Environmental Studies of the St. Croix River and Big St. Margarets Bay Lake Systems Nova Scotia

Final Report
to
Minas Basin Pulp and Power
Company Limited

Prepared by
Graham R. Daborn, Michael Brylinsky
and Ruth Newell

September 2001

Acadia Centre for Estuarine Research
Publication No. 63

ACADIA ESTUARINE CENTRE FOR RESEARCH

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Executive Summary

3.0/3.1. Between May and August 2001 the Acadia Centre for Estuarine Research conducted extensive field investigations of the streams and impoundments involved in the St. Croix River watershed, and the adjacent watershed of Big St. Margarets Bay Lake. Field studies for water quality, fish, macroinvertebrates and fish habitat were organised around two campaigns, one in late May and the other in July, and supplemented by extensive field observations at other times. A separate campaign in August characterized the aquatic flora at a time when many species were flowering or in fruit. A third campaign to survey fish and water quality is scheduled for October 2001.

3.2. The waters of the St. Croix and Big St. Margarets Bay Lake systems above the Upper St. Croix Dam, are clear, often heavily stained by humic acids, acidic, and extremely low in dissolved nutrients. Alkalinity, conductivity and hardness are all extremely low, and with almost no buffering capacity, pH values mostly range between 5.2 and 5.5 in impoundments, and to well below 5 in tributary streams. The waters of the system are clearly susceptible to acid precipitation. Concentrations of dissolved nutrients (e.g. nitrogen and phosphorus) and all metals were extremely low or undetectable in both lakes and streams, except for aluminium and iron, both of which were elevated, as is typical in acidic lakes of Nova Scotia.

All the impoundments tended to stratify in summer, but although oxygen concentrations declined in deep water, few reached as low as 50% saturation. Chlorophyll *a* concentrations were low to very low in both spring and summer in all impoundments, and are typical of oligotrophic lakes. Highest chlorophyll values were found in Big St. Margarets Bay Lake, in summer. In streams, waters tended to be well oxygenated, except where they are shallow and very well shaded, and where organics from the watershed may accumulate and decay, depleting oxygen. These conditions in headwaters of tributary streams may be important in limiting fish production.

3.3. Fish surveys were carried out in impoundments and streams. Six species were recorded from Panuke Lake and Big St. Margarets Bay Lake, including Brook trout, White sucker, and Yellow perch. Smallmouth bass were common in Panuke Lake and the lower St. Croix impoundments, but not in Big St. Margarets Bay Lake. Length-weight relationships indicate that the Brook trout and Smallmouth bass were generally in good condition. Mercury content of Brook trout epaxial muscle (0.08-0.59 mg/kg) was similar to the Nova Scotia average, but less than reported in some other studies. Higher levels of mercury were found in Smallmouth bass (0.27-1.60 mg/kg) and Yellow perch (0.35-1.60 mg/kg), but well within the range found in other Nova Scotia lakes.

Eight fish species were captured during electrofishing surveys of 8 streams entering Panuke Lake and Big St. Margarets Bay Lake. These included Brook trout, White sucker, Eel, Smallmouth bass, Creek chub and Common shiner. Numbers were low in most cases.

3.4. Vegetation surveys of the shores and riparian zone indicated few localities where littoral vegetation was well established, and these were dominated by common species. Two rare species were recorded: the Silky willow and the Floating Bladderwort. Elements of the Atlantic Coastal Plain Flora, a special association of species found in southwestern Nova Scotia and adapted to fluctuating water levels, were found on the shores of Big St. Margarets Bay Lake. These constitute the principal discoveries of unusual or uncommon species in the region. A few rare plants had been listed by previous researchers, but the observations are limited in detail. New observations on amphibians and reptiles have been contributed to the Nova Scotia Herpetofaunal Atlas.

3.5. Most of the streams entering Panuke Lake exhibit extremely variable flows, and substrate is dominated by coarse sediments, with few riffle-run sequences. Few potential spawning sites were encountered during detailed habitat surveys extending < 0.5 km from the lake shore. Extremely low water levels and very high water temperatures were found in streams near the impoundments during summer months, as a result of exposure and absence of wetlands to retain water derived from spring runoff. At higher elevations, shade and accumulation of organic matter in stream beds, leave streams susceptible to oxygen depletion. The most productive streams were those entering Big St. Margarets Bay Lake or the eastern side of Panuke Lake. The intermittent nature of streams in this system, the dominance of coarse substrates and limitations of spawning sites, may be characteristic of this watershed. The severity of the physical conditions severely limit the fish habitat potential of these streams.

3.6. Collections of macroinvertebrates were made at electrofishing sites on streams and in submersed vegetation in the impoundments. Analysis of the collections is ongoing. Initial analyses of collections in spring indicate that the major invertebrate fauna of most streams of the St. Croix River and Big St. Margarets Bay Lake systems is dominated by mayflies (Ephemeroptera) or stoneflies (Plecoptera), and by species that are associated with clean (uncontaminated) water. in some streams where organic detritus has accumulated, diversity is reduced, and larger numbers of flies (Diptera), caddisflies (Trichoptera) and dragonflies (Odonata) may be found, but these are also forms that are associated with water of at least fair quality. Quantitative samples could not be taken in most cases, and so macroinvertebrate densities are not generally available.

3.7. Investigations in the field have yielded two plant species that are listed as rare for Nova Scotia. Elements of the Coastal Plain flora that persist on the shore of Big St. Margarets Bay Lake. Within the St. Croix River watershed, there are two principal areas of special interest from the perspective of rare or sensitive flora: an area of Kärst topography on the east side of the St. Croix River, below the St. Croix powerhouse, that harbors two rare orchids, and an old growth forest of Red spruce and Hemlock on the east side of Panuke Lake. Another old growth stand was once identified in the Shady Lake Brook watershed and unsuccessfully nominated as an IBP study site. Investigations regarding other species at risk in the watershed are ongoing.

This study constitutes the first extensive study of the St. Croix and Big St. Margarets Bay Lake systems. The conclusion is that the lakes and streams are generally unproductive, providing limited habitat for several species of fish. Productivity is mainly limited by physical and chemical characteristics, notably the intermittent nature of the streams, extremely low nutrient concentrations, absence of buffering capacity, and high acidity.

3.8 Archaeological resources in the watershed include a known pre-Contact site beside the St. Croix River below the St. Croix powerhouse. No other site investigations have apparently been conducted within the area of St. Croix and Big St. Margarets Bay Lake, but the region is considered by Nova Scotia Museum authorities to have high potential. A Management Strategy for archaeological resources that might be identified in the future has been drawn up.

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ACADIA ESTUARINE CENTRE FOR RESEARCH

Environmental Studies of the St. Croix River System, Nova Scotia

Final Report

15 September 2001

1. 0 Introduction.

During May through August 2001 the Acadia Centre for Estuarine Research conducted environmental studies of the St. Croix River system, which includes Panuke Lake and part of the Ingram River watershed. The work was carried out under contract to Minas Basin Pulp and Power Company Limited in response to Terms of Reference dated 15 February 2001 provided by the Nova Scotia Department of Environment and Labour for Renewal of Water Licenses for the St. Croix system.

Environmental surveys of the St. Croix system were primarily organised around three field campaigns scheduled for late May, July and October-November 2001, respectively. The first campaign was conducted between 22 May and 1 June; the second field campaign took place between 16 and 23 July. Field measurements, observations and collections were also made on many other days to ensure comprehensiveness of the studies.

All major objectives in meeting the Terms of Reference were achieved, with the exception of the fall series of studies, which will be completed in October. This report is organised with sections that correspond to the Terms of Reference. These sections parallel those in a companion report dealing with the Halfway River system.

1.1 Personnel.

The study was coordinated by Dr. Graham R. Daborn, Director of the Acadia Centre for Estuarine Research. The research team was composed of the following personnel:

Dr. Graham R. Daborn – Director, ACER, Acadia University
Dr. Michael Brylinsky –Honorary Research Associate, ACER
Ms. Ruth Newell, M.Sc. – E.C. Smith Herbarium, Acadia University
Mr. Michael Parker (B.Sc. Biol) – President, East Coast Aquatics
Ms. Dawn MacNeill (B.Sc.H. Environmental Science. 2001)
Ms. Kerri Seward (B.Sc. Environmental Science. 2001)
Ms. Melanie Barker (B.Sc.H. Environmental Science. 2001)
Mr. Steven Sandford (B.Sc. Environmental Science. 2001)
Ms. Susan Snyder (B.Sc.H. Environmental Science – in progress)
Mr. Leon deVreede (B.Sc. Environmental Science – in progress)
Ms. Marla MacAulay (B.Sc Biology – in progress).

Additional expertise and assistance was also provided by the following:

Dr. Trefor Reynoldson , National Water Research Institute and ACER
Dr. Ian Spooner – Associate Professor of Geology, Acadia University
Mr. Fred Scott (M.Sc.) – Acadia Museum
Dr. David Christianson – Nova Scotia Museum
Mr. Stephen Powell – Nova Scotia Museum
Dr. John Gilhen – Nova Scotia Museum
Dr. Alex Wilson – Nova Scotia Museum
Mr. George Archibald – NS Department of Natural Resources
Mr. Lawrence Benjamin – NS Department of Natural Resources
Mr. Douglas Parker – Bridgetown

1.2 Field Operations.

Field investigations on the St. Croix system, including Panuke Lake and its tributaries, were based at a field trailer at the Upper St. Croix Hydro Dam and Power Plant, provided by Minas Basin Pulp and Power Company Limited (MBPP). This provided reasonable access to shores and streams of Panuke Lake, allowing transport of extensive field equipment required for fish and limnological surveys. MBPP also provided a boat and motor needed in addition to two provided by ACER.

Access to the Big St. Margarets Bay Lake watershed was by road, courtesy of Bowater Mersey Company Ltd..

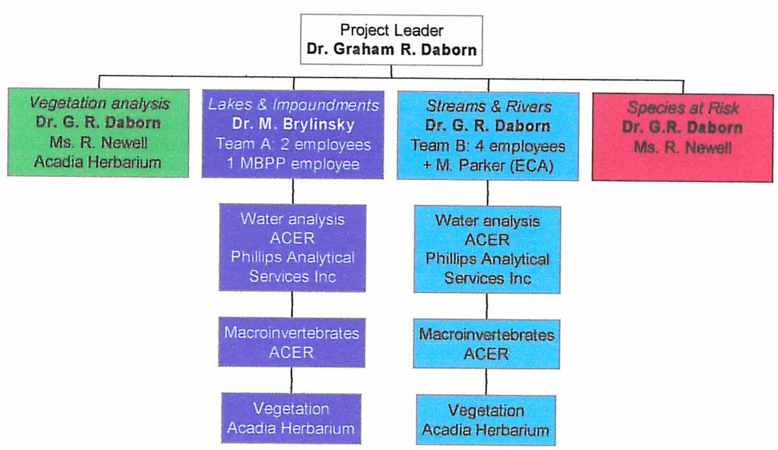
3.1 Environmental Studies of the St. Croix River and Big St. Margarets Bay Lake Systems

Field investigations were organized into the following activities, corresponding to sections of the Terms of Reference:

Water Quality (3.2)
Fish Surveys (3.3)
Shoreline and Littoral Zone Vegetation (3.4)
Fish Habitat (3.5)
Macroinvertebrates (3.6)
Species at Risk (3.7)

Two separate teams were constructed, one dealing primarily with stream studies, and the other with impoundments. Although in some respects the results involve overlapping information, the Report attempts to present information on lentic (i.e. impoundments) and lotic (flowing waters) habitats separately.

Dr. Michael Brylinsky supervised the work on the impoundments. Dr. Graham Daborn supervised the stream work, which was coordinated by Ms. Dawn McNeill. Mr. Michael Parker conducted the electrofishing surveys, and provided identification of fish captured. Data processing and analysis of invertebrates were a team effort.
Organisation of the study is as shown in Figure 3.1:



3.1.2. Laboratory Operations

Water samples for complete analysis were collected and sent to Phillip Analytical Services of Bedford, N.S. Analyses of other water and invertebrate samples were conducted at the Acadia Centre for Estuarine Research (ACER). Fish tissues for mercury analysis were prepared at ACER before being sent to Phillips Analytical Services for analysis.

In addition to field surveys, attempts have been made to identify sources of data from previous environmental work in the watersheds. Only two aspects have been identified. During the 1970s, provincial agencies conducted field surveys of many lakes in Nova Scotia, including Panuke Lake and Armstrong Lake, primarily to ascertain their suitability for stocking of brook trout. Basic limnological characteristics were provided, together with an assessment of fish habitat potential. The summaries are included as Appendices 3.1.1 and 3.1.2. In the 1970s also, a relatively untouched stand of old growth forest, mostly Red Spruce (*Picea rubens*) and Hemlock (*Tsuga canadensis*), in the Shady Lake Brook valley was nominated for consideration as a protected research area for the International Biological Program (IBP). The nomination was apparently not successful.

In 2000 a survey of many rivers and streams in the inner Bay of Fundy was conducted by federal and provincial authorities. This included the St. Croix River, in which a total of 5 Atlantic salmon (*Salmo salar*) parr were collected in four transects. Apart from the above, the studies reported here appear to be the first systematic investigations of lakes, impoundments and streams in the St. Croix—Big St. Margarets Bay Lake system.

3.2 Water Quality

During field campaigns in spring and summer, water samples were taken for analysis of major chemical constituents of both lotic and lentic waters. The objective was to provide an assessment of the water quality in the St. Croix River system, including Big St. Margarets Bay Lake and its watershed, and to provide a basis for interpreting results of faunal studies. Four impoundments were studied: Big St. Margarets Bay Lake, Panuke Lake, Parsons Dam reservoir and the Trash Rack reservoir. In addition, segments of the the St. Croix River, of 6 tributaries entering Panuke Lake (Stoney Brook, Thans Brook, Armstrong River, Southwest Brook, Shady Brook and the canal between Big St. Margarets Bay Lake and Panuke Lake), and Piney Brook (entering Big St. Margarets Bay Lake) were chosen as representative lotic habitats.

3.2.1 Methods

A. Impoundments

Depth profiles and water samples for water quality analyses were collected during both spring and summer at one or more stations at each impoundment (see Figures 3.2.1 - 3.2.3). In most cases, the sampling station was located at the deepest part of the impoundment. For Panuke Lake and Big St. Margarets Bay Lake, which contain multiple basins, sampling was carried out at a number of stations, each of which corresponded to a major basin. A Magellan 315 GPS was used to determine the UTM coordinates of each station.

Water temperature and conductivity depth profiles were measured with a Yellow Springs Instrument 6920 Data Sonde. Surface water samples for water chemistry, suspended particulate matter (SPM) and chlorophyll *a* analyses were collected at depths of 0.5 or 1 m. Bottom water samples for the same parameters were collected at 15 m depth or, when water column stratification occurred or depths were less than 15 m, one meter above the bottom. Water samples for dissolved oxygen analyses were collected in BOD bottles from the same surface and bottom depths as for water chemistry. When water column stratification was evident, dissolved oxygen samples were collected at a depth corresponding to the depth of the thermocline. In most cases, dissolved oxygen profiles were also collected with the Yellow Springs Instrument 6920 Data Sonde.

Figure 3.2.1. Location of water quality sampling stations at the lower St. Croix impoundments.

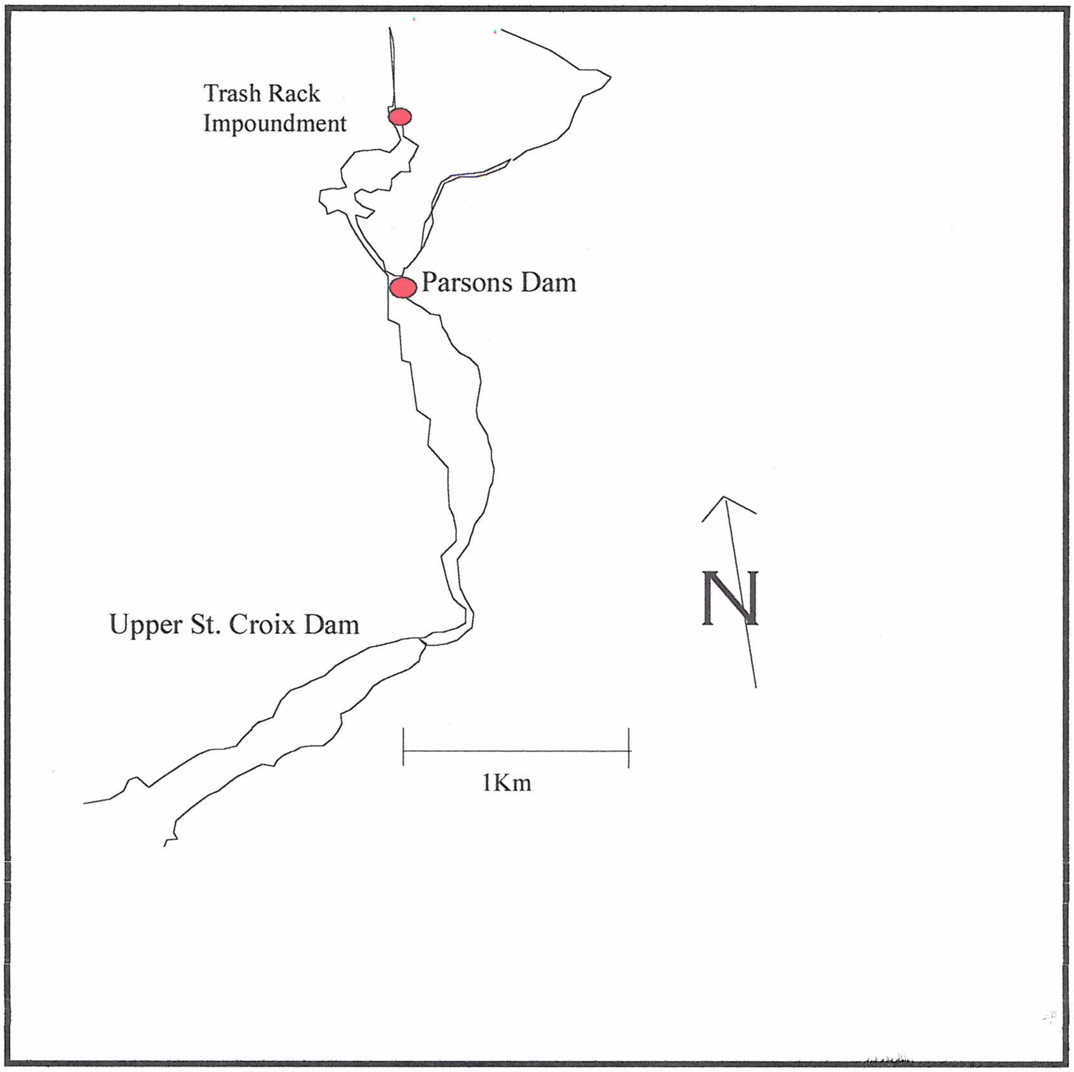


Figure 3.2.2. Location of spring water quality sampling stations at Panuke and Big St. Margarets Bay Lakes.

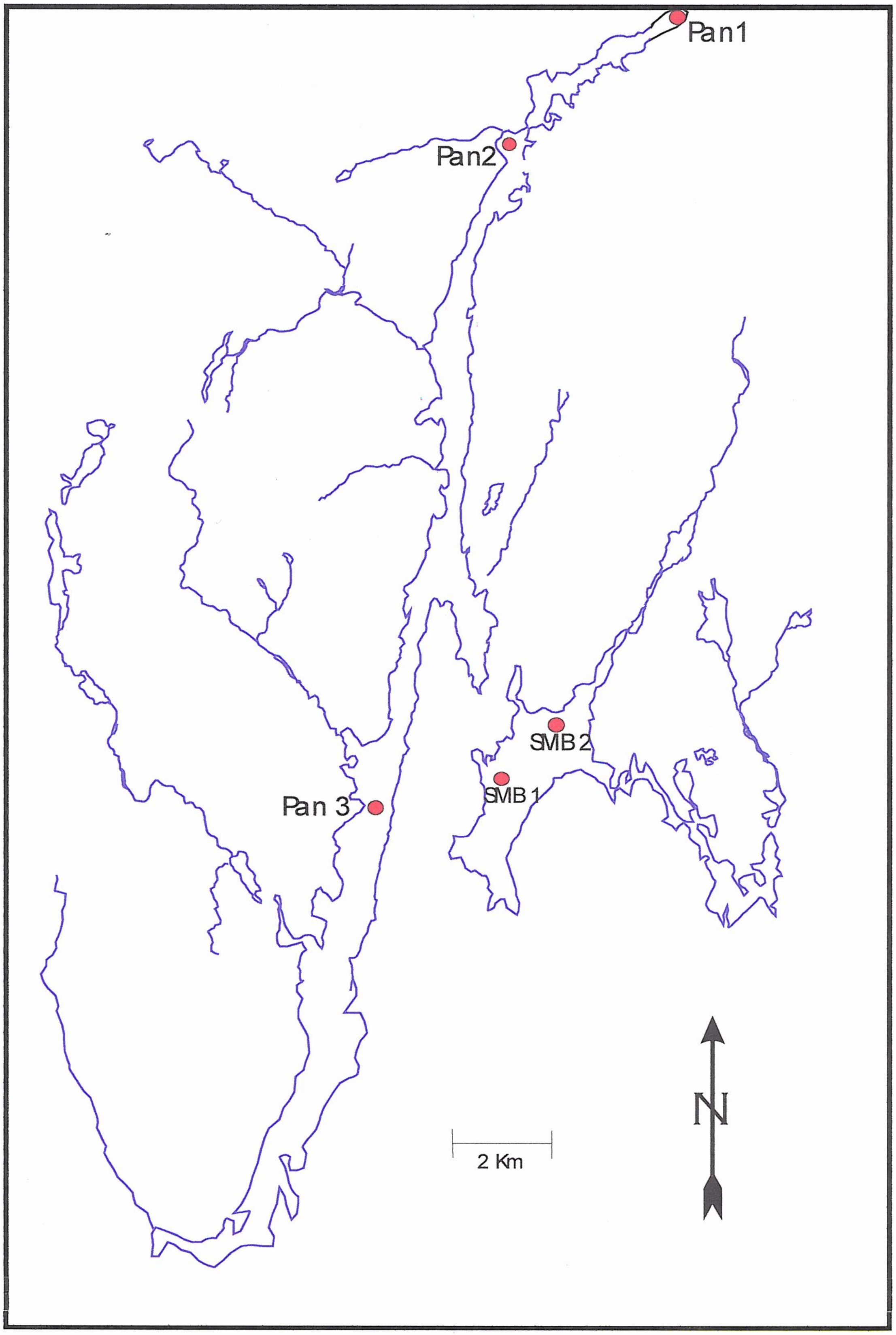
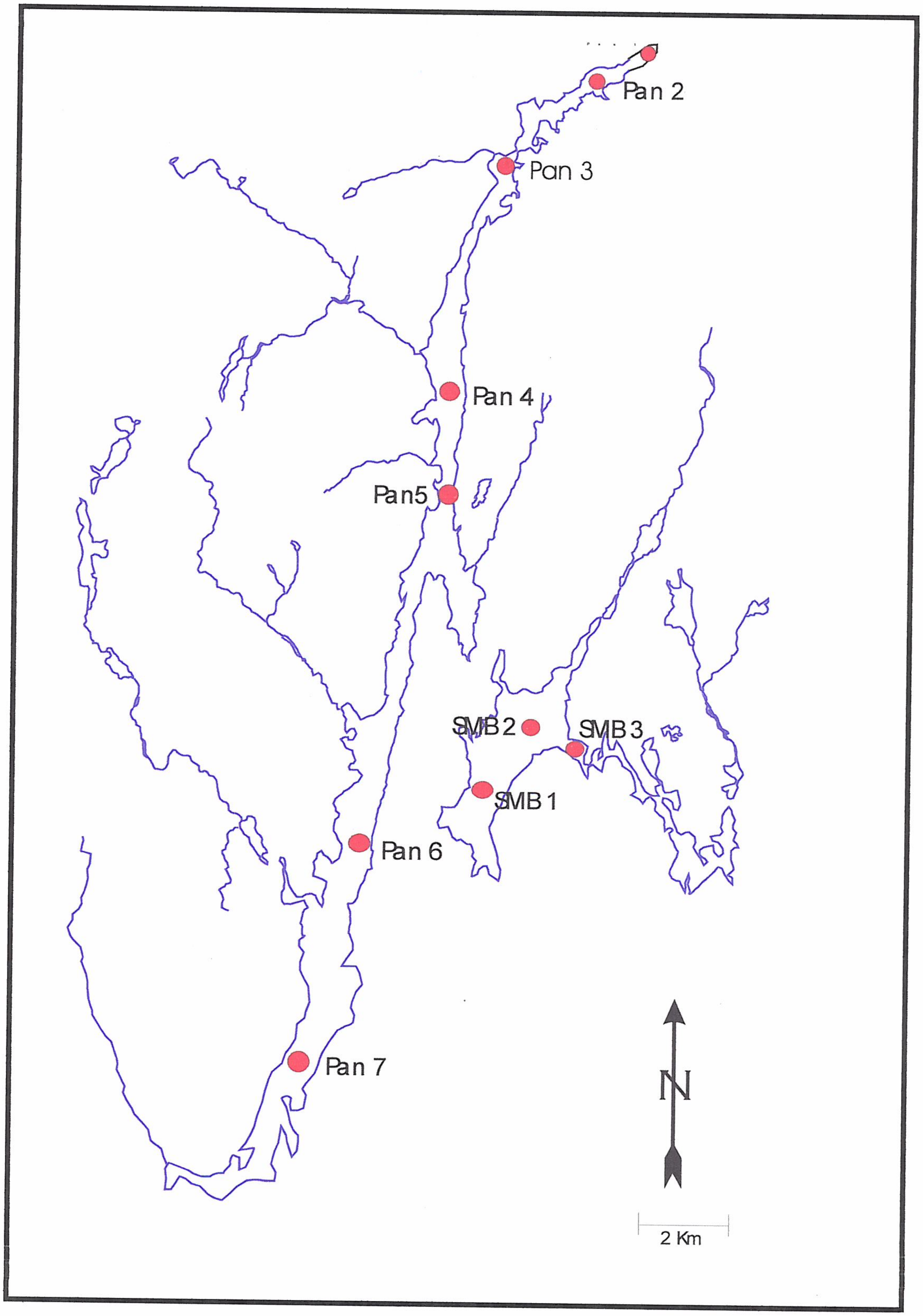


Figure 3.2.3 Location of summer water quality sampling stations at Panuke and Big St. Margarets Bay Lakes.



Total SPM was measured by filtering up to 1 litre of water through pre-weighed Watman GF/C glass fibre filters and re-weighing the filters after oven drying at 70 °C to a constant dry weight.

Samples for phytoplankton chlorophyll *a* and pheophytin measurements were collected in 1 litre polyethylene containers and stored refrigerated until analysis (usually within 12 h of collection). The samples were filtered through Watman GF/C filters under gentle vacuum (<20 mm Hg) and chlorophyll extracted from the filters by adding 18 ml of 95 percent acetone and storing the sample refrigerated in the dark for 24 hr. After extraction the samples were centrifuged at 2500 rpm for 5 min, decanted into a 5 cm path length cuvette and absorption measured spectrophotometrically at 665 and 750 nm before and after acidification with 0.1 mL of 10 percent HCl. Chlorophyll *a* and pheophytin concentrations were calculated according to the equations presented by Wetzel and Likens (1990).

B. Streams

Water samples from flowing waters for laboratory analysis were taken by filling pre-sterilized and washed 250 and 500 mL bottles by dipping beneath the surface. Subsamples for Total Organic Carbon and Total Kjeldahl Nitrogen were transferred to brown glass bottles or prepared centrifuge tubes for preservation.

Routine field determinations of temperature and conductivity, supported by measurements of pH and dissolved oxygen at various times, were made at all stream electrofishing sites to amplify results from water samples analysed in the laboratory. Temperature and conductivity at stream sites were measured with a YSI S-C-T meter. Water samples for dissolved oxygen were taken using a Van Dorn water sampler, and analysed using the standard Winkler method at the Acadia Centre for Estuarine Research. pH was measured in streams using a portable meter.

During May and early June, when flows were still quite high, water samples were obtained at each electrofishing site for analysis of suspended sediments. One litre of water was filtered through a pre-dried and pre-weighed 0.45 μm Millipore™ filter, and then dried and weighed.

Water samples from the impoundments and streams were shipped on ice to Philip Analytical Services (Bedford, NS) for analysis.

3.2.2 Results: Impoundments.

Results of all water chemistry analyses carried out by Phillips Analytical Services are contained in Appendix 3.2.1. Table 3.2.1 provides a summary of a number of these parameters as well as of the parameters analyzed by the ACER laboratory.

Water Temperature and Water Column Stratification

Most of the impoundments exhibited weak temperature stratification during the spring (late May- early June) survey (Figures 3.2.4-3.2.16). At most stations, temperature stratification became more pronounced during summer. Thermocline depths and the degree of temperature difference between surface and bottom waters varied greatly, especially at Panuke Lake where there was a general trend of shallower thermoclines and stronger stratification in the more southerly basins. This difference is probably due to the effects of wind fetch and proximity to the dam. The predominant wind direction during summer is from the south, which results in a much longer fetch, and correspondingly deeper thermocline, for the more northerly areas of the Lake. The more northerly areas are also subject to removal of deep, cold water during draw down for hydropower generation, which further decreases the thermocline depth and temperature difference between surface and bottom waters.

Table 3.2.1 Summary of selected water quality parameters for Impoundments.

SITE	STATION	Date	Sample Depth (m)	Temp (Celsius)	Conductivity (uS/cm)	Total Hardness (mg/L)	pH	Alkalinity (mg/L)	Chlorophyll a (ug//L)	Phaeophytin (ug/L)	SPM (mg/L)	Secchi Depth (m)	Turbidity (NTUs)	Color (TCUs)	Dissolved Oxygen (mg/L)	DO Saturation (%)
SPRING SURVEY																
Big St. Margarets Bay Lake	SMB1	30 May	0.5	14.8	26	3.5	5.2	<1	1.4	1.5	1.3	2.1	0.6	27	9.5	93
"	SMB1	30 May	14	8.1	24	3.6	5.2	<1	1.0	0.6	1.5	-	0.2	25	10.1	85
"	SMB2	30 May	0.5	16.0	24	3.2	5.3	<1	0.8	2.4	1.8	2.2	0.2	26	9.7	97
"	SMB2	30 May	14	8.2	23	3.6	5.2	<1	0.2	1.9	0.8	-	<0.1	29	10.1	85
Panuke Lake	PAN1	28 May	0.5	18.0	21	3.0	5.4	<5	0.6	2.7	2.4	1.7	0.8	21	9.5	100
"	PAN1	28 May	14	11.1	22	4.1	5.3	<5	0.0	53.8	224.0	-	26.8	25	10.2	92
"	PAN2	28 May	0.5	15.3	21	3.0	5.3	<5	1.3	6.0	6.4	1.8	0.6	25	10.0	99
"	PAN2	28 May	9	13.8	22	3.4	5.5	<5	1.9	11.4	99.0	-	6.3	26	9.9	95
"	PAN3	29 May	0.5	13.3	24	2.5	5.1	<5	0.9	2.2	1.4	1.9	0.3	29	10.1	96
"	PAN3	29 May	14	8.5	24	2.5	5.0	<5	0.6	0.8	1.3	-	0.4	29	11.1	94
Parsons Dam	PD	06 June	0.5	14.1	21	-	5.8	-	0.3	1.6	1.6	2.3	0.8	-	10.7	103
"	PD	06 June	10	9.7	21	-	5.5	-	0.3	1.9	2.6	-	0.2	-	9.6	83
Trash Rack	LSC	06 June	0.5	13.7	21	3.5	6.0	<5	0.3	1.5	1.4	2.0	0.8	24	9.9	95
"	LSC	06 June	4.5	13.6	21	3.5	5.7	<5	4.6	3.4	0.0	-	0.7	24	9.9	94
SUMMER SURVEY																
Big St. Margarets Bay Lake	SMB1	31 July	2	22.5	20	3	5.5	<1	3.4	0.0	0.0	2.4	0.2	19	8.3	95
"	SMB1	31 July	7	20.3	10	3.0	5.6	1	1.1	1.2	1.1	-	0.3	21	7.2	79
"	SMB1	31 July	15	8.5	21	3.2	5.5	<1	-	-	1.2	-	0.2	24	7.6	64
"	SMB1	31 July	25	7.1	21	3.2	5.5	2	1.3	0.4	0.0	-	0.3	26	6.4	52
"	SMB2	31 July	2	23.0	20	3.2	5.7	<1	3.4	0.0	0.0	2.0	0.4	19	8.0	92
"	SMB2	31 July	7	9.3	20	3.0	5.5	<1	1.7	0.0	1.8		0.5	21	7.4	64
"	SMB2	31 July	11	10.0	-	-	-	-	-	-	-	-	-	-	7.8	68
"	SMB2	31 July	15	9.3	-	-	-	-	-	-	-	-	-	-	7.4	63
"	SMB2	31 July	23	9.1	21	3.6	5.4	<1	1.7	0.5	2.7		0.2	25	7.3	63
"	SMB3	31 July	2	22.7	20	3.2	5.6	<1	1.9	0.4	1.3	2.3	0.4	19	8.0	92
"	SMB3	31 July	7	9.5	21	3.6	5.5	<1	1.7	0.7	2.8	-	0.6	24	3.2	28
"	SMB3	31 July	11	7.3	22	3.6	5.7	1	2.3	2.7	-	-	1.2	32	1.6	13
Panuke Lake	PAN1	23 July	2	25.0	19	3.0	5.8	<1	2.7	0.3	1.5	2.2	0.7	18	8.7	104
"	PAN1	23 July	19	9.6	20	3.2	5.8	1	0.8	0.0	1.3	-	0.5	20	6.4	56
"	PAN2	23 July	2	24.2	19	3.0	5.7	1	3.1	0.7	8.0	1.9	0.5	18	7.9	93
"	PAN2	23 July	15	15.3	20	3.0	5.9	1	2.4	2.7	8.0	-	6.1	46	5.2	51
"	PAN3	24 July	2	22.9	20	3.2	5.7	1	2.9	0.8	1.8	2.4	0.5	21	7.9	91
"	PAN3	24 July	14	22.6	20	3.0	5.5	1	1.7	0.4	1.7	-	0.8	23	8.0	92
"	PAN4	24 July	2	22.7	20	2.7	5.5	2	3.0	0.0	1.1	2.0	0.3	20	7.9	91
"	PAN4	24 July	10	13.9	19	3.0	5.5	1	0.8	0.0	0.0	-	<0.1	22	6.3	60
"	PAN4	24 July	14	11.8	19	3.0	5.4	2	0.6	0.0	0.2	-	<0.1	22	5.4	49
"	PAN5	24 July	2	23.3	19	2.7	5.4	1	2.8	0.0	1.5	2.0	0.3	21	6.7	78
"	PAN5	24 July	9	14.0	20	2.7	5.4	1	1.1	0.0	0.7	-	0.3	24	6.2	60
"	PAN5	24 July	20	8.6	20	3.0	5.5	2	0.8	0.0	0.0	-	0.3	24	4.2	36
"	PAN6	25 July	2	22.1	20	2.7	5.3	<1	2.0	0.0	0.6	2.0	0.6	22	7.9	89
"	PAN6	25 July	9	14.8	20	2.5	5.2	<1	2.3	0.0	0.2	-	0.1	24	7.7	75
"	PAN6	25 July	30	9.3	20	2.5	5.1	<1	0.7	0.0	0.4	-	<0.1	26	7.7	66
"	PAN7	25 July	2	21.4	20	2.5	5.2	<1	1.9	0.0	0.2	2.0	0.1	23	8.2	92
"	PAN7	25 July	11	13.3	31	2.5	5.2	<1	0.6	0.0	0.4	-	0.2	26	8.0	76
"	PAN7	25 July	25	9.4	21	2.5	5.2	<1	0.0	0.2	0.2	-	0.2	26	8.0	69
Parsons Dam	PD	08 Aug	1	23.0	-	-	-	-	-	-	2.6	2.6	-	-	7.1	82
"	PD	08 Aug	8	13.9	-	-	-	-	-	-	-	-	-	-	3.8	36
"	PD	08 Aug	10	10.2	-	-	-	-	-	-	-	-	-	-	0.4	4
"	PD	08 Aug	11	9.8	-	-	-	-	-	-	-	-	-	-	0.0	0
Trash Rack	LSC	19 July	0.5	21.7	20	3.0	6.2	<1	0.0	1.4	1.7	2.1	0.8	20	7.2	81
"	LSC	19 July	4.5	21.5	20	3.0	6.0	<1	0.0	1.4	1.3	-	1.2	20	7.1	80

The station closest to the dam (PAN1 – Figure 3.2.4), exhibited an unusual temperature stratification with two thermoclines, a shallow one at about 6 m depth and a much deeper one at a depth of about 16 m. A similar condition was present at PAN2 (Figure 3.2.5), but was less well developed. This is most likely a result of the removal of bottom water during draw down.

Figure 3.2.4 Temperature, dissolved oxygen and percent dissolved oxygen saturation depth profiles for station PAN1 during spring (o) and summer (x).

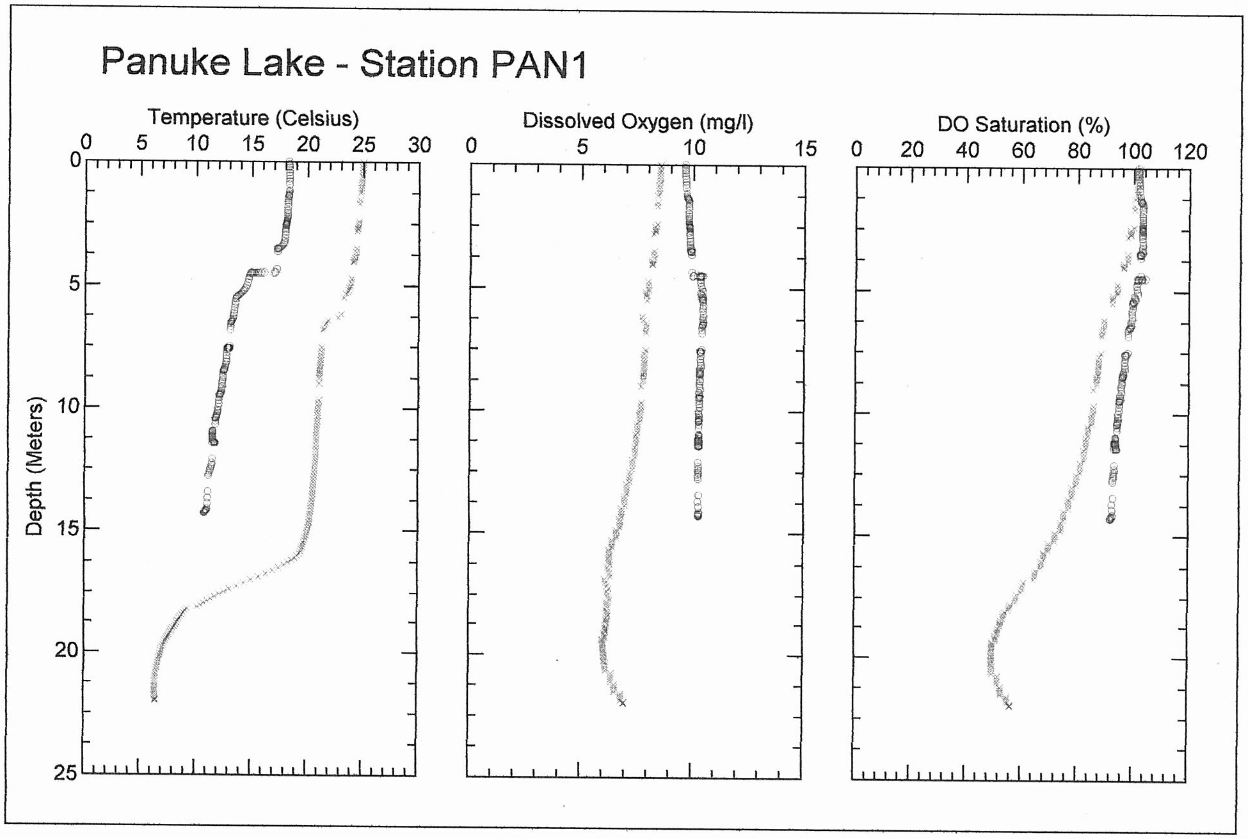


Figure 3.2.5 Temperature, dissolved oxygen and percent dissolved oxygen saturation depth profiles for station PAN2 during spring (o) and summer (x).

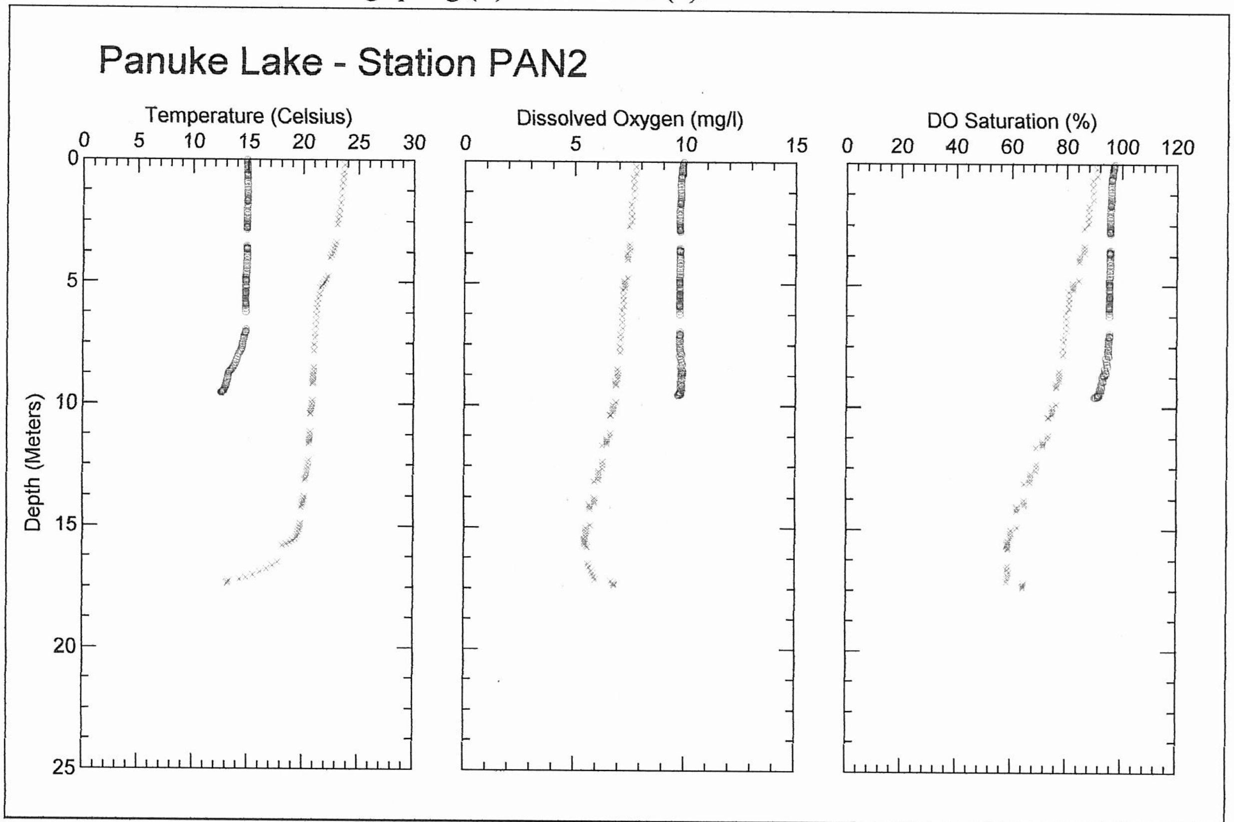


Figure 3.2.6 Temperature, dissolved oxygen and percent dissolved oxygen saturation depth profiles for station PAN3 during spring.

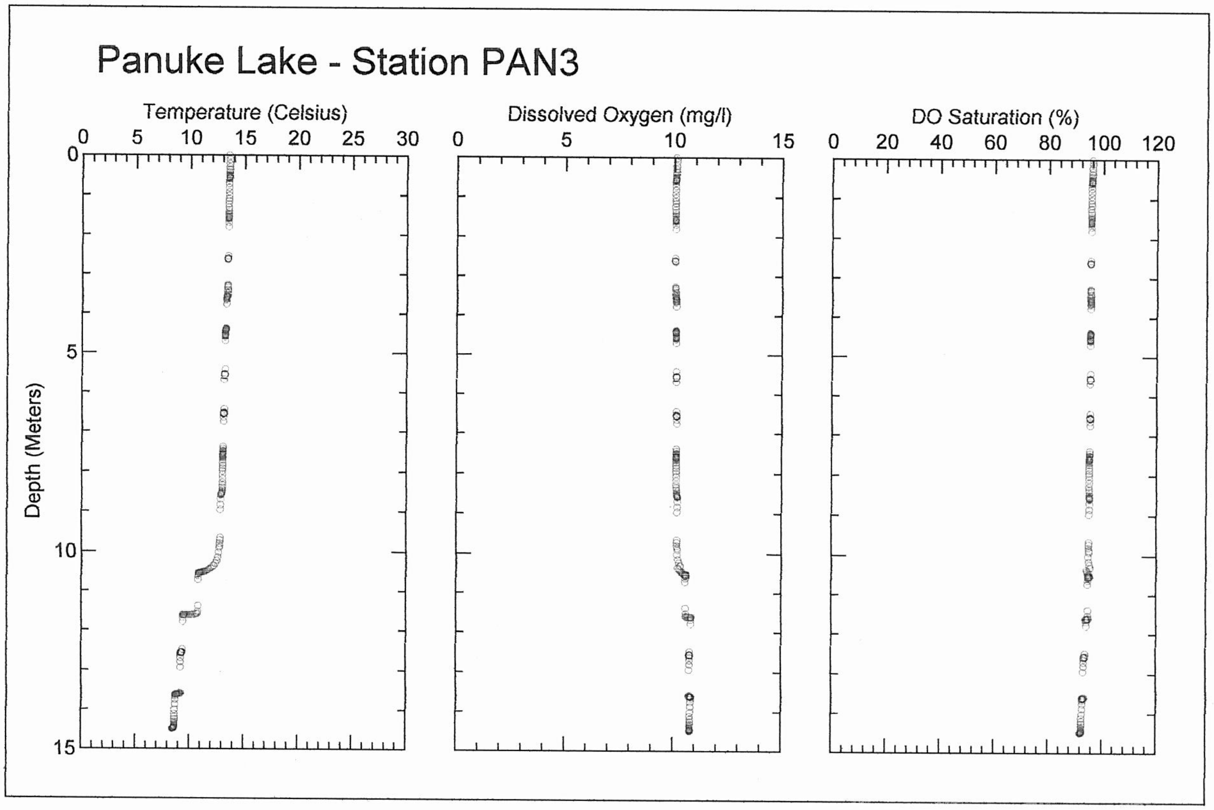


Figure 3.2.7 Temperature, dissolved oxygen and percent dissolved oxygen saturation depth profiles for station PAN3 during summer.

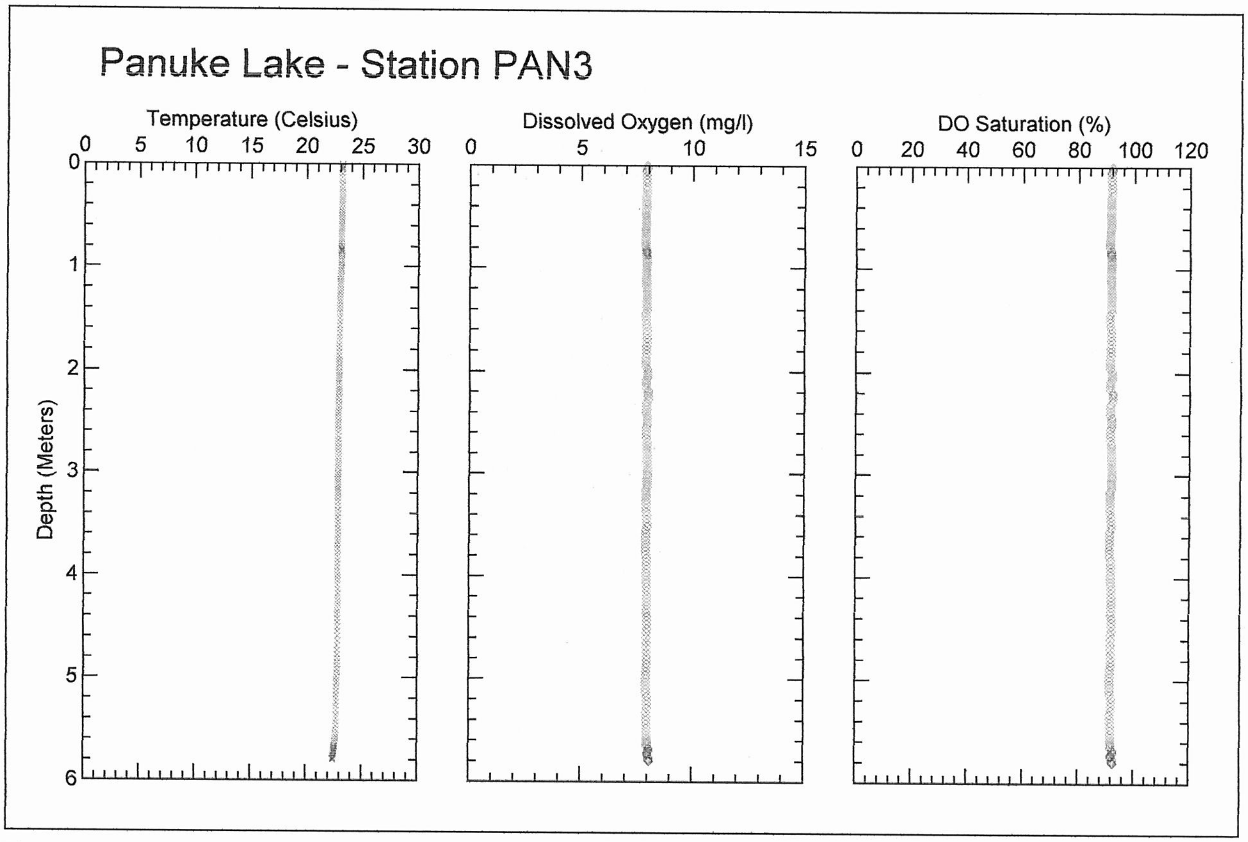


Figure 3.2.8 Temperature, dissolved oxygen and percent dissolved oxygen saturation depth profiles for station PAN4 during summer.

