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Summer Availability of Cold Lake Water off Toronto based on data from 1981 to 1993.

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Abstract

Water temperatures are examined at a location 2.5km offshore of Toronto Island in Lake Ontario for the purposes of supplying a proposed cooling water facility. The results of this study which is based on data from the period from 1981 to 1993 are similar those of an earlier study conducted nearly the same area based on data from 1960 to 1980. Both find an adequate supply with only about a 1% chance of disruption for more than few hours during occasional downwelling events. The possibility of drawdown of warmer water at the intake is also examined.

Introduction

The principal issue to be examined is in this report the adequate supply of water at the temperature of 4.7 °C and the rate of $5m^3/s$ at a depth of 70m 2.5 km offshore of Gibraltar Point in the Toronto waterfront region of Lake Ontario. It is assumed that the concern for 4°C water is for the summer months of June, July and August and that increases above this which are usual in later October and November are not of concern.

Boyce et al. (1981) reported thoroughly on the suitability of cooling water at a similar location and at a variety of depths based on the 20 or so years of data available up to 1980. Since then, similar data to those analysed by Boyce et al. (1981) were collected and archived up to 1993 when archiving was unfortunately terminated due to funding constraints.

Since it was found that the quantity of data available since the study of Boyce et al. (1981) is similar, the new analyses excluded the former data. In this way it can be established if there are trends in the climatolgy of north-shore Lake Ontario water temperatures over the approximately 40-year period. The analyses of Boyce et al. may be classified into three types of field observations, historical temperature profile data, fixed point temperature data from moored current meters and thermistor chain data.

Data Analysis

a) Historical Data

Approximately 300 profiles of temperature were extracted from the data archive of the National Water Research Institute over the period from 1981 to 1993 for the three summer months. The locations of the stations are shown in the accompanying plot, Figure 1. The selection was made on the same basis as the Boyce et al. (1981) study, a box having dimensions of 33 by 22 km, except that the centre of the box is at the new proposed location rather than the former site. While the majority of stations were taken in depths less than 70m, there were a sufficient number (120) at deeper depths also indicated in the figure to proceed with an identical statistical analysis to that of Boyce et al. (1981).

First, a weighting factor was established for each station according to the elliptical distance squared from the intake location relation of Boyce et al. (1981), (see, Boyceet al., figure 4). Next the temperature for each station at a depth of 70m was obtained by linear interpolation of the temperatures at the nearest depths for the 120 profiles having maximum depths of 70m or more. The distance-weighted mean temperature was 3.99 °C with a standard deviation 0.492. These compare to the corresponding values reported by Boyce et al. (1981) of 4.0 °C and 0.1869 based on 142 observations. The average distance weighting factor is 0.621 compared to the earlier study's value of 0.83. Thus, the new stations are situated somewhat less favourably than the former stations. The maximum temperature was 8.8°C in the recent data but was not reported by Boyce et al. (1981). It is evident that the two means are indistinguishable from one another, indicating no evidence of a temperature trend. However, the standard deviation is much larger. This is doubtless due to a large extreme temperature of 8.8°C. Extreme temperatures were not reported by Boyce et al. (1981).

b)Current Meter Data and Thermistor Chain Data

The archive of thermistor chain data and current meter data indicated one mooring of interest, marked as 52A in Figure 1. The position of the proposed intake and the Toronto region shoreline is shown for reference purposes. It is evident that the current meter was located quite close to the proposed intake. For the instrument at 79m the mean temperature was 3.72 +/-0.079, 3.62+/- 0.0033 and 3.81+/-0.0058 °C for the months of June, July and August of 1982. These values compare closely to the fixed thermistor chain data of Boyce et al. Of 3.9 +/- 0.1 at a depth of 80m. The monthly temperature statistics are also tabulated in these figures. Temporal plots of the temperature behaviour show in Figures 2 to 4 that maximum extreme temperatures are less than 4.5°C for the 1982 cooling season.

Warm Water Drawdown

Boyce et al. (1981) calculated the likelihood of drawdown of warmer water above the intake. They employed a densimetric Froude number criterion based on laboratory data. As the new intake draws only

50% of the original flow, the effectiveness of the intake being located 10m closer to the thermocline in drawing in warmer water is cancelled. Therefore, we find no increase in the tendency for drawdown provided that the intake is designed to prevent swirling flow as pointed out by Boyce et al. (1981).

