Analysis of Precipitation and Water Quality Trends in Ontario, Québec, Nova Scotia, and Newfoundland (1983-1991)

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Management Perspective

Over the last decade, networks were established in southeastern Canada by various federal and provincial government organizations to monitor changes in surface water chemistry resulting from changes in SO_2 emissions. Recently, LRTAP aquatic network managers expressed interest in conducting a unified assessment of trends in water quality across southeastern Canada using a consistent statistical methodology and a given time period (1983-1991). This idea, in turn, interested the office of State of the Environment Reporting (SOE) of Environment Canada, which subsequently led to this study. For SOE, the project would also be used to determine how to best portray environmental indicators on the specific issue of aquatic responses to acid rain.

Perspective de gestion

Pour déterminer les effets des réductions des émissions de SO_2 sur la qualité des eaux de surface, des réseaux de surveillance ont été établis dans le sud-est du Canada au cours des dix dernières années. Récemment, les gestionnaires des réseaux TADPA pour la surveillance du milieu aquatique ainsi que le bureau du rapport sur l'état de l'environnement (EDE), se sont dits intéressés à obtenir une évaluation uniformisée des tendances de la qualité de l'eau dans cette région en recourant à une méthodologie commune, appliquée à une période de temps déterminée (1983-1991), d'où la présent étude. Pour l'EDE, l'étude devrait également servir à déterminer la meilleure façon de décrire des indicateurs environnementaux applicables spécifiquement aux réactions des milieux aquatiques aux pluies acides.

Abstract

To determine if acidification-related chemical variables had changed over the period 1983 to 1991, we analysed monotonic trends (α=0.05) for precipitation concentrations and deposition at 6 sites and surface water concentrations at 111 sites, located from central Ontario to eastern Newfoundland. Precipitation showed both significantly decreasing H^+ and SO_4^{2-} concentrations and deposition in central and eastern Ontario, and decreasing deposition at one of two sites in Québec. Two precipitation monitoring sites in the Atlantic provinces showed only an increase in NO_3^- deposition. In many cases, trends in surface water chemistry were not parallel to the deposition trends and showed substantial inter-regional differences. Based on the hypothesis of simple acid-base titration, much between-variable inconsistency was found for the trends observed at a particular site. For Ontario surface water sites, only increasing or stable SO_4^{2-} trends were observed, and these had both concomitantly increasing and decreasing trends for pH and/or ANC. Despite a considerable number of lakes showing decreasing SO_4^{2-} trends in Québec, pH and ANC also decreased. Québec was also the only region showing extensive evidence of increasing NO_3^-. The opposite situation was observed in Atlantic Canada lakes where, despite increasing SO_4^{2-}, mostly increasing trends for pH and ANC were observed. Consistent trends in base cation concentrations (Ca^{2+} + Mg^{2+}) were found only for Ontario and Newfoundland sites (both increasing). Trends observed for pH and ANC were used to classify the acidification status of our surface water sites: 60 of the 111 sites were found to be stable (i.e., showing no trends), 17 were continuing to acidify, and 34 were improving.

Résumé

Afin de déterminer si des variables chimiques liées à l'acidification avaient changé durant la période 1983 à 1991, nous avons analysé les tendances temporelles monotones (α=0.05) pour les concentrations et les dépôts par les précipitations à six sites et pour les concentrations des eaux de surface à 111 sites répartis du centre de l'Ontario jusqu'à l'est de Terre-Neuve. On constate des diminutions significatives des concentrations de H^+ et de SO_4^{2-} dans les précipitations, et par le fait des dépôts de ces substances dans le centre et l'est de l'Ontario et à un des deux sites du Québec (dépôts seulement). À deux sites de surveillance des précipitations dans les provinces atlantiques, seules des augmentations des dépôts de NO_3^- ont été observées. Dans plusieurs cas, les tendances pour la chimie des eaux de surface n'étaient pas parallèles aux tendances observées pour les dépôts et montraient des différences inter-régionales substantielles. Basé sur l'hypothèse d'un titrage simple acide-base, des inconséquences ont été trouvées entre les tendances observées pour différentes variables à un site particulier. Pour les sites d'eau de surface de l'Ontario, seules l'absence de tendance ou des augmentations des concentrations de SO_4^{2-} ont été observées et, dans les deux cas, il y avait augmentation ou diminution concomitantes du pH et(ou) de la capacité de neutralisation des acides (CNA). En dépit du nombre considérable de lacs du Québec montrant des baisses des concentrations de SO_4^{2-}, le pH et la CNA diminuaient aussi. Le Québec est également la seule région où l'augmentation des concentrations de NO_3^- est très évidente. La situation est inverse pour les lacs des provinces atlantiques puisque, en dépit des hausses de SO_4, la tendance dominante observée pour le pH et la CNA était une augmentation. Des tendances uniformes dans les concentrations des cations de base (Ca^{2+} + Mg^{2+}) ont été trouvées seulement pour les sites de l'Ontario et de Terre-Neuve (Ca^{2+} + Mg^{2+} tous deux à la hausse). Les tendances observées pour le pH et la CNA ont été utilisées pour classer l'état d'acidification de nos sites d'eau de surface : 60 des 111 sites étaient stables (i.e., aucune tendance), 17 ont continué de s'acidifier et 34 se sont améliorés.

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1 Introduction

It is estimated that there are more than 700 000 lakes in the region of southeastern Canada which, based on their geological characteristics and sulphate (SO_4) loading rates are sensitive to acidification (Jeffries 1991). These susceptible lakes are located east of the Ontario/Manitoba border and south of the 52°N parallel, and include those watersheds located in the provinces of Ontario, Québec, New Brunswick, Nova Scotia and Newfoundland.

Concern over the effect of the deposition of acidifying substances on lake water quality has led to the establishment of various federal and provincial monitoring programs. For instance, as part of the Long-Range Transport of Atmospheric Pollutants (LRTAP) program, Environment Canada has been operating lake monitoring networks in Québec and the Atlantic provinces since 1983. The federal government also operates four of the five existing calibrated watersheds. At the provincial level, the ministère de l'Environnement du Québec (MENVIQ) has established RESSALQ (the Québec spatial lake acidity network), while the Ontario Ministry of the Environment (OME) operates the fifth calibrated watershed area in the Muskoka/Haliburton region. In addition, the OME conducts extensive spatial sampling: 120 lakes in the Sudbury region are sampled annually, while 150 lakes in central Ontario are sampled every five years. As a result of these efforts, the spatial and temporal variations in lake water chemistry are beginning to be understood.

One important objective of the aquatic monitoring program is to be able to document changes and relate improvements in water quality to government-mandated decreases in SO_2 emissions. For instance, in the Sudbury region, Dillon et al. (1986) reported decreases in lake sulphate concentrations following reductions in SO_2 emissions from 1979-1985. At Algoma in central Ontario a similar pattern was reported by Kelso and Jeffries (1988). In Kejimkujik, Nova Scotia, declining SO_2 emissions over the 1980-1985 period (RMCC 1990) have resulted in a downward trend for SO_4 in precipitation from 1980-1987 (Sirois and Summers 1989). Clair et al. (1992) have shown a corresponding upward trend in alkalinity for 13 of 39 Nova Scotia lakes sampled over the 1983-1989 period. The situation is not always straightforward, however, since lag periods may be involved between reduced emissions and subsequent water quality improvements (see, for example, Dillon et al. 1987; Bouchard 1992a, 1992b).

The purpose of this report, then, is the following: 1) to describe changes in precipitation chemistry from 1983-1991; 2) to characterize the changes in water quality for selected sampling sites in Ontario, Québec, Nova Scotia, and Newfoundland over the same period; 3) to update earlier studies by Clair et al. (1992) in Nova Scotia, and Bouchard and Haemmerli (1990) in Québec; and, 4) to attempt to develop a suitable water quality indicator in terms of acidic deposition.

1.1 STUDY AREA

The location of sampling sites is shown in Figure 1. These include sites from the Québec and Atlantic monitoring networks as well as two calibrated watersheds in Ontario (the Turkey Lakes Watershed and Harp and Plastic lakes). Precipitation chemistry data was obtained from six Canadian Air and Precipitation Monitoring Network (CAPMoN) stations: Algoma (located at Turkey lakes) and Chalk River in Ontario; Montmorency (located at Lake Laflamme) and Sutton in Québec; Kejimkujik in Nova Scotia; and Bay d'Espoir in Newfoundland. Water chemistry data was obtained for 111 sites: 11 stream stations in Ontario and 29, 38, and 33 lakes in Québec, Nova Scotia and Newfoundland, respectively. Lake names and locations are presented in Table 1.

The 11 Ontario sites are represented by two stream stations from the Turkey Lakes Watershed (TLW), seven stream stations from the Harp Lake catchment, and two stream sites from the Plastic Lake catchment. The TLW is located in the Algoma region, approximately 200 km west of Sudbury and 50 km north of Sault Ste. Marie. It is a headwater basin containing a chain of four lakes, each containing a monitored outlet stream station. Only data from two of the lakes – the Batchawana Lake outlet (site S1) and the Turkey Lake outlet (site S4) – are reported in this study (Table 1). The total area of the TLW is 10.5 km^2 in size with individual lakes ranging from 6 to 52 ha. The lakes are located on the Canadian Shield, on silicate bedrock (greenstones and granites), overlain by generally shallow glacial tills. Lowland soils have a low carbonate content (0-2%) while upland soils are mostly ferro-humic and humo-ferric podzols. Vegetation is typical of the Great Lakes-St. Lawrence forest region, being mostly old-growth

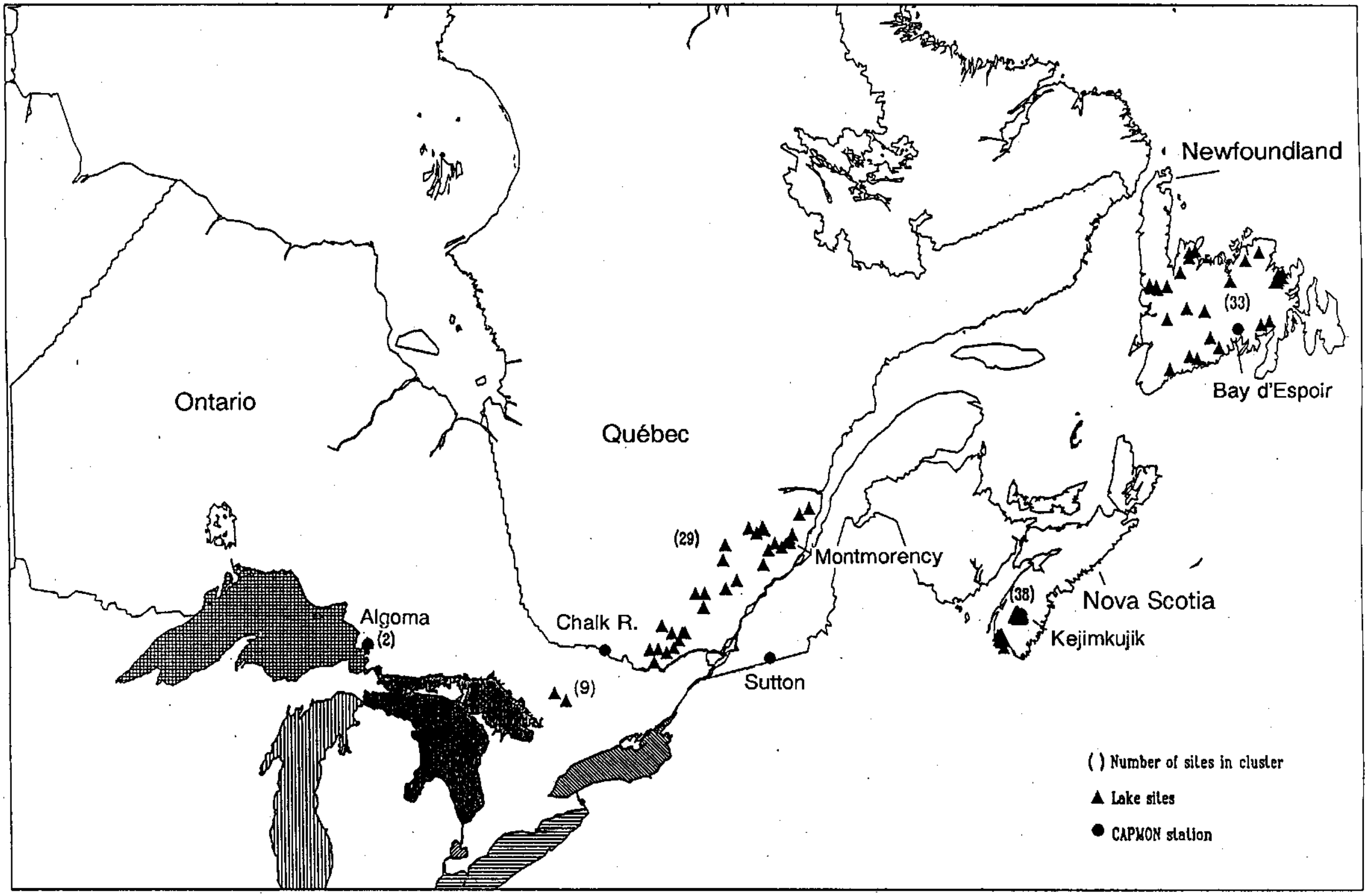

Figure 1 Location of study sites

Table 1
List of study sites

Lake ID	Name	NAQUADAT No.	Longitude	Latitude	Study Period
ONTARIO					
S1	Batchawana (outflow)	000N02BF011000	84 23 57	47 03 34	1/83-12/91
S4	Turkey (outflow)	000N02BF014100	84 24 47	47 03 02	1/83-12/91
HPO	Harp (outflow)		79 07	45 23	1/83-12/91
HP3	Harp (inflow)		79 07	45 23	1/83-12/91
HP4	Harp (inflow)		79 07	45 23	1/83-12/91
HP5	Harp (inflow)		79 07	45 23	1/83-12/91
HP6	Harp (inflow)		79 07	45 23	1/83-12/91
HP6A	Harp (inflow)		79 07	45 23	1/83-12/91
PC1	Plastic (inflow)		78 50	45 11	1/83-12/91
PCO	Plastic (outflow)		78 50	45 11	1/83-12/91
QUÉBEC					
101	Bonneville	01QU02PC0001	71 24 20	47 16 40	6/83-11/91
104	Lagou	01QU02PB0003	71 49 20	47 18 15	6/83-11/91
111	Veilleux	01QU02PB0004	71 34 30	47 23 40	6/83-11/91
112	Macleod	01QU02PE0001	70 58 40	45 28 00	6/83-11/91
114	Najoua	01QU02PB0002	72 05 00	47 02 30	6/83-11/91
201	Éclair	01QU02NF0003	73 00 10	46 51 20	6/83-11/91
202	Lemaine	01QU02RG0002	71 46 10	47 43 10	6/83-11/91
211	Congre	01QU02PA0002	72 01 40	47 42 00	6/83-11/91
212	Fauvette	01QU02NE0001	73 14 00	47 20 20	6/83-11/91
213	Adanys	01QU02NF0001	74 19 30	46 48 20	6/83-11/91
214	Boisvert	01QU02NF0002	74 02 40	46 45 30	6/83-11/91
301	Chômeur	01QU02NE0003	72 13 00	47 50 00	6/83-11/91
302	Thomas	01QU02RH0001	70 14 30	47 53 00	6/83-11/91
304	Laflamme	01QU02PD0001	71 07 00	47 19 00	6/83-11/91
311	Daniel	01QU02RG0001	71 48 20	47 47 20	6/83-11/91
312	Belle Truite	01QU02PF0001	70 35 40	47 49 30	6/83-11/91
313	Pothier	01QU02NE0002	73 02 30	47 38 30	6/83-11/91
314	Laurent	01QU02NF0021	74 12 00	46 28 30	6/83-12/91
401	Chevreuil	01QU02LD0009	74 56 00	46 03 00	5/83-12/91
411	Des Joncs	01QU02OC0002	73 23 00	46 45 00	6/83-12/91
414	Des Papillons	01QU02LF0011	75 20 00	46 06 30	5/83-12/91
501	Blais	01QU02LD0005	75 10 00	45 56 00	5/83-12/91
502	David	01QU02LF0002	75 35 00	46 18 30	5/83-12/91
511	Scelier	01QU02LD0008	75 01 00	46 03 30	5/83-12/91
512	Bohême	01QU02LH0185	76 07 00	45 52 30	5/83-12/91
513	Sheridan	01QU02LF0004	75 37 30	45 44 00	5/83-12/91
514	Clair	01QU02LH0186	76 04 00	45 36 00	5/83-12/91
515	Duck	01QU02LH0187	75 51 30	45 50 30	5/83-12/91
516	Graham	01QU02LF0003	75 23 00	45 48 00	5/83-12/91

Lake ID	Name	NAQUADAT No.	Longitude	Latitude	Study Period
NOVA SCOTIA					
DA2	Tedford	01NS01DA0002	66 01 00	44 06 00	5/83-5/91
DA3	Killams	01NS01DA0003	66 04 57	44 00 03	5/83-5/91
DA4	Cedar	01NS01DA0004	66 06 36	44 01 36	5/83-5/91
DA5	Comings	01NS01DA0005	66 05 00	44 03 00	5/83-5/91
DA6	Pierce	01NS01DA0006	66 05 50	44 07 10	5/83-5/91
EA2	George	01NS01EA0002	66 04 00	44 00 00	5/83-5/91
EA4	Jesse	01NS01EA0004	66 00 29	44 01 59	5/83-5/91
EA9	Brenton	01NS01EA0009	66 04 09	43 57 41	5/83-5/91
EA10	Snare	01NS01EA0019	65 58 32	44 06 20	5/83-5/91
EA20	Bird	01NS01EA0020	65 56 39	43 58 23	5/83-5/91
ED1	Back	01NS01ED0001	65 16 00	44 17 30	5/83-10/91
ED2	Big Dam West	01NS01ED0002	65 17 30	44 27 30	5/83-10/91
ED3	Big Dam East	01NS01ED0003	65 16 00	44 27 00	5/83-10/91
ED4	Mountain	01NS01ED0004	65 16 00	44 19 30	5/83-10/91
ED5	Peskowesk	01NS01ED0005	65 17 00	44 19 00	5/83-10/91
ED6	Grafton	01NS01ED0006	65 10 00	44 23 00	5/83-10/91
ED7	Kejimkujik	01NS01ED0007	65 13 30	44 22 00	5/83-10/91
ED8	High	01NS01ED0008	65 15 30	44 21 30	5/83-5/91
ED10	Pebblogitch	01NS01ED0010	65 21 00	44 19 00	5/83-10/91
ED11	Cobrielle	01NS01ED0011	65 14 00	44 19 00	5/83-10/91
ED13	Ben	01NS01ED0013	65 20 00	44 20 30	5/83-10/91
ED14	Big Red	01NS01ED0014	65 23 00	44 21 00	5/83-10/91
ED15	Mud	01NS01ED0015	65 13 30	44 21 30	5/83-10/91
ED16	Snake	01NS01ED0016	65 12 30	44 21 30	5/83-10/91
ED17	Liberty	01NS01ED0017	65 25 30	44 23 00	5/83-10/91
ED19	Frozen Ocean	01NS01ED0019	65 21 00	44 27 00	5/83-10/91
ED20	Channel	01NS01ED0020	65 18 30	44 25 00	5/83-10/91
ED21	Little Red	01NS01ED0021	65 23 45	44 20 21	5/83-10/91
ED22	Poplar	01NS01ED0022	65 26 30	44 21 30	5/83-10/90
ED25	Luxton	01NS01ED0025	65 20 30	44 21 30	5/83-10/91
ED27	Beaverskin	01NS01ED0027	65 20 00	44 18 30	2/83-9/91
ED28	McGinty	01NS01ED0028	65 09 30	44 21 30	1/83-10/91
ED29	Peskawa	01NS01ED0029	65 22 00	44 19 00	1/83-10/91
ED30	Upper Silver	01NS01ED0030	65 15 00	44 17 00	5/83-10/91
ED43	Mount Tom	01NS01ED0043	65 18 00	44 22 05	5/83-5/91
ED47	George	01NS01ED0047	65 13 15	44 20 25	5/83-10/91
ED48	Loon	01NS01ED0048	65 11 00	44 19 00	5/83-10/91
NEWFOUNDLAND					
YH11	unnamed	01NF02YH0011	57 43 25	49 33 40	9/84-10/91
YH12	unnamed	01NF02YH0012	57 42 39	49 31 24	9/84-6/91
YH13	unnamed	01NF02YH0013	57 44 00	49 35 48	9/84-6/91
YH14	unnamed	01NF02YH0014	57 31 54	49 26 14	9/84-10/91
YH15	unnamed	01NF02YH0015	57 31 30	49 27 39	9/84-10/91
YK6	unnamed	01NF02YK0006	57 39 37	48 47 45	10/83-10/91
YL1	unnamed	01NF02YL0001	57 13 18	49 24 28	10/83-6/91

Lake ID	Name	NAQUADAT No.	Longitude	Latitude	Study Period
YL10	unnamed	01NF02YL0010	57 32 44	49 30 00	9/84-10/91
YM1	Noble Pond	01NF02YM0001	55 54 51	49 49 05	10/83-6/91
YM3	unnamed	01NF02YM0003	56 38 16	49 32 29	6/83-6/91
YM6	unnamed	01NF02YM0006	56 10 01	49 44 29	10/83-6/91
YM7	unnamed	01NF02YM0007	56 05 44	49 50 39	10/83-6/91
YN8	Sandy	01NF02YN0008	56 56 43	48 49 04	6/83-6/91
YO7	Gull	01NF02YO0007	55 21 50	48 56 05	10/83-6/91
YO9	Tally Pond	01NF02YO0009	56 29 27	48 36 34	10/83-6/91
YQ1	Bellman's Pond	01NF02YQ0001	54 39 07	49 10 46	6/83-6/91
YR5	unnamed	01NF02YR0005	54 08 00	49 12 05	6/83-6/91
YS3	Rattle Pond	01NF02YS0003	53 49 28	48 30 50	10/83-10/91
YS5	Shallow Pond #3	01NF02YS0005	53 49 30	48 30 15	10/83-10/91
YS9	Ochre Hill Pond	01NF02YS0009	53 57 50	48 30 10	10/83-10/91
YS10	Chatham Pond West	01NF02YS0010	53 59 03	48 29 39	10/83-10/91
YS16	unnamed	01NF02YS0016	53 51 00	49 33 00	10/83-10/91
YS21	Bog Pond	01NF02YS0021	54 07 59	48 29 39	10/83-10/91
YS29	Long Waters	01NF02YS0029	54 03 20	48 27 29	6/83-10/91
YS45	Jay Pond	01NF02YS0045	53 53 03	48 38 12	6/83-10/91
YS48	Moses Cove Pond	01NF02YS0048	53 45 16	48 35 48	6/83-6/91
ZB1	Big Pond	01NF02ZB0001	53 13 18	47 50 54	10/83-6/91
ZC2	unnamed	01NF02ZC0002	57 18 43	47 48 06	10/83-6/91
ZC3	Stephenson's	01NF02ZC0003	57 29 47	47 54 45	10/83-10/91
ZD1	unnamed	01NF02ZD0001	56 34 54	47 48 39	6/83-6/91
ZD2	unnamed	01NF02ZD0002	56 41 33	48 04 31	6/83-10/91
ZF3	unnamed	01NF02ZF0003	54 49 13	47 50 03	6/83-6/91
ZF4	Hungry Grove	01NF02ZF0004	55 07 00	47 50 42	6/83-6/91

hardwood forest and dominated by sugar maple (90%), other hardwoods such as yellow birch (9%) and conifers (1%). A more complete description of the TLW area can be found in Jeffries et al. (1988).

Harp (71.4 ha) and Plastic (32.3 ha) lakes are located in the Muskoka-Haliburton area of central Ontario, a region approximately 200 km north of Toronto and 200 km southeast of Sudbury. Harp Lake has six inflows (stations HP3-HP6A) and one outflow (station HPO) (Table 1). The Harp Lake catchment is located on granitized biotite and hornblende gneiss, about 50% of which is covered by glacially deposited sandy and sandy loam tills varying from >1 m to 10 m thick. The Plastic Lake catchment overlies orthogneiss bedrock with shallow (<1 m) sandy basal tills. Soils are mostly podzolic with gleysols occurring in the lowlands. The lake has six inflowing streams, only one of which (PC1) is not ephemeral. These streams drain wetlands which are either sphagnum-conifer swamps or shallow beaver ponds (Dillon et al. 1987). The Muskoka-Haliburton area is also in the Great Lakes-St. Lawrence forest region. Forests are mostly second-growth characterized by sugar maple and aspen with smaller numbers of yellow birch, white spruce, tamarack, eastern hemlock, beech, basswood, red maple, red oak, and eastern white cedar also being common. Wetland areas are often populated by black spruce (Dillon et al. 1991). See the two references cited above for a more detailed description of the study area.

The 29 Québec lakes chosen for this study include a calibrated watershed (Lake Laflamme (LL), i.e., Lake 304) and 28 lakes belonging to the LRTAP-Québec (LQN) network. This network consists of 64 headwater lakes situated on the Canadian Shield and which are classified into eight homogeneous regions according to their chemical characteristics. Lake areas range from 5 to 200 ha. Only lakes from regions 1-5 (lakes 101-516) have been included in the present study (Table 1). Physical characteristics of these regions are discussed in depth in Bouchard (1992a). Briefly, the geology of the area is characterized by slow-weathering bedrock composed largely of igneous rock (anorthosite, gabbro, granite and syenite) and metamorphic rock (gneiss, paragneiss, amphibolite and quartzite). Soils in the region are largely humo-ferric podzols. Lakes in regions 1, 2 and 3 are situated in boreal forest which is characterized by white and black spruce, tamarack, balsam fir and jack pine. Less common deciduous species include white birch, trembling aspen and balsam poplar. Lakes in regions 4 and 5 are mostly found in mixed forest, of which typical tree species are white pine, red pine, yellow birch, hemlock, and poplar.

The remaining 71 sampling sites are located in Atlantic Canada. Of the 38 Nova Scotia sites, 27 lakes are located in Kejimkujik National Park (Keji) (lakes ED1-ED48). The remaining 11 lakes (EA2-EA20) are located in the Yarmouth area. The 33 Newfoundland lakes are more evenly spread throughout the province. All of the Atlantic lakes are headwater lakes. Surface areas for Nova Scotia lakes range from 5 to 2600 ha; those for Newfoundland range from 3 to 580 ha.

Geological formations for the Atlantic region are quite heterogeneous. As shown in Table 2, four different types of geological formations underlie Nova Scotia lakes.

Table 2
Summary of geological formations of Nova Scotia lakes

Goldenville Formation[a]	Halifax Formation[b]	Middle Devonian[c]	Upper Silurian[d]
DA2	DA3	ED8	EA2
DA5	DA4	ED13	EA4
DA6	ED3	ED14	EA9
EA10	ED6	ED17	
EA19	ED7	ED17	
EA20	ED15	ED22	
ED1	ED20	ED25	
ED2	ED28	ED29	
ED4	ED47	ED43	
ED5			
ED10			
ED11			
ED16			
ED17			
ED27			
ED30			
ED48			

Source: Howell (1986).
[a] Composed of greywacke, quartzite, gneiss, and minor slate.
[b] Composed of slate, schist, minor quartzite.
[c] Composed of granitic and allied rocks.
[d] Composed of quartzite with slate interbeds, and volcanic rocks.

Note: See Table 1 for lake IDs.

Kejimkujik lakes (ED1-ED48) are underlain by the Goldenville, Halifax, and Middle Devonian formations while Yarmouth lakes (DA2-EA20) are underlain by Goldenville, Halifax and Upper Silurian formations. The Goldenville formation, characterized by greywacke, quartzite, gneiss and slate, underlies 11 of the 27 Kejimkujik lakes and 6 of the 11 Yarmouth lakes. In previous monitoring studies, Keji lakes overlying the Middle Devonian formation were among the most acidic Nova Scotia lakes (Howell 1986). Soils in the Yarmouth area are quartzite- and schist-derived, being mostly shallow and stony sandy loams. Forest stands are mixed coniferous-deciduous, dominated by sugar maple, yellow birch, beech, red oak, red spruce, hemlock and pine. Black spruce, balsam, fir, larch and white cedar dominate poorly drained lowland areas (Simmons et al. 1984). Soils in the Keji watersheds are varied, including the slate-derived, well drained sandy loams found in the Kejimkujik drumlins (Simmons et al. 1984);

granitic till-derived Gibraltar soil which is a shallow stony, sandy loam soil; and, peaty, organic soils dominated by Sphagnum-heath communities (Kerekes and Freedman 1989). Keji is 94% forested, characterized by a mixed forest type that includes red spruce, eastern hemlock, red pine, red maple, sugar maple, beech and yellow birch. Many Keji lakes are highly coloured due to the presence of organic substrates in the more poorly drained watersheds (Kerekes and Freedman 1989).

The principal geological formations underlying Newfoundland lakes are presented in Table 3. As is the case for Nova Scotia, there is considerable variation in bedrock geology. The majority of the lakes (25 out of 33) fall under the Devonian, Helikian, or Hadrynian categories.

