Ekati Diamond Mine

2014 Aquatic Effects Monitoring Program
Summary Report

DOMINION DIAMOND™

DOMINION DIAMOND

March 31st 2015

Ms. Violet Camsell-Blondin
Chair
Wek'èezhìi Land and Water Board
#1, 4905-48th Street
Yellowknife, NT, CA X1A 2P6

Dear Ms. Camsell-Blondin
Re: Ekati Diamond Mine 2014 Aquatic Effects Monitoring Program

Dominion Diamond Ekati Corporation (DDEC) is pleased to provide the *2014 Aquatic Effects Monitoring Program* annual report. The report is submitted under Part J Item 7 of Water Licence W2012L2-0001. In addition to the Summary Report, the 2014 AEMP consists of three separate documents:

- Ekati Diamond Mine: 2014 Aquatic Effects Monitoring Program Part 1 – Evaluation of Effects
- Ekati Diamond Mine: 2014 Aquatic Effects Monitoring Program Part 2 – Data Report
- Ekati Diamond Mine: 2014 Aquatic Effects Monitoring Program Part 3 – Statistical Report

The 2014 AEMP was conducted as specified in the Ekati Diamond Mine: Aquatic Effects Monitoring Program Plan for 2013-2015 (Rescan 2013d). This plan is currently under re-evaluation for the upcoming three year period of 2016-2018, and will be submitted by December 15, 2015. In addition to the above mentioned documents, updates have been made to the Dominion Diamond Ekati Corporation's Nitrogen Response Plan. These updates can be found in Section 8 of the Ekati Diamond Mine: 2014 Aquatic Effects Monitoring Report - Summary Report. In regards to the request following the revision of the 2013 AEMP report for the submission of a Response Plan for Potassium in relation to Part J Item 10(b) of the Water License W2012L2-0001, this report is complete and will be submitted separately from the AEMP by March 31, 2015.

DDEC trusts that you will find the report to be clear and informative. Please contact Tom Jeffery, Environmental Advisor - Fisheries and Aquatics at Tom.Jeffery@ekati.ddcorp.ca or 867-669-6135 or the undersigned at Harry.O'Keefe@ekati.ddcorp.ca or 867-669-6164 should you have any questions.

DOMINION DIAMOND EKATI CORPORATION
1102, 4920-52nd Street, Yellowknife, Canada X1A 3T1 T 1.867.669.6100 F 1.867.669.9293 www.ddcorp.ca

DOMINION DIAMOND

Yours sincerely,

Dominion Diamond Ekati Corporation

Harry O'Keefe
Team Leader – Environment Projects
Ekati Diamond Mine

DOMINION DIAMOND EKATI CORPORATION
1102, 4920-52nd Street, Yellowknife, Canada X1A 3T1 T 1.867.669.6100 F 1.867.669.9293 www.ddcorp.ca

Dominion Diamond Ekati Corporation

EKATI DIAMOND MINE

2014 Aquatic Effects Monitoring Program Summary Report

March 2015

Project #0211136-0017

Citation:
ERM. 2015. *Ekati Diamond Mine: 2014 Aquatic Effects Monitoring Program Summary Report*. Prepared for Dominion Diamond Ekati Corporation by ERM Consultants Canada Ltd.: Yellowknife, Northwest Territories.

ERM
5120 49th Street, Suite 201
Yellowknife, NT
Canada X1A 1P8
T: (867) 920-2090
F: (867) 920-2015

Table of Contents

Table of Contents i
List of Figures ii
List of Tables viii

Glossary and Abbreviations ix

1. Introduction 1-1
1.1 Background 1-1
1.2 Overview of the Ekati Diamond Mine Activities 1-5
1.2.1 Koala Watershed 1-5
1.2.2 The King-Cujo Watershed 1-7
1.2.3 Carrie Pond Watershed 1-8
1.2.4 Pigeon-Fay and Upper Exeter Watershed 1-8
1.3 Changes to Evaluation of Effects Following the 2012 Re-evaluation 1-9

2. Methodology 2-1
2.1 2014 Sampling Locations 2-1
2.2 2014 Sampling Program 2-7
2.3 Variables Evaluated in 2014 2-7
2.4 Evaluation Framework 2-7

3. General Climatic and Hydrological Conditions In 2014 3-1
3.1 Climatic Conditions 3-1
3.2 Hydrological Conditions 3-2

4. Summary of Evaluation of Effects for the Koala Watershed and Lac de Gras 4-1

5. Summary of Evaluation of Effects for the King-Cujo Watershed and Lac du Sauvage 5-1

6. Summary of Evaluation of Effects for the Pigeon-Fay and Upper Exeter Watershed 6-1

7. Summary of Special Studies 7-1

7.1 Lac de Gras 7-1

7.2 Grizzly Lake Biological Communities 7-1

8. Nitrogen Response Plan update 8-1

8.1 Rationale and Objectives 8-1

8.2 Nitrogen Sources and Control Practices at the Ekati Diamond Mine 8-1

8.2.1 Underground Minewater as a Source of Nitrogen 8-1

8.2.2 Open-pit Minewater as a Source of Nitrogen 8-3

8.2.3 Process Plant Discharge as a Source of Nitrogen 8-3

8.2.4 Nitrogen Trends in the LLCF and Receiving Environment 8-3

8.2.5 Current Nitrogen Source Control and Release Practices 8-10

8.2.5.1 Nitrogen Source Control Practices 8-10

8.2.5.2 Nitrogen Release Control Practices 8-11

8.2.5.3 Nitrogen Mass-Balance 8-11

8.3 Implementation Plan 8-14

8.3.1 Update on Implementation of the Nitrogen Response Plan 8-14

8.3.2 Additional Management Practices Included in the Nitrogen Response Plan 8-17

8.3.3 Looking Forward: Incorporating the Nitrogen Response Plan in the Response Framework 8-18

References R-1

List of Figures

Figure 1.1-1. Schematic of Aquatic Monitoring Programs at the Ekati Diamond Mine 1-3

Figure 2.1-1. AEMP Lake and Stream Sampling Locations, 2014 2-3

Figure 2.1-2. Surface Water Flow through the AEMP Sampling Area 2-5

Figure 2.4-1. Evaluation Framework for the 2014 AEMP 2-10

Figure 4-1. Summary of Mine-related Changes in the Variables Evaluated for the Koala Watershed and Lac de Gras, 2014 4-2

Figure 4-2a. Under-ice Dissolved Oxygen and Temperature Profiles for AEMP Reference Lakes, 1998 to 2014 4-10

Figure 4-2b. Under-ice Dissolved Oxygen and Temperature Profiles for AEMP Reference Lakes, 1998 to 2014 4-11

Figure 4-2c. Under-ice Dissolved Oxygen and Temperature Profiles for AEMP Reference Lakes, 1998 to 2014 4-12

Figure 4-3a. Under-ice Dissolved Oxygen and Temperature Profiles for Koala Watershed Lakes and Lac de Gras, 1994 to 2014 4-13

Figure 4-3b. Under-ice Dissolved Oxygen and Temperature Profiles for Koala Watershed Lakes and Lac de Gras, 1994 to 2014 4-14

Figure 4-3c. Under-ice Dissolved Oxygen and Temperature Profiles for Koala Watershed Lakes and Lac de Gras, 1994 to 2014 4-15

Figure 4-3d. Under-ice Dissolved Oxygen and Temperature Profiles for Koala Watershed Lakes and Lac de Gras, 1994 to 2014 4-16

Figure 4-3e. Under-ice Dissolved Oxygen and Temperature Profiles for Koala Watershed Lakes and Lac de Gras, 1994 to 2014 4-17

Figure 4-3f. Under-ice Dissolved Oxygen and Temperature Profiles for Koala Watershed Lakes and Lac de Gras, 1994 to 2014 4-18

Figure 4-3g. Under-ice Dissolved Oxygen and Temperature Profiles for Koala Watershed Lakes and Lac de Gras, 1994 to 2014 4-19

Figure 4-3h. Under-ice Dissolved Oxygen and Temperature Profiles for Koala Watershed Lakes and Lac de Gras, 1994 to 2014 4-20

Figure 4-4. Observed and Fitted Means for pH in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014 4-21

Figure 4-5. Observed and Fitted Means for Total Alkalinity in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014 4-22

Figure 4-6. Observed and Fitted Means for Water Hardness in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014 4-23

Figure 4-7. Observed and Fitted Means for Chloride Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014 4-24

Figure 4-8. Observed and Fitted Means for Sulphate Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014 4-25

Figure 4-9. Observed and Fitted Means for Potassium Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014 4-26

Figure 4-10. Observed and Fitted Means for Total Ammonia-N Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014 4-27

Figure 4-11. Observed and Fitted Means for Nitrite-N Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014 4-28

Figure 4-12. Observed and Fitted Means for Nitrate-N Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994- to 2014 4-29

Figure 4-13. Observed and Fitted Means for Total Phosphate-P Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014 4-30

Figure 4-14. Observed and Fitted Means for Total Antimony Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014 4-31

Figure 4-15. Observed and Fitted Means for Total Arsenic Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014 4-32

Figure 4-16. Observed and Fitted Means for Total Barium Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014 4-33

Figure 4-17. Observed and Fitted Means for Total Boron Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014 4-34

Figure 4-18. Observed and Fitted Means for Total Molybdenum Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014 4-35

Figure 4-19. Observed and Fitted Means for Total Nickel Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014 4-36

Figure 4-20. Observed and Fitted Means for Total Selenium Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014 4-37

Figure 4-21. Observed and Fitted Means for Total Strontium Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014 4-38

Figure 4-22. Observed and Fitted Means for Total Uranium Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014 4-39

Figure 4-23. Observed and Fitted Means for Total Organic Carbon in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014 4-40

Figure 4-24. Observed and Fitted Means for Total Antimony Concentrations in Sediments in Koala Watershed Lakes and Lac de Gras, 1994 to 2014 4-41

Figure 4-25. Observed and Fitted Means for Total Molybdenum Concentrations in Sediments in Koala Watershed Lakes and Lac de Gras, 1994 to 2014 4-42

Figure 4-26. Observed and Fitted Means for Total Strontium Concentrations in Sediments in Koala Watershed Lakes and Lac de Gras, 1994 to 2014 4-43

Figure 4-27a. Average Diversity Indices for Phytoplankton in Koala Watershed Lakes and Lac de Gras, 1996 to 2014 4-44

Figure 4-27b. Average Diversity Indices for Phytoplankton in Koala Watershed Lakes and Lac de Gras, 1996 to 2014 4-45

Figure 4-28. Average Phytoplankton Density by Taxonomic Group for AEMP Reference Lakes, 1996 to 2014 4-46

Figure 4-29a. Average Phytoplankton Density by Taxonomic Group for Lakes of the Koala Watershed, 1996 to 2014 4-47

Figure 4-29b. Average Phytoplankton Density by Taxonomic Group for Lakes of the Koala Watershed, 1996 to 2014 4-48

Figure 4-30. Average Phytoplankton Density by Taxonomic Group for Lac de Gras, 1996 to 2014 4-49

Figure 4-31. Relative Densities of Phytoplankton Taxa in AEMP Reference Lakes, 1996 to 2014 4-50

Figure 4-32a. Relative Densities of Phytoplankton Taxa in Lakes of the Koala Watershed, 1996 to 2014 4-51

Figure 4-32b. Relative Densities of Phytoplankton Taxa in Lakes of the Koala Watershed, 1996 to 2014 4-52

Figure 4-33. Relative Densities of Phytoplankton Taxa in Lac de Gras, 1996 to 2014 4-53

Figure 4-34. Average Diversity Indices for Zooplankton in Koala Watershed Lakes and Lac de Gras, 1995 to 2014 4-54

Figure 4-35. Average Zooplankton Density by Taxonomic Group for AEMP Reference Lakes, 1995 to 2014 4-55

Figure 4-36a. Average Zooplankton Density by Taxonomic Group for Lakes of the Koala Watershed, 1995 to 2014 4-56

Figure 4-36b. Average Zooplankton Density by Taxonomic Group for Lakes of the Koala Watershed, 1995 to 2014 4-57

Figure 4-37. Relative Densities of Zooplankton Taxa in AEMP Reference Lakes, 1995 to 2014 4-58

Figure 4-38a. Relative Densities of Zooplankton Taxa in Lakes of the Koala Watershed, 1995 to 2014 4-59

Figure 4-38b. Relative Densities of Zooplankton Taxa in Lakes of the Koala Watershed, 1995 to 2014 4-60

Figure 4-39. Average Diptera Density by Taxonomic Group for AEMP Reference Lakes, 1994 to 2014 4-61

Figure 4-40a. Average Diptera Density by Taxonomic Group for Lakes of the Koala Watershed and Lac de Gras, 1994 to 2014 4-62

Figure 4-40b. Average Diptera Density by Taxonomic Group for Lakes of the Koala Watershed and Lac de Gras, 1994 to 2014 4-63

Figure 4-41. Relative Densities of Diptera Taxa in AEMP Reference Lakes, 1994 to 2014 4-64

Figure 4-42a. Relative Densities of Diptera Taxa in Lakes of the Koala Watershed and Lac de Gras, 1994 to 2014 4-65

Figure 4-42b. Relative Densities of Diptera Taxa in Lakes of the Koala Watershed and Lac de Gras, 1994 to 2014 4-66

Figure 4-43. Observed and Fitted Means for Benthos Densities in Koala Watershed Streams, 1995 to 2014 4-67

Figure 5-1. Summary of Mine-related Changes in the Variables Evaluated for the King-Cujo Watershed and Lac du Sauvage, 2014 5-2

Figure 5-2. Observed and Fitted Means for pH in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014 5-7

Figure 5-3. Observed and Fitted Means for Total Alkalinity in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014 5-8

Figure 5-4. Observed and Fitted Means for Water Hardness in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014 5-9

Figure 5-5. Observed and Fitted Means for Chloride Concentrations in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014 5-10

Figure 5-6. Observed and Fitted Means for Sulphate Concentrations in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014 5-11

Figure 5-7. Observed and Fitted Means for Potassium Concentrations in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014 5-12

Figure 5-8. Observed and Fitted Means for Total Barium Concentrations in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014 5-13

Figure 5-9. Observed and Fitted Means for Total Boron Concentrations in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014 5-14

Figure 5-10. Observed and Fitted Means for Total Molybdenum Concentrations in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014 5-15

Figure 5-11. Observed and Fitted Means for Total Strontium Concentrations in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014 5-16

Figure 5-12. Observed and Fitted Means for Total Ammonia-N Concentrations in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014 5-17

Figure 5-13. Observed and Fitted Means for Total Copper Concentrations in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014 5-18

Figure 5-14. Observed and Fitted Means for Total Organic Carbon Concentrations in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014 5-19

Figure 5-15. Observed and Fitted Means for Total Nitrogen Percentages in Sediments in King-Cujo Watershed Lakes and Lac du Sauvage, 1994 to 2014 5-20

Figure 5-16. Observed and Fitted Means for Total Molybdenum Concentrations in Sediments in King-Cujo Watershed Lakes and Lac du Sauvage, 1994 to 2014 5-21

Figure 5-17. Observed and Fitted Means for Total Strontium Concentrations in Sediments in King-Cujo Watershed Lakes and Lac du Sauvage, 1994 to 2014 5-22

Figure 5-18. Observed and Fitted Means for Benthos Densities in King-Cujo Watershed Lakes and Lac du Sauvage, 1994 to 2014 5-23

Figure 5-19. Average Density of Diptera Taxa for Lakes of the King-Cujo Watershed and Lac du Sauvage, 1994 to 2014 5-24

Figure 5-20. Relative Density of Diptera Taxa in Lakes of the King-Cujo Watershed and Lac du Sauvage, 1994 to 2014 5-25

Figure 6-1. Summary of Mine-related Changes in the Variables Evaluated for the Pigeon-Fay and Upper Exeter Watershed, 2014 6-3

Figure 6-2. Observed and Fitted Means for Total Alkalinity in Pigeon-Fay and Upper Exeter Watershed Lakes and Streams, 1994 to 2014 6-4

Figure 6-3. Observed and Fitted Means for Water Hardness in Pigeon-Fay and Upper Exeter Watershed Lakes and Streams, 1994 to 2014 6-5

Figure 6-4. Observed and Fitted Means for Chloride Concentrations in Pigeon-Fay and Upper Exeter Watershed Lakes and Streams, 1994 to 2014 6-6

Figure 6-5. Observed and Fitted Means for Sulphate Concentrations in Pigeon-Fay and Upper Exeter Watershed Lakes and Streams, 1994 to 2014 6-7

Figure 6-6. Observed and Fitted Means for Potassium Concentrations in Pigeon-Fay and Upper Exeter Watershed Lakes and Streams, 1994 to 2014 6-8

Figure 6-7. Observed and Fitted Means for Total Organic Carbon Concentrations in Pigeon-Fay and Upper Exeter Watershed Lakes and Streams, 1994 to 2014 6-9

Figure 6-8. Observed and Fitted Means for Total Barium Concentrations in Pigeon-Fay and Upper Exeter Watershed Lakes and Streams, 1994 to 2014 6-10

Figure 6-9. Observed and Fitted Means for Total Nickel Concentrations in Pigeon-Fay and Upper Exeter Watershed Lakes and Streams, 1994 to 2014 6-11

Figure 6-10. Observed and Fitted Means for Total Strontium Concentrations in Pigeon-Fay and Upper Exeter Watershed Lakes and Streams, 1994 to 2014 6-12

Figure 6-11. Observed and Fitted Means for Total Nickel Concentrations in Sediments in Pigeon-Fay and Upper Exeter Watershed Lakes, 1994 to 2014 6-13

Figure 6-12. Observed and Fitted Means for Chlorophyll *a* Concentrations and Phytoplankton Density in Pigeon-Fay and Upper Exeter Watershed Lakes, 1994 to 2014 6-14

Figure 6-13. Average Phytoplankton Density by Taxonomic Group for Lakes of the Pigeon-Fay and Upper Exeter Watershed, 1996 to 2014 6-15

Figure 6-14. Relative Densities of Phytoplankton Taxa in Lakes of the of the Pigeon-Fay and Upper Exeter Watershed, 1996 to 2014 6-16

Figure 6-15. Average Diversity Indices for Phytoplankton in Pigeon-Fay and Upper Exeter Watershed Lakes, 1996 to 2014 6-17

Figure 8.2-1. Underground Minewater Concentrations of Total Ammonia-N and Nitrate-N, 2010 to 2014 8-2

Figure 8.2-2. Fox Pit Minewater Concentrations of Total Ammonia-N and Nitrate-N, 2010 to 2014 8-4

Figure 8.2-3. Process Plant Slurry Concentrations of Total Ammonia-N and Nitrate-N, 2010 to 2014 8-5

Figure 8.2-4. Total Ammonia-N Concentration in the LLCF, 2010 to 2014 8-8

Figure 8.2-5. Nitrate-N Concentration in the LLCF, 2010 to 2014 8-9

List of Tables

Table 2.1-1. AEMP Lake Sampling Locations for 2013 to 2015 Period 2-1

Table 2.1-2. AEMP Stream Sampling Locations for 2013 to 2015 Period 2-2

Table 2.2-1. Summary of the 2014 AEMP Sampling Program 2-8

Table 2.3-1. Aquatic Variables Evaluated in 2014 2-9

Table 8.2-1. Monthly Nitrate Loading from the Process Plant to the LLCF, 2012 to 2014 8-6

Table 8.2-2. Process Plant Discharge to the LLCF and Beartooth Pit, 2012 to 2014 8-7

Table 8.2-3. Monthly Summaries of Nitrogen Delivered to Surface and Underground Operations as ANFO and Emulsion and Nitrogen Loads in Underground and Surface Minewater, 2014 8-12

Table 8.2-4. Monthly Summaries of Nitrate Loading from Process Plant Discharge, 2014 8-13

Table 8.2-5. Nitrogen Available for Transport to Waste Rock Storage Areas in 2014 Based on Estimates of 5% Loss of Nitrogen During Blasting 8-14

GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

AANDC	Aboriginal Affairs and Northern Development Canada
AEMP	Aquatic Effects Monitoring Program. A comprehensive, early-warning monitoring program designed to detect changes in aquatic ecosystems potentially influenced by the Ekati Diamond Mine.
AIC	Akaike Information Criterion
AN	Ammonium Nitrate
ANFO	Ammonium Nitrate/Fuel Oil
BACI	Before After Control Impact
Benthic	Pertaining to the bottom region of a water body, on or near bottom sediments or rocks.
Benthos	Benthos communities are a group of organisms that live associated with the bottom of lakes or streams. These communities contain a diverse assortment of organisms that have different mechanisms of feeding. The term benthos is used interchangeably with benthic invertebrates in this report. Benthos are an important food source for fish.
Biomass	The amount of living matter as measured on a weight or concentration basis. Biomass is an indication of the amount of food available for higher trophic levels. In the AEMP, phytoplankton biomass is estimated as chlorophyll *a*, and zooplankton biomass is measured as milligrams of dry weight per cubic metre.
CCME	Canadian Council of Ministers of the Environment
CCREM	Canadian Council of Resource and Environment Ministers
Chlorophyll	Chlorophyll is a molecule contained in photosynthetic organisms which is required to carry out photosynthesis. Chlorophyll *a* is used as an indicator of phytoplankton biomass in this report.
CPK	Coarse Processed Kimberlite
CPOM	Coarse Particulate Organic Matter
DDEC	Dominion Diamond Ekati Corporation
DFO	Fisheries and Oceans Canada

Diatom	Diatoms are a type of single celled algae. They photosynthesize and may live either free-floating in water (as phytoplankton) or attached to substrates (as periphyton). Diatoms contain a silica shell (called a frustule) outside of their cell membrane.
Diptera	Refers to a taxonomic order of insects. Dipterans are the true flies, and their larval stages are a major component of lake and stream benthos communities. Dipterans are characterized by a single pair of functional wings and include a wide diversity of species. Diptera include the familiar mosquito and black-fly, and their larvae are an important food source for fish. Their abundance and diversity can be used as an indicator of lake or stream water and sediment quality.
Diversity Indices	A measure of how varied in terms of genera a community of organisms is. In general, a healthy ecosystem will support a variety of species and have a high diversity index.
DO	Dissolved Oxygen
EC	Environment Canada
Ecology	The study of the interactions between organisms and their environment.
Ecosystem	A community of interacting organisms considered together with the chemical and physical factors that make up their environment.
Effect	Refers to any potential change in the aquatic environment that is a result of project activities associated with the Ekati Diamond Mine.
EPT	Ephemeroptera, Plecoptera and Trichoptera
EQC	Effluent Quality Criteria
EROD	Ethoxyresorufin-O-deethylase
ERM	Environmental Resources Management
ERT	Emergency Response Team
Euphotic Zone	The euphotic zone refers to the upper portion of the water column in which adequate light is present for photosynthesis to occur.
FPe	The Ekati Diamond Mine's incident and reporting management system
FPK	Fine Processed Kimberlite
FPOM	Fine Particulate Organic Matter
Freshet	Freshet refers to a high water flow event within a stream. In snowmelt driven systems such as the Arctic, the term is commonly used to refer to spring hydrology conditions in which the majority of annual water volume passes through streams in a short period of time. At the Ekati Diamond Mine, freshet typically begins in late May or early June, and lasts for a few weeks.

GCL	Geosynthetic Clay Liner
HDPE	High Density Polyethylene
Hydrology	The study of the properties of water and its movement in relation to land.
IEMA	Independent Environmental Monitoring Agency
Invertebrates	Collective term for all animals without a backbone or spinal column.
ISQG	Interim Sediment Quality Guideline
Kimberlite	An ultrabasic igneous rock that consists mainly of the mineral olivine and is found in volcanic pipes. The name is derived from Kimberley, South Africa, where the rock was first identified. The host rock for diamonds at the Ekati Diamond Mine.
KPSF	King Pond Settling Facility. A settlement facility in the King-Cujo Watershed used to store mine water at the Ekati Diamond Mine.
Lake Benthos	Lake benthos communities are a group of organisms that live associated with the bottom of lakes. These communities contain a diverse assortment of organisms that have different mechanisms of feeding. The term lake benthos is used interchangeably with lake benthic macroinvertebrates in this report. Lake benthos are an important food source for fish.
Larva	The immature stage, between egg and pupa, of an insect with complete metamorphosis.
Limnology	The study of lakes, including their physical, chemical, and biological processes.
LLCF	Long Lake Containment Facility. An engineered storage site used to confine the fine fraction of the processed kimberlite (i.e., tailings) and mine water in Long Lake at the Ekati Diamond Mine.
LME	Linear Mixed Effects
NRP	Nitrogen Response Plan
PDC	Panda Diversion Channel. An engineered channel used to divert water from North Panda Lake to Kodiak Lake.
PEL	Probable Effects Level
PET	Potential Evapotranspiration
Photosynthesis	The metabolic process by which carbon dioxide and sunlight are converted to simple sugars and oxygen. Organisms that photosynthesize contain the molecule chlorophyll.
Phytoplankton	Phytoplankton are microscopic primary producers that live free-floating in water. These organisms are single-celled algae that photosynthesize. Some common types of phytoplankton include diatoms and cyanobacteria.

PPD	Process Plant Discharge
Primary Producers	In this report, primary producers refer to organisms that convert sunlight into food through the process of photosynthesis. Aquatic primary producers can include phytoplankton, periphyton, macrophytes, and submerged vegetation. Only phytoplankton are examined as part of the Ekati Diamond Mine AEMP.
Processed Kimberlite	The residual material left behind when the processing of kimberlite ore has been completed to extract the diamonds.
PSD	Pigeon Stream Diversion. An engineered diversion constructed to allow flows from the headwater reaches of the Yamba/Exeter Watershed to enter Fay Bay channel unaltered and to circumvent Pigeon Pit.
Pupa	The stage between larva and adult in insects with complete metamorphosis.
Secchi Depth	Secchi depth is the depth at which a Secchi disc (standardized white and black disc) can no longer be seen when it is lowered into a lake. Secchi depth can be used to calculate the depth of the euphotic zone.
Shannon Diversity Index (H)	Is an index defined as: H = -∑pi × ln(pi), where pi is the proportion of the ith species or genera at a sampling station and ∑ indicates that the pi × ln(pi) is summed over all species or genera.
Simpson's Diversity Index (D)	Is considered a dominance index because it weights towards the most abundant species (represents the probability that two individuals selected at random from the population are different species or genera) and is defined as: D = 1 - $\sum(p_i)2$, where p_i is the proportion of the i^{th} species or genera at a sampling station and ∑ indicates that the $(p_i)2$ is summed over all species or genera.
SNP	Surveillance Network Program.
SSWQO	Site-specific Water Quality Objective
SWE	Snow-water-equivalent
Stream Benthos	Stream benthos communities are a group of organisms that live associated with the bottom of streams. These communities contain a diverse assortment of organisms that have different mechanisms of feeding. The term stream benthos is used interchangeably with stream benthic macro-invertebrates in this report. Stream benthos are an important food source for fish.
Tailings	Ground waste material and water (slurry) rejected from a mill or process plant after most of the valuable minerals have been extracted.
TBRG	Tipping Bucket Rain Gauge

TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TSS	Total Suspended Solids
Trophic Levels	Functional classification of organisms in an ecosystem according to feeding relationships. Primary producers constitute the first trophic level, and convert energy from the sun into food. All other trophic levels depend upon primary producers for their food. Secondary producers (or primary consumers) constitute the second trophic level, and tertiary producers (or secondary consumers) constitute the third trophic level. In a lake, phytoplankton constitute the first trophic level, zooplankton and some benthic organisms the second, and fish the third.
VOD	Velocity of Detonation
Waste Rock	Barren rock or rock too low in grade to be mined or processed economically.
WLWB	Wek'èezhìi Land and Water Board
WRSA	Waste Rock Storage Area
WSCC	Workers' Safety and Compensation Commission
Zooplankton	Zooplankton are small animals that live in the water column. They are secondary producers and feed mainly on phytoplankton.

<u>Units of Measurement and Symbols</u>

Centimetre	cm	**Metres above sea level**	masl
Cubic metre	m^3	**Micrometre (micron)**	µ
Degree	^{o}	**Microsiemens**	µS
Degrees Celsius	^oC	**Microsiemens per centimetre**	µS/cm
Gram	g	**Milligrams per kilogram**	mg/kg
Greater than	>	**Milligrams per litre**	mg/L
Kilogram	kg	**Millimetre**	mm
Kilometre	km	**Parts per million**	ppm
Less than	<	**Percent**	%
Litre	L	**Plus or minus**	±
Meter	m		

1. INTRODUCTION

1.1 BACKGROUND

The Aquatic Effects Monitoring Program (AEMP) at the Ekati Diamond Mine is a requirement specified in Dominion Diamond Ekati Corporations's (DDEC's) Class A Water Licence (W2012L2-0001). Sampling conducted for the 2014 AEMP was permitted through the Aurora Research Institute Scientific Research Licence (15382) issued for the Ekati Diamond Mine for the collection of samples between January 1 and December 31, 2014.

The AEMP is designed to detect changes in the aquatic ecosystem that may be caused by mine activities. The 2014 AEMP was conducted as specified in the document titled *Ekati Diamond Mine: Aquatic Effects Monitoring Program Plan for 2013-2015* (Rescan 2013d). This plan was developed following a detailed review or re-evaluation of 2010 to 2012 AEMP results completed in November of 2012 and presented to stakeholders at a workshop in December 2012 (Rescan 2012b). Stakeholders that participated in the meetings and provided feedback to the program included Environment Canada (EC), Fisheries and Oceans Canada (DFO), Aboriginal Affairs and Northern Development Canada (AANDC), the Yellowknives Dene First Nation, the Independent Environmental Monitoring Agency (IEMA) and the Wek'eezhii Land and Water Board (WLWB; Rescan 2013d).

Following the workshops, the WLWB solicited written comments from stakeholders to consider and provided recommendations to be incorporated into an AEMP design summary for 2013 to 2015. The final AEMP Plan for 2013 to 2015 (Rescan 2013b) incorporated each of the recommendations provided in the 2012 Re-evaluation (Rescan 2012a) and two additional requests made by the WLWB. A summary of the changes made to the Evaluation of Effects following the 2012 Re-evaluation is provided in Section 1.4.

As completed in the past, the 2014 AEMP report includes a Summary Report which provides an overall summary of the Evaluation of Effects. The main 2014 AEMP report is comprised of three parts:

1. Part 1 - Evaluation of Effects: provides the methods used to assess change in the aquatic environment and summarizes the results of the effects assessments;
2. Part 2 - Data Report: reports on the state of the aquatic environment at the Ekati Diamond Mine in 2014, including the field methodology and results for each of the aquatic environmental components (e.g., physical limnology); and
3. Part 3 - Statistical Report: provides the detailed results of the statistical analyses reported in the effects analysis.

The objective of the AEMP is to identify changes occurring in the aquatic environment that may be caused by Ekati Diamond Mine activities. To that end, the following components of the aquatic ecosystem were monitored in 2014:

- hydrology (October 2013 to September 2014);
- under-ice physical limnology (April/May 2014);
- open water season physical limnology (August 2014);
- ice-covered season lake water quality (April/May 2014);
- open water season lake water quality (August 2014);
- open water season stream water quality (June, July, August, and September 2014);
- lake sediment quality (August 2014);
- phytoplankton (August 2014);
- zooplankton (August 2014);
- lake benthos (August 2014); and
- stream benthos (August to September 2014).

Lake water quality and physical limnology were also monitored in July and September in the Pigeon-Fay and Upper Exeter Watershed.

Meteorological data are collected year round at the Ekati Diamond Mine between October 2013 and September 2014 and are reported in the AEMP because they are directly related to hydrology at the site (see Section 3.1 of Part 2 - Data Report).

AEMP fish community sampling has occurred once every five years and was most recently completed in 2012. As part of a 2011 evaluation of the fish sampling program, slimy sculpin were proposed as a sentinel species and changes to the 2012 AEMP field sampling program included the addition of slimy sculpin to be assessed with a sampling frequency of once every three years and a decrease in the sampling frequency of lake trout and round whitefish to once every six years to link it with the sampling frequency of slimy sculpin (and to further minimize total sampling mortality; Rescan 2011d, 2013a). Thus, slimy sculpin monitoring will be conducted in 2015 and monitoring of large-bodied fish (i.e., lake trout and round whitefish) will be conducted in 2018. The use of slimy sculpin as a sentinel species will continue to be evaluated as fish monitoring progresses.

There are three other components to the aquatic monitoring at the Ekati Diamond Mine, including Surveillance Network Program (SNP), special effects studies and monitoring programs, and environmental baseline studies (Figure 1.1-1). The SNP assesses DDEC's compliance with the Water Licence (W2012L2-0001) and sampling is completed by DDEC staff according to the Water Licence. Data from two SNP sampling stations, located at the two effluent discharge locations, 1616-30 in the Long Lake Containment Facility (LLCF) and 1616-43 in the King Pond Settling Facility (KPSF), are also incorporated into the AEMP for comparative purposes. Special effects studies are carried out on an as-needed basis to answer questions raised by the results of AEMP monitoring that require further investigation or to focus on specific topics by providing additional information not typically collected in the AEMP.

Figure 1.1-1

Schematic of Aquatic Monitoring Programs at the Ekati Diamond Mine

ERM

SUMMARY OF WATER MONITORING PROGRAMS AT EKATI

Surveillance Network Program (SNP)
(Monthly Reports)

- Program specified in Class A Water Licence.
- Designed to measure compliance with water licence.
- Three major compliance points are discharge from Cell E of the Long Lake Containment Facility (LLCF), discharge from the King Pond Settling Facility (KPSF), and discharge from Desperation Pond.
- If water from the three compliance points does not meet water licence criteria, no water is discharged from the facilities.

Aquatic Effects Monitoring Program
(Annual Report)

- Program is a comprehensive monitoring tool.
- Designed to be sensitive and able to determine changes in the aquatic environment regardless of the cause.
- Provides DDEC with information so that mitigation measures can be evaluated and implemented if required before any changes become a significant environmental impact (Adaptive Management).
- Program designed to determine nature and magnitude of changes.
- Program guidelines are provided in Class A Water Licence, but the program is much more comprehensive and flexible compared to the SNP. Program has been updated in response to stakeholder input and information identified during the past 17 years.

Special Effects Monitoring Programs and Studies
(Annual Report or more frequent)
e.g., Pigeon Stream Diversion Monitoring Program

- Designed to focus on specific issues or provide additional information not collected as part of the AEMP.
- Designed to meet the needs of other regulatory requirements of the mine (e.g., Fisheries Authorizations).

Environmental Baseline Studies

- Baseline monitoring that is conducted in geographical areas not currently being monitored and where future mining activities may occur.
- Sampling design for aquatics is typically based on AEMP design, as baseline data will form part of future AEMP.

In 2014, the following four studies were undertaken as part of the special effects studies and monitoring programs:

1. Lac de Gras Water Quality Monitoring Station – sampling at sites S5 and S6 in the north arm of Lac de Gras, beyond the current extent of the AEMP, was continued to determine if a new water quality monitoring station is required beyond the current site, S3. Sampling at sites S5 and S6 began in 2013 and the necessity of the addition of one or both stations to the annual AEMP program will be assessed in the 2015 AEMP Re-evaluation.
2. Grizzly Lake Biological Communities – phytoplankton and zooplankton were sampled in August to assess if communities have been altered following observed changes in the under-ice temperature profiles from 2011 to 2013. Results from biological monitoring in 2013 indicated that the taxonomic composition of the zooplankton assemblage may have changed through time; however, the lack of data from 2004 to 2012 made it difficult to determine whether these changes represented a trend through time or natural variability (ERM Rescan 2014b). Thus, an additional year of phytoplankton and zooplankton monitoring was recommended in 2014 (ERM Rescan 2014b)
3. 2014 Pigeon Stream Diversion (PSD) Monitoring Program – the PSD was designed and constructed as compensation for the loss of stream habitat during the development of Pigeon Pit at the Ekati Diamond Mine in accordance with *Fisheries Authorization* #SC99037. Under the agreement a monitoring program was established to assess the effectiveness of the PSD in providing productive fish habitat. The 2014 report describes the results of the first post-construction year of the monitoring program of the PSD. Physical components including stream flow, water temperature, stream habitat, water quality and soil and sediment quality were assessed. Sampled biological components included vegetation monitoring, coarse and fine particulate organic matter (CPOM/FPOM), CPOM retention, organic matter processing (leaf packs), periphyton/epilithon, benthic invertebrates, and the number, biological characteristics and migration patterns of all species and life stages of fish, although fish monitoring efforts focused primarily on Arctic grayling.
4. Hydrocarbon Exposure to Fish – a follow-up study to the results of the 2012 EROD (ethoxyresorufin-O-deethylase) activity analyses which indicated evidence of hydrocarbon exposure in slimy sculpin and round whitefish that may have been related to mine activities.

The results of the two first studies are presented in Part 2 – Data Report. The results of the PSD monitoring are presented in a separate report (ERM 2015). The results from the hydrocarbon exposure to fish study were submitted on December 18, 2014 to the WLWB in a separate report entitled "Characterization of Hydrocarbons found in the Arctic Aquatic Environment near the Ekati Diamond Mine" (DDEC 2014).

Baseline studies are carried out on lakes and streams of the DDEC claim block prior to development in order to define background conditions from which mine effects can be assessed. Baseline studies were carried out by Golder Associates in the Jay Pipe area and those data are presented separately from the AEMP report.

1.2 OVERVIEW OF THE EKATI DIAMOND MINE ACTIVITIES

1.2.1 Koala Watershed

The Koala Watershed contains the majority of the Ekati Diamond Mine infrastructure including the main camp, the process plant, the LLCF, and the airstrip, as well as the Panda, Koala, Koala North, Fox, and Beartooth pits with associated waste rock storage areas (WRSAs). The following major activities took place in the Koala Watershed during the 2014 AEMP period (October 1, 2013 to September 30, 2014):

- Main camp housed an average of 16,050 people per month (535 people per night);
- Construction:
  - Old Camp South Pond Reclamation: Commencing in July 2014, excavation of the Phase 1 Processed Kimberlite South Pond was undertaken to begin reclamation activities. Work in the area began by discharging surface water in the South Pond to Larry Lake after it was tested and confirmed to meet water licence discharge criteria. Pumping activities were stopped when the remaining water began to be contaminated with sediment, and this water was instead trucked to the LLCF for disposal. The existing Old Camp Road was improved to allow safe usage by 777 haul trucks. The approach lights within the center of the pond were deactivated, and a temporary bypass installed around the pond. Reclamation activities involved the removal of both the processed kimberlite and the pond liner system. Crews separated the high-density polyethylene (HDPE) and geosynthetic clay liners (GCL) and disposed of them within the Ekati Diamond Mine landfill. The processed kimberlite was loaded into trucks and disposed in the designated coarse processed kimberlite (CPK) disposal facility. The entire excavated surface was topped with clean esker sand and graded to facilitate surface water management. The only remaining activities are to complete the construction of a runoff channel through the reclaimed area and subsequent water quality monitoring, as well as minor grading and housekeeping of liner debris;
  - Misery Power Supply Phase 1: Commencing in August 2014, the Misery Power Supply project will allow power generated at the main Ekati Diamond Mine power plant to be provided to the Misery Camp. The generating system at the Misery Camp will be shut-down when the new power distribution system is operational and only utilized for emergency back-up purposes. Project activities for Phase 1 include the installation of utility poles along the East side of the Misery Road and related conductor, communication, and protection systems. As of writing, the construction of access push-outs along the Misery Road had begun. Drilling of pole holes and installation of framed utility poles is underway;
  - Construction of Pigeon WRSA: Placement of clean granite material for the Pigeon WRSA and road access development began on May 13, 2014, and movement of the Pigeon till dump from the previously mined Pigeon bulk sample pit started on July 16, 2014. In the period up to September 30, 2014, 1,240,570 tonnes of granite and 227,610 tonnes of till were moved. Construction of an access road around the location of the final pit extent was also completed during this time, with the construction of a water diversion berm still in progress;

  - Panda Diversion Channel (PDC) Phase 3: Commencing in January 2014, the final phase of the Panda Diversion Channel stabilization project was started. This last phase of work involved the benching of the North East portion of the canyon section to provide long-term stability (approximately last remaining quarter of the project). Construction started with the installation of a protective ice pad in the bottom of the PDC. Crews utilized drill and blast techniques to create the final designed bench and then load and haul techniques to remove and dispose of the blasted material. Where required, a rock fillet was installed to prevent future permafrost degradation. A geotextile-lined berm was installed on the crest of the new bench to provide sediment control. Final clean-up activities included scraping of the ice pad surface to remove sediment material, and excavation of a trench to allow freshet water flow. Environmental staff performed regular water quality testing to ensure water licence standards were being met;
  - Grizzly Road Realignment: Commencing in July 2014, a short section of the Grizzly Road was re-aligned, due to the close proximity of the new catch bench installed in the North East section of the PDC. Construction activities included realignment of a short section of road, installation of safety berms, and realignment of the freshwater pipeline; and
  - LLCF Reclamation Vegetation Trial: Commencing in winter 2014, an experimental placement of rock cover was completed in Cell B over the area seeded in fall 2013. Construction activities included the haulage of rock material with various material specifications to the North end of Cell B, and the placement of this material over the seeded area by 730 haul truck and excavator (according to design requirements).

- Mining activities:
  - Fox Pit:
    - Kimberlite ore was transported to the process plant;
    - Waste rock was transported to the Fox WRSA; and
    - Kimberlite coarse ore rejects were placed in the coarse kimberlite rejects area of the Panda/Koala WRSA.
  - Beartooth Pit: No mining of Beartooth Pit occurred.
  - Panda Pit: No mining of Panda Pit occurred.
  - Koala North Pit:
    - Kimberlite ore from underground was transported to the process plant;
    - Waste rock from the underground was transported to the Panda/Koala WRSA; and
    - Kimberlite coarse ore rejects were placed in the coarse rejects area of the Panda/Koala WRSA.
  - Koala Pit:
    - Kimberlite ore from underground was transported to the process plant;
    - Waste rock from the underground was transported to the Panda/Koala WRSA; and
    - Kimberlite coarse ore rejects were placed in the coarse rejects area of the Panda/Koala WRSA.
- Dewatering and discharge:

- Surface sump water and treated effluent from the sewage treatment plant continued to be deposited into the LLCF. Fine processed kimberlite was deposited to both the LLCF and Beartooth pit;
- Fine processed kimberlite and underground minewater were pumped to Beartooth Pit (total volume = 2,147,165 m^3 and 170,886 m^3, respectively);
- Grizzly Lake drawdown for use at main camp continued (volume = 82,311 m^3). Total volume of water drawn from Grizzly Lake (including for use at Main Camp and for PSD and PDC ice pad construction) was 91,135 m^3;
- Water was pumped from Bearclaw Lake to North Panda Lake from August 7 to 14, 2014 (total volume = 132,623 m^3);
- Water was pumped from Beartooth Pit to Cell C of the LLCF from June 25 to September 30, 2014 (ongoing). The total volume pumped from June 25 to September 30, 2014 was 971,312 m^3;
- Water from Cell E of the LLCF was discharged into Leslie Lake from October 1 to November 19, 2013 (ongoing from September 2013; total volume = 1,043,235 m^3) and from July 28 to August 6, 2014 (total volume = 315,849 m^3);
- Water was pumped from the Pigeon Test Pit to Cell B of the LLCF from June 26 to July 12, 2014. The total volume pumped was approximately 115,200 m^3; and
- All water discharged from Cell E to the receiving environment met Effluent Quality Criteria (EQC) defined in Water Licence W2012L2-0001.

1.2.2 The King-Cujo Watershed

The King-Cujo Watershed contains the KPSF, as well as a portion of the Misery Camp and Misery WRSA. The following major activities took place in the King-Cujo Watershed during the 2014 AEMP period (October 1, 2013 to September 30, 2014):

- Misery camp housed an average of 2,991 people per month (99 people per night).
- Construction: No construction took place within the King-Cujo Watershed
- Mining activities:
    - Misery Pit:
        - Kimberlite was stored on Ore Storage Pads at Misery Camp before transport to and processing at the Main Camp Process Plant; and
        - Waste rock was hauled to the Misery WRSA.
- Dewatering and discharge:
    - No water was pumped from the Waste Rock Dam into the KPSF in 2014;
    - No water was pumped from Misery Pit into the KPSF in 2014; and
    - No water was pumped from the KPSF to Cujo Lake in 2014.
    - Water was discharged from Desperation Pond to KPSF between July 4 to 7, 2014 (total volume = 20,763 m^3).

1.2.3 Carrie Pond Watershed

The Carrie Pond Watershed contains a portion of the Misery Pit, the associated WRSA, and Desperation Pond. The following major activities took place in the Carrie Pond Watershed during the 2014 AEMP period (October 1, 2013 to September 30, 2014):

- Mining activities:
- Dewatering and discharge:
  - No water was pumped from Desperation Pond into Carrie Pond in 2014.

1.2.4 Pigeon-Fay and Upper Exeter Watershed

The Pigeon-Fay and Upper Exeter Watershed contains the Pigeon test pit and the PSD. The following major activities took place in the Pigeon-Fay and Upper Exeter Watershed during the 2014 AEMP period (October 1, 2013 to September 30, 2014):

- Construction:
  - Pigeon Stream Diversion (PSD): Commencing in January 2014, the final portion of construction activities was completed at the PSD. Construction activities included the installation of a protective ice road to allow access to the area by construction equipment, and completion of the inlet and outlet sections. Construction crews worked to close-up the inlet to the existing Pigeon Stream, extend and complete the inlet berm to design specifications, and install a fish barrier at the outlet of the existing Pigeon Stream. During freshet of 2014, the PSD was the main route for water flow through the area, as the original Pigeon Stream was hydrologically isolated from upstream water flow via the water diversion berm at the inlet section of the PSD;
  - Pigeon infrastructure: New infrastructure for the Pigeon Pit development included two explosives magazines, a refuge trailer, and a power generating system. In the spring of 2014, two laydown pads were installed at the re-aligned section of the Sable Road to locate the new explosives magazines. The two explosives magazines were installed and commissioned according to the regulatory requirements. A constructed pad was established along Sable Road to allow installation of the refuge station, generators, and an equipment parking area. A lined berm was installed to provide secondary containment for the fuel storage tank (double-walled) and generator enclosure. The fuel storage and generating system was installed and commissioned according to regulatory and manufacturer requirements. The refuge station was installed and provides washroom facilities to workers and a safe refuge during winter storms; and
  - Pigeon ring road and water management berms: Commencing in August 2014, an access ring road was constructed around the perimeter of the planned Pigeon Pit. This ring road also provided access for construction equipment to install the water management berms that will help to prevent surface water from entering the pit. Construction activities for the water management berms include the excavation of a key trench and placement of till in designated lifts to a higher elevation than the existing height of ground. These water management berms will deflect water around the pit when

completed. In 2014, it is planned to complete installation of the North water management berms and in 2015 to complete installation of the South water management berms.

- Mining activities:
  - No mining activities took place in 2014.

The year 2014 was the 17th consecutive year of post-baseline monitoring within the Koala Watershed and Lac de Gras, the 14th consecutive year of post-baseline monitoring within the King-Cujo Watershed and Lac du Sauvage, the 2^{nd} year of monitoring in the Carrie Pond Watershed, and the 1st year of post-baseline monitoring within the Pigeon-Fay and Upper Exeter Watershed.

1.3 CHANGES TO EVALUATION OF EFFECTS FOLLOWING THE 2012 RE-EVALUATION

Seven changes were made to the Evaluation of Effects beginning in 2013, following the 2012 AEMP Re-evaluation:

1. The list of evaluated water quality variables was altered to include total barium, total boron, total cadmium, and total vanadium. Meanwhile, total dissolved solids, ortho-phosphate-P, total aluminum, total iron, and total zinc were removed from the list of evaluated variables in both the Koala and King-Cujo watersheds. In the Koala watershed, total organic carbon (TOC) was added and total copper was removed from the list of evaluated variables.
2. Given that there is now five years of data available, water quality data collected from Leslie-Moose Stream were analyzed in accordance with the analytical approach employed for other water quality stations in the annual AEMP Evaluation of Effects beginning in 2012. However, the relatively small number of data points available for Leslie-Moose Stream decreases the probability of detecting statistically significant changes in evaluated variables. Thus, graphical analysis was the primary means through which change in evaluated variables and potential mine effects were assessed in Leslie-Moose Stream in 2014.
3. To better distinguish natural variation from potential mine effects in cases where temporal trends in reference lakes did not share a common slope and the trend in the monitored lake differs from a slope of zero, the slope of monitored lakes was compared to the slope of each reference lake in order. Lack of statistical differences between the slope observed in a given monitored lake and at least two reference lakes would indicate natural variability as the underlying cause of temporal trends in the monitored lake. Significant differences between the trend observed in a monitored lake and two or more reference lakes would indicate a potential mine effect. Graphical analysis and best professional judgment were used to assess the likelihood that a given trend resulted from mining operations.
4. The Akaike Information Criterion (AIC) was used to directly compare the 'fit' or error associated with each reference model. This information was used in combination with reference model testing to ensure the most robust reference model was selected for use in hypothesis testing.

5. In the event that both transformed and untransformed data satisfied parametric assumptions, the AIC was used to determine which transformation provides the best fit. This information was used to inform professional judgment with respect to model selection in order to ensure that the best possible model was used in statistical analyses.
6. The coefficient of determination was examined in cases where there was reason to suspect poor model fit for a given variable and waterbody based on graphical analysis. Low R-squared values indicated that model fit was weak ($r^2 < 0.5$) or poor ($r^2 < 0.2$) and that results of statistical analyses should be interpreted with caution
7. To provide a more streamlined and explicit discussion on linkages between physical variables and biotic effects as well as trophic effects, the phytoplankton, zooplankton, and benthos sections were merged into a single "biology" section for each watershed (Sections 3.3, 4.3 and 5.3 in Part 1 – Evaluation of Effects).

In 2014, the final portion of construction activities were completed at the PSD and it was connected to the natural Pigeon Stream. During freshet of 2014, the PSD was the main route for water flow through the Pigeon Pit area. Thus, the Pigeon AEMP was implemented in the winter of 2014. The Pigeon AEMP involved the monitoring of two lake sites and two stream sites in the Pigeon-Fay and Upper Exeter Watershed. Details on sampling locations and the sampling program undertaken in the Pigeon-Fay and Upper Exeter Watershed are provided in Sections 2.1 and 2.2.

2. METHODOLOGY

2.1 2014 SAMPLING LOCATIONS

The 2014 AEMP lake and stream sampling sites are provided in Tables 2.1-1 and 2.1-2 and shown in Figure 2.1-1. A surface water flow diagram through the AEMP sampling area is provided in Figure 2.1-2. Bathymetric maps depicting the aquatic sampling locations within each lake are provided in Figures 2.1-3 through 2.1-16 of Part 2 - Data Report.

Table 2.1-1. AEMP Lake Sampling Locations for 2013 to 2015 Period

Location	Physical Limnology, Water Quality and Plankton			Sediment Quality and Benthos		
	NAD83 UTM Zone 12N		Approximate Water Column Depth (m)	NAD83 UTM Zone 12N		Approximate Water Column Depth (m)
	Easting (m)	Northing (m)		Easting (m)	Northing (m)	
Reference						
Nanuq	534200	7199287	28	534667	7199080	5-10
Counts	533825	7169850	15	533681	7169826	5-10
Vulture	521183	7180882	37	522157	7182148	5-10
Koala Watershed						
Grizzly	521303	7177743	40	-	-	-
Kodiak	518273	7175550	11	518297	7175647	5-10
Leslie	515938	7173285	13	515827	7173190	5-10
Moose	516630	7172852	10	516630	7172852	10
Nema	513575	7171132	9	513575	7171132	9
Slipper	507098	7165297	16	507194	7165436	5-10
S2	507638	7164468	7	507638	7164468	7
S3	505912	7164439	14	-	-	-
S5	503125	7161482	18	-	-	-
S6	501976	7159857	24	-	-	-
King-Cujo Watershed						
Cujo	538721	7162007	8	538721	7162007	8
LdS2	541240	7164235	2	-	-	-
LdS1	541616	7164530	8	541616	7164530	8
Pigeon Watershed						
Fay Bay	515055	7181172	7	515055	7181172	7
Upper Exeter Lake	513066	7180902	13	513066	7180902	13

Note: not all components sampled at each lake site, see Table 2.1-1 in Part 1 – Evaluation of Effects for site specific sampling details.

Table 2.1-2. AEMP Stream Sampling Locations for 2013 to 2015 Period

Location	NAD83 UTM Zone 12N	
	Easting (m)	Northing (m)
Reference		
Nanuq Outflow	532197	7199430
Counts Outflow	535488	7169709
Vulture-Polar	521503	7179655
Pigeon Reach 7	517174	7182352
Koala Watershed		
Lower PDC	518587	7175997
Kodiak-Little	517943	7174808
1616-30[1] (LLCF)	514021	7173081
Leslie-Moose	516481	7172868
Moose-Nero	517460	7172818
Nema-Martine	513921	7170646
Slipper-Lac de Gras	507643	7164878
King-Cujo Watershed		
1616-43[2] (KPSF)	538785	7161359
Cujo Outflow	538942	7162432
Christine-Lac du Sauvage	540025	7163840
Carrie Pond Watershed		
Mossing Outflow	536951	7160761
Pigeon Watershed		
Pigeon Reach 1	515381	7181324

Note: not all components sampled at each stream site, see Table 2.1-1 in Part 1 – Evaluation of Effects for site specific sampling details.
[1]1616-30 is the SNP station for discharge from the LLCF (samples are collected within Cell E).
[2]1616-43 is the SNP station for discharge from the KPSF (samples are collected within the facility)

Most of the AEMP sampling locations within the Koala Watershed are located downstream of mine discharge (Figure 2.1-1). Exceptions include Vulture Lake and Vulture-Polar Stream, which are internal reference sites located upstream of mine discharge in the Koala Watershed. Grizzly Lake, Kodiak Lake, Kodiak-Little Stream, and the Lower PDC are also located upstream of the LLCF, but are in close proximity to the mine which leaves them susceptible to effects from mine activities. Potential effects at these sites stem from fugitive dust deposition (i.e., from roads, the airstrip, and blasting), road runoff, and potential spills. In addition, Kodiak Lake and Kodiak-Little Stream are susceptible to effects associated with the weathering of the PDC, an artificial channel constructed to allow fish passage from North Panda to Kodiak Lake. Kodiak Lake and Kodiak-Little Stream are also susceptible to surface runoff from the vicinity of the ammonium nitrate building (situated near the western shore of Kodiak Lake). Downstream of the LLCF, all lakes and streams are susceptible to the quantity and quality of water discharged from the LLCF as far as Lac de Gras, which receives water from the Koala Watershed at its northern end. In addition, Nema Lake and Nema-Martine Stream are located near the active Fox Pit and are susceptible to fugitive dust and seepage from Fox Pit and its associated WRSAs.

Figure 2.1-1
AEMP Lake and Stream Sampling Locations, 2014

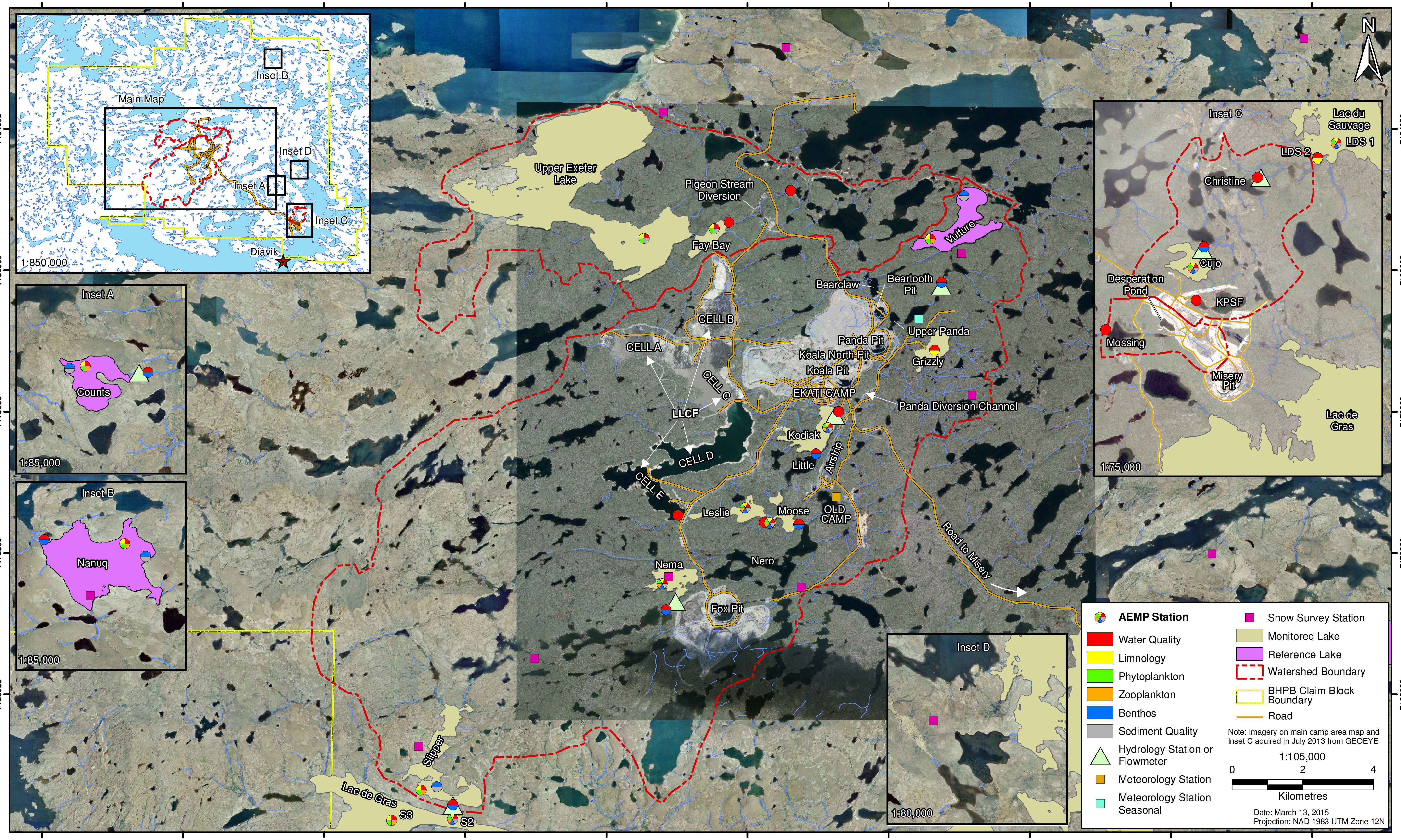
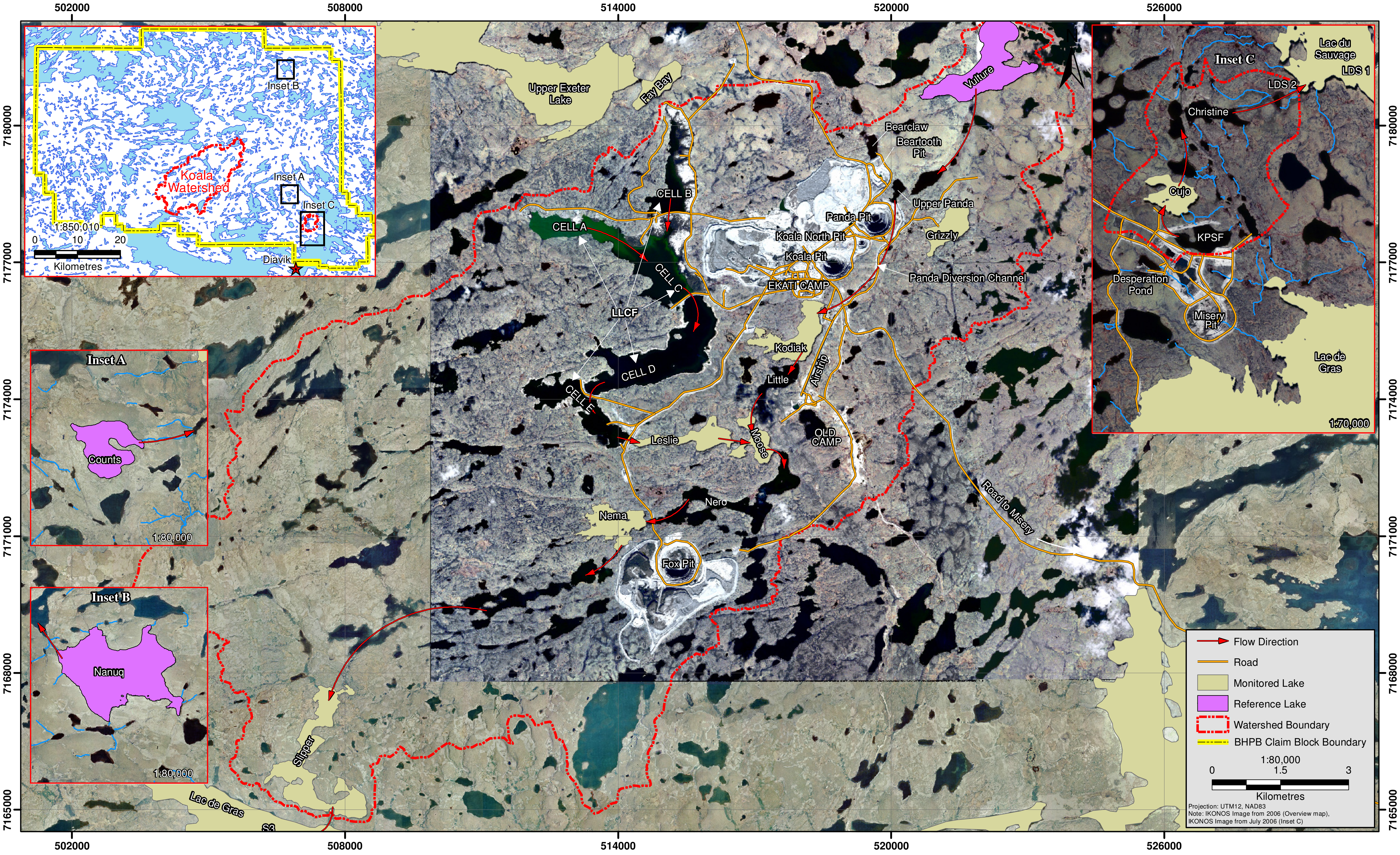


Figure 2.1-2
Surface Water Flow Through the AEMP Sampling Area



All AEMP sampling stations in the King-Cujo Watershed are located downstream of the KPSF (Figure 2.1-1). This includes Lac du Sauvage, which receives water from the King-Cujo Watershed along its western shore. The AEMP lakes and streams are therefore susceptible to changes in the quantity and quality of water discharged from the KPSF.

The Carrie Pond Watershed includes one AEMP sampling station (i.e., Mossing Outflow). The main influence to Mossing Outflow is Desperation Pond, which is located upstream (Figure 2.1-1).

All but one of the AEMP sampling stations in the Pigeon-Fay and Upper Exeter Watershed are located downstream of the PSD. The one exception is Pigeon Reach 7, which is an internal reference site located upstream of the PSD. The Pigeon-Fay and Upper Exeter Watershed does not receive any discharge from Pigeon Pit, as all minewater and drainage from the WRSA is directed into the LLCF. Thus, potential effects at these sites stem from the construction and operation of the PSD and from fugitive dust deposition from Pigeon Pit activities.

The external reference lakes and streams (Nanuq and Counts lakes and their respective outflows) are located well away from any mine activities (Figure 2.1-1). Nanuq Lake is located in the northeast corner of the Ekati Diamond Mine's claim block, approximately 26 km from the nearest possible mine influence. Counts Lake is located southeast of the Ekati Diamond Mine Main Camp, approximately halfway between the camp and Misery Pit. The most proximate source of potential mine effects on Counts Lake is Misery Road, which is approximately 5 km from Counts Lake at its closest point.

2.2 2014 Sampling Program

Table 2.2-1 summarizes sampling components, frequency, and replication completed during the ice-covered and open water seasons as part of the 2014 AEMP sampling program.

2.3 Variables Evaluated in 2014

The variables evaluated in the 2014 AEMP included the list of variables of interest identified in the AEMP plan for 2013 to 2015 (Table 2.3-1; Rescan 2013d).

2.4 Evaluation Framework

Evaluation of the AEMP results relies on a hierarchy of steps (Figure 2.4-1). First, data was collected based on the AEMP plan for 2013 to 2015 (Rescan 2013d). The methods and results of the 2014 AEMP sampling program are reported in Part 2 – Data Report of the 2014 AEMP report.

Observed data were evaluated for quality. Any large dataset is likely to contain some outliers or questionable records caused by instrument failure, transcription errors, laboratory errors, etc. Thus, questionable data were identified and excluded prior to the evaluation of effects. However, all of the data collected as part of the sampling program, including data that were excluded from subsequent analyses, are presented in Part 2 – Data Report of the 2014 AEMP report.

Table 2.2-1. Summary of the 2014 AEMP Sampling Program

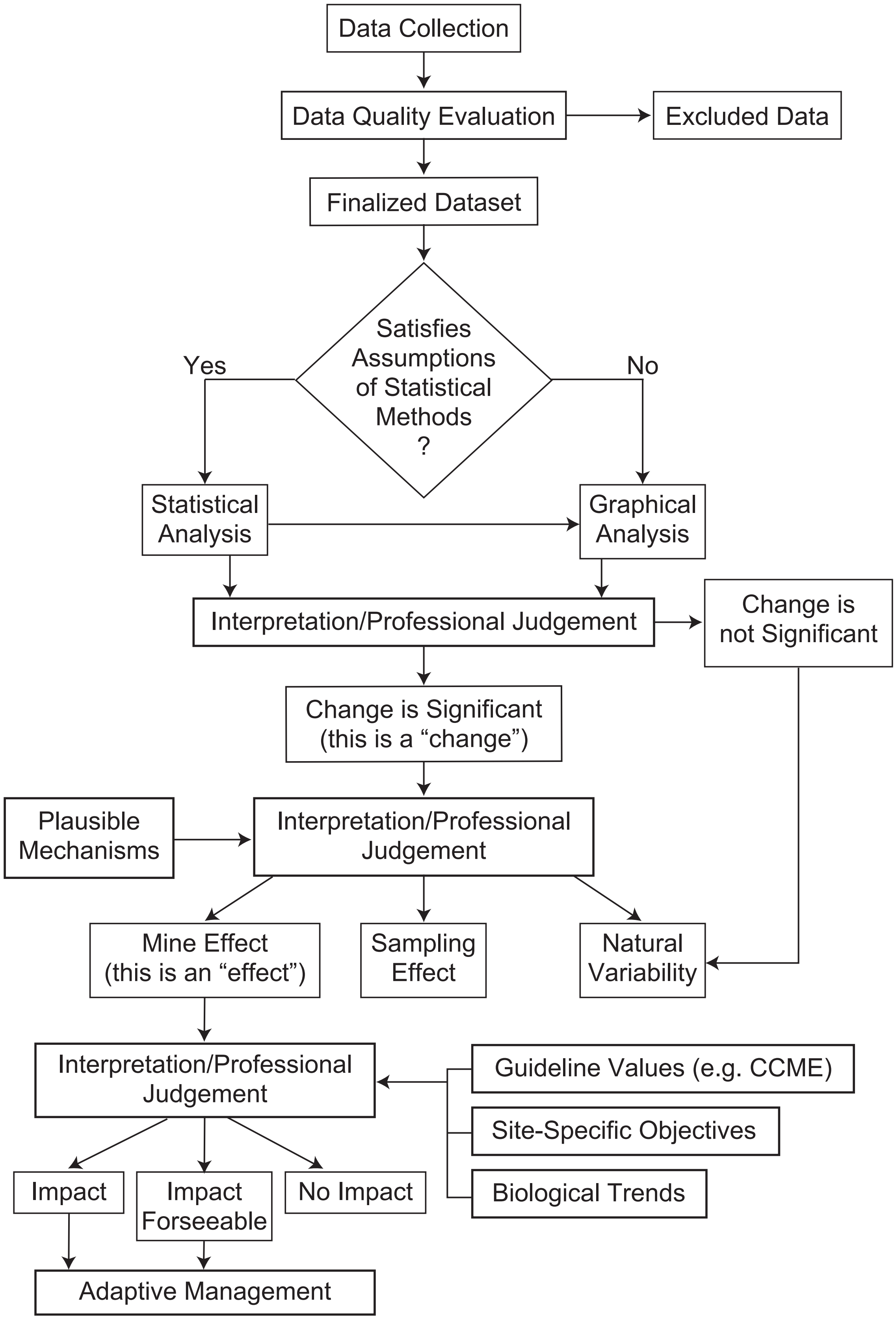
Monitoring	Seasonal Frequency	Replication and Depths at each Lake/ Stream per Sampling Event
Lakes		
Water quality	April	n=2 @ mid water column depth n=2 @ 2 m from the bottom
	early August	n=2 @ 1 m below surface n=2 @ mid water column depth n=2 @ 2m from the bottom (Leslie Lake only)
	July and September	Pigeon-Fay and Upper Exeter Watershed Only n=2 @ 1 m below surface n=2 @ mid water column depth
Physical Limnology	April[1]	n=1 profile over deepest part of lake, or at lake station
	early August	n=1 profile over deepest part of lake, or at lake station, Secchi depth
	July and September	Pigeon-Fay and Upper Exeter Watershed Only n=1 profile over deepest part of lake, or at lake station
Phytoplankton	early August	n=3 @ 1 m
Zooplankton[2]	early August	n=3 vertical hauls from 1 m above bottom to surface, with flowmeter
Benthos[2]	early August	n=3 @ 5–10 m depth (mid)
Sediment quality	early August	n=3 @ 5-10 m depth (mid) Ekman grabs and cores
Streams		
Water quality	June (freshet), early July, early/mid-August, September (fall high flows)	n=2
	Biweekly during open water season	Pigeon Reach 1 Only n=2
Benthos	early August to early September	n=5
Automated station installation	installation prior to freshet, maintenance as necessary	n=1
Hydrology manual flow measurements[3]	late-May to late August	bi-weekly, 2 to 3 times during freshet
Hydrometric levelling surveys	early May to late August	at time of installation, then bi-weekly to monthly
Hydraulic Geometry Survey	August	during low flow

n = number of samples or measurements
Note: not all components sampled at site, see Table 2.1-1 in Part 1 – Evaluation of Effects for site specific sampling details.
[1] *DO and temperature profiles were collected several times throughout the ice-covered season in Cujo Lake and Kodiak Lake.*
[2] *Reference lakes and lakes of the Koala and King-Cujo watersheds only.*
[3] *Reference streams and streams of the Koala and King-Cujo watersheds only.*

Table 2.3-1. Aquatic Variables Evaluated in 2014

Physical Limnology - Lakes	Water Quality – Lakes and Streams	Sediment Quality – Lakes	Aquatic Ecology
• Under-ice dissolved oxygen • Secchi depth • Open water dissolved oxygen[1] • Hydrology[1,2]	Physical/Ions • pH • Total alkalinity • Water hardness • Chloride • Potassium • Sulphate • Total suspended solids[3] Nutrients • Total ammonia-N • Nitrite-N • Nitrate-N • Total phosphate-P • Total organic carbon Metals • Total antimony • Total arsenic • Total barium • Total boron • Total cadmium • Total copper[4] • Total molybdenum • Total nickel • Total selenium • Total strontium • Total uranium • Total vanadium	Nutrients • Available Phosphorus • Total Nitrogen • Total Organic Carbon Metals • Antimony • Arsenic • Copper[4] • Cadmium • Molybdenum • Nickel • Phosphorus • Selenium • Strontium	Phytoplankton • Chlorophyll *a* concentrations • Phytoplankton density • Phytoplankton diversity • Relative densities of major phytoplankton taxa Zooplankton[5] • Zooplankton biomass • Zooplankton density • Zooplankton diversity • Relative densities of major zooplankton taxa Lake Benthos[5] • Lake benthos density • Lake benthos dipteran diversity • Relative densities of major dipteran taxa Stream Benthos[5] • Stream benthos density • Stream benthos dipteran diversity • Relative densities of major dipteran taxa • Stream benthos EPT diversity • Relative densities of EPT taxa

[1] *Open water season DO and 2014 hydrology results are only reported in Part 2 - Data Report and discussed where relevant in this report.*
[2] *Historical values of key hydrological variables are presented in Section 6 of Part 1 – Evaluation of Effects.*
[3] *Pigeon-Fay and Upper Exeter Watershed only.*
[4] *King-Cujo Watershed only.*
[5] *Koala and King-Cujo watersheds only.*


Data Collection
Data Quality Evaluation
Excluded Data
Finalized Dataset
Satisfies Assumptions of Statistical Methods ?
Yes
No
Statistical Analysis
Graphical Analysis
Interpretation/Professional Judgement
Change is not Significant
Change is Significant (this is a "change")
Plausible Mechanisms
Interpretation/Professional Judgement
Mine Effect (this is an "effect")
Sampling Effect
Natural Variability
Interpretation/Professional Judgement
Guideline Values (e.g. CCME)
Site-Specific Objectives
Biological Trends
Impact
Impact Forseeable
No Impact
Adaptive Management

The finalized dataset was graphically and statistically analysed to detect possible mine effects. For sites in the Koala Watershed and Lac de Gras, and sites in the King-Cujo Watershed and Lac du Sauvage, regression modelling was used to detect any changes that might be occurring in lakes and streams through time and also to determine whether temporal patterns differed between monitored and reference sites. Different regression models were applied to different variables depending on the number of years of data that were available and, in the case of water quality, the proportion of data that were greater than the analytical detection limit (see Section 2.2.4 of Part 1 – Evaluation of Effects). The Mossing Outflow site in the Carrie Pond Watershed was not evaluated for effects in 2014 as only two years of data were available for that location. The inclusion of Mossing Outflow in the Evaluation of Effects will be assessed as part of the 2015 AEMP Re-evaluation. For sites in the Pigeon-Fay and Upper Exeter Watershed, Before-After/Control-Impact (BACI) analysis was used to detect changes in the aquatic environment as a result of Pigeon development activities. The BACI analysis compared before-after trends apparent at monitored sites with that of a corresponding reference site to determine if the trends were parallel and thus attributable to a natural process. If statistical analyses were not possible because assumptions or data requirements were not satisfied, variables were subjected to graphical analysis (see Section 2.2.6 of Part 1 – Evaluation of Effects). In such cases, data were examined for historical trends and spatial gradients.