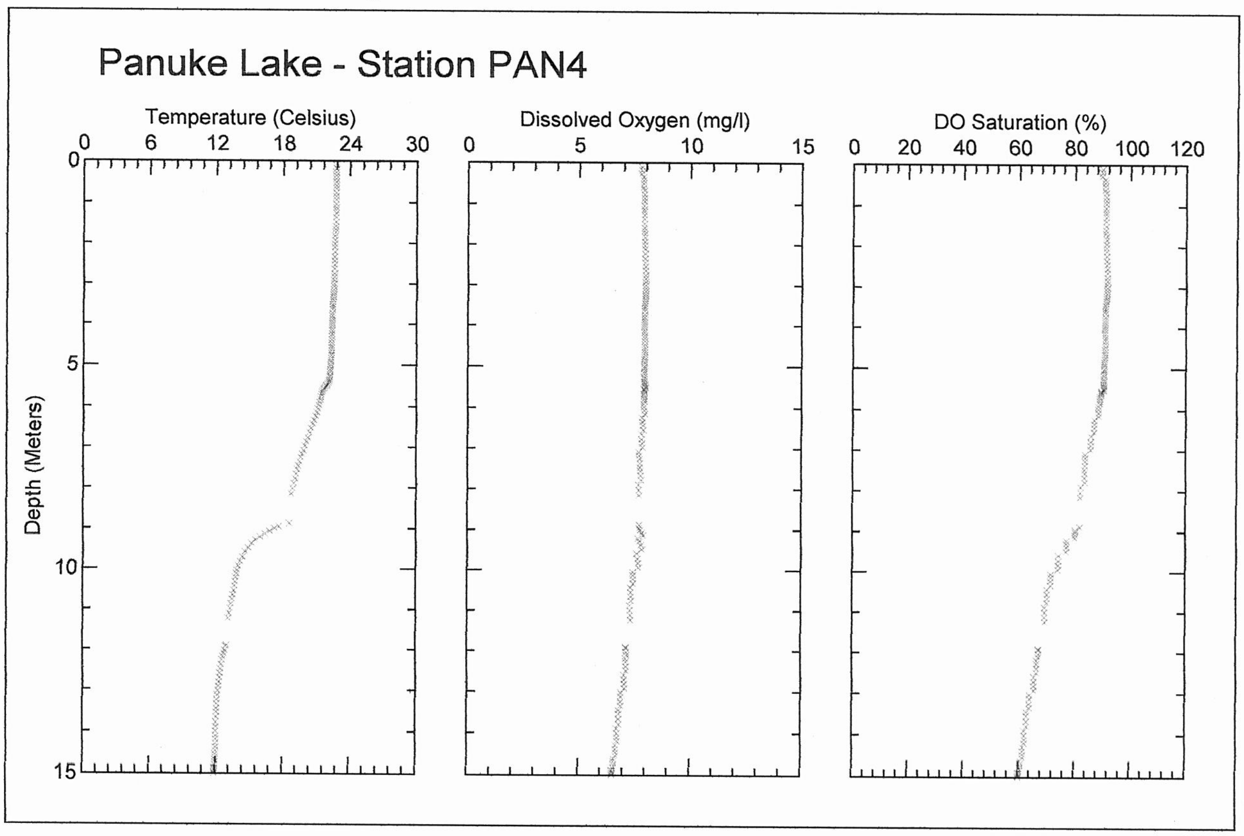


Figure 3.3.9 Temperature, dissolved oxygen and percent dissolved oxygen saturtion depth profiles for station PAN5 during summer.

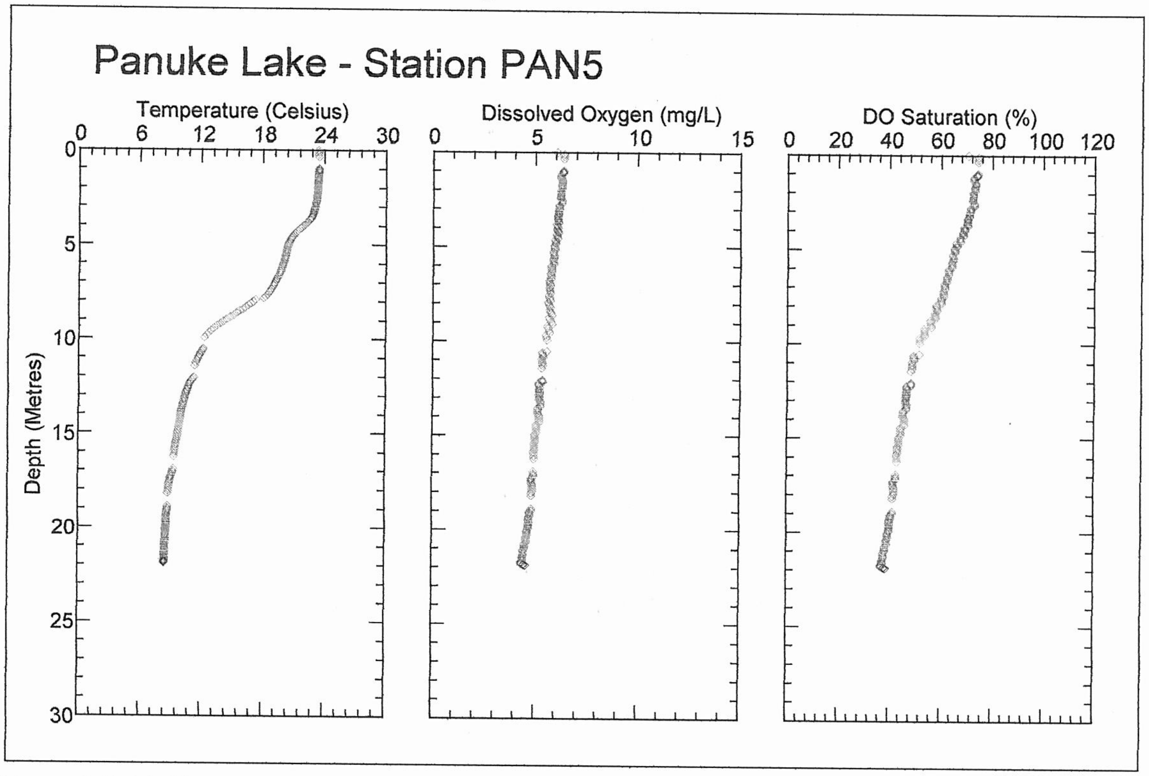


Figure 3.2.10 Temperature, dissolved oxygen and percent dissolved oxygen saturation depth profiles for station PAN6 during summer.

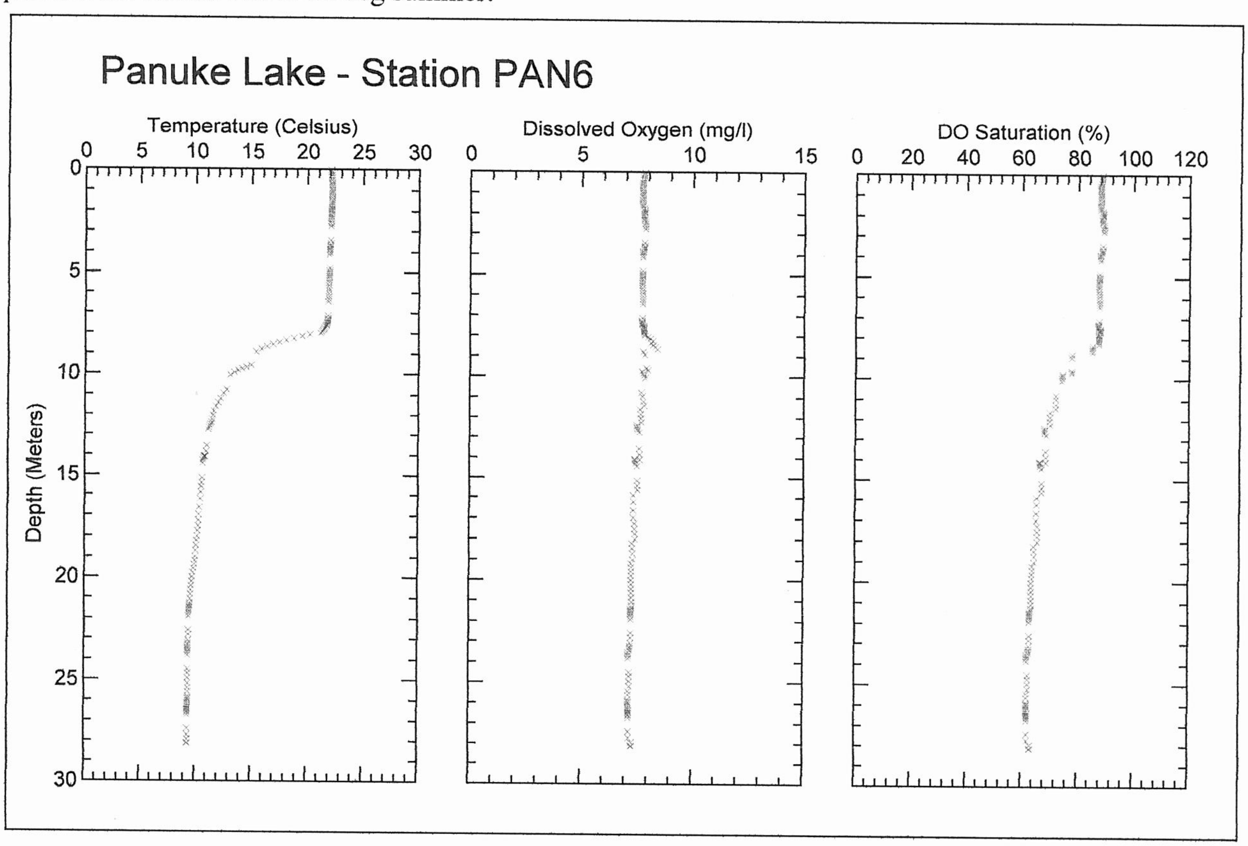


Figure 3.2.11 Temperature, dissolved oxygen and percent dissolved oxygen saturation depth profiles for station PAN7 during summer.

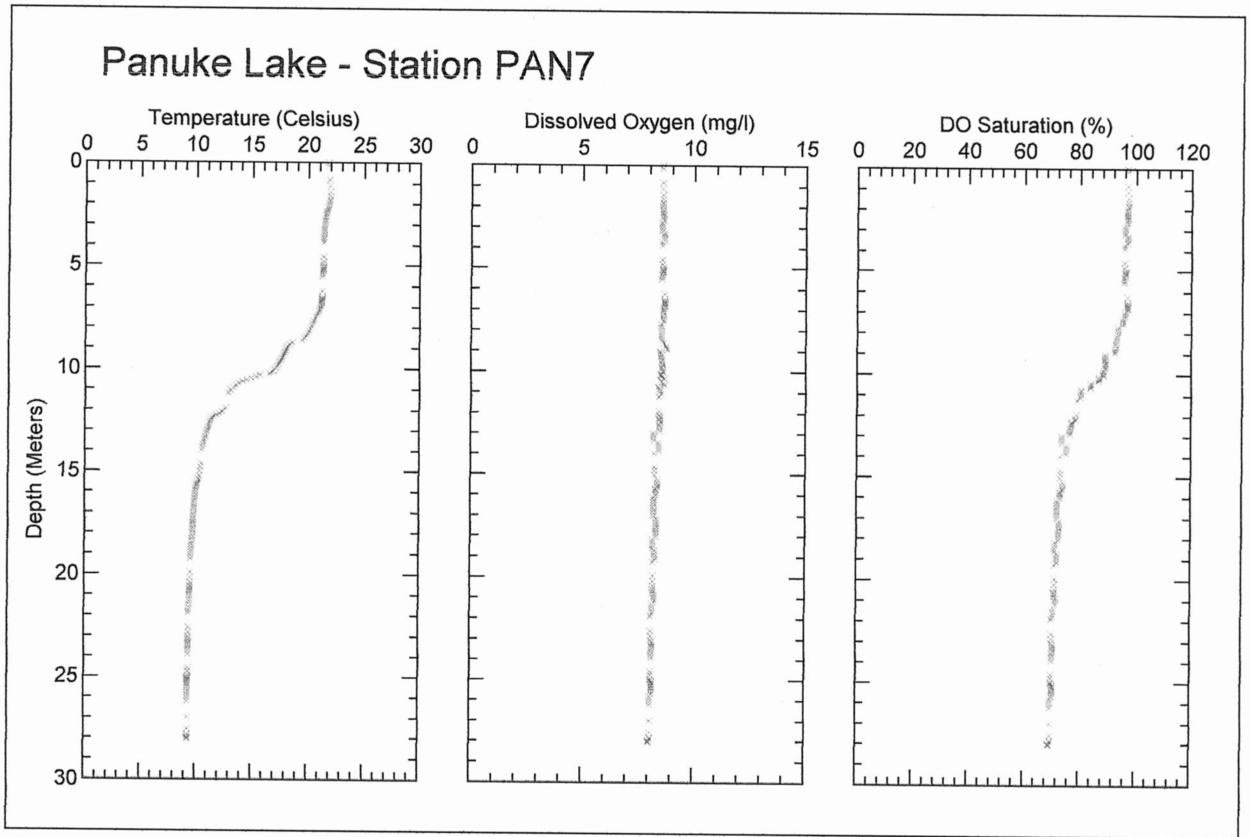


Figure 3.2.12 Temperature, dissolved oxygen and percent dissolved oxygen saturation depth profiles for station SMB1 during spring (o) and summer (x).

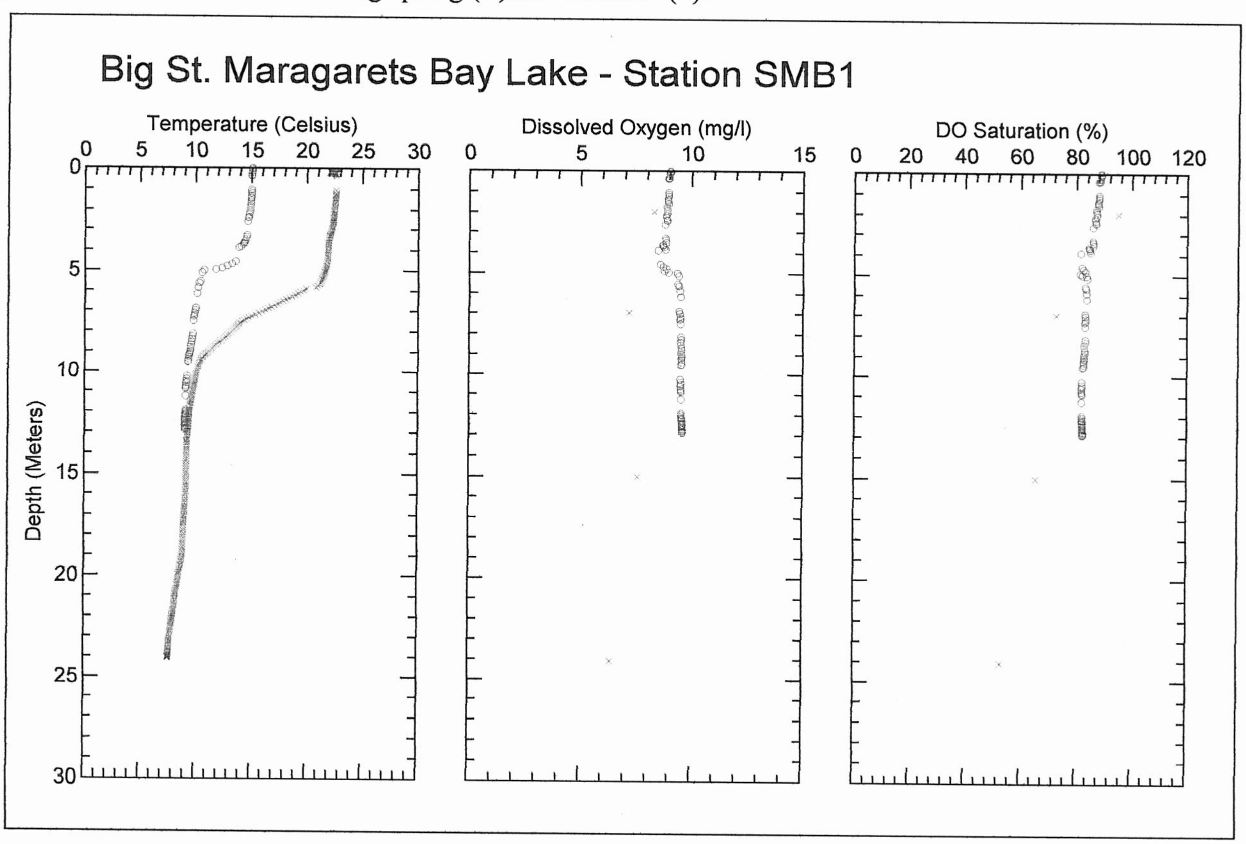


Figure 3.2.13 Temperature, dissolved oxygen and percent dissolved oxygen saturation depth profiles for station SMB2 during spring (○) and summer (x).

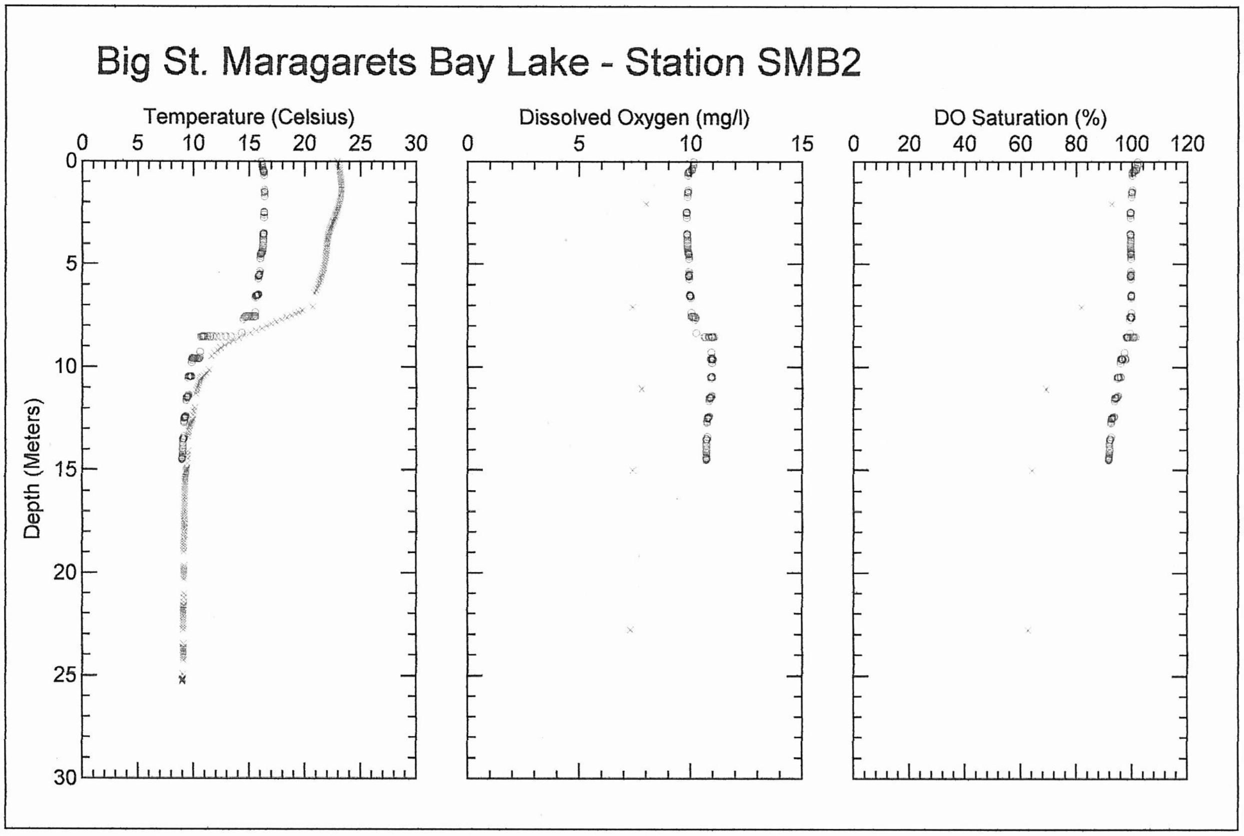


Figure 3.2.14 Temperature, dissolved oxygen and percent dissolved oxygen saturation depth profiles for station SMB3 during summer.

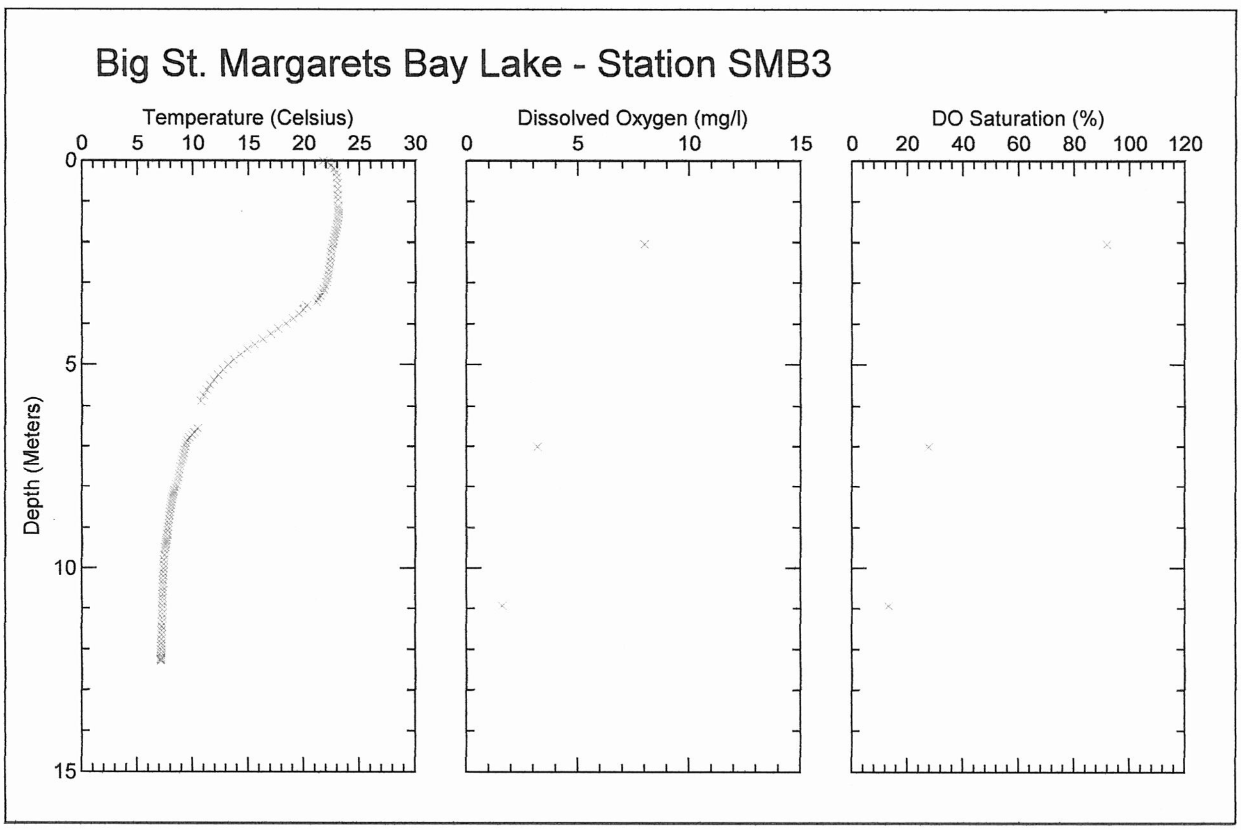


Figure 3.2.15 Temperature, dissolved oxygen and percent dissolved oxygen saturation depth profiles for Parsons Dam reservoir during spring (○) and summer (x).

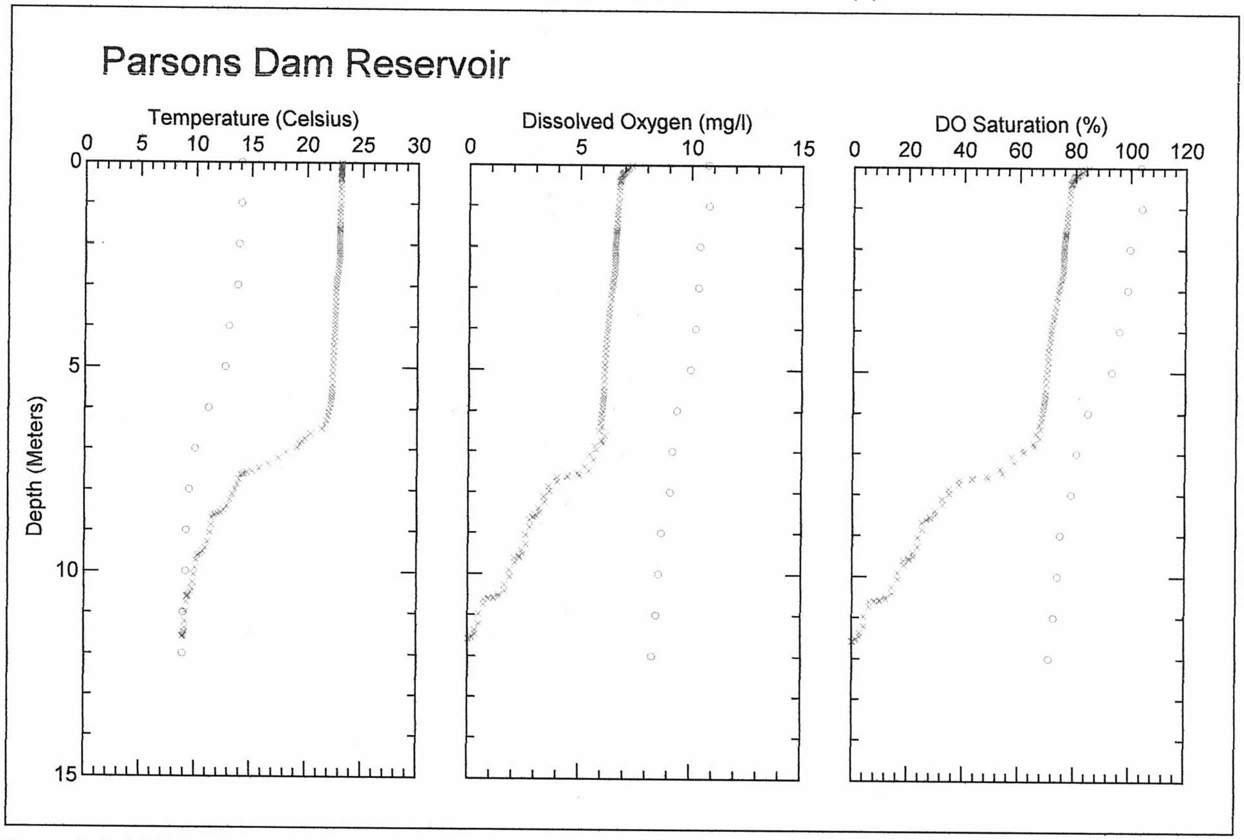
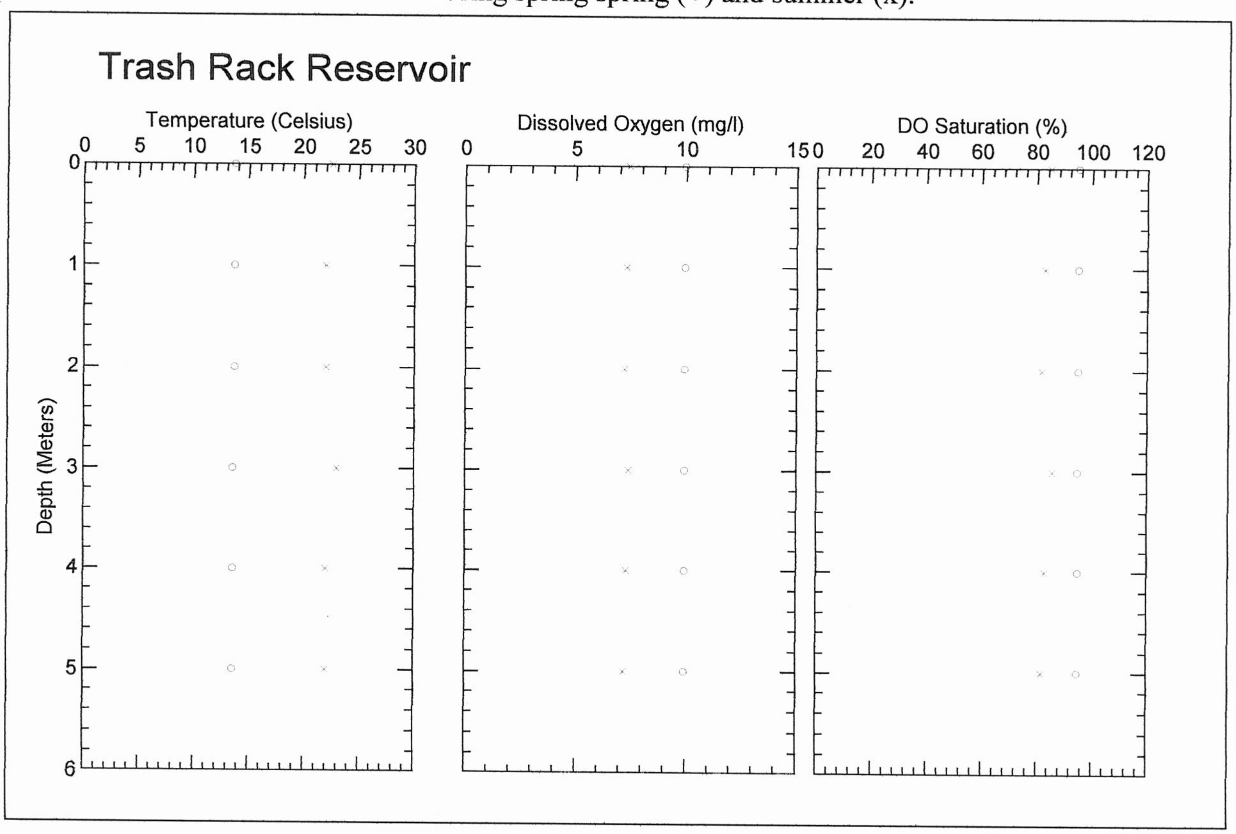


Figure 3.2.16 Temperature dissolved oxygen and percent dissolved oxygen saturation depth profiles for the Trash Rack reservoir during spring spring (○) and summer (x).



Big St. Margarets Bay Lake was strongly stratified during summer with a thermocline between 6 and 9 m (Figures 3.2.12- 3.2.14). The two reservoirs located below the Upper St. Croix (Panuke Lake) dam were quite different from each other. Parsons Dam reservoir stratified very strongly (Figure 3.2.15) whereas the Trash Rack reservoir never became stratified (Figure 3.2.16).

Dissolved Oxygen and Percent Dissolved Oxygen Saturation

Dissolved oxygen concentrations at Panuke and Big St. Margarets Bay Lake varied little with depth (Figures 3.2.4-3.2.14). During spring, percent dissolved oxygen saturation was always above 90 percent except at Big St. Margarets Bay Lake where the deeper waters had values closer to 85 percent. Summer percent saturation values varied much more, but none of the stations, with the exception of PAN5 and SMB3, had values below 50 percent.

Parsons Dam reservoir (Figure 3.2.15) was the only site that became anaerobic below the thermocline during summer. The Trash Rack reservoir had little variation in dissolved oxygen with depth.

Secchi Depth, Color, Turbidity and SPM

Secchi disk depths ranged from 1.7 to 2.4 m. There was little difference between spring and summer. SPM and turbidity levels were generally low at all times in all impoundments with the exception of two samples taken at 9 and 15 m depth at the upper Panuke Lake stations (PAN1 and PAN2) during spring. In these instances, SPM and turbidity levels were exceptionally high. With the exception of one high value of 46, true colour ranged between 19 and 29 TCUs. These values are moderately high and typical of the brown, humic stained water common in Atlantic Maritime lakes.

Water Chemistry

Total Hardness, Conductivity, Alkalinity and pH

Total hardness and conductivity values were very low, less than 5 $mg.L^{-1}$ and 26 $\mu S.cm^{-1}$ respectively, in all impoundments, and showed little seasonal variation. Alkalinity was either very low or below the limits of detection. pH values were also low and mostly in the range of 5.2-5.5. The Parsons Dam and Trash Rack reservoirs had slightly greater pH values than either Big St. Margarets Bay and Panuke Lake. It is obvious that all of the impoundments are being impacted by acid precipitation.

Nutrients, Chlorophyll *a* and Trophic Status

Nitrogen and phosphorus, the two most important nutrients determining the trophic status of freshwater systems, were in very low concentrations in all impoundments. Phosphorus, nitrate and nitrite were usually below detectable levels. The only nutrient present in substantial concentrations was ammonia, and this occurred only during the summer in bottom waters having low dissolved oxygen concentrations.

Spring chlorophyll *a* values were very low in all of the impoundments. In Big St Margarets Bay and Panuke Lake, summer surface water chlorophyll *a* values were higher, ranging between 1.9 and 3.4 $\mu g.L^{-1}$, values that are typical of oligotrophic lakes. Big St. Margarets Bay Lake had the highest summer chlorophyll *a* levels. Chlorophyll *a* concentrations were always very low in the Parsons Dam and Trash Rack reservoirs.

Metals

The concentration of aluminium, iron, zinc and copper measured in surface and bottom water samples is contained in Appendix 3.2.1. In most cases, levels of zinc and copper were below the Canadian Water Quality Guidelines for freshwater aquatic life established by the Canadian Council of Resource and Environment Ministers (1996). In contrast, aluminium and iron were usually above the guidelines, which is usual for when pH levels are below 6.0.

3.2.3 Results: Streams

Complete water quality results obtained from samples at the St. Croix and Big St. Margarets Bay Lake system electrofishing sites and sent for laboratory analysis are presented in Appendices 3.2.2 and 3.2.3. This section highlights specific results and characteristics that describe the overall quality of the streams as a habitat, with particular reference to fish habitat and seasonal characteristics.

pH: The waters of the tributary streams entering Panuke Lake and Big St. Margarets Bay Lake are, without exception, acidic. Both watersheds are underlain by granitic rocks, and covered (except for areas of active forestry) by softwoods; bogs and forested slopes dominated by coniferous trees tend to yield water that is acidic.

In spring and summer, pH in the St. Croix streams was not above 5.3, and several were well below 5. Values in the St. Margarets Bay Lake system were slightly higher, but all are marginal from the point of salmonid reproduction, which is eliminated at pH values <5.2.

One sample station (SC6) is on the original course of the St. Croix River below Parsons Dam. pH values here were closer to neutral (6.6-6.8) as a result of the local water supply. This stretch receives little or no water from the acid-stressed tributaries above Upper St. Croix Dam.

Alkalinity: Alkalinity values in spring were very low, <5 $mg.L^{-1}$, which was the level of detection provided by the laboratory at that time. In summer, alkalinity values throughout were so low as to be undetectable, except for the St. Croix River sample (SC6) at which a small amount of alkalinity was recorded—again a consequence of receiving little or no outflow from Panuke Lake.

Alkalinity is a measure of the buffering capacity of water: the ability to neutralise hydrogen ions. It is related to the concentrations of salts, particularly carbonates and phosphates, that are usually derived from the weathering of sedimentary rocks. In the St. Croix and Ingram River systems (including Big St. Margarets Bay Lake), there are no carbonate-bearing sediments, and the concentrations of ions such as calcium, magnesium, carbonates and bicarbonates, are also very low (Appendices 3.2.2 and 3.2.3). It is worth noting, however, that the concentrations of sodium and chloride ions are relatively much higher than carbonates and bicarbonates; this is a feature of many maritime oligotrophic waters.

Hardness: Hardness is a parameter related to the concentrations of cations such as calcium and magnesium, which will bind with available anions such as bicarbonate, carbonate, sulphate and chloride. This measure is related, therefore, to some of the parameters giving rise to alkalinity, but is not identical with it, and does not express the capacity of the water to absorb acid ions.

Hardness values throughout were extremely low (<3.2 $mg.L^{-1}$) in spring, and only slightly higher in summer (<7 $mg.L^{-1}$). The exception, again was the main stem of the St. Croix below the dams.

Nitrogen and Phosphorus: These two nutrients are important indicators of the trophic state of water, and may be the principal factors determining the productivity of a lake or stream. In poorly buffered waters that receive very little in the way of dissolved ions from weathering of rock, nitrogen and phosphorus concentrations commonly reflect human activities and land use. Nitrogen occurs in three exchangeable forms (nitrate, nitrite and ammonia) whose state depends on the oxygen (strictly the redox) level. Phosphorus is an essential nutrient, which is accessed by plants in its soluble, orthophosphate form; however, much phosphorus may be tied up with other compounds, so that the total amount of phosphorus may be much larger than that actually available for use by plants. For this reason, all the above forms need to be analysed.

All water samples taken during the spring and summer in the St. Croix system showed extremely low or undetectable values of all forms of nitrogen and orthophosphate. However, in spring, all samples were recorded as having exceptionally high levels of total phosphate (up to 1.7 mg.L^{-1}), whereas in summer the values were below the detection limit. These results represent unexplained anomalies.

Conductivity: Conductivity was measured during electrofishing activities because it influences the efficiency of the shocking equipment. It is a measure of the electrical conductivity, and therefore reflects the concentrations of all soluble ions. Conductivity values were all below 25 μS.cm^{-1} during the spring sampling, except for SC6, which was marginally higher (at 42 μS.cm^{-1}). In summer, conductivity was very slightly higher at some stations than in spring. Overall, the waters of this system are extremely low in dissolved ions.

Table 3.2.2. Incidental temperature and conductivity records, St. Croix & Big St. Margarets Bay systems, Summer 2001.

Site	Date	Temperature	Conductivity
		°C	μS.cm^{-1}
SC1	1-Jun	15	15
	3-Jul	15	20
	20-Jul	15	15
	22-Aug	19.5	
SC2	1-Jun	15	19
	6-Jul	15	19
	20-Jul	13	20
	22-Aug	20.5	
SC3	26-May	13	
	3-Jul	20.5	20
	20-Jul	19.5	22
	22-Aug	23	
SC4	1-Jun	11.5	15
	6-Jul	18	20
	19-Jul	12.5	25
	22-Aug	21	
SC5	1-Jun	12	18
	19-Jul	20	22
	22-Aug	22	
SC6	28-May	14	49
	27-Jun	21	35
	22-Jul	15	30
	31-Jul	14	33
	19-Aug	25	
SC7	28-May	14.5	20
	22-Jul	14.5	38
	31-Jul	13.5	30
	19-Aug	21.5	
SM1	29-May	14	20
	21-Jul	19.9	22
	23-Aug	22	
SM2	21-Jul	21	25
	23-Aug	22	
SM3	21-Jul	16.9	32
	23-Aug	21	

Additional values, taken in association with electrofishing or habitat surveys, are given in Table 3.2.2.

Colour: All the tributary streams entering Panuke Lake and Big St. Margarets Bay Lake are rather stained, sometimes strongly so. The colour is derived from exudates of plants (humics and tannic acids) in bogs or coniferous woodlands, producing 'brown water' streams that are a feature of the taiga and elsewhere in Canada. The ecological significance is not entirely clear. The values from the St. Croix and St. Margaret systems are much higher (i.e. the waters are much more strongly stained) than in the Halfway River watershed.

Dissolved Oxygen: Water samples for dissolved oxygen were taken at times of fish collection from streams in the St. Croix and Big St. Margarets Bay systems. Results are indicated in Table 3.2.3.

Table 3.2.3. Dissolved Oxygen, July 2001

Site	Temp C	DO mg/L	% Sat		Site	Temp C	DO mg/L	% Sat
St. Croix Watershed					**St. Margarets Bay Watershed**			
SC1	17.5	7.64	79%		**SMB1**	19.9	7.36	79%
SC2	13	7.86	73%		**SMB2**	21	7.53	84%
SC3	19.5	8.09	85%		**SMB3**	16.9	5.26	55%
SC4	n/a	8.43	n.a.					
SC5	20	7.7	84%					
SC6	15	6.7	65%					
SC7	14.5	5	50%					

In summer, oxygen concentrations were also high at most stations, with the exception of SMB3, where the water issues from a large, relatively stagnant portion of Shady Lake Brook, and SC6, which is downstream of the two main dams on the St. Croix system. Concentrations above 60% are necessary for trout and other game fish; if the oxygen levels drop much below this, trout will generally seek out cooler or more turbulent stretches of stream (where oxygen levels may be replenished). The results indicate that oxygen conditions in shallower streams in these watersheds can become limiting for trout during dry and warm summer months.

Most other chemical constituents in the streams are consistent with water of extremely low nutrient and ion concentration. There is low turbidity throughout, indicating that even in wet weather (as occurred in May and early June), little sediment enters the streams in overland flow.

Compared with the Halfway River system, the waters of the St. Croix system, including Big St Margarets Bay tributaries, are much lower in dissolved solids and conductivity. The waters are more heavily stained, limiting light penetration in lakes and reservoirs. It is no surprise that fish populations, especially brook trout populations, are relatively low.

3.2.4 Summary & Conclusions.

The impoundments of the St. Croix River and Big St. Margarets Bay Lake systems are filled with water that is very low in most dissolved ions, and tend to be both acidic and highly coloured. The waters are derived from streams that are also extremely low in both nutrients and pH. In both tributary streams and the uppermost impoundments (Panuke Lake and Big St. Margarets Bay Lake), spring pH values are below or only marginally above the level (~5.2) necessary for successful spawning of brook trout. In summer values were slightly higher.

Impoundments above the Upper St. Croix Dam exhibit strong stratification in summer, but the hypolimnion remains generally well oxygenated, reflecting the low levels of organic matter. However, the two impoundments below the Upper St. Croix Dam. Either do not stratify, or tend to become depleted in oxygen at depth.

All indications from water chemistry are that the impoundments and streams are oligotrophic and unproductive. Critical nutrients such as phosphorus and nitrogen are at barely detectable levels, and chlorophyll was low in spring throughout, rising to levels typical of oligotrophic lakes in summer.

Like the impoundments, streams in the system are acidic, extremely low in nutrients, and have no buffering capacity. Oxygen concentrations tend to remain high, but several of the streams exhibit very high temperatures during summer that limit their suitability for support of salmonids at these times.

3.3 Fish Surveys of the St. Croix River and Big St. Margarets Bay Lake Systems.

3.3.1 Introduction

Surveys of fish populations were conducted both within four major impoundments, and at selected sites on the streams of the St. Croix and Big St. Margarets Bay Lake systems. Field campaigns took place in late May and in July. Because the objectives, methods and results of the two major habitats were different, they are treated separately below.

3.3.2 Methods

A. Fish Surveys of the Impoundments.

Fish surveys were carried out using experimental gill nets, minnow traps, and angling. The experimental gill nets consisted of four 8 m long, 1.8 m deep panels, having stretched mesh sizes of 2.5, 5.0, 6.5 and 8.0 cm. The minnow traps were standard size traps baited with dog food.

At least two gill net sets were made at each impoundment during each survey (Figures 3.3.1-3.3.3). Two minnow traps were set in close proximity to each gill net, usually along the shoreline in water depths of > 1 m. The gill nets and minnow traps were typically set at dusk and retrieved early the following morning. The total time of gill net set ranged between 10-12 h. Locations of gill net and water collections are shown in Table 3.3.1

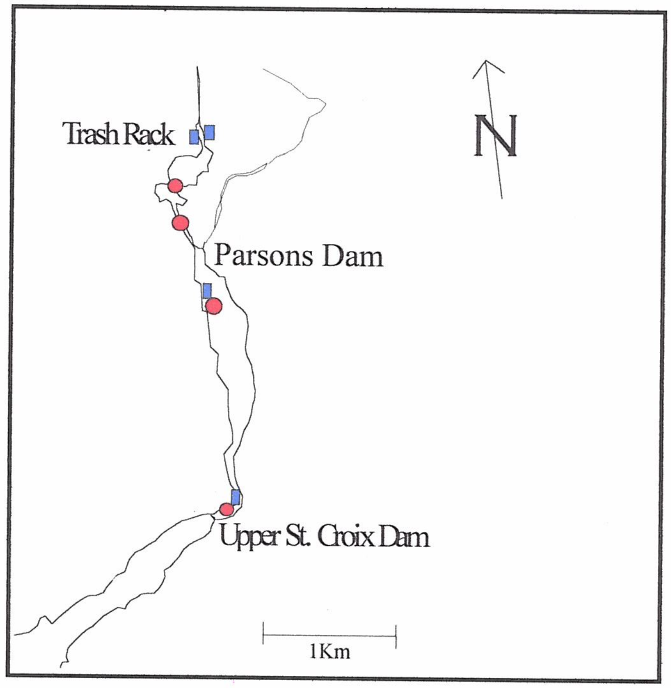
The number and species of all fish collected in the gill nets and minnow traps was recorded and, with the exception of white suckers, all gill net collections were retained for length/weight measurements. White suckers (*Catostomus commersoni*), which were often the most numerous species collected in the gill nets, were measured for length in the field.

Table 3.3.1 Locations of Fish and Water Collections in Impoundments of the St. Croix and Big St. Margarets Bay Lake systems, May & July 2001

SITE	Station	Date	Time	Location (UTM)		Water Depth (m)
				Northing	Easting	
SPRING SURVEY						
Big St. Margarets Bay Lake	SMB1	30/05/01	14:55	4959544	414177	27
"	SMB2	30/05/01	17:46	4960798	415381	22
Panuke Lake	PAN1	28/05/01	14:54	4987803	404105	26
"	PAN2	28/05/01	16:39	4972232	414507	10
"	PAN3	29/05/01	9:34	4959343	411653	24
Parsons Dam	PD	06/06/01	13:11	4977132	418946	12
Trash Rack	LSC	06/06/01	12:26	4978250	418150	5
SUMMER SURVEY						
Big St. Margarets Bay Lake	SMB1	30/07/01	14:12	4959517	41419	27
"	SMB2	30/07/01	16:15	4960556	415083	26
"	SMB3	30/07/01	17:30	4960296	416037	13
Panuke Lake	PAN1	23/07/01	16:00	4975198	417740	23
"	PAN2	23/07/01	17:00	4974437	416560	18
"	PAN3	24/07/01	17:35	4972267	414463	6?
"	PAN4	24/07/01	12:55	4967478	413365	15
"	PAN5	24/07/01	13:45	4965514	413238	23
"	PAN6	25/07/01	10:15	4957641	411363	33
"	PAN7	25/07/01	11:10	4954238	410375	27
Parsons Dam	PD	08/08/01	15:43	4977132	418946	12
Trash Rack	LSC	19/07/01	16:00	4978250	418150	5

Angling was used to collect fish on two occasions. Seventeen smallmouth bass (*Micropterus dolomieui*) were collected from anglers participating in a fish derby sponsored by the Minas Basin Pulp and Power Company Limited at Panuke Lake on 24 June 2001. These were measured for length and weight and a sub-sample of ten fish taken for analysis of mercury levels. Angling was also used to collect smallmouth bass at the Parsons Dam and Trash Rack reservoirs.

Figure 3.3.1. Location of gill net (□) and minnow trap sets (○) in the Parsons Dam and Trash Rack reservoirs.



All fish specimens used for tissue mercury analysis were frozen within six hours of collection. Preparation of samples for mercury analysis consisted of removal and homogenization of an approximately 30 g sample of epaxial muscle tissue, and refreezing the sample until analysis. Homogenized tissue was forwarded to Phillip Analytical Services (Bedford, N.S) for analysis of mercury levels.

Figure 3.3.2 Location of spring gill net (□)and minnow trap sets (○) in Big St. Margarets Bay and Panuke Lake.

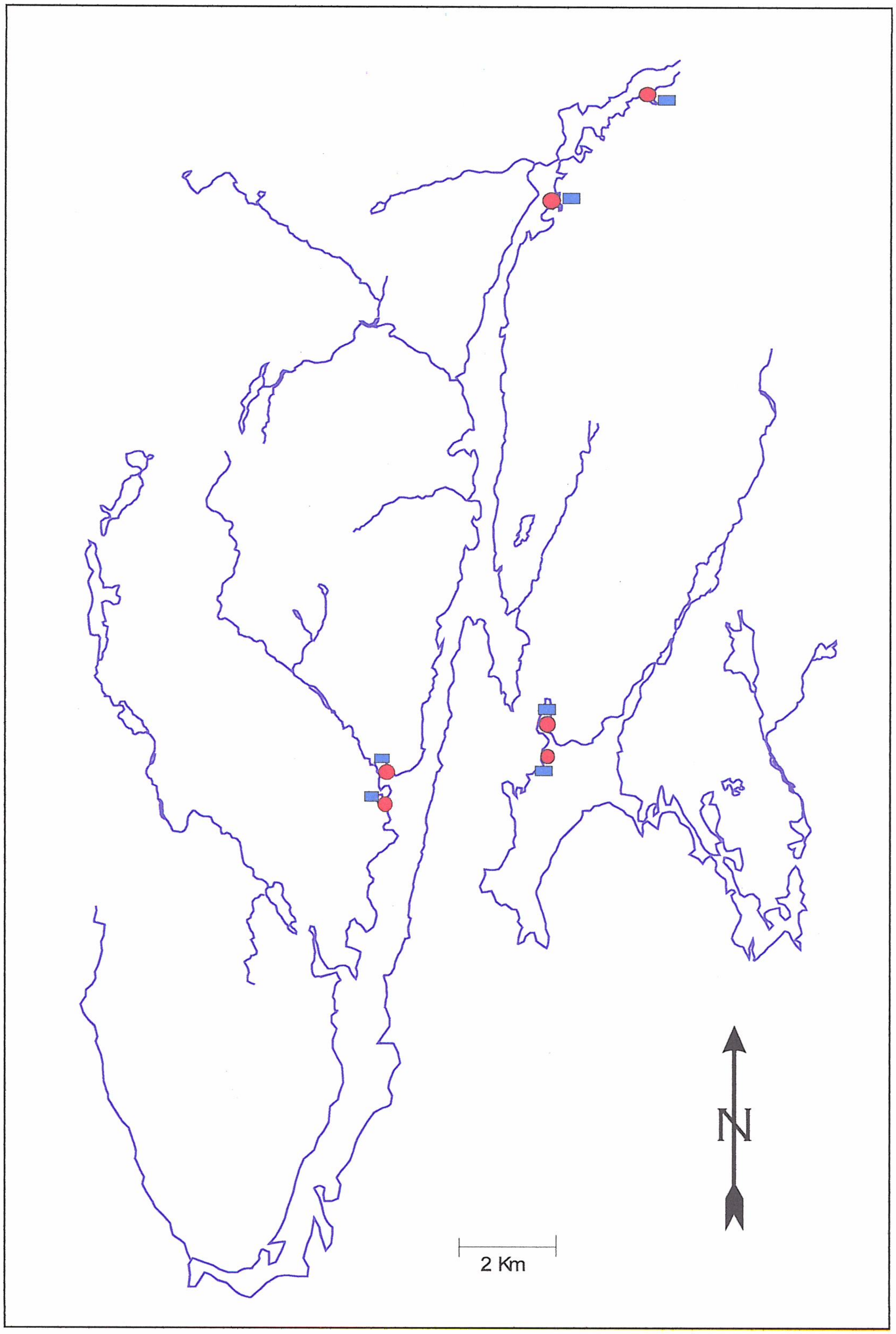
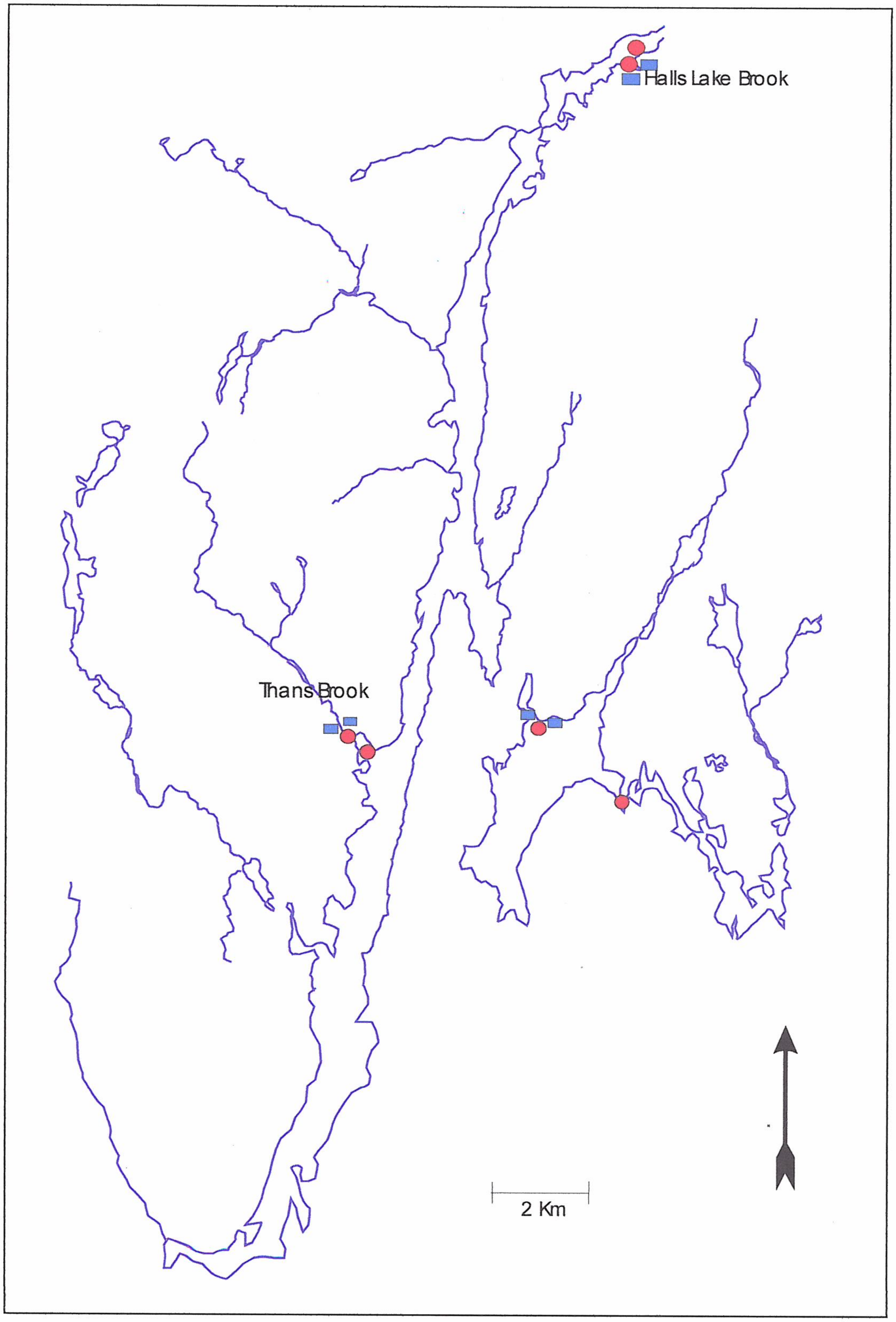


Figure 3.3.3 Location of summer gill net (□) and minnow trap sets (○)in Big St. Margarets Bay and Panuke Lake.



