DOMINION DIAMOND

ANNEX XIII

BENTHIC INVERTEBRATE BASELINE REPORT FOR THE JAY PROJECT

BENTHIC INVERTEBRATE BASELINE REPORT FOR THE JAY PROJECT

Prepared for: Dominion Diamond Ekati Corporation

Prepared by: Golder Associates Ltd.

September 2014

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DOMINION DIAMOND

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Abbreviations

Abbreviation	Definition
AEMP	Aquatic Effects Monitoring Program
BHP	Broken Hill Proprietary Company
BHP Billiton	BHP Billiton Canada Inc. including subsidiary BHP Billiton Diamonds Inc.
BSA	baseline study area
Diavik Mine	Diavik Diamond Mine
Dominion Diamond	Dominion Diamond Ekati Corporation
DDMI	Diavik Diamond Mines Inc.
e.g.,	for example
Ekati Mine	Ekati Diamond Mine
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
NAD	North American Datum
NWT	Northwest Territories
Project	Jay Project
QA	quality assurance
QC	quality control
Rescan	Rescan Environmental Services Ltd.
SDI	Simpson’s diversity index
SEI	Simpson’s evenness index
TOC	total organic carbon
UTM	Universal Transverse Mercator
X	sample collected

Units of Measure

Unit	Definition
%	percent
μm	micrometre
μS/cm	microsiemens per centimetre
°C	degrees Celsius
cm	centimetre
km	kilometre
km^2	square kilometre
m	metre
m/s	metres per second
masl	metres above sea level
mm	millimetre
n	number of replicates
No.	number
org/m^2	number organisms per square metre
taxa/station	taxa per station

1 INTRODUCTION

1.1 Background

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).

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

BENTHIC INVERTEBRATE 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_045_GIS	
DESIGN	CG	24/07/14	SCALE AS SHOWN	REV. 0
GIS	ANK	08/09/14		
CHECK	CG	08/09/14	MAP 1.1-1	
REVIEW	SM	08/09/14		

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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

BENTHIC INVERTEBRATE 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_046_GIS	
DESIGN	SM	12/08/14	SCALE AS SHOWN	REV 0
GIS	ANK	08/09/14	MAP 1.1-2	
CHECK	CG	08/09/14		
REVIEW	SM	08/09/14		

This baseline report describes existing benthic invertebrate communities in waterbodies within the Lac du Sauvage and Lac de Gras basins. The benthic invertebrate 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 effects on valued components, and will help to identify mitigation and protective actions that could be implemented to avoid or reduce potentially adverse effects of the Project on the existing environment.

1.2 Objectives

The objectives of the benthic invertebrate baseline program were to characterize:

- benthic invertebrate communities in lakes and streams within the baseline study area during open-water conditions, according to density, richness, and community composition; and,
- spatial and temporal variability in benthic invertebrate communities, where possible.

The following two approaches were used to meet these objectives:

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

Section 2 summarizes the available historical benthic invertebrate community data from baseline and monitoring programs related to the Ekati AEMP (Rescan 2012, ERM Rescan 2013), the 2006 Jay pipe aquatic baseline study (Rescan 2007), and the Diavik AEMP (Golder 2011; DDMI 2012, 2013). These data sources were reviewed and relevant data were compiled to provide regional context.

Section 3 describes the methods for the collection and analysis of benthic invertebrate community data in the 2013 baseline program. The results of the 2013 benthic invertebrate community sampling program are also provided in this section.

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. Outflow from Lac de Gras discharges to the Coppermine River, which drains into the Arctic Ocean at Coronation Gulf.

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 SITE
- INCLUDED HISTORICAL SITE

NOTES

(a) STATION F16 WAS ONLY SAMPLED IN 1996; FOR THE HISTORICAL REVIEW THIS STATION WAS CLASSIFIED AS PART OF THE FF1 AREA FOR EASE OF REFERENCE.

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

BENTHIC INVERTEBRATE BASELINE REPORT

5 0 5
SCALE 1:225,000 KILOMETRES

PROJECT
DOMINION DIAMOND
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

HISTORICAL BENTHIC INVERTEBRATE COMMUNITY SAMPLING LOCATIONS

Golder Associates

PROJECT	13-1328-0041		FILE No. B_JC_Aqua_036_GIS	
DESIGN	CC	02/04/14	SCALE AS SHOWN	REV 0
GIS	ANK	12/09/14		
CHECK	CG	12/09/14	MAP 1.3-1	
REVIEW	SM	12/09/14		

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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); 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 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 Benthic Invertebrate Community Study Area

Lake and stream stations included in the historical review (Map 1.3-1) were:

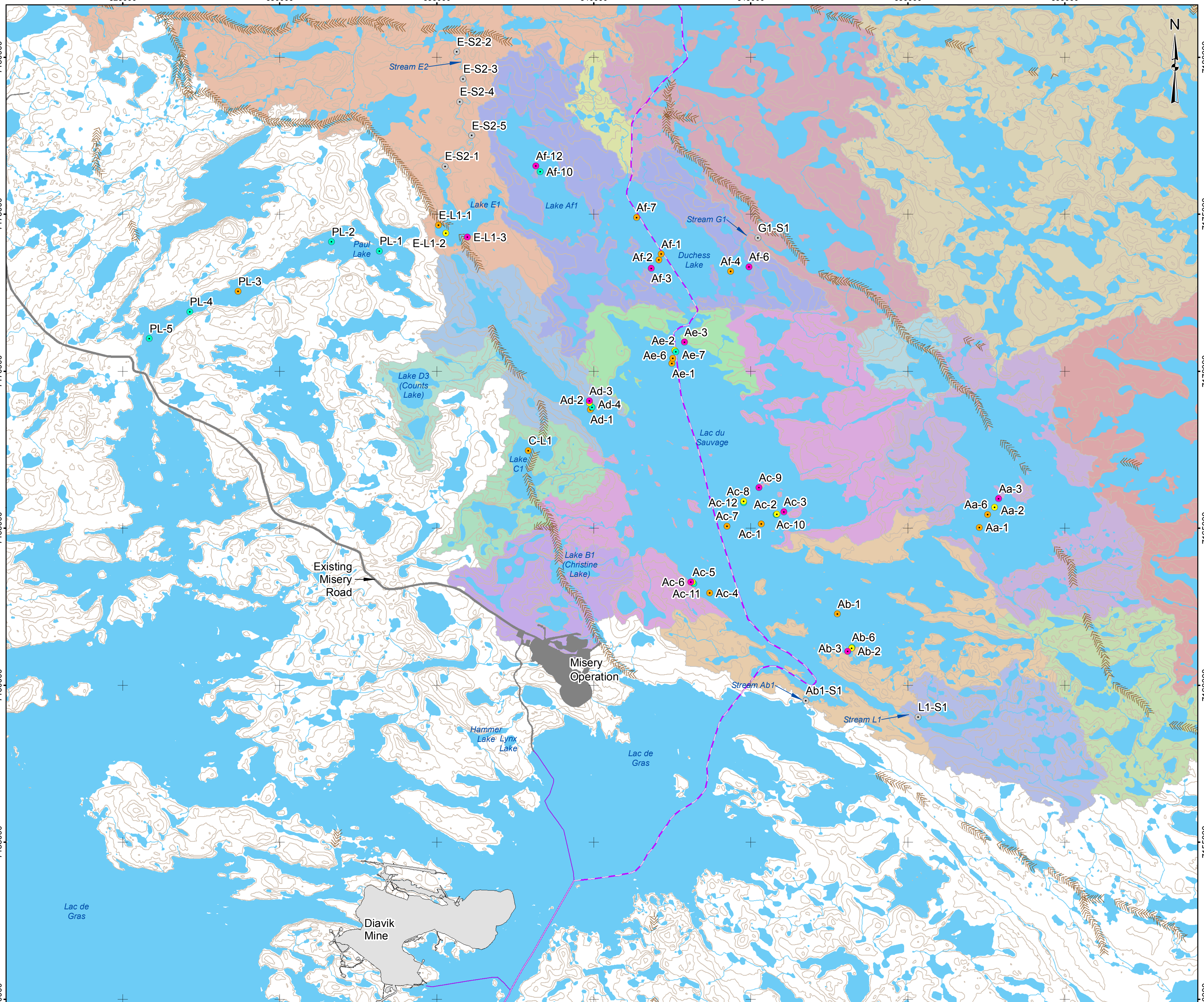
- Lac du Sauvage basin: Lac du Sauvage in A sub-basin, Lake B1 (Christine Lake) in B sub-basin, Lake D3 (Counts Lake and its outflow) in D sub-basin, and Ursula Lake in E sub-basin; and,
- Lac de Gras basin: Lac de Gras, Nanuq Lake and its outflow, Vulture Lake, and the Vulture-Polar Outflow.

Historic stations located in areas exposed to treated effluent were excluded from the historical review, with exceptions; further details are provided in Section 2.

1.3.3 2013 Benthic Invertebrate Community Baseline Study Area

The 2013 benthic invertebrate community baseline study area (BSA) included the following lakes and streams (Map1.3-2):

- Lac du Sauvage basin:
  - Lakes: Lac du Sauvage, Duchess Lake, and Lake Af1 in the A sub-basin, Lake C1 in the C sub-basin, and Lake E1 in the E sub-basin; and,
  - Streams: Stream Ab1 in the A sub-basin, Stream G1 in the G sub-basin, Stream L1 in the L sub-basin, and Stream E2 in the E sub-basin.
- Lac de Gras basin: Paul Lake.



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LEGEND

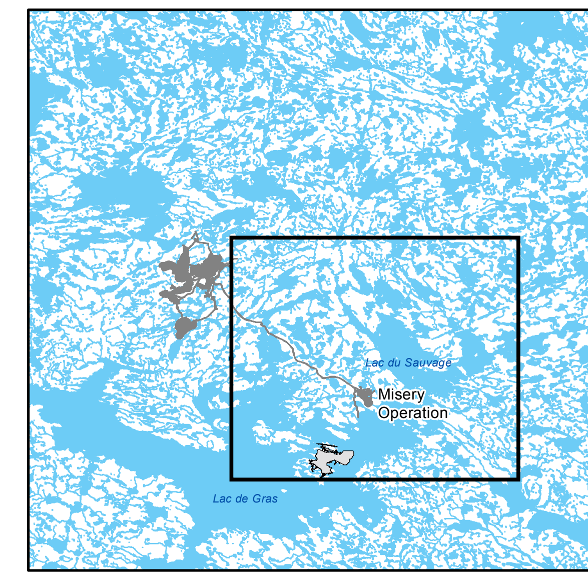
- EKATI MINE FOOTPRINT
- DIAVIK MINE FOOTPRINT
- WINTER ROAD
- TIBBITT TO CONTWOYTO WINTER ROAD
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- ELEVATION CONTOUR (10 m INTERVAL)
- ESKER
- WATERCOURSE
- WATERBODY

STATION DEPTH CATEGORIES

- LITTORAL STATION
- SHALLOW STATION
- MID-DEPTH STATION
- DEEP STATION
- STREAM STATION

BASIN

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



REFERENCE

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

DOCUMENT

BENTHIC INVERTEBRATE BASELINE REPORT

2.5 0 2.5

SCALE 1:125,000 KILOMETRES

PROJECT

DOMINION DIAMOND™

JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE

BENTHIC INVERTEBRATE COMMUNITY SAMPLING LOCATIONS, 2013

Golder Associates

PROJECT	13-1328-0041	FILE No. B_JC_Aqua_015_GIS	
DESIGN	AC	20/12/13	SCALE AS SHOWN	REV 0
GIS	ANK	08/09/14	
CHECK	CG	08/09/14	MAP 1.3-2
REVIEW	SM	08/09/14	

1.3.4 2013 Basin and Lake 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 (Annex IX, Hydrology Baseline, Appendix D – Basin Characteristics).

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

- Major sub-basins were identified using a capital letter (e.g., 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 sub-basins, designated using an additional lower case letter (e.g., Aa, Ab, Ac). These were designated according to internal basins as identified by the available coarse bathymetry.
- Lake names were designated by the basin letter and lake number (e.g., 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.

Where applicable, lake names in this baseline report also reference the Ekati lake names consistent with the terminology in historical reports, for example, Lake B1 (Christine Lake) and Lake D3 (Counts Lake).

2 HISTORICAL BENTHIC INVERTEBRATE COMMUNITY

2.1 Data Sources

The historical benthic invertebrate data used for this summary were obtained from the following sources:

- baseline and long-term AEMP data from 1996 to 2013 for the Diavik Mine, summarized by DDMI (2001, 2002, 2010, 2011, and 2012) and Golder (1996, 2011);
- baseline and long-term AEMP data from 1994 to 2013 for the Ekati Mine, summarized by reports Rescan (1995, 2002, 2011) and ERM Rescan (2013); and,
- baseline data from a 2006 baseline program for the proposed development of the Jay pipe as part of the Ekati Mine summarized by Rescan (2007).

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

- **Ekati Mine:** No Ekati mine-related impacts on total benthic invertebrate density or dipteran diversity have been documented (ERM Rescan 2013). Although overall densities have not changed, relative densities of Orthocladiinae have decreased within the Chironomidae, while densities of Diamesinae, Prodiamesinae, and Chironominae have increased in all lakes in the Ekati Project Area, except for the reference lakes (ERM Rescan 2013). These changes were noted in 2005, although the exact reason for the shift is unknown (ERM Rescan 2013). It is hypothesized that changes in the absolute quantities or relative availability of nitrogen and phosphorus are likely the underlying cause for the shift, rather than sensitivities of different species to changes in water quality (ERM Rescan 2013). Changes in water quality have been documented within lakes that are located downstream of the Long Lake Containment Facility and Ekati Mine King Pond Settling Facility (Rescan 2007; ERM Rescan 2013). Therefore, the majority of lake stations from the Ekati AEMP were excluded from this historical summary, except for Stations S2 and S3 in Lac de Gras, which are important for characterizing the mid-depth and deep benthic invertebrate communities at the northern end of Lac de Gras, and LDS1, which is located within the Jay pipe study area.
- **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 were possibly due to the location of Christine Lake, downstream of the discharge from the Ekati Mine King Pond Settling Facility (Rescan 2007). Despite the potential project-related effects on water quality and potentially on aquatic life, 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 East 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 benthic invertebrate baseline program and AEMP stations that were included in this historic review are located in Lac de Gras (Map 1.3-1). There are additional water quality stations in the Coppermine River and Lac du Sauvage. The 1997 baseline data were available for only the far-field reference area 1 (FF1 area); baseline data were not collected from the other far-field reference areas currently monitored as part of the AEMP (Golder 2011). The FF1 area was referred to as F16 in the 1997 baseline report; however, as it falls within the FF1 area, it is referred to as FF1 in this historical review. Diavik Mine AEMP data were reported for the far-field/exposure area 2 (FF2 area) as well as for the other far-field/reference areas (FFA, FFA, and FFB) (Map 1.3-1).

The Diavik Mine benthic invertebrate baseline surveys took place in 1996 and 1997 as part of the environmental assessment for the Diavik Mine (Golder 1996). Benthic invertebrate sampling has taken place from 2001 to 2011 as part of the Diavik Mine AEMP (Golder 2011; DDMI 2012). Sampling was completed annually in the summer (i.e., early August/late August) up to 2011. Data are not available for 2012 and 2013 because the benthic invertebrate monitoring program was changed to a 3-year program in 2011. All stations are classified as deep; they are at locations approximately 20 metres (m) in depth.

2.2.1.2 Field and Laboratory Methods

Detailed field and laboratory methods for the Diavik Mine AEMP benthic invertebrate program are presented in the 2011 AEMP Annual Report (DDMI 2012). 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

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 benthic invertebrate baseline survey and AEMP evaluated lakes and streams in the Lac du Sauvage basin (Lac du Sauvage, and Counts Lake [Lake D3] and its outflow stream) and the Lac de Gras basin (Lac de Gras, Vulture Lake and its outflow, and Nanuq Lake and its outflow stream). One mid-depth station (LDS1) was evaluated in Lac du Sauvage, and three stations (shallow, mid-depth and deep) were evaluated at Counts Lake, which is a reference lake situated southeast of the Ekati camp. One mid-depth (iS2) and one deep (S3) station were sampled in Las de Gras. Three stations (shallow, mid-depth, and deep), were evaluated in both Vulture Lake and Nanuq Lake, which are located within the northeast corner of the Ekati claim block, just beyond the Lac de Gras basin boundary in the Coppermine River basin (ERM Rescan 2013). For the purposes of this historical review, Nanuq Lake was included in the Lac de Gras basin lakes.

Table 2.2-1 Summary of Historical Benthic Invertebrate Studies in the Jay Project Baseline Study Area

Waterbody	Project	Year	Location	Number of Stations	Sampling Depth	Sampler Type and Surface Area	Mesh Size	Number of Sub-Samples	Source
Depositional Habitat									
Lac du Sauvage	Ekati Mine AEMP	2000 to 2012	LDS1	1	mid-depth (5.1 to 10 m)	Ekman grab	500 µm; 250 µm (2010 to 2012)	3	ERM Rescan 2013
	Jay Pipe 2006 Baseline	2006	LDS1 to LDS12	12	shallow (<5 m; six stations), mid-depth (5.1 to 10 m; three stations), and deep (>10 m; four stations)	Ekman grab	595 µm	3	ERM Rescan 2013
Counts Lake (Lake D3)	Ekati Mine Baseline	1997	-	1	shallow (<5 m; 1997)	Ekman grab	595 µm (field)	3	ERM Rescan 2013
	Ekati Mine AEMP	1998 to 2012	-	2 to 3	shallow (<5 m; 1999 to 2006), mid-depth (5.1 to 10 m; 1998 to 2012), and deep (>10 m: 1998 to 2012)	Ekman grab	500 µm; 250 µm (2010 to 2012)	3	ERM Rescan 2013
Christine Lake (Lake B1)	Jay Pipe 2006 Baseline	2006	Christine (CL-1)	1	mid-depth (5.1 to 10 m)	Ekman grab	595 µm	3	Rescan 2007
Ursula Lake	Jay Pipe 2006 Baseline	2006	UL3	1	shallow (<5 m)	Ekman grab	595 µm	3	Rescan 2007
Lac de Gras	Diavik Mine Baseline Program	1996	FF1[(a)]	3	20 m	Ekman grab	250 µm	3	DDMI 1998
	Diavik Mine AEMP	2001 to 2011	FF1	5	20 m	Ekman grab	500 µm	6 sub-samples composited	DDMI 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013
	Diavik Mine AEMP	2001 to 2011	FF2	5	20 m	Ekman grab	500 µm	6 sub-samples composited	

Table 2.2-1 Summary of Historical Benthic Invertebrate Studies in the Jay Project Baseline Study Area

Waterbody	Project	Year	Location	Number of Stations	Sampling Depth	Sampler Type and Surface Area	Mesh Size	Number of Sub-Samples	Source
Depositional Habitat (Continued)									
Lac de Gras	Diavik Mine AEMP	2001 to 2011	FFA	5	20 m	Ekman grab	500 µm	6 sub-samples composited	
	Diavik Mine AEMP	2001 to 2011	FFB	5	20 m	Ekman grab	500 µm	6 sub-samples composited	
	Ekati Mine Baseline	1994 and 1997	S2	1	mid-depth (5.1 to 10 m)	Ekman grab	595 µm (field)	3	ERM Rescan 2013
	Ekati Mine Baseline	1994 and 1997	S3	1	deep (>10 m)	Ekman grab	595 µm (field)	3	ERM Rescan 2013
	Ekati Mine AEMP	1998 to 2012	S2	1	mid-depth (5.1 to 10 m)	Ekman grab	500 µm; 250 µm (2010 to 2012)	3	ERM Rescan 2013
	Ekati Mine AEMP	1998 to 2012	S3	1	deep (>10 m)	Ekman grab	500 µm; 250 µm (2010 to 2012)	3	ERM Rescan 2013
Vulture Lake	Ekati Mine Baseline	1994 to 1997	-	2 to 3	one shallow (<5 m; 1994 to 1997), one mid-depth (5.1 to 10 m; 1994 to 1996), and one deep (>10 m; 1994 to 1997)	Ekman grab	595 µm	3	ERM Rescan 2013
	Ekati Mine AEMP	1998 to 2011	-	2 to 3	one shallow (<5 m; 1999 to 2006), one mid-depth (5.1 to 10 m; 1998 to 2005), and one deep (>10 m; 1998 to 2011)	Ekman grab	500 µm; 250 µm (2010 to 2012)	3	ERM Rescan 2013

Table 2.2-1 Summary of Historical Benthic Invertebrate Studies in the Jay Project Baseline Study Area

Waterbody	Project	Year	Location	Number of Stations	Sampling Depth	Sampler Type and Surface Area	Mesh Size	Number of Sub-Samples	Source
Depositional Habitat (Continued)									
Nanuq Lake	Ekati Mine Baseline	1997	-	2 to 3	shallow (<5 m; 1997), mid-depth (5.1 to 10 m; 1997), and deep (>10 m, 1997)	Ekman grab	595 µm	3	ERM Rescan 2013
	Ekati Mine AEMP	1998 to 2012	-	2 to 3	shallow (<5 m; 1999 to 2005), mid-depth (5.1 to 10 m; 1998 to 2012), and deep (>10 m; 1998 to 2012)	Ekman grab	500 µm; 250 µm (2010 to 2012)	3	ERM Rescan 2013
Littoral Habitat									
Lac du Sauvage	Jay Pipe 2006 Baseline	2006	B1, B2, B4, B5[b]	4	<5 m	Ekman grab	595 µm	3	Rescan 2007
Near-shore Boulder Habitat									
Lac du Sauvage	Jay Pipe 2006 Baseline	2006	B1 to B5	5	<5 m	Hester-Dendy artificial substrates	595 µm	3	Rescan 2007
Erosional Habitat									
Nanuq Outflow (1997), Vulture-Polar Outflow (1995 and 1997), and Counts Outflow (1997)	Ekati Mine Baseline	1995 and 1997	-	1	unknown	Hess sampler	250 µm	5[d]	ERM Rescan 2013
Nanuq Outflow, Vulture-Polar Outflow, and Counts Outflow	Ekati Mine AEMP	1998 to 2012[c]	-	1	unknown	Hester-Dendy artificial substrates	106 µm	5[d]	ERM Rescan 2013

a) Station F16 is located in the far-field 1 (FF1) area currently monitored for the Diavik Mine AEMP. This station is categorized within the FF1 area for ease of reference in this historical review.

b) Station B3 was not sampled due to rocky substrate preventing the collection of an Ekman grab sample.

c) 2010 data omitted due to laboratory error.

d) Three replicates were collected in 1997 and 1998.

AEMP = Aquatic Effects Monitoring Program; <= less than; >= greater than; m = metre; µm = micrometre; - = stations were not formally named.

Baseline data for the Ekati Mine include lake and stream data collected from 1994 to 1997; benthic invertebrate sampling was completed in late July or early August. The Ekati AEMP has been operating since 1998 and data from the AEMP benthic invertebrate program were available from 1998 to 2012. Benthic invertebrate sampling began in Lac du Sauvage in 2000. The AEMP benthic invertebrate program in the lakes and streams included in this historical review occurs annually during the summer (August) sampling period.

2.2.2.2 Field and Laboratory Methods

Detailed field and laboratory methods for the Ekati AEMP benthic invertebrate program are presented in the 2012 Ekati 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 Baseline Program

2.2.3.1 Sampling Locations and Timing

The Jay pipe is located under the southeast region of Lac du Sauvage. The Jay pipe aquatic baseline program took place in 2006 and was the first year of a two-year baseline program to support the environmental assessment and a future AEMP for the development of the Jay pipe (Rescan 2007). As part of the 2006 baseline program, 12 lake stations and 9 shoreline stations (including 5 boulder and 4 littoral stations) were sampled in Lac du Sauvage, including LDS1, which is sampled as part of the Ekati AEMP (Rescan 2007 ERM Rescan 2013; Map 1.3-1). Stations were classified as shallow (i.e., less than 5 m deep) and deep (i.e., greater than 10 m deep). Lake stations LDS2, LDS4, LDS6, LDS9, and LDS12 were shallow water stations. Stations LDS1, LDS7, and LDS10 were mid-depth stations. Stations LDS3, LDS5, LDS8, and LDS11 were deep water stations. In addition, one mid-depth station was sampled in Christine Lake (Lac du Sauvage basin), which is within the Ekati exposure area. Baseline data were also collected from one shallow station 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). Although three stations were established in Ursula Lake, two stations were not sampled due to boulder substrates.

The Jay pipe aquatic baseline program involved one summer sampling period in 2006 (i.e., August) for benthic invertebrates.

2.2.3.2 Field and Laboratory Methods

Detailed field and laboratory methods for the Jay pipe benthic invertebrate baseline program are presented in the Ekati Mine 2006 Jay Pipe Aquatic Baseline Report (Rescan 2007). Two different sampling methods were used depending on substrate type: an Ekman grab sampler (soft substrates in depositional areas) or a Hester-Dendy artificial substrates (boulder habitat in littoral areas). Sampling methods relevant to this historical review are summarized in Table 2.2-1.

2.2.4 Data Assessment Approach

The development of this historical summary report entailed a review and synthesis of a large amount of benthic invertebrate community data from the three sampling programs described above. In addition to compiling the data from the three programs, the review required additional data analyses using publicly available data.

Direct comparisons of data among programs were limited by differences in the mesh size and sampling depth (Table 2.2-1). Due to these differences among programs, comparisons presented in this report are largely qualitative.

Historical benthic invertebrate data were prepared for compilation and review by excluding non-benthic organisms (i.e., planktonic and terrestrial invertebrates) from samples collected using 250 and 500 micrometre (µm) mesh. Meiofauna (Nematoda, Harpacticoida, Ostracoda) were removed for samples processed using a 500 µm mesh because only a fraction of these specimens will be captured with this mesh size. Typically, meiofauna are retained in samples processed using a 250 µm mesh, but because two mesh sizes were used for the historical lake samples, meiofauna were consistently removed from all datasets regardless of mesh. Although non-benthic taxa and meiofauna represented a small proportion of the historical benthic invertebrate communities, this exclusion step caused the values presented in this historical summary to differ slightly from the values presented in the Jay pipe 2006 baseline report (Rescan 2007) and AEMP results (ERM Rescan 2013). Because all stream samples were collected with a 250 µm mesh, meiofauna were not removed from the stream dataset. All calculated values, tables, and summary figures generated from the dataset underwent an additional quality assurance and quality control (QA/QC) verification by a second person not involved in the initial calculations.

To allow for comparisons of benthic invertebrate communities among similar habitat types, stations were grouped by habitat type as follows before data analysis: pelagic (i.e., shallow [less than 5 m], mid-depth [5 to 10 m], and deep [greater than 10 m]); near-shore boulder (near-shore habitats with boulder habitat); and littoral (i.e., near-shore habitats with soft substrates).

The following variables were qualitatively evaluated:

- total density (number of organisms per square metre [org/m^2]);
- richness (total number of taxa per station [taxa/station] at the lowest level of identification);
- Simpson's diversity index (SDI, a means of measuring taxonomic diversity);
- Simpson's evenness index (SEI, a means of measuring the balance among numbers of different invertebrates present at a location); and,
- relative densities of major benthic invertebrate taxa.

2.3 Results

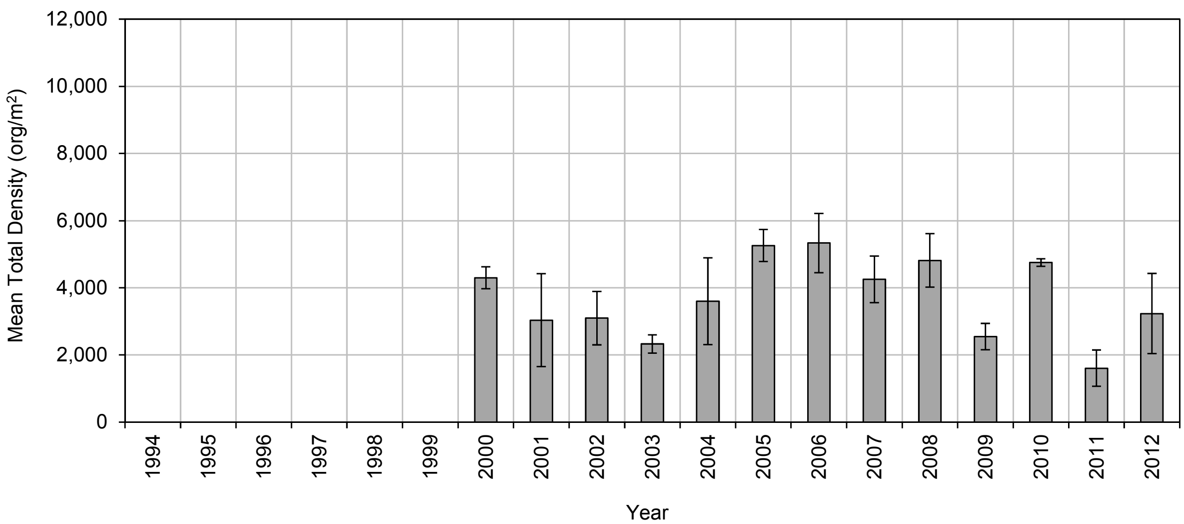
2.3.1 Lac du Sauvage Basin

2.3.1.1 Lac du Sauvage

Mean Total Density and Total Richness

Mean total density at Station LDS1 in in Lac du Sauvage exhibited variability between 1997 and 2012, ranging from 1,605 org/m^2 (2011) to 5,333 org/m^2 (2008) (Figure 2.3-1). In most years, mean total density was greater than 3,000 org/m².

Figure 2.3-1 Mean Total Density of Benthic Invertebrates in Lac du Sauvage at Station LDS1, 2000 to 2012



Source: ERM Rescan (2013).
Note: Error bars represent one standard error of the mean.
org/m^2 = number or organisms per square metre.

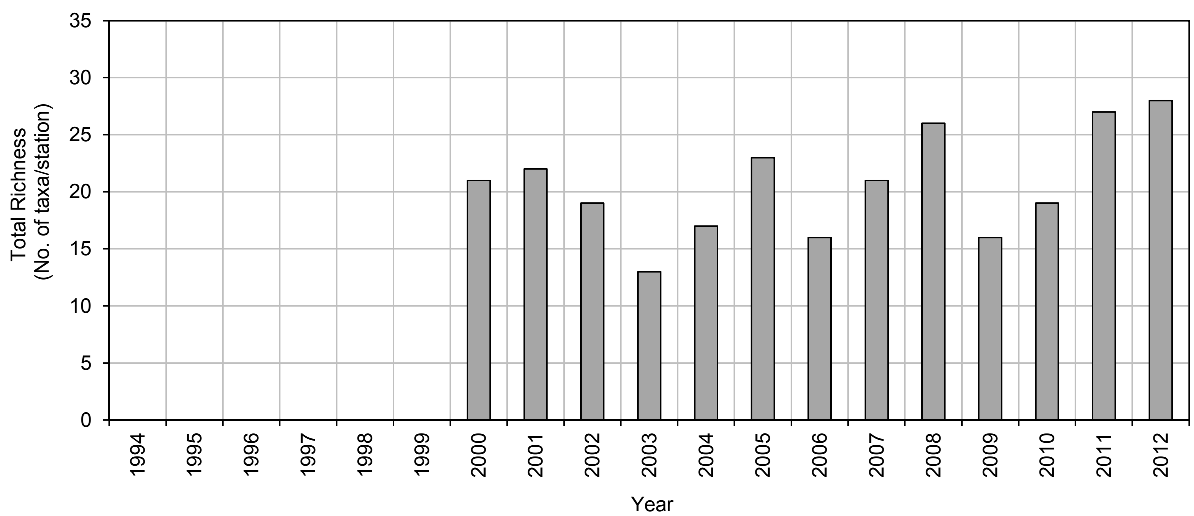
The 2006 mean total densities at depositional lake stations in Lac du Sauvage were variable, even when differences in sampling depth were accounted for (Appendix A, Historical Benthic Invertebrate Data Tables and Figures, Figure A-1). Mean total densities were highest at the shallow stations (489 to 10,874 org/m^2) and mid-depth stations (637 to 11,230 org/m^2), and lowest at the deep stations (489 to 3,511 org/m^2).

Within near-shore boulder habitat in 2006, the mean total density ranged from 282 org/m^2 to 1,616 org/m^2 (Appendix A, Figure A-2). Within littoral habitat, mean total density ranged from 503 org/m^2 to 3,066 org/m^2 (Appendix A, Figure A-3).

In general, moderate variability in total richness at Station LDS1 in Lac du Sauvage has been observed between 2000 and 2012 (Figure 2.3-2). Overall, richness has ranged from a minimum of 13 taxa (2003) to a maximum of 28 taxa (2012); the highest richness values were noted in 2011 and 2012.

In 2006, total richness varied by depth at the 12 lake stations in Lac du Sauvage. Total richness was lowest at the deep and mid-depth stations, and highest at a shallow station (Appendix A, Figure A-4). Total richness ranged from 6 taxa (LDS7, mid-depth) to 21 taxa (LDS6, shallow) in 2006. At the near-shore boulder stations, total richness ranged between 11 and 19 taxa (Appendix A, Figure A-5); at the littoral stations, total richness was similar, ranging between 13 and 21 taxa (Appendix A, Figure A-6).

Figure 2.3-2 Total Benthic Invertebrate Richness in Lac du Sauvage at Station LDS1, 2000 to 2012



Source: ERM Rescan (2013).
No. of taxa/station = number of taxa per station.

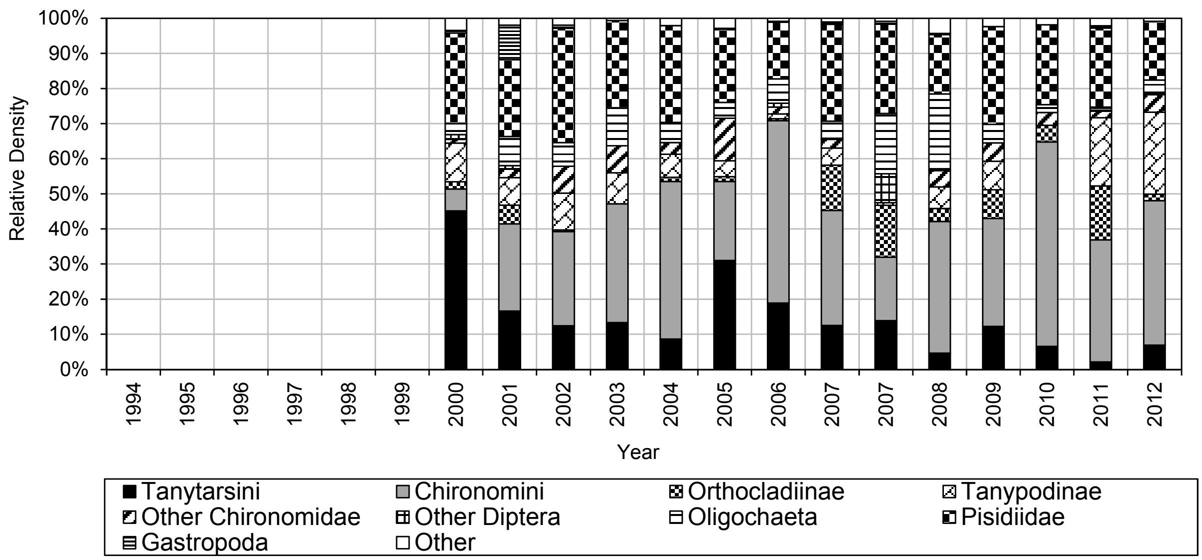
Community Composition by Major Taxonomic Group

The benthic invertebrate community at Station LDS1 has consistently been dominated by Chironomidae (non-biting midges), which have accounted for greater than 50% of the total density since 1997 (Figure 2.3-3). Pisidiidae (fingernail clams) have regularly accounted for between 10% and 25% of the benthic invertebrate community. Oligochaeta (worms), followed by Gastropoda (snails), have varied annually (between 1% and 35%). Acari (mites), *Hydra*, Eubranchiopoda (tadpole shrimp), Turbellaria (flatworms), and Trichoptera (caddisflies) have all contributed a small proportion of the overall benthic invertebrate abundance (approximately 1% each).

Between 1997 and 2012, the benthic invertebrate taxa present in Lac du Sauvage were generally similar among years (Appendix A, Table A-1). Several major taxa, including Oligochaeta (Lumbriculidae), Pisidiidae, and Chironomidae (*Tanytarsus*, *Monodiamesa*, and *Procladius*) were present in all years.

In 2006, the Chironomidae was the dominant taxonomic group at 10 of the 12 Lac du Sauvage stations. Hydrozoa (*Hydra*) were the dominant group at two stations (52% and 65%), but also accounted for greater than 20% of the benthic invertebrate community at six other stations (Appendix A, Figure A-7). Pisidiidae contributed 2% to 30% of the benthic invertebrate abundance at all stations. Oligochaeta accounted for approximately 25% of the benthic invertebrate community at two mid-depth stations. Turbellaria, Acari, Gastropoda, Trichoptera, and other Diptera (flies) accounted for less than 10% of the benthic invertebrate community.

Figure 2.3-3 Relative Density of Benthic Invertebrates in Lac du Sauvage at Station LDS1, 2000 to 2012



Source: ERM Rescan (2013).
Note: "Other" category includes *Hydra*, Turbellaria, Eubranchiopoda, Acari, and Trichoptera.
% = percent.

Chironomidae was also the dominant taxonomic group at the near-shore boulder and littoral habitats in Lac du Sauvage in 2006, although the dominant subfamily or tribe varied by station (Appendix A, Figures A-8 and A-9). At the near-shore boulder stations, Pisidiidae and Turbellaria were also well-represented, and Oligochaeta were present at all stations. Other groups including Acari, Gastropoda, and Trichoptera, were represented in small proportions at several stations, although the proportions of each differed between the habitat types.

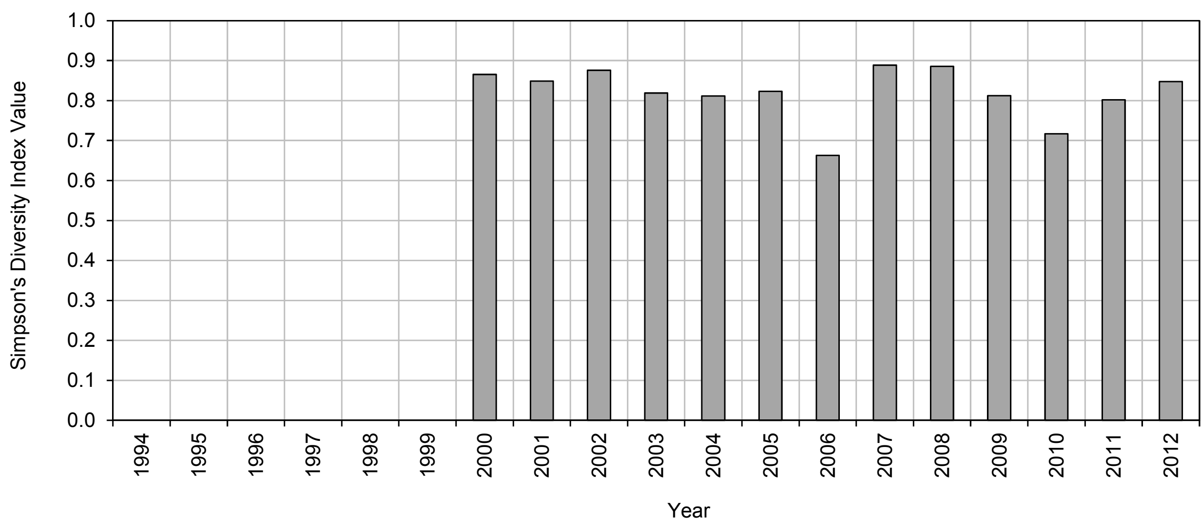
The benthic invertebrate community composition in Lac du Sauvage was variable among stations in 2006 (Appendix A, Table A-2). Although depth was a factor, community composition also varied among stations located at similar depths.