The results of statistical and graphical analyses were then interpreted using best professional judgment (see Section 2.2.7 of Part 1 - Evaluation of Effects). Graphical analysis was used to confirm and/or interpret conclusions reached by the statistical analysis. The result was an assessment of whether change had occurred and whether the change was ‘significant’, as defined by the statistical and/or graphical analyses.

Changes deemed significant were assessed to determine whether they were likely to be the result of mine activities, sampling activities, or natural variation. The identification of a change as a mine effect required the existence of plausible mechanisms that could link mine activities and change. For example, a mine effect on pH required that there be a clear spatial gradient in pH in the lakes and streams downstream of the LLCF. If reduced pH was found in one lake without corresponding changes in upstream lakes, the change was attributed to natural variation.

If a mine effect was detected, the extent to which the effect was having an impact on the environment was evaluated. Benchmark values, including applicable Canadian Council of Ministers of the Environment (CCME) guideline values for the protection of aquatic life and relevant site specific water quality objectives (SSWQOs), or other benchmarks, and biological trends were important in the determination of mine impacts (see Sections 2.3 and 2.4 of Part 1 - Evaluation of Effects). For example, if a biological effect (such as an increase in phytoplankton density) was associated with increasing concentrations of a water quality variable downstream of the LLCF for which a benchmark value was exceeded, the effects would likely be deemed an environmental impact. Impacts or foreseeable impacts would then lead to appropriate adaptive management measures.

3. GENERAL CLIMATIC AND HYDROLOGICAL CONDITIONS IN 2014

3.1 CLIMATIC CONDITIONS

The meteorological monitoring program at the Ekati Diamond Mine in 2014 included the operation of the Koala automated meteorological station, and the micrometeorological station on Polar Lake. During the winter of 2013/2014, DDEC Environment personnel monitored a Nipher snow gauge at the Koala meteorological station to generate monthly totals for snow-water-equivalent (SWE) precipitation. In addition, snow surveys were completed between April 5 and April 10, 2014 at twelve locations within the DDEC claim block (Figure 2.1-1). See Part 2 - Data Report (Sections 2.2 and 3.1) for a detailed account of meteorological monitoring as part of the 2014 AEMP.

The 12-month (October 2013 to September 2014) mean air temperature was -9.7ºC at the Koala station. In the Mackenzie District region (which includes the Ekati Diamond Mine), mean temperatures during each season ranged from 0.2ºC to 1.6ºC above normal (Table 3.1-4 in Part 2 – Data Report). Although the 2013/2014 winter was only 0.2ºC above normal, the last time the Mackenzie District region had a cooler than normal winter was 1993/1994 (Environment Canada 2014). The summer of 2014 was the 7th warmest summer of the past 67 years on record, with a departure of 1.6ºC above the normal.

Observations from the Koala Nipher snow gauge between October 2013 and May 2014 produced SWE estimates of 178 mm (uncorrected for wind effects), or 201 mm (corrected for wind effects; Table 3.1-5 in Part 2 – Data Report). The snow survey yielded a mean SWE value of 67 mm (Table 3.1-6 in Part 2 – Data Report). This indicates that while 178 to 201 mm of snow may have fallen, a substantial portion of the snow pack was lost to sublimation, evaporation, and wind redistribution. The snow survey value of 67 mm represents the volume available for snow melt runoff during the freshet.

From the available October 2013 to September 2014 rainfall data, a total of 98 mm of rain was recorded at the Koala station (Table 3.1-7 in Part 2 – Data Report). Combining winter SWE and summer rainfall, the total precipitation was 275 mm (uncorrected for wind effects), or 299 mm (corrected for wind effects) during the 2014 water year (Tables 3.1-8 and 3.1-9 in Part 2 – Data Report), which is less than the expected mean of 345 mm for the Ekati Diamond Mine site (Rescan 2000). Rainfall between June and August accounted for 65% of the total annual rainfall. Rainfall made up 49% of the total precipitation (corrected for wind effects) over the entire year. The Mackenzie District region was drier than normal in all seasons in 2014, with precipitation amounts ranging from 34% to 5% lower than normal (Table 3.1-4 in Part 2 – Data Report). Winter 2013/2014 was the second driest winter in 67 years (34% lower than normal), and fall 2014 was the ninth driest (14% lower than normal).

Wind speed and direction data collected from the Koala station indicate that the prevailing wind direction during the winter period (October 2013 to May 2014) was from the northwest with a secondary component from the east (Figure 3.1-1 in Part 2 – Data Report). During the summer period

(June to September), the wind directions primarily came from the northeast, and were more omnidirectional than in the winter (Figure 3.1-1 in Part 2 – Data Report). Mean wind speeds were about 5 m/s in all seasons. Calm conditions (hourly mean wind speeds of < 0.5 m/s) represented 2.5% of winter observations, and 0.4% of summer observations.

Open water evaporation at the Polar Lake station was calculated to be 313 mm for the ice-free period (assumed to be from May 26 to October 2) with the exclusion of May as a result of missing evaporation data (Polar Lake station was not installed and PET method could not be used accurately; Table 3.1-11 in Part 2 – Data Report).

3.2 Hydrological Conditions

Streamflow monitoring was undertaken in 2014 at four streams within the Koala Watershed (Vulture-Polar, Lower PDC, Nema-Martine, and Slipper-Lac de Gras), and two streams within the King-Cujo Watershed (Cujo Outflow and Christine-Lac du Sauvage), along with one reference watershed (Counts Outflow; Table 3.2-1 in Part 2 – Data Report). Automated hydrometric monitoring stations were installed from late May to early June, and operated until late September, when stations were demobilized for winter. See Part 2 - Data Report (Sections 2.3 and 3.2) for a detailed account of hydrological monitoring as part of the 2014 AEMP.

The 2014 hydrologic year began in mid-October 2013 and ended in mid-October 2014. Following winter, daily average air temperature first rose above zero for one day on April 30, 2014. Temperatures dropped again, ranging from -17 to 5°C, before consistently maintaining an average daily temperature above zero. Long days in late May/early June provide large amounts of solar energy to generate snow melt runoff, and the frozen ground inhibited infiltration. The majority of snowmelt and runoff occurred in the first week of June. As a result, discharge rose very quickly at the start of the freshet season. Streamflow began first at Counts Outflow, followed by the Lower PDC. Peak flow was estimated to have occurred between May 29 and June 1 following the rapid freshet rising limb of the hydrograph (see Figures 3.2-1 to 3.2-7 in Part 2 – Data Report). Between 48% and 88% of total annual runoff occurred in May and June (Figure 3.2-8 in Part 2 – Data Report; see also Table 8-2 in Part 1 – Evaluation of Effects). Winter freeze up is expected to have occurred at all of monitored streams by October 10 based on a review of available air temperature records.

During the hydrologic year, 263 mm of precipitation fell in the Ekati Diamond Mine area (Table 3.1-7 in Part 2 – Data Report), which is below the normal value of 345 mm. Two large rain events occurred in the summer of 2014: one on May 2 (57 mm) and another on July 16 (29 mm). Total runoff in 2014 varied from 28 mm at Cujo Outflow to 100 mm at Counts Outflow (Table 3.2-17 in Part 2 – Data Report). Maximum daily discharges varied from 0.06 m^3/s at Cujo Outflow to 7.14 m^3/s at Slipper-Lac de Gras Stream (Table 3.2-16 in Part 2 – Data Report). The majority of annual runoff occurred during freshet (Figures 3.2-1 to 3.2-7 in Part 2 – Data Report), with the exception of Counts Outflow and Slipper-Lac de Gras Stream, which had a secondary peak occur around July 17, following a large rain event. Pumping of approximately 133,000 m^3 of water from Bearclaw Lake to North Panda Lake between August 7 and 14 is also evident in the Lower PDC hydrograph (Figure 3.2-2 in Part 2 – Data Report).

4. SUMMARY OF EVALUATION OF EFFECTS FOR THE KOALA WATERSHED AND LAC DE GRAS

Figure 4-1 summarizes the evaluation of effects for the Koala Watershed and Lac de Gras. Because statistical tests were two-sided and only tested for differences between reference and monitored lakes or streams, conclusions on the direction of change were made from graphical analysis. Figures 4-2 to 4-43 provide support for the summary of effects for the Koala Watershed and Lac de Gras presented below. For a discussion of graphical and regression analysis that were used to assist in interpreting statistical results for each of the variables see Part 1 – Evaluation of Effects.

Under-ice temperature profiles suggest that there has been a trend towards cooling in all lakes downstream of the LLCF as far as Nema Lake (Figure 4.2a to 4.3h). Although the cause of this shift is unclear, there is also some evidence of a general cooling trend, at all depths, in two of the reference lakes (i.e., Nanuq and Vulture lakes; Figures 4.2a and 4.3c) in recent years, suggesting that shifts in temperature profiles in monitored lakes may reflect natural climatic variability rather than mine effects. In Grizzly Lake, the shape of the temperature profile has changed in recent years. Specifically, from 2011 to 2013, under-ice temperature profiles in Grizzly Lake showed some degree of thermal stratification, with cooler surface temperatures and increasing temperatures with increasing depth (Figure 4.3a). Although surface temperatures in Grizzly Lake were warmer in 2014, the pattern of increasing temperature with increasing depth was still present. The cause of the change in Grizzly Lake is unclear. In contrast, a warming trend was detected in Kodiak Lake, along with corresponding changes in dissolved oxygen (DO) profiles (Figure 4.3b). The observed changes in Kodiak Lake likely stem from DDEC's efforts to improve DO concentrations in Kodiak Lake, which have included the use of aerators beginning in 1997. The changes in the under-ice temperature and DO profiles in Kodiak Lake correspond to the first year in which aerators were no longer used (2007). The more recent DO profiles likely represent undisturbed conditions in Kodiak Lake: aerators would cause mixing of the water column which would result in homogeneity of temperature throughout the water column and greater availability of oxygen in the upper portions of the water column.

Open water season temperature and DO profiles are not evaluated as part of the AEMP; however, recent trends of decreasing temperature and increasing DO with increasing depth are becoming apparent in some lakes downstream of the LLCF (i.e., Leslie, Moose and Slipper lakes) and in Kodiak Lake (data not shown). In contrast, Secchi depths were similar to those observed in previous years in all monitored lakes.

Figure 4-1

Summary of Mine-related Changes in the Variables Evaluated for the Koala Watershed and Lac de Gras, 2014

ERM

Water Quality

(LLCF → Downstream: Leslie, Leslie-Moose, Moose, Moose-Nero, Nema, Nema-Martine, Slipper, Slipper-Lac de Gras, Lac de Gras S2, Lac de Gras S3)

	Grizzly	Lower PDC	Kodiak	Kodiak-Little	Leslie	Leslie-Moose	Moose	Moose-Nero	Nema	Nema-Martine	Slipper	Slipper-Lac de Gras	Lac de Gras S2	Lac de Gras S3
Under-ice Temperature	—	●	◆	●	—	●	—	●	—	●	—	●	—	—
Under-ice Dissolved Oxygen	—	●	◆	●	—	●	—	●	—	●	—	●	—	—
Secchi Depth	—	●	—	●	—	●	—	●	—	●	—	●	—	—
pH	▲26-50% ≠	—	—	—	▲0-25%	▲0-25%	▲0-25%	▲0-25%	▲0-25%	▲0-25%	▲0-25%	▲0-25%	▲0-25%	▲0-25%
Total Alkalinity	—	—	—	—	▲76-100%	▲26-50%	▲76-100%	▲51-75%	▲76-100%	▲76-100%	▲76-100%	▲51-75%	▲51-75%	—
Water Hardness	—	—	—	—	▲51-75%	—	▲76-100%	▲51-75%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲51-75%	▲51-75%
Chloride	—	—	—	—	▲76-100%	▲0-25%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲76-100%
Sulphate	—	—	▲51-75%	—	▲76-100%	▲26-50%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲76-100%
Potassium	—	—	—	—	▲76-100% **	▲26-50%	▲76-100% **	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲51-75%	▲51-75%
Total Ammonia-N	—	—	—	—	▲76-100%	—	▲51-75%	—	▲76-100%	—	▲26-50%	—	—	—
Nitrite-N	—	—	—	—	▲76-100%	▲0-25%	▲76-100%	^	—	—	—	—	—	—
Nitrate-N	—	—	—	—	▲76-100%	—	▲51-75%	^	▲76-100%	▲76-100%	▲51-75%	—	—	—
Total Phosphate-P	—	—	—	—	▲51-75% *	▲0-25%	▲76-100% **	—	*	—	*	—	—	—
Total Organic Carbon	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Total Antimony	—	—	—	—	▲51-75%	▲0-25%	▲51-75%	▲26-50%	▲51-75%	▲51-75%	—	—	—	—
Total Arsenic	—	—	—	—	▲51-75%	▲26-50%	▲51-75%	▲76-100%	▲26-50%	—	—	—	—	—
Total Barium	—	—	—	—	▲51-75%	—	▲51-75%	▲51-75%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	—	—
Total Boron	—	—	—	—	▲76-100%	▲51-75%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	—	—
Total Cadmium	—	—	—	—	—	—	—	€	—	—	—	—	—	—
Total Molybdenum	—	—	—	—	▲76-100%	▲0-25%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲76-100%
Total Nickel	—	—	▲0-25%	▲0-25%	▲76-100%	▲0-25%	▲76-100%	▲51-75%	▲51-75%	▲51-75%	▲51-75%	▲0-25%	—	—
Total Selenium	—	—	—	—	▲76-100%	▲51-75%	▲76-100%	—	—	—	—	—	—	—
Total Strontium	—	—	—	—	▲76-100%	▲0-25%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲76-100%	▲76-100%
Total Uranium	—	—	—	—	▲76-100%	▲0-25%	▲76-100%	▲51-75%	▲76-100%	▲51-75%	▲76-100%	—	—	—
Total Vanadium	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Sediment Quality

	Grizzly	Lower PDC	Kodiak	Kodiak-Little	Leslie	Leslie-Moose	Moose	Moose-Nero	Nema	Nema-Martine	Slipper	Slipper-Lac de Gras	Lac de Gras S2	Lac de Gras S3
Total Organic Carbon	●	●	—	●	—	●	—	●	—	●	—	●	—	●
Available Phosphorus	●	●	—	●	—	●	—	●	—	●	—	●	—	●
Total Nitrogen	●	●	—	●	—	●	—	●	—	●	—	●	—	●
Total Antimony	●	●	—	●	£	●	£	●	£	●	£	●	—	●
Total Arsenic	●	●	***	●	***	●	***	●	**	●	***	●	***	●
Total Cadmium	●	●	—	●	—	●	—	●	—	●	*	●	*	●
Total Molybdenum	●	●	—	●	▲0-25%	●	▲76-100%	●	▲76-100%	●	▲76-100%	●	—	●
Total Nickel	●	●	—	●	—	●	—	●	—	●	—	●	—	●
Total Phosphorus	●	●	—	●	—	●		●	—	●	—	●	—	●
Total Selenium	●	●	—	●	—	●	—	●	—	●	—	●	—	●
Total Strontium	●	●	▲26-50%	●	▲26-50%	●	▲26-50%	●	▲26-50%	●	▲26-50%	●	▲51-75%	●

Biology

	Grizzly	Lower PDC	Kodiak	Kodiak-Little	Leslie	Leslie-Moose	Moose	Moose-Nero	Nema	Nema-Martine	Slipper	Slipper-Lac de Gras	Lac de Gras S2	Lac de Gras S3
Phytoplankton														
Chlorophyll *a* Concentration	—	●	—	●	—	●	—	●	—	●	—	●	—	—
Phytoplankton Density	—	●	—	●	—	●	—	●	—	●	—	●	—	—
Phytoplankton Diversity	—	●	◆	●	◆	●	—	●	—	●	—	●	—	—
Relative Densities of Major Phytoplankton Taxa	—	●	◆	●	◆	●	◆	●	◆	●	◆	●	◆	—
Zooplankton														
Zooplankton Biomass	—	●	—	●	—	●	—	●	—	●	—	●	—	—
Zooplankton Density	—	●	—	●	—	●	—	●	—	●	—	●	—	—
Zooplankton Diversity	—	●	—	●	◆	●	◆	●	◆	●	—	●	—	—
Relative Densities of Major Zooplankton Taxa	◆	●	—	●	◆	●	◆	●	◆	●	—	●	—	—
Benthos														
Lake Benthos Density	●	●	—	●	—	●	—	●	—	●	—	●	—	●
Lake Benthos Dipteran Diversity	●	●	—	●	—	●	—	●	—	●	—	●	—	●
Lake Benthos Dipteran Relative Density	●	●	—	●	◆	●	◆	●	◆	●	—	●	◆	●
Stream Benthos Density	●	●	●	◆	●	●	●	—	●	—	●	—	●	●
Stream Benthos Dipteran Diversity	●	●	●	—	●	●	●	—	●	—	●	—	●	●
Stream Benthos Dipteran Relative Density	●	●	●	—	●	●	●	—	●	—	●	—	●	●
Stream Benthos EPT Diversity	●	●	●	—	●	●	●	—	●	—	●	—	●	●
Stream Benthos EPT Relative Density	●	●	●	—	●	●	●	—	●	—	●	—	●	●

Notes:

The direction and degree of change was inferred from historical data. For water quality data, differences were assessed relative to data from 2000 (August lakes and streams), 2002 (April lakes), or the first year in which data was collected (i.e., TOC = 2005; chloride in streams = 2001). The season in which the greatest change occurred (i.e. April or August) is represented in the table. If opposing trends were observed between seasons, the increasing trend was selected. For sediment quality data, differences were assessed relative to data from 2002 or the first year in which data was collected (i.e., total molybdenum = 2005).

For water and sediment quality data, % change was calculated as 1-(historical concentration/current concentration). For biology data, % change was calculated as (current concentration/historical concentration).

** Indicates that the upper bound of the 95% CI exceeded the SSWQO, water quality benchmark, CCME water quality guideline, or CCME ISQG value during the ice-covered or open water season.*

*** Indicates that the observed mean exceeded the SSWQO, water quality benchmark, CCME water quality guideline, or CCME ISQG value during the ice-covered or open water season.*

****Indicates that the upper bound of the 95% CI or the observed mean exceeded the CCME PEL.*

≠ Indicates that the lower bound of the 95% CI was less than the lower CCME guideline value for pH during the ice-covered or open water season.

Legend:

Increased over time in comparison to reference lakes/streams or different from a constant+
- ▲0-25% 0-25%
- ▲26-50% 26-50%
- ▲51-75% 51-75%
- ▲76-100% 76-100%

Decreased over time in comparison to reference lakes/streams or different from a constant+
- ▼0-25% 0-25%
- ▼26-50% 26-50%
- ▼51-75% 51-75%
- ▼76-100% 76-100%

— Did not change over time or differ significantly over time from reference lakes/streams

● Variable was not sampled at this lake/stream

◆ Changed over time

€: Indicates the observation in one sample exceeded the SSWQO, water quality benchmark, CCME water quality guideline, or CCME sediment quality guideline value during the ice-covered or open water season.

^: Indicates that the overall trend through time was increasing, but the observed mean in 2014 was less than the baseline mean.

£: Indicates that no comparison to baseline was possible.

Grizzly Lake is the source of potable water for the Ekati Diamond Mine's Main Camp and was added to the statistical evaluation of effects for the AEMP in 2009. At present, biological variables and sediment quality are not monitored in Grizzly Lake as part of the AEMP. However, the recent change in the shape of the under-ice temperature profile may have implications for biological communities. Most species have thermal optima (i.e., temperature ranges over which they thrive) (Kravtsova 2000). All ectothermic organisms (i.e., organisms that do not generate their own body heat) are sensitive to changes in temperature, with increases in temperature resulting in higher basal metabolic rates, higher activity levels, shorter lifespans, and smaller body sizes (Angilletta 2010). Thus, changes in temperature can cause shifts in community composition and food web dynamics (Gillooly et al. 2001; Brown et al. 2004; Kingsolver and Huey 2008). Biological variables (i.e., phytoplankton and zooplankton) were assessed in Grizzly Lake in 2014 to examine if any changes in biological communities were observed that may be related to the change in temperature profile and results are summarized in section 7.2.

Twenty-two water quality variables were evaluated in the 2014 AEMP for the Koala Watershed and Lac de Gras. Of these, concentrations of 19 variables have changed in lakes or streams in the Koala Watershed or Lac de Gras (Figures 4-1 and 4-4 to 4-22):

- pH (downstream to Lac de Gras site S3 and in Grizzly Lake)
- total alkalinity (downstream to Lac de Gras site S2)
- water hardness (downstream to Lac de Gras site S3)
- chloride (downstream to Lac de Gras site S3)
- sulphate (downstream to Lac de Gras site S3; Kodiak Lake)
- potassium (downstream to Lac de Gras site S3)
- total ammonia-N (in lakes downstream to Slipper Lake)
- nitrite-N (downstream to Moose-Nero Stream)
- nitrate-N (downstream to Slipper Lake)
- total phosphate-P (downstream to Moose Lake)
- total antimony (downstream to Nema-Martine Stream)
- total arsenic (downstream to Nema Lake)
- total barium (downstream to Slipper-Lac de Gras Stream)
- total boron (downstream to Slipper-Lac de Gras Stream)
- total molybdenum (downstream to Lac de Gras site S3)
- total nickel (downstream to Slipper-Lac de Gras Stream; Kodiak Lake and Kodiak-Little Stream)
- total selenium (downstream to Moose Lake)
- total strontium (downstream to Lac de Gras site S3)
- total uranium (downstream to Slipper Lake)

Although concentrations of seven water quality variables have stabilised at some sites in recent years, concentrations remain elevated above baseline or reference concentrations in all 19 cases. The extent to which concentrations have changed through time generally decreases with downstream distance from the LLCF. Patterns were similar during the ice-covered and open water seasons, though concentrations were sometimes greater during the ice-covered season as a consequence of solute exclusion during freeze up. In reference lakes, concentrations of water quality variables have generally been low and stable through time. Together, the evidence suggests that the observed changes in concentrations in the 19 water quality variables identified in Figure 4-1 in lakes and streams that are downstream of the LLCF are mine effects that stem from the discharge of water from the LLCF into the receiving environment under Water Licence W2012L2-0001. A 20th variable (i.e., TOC) also showed evidence of an increase through time; however, no clear downstream spatial gradient was present suggesting that observed patterns may represent natural regimes (Figure 4-23). In monitored lakes and streams that are not downstream of the LLCF (i.e., Grizzly Lake, Kodiak Lake and associated streams), only three water quality variables have increased through time: pH has increased in Grizzly Lake, sulphate has increased in Kodiak Lake and total nickel has increased in Kodiak Lake and Kodiak-Little.

CCME guidelines for the protection of aquatic life exist for nine of the evaluated water quality variables, including pH, total ammonia-N, nitrite-N, total arsenic, total boron, total cadmium, total nickel, total selenium, and total uranium (CCME 2014). In addition, DDEC has established SSWQO for six of the evaluated variables, including chloride, sulphate, potassium, nitrate-N, total molybdenum, and total vanadium. Total phosphate concentrations were compared to lake-specific benchmark trigger values that were established using guidelines set out in the Canadian Guidance Framework for the Management of Phosphorus in Freshwater Systems (CCME 2004). Other water quality benchmark values include provincial guidelines or those taken from the published literature (i.e., antimony, barium, and strontium). In general, the 95% confidence intervals around the fitted mean and the observed mean concentrations were below their respective benchmark value except for pH, total phosphate-P, potassium, and total cadmium (Figure 4-1). For pH and total phosphate-P, levels and concentrations in reference lakes or streams also exceeded CCME guidelines, suggesting that exceedances are not related to mine activities. For total cadmium, the concentration was greater than the CCME guideline in only one sample from one stream in June. Since total cadmium concentrations have generally been below detection limits in all reference and monitored sites since monitoring began, this exceedance is unlikely related to mine activities. In contrast, potassium exceedances were unique to the two most upstream monitored lakes (i.e., Leslie and Moose lakes) and are thus likely related to mine activities.

Eleven sediment quality variables were evaluated in the 2014 AEMP for the Koala Watershed and Lac de Gras. Of these, the concentration of one variable (i.e., total molybdenum) has changed through time and two other variables (i.e., total antimony and total strontium) showed signs of potential increases or mine effects (Figures 4-1, and 4-24 to 4-26). Total molybdenum concentrations in sediments have increased in lakes downstream of the LLCF as far as Slipper Lake. In monitored lakes downstream from the LLCF, total antimony concentrations as far as Slipper Lake and total strontium concentrations as far as site S2 were higher than those observed in reference lakes. In both cases, concentrations decreased with increasing distance from the LLCF. Concentrations of molybdenum, antimony, and strontium follow the same pattern observed for concentrations in water quality samples; suggesting that increased concentrations in sediments are likely mine effects that stem from LLCF discharge.

CCME guidelines for the protection of aquatic life exist for two of the evaluated sediment quality variables, including arsenic and cadmium. For arsenic, the observed mean exceeded the CCME Interim Sediment Quality Guideline (ISQG) in all monitored sites and the CCME Probable Effects Level (PEL) in Slipper Lake and at site S2 in Lac de Gras (Figure 4-1). The 95% confidence intervals around the fitted mean arsenic concentration exceeded the CCME PEL in all monitored sites, except Nema Lake (Figure 4-1). However, similar exceedances were observed in all three reference lakes. For cadmium, the 95% confidence intervals around the fitted mean in 2014 exceeded the CCME ISQG in Slipper Lake and at site S2 in Lac de Gras (Figure 4-1); however, a similar pattern was observed in one reference lake. Cadmium concentrations in sediments were less than the CCME PEL value in all monitored sites (Figure 4-1).

Results from water quality analyses in the Koala Watershed and Lac de Gras suggest that changes might be expected in biological communities downstream of the LLCF as far as site S3 in Lac de Gras. However, concentrations of water quality variables that have increased in monitored lakes at the Ekati Diamond Mine for which SSWQO or species sensitivity-based CCME guidelines exist were reviewed as part of the 2012 AEMP Re-evaluation with a specific focus on identifying possible chronic toxic effects on species present in the receiving environment at the Ekati Diamond Mine (Rescan 2012b). As in previous years, with the exception of potassium, concentrations of all the water quality variables in the Koala Watershed and Lac de Gras in 2014 remained below the lowest identified chronic effect level for the most sensitive species (Rescan 2012d). The observed mean potassium concentrations in Leslie and Moose lakes during the ice-covered season, and in samples collected from two meters above the sediment-water interface (deep) in Leslie Lake during the open water season, exceeded the potassium SSWQO (41 mg/L; see Part 2 - Data Report; Rescan 2012d). In Leslie and Moose lakes, the upper 95% confidence interval of the fitted mean during the ice-covered season also exceeded the lowest identified potassium chronic effect level of 53 mg/L for the most sensitive species (i.e., *Daphnia magna*) (see Section 3.2.4.6 of Part 1 - Evaluation of Effects; Biesinger and Christensen 1972). Potassium plays an important role in nerve function and is therefore required by many aquatic species (Environment Canada 2002). However, potassium can become toxic at elevated concentrations, and is substantially more toxic than other major ions of earth metals (i.e., magnesium, calcium, and sodium). On the other hand, potassium toxicity may decrease as the total ion concentration increases as a consequence of strong interactions with other metals (Trotter 2001).

Concentrations of nutrients are among the water quality variables that have changed through time in the Koala Watershed and changes in nutrients can have an effect on the composition of biological communities that are not related to toxic effects. Accumulating research suggests that the ratio of available elements, especially macronutrients like carbon (C), nitrogen (N), and phosphorus (P), can play an important role in determining community composition and relative abundance by providing a competitive advantage to taxa whose relative elemental requirements best match current conditions (Sterner et al. 1997; Dobberfuhl and Elser 2000; Elser et al. 2000). For example, relatively low nitrogen environments favour phytoplankton species that are capable of fixing nitrogen (i.e., blue-green algae) while those that can take up nitrogen directly from the environment thrive when the relative availability of nitrogen increases (i.e., diatoms; Tillman et al. 1986).

The ratio of available nutrients in the Koala Watershed has shifted through time as nitrogen levels have increased. This coincides with the overall results of the 2012 AEMP Re-evaluation, which suggested that observed changes in biological community composition at the Ekati Diamond Mine likely resulted from inter-specific differences in the competitive ability of different taxonomic groups under changing quantities or ratios of macronutrients like nitrogen or phosphorus, rather than elemental toxicity (Rescan 2012b). As the trends in the evaluated water quality variables in 2014 are consistent with those observed in the 2011, 2012, and 2013 AEMP (Rescan 2012a, 2013b; ERM Rescan 2014a), it was expected that the relative availability of macronutrients would continue to be the dominant driver of change in biological communities; however, increasing potassium concentrations could also play a role in explaining changes to species composition observed in 2014. Increasing potassium concentrations may be particularly important for changes in zooplankton composition as the most sensitive species identified in the development of the SSWQO was the cladoceran *Daphnia magna* (Biesinger and Christensen 1972; Rescan 2012d).

Results from sediment quality analyses in the Koala Watershed and Lac de Gras also suggest that changes might be expected in biological communities downstream of the LLCF, because the concentration of one evaluated sediment quality variable (i.e., molybdenum) has increased as far as Slipper Lake and elevated concentrations of two other evaluated sediment quality variables (i.e., antimony and strontium) have been detected downstream of the LLCF. However, no CCME guidelines or other relevant benchmark values currently exist for these three sediment quality variables, suggesting that no toxic effects were expected.

Six changes in biological variables were observed in 2014:

- Altered phytoplankton genera diversity in Leslie and Kodiak lakes, though Leslie Lake diversity returned to historical levels in 2013 (Figure 4-27);
- Altered taxonomic composition of phytoplankton assemblages in lakes downstream of the LLCF as far as site S2 in Lac de Gras and in Kodiak Lake (Figures 4-28 to 4-33);
- Decreased zooplankton diversity in lakes downstream of the LLCF as far as Nema Lake, though diversity has increased in recent years (Figure 4-34);
- Altered taxonomic composition of zooplankton assemblages in Leslie, Moose, and Nema lakes (Figures 4-35 to 4-38);
- Altered taxonomic composition of lake benthos communities in lakes downstream of the LLCF as far as Nema Lake, and at site S2 in Lac de Gras (Figures 4-39 to 4-42); and
- Decreased benthos density in Kodiak-Little Stream (Figure 4-43).

Phytoplankton diversity has been stable through time in all monitored lakes of the Koala Watershed and Lac de Gras, except Leslie and Kodiak lakes (Figure 4-27). Phytoplankton diversity in Leslie Lake decreased from 2006 to 2011, but returned to historical levels by 2013. Phytoplankton community composition has shifted in all lakes downstream of the LLCF as far as site S2 in Lac de Gras, with a decrease in the relative densities of Myxophyceae (blue-green algae) and an increase in the proportion of Bacillariophyceae (diatoms) through time (Figures 4-28 to 4-33). This shift from blue-green algae to diatoms is likely related to increases in nitrate-N concentrations following the onset and subsequent expansion of underground mining operations in 2002; these changes in nitrate-N concentration also show a spatial gradient with downstream distance from the LLCF (see Section 3.2.4.9 in Part 1 – Evaluation of Effects). In lakes that are not downstream of the LLCF, a recent trend of decreasing diversity has been observed in Kodiak Lake (Figure 4-27). In contrast to lakes downstream of the LLCF, Kodiak Lake has shown a recent increase in the densities of blue-green algae with a corresponding decrease in diatoms and Chlorophyceae (green algae; Figures 4-28 to 4-33). This shift from diatoms and green algae to blue-green algae may reflect the decreasing trend in nitrate-N concentrations observed in Kodiak Lake (see Section 3.2.4.9 of Part 1 – Evaluation of Effects).

The shift in phytoplankton community composition and associated increase in nitrogen in lakes downstream of the LLCF has been recognized for some time and DDEC has undertaken a number of adaptive management actions to reduce the amount of nitrate-N released into the receiving environment. These include the diversion of underground mine water to Beartooth Pit and the addition of phosphorus to Cell D of the LLCF to stimulate nitrogen uptake by phytoplankton (Rescan 2010, 2011b; Golder 2013a). Recent trends in nitrate-N in Cell D and Koala Watershed lakes suggest that such mitigation measures may be working because nitrate-N concentrations have stabilised in recent years (Rescan 2011b; Golder 2013a). In fulfilment of Part J, Item 11 of W2012L2-0001, DDEC's Nitrogen Response Plan v1.1 was approved by the WLWB on August 11, 2014. This plan was designed to describe current nitrogen sources and management practices, assess current blasting practices at the Ekati Diamond Mine via an audit conducted by appropriate experts and address recommendations from the audit report. Key findings from the audit indicate that DDEC has many positive practices in place to contain, handle, use and dispose of explosives. Moreover, many of the recommendations made in a 2008 blast audit have been incorporated into standard operating procedures on site. The report concludes that the most significant area of potential for minimizing the availability of nitrogen for dissolution into minewater, and subsequent release to the receiving environment, is through improved usage practices in the open pits. In 2014, DDEC worked actively towards fulfilling the commitments made in the Implementation plan. A full update on the Nitrogen Response Plan (NRP) is available in Section 8. Although water quality modelling predicts that nitrate concentrations will continue to increase in the LLCF and Koala Watershed lakes downstream of the LLCF (Rescan 2012e), results suggest that nitrogen concentrations have remained stable in 2014 (see Section 3.2.4.9 of Part 1 – Evaluation of Effects).

A second shift in phytoplankton community composition, toward increased densities of Chlorophyceae, was observed in Leslie Lake from 2010 to 2012 and in Nema and Slipper lakes in 2013. Although Chlorophyceae densities in 2014 have decreased in Nema and Slipper lakes, they remain elevated in Leslie Lake. This second shift in primary producer community composition may be explained by the addition of phosphorus to Cell D of the LLCF from 2009 to 2011 as an adaptive management response to increased nitrate concentrations (Rescan 2011c). The addition of phosphorous to the LLCF ceased in 2011 and in 2013, the phytoplankton assemblage in Leslie Lake returned toward historic community compositions. The increase in Chlorophyceae observed further downstream, in Nema and Slipper lakes, in 2013, may reflect a spatiotemporal lag in the effect of phosphorus additions to Cell D of the LLCF. Chlorophyceae are known to outcompete diatoms at intermediate ratios of N:P (Tillman et al. 1986; Lagus et al. 2004).

Overall, the main change in phytoplankton community composition observed in lakes downstream of the LLCF has been a shift from blue-green algae to diatoms. Such a shift may cause cascading effects through the foodweb, where changes in phytoplankton composition may be associated with changes in the proportion of edible phytoplankton or the nutritional quality of phytoplankton. Diatoms generally have a higher fatty acid content than blue-green algae, which renders them a better quality food for herbivorous zooplankton (Lamberti 1996 as in Wehr and Sheath 2003). This may lead to changes in the nutrient content, abundance, or taxonomic composition of zooplankton, which may, in turn, cascade upward to affect higher trophic levels from secondary consumers to top predators like fish. While dominant taxa in reference lakes consist mostly of inedible organisms, dominant taxa at sites downstream of the LLCF (as far as site S3 in Lac de Gras) include large fractions of edible species from the diatom genus *Cyclotella* or the golden algae genus *Ochromonas* (see Table 3.5-2 in Part 2 – Data Report). The subsequent shift from diatoms to chlorophytes in Leslie Lake observed from 2010 to 2014, may also affect higher trophic levels. Chlorophytes are usually rare in sub-Arctic freshwater systems in the Northwest Territories (Moore 1978). Of the chlorophytes, the edible *Tetrastrum komarekii* predominates in Leslie Lake (see Table 3.5-2 in Part 2 – Data Report).

Concentrations of all the evaluated water quality variables in the Koala Watershed have remained below the lowest identified chronic effect level for the most sensitive species, except potassium (Rescan 2012b, 2012d). However, there was no evidence that elevated potassium concentrations have led to declines in the density of the most sensitive species (*Daphnia magna*; see Section 3.4.2 of Part 1 – Evaluation of Effects). Thus, the correlations between changes in phytoplankton community composition and increases in some water quality variables (e.g., chloride, sulphate, potassium, total arsenic, etc.) may reflect shifts in the relative availability of macronutrients at the Ekati Diamond Mine, rather than species sensitivities to changes in water quality variables.

Although zooplankton biomass and density have been stable through time in all monitored and reference lakes, zooplankton diversity has declined in lakes downstream of the LLCF as far as Nema Lake (Figure 4-34). Declines in zooplankton diversity have been associated with a shift in community composition that extends as far as Nema Lake. In these lakes, cladocerans (particularly *Holopedium gibberum*) and rotifers (particularly *Conochilus* sp. and *Kellicottia longispina*) have been replaced, to an extent, by copepods (Figures 4-35 to 4-38). Although diversity increased in Leslie, Moose, and Nema lakes in recent years, the zooplankton communities remain dominated by copepods. Similar to phytoplankton communities, overall shifts in zooplankton communities showed some evidence of tracking changes in the relative availability of macronutrients, with the relative densities of consumers with high somatic N:P ratios increasing through time and with spatial proximity to the LLCF (e.g., calanoid and cyclopoid copepods; Dobberfuhl and Elser 2000; McCarthy, Donohue, and Irvine 2006). As noted earlier, the observed mean potassium concentrations in Leslie and Moose lakes exceeded the potassium SSWQO (41 mg/L; see Part 2 - Data Report; Rescan 2012d). In Leslie and Moose lakes, the upper 95% confidence interval of the fitted mean during the ice-covered season also exceeded the lowest identified potassium chronic effect level of 53 mg/L for the most sensitive species (i.e., *Daphnia magna*) (see Section 3.2.4.6 of Part 1 - Evaluation of Effects; Biesinger and Christensen 1972). To date, there is no evidence that elevated potassium concentrations have led to a decline in the density of *Daphnia* sp. in Leslie or Moose lakes. Thus, the observed changes in zooplankton community composition are likely driven, ultimately, by changes in the availability of macronutrients including nitrogen and phosphorus in lakes downstream of the LLCF.

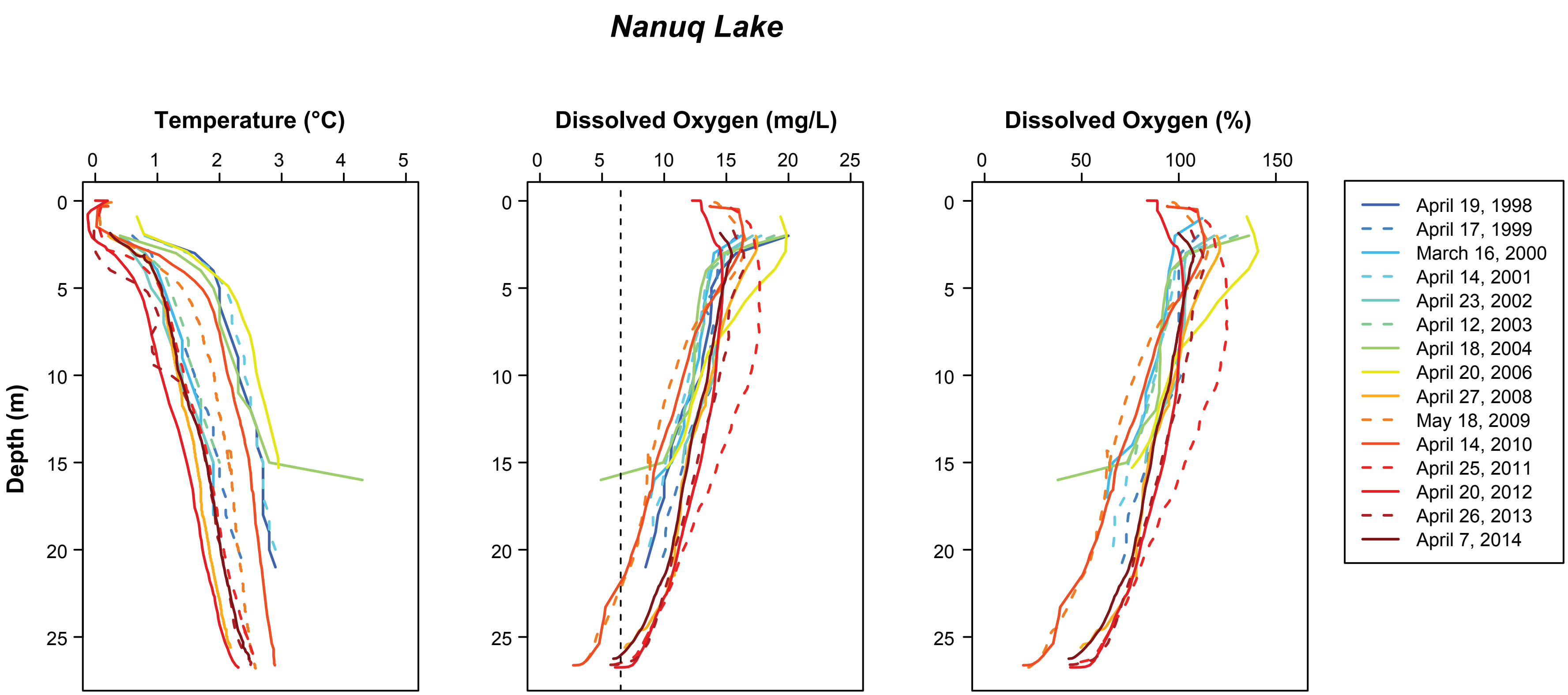
Lake benthos density, dipteran diversity, and dipteran community composition have been variable through time in all monitored and reference lakes. However, the relative densities of dipteran taxonomic communities have changed through time in Leslie and Moose lakes (Figures 4-39 to 4-42), a pattern that was first identified through the multivariate analyses conducted as part of the 2012 AEMP Re-evaluation (Rescan 2012b). In these lakes, the relative densities of organisms from the Chironomidae subfamily Orthocladiinae (likely from the genera *Heterotanytarsus, Rheocricotopus* and *Psectrocladius*) have decreased, while densities of Diamesinae (most likely organisms from the genus *Protanypus*), Prodiamesinae (most likely organisms from the genus *Monodiamesa*), Chironominae (most likely organisms from the genera *Cladotanytarsus*, *Paratanytarsus* and *Stempellinella*) and/or Tanypodinae (most likely organisms from the genera *Procladius* and *Ablabesmyia*) have increased through time. Most of these shifts in taxonomic composition began around 2005. In addition, more recent changes in dipteran community composition have been observed in Nema Lake and site S2 in Lac de Gras (Figure 4-39 to 4-42). Similar to Leslie and Moose lakes, densities of Orthocladiinae (likely from the genera *Psectrocladius, Zalutschia, and Heteroctrissocladius*) in Nema Lake have decreased, but with a coincidental increase in densities of Tanypodinae (likely from the genera *Procladius* and *Ablabesmyia*). Meanwhile, overall densities of Prodiamesinae (likely from the genus *Monodiamesa*) have recently increased at site S2 in Lac de Gras. Little information is available on the ecology of these groups and the cause of these shifts is unclear (Oliver and Dillon 1997). For similar reasons identified for phytoplankton and zooplankton, it is likely that changes in benthos community composition are associated with changes in macronutrient availability, rather than toxic effects.

At stream sites downstream from the LLCF, no mine effects were detected with respect to stream benthos density, dipteran diversity, dipteran community composition, EPT diversity, or EPT community composition. A decrease in benthos density was observed in Kodiak-Little Stream (Figure 4-43). The cause of the decline observed in Kodiak-Little Stream is unclear at this time, but may reflect historical effects as graphical analysis indicates that benthos density in Kodiak-Little Stream has declined from initially high levels. The only water quality parameter that has changed through time in Kodiak-Little Stream is total nickel; however, concentrations have remained below the hardness-dependent nickel CCREM guideline value (CCREM 1987).

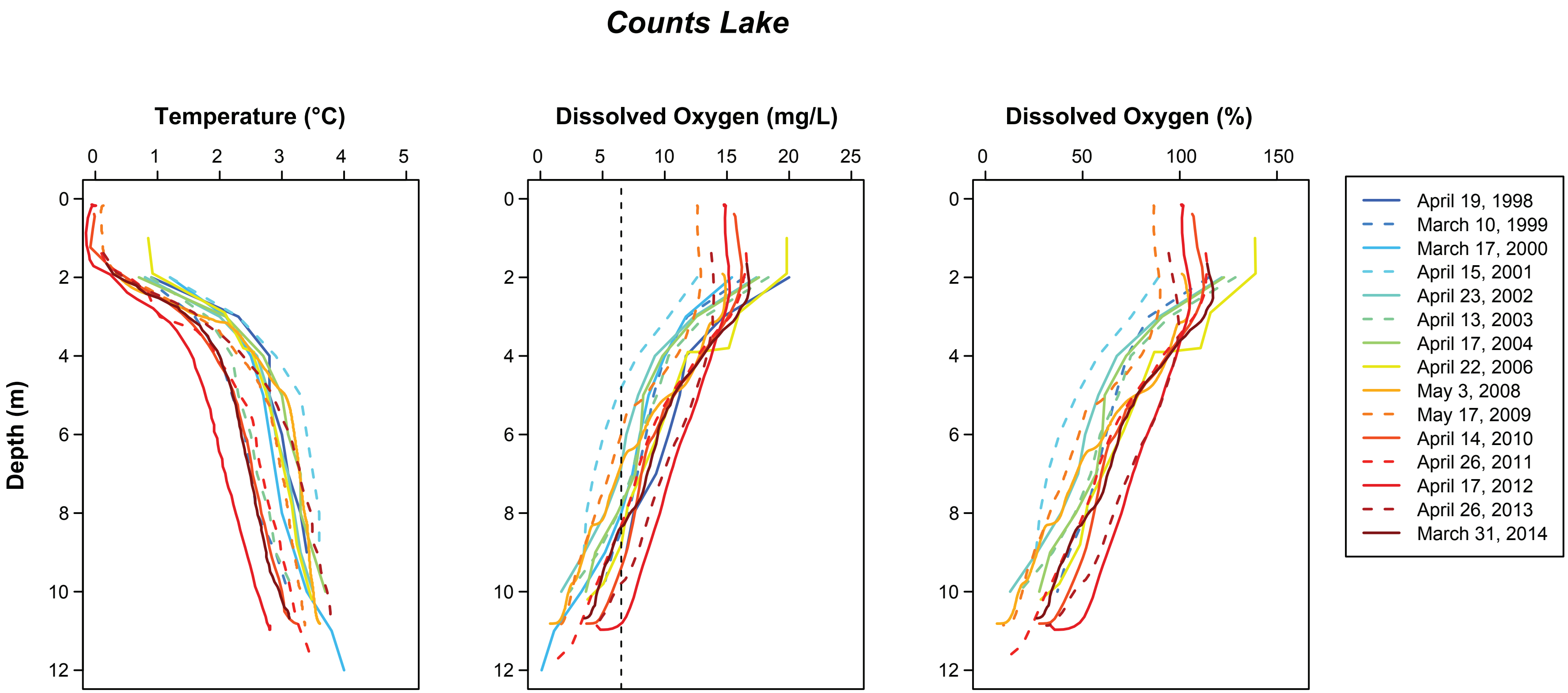
Both zooplankton and lake benthos provide an important source of food for many species of fish. Changes in community composition could have important consequences for fish, especially if preferred prey items are replaced with non-preferred ones. Results of the 2012 AEMP Evaluation of Effects found no evidence of strong mine effects on monitored fish populations in the Koala Watershed (Rescan 2012b). Shifts in phytoplankton, zooplankton, and benthos communities, do not appear to have influenced fish populations to date. Both round whitefish and lake trout are considered opportunistic feeders where in the absence of strong prey community-wide effects, may not exhibit strong biological changes, including any bioenergetics-related response variables. Furthermore, the mobile nature of these larger-bodied fish populations may also serve to reduce any potential effects. Lakes in the Ekati Diamond Mine study area are not isolated and individual fish are able to move freely between upstream and downstream lakes. This likely serves to buffer any potential effects or may delay the appearance of mine effects. Monitoring of fish populations will be conducted in 2015 to re-assess these results, using the slimy sculpin as a sentinel species.

Figure 4-2a

Under-ice Dissolved Oxygen and Temperature Profiles for AEMP Reference Lakes, 1998 to 2014



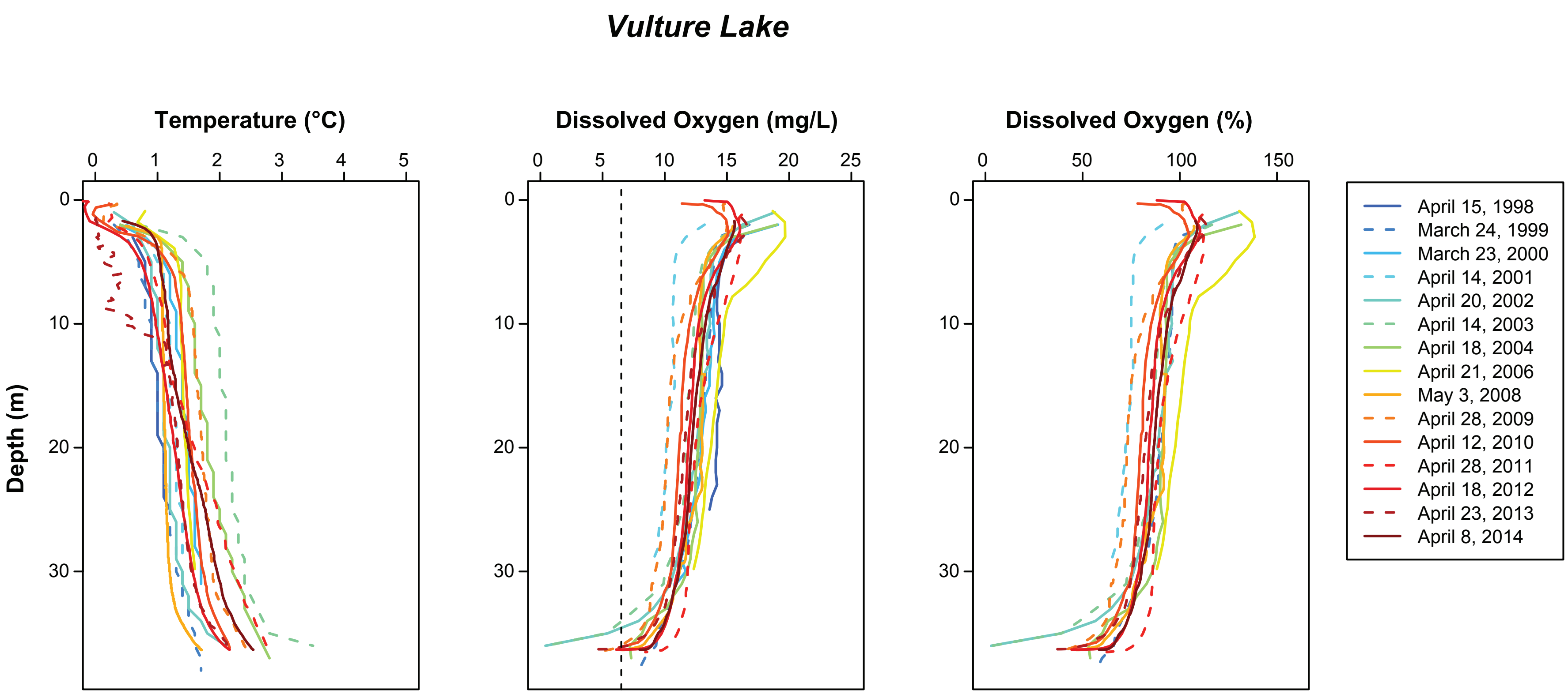
Note: Vertical dashed line represents the CCME guideline for non-early life stages (6.5 mg/L).
Data collected and supplied by DDEC.



Note: Vertical dashed line represents the CCME guideline for non-early life stages (6.5 mg/L).
Data collected and supplied by DDEC.

Figure 4-2c

Under-ice Dissolved Oxygen and Temperature Profiles for AEMP Reference Lakes, 1998 to 2014

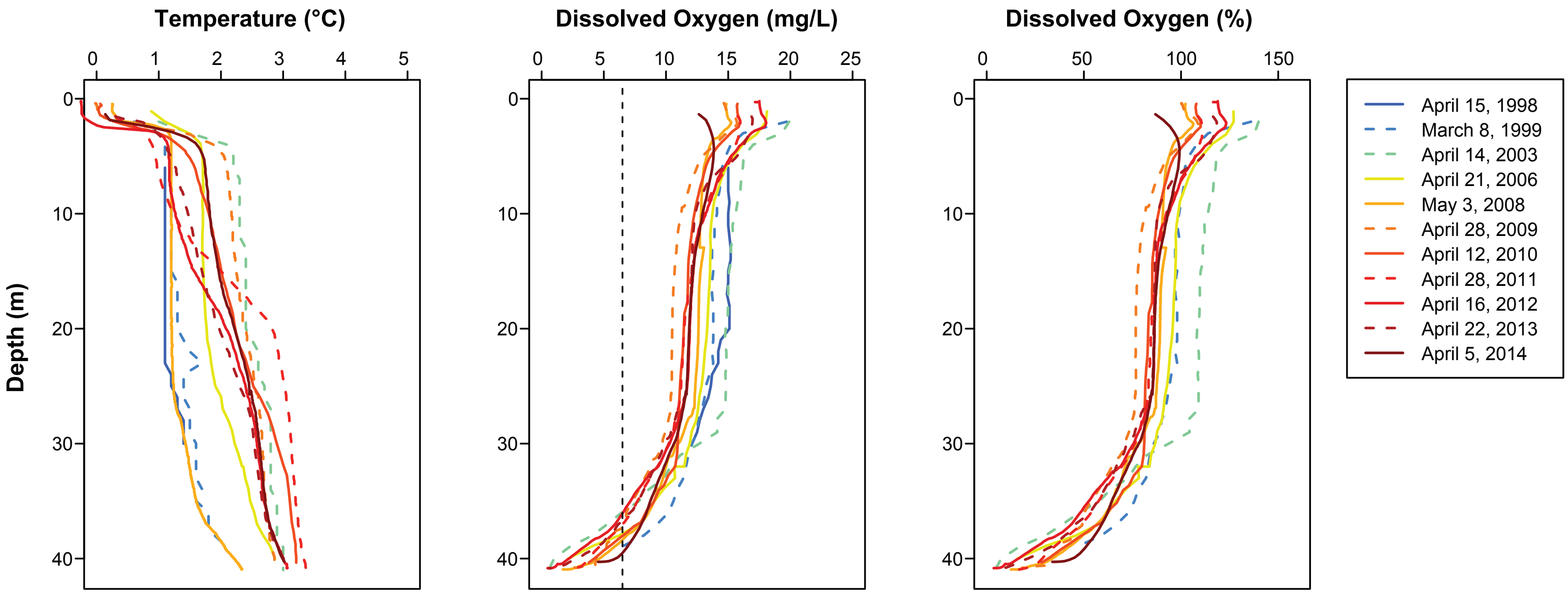


Note: Vertical dashed line represents the CCME guideline for non-early life stages (6.5 mg/L).
Data collected and supplied by DDEC.

Figure 4-3a

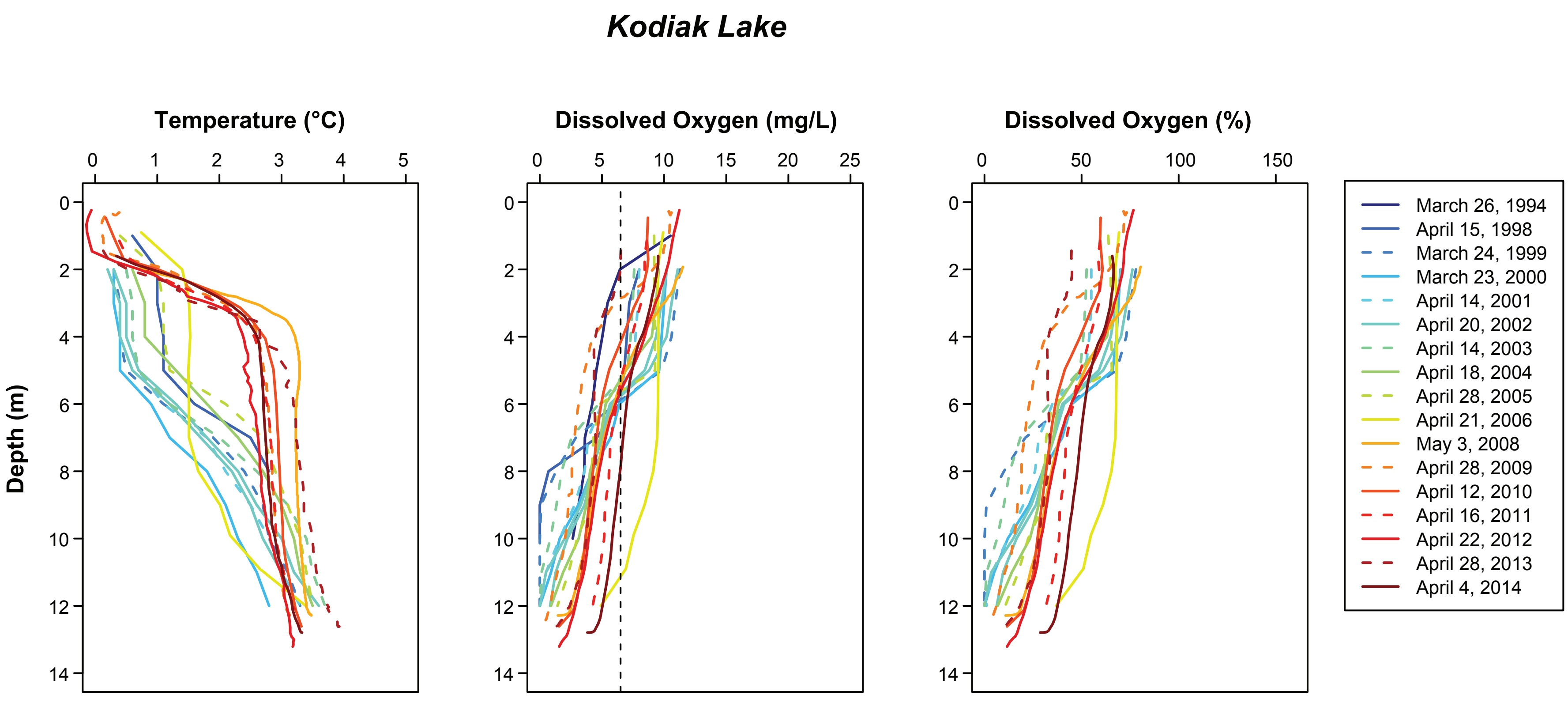
Under-ice Dissolved Oxygen and Temperature Profiles for Koala Watershed Lakes and Lac de Gras, 1994 to 2014

Grizzly Lake



Note: Vertical dashed line represents the CCME guideline for non-early life stages (6.5 mg/L).
Data collected and supplied by DDEC.

ERM

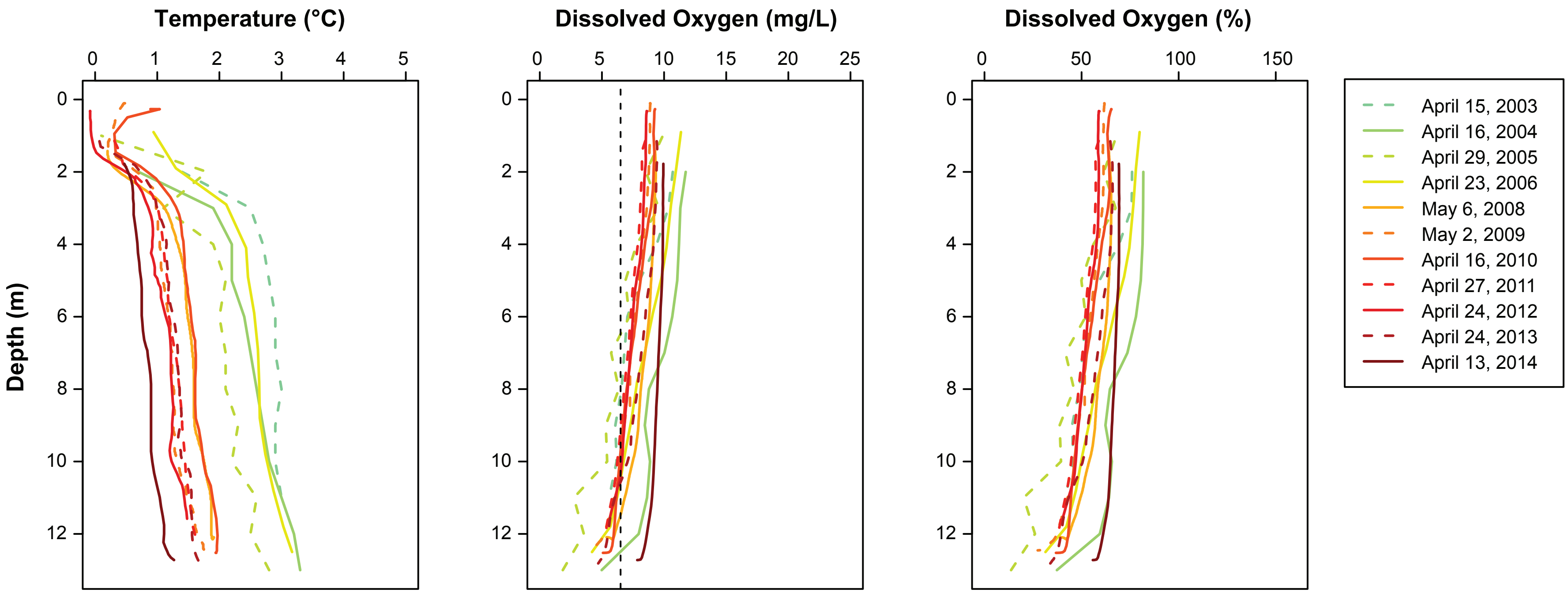


*Note: Vertical dashed line represents the CCME guideline for non-early life stages (6.5 mg/L).
Data collected and supplied by DDEC.*

Under-ice Dissolved Oxygen and Temperature Profiles for Koala Watershed Lakes and Lac de Gras, 1994 to 2014

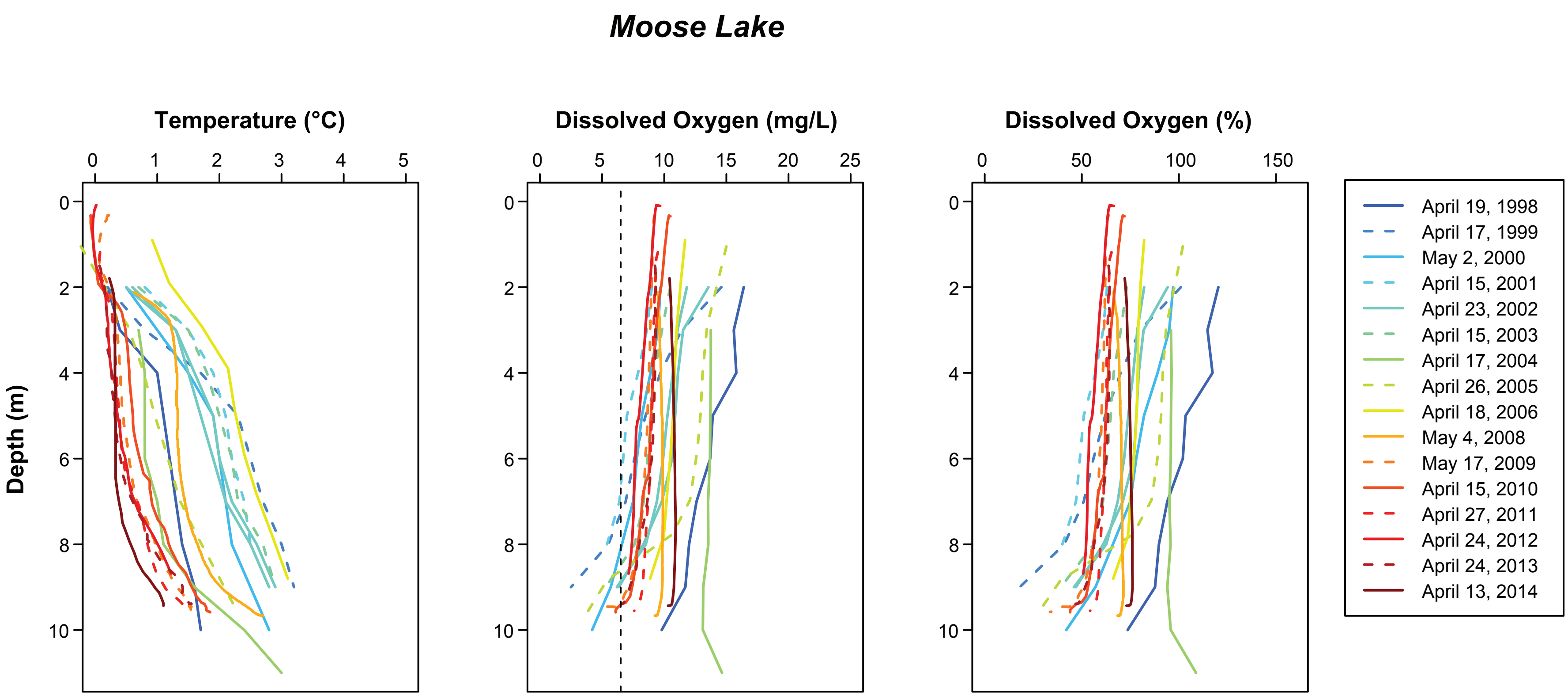
ERM

Leslie Lake



Note: Vertical dashed line represents the CCME guideline for non-early life stages (6.5 mg/L).
Data collected and supplied by DDEC.

