 2012



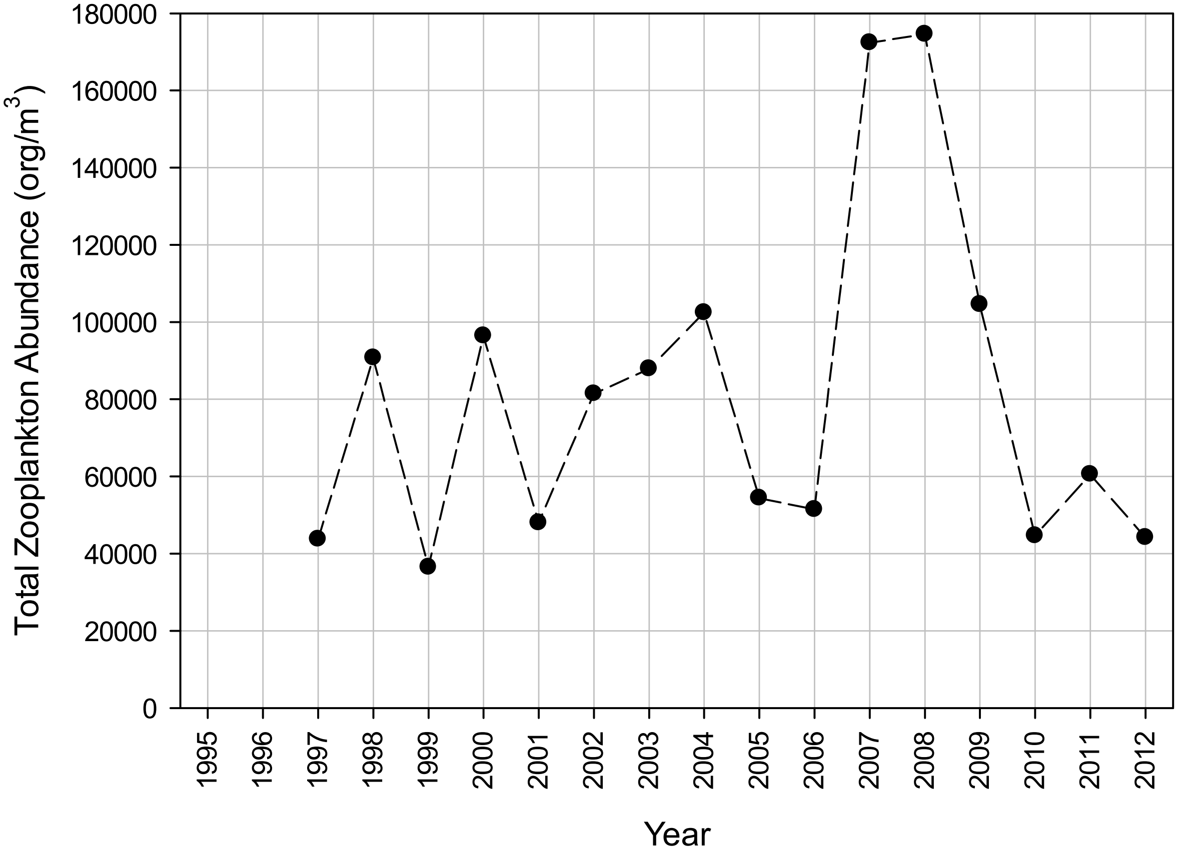
Source: ERM Rescan (2013).
% = percent.

2.3.1.2.1 *Zooplankton*

Abundance and Biomass

Summer total zooplankton abundance in Counts Lake was highly variable over the years (Figure 2.3-13). In 1997, total zooplankton abundance was 43,710 org/m^3. Peak total zooplankton abundance was observed in 2007 (172,365 org/m^3) and 2008 (174,581 org/m^3). Total zooplankton abundance declined in subsequent years, and has fluctuated between approximately 45,000 and 60,000 org/m^3 since 2010.

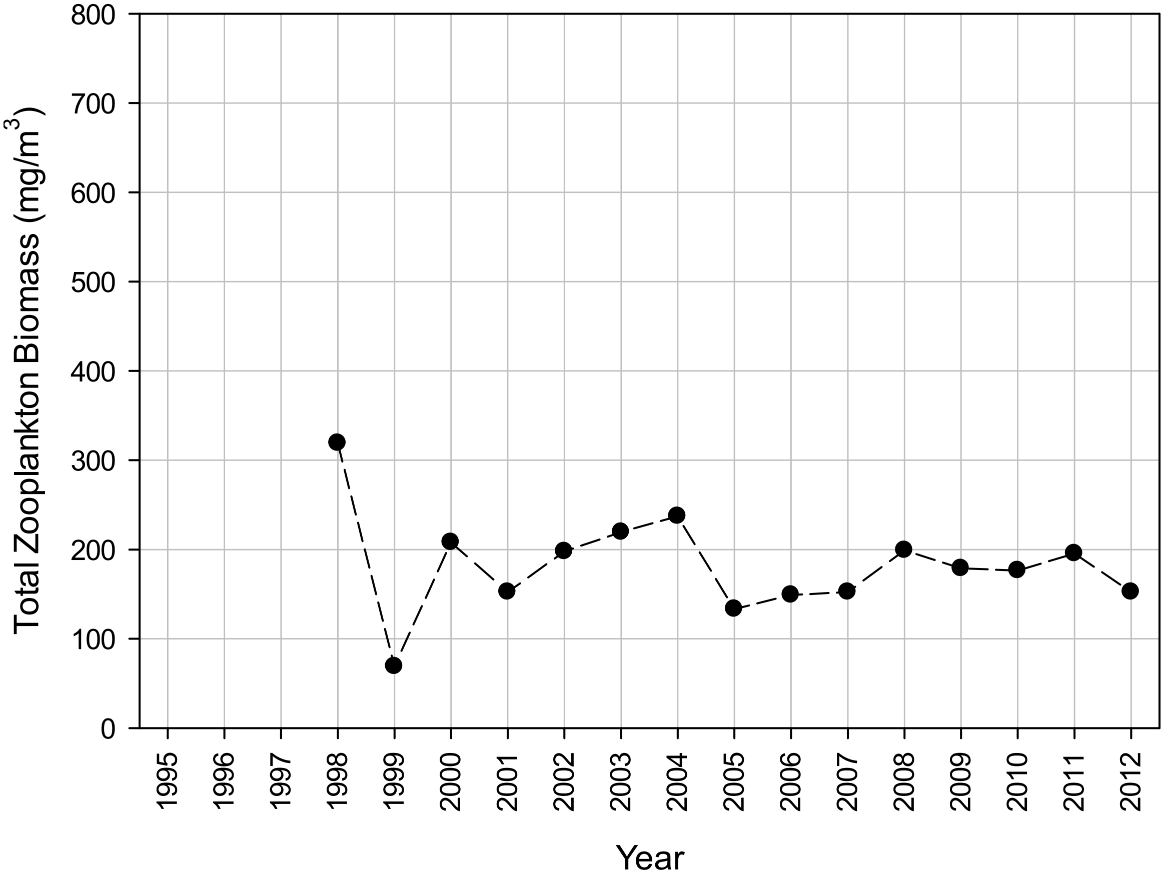
Figure 2.3-13 Summer Total Zooplankton Abundance in Counts Lake, 1997 to 2012



Source: ERM Rescan (2013).
org/m^3 = organisms per cubic metre.

In Counts Lake, summer total zooplankton biomass was less variable over time (Figure 2.3-14). Summer total zooplankton biomass was highest in 1998 (319 mg/m^3) and lowest in 1999 (69 mg/m^3). Since 2000, summer total zooplankton biomass was relatively stable, typically fluctuating between 150 and 200 mg/m^3.

Figure 2.3-14 Summer Total Zooplankton Biomass in Counts Lake, 1998 to 2012

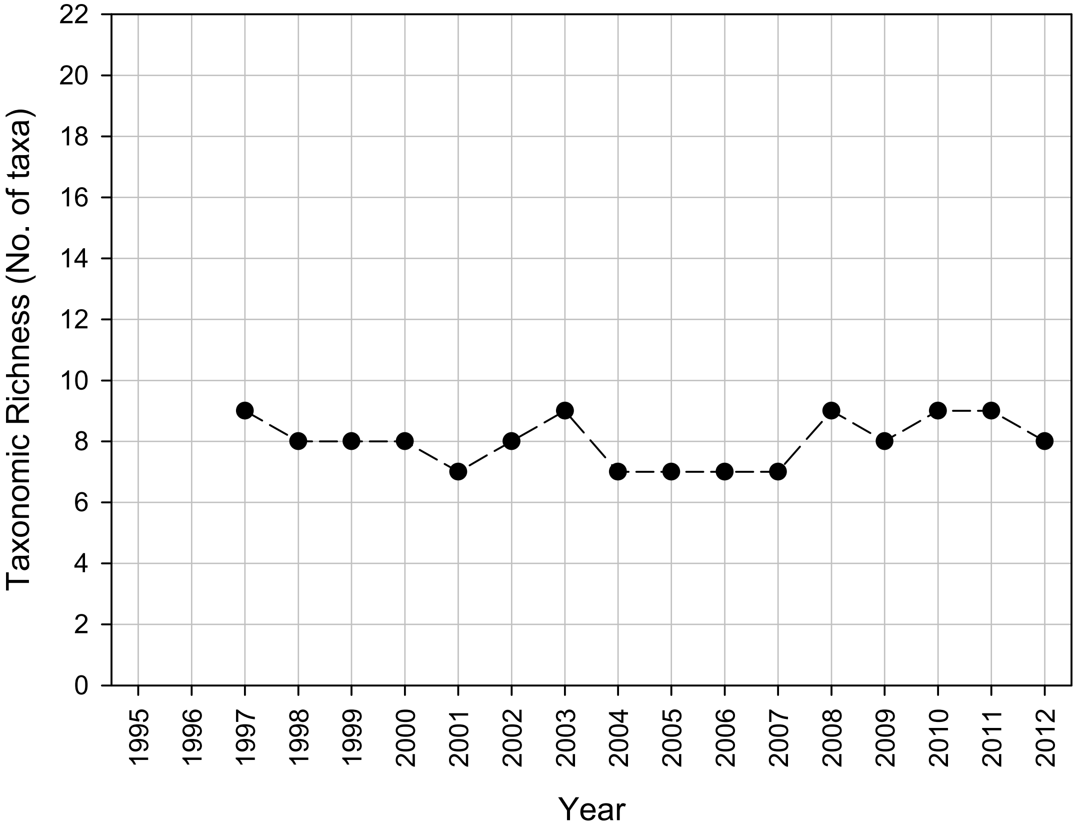


Source: ERM Rescan (2013).
mg/m^3 = milligrams per cubic metre.

Community Composition

Total zooplankton taxonomic richness in Counts Lake ranged between seven and nine taxa (Figure 2.3-15, Appendix A, Table A-6). Overall, there was little variation in zooplankton taxonomic richness between 1997 and 2012. In general, the same taxa were present in all years that Counts Lake was sampled (Appendix A, Table A-6); however, variability in the presence of the cladoceran *Bosmina* sp. and rotifer *Keratella* sp. was observed between 1997 and 2012.

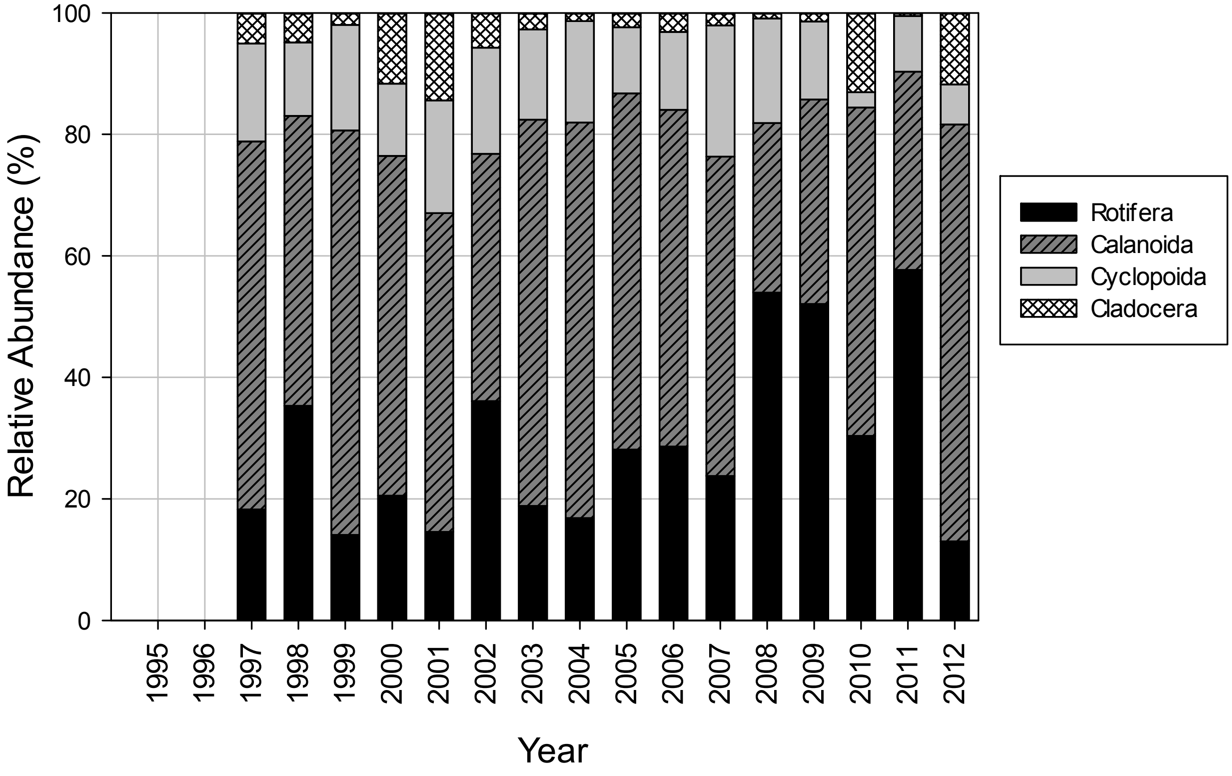
Figure 2.3-15 Summer Total Zooplankton Taxonomic Richness in Counts Lake, 1997 to 2012



Source: ERM Rescan (2013).
No. = number.

The summer zooplankton community (based on relative abundance) in Counts Lake was typically dominated by calanoid copepods, which accounted for more than 30% of the community in all years except 2008 (28%) (Figure 2.3-16). Rotifers were consistently sub-dominant in the zooplankton community, but were the dominant group in 2008 (54%), 2009 (52%), and 2011 (58%). Cyclopoid copepods accounted for 10% to 20% of the summer zooplankton community, but declined in 2010 (3%), 2011 (9%), and 2012 (7%). In general, cladocerans were present in low numbers (less than 10%) with the exception of 2000 (12%), 2001 (14%), 2010 (13%), and 2012 (12%).

Figure 2.3-16 Summer Relative Zooplankton Abundance in Counts Lake, 1997 to 2012



Source: ERM Rescan (2013).

% = percent.

2.3.1.3 *Christine and Ursula Lakes, 2006*

2.3.1.3.1 *Chlorophyll a*

Chlorophyll *a* concentrations in Christine Lake (Lake B1) were approximately two to three times higher than chlorophyll *a* concentrations in Ursula Lake (Table 2.3-1; Rescan 2007). In both lakes, chlorophyll *a* concentrations were lowest in the summer and highest in the fall. Chlorophyll *a* concentrations in Christine Lake and Ursula Lake were within the oligotrophic range (Wetzel 2001).

Table 2.3-1 Chlorophyll *a* Concentrations in Christine and Ursula Lakes, 2006

Lake	Date	Chlorophyll a (µg/L)
Christine	5-Jul-06	0.50
	30-Jul-06	0.33
	8-Sep-06	1.46
Ursula	7-Jul-06	0.24
	29-Jul-06	0.18
	8-Sep-06	0.47

Source: Rescan (2007).

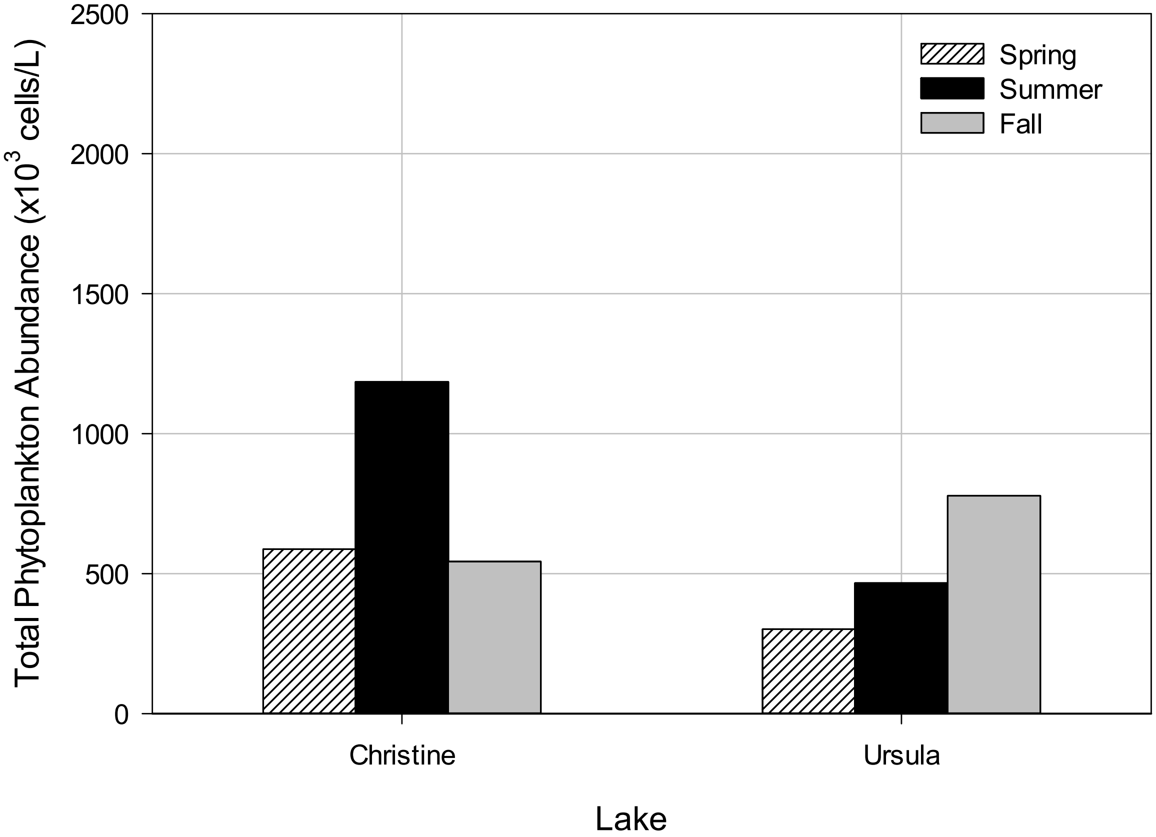
µg/L = micrograms per litre; Jul = July; Sep = September.

2.3.1.3.2 *Phytoplankton*

Abundance

In 2006, total phytoplankton abundance in Christine Lake was higher than in Ursula Lake, with the exception of the fall sampling period (Figure 2.3-17). In Christine Lake, total phytoplankton abundance was lowest in the late spring (587,533 cells/L) and fall (543,200 cells/L), and highest in the summer (1,884,000 cells/L). Conversely, total phytoplankton abundance in Ursula Lake increased over the course of the open-water sampling period, from 301,622 cells/L in the late spring to 778,400 cells/L in the fall.

Figure 2.3-17 Total Phytoplankton Abundance in Christine Lake and Ursula Lake, 2006



Source: Rescan (2007).
cells/L =cells per litre; x = times.

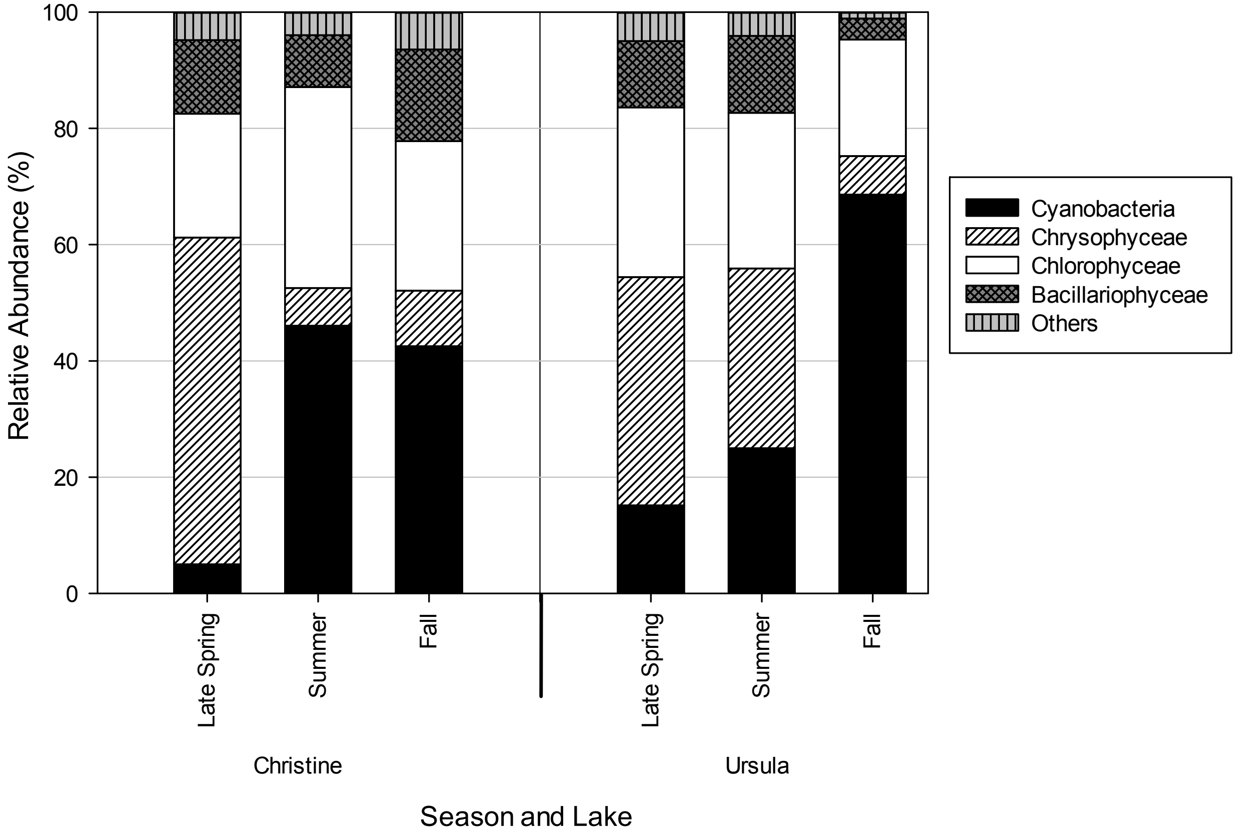
Community Composition

Total phytoplankton taxonomic richness in Christine Lake was 67 taxa (Appendix A, Table A-2). Among the three stations in Ursula Lake, total phytoplankton richness ranged between 60 and 64 taxa (Appendix A, Table A-2). Chlorophytes were the most taxonomically diverse group, while euglenoids were rare in both lakes.

In 2006, seasonal variability was observed in the Christine Lake phytoplankton community composition (based on abundance) (Figure 2.3-18). The late spring phytoplankton community was dominated by chrysophytes (56%); however, this group accounted for less than 10% of the summer and fall phytoplankton community composition. The proportion of cyanobacteria increased from 5% in the spring to 46% in the summer, and this group remained dominant (43%) into the fall. Chlorophytes were consistently sub-dominant in the phytoplankton community by abundance, accounting for 21%, 35%, and 28% in the late spring, summer, and fall, respectively. The proportion of diatoms was higher in the spring (13%) and fall (16%) compared with the summer (9%).

In 2006, seasonal variability was also observed in phytoplankton community composition in Ursula Lake (based on abundance; Figure 2.3-18). The phytoplankton community was co-dominated by chlorophytes and chrysophytes in the late spring (29% and 39%, respectively) and summer (27% and 31%, respectively). In the fall, the proportion of chrysophytes decreased to 7% and the proportion of chlorophytes declined to 20%. The proportion of cyanobacteria increased over the open-water season, from 15% in the late spring, to 25% in the summer, and 69% in the fall. Diatoms were more abundant in the late spring (11%) and summer (13%) compared to the fall (4%).

Figure 2.3-18 Relative Phytoplankton Abundance in Christine Lake and Ursula Lake, 2006



Source: Rescan (2007).

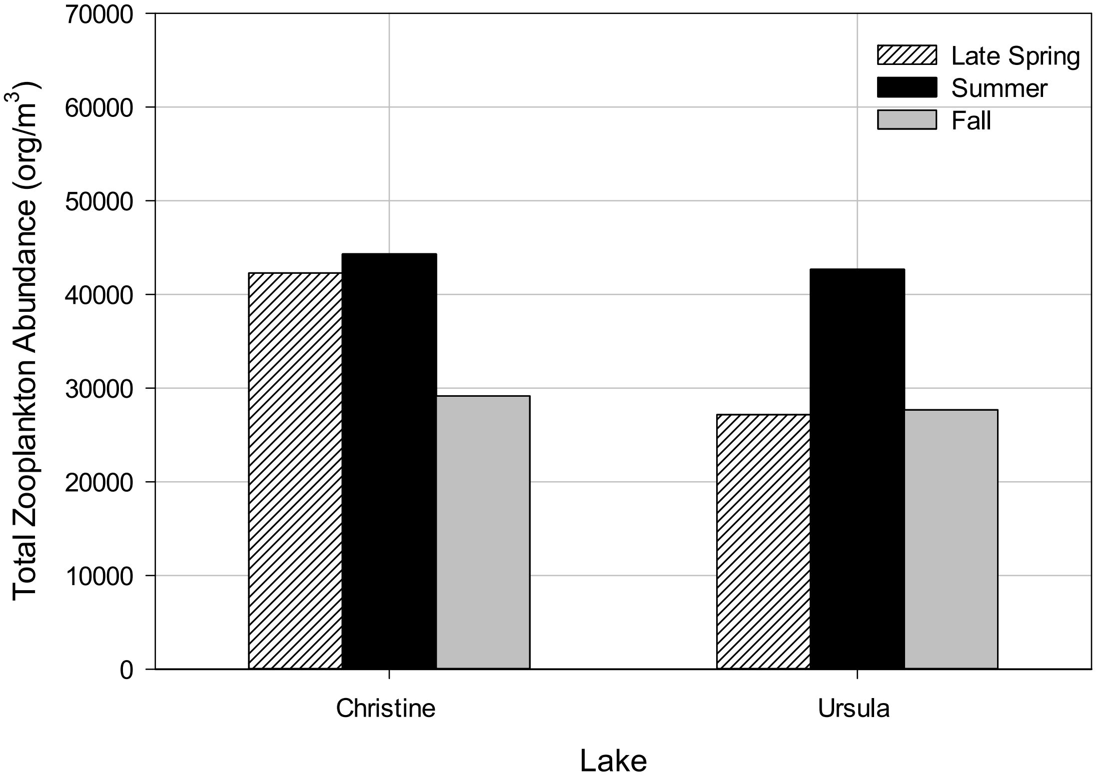
% = percent.

2.3.1.3.3 *Zooplankton*

Abundance and Biomass

In 2006, total zooplankton abundance was similar in Christine Lake and Ursula Lake, with the exception of the late spring sampling period (Figure 2.3-19). In Christine Lake, total zooplankton abundance was highest in the late spring (42,270 org/m^3) and summer (44,291 org/m^3), and lowest in the fall (29,140 org/m^3). In Ursula Lake, total zooplankton abundance was lower in the late spring (27,160 org/m^3) and fall (27,669 org/m^3) compared to the summer (42,646 org/m^3).

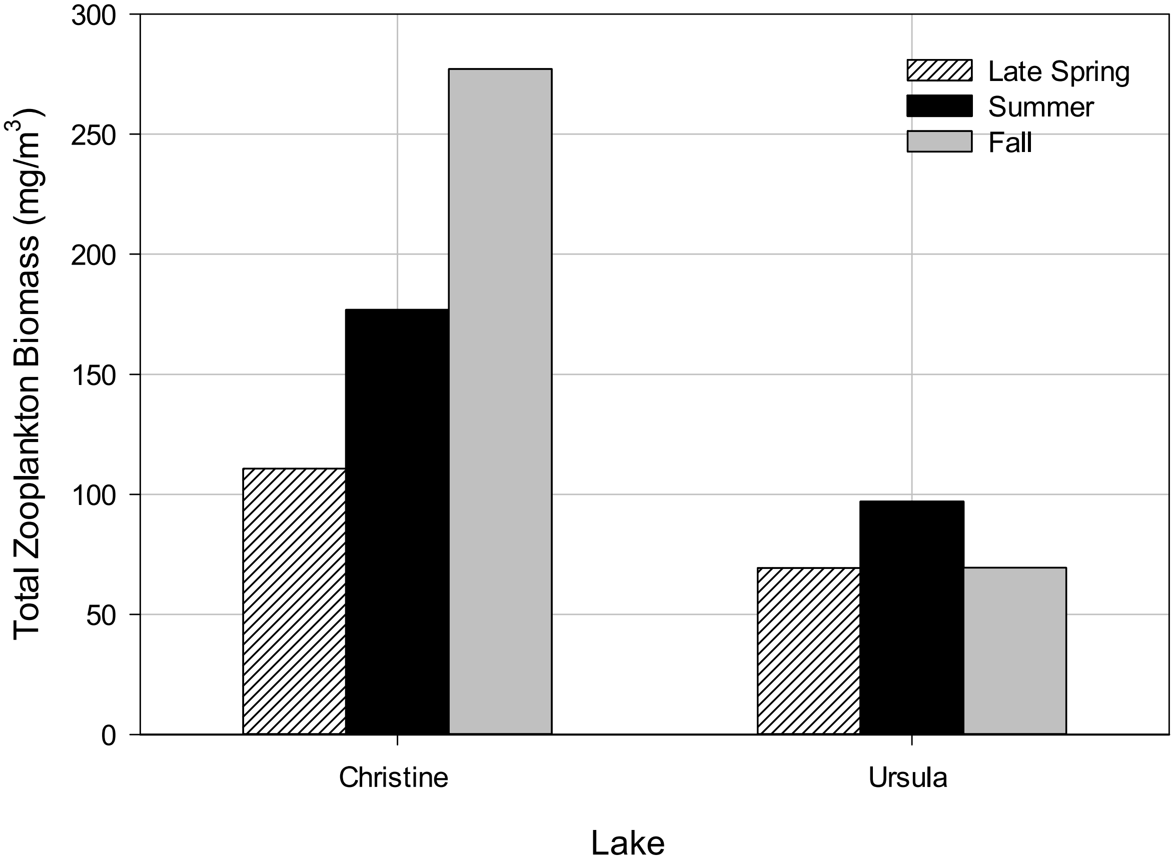
Figure 2.3-19 Total Zooplankton Abundance in Christine Lake and Ursula Lake, 2006



Source: Rescan (2007).
org/m^3 = organisms per cubic metre.

In 2006 total zooplankton biomass was higher in Christine Lake compared to Ursula Lake (Figure 2.3-20). Total zooplankton biomass in Christine Lake increased over the open-water period from 111 mg/m^3 in late spring, to 177 mg/m^3 in summer, and 277 mg/m^3 in fall. In Ursula Lake, total zooplankton biomass followed a similar pattern as total zooplankton abundance, i.e., lower biomass in the spring (69 mg/m^3) and fall (70 mg/m^3) compared to summer (97 mg/m^3)

Figure 2.3-20 Total Zooplankton Biomass in Christine Lake and Ursula Lake, 2006



Source: Rescan (2007).
mg/m^3 = milligrams per cubic metre.

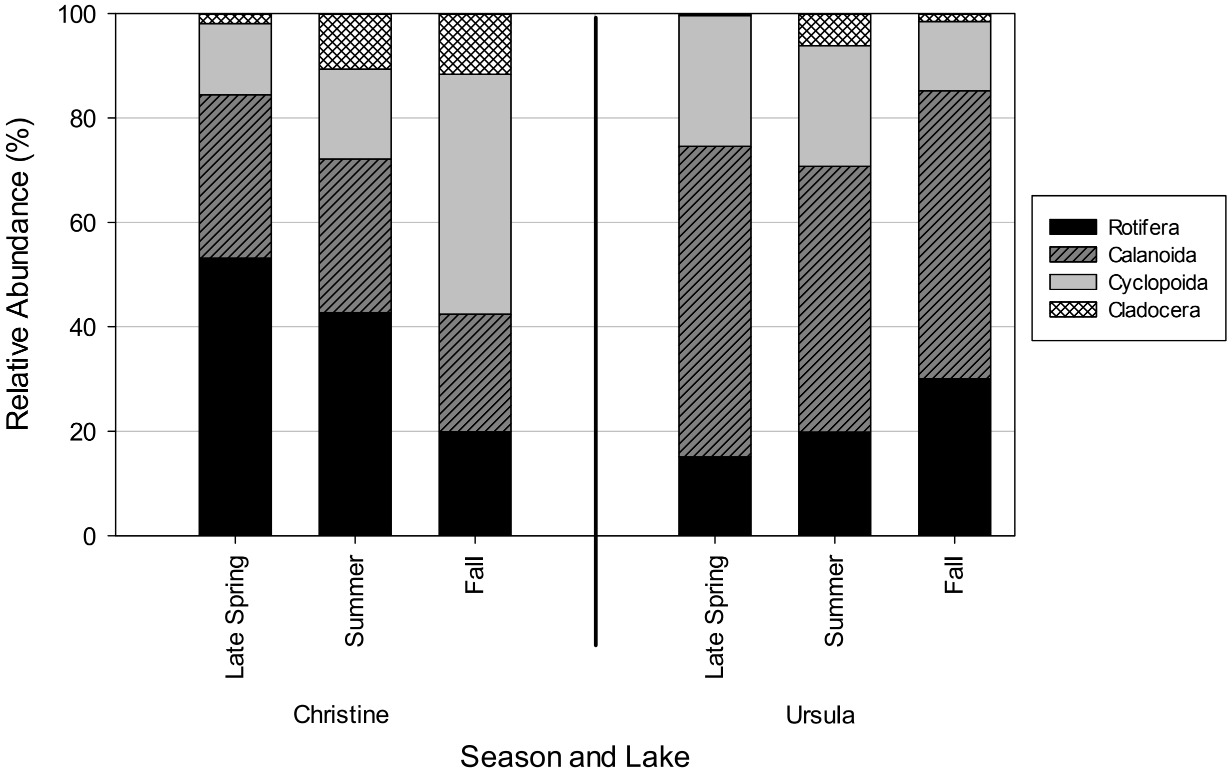
Community Composition

Total zooplankton taxonomic richness ranged from 9 to 10 taxa in Christine Lake and Ursula Lake (Appendix A, Table A-4). In general, taxonomic composition was similar in the two lakes. The calanoid copepods, *Epischura nevadensis* and *Leptodiaptomus sicilis*, were only present in Christine Lake, while the cyclopoid copepod *Cyclops bicuspidatus thomasi* and the rotifer *Keratella cochlearis* were only present in Ursula Lake.

In 2006, seasonal variability was observed in the composition of the Christine Lake zooplankton community (based on abundance; Figure 2.3-21). The proportion of rotifers decreased during the open-water period from 53% in late spring, 43% in summer, and 20% in fall. Cyclopoid copepods accounted for less than 20% of the zooplankton community in the late spring and summer, but increased to 46% in the fall. Calanoid copepod zooplankton community composition remained relatively consistent throughout the open-water season, ranging from 23% in the late spring, to approximately 30% in the summer and fall. Cladocera accounted for only 2% of the late spring zooplankton community, but approximately 10% of the summer and fall zooplankton communities.

In contrast, the zooplankton community composition (based on abundance) in Ursula Lake in 2006 had less pronounced seasonal variability (Figure 2.3-21). The zooplankton community was consistently dominated by calanoid copepods, which accounted for more than 50% of the zooplankton community in all seasons. The proportion of rotifers increased from 15% in the late spring, to 20% in the summer, and 30% in the fall. Cyclopoid copepods accounted for approximately 25% of the zooplankton community in the late spring and summer, but only 13% in the fall. The proportion of cladocerans was consistently low, ranging from less than 1% to 6% of the zooplankton community.

Figure 2.3-21 Relative Zooplankton Abundance for Christine Lake and Ursula Lake, 2006



Source: Rescan (2007).

% = percent.

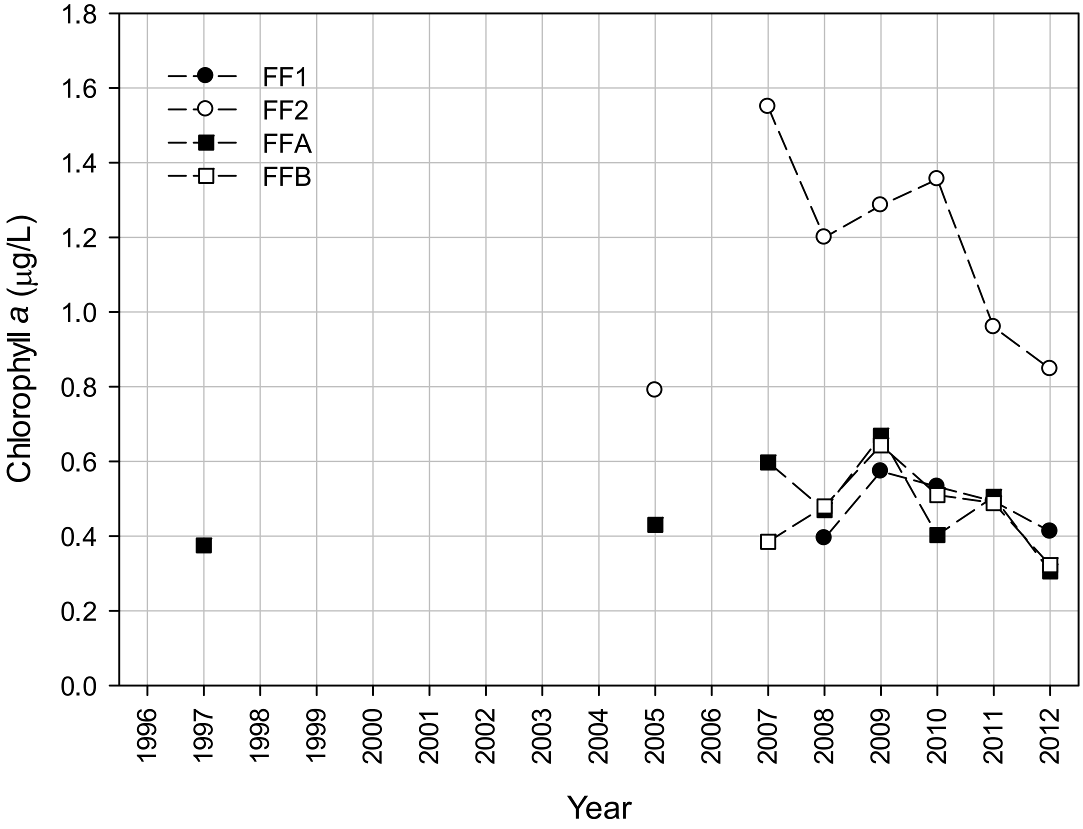
2.3.2 Lac de Gras Basin

2.3.2.1 Lac de Gras, 1997 to 2012

2.3.2.1.1 Chlorophyll a

Lac de Gras is an oligotrophic lake, although the Diavik Mine has had a slight enrichment effect in the near-field area of the lake close to the mine discharge, which is reflected in increased chlorophyll *a* concentrations (DDMI 2013). In 1997, the chlorophyll *a* concentration at far-field A (FFA) was 0.38 µg/L, and since then, chlorophyll *a* concentrations have ranged between 0.31 µg/L (2012) and 0.67 µg/L (2009) (Figure 2.3-22). Chlorophyll *a* concentrations in FF1 and FFB have been comparable to FFA, ranging between 0.32 and 0.64 µg/L (FFB), and 0.39 and 0.57 µg/L (FF1). Baseline data do not exist for the FF2 area but, since 2005, chlorophyll *a* concentrations in this area have been twice as high compared to the other far-field areas. Mean annual chlorophyll *a* concentrations in the FF2 area ranged from 0.79 µg/L (2005) to 1.55 µg/L (2007), and have exhibited a decreasing trend since 2007.