Table 3
Summary of geological formations of Newfoundland lakes

Devonian[a]	Ordovician[b]	Helikian[c]	Silurian[d]	Hadrynian[e]	Carboniferous[f]
YK6	YQ1	YH11	YM1	YS3	YL1
YM3	YR5	YH12	YN8	YS5	
YM7		YH13	YO9	YS9	
YM6		YH14		YS16	
YO7		YH15		YS45	
ZB1		YL10		YS10	
ZC3					
ZF3					
ZF4					
ZD1					
ZD2					
ZC2					

Source: Howell (1986).
[a] Composed of granite, granodiorite, monzonite, quartz, diorite, syenite.
[b] Composed of siltstone, quartzite, limestone, slate, greywacke, sandstone.
[c] Composed of quartzo-feldspathic gneiss and schist, amphibolite, psammitic to pelitic gneiss.
[d] Composed of sandstone, conglomerate, greywacke, shale, limestone.
[e] Composed of quartzite, siltstone, conglomerate, greywacke, volcanic rocks.
[f] Composed of conglomerate, sandstone, siltstone, shale, limestone, gypsum, anhydrite, coal.

Note: See Table 1 for lake IDs.

Of these 25 lakes, 12 are underlain by the Devonian geological formation, characterized by granite, granodiorite, monzonite, quartz, diorite and syneite. Bedrock composition in the Helikian formation is mostly gneiss, schist and amphibolite, while it is largely quartzite, siltstone, greywacke and volcanic rocks in the Hadrynian (Howell 1986). Most Newfoundland lakes are located on coarse to medium textured glacial tills. Soils are typically humo-ferric podzols (Roberts 1983). Newfoundland is located in the Boreal Shield Ecozone (Environment Canada 1986). In general, the northern half of the island is dominated by typical boreal forest species such as balsam fir, white and black spruce, and tamarack. The south central/southeastern part of the island has seen the destruction of the original forest cover, largely due to forest fires. As a result, the region is largely barren, dominated by dwarf shrub heaths (especially *Kalmia angustifolia*), bogs and fens. Balsam fir is the dominant tree in the few remaining forests of this region (Damman 1983).

1.2 METHODS

Stream sites in the TLW were sampled 2-5 times per week in March, 4-6 times per week in April, and once weekly throughout the rest of the year. Stream sites at Harp and Plastic lakes were sampled on average 1-3 times per week. A description of sampling methods for the Harp and Plastic lake sites can be found in Locke and Scott (1985). LQN lakes are divided into spatial and temporal sites. The spatial sites were sampled twice a year (spring and fall) while the temporal sites were sampled once every two months. The temporal sites are identified in Table 2 as those lakes which have a zero (0) in the second position of their three-digit code (e.g. Lake 101). Lake Laflamme was sampled weekly (Papineau 1987). The collected water samples are all integrated samples (0 to 5 m or to Z-5 m, according to maximum depth). Validated data and sampling protocol for the LQN lakes are described in Dubois et al. (1992). Atlantic lakes were sampled (grab samples) twice a year (spring and fall). The sampling protocol for Nova Scotia and Newfoundland lakes is documented in Clair et al. (1992). Lakes in Québec and the Atlantic region were accessed by helicopter.

Samples collected at the TLW sites were analysed at the National Water Quality Laboratory (NWQL) in Burlington, Ontario. LQN and LL samples were analysed at NWQL and at the regional laboratory in Longueuil, Québec, while Atlantic lake samples were analysed at the NWQL and Environment Canada's regional laboratory in Moncton, New Brunswick. All samples were analysed for a wide variety of parameters using standard Environment Canada procedures (Anonymous 1984). Plastic and Harp lake samples were analysed by the Ontario

Ministry of the Environment's (OME) laboratories using standard analytical methods described in OME (1983). Only the results for pH, alkalinity or acid neutralizing capacity (ANC) (measured using the Gran titration procedure), sulphates (SO_4^{2-}) (measured using the ion chromatography or colourimetry methods), nitrates (sum of NO_3^- and NO_2^-), Ca^{2+}+Mg^{2+} and colour are reported in this study, for which all data were validated. Data validation procedures included ion balancing, measured conductivity vs. calculated conductivity, outlier analysis, and various QA/QC measures (see, for example, Bouchard 1992a). Data from Atlantic lakes were corrected in order to account for seaspray contribution (Clair et al. 1992).

Precipitation data for the six CAPMoN stations studied in this report were obtained from the Atmospheric Environment Service (AES) in Downsview, Ontario. Complete descriptions of the CAPMoN sampling protocol and analytical methods used can be found in the CAPMoN annual data summary reports (e.g. Vet et al. 1989). Data supplied by the AES were in the form of monthly averages which were combined to produce bi-monthly averages. Monotonic trend analysis was then conducted on mean bi-monthly volume weighted concentrations and mean bi-monthly total deposition for H^+, sea salt-corrected SO_4, nitrate (sum of NO_3^- and NO_2^-), Ca^{2+}, and Mg^{2+}. In addition, mean bi-monthly pH and precipitation depth were analysed for significant trends. Yearly average values for H^+ deposition, sulphate deposition, and total precipitation depth were also obtained from the AES and used for graphical display.

For surface water, monotonic trend analysis was carried out on the time series of each parameter measured at a given sampling site. In addition, step trend analysis was undertaken for several of the sulphate series following visual inspection of individual sulphate time series plots. All trend analyses were undertaken using the DETECT software package (Cluis et al. 1988) and consisted of a series of non-parametric tests, the choice of which depended upon whether or not there was seasonality and/or persistence in the data (Berryman et al. 1988). These tests are summarized in Table 4.

Seasonality is present when the means of pre-defined seasons (e.g. monthly, bi-monthly, semi-annually, etc.) are found through analysis of variance to be significantly different. Persistence is ascertained by analysing the correlation coefficients: a first order correlation coefficient significantly different from zero indicates Markovian persistence. If both the first and second order coefficients are significantly different from zero, then there is non-Markovian persistence. There is no persistence if the first order coefficient is not significantly different from zero (Cluis et al. 1988). In the DETECT software package, a trend is considered significant when its probability of occurring only by chance is below 5% (α=0.05).

Table 4
List of non-parametric tests used to analyse trends

Preferred Test	Persistence	Seasonality
Monotonic		
Kendall[a]	No	No
Kendall Seasonal[a]	No	Yes
Spearman/Lettenmaier[b]	Yes	No
Hirsch and Slack[c]	Yes	Yes
Step		
Mann-Whitney Modified[d]	No	Yes
Mann-Whitney/Lettenmaier[b]	Yes	Yes

[a] Hirsch et al. (1982).
[b] Lettenmaier (1976).
[c] Hirsch and Slack (1984).
[d] Berryman (1984).

Any missing values in the data series were replaced by the mean seasonal value calculated over the whole time period. Values below the limit of detection (LOD) were replaced by a value equalling two-thirds of the LOD. This estimation was only necessary for nitrates and colour. Trend analyses were carried out for the following parameters: pH, alkalinity, sulphates, sum of Ca^{2+}+Mg^{2+}, nitrates, and colour (for Maritime provinces only). For lakes sampled twice a year (temporal Québec and all Atlantic lakes), a seasonal interval of six months was used when running the time series through DETECT. A seasonal interval of two months was used for temporal Québec and Ontario sites. For the very long data series found at the Ontario stations, the software automatically calculated bi-monthly averages.

The number of data points (N) in each time series varied according to region. There were between 685 and 721 values for the TLW sites and between 702 and 1795 samples for the Harp/Plastic lakes sites. See Appendix B for the sample size of each individual site. For Québec lakes, N was generally 52 for temporal lakes and between 17 and 18 for spatial lakes. In the case of the Atlantic lakes, N varies between 14 and 18 values per time series. The varying length of the individual time series depended on the number of missing values and the start/end date of each series. The length of the study period for each site is shown in Table 1. Data for most sites encompassed the period 1983-1991. The exceptions were the Newfoundland lakes YH11, YH12, YH13, YH14, YH15, YL10, and YM1, for which data were only available for the period 1984-1991; and, the Nova Scotia lake ED22, for which data were only available for the period 1983-1990. Due to missing values, a number of the alkalinity series ran from December 1984 to 1991. These included lakes 111, 213, 214, 515, and 516 in Québec, and Lake ZB1 in Newfoundland. Alkalinity was the parameter which was most often missing for Québec and Atlantic lakes, with approximately six lakes in each region having a missing value. Ten lakes in Nova Scotia and nine in Newfoundland were also missing a data series corresponding to one sampling run. In Ontario, for most sites, generally between 1% and 2% of the data points were missing for the time series of a given parameter. Data that were deemed to be outliers were removed from the series and replaced by average values for the same season. Values which were below the LOD were replaced by a value equal to two-thirds of the LOD. This was only a factor for nitrates in Québec and colour in the Atlantic lakes (DA2, DA3, DA6, EA2, EA20, ED1, ED3, ED4, ED11, ED27, ED30, YH11, YH13, YM1, YO9, ZB1, ZF3).

2 Results and Discussion

2.1 PRECIPITATION

Trend analysis results for precipitation data are presented in Table 5. Individual trend statistics, including test type and degree of significance, are listed in Appendix A. Of the 72 series analysed (6 stations x 12 parameters per station), 35 showed seasonality and 12 exhibited persistence (Appendix A). Most of the series (60 out of 72) were analysed with the Kendall or Kendall Seasonal test. Persistence was most common among the cation series (8 out of 12) and required the use of a Spearman/Lettenmaier test. The sulphate series (both concentration and deposition) exhibited the most seasonality, followed by Mg^{2+} and NO_{3-}. Concentration and deposition did not always correspond with respect to seasonality. Precipitation quantity was seasonal at both Ontario stations. There was a general lack of seasonality in the data with respect to pH and H^+.

Table 5
Summary of monotonic trends in precipitation data for six CAPMoN stations (1983-1991)

Variable Measured	Algoma station	Chalk River station	Montmorency station	Sutton station	Kejimkujik station	Bay d'Espoir station
Precipitation depth	-	-	-	-	-	-
pH	↑	↑	-	-	-	-
H^+ conc.	↓	↓	-	-	-	-
H^+ dep.	↓	↓	↓	-	-	-
SO_4 conc.	↓	↓	-	-	-	-
SO_4 dep.	-	↓	↓	-	-	-
NO_3 conc.	-	-	-	-	-	↑
NO_3 dep.	-	-	-	-	↑	↑
Ca conc.	-	↓	-	↓	-	↓ (EV)
Ca dep.	-	↓	-	-	-	↓ (EV)
Mg conc.	-	-	-	↓	-	-
Mg dep.	↑	↓	-	-	-	-

EV: Indicates a trend influenced by an extreme value.
Note: The data were combined into two-month values for the test application.

As shown in Table 5, no trends were reported in the amount of precipitation at any location. Significant increases in pH and decreases in H^+ deposition and concentration were observed for Ontario stations, while at Montmorency there was a decreasing H^+ deposition trend. Decreased H^+ deposition was accompanied by decreased SO_4 deposition and/or concentration at each of the three stations. Couture (1993) also found a decrease in SO_4 concentration and deposition at Montmorency for the period 1981-1991 using the Kendall Seasonal test. Sirois (1993), using different statistical techniques (i.e. model fitting using least-squares regression), reported statistically significant decreasing sulphate trends for the period 1979-1990 for Kejimkujik, Chalk River, Montmorency, and Algoma (Sutton and Bay d'Espoir were not tested). Unlike the present study, Sirois'(1993) methodology did not assume *a priori* that trends necessarily varied monotonically. Overall, the long-term sulphate trend curves were characterized by a decrease from the beginning to the mid- to late-1980s, followed either by a slight increase or a levelling off. The point at which the sulphate decreases ended variously from 1985 at Kejimkujik, to 1987 at Montmorency, to 1988 at Chalk River and Algoma.

The overall lack of SO_4 trends from 1983-1991 is indicative of a general levelling off of SO_2 emissions from the early to mid-1990s. Dillon and Lazerte (1992), for instance, found that SO_4 concentrations in precipitation samples taken from the Muskoka-Haliburton area of Dorset, Ontario remained relatively constant from 1983 to 1989. This is in contrast to the many decreasing SO_4 trends reported from the late 1970s to the mid-1980s. For example, the RMCC (1990) reported decreased SO_4 deposition at Algoma, Chalk River and Kejimkujik for the period 1979-1987. Similarly, Dillon et al. (1988) observed decreased SO_4 deposition rates at Dorset from 1976 to 1986.

With respect to NO_3, significant increases were found at both Atlantic stations but not at Ontario or Québec stations. At Montmorency, however, Couture (1993) reported a significant increasing NO_3 concentration trend for the period 1981-1991, while Sirois (1993) found an increasing NO_3 concentration trend for the period 1981-1990. Similarly, Couture (1993) reported increasing trends for Mg^{2+} deposition and concentration at Montmorency over the period 1981-1991 even though no trends were found for this parameter in this study. These differences were most likely due to the effect of adding two extra years of data (1981 and 1982) to the time series. Decreasing Ca^{2+} trends were observed at Chalk River, Sutton and Bay d'Espoir. The Bay d'Espoir series should be viewed with caution since the trends were found to be caused by unduly high values in July 1984.

Yearly precipitation amounts and mean annual loading rates for H^+ and SO_4 over the period 1983-1991 are shown in Figures 2 to 4. With the exception of Sutton, 1987 was the driest year for every station. Annual precipitation amounts were quite variable, with the exception of Chalk River, where it remained near-constant at about 80 cm per year from 1983 to 1991. Further west at Algoma, annual precipitation was considerably higher than at Chalk River with 1987 and 1988 being the driest and wettest years at 105 and 155 cm of precipitation, respectively. At Montmorency, starting in 1985, an overall dry year/wet year pattern is evident. Roughly the same pattern was observed at Sutton even though the amount received was generally lower. Precipitation patterns at Kejimkujik and Bay d'Espoir were also cyclical, with 1987 and 1990 being the driest and wettest years, respectively, for each region.

The most common pattern in yearly sulphate deposition seems to be a reduction in deposition over the period 1983-1987, followed by a substantial increase in 1988, followed in turn by a decrease in 1989 and then a levelling off (Figure 3). This is the pattern exhibited by Algoma, Montmorency, and Bay d'Espoir. Chalk River showed more of a steady decrease in SO_4 deposition over the period 1984-1991. Decreasing SO_4 trends at Chalk River, Algoma, and Montmorency were associated with 1991 SO_4 deposition levels that were 26%, 15%, and 14% lower than those in 1983. The Sutton station shows more of a step trend where a decrease before the drop in 1987 is not evident, and values level off except for a sharp increase in 1990. SO_4 deposition at Kejimkujik seems to increase from 1983 to 1986, followed by a drop in 1987 and then an increase from 1987-1989, followed by a levelling off in the early 1990s. Sulphate deposition at Kejimkujik in 1991 was 23% higher than it was in 1983.

Overall, H^+ deposition followed the same general pattern as that of SO_4 in Ontario and Nova Scotia (Figure 4). At Montmorency, Sutton and Bay d'Espoir, there was a higher proportion of H^+ deposition to SO_4 deposition in the mid-1980s. NO_3 may be a factor in explaining the relatively higher H^+ deposition. The significant negative H^+ deposition trends found at Chalk River and Montmorency (Table 5) were associated with 1991 deposition rates that are 33% and 9% lower, respectively, than those in 1984.

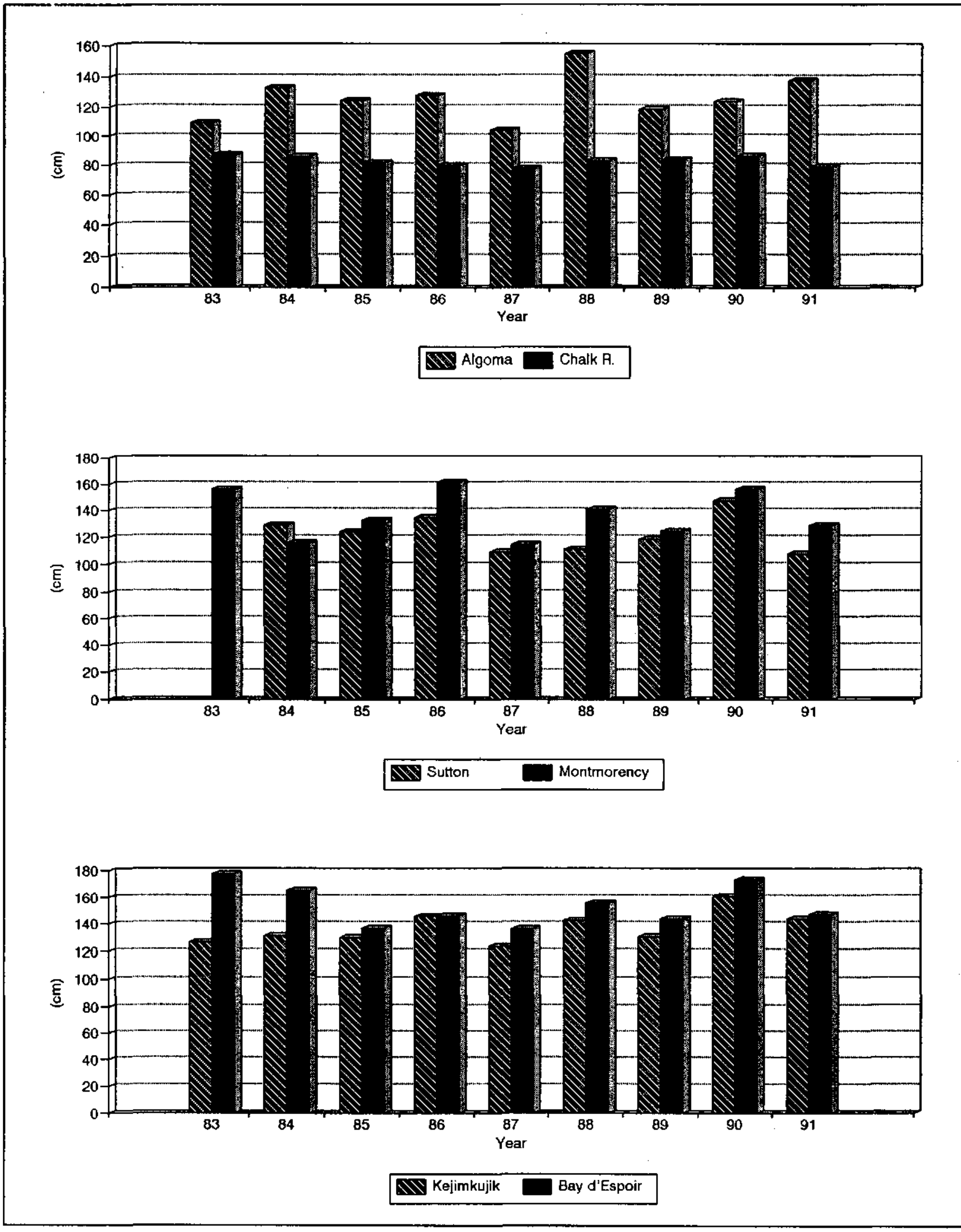

Figure 2 Annual precipitation for six CAPMoN stations

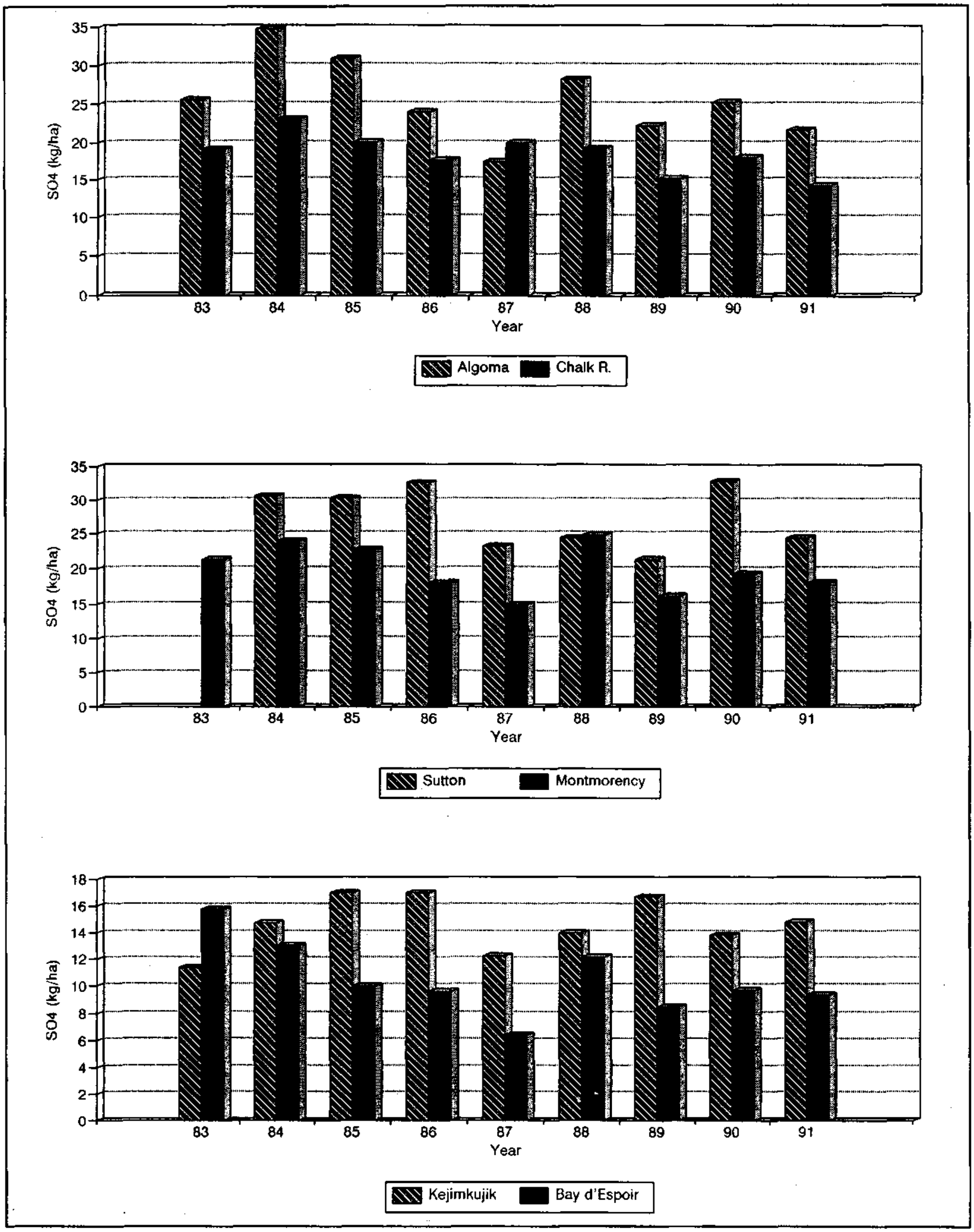

Figure 3 Annual sulphate deposition for six CAPMoN stations

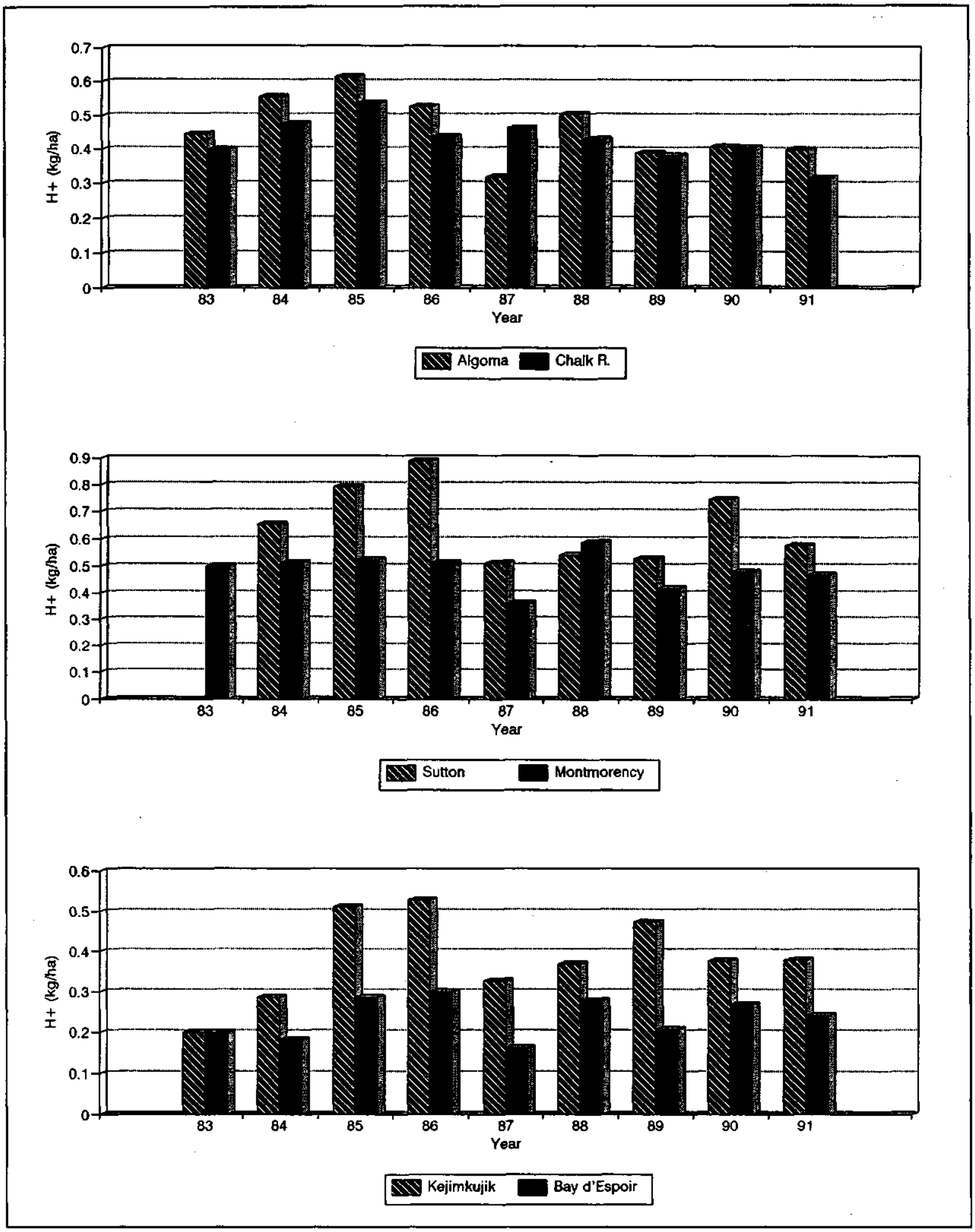

Figure 4 Annual hydrogen ion deposition for six CAPMoN stations

2.2 REGIONAL WATER QUALITY CHARACTERISTICS

This section will present a description of water quality characteristics for the lakes sampled in the present study. For more detailed information, please consult the following references: TLW (Jeffries et al. 1987), Harp Lake (Dillon et al. 1987; Schuler et al. 1990); Plastic Lake (Dillon et al. 1987; Dillon and Lazerte 1992); Québec (Bouchard 1992a, 1992b); Nova Scotia and Newfoundland (Howell 1986; Howell and Brooksbank 1987; Clair and Esterby 1991; Clair et al. 1992). See also RMCC (1990) and Jeffries (1991) for an overview of the effects of acid deposition on lakes in southeast Canada.

Jeffries (1991) recently summarized the water quality characteristics of southeastern Canadian lakes using a database consisting of 7403 lakes belonging to 8 sub-regions (Newfoundland, Labrador, Nova Scotia, New Brunswick, Québec, and three Ontario sub-regions). Regional differences in water quality were largely a function of terrain geochemistry and atmospheric deposition. Sulphate deposition levels were generally highest in southern Ontario, southern Québec and southern New Brunswick. While most of the lakes were located on the Canadian Shield, overlying generally carbonate-poor, shallow glacial tills, Ontario lakes had higher overall CaMg levels due to the presence of localized, glacially-derived deposits of easily weathered $CaCO_3$. In the present study, the Nova Scotia and Ontario subset of sites were slightly more acidic while the Québec subset was less acidic than the larger set of lakes included in Jeffries' (1991) regional database.

Descriptive regional statistics for four parameters are presented in Table 6. Median values and full descriptive statistics for each parameter at each individual site are shown in Appendix B. The values calculated in Table 6 were based on a twice-yearly sampling frequency. In order that the extra data available for Ontario sites and temporal Québec lakes did not unduly influence the calculation of regional statistics, the data sets for these lakes were adjusted to include only two values per year for each parameter. Characteristics for each parameter and region are discussed below.

Table 6
Descriptive regional statistics, by parameter, for all lakes sampled

	Ontario	Québec	Nova Scotia	Newfoundland
Number of sites	11	29	38	33
pH (units)				
No. of samples	198	499	658	535
Mean	5.77	6.47	5.29	5.98
Median	5.8	6.5	5.2	6.1
s	0.72	0.73	0.62	0.50
Min.	4.2	4.8	4.1	4.6
Max.	7.2	7.9	6.7	6.9
Alkalinity (mg/L)				
No. of samples	198	488	652	527
Mean	2.52	8.08	0.28	2.04
Median	2.1	4.9	0.1	1.7
s	3.02	9.11	1.29	1.73
Min.	-4.0	-1.5	-3.8	-0.6
Max.	10.32	36.45	3.8	10.5
Sulphates (mg/L)				
No. of samples	197	502	658	532
Mean	7.81	5.65	1.96	1.00
Median	7.2	5.3	1.86	0.98
Ca+Mg (µeq/L)*				
No. of samples	197	503	658	534
Mean	231.12	263.06	47.59	70.32
Median	217.42	172.92	38.27	65.91
s	95.53	217.83	30.31	40.98
Min.	84.75	51.31	7.80	12.70
Max.	705.02	956.05	158.71	270.11

* Corrected for sea salts in Nova Scotia and Newfoundland.
Note: *s* = standard deviation.