B. Fish Surveys of Streams

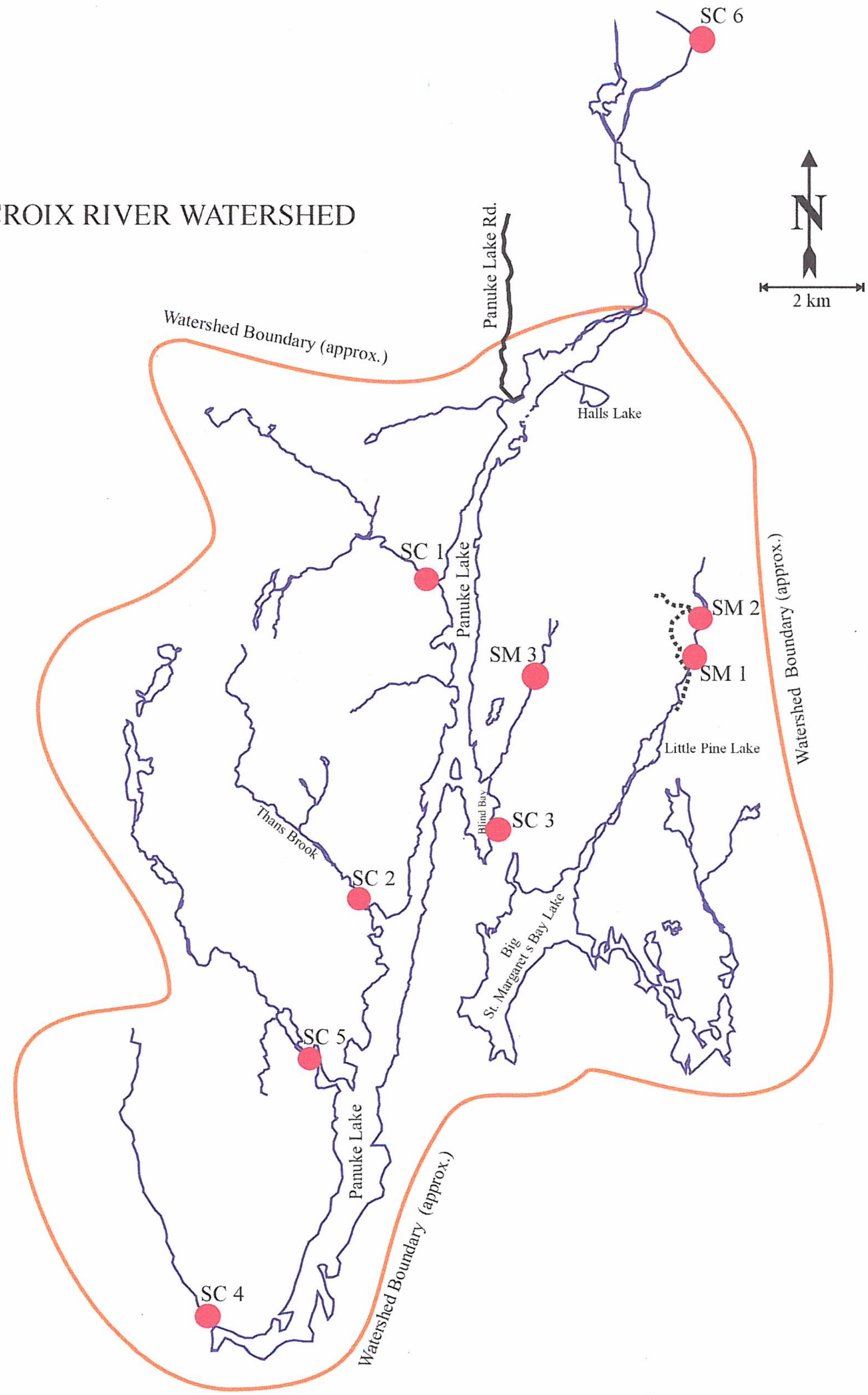
Fish collections by electroseining were made at 7 stream sites on tributaries entering Panuke Lake, at a site on the St. Croix River below Parson's Dam, and at two sites on Piney River in the Big St. Margarets Bay watershed. Access difficulties (washed out roads) prevented sampling in the Black Brook that enters South Lake (connected to Big St. Margarets Bay Lake). Geographic coordinates are given in Table 3.3.2, and the locations indicated in Figure 3.3.4.

Table 3.3.2 Geographic Coordinates of St. Croix and Big St. Margarets Bay Electrofishing Sites.

Tributaries to Panuke Lake		Easting	Northing	Latitude	Longitude
SC1	Stoney Brook	414707	4971694	44 53.721 N	064 04.764' W
SC2	Thans Brook-Lower	410750	4961158	44 48.001' N	064 07.660' W
SC3	St. Margarets-Panuke Canal	413951	4963264	44 49.169' N	064 05.253' W
SC4	Southwestern Brook	407411	4952248	44 49.170' N	064 05.252' W
SC5	Armstrong Brook	409750	495780	44 46.130' N	064 08.125 ' W
SC6	St. Croix River	418764	4978066	44 57.196' N	064 01.742' W
SC7	Thans Brook-Upper	408221	4965233	44 50.189' N	064 9.620' W
SM3	Shady Brook	414863	4966230	44 50.780' N	064 04.585' W
Tributaries to Big St. Margarets Bay Lake					
SM1	Piney Brook-Lower	418671	4967505	44 51'.491 N	064 01'.712 W
SM2	Piney Brook-Upper	418070	4967600	44 51.60 ' N	064 01.200 W

Collections were made between 26 and 29 May 2001, and again from 20-22 July 2001. Sites SC6, SC7, SM1, SM2 and SM3 were accessed by road; all other sites were reached by boat from Upper St. Croix Dam on Panuke Lake. A trailer provided by Minas Basin Pulp and Power Company Limited enabled storage of equipment, and provided a base of operations for lake and stream work in the St. Croix system.

Figure 3.3.4 Electrofishing Sites in the St. Croix—St. Margarets Bay Lake systems



Electrofishing sites were chosen to provide varied examples of the fish habitats to be found in the St. Croix—Big St. Margarets Bay system. At each site where possible, a section of stream was enclosed between barrier nets of 1 cm stretched mesh. Each barrier net was carefully anchored into the stream bed, and supported by tripods. Electroseining was carried out by M. Parker of East Coast Aquatics, and proceeded in a downstream direction. In general, 3 passes were attempted, separated by 45 – 60 minute intervals; fewer passes were completed if few or no fish were obtained on the second or first pass. Electroseining was not conducted when temperatures exceeded 20°C, or when it was raining. During the May survey, we encountered white suckers (*Catostomous commersoni*) spawning in the study area at Stoney Brook (SC1) and at the mouth of Thans Brook (SC2); shocking was not carried out if actively spawning fish were present within the sampling reach.

Conductivity and temperature were recorded at the time of each survey.

All fish captured were transferred to a holding tank for identification and measurement. Prior to measurements, the fish were moved into a tank containing stream water with Alka Seltzer Gold™ as a mild soporific. Most fish (except eels) were successfully sedated by immersion in the solution for a few minutes, making measurements easier and more accurate. All apparently recovered from the sedation.

Total and Fork lengths (where appropriate) were recorded to the nearest 1 mm, and wet weight determined to the nearest 0.1 g. Not all fish obtained could be weighed in the field because of balance failure. Following measurement, all fish were transferred to a screened live box submersed in the stream, and held until release at the end of collection and recording.

Position of all sites was recorded using a Magellan Model 315 GPS, and results are given in Table 3.2.1. Below is a brief site description for the St. Croix and St. Margarets Bay Lake sites. More complete locality descriptions, obtained from stream surveys conducted at other times, are included under Section 3.5.

3.3.3. Description of Electrofishing Sites.

Site SC1. Stoney Brook.

The survey site was selected approximately 150 m above the mouth of this well-named brook (Figure 3.3.5). At the mouth, the substrate is a mix of various-sized boulders, providing plenty of instream cover downstream of the larger boulders. The shoreline is exposed near the mouth, with no canopy or instream vegetation, but further up the river the mixed forest comes closer to the stream providing <40% canopy cover. Large rocks near the mouth of the stream were devoid of mosses or grasses, although they may bear a few lichens. Further upstream, however, mosses were much more common; presumably their absence downstream is related to ice conditions in winter.

Figure 3.3.5. Stoney Brook, Site SC1.

Collections at this site in May were restricted to a single pass for spot checking because of the large number of spawning suckers seen in the area after preliminary examination.

One female was turned and found to be releasing eggs, so no further shocking was conducted. No other species were observed in the stream at this time.

Site SC2. Thans Brook (lower).

This site was very similar to Stoney Brook, particularly in its lowermost reaches (Figure 3.3.6). The substrate is largely massive boulders that are exposed even during very high flows. There are abundant calm refuges behind these boulders, but virtually no areas of riffle or finer substrate. Fallen timber lying across the stream had all been cut, derived from some recent forestry in the upper portions of the brook watershed, and probably brought down the river during the spring flood.

Figure3.3.6 Lower Thans Brook near mouth.

Surrounding woodland is mixed second growth, with small hardwoods dominating nearest the stream edge. Mosses are abundant on the stream bank and on some of the larger, permanently exposed, boulders, especially further upstream, away from the lake edge. Further back from the stream, and further up the valley, softwoods dominated, that have been subject to harvest within the last couple of years. The banks are generally rocky, with little streamside grass and no undercutting.

The electrofishing site began approximately 270 m from the mouth of the brook, and extended for 35 m. Width varied from 4.5-6.0m (ave. 5.3 m). When visited in May, 53 adult spawning suckers were counted in the 150 m from the mouth upstream; no sampling was carried out as a result.

Figure 3.3.7 Cascade at electrofishing reach, Lower Thans Brook.

A detailed survey upstream from the mouth of the brook (for 0.5 km) indicated that beyond a narrow, steep gorge at about 400 m, the slope decreased and the higher parts of Thans Brook consist of more extensive slow-moving pools of very darkly stained water.

Site SC3. Canal from Big. St. Margarets Bay Lake to Panuke Lake.

The lower portion of this system, by which water is moved from Big St. Margarets Bay Lake into Panuke Lake, is open without cover, emptying into the relatively shallow Blind Bay. The channel is generally straight, rather than meandering, as streams typically are in these watersheds, presumably because it was constructed in connection with water transfers from Big St. Margarets Bay Lake.

Further upstream, canopy cover increases, and the stream varies from extensive runs to small riffle areas, with a good deal of woody debris. Because of the width and conditions, it was not possible to erect barrier nets on this system, so only spot collections were made on each occasion.

Site SC 4. Southwestern Brook.

Southwestern Brook enters Panuke Lake at its most southerly end. Near the mouth is a small bay with very boggy shoreline. The lowest portions of the river appear as swiftly moving pools lying between massive boulders or outcropping bedrock, with several sharp elevation changes (<1.5 m). Rock surfaces exhibit very little moss. Above 300 m from the mouth there are several outcroppings of bedrock, and the slope becomes more moderate. The electrofishing reach begins at 400 m and extends upstream for 50 m (Figure 3.3.8). In this area and above, boulder size is less, some surfaces are covered with mosses as well as lichens, and there are occasional patches of grasses.

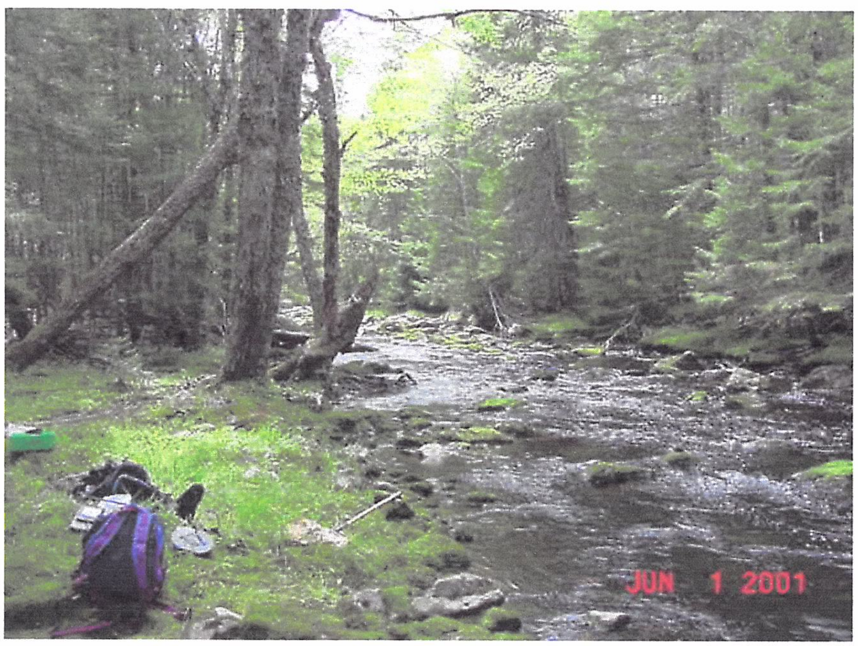
Figure 3.3.8. Southwest Brook electrofishing reach, looking upstream.

Most of the substrate was too coarse for sampling with a Surber. This stream, however, appears to be more productive in the upper reaches than down at the mouth; observations during the detailed field survey, which extended >600 m above the mouth, included numerous flying insects (Odonata, Hymenoptera, Hemiptera and Diptera), and amphibians.

SC5. Armstrong Brook.

The mouth of Armstrong Brook includes two small lakes (the Mud Lake Deadwaters) that are still, deep and difficult to navigate because of large boulders and deadheads. The electrofishing reach begins where Armstrong Brook enters the Upper Mud Lake Deadwater and extends for 27 m through a wide, shallow, gently sloped stretch (Figure 3.3.9).

Figure 3.3.9. Armstrong Brook electrofishing reach



The stream is well bordered by largely coniferous trees, providing shade, and the relatively stable flow regime is indicated by extensive moss coverings on the banks and rocks.

SC6. St. Croix River.

This site is located on the main stem of the St. Croix River, downstream of Parsons Dam. Relatively low flows in this river resulting mostly from overflow at the Dam, have led to development of extensive grassy beds along the edges and midstream. When surveyed in late May and again in July, most of the river was a smoothly flowing flat, with no riffles, and only a few small, deeper pools, largely formed between rocks or bedrock outcrops.

Figure 3.3.10 St. Croix River, below Parsons Dam.

The electrofishing reach was 46 m in length. Very few areas exhibit small pebbles or cobbles, and these are mostly found downstream of an ATV crossing, where there is considerable disturbance. This site was studied by D. MacNeill (MacNeill 2000), at which time it was identified as being a rearing area for trout.

SC7. Thans Brook (Upper)

This site is in the upper levels of Thans Brook, just below an extensive meadow pond. It is a deeply wooded stream, relatively slow flowing, that is impounded into a series of pools by large boulders or accumulated woody debris (Figure 3.3.11). The reach length is 23 m, with a width that varies from 2.3 m to >7 m. Depths are variable, but exceed 1 m in places.

Figure 3.3.11 Upper Thans Brook, looking upstream through electrofishing reach.

The water is deep and highly stained. Surrounding vegetation is a dense forest of softwoods, with *Sphagnum* and mosses under foot. Shorelines are mostly soft, stabilized by tree roots, and only slightly undercut, and the bottom is generally a mix of large boulders, sand, and organic detritus.

SM1. Lower Piney Brook.

The electrofishing site is on Piney Brook, which enters Little Pine Lake, and thence into Big St. Margarets Bay Lake.

Figure 3.3.12. Lower Piney Brook electrofishing site SM1.

It is a shallow, meandering brook, bordered by alders and a coniferous forest, that drains out of a small, unnamed flowage. The channel is fairly wide (<12 m), with predominantly gravel-cobble substrate, and intermittent pools up to 2 m in depth (Figure 3.3.12). This site provided the first indications of suitable spawning sites in the St. Croix—St. Margarets Bay system, since the gravel bed shown in the foreground of Figure 3.3.12 lies at the edge of a deeper pool, and downstream from a run-riffle sequence. At the first sampling in early June, suckers were present, but it appeared that spawning was mostly completed: numerous eggs were retrieved in Surber samples.

SM2. Upper Piney Brook

The second site in the Big St. Margarets Bay Lake system was further up Piney Brook. Originally it was intended to sample Black Brook, which drains into South Lake, an adjacent sub-watershed to Big St. Margarets Bay Lake, however access roads had been washed out and were impassable this summer.

Figure 3.3.13. Upper Piney Brook electrofishing site, SM2.

This shallow site issues from a large meadow that provides deeper, cool water where fish may move in extremely warm summer days.

Site SM3. Shady Brook.

This site is downstream from a stillwater area, in a stream that issues from Shady Lake. Unlike Piney Brook, this stream empties into Panuke Lake at Blind Bay, hence it is truly part of the St. Croix—Panuke Lake watershed.

The site (Figure 3.3.14) is completely shaded. The sampling reach begins 5 m downstream of a bridge that has almost washed out, and there are indications from large and recent gravel-cobble deposits in the woodland adjacent to the site, and large bridge timbers and logs trapped in the trees, that severe flows have been experienced in the past.

Figure 3.3.14. Shady Brook electrofishing site SM3.

Substrate at this site ranged from boulders to fine gravel, the latter probably having been recently deposited. The gravel sites were the only ones suitable for Surber sampling (see Section 3.6). Flying aquatic insects (Zygoptera, Culicidae and Simuliidae) were extremely abundant at this site whenever sampling was being conducted.

3.3.4. Results: Impoundments.

Fish Species Collected

A total of six fish species was collected from the impoundments (Table 3.3.3 and Appendix 3.3.1). These included brook trout (*Salvelinus fontinalis*), white sucker (*Catostomus commersoni*), smallmouth bass (*Micropterus dolomieui*), yellow perch (*Perca flavescens*) and banded killifish (*Fundulus diaphanus*). Yellow perch and white sucker were collected at all impoundments. Brook trout were collected from all impoundments except the Trash Rack reservoir. Smallmouth bass and brown bullhead

(*Ictalurus nebulosus*) were collected at all impoundments except Big St. Margarets Bay Lake. Banded killifish were collected only at Big St. Margarets Bay Lake.

Yellow perch was the most common and abundant species. Brook trout appear to be abundant in both Big St. Margarets Bay and Panuke Lake, and smallmouth bass appear to be abundant in all of the impoundments except Big St. Margarets Bay Lake.

The length-weight relationships of brook trout, yellow perch and smallmouth bass collected from each impoundment are listed in Table 3.3.3. and illustrated graphically in Figures 3.3.15-3.3.17. For the most part, the slope coefficients are very near three and indicative of fish in good condition.*

Table 3.3.3. Length weight relationships of fish from impoundments.

SITE	**Species**	**Log Weight/Length Regression**	**N**	r^2
Panuke Lake	*S. fontinalis*	Log Wt = -2.211 + 3.225 (Log Lgth)	13	0.985
Big St. Margarets Bay Lake	*S. fontinalis*	Log Wt = -1.908 + 2.983 (Log Lgth)	15	0.864
Parsons Dam	*P. flavescens*	Log Wt = -1.708 + 2.872 (Log Lgth)	22	0.989
Panuke Lake	*P. flavescens*	Log Wt = -2.429 + 3.404 (Log Lgth)	18	0.964
Big St. Margarets Bay Lake	*P. flavescens*	Log Wt = -2.190 + 3.193 (Log Lgth)	126	0.975
Parsons Dam	*M. dolomieui*	Log Wt = -1.778 + 2.973 (Log Lgth)	13	0.983
Panuke Lake	*M. dolomieui*	Log Wt = -1.332 + 2.606 (Log Lgth)	20	0.971

* In general, a regression coefficient for the slope that is greater than three indicates good condition while a value less than three indicates poor condition.

Table 3.3.4. Summary of fish collections from St. Croix—Big St. Margarets Bay impoundments.

Site	Date	Method			Location		Total Number Fish Collected	Total Number Species Collected	Number of Each Species					
		Gill Net	Minnow Trap	Angling	Northing	Easting			*S. fontinalis*	*M. dolomieui*	*P. flavescens*	*I. nebulosus*	*C. commersoni*	*F. diaphanus*
St. Marg. Bay Lake	29/30 May	X			4961585	414526	13	1					13	
"	29/30 May	X			4961267	414349	120	3	14		85		21	
"	29/30 May		X		4961585	414526	5	3			2		1	2
"	29/30 May		X		4961585	414526	5	1			5			
"	29/30 May		X		4961267	414349	2	1			2			
"	30/31 July	X			4961342	414359	67	2			51		16	
"	30/31 July	X			4960296	416037	3	2	1				2	
"	30/31 July		X		4961342	414359	6	1			6			
"	30/31 July		X		4961342	414359	4	1			4			
"	30/31 July		X		4961342	414359	0	0						
"	30/31 July		X		4961342	414359	35	1			35			
Panuke Lake	27/28 May	X			4972000	414800	18	4	12	2	3	1		
"	27/28 May	X			4974054	416444	20	4	1		17	1	1	
"	27/28 May		X		4972000	414800	0	0						
"	27/28 May		X		4972000	414800	0	0						
"	27/28 May		X		4974100	416500	0	0						
"	27/28 May		X		4974100	416500	0	0						
"	28/29 May	X			4961165	411172	10	1					10	
"	28/29 May	X			4960450	411200	9	2			8		1	
"	28/29 May		X		4961150	411000	16	1			16			
"	28/29 May		X		4961150	411000	0	0						
"	28/29 May		X		4960450	411200	8	1			8			
"	28/29 May		X		4960450	411200	23	1			23			
"	23/24 June			X	n/a	n/a	17	1		17				
"	23/24 July	X			4974054	416444	16	3		5		5	6	
"	23/24 July	X			4974386	416571	1	1					1	
"	23/24 July		X		4974054	416444	0	0						
"	23/24 July		X		4974054	416444	5	1			5			
"	23/24 July		X		4974054	416444	0	0						
"	23/24 July		X		4974054	416444	0	0						
"	24/25 July	X			4961165	411172	3	2		1			2	
"	24/25 July	X			4961200	410950	14	3		4	2		8	
"	24/25 July		X		4961200	410950	12	1			12			
"	24/25 July		X		4961200	410950	7	1			7			
"	24/25 July		X		4961200	410950	12	1			12			
"	24/25 July		X		4961200	410950	0	0						
"	24/25 July			X	n/a	n/a	2	1		2				
Parsons Dam	06/07 June		X		4977132	418046	5	1			5			
"	06/07 June		X		4977132	418046	3	1			3			
"	8/9 August	X			4976795	418197	4	1				2	4	
"	8/9 August	X			4975697	418122	32	5	2	3	20		5	
"	8/9 August		X		4975697	418122	3	1			3			
"	8/9 August			X	n/a	n/a	10	1		10				
Trash Rack	06/07 June		X		4978050	418100	0	0						
"	19/20 July	X			4977500	417900	0	0						
"	19/20 July	X			4977750	417900	15	3			2	3	10	
"	19/20 July		X		4978050	418100	0	0						
"	19/20 July		X		4978050	418100	0	0						

Figure 3.3.15. Length-weight relationship for brook trout.

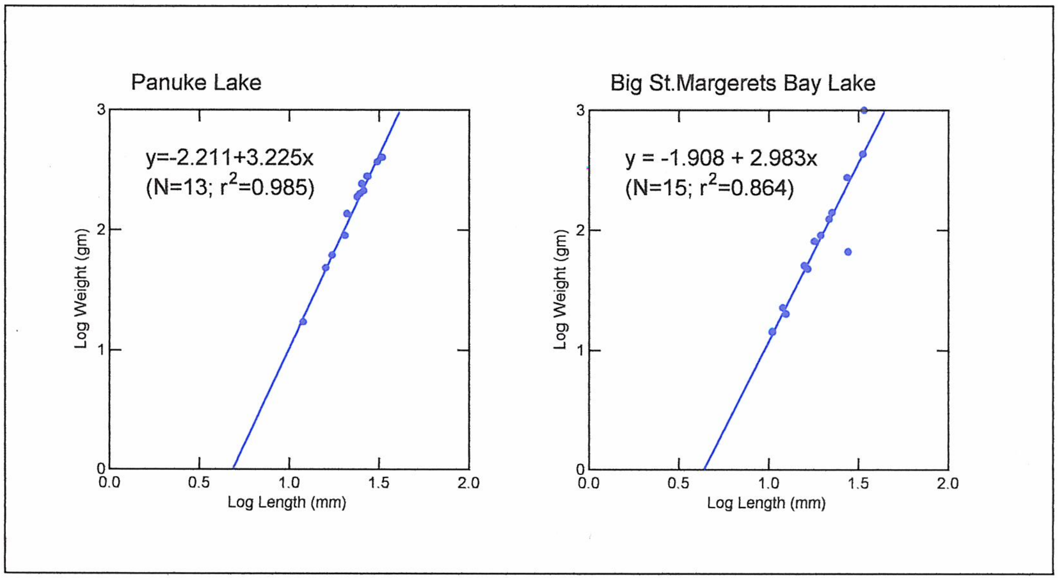


Figure 3.3.16. Length-weight relationship for smallmouth bass.

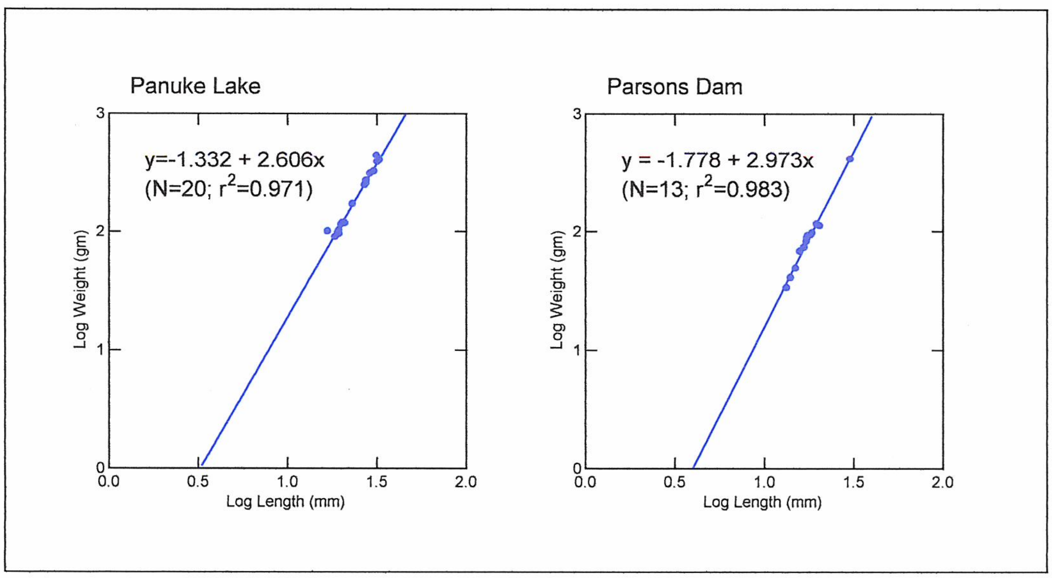
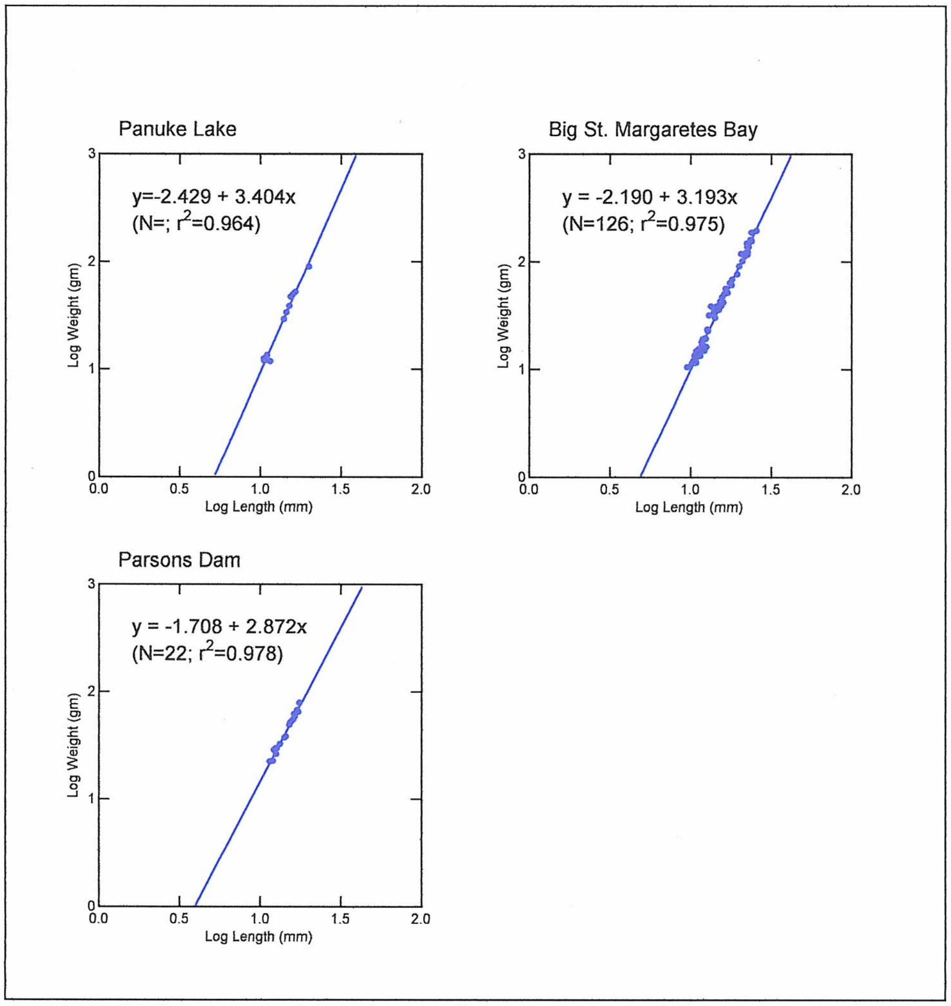


Figure 3.3.17 Length-weight relationship for yellow perch.



Mercury content of fish

Table 3.3.5 provides a summary of the mercury content of brook trout, smallmouth bass and yellow perch collected from the various impoundments. Figures 3.3.18-3.3.20 show the relationship between mercury content and size.

The values for brook trout are well below the Health Canada guideline of 0.5 mgHg/kg and are about average for Nova Scotia brook trout. A survey of brook trout collected from lakes throughout Nova Scotia carried out by the Nova Scotia Department of Environment (1994) found an average and range of 0.17 and 0.03-0.29 mgHg/kg wet weight respectively. Similar averages and ranges have been reported for brook trout collected from Kejimkujik National Park. N.S. In a study carried out by Nova Scotia weight respectively. Similar averages and ranges have been reported for brook trout collected from Kejimkujik National Park. N.S. In a study carried out by Nova Scotia Power Inc. (1995) on ten lakes and reservoirs associated with hydropower systems, twenty-five brook trout were sampled from 10 lakes and reservoirs. In that study, the average and range of mercury levels for brook trout was found to be quite high: 0.77 and <0.13-1.68 mgHg/kg respectively, which is considerably higher than the values found for the impoundments examined in the St. Croix – Big St. Margarets Bay Lake system in the present study.

Table 3.3.5 Summary of tissue mercury levels in fish of the St. Croix and Big St Margarets Bay Lake systems.

SITE	Species	N	Range in Fork Length (cm)	Range in Hg Content (mg/kg)
Panuke Lake	*S. fontinalis*	10	18.3-34.0	0.080-0.200
Big St. Margarets Bay Lake	*S. fontinalis*	10	16.4-35.0	0.080-0.580
Parsons Dam	*S. fontinalis*	2	20.2-20.8	0.090-0.140
Panuke Lake	*P. flavescens*	10	15.6-21.0	0.350-0.800
Big St. Margarets Bay Lake	*P. flavescens*	10	15.6-26.7	0.550-1.600
Parsons Dam	*P. flavescens*	10	13.0-18.3	0.510-0.710
Parsons Dam	*M. dolomieui*	10	14.5-31.2	0.270-1.300
Panuke Lake	*M. dolomieui*	12	19.6-34.2	0.450-1.600

The two Nova Scotia studies cited above also reported mercury contents of yellow perch and smallmouth bass, which typically have higher mercury levels than brook trout, presumably because they grow more slowly and live longer. In the Nova Scotia Department of Environment study, the average and range of mercury content of smallmouth bass was 0.84 and 0.6-1.3 respectively. For yellow perch, it was 0.53 and 0.38-0.7. Similar values, a mean and range of 0.70 and 0.34-1.49, for smallmouth bass were reported in the Nova Scotia Power Inc. study. In the same study, the mean and range for yellow perch was much higher, 1.97 and 1.37-2.71 respectively. Although there is a two-fold difference between the values of mercury content for smallmouth bass in Panuke Lake and the Parsons Dam reservoir, both are within the range of the Nova

Scotia Department of Environment study, but considerably lower than the values reported in the Nova Scotia Power Inc. study.

In all of the studies cited, larger and heavier fish exhibited higher mercury levels per gram of tissue. This is also true for all of the fish species examined in this study (Figures 3.3.18-3.3.20).

Figure 3.3.18. Relationship between mercury content and size for brook trout.

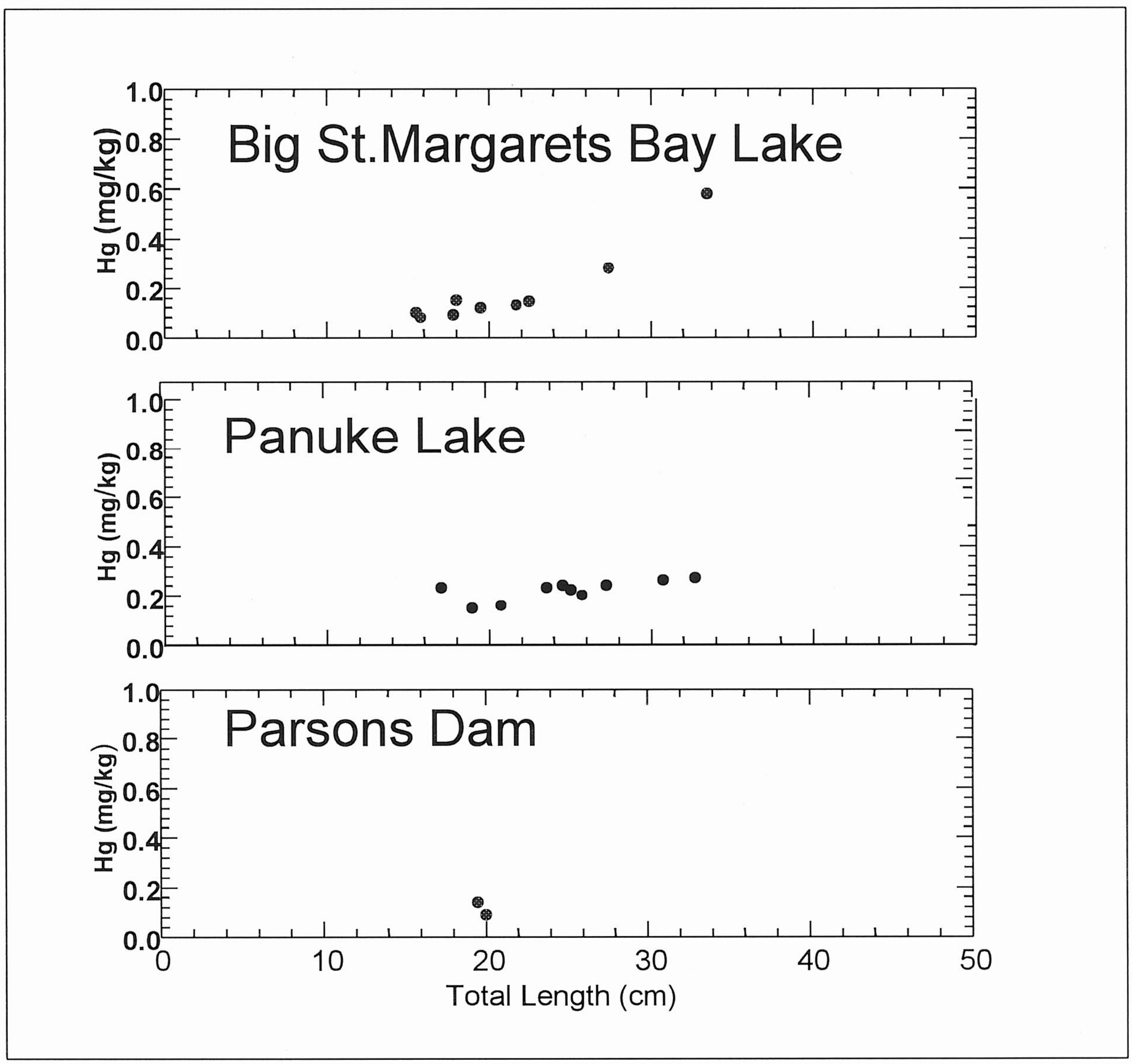
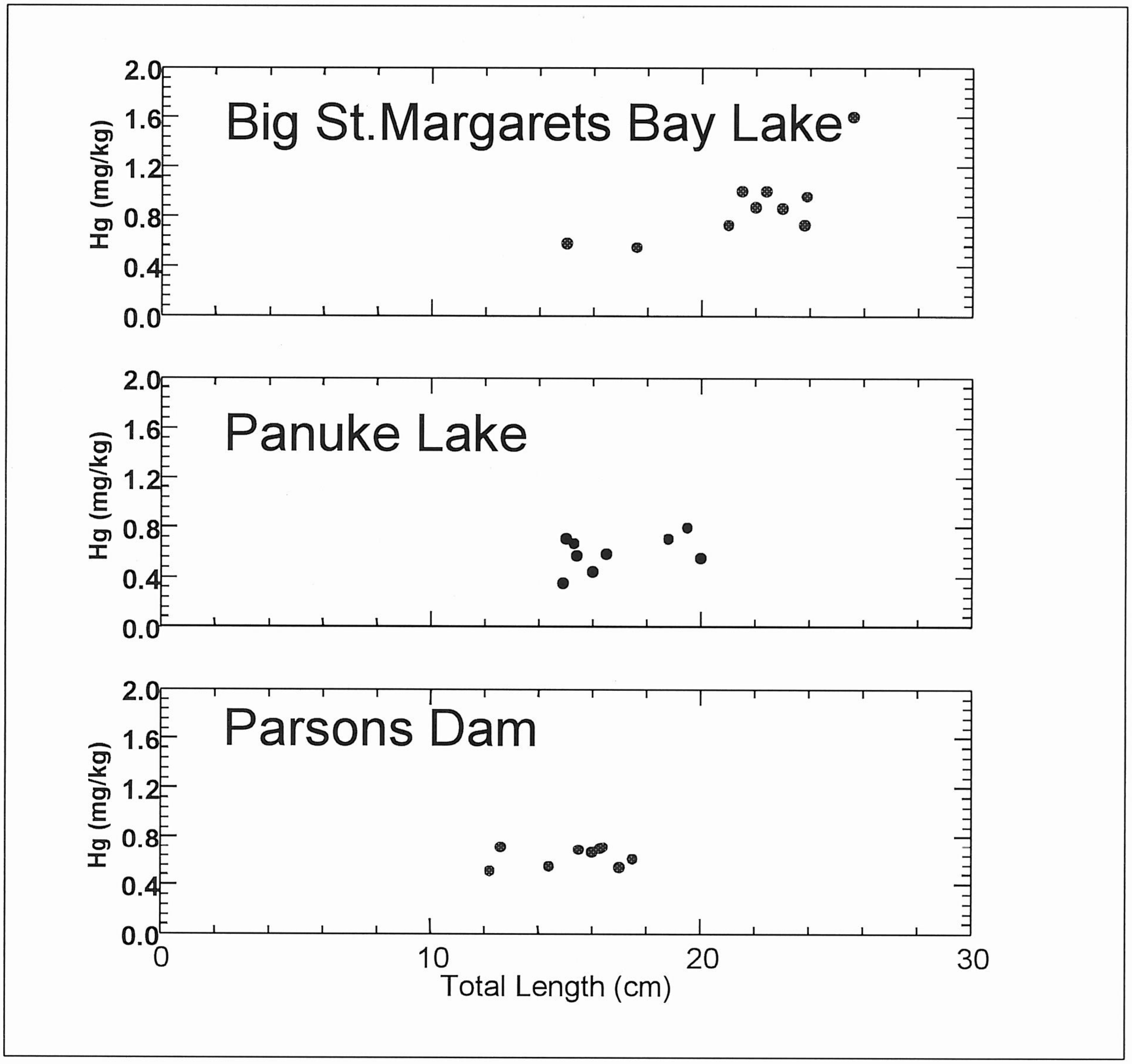


Figure 3.3.19. Relationship between mercury content and size for yellow perch.



Fish Stomach Contents

Fish collected and retained for mercury analysis were also examined to provide an assessment of principal dietary components in the impoundments. Results are given in Tables 3.3.6 to 3.3.7. Because the fish were caught in gill nets, it was common to find little or no identifiable material in the stomachs.

Figure 3.3.20 Relationship between mercury content and size for smallmouth bass.

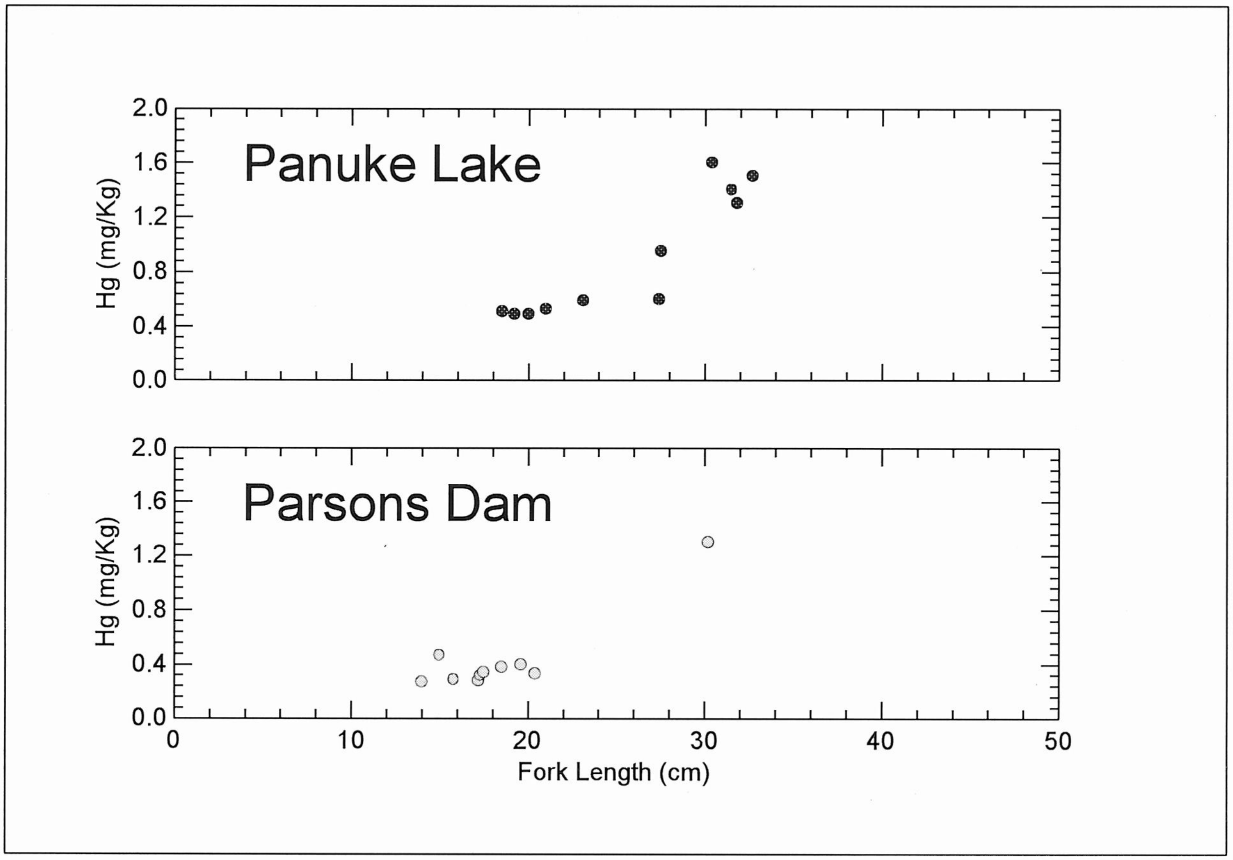


Table 3.3.6 Stomach contents of Panuke Lake fish.

I.D. No.	Species	Sex	Fork Length (cm)	Total Length (cm)	Weight (g)	Collection Date	Stomach Contents
PAN(1)	*I. nebulosus*		26.0	26.0	217.0	27/05	(1) Odonata; Anisoptera (2) Ephemeroptera; Ephemeridae (3) Plecoptera
PAN(4)	*M. dolomieui*		20.0	20.5	95.8	27/05	(1) Trichoptera (2) Diptera (3) Plecoptera; Nemouridae
PAN(5)	*M. dolomieui*		21.0	22.0	114.0	27/05	(1) Odonata; Anisoptera; Cordulegastridae (2) Plecoptera; Pteronarcidae

I.D. No.	Species	Sex	Fork Length (cm)	Total Length (cm)	Weight (g)	Collection Date	Stomach Contents
							(3) Coleoptera
PAN(6)	*S. fontinalis*		21.0	21.5	136.0	27/05	(1) Coleoptera; Gyrinidae (2) Coleoptera; Hydrophilidae (3) Coleoptera; Elmidae
PAN(7)	*S. fontinalis*	F	24.8	26.0	200.0	27/05	(1) Ephemeroptera; Ephemeridae
PAN(8)	*S. fontinalis*	F	27.5	28.5	278.0	27/05	(1) Ephemeroptera; (2) Coleoptera; Gyrinidae (3) Plecoptera
PAN(9)	*S. fontinalis*		31.0	32.0	370.0	27/05	(1) Plecoptera (2) Odonata
PAN(19)	*S. fontinalis*	F	23.8	25.0	190.0	27/05	(1) Coleoptera; Elmidae (2) Coleoptera (3) Diptera
PAN(20)	*S. fontinalis*	F	19.2	20.3	90.0	27/05	(1) Coleoptera
PAN(21)	*S. fontinalis*	F	25.3	26.2	242.0	27/05	(1) Ephemeroptera; Ephemeridae
PAN(22)	*S. fontinalis*		26.0	27.3	214.0	27/05	(1) Coleoptera; Elmidae (2) Coleoptera; Haliplidae (3) Coleoptera
PL(1)	*M. dolomieui*		31.5	32.8	442.0	23/06	(1) Coleoptera
PL(2)	*M. dolomieui*		32.7	34.2	402.0	23/06	(1) Ephemeroptera; Ephemeridae
PL(3)	*M. dolomieui*		31.8	33.0	376.0	23/06	(1) Odonata; Anisoptera
PL(5)	*M. dolomieui*		27.5	29.3	270.0	23/06	(1) Ephemeroptera; Ephemeridae
PL(9)	*M. dolomieui*		18.5	19.6	90.0	23/06	(1) Odonata; Anisoptera
PL(10)	*M. dolomieui*		19.2	20.2	98.0	23/06	(1) unidentifiable small fish

Table 3.3.7. Stomach contents of Big St. Margarets Bay Lake fish.