Figure 2.3-22 Mean Annual Chlorophyll *a* Concentrations in the Far-Field Areas in Lac de Gras, 1997 to 2012

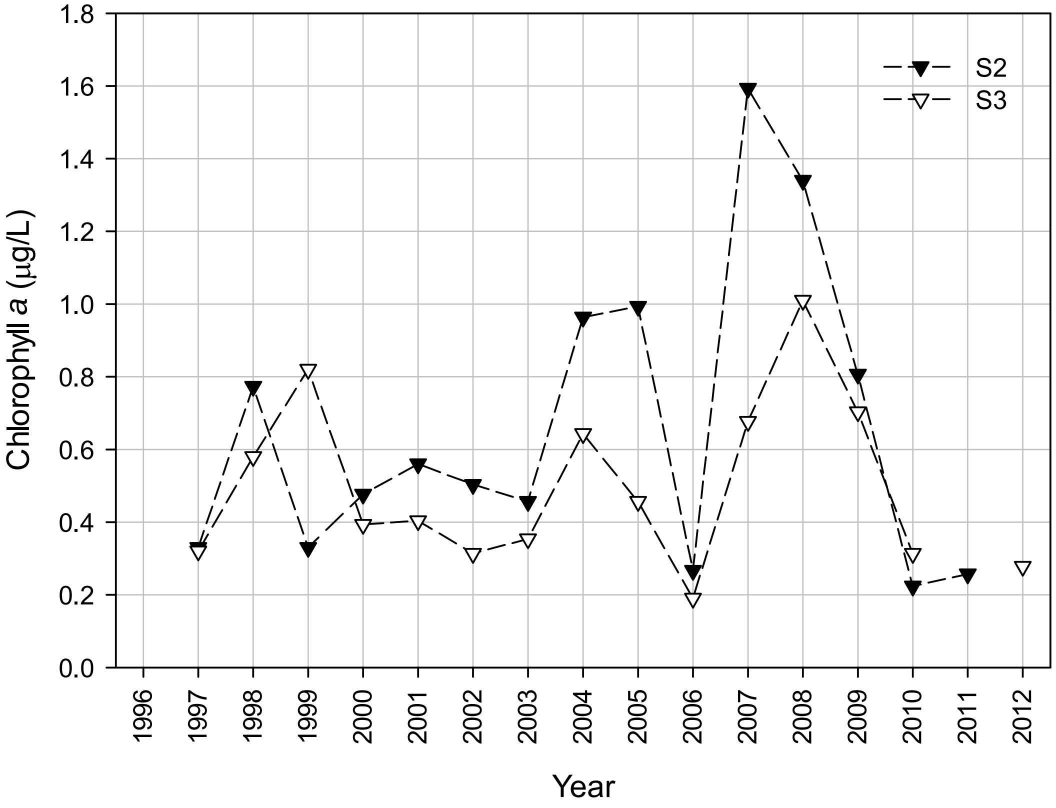


Sources: Golder (2011); DDMI (2012, 2013).

µg/L = micrograms per litre.

In 1997, summer chlorophyll *a* concentrations at S2 and S3 in the northern part of Lac de Gras were 0.33 µg/L and 0.32 µg/L, respectively. Since 1997, summer chlorophyll *a* concentrations have been highly variable, although concentrations were typically higher at Station S2 (Figure 2.3-23). Summer chlorophyll *a* concentrations ranged between 0.22 µg/L (2010) and 1.59 µg/L (2007) at Station S2, and between 0.20 µg/L (2006) and 1.01 µg/L (2008) at Station S3.

Figure 2.3-23 Summer Chlorophyll *a* Concentrations at Stations S2 and S3 in Lac de Gras, 1997 to 2012



Source: ERM Rescan (2013).

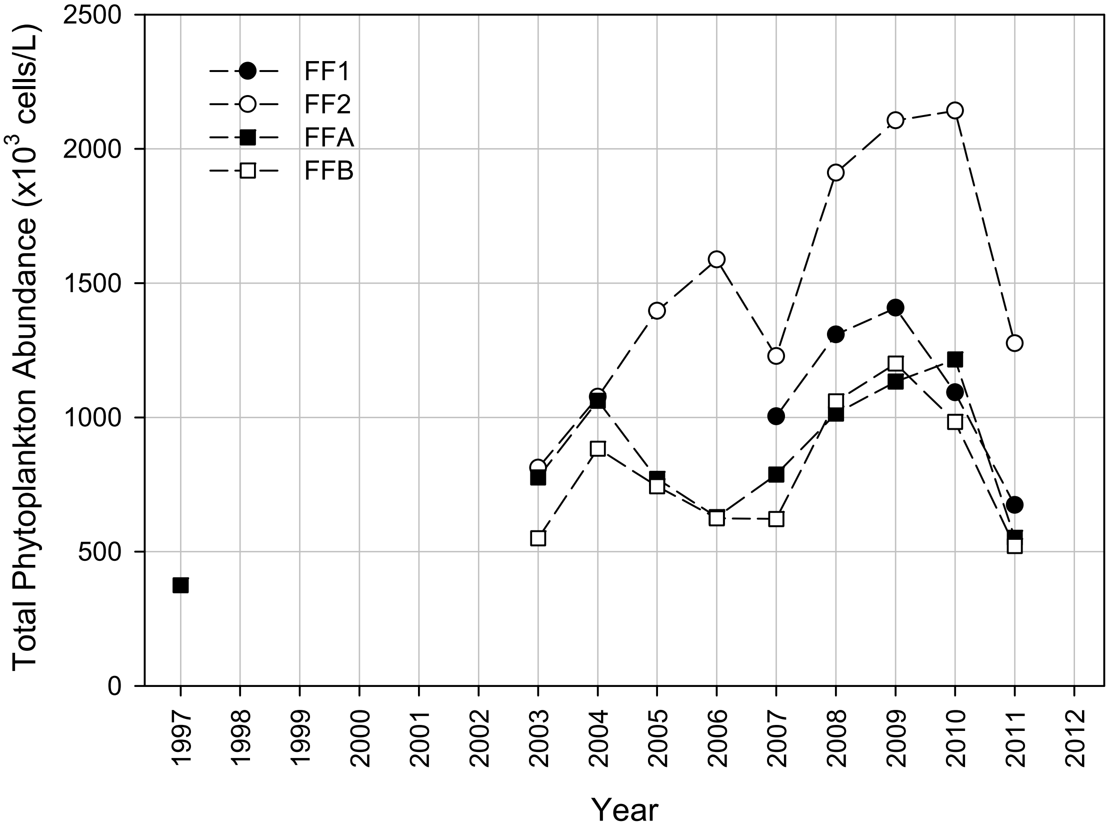
µg/L = micrograms per litre.

2.3.2.1.2 *Phytoplankton*

Abundance and Biomass

Mean annual total phytoplankton abundance in the FFA, FFB, and FF1 areas of Lac de Gras has fluctuated between 375,000 and 1,408,490 cells/L (Figure 2.3-24). Mean annual total phytoplankton abundance has been consistently higher at FF2, ranging between 1,228,280 cells/L and 2,142,160 cells/L. Although there have been no consistent temporal trends among these areas in Lac de Gras, an increase between 2007 and 2009 followed by a decrease until 2012 was observed in all four areas. This increase in mean annual total phytoplankton abundance suggests that, while there is likely enrichment occurring in the FF2 area, there is also a regional factor influencing phytoplankton abundance.

Figure 2.3-24 Mean Annual Total Phytoplankton Abundance in the Far-Field Areas in Lac de Gras, 1997 to 2011

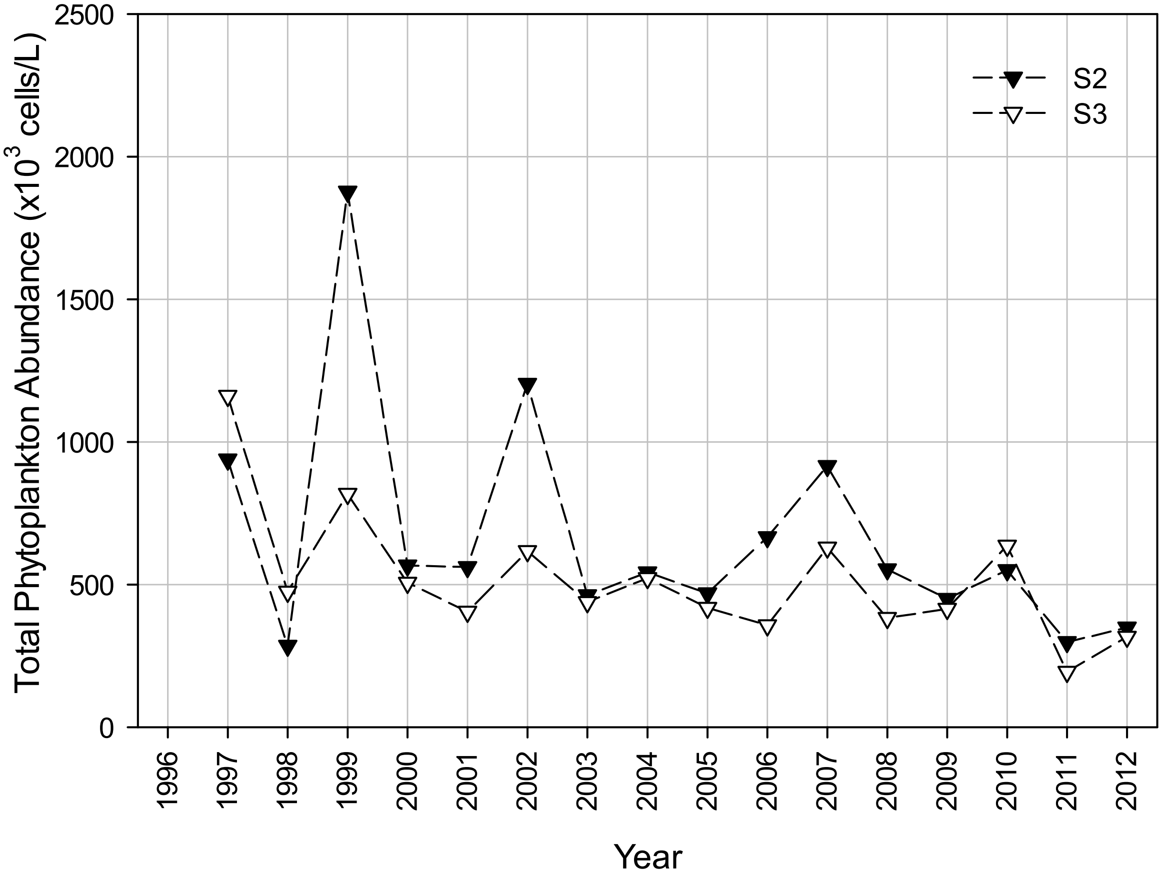


Sources: Golder (2011); DDMI (2012).

cells/L = cells per litre; x = times.

In 1997, summer total phytoplankton abundance was 938,183 cells/L at Station S2 and 1,161,400 cells/L at Station S3 in Lac de Gras. There has been no temporal trend observed at either station, and variability has been more pronounced at Station S3 (Figure 2.3-25). Summer total phytoplankton abundances reported in 2011 (298,430 cells/L at Station S2; 194,130 cells/L at Station S3) and 2012 (348,600 cells/L at Station S2; 316,870 cells/L at Station S3) were the lowest values reported for Station S3 since monitoring began in 1997, and were comparable to the value reported in 1998 (285,133 cells/L) for Station S2.

Figure 2.3-25 Summer Total Phytoplankton Abundance at Stations S2 and S3 in Lac de Gras, 1997 to 2012

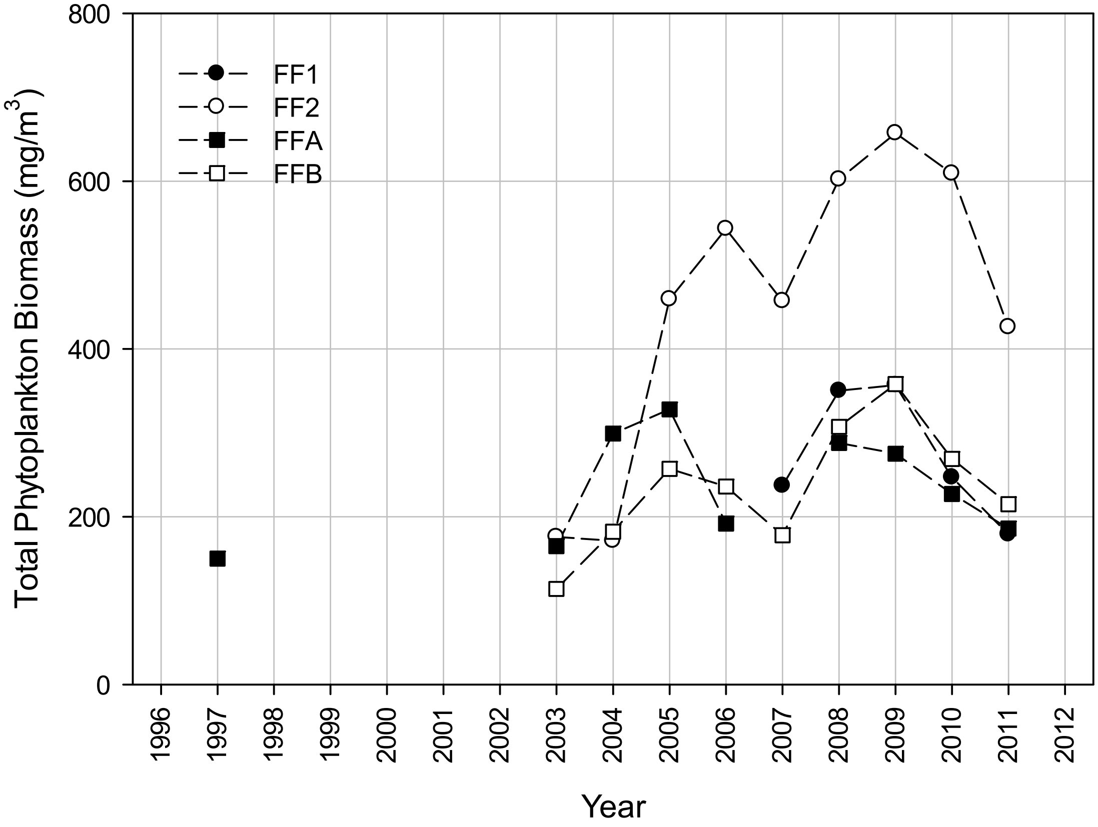


Source: ERM Rescan (2013).

cells/L = cells per litre.; x = times.

Phytoplankton biomass values in Lac de Gras have been consistently higher at FF2 than in the far-field reference area since 2005, although the 2003 and 2004 values were comparable to the far-field reference areas (Figure 2.3-26; DDMI 2013). Biomass values in the far-field reference areas in Lac de Gras have ranged between 114 mg/m^3 at FFB in 2003 to 357 mg/m^3 at FF1 in 2008; biomass values at FF2 ranged between 171 mg/m^3 in 2004 to 657 mg/m^3 in 2009 (Figure 2.3-26). Peak biomass values in Lac de Gras were documented in 2008 and 2009; values in all areas have been declining since 2009 (Figure 2.3-26).

Figure 2.3-26 Mean Annual Total Phytoplankton Biomass in the Far-Field Areas in Lac de Gras, 1997 to 2011



Sources: Golder (2011); DDMI (2012).

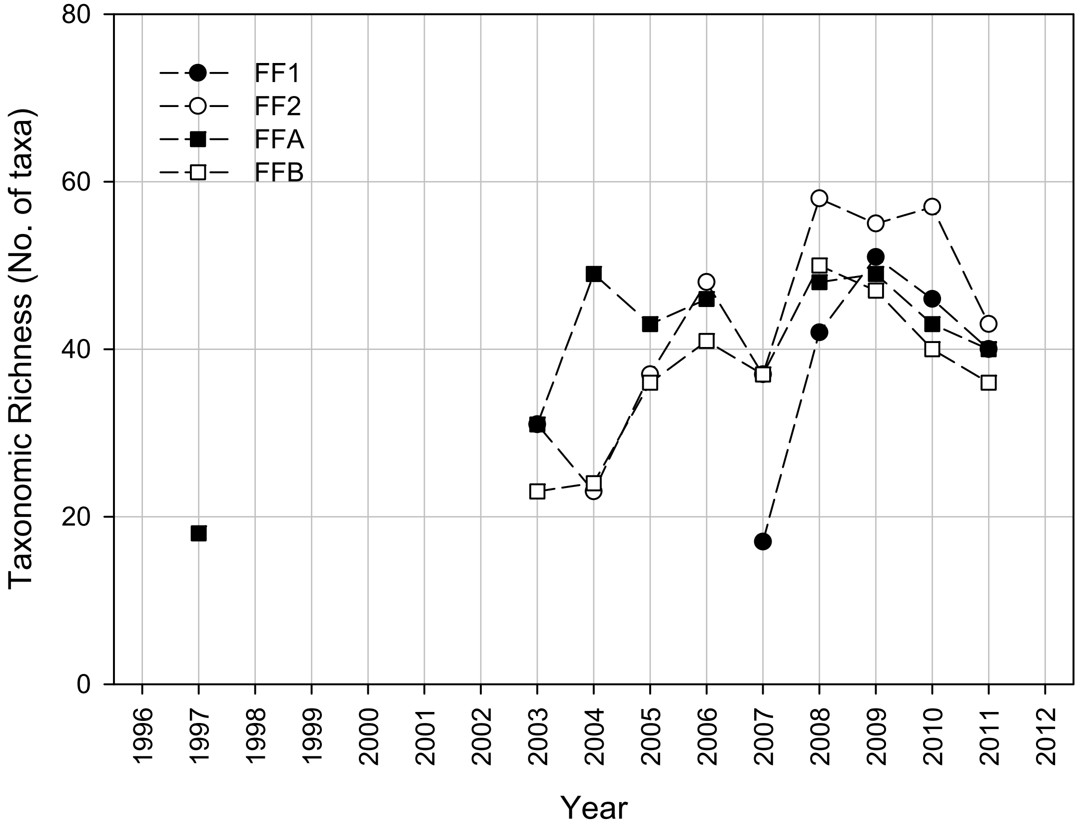
mg/m^3 = milligrams per cubic metre.

Community Composition

In general, in areas of Lac de Gras monitored by the Diavik Mine, total phytoplankton taxonomic richness increased between 2003 and 2009, and then decreased from 2009 to 2011 (Figure 2.3-27). Between 1997 and 2011, total phytoplankton taxonomic richness ranged between 17 and 58 genera, with the highest number of genera typically occurring in the FF2 area (Appendix A, Table A-7). There was less variability over time in the areas of Lac de Gras monitored by the Ekati Mine, where total phytoplankton taxonomic richness at stations S2 and S3 ranged between 38 and 64 taxa (Figure 2.3-28). There was a slight increasing trend over time at both stations monitored by the Ekati Mine.

Within all areas in Lac de Gras, there was a high degree of variability in appearance and disappearance of phytoplankton genera (Appendix A, Tables A-7 and A-8). The greatest taxonomic diversity was observed in the chlorophytes and chrysophytes, while taxa within the euglenoids and xanthophytes were the most sporadic throughout the monitoring period (Appendix A, Table A-7 and Table A-8).

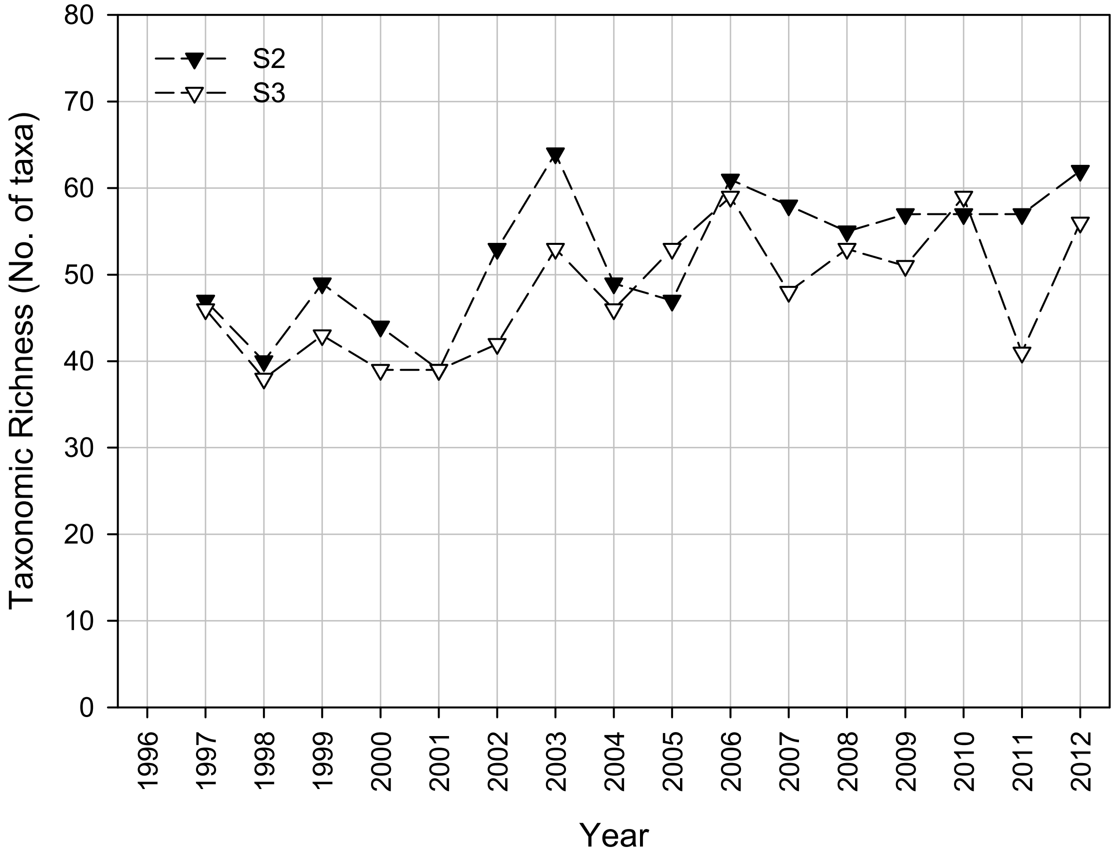
Figure 2.3-27 Mean Annual Total Phytoplankton Taxonomic Richness in Far-Field Areas in Lac de Gras, 1997 to 2011



Sources: Golder (2011); DDMI (2012).

No. = number.

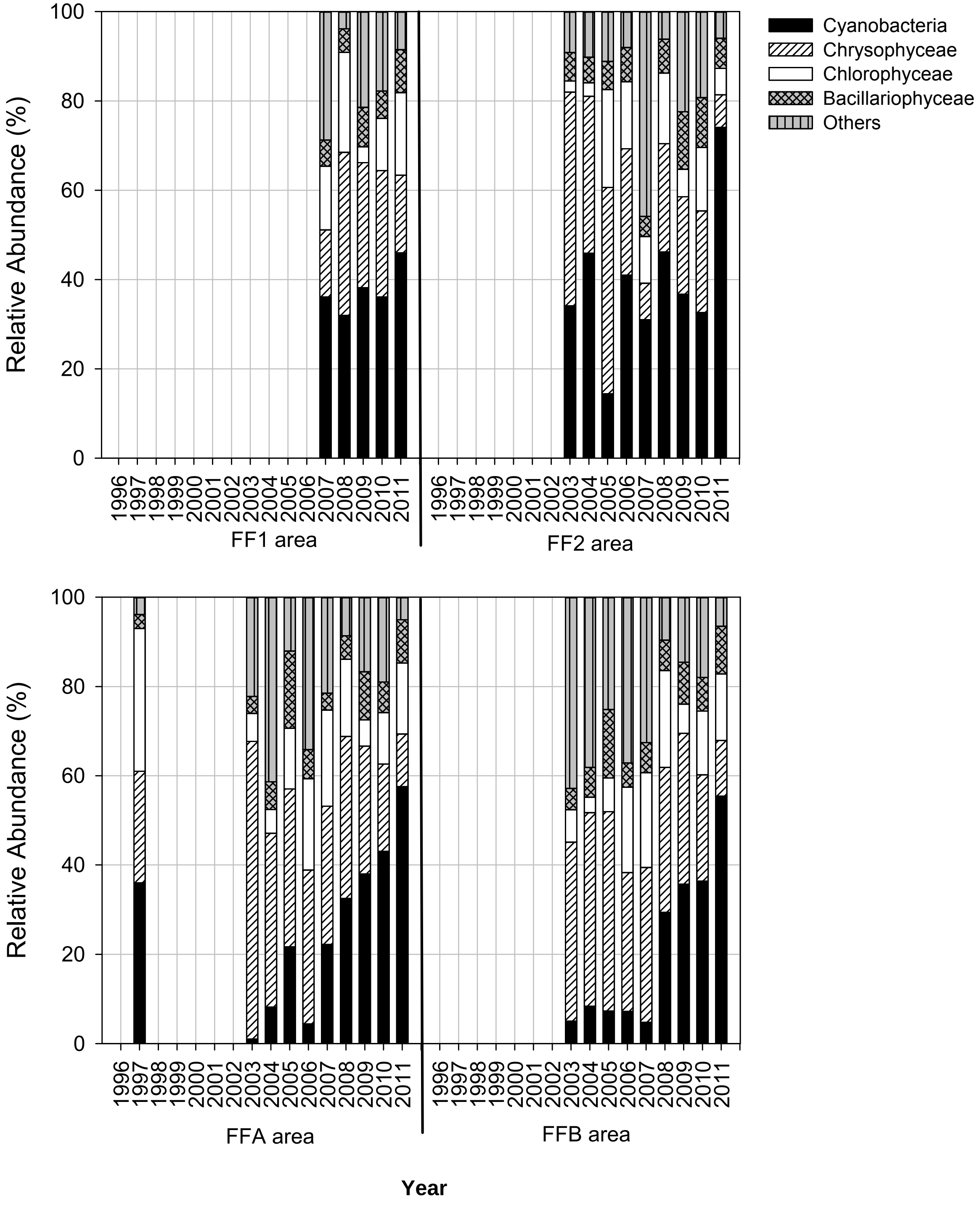
Figure 2.3-28 Summer Total Phytoplankton Taxonomic Richness at Stations S2 and S3 in Lac de Gras, 1997 to 2012



Source: ERM Rescan (2013).
No. = number.

Overall group dominance (based on abundance) in the FFA and FFB reference areas in Lac de Gras shifted from chrysophyte dominance from 2003 to 2006, to cyanobacteria dominance from 2007 to 2010 (Figure 2.3-29). Chrysophytes and cyanobacteria co-dominated the community in the FF2 area from 2003 to 2006, and 2008 to 2010; in 2007, “others” dominated the community and in 2011 cyanobacteria were dominant. Similarly, cyanobacteria and chrysophytes co-dominated the community in the FF1 area from 2007 to 2011. The relative abundance of diatoms was consistently low (less than 20%) in all four areas of Lac de Gras from 1997 to 2011 (Figure 2.3-29).

Figure 2.3-29 Mean Annual Relative Phytoplankton Abundance in Far-Field Areas in Lac de Gras, 1997 to 2011

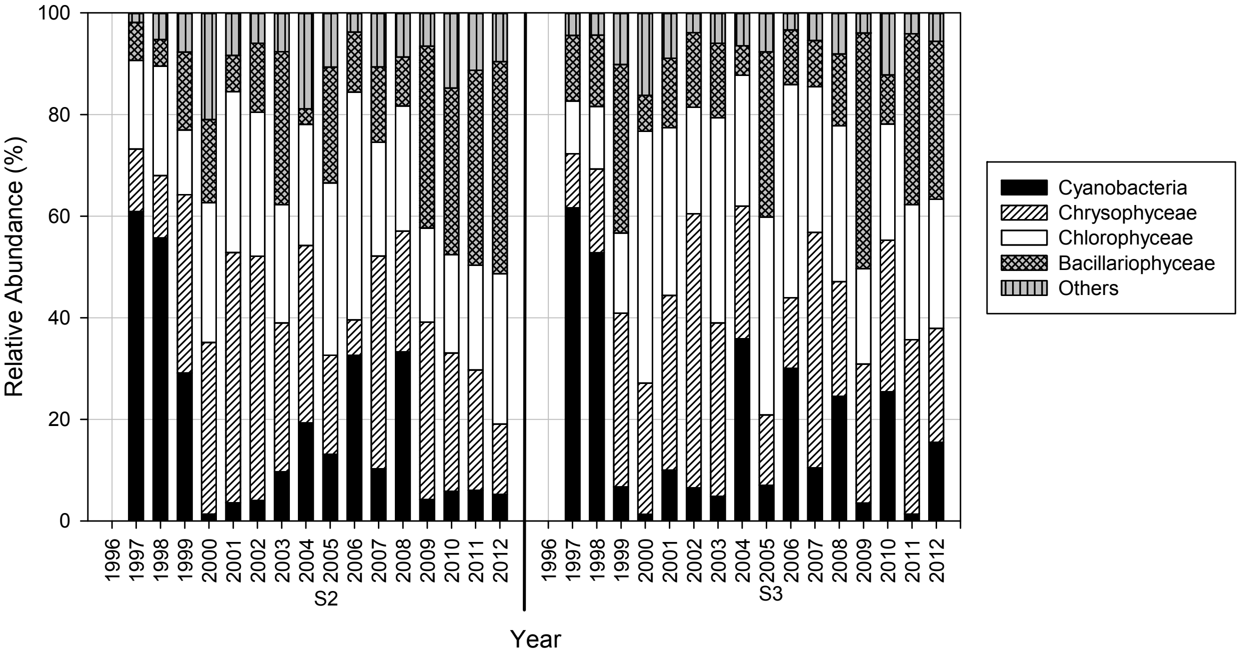


Sources: Golder (2011); DDMI (2012).

% = percent.

Relative abundance in Lac de Gras, monitored by the Ekati Mine, has been variable from 1997 to 2012 (Figure 2.3-30). Cyanobacteria were the dominant group at stations S2 and S3 in 1997 and 1998, accounting for 50% to 60% of the phytoplankton community (Figure 2.3-30; data from ERM Rescan 2013). Since 1998, the proportion of cyanobacteria periodically increased, but never exceeded 40% of the phytoplankton community. Chrysophytes were a sub-dominant group from 1999 to 2012, accounting for between 20% and 50% of the phytoplankton community; however, a decreasing trend has been observed at Station S2 since 2007. The relative abundance of diatoms has increased at stations S2 and S3 since 1997; at Station S2, diatom abundance has followed an increasing trend since 2009. Chlorophytes varied over time, ranging from 12% to 45% at Station S2, and 10% to 50% at Station S3. Euglenoids were absent from stations S2 and S3 from 1997 to 2001, but have been documented in small numbers at Station S2 since 2002 (Appendix A, Table A-8). Dinoflagellates were documented in small numbers at both stations.

Figure 2.3-30 Summer Relative Phytoplankton Abundance at Stations S2 and S3 in Lac de Gras, 1997 to 2012

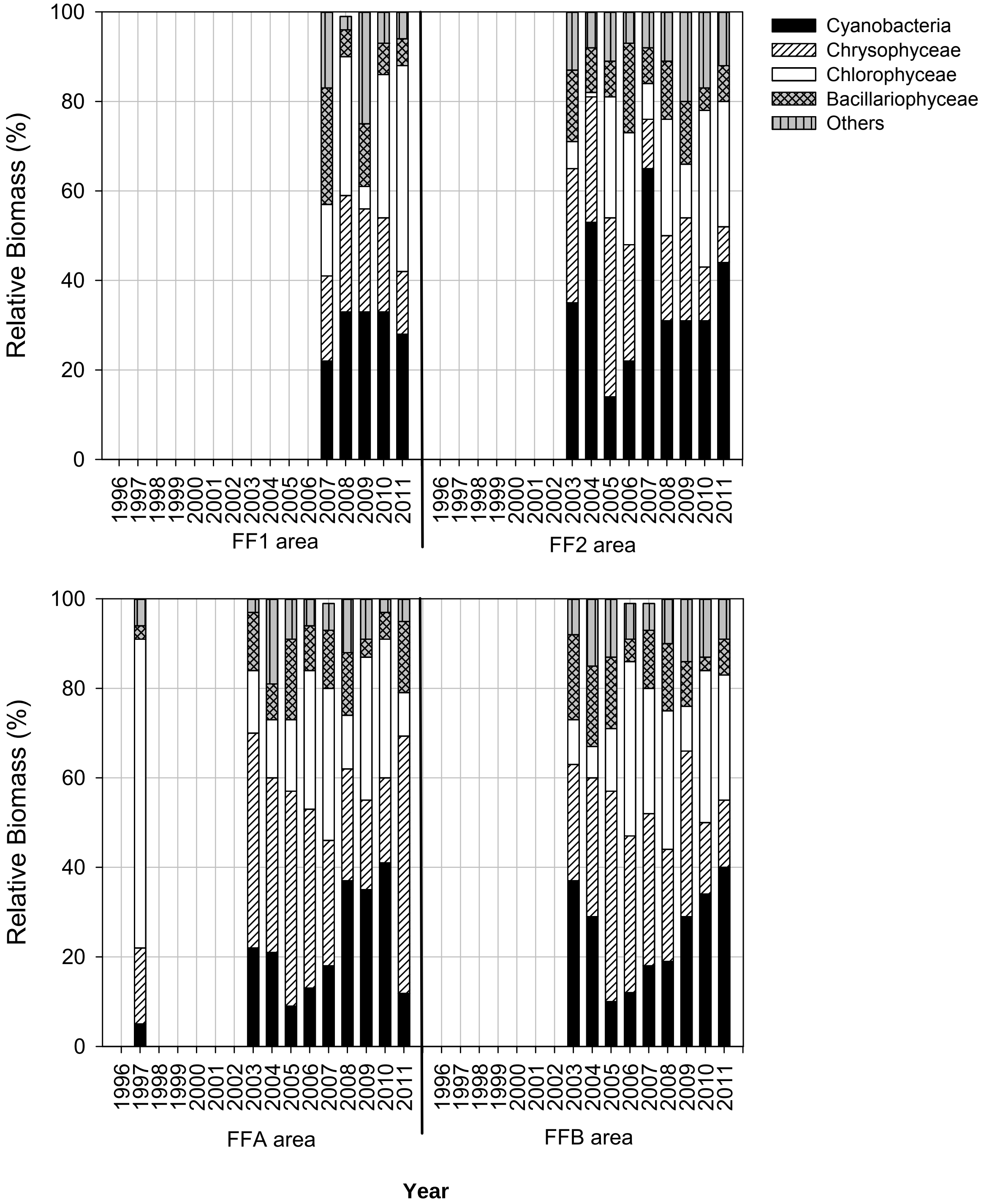


Source: ERM Rescan (2013).

% = percent.

Chlorophytes in Lac de Gras were the dominant group (based on biomass) in the FFA area in 1997 (Figure 2.3-31). From 2003 to 2011, cyanobacteria and chrysophytes generally dominated the community in the FF1, FF2, FFA, and FFB areas of Lac de Gras. The proportion of chlorophytes increased in the FFB area from 2003 to 2011, while proportions fluctuated from year-to-year in the other areas. Diatoms and “others” were consistently low in these four areas of Lac de Gras from 1997 to 2011.

Figure 2.3-31 Mean Annual Relative Phytoplankton Biomass in the Far-Field Areas in Lac de Gras, 1997 to 2011



Sources: Golder (2011); DDMI (2012).

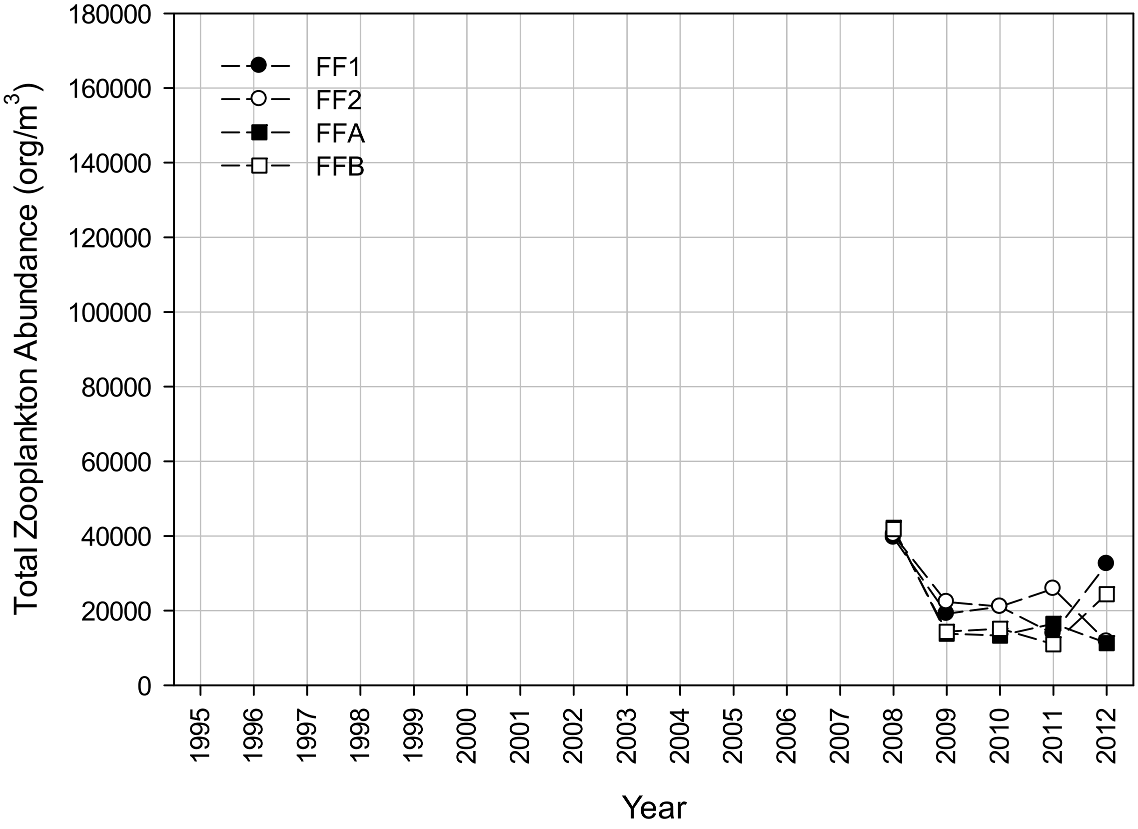
% = percent.

2.3.2.1.3 *Zooplankton*

Abundance and Biomass

Mean annual zooplankton abundance has varied in Lac de Gras since 2007 (Figure 2.3-32). Zooplankton abundances in the far-field reference areas in Lac de Gras have ranged between 10,994 org/m^3 in the FFB area (2011) to 42,184 org/m^3 in the FFA area (2008). Peak abundances were observed in the reference areas in 2008, followed by a sharp decline in 2009.