2.2.1 pH

The pH of a lake is a measure of its H^+ concentration. H^+ ions are important toxic species in acidified waters and their effect can be exacerbated by low Ca^{2+} levels and/or high aluminum levels (RMCC 1990). A pH level of 6.0 is considered to be the threshold below which deleterious effects to biota may occur. The Ontario sites as a whole have a median pH of 5.8 (Table 6) with median pH ranging from 4.35 (PCI) to 6.66 (Turkey). Low pH at a number of sites may be due to the fact that several of the lake inflows drain wetland areas (Dillon et al. 1987).

The median pH for Québec lakes was 6.5, with median pH by site ranging from 5.0 to 7.5. The median pH was generally lowest in Region 1 lakes and highest in Region 5 lakes. Nova Scotia lakes were the most acidic, having a median pH of 5.2. This high level of acidity was mostly due to the Kejimkujik lakes (ED1 to ED48), nearly all of which had median pH values below 6.0 and many of which were below 5.0. The Kejimkujik lakes were more acidic because of the high levels of organic acids found in the lake drainage basins (Clair et al. 1992). Newfoundland lakes had higher pH levels, with a median value of 6.1; this is in part attributable to lower sulphate deposition (see previous section).

2.2.2 ANC

For most lakes in the present study, ANC is generated by HCO_3^- (bicarbonate), where HCO_3^- combines with H^+ to yield CO_2 and water. The presence of bicarbonate in a lake watershed is a function of bedrock geology. Most southeastern Canadian lakes are situated on slowly weathered bedrock which is overlain by carbonate-poor tills. For lakes in this study, sites with a pH of 6.0 usually have alkalinity values of approximately 2 mg/L (Figure 5). Lakes with ANCs of less than 10 mg/L (200 μeq/L) are considered susceptible to acidification (Harvey et al. 1981), while lakes with ANCs of less than 2 mg/L are considered to be extremely susceptible to acidification (RMCC 1990). Out of the 111 sites analysed for this report, 66 have median values of less than 2 mg/L and most of these are located in Nova Scotia and Newfoundland. In terms of percentages, 36%, 29%, 89%, and 61% of Ontario, Québec, Nova Scotia, and Newfoundland sites, respectively, have median ANC values below 2 mg/L.

The median ANC for Ontario sites was 2.1 mg/L (Table 6) but, as with pH, there exist significant differences between median ANC values at individual study sites (-2.4 to 8.9 mg/L). The median ANC of 4.87 for Québec lakes was also accompanied by considerable inter-regional variability, with ANC being lowest in Region 1 and highest in Region 5. For Nova Scotia, the median ANC was 0.1, with the Kejimkujik lakes influencing the overall median due to the preponderance of negative ANC values. Lower ANC in the Kejimkujik lakes is partly due to the presence of organic acids in lake watersheds (Clair et al. 1992). Median ANC for Newfoundland was 1.7 and ranged from -0.2 to 6.6. The higher ANC levels found in Newfoundland lakes were probably due to lower sulphate deposition and to the fact that the lakes are located on more heterogeneous geology than are the Nova Scotia sites.

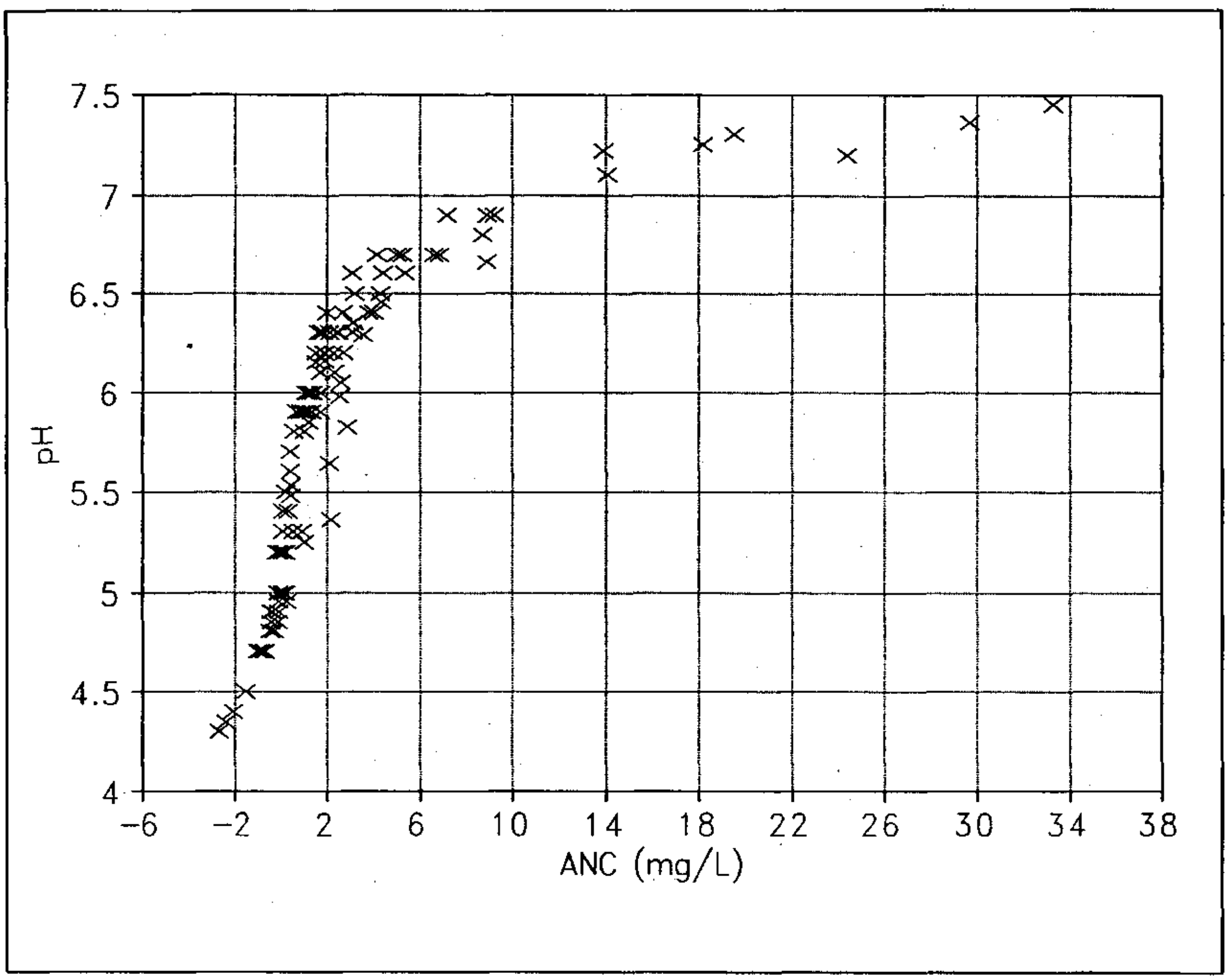

Figure 5 Relationship between median pH and ANC for all study sites

2.2.3 Ca^{2+} and Mg^{2+}

The most significant base cations in the study of acid deposition are Ca^{2+} and Mg^{2+}, here represented by the sum of Ca^{2+} and Mg^{2+} (CaMg). CaMg production in the watershed is due to bedrock weathering and cation exchange processes. Since most of the ANC for eastern Canadian lakes is generated by bedrock weathering (Jeffries 1991) with the subsequent release of Ca^{2+}, Mg^{2+}, and HCO_3^- into aqueous solution, there is a strong correlation between CaMg and HCO_3^- concentrations. Bouchard (1992a), for example, reported a correlation coefficient of 0.987 between CaMg and ANC for LTQ lakes.

The median CaMg concentrations (sea salt-corrected for Atlantic lakes) were 217, 173, 38, and 66 μeq/L for Ontario, Québec, Nova Scotia, and Newfoundland sites, respectively. Due to the processes described above, CaMg concentrations for lakes in the various regions follow the same pattern as do alkalinity levels. Lakes with CaMg levels below 200 μeq/L are considered to be very susceptible to acid precipitation (Harvey et al. 1981). By this criterion, 36% and 37% of Ontario and Québec sites, and all of the Atlantic lakes were below 200 μeq/L. In lakes not subject to acid deposition, the ANC/CaMg ratio is typically near one (1). As a result of sulphate deposition, and due to the principle of electrochemical neutrality, this ratio decreases due to loss of alkalinity and/or an increase in CaMg production (Jeffries 1991). In all four locations, median CaMg is much higher than median ANC (μeq/L).

2.2.4 Sulphates

The main acidifying species in acid precipitation are H^+, NO_2^-, NO_3^- and SO_4^-. However, H^+ and the nitrogen oxides are frequently poor measures of acidic deposition because of their involvement in biotic and abiotic processes. Therefore, due to the conservative nature of the sulphate ion in biological and chemical systems, it is used as a surrogate for H^+ loading, assuming that significant natural sulphate sources are not present (Howell and Brooksbank 1987).

As was the case for sulphate deposition, sulphate levels in water generally follow a decreasing west-east gradient, with median concentrations (sea salt-corrected in Maritimes) of 7.2, 5.3, 1.9, and 1.0 mg/L for the Ontario, Québec, Nova Scotia, and Newfoundland sites, respectively (Table 6). For the Ontario sites, however, median levels were higher at the Harp/Plastic sites than at the TLW sites further west (8.0 vs 5.8 mg/L, respectively). In Nova

Scotia, median sea salt-corrected sulphate levels for Yarmouth lakes (2.17-2.94 mg/L) were higher than the median levels for Kejimkujik lakes (0.58-2.06 mg/L).

2.2.5 Nitrates

Though nitrates, as previously mentioned, are an important component of acid precipitation, it is difficult to measure their impact on water quality. Nitrates are a nutrient and as such exhibit seasonal patterns. In LTQ lakes, for example, highest NO_3^- levels are found in March, while the lowest values are found at the height of biological activity in the months of July, August and September (Bouchard 1992a).

The median nitrate level for Ontario was 114 μg/L. The high median NO_3^- levels found at TLW sites (273 and 389 μg/L) (Appendix B) were probably due to a lack of nitrate retention in the lake watersheds rather than to higher nitrate deposition (Jeffries et al. 1988). Median nitrate concentrations ranged from 10 to 218 μg/L for the Harp Lake sites and between 22 and 51 μg/L for Plastic Lake sites. Dillon et al. (1987) reported concentrations of 20 μg/L and 110 μg/L for Plastic and Harp lakes, respectively, over the period 1980-1981. Differences between the lakes are probably due to watershed processes, as was the case for the TLW sites. The median nitrate level for Québec was 26 μg/L, with median values ranging from 7 to 110 μg/L. All but three of the Atlantic lakes had NO_3^- values that were below the limit of detection. As such, descriptive statistics were not calculated for these regions.

2.2.6 Colour

Water colour is influenced by the production of natural organic acids in lake basins and watersheds. Lakes that have bogs and other wetlands in their drainage basin typically have highly coloured waters. The presence of these organic acids serves to complicate the interpretation of water quality trends for the reason that these acids can both contribute to lake acidity and, at lower pH, the organic anions formed by the dissociation of organic acids can act as buffers (Clair et al. 1992). For the present study, the analysis of water colour was limited to the Atlantic lakes since these have the most highly coloured waters.

Nova Scotia lakes have the more highly coloured waters with a median value of 58 Hazen units as compared to a median of 30 Hazen units for Newfoundland lakes. With the exception of two lakes in the Yarmouth area (EA9 and EA19), most lakes with colour values over 30 were located in the Kejimkujik area (Table B7). In Newfoundland, lakes with colour readings over 30 were evenly spread out, being found in a number of different basins (e.g. YH, YK, YL, YM, YN, YO, YR, YS, and ZD).

2.3 TREND ANALYSIS RESULTS

Trend analysis was conducted on data obtained for the six parameters analysed in this report: pH, ANC, sulphates, CaMg, nitrates, and colour. With the exception of nitrates and colour, trend results are available for each parameter and for each of the 111 sites analysed. In the case of the nitrate series, most of the Atlantic sites had too many values below the LOD to allow time series analysis to be performed. Colour trend analysis was only conducted on Atlantic data.

A summary of trend analysis results is presented in Table 7, while detailed trend statistics for individual sites are documented in Appendix C. Representative trends for each parameter are shown graphically in Figures 6 to 9. For the Ontario region, with the exception of station HP6A, seasonality was exhibited by every site for every parameter (Table 8). Similarly, persistence was shown at 9 out of 11 sites for the pH, sulphate and CaMg analyses and at approximately 50% of the sites analysed for alkalinity and nitrate trends. These results were based on running DETECT with the data grouped into two-month intervals. For these same intervals applied to data from the Québec temporal lakes, only for CaMg (8 out of 9 lakes) and nitrates (9 out of 9 lakes) were seasonality common. With respect to persistence, the most affected variables were pH (8 out of 9 lakes) and sulphates (5 out of 9 lakes). Seasonality in the data is most likely explained by the hydrological cycle and, especially for nitrates, by biological activity.

For the Québec and Atlantic lakes tested with a seasonal interval of six months, the number of cases of persistence was surprising given the twice-yearly sampling frequency (Table 8). The variables most influenced by seasonal cycles were alkalinity (39 out of 91 lakes) and CaMg (51 out of 91 lakes). That pH and colour exhibited higher seasonality in Nova Scotia lakes may be related to hydrological and biological wetland processes. Trend results for individual parameters and regions follow, ending with an overall inter-regional comparison.

Table 7
Summary of trend analysis results, by sampling site

Station	pH	Alkalinity	SO_4	Step	CaMg	No_3	Colour
Ontario							
Batchawana	-	-	-	↑	-	-	NT
Turkey	-	↑	-	-	↑	-	NT
HPO	↑	↑	-	-	↑	-	NT
HP3	↓	-	-	-	-	↓	NT
HP3A	-	-	-	-	-	-	NT
HP4	-	-	-	↑	↑	↑	NT
HP5	↑	↑	-	-	-	-	NT
HP6	↓	↓	-	↑	↑	-	NT
HP6A	↓	-	-	↑	↑	-	NT
PCO	-	-	↑ (EV)	-	-	-	NT
PCI	-	-	-	↑	-	-	NT
Québec							
101	-	-	-		-	-	NT
102	↓	-	↓		↓	-	NT
111	-	↓	-		-	-	NT
112	-	↓	-		↓	-	NT
114	↓	↓	↓		↓	-	NT
201	-	-	↓		-	↑	NT
202	-	-	-		↑	-	NT
211	-	-	-		-	-	NT
212	-	↓	-		-	↑	NT
213	↓	↓	-		↓	↑	NT
214	-	-	-		-	-	NT
301	-	-	-		↑	↑	NT
302	-	-	-		↑	-	NT
304	-	↓	-		↓	-	NT
311	-	-	-		↓	↓	NT
312	-	↓	-		-	-	NT
313	-	-	↓		-	-	NT
314	-	-	↓		↑	↓	NT
401	-	↓	↓		-	↑	NT
411	-	-	-		↑	-	NT
414	-	-	↑		↑	↑	NT
501	-	-	↓		-	↑	NT
502	-	-	↓		-	↑	NT
511	↓	-	↓		-	-	NT
512	-	↓	↓		↓	↑	NT
513	-	-	↓		-	↑	NT
514	-	-	↓		-	↑	NT
515	-	↓	↓		-	-	NT
516	↓	-	↓		-	-	NT

Station	pH	Alkalinity	SO_4	CaMg	NO_3	Colour
Nova Scotia						
DA0002	-	-	-	-	NT	-
DA0003	↑	↑	-	-	NT	↑(EV)
DA0004	-	↑	-	-	NT	-
DA0005	-	↑	-	-	NT	-
DA0006	-	-	-	↓	NT	↑
EA0002	-	↑	↓	-	NT	-
EA0004	-	-	-	-	NT	-
EA0009	-	-	-	-	NT	-
EA0010	-	-	↑	-	NT	-
EA0019	-	-	-	-	NT	-
EA0020	-	-	-	-	NT	-
ED0001	-	-	↑	-	NT	-
ED0002	-	-	-	-	NT	-
ED0003	-	↑	-	-	NT	↑
ED0004	-	↑	↑	-	NT	-
ED0005	-	↑	-	-	-	-
ED0006	↓	↑	-	↓	NT	-
ED0007	-	-	↑	-	NT	-
ED0008	-	-	-	-	NT	-
ED0010	-	-	-	↑	NT	-
ED0011	-	-	↑	-	NT	-
ED0013	-	-	-	-	NT	-
ED0014	-	-	-	-	NT	-
ED0015	-	-	↑	↑	NT	-
ED0016	-	↑	↑	-	NT	-
ED0017	-	↑	↑	-	NT	-
ED0019	-	-	-	-	NT	-
ED0020	-	-	-	-	NT	-
ED0021	-	-	-	-	NT	↑
ED0022	↑	↑	↑	↑	NT	-
ED0025	-	-	-	-	NT	-
ED0027	-	-	↑	-	NT	↑(BL)
ED0028	-	-	-	-	NT	-
ED0029	↑	↑	↑	-	NT	-
ED0030	-	↑	-	-	NT	-
ED0043	-	↑	-	-	NT	-
ED0047	-	-	↑	-	NT	-
ED0048	-	↑	↑	-	NT	-

Station	pH	Alkalinity	SO_4	CaMg	NO_3	Colour
Newfoundland						
YH0011	↓	-	↓	-	NT	↑
YH0012	-	-	↓	-	NT	↑
YH0013	-	-	-	-	-	NT
YH0014	-	-	↓	-	NT	↑
YH0015	-	↑	-	↑	NT	↑
YK0006	-	-	↑	-	NT	-
YL0001	-	↑	-	-	NT	-
YL0010	-	↑	↓	-	NT	↑
YM0001	-	↑	-	↑	NT	-
YM0003	-	↑	-	-	NT	-
YM0006	-	↑	-	↑	NT	-
YM0007	-	↑	-	-	NT	-
YN0008	↑	-	-	-	NT	-
YO0007	-	-	-	-	NT	-
YO0009	↑	↑	-	↑	NT	-
YQ0001	-	-	↑	↑	NT	↑
YR0005	-	↑	↑	-	NT	-
YS0003	-	↑	-	-	NT	-
YS0005	-	-	-	-	NT	-
YS0009	-	-	↑	-	NT	-
YS0010	-	-	↑	-	NT	-
YS0016	-	-	-	-	NT	-
YS0021	-	-	-	-	NT	-
YS0029	-	↑	-	-	NT	-
YS0045	-	-	-	-	NT	-
YS0048	↑	↑	-	-	NT	-
ZB0001	-	-	-	-	↑	-
ZC0002	-	↑	-	-	NT	-
ZC0003	-	↑	↓	-	NT	-
ZD0001	-	↑	-	-	NT	-
ZD0002	-	-	↑	-	NT	-
ZF0003	-	-	-	-	NT	-
ZF0004	↑	↑	-	-	NT	-

EV: Trend influenced by extreme value.
NT: Not tested.
BL: Many values in series were below the LOD.

Table 8
Frequency of seasonality and persistence for study sites

Parameter	Ontario (11 sites)	Québec (9 temporal sites)	Québec (20 spatial sites)	Nova Scotia (38 sites)	Newfoundland (33 sites)
Seasonality					
pH	11	1	3	15	2
ANC	11	3	11	14	14
SO_4	11	2	2	5	4
CaMg	11	8	18	13	20
NO_3	10	9	5	-	-
Colour				12	1
Persistence					
pH	9	8	7	12	3
ANC	6	3	1	10	6
SO_4	9	6	5	0	3
CaMg	9	2	11	14	12
NO_3	5	1	4	-	-
Colour				5	1

2.3.1 pH

Few trends were seen in pH. Overall, Ontario stream sites exhibited two increasing trends and three decreasing trends (Table 7). These were all located at the Harp Lake stations. Whereas acidity decreased in the outflow (HPO) and at one of the inflows (HP5), it increased at three of the other inflows (HP3, HP6, and HP6A) (Figure 6). For the nine-year period, the magnitude of the pH decrease was greatest at HP3 (from 6.04 to 5.71 units). Increases at HPO and HP5 were 0.27 and 0.26 units over the study period. In Québec, only pH decreases were observed, at the following five lakes: 102 (5.91 to 5.48), 114 (5.38 to 4.79), 213 (5.58 to 4.96), 511 (7.65 to 7.40), and 516 (6.89 to 6.54). Thus, pH decreases were recorded in lakes from both the most susceptible (Region 1) and least susceptible regions (Region 5). Of the 38 Nova Scotia lakes, there were three increasing trends and one decreasing trend. The acidity increase occurred at the Kejimkujik Lake ED6, where the change was very slight, with pH going from 5.89 to 5.84

units. The pH increases were at lakes DA3 (from pH 5.79 to 6.05), ED22 (4.75 to 4.94), and ED29 (4.62 to 4.79). Similarly, in Newfoundland, four of the 33 lakes registered a pH increase (lakes YN8, YO9, YS48, and ZF4), while one lake (YH11) had a decreasing trend, going from pH 5.72 to 5.53 over the study period. The magnitude of the increasing trend was between 0.04 and 0.05 units for lakes YN8, YO9, and ZF4, and about 0.02 units for YS48 over the nine-year period.

2.3.2 ANC

For all regions considered together, there were 34 increasing and 11 decreasing ANC trends. Three increasing ANC trends were found at Ontario sites: one at TLW (from 0.17 to 0.20 mg/L), and two others at Harp Lake (HPO and HP5, going from 3.13 to 4.18 mg/L and 1.70 and 4.70 mg/L, respectively) (Figure 7). The trends observed at the latter two stations were consistent with the increasing pH trends. Similarly, consistent with the decreasing pH at HP6, alkalinity also diminished at this site (dropping from 4.64 to 2.90 mg/L). The ANC trend at the TLW site did not have a corresponding pH trend. Also, though pH decreased at HP3 and HP6A, there was no significant change in alkalinity for these two sites.

In Québec, only decreasing ANC trends were observed. In all, ten lakes, at least one from each region, had decreasing ANC trends. The magnitude of the negative change over the nine years ranged from 0.25 to 1.03 mg/L for lakes in regions 1-4, up to 3.4 and 8.52 mg/L for lakes 515 and 512, respectively. Among these ten lakes, two were matched by corresponding pH decreases (lakes 114 and 213). Two lakes (lakes 114 and 512) had corresponding decreasing trends for ANC, SO_4, and CaMg, a pattern that might be due to a dilution effect.

The situation is completely reversed in Nova Scotia lakes, where 15 out of 38 lakes show increasing ANC trends. These lakes are located in both the Yarmouth and Kejimkujik areas. The magnitude of the increase over the study period ranges from 0.26 to 1.1 mg/L. Despite this increasing ANC trend, four lakes still have negative alkalinities (ED5, ED22, ED29, ED43). All three lakes which exhibited increasing pH trends (DA3, ED22, and ED29) also had positive ANC trends. Surprisingly, ANC for ED6 increased while pH decreased. In Newfoundland, 16 positive ANC trends were observed. Trends were spread out among most of the study basins and ranged

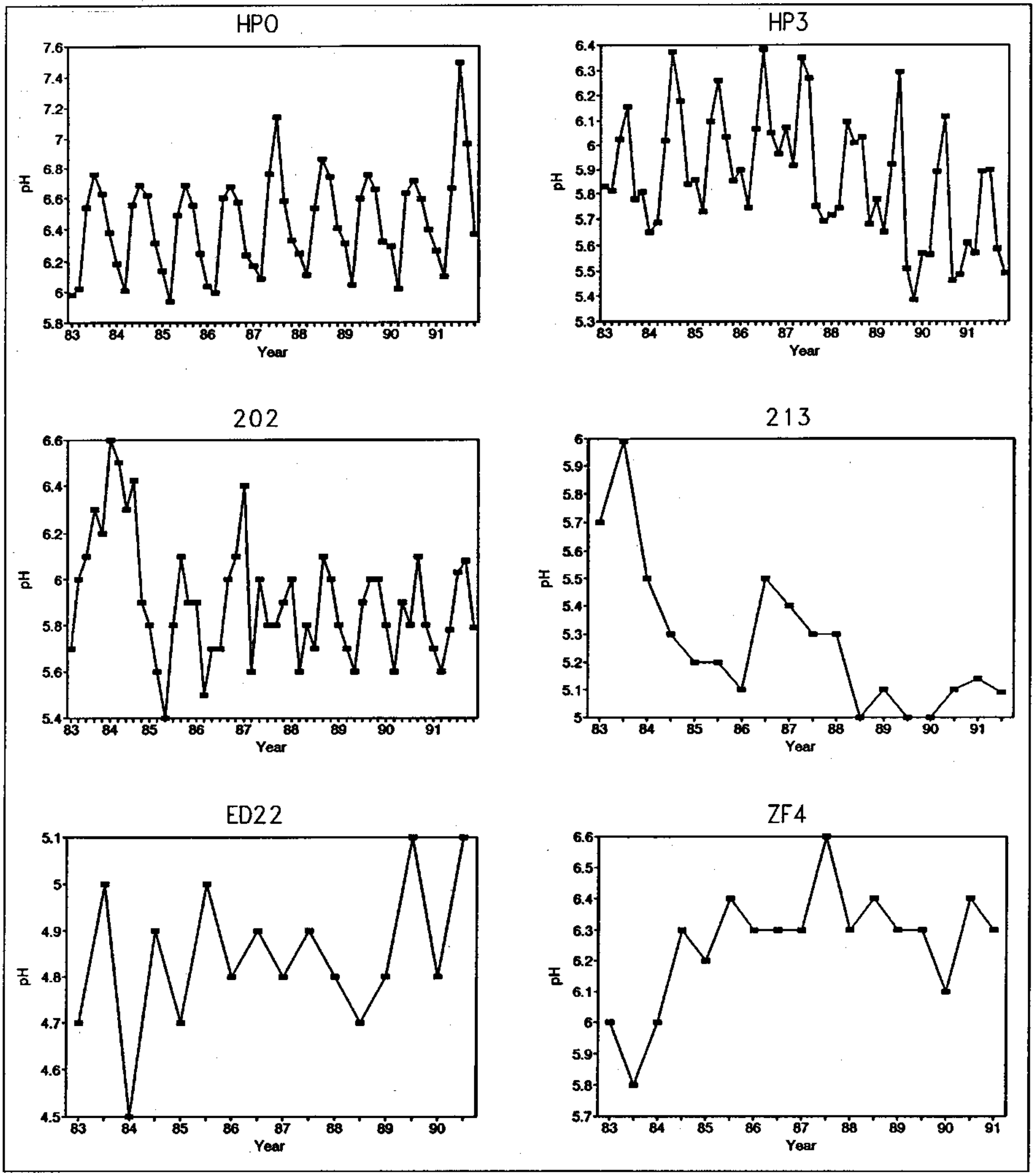

Figure 6 pH time series plots for selected lakes

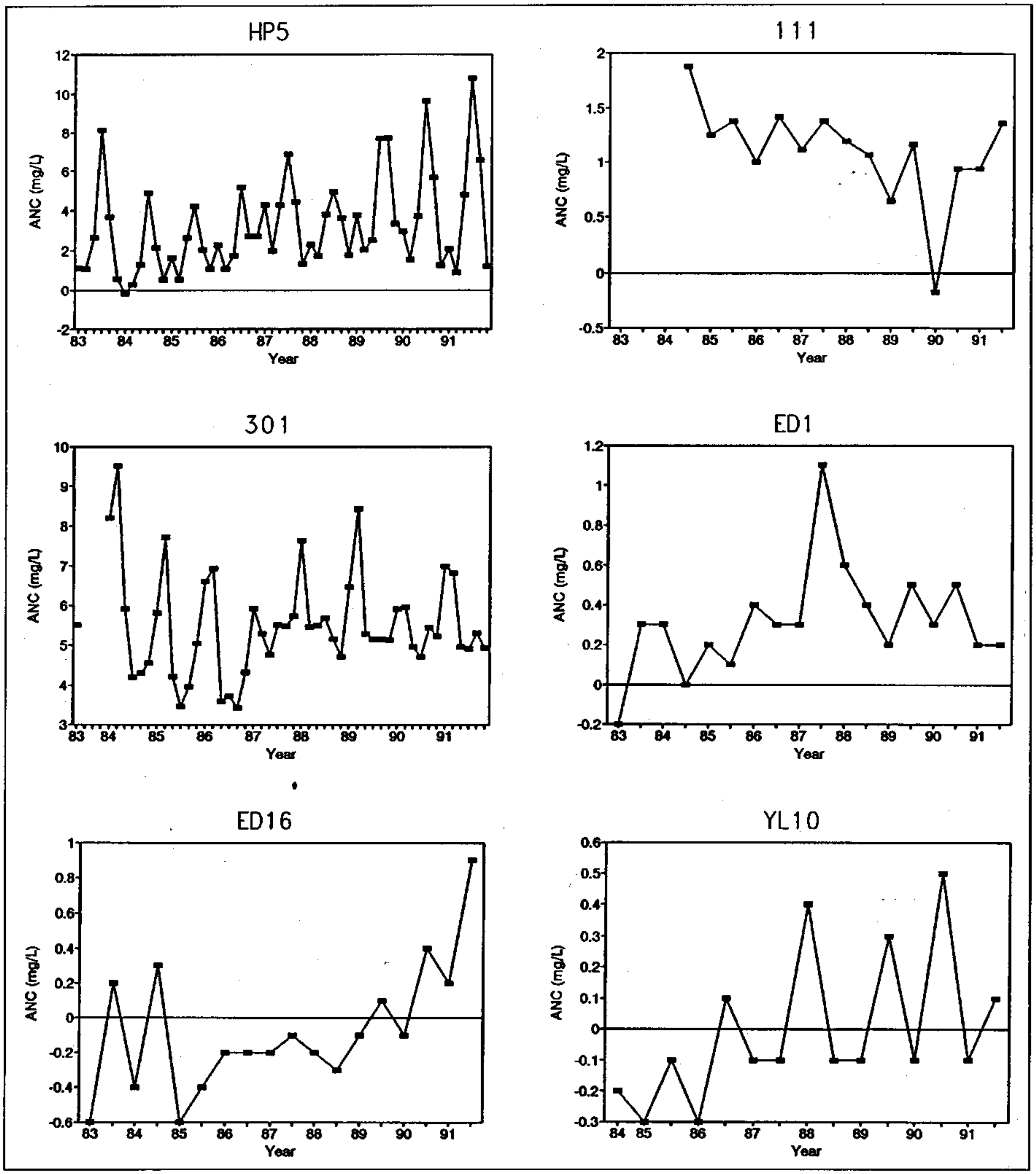

Figure 7 ANC time series plots for selected lakes

in magnitude from 0.23 to 1.32 mg/L over the nine years. Three of the lakes (YO9, YS48, ZF4) had corresponding pH increases.