Conclusion

This study based on new data reinforces the earlier findings of Boyce et al. (1981) that there is an adequate supply of water at 4°C during the months of June, July and August at the new location and at 70m depth. Furthermore, disruptions of the supply by water exceeding 4.7°C are rare and are likely to occur on average only about one day over the annual cooling period. Since the new proposal will utilise much less cooling water there ought to be no overall impacts on the thermal regime of Lake Ontario as discussed by Boyce et al. (1993).

References

Boyce, F.M., D.G. Robertson and G.N. Ivey. 1981 Summer availability of cold lake water off Toronto, Unpublished Report NWRI.

Boyce, F.M., P.F.Hamblin, L.D.Harvey, W.M.Schertzer and R.C.McCrimmon, 1993. Response of the thermal structure of Lake Ontario to deep cooling water withdrawals and to global warming. J. Great Lales Res. 19: 603-606.

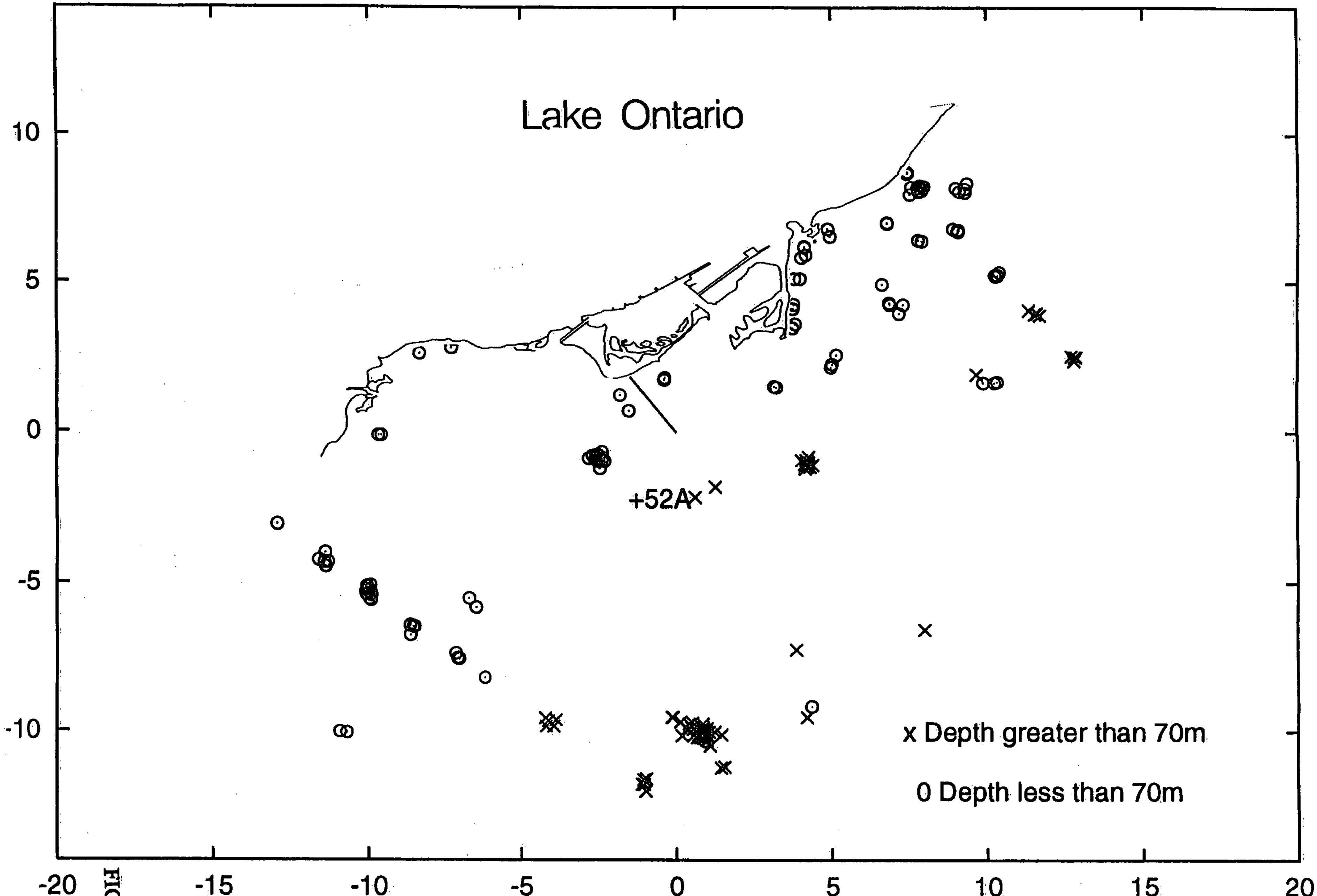
Figure Captions

Figure 1.Locations of stations used in this study. The symbols, x and o refer to the historical profile data over the period from 1981 to 1993 and for the months of June, July and August. The line out from Toronto Island represents the proposed intake pipe. Station 52A is a moored current meter at a depth of 79m.

Figure 2. Upper, current meter temperature statistics for June, 1982. Lower, Hourly water temperatures at the current meter June, 1982.

Figure 3. Same as Figure 2 except for July, 1982.

Figure 4. Same as Figure 2 except for August, 1982.



Lake Ontario
+52A
x Depth greater than 70m
0 Depth less than 70m
10
5
0
-5
-10
-20
-15
-10
-5
0
5
10
15
20

FIGURE 1

Descriptive Statistics for Temperature Data (Degrees C)
Mooring 82-00C-52a079
0000 Jun 1 to 2300 Jun 30, 1982

Column 1	
Mean	3.72
Standard Error	0.0029
Median	3.7
Mode	3.7
Standard Deviation	0.0790
Variance	0.0062
Kurtosis	3.71
Skewness	1.45
Range	0.5
Minimum	3.6
Maximum	4.1
Sum	2681.45
Count	720
Smallest(1)	3.6
Largest(1)	4.1
Confidence Level(0.95)	0.0058