Benthic Invertebrate Community Indices

The SDI values have remained relatively stable at the mid-depth station LDS1 in Lac du Sauvage since 2000 (Figure 2.3-4). The SDI values have ranged between 0.66 (2006) and 0.89 (2007 and 2008), indicating a diverse benthic invertebrate community.

In 2006, SDI values were similar among all 12 stations sampled in Lac du Sauvage (Appendix A, Figure A-10). The SDI values ranged between 0.67 and 0.85 at the shallow stations, 0.58 and 0.83 at the mid-depth stations, and 0.41 and 0.76 at the deep stations. Overall, SDI values indicated a moderate to high level of community diversity at all depths.

Figure 2.3-4 Simpson's Diversity Index Values for the Benthic Invertebrate Community in Lac du Sauvage at Station LDS1, 2000 to 2012



Source: ERM Rescan (2013).

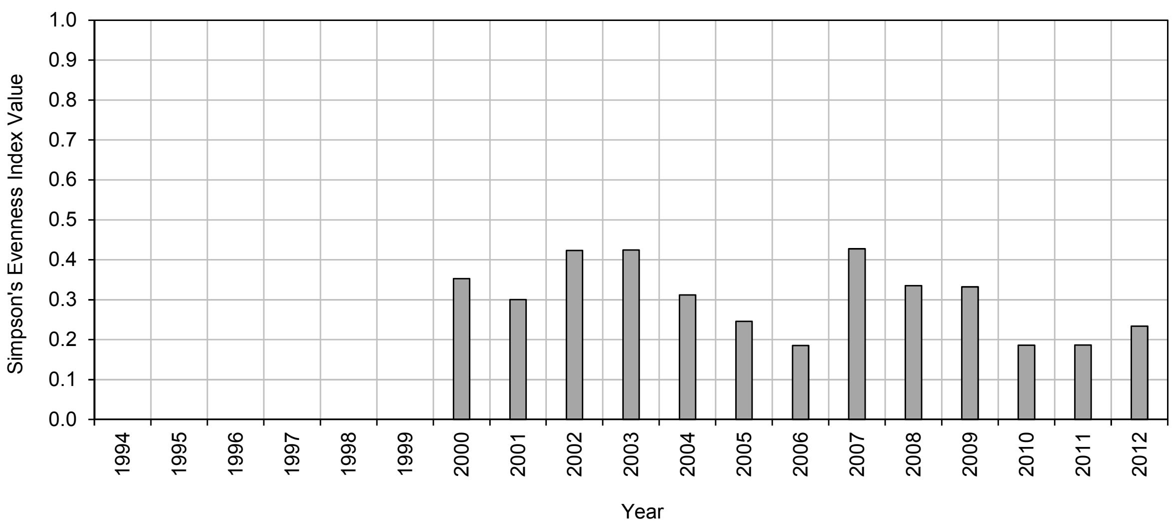
The SDI values were highest in littoral habitat in Lac du Sauvage in 2006; values ranged between 0.80 and 0.89 indicating a high level of diversity (Appendix A, Figure A-11). In the near-shore boulder habitat, SDI values had a greater range (0.66 and 0.88) indicating a moderate to high level of diversity (Appendix A, Figure A-12).

Evenness index values have been relatively stable over time at Station LDS1 in Lac du Sauvage (Figure 2.3-5). Values have ranged between 0.19 (2006) and 0.43 (2007), indicating that a few taxa accounted for the majority of the total density each year. Chironomidae typically dominated the benthic invertebrate community at Station LDS1, which resulted in low SEI values at this station. During the years where SEI values were slightly higher, taxonomic groups such as Oligochaeta and Pisidiidae contributed to larger proportion of the benthic invertebrate community.

Evenness index values were more variable at the 12 stations sampled in Lac du Sauvage in 2006 (Appendix A, Figure A-13). Evenness index values ranged between 0.17 and 0.43 at shallow stations, 0.23 and 0.26 at the mid-depth stations, and 0.13 and 0.71 at the deep stations. The high SEI value observed at Station LDS8 was due to an even distribution of Diptera (primarily Chironomidae), Oligochaeta, and Pisidiidae, each of which accounted for approximately 25% to 35% of the benthic invertebrate community.

Evenness index values were slightly higher at the littoral stations (0.37 to 0.64) compared to the boulder stations (0.18 to 0.51). This was due to a higher proportion of one or two taxonomic groups at each station (Appendix A, Figures A-14 and A-15).

Figure 2.3-5 Simpson's Evenness Index Values for the Benthic Invertebrate Community at Station LDS1 in Lac du Sauvage, 2000 to 2012



Source: ERM Rescan (2013).

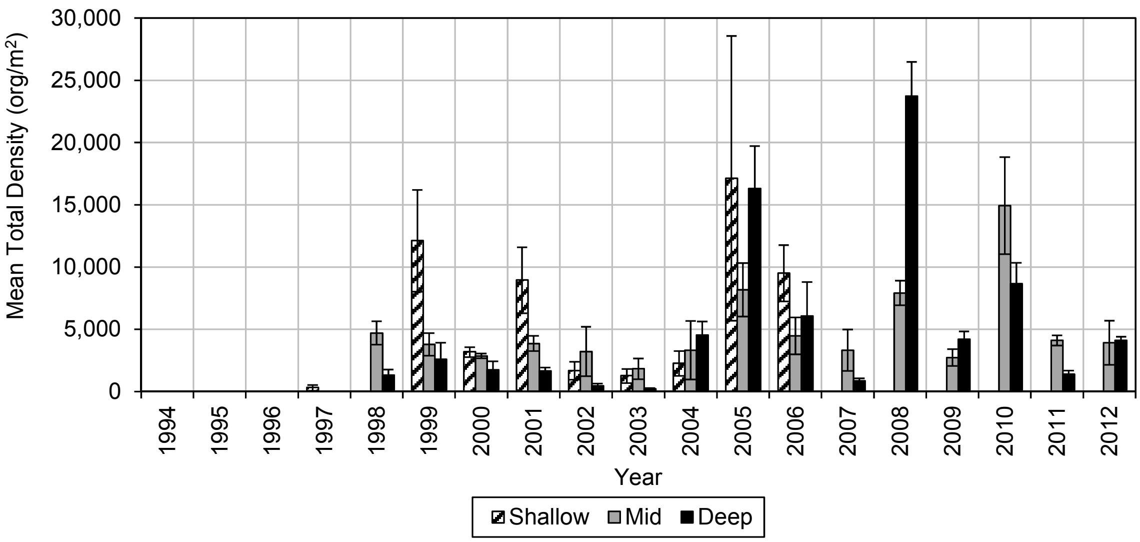
2.3.1.2 *Counts Lake (Lake D3)*

Mean Total Density and Total Richness

Mean total density in Counts Lake (Lake D3) has varied over time and among stations (Figure 2.3-6). At the shallow station, mean total density ranged from 296 org/m^2 (1997) to 17,126 org/m^2 (2005) between 1997 and 2006. Mean total density at the mid-depth and deep stations ranged from 1,822 org/m^2 (2003) to 14,932 org/m^2 (2010), and 207 org/m^2 (2003) to 23,733 org/m^2 (2008), respectively, between 1998 and 2012. Although densities have been variable among years, they have increased over time at the mid-depth and deep stations in Counts Lake.

Total richness in Counts Lake has also varied over time and among stations, with an increasing trend observed at the mid-depth and deep stations since 2007 (Figure 2.3-7), Between 1997 and 2006, total richness at the shallow station ranged from 11 taxa (1997) to 23 taxa (2005). Between 1998 and 2012, total richness ranged from 13 taxa (2001) to 32 taxa (2012) at the mid-depth station, and 6 taxa (2002 and 2003) to 28 taxa (2012) at the deep station.

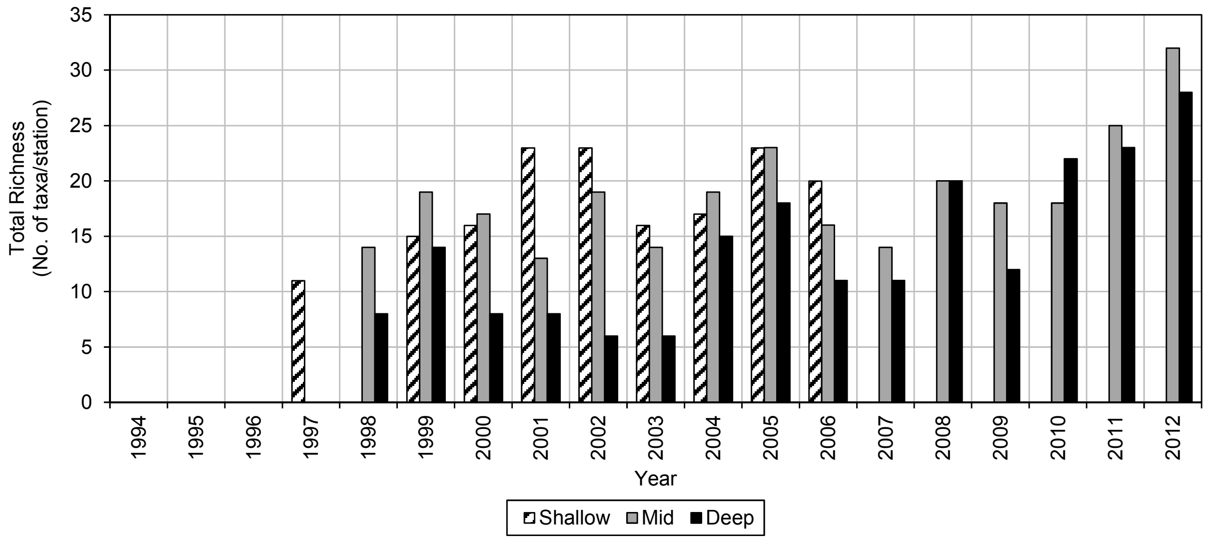
Figure 2.3-6 Mean Total Density of Benthic Invertebrates in Counts Lake, 1997 to 2012



Source: ERM Rescan (2013).

Note: Error bars represent one standard error of the mean.org/m^2 = number or organisms per square metre.

Figure 2.3-7 Total Benthic Invertebrate Richness in Counts Lake, 1997 to 2012



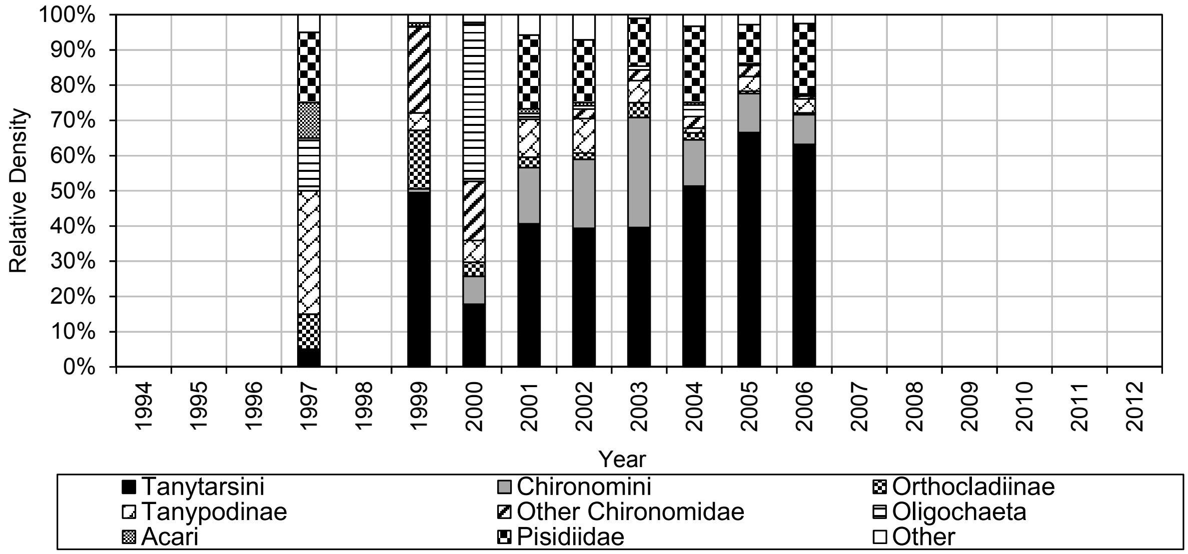
Source: ERM Rescan (2013).
No. of taxa/station = number of taxa per station.

Community Composition by Major Taxonomic Group

Between 1997 and 2006, the benthic invertebrate community at the shallow station in Counts Lake consisted primarily of Chironomidae (Tanytarsini, Chironomini, and Tanypodinae), with Pisidiidae typically accounting for 10% to 20% of the benthic invertebrate community (Figure 2.3-8). Chironomidae also dominated the benthic invertebrate communities at the mid-depth and deep stations between 1998 and 2012 (Figures 2.3-9 and 2.3-10). Pisidiidae contributed to a greater proportion of the community at the mid-depth and deep stations (up to 75%), and have increased proportionally in recent years. Chironomidae (Chironomini) has also increased proportionally over the years.

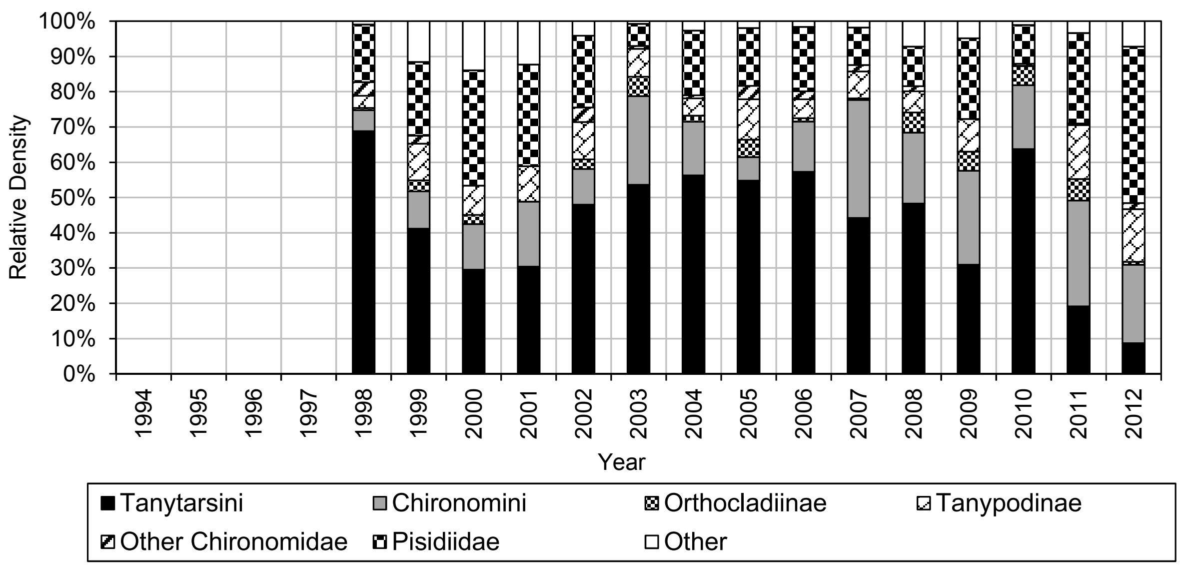
The chironomid, *Procladius*, has been present all years at the shallow station (Appendix A, Table A-1). Several other chironomid genera including *Pisidium*, *Procladius*, *Phaenopsectra*, and *Tanytarsus* were present most years. The same chironomid genera, as well as *Paratanytarsus*, were present most years at the mid-depth and deep station. Although present most years at the mid-depth station, *Phaenopsectra* was only present in 7 of the 15 years at the deep station.

Figure 2.3-8 Benthic Invertebrate Relative Density at Counts Lake Shallow Station, 1997 to 2006



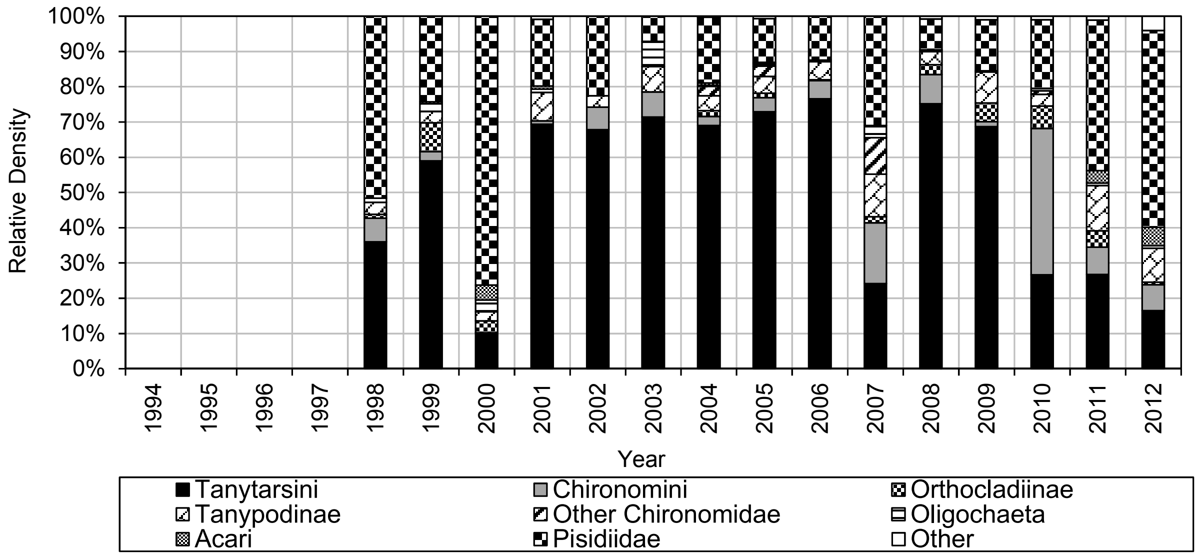
Source: ERM Rescan (2013).
Note: No data for "shallow station" in 1998.
"Other" category includes *Hydra*, Turbellaria, Trichoptera, Gastropoda, and other Diptera.

Figure 2.3-9 Benthic Invertebrate Relative Density at Counts Lake Mid-depth Station, 1998 to 2012



Source: ERM Rescan (2013).
Note: "Other" category includes Turbellaria, Oligochaeta, Eubranchiopoda, Acari, Trichoptera, and Gastropoda.
% = percent.

Figure 2.3-10 Benthic Invertebrate Relative Density at Counts Lake Deep Station, 1998 to 2012



Source: ERM Rescan (2013).

Note: "Other" category includes *Hydra*, Turbellaria, Eubranchiopoda, Trichoptera, and Gastropoda.

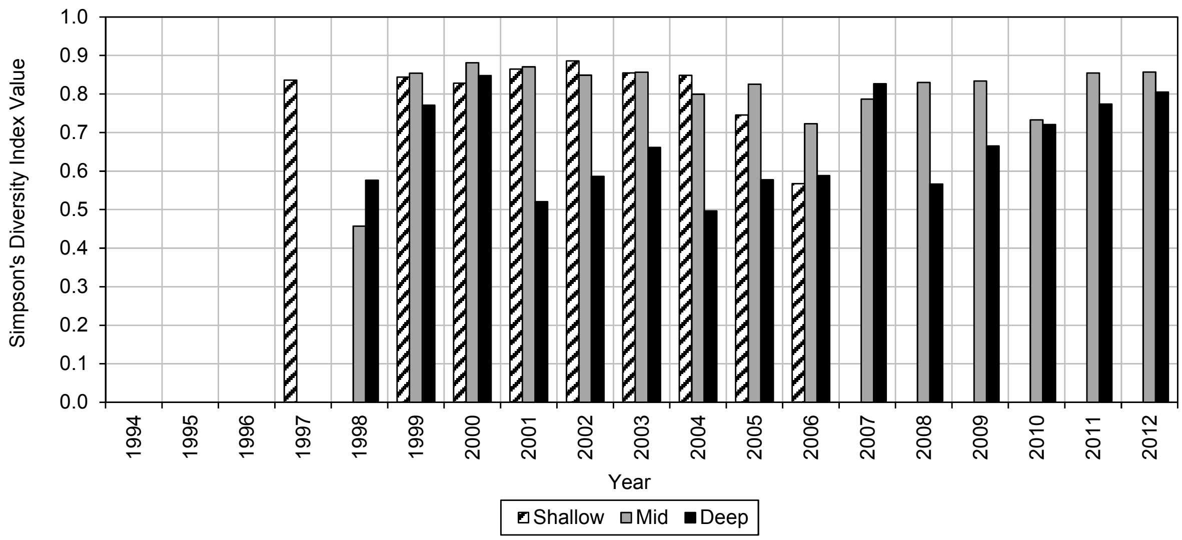
% = percent.

Benthic Community Indices

The SDI values exhibited variability over time and among stations, with the deep stations having the greatest temporal variability between 1998 and 2012 (Figure 2.3-11). Between 1997 and 2006, SDI values at the shallow station ranged from 0.57 (2006) to 0.88 (2002). Between 1998 and 2012, SDI values ranged from 0.46 (1998) to 0.88 (2000) at the mid-depth station, and 0.50 (2004) to 0.85 (2000) at the deep station, indicating a moderate to high level of diversity. The SDI has been stable at the shallow and mid-depth stations.

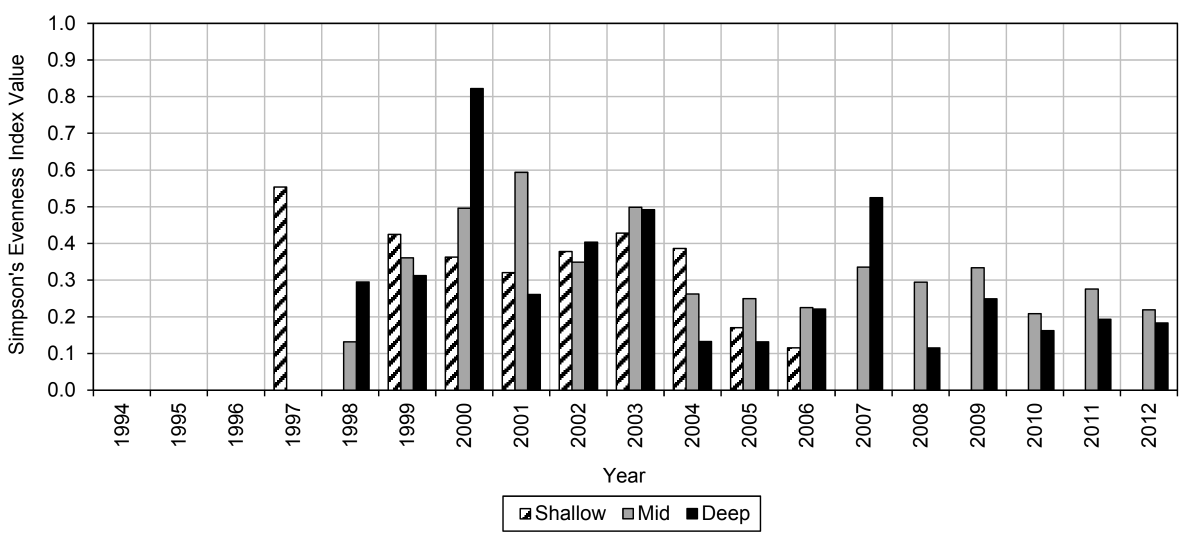
Evenness values have also exhibited variation over time and among stations; however, values have typically been low, indicating that a few taxa accounted for the majority of the total density in each year (Figure 2.3-12). Evenness values have ranged from 0.12 (2006) to 0.55 (1997) at the shallow station, 0.13 (1998) to 0.59 (2001) at the mid-depth station, and 0.12 (2008) to 0.82 (2000) at the deep station.

Figure 2.3-11 Simpson's Diversity Index Values for the Benthic Invertebrates in Counts Lake, 1997 to 2012



Source: ERM Rescan (2013).

Figure 2.3-12 Simpson's Evenness Index Values for the Benthic Invertebrate Community in Counts Lake, 1997 to 2012



Source: ERM Rescan (2013).

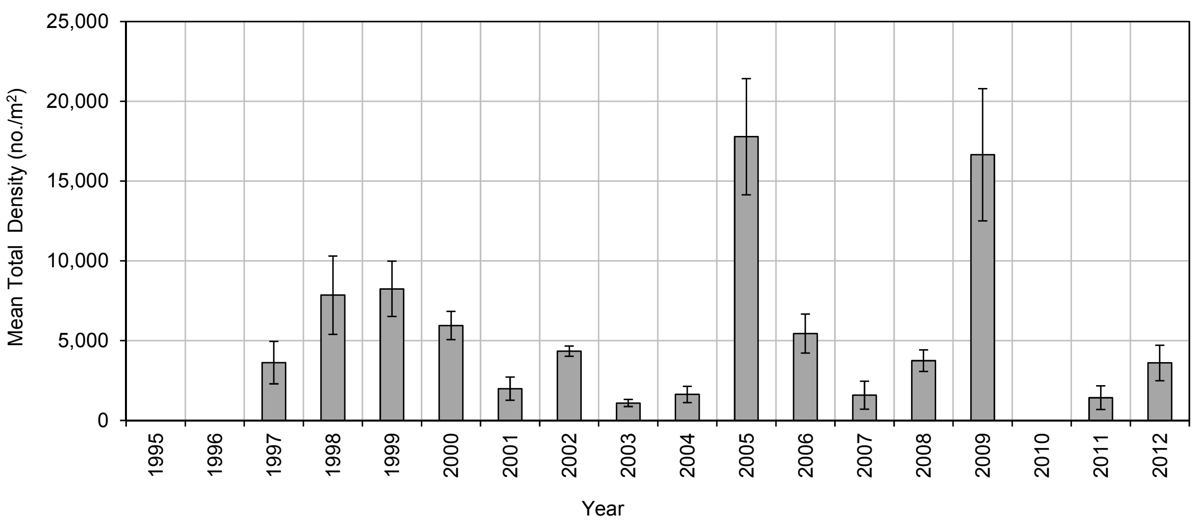
2.3.1.3 Counts Lake (Lake D3) Outflow

Mean Total Density and Total Richness

Between 1997 and 2012, mean total density in the Counts Lake outflow stream has varied by approximately one and a half orders of magnitude (Figure 2.3-13). Mean total density in the Counts Lake Outflow has ranged from a minimum of 1,096 org/m² (2003) to a maximum of 17,776 org/m² (2005). There was no apparent temporal trend in invertebrate abundance.

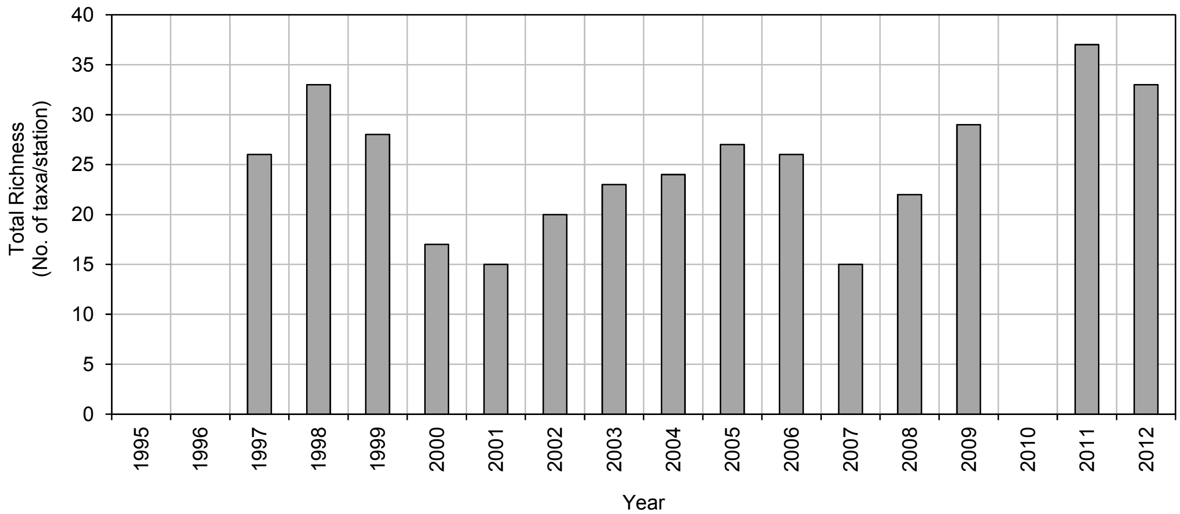
Total richness values in the Counts Lake Outflow have exhibited variability between 1997 and 2012, but do not indicate a temporal trend (Figure 2.3-14). Total richness values at this station have ranged between 15 taxa (2001 and 2007) and 37 taxa (2011).

Figure 2.3-13 Mean Total Density of Benthic Invertebrates in Counts Lake Outflow, 1997 to 2012



Source: ERM Rescan (2013).
Note: Error bars represent one standard error of the mean. In 2010, samples were discarded from analysis due to laboratory error.
org/m^2 = number or organisms per square metre.

Figure 2.3-14 Benthic Invertebrate Richness in Counts Lake Outflow, 1997 to 2012



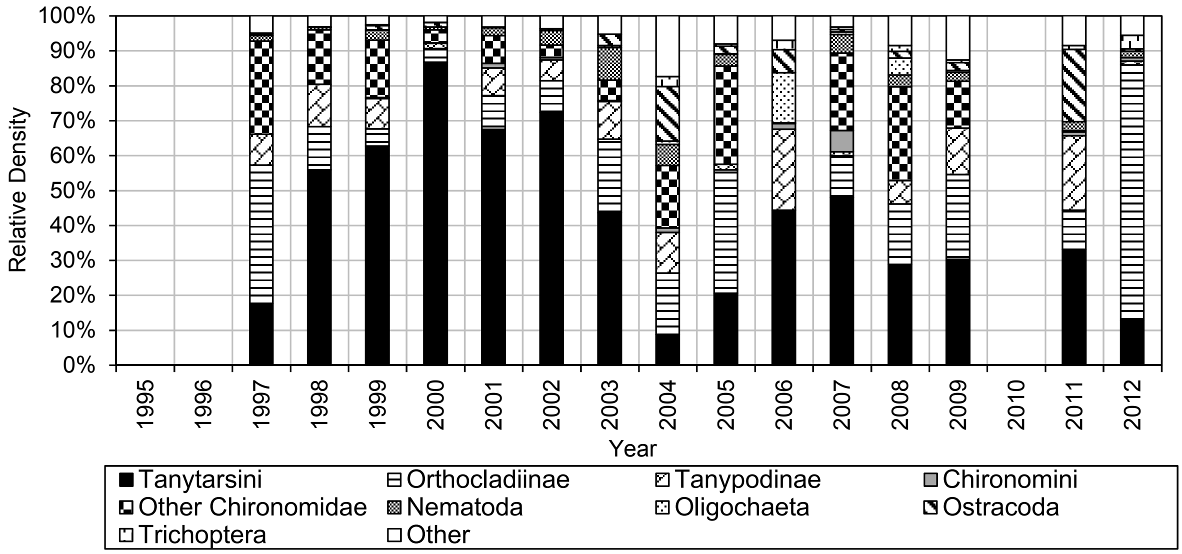
Source: ERM Rescan (2013).
Note: Samples were discarded before analysis due to laboratory error in 2010.
No. of taxa/station = number of taxa per station.

Community Composition by Major Taxonomic Group

The Chironomidae (primarily of the tribe Tanytarsini) have dominated the benthic invertebrate community in the Counts Lake Outflow since 1998 (Figure 2.3-15). The relative densities of Nematoda (nematodes), Ostracoda (seed shrimp), and Oligochaeta were typically no more than 10% of the community composition. The “other” category included *Hydra*, Turbellaria, Harpacticoida (harpacticoid copepods), Acari, Ephemeroptera (mayflies), Plecoptera (stoneflies), Coleoptera (beetles), Trichoptera, other Diptera, Gastropoda, and Pisidiidae; collectively, these taxa accounted for a small proportion of the benthic invertebrate community.

Only *Procladius* (Chironomidae) has been present all years at the shallow station. Several other chironomid genera including *Procladius*, *Phaenopsectra*, and *Tanytarsus* as well as *Pisidium* (Pisidiidae) were present at the Counts Lake Outflow most years (Appendix A; Table A-1). The same genera, as well as *Paratanytarsus* (Chironomidae), were present most years at the mid-depth and deep station. Although present most years at the mid-depth station, *Phaenopsectra* was only present 7 of the 14 years at the deep station.

Figure 2.3-15 Relative Density of Benthic Invertebrates in Counts Lake Outflow, 1997 to 2012



Source: ERM Rescan (2013).

Note: "Other" category includes *Hydra*, Turbellaria, Harpacticoida, Acari, Ephemeroptera, Plecoptera, Trichoptera, Coleoptera, Other Diptera, Gastropoda, Pisidiidae.

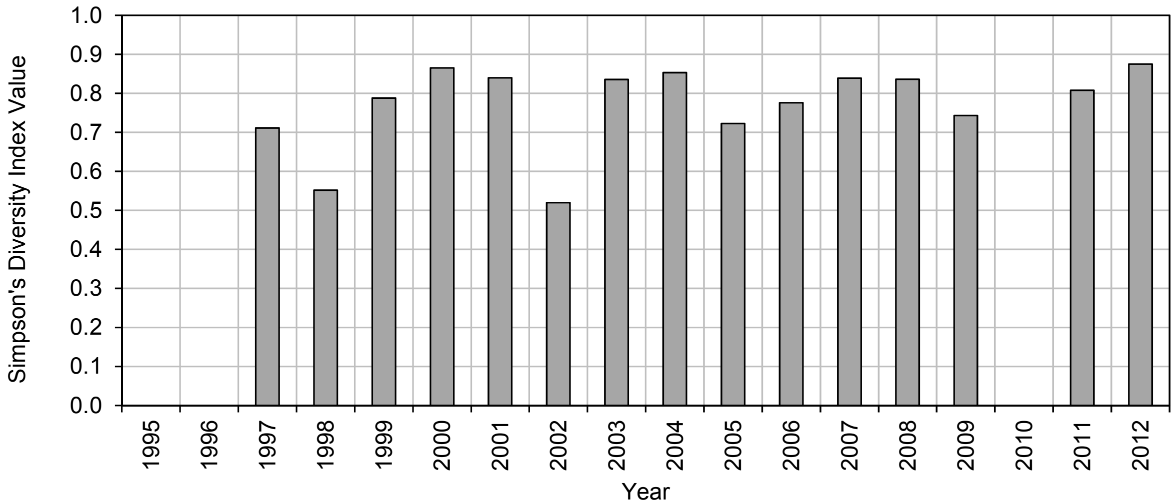
Samples were discarded before analysis due to laboratory error in 2010.

% = percent.

Benthic Community Indices

The SDI values at the Counts Lake Outflow station ranged from 0.52 (2002) to 0.88 (2012), indicating a moderate to high level of diversity (Figure 2.3-16). Evenness values were low, ranging from 0.07 (1998) to 0.44 (2000) indicating that a few taxa accounted for the majority of the total density in the Counts Lake Outflow (Figure 2.3-17).

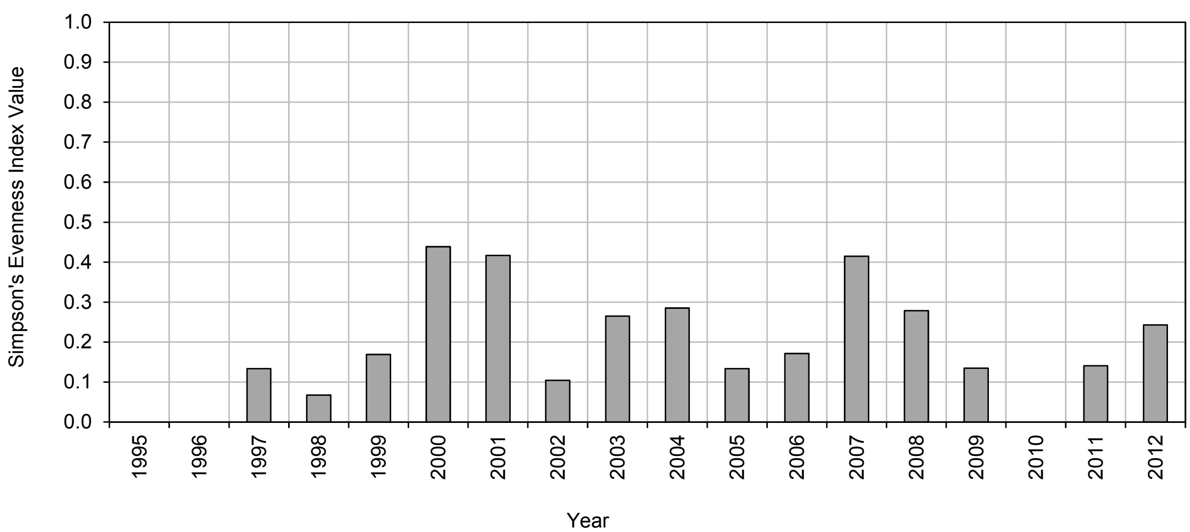
Figure 2.3-16 Simpson's Diversity Index Values for the Benthic Invertebrates in Counts Lake Outflow, 1997 to 2012



Source: ERM Rescan (2013).

Note: Samples collected in 2010 were discarded before analysis due to laboratory error.

Figure 2.3-17 Simpson's Evenness Index Values for the Benthic Invertebrates in Counts Lake Outflow, 1997 to 2012



Source: ERM Rescan (2013).

Note: Samples collected in 2010 were discarded before analysis due to laboratory error.