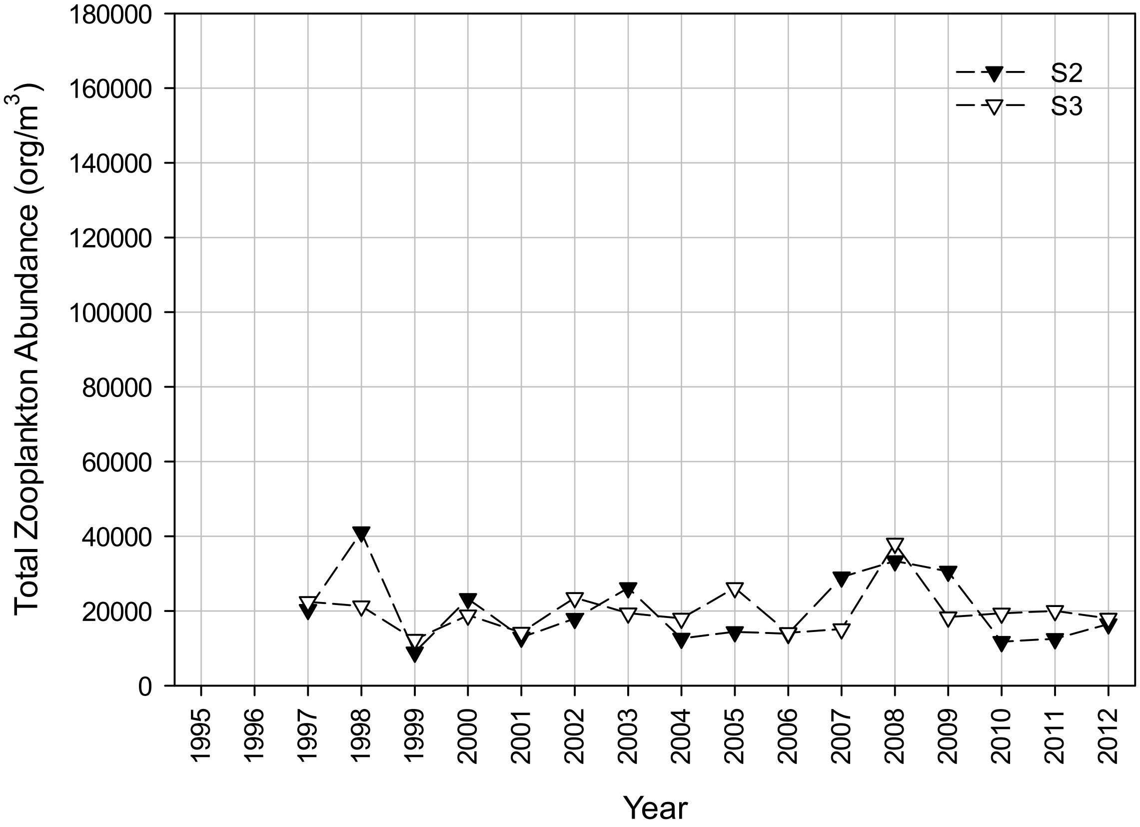
Figure 2.3-32 Mean Annual Total Zooplankton Abundance in the Far-Field Areas in Lac de Gras, 2008 to 2012



Sources: Golder (2011); DDMI (2012, 2013).
org/m^3 = organisms per cubic metre.

No clear temporal trend was observed at the Ekati Mine AEMP stations (S2 and S3). Summer zooplankton abundances have varied since 1997, ranging between 8,912 org/m^3 and 41,105 org/m^3 at Station S2, and between 12,332 org/m^3 and 38,091 org/m^3 at Station S3 (Figure 2.3-33). Peak values were reported in 1998 and in 2008 (Figure 2.3-33).

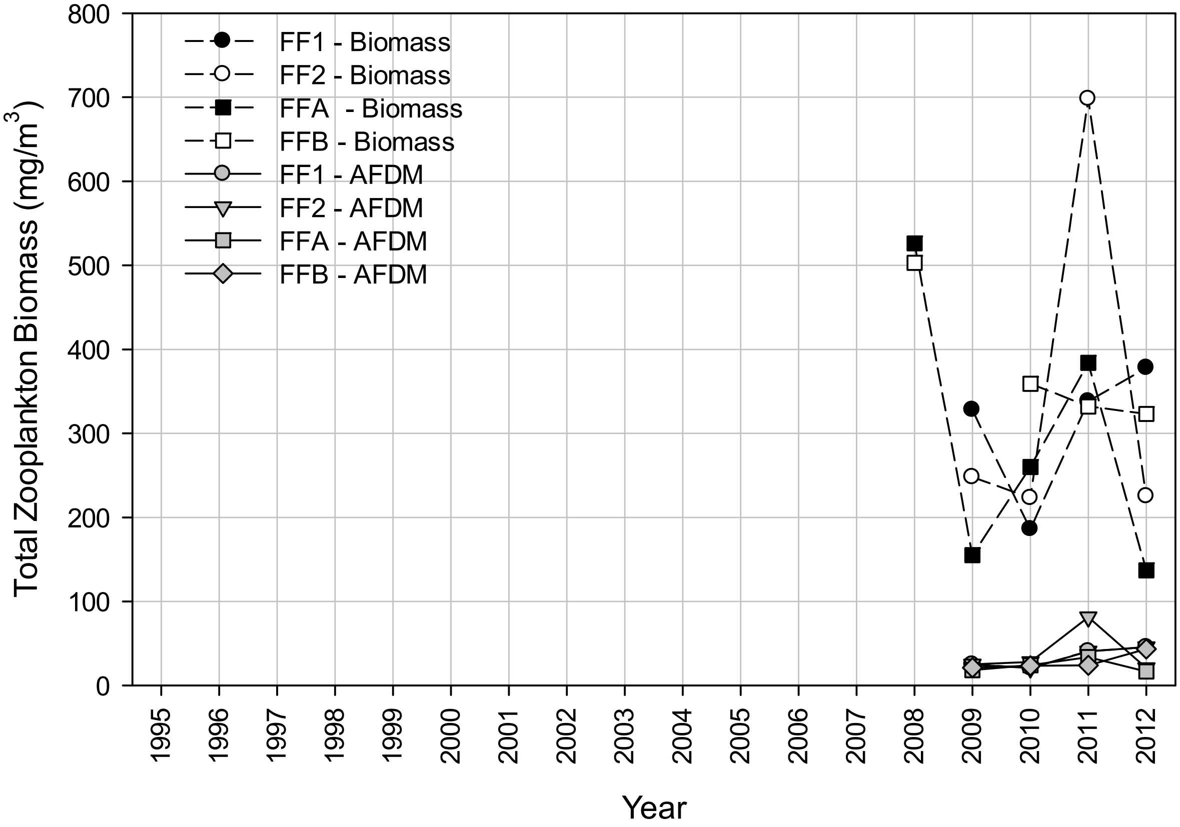
Figure 2.3-33 Summer Total Zooplankton Abundance at Station S2 and S3 in Lac de Gras, 1997 to 2012



Source: ERM Rescan (2013).
org/m^3 = organisms per cubic metre.

As part of the Diavik Mine AEMP, zooplankton biomass was measured as ash free dry mass (AFDM) as dry weight and a microscope-based length-weight biomass estimate as wet weight. The AFDM estimates of zooplankton were an order of a magnitude less than the length-weight-based biomass estimates due to AFDM being a dry weight estimate rather than wet weight (Figure 2.3-34). No clear trends were observed in either estimate of mean annual zooplankton biomass in the far-field areas of Lac de Gras between 2008 and 2012 (Figure 2.3-34). Total biomass in the FF2 area was consistent from 2008 and 2011, and ranged from 21 to 28 mg/m^3 (AFDM estimate) and 223 to 248 mg/m^3 (length-weight biomass estimate), with the exception of 2011 when values were higher (81 mg/m^3, and 698 mg/m^3, respectively). Summer zooplankton biomass values from the Ekati Mine AEMP remained relatively stable at Stations S2 and S3, and ranged between 4 mg/m^3 and 118 mg/m^3, based on AFDM (Figure 2.3-35).

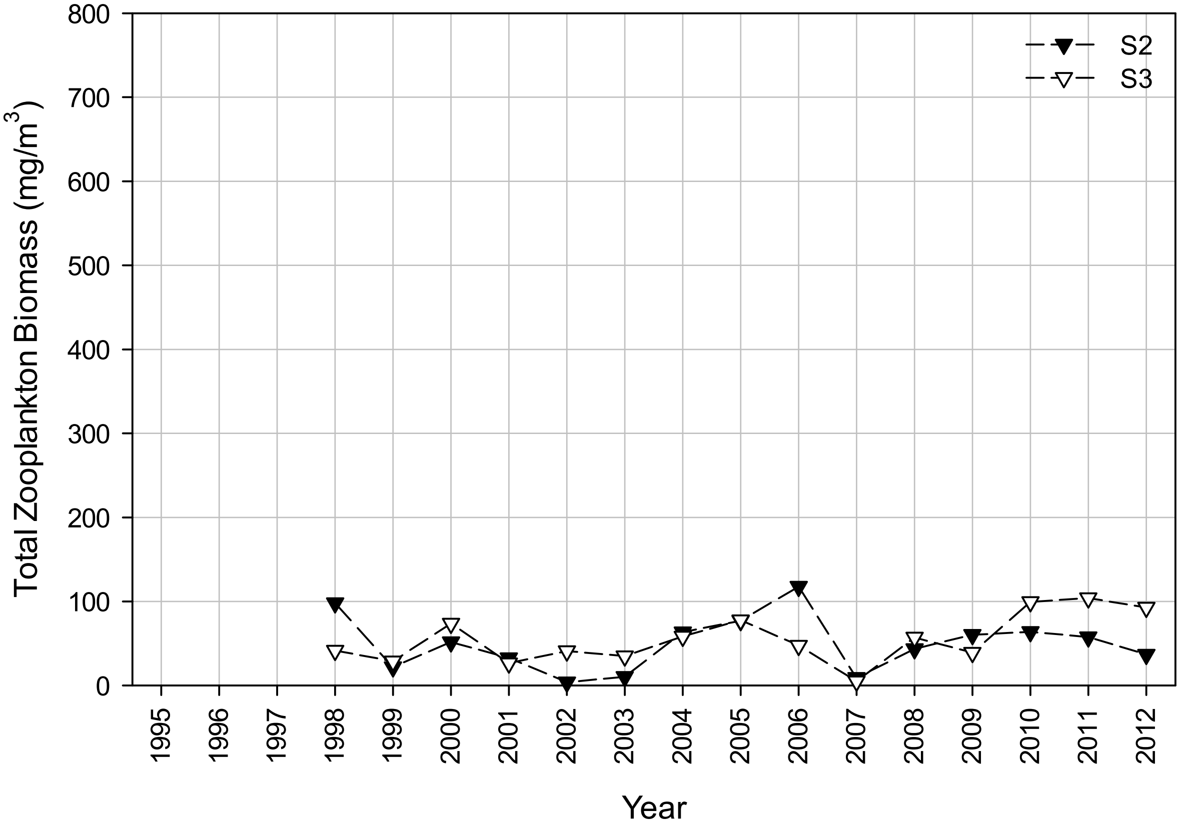
Figure 2.3-34 Mean Annual Total Zooplankton Biomass in the Far-Field Areas in Lac de Gras, 2008 to 2012



Sources: Golder (2011); DDMI (2012, 2013).

mg/m^3 = milligrams per cubic metre; biomass = wet weight biomass derived from length-weight regressions; AFDM = ash free dry mass.

Figure 2.3-35 Summer Total Zooplankton Biomass at Stations S2 and S3 in Lac de Gras, 1998 to 2012



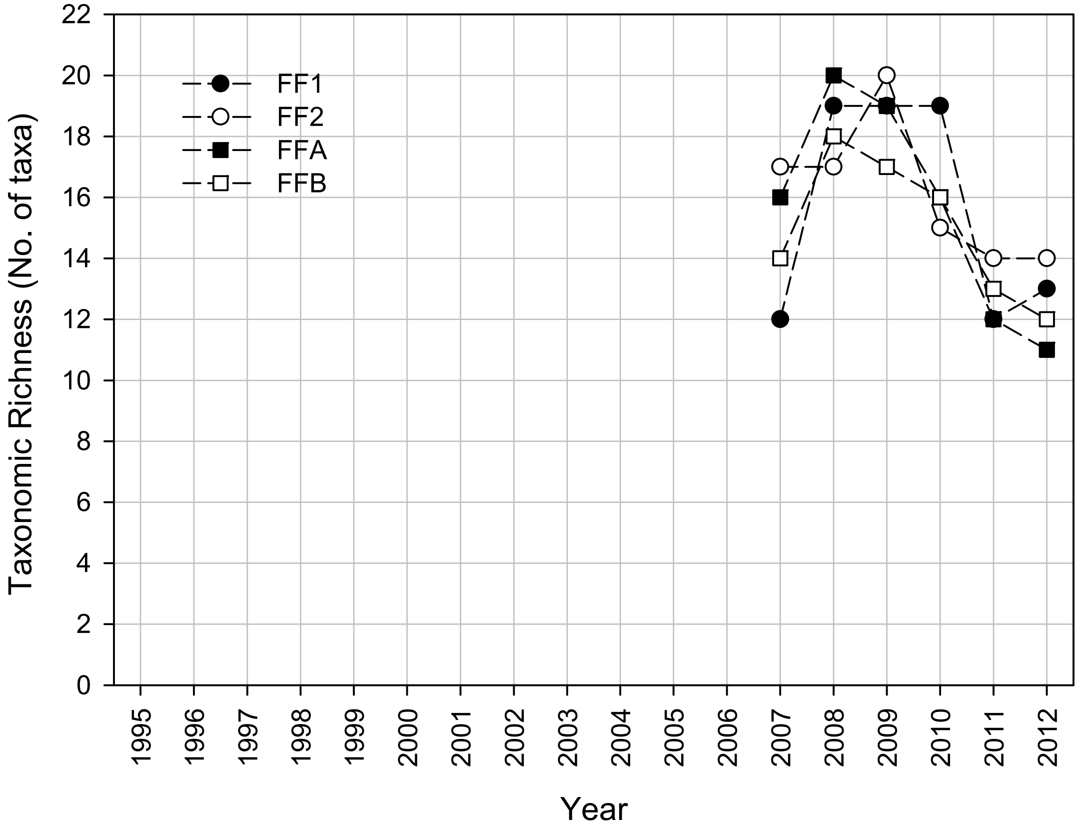
Source: ERM Rescan (2013).

mg/m^3 = milligrams per cubic metre; biomass = dry weight ash free dry mass estimate.

Community Composition

Total zooplankton taxonomic richness in the far-field areas (FF1, FF2, FFA, and FFB) in Lac de Gras increased between 2007 and 2008, and subsequently have decreased since 2008 (Figure 2.3-36). Zooplankton taxonomic richness values at the far-field reference stations ranged between 11 and 20 taxa per station from 2008 to 2012 (Appendix A, Table A-9). Total zooplankton taxonomic richness has been consistent at Stations S2 and S3 since 1997, with richness values ranging between 7 and 11 taxa (Appendix A, Table A-10). Richness values recorded in 2012 were similar to baseline values (Figure 2.3-37).

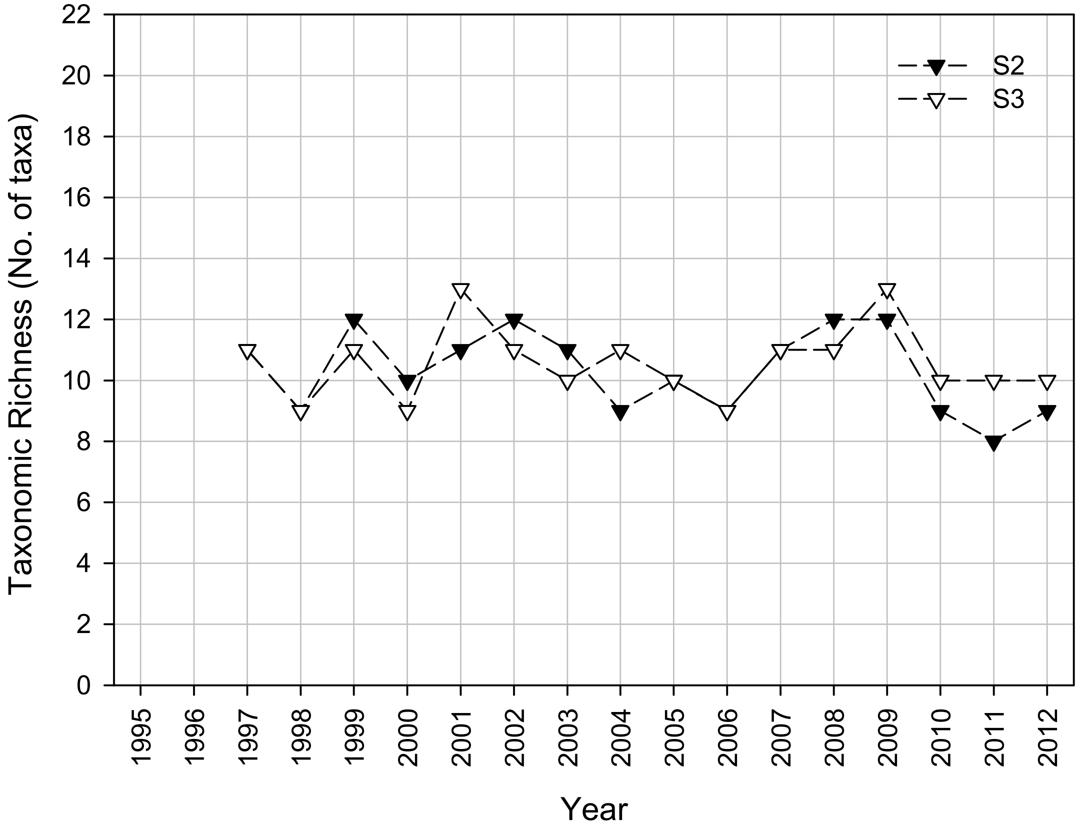
Figure 2.3-36 Mean Annual Total Zooplankton Taxonomic Richness in the Far-Field Areas in Lac de Gras, 2007 to 2012



Sources: Golder (2011); DDMI (2012, 2013).

No. = number.

Figure 2.3-37 Summer Total Zooplankton Taxonomic Richness at Stations S2 and S3 in Lac de Gras, 1997 to 2012

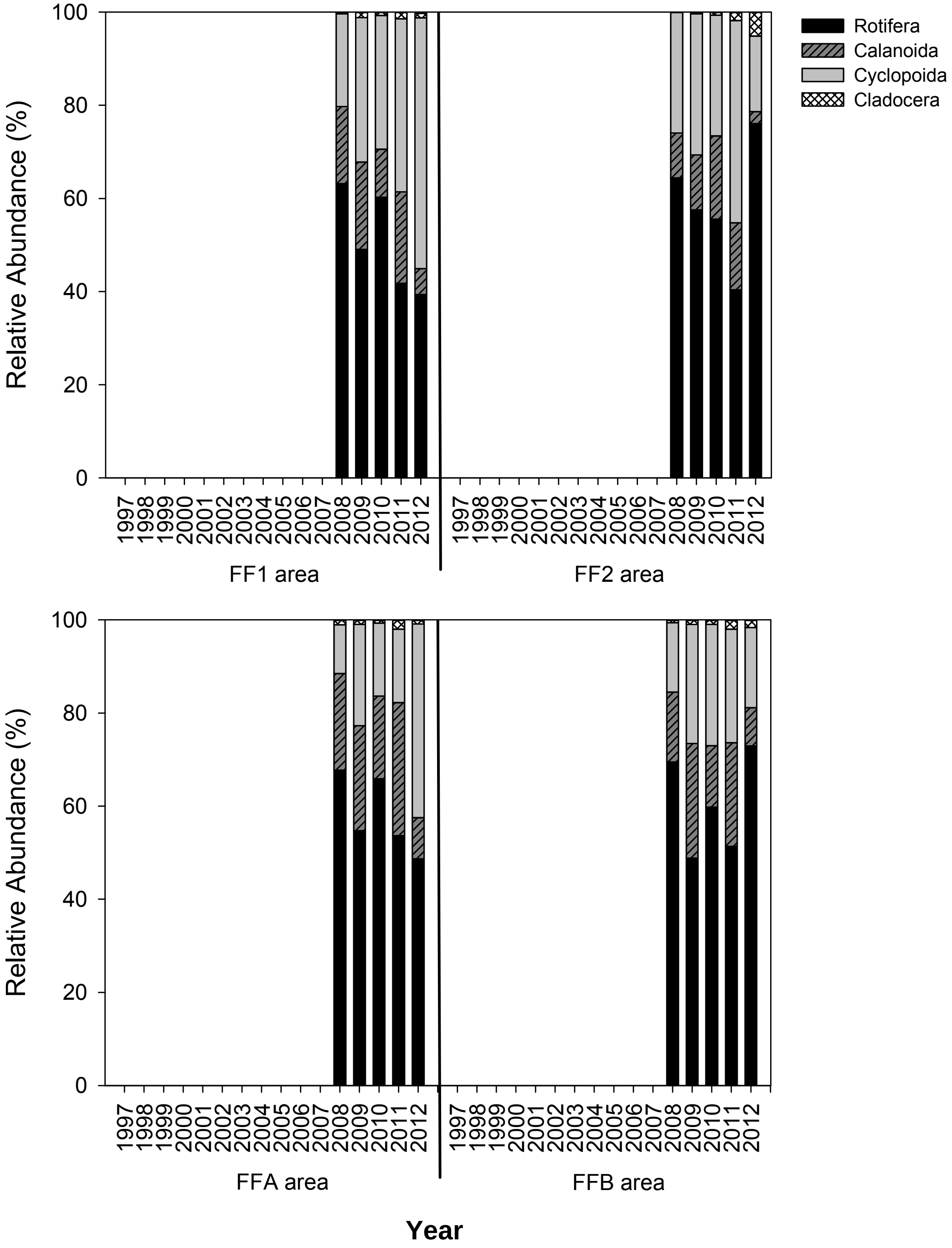


Source: ERM Rescan (2013).
No. = number.

The zooplankton community in the far-field areas of Lac de Gras was dominated by rotifers (based on abundance; Figure 2.3-38). Cyclopoid copepods were sub-dominant in these areas between 2008 and 2012. The relative proportions of cladocerans and calanoid copepods were low.

The zooplankton community at Stations S2 and S3 in Lac de Gras was also dominated by rotifers (based on abundance; Figure 2.3-39). Communities at Stations S2 and S3 varied in overall rotifer abundance since sampling began in 2007. Cyclopoid copepods increased over time at Stations S2 and S3. Generally, calanoid copepods represented a low proportion of the zooplankton community in Lac de Gras, with the exception of peak abundances observed at stations S2 and S3 in 2000, 2006, and 2011. During these peaks, calanoid copepods remained the sub-dominant group. Cladocerans represented less than 20% of the community, with the exception of Station S2 in 1997.

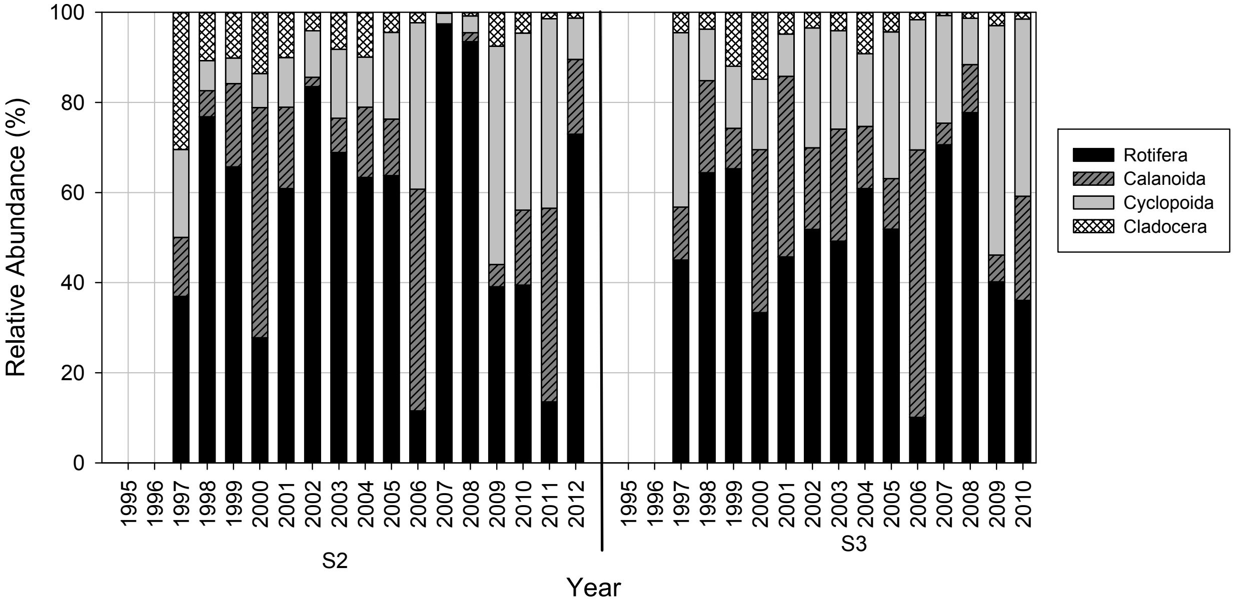
Figure 2.3-38 Mean Annual Relative Zooplankton Abundance in the Far-Field Areas in Lac de Gras, 2008 to 2012



Sources: Golder (2011); DDMI (2012, 2013).

% = percent.

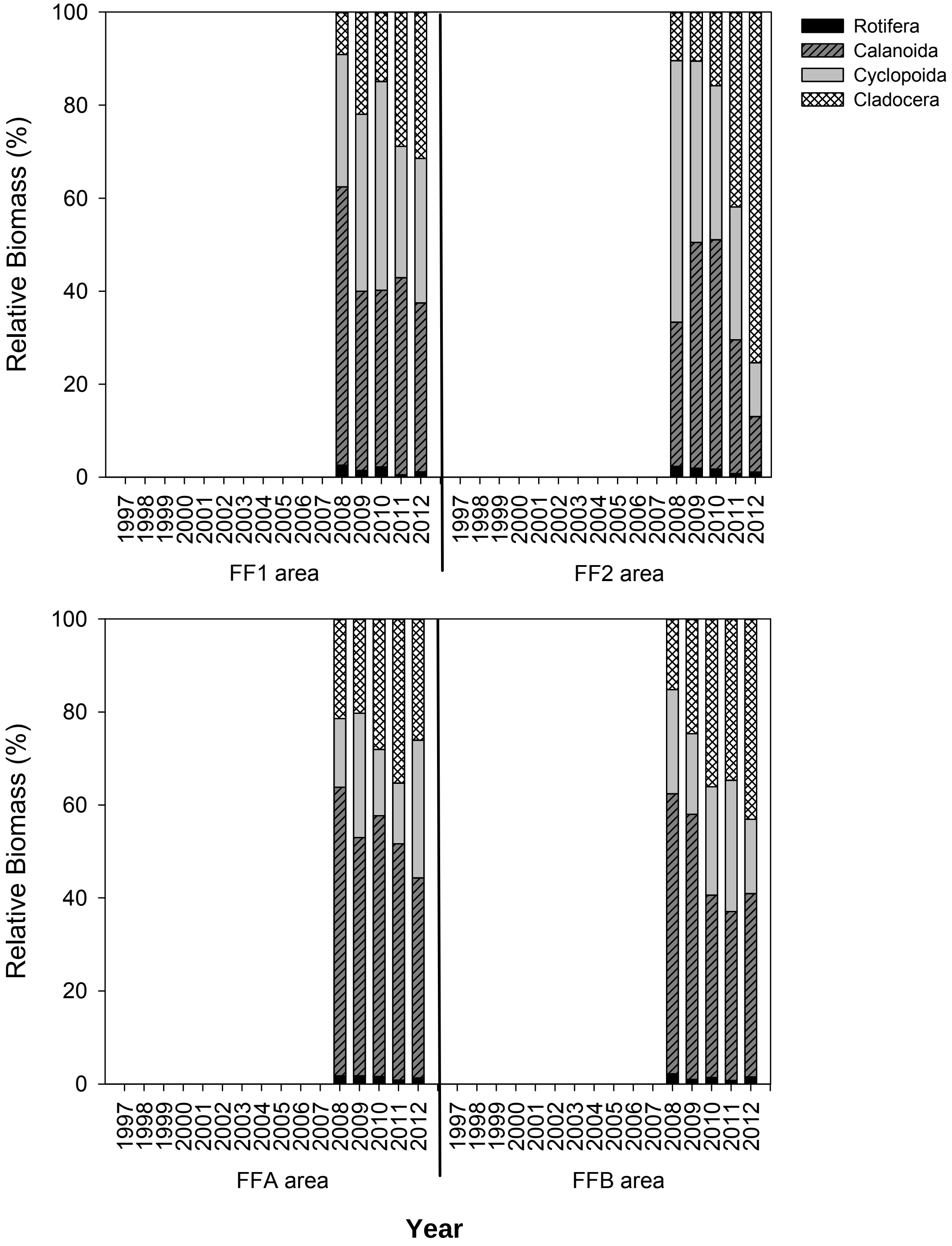
Figure 2.3-39 Summer Relative Zooplankton Abundance at Stations S2 and S3 in Lac de Gras, 1997 to 2012



Source: ERM Rescan (2013).
% = percent.

Based on biomass, the zooplankton community in the far-field areas of Lac de Gras was dominated by calanoid copepods (Figure 2.3-40). Cyclopoid copepods were the sub-dominant zooplankton group in the far-field areas of Lac de Gras between 2008 and 2012. The relative proportions of cladocerans were low in all areas, except in the FF2 area in 2012, which was dominated by cladocerans (75%).

Figure 2.3-40 Mean Annual Relative Zooplankton Biomass in the Far-Field Areas in Lac de Gras, 1997 to 2012



Sources: Golder (2011); DDMI (2012, 2013).

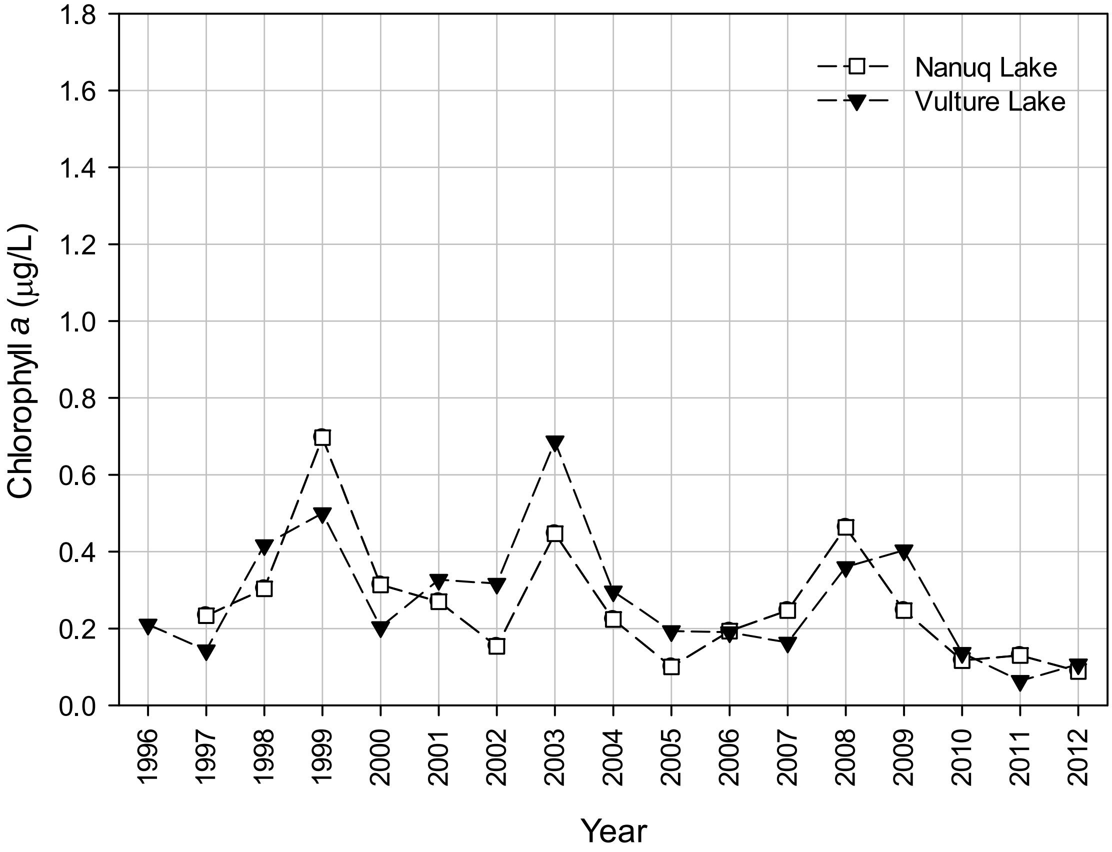
% = percent.

2.3.2.2 Nanuq and Vulture Lakes, 1995 to 2012

2.3.2.2.1 Chlorophyll a

Summer chlorophyll *a* concentrations in Nanuq and Vulture lakes were variable over time (Figure 2.3-41), but remained in the oligotrophic range throughout the monitoring period. Between 1997 and 2012, summer chlorophyll *a* concentrations in Nanuq Lake ranged from 0.08 µg/L to 0.70 µg/L. Similarly, summer chlorophyll *a* concentrations in Vulture Lake between 1996 and 2012 ranged from 0.11 to 0.69 µg/L.

Figure 2.3-41 Summer Chlorophyll *a* Concentrations in Nanuq Lake and Vulture Lake, 1996 to 2012



Source: ERM Rescan (2013).

µg/L = micrograms per litre.

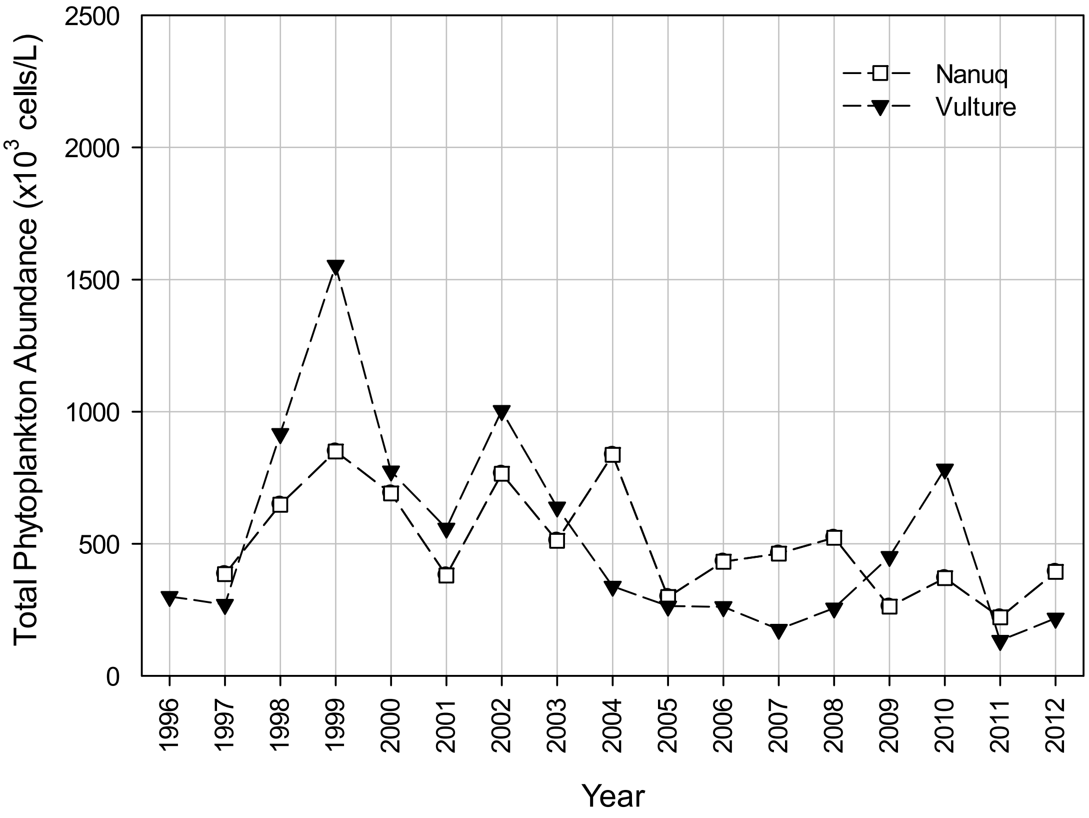
2.3.2.2.2 *Phytoplankton*

Abundance

In Nanuq Lake, an increase in summer total phytoplankton abundance occurred between 1997 (384,983 cells/L) and 1999 (848,733 cells/L), followed by a general decreasing trend (Figure 2.3-42). Since 2009, summer total phytoplankton abundance in Nanuq Lake has ranged between 221,200 cells/L and 392,933 cells/L, which is comparable to the 1997 baseline condition (384,983 cells/L).

In Vulture Lake, summer total phytoplankton biomass was more variable over time (133,233 to 1,552,867 cells/L), but was often within the range of the 1997 baseline data (269,367 cells/L).

Figure 2.3-42 Summer Total Phytoplankton Abundance in Nanuq Lake and Vulture Lake, 1997 to 2012



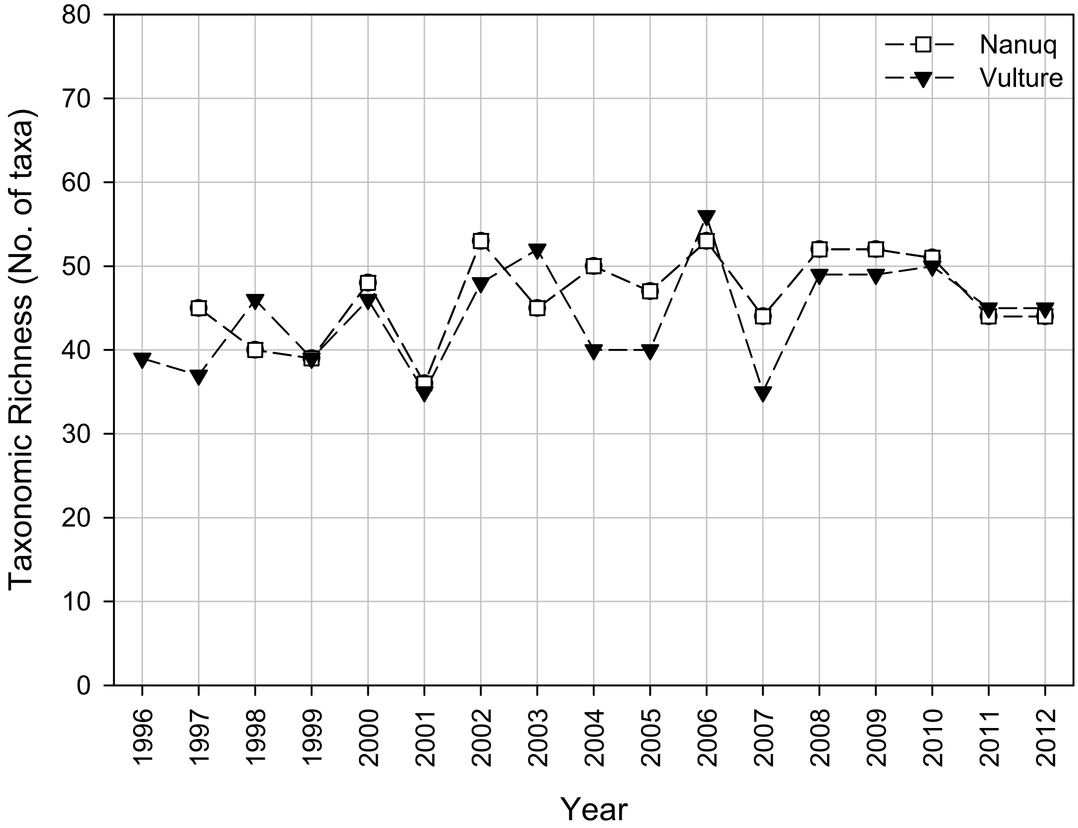
Source: ERM Rescan (2013).

cells/L = cells per litre; x = times.

Community Composition

Total phytoplankton taxonomic richness fluctuated in Nanuq and Vulture lakes, but no temporal trend was apparent in either lake (Figure 2.3-43). In Nanuq Lake, total phytoplankton richness has varied between 36 and 53 genera, while in Vulture Lake total phytoplankton richness varied between 35 and 56 genera. In both lakes, chlorophytes and diatoms were the most taxonomically diverse groups, while euglenoids and xanthophytes were rarely encountered (Appendix A, Table A-11). The majority of genera appeared and disappeared throughout the years in both lakes.