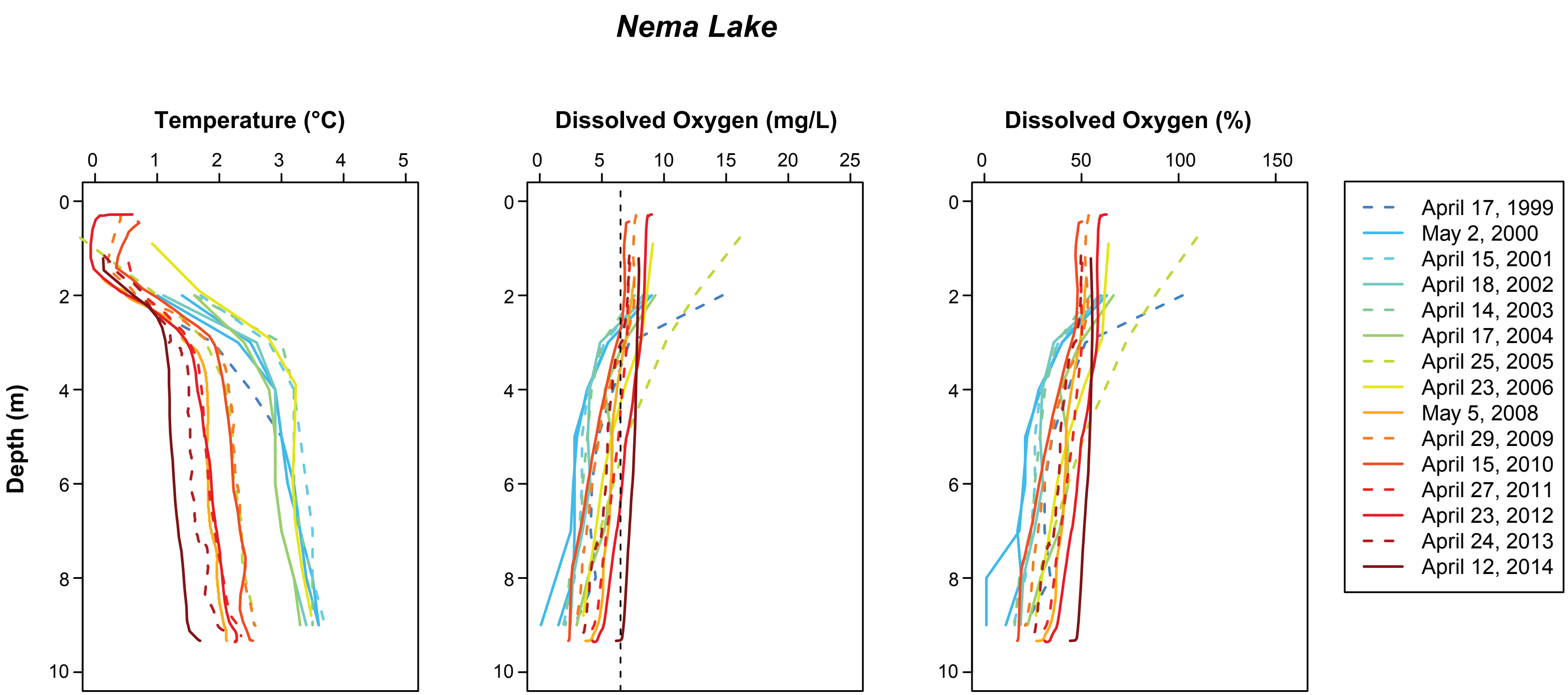
Figure 4-3d
Under-ice Dissolved Oxygen and Temperature Profiles for Koala Watershed Lakes and Lac de Gras, 1994 to 2014



Note: Vertical dashed line represents the CCME guideline for non-early life stages (6.5 mg/L).
Data collected and supplied by DDEC.

Figure 4-3e

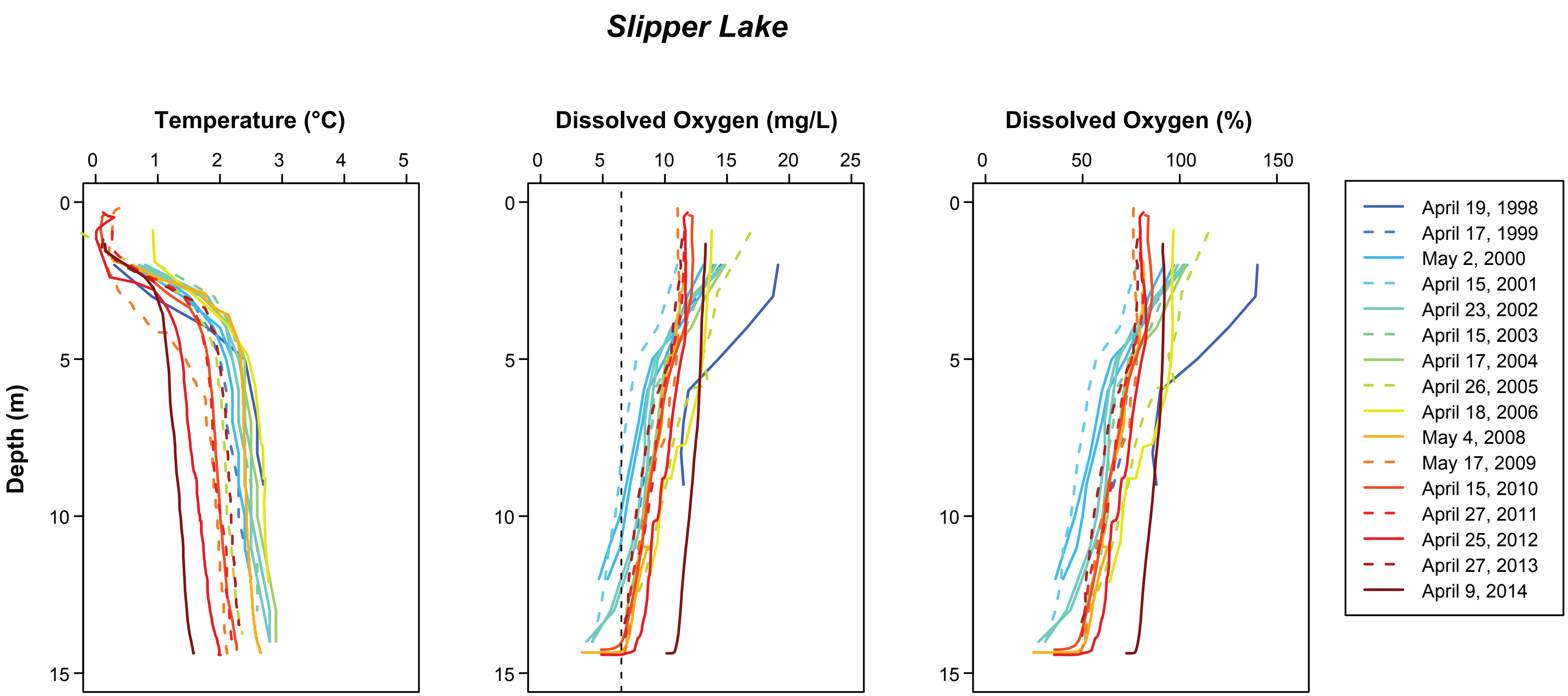
Under-ice Dissolved Oxygen and Temperature Profiles for Koala Watershed Lakes and Lac de Gras, 1994 to 2014



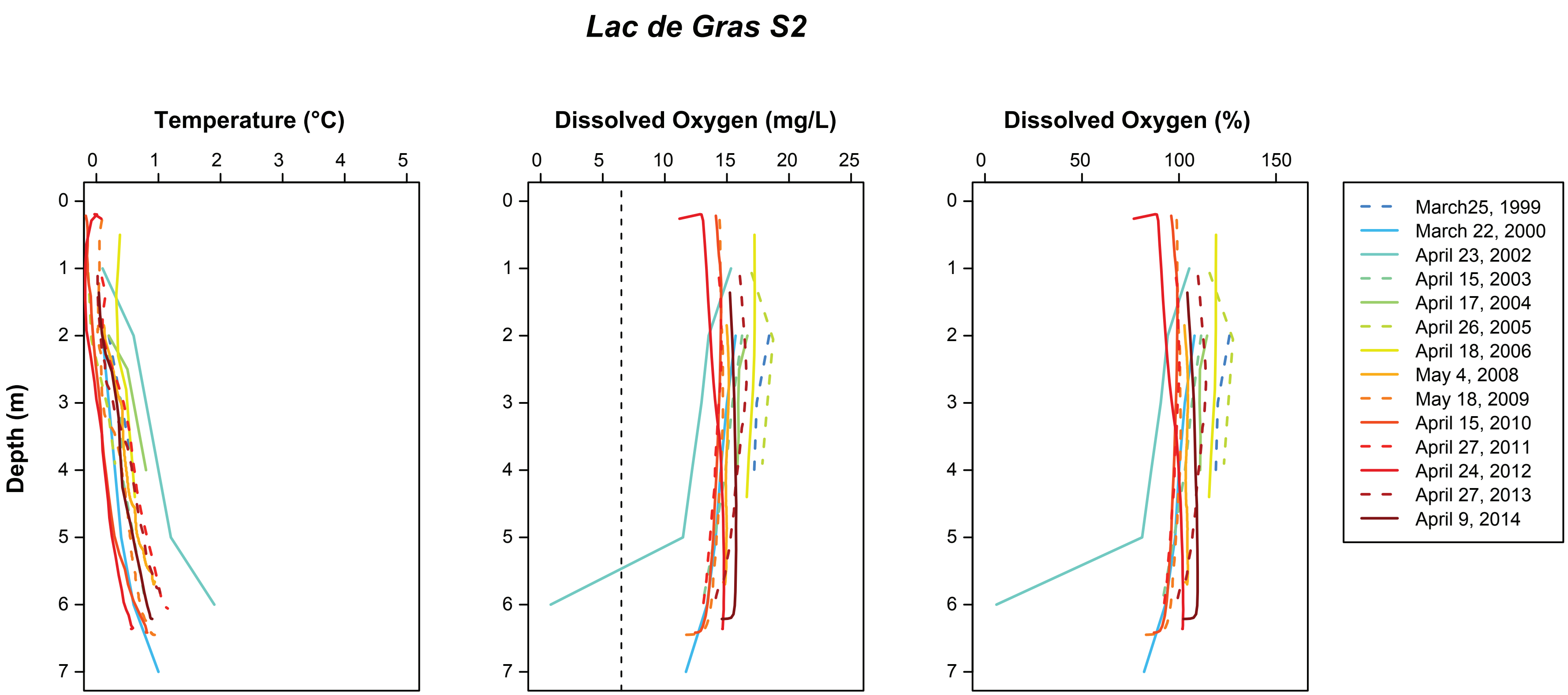
Note: Vertical dashed line represents the CCME guideline for non-early life stages (6.5 mg/L).
Data collected and supplied by DDEC.

Figure 4-3f

Under-ice Dissolved Oxygen and Temperature Profiles for Koala Watershed Lakes and Lac de Gras, 1994 to 2014



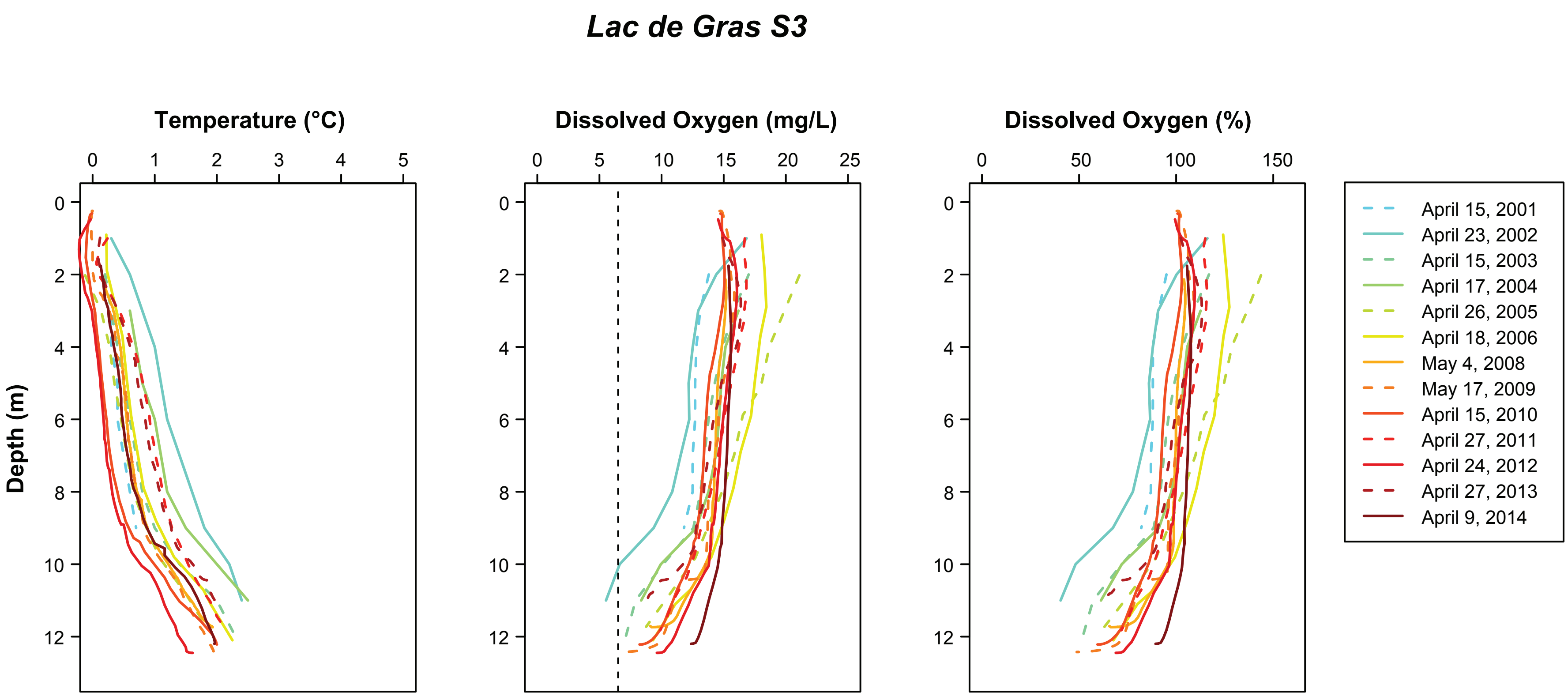
Note: Vertical dashed line represents the CCME guideline for non-early life stages (6.5 mg/L).
Data collected and supplied by DDEC.



*Note: Vertical dashed line represents the CCME guideline for non-early life stages (6.5 mg/L).
Data collected and supplied by DDEC.*

Figure 4-3h

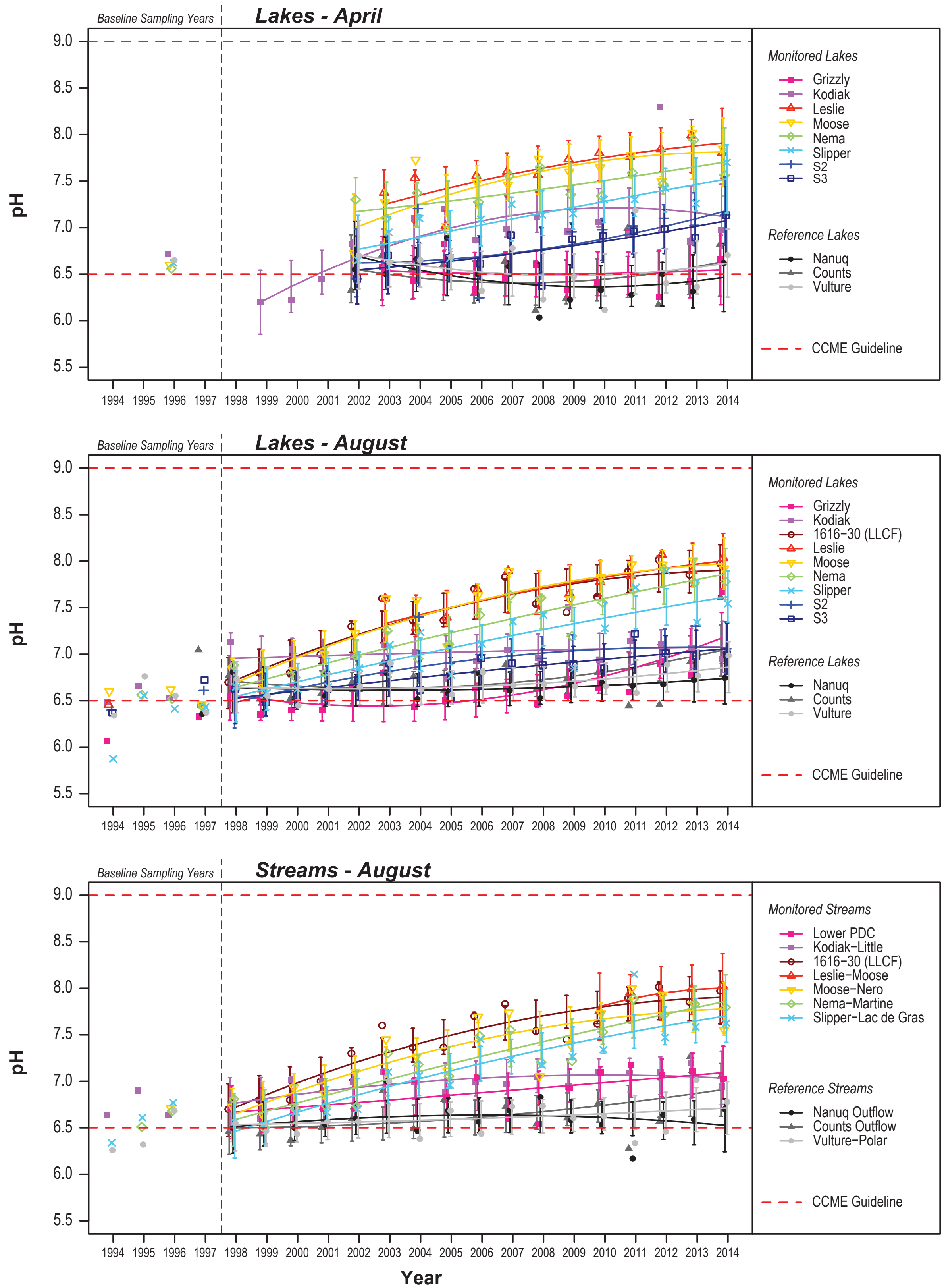
Under-ice Dissolved Oxygen and Temperature Profiles for Koala Watershed Lakes and Lac de Gras, 1994 to 2014



Note: Vertical dashed line represents the CCME guideline for non-early life stages (6.5 mg/L). Data collected and supplied by DDEC.

Figure 4-4

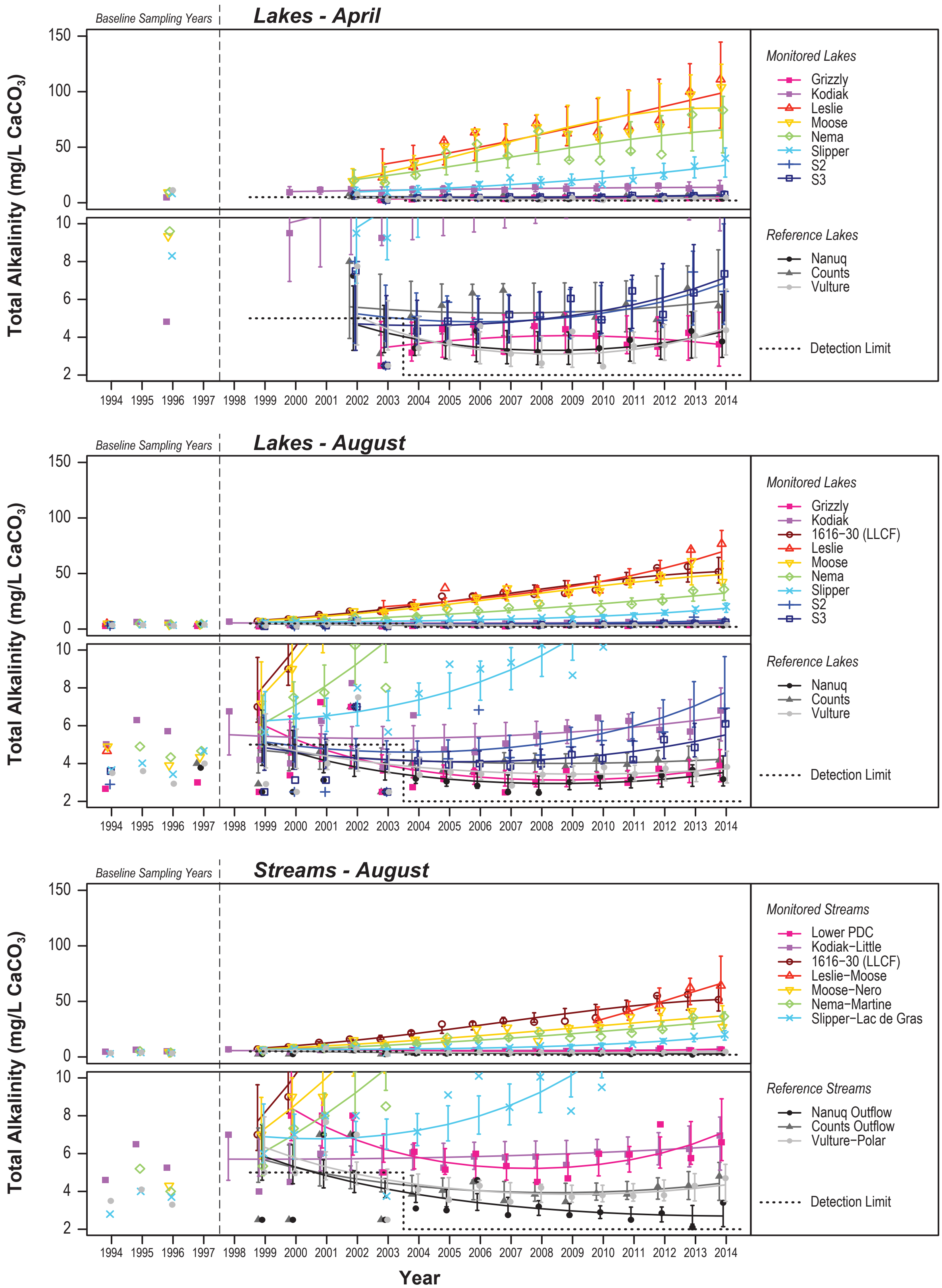
Observed and Fitted Means for pH in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
CCME guideline = 6.5 - 9.0.

Figure 4-5

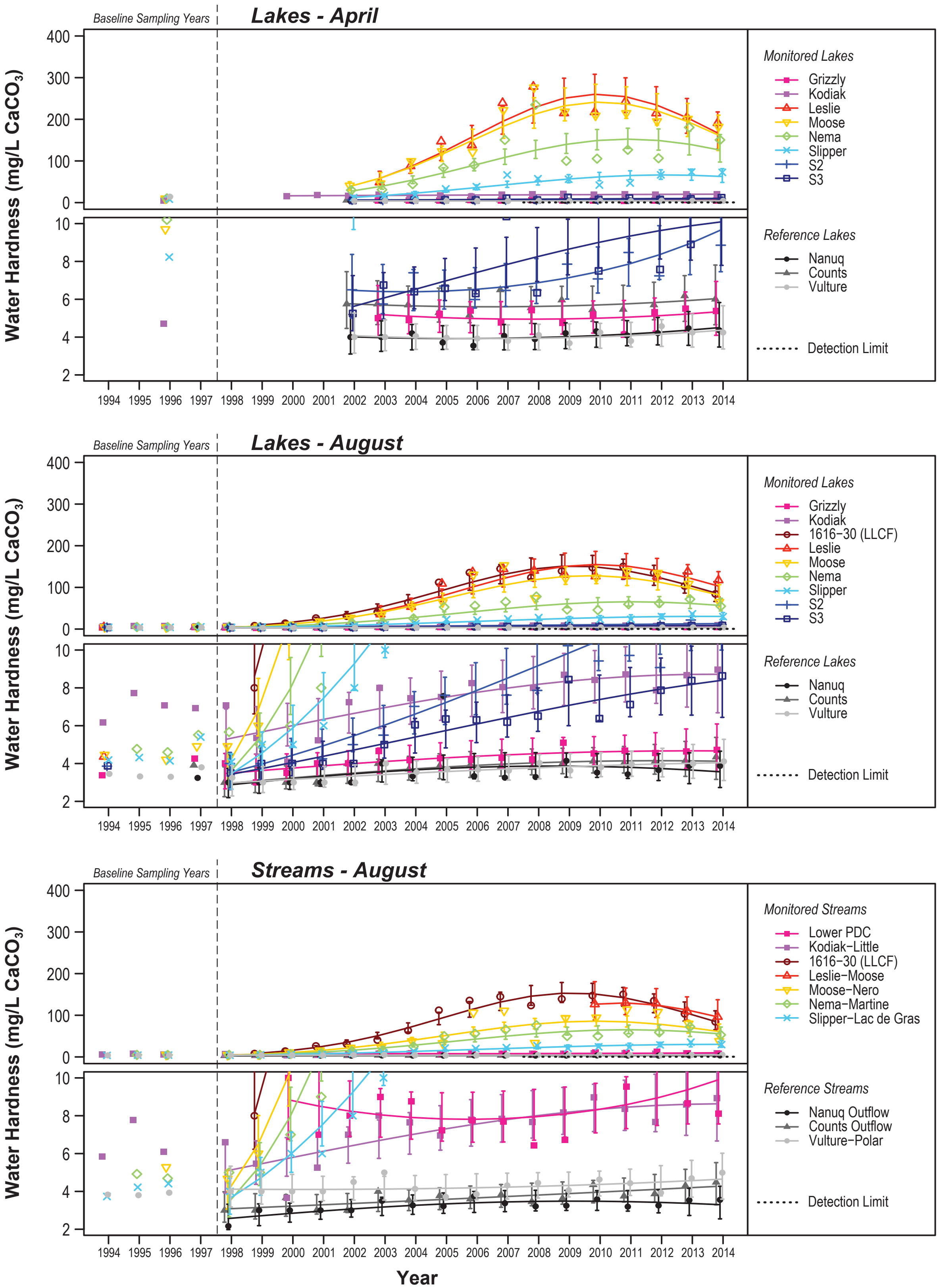
Observed and Fitted Means for Total Alkalinity in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014



Notes: *Symbols represent observed mean values.*
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.

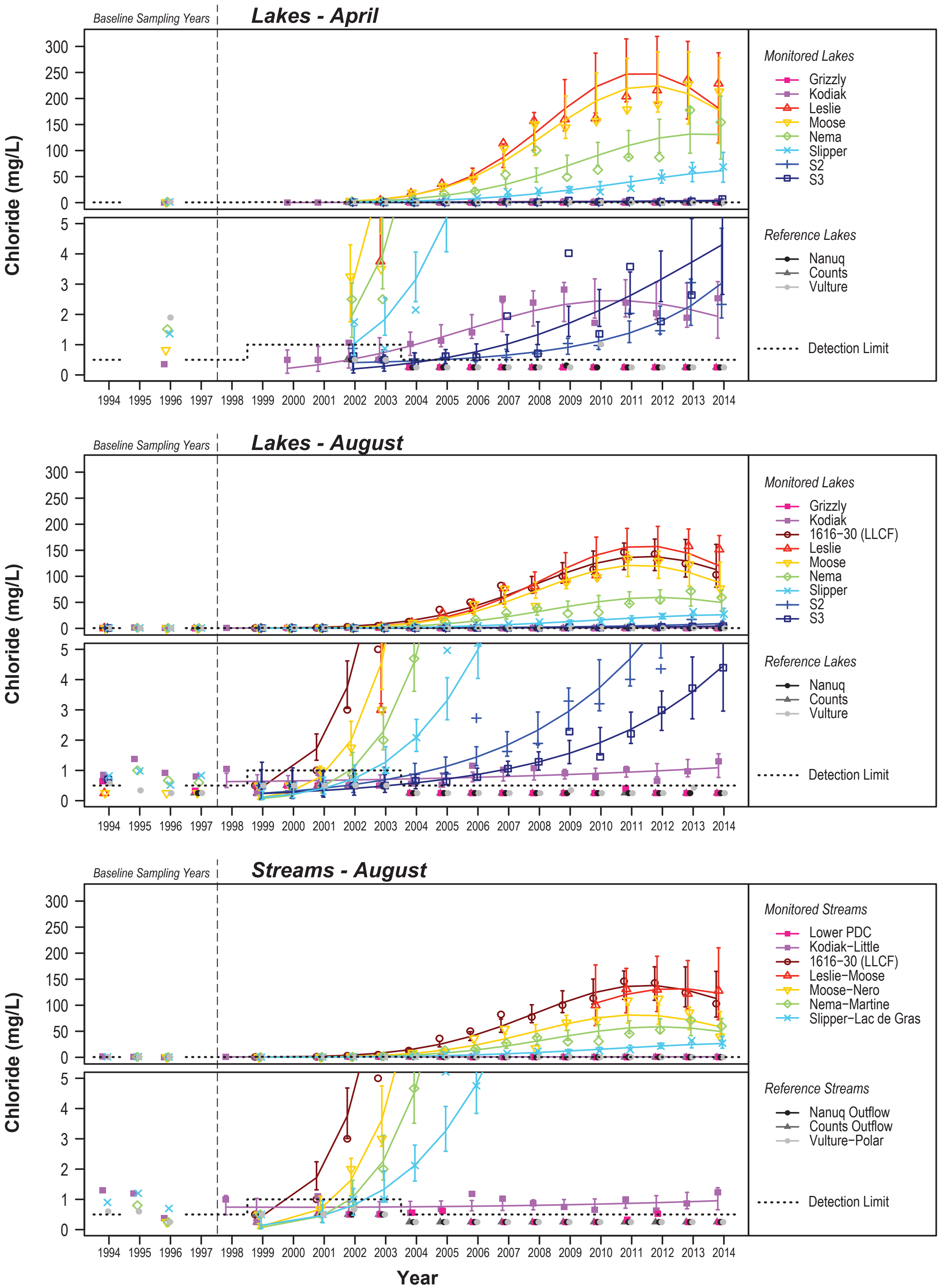
Figure 4-6

Observed and Fitted Means for Water Hardness in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.

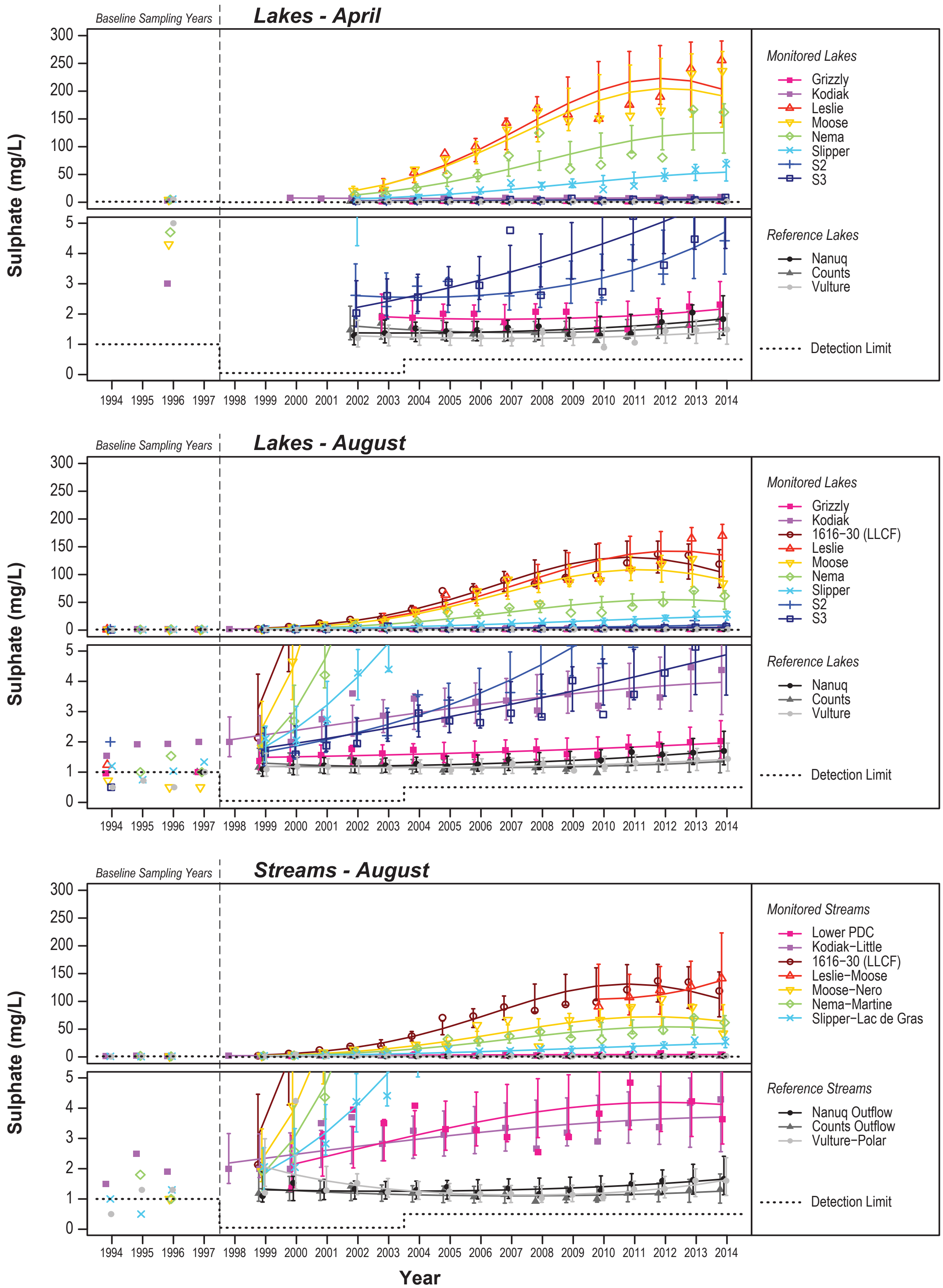
Observed and Fitted Means for Chloride Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
SSWQO = 116.6 X ln(Hardness) - 204.1, where hardness = 10 - 160 mg/L.

Figure 4-8

Observed and Fitted Means for Sulphate Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014

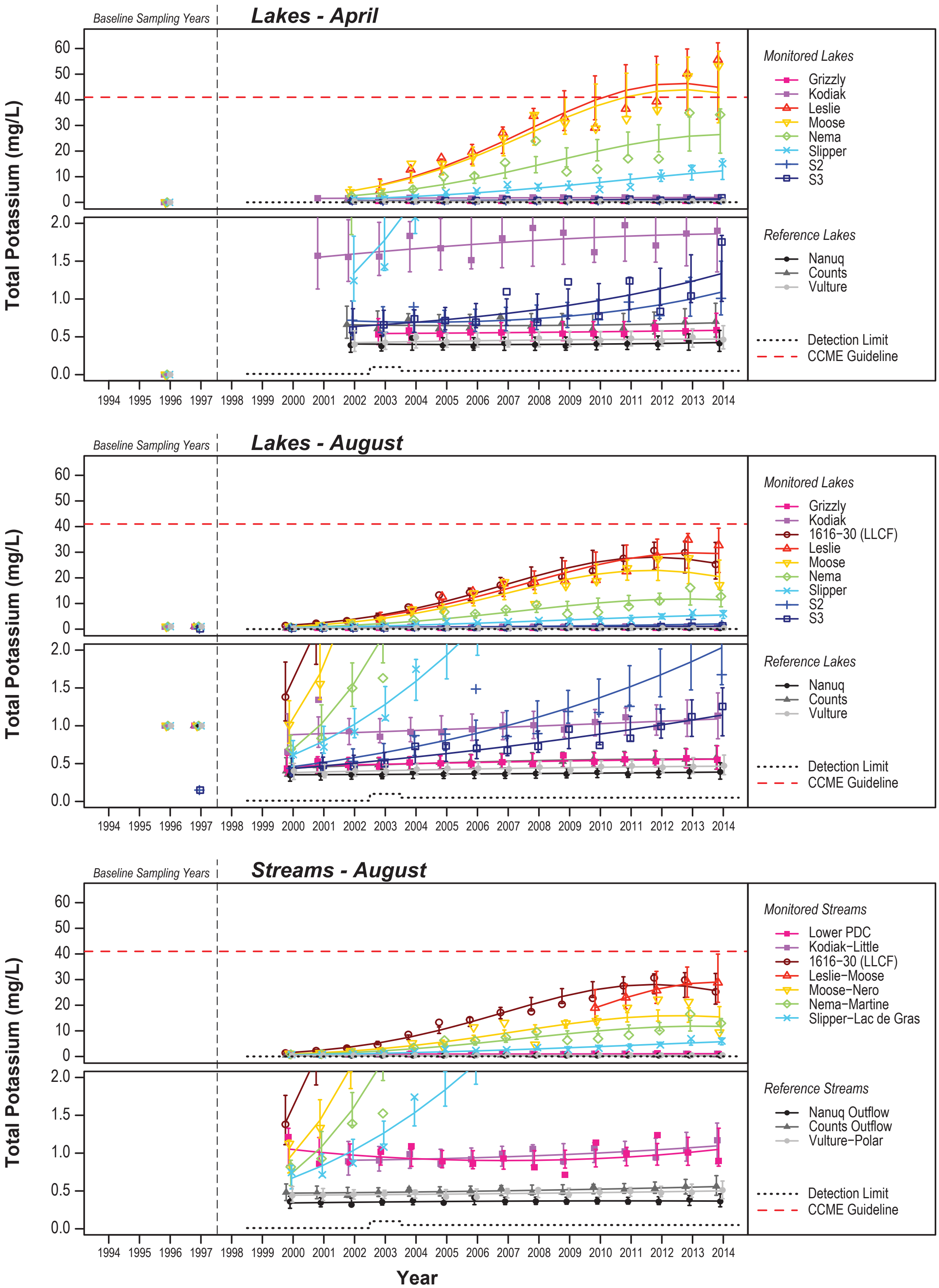


Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
SSWQO = $e^{(0.9116 \times \ln(Hardness) + 1.712)}$ mg/L, where hardness < 160 mg/L.

Figure 4-9

Observed and Fitted Means for Potassium Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014

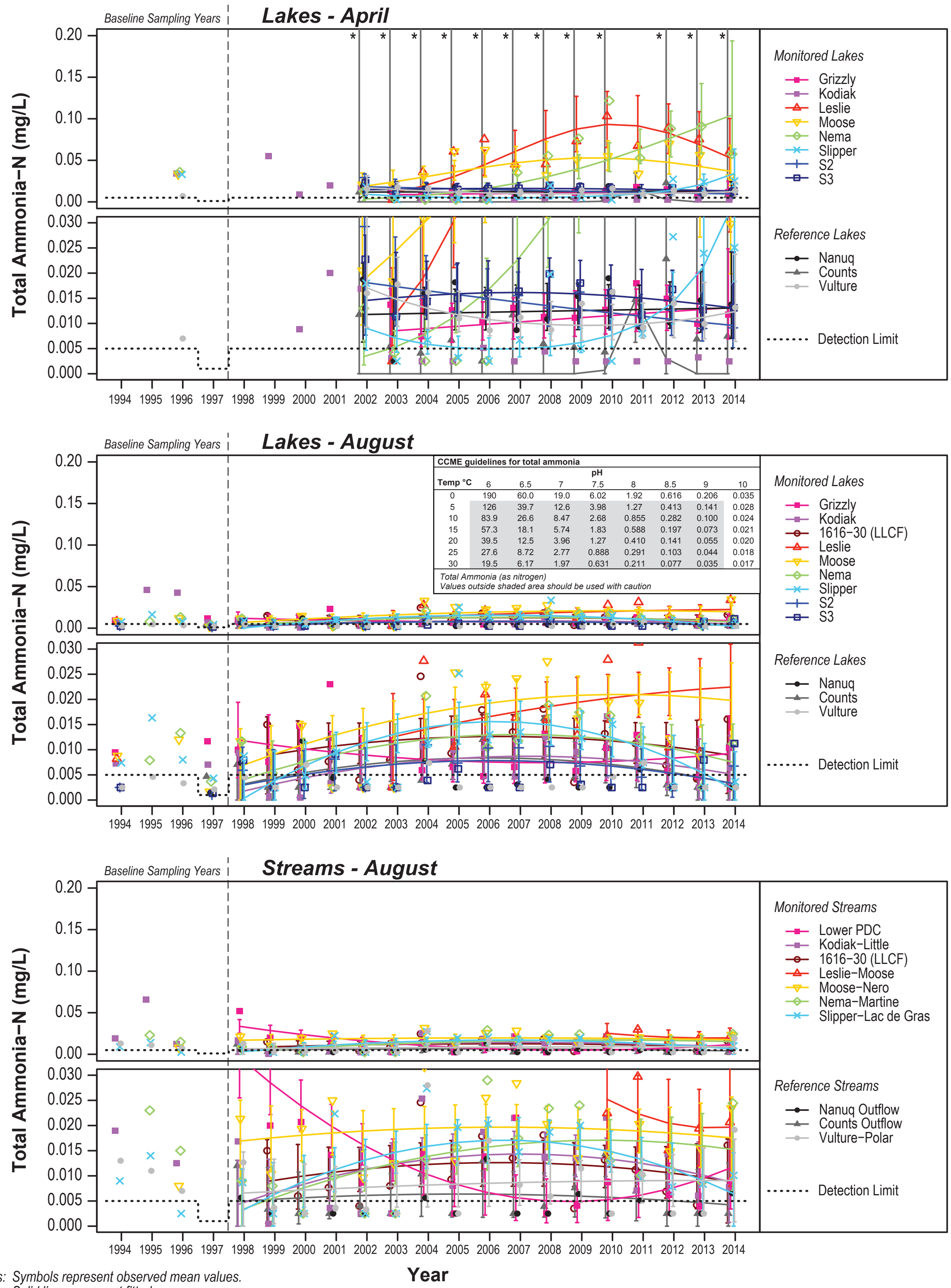
ERM



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
SSWQO = 41 mg/L.

Figure 4-10

Observed and Fitted Means for Total Ammonia-N Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014



CCME guidelines for total ammonia

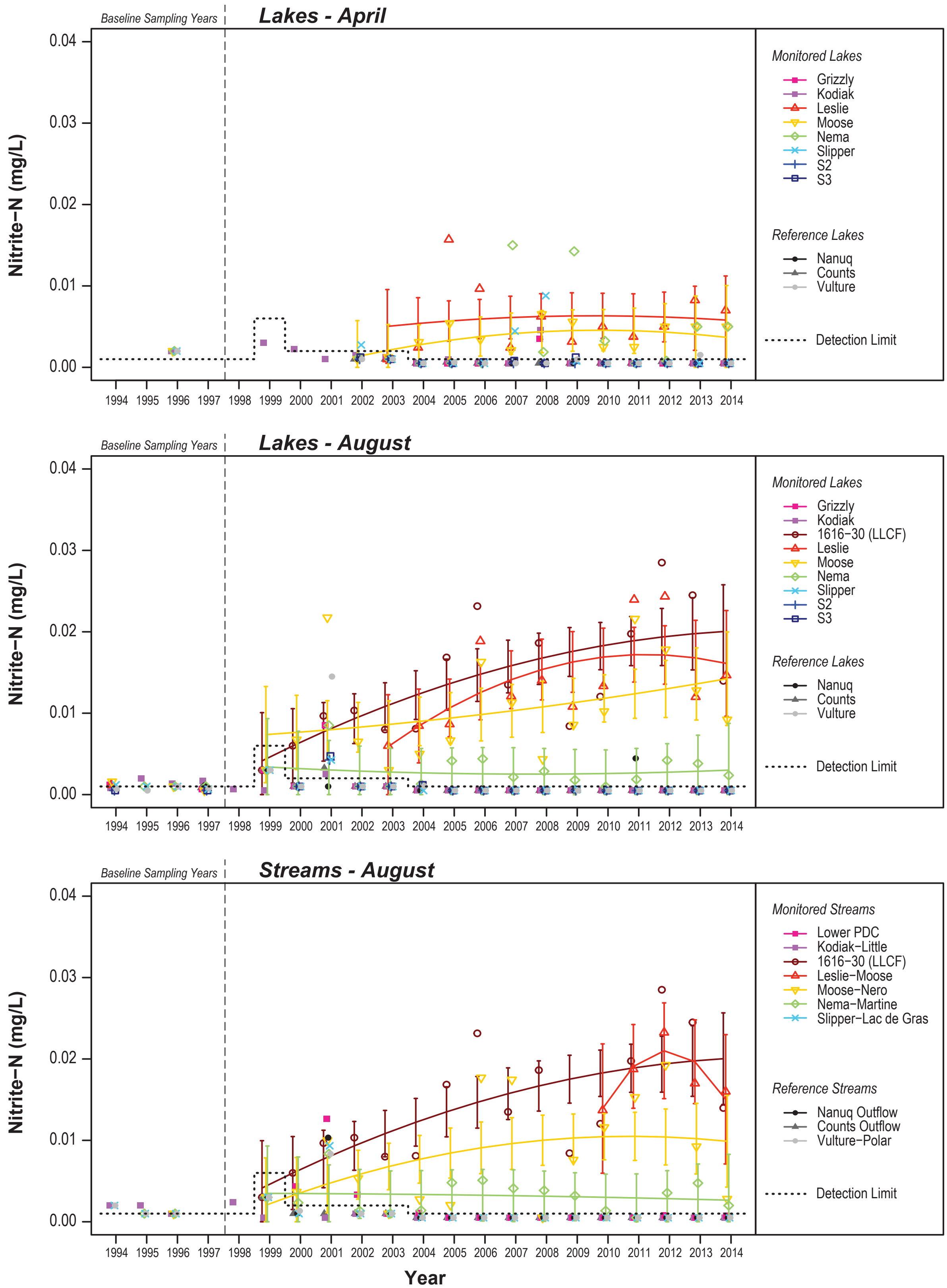
Temp °C	pH 6	6.5	7	7.5	8	8.5	9	10
0	190	60.0	19.0	6.02	1.92	0.616	0.206	0.035
5	126	39.7	12.6	3.98	1.27	0.413	0.141	0.028
10	83.9	26.6	8.47	2.68	0.855	0.282	0.100	0.024
15	57.3	18.1	5.74	1.83	0.588	0.197	0.073	0.021
20	39.5	12.5	3.96	1.27	0.410	0.141	0.055	0.020
25	27.6	8.72	2.77	0.888	0.291	0.103	0.044	0.018
30	19.5	6.17	1.97	0.631	0.211	0.077	0.035	0.017

Total Ammonia (as nitrogen)
Values outside shaded area should be used with caution

Notes: *Symbols represent observed mean values.*
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
CCME Guideline is pH and temperature dependent (see inset table).
** Upper 95% Confidence Interval on the fitted mean of Counts Lake in April 2002 = 1.12×10^{270}, 2003 = 4.10×10^{259}, 2004 = 1.71×10^{244}, 2005 = 8.12×10^{223} mg/L, 2006 = 4.40×10^{198} mg/L, 2007 = 2.72×10^{168}, mg/L, 2008 = 1.92×10^{133} mg/L, 2009 = 1.54×10^{93} mg/L, 2010 = 1.41×10^{48} mg/L, 2012 = 5.21×10^{51} mg/L, 2013 = 1.53×10^{106} mg/L, and 2014 = 3.74×10^{161} mg/L.*

Figure 4-11

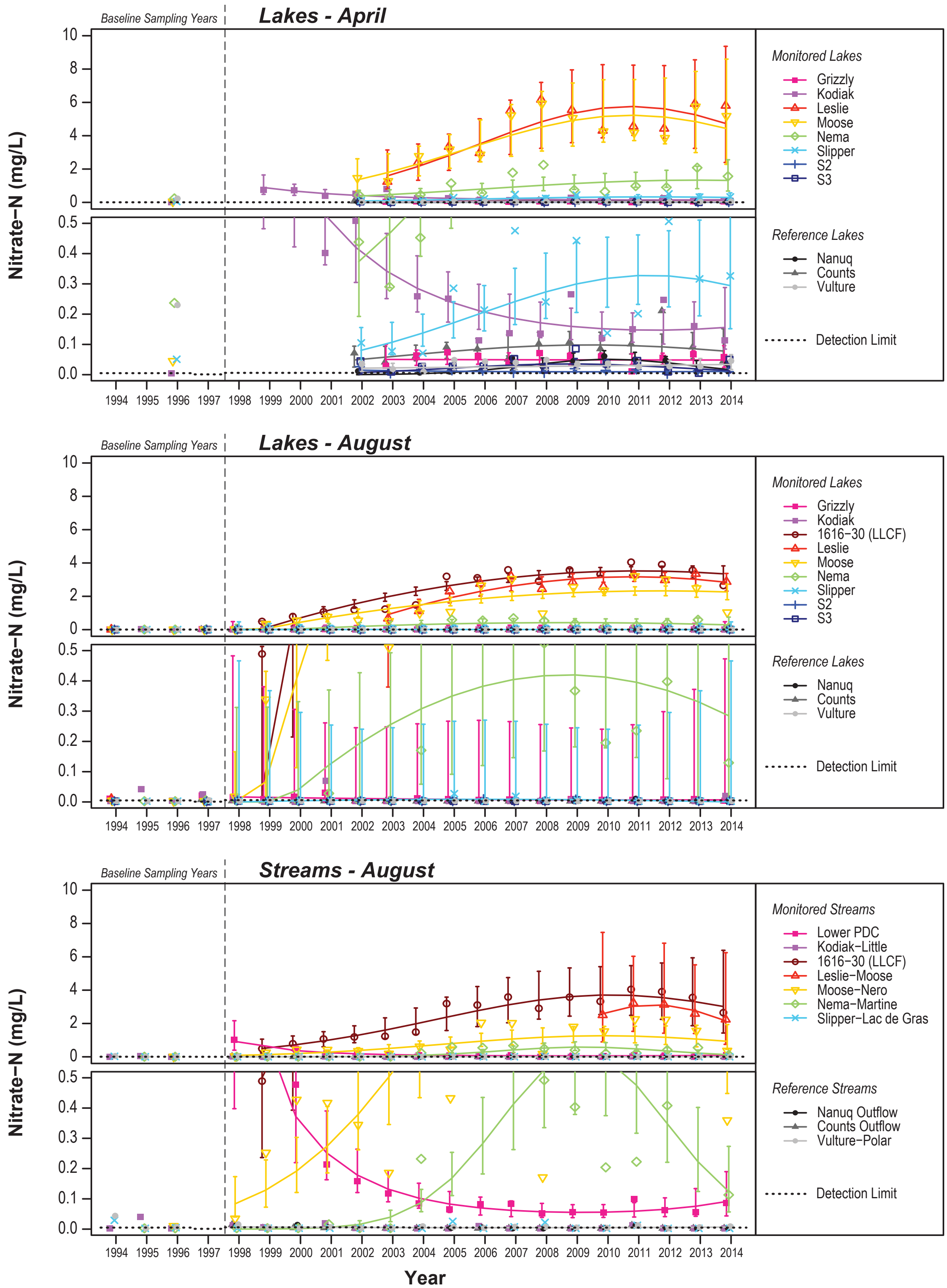
Observed and Fitted Means for Nitrite-N Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
CCME Guideline = 0.06 mg/L.

Figure 4-12

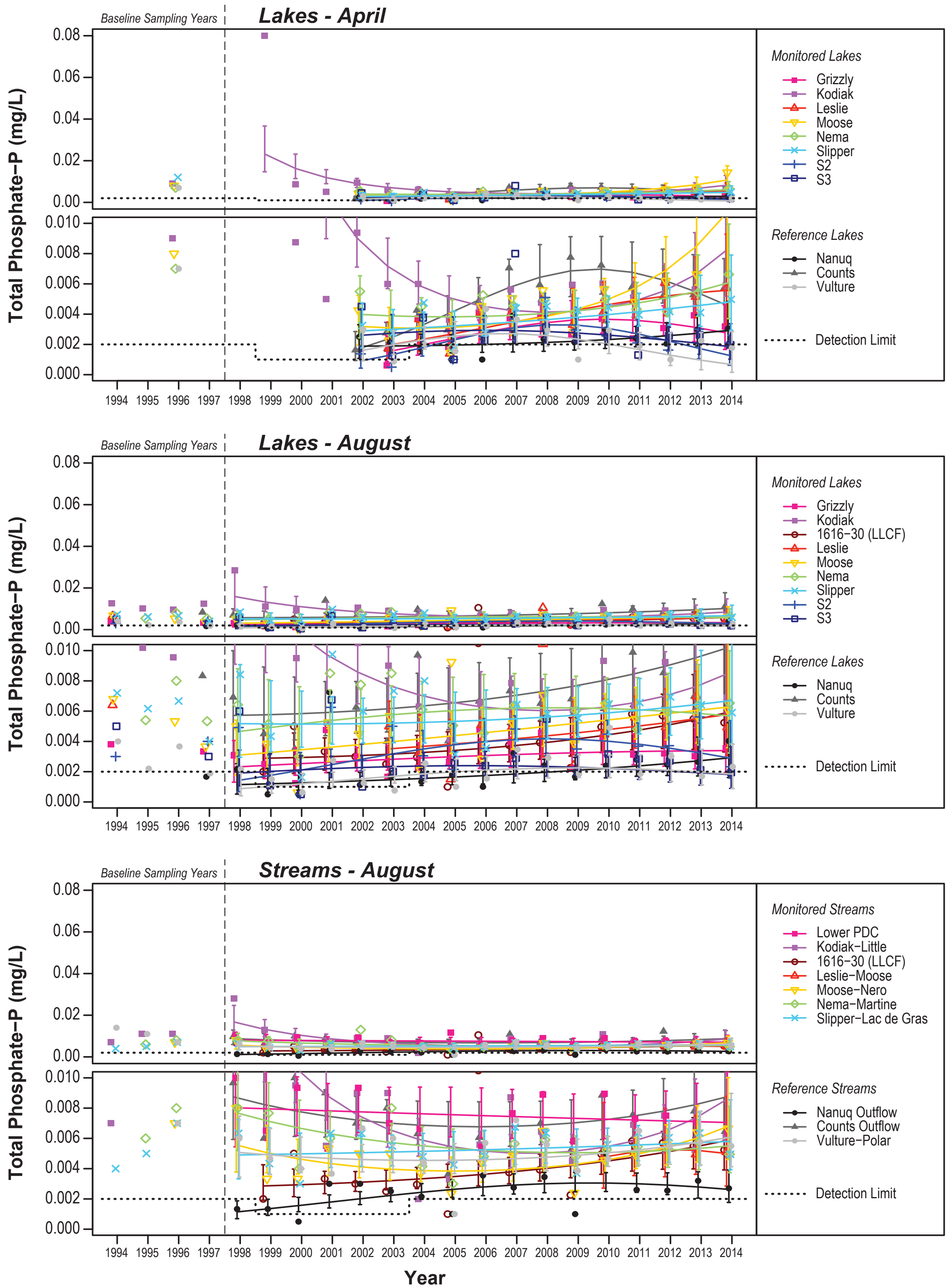
Observed and Fitted Means for Nitrate-N Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014



Notes: *Symbols represent observed mean values.*
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
SSWQO = $e^{0.9518 \times \ln(Hardness) - 2.032}$ *mg/L, where hardness < 160mg/L.*

Figure 4-13

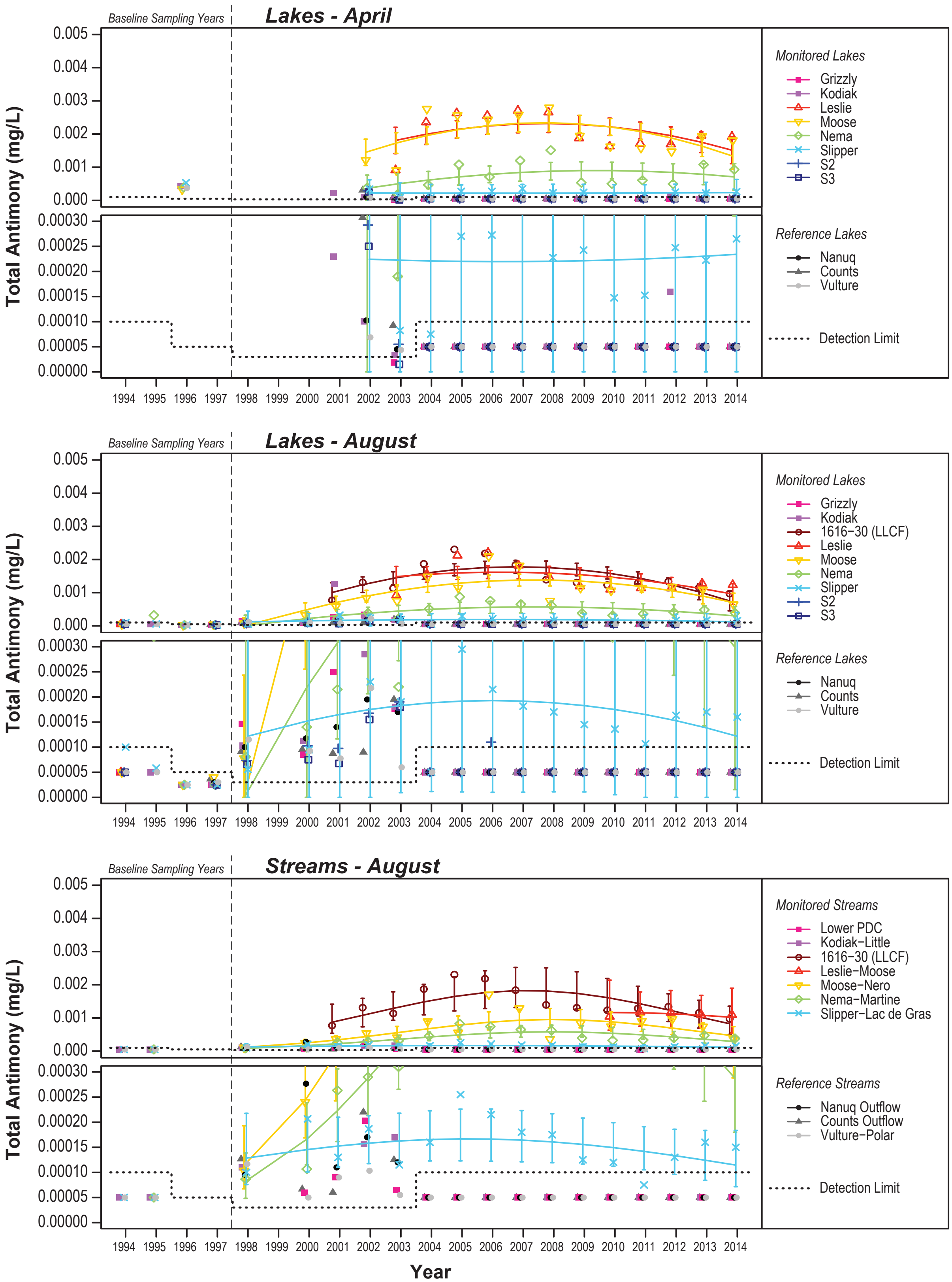
Observed and Fitted Means for Total Phosphate-P Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.

Figure 4-14

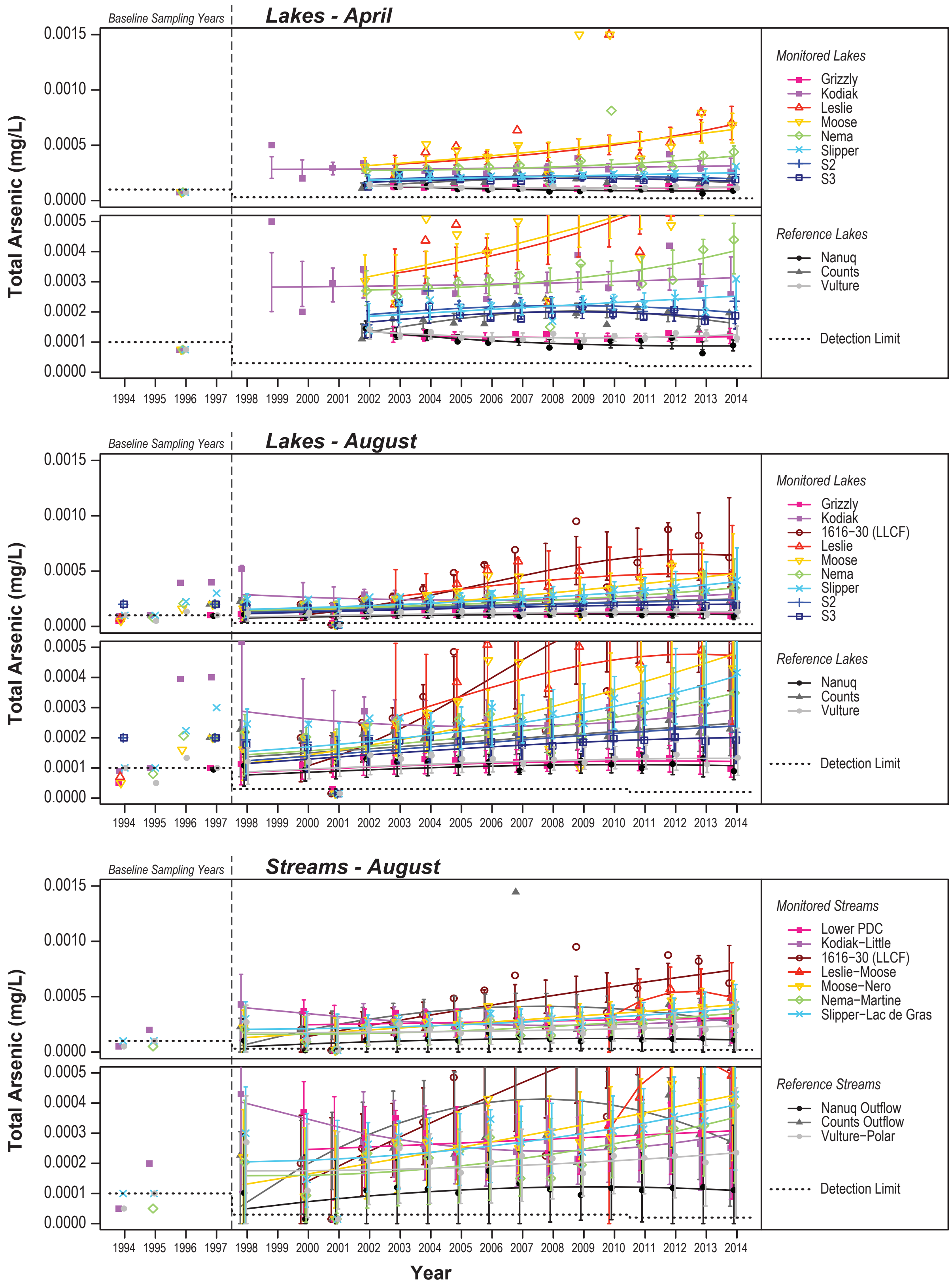
Observed and Fitted Means for Total Antimony Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014



Notes: *Symbols represent observed mean values.*
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
Water quality benchmark (Fletcher et al. 1996) = 0.02 mg/L.

Figure 4-15

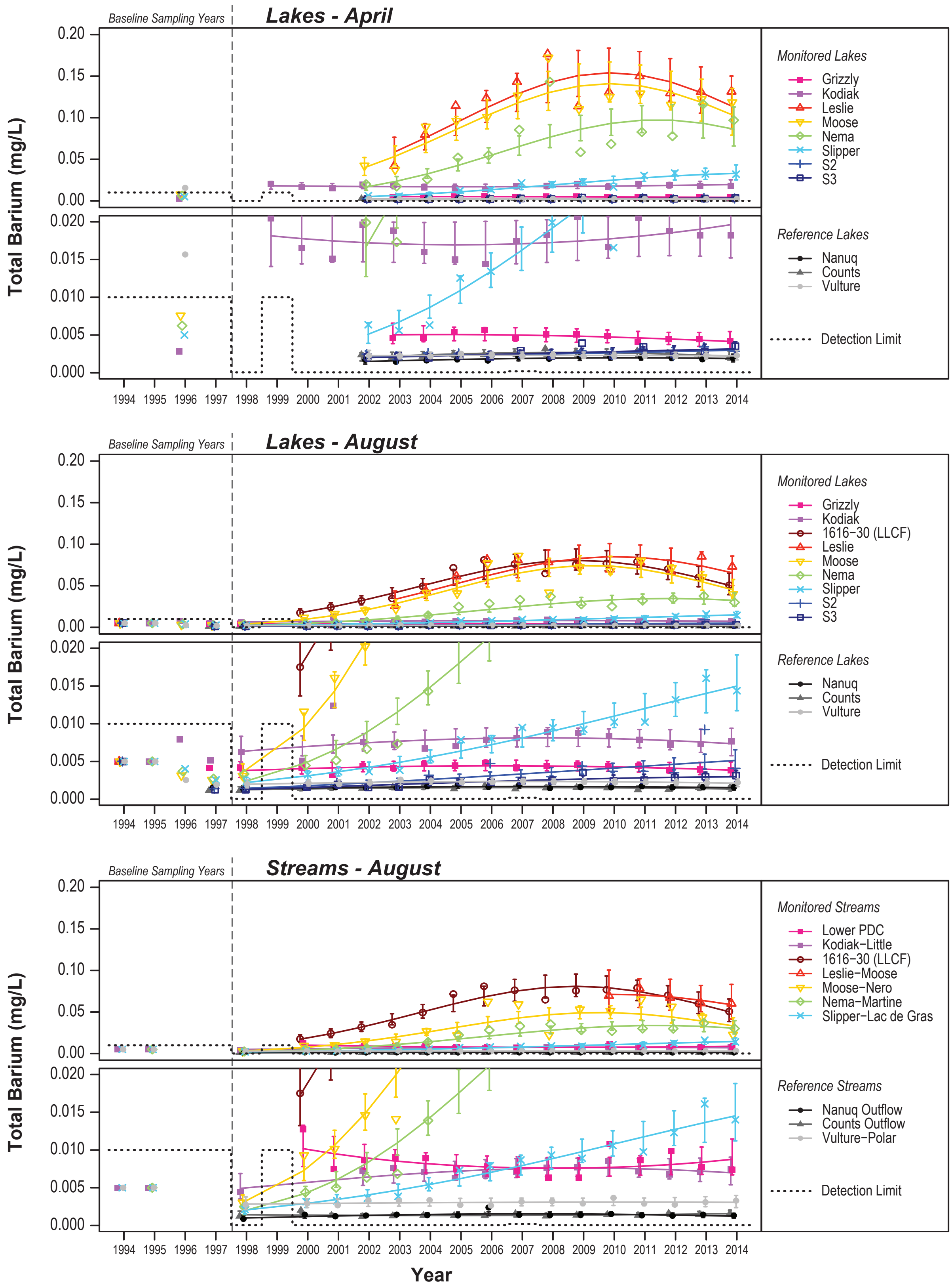
Observed and Fitted Means for Total Arsenic Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
CCME Guideline = 0.005 mg/L.

Figure 4-16

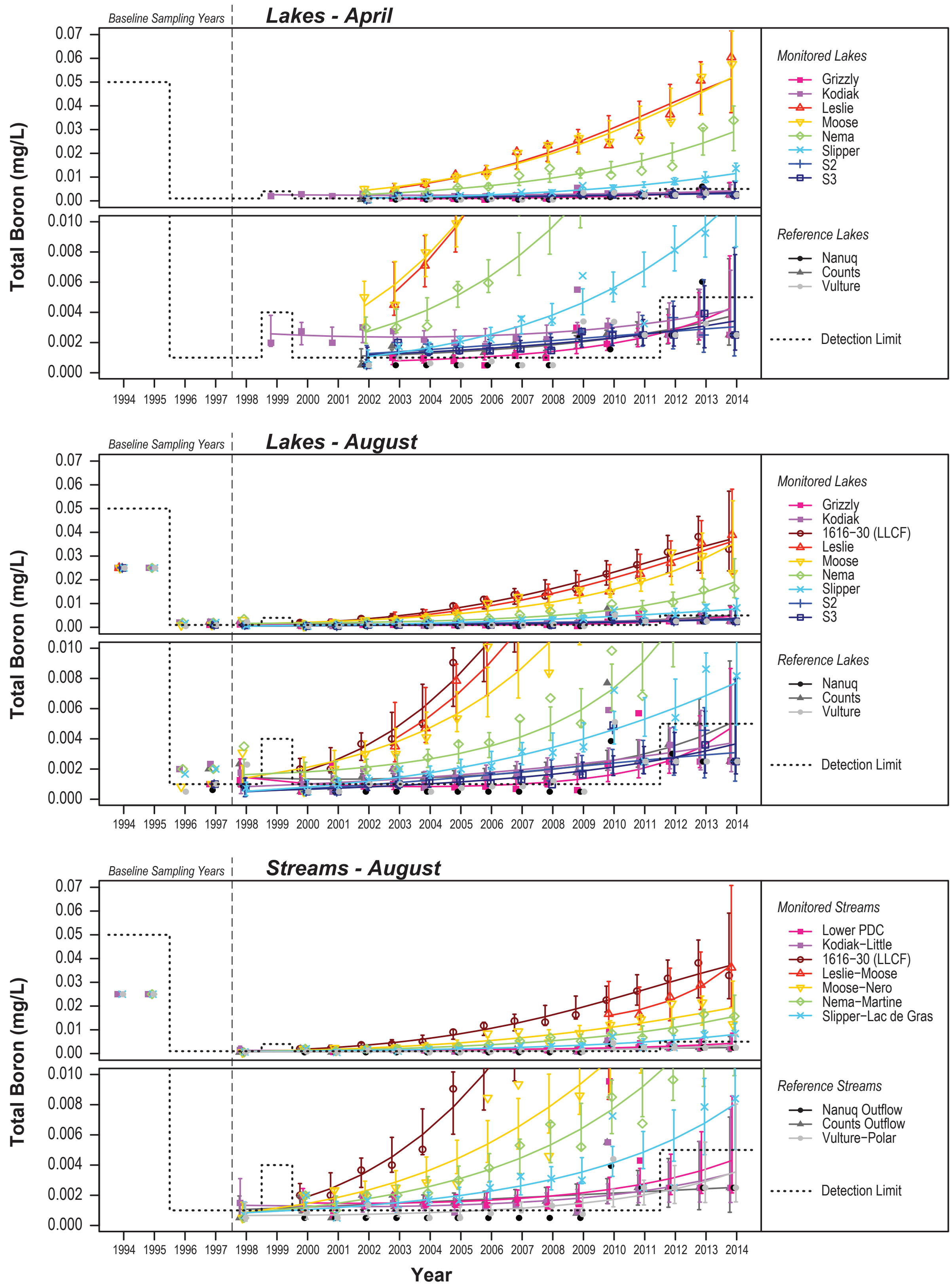
Observed and Fitted Means for Total Barium Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
Water quality benchmark (Haywood and Drinnan 1983) = 1 mg/L.