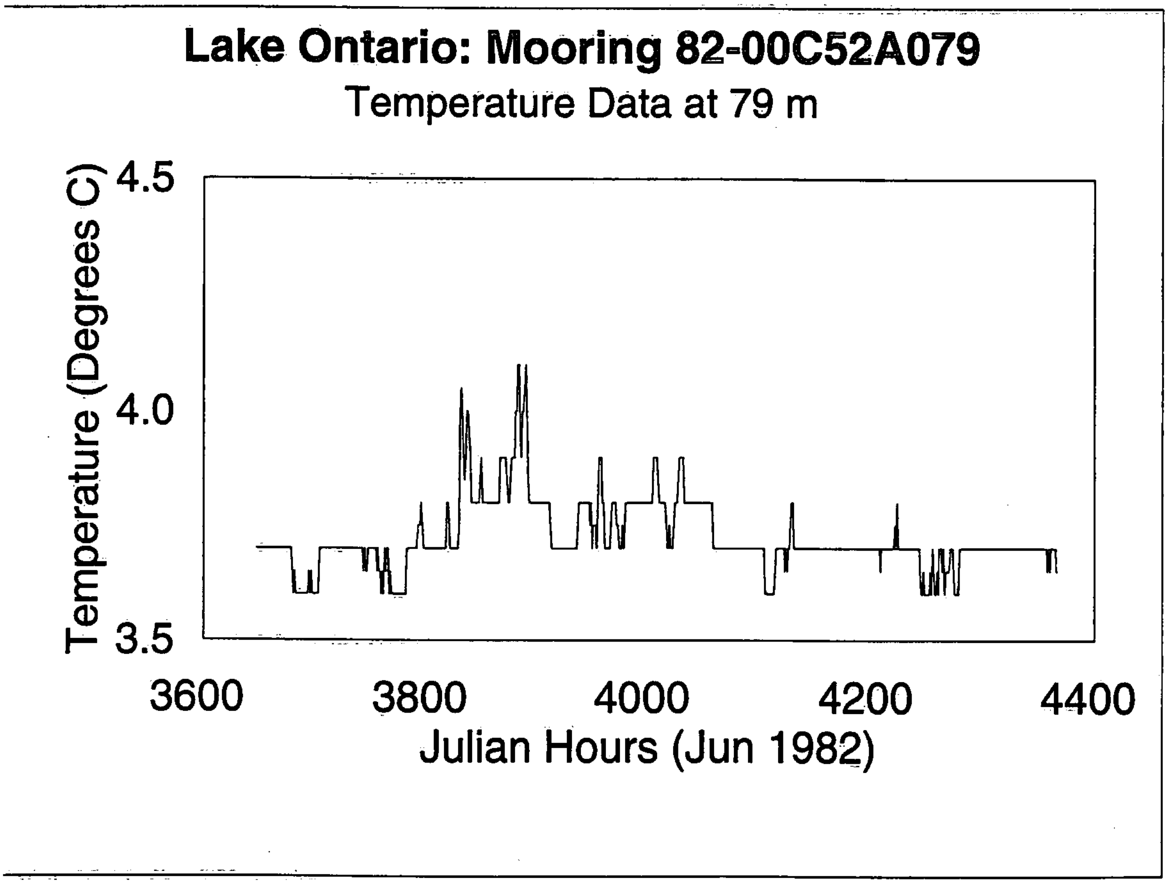


FIGURE 2

Descriptive Statistics for Temperature Data (Degrees C)
Mooring 82-00C-52a079
0000 Jul 1 to 2300 JUL 31, 1982

Column 1	
Mean	3.68
Standard Error	0.0033
Median	3.7
Mode	3.6
Standard Deviation	0.0906
Variance	0.0082
Kurtosis	-0.1271
Skewness	0.8690
Range	0.3
Minimum	3.6
Maximum	3.9
Sum	2740.9
Count	744
Smallest(1)	3.6
Largest(1)	3.9
Confidence Level(0.95)	0.0065