I.D. No.	Species	Sex	Fork Length (cm)	Total Length (cm)	Weight (g)	Collection Date	Stomach Contents
SMB(2)	*P. flavescens*		21.0	22.0	105.9	31/05	(1) Odonata
SMB(4)	*S. fontinalis*		15.8	16.5	50.3	31/05	(1) Odonata; Anisoptera
SMB(5)	*S. fontinalis*		18.0	19.2	76.1	31/05	(1) Coleoptera; Elmidae
SMB(7)	*S. fontinalis*		21.7	23.0	123.4	31/05	(1) Odonata (2) Coleoptera
SMB(9)	*S. fontinalis*		27.4	29.0	275.1	31/05	(1) Coleoptera; Gyrinidae (2) Coleoptera; Elmidae (3) Ephemeroptera (4) Trichoptera
SMB(10)	*S. fontinalis*		33.5	35.0	432.0	31/05	(1) Coleoptera (2) Odonata; Anisoptera
SMB(11)	*S. fontinalis*		15.5	16.4	46.0	31/05	(1) Coleoptera; Hydrophilidae (2) Coleoptera; Elmidae
SMB(12)	*S. fontinalis*	F	17.8	18.9	82.0	31/05	(1) Odonata; Anisoptera (2) Coleoptera; Gyrinidae (3) Coleoptera; Hydrophilidae (4) Coleoptera; Elmidae
SMB(15)	*P. flavescens*		21.5	22.6	114.0	31/05	(1) Odonata; Anisoptera
SMB(17)	*P. flavescens*		15.0	15.6	36.0	31/05	(1) Odonata; Anisoptera
SMB(18)	*P. flavescens*		22.0	22.6	124.0	31/05	(1) Ephemeroptera; Ephemeridae
SMB(19)	*P. flavescens*		17.6	18.6	66.0	31/05	(1) Odonata; Anisoptera; Macromiidae

3.3.5. Results: Streams

Species captured during electrofishing surveys of streams included brook trout (*Salvelinus fontinalis*), white sucker (*Catostomus commersoni*), ninespine stickleback (*Pungitius pungitius*), common shiner (*Notropis cornutus*), banded killifish (*Fundulus diaphanus*), yellow perch (*Perca flavescens*), smallmouth bass (*Micropterus dolomieui*), and eel (*Anguilla rostrata*). Other cyprinids included creek chub (*Semotilus atromaculatus*), and one tentatively identified as a blacknose dace (*Rhinichthyes atratulus*), was also recorded.

During the May collections, all fish were returned alive; during July, however, 8 young suckers (of 81 fish caught) died as a result of shocking or being caught in barrier nets. Summaries of electrofishing results in the spring (May) and summer (July) are given in Tables 3.3.8 to 3.3.11. More detailed results, including length and weight measurements are in Appendix 3.3.2.

Table. 3.3.8 Summary of electrofishing results, St. Croix tributaries, 26-29 May 2001.

St. Croix/Panuke Tributary Sites
May-June 2001

Site	Pass	Total No. Fish	# **Trout**	# **Suckers**	# **Eels**	# **Chub**	# **Killifish**	# **9 Spine**	# **Perch**	# **Bass**	Others	Area Sampled sq.m	Fish per Habitat Unit 100 sq.m
SC1	1	1		1(sp)									
SC2	1	0		(sp)									
SC3	1	7	1						6				
SC4	1	0											
SC5	1	18		17		1							
	2	4		1		2					1	**251.1**	**8.76**
	Totals	**22**		**18**		**3**					1		
SC6	1	50		10	11	26		2		1			
	2	42		6	9	24		1			2		
	3	20		1	2	11		3			3	**428.6**	**26.13**
	Totals	**112**		**17**	**22**	**61**		**6**		**1**	**5**		
SC7	1	1	1										
	2	3	1			2						**73.6**	**5.43**
	Totals	**4**	**2**			**2**							
SM3	1	3	1	1				1					
	2	2	2									**102.3**	**4.89**
	Totals	**5**	**3**	**1**				**1**					

Trout were uncommon during the May sampling campaign: only 6 were captured in total in all stations sampled in the St. Croix and St. Margarets systems. This may be an artefact of our inability to sample when suckers were actively spawning, or it may be that trout move out of areas that are being used by suckers at spawning time. In summer, 17 Brook trout were recovered from fewer of the same sampling stations.

Suckers were the most prominent species during the early sampling. Spawning groups were found in or near the sampling reaches at SC1, SC2, SM1 and SM3, and also at Sucker Brook, where an estimated 50+ spawners were counted in an area of approximately 40 m^2.

Table 3.3.9 Summary of electrofishing results, St. Margarets Bay Lake tributaries, 26-29 May 2001

St. Margarets Bay Sites May-June 2001													
		Total	#	#	#	#	#	#	#	#		Area	Fish per
Site	Pass	No. Fish	Trout	Suckers	Eels	Shiners	Chub	9 Spine	Killifish	Perch	Others	Sampled	Habitat Unit
												sq.m	100 sq.m
SM1		16			1			1	13	1			
		26			4			4	17	1			
		9		1	2				6				
	Totals	**51**		**1**	**7**			**5**	**36**	**2**		**138.6**	**36.80**
SM2		10	1	9									
		3		3									
	Totals	**13**	**1**	**12**								**125**	**10.4**

Only one trout was turned in the two Piney Brook stations (Table 3.3.5), together with a number of suckers. The suckers, however, appeared not to be spawning at the time of the survey: possibly spawning had been completed in the St. Margarets Bay Lake area in view of the large numbers of eggs recovered in a Surber sample at SM3 in May. It is possible that higher water temperatures are reached earlier at the shallow, exposed sites in the Big St. Margarets Bay Lake system.

Table. 3.3.10 Summary of electrofishing results, St. Croix tributaries, July 2001

St. Croix/Panuke Sites July 2001											
Site	Pass	Total No. Fish	# Trout	# Suckers	# Eels	# Chub	# Killifish	# 9 Spine	Others	Area Sampled sq.m	Fish per Habitat Unit 100 sq.m
SC1	1	10	5	2			3				
SC2	1	2	2							**182**	**3.30**
	2	4	4								
	Totals	**6**	**6**								
SC3	1	0									
SC4	1	2	2								
SC5	1	1					1				
SC6	1	13		4	5	4					
SC7	1	1				1					
SM3	1	22	8	8		1		5			
	2	118.3	3	11				2		**102.3**	**137.1**
	Totals	**140.3**	**11**	**19**		**1**		**7**			

By the July sampling period, suckers had apparently largely moved out of the sample reaches, probably into deeper, cooler water. Because of a combination of high temperatures and low water levels, relatively few fish were captured except at the Shady Brook site (SM3), which is completely canopied. Densities of both trout and suckers in this stream in July were the highest achieved anywhere in the St. Croix and Big St. Margarets Bay Lake systems, and were comparable with the best site of the Halfway River (Gold Brook).

Killifish were notably more common in the Piney Brook (SM1 & 2) and Shady Brook (SM3) stations. A large school (estimated in the thousands) was observed at the mouth of the canal between Big St. Margarets Bay Lake and Panuke Lake (SC3), below the sampling reach, during July. It should be noted that killifish were not caught at all in Panuke Lake in either nets or minnow traps.

Table 3.3.11. Summary of Electrofishing Results, St. Margarets Bay Lake Tributaries, July 2001.

St. Margarets Bay Sites Jul 2001											
		Total	#	#	#	#	#	#		Area	Fish per
Site	Pass	No. Fish	Trout	Suckers	Eels	Chub	Killifish	9 Spine	Others	Sampled	Habitat Unit
										sq.m	100 sq.m
SM1	1	19		1	3		8	7			
	2	11		1	2		4	4			
	Totals	**30**	**0**	**2**	**5**	**0**	**12**	**11**		**138.6**	**21.65**
SM2	0	Temperatures too high for sampling									

Fish Population Characteristics.

Results for common species in the St. Croix and St. Margarets Bay collections have been examined to investigate the population characteristics of the stock. Figures 3.3.21 to 3.3.23 show the length-weight relationships for brook trout, banded killifish and white sucker. All data from the two sample periods have been combined. Numbers for eel, and yellow perch were insufficient for meaningful analysis. The length-weight relationship can be used as an indicator of fish health, but a large number of values is needed. There does not appear to be anything exceptional about these results.

Figure 3.3.21. Length-weight relationships of brook trout in St. Croix and Big St. Margarets Bay Lake systems

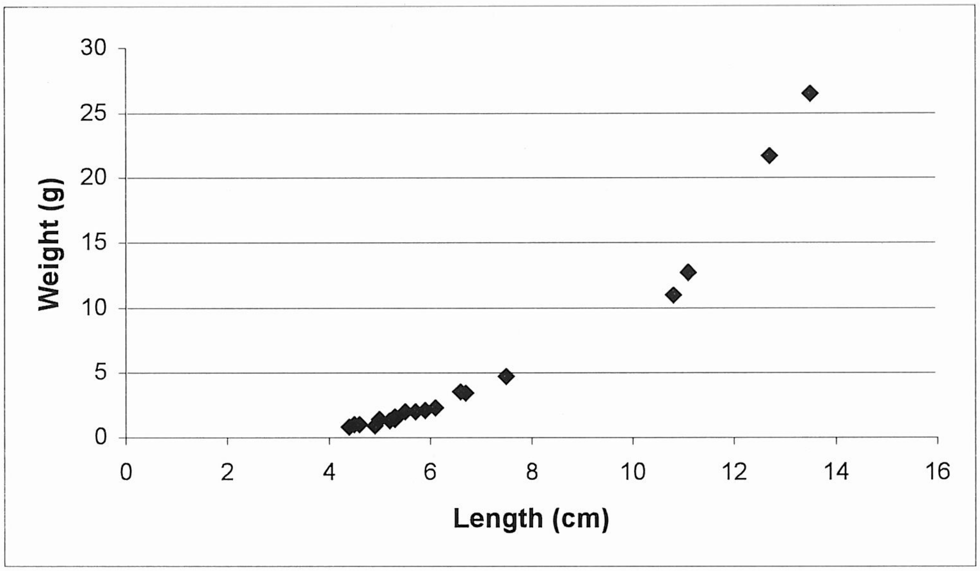


Figure 3.3.22. Length-weight relationships of banded killifish in St. Croix and Big St. Margarets Bay Lake systems

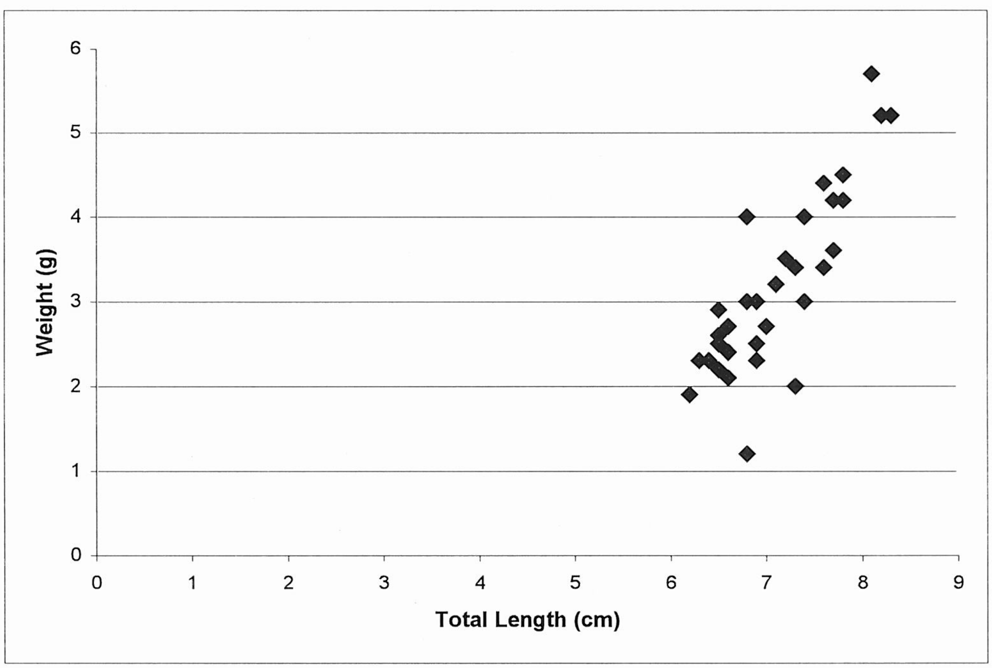
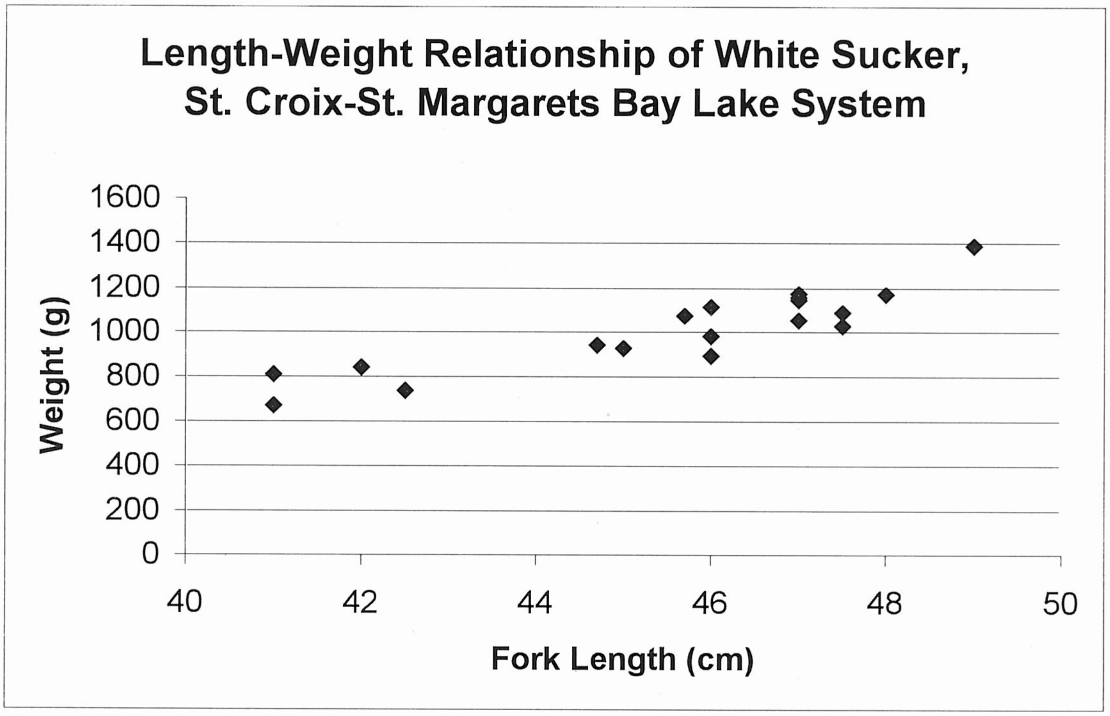


Figure 3.3.23 Length-weight relationships of white sucker in St. Croix and Big St. Margarets Bay Lake systems



Age structures of the populations are indicated in the length frequency diagrams in Figures 3.3.24 to 3.3.26.

Figure 3.3.24 Length frequencies of killifish in St. Croix and Big St. Margarets Bay Lake systems

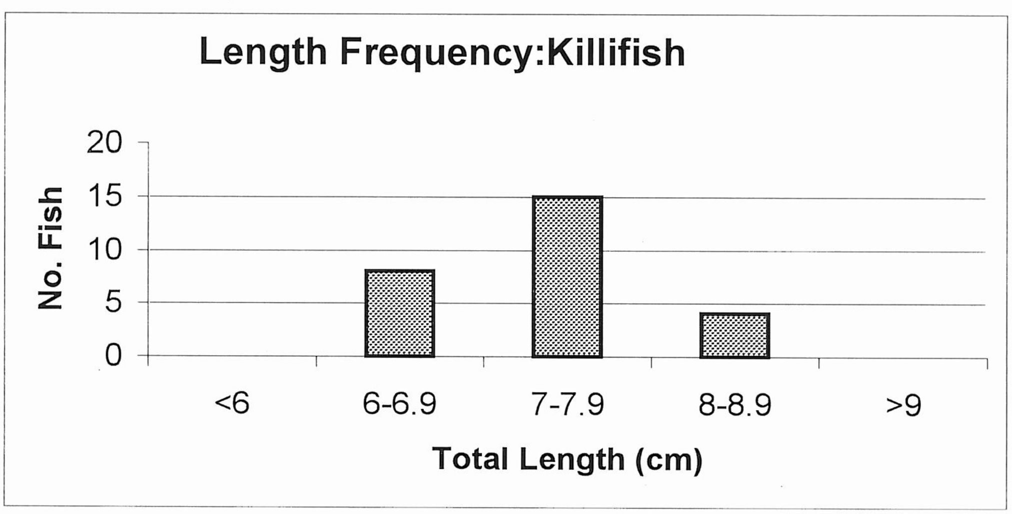


Figure 3.3.25 Length frequencies of white sucker in St. Croix and Big St. Margarets Bay Lake systems

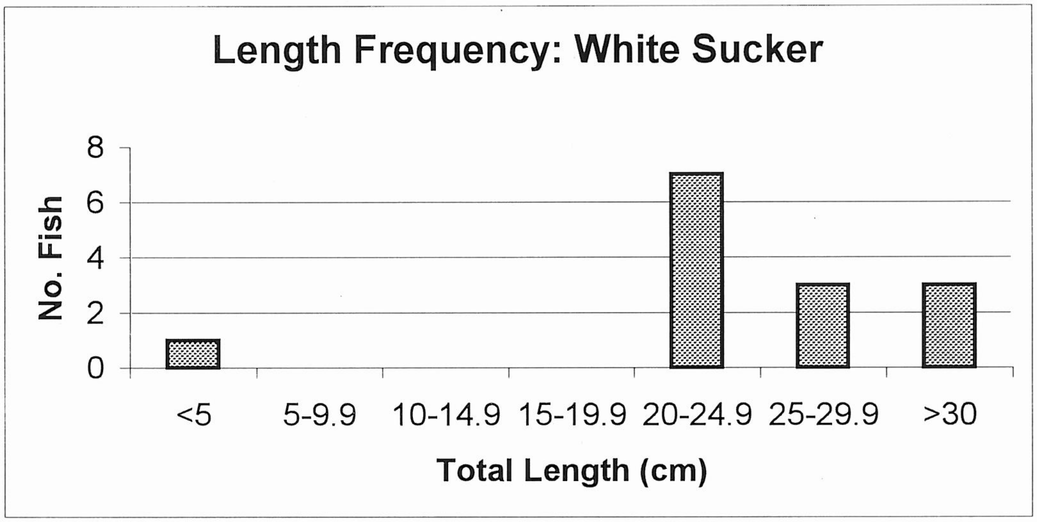
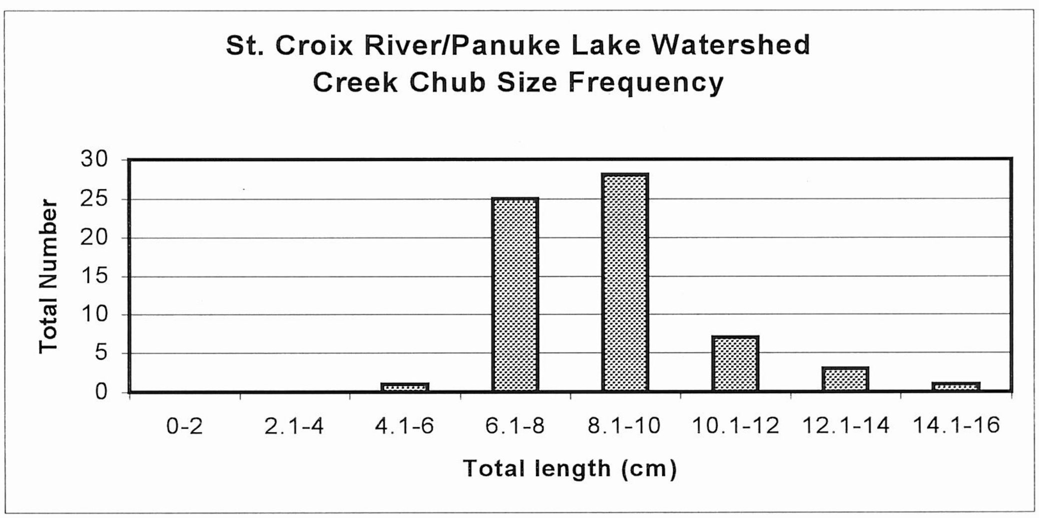


Figure 3.3.26 Length Frequencies of Creek chub in St. Croix and Big St. Margarets Bay Lake systems



3.3.6 Summary & Conclusions

Electrofishing surveys of 10 tributaries of the St. Croix—Panuke Lake system and Big St. Margarets Bay Lake have been attempted according to standard procedures. Sample locations were chosen to represent the variety of potential fish habitat to be found in the system, and were modified as necessary on the basis of experience.

Results indicate that the rivers entering Panuke lake are rugged environments in which water flows at times must be quite strong. Substrates tend to be dominated by massive structures, either bedrock or large boulders, and often these, although stable, exhibit very little moss or grass growth. This is particularly true at the points of access near the entry of each stream to the lake. Higher up the watershed, however, we often encountered more modest slopes, smaller substrate components, and a correspondingly richer instream vegetation.

Fish collections were made only with difficulty. The massive substrate features, combined with extremely low conductivity, limited the effectiveness of the shocker. Presence of spawning fish in the spring (May) sample period prevented electrofishing in some selected places, and difficulties of access precluded changing of sites. In summer, high temperatures presented another problem.

Nonetheless, where sampling was feasible, several species were caught consistently. Very few brook trout were obtained, although they are present. Of the ten sampling sites, only two (SM1 and SM2) contained suitable spawning habitat, although several are probably fair rearing habitat for salmonids. Where density estimates could be obtained, the results were generally rather low, with the exception of SM1 and SM2, both of which appear to be reasonably productive. It is important to note, however, that only a miniscule fraction of the potential fish habitat could be surveyed, and some of the best habitat may be in areas that are difficult to access.

Low conductivity, and very high summer temperatures, are characteristic of most of these streams, unless the riparian vegetation is sufficiently well developed. The shadier inner portions of the streams undoubtedly are more suitable from a temperature point of view, although of the sites examined in this study (SC7, SM 1-3), the prevalence of high organic debris in these areas means that oxygen may also become problematic, especially for salmonids. Even though the water may be unproductive because of the extremely low nutrients and high colour, terrestrial food sources are probably important in providing reasonable feeding conditions for fish.

Further investigation of the inner portions of these streams is necessary for a real assessment of their potential productivity.

3.4 Shoreline & Littoral Zone Vegetation Surveys.

3.4.1 Introduction.

Shoreline and littoral zone investigations were conducted in the impoundments of the St. Croix system, including Big St. Margarets Bay Lake. The objectives of the survey were:

1. to characterize the terrestrial vegetation around the impoundments, to complement the study conducted under Section 2.7 and 2.8;
2. to conduct sampling in the littoral zone at representative transects to identify the presence and relative abundance of submerged and emergent vegetation.

These surveys were conducted by foot and boat on 7, 8, 10 and 23 August by Ms. Ruth Newell, Curator of the E.C. Smith Herbarium at Acadia University, assisted by Dr. Michael Brylinsky, Dr. Trefor Reynoldson, Ms. Melanie Barker, Ms. Dawn MacNeill, Leon deVreede and Stephen Sandford. Survey time was selected in order to capture the main flowering times of aquatic and coastal plain species. Because of the low waters encountered at this time, some of the submersed vegetation had become exposed.

Representative specimens were collected to confirm identity of species; the data collected are very extensive, and still undergoing analysis.

3.4.2 Panuke Lake

A number of sites on the northern half of Panuke Lake were surveyed, including the mouth of Stoney Brook, the mouth of the canal from Big St. Margarets Bay Lake, two small pools on the lower end of Thanes Brook, some old-growth forest reserve, and several random sites along lake edge. For the southern half of the lake, sites were surveyed at the mouth of Southwest Brook, Armstrong Brook and a large rock outcropping on the west side of Panuke Lake.

The riparian vegetation of Panuke Lake is commonly made up of 1-3 vegetation zones, depending on shoreline width, substrate and degree of slope. Areas that are very rocky and steeply-sloped generally lack vegetation, with the possible exception of an upper, narrow shrub zone immediately adjacent to woodland. Dominant species in shrub zone include: *Spiraea alba* (meadowsweet), *Myrica gale* (sweet gale), *Chamaedaphne calyculata*, (leatherleaf). Shoreline areas that are moderately sloped, are generally somewhat wider and have two zones of vegetation present: an upper shrub zone, and a lower, newly exposed zone often dominated by tussocks of a sedge species, *Carex lenticularis*; these areas are made up of various combinations of rocks, gravel and sand. Sections of island shorelines that are wide and gently sloping, can have extensive areas of shoreline vegetation. These habitats often have 3 conspicuous zones of vegetation: a lower, wide, sedge zone, a middle, generally narrow, cranberry-dominated zone, and an upper, sometimes very extensive, shrub zone.

Aquatic and emergent vegetation ranges from sparse to nonexistent along the shore of Panuke Lake, probably due to the sharp depth increase immediately offshore. Wooded areas surrounding the lake generally are a mix of coniferous and deciduous species although in the upper (southern) end of the lake, the coniferous component appears to dominate.

A preliminary survey of the old-growth forest reserve on the eastern shore of Panuke Lake was also conducted. Main species observed included: mature *Picea rubens,* (Red Spruce), *Tsuga canadensis,* (Eastern Hemlock), *Pinus strobus* (White Pine), and *Betula papyrifera* (White Birch). Ground and understory vegetation was limited, principally composed of *Aralia nudicaulis* (Wild Sarsaparilla), *Phegopteris connectilis* (Beech Fern), *Monotropa uniflora* (Indian Pipe), *Dennstaedtia punctilobula* (Hay-scented Fern), young *Populus tremuloides* (Trembling Aspen), *Betula lutea* (Yellow Birch), *Abies balsamea* (Balsam Fir), and *Acer rubrum* (Red Maple).

Of particular interest during this survey, was the record of *Salix sericea*, the Silky Willow, which was found near the main dam on the west shoreline of Panuke Lake. This is a rare Nova Scotia willow (listed in *Atlas of Rare Vascular Plants in Nova Scotia*, Pronych & Wilson, 1993). Approximately 10 plants (shrubs) were observed along the upper shoreline at the one location. Silky Willow was not observed anywhere else on Panuke Lake during this survey. A plant conspicuous by its absence in Panuke Lake was the pickerel-weed, *Pontedaria cordata.* This is generally a very common and abundant lake edge species in the region, but only a small number of plants was observed, and those only in the ponds at the mouth of Armstrong Brook.

Table 3.4.1 gives a list of species recorded from the Panuke Shore.

(In the plant lists below, asterisks indicate the most abundant and widely occurring species.)

Aquatic and emergent species:
*Lysimachia terrestris**, swamp candle
Sparganium spp., bur-reed
*Eleocharis acicularis**, spikerush
Juncus sp.*, rush
Proserpinaca palustris, mermaidweed
Hypericum boreale f. callitrichoides, St.John's-wort (an aquatic form)
Sagittaria sp, arrowhead (as submerged, vegetative rosettes)
Hippuris vulgaris, mare's-tail (observed at one location only: upper Thanes Brook pond)
Nuphar x rubrodisca, yellow pond-lily (observed at one location only: Thanes Brook ponds)
Utricularia intermedia, bladderwort (Thanes Brook ponds only)
Carex lenticularis *, sedge
Eriocaulon septangulare (pond edges only: Thanes Brook & Armstrong Brook)
Nymphoides cordata , floating heart (Thanes Brook ponds only)
Lobelia dortmanna, water lobelia (Thanes Bk ponds only)
Nuphar variegata , cow lily (Thanes Brook & Armstrong Brook ponds only)
Pontederia cordata., pickerelweed (Armstrong Brook ponds only)

Mid-upper shoreline species:
*Spiraea alba**, meadow-sweet
*Spiraea tomentosa**, steeplebush
*Euthamia graminifolia**, narrow-leaved goldenrod
Onoclea sensibilis, sensitive fern
Veronica scutellata, marsh speedwell
*Triadenum fraseri**, marsh St. John's-wort
Juncus canadensis, Canada rush
Eupatorium perfoliatum, boneset
Carex crinita, sedge
Myrica gale, sweet gale

Calamagrostis canadensis, blue-joint
Osmunda cinnamomea, cinnamon fern
Osmunda claytoniana, interrupted fern
*Vaccinium macrocarpon**, large cranberry
Salix sericea, silky willow
Osmunda regalis, royal fern
Panicum lanuginosum, panic-grass
*Chamadaphne calyculata**, leather-leaf
Ilex verticillata, Canada holly
Alnus incana, speckled alder
Thelypteris palustris, marsh fern
Carex stricta, sedge
Myrica pensylvanica, bayberry
Rhododendron canadense, rhodora
Kalmia angustifolia, sheep laurel
*Agrostis hyemalis**, tickle grass
*Glyceria canadensis**, rattlesnake grass
*Scirpus cyperinus**, wool grass
Iris versicolor, blue-flag
*Osmunda regalis**, royal fern

Lower shoreline species:
*Viola lanceolata**, lance-leaved violet
*Lysimachia terrestris**, swamp-candle
Agrostis hyemalis, tickle grass
Lycopus uniflorus, water horehound
*Juncus pelocarpus**, rush
Scirpus cyperinus, wool grass
*Juncus filiformis**, rush
*Carex lenticularis**, sedge
Eleocharis sp., spikerush
*Glyceria canadensis**, rattlesnake grass
Lycopus americanus, water horehound
Iris versicolor, blueflag
*Drosera intermedia**, narrow-leaved sundew
Hypericum ellipticum, St. John's-wort

Lake edge woodland species (trees):
Abies balsamea, balsam fir
Pinus strobus, white pine
Acer rubrum, red maple
Fraxinus americana, white ash
Picea rubens, red spruce
Betula papyrifera, white birch
Tsuga canadensis, hemlock

Lake edge woodland species (understory & ground vegetation):
*Osmunda claytoniana**, interrupted fern
Petasites frigidus, sweet coltsfoot
Thalictrum pubescens, meadow-rue
Thelypteris noveboracensis, New York fern
Corylus cornuta, beaked hazelnut
Equisetum sylvaticum, wood horsetail
Aster lateriflorus, calico aster
*Aralia nudicaulis**, wild sarsaparilla
*Maianthemum canadense**, wild lily-of-the-valley
Abies balsamea, balsam fir
Pteridium aquilinum, bracken

Wooded stream edges:
*Acer rubrum**, red maple
*Tsuga canadensis**, hemlock
Amelanchier sp., shadbush
*Picea rubens**, red spruce
Onoclea sensibilis, sensitive fern
*Calamagrostis canadensis**, blue-joint
Betula papyrifera, white birch
Spiraea alba, meadow-sweet
*Osmunda claytoniana**, interrupted fern
Hamamelis virginiana, witch-hazel
Aralia nudicaulis, wild sarsaparilla
Acer saccharum, sugar maple
Fraxinus americana, white ash
Betula lutea, yellow birch
Ilex verticillata, Canada holly
Lycopus uniflorus, water horehound
Lysimachia terrestris, swamp candle
Leersia oryzoides, cut-grass
Alnus incana, speckled alder
*Osmunda cinnamomea**, cinnamon fern
Drosera rotundifolia, round-leaved sundew
Viburnum cassinoides, witherod
*Cornus canadensis**, bunchberry
Kalmia angustifolia, sheep laurel
Brachyelytrum erectum, long-awned wood-grass
*Myrica pensylvanica**, bayberry
Gaylussacia baccata, huckleberry
Vaccinium angustifolium, lowbush blueberry
Vaccinium myrtilloides, velvet-leaf blueberry
Sorbus decora, mountain ash
*Rhododendron canadense**, rhodora
Gaultheria hispidula, trailing snowberry

Acer pensylvanicum, moose maple
*Coptis trifolia**, gold thread
Oxalis sp., wood sorrel
Corylus cornuta, beaked hazelnut
Streptopus amplexifolius, white twisted stalk
Viola macloskeyi, small white violet
*Aster acuminatus**, wood aster
Carex arctata?, sedge
*Pinus strobus**, white pine
*Aster umbellatus**, tall white aster
Prenanthes trifoliolata, lion's-paw
Phegopteris connectilis, beech fern

Wooded pond edges (Ponds at the mouth of Thanes Brook):
Osmunda regalis, royal fern
Lysimachia terrestris, swamp candle
Iris versicolor, blue flag
Chamaedaphne calyculata, leatherleaf
Ilex verticillata, Canada holly
Spiraea alba, meadow-sweet
Triadenum fraseri, marsh St. John's-wort
Calamagrostis canadensis, blue joint
Osmunda cinnamomea, cinnamon fern
Acer rubrum, red maple
Betula lutea, yellow birch
Alnus incana, speckled alder
Maianthemum canadense, wild lily-of-the-valley

Outcrop vegetation:
*Vaccinium angustifolium**, lowbush blueberry
*Danthonia spicata**, poverty grass
Cladonia spp., lichen
Betula papyrifera, white birch
*Corema conradii**, broom crowberry
*Gaylussacia baccata**, huckleberry
Quercus rubra, red oak
Pinus strobus, white pine
Pinus resinosa, red pine
Pteridium aquilinum, bracken
Kalmia angustifolia, sheep laurel
Amelanchier sp., shadbush
Viburnum cassinoides, witherod
Cypripedium acaule, pink lady's-slipper
Populus grandidentata, large-toothed aspen
Rhododendron canadense, rhodora
Gaultheria procumbens, teaberry

Picea rubens, red spruce
Nemopanthus mucronata, black holly
Alnus viridis, downy alder
Acer rubrum, red maple

3.4.3 Parsons Dam Impoundment

At the top end of the impoundment, just below the Upper St. Croix dam, there are sandy/rocky flats on both sides of the waterway. These have a variety of shoreline species including sedges (*Carex* spp.), wool grass (*Scirpus cyperinus*), a number of grass species including northern manna-grass (*Glyceria borealis*), common beggar's-ticks (*Bidens frondosa*) and three-way sedge (*Dulichium arundinaceum*). Aquatic and emergent species are present in limited amounts. These consist primarily of an emergent bur-reed (*Sparganium americanum*). There were also small amounts of a bladderwort (*Utricularia geminiscapa*) and a pondweed (*Potamogeton* sp.).

There are several areas with beds of aquatic vegetation downstream from the dam on the west side of the impoundment (before impoundment opens up into the wider section). Dominant species include water-lily (*Nymphaea odorata*) and bur-reed (*Sparganium americanum*). Beds of submerged purple bladderwort (*Utricularia purpurea*) also occur here. Other species, occurring in relatively small amounts, include Northern manna-grass (*Glyceria borealis*), pondweed (*Potamogeton confervoides*), water shield (*Brasenia schreberi*), and cow lily (*Nuphar variegata*).

For the most part, on the upper impoundment, there is very little exposed, shoreline area, presumably because of the relatively limited water level fluctuations. Dry, treed slopes come down to the water's edge in most places. Aquatic and emergent plants are not abundant. There are however, several, small, sphagnous, boggy islands on the east side of the impoundment. Vegetation on these islands includes *Dulichium arundinaceum*, *Chamaedaphne calyculata*, *Myrica gale*, *Osmunda cinnamomea*, and *Alnus incana*. Water plants in the vicinity of these small islands include *Nymphaea odorata*, *Dulichium arundinaceum* and *Sparganium americium*.

Tree species around the upper impoundment include: Hemlock, Red Spruce, Beech, Red Maple, White Birch, Moose Maple, and Ironwood.

3.4.4 Trash Rocks Impoundment

There were more aquatic and emergent plants in evidence overall in the lower impoundment than in the upper impoundment. The upper part of the lower impoundment in particular, had a significant amount of aquatic vegetation. This region encompasses a number of quiet, cove-like shallow water areas. Water plants observed include: *Nymphaea odorata*, several Bur-reed species including *Sparganium americanum*, *Nuphar variegata*, *Brasenia schreberi*, beds of *Utricularia purpurea*, and a number of *Potamogeton* species.

The lower end of the lower impoundment had smaller amounts of aquatic vegetation. A small number of quillwort (*Isoetes* sp.) was observed at one location. At the lower end of the lower impoundment, aquatic vegetation includes, *Callitriche palustris*, *Eleocharis acicularis*, *Sparganium americanum*, *Eriocaulon septangulare* and *Utricularia purpurea*.

Much of the shoreline of the lower St. Croix impoundment is boggy-edged. Tree species include red maple, black spruce, wire birch. Shrub and herbaceous species include: *Gaylussacia baccata*, *Chamaedaphne calyculata*, *Viburnum cassinoides*, *Spiraea tomentosa*, *Rhododendron canadense*, *Rhynchospora alba*, *Carex trisperma*, *Lycopus uniflorus*, *Juncus pelocarpus*, *Drosera rotundifolia*, and *Osmunda cinnamomea*.

3.4.5 Big St. Margarets Bay Lake

This lake has a variety of shoreline types ranging from relatively broad shorelines as on points of land or in various coves, to somewhat narrow shorelines (2 – 4 m wide), to essentially nonexistent shorelines where vertical bedrock edges occur. Most shorelines have mixtures of rock and sand, with stream mouths having a high predominance of rocks and boulders.

In terms of shoreline vegetation, there is generally a lower, wet zone and a higher, relatively dry zone adjacent to the treeline. The lower zone is often visually dominated by pure stands of Three-way Sedge (*Dulichium arundinaceum*). Other commonly occurring species in this zone are *Lysimachia terrestris*, *Juncus pelocarpus*, and *Drosera intermedia*. In areas with broader shorelines, a greater variety of species can be found in the lower zone. Some of these species include: *Juncus filiformis*, *Eriocaulon septangulare*, *Glyceria borealis*, *Bartonia paniculata*, *Lycopus uniflorus*, *Viola lanceolata*, *Juncus* spp., *Drosera intermedia*, *Scirpus cyperinus*, *Eleocharic acicularis*, *Triadenum fraseri*, *Hypericum* spp., *Osmunda regalis* and *Spiraea tomentosa*.

Upper shoreline plants include a number of shrub and herbaceous species that grow next to the woods. Commonly occurring species in this zone include: *Myrica gale*, *Osmunda regalis,* *Calamagrostis canadensis*, *Chamaedaphne calyculata*, *Ilex verticillata*, *Acer rubrum* saplings, *Spiraea tomentosa*, *Myrica pensylvanica*, and *Gaylussacia baccata*.

Aquatic plants are abundant in some of the quieter waters especially in the long, narrow coves at the north end of the lake. Large, submerged and floating beds of Greater Purple Bladderwort (*Utricularia purpurea*) were observed in many areas. Several locations at the north end of the lake had small numbers of the rare Floating Bladderwort (*Utricularia radiata*). Present in many of the coves around the lake are large submerged beds of a slender-leaved species of Pondweed *(Potamogeton* sp.). Dense beds of a species of Water-milfoil (*Myriophyllum* sp.) were observed in the cove that leads to the outlet canal to Panuke Lake. Cow Lily (*Nuphar variegata*) and White Water Lily (*Nymphaea odorata*) occur in small numbers in a few places around the lake. Dense beds of an aquatic *Sphagnum* species were also observed in the cove at the inlet from Three-cornered Lake.

Emergents are absent in some areas and in others form a narrow zone of vegetation just offshore. Some of the more common emergent plant species are: Pickerel-weed (*Pontederia cordata*), Pipewort (*Eriocaulon septangulare*), and Bur-reed (*Sparganium americium).*

Big St. Margarets Bay Lake has more representatives of the Atlantic Coastal Plain Floral Element than Panuke Lake or any of the St. Croix and Halfway River impoundments. This is a group of plants that occur on the coastal plain along the Atlantic seaboard from Texas northwards to Cape Cod, Massachusetts. Disjunct populations occur in southwestern Nova Scotia and in the Great Lakes drainage basin. Many of the species of this floral element occur on lakeshores and are listed as endangered or threatened in Canada and the United States because of their very limited distribution and the threats to existing populations such as the establishment of new hydro dams, cottage development and recreational activities along lakeshores. The only rare coastal plain species that was observed during this survey on Big St. Margarets Bay Lake is the Floating Bladderwort mentioned above. However, several other coastal plain species were observed on this lake. These are Yellow-eyed Grass (*Xyris difformis*) and a species of Panic Grass (*Panicum spretum*). Both of these are fairly widespread on lakeshores in southwestern Nova Scotia. They are however, often recognized as indicators that more rare coastal plain species may be present or were present in the past. These species require natural water level fluctuations to prevent the establishment of more competitive, aggressive plant species. Hydro and storage dams stabilize water levels in lakes and often lead to the elimination of rare coastal plain species.

The woodlands around the lake are primarily coniferous. The main species include: Hemlock, Red Spruce, White Pine and Balsam Fir. Extensive clear-cutting has been conducted recently near Big St. Margarets Bay Lake, however a buffer zone of trees was left next to the lake.

3.5 Qualitative Fish Habitat Survey of the St. Croix and St. Margarets Bay Lake Systems

3.5.1 Introduction.

The St. Croix River receives water from Panuke Lake, which is fed by a number of natural streams, and from Big St. Margarets Bay Lake, part of the Ingram River watershed. The linked watersheds have an area of nearly 300 km^2, and the major streams total nearly 50 km in length (Table 3.5.1). Highest points of the watersheds are c. 200 m elevation, and there is a little more than 100 m drop to the operating levels of Panuke Lake. Much of the watershed area is at or above 150 m, so that the greatest elevational change tends to be near the shoreline of the lake. This means that the longer streams are characterised by a zone of relatively slight to moderate slope extending from the head of the watershed to near the lake, followed by a steeper drop as the stream approaches its mouth.

Table 3.5.1. Stream Lengths in the St. Croix and Big St. Margarets Bay Lake watersheds.

St. Croix River System		**Big St.Margarets Bay Lake System**	
Watershed Area:	225 sq. km	Watershed Area:	51 sq. km
Tributaries	km	Tributary	km
Halls Lake Brook	1.25		
Sucker Brook	5.85	Piney Stream	5.80
Stoney Brook (SC1)	6.25		
Shady Lake Brook (SM3)	6.50		
Eagle Cove Brook	2.90		
Thans Brook (SC2, SC7)	8.30		
Armstrong Brook (SC5)	6.67		
Southwest Brook (SC4)	7.50	**Total Tributaries**	**51.02**

Fish and invertebrate collections covering a few habitat units (100 m^2 each) only provide a limited indicator of fish habitat in a large watershed such as this. To amplify the assessment, longer portions of the streams were surveyed to provide a qualitative account of stream conditions, with a focus on those characteristics that seem most permanent, or have most significance for determining the quality of fish habitat. Difficulties of access are a major problem in this area. The only reasonable access to many streams is by boat along Panuke Lake, or by controlled access logging roads through the Ingram River watershed. Washouts prevented access to some planned sites in the Big St. Margarets Bay Lake system, and the forest fire hazard led to woodlands being closed for parts of the summer of 2001. Consequently, the surveys were limited to stretches of stream that could be accessed by boat or by established road.

3.5.2 Methods

Using the electrofishing sites as a base, upstream and downstream sections of the streams entering Panuke Lake or Big. St. Margarets Bay Lake system were surveyed on foot. Each survey attempted to cover at least 200m above and below the site selected for electrofishing, and took up to several hours. Because of topography and access problems, most of the electrofishing sites in the St. Croix streams (except Upper Thans Brook) were near the lake. The steep topography in the lowermost reaches of the streams means that sections of stream habitat that are directly influenced by water level changes in Panuke Lake are short.

In the Big St. Margarets Bay Lake system, road access enabled us to reach two locations on Piney Stream that were at slightly higher elevations (<120 m), and thus may reasonably represent conditions in other streams further away from the lake shore. Information from water quality investigations and fish surveys suggest that the Big St. Margarets Bay Lake system is more productive than the St. Croix system.

Observations were made on substrate characteristics, instream vegetation, and bank stability, together with measurements of stream width, depth, and flow. Locations were recorded with a Magellan 315 GPS Unit. A photographic record was established for most sites; the record will be completed when access can be gained to two sites during the next campaign.

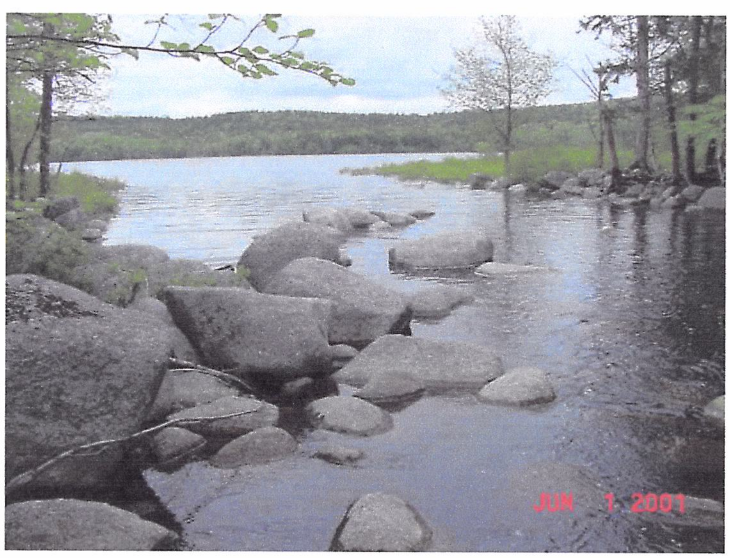
3.5.3. Results

Complete field notes are provided in Appendix 3.5.1. Brief summaries from those notes are provided below.

Stoney Brook near SC1.

Stoney Brook is a relatively large sub-watershed, receiving water from Green Lake and Burnt Lake, and Bog Brook. There are several still water ponds along its course at elevations ~ 50 m above the level of Panuke Lake. The electrofishing reach was in the lower portion of the system up to c. 150 m from the mouth. Because of high flows and spawning suckers in May, and low water levels and high temperatures in July, it was not possible to obtain quantitative fish data from this site. Near the mouth, the substrate is characterised by large and small boulders (Figure 3.5.1), many of which have a coating of green moss on the downstream side. The large boulders provide plenty of instream cover, but this portion of the stream has little to no canopy cover.

Figure 3.5.1. Stoney Brook at mouth.



From 50 to 150 m from the mouth, the gradient is relatively small, but the stream is narrower (< 5 m in summer) and provided with < 60% canopy cover. Substrate size becomes progressively smaller upstream, through the fish survey reach, with more areas of gravel and small cobble (Figs. 3.5.3 and 3.5.20).

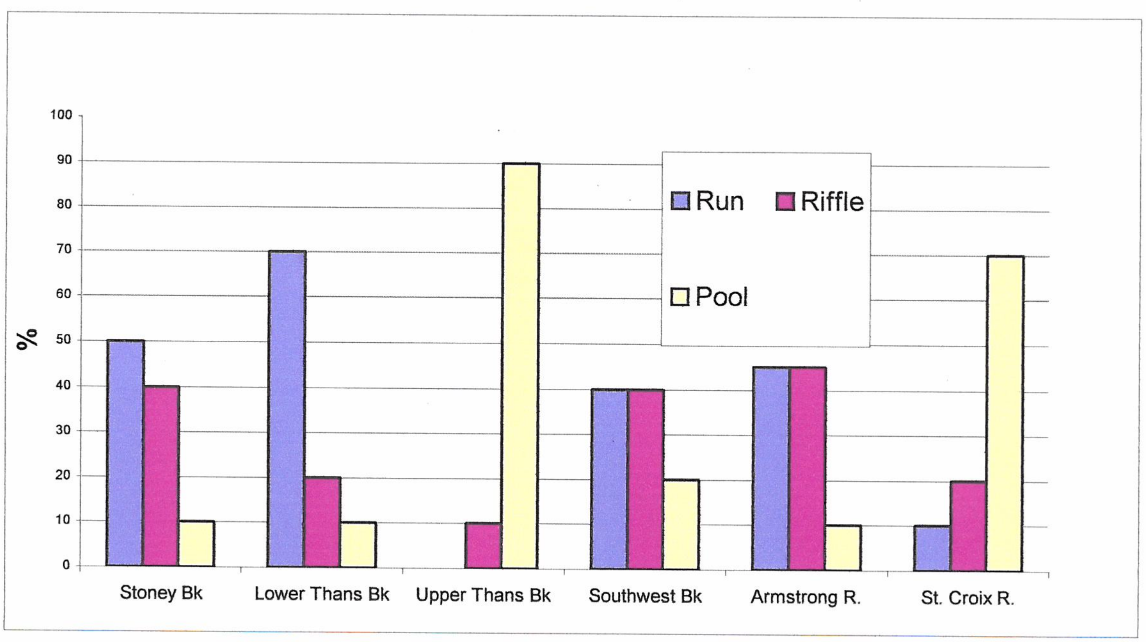
Figure 3.5.2 Stoney Brook, looking upstream in electrofishing reach.

The abundance of mosses and algae on downstream faces of rocks testifies to a relatively rich and stable habitat, with good instream and riparian cover. However, only a small fraction of the substrate is fine enough for spawning habitat (Figure 3.5.20). The slope begins to increase again at 200 – 250 m from the mouth. Larger boulders and more extensive bedrock outcroppings then become prominent, and there are relatively large falls of water (hydraulic jumps) below ledges.

Figure 3.5.3. Stoney Brook above fishing reach.

This stream has a mix of habitat types (Figure 3.5.4), consisting mostly of runs and riffles. Pools are relatively infrequent. As fish habitat it provides good feeding area over much of its length, but the high temperatures recorded in summer (despite the riparian cover) would drive sensitive species further upstream or downstream.

Figure 3.5.4 Habitat types of St. Croix River system tributaries.



Thans Brook (Sites SC2 and SC7).

The Thans Brook watershed is somewhat smaller in size, less than ¼ of it being above 150 m elevation, but it is principally stream, with no large lakes. There are a series of unnamed still waters throughout, many of them in the lower half of the watershed. The principal headwater rises in a marshy area between Burnt Lake and the upper Armstrong Lakes. Site SC 7 was located just below an open still water area, and for most of its length is densely canopied (Figure 3.5.5).

At Site 7, the stream is 5-8 m wide, and flows very slowly between large boulders and accumulations of detritus. The water is very darkly stained (Figure 3.5.6). Substrate type is very bimodal (Figure 3.5.2) consisting of large boulders and expanses of sand or fine gravel accumulating in the spaces between, but with little pebble or gravel-sized substrate. Because of substrate limitations, invertebrates are restricted in diversity, being dominated by grazing herbivores or detritivores such as the Trichoptera, or particulate-feeding Diptera (cf. Section 3.6).

Figure 3.5.5. Upper Thans Brook, Station SC7.

The combination of shaded reaches and open, wetland-bordered still waters, creates a fairly favourable habitat for fish during the heat of the summer, although none were caught within the survey reach in July (Section 3.3).

Figure 3.5.6. Brown Water of Thans Brook.

Site SC2 (Fig 3.5.8) is located in the lower portion of Thans Brook, just between two major still water ponds. The fish survey reach begins about 270 m above the mouth of the brook. At this elevation, the slope is moderate, and the stream consists principally of fairly straight runs (Fig. 3.5.3) between a few large boulders usually greater in height than the bankfull level, often with good moss growth on the downstream sides. Apart from the big rocks, the substrate is mostly of small boulders, with virtually no fine material or outcropping bedrock.

Figure 3.5.7. Lower Thans Brook, above site SC2.

Figure 3.5.8. Lower Thans Brook at Site SC2.

Further upstream (Figure 3.3.7), the slope increases a little, and the stream becomes a series of small cascades that apparently run with water all summer, in between slow-moving pools. Streamside vegetation is mostly of softwoods, and provides reasonable cover.

As fish habitat, Thans Brook qualifies as potentially very good feeding and refuge habitat, but the results so far do not indicate suitable spawning sites.