Figure 4-17

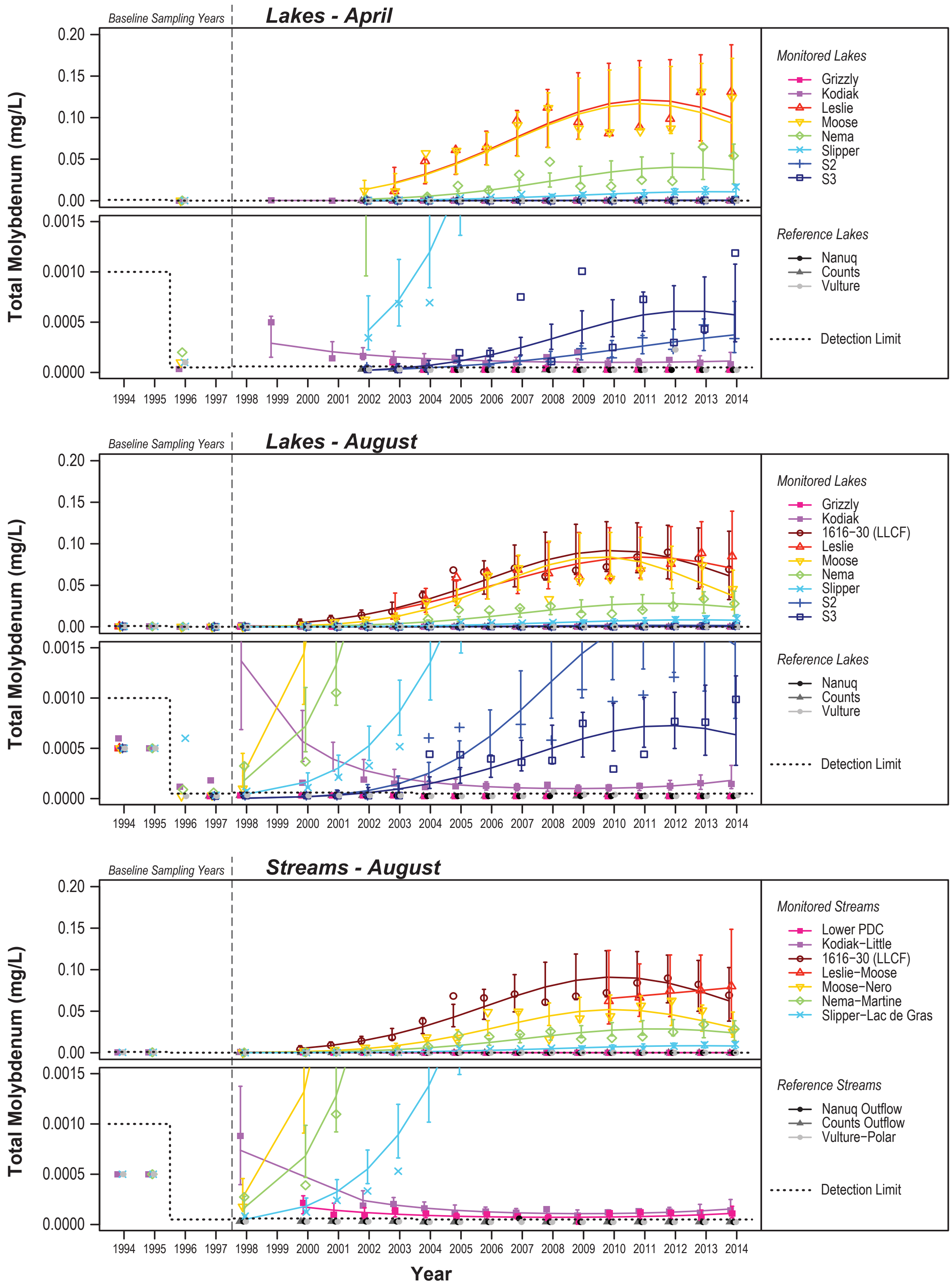
Observed and Fitted Means for Total Boron Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
CCME Guideline = 1.5 mg/L.

Figure 4-18

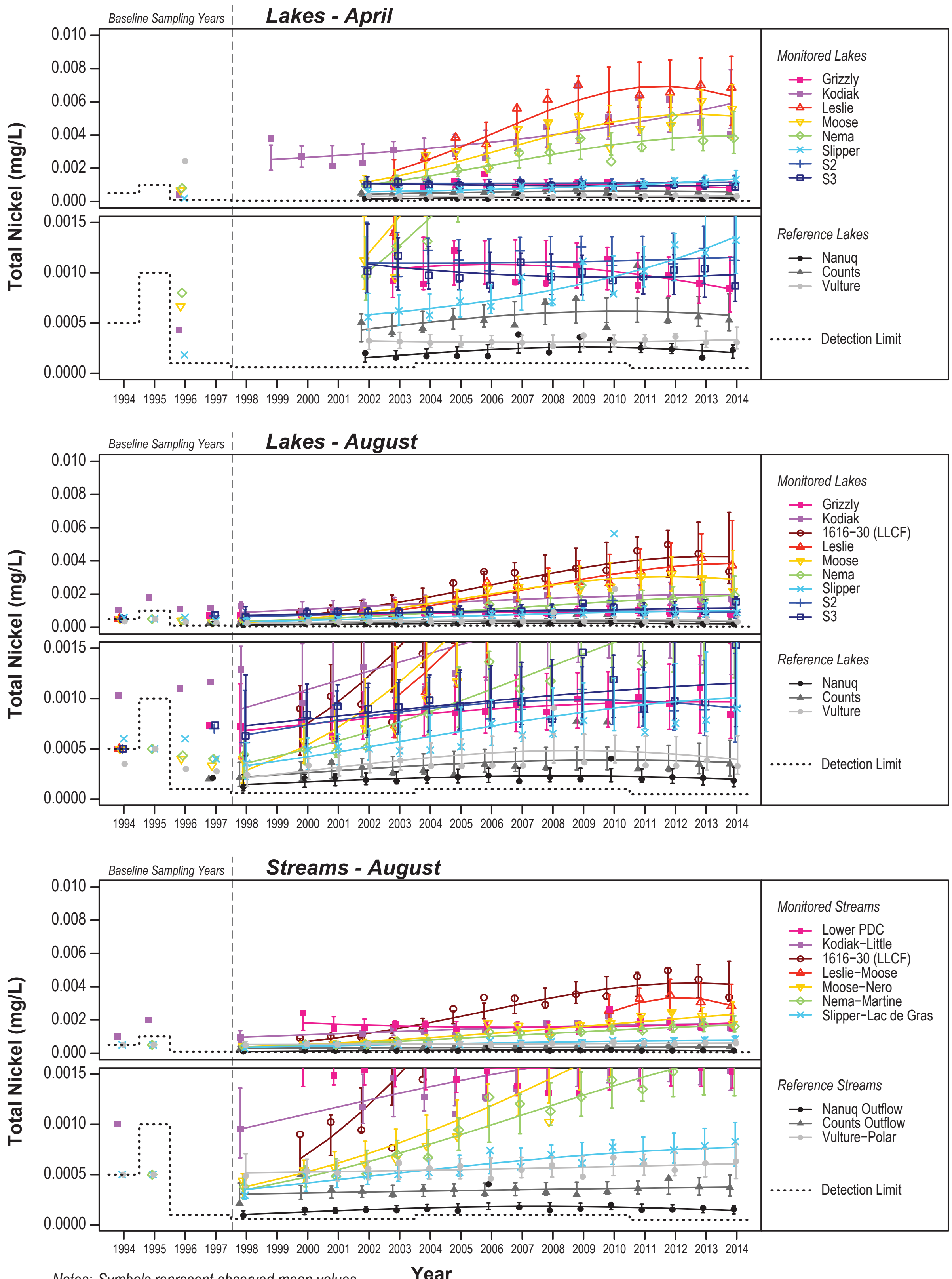
Observed and Fitted Means for Total Molybdenum Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
SSWQO = 19.38 mg/L.

Figure 4-19

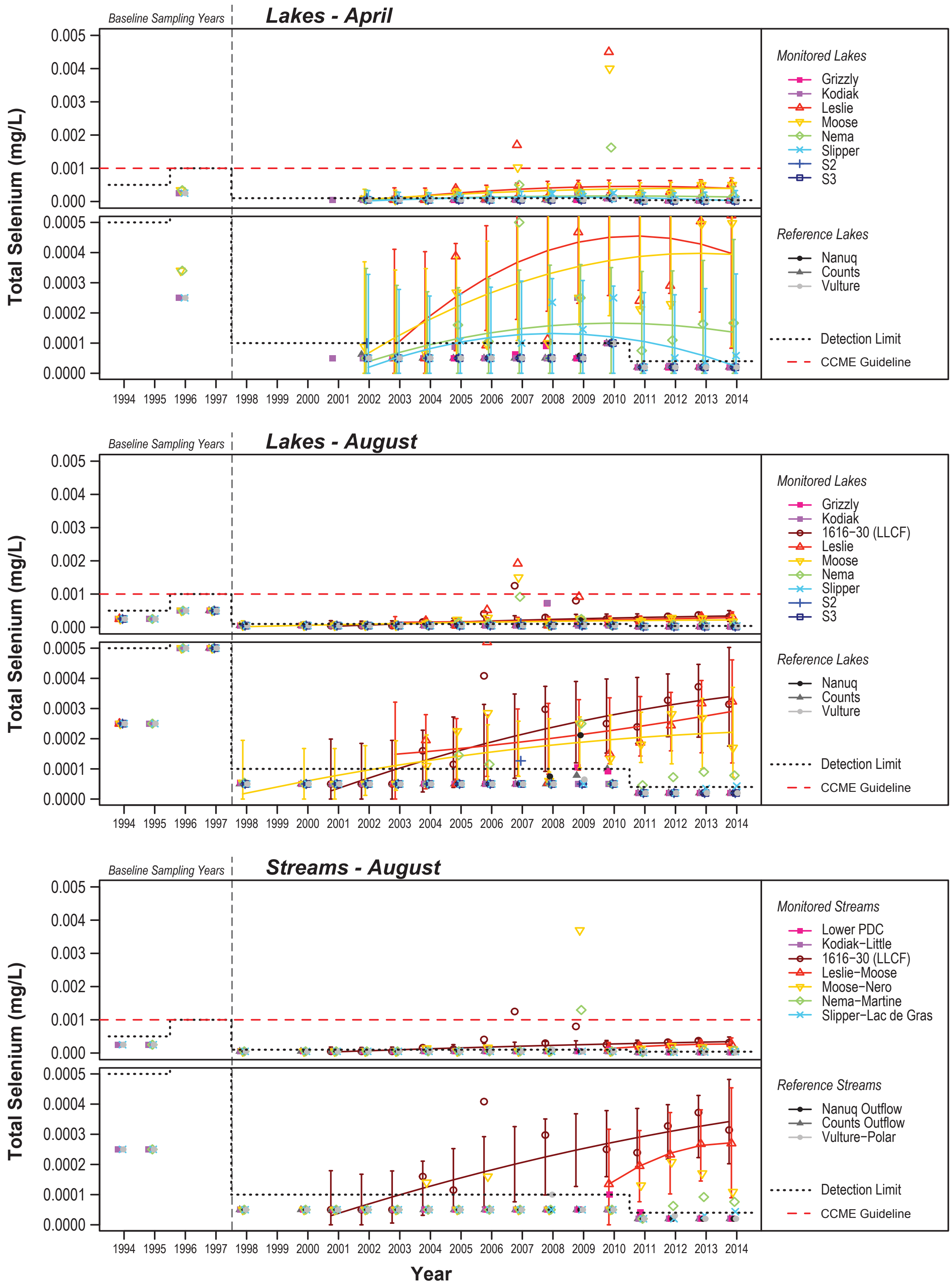
Observed and Fitted Means for Total Nickel Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
CCME Guideline = $e^{0.76 X (lnHardness) + 1.06}$/1000 mg/L, where hardness = 60 - 180 mg/L, 0.025 mg/L where hardness < 60 mg/L, and 0.15 mg/L where hardness > 180 mg/L.

Figure 4-20

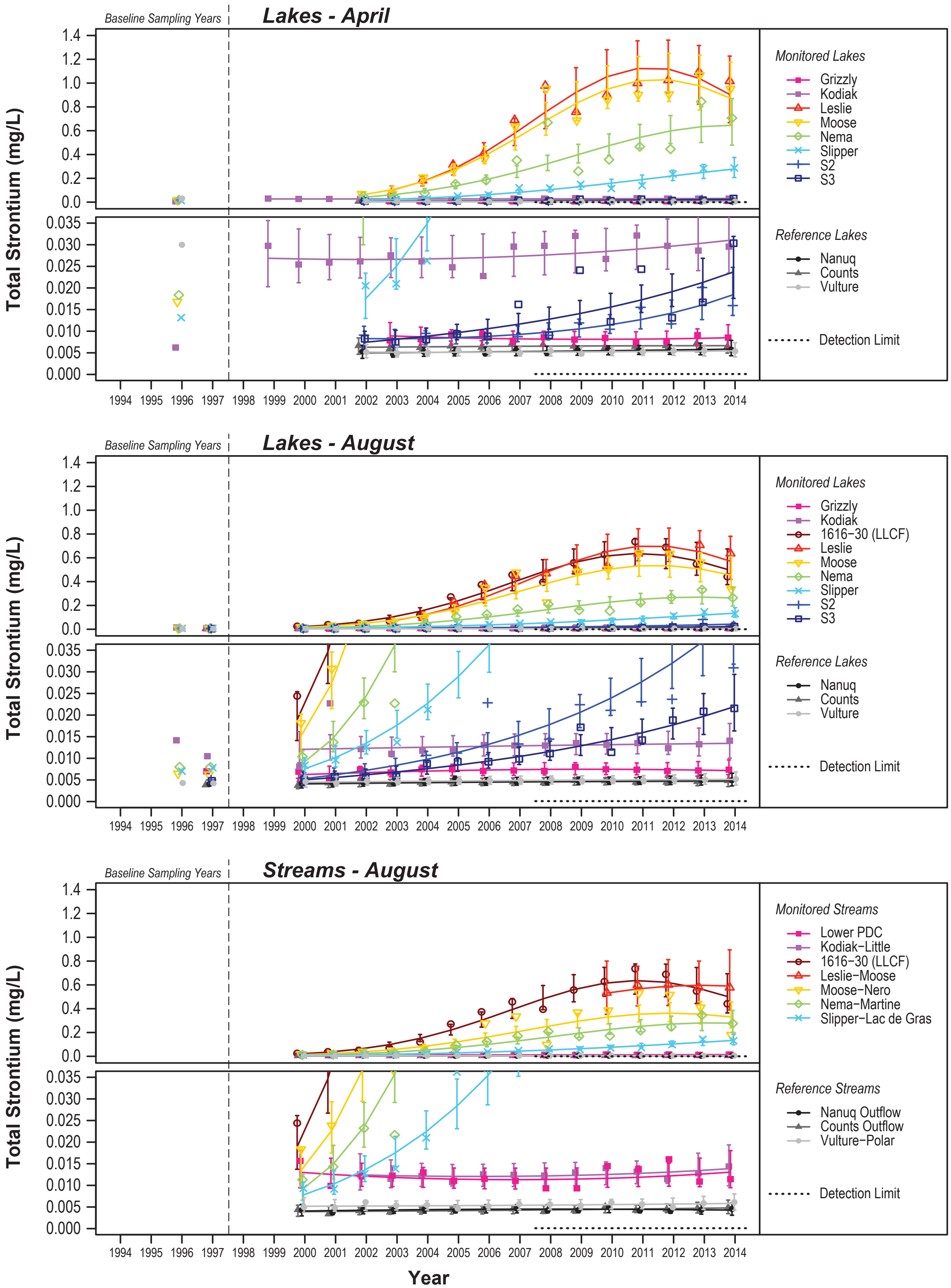
Observed and Fitted Means for Total Selenium Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
CCME Guideline = 0.001 mg/L

Figure 4-21

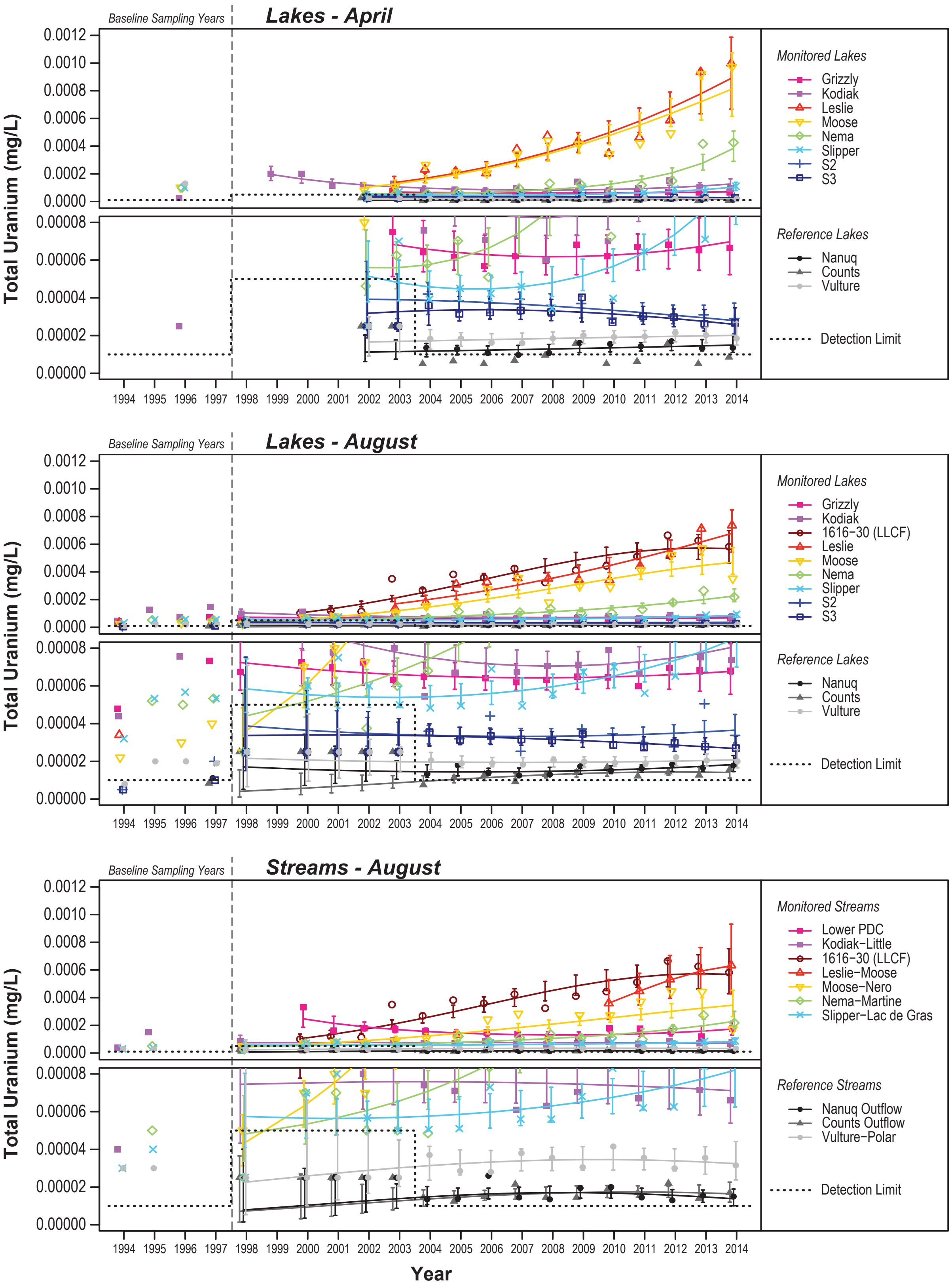
Observed and Fitted Means for Total Strontium Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
Water quality benchmark (Golder 2011) = 6.242 mg/L.

Figure 4-22

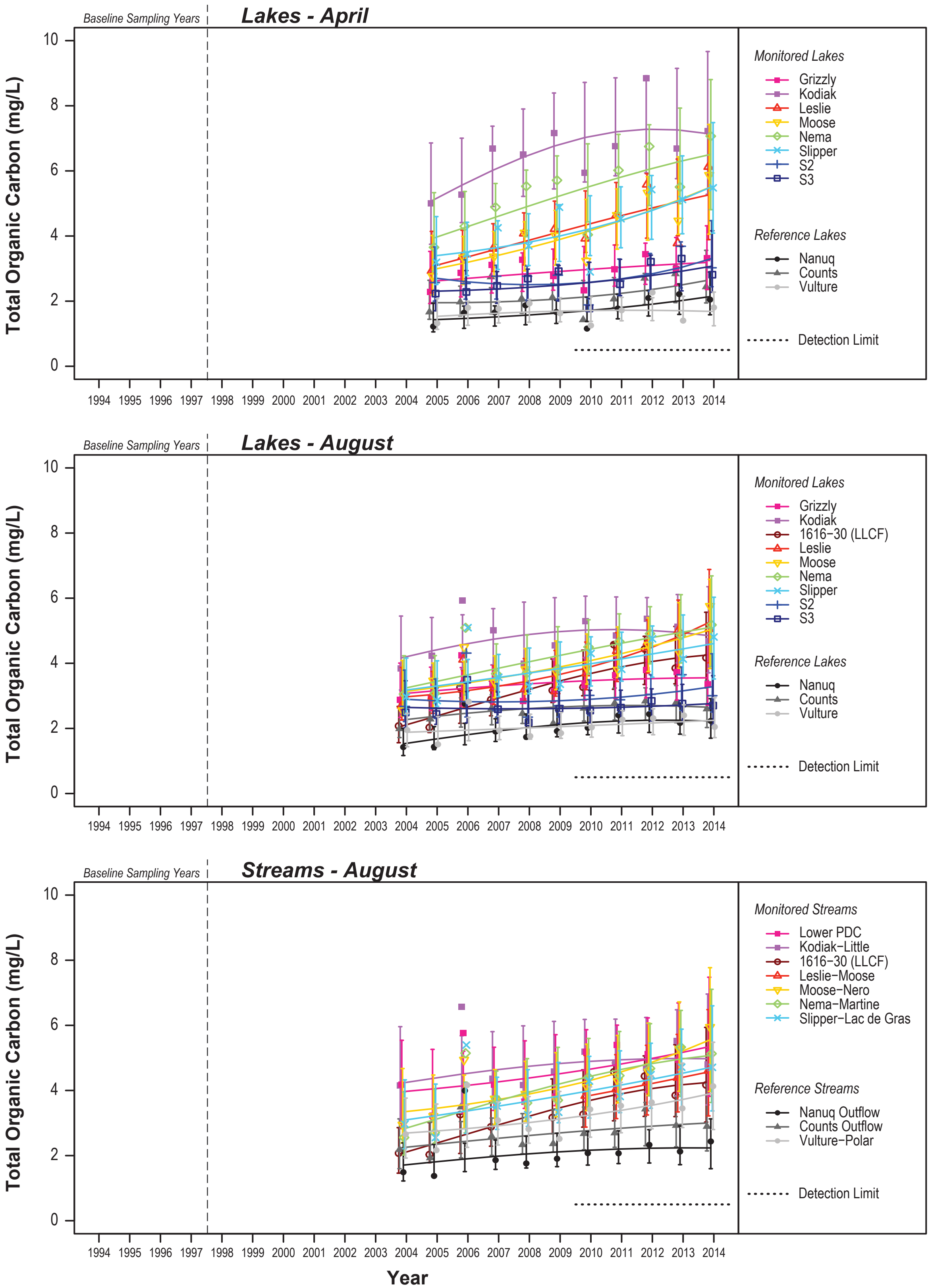
Observed and Fitted Means for Total Uranium Concentrations in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
CCME Guideline = 0.015 mg/L.

Figure 4-23

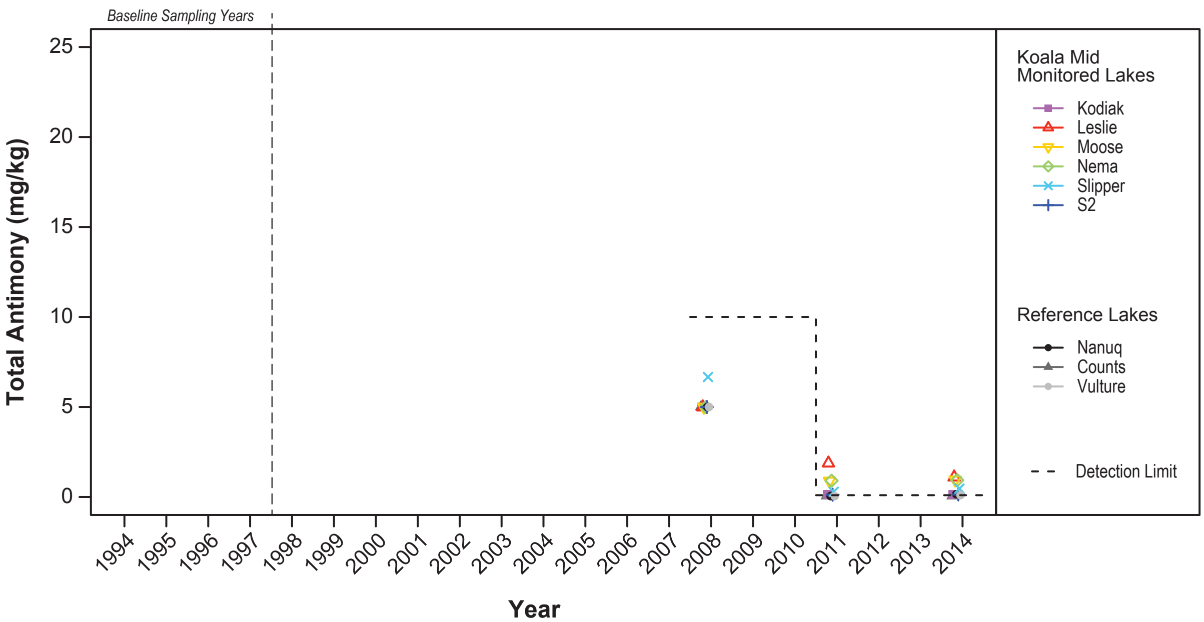
Observed and Fitted Means for Total Organic Carbon in Koala Watershed Lakes and Streams and Lac de Gras, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.

Figure 4-24

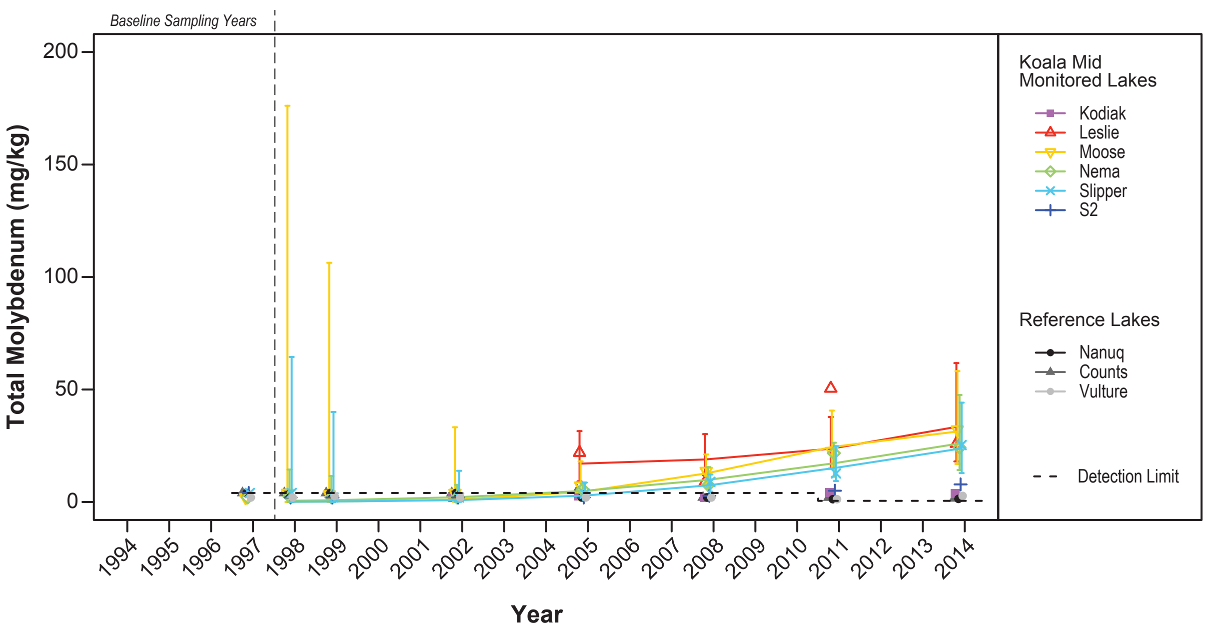
Observed and Fitted Means for Total Antimony Concentrations in Sediments in Koala Watershed Lakes and Lac de Gras, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.

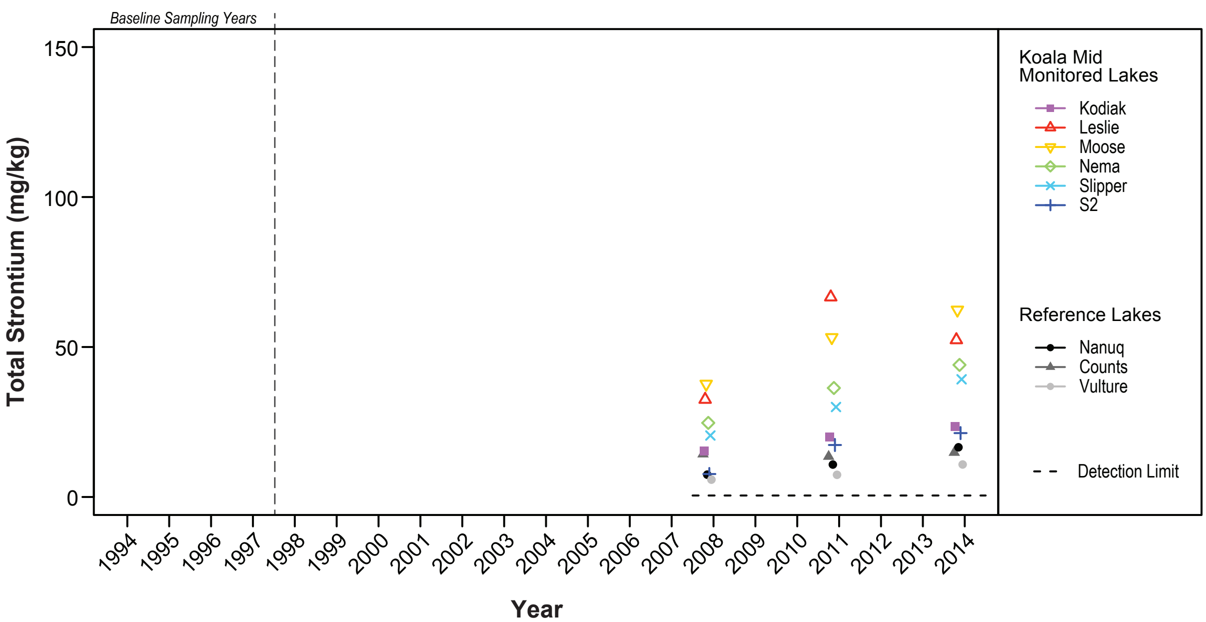
Figure 4-25

Observed and Fitted Means for Total Molybdenum Concentrations in Sediments in Koala Watershed Lakes and Lac de Gras, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.

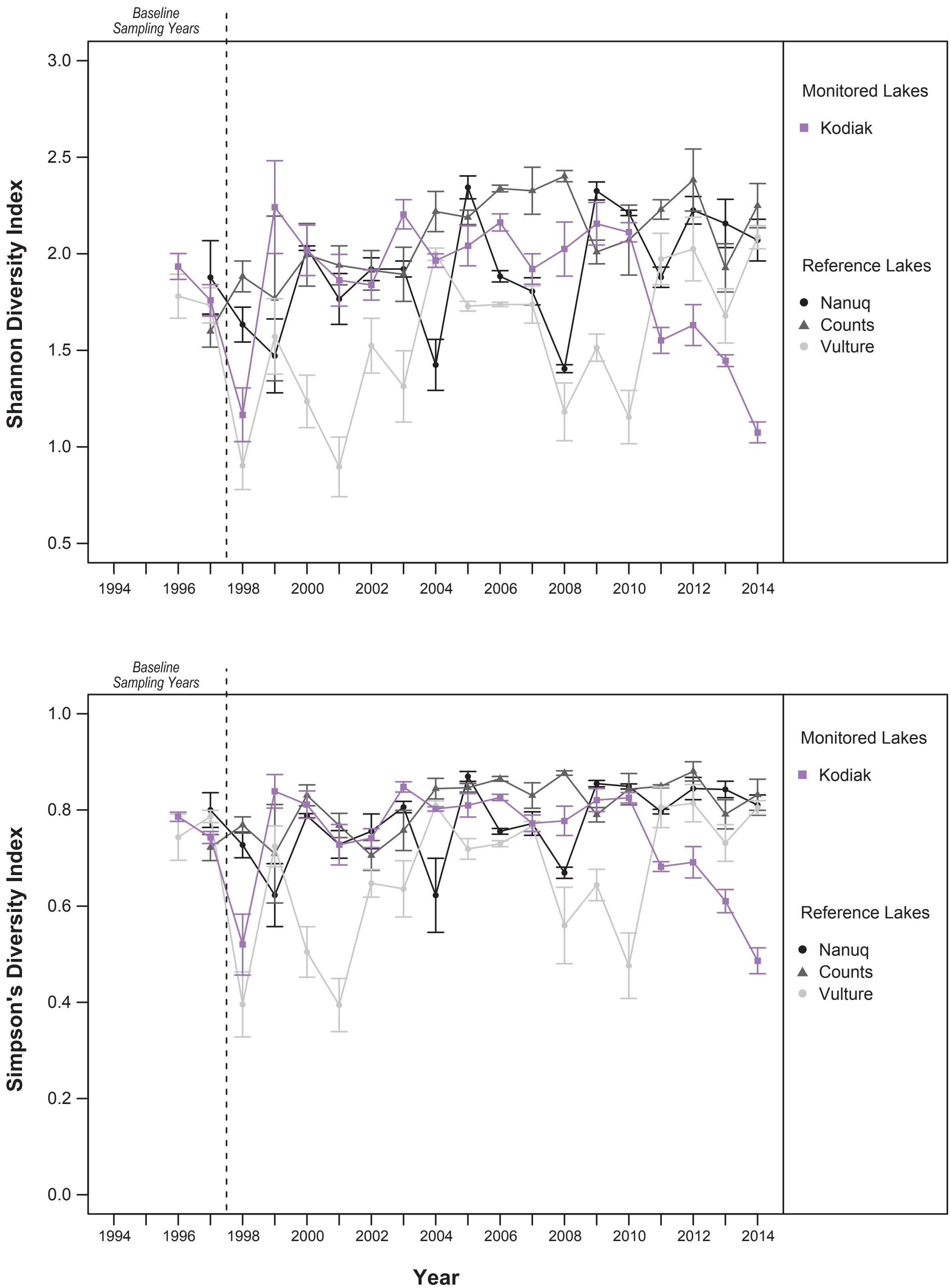
Observed and Fitted Means for Total Strontium Concentrations in Sediments in Koala Watershed Lakes and Lac de Gras, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.

Figure 4-27a

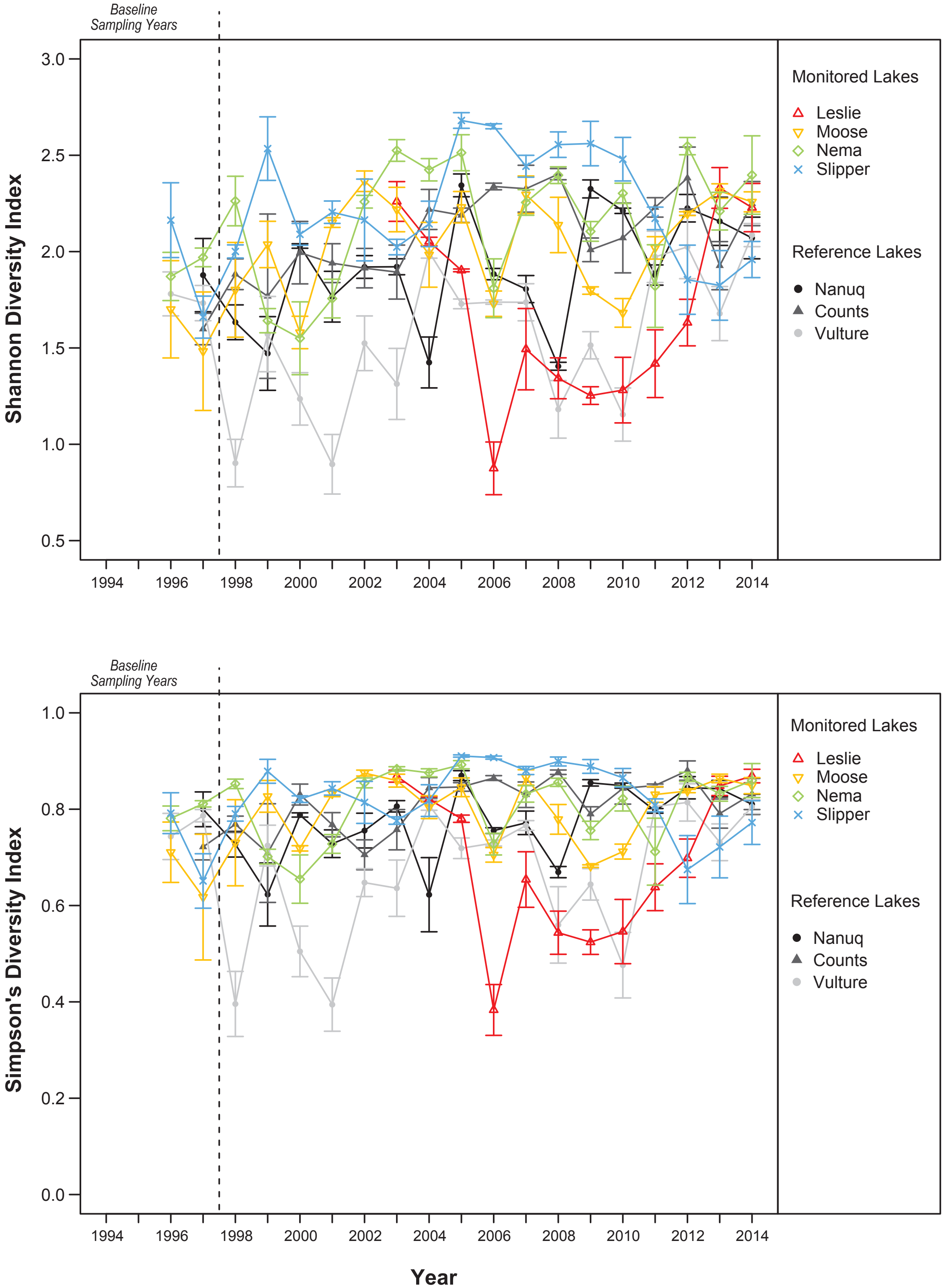
Average Diversity Indices for Phytoplankton in Koala Watershed Lakes and Lac de Gras, 1996 to 2014



Notes: Symbols represent observed mean values.
Error bars indicate standard error of the observed means.

Figure 4-27b

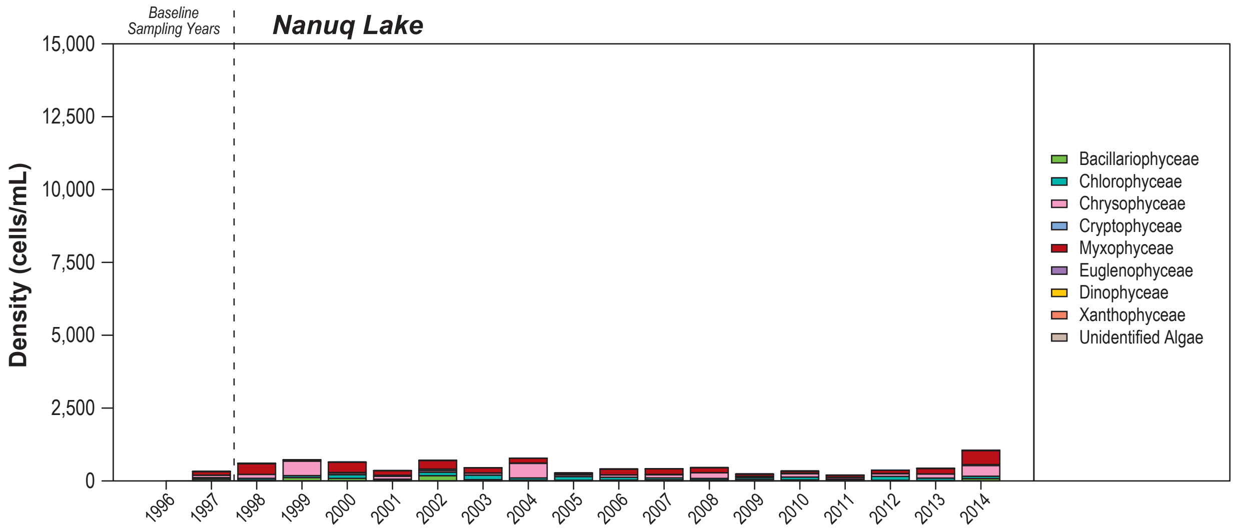
Average Diversity Indices for Phytoplankton in Koala Watershed Lakes and Lac de Gras, 1996 to 2014

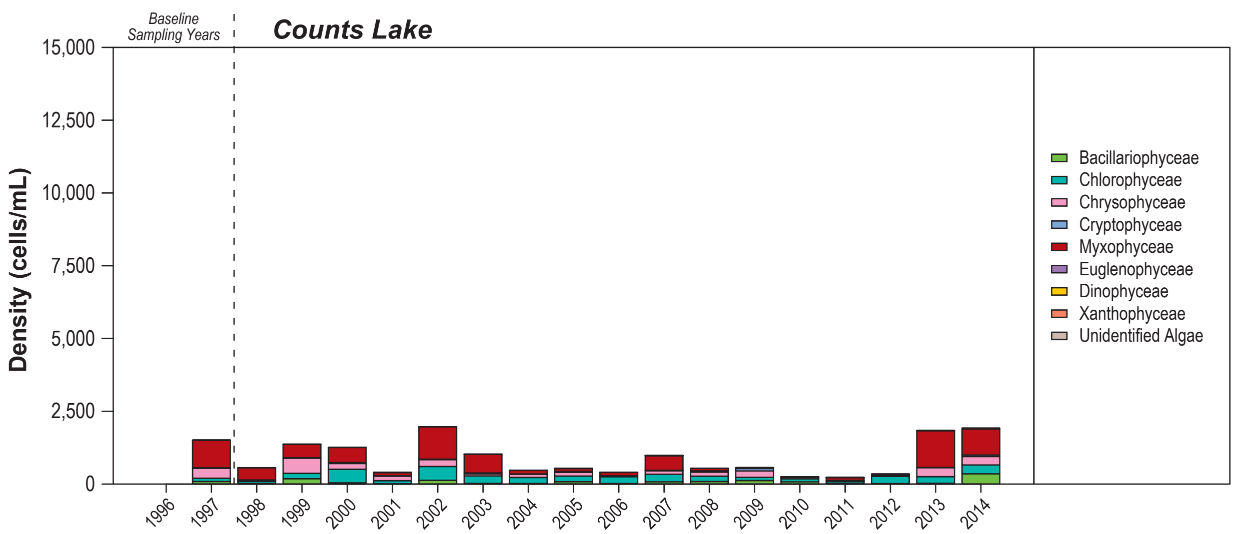


Notes: Symbols represent observed mean values.
Error bars indicate standard error of the observed means.

Figure 4-28

Average Phytoplankton Density by Taxonomic Group for AEMP Reference Lakes, 1996 to 2014





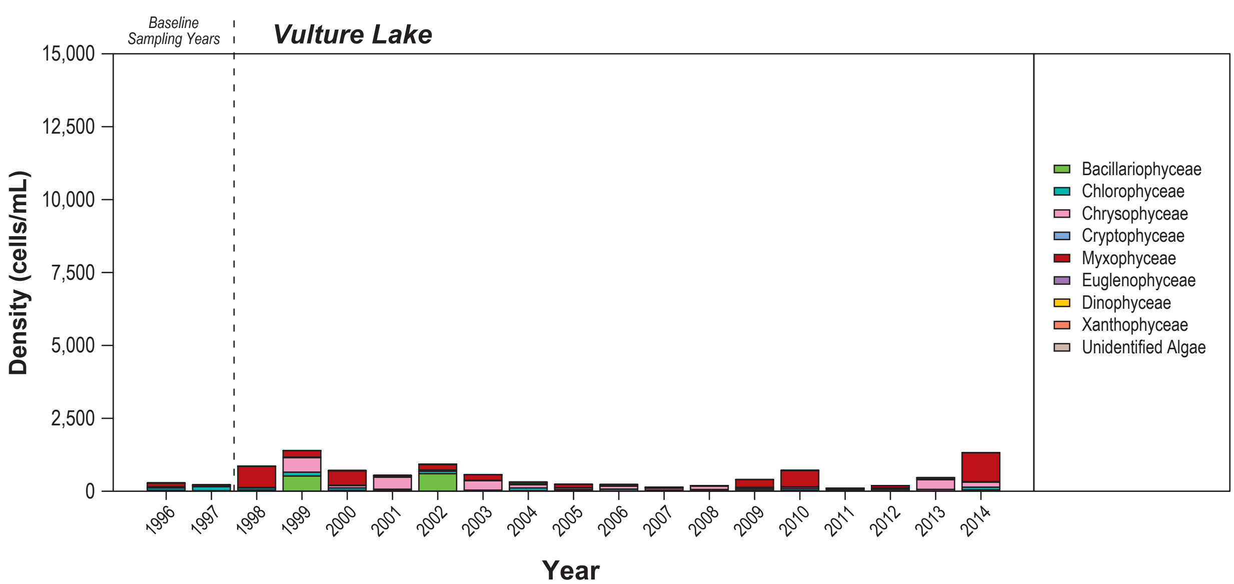
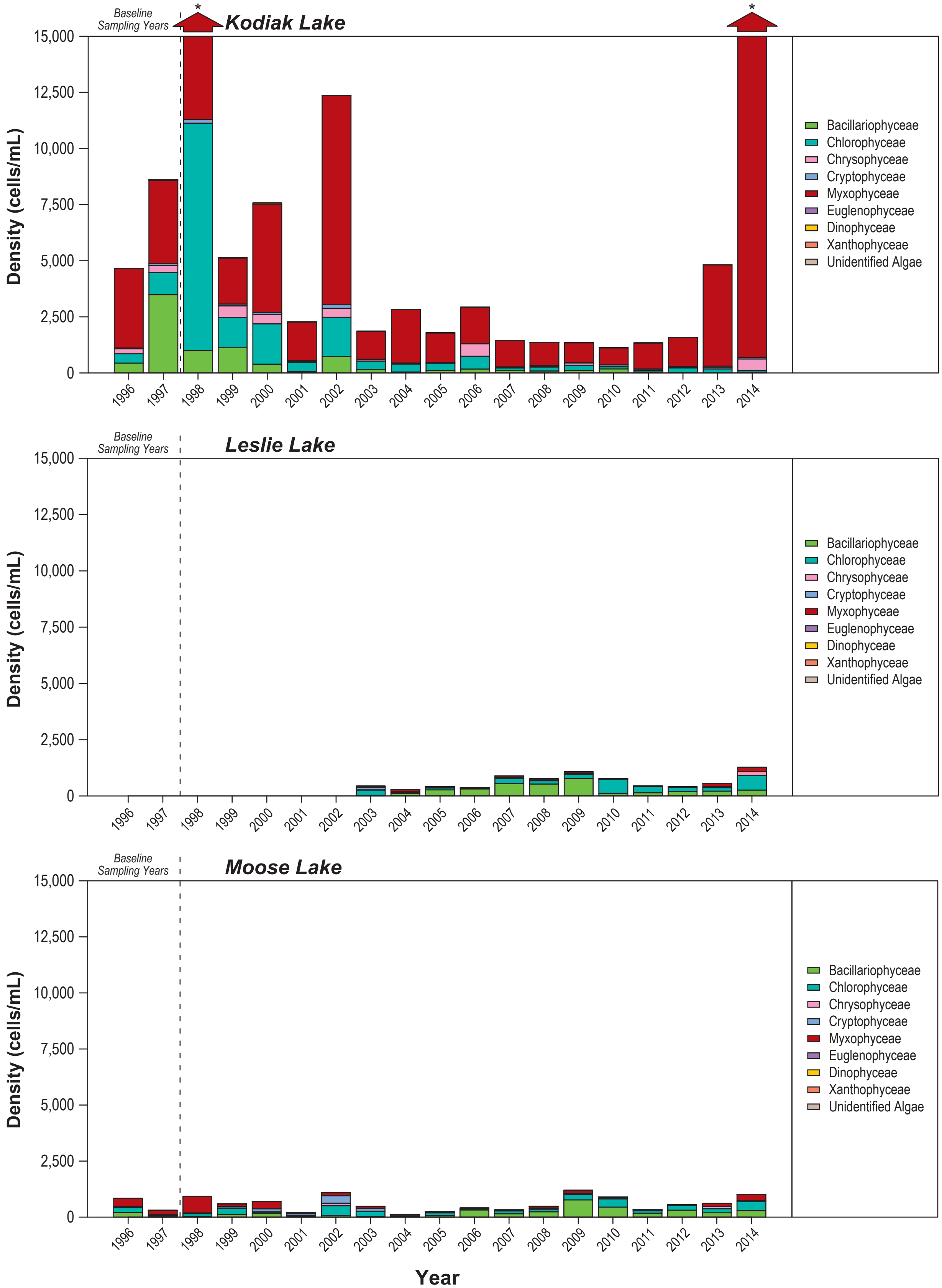


Figure 4-29a

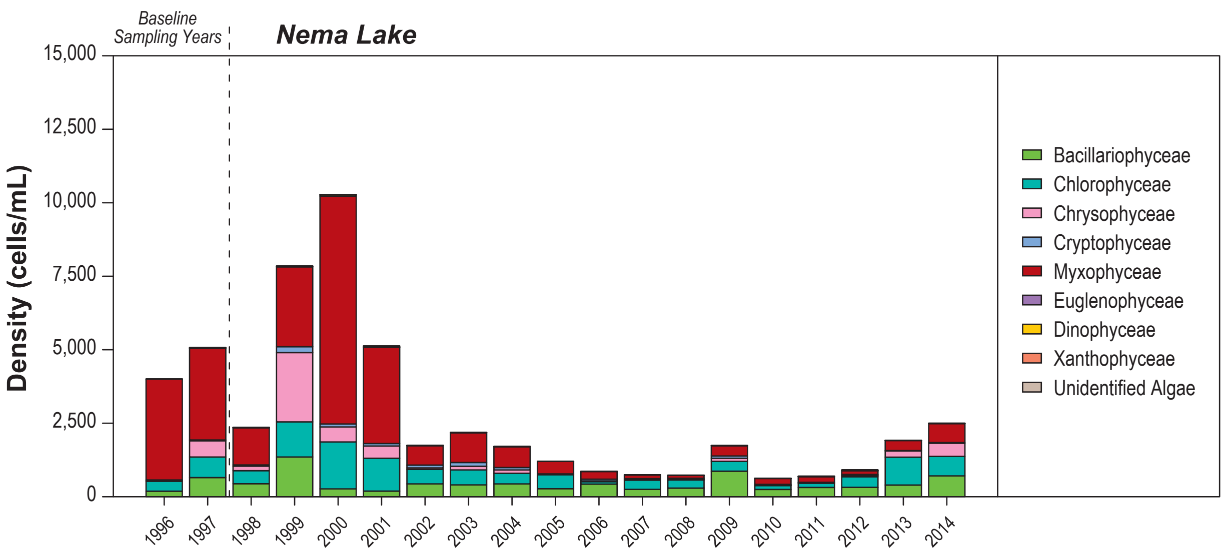
Average Phytoplankton Density by Taxonomic Group for Lakes of the Koala Watershed, 1996 to 2014



*Note: *Total density in 1998 = 15,705: Myxophyceae = 4,409; Total density in 2014 = 22,912: Myxophyceae = 22,197, Euglenophyceae = 4, Dinophyceae = 15.*

Figure 4-29b

Average Phytoplankton Density by Taxonomic Group for Lakes of the Koala Watershed, 1996 to 2014



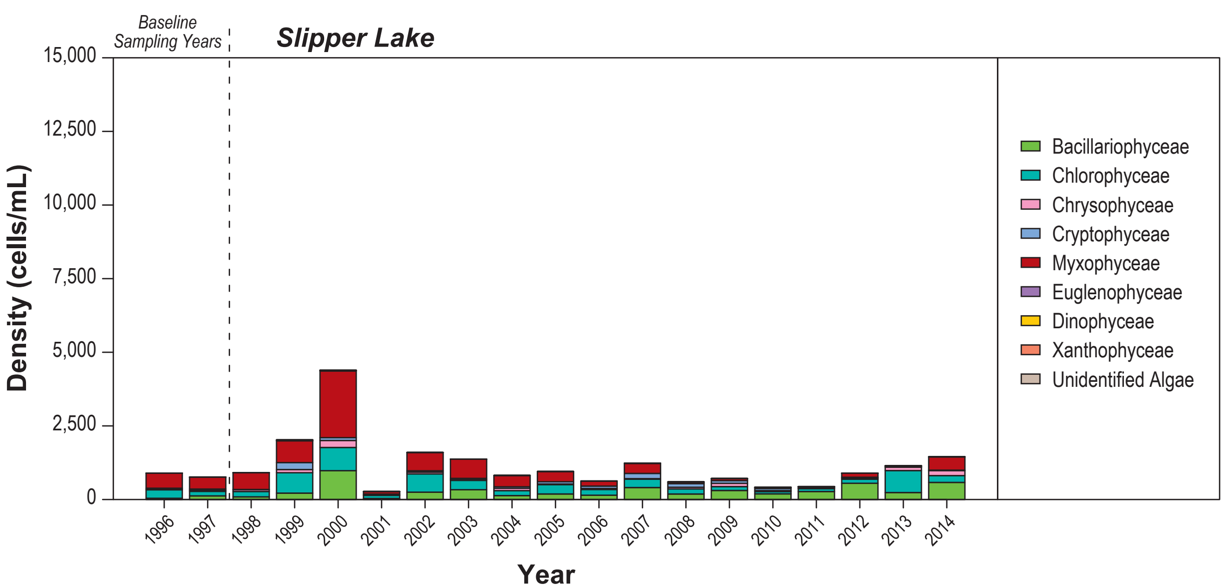
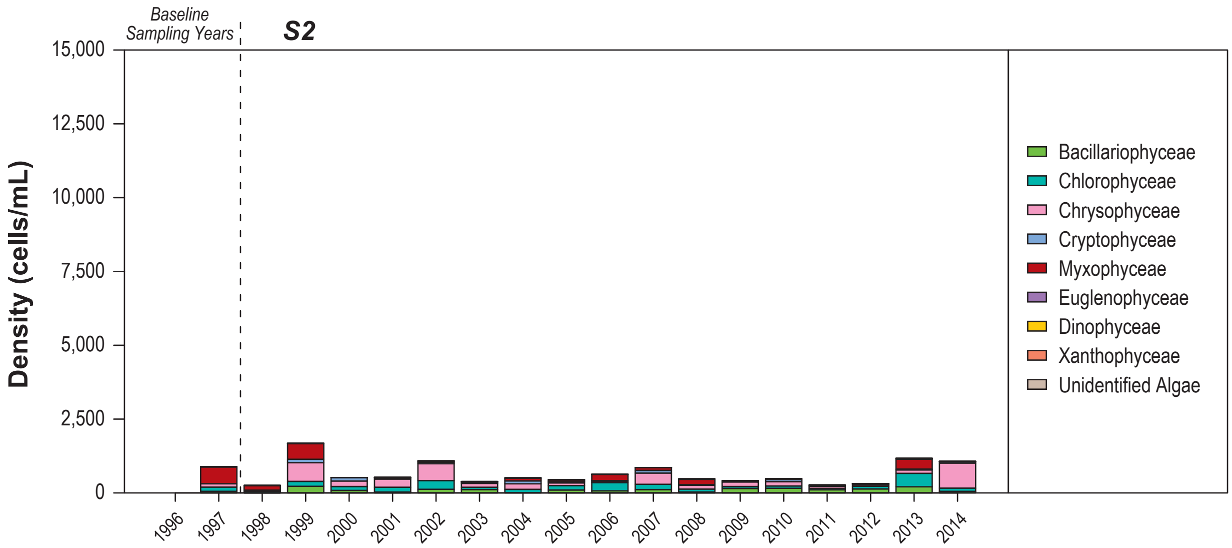


Figure 4-30

Average Phytoplankton Density by Taxonomic Group for Lac de Gras, 1996 to 2014



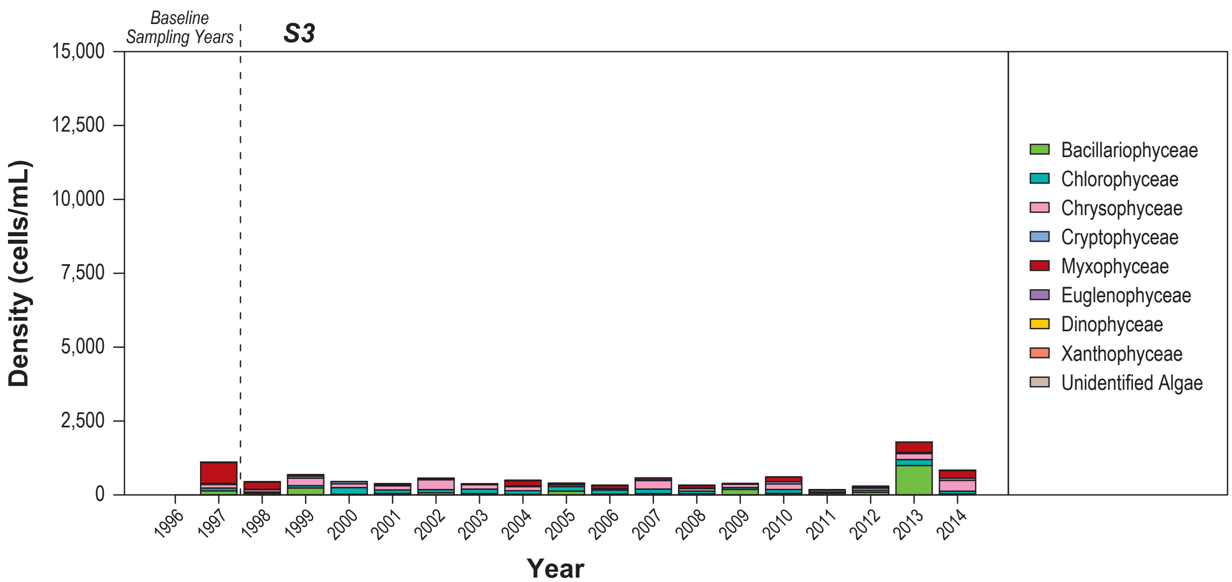


Figure 4-31

Relative Densities of Phytoplankton Taxa in AEMP Reference Lakes, 1996 to 2014

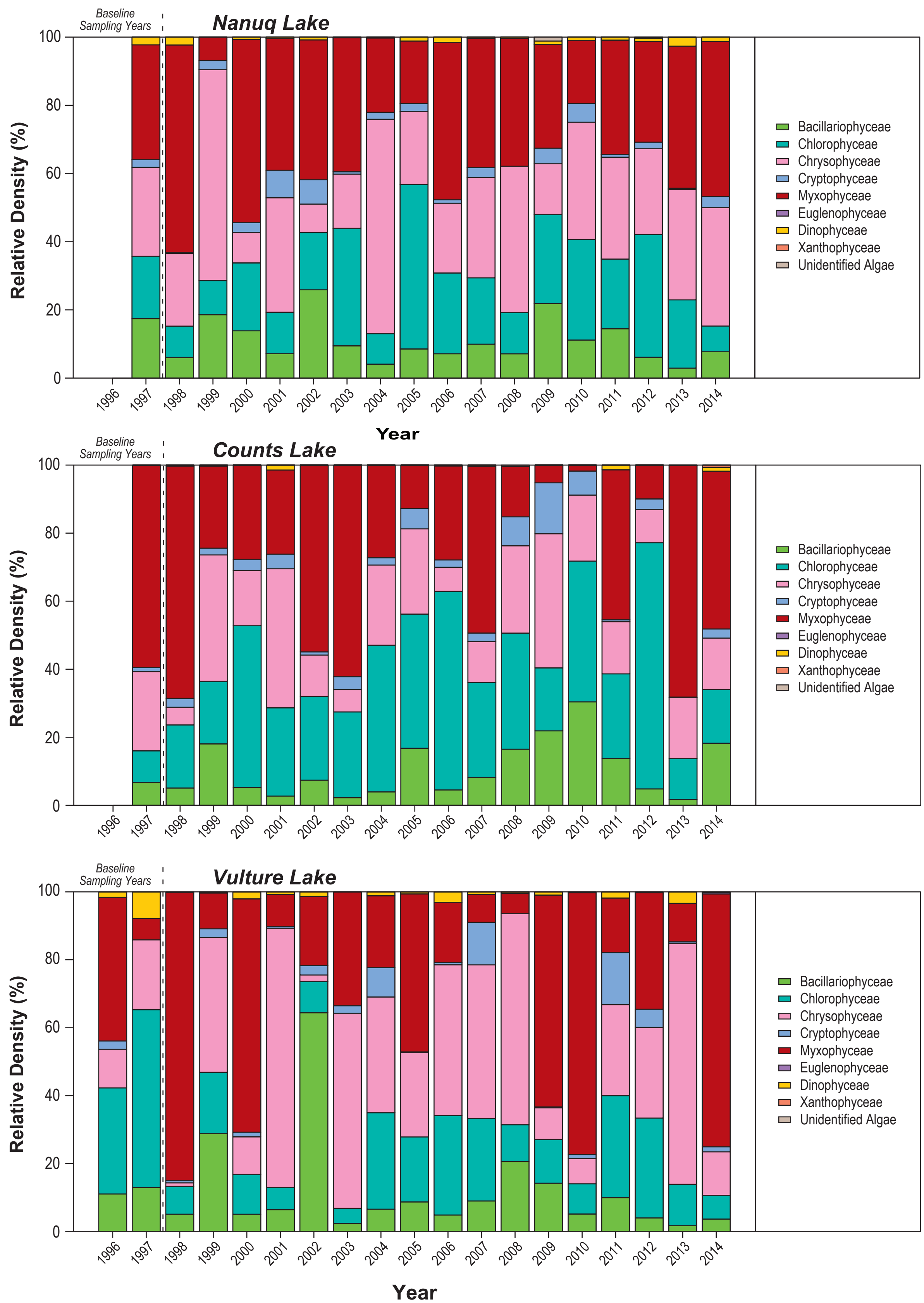


Figure 4-32a

Relative Densities of Phytoplankton Taxa in Lakes of the Koala Watershed, 1996 to 2014

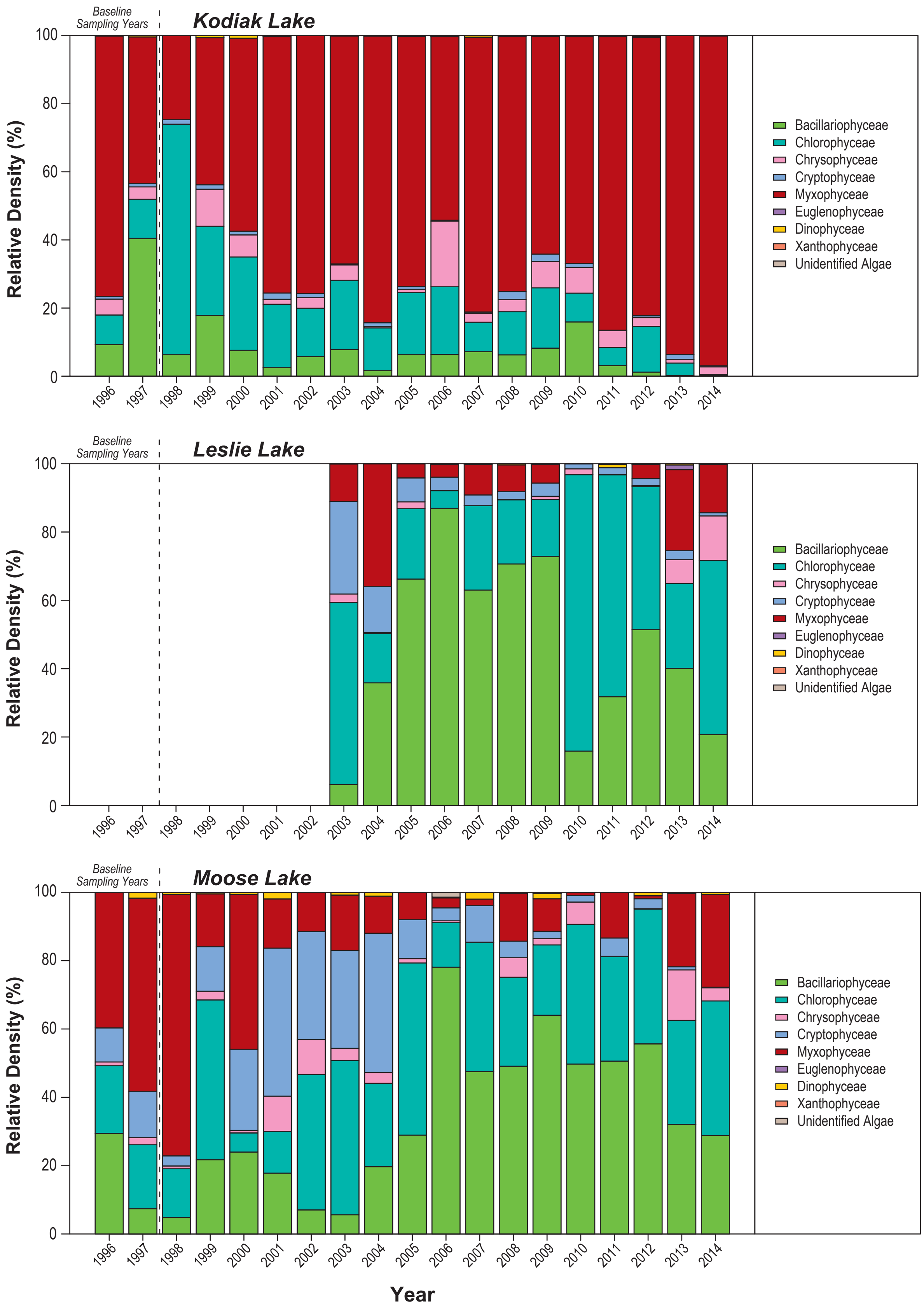


Figure 4-32b

Relative Densities of Phytoplankton Taxa in Lakes of the Koala Watershed, 1996 to 2014