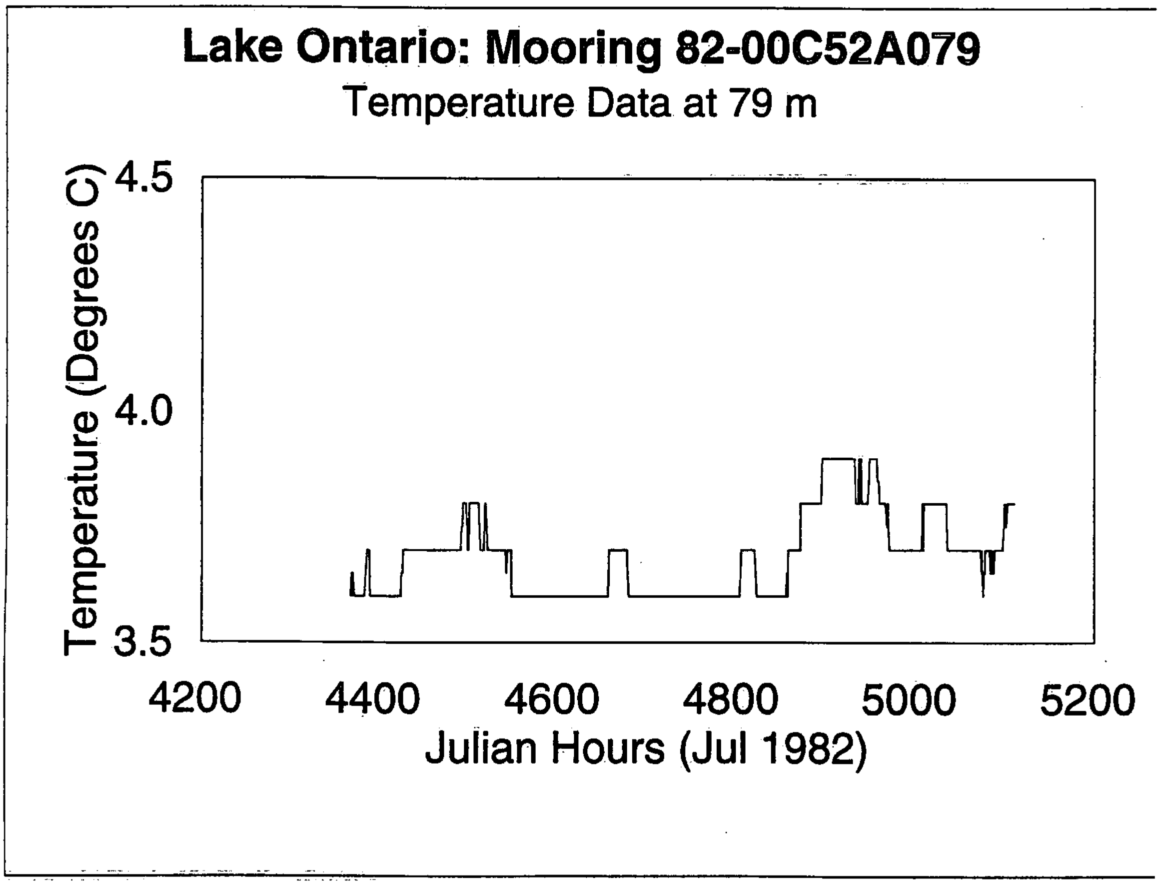


FIGURE 3

Descriptive Statistics for Temperature Data (Degrees C)
Mooring 82-00C-52a079
0000 Aug 1 to 1900 Aug 30, 1982

Column 1	
Mean	3.81
Standard Error	0.0058
Median	3.7
Mode	3.7