2.3.3 Ca^{2+}+Mg^{2+}

In all, there were 18 increasing and 9 decreasing trends for CaMg. In Ontario, CaMg increased at four sites: Turkey (303 to 336 μeq/L), HPO (218 to 235 μeq/L), HP4 (230 to 275 μeq/L), and HP6 (265 to 455 μeq/L)(Figure 8). Two of these sites had increasing alkalinity (Turkey and HPO), one had increasing NO_3 (HP4), and one had decreasing ANC and pH (HP6). Thirteen trends were detected for Québec sites, of which six were increases and seven were decreases. The magnitude of the decreases over the nine-year period ranged from 7.5 to 160.7 μeq/L, while the increases ranged in magnitude from 4.7 to 27.3 μeq/L. Three of the seven decreases were accompanied by decreasing SO_4 (102, 114, 512). For three lakes, increasing CaMg was the only trend found. Interestingly, lakes 301 and 311 have CaMg and NO_3 trends that move in unison.

With CaMg decreasing at two lakes (DA6 and ED6) and increasing at three others (ED10, ED15, and ED22) there were few trends in Nova Scotia for this parameter. All of the increases were located in the Kejimkujik sites and ranged from 5.4 to 21.8 μeq/L for the study period. Similarly, there were few significant trends in Newfoundland, where CaMg increased at only five sites. Ranges for magnitudes of increase were similar to those in Nova Scotia, varying from 8.6 to 21.8 μeq/L.

2.3.4 Sulphates

With respect to monotonic trends, sulphate concentrations for Ontario sites showed no net trend with the exception of one increasing SO_4 trend at the Plastic Lake outflow. This trend, however, should be viewed with caution since it was a result of several extreme values in the September/October 1989 interval. The sulphate increased from 6.50 to 7.01 mg/L. Step trend analysis was undertaken for several of the series following visual examination of sulphate time series plots. Increasing step trends were found for five of the Ontario sites (Table 9, Figure 9). In several series, there was a decrease during the few first years, followed by an increase.

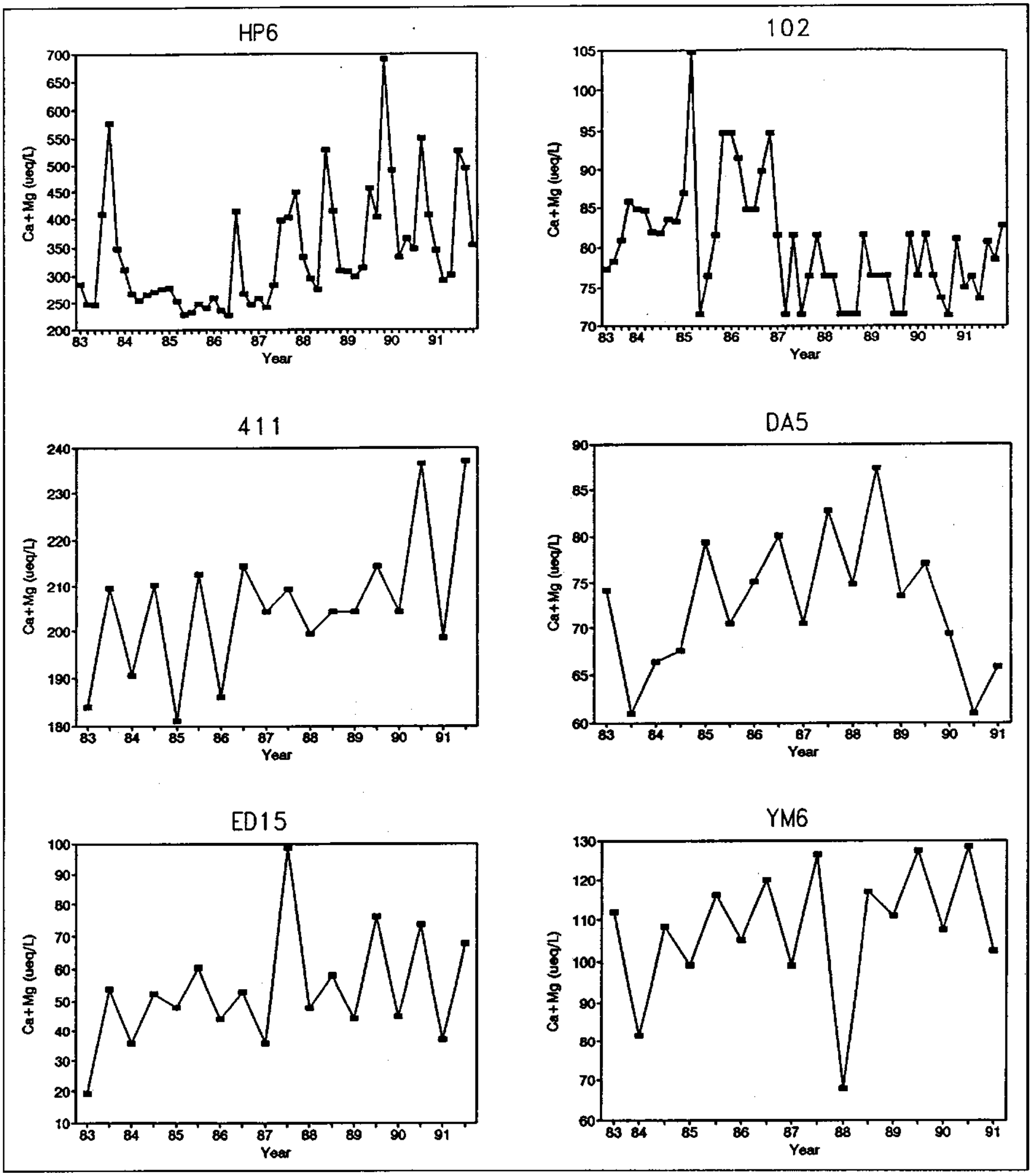

Figure 8 Sum of calcium and magnesium time series plots for selected lakes

In Québec, 14 lakes had decreasing sulphate trends while one (Lake 414) had an increasing trend. Not only did all eight lakes in Region 5 have negative sulphate trends, but the magnitude of the decrease for the study period was also the highest for these lakes, ranging from 0.84 to 2.55 mg/L, with five of the eight lakes having decreases of 1.78 mg/L or more. Decreases for the other six lakes in regions 1 to 4 ranged from 0.34 to 1.54 mg/L, with five of the six lakes being below 0.81 mg/L. Several lakes also show a reversal pattern in SO_4 concentrations in the late-1980s, leading to no overall trend (Figure 9, Lake 101), a pattern quite different from that seen in Ontario. Seven of the 14 lakes with sulphate decreases also showed either decreasing pH and/or alkalinity trends. These include lakes 102, 114, 401, 511, 512, 515, and 516. The remaining seven lakes had no associated pH or alkalinity trend. Therefore, some lakes with reduced sulphate concentrations may be continuing to acidify while others have yet to show improvement.

There are a number of possible explanations for this phenomenon. First, there may be a lag period between reduced sulphate concentrations and water improvement due to the possibility that an equilibrium condition has not yet been reached. In this respect, bogs and wetlands may play an important role. Secondly, the role of nitrates has yet to be clearly elucidated. It may be that they are retarding lake recovery to a measurable extent. The third possibility has previously been mentioned; that is, a dilution effect. One would expect to see three parameters (ANC, SO_4, and CaMg) moving in unison if dilution was occurring. This pattern, however, was only observed for two lakes. Fourthly, it may be that SO_4 levels, though decreasing, are still exceeding a critical load, and for that reason recovery is still not evident. Lastly, there is the "window effect" to be considered. It may be that the window with which we have chosen to observe the lakes is revealing a transition period, a time when the water chemistry is confusing and the lakes are in various stages of disequilibrium.

In Nova Scotia, ten Kejimkujik lakes had increasing sulphate trends while in the Yarmouth area there was one increasing (EA10) and one decreasing trend (EA2). The magnitude of the sulphate increases over the nine-year period ranged from 0.28 to 0.87 mg/L. The sulphate decrease for EA2 was 0.39 mg/L. Six of the lakes with increasing sulphate also had increasing alkalinity; two of these (ED22 and ED29) had both increasing alkalinity and increasing pH.

Table 9
Summary of step trends for the Ontario region

Station	Trend	Test[1]	Significance	1st interval[2]	2nd interval[2]
Batchawana	↑	MWM	0.003	5.65	6.21
Turkey	-				
HPO	-				
HP3	-				
HP3A	-				
HP4	↑	MW/L	0.016	7.02	8.28
HP5	-				
HP6	↑	MW/L	0.043	8.68	11.87
HP6A	↑	MW/L	0.031	8.96	14.02
PC1	↑	MW/L	0.025	6.80	11.11

[1] MWM = Mann Whitney/Modified; MW/L = Mann Whitney/Lettenmaier.
[2] Global averages during first and second step intervals (mg/L).

Sulphate trends in Newfoundland lakes are more evenly balanced, with six increasing and five decreasing trends. Three of the five decreases are located in the YH (west coast) basin. The magnitude of the decreases occupied a narrow range between 0.44 and 0.58 mg/L. Similarly the magnitude of the sulphate increases varied between 0.39 and 0.66 mg/L for the study period. For only two of the lakes (YL10, ZC3) is the "classical" expectation met; that is, where decreased sulphate is associated with increased ANC. Lake YH11 has both decreased sulphate and a decreasing pH trend. The remaining two decreasing sulphate trends have no corresponding change in pH or alkalinity. Neither do five out of six increasing sulphate trends. Lake YR5 has both increased sulphate and increased ANC. Most of the ANC increases (13 out of 16) are not associated with any significant change in sulphate levels.

It is evident, then, that the situation in the Atlantic lakes is not straightforward and that equilibrium conditions have not yet been met. A "concentration effect" could be advanced as one possible explanation but in only one instance do ANC, SO_4, and CaMg move in unison.

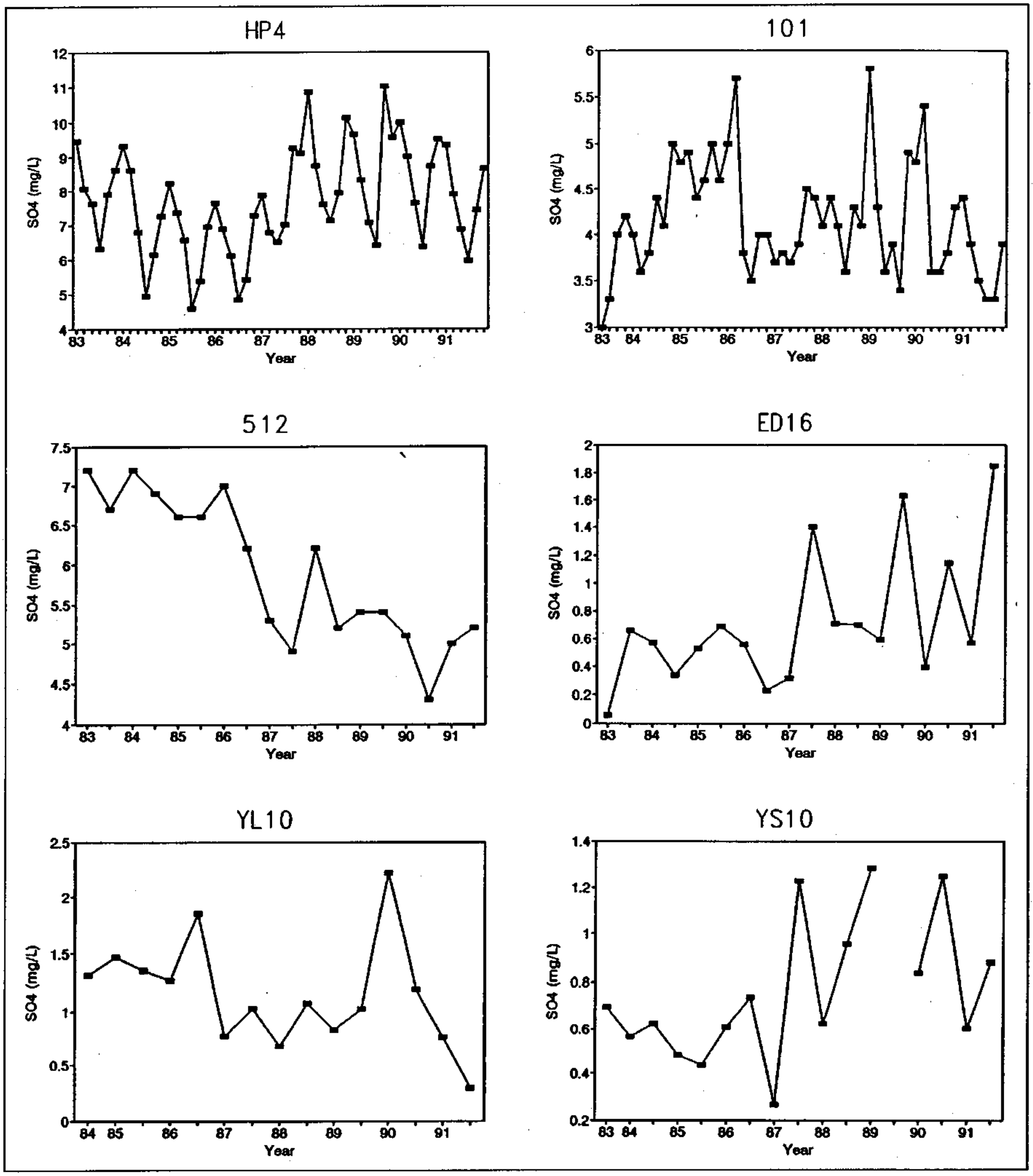

Figure 9 Sulphate time series plots for selected lakes

Similarly, the few trends found for colour were not present in those lakes where both ANC and SO_4 were increasing. Furthermore, the latter part of the 1980s was wetter than the first half, with 1990 being a particularly wet year (Figure 2). It is also possible that wetlands are playing an important role, especially for Kejimkujik lakes. Lastly, it is possible that sea salt contributions in recent years were adding more sulphate than is accounted for by the sea salt correction. Most sulphate trends in Newfoundland are not associated with corresponding trends in ANC or pH, while in Nova Scotia, about one-half of the lakes with sulphate increases have corresponding ANC increases. The window effect for the Atlantic lakes is considerable since Clair et al. (1992), using the same lakes, found quite different results with respect to SO_4 for the period 1983-1989 (Table 12).

2.3.5 Nitrates

Nitrate increased at one Ontario site (HP4, from 106.9 to 124.3 µg/L) and decreased at another (HP3, from 117.0 to 58.5 µg/L). In the Québec region, nitrate increased in 11 lakes and decreased in 2 lakes. Increases were found in regions 2 through 5 for both temporal and spatial lakes, and ranged from 6 to 37 µg/L over the entire study period. Both decreases were in Region 3. With respect to the Atlantic lakes, one increasing trend was found in Newfoundland. Only two Newfoundland lakes and one Nova Scotia lake were analysed for this parameter since most nitrate levels were below the LOD during the May and October sampling periods.

2.3.6 Colour

Five increasing colour trends were detected in Nova Scotia, though the results should be interpreted cautiously due to one trend (DA3) being influenced by extreme values and one (ED27) having a large number of values below the LOD. Six Newfoundland sites had colour increases. The small number of colour trends for both of these provinces suggests that organic acids remained relatively stable over the study period and probably did not affect trends observed for other parameters. There were no colour increases in those Nova Scotia lakes which had both sulphate and alkalinity increases.

2.4 OVERALL REGIONAL TRENDS AND LAKE BEHAVIOURS

A summary of the regional trends for each parameter is presented in Table 10. The same information is shown graphically in Figure 10 for pH, ANC, sulphates and CaMg.

Table 10
Summary of parameter trends by region

Parameter	Ontario	Québec	Nova Scotia	Newfoundland
Increasing				
pH	2	0	3	4
Alkalinity	3	0	15	16
Sulphates	1	1	13	6
(Step trend)	5			
Ca+Mg	4	6	3	5
Nitrates	1	11	0	1
Colour			5	6
Decreasing				
pH	3	5	1	1
Alkalinity	1	10	0	0
Sulphates	0	14	1	5
Ca+Mg	0	7	2	0
Nitrates	1	2	0	0
Colour			0	0
Stable				
pH	6	24	34	28
Alkalinity	7	19	23	17
Sulphates	10	14	24	22
Ca+Mg	7	16	33	28
Nitrates	9	16	1	1
Colour			33	26

Note: In Nova Scotia, only one lake was tested for nitrates; most lakes < LOD.
In Newfoundland, only two lakes were tested for nitrates; most lakes < LOD.

By considering all trends together it is possible to assess the regional picture for eastern Canada. It is clear from Figure 10, for example, that despite a considerable number of net decreasing sulphate trends in Québec, pH and ANC show declining trends in a number of lakes. The situation is reversed in the Maritimes where, despite increasing sulphate trends, pH

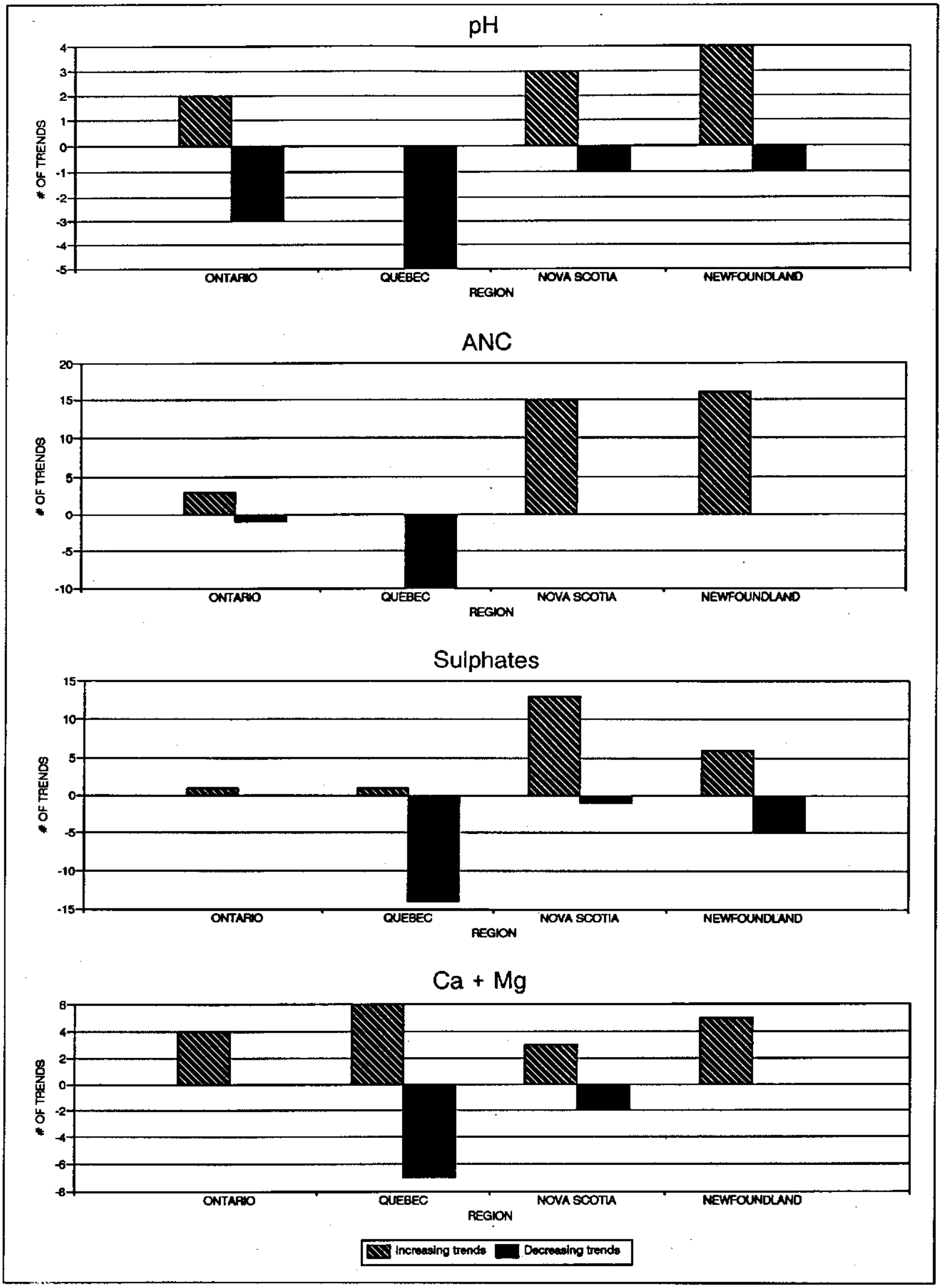

Figure 10 List of significant monotonic trends for each region

and ANC are rising for many lakes. In Ontario, between 1983 and 1991 sulphates showed either no trend or exhibited step trend increases, with some sites continuing to acidify while some are improving with respect to pH and ANC. CaMg levels are generally stable, with several increases in all four regions and some decreases in Québec and Nova Scotia.

By considering monotonic trends for pH, ANC, and SO_4, sample sites were classified according to their overall acidification levels between 1983 and 1991 in Table 11. Classes were assigned as follows: Class 1) lakes where pH and ANC were stable, and SO_4 did not increase; Class 2) SO_4 increased but pH and ANC were stable; Class 3) pH or ANC decreased, SO_4 was either stable, increasing, or decreasing; Class 4) pH and/or ANC increased, SO_4 was either stable, increasing or decreasing. Class 1 lakes can be considered stable with respect to acidification status. Class 2 lakes are stable but may acidify given continued SO_4 inputs. Class 3 lakes are acidifying as measured by decreased pH and/or ANC regardless of sulphate trends, while Class 4 lakes are recovering or improving as measured by increasing pH or ANC, regardless of sulphate trends. For this classification scheme, CaMg trends were not considered as a sorting factor when assigning lakes to the various classes.

Using this classification scheme, we can see that five Ontario sites were stable, three were acidifying, and three were recovering. All three acidifying sites were Harp Lake inflows. Dillon et al. (1987), using regression analysis, studied Harp Lake itself from 1979 to 1985, and reported a decreasing sulphate trend yet no changes in pH, ANC, or CaMg levels. In the same study, Plastic Lake was found to have decreasing trends for ANC, pH, base cations (Cb), and DOC, yet not for sulphate, despite reduced sulphate deposition over the study period. As a result, the decrease in ANC was offset by a decrease in base cations. It was suggested that the acidification of Plastic Lake was due to desorption of sulphate from the catchment. In the present study, for the period 1983-1991, no trends were observed for Plastic Lake with the exception of a possible increasing sulphate trend for the outflow (PCO).

Nearly all of the Québec lakes fell into one of two categories. Fifteen of the 29 Québec lakes can be classified as having stable acidification levels while 13 are acidifying. However, 3 of the 13 lakes are from Region 5, where the median pH > 7.0 and the median ANC > 10 mg/L. Lake 414 is stable, but may potentially acidify. The results reported here are similar

Table 11
Net change in the state of acidification of lakes (1983-1991)

Class	Behaviour	Lakes
Ontario		
CLASS 1 pH, ANC, SO_4: stable	Stable	Batch, HP3A, HP4 (↑Cb), PCI
CLASS 2 SO_4↑, pH, ANC: stable	Stable (may acidify)	PCO Batch (step), HP4 (step), PC1 (step)
CLASS 3 pH↓ or ANC↓ and SO_4 stable or ↑	Acidification	HP3, HP6 (↑Cb, SO_4↑ step), HP6A (↑SO_4 step)
CLASS 4 ANC or pH ↑; SO_4 stable	Improving (recovery)	Turkey (↑CaMg), HPO (↑Cb), HP5
Québec		
CLASS 1 pH, ANC stable; SO_4 stable or ↓	Stable	101, 202 (↑Cb), 211, 214, 301 (↑Cb), 302 (↑Cb), 311 (↓Cb), 411 (↑Cb), 201, 313, 314, 501, 502, 513, 514
CLASS 2 SO_4↑; pH, ANC: stable	Stable (may acidify)	414
CLASS 3 pH↓ or ANC↓ and SO_4 stable or ↓	Acidification	111, 112, 212, 213, 312, 304, 102, 114, 401; (511, 512, 515, 516: ANC > 200 µeq/L)
CLASS 4 ANC↑ or ↑pH	Improving (recovery)	None

Class	Behaviour	Lakes
Atlantic Lakes		
CLASS 1 pH, ANC stable; SO_4 stable or ↓	Stable	EA4, ED13, DA2, EA20, EA19, ED2, ED8, ED19, ED20, ED25, ED28, EA9, ED14, ED21 (↑Cb), DA6 (↓Cb), YH13, ZB1, ZF3, YO7, YS5, YS16, YS21, YS45, YH12, YH14
CLASS 2 SO_4↑; pH, ANC stable	Stable (may acidify)	ED1, ED11, ED27, ED7, ED47, EA10, ED15 (↑Cb), YS9, ZD2, YQ1 (Cb↑), YS10, YK6
CLASS 3 pH, ANC stable; SO_4 stable or ↓	Acidification	YH11
CLASS 4 SO_4↓, ANC↑	Improving (recovery)	EA2, YL10, ZC3
ANC↑, SO_4↑ (↑pH, ↑Cb)		ED4, ED17, ED48, ED16, ED29 (↑pH), ED22, YR5
ALK↑, pH stable or ↑; SO_4 stable		ED5, ED30, DA5, ED43, DA4, ED3, ZC2, ZD1, YM3, YS3, YS29, YM6 (↑Cb), YL1, YM7, YH15 (↑Cb), YM1 (↑Cb)
pH↑, SO_4 stable		(DA3, YO9 (↑Cb), ZF4, YS4): all have pH↑, YN8

Class 1: pH and ANC stable, SO_4 stable or ↓; lake behaviour is stable.
Class 2: SO_4↑, pH and ANC stable: lake behaviour is stable, but may acidify.
Class 3: pH or ANC ↓, SO_4 either stable, ↑ or ↓: lake is acidifying.
Class 4: pH and/or ANC ↑, SO_4 either stable, ↑ or ↓: lake improving or recovering.

to those reported by Bouchard (1992a) for LTQ lakes from 1984 to 1990. However, Bouchard (1992b), reports that 1991 and 1992 data confirm SO_4 decreases in almost all lakes and that ANC and pH levels are increasing, which leads to the appearance of some increasing ANC trends for the December 1984 to December 1992 period.

Most Atlantic lakes fell into Class 1 (26 lakes), Class 2 (12 lakes), or Class 4 (31 lakes). One lake (ED6) does not fit into any of the classes since it has both increasing ANC and decreasing pH. For a few of the parameters, the results presented in this study are similar to those reported by Clair et al. (1992) for the same lakes studied over the period 1983-1989 (Table 12).

Table 12
Comparison of Atlantic results

Clair et al. (1992)				Present study		
	↑	↓	<-->	↑	↓	<-->
Nova Scotia						
pH	0	1	39	3	1	34
ANC	13	0	t27	15	0	23
SO_4	2	6	32	13	1	24
C_b	1	2	37	3	2	33
Colour	2	0	26	5	0	33
Newfoundland						
pH	15	1	16	4	1	28
ANC	6	0	26	16	0	17
SO_4	2	3	27	6	5	22
C_b	2	3	27	5	0	28
Colour	5	3	24	6	0	26

Note: C_b = Sum of sea salt-corrected base cations (Ca, Na, K, Mg).

For Nova Scotia, pH, ANC and CaMg trends are similar in number whereas many more increasing sulphate trends were found in the present study. For Newfoundland lakes, Clair et al. (1992) detected 15 pH increases as compared to 4 in this study. By contrast, we detected

16 ANC increases as compared to 6 for Clair et al. (1992). More sulphate and CaMg increases were also found in our study.

In order to better understand acidification pH trends in Atlantic lakes, Clair and Esterby (1991) divided these lakes into five clusters based on organic anion (A^-) content and base cation (Cb) concentrations. The clusters are defined as follows: 1) low Cb, low A^-; 2) moderate Cb, low A^-; 3) low Cb, moderate A^-; 4) high Cb, moderate A^-; and 5) high Cb, moderate A^- (Clair and Esterby 1991). Table 13 shows the classification of lakes according to class (as defined in Table 11) and cluster. As can be seen, trends seem to be evenly spread out rather than being limited to any one cluster.

The number of lakes belonging to each class in a given region is summarized in Table 14. This table supports the regional trend results which were shown in Figure 10 and discussed earlier. Considering the 111 sites all together, 41% have experienced no net acidification effects and no net increase in sulphates, while 13% were stable with respect to pH and ANC, but may be prone to acidification due to increasing sulphate levels in water. Most of these latter lakes (12 out of 14) were located in the Maritimes. Fifteen percent of the lakes were acidifying due to declining pH and/or ANC despite stable or reduced sulphate levels (except for HP6 and HP6A in Ontario where SO_4 shows an increasing step trend). With the exception of one lake in Newfoundland, these lakes were located in Ontario and Québec. The proportion of sites that continued to acidify in Ontario and Québec was 27% and 45%, respectively. Water quality improvement or recovery as indicated by increasing pH and/or increasing ANC trends was evident for 31% of the study sites. The majority of the recovering lakes (31 out of 34) were located in the Maritimes. The remaining three sites were located in Ontario.

