Assessment of Changes in Cold Water Lake Habitat in the Upper Mersey Watershed

Prepared by

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SUMMARY

A survey of five lakes located within the upper Mersey watershed was carried out to assess the degree to which they presently contain summer cold water habitat, and to determine if current levels of cold water lake habitat differ from that observed during surveys carried out several decades earlier. Of the five lakes surveyed, four lacked suitable cold water habitat during August, and the remaining lake only contained suitable cold water habitat within the lower portion of the metalimnion. When compared to surveys carried out two to three decades earlier, all of the lakes except one exhibited a significant decrease in cold water habitat. This decrease was due to reduced levels of dissolved oxygen rather than elevated water temperatures.

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Assessment of Changes in Cold Water Lake Habitat in the Upper Mersey Watershed

1.0 Introduction

A major objective of the Mersey Tobiatic Research Institute is to assess the health of aquatic ecosystems in the upper Mersey River watershed. With respect to cold water fish species, such as brook trout (*Salvelinus fontinalis)*, a major limiting factor is the presence of summer refugia having cold water and adequate dissolved oxygen. Although brook trout can withstand water temperatures as high as 24-27 ^{o}C for short periods, they prefer temperatures in the range of 12-14 ^{o}C and tend to avoid waters warmer than 20 ^{o}C. They are also seldom found in waters having dissolved oxygen levels less than 5.0 mg/l (Lagler 1956; Bennett 1970), which at 20 ^{o}C is equal to about 50 % dissolved oxygen saturation.

The extent of well-oxygenated, cold-water refugia present in the deeper, stratified lakes of the Province is not well known. Although considerable data has been collected over the last several decades as part of the Lake Survey Program carried out by the Nova Scotia Department of Agriculture and Fisheries, it has never been adequately analyzed to determine how many and which of the of the approximately 1600 lakes surveyed to date contain cold-water habitat suitable for brook trout. In addition, and perhaps more importantly, lakes surveyed in the past have seldom been revisited to determine if changes have occurred in the extent of cold water habitat within any particular lake. A recent study (Brylinsky 2002) of 20 stratified Nova Scotia lakes located province wide revealed that, over the past 20 years, many lakes have experienced a decrease in suitable cold water habitat. The reason for this decrease is not entirely clear, but could be related to factors causing enhanced eutrophication as a result of increased development within the lake's watershed, or longer growing periods as a result of earlier ice-out and later ice-in times.

Information on the status and general abundance of cold water lake habitats within the Mersey River watershed is necessary for development of conservation and protection efforts intended to preserve these important habitats, especially in light of the increasing pressure being placed on many lakes as a result of forestry and agricultural activities as well as the increase in lakeshore cottage and residential home development that is evident in many areas of the Province.

The primary objective of this study was to initiate a survey of lakes within the upper Mersey watershed to determine the current level of existing cold water lake habitat present. A secondary objective was to determine if there has been any change over time in the extent of cold water habitat present in these lakes.

2.0 Approach

The general approach adopted to meet these objectives was to initially identify lakes within the upper Mersey watershed likely to contain cold water habitat based on information contained in the FINS[1] database and the extensive database developed on lakes within Kejimkujik National Park by Kerekes (1973a; 1973b; 1975). The primary condition for selection was that the maximum depth of the lake had to be >6 m to ensure sufficient hypolimnetic volume to serve as cold-water habitat. A secondary selection condition, necessary to assess the degree of change in cold water habitat, was the availability of historical survey data collected during either July or August, the time when water column stratification is strongest and hypolimnion dissolved oxygen concentrations are the lowest. A total of 45 lakes met these conditions. These lakes are listed in Appendix I.

Of the 45 lakes identified, five were selected for survey during August 2005[2]. Their location is shown in Figure 2.1, and Table 2.1 lists their morphological characteristics.