<u>Canal between Big. St. Margarets Bay Lake and Panuke Lake (Site SC3).</u>

When surveyed at the end of June, there was a good flow along the river, in contrast to most other streams at that time. Flow in this valley is largely controlled by stop logs in the dam at Big St. Margarets Bay Lake. This channel is broadly open at the lower end, adjacent to Panuke lake, and dominated by large boulders like most of the streams. Much of its length is a mix of riffle and run, with cascades at several places. Substrate becomes somewhat smaller between 100 and 200 m from the lake shore, including some sand-gravel-pebble deposits. Further upstream, cobble becomes dominant. Many of the larger rocks are covered with mosses, particularly on the downstream end. Good instream cover is provided by rocks and overhanging banks in many places, but canopy cover rarely exceeds 50%. Compared with other waters in the St. Croix system, samples from this stream were generally very clear, with little colour (Appendix 3.2.2).

Fish surveys of this stream produced relatively little in May (1 Brook trout and 6 Yellow perch), and nothing in July. However, despite its relative lack of cover at the downstream end, it appears to be reasonable feeding habitat.

<u>Armstrong River (Site SC 5).</u>

The Armstrong River watershed is the largest in the St. Croix system, and contains a number of lakes that probably moderate seasonal fluctuations in outflow. At its mouth are two still water areas (the Mud Lake Deadwaters (Figure 3.5.9).

At the mouth of Armstrong River, which is the Lower Deadwater, the water is deep and slow-moving though an array of large rocks. Substrate is a mix of bedrock and large boulders interspersed with patches of finer sediment (sand, gravel) and accumulations of woody detritus. The Upper Deadwater (Figure 3.5.9) is bordered on the west side by a small floodplain with mosses and ferns, and is 1.5-2 m in depth. During early June a female common merganser (*Mergus merganser*) was observed feeding in this pool.

Figure 3.5.9. Upper Mud Lake Deadwater

Figure 3.5.10. Armstrong River at Electrofishing Site SC5 (view toward Upper Mud Lake Deadwater).

The electrofishing reach begins just above the Upper Deadwater. At this point, the river exhibits a moderate slope that is enclosed by a canopy in places, but is relatively exposed in other stretches (Figure 3.5.10). Substrate is a mix of coarse and very coarse materials, many of which are covered with mosses on many sides (Figure 3.5.11). These mosses represent more than one year's growth, indicating that, relative to other streams on this side of Panuke Lake, the lower part of the Armstrong River probably experiences much less extreme flows. Mosses do not persist, nor are able to grow on exposed (upstream) faces where they are subjected to very high flows at least once each year. In this respect, it is strikingly different from other streams surveyed.

Figure 3.5.11. Moss-covered rocks in Armstrong River.

The water colour throughout is dark (60-68 CU), notably stained with humics and tannins, and very low in pH (<5). As fish habitat, this appears to be fine feeding and rearing site, and in the May collections there were a number of White suckers turned at SC5. However, no trout were taken, although the mouth of the Armstrong River is a popular local fishing spot. In summer, a single pass turned only one Killifish. Because of the low pH and absence of suitable spawning sites, the lower reaches of Armstrong River do not appear to be good salmonid spawning habitat.

Southwest Brook (SC4)

Like Armstrong River, Southwest Brook enters Panuke Lake through a large still water embayment that is 1-2 m deep, however, within a very short distance of the mouth the gradient increases as the stream negotiates massive bedrock outcrops and large boulders. There is almost no sediment finer than cobbles anywhere in the lower portion of the river. A survey in July 2001 explored the lowermost 650 m (Appendix 3.5.1).

Figure 3.5.12 Southwest Brook at SC4.

The electrofishing site (SC4) was located 400-450 m above the mouth, and just upstream of a major cascade, where the water tumbles over a series of ledges and massive boulders. Above this cascade the gradient is very moderate, and the shoreline rocks are covered with an array of ferns and grasses.

Upstream of the fish survey reach, the stream substrate is of small to large boulders interspersed with massive bedrock outcrops that control the course of the stream. Riparian vegetation is of ferns and *Sphagnum* moss, and appears to be relatively lush even in the middle of summer. At the time of the survey, the stream only filled about 20% of the bankfull width, and there were a number of isolated pools. It was not possible to set up barrier nets at this site, and spot fishing failed to turn up any fish in May, when flows were relatively high. In July, however, sampling was conducted following some heavy rain, and the stream was much deeper and faster flowing than earlier when the habitat survey was conducted (4 July 2001); two trout were recovered during a single pass.

In many respects, this stream also affords some good feeding habitat, although it tends to be flashy (more than Armstrong River, but like most of the other streams on the west side of Panuke Lake). Macroinvertebrates, particularly mayflies (Ephemeroptera) were very abundant at this site, and numerous other adults of aquatic (Odonata, Ephemeroptera, Diptera) and terrestrial (Hymenoptera) insects were observed during each visit. The principal limitations to this stream as fish habitat are the very low pH (<5), fluctuating flows, and relative exposure to sunlight.

Shady Lake Brook (SM3).

Shady Lake Brook enters Blind Bay, on the east side of Panuke Lake; because of time and travel restrictions no extensive habitat survey could be conducted for the streams on the east side of Panuke Lake. By comparison with the western streams, the valley topography is more consistent, and the slope of the stream is similar for much of its length. Shady Lake Brook drains softwood forests that are undergoing active harvesting.

The electrofishing site lies just at the outlet of a long, unnamed stillwater, and is completely canopied (Figure 3.3.14). The course of the stream is impeded at many places by fallen timber, some of which is covered with grasses and mosses, indicting that it has been there for a long time. These obstructions, together with relatively large boulders (also moss- and grass-covered), create some relatively deep water pools, although through much of its length the stream is shallow. Evidence of relatively high flows in the past is in large deposits of gravel that have been deposited along the banks and riparian zone; these have not developed grass cover, suggesting that the extreme event was fairly recent. The basic stream substrate appears to be cobble and small boulders, but large deposits of sand and/or gravel also occur at intervals in peripheral regions of the stream where they might have settled from a high stream flow event.

Piney Stream (Sites SM 1 & SM2)

Piney Stream is the principal tributary of Big St. Margarets Bay Lake, rising at Big Pine Lake, and flowing through a series of lakes and still waters. Two sample sites were established on this stream, between Big Pine Lake and Little Pine Lake. Extensive habitat surveys are not available for these two sites, because of access and time restrictions.

The lower fish survey site (SM1) is just below a stillwater lake, and consists of a shallow, broad stream with a mix of substrate and habitat types. In the 100 m between a culvert and the lower end of the electrofishing reach, there is a run, with depths <1 m between large boulders, a riffle area with fine gravel and pebbles, and a deep pool just below the riffle, where logs and rocks can be seen at depths >2 m. Figures 3.5.13 and 3.5.14 show two types of habitat: riffle (including the fish survey site) and pool. At the side of the stream alders provide cover, and parts of the stream flow among alder roots. Grasses and herbs are well established on gravel bars.

Figure 3.5.13. Lower Piney Brook site SM1.

Foreground shows White sucker spawning riffle just below fish survey reach.

This stream appears to be relatively rich and productive. The deep pool is partially shaded, with plenty of in-stream cover provided by submerged logs and large boulders. All substrate in the pool is covered by a brown well-developed organic mixture, (technically an *aufwuchs*), that consists of diatoms, filamentous algae, and detritus (cf. Figure 3.5.15).

Figure 3.5.14. Lower Piney Brook Site SM1. Pool with *Nymphaea odorata*

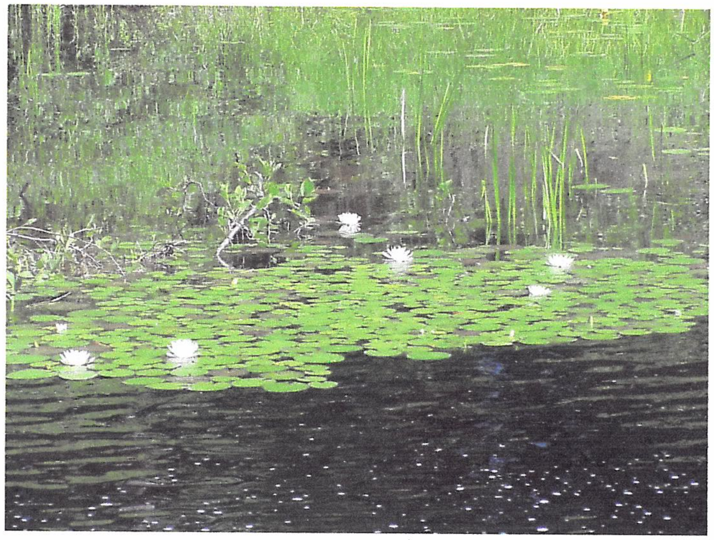


Figure 3.5.15. *Aufwuchs* in pool at SM1

Upper Piney Brook (SM2) is similarly a shallow stream arising out of a stillwater, with relatively good riparian cover of alders, and gravel to cobble substrate (Figure 3.5.16).

Figure 3.5.16. Upper Piney Stream site SM2

Figure 3.5.17. Upper Piney Stream stillwater above site SM2

This stream seems also to be suitable both as feeding and as spawning habitat. In May, several suckers and one trout were captured out of the reach, but in July water temperatures were too high to permit sampling. Numerous frogs were collected in the stream, including Green (*Rana clamitans*) and Pickerel (*Rana palustris*) frogs, and Surber samples indicate that, numerically, this is more productive than the streams entering Panuke Lake (cf. section 3.6).

Although not extensively surveyed beyond the electrofishing sites, the stations on Piney Stream indicate that this brook may provide relatively productive and varied fish habitat. Chemically, like all of the streams in the region, it has virtually no buffering capacity, and as a consequence, pH values in spring at both stations were very low (5.1); however, these were higher in summer (5.4-6.0) than most of the other stream systems studied.

St. Croix River (Site SC6).

This site was below Parsons Dam (Figure 3.5.18), in the natural course of the St. Croix River. It is an area dominated by bedrock outcroppings (Figure 3.5.19), with scattered boulders, some small gravel areas, and a good supply of instream and riparian cover. This area was previously studied and described by MacNeill (MacNeill 2000).

Figure 3.5.18 Parson s Dam, St. Croix River.

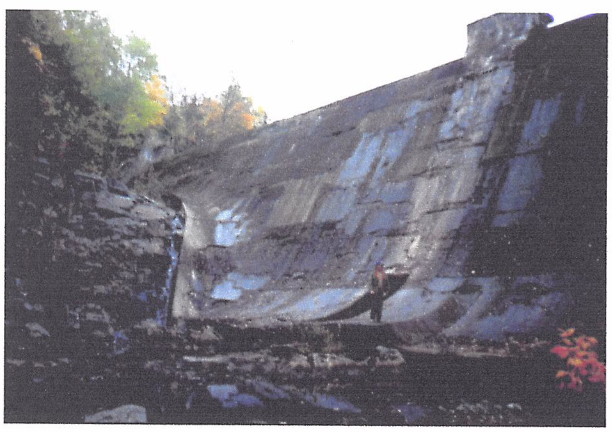
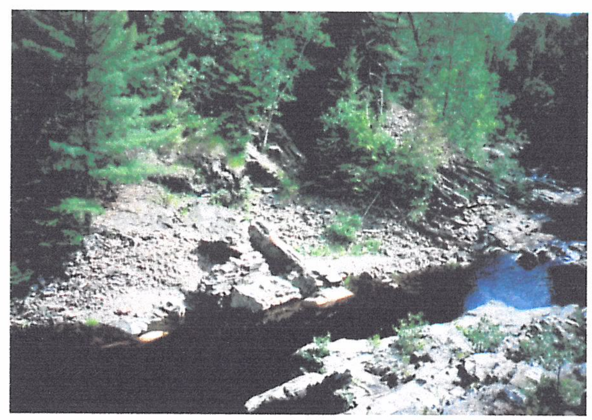


Figure 3.5.19. St. Croix River



Physically and chemically, this portion of the system is quite different from the tributary streams described above. Apart from the relative absence of fine sediments, the dominance of bedrock features is unusual. It provides cover and refuge for fish, and substrate for vegetation. The water sustaining the stream comes primarily from the immediately surrounding watershed, with only a small amount from Panuke Lake as seepage through Parsons Dam. This water is both relatively clear (low colour) and with a notably higher and more constant pH : 6.7-6.8 than found upstream of Parsons Dam. It appears to provide good fish habitat for feeding, and densities here were higher than most other sites (except SM 1 and 3); however, no trout were turned in this reach during either survey. Absence of spawning gravels limits its capacity for sustaining local stocks.

Substrate Characteristics.

Figures 3.5.20-3.5.28 show the relative size distribution of different substrate sizes, based on estimates of area covered during habitat surveys. As noted in habitat accounts presented above, substrate characteristics often varied greatly along the length of a stream as a result of topography. The data shown here relate to the area of a fishing survey reach and adjacent areas upstream and downstream.

The figures show clearly that substrate types for some of the streams are consistently dominated by coarse material, especially boulders, rubble and cobbles, with a skewed distribution toward the coarser end. Notable exceptions are Upper Thans Brook and Shady Lake Stream, where a combination of low slope, and extensive overhead cover are accompanied by fairly large proportions of very fine sediments. However, the distribution at both of these sites is bimodal, and provides insufficient intermediate-sized material to afford suitable spawning areas. The best combination of substrates for fish habitat is a broad distribution of particle sizes that includes finer spawning gravels, coarser rocks for development of diatoms and invertebrate food, and larger elements to provide cover and hydraulic jumps that maintain high oxygen levels. The only habitats surveyed to approach that ideal were Piney Stream, Armstrong River, and Southwest Brook.

Figure 3.5.20. Substrate Type: Stoney Brook

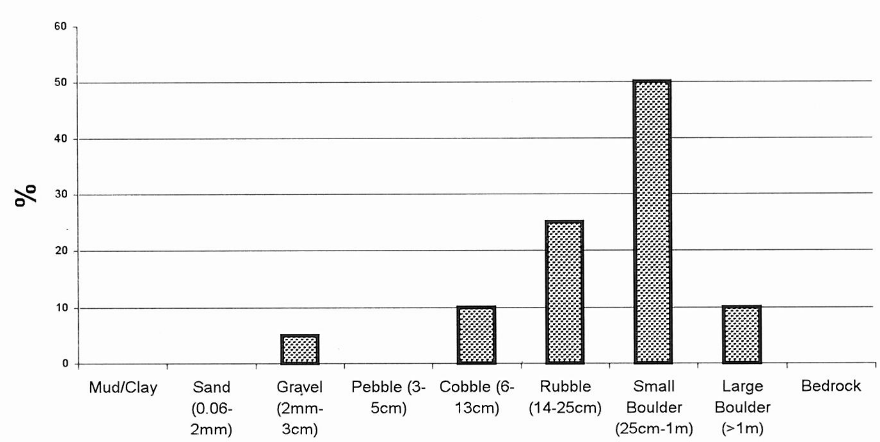


Figure 3.5.21. Substrate Type: Lower Thans Brook

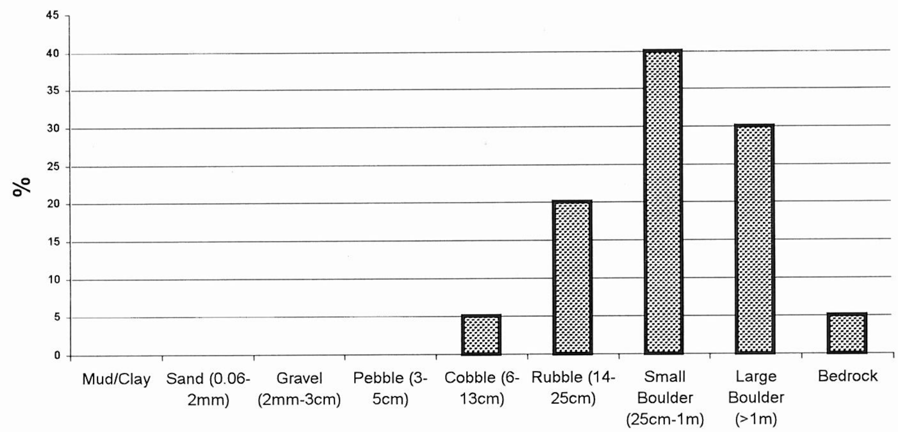


Figure 3.5.22. Substrate Type: Upper Thans Brook

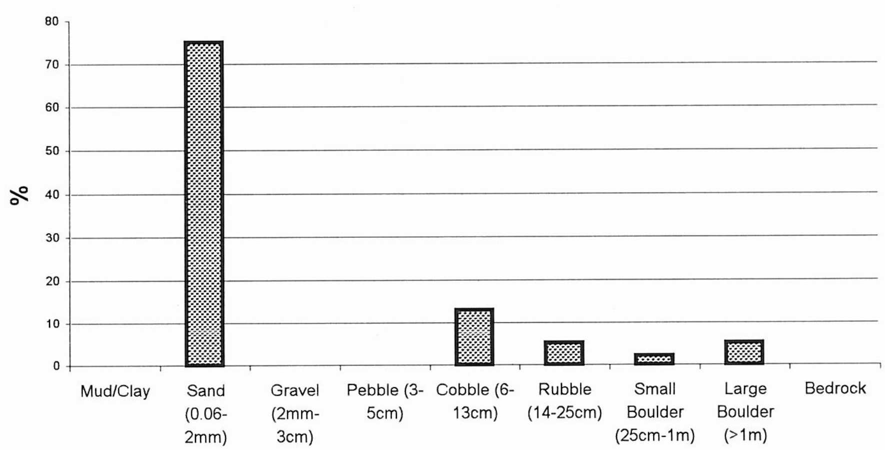
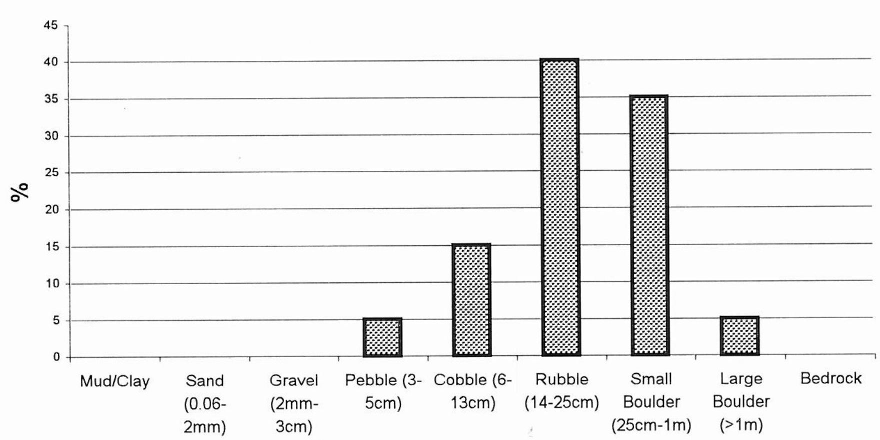


Figure 3.5.23. Substrate Type: Armstrong River



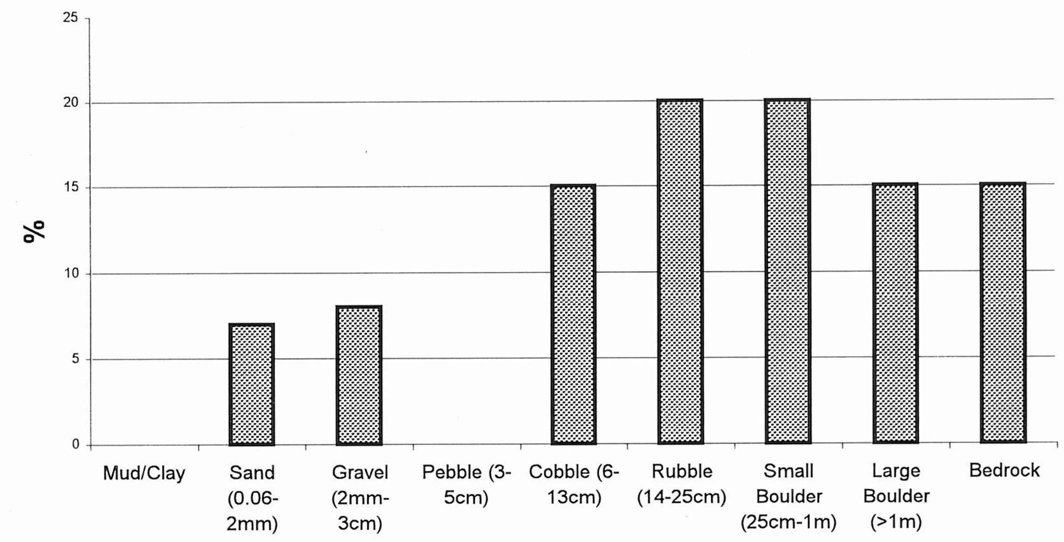


Figure 3.5.24. Substrate Type: Southwest Brook

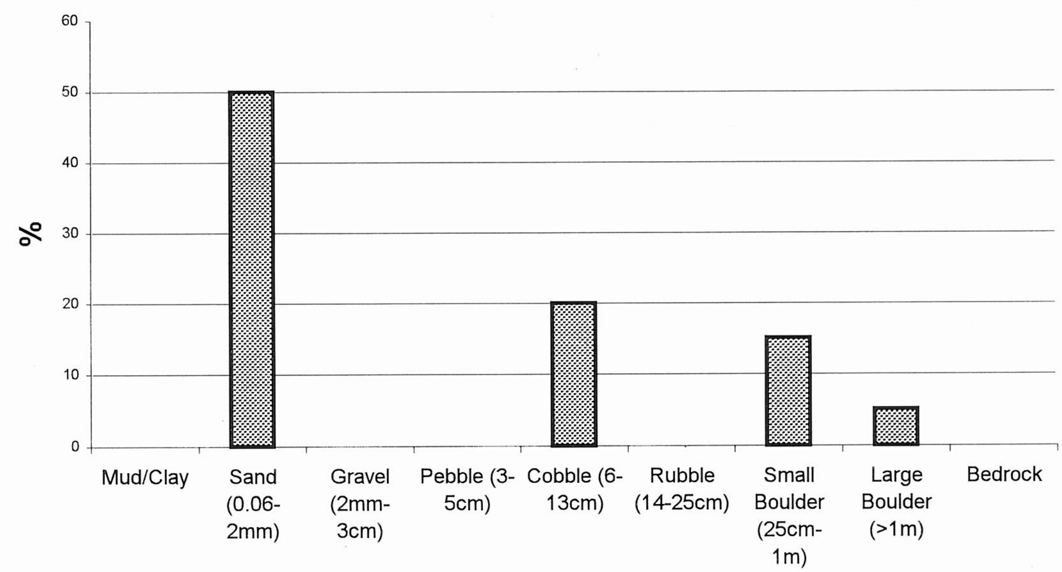


Figure 3.5.25. Substrate Type: Shady Lake Brook

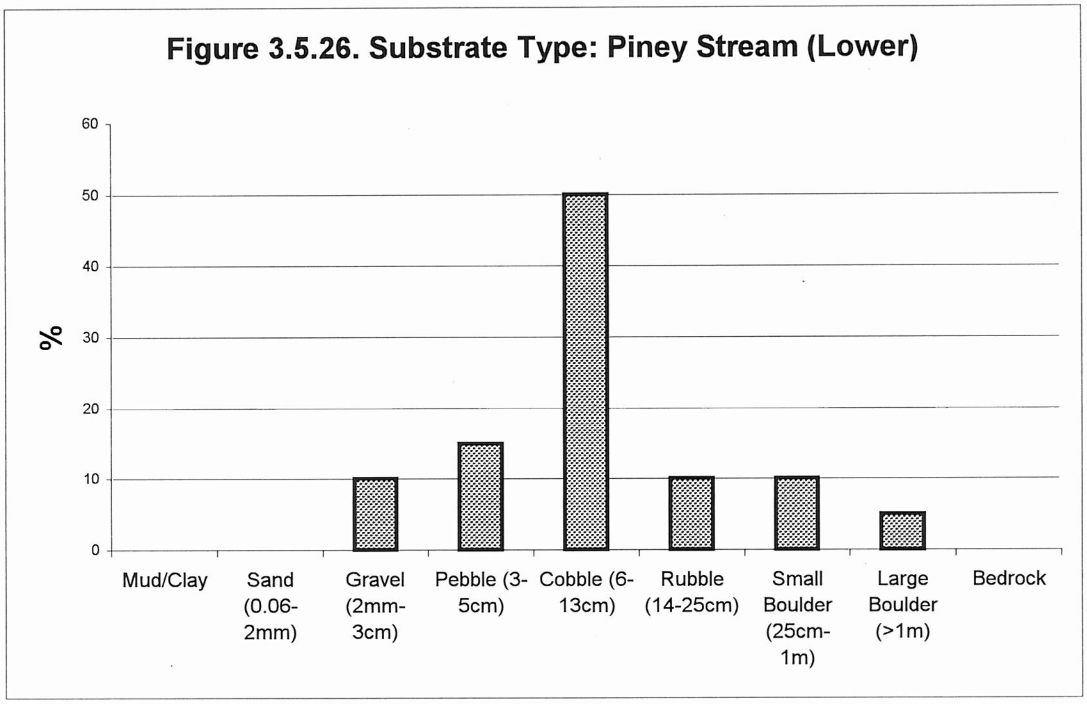


Figure 3.5.26. Substrate Type: Piney Stream (Lower)
%
60
50
40
30
20
10
0
Mud/Clay
Sand (0.06-2mm)
Gravel (2mm-3cm)
Pebble (3-5cm)
Cobble (6-13cm)
Rubble (14-25cm)
Small Boulder (25cm-1m)
Large Boulder (>1m)
Bedrock

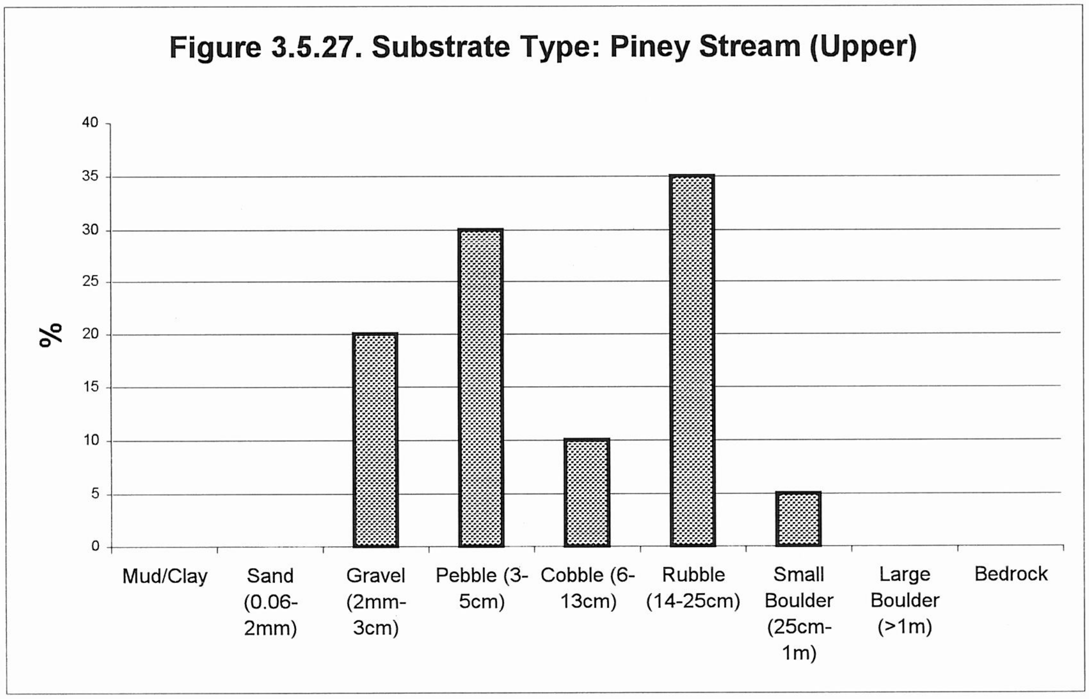
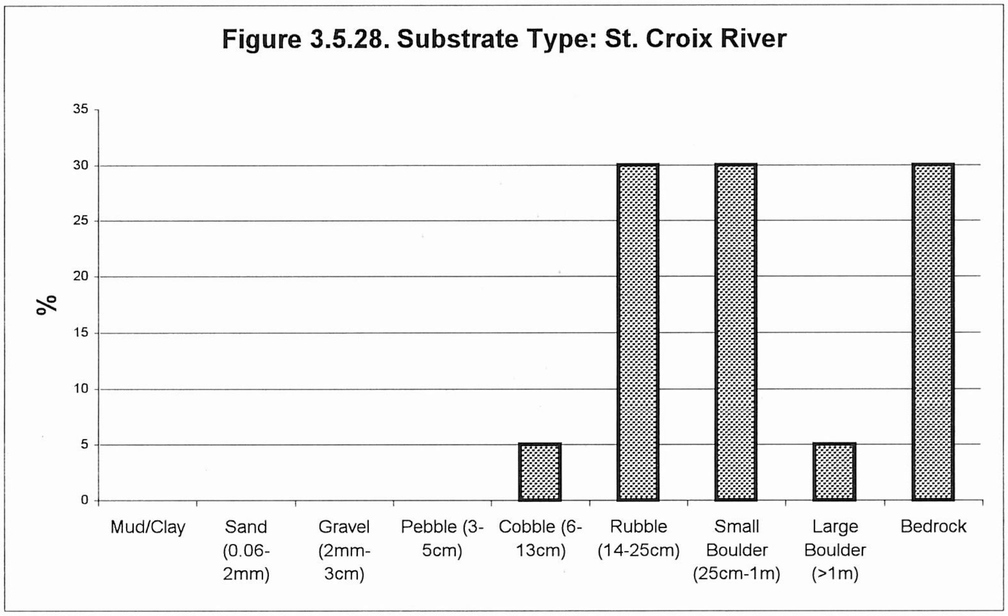


Figure 3.5.27. Substrate Type: Piney Stream (Upper)
%
40
35
30
25
20
15
10
5
0
Mud/Clay
Sand (0.06-2mm)
Gravel (2mm-3cm)
Pebble (3-5cm)
Cobble (6-13cm)
Rubble (14-25cm)
Small Boulder (25cm-1m)
Large Boulder (>1m)
Bedrock



3.5.4. Summary and Conclusions

Extensive surveys of streams entering Panuke and Big St. Margarets Bay Lakes provide a first attempt at characterising the fish habitat represented in the St. Croix system. Of more than 50 km of stream involved, less than 3 km have actually been surveyed. Much of the rest is difficult to access, or was in late summer when the fire hazard was high. The results show that there are a variety of habitats formed as a result of topography, influenced by the degree of riparian vegetation existing. The physical character of most of the streams, especially those entering Panuke Lake from the west, is that much of their course is divided into a higher plateau and a relatively steep slope to the lake. In some instances the steeper change in elevation is near the lake, in which case much of the watershed is at higher levels (>150 m), and these have not been extensively surveyed. The steeper reaches are commonly a mix of very coarse substrate (boulders) and bedrock, affording little suitable sites for spawning.

All the streams, but particularly those on the west side, bear evidence of a 'flashy' nature, with very high flows occurring in the spring that clear out any fine material that might accumulate in crevices during periods of low flow. The exceptions appear to be Armstrong River, Shady Lake Brook and Piney Stream. Armstrong River, in particular, shows signs of relative stability, a fact that may be attributed to the extensive lake and stillwater bodies in the valley. In general, lakes and still ponds (i.e. 'deadwaters') tend to trap sediment, and to modulate the strongly seasonal flows that snowmelt and intermittent rains tend to bring.

It is tempting to attribute the present state of these streams to land-based activities, especially forestry. However, there is little evidence for that. Although an area of active forestry for more than a century, most of the watershed is still largely tree-covered. There is a growing view that the intermittent characteristics of streams in this area may have persisted for a very long time. In New England and the Maritimes, ancient middens show a great deal of inconsistency in the record of fish species utilised by pre-Contact inhabitants of the region (T. Hennessey, P. Amiro, personal communications), suggesting that the stocks underwent large scale fluctuations in the past as well. The present physical state of streams in these the watersheds may have little or nothing to do with the current land or water management of the systems.

In general, the stream systems appear to support a typical array of fish species, but abundances are low. Absence of spawning sites might be a factor, but since almost all waters in the systems frequently dry up, are extremely low in nutrients, have little or no buffering capacity and are acid-stressed, it is probable that these factors, combined with high temperatures where the stream has insufficient cover, are the primary causes of low productivity of fish.

3.6 Macroinvertebrate Survey

3.6.1. Introduction

Aquatic invertebrates represent the major food supplies of fish in streams and lakes. Their abundance is a primary factor that determines the presence and abundance of highly desired species such as trout, or migratory species such as alewife or shad (*Alosa* spp.), especially in winter when terrestrial-derived food is minimal. Identification of invertebrates to genus or family is usually necessary to obtain a clear perspective on the nature of the invertebrate community. However, the general composition of the macroinvertebrates can also be used to indicate water quality. No previous studies have apparently been conducted on the streams of the St. Croix system; hence the collections undertaken as part of this project represent the first from these rivers.

3.6.2. Methods.

Samples for macroinvertebrates were taken at each of the electrofishing sites, coincident with, or shortly after the electrosurvey was conducted. Where suitable riffles were found, samples were taken using a standard 1ft^2 Surber sample. The sampler was positioned in the stream where the substrate was sufficiently fine for removal and scraping (generally less than cobble size). All rocks were removed from the 1ft^2 area, brushed by hand so that the flow would carry any dislodged material into the net, and then the rocks were discarded. The procedure was repeated twice in different locations if possible, and the three samples combined into a single composite sample.

A Surber sample is best described as semiquantitative, since it provides an estimate of abundance that is subject to many sources of error. In addition, seemingly homogeneous substrates are nonetheless heterogeneous, so the selection of appropriate sampling sites becomes a factor influencing results. For this study, Surber collections were made wherever feasible, however the substrate often dictated that the three samples taken were from the only areas suitable (i.e. the majority of the substrate was inappropriate).

In general, the streams of the St. Croix system are dominated by massive glacial erratic boulders and other coarse sediments (cf. Section 3.5). At many sample reaches, where the substrate was bedrock or large boulders, use of a Surber sampler was inappropriate or impossible. Also, riffle areas or shallow runs, where a Surber sampler can be used, do not represent the only significant habitat for invertebrates that are important indicators or food for fish: undercut banks, pools below rock outcrops, and areas with cobble or boulders, all provide microhabitat that supports different invertebrate species that may also become part of the stream drift utilised by fish. Consequently, sampling of organisms in riffle areas (where a Surber sampler can be applied) gives only a modest indication of the potential value of an area for supporting fish.

In circumstances where a semiquantitative Surber sample was impossible, a dip-net collection was made using a D-net. These results cannot be related to area, and therefore provide no indication of invertebrate density, but provide a wealth of information on species presence and relative abundance to one another.

Samples were stored in glass jars fixed in ethanol.

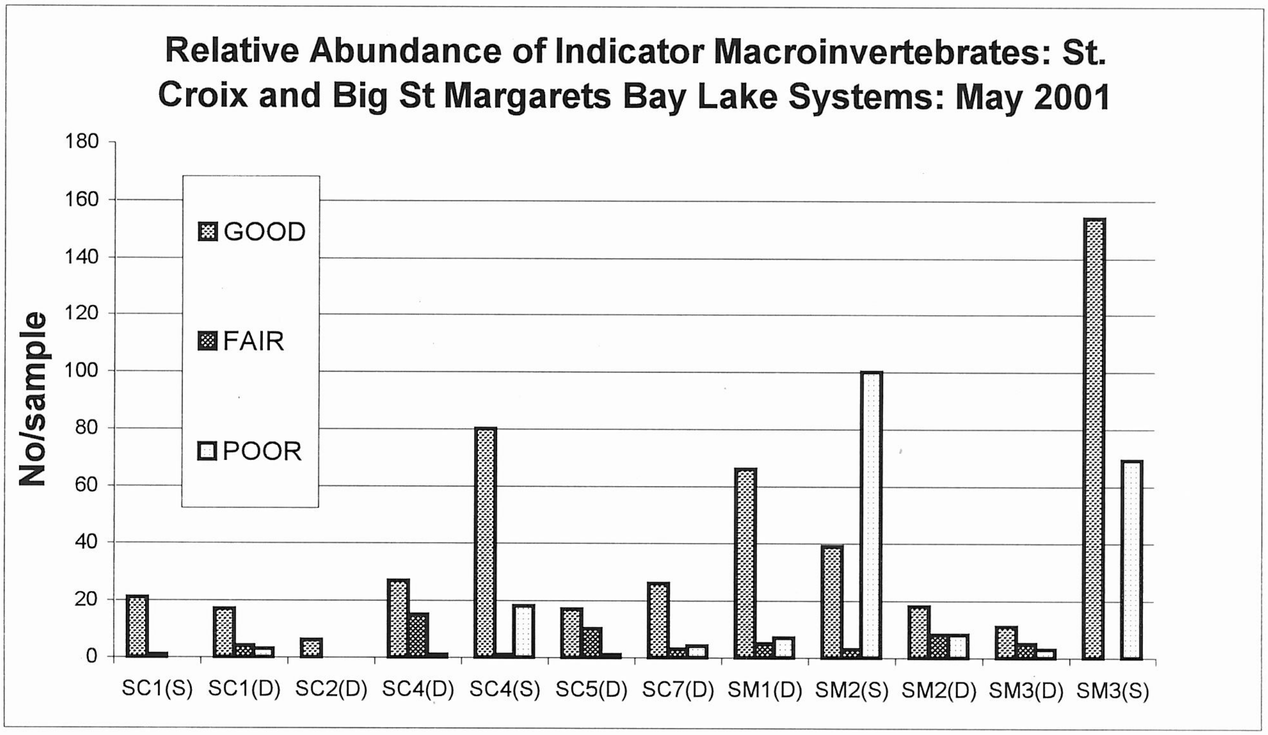
Analysis of invertebrate samples is a long, time-consuming process. An adequate representation of aquatic fauna requires identification at least to the level of Family, and preferably to Genus and Species. At the higher level of Order, diversity of invertebrates may yield very little information about habitat quality or productivity that is relevant to fish, because several Orders have representatives living in a wide variety of habitats, both favourable and unfavourable for fish. For the purposes of the present report, identification to Order, which is the first step in analysis, has been modified to represent quality of fish habitat. The records are presented according to the association of particular groups with either good, fair or poor water quality: some Orders (e.g. beetles -- O. Coleoptera) and flies -- O. Diptera) are subdivided into families according to whether they are associated with Good, Fair or Poor water quality.

Analysis of the invertebrate samples is continuing. Eventually it is intended to record the data as part of the national database of stream invertebrates being designed by Dr. Trefor Reynoldson (National Water Research Institute and Acadia University).

3.6.3 Results.

All the indications are that the invertebrate fauna of the streams entering Panuke Lake or Big St. Margarets Bay Lake is dominated by groups that are typical of clean, uncontaminated water (Figure 3.6.1).

Figure 3.6.1. Spring invertebrate collections from St. Croix and Big St. Margarets Bay Lake watersheds.



In Figure 3.6.1, samples are identified according to whether they were taken with a semiquantitative Surber sampler (S), or a Dip Net (D). Because the dip net is completely non-quantitative, the data represented are only informative from the relative height of the bars in any given sample; in the case of Surber samples, the absolute number in the collection may be taken as a weak indicator of the richness of the habitat.

The data in Figure 3.6.1 show that all samples, except for a Surber sample at SM2 (Upper Piney Stream), are dominated by forms associated with clear water. The large number of apparently poor water quality organisms in SM2(S) was a consequence of capturing very large numbers of blackfly larvae (Diptera:Simuliidae) in the sample. Blackfly larvae are gregarious, clustering in large numbers on rocks that experience the right kind of water flow, and hence their distribution is not homogeneous. They are not specifically associated with contaminated water, although they are tolerant of some conditions that exclude other organisms. In natural waters they are particularly abundant just downstream of still water regions that generate fine particulate organic matter that is their principal food.

With that exception (and possibly Shady Lake Stream – SM3 – where similar conditions apply), the majority of organisms are associates of clean (i.e. uncontaminated) water, as would be expected. Dominant forms are mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddis or shad flies (Trichoptera).

The relative abundance of major Orders in each of the samples is given in Figures 3.6.2 to 3.6.9. Full data from the spring collections are given in Appendices 3.6.1. and 3.6.2.

Figure 3.6.2. Stoney Brook Invertebrates.

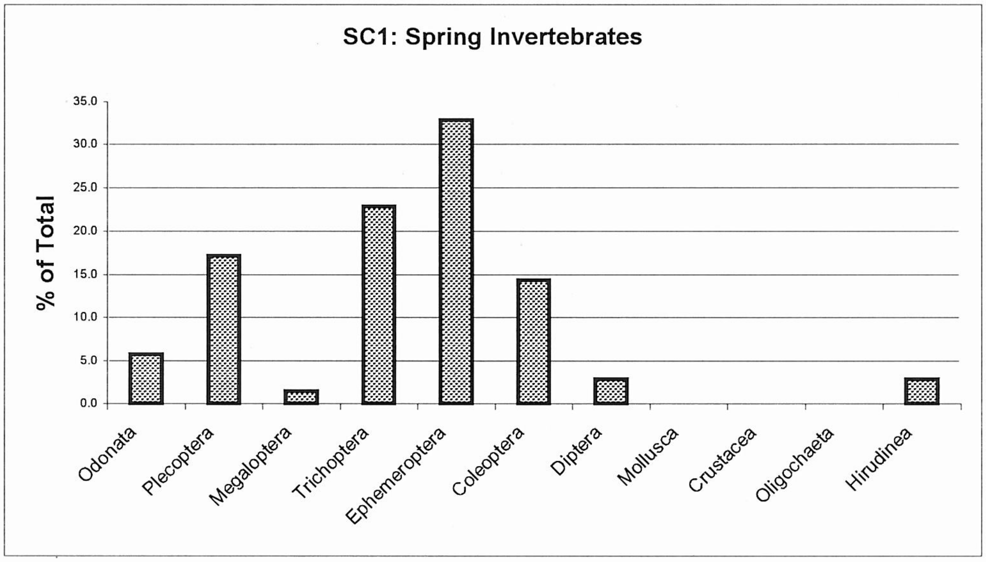


Figure 3.6.3. Thans Brook (Lower) Macroinvertebrates.

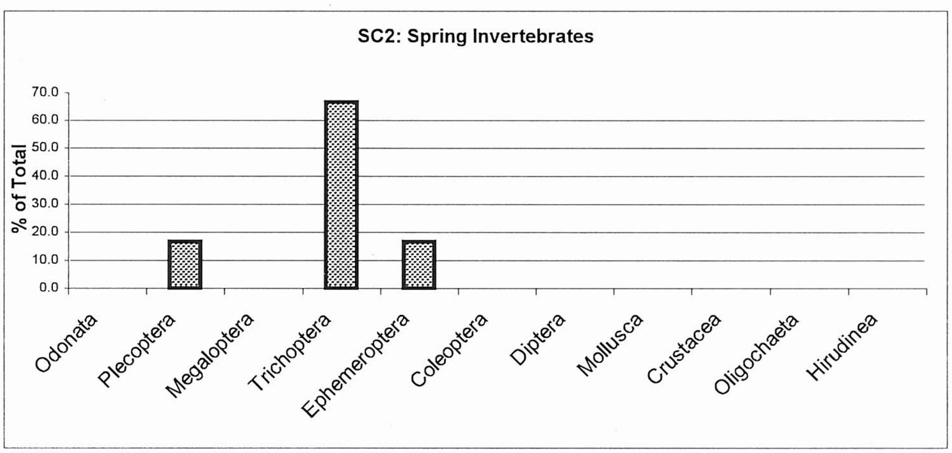


Figure 3.6.4 Southwest Brook Macoinvertebrates

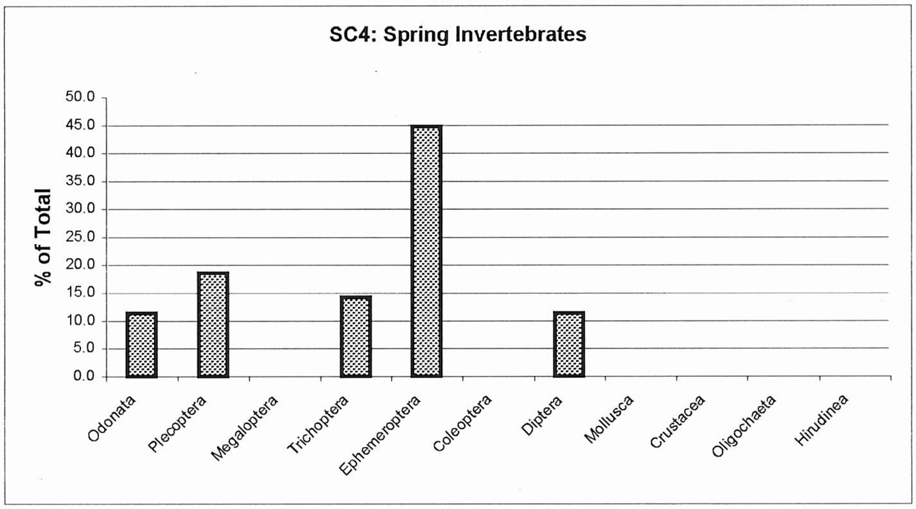


Figure 3.6.5 Armstrong River Macroinvertebrates.

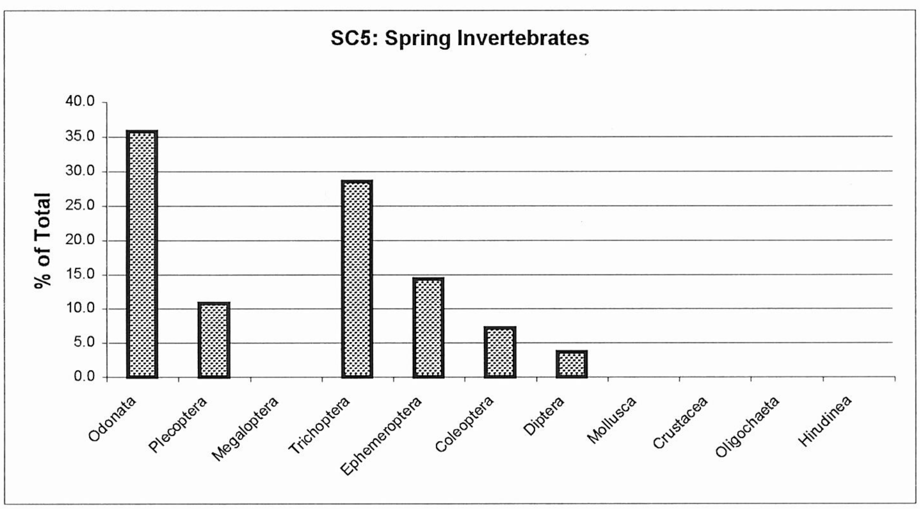


Figure 3.6.6. Thans Brook (Upper)

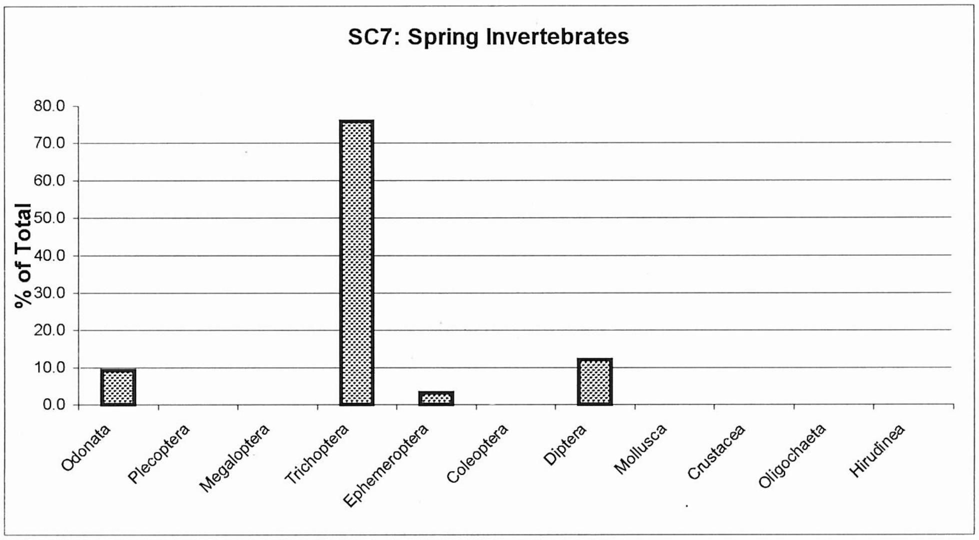


Figure 3.6.7. Piney Stream (Lower)

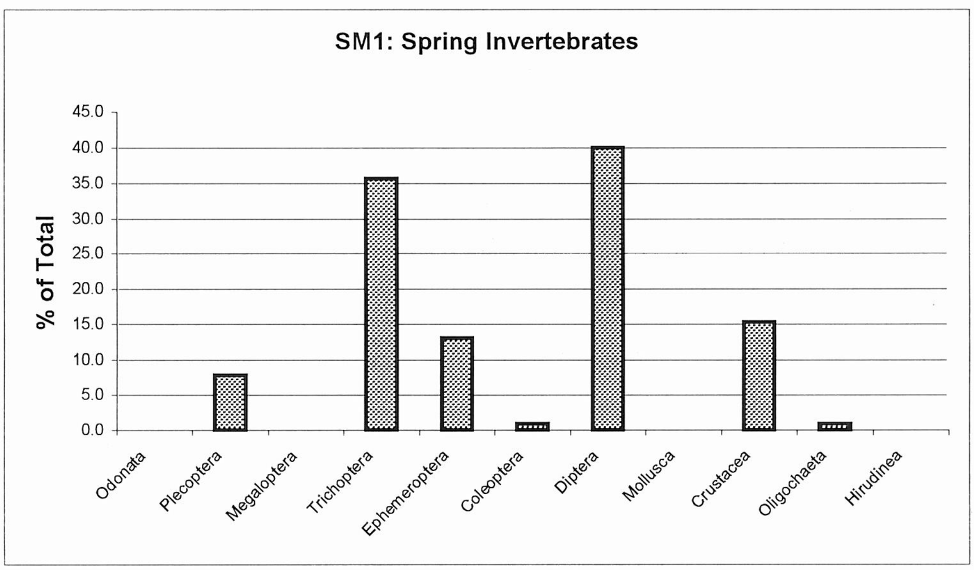


Figure 3.6.8 Piney Stream (Upper)

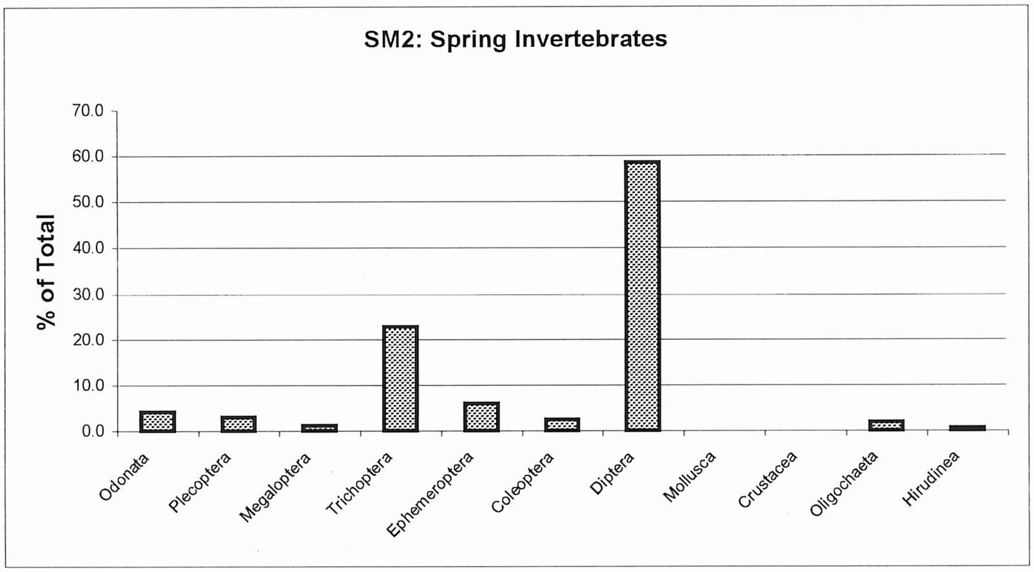
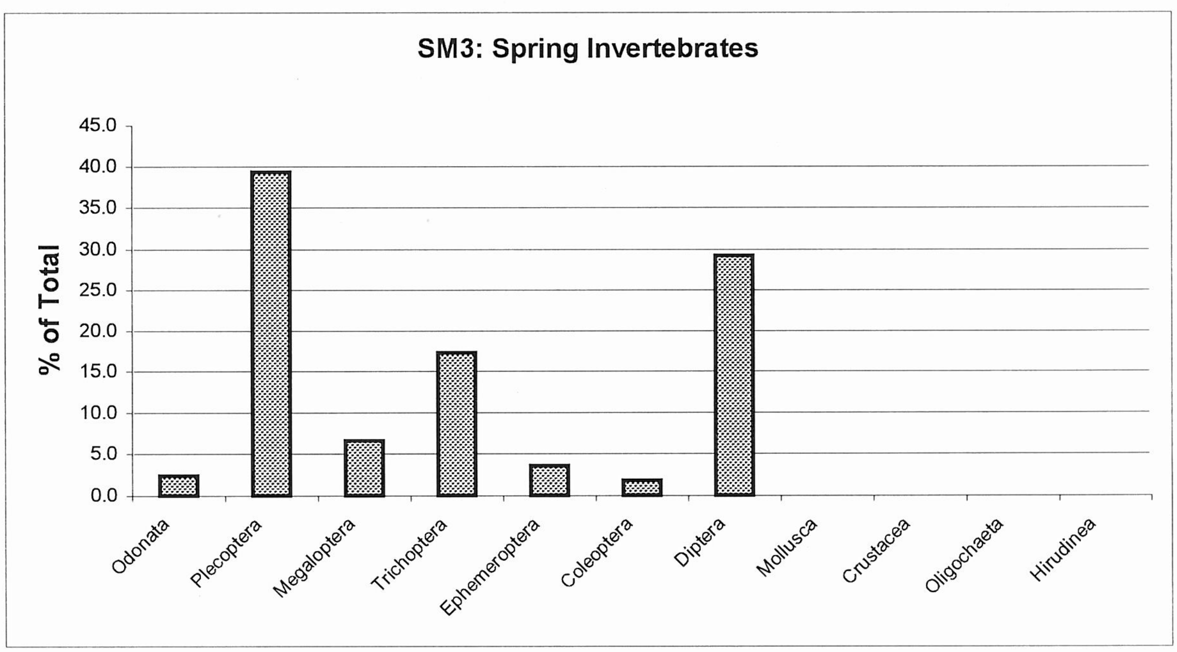


Figure 3.6.9. Shady Lake Brook



The results reflect the habitat conditions that were described in Section 3.5. Stream habitats in which the substrate is varied in size, reasonably stable, and not constantly being disturbed by extreme flows, tend to show a diversity of insect species, particularly if there is effective aeration of the water by riffles or cascades. Such conditions show an abundance of stoneflies (Plecoptera), mayflies (Ephemeroptera) and caddis flies (Trichoptera). Dragonflies and damselflies (Odonata) tend to be less common in such situations, as they prefer quieter water, commonly where organic material may collect. In slow-moving, organically enriched pools, the fauna shows a greater number of cased caddis larvae, odonates, and flies (Diptera), and rather fewer mayflies or stoneflies.