Figure 2.3-43 Summer Total Phytoplankton Taxonomic Richness in Nanuq Lake and Vulture Lake, 1996 to 2012

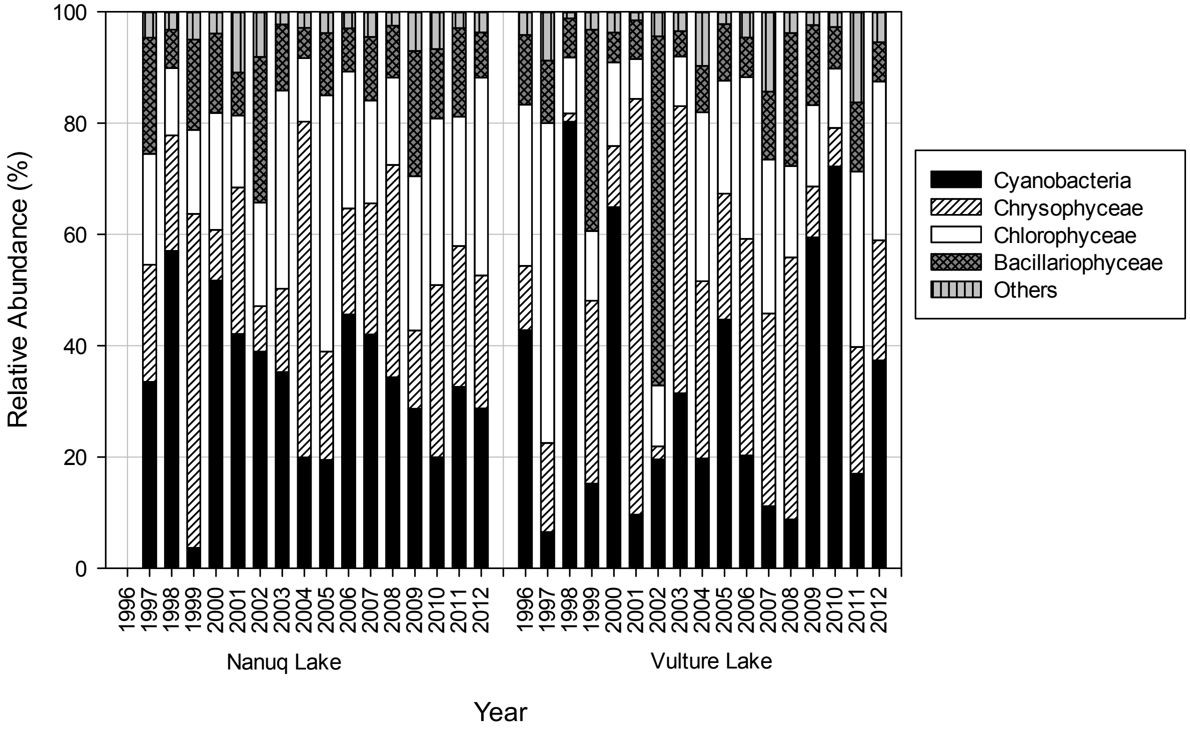


Source: ERM Rescan (2013).

No. = number.

In Nanuq Lake, composition of the phytoplankton community (based on abundance) was variable between 1997 and 2012, but was typically dominated by a mixture of cyanobacteria (20% to 57%), chrysophytes (20% to 60%), and chlorophytes (21% to 46%; Figure 2.3-44). Diatoms rarely accounted for more than 20% of the community.

Figure 2.3-44 Summer Relative Phytoplankton Abundance in Nanuq Lake and Vulture Lake, 1996 to 2012



Source: ERM Rescan (2013).

% = percent.

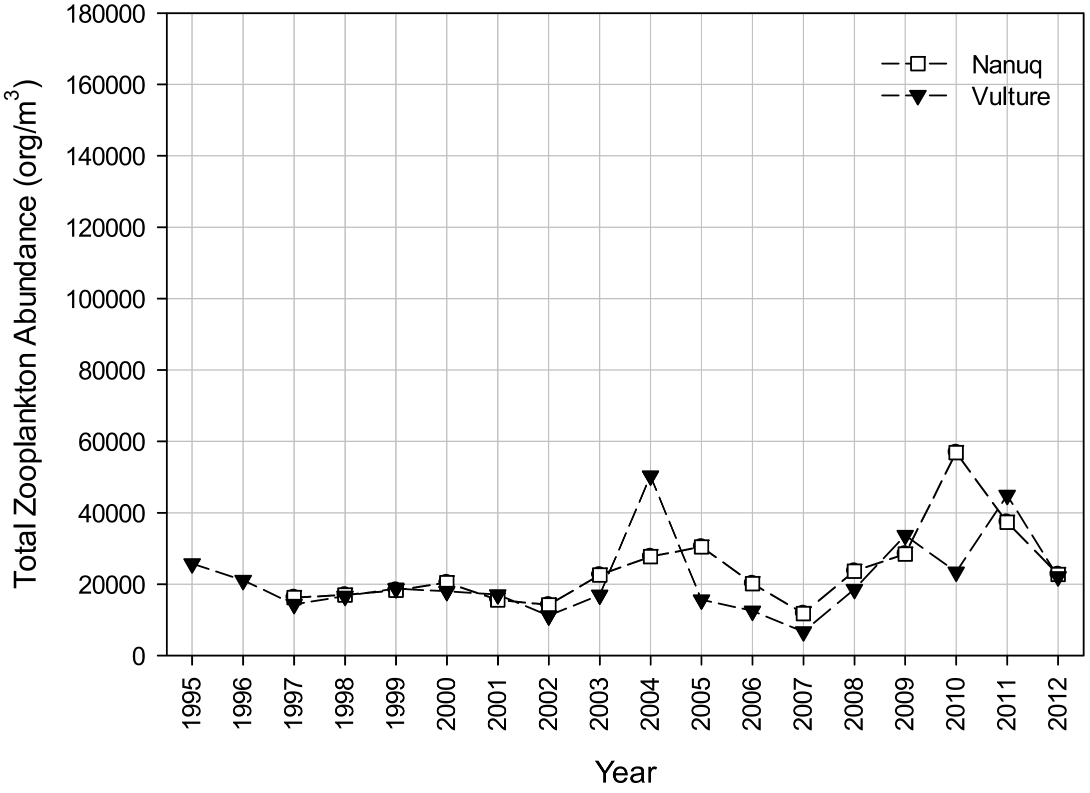
The composition of the phytoplankton community (based on abundance) in Vulture Lake was more variable over time (Figure 2.3-44). In some years, cyanobacteria were the single dominant major taxonomic group, accounting for 59% to 80% of the phytoplankton community. In other years, the phytoplankton community was co-dominated by chlorophytes (20% to 57%) and chrysophytes (21% to 74%), occasionally with cyanobacteria (20% to 45%) forming the third dominant group. Diatoms rarely accounted for more than 20% of the phytoplankton community.

2.3.2.2.3 Zooplankton

Abundance and Biomass

Summer total zooplankton abundances in Nanuq and Vulture lakes has remained stable and similar since 1997 (Figure 2.3-45). Summer total zooplankton abundance in Nanuq Lake ranged between 11,751 org/m^3 (2007) and 56,848 org/m^3 (2010). In Vulture Lake, summer total zooplankton abundances were slightly lower, ranging between 6,684 org/m^3 (2007) and 50,318 org/m^3 (2004).

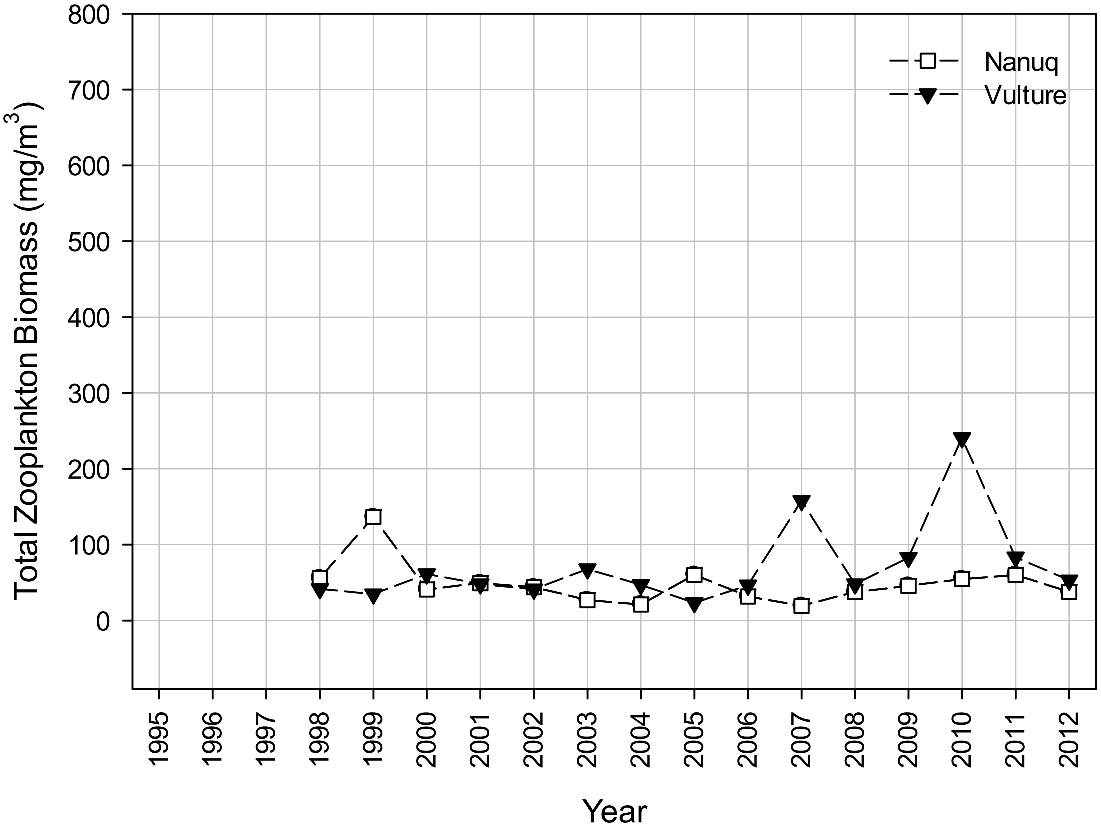
Figure 2.3-45 Summer Total Zooplankton Abundance in Nanuq Lake and Vulture Lake, 1995 to 2012



Source: ERM Rescan (2013).
org/m^3 = organisms per cubic metre.

Similarly, summer total zooplankton biomass was relatively stable and similar in Nanuq and Vulture Lakes (Figure 2.3-46). In Nanuq Lake, the majority of the values fell within the range of 19 to 60 mg/m^3, with a peak value in 1999 (136 mg/m^3). Summer total zooplankton biomass in Vulture Lake was typically in the range of 23 and 83 mg/m^3, with the exception of 2007 and 2010, which had peak values of 158 and 241 mg/m^3, respectively.

Figure 2.3-46 Summer Total Zooplankton Biomass in Nanuq Lake and Vulture Lake, 1998 to 2012

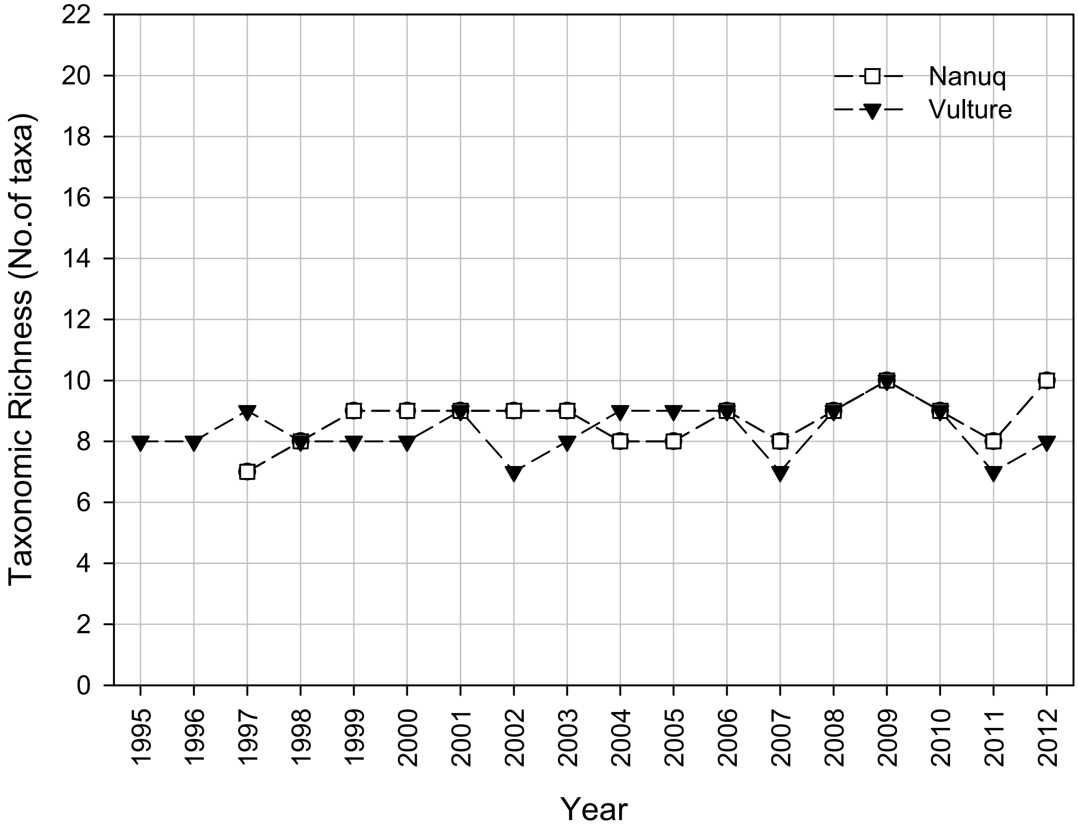


Source: ERM Rescan (2013).
mg/m^3 = milligrams per cubic metre.

Community Composition

Total zooplankton taxonomic richness was stable in Nanuq Lake and Vulture Lake, with both lakes ranging between 7 and 10 taxa between 1997 and 2012 (Figure 2.3-47). In Nanuq Lake, the calanoid copepod, *Leptodiaptomus*, was present in all years except 2012, while the cladoceran, *Chydorus*, was present only in 2009 (Appendix A, Table A-12). Of the five rotifer genera identified in Nanuq Lake, only *Kellicottia* was present in all years, and *Conochilus* was present in all years except 1997. In Vulture Lake, the same taxa (i.e., *Heterocope*, *Leptodiaptomus*, *Cyclops*, *Daphnia*, *Holopedium*, and *Kellicottia*) were consistently present in all years, with the exception of the cladoceran, *Bosmina*, and the rotifer, *Keratella*. In Vulture Lake, the rotifer, *Conochilus*, was present in all years except 2011, while the cladoceran, *Chydorus*, was only present in 2009.

Figure 2.3-47 Summer Total Zooplankton Taxonomic Richness in Nanuq Lake and Vulture Lake, 1995 to 2012

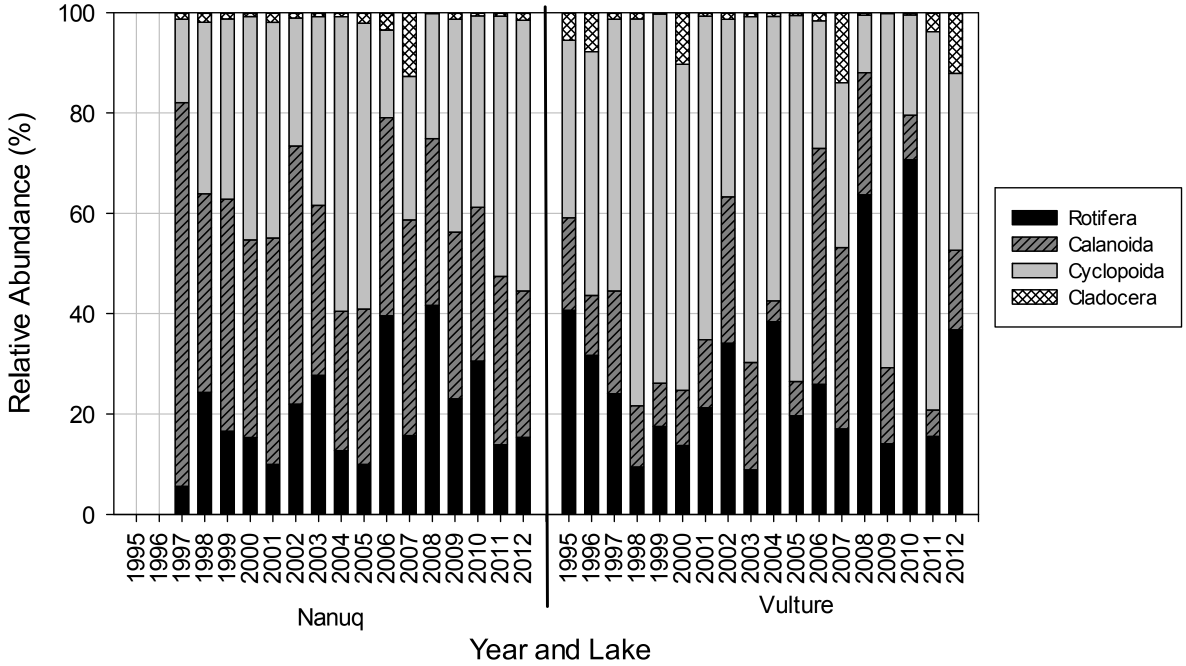


Source: ERM Rescan (2013).

No. = number.

The zooplankton community composition of Nanuq and Vulture lakes differed from each other over time (Figure 2.3-48). In general, calanoid copepods (28% to 76%) and cyclopoid copepods (17% to 59%) co-dominated the zooplankton community (based on abundance) in Nanuq Lake. Rotifers also typically accounted for a moderate proportion of the zooplankton community (10% to 42%), with the exception of 1997, when the proportion of rotifers only accounted for 6% of the community. The zooplankton community in Vulture Lake has been consistently dominated by cyclopoid copepods (up to 77%), with rotifers and calanoid copepods periodically increasing in proportion. Cladoceran abundance was generally low in both lakes (less than 5%).

Figure 2.3-48 Summer Relative Zooplankton Abundance in Nanuq Lake and Vulture Lake, 1995 to 2012



Source: ERM Rescan (2013).

% = percent.

2.4 Historical Summary

2.4.1 Chlorophyll *a* Concentrations

Chlorophyll *a* concentrations were variable over time in all the lakes included in this historical review, with the exception of Christine and Ursula lakes, which were only sampled in 2006. The limited 2006 seasonal data indicated seasonal variability in Lac du Sauvage, Christine Lake, and Ursula Lake; however, the seasonal patterns were inconsistent among lakes. All chlorophyll *a* concentrations were within the oligotrophic range of 0.3 to 4.5 µg/L (Wetzel 2001).

2.4.2 Phytoplankton Community

Total phytoplankton abundance was variable over time in the lakes included in this historical review, with the exception of Christine and Ursula lakes, which were only sampled in 2006 and thus could not be evaluated for temporal trends. The limited seasonal data available for Lac du Sauvage, Christine Lake, and Ursula Lake typically had the lowest total phytoplankton abundance occurring in the spring, but peak values varied between summer and fall depending on the lake/station. Total phytoplankton abundance was consistently higher at the FF2 area compared with the other three far-field/reference areas in Lac de Gras. A decreasing trend in phytoplankton biomass was observed in all areas monitored as part of the Diavik Mine AEMP between 2008 and 2011.

Total phytoplankton biomass was consistently higher in the FF2 exposure area compared with the other three far-field/reference areas in Lac de Gras. A decreasing trend in phytoplankton biomass was observed in all areas monitored as part of the Diavik Mine AEMP between 2008 and 2011, consistent with the total phytoplankton abundance results. This trend suggests that a regional factor beyond Mine-related effects was influencing the phytoplankton community.

In Lac du Sauvage and Counts Lake, total phytoplankton richness was variable and increased slightly over time. In areas of Lac de Gras monitored as part of the Diavik Mine AEMP, total phytoplankton richness has increased since the 1997 baseline condition, but recently showed a decline. In contrast, areas of Lac de Gras monitored as part of the Ekati Mine AEMP showed fluctuations in total phytoplankton richness, but no distinct trend over time. Overall, richness values were stable in Nanuq Lake and Vulture Lake. Total phytoplankton richness varied seasonally in Lac du Sauvage, Christine Lake, and Ursula Lake in 2006.

Phytoplankton community composition varied among lakes and among years, although cyanobacteria, chlorophytes, and chrysophytes were commonly the dominant taxonomic groups. Temporal trends were observed in Lac de Gras. In recent years, the proportion of chrysophytes at Station S2 decreased, while the proportion of diatoms increased at stations S2 and S3. In the FFA and FFB reference areas, composition shifted from chrysophyte dominance (2003 to 2006), to cyanobacteria dominance (2007 to 2010). The communities in the FF2 and FF1 areas consisted predominantly of chrysophytes and cyanobacteria.

2.4.3 Zooplankton Community

Total zooplankton abundance varied over time in most of the lakes included in this historical review, with the exception of Christine and Ursula lakes, which were only sampled in 2006 and thus could not be evaluated for temporal trends. The limited seasonal data available for Lac du Sauvage, Christine Lake, and Ursula Lake indicated seasonal variability but no consistent seasonal pattern among these three lakes. Total zooplankton abundance in Lac de Gras decreased in 2009 in all areas monitored as part of the Diavik Mine AEMP. A slight increase was observed in the FF1 area in 2012. Total zooplankton abundance was similar in the FF2 exposure area and the other three far-field/reference areas. Conversely, summer zooplankton biomass at Lac de Gras stations monitored as part of the Ekati Mine AEMP showed little variation over time.

Zooplankton biomass (as AFDM) showed variability in most of the lakes included in this historical review, but overall remained relatively stable over time. Total zooplankton biomass based on wet-weight was only available in Lac de Gras in relation to the Diavik Mine AEMP. These results were much more variable relative to the AFDM data; however, no temporal trend was evident in any of the four sampling areas.

With the exception of Lac de Gras, total zooplankton richness was relatively stable within each lake and over time. In areas of Lac de Gras monitored as part of the Diavik Mine AEMP, total zooplankton richness increased over time.

In general, rotifers and copepods dominated the zooplankton community compositions in most lakes included in this historical review. No temporal trends were observed in zooplankton community composition. Cyanobacteria, chlorophytes, and chrysophytes were commonly the dominant taxonomic groups. Temporal trends were observed in Lac de Gras. In recent years, the proportion of chrysophytes at Station S2 decreased, while the proportion of diatoms increased at stations S2 and S3. In the FFA and FFB reference areas, composition has shifted from chrysophyte dominance (2003 to 2006), to cyanobacteria dominance (2007 to 2010). The communities in the FF2 and FF1 areas consisted predominantly of chrysophytes and cyanobacteria.

3 2013 BASELINE PLANKTON PROGRAM

3.1 Methods

3.1.1 Sampling Locations and Timing

The 2013 plankton baseline program was completed during the open-water sampling period from late July to mid-September 2013. Phytoplankton and zooplankton samples were collected during three open-water field programs in 2013:

- July 20 to 29 (late spring);
- August 8 to 17 (summer); and,
- September 5 to 19 (fall).

Chlorophyll *a* and depth-integrated nutrients (i.e., total phosphorus, total nitrogen, and soluble reactive silica) samples were collected as part of the plankton program; detailed nutrient results are presented in the Water and Sediment Quality Baseline Report (Annex XI).

Plankton sampling occurred in four lakes in the Lac du Sauvage basin (Lac du Sauvage, Duchess Lake, Lake Af1, and Lake E1), and one lake (Paul Lake) in the Lac de Gras basin (Map 1.3-2; Table 3.1-1).

Sampling stations were only accessible by helicopter and boat, and inclement weather (e.g., fog, high winds) caused delays in the field programs. Sampling was not completed at the following stations for specific programs (Table 3.1-1):

- Paul Lake: PL-5 in late spring, PL-4 in summer, and PL-1 in fall; and,
- Lake E1: Station E-L1-1 in late spring.

Table 3.1-1 Plankton Sampling Station Locations and Sampling Events in the Jay Project Area, 2013

Basin	Waterbody Name	Station	UTM Coordinates[a]		Phytoplankton and Zooplankton		
			Easting (m)	Northing (m)	Late Spring (July)	Summer (August)	Fall (September)
Lac du Sauvage	Lac du Sauvage	Aa-1	552282	7165025	X	X	X
		Ab-1	547766	7162266	X	X	X
		Ac-1	545339	7165138	X	X	X
		Ac-4	543695	7162938	X	X	X
		Ac-7	544247	7165068	X	X	X
		Ad-1	539898	7168781	X	X	X
		Ae-1	542494	7170252	X	X	X

Table 3.1-1 Plankton Sampling Station Locations and Sampling Events in the Jay Project Area, 2013

Basin	Waterbody Name	Station	UTM Coordinates[(a)]		Phytoplankton and Zooplankton		
			Easting (m)	Northing (m)	Late Spring (July)	Summer (August)	Fall (September)
Lac du Sauvage	Duchess Lake	Af-1	542155	7173731	X	X	X
		Af-7	541367	7174902	X	X	X
	Lake Af1	Af-10	538299	7176361	X	X	X
	Lake E1	E-L1-1	535065	7174657	n/c	X	X
Lac de Gras	Paul Lake	PL-1	533179	7173835	X	X	n/c
		PL-2	531655	7174122	X	X	X
		PL-3	528681	7172550	X	X	X
		PL-4	527145	7171895	X	n/c	X
		PL-5	525859	7171047	n/c	X	X

Note: All UTM coordinates are in Zone 12V, North American Datum (NAD) 83.

a) UTM coordinates are from the first sampling event at each station.

UTM = Universal Transverse Mercator coordinate system; m = metre; X = sample collected; n/c = sample not collected.

3.1.2 Field Methods

3.1.2.1 Supporting Variables, Nutrients, and Chlorophyll a

Depth-integrated and discrete nutrient samples and chlorophyll *a* samples were collected as part of the water quality component as supporting data for the plankton component. Depth-integrated nutrient samples and chlorophyll *a* samples were collected from the euphotic zone, which is defined as the extent of the water column that is exposed to sufficient sunlight for photosynthesis to occur (typically to a depth in the water column where 1% of the surface irradiance is measured). During the field program, the euphotic zone was calculated as two times the Secchi depth (Koenings and Edmundson 1991; AENV 2006). Discrete nutrient samples were collected from either top, mid, or bottom depths depending on the total depth of the water column and presence of stratification (Annex XI). Chlorophyll *a* samples were collected in triplicate at deep stations during the late spring, summer, and fall sampling programs.

The depth-integrated nutrient samples were analyzed for TN, TP, and soluble reactive silica. Discrete nutrient samples were analyzed for total organic carbon, dissolved organic carbon, TN, total Kjeldahl nitrogen, total ammonia, nitrate, nitrite, TP, total dissolved phosphorus, dissolved orthophosphate, and soluble reactive silica. The nutrient samples were analyzed by ALS Laboratories, Edmonton, Alberta, and the chlorophyll *a* samples were analyzed, as total chlorophyll *a*, by the Biogeochemical Analytical Service Laboratory at the University of Alberta, Edmonton, Alberta.

In situ water quality profiles (i.e., pH, temperature, dissolved oxygen, and specific conductivity), light profiles, and Secchi depths were collected in conjunction with the water quality baseline program. Detailed field methods for the collection and analysis of the nutrient and chlorophyll *a* samples, and field measurements are presented in Annex XI.

3.1.2.2 Phytoplankton

The phytoplankton sampling depth was determined to be the euphotic zone sampling depth defined as two-times the Secchi depth. At each station, discrete water samples were collected at 2-m intervals within the euphotic zone using a Kemmerer sampler. For example, if the water depth was 6 m, then samples were collected at the surface (0 m), 2 m, 4 m, and 6 m. If the water depth was less than 6 m, then samples were collected at surface (0 m), 2 m, and 4 m. If the water depth was less than the Secchi depth, then samples were collected every 2 m from the surface to a depth of 2 m above the lake bed.

Equal volumes of water from each depth were combined in a large clean bucket and mixed thoroughly to form a composite sample. Samples of water were taken from this composite water sample and used to fill individual 250 millilitre (mL) amber Nalgene bottles for phytoplankton. Phytoplankton samples were preserved with 2.5 mL (i.e., six to eight drops) of acid Lugol's solution. Triplicate phytoplankton samples were collected at each station; two samples were submitted for taxonomic analysis and the third sample was archived for potential future analyses. Samples were stored in the dark at 4 degrees Celsius (°C) before shipping to EcoAnalysts, Inc. (EcoAnalysts) in Moscow, Idaho, United States for taxonomic identification.

3.1.2.3 Zooplankton

Maximum water depth was measured before plankton sampling to determine zooplankton sampling depth. A 30-centimetre (cm) diameter, 80 µm mesh Turtox plankton tow net was used to collect three replicate zooplankton samples at each station. A single vertical haul was collected for each zooplankton sample. The plankton net was lowered to a depth of 1 m above the bottom and then pulled vertically through the water column at a rate of approximately 0.5 metres per second (m/s).

Haul depths were recorded for each sample and were used to calculate the volume of water filtered through the net (Table 3.1-2). The plankton net was rinsed by splashing lake water on the outside to wash clinging zooplankton into the bottom of the plankton net. A 250 mL clear Nalgene bottle was placed below the tube of the plankton net. The stop-cock was then opened and the sample was transferred into the sample bottle below.

Before preservation, one half of an Alka-Seltzer tablet was added as a narcotizing agent to each sample bottle to prevent the zooplankton from being contorted by the preservative, thereby allowing for easier identification by the taxonomist. Each sample was preserved by doubling the sample volume with 10% buffered formalin solution (approximately 125 mL of formalin was added). Samples were stored at 4°C.

Two zooplankton samples per station, and the supporting information (i.e., haul depth), were sent to EcoAnalysts for taxonomic analysis. The third zooplankton sample from each station was archived for potential future taxonomic analysis.

Table 3.1-2 Zooplankton Haul Depths for Stations Sampled in the Jay Project Area, 2013

Basin	Waterbody Name	Station	Zooplankton Haul Depth (m)		
			Late Spring	Summer	Fall
Lac du Sauvage	Lac du Sauvage	Aa-1	10	10	9
		Ab-1	11.5	11.5	10.5
		Ac-1	12	11.5	10
		Ac-4	11	11	11
		Ac-7	12	11.5	11
		Ad-1	12	11.5	12
		Ae-1	11	13	9
	Duchess Lake	Af-1	12	12.5	11
		Af-7	11	9.5	11.5
	Lake Af1	Af-10	7	7.5	7.5
	Lake E1	E-L1-1	n/c	10.5	7
Lac de Gras	Paul Lake	PL-1	8	9	n/c
		PL-2	6	7	6.5
		PL-3	11	12.5	11
		PL-4	12	n/c	11
		PL-5	n/c	5	6.5

m = metre; n/c = sample not collected.

3.1.3 Laboratory Methods

3.1.3.1 Phytoplankton

Phytoplankton samples were analyzed for species composition at the lowest possible taxonomic level (typically species), and abundance and biomass by EcoAnalysts (2009a). A 10-mL aliquot was extracted for analysis of turbid samples, while 20 mL was extracted for analysis of clear samples. A minimum of 10 mL was subsampled for both soft algae and diatoms. Samples were shaken vigorously and 0.1 mL of the homogenized sample was placed in a Palmer-Maloney counting chamber. Samples were examined at 400 times (X) magnification using a Nikon compound light microscope to evaluate whether the sample was too dense or dilute to achieve a desirable cell count (approximately 15 to 20 counting units per field of view). Samples were diluted or concentrated, as necessary, and the new volume and concentration ratios were noted.

Soft algal units were counted and identified to the lowest practical taxonomic level using the transect method. A minimum of 300 units were counted for each sample. Counting units were individual cells, filaments, or colonies, depending on the organization of the algae. Diatoms were counted and identified at 1,000X magnification using a Nikon compound light microscope. The transect method was used to count a minimum of 300 cells (600 valves) per sample. Taxonomic identifications were based on the following standard taxonomic references: Dillard (1991a,b, 1993); Wehr and Sheath (2003); Siver et al. (2005); Pfeil (2010); and John et al. (2011).

Biovolume (cubic micrometre [μm^3] wet weight) of each phytoplankton species was estimated from the average dimensions of 10 to 15 individuals and related to geometric solids (Rott 1981). The biovolumes of colonial taxa were based on the number of individuals within each colony. Biovolume (cubic micrometres per litre [$\mu m^3/L$]) was calculated for each sample by multiplying abundance (reported as cells/L) by the average biovolume. Cell biovolume was converted to biomass by assuming a specific gravity of 1 (i.e., 1,000,000 μm^3 = 1.0 microgram [µg]). Phytoplankton biomass was reported as mg/m^3 (wet weight).

3.1.3.2 Zooplankton

Zooplankton samples were analyzed for species composition at the lowest possible taxonomic level (typically species), abundance, and biomass according to methods provided by EcoAnalysts (2009b). Zooplankton samples were rinsed into a 400 mL beaker with 70% ethanol and allowed to settle overnight. To attain a reasonable sample for counting, the supernatant was decanted from the samples using a variable flow chemical pump. Following decanting, the volume of the sample was determined by weighing it before counting.

The sample was mixed in a random fashion and a homogeneous subsample was extracted using a 1 mL Hensen-Stempel pipette. To facilitate even distribution of organisms in the counting chamber and, thus, accurate abundance calculations, no more than 3 mL volumes were counted at one time and each dish was counted in its entirety. The subsample was rinsed with water (with a drop of soap added to reduce surface tension) into a gridded Corning counting chamber. To achieve the target count (between 200 and 400 organisms), adjustments were made either by adding or reducing the volume or taking aliquots from the first dilution into a second beaker and further diluting the subsample. Coarse (non-rotifers) and fine (rotifers) zooplankters were identified separately. A Leica S8A10 Stereoscope (80X maximum) and a Zeiss Axiolab Compound scope (100X maximum), at an average magnification of 40X, were used to identify and enumerate the zooplankton.

Cyclopoid and calanoid copepods specimens (mature and immature) were identified to species, with the exception of nauplii, which were classified as copepod nauplii. Organisms that could not be identified to species were identified to genus. Taxonomic identifications were based primarily on Alberti et al. (2007), Edmondson (1959), and Stemberger (1979).

Wet weight biomass (mg/m^3) for each zooplankton taxon was based on published length-weight regressions and mean length measurements (Dumont et al. 1975; USEPA 2012). Single length measurements were made for the dominant taxa per sample. Zooplankton lengths were determined directly on the microscope fitted with an ocular micrometer. After the length measurements for the sample were completed, the sample was weighed to obtain the final volume counted. EcoAnalysts did not perform length measurements nor biomass estimates on the rare taxa. The following two approaches were used to estimate biomass for the rare taxa, which were dependant on the availability of data:

1) The entire 2013 Jay Project dataset was reviewed to determine whether the rare taxa were present in other stations and whether biomass estimates were provided by EcoAnalysts. If so, the average of these measurements was applied to the taxon missing a biomass estimate.

2) If a rare taxon was not observed anywhere else in the dataset, published biovolume estimates from Malley et al. (1989) and Lawrence et al. (1987) were used.

Four rare taxa (*Acomorpha ovalis*, *Euchlanis* sp., Macrothricidae, and Bdelloidae) lacked biomass estimates in the 2013 Jay Project dataset and were not reported in Malley et al. (1989) or Lawrence et al. (1987). Biomass estimates for these taxa were obtained from EcoAnalysts, who provided a single length measurement and the appropriate length-weight regression for each taxon (Barrett 2014).

3.1.4 Data Analyses

3.1.4.1 Trophic Status

The trophic status of each major waterbody was evaluated by examining the nutrient data, chlorophyll *a*, and water transparency (Secchi depth) data. The trophic status was determined using the Vollenweider (1970) trophic classification scheme for lakes (using TP, TN, chlorophyll *a*, and Secchi depth); the Canadian Council of Ministers of the Environment (CCME) (2004) trophic classification scheme for Canadian lakes and streams (using TP); and the Trophic State Index (TSI) developed by Carlson (1977). The TSI is a numerical trophic state index for lakes that classifies lakes on a scale of 0 to 100 (Carlson 1977). The index number is calculated from Secchi depth, chlorophyll *a*, and TP using the following equations (Carlson 1977):

Equation 3.1-1

$$TSI\ (TP)\ =\ 10\left(6\ -\ \frac{\ln\frac{48}{TP}}{\ln 2}\right)$$

Equation 3.1-2

$$TSI\ (Chl)\ =\ 10\left(6-\frac{2.04-0.68\ln Chl}{\ln 2}\right)$$

Equation 3.1-3

$$TSI\ (Secchi)\ =\ 10\left(6-\frac{\ln SD}{\ln 2}\right)$$

where:

TSI = trophic state index;
TP = total phosphorus;
ln = the natural log;
Chl = chlorophyll *a*; and,
Secchi = Secchi depth.

Values calculated using these equations are multiplied by 10 to give the scale a range of 0 to 100. The numerical scales for each of the trophic status indices are presented in Annex XI.

3.1.4.2 Plankton Data Analysis

Phytoplankton and zooplankton data were analyzed separately, but the same approach was used to analyze the data. Abundance and biomass data were divided into major taxonomic groups. Phytoplankton groups were Cyanobacteria, Chlorophyceae (chlorophytes), Chrysophyceae (chrysophytes), Cryptophyceae (cryptophytes), Dinophyceae (dinoflagellates), Bacillariophyceae (diatoms), and Euglenophyceae (euglenoids). Zooplankton groups were Cladocera (cladocerans), Calanoida (calanoid copepods), Cyclopoida (cyclopoid copepods), Rotifera (rotifers), and copepod nauplii. Cyclopoid and calanoid copepods were considered separately because of taxonomic and ecological differences. Copepod nauplii were not identified as either cyclopoid or calanoid copepods, but occurred in high abundances in certain samples; therefore, they were treated as a unique taxonomic group for plotting purposes.

Total abundance and total biomass for phytoplankton and zooplankton were calculated as the average of the two replicate samples collected at each station. Total abundance and total biomass were plotted as bar graphs by major taxonomic groups, with error bars representing the standard error of the mean. The relative proportion accounted for by each major taxonomic group, based on both abundance and biomass, was calculated separately for each station to evaluate variability in community structure among stations.

Total taxonomic richness at the genus level was summarized for each station and plotted as a bar graph for both phytoplankton and zooplankton. Taxonomic richness provides an indication of the diversity at a station; higher richness values typically indicate more healthy and balanced communities.

Dominant taxa were identified based on the lowest practical taxonomic level and biomass estimates, for each lake and each sampling period. The relative biomass of each taxon was calculated and ordered from most abundant to least abundant. For phytoplankton, all taxa greater than 10% were reported whereas, for zooplankton, the taxa accounting for greater than 20% of total biomass for a lake and sampling period were reported.

3.1.5 Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) procedures were applied during all aspects of the plankton component to verify that the data collected were of acceptable quality. In accordance with Golder Associates Ltd. (Golder) QA/QC protocols, all data entered electronically were reviewed for data entry errors and appropriate corrections were made. Samples identified by the taxonomist as spoiled or compromised were invalidated and removed from further analyses.

EcoAnalysts performed an internal QC of the phytoplankton data by having a separate taxonomist re-analyze 10% of the samples to verify taxonomic accuracy and reproducibility of the processing and analytical methods. Internal QC was not performed on the zooplankton data due to laboratory error. The percent similarity index was calculated from the two independent phytoplankton counts. The internal QC standards set by EcoAnalysts required that the dominant phytoplankton taxa were aligned, percent similarity was equal to or greater than 50%, and the common phytoplankton taxa accounting for more than 10% relative abundance were identified similarly by both taxonomists. If any one of these criteria were not met, the sample was reanalyzed. Discrepancies between taxonomists were resolved by re-examining digital images and/or preserved specimens, and the final organism counts and identifications were adjusted according to the recommendations of both taxonomists.

To examine the variability introduced by field sampling procedures, taxonomic accuracy, and reproducibility of the processing and analysis methods, replicate phytoplankton and zooplankton samples were analyzed by two QC approaches: Bray-Curtis index and relative percent difference (RPD).

The Bray-Curtis index is a measure of the ecological distance between two communities. The Bray-Curtis index was calculated in SYSTAT (2009), according to the formula below, to evaluate the overall similarity between the original and duplicate plankton samples:

Equation 3.1-4

$$b = \frac{\sum_{k=1}^{n} \left| x_{ik} - x_{jk} \right|}{\sum_{k=1}^{n} \left(x_{ik} + x_{jk} \right)}$$

where,

x_{ik} *and* x_{jk} = the abundance from the original and duplicate samples, respectively.

Since the Bray-Curtis index only allows comparisons of entire samples, the RPD was also calculated to compare abundances of each major group between duplicate samples.

The QC standards set by Golder for duplicate samples required the following:

- dominant taxa were aligned;
- the RPD values comparing abundances of major taxa met the established criterion (i.e., less than 50%); and,
- the Bray-Curtis similarity index comparing the original and duplicate samples was less than 0.5.