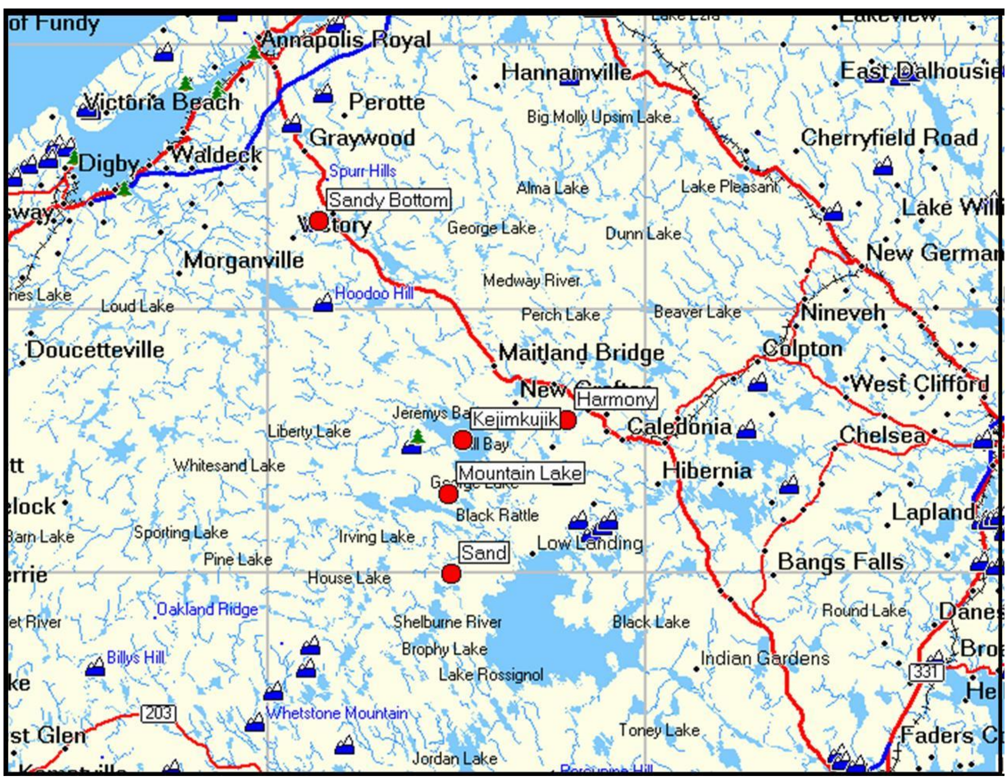

Figure 2.1 Location of study sites.

[1] The FINS database is maintained by the Nova Scotia Department of Agriculture and Fisheries and contains all of the data collected as part of the Province's Lake Survey Program.

[2] Originally Little Tupper Lake was selected for survey but it proved to be inaccessible due to poor road conditions. Sand lake was chosen as a replacement but does not meet the requirement of having been surveyed previously during July or August (although it was surveyed, the survey was carried out during early April).

Table 2.1. Morphological characteristics of surveyed lakes.

Parameter	Lake				
	Sand	**Harmony**	**Sandy Bottom**	**Kejimkujik**	**Mountain**
Mean Depth (m)	2.8	-	3.1	4.4	4.3
Max Depth (m)	9	11	12	19.2	14.3
Surface Area (ha)	117	354	104	2435	136
Volume (10^3 m^3)	3,259	-	3,204	106,017	5,790
Shoreline Development	3.0	5.1	2.8	5.5	3.3
Drainage Basin Area (ha)	17,408	-	1045	68200	820
Flushing Rate (times/yr)	42.7	-	2.3	5.5	1.2

3.0 Field and Laboratory Methods

The parameters measured for the survey included Secchi Disk depth, chlorophyll *a* concentration, total phosphorus concentration, and depth profiles of specific conductivity, temperature, dissolved oxygen concentration, and percent dissolved oxygen saturation.

One sampling station was established over the deepest part of the lake[3]. Water transparency was measured using a 20 cm diameter Secchi Disk. Water temperature and conductivity vertical profiles were measured with a YSI Model 30 SCT meter. Water column dissolved oxygen vertical profiles were measured at 1 m depth intervals with a Yellow Springs Instruments Model 55 Dissolved Oxygen Meter. Water samples for dissolved oxygen measurements were also collected from the middle of the epi-, meta- and hypolimnion with a Van-Dorn water sampler, and transferred into 300 ml BOD bottles and fixed in the field. Analysis of dissolved oxygen for these samples was carried out using the Winkler procedure (American Public Health Association 1989). These measurements were used to calibrate the YSI Dissolved Oxygen meter.

Water samples for total phosphorous analyses were collected from the middle of the epilimnion with a Van Dorn water sampler and transferred to 250 ml acid washed polyethylene bottles and stored refrigerated until analysis. Analysis for total phosphorus was carried out by Maxxam Analytics Inc.

[3] We were, however, unable to locate the 11 m maximum depth position at Harmony Lake as recorded in the FINS database.

Samples for phytoplankton chlorophyll *a* measurements were collected from the epilimnion in 1-liter polyethylene containers and stored refrigerated until filtration, the same day as collection, through Watman GF/C filters under gentle vacuum (<20 mm Hg). Chlorophyll was extracted from the filters by adding 20 ml of 95 percent acetone and storing the sample refrigerated in the dark until analysis. Analysis for chlorophyll *a* was carried out by centrifuging each sample at 2500 rpm for 5 min, decanting into a 5 cm pathlength cuvette and measuring absorption of the sample spectrophotometrically at 665 and 750 nanometers before and after acidification with 0.1 ml of 10 percent HCl. Chlorophyll *a* concentration was calculated according to the equations presented in Likens and Wetzel (1990).

4. 0 Results

Appendix II contains a listing of all the data collected during the August 2005 surveys. Figures 4.1 to 4.5 contain depth profiles of water temperature, dissolved oxygen concentration and percent dissolved oxygen saturation for the August 2005 surveys as well as the available data documented in the FINS and Kejimkujik Park databases.