It should be mentioned that the classification scheme was based on very generous criteria since many combinations of trends in acidity indicators (pH and ANC) and stress indicators were found. The "classical" patterns associated with recovery (↑ANC, ↑ pH, ↓SO_4) and acidification (↓ANC, ↓pH, ↑SO_4) were not found except if HP6 is considered (↓pH, ↓ANC, ↑SO_4 step trend). It could also be argued that decreasing SO_4 and decreasing CaMg would be considered an improvement in water quality but this combination was not found in the present study.

Table 13
Division of Nova Scotia and Newfoundland lakes, by cluster and class

Lake	Class[1]	Cluster[2]	pH	ANC	SO_4	CaMg
Nova Scotia						
EA4	1	1	-	-	-	-
ED13	1	1	-	-	-	-
DA2	1	2	-	-	-	-
DA6	1	2	-	-	-	↓
EA20	1	2	-	-	-	-
EA19	1	3	-	-	-	-
ED2	1	3	-	-	-	-
ED8	1	3	-	-	-	-
ED10	1	3	-	-	-	↑
ED19	1	3	-	-	-	-
ED20	1	3	-	-	-	-
ED25	1	3	-	-	-	-
ED28	1	3	-	-	-	-
EA9	1	5	-	-	-	-
ED14	1	5	-	-	-	-
ED21	1	5	-	-	-	-
ED1	2	1	-	-	↑	-
ED11	2	1	-	-	↑	-
ED27	2	1	-	-	↑	-
ED7	2	3	-	-	↑	-
ED15	2	3	-	-	↑	↑
ED47	2	3	-	-	↑	-
EA10	2	4	-	-	↑	-
EA2	4	1	-	↑	↓	-
ED3	4	1	-	↑	-	-
ED4	4	1	-	↑	↑	-
ED5	4	1	-	↑	-	-
ED17	4	1	-	↑	↑	-
ED22	4	1	↑	↑	↑	↑
ED30	4	1	-	↑	-	-
DA3	4	2	↑	↑	-	-
DA5	4	2	-	↑	-	-
ED29	4	3	↑	↑	↑	-
ED43	4	3	-	↑	-	-
ED48	4	3	-	↑	↑	-
DA4	4	4	-	↑	-	-
ED16	4	5	-	↑	↑	-

Lake	Class[1]	Cluster[2]	pH	ANC	SO_4	CaMg
Newfoundland						
YH12	1	1	-	-	↓	-
YH13	1	1	-	-	-	-
YH14	1	1	-	-	↓	-
ZB1	1	1	-	-	-	-
ZF3	1	1	-	-	-	-
YO7	1	3	-	-	-	-
YS5	1	3	-	-	-	-
YS16	1	4	-	-	-	-
YS21	1	4	-	-	-	-
YS45	1	5	-	-	-	-
YS9	2	3	-	-	↑	-
ZD2	2	3	-	-	↑	-
YK6	2	4	-	-	↑	-
YQ1	2	4	-	-	↑	↑
YS10	2	5	-	-	↑	-
YH11	3	1	↓	-	↓	-
YH15	4	1	-	↑	-	↑
YL10	4	1	-	↑	↓	-
YM1	4	1	-	↑	-	↑
ZC24	4	1	-	↑	-	-
ZC3	4	1	-	↑	↓	-
ZD1	4	1	-	↑	-	-
YO9	4	2	↑	↑	-	↑
ZF4	4	2	↑	↑	-	-
YM3	4	3	-	↑	-	-
YM6	4	3	-	↑	-	↑
YR5	4	3	-	↑	↑	-
YS3	4	3	-	↑	-	-
YS29	4	3	-	↑	-	-
YS48	4	3	↑	↑	-	-
YL1	4	4	-	↑	-	-
YN8	4	4	↑	-	-	-
YM7	4	5	-	↑	-	-

[1] Class 1 = stable; Class 2 = stable, may acidify; Class 3 = acidification; Class 4 = recovery.
[2] As defined in Clair and Esterby (1991): Cluster 1 = low base cations (Cb), low organic anions (A^-); Cluster 2 = moderate Cb, low A^-; Cluster 3 = low Cb, moderate A^-; Cluster 4 = high Cb, moderate A^-; Cluster 5 = high Cb, moderate A^-.

Table 14
Summary of lake behaviours for all regions

Class	Behaviour	Ontario	Québec	Maritimes	Total
1	Stable	4	15	27	46
2	Stable (may acidify)	1	1	12	14
3	Acidifying	3	13	1	17
4	Improving	3	0	31	34
	Total	11	29	71	111

2.5 REGIONAL WATER QUALITY INDICATORS

This section will discuss the change in average regional concentrations over time for several parameters. Mean values were calculated by taking the average of all sampling runs (maximum of two samples per lake per year) for a given region in a given year. The exception is Ontario where, due to the varying sampling frequencies, yearly averages were first calculated for each lake after which a global yearly average was calculated. For Québec, data for the temporal lakes were adjusted to include only two sampling runs per year in order to correspond with the sampling frequencies of the spatial lakes. Approximately one-half of the Nova Scotia and Newfoundland lakes were not sampled in the fall of 1991. In order to more accurately reflect a true yearly average for 1991, these fall 1991 values were estimated for each lake by taking the average of all fall values over the time series for a given lake. This same estimate was carried out for 15 Newfoundland lakes in the spring of 1983. Mean annual regional values for each parameter are presented in Table 15. The following discussion will focus on pH, ANC, SO_4 and CaMg since these are the most important acidification related parameters (Figures 11 to 15).

For pH, in both Ontario and the Maritime sites, regional pH increased from 1983 to 1987, followed by a slight decrease (Figure 11). In Québec, regional pH increased between 1985 and 1987 and thereafter decreased, as it did in the other areas. The patterns were generally consistent with the sulphate deposition patterns discussed earlier where the most common sulphate deposition trend was a decrease up until the mid-1980s followed by an increase in 1988

Table 15
Average yearly values for several parameters

	pH	Alkalinity	SO_4	Ca+Mg	NO_3	Colour
Ontario						
1983	5.68	2.12	8.86	231.40	163.17	NC
1984	5.63	2.13	7.82	229.28	149.06	NC
1985	5.72	2.63	6.67	214.34	163.62	NC
1986	5.77	3.48	5.89	210.86	120.32	NC
1987	5.90	3.98	9.90	287.75	189.99	NC
1988	5.76	3.16	9.70	279.51	150.45	NC
1989	5.78	3.37	9.82	291.44	205.09	NC
1990	5.77	3.07	9.23	276.90	152.02	NC
1991	5.77	3.24	8.31	254.56	127.48	NC
Québec						
1983	6.67	8.81	5.51	244.23	33.85	NC
1984	6.60	9.14	6.07	268.42	39.46	NC
1985	6.32	8.21	5.90	262.89	41.5	NC
1986	6.46	7.86	5.86	269.92	35.64	NC
1987	6.57	8.26	5.81	269.98	33.48	NC
1988	6.49	7.87	5.76	262.78	33.13	NC
1989	6.4	7.85	5.51	262.70	41.14	NC
1990	6.30	7.29	5.27	265.41	33.23	NC
1991	6.45	7.67	5.17	260.50	34.22	NC
Nova Scotia						
1983	5.29	0.11	1.86	48.69	NC	65.08
1984	5.28	0.27	1.88	46.56	NC	63.88
1985	5.32	0.20	1.98	49.45	NC	64.67
1986	5.31	0.24	1.70	49.04	NC	71.78
1987	5.34	0.20	2.05	46.22	NC	58.96
1988	5.25	0.44	1.93	51.55	NC	72.64
1989	5.36	0.36	2.16	49.47	NC	59.0
1990	5.26	0.39	2.05	45.02	NC	69.84
1991	5.32	0.47	2.09	46.82	NC	65.0
Newfoundland						
1983	5.91	2.57	0.79	84.18	NC	49.21
1984	5.94	1.69	0.84	67.19	NC	55.00
1985	5.99	1.80	1.19	68.29	NC	29.22
1986	6.05	2.00	1.09	71.03	NC	31.42
1987	6.13	2.05	0.94	69.72	NC	28.98
1988	5.98	2.00	0.94	68.93	NC	43.73
1989	6.02	2.23	1.00	70.97	NC	44.66
1990	5.94	2.14	1.29	69.94	NC	51.33
1991	5.99	2.48	0.91	77.67	NC	59.79

NC = not calculated.

and then a levelling off from 1989 to 1991. The sharp decrease in annual mean pH for Québec in 1990 was matched by an increase in SO_4 deposition at the Sutton CAPMoN station (Figure 3).

Average annual CaMg remained very stable in Québec, Nova Scotia, and Newfoundland (Figure 11). In contrast, for Ontario sites, there was a definite increase in CaMg levels between 1986 and 1987, after which levels tapered off. The increase in annual mean CaMg concentrations is consistent with the four increasing trends observed for Ontario sites (Table 11) and with regional SO_4 concentrations (Figures 12 to 15).

Perhaps the most reliable indicators of water quality are alkalinity and sulphates: alkalinity because it is conservative with respect to H_2CO_3 (Dillon et al. 1987), and SO_4 because it is the main acidifying ion and an indicator of sulphate deposition. As another indicator of water quality, the mean yearly ANC/SO_4 ratio was also calculated. This ratio serves as an indicator of anion dominance. Mean annual sulphate and ANC concentration, and ANC/SO_4 ratios are shown in Figure 12 for Ontario stations. A steady decrease in mean sulphate concentrations over the period 1983-86 was followed by a sharp increase in 1987. This was consistent with the increasing sulphate step trends observed for five of the Ontario sites. Mean yearly ANC has remained relatively stable since 1988. Increases in the mean ANC/SO_4 ratio from 1983 to 1986 were mostly due to sulphate decreases.

The average yearly sulphate concentration in Québec decreased steadily from 1984 onward (Figure 13). Concurrently, mean ANC also dropped. The sulphate decrease was matched by decreasing sulphate deposition (Figure 3). The ANC/SO_4 ratio has remained relatively stable since 1985. The overall higher ANC:SO_4 ratios found in Québec as compared to Ontario are in part due to the influence of high ANC lakes in Region 5. The use of a global indicator for Québec tends to overshadow the inter-regional differences.

In Nova Scotia, for the period 1987-1991, both mean yearly sulphate and ANC levels are generally higher than for the period 1983-1986 (Figure 14). The sulphate increases are slight, however. In terms of SO_4 deposition, the situation is reversed, with the 1983-1986 period receiving higher overall sulphate (Figure 3). Higher SO_4 concentrations in water may be due to the washing-out of stored sulphate from the watershed. Overall, the ANC/SO_4 ratios are

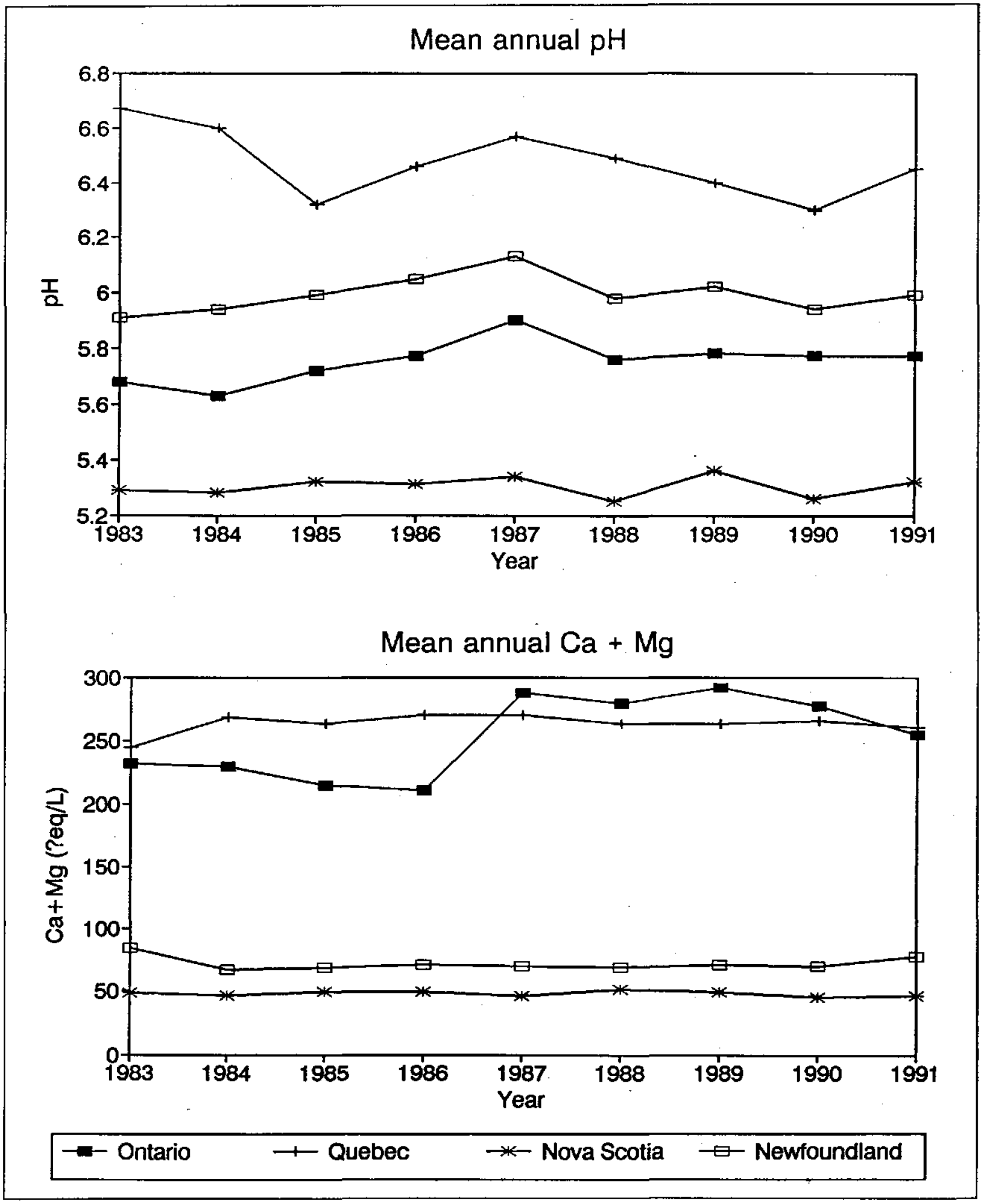

Figure 11 Mean annual pH and sum of calcium and magnesium for each region

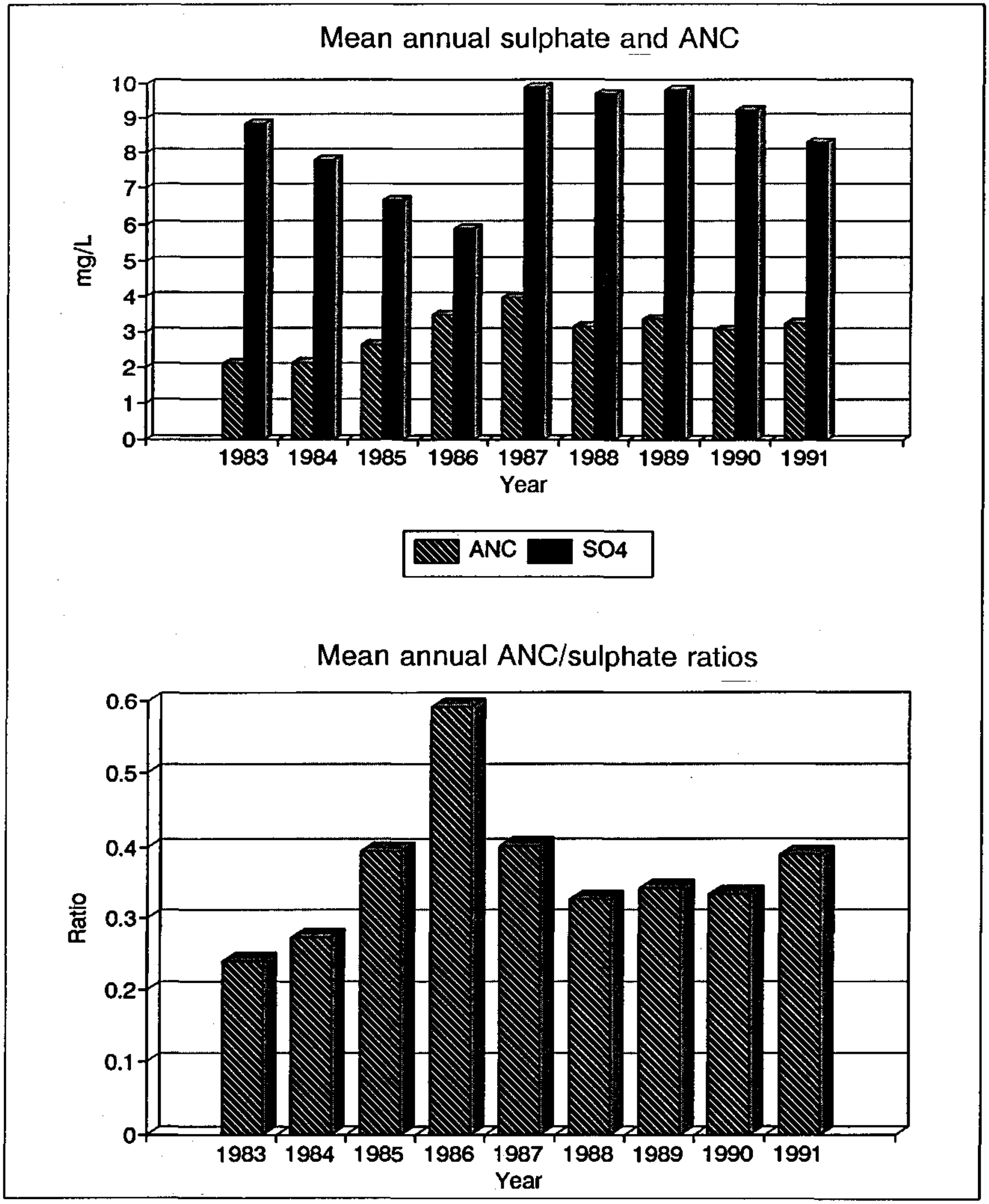

Figure 12 Mean annual sulphate, ANC and ANC/sulphate ratios for Ontario sites

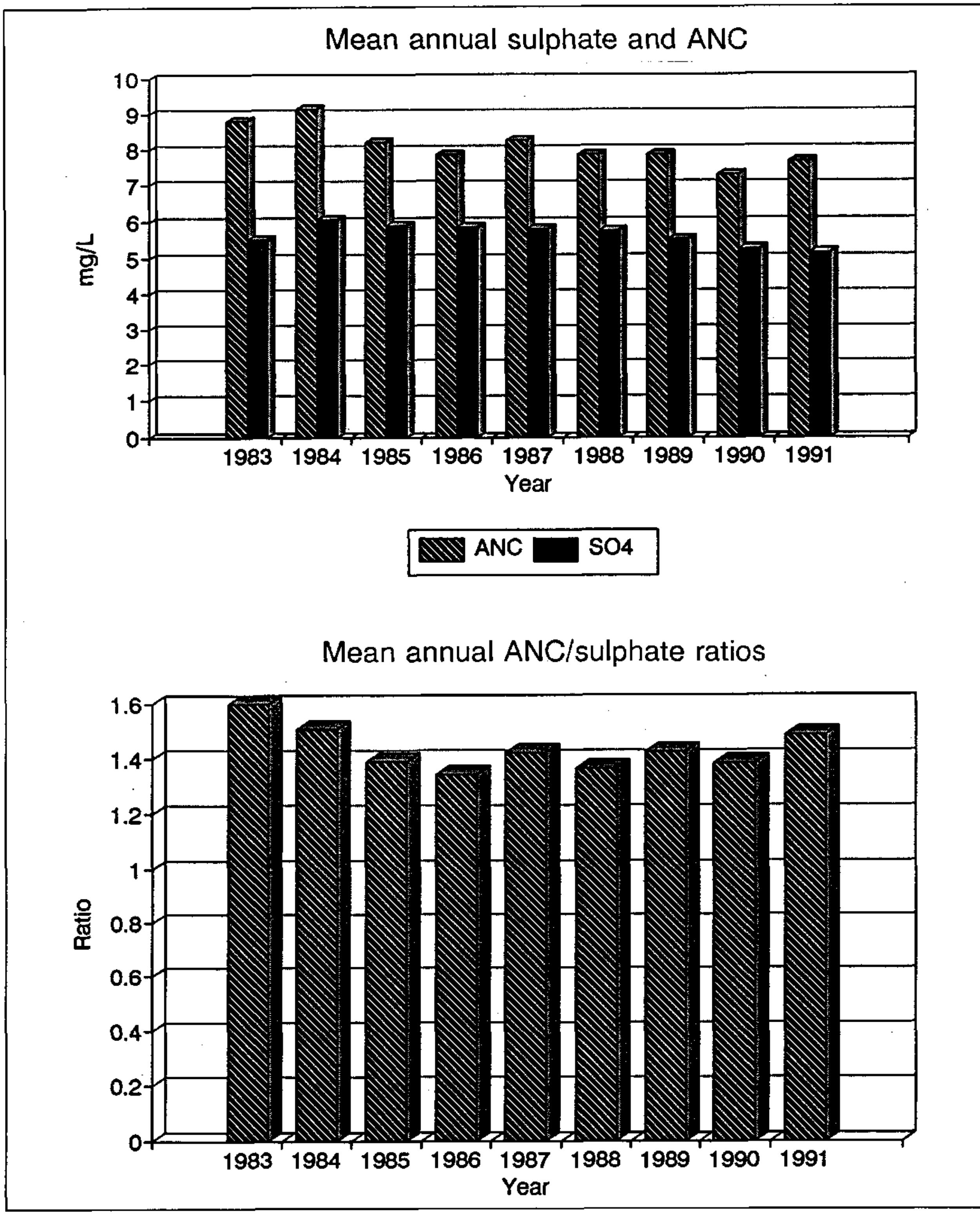

Figure 13 Mean annual sulphate, ANC and ANC/sulphate ratios for Québec sites

increasing over the nine-year period, showing that despite the apparent increase in sulphate, HCO_3^- ions are increasingly present. For both anions to increase, it would seem that either CaMg has to be increasing or organic anions are decreasing. As shown earlier, neither of these conditions is being met. Perhaps a combination of meteorological, hydrological, and wetland processes is involved. The effect of sea spray (i.e., at concentrations above that corrected for) for certain lakes may be important.

Mean yearly ANC in Newfoundland lakes has been increasing slightly since 1984 (Figure 15). Despite peaks in 1985, 1986 and 1990, mean yearly sulphate levels have remained about the same. Sulphate deposition has also been relatively constant despite peaks in 1984 and 1988 (Figure 3). Low ANC:SO_4 ratios in 1990 may be related to high precipitation in that year, resulting in stored sulphate being released from lake watersheds. Overall, the ANC/SO_4 ratios give a less clear-cut picture of increasing lake quality in Newfoundland than does a study of the intra-regional trends.

In summary, the regional indicators are useful for characterizing overall trends but they do not give any insight into the types of basin processes which are occurring – but for that matter, neither do individual trends.

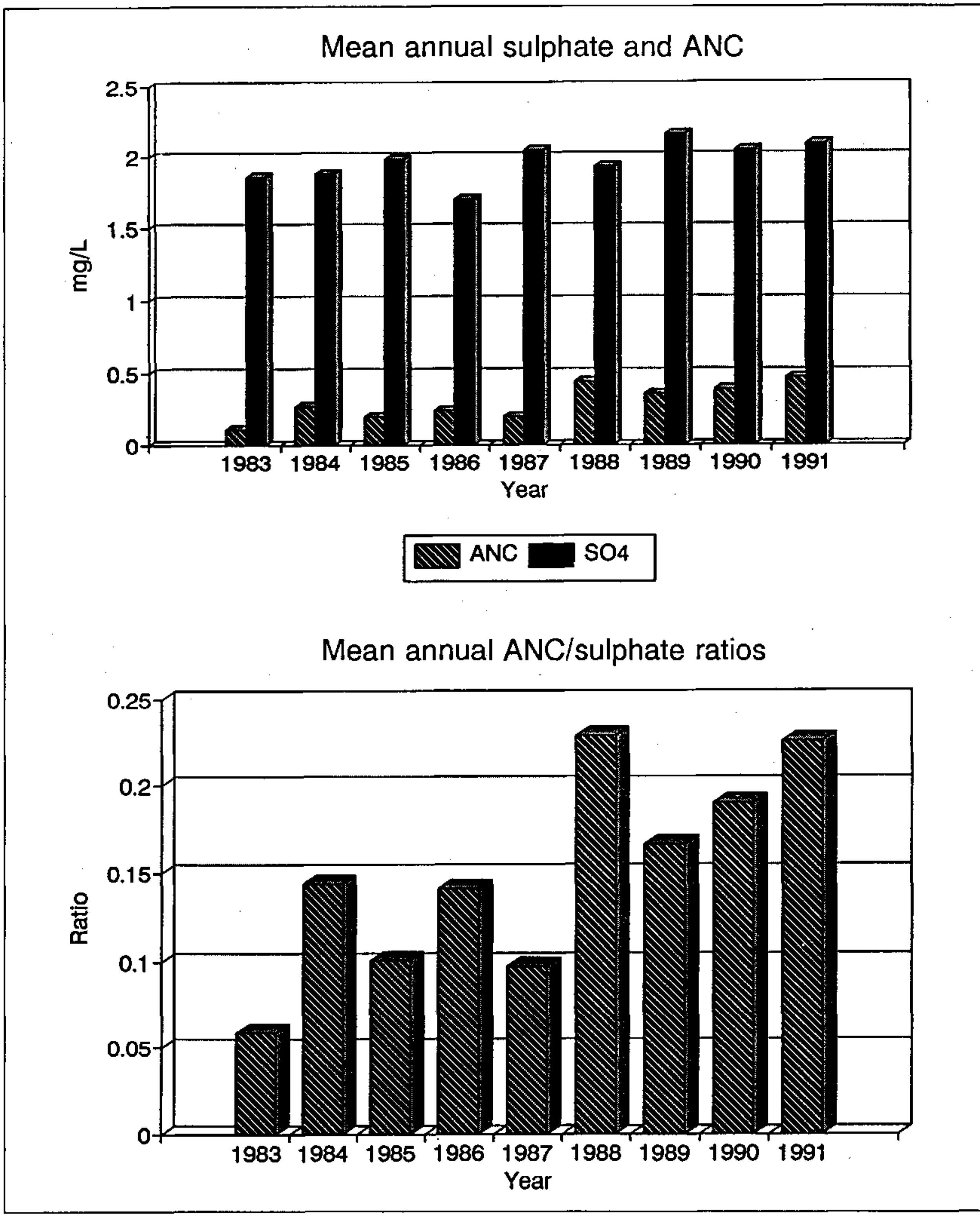

Figure 14 Mean annual sulphate, ANC and ANC/sulphate ratios for Nova Scotia sites

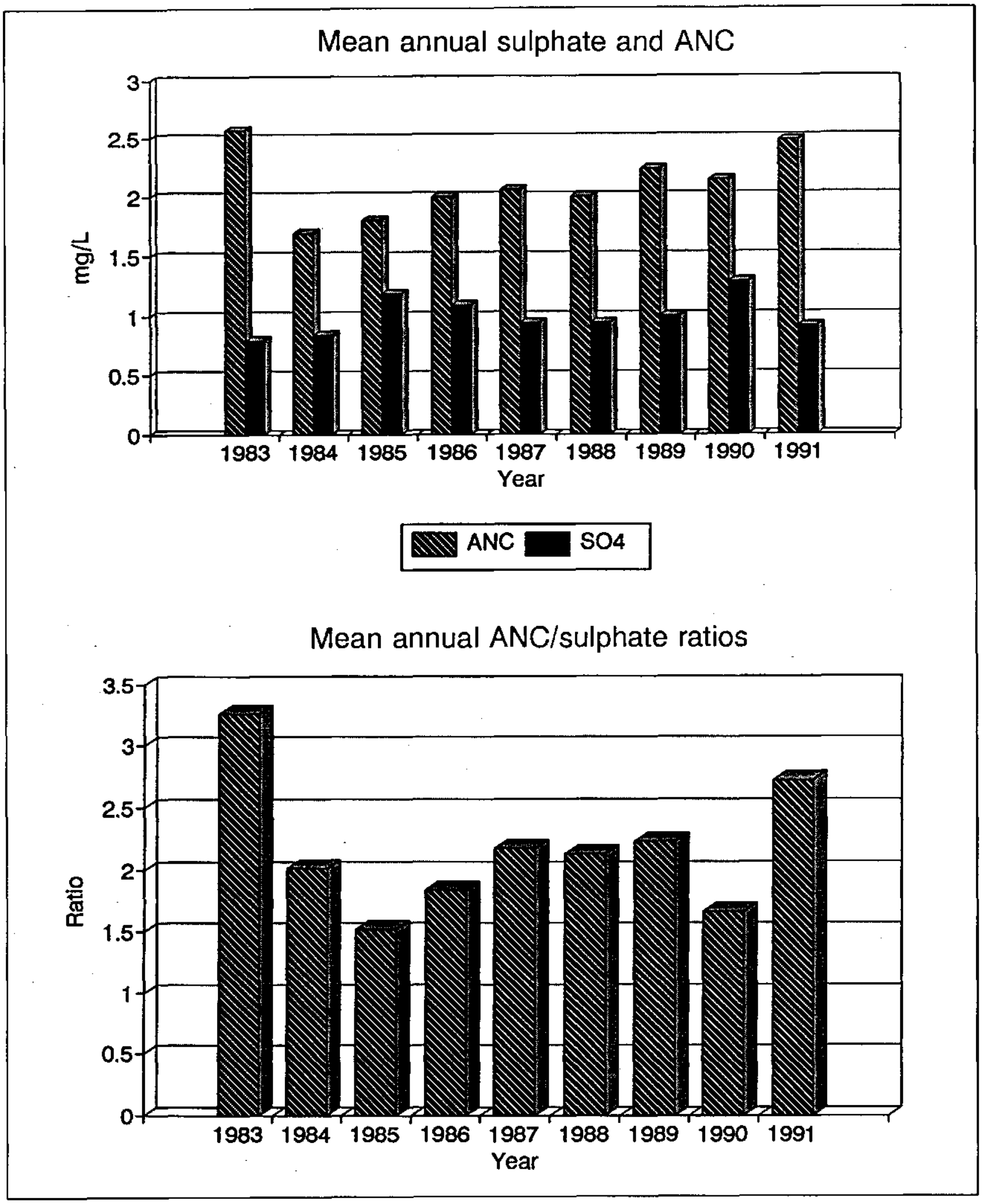

Figure 15 Mean annual sulphate, ANC and ANC/sulphate ratios for Newfoundland sites

3 Conclusion

Trend analysis conducted on precipitation data from six CAPMoN stations for 1983-1991 revealed significant sulphate decreases at only two sites: Chalk River (for sulphate deposition and concentration) and Montmorency (sulphate deposition only). Sulphate decreases at the Chalk River site were matched by an increase in pH and by decreases in both concentration and deposition for H^+ and Ca^{2+}, and by decreases in concentration for Mg^{2+}. Montmorency had a corresponding decrease in H^+ deposition. From 1985 to 1991, despite the absence of sulphate trends, pH increased and H^+ concentration decreased at Algoma. At Sutton, located in southeastern Québec, decreasing trends for Ca and Mg concentrations were registered. In the Maritimes, NO_3 increased at both Kejimkujik and Bay d'Espoir while Ca decreased at Kejimkujik. Based on annual deposition, the most common pattern for sulphate is a decrease over the period 1983-1987, followed by an increase in 1988 after which sulphate deposition levels off. Trend analysis findings differ somewhat from trends documented for earlier periods in studies by Dillon et al. (1987), RMCC (1990), Couture (1993) and Sirois (1993).