Stream macroinvertebrates undergo seasonal changes in abundance in relation to life cycle; hence the results from a single date and season are often greatly influenced by emergence patterns, in which all members of a species may leave the stream at the same time. This, added to the heterogeneity of distributions in streams makes it impossible to interpret the data to any greater extent.

It may be fairly concluded, however, that the fauna reflect essentially clean, if acid stressed water, and the probability that some streams (notably Armstrong River, Shady Lake Brook and Piney Stream) provide the kind of food supply that insectivorous species such as trout need.

3.7 Species at Risk

3.7.1. Introduction.

During the course of field investigations during May to August 2001, attempts were made to determine if any species or habitats of significance exist in the St. Croix—Big St. Margarets Bay Lake watershed. Because the major terrestrial flora on much of the watershed is similar to many parts of Nova Scotia, the principal concerns about species at risk are on species of wetlands, or of terrestrial habitats in close proximity to water courses (riparian zone). For this reason, an extensive survey was conducted of the riparian and submersed flora associated with the four impoundments (Panuke Lake, Big. St. Margarets Bay Lake, Parsons Dam impoundment and the Trash Racks impoundment - - cf. Section 3.4). In addition, during surveys of fish habitat on the main river and selected tributaries, observers were instructed to record observations of reptiles, amphibians, and birds, or any unusual plant species.

3.7.2 Significant Habitats

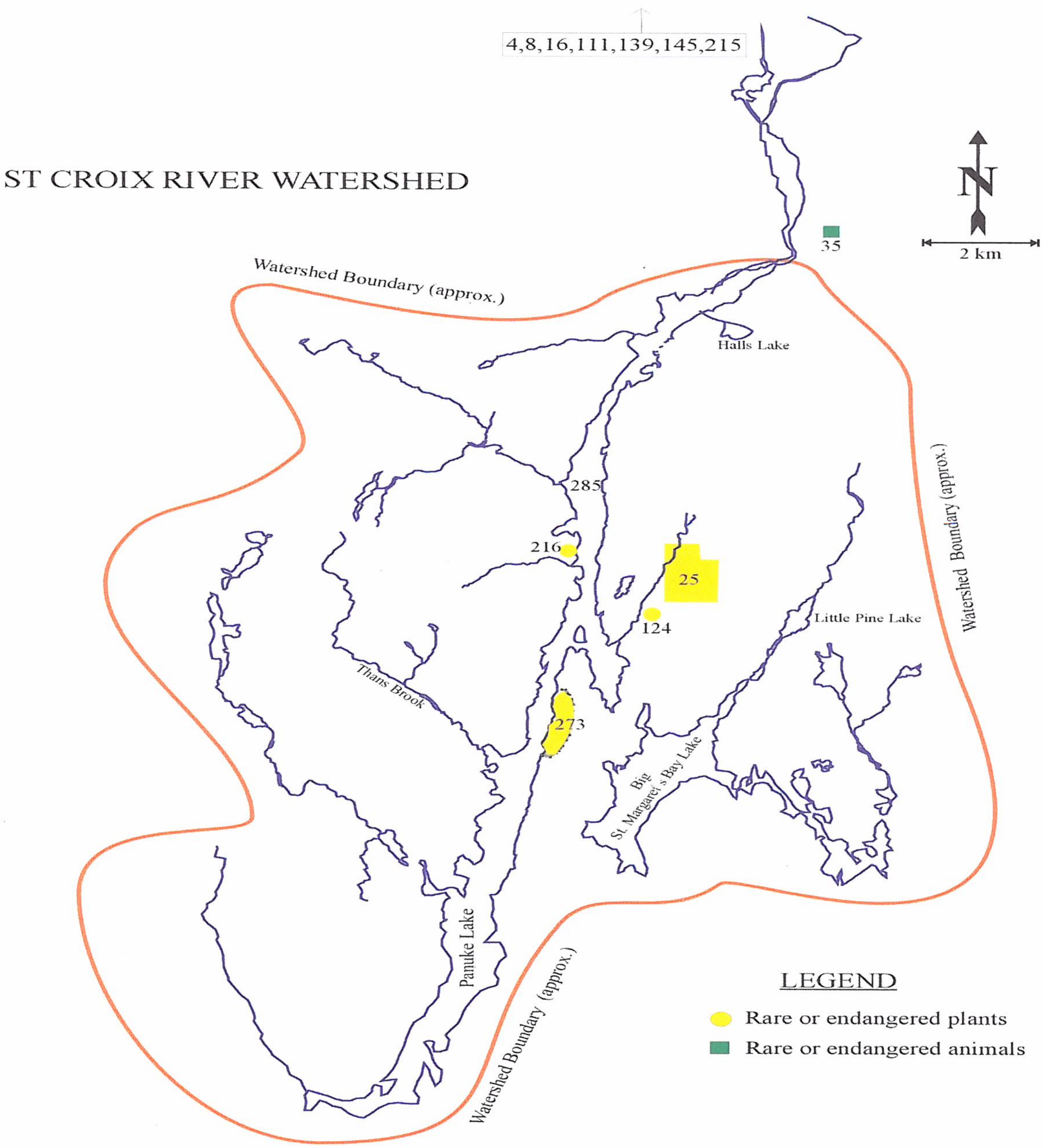
A number of records exist of species and habitats that are considered rare or at risk in Nova Scotia, particularly of wetland plants, and several species of animals might be expected to occur in the watersheds concerned. Some of these records are in the Significant Habitats and Species databases (SIGHAB), maintained by the Nova Scotia Department of Natural Resources. SIGHAB numbers are identified in parentheses below. A map showing the approximate location of these records is included as Figure 3.7.1.

a) Old Growth Forest.

Two areas of old growth forest have been recognised in the watersheds of the St. Croix—Big St. Margarets Bay Lake areas. One of these (SIGHAB # 273) lies on the eastern shore of Panuke Lake, and was investigated during the Vegetation Survey in 2001 (cf. Section 3.4). Main species observed included: mature *Picea rubens,* (Red Spruce), *Tsuga canadensis,* (Eastern Hemlock), *Pinus strobus* (White Pine), and *Betula papyrifera* (White Birch). Ground and understory vegetation was limited, principally composed of

Aralia nudicaulis (Wild Sarsaparilla), *Phegopteris connectilis* (Beech Fern), *Monotropa uniflora* (Indian Pipe), *Dennstaedtia punctilobula* (Hay-scented Fern), young *Populus tremuloides* (Trembling Aspen), *Betula lutea* (Yellow Birch), *Abies balsamea* (Balsam Fir), and *Acer rubrum* (Red Maple).

Figure 3.7.1. Locations of significant habitat and species (SIGHAB) records for St. Croix River and Big St. Margarets Bay Lake watersheds.



A second, similar extent of old growth forest was identified in the Shady Lake Brook watershed in the 1970s and listed by the Canadian Committee for the International Biological Programme (1974). The Shady Lake Brook site (SIGHAB # 25) was described as a "good, relatively undisturbed example" of the Red Spruce (*Picea rubens*) – Hemlock (*Tsuga canadensis*) forest extending to c. 90 h (220 acres). It was considered a candidate for a study area under the International Biology Programme, but was not designated. Information from foresters in the region indicates that at least part of the forest had been cut by 1988, and the Nova Scotia Department of Natural Resources has dropped it from the inventory of Significant Habitats.

b) St. Croix River Ecological Reserve (SIGHAB # 16).

A habitat of major interest is the St. Croix River Ecological Reserve that lies on the east side of the St. Croix River north of Highway 101. The reserve covers approximately 120 h (300 acres) of Kärst topography and gypsum outcropping, supporting a mixed forest of White Spruce (*Picea glauca*) and Red Oak (*Quercus borealis*). The understory contains two of the rarest orchids in the province: *Cypripedium calceolus* (Yellow Lady's Slipper) and *Cypripedium arietinum* (Ram's Head Lady's Slipper). Three other species which are associated with gypsum have been recorded in the general area and assigned to this site. These are *Dirca palustris* (leatherwood), *Antennaria plantaginifolia* (everlasting), and *Cynoglossum boreale* (northern wild comfrey). There is no certainty that they are present in the reserve.

The gypsum outcrops also contain Frenchman's Caves, a hibernaculum for Nova Scotia bats. The Reserve is below the Lower St. Croix powerhouse, and is thus unaffected by water management activities.

c) Wetlands.

Surveys of wetlands in Nova Scotia by the Department of Natural Resources and the Nova Scotia Museum have identified three of significance in the St. Croix system: one at Eagle Cove Brook (SIGHAB # 216), and two north of the village of St. Croix adjacent to the St. Croix ballfield (SIGHAB # 4) and on the north side of Highway 101 (SIGHAB #

215). No details are available. However, recent landforming near the ballfield may have had some significance for the pond indicated as SIGHAB site # 4.

d) Panuke Lake.

Panuke Lake itself is recognised as an important habitat (SIGHAB # 285) for the Common loon (*Gavia immer*). Wildlife officials have determined that at least one pair of loons has raised young on the lake each year since 1996. During our May field campaign, four pairs of loons and one single individual were sighted on a transect of the lake on 28 May.

Concern over loons in Nova Scotia has recently increased because recruitment seems to be failing. Attention has been focussed on the combination of high mercury in their fish food, and the decline in forage fish populations attributed to increasing acid stress of unbuffered lakes. Panuke Lake and Big St. Margarets Bay Lake would seem to be prime candidates for acid-stress effects, but the information reported here does not suggest that mercury contents in fish are as high as have been recorded in other lakes and impoundments studied in Nova Scotia.

3.7.3. Species at Risk: Flora.

The Significant Species database contains records for three species of plants. There is a single unconfirmed record (SIGHAB #124) for *Adiantum pedatum* (maidenhair fern) in the Shady Lake Brook watershed, which may or may not be associated with the Red Spruce—Hemlock old growth stand nearby. This northern variety is an inhabitant of wooded, well-drained, rich-soil slopes, and generally does not favour very acidic conditions. Its occurrence in the Shady Lake Brook watershed is surprising. A 1927 collection (SIGHAB #145) of *Hepatica americana* (round leaf hepatica) indicates that it grew in the area north of the Lower St. Croix powerhouse, perhaps in the same general vicinity of the St. Croix Reserve.

During the course of investigations in the St. Croix—Big St. Margarets Bay Lake system, two rare species were encountered: the Silky willow (*Salix sericea),* found at the north end of Panuke Lake in the vicinity of the Upper St. Croix Dam, and the Floating Bladderwort (*Utricularia radiata),* found in small patches in Big St. Margarets Bay Lake. The first species was represented by 10 specimens only, in a restricted area. The Floating Bladderwort was encountered only in localised areas of Big St. Margarets Bay Lake, and its status is uncertain. Because it is rarely visible, only floating at the surface during flowering, it is commonly missed, and may be more widespread than currently known.

Table 3.7.1 lists the wetland species that are considered of special concern in Nova Scotia, that have been recorded from the general area of the watersheds (derived from Zinck *et al.* 1994).

Table 3.7.1. Potential Wetland Plant Species of Concern in Nova Scotia

Species	Common name	NS Status
Fraxinus pennsylvanica	Red ash	R
Salix candida	Hoary willow	R
Salix sericea	Silky willow	R
Rumex mexicanus	Sorrel	R
Listera australis	Southern twayblade	I
Hepatica americana	Blunt-leaved hepatica	T
Cryptogramma stelleri	Slender cliff-brake	R
Carex bromoides	Brome-like sedge	R
Carex comosa	Sedge	R
Carex tuckermanii	Sedge	R
Verbena hastata	Blue vervain	R
Cypripedium calceolus	Yellow lady's-slipper	T
Ranunculus flammula	Buttercup	R
Anemone canadensis	Canada anemone	R
Lilium canadense	Canada lily	T
Bartonia virginica	Bartonia	R
Euthamia tenuifolia		R
Asclepias incarnata	Swamp milkweed	R
Polygonum puritanorum	Smartweed	R
Thuja occidentalis	Cedar	R
Source: Zinck, M. et al. 1994. Wetland Plants of Nova Scotia: Species of Concern.		R= rare, T= threatened

With the exception of *Salix sericea,* none of these species was recorded during the survey in August.

3.7.4 Species at Risk: Fauna

The Nova Scotia Department of Natural Resources has recently augmented its list of animal species considered rare or at risk in Nova Scotia. The current list is given in Table 3.7.2.

Table 3.7.2. Animal Species at Risk

Source: Nova Scotia Government/Natural Resources Website			
Species	Common Name	Status	Possible in Watershed?
MOLLUSCS:Bivalvia			
Lampsilis cariosa	Yellow lamp mussel	R	U
Lampsilis ochraceae	Delicate lamp mussel	S	U
Lampsilis radiata	Eastern lamp mussel	S	U
Strophitus undulatus	Squawfoot	R	U
Alasmidonta varicosa	Brook floater	S	U
Margaritifera margaritifera	Eastern r. pearl mussel	S	U
INSECTS:Odonata			
Ophiogomphus adspersus	Brook snaketail	R	Y
Ophiogomphus rupinsulensis	Rusty snaketail	R	Y
Aeshna verticalis	Greenstriped darner	S	Y
Aeshna sitchensis	Zigzag darner	S	Y
Species	Common Name	Status	Possible in Watershed?
Aeshna clepsydra	Mottled darner	S	Y
Enallagma minusculum	Little bluet	S	Y
Gomphaeschna furcillata	Harlequin darner	S	Y
Sympetrum danae	Black meadowfly	S	Y
INSECTS: Lepidoptera			
Oeneis jutta	Actic jutta	R	N
Incisalia lanoraieensis	Bog elfin	R	Y
Stylurus scudderi	Zebra clubtail	R	Y
Erora laetus	Early Hairstreak	R	Y
Boloria chariclea	Arctic fritillary	R	Y
Thorybes pylades	Northern cloudywing	S	N

Table 3.7.2. Animal Species at Risk (continued)

Species	Common Name	Status	Possible in Watershed?
Danaus plexippus	Monarch	S	Y
Polygonia satyrus	Satyr angelwing	S	Y
Papilio brevicauda	Short-tailed swallowtail	S	N
Polygonia gracilis	Hoary comma	S	Y
Nannothemis bella	Elfin skimmer	S	Y
Somatochlora septentrionalis	Muskeg emerald	S	Y
Epitheca princeps	Prince baskettail	S	Y
Lanthus parvulus	Zorro clubtail	S	Y
FISH:			
Salmo salar	Atlantic salmon	R	no longer
Coregonus huntsmani	Atlantic whitefish	R	N
Acipenser oxyrhynchus	Atlantic sturgeon	R	N
Morone saxatilis	Striped bass	R	no longer
Salvelinus namaycush	Lake char	R	N
Alosa pseudoharengus	Alewife	S	no longer
Apeltes quadracus	Fourspine stickleback	S	Y
Margariscus margarita	Pearl dace	S	Y
Salvelinus fontinalis	Brook trout	S	Y
AMPHIBIANS:			
Hemidactylium scutatum	Four-toed salamander	S	Y
REPTILES:			
Embydoidea blandingi	Blanding's turtle	R	N
Thamnophis s. septentrionalis	Northern Ribbon Snake	S	N
Clemmys insculpta	Wood turtle	S	Y
BIRDS:			
Sialia sialis	Eastern bluebird	S	Y
Bucephala islandica	Barrow's goldeneye	S	Y
Sturnella magna	Eastern meadowlark	S	N
Phalaropus lobatus	Red-necked phalarope	S	N
Phalaropus fulicaria	Red phalarope	S	N
Asio flammeus	Short-eared owl	S	Y
Falco peregrinus	Peregrin falcon	R	Y
Sterna dougallii	Roseate tern	R	N
Sterna paradisea	Arctic tern	S	N
Sterna hirundo	Common tern	S	Y
Charadrius melodus	Piping plover	R	N
Histrionicus histrionicus	Harlequin duck	R	Y
Asio otus	Long-eared owl	S	Y
Fratercula arctica	Atlantic puffin	S	N
Alca torda	Razorbill	S	N
Accipiter gentilis	Northern goshawk	S	Y
Calidris pusilla	Semipalmated sandpiper	S	Y

Table 3.7.2. Animal Species at Risk (continued)

Species	Common Name	Status	Possible in Watershed?
MAMMALS:			
Lasiurus cinereus	Hoary bat	S	Y
Lasiurus borealis	Red bat	S	Y
Lasionycteris noctivagans	Silver-haired bat	S	Y
Pipistrellus subflavus	Eastern pipistrelle	S	Y
Myotis septentrionalis	Northern long-eared bat	S	Y
Myotis lucifugus	Little brown bat	S	Y
Alces alces	Moose	R	Y
Lynx lynx	lynx	R	Y
Martes pennanti	Fisher	S	N
Martes americana	Marten	R	N

Of the above species, several are expected to be present in the St. Croix and Big St. Margarets Bay Lake watersheds, but only one, the brook trout (*Salvelinus fontinalis)* was recorded during surveys in 2001. This species has been widely raised in hatcheries and released for many years. It has not been determined whether the brook trout occurring in the St. Croix system are an original stock or whether they are remnants of stocking programs. Armstrong Lake has been stocked with brook trout for many years. It is, however, probable that they are native, since stocking has been reduced in recent years, and hatchery-reared fish do not survive well under stressed conditions in the wild. Intermittent streams, such as those that are characteristic of all the streams surveyed in 2001, represent a stressed habitat that requires a suite of genetic adaptations for a stock to persist; such genotypes are not usually present in hatchery-reared fish. Until it is determined otherwise, it is prudent to assume the stock is a natural one.

Migratory fish were undoubtedly present in the St. Croix River system in times past, as indicated by evidence from archaeological work at St. Croix (cf. Section 3.8). Species that were likely users of the St. Croix include Atlantic salmon, American shad, alewife, rainbow smelt, trout and ninespine or fourspine sticklebacks. Only the catadromous eel persists today. Access to the lakes has been prevented for at least 70 years, and may have been since 1923 (R. Dunfield notes – see Appendix 3.7.2). Reference to earlier 18th and

19th century developments on the river (Section 2) could mean that anadromous stocks might have been precluded for far longer.

Of the species listed in Table 3.7.2, one, the Atlantic salmon is now listed as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). In 2000, a provincial fisheries survey investigated the major rivers in the Inner Bay of Fundy, including the St. Croix. Four sampling areas surveyed yielded 5 salmon parr. This record raises the issue of the origin of these fish: whether they are remnants of the original St. Croix stock that have persisted in the limited spawning areas available, or whether the adults were vagrants from other stocks. The 1970s survey of habitats, from which Dunfield obtained some of his data, had previously indicated that a limited spawning area for salmon existed between the Lower St. Croix powerhouse and the tidal waters of St. Croix Estuary, somewhere south of the present Highway 101. Apparently, brood stock was still being obtained from the St. Croix in the 1980s, and being segregated at the hatchery on the assumption that it was a distinct stock from other rivers (A. J. F. Gibson, personal communication).

Atlantic salmon (also shad and alewife) are considered to be fairly faithful to the streams of their birth. Although occasional wandering does occur, it is relatively rare for an uninhabited river to become successfully colonised in that way, suggesting that even if wandering fish spawn there they may not have the appropriate genetic constitution to establish a viable population.

It is a moot point whether the fish in the lowest reaches of the St. Croix River could expand to occupy any of the habitat currently sequestered behind the dams. Most of the evidence gathered during the studies during 2001 suggests that the low pH, low nutrients, limited spawning habitat, and highly intermittent nature of the streams would be unlikely to afford much opportunity for fish that had not evolved there.

Further investigations with regard to rare and endangered species would be valuable, these watersheds have hitherto received little attention. In particular, the odonates and other insects that are rare or uncommon in the province require survey, and the talus slopes along Panuke Lake might prove to be habitat supporting the Gaspé shrew (F. Scott, personal communication).

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ENVIRONMENTAL ASSESSMENT OF THE ST. CROIX AND BIG ST. MARGARETS BAY LAKE SYSTEM , NOVA SCOTIA

Final Report

19 September 2001

3.8 Archaeological Assessment

3.8.1 Introduction.

Discussions with Dr. David Christianson and Mr. Stephen Powell of the Nova Scotia Museum, and Mr. Mark Pulsifer (NS Department of Natural Resources) have indicated that there is one site of archaeological significance officially recorded and evaluated for the St. Croix River watershed. This site, known officially as BfDa-1, which lies on the east bank of the St. Croix estuary, is below the lowermost power station in the St. Croix system, and thus is not affected directly by water level fluctuations. A second record relates to an artefact (BeDa-1), a stone celt (axe) that was recorded in 1900 as having been collected "in the vicinity of Panuke Lake". No further information is available for it.

Contacts have been made with known collectors in the area in an attempt to ascertain the presence and location of any archaeological sites. Mr. Ellis Gertridge of Gaspereau is widely recognised as an authority on pre-Contact sites, but has not made any collections himself in the St. Croix system. So far, we have been unable to identify any person who has explored in the area other than Mr. John Erskine, who rediscovered the St. Croix site during the 1960s.

Because the natural watershed of the St. Croix system has been functionally enhanced for water management purposes by linking Panuke Lake with Big St. Margarets Bay Lake, the Terms of Reference indicate that review should also consider relevant portions of the Ingram River system. Adjacent to, but separate from, the Ingram River is the Indian River, a watershed that is managed by Nova Scotia Power Inc. In 1996, a planned draw down of water levels in two lakes in this system afforded an opportunity for archaeological work.

3.8.2 The St. Croix Site (BfDa-1).

The St. Croix site, designated as site BfDa-1 in the Maritime Archaeological Resource Inventory maintained by the Nova Scotia Museum, was first investigated and reported by Mr. John Erskine of Wolfville in the 1960s. The location is along the southeastern bank of the St. Croix River, in the tidal reach below the St. Croix Power House. Mr. Erskine dug test pits, but eventually concluded that the site had been completely disturbed.

In 1989, an archaeological survey relocated the site, and in 1990 and 1993 portions of it were subjected to intense and careful investigation supervised by Dr. Michael Deal of the Archaeology Unit, Memorial University of Newfoundland. The St. Croix site, which extended for an estimated half kilometre along the river, appears to represent a large campsite or village, possibly a location at which one or more groups gathered to fish for anadromous species such as alewife, blueback herring, smelt, striped bass or shad during the spring, and/or salmon in the spring or fall. Pottery sherds and charcoal samples collected at the site have been carbon dated and identified as of Maritime Woodland Period (2,500 to 500 years before present).

A bibliography of publications relating to the St. Croix site is included below.

Since the site is downstream of the St. Croix powerhouse, it is not directly influenced by water level management of the St. Croix system. Operation of the St. Croix system tends to store water in spring and fall, releasing it more steadily over the year, and thus moderates the flow to the estuary. As a result, the site is less likely to be flooded when high river flows coincide with high spring tides. To an extent, therefore, the St. Croix hydrological system may provide a small degree of protection to the site, although indirectly, by minimising flood risk, it may encourage other kinds of shoreline development that are not beneficial for the site.

3.8.3 Rafter Lake and Sandy Lake Archaeological Assessment.

In 1996 Nova Scotia Power Inc. retained Porter Dillon Ltd. to conduct an archaeological assessment of two lakes in the Indian River system that were to be drawn down for maintenance purposes. Five pre-Contact archaeological sites (labelled BeCx-1 to BeCx-5) had previously been known on the northwestern shore of Rafter Lake, and in view of the planned drawdown, the Nova Scotia Museum requested that Nova Scotia Power Inc. conduct an assessment to map and retrieve artefacts from the known sites, and explore the exposed shoreline for other indicators.

The assessment field work took place in 1996, when the controlled release of water from the lakes returned them to approximately their natural levels. Sandy Lake was dropped by 7 m, and Rafter Lake by 0.8 m.

Results of the assessment were that the 5 previously known sites were relocated, mapped in precise detail, and some 287 artefacts recovered. Four new pre-Contact sites were also discovered, mapped and > 500 artefacts recovered, including ceramic sherds and bone fragments. The latter are of particular interest because organic materials do not usually survive from pre-Contact sites because of the acidic nature of surface waters in most parts of Nova Scotia.

Four other historic sites of post-Contact times were also identified, but not fully described or evaluated.

3.8.4 Management Strategy.

Requirements of the Terms of Reference are for submission of a Management Strategy that will take advantage of any extensive drawdown of water in the impoundments. Seasonal lows within the normal operating range provide only limited opportunities for archaeological investigations, because of the extensive planning and time requirements of a formal investigation, and because the only material exposed has been equally accessible since the impoundments in the St. Croix system (including Big St. Margarets Bay Lake) were first established. Prolonged unofficial and unregulated collecting of artifacts occurred in some areas of Nova Scotia prior to establishment of the *Special Places Protection Act.* R.S., c. 438, s.1 in 1989. It is probable that any such normally exposed sites have potentially been disturbed or destroyed.

Management Strategy for Archaeological Resources of the St. Croix-St. Margarets Bay Lake system, N.S.

The following Management Strategy outlines the plans of Minas Basin Pulp and Power Company Limited for management of archaeological and historical resources that may be encountered in the St. Croix River system, including Big St. Margarets Bay Lake, in areas that are affected by management of the water resources. These consist principally of the land covered by water and the adjacent riparian zone, and access roads or paths to control facilities.

1. **Inventory of Known Archaeological and Historic Resources.**

At the present time, the only record held by the Nova Scotia Museum in the Maritime Archaeological Resource Inventory of archaeological or historical sites in the St. Croix Watershed is that at Lower St. Croix, below the lowermost unit of the St. Croix system. Information may be in the possession of individuals who have been involved in the collection of artefacts in the watershed; however, such information has not so far been provided to the Company.

2. Procedure for Survey of Archaeological or Historical Resources.

The Company undertakes to consider the spirit and requirements of the *Special Places Protection Act* in relation to archaeological and historical resources that are discovered as a result of:

a) normal operations;
b) special investigations conducted at times of planned exceptional lowering of water levels in any of the St. Croix—St. Margarets Bay Lake impoundments, and
c) prior to any new work that has the potential for affecting or detecting archaeological or historical resources.

In the event that water levels must be dropped to levels below the normal operating levels for maintenance or repair purposes, the Company will initiate procedures for a more comprehensive survey, the extent of which will depend upon initial results, and on the expected period of low water levels. Because of the long establishment of the two impoundments, sediment accumulation on the bottom in deeper portions may prevent ready observation of artefacts *in situ*, and thus the expected area of investigation will be limited to the swash zone within a few feet (vertically) of the normal lowest water level.

Procedures to be followed in such a survey are indicated below.

<u>Procedures for Site Investigation.</u>

A. Contract with a professional archaeologist registered with the Nova Scotia Museum to plan and supervise the survey.
B. Complete an application for a Heritage Research Permit through the Nova Scotia Museum.
C. Invite the Curator of Archaeology or his/her designate to participate in planning and fieldwork.

D. Form a Site Investigation Team consisting of the Consultant Archaeologist, the Curator of Archaeology (or designate), at least one company official, and such other persons as the Company shall determine.

E. Compile and examine aerial photographs, and any historic maps held in the Provincial Archives of Nova Scotia, relating to the study area.

F. Conduct an Initial Pedestrian Survey of the site. The survey will be under the direction of the Consultant Archaeologist and the Curator of Archaeology (or designate).

G. Location of all artefacts and suspected sites of archaeological or historical significance will be recorded as precisely as possible, using Global Positioning System (GPS) techniques and/or measured distances and directions from permanent anthropogenic, geological or geographic features.

H. Following the Initial Survey, any decisions to be made regarding collection of surface artefacts or further site investigation will be the responsibility of the Consultant Archaeologist and the Curator of Archaeology (or designate).

I. Sites containing rich assemblages of artefacts or indicators of undisturbed archaeological resources will be properly mapped prior to removal of any artefacts. Photographs of *in situ* condition and context will accompany documentation of collections or other records wherever feasible.

3. Procedure for Notification of Discovery.

The Company will establish a policy to ensure appropriate notification of discovery in the event that archaeological or historical resources are discovered during routine operations. The essence of this policy is as follows.

a. Any employee of Minas Basin Pulp and Power Co. Ltd. encountering potential indicators of previously unknown archaeological or historical resources on land owned or managed by the Company along the shoreline of the impoundments will inform their immediate supervisor, providing information on the location and nature of the indicator(s).

b. The Supervisor will forward this report to the Electrical/Project Engineer of the Company, who will advise the following company officials:

1) The President and Chief Operating Officer;
2) The General Manager
3) The Maintenance Assistant, Upper St. Croix Power Dam

c. The General Manager will advise the Curator of Archaeology at the Nova Scotia Museum of the discovery, providing such information as exists. Further official reporting action will be the responsibility of the Curator of Archaeology, and may include notifying the Advisory Committee on Protection of Special Places.

4. Responses following Discovery.

Following the discovery of new archaeological or historical resources in association with the impoundments owned or managed by the Company, the Company will attempt an initial determination of the condition and degree of vulnerability of the resources to continued company operations. This determination may be made with the assistance of the Curator of Archaeology (or designate) and/or a Consultant Archaeologist engaged for the purpose.

The Company will be diligent in keeping the nature and location of the discovery confidential until all appropriate notifications have been made. No public announcement will be made without the prior approval of the Curator of Archaeology (or designate), and will only be made if it is conformable with the spirit and letter of the *Special Places Protection Act*.

If it is determined that the newly discovered resources are at risk of destruction or serious damage from continued company activities (e.g. if the discovery is associated with excavation or other earthworks), such activity shall stop for a reasonable time to permit a more careful evaluation of:

i. the nature of the discovery;
ii. the extent of risk associated with continued Company activities;
iii. the extent of risk associated with no action for protection or removal of the resource; and
iv. appropriate measures to be taken for documentation and protection of the resource.

If, on the other hand, it is determined that normal operations, once resumed, render no new threat to the resource, the Company will continue activities and reserve further study or documentation of the resource until a more convenient opportunity. This response would be appropriate where the discovery is associated with temporary change in water levels such that returning the system to normal operating levels would act to preserve the resource.

3.8.5 Summary and Conclusions.

Only one pre-Contact site has been formally studied and documented in the St. Croix—Big St. Margarets Bay Lake watersheds. This site, on the eastern bank of the St. Croix River below the St. Croix Powerhouse, appears to represent a significant area of activity dated to the Maritime Woodland Period, 2500-500 years BP. An artefact with no known provenance is also on record as associated with Panuke Lake. No other archaeological work appears to have been conducted in the St. Croix River watershed, but it is evident that numerous sites of historical interest, including the older dam and mill structures of the 19th and 20th centuries, probably occur in the region.

Exploratory work in 1996 at Rafter Lake and Sandy Lake in the neighbouring Indian river system produced a number of new sites, both historic post-Contact and pre-Contact. The results of that survey have convinced experts at the Nova Scotia Museum, that the St. Croix—Big St. Margarets Bay Lake system has high potential as an area of archaeological interest.

3.8.6. Bibliography for BfDa- 1 Archaeological Assessment

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3.9.1 Appendices

St. Croix & St. Margarets Bay Lake Systems

Report.

September 2001.

Appendix 3.1.1. Limnological description of Armstrong Lake, Nova Scotia Department of Fisheries and Aquaculture.

NOVA SCOTIA
Department of Fisheries and Aquaculture
Inland Fisheries Division

LAKE SURVEY

Page 1

2000/Ap

Lake Name: ARMSTRONG
Ns Map Reference: 20A3
Coordinates: 44506412
Area (ha): 52.00
Max. Depth (m.): 7.00
Access: 4x4

County: Hants
Site Code: 09015
Survey Date: 1977/Jul/21
pH:
Temperature (C): Bottom 24.0
Surface 26.0
Dissolved O2 (mg/L) Bottom 4.0
Surface 8.0
Water Class: B
Fisheries Resource: FS

Species Sampled:

Brook Trout
White Sucker
Lake Chub

Stocking History

Year	Species	Class	# Fish
1999	Brook Trout	Fingerling	5000
1998	Brook Trout	Fingerling	2520
1997	Brook Trout	Fingerling	6080
1994	Brook Trout	Fingerling	2800
1993	Brook Trout	Fingerling	4400
1992	Brook Trout	Fingerling	6000
1991	Brook Trout	Fingerling	3000
1990	Brook Trout	Fingerling	2500
1989	Brook Trout	Fingerling	2000
1988	Brook Trout	Fingerling	2500
1980	Brook Trout	Fingerling	2002

Management Recommendations:

Appendix 3.1.2. Limnological description of Panuke Lake, Nova Scotia Department of Fisheries and Aquaculture.

Panuke Lake 73070

Date: July 25, 1973

Location: 44° 50"N 64° 06"W, Hants County.

Surface area: 4050 acres = 1639.0 ha

Area less than 20 feet deep: 775 acres = 313.6 ha

Shoreline length: 56 miles 90123 m

Maximum depth: 114 feet 34.1 m Shoreline development 6.28

Access: Vehicle access is only fair via either of two gravel roads which pass on either side of the lake.

Present uses: The lake is a reservoir for the Minas Basin Pulp and Power Company and has a 90 foot dam at the outlet. Fishing and boating are the recreational uses of this lake as there are 56 camps near the lake.

Streams: The lake receives water from thirteen streams. Seven of these were found to be very small and intermittent or have falls prohibiting fish migration. The others are described as follows:

1. The Southwest River at the head of the lake is described as steep and about ten or twelve feet wide. There may be salmonoid and rearing potential of at least the lower end.
2. The Armstrong River has a fair flow and probably would provide spawning and rearing areas.
3. The Thons Brook system was flooded at time of survey and would probably not be suitable for salmonoid spawning.
4. Although Shady Brook is of the intermittent streams a stream nearby was considered by the surveyers as very good for salmonoid spawning and rearing.
5. Stony Brook has a steep gradient and may be suitable for some salmonoid spawning.
6. Sucker Brook was very small but may offer some spawning potential.

Biological studies: Six species of fish were taken in two overnight sets of the standard gang of gillnets. Yellow perch were the dominant species but suckers were also common. Only one trout with an estimated length of 25 cm. was taken.

Netting

Species	Number	Range	Mean
Yellow perch	90	7.5 - 25.5 cm.	
White sucker	18	21.0 - 33.7 cm.	21.8 cm.
Bullhead	3	19.0 - 21.5 cm.	20.5 cm.
Unidentified Cyprinid	2	-	-
Trout	1	25.0 cm. (approx.)	-
American eel	1	60.0 cm.	-

Appendix 3.2.1. Water Quality in Impoundments of the St. Croix and Big St. Margarets Bay Lake Systems, May 2001.

Water Quality Results from Impoundments: Panuke Lake (PAN) & Big St.Margarets Bay Lake (SMB).

May-01				**PAN1-0.5**	**PAN1-14.0**	**PAN2-0.5**	**PAN2-0.5 Dup**	**PAN2-9.0**	**PAN3-0.5**	**PAN3-14.0**
Kjeldahl Nitrogen	Blk Digest	0.1	mg/L	0.4	1.1	0.3	0.3	0.8	1.4	0.6
Total Water Digest		-		Completed	Completed	Completed	Completed	Completed	Completed	Completed
Total Organic Carbon	SM5310	2	mg/L	13	19	7	7	11	8	10
Sodium	ICP-OES	0.1	mg/L	1.9	2.1	2	1.8	1.8	2.1	2.1
Potassium	ICP-OES	0.1	mg/L	0.2	0.2	0.2	0.3	0.3	0.2	0.3
Calcium	ICP-OES	0.1	mg/L	0.7	0.8	0.7	0.7	0.7	0.5	0.5
Magnesium	ICP-OES	0.1	mg/L	0.3	0.5	0.3	0.3	0.4	0.3	0.3
Alkalinity (as CaCO3)	COBAS	1	mg/L	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Sulfate	COBAS	2	mg/L	8	8	8	9	9	9	9
Chloride	COBAS	1	mg/L	2.8	2.8	3	2.1	2.9	3.2	3.2
Reactive Silica (as SiO2)	COBAS	0.5	mg/L	2.8	3	2.8	2.8	3	3.1	3.2
Ortho Phosphate (as P)	COBAS	0.01	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Nitrate + Nitrite (as N)	COBAS	0.05	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ammonia (as N)	COBAS	0.05	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Iron	ICP-OES	0.02	mg/L	0.08	4.77	0.13	0.13	0.95	0.15	0.17
Manganese	ICP-OES	0.01	mg/L	0.03	0.08	0.03	0.03	0.05	0.04	0.04
Copper	ICP-OES	0.01	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zinc	ICP-OES	0.05	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Color	COBAS	5	TCU	21	25	25	25	26	29	29
Turbidity	NEPH.	0.1	NTU	0.8	26.8	0.6	0.5	6.3	0.3	0.4
Conductivity (RCAp)	Electrode	1	uS/cm	21	22	21	21	22	24	24
pH	Electrode	-	Units	5.4	5.3	5.3	5.3	5.5	5.1	5
Hardness (as CaCO3)	Calculated	0.1	mg/L	3	4.1	3	3	3.4	2.5	2.5
Bicarbonate (as CaCO3)	Calculated	1	mg/L	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Carbonate (as CaCO3)	Calculated	1	mg/L	< 5	< 5	< 5	< 5	< 5	< 5	< 5
TDS (Calculated)	Calculated	1	mg/L	20	21	20	20	21	22	22
Cation Sum	Calculated	0.1	meq/L	0.15	0.19	0.16	0.15	0.16	0.16	0.16
Anion Sum	Calculated	0.1	meq/L	0.35	0.35	0.35	0.35	0.37	0.38	0.38
Ion Balance	Calculated	-	%	38.5	30.4	37.7	38.8	39.8	41.5	40.3
Langlier Index @ 4C	Calculated	-		-5.71	-5.81	-5.81	-5.81	-5.61	-6.01	-6.11
Langlier Index @ 20C	Calculated	-		-5.31	-5.41	-5.41	-5.41	-5.21	-5.61	-5.71
Saturation pH @ 4C	Calculated	-	Units	11.1	11.1	11.1	11.1	11.1	11.1	11.1
Saturation pH @ 20C	Calculated	-	Units	10.7	10.7	10.7	10.7	10.7	10.7	10.7
Dissolved Organic Carbon	U.V.-ox	0.5	mg/L	4.8	8	5.4	5.4	6.2	5.9	6.6

Appendix 3.2.1. Water Quality in Impoundments of the St. Croix and Big St. Margaets Bay Lake Systems, May 2001 (continued).

				SMB1-0.5	SMB1-14.0	SMB2-0.5	SMB2-14.0
Kjeldahl Nitrogen	Blk Digest	0.1	mg/L	0.6	0.4	0.4	0.7
Total Water Digest		-		Completed	Completed	Completed	Completed
Total Organic Carbon	SM5310	2	mg/L	9	11	9	10
Sodium	ICP-OES	0.1	mg/L	2.1	2	2	2.1
Potassium	ICP-OES	0.1	mg/L	0.3	0.3	0.3	0.2
Calcium	ICP-OES	0.1	mg/L	0.8	0.8	0.8	0.8
Magnesium	ICP-OES	0.1	mg/L	0.3	0.4	0.3	0.4
Alkalinity (as CaCO3)	COBAS	1	mg/L	< 5	< 5	< 5	< 5
Sulfate	COBAS	2	mg/L	8	9	8	8
Chloride	COBAS	1	mg/L	3.3	3.2	3.2	3.1
Reactive Silica (as SiO2)	COBAS	0.5	mg/L	2.3	2.6	2.2	2.6
Ortho Phosphate (as P)	COBAS	0.01	mg/L	0.01	< 0.01	0.01	0.01
Nitrate + Nitrite (as N)	COBAS	0.05	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Ammonia (as N)	COBAS	0.05	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Iron	ICP-OES	0.02	mg/L	0.13	0.14	0.12	0.15
Manganese	ICP-OES	0.01	mg/L	0.03	0.03	0.03	0.03
Copper	ICP-OES	0.01	mg/L	0.01	< 0.01	< 0.01	< 0.01
Zinc	ICP-OES	0.05	mg/L	< 0.05	< 0.05	< 0.05	< 0.05
Color	COBAS	5	TCU	27	25	26	29
Turbidity	NEPH.	0.1	NTU	0.6	0.2	0.2	< 0.1
Conductance (RCAp)	Electrode	1	uS/cm	25	24	24	23
pH	Electrode	-	Units	5.2	5.2	5.3	5.2
Hardness (as CaCO3)	Calculated	0.1	mg/L	3.2	3.6	3.2	3.6
Bicarbonate (as CaCO3)	Calculated	1	mg/L	< 5	< 5	< 5	< 5
Carbonate (as CaCO3)	Calculated	1	mg/L	< 5	< 5	< 5	< 5
TDS (Calculated)	Calculated	1	mg/L	20	22	20	20
Cation Sum	Calculated	0.1	meq/L	0.17	0.18	0.17	0.18
Anion Sum	Calculated	0.1	meq/L	0.36	0.38	0.36	0.36
Ion Balance	Calculated	-	%	35.3	36.5	36.4	33.2
Langlier Index @ 4C	Calculated	-		-5.91	-5.91	-5.81	-5.91
Langlier Index @ 20C	Calculated	-		-5.51	-5.51	-5.41	-5.51
Saturation pH @ 4C	Calculated	-	Units	11.1	11.1	11.1	11.1
Saturation pH @ 20C	Calculated	-	Units	10.7	10.7	10.7	10.7
Dissolved Organic Carbon	U.V.-ox	0.5	mg/L	6.1	6.1	5.9	5.9

Appendix 3.2.2. Water Quality in Impoundments of the St. Croix and Big St. Margarets Bay Lake Systems, July 2001.

Water Quality Results from Impoundments: Panuke Lake (PAN) & Big St.Margarets Bay Lake (SMB).

				LSC	LSC	PANISU	PANISU	PANISU	PAN2SU
Jul-01	Depth:			0.5	4.5	2	19	19.0 Dup	2
Kjeldahl Nitrogen	Blk Digest	0.1	mg/L	0.3	0.3	0.3	0.2	0.2	0.3
Total Organic Carbon	SM5310	2	mg/L	8	9	8	7	6	10
Sodium	ICP-OES	0.1	mg/L	2.2	2.2	2.4	2.2	2.1	2.1
Potassium	ICP-OES	0.1	mg/L	0.3	0.2	0.2	0.2	0.2	0.3
Calcium	ICP-OES	0.1	mg/L	0.7	0.7	0.7	0.8	0.8	0.7
Magnesium	ICP-OES	0.1	mg/L	0.3	0.3	0.3	0.3	0.3	0.3
Alkalinity (as CaCO3)	COBAS	1	mg/L	< 1	< 1	< 1	1	1	1
Sulfate	COBAS	2	mg/L	2	2	2	3	2	2
Chloride	COBAS	1	mg/L	3.3	3.6	3.2	3.2	3.1	3.2
Reactive Silica (as SiO2)	COBAS	0.5	mg/L	2.7	2.6	2.6	3.4	3.4	2.6
Ortho Phosphate (as P)	COBAS	0.01	mg/L	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01
Nitrite	COBAS	0.01	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nitrate + Nitrite (as N)	COBAS	0.05	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Nitrate (as N)	COBAS	0.05	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ammonia (as N)	COBAS	0.05	mg/L	< 0.05	< 0.05	< 0.05	0.07	0.08	0.05
Color	COBAS	5	TCU	20	20	18	20	19	18
Turbidity	NEPH.	0.1	NTU	0.8	1.2	0.7	0.5	0.8	0.5
Condutivity (RCAp)	Electrode	1	uS/cm	20	20	19	20	20	19
pH	Electrode	-	Units	6.2	6	5.8	5.8	5.7	5.7
Hardness (as CaCO3)	Calculated	0.1	mg/L	3	3	3	3.2	3.2	3
Bicarbonate (as CaCO3)	Calculated	1	mg/L	< 1	< 1	< 1	< 1	< 1	< 1
Carbonate (as CaCO3)	Calculated	1	mg/L	< 1	< 1	< 1	< 1	< 1	< 1
TDS (Calculated)	Calculated	1	mg/L	12	12	12	14	13	12
Cation Sum	Calculated	0.1	meq/L	0.17	0.17	0.17	0.17	0.17	0.16
Anion Sum	Calculated	0.1	meq/L	0.16	0.17	0.16	0.18	0.15	0.16
Ion Balance	Calculated	-	%	2.76	0.51	5.73	1.21	5.04	2.75
Langlier Index @ 4C	Calculated	-		-5.61	-5.81	-6.01	-6.01	-6.11	-6.11
Langlier Index @ 20C	Calculated	-		-5.21	-5.41	-5.61	-5.61	-5.71	-5.71
Saturation pH @ 4C	Calculated	-	Units	11.8	11.8	11.8	11.8	11.8	11.8
Saturation pH @ 20C	Calculated	-	Units	11.4	11.4	11.4	11.4	11.4	11.4
Aluminum	ICP-MS	10	µg/L	170	170	170	180	180	170
Antimony	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Arsenic	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Barium	ICP-MS	5	µg/L	5	5	5	5	5	5
Beryllium	ICP-MS	5	µg/L	< 5	< 5	< 5	< 5	< 5	< 5

Appendix 3.2.2. Water Quality in Impoundments of the St. Croix and Big St. Margarets Bay Lake Systems, July 2001 (continued).

				LSC	LSC	PANISU	PANISU	PANISU	PAN2SU
Jul-01	Depth:			0.5	4.5	2	19	19.0 Dup	2
Bismuth	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Boron	ICP-MS	5	µg/L	5	< 5	< 5	< 5	< 5	< 5
Cadmium	ICP-MS	0.3	µg/L	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Chromium	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Cobalt	ICP-MS	1	µg/L	< 1	< 1	< 1	< 1	< 1	< 1
Copper	ICP-MS	2	µg/L	3	5	< 2	< 2	< 2	< 2
Iron	ICP-MS	20	µg/L	150	150	80	190	190	80
Lead	ICP-MS	0.5	µg/L	0.6	< 0.5	< 0.5	0.7	< 0.5	< 0.5
Manganese	ICP-MS	2	µg/L	63	60	48	63	62	47
Molybdenum	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Nickel	ICP-MS	2	µg/L	7	2	< 2	< 2	< 2	< 2
Selenium	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Silver	ICP-MS	0.5	µg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Strontium	ICP-MS	5	µg/L	< 5	5	5	5	5	5
Thallium	ICP-MS	0.1	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Tin	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Titanium	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Uranium	ICP-MS	0.1	µg/L	0.2	0.1	0.1	0.1	0.1	0.1
Vanadium	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Zinc	ICP-MS	2	µg/L	11	13	7	5	6	6
Phosphorus	ICP-OES	0.1	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Dissolved Organic Carbon	U.V.-ox	0.5	mg/L	4.1	3.7	3.9	3.8	3.5	4.1

				PAN2SU	PAN3SU	PAN3SU	PAN4SU	PAN4SU	PAN4SU
	Depth:			18.0	2.0	9.0	2.0	10.0	14.0
Kjeldahl Nitrogen	Blk Digest	0.1	mg/L	0.4	0.3	0.4	0.5	0.8	0.6
Total Organic Carbon	SM5310	2	mg/L	9	8	6	6	6	6
Sodium	ICP-OES	0.1	mg/L	2.3	2.2	2.2	2.1	2.3	2.2
Potassium	ICP-OES	0.1	mg/L	0.3	0.3	0.2	0.2	0.3	0.2
Calcium	ICP-OES	0.1	mg/L	0.7	0.8	0.7	0.6	0.7	0.7
Magnesium	ICP-OES	0.1	mg/L	0.3	0.3	0.3	0.3	0.3	0.3
Alkalinity (as CaCO3)	COBAS	1	mg/L	1	1	1	2	1	2
Sulfate	COBAS	2	mg/L	< 2	< 2	2	< 2	2	< 2
Chloride	COBAS	1	mg/L	3.2	3.4	3.2	3.2	3	3
Reactive Silica (as SiO2)	COBAS	0.5	mg/L	3.6	2.8	3	2.8	3.3	3.5
Ortho Phosphate (as P)	COBAS	0.01	mg/L	< 0.01	< 0.01	0.01	< 0.01	0.03	< 0.01
Nitrite	COBAS	0.01	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nitrate + Nitrite (as N)	COBAS	0.05	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Nitrate (as N)	COBAS	0.05	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

Appendix 3.2.2. Water Quality in Impoundments of the St. Croix and Big St. Margarets Bay Lake Systems, July 2001 (continued).