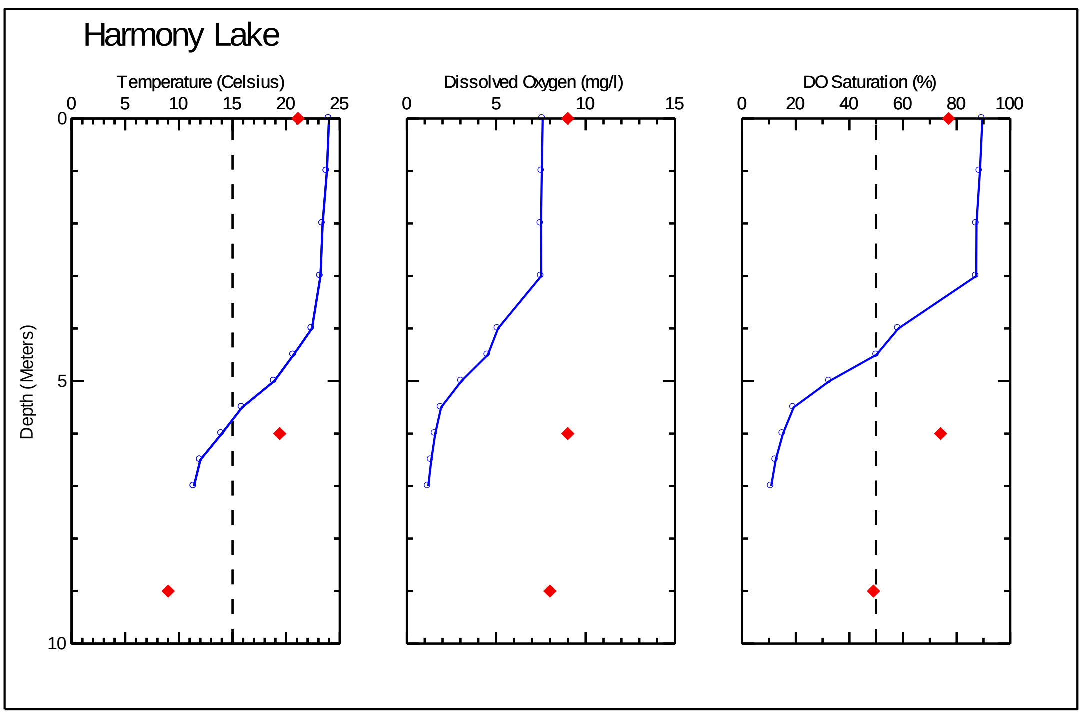

Fig. 4.1 Temperature, dissolved oxygen and percent dissolved oxygen profiles for Harmony Lake collected on 23 August 2005 (o--o) and 21 August 1972 (♦).

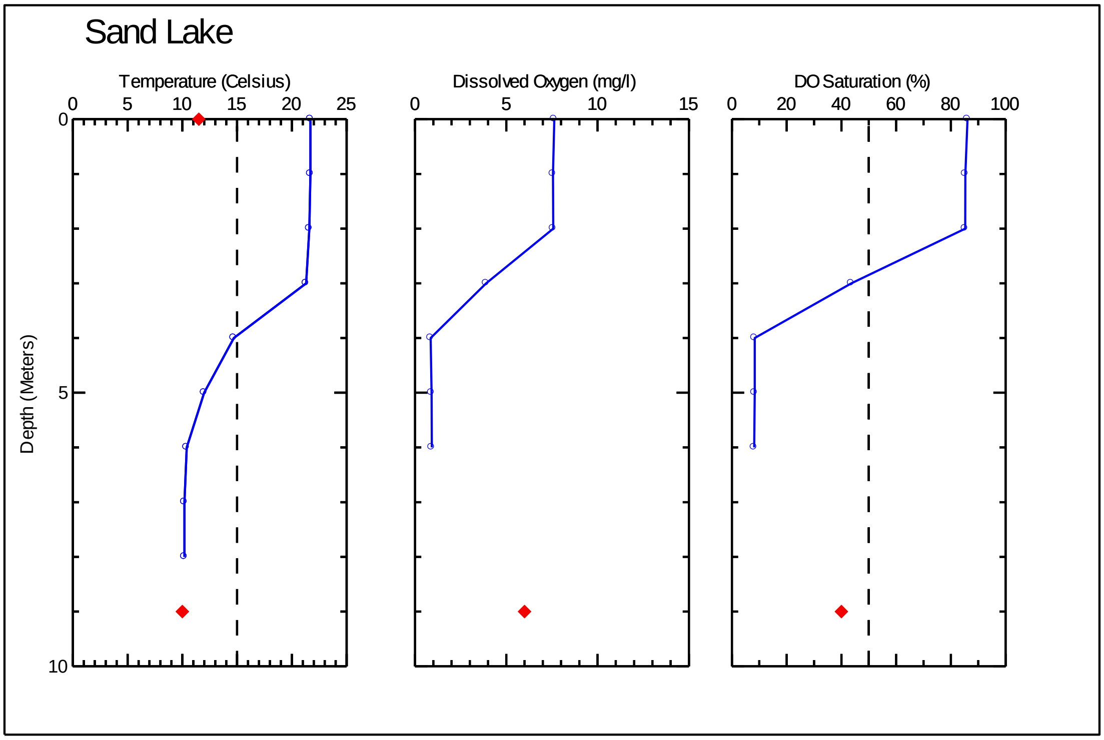

Fig. 4.2 Temperature, dissolved oxygen and percent dissolved oxygen profiles for Sand Lake collected on 25 August 2005 (o--o) and 2 April 1985 (♦).