If any one of these criteria was not met, the sample was flagged. Flagged data were not automatically rejected because of an exceedance of the acceptance criterion; rather, they were evaluated on a case-by-case basis, as a certain level of within-station variability is expected in taxonomy data.

3.2 Results

3.2.1 Quality Assurance and Quality Control

Detailed QC results for phytoplankton and zooplankton are presented in 2013 Plankton Taxonomy Data (Appendix B). Overall, sample percent similarity met the 50% criterion for all QC comparisons for phytoplankton and zooplankton. Plankton data QC results indicate that the overall occurrence of dominant taxa was consistent between the original and duplicate samples for phytoplankton and zooplankton. Differences between original and QC samples were within the range of variability expected for plankton samples and subsampling variance.

3.2.1.1 EcoAnalysts Inc. Internal Quality Control

For phytoplankton QC comparisons, EcoAnalysts re-counted three samples from late spring (Ac-7 replicate 1, Ae-1 replicate 2, PL-3 replicate 2), three samples from summer (Ac-1 replicate 1, Ae-1 replicate 1, PL-1 replicate 1), and two samples from fall (Ac-4 replicate 2, Ab-1 replicate 1). All eight QC samples were above the 50% criterion (ranging from 64% to 71%), with the exception of the replicate 1 sample collected at Ac-7 on July 20, which had a sample percent similarity of 46%. The original sample collected at Ac-7 was co-dominated by *Chrysocapsella planctonica* (47%) and *Ochromonas* sp. (33%), while the QC sample was dominated by *Ochromonas* sp. (70%); *Chrysocapsella planctonica* was absent from the QC sample. There was a 33% similarity in the relative abundance of *Ochromonas* sp. between the two samples. For the remainder of the QC comparisons, the dominant phytoplankton taxa were the same (i.e., *Chrysocapsella planctonica*, *Ochromonas* sp., *Plagioselmis nannoplanctica*, *Achnanthidium* (multiple species [spp.]), *Asterionella formosa*) in both the original and the QC samples. Overall, internal QC comparison results by EcoAnalysts suggest that the phytoplankton data were of acceptable quality.

3.2.1.2 Golder Quality Control

The Bray-Curtis index for abundance for one set of phytoplankton samples (Ae-1 in summer) was 0.55, which yielded a flag for further investigation (Appendix B, Table B-1). However, the summer sample from Station Ae-1 was not flagged in the RPD comparison; therefore, the data were considered to be of acceptable quality and were not invalidated. The Bray-Curtis index values for the other phytoplankton samples were acceptable for abundance and ranged from 0.05 to 0.44. For zooplankton abundance, the Bray-Curtis index values ranged from 0.03 to 0.42 and no data required further investigation (Appendix B, Table B-2).

For phytoplankton abundance, six duplicate samples had a single RPD result of greater than 50% in the major taxonomic group comparison (Appendix B, Table B-1). For zooplankton abundance, 14 duplicate samples yielded RPD values greater than 50% in the major taxonomic group comparison (Appendix B, Table B-2).

Overall, differences between original and QC phytoplankton and zooplankton samples were deemed minor and within the range of variability expected in plankton data. Therefore, QC results indicated that the 2013 phytoplankton and zooplankton data were considered to be of acceptable quality and no data were invalidated.

3.2.2 Lac du Sauvage Basin

3.2.2.1 Lac du Sauvage

3.2.2.1.1 Trophic Status Classification

Trophic status was evaluated by examining the concentrations of total phosphorus (TP), chlorophyll *a,* and water transparency (Secchi depth). The discrete water sampling program yielded mean annual concentrations of 0.0057 mg/L for TP and 6.5 m for Secchi depth in Lac du Sauvage. The corresponding TSI values were 29 using TP and 33 using Secchi depth, resulting in a rounded average of 31.

The depth-integrated sampling program yielded mean annual concentrations of 0.0080 mg/L for TP, 7.3 m for Secchi depth, and 1.94 µg/L for chlorophyll *a*. The corresponding TSI values were 37 using chlorophyll *a*, 34 using TP, and 31 using Secchi depth, resulting in a rounded average of 34.

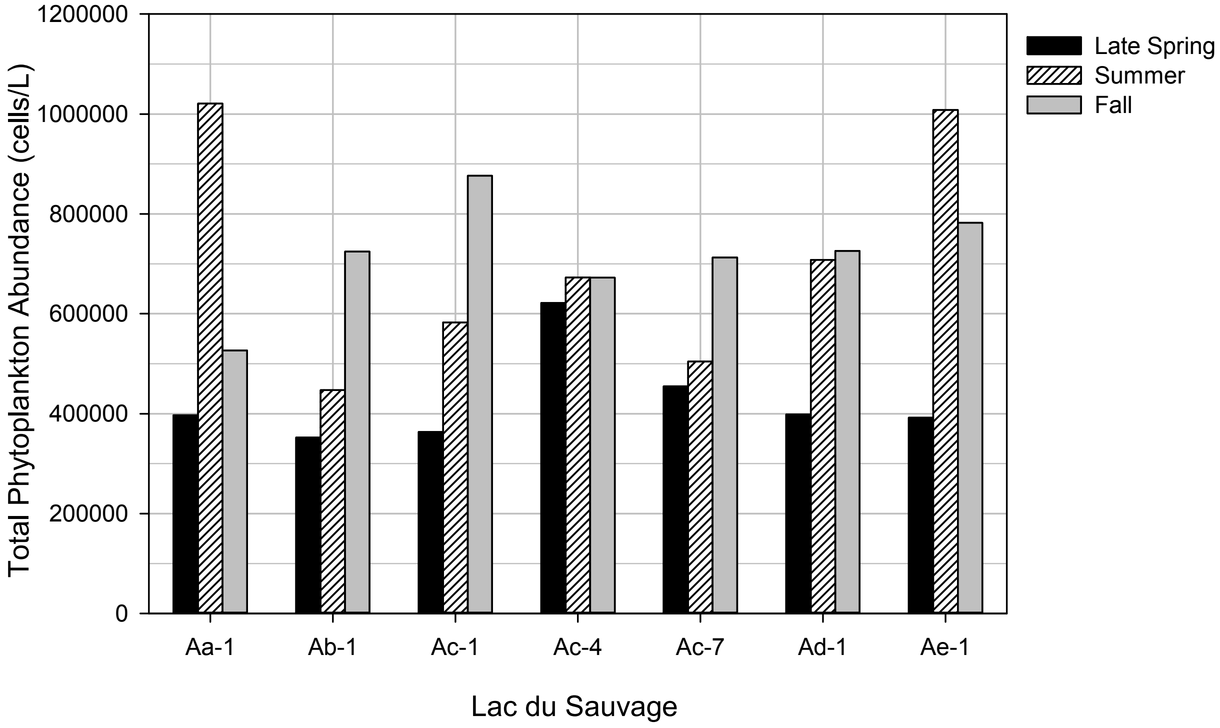
Based on these values, and the classification systems of Vollenweider (1970), CCME (2004), and Carlson (1977), Lac du Sauvage can be classified as an oligotrophic lake.

3.2.2.1.2 Phytoplankton

Abundance and Biomass

Seasonal and spatial variation in total phytoplankton abundance were observed in Lac du Sauvage during the 2013 open-water sampling period (Figure 3.2-1). Total phytoplankton abundance peaked in the summer at stations Aa-1 and Ae-1 (1,020,835 and 1,008,336 cells/L, respectively), while abundance peaked in the fall at Station Ac-1 (876,678 cells/L). Total phytoplankton abundance varied little between the summer and fall at stations Ac-4 (672,976 and 672,455 cells/L, respectively) and Ad-1 (707,847 and 725,883 cells/L, respectively). The highest total phytoplankton abundances in Lac du Sauvage were observed in the summer at stations Aa-1 and Ae-1. Total phytoplankton abundance was consistently lowest in late spring, with values at the majority of stations being below 500,000 cells/L.

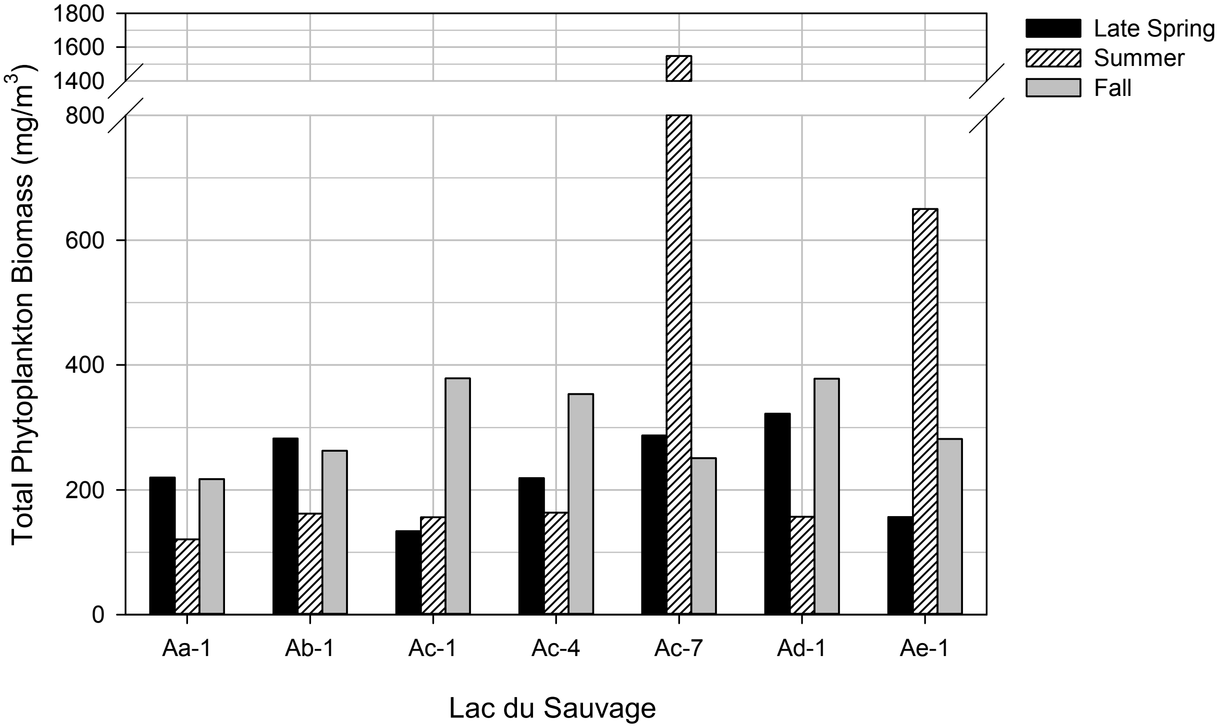
Figure 3.2-1 Total Phytoplankton Abundance in Lac du Sauvage in Late Spring, Summer, and Fall, 2013



cells/L = cells per litre.

During the open-water sampling period, total phytoplankton biomass at the majority of stations in Lac du Sauvage ranged between 100 and 400 mg/m^3. However, no clear seasonal trend in total phytoplankton biomass was observed (Figure 3.2-2). Four of the seven stations exhibited declines in total phytoplankton biomass between late spring and summer; however, unusually high biomass values were observed in summer at stations Ac-7 (1,548 mg/m^3) and Ae-1 (650 mg/m^3). The relatively high biomass observed at Station Ac-7 in summer was largely driven by the large dominant chrysophyte, *Dinobryon divergens*, while the dominant taxon driving the high biomass at Station Ae-1 in the summer was the chlorophyte, *Eudorina elegans.*

Figure 3.2-2 Total Phytoplankton Biomass in Lac du Sauvage in Late Spring, Summer, and Fall, 2013

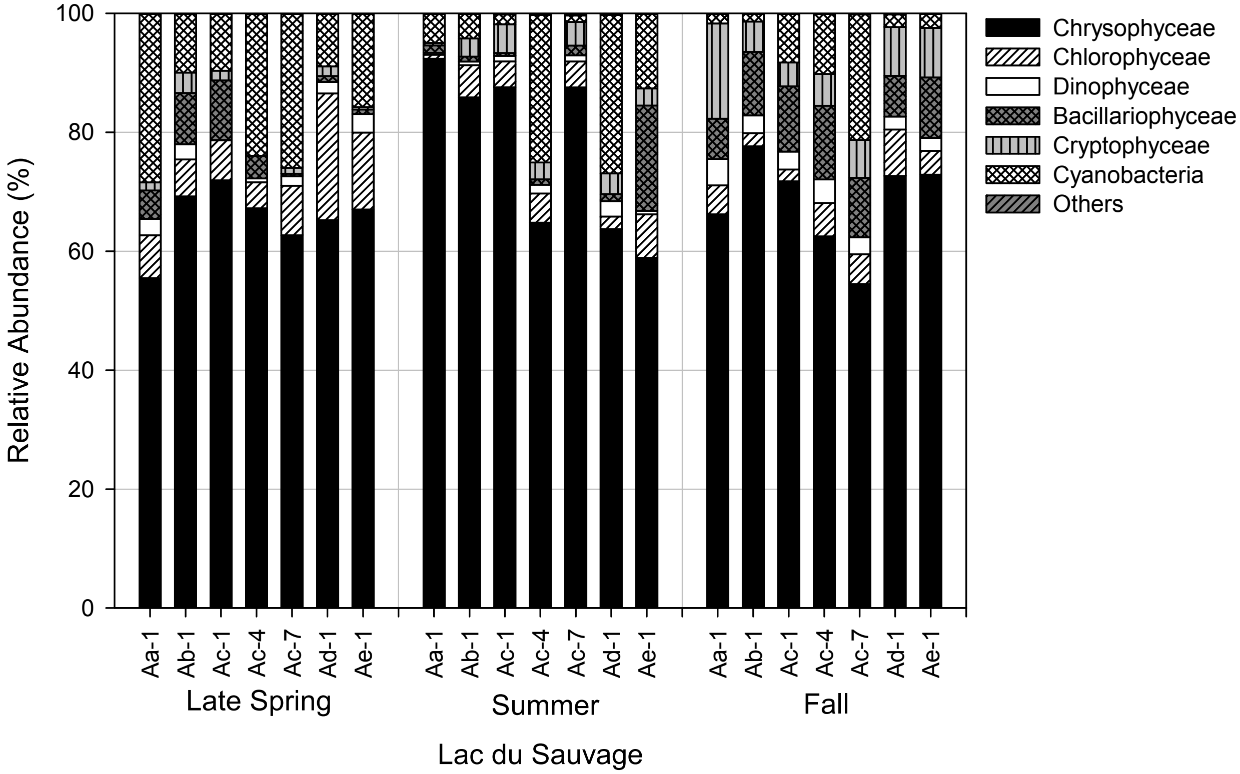


mg/m^3 = milligrams per cubic metre.

Community Composition

Chrysophytes consistently dominated the community composition by abundance in Lac du Sauvage throughout the open-water sampling period, making up 56% to 72% of the phytoplankton assemblage in late spring, 59% to 92% in summer, and 54% to 78% in the fall (Figure 3.2-3). Other major taxonomic groups such as cyanobacteria (less than 28%), chlorophytes (less than 21%), diatoms (less than 18%), cryptophytes (less than 16%), and dinoflagellates (less than 4%) were present in Lac du Sauvage at varying relative abundances throughout the open-water sampling period.

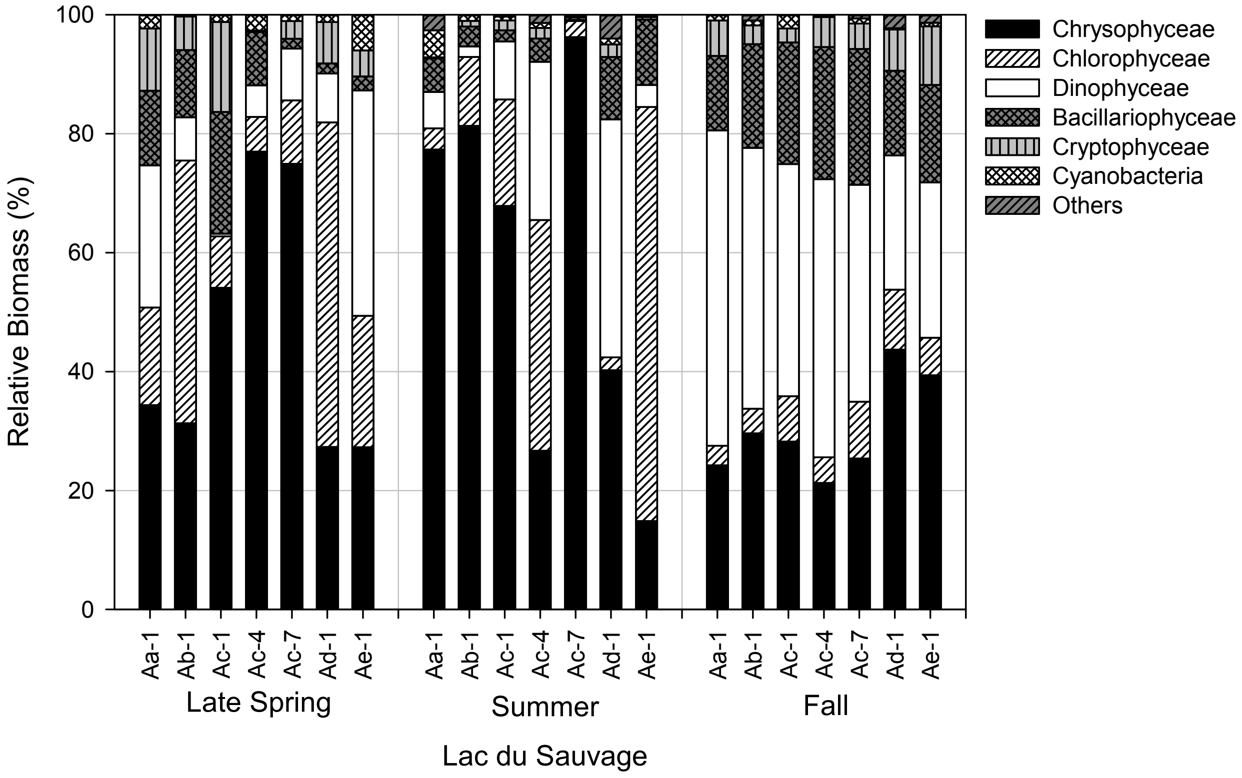
Figure 3.2-3 Relative Phytoplankton Abundance in Lac du Sauvage in Late Spring, Summer, and Fall, 2013



% = percent.

In terms of biomass, the phytoplankton community composition in Lac du Sauvage varied seasonally and spatially throughout the open-water sampling period (Figure 3.2-4). Spatial differences were particularly pronounced in the late spring and summer. In late spring, chrysophytes dominated at stations Ac-1, Ac-4, and Ac-7, making up 54% to 77% of the community composition by biomass. Stations Aa-1 and Ae-1 were dominated by a mixture of chrysophytes (34% and 27%, respectively), dinoflagellates (24% and 38%, respectively), and chlorophytes (16% and 22%, respectively) in the late spring, while stations Ab-1 and Ad-1 were co-dominated by chlorophytes (44% and 55%, respectively) and chrysophytes (31% and 27%, respectively).

Figure 3.2-4 Relative Phytoplankton Biomass in Lac du Sauvage in Late Spring, Summer, and Fall, 2013



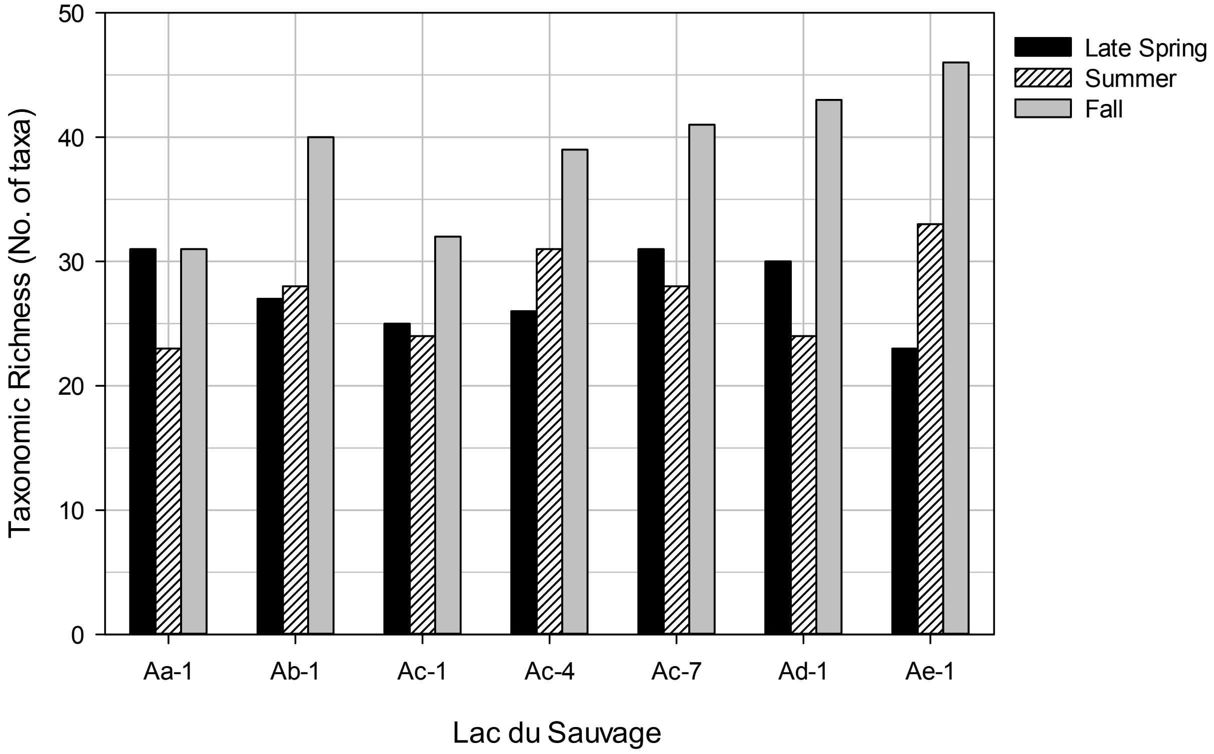
% = percent.

In the summer, chrysophytes (68% to 96%) dominated stations Aa-1, Ab-1, Ac-1, and Ac-7 in Lac du Sauvage (Figure 3.2-4). Relatively equal proportions of chlorophytes (39%), chrysophytes (27%), and dinoflagellates (27%) dominated Station Ac-4 in the summer. Station Ad-1 was co-dominated by chrysophytes and dinoflagellates (40% and 40%, respectively) in the summer, while Station Ae-1 was primarily dominated by chlorophytes (70%).

In the fall, community composition by biomass was consistent among stations in Lac du Sauvage (Figure 3.2-4). A mixture of dinoflagellates (23% to 53%), chrysophytes (21% to 44%), and diatoms (13% to 23%) dominated the phytoplankton biomass in Lac du Sauvage in the fall.

In total, 88 phytoplankton taxa were identified in Lac du Sauvage in 2013: 37 chlorophytes, 19 diatoms, 11 cyanobacteria, 9 chrysophytes, 4 dinoflagellates, 3 cryptophytes, 4 euglenoids, and 1 xanthophyte (Appendix B, Table B-3). Seasonal variation in phytoplankton taxonomic richness was observed in Lac du Sauvage in 2013, ranging from 23 taxa (Station Ac-1 in summer) to 46 taxa (Station Ae-1 in fall). The highest phytoplankton richness was observed in the fall at all stations; however, there was no consistent seasonal pattern among stations (Figure 3.2-5).

Figure 3.2-5 Total Phytoplankton Taxonomic Richness in Lac du Sauvage in Late Spring, Summer, and Fall, 2013



No. = number.

The dominant taxa, accounting for greater than 10% of total phytoplankton biomass, differed among sampling periods in Lac du Sauvage (Table 3.2-1). In late spring, one chlorophyte taxon, *Euastrum verrucosum*, and one chrysophyte taxon, *Dinobryon bavaricum*, accounted for 22% and 14% of the total phytoplankton biomass in Lac du Sauvage, respectively. In the summer, two different chrysophyte and chlorophyte taxa dominated: *Chrysocapsa planktonica* accounted for 50% of the total phytoplankton biomass, and *Eudorina elegans* accounted for 29%. In the fall, dominance was evenly distributed among four taxa: two chrysophyte taxa, *Ochromonas* sp. (13%) and *Dinobryon divergens* (11%); and two dinoflagellate taxa, *Peridinium umbonatum* (13%) and *Peridinium* sp. (12%).

Table 3.2-1 Dominant Phytoplankton Taxa in Lac du Sauvage in Late Spring, Summer, and Fall, 2013

Sampling Period	Major Taxonomic Group	Taxon	Biomass (mg/m^3)	Dominance (%)
Late Spring	Chlorophyceae	*Euastrum verrucosum*	80	22
	Chrysophyceae	*Dinobryon bavaricum*	52	14
Summer	Chrysophyceae	*Chrysocapsa planktonica*	714	50
	Chlorophyceae	*Eudorina elegans*	407	29
Fall	Chrysophyceae	*Ochromonas* sp.	45	13
	Dinophyceae	*Peridinium umbonatum*	48	13
	Dinophyceae	*Peridinium* sp.	44	12
	Chrysophyceae	*Dinobryon divergens*	40	11

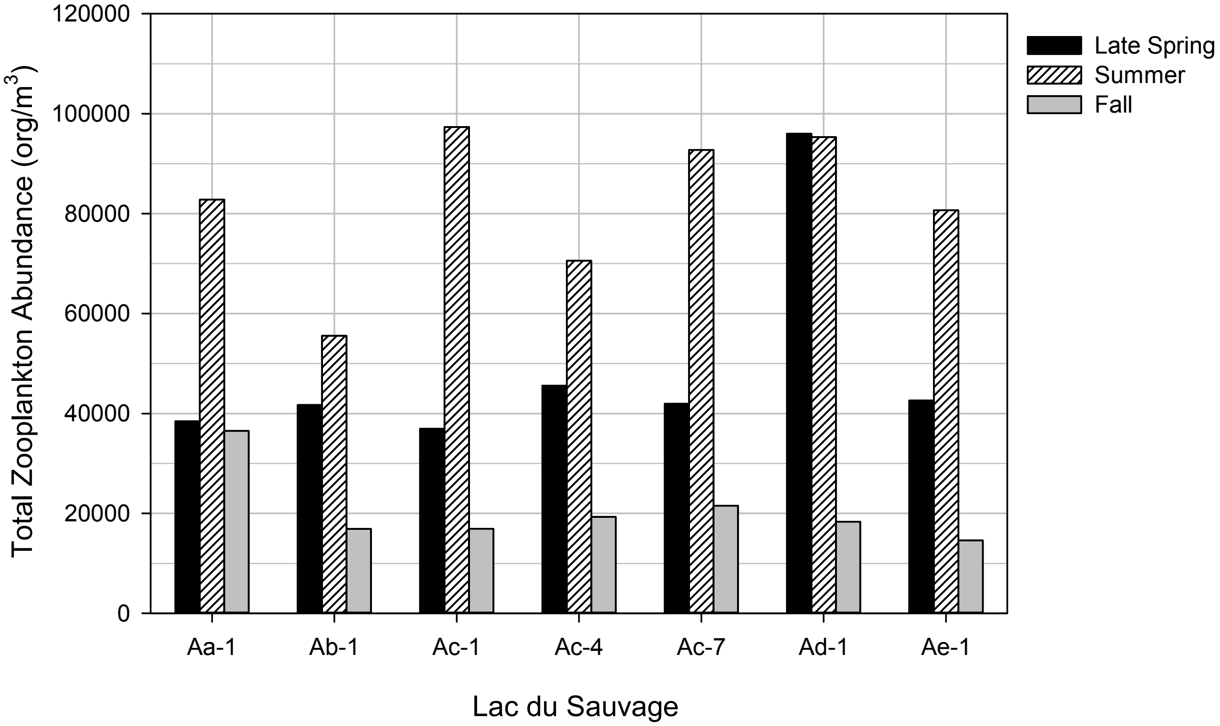
mg/m^3 = milligrams per cubic metre;% = percent; sp. = species.

3.2.2.1.3 Zooplankton

Abundance and Biomass

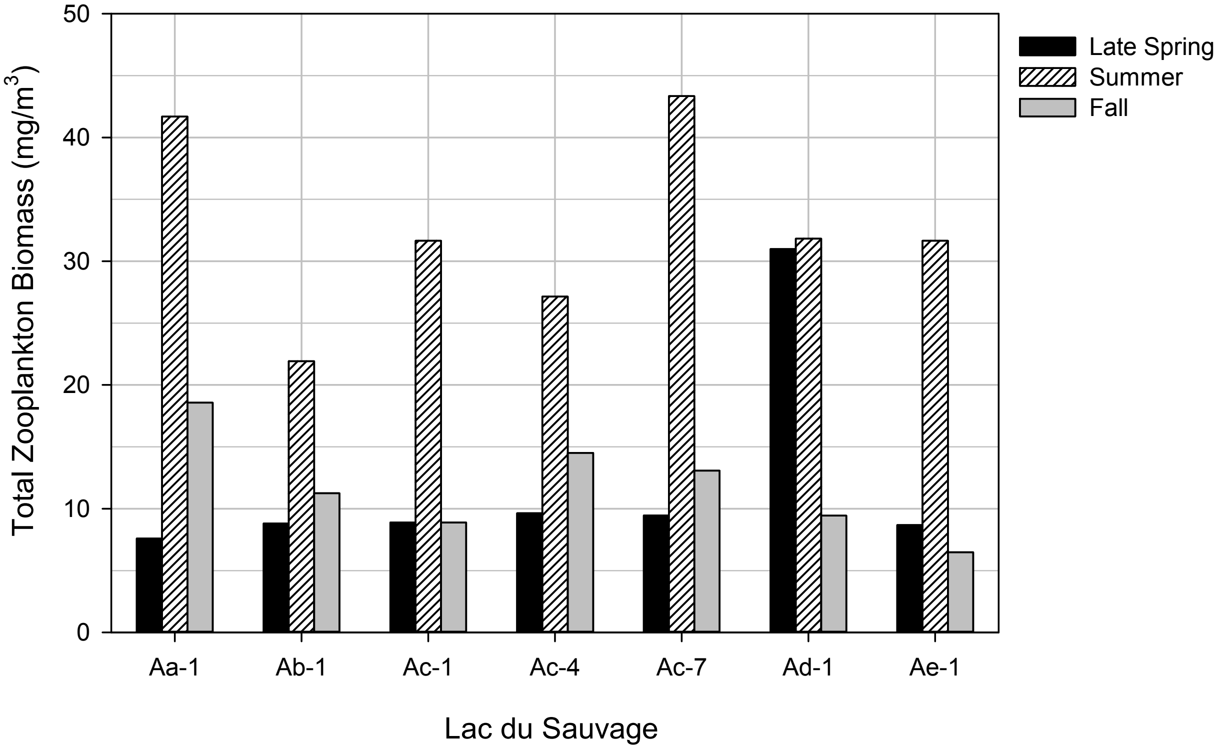
Seasonal and spatial variability were observed in total zooplankton abundance and biomass in Lac du Sauvage in 2013 (Figure 3.2-6 and Figure 3.2-7). Seasonal peaks in total zooplankton abundance were observed in the summer at all stations, with values ranging from 55,571 to 97,353 org/m^3. Late spring total zooplankton abundances were similar among stations (36,990 to 45,590 org/m^3), with the exception of Station Ad-1 (95,967 org/m^3) where zooplankton abundance was similar in late spring and summer. Total zooplankton abundances were lowest during the fall at all Lac du Sauvage stations and ranged from 14,592 to 36,516 org/m^3.

Figure 3.2-6 Total Zooplankton Abundance in Lac du Sauvage in Late Spring, Summer, and Fall, 2013



org/m^3 = organisms per cubic metre.

Figure 3.2-7 Total Zooplankton Biomass in Lac du Sauvage in Late Spring, Summer, and Fall, 2013



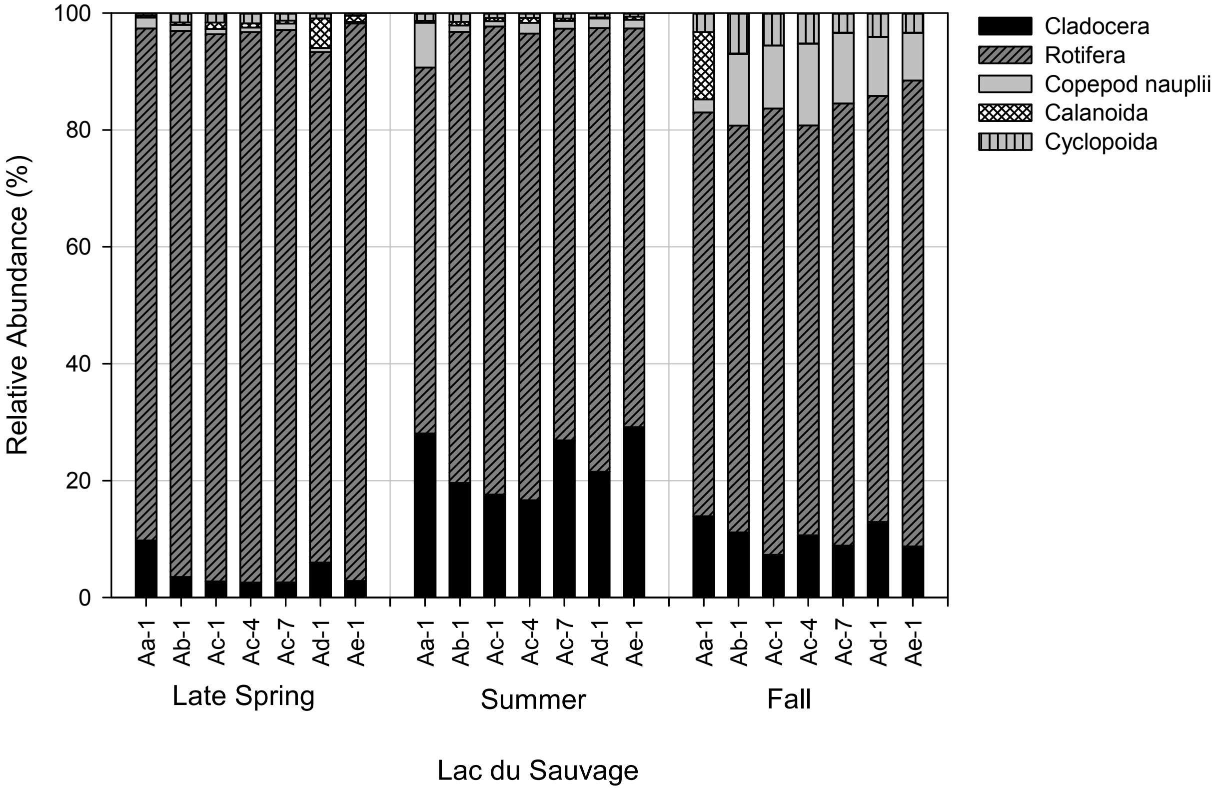
mg/m^3 = milligrams per cubic metre.

Seasonal peaks in total zooplankton biomass were observed in the summer at all stations in Lac du Sauvage (Figure 3.2-7). Spatial variability among stations in total zooplankton biomass was greatest in the summer, with little variability observed in the late spring or fall. With the exception of Station Ac-7 (31 mg/m^3) in late spring, total zooplankton abundance at the majority of the stations in Lac du Sauvage in late spring and fall fell within a range of 6 to 19 mg/m^3. In the summer, higher total zooplankton abundance was observed at stations Aa-1 (42 mg/m^3) and Ac-7 (43 mg/m^3) compared to the remainder of the Lac du Sauvage stations (22 to 32 mg/m^3).

Community Composition

Zooplankton community composition by abundance in Lac du Sauvage was similar among stations, but varied with sampling period (Figure 3.2-8). Rotifers dominated the zooplankton biomass in Lac du Sauvage during all three sampling periods. During late spring, rotifers represented 87% to 95% of the total abundance in Lac du Sauvage. The percentage of rotifers decreased in summer (63% to 80%) and fall (69% to 80%) compared to the late spring. Cladocerans represented a relatively small percentage of the total abundance (2% to 14%) in the late spring and fall. Cladoceran abundance was higher in the summer, ranging from 17% to 29%. Copepod nauplii abundance was low in the late spring and summer (less than 8%), but increased in the fall and represented up to 14% of the zooplankton community abundance. Calanoid copepods were present in low abundances in Lac du Sauvage throughout the open-water sampling period (less than 1%), with the exception of stations Ad-1 in the late spring and Aa-1 in the fall (5% and 11%, respectively).

Figure 3.2-8 Relative Zooplankton Abundance in Lac du Sauvage in Late Spring, Summer, and Fall, 2013



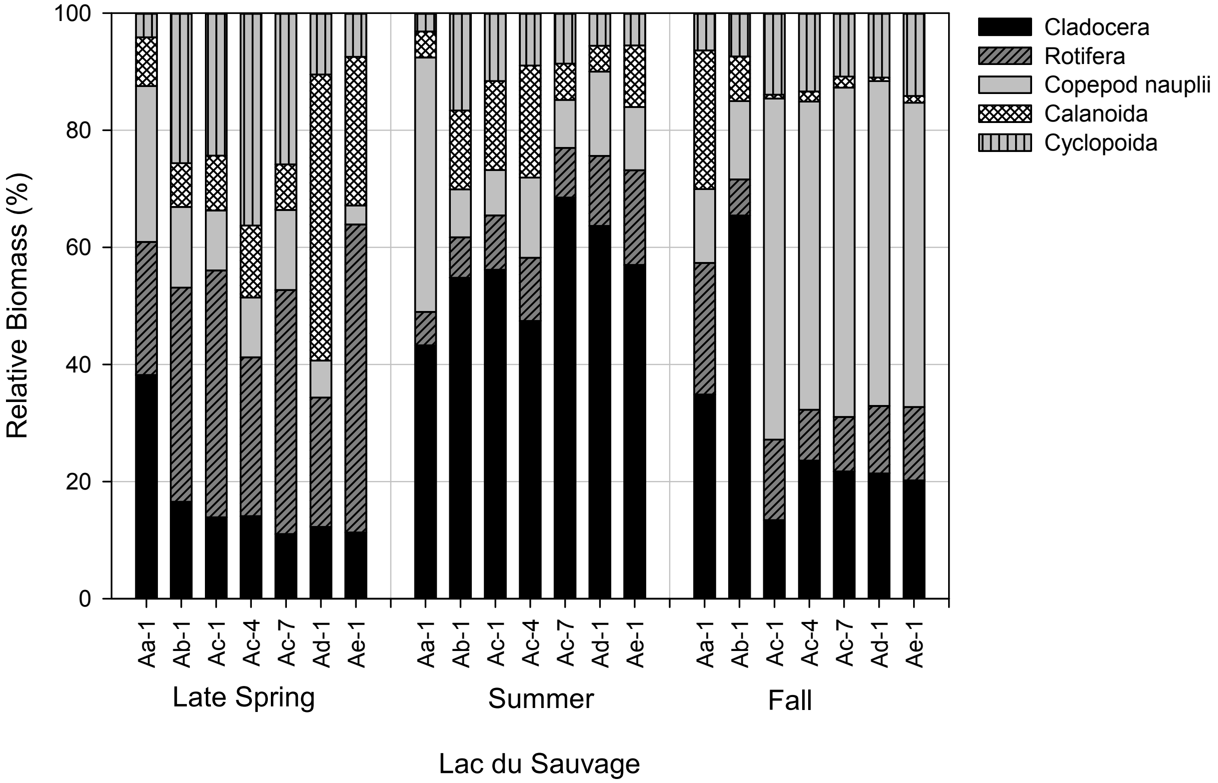
% = percent.

Zooplankton community composition by biomass in Lac du Sauvage varied among stations and throughout the open-water sampling period (Figure 3.2-9). Rotifers accounted for a large amount of late spring biomass at the majority of stations (20% to 53%). At Station Aa-1, the zooplankton community by abundance was a mixture of cladocerans (38%), copepod nauplii (27%), and rotifers (23%). Cyclopoid copepods (36%) and rotifers (27%) co-dominated the zooplankton biomass at Station Ac-4 in the late spring. Calanoid copepods and rotifers dominated at stations Ad-1 and Ae-1; the community at Station Ad-1 consisted of 49% calanoid copepods and 22% rotifers, while the Station Ae-1 community consisted of 25% calanoid copepods and 53% rotifers.