				PAN2SU	PAN3SU	PAN3SU	PAN4SU	PAN4SU	PAN4SU
	Depth:			18.0	2.0	9.0	2.0	10.0	14.0
Ammonia (as N)	COBAS	0.05	mg/L	0.1	< 0.05	< 0.05	< 0.05	0.06	0.06
Color	COBAS	5	TCU	46	21	23	21	22	22
Turbidity	NEPH.	0.1	NTU	6.1	0.5	0.8	0.3	< 0.1	< 0.1
Conductivity (RCAp)	Electrode	1	uS/cm	20	20	20	20	19	19
pH	Electrode	-	Units	5.9	5.7	5.5	5.5	5.5	5.4
Hardness (as CaCO3)	Calculated	0.1	mg/L	3	3.2	3	2.7	3	3
Bicarbonate (as CaCO3)	Calculated	1	mg/L	< 1	< 1	< 1	2	< 1	2
Carbonate (as CaCO3)	Calculated	1	mg/L	< 1	< 1	< 1	< 1	< 1	< 1
TDS (Calculated)	Calculated	1	mg/L	13	13	12	13	13	13
Cation Sum	Calculated	0.1	meq/L	0.18	0.17	0.17	0.16	0.17	0.17
Anion Sum	Calculated	0.1	meq/L	0.16	0.16	0.16	0.18	0.15	0.17
Ion Balance	Calculated	-	%	6.14	3.74	3.65	5.27	7.71	0.31
Langlier Index @ 4C	Calculated	-		-5.91	-6.11	-6.31	-6.01	-6.31	-6.11
Langlier Index @ 20C	Calculated	-		-5.51	-5.71	-5.91	-5.61	-5.91	-5.71
Saturation pH @ 4C	Calculated	-	Units	11.8	11.8	11.8	11.5	11.8	11.5
Saturation pH @ 20C	Calculated	-	Units	11.4	11.4	11.4	11.1	11.4	11.1
Aluminum	ICP-MS	10	µg/L	290	190	230	210	210	210
Antimony	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Arsenic	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Barium	ICP-MS	5	µg/L	5	5	5	< 5	5	5
Beryllium	ICP-MS	5	µg/L	< 5	< 5	< 5	< 5	< 5	< 5
Bismuth	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Boron	ICP-MS	5	µg/L	< 5	5	< 5	< 5	< 5	< 5
Cadmium	ICP-MS	0.3	µg/L	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Chromium	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Cobalt	ICP-MS	1	µg/L	< 1	< 1	< 1	< 1	< 1	< 1
Copper	ICP-MS	2	µg/L	< 2	2	< 2	< 2	< 2	< 2
Iron	ICP-MS	20	µg/L	1600	100	160	100	130	160
Lead	ICP-MS	0.5	µg/L	0.6	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Manganese	ICP-MS	2	µg/L	250	53	52	48	51	51
Molybdenum	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Nickel	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Selenium	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Silver	ICP-MS	0.5	µg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Strontium	ICP-MS	5	µg/L	5	5	< 5	< 5	5	< 5
Thallium	ICP-MS	0.1	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Tin	ICP-MS	2	µg/L	< 2	< 2	2	< 2	< 2	< 2
Titanium	ICP-MS	2	µg/L	3	< 2	< 2	< 2	< 2	< 2
Uranium	ICP-MS	0.1	µg/L	0.1	0.1	0.1	0.1	0.1	0.1
Vanadium	ICP-MS	2	µg/L	2	< 2	< 2	< 2	< 2	< 2
Zinc	ICP-MS	2	µg/L	5	6	5	5	13	6

Appendix 3.2.2. Water Quality in Impoundments of the St. Croix and Big St. Margarets Bay Lake Systems, July 2001 (continued).

				PAN2SU	PAN3SU	PAN3SU	PAN4SU	PAN4SU	PAN4SU
	Depth:			18.0	2.0	9.0	2.0	10.0	14.0
Phosphorus	ICP-OES	0.1	mg/L	< 0.1	< 0.1	0.1	0.1	< 0.1	< 0.1
Dissolved Organic Carbon	U.V.-ox	0.5	mg/L	5.3	5.2	4.7	3.9	4	4.2

				PAN5SU	PAN5SU	PAN5SU	PAN6SU	PAN6SU	PAN6SU
	Depth:			2.0	9.0	20.0	2.0	9.0	9.0 dup
Kjeldahl Nitrogen	Blk Digest	0.1	mg/L	0.2	0.4	0.3	0.3	0.3	0.3
Total Organic Carbon	SM5310	2	mg/L	7	6	8	13	8	8
Sodium	ICP-OES	0.1	mg/L	2.2	2.1	2.1	2.2	2.2	2.1
Potassium	ICP-OES	0.1	mg/L	0.2	0.1	0.2	0.2	0.3	0.3
Calcium	ICP-OES	0.1	mg/L	0.6	0.6	0.7	0.6	0.5	0.5
Magnesium	ICP-OES	0.1	mg/L	0.3	0.3	0.3	0.3	0.3	0.2
Alkalinity (as CaCO3)	COBAS	1	mg/L	1	1	2	< 1	< 1	< 1
Sulfate	COBAS	2	mg/L	< 2	2	3	3	4	3
Chloride	COBAS	1	mg/L	3.2	3	3.2	2.7	2.7	2.8
Reactive Silica (as SiO2)	COBAS	0.5	mg/L	3	3.2	4.2	2.8	3.1	3.1
Ortho Phosphate (as P)	COBAS	0.01	mg/L	< 0.01	< 0.01	< 0.01	0.01	< 0.01	0.01
Nitrite	COBAS	0.01	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nitrate + Nitrite (as N)	COBAS	0.05	mg/L	< 0.05	< 0.05	< 0.05	0.07	< 0.05	< 0.05
Nitrate (as N)	COBAS	0.05	mg/L	< 0.05	< 0.05	< 0.05	0.07	< 0.05	< 0.05
Ammonia (as N)	COBAS	0.05	mg/L	0.07	< 0.05	0.09	< 0.05	< 0.05	< 0.05
Color	COBAS	5	TCU	21	24	24	22	24	25
Turbidity	NEPH.	0.1	NTU	0.3	0.3	0.3	0.6	0.1	< 0.1
Conductivity (RCAp)	Electrode	1	uS/cm	19	20	20	20	20	20
PH	Electrode	-	Units	5.4	5.4	5.5	5.3	5.2	5.3
Hardness (as CaCO3)	Calculated	0.1	mg/L	2.7	2.7	3	2.7	2.5	2.1
Bicarbonate (as CaCO3)	Calculated	1	mg/L	< 1	< 1	2	< 1	< 1	< 1
Carbonate (as CaCO3)	Calculated	1	mg/L	< 1	< 1	< 1	< 1	< 1	< 1
TDS (Calculated)	Calculated	1	mg/L	12	12	15	13	14	13
Cation Sum	Calculated	0.1	meq/L	0.16	0.16	0.17	0.16	0.16	0.15
Anion Sum	Calculated	0.1	meq/L	0.16	0.15	0.2	0.16	0.18	0.16
Ion Balance	Calculated	-	%	2.82	2.07	8.44	0.15	5.79	5.07
Langlier Index @ 4C	Calculated	-		-6.41	-6.41	-6.01	-6.51	-6.61	-6.51
Langlier Index @ 20C	Calculated	-		-6.01	-6.01	-5.61	-6.11	-6.21	-6.11
Saturation pH @ 4C	Calculated	-	Units	11.8	11.8	11.5	11.8	11.8	11.8
Saturation pH @ 20C	Calculated	-	Units	11.4	11.4	11.1	11.4	11.4	11.4
Aluminum	ICP-MS	10	µg/L	220	230	210	250	240	230
Antimony	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Arsenic	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Barium	ICP-MS	5	µg/L	< 5	< 5	< 5	< 5	< 5	< 5

Appendix 3.2.2. Water Quality in Impoundments of the St. Croix and Big St. Margarets Bay Lake Systems, July 2001 (continued).

				PAN5SU	PAN5SU	PAN5SU	PAN6SU	PAN6SU	PAN6SU
	Depth:			2.0	9.0	20.0	2.0	9.0	9.0 dup
Beryllium	ICP-MS	5	µg/L	< 5	< 5	< 5	< 5	< 5	< 5
Bismuth	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Boron	ICP-MS	5	µg/L	< 5	< 5	5	< 5	10	6
Cadmium	ICP-MS	0.3	µg/L	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Chromium	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Cobalt	ICP-MS	1	µg/L	< 1	< 1	< 1	< 1	< 1	< 1
Copper	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Iron	ICP-MS	20	µg/L	90	120	260	100	120	110
Lead	ICP-MS	0.5	µg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Manganese	ICP-MS	2	µg/L	44	51	55	46	46	44
Molybdenum	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Nickel	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Selenium	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Silver	ICP-MS	0.5	µg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Strontium	ICP-MS	5	µg/L	< 5	< 5	5	< 5	< 5	< 5
Thallium	ICP-MS	0.1	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1
Tin	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Titanium	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Uranium	ICP-MS	0.1	µg/L	0.1	0.1	0.1	0.1	0.2	0.1
Vanadium	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Zinc	ICP-MS	2	µg/L	5	7	5	7	6	6
Phosphorus	ICP-OES	0.1	mg/L	< 0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1
Dissolved Organic Carbon	U.V.-ox	0.5	mg/L	4.1	5	4.3	4.4	5.3	4.9

				PAN6SU	PAN7SU	PAN7SU	PAN7SU	SMB1SU	SMB1SU
	Depth:			30.0	2.0	11.0	25.0	2.0	7.0
Kjeldahl Nitrogen	Blk Digest	0.1	mg/L	0.4	3.8	0.5	0.2	0.3	11
Total Organic Carbon	SM5310	2	mg/L	8	9	8	9	8	7
Sodium	ICP-OES	0.1	mg/L	2.3	2.2	2.1	2.2	2.1	2.1
Potassium	ICP-OES	0.1	mg/L	0.3	0.2	0.2	0.2	0.3	0.3
Calcium	ICP-OES	0.1	mg/L	0.5	0.5	0.5	0.5	0.7	0.7
Magnesium	ICP-OES	0.1	mg/L	0.3	0.3	0.3	0.3	0.3	0.3
Alkalinity (as CaCO3)	COBAS	1	mg/L	< 1	< 1	< 1	< 1	< 1	1
Sulfate	COBAS	2	mg/L	4	3	5	3	4	3
Chloride	COBAS	1	mg/L	2.9	2.8	3	3	3.3	3.2
Reactive Silica (as SiO2)	COBAS	0.5	mg/L	3.4	2.9	3	3.4	1.5	1.9
Ortho Phosphate (as P)	COBAS	0.01	mg/L	0.01	0.02	0.01	< 0.01	< 0.01	< 0.01
Nitrite	COBAS	0.01	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nitrate + Nitrite (as N)	COBAS	0.05	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Nitrate (as N)	COBAS	0.05	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ammonia (as N)	COBAS	0.05	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

Appendix 3.2.2. Water Quality in Impoundments of the St. Croix and Big St. Margarets Bay Lake Systems, July 2001 (continued).

				PAN6SU	PAN7SU	PAN7SU	PAN7SU	SMB1SU	SMB1SU
	Depth:			30.0	2.0	11.0	25.0	2.0	7.0
Color	COBAS	5	TCU	26	23	26	26	19	21
Turbidity	NEPH.	0.1	NTU	< 0.1	0.1	0.2	0.2	0.2	0.3
Conductivity (RCAp)	Electrode	1	uS/cm	20	20	31	21	20	10
PH	Electrode	-	Units	5.1	5.2	5.2	5.2	5.5	5.6
Hardness (as CaCO3)	Calculated	0.1	mg/L	2.5	2.5	2.5	2.5	3	3
Bicarbonate (as CaCO3)	Calculated	1	mg/L	< 1	< 1	< 1	< 1	< 1	< 1
Carbonate (as CaCO3)	Calculated	1	mg/L	< 1	< 1	< 1	< 1	< 1	< 1
TDS (Calculated)	Calculated	1	mg/L	15	13	15	13	13	12
Cation Sum	Calculated	0.1	meq/L	0.17	0.16	0.16	0.16	0.17	0.16
Anion Sum	Calculated	0.1	meq/L	0.19	0.16	0.21	0.17	0.2	0.18
Ion Balance	Calculated	-	%	5.5	1.41	15.3	3.09	9.43	3.37
Langlier Index @ 4C	Calculated	-		-6.71	-6.61	-6.61	-6.61	-6.31	-6.21
Langlier Index @ 20C	Calculated	-		-6.31	-6.21	-6.21	-6.21	-5.91	-5.81
Saturation pH @ 4C	Calculated	-	Units	11.8	11.8	11.8	11.8	11.8	11.8
Saturation pH @ 20C	Calculated	-	Units	11.4	11.4	11.4	11.4	11.4	11.4
Aluminum	ICP-MS	10	µg/L	250	240	240	260	170	180
Antimony	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Arsenic	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Barium	ICP-MS	5	µg/L	< 5	< 5	< 5	< 5	< 5	5
Beryllium	ICP-MS	5	µg/L	< 5	< 5	< 5	< 5	< 5	< 5
Bismuth	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Boron	ICP-MS	5	µg/L	5	5	< 5	< 5	< 5	< 5
Cadmium	ICP-MS	0.3	µg/L	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Chromium	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Cobalt	ICP-MS	1	µg/L	< 1	< 1	< 1	< 1	< 1	< 1
Copper	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Iron	ICP-MS	20	µg/L	150	110	130	160	60	80
Lead	ICP-MS	0.5	µg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Manganese	ICP-MS	2	µg/L	49	44	48	50	41	47
Molybdenum	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Nickel	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Selenium	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Silver	ICP-MS	0.5	µg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Strontium	ICP-MS	5	µg/L	< 5	< 5	< 5	< 5	5	5
Thallium	ICP-MS	0.1	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Tin	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Titanium	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Uranium	ICP-MS	0.1	µg/L	0.1	0.2	0.1	0.1	0.1	0.1
Vanadium	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Zinc	ICP-MS	2	µg/L	6	6	9	6	6	6
Phosphorus	ICP-OES	0.1	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Dissolved Organic Carbon	U.V.-ox	0.5	mg/L	4.1	4	4.3	4.8	3.6	4.9

Appendix 3.2.2. Water Quality in Impoundments of the St. Croix and Big St. Margarets Bay Lake Systems, July 2001 (continued).

				SMB1SU	SMB1SU	SMB2SU	SMB2SU	SMB2SU	SMB2SU
	Depth:			**15.0**	**25.0**	**2.0**	**7.0**	**7.0 dup**	**23.0**
Kjeldahl Nitrogen	Blk Digest	0.1	mg/L	0.5	0.8	0.4	0.4	0.6	7.3
Total Organic Carbon	SM5310	2	mg/L	7	8	7	7	8	8
Sodium	ICP-OES	0.1	mg/L	2.1	2.2	2.2	2.2	2.2	2.2
Potassium	ICP-OES	0.1	mg/L	0.3	0.3	0.2	0.3	0.2	0.3
Calcium	ICP-OES	0.1	mg/L	0.8	0.8	0.8	0.7	0.8	0.8
Magnesium	ICP-OES	0.1	mg/L	0.3	0.3	0.3	0.3	0.3	0.4
Alkalinity (as CaCO3)	COBAS	1	mg/L	< 1	2	< 1	< 1	< 1	< 1
Sulfate	COBAS	2	mg/L	3	3	2	3	2	3
Chloride	COBAS	1	mg/L	3.4	3.5	3.1	3.4	3.2	3.3
Reactive Silica (as SiO2)	COBAS	0.5	mg/L	2.9	3.2	1.5	1.9	1.9	3
Ortho Phosphate (as P)	COBAS	0.01	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nitrite	COBAS	0.01	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nitrate + Nitrite (as N)	COBAS	0.05	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Nitrate (as N)	COBAS	0.05	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ammonia (as N)	COBAS	0.05	mg/L	< 0.05	0.07	< 0.05	< 0.05	< 0.05	< 0.05
Color	COBAS	5	TCU	24	26	19	21	21	25
Turbidity	NEPH.	0.1	NTU	0.2	0.3	0.4	0.5	0.6	0.2
Conductivity (RCAp)	Electrode	1	uS/cm	21	21	20	20	20	21
pH	Electrode	-	Units	5.5	5.5	5.7	5.5	5.5	5.4
Hardness (as CaCO3)	Calculated	0.1	mg/L	3.2	3.2	3.2	3	3.2	3.6
Bicarbonate (as CaCO3)	Calculated	1	mg/L	< 1	2	< 1	< 1	< 1	< 1
Carbonate (as CaCO3)	Calculated	1	mg/L	< 1	< 1	< 1	< 1	< 1	< 1
TDS (Calculated)	Calculated	1	mg/L	14	15	11	13	11	14
Cation Sum	Calculated	0.1	meq/L	0.17	0.18	0.17	0.17	0.17	0.18
Anion Sum	Calculated	0.1	meq/L	0.18	0.2	0.15	0.18	0.16	0.18
Ion Balance	Calculated	-	%	3.26	7.49	5.69	3.45	5.11	1.31
Langlier Index @ 4C	Calculated	-		-6.31	-6.01	-6.11	-6.31	-6.31	-6.41
Langlier Index @ 20C	Calculated	-		-5.91	-5.61	-5.71	-5.91	-5.91	-6.01
Saturation pH @ 4C	Calculated	-	Units	11.8	11.5	11.8	11.8	11.8	11.8
Saturation pH @ 20C	Calculated	-	Units	11.4	11.1	11.4	11.4	11.4	11.4
Aluminum	ICP-MS	10	µg/L	220	230	170	190	190	180
Antimony	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Arsenic	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Barium	ICP-MS	5	µg/L	5	5	5	5	5	< 5
Beryllium	ICP-MS	5	µg/L	< 5	< 5	< 5	< 5	< 5	< 5
Bismuth	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Boron	ICP-MS	5	µg/L	< 5	< 5	< 5	< 5	5	< 5
Cadmium	ICP-MS	0.3	µg/L	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Chromium	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Cobalt	ICP-MS	1	µg/L	< 1	< 1	< 1	< 1	< 1	< 1
Copper	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Iron	ICP-MS	20	µg/L	120	190	60	80	80	120

Appendix 3.2.2. Water Quality in Impoundments of the St. Croix and Big St. Margarets Bay Lake Systems, July 2001 (continued).

				SMB1SU	SMB1SU	SMB2SU	SMB2SU	SMB2SU	SMB2SU
	Depth:			**15.0**	**25.0**	**2.0**	**7.0**	**7.0 dup**	**23.0**
Lead	ICP-MS	0.5	µg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Manganese	ICP-MS	2	µg/L	37	42	42	45	47	32
Molybdenum	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Nickel	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Selenium	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Silver	ICP-MS	0.5	µg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Strontium	ICP-MS	5	µg/L	5	5	5	5	5	< 5
Thallium	ICP-MS	0.1	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Tin	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Titanium	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Uranium	ICP-MS	0.1	µg/L	0.1	0.1	0.1	0.1	0.1	0.1
Vanadium	ICP-MS	2	µg/L	< 2	< 2	< 2	< 2	< 2	< 2
Zinc	ICP-MS	2	µg/L	6	6	6	6	6	6
Phosphorus	ICP-OES	0.1	mg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Dissolved Organic Carbon	U.V.-ox	0.5	mg/L	4.7	4.7	4	4.1	4.3	3.5

				SMB3SU	SMB3SU	SMB3SU
			Depth:	**2.0**	**7.0**	**11.0**
Kjeldahl Nitrogen	Blk Digest	0.1	mg/L	11	9.2	0.5
Total Organic Carbon	SM5310	2	mg/L	7	7	8
Sodium	ICP-OES	0.1	mg/L	2.1	2.1	2.2
Potassium	ICP-OES	0.1	mg/L	0.3	0.2	0.1
Calcium	ICP-OES	0.1	mg/L	0.8	0.8	0.8
Magnesium	ICP-OES	0.1	mg/L	0.3	0.4	0.4
Alkalinity (as CaCO3)	COBAS	1	mg/L	< 1	< 1	1
Sulfate	COBAS	2	mg/L	8	3	2
Chloride	COBAS	1	mg/L	3.2	3.2	3.6
Reactive Silica (as SiO2)	COBAS	0.5	mg/L	1.5	4.1	4.4
Ortho Phosphate (as P)	COBAS	0.01	mg/L	< 0.01	< 0.01	< 0.01
Nitrite	COBAS	0.01	mg/L	< 0.01	< 0.01	< 0.01
Nitrate + Nitrite (as N)	COBAS	0.05	mg/L	< 0.05	< 0.05	< 0.05
Nitrate (as N)	COBAS	0.05	mg/L	< 0.05	< 0.05	< 0.05
Ammonia (as N)	COBAS	0.05	mg/L	< 0.05	< 0.05	0.12
Color	COBAS	5	TCU	19	24	32
Turbidity	NEPH.	0.1	NTU	0.4	0.6	1.2
Conductivity (RCAp)	Electrode	1	uS/cm	20	21	22
pH	Electrode	-	Units	5.6	5.5	5.7
Hardness (as CaCO3)	Calculated	0.1	mg/L	3.2	3.6	3.6
Bicarbonate (as CaCO3)	Calculated	1	mg/L	< 1	< 1	< 1
Carbonate (as CaCO3)	Calculated	1	mg/L	< 1	< 1	< 1
TDS (Calculated)	Calculated	1	mg/L	17	15	14

Appendix 3.2.2. Water Quality in Impoundments of the St. Croix and Big St. Margarets Bay Lake Systems, July 2001 (continued).

				SMB3SU	SMB3SU	SMB3SU
			Depth:	2.0	7.0	11.0
Cation Sum	Calculated	0.1	meq/L	0.17	0.18	0.18
Anion Sum	Calculated	0.1	meq/L	0.28	0.18	0.17
Ion Balance	Calculated	-	%	24.6	0.05	4.3
Langlier Index @ 4C	Calculated	-		-6.21	-6.31	-6.11
Langlier Index @ 20C	Calculated	-		-5.81	-5.91	-5.71
Saturation pH @ 4C	Calculated	-	Units	11.8	11.8	11.8
Saturation pH @ 20C	Calculated	-	Units	11.4	11.4	11.4
Aluminum	ICP-MS	10	µg/L	170	250	300
Antimony	ICP-MS	2	µg/L	< 2	< 2	< 2
Arsenic	ICP-MS	2	µg/L	< 2	< 2	< 2
Barium	ICP-MS	5	µg/L	< 5	6	6
Beryllium	ICP-MS	5	µg/L	< 5	< 5	< 5
Bismuth	ICP-MS	2	µg/L	< 2	< 2	< 2
Boron	ICP-MS	5	µg/L	< 5	< 5	< 5
Cadmium	ICP-MS	0.3	µg/L	< 0.3	< 0.3	< 0.3
Chromium	ICP-MS	2	µg/L	< 2	< 2	< 2
Cobalt	ICP-MS	1	µg/L	< 1	< 1	< 1
Copper	ICP-MS	2	µg/L	< 2	< 2	< 2
Iron	ICP-MS	20	µg/L	80	210	500
Lead	ICP-MS	0.5	µg/L	< 0.5	< 0.5	0.6
Manganese	ICP-MS	2	µg/L	36	64	60
Molybdenum	ICP-MS	2	µg/L	< 2	< 2	< 2
Nickel	ICP-MS	2	µg/L	< 2	< 2	< 2
Selenium	ICP-MS	2	µg/L	< 2	< 2	< 2
Silver	ICP-MS	0.5	µg/L	< 0.5	< 0.5	< 0.5
Strontium	ICP-MS	5	µg/L	5	5	5
Thallium	ICP-MS	0.1	µg/L	< 0.1	< 0.1	< 0.1
Tin	ICP-MS	2	µg/L	< 2	< 2	< 2
Titanium	ICP-MS	2	µg/L	< 2	2	3
Uranium	ICP-MS	0.1	µg/L	0.1	0.1	0.1
Vanadium	ICP-MS	2	µg/L	< 2	< 2	< 2
Zinc	ICP-MS	2	µg/L	6	7	7
Phosphorus	ICP-OES	0.1	mg/L	< 0.1	< 0.1	0.1
Dissolved Organic Carbon	U.V.-ox	0.5	mg/L	3.8	3.6	4.2

Appendix 3.2.3 Water Quality of Streams in the St. Croix River System and Big St. Margarets Bay Lake, July 2001.

Parameter	Units	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SM1	SM2	SM3
Kjeldahl Nitrogen	mg/L	-	-	-	-	-	-	-	-	-	-
Sodium	mg/L	2.4	2.4	2.1	2.9	1.9	3	2.6	2	2.3	2.7
Potassium	mg/L	0.1	0.3	0.4	0.5	0.3	0.4	< 0.1	0.3	0.2	0.5
Calcium	mg/L	0.9	0.8	0.8	0.7	0.3	3	1.5	0.8	0.9	1.7
Magnesium	mg/L	0.4	0.3	0.4	0.3	0.2	0.7	0.6	0.3	0.4	0.7
Alkalinity (as CaCO3)	mg/L	< 1	< 1	1	< 1	< 1	9	< 1	1	1	< 1
Sulfate	mg/L	3	3	3	< 2	< 2	3	3	< 2	2	< 2
Chloride	mg/L	2.7	3.3	3.2	4.1	3.2	4	3.8	2.7	3.1	3.8
Reactive Silica (as SiO2)	mg/L	2.1	3.7	1.7	5.8	1	3.5	3.1	1.1	1.4	4.8
Ortho Phosphate (as P)	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.01	< 0.01	< 0.01	< 0.01
Nitrite	mg/L	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Nitrate + Nitrite (as N)	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Nitrate (as N)	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ammonia (as N)	mg/L	< 0.05	< 0.05	< 0.05	0.1	0.06	< 0.05	0.07	0.07	0.08	< 0.05
Color	TCU	61	86	25	68	42	11	120	41	69	140
Turbidity	NTU	2.1	1.5	1.3	1.1	1	4.5	1.5	0.9	0.9	1.2
Conductivity (RCAp)	µS/cm	22	24	21	26	18	34	34	19	21	33
pH	-	5.2	4.9	5.5	4.9	5.1	6.8	4.6	6	5.4	4.7
Hardness (as CaCO3)	mg/L	3.9	3.2	3.6	3	1.6	10.4	6.2	3.2	3.9	7.1
Bicarbonate (as CaCO3)	mg/L	< 1	< 1	< 1	< 1	< 1	9	< 1	< 1	< 1	< 1
Carbonate (as CaCO3)	mg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
TDS (Calculated)	mg/L	12	15	12	17	10	23	16	10	11	17
Cation Sum	meq/L	0.19	0.19	0.18	0.22	0.13	0.35	0.27	0.17	0.19	0.3
Anion Sum	meq/L	0.16	0.18	0.18	0.18	0.16	0.36	0.19	0.14	0.15	0.17
Ion Balance	-	9.13	3.72	1.39	9.4	7.4	0.98	16.6	7.82	11.6	26.4
Langlier Index @ 4C	-	-6.61	-6.91	-6.31	-6.91	-6.71	-3.58	-7.03	-5.81	-6.41	-6.88
Langlier Index @ 20C	-	-6.21	-6.51	-5.91	-6.51	-6.31	-3.18	-6.63	-5.41	-6.01	-6.48
Saturation pH @ 4C	-	11.8	11.8	11.8	11.8	11.8	10.4	11.6	11.8	11.8	11.6
Saturation pH @ 20C	-	11.4	11.4	11.4	11.4	11.4	9.98	11.2	11.4	11.4	11.2
Aluminum	µg/L	290	440	200	490	230	20	570	250	270	640
Antimony	µg/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Arsenic	µg/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Barium	µg/L	6	6	5	< 5	< 5	18	10	< 5	5	10
Beryllium	µg/L	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Bismuth	µg/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Boron	µg/L	5	6	7	6	5	6	5	6	6	6
Cadmium	µg/L	< 0.3	< 0.3	< 0.3	0.6	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Chromium	µg/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Cobalt	µg/L	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Copper	µg/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Iron	µg/L	170	310	100	220	160	40	370	150	200	480
Lead	µg/L	< 0.5	0.7	< 0.5	0.6	< 0.5	< 0.5	0.9	0.5	< 0.5	0.7
Manganese	µg/L	31	48	25	21	18	6	34	27	28	54

Appendix 3.2.3 Water Quality of Streams in the St. Croix River System and Big St. Margarets Bay Lake, July 2001 (continued).

Parameter	Units	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SM1	SM2	SM3
Molybdenum	µg/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Nickel	µg/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Selenium	µg/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Silver	µg/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Strontium	µg/L	6	6	5	6	< 5	14	10	5	6	10
Thallium	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Tin	µg/L	4	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Titanium	µg/L	2	4	< 2	2	< 2	< 2	5	2	3	7
Uranium	µg/L	0.1	0.2	0.1	0.3	0.1	< 0.1	0.1	0.1	0.1	0.1
Vanadium	µg/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Zinc	µg/L	5	6	4	25	6	4	8	4	4	13
Phosphorus	µg/L	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Dissolved Organic Carbon	µg/L	11.9	15.9	5.4	14.3	6.5	2.6	25.5	6.9	11.4	23.2

Appendix 3.3.1.

Database of Fish Collected from Panuke Lake and Big St. Margarets Bay Lake, May - July 2001.
(*- indicates fish processed for mercury analysis).

Site	Collection Method	Collection Date	Species	Fork Length (cm)	Total Length (cm)	Weight (g)
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	31.0	32.0	370
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	33.0	34.0	403
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	27.1	28.0	280
Panuke Lake	Gill Net	27/28 May	*S. fontinalis**	27.5	28.5	278
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	24.0	24.8	189
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	26.0	27.0	212
Panuke Lake	Gill Net	27/28 May	*S. fontinalis**	24.8	26.0	200
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	25.4	26.0	242
Panuke Lake	Gill Net	27/28 May	*M. dolomieui**	19.5	20.5	95
Panuke Lake	Gill Net	27/28 May	*M. dolomieui**	21.0	22.0	114
Panuke Lake	Gill Net	27/28 May	*I. natalis**		26.0	217
Panuke Lake	Gill Net	27/28 May	*S. fontinalis**	21.0	21.5	136
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	20.5	21.5	89
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	17.4	18.4	61
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	12.0	12.6	17
Panuke Lake	Gill Net	27/28 May	*P. flavescens**	16.5	17.2	52
Panuke Lake	Gill Net	27/28 May	*P. flavescens**	16.0	16.8	49
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	20.0	21.1	90
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	16.0	16.5	48
Panuke Lake	Gill Net	27/28 May	*I. natalis*		20.0	100
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	16.0	17.0	51
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	14.5	15.0	36
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	15.1	16.0	41
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	14.5	15.5	33
Panuke Lake	Gill Net	27/28 May	*C. commersoni*	16.0	17.0	53
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	15.1	15.6	36
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	10.5	11.0	13
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	15.4	16.0	47
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	14.5	15.0	32
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	10.5	11.0	12
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	14.0	14.6	29
Panuke Lake	Gill Net	27/28 May	*P. flavescens*		12.0	17
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	11.0	11.7	13
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	11.5	12.1	14
Panuke Lake	Gill Net	27/28 May	*P. flavescens*		11.0	13
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	11.0	11.5	14
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	10.6	10.8	12
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	11.5	12.0	10
Panuke Lake	Gill Net	28/29 May	*P. flavescens*	11.4	12.0	

Appendix 3.3.1. Database of Fish Collected from Panuke Lake and Big St. Margarets Bay Lake, May - July 2001 (continued).

Site	Collection Method	Collection Date	Species	Fork Length (cm)	Total Length (cm)	Weight (g)
Panuke Lake	Gill Net	28/29 May	*P. flavescens*	10.0	11.4	
Panuke Lake	Gill Net	28/29 May	*P. flavescens*	10.8	11.4	
Panuke Lake	Gill Net	28/29 May	*P. flavescens*	10.5	11.1	
Panuke Lake	Gill Net	28/29 May	*P. flavescens*	10.6	11.1	
Panuke Lake	Gill Net	28/29 May	*P. flavescens*	10.6	11.1	
Panuke Lake	Gill Net	28/29 May	*P. flavescens*	10.6	11.1	
Panuke Lake	Gill Net	28/29 May	*P. flavescens*	9.9	10.4	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	36.2	39.1	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	34.9	37.5	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	37.9	41.5	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	37.4	40.5	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	36.5	39.0	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	33.4	35.0	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	34.4	37.7	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	33.3	35.6	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	35.6	37.6	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	35.5	38.5	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	35.7	37.7	
Panuke Lake	Angling	23/24 June	*M. dolomieui*	31.5	32.8	442
Panuke Lake	Angling	23/24 June	*M. dolomieui*	32.7	34.2	402
Panuke Lake	Angling	23/24 June	*M. dolomieui*	31.8	33.0	376
Panuke Lake	Angling	23/24 June	*M. dolomieui*	27.0	28.4	248
Panuke Lake	Angling	23/24 June	*M. dolomieui*	31.8	33.1	400
Panuke Lake	Angling	23/24 June	*M. dolomieui*	30.4	32.0	322
Panuke Lake	Angling	23/24 June	*M. dolomieui*	29.0	31.0	310
Panuke Lake	Angling	23/24 June	*M. dolomieui*	27.5	29.3	270
Panuke Lake	Angling	23/24 June	*M. dolomieui*	27.0	28.6	244
Panuke Lake	Angling	23/24 June	*M. dolomieui*	27.4	29.0	254
Panuke Lake	Angling	23/24 June	*M. dolomieui*	23.1	24.3	170
Panuke Lake	Angling	23/24 June	*M. dolomieui*	21.0	22.0	120
Panuke Lake	Angling	23/24 June	*M. dolomieui*	19.4	20.5	102
Panuke Lake	Angling	23/24 June	*M. dolomieui*	18.5	19.6	90
Panuke Lake	Angling	23/24 June	*M. dolomieui*	20.0	21.2	114
Panuke Lake	Angling	23/24 June	*M. dolomieui*	19.2	20.2	98
Panuke Lake	Angling	23/24 June	*M. dolomieui*	20.2	21.3	118
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	36.0	38.5	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	34.8	37.1	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	25.7	27.5	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	32.3	34.6	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	23.0	25.5	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	22.0	23.5	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	17.6	19.0	

Appendix 3.3.1. Database of Fish Collected from Panuke Lake and Big St. Margarets Bay Lake, May - July 2001 (continued).

Site	Collection Method	Collection Date	Species	Fork Length (cm)	Total Length (cm)	Weight (g)
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	16.8	18.0	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	16.6	17.5	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	16.3	17.2	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	26.3	28.2	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	21.6	23.7	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	43.0	46.0	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	24.2	25.8	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	17.5	18.5	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	31.5	33.5	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	29.2	31.0	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	23.7	24.7	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	23.3	25.1	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	21.5	23.7	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	17.5	18.5	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	24.0	26.0	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	25.5	26.7	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	26.3	28.7	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	32.0	34.0	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	22.2	24.5	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	32.3	34.2	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	26.5	27.9	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	16.2	17.4	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	23.7	25.0	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	16.5	17.7	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	20.7	22.6	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	24.6	25.7	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	16.5	17.5	49
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	12.3	13.0	20
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.0	11.7	15
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.5	12.5	17
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.4	10.8	12
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.0	11.7	12
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	14.2	15.0	31
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.4	11.0	11
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.2	11.8	15
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.7	12.7	21
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.0	11.5	12
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.5	11.0	10
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	12.0	12.5	16
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.0	11.5	11
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.5	11.9	11
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	12.5	12.8	16

Appendix 3.3.1. Database of Fish Collected from Panuke Lake and Big St. Margarets Bay Lake, May - July 2001 (continued).

Site	Collection Method	Collection Date	Species	Fork Length (cm)	Total Length (cm)	Weight (g)
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.5	11.2	9
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.8	12.3	17
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.5	11.1	11
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	13.0	13.5	32
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.0	11.5	15
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.8	11.2	12
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	12.4	13.1	21
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	12.4	13.0	18
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.0	11.5	12
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.4	12.0	13
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.3	12.0	16
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.2	10.9	11
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.5	12.0	12
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.0	11.5	12
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.4	10.9	11
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.0	11.5	16
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.5	12.0	12
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.5	12.0	14
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	12.0	12.4	17
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.5	12.0	15
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.5	11.1	13
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.5	11.0	10
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.6	12.2	17
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.7	11.4	12
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	15.7	16.5	47
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	16.5	17.3	67
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	23.8	24.3	159
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	21.0	22.0	106
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	17.5	18.5	62
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	18.0	18.6	61
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	15.1	15.7	38
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	17.0	17.7	49
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	15.1	15.8	38
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	14.5	15.6	39
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	17.0	18.0	51
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	16.2	17.0	50
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	16.0	17.0	41
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	14.2	14.9	30
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	22.0	22.5	117
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	21.6	22.2	113
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	24.0	24.5	155
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	15.0	15.4	35

Appendix 3.3.1. Database of Fish Collected from Panuke Lake and Big St. Margarets Bay Lake, May - July 2001 (continued).

Site	Collection Method	Collection Date	Species	Fork Length (cm)	Total Length (cm)	Weight (g)
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	20.0	21.0	91
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	15.5	16.5	39
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	15.4	16.0	39
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	18.1	18.5	68
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	15.3	16.0	43
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	16.0	16.7	43
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	16.5	17.1	47
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	18.0	19.0	61
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	23.5	24.5	160
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	21.2	22.0	121
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	21.0	22.2	98
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	17.0	17.6	55
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	22.6	23.5	117
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	14.0	14.6	37
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	15.0	15.6	37
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	15.1	16.0	41
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	13.4	14.0	39
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	22.0	23.0	126
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	27.4	29.0	275
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	33.5	35.0	432
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	22.5	23.0	139
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	22.5	23.5	142
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	21.7	23.0	123
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	27.7	28.6	66
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	19.5	20.5	90
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	18.0	19.0	84
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	18.0	19.2	76
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	16.5	17.5	47
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	15.8	16.5	50
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	12.0	12.6	22
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	12.5	13.0	20
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	10.5	11.0	14
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	31.0	32.0	370
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	33.0	34.0	403
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	27.1	28.0	280
Panuke Lake	Gill Net	27/28 May	*S. fontinalis**	27.5	28.5	278
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	24.0	24.8	189
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	26.0	27.0	212
Panuke Lake	Gill Net	27/28 May	*S. fontinalis**	24.8	26.0	200
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	25.4	26.0	242
Panuke Lake	Gill Net	27/28 May	*M. dolomieui**	19.5	20.5	95

Appendix 3.3.1. Database of Fish Collected from Panuke Lake and Big St. Margarets Bay Lake, May - July 2001 (continued).

Site	Collection Method	Collection Date	Species	Fork Length (cm)	Total Length (cm)	Weight (g)
Panuke Lake	Gill Net	27/28 May	*M. dolomieui**	21.0	22.0	114
Panuke Lake	Gill Net	27/28 May	*I. natalis**		26.0	217
Panuke Lake	Gill Net	27/28 May	*S. fontinalis**	21.0	21.5	136
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	20.5	21.5	89
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	17.4	18.4	61
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	12.0	12.6	17
Panuke Lake	Gill Net	27/28 May	*P. flavescens**	16.5	17.2	52
Panuke Lake	Gill Net	27/28 May	*P. flavescens**	16.0	16.8	49
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	20.0	21.1	90
Panuke Lake	Gill Net	27/28 May	*S. fontinalis*	16.0	16.5	48
Panuke Lake	Gill Net	27/28 May	*I. natalis*		20.0	100
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	16.0	17.0	51
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	14.5	15.0	36
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	15.1	16.0	41
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	14.5	15.5	33
Panuke Lake	Gill Net	27/28 May	*C. commersoni*	16.0	17.0	53
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	15.1	15.6	36
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	10.5	11.0	13
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	15.4	16.0	47
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	14.5	15.0	32
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	10.5	11.0	12
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	14.0	14.6	29
Panuke Lake	Gill Net	27/28 May	*P. flavescens*		12.0	17
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	11.0	11.7	13
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	11.5	12.1	14
Panuke Lake	Gill Net	27/28 May	*P. flavescens*		11.0	13
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	11.0	11.5	14
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	10.6	10.8	12
Panuke Lake	Gill Net	27/28 May	*P. flavescens*	11.5	12.0	10
Panuke Lake	Gill Net	28/29 May	*P. flavescens*	11.4	12.0	
Panuke Lake	Gill Net	28/29 May	*P. flavescens*	10.0	11.4	
Panuke Lake	Gill Net	28/29 May	*P. flavescens*	10.8	11.4	
Panuke Lake	Gill Net	28/29 May	*P. flavescens*	10.5	11.1	
Panuke Lake	Gill Net	28/29 May	*P. flavescens*	10.6	11.1	
Panuke Lake	Gill Net	28/29 May	*P. flavescens*	10.6	11.1	
Panuke Lake	Gill Net	28/29 May	*P. flavescens*	10.6	11.1	
Panuke Lake	Gill Net	28/29 May	*P. flavescens*	9.9	10.4	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	36.2	39.1	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	34.9	37.5	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	37.9	41.5	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	37.4	40.5	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	36.5	39.0	

Appendix 3.3.1. Database of Fish Collected from Panuke Lake and Big St. Margarets Bay Lake, May - July 2001 (continued).

Site	Collection Method	Collection Date	Species	Fork Length (cm)	Total Length (cm)	Weight (g)
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	33.4	35.0	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	34.4	37.7	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	33.3	35.6	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	35.6	37.6	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	35.5	38.5	
Panuke Lake	Gill Net	28/29 May	*C. commersoni*	35.7	37.7	
Panuke Lake	Angling	23/24 June	*M. dolomieui*	31.5	32.8	442
Panuke Lake	Angling	23/24 June	*M. dolomieui*	32.7	34.2	402
Panuke Lake	Angling	23/24 June	*M. dolomieui*	31.8	33.0	376
Panuke Lake	Angling	23/24 June	*M. dolomieui*	27.0	28.4	248
Panuke Lake	Angling	23/24 June	*M. dolomieui*	31.8	33.1	400
Panuke Lake	Angling	23/24 June	*M. dolomieui*	30.4	32.0	322
Panuke Lake	Angling	23/24 June	*M. dolomieui*	29.0	31.0	310
Panuke Lake	Angling	23/24 June	*M. dolomieui*	27.5	29.3	270
Panuke Lake	Angling	23/24 June	*M. dolomieui*	27.0	28.6	244
Panuke Lake	Angling	23/24 June	*M. dolomieui*	27.4	29.0	254
Panuke Lake	Angling	23/24 June	*M. dolomieui*	23.1	24.3	170
Panuke Lake	Angling	23/24 June	*M. dolomieui*	21.0	22.0	120
Panuke Lake	Angling	23/24 June	*M. dolomieui*	19.4	20.5	102
Panuke Lake	Angling	23/24 June	*M. dolomieui*	18.5	19.6	90
Panuke Lake	Angling	23/24 June	*M. dolomieui*	20.0	21.2	114
Panuke Lake	Angling	23/24 June	*M. dolomieui*	19.2	20.2	98
Panuke Lake	Angling	23/24 June	*M. dolomieui*	20.2	21.3	118
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	36.0	38.5	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	34.8	37.1	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	25.7	27.5	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	32.3	34.6	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	23.0	25.5	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	22.0	23.5	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	17.6	19.0	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	16.8	18.0	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	16.6	17.5	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	16.3	17.2	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	26.3	28.2	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	21.6	23.7	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	43.0	46.0	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	24.2	25.8	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	17.5	18.5	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	31.5	33.5	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	29.2	31.0	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	23.7	24.7	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	23.3	25.1	

Appendix 3.3.1. Database of Fish Collected from Panuke Lake and Big St. Margarets Bay Lake, May - July 2001 (continued).

Site	Collection Method	Collection Date	Species	Fork Length (cm)	Total Length (cm)	Weight (g)
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	21.5	23.7	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	17.5	18.5	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	24.0	26.0	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	25.5	26.7	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	26.3	28.7	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	32.0	34.0	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	22.2	24.5	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	32.3	34.2	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	26.5	27.9	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	16.2	17.4	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	23.7	25.0	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	16.5	17.7	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	20.7	22.6	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	24.6	25.7	
St. Margarets Bay Lake	Gill Net	30/31 May	*C. commersoni*	16.5	17.5	49
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	12.3	13.0	20
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.0	11.7	15
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.5	12.5	17
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.4	10.8	12
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.0	11.7	12
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	14.2	15.0	31
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.4	11.0	11
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.2	11.8	15
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.7	12.7	21
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.0	11.5	12
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.5	11.0	10
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	12.0	12.5	16
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.0	11.5	11
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.5	11.9	11
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	12.5	12.8	16
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.5	11.2	9
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.8	12.3	17
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.5	11.1	11
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	13.0	13.5	32
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.0	11.5	15
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.8	11.2	12
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	12.4	13.1	21
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	12.4	13.0	18
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.0	11.5	12
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.4	12.0	13
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.3	12.0	16
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.2	10.9	11

Appendix 3.3.1. Database of Fish Collected from Panuke Lake and Big St. Margarets Bay Lake, May - July 2001 (continued).

Site	Collection Method	Collection Date	Species	Fork Length (cm)	Total Length (cm)	Weight (g)
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.5	12.0	12
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.0	11.5	12
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.4	10.9	11
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.0	11.5	16
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.5	12.0	12
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.5	12.0	14
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	12.0	12.4	17
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.5	12.0	15
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.5	11.1	13
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.5	11.0	10
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	11.6	12.2	17
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	10.7	11.4	12
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	15.7	16.5	47
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	16.5	17.3	67
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	23.8	24.3	159
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	21.0	22.0	106
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	17.5	18.5	62
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	18.0	18.6	61
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	15.1	15.7	38
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	17.0	17.7	49
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	15.1	15.8	38
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	14.5	15.6	39
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	17.0	18.0	51
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	16.2	17.0	50
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	16.0	17.0	41
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	14.2	14.9	30
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	22.0	22.5	117
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	21.6	22.2	113
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	24.0	24.5	155
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	15.0	15.4	35
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	20.0	21.0	91
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	15.5	16.5	39
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	15.4	16.0	39
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	18.1	18.5	68
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	15.3	16.0	43
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	16.0	16.7	43
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	16.5	17.1	47
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	18.0	19.0	61
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	23.5	24.5	160
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	21.2	22.0	121
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	21.0	22.2	98

Appendix 3.3.1.Database of Fish Collected from Panuke Lake and Big St. Margarets Bay Lake, May - July 2001 (continued).

Site	Collection Method	Collection Date	Species	Fork Length (cm)	Total Length (cm)	Weight (g)
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	17.0	17.6	55
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	22.6	23.5	117
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	14.0	14.6	37
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	15.0	15.6	37
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	15.1	16.0	41
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	13.4	14.0	39
St. Margarets Bay Lake	Gill Net	30/31 May	*P. flavescens*	22.0	23.0	126
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	27.4	29.0	275
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	33.5	35.0	432
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	22.5	23.0	139
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	22.5	23.5	142
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	21.7	23.0	123
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	27.7	28.6	66
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	19.5	20.5	90
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	18.0	19.0	84
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	18.0	19.2	76
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	16.5	17.5	47
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	15.8	16.5	50
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	12.0	12.6	22
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	12.5	13.0	20
St. Margarets Bay Lake	Gill Net	30/31 May	*S. fontinalis*	10.5	11.0	14

Appendix 3.3.2. Database of collections by electrofishing in St. Croix and Big St. Margarets Bay Lake Watersheds, May-July 2001.

Database of Fish caught by Electrofishing,
St. Croix & St. Margarets Bay Lake systems

May 2001.

Site	Date	Pass	Species	Total L cm	Weight g	Fork L cm	Comments
SC1a	25/05/01	1	Sucker	42.5	734	40.5	20-30 adult suckers
							spawning in lower reach
SC1b	25/05/01	1	Vis: Suckers	N/A	N/A	N/A	50 spawning suckers
							observed in 40 m2;
							real time 3:30pm
SC2	26/05/01	1	N/A	N/A	N/A	N/A	53 adult spawning suckers
							in the 1st 150m of stream
SC3	26/05/01	1	Yellow Perch	5	N/A	4.8	real time 4:15
SC3	26/05/01	1	Yellow Perch	5.5	N/A	5.2	
SC3	26/05/01	1	Yellow Perch	5.7	N/A	5.4	
SC3	26/05/01	1	Yellow Perch	6	N/A	5.9	
SC3	26/05/01	1	Yellow Perch	5	N/A	4.8	
SC3	26/05/01	1	Yellow Perch	5.4	N/A	5	
SC3	26/05/01	1	Brook Trout	4	N/A	3.9	
SC4	27/05/01	1	N/A	N/A	N/A	N/A	st. time 2:35/end time 3:00
SC5	27/05/01	1	Sucker	46	1114	44.5	no GPS reading
SC5	27/05/01	1	Sucker	46	890	43	5:45 time start
SC5	27/05/01	1	Sucker	47	1156	44	6:15 time end pass 1
SC5	27/05/01	1	Sucker	47	1145	45	
SC5	27/05/01	1	Sucker	46	980	43	
SC5	27/05/01	1	Sucker	47.5	1086	44.5	
SC5	27/05/01	1	Sucker	45	925	42.5	
SC5	27/05/01	1	Sucker	47	1172	43	
SC5	27/05/01	1	Sucker	47.5	1025	44	
SC5	27/05/01	1	Sucker	41	808	39	
SC5	27/05/01	1	Sucker	49	1386	46	
SC5	27/05/01	1	Sucker	47	1052	42	
SC5	27/05/01	1	Sucker	41	670	39	
SC5	27/05/01	1	Sucker	45.7	1072	42.5	
SC5	27/05/01	1	Sucker	44.7	940	42.3	
SC5	27/05/01	1	Sucker	42	840	40	
SC5	27/05/01	1	Sucker	48	1170	45	
SC5	27/05/01	1	Chub	11.3	10	10.5	18 in pass 1
SC5	27/05/01	2	Sucker	8.6		8.2	
SC5	27/05/01	2	Unknown	6.7		N/A	back at lab
SC5	27/05/01	2	Chub	12.4		11.5	
SC5	27/05/01	2	Chub	8.7		8.1	

Appendix 3.3.2. Database of collections by electrofishing in St. Croix and Big St. Margarets Bay Lake Watersheds, May-July 2001 (continued).