2.3.1.4 Christine Lake (Lake B1) and Ursula Lake

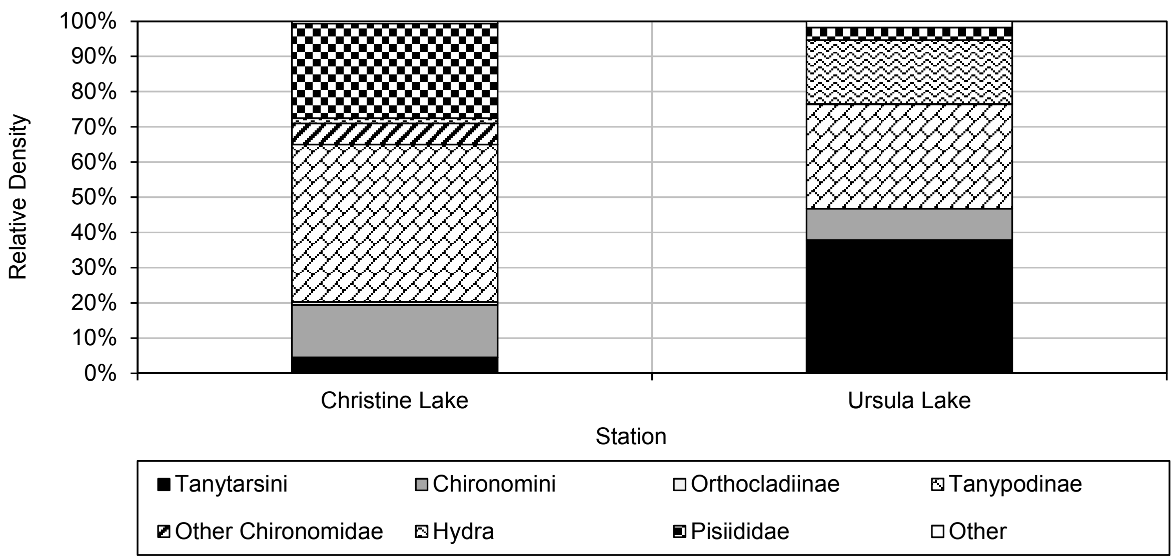
Mean Total Density and Total Richness

In 2006, mean total density at the mid-depth station in Christine Lake (Lake B1) was 1,985 org/m^2 (Appendix A; Figure A-16). At the shallow station in Ursula Lake, mean total density was 7,541 org/m^2. Total richness was 10 taxa/station at the mid-depth station in Christine Lake and 16 taxa/station in the shallow station in Ursula Lake (Appendix A; Figure A-17).

Community Composition by Major Taxonomic Group

Chironomidae were the dominant taxon at the mid-depth station in Christine Lake (70%) and the shallow station in Ursula Lake (75%); however, the composition of the Chironomidae differed between the two lakes (Figure 2.3-18). Within the family Chironomidae, the subfamily Tanypodinae contributed 45% of the benthic invertebrate community in Christine Lake, while the tribe Tanytarsini accounted for 38% of the community in Ursula Lake. Pisidiidae accounted for almost 30% of the community at the mid-depth station in Christine Lake, but only 4% of the community at the shallow station in Ursula Lake. Oligochaeta, other Diptera, and Gastropoda were present in small proportions at each station; Acari were only present in Ursula Lake.

Figure 2.3-18 Relative Density of Benthic Invertebrates in Christine and Ursula Lakes, August 2006



Source: Rescan (2007).
Note: "Other" includes Oligochaeta, Acari, Other Diptera, and Gastropoda.
% = percent.

Benthic Community Indices

The SDI values were comparable at the mid-depth station in Christine Lake (0.62) and the shallow station in Ursula Lake (0.71) (Appendix A; Figure A-18). The higher SDI value for Ursula Lake was related to a greater number of taxa present. Despite differences in water depth, SEI values was similar between the two lakes, at 0.26 in Christine Lake and 0.22 in Ursula Lake (Appendix A; Figure A-19). These low SEI values are reflective of the community being dominated by two or three taxa (Figure 2.3-18).

2.3.2 Lac de Gras Basin

2.3.2.1 Lac de Gras

Mean Total Density and Total Richness

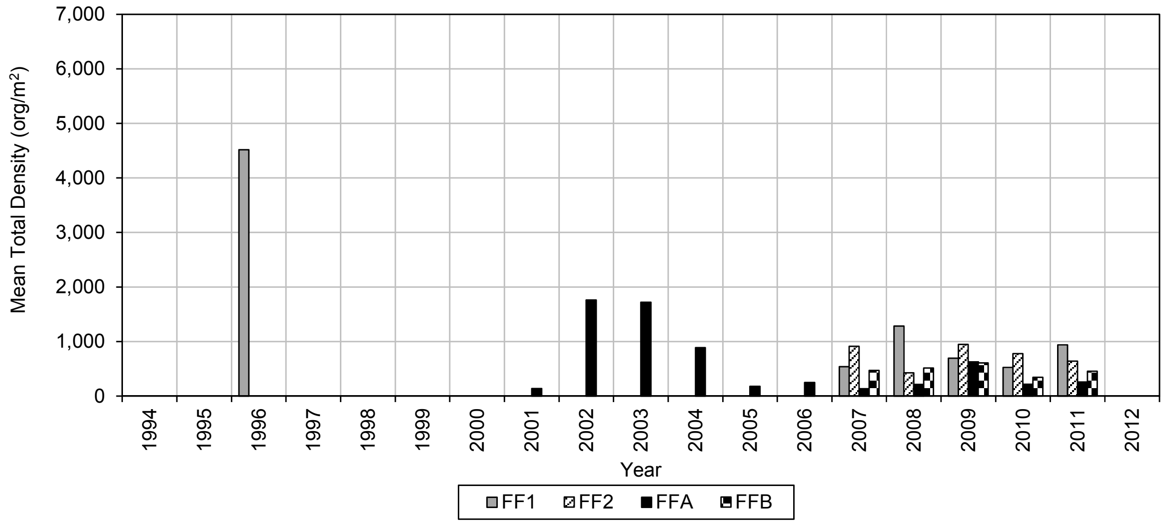
Mean total benthic invertebrate density has been relatively stable and low in the far-field areas of Lac de Gras sampled for the Diavik Mine AEMP since 2001 (Figure 2.3-19). Within area FFA, density and richness increased in the early 2000s, declined in 2005 and 2006, and have fluctuated since. Total density values have ranged between 136 org/m^2 (FFA, 2007) and 1,762 org/m^2 (FFA, 2002); maximum densities were recorded at two of the four Diavik Mine far-field areas in 2009. Total density at Station FF1 was reported as 4,518 org/m^2 in 1996; however, the samples were sieved using a 250 µm mesh, which may have resulted in the higher abundance estimate compared to data collected since 2001 (Golder 2011).

Total benthic invertebrate densities at Lac de Gras Stations S2 (mid) and S3 (deep) sampled for the Ekati Mine AEMP were higher and more variable compared to those sampled at the Diavik far-field stations; densities have ranged from 252 org/m^2 (2006) to 5,673 org/m^2 (2008) at Station S2 and from 59 org/m^2 (2006) to 5,984 org/m^2 (2010) at Station S3 (Figure 2.3-20). The higher variability may be related to the lower number of replicates (n) collected for the Ekati Mine AEMP (n=3) versus the Diavik Mine AEMP (n=6); in addition, it may also reflect the habitat type sampled (i.e., less physically stable near-shore habitat versus more stable deep water habitat, respectively).

A similar trend was apparent in total richness in the far-field areas in Lac de Gras (Figure 2.3-21); total richness increased in the early 2000s, declined in 2004 to 2007, and has fluctuated since. Total benthic invertebrate richness at the far-field areas of Lac de Gras ranged from 6 taxa/station (2001, FFA; 2007) to a maximum of 18 taxa/station (FF1, 2012; Figure 2.3-21). Overall, richness has remained relatively consistent over time at all far-field areas.

Benthic invertebrate density in Lac de Gras at Stations S2 (mid) and S3 (deep) has been more variable over time; total richness has been generally higher at the mid-depth station (S2) than the deep station (S3) (Figure 2.3-22). Total richness at S2 ranged from 7 taxa/station in 2003 and 2006, to 27 taxa/station in 2012. Total richness at S3 ranged from 3 taxa/station in 2006 to 20 taxa/station in 2012. An increasing trend in benthic invertebrate density has been observed at these stations since 2006. Lac de Gras had the lowest densities at the deep station (S3) of all the lakes monitored by the Ekati Mine AEMP (ERM Rescan 2013).

Figure 2.3-19 Mean Total Density of Benthic Invertebrates in the Far-field Areas in Lac de Gras, 1996 to 2011

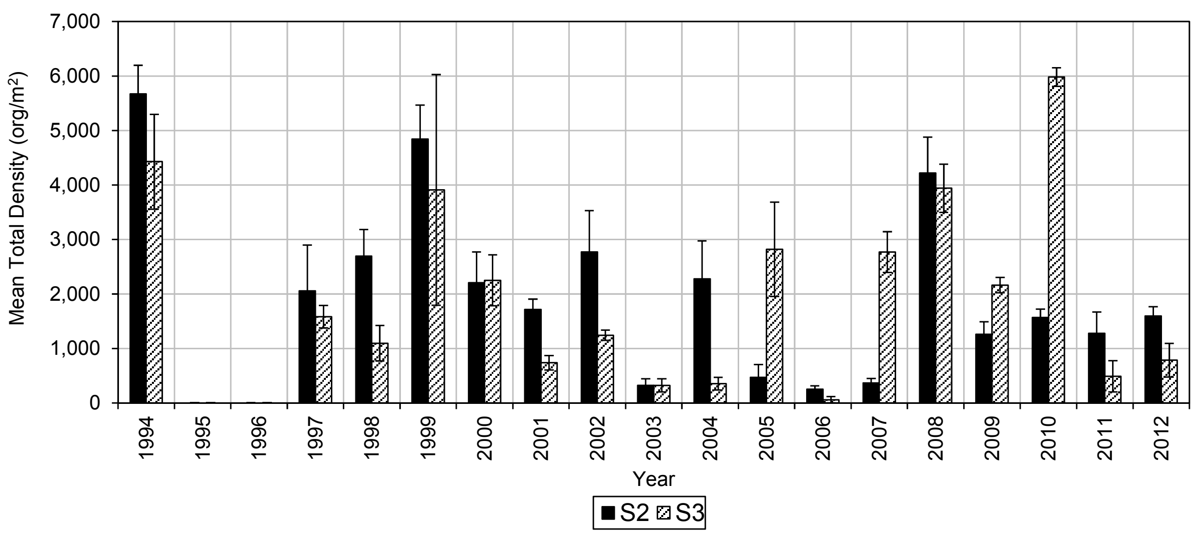


Source: Golder (2011); DDMI (2012).

Note: Error bars represent one standard error of the mean.

org/m^2 = number or organisms per square metre.

Figure 2.3-20 Mean Total Density of Benthic Invertebrates at Stations S2 and S3 in Lac de Gras, 1994 to 2012

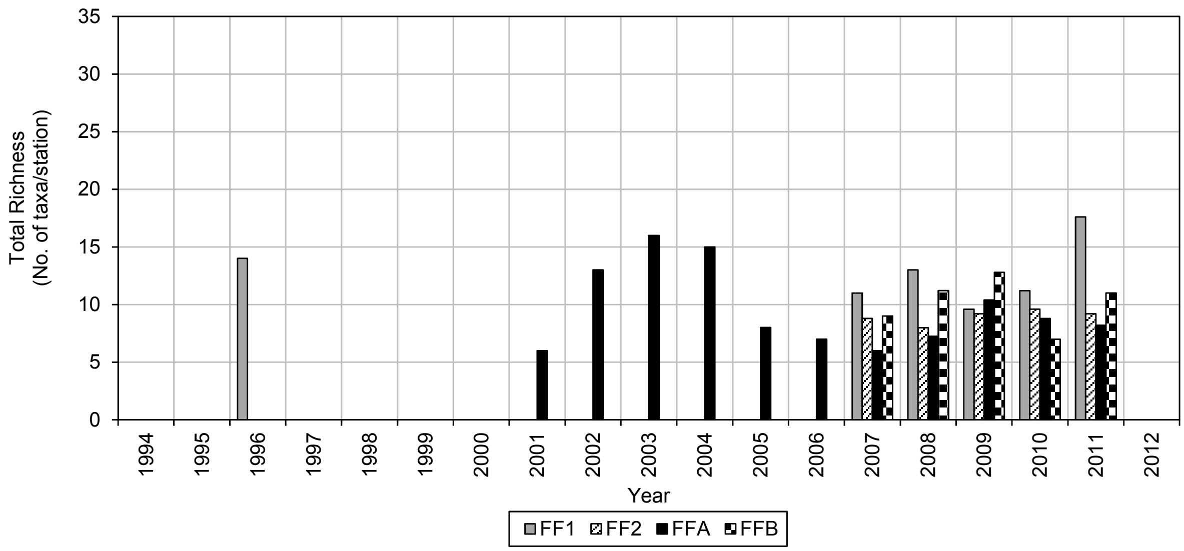


Source: ERM Rescan (2013).

Note: Error bars represent one standard error of the mean.

org/m^2 = number or organisms per square metre.

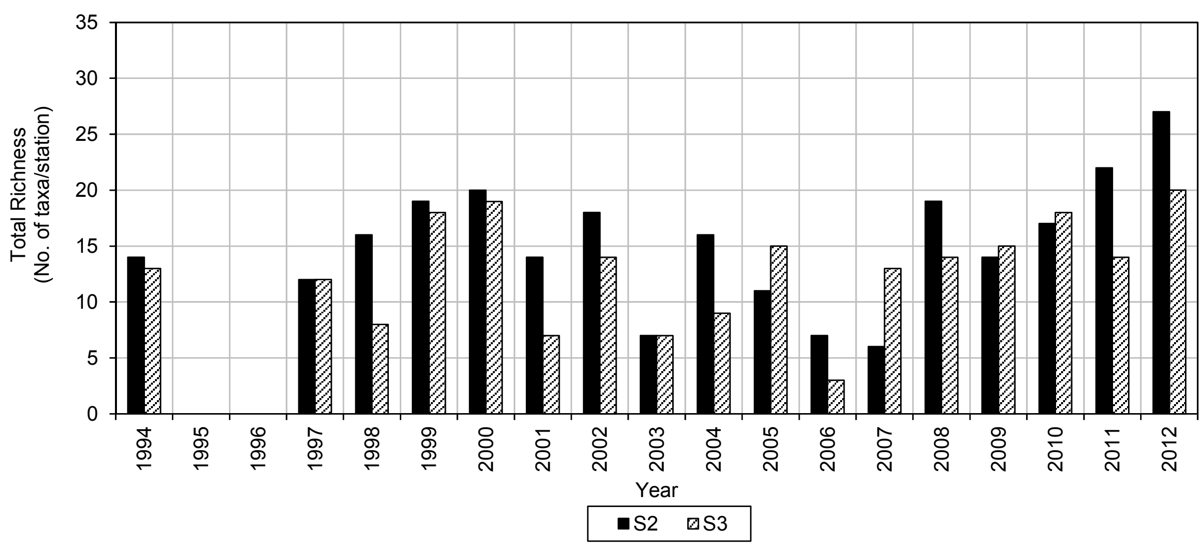
Figure 2.3-21 Total Benthic Invertebrate Richness in the Far-Field Areas in Lac de Gras, 1996 to 2011



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

No. of taxa/station = number of taxa per station.

Figure 2.3-22 Total Benthic Invertebrate Richness at Stations S2 and S3 in Lac de Gras, 1994 to 2012



Source: ERM Rescan (2013).

No. of taxa/station = number of taxa per station.

Community Composition by Major Taxonomic Group

The benthic invertebrate communities at the far-field stations in Lac de Gras were dominated by the Chironomidae followed by Oligochaeta, Pisidiidae and Acari. Other groups such as *Hydra*, Gastropoda, Eubranchiopoda, Amphipoda (freshwater shrimp), and other Diptera (Empididae) together contributed to a small proportion of the overall benthic invertebrate community.

Benthic community composition has been variable in the FFA area from 2001 to 2010 (Figure 2.3-23). No consistent temporal trends have been apparent, although gradual increases in the relative densities of Oligochaeta and Acari were noted from 2001 to 2004, followed by declines in the relative densities of both taxa through 2008. Less variability is apparent in 2007 to 2010 data collected from the FFB, FF1, and FF2 areas; temporal trends are not apparent (Figures 2.3-23 and 2.3-24).

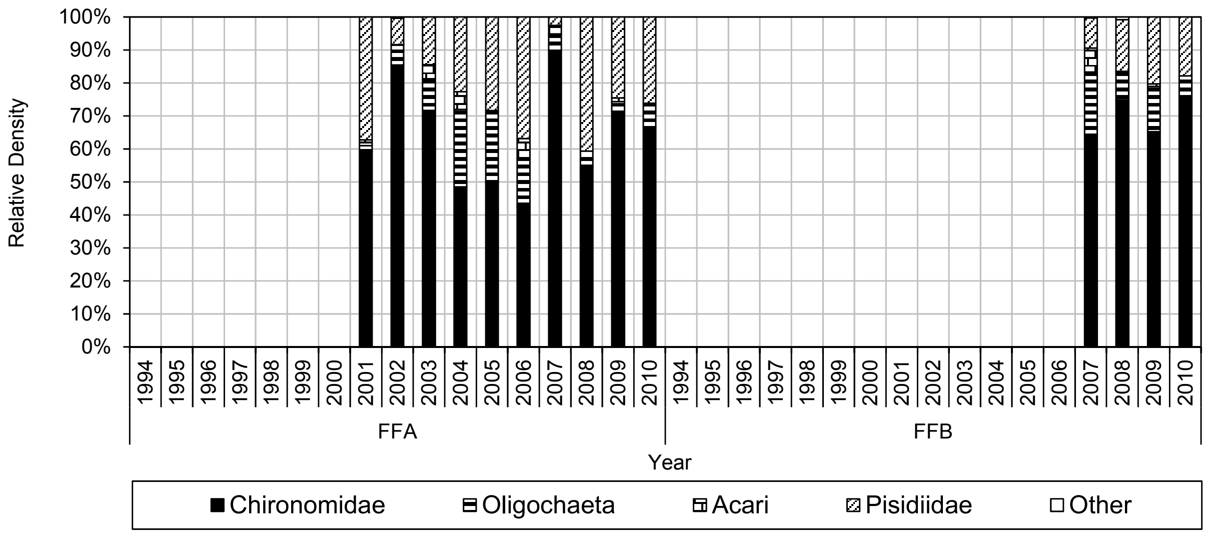
The composition of invertebrates present and the ranges in total number of taxa in the far-field areas of Lac de Gras were generally similar, with the exception of the FF1 area, where a greater number of taxa were present in 2010 and 2011 (Appendix A, Table A-4). Only one taxon, *Sphaerium*, was documented at all far-field stations over all years. Several Chironomidae taxa, including *Procladius*, *Micropsectra*, *Heterotrissocladius,* and *Monodiamesa*, were present at all stations in Lac de Gras during the majority of years.

The community composition at Stations S2 and S3 was similar to the Diavik sampling areas; Chironomidae was the dominant taxonomic group at the mid-depth and deep stations (Figure 2.3-25). Tanytarsini and Tanypodinae were the dominant midge groups although dominance varied among years. Oligochaeta and Pisidiidae were present at both stations, although in higher densities at the deep (S3) station. *Hydra*, Turbellaria, Acari, Eubranchiopoda, Trichoptera, Harpacticoida, Plecoptera, Gastropoda, and other Diptera each contributed less than 10% for the total community in any given year.

No consistent temporal trends were apparent in community composition, although a gradual increase in the relative density of Orthocladiinae was noted at S2 (Figure 2.3-25). Relative densities of Pisidiidae have fluctuated at both stations, although 2012 values were similar to baseline values.

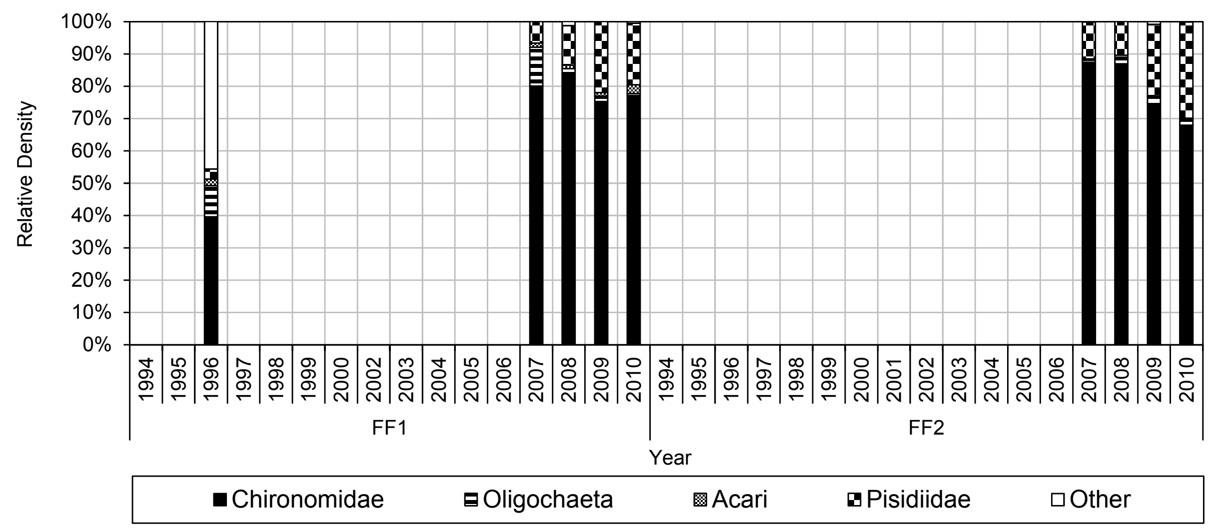
The benthic invertebrates present and ranges in total number of taxa were generally similar, although a higher number of taxa was observed in 2011 and 2012 at S2, and in 2012 at S3 (Appendix A; Table A-1). As observed at the Diavik far-field areas, several Chironomidae taxa including *Procladius*, *Micropsectra*, *Heterotrissocladius*, and *Monodiamesa* were present during the majority of years.

Figure 2.3-23 Relative Densities of Benthic Invertebrates at the Far-Field Area Stations FFA and FFB in Lac de Gras, 2001 to 2010



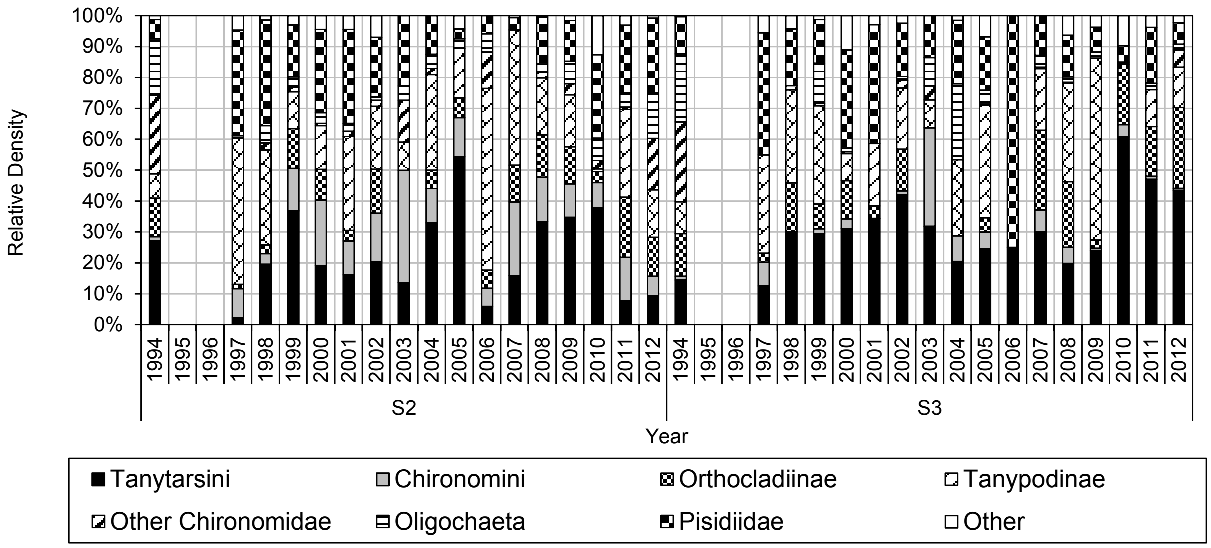
Source: Golder (2011); DDMI (2012).
Note: “Other" category includes *Hydra*, Eubranchiopoda, Amphipoda, Gastropoda, and other Diptera.
% = percent.

Figure 2.3-24 Relative Densities of Benthic Invertebrates at the Far-Field Area Stations FF1 and FF2 in Lac de Gras, 1996 to 2010



Source: Golder (2011); DDMI (2012).
Note: “Other" category includes *Hydra*, Eubranchiopoda, Amphipoda, Gastropoda, and other Diptera.
% = percent.

Figure 2.3-25 Relative Densities of Benthic Invertebrates at Stations S2 and S3 in Lac de Gras, 1997 to 2012



Source: ERM Rescan (2013).

Note: “Other" category includes *Hydra*, Turbellaria, Acari, Eubranchiopoda, Trichoptera, Harpacticoida, Plecoptera, Gastropoda, and other Diptera.

% = percent.

Benthic Community Indices

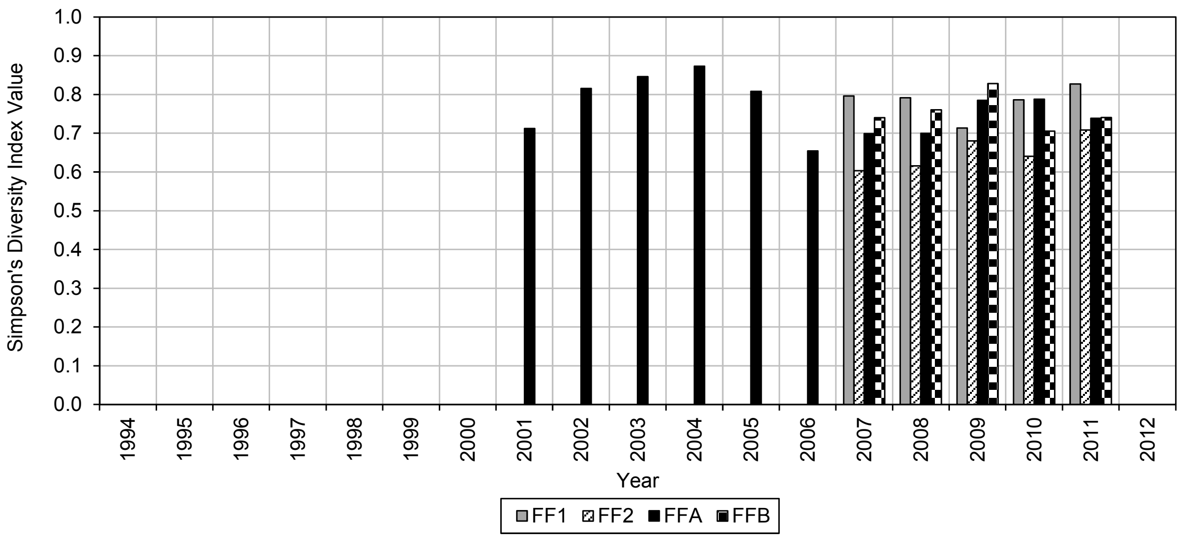
The SDI has remained stable over time at far-field areas of Lac De Gras (Figure 2.3-26). Overall, diversity values have ranged from 0.60 (FF2, 2007) to 0.87 (FFA, 2004) indicating a moderately to highly diverse benthic invertebrate community. In 2011, diversity was near the highest values, with values ranging from 0.74 to 0.83.

The SDI values ranged between 0.62 (2006) and 0.89 (1999, 2011, and 2012) at S2, and 0.46 (2009) and 0.88 (2012) at S3 (Figure 2.3-27), with a notable difference in diversity between these stations in 2009.

Evenness has been more variable over time compared to diversity. Overall, SEI values have ranged from 0.33 (FF1, 2011) to 0.67 (FFA, 2005) (Figure 2.3-28). In 2011, SEI values were near the lower part of the range in the far-field areas; values ranged from 0.33 to 0.50 due to the high proportion of Chironomidae contributing to the benthic invertebrate community at the far-field areas in Lac de Gras (Figure 2.3-28).

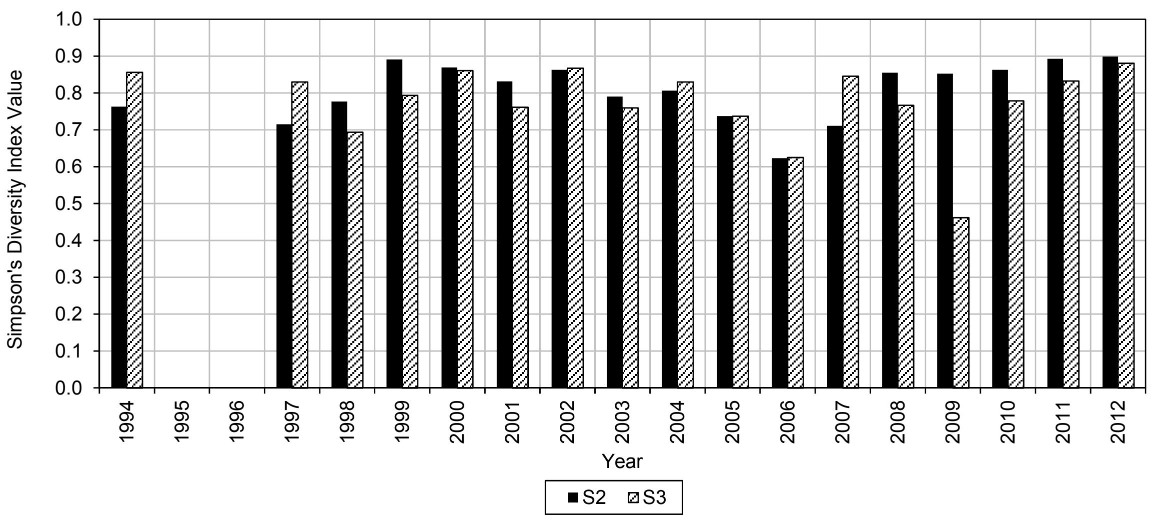
Evenness values at Stations S2 and S3 have demonstrated high variability over time and between stations. Values have ranged between 0.28 (1998) to 0.68 (2003) at S2, and 0.12 (2009) and 0.89 (2006) at S3 (Figures 2.3-29).

Figure 2.3-26 Simpson's Diversity Index Values for the Benthic Invertebrate Community in the Far-Field Areas in Lac de Gras, 2001 to 2011



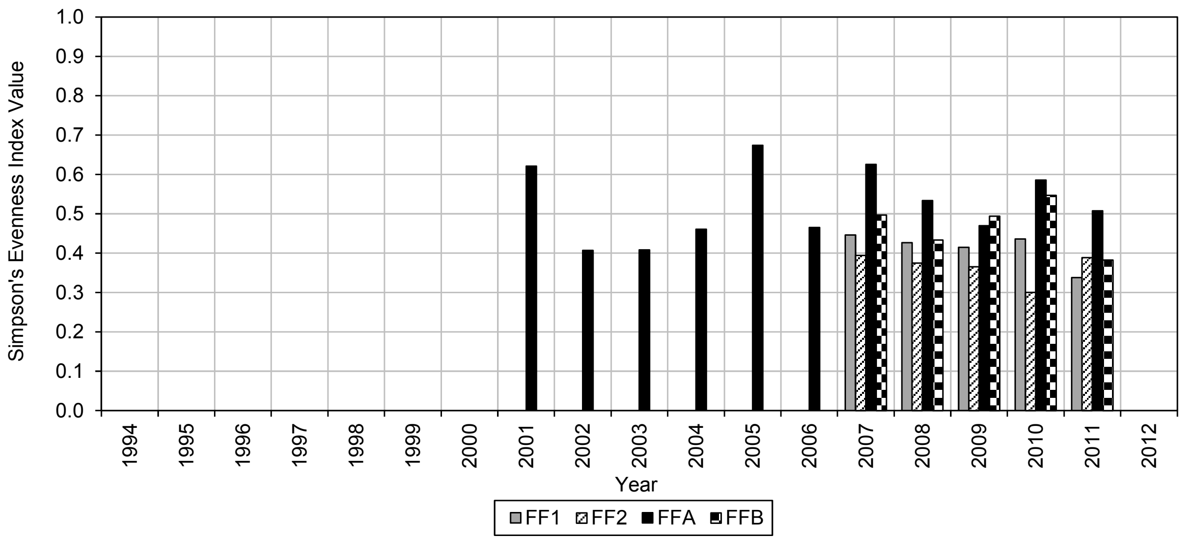
Source: Golder (2011); DDMI (2012).

Figure 2.3-27 Simpson's Diversity Index Values for the Benthic Invertebrate Community at Stations S2 and S3 in Lac de Gras, 1997 to 2012



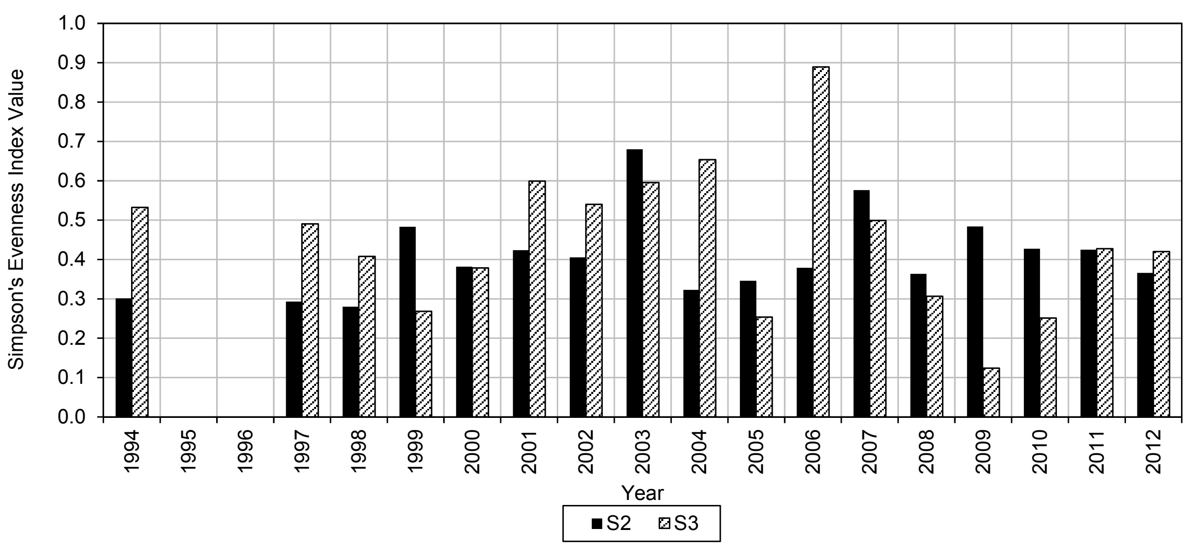
Source: ERM Rescan (2013).

Figure 2.3-28 Simpson's Evenness Index Values for the Benthic Invertebrate Community in the Far-Field Areas in Lac de Gras, 2001 to 2011



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

Figure 2.3-29 Simpson's Evenness Index Values for the Benthic Invertebrate Community at Stations S2 and S3 in Lac de Gras, 1997 to 2012



Source: ERM Rescan (2013).

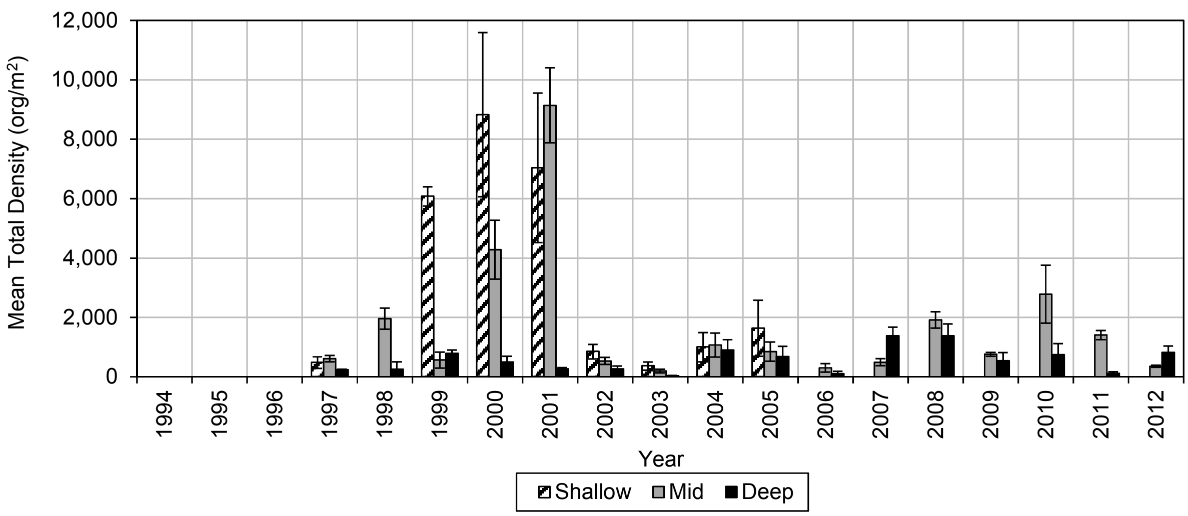
2.3.2.2 Nanuq Lake

Mean Total Density and Total Richness

Mean total density in Nanuq Lake was variable between 1997 and 2001, but has remained relatively stable within a given sampling depth since 2001 (Figure 2.3-30). Between 1997 and 2005, mean total density at the shallow station ranged from 355 org/m^2 (1997) to 8,830 org/m^2 (2000). Between 1997 and 2012, mean total density has ranged from 193 org/m^2 (2003) to 9,140 org/m^2 (2001) at the mid-depth station, and 30 org/m^2 (2003) to 1,378 org/m^2 (2007) at the deep station. Mean total density was highest at the shallow and mid-depth stations between 1999 and 2001; an increase was not observed at the deep station during this time period.

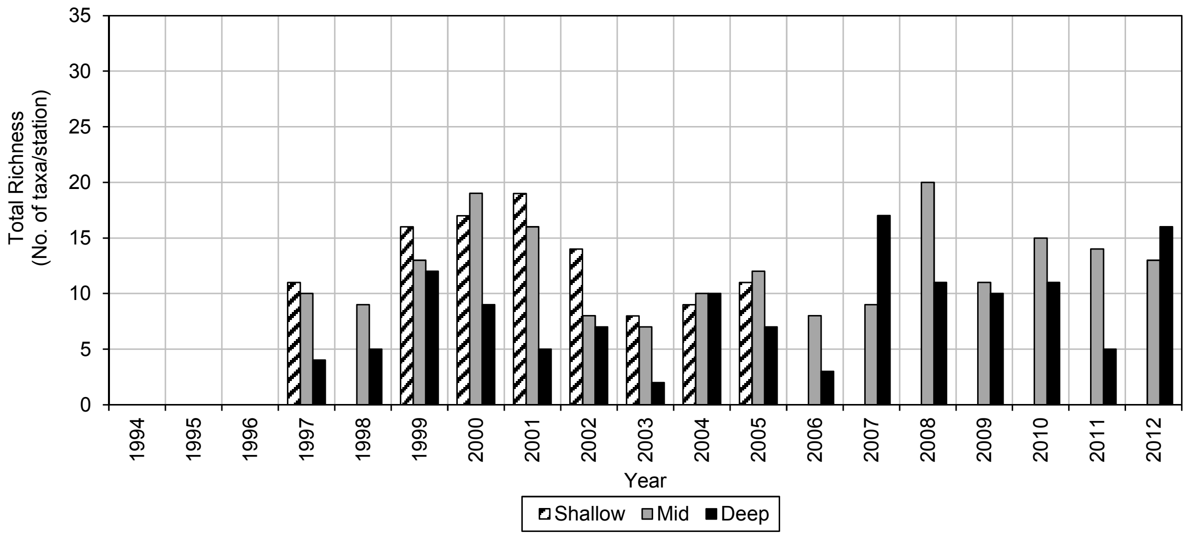
Total richness was variable over time and among stations, with the greatest variability occurring at the deep station (Figure 2.3-31). Between 1997 and 2005, total richness values at the shallow station ranged from 8 taxa (2003) to 19 taxa (2001). Between 1997 and 2012, total richness values ranged from 7 taxa (2003) to 20 taxa (2008) at the mid-depth station, and 2 taxa (2003) to 17 taxa (2007) at the deep station.