Results of trend analysis on water quality parameters for 111 sites has shown that the smallest number of trends occurred for pH and CaMg with 19 and 27 significant trends, respectively. There were quite a few trends for ANC and SO_4 (45 and 41 significant trends, respectively). Both increasing and decreasing trends and stable patterns were observed. Ontario and Newfoundland sites did not necessarily exhibit consistency of response with respect to trend direction. For all regions, it is likely that the study "window" is opening upon lakes in various stages of recovery. As such, it is not surprising to find complicated lake chemistry at work.

Most decreasing SO_4 trends were found in Québec (consistent with decreased SO_4 deposition at Chalk River and Montmorency) and Newfoundland. Only decreasing ANC trends were found in Québec, attributable perhaps to a combination of factors: 1) a lag period between reduced SO_4 deposition and improved water quality due to lakes not having yet achieved an equilibrium state; 2) the "window effect", i.e., the choice of study period; 3) nitrates may be playing a role in slowing down recovery; 4) ANC may be continuing to decline because SO_4

deposition, though generally declining over the study period, is still above a critical threshold. Most increasing SO_4 trends were found in Nova Scotia. The increasing SO_4 trends in the Maritimes (along with, in many cases, a concomitant increase in ANC), despite the fact that SO_4 deposition is not increasing, can be attributed to poorly understood basin processes (especially the effect of wetlands), the influence of local geology, or perhaps higher than expected sea salt contributions.

The classical and expected pattern of recovery – decreased SO_4 concentrations accompanied by increased ANC and/or pH – was rarely observed, occurring at only two Newfoundland sites. Conversely, the expected acidification pattern of increasing SO_4 accompanied by decreasing ANC and/or pH was only found at one Ontario site. Considering the 111 sites: 41% have experienced no net acidification effects and no net increase in sulphates; 13% are stable with respect to pH and ANC but may acidify because SO_4 values are increasing (mostly in the Maritimes); 15% of the lakes (mostly in Québec and Ontario) are acidifying due to declining ANC and/or pH; and, 31% are improving (mostly in the Maritimes but several in Ontario).

In terms of indicators of regional water quality, three parameters were considered: ANC, SO_4, and ANC/SO_4 ratios. Though these indicators are useful at summarizing overall trends, they will not be very useful at explaining trends within a given region until a clearer pattern has emerged between ANC and SO_4.

The results of this study underscore the fact that the chemistry of lakes and watersheds is complicated and that reduced SO_2 emissions do not necessarily lead to a rapid and regionalized response with respect to water chemistry. As more data are collected, and as emission controls take effect, further evaluation of trends should reveal more consistent patterns across eastern Canada.

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Appendices

Appendix A

Detailed trend statistics are presented for each CAPMoN station and for each parameter analysed. Abbreviations appearing in the tables are defined as follows:

Pers.:	Persistence (based on bi-monthly averages)
Seas.:	Seasonality (based on bi-monthly averages)
Sign.:	Significance level of test
Vi:	Initial value of a significant trend
Vf:	Final value of a significant trend
KS:	Kendall Seasonal
Kend.:	Kendall
H/S:	Hirsch and Slack
S/L:	Spearman/Lettenmaier
Precip.:	precipitation depth measured in cm
pH:	measured in units
conc.:	concentration (mg/L)
dep.:	deposition (kg/ha) per month
NA:	Not available
N:	Not present
Y:	Present
↑:	Monotonic increase
↓:	Monotonic decrease

Table A1
Trend statistics for Algoma and Chalk River precipitation data

Parameter	Pers.	Seas.	Trend	Test	Sign.	Vi	Vf	Slope
Algoma (1/83-12/91)								
Precip.	N	Y	-	KS	0.276			
pH	N	N	↑	Kend.	0.000	4.330	4.563	0.026
H+ conc.	N	N	↓	Kend.	0.000	0.050	0.028	-0.002
H+ dep.	N	Y	↓	KS	0.013	0.044	0.034	-0.001
SO_4 conc.	Y	Y	↓	H/S	0.017	2.674	1.608	-0.121
SO_4 dep.	N	Y	-	KS	0.074			
NO_3 conc.	N	Y	-	KS	0.432			
NO_3 dep.	Y	Y	-	H/S	0.145			
Ca conc.	N	Y	-	KS	0.230			
Ca dep.	N	N	-	Kend.	0.074			
Mg conc.	N	Y	-	KS	0.079			
Mg dep.	N	Y	↑	KS	0.018	0.024	0.037	0.002
Chalk River (9/83-12/91)								
Precip.	N	Y	-	KS	0.388			
pH	N	N	↑	Kend.	0.003	4.211	4.371	0.020
H+ conc.	N	N	↓	Kend.	0.003	0.065	0.045	-0.002
H+ dep.	N	Y	↓	KS	0.004	0.042	0.030	-0.002
SO_4 conc.	N	Y	↓	KS	0.002	2.503	1.917	-0.072
SO_4 dep.	N	Y	↓	KS	0.048	1.756	1.318	-0.054
NO_3 conc.	N	Y	-	KS	0.078			
NO_3 dep.	N	N	-	Kend.	0.225			
Ca conc.	N	Y	↓	KS	0.028	0.201	0.134	-0.008
Ca dep.	N	Y	↓	KS	0.021	0.146	0.078	-0.008
Mg conc.	N	Y	-	KS	0.050			
Mg dep.	N	Y	↓	KS	0.010	0.022	0.013	-0.001

Table A2
Trend statistics for Montmorency and Sutton precipitation data

Parameter	Pers.	Seas.	Trend	Test	Sign.	Vi	Vf	Slope
Montmorency (1/83-12/91)								
Precip.	N	N	-	Kend.	0.063			
pH	N	N	-	Kend.	0.164			
H+ conc.	N	N	-	Kend.	0.226			
H+ dep.	N	N	↓	Kend.	0.044	0.046	0.035	-0.001
SO_4 conc.	Y	Y	-	H/S	0.160			
SO_4 dep.	Y	Y	↓	H/S	0.019	1.982	1.277	-0.080
NO_3 conc.	N	Y	-	KS	0.276			
NO_3 dep.	N	Y	-	KS	0.428			
Ca conc.	Y	N	-	S/L	NA			
Ca dep.	N	N	-	Kend.	0.232			
Mg conc.	N	N	-	Kend.	0.114			
Mg dep.	N	N	-	Kend.	0.244			
Sutton 9/83-12/91								
Precip.	N	N	-	Kend.	0.385			
pH	N	N	-	Kend.	0.443			
H+ conc.	N	N	-	Kend.	0.401			
H+ dep.	N	N	-	Kend.	0.305			
SO_4 conc.	N	Y	-	KS	0.388			
SO_4 dep.	N	Y	-	KS	0.092			
NO_3 conc.	N	Y	-	KS	0.109			
NO_3 dep.	N	N	-	Kend.	0.388			
Ca conc.	N	N	↓	Kend.	0.030	0.248	0.110	-0.017
Ca dep.	Y	N	-	S/L	NA			
Mg conc.	N	Y	↓	KS	0.031	0.027	0.016	-0.001
Mg dep.	Y	Y	-	H/S	0.130			

Table A3
Trend statistics for Kejimkujik and Bay d'Espoir precipitation data

Parameter	Pers.	Seas.	Trend	Test	Sign.	Vi	Vf	Slope
Kejimkujik (7/83-12/91)								
Precip.	N	N	-	Kend.	0.177			
pH	Y	N	-	S/L	NA			
H+ conc.	N	Y	-	KS	0.107			
H+ dep.	Y	N	-	S/L	NA			
SO_4 conc.	N	Y	-	KS	0.306			
SO_4 dep.	N	Y	-	KS	0.427			
NO_3 conc.	N	N	-	Kend.	0.054			
NO_3 dep.	N	Y	↑	KS	0.033	0.741	1.048	0.037
Ca conc.	Y	N	-	S/L	NA			
Ca dep.	Y	N	-	S/L	NA			
Mg conc.	N	Y	-	KS	0.181			
Mg dep.	N	Y	-	KS	0.378			
Bay d'Espoir (7/83-12/91)								
Precip.	N	N	-	Kend.	0.484			
pH	N	Y	-	KS	0.180			
H+ conc.	N	Y	-	KS	0.323			
H+ dep.	N	N	-	Kend.	0.147			
SO_4 conc.	N	Y	-	KS	0.232			
SO_4 dep.	N	N	-	Kend.	0.351			
NO_3 conc.	N	N	↑	Kend.	0.046	0.336	0.549	0.026
NO_3 dep.	N	N	↑	Kend.	0.020	0.384	0.612	0.027
Ca conc.	Y	N	↓	S/L	NA	0.147	0.006	-0.017
Ca dep.	Y	N	↓	S/L	NA	0.211	-0.007*	-0.026
Mg conc.	N	Y	-	KS	0.152			
Mg dep.	N	Y	-	KS	0.386			

* Regression line is influenced by an extreme value.

Appendix B

Detailed statistics calculated for the entire study period (i.e., generally 1983-1991, but 1984-1991 for selected lakes) for each lake and parameter are presented here. A summary of median values is shown in Table B1. Units used are: pH (units); alkalinity and SO_4 (mg/L); NO_3 (μg/L); and colour (Hazen units). Abbreviations appearing in the tables are defined as follows:

N: Number of data points in the time series

s: Standard deviation

Min.: Minimum value

Max.: Maximum value

NAn: Not analysed

Table B1
List of median values

Lake ID	pH (units)	Alkalinity (mg/L)	SO_4^* (mg/L)	Ca+Mg* (µeq/L)	NO_3 (µg/L)	Colour (Hazen)
Ontario						
Batchawana	6.16	1.87	5.7	185.24	388.5	NAn
Turkey	6.66	8.86	5.93	315.17	273.0	NAn
HPO	6.29	3.52	7.75	227.04	115.0	NAn
HP3	5.82	2.88	8.1	270.83	64.0	NAn
HP3A	5.98	2.57	8.76	243.04	152.0	NAn
HP4	6.45	4.38	7.67	243.36	114.0	NAn
HP5	5.36	2.19	7.32	232.98	61.0	NAn
HP6	5.64	2.12	9.25	282.97	218.0	NAn
HP6A	4.95	-0.08	8.5	196.08	10.0	NAn
PC1	4.35	-2.38	7.75	139.57	22.0	NAn
PCO	5.53	0.38	6.78	143.00	50.5	NAn
Québec						
101	5.2	0.07	4.05	66.46	30.5	NAn
102	5.7	0.41	4.3	80.77	30	NAn
111	6.0	1.16	3.2	76.46	37.5	NAn
112	5.48	0.43	3.9	77.25	10	NAn
114	5.0	-0.14	5.5	86.46	26	NAn
201	6.4	2.01	4.0	109.55	10	NAn
202	5.9	1.32	5.1	119.70	21.5	NAn
211	5.9	1.28	4.8	117.92	40	NAn
212	6.3	1.83	5.0	134.38	35.5	NAn
213	5.2	0.06	4.6	84.19	21	NAn
214	6.2	1.84	5.9	151.15	20	NAn
301	6.7	5.27	4.15	167.92	10	NAn
302	6.9	8.9	3.3	227.57	90	NAn
304	6.45	4.93	4.3	159.38	45.0	NAn
311	6.0	1.71	4.8	122.92	11	NAn
312	6.8	8.73	4.1	249.38	14.5	NAn
313	6.4	4.01	4.3	154.38	20	NAn
314	6.9	9.23	6.3	300.53	10	NAn
401	6.9	7.16	5.4	253.91	30	NAn
411	6.6	5.37	5.8	204.38	10	NAn
414	6.7	4.16	6.15	202.61	60	NAn
501	7.1	14.05	7.95	434.38	30	NAn
502	7.25	18.16	7.2	503.45	10	NAn
511	7.45	33.3	10.6	881.66	20	NAn
512	7.2	24.37	5.4	606.68	35	NAn
513	7.36	29.66	9.35	799.96	7	NAn
514	7.22	13.9	8.4	440.84	10.5	NAn
515	7.3	19.56	8.0	568.14	55	NAn
516	6.7	6.86	7.3	256.66	65	NAn
Nova Scotia						
DA2	6.3	2.1	2.17	86.13	NAn	5
DA3	5.9	1.0	2.52	68.61	NAn	10
DA4	6.3	2.5	2.86	110.57	NAn	12.5
DA5	5.9	1.1	2.64	73.86	NAn	25
DA6	5.8	1.0	2.65	64.25	NAn	12.5
EA2	5.8	0.55	2.59	60.80	NAn	5
EA4	6.0	1.3	2.31	91.03	NAn	17.5
EA9	4.95	0.25	2.48	90.89	NAn	210
EA10	6.3	3.1	2.88	121.91	NAn	25
EA19	4.8	-0.3	2.24	49.18	NAn	110
EA20	6.5	3.2	2.94	112.55	NAn	5
ED1	5.4	0.3	1.83	31.12	NAn	15
ED2	5.0	0.15	1.46	43.61	NAn	95
ED3	5.9	1.0	1.73	42.50	NAn	10

Lake ID	pH (units)	Alkalinity (mg/L)	SO_4^* (mg/L)	$Ca+Mg^*$ (μeq/L)	NO_3 (μg/L)	Colour (Hazen)
ED4	5.2	-0.1	1.72	23.19	NAn	10
ED5	4.9	-0.4	1.99	22.02	NAn	40
ED6	5.85	1.25	1.68	48.25	NAn	30
ED7	5.0	0.1	1.77	40.58	NAn	75
ED8	4.9	-0.1	1.20	31.02	NAn	90
ED10	4.5	-1.5	1.62	21.11	NAn	100
ED11	5.4	0.1	1.59	21.48	NAn	5
ED13	4.7	-1.0	2.06	12.39	NAn	35
ED14	4.3	-2.65	1.67	18.85	NAn	160
ED15	4.85	-0.15	2.06	50.24	NAn	87.5
ED16	4.85	-0.15	0.58	38.46	NAn	135
ED17	5.3	0.1	1.79	24.39	NAn	25
ED19	4.9	-0.35	1.47	38.72	NAn	100
ED20	4.8	-0.5	1.46	37.91	NAn	110
ED21	4.4	-2.05	1.50	23.90	NAn	160
ED22	4.85	-0.4	2.02	23.79	NAn	57.5
ED25	4.7	-0.7	2.02	20.60	NAn	72.5
ED27	5.5	0.2	1.70	19.23	NAn	5
ED28	6.05	2.6	1.32	72.08	NAn	55
ED29	4.7	-0.9	1.92	20.77	NAn	70
ED30	5.9	0.85	1.91	37.02	NAn	5
ED43	4.7	-0.75	1.20	18.33	NAn	90
ED47	5.0	-0.1	1.77	38.36	NAn	72.5
ED48	5.0	0.2	1.73	38.87	NAn	70
Newfoundland						
YH11	5.6	0.4	1.11	29.35	NAn	10
YH12	5.9	1.1	1.04	26.55	NAn	10
YH13	5.2	-0.2	0.97	17.47	NAn	10
YH14	5.2	0.1	1.12	23.40	NAn	40
YH15	5.2	0.2	1.15	30.01	NAn	45
YK6	6.7	5.0	1.12	146.69	NAn	45
YL1	6.7	6.6	0.81	144.24	NAn	32.5
YL10	5.2	-0.1	1.08	22.65	NAn	30
YM1	6.3	1.6	1.02	52.34	NAn	5
YM3	6.2	1.9	0.91	73.84	NAn	40
YM6	6.35	3.15	0.91	109.66	NAn	52.5
YM7	5.25	1.0	0.65	85.83	NAn	150
YN8	6.5	4.3	1.00	151.36	NAn	40
YO7	6.4	2.7	1.00	91.31	NAn	32.5
YO9	6.6	3.1	1.23	90.19	NAn	10
YQ1	6.6	4.4	0.91	118.81	NAn	15
YR5	5.3	0.5	0.52	41.35	NAn	90
YS3	6.4	2.7	1.00	76.92	NAn	30
YS5	6.2	2.3	1.10	76.13	NAn	35
YS9	5.9	1.75	0.84	70.30	NAn	77.5
YS10	6.1	2.35	0.66	87.27	NAn	80
YS16	6.4	3.8	1.08	111.91	NAn	47.5
YS21	6.0	1.4	0.99	43.44	NAn	25
YS29	6.3	2.4	0.84	76.64	NAn	35
YS45	6.2	2.7	0.71	131.63	NAn	80
YS48	6.1	1.7	1.32	56.48	NAn	12.5
ZB1	5.9	0.7	1.17	41.19	NAn	10
ZC2	5.2	-0.1	1.07	20.81	NAn	17.5
ZC3	6.0	1.05	1.05	35.96	NAn	20
ZD1	6.15	1.5	0.87	48.80	NAn	20
ZD2	5.3	0.9	0.74	47.45	NAn	85
ZF3	6.2	1.5	0.76	35.33	NAn	7.5
ZF4	6.3	1.8	0.95	61.57	NAn	25

* Sea salt-corrected in Atlantic Canada.

Table B2
pH: Descriptive statistics

Lake ID	N	Average	Median	*s*	Min.	Max.
Ontario						
S1	713	6.14	6.16	0.262	5.29	6.76
S4	720	6.72	6.66	0.302	6.13	7.5
HPO	730	6.33	6.29	0.298	5.74	8.08
HP3	1182	5.86	5.82	0.286	5.28	6.76
HP3A	1352	5.98	5.98	0.154	5.47	6.4
HP4	1757	6.41	6.45	0.317	5.27	7.12
HP5	1340	5.39	5.36	0.299	4.42	6.66
HP6	1147	5.68	5.64	0.246	5.07	6.59
HP6A	1061	4.96	4.95	0.207	4.47	5.7
PC1	1082	4.38	4.35	0.194	3.97	5.89
PCO	707	5.55	5.53	0.253	4.73	6.7
Québec						
101	52	5.21	5.2	0.269	4.5	6.1
102	51	5.69	5.7	0.279	4.9	6.5
111	19	5.99	6.0	0.210	5.6	6.4
112	18	5.47	5.48	0.308	4.9	6.2
114	19	5.08	5.0	0.258	4.8	5.8
201	52	6.40	6.4	0.244	5.7	7.0
202	52	5.91	5.9	0.258	5.4	6.6
211	19	5.96	5.9	0.267	5.6	6.7
212	19	6.26	6.3	0.193	6.0	6.7
213	19	5.27	5.2	0.258	5.0	5.99
214	19	6.26	6.2	0.251	5.7	6.7
301	52	6.68	6.7	0.263	6.2	7.2
302	51	6.81	6.9	0.330	6.1	7.7
304	42	6.45	6.45	0.227	6.0	7.0
311	18	6.03	6.0	0.259	5.5	6.8
312	18	6.76	6.8	0.329	6.2	7.5
313	19	6.48	6.4	0.249	6.0	6.9
314	19	6.91	6.9	0.242	6.4	7.3
401	51	6.87	6.9	0.262	6.2	7.5
411	19	6.66	6.6	0.270	6.01	7.1
414	19	6.70	6.7	0.262	6.3	7.3
501	52	7.13	7.1	0.289	6.4	7.6
502	52	7.24	7.25	0.337	6.4	7.8
511	18	7.49	7.45	0.236	6.9	7.9
512	19	7.18	7.2	0.322	6.6	7.9
513	18	7.41	7.40	0.279	7.0	7.9
514	19	7.22	7.22	0.204	6.9	7.6
515	19	7.34	7.3	0.297	6.7	7.9
516	19	6.68	6.7	0.254	6.1	7.2
Nova Scotia						
DA2	17	6.29	6.3	0.158	5.9	6.5
DA3	17	5.92	5.9	0.204	5.5	6.2
DA4	16	6.28	6.3	0.198	5.8	6.5
DA5	15	5.84	5.9	0.220	5.3	6.1
DA6	19	5.82	5.8	0.202	5.4	6.2
EA2	16	5.75	5.8	0.132	5.5	6.0
EA4	16	6.06	6.0	0.193	5.7	6.5
EA9	16	5.01	4.95	0.304	4.6	5.8
EA10	17	6.29	6.3	0.195	5.9	6.6
EA19	17	4.85	4.8	0.101	4.7	5.0
EA20	17	6.42	6.5	0.347	5.3	6.7
ED1	18	5.42	5.4	0.248	5.1	6.3
ED2	18	5.01	5.0	0.150	4.7	5.3
ED3	18	5.95	5.9	0.129	5.8	6.2

Lake ID	N	Average	Median	*s*	Min.	Max.
ED4	18	5.26	5.2	0.150	5.0	5.6
ED5	17	4.89	4.9	0.156	4.6	5.2
ED6	18	5.87	5.85	0.194	5.6	6.2
ED7	18	5.07	5.0	0.183	4.8	5.4
ED8	15	4.94	4.9	0.130	4.7	0.4
ED10	18	4.53	4.5	0.069	4.4	4.6
ED11	18	5.39	5.4	0.096	5.2	5.5
ED13	17	4.65	4.7	0.087	4.5	4.8
ED14	18	4.3	4.3	0.097	4.1	4.4
ED15	18	4.87	4.85	0.124	4.6	5.1
ED16	18	4.86	4.85	0.138	4.6	5.2
ED17	17	5.27	5.3	0.161	4.9	5.5
ED19	18	4.87	4.9	0.136	4.6	5.2
ED20	18	4.77	4.8	0.132	4.5	5.0
ED21	18	4.39	4.4	0.090	4.2	4.5
ED22	18	4.87	4.85	0.164	4.5	5.1
ED25	16	4.75	4.7	0.167	4.4	5.1
ED27	17	5.49	5.5	0.117	5.3	5.7
ED28	18	6.04	6.05	0.378	4.8	6.6
ED29	18	4.71	4.7	0.126	4.4	4.9
ED30	18	5.87	5.9	0.129	5.7	6.1
ED43	16	4.68	4.7	0.091	4.5	4.8
ED47	18	5.03	5.0	0.211	4.6	5.4
ED48	18	5.09	5.0	0.222	4.7	5.5
Newfoundland						
YH11	15	5.62	5.6	0.121	5.3	5.8
YH12	14	5.94	5.9	0.155	5.7	6.3
YH13	14	5.22	5.2	0.112	5.1	5.5
YH14	16	5.24	5.2	0.163	5.0	5.5
YH15	15	5.32	5.2	0.375	5.0	6.4
YK6	17	6.6	6.7	0.224	6.1	6.9
YL1	17	6.65	6.7	0.227	6.1	6.9
YL10	15	5.15	5.2	0.089	5.0	5.3
YM1	14	6.31	6.3	0.053	6.2	6.4
YM3	17	6.15	6.2	0.212	5.7	6.5
YM6	16	6.27	6.35	0.391	5.1	6.8
YM7	16	5.35	5.25	0.314	5.0	6.2
YN8	17	6.47	6.5	0.222	6.1	6.8
YO7	16	6.34	6.4	0.186	6.0	6.6
YO9	16	6.51	6.6	0.177	6.0	6.7
YQ1	17	6.54	6.6	0.199	6.2	6.8
YR5	17	5.31	5.3	0.090	5.2	5.5
YS3	17	6.3	6.4	0.206	6.0	6.6
YS5	17	6.19	6.2	0.249	5.6	6.5
YS9	18	5.83	5.9	0.329	5.1	6.4
YS10	16	6.09	6.1	0.396	5.0	6.6
YS16	16	6.36	6.4	0.250	5.9	6.8
YS21	17	5.92	6.0	0.392	4.6	6.4
YS29	17	6.22	6.3	0.208	5.9	6.5
YS45	17	6.08	6.2	0.364	5.0	6.6
YS48	16	6.1	6.1	0.132	5.9	6.3
ZB1	16	5.86	5.9	0.120	5.7	6.0
ZC2	16	5.21	5.2	0.102	5.1	5.4
ZC3	17	6.0	6.0	0.158	5.7	6.3
ZD1	16	6.12	0.172	0.172	5.8	6.4
ZD2	17	5.31	5.3	0.187	4.9	5.6
ZF3	17	6.21	6.2	0.180	5.9	6.6
ZF4	17	6.25	6.3	0.187	5.8	6.6

Table B3
Alkalinity: Descriptive statistics

Lake ID	N	Average	Median	*s*	Min.	Max.
Ontario						
S1	685	2.12	1.87	1.45	0.09	12.62
S4	708	8.67	8.86	1.62	4.35	16.17
HPO	729	3.57	3.52	1.39	1.73	30.63
HP3	1188	3.79	2.88	2.63	0.55	17.99
HP3A	1356	3.65	2.57	2.65	0.66	12.72
HP4	1786	5.35	4.38	3.56	0.08	16.04
HP5	1345	3.00	2.19	2.91	-2.0	17.47
HP6	1158	3.32	2.12	4.20	0.18	36.34
HP6A	1056	0.23	-0.08	0.93	-1.36	5.56
PC1	1074	-2.29	-2.38	1.04	-6.33	4.51
PCO	697	0.55	0.38	0.77	-1.1	5.2
Québec						
101	48	0.25	0.07	0.63	-1.24	2.3
102	46	0.40	0.41	0.25	-0.42	1.1
111	17	1.16	1.16	0.50	-0.17	2.2
112	18	0.63	0.43	0.66	-0.58	2.0
114	17	-0.22	-0.14	0.49	-1.5	0.66
201	52	2.00	2.00	0.34	0.7	2.8
202	50	1.30	1.32	0.30	0.6	2.0
211	18	1.29	1.28	0.38	0.63	2.13
212	18	1.78	1.83	0.31	0.7	2.1
213	18	0.07	0.06	0.41	-0.54	0.92
214	17	1.91	1.84	0.51	0.98	2.75
301	49	5.50	5.27	1.28	3.43	9.5
302	51	8.86	8.9	1.60	5.8	11.52
304	43	5.11	4.93	2.76	2.43	9.26
311	18	1.79	1.71	0.81	0.71	4.3
312	18	8.47	8.73	1.50	6.29	11.4
313	18	3.89	4.01	0.58	2.61	4.76
314	18	9.11	9.23	0.75	7.85	10.55
401	52	7.28	7.16	0.69	5.5	9.8
411	18	5.43	5.37	0.60	4.63	6.56
414	18	4.29	4.16	0.73	2.74	5.38
501	52	14.07	14.05	0.97	11.94	17.4
502	52	18.26	18.16	1.41	15.2	24.4
511	18	32.38	33.1	2.70	27.12	36.45
512	18	25.59	24.37	4.07	18.21	34.6
513	18	29.38	29.66	1.66	25.88	31.6
514	18	13.77	13.9	1.05	11.17	15.6
515	18	19.75	19.56	2.84	15.6	25.35
516	18	6.98	6.86	1.49	4.42	9.73
Nova Scotia						
DA2	16	2.12	2.1	0.29	1.7	2.8
DA3	16	1.18	1.0	0.72	0.5	3.7
DA4	15	2.42	2.5	0.53	1.5	3.3
DA5	16	1.14	1.1	0.38	0.4	1.7
DA6	18	1.01	1.0	0.27	0.5	1.5
EA2	16	0.62	0.55	0.26	0.2	1.1
EA4	15	1.53	1.3	0.45	1.0	2.3
EA9	16	0.38	0.25	0.55	-0.2	1.7
EA10	16	3.11	3.1	0.58	2.0	3.8
EA19	17	-0.26	-0.3	0.29	-0.7	0.3
EA20	16	3.08	3.2	0.74	0.6	3.7
ED1	18	0.32	0.3	0.27	-0.2	1.1
ED2	18	0.16	0.15	0.38	-0.4	1.0
ED3	18	0.97	1.0	0.25	0.5	1.5