Cladocerans were the dominant taxonomic group in Lac du Sauvage in the summer, representing 43% to 69% of the total biomass (Figure 3.2-9). With the exception of Station Aa-1, summer zooplankton biomass in Lac du Sauvage consisted of calanoid copepods (4% to 19%), cyclopoid copepods (6% to 17%), rotifers (7% to 16%), and copepod nauplii (8% to 14%). Copepod nauplii represented a relatively larger percentage of the summer zooplankton biomass at Station Aa-1 (43%), compared to other stations (8% to 14%) in Lac du Sauvage.

In the fall, copepod nauplii (52% to 58%) dominated the zooplankton composition by biomass at all stations except Aa-1 (13%) and Ab-1 in Lac du Sauvage (13%; Figure 3.2-9). The zooplankton biomass at Station Aa-1 was mixed between cladocerans (35%), calanoid copepods (24%), and rotifers (23%), while cladocerans accounted for 65% of the zooplankton biomass at Station Ab-1. Zooplankton biomass at the remaining stations in Lac du Sauvage consisted of cladocerans (13% to 24%), cyclopoid copepods (11% to 14%), and rotifers (9% to 14%). Compared to the other sampling periods, calanoid copepods represented a relatively small percentage of the total biomass at these stations in the fall (less than 2%).

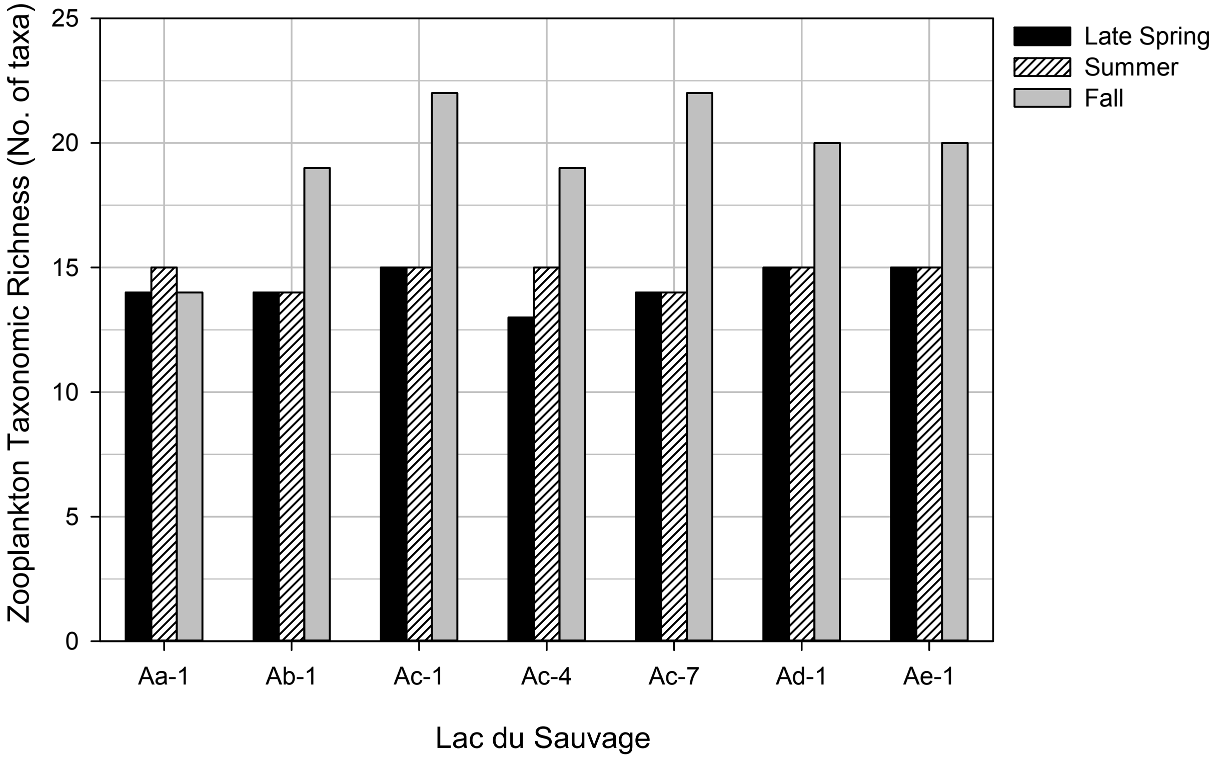
Figure 3.2-9 Relative Zooplankton Biomass in Lac du Sauvage in Late Spring, Summer, and Fall, 2013



% = percent.

In total, 25 zooplankton taxa were identified in Lac du Sauvage in 2013: 15 rotifers, 6 cladocerans, 3 calanoid copepods, and 1 cyclopoid copepod (Appendix B, Table B-9). In 2013, seasonal variability in zooplankton taxonomic richness was observed to increase from late spring and summer to fall (Figure 3.2-10). Within a given sampling period, zooplankton taxonomic richness was relatively similar among stations. Taxonomic richness increased throughout the open-water sampling period in Lac du Sauvage, ranging between 13 and 15 taxa in the late spring and summer, to between 14 and 22 taxa in the fall.

Figure 3.2-10 Total Zooplankton Taxonomic Richness in Lac du Sauvage in Late Spring, Summer, and Fall, 2013



No. = number.

The dominant taxa, accounting for greater than 20% of total zooplankton biomass in Lac du Sauvage, differed among sampling periods (Table 3.2-2). In late spring, one cyclopoid copepod, *Diacyclops thomasi*, and one species of rotifer, *Asplanchna priodonta*, accounted for 22% and 21% of the total zooplankton biomass in Lac du Sauvage, respectively. In the summer, two cladoceran taxa, *Bosmina longirostris* and *Holopedium gibberum*, accounted for 30% and 24% of the total zooplankton biomass, respectively. In the fall, *Daphnia longiremis* was the most dominant zooplankton taxon, accounting for 34% of the total zooplankton biomass. *B. longirostris* was the second most dominant taxon, accounting for 21% of total zooplankton biomass in the fall.

Table 3.2-2 Dominant Zooplankton Taxa in Lac du Sauvage in Late Spring, Summer, and Fall, 2013

Sampling Period	Major Taxonomic Group	Taxa	Biomass (mg/m^3)	Dominance (%)
Late Spring	Cyclopoida	*Diacyclops thomasi*	11.81	22
	Rotifera	*Asplanchna priodonta*	11.28	21
Summer	Cladocera	*Bosmina longirostris*	55.67	30
	Cladocera	*Holopedium gibberum*	45.57	24
Fall	Cladocera	*Daphnia longiremis*	14.10	34
	Cladocera	*Bosmina longirostris*	8.72	21

mg/m^3 = milligrams per cubic metre;% = percent.

3.2.2.2 Duchess Lake

3.2.2.2.1 Trophic Status Classification

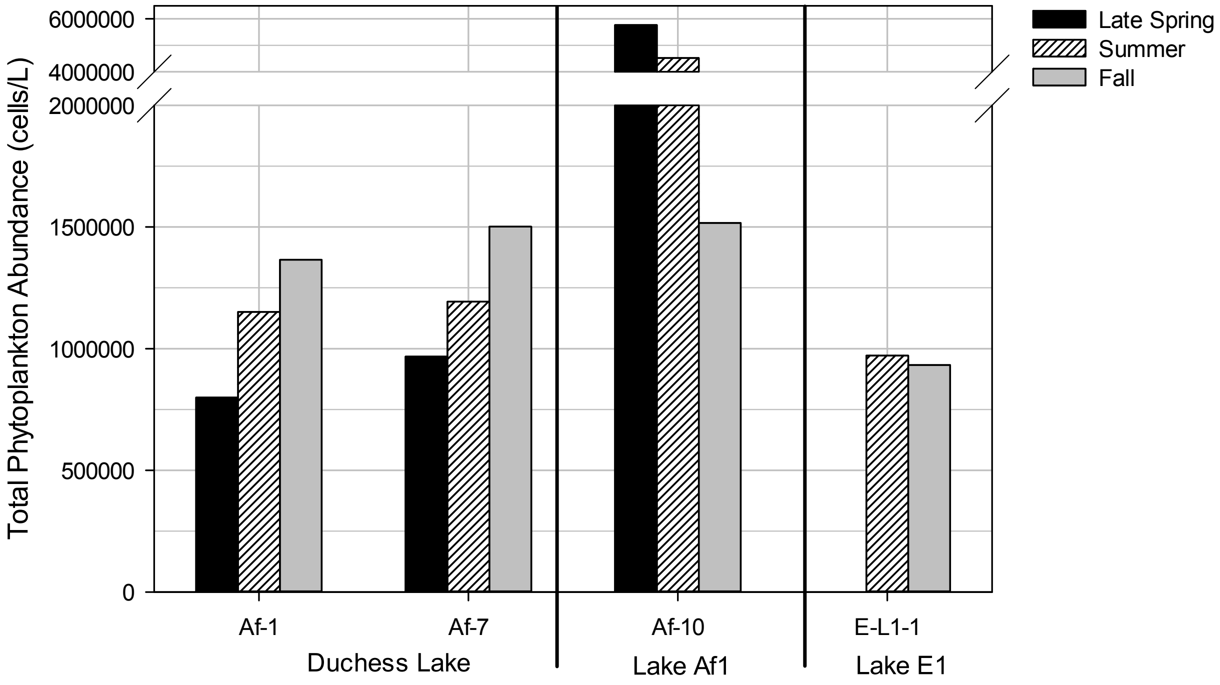
The discrete water sampling program yielded mean annual concentrations of 0.0091 mg/L for TP and 4.2 m for Secchi depth in Duchess Lake. The corresponding TSI values were 36 using TP and 39 using Secchi depth, for a rounded average of 38. The depth-integrated sampling program yielded mean annual concentrations of 0.027 mg/L for TP, 4.1 m for Secchi depth, and 3.7 µg/L for chlorophyll *a*. The corresponding TSI values were 52 using chlorophyll *a*, 40 using TP, and 44 using Secchi depth, for a rounded average of 45. Based on the concentrations of nutrients and chlorophyll *a*, Duchess Lake would be classified as an oligotrophic to mesotrophic system using the Vollenweider (1970) criteria, and as a mesotrophic system according to CCME (2004). Based on the TSI values, Duchess Lake would be classified as a mesotrophic system according to Carlson (1977).

3.2.2.2.2 Phytoplankton

Abundance and Biomass

Total phytoplankton abundance in Duchess Lake varied seasonally, but was similar between the two stations sampled in Duchess Lake, Af-1 and Af-7 (Figure 3.2-11). The lowest total phytoplankton abundance occurred in late spring (799,701 cells/L [Station Af-1] and 967,023 cells/L [Station Af-7]). Total phytoplankton abundance increased at both stations through the summer (1,151,180 cells/L [Station Af-1] and 1,193,123 cells/L [Station Af-7]), with peak abundance occurring in the fall (1,364,980 cells/L [Station Af-1] and 1,501,246 cells/L [Station Af-7]).

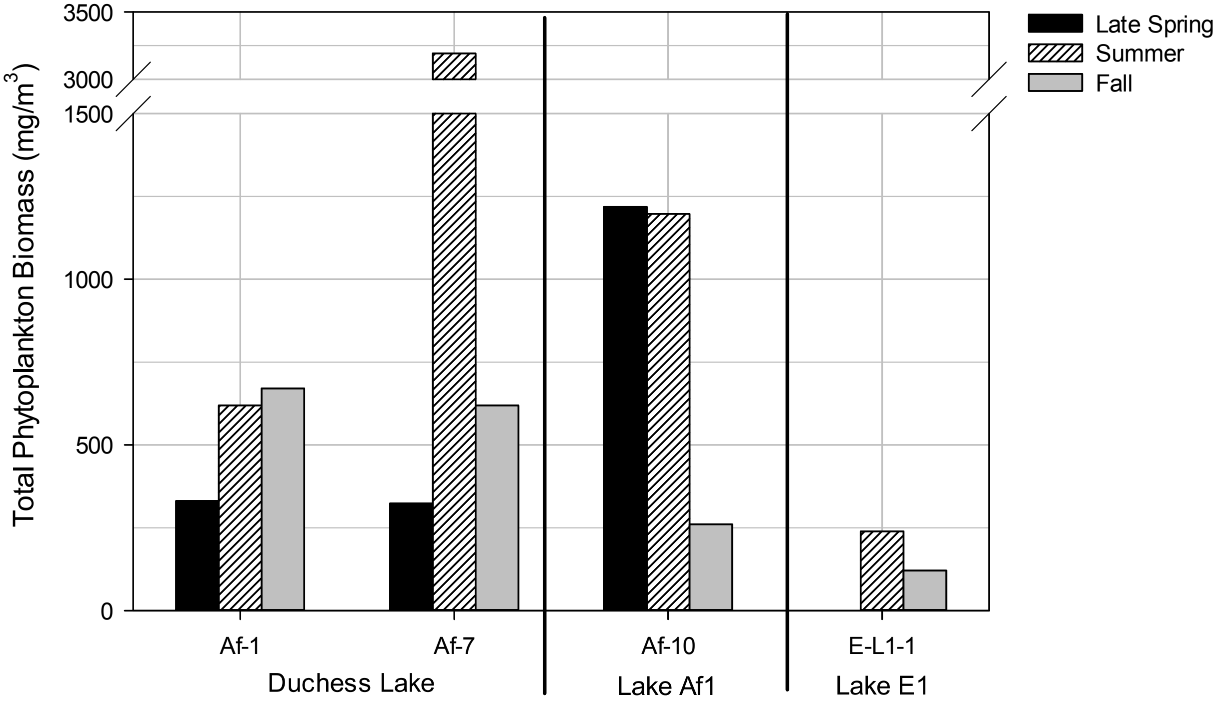
Figure 3.2-11 Total Phytoplankton Abundance in Duchess Lake, Lake Af1, and Lake E1 in Late Spring, Summer, and Fall, 2013



Note: Late spring samples were not collected in Lake E1.
cells/L = cells per litre.

Total phytoplankton biomass in Duchess Lake was similar among sampling periods and between stations, with the exception of Station Af-7 in summer, when total biomass increased to 3,193 mg/m^3 (Figure 3.2-12). The relatively high biomass observed at Station Af-7 in summer was largely driven by the large dominant chlorophyte, *Micrasterias fimbriata*. At stations Af-1 and Af-7, the lowest total biomass was observed in the late spring (331 and 324 mg/m^3, respectively). Compared to Station Af-7, Station Af-1 showed only a minor increase in total phytoplankton biomass throughout the open-water sampling period, ranging from 331 mg/m^3 in late spring to 671 mg/m^3 in the fall.

Figure 3.2-12 Total Phytoplankton Biomass in Duchess Lake, Lake Af1, and Lake E1 in Late Spring, Summer, and Fall, 2013

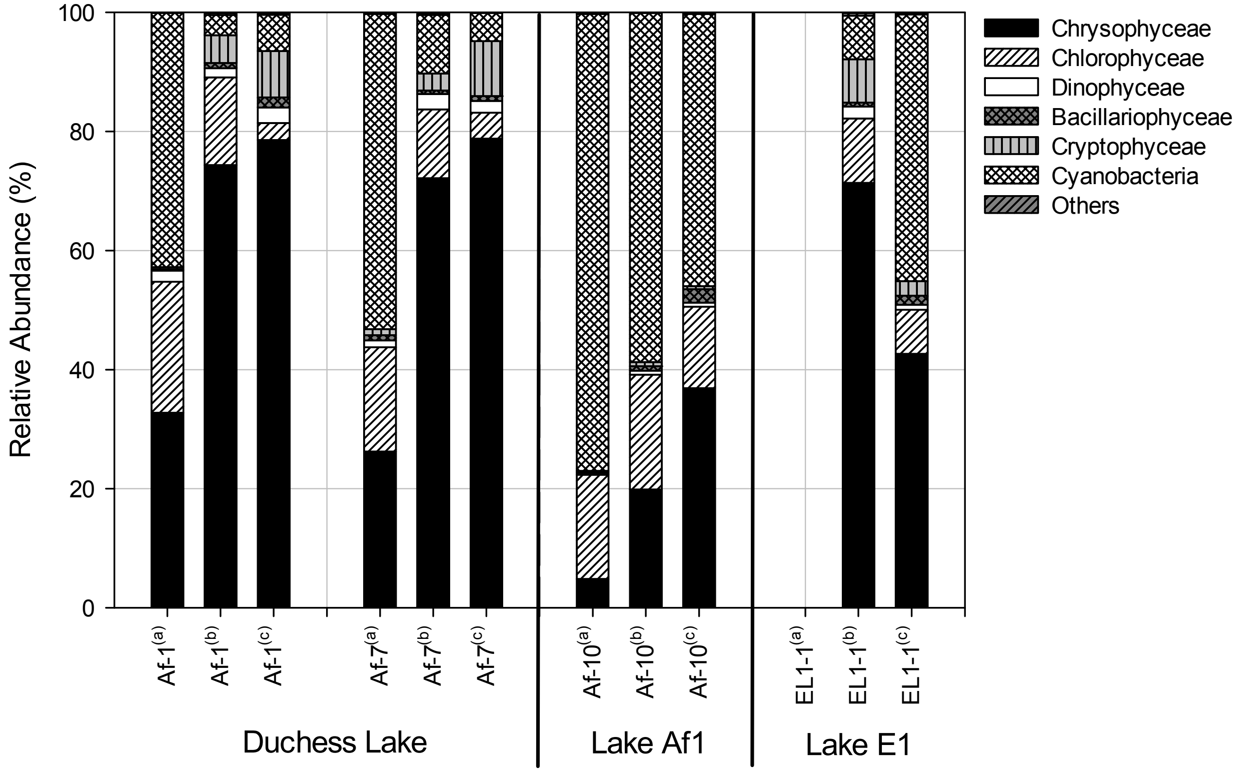


Note: Late spring samples were not collected in Lake E1.
mg/m^3 = milligrams per cubic metre.

Community Composition

In terms of abundance, cyanobacteria, chrysophytes, and chlorophytes dominated the phytoplankton community at both stations in Duchess Lake, but the percentages varied between stations and among sampling periods (Figure 3.2-13). In the late spring, phytoplankton biomass in Duchess Lake consisted of a mixture of cyanobacteria (43% to 53%), chrysophytes (33% and 26%), and chlorophytes (22% and 17%). Phytoplankton abundance in Duchess Lake was dominated primarily by chrysophytes in the summer (72% to 74%) and fall (79% at both stations).

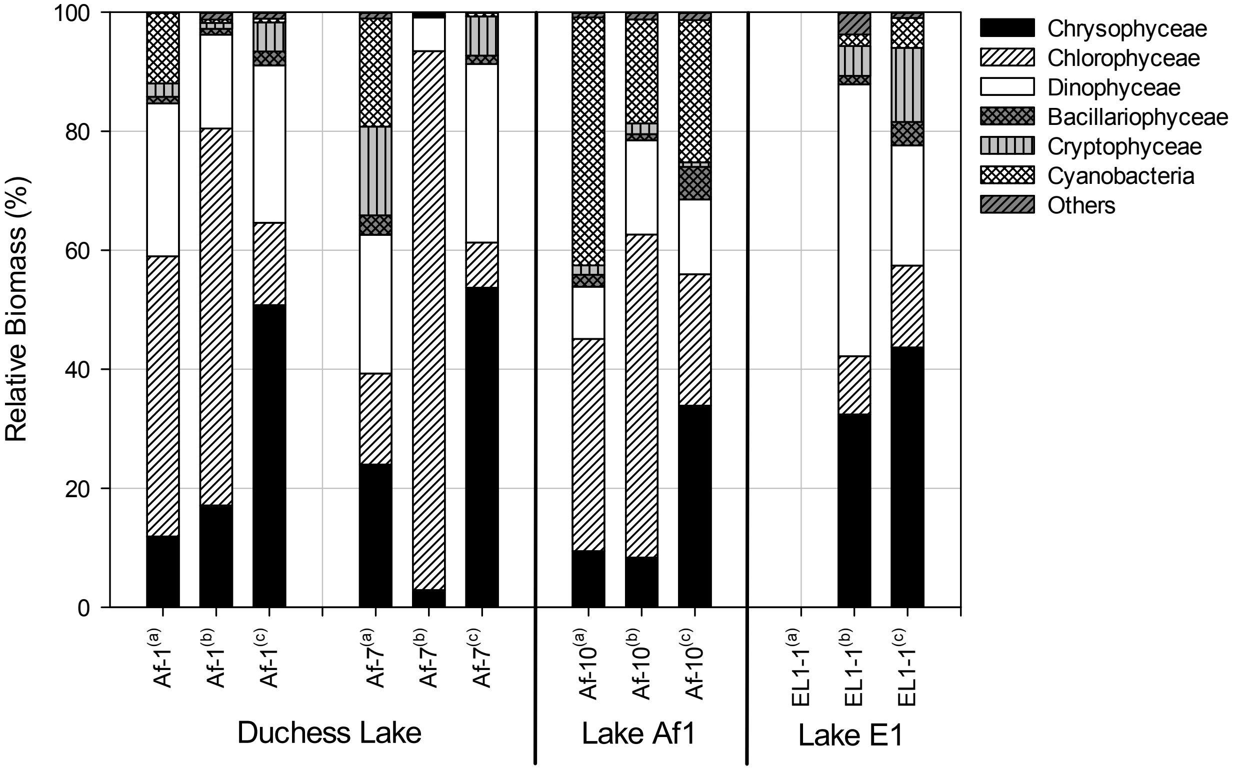
Figure 3.2-13 Relative Phytoplankton Abundance in Duchess Lake, Lake Af1, and Lake E1 in Late Spring, Summer, and Fall, 2013



Note: Late spring samples were not collected in Lake E1.
a) late spring sampling event.
b) summer sampling event.
c) fall sampling event.
% = percent.

In late spring, the biomass at the two Duchess Lake stations was split between chlorophytes (15% and 47%), dinoflagellates (23% and 26%), chrysophytes (12% and 24%), and cyanobacteria (12% and 18%); cryptophytes accounted for 15% at Station Af-7, but only 2% at Station Af-1 (Figure 3.2-14). Chlorophytes dominated the biomass at stations Af-1 (63%) and Af-7 (91%) in the summer. Dinoflagellates and chrysophytes were also present in Duchess Lake in the summer, but were present in higher percentages at Station Af-1 (16% and 17%, respectively) than at Station Af-7 (6% and 3%, respectively). In the fall, the phytoplankton assemblage by biomass shifted in Duchess Lake such that stations Af-1 and Af-7 were dominated by chrysophytes (51% and 54%, respectively), and to a lesser extent, dinoflagellates (26% and 30%, respectively) and chlorophytes (14% and 8%, respectively).

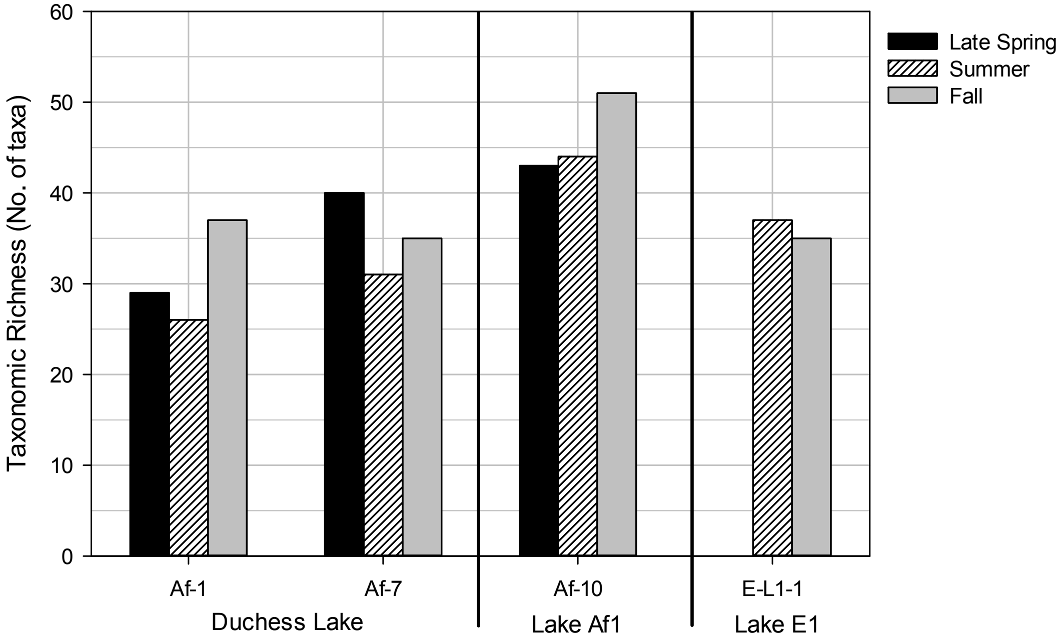
Figure 3.2-14 Relative Phytoplankton Biomass in Duchess Lake, Lake Af1, and Lake E1 in Late Spring, Summer, and Fall, 2013



Note: Late spring samples were not collected in Lake E1
a) late spring sampling event.
b) summer sampling event.
c) fall sampling event.
% = percent.

In total, 63 phytoplankton taxa were identified in Duchess Lake in 2013: 30 chlorophytes, 9 diatoms, 9 cyanobacteria, 4 chrysophytes, 2 dinoflagellates, 3 cryptophytes, 3 euglenoids, and 3 xanthophytes (Appendix B, Table B-4). Phytoplankton taxonomic richness was similar at stations Af-1 and Af-7 in Duchess Lake; however, seasonal trends varied (Figure 3.2-15). At Station Af-1, phytoplankton richness was similar between late spring and summer (29 and 26 taxa, respectively), and then increased in the fall (37 taxa). At Station Af-7, phytoplankton richness was highest in late spring (40 taxa) compared with summer (31 taxa) and fall (35 taxa).

Figure 3.2-15 Total Phytoplankton Taxonomic Richness in Duchess Lake, Lake Af1, and Lake E1 in Late Spring, Summer, and Fall, 2013



Note: Late spring samples were not collected in Lake E1.
No. = number.

The dominant taxa, accounting for greater than 10% of total phytoplankton biomass in Duchess Lake, differed among the sampling periods (Table 3.2-3). In late spring, a chlorophyte, *Crucigenia tetrapedia*, a dinoflagellate, *Peridinium* sp., and a cyanobacterium, *Anabaena* sp., accounted for 16%, 13%, and 12% of the total phytoplankton biomass in Duchess Lake, respectively. In the summer, a chlorophyte taxon, *Micrasterias fimbriata* dominated the assemblage, accounting for 81% of the total phytoplankton biomass. In the fall, dominance was evenly distributed among three chrysophyte taxa: *Ochromonas* sp. (16%); *Dinobryon bavarium* (13%)*;* and *Dinobryon divergens* (13%).

Table 3.2-3 Dominant Phytoplankton Taxa in Duchess Lake in Late Spring, Summer, and Fall, 2013

Sampling Period	Major Taxonomic Group	Taxa	Biomass (mg/m^3)	Dominance (%)
Late Spring	Chlorophyceae	*Crucigenia tetrapedia*	58	16
	Dinophyceae	*Peridinium* sp.	46	13
	Cyanobacteria	*Anabaena* sp.	42	12
Summer	Chlorophyceae	*Micrasterias fimbriata*	2,851	81
Fall	Chrysophyceae	*Ochromonas* sp.	110	16
	Chrysophyceae	*Dinobryon bavarium*	94	13
	Chrysophyceae	*Dinobryon divergens*	89	13

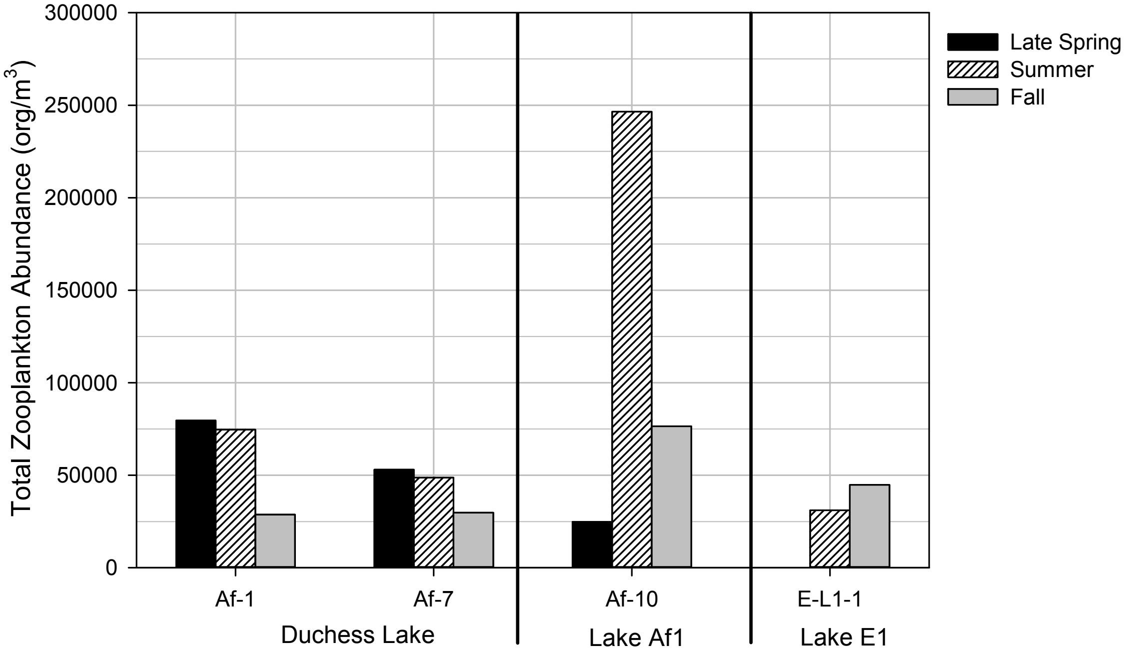
mg/m^3 = milligrams per cubic metre;% = percent; sp. =species.

3.2.2.2.3 *Zooplankton*

Abundance and Biomass

Total zooplankton abundance was similar in late spring and summer and higher compared to the fall at both stations in Duchess Lake (Figure 3.2-16). The highest total zooplankton abundances were observed at Station Af-1 in the late spring (79,549 org/m^3) and summer (74,676 org/m^3). Total zooplankton abundances at Station Af-1 in the fall and at Station Af-7 during all three sampling periods were similar and ranged from 28,768 to 53,101 org/m^3.

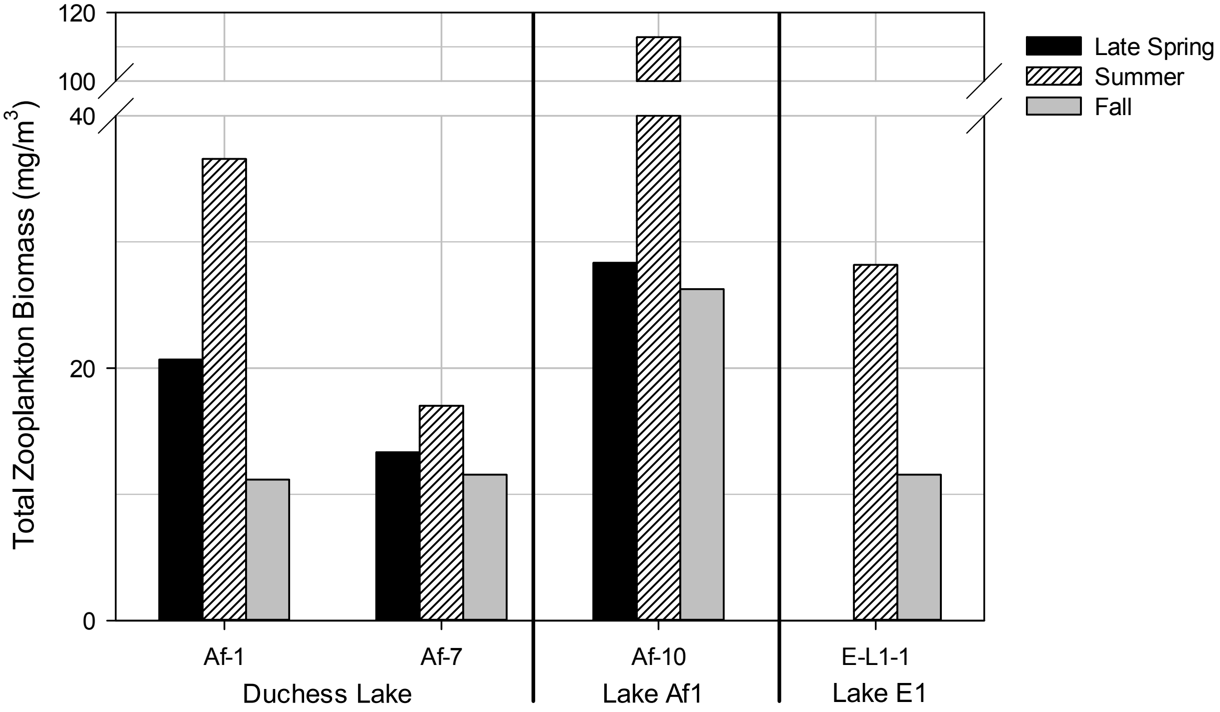
Figure 3.2-16 Total Zooplankton Abundance in Duchess Lake, Lake Af1, and Lake E1 in Late Spring, Summer, and Fall, 2013



Note: Late spring samples were not collected in Lake E1.
org/m^3 = organisms per cubic metre.

Total zooplankton biomass peaked in the summer at both stations in Duchess Lake (Figure 3.2-17). Seasonal variability was observed in total zooplankton biomass at Station Af-1 in Duchess Lake; however, little seasonal variability was observed at Station Af-7 in 2013 (Figure 3.2-17). The highest total zooplankton biomass was observed at Station Af-1 in the summer (37 mg/m^3). Zooplankton biomass at Station Af-1 in the late spring and fall, and at Station Af-7 in all three sampling periods, was similar and ranged from 11 to 21 mg/m^3.

Figure 3.2-17 Total Zooplankton Biomass in Duchess Lake, Lake Af1, and Lake E1 in Late Spring, Summer, and Fall, 2013

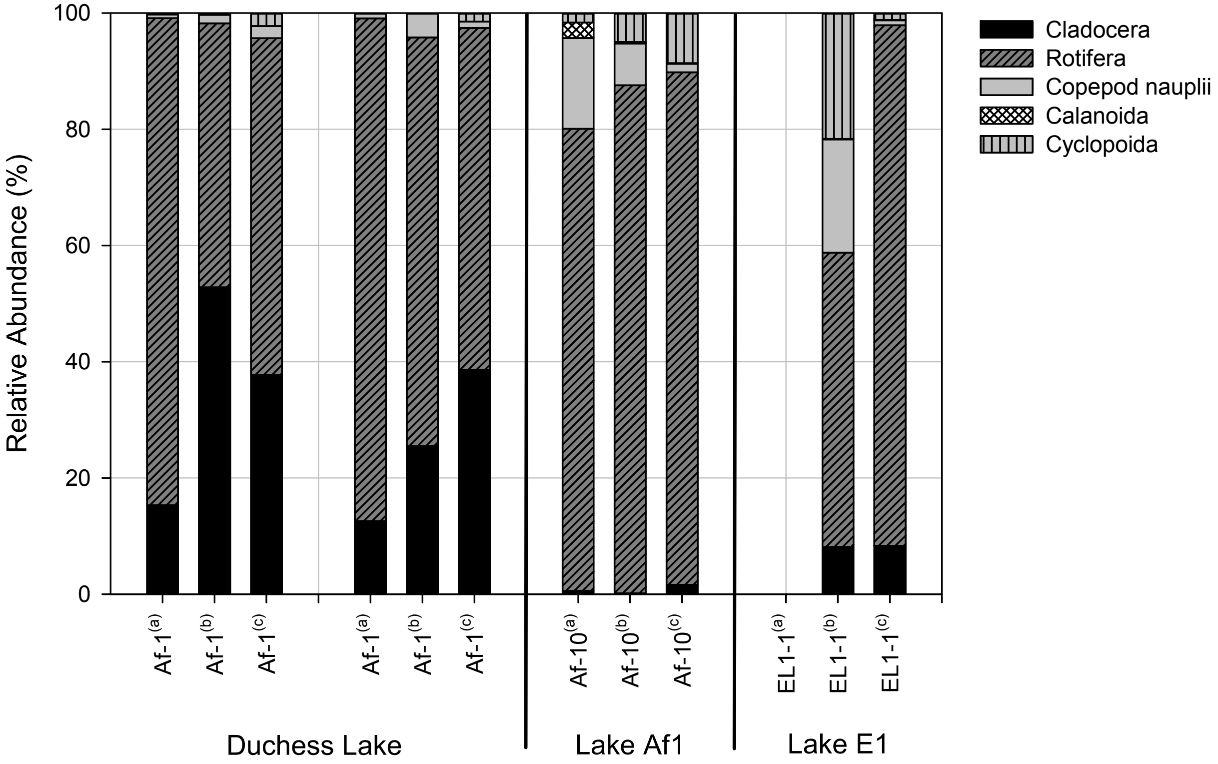


Note: Late spring samples were not collected in Lake E1.
mg/m^3 = milligrams per cubic metre.

Community Composition

Zooplankton community composition by abundance was relatively similar between stations in Duchess Lake in 2013 (Figure 3.2-18). Rotifers and cladocerans dominated throughout the open-water sampling period. Station Af-1 was dominated by rotifers in the late spring (84%), and co-dominated by rotifers and cladocerans in the summer (45% and 53%, respectively) and fall (58% and 38%, respectively). In contrast, Station Af-7 was dominated by rotifers in late spring and summer (87% and 70%, respectively), and co-dominated by rotifers and cladocerans (59% and 39%, respectively) in the fall. Copepod nauplii and cyclopoid copepods represented less than 4%, and calanoid copepods represented less than 1% of the total abundance in Duchess Lake during the open-water sampling period.

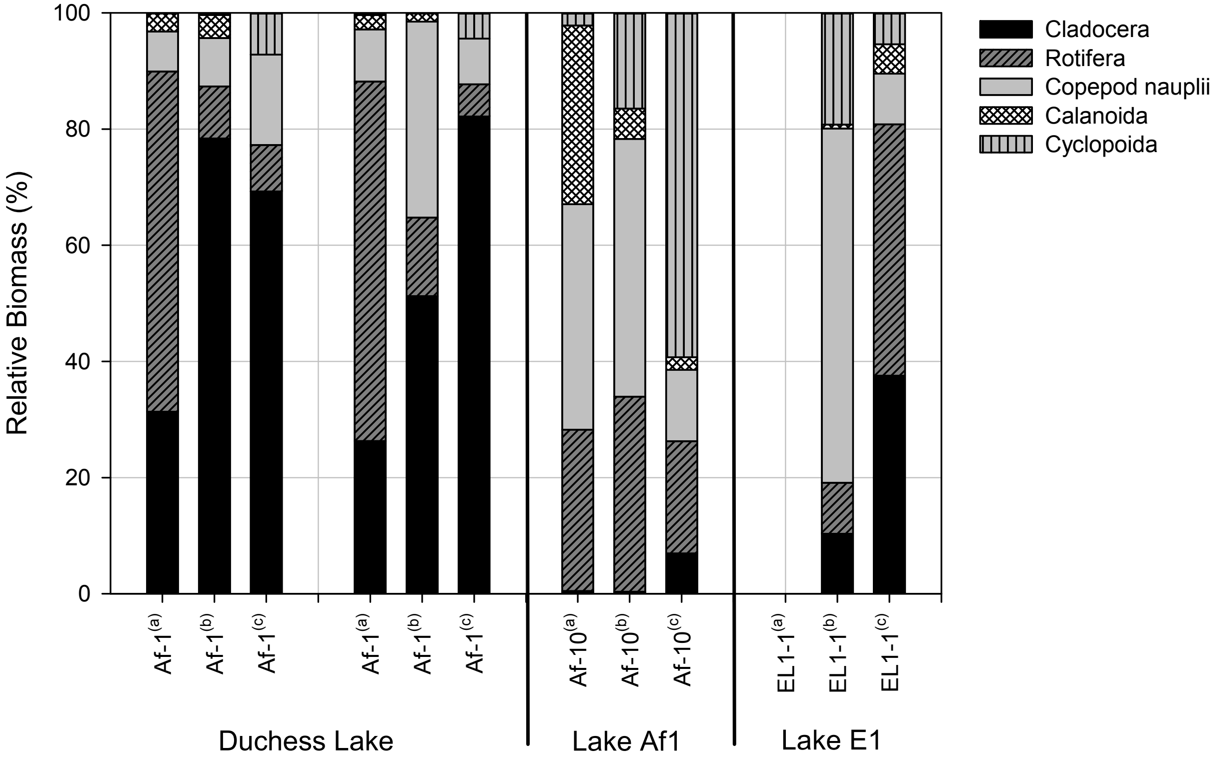
Figure 3.2-18 Relative Zooplankton Abundance in Duchess Lake, Lake Af1, and Lake E1 in Late Spring, Summer, and Fall, 2013



Note: Late spring samples were not collected in Lake E1.
a) late spring sampling event.
b) summer sampling event.
c) fall sampling event.
% = percent.