Figure 2.3-30 Mean Total Density of Benthic Invertebrates in Nanuq Lake, 1997 to 2012



Source: ERM Rescan (2013).
Note: Error bars represent one standard error of the mean.
org/m^2 = number or organisms per square metre.

Figure 2.3-31 Total Benthic Invertebrate Richness in Nanuq Lake, 1997 to 2012



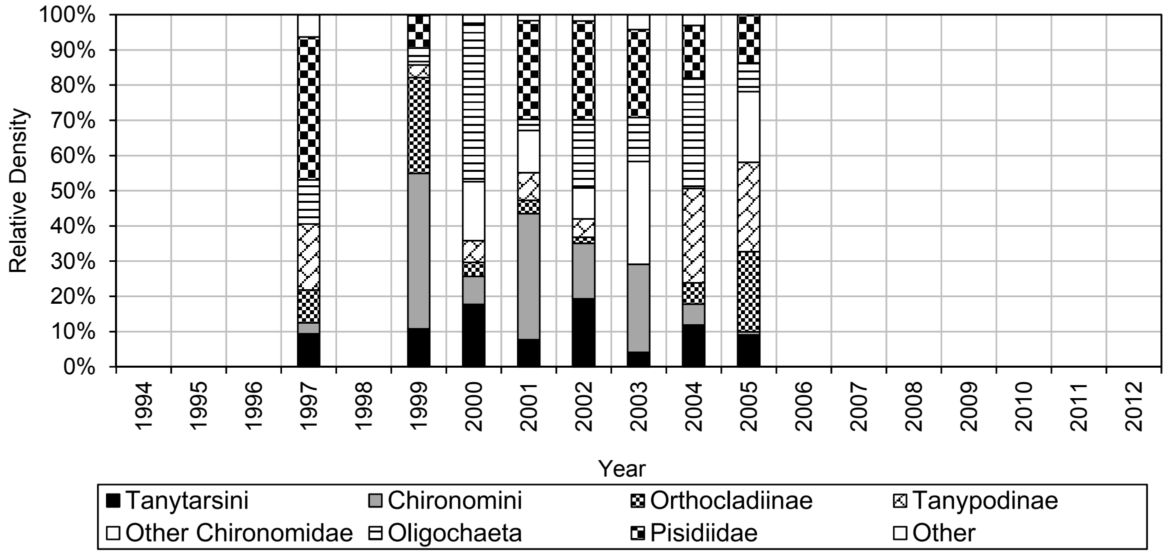
Source: ERM Rescan (2013).

No. of taxa/station = number of taxa per station.

Community Composition by Major Taxonomic Group

The benthic invertebrate community at all stations in Nanuq Lake consisted primarily of Chironomidae, with the proportions of Chironomidae tribes varying over time and among stations (Figure 2.3-32). Pisidiidae and Oligochaeta were periodically the dominant taxa at the mid-depth and deep stations (Figures 2.3-33 and 2.3-34). Turbellaria, Acari, Eubranchiopoda, and Trichoptera were present at all stations, although their contribution to the community varied among years (Appendix A, Table A-1). Gastropoda were not documented at any of the stations in Nanuq Lake.

Figure 2.3-32 Benthic Invertebrate Relative Density at Nanuq Lake Shallow Station, 1997 to 2005

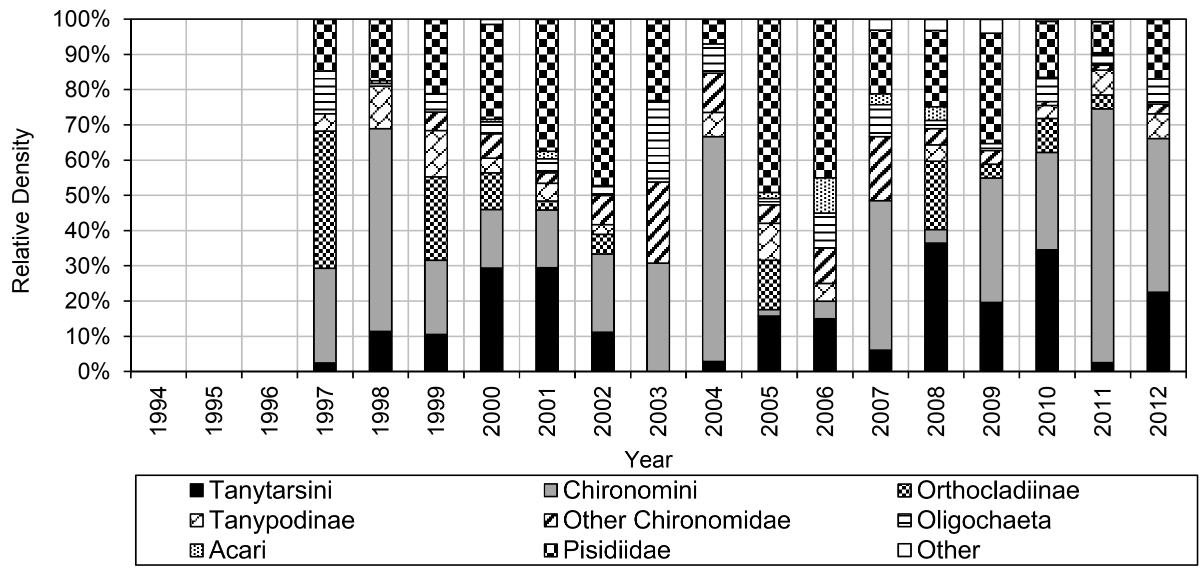


Source: ERM Rescan (2013).

Note: “Other" category includes Acari, Trichoptera, and other Diptera.

% = percent.

Figure 2.3-33 Benthic Invertebrate Relative Density at Nanuq Lake Mid-depth Station, 1997 to 2012

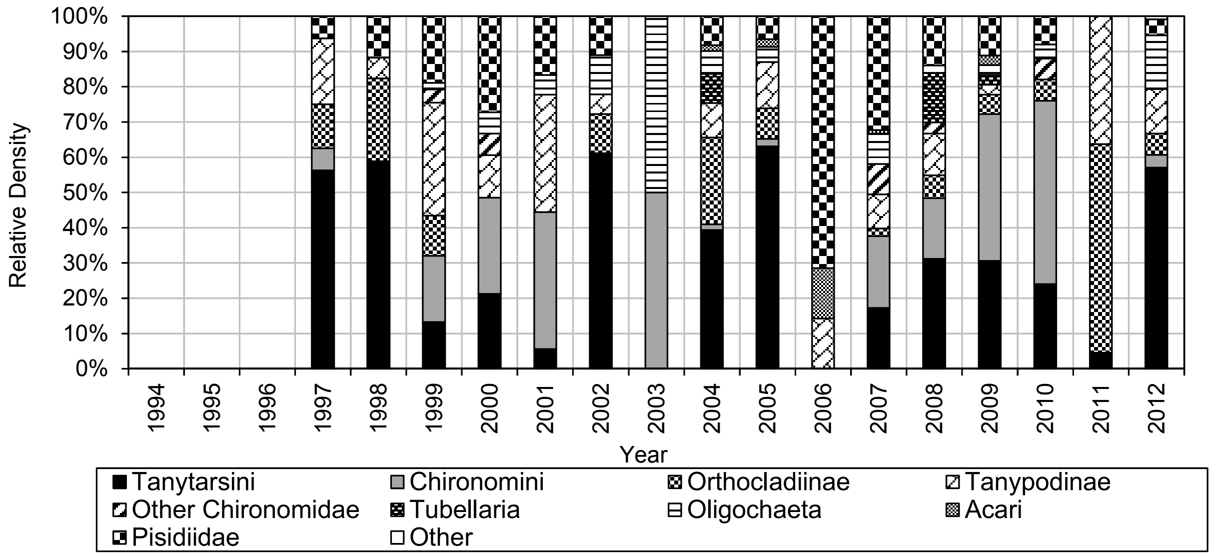


Source: ERM Rescan (2013).

Note: “Other" category includes Turbellaria, Eubranchiopoda, and Trichoptera.

% = percent.

Figure 2.3-34 Benthic Invertebrate Relative Density at Nanuq Lake Deep Station, 1997 to 2012



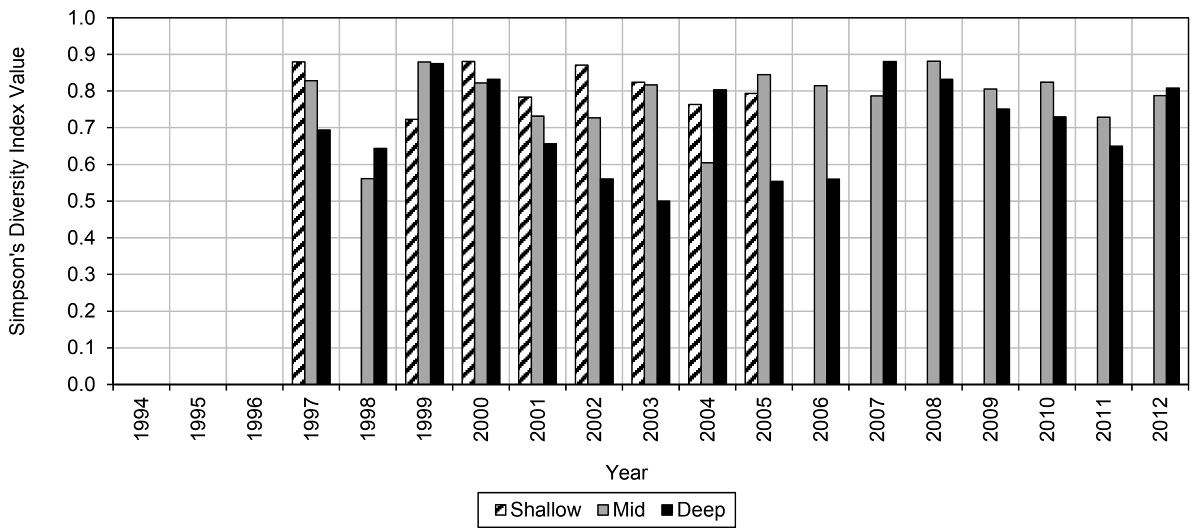
Source: ERM Rescan (2013).
Note: "Other" category includes Eubranchiopoda.
% = percent.

Benthic Community Indices

Within Nanuq Lake, the SDI values were relatively stable between 1997 and 2005 at the shallow station; values ranged between 0.72 (1999) to 0.88 (1997 and 2000) (Figure 2.3-35). Between 1997 and 2012, variability in SDI values was greater at the mid-depth and deep stations. Values ranged between 0.56 (1998) to 0.88 (2008) and 0.50 (2003) to 0.88 (2007), respectively. These SDI values indicated a consistently high level of diversity at the shallow station, and a moderate to high level of diversity at the mid-depth and deep stations.

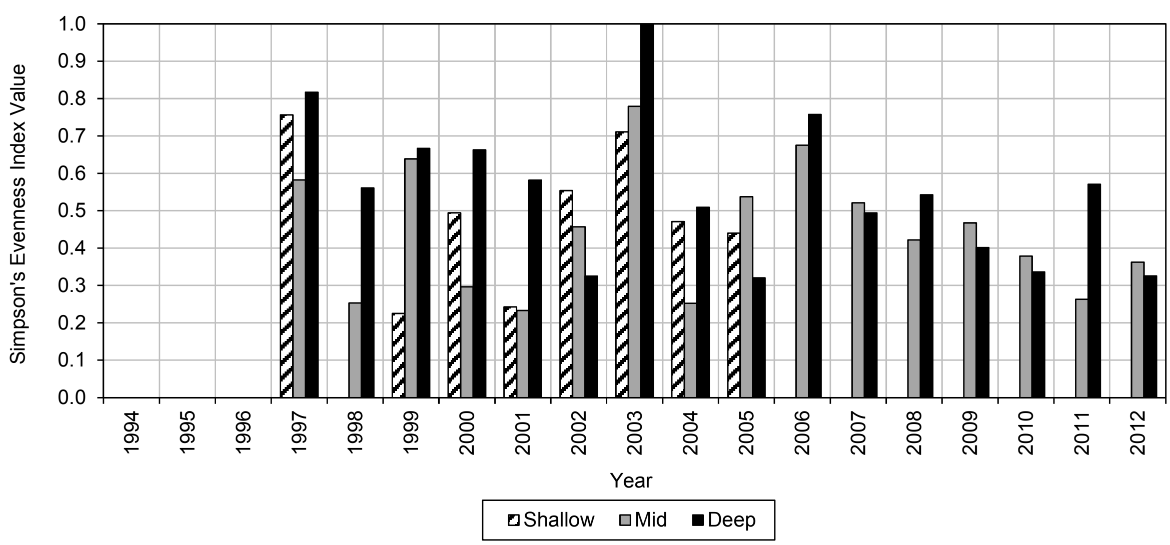
Evenness values in Nanuq Lake have been highly variable temporally and spatially (Figure 2.3-36). Between 1997 and 2005, SEI values ranged from 0.23 (1999) to 0.76 (1997) at the shallow station. Between 1997 and 2012, a similar level of variability was observed at the mid-depth and deep stations, as values ranged between 0.23 (2001) and 0.78 (2003), and 0.32 (2005) and 1.00 (2003), respectively. The SEI value of 1 at the deep station in 2003 was due to the benthic invertebrate community consisting of equal proportions of Oligochaeta (50%) and Chironomidae (50%; Chironomini). The wide range among the SEI values reflects the temporal variability in the benthic invertebrate community in Nanuq Lake.

Figure 2.3-35 Simpson's Diversity Index Values for the Benthic Invertebrate Community in Nanuq Lake, 1997 to 2012



Source: ERM Rescan (2013).

Figure 2.3-36 Simpson's Evenness Index Values for the Benthic Invertebrate Community in Nanuq Lake, 1997 to 2012



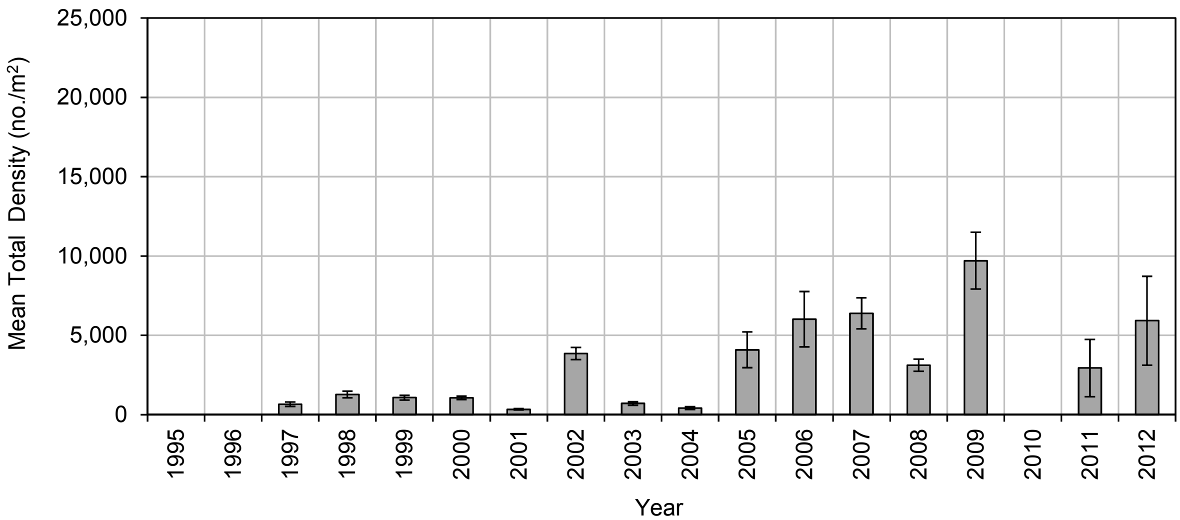
Source: ERM Rescan (2013).

2.3.2.3 Nanuq Lake Outflow

Mean Total Density and Total Richness

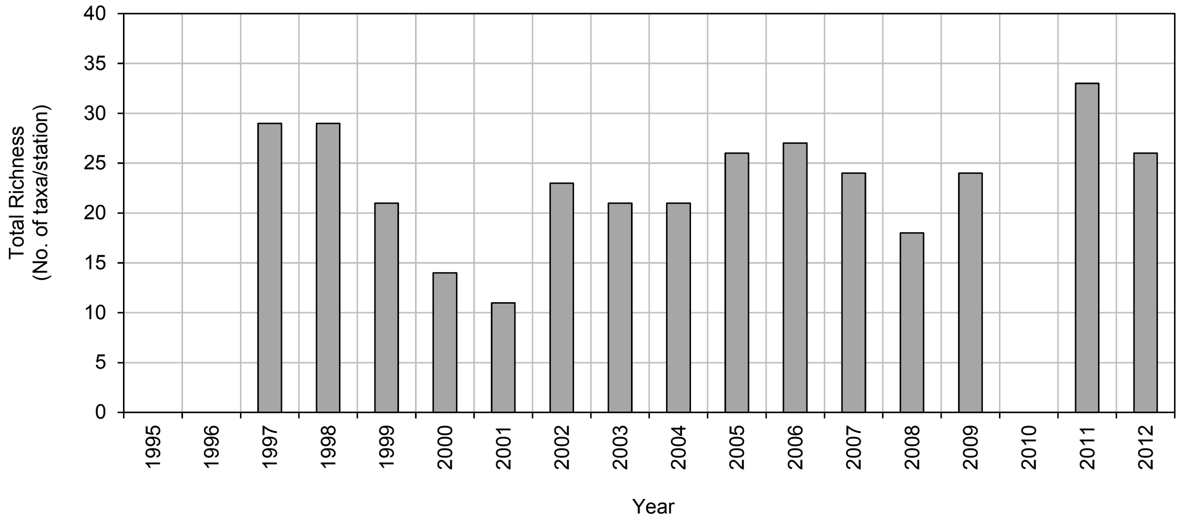
Mean total density from 1997 to 2012 varied by over two orders of magnitude in the Nanuq Lake outflow stream (Figure 2.3-37). Mean total density ranged from 331 org/m^2 (2001) to 9,704 org/m^2 (2009). Between 1997 and 2012, total richness values at the Nanuq Outflow were variable, ranging from 11 taxa/station (2001) to 33 taxa taxa/station (2011) (Figure 2.3-38).

Figure 2.3-37 Mean Total Density of Benthic Invertebrates at the Nanuq Lake Outflow, 1997 to 2012



Source: ERM Rescan (2013).
Note: Error bars represent one standard error of the mean.
Samples were discarded before analysis due to laboratory error in 2010.
org/m^2 = number or organisms per square metre.

Figure 2.3-38 Total Benthic Invertebrate Richness at the Nanuq Lake Outflow, 1997 to 2012

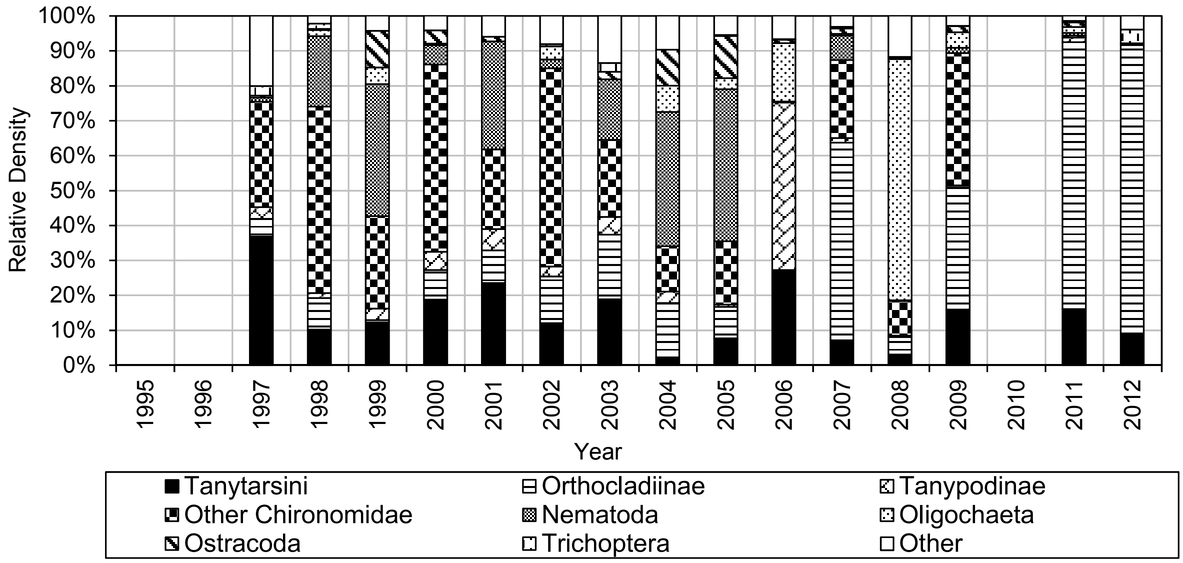


Source: ERM Rescan (2013).
Note: Samples were discarded before analysis due to laboratory error in 2010.
No. of taxa/station = number of taxa per station.

Community Composition by Major Taxonomic Group

The Chironomidae have dominated the benthic invertebrate community at the Nanuq Outflow since 1998. The Nematoda and Oligochaeta have periodically contributed to a high proportion (up to 44% and 69%, respectively) of the community at the Nanuq Outflow. Ostracoda, followed by Plecoptera, *Hydra*, Trichoptera, other Diptera, Ephemeroptera, Acari, Harpacticoida, Gastropoda, and Pisidiidae have been present in very small numbers (Figure 2.3-39).

Figure 2.3-39 Benthic Invertebrate Relative Density at Nanuq Lake Outflow, 1997 to 2012



Source: ERM Rescan (2013).

Note: “Other” category includes *Hydra*, Turbellaria, Harpacticoida, Acari, Ephemeroptera, Plecoptera, Coleoptera, other Diptera, Chironomini, Gastropoda, and Pisidiidae.

Samples were discarded before analysis due to laboratory error in 2010.

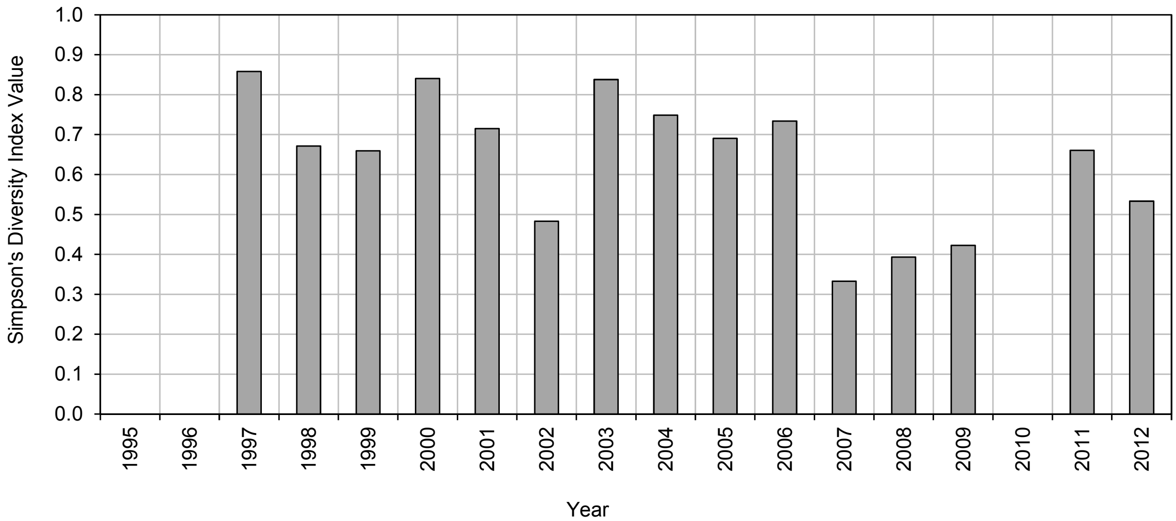
% = percent.

Benthic Community Indices

The SDI values at the Nanuq Lake Outflow were relatively stable between 1997 (0.86) and 2006 (0.73; Figure 2.3-40). Between 2007 and 2012, SDI values were more variable, ranging from 0.33 to 0.66. In general, these values indicate moderate to high diversity.

Evenness values at the Nanuq Lake Outflow have also exhibited variability over time, with values ranging from 0.06 (2007) to 0.45 (2000) (Figure 2.3-41). In general, SEI values were low, indicating that a few taxa accounted for the majority of the total density.

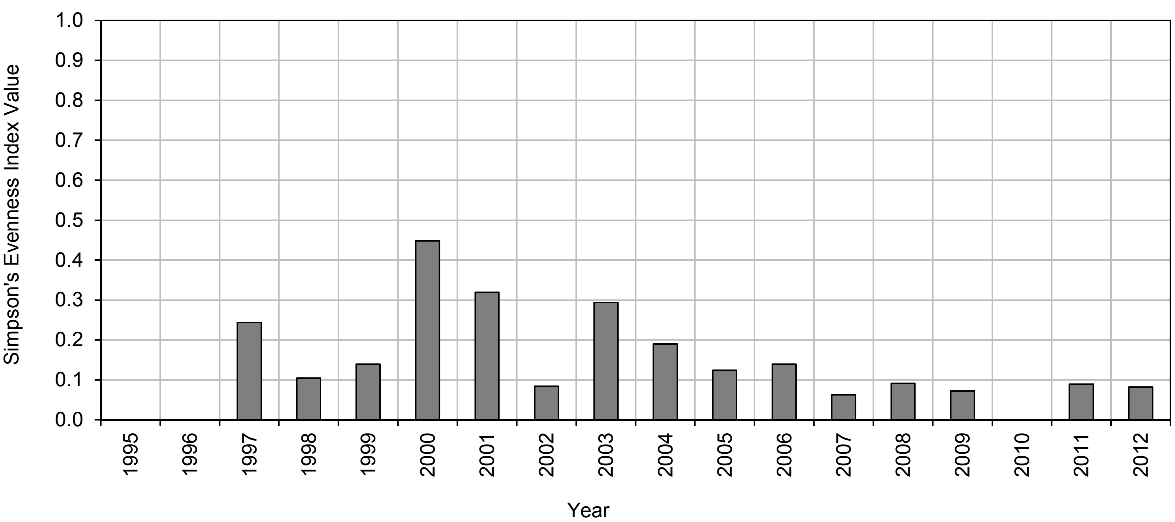
Figure 2.3-40 Simpson's Diversity Index Values for the Benthic Invertebrate Community at the Nanuq Lake Outflow, 1997 to 2012



Source: ERM Rescan (2013).

Note: Samples were discarded before analysis due to laboratory error in 2010.

Figure 2.3-41 Simpson's Evenness Index Values for the Benthic Invertebrate Community at the Nanuq Lake Outflow, 1997 to 2012



Source: ERM Rescan (2013).

Note: Samples were discarded before analysis due to laboratory error in 2010.

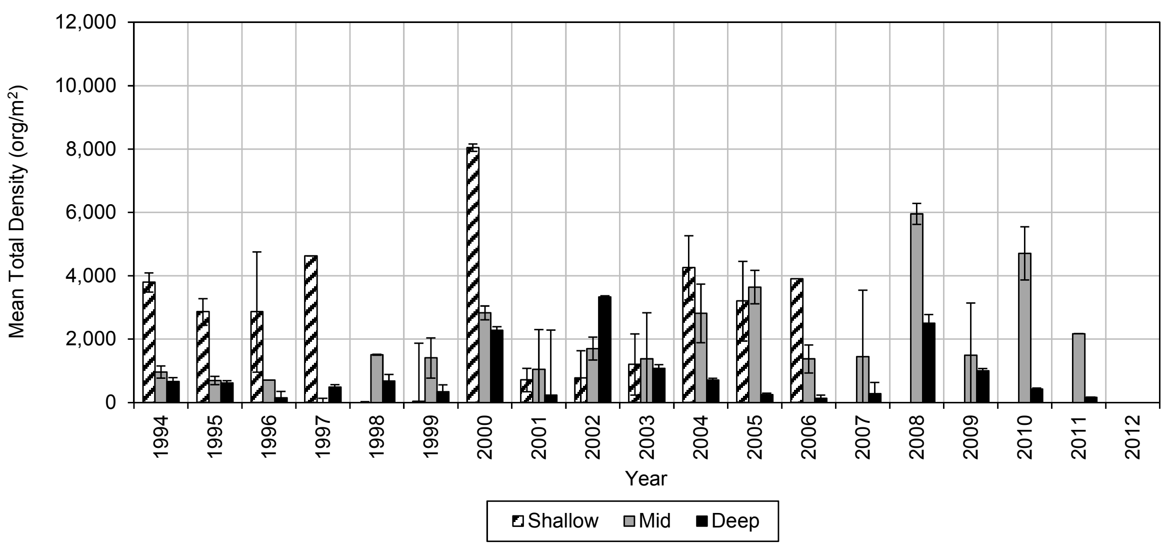
2.3.2.4 Vulture Lake

Mean Total Density and Total Richness

In Vulture Lake, mean total density has been highly variable over time and among stations (Figure 2.3-42). Between 1994 and 2006, mean total density in Vulture Lake ranged from 30 org/m^2 (1999) to 8,044 org/m^2 (2000) at the shallow station. Between 1994 and 2011, mean total density ranged from 696 org/m^2 (1995) to 5,956 org/m^2 (2008) at the mid-depth station, and from 133 org/m^2 (2006) to 3,333 org/m^2 (2002) at the deep station.

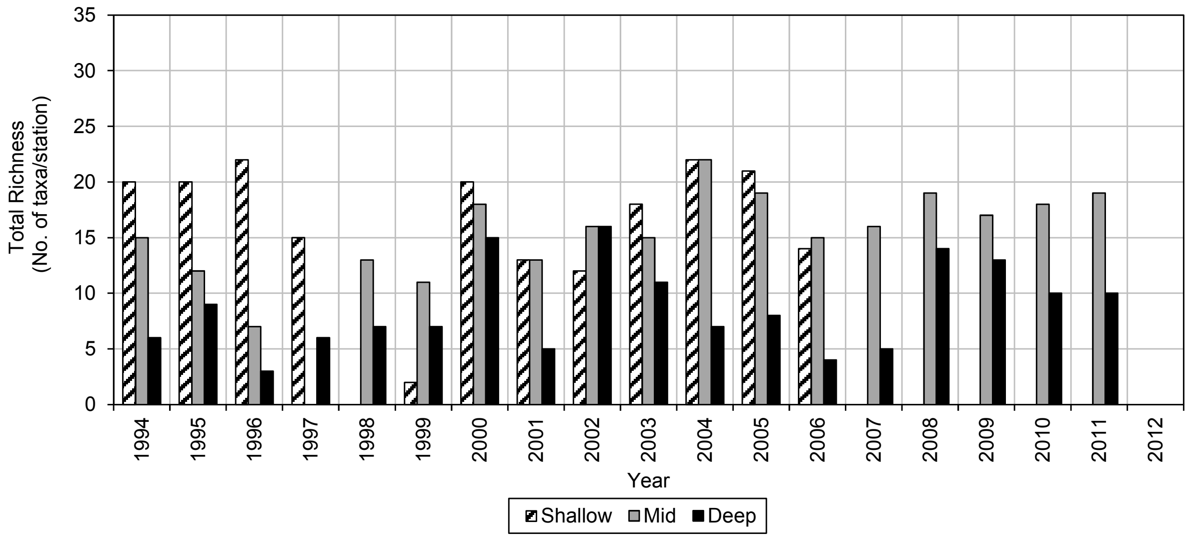
Total richness values in Vulture Lake have also been variable over time and among stations (Figure 2.3-43). Total richness values ranged from two taxa (1999) to 22 taxa (1996 and 2004) at the shallow station in Vulture Lake, 7 taxa (1996) to 22 taxa (2004) at the mid-depth station, and 3 taxa (1996) to 16 taxa at the deep station (2002).

Figure 2.3-42 Mean Total Density of Benthic Invertebrates in Vulture Lake, 1994 to 2011



Source: ERM Rescan (2013).
Note: Error bars represent one standard error of the mean. No data collected in 2012.
org/m^2 = number or organisms per square metre.

Figure 2.3-43 Total Benthic Invertebrate Richness in Vulture Lake, 1994 to 2011

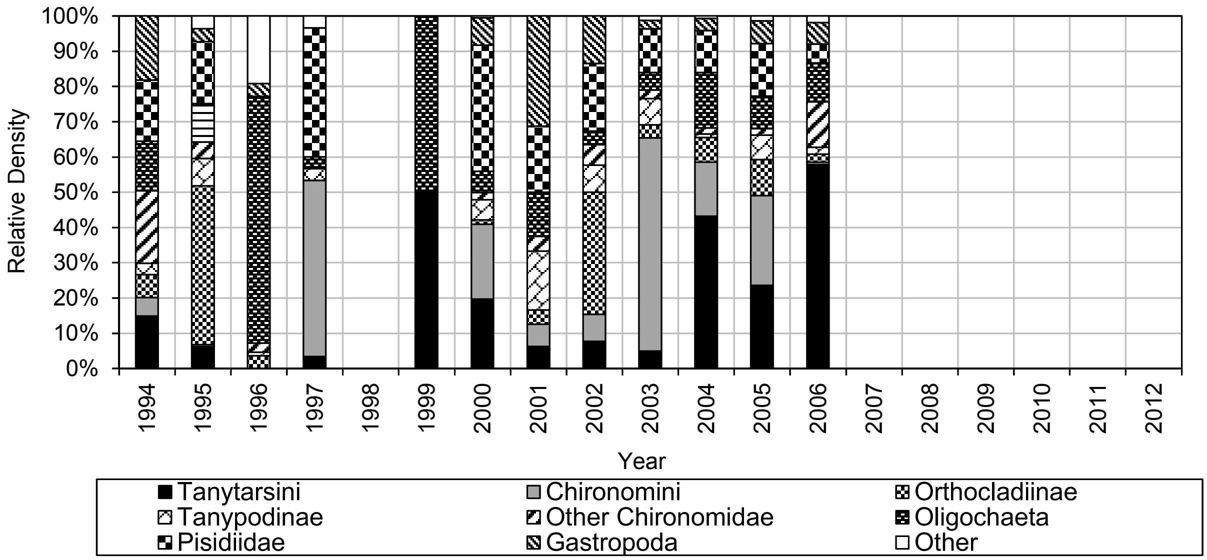


Source: ERM Rescan (2013).
Note: No data collected in 2012.
No. of taxa/station = number of taxa per station.

Community Composition by Taxonomic Group

In general, the benthic invertebrate community in Vulture Lake was dominated by Chironomidae (Figures 2.3-44 to 2.3-46). The relative proportions of Oligochaeta and Pisidiidae were variable among stations over time, but one of these taxonomic groups was usually dominant within the benthic invertebrate community. Gastropoda accounted for up to 30% of the benthic invertebrate community at the shallow station, but typically accounted for less than 10% at the mid-depth and deep stations.

Figure 2.3-44 Relative Density of Benthic Invertebrates in Vulture Lake Shallow Station, 1994 to 2006

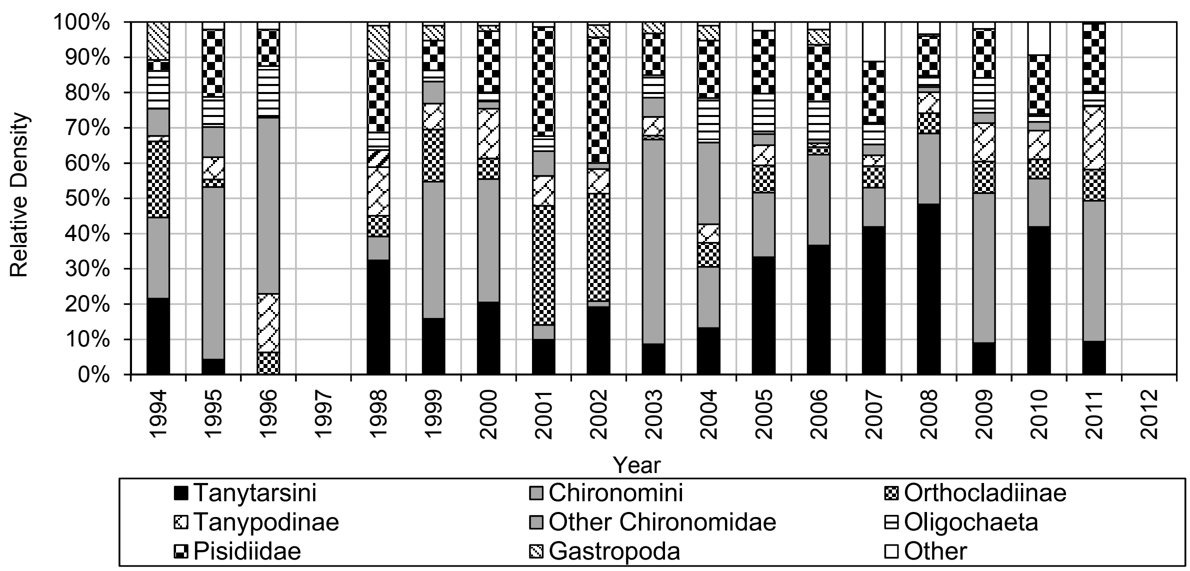


Source: ERM Rescan (2013).

Note: "Other" category includes Turbellaria, Eubranchiopoda, Acari, Trichoptera, and other Diptera.

% = percent.