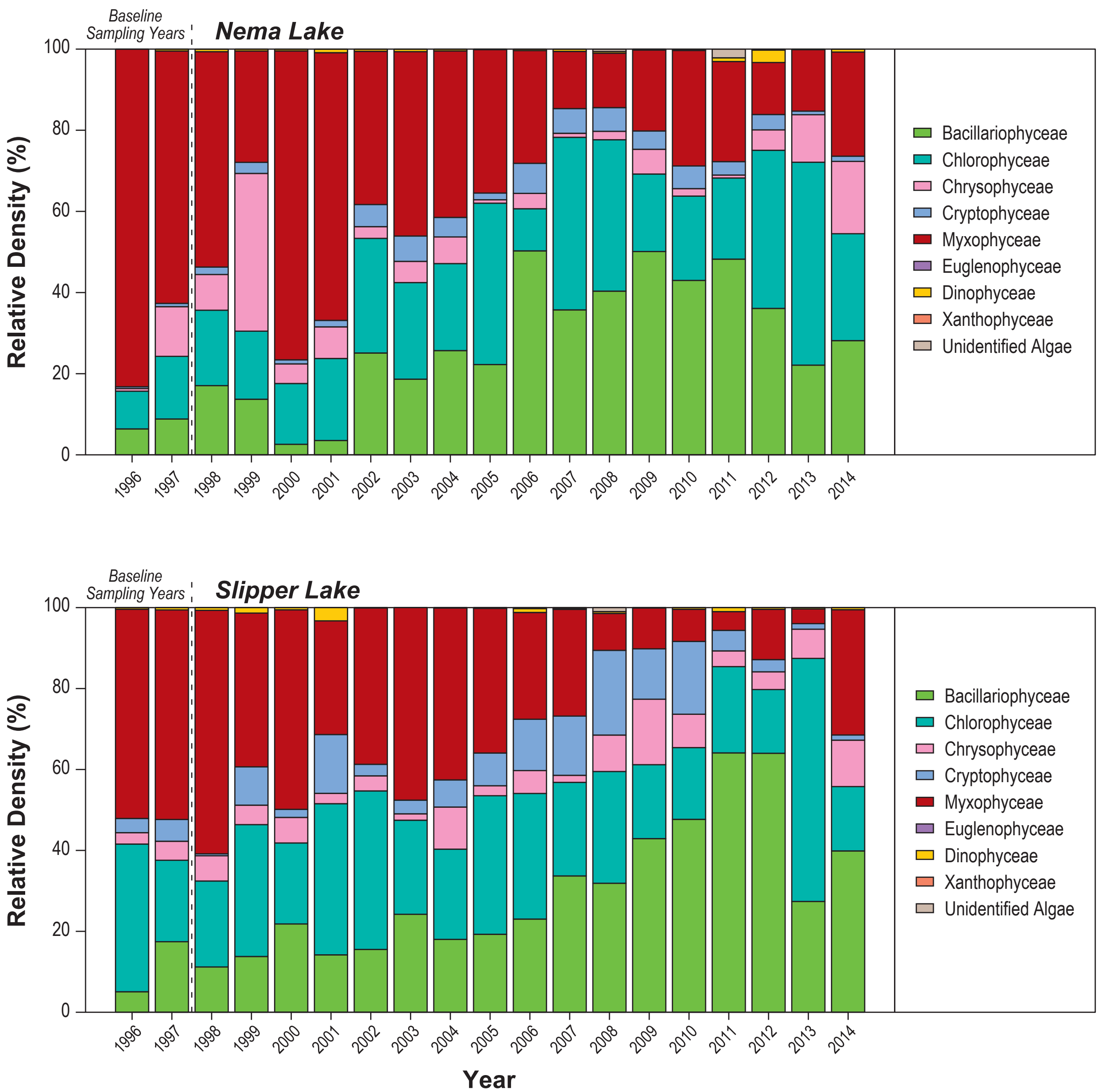


Figure 4-33

Relative Densities of Phytoplankton Taxa in Lac de Gras, 1996 to 2014

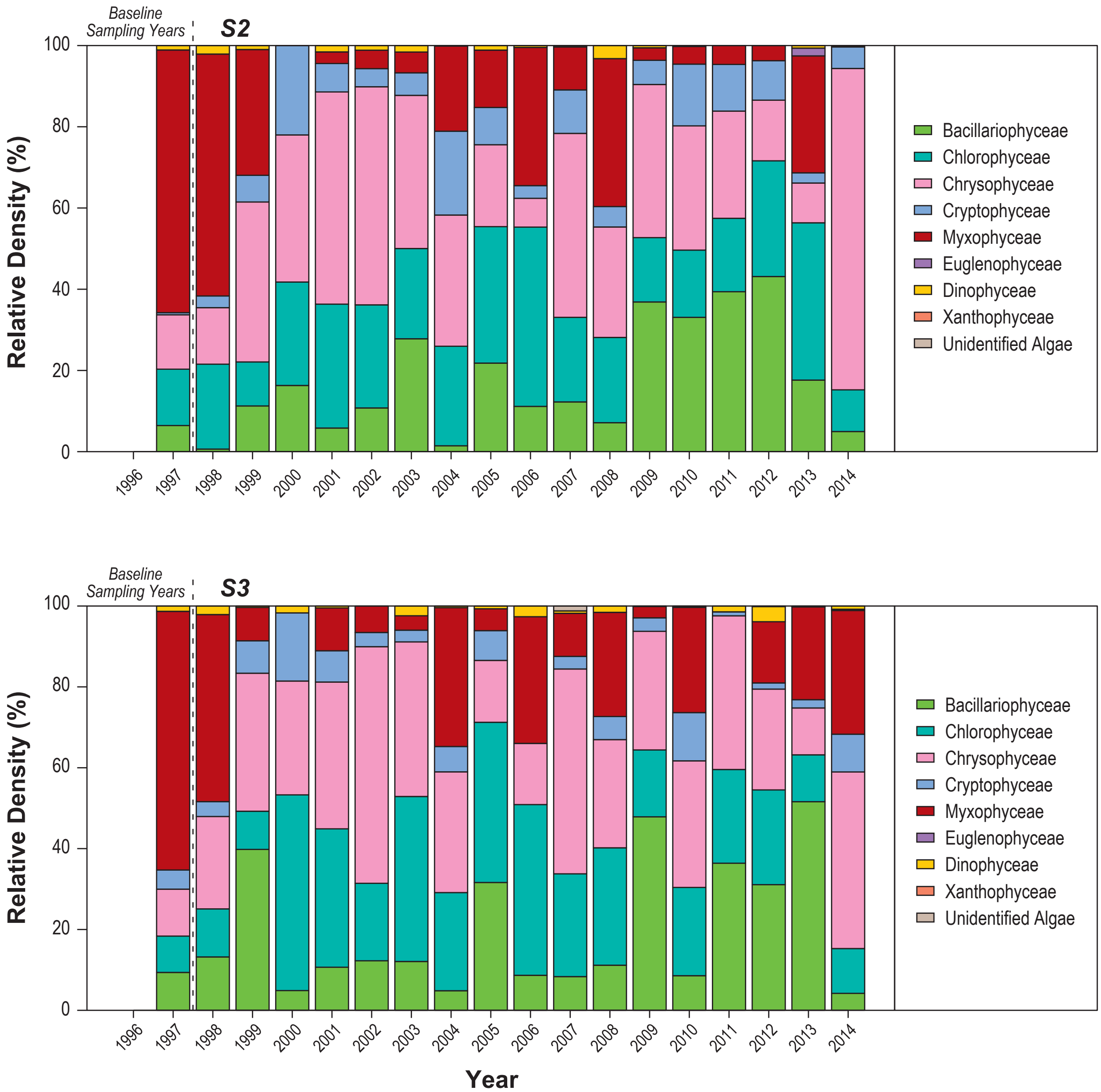
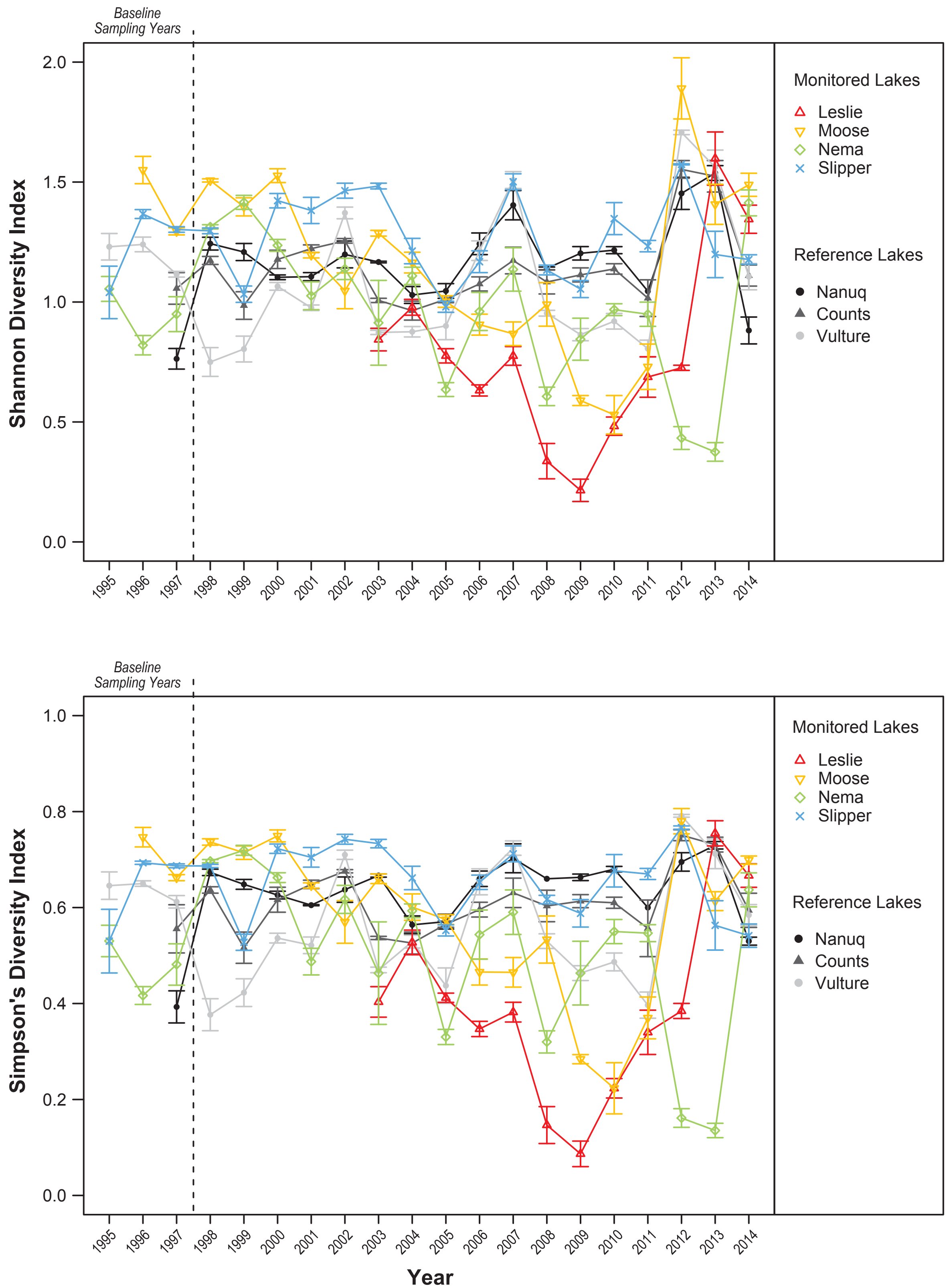


Figure 4-34

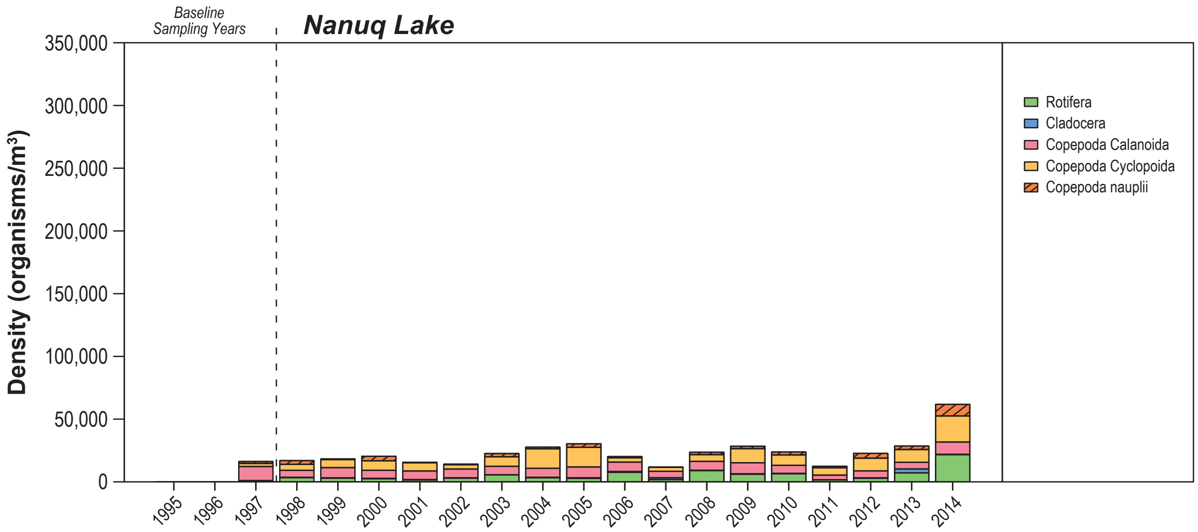
Average Diversity Indices for Zooplankton in Koala Watershed Lakes and Lac de Gras, 1995 to 2014

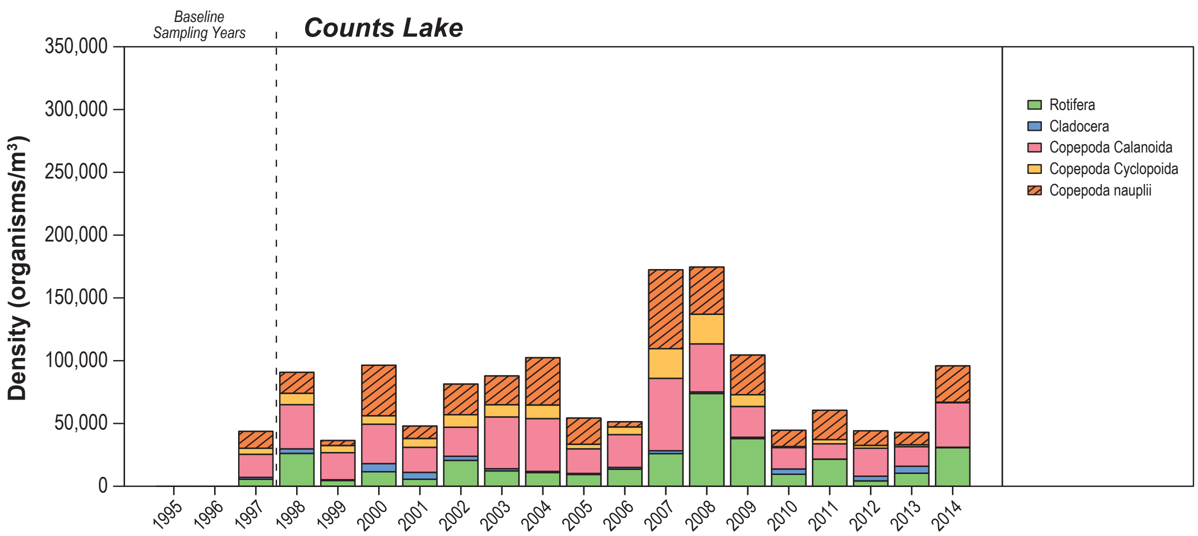


Notes: Symbols represent observed mean values.
Error bars indicate standard error of the observed means.

Figure 4-35

Average Zooplankton Density by Taxonomic Group for AEMP Reference Lakes, 1995 to 2014





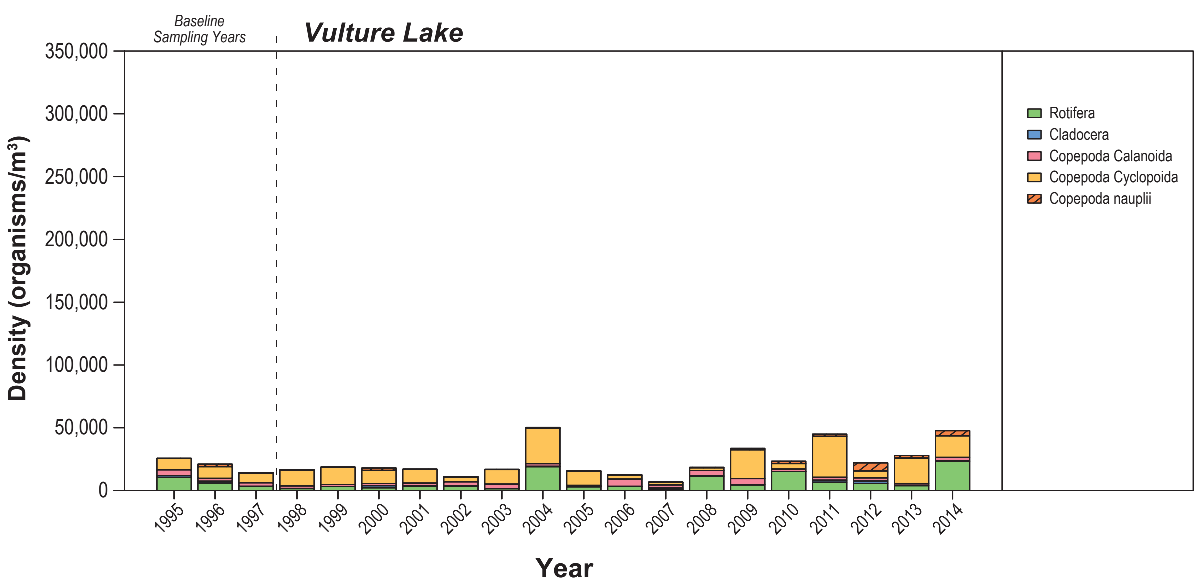


Figure 4-36a

Average Zooplankton Density by Taxonomic Group for Lakes of the Koala Watershed, 1995 to 2014

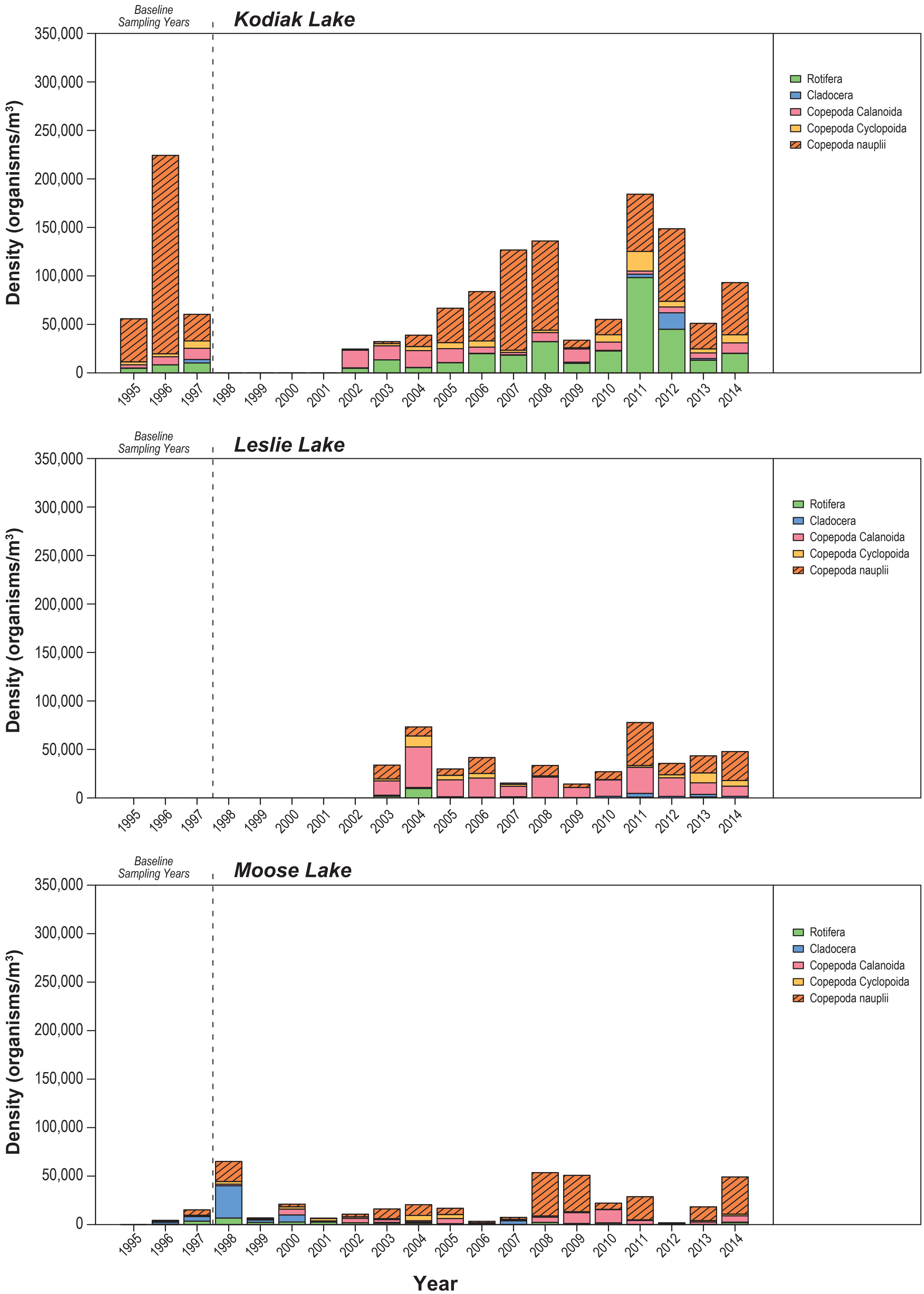


Figure 4-36b

Average Zooplankton Density by Taxonomic Group for Lakes of the Koala Watershed, 1995 to 2014

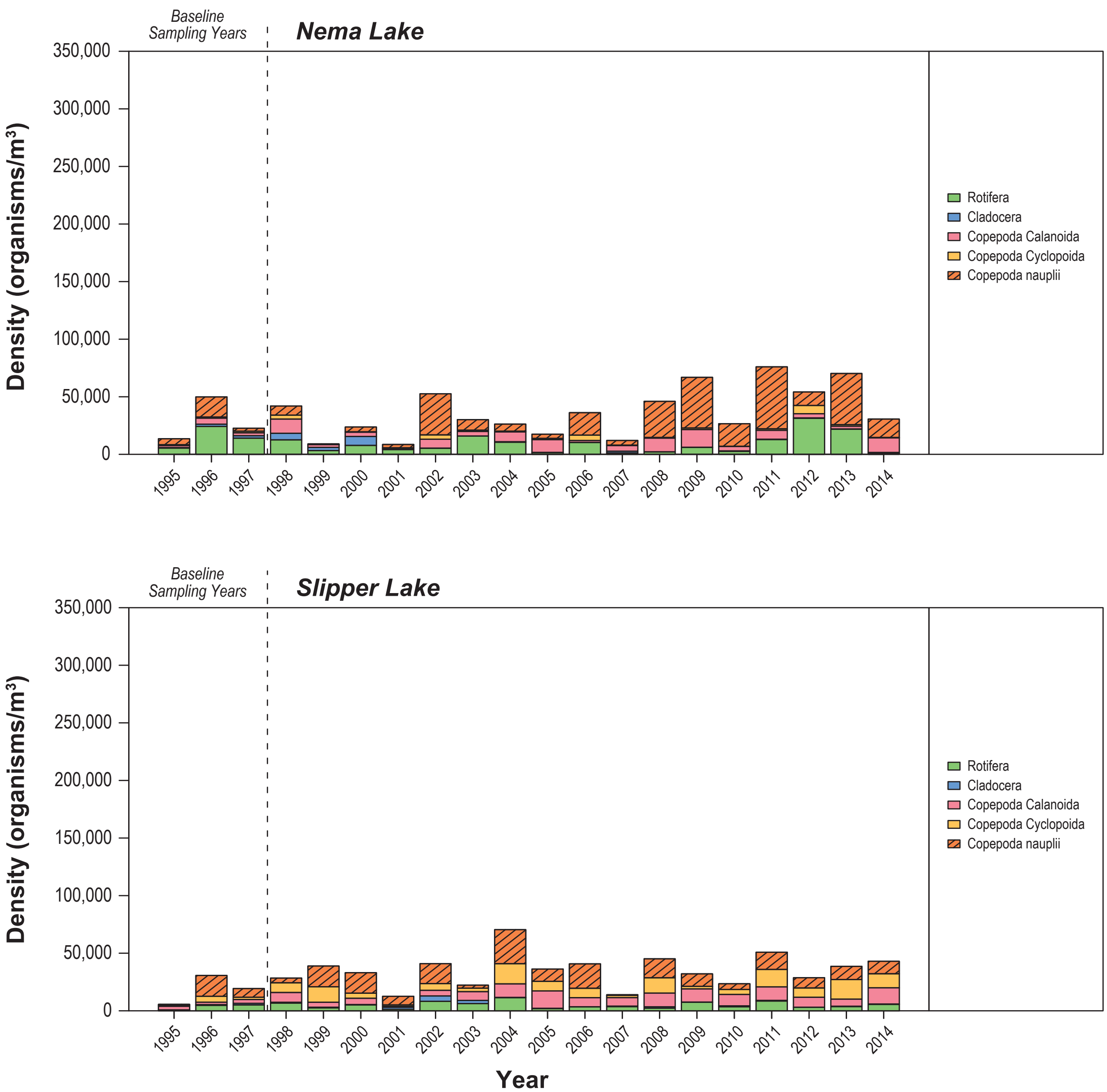


Figure 4-37

Relative Densities of Zooplankton Taxa in AEMP Reference Lakes, 1995 to 2014

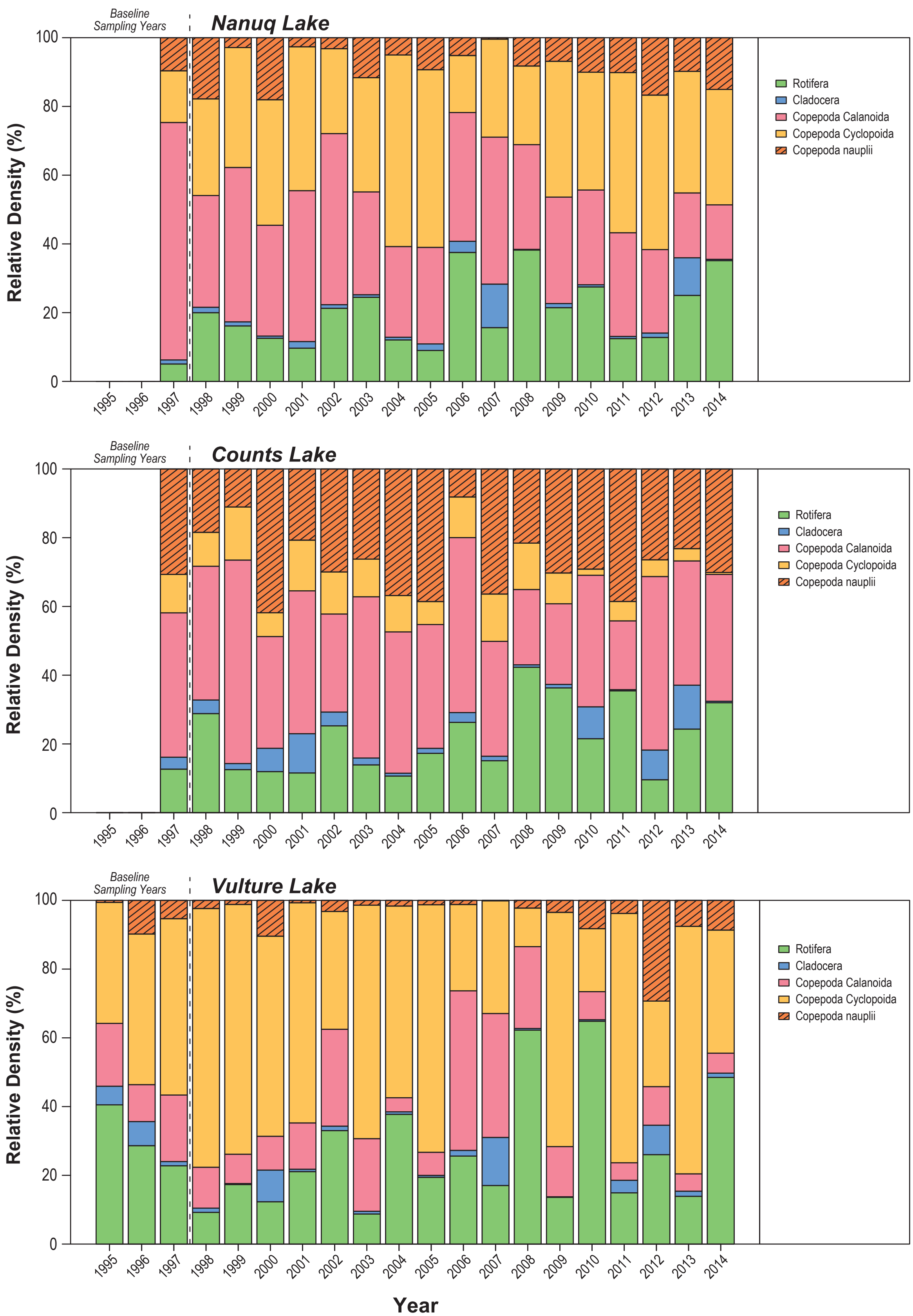


Figure 4-38a

Relative Densities of Zooplankton Taxa in Lakes of the Koala Watershed, 1995 to 2014

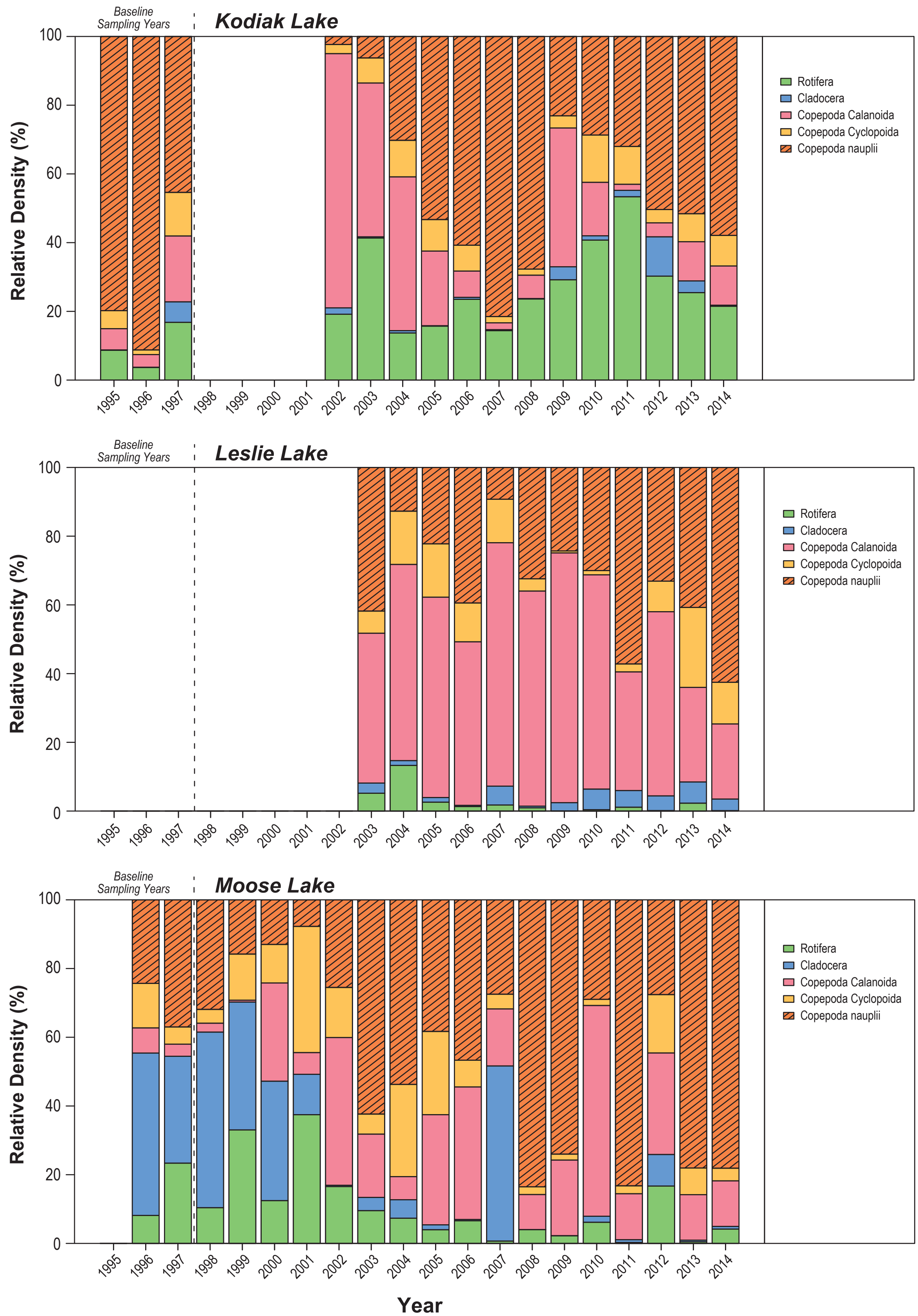
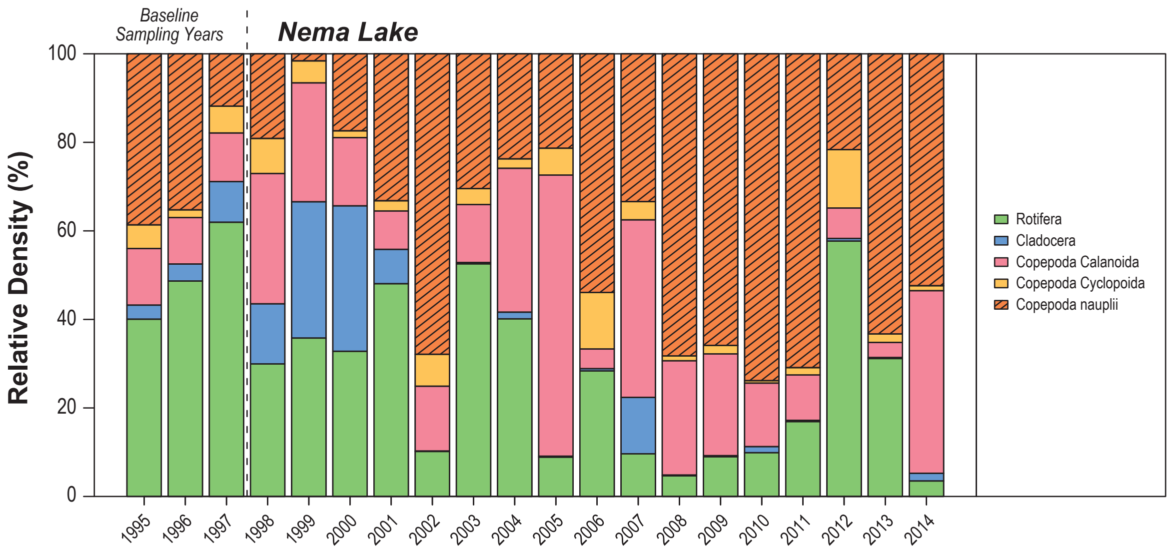


Figure 4-38b

Relative Densities of Zooplankton Taxa in Lakes of the Koala Watershed, 1995 to 2014



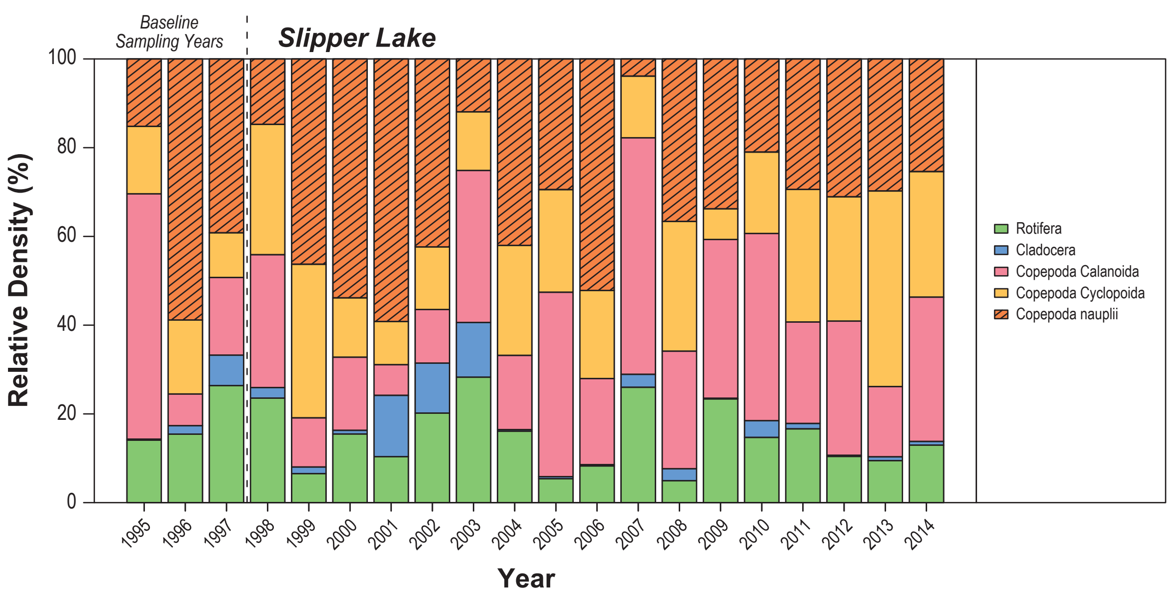


Figure 4-39

Average Diptera Density by Taxonomic Group for AEMP Reference Lakes, 1994 to 2014

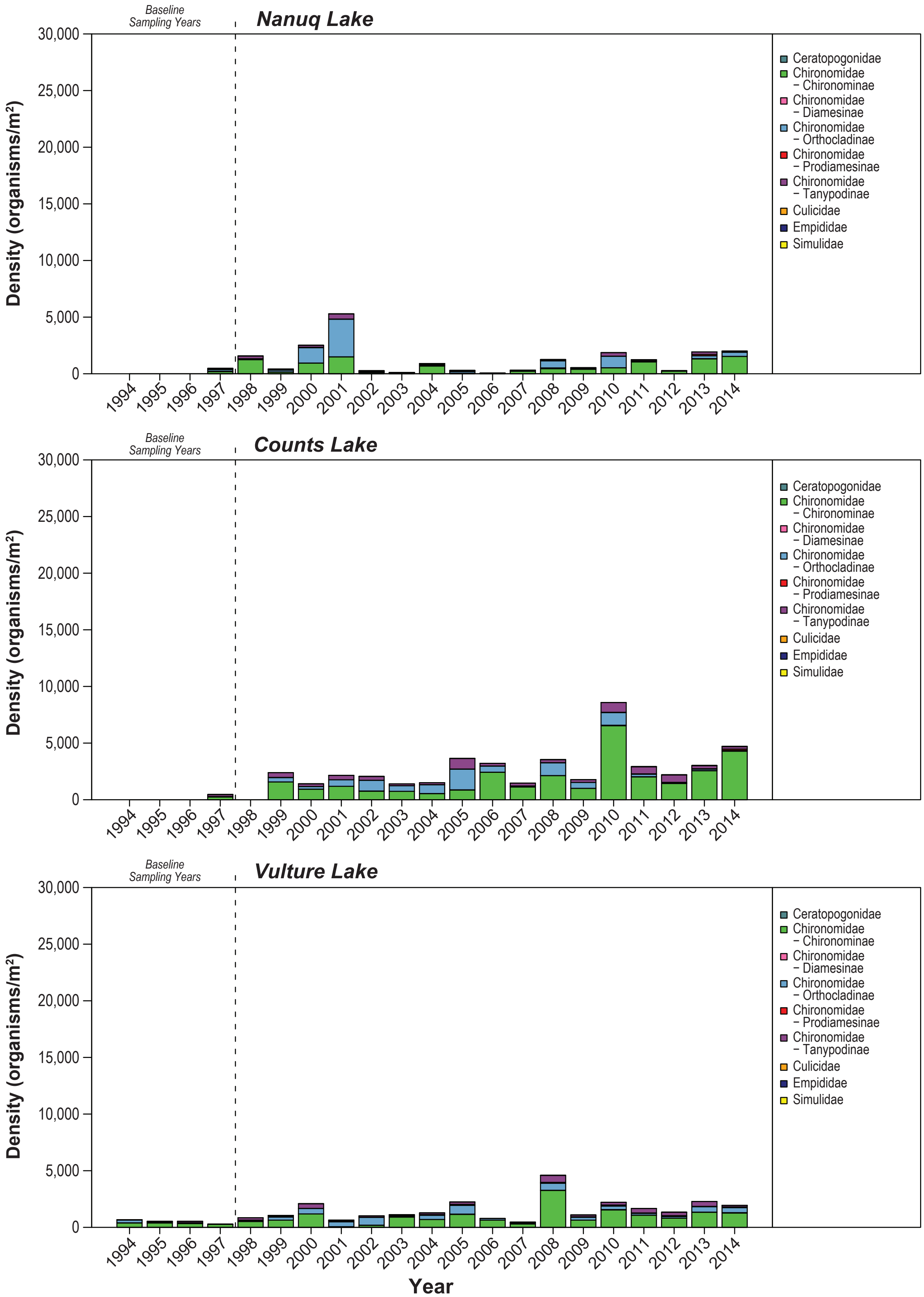


Figure 4-40a

Average Diptera Density by Taxonomic Group for Lakes of the Koala Watershed and Lac de Gras, 1994 to 2014

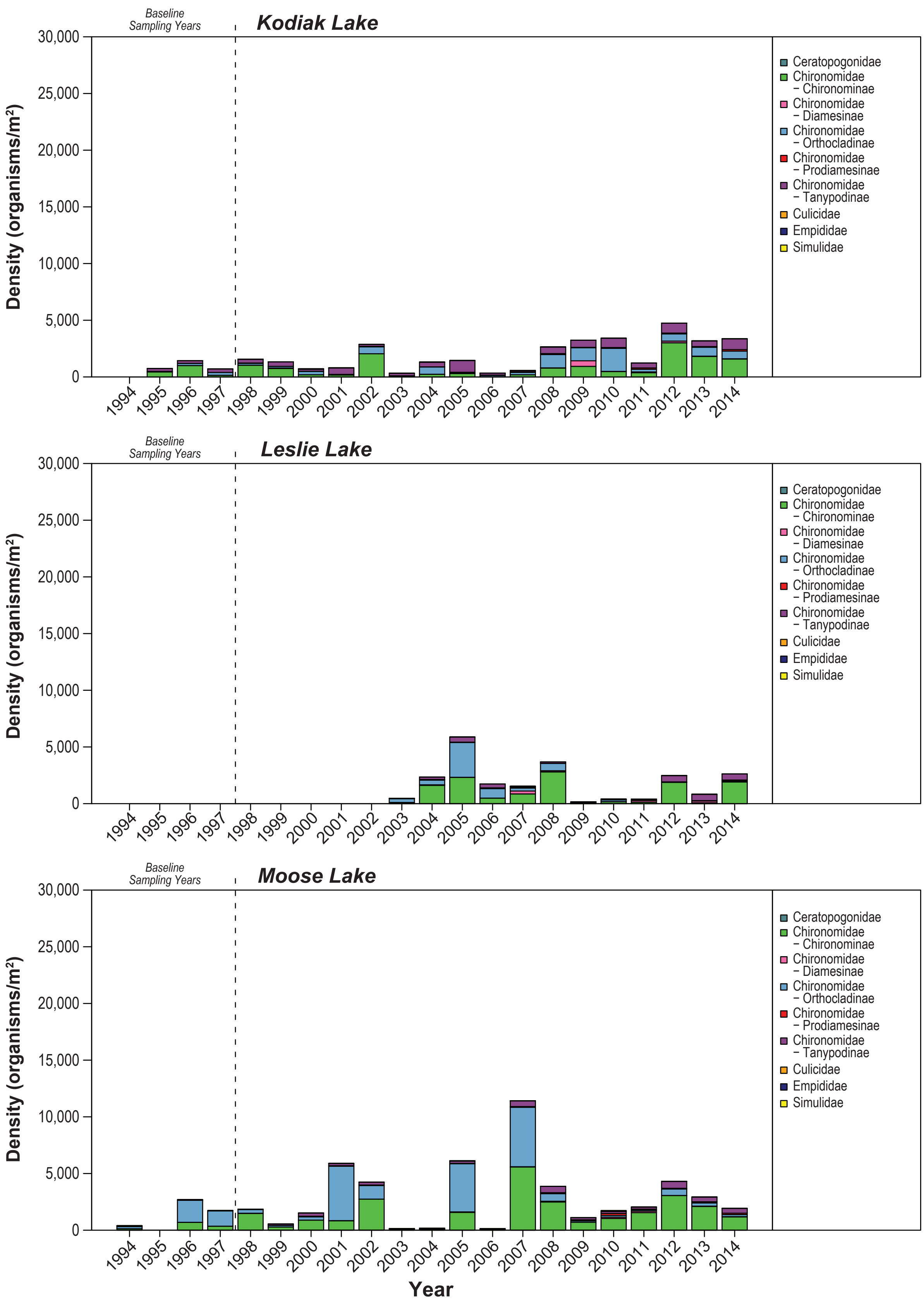


Figure 4-40b

Average Diptera Density by Taxonomic Group for Lakes of the Koala Watershed and Lac de Gras, 1994 to 2014

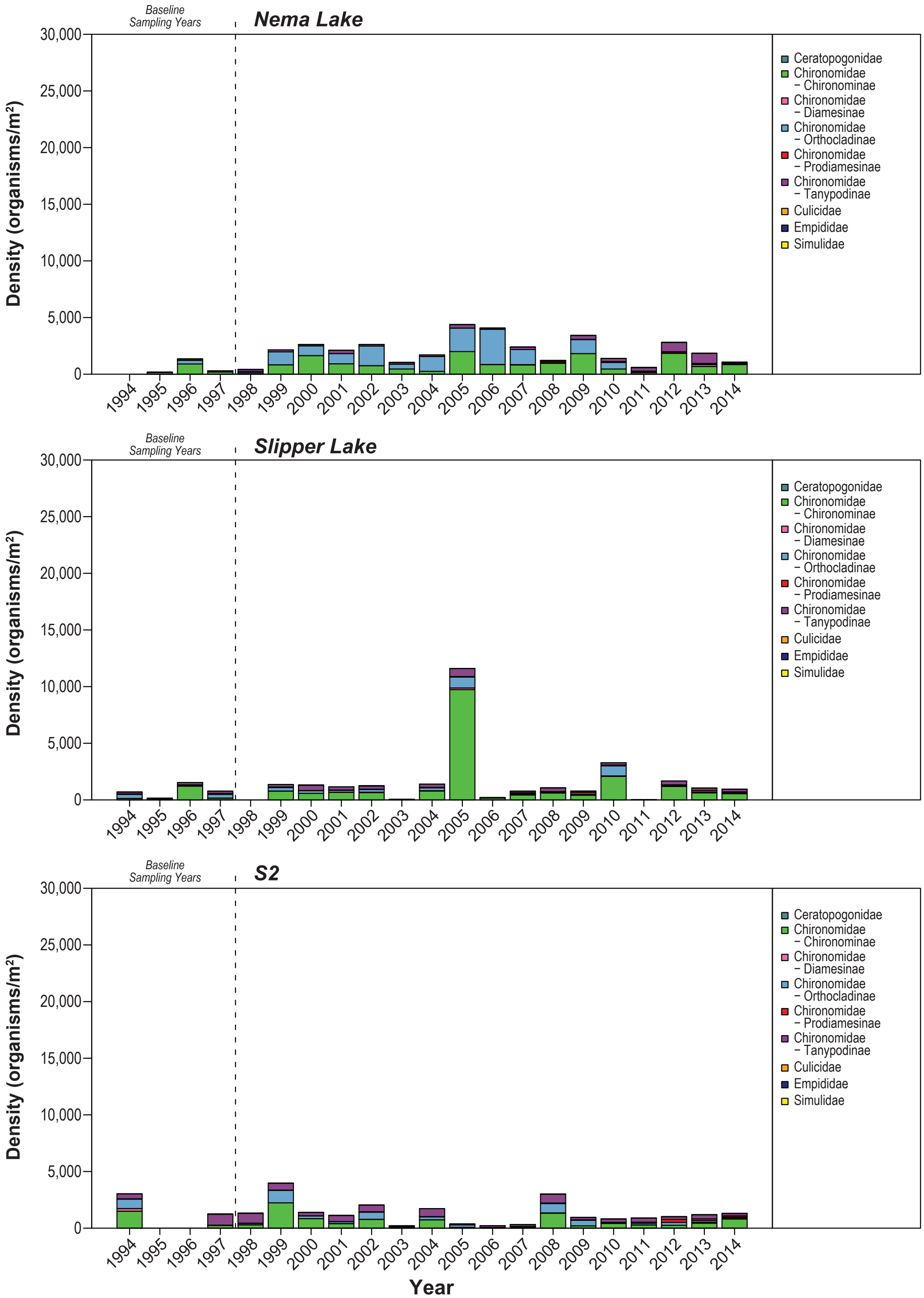


Figure 4-41

Relative Densities of Diptera Taxa in AEMP Reference Lakes, 1994 to 2014

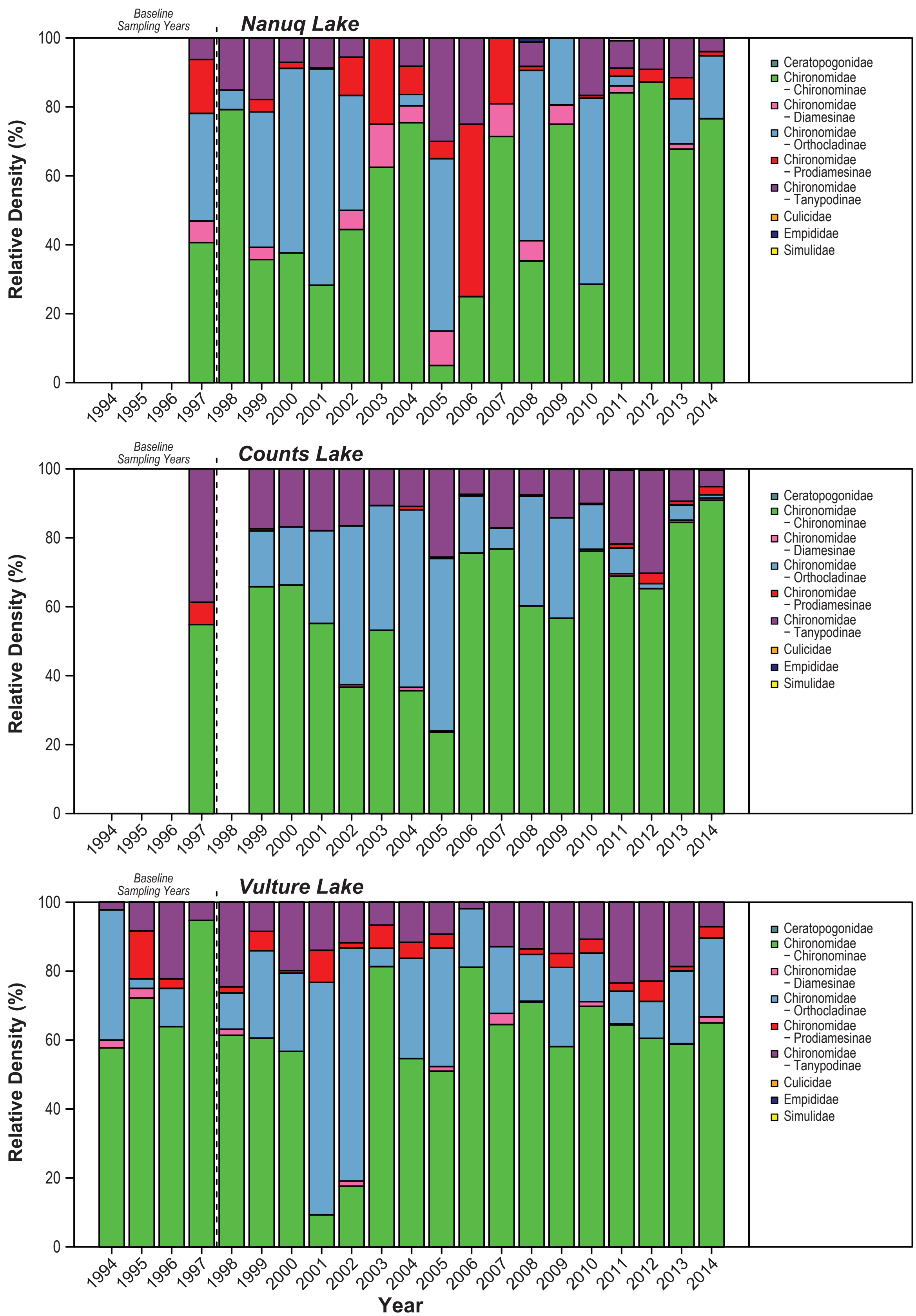


Figure 4-42a

Relative Densities of Diptera Taxa in Lakes of the Koala Watershed and Lac de Gras, 1994 to 2014

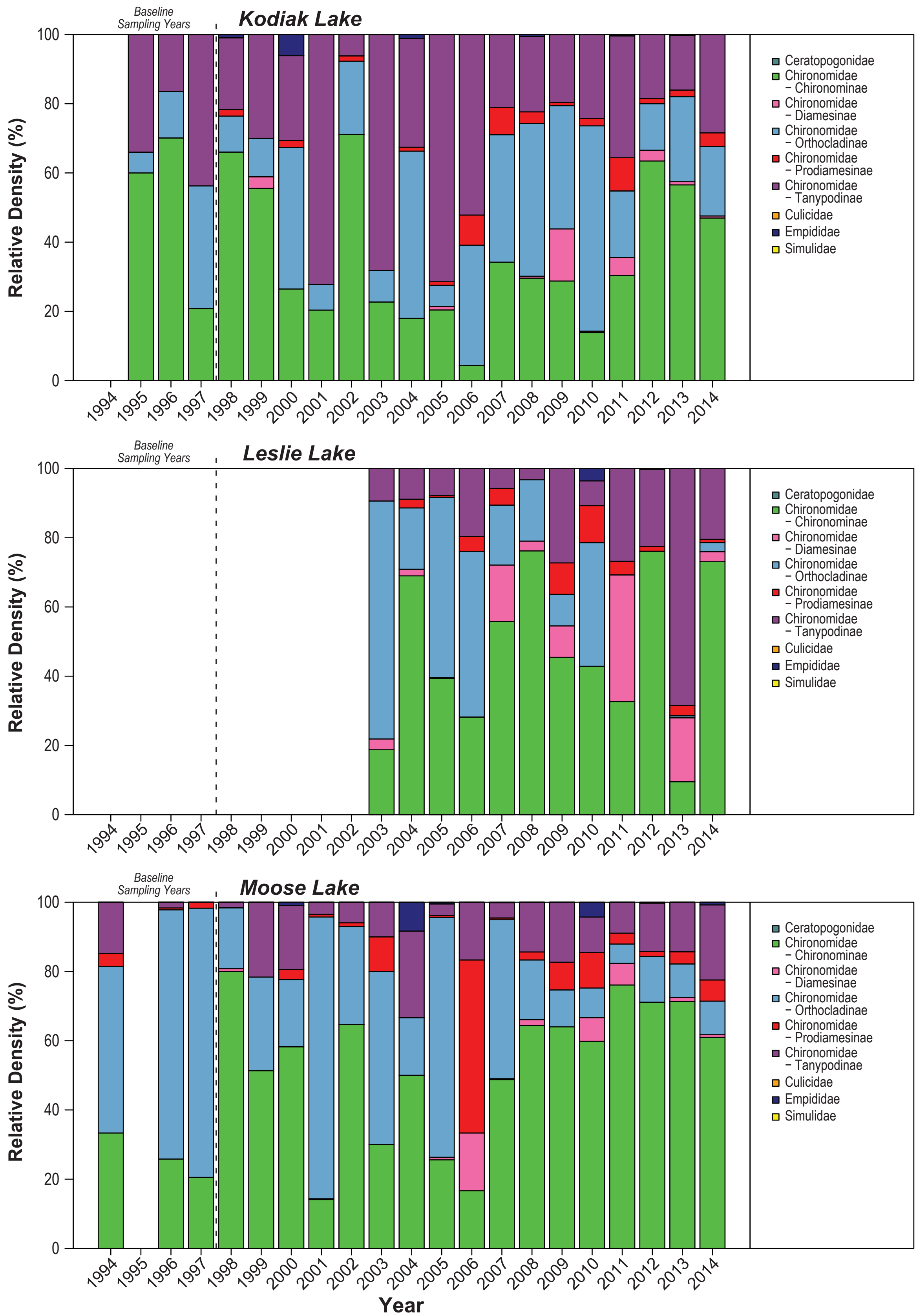


Figure 4-42b

Relative Densities of Diptera Taxa in Lakes of the Koala Watershed and Lac de Gras, 1994 to 2014

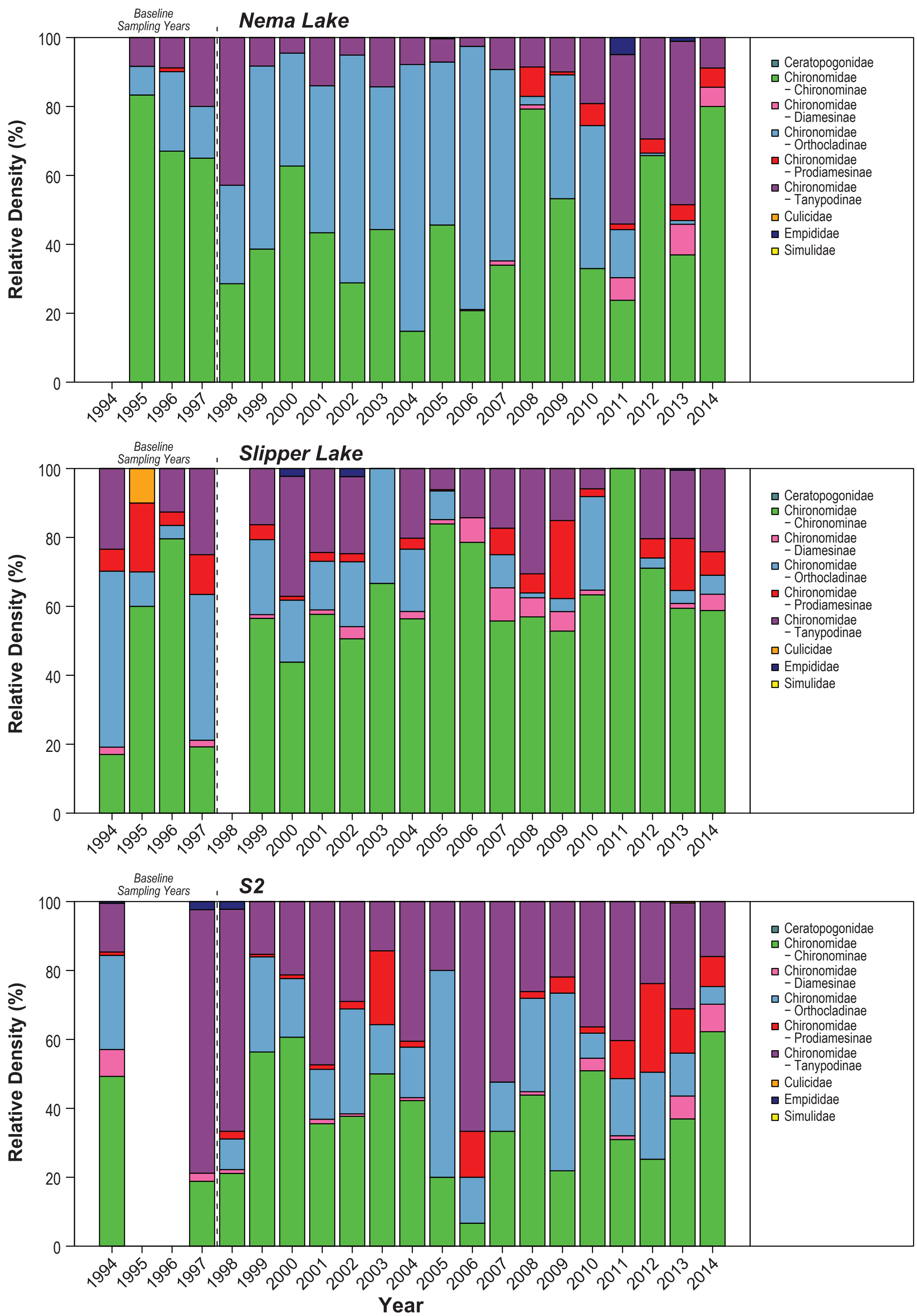
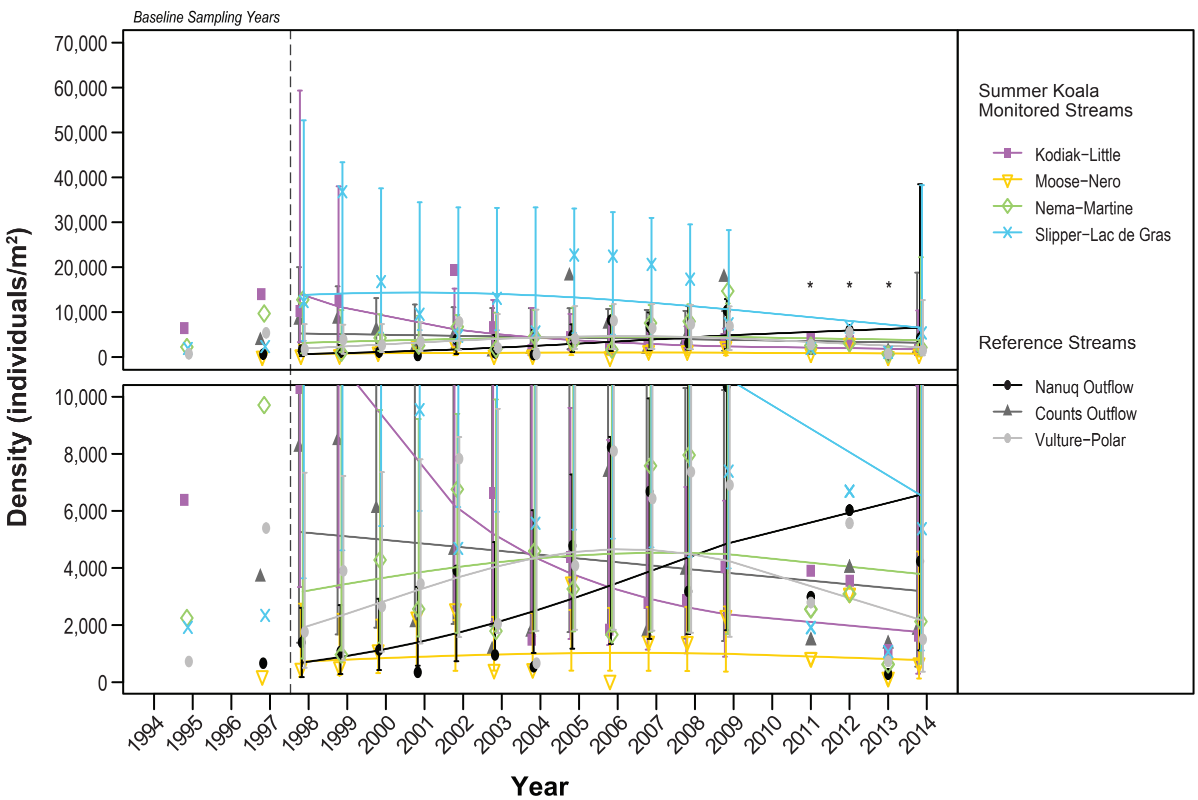


Figure 4-43

Observed and Fitted Means for Benthos Densities in Koala Watershed Streams, 1995 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
** Density values in 2011, 2012, and 2013 were not included in the statistical analysis. Observed means are plotted here for reference only.*

5. SUMMARY OF EVALUATION OF EFFECTS FOR THE KING-CUJO WATERSHED AND LAC DU SAUVAGE

Figure 5-1 summarizes the evaluation of effects for the King-Cujo Watershed and Lac du Sauvage. Because statistical tests were two-sided and only tested for differences between reference and monitored lakes or streams, conclusions on the direction of change were made from graphical analysis. Figures 5-2 to 5-20 illustrate regression analyses and graphical representations of historical data that were used to assist in interpreting statistical results and provide support for the summary of effects for the King-Cujo Watershed and Lac du Sauvage presented below. For additional details, please refer to Part 1 – Evaluation of Effects.

No mine effects were detected with respect to physical limnology variables (i.e., temperature, DO, and Secchi depths) in monitored lakes during either the ice-covered or open water season in 2014 (Figure 5-1). Under-ice DO concentrations were greater than the CCME guideline value of 6.5 mg/L throughout the majority of the water column in most monitored sites in the King-Cujo Watershed and Lac du Sauvage (CCME 1999). In Cujo Lake, DO measurements were less than the CCME guideline throughout the bottom half of the water column in mid-February and mid-March but had begun to increase by April, coincident with the longer photo-period. Data from reference lakes suggests that deeper sections of sub-Arctic lakes are generally less than the CCME threshold during the ice-covered period. Although, the low under-ice DO concentrations in Cujo Lake may be related to elevated TOC concentrations in Cujo Lake, DO and TOC concentrations were not measured during baseline years, making it difficult to discern whether the correlation results from mine operations or represents undisturbed conditions in the King-Cujo Watershed. However, similar to past years, a portion of the surface ice on Cujo Lake was cleared of snow in late winter (April 21, 2014) to allow for increased light penetration and thus increased DO production through photosynthesis.

A total of 23 water quality variables were evaluated for lakes and streams in the King-Cujo Watershed and Lac du Sauvage in the 2014 AEMP. Of these, concentrations of 13 variables have changed through time in monitored sites downstream of the KPSF (Figure 5-1). Concentrations remain elevated above baseline or reference concentrations in ten cases (Figures 5-2 to 5-11):

- pH (downstream to Christine-Lac du Sauvage Stream)
- total alkalinity (downstream to Christine-Lac du Sauvage Stream)
- water hardness (downstream to Christine-Lac du Sauvage Stream)
- chloride (downstream to Cujo Outflow)
- sulphate (downstream to Christine-Lac du Sauvage Stream)
- potassium (downstream to Christine-Lac du Sauvage Stream)
- total barium (downstream to Cujo Outflow)
- total boron (downstream to Cujo Outflow)

Figure 5-1

Summary of Mine-related Changes in the Variables Evaluated for the King-Cujo Watershed and Lac du Sauvage, 2014

ERM

Water Quality

KPSF → Downstream	Cujo Lake	Cujo Outflow	Christine-Lac du Sauvage	Lac du Sauvage LdS2	Lac du Sauvage LdS1
Under-ice Temperature	—	●	●	—	—
Under-ice Dissolved Oxygen	—	●	●	—	—
Secchi Depth	—	●	●	—	—
pH	↑ 0-25%	↑ 0-25%	↑ 0-25%	—	—
Total Alkalinity	↑ 76-100%	↑ 76-100%	↑ 51-75%	—	—
Water Hardness	↑ 76-100%	↑ 76-100%	↑ 76-100%	—	—
Chloride	↑ 76-100%	↑ 76-100%	—	—	—
Sulphate	↑ 76-100%	↑ 76-100%	↑ 76-100%	—	—
Potassium	↑ 76-100%	↑ 76-100%	↑ 51-75%	—	—
Total Ammonia-N	—	—	—	—	—
Nitrite-N	—	—	—	—	—
Nitrate-N	—	—	—	—	—
Total Phosphate-P	—	—	—	—	—
Total Organic Carbon	■	■	■	—	—
Total Antimony	—	—	—	—	—
Total Arsenic	—	—	—	—	—
Total Barium	↑ 76-100%	↑ 76-100%	—	—	—
Total Boron	↑ 76-100%	↑ 51-75%	—	—	—
Total Cadmium	—	—	—	—	—
Total Copper	—	—	—	—	—
Total Molybdenum	↑ 76-100%	↑ 76-100%	↑ 26-50%	—	—
Total Nickel	—	—	—	—	—
Total Selenium	—	—	—	—	—
Total Strontium	↑ 76-100%	↑ 76-100%	↑ 51-75%	—	—
Total Uranium	—	—	—	—	—
Total Vanadium	—	—	—	—	—

Sediment Quality

KPSF → Downstream	Cujo Lake	Cujo Outflow	Christine-Lac du Sauvage	Lac du Sauvage LdS2	Lac du Sauvage LdS1
Total Organic Carbon	—	●	●	●	—
Available Phosphorus	—	●	●	●	—
Total Nitrogen	↑ 51-75%	●	●	●	—
Total Antimony	—	●	●	●	—
Total Arsenic	***	●	●	●	***
Total Cadmium	—	●	●	●	—
Total Copper	**	●	●	●	*
Total Molybdenum	↑ 76-100%	●	●	●	—
Total Nickel	—	●	●	●	—
Total Phosphorus	—	●	●	●	—
Total Selenium	—	●	●	●	—
Total Strontium	↑ 51-75%	●	●	●	—

Biology

KPSF → Downstream	Cujo Lake	Cujo Outflow	Christine-Lac du Sauvage	Lac du Sauvage LdS2	Lac du Sauvage LdS1
Phytoplankton					
Chlorophyll *a* Concentration	—	●	●	●	—
Phytoplankton Density	—	●	●	●	—
Phytoplankton Diversity	—	●	●	●	—
Relative Densities of Major Phytoplankton Taxa	—	●	●	●	—
Zooplankton					
Zooplankton Biomass	—	●	●	●	—
Zooplankton Density	—	●	●	●	—
Zooplankton Diversity	—	●	●	●	—
Relative Densities of Major Zooplankton Taxa	—	●	●	●	—
Benthos					
Lake Benthos Density	◆	●	●	●	—
Lake Benthos Dipteran Diversity	—	●	●	●	—
Lake Benthos Dipteran Relative Density	◆	●	●	●	◆
Stream Benthos Density	●	—	●	●	●
Stream Benthos Dipteran Diversity	●	—	●	●	●
Stream Benthos Dipteran Relative Density	●	—	●	●	●
Stream Benthos EPT Diversity	●	—	●	●	●
Stream Benthos EPT Relative Density	●	—	●	●	●

Notes:

The direction and degree of change was inferred from historical data. For water quality data, differences were assessed relative to data from 2000 (August lakes and streams), 2002 (April lakes), or the first year in which data was collected (i.e., TOC = 2005; chloride in streams = 2001). The season in which the greatest change occurred (i.e., April or August) is represented in the table. If opposing trends were observed between seasons, the increasing trend was selected. For sediment quality data, differences were assessed relative to the first year in which data was collected (i.e. 2005).