Rotifers accounted for approximately 60% of the zooplankton composition by biomass in Duchess Lake in late spring, but made up less than 14% of the total biomass in the summer and fall (Figure 3.2-19). Cladocerans dominated the zooplankton biomass in Duchess Lake in the summer (78% at Station Af-1 and 51% at Station Af-7) and fall (69% at Station Af-1 and 82% at Station Af-7). Copepod nauplii contributed between 7% and 34% of the total zooplankton biomass in Duchess Lake in 2013, while, cyclopoid and calanoid copepods accounted for less than 7% of the total biomass in Duchess Lake throughout the open-water sampling period.

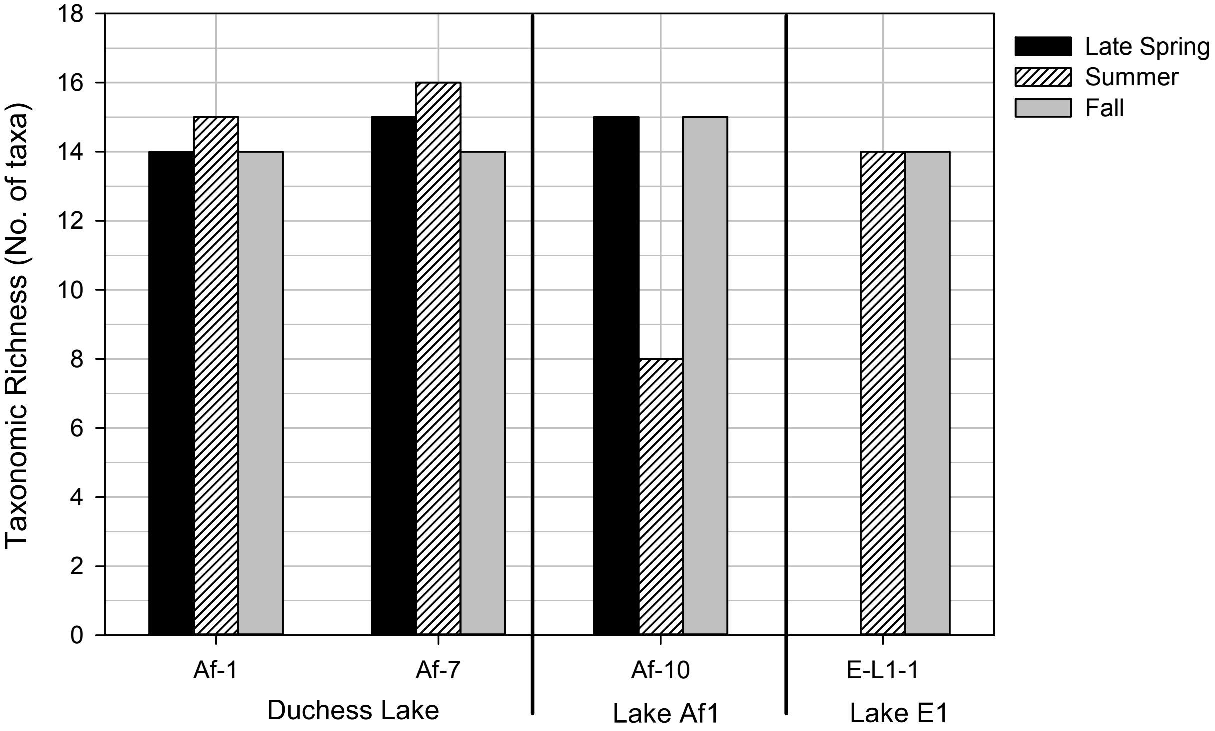
Figure 3.2-19 Relative Zooplankton Biomass in Duchess Lake, Lake Af1, and Lake E1 in Late Spring, Summer, and Fall, 2013



Note: Late spring samples were not collected in Lake E1.
a) late spring sampling event.
b) summer sampling event.
c) fall sampling event.
% = percent.

In total, 21 zooplankton taxa were identified in Duchess Lake in 2013: 14 rotifers, 4 cladocerans, 1 calanoid copepod, and 2 cyclopoid copepods (Appendix B, Table B-10). Zooplankton taxonomic richness was similar at the two stations and during all three sampling periods in Duchess Lake, and ranged from 14 to 16 taxa in 2013 (Figure 3.2-20).

Figure 3.2-20 Total Zooplankton Taxonomic Richness in Duchess Lake, Lake Af1, and Lake E1 in Late Spring, Summer, and Fall, 2013



Note: Late spring samples were not collected in Lake E1.
No. = number.

The dominant taxon, accounting for greater than 20% of total zooplankton biomass in Duchess Lake, in all three sampling periods, was the cladoceran, *Bosmina longirostris* (25% to 61%; Table 3.2-4). In late spring, one species of rotifer, *Conochilus unicornis*, also accounted for 32% of the total zooplankton biomass in Duchess Lake. In the fall, the cladoceran, *Daphnia longiremis*, also accounted for 42% of the total zooplankton biomass.

Table 3.2-4 Dominant Zooplankton Taxa in Duchess Lake in Late Spring, Summer, and Fall, 2013

Sampling Period	Major Taxonomic Group	Taxa	Biomass (mg/m^3)	Dominance (%)
Late Spring	Rotifera	*Conochilus unicornis*	5.01	32
	Cladocera	*Bosmina longirostris*	3.87	25
Summer	Cladocera	*Bosmina longirostris*	27.20	61
Fall	Cladocera	*Bosmina longirostris*	8.22	43
	Cladocera	*Daphnia longiremis*	8.02	42

mg/m^3 = milligrams per cubic metre;% = percent.

3.2.2.3 Lake Af1

3.2.2.3.1 Trophic Status Classification

The discrete water sampling program yielded mean annual concentrations of 0.020 mg/L for TP, and 2.1 m for Secchi depth in Lake Af1. The corresponding TSI values were 47 using TP and 49 using Secchi depth, for a rounded average of 48. The depth-integrated sampling program yielded concentrations of 0.021 mg/L for TP, 1.8 m for Secchi depth, and a mean annual concentration of 11 µg/L for chlorophyll *a*. The corresponding TSI values were 52 using chlorophyll *a*, 48 using TP, and 54 using Secchi depth, for a rounded average of 51. Based on the concentrations of nutrients and chlorophyll *a*, Lake Af1 would be classified as a mesotrophic to eutrophic system according to Vollenweider (1970), and as a mesotrophic system according to CCME (2004). Based on the TSI values, Lake Af1 would be classified as a mesotrophic system according to Carlson (1977).

3.2.2.3.2 Phytoplankton

Abundance and Biomass

Total phytoplankton abundance at the single station in Lake Af1 (Af-10) was highest in the late spring (5,767,686 cells/L) and decreased through the summer (4,514,544 cells/L) and into the fall (1,516,269 cells/L; Figure 3.2-11). Total phytoplankton biomass in Lake Af1 was relatively similar in late spring (1,219 mg/m^3) and summer (1,197 mg/m^3), but decreased to 260 mg/m^3 in the fall (Figure 3.2-12). The relatively high total abundance and total biomass values observed at Station Af-10 in late spring and summer were largely driven by the dominant colonial cyanobacterium, *Anabaena* sp.

Community Composition

The same three taxonomic groups (i.e., cyanobacteria, chrysophytes, and chlorophytes) dominated phytoplankton abundance at Station Af-10 in Lake Af1 throughout the open-water sampling period, but the percentages varied with sampling period (Figure 3.2-13). In late spring, the phytoplankton abundance was dominated by cyanobacteria (77%). Cyanobacteria remained the dominant taxa in summer (59%), but the relative abundance of chrysophytes and chlorophytes increased to 20% and 19%, respectively. The fall phytoplankton community was co-dominated by cyanobacteria (46%) and chrysophytes (37%).

Cyanobacteria (42%) and chlorophytes (36%) made up the majority of the community by biomass in Lake Af1 in late spring; the same two taxonomic groups dominated the assemblage in Lake Af1 in summer (17% and 54%, respectively; Figure 3.2-14). In the fall, the phytoplankton community composition in Lake Af1 shifted to one dominated by chrysophytes (34%), cyanobacteria (24%), and chlorophytes (22%), with smaller percentages of dinoflagellates (13%).

In total, 67 phytoplankton taxa were identified in Lake Af1 in 2013: 32 chlorophytes, 12 diatoms, 7 cyanobacteria, 6 chrysophytes, 3 dinoflagellates, 3 cryptophytes, 2 euglenoids, and 2 xanthophytes (Appendix B, Table B-5). Phytoplankton taxonomic richness increased throughout the open-water sampling period at the single station in Lake Af1, ranging from 43 taxa in late spring to 51 taxa in the fall (Figure 3.2-15).

The dominant taxa, accounting for greater than 10% of total phytoplankton biomass in Lake Af1, differed among the sampling periods; however, a cyanobacterium, *Anabaena* sp. was present during all three sampling periods (Table 3.2-5). In late spring, *Anabaena* sp. was the dominant taxon accounting for 29% of total phytoplankton biomass. Two chlorophytes, *Staurodesmus triangularis* and *Staurodesmus* sp., were sub-dominant, accounting for 12% and 11% of total biomass, respectively. In the summer, a chlorophyte, *Crucigeniella rectangularis*, dominated the assemblage, accounting for 25% of total phytoplankton biomass. Three taxa, *Anabaena* sp. (16%), a chlorophyte *Closterium kuetzingii* (13%), and a dinoflagellate, *Gymnodinium* sp. (11%) were sub-dominant in the summer. In the fall, a chrysophyte, *Ochromona*s sp. dominated the assemblage, accounting for 26% of total phytoplankton biomass; three taxa were sub-dominant: *Anabaena* sp. (19%), *Staurodesmus triangularis* (11%), and *Gymnodinium* sp. (11%).

Table 3.2-5 Dominant Phytoplankton Taxa in Lake Af1 in Late Spring, Summer, and Fall, 2013

Sampling Period	Major Taxonomic Group	Taxa	Biomass (mg/m^3)	Dominance (%)
Late Spring	Cyanobacteria	*Anabaena* sp.	352	29
	Chlorophyceae	*Staurodesmus triangularis*	148	12
	Chlorophyceae	*Staurodesmus* sp.	135	11
Summer	Chlorophyceae	*Crucigeniella rectangularis*	302	25
	Cyanobacteria	*Anabaena* sp.	186	16
	Chlorophyceae	*Closterium kuetzingii*	160	13
	Dinophyceae	*Gymnodinium* sp.	133	11
Fall	Chrysophyceae	*Ochromonas* sp.	69	26
	Cyanobacteria	*Anabaena* sp.	49	19
	Chlorophyceae	*Staurodesmus triangularis*	28	11
	Dinophyceae	*Gymnodinium* sp.	28	11

mg/m^3 = milligrams per cubic metre;% = percent; sp. = species.

3.2.2.3.3 Zooplankton

Abundance and Biomass

Total zooplankton abundance at the single station in Lake Af1 was 10 times higher in the summer (246,508 org/m^3) compared to late spring (24,871 org/m^3) and fall (76,483 org/m^3; Figure 3.2-16). Similarly, total zooplankton biomass was four times higher in the summer (113 mg/m^3) compared to late spring and fall (28 and 26 mg/m^3, respectively) (Figure 3.2-17).

Community Composition

Rotifers consistently contributed the majority of the zooplankton community by abundance in Lake Af1 in 2013, with numbers ranging from 80% to 88% of total abundance (Figure 3.2-18). Copepod nauplii and cyclopoid copepods made up 10% to 18% of the total abundance, while calanoid copepods and cladocerans comprised less than 3% of the total abundance at Station Af-10.

Zooplankton community composition by biomass in Lake Af1 varied throughout the open-water sampling period (Figure 3.2-19). A mixture of copepod nauplii (39%), calanoid copepods (31%), and rotifers (28%) dominated the biomass at Station Af-10 in late spring. Copepod nauplii (44%) and rotifers (34%) made up the majority of the total biomass in summer, while cyclopoid copepods dominated the zooplankton biomass in fall, making up 59% of the total biomass. Rotifers (19%), copepod nauplii (12%), and cladocerans (7%) were present in Lake Af1 in the fall, but in lower proportions compared to late spring and summer. Rotifers represented 19% to 34% of the total biomass throughout the open-water sampling period.

In total, 20 zooplankton taxa were identified in Lake Af1 in 2013: 11 rotifers, 4 cladocerans, 3 calanoid copepods, and 2 cyclopoid copepods (Appendix B, Table B-11). Zooplankton taxonomic richness was 15 taxa in spring and fall, but decreased to eight taxa in the summer (Figure 3.2-20).

The dominant taxon, accounting for greater than 20% of total zooplankton biomass in Lake Af1 in all three sampling periods was a rotifer, *Conochilus unicornis* (Table 3.2-6). In late spring, *C. unicornis* accounted for 45% of the total zooplankton biomass; in summer, *C. unicornis* accounted for 76% of total zooplankton biomass, and in the fall, it accounted for 43% of total zooplankton biomass. Sub-dominance differed between the late spring and fall in Lake Af1. In the late spring, a calanoid copepod, *Leptodiaptomus minutus*, was the sub-dominant taxon (22%), while in the fall, a cladoceran, *Holopedium gibberum,* was sub-dominant (21%) in the zooplankton community.

Table 3.2-6 Dominant Zooplankton Taxa in Lake Af1 in Late Spring, Summer, and Fall, 2013

Sampling Period	Major Taxonomic Group	Taxa	Biomass (mg/m^3)	Dominance (%)
Late Spring	Rotifera	*Conochilus unicornis*	7.35	45
	Calanoida	*Leptodiaptomus minutus*	3.60	22
Summer	Rotifera	*Conochilus unicornis*	32.50	76
Fall	Rotifera	*Conochilus unicornis*	3.57	43
	Cladocera	*Holopedium gibberum*	1.78	21

mg/m^3 = milligrams per cubic metre; % = percent.

3.2.2.4 Lake E1

3.2.2.4.1 Trophic Status Classification

The discrete water sampling program yielded mean annual concentrations of 0.011 mg/L for TP and 3.4 m for Secchi depth in Lake E1. The TSI values were 38 using TP and 42 using Secchi depth, for a rounded average of 41. The depth-integrated sampling program yielded a concentration of 0.015 mg/L for TP, 4.0 m for Secchi depth, and an annual mean concentration of 3.8 µg/L for chlorophyll *a*. The TSI values were 44 using chlorophyll *a*, 39 using TP, and 42 using Secchi depth, for a rounded average of 42. Based on these values and the classification systems of Vollenweider (1970), CCME (2004), and Carlson (1977), Lake E1 can be classified as a mesotrophic lake.

3.2.2.4.2 Phytoplankton

Abundance and Biomass

An evaluation of seasonality in Lake E1 is limited because of the lack of late spring samples; therefore, comparisons are based on summer and fall. Total phytoplankton abundance in Lake E1 showed very little difference between summer (971,318 cells/L) and fall (933,153 cells/L) (Figure 3.2-11). Total phytoplankton biomass in Lake E1 decreased between summer and fall (239 and 121 mg/m^3, respectively) (Figure 3.2-12).

Community Composition

Chrysophytes (71%) dominated the phytoplankton community by abundance at Station E-L1-1 in the summer (Figure 3.2-13). In the fall, the community at this station was co-dominated by cyanobacteria and chrysophytes (45% and 43%, respectively). Two major taxonomic groups, dinoflagellates and chrysophytes, dominated the phytoplankton community by biomass at Station E-L1-1 in the summer (46% and 32%, respectively) and fall (20% and 44%, respectively), but the percentages varied with sampling period (Figure 3.2-14).

In total, 52 phytoplankton taxa were identified in Lake E1 in 2013: 21 chlorophytes, 12 diatoms, 7 cyanobacteria, 4 chrysophytes, 2 dinoflagellates, 3 cryptophytes, 2 euglenoids, and 1 xanthophyte (Appendix B, Table B-6). Phytoplankton richness decreased from 48 taxa in summer to 41 taxa in the fall (Figure 3.2-15).

The dominant taxa, accounting for greater than 10% of total phytoplankton biomass in Lake E1, were similar between the summer and fall sampling periods; however, the proportion of dominance switched between summer and fall (Table 3.2-7). In the summer, a dinoflagellate, *Gymnodinium* sp., dominated the assemblage, accounting for approximately 39% of the phytoplankton biomass; a chrysophyte, *Ochromonas* sp., was the sub-dominant taxon (27%). In the fall, *Ochromonas* sp. dominated the assemblage accounting for 37% of total phytoplankton biomass and *Gymnodinium* sp. Was the sub-dominant taxon (12%).

Table 3.2-7 Dominant Phytoplankton Taxa in Lake E1 in Summer and Fall, 2013

Sampling Period[(a)]	Major Taxonomic Group	Taxa	Biomass (mg/m^3)	Dominance (%)
Summer	Dinophyceae	*Gymnodinium* sp.	92	39
	Chrysophyceae	*Ochromonas* sp.	65	27
Fall	Chrysophyceae	*Ochromonas* sp.	45	37
	Dinophyceae	*Gymnodinium* sp.	14	12

a) Late spring samples were not collected in Lake E1.

mg/m^3 = milligrams per cubic metre;% = percent; sp. = species.

3.2.2.4.3 Zooplankton

Abundance and Biomass

Total zooplankton abundance at Station E-L1-1was similar during the summer (31,065 org/m^3) and fall (44,894 org/m^3) sampling periods (Figure 3.2-16). However, total zooplankton biomass was higher in the summer (28 mg/m^3) compared to the fall sampling period (12 mg/m^3) (Figure 3.2-17).

Community Composition

Rotifers dominated the zooplankton community by abundance in Lake E1 in summer (51%) and fall (90%; Figure 3.2-18). Together, cyclopoid copepods and copepod nauplii represented 41% of the total abundance in Lake E1 in summer, compared to only 2% in the fall. Cladocerans represented a small percentage of the total abundance (8%) in Lake E1 during both sampling periods.

Despite making up a significant proportion of the total abundance, rotifers represented a much lower proportion of the total biomass in Lake E1 in summer and fall (9% and 43%, respectively; Figure 3.2-19). In terms of biomass, Lake E1 was dominated by copepod nauplii in the summer (61%), and co-dominated by rotifers (43%) and cladocerans (37%) in the fall.

In total, 19 zooplankton taxa were identified in Lake E1 in the summer and fall in 2013: 12 rotifers, 5 cladocerans, and 2 calanoid copepods (Appendix B, Table B-12). Cyclopoid copepods were not identified to the genus level in Lake E1 in 2013. Zooplankton taxonomic richness was identical in the summer and fall (14 taxa) sampling periods (Figure 3.2-20).

The dominant taxon, accounting for greater than 20% of total zooplankton biomass in Lake E1, in both the summer and fall was a cladoceran, *Daphnia longiremis*, accounting for 34% and 44%, respectively (Table 3.2-8). Sub-dominance differed between the summer and fall sampling periods. In the summer, a rotifer, *Conochilus unicornis*, was sub-dominant and accounted for approximately 30% of the total zooplankton biomass in Lake E1. In the fall, a different rotifer species, *Asplanchna priodonta, was* sub-dominant and accounted for approximately 35% of the total zooplankton biomass.

Table 3.2-8 Dominant Zooplankton Taxa in Lake E1 in Summer and Fall, 2013

Sampling Period[(a)]	Major Taxonomic Group	Taxa	Biomass (mg/m^3)	Dominance (%)
Summer	Cladocera	*Daphnia longiremis*	1.85	34
	Rotifera	*Conochilus unicornis*	1.68	30
Fall	Cladocera	*Daphnia longiremis*	4.13	44
	Rotifera	*Asplanchna priodonta*	3.23	35

a) Late spring samples were not collected in Lake E1.

mg/m^3 = milligrams per cubic metre;% = percent.

3.2.3 Lac de Gras Basin

3.2.3.1 Paul Lake

3.2.3.1.1 Trophic Status Classification

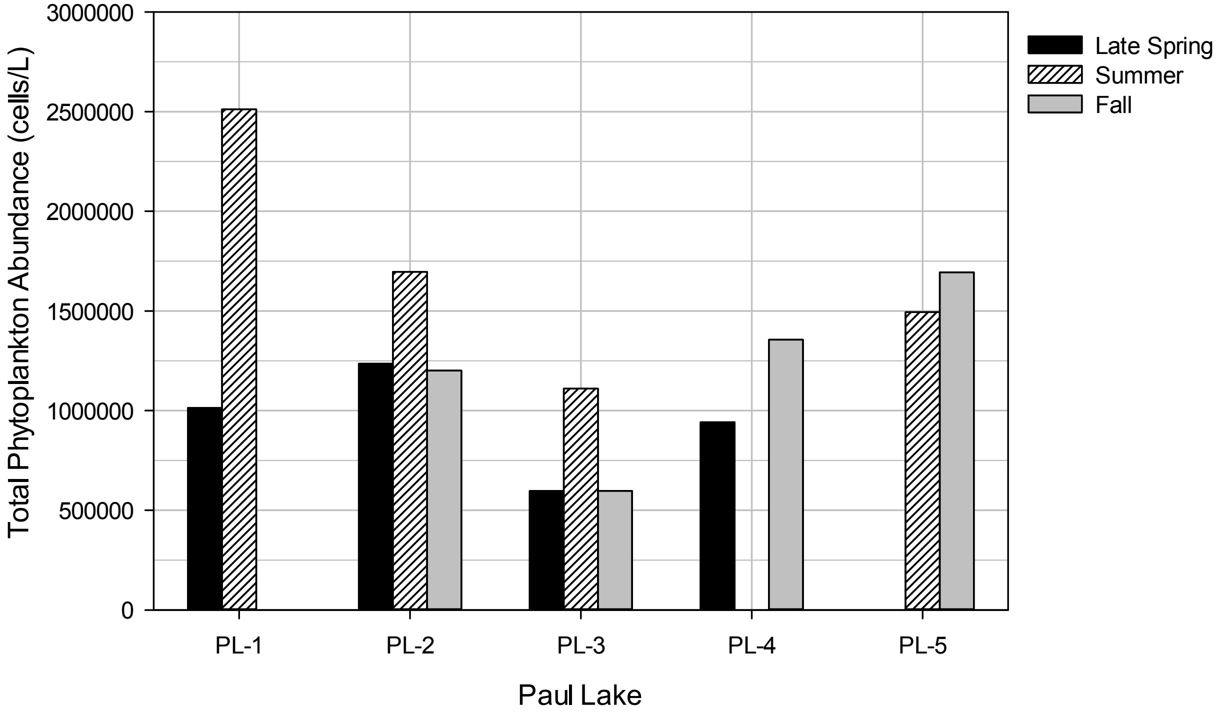
The discrete water sampling program yielded a mean annual concentration of 0.010 mg/L for TP and 3.9 m for Secchi depth in Paul Lake. The TSI values were 37 using TP and 40 using Secchi depth, for a rounded average of 39. The depth-integrated sampling program yielded a mean annual concentration of 0.012 mg/L for TP, 3.9 m for Secchi depth, and 3.3 µg/L for chlorophyll *a*. The TSI values were 43 using chlorophyll *a*, 41 using TP, and 40 using Secchi depth, for a rounded average of 41. Based on these values and the classification systems of Vollenweider (1970), CCME (2004), and Carlson (1977), Paul Lake can be classified as an oligotrophic to mesotrophic lake.

3.2.3.1.2 Phytoplankton

Abundance and Biomass

Total phytoplankton abundance in Paul Lake varied seasonally and spatially (Figure 3.2-21). Total phytoplankton abundance was lowest in late spring at all stations with available data, ranging from 596,621 to 1,235,889 cells/L. Total phytoplankton abundance peaked in summer at stations PL-1, PL-2, and PL-3 (1,110,659 to 2,512,095 cells/L), and was similar in the late spring and the fall at these stations, where data were available. Stations PL-4 and PL-5 exhibited peaks in total phytoplankton abundance in the fall of 1,355,672 and 1,693,260 cells/L, respectively; however, these stations were both missing data for one sampling period (i.e., no summer sample was collected at Station PL-4 and no late spring sample was collected at Station PL-5). The highest recorded abundance in Paul Lake was observed at Station PL-1 in the summer (2,512,095 cells/L).

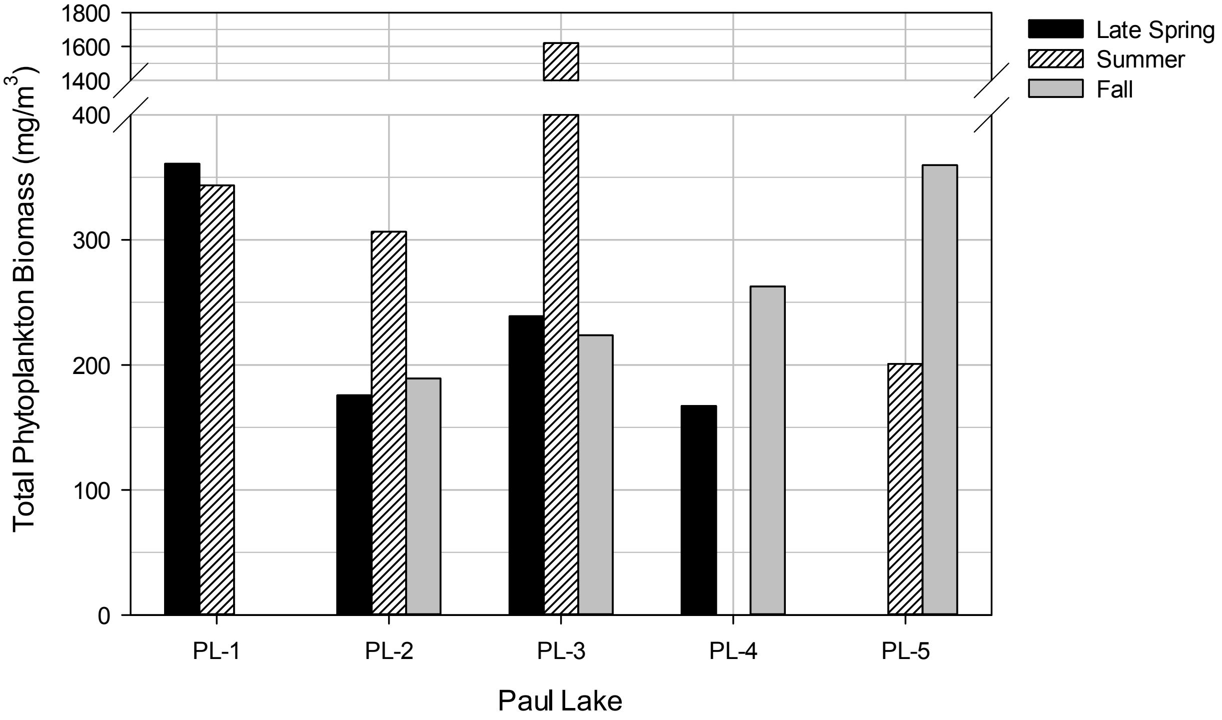
Figure 3.2-21 Total Phytoplankton Abundance in Paul Lake in Late Spring, Summer, and Fall, 2013



Note: Samples were not collected at Station PL-1 in fall, Station PL-4 in summer or Station PL-5 in late spring.
cells/L= cells per Litre.

Seasonal and spatial variability were observed in total phytoplankton biomass in Paul Lake (i.e., no clear seasonal trends were observed) (Figure 3.2-22). Total phytoplankton biomass was approximately 1.5 to 2 times higher at Station PL-1 compared with other stations sampled in the late spring. Peaks in total phytoplankton biomass occurred in the summer at stations PL-2 and PL-3. Station PL-3 had four times more total phytoplankton biomass (1,620 mg/m^3) in the summer, compared to other stations (201 to 344 mg/m^3). Total biomass was highest in fall at stations PL-4 (263 mg/m^3) and PL-5 (360 mg/m^3). Total phytoplankton biomass at Station PL-1 exhibited little variation between the late spring (361 mg/m^3) and summer (344 mg/m^3).

Figure 3.2-22 Total Phytoplankton Biomass in Paul Lake in Late Spring, Summer, and Fall, 2013

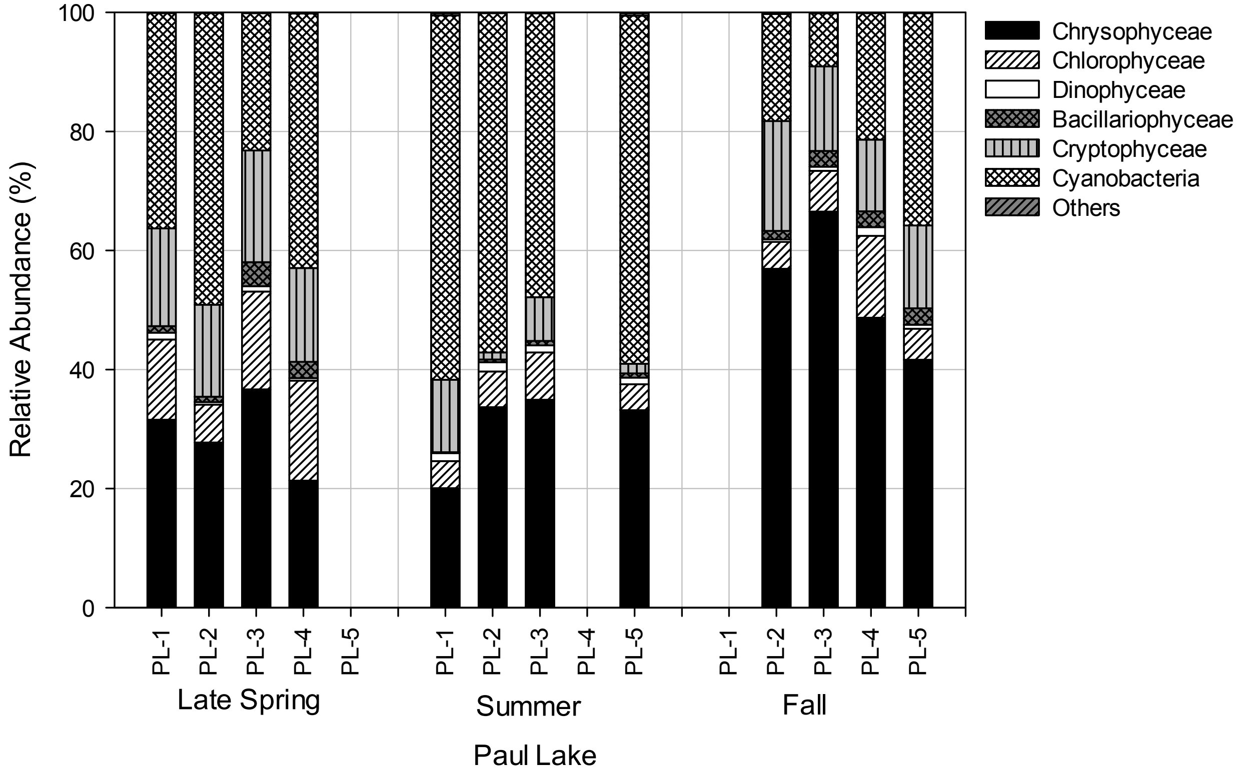


Note: Samples were not collected at Station PL-1 in fall, Station PL-4 in summer or Station PL-5 in late spring.
mg/m^3 = milligrams per cubic metre.

Community Composition

In general, two major taxonomic groups (i.e., chrysophytes and cyanobacteria) dominated the phytoplankton assemblage by abundance in Paul Lake throughout the open-water sampling period, but the percentages of these groups varied among stations and sampling periods (Figure 3.2-23). The phytoplankton community in Paul Lake was co-dominated by cyanobacteria and chrysophytes in late spring (23% to 49% and 21% to 37%, respectively) and summer (48% to 61% and 20% to 35%, respectively); however, cyanobacteria represented a higher proportion of the relative abundance in the summer compared to the late spring. Chrysophytes (42% to 67%) made up the majority of the phytoplankton assemblage by abundance in Paul Lake in the fall. Cyanobacteria (9% to 36%) were present in Paul Lake in the fall, but represented a much smaller percentage of the community compared to the late spring and summer.

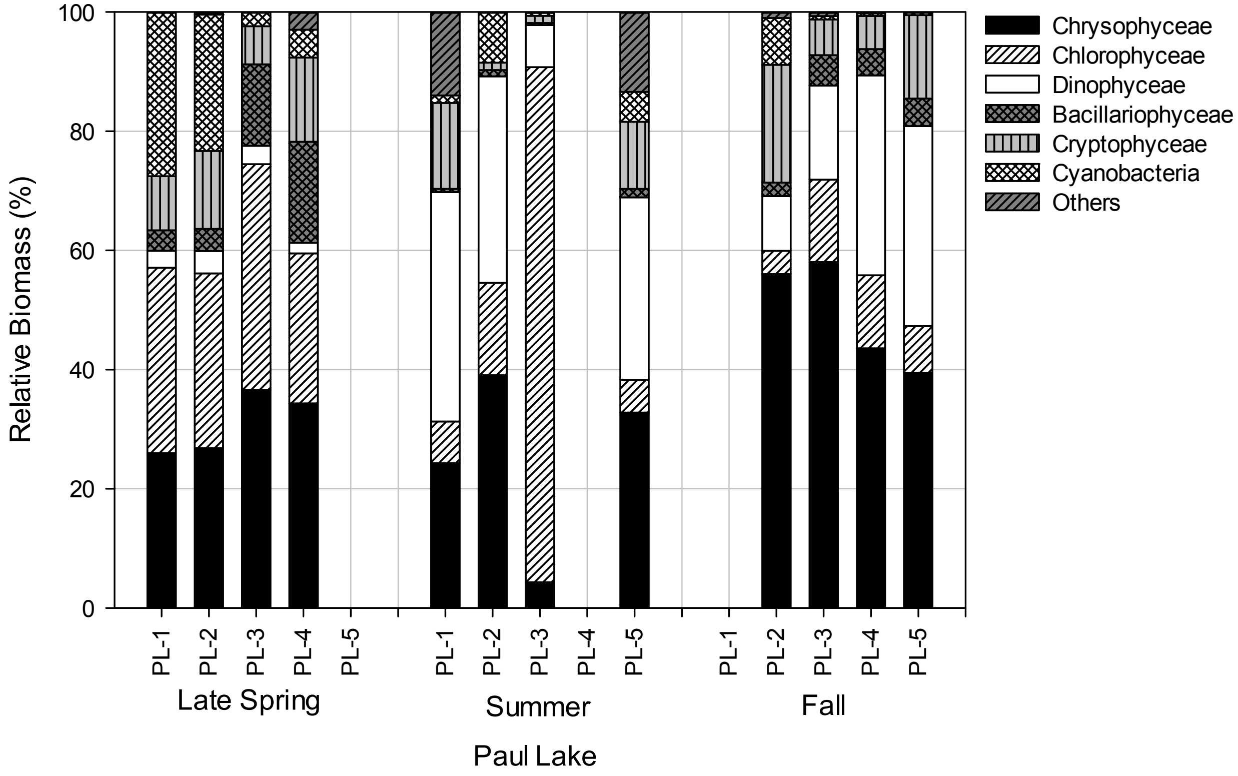
Figure 3.2-23 Relative Phytoplankton Abundance in Paul Lake in Late Spring, Summer, and Fall, 2013



Note: Samples were not collected at Station PL-1 in fall, Station PL-4 in summer or Station PL-5 in late spring.
% = percent.

Chrysophytes (26% to 37%) and chlorophytes (25% to 38%) dominated the phytoplankton composition by biomass in Paul Lake in the late spring (Figure 3.2-24). The remainder of the community composition in late spring consisted of variable amounts of cyanobacteria (2% to 28%), diatoms (3% to 17%), and cryptophytes (6% to 14%). Stations PL-1, PL-2, and PL-5 had similar community composition in the summer; these stations were co-dominated by dinoflagellates (31% to 39%) and chrysophytes (24% to 39%). Unlike the other stations in Paul Lake, the relative biomass of Station PL-3 in the summer was heavily dominated by chlorophytes (86%). In the fall, primarily chrysophytes (39% to 58%) dominated the phytoplankton community by biomass in Paul Lake. The remainder of the biomass in Paul Lake was made up of varying percentages of dinoflagellates (9% to 34%), cryptophytes (6% to 20%), chlorophytes (4% to 14%), diatoms (2% to 5%), and cyanobacteria (less than 8%).

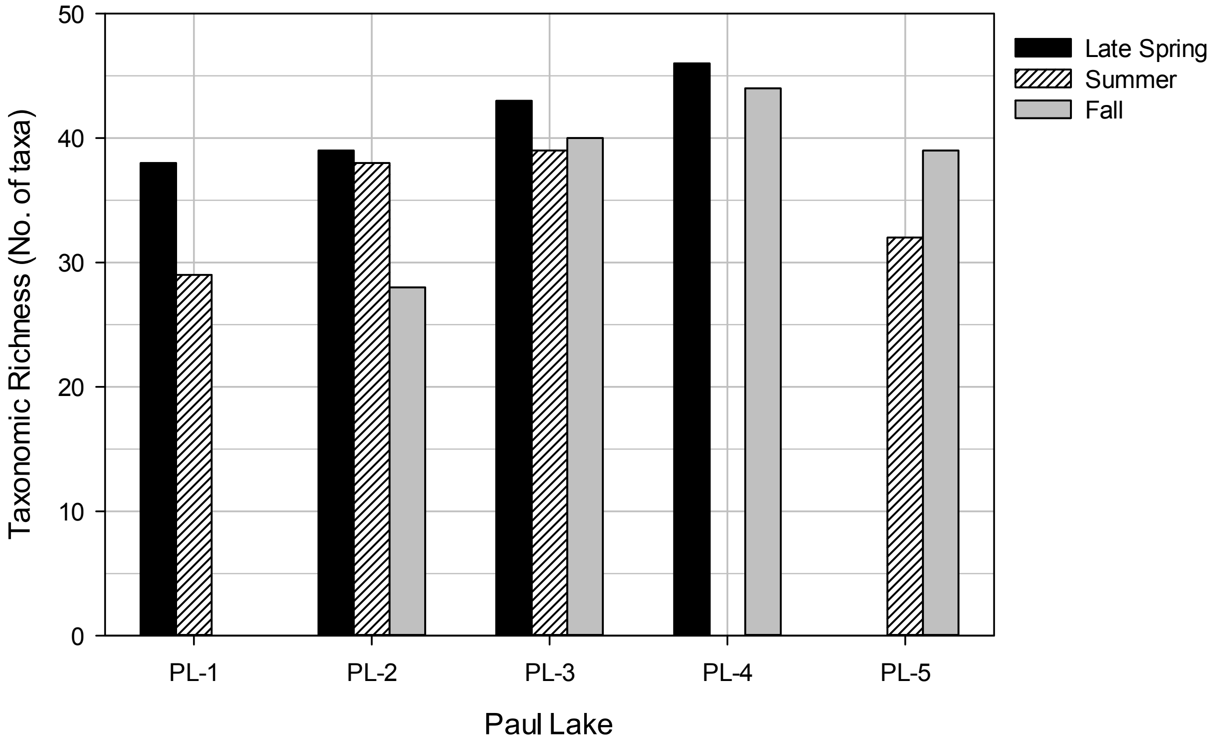
Figure 3.2-24 Relative Phytoplankton Biomass in Paul Lake in Late Spring, Summer, and Fall, 2013



Note: Samples were not collected at Station PL-1 in fall, Station PL-4 in summer or Station PL-5 in late spring.
% = percent.