Figure 2.3-45 Relative Density of Benthic Invertebrates in Vulture Lake Mid-depth Station, 1994 to 2011

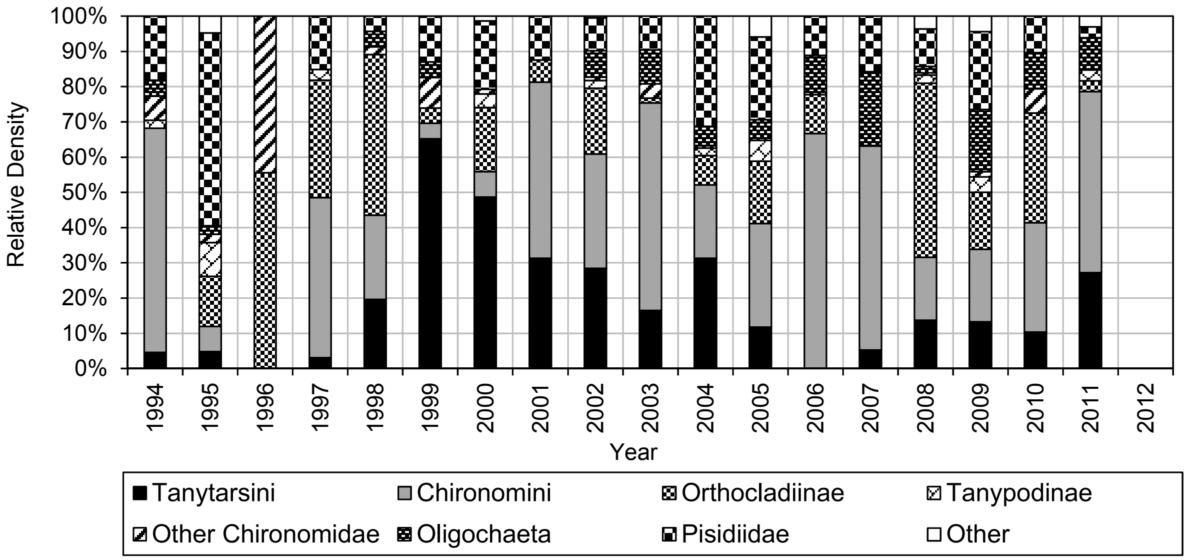


Source: ERM Rescan (2013).

Note: "Other" category includes *Hydra*, Turbellaria, Eubranchiopoda, Acari, Trichoptera, and other Diptera. No data collected in 2012.

% = percent.

Figure 2.3-46 Relative Density of Benthic Invertebrates in Vulture Lake Deep Station, 1994 to 2011



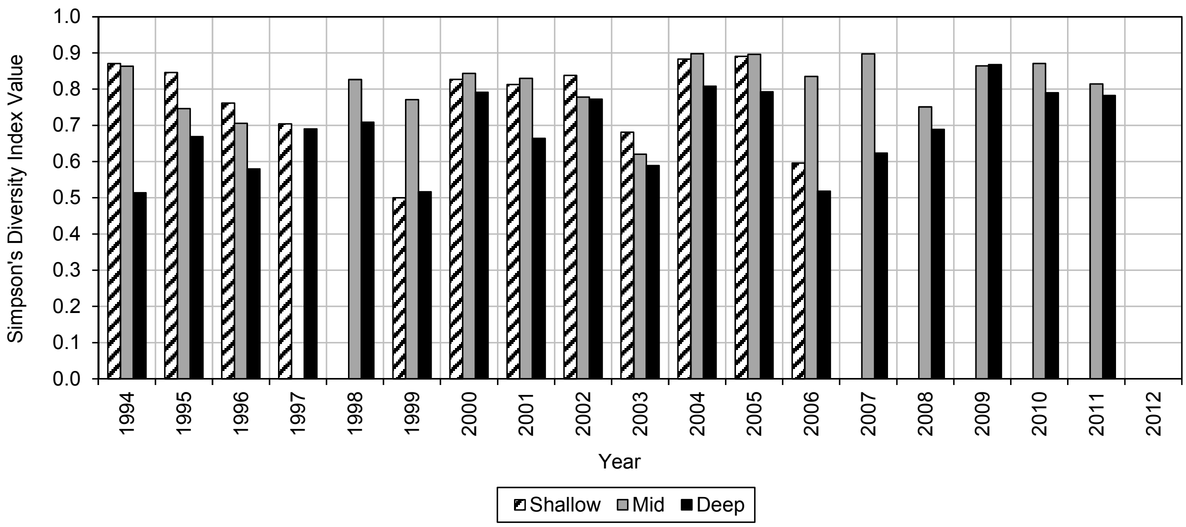
Source: ERM Rescan (2013).
Note: “Other" category includes of Turbellaria, Eubranchipoda, Acari, and Gastropoda. No data collected in 2012.
% = percent.

Benthic Community Indices

In Vulture Lake, the SDI values varied slightly over time and among stations (Figure 2.3-47). Between 1994 and 2006, SDI values ranged from 0.50 (1999) to 0.89 (2005) at the shallow station. Between 1994 and 2011, SDI values ranged from 0.62 (2003) to 0.90 (2007) at the mid-depth station, and 0.51 (1994) to 0.87 (2009) at the deep station. These SDI values indicate a moderate to high level of diversity in the Vulture Lake benthic invertebrate community.

Evenness values have exhibited a wide range in variability over time at all stations in Vulture Lake (Figure 2.3-48). Between 1994 and 2006, SEI values ranged from 0.17 (2003) to 1.00 (1999) at the shallow station. Between 1994 and 2011, SEI values ranged from 0.18 (2003) to 0.61 (2007) at the mid-depth station, and 0.22 (2003) to 0.79 (1996) at the deep station. This range of values indicates that few taxa account for the majority of the total density (low SEI values), whereas in other years the total density was more evenly distributed among the taxa present. The value of 1 at the shallow station in 1999 is due to an equal proportion of Oligochaeta (50%) and Chironomidae (50%; Tanytarsini).

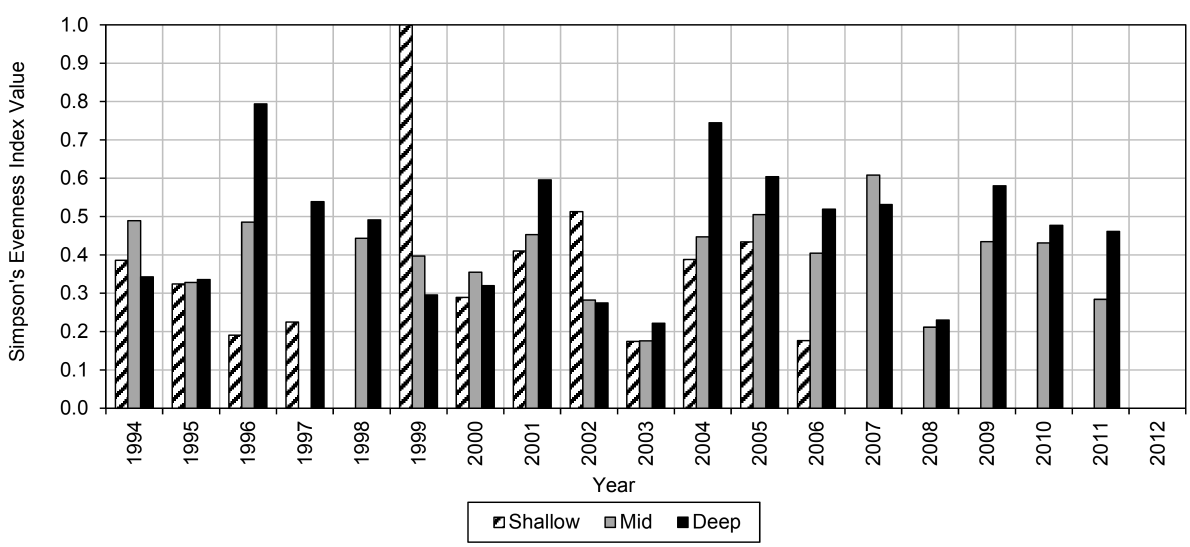
Figure 2.3-47 Simpson's Diversity Index Values for the Benthic Invertebrates in Vulture Lake, 1994 to 2011



Source: ERM Rescan (2013).

Note: No data collected in 2012.

Figure 2.3-48 Simpson's Evenness Index Values for the Benthic Invertebrate Community in Vulture Lake, 1994 to 2011



Source: ERM Rescan (2013).

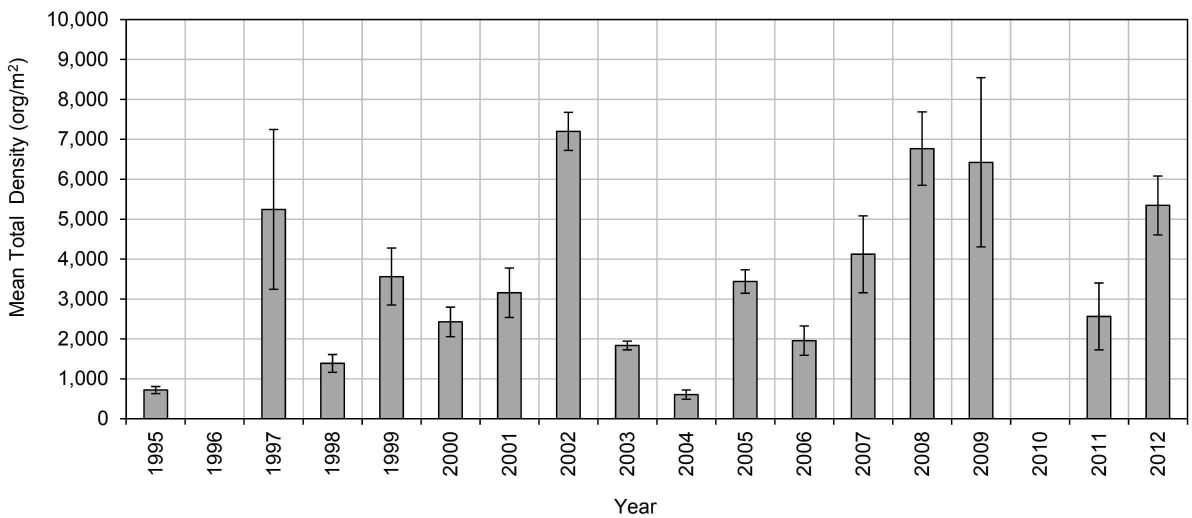
Note: No data collected in 2012.

2.3.2.5 Vulture-Polar Stream

Mean Total Density and Total Richness

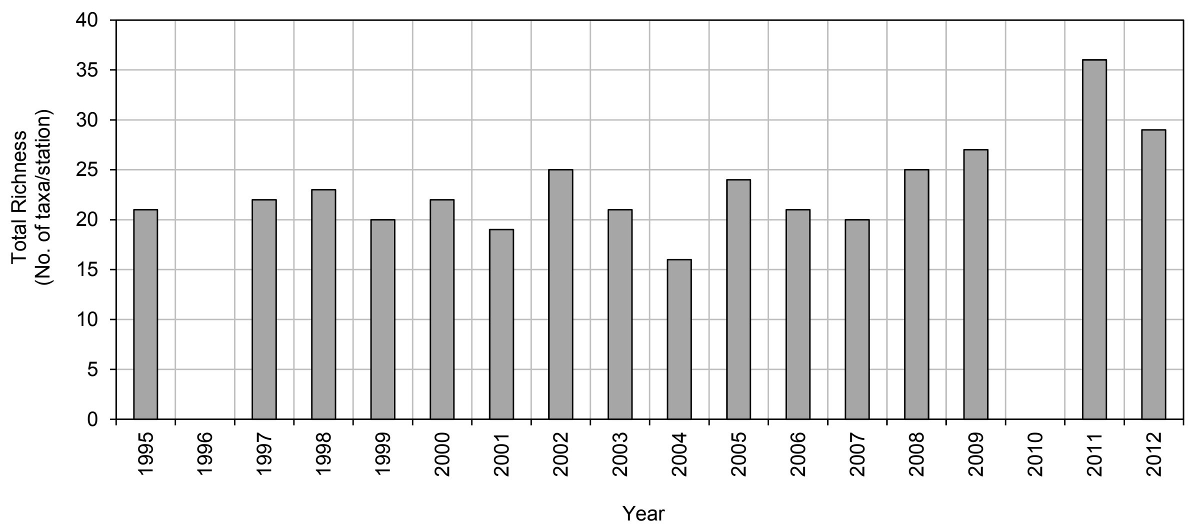
Mean total density in the Vulture-Polar Stream varied greatly between 1995 and 2012 (Figure 2.3-49). Mean total density ranged from 609 (2004) to 7,200 org/m^2 (2002). Total richness at this station ranged from 16 taxa/station (2004) to 36 taxa/station (2011), and has generally been stable over time, with the exception of an increase during the last two years of monitoring (Figure 2.3-50).

Figure 2.3-49 Mean Total Density of Benthic Invertebrates at the Vulture-Polar Stream, 1995 to 2012



Source: ERM Rescan (2013).
Note: Error bars represent one standard error of the mean.
Data were not collected in 1996. Samples were discarded before analysis due to laboratory error in 2010.
org/m^2 = number or organisms per square metre.

Figure 2.3-50 Total Benthic Invertebrate Richness at the Vulture-Polar Stream, 1995 to 2012

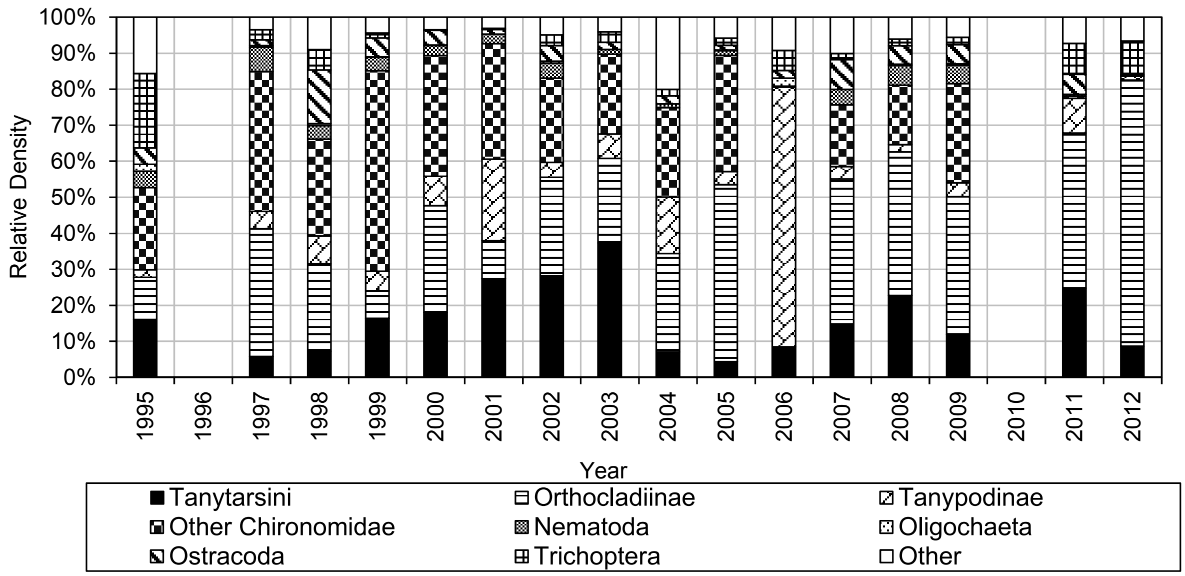


Source: ERM Rescan (2013).
Note: Data were not collected in 1996. Samples were discarded before analysis due to laboratory error in 2010.
No. of taxa/station = number of taxa per station.

Community Composition by Major Taxonomic Group

The Chironomidae have dominated the benthic invertebrate community at the Vulture-Polar Stream since 1995 (Figure 2.3-51). Relative densities of Ostracoda and Trichoptera have been variable among years, each contributing between 1% and 20% to the overall benthic invertebrate community. Nematoda, Oligochaeta, Harpacticoida, Acari, Ephemeroptera, Plecoptera, and other Diptera have contributed to less than 10% of the benthic invertebrate community at the Vulture-Polar Stream. Coleoptera, Gastropoda, and Pisidiidae have all contributed to less than 1% and have only been present a limited number of years.

Figure 2.3-51 Relative Density of Benthic Invertebrate Taxonomic Groups at the Vulture-Polar Stream, 1995 to 2012



Source: ERM Rescan (2013).

Note: Data were not collected in 1996. Samples were discarded before analysis due to laboratory error in 2010.

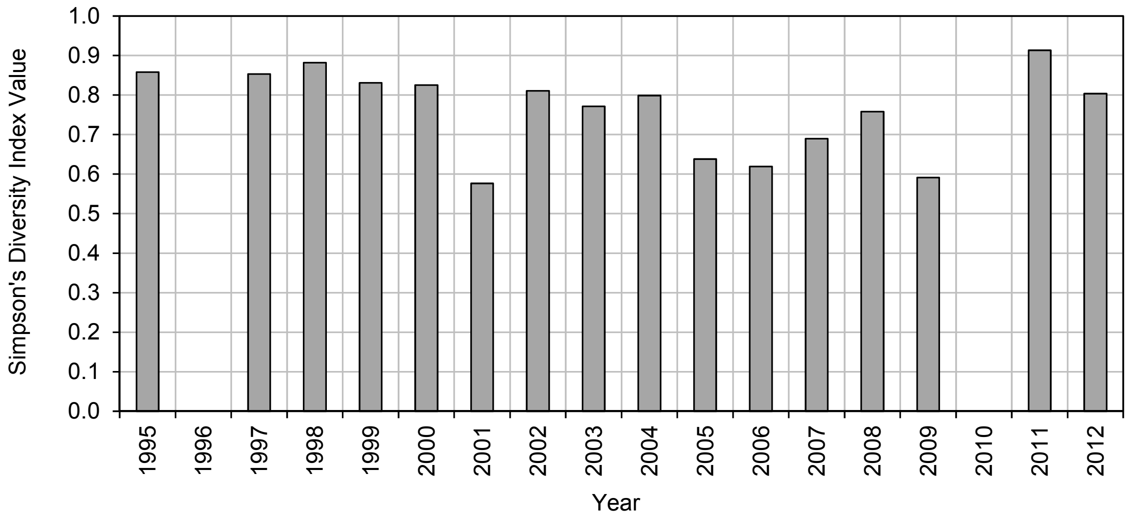
“Other” includes *Hydra*, Harpacticoida, Acari, Ephemeroptera, Plecoptera, Coleoptera, Other Diptera, Gastropoda, and Pisidiidae.

% = percent.

Benthic Community Indices

Between 1995 and 2012, SDI values at the Vulture-Polar Stream ranged from 0.58 (2001) to 0.91 (2011); the majority of SDI values were greater than 0.7, indicating a high level of diversity (Figure 2.3-52). Evenness values at this station were consistently low over time, ranging from 0.09 (2009) to 0.37 (1998) (Figure 2.3-53). These low values are indicative of the Chironomidae sub-families and tribes that dominated the community composition each year.

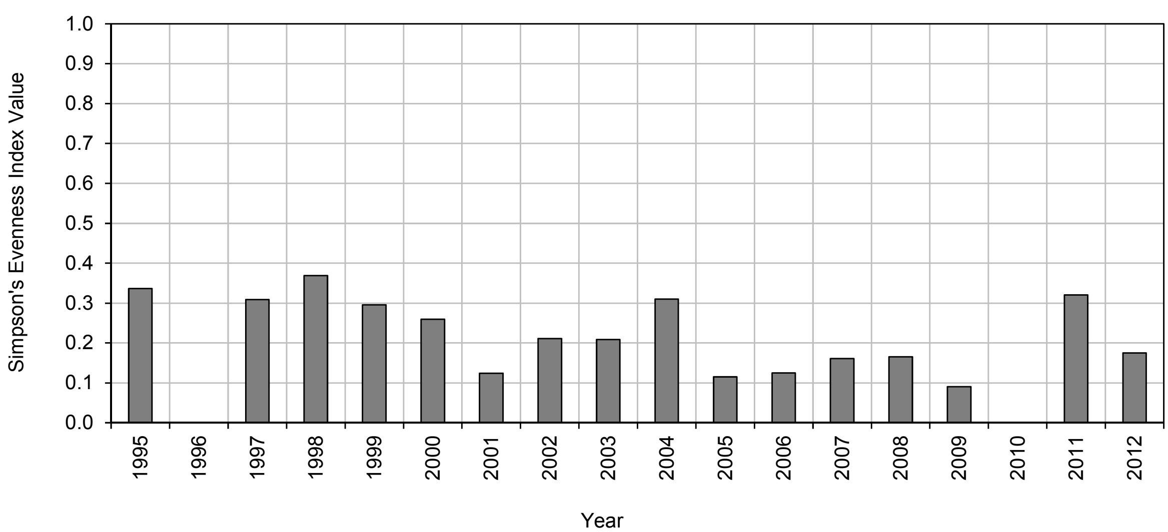
Figure 2.3-52 Simpson's Diversity Index Values for the Benthic Invertebrate Community at the Vulture-Polar Stream, 1995 to 2012



Source: ERM Rescan (2013).

Note: Data were not collected in 1996. Samples were discarded before analysis due to laboratory error in 2010.

Figure 2.3-53 Simpson's Evenness Index Values for the Benthic Invertebrate Community at the Vulture-Polar Stream, 1995 to 2012



Source: ERM Rescan (2013).

Note: Data were not collected in 1996. Samples were discarded before analysis due to laboratory error in 2010.

3 2013 FIELD SUMMARY

3.1 Methods

3.1.1 Sampling Locations and Timing

3.1.1.1 Lakes

Benthic invertebrate samples and supporting data were collected in fall 2013, between August 16 and September 14, from the following waterbodies and depths (Map 1.3-1; Table 3.1-1):

- 29 stations in Lac du Sauvage (7 shallow, 7 mid-depth, 8 deep, and 7 littoral stations);
- 6 stations in Duchess Lake (2 each of shallow, deep, and littoral stations);
- 2 stations in Lake Af1 (1 mid-depth station and 1 littoral station);
- 1 station in Lake C1 (deep station);
- 3 stations in Lake E1 (1 station each of shallow, deep, and littoral); and,
- 5 stations in Paul Lake (4 mid-depth stations and 1 deep station).

Depth categories were defined as follows:

- shallow (1 to 5 m);
- mid-depth (5.1 to 10 m);
- deep (greater than 10 m); and,
- littoral (near-shore and less than 1 m).

Sediment quality samples were also collected at the shallow, mid-depth, and deep water sampling locations.

Table 3.1-1 Benthic Invertebrate Lake and Littoral Sampling Stations in the Jay Project Baseline Study Area, August and September 2013

Waterbody	Sub-Basin	Location in Sub-Basin	Station	Date Sampled	UTM Coordinates Easting (m)	UTM Coordinates Northing (m)	Sample Depth Category	Mean Depth (m)	Kick-net Samples	Ekman Grab Samples	Sediment Quality Samples
Lac du Sauvage	Aa	—	Aa-1	27-Aug-13	552282	7165025	deep	11.2	—	X	X
			Aa-6	27-Aug-13	552546	7165438	mid-depth	8.0	—	X	X
			Aa-2	27-Aug-13	552773	7165665	shallow	5.0	—	X	X
			Aa-3	27-Aug-13	552900	7165940	littoral	0.4	X	—	—
	Ab	—	Ab-1	26-Aug-13	547766	7162266	deep	12.4	—	X	X
			Ab-6	26-Aug-13	548229	7161205	mid-depth	7.6	—	X	X
			Ab-2	26-Aug-13	548215	7161177	shallow	5.0	—	X	X
			Ab-3	26-Aug-13	548095	7161077	littoral	0.4	X	—	—
	Ac	Northeast	Ac-1	25-Aug-13	545339	7165138	deep	12.8	—	X	X
			Ac-10	24-Aug-13	545819	7165433	mid-depth	7.3	—	X	X
			Ac-2	25-Aug-13	545832	7165447	shallow	5.0	—	X	X
			Ac-3	24-Aug-13	546058	7165524	littoral	0.3	X	—	—
			Ac-7	24-Aug-13	544247	7165068	deep	12.4	—	X	X
			Ac-12	24-Aug-13	544776	7165818	mid-depth	6.5	—	X	X
			Ac-8	24-Aug-13	544777	7165855	shallow	4.8	—	X	X
			Ac-9	24-Aug-13	545265	7166294	littoral	0.4	X	—	—
		Southwest	Ac-4	19-Aug-13	543695	7162938	deep	12.3	—	X	X
			Ac-11	19-Aug-13	543185	7163231	mid-depth	8.2	—	X	X
			Ac-5	19-Aug-13	543149	7163287	shallow	3.6	—	X	X
			Ac-6	19-Aug-13	543092	7163291	littoral	0.4	X	—	—
	Ad	—	Ad-1	17-Aug-13	539898	7168781	deep	12.6	—	X	X
			Ad-4	17-Aug-13	539949	7168851	mid-depth	7.9	—	X	X
			Ad-2	17-Aug-13	539868	7168991	shallow	4.2	—	X	X
			Ad-3	17-Aug-13	539868	7169057	littoral	0.4	X	—	—

Table 3.1-1 Benthic Invertebrate Lake and Littoral Sampling Stations in the Jay Project Baseline Study Area, August and September 2013

Waterbody	Sub-Basin	Location in Sub-Basin	Station	Date Sampled	UTM Coordinates Easting (m)	UTM Coordinates Northing (m)	Sample Depth Category	Mean Depth (m)	Kick-net Samples	Ekman Grab Samples	Sediment Quality Samples
Lac du Sauvage	Ae	—	Ae-1	18-Aug-13	542494	7170252	deep	12.4	—	X	X
			Ae-6	16-Aug-13	542520	7170406	deep	12.2	—	X	X
			Ae-7	18-Aug-13	542619	7170623	mid-depth	6.4	—	X	X
			Ae-2	16-Aug-13	542589	7170664	shallow	5.0	—	X	X
			Ae-3	16-Aug-13	542895	7170927	littoral	0.3	X	—	—
Duchess Lake	Af	—	Af-1	21-Aug-13	542155	7173731	deep	13.5	—	X	X
			Af-2	21-Aug-13	542074	7173542	shallow	4.3	—	X	X
			Af-3	20-Aug-13	541835	7173283	littoral	0.3	X	—	—
			Af-4	20-Aug-13	544360	7173181	shallow	3.0	—	X	X
			Af-6	15-Aug-13	544948	7173327	littoral	0.4	X	—	—
			Af-7	20-Aug-13	541367	7174902	deep	12.4	—	X	X
Lake Af1	—	—	Af-10	12-Sep-13	538299	7176361	mid-depth	8.7	—	X	X
			Af-12	12-Sep-13	538164	7176540	littoral	0.4	X	—	—
Lake C1	—	—	C-L1	15-Sep-13	537922	7167471	deep	10.2	—	X	X
Lake E1	—	—	E-L1-1	23-Aug-13	535065	7174657	deep	11.7	—	X	X
			E-L1-2	23-Aug-13	535292	7174406	shallow	3.5	—	X	X
			E-L1-3	23-Aug-13	535979	7174271	littoral	0.4	X	—	—
Paul Lake	—	—	PL-1	14-Sep-13	533179	7173835	mid-depth	8.8	—	X	X
			PL-2	14-Sep-13	531655	7174122	mid-depth	8.0	—	X	X
			PL-3	14-Sep-13	528681	7172550	deep	13.0	—	X	X
			PL-4	14-Sep-13	527145	7171895	mid-depth	8.0	—	X	X
			PL-5	14-Sep-13	525855	7171047	mid-depth	8.0	—	X	X

Note: Universal Transverse Mercator (UTM) coordinates are North American Datum (NAD) 83, Zone 12.
m = metre; X = sample collected; — = not applicable; Aug = August; Sep = September.

3.1.1.2 Streams

Benthic invertebrate samples were collected between August 5 and September 16, 2013, from four streams in the Lac du Sauvage basin. One station was sampled in each of Stream Ab1, Stream G1, and Stream L1; five stations were sampled in Stream E2 (Table 3.1-2).

Table 3.1-2 Benthic Invertebrate Stream Sampling Stations in the Jay Project Baseline Study Area, August and September 2013

Waterbody	Station	Date Sampled	UTM Coordinates		Mean Depth (m)
			Easting (m)	Northing (m)	
Stream Ab1	Ab-S1	12-Sep-2013	546755	7159513	0.3
Stream E2	E-S2-1	13-Sep-2013	535267	7176533	0.2
	E-S2-2	14-Sep-2013	535639	7180179	0.2
	E-S2-3	14-Sep-2013	535848	7179317	0.3
	E-S2-4	13-Sep-2013	535738	7178586	0.3
	E-S2-5	13-Sep-2013	536119	7177511	0.3
Stream G1	G-S1	05-Aug-2013	545228	7174255	0.3
Stream L1	L-S1	16-Sep-2013	550337	7158991	0.3

Note: Universal Transverse Mercator (UTM) coordinates are North American Datum (NAD) 83, Zone 12.
m = metre; Aug = August; Sep = September.

3.1.2 Field Methods

3.1.2.1 Lake Stations

Benthic invertebrate samples were collected from the lake sampling stations according to standard operating procedures (unpublished file information), which were based on relevant scientific literature (Alberta Environment 1990; Klemm et al. 1990; Environment Canada 1993; Rosenberg and Resh 1993). At each station, a standard Ekman grab (15.24 centimetre [cm] × 15.24 cm: bottom sampling area of 0.0232 square metre [m²]) was used from an anchored boat to collect benthic invertebrate samples. Five individual Ekman grab samples were collected at each station; each grab sample was sieved through a 250-μm mesh screen in the field. Material retained in the mesh was placed in a separate 500-millilitre sample bottle and preserved in 70% ethanol. Benthic invertebrate samples were shipped to EcoAnalysts Inc. (EcoAnalysts) in Moscow, Idaho (USA) for taxonomic identification and enumeration of invertebrates.

At each station, three additional Ekman grab samples were collected and combined into a composite sample for sediment chemistry analysis. The top 5 cm of sediment was removed from the grab using a plastic spoon and was placed in sample jars. Care was taken to confirm that sediment in direct contact with the metal of the Ekman grab was not collected as part of the sediment sample sent to the laboratory. Sediment samples were shipped to ALS Environmental (ALS) in Edmonton, Alberta, for analyses.

3.1.2.2 Littoral Stations

Benthic invertebrate samples were collected from the littoral sampling stations according to standard operating procedures (unpublished file information), which were based on relevant scientific literature (Alberta Environment 1990; Klemm et al. 1990; Environment Canada 1993; Rosenberg and Resh 1993). At each littoral station, a kick-net equipped with a 500 µm mesh screen was used to sample a combined distance of 6 to 9 m for 90 to 120 seconds at a water depth of less than 1 m. The area of collection was dependent on the productivity of the station and was adjusted accordingly (time and distance) to avoid over-collection. This kick-net method was repeated three times; the collected material was placed in a single jar to create a composite sample at each littoral station. Benthic invertebrate samples were shipped to EcoAnalysts for taxonomic identification and enumeration of invertebrates.

3.1.2.3 Stream Stations

Benthic invertebrate samples were collected according to standard operating procedures (unpublished file information), which were based on relevant scientific literature (Alberta Environment 1990; Klemm et al. 1990; Environment Canada 1993; Rosenberg and Resh 1993). Five individual benthic invertebrate samples were collected at each stream station using a Surber sampler with a bottom sampling area of 0.1 m, equipped with a 250-µm mesh Nitex screen. The Surber sampler was placed on the stream bottom in cobble/gravel substrate, with the net opening facing upstream. The substrate within the area enclosed by the Surber frame was agitated manually to dislodge invertebrates. The entire surface of large rocks was gently rubbed by hand and the large rocks were removed from the sample frame until only smaller sized particles (gravel and smaller) were left in the sampling area. A garden trowel was used to stir up the remaining particles within the Surber frame to a depth of 5 to 10 cm. Suspended material was transported into the Surber net. The Surber sampler was then removed from the stream and the material that was retained in the net was washed into a sample bottle attached to the end of the net. Benthic invertebrate samples were preserved in 70% ethanol and were shipped to EcoAnalysts for taxonomic identification and enumeration of invertebrates.

3.1.3 Supporting Environmental Variables

The following supporting environmental information was recorded during the benthic invertebrate survey:

- weather conditions, such as air temperature, wind velocity, and wind direction;
- habitat description, including visual estimates of bottom substrates (i.e., percentage of substrate represented by each category) at stream and littoral stations and bottom sediment-related information (i.e., texture, colour, odour, particle size) at depositional stations;
- water depth (for each replicate sample);
- current velocity (for each replicate sample) using a Marsh-McBirney flow meter and wading rod at stream stations;
- field measurements of conductivity and water temperature using a YSI-650 multi-meter; vertical profiles were measured at lake stations and spot measurements were recorded at littoral and stream stations; and,
- benthic invertebrate sample-related information (sampler type, sieve mesh size, sampler fullness, preservative).

Additional details of field water quality methods are provided in Annex XI, the Water and Sediment Quality Baseline Report for the Jay Project. Water quality profile data for the mid-depth stations (Aa-6, Ab-6, Ac-10, Ac-11, Ac-12, Ad-4, and Ae-7) and one deep station (Ae-6) in Lac du Sauvage are included in this report. Profile data for the shallow and deep stations where benthic invertebrate samples were collected are included in Annex XI.

Substrate composition (as a percentage) was evaluated visually at each littoral and stream stations. Substrate categories were as follows:

- boulder (greater than 256 millimetres [mm]);
- large cobble (128 to 256 mm);
- small cobble (64 to 128 mm);
- large gravel (16 to 64 mm);
- small gravel (2 to 16 mm); and,
- fine sediment (less than 2 mm).

The proportion of benthic algal cover was visually evaluated at littoral and stream stations. Benthic algal cover was qualitatively categorized as follows:

- none (benthic algae absent, bare substrate);
- low;
- moderate; and,
- high.

3.1.4 Laboratory Methods

3.1.4.1 Benthic Invertebrate Sample Sorting, Enumeration, and Identification

Originally, benthic invertebrate samples were to be analyzed at both the 250-µm and 500-µm size fractions; however, due to a laboratory error, only the 500-µm fraction was analyzed in samples from 29 lake and littoral stations from Lac du Sauvage and 2 stations from Duchess Lake. For these samples, the benthic invertebrate samples were placed into a 500-µm mesh screen and washed to remove preservative and any remaining fine sediment (EcoAnalysts 2013).

The remaining lake samples, littoral samples, and stream samples were processed using a 250-µm mesh screen (EcoAnalysts 2013). Samples with high inorganic content were elutriated to separate the organic material from the inorganic material before sorting. The inorganic material was checked for shelled or cased invertebrates, which may have been too heavy to elutriate, and this heavier material was included in the remaining sample.

After the benthic invertebrate samples were processed to remove preservative and any remaining fine sediment, the samples were prepared for sub-sampling, if required. The organic material and other contents in the sieve were evenly distributed into the bottom of a Caton subsampling tray (Caton 1991) with a two-inch grid and a bottom, equipped with a 250-µm mesh screen (EcoAnalysts 2013). A grid cell was randomly selected and the contents were transferred to a Petri dish for sorting under a dissecting microscope. Further grid cells were selected until the target number of 300 organisms was reached. When the target number of organisms was reached, the last grid cell selected was still sorted in its entirety (i.e., the target number of organisms was exceeded).

Invertebrates were identified to the lowest practical taxonomic level, typically genus or species, by qualified taxonomists using recognized taxonomic keys (Appendix E2, EcoAnalysts, Inc. Taxonomic Reference List). Exceptions included the Turbellaria, Nematoda, and Ostracoda, which were identified to major group.

Organisms that could not be identified to the desired taxonomic level, such as immature or damaged specimens, were reported as a separate category at the lowest taxonomic level possible, typically family. The most common taxa were distinguishable based on gross morphology and required only a few slide mounts (five to ten) for verification. Organisms requiring detailed microscopic examination, such as midges (Chironomidae) and aquatic worms (Oligochaeta), were mounted on microscope slides using an appropriate mounting medium. A reference collection containing representative specimens of each identified taxon was prepared.

3.1.4.2 Sediment Quality Samples

Sediment samples were shipped to ALS in Edmonton, Alberta, for analyses of the following parameters at deep and shallow stations:

- physical parameters: organic content, pH, and particle size distribution;
- nutrients: available ammonium as nitrogen, organic nitrogen, total Kjeldahl nitrogen, available phosphate as phosphorus, total phosphorus, inorganic carbon, total carbon, and total organic carbon (TOC); and,
- total metals[1]: aluminum, antimony, arsenic, barium, beryllium, bismuth, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, sulfur, thallium, tin, titanium, uranium, vanadium, and zinc.

Particle size distribution was analyzed as a percentage (%) of the total sediment according to the following size classification:

- gravel (greater than 2.0 mm to 16.0 mm);
- coarse sand (greater than 0.2 mm to 2.0 mm);
- fine sand (greater than 0.063 mm to 0.2 mm);

[1] For the purposes of this report, the term “total metals” includes metalloids such as arsenic and non-metals such as selenium.

- silt (0.004 mm to 0.062 mm); and,
- clay (less than 0.004 mm).

For stations that were only sampled as part of the benthic invertebrate program (i.e., Lac du Sauvage mid-depth stations and deep Station Ae-6), TOC and particle size distribution were the only parameters analyzed by the laboratory.

3.1.5 Data Analysis

Habitat data were summarized in tabular format to allow comparisons of areas of similar habitat type (i.e., lake, littoral, or stream) in the BSA. In the summary tables, silt and clay were combined into a “fines” category, and coarse and fine sand were combined into a “sand” category.

Raw invertebrate abundance data were screened during the preparation of data for analysis, and the following non-benthic organisms were removed:

- **Nematoda –** removed from lake samples (Ekman grab and kick-net) because data are from a 500 µm mesh, which results in unreliable estimates of nematode numbers (Environment Canada 2012); included in stream Surber samples because these were from a 250 µm mesh;
- **Ostracoda –** removed from lake samples (Ekman grab and kick-net) because they are unreliably collected using a 500 µm mesh; included in stream Surber samples because these were from a 250 µm mesh; and,
- **Hemiptera –** removed because they are not strictly benthic organisms.

Cladocera and Copepoda, which are planktonic organisms, were not enumerated.

The following benthic invertebrate summary variables were calculated for each lake and stream station:

- mean total invertebrate density (number of organisms per square metre [org/m^2]);
- total taxonomic richness (number of taxa per station [taxa/station]);
- Simpson’s diversity index (SDI);
- Simpson’s evenness index (SEI); and,
- community composition as percentages of major taxa.

For the littoral stations, samples were qualitative; therefore, summary variables were limited to total taxonomic richness and community composition.

Density was calculated as the total number of organisms per square metre for each replicate sample per station. These calculations were based on the bottom area of the Ekman grab (0.0232 square metres). Richness is the total number of taxa within a station at the lowest level of identification. It provides an indication of the diversity of benthic invertebrates in an area; a higher richness value typically indicates a more healthy and balanced community.

For interpretation purposes, benthic invertebrate densities and richness values were categorized as follows:

- low: density less than 5,000 org/m² and richness less than 10 taxa/station;
- moderate: density ranging from 5,000 to 50,000 org/m², and richness ranging from 10 to 40 taxa/station; and,
- high: density greater than 50,000 org/m² and richness greater than 40 taxa/station.

The SDI measures the proportional distribution of organisms in the community, given that not all organisms have the same success in the environment. Certain conditions may favour one organism over another (Simpson 1949). The SDI values range between zero and one, where lower values indicate a less diverse community and higher values indicate a more diverse community. Both taxonomic richness and how evenly the total density is distributed among these taxa are taken into account in the calculation of SDI. The SDI was calculated using the formula provided by Krebs (Krebs 1999):

$$D = 1 - \sum_{i=1}^{S} (p_i)^2$$

Where:

D = Simpson's index of diversity;

S = the total number of taxa; and,

p_i = the proportion of the i^{th} taxon.