** Indicates that the upper bound of the 95% CI exceeded the SSWQO, water quality benchmark, CCME water quality guideline, or CCME ISQG value during the ice-covered or open water season.*

*** Indicates that the observed mean exceeded the SSWQO, water quality benchmark, CCME water quality guideline, or CCME ISQG value during the ice-covered or open water season.*

**** Indicates that the upper bound of the 95% CI or the observed mean exceeded the CCME PEL.*

Legend:

Increased over time in comparison to reference lakes/streams or different from a constant+

↑ 0-25% ↑ 26-50% ↑ 51-75% ↑ 76-100%

Decreased over time in comparison to reference lakes/streams or different from a constant+

↓ 0-25% ↓ 26-50% ↓ 51-75% ↓ 76-100%

— Did not change over time or differ significantly over time from reference lakes/streams

● Variable was not sampled at this lake/stream

◆ Changed over time

■ Elevated, but has not changed through time

- total molybdenum (downstream to Christine-Lac du Sauvage Stream)
- total strontium (downstream to Christine-Lac du Sauvage Stream)

In two cases (i.e., total ammonia-N and total copper), concentrations have returned to baseline concentrations in recent years, with no mine effects detected since 2012 (Figure 5-12 and 5-13). In one case (i.e., TOC), concentrations have been consistently elevated in comparison to reference lakes and streams downstream as far as Christine-Lac du Sauvage Stream, but have not increased over time (Figure 5-14).

TOC is a measure of the amount of live and decomposing organic matter in the water column. Elevated TOC may reflect increases in available nutrients, which stimulate the growth and reproduction of aquatic organisms. In oligotrophic (i.e., nutrient poor) systems, like those found in the sub-Arctic, changes in nutrient levels may not be detected because of the speed with which available nutrients are incorporated into biotic material. Thus, elevated TOC may indicate an increase in the overall productivity of a system, which may also be reflected in changes in the biomass of primary producers (e.g., phytoplankton, periphyton), primary consumers (e.g., zooplankton, benthic invertebrates), or secondary consumers (e.g., fish), depending on how far up the food web the changes have progressed. No changes through time in phytoplankton or zooplankton have been observed in the King-Cujo Watershed or Lac du Sauvage (Figure 5-1). However, an increase in lake benthos density was observed in Cujo Lake (Figures 5-1). Elevated TOC may also be associated with reductions in DO because bacteria consume oxygen as they decompose organic matter. Under-ice DO concentrations in Cujo Lake have historically been less than the CCME guidelines throughout the majority of the water column (see Section 4.1.3 of Part 1 – Evaluation of Effects). Thus, the observed elevated TOC in Cujo Lake, relative to reference lakes and Lac du Sauvage, could be related to the observed low DO concentrations. However, DO and TOC concentrations were not measured during baseline years, making it difficult to discern whether the correlation results from mine operations or represents undisturbed conditions in the King-Cujo Watershed.

Overall, the extent to which concentrations of water quality variables have changed through time generally decreases with downstream distance from the KPSF. Patterns were similar during the ice-covered and open water seasons, though concentrations were sometimes elevated during the ice-covered season, relative to the open water season, as a consequence of solute exclusion during freeze up. In reference lakes, concentrations have generally been low and stable through time. Together, the evidence suggests that the observed changes in concentrations in the variables listed in Figure 5-1 are mine effects that stem from the discharge of water from the KPSF into the receiving environment under Water Licence W2012L2-0001.

CCME guidelines for the protection of aquatic life exist for ten of the evaluated water quality variables, including pH, total ammonia-N, nitrite-N, total arsenic, total boron, total cadmium, total copper, total nickel, total selenium, and total uranium (CCME 2014). In addition, DDEC has established SSWQO for six of the evaluated variables, including chloride, sulphate, potassium, nitrate-N, total molybdenum, and total vanadium. Total phosphate concentrations were compared to lake-specific benchmark trigger values that were established using guidelines set out in the Canadian Guidance Framework for the Management of Phosphorus in Freshwater Systems (CCME 2004). Other water quality benchmark values include provincial guidelines or those taken from the published literature (i.e., antimony, barium, and strontium). With the exception of total phosphate-P, the 95% confidence intervals around the fitted mean and the observed mean concentrations were below their respective benchmark value. However, for total phosphate-P, concentrations in reference lakes also exceeded CCME guidelines, suggesting that exceedances are not related to mine activities.

Twelve sediment quality variables were evaluated in the 2014 AEMP for the King-Cujo Watershed and Lac du Sauvage. Of these, the concentrations of two variables (i.e., total nitrogen, total molybdenum) have changed through time and one other variable (i.e., total strontium) showed signs of a potential increase or mine effect (Figures 5-1 and 5-15 to 5-17). Total nitrogen and total molybdenum concentrations have increased in sediments of Cujo Lake; however, the cause of the increase in total nitrogen is unclear at this time and may represent natural variability. Total strontium concentrations in Cujo Lake were higher than those observed in reference lakes. CCME guidelines for the protection of aquatic life exist for three of the evaluated sediment quality variables, including arsenic, cadmium, and copper. The observed mean exceeded the CCME ISQG and PEL for arsenic in all monitored sites (Figure 5-1); however, similar exceedances were observed in all three reference lakes. For cadmium, the 95% confidence intervals around the fitted mean and the observed mean concentrations were below the CCME ISQG and PEL at all monitored sites (Figure 5-1). For copper, the observed mean in Cujo Lake and the 95% confidence interval around the fitted mean for site LdS1 exceeded the CCME ISQG in 2014; however, similar patterns were observed in reference lakes; copper concentrations were less than the CCME PEL at all monitored sites in 2014 (Figure 5-1). Exceedances for arsenic and copper were similar in both monitored and reference lakes, suggesting that exceedances are not related to mine activities.

Results from water quality analyses in the King-Cujo Watershed and Lac du Sauvage suggest that changes might be expected in biological communities downstream of the KPSF as far as Christine-Lac du Sauvage Stream. However, concentrations of water quality variables that have increased in monitored lakes at the Ekati Diamond Mine for which SSWQO or species sensitivity-based CCME guidelines exist were reviewed as part of the 2012 AEMP Re-evaluation with a specific focus on identifying possible chronic toxic effects on species present in the receiving environment at the Ekati Diamond Mine (Rescan 2012b). As in previous years, concentrations of all the water quality variables in the King-Cujo Watershed and Lac du Sauvage in 2014 remained below the lowest identified chronic effect level for the most sensitive species (Rescan 2012b). Thus, populations of even the most sensitive species were not expected to experience deleterious effects as a result of concentrations of the evaluated water quality variables in the King-Cujo Watershed and Lac du Sauvage.

Results from sediment quality analyses in the King-Cujo Watershed and Lac du Sauvage also suggest that changes might be expected in biological communities downstream of the KPSF, because the concentrations of two evaluated sediment quality variables (i.e., total nitrogen and molybdenum) have increased in Cujo Lake and elevated concentrations of one other evaluated sediment quality variable (i.e., strontium) was detected in Cujo Lake. However, no CCME guidelines or other relevant benchmark values currently exist for these three sediment quality variables, suggesting that no toxic effects are expected.

Two changes in biological variables were observed in 2014:

- an increase in lake benthos density in Cujo Lake (Figure 5-18); and

- a change in lake benthos dipteran community composition in Cujo Lake and site LdS1 (Figure 5-19 and 5-20).

No mine effects were detected with respect to phytoplankton biomass, density, diversity, or community composition in the King-Cujo Watershed or Lac du Sauvage.

Zooplankton biomass, density, diversity, and overall community composition have remained relatively stable through time in Cujo Lake and site LdS1 in Lac du Sauvage. However, although no mine effects were detected with respect to zooplankton diversity or community composition, a close examination of zooplankton species compositions suggests that the rotifer *Conochilus* sp. and the cladoceran *Holopedium gibberum*, have been largely absent from Cujo Lake since 2002. A similar trend was observed in lakes downstream of the LLCF. *Conochilus* sp. returned to Cujo Lake in 2011, but was once again absent from Cujo Lake in 2012, 2013, and 2014. The reason for the change in composition of cladoceran genera remains unclear.

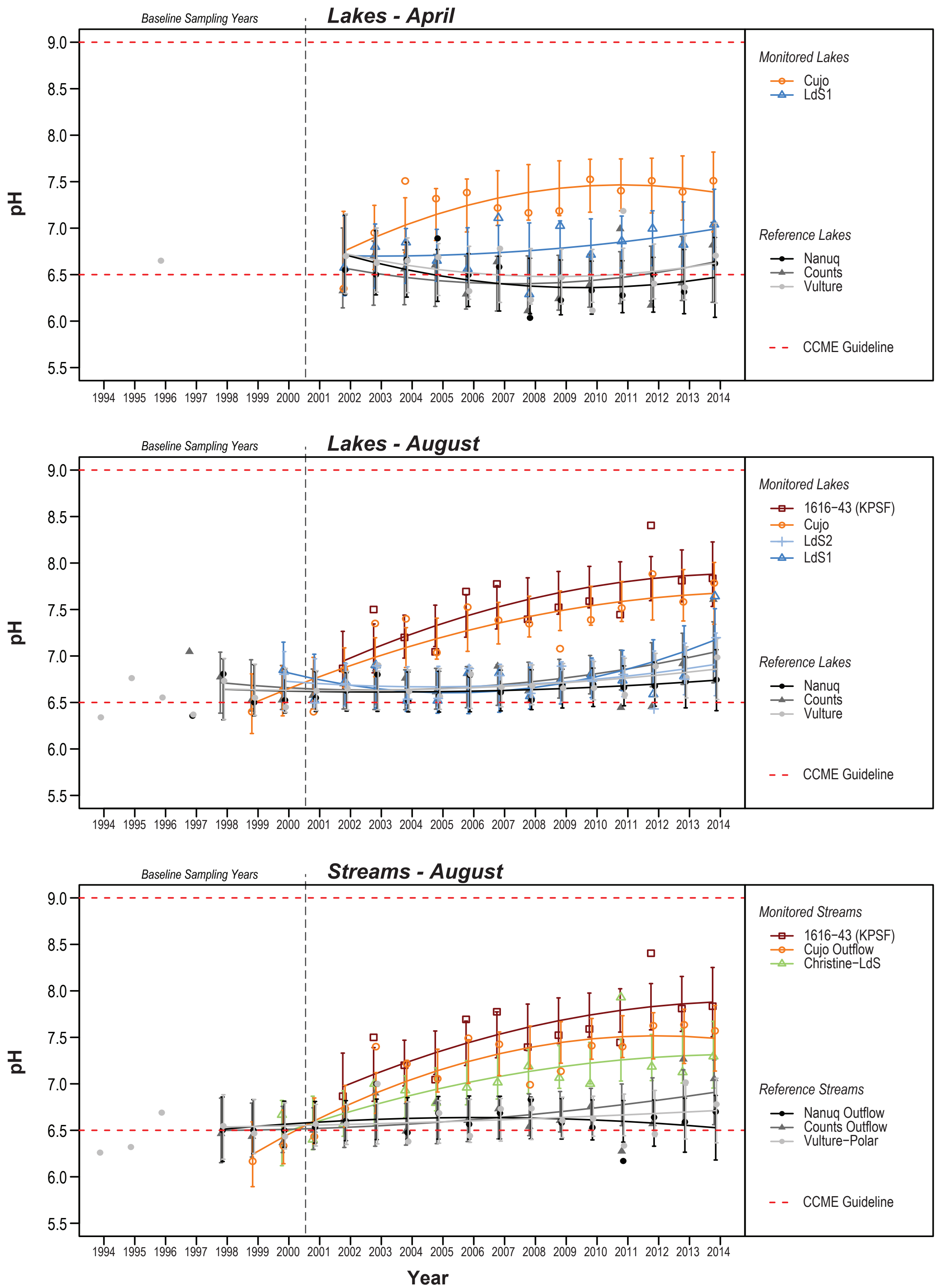
Lake benthos density has increased through time in Cujo Lake, but appears to have remained stable, though elevated, since around 2003 (Figure 5-18). Although dipteran diversity has been variable through time, diversity has been relatively stable in monitored and reference lakes since 2007. Shifts in the benthos community composition have been observed in Cujo Lake and at site LdS1 in Lac du Sauvage, in which the relative densities of organisms from the Chironomidae sub-family Orthocladiinae (most likely organisms from the genera *Psectrocladius* and *Zalutschia* in Cujo Lake and from the genus *Heterotanytarsus* at site LdS1) have decreased through time while densities of organisms from the subfamilies Tanypodinae (most likely organisms from the genera *Procladius* and *Ablabesmyia*) and Prodiamesinae (most likely organisms from the genus *Monodiamesa*) have increased through time (Figures 5-19 and 5-20). Organisms from the subfamily Chironominae (likely organisms from the genera *Cladotanytarsus*, *Corynocera*, *Microtendipes,* and *Stictochironomus*) have also increased through time in Cujo Lake (Figures 5-19 and 5-20). Most of these changes began in Cujo Lake in 2005 and were first identified through the multivariate analyses conducted as part of the 2012 AEMP Re-evaluation (Rescan 2012b). The shift in taxonomic composition was more recently observed at site LdS1 in 2013. Unfortunately, little information is available on the ecology of these benthic invertebrates and the cause of these shifts is unclear (Oliver and Dillon 1997). However, these shifts are similar to those that have occurred in Leslie and Moose lakes in the Koala Watershed and concentrations of all the evaluated water quality variables in the King-Cujo Watershed have remained below the lowest identified chronic effect level for the most sensitive species. Thus, the observed changes in lake benthos community composition are likely associated with changes in macronutrient availability, rather than toxic effects. in lakes downstream of the KPSF.

No mine effects were detected with respect to stream benthos density, dipteran diversity or EPT diversity, or dipteran or EPT community composition in the King-Cujo Watershed.

Lake benthos provide an important source of food for many species of fish. Changes in community composition could have important consequences for fish, especially if preferred prey items are replaced with non-preferred ones. Similar to the Koala Watershed, results of the 2012 AEMP Evaluation of Effects found no evidence of strong mine effects on monitored fish populations in the King-Cujo Watershed (Rescan 2012b). Thus, shifts in lake benthos communities do not appear to have influenced fish populations to date. Both round whitefish and lake trout are considered opportunistic feeders where in the absence of strong prey community-wide effects, may not exhibit strong biological changes, including any bioenergetics-related response variables. Furthermore, the mobile nature of these larger-bodied fish populations may also serve to reduce any potential effects. Lakes in the Ekati Diamond Mine study area are not isolated and individual fish are able to move freely between upstream and downstream lakes. This likely serves to buffer any potential effects or may delay the appearance of mine effects. Monitoring of fish populations will be conducted in 2015 to re-assess these results, using the slimy sculpin as a sentinel species.

Figure 5-2

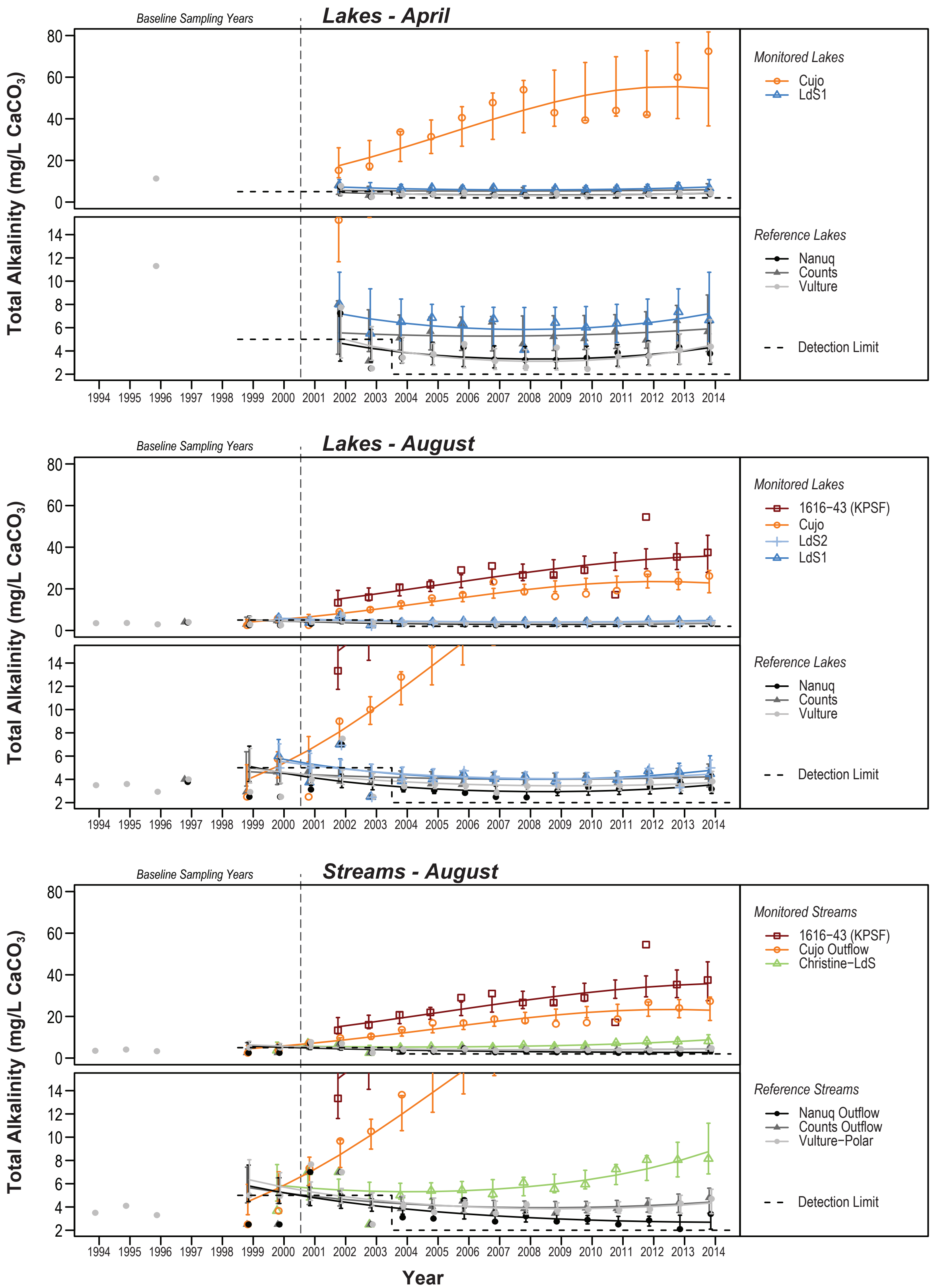
Observed and Fitted Means for pH in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
CCME guideline = 6.5 - 9.0

Figure 5-3

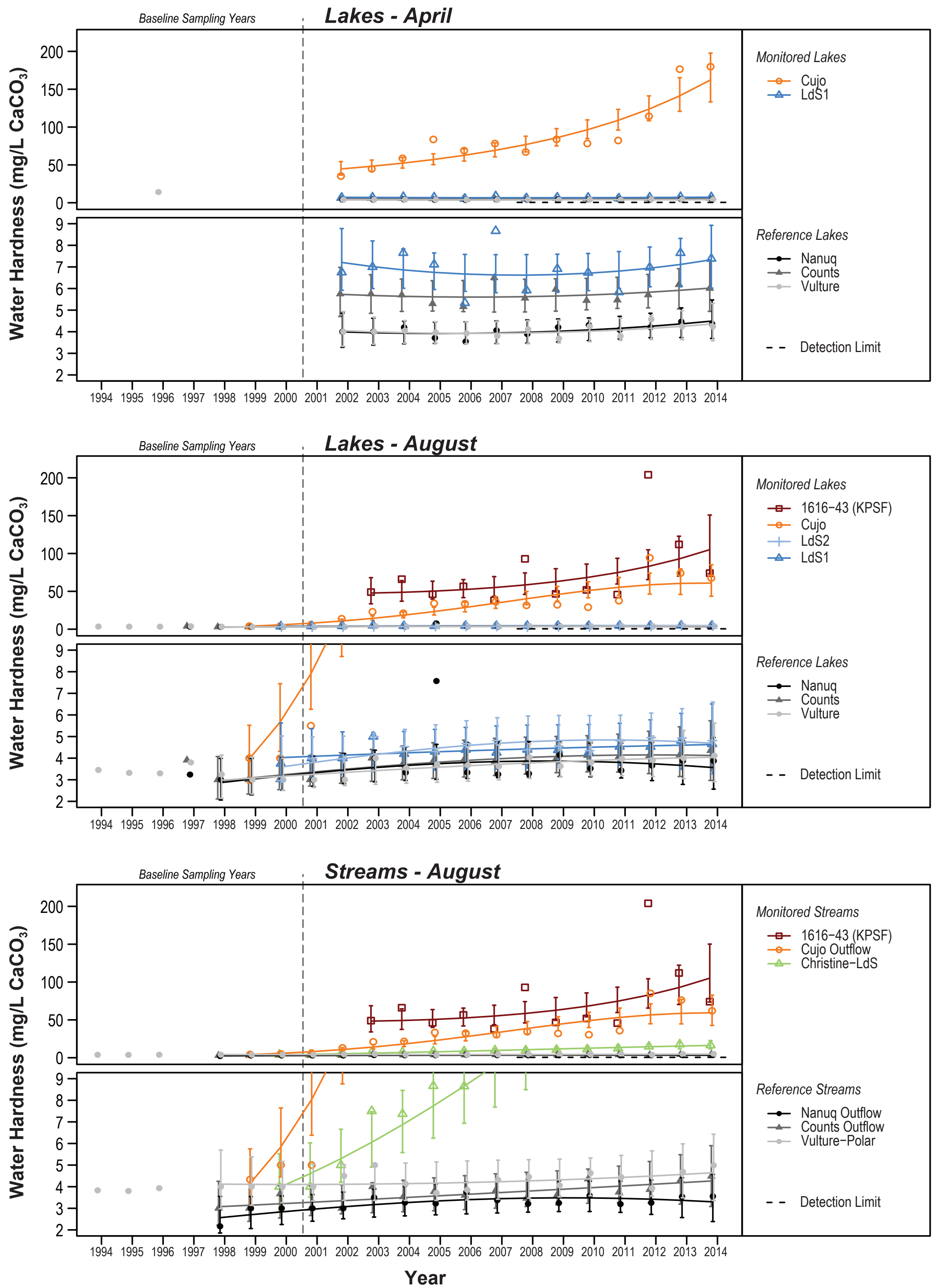
Observed and Fitted Means for Total Alkalinity in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.

Figure 5-4

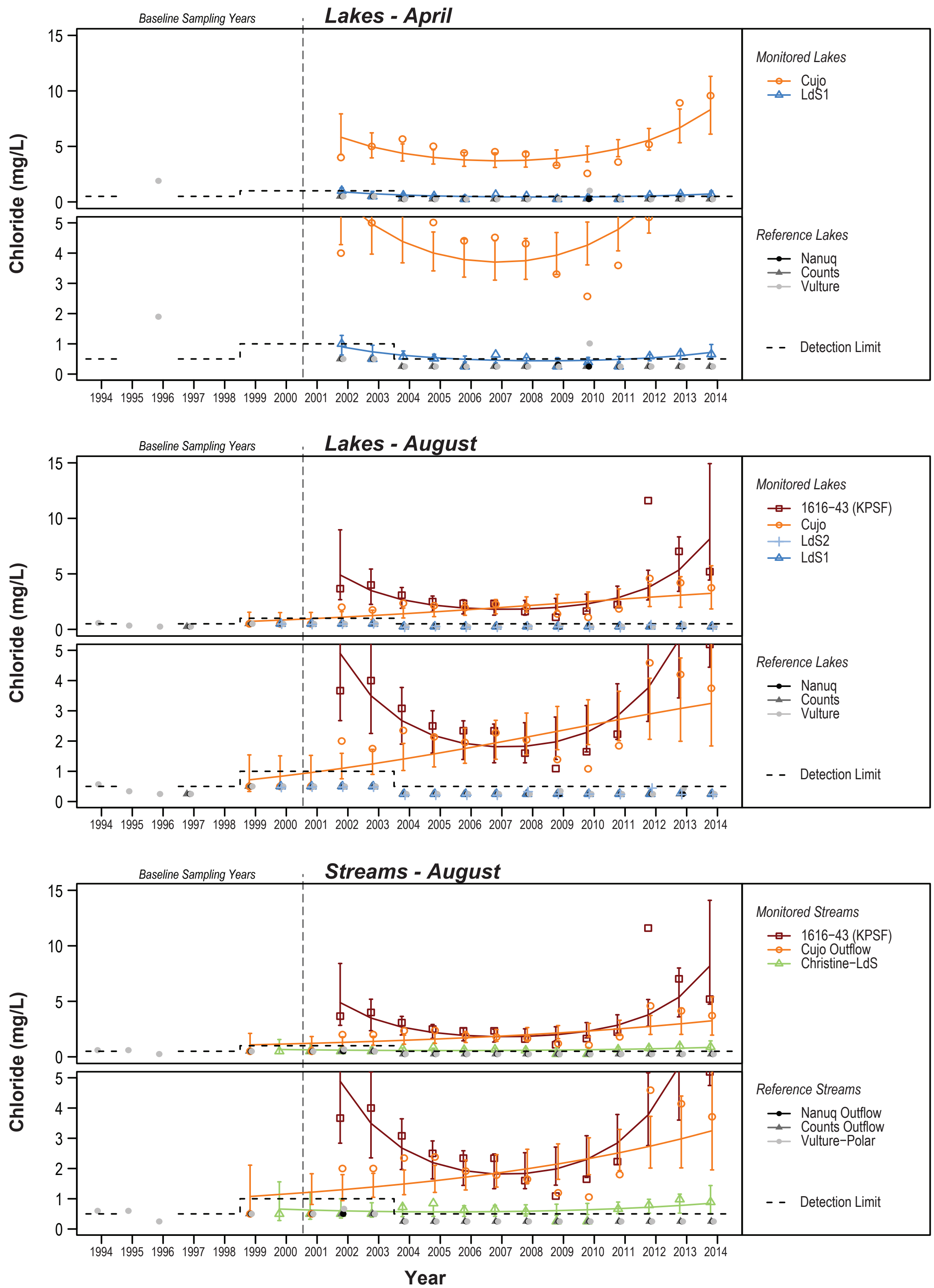
Observed and Fitted Means for Water Hardness in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.

Figure 5-5

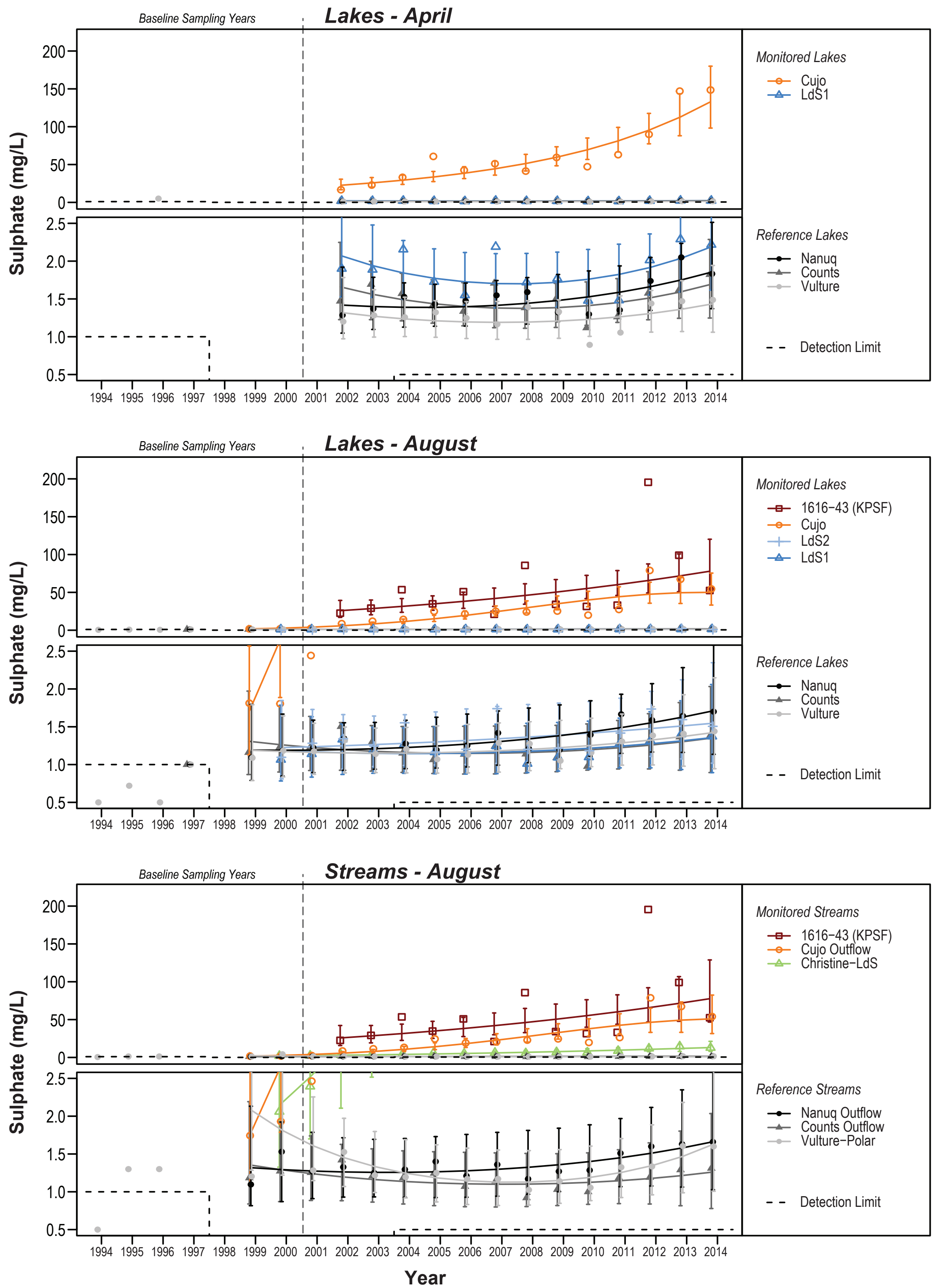
Observed and Fitted Means for Chloride in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
SSWQO = 116.6 X ln(Hardness) - 204.1, where hardness = 10 - 160 mg/L.

Figure 5-6

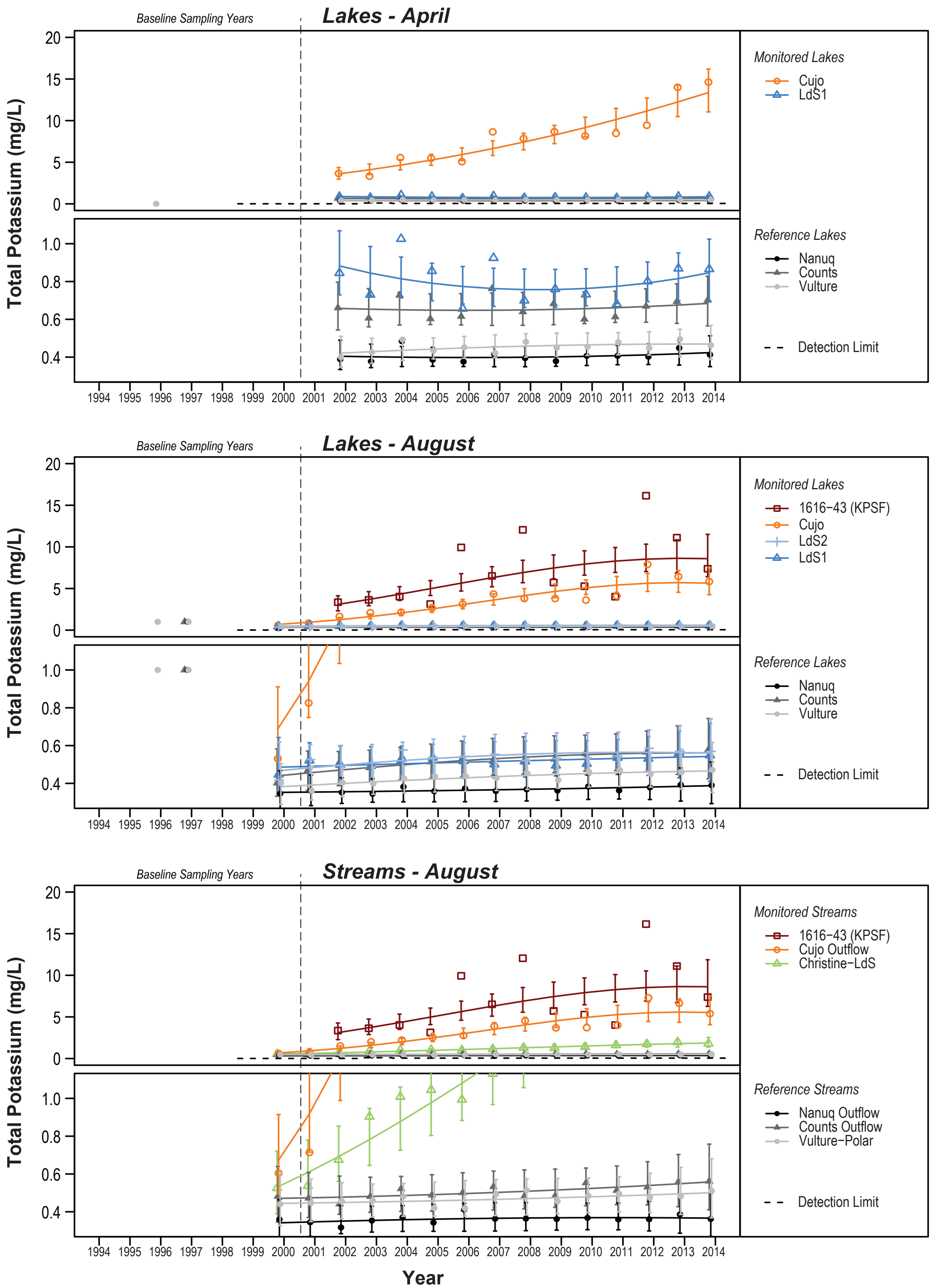
Observed and Fitted Means for Sulphate in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
SSWQO = $e^{(0.9116 \times \ln(Hardness) + 1.712)}$ mg/L, where hardness < 160 mg/L.

Figure 5-7

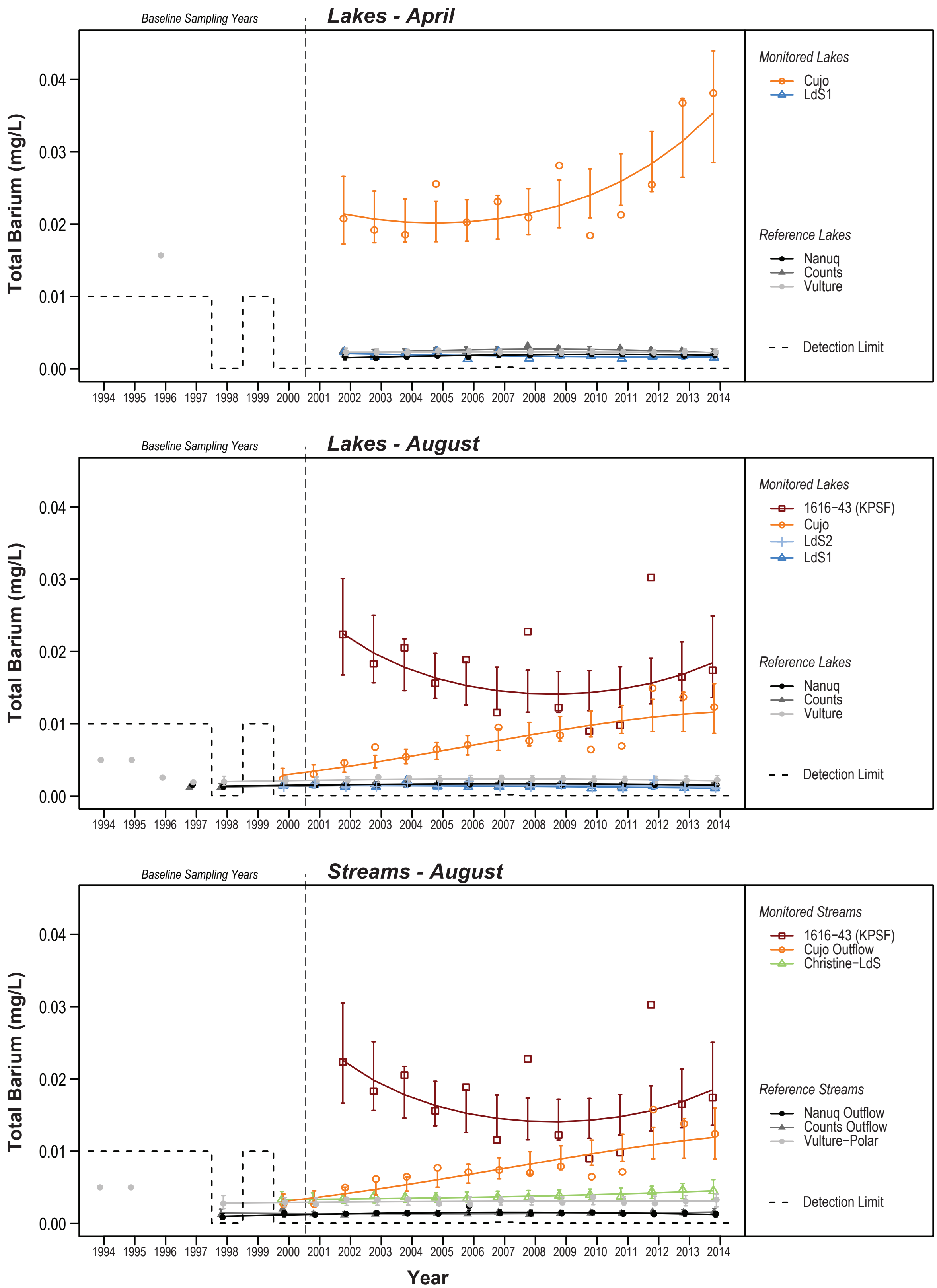
Observed and Fitted Means for Potassium in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
SSWQO = 41 mg/L.

Figure 5-8

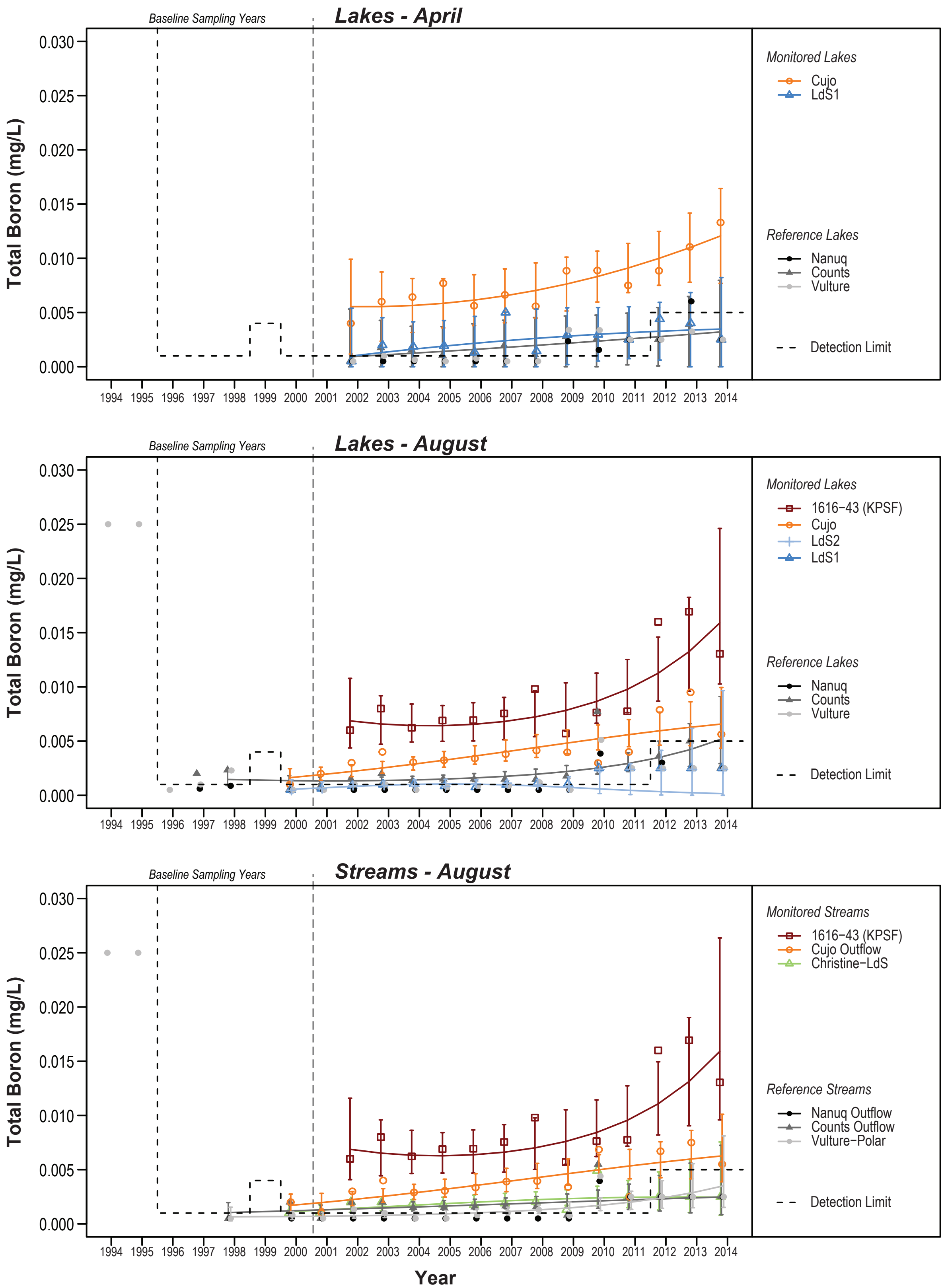
Observed and Fitted Means for Total Barium in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
Water quality benchmark (Haywood and Drinnan 1983) = 1 mg/L.

Figure 5-9

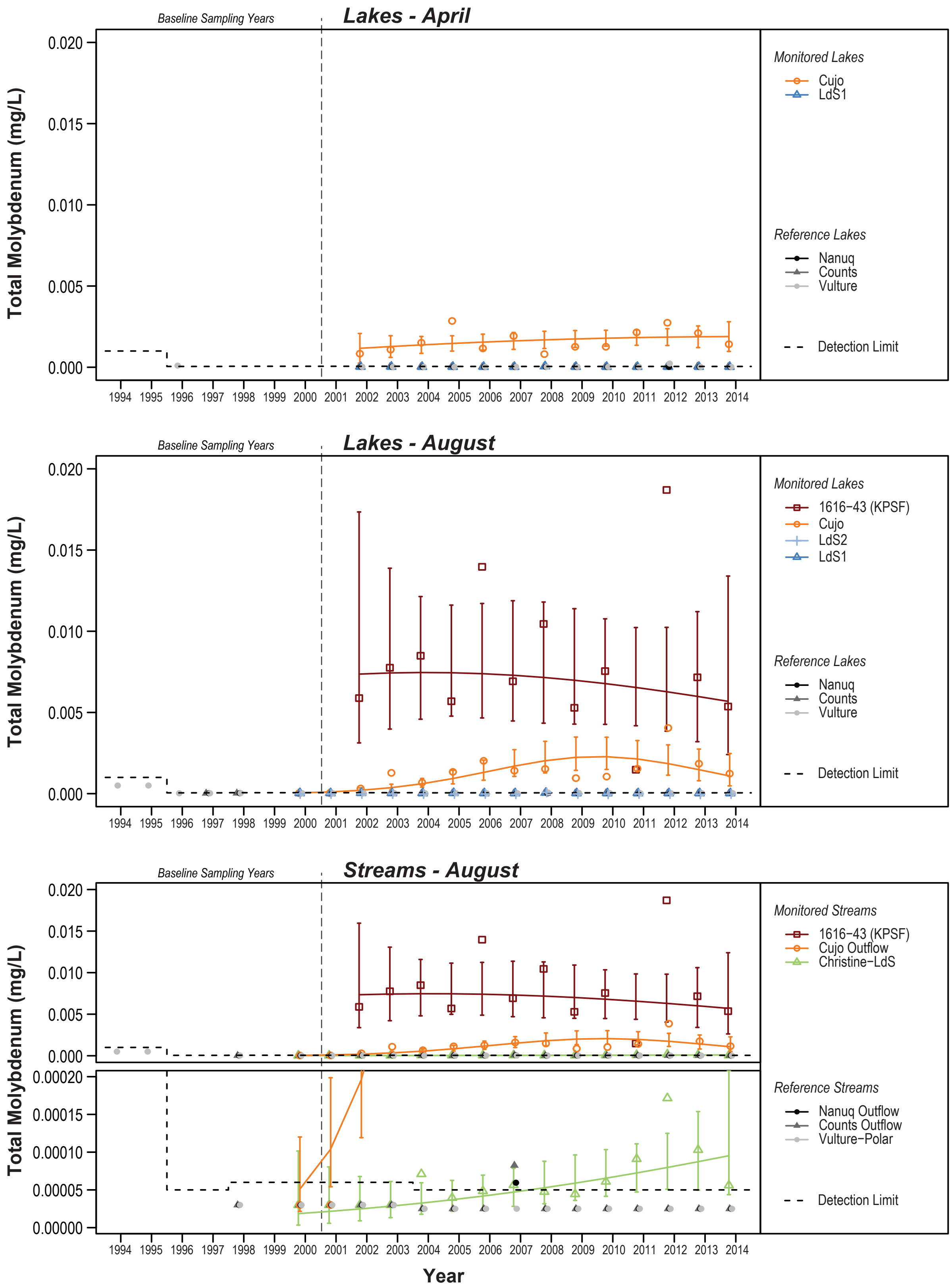
Observed and Fitted Means for Total Boron in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
CCME Guideline = 1.5 mg/L.

Figure 5-10

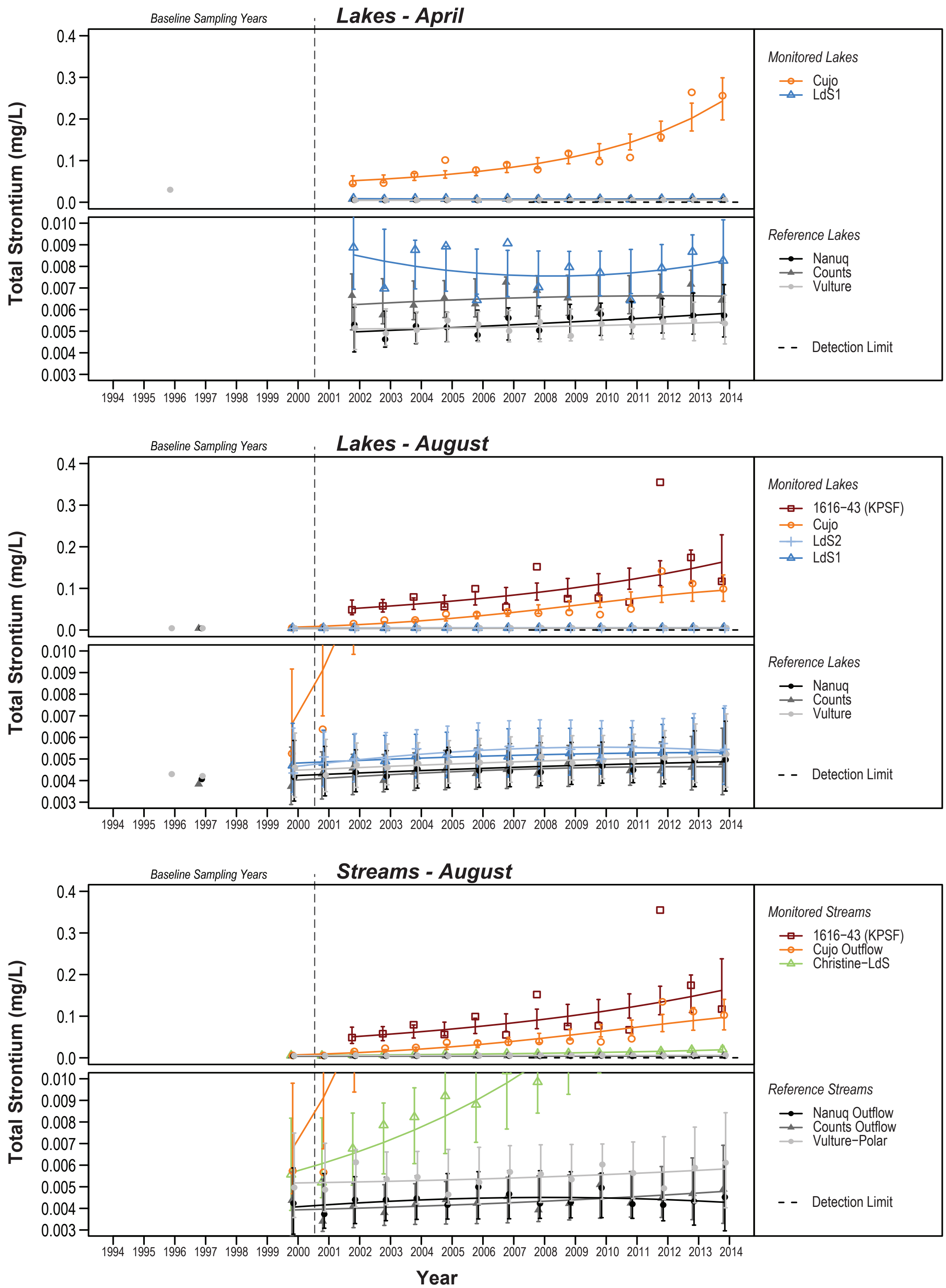
Observed and Fitted Means for Total Molybdenum in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
SSWQO = 19.38 mg/L.

Figure 5-11

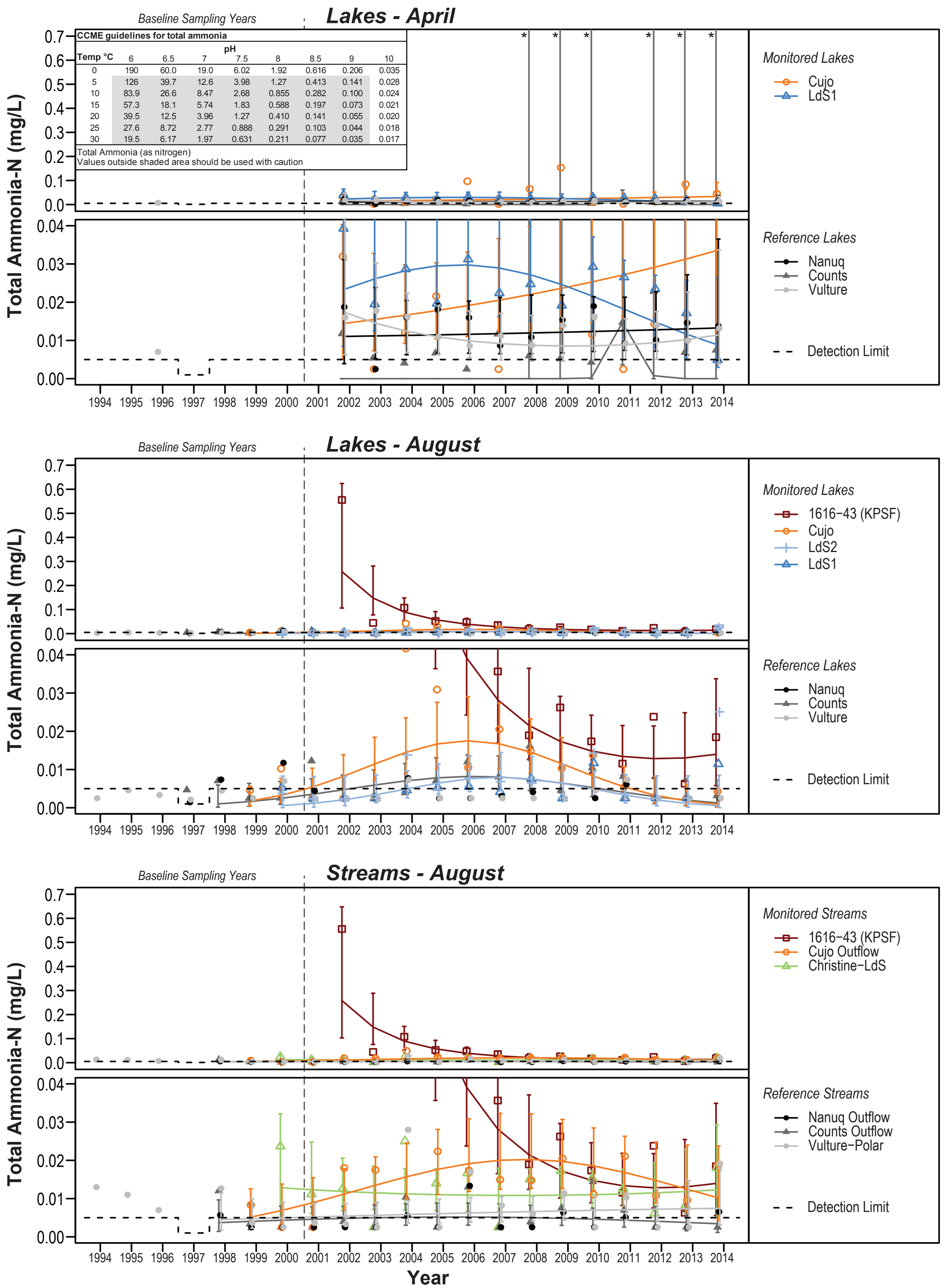
Observed and Fitted Means for Total Strontium in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
Water quality benchmark (Golder 2011) = 6.242 mg/L.

Figure 5-12

Observed and Fitted Means for Total Ammonia-N in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014



CCME guidelines for total ammonia

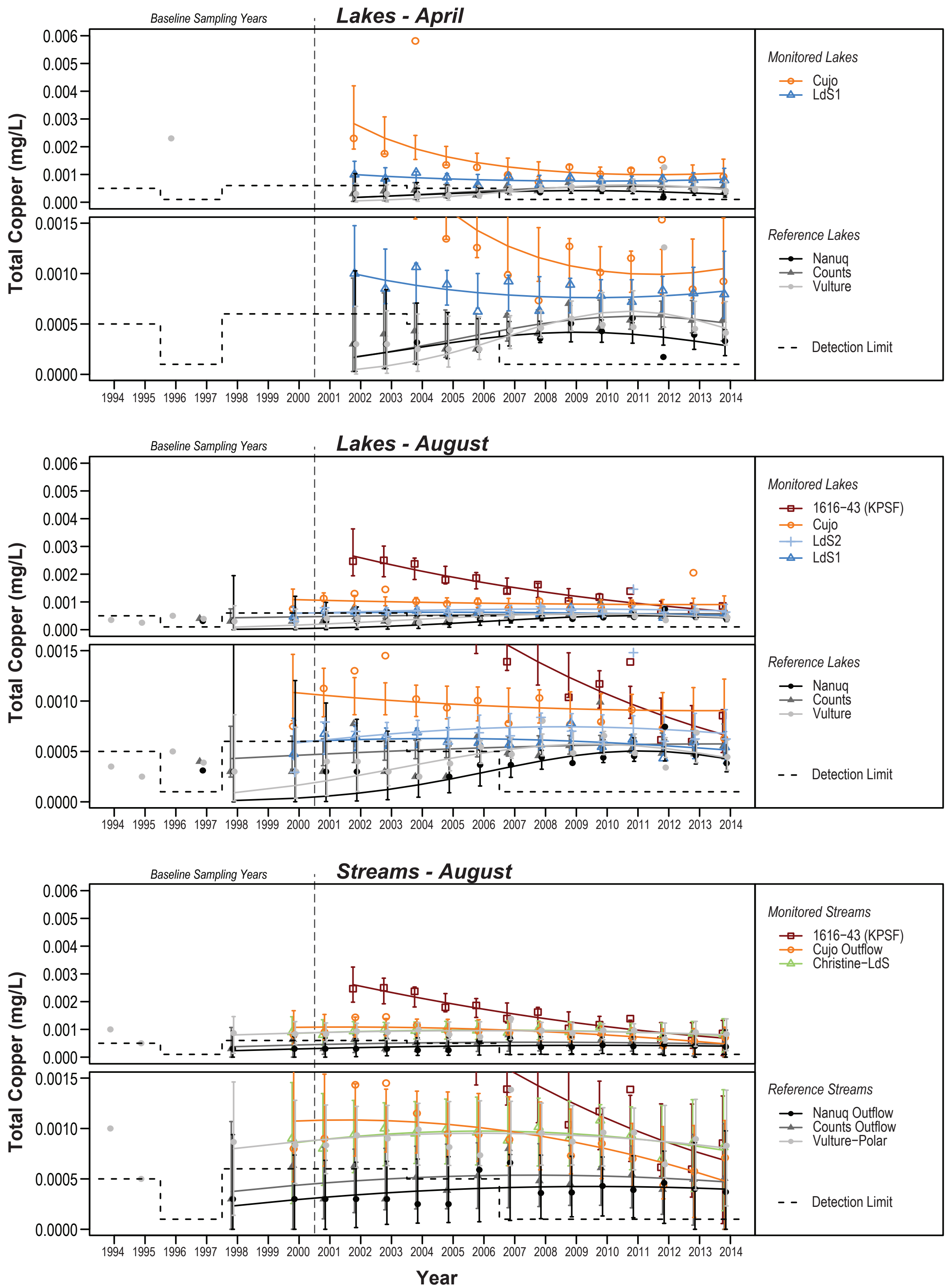
Temp °C	pH 6	6.5	7	7.5	8	8.5	9	10
0	190	60.0	19.0	6.02	1.92	0.616	0.206	0.035
5	126	39.7	12.6	3.98	1.27	0.413	0.141	0.028
10	83.9	26.6	8.47	2.68	0.855	0.282	0.100	0.024
15	57.3	18.1	5.74	1.83	0.588	0.197	0.073	0.021
20	39.5	12.5	3.96	1.27	0.410	0.141	0.055	0.020
25	27.6	8.72	2.77	0.888	0.291	0.103	0.044	0.018
30	19.5	6.17	1.97	0.631	0.211	0.077	0.035	0.017

Total Ammonia (as nitrogen)
Values outside shaded area should be used with caution

Notes: Symbols represent observed mean values. Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
CCME Guideline is pH and temperature dependent (see inset table).
** Upper 95% Confidence Interval on the fitted mean of Counts Lake in April 2008 = $3.25x10^{246}$ mg/L, 2009 = $1.76x10^{172}$ mg/L, 2010 = $2.92x10^{89}$ mg/L, 2012 = $2.66x10^{95}$ mg/L, 2013 = $6.58x10^{194}$ mg/L, and 2014 = $2.24x10^{296}$*

Figure 5-13

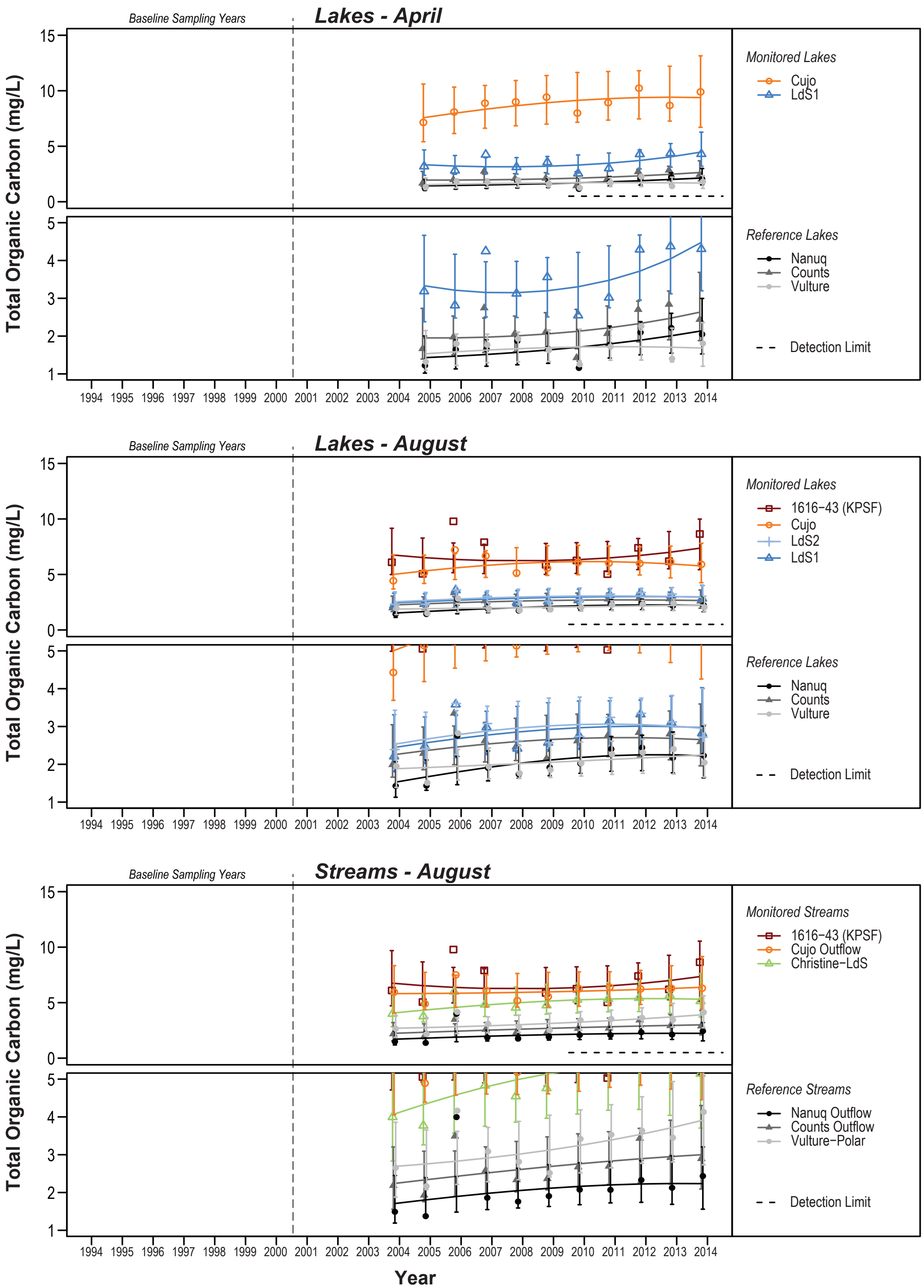
Observed and Fitted Means for Total Copper in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.
WL = Maximum average concentration premitted in water licence W2009L2-0001. WL = 0.10 mg/L.
*CCME Guideline = $e^{0.8545 X (\ln Hardness) - 1.465}$ * 0.2/1000 mg/L, where hardness < 180 mg/L and 0.004 mg/L where hardness is ≥ to 180 mg/L.*
Minimum benchmark = 0.002 mg/L.

Figure 5-14

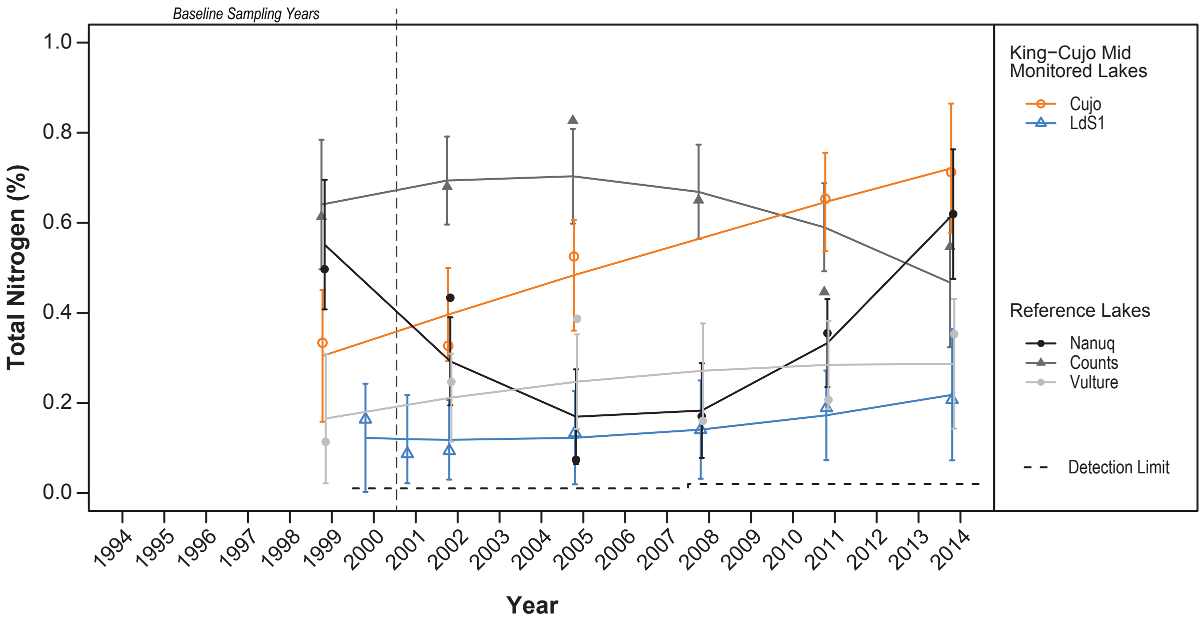
Observed and Fitted Means for Total Organic Carbon in King-Cujo Watershed Lakes and Streams and Lac du Sauvage, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.

Figure 5-15

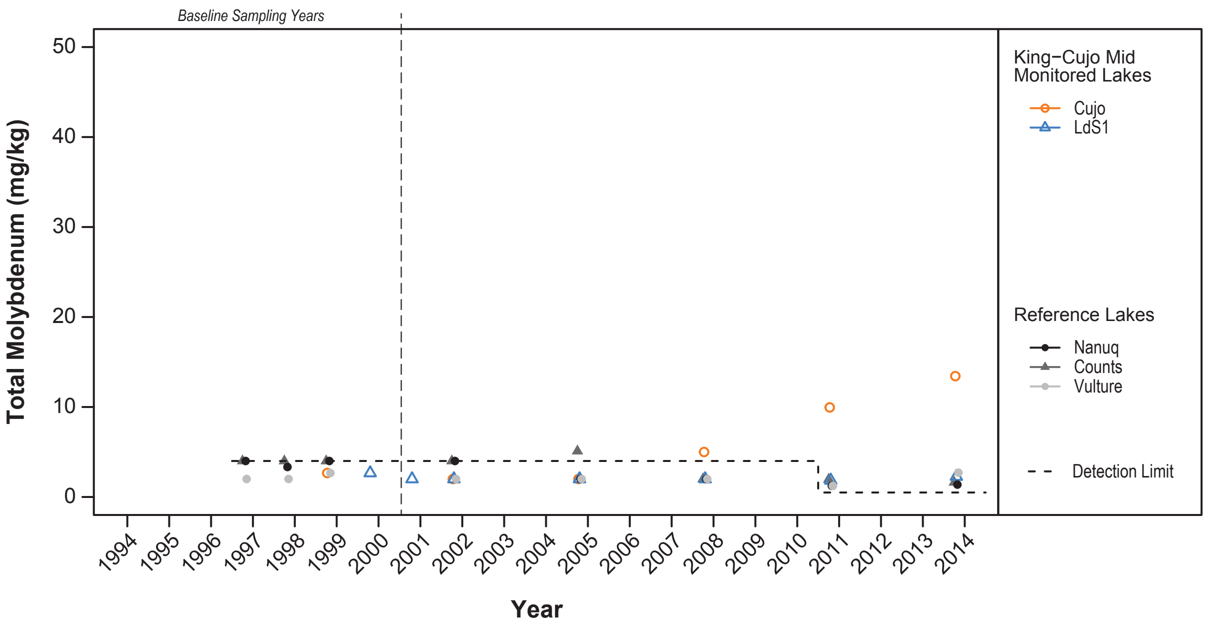
Observed and Fitted Means for Total Nitrogen Percentages in Sediments in King-Cujo Watershed Lakes and Lac du Sauvage, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.

Figure 5-16

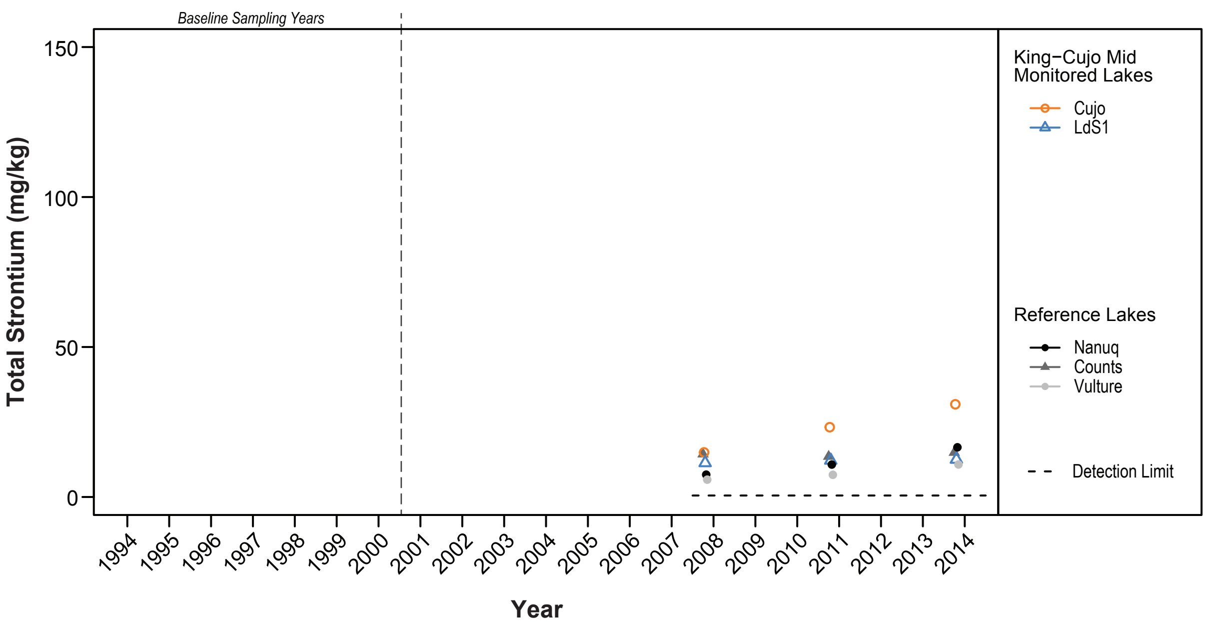
Observed and Fitted Means for Total Molybdenum Concentrations in Sediments in King-Cujo Watershed Lakes and Lac du Sauvage, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.