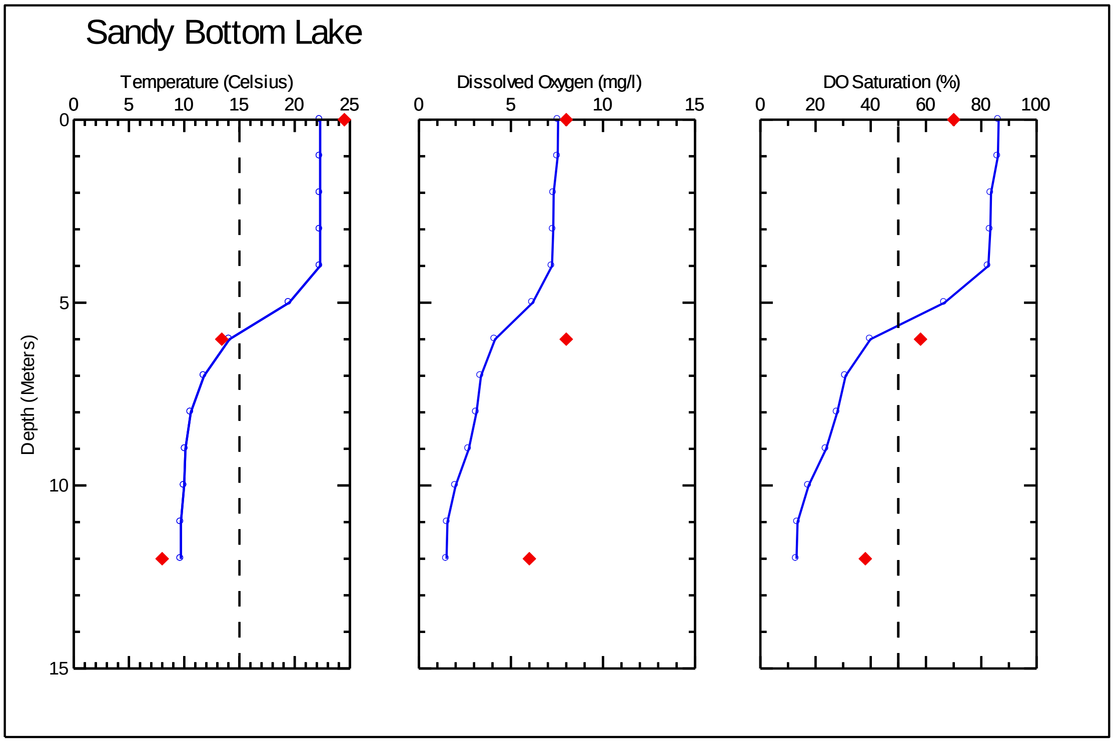

Fig. 4.3 Temperature, dissolved oxygen and percent dissolved oxygen profiles for Sandy Bottom Lake collected on 25 August 2005 (o--o) and 21 July 1985 (♦).

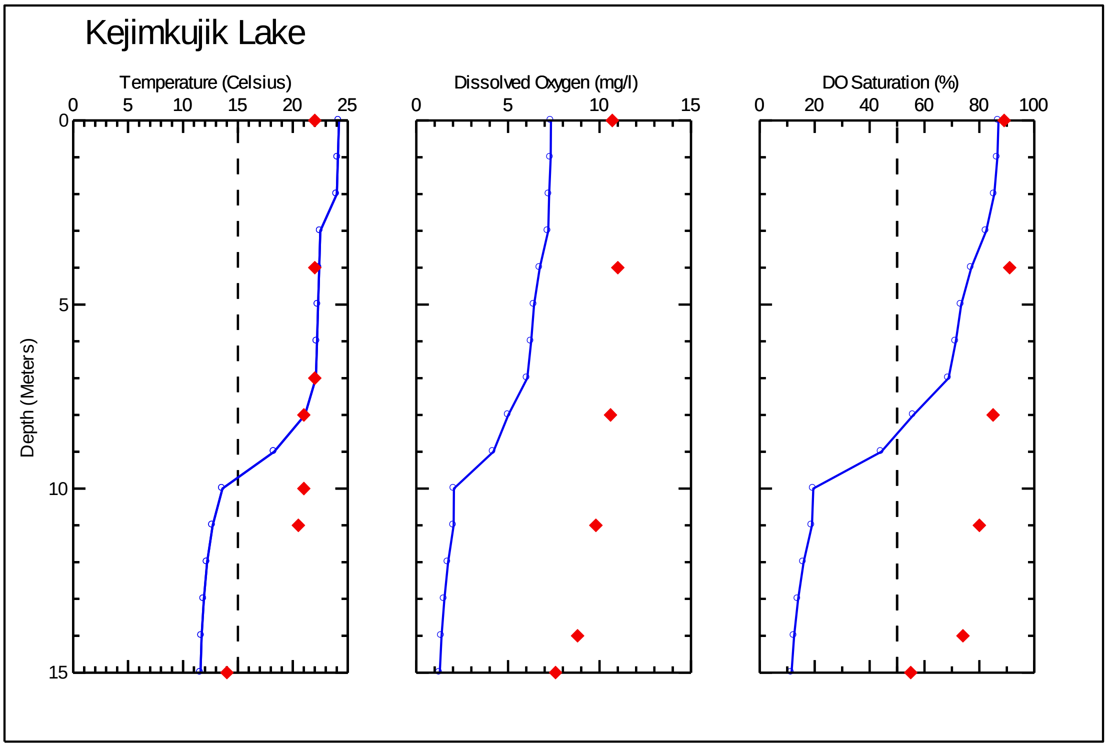

Fig. 4.4 Temperature, dissolved oxygen and percent dissolved oxygen profiles for Kejimkujik Lake collected on 23 August 2005 (o--o) and 3 August 1971 (♦).