The SEI is an index recommended by Environment Canada (2012) for analyzing environmental effects monitoring data. It is a measure of how evenly the total invertebrate density is distributed among the taxa present at the station. The SEI is included along with the SDI to provide context as to whether taxonomic richness or the distribution of total density among taxa is driving the SDI values. The SEI is also expressed as a value between one and zero, with one representing high evenness (i.e., equal numbers of all taxa present in a sample) and zero representing low evenness (i.e., a high degree of dominance by one or a few organisms). The SEI values were calculated using the following formula (Smith and Wilson 1996):

$$E = 1/\sum_{i=1}^{S}(p_i)^2 \ /S$$

Where:

E = evenness;

p_i = the proportion of the i^{th} taxon; and,

S = the total number of taxa.

For lake and stream stations, Spearman rank correlation analysis between habitat variables and benthic invertebrate community variables was used to investigate habitat relationships. Spearman rank correlation coefficients were calculated using SYSTAT 13 (SYSTAT 2009). Correlations were identified as significant at $P<0.05$, $P<0.01$, and $P<0.001$.

Mesh size used during sampling and sample processing will influence what organisms are sorted and subsequently identified, and can thus affect the sensitivity of effects monitoring. As an initial step to understand the effect of laboratory mesh size on benthic invertebrate data collected in the BSA, the data generated for the same stations using 250 and 500 µm mesh screens in the laboratory were compared (Appendix B, Mesh Size Comparison). This comparison was done for samples processed using a 250 µm screen that were also fractionated using a 500 µm screen in the laboratory. The ratio of the mean total number of organisms collected at a station in all sample fractions (i.e., the 250 µm data set) to the number of organisms in the 500 µm fraction was calculated for major taxa and major groups of the Chironomidae.

3.1.6 Quality Assurance and Quality Control

3.1.6.1 Field

Quality assurance and quality control procedures and requirements are an important aspect of any field or laboratory testing program. Good QA/QC practices result in field sampling, data entry, data analysis, and report preparation that produce technically sound and scientifically defensible results.

Detailed specific work instructions outlining each field task were provided to the field personnel before the field program. Samples were collected by experienced personnel and were labelled, preserved, and shipped according to Golder Technical Procedure 8.6-1: Benthic Invertebrate Sampling and approved specific work instructions (unpublished file information). Field equipment, such as water quality and flow meters, were regularly calibrated according to the manufacturer's recommendations. Benthic invertebrate samples were accompanied by a chain-of-custody form.

Field data were recorded on standardized field data sheets or in a bound field book, according to established field record-keeping procedures.

3.1.6.2 Laboratory

Quality control procedures included verifying the sorting efficiency of each benthic invertebrate sample. Sorting efficiency was verified by an individual other than the original sorter, by re-sorting at least 20% of the sorted material of every sample (EcoAnalysts 2013). The data quality objective was a minimum removal of 90% of the organisms in the sample. If the estimate of sorting efficiency was less than 90%, the sample was re-sorted until this data quality objective was achieved.

3.1.6.3 Data Entry and Screening

Raw benthic invertebrate data were received from the taxonomy laboratory in Microsoft Excel spreadsheet format, with data entry already verified. For the lake and stream stations, raw abundance data received as number of organisms per sample were converted to density expressed as the number of organisms per square metre. Unusual abundance values were validated before data summary and analysis.

Field data entered into electronic format underwent a 100% transcription and validity check by a second person not involved in the initial data entry process. All calculated values, tables, and summary figures generated from the dataset underwent an additional QA/QC verification by a second person not involved in the initial calculations.

3.2 Results

3.2.1 Quality Assurance and Quality Control

Sorting efficiency for benthic invertebrate samples met the requirement of 90% removal of organisms in the initial sample sort for most samples. Results for the three habitat types were as follows:

- For lake samples, sorting efficiency ranged from 91% to 100% removal in the initial sort. Detailed QA/QC results are provided in Appendix C, Benthic Invertebrate Taxonomy Quality Assurance/Quality Control Data, Table C-1.
- For littoral samples, sorting efficiency was 100% removal for all samples in the initial sort. Detailed QA/QC results are provided in Appendix C, Table C-2.
- For stream samples, sorting efficiency met the requirement of 90% removal of organisms in the initial sample sort, with the exception of two samples. Sample E-S2-B had 64% recovery from the 250 µm fraction, and sample E-S2-4-A had 77% recovery in the 1 mm fraction after the initial sort (Appendix C, Table C-3). However, both sample fractions had 100% recovery after the re-sort. Sorting efficiency ranged from 94% to 100% removal for other samples.

3.2.2 Effect of Habitat Variation at Lake Stations

The following physical factors varied sufficiently among lake stations to potentially contribute to among-station variation in benthic invertebrate community structure:

- Water depth varied from 3.0 to 13.5 m.
- The TOC varied from 1% to 4%.

- The percentages of gravel, sand, and fines in bottom sediments varied from 0% to 3%, 0% to 49%, and 48% to 100%, respectively.

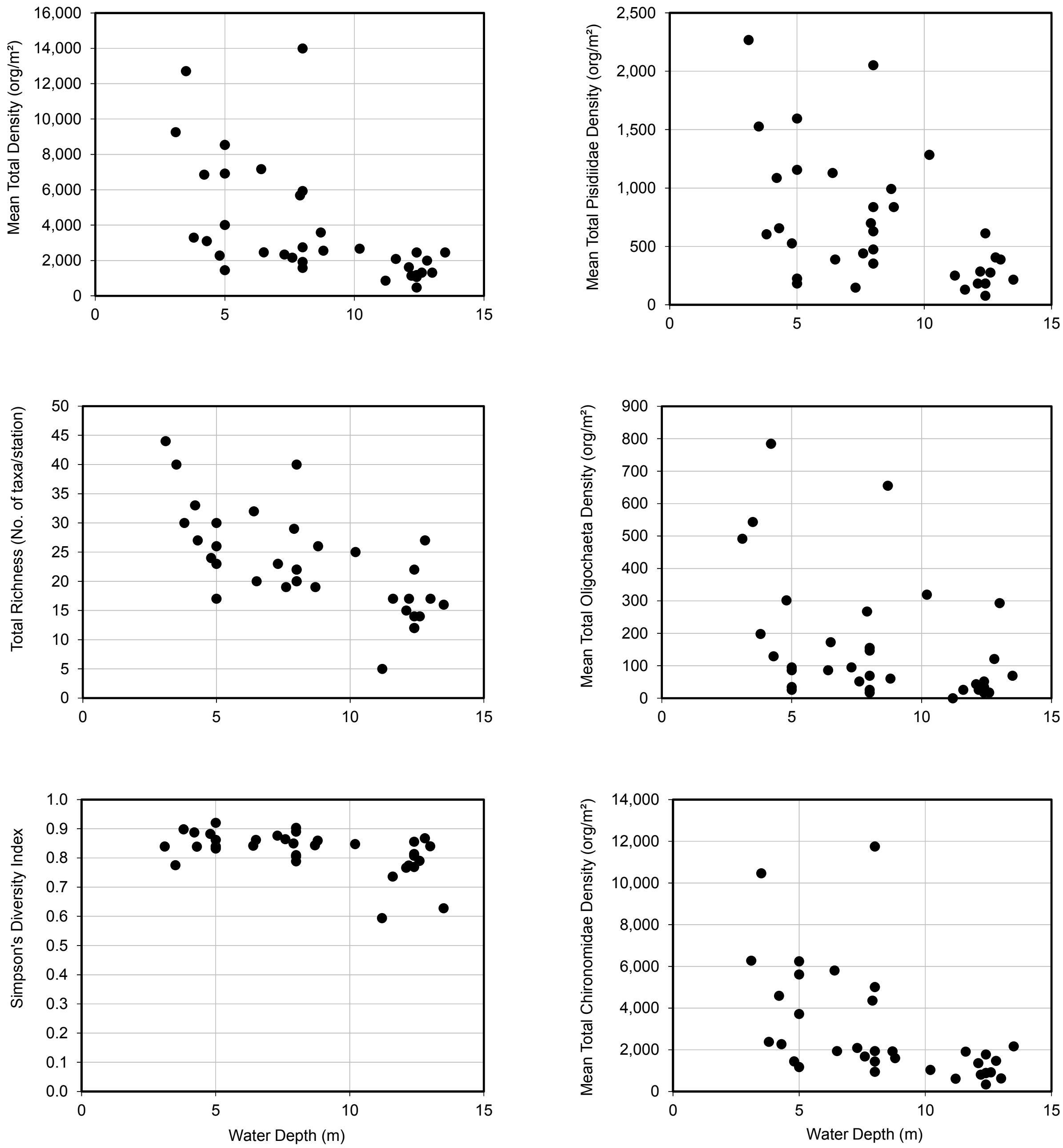
These variables were included in a Spearman rank correlation analysis of the entire data set, excluding littoral stations, to investigate their influence on benthic invertebrate community variables. Significant correlations were detected between water depth and all community variables, with the exception of SEI (Table 3.2-1). These correlations were negative in direction, indicating that community variables decreased in value with increasing water depth (Figure 3.2-1). These results are consistent with expectations, because benthic invertebrate density and diversity tend to decline with increasing water depth.

Table 3.2-1 Spearman Rank Correlations between Benthic Invertebrate Community Variables and Selected Habitat Variables at Lake Stations in the Jay Project Baseline Study Area, 2013

Community Variable	Spearman Correlation Coefficient (r_s)				
	Water Depth	**Total Organic Carbon**	**Gravel**	**Sand**	**Fines**
Mean total density	-0.660***	0.131	0.000	0.021	-0.032
Total richness	-0.694***	0.108	-0.014	0.092	-0.095
Simpson's Diversity Index	-0.422**	0.117	-0.034	0.098	-0.094
Simpson's Evenness Index	0.205	-0.048	-0.067	0.038	-0.023
Pisidiidae density	-0.507**	0.229	-0.312	-0.120	0.121
Oligochaeta density	-0.464**	0.317	-0.070	-0.024	0.018
Chironomidae density	-0.663***	0.023	0.072	0.106	-0.117

Notes:
Critical value (alpha = 0.05, n = 35, 2-tailed test) = 0.335.
Critical value (alpha = 0.01, n = 35, 2-tailed test) = 0.433
Critical value (alpha = 0.001, n = 35, 2-tailed test) = 0.539
Significant correlations are denoted as: ** = *P*<0.01 and *** *P*<0.001.

Figure 3.2-1 Scatter-Plots of Water Depth versus Selected Benthic Invertebrate Community Variables at Lake Stations, Jay Project Baseline Study Area, 2013



m = metre; org/m^2 = number of organisms per square metre; No. of taxa/station = number of taxa per station.

3.2.3 Lac du Sauvage Basin

3.2.3.1 Lac du Sauvage

3.2.3.1.1 Aquatic Habitat – Lake Stations

Habitat data for lake stations in Lac du Sauvage are summarized in Table 3.2-2; water quality profile data for Lac du Sauvage are provided in Appendix D, Table D-1. Additional water quality data, including field profiles summaries, at overlapping benthic invertebrate and water quality stations, are summarized in Annex XI.

Conductivity values were similar among stations in Lac du Sauvage and uniform through the water column at the time of the benthic invertebrate program. Water temperature was variable among stations, ranging from 11.3 degrees Celsius (°C) to 19.3°C at the surface, and 11.3°C to 17.4°C at the bottom of the water column. However, no thermal stratification was evident, with the exception of the deep station, Station Ae-6 (Figure 3.2-2). Variation in water temperature was likely the result of weather conditions at time of sampling. Field water quality was within or slightly above the range of other Arctic tundra lakes located north of Yellowknife (Pienitz et al. 1997).

Detailed sediment chemistry results for deep and shallow stations are provided in Annex XI.
The proportions of TOC and sediment particle size distribution were similar among stations. Total organic carbon was low at all stations, ranging from 1% to 2%; the predominant substrate consisted of fine sediments (i.e., silt and clay), ranging from 69% to 100% fines.

Table 3.2-2 Summary of Habitat Variables for Lake Stations in Lac du Sauvage, August and September 2013

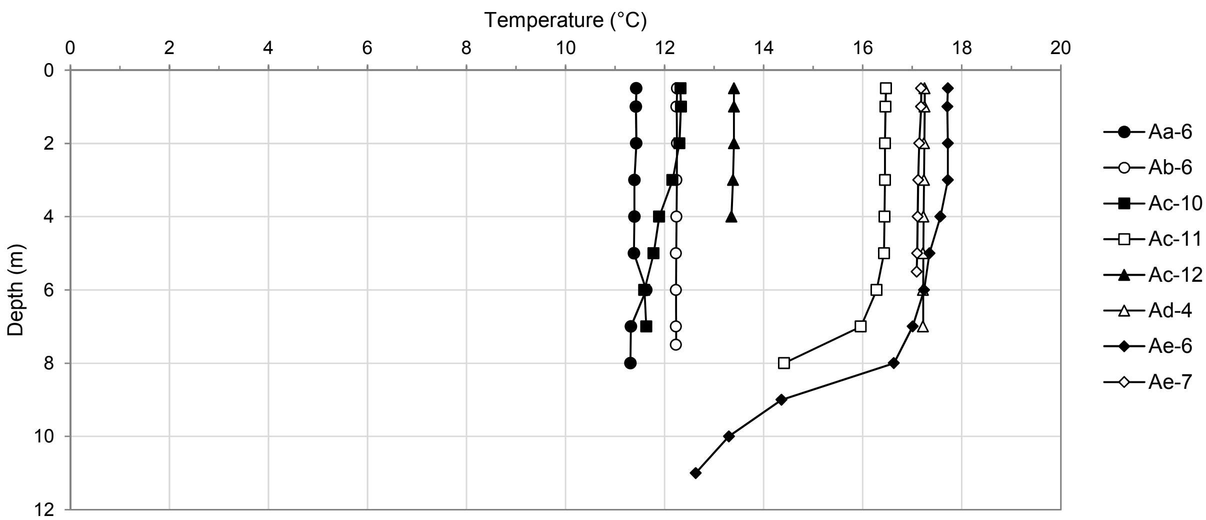
Depth Category	Station	Station Depth (m)	Field Water Quality				Sediment Composition			
			Conductivity (µS/cm)		Temperature (°C)		Total Organic Carbon (%)	Gravel (%)	Sand (%)	Fines (%)
			Surface	Bottom	Surface	Bottom				
Shallow	Aa-2	5.0	14	14	11.3	11.3	1	0	3	97
	Ab-2	5.0	14	14	12.2	12.2	2	0	30	69
	Ac-2	5.0	14	14	11.8	11.7	1	0	8	92
	Ac-5	3.8	14	14	16.7	16.6	1	3	49	48
	Ac-8	4.6	14	14	13.4	13.3	1	0	3	97
	Ad-2	4.2	14	14	17.4	17.4	2	0	1	99
	Ae-2	5.0	14	14	19.3	14.7	1	0	2	98
	Mean	**4.7**	**14**	**14**	**14.6**	**13.9**	**1**	**1**	**14**	**86**
	Minimum	**3.8**	**14**	**14**	**11.3**	**11.3**	**1**	**0**	**1**	**48**
	Maximum	**5.0**	**14**	**14**	**19.3**	**17.4**	**2**	**3**	**49**	**99**

Table 3.2-2 Summary of Habitat Variables for Lake Stations in Lac du Sauvage, August and September 2013

Depth Category	Station	Station Depth (m)	Field Water Quality				Sediment Composition			
			Conductivity (µS/cm)		Temperature (°C)		Total Organic Carbon (%)	Gravel (%)	Sand (%)	Fines (%)
			Surface	Bottom	Surface	Bottom				
Mid-depth	Aa-6	8.0	14	14	11.4	11.3	2	0	3	97
	Ab-6	7.6	14	14	12.3	12.2	2	0	14	86
	Ac-10	7.3	14	14	12.3	11.6	1	0	2	98
	Ac-11	8.2	14	14	16.5	14.4	1	0	25	75
	Ac-12	6.5	14	14	13.4	13.4	1	0	6	94
	Ad-4	7.9	14	14	17.3	17.2	2	0	1	99
	Ae-7	6.4	14	14	17.2	17.1	1	0	1	99
	Mean	**7.4**	**14**	**14**	**14.3**	**13.9**	**1**	**0**	**8**	**92**
	Minimum	**6.4**	**14**	**14**	**11.4**	**11.3**	**1**	**0**	**1**	**75**
	Maximum	**8.2**	**14**	**14**	**17.3**	**17.2**	**2**	**0**	**25**	**99**
Deep	Aa-1	11.2	15	14	11.4	11.3	1	0	5	95
	Ab-1	12.4	14	15	12.4	12.4	1	0	1	99
	Ac-1	12.8	14	14	12.4	12.0	1	0	2	98
	Ac-4	12.3	14	14	16.7	12.2	1	0	2	98
	Ac-7	12.4	14	14	13.5	13.2	1	0	1	99
	Ad-1	12.6	14	14	17.3	11.7	1	0	1	99
	Ae-1	12.4	14	15	17.1	11.9	1	0	0	100
	Ae-6	12.2	14	14	17.7	12.6	1	0	1	99
	Mean	**12.3**	**14**	**14**	**14.8**	**12.2**	**1**	**0**	**2**	**98**
	Minimum	**11.2**	**14**	**14**	**11.4**	**11.3**	**1**	**0**	**0**	**95**
	Maximum	**12.8**	**15**	**15**	**17.7**	**13.2**	**1**	**0**	**5**	**100**

m = metre; µS/cm = microsiemens per centimetre; °C = degrees Celsius; % = percent.

Figure 3.2-2 Field Temperature Profiles from Selected Mid-depth and Deep Lake Stations in Lac du Sauvage, August 2013



m = metre; °C = degrees Celsius.

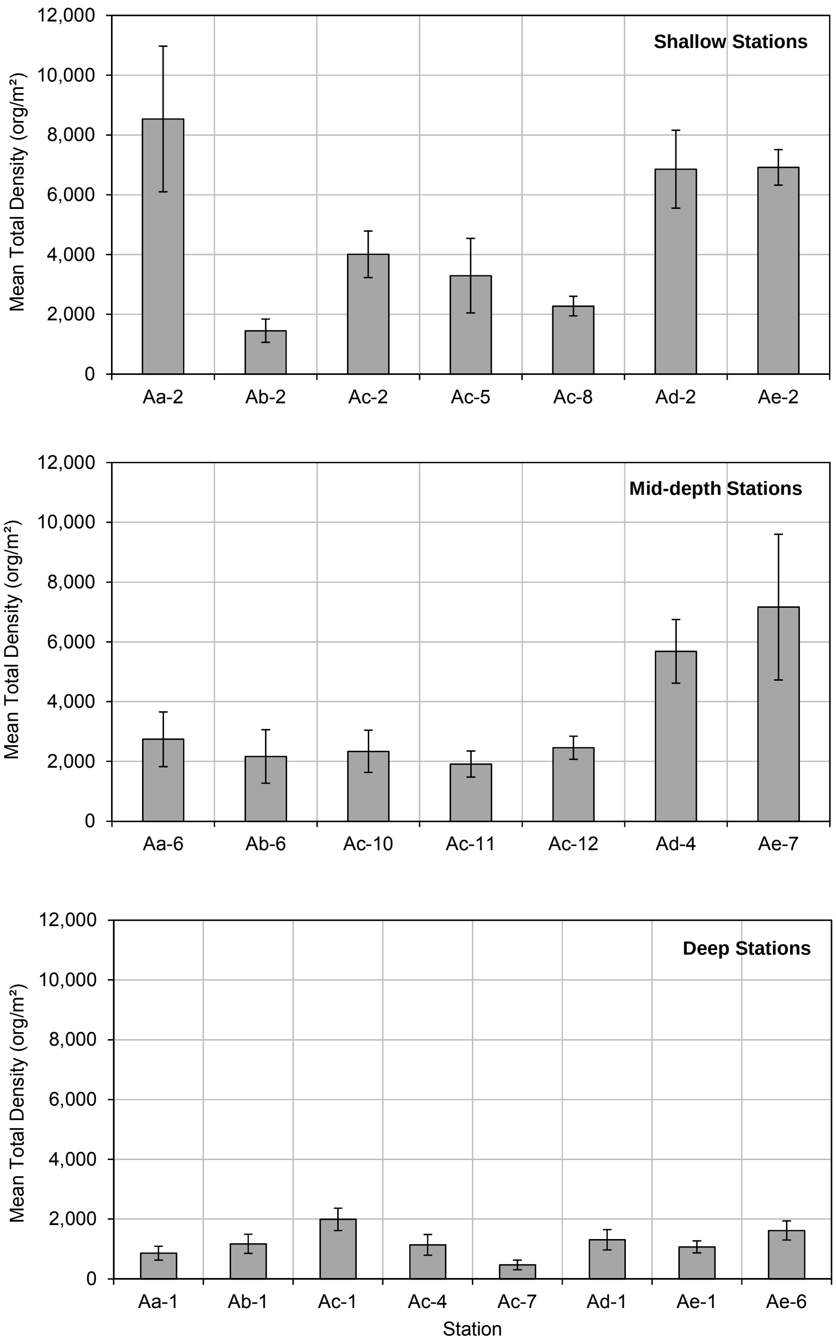
3.2.3.1.2 Benthic Invertebrate Community Variables – Lake Stations

Raw benthic invertebrate abundance data for lake stations in Lac du Sauvage are provided in Appendix E1, Benthic Invertebrate Taxonomy Data, Table E1-1.

Mean Total Density and Total Richness

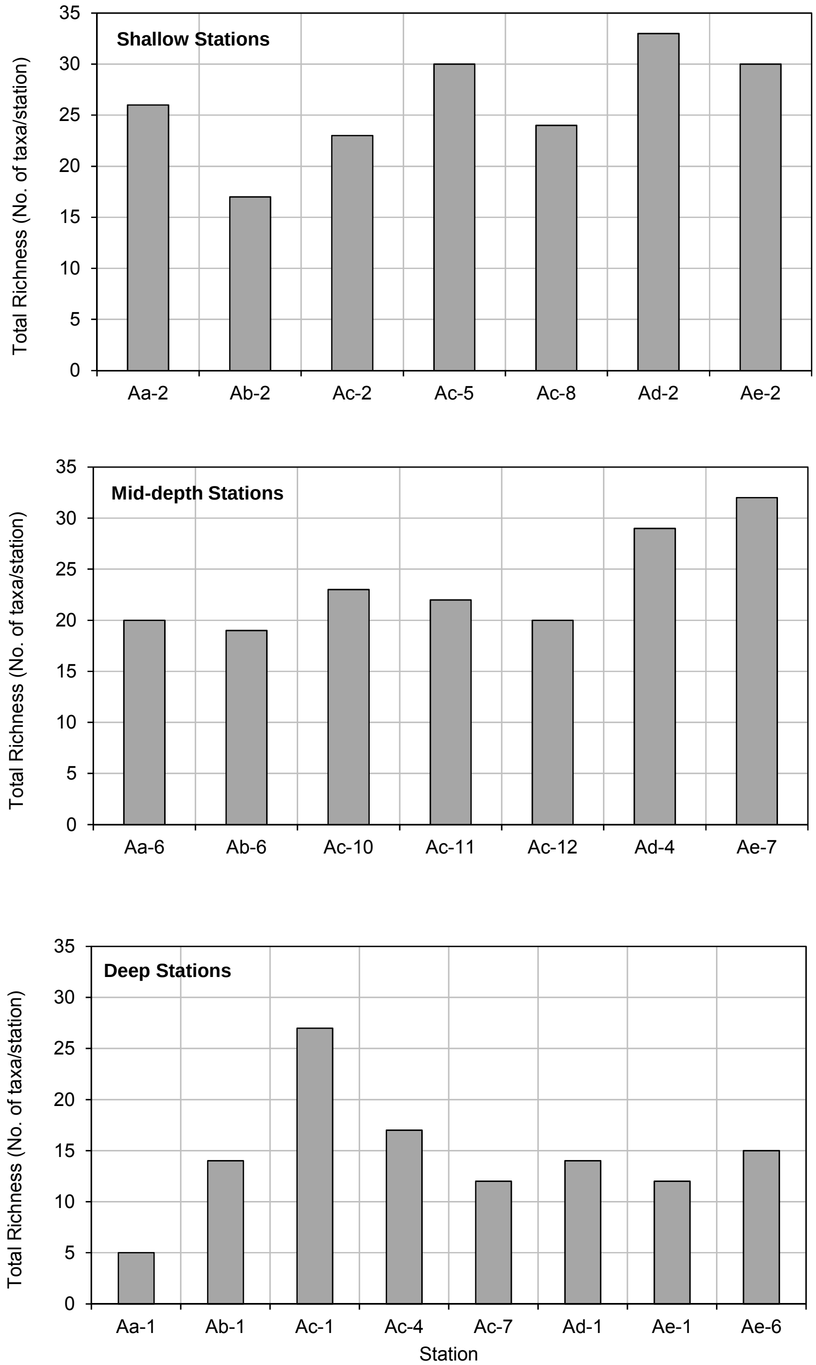
Mean total benthic invertebrate density at shallow and mid-depth lake stations in Lac du Sauvage was low to moderate, ranging from 1,448 to 8,534 org/m² at shallow stations, and from 1,914 to 7,164 at mid-depth stations (Figure 3.2-3). Mean total benthic invertebrate density was lower at deep stations, ranging from 466 to 1,991 org/m². Total richness was moderate, with the exception of Station Aa-1, which had low total richness. Total richness ranged from 17 to 33 taxa/station at shallow stations, 19 to 32 taxa/station at mid-depth stations, and from 5 to 27 taxa/station at deep stations (Figure 3.2-4).
In general, mean total density and total richness in Lac du Sauvage were highest at the shallow stations and lowest at deep stations, with the mid-depth stations having intermediate values.

Figure 3.2-3 Mean Total Density at Lake Stations in Lac du Sauvage, August 2013



Note: Error bars represent one standard error of the mean.
org/m^2 = number of organisms per square metre.

Figure 3.2-4 Total Richness at Lake Stations in Lac du Sauvage, August 2013



No. of taxa/station = number of taxa per station.

Simpson's Diversity and Evenness Indices

The SDI values were high at all lake stations in Lac du Sauvage, ranging from 0.83 to 0.92 at shallow stations, from 0.81 to 0.89 at mid-depth stations, and from 0.59 to 0.87 at deep stations (Figure 3.2-5). Diversity was similar at shallow and mid-depth stations, and slightly lower at deep stations. Evenness was variable among lake stations in Lac du Sauvage, but was generally low, ranging from 0.24 to 0.48 at shallow stations, from 0.20 to 0.46 at mid-depth stations, and from 0.26 to 0.49 at deep stations (Figure 3.2-5). Evenness was slightly higher at deep stations compared to shallow and mid-depth stations. Overall, diversity values for Lac du Sauvage indicated a diverse benthic invertebrate community; however, SEI values indicated that a few taxa accounted for the majority of the density at each station.

Community Composition

Chironomidae (non-biting midges) dominated the benthic invertebrate communities at all lake stations in Lac du Sauvage, with the various chironomid tribes collectively accounting for 63% to 93% of the total density at shallows stations, and for 71% to 87% of the total density at mid-depth stations (Figure 3.2-6). The Chironomini and Tanytarsini tribes were the two dominant chironomid groups at shallow and mid-depth stations. At deep stations, the Chironomidae accounted for 69% to 84% of the total density, with the Chironomini and Tanypodinae the dominant chironomid groups. Dominance of the benthic invertebrate community by Chironomidae is expected in sub-Arctic lakes (Beaty et al. 2006; Northington et al. 2010). The Pisidiidae (fingernail clams) also accounted for a large proportion of the total density at each station, ranging from 5% to 23% at shallow stations, from 6% to 23% at mid-depth stations, and from 11% to 29% at deep stations.

Taxa present were similar at shallow and mid-depth stations in Lac du Sauvage (Appendix F, Benthic Invertebrate Taxa. Table F-1). Deep stations had fewer Gastropod (snails) and Acari (water mites) taxa compared to shallow and mid-depth stations. Deep stations also had fewer Chironomini and Orthocladiinae taxa compared to the shallow and mid-depth stations. Station Ae-1 (deep station) only had Pisidiidae and Chironomidae taxa present, with only four Chironomidae genera present.

Figure 3.2-5 Simpson's Diversity and Evenness Indices for the Benthic Invertebrate Community at Lake Stations in Lac du Sauvage, August 2013

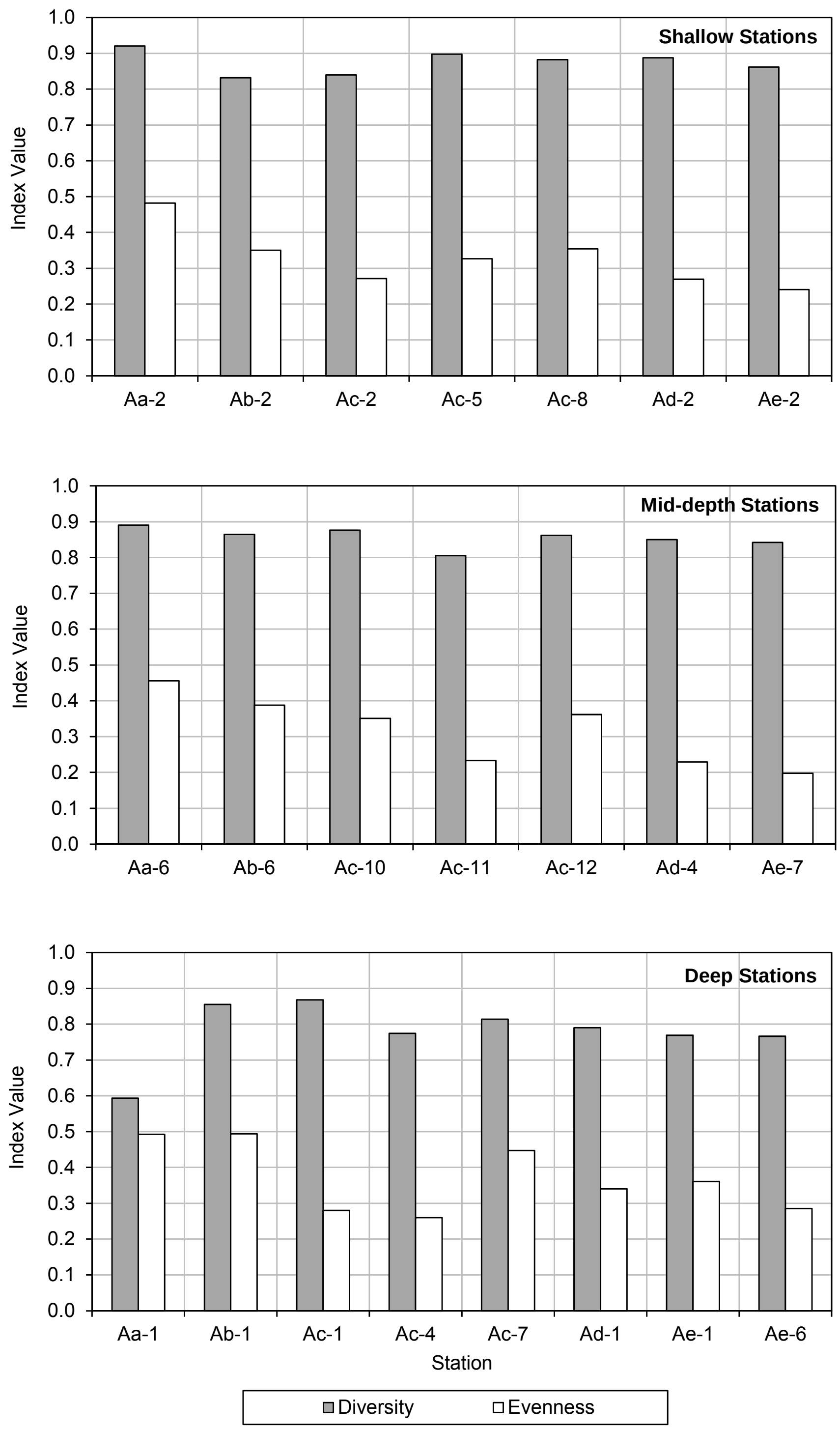
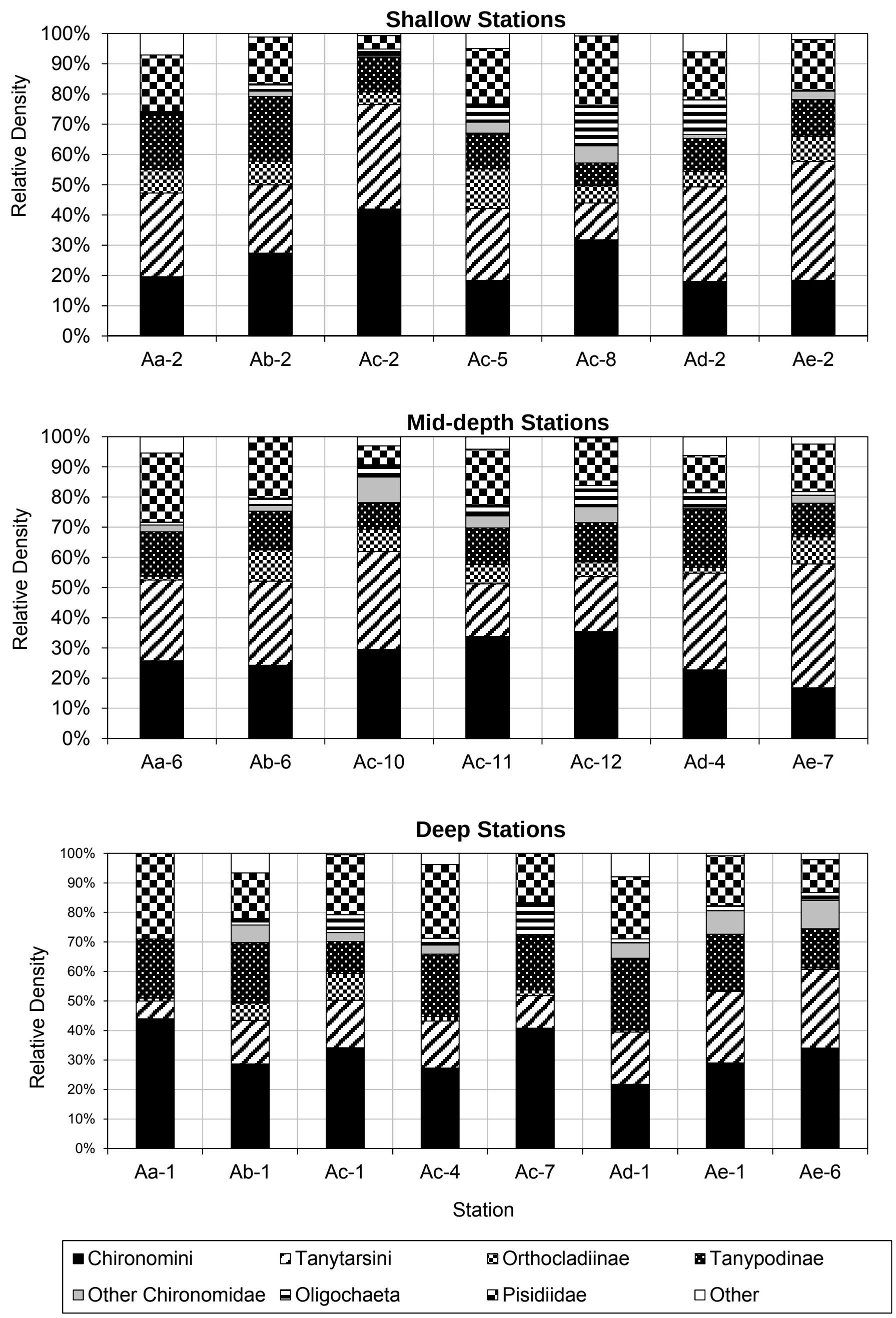


Figure 3.2-6 Relative Density of Major Benthic Invertebrate Taxa at Lake Stations in Lac du Sauvage, August 2013



Note: "Other" taxa category includes Hydridae, Acari, Gastropoda, Turbellaria, Trichoptera, and Empididae.
% = percent.

3.2.3.1.3 Aquatic Habitat – Littoral Stations

Conductivity was similar among littoral stations in Lac du Sauvage, but water temperatures were variable among stations (Table 3.2-3). Variation in water temperature was likely the result of weather conditions at time of sampling. Field water quality was within or slightly above the range of other Arctic tundra lakes located north of Yellowknife (Pienitz et al. 1997) and similar to other stations in Lac du Sauvage. Littoral stations were characterized by low benthic algal cover, with the exception of Station Aa-3, which had moderate benthic algal cover. Most littoral stations had cobble-gravel substrates, with the exception of Station Ae-3, which consisted of 50% boulder and 50% cobble-gravel substrates.

Table 3.2-3 Habitat Data for Littoral Stations in Lac du Sauvage, August 2013

Station	Field Water Quality		Benthic Algal Cover (%)[a]	Substrate Composition (%)[a]				
	Specific Conductivity (µS/cm)	Temperature (°C)		Small Gravel	Large Gravel	Small Cobble	Large Cobble	Boulder
Aa-3	14	10.9	moderate	50	0	50	0	0
Ab-3	15	12.8	low	0	40	30	30	0
Ac-3	15	12.7	none	0	20	40	40	0
Ac-6	14	16.4	low	0	30	10	40	20
Ac-9	14	12.7	low	20	50	30	0	0
Ad-3	15	18.7	low	0	10	20	20	50
Ae-3	13	16.0	low	0	20	0	30	50

a) Visual field estimate.

µS/cm = microsiemens per centimetre; °C = degrees Celsius; % = percent.

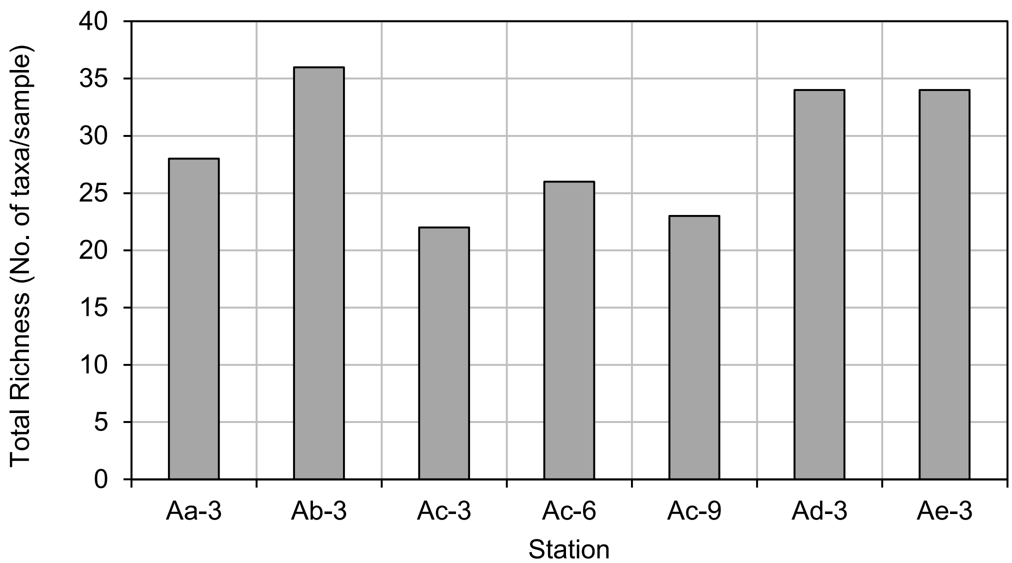
3.2.3.1.4 Benthic Invertebrate Community Variables – Littoral Stations

Raw benthic invertebrate abundance data for littoral stations in Lac du Sauvage are provided in Appendix E1, Table E1-2.