Site	Date	Pass	Species	Total L cm	Weight g	Fork L cm	Comments
SC6	28/05/01	1	Bass	13.5		13.1	st. time 10:25
SC6	28/05/01	1	Sucker	11.5		10.9	length of pass 45.6m
SC6	28/05/01	1	Chub	9.7		9	
SC6	28/05/01	1	Sucker	10.5		10.1	
SC6	28/05/01	1	Chub	6.9		6.3	
SC6	28/05/01	1	Stickleback	5		N/A	
SC6	28/05/01	1	Chub	8.5		7.8	
SC6	28/05/01	1	Chub	8.5		7.9	
SC6	28/05/01	1	Chub	7		7.7	
SC6	28/05/01	1	Sucker	9.5		8.9	
SC6	28/05/01	1	Sucker	10.5		9.9	
SC6	28/05/01	1	Chub	9.6		9.2	
SC6	28/05/01	1	Chub	7		6.5	
SC6	28/05/01	1	Chub	7.4		6.8	shocked to death/at lab
SC6	28/05/01	1	Chub	6.9		6.4	
SC6	28/05/01	1	Chub	5.8		5.6	
SC6	28/05/01	1	Chub	8.6		8.1	
SC6	28/05/01	1	Sucker	11		10.2	
SC6	28/05/01	1	Chub	8.3		7.1	
SC6	28/05/01	1	Chub	8.6		8.7	
SC6	28/05/01	1	Chub	7.5		7	
SC6	28/05/01	1	Stickleback	4.4		4.3	
SC6	28/05/01	1	Sucker	9		8.1	
SC6	28/05/01	1	Chub	11		10.2	
SC6	28/05/01	1	Chub	9.5		8.8	
SC6	28/05/01	1	Sucker	11.9		11	
SC6	28/05/01	1	Chub	9		8.3	
SC6	28/05/01	1	Chub	9.6		9.1	
SC6	28/05/01	1	Chub	9.4		8.8	
SC6	28/05/01	1	Chub	13.2		12.3	
SC6	28/05/01	1	Chub	7.6		7.1	
SC6	28/05/01	1	Chub	8.5		7.9	
SC6	28/05/01	1	Sucker	12.1		11.2	
SC6	28/05/01	1	Chub	11		10.2	
SC6	28/05/01	1	Eel	19		N/A	
SC6	28/05/01	1	Chub	8.4		7.9	
SC6	28/05/01	1	Sucker	10.2		9.5	
SC6	28/05/01	1	Sucker	11.5		10.6	
SC6	28/05/01	1	Chub	8.1		7.6	
SC6	28/05/01	1	Chub	9.1		8.4	
SC6	28/05/01	1	Eel	44		N/A	

Appendix 3.3.2. Database of collections by electrofishing in St. Croix and Big St. Margarets Bay Lake Watersheds, May-July 2001 (continued).

Site	Date	Pass	Species	Total L cm	Weight g	Fork L cm	Comments
SC6	28/05/01	1	Eel	28		N/A	
SC6	28/05/01	1	Eel	25		N/A	
SC6	28/05/01	1	Eel	27		N/A	
SC6	28/05/01	1	Eel	19		N/A	
SC6	28/05/01	1	Eel	11		N/A	
SC6	28/05/01	1	Eel	15		N/A	
SC6	28/05/01	1	Eel	9		N/A	
SC6	28/05/01	1	Eel	15		N/A	
SC6	28/05/01	1	Eel	13		N/A	51 in pass 1
SC6	28/05/01	2	Stickleback	4.3		N/A	12:00 st time pass 2
SC6	28/05/01	2	Sucker	11.4		10.5	
SC6	28/05/01	2	Sucker	9.2		8.6	
SC6	28/05/01	2	Chub	6.8		6.2	
SC6	28/05/01	2	Chub	8.1		7.6	
SC6	28/05/01	2	Chub	7.9		7.4	
SC6	28/05/01	2	Sucker	8.9		8.3	
SC6	28/05/01	2	Chub	7.9		7.2	clipped fin
SC6	28/05/01	2	Chub	9.1		8.4	
SC6	28/05/01	2	Chub	8.2		7.8	
SC6	28/05/01	2	Chub	6.5		6	
SC6	28/05/01	2	Chub	7.7		7.3	
SC6	28/05/01	2	Chub	7.8		7.4	
SC6	28/05/01	2	Chub	7.8		7.3	
SC6	28/05/01	2	Chub	12.2		11.5	
SC6	28/05/01	2	Chub	9.6		8.9	
SC6	28/05/01	2	Chub	9.8		8.9	
SC6	28/05/01	2	Chub	7.7		7	
SC6	28/05/01	2	Common Shiner	9.1		8.3	
SC6	28/05/01	2	Chub	9.2		8.4	
SC6	28/05/01	2	Chub	10.1		9.2	
SC6	28/05/01	2	Chub	10.1		9.2	
SC6	28/05/01	2	Chub	8.9		8.1	
SC6	28/05/01	2	Chub	10.9		9.6	
SC6	28/05/01	2	Chub	7.9		7.3	
SC6	28/05/01	2	Chub	11		10	
SC6	28/05/01	2	Spot Tailed Shiner	9.2		8.5	
SC6	28/05/01	2	Sucker	10.3		9.1	
SC6	28/05/01	2	Chub	7.9		7.5	
SC6	28/05/01	2	Chub	7.5		6.9	
SC6	28/05/01	2	Chub	8.6		8.2	
SC6	28/05/01	2	Sucker	10.3		9.9	
SC6	28/05/01	2	Sucker	10		9.3	

Appendix 3.3.2. Database of collections by electrofishing in St. Croix and Big St. Margarets Bay Lake Watersheds, May-July 2001 (continued).

Site	Date	Pass	Species	Total L cm	Weight g	Fork L cm	Comments
SC6	28/05/01	2	Eel	26		N/A	
SC6	28/05/01	2	Eel	28		N/A	
SC6	28/05/01	2	Eel	38		N/A	
SC6	28/05/01	2	Eel	34		N/A	
SC6	28/05/01	2	Eel	28		N/A	
SC6	28/05/01	2	Eel	22		N/A	
SC6	28/05/01	2	Eel	18		N/A	
SC6	28/05/01	2	Eel	24		N/A	
SC6	28/05/01	2	Eel	14		N/A	42 in pass 2
SC6	28/05/01	3	Stickleback	4		N/A	
SC6	28/05/01	3	Unknown	7.1		6.5	Spottailed' shiner?
SC6	28/05/01	3	Chub	8.1		7.3	
SC6	28/05/01	3	Common Shiner	6.9		6.3	
SC6	28/05/01	3	Common Shiner	9		8.3	spotted
SC6	28/05/01	3	Chub	5.7		5.3	big eye and shiny
SC6	28/05/01	3	Chub	9.1		8.5	
SC6	28/05/01	3	Chub	7.9		7.4	
SC6	28/05/01	3	Stickleback	4.6		4.5	
SC6	28/05/01	3	Chub	6.6		6	
SC6	28/05/01	3	Chub	9.4		8.8	
SC6	28/05/01	3	Chub	6.9		6.5	
SC6	28/05/01	3	Chub	7.1		6.6	
SC6	28/05/01	3	Chub	6.5		5.9	
SC6	28/05/01	3	Chub	7.5		6.9	
SC6	28/05/01	3	Chub	15.6		15.1	
SC6	28/05/01	3	Sucker	9.8		9.5	
SC6	28/05/01	3	Stickleback	4		N/A	
SC6	28/05/01	3	Eel	15		N/A	
SC6	28/05/01	3	Eel	23		N/A	20 in pass 3
SC7	28/05/01	1	Brook Trout	19.1	78	18.3	start time 4:15, 1 in pass 1
SC7	28/05/01	2	Chub	9		8.1	
SC7	28/05/01	2	Chub	7.8	4	7.3	
SC7	28/05/01	2	Brook Trout	3		2.8	3 in pass 2

Appendix 3.3.2. Database of collections by electrofishing in St. Croix and Big St. Margarets Bay Lake Watersheds, May-July 2001 (continued).

Database of Fish caught by Electrofishing,
St. Croix & St. Margarets Bay Lake systems

July 2001.

Site	Date	Pass	Species	Total L cm	Weight (g) g	Fork L cm	Comments
SC1	20-Jul	1	Brook Trout	10.8	14.3	10.2	
SC1	20-Jul	1	Brook Trout	11	14.4	10.5	
SC1	20-Jul	1	Brook Trout	14.1	29.7	13.3	
SC1	20-Jul	1	Brook Trout	17	na	16.6	
SC1	20-Jul	1	Brook Trout	7.5	4.7	7.1	10 in pass 1
SC1	20-Jul	1	Killifish	6.1	2.2	5.6	
SC1	20-Jul	1	Killifish	3.6	0.1	3.5	
SC1	20-Jul	1	Killifish	6.2	2.6	6	
SC1	20-Jul	1	Sucker	10	9.9	9.2	spot fishing
SC1	20-Jul	1	Sucker	9.3	9	8.6	
SC2	20-Jul	1	Brook Trout	6.1	2.3	5.7	
SC2	20-Jul	1	Brook Trout	6.7	3.4	6.4	2 in pass 1, 3 other visuals
SC2	20-Jul	2	Brook Trout	5.9	2.1	5.7	
SC2	20-Jul	2	Brook Trout	5.5	2	5.3	
SC2	20-Jul	2	Brook Trout	6.6	3.5	6.3	
SC2	20-Jul	2	Brook Trout	13.5	26.5	12.7	4 in pass 2
SC3	20-Jul	1					no fish in pass 1;
SC1	21-Jul	-					2 eels + 1 minnow seen
SC2	22-Jul	-					
SC3	20-Jul	1					thousands of 0+ killifish
							at river mouth in Blind Bay
SC4	19-Jul	1	trout	12.7	21.7	12.3	visit was day after heavy
SC4	19-Jul	1	trout	11.1	12.7	10.6	rain, water levels and flows
							are much higher than
							during the habitat survey
SC5	19-Jul	1	killifish	6	2.3	5.6	
SC6	22-Jul	1	Chub	7.4	3.4	6.7	
SC6	22-Jul	1	Chub	7.4	3.5	7	broken tail
SC6	22-Jul	1	Chub	8.5	5.6	7.8	
SC6	22-Jul	1	Chub	9.9	6.8	8.9	
SC6	22-Jul	1	Eel	25 ish	58.9 ish	na	
SC6	22-Jul	1	Eel	17	lost before weight	na	
SC6	22-Jul	1	Eel	22.5	18.4	na	
SC6	22-Jul	1	Eel	27	lost before weight	na	
SC6	22-Jul	1	Eel	21	lost before weight	na	
SC6	22-Jul	1	Sucker	14.1	34.1	13.5	
SC6	22-Jul	1	Sucker	14.1	29.5	13.1	
SC6	22-Jul	1	Sucker	14.7	32.6	13.3	

Appendix 3.3.2. Database of collections by electrofishing in St. Croix and Big St. Margarets Bay Lake Watersheds, May-July 2001 (continued).

Site	Date	Pass	Species	Total L cm	Weight (g) g	Fork L cm	Comments
SC6	22-Jul	1	Sucker	13.2	26.6	12.1	
SC7	22-Jul	1	Chub	5.8	1.4	5.4	
SM1	21-Jul	1	Eel	13.7	4.7		
SM1	21-Jul	1	Eel	17.3	5.9		
SM1	21-Jul	1	Eel	16			16 fish + 3 eels for pass 1
SM1	21-Jul	2	Eel	15	6.4		
SM1	21-Jul	2	Eel	15.5	8		9 fish + 2 eels for pass 2
SM1	21-Jul	1	Killifish	6.7	2.2		
SM1	21-Jul	1	Killifish	5.6	1.3		
SM1	21-Jul	1	Killifish	5.1	1.5		
SM1	21-Jul	1	Killifish	4.2	0.8		
SM1	21-Jul	1	Killifish	7.4	3.3		
SM1	21-Jul	1	Killifish	7.2	2.9		
SM1	21-Jul	1	Killifish	7.4	3.3		
SM1	21-Jul	1	Killifish	6.5	2.9		
SM1	21-Jul	2	Killifish	7	2.6		
SM1	21-Jul	2	Killifish	7.1	3.2		
SM1	21-Jul	2	Killifish	7.5	3.5		
SM1	21-Jul	2	Killifish	5.7	1.2		
SM1	21-Jul	1	Stickle (9)	5.2	0.8		
SM1	21-Jul	1	Stickle (9)	6.2	3		
SM1	21-Jul	1	Stickle (9)	5.3	0.7		
SM1	21-Jul	1	Stickle (9)	4.7	0.7		
SM1	21-Jul	1	Stickle (9)	5.2	0.7		
SM1	21-Jul	1	Stickle (9)	5.2	1.2		
SM1	21-Jul	1	Stickle (9)	4.9	0.8		
SM1	21-Jul	2	Stickle (9)	5.3	1.2		
SM1	21-Jul	2	Stickle (9)	5	1.1		
SM1	21-Jul	2	Stickle (9)	5.9	1.6		
SM1	21-Jul	2	Stickle (9)	4.7	0.9		
SM1	21-Jul	1	Sucker	8	5.2	7.2	
SM1	21-Jul	2	Sucker	3.6	0.4	3.4	mortality
SM2-too warm							
SM3	21-Jul	1	Brook Trout	5.7	2	5.3	
SM3	21-Jul	1	Brook Trout	4.4	0.8	4.2	
SM3	21-Jul	1	Brook Trout	10.8	11	10.2	
SM3	21-Jul	1	Brook Trout	4.5	1	4.3	
SM3	21-Jul	1	Brook Trout	5.3	1.6	5	
SM3	21-Jul	1	Brook Trout	4.9	0.9	4.7	
SM3	21-Jul	1	Brook Trout	5.3	1.4	5	
SM3	21-Jul	1	Brook Trout	5	1.4	4.9	

Appendix 3.3.2. Database of collections by electrofishing in St. Croix and Big St. Margarets Bay Lake Watersheds, May-July 2001 (continued).

Site	Date	Pass	Species	Total L cm	Weight (g) g	Fork L cm	Comments
SM3	21-Jul	2	Brook Trout	5.2	1.3	5	
SM3	21-Jul	2	Brook Trout	4.5	1	4.2	
SM3	21-Jul	2	Brook Trout	4.6	1	4.3	
SM3	21-Jul	1	Chub	10	9	9	22 fish/pass 1
SM3	21-Jul	1	Stickle (9)	5.1	1.3		
SM3	21-Jul	1	Stickle (9)	5.3	1.5	na	
SM3	21-Jul	1	Stickle (9)	4.9	1	na	
SM3	21-Jul	1	Stickle (9)	4.6	0.8	na	
SM3	21-Jul	1	Stickle (9)	4.8	0.8	na	
SM3	21-Jul	2	Stickle (9)	5.8	1.7	na	
SM3	21-Jul	3	Stickle (9)	5.1	1		
SM3	21-Jul	1	Sucker	6.8	3.1	6.4	
SM3	21-Jul	1	Sucker	5.8	1.7	5.4	
SM3	21-Jul	1	Sucker	11.4	15.2	10.6	
SM3	21-Jul	1	Sucker	2.7	<.1	2.5	mortality
SM3	21-Jul	1	Sucker	2.7	<.1	2.4	mortality
SM3	21-Jul	1	Sucker	2.4	<.1	2.2	mortality
SM3	21-Jul	1	Sucker	2.6	0.1	2.4	mortality
SM3	21-Jul	1	Sucker	2.5	0.1	2.3	mortality (2)
SM3	21-Jul	2	Sucker	6.7	2.5	6.3	
SM3	21-Jul	2	Sucker	6.3	2.9	5.8	
SM3	21-Jul	2	Sucker	6.9	1	6.5	
SM3	21-Jul	2	Sucker	6.1	2.6	5.7	
SM3	21-Jul	2	Sucker	2.5	0.5	2.3	
SM3	21-Jul	2	Sucker	2.6	0.2	2.4	
SM3	21-Jul	2	Sucker	2.9	0.3	2.7	
SM3	21-Jul	2	Sucker	2.3	0.2	2.1	mortality 12 fish/pass 2
SM3	21-Jul	3	Sucker	2.1	0.1		missing part of tail
SM3	21-Jul	3	Sucker	2	0.1		
SM3	21-Jul	3	Sucker	6.5	3.1	6.1	4 total/pass 3

Appendix 3.5.1. Field Notes from Qualitative Habitat Surveys.

SC1: Stoney Brook (July 3)

0-25 m (from mouth of stream)
-substrate is large and small boulders, they are mostly exposed and the water has dropped considerably since electrofishing was done
-there is green vegetation on the rocks
-there are lots of ferns on the banks
-the forest is mixed
-the banks are rocky (supported by large rocks)
-there are exposed roots along the bank where there are no rocks
-at the mouth of the stream there is no cover or overhang
-at about 12 m there is >50% cover
-there are lots of dragonflies and damselflies
-the instream cover is very good because of the rocks
-runs and pools
-pretty straight

25-50 m
-substrate, banks, and vegetation is the same
-75% cover (canopy)
-there is a large pool at the 50 m mark

50-75 m
-there is some foam, pools, and very small waterfalls <20cm (cobble riffle?)
-cover is 80% (canopy)
-looking upstream on the left bank: is a slope that gets steeper as we approach the meander
-the right bank is more flat and there is cobble-rubble-small boulder deposition (few metres) before the vegetation
-the water course narrows
-there is outcropping around the corner

75-100 m
-the water course is much narrower
-riffle area with pools
-bank is 5-10 m high
-there is more deposition on the right bank (bar) and the left bank is bedrock with lots of moss growing on it
-the water is not visible in many areas but you can tell that it flows under and around the rocks
-cover is 30-40% (canopy)
-the bank slopes down near 100 m

100-125 m
-20-30% canopy
-the left slope is flattening out
-cover improves by about 115m
-runs and pools
-there is some smaller material; getting into cobble-rubble; but still lots of small boulders and some large boulders

125-150 m
-10% canopy
-some overhang ~15% right along the right bank
-some undercutting and gravel deposits along the banks
-this is approx where the spot fishing ended

150-175 m
-the rocks are mostly covered by water now
-there is almost no canopy <<10%
-there is some overhang right along the banks
-there are lots of large boulders (mostly along the banks)

175-200 m
-small and large boulders
-some riffle areas formed by the water running between the rocks
-pools
-cover 80%
-the plain is flat
-the gradient is steeper

200-225 m
-straight reach
-large boulders with cobble-rubble
-pools, riffles
-dry channel on the left bank (meets river in 175-200 m, starts in 275-300 m)
-cover is 80%
-at 225 m the is a dry channel that starts on the right bank

225-250 m
-riffle, pool
-there's a meander to the left
-overhang is 90% at the bend
-canopy is 60%
-the substrate is bedrock around the corner
-the right bank steepens and is granitic bedrock
-the left bank is cobble-small boulders deposition

250-275 m
-there are ½ metre water drops between rocks
-very large boulders
-pools
-low canopy 10%
-some overhang right along the bank
-the gradient is increasing some more
-the rocks in and out of the water are covered with moss and vegetation
-stream is straight following the previous meander
-the right slope is still high but not as steep

275-300 m
-the gradient is still climbing
-large boulder substrate
-20% cover overall, but is higher in some areas
-the plain is flatter and the slope begins a few metres back from the bank

SC2: (July 6)

Overall: no fish observed, much wood debris in the forest
0m-stillwater (from mouth of stream)
43 m-boulder riffle and 5 pieces of large woody debris
71 m-glide and 2 pieces of large woody debris
75 m-boulder cascade
85 m-glide
89 m-boulder riffle
109 m-glide and 3 pieces of large woody debris
132 m-pool, start of back channel, 4 pieces of large woody debris
166 m-boulder riffle, 7 pieces of large woody debris
175 m-pool, end of backchannel, 1 piece of large woody debris
191 m-boulder riffle
198 m-pool, 1 piece of large woody debris
215 m-boulder cascade
227 m-pool, 1 piece of large woody debris
239 m-boulder cascade, 1 piece of large woody debris
243 m-pool
271 m-boulder riffle, start of electro fishing reach

0-271 m
-straight river with instream variations
-cover varies, but generally fair
-small and large boulders dominated substrate
-banks are bare stable

296-321 m
-pool, then a riffle as the gradient increases

-the plain is a thin, mixed forest, not dense
-the floor is covered with moss
-the banks are anchored by small and large boulders
-there is some overhang from ferns and rocks along the banks
-there is great instream cover from the boulders in the stream
-the canopy cover is ~50%
-there are many seedlings and saplings along the forest floor
-the left bank is slope dominated, the right side is more flat

321-346 m
-large granite boulders with quartz veins
-the banks are covered with ferns and moss, the site is more moist than other sites
-the substrate is mainly small and large boulders
-the habitats are a sequence of runs, riffles, and pools
-the gradient is still increasing
-instream cover is very good
-there is some foam observed
-the banks are undercut where there is a lack of bank armouring by boulders

346-371 m
-everything is the same as previous except that there is better canopy (65%) and there was some woody debris

371-396 m
-there is a small pond/lagoon ~10m from the right bank
-the substrate is smaller: cobble-small boulders
-the water is flat and shallower
-40% canopy
-fewer large boulders on the plain
-there's undercutting where there is not much bank support from the rocks
-there is a pool at the 396 m

396-421 m
-there is a fallen tree across the river and woody debris has collected around it
-there is an increased amount of overhang
-the water is still and flat (pool like)
-there are few exposed rocks within the stream
-the banks are steep
-there is outcropping on the left bank
-the canopy is 30%
-the water is very dark

421-446 m
-evidence of human clearing
-there is a bridge at 421 m and a bedrock gorge that is probably a bedrock cascade at high water
-the gradient is increasing still
-after the bridge there is a pool and ferns along the bank
-to the far left by the bridge is a logging road
-the is <10% canopy and some fern and rock overhang
-can see the water lines on the rocks and it appears that the water level has dropped ~10 cm recently

446-471 m
-at 446 m there is a small riffle ~1m long then a large pool that meanders a bit
-we are half way through the pool at 471 m
-the water is black and it is hard to see
-there's little canopy ~10%
-good overhang 89-90% (but only near the bank, pool too wide to support complete overhang cover)
-the plains are pretty flat
-the banks are eroding because there is not much bank support (~50% of banks are eroding)
-the substrate appears smaller: there is gravel and sand between the cobble and small boulders

471-496 m
-second half of the pool, same as the first half

496 m+
-the water is flat and still
-there is some woody debris then a small meander to the left
-it goes like this for ~50m then narrows and there is a large pool ~25m wide, 50-70m long, with large boulders

SC3: (June 29)

0-25 m (from mouth of stream)
-at river mouth the area is very open with no cover
-the banks are lined with small and large boulders and then ferns and there are both hardwood and softwood along the bank and flood plain
-the substrate is dominated by small and large boulders
-the river is straight
-this is mostly a riffle area with a high velocity so we doubt the presence of finer sediment
-the top of the bank is about 1-1.5 m above the water level
-the water fills the channel width for the entire length of the surveyed portion of the river
-there is a path that follows the river

25-50 m
-the flow is slightly less, so there is more small boulders but we still suspect very low amounts of finer sediment
-there is good canopy cover and the some overhang which is mostly provided by the rocks
-still a riffle area
-the flood plain has lots of boulders, ferns, grasses, trees (well vegetated); the ground is quite mossy and the terrain is hummocky
-some of the banks show potential for future mass wasting

50-75 m
-at the 50 m boundary there is a boulder cascade and the river is narrower
-above the cascade is a riffle and a small meander
-the gradient is a bit lower (not as steep)
-the banks are more vegetated and they are lower (ie less distance from water level to bankfull)
-there is leaf litter and soil forming on the rocks→vegetation; there's moss on the instream rocks
-as you get to the 75 m mark the area is more open, but the cover is still ok
-although the canopy decreases slightly, the overhang increases
-there is a riff-run sequence which alternates every ~2 m

75-100 m
-this part of the reach is more of a glide and the water slows along the edges
-the canopy cover is good but some sunlight is still reaching the water
-there is some overhang, but the branches are bare
-the substrate is smaller; mostly cobble instream with sand-gravel-pebble along the banks
-the banks slope more gradually to the stream rather abruptly
-the right bank looking upstream is more open

100-125 m
-water velocity is slower but still fast
-run with riffle area
-the water is shallower in some areas
-there are not as many instream boulders or as much canopy
-there is ~50% overhang along the banks from ferns and low branches

125-150 m
-there is increased overhang with less canopy
-there is a fallen tree across the river, the woody debris is trapping some of the fine sediment
-riffle-run area
-banks keep getting lower
-there is evidence of clearing by humans along the plain
-as well, there is flagging tape along the path that follows the stream

150-175 m
-the path is closer to the stream's edge
-the is good overhang and canopy ~60-70% overall cover
-the banks are getting higher again, there is some undercutting on the right bank and there is fracturing in the rocks that can act as caverns during high water. The undercutting occurs when the water is high
-run with smaller riffles

175-200 m
-run with a large riffle
-sand along the banks that has been trapped around rocks, and tree roots
-the right plain is much more open than the left plain; there is lots of starting understory veg
-the overhang is good but the canopy is ok <50%
-at the 200m there is a large undercut area that exposes lots of roots
-the number of not water covered instream rocks is much smaller (hardly any) except along the banks
-in the stream is mostly a cobble substrate

200-225 m
-very straight
-substrate is mostly cobble but varies from gravel-rubble
-<5% overhang
-~50% canopy
-mostly a run area but the velocity is still high (standing waves)
-there is an instream fallen tree

225-250 m
-very little overhang and ~75% canopy
-standing waves again
-some riffle areas but more near the 250 m mark
-water is still near some of the banks
-there is some woody debris and undercutting
-small boulders are exposed instream (ie not covered by water)

250-275 m
-woody debris present
-small boulder riffle area with runs
-good canopy cover ~60%
-lots of moss along the edge of the stream/bank
-there are finer sediments under the larger rocks
-there is a strong flow

275-300 m
-increased overhang cover
-less canopy 30-40%
-exposed instream small boulders
-see sketch

300-325 m
-lots of debris due to the bridge
-large boulders in the stream >1 m high
-first real sign of alders →overhang cover
-no canopy
-there is a run until you get to the boulder and debris area, then there is a large boulder riffle
-there is foam around the debris
-there are large boulders along the bank by the bridge

325-350 m
-~325 m is the bridge (road) which is 8.5 m long followed by 1-2 m of supported banks on either side
-there is lots of wood plank debris under the bridge
-very open area, some overhang close to the bank
-the bank is very low
-there is a small boulder riffle and a run (with standing waves)
-the substrate is variable with gravel-cobble and some rubble and small boulders

We walked up another few minutes to the waterfall. The walls are all outcropped and are very steep with eroded banks, which appear to be susceptible to future mass wasting on the right side. There is lots of debris and an organicy smell. At the top of the cliff the trees look thinly distributed (possible clearing?).

SC4: (July 4)

Note:
-Distances are taken from the mouth of the stream (where it enters Panuke Lake) going up stream.
-All directions are taken looking downstream (perspective)
-observed frogs but no fish

0-200 m
-Bedrock and large to small boulders, granite
-less algae and moss in the stream as compared to upstream
-runs, pools
-tadpoles at stream mouth and lake edge

200-225 m
-measurements taken over a pool on the left and boulders on the right
-bedrock outcrop on left
-lots of tanics in water

@ 225 m – top of deep pool which has approximately a 1.5 m depth

225-250 m
-massive bedrock
-pools, riffle, run
-potholes

@ 250 m – a drop in the bedrock of approximately 1.5 m and potholes

250-275 m
-riffle water is being channelled into small space just above 250 m mark
-potholes
-bedrock with a few small boulders lying on top of the bedrock

@ 275 m – riffle flowing into a pool over bedrock and boulders, with a divided channel, frog

275-300 m
-bedrock, small and large boulders

300-325 m
-ferns over boulders on right
-small and large boulders

325-350 m
-bedrock outcrop on the right side (continues approximately 5m into the 300-325m reach)

350-375 m
-bedrock outcrop

@375 m – bedrock outcrop

375-400 (398) m
-small boulders

400 (398)-450 m
-electrofishing reach
-grass bar within reach
-located just above 400 m (398 m) mark there is a large (in surface area) pool

450 m+ (upstream from electrofishing reach)
-majority is small to large boulder, with minimal surrounding gravel to rubble. All of which is overlaying massive bedrock that is exposed in some areas. Substrate is open (lots of space between rocks) showing layers of rocks
-stream width overall (generally) approximately 20% of bankfull width. There are many areas of stagnant pools.
-consists mainly of runs and pools
-some woody debris in stream (fallen trees, logs) providing minor cover
-vegetation: -Lots of ferns on banks
-80% softwood, 20% hardwood (including alders) in riparian zone
-5-10% canopy (minimal overhang)
-stringy, green algae on rocks in stream (where water is present)
-exposed moss and algae on rocks that is drying up
-mainly stable banks (because of or due to vegetation, rock, roots)
-sphagnum moss on banks
-animal evidence: -Lots of bees/wasps
-frogs
-dragonflies, damselflies, water striders, mosquitoes, blackflies, surface water bugs
-small to medium size mammal (foxlike) [observed upstream of the 650 m marker]

Note: at wetted widths (450-650 m) there are boulders above the water and water flowing under the rocks

@475 m – frog

500-525 m
-approximately 5% canopy cover
-bedrock outcrop just above the 500 m mark, riffles here and a pool is located behind the bedrock outcrop

525-550 m
-bedrock, large boulders, and small boulders
-frog
-riffle, run, pool

@550 m pools

550-575 m
-wetted width is smaller than upstream

575-600 m
-dry channel enters stream on left
-gravel bar on right side
-substrate: rubble and small boulder

600-625 m
-dry branch to the left that has 2 channels (re-enters in the 575-600 m reach) with stagnant pools. Lots of algae, moss, bugs
-90% canopy cover over the dry branch
-small riffle

625-650 m
-wetted width approximately 80% of bankfull
-frog
-some fines

650 m+ (above the 650 m mark)
-meandering
-at the first turn bedrock outcrop as in below the electrofishing site, then substrate is small boulder. Bankfull width narrows and greater canopy coverage (shadier). From this point approximately 150 m can be viewed upstream.

SC6: (June 27)

GPS at Start of survey reach 45 02.840N, 064 10.616 W
Elevation is 54 m
UTM is 407252 E 4988676 W
Measurements taken looking upstream.

<u>Survey reach from end of electrofishing site to 25 m upstream</u>
-50/50 alders/hardwoods
-substrate mostly bedrock with large and small boulders and finer sediment as substrate cover
-good instream rock cover except for bedrock outcrops
-good overhang at banks but almost no cover or canopy
-softwood mostly on the left side of the stream and hardwood dominating the right side
-water occupies almost 100% of channel and maintains a relatively good depth
-undercut banks
-large rocky island at the end of the survey reach with alders dominating (bedrock, boulders, some gravel)

<u>Survey reach from 25m to 50 m upstream from electrofishing reach</u>
-open canopy
-instream woody debris
-some bank vegetation
-more small boulder and rubble on the right bank.
-channel narrows
-same substrate but with increasing rubble content
-little canopy within 1m of the bank
-overhang is good (especially on the left bank)

-little instream rock cover
-flow diverted around small instream island
-left bank is undercut, right bank is made up of rocks of all sizes and is quite stable
-increasing substrate size back to small boulders thus increasing instream cover
-still run (slow paced)

Survey reach from 50 m to 75 m upstream from electrofishing reach
- still water acting as a deep pool
-substrate similar; bedrock and boulders
-same vegetation continues
-deeper through middle (> 1 m)
-large outcrop of bedrock with ferns and alders (about 10 m in length)
-same fine sediment over substrate
-lots of good instream rock cover
-stable rock banks
-large bedrock outcrop on either side of stream
-several deep pockets (great instream cover)
-little to no canopy or cover
-bedrock outcrops provide some shade on banks
-almost all bedrock as you approach the end of the survey reach
-reach ends in a riffle on a high slope with deep pool at the bottom; lots of cliffy bedrock for instream cover and riffle formation

Survey reach from 75 m to 100 m upstream from electrofishing reach
-less sediment covering the substrate
-riffles and running water
-run, riffle, pool sequences
-run, riffle, deep pool sequence
-lots of grass around rocks and smaller alders
-good riffle (high velocity flow)
-almost all bedrock with no canopy cover
-on other side of the hydraulic lift there is a lot of still water and more cobbles
-pools fed by riffles and more smaller hydraulic lifts
-little vegetation and overhang but good instream rock/bedrock cover
-many smaller channels with less water; channel narrows

Survey reach from 100 m to 125 m upstream from electrofishing reach
-riffle, run, pool sequences
-lots of cobble, small boulder and grass instream and on banks between this and the previous reach
-very wide vegetated channel with only about 15% occupancy of the channel by water
-lots of dragon and damsel flies within the reach
-after the run, riffle, pool sequences there is a large level pool with lots of outcropping fed by a single small riffle
-much more softwoods and virtually no canopy cover
-small boulder/cobble intertwined

-large sloping rocky banks to pool with grass boundary between the slope and the pool
-less fine sediment present
-forest line about 7 m away
-lots of frogs
-human clearing around ponding areas (i.e old treehouse)
-house about 50 m away perched on a nearby hill looking down on pooling area at the end of the reach where bedrock barriers are present (about 99% of channel) allowing about 2% water entry
-much more clear with the same forest cover
-left banks are mostly softwoods and the right banks are mostly alders and hardwoods

<u>Survey reach from 125 m to 150 m upstream from electrofishing reach</u>
-several strata of angled bedrock with small pools but no cover in the series of the pools formed between the bedrock sheets
-lichen covered sandstone or siltstone
-area is fed by a large hydraulic lift/riffle
-following the shelved bedrock strata the stream narrows into a completely different (more defined) flow
-grass covers the sides and sediment increases
-forest edge is a lot closer on the right
-slight meander in the stream with the left side being the slight point bar and the right side being the slight cut bank
-stream narrows with pools on the sides of the wide channel
-filled with grass, rocks and deep pools
-run
-drying vegetation (but not completely dried out) in the channel, still some water flow around grasses and rocks
-braided stream with several channels
-same vegetation but bankful is much greater (low water levels with ferns and grasses filing in)

<u>Survey reach from 150 m to 175 m upstream from electrofishing reach</u>
-approximately 10% visible run with the rest being vegetated especially with grass cover
-several pools interspersed
-lots of water striders
-hardwoods (birch and alders) on same side with mostly softwoods on the opposite side
-overhang is good on the softwood side
-cobble to small boulder substrate with lots of sun exposure

<u>Survey reach from 175 m and beyond upstream from electrofishing reach</u>
-same channel morphology as the previous survey reach but even narrower water width and wider channel width
-lots of water striders and lots of grass
-very old softwood growth
-forest is found at the end of the reach on a steep slope
-at bankful there would be a deep channel

-at exposed bankful levels there are many exposed bank rocks and tree roots

GPS at end of upstream survey reach 44 57.181N, 064 01.709 W
UTM 418 808 E, 497803N

Downstream: 0-25 m
-scattered pools with lots of fish
-the substrate is rubble-small boulder, this provides good instream cover
-there is no canopy
-the grass patches separate a series of pools
-there is a high amount of fine sediment
-90% of the wetted width is under grass near the 25 m mark
-think alders and grass along the banks
-a big frog!

25-50 m
-much the same as above
-the substrate is mainly bedrock
-there is a bit of a riffle through the grass
-towards the end the water in the channel widens and there is less bedrock
-the banks are either vegetated or are an outcrop
-see drawings

50-75 m
-still water
-grass pool sequence still
-mixed forest with no canopy
-some bank overhang
-substrate is small boulders
-two riffles on either side of a grass bar at the end of the 75 m
-low sediments on the rocks
-see drawings

75-100 m
-very open, wide, and still
-there is some overhang from the alders
-the substrate varies, but provides good instream cover
-the banks are vegetated or outcropping but are eroding
-there are a couple of pools between the bedrock pools
-the pool is >1 m deep
-see drawings on original
100-150 m
-much the same as above
-the width is comparable
-there is lots of moss on the rocks

-the water occupies the channel well
-there are more ferns and the water is shallower

150-175 m
-same but shallower, more rocks are exposed
-the left bank is steeper
-there is high amount of sediment and moss
-there are bull frog tadpoles

175-200 m
-large grass/shrub area
-channel is narrow, but water fills most of the channel

Appendix 3.5.2. Quantitative Measurements of fish habitat, St. Croix and Big St. Margarets Bay Lake systems

Downstream Measurements	**SC1**	**SC2**	**SC3**	**SC4**	**SC5**	**SC6**	**SC7**	**SM1**	**SM2**	**SM3**
Date	20-Jul	**20-Jul**	20-Jul	19-Jul	19-Jul	22-Jul	22-Jul	21-Jul	21-Jul	21-Jul
Wetted Width (m)	9.8	4.8	6.1	7.6	9.4	11.2	4.1	13.5	4.8	5.3
Bankful Width (m)	14.9	8.4	7.8	12.0	12.3	13.6	6.6	13.5	5.8	7.1
Height to Surface (cm)	90.0	35.0	70.0	70.0	35.0	25.0	50.0	5 or 10	5 or 10	20.0
Depth 1 (cm)	24.0	33.0	45.5	21.0	10.5	17.5	16.0	2.2	9.5	18.0
Depth 2 (cm)	31.5	28.0	42.0	37.0	34.0	36.5	32.0	16.8	6.5	12.0
Depth 3 (cm)	28.0	35.0	44.0	24.0	26.0	34.0	23.0	14.5	10.0	22.0
Average Depth (cm)	27.8	32.0	43.8	27.3	23.5	29.3	23.7	11.2	8.7	17.3
Flow 1 (rpm)	276.0	40.0	308.0	120.0	1112.0	0.0	0.0	0.0	670.0	112.0
Flow 2	370.0	680.0	654.0	74.0	1380.0	0.0	0.0	460.0	0.0	322.0
Flow 3	298.0	420.0	220.0	280.0	840.0	0.0	0.0	0.0	0.0	0.0
Average Flow (rpm)	314.7	380.0	394.0	158.0	1110.7	0.0	0.0	153.3	223.3	144.7
Midstream Measurements										
Wetted Width (m)	4.5	4.6	5.2	9.0	8.3	10.1	7.1	7.0	5.7	6.1
Bankful Width (m)	18.9	9.8	8.5	14.5	12.6	12.6	8.3	9.3	5.7	9.5
Height to Surface (cm)	50.0	30.0	60.0	72.0	38.0	27.0	35.0	5 or 10	5 or 10	34.0
Depth 1 (cm)	18.0	53.0	37.0	18.5	21.0	46.5	16.0	16.5	11.0	28.0
Depth 2 (cm)	38.0	29.0	31.0	32.5	26.5	22.8	20.0	37.0	4.5	24.0
Depth 3 (cm)	19.0	40.0	10.0	17.5	29.0	28.3	20.0	32.0	7.0	10.0
Average Depth (cm)	25.0	40.7	26.0	22.8	25.5	32.5	18.7	28.5	7.5	20.7
Flow 1 (rpm)	294.0	56.0	900.0	1244.0	494.0	0.0	0.0	78.0	1420.0	26.0
Flow 2	684.0	440.0	1026.0	706.0	460.0	0.0	2.0	58.0	0.0	0.0
Flow 3	770.0	740.0	478.0	554.0	212.0	0.0	14.0	0.0	0.0	0.0
Average Flow (rpm)	582.7	412.0	801.3	834.7	388.7	0.0	5.3	45.3	473.3	8.7
Upstream Measurements										
Wetted Width (m)	13.1	5.0	6.3	7.2	8.4	11.4	2.2	7.7	4.4	6.0
Bankful Width (m)	19.7	8.7	6.9	14.1	10.2	14.5	4.9	9.3	6.4	6.4
Height to Surface (cm)	30.0	50.0	64.0	87.0	39.0	32.0	10.0	5 or 10	5 or 10	35.0
Depth 1 (cm)	21.5	24.0	34.0	17.0	24.5	65.8	25.7	14.6	10.5	9.0
Depth 2 (cm)	23.0	57.0	52.0	34.0	34.0	63.0	25.0	29.0	11.5	10.0
Depth 3 (cm)	21.0	73.0	55.0	24.0	49.0	22.5	29.4	13.0	9.5	18.5
Average Depth (cm)	21.8	51.3	47.0	25.0	35.8	50.4	26.7	18.9	10.5	12.5
Flow 1 (rpm)	30.0	0.0	10.0	500.0	400.0	0.0	46.0	330.0	436.0	1734.0
Flow 2	208.0	160.0	924.0	1200.0	740.0	0.0	122.0	296.0	664.0	0.0
Flow 3	582.0	680.0	310.0	700.0	0.0	0.0	84.0	0.0	492.0	0.0
Average Flow (rpm)	273.3	280.0	414.7	800.0	380.0	0.0	84.0	208.7	530.7	578.0

Appendix 3.5.3. Instream Characteristics of St. Croix River and Big.St. Margarets Bay Lake Tributaries.

	SC1	SC2	SC3	SC4	SC5	SC6	SC7
Date	6/1/01	6/1/01	6/27/01	6/1/01	6/1/01	6/27/01	6/1/01
Reach Length (m)	N/A	35	N/A	50	27	45.6	23
Temperature (C)	15	15	20.5 (July 3)	11.5	12	23	14.5
Conductivity (μS/cm)	15	19	20 (July 3)	15	18	35	20
Habitat Types (%)			mouth of river off of the lake				
Run	50	70		40	45	0	0
Riffle	40	20		40	45	0	10
Pool	10	10	still water 100%	20	10	100 (flat)	90
Substrate (100%)			large granitic boulders/bedrock outcropping with fine sedimetn from which vegetation is growing			all overlain with fine layer of silt	
Mud/Clay	0	0	NA	0	0	0	0
Sand (0.06-2 mm)	0	0	NA	7	0	0	75
Gravel (2mm-3 cm)	5	0	NA	8	0	0	0
Pebble (3-5 cm)	0	0	NA	0	5	0	0
Cobble (6-13 cm)	10	5	NA	15	15	5	13
Rubble (14-25 cm)	25	20	NA	20	40	30	5
Small Boulder (25 cm-1 m)	50	40	NA	20	35	30	2
Large Boulder (>1 m)	10	30	NA	15	5	5	5
Bedrock	0	5	NA	15	0	30	0
Cover (%)							
Riparian							
Overhang (up to 1 m ht)	0	5	0	0	8	5	3
Canopy	40	35	0	5	75	0	40
Instream Cover			80-90				
Instream	65	60	large boulders, dead heads	60	50	30	50 (large amount of woody debris)
Vegetation	0	0	grasses	5	0	5	30
Deep Pool	5	0	present	0	0	0	0

Appendix 3.5.3. Instream Characteristics of St. Croix River and Big. St. Margarets Bay Lake Tributaries (continued).

	SC1	SC2	SC3	SC4	SC5	SC6	SC7
Riparian Vegetation							
Hardwood	70	40	split with s.wood(back ~ 8m on bank	40 @bankfull	30 (more upstream)	50	25
Softwood	30	60	split with h.wood (back ~ 8m on bank)	60 @ bankfull	70	20	60
Alders	0	0		0	0	20	0
Shrubs	0	0		0	0	0	5
Grasses	80 (on banks)	20 (ferns)		100 ferns and fiddleheads	25	10	5
Bog	0	0	most	0	25	0	0
Erosion			lake bank is all armoured with rocks and outcrop				
Stable Bank	40	5	NA	85 (some undercutting)	90	100	65
Bare-stable Bank	50	95	NA	10	0	0	25
Eroding Bank	10	0	NA	5	10	0	10 (undercutting)
Bank Stability							
Good	x	x	x	x	x	x	x
Fair							
Poor							
Downstream Measurements							
Wetted Width (m)	8.4	4.85	NA	6.63	8.95	9.7	7.4
Bankful Width (m)	12.85	7.45	NA	16.52	11.6	9.8	8.7
Height to Surface (cm)	100	45	NA	105	43	20	78
Depth 1 (cm)	37	31	NA	22	25	10	38.5
Depth 2 (cm)	23	28	NA	36	33	18	53
Depth 3 (cm)	16	7.5	NA	20	27	20	58
Average Depth (cm)	25.3	22.2	NA	26.0	28.3	16	49.8
Flow 1 (rpm)	728.0	244.0	NA	33.0	515.0	0	
Flow 2	188.0	228.0	NA	7 (behind a rock)	787.0	0	
Flow 3	105.0	0 (behind rocks)	NA	50.0	2 (behind a bank)	0	
Average Flow (rpm)	340.3	157.3	NA	30.0	434.7	0	

Appendix 3.5.3. Instream Characteristics of St. Croix River and Big. St. Margarets Bay Lake Tributaries (continued).

	SC1	SC2	SC3	SC4	SC5	SC6	SC7
Midstream Measurements			NA				
Wetted Width (m)	6.71 (including back channel 11.04)	4.5	NA	11.25	9.9	10.9	6
Bankful Width (m)	17.17	6.8	NA	15	11.5	11.4	8.67
Height to Surface (cm)	75	60	NA	90	42	25	1.4
Depth 1 (cm)	2	27	NA	11	7	27	17
Depth 2 (cm)	20	19	NA	15	25	16	35
Depth 3 (cm)	17	37	NA	15	33	31	26
Average Depth (cm)	13.0	27.7	NA	13.7	21.7	24.7	26.0
Flow 1 (rpm)	350.0	275.0	NA	170.0	255.0	0	
Flow 2	820.0	518.0	NA	475.0	614.0	0	
Flow 3	1120.0	243.0	NA	620.0	884.0	0	
Average Flow (rpm)	763.3	345.3	NA	421.7	584.3	0.0	0.0
Upstream Measurements			NA				
Wetted Width (m)	14.05	5.72	NA	7.17 (including back channel-10.69)	8.7	8.15	2.26
Bankful Width (m)	17.97	8.7	NA	16.3	11.3	11.57	4.59
Height to Surface (cm)	60	?	NA	95	50	20	120
Depth 1 (cm)	16	38	NA	30	17	43	27
Depth 2 (cm)	25	46	NA	26	33	51	32
Depth 3 (cm)	29	16.5	NA	15	43	28	4
Average Depth (cm)	23.3	33.5	NA	23.7	31.0	40.7	21.0
Flow 1 (rpm)	128.0	54.0	NA	13.0	0 (behind a rock)	0	
Flow 2	235.0	87.0	NA	70.0	424.0	0	
Flow 3	540.0	90.0	NA	39.0	99.0	0	
Average Flow (rpm)	301.0	77.0	NA	40.7	174.3	0	
Average Depth (cm)	20.6	27.8	NA	21.1	27	27.1	32.277777778
Average Flow (rpm)	468.22	193.22	high along the entire reach	164.11	397.78	0	0.00

Appendix 3.5.3. Instream Characteristics of St. Croix River and Big. St. Margarets Bay Lake Tributaries.

	SC1	SC2	SC3	SC4	SC5	SC6	SC7
Comments			spot fishing was done, so many parametres were NA				pool: w-10 / B-11.3 / DTS-50 / D1-60 / D2-63 / D3-46

Appendix 3.6.1. Spring Invertebrate collections : St. Croix River system streams

Spring Invertebrate Collections	SC1	SC1A	SC2	SC4	SC4b	SC5	SC7
Date Sampled	1/6/01	1/6/01	1-Jun	1/6/01	1/5/01	5-Jun	27/05/01
Time Sampled	18:00		16:00		11:15	14:10	
Number of Samples	3x				3x		
Sample Type	surber	Dip net	Dip net	Dip net	surber	Dip Net	Dip Net
Recorders Name	DM	MB	DM	DM	LdV	DM	SS
Good Water Quality							
Order Plecoptera (stonefly)	2	10	1	8	18	3	0
Suborder Megaloptera (dobsonfly)	0	1	0	0	0	0	0
Order Trichoptera (caddisfly)	9	7	4	3	17	8	25
Order Coleoptera (waterpenny/riffle beetle)	2	8	0	0	0	2	0
Order Ephemeroptera (mayfly)	8	15	1	16	45	4	1
Phylum Mollusca (snails/slugs)	0	0	0	0	0	0	0
Total GWQ	21	41	6	27	80	17	26
Fair Water Quality							
Order Crustacea (crayfish/sow bug/scuds)	0	0	0	0	0	0	0
Order Odonata (damselfly/dragonfly/cranefly)	1	3	0	15	1	10	3
Order Diptera (watersnipe fly larva)	0	1	0	0	0	0	0
Order Coleoptera (beetle larvae)	0	0	0	0	0	0	0
Phylum Mollusca (clams)	0	0	0	0	0	0	0
Total FWQ	1	4	0	15	1	10	3
Poor Water Quality							
Order Oligochaeta (worms)	0	0	0	0	0	0	0
Order Hirudinea (leeches)	0	2	0	0	0	0	0
Order Diptera (midge/blackfly larva)	0	1	0	1	15 larvae, 3 adult?	1	4
Phylum Mollusca (pouch snails)	0	0	0	0	0	0	0
Total PWQ	0	3	0	1	18	1	4
GWQ:FWQ:PWQ	**21:01:00**	**17:04:03**	**6:00:00**	**27:15:01**	**80:01:18**	**17:10:01**	**26:03:04**

Appendix 3.6.2. Spring Invertebrate Collections: Big St. Margarets Bay Lake streams

Spring Invertebrate Collections	**SM1**	**SM2**	**SM2b**	**SM3**	**SM3b**
Date Sampled	29/05/01	29/05/01	29/05/01	29/05/01	29/05/01
Time Sampled	11:00			17:30	29/05/01
Number of Samples		3x			18:30
Sample Type	dipnet non Q	surber	dip net	dipnet	2x surber
Recorders Name	DM	SS	SS	SS	KS &LvD
Good Water Quality					
Order Plecoptera (stonefly)	9	4	1	4	62
Suborder Megaloptera (dobsonfly)	0	2	0	0	11
Order Trichoptera (caddisfly)	41	31	8	7	22
Order Coleoptera (waterpenny/riffle beetle)	1?	0	0	0	2
Order Ephemeroptera (mayfly)	15	2	8	0	6
Phylum Mollusca (snails/slugs)	0	0	1	0	0
Total GWQ	66	39	18	11	103
Fair Water Quality					
Order Crustacea (crayfish/sow bug/scuds)	2	0	0	0	0
Order Odonata (damselfly/dragonfly/cranefly)	0	3	4	4	0
Order Diptera (watersnipe fly larva)	0	0	0	0	0
Order Coleoptera (beetle larvae)	0	0	4	1	0
Phylum Mollusca (clams)	3	0	0	0	0
Total FWQ	5	3	8	5	0
Poor Water Quality					
Order Oligochaeta (worms)	1	0	3	0	0
Order Hirudinea (leeches)	0	0	1	0	0
Order Diptera (midge/blackfly larva)	46	too many to count	4	3	46
Phylum Mollusca (pouch snails)	0	0	0	0	0
Total PWQ	47	lots	8	3	46
GWQ:FWQ:PWQ	**66:05:47**	**39:3:lots**	**18:08:08**	**11:05:03**	**103:00:46**