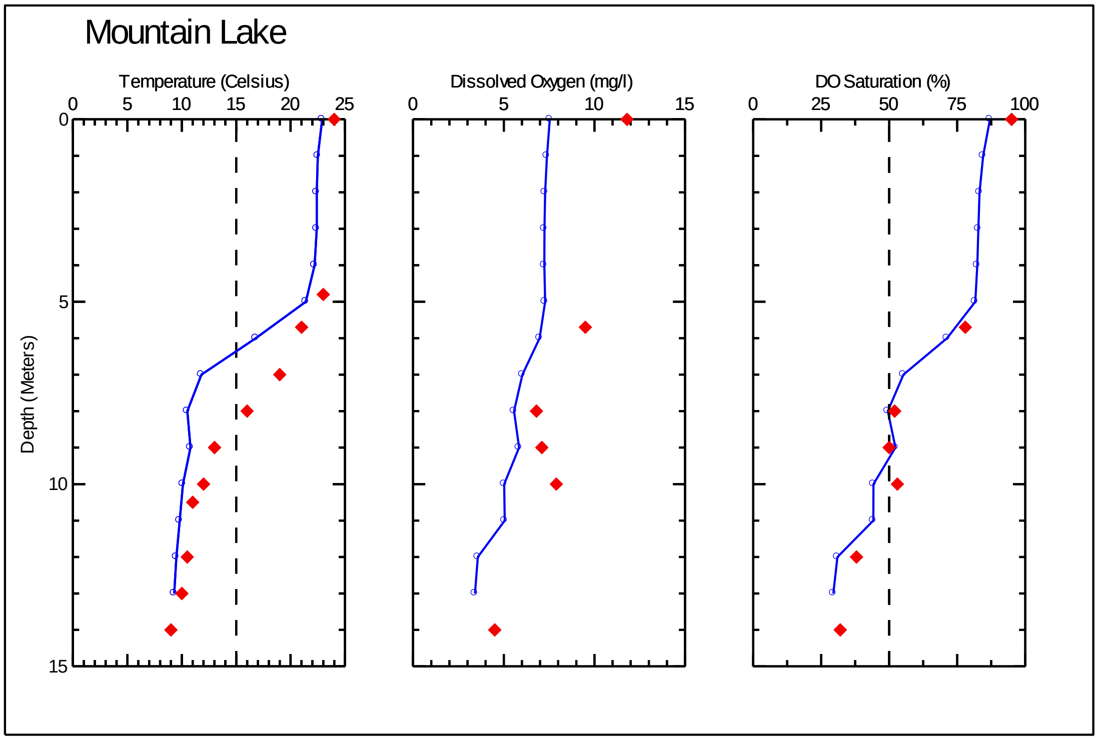

Fig. 4.5 Temperature, dissolved oxygen and percent dissolved oxygen profiles for Mountain Lake collected on 24 August 2005 (o--o) and 5 August 1971 (♦).

4.1. Comparison of Temperature and Dissolved Oxygen Profiles

Most of the lakes exhibited strong thermal stratification which, with the exception of slightly shallower thermoclines, in most cases varied little when compared to the earlier survey data. Sand Lake was an exception in that it did not exhibit any thermal stratification in the earlier survey[4].

In most cases, hypolimnetic water temperatures were very similar to those measured in the earlier surveys. In contrast, four of the five lakes surveyed had significantly reduced dissolved oxygen concentrations. Only Mountain Lake remained relatively unchanged in comparison to the earlier surveys.

Harmony, Sand, Sandy Bottom and Kejimkujik Lakes did not contain any suitable cold water habitat (i.e., water temperatures ≤15 °C and dissolved oxygen saturation ≥50 %). Only Mountain Lake contained cold water habitat and this was restricted to 2 m depth layer within the lower portion of the metalimnion.

4.2. Comparison of Past and Present Trophic States

Table 4.1 lists the ranges of parameters typically used to determine the trophic status of temperate zone lakes, and Table 4.2 provides a comparison of the values of these parameters recorded during the original earlier surveys and the August 2005 surveys.

Table 4.1. Generalized lake trophic classification based on OECD guidelines (OECD 1982).

Parameter	Oligotrophic	Mesotrophic	Eutrophic
Total P (µg/l)	<10	10 - 20	>20
Chl *a* (µg/l)	<3.5	3.5 - 5	>5
Secchi Depth (m)	>5	3 - 5	<3

Data on the required parameters for assessment of lakes previously surveyed is only available for those located in Kejimkujik Park. Based on Secchi Disk depth and chlorophyll *a* concentration, Kejimkujik Lake appears to be moving towards a higher trophic state. Mountain Lake, in contrast, shows very little change. Sand and Sandy Bottom Lakes are currently on the borderline between oligo- and mesotrophic while Harmony is oligotrophic.

[4] However, as indicted previously, the earlier survey for Sand Lake was carried out in early April and it is unlikely that stratification would have developed this early in the spring.

Table 4.2. Trophic state variables for lakes surveyed.