Figure 5-17

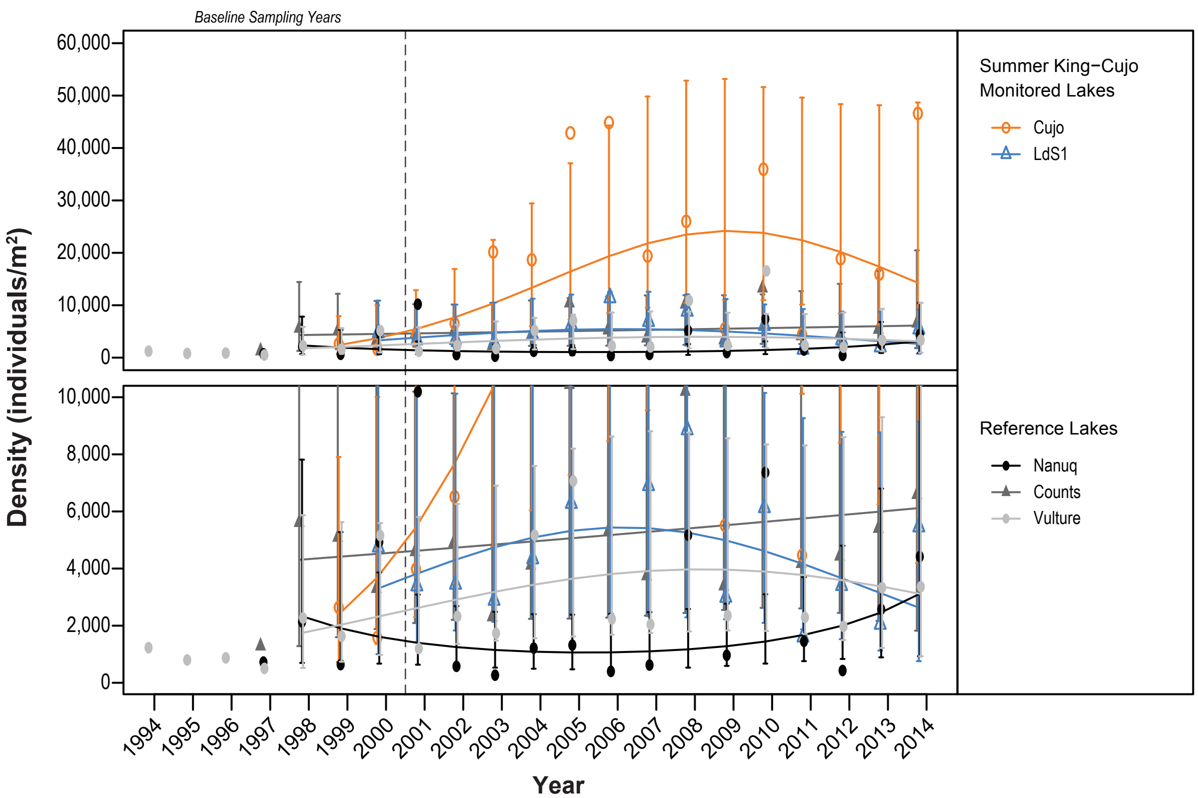
Observed and Fitted Means for Total Strontium Concentrations in Sediments in King-Cujo Watershed Lakes and Lac du Sauvage, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.

Figure 5-18

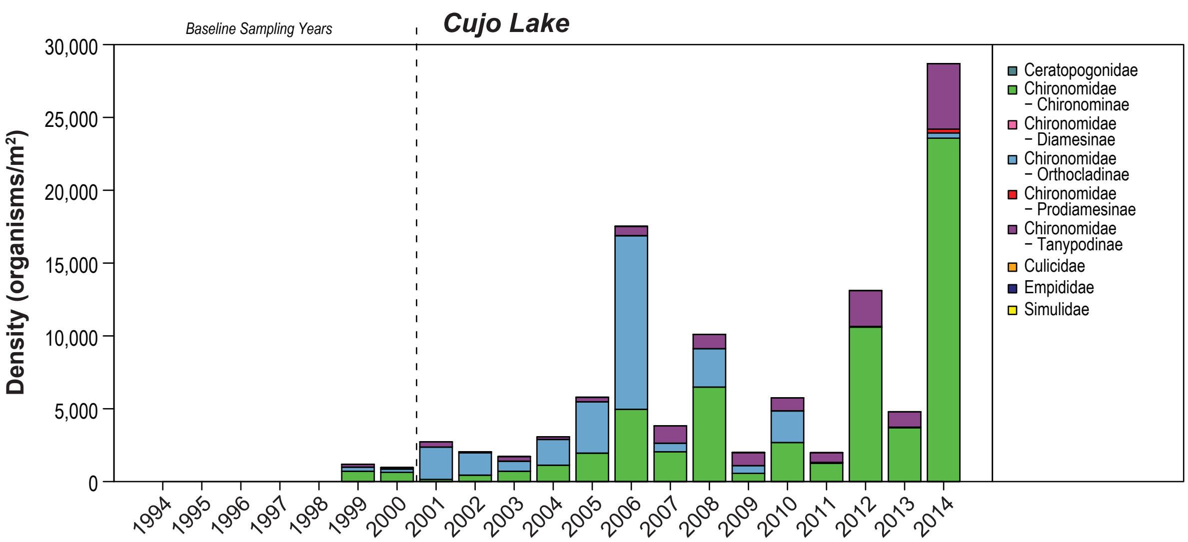
Observed and Fitted Means for Benthos Densities in King-Cujo Watershed Lakes and Lac du Sauvage, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars indicate upper and lower 95% confidence intervals of the fitted means.

Figure 5-19

Average Density of Diptera Taxa for Lakes of the King-Cujo Watershed and Lac du Sauvage, 1994 to 2014



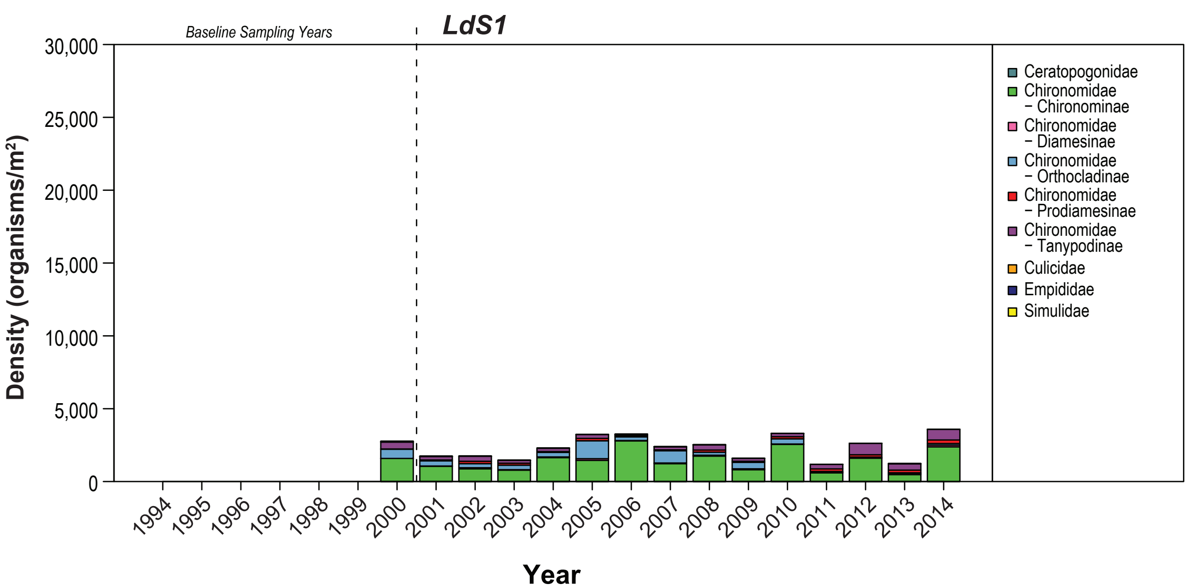
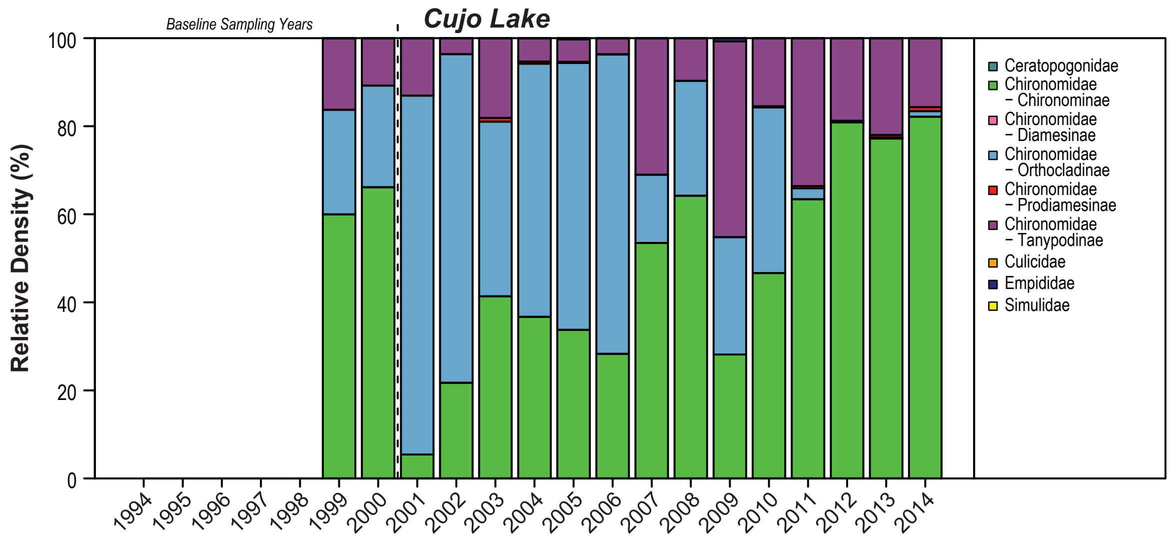
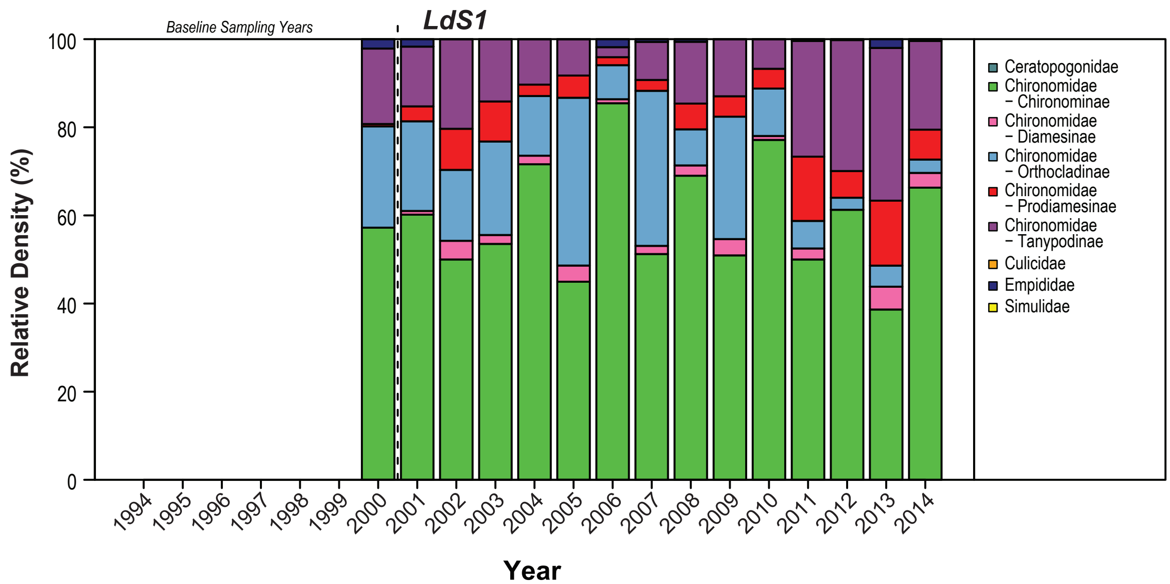


Figure 5-20

Average Density of Diptera Taxa for Lakes of the King-Cujo Watershed and Lac du Sauvage, 1994 to 2014





6. SUMMARY OF EVALUATION OF EFFECTS FOR THE PIGEON-FAY AND UPPER EXETER WATERSHED

Figure 6-1 summarizes the evaluation of effects for the Pigeon-Fay and Upper Exeter Watershed. Because statistical tests were two-sided and only tested for differences between reference and monitored lakes or streams between the before and after periods, conclusions on the direction of change were made from graphical analysis. Figures 6-2 to 6-15 illustrate BACI analyses and graphical representations of historical data that were used to assist in interpreting statistical results and provide support for the summary of effects for the Pigeon-Fay and Upper Exeter presented below. For additional details, please refer to Part 1 – Evaluation of Effects.

No mine effects were detected with respect to Secchi depth in monitored lakes during the open water season in 2014 (Table 5.5-1). Under-ice temperature and DO concentrations were not evaluated because the winter of 2014 predates the opening of the PSD and its connection with the natural Pigeon Stream.

A total of 23 water quality variables were evaluated for lakes and streams in the Pigeon-Fay and Upper Exeter Watershed in the 2014 AEMP. Of these, concentrations of nine variables have increased in Fay Bay in 2014, when compared to the before period (Figures 6-1 and 6-2 to 6-10):

- total alkalinity
- water hardness
- chloride
- sulphate
- potassium
- TOC
- total barium
- total nickel
- total strontium

In all cases, the source of the increase in Fay Bay is unclear at this time, but may be related to the unplanned release of FPK in May of 2008 (Rescan 2011a). CCME guidelines for the protection of aquatic life exist for ten of the evaluated water quality variables, including pH, total suspended solids (TSS), total ammonia-N, nitrite-N, total arsenic, total boron, total cadmium, total nickel, total selenium, and total uranium (CCME 2014). In addition, DDEC has established SSWQO for six of the evaluated variables, including chloride, sulphate, potassium, nitrate-N, total molybdenum, and total vanadium (see Table 2.3-1 in Section 2.3). Total phosphate concentrations were compared to lake-specific benchmark trigger values that were established using guidelines set out in the Canadian Guidance Framework for the Management of Phosphorus in Freshwater Systems (CCME 2004). Other water quality benchmark values include provincial guidelines or those taken from the published literature (i.e., antimony, barium, and strontium). All observed mean concentrations of the evaluated water quality variables were below their respective benchmark value in 2014 (Figure 6-1), and in general, increases in magnitude were relatively small (Figure 6-1).

Eleven sediment quality variables were evaluated in the 2014 AEMP for the Pigeon-Fay and Upper Exeter Watershed. Of these, the concentrations of one variable (i.e., total nickel) showed signs of an increase, but the cause was unlikely related to mine activities (Figure 6-1 and 6-11). CCME guidelines for the protection of aquatic life exist for two of the evaluated sediment quality variables, including arsenic and cadmium. For arsenic, the 95% confidence intervals of the fitted mean in Fay Bay and the observed mean in Upper Exeter Lake exceeded the CCME ISQG and PEL in 2014 (Figure 6-1); however, similar patterns were observed in reference lakes. For cadmium, observed mean concentrations in 2014 were below the CCME ISQG and PEL guideline value in 2014 (Figure 6-1).

Results from water quality and sediment quality analyses in the Pigeon-Fay and Upper Exeter Watershed suggest that changes might be expected in phytoplankton communities in Fay Bay, as concentrations of nine evaluated water quality variables and one sediment quality variable have increased in 2014. Increases in water quality variables may be related to the unplanned release of FPK in 2008 (Rescan 2011a), while the source of the increase in the one sediment quality variable (i.e., nickel) is unclear at this time and unlikely related to mine activities. The overall results of the 2012 AEMP Re-evaluation suggested that observed changes in biological community composition in the Koala and King-Cujo watersheds likely resulted from inter-specific differences in the competitive ability of different taxonomic groups under changing quantities or ratios of macronutrients (i.e., nitrogen and phosphorus), rather than elemental toxicity (Rescan 2012b). In contrast to those two watersheds, no major changes in nutrients were observed in the Pigeon-Fay and Upper Exeter Watershed. As the concentrations of all water and sediment quality variables in the Pigeon-Fay and Upper Exeter Watershed have remained below all guideline values with no toxic effects expected, and no major changes in nutrient availability have been observed, there was no reason to expect adverse biological effects in 2014.

No mine-related effects in chlorophyll *a* concentrations were detected in either Fay Bay or Upper Exeter Lake. Chlorophyll *a* concentration and phytoplankton density increased in 2014 in Fay Bay compared to the before period (Figure 6-12), and this increase was driven by a large abundance of Myxophyceae (i.e., blue-green algae; Figures 6-13 and 6-14). The cause of the large density of Myxophyceae observed at Fay Bay in 2014 is unclear at this time and may represent natural variability. Phytoplankton diversity in Upper Exeter Lake appears to have increased in 2014 compared to the before period, likely as a result of increases in the density of Chlorophyceae and Chrysophyceae, corresponding to a more even distribution in abundance among the phytoplankton groups (Figures 6-13 to 6-15). Phytoplankton density, diversity, and community composition have been assessed sporadically through time making it difficult to discern temporal trends. In particular, the lack of data from 2011 to 2013 makes it difficult to determine whether observed changes in blue-green algae density in Fay Bay and increased diversity in Upper Exeter Lake represent a trend through time and a mine effect, rather than representing natural variability. At this time, no mine effects were detected with respect to phytoplankton biomass, density, diversity, or community composition in the Pigeon-Fay and Upper Exeter Watershed.

Figure 6-1

Summary of Mine-related Changes in the Variables Evaluated for the Pigeon-Fay and Upper Exeter Watershed, 2014

ERM

Water Quality

Downstream →	Pigeon Reach 1	Fay Bay	Upper Exeter
Under-ice Temperature	●	●	●
Under-ice Dissolved Oxygen	●	●	●
Secchi Depth	●	—	—
pH	—	—	—
Total Alkalinity	—	!!	—
Water Hardness	—	▲ 0-25%	▲ 0-25%
Chloride	—	▲ 51-75%	—
Sulphate	—	!!	—
Potassium	—	!!	—
Total Suspended Solids	—	—	—
Total Ammonia-N	—	—	—
Nitrite-N	—	—	—
Nitrate-N	—	—	—
Total Phosphate-P	—	—	—
Total Organic Carbon	—	▲ 76-100%	—
Total Antimony	—	—	—
Total Arsenic	—	—	—
Total Barium	—	▲ 0-25%	—
Total Boron	—	—	—
Total Cadmium	—	—	—
Total Molybdenum	—	—	—
Total Nickel	—	▲ 0-25%	—
Total Selenium	—	—	—
Total Strontium	—	▲ 51-75%	—
Total Uranium	—	—	—
Total Vanadium	—	—	—

Sediment Quality

Downstream →	Pigeon Reach 1	Fay Bay	Upper Exeter
Total Organic Carbon	●	—	—
Available Phosphorus	●	—	—
Total Nitrogen	●	—	—
Total Antimony	●	—	—
Total Arsenic	●	***	***
Total Cadmium	●	—	—
Total Molybdenum	●	—	—
Total Nickel	●	—	—
Total Phosphorus	●	—	—
Total Selenium	●	—	—
Total Strontium	●	—	—

Biology

Downstream →	Pigeon Reach 1	Fay Bay	Upper Exeter
Phytoplankton			
Chlorophyll *a* Concentration	●	—	—
Phytoplankton Density	●	—	—
Phytoplankton Diversity	●	—	—
Relative Densities of Major Phytoplankton Taxa	●	—	—

Notes:

The direction and degree of change was inferred from historical data. For water quality data, differences were assessed relative to data from 2002 (summer lakes and streams), or the first year in which data was collected (i.e., TOC = 2001 in Fay Bay and 2005 in Upper Exeter Lake). The month in which the greatest change occurred (i.e., July, August, or September) is represented in the table. For sediment quality data, differences were assessed relative to data from 2002.

For water quality and sediment quality data, % change was calculated as 1-(historical concentration/current concentration). For biology data, % change was calculated as (current concentration-historical concentration)/historical concentration.

** Indicates that the upper bound of the 95% CI exceeded the SSWQO, water quality benchmark, CCME water quality guideline, or CCME ISQG value during the ice-covered or open water season.*

*** Indicates that the observed mean exceeded the SSWQO, water quality benchmark, CCME water quality guideline, or CCME ISQG value during the ice-covered or open water season.*

**** Indicates that the upper bound of the 95% CI or the observed mean exceeded the CCME PEL.*

!!: Indicates cases where an increase in concentration was observed during the ice-covered season only.

Legend:

Increased over time in comparison to reference lakes/streams or different from a constant+
▲ 0-25% ▲ 26-50% ▲ 51-75% ▲ 76-100%

Decreased over time in comparison to reference lakes/streams or different from a constant+
▼ 0-25% ▼ 26-50% ▼ 51-75% ▼ 76-100%

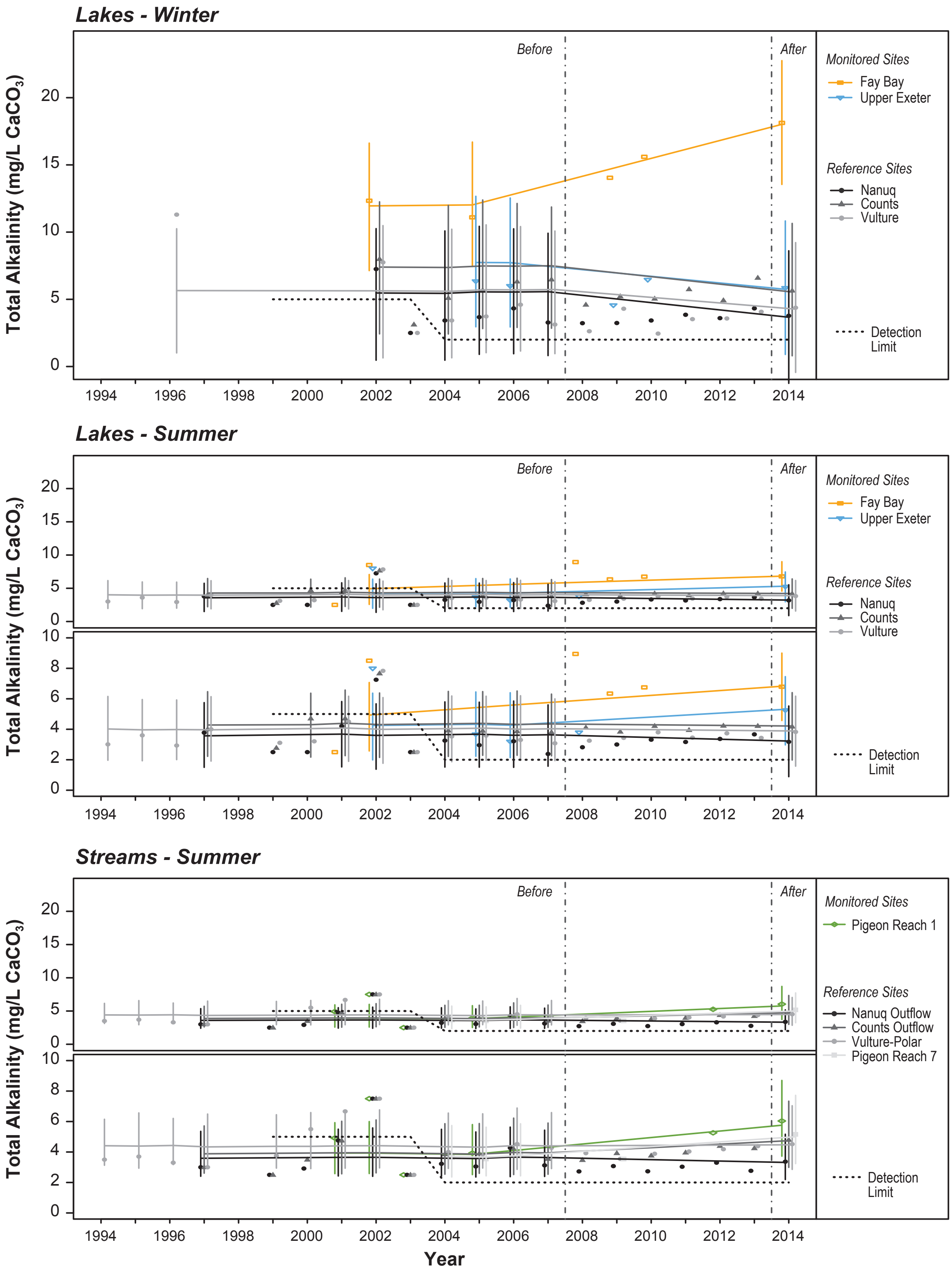
— Did not change over time or differ significantly over time from reference lakes/streams

● Variable was not sampled at this lake/stream

◆ Changed over time

Figure 6-2

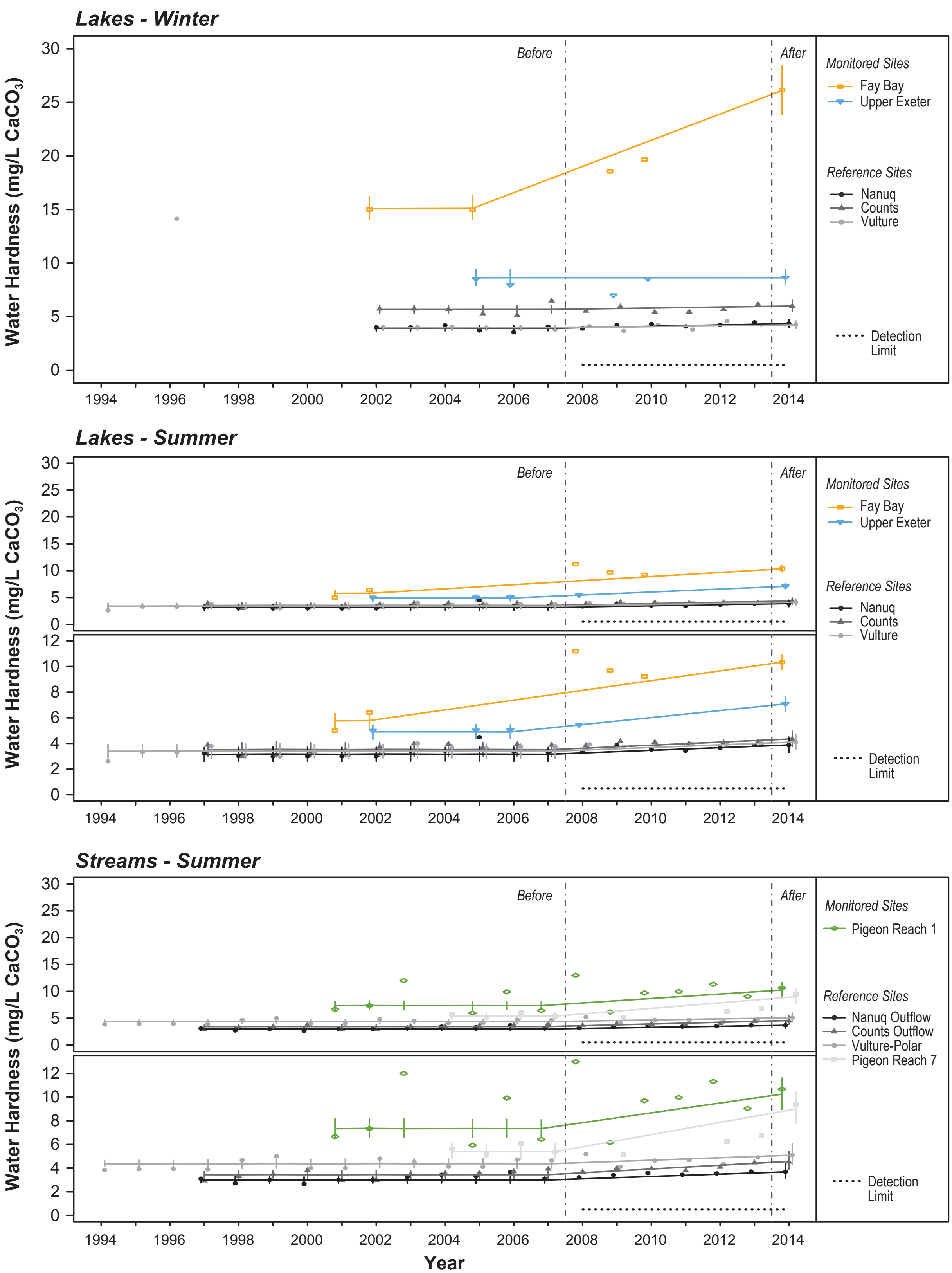
Observed and Fitted Means for Total Alkalinity in Pigeon-Fay and Upper Exeter Watershed Lakes and Streams, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars represent the 95% inter-quantile range of bootstrapped fitted values based on the model.
Censored data and outliers are excluded from the model and the fitted values.
The positions of data along the x-axis have been adjusted for legibility.

Figure 6-3

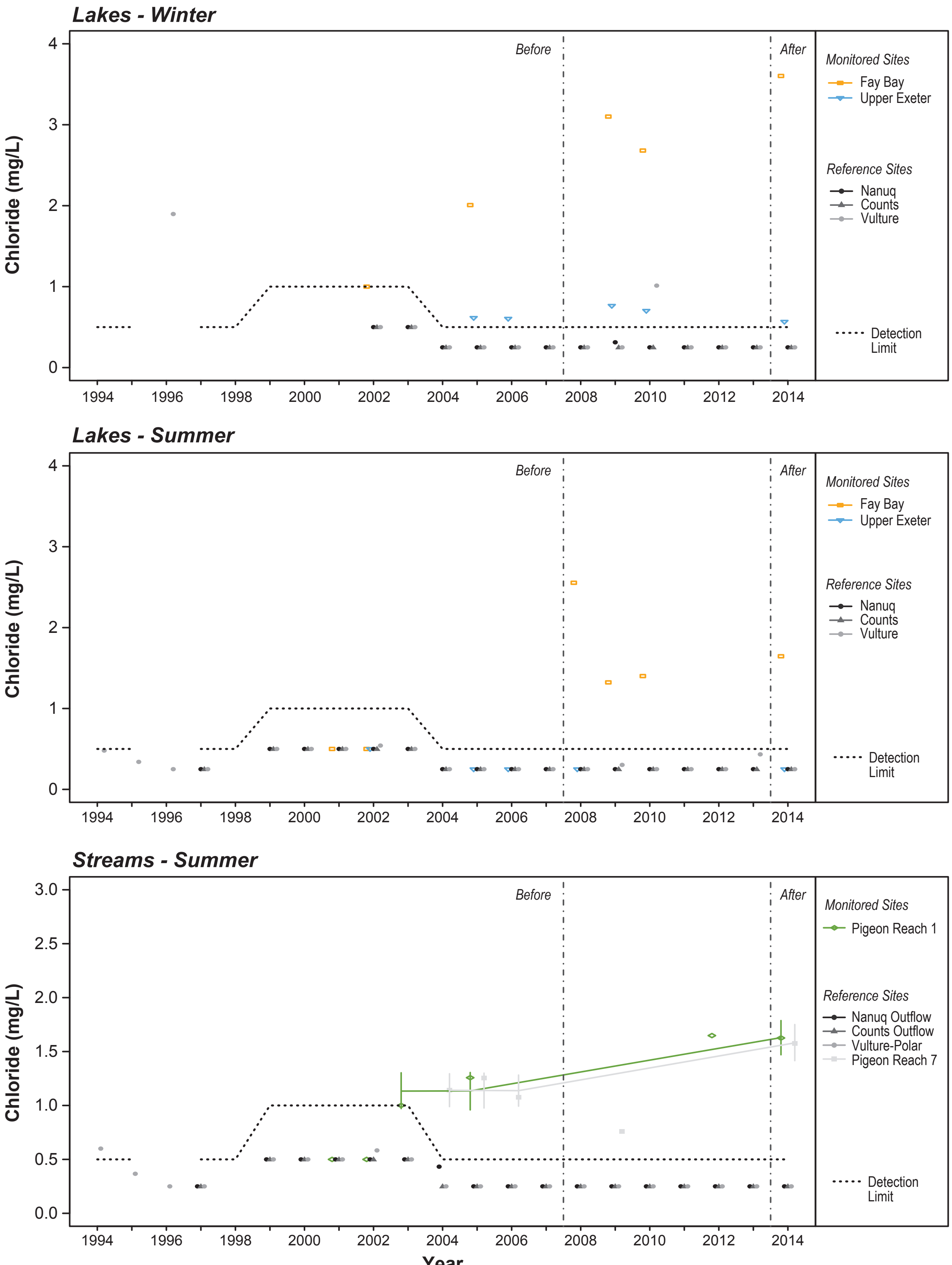
Observed and Fitted Means for Water Hardness in Pigeon-Fay and Upper Exeter Watershed Lakes and Streams, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars represent the 95% inter-quantile range of bootstrapped fitted values based on the model.
Censored data and outliers are excluded from the model and the fitted values.
The positions of data along the x-axis have been adjusted for legibility.

Figure 6-4

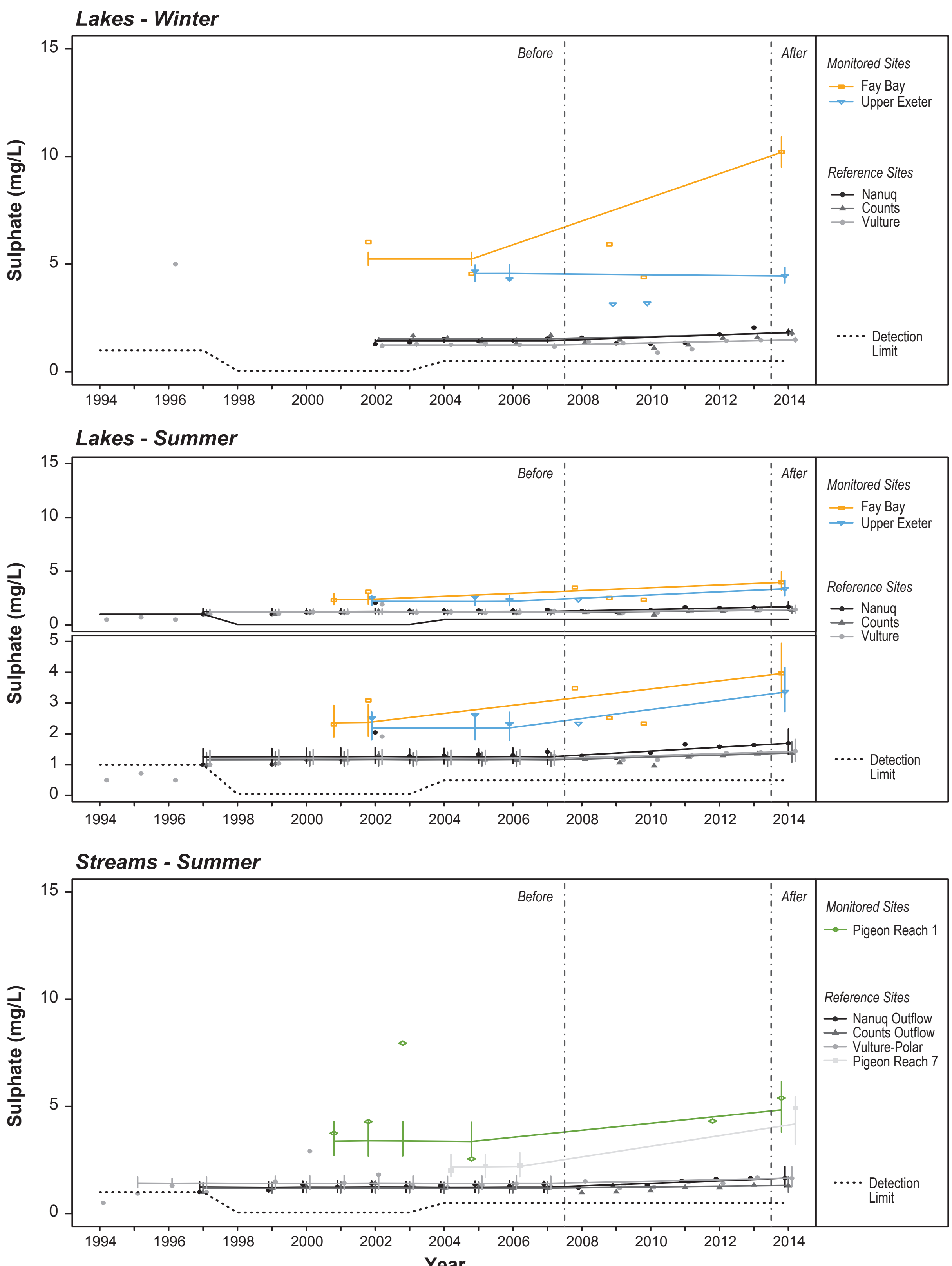
Observed and Fitted Means for Chloride Concentrations in Pigeon-Fay and Upper Exeter Watershed Lakes and Streams, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars represent the 95% inter-quantile range of bootstrapped fitted values based on the model.
Censored data and outliers are excluded from the model and the fitted values.
The positions of data along the x-axis have been adjusted for legibility.
SSWQO = 116.6 X ln(Hardness) - 204.1, where hardness = 10 - 160 mg/L.

Figure 6-5

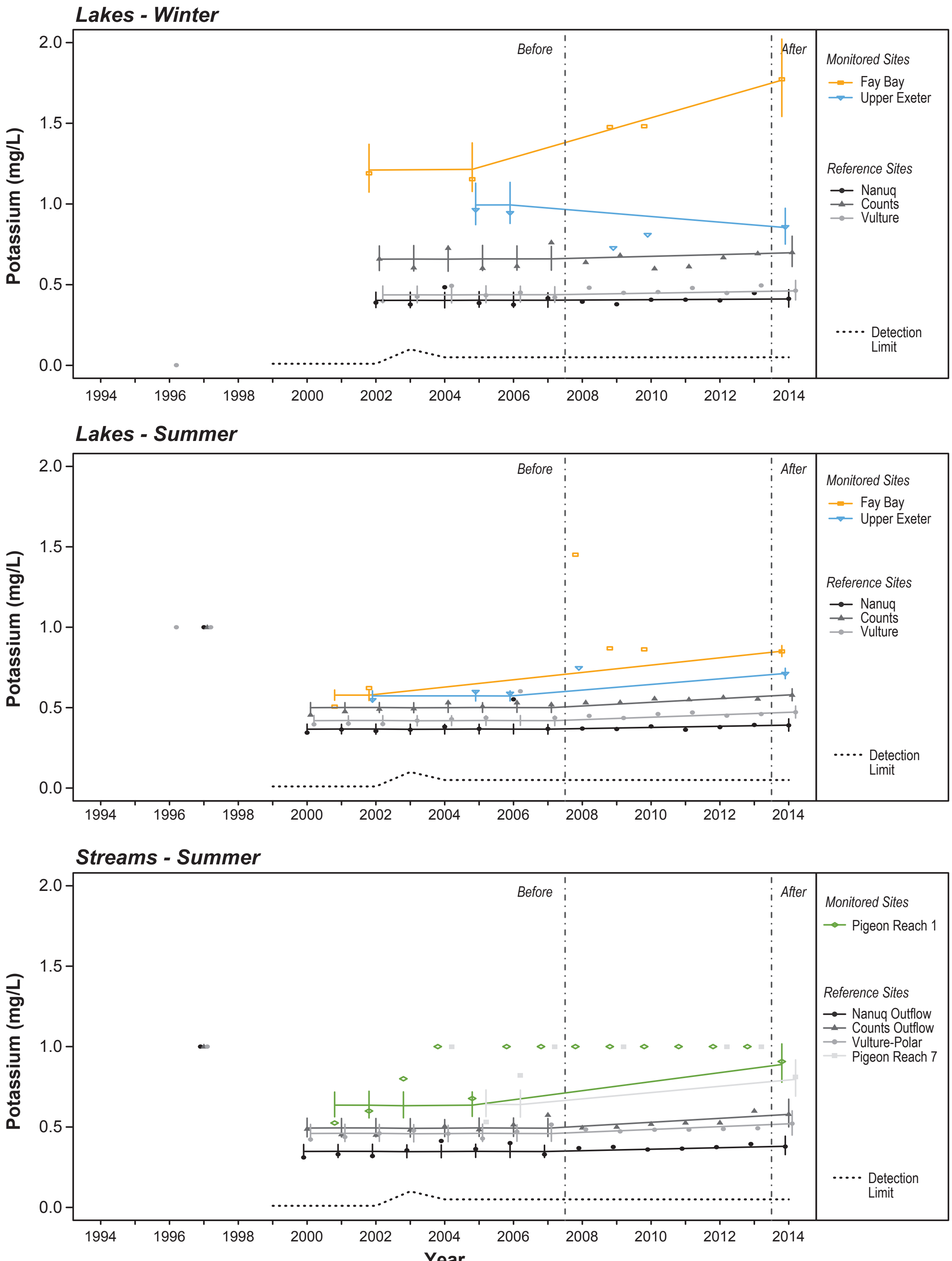
Observed and Fitted Means for Sulphate Concentrations in Pigeon-Fay and Upper Exeter Watershed Lakes and Streams, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars represent the 95% inter-quantile range of bootstrapped fitted values based on the model.
Censored data and outliers are excluded from the model and the fitted values.
The positions of data along the x-axis have been adjusted for legibility.
SSWQO = $e^{(0.9116 \times \ln(Hardness) + 1.712)}$ mg/L, where hardness < 160 mg/L.

Figure 6-6

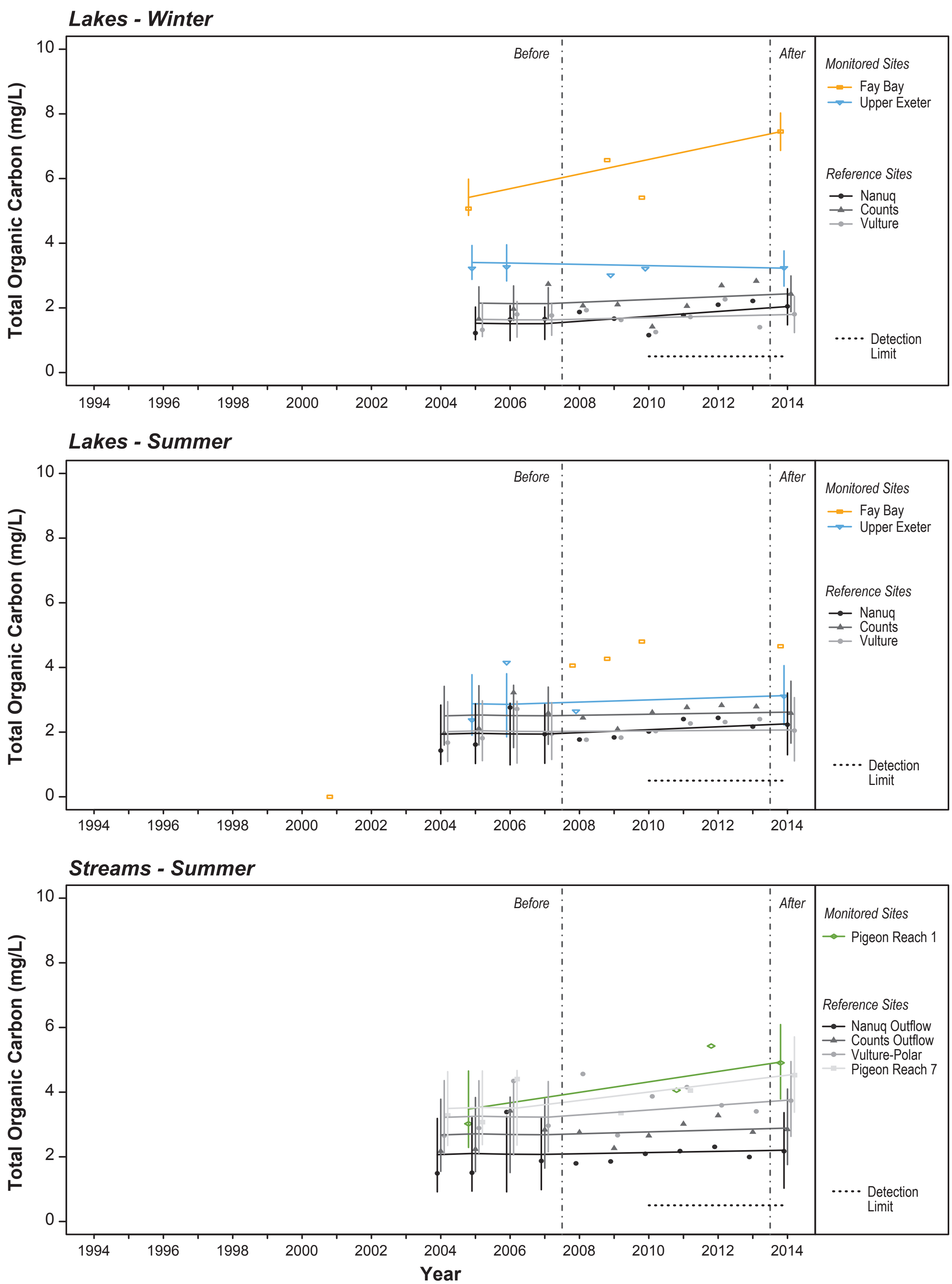
Observed and Fitted Means for Potassium Concentrations in Pigeon-Fay and Upper Exeter Watershed Lakes and Streams, 1994 to 2014



Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars represent the 95% inter-quantile range of bootstrapped fitted values based on the model.
Censored data and outliers are excluded from the model and the fitted values.
The positions of data along the x-axis have been adjusted for legibility.
SSWQO = 41 mg/L.

Figure 6-7

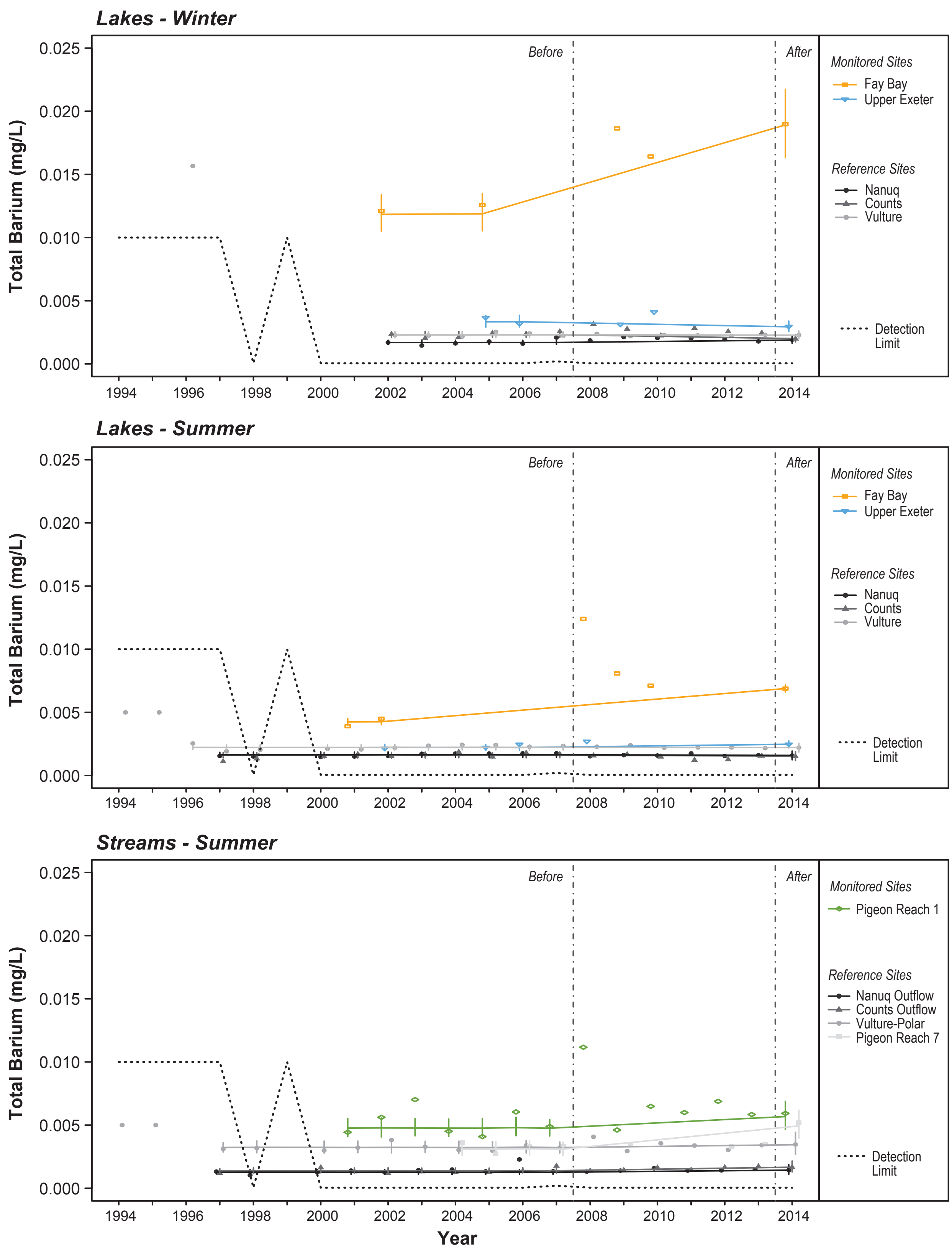
Observed and Fitted Means for Total Organic Carbon Concentrations in Pigeon-Fay and Upper Exeter Watershed Lakes and Streams, 1994 to 2014



Notes: *Symbols represent observed mean values; solid lines represent fitted curves.*
Error bars represent the 95% inter-quantile range of bootstrapped fitted values based on the model.
Censored data and outliers are excluded from the model and the fitted values.
The positions of data along the x-axis have been adjusted for legibility.

Figure 6-8

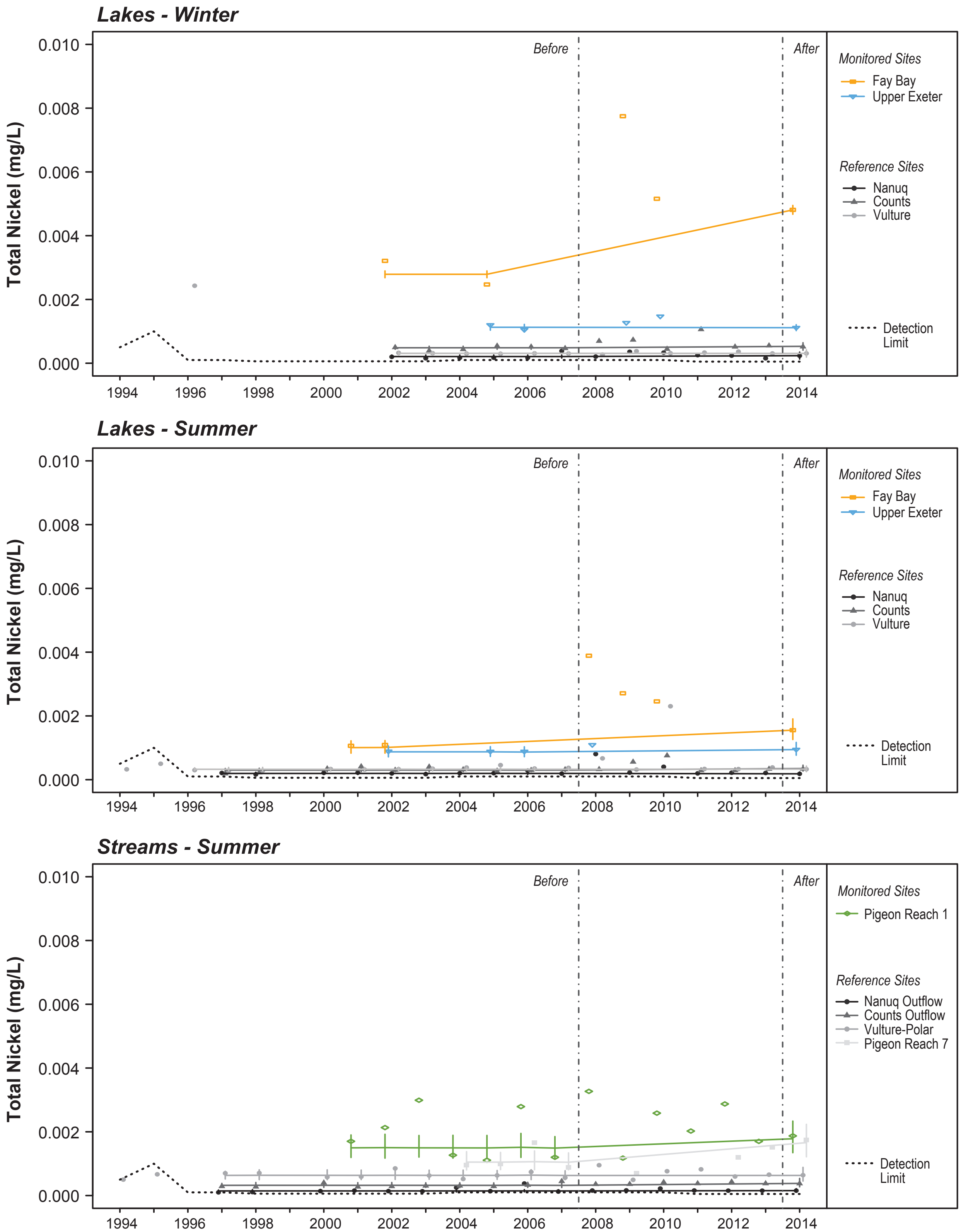
Observed and Fitted Means for Total Barium Concentrations in Pigeon-Fay and Upper Exeter Watershed Lakes and Streams, 1994 to 2014



Notes: *Symbols represent observed mean values; solid lines represent fitted curves.*
Error bars represent the 95% inter-quantile range of bootstrapped fitted values based on the model.
Censored data and outliers are excluded from the model and the fitted values.
The positions of data along the x-axis have been adjusted for legibility.
Water quality benchmark (Haywood and Drinnan 1983) = 1 mg/L.

Figure 6-9

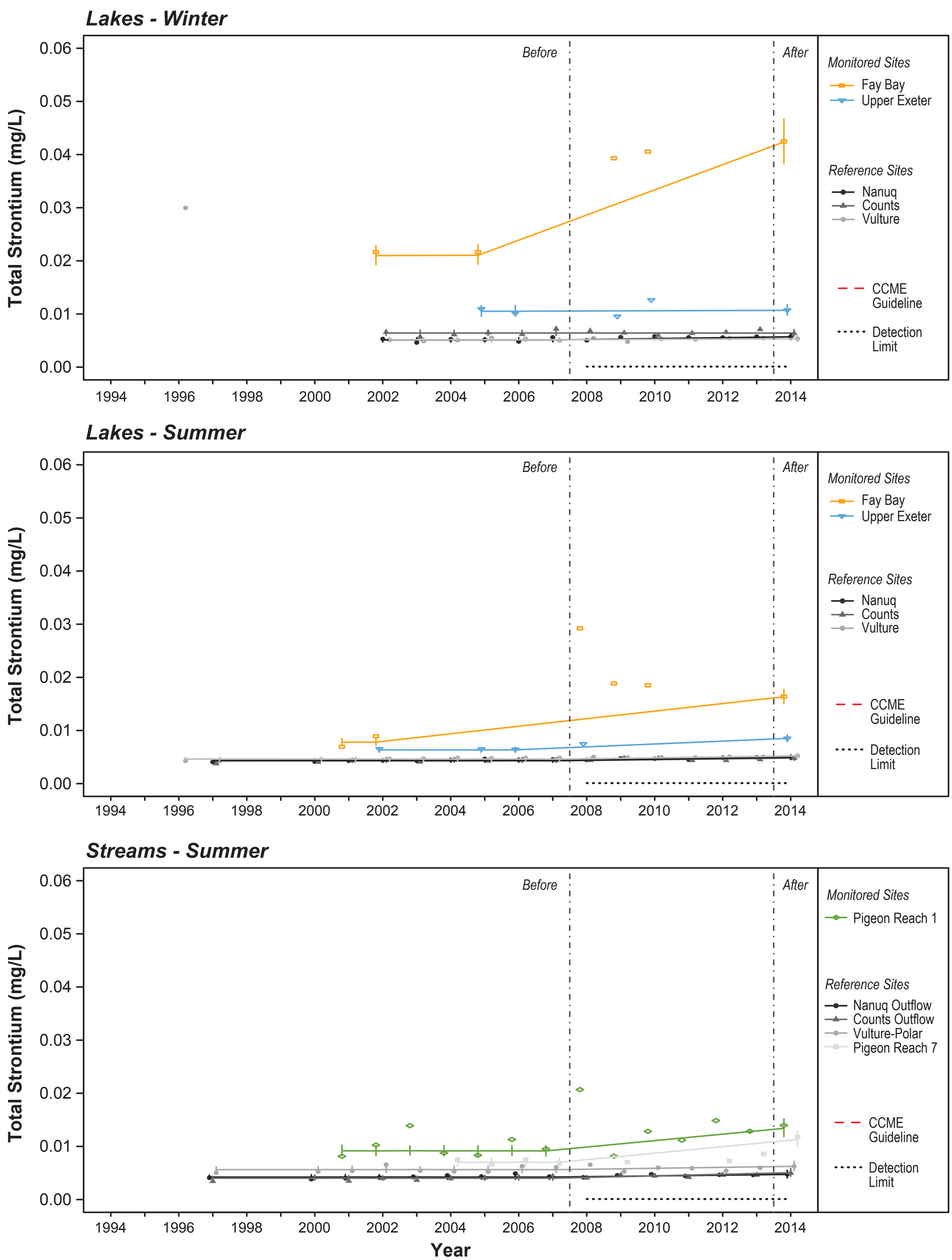
Observed and Fitted Means for Total Nickel Concentrations in Pigeon-Fay and Upper Exeter Watershed Lakes and Streams, 1994 to 2014



Notes: Symbols represent observed mean values; solid lines represent fitted curves.
Error bars represent the 95% inter-quantile range of bootstrapped fitted values based on the model.
Censored data and outliers are excluded from the model and the fitted values.
The positions of data along the x-axis have been adjusted for legibility.
CCME Guideline = $e^{0.76 X (lnHardness) + 1.06}$*/1000 mg/L, where hardness = 60 - 180 mg/L,*
0.025 mg/L where hardness < 60 mg/L, and 0.15 mg/L where hardness > 180 mg/L.

Figure 6-10

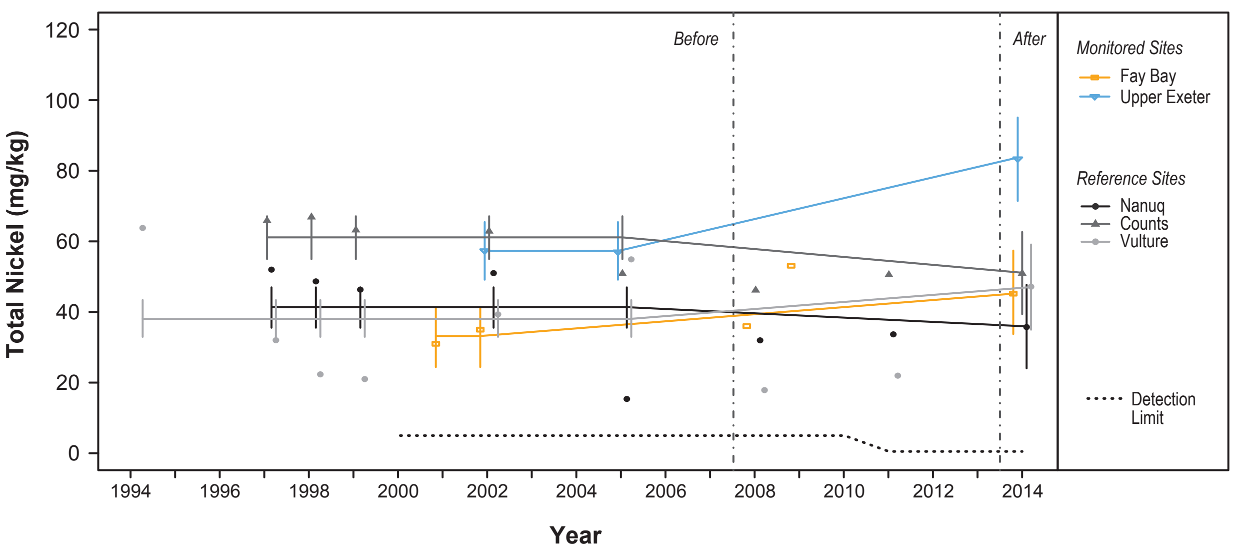
Observed and Fitted Means for Total Strontium Concentrations in Pigeon-Fay and Upper Exeter Watershed Lakes and Streams, 1994 to 2014



Notes: Symbols represent observed mean values; Solid lines represent fitted curves.
Error bars represent the 95% inter-quantile range of bootstrapped fitted values based on the model.
Censored data and outliers are excluded from the model and the fitted values.
The positions of data along the x-axis have been adjusted for legibility.
Water quality benchmark (Golder 2011) = 6.242 mg/L.

Figure 6-11

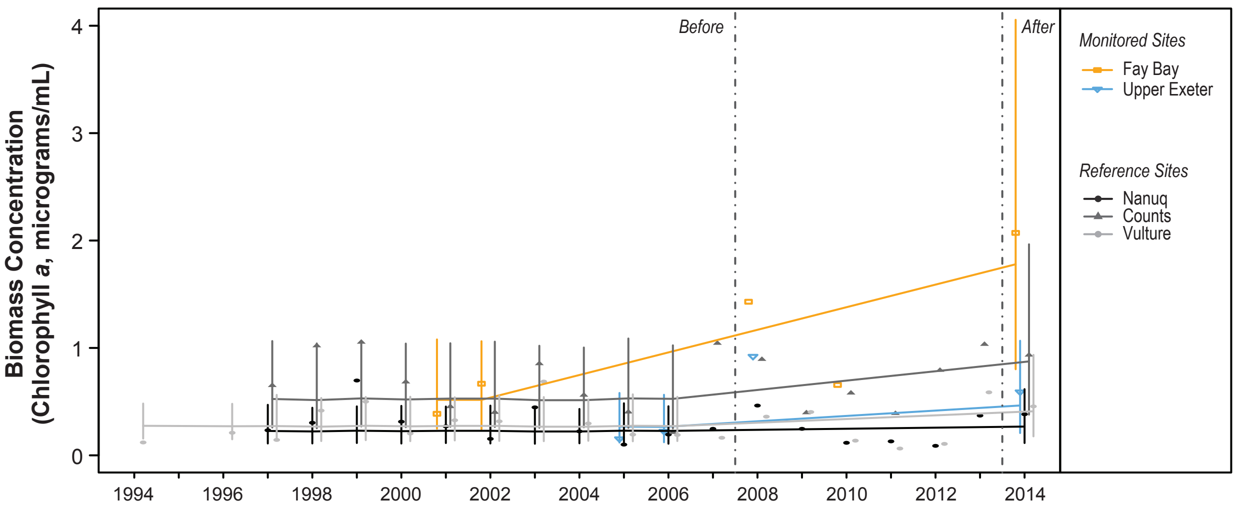
Observed and Fitted Means for Total Nickel Concentrations in Sediments in Pigeon-Fay and Upper Exeter Watershed Lakes, 1994 to 2014

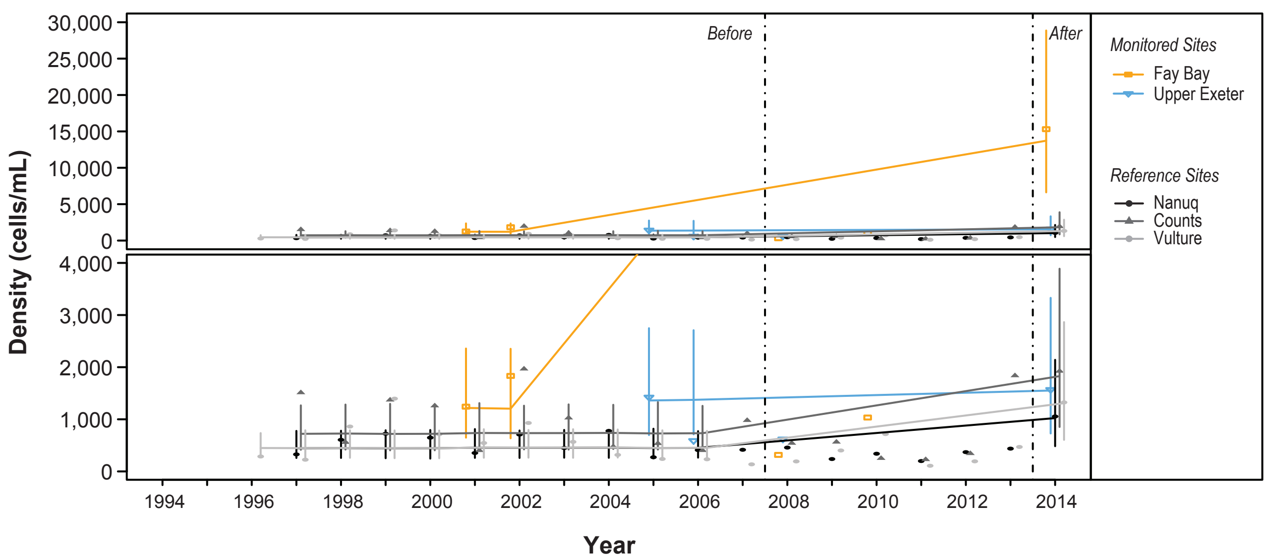


Notes: Symbols represent observed mean values.
Solid lines represent fitted curves.
Error bars represent the 95% inter-quantile range of bootstrapped fitted values based on the model.
Censored data and outliers are excluded from the model and the fitted values.
The positions of data along the x-axis have been adjusted for legibility.

Figure 6-12

Observed and Fitted Means for Chlorophyll *a* Concentrations and Phytoplankton Density in Pigeon-Fay and Upper Exeter Watershed Lakes, 1994 to 2014

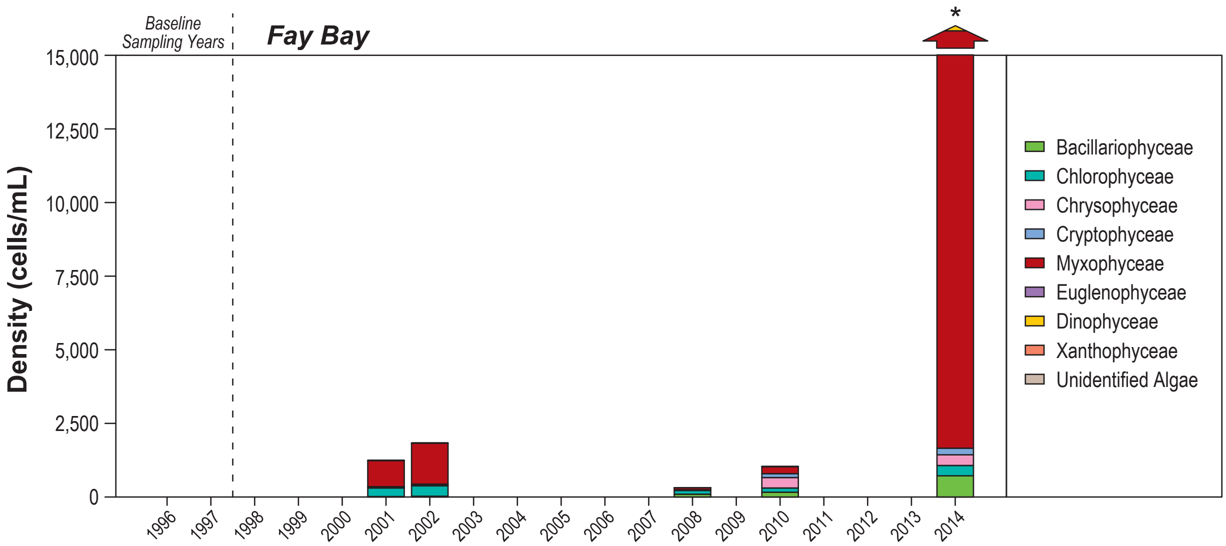


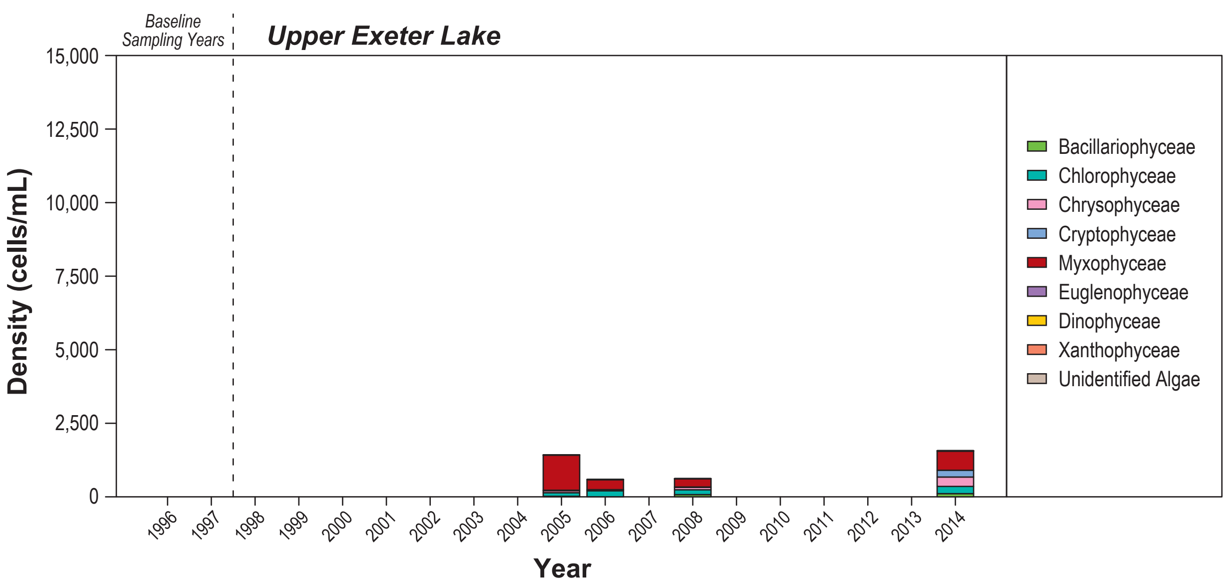


Notes: *Symbols represent observed mean values.*
Solid lines represent fitted curves.
Error bars represent the 95% inter-quantile range of bootstrapped fitted values based on the model.
Censored data and outliers are excluded from the model and the fitted values.
The positions of data along the x-axis have been adjusted for legibility.