Standard Deviation	0.1544
Variance	0.0238
Kurtosis	2.0102
Skewness	1.5477
Range	0.8
Minimum	3.6
Maximum	4.4
Sum	2727.65
Count	716
Smallest(1)	3.6
Largest(1)	4.4
Confidence Level(0.95)	0.0113

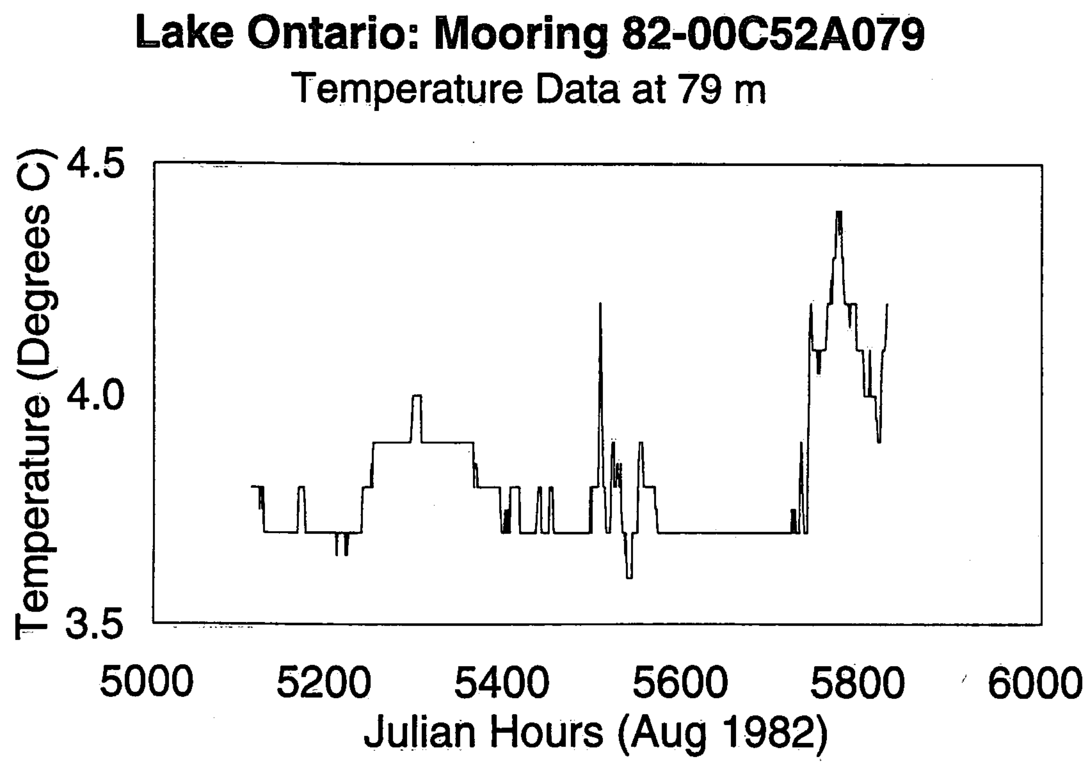


FIGURE 4