Lake	Survey Date	Total P* (µg P/L)	Secchi Depth (m)	Chl *a* (µg/L)	Trophic Status**
Harmony	8 August 1972	-	-	-	-
”	23 August 2005	5	3.4	2.5	Oligotrophic
Sand	2 April 1985	9	0.5	-	-
”	25 August 2005	15	0.6	2.3	Meso-Eutrophic
Sandy Bottom	21 July 1975	-	3.6	-	-
”	25 August 2005	16	1.7	5.7	Meso-eutrophic
Kejimkujik	3 August 1972	8	1.6	1.5	Oligotrophic
”	23 August 2005	7	1.1	4.3	Oligo-mesotrophic
Mountain	5 August 1971	3	6	1.0	Oligotrophic
”	24 August 2005	3	5	1.4	Oligotrophic

* Surface water values
** Based on OECD criteria

5. 0 Discussion

Of the five lakes surveyed in this study, four lacked suitable cold water habitat during August, and the remaining lake only contained suitable cold water habitat within the lower portion of the metalimnion. When compared to surveys carried out 20-30 years earlier, all of the lakes except Mountain Lake exhibited a significant decrease in cold water habitat. This decrease was due to reduced levels of dissolved oxygen rather than elevated water temperatures.

These results are similar to that obtained by Brylinsky (2002) in a similar survey of 20 lakes located throughout Nova Scotia. In that study it was suggested that the differences observed over time could be a result of either a change in the trophic status of the lakes or to a difference in the length of the growing seasons between survey years. With respect to differences in trophic status, the required data for evaluation is only available for Kejimkujik and Mountain Lakes. Mountain Lake does not appear to have changed significantly in either trophic status or available cold water habitat. In contrast, Kejimkujik Lake had less available cold water habitat and the trophic status has increased from oligotrophic to oligo-mesotrophic.

Because of the lack of data on trophic state for the early surveys, it is not possible to determine if the decrease in cold water habitat of the remaining three lakes may be related to changes in trophic status. Both Harmony and Sandy Bottom Lakes are easily accessible and appear to be in areas that have been subjected to increased levels of shoreline development and it is conceivable that they have undergone changes in trophic status. In the case of Sand Lake, the observed differences in cold water habitat appear to be a result of differences in water column stratification at the times of the surveys. During the earlier survey the water column was completely mixed while in the more recent survey it was strongly stratified and thus more susceptible to depletion of dissolved oxygen in the colder bottom waters. The dissimilarity in stratification between the two surveys is probably related to the difference in times that the surveys were carried out.

In summary, of the five lakes surveyed, four have exhibited decreases in cold water habitat. Because the availability of cold water habitat is a major limiting factor for cold water fish species in Nova Scotia, it is important to further document the availability of cold water habitat and the extent of decrease in other lakes. It is also necessary to attempt to determine the reasons for any observed declines in order to develop appropriate remediation plans to mitigate further loss of this valuable habitat as well as to protect that which is currently available.

6.0 Acknowledgements

This project was funded through the Mersey Tobiatic Research Institute. I would especially like to thank Ms. Amanda Lavers, MTRI Project Scientist, for her logistic support throughout this project. Ms. Sally O'Grady and Gary Corbett of Parks Canada aided in arranging for personnel to assist in the field work which was ably provided by Cody Joudry, Nick Whynot and Pierre Martel.