In total 75 phytoplankton taxa were identified in Paul Lake in 2013: 34 chlorophytes, 11 diatoms, 11 cyanobacteria, 8 chrysophytes, 4 dinoflagellates, 3 cryptophytes, 3 euglenoids, and 1 xanthophyte (Appendix B, Table B-7). Phytoplankton taxonomic richness peaked in late spring at all stations in Paul Lake, with the exception of Station PL-5, where no late spring data were available (Figure 3.2-25). Taxonomic richness decreased throughout the open-water sampling period at all stations, with the exception of Station PL-5, where richness increased between summer and fall. Overall, Station PL-4 (44 to 46 taxa) had the highest taxonomic richness compared to the other stations in Paul Lake (28 to 43 taxa).

Figure 3.2-25 Total Phytoplankton Taxonomic Richness in Paul Lake in Late Spring, Summer, and Fall, 2013



Note: Samples were not collected at Station PL-1 in fall, Station PL-4 in summer or Station PL-5 in late spring.
No. = number.

The dominant taxa, accounting for greater than 10% of total phytoplankton biomass in Paul Lake, differed among the sampling periods (Table 3.2-9). In late spring, one chlorophyte taxon, *Staurodesmus* sp., and one chrysophyte taxon, *Ochromonas* sp., accounted for 15% and 14% of the total phytoplankton biomass in Paul Lake, respectively. In the summer, a chlorophyte taxon, *Eudorina elegans*, dominated the assemblage, accounting for approximately 81% or total phytoplankton biomass. In the fall, *Ochromonas* sp. again dominated the assemblage, accounting for 25% of total phytoplankton biomass; sub-dominance was evenly distributed between a dinoflagellate, *Peridinium aciculiferum*, and a chrysophyte, *Dinobryon bavaricum*, accounting for 12% and 10%, respectively.

Table 3.2-9 Dominant Phytoplankton Taxa in Paul Lake in Late Spring, Summer, and Fall, 2013

Sampling Period	Major Taxonomic Group	Taxa	Biomass mg/m^3	Dominance %
Late Spring	Chlorophyceae	*Staurodesmus* sp.	50	15
	Chrysophyceae	*Ochromonas* sp.	47	14
Summer	Chlorophyceae	*Eudorina elegans*	1,384	81
Fall	Chrysophyceae	*Ochromonas* sp.	80	25
	Dinophyceae	*Peridinium aciculiferum*	38	12
	Chrysophyceae	*Dinobryon bavaricum*	32	10

mg/m^3 = milligrams per cubic metre; % = percent; sp. = species.

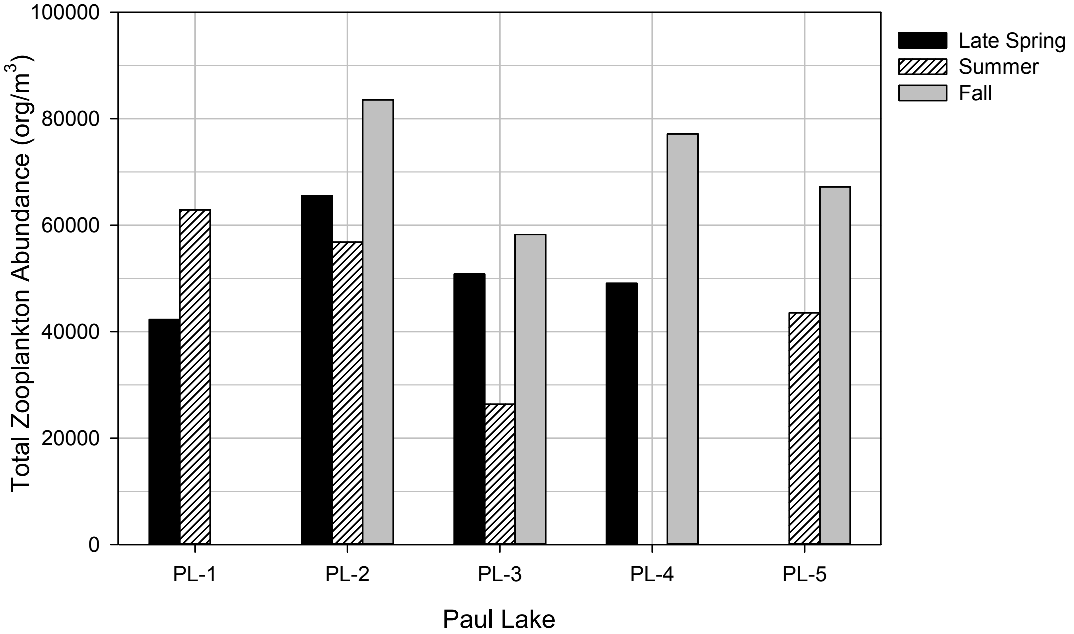
3.2.3.1.3 Zooplankton

Abundance and Biomass

Seasonal and spatial variability in total zooplankton abundance was observed in Paul Lake in 2013 (Figure 3.2-26). Total zooplankton abundance peaked in the fall at the majority of the stations in Paul Lake (58,265 to 83,559 org/m^3). Station PL-1 was not sampled in the fall; therefore, peak total zooplankton abundance was observed at that station in the summer. In general, total zooplankton abundance ranged from 26,363 org/m^3 at Station PL-3 in the summer to 83,559 org/m^3 at Station PL-2 in the fall.

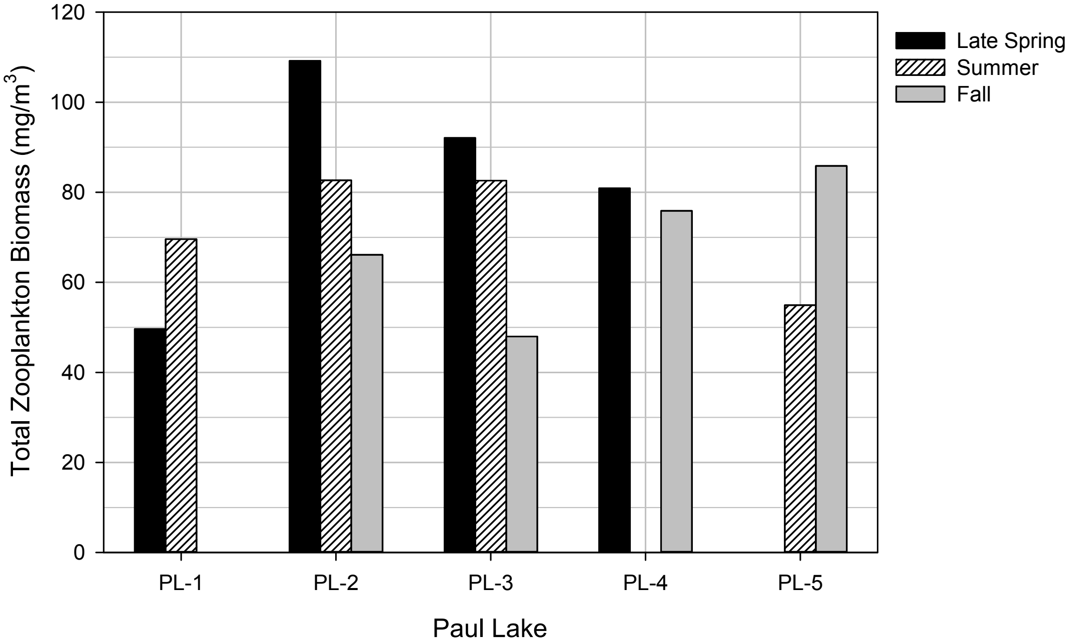
Clear seasonal or spatial patterns in total zooplankton biomass were not observed in Paul Lake in 2013 (Figure 3.2-27). Total zooplankton biomass peaked: in late spring at three stations (i.e., PL-2, PL-3, and PL-4), ranging from 81 to 109 mg/m^3, in the summer at Station PL-1 (70 mg/m^3), and in the fall at Station PL-5 (86 mg/m^3). Overall, total zooplankton biomass in Paul Lake ranged from 48 to 109 mg/m^3 throughout the open-water season.

Figure 3.2-26 Total Zooplankton Abundance in Paul Lake in Late Spring, Summer, and Fall, 2013



Note: Samples were not collected at Station PL-1 in fall, Station PL-4 in summer or Station PL-5 in late spring.
org/m^3 = organisms per cubic metre.

Figure 3.2-27 Total Zooplankton Biomass in Paul Lake in Late Spring, Summer, and Fall, 2013

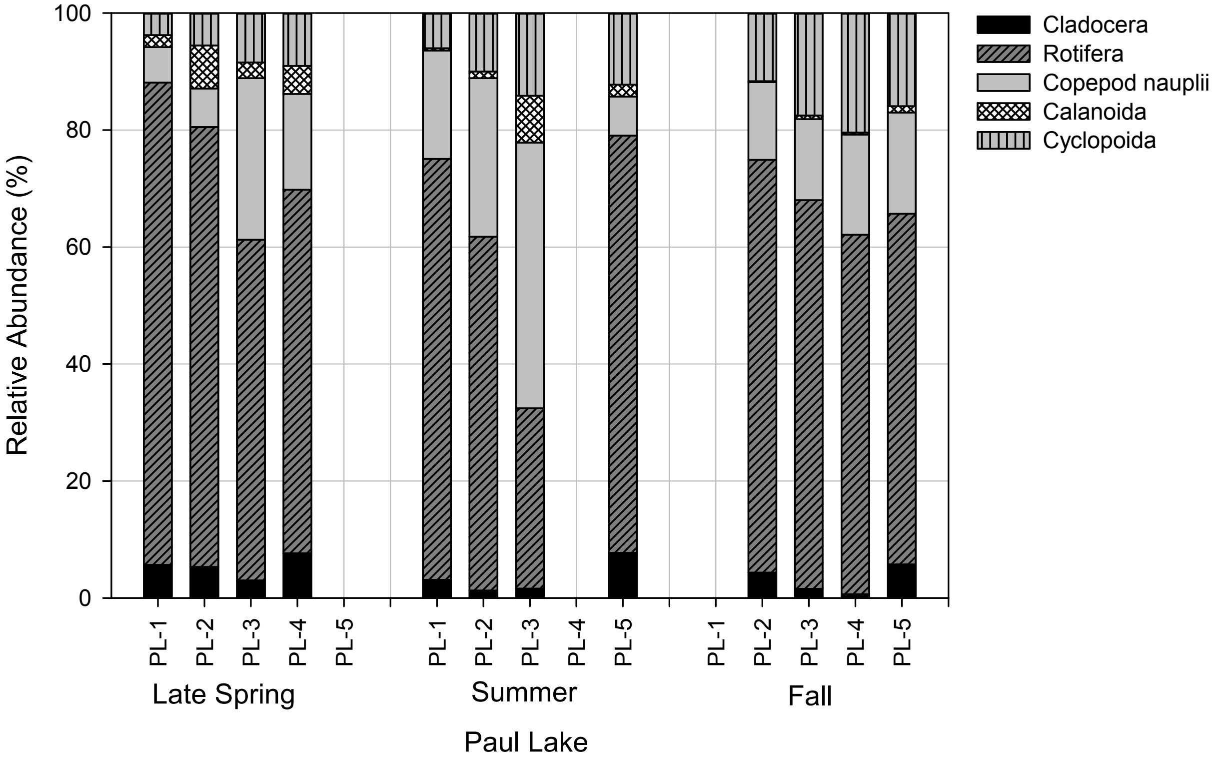


Note: Samples were not collected at Station PL-1 in fall, Station PL-4 in summer or Station PL-5 in late spring.
mg/m^3 = milligrams per cubic metre.

Community Composition

Rotifers dominated the zooplankton community by abundance in Paul Lake (greater than 60%) throughout the open-water season, with the exception of Station PL-3 in the summer (31%; Figure 3.2-28). Cyclopoid and calanoid copepods as well as cladocerans comprised a small proportion of total abundance in Paul Lake in the late spring. The relative abundance of cyclopoid copepods in Paul Lake increased throughout the open-water sampling period, ranging from 4% to 9% in late spring, to 12% to 20% in the fall. Calanoid copepods were present in relatively low abundances (less than 8%) in Paul Lake throughout the open-water sampling period. Copepod nauplii represented a greater proportion of the abundance at stations PL-3 and PL-4 (28% and 16%, respectively) compared to PL-1 and PL-2 (6% and 7%, respectively) in late spring. Copepod nauplii made up a larger percentage of the total abundance in Paul Lake in the summer (7% to 46%) compared to late spring (6% to 28%) and fall (13% to 17%).

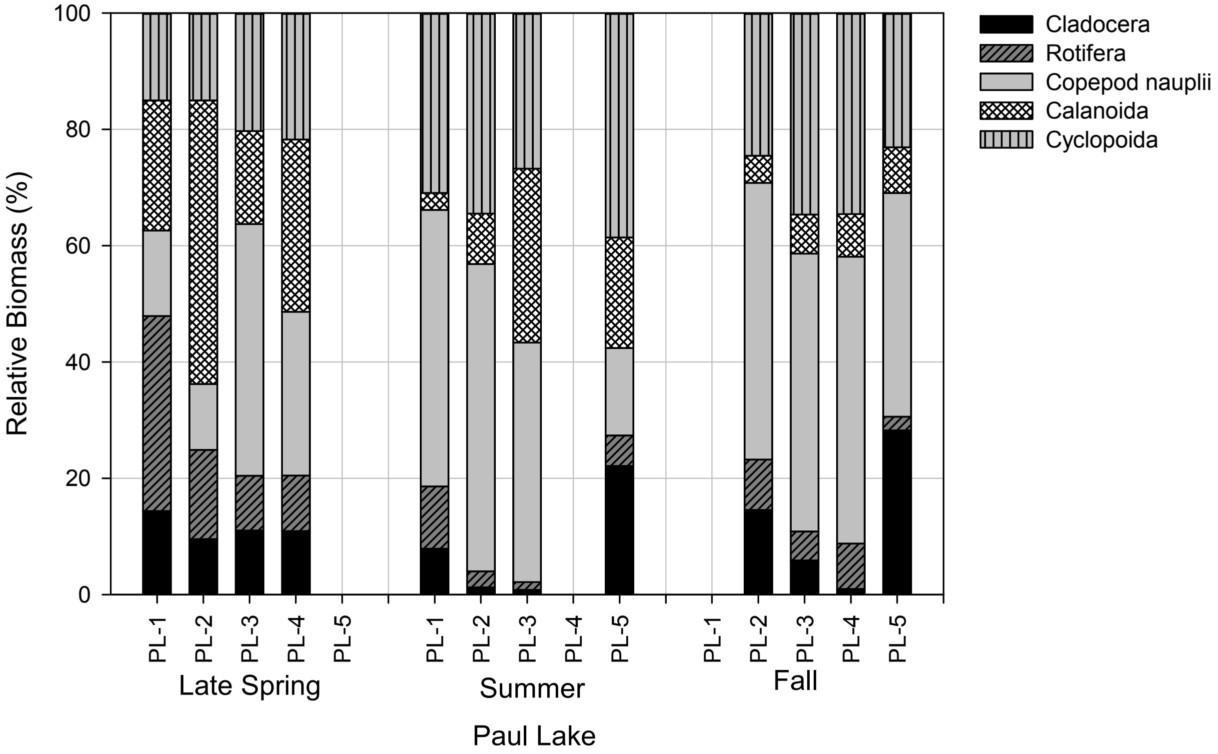
Figure 3.2-28 Relative Zooplankton Abundance in Paul Lake in Late Spring, Summer, and Fall, 2013



Note: Samples were not collected at Station PL-1 in fall, Station PL-4 in summer or Station PL-5 in late spring.
% = percent.

Zooplankton community composition by biomass varied among stations in Paul Lake (Figure 3.2-29). Late spring zooplankton community composition by biomass was more evenly mixed between the major taxonomic groups compared to the other sampling periods. Overall, rotifers represented only a small fraction of the total biomass in Paul Lake, particularly in summer (1% to 11%) and fall (2% to 9%). Copepod nauplii and cyclopoid copepods were a dominant group at the majority of stations in the summer (41% to 48% and 27% to 39%, respectively) and the fall (38% to 49% and 23% to 35%, respectively). The proportion of cladocerans by biomass remained relatively low throughout the open-water season (1% to 15%), with the exception of PL-5 in the summer (22%) and the fall (28%).

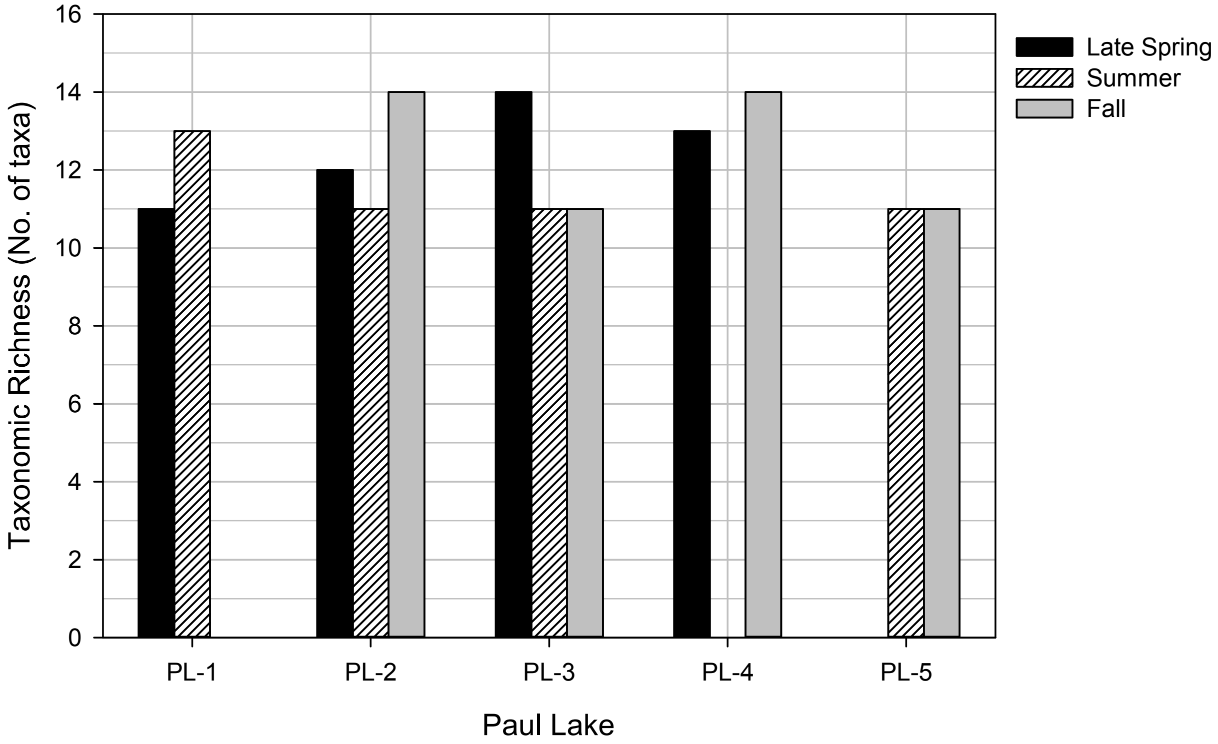
Figure 3.2-29 Relative Zooplankton Biomass in Paul Lake in Late Spring, Summer, and Fall, 2013



Note: Samples were not collected at Station PL-1 in fall, Station PL-4 in summer or Station PL-5 in late spring.
% = percent.

In total, 22 zooplankton taxa were identified in Paul Lake in 2013: 11 rotifers, 6 cladocerans, 4 calanoid copepods, and 1 cyclopoid copepod (Appendix B, Table B-13). There was little seasonal or spatial variability, with overall taxonomic richness ranging from 11 to 14 taxa (Figure 3.2-30).

Figure 3.2-30 Total Zooplankton Taxonomic Richness in Paul Lake in Late Spring, Summer, and Fall, 2013



Note: Samples were not collected at Station PL-1 in fall, Station PL-4 in summer or Station PL-5 in late spring.
No. = number.

The dominant taxon, accounting for greater than 20% of total zooplankton biomass in Paul Lake differed among the sampling periods. In late spring, one calanoid copepod, *Leptodiaptomus pribilofensis*, and one species of rotifer, *Conochilus unicornis*, accounted for 29% and 24% of the total zooplankton biomass in Paul Lake, respectively (Table 3.2-10). In the summer and fall 2013, a cyclopoid copepod, *Cyclops strenuus*, dominated the total zooplankton biomass in Paul Lake, accounting for 44% and 23%, respectively. In the summer, sub-dominance by the calanoid copepod, *L. pribilofensis,* was observed, accounting for approximately 25% of total zooplankton biomass.

Table 3.2-10 Dominant Zooplankton Taxa in Paul Lake in Late Spring, Summer, and Fall, 2013

Sampling Period	Major Taxonomic Group	Taxa	Biomass (mg/m^3)	Dominance (%)
Late Spring	Calanoida	*Leptodiaptomus pribilofensis*	60.01	29
	Rotifera	*Conochilus unicornis*	48.67	24
Summer	Cyclopoida	*Cyclops strenuus*	71.57	44
	Calanoida	*Leptodiaptomus pribilofensis*	40.27	25
Fall	Cyclopoida	*Cyclops strenuus*	27.60	23

mg/m^3 = milligrams per cubic metre; % = percent.

3.3 Summary of Baseline Plankton Community, 2013

3.3.1 Trophic Status Classification

Based on the TSI calculations for discrete and depth-integrated TP, Secchi depths, and chlorophyll *a* concentrations from the open water-sampling period in 2013, the trophic status of the lakes sampled in 2013 ranged primarily from oligotrophic to mesotrophic (Table 3.3-1). Lake Af1 was within the range of a mesotrophic to eutrophic system based on the Vollenweider (1970) classification.

Table 3.3-1 Summary of 2013 Baseline Plankton Community, 2013

Community Variable	Lac du Sauvage	Duchess Lake	Lake Af1	Lake E1	Paul Lake
Trophic Status Classification	oligotrophic	mesotrophic	mesotrophic to eutrophic[(a)]	mesotrophic	oligotrophic
Phytoplankton					
Total Abundance (cells/L)	352,382 to 1,020,835	799,701 to 1,501,246	1,516,269 to 5,767,686	933,153 to 971,318	596,621 to 2,512,095
Total Biomass (mg/m^3)	121 to 1,548	324 to 3,193	260 to 1,219	121 to 239	167 to 1,620
Total Richness (No. of taxa)	88	63	67	52	75
Zooplankton					
Total Abundance (org/m^3)	14,592 to 97,353	28,768 to 79,549	24,871 to 246,508	31,065 to 44,894	26,363 to 83,559
Total Biomass (mg/m^3)	6 to 43	11 to 37	26 to 113	12 to 28	40 to 109
Total Richness (No. of taxa)	25	21	20	19	22

a) Mesotrophic to eutrophic system based on Vollenweider (1970).

cells/L = cells per litre; mg/m^3 = milligrams per cubic metre; No. = number; org/m^3 = organisms per cubic metre.

3.3.2 Phytoplankton

In general, there was a wide range in total phytoplankton abundance and biomass both within and among lakes sampled in the Lac du Sauvage and Lac de Gras basins (Table 3.3-1). Seasonal and spatial differences in total phytoplankton abundance were observed in lakes sampled in 2013. Total phytoplankton abundance was usually lowest in late spring in Lac du Sauvage, Duchess Lake, and Paul Lake. Unlike the other lakes in the Lac du Sauvage basin, total phytoplankton abundance in Lake Af1 was highest in late spring and lowest in the fall. Total phytoplankton abundance in Lake E1 was similar and showed very little variation between summer and fall.

In 2013, total phytoplankton biomass was similar among stations in Lac du Sauvage, Lake Af1, and Paul Lake, while Duchess Lake had higher biomass. Seasonal and spatial variability in the timing of peak total phytoplankton biomass was not consistent among lakes.

The total number of phytoplankton taxa identified in lakes in the Lac du Sauvage and Lac de Gras basins ranged from 52 (Lake E1) to 88 (Lac du Sauvage). Chlorophytes had the greatest diversity, followed by diatoms, cyanobacteria, and chrysophytes. Dinoflagellates, cryptophytes, euglenoids, and xanthophytes made up relatively small percentages of the total taxa count in each lake. There were no consistent dominant taxa identified within or among lakes sampled in 2013.

Chrysophytes dominated the community by abundance in Lac du Sauvage throughout the open-water sampling period in 2013. In terms of abundance, the same three major taxonomic groups (cyanobacteria, chrysophytes, and chlorophytes) made up the majority of the phytoplankton community in Duchess Lake, Lake Af1, and Lake E1, but the percentages varied among stations and sampling periods. In general, chrysophytes and cyanobacteria dominated the phytoplankton assemblage by abundance in Paul Lake throughout the open-water sampling period, but the percentages of these groups varied seasonally and spatially. Differences in community composition by biomass were observed seasonally and among lakes, and no consistent dominant major taxonomic group was identified.

3.3.3 Zooplankton

Overall, total zooplankton abundance and biomass varied both within and among lakes in 2013 (Table 3.3-1), with the exception of Lake E1, where little variation was observed between summer and fall. Seasonal and spatial variability was observed in total zooplankton abundance and biomass in lakes in the Lac du Sauvage and Lac de Gras basins. Seasonal peaks in total zooplankton abundance were observed in summer in Lac du Sauvage and Lake Af1, late spring in Duchess Lake, and the fall in Paul Lake and Lake E1. Seasonal peaks in total zooplankton biomass were observed in summer in Lac du Sauvage, Duchess Lake, Lake Af1, and Lake E1, while Paul Lake exhibited no consistent seasonal peak. Total zooplankton biomass was similar among Lac du Sauvage, Duchess Lake, and Lake E1, and was generally lower than the biomass observed in Paul Lake and Lake Af1.

The total number of zooplankton taxa identified in lakes in the Lac du Sauvage and Lac de Gras basins ranged from 19 taxa (Lake E1) to 25 taxa (Lac du Sauvage). Rotifer taxa were present in the highest numbers, followed by cladocerans, calanoid copepods, and cyclopoid copepods. The dominant taxon, accounting for greater than 20% of the total zooplankton biomass, varied among lakes as well as seasonally.

Zooplankton community composition by abundance in lakes in the Lac du Sauvage and Lac de Gras basins was similar among stations, but varied with sampling period. Rotifers made up majority of the zooplankton community by abundance in all lakes, with cladocerans co-dominating the zooplankton assemblage in Duchess Lake. Zooplankton community composition by biomass varied seasonally and spatially in Lac du Sauvage, Duchess Lake, Lake Af1, Lake E1, and Paul Lake.

4 SUMMARY

This Plankton Baseline Report provides a summary of existing plankton communities in waterbodies within the Lac du Sauvage and Lac de Gras basins, near the proposed Jay Project. The objectives of this report were to characterize the trophic status of waterbodies, describe plankton communities of lakes in the baseline study area during open-water conditions, and describe spatial and seasonal variability in phytoplankton and zooplankton communities. Data collected during previous studies and the 2013 plankton baseline program were summarized to address these objectives.

4.1 Trophic Status

Chlorophyll *a* concentrations were variable over time in the lakes included in the historical review; however, all chlorophyll *a* concentrations were within the oligotrophic range. The 2013 baseline study evaluated trophic status as the TSI, based on discrete and depth-integrated TP, Secchi depth, and chlorophyll *a* concentrations from the open water-sampling period. The trophic status of the lakes sampled in 2013 ranged mostly from oligotrophic (Lac du Sauvage and Paul Lake) to mesotrophic (Duchess Lake and Lake E1); trophic status of Lake Af1 was found to be in the range of mesotrophic to eutrophic.

4.2 Phytoplankton

Total phytoplankton abundance was variable over time in the lakes included in the historical review. The limited seasonal data available for Lac du Sauvage, Christine Lake, and Ursula Lake typically showed the lowest total phytoplankton abundance occurring in the spring, but timing of peak values varied between summer and fall. Total phytoplankton abundance and biomass were consistently higher in the FF2 area in Lac de Gras compared to other far-field/reference areas in this lake. A decreasing trend in phytoplankton abundance and biomass was observed in all areas monitored as part of the Diavik AEMP between 2008 and 2011.

In 2013, wide ranges in total phytoplankton abundance and biomass were documented both within and among lakes sampled in the Lac du Sauvage and Lac de Gras basins. Total phytoplankton abundance was usually lowest in late spring in Lac du Sauvage, Duchess Lake, and Paul Lake. Total phytoplankton abundance in Lake Af1 was highest in late spring and lowest in the fall. Total phytoplankton abundance in Lake E1 was similar and showed very little variation between summer and fall. Total phytoplankton biomass was similar among stations in Lac du Sauvage, Lake Af1, and Paul Lake, while Duchess Lake had higher biomass. Seasonal and spatial variability in the timing of peak total phytoplankton biomass was not consistent among lakes.

In Lac du Sauvage and Counts Lake, total phytoplankton richness was variable and increased slightly over time in the historical dataset. In areas of Lac de Gras monitored by the Diavik Mine AEMP, total phytoplankton richness had increased since 1997, but recently showed a decline. In contrast, areas of Lac de Gras monitored by the Ekati Mine AEMP showed fluctuations in total phytoplankton richness, but no distinct trend over time. Overall, richness values were stable in Nanuq Lake and Vulture Lake. Total phytoplankton richness varied seasonally in Lac du Sauvage, Christine Lake, and Ursula Lake in 2006.

In 2013, the total number of phytoplankton taxa identified in lakes in the Lac du Sauvage and Lac de Gras basins ranged from 52 (Lake E1) to 88 (Lac du Sauvage). Chlorophytes had the greatest diversity, followed by diatoms, cyanobacteria, and chrysophytes. Dinoflagellates, cryptophytes, euglenoids, and xanthophytes made up relatively small percentages of the total taxa count in each lake.

Phytoplankton community composition varied among lakes and years in the historical dataset, although cyanobacteria, chlorophytes, and chrysophytes were commonly the dominant taxonomic groups. Temporal trends were observed in Lac de Gras. In recent years, the proportion of chrysophytes at Station S2 decreased, while the proportion of diatoms increased at stations S2 and S3. In the FFA and FFB reference areas, composition shifted from chrysophyte dominance (2003 to 2006) to cyanobacteria dominance (2007 to 2010). The communities in the FF2 and FF1 areas consisted predominantly of chrysophytes and cyanobacteria.

Chrysophytes dominated the community by abundance in Lac du Sauvage throughout the open-water sampling period in 2013. In terms of abundance, the same three major taxonomic groups (cyanobacteria, chrysophytes, and chlorophytes) made up the majority of the phytoplankton community in Duchess Lake, Lake Af1, and Lake E1, but the percentages varied among stations and sampling periods. In general, chrysophytes and cyanobacteria dominated the phytoplankton assemblage by abundance in Paul Lake throughout the open-water sampling period, but the percentages of these groups varied seasonally and spatially. Differences in community composition by biomass were observed seasonally and among lakes, and no consistent dominant major taxonomic group was identified.

4.3 Zooplankton

Total zooplankton abundance varied over time in most of the lakes included in the historical review. The limited seasonal data available for Lac du Sauvage, Christine Lake, and Ursula Lake indicated seasonal variability but no consistent seasonal pattern. Total zooplankton abundance in Lac de Gras decreased in all areas monitored by the Diavik Mine AEMP, with increases occurring in the FFA and FFB areas in 2012. Total zooplankton abundance was similar in the FF2 exposure area and the other three far-field/reference areas. Conversely, summer zooplankton biomass at Lac de Gras stations monitored by the Ekati Mine AEMP showed little variation over time. Zooplankton biomass (as AFDM) showed variability in most of the lakes included in the historical review, but overall remained relatively stable over time.

Total zooplankton abundance and biomass varied both within and among lakes in 2013, with the exception of Lake E1, where little variation was observed between summer and fall. Seasonal and spatial variability was observed in total zooplankton abundance and biomass in lakes in the Lac du Sauvage and Lac de Gras basins. Seasonal peaks in total zooplankton abundance were observed in summer in Lac du Sauvage and Lake Af1, late spring in Duchess Lake, and the fall in Paul Lake and Lake E1. Seasonal peaks in total zooplankton biomass were observed in summer in Lac du Sauvage, Duchess Lake, Lake Af1, and Lake E1, while Paul Lake exhibited no consistent seasonal peak. Total zooplankton biomass was similar among Lac du Sauvage, Duchess Lake, and Lake E1, and generally lower than the biomass observed in Paul Lake and Lake Af1.

With the exception of Lac de Gras, total zooplankton richness was relatively stable within each lake and over time in the historical dataset. In areas of Lac de Gras monitored as part of the Diavik Mine AEMP, total zooplankton richness increased over time. In 2013, zooplankton richness in lakes in the Lac du Sauvage and Lac de Gras basins ranged from 19 to 25. Rotifer taxa were present in the highest numbers, followed by cladocerans, calanoid copepods, and cyclopoid copepods. The dominant taxon, accounting for greater than 20% of the total zooplankton biomass, varied among lakes as well as seasonally.

In general, rotifers and copepods dominated the zooplankton community in most lakes included in the historical review. No temporal trends were observed in zooplankton community composition. In 2013, zooplankton community composition by abundance in lakes in the Lac du Sauvage and Lac de Gras basins was similar among stations, but varied with sampling period. Rotifers made up majority of the zooplankton community by abundance in all lakes, with cladocerans co-dominating the zooplankton assemblage in Duchess Lake. Zooplankton community composition by biomass varied seasonally and spatially in Lac du Sauvage, Duchess Lake, Lake Af1, Lake E1, and Paul Lake.

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6 GLOSSARY

Term	**Description**
Abundance	The number of individuals in a given area or sample.
Bathymetry	Measurement of water depths in a lake.
Biomass	The weight of living matter in a given area or sample.
Calanoida	An order of copepods; small animals in the water column that are a component of zooplankton.
Chlorophyll *a*	The primary photosynthetic pigment contained in the phytoplankton (primary producers; small plants in the water column).
Cladocera	A group of small planktonic animals (crustaceans) also known as water fleas; a component of zooplankton.
Colonial	Individuals of the same species clustered together to form a group.
Conductivity	A measure of the resistance of a solution to electrical flow; an indirect measure of the salinity of the water.
Crustaceans	A large group of primarily aquatic arthropods of the class Crustacea, which are free-living, have a segmented body and an exoskeleton.
Cyanobacteria	Blue-green algae; a component of phytoplankton.
Cyclopoida	An order of copepods; small animals in the water column that are a component of zooplankton.
Diatom	A group of algae that are encased within a frustule (shell) made of silica; a component of phytoplankton.
Dissolved oxygen	Oxygen dissolved within the water column.
Diversity	A numerical index that incorporates evenness and richness; the diversity index measures the proportional distribution of organisms in the community.
Drainage Basin	A region of land that eventually contributes water to a river or lake.
Drumlins	A long narrow hill, made up of till, which points in the direction of the glacier movement.
Effluent	Outflowing of water or other liquids from a man-made structure.
Eskers	Long, narrow bodies of sand and gravel deposited by a subglacial stream running between ice walls or in an ice tunnel, left behind after melting of the ice of a retreating glacier.
Eutrophic	The nutrient-rich status (amount of nitrogen, phosphorus, and potassium) of an ecosystem.
Evenness	A measure of how evenly the total invertebrate abundance is distributed among the different types of organisms present at a site.
Food web	Interconnected linear sequences of who eats whom in a biological community.
Grab sample	A single sample collected at a particular time and place that represents the composition of the material samples (i.e., water) only at that time and place.
Headwater	The source of water at the top of a watershed, typically a lake or marsh.
Herbivore	Animals that eat plants.
Hydrology	The study of flowing water and effects of flowing water on the Earth's surface, in the soil and underlying rocks, and in the atmosphere.
Kettle Lakes	A steep-sided bowl or basin-shaped hole or depression in glacial drift deposits, especially outwash or kame, and believed to have formed by the melting of a large, detached block of stagnant ice (left behind by a retreating glacier) that had been wholly or partly buried in the glacial drift. Kettles commonly lack surface drainage and some may contain a lake or swamp.
Kimberlite	Igneous rocks that originate deep in the Earth’s mantle and intrude the Earth’s crust. These rocks typically form narrow pipe-like deposits that sometimes contain diamonds.
Kimberlite pipe	A more or less vertical, cylindrical body of kimberlite that resulted from the forcing of the kimberlite material to the Earth’s surface.
Lichens	Any complex organism of the group Lichenes, composed of a fungus in symbiotic union with an alga and having a greenish, grey, yellow, brown, or blackish thallus that grows in leaflike, crustlike, or branching forms on rocks, trees, and other surfaces.
Littoral	The shallow shoreline area of a lake.

Term	Description
Mainstem	The main portion of a watercourse extending continuously upstream from its mouth, but not including any tributary watercourses.
Mesotrophic	Trophic state classification for lakes characterized by moderate productivity and nutrient inputs (particularly total phosphorus).
Nutrients	Environmental substances (elements or compounds) such as nitrogen or phosphorus, which are necessary for the growth and development of plants and animals.
Oligotrophic	A lake lacking in nutrients and having low organic productivity.
Omnivore	An animal species that feeds on either plants or animals.
Pelagic	Relating to fish or other aquatic organisms that live offshore in the open water.
Permafrost	Permanently frozen subsoil occurring throughout the polar regions.
pH	A measure of the acidity or alkalinity of water.
Phytoplankton	Small, usually microscopic, plants that live in the water column of lakes and make their food through primary production.
Plankton	Small, often microscopic, plants (phytoplankton) and animals (zooplankton) that live in the open water column of lakes. They are an important food source for many larger animals.
Relative abundance	The proportional representation of the abundance of each species in a sample or a community.
Relative biomass	The proportional representation of the biomass of each species in a sample or a community.
Richness	The number of different types of animals present in a sample or at a location.
Rotifera	A phylum of microscopic and near-microscopic pseudocoelomate animals; a component of zooplankton.
Secchi Depth	A measure of water clarity, measured by lowering a 20 cm diameter disk (Secchi disk) with alternating black and white coloured quadrants. The shallowest depth at which the disk is no longer visible is the Secchi depth.
Sedges	A grass-like plant with a triangular stem often growing in wet areas. Sedge wetland habitats are typically wet sedge meadows and other sedge associations of non-tussock plant species. Sedge species such as *Carex aquatilis* and *C. bigelowii*, and cotton grass (*Eriophorum angustifolium*) are the dominant vegetation types. Plant species occupy wet, low-lying sites where standing water is present throughout much of the growing season.
Specific conductivity	A measure of the capacity of water to conduct an electrical current. It is the reciprocal of resistance. This measurement provides an estimate of the total concentration of dissolved ions in the water (specific conductance is normalized to 25°C).
Taxon	A group of organisms at the same level of the standard biological classification system; the plural of taxon is taxa.
Total dissolved solids	The total concentration of all dissolved compounds solids found in a water sample.
Total Kjeldahl nitrogen	The sum of organic nitrogen; ammonia (NH_3) and ammonium (NH_4^+).
Total richness	The total number of different taxa occupying a given area.
Tributary	A stream that flows into a larger stream or lake.
Trophic status	Eutrophication is the process by which lakes are enriched with nutrients, increasing the production of rooted aquatic plants and algae. The extent to which this process has occurred is reflected in a lake's trophic classification or status, which can be oligotrophic (nutrient poor), mesotrophic (moderately productive), or eutrophic (very productive).
Tundra	A vast, mostly flat, treeless Arctic region of Europe, Asia, and North America in which the subsoil is permanently frozen. The dominant vegetation is low-growing stunted shrubs, mosses, and lichens.
Upland	Forested or non-forested areas of the landscape with non-saturated and non-peat-forming soils. Excludes bogs, fens, swamps and marshes. Areas where the soil is not saturated for extended periods as indicated by vegetation and soils.
Waste Rock	Rock moved and discarded to access coal resources.
Waterbody	A general term that refers to rivers, streams, and lakes.
Watercourse	Riverine systems such as creeks, brooks, streams, and rivers.

Term	Description
Wetlands	Area where the water table is at, near, or above the surface or that is saturated for a long enough period to promote such features as wet-altered soils and water-tolerant vegetation. Wetlands include organic wetlands or peatlands, and mineral wetlands or mineral soil areas that are influenced by excess water but produce little or no peat.
Zooplankton	Small, sometimes microscopic, animals that live in the water column of lakes and mainly eat primary producers (phytoplankton).

Appendix A Historical Taxa Presence or Absence Summary

Appendix B 2013 Plankton Taxonomy Data