Total Richness

Total richness was moderate at littoral stations in Lac du Sauvage, ranging from 22 to 36 taxa/station (Figure 3.2-7). Spatial variation in richness did not appear to be related to habitat variation.

Figure 3.2-7 Total Benthic Invertebrate Richness at Littoral Stations in Lac du Sauvage, August 2013



No. of taxa/sample = number of taxa per sample.

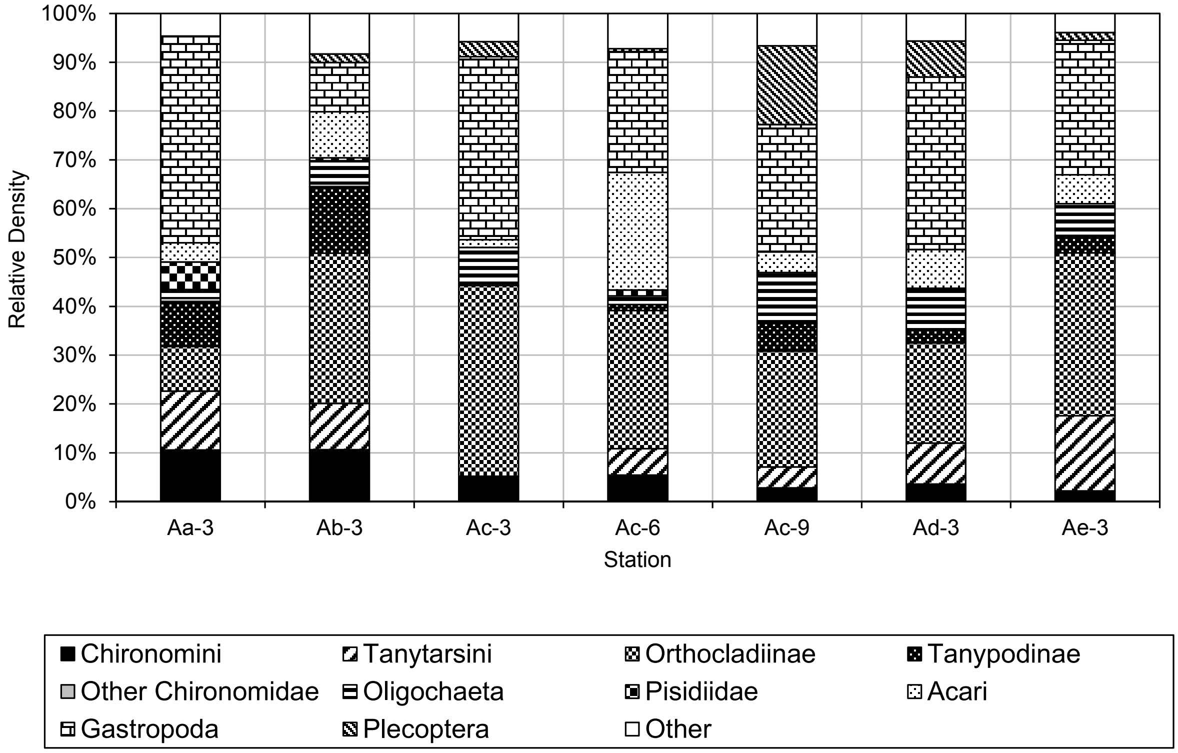
Community Composition

The benthic invertebrate community at littoral stations in Lac du Sauvage was variously dominated by the Chironomidae and Gastropoda (snails) (Figure 3.2-8). The Chironomidae accounted for 35% to 65% of the total abundance at each station, and the Gastropoda accounted for 10% to 42% of the total abundance. The Orthocladiinae was the dominant chironomid group. The Acari generally accounted for a small proportion of the benthic invertebrate community, with the exception of Station Ac-6 where they accounted for 24% of the community. The dominance of the benthic invertebrate community by the Chironomidae is expected in sub-Arctic lakes (Beaty et al. 2006; Northington et al. 2010).

Taxa present were similar among littoral stations in Lac du Sauvage, with the exception of the Pisidiidae, which were only present at Stations Aa-3, Ab-3, and Ac-6 (Appendix F, Table F-2). The Gastropoda also had a greater number of taxa present in the Ac, Ab, and Ae sub-basins compared to the Aa sub-basin.

The benthic invertebrate community at littoral stations of Lac du Sauvage had a lower percentage of Chironomidae and higher percentage of Gastropoda compared to shallow, mid-depth, and deep stations. The Chironomidae were dominated by the Orthocladiinae at littoral stations compared to the shallow, mid-depth, and deep stations, where the Chironomini, Tanytarsini, and Tanypodinae were the variously dominant taxa. The Acari and Plecoptera were also present in higher numbers at littoral stations compared to the shallow, mid-depth, and deep stations.

Figure 3.2-8 Relative Density of Major Benthic Invertebrate Taxa at Littoral Stations in Lac du Sauvage, August 2013



Note: "Other" taxa category includes Coleoptera, Trichoptera, Ceratopogonidae, Empididae, Muscidae and Tipulidae.
% = percent.

3.2.3.2 Duchess Lake

Raw abundance data for the benthic invertebrate samples collected Duchess Lake are provided in Appendix E1, Table E1-1.

3.2.3.2.1 Aquatic Habitat – Lake Stations

Field water quality was generally similar among lake stations in Duchess Lake (Table 3.2-4). Additional water quality data, including field profile summaries at overlapping benthic invertebrate and water quality stations, are summarized in Annex XI. Conductivity was the same at the surface at all stations (12 microsiemens per centimetre [µS/cm]), and varied little from top to bottom of the water column. Water temperature at the surface was similar at each station, ranging from 15.8°C to 16.7°C, and decreased slightly with depth. Field water quality was within or slightly above the range of other Arctic tundra lakes north of Yellowknife (Pienitz et al. 1997), and similar to stations in Lac du Sauvage.

Total organic carbon and sediment particle size were similar among stations in Duchess Lake (Table 3.2-4). Total organic carbon was low (1%) at all stations; sediments consisted of primarily fine sediment (silt and clay), ranging from 95% to 99% fines.

Table 3.2-4 Habitat Data for Stations in Duchess Lake, Lake Af1, Lake C1, and Lake E1 in the Jay Project Baseline Study Area, August to September 2013

Waterbody	Station	Station Depth (m)	Field Water Quality				Sediment Composition			
			Conductivity (µS/cm)		Temperature (°C)		Total Organic Carbon (%)	Gravel (%)	Sand (%)	Fines (%)
			Surface	Bottom	Surface	Bottom				
Duchess Lake	Af-1	13.5	12	13	15.8	12.3	1	0.1	1	99
	Af-2	4.3	12	12	16.3	16.2	1	0.1	1	99
	Af-4	3.1	12	13	16.7	16.6	1	0.1	5	95
	Af-7	12.4	12	13	15.9	14.0	1	0.1	2	98
	Mean	**6.6**	**12**	**13**	**16.3**	**15.6**	**1**	**0.1**	**3**	**97**
	Minimum	**3.1**	**12**	**12**	**15.9**	**14.0**	**1**	**0.1**	**1**	**95**
	Maximum	**12.4**	**12**	**13**	**16.7**	**16.6**	**1**	**0.1**	**5**	**99**
Lake Af1	Af-10	8.7	12	12	6.9	6.9	2	0.1	0	100
C1	C-L1	10.2	17	17	8.0	7.6	6	0.1	2	98
E1	E-L1-1	11.6	12	15	13.6	9.5	3	0.9	4	95
	E-L1-2	3.5	11	11	13.6	13.3	4	0.1	3	97
	Mean	**7.6**	**12**	**13**	**13.6**	**11.4**	**4**	**0.5**	**3.5**	**96.0**
	Minimum	**3.5**	**11**	**11**	**13.6**	**9.5**	**3**	**0.1**	**3.0**	**95.1**
	Maximum	**11.6**	**11**	**15**	**13.6**	**13.3**	**4**	**1**	**4.0**	**96.9**

m = metre; µS/cm = microsiemens per centimetre; °C = degrees Celsius; % = percent.

3.2.3.2.2 Benthic Invertebrate Community Variables – Lake Stations

Mean Total Density and Total Richness

Mean total benthic invertebrate density in Duchess Lake was low to moderate at the shallow stations, ranging from 3,095 to 9,259 org/m², and low at the deep stations, ranging from 2,448 to 2,448 org/m² (Figure 3.2-9). Total richness was moderate to high at shallow stations (27 to 44 taxa/station), and moderate at deep stations (16 to 22 taxa/station; Figure 3.2-10). Mean total density and richness were higher at shallow stations compared to deep stations.

Simpson's Diversity and Evenness Indices

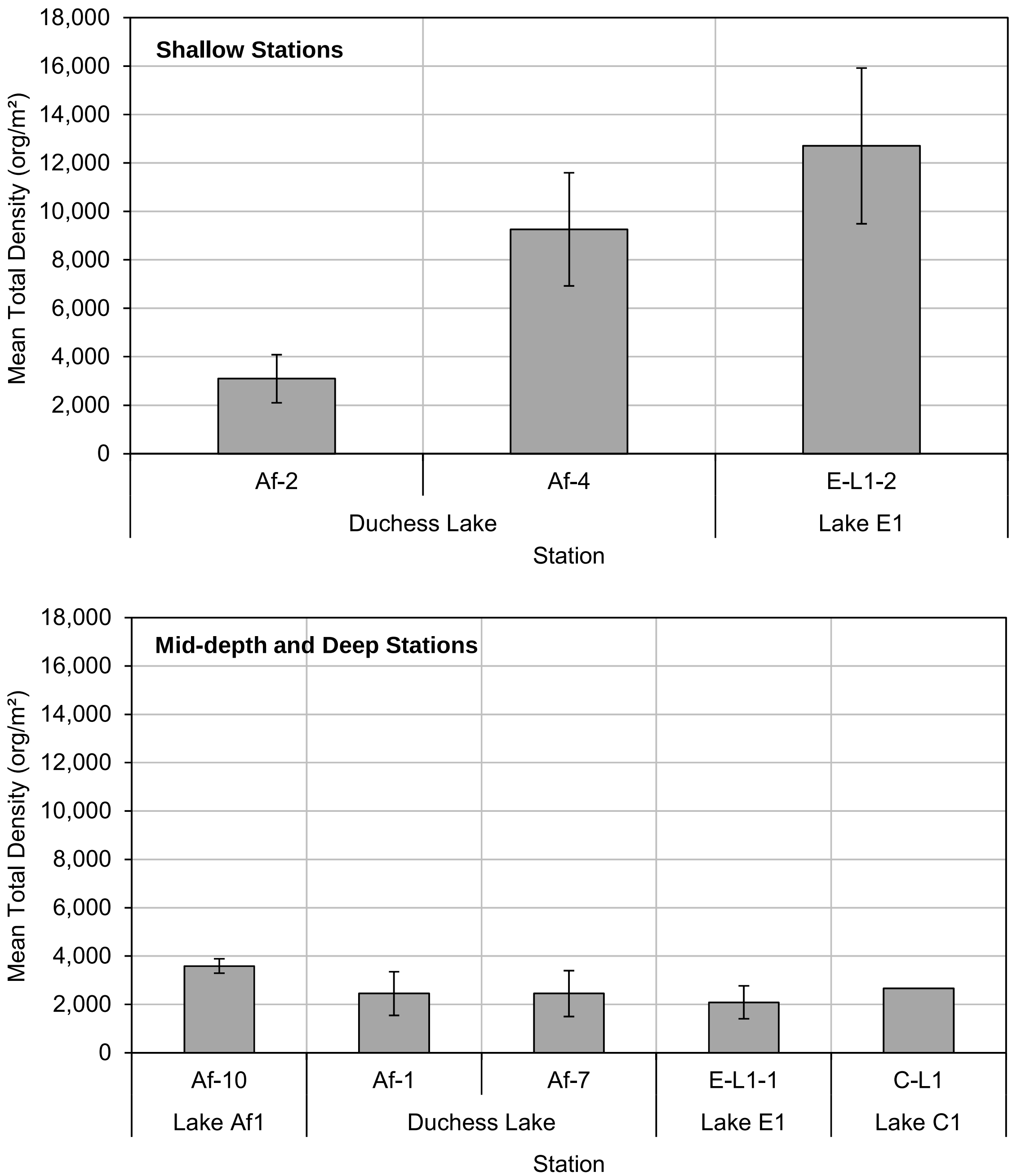
The SDI values were generally high at stations in Duchess Lake, at 0.84 for shallow stations, and ranging from 0.63 to 0.81 at deep stations (Figure 3.2-11). Diversity was slightly lower at deep stations compared to shallow stations. Evenness was similar among shallow (0.14 to 0.23) and deep stations (0.17 to 0.24; Figure 3.2-11). Overall, SDI values for Duchess Lake stations indicated a diverse benthic invertebrate community; however, SEI values indicated that a few taxa accounted for the majority of the total density at each station.

Community Composition

The benthic invertebrate community at stations in Duchess Lake was dominated by the Chironomidae at both shallow and deep stations (Figure 3.2-12). The Chironomidae accounted for 68% to 73% of the total density at shallow stations, and for 73% to 88% of the total density at deep stations. The Orthocladiinae and the Chironomini were the two dominant chironomid taxa at pelagic stations in Duchess Lake. Dominance of the benthic invertebrate community by the Chironomidae is expected in sub-Arctic lakes (Beaty et al. 2006; Northington et al. 2010). The Pisidiidae also accounted for a large proportion of the total density at each station, ranging from 21% to 24% at the shallow station, and from 9% to 25% at the deep stations.

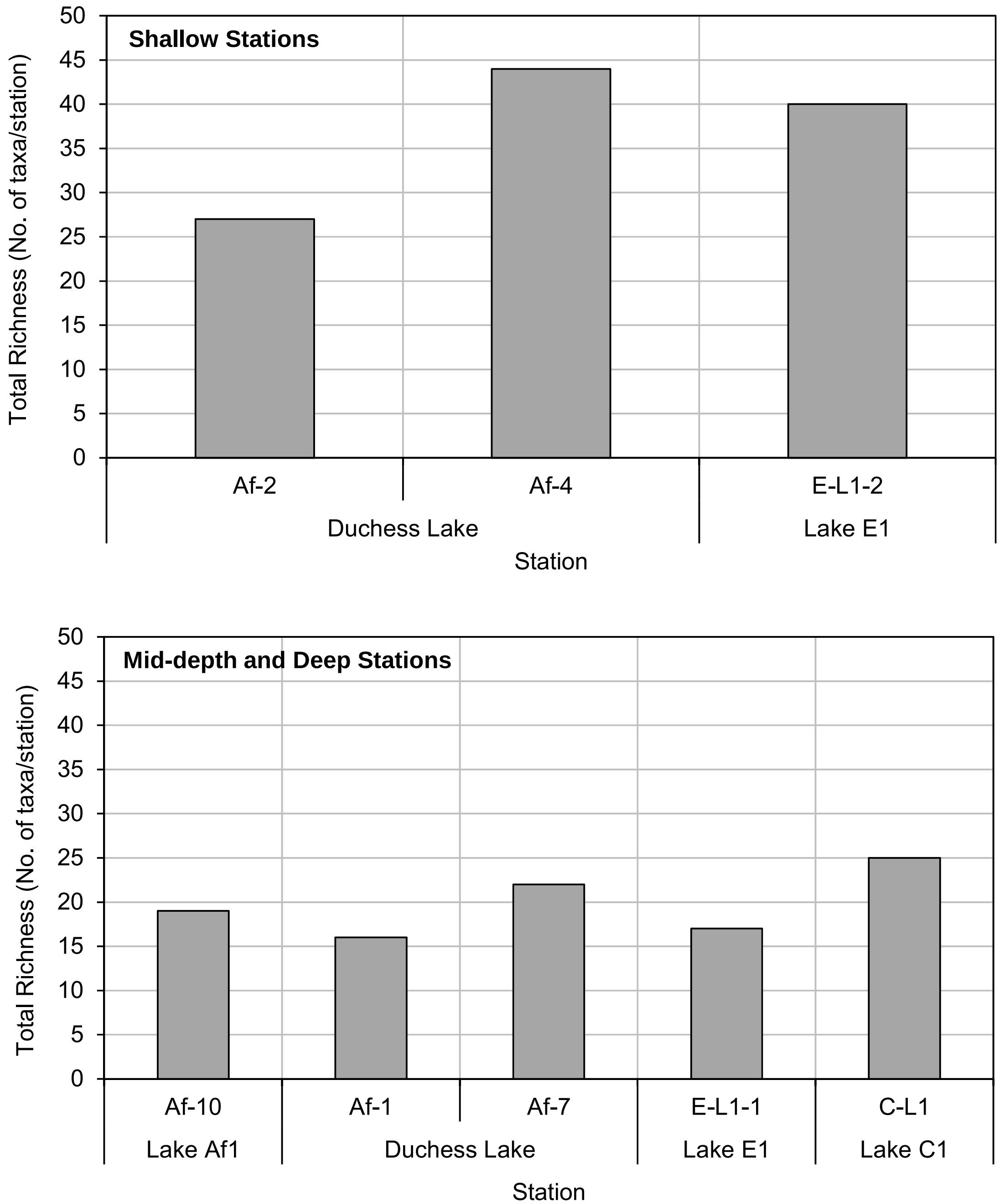
Taxa present were similar among pelagic stations in Duchess Lake, with the exception of the lack of Gastropoda at deep stations, and fewer Chironomini and Tanytarsini genera at deep stations, compared to shallow stations (Appendix F, Table F-3).

Figure 3.2-9 Mean Total Benthic Invertebrate Density in Duchess Lake, Lake Af1, Lake C1, and Lake E1, August and September 2013



Note: Error bars represent one standard error of the mean.
org/m^2 = number of organisms per square metre.

Figure 3.2-10 Total Benthic Invertebrate Richness in Duchess Lake, Lake Af1, Lake C1, and Lake E1, August and September 2013



No. of taxa/station = number of taxa per station.

Figure 3.2-11 Simpson's Diversity and Evenness Index Values in Duchess Lake, Lake Af1, Lake C1, and Lake E1, August and September 2013

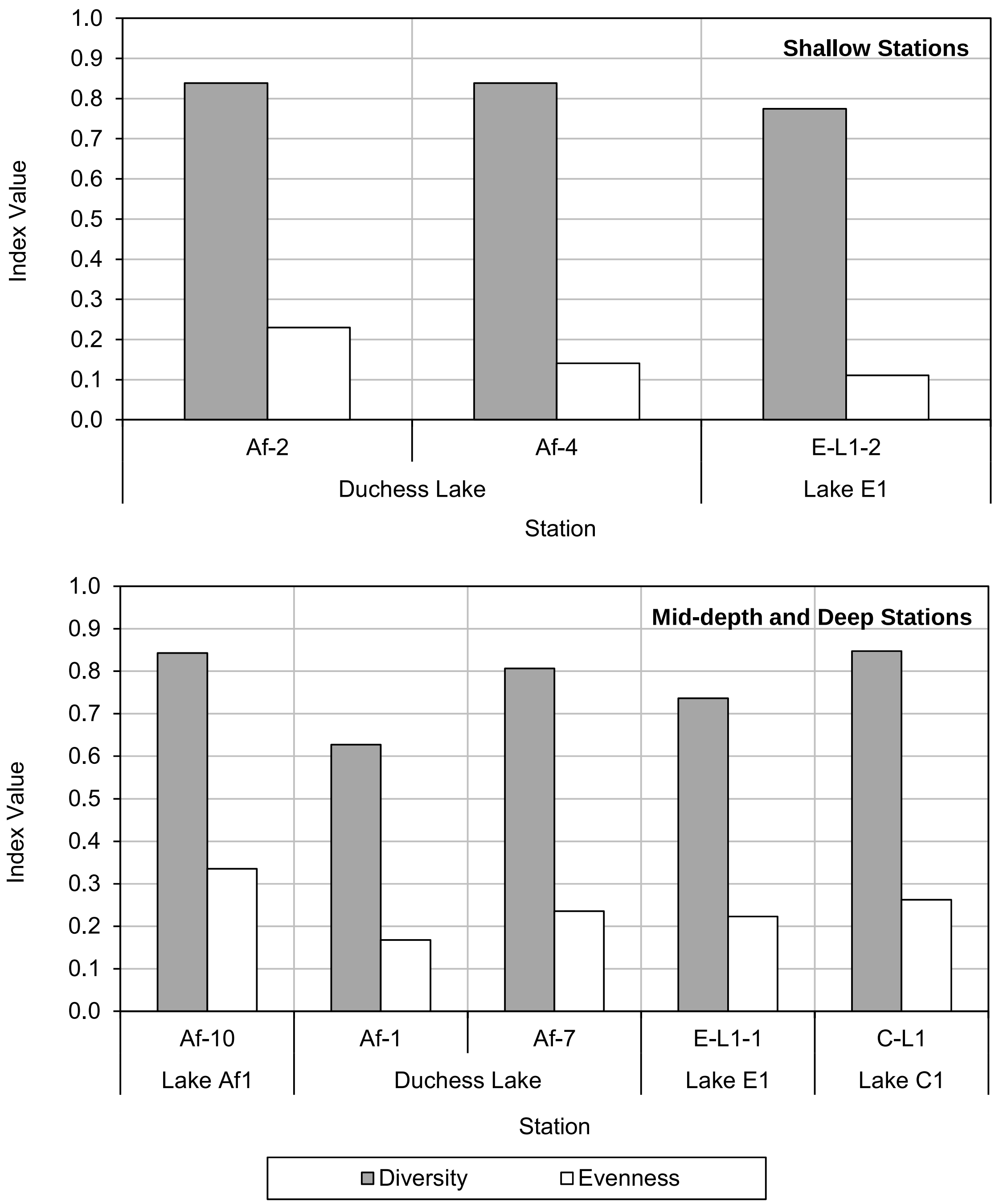
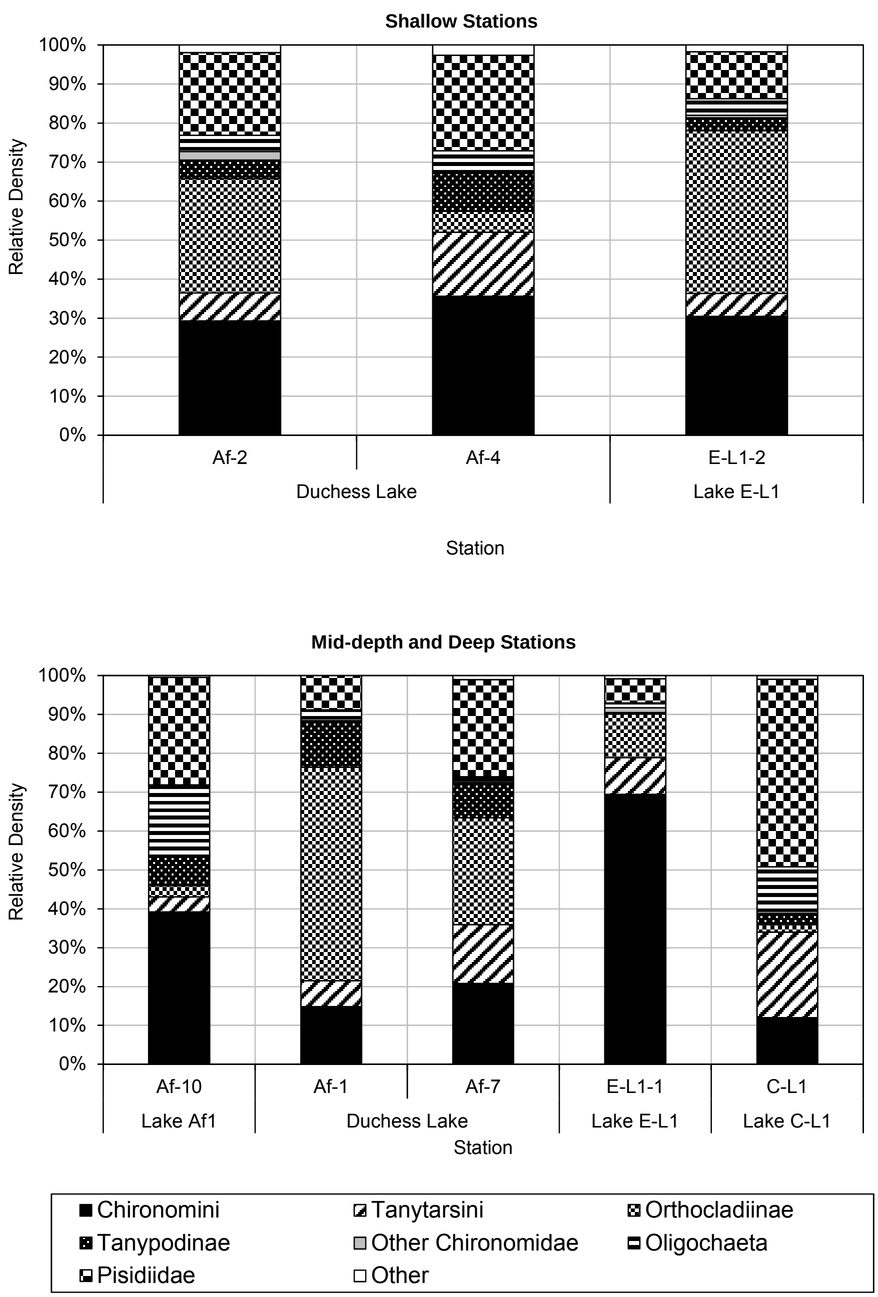


Figure 3.2-12 Relative Density of Major Benthic Invertebrate Taxa in Duchess Lake, Lake Af1, Lake C1, and Lake E1, August and September 2013



Note: "Other" taxa category includes Hydridae, Acari, Gastropoda, Turbellaria, Trichoptera and Empididae.
% = percent.

3.2.3.2.3 Aquatic Habitat – Littoral Stations

Field water quality was similar at littoral stations in Duchess Lake (Table 3.2-5). Conductivity ranged from 12 to 13 µS/cm. Water temperature ranged from 16.5°C to 20.4°C, likely reflecting weather conditions at time of sampling. Field water quality was within or slightly above the range of other Arctic tundra lakes located north of Yellowknife (Pienitz et al. 1997) and similar to stations in Lac du Sauvage. Littoral stations were characterized by low benthic algal cover. Bottom substrates were mainly cobble and gravel at Station Af-3; fine sediments were dominant at Station Af-6.

3.2.3.2.4 Benthic Invertebrate Community Variables – Littoral Stations

Raw benthic invertebrate abundance data for littoral stations in Duchess Lake are provided in Appendix E1, Table E1-2.

Total Richness

Total richness at the two littoral stations in Duchess Lake was moderate. Overall, total richness was comparable between the two littoral stations, varying between 24 and 28 taxa/sample (Figure 3.2-13).

Community Composition

The benthic invertebrate communities at littoral stations in Duchess Lake were dominated by the Chironomidae at Station Af-6 and the Gastropoda at Station Af-3, accounting for 85% and 44% of the total abundance at each station, respectively (Figure 3.2-14). The dominant chironomid group at Station Af-6 was the Tanytarsini. The Acari also accounted for a large proportion of the abundance (20%) at Station Af-3.

Differences were observed in taxa present at the two littoral stations in Duchess Lake (Appendix F, Table F-4). Gastropoda were absent from Station Af-6, and fewer dipteran taxa were present at Station Af-3 compared to Station Af-6. Also, fewer Acari taxa were present at Station Af-3 compared to Station Af-6.

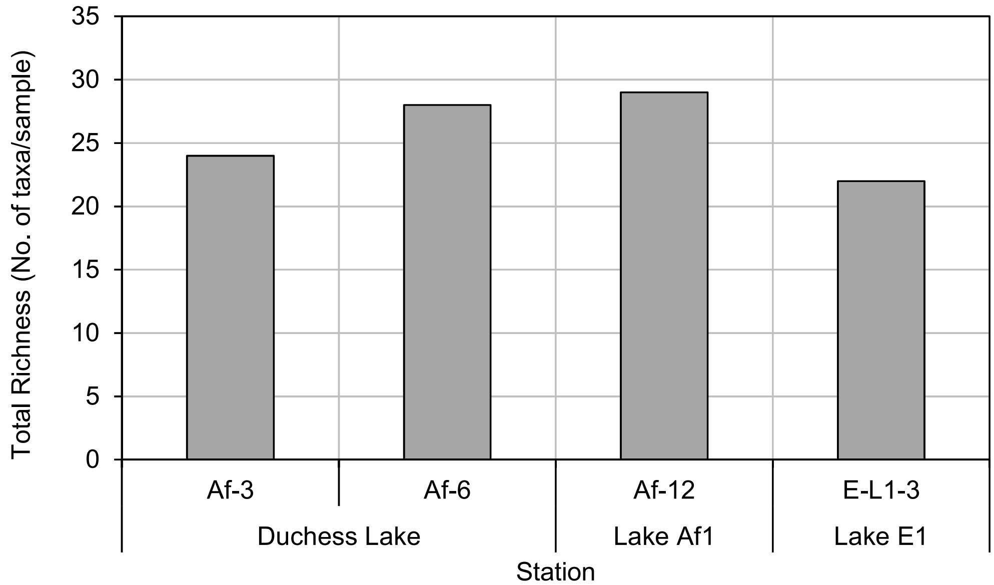
Table 3.2-5 Habitat Data for Littoral Stations in Duchess Lake, Lake Af1, and Lake E1, September 2013

Waterbody	Station	Field Water Quality		Benthic Algal Cover (%)[a]	Substrate Composition (%)[a]					
		Specific Conductivity (µS/cm)	Temperature (°C)		Fine Sediment	Small Gravel	Large Gravel	Small Cobble	Large Cobble	Boulder
Duchess Lake	Af-3	12	16.5	low	0	0	10	40	50	0
	Af-6	13	20.4	none	80	0	0	0	15	5
Lake Af1	Af-12	12	6.9	low	0	0	20	0	50	30
Lake E1	E-L1-3	11	12.4	none	20	30	0	0	50	0

a) Visual field estimate.

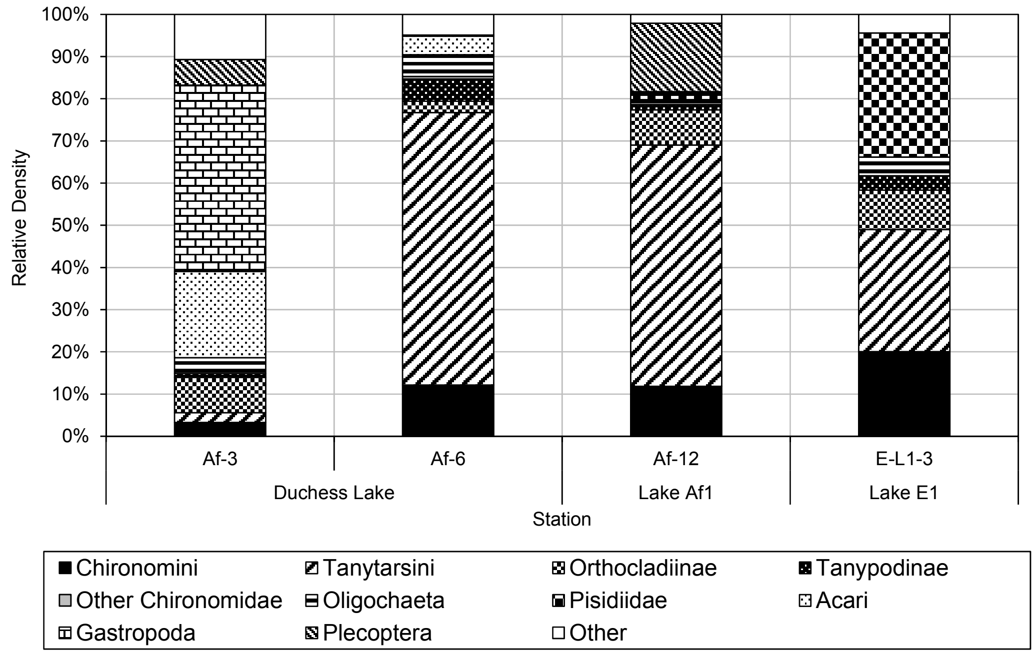
µS/cm = microsiemens per centimetre; °C = degrees Celsius; % = percent.

Figure 3.2-13 Total Benthic Invertebrate Richness at Littoral Stations in Duchess Lake, Lake Af1, Lake C1, and Lake E1, August and September 2013



No. of taxa/sample = number of taxa per sample.

Figure 3.2-14 Relative Density of Major Benthic Invertebrate Taxa at Littoral Stations in Lakes of the Lac du Sauvage Basin, August and September 2013



Note: "Other" taxa category includes Coleoptera, Trichoptera, Ceratopogonidae, Empididae, Muscidae, and Tipulidae.
% = percent.

3.2.3.3 Lake Af1

3.2.3.3.1 Aquatic Habitat – Lake Station

At the one lake station (Af-10) sampled in Lake Af1, conductivity was 12 µS/cm at the surface and bottom of the water column; water temperature was also consistent at 6.9°C at the top and bottom of the water column (Table 3.2-4). Additional water quality data, including a field profile summary at the overlapping benthic invertebrate and water quality station are summarized in Annex XI. Total organic carbon was low (2%); bottom sediments consisted of fine particles (silt and clay) (Table 3.2-4).

3.2.3.3.2 Benthic Invertebrate Community Variables – Lake Station

Raw abundance data for the benthic invertebrate samples collected in Lake Af1 are provided in Appendix E1, Table E1-1.

Mean Total Density and Total Richness

Mean total benthic invertebrate density at mid-depth Station Af-10 in Lake Af1 was low, at 3,586 org/m² (Figure 3.2-9). Total richness was moderate, at 19 taxa/station (Figure 3.2-10).

Simpson's Diversity and Evenness Indices

The SDI value was high at 0.83 and the SEI value was low at 0.34 at Station Af-10 (Figure 3.2-11). The SDI value indicates that the benthic invertebrate community at Station Af-10 was diverse; however, the low SEI value indicates that a few taxa accounted for the majority of the density at the station.

Community Composition

The benthic invertebrate community at Station Af-10 in Lake Af1 was dominated by the Chironomidae and the Pisidiidae, accounting for 54% and 28% of the total density, respectively (Figure 3.2-12). The Chironomini were the dominant chironomid group at Station Af-10. Dominance of the benthic invertebrate community by the Chironomidae is expected in sub-Arctic lakes (Beaty et al. 2006; Northington et al. 2010). The taxa present at Station Af-10 were similar to those observed in other lakes in the Lac du Sauvage basin (Appendix F, Table F-3).

3.2.3.3.3 Aquatic Habitat – Littoral Station

Conductivity and water temperature at the one littoral station (Af-12) sampled in Lake Af1 were 12 µS/cm and 6.9°C, respectively (Table 3.2-5). Benthic algal cover was low. The substrate at this station consisted of large gravel, large cobble, and boulders.

3.2.3.3.4 Benthic Invertebrate Community Variables – Littoral Station

Raw benthic invertebrate abundance data for littoral Station Af-12 in Lake Af1 are provided in Appendix E1, Table E1-2.

Total Richness

Total richness at littoral Station Af-12 was moderate, at 29 taxa/sample (Figure 3.2-13).

Community Composition

The benthic invertebrate community at littoral Station Af-12 in Lake Af1 was dominated by the Chironomidae, which accounted for 79% of the total abundance (Figure 3.2-14). The Tanytarsini was the most dominant chironomid group. The dominance of the benthic invertebrate community by the Chironomidae is expected in a sub-Arctic lake (Beaty et al. 2006; Northington et al. 2010). The taxa present were similar to those at other littoral stations in lakes sampled within the Lac du Sauvage basin (Appendix F, Table F-4).

3.2.3.4 Lake C1

3.2.3.4.1 Aquatic Habitat – Lake Station

Station C-L1 in Lake C1 had a conductivity of 17 µS/cm at the surface and bottom of the water column; the water temperature at Station C-L1 was comparable between the surface (8.0°C) and bottom (7.6°C) of the water column (Table 3.2-4). Additional water quality data, including a field profile summary at the overlapping benthic invertebrate and water quality station, are summarized in Annex XI. Field water quality was within or slightly above the range of other Arctic tundra lakes located north of Yellowknife (Pienitz et al. 1997). Total organic carbon at Station C-L1 was 6%; the substrate consisted of 98% fine sediments (silt and clay) (Table 3.2-4).

3.2.3.4.2 Benthic Invertebrate Community Variables – Lake Station

Raw abundance data for the benthic invertebrate samples collected in Lake C1 are provided in Appendix E1, Table E1-1.

Mean Total Density and Total Richness

Mean total density at lake Station C-L1 was low at 2,664 org/m² (Figure 3.2-9). Total richness was moderate at 25 taxa/station (Figure 3.2-10).

Simpson's Diversity Index and Evenness

The SDI value at Station C-L1 was high at 0.85, and the SEI value was low at 0.26 (Figure 3.2-11). The SDI value indicates a diverse benthic invertebrate community at Station C-L1; however, the low SEI value indicates that a few taxa accounted for the majority of the total density at the station.

Community Composition

The benthic invertebrate community at Station C-L1 was dominated by the Pisidiidae, which accounted for 48% of the total density (Figure 3.2-12). The Chironomidae were also a dominant taxon accounting for 39% of the total density. Taxa present were similar to other lakes in the Lac du Sauvage basin (Appendix F, Table F-3).

3.2.3.5 Lake E1

3.2.3.5.1 Aquatic Habitat – Lake Stations

Surface conductivity and water temperature were similar between the shallow and deep stations in Lake E1, with conductivity ranging from 11 to 12 µS/cm, and water temperature of 13.6°C at the surface of both stations (Table 3.2-4). Additional water quality data, including a field profile summary at the overlapping benthic invertebrate and water quality station, are summarized in Annex XI. Field water quality was within or slightly above the range of other Arctic tundra lakes located north of Yellowknife (Pienitz et al. 1997). Total organic carbon at the lake stations in Lake E1 was low (3% to 4%). Sediments consisted primarily of fine sediments (silt and clay) at both stations (95% to 97% fines) (Table 3.2-4).

3.2.3.5.2 Benthic Invertebrate Community Variables – Lake Stations

Raw abundance data for the benthic invertebrate samples collected in Lake E1 are provided in Appendix E1, Table E1-1.

Mean Total Density and Total Richness

Mean total benthic invertebrate density was moderate at the shallow station (12,707 org/m²) and low at the deep station (2,086 org/m²) in Lake E1 (Figure 3.2-9). Total richness was moderate at both stations, with richness of 40 taxa/station at the shallow station, and 17 taxa/station at the deep station (Figure 3.2-10).