Lake ID	N	Average	Median	*s*	Min.	Max.
ED4	18	0.0	-0.1	0.21	-0.4	0.5
ED5	17	-0.41	-0.4	0.31	-0.8	0.1
ED6	18	1.23	1.25	0.27	0.9	1.8
ED7	18	0.06	0.1	0.26	-0.3	0.5
ED8	15	-0.01	-0.1	0.29	-0.5	0.5
ED10	18	-1.46	-1.5	0.28	-1.9	-0.7
ED11	18	0.1	0.1	0.21	-0.2	0.5
ED13	17	-1.02	-1.0	0.23	-1.3	-0.5
ED14	18	-2.7	-2.65	0.51	-3.8	-1.9
ED15	18	-0.23	-0.15	0.32	-1.0	0.2
ED16	18	-0.07	-0.15	0.37	-0.6	0.9
ED17	17	0.15	0.1	0.23	-0.2	0.5
ED19	18	-0.18	-0.35	0.35	-0.7	0.5
ED20	18	-0.46	-0.5	0.39	-1.0	0.4
ED21	18	-2.03	-2.05	0.47	-3.1	-1.1
ED22	18	-0.37	-0.4	0.35	-1.0	0.1
ED25	16	-0.66	-0.7	0.32	-1.2	-0.2
ED27	17	0.19	0.2	0.24	-0.2	0.6
ED28	17	2.49	2.6	0.88	0.2	3.5
ED29	18	-0.82	-0.9	0.35	-1.3	0.1
ED30	18	0.88	0.85	0.21	0.5	1.3
ED43	16	-0.74	-0.75	0.27	-1.2	-0.3
ED47	18	-0.02	-0.1	0.30	-0.4	0.5
ED48	18	0.14	0.2	0.30	-0.4	0.5
Newfoundland						
YH11	15	0.45	0.4	0.21	0.1	0.9
YH12	13	1.07	1.1	0.21	0.7	1.3
YH13	14	-0.17	-0.2	0.21	-0.6	0.4
YH14	16	0.09	0.1	0.31	-0.4	0.7
YH15	15	0.29	0.2	0.59	-0.3	2.2
YK6	16	5.13	5.0	1.13	3.0	7.4
YL1	17	6.31	6.6	1.02	4.6	7.7
YL10	15	-0.01	-0.1	0.24	-0.3	0.5
YM1	13	1.61	1.6	0.27	1.2	2.0
YM3	17	1.99	1.9	0.40	1.6	2.7
YM6	16	3.07	3.15	0.87	0.8	4.6
YM7	16	1.14	1.0	0.58	0.4	2.8
YN8	17	4.93	4.3	2.36	1.8	10.5
YO7	15	2.71	2.7	0.47	1.9	3.5
YO9	16	3.27	3.1	0.54	2.6	4.5
YQ1	17	4.46	4.4	0.45	3.4	5.1
YR5	17	0.51	0.5	0.24	0.1	0.9
YS3	17	2.52	2.7	0.52	1.7	3.4
YS5	17	2.4	2.3	0.62	1.5	3.9
YS9	18	1.74	1.75	0.54	0.8	2.5
YS10	16	2.84	2.35	1.27	0.5	5.1
YS16	16	3.78	3.8	0.86	2.5	5.0
YS21	16	1.44	1.4	0.45	0.6	2.4
YS29	17	2.36	2.4	0.63	1.6	4.1
YS45	17	2.99	2.7	0.72	1.9	4.5
YS48	15	1.68	1.7	0.35	1.2	2.3
ZB1	15	0.72	0.7	0.23	0.4	1.1
ZC2	16	-0.03	-0.1	0.20	-0.3	0.4
ZC3	16	1.05	1.05	0.20	0.7	1.4
ZD1	16	1.57	1.5	0.43	0.9	2.6
ZD2	17	0.76	0.9	0.31	0.2	1.1
ZF3	17	1.54	1.5	0.37	1.1	2.4
ZF4	17	1.91	1.8	0.42	1.4	2.7

Table B4
Sulphate: Descriptive statistics

Lake ID	N	Average	Median	*s*	Min.	Max.
Ontario						
S1	694	5.77	5.7	1.08	3.71	13.26
S4	705	5.91	5.93	0.48	4.38	8.23
HPO	715	7.94	7.75	0.73	5.8	10.13
HP3	1167	9.53	8.1	7.68	0.62	80.75
HP3A	1335	9.14	8.76	2.24	4.12	29.0
HP4	1778	7.77	7.67	1.72	3.18	13.9
HP5	1377	7.24	7.32	4.23	0.0	32.1
HP6	1140	10.48	9.25	7.53	0.26	69.9
HP6A	1029	9.99	8.5	9.04	0.0	74.4
PC1	1075	8.96	7.75	7.22	0.38	61.5
PCO	685	6.84	6.78	0.91	4.4	15.6
Québec						
101	52	4.15	4.05	0.62	3.0	5.8
102	52	4.27	4.3	0.30	3.6	5.1
111	18	3.24	3.2	0.29	2.9	3.8
112	18	3.85	3.9	0.49	2.8	4.8
114	18	5.74	5.5	0.54	4.9	7.2
201	52	3.97	4.0	0.40	3.2	5.7
202	52	5.13	5.1	0.56	3.9	6.5
211	18	4.83	4.8	0.48	4.1	5.7
212	18	5.03	5.0	0.42	4.4	5.7
213	18	4.64	4.6	0.51	3.6	5.5
214	18	6.03	5.9	0.55	5.3	7.2
301	52	4.17	4.15	0.59	2.9	5.3
302	52	3.37	3.3	0.34	2.6	4.2
304	42	4.23	4.3	0.38	3.1	5.1
311	18	4.89	4.8	0.68	3.9	6.0
312	18	4.14	4.1	0.41	3.3	5.0
313	18	4.52	4.3	0.42	3.9	5.4
314	18	6.35	6.3	0.41	5.8	7.3
401	52	5.43	5.4	0.57	4.5	7.0
411	18	5.82	5.8	0.31	5.4	6.8
414	18	6.34	6.15	0.60	5.6	7.7
501	52	7.83	7.95	0.56	6.7	9.6
502	52	7.24	7.2	0.60	6.0	8.9
511	18	10.4	10.6	0.80	8.9	11.8
512	18	5.86	5.4	0.92	4.3	7.2
513	18	9.13	9.35	0.73	7.7	10.2
514	18	8.36	8.4	0.51	7.1	9.6
515	18	8.14	8.0	1.04	6.5	10.7
516	18	7.0	7.3	0.64	6.0	7.9
Nova Scotia						
DA2	17	2.16	2.17	0.33	1.26	2.7
DA3	17	2.52	2.52	0.28	1.97	2.94
DA4	16	2.89	2.86	0.42	1.95	3.82
DA5	16	2.58	2.64	0.33	1.92	3.17
DA6	18	2.72	2.65	0.28	2.35	3.19
EA2	16	2.57	2.59	0.26	2.08	3.03
EA4	15	2.32	2.31	0.31	1.71	2.99
EA9	16	2.72	2.48	0.98	1.38	5.51
EA10	17	3.05	2.88	0.44	2.58	4.02
EA19	17	2.38	2.24	0.57	1.52	3.74
EA20	17	2.93	2.94	0.19	2.60	3.21
ED1	18	1.87	1.83	0.22	1.57	2.37
ED2	18	1.51	1.46	0.52	0.71	2.99
ED3	18	1.71	1.73	0.21	1.31	1.96

Lake ID	N	Average	Median	*s*	Min.	Max.
ED4	18	1.75	1.71	0.20	1.40	2.28
ED5	17	2.00	1.99	0.24	1.60	2.40
ED6	18	1.71	1.68	0.36	1.27	3.01
ED7	18	1.74	1.77	0.23	1.27	2.12
ED8	15	1.39	1.20	0.59	0.74	3.07
ED10	18	1.74	1.62	0.53	1.06	2.83
ED11	18	1.63	1.59	0.21	1.33	2.10
ED13	17	2.10	2.06	0.38	1.57	2.67
ED14	18	1.74	1.67	0.47	0.99	2.92
ED15	18	2.26	2.06	0.79	1.54	5.02
ED16	18	0.72	0.58	0.48	0.06	1.85
ED17	17	1.76	1.79	0.25	1.25	2.17
ED19	18	1.55	1.47	0.51	0.66	2.96
ED20	18	1.61	1.46	0.64	0.69	3.63
ED21	18	1.56	1.50	0.46	0.70	3.06
ED22	18	2.04	2.02	0.24	1.69	2.46
ED25	16	2.03	2.02	0.29	1.57	2.60
ED27	17	1.65	1.70	0.28	1.07	2.10
ED28	18	1.21	1.32	0.44	0.41	2.03
ED29	18	1.89	1.92	0.30	1.39	2.36
ED30	18	1.91	1.91	0.25	1.56	2.44
ED43	16	1.28	1.20	0.35	0.80	2.13
ED47	18	1.77	1.77	0.24	1.37	2.22
ED48	18	1.76	1.73	0.26	1.27	2.39
Newfoundland						
YH11	15	1.12	1.11	0.23	0.72	1.48
YH12	14	1.04	1.04	0.24	0.63	1.39
YH13	14	1.03	0.97	0.21	0.65	1.52
YH14	16	1.08	1.12	0.37	0.29	1.71
YH15	15	1.18	1.15	0.33	0.78	1.74
YK6	16	1.28	1.12	0.37	0.78	1.92
YL1	17	0.85	0.81	0.33	0.17	1.57
YL10	15	1.14	1.08	0.48	0.29	2.22
YM1	14	1.09	1.02	0.18	0.88	1.38
YM3	17	0.98	0.91	0.32	0.66	1.78
YM6	16	1.01	0.91	0.40	0.31	1.84
YM7	16	0.67	0.65	0.29	0.25	1.24
YN8	17	1.14	1.00	0.42	0.67	1.97
YO7	16	1.16	1.00	0.35	0.71	1.71
YO9	16	1.25	1.23	0.27	0.82	1.75
YQ1	17	0.91	0.91	0.33	0.41	1.65
YR5	17	0.60	0.52	0.27	1.00	1.23
YS3	17	1.09	1.00	0.43	0.53	2.21
YS5	17	1.18	1.10	0.45	0.54	2.24
YS9	18	0.87	0.84	0.24	0.57	1.38
YS10	16	0.76	0.66	0.30	0.27	1.28
YS16	16	1.15	1.08	0.44	0.46	2.24
YS21	17	0.95	0.99	0.30	0.48	1.41
YS29	17	0.92	0.84	0.39	0.47	1.68
YS45	16	0.70	0.71	0.31	0.13	1.27
YS48	15	1.31	1.32	0.19	1.04	1.67
ZB1	16	1.19	1.17	0.23	0.75	1.71
ZC2	16	1.02	1.07	0.32	0.47	1.74
ZC3	17	1.01	1.05	0.27	0.55	1.38
ZD1	16	0.93	0.87	0.27	0.58	1.38
ZD2	17	0.78	0.74	0.25	0.35	1.32
ZF3	17	0.83	0.76	0.30	0.49	1.79
ZF4	17	0.99	0.95	0.35	0.40	1.60

Table B5
Ca+Mg: Descriptive statistics

Lake ID	N	Average	Median	*s*	Min.	Max.
Ontario						
S1	688	188.57	185.24	37.91	127.87	416.37
S4	708	313.89	315.17	28.52	201.81	454.79
HPO	718	230.45	227.04	23.61	177.55	532.54
HP3	1178	311.81	270.83	146.49	159.85	1677.48
HP3A	1349	253.91	243.04	50.41	153.06	554.41
HP4	1795	250.07	243.36	49.20	88.88	448.78
HP5	1375	251.80	232.98	78.47	118.86	700.86
HP6	1145	329.95	282.97	152.08	184.90	1695.65
HP6A	1045	248.47	196.08	179.40	84.69	1474.61
PC1	1073	177.44	139.57	130.20	58.31	1084.70
PCO	695	143.98	143.00	19.20	99.57	356.29
Québec						
101	52	68.37	66.46	11.80	51.31	112.92
102	52	80.20	80.77	7.15	71.28	104.69
111	18	77.36	76.46	6.40	66.46	86.46
112	18	73.21	77.25	11.79	55.14	92.48
114	18	89.41	86.46	11.87	73.46	118.34
201	52	111.78	109.55	7.98	97.92	144.38
202	52	118.40	119.70	10.34	94.69	147.92
211	18	113.71	117.92	11.81	94.69	139.71
212	18	134.46	134.38	8.32	121.15	149.38
213	18	80.77	84.19	7.35	66.46	89.69
214	18	155.40	151.15	11.64	137.50	171.91
301	52	170.88	167.92	18.79	134.69	236.15
302	52	228.14	227.57	30.22	167.92	286.52
304	43	161.18	159.38	28.77	109.69	230.84
311	18	121.35	122.92	16.70	93.69	148.00
312	18	243.62	249.38	24.03	196.15	283.67
313	18	153.62	154.38	15.14	124.39	179.38
314	18	298.31	300.53	17.81	267.51	324.85
401	52	253.51	253.91	10.65	228.65	279.38
411	18	206.53	204.38	15.30	181.15	236.96
414	18	201.24	202.61	14.60	179.38	234.40
501	52	434.63	434.38	20.18	389.38	482.61
502	52	504.72	503.45	24.48	455.22	566.68
511	18	874.61	881.66	57.78	760.96	956.05
512	18	622.25	606.68	75.57	505.22	790.55
513	18	783.54	799.96	54.21	686.73	874.07
514	18	439.97	440.84	27.78	392.61	490.84
515	18	559.69	568.14	62.92	463.45	646.06
516	18	258.70	256.66	23.84	212.61	299.07
Nova Scotia						
DA2	17	85.8	86.13	12.05	67.02	117.83
DA3	17	70.90	68.61	13.94	60.08	120.75
DA4	16	110.44	110.57	9.22	86.35	125.90
DA5	16	73.47	73.86	6.86	61.00	87.32
DA6	19	65.17	64.25	4.51	55.46	72.54
EA2	16	59.62	60.80	5.57	45.60	68.20
EA4	16	90.17	91.03	8.09	76.48	104.48
EA9	16	99.17	90.89	26.38	62.82	138.77
EA10	17	121.79	121.91	20.01	58.75	158.71
EA19	17	51.00	49.18	11.59	35.75	74.92
EA20	17	111.71	112.55	14.55	70.54	143.72
ED1	18	31.27	31.12	4.80	25.44	45.45
ED2	18	43.70	43.61	12.64	24.77	68.04
ED3	17	42.52	42.50	2.10	38.71	45.13

Lake ID	N	Average	Median	*s*	Min.	Max.
ED4	18	23.16	23.19	3.33	18.87	30.51
ED5	17	21.95	22.02	4.08	15.77	30.03
ED6	18	48.96	48.24	7.27	35.34	63.11
ED7	18	40.18	40.58	6.88	29.36	56.21
ED8	15	32.53	31.02	8.97	19.39	50.71
ED10	18	21.10	21.11	7.32	10.46	35.37
ED11	18	22.12	21.48	3.08	17.76	28.63
ED13	17	13.02	12.39	3.66	8.45	21.32
ED14	18	21.79	18.85	9.24	7.80	40.49
ED15	18	52.88	50.24	18.15	19.13	98.61
ED16	18	45.24	38.46	17.59	24.89	76.64
ED17	17	24.73	24.39	4.40	19.15	35.30
ED19	18	39.41	38.72	10.98	24.37	63.01
ED20	18	38.98	37.91	12.17	22.27	60.64
ED21	18	26.31	23.90	9.85	11.26	42.67
ED22	18	23.85	23.79	3.73	17.39	34.44
ED25	16	20.29	20.60	3.32	14.71	29.60
ED27	17	20.15	19.23	3.40	13.57	25.83
ED28	18	74.35	72.08	16.59	43.91	100.32
ED29	18	20.69	20.77	4.02	14.10	31.60
ED30	18	38.73	37.02	6.03	32.74	60.40
ED43	16	19.56	18.33	4.67	13.43	30.43
ED47	18	38.69	38.36	6.86	26.24	51.81
ED48	18	39.94	38.87	7.26	29.04	55.23
Newfoundland						
YH11	15	29.67	29.35	2.60	26.12	34.37
YH12	14	27.39	26.55	6.81	15.23	38.66
YH13	14	17.81	17.47	3.63	12.70	26.52
YH14	16	23.56	23.40	5.69	14.19	34.37
YH15	15	31.72	30.01	7.43	21.36	48.33
YK6	17	148.27	146.69	25.34	106.48	195.42
YL1	17	138.95	144.24	20.69	98.11	164.90
YL10	15	22.48	22.65	3.50	16.86	31.48
YM1	14	52.96	52.34	3.79	46.69	60.59
YM3	17	75.05	73.84	8.04	56.49	88.73
YM6	16	108.09	109.66	16.28	67.75	128.48
YM7	16	87.29	85.83	16.72	59.09	126.48
YN8	17	149.20	151.36	55.78	79.67	270.11
YO7	16	91.54	91.31	10.64	70.85	110.05
YO9	16	93.83	90.19	11.39	78.97	128.33
YQ1	17	117.17	118.81	9.58	96.06	130.31
YR5	17	42.00	41.35	6.30	32.62	51.72
YS3	17	75.04	76.92	8.18	62.63	94.60
YS5	17	76.73	76.13	9.43	63.29	101.57
YS9	18	67.48	70.30	11.90	45.43	84.15
YS10	16	94.91	87.27	27.90	50.25	137.98
YS16	16	107.65	111.91	17.76	80.76	139.11
YS21	17	45.45	43.44	23.44	22.62	127.58
YS29	17	81.11	76.64	14.58	64.82	129.67
YS45	17	115.40	131.63	23.91	81.89	147.47
YS48	16	58.45	56.48	8.90	47.50	88.00
ZB1	16	41.08	41.19	3.35	34.69	46.85
ZC2	15	20.87	20.81	3.71	16.37	31.19
ZC3	17	37.05	35.96	8.42	24.83	61.72
ZD1	16	47.60	48.80	9.67	33.76	63.04
ZD2	17	55.83	47.45	23.48	18.83	91.02
ZF3	17	38.47	35.33	14.29	24.18	84.44
ZF4	17	64.47	61.57	12.48	45.06	98.23

Table B6
Nitrate: Descriptive statistics

Lake ID	N	Average	Median	*s*	Min.	Max.
Ontario						
S1	706	425.92	388.50	260.16	5.0	216.0
S4	715	333.39	273.0	197.68	0	1.1
HPO	702	117.31	115.0	90.92	0	490.0
HP3	1177	102.13	64	278.68	0	9000.0
HP3A	1293	205.99	152	240.63	0	5260.0
HP4	1751	118.48	114	70.53	0	600.0
HP5	1359	115.26	61	162.22	0	1850.0
HP6	1095	263.49	218.0	401.28	0	7500
HP6A	995	33.69	10	111.17	0	2100
PC1	1021	60.18	22.0	144.30	0	1950
PCO	666	64.77	50.5	49.48	0	425
Québec						
101	52	56.9	30.5	71.8	3.0	350
102	51	46.6	30.0	49.25	7.0	250
111	18	38.0	37.5	21.75	7.0	80
112	18	15.2	10.0	9.48	6.0	40
114	18	25.7	26.0	16.05	3.0	60
201	51	23.5	10.0	41.06	3.0	250
202	52	40.2	21.5	44.66	3.0	180
211	18	42.1	40.0	30.44	7.0	100
212	18	32.9	35.5	14.37	3.0	50
213	18	26.4	21.0	21.60	3.0	70
214	18	22.2	20.0	19.36	3.0	83
301	51	28.1	10.0	39.44	3.0	210
302	50	95.6	90.0	80.86	3.0	300
304	40	84.95	45.0	93.00	7.0	360
311	17	121.9	110.0	88.58	10.0	340
312	18	22.2	14.5	20.26	6.0	780
313	18	27.1	20.0	25.29	7.0	90
314	18	15.9	10.0	14.62	3.0	60
401	51	46.8	30.0	55.35	3.0	260
411	18	15.4	10.0	12.39	3.0	50
414	17	79.1	60.0	51.74	14.0	170
501	52	41.3	30.0	44.85	3.0	190
502	52	26.0	10.0	29.35	3.0	130
511	17	28.1	20.0	23.80	6.0	70
512	18	47.3	35.0	35.72	3.0	110
513	17	15.2	7.0	14.39	3.0	60
514	18	16.9	10.5	11.44	5.0	40
515	18	56.6	55.0	42.21	3.0	170
516	18	53.2	65.0	32.23	3.0	104

Table B7
Colour: Descriptive statistics

Lake ID	N	Average	Median	*s*	Min.	Max.
Nova Scotia						
DA2	11	5.5	5.0	1.51	5	10
DA3	16	13.1	10.0	11.38	5	50
DA4	16	16.9	12.5	9.98	5	30
DA5	17	25.6	25.0	11.58	5	50
DA6	16	14.1	12.5	7.58	5	25
EA2	13	7.3	5.0	3.30	5	15
EA4	16	15.3	17.5	7.63	5	30
EA9	16	223.1	210.0	76.92	140	420
EA10	16	24.4	25.0	9.98	5	40
EA19	16	120.6	110.0	32.35	90	200
EA20	10	11.5	5.0	20.55	5	70
ED1	15	15.7	15.0	7.99	5	30
ED2	18	100.0	95.0	24.07	70	160
ED3	15	10.33	10.0	5.16	5	20
ED4	15	13.7	0.0	7.19	5	25
ED5	17	42.9	40.0	20.85	10	80
ED6	18	29.17	30.0	12.98	10	60
ED7	19	77.4	75.0	19.39	45	120
ED8	15	96.7	90.0	23.88	55	150
ED10	18	114.7	100.0	26.27	80	180
ED11	9	6.7	5.0	2.50	5	10
ED13	17	31.2	35.0	18.33	5	70
ED14	18	172.22	160.0	38.13	120	240
ED15	18	85.3	87.5	23.29	10	110
ED16	18	126.1	135.0	26.82	60	160
ED17	17	24.1	25.0	13.83	5	45
ED19	18	109.4	100.0	25.72	80	160
ED20	18	118.9	110.0	19.67	100	160
ED21	18	158.3	160.0	28.54	110	200
ED22	16	52.8	57.5	16.53	25	75
ED25	16	64.1	72.5	27.46	20	100
ED27	8	19.4	5.0	38.68	5	115
ED28	18	63.3	55.0	30.0	20	160
ED29	18	70.3	70.0	18.11	40	100
ED30	13	6.2	5.0	2.19	5	10
ED43	15	90.3	90.0	15.98	65	120
ED47	18	78.6	72.5	19.08	40	120
ED48	18	75.0	70.0	18.47	40	120
Newfoundland						
YH11	14	11.8	10.0	6.68	5	25
YH12	14	12.9	10.0	8.93	5	30
YH13[1]						
YH14	15	41.7	40.0	18.29	10	70
YH15	15	42.0	45.0	16.45	15	80
YK6	17	46.2	45.0	19.33	15	80
YL1	16	30.9	52.5	14.74	5	50
YL10	15	33.3	30.0	16.11	5	60
YM1	10	10.5	5.0	9.26	5	30
YM3	17	45.0	40.0	19.04	20	100
YM6	16	60.6	52.5	37.63	25	180

Lake ID	N	Average	Median	*s*	Min.	Max.
YM7	16	147.5	150.0	41.55	70	220
YN8	17	43.5	40.0	19.43	15	80
YO7	16	33.8	32.5	17.65	5	60
YO9	13	10.4	10.0	5.94	5	20
YQ1	17	17.6	15.0	9.86	5	35
YR5	17	86.8	90.0	29.41	55	180
YS3	17	25.0	30.0	14.47	5	50
YS5	17	36.8	35.0	19.44	5	90
YS9	16	85.6	77.5	34.7	35	190
YS10	16	88.4	80.0	28.97	40	160
YS16	16	45.3	47.5	24.18	10	90
YS21	17	36.5	25.0	42.08	5	190
YS29	17	36.5	35.0	20.21	5	80
YS45	17	82.4	80.0	36.36	15	160
YS48	16	18.4	12.5	16.61	5	70
ZB1	14	11.1	10.0	5.94	5	20
ZC2	16	17.5	17.5	11.54	5	40
ZC3	17	18.5	20.0	11.15	5	40
ZD1	16	29.4	20.0	19.31	10	65
ZD2	17	92.6	85.0	33.22	25	160
ZF3	10	13.0	7.5	9.78	5	30
ZF4	17	25.29	25.0	13.4	5	55

[1] Not calculated, too many values below LOD.

Appendix C

Detailed trend statistics are presented for each lake and stream station and for each parameter analysed. Units used are: pH (units), alkalinity and SO_4 (mg/L), Ca+Mg (μeq/L), NO_3 (μg/L), and colour (Hazen units). Abbreviations appearing in the tables are defined as follows:

Pers.:	Persistence
Seas.:	Seasonality
Sign.:	Significance level of test
Vi:	Initial value of a significant trend
Vf:	Final value of a significant trend
KS:	Kendall Seasonal
Kend.:	Kendall
H/S:	Hirsch and Slack
S/L:	Spearman/Lettenmaier
NA:	Not available
N:	Not present
Y:	Present
↑:	Monotonic increase
↓:	Monotonic decrease

Table C1
pH trend statistics for Ontario, Québec and Atlantic sites

Station	Pers.	Seas.	Trend	Test	Sign.	Vi	Vf	Slope
Ontario								
Batchawana	Y	Y	-	H/S	0.263			
Turkey	Y	Y	-	H/S	0.084			
HPY	Y	Y	↑	H/S	0.029	6.307	6.578	0.031
HP3	Y	Y	↓	H/S	0.022	6.039	5.706	-0.038
HP3A	Y	Y	-	H/S	0.259			
HP4	Y	Y	-	H/S	0.320			
HP5	Y	Y	↑	H/S	0.022	5.295	5.551	0.029
HP6	Y	Y	↓	H/S	0.019	5.831	5.573	-0.029
HP6A	N	Y	↓	KS	0.016	5.058	4.902	-0.018
PCO	Y	Y	-	H/S	0.426			
PCI	N	Y	-	KS	0.053			
Québec								
101	Y	N	-	S/L	NA			
102	Y	N	↓	S/L	NA	5.906	5.484	-0.050
111	N	N	-	Kend.	0.484			
112	Y	Y	-	H/S	0.153			
114	Y	N	↓	S/L	NA	5.382	4.785	-0.070
201	Y	N	-	S/L	NA			
202	Y	N	-	S/L	NA			
211	N	N	-	Kend.	0.468			
212	N	N	-	Kend.	0.500			
213	Y	N	↓	S/L	NA	5.583	4.964	-0.073
214	Y	N	-	S/L	NA			
301	Y	N	-	S/L	NA			
302	Y	N	-	S/L	NA			
304	Y	Y	-	H/S	0.200			
311	N	N	-	Kend.	0.388			
312	N	N	-	Kend.	0.350			
313	N	N	-	Kend.	0.345			
314	Y	N	-	S/L	NA			
401	Y	N	-	S/L	NA			
411	N	N	-	Kend.	0.109			
414	N	N	-	Kend.	0.052			
501	N	Y	-	KS	0.072			
502	Y	N	-	S/L	NA			
511	N	N	↓	Kend.	0.043	7.649	7.404	-0.029
512	Y	N	-	S/L	NA			
513	N	Y	-	KS	0.144			
514	N	N	-	Kend.	0.051			
515	N	N	-	Kend.	0.484			
516	N	N	↓	Kend.	0.013	6.888	6.542	-0.041
Nova Scotia								
DA0002	N	N	-	Kend.	0.308			
DA0003	N	Y	↑	KS	0.035	5.788	6.047	0.032
DA0004	N	N	-	Kend.	0.270			
DA0005	N	N	-	Kend.	0.227			
DA0006	N	Y	-	KS	0.255			
EA0002	N	N	-	Kend.	0.063			
EA0004	N	Y	-	KS	0.468			
EA0009	N	N	-	Kend.	0.482			
EA0010	N	N	-	Kend.	0.271			
EA0019	Y	Y	-	H/S	0.232			
EA0020	N	N	-	Kend.	0.464			
ED0001	N	N	-	Kend.	0.249			
ED0002	N	N	-	Kend.	0.206			
ED0003	N	N	-	Kend.	0.307			

