Glacial Relicts of the Elk River Chain-of-Lakes, Antrim, Kalkaska, and Grand Traverse Counties, Michigan

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Three Lake and Elk-Skegemog Lake Associations, summer 2007.
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Introduction

Glacial relicts (also called "glacial opportunists") are minute micro-invertebrates that inhabit many freshwater lakes in arctic to cold-temperate regions of North America, Europe, and Asia. Prevalent in the Great Lakes region of North America, these benthic invertebrates