Simpson's Diversity and Evenness Indices

The SDI values were high at both the shallow (0.77) and deep (0.74) stations (Figure 3.2-11). Evenness was low at both the shallow (0.11) and deep (0.22) stations. The SDI values indicate a diverse benthic invertebrate community; however, the low SEI values indicate that a few taxa account for the majority of the total density at each station.

Community Composition

The benthic invertebrate community in Lake E1 was dominated by the Chironomidae (Figure 3.2-12), which accounted for 82% (shallow station) to 92% (deep station) of the total density. The Orthocladiinae and Chironomini were the most dominant chironomid groups at the shallow and deep stations, respectively. Dominance of the benthic invertebrate community by the Chironomidae is expected in sub-Arctic lakes (Beaty et al. 2006; Northington et al. 2010).

Taxa present differed between the shallow and deep stations (Appendix F, Table F-3). The shallow station had more Oligochaeta, Chironomini, and Orthocladiinae taxa compared to the deep station.

3.2.3.5.3 Aquatic Habitat – Littoral Station

Conductivity at Station E-L1-3 was 11 µS/cm, and water temperature was 12.4°C (Table 3.2-5). No benthic algae were observed at this station and the substrate was characterized by a mixture of fine sediment, small gravel, and large cobble.

3.2.3.5.4 Benthic Invertebrate Community Variables – Littoral Station

Raw benthic invertebrate abundance data for the littoral station in Lake E1 are provided in Appendix E1, Table E1-2.

Total Richness

Total richness at the littoral station in Lake E1 was moderate, at 22 taxa/station (Figure 3.2-13).

Community Composition

The benthic invertebrate community at littoral Station E-L1-3 in Lake E1 was dominated by the Chironomidae, which accounted for 62% of the total abundance (Figure 3.2-14). Tanytarsini (29%) was the most dominant chironomid group at this littoral station. Pisidiidae was also a dominant taxa, accounting for 29% of the benthic invertebrate community. The dominance of the benthic invertebrate community by the Chironomidae is expected in the sub-Arctic lakes (Beaty et al. 2006; Northington et al. 2010). Overall the taxa present were similar to other littoral stations at lakes sampled within the Lac du Sauvage basin (Appendix F, Table F-4).

3.2.3.6 Streams

Raw abundance data for the benthic invertebrate samples collected in streams in the BSA are provided in Appendix E1, Table E1-3.

3.2.3.6.1 Aquatic Habitat

Water depth was similar among stream stations (0.20 to 0.31 m), but current velocity (less than 0.01 metres per second [m/s] to 0.56 m/s) and wetted channel width (2 to 30 m) varied widely among stations (Table 3.2-6). Variability was also observed among stream stations for benthic algal cover (none to high) and macrophyte cover (0% to 60%). Substrate composition was generally reflective of current velocity, with coarser substrates at stations with faster velocities. Conductivity was variable, ranging from 12 to 20 µS/cm, while water temperature ranged from 5.2°C to 19.9°C, and likely reflected weather conditions and time of sampling.

3.2.3.6.2 Benthic Invertebrate Community Variables

Mean Total Density and Total Richness

Mean benthic invertebrate density was variable among stream stations in the Lac du Sauvage basin (Figure 3.2-15). Mean benthic invertebrate density was low in Stream G1 (1,662 org/m²) and Stream L1 (1,834 org/m²), moderate in Stream E2 (6,379 to 16,339 org/m²), and high in Stream Ab1 (39,402 org/m²). The highest mean total density was observed in Stream Ab1, which is the narrows that connects Lac du Sauvage to Lac de Gras.

Total richness was less variable among stream stations (Figure 3.2-16), and was moderate in Stream G1 (37 taxa/station) and Stream L1 (35 taxa/station), moderate to high in Stream E2 (38 to 51 taxa/station), and high in Stream Ab1 (51 taxa/station). The highest richness values were observed in Stream Ab1 and Stream E2.

Simpson's Diversity and Evenness Indices

The SDI values were high at all streams stations in the Lac du Sauvage basin, ranging from 0.75 to 0.90 (Figure 3.2-17). Evenness was low (0.09 to 0.22) at all stream stations. The SDI values indicate a diverse benthic invertebrate community at stream stations; however, the low SEI values indicate that a few taxa account for the majority of the total density at each station.

Table 3.2-6 Habitat Data for Stream Stations in the Lac du Sauvage Basin, August and September 2013

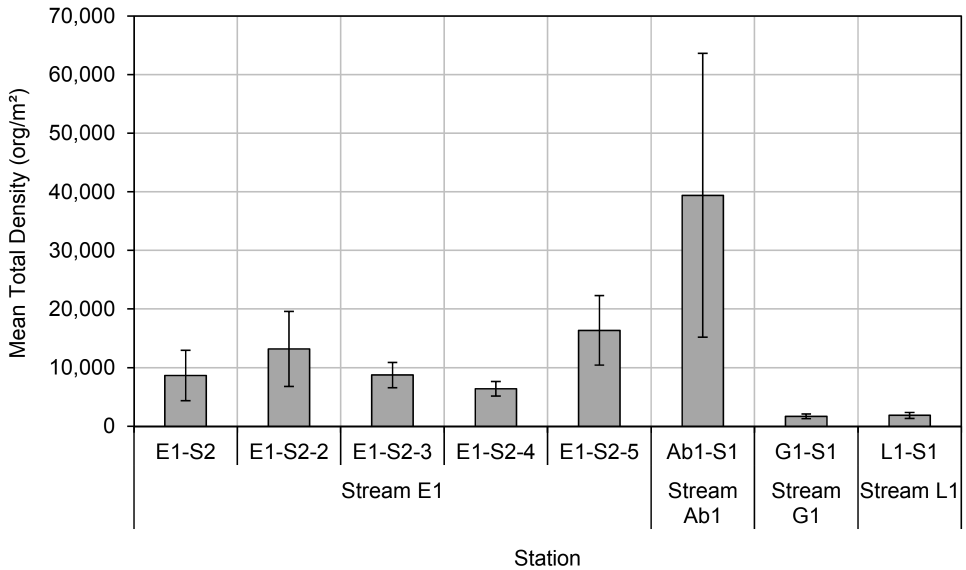
Stream	Station	Habitat Type	Wetted Channel Width (m)	Mean Water Depth (m)	Mean Current Velocity (m/s)	Benthic Algal Cover (%)[(a)]	Macrophyte Cover (%)[(a)]	Field Water Quality	
								Specific Conductivity (µS/cm)	Temperature (°C)
Ab1	AB-S1	run	30	0.27	0.12	high	<10	18	9.4
E2	E-S2	run	8	0.20	0.23	moderate	40	13	7.4
	E1-S2-2	run/riffle	15	0.23	0.21	moderate	—	—	—
	E1-S2-3	flat	10	0.30	0.05	low	60	13	5.2
	E1-S2-4	flat	10	0.27	0.03	low	5	13	7.8
	E1-S2-5	riffle/run	5	0.26	0.38	none	20	13	7.5
G1	G-S1	riffle	15	0.31	0.56	low	0	12	19.9
L1	L-S1	flat	2	0.30	<0.01	none	60	20	6.8

Stream	Station	Habitat Type	Substrate Composition (%)[(a)]						
			Fine Sediment	Small Gravel	Large Gravel	Small Cobble	Large Cobble	Boulder	Bedrock
Ab1	Ab-S1	run	5	0	5	0	10	80	0
E2	E1-S2	run	100	0	0	0	0	0	0
	E1-S2-2	run/riffle	0	0	0	20	30	50	0
	E1-S2-3	flat	100	0	0	0	0	0	0
	E1-S2-4	flat	100	0	0	0	0	0	0
	E1-S2-5	riffle/run	0	10	30	20	20	20	0
G1	G1-S1	riffle	5	10	10	30	30	10	5
L1	L1-S1	flat	100	0	0	0	0	0	0

a) Visual field estimate.

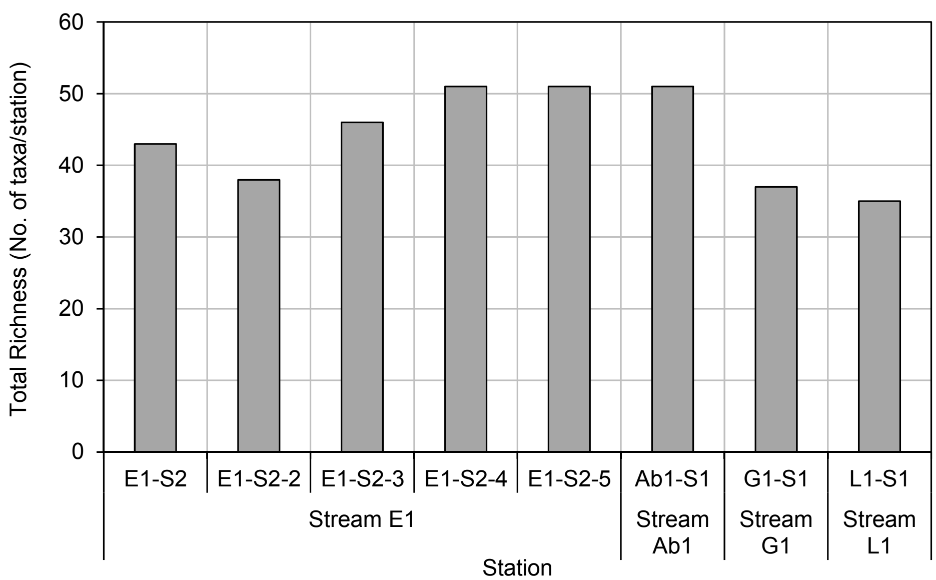
m = metre; m/s = metres per second; µS/cm = microsiemens per centimetre; °C = degrees Celsius; % = percent; — = not recorded.

Figure 3.2-15 Mean Total Benthic Invertebrate Density at Stream Stations in the Lac du Sauvage Basin, August and September 2013



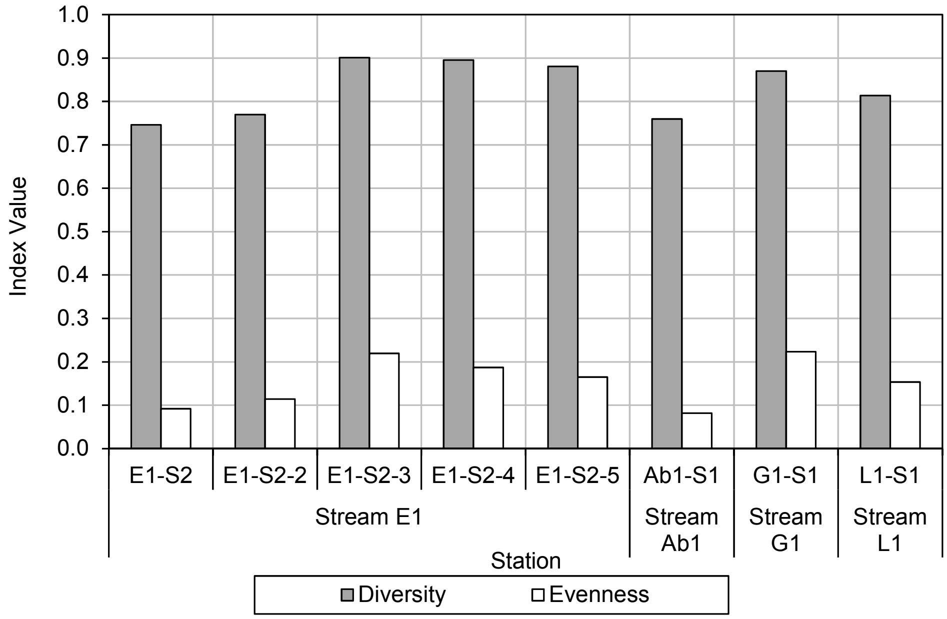
Note: Error bars represent one standard error of the mean.
org/m^2 = number of organisms per square metre.

Figure 3.2-16 Total Benthic Invertebrate Richness at Stream Stations in the Lac du Sauvage Basin, August and September 2013



No. of taxa/station = number of taxa per station.

Figure 3.2-17 Simpson's Diversity Index and Evenness for Benthic Invertebrates for Stream Station in the Lac du Sauvage Basin, August and September 2013

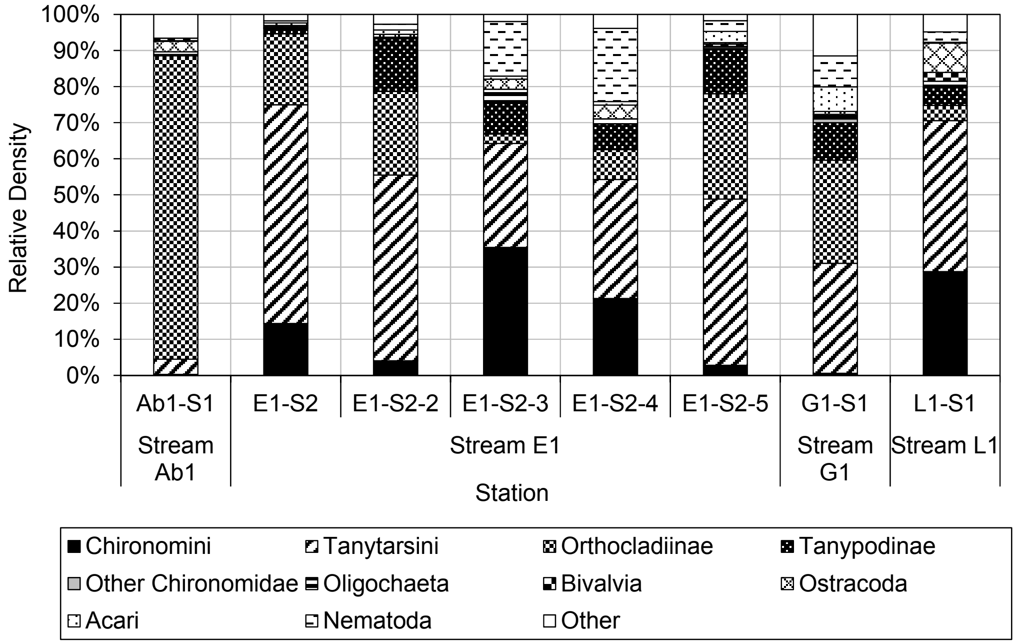


Community Composition

The benthic invertebrate community was dominated by the Chironomidae at all stream stations in the Lac du Sauvage basin (Figure 3.2-18). The Chironomidae accounted for 71% and 81% of the total density in Stream G1 and Stream L1, respectively, for 70% to 96% of the total density in Stream E1-S2, and for 89% of the total density in Stream Ab1. The dominant chironomid groups were the Tanytarsini and Orthocladiinae in Stream G1, Tanytarsini and Chironomini in Stream L1, Tanytarsini, Chironomini, and Orthocladiinae in Stream E1 (depending on station), and Orthocladiinae Stream Ab1.

Taxa present were similar among streams, with the exception of the Ephemeroptera, Plecoptera, and Trichoptera, which were absent from Stream L1 (Appendix F, Table F-6). This result is likely related to sampling in an area with no measureable flow. Also in Stream G1, there were fewer Chironomini taxa compared to other streams.

Figure 3.2-18 Relative Density of Major Benthic Invertebrate Taxa at Stream Stations in the Lac du Sauvage Basin, August and September 2013



Note: "Other" taxa category includes Gastropoda, Turbellaria, Coleoptera, Ephemeroptera, Plecoptera, Trichoptera, Ceratopogonidae, Empididae, Muscidae, Simuliidae, and Tipulidae.

% = percent.

3.2.4 Lac de Gras Basin

3.2.4.1 Paul Lake

3.2.4.1.1 Aquatic Habitat – Lake Stations

Field water quality was similar at the stations sampled in Paul Lake (Table 3.2-7). Conductivity was nearly uniform among stations (16 to 17 µS/cm), and varied little between surface and bottom waters. Water temperature was also similar among stations, ranging from 7.4°C to 8.1°C, and decreased little with depth. Total organic carbon was low at all stations, ranging from 2% to 3%; the substrate at all stations consisted of 100% fine sediments (silt and clay).

Table 3.2-7 Habitat Data for Lake Stations in Paul Lake, September 2013

Station	Sample Depth (m)	Field Water Quality				Sediment Composition	
		Conductivity (µS/cm)		Temperature (°C)		Total Organic Carbon (%)	Fines (%)
		Surface	Bottom	Surface	Bottom		
PL-1	8.8	16	16	7.5	7.4	2	100
PL-2	8.0	16	16	7.4	7.4	2	100
PL-3	13.0	17	17	8.1	8.0	2	100
PL-4	8.0	17	17	8.1	7.8	2	100
PL-5	8.0	17	17	7.8	7.8	3	100
Mean	**9.2**	**17**	**17**	**7.8**	**7.7**	**2**	**100**
Minimum	**8.0**	**16**	**16**	**7.4**	**7.4**	**2**	**100**
Maximum	**13.0**	**17**	**17**	**8.1**	**8.0**	**3**	**100**

m = metre; µS/cm = microsiemens per centimetre; °C = degrees Celsius; % = percent.

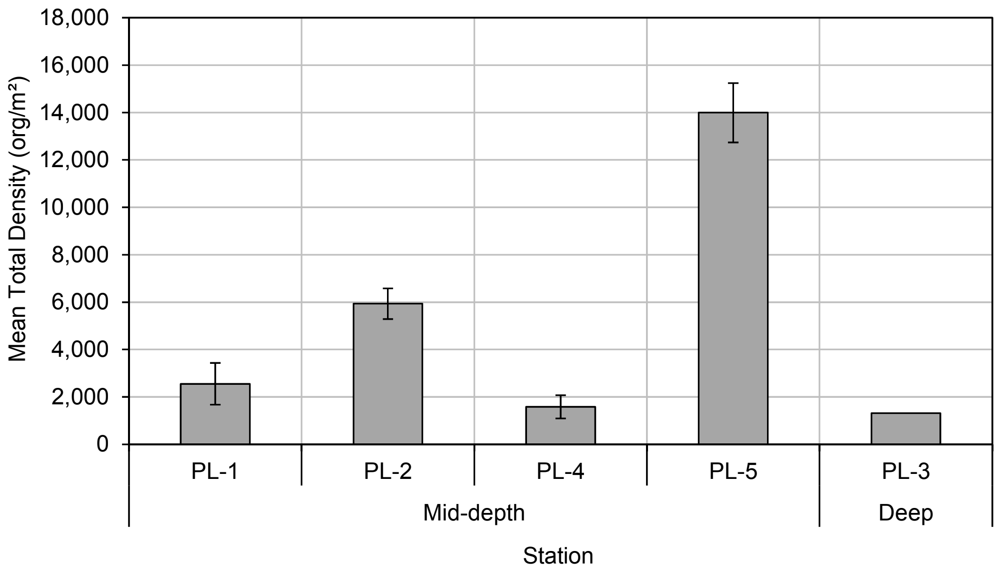
3.2.4.1.2 Benthic Invertebrate Community Variables – Lake Stations

Raw abundance data for the benthic invertebrate samples collected in Paul Lake are provided in Appendix E1, Table E1-1.

Mean Total Density and Total Richness

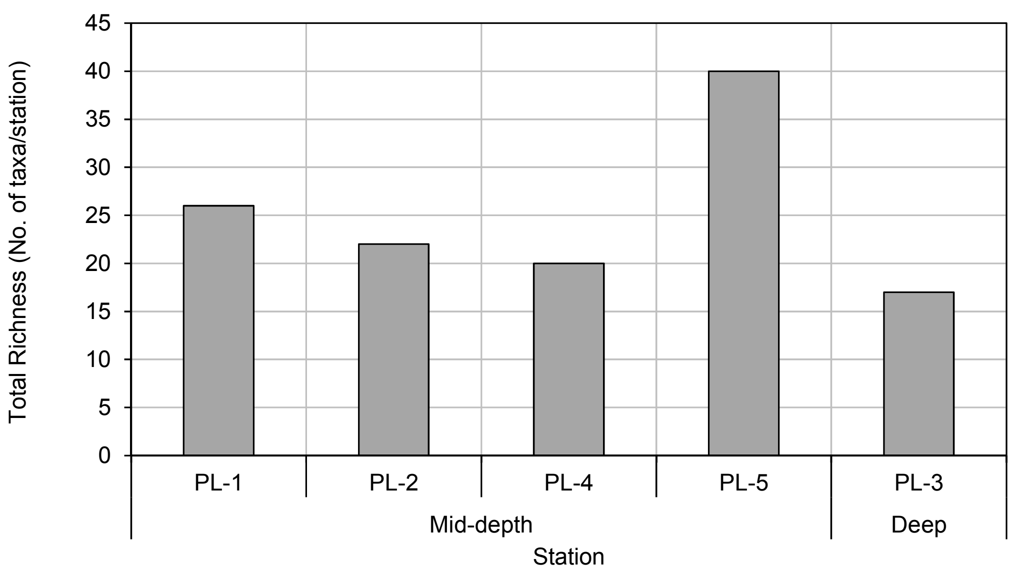
Mean total benthic invertebrate densities at the mid-depth stations in Paul Lake were low to moderate, ranging from 1,578 to 13,991 org/m², and low at the deep station at 1,310 org/m² (Figure 3.2-19). Total richness was moderate at all stations, ranging from 20 to 40 taxa/station at the mid-depth stations, and 17 taxa/station at the deep station (Figure 3.2-20).

Figure 3.2-19 Mean Total Benthic Invertebrate Density at Lake Stations in Paul Lake, September 2013



org/m^2 = number of organisms per square metre.

Figure 3.2-20 Total Benthic Invertebrate Richness at Lake Stations in Paul Lake, September 2013

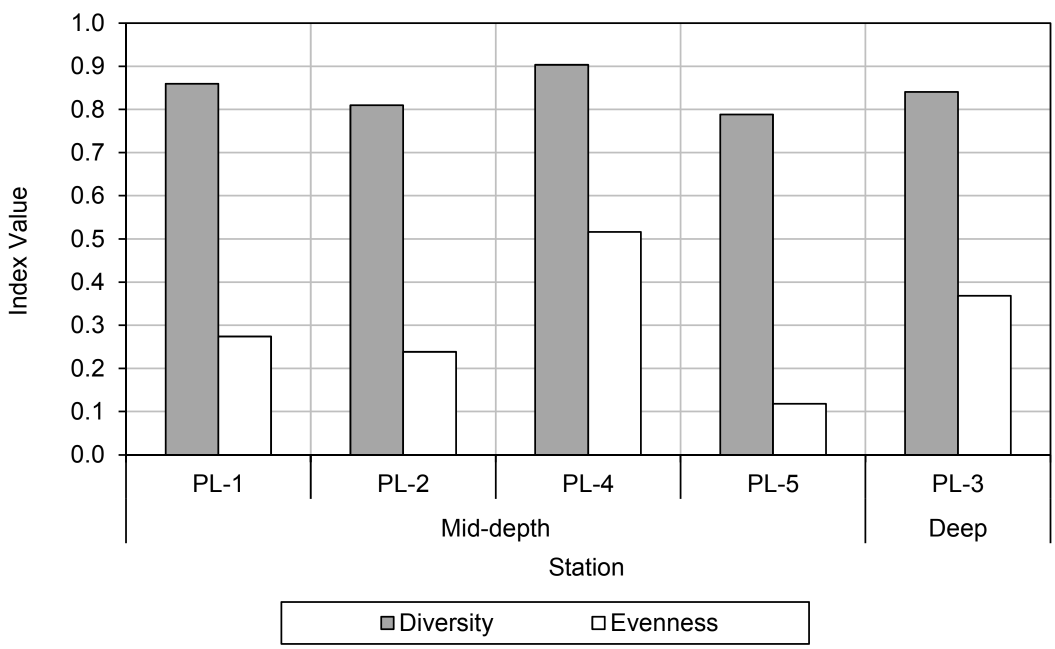


No. of taxa/station = number of taxa per station.

Simpson's Diversity and Evenness Indices

The SDI values were high at the lake stations in Paul Lake, ranging from 0.79 to 0.90 at the mid-depth stations and 0.84 at the deep station (Figure 3.2-21). Evenness was low at all stations (0.12 to 0.37), with the exception of Station PL-4, which had a moderate SEI value of 0.52. The SDI values indicated that the benthic invertebrate community at lake stations in Paul Lake was diverse; however, the low SEI values indicated that a few taxa accounted for the majority of the density at each station.

Figure 3.2-21 Simpson's Diversity and Evenness Index Values for Lake Stations in Paul Lake, September 2013

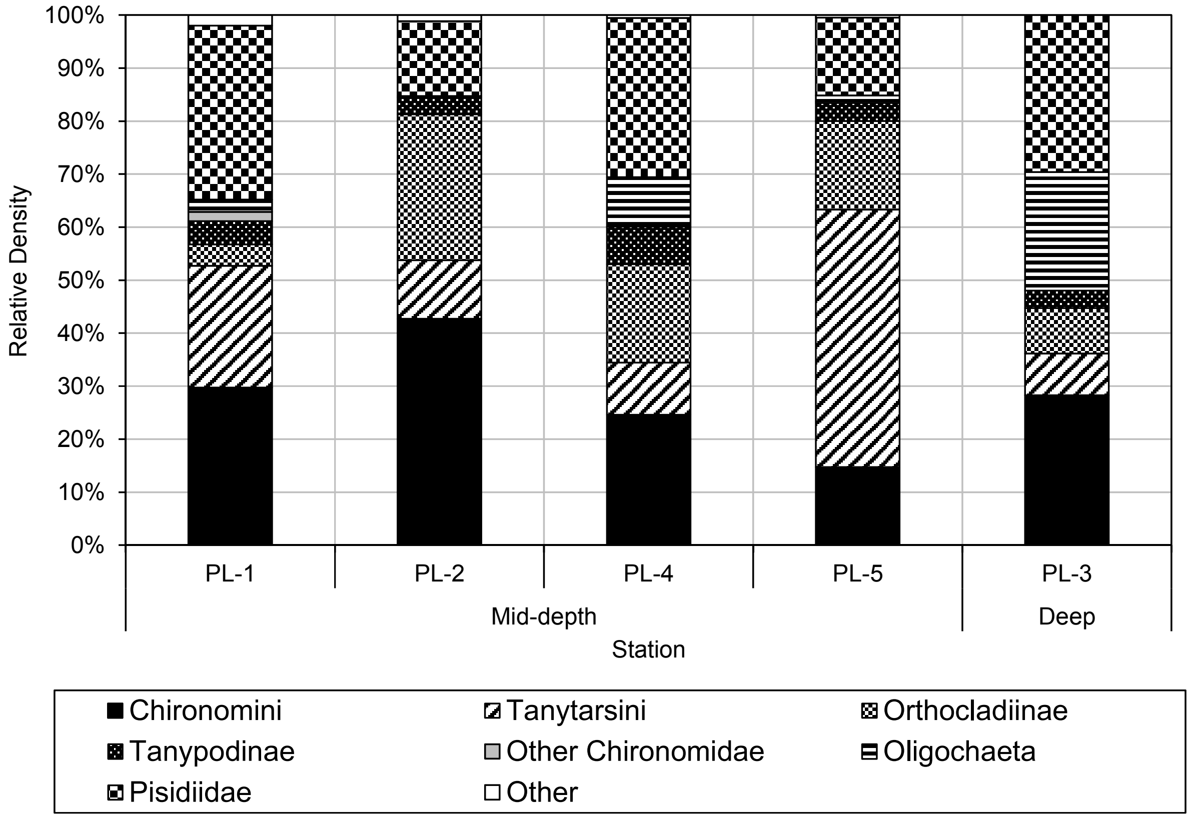


Community Composition

The benthic invertebrate community in Paul Lake was dominated by the Chironomidae (Figure 3.2-22). The Chironomidae accounted for 60% to 84% of the total density at Paul Lake stations, with the Chironomini, Tanytarsini, and the Orthocladiinae being the most dominant chironomid groups. Dominance of the benthic invertebrate community by the Chironomidae is expected in sub-Arctic lakes (Beaty et al. 2006; Northington et al. 2010). The Pisidiidae also accounted for a large proportion of the total density at the Paul Lake stations, ranging from 14% to 33% of the total density.

Taxa present were similar among stations in Paul Lake (Appendix F, Table F-5), with the exception of three major groups: Gastropoda and Trichoptera, which were only present at Station PL-5; and the Acari, which were absent from Station PL-3.

Figure 3.2-22 Relative Density of Major Benthic Invertebrate Taxa at Lake Stations in Paul Lake, September 2013



Note: "Other" taxa category includes Hydridae, Acari, Gastropoda, Turbellaria, Trichoptera, and Empididae.
% = percent.

4 SUMMARY

4.1 Historical Benthic Invertebrate Data

4.1.1 Lakes

Benthic invertebrate communities from shallow, mid-depth, and deep habitats from seven lakes in two basins were evaluated during this historical review:

- Lac du Sauvage Basin (Lac du Sauvage, Christine Lake, Ursula Lake, Counts Lake); and,
- Lac de Gras Basin (Lac de Gras, Nanuq Lake, and Vulture Lake).

Within the lake habitats, mean benthic invertebrate densities tended to be greater at the shallow and mid-depth stations compared to the deep stations. Temporal trends were also noted. For example, lowest densities were observed in 1997 and 2003 at many of the mid-depth and deep stations; peak densities were observed in 2007 and 2008. An increasing trend in density has been observed in a few lakes (i.e., Vulture Lake and Counts Lake); however, densities have generally remained fairly consistent among lakes over time (ERM Rescan 2013).

A similar trend was noted for richness. Increasing richness values were noted in several lakes, including Vulture Lake, Counts Lake, and Stations S2 and S3 in Lac de Gras; however, this trend was not observed at the far-field stations in Lac de Gras, and in Lac du Sauvage or Nanuq Lake.

Benthic invertebrate communities in lake habitats were dominated by the Chironomidae (non-biting midges) and Pisidiidae (fingernail clams). Chironomidae dominated the majority of the lakes examined in this historical summary; however, the Pisidiidae were the dominant group at several deep stations, including Counts Lake. Other groups such as Oligochaeta (worms), *Hydra*, Acari (mites), Turbellaria (flatworms), Eubranchiopoda (tadpole shrimp), Gastropoda (snails), Ostracoda (seed shrimp), Trichoptera (caddisflies), Ephemeroptera (mayflies), other Diptera (true files), and Coleoptera (beetles) contributed to smaller proportions of the benthic community in the lake habitat. The dominance of the benthic invertebrate community by the Chironomidae is expected in the sub-Arctic region (Beaty et al. 2006; Northington et al. 2010), where the BSA is located.

Generally, diversity and evenness mirrored one another within the lakes. Diversity tended to be greater at the shallow and mid-depth stations, compared to the deep stations. Overall diversity was high and evenness was low, indicating that a few taxa accounted for the majority of the total density. There were no apparent spatial patterns with respect to diversity and evenness, and both diversity and evenness were typically variable over time.

4.1.2 Streams

Benthic invertebrate communities of streams from two basins were evaluated during this historical assessment:

- Lac du Sauvage (Counts Lake Outflow and the Vulture-Polar Lake Outflow); and,
- Lac de Gras (Nanuq Lake Outflow).

Overall, benthic invertebrate densities have remained stable in the streams over time. Temporal trends with respect to richness were noted in the stream habitats; minimum richness values were noted in streams in 2001 and maximum values were recorded in 2011.

The Chironomidae were also the dominant taxonomic group in the streams examined in this study, although the dominant subfamily or tribe varied by location. For example, Tanytarsini were most abundant at the Counts Lake Outflow, and Orthocladiinae were most abundant at the Nanuq Lake Outflow. The dominance of the benthic invertebrate community by the Chironomidae is typical for the sub-Arctic region (Beaty et al. 2006; Northington et al. 2010) where the BSA is located.

The contribution of the other groups to the benthic invertebrate community was variable among streams. For example, Ostracoda and Trichoptera contributed to between 1% and 20% of the community at the Vulture-Polar Lake Outflow, but were only present in small numbers at the Counts Lake and Nanuq Lake outflows. The EPT taxa (Ephemeroptera, Plecoptera, Trichoptera) contributed to a small proportion of the benthic invertebrate communities in the streams, and their relative contribution to the community has not changed over time.

Mean diversity values were variable among the streams, but were generally high, indicating a diverse benthic invertebrate community. No clear spatial patterns were apparent. Evenness values were also variable but generally low, indicating that a few taxa accounted for the majority of the total density in the streams.

4.2 Summary of Baseline Benthic Invertebrate Community, 2013

4.2.1 Lakes

Benthic invertebrate stations were located in littoral, shallow, mid-depth, and deep habitat; thus, the full range of benthic invertebrate habitats was sampled during the baseline survey. Field water quality was similar among lakes throughout the BSA. Field water quality parameters varied little with depth, indicating that the lakes were well mixed at the time of sampling.

The benthic invertebrate community at lake stations was characterized by variable mean total density and richness, which both ranged from low to moderate in the lakes sampled. Mean total density and total richness were within the range expected for sub-Arctic lakes. Simpson’s diversity index values at lake stations were moderate to high, indicating a diverse benthic invertebrate community. Evenness was variable and ranged from low to moderate, indicating that a few taxa accounted for the majority of the total density at lake stations.

The benthic invertebrate community at lake stations was dominated by the Chironomidae, and to a lesser extent, the Pisidiidae, which accounted for a moderate proportion of the community at most stations. Dominance of the benthic invertebrate community by the Chironomidae at lake stations is expected in sub-Arctic lakes (Beaty et al. 2006; Northington et al. 2010). Gastropoda and Acari accounted for a large proportion of total density in littoral stations.

4.2.2 Streams

Benthic invertebrate sampling stations were located in streams of various sizes in the BSA. Field water quality parameters varied little among stations, indicating that most of the small streams had similar headwater characteristics. Stream Ab1, the narrows that connect Lac du Sauvage with Lac de Gras, also had similar water quality as the small streams.

The benthic invertebrate community at stream stations was characterized by variable mean total density, which ranged from low to moderate. Total richness ranged from moderate to high. Simpson’s diversity index values were high indicating a diverse benthic invertebrate community. Evenness was variable and ranged from low to moderate, indicating that a few taxa accounted for the majority of the total density.

The benthic invertebrate community was dominated by Chironomidae at all stations, which is expected in sub-Arctic streams. Nematoda, Hydrozoa, and Plecoptera also accounted for a significant proportion of the total density at a few streams.

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6 GLOSSARY

Term	Definition
Abundance	The number of individuals in a given area or sample.
Baseline	A surveyed or predicted condition that serves as a reference point with which later surveys are coordinated or correlated.
Bathymetry	Measurement of water depths in a lake.
Benthic Invertebrates	Animals without backbones that live on river and lake bottoms. Benthic refers to the bottom.
Cladocera	A group of small planktonic animals (crustaceans) also known as water fleas; a component of zooplankton.
Conductivity	A measure of the resistance of a solution to electrical flow; an indirect measure of the salinity of the water.
Copepoda	An order of planktonic crustacean; a component of zooplankton.
Density	The number of individuals per unit area.
Dissolved Oxygen	Oxygen dissolved within the water column.
Diversity	A numerical index that 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 glacier movement
Effluent	Outflowing of water or other liquids from a man-made structure.
Ekman Grab	Cube-shaped mechanical device with a spring-loaded opening that is lowered to the bottom of a waterbody and triggered to close to collect a sample of the bottom sediments.
Enumeration	The act of counting individuals.
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.
Grab Sample	A single sample collected at a particular time and place that represents the composition of the material sampled (e.g.., water) only at that time and place.
Habitat	The physical location or type of environment in which an organism or biological population lives or occurs.
Headwater	The source of water at the top of a watershed, typically a lake or marsh.
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 Lake	A steep-sided bowl or basin-shaped hole or depression in glacial drift deposits, especially outwash or kame, 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 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.
Mainstem	The main portion of a watercourse extending continuously upstream from its mouth, but not including any tributary watercourses.
Mean	Arithmetic average value in a distribution.
Nutrients	Environmental substances (elements or compounds) such as nitrogen or phosphorus, which are necessary for the growth and development of plants and animals.

Term	Definition
Organics	Chemical compounds, naturally occurring or otherwise, which contain carbon, with the exception of carbon dioxide (CO_2) and carbonates (e.g., $CaCO_3$).
Pelagic	Relating to fish or other aquatic organisms that live offshore in the middle or lower part of the water column.
Permafrost	Permanently frozen subsoil occurring throughout the polar regions.
pH	A measure of the acidity or alkalinity of water.
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 Density	The proportional representation 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.
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.
Sediment	Solid material that is transported by, suspended in, or deposited from water. It originates mostly from disintegrated rocks; it also includes chemical and biochemical precipitates and decomposed organic material, such as humus. The quantity, characteristics, and cause of the occurrence of sediment in streams are influenced by environmental factors. Major factors are degree of slope, length of slope soil characteristics, land usage, and quantity and intensity of precipitation.
Simpson's Diversity Index	An index used to measure diversity, to quantify the biodiversity of a habitat. It takes into account the number of species present, as well as the relative abundance of each species. It represents the probability that two randomly selected individuals in the habitat will not belong to the same species.
Simpson's Evenness Index	An index use to measure how evenly the total invertebrate density is distributed among the taxa present at a station.
Substrate	The bottom of a waterbody, usually consisting of sediments of various particle sizes (e.g., sand, silt, clay, gravel, cobble, boulder) and organic material (e.g., living or dead plant material).
Taxon	A group of organisms at the same level of the standard biological classification system; the plural of taxon is taxa.
Terrestrial	Living or growing on land.
Thermal stratification	Horizontal layers of differing densities produced in a lake by temperature changes at different depths.
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 Metals	Metallic elements that have been digested in strong acid before analysis, including suspended, dissolved, and colloidal forms.
Total Organic Carbon	Total organic carbon is composed of both dissolved and particulate forms. Total organic carbon is often calculated as the difference between total carbon and total inorganic carbon. Total organic carbon has a direct relationship with both biochemical and chemical oxygen demands, and varies with the composition of organic matter present in the water. Organic matter in soils, aquatic vegetation, and aquatic organisms are major sources of organic carbon.
Total Richness	The total number of different taxa occupying a given area.
Tributary	A stream that flows into a larger stream or lake.
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.

Term	Definition
Waste Rock	Rock moved and discarded to access resources (e.g., mining kimberlite for diamonds).
Waterbody	An area of water such as a river, stream, lake, or sea.
Wetland	Land having the water table at, near, or above the land surface or which is saturated for a long enough period to promote wetlands or aquatic processes, as indicated by hydric soils, hydrophytic vegetation, and various kinds of biological activity adapted to the wet environment.

DOMINION DIAMOND

Appendix A Historical Benthic Invertebrate Data Tables and Figures

Appendix B Mesh Size Comparison

Appendix C Benthic Invertebrate Taxonomy Quality Assurance/Quality Control Data

Appendix D Field Water Quality Data for Lac du Sauvage – August 2013

Appendix E1 Benthic Invertebrate Taxonomy Data, 2013

Appendix E2 EcoAnalysts, Inc. Taxonomic Reference List

Appendix F Benthic Invertebrate Taxa, 2013