Station	Pers.	Seas.	Trend	Test	Sign.	Vi	Vf	Slope
ED0004	Y	Y	-	H/S	0.201			
ED0005	Y	Y	-	H/S	0.102			
ED0006	Y	Y	↓	H/S	0.025	5.893	5.840	-0.006
ED0007	Y	Y	-	H/S	0.284			
ED0008	N	N	-	Kend.	0.199			
ED0010	Y	N	-	S/L	NA			
ED0011	Y	Y	-	H/S	0.261			
ED0013	N	N	-	Kend.	0.500			
ED0014	N	N	-	Kend.	0.264			
ED0015	N	N	-	Kend.	0.304			
ED0016	N	N	-	Kend.	0.065			
ED0017	Y	Y	-	H/S	0.152			
ED0019	N	N	-	Kend.	0.381			
ED0020	N	N	-	Kend.	0.166			
ED0021	N	N	-	Kend.	0.426			
ED0022	N	Y	↑	KS	0.024	4.752	4.935	0.024
ED0025	Y	Y	-	H/S	0.464			
ED0027	N	N	-	Kend.	0.125			
ED0028	N	Y	-	KS	0.472			
ED0029	N	N	↑	Kend.	0.037	4.622	4.789	0.020
ED0030	N	N	-	Kend.	0.156			
ED0043	Y	N	-	S/L	NA			
ED0047	Y	Y	-	H/S	0.224			
ED0048	Y	Y	-	H/S	0.151			
Newfoundland								
YH0011	N	N	↓	Kend.	0.023	5.715	5.525	-0.027
YH0012	Y	Y	-	H/S	0.185			
YH0013	Y	N	-	S/L	N/A			
YH0014	N	N	-	Kend.	0.151			
YH0015	N	N	-	Kend.	0.456			
YK0006	N	N	-	Kend.	0.066			
YL0001	N	N	-	Kend.	0.102			
YL0010	Y	N	-	S/L	N/A			
YM0001	N	N	-	Kend.	0.468			
YM0003	N	Y	-	KS	0.334			
YM0006	N	N	-	Kend.	0.239			
YM0007	N	N	-	Kend.	0.264			
YN0008	N	N	↑	Kend.	0.048	6.294	6.647	0.044
YO0009	N	N	↑	Kend.	0.004	6.333	6.679	0.046
YQ0001	N	N	-	Kend.	0.053			
YR0005	N	N	-	Kend.	0.405			
YS0003	N	N	-	Kend.	0.447			
YS0005	N	N	-	Kend.	0.348			
YS0009	N	N	-	Kend.	0.349			
YS0010	N	N	-	Kend.	0.417			
YS0016	N	N	-	Kend.	0.432			
YS0021	N	N	-	Kend.	0.302			
YS0029	N	N	-	Kend.	0.300			
YS0045	N	N	-	Kend.	0.142			
YS0048	N	N	↑	Kend.	0.033	6.006	6.191	0.023
ZB0001	N	N	-	Kend.	0.440			
ZC0002	N	N	-	Kend.	0.067			
ZC0003	N	N	-	Kend.	0.411			
ZD0001	N	N	-	Kend.	0.056			
ZD0002	N	N	-	Kend.	0.190			
ZF0003	N	N	-	Kend.	0.199			
ZF0004	N	N	↑	Kend.	0.019	6.098	6.408	0.039
YO0007	N	N	-	Kend.	0.281			

Table C2
Alkalinity trend statistics for Ontario, Québec and Atlantic sites

Station	Pers.	Seas.	Trend	Test	Sign.	Vi	Vf	Slope
Ontario								
Batchawana	N	Y	-	KS	0.432			
Turkey	Y	Y	↑	H/S	0.026	0.174	0.195	0.002
HPO	Y	Y	↑	H/S	0.002	3.133	4.178	0.118
HP3	N	Y	-	KS	0.053			
HP3A	Y	Y	-	H/S	0.138			
HP4	Y	Y	-	H/S	0.168			
HP5	Y	Y	↑	H/S	0.014	1.698	4.703	0.340
HP6	N	Y	↓	KS	0.021	4.635	2.896	-0.197
HP6A	N	Y	-	KS	0.340			
PCO	Y	Y	-	H/S	0.191			
PCI	N	Y	-	KS	0.134			
Québec								
101	Y	N	-	S/L	N			
102	N	N	-	Kend.	0.286			
111	N	Y	↓	KS	0.003	1.465	0.738	-0.104
112	N	N	↓	Kend.	0.040	1.210	0.179	-0.121
114	N	N	↓	Kend.	0.023	0.163	-0.648	-0.101
201	N	N	-	Kend.	0.278			
202	Y	Y	-	H/S	0.280			
211	N	N	-	Kend.	0.450			
212	N	N	↓	Kend.	0.002	1.983	1.729	-0.032
213	N	N	↓	Kend.	0.002	0.365	-0.374	-0.106
214	N	N	-	Kend.	0.063			
301	Y	Y	-	H/S	0.311			
302	N	Y	-	KS	0.129			
304	N	Y	↓	KS	0.005	5.682	4.733	-0.108
311	N	Y	-	KS	0.188			
312	N	Y	↓	KS	0.019	9.070	7.649	-0.167
313	N	Y	-	KS	0.092			
314	Y	Y	-	H/S	0.392			
401	N	N	↓	Kend.	0.011	7.781	6.775	-0.118
411	N	Y	-	KS	0.188			
414	N	N	-	Kend.	0.063			
501	N	N	-	Kend.	0.219			
502	N	N	-	Kend.	0.076			
511	N	Y	-	KS	0.329			
512	N	N	↓	Kend.	0.001	29.486	20.966	-1.002
513	N	Y	-	KS	0.329			
514	N	Y	-	KS	0.092			
515	N	Y	↓	KS	0.014	21.918	18.516	-0.486
516	Y	Y	-	H/S	0.288			
Nova Scotia								
DA0002	N	Y	-	KS	0.289			
DA0003	N	N	↑	Kend.	0.007	0.614	1.716	0.138
DA0004	Y	Y	↑	H/S	0.030	2.41	2.607	0.058
DA0005	N	N	↑	Kend.	0.002	0.757	1.608	0.106
DA0006	Y	N	-	S/L	NA			
EA0002	N	N	↑	Kend.	0.003	0.365	0.866	0.063
EA0004	Y	Y	-	H/S	0.088			
EA0009	N	Y	-	KS	0.124			
EA0010	Y	Y	-	H/S	0.101			
EA0019	Y	N	-	S/L	NA			
EA0020	N	N	-	Kend.	0.326			
ED0001	N	N	-	Kend.	0.092			
ED0002	Y	Y	-	H/S	0.051			
ED0003	N	Y	↑	KS	0.043	0.827	1.117	0.034

Station	Pers.	Seas.	Trend	Test	Sign.	Vi	Vf	Slope
ED0004	N	N	↑	Kend.	0.050	-0.132	0.132	0.031
ED0005	N	Y	↑	KS	0.000	-0.673	-0.126	0.064
ED0006	N	Y	↑	KS	0.019	1.058	1.409	0.041
ED0007	Y	Y	-	H/S	0.063			
ED0008	N	N	-	Kend.	0.089			
ED0010	N	N	-	Kend.	0.437			
ED0011	N	N	-	Kend.	0.112			
ED0013	N	N	-	Kend.	0.233			
ED0014	N	N	-	Kend.	0.453			
ED0015	N	N	-	Kend.	0.109			
ED0016	N	N	↑	Kend.	0.002	-0.419	0.274	0.082
ED0017	N	N	↑	Kend.	0.015	-0.053	0.335	0.046
ED0019	N	N	-	Kend.	0.066			
ED0020	N	N	-	Kend.	0.216			
ED0021	N	N	-	Kend.	0.228			
ED0022	N	N	↑	Kend.	0.009	-0.749	-0.101	0.086
ED0025	Y	Y	-	H/S	0.058			
ED0027	N	N	-	Kend.	0.088			
ED0028	Y	Y	-	H/S	0.222			
ED0029	N	N	↑	Kend.	0.015	-1.103	-0.542	0.066
ED0030	N	N	↑	Kend.	0.019	0.718	1.049	0.039
ED0043	N	N	↑	Kend.	0.044	-0.908	-0.561	0.043
ED0047	Y	Y	-	H/S	0.194			
ED0048	N	Y	↑	KS	0.008	-0.08	0.369	0.053
Newfoundland								
YH0011	N	N	-	Kend.	0.320			
YH0012	Y	N	-	S/L	NA			
YH0013	N	N	-	Kend.	0.330			
YH0014	N	N	-	Kend.	0.066			
YH0015	N	N	↑	Kend.	0.003	-0.281	0.854	0.162
YK0006	N	Y	-	KS	0.052			
YL0001	N	Y	↑	KS	0.004	5.890	6.910	0.136
YL0010	N	N	↑	Kend.	0.009	-0.199	0.186	0.055
YM0001	N	N	↑	Kend.	0.014	1.357	1.843	0.075
YM0003	N	Y	↑	KS	0.044	1.751	2.237	0.061
YM0006	N	Y	↑	KS	0.001	2.587	3.551	0.129
YM0007	N	N	↑	Kend.	0.011	0.664	1.624	0.128
YN0008	N	Y	-	KS	0.262			
YO0009	Y	N	↑	S/L	NA	2.601	3.924	0.176
YQ0001	N	Y	-	KS	0.366			
YR0005	N	N	↑	Kend.	0.012	0.325	0.698	0.047
YS0003	N	Y	↑	KS	0.019	2.241	2.806	0.071
YS0005	N	N	-	Kend.	0.305			
YS0009	N	Y	-	Kend.	0.094			
YS0010	Y	Y	-	H/S	0.150			
YS0016	N	Y	-	KS	0.145			
YS0021	N	N	-	Kend.	0.337			
YS0029	N	Y	↑	KS	0.002	1.779	2.894	0.131
YS0045	Y	Y	-	H/S	0.079			
YS0048	N	N	↑	Kend.	0.012	1.469	1.893	0.053
ZB0001	Y	N	-	S/L	NA			
ZC0002	N	N	↑	Kend.	0.047	0.862	1.087	0.030
ZC0003	N	N	↑	Kend.	0.014	0.871	1.212	0.043
ZD0001	N	N	↑	Kend.	0.002	1.109	2.036	0.116
ZD0002	N	N	-	Kend.	0.096			
ZF0003	N	N	-	Kend.	0.194			
ZF0004	N	Y	↑	KS	0.007	1.567	2.245	0.085
YO0007	Y	Y	-	H/S	0.101			

Table C3
Sulphate trend statistics for Ontario, Québec and Atlantic sites

Station	Pers.	Seas.	Trend	Test	Sign.	Vi	Vf	Slope
Ontario								
Batchawana	N	Y	-	KS	0.233			
Turkey	Y	Y	-	H/S	0.393			
HPO	Y	Y	-	H/S	0.379			
HP3	Y	Y	-	H/S	0.282			
HP3A	Y	Y	-	H/S	0.500			
HP4	Y	Y	-	H/S	0.168			
HP5	Y	Y	-	H/S	0.242			
HP6	Y	Y	-	H/S	0.262			
HP6A	Y	Y	-	H/S	0.366			
PCO	N	Y	↑	KS	0.049	6.498	7.007	0.059
PCI	Y	Y	-	H/S	0.397			
Québec								
101	Y	Y	-	H/S	0.157			
102	N	Y	↓	KS	0.004	4.435	4.096	-0.040
111	N	N	-	Kend.	0.125			
112	N	Y	-	KS	0.179			
114	N	N	↓	Kend.	0.022	6.156	5.344	-0.096
201	N	N	↓	Kend.	0.0000	4.280	3.666	-0.072
202	Y	N	-	S/L	NA			
211	N	N	-	Kend.	0.335			
212	N	N	-	Kend.	0.130			
213	N	N	-	Kend.	0.335			
214	N	N	-	Kend.	0.060			
301	Y	N	-	S/L	NA			
302	N	N	-	Kend.	0.088			
304	Y	Y	-	H/S	0.264			
311	N	N	-	Kend.	0.409			
312	N	N	-	Kend.	0.407			
313	N	N	↓	Kend.	0.021	4.829	4.227	-0.071
314	N	N	↓	Kend.	0.028	6.641	6.048	-0.070
401	Y	N	↓	S/L	NA	6.203	4.662	-0.181
411	N	N	-	Kend.	0.235			
414	N	N	↑	Kend.	0.036	5.724	6.858	0.133
501	Y	N	↓	S/L	NA	8.478	7.179	-0.153
502	Y	N	↓	S/L	NA	8.036	6.449	-0.187
511	Y	N	↓	S/L	NA	11.474	9.281	-0.258
512	Y	N	↓	S/L	NA	7.188	4.634	-0.301
513	Y	N	↓	S/L	NA	10.023	8.245	-0.209
514	N	N	↓	Kend.	0.011	8.766	7.923	-0.099
515	N	N	↓	Kend.	0.003	9.165	7.057	-0.248
516	Y	N	↓	S/L	NA	7.946	6.076	-0.220
Nova Scotia								
DA0002	N	N	-	Kend.	0.069			
DA0003	N	N	-	Kend.	0.205			
DA0004	N	N	-	Kend.	0.229			
DA0005	N	N	-	Kend.	0.255			
DA0006	N	N	-	Kend.	0.241			
EA0002	N	N	↓	Kend.	0.042	2.760	2.371	-0.049
EA0004	N	N	-	Kend.	0.340			
EA0009	N	N	-	Kend.	0.311			
EA0010	N	N	↑	Kend.	0.013	2.705	3.391	0.086
EA0019	N	N	-	Kend.	0.467			
EA0020	N	N	-	Kend.	0.311			
ED0001	N	N	↑	Kend.	0.042	1.678	2.067	0.046
ED0002	N	N	-	Kend.	0.170			
ED0003	N	N	-	Kend.	0.440			

Station	Pers.	Seas.	Trend	Test	Sign.	Vi	Vf	Slope
ED0004	N	N	↑	Kend.	0.016	1.578	1.917	0.040
ED0005	N	N	-	Kend.	0.153			
ED0006	N	N	-	Kend.	0.381			
ED0007	N	N	↑	Kend.	0.016	1.552	1.918	0.043
ED0008	N	Y	-	KS	0.189			
ED0010	N	Y	-	KS	0.151			
ED0011	N	Y	↑	KS	0.022	1.487	1.768	0.033
ED0013	N	Y	-	KS	0.119			
ED0014	N	N	-	Kend.	0.086			
ED0015	N	N	↑	Kend.	0.007	1.850	2.678	0.097
ED0016	N	N	↑	Kend.	0.019	0.281	1.154	0.103
ED0017	N	Y	↑	KS	0.019	1.604	1.892	0.034
ED0019	N	N	-	Kend.	0.153			
ED0020	N	N	-	Kend.	0.285			
ED0021	N	N	-	Kend.	0.213			
ED0022	N	N	↑	Kend.	0.013	1.791	2.225	0.058
ED0025	N	N	-	Kend.	0.213			
ED0027	N	N	↑	Kend.	0.004	1.372	1.927	0.069
ED0028	N	N	-	Kend.	0.134			
ED0029	N	N	↑	Kend.	0.022	1.630	2.151	0.061
ED0030	N	N	-	Kend.	0.076			
ED0043	N	N	-	Kend.	0.268			
ED0047	N	N	↑	Kend.	0.040	1.607	1.939	0.039
ED0048	N	N	↑	Kend.	0.015	1.551	1.972	0.050
Newfoundland								
YH0011	N	N	↓	Kend.	0.021	1.317	0.921	-0.056
YH0012	N	Y	↓	KS	0.017	1.214	0.859	-0.055
YH0013	N	N	-	Kend.	0.125			
YH0014	N	N	↓	Kend.	0.034	1.363	0.782	-0.083
YH0015	N	N	-	Kend.	0.293			
YK0006	N	N	↑	Kend.	0.024	1.034	1.520	0.065
YL0001	N	N	-	Kend.	0.376			
YL0010	N	N	↓	Kend.	0.027	1.412	0.875	-0.077
YM0001	N	N	-	Kend.	0.236			
YM0003	N	Y	-	KS	0.076			
YM0006	N	Y	-	KS	0.147			
YM0007	N	N	-	Kend.	0.342			
YN0008	N	N	-	Kend.	0.205			
YO0009	Y	N	-	S/L	NA			
YQ0001	N	N	↑	Kend.	0.006	0.584	1.242	0.082
YR0005	N	N	↑	Kend.	0.045	0.406	0.789	0.048
YS0003	N	N	-	Kend.	0.311			
YS0005	N	N	-	Kend.	0.094			
YS0009	N	N	↑	Kend.	0.001	0.657	1.042	0.048
YS0010	N	Y	↑	KS	0.013	0.523	0.966	0.055
YS0016	N	N	-	Kend.	0.108			
YS0021	N	N	-	Kend.	0.386			
YS0029	N	N	-	Kend.	0.153			
YS0045	Y	N	-	S/L	NA			
YS0048	N	N	-	Kend.	0.129			
ZB0001	N	N	-	Kend.	0.081			
ZC0002	N	N	-	Kend.	0.295			
ZC0003	N	N	↓	Kend.	0.028	1.226	0.784	-0.055
ZD0001	N	N	-	Kend.	0.500			
ZD0002	Y	N	↑	S/L	NA	0.533	1.033	0.059
ZF0003	N	N	-	Kend.	0.079			
ZF0004	N	N	-	Kend.	0.282			
YO0007	N	N	-	Kend.	0.138			

Table C4
Ca+Mg trend statistics for Ontario, Québec and Atlantic sites

Station	Pers.	Seas.	Trend	Test	Sign.	Vi	Vf	Slope
Ontario								
Batchawana	N	Y	-	KS				0.222
Turkey	Y	Y	↑	H/S	0.021	303.202	335.587	3.666
HPO	N	Y	↑	KS	0.001	218.112	235.166	1.931
HP3	Y	Y	-	H/S				0.087
HP3A	Y	Y	-	H/S				0.334
HP4	Y	Y	↑	H/S	0.044	229.707	275.144	5.144
HP5	Y	Y	-	H/S				0.121
HP6	Y	Y	↑	H/S	0.028	264.987	454.601	21.466
HP6A	Y	Y	-	H/S				0.197
PCO	Y	Y	-	H/S				0.061
PCI	Y	Y	-	H/S				0.344
Québec								
101	Y	Y	-	H/S				0.105
102	Y	N	↓	S/L	NA	85.347	75.049	-1.211
111	N	N	-	Kend.				0.147
112	Y	Y	↓	H/S	0.002	76.629	68.511	-0.955
114	N	N	↓	Kend.	0.001	102.218	77.483	-2.910
201	N	Y	-	KS				0.480
202	N	Y	↑	KS	0.042	116.065	120.744	0.550
211	Y	Y	-	H/S				0.162
212	N	Y	-	KS				0.085
213	N	Y	↓	KS	0.011	84.578	77.073	-0.883
214	N	Y	-	KS				0.125
301	N	Y	↑	KS	0.007	167.205	174.558	0.865
302	N	Y	↑	KS	0.001	215.865	240.405	2.887
304	N	Y	↓	KS	0.014	168.853	155.038	1.579
311	Y	Y	↓	H/S	0.022	126.343	116.176	-1.196
312	Y	Y	-	H/S				0.360
313	Y	Y	-	H/S				0.225
314	Y	Y	↑	H/S	0.016	288.325	307.496	2.255
401	N	Y	-	KS				0.085
411	N	Y	↑	KS	0.005	191.979	219.295	3.214
414	N	Y	↑	KS	0.001	187.963	213.252	2.975
501	N	Y	-	KS				0.312
502	N	Y	-	KS				0.059
511	Y	Y	-	H/S				0.258
512	N	Y	↓	KS	0.000	699.413	538.690	-18.909
513	Y	Y	-	H/S				0.293
514	Y	Y	-	H/S				0.076
515	Y	Y	-	H/S				0.320
516	Y	Y	-	H/S				0.301
Nova Scotia								
DA0002	Y	N	-	S/L				NA
DA0003	N	N	-	Kend.				0.371
DA0004	N	Y	-	KS				0.259
DA0005	N	N	-	Kend.				0.402
DA0006	Y	N	↓	S/L	NA	67.102	63.810	-0.411
EA0002	N	N	-	Kend.				0.255
EA0004	N	N	-	Kend.				0.081
EA0009	Y	Y	-	H/S				0.197
EA0010	N	N	-	Kend.				0.311
EA0019	Y	Y	-	H/S				0.421
EA0020	N	N	-	Kend.				0.142
ED0001	N	N	-	Kend.				0.367
ED0002	Y	Y	-	H/S				0.309
ED0003	N	N	-	Kend.				0.060

Station	Pers.	Seas..	Trend	Test	Sign.	Vi	Vf	Slope
ED0004	N	N	-	Kend.				0.425
ED0005	N	N	-	Kend.				0.086
ED0006	N	N	↓	Kend.	0.010	54.619	43.297	-1.332
ED0007	N	N	-	Kend.				0.060
ED0008	Y	Y	-	H/S				0.212
ED0010	Y	Y	↑	H/S	0.040	18.424	23.772	0.629
ED0011	N	N	-	Kend.				0.236
ED0013	N	N	-	Kend.				0.425
ED0014	Y	Y	-	H/S				0.100
ED0015	N	Y	↑	KS	0.038	41.958	63.801	2.570
ED0016	Y	Y	-	H/S				0.131
ED0017	N	N	-	Kend.				0.425
ED0019	Y	Y	-	H/S				0.089
ED0020	Y	Y	-	H/S				0.077
ED0021	Y	Y	-	H/S				0.225
ED0022	N	N	↑	Kend.	0.029	21.288	26.721	0.724
ED0025	N	N	-	Kend.				0.395
ED0027	Y	N	-	S/L				NA
ED0028	Y	Y	-	H/S				0.393
ED0029	N	N	-	Kend.				0.213
ED0030	N	N	-	Kend.				0.395
ED0043	N	N	-	Kend.				0.402
ED0047	N	N	-	Kend.				0.070
ED0048	N	N	-	Kend.				0.070
Newfoundland								
YH0011	N	N	-	Kend.				0.128
YH0012	Y	Y	-	H/S				0.392
YH0013	N	N	-	Kend.				0.435
YH0014	N	N	-	Kend.				0.149
YH0015	N	Y	↑	KS	0.035	26.957	36.484	1.361
YK0006	Y	Y	-	H/S				0.404
YL0001	Y	Y	-	H/S				0.242
YL0010	N	N	-	Kend.				0.091
YM0001	N	N	↑	Kend.	0.021	48.817	57.099	1.274
YM0003	Y	Y	-	H/S				0.129
YM0006	N	Y	↑	KS	0.004	101.371	114.816	1.793
YM0007	N	N	-	Kend.				0.264
YN0008	N	Y	-	KS				0.213
YO0009	Y	N	↑	S/L	NA	82.900	104.753	2.914
YQ0001	N	N	↑	Kend.	0.050	112.885	121.463	1.072
YR0005	N	Y	-	KS				0.437
YS0003	N	Y	-	KS				0.437
YS0005	N	Y	-	KS	0.101			
YS0009	Y	Y	-	H/S				0.449
YS0010	Y	Y	-	H/S				0.357
YS0016	Y	Y	-	H/S				0.500
YS0021	N	Y	-	KS				0.262
YS0029	N	Y	-	KS				0.119
YS0045	Y	Y	-	H/S				0.248
YS0048	N	N	-	Kend.				0.435
ZB0001	N	N	-	Kend.				0.236
ZC0002	N	N	-	Kend.				0.209
ZC0003	N	Y	-	KS				0.132
ZD0001	Y	Y	-	H/S				0.084
ZD0002	Y	Y	-	H/S				0.143
ZF0003	N	N	-	Kend.				0.435
ZF0004	N	N	-	Kend.				0.311
YO0007	Y	Y	-	H/S				0.500

Table C5
Nitrate trend statistics for Ontario, Québec and Atlantic sites

Station	Pers.	Seas.	Trend	Test	Sign.	Vi	Vf	Slope
Ontario[1]								
Batchawana	N	Y	-	KS				0.399
Turkey	Y	Y	-	H/S				0.364
HPY	O	O	-	H/S				0.158
HP3	O	Y	↓	H/S	0.016	116.956	58.471	-6.621
HP3A	N	Y	-	KS				0.053
HP4	N	Y	↑	KS	0.005	106.859	124.307	1.975
HP5	Y	Y	-	H/S				0.219
HP6	Y	Y	-	H/S				0.133
HP6A	N	N	-	Kend.				0.072
PCO	N	Y	-	KS				0.108
PCI	N	Y	-	KS				0.367
Québec[2]								
101	N	Y	-	KS				0.071
102	N	Y	-	KS				0.379
111	N	N	-	Kend.				0.360
112	N	N	-	Kend.				0.266
114	N	N	-	Kend.				0.126
201	N	Y	↑	KS	0.000	0.015	0.032	0.002
202	N	Y	-	KS				0.123
211	N	N	-	Kend.				0.485
212	Y	Y	↑	H/S	0.030	0.025	0.041	0.002
213	Y	Y	↑	H/S	0.004	0.011	0.041	0.004
214	N	N	-	Kend.				0.158
301	N	Y	↑	KS	0.000	0.022	0.034	0.001
302	Y	Y	-	H/S				
311	N	N	↓	Kend.	0.002	0.212	0.034	-0.021
312	N	N	-	Kend.				0.500
313	N	N	-	Kend.				0.300
314	N	N	↓	Kend.	0.045	0.018	0.014	-0.001
401	N	Y	↑	KS	0.000	0.034	0.059	0.003
411	N	N	-	Kend.				0.050
414	N	Y	↑	KS	0.014	0.059	0.096	0.004
501	N	Y	↑	KS	0.001	0.034	0.048	0.002
502	N	Y	↑	KS	0.030	0.023	0.029	0.0007
511	N	N	-	Kend.				0.062
512	Y	Y	↑	H/S	0.008	0.028	0.066	0.004
513	N	N	↑	Kend.	0.031	0.015	0.017	0.000
514	N	N	↑	Kend.	0.016	0.010	0.024	0.002
515	N	N	-	Kend.				0.438
516	N	N	-	Kend.				0.197
LAF	Y	Y	-	H/S				0.078
Nova Scotia								
ED0005	N	N	-	Kend.				0.432
Newfoundland[2]								
YH0013	N	N	-	Kend.				0.282
ZB0001	N	N	↑	Kend.	0.042	0.027	0.075	0.006

[1] Vi, Vf and slope are measured in μg/L.
[2] Vi, Vf and slope are measured in mg/L.

Table C6
Colour trend statistics for Nova Scotia and Newfoundland

Station	Pers.	Seas.	Trend	Test	Sign.	Vi	Vf	Slope
Nova Scotia								
DA0002	N	N	-	Kend.				0.220
DA0003	N	N	↑	Kend.	0.016	3.884	21.210	2.166
DA0004	N	Y	-	KS				0.393
DA0005	N	N	-	Kend.				0.148
DA0006	N	Y	↑	KS	0.048	9.604	17.255	0.956
EA0002	N	N	-	Kend.				0.081
EA0004	N	N	-	Kend.				0.293
EA0009	Y	N	-	S/L				NA
EA0010	N	N	-	Kend.				0.466
EA0019	N	N	-	Kend.				0.500
EA0020	N	N	-	Kend.				0.088
ED0001	N	Y	-	KS				0.067
ED0002	N	N	-	Kend.				0.182
ED0003	N	N	↑	Kend.	0.035	5.515	12.808	0.858
ED0004	N	Y	-	KS				0.206
ED0005	Y	Y	-	H/S				0.409
ED0006	N	N	-	Kend.				0.468
ED0007	N	N	-	Kend.				0.236
ED0008	N	N	-	Kend.				0.268
ED0010	N	N	-	Kend.				0.103
ED0011	N	Y	-	KS				0.063
ED0013	N	N	-	Kend.				0.179
ED0014	Y	Y	-	H/S				0.474
ED0015	N	N	-	Kend.				0.084
ED0016	N	N	-	Kend.				0.421
ED0017	N	Y	-	KS				0.391
ED0019	Y	Y	-	H/S				0.317
ED0020	N	Y	-	KS				0.121
ED0021	Y	Y	↑	H/S	0.030	142.63	174.035	3.695
ED0022	N	N	-	Kend.				0.213
ED0025	N	Y	-	KS				0.276
ED0027	N	N	↑	Kend.	0.014	2.943	5.645	0.338
ED0028	N	N	-	Kend.				0.263
ED0029	N	N	-	Kend.				0.484
ED0030	N	N	-	Kend.				0.134
ED0043	N	N	-	Kend.				0.365
ED0047	N	N	-	Kend.				0.293
ED0048	N	N	-	Kend.				0.326
Newfoundland								
YH0011	N	N	↑	Kend.	0.003	3.633	18.808	2.168
YH0012	N	N	↑	Kend.	0.001	2.429	23.286	3.209
YH0013[1]								
YH0014	N	N	↑	Kend.	0.001	20.167	63.167	6.143
YH0015	N	N	↑	Kend.	0.001	24.375	59.625	5.036
YK0006	N	N	-	Kend.				0.307
YL0001	N	N	-	Kend.				0.318
YL0010	N	N	↑	Kend.	0.001	14.208	54.458	5.464
YM0001	N	N	-	Kend.				0.154
YM0003	N	N	-	Kend.				0.063
YM0006	N	N	-	Kend.				0.427
YM0007	N	N	-	Kend.				0.334
YN0008	N	N	-	Kend.				0.100
YO0009	N	N	-	Kend.				0.132
YQ0001	N	N	↑	Kend.	0.040	10.588	24.706	1.765
YR0005	N	N	-	Kend.				0.483
YS0003	N	N	-	Kend.				0.106

Station	Pers.	Seas.	Trend	Test	Sign.	Vi	Vf	Slope
YS0005	N	N	-	Kend.				0.133
YS0009	N	N	-	Kend.				0.321
YS0010	N	N	-	Kend.				0.304
YS0016	N	N	-	Kend.				0.189
YS0021	N	N	-	Kend.				0.163
YS0029	N	N	-	Kend.				0.334
YS0045	N	N	-	Kend.				0.197
YS0048	N	N	-	Kend.				0.465
ZB0001	N	N	-	Kend.				0.149
ZC0002	N	N	-	Kend.				0.313
ZC0003	N	N	-	Kend.				0.125
ZD0001	N	Y	-	KS				0.179
ZD0002	N	N	-	Kend.				0.438
ZF0003	Y	N	-	S/L				NA
ZF0004	N	N	-	Kend.				0.121
YO0007	N	N	-	Kend.				0.463

[1] Not tested; too many values below the limit of detection.