Figure 6-13

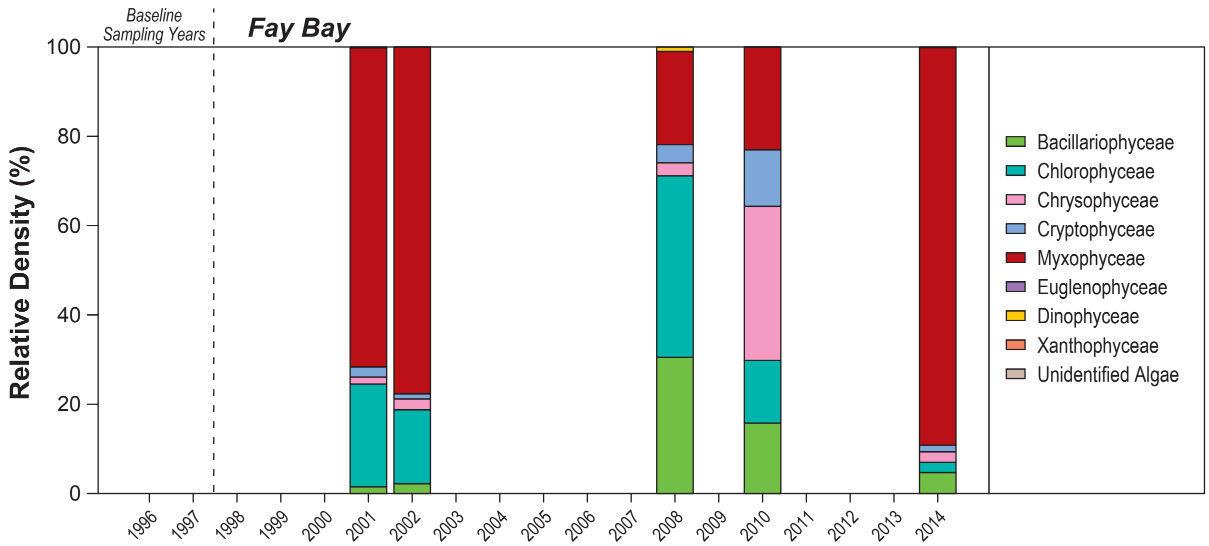
Average Phytoplankton Density by Taxonomic Group for Lakes of the Pigeon-Fay and Upper Exeter Watershed, 1996 to 2014





*Note: *Total density in 2014 = 15,307: Myxophyceae = 13,627; Dinophyceae = 22.*

Relative Densities of Phytoplankton Taxa in Lakes of the Pigeon-Fay and Upper Exeter Watershed, 1996 to 2014



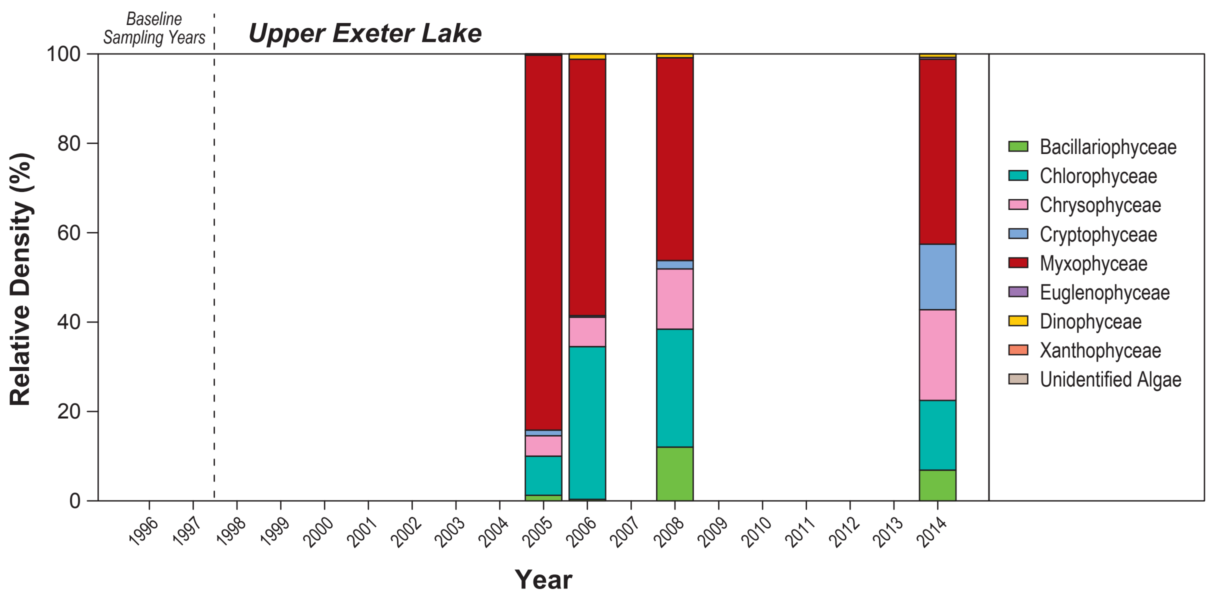
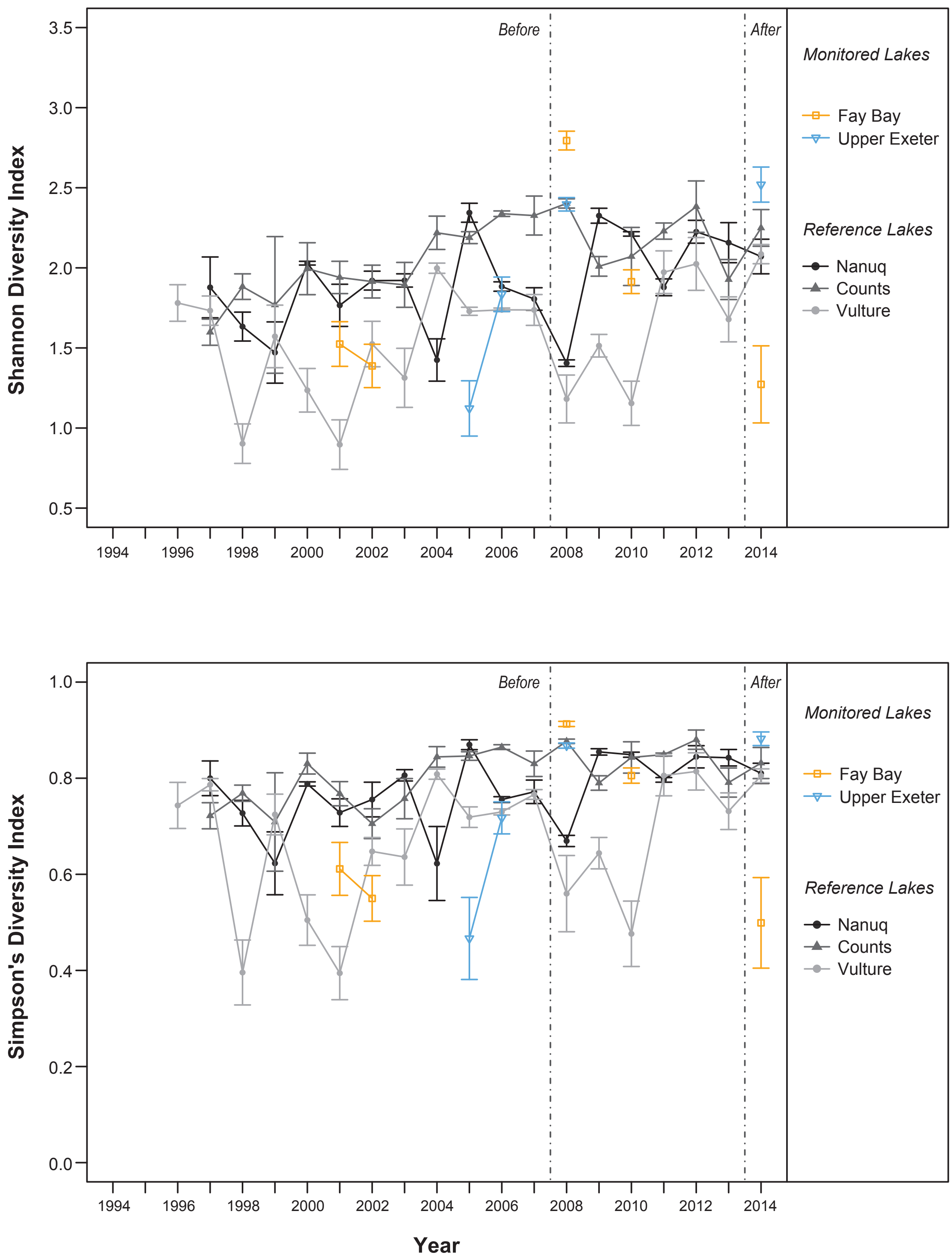


Figure 6-15

Average Diversity Indices for Phytoplankton in Pigeon-Fay and Upper Exeter Watershed Lakes, 1996 to 2014



Notes: Symbols represent observed mean values.
Error bars indicate standard error of the observed means.

7. SUMMARY OF SPECIAL STUDIES

7.1 LAC DE GRAS

In 2012, mine effects were detected downstream of the Long Lake Containment Facility (LLCF) as far as site S3 in Lac de Gras for eight water quality variables (Rescan 2013c). Site S3 marks the current downstream extent of the AEMP sampling program for the Koala Watershed. In August 2013, an additional sampling program was undertaken in the north arm of Lac de Gras (at three sampling sites) beyond the current extent of the AEMP to determine if a new water quality monitoring station was required (ERM Rescan 2014c). The 2013 results from the additional Lac de Gras sites indicated that water quality was similar between sites S3 and S4, and that some elevated water quality variables extended as far as S6. To improve the ability of detecting effects in Lac de Gras, additional sampling was undertaken in 2014 at sites S5 and S6. Details on the methods and results are provided in Sections 2.10 and 3.10 of Part 2 – Data Report. Physical limnology and water quality data obtained in 2014 will be discussed in the 2015 Re-evaluation, which will include an investigation into the necessity of adding one or both of these stations to the annual AEMP program beginning in 2016.

7.2 GRIZZLY LAKE BIOLOGICAL COMMUNITIES

Biological communities (phytoplankton, zooplankton and benthic invertebrates) were sampled in Grizzly Lake in August 2013 to assess if communities had changed following observed changes (thermal stratification with cooler surface temperatures) in the under-ice temperature profiles of Grizzly Lake in 2011 and 2012 (Rescan 2013c). Grizzly Lake results in 2013 indicated that the taxonomic composition of the zooplankton assemblage appeared to have changed over time; therefore, further phytoplankton and zooplankton sampling was completed in 2014. Details on the methods and results are provided in Sections 2.10 and 3.10 of Part 2 – Data Report.

Similar to the 2013 results, one potential change was identified in the Grizzly Lake biological variables observed in 2014:

- Altered taxonomic composition of the zooplankton assemblage through time

Zooplankton biomass, density, and diversity in Grizzly Lake have appeared to remain relatively stable through time. However, the relative density of zooplankton groups in Grizzly Lake may have shifted through time as densities of rotifers appear to have increased. Increases in rotifer density contrast patterns observed in other monitored lakes within the Koala Watershed and are consistent with what might be expected as a result of increasing water temperatures. However, the lack of data from 2004 to 2012 makes it difficult to determine whether these changes in rotifer density represent a real trend though time and a mine effect, rather than representing natural variability through time. It is thus recommended that an additional year of phytoplankton and zooplankton monitoring be conducted in Grizzly Lake in order to better detect potential effects.

Recent changes in the thermal profile of Grizzly Lake were found to have no effect on variables assessed for phytoplankton.

8. NITROGEN RESPONSE PLAN UPDATE

8.1 RATIONALE AND OBJECTIVES

Part J, Item 11 of Water Licence W2012L2-0001 stipulates DDEC submit a Nitrogen Response Plan (NRP) to the WLWB for approval. The objective of this plan is to minimize the amount of nitrogen entering the receiving environment at the Ekati Diamond Mine and is achieved through the following items detailed in this report, as prescribed in Schedule 8, Part 5:

1. Description of current nitrogen sources and management practices;
2. Assessment of current blasting practices conducted by appropriate experts (Golder 2013b); and
3. Development of an implementation plan to address recommendations from assessment described in (2) above.

Version 1.0 of DDEC's NRP was submitted to the WLWB on December 31, 2013. The WLWB met on April 14, 2014 to consider this document. The plan was approved and a directive was issued on May 14, 2014 requiring DDEC to submit a Version 1.1 of the NRP by June 30, 2014, for a conformity check and to address 5 additional items. DDEC submitted Version 1.1 on July 3, 2014.

The WLWB approved Version 1.1 of DDEC's NRP, with the direction to provide an update on the implementation of three of Golder Associates' recommendations (i.e., #3, #6, and #7; Golder 2013b) as part of the 2014 AEMP and to outline any necessary follow up actions or timelines to implementation. Additionally, Version 1.1 of the NRP committed to including an update to current total ammonia-N and nitrate-N trends in the receiving environment in the 2014 AEMP. The following update is intended to serve these dual purposes.

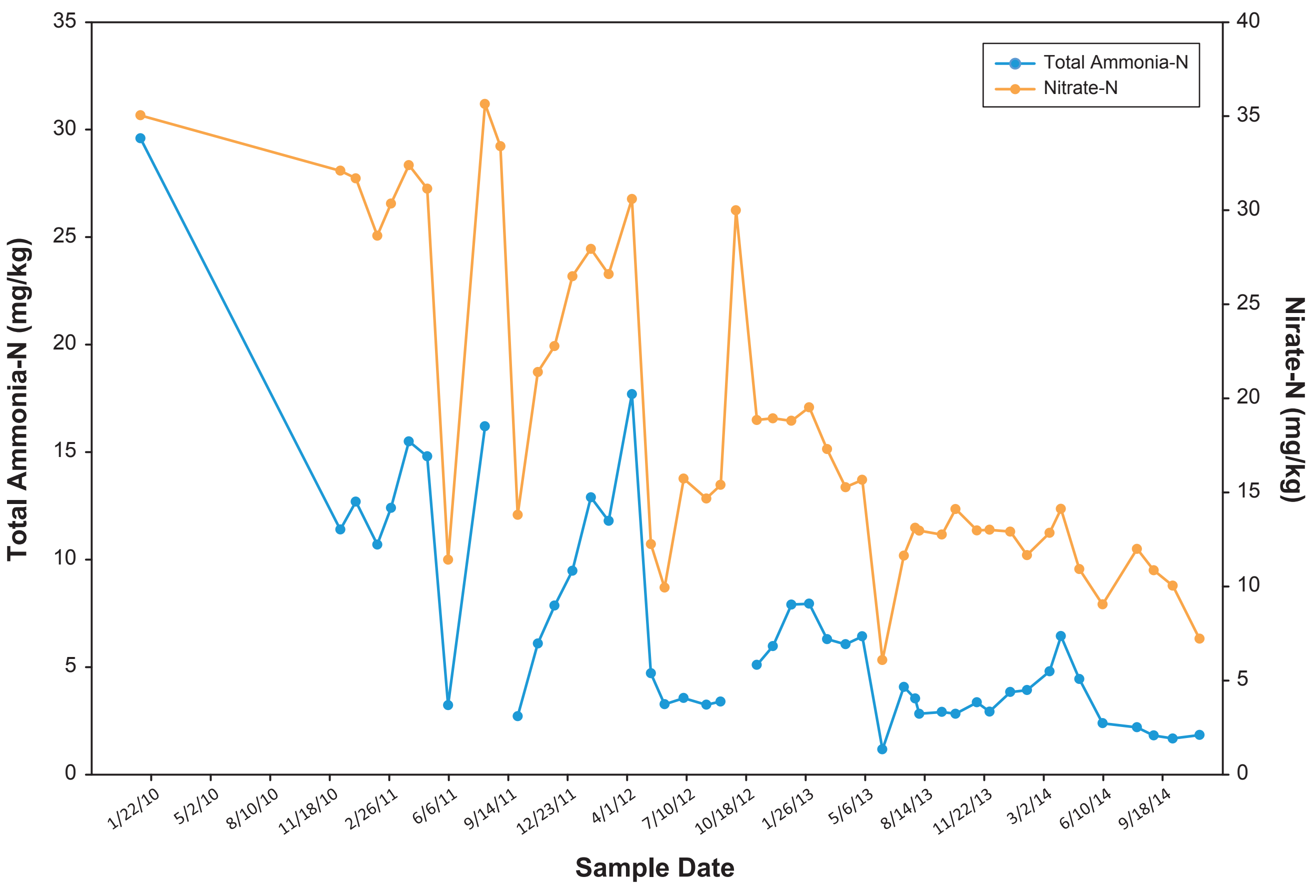
8.2 NITROGEN SOURCES AND CONTROL PRACTICES AT THE EKATI DIAMOND MINE

8.2.1 Underground Minewater as a Source of Nitrogen

Nitrogen (total ammonia-N and nitrate-N) concentrations in minewater from the underground workings to containment facilities were monitored on a monthly basis through internal monitoring programs. Graphical analysis suggests that both total ammonia-N and nitrate-N concentrations in underground minewater have decreased in the last five years, likely as a result of declining rates of development in Koala and Koala North workings (Figure 8.2-1). Since the issuance of Version 1.1 of the NRP, DDEC has ceased using dry ammonium nitrate/fuel oil (ANFO) explosives underground, as development mining in this area has been completed. DDEC is exclusively using bulk liquid emulsion explosives for Koala North production blasting. Additionally, by June of 2015 DDEC will have finished using all bulk liquid explosives underground due to the completion of Koala North. Only the occasional use of small amounts of cartridge explosives is expected for breaking oversize material that is too large to remove from the drawpoint.

Figure 8.2-1

Underground Minewater Concentrations of Total Ammonia-N and Nitrate-N, 2010 to 2014



8.2.2 Open-pit Minewater as a Source of Nitrogen

There are currently no dewatering activities taking place in Misery Pit; activities are on hold until the pushback advances to an elevation that will enable pumping from the pit bottom. Similarly, Pigeon Pit has begun the dewatering process through the removal of surface runoff from the test pit; however, no true minewater has yet to be pumped from Pigeon Pit. Dewatering in Fox Pit ceased as of March 2014 as planned mining in the pit had been completed. During dewatering, Fox Pit sump water was sampled during the open water season on a monthly basis through internal monitoring programs (Figure 8.2-2). Total ammonia-N and nitrate-N concentrations in Fox Pit minewater were comparable to those observed in underground minewater and were generally stable over time. Periodically however, total ammonia-N and nitrate-N concentrations in Fox Pit sump water were elevated above normal levels (for example in July of 2011, October 2013 or March 2014). During these periods, the sump was usually located close to blast patterns that had been problematic and may have experienced misfires, thus leading to temporarily increased availability of explosives for dissolution into minewater and subsequently elevated nitrogen levels in sump water. Sump locations within open pits are continually changing and are selected to accommodate crew safety, pit wall stability and ease of access.

8.2.3 Process Plant Discharge as a Source of Nitrogen

Processed kimberlite slurry water pumped from the Process Plant is a source of nitrogen at the Ekati Diamond Mine. Concentrations of total ammonia-N and nitrate-N in process plant slurry were generally stable over time, showing limited trends in seasonal or annual variability (Figure 8.2-3). From 2012 to 2014, monthly loads of nitrate-N from the Process Plant to the LLCF, which is a function of both concentration and volume of discharge, ranged from 2,163 to 11,614 kg, averaging 6,334 kg/month (Table 8.2-1). Historically, process plant discharge (PPD) and the associated nitrate loads, were directed to the LLCF. In February 2013, construction of the Process Plant to Beartooth line was completed, allowing for pumping of PPD to the decomissioned Beartooth Pit in addition to the LLCF (Table 8.2-2).

8.2.4 Nitrogen Trends in the LLCF and Receiving Environment

Nitrogen trends at the Ekati Diamond Mine’s LLCF are regularly assessed and monitored through internal monitoring programs, LLCF monitoring activities, monthly SNP reports and the annual AEMP. In both Cells D and E of the LLCF, total ammonia-N concentrations have decreased over the past five years, while nitrate-N concentrations have remained relatively stable. Graphical observation also indicates a strong seasonal trend of increased concentrations of total ammonia-N and nitrate-N during winter months due to solute exclusion from ice formation and decreased concentrations following dilution associated with freshet (Figures 8.2-4 and 8.2-5).

Results from the 2014 AEMP reports that concentrations of total ammonia-N at all sites downstream of the LLCF were less than the pH- and temperature-dependent CCME guideline in 2014. Statistical and graphical analyses suggest that total ammonia-N concentrations have increased at all lake sites downstream of the LLCF as far as Slipper Lake (see Figure 4-10 in Section 4). However, in most cases, concentrations of total ammonia-N downstream of the LLCF have either stabilised or declined in recent years.

Figure 8.2-2

Fox Pit Minewater Concentrations of Total Ammonia-N and Nitrate-N, 2010 to 2014

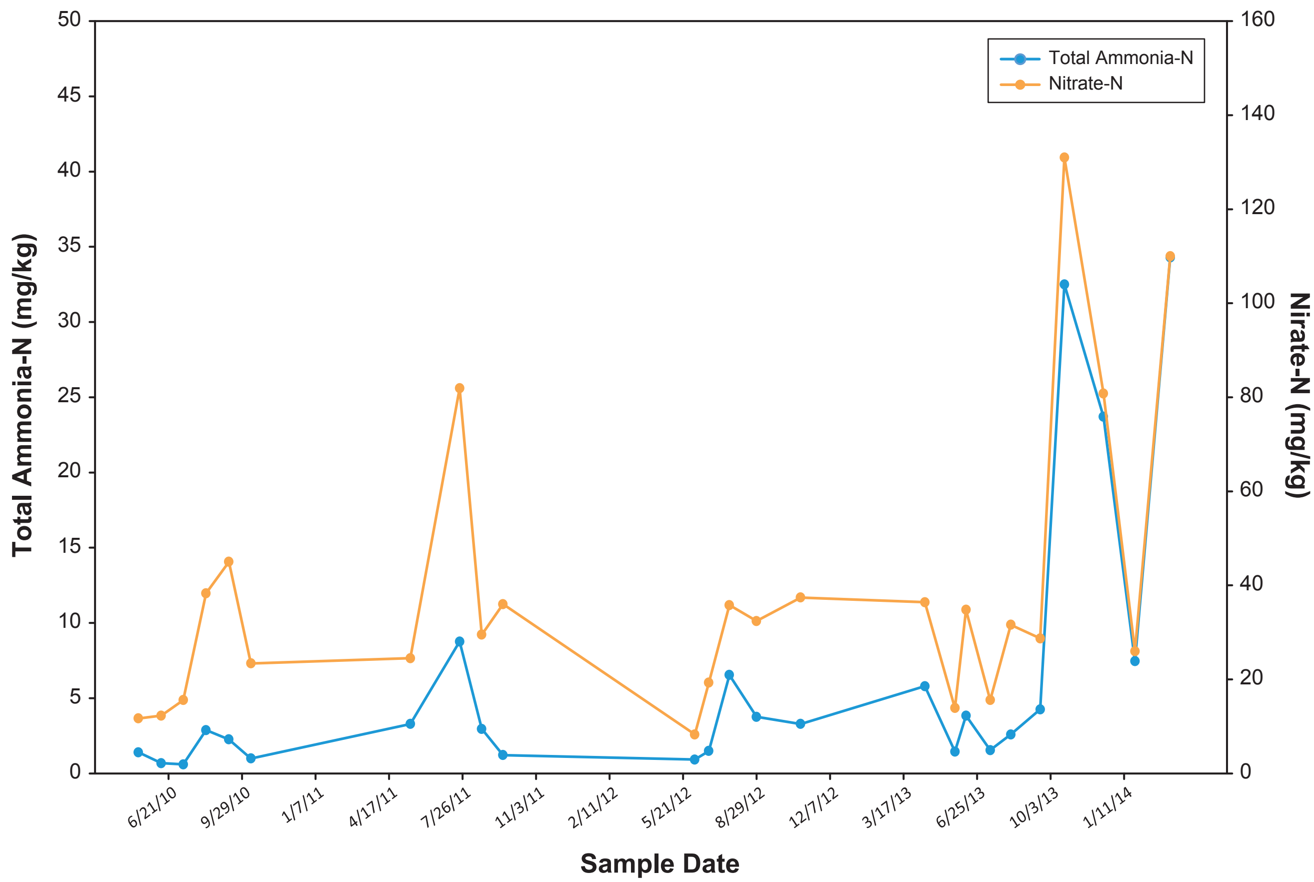


Figure 8.2-3

Process Plant Slurry Concentrations of Total Ammonia-N and Nitrate-N, 2010 to 2014

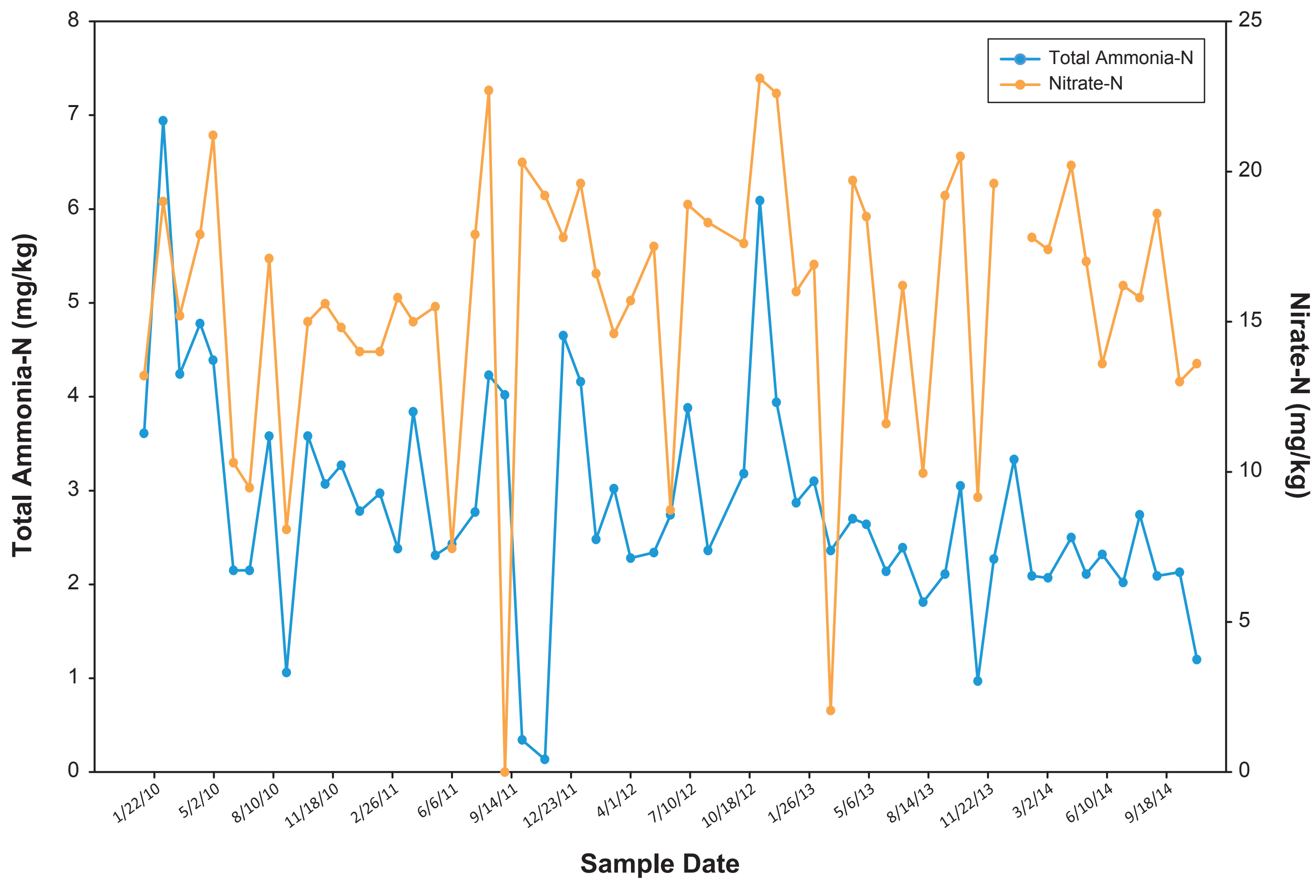


Table 8.2-1. Monthly Nitrate Loading from the Process Plant to the LLCF, 2012 to 2014

Sampling Date	Year	Nitrate Concentration in PPD (mg/L)	Volume PPD to LLCF (L)	PPD to LLCF Nitrate Loading (kg)
Jan-8	2012	19.6	462776000	9070
Feb-3	2012	16.6	433581000	7197
Mar-4	2012	14.6	444206000	6485
Apr-1	2012	15.7	447902000	7032
May-10	2012	17.5	475167000	8315
Jun-7	2012	8.73	516383000	4508
Jul-6	2012	18.9	545658000	10313
Aug-9	2012	18.3	518906000	9496
Oct-8	2012	17.6	484776000	8532
Nov-4	2012	23.1	502770000	11614
Dec-2	2012	22.6	444459000	10045
Jan-4	2013	16	461741000	7388
Feb-3	2013	16.9	173614000	2934
Mar-3	2013	2.05	96975000	199
Apr-9	2013	19.7	115470000	2275
May-2	2013	18.5	116899000	2163
Jun-4	2013	11.6	274096000	3180
Jul-2	2013	16.2	571516000	9259
Aug-5	2013	9.95	596632000	5936
Sep-11	2013	19.2	539820000	10365
Oct-7	2013	20.5	452046000	9267
Nov-5	2013	9.15	421118000	3853
Dec-2	2013	19.6	167951000	3292
Feb-4	2014	17.8	105728000	1882
Mar-3	2014	17.4	108150000	1882
Apr-11	2014	20.2	102966000	2080
May-6	2014	17	125810000	2139
Jun-2	2014	13.6	463189000	6299
Jul-7	2014	16.2	535534000	8676
Aug-4	2014	15.8	590004000	9322
Sep-2	2014	18.6	548906000	10210
Oct-10	2014	13	534665000	6951
Nov-8	2014	13.6	504460000	6861

Table 8.2-2. Process Plant Discharge to the LLCF and Beartooth Pit, 2012 to 2014

Sampling Date	Year	Volume PPD discharged to LLCF (m^3)	Volume Discharged to Beartooth Pit (m^3)
Jan-8	2012	462,776	0
Feb-3	2012	433,581	0
Mar-4	2012	444,206	0
Apr-1	2012	447,902	0
May-10	2012	475,167	0
Jun-7	2012	516,383	0
Jul-6	2012	545,658	0
Aug-9	2012	518,906	0
Oct-8	2012	484,776	0
Nov-4	2012	502,770	0
Dec-2	2012	444,459	0
Jan-4	2013	461,741	0
Feb-3	2013	173,614	242,462
Mar-3	2013	96,975	323,359
Apr-9	2013	115,470	295,911
May-2	2013	116,899	401,231
Jun-4	2013	274,096	268,600
Jul-2	2013	571,516	0
Aug-5	2013	596,632	0
Sep-11	2013	539,820	0
Oct-7	2013	452,046	83,409
Nov-5	2013	421,118	77,702
Dec-2	2013	167,951	295,003
Feb-4	2014	105,728	321,444
Mar-3	2014	108,150	284,187
Apr-11	2014	102,966	273,306
May-6	2014	125,810	421,190
Jun-2	2014	463,189	110,420
Jul-7	2014	535,534	0
Aug-4	2014	590,004	0
Sep-2	2014	548,906	0
Oct-10	2014	534,665	0
Nov-8	2014	504,460	0

Figure 8.2-4

Total Ammonia-N Concentration in the LLCF, 2010 to 2014

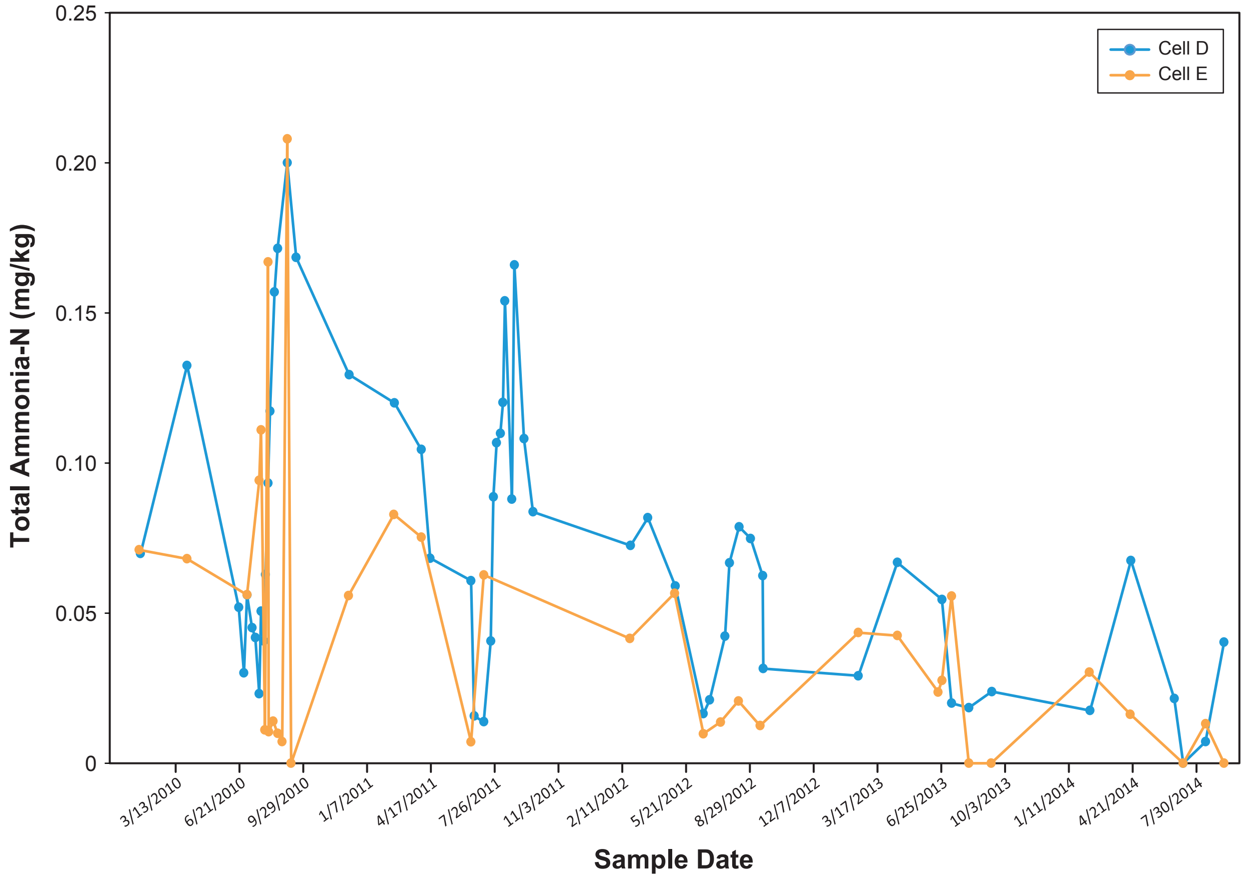
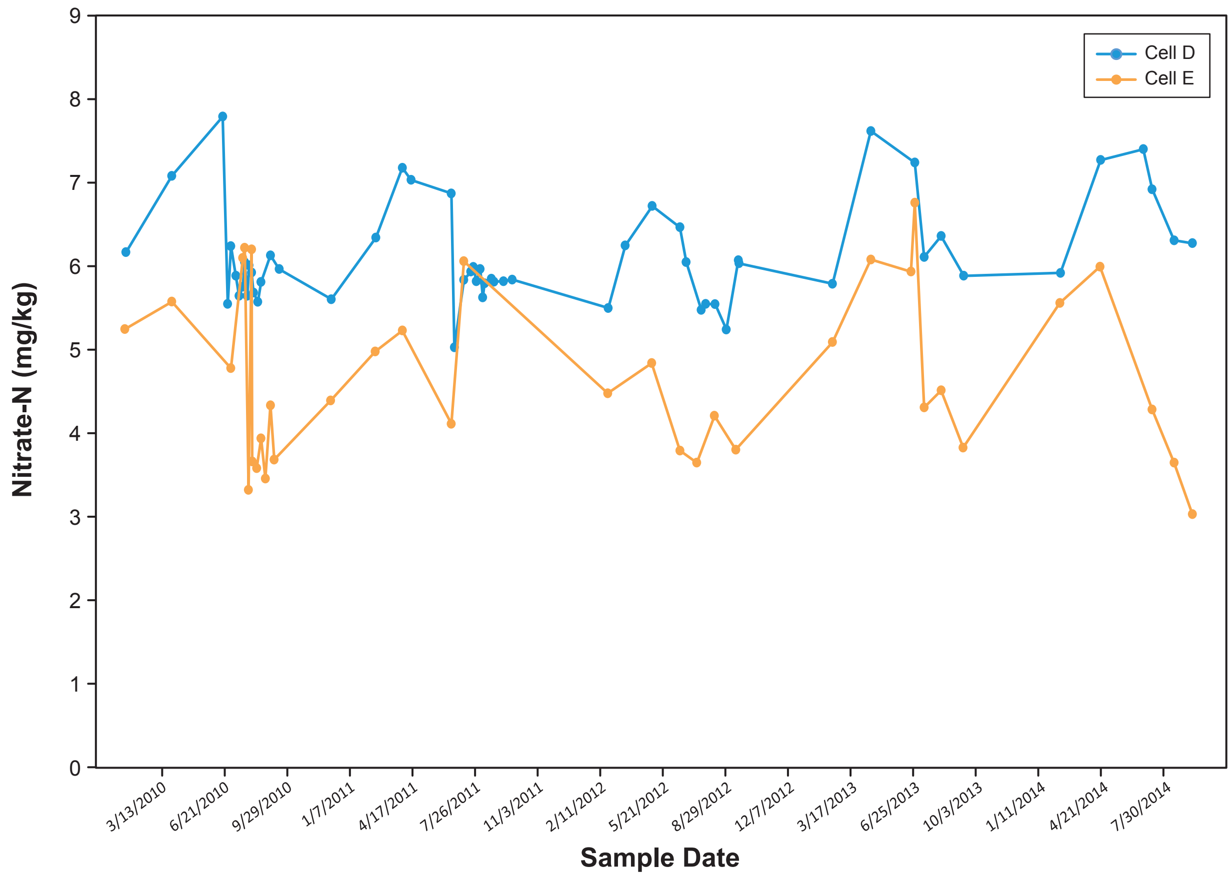


Figure 8.2-5

Nitrate-N Concentration in the LLCF, 2010 to 2014



Similarly, results from the 2014 AEMP indicate that observed and fitted mean nitrate-N concentrations were less than the hardness-dependent SSWQO at all sites downstream of the LLCF. Furthermore, results also indicate that concentrations at all sites downstream of the LLCF have stabilised or decreased in recent years, during the open water and ice-covered seasons (see Figure 4-12 in Section 4).

The observation that concentrations of total ammonia-N and nitrate-N downstream of the LLCF have either stabilised or declined in recent years is consistent with the trend of decreasing and stabilizing concentrations of total ammonia-N and nitrate-N, respectively, in the LLCF, as well as the diversion of underground minewater and some PPD to Beartooth Pit. Maximum total ammonia-N and nitrate-N concentrations in the receiving environment at the Ekati Diamond Mine are expected to be reached during the winter of 2020 due to pumping out of Beartooth Pit;, although, these maximum concentrations are predicted to be less than benchmark concentrations for all AEMP sampling locations downstream of the LLCF (i.e., a maximum of 6% of benchmark concentration for total ammonia-N and 56 for nitrate-N; Rescan 2012e).

8.2.5 Current Nitrogen Source Control and Release Practices

DDEC recognizes the potential impact of increased nitrogen loading into surrounding water bodies and currently has several practices in place to limit both the amount of nitrogen available for dissolution through source control practices, as well as the amount of nitrogen released from containment through release control practices.

8.2.5.1 Nitrogen Source Control Practices

Nitrogen source control activities designed to limit the amount of nitrogen available for dissolution into minewater or transportation to the process plant, and subsequent discharge to containment facilities, are continuously carried out at the Ekati Diamond Mine. Nitrogen source control activities are carried out by a number of departments and personnel on site and include the following:

- Continual assessment of drilling and blasting practices to ensure maximum blast efficiency and pit wall stability, and to minimize misfires;
- Periodic blast audits from external consultants, including the 2008 and 2013 Explosives Management audits by Golder Associates;
- Supplementary training for drill and blast engineers to support and encourage continual development of best practices for staff, including training conducted in January 2014;
- Ongoing spill control and clean-up activities to prevent and address spillage of explosives;
- Cessation of the use of dry ANFO explosives underground, as development blasting underground is complete; Bottom loading wet-holes in open pit mines, when safe and appropriate to do so; and
- Other activities as described in the Implementation Plan (see Section 8.3).

8.2.5.2 Nitrogen Release Control Practices

In addition to source control practices, DDEC conducts a number of activities to regulate the release of nitrogen from containment facilities to the receiving environment. These practices highlight DDEC's commitment to adaptive management and will continue to be used in the future, wherever appropriate:

- Diversion of minewater streams and PPD from the LLCF to the de-commissioned Beartooth Pit;
- Discharge of water from the LLCF during ice-free periods to maximize dilution effects;
- *In situ* LLCF fertilization study, whereby phytoplankton growth and the biological uptake of nitrogen was stimulated through the addition of phosphorus to the LLCF, successfully reducing the amount of nitrate available for discharge into the receiving environment (Rescan 2011b);
- Additional research programs focused on the potential severity, ecological significance and persistence of changes to the aquatic community based on nutrient addition (i.e. the Aquatic Effects Synthesis Study and the 2015 AEMP Re-Evaluation);
- Numerical modeling of water quality to evaluate potential effects in the receiving environment (Rescan 2012e);
- Development of a SSWQO for nitrate (Rescan 2012c); and
- Development of an Aquatic Response Framework, which will provide a tool for assessing nitrate source and release management strategies at the Ekati Diamond Mine by providing a direct link between the results of the AEMP and actions designed to ensure that nitrogen levels in the receiving environment remain within an acceptable range.

8.2.5.3 Nitrogen Mass-Balance

In the WLWB's decision package on Version 1.0 of the NRP, it was requested that DDEC incorporate *"an effective method of reporting total nitrogen entering, re-used in and exiting (including potential losses in transportation) mining processes at the Ekati Diamond Mine, and to include these values in its annual AEMP report"*. While results of the AEMP indicate that concentrations of total ammonia-N and nitrate-N are below the pH- and temperature-dependant CCME guideline and the hardness SSWQO, respectively, at all monitoring locations downstream of the LLCF, DDEC is committed to continuing diligent management, including monitoring of the use and transport of nitrogen in and around the Ekati Diamond Mine and receiving environment.

Nitrogen enters the mining process at the Ekati Diamond Mine through the use of explosives in both underground and open pit mining. A fraction of the nitrogen present in explosive materials may not be consumed during blasting and as such, can exit the mining process via one of three potential pathways:

- Dissolution into minewater and subsequent transportation in solution to a containment facility;
- Mucking as solid material adhering to waste rock and disposed of in WRSAs, where it may be dissolved by rainwater and transported to the receiving environment or containment facilities, depending on the WRSA location, as seepage; and

- Mucking as solid material adhering to kimberlite that is transported to the Process Plant, dissolved by water used in kimberlite processing and transported along with processed kimberlite in the form of discharge slurry to a containment facility (Golder 2008).

Minewater is directly pumped out of the open pits (i.e., not "re-used" in the dewatering system in any way). Some minewater is circulated within the underground workings for drilling, representing a "re-use" of the water which reduces the quantity of freshwater that would otherwise be needed in the underground workings. However, the circulation of minewater in the underground mine does not represent any additional sources or losses of nitrogen to the minewater stream, and therefore does not affect the tracking of either source or release control practices. It is the quantity and nitrogen concentration of minewater that is pumped from the underground workings to the surface environment (LLCF or Beartooth pit) that is of interest. Circulation of underground minewater for drilling is undertaken on an as-needed basis from various intermediate sumps within the underground workings and, as such, is not readily measured. This water is ultimately pumped to surface where it is then captured in established sampling routines, as described in Section 8.2.4 above.

There is an inherent time delay that would complicate an attempted single-blast reconciliation in the underground mine due to interacting factors such as location within the underground workings relative to the collection sump and to other blasts, minewater residence/travel time, fault zone influx, and surface water influx. However, given that that the nitrate reconciliation is a matter of diligent management rather than environmental urgency and in order to address the Board's request to incorporate "an effective method of reporting total nitrogen entering, re-used in and exiting (including potential losses in transportation) mining processes at Ekati", DDEC has committed to providing the following information in the Nitrogen Response Plan update:

- 2014 monthly summaries of explosives that are used in open pit and underground mines, including total nitrogen loads and 2014 monthly summaries of internal monitoring programs tracking the amount of nitrogen (considering total ammonia-N and nitrate-N) exiting both underground and open pit mines in minewater streams (Table 8.2-3);
- 2014 monthly summaries of nitrogen loads in process plant slurry (Table 8.2-4);
- Estimates of approximate nitrogen loading in waste rock that would be available for dissolution in runoff and transport to containment facilities; and
- Estimates of any nitrogen lost during transportation, as reported in Spill Reports.

Table 8.2-3. Monthly Summaries of Nitrogen Delivered to Surface and Underground Operations as ANFO and Emulsion and Nitrogen Loads in Underground and Surface Minewater, 2014

Month	Nitrogen (kg) Delivered to Underground Operations	Underground Minewater Nitrogen Loads (kg)	Nitrogen (kg) Delivered to Surface Operations[1]	Surface Minewater Nitrogen Loads (kg)
January	8,443	380	204,600	645
February	9,185	247	205,664	-
March	8,852	323	160,635	7,076[2]

(continued)

Table 8.2-3. Monthly Summaries of Nitrogen Delivered to Surface and Underground Operations as ANFO and Emulsion and Nitrogen Loads in Underground and Surface Minewater, 2014 (completed)

Month	Nitrogen (kg) Delivered to Underground Operations	Underground Minewater Nitrogen Loads (kg)	Nitrogen (kg) Delivered to Surface Operations[1]	Surface Minewater Nitrogen Loads (kg)
April	13,461	409	307,849	-
May	12,860	589	180,281	-
June	5,196	446	202,429	-
July[3]	7,580	1,037	191,810	-
August	0[4]	809	168,106	-
September	2,629	512	273,664	-
October	2,359	374	136,940	-
November	3,222	214	240,545	-
December	781	359	233,681	-
TOTAL	**74,567**	**5,700**	**2,272,524**	**7,722**

[1] *Includes Fox, Misery and Pigeon developments.*
[2] *Includes both February and March data, as no Fox Sump sample was taken in February. No dewatering in surface mines took place following March 2014.*
[3] *As of July, all underground minewater was diverted to the LLCF rather than Beartooth Pit.*
[4] *No explosives were delivered to underground operations in August.*

Table 8.2-4. Monthly Summaries of Nitrate Loading from Process Plant Discharge, 2014

Month	Nitrate Loads (kg) to LLCF in PPD
February	1,882
March	1,882
April	2,080
May	2,139
June	6,299
July	8,676
August	9,322
September	10,210
October	6,951
November	6,861
December	7,766
TOTAL	**64,006**

Numerous studies and reports (e.g., Ferguson and Leask 1988; Bailey et al. 2013) indicate that between 0.1 and 5.4% of the total nitrogen used in explosives is not consumed during the blast and is therefore available for transport to WSRAs and eventual transport to containment facilities as seepage. This value varies between mines and blasts depending on a number of conditions, including powder factor and hole wetness. DDEC proposes that due to the relatively small fraction of total nitrogen represented by this transport mechanism, and the fact that the majority of holes blasted at the Ekati Diamond Mine are both dry and have short sleep times (i.e., under 24 hours), an estimation that 5% of the total nitrogen available in explosives would be unconsumed during blasts and thus available for transport to the WRSAs, is conservative and appropriate for the purposes of approximation. The amount of nitrogen available for transport to WSRAs in 2014 was calculated based on an estimate of 5% nitrogen loss during blasting (Table 8.2-5). No losses of ANFO or emulsion during transportation were reported in Spill Reports in 2014.

Table 8.2-5. Nitrogen Available for Transport to Waste Rock Storage Areas in 2014 Based on Estimates of 5% Loss of Nitrogen During Blasting

	Underground Nitrogen (kg)	Surface Nitrogen (kg)	Total Nitrogen (kg)
Total Nitrogen Used in Explosives in 2014	74,567	2,506,205	2,580,772
Nitrogen Available for Transport to WRSAs in 2014	3,728	125,310	129,038

8.3 IMPLEMENTATION PLAN

DDEC aims to continually reduce nitrogen sources to the receiving environment, monitor nitrogen trends at the Ekati Diamond Mine and adaptively manage increased nutrient loading if necessary. The *Review of Blasting Operations and Explosives Management Plan at Ekati Mine* conducted by Golder Associates (Golder 2013b) concluded that many positive practices are currently in place to meet these objectives and offers recommendations for continued improvement.

The report states that the most significant potential improvements in minimizing the availability of explosives for dissolution into minewater can be realized by "improved handling and usage practices in the open pit and underground mines and in particular by minimizing malfunctions and misfires in the open pit"(Golder 2013b). Based on that assessment, and the specific recommendations offered by Golder Associates towards that end, DDEC has developed the following Implementation Plan.

8.3.1 Update on Implementation of the Nitrogen Response Plan

Recommendation 1: Continue Currently Existing Mitigation Practices

Specific recommendations include:

- Managing the emulsion plant and ammonium nitrate (AN) storage facility with controls in place to capture accidental spills; and
- Monitoring of the nitrate-N levels in the LLCF, Beartooth and Misery Holding Ponds.

DDEC has continued to practice both of the specific recommendations above relating to existing mitigation practices throughout 2014. The processes and procedures in place at the AN storage facility and emulsion plant are well established and effective at preventing and minimizing the environmental effect of potential spills. Effective management of these facilities takes place daily, and spill kits and catchment basins are in place on a permanent basis in order to facilitate potential spill clean-up. During 2014, Emergency Response Team (ERT) members continued their ongoing spill response training with a dedicated spill response training session on August 23, 2014.

Continual monitoring of nitrogen trends in the LLCF, Beartooth Pit and the KPSF has also been continued as a requirement of W2012L2-0001 and through internal monitoring plans. LLCF nitrogen trends are monitored through monthly internal sampling in both Cells D and E during the open water season and twice during the ice-covered season (February and April). Water quality is also monitored weekly at the 1616-30 discharge location in Cell E during discharge, prior to discharge, quarterly as part of the sampling conducted for bacteriology, and twice annually as part of the chronic and acute toxicity tests. Water quality results are reported as part of the monthly SNP reports. Beartooth Pit water is sampled twice annually, once during the ice-covered season and once during the open water season. Water quality at the 1616-43 discharge location in the KPSF is assessed weekly during discharge, prior to discharge, quarterly as part of the sampling conducted for bacteriology, and twice annually as part of the chronic and acute toxicity tests. These results are also as part of the monthly SNP reports.

<u>Recommendation 2: Consider Additional Best Practices</u>

Golder Associates specifically recommend:

- Bottom loading wet holes; and
- Using "birdie" plugs at the collar in wet underground production blasts to aid in explosive retention.

DDEC has instituted both of these practices into standard operating procedures. Bottom loading wet holes is part of the current practice in open pit mines whenever necessary based on blast requirements, ground conditions, and other factors. Collar hole-plugs are used underground whenever appropriate.

To prevent bulk explosive migration when blasting unconsolidated material in the Beartooth WSRA, DDEC has implemented the use of plastic liners. These liners are also being considered for blasting in the Coarse Ore Rejects storage area.

<u>Recommendation 3: Consider an Education Program to Increase General Awareness of Nitrate and Explosive Loss to the Environment That Highlights the Significance of Obtaining a Water Licence in order to Operate</u>

DDEC has considered, but does not accept this recommendation. As such, it has not been incorporated into the NRP. DDEC offers training to all employees and contractors regarding the company's commitment to the environment and a general introduction into operating requirements, including reference to land permits and water licences, as a mandatory component of orientation training upon arrival to site. The majority of employees and contractors on site never come into contact with explosives, and therefore specific training addressing nitrogen and explosive loss for all employees would do little to decrease nitrogen losses at the Ekati Diamond Mine, and potentially detract from the training that is relevant to that employee's position.

For those employees who do work with explosives, DDEC mandates the completion of a one-time education program which is run through the training department at the Ekati Diamond Mine. This program builds on the requirements of the *Mines Act*, which stipulates required levels of training and competency for those handling and transporting explosive materials. Further to this, all employees involved in loading and blasting activities are required to hold their blasting tickets, issued by the Workers' Safety and Compensation Commission (WSCC), which must be renewed every 5 years.

DDEC continually looks for opportunities for increased communication of environmental commitments including ongoing waste management, wildlife awareness and other special presentations, which are delivered to various departments on site by Environment or Waste Management personnel on a rotating basis. Examples of this type of outreach activity in 2014 include presentations to all mine services employees regarding water licence commitments and responsibilities, and periodic site-wide emails reminding all employees of the correct pathways for waste disposal on site. These activities will continue into the future on an as-needed basis. Additionally, the development and review of the NRP has provided a platform for the collaboration of the Environment and Mine Operation departments, thereby increasing mutual understanding of employees in both areas regarding the use, transport, and discharge of nitrogen in and around the Ekati Diamond Mine and the receiving environment.

Recommendation 4: Continue to Conduct Operational Reviews

Golder Associates recommend specific foci to ensure that:

- Plans are being followed;
- Drills are not over drilling holes;
- Blast holes are not overloaded with emulsion;
- The engineering team is informed of the condition of blast patterns prior to a tie-in map being created;
- Tie-in maps are checked;
- Patterns are checked once they have been tied in;
- Blast results are checked;
- Shovel operators and pit foremen are communicated with to confirm that blasted material is in the correct muck profile for the loading unit and that the designed fragmentation is being achieved; and
- Any misfires or excess emulsion remaining in the pit after a blast are reported to the environment department.

DDEC carries out operational reviews of drilling and blasting operations, and will continue to do so including focusing on the specific items above. In 2014, operational reviews were conducted on a monthly basis. These reviews, which are a collaborative effort of the drill and blast engineering team as well as the operational crews, are centered on reviewing videos, tie-ins and blast results, and are designed to continually identify potential problems with blasts or efficiencies that may be targeted.

Individual blast reviews are conducted by the drill and blast engineering team for every blast in open pits, where results regarding fume release, rock breakage, fly rock and other blast issues are discussed. Because of these reviews, the drill and blast engineers were able to determine product failures in the MS Connector tie-in system used to initiate blast holes. DDEC has worked with Polar Explosives to mitigate the product failures, and is also conducting testing with the EZDet initiation system to better improve blast performance.

Recommendation 5: Consider Near-field Blast Vibration Monitoring to Provide a Means to Compare Blast Designs with Actual Blast Performance by Diagnosing Vibration Traces in Millisecond Detail

Near-field vibration monitoring can be an effective tool to assess blast performance and identify potential actions for improving blasting practices, and has been used at the Ekati Diamond Mine in the past. Blast vibration monitoring was reinstated in the fall of 2014 to collect data with Misery open pit trim blasting. Due to technical issues with the equipment required for near-field analyses, DDEC was unable to complete the vibration monitoring program during the 2014 calendar year. However, new equipment has been ordered and is expected to arrive in February of 2015. Additionally, Tetra-Tech EBA has been contracted to provide on-site training for DDEC engineering personnel in order to facilitate vibration monitoring at both Pigeon and Misery pits during 2015 and as required in the future. Relevant results and action items that come from these monitoring activities can be reported upon in the 2015 AEMP.

Recommendation 6: If Vibration Monitoring Reveals Potential Issues with Certain Holes in a Blast, Perform Velocity of Detonation (VOD) Measurements to Ensure Water Infiltration, Over-fuelling, or Shoot-throughs are not Degrading the Explosive Performance and Resulting in Undetonated Product

Pending results of vibration monitoring, DDEC will investigate the use of VOD measurements to provide additional information regarding the aforementioned factors that may be affecting blast performance. The use and frequency of these additional measures will be determined following the completion of vibration monitoring.

Recommendation 7: Further Blast Diagnostics Could Employ Borehole Camera Surveys in Selected Open Pit Production Blasts to Provide Insight on the Condition of the Blastholes and How Hole Irregularities, such as Large Cracks or Cavities, May Be Affecting Blast Loading and Performance

Pending results of vibration monitoring, DDEC will investigate the use of borehole camera surveys to provide additional information regarding the aforementioned factors that may be affecting blast performance. The use and frequency of these additional measures will be determined following the completion of vibration monitoring.

8.3.2 Additional Management Practices Included in the Nitrogen Response Plan

In addition to the seven recommendations made by Golder Associates (Golder 2013b), DDEC is committed to investigating and implementing other relevant nitrogen management practices and source control at the Ekati Diamond Mine. These practices include:

- Full decontamination and cleaning of explosives trucks on an annual basis;
- Monthly internal inspection of trucks for any retention of explosives product. In the event of product retention, trucks are steamed out to remove any built-up residues. This procedure ensures that product is being continually removed from the trucks, thereby eliminating the risk of contaminating fresh, effective explosives with older, potentially problematic explosives, thus improving blast efficiency;
- Continual monitoring of the amount of explosives planned versus the amount of explosives used in each blast pattern to identify any potential losses during transportation or due to blast hole over-loading; and
- Reporting of misfires into FPe (the Ekati Diamond Mine's incident and reporting management system), and the investigation by mine operations and the drill and blast engineering team.

8.3.3 Looking Forward: Incorporating the Nitrogen Response Plan in the Response Framework

Since 2012, concentrations of nitrogen (total ammonia-N and nitrate-N) in the receiving environment at the Ekati Diamond Mine have either stabilised or decreased. This is likely due to a combination of factors, including diversion of PPD to Beartooth Pit, reduction of underground mine production blasting, and a decrease in the rate of discharge from the LLCF to Leslie Lake, most notably during the summer of 2014 due to low water levels in and around the Ekati Diamond Mine.

Results from the 2014 AEMP indicate that concentrations of total ammonia-N and nitrate-Nin near-field locations during the open water season were below the pH- and temperature-dependent and hardness-dependent water quality benchmarks, respectively. Based on these results, and the fact that concentrations of total ammonia-N and nitrate-N in the LLCF (i.e., the source of nitrogen to downstream water bodies) and downstream water bodies have been decreasing or stabilizing over the past five years, DDEC expects that the likelihood of future increases in the concentrations of these water quality variables is low.

DDEC proposes that future iterations of the NRP be incorporated into DDEC's Aquatic Response Framework, upon its approval by the WLWB. The need for future work on the NRP will depend on whether or not low action levels have been exceeded for specific nitrogen species (i.e., total ammonia-N, nitrate-N, and nitrite-N) and will be geared towards meeting the requirements of an action plan described in the Response Framework. This work will include, for example, the setting of medium and high action levels and the specific items described in W2012L2-0001, Schedule 8 Item 4.

REFERENCES

Angilletta, M. J. J. 2010. *Thermal Adaptation: A theoretical and Empirical Synthesis*. Oxford, New York: Oxford University Press.

Bailey, B. L., L. J. D. Smith, D. W. Blowes, C. J. Ptacek, L. Smith, and D. C. Sego. 2013. The Diavik Waste Rock Project: Persistence of contaminants from blasting agents in waste rock effluent. *Applied Geochemistry*, 36: 256-70.

Biesinger, K. E. and G. M. Christensen. 1972. Effects of various metals on survival, growth, reproduction and metabolism of *Daphnia magna*. *Journal of the Fisheries Research Board of Canada*, 29: 1691-700.

Brown, J. H., J. F. Gillooly, A. P. Allen, V. M. Savage, and G. B. West. 2004. Toward a metabolic theory of ecology. *Ecology*, 85 (7): 1771-89.

CCME. 1999. Canadian water quality guidelines for the protection of aquatic life: Dissolved oxygen (freshwater). In *Canadian environmental quality guidelines, 1999*.Winnipeg, MB: Canadian Council of Ministers of the Environment.

CCME. 2004. Canadian Water Quality Guidelines for the Protection of Aquatic Life: Phosphorus. In *Canadian Guidance Framework for the Management of Freshwater Systems*.Winnipeg, MB: Canadian Council of Ministers of the Environment.

CCME. 2014. *Water Quality Guidelines for the Protection of Aquatic Life. Canadian Environmental Quality Guidelines Summary Table*. http://st-ts.ccme.ca (accessed September 2014).

CCREM. 1987. *Canadian water quality guidelines*. Prepared by the Task Force on Water Quality Guidelines: Canadian Council of Resource and Environment Ministers.

DDEC. 2014. *Characterization of Hydrocarbons Found in the Arctic Aquatic Environment near the Ekati Diamond Mine*. Yellowknife, NT.

Dobberfuhl, D. R. and J. J. Elser. 2000. Elemental stoichiometry of lower food web components in arctic and temperate lakes. *Journal of Plankton Research*, 22 (7): 1341-54.

Elser, J. J., W. F. Fagan, R. F. Denno, D. R. Dobberfuhl, A. Folarin, A. Huberty, S. Interlandi, S. S. Kilham, E. McCauley, K. L. Schulz, E. H. Siemann, and R. W. Sterner. 2000. Nutritional constraints in terrestrial and freshwater food webs. *Nature*, 408 (6812): 578-80.

Environment Canada. 2002. *Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring*. National EEM Office, Environment Canada: Ottawa, Ontario.

ERM. 2015. *Ekati Diamond Mine: 2014 Pigeon Stream Diversion Monitoring Program - Volume I Technical Report*. Prepared for Dominion Diamond Ekati Corporation by ERM Consultants Canada Ltd.: Yellowknife, Northwest Territories.

ERM Rescan. 2014a. *Ekati Diamond Mine: 2013 Aquatic Effects Monitoring Program Part 1 - Evaluation of Effects*. Prepared for Dominion Diamond Ekati Corporation by ERM Rescan: Yellowknife, Northwest Territories.

ERM Rescan. 2014b. *Ekati Diamond Mine: 2013 Aquatic Effects Monitoring Program Part 2 - Data Report*. Prepared for Dominion Diamond Ekati Corporation by ERM Rescan: Yellowknife, Northwest Territories.

ERM Rescan. 2014c. *EKATI Diamond Mine: 2013 Aquatic Effects Monitoring Program. Summary Report, Part 1: Evaluation of Effects, Part 2: Data Report, Part 3: Statistical Report*

Dominion Diamond Ekati Corporation: Yellowknife, Northwest Territories.

Ferguson, K. D. and S. M. Leask. 1988. *The Export of Nutrients from Surface Coal Mines, Environment Canada Regiona Program Report 87-12*

Gillooly, J. F., J. H. Brown, G. B. West, V. M. Savage, and E. L. Charnov. 2001. Effects of size and temperature on metabolic rate. *Science*, 293: 2248-51.

Golder. 2008. *Blasting Practices at Ekati Mine and Sources of Nitrate Available for Dissolution by Mine Drainage Water.* Prepared for BHP Canada Inc. by Golder Associates Ltd.: Vancouver, British Columbia.

Golder. 2013a. *Nitrogen Response Plan*. Prepared for Dominion Diamond Ekati Corporation by Golder Associates Ltd.: Yellowknife, Northwest Territories.

Golder. 2013b. *Review of Blasting Operations and Explosives Management at Ekati Mine.* Prepared for Dominion Diamond Ekati Corporation by Golder Associates Ltd.: Vancouver, British Columbia.

Kingsolver, J. G. and R. B. Huey. 2008. Size, temperature, and fitness: three rules. *Evolutionary Ecology Research*, 10: 251-68.

Kravtsova, L. S. 2000. List of Chironomidae (Diptera) of South Part of the Eastern Siberia. *Far Eastern Entomologist*, 93: 1-28.

Lagus, A., J. Suomela, G. Weithoff, K. Heikkilä, H. Helminen, and J. Sipura. 2004. Species-specific differences in phytoplankton responses to N and P enrichments and the N:P ratio in the Archipelago Sea, northern Baltic Sea. *Journal of Plankton Research*, 26 (7): 779-98.

McCarthy, V., I. A. N. Donohue, and K. Irvine. 2006. Field evidence for stoichiometric relationships between zooplankton and N and P availability in a shallow calcareous lake. *Freshwater Biology*, 51 (9): 1589-604.

Moore, J. W. 1978. Distribution and abundance of phytoplankton in 153 lakes, rivers, and pools in the Northwest Territories. *Canadian Journal of Botany-Revue Canadienne De Botanique*, 56 (15): 1765-73.

Oliver, D. R. and M. E. Dillon. 1997. Chironomids (Diptera: Chironomidae) of the Yukon Arctic North Slope and Herschel Island. In *Insects of the Yukon*. Eds. H. V. Danks and J. A. Downes. Ottawa, Ontario: Biological Survey of Canada (Terrestrial Arthropods).

Rescan. 2010. *EKATI Diamond Mine: 2008/2009 Long Lake Containment Facility Nitrate In Situ Treatment Test*. Prepared for BHP Canada Inc. by Rescan Environmental Services Ltd.: Yellowknife, Northwest Territories.

Rescan. 2011a. *EKATI Diamond Mine: 2010 Fay Bay Monitoring Program.* BHP Billiton Canada Inc.: Yellowknife, Northwest Territories.

Rescan. 2011b. *EKATI Diamond Mine: 2010 Long Lake Containment Facility Nitrate In Situ Treatment Test*. Prepared for BHP Canada Inc. by Rescan Environmental Services Ltd.: Yellowknife, Northwest Territories.

Rescan. 2011c. *EKATI Diamond Mine: 2010 Long Lake Containment Facility Nitrate in Situ Treatment Test*. Prepared for BHP Canada Inc. by Rescan Environmental Services Ltd.: Vancouver, BC.

Rescan. 2011d. *Summary Evaluation and Proposed Work Plan for the Fish Component of the 2012 Aquatic Effects Monitoring Program.* Prepared for BHP Canada Inc. by Rescan Environmental Services Ltd.: Yellowknife, Northwest Territories.

Rescan. 2012a. *EKATI Diamond Mine: 2011 Aquatic Effects Monitoring Program Part 1 - Evaluation of Effects*. Prepared for BHP Canada Inc. by Rescan Environmental Services Ltd.: Yellowknife, NT.

Rescan. 2012b. *EKATI Diamond Mine: 2012 Aquatic Effects Monitoring Program Re-Evaluation*. Prepared for BHP Canada Inc. by Rescan Environmental Services Ltd.: Yellowknife, Northwest Territories.

Rescan. 2012c. *EKATI Diamond Mine: Site-Specific Water Quality Objective for Nitrate, 2012*. Prepared for BHP Billiton Canada Inc. by Rescan Environmental Services Ltd.: Yellowknife, NT.

Rescan. 2012d. *EKATI Diamond Mine: Site Specific Water Quality Objective for Potassium*. Prepared for BHP Canada Inc. by Rescan Environmental Services Ltd.: Yellowknife, Northwest Territories.

Rescan. 2012e. *EKATI Diamond Mine: Water Quality Modelling of the Koala Watershed*. Prepared for BHP Canada Inc. by Rescan Environmental Services Ltd.: Yellowknife, Northwest Territories.

Rescan. 2013a. *EKATI Diamond Mine: 2012 Aquatic Effects Monitoring Program*. Prepared for BHP Billiton Canada Inc. by Rescan Environmental Services Ltd.: Yellowknife, Northwest Territories.

Rescan. 2013b. *EKATI Diamond Mine: 2012 Aquatic Effects Monitoring Program Part 1 - Evaluation of Effects*. Prepared for BHP Canada Inc. by Rescan Environmental Services Ltd.: Yellowknife, NT.

Rescan. 2013c. *EKATI Diamond Mine: 2012 Aquatic Effects Monitoring Program. Summary Report, Part 1: Evaluation of Effects, Part 2: Data Report, Part 3: Statistical Report*. BHP Billiton Canada Inc.: Yellowknife, Northwest Territories.

Rescan. 2013d. *Ekati Diamond Mine: Aquatic Effects Monitoring Program Plan for 2013 to 2015*. Prepared for Dominion Diamond Ekati Corporation by Rescan Environmental Services Ltd.: Yellowknife, Northwest Territories.

Sterner, R. W., J. J. Elser, J. R. Everett, S. J. Guildford, and T. H. Chrzanowski. 1997. The light:nutrient Ratio in Lakes: the Balance of Energy and Materials Affects Ecosystem Strucutre and Process. *The American Naturalist*, 150 (6): 663-84.

Tillman, D., R. L. Kiesling, R. W. Sterner, S. S. Kilham, and F. A. Johnson. 1986. Green, bluegreen and diatom algae: taxonomic differences in competitive ability for phosphorus, silicon, and nitrogen. *Archiv fru Hydrobiologie*, 106: 473-85.

Trotter, D. 2001. *Recommendations for water quality limits of major ions related to discharges of mine water to surface water bodies to protect aquatic plants and animals at all life stages*. AMEC Earth and Environmental Ltd.: MacKenzie Valley Land and Water Board.

Wehr, J. D. and R. G. Sheath. 2003. *Freshwater algae of North America: Ecology and classification*. Burlington, Massachusetts: Academic Press.