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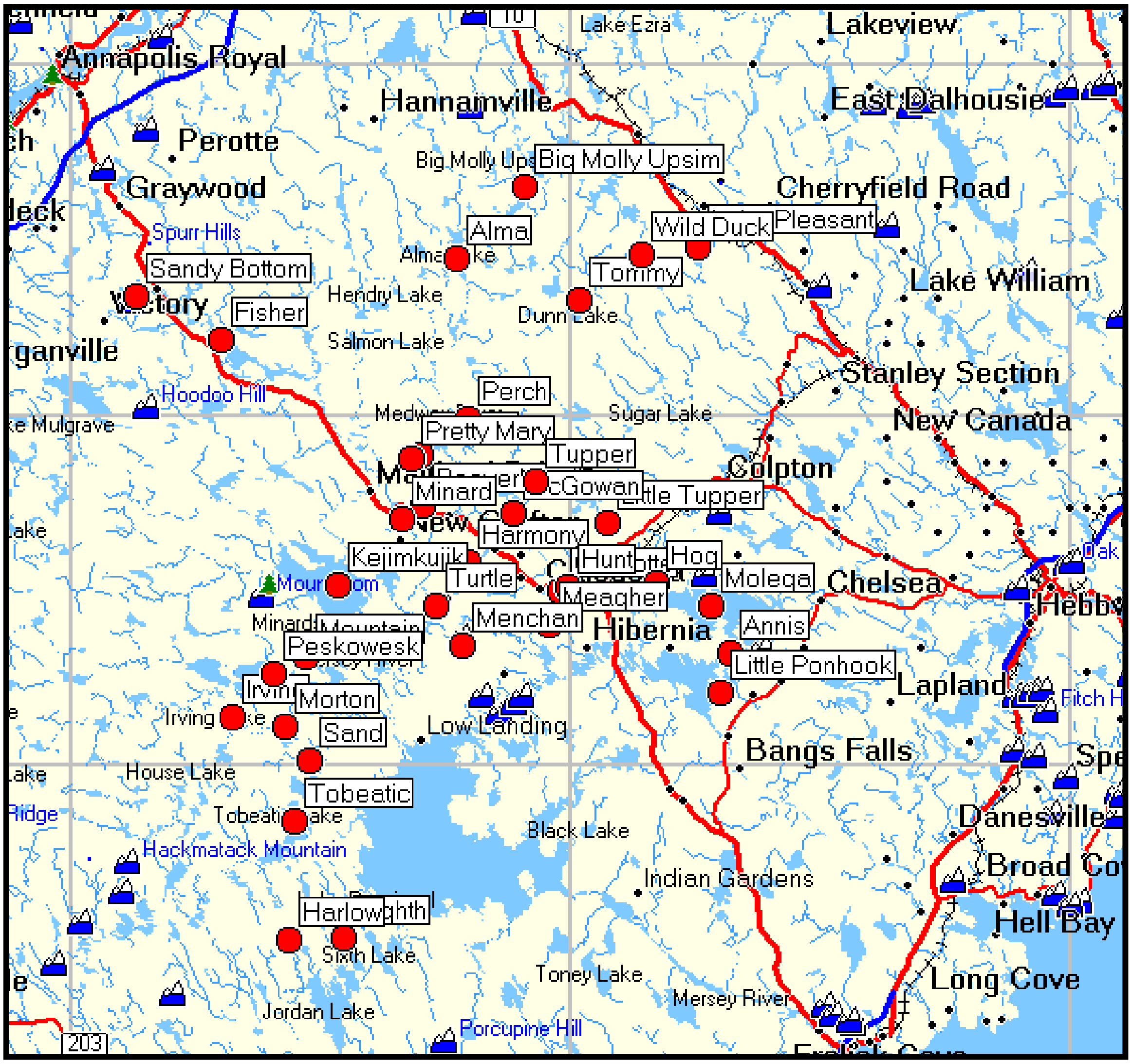
Appendix I – Lakes located within the upper Mersey-Medway watershed having the potential to contain cold water habitat.

Lake	Survey Date	Lat	Long	Surface Area (km^2)	Volume (10^6 m^3)	Max Depth (m)	Mean Depth (m)
DUNN (EAST)	06/06/84	44 16	65 17	21.9	404942	6	1.8
MURPHYS	07/28/88	44 17	65 06	23.6	545000	6	2.3
MORTON	05/29/74	44 17	65 16	3.2	95200	6	3
HARLOW	07/21/66	44 17	65 16	2.9	73200	6	2.5
MURPHY	01/12/81	44 18	65 05	23.6	544805	6	2.3
THIRD CHRISTOPHER	30/07/82	44 19	65 01	67.7	1294855	6	1.9
SPECTACLE	08.08/81	44 25	65 05	16.6	302850	6	1.8
MINARD	22/08/74	44 25	65 10	111.9	2704100	6	2.4
BEAVERHEAD	08/21/74	44 26	65 10	15.4	278200	6	1.8
MILL	06/08/90	44 29	65 08	77.7	1260000	6	1.6
TWIN	07/14/75	44 29	65 14	18.2	257043	6	1.4
PERCH	09/08/82	44 30	65 06	34.8	658948	6	1.9
HIDDEN HILLS	01/08/90	44 21	64 51	5.4	177000	7	3.3
MEAGHER	27/07/82	44 21	65 01	7.6	166679	7	2.2
CHARLOTTE	15/07/82	44 22	65 01	40.3	819567	7	2
HOG	15/08/82	44 23	64 55	98.3	-	7	-
HUNT	30/08/72	44 24	65 09	3.3	-	7	-
MUDFLAT	01/08/82	44 28	65 09	27.1	564985	7	2.1
PRETTY MARY	08/01/82	44 28	65 10	68.4	1592356	7	2.3
MUNROE	07/30/91	44 32	65 20	37	678980	7	1.8
WILD DUCK	06/19/75	44 37	64 56	7.5	131544	7	1.8
IRVING	06/10/74	44 17	65 20	135.9	3302200	8	2.4
FIRST CHRISTOPHER	07/08/82	44 20	64 58	138.6	3245712	8	2.3
ROUND	10/26/83	44 30	65 00	11	340000	8	3
FISHER	08/21/75	44 33	65 20	396.4	8740400	8	2.2
TOMMY	06/23/75	44 35	65 00	26.2	741000	8	2.8
LAKE PLEASANT	06/18/75	44 37	64 52	163.1	5410600	8	3.3
ALMA	06/07/90	44 37	65 07	276.7	9085074	8	3.3
EIGHTH	06/16/84	44 08	65 14	34	715824	9	2.1
SAND	08/24/89	44 15	65 15	116.9	3259200	9	2.8
TURTLE	08/28/74	44 21	65 08	77.9	2385200	9	3.1
LITTLE TUPPER	14/07/82	44 25	64 58	113.3	2622251	9	2.3
TOBEATIC	08/24/94	44 12	65 17	530.4	17223200	10	3.2
HARMONY	08/21/72	44 23	65 06	354.1	-	11	-
BIG MOLLY UPSIM	07/07/75	44 40	65 03	507.3	13183000	11	2.6
MENCHAN	05/24/74	44 20	65 07	52.7	-	12	-
MCGOWAN	15/07/82	44 26	65 03	430.4	12014200	13	2.8
LITTLE PONHOOK	06/28/89	44 18	64 51	90.7	5288042	14	5.8
TUPPER	15/07/82	44 27	65 00	439.9	12548500	14	2.9
MCGILL	04/07/75	44 42	65 00	221.5	10337300	16	4.7
ANNIS	26/08/82	44 20	64 50	75	6052150	18	8.1
MOLEGA	13/08/82	44 22	64 51	1995.9	100477618	26	5
SANDY BOTTOM	21/07/75	44 35	65 26	10.4	3204	12	3.1
KEJIMKUJIK	23/08/71	44 23	65 15	243.5	106017	19.2	4.4
MOUNTAIN	05/08/71	44 20	65 16	13.6	5790	14.3	4.3
PESKOWESK	01/09/71	44 19	65 18	68.5	26231	13	3.9

Appendix II. Data Summary

Lake	Depth (m)	Temperature (◦C)	Conductivity (µSi/cm)	Dissolved Oxygen (mg/L)	DO Saturation (%)
Harmony	0.0	24.0	22.6	7.6	89.6
Harmony	1.0	23.8	22.6	7.6	88.6
Harmony	2.0	23.4	22.5	7.5	87.4
Harmony	3.0	23.2	22.6	7.5	87.3
Harmony	4.0	22.4	22.7	5.1	58.3
Harmony	4.5	20.7	24.1	4.5	50.1
Harmony	5.0	18.9	27.1	3.1	32.6
Harmony	5.5	15.9	27.1	1.9	19.2
Harmony	6.0	14.0	26.3	1.6	15.2
Harmony	6.5	12.0	27.0	1.4	12.5
Harmony	7.0	11.4	63.4	1.2	10.8
Sand	0.0	21.7	41.0	7.6	86.1
Sand	1.0	21.7	41.2	7.6	85.3
Sand	2.0	21.6	41.0	7.6	85.2
Sand	3.0	21.3	41.1	3.9	43.7
Sand	4.0	14.7	41.9	0.9	8.3
Sand	5.0	12.0	43.4	0.9	8.3
Sand	6.0	10.4	43.7	0.9	8.1
Sand	7.0	10.2	43.6		
Sand	8.0	10.2	43.1		
Sandy Bottom	0.0	22.3	56.3	7.6	86.3
Sandy Bottom	1.0	22.3	56.5	7.5	86.0
Sandy Bottom	2.0	22.3	56.4	7.3	83.5
Sandy Bottom	3.0	22.3	56.5	7.3	83.3
Sandy Bottom	4.0	22.3	56.6	7.2	82.5
Sandy Bottom	5.0	19.5	58.0	6.2	66.7
Sandy Bottom	6.0	14.1	58.7	4.1	39.9
Sandy Bottom	7.0	11.8	59.3	3.4	30.9
Sandy Bottom	8.0	10.6	60.1	3.1	27.8
Sandy Bottom	9.0	10.1	60.4	2.7	23.8
Sandy Bottom	10.0	10.0	60.5	2.0	17.5
Sandy Bottom	11.0	9.7	66.0	1.5	13.5
Sandy Bottom	12.0	9.7	65.0	1.5	13.1
Kejimkujik	0.0	24.2	27.3	7.4	86.9
Kejimkujik	1.0	24.1	27.3	7.3	86.6
Kejimkujik	2.0	24.0	27.3	7.3	85.4
Kejimkujik	3.0	22.5	27.4	7.2	82.5
Kejimkujik	4.0	22.4	27.4	6.7	77.1
Kejimkujik	5.0	22.3	27.4	6.4	73.4
Kejimkujik	6.0	22.2	30.9	6.3	71.4
Kejimkujik	7.0	22.1	30.2	6.1	68.8
Kejimkujik	8.0	21.1	30.1	5.0	56.0

Kejimkujik	9.0	18.3	31.3	4.2	44.3
Kejimkujik	10.0	13.6	32.3	2.1	19.5
Kejimkujik	11.0	12.7	32.0	2.0	19.0
Kejimkujik	12.0	12.2	32.1	1.7	16.0
Kejimkujik	13.0	11.9	32.0	1.5	14.0
Kejimkujik	14.0	11.7	32.1	1.4	12.5
Kejimkujik	15.0	11.6	32.0	1.3	11.6
Mountain	0.0	22.9	31.0	7.5	87.0
Mountain	1.0	22.5	31.2	7.4	84.5
Mountain	2.0	22.4	31.4	7.3	83.2
Mountain	3.0	22.4	31.4	7.2	82.8
Mountain	4.0	22.2	31.6	7.2	82.4
Mountain	5.0	21.4	32.2	7.3	81.6
Mountain	6.0	16.8	35.2	7.0	71.3
Mountain	7.0	11.8	36.6	6.0	55.2
Mountain	8.0	10.5	37.1	5.6	49.5
Mountain	9.0	10.8	36.8	5.8	52.3
Mountain	10.0	10.1	37.2	5.0	44.2
Mountain	11.0	9.8	37.5	5.1	44.2
Mountain	12.0	9.5	37.7	3.6	31.0
Mountain	13.0	9.3	38.1	3.4	29.5



Map showing location of lakes that have the potential to contain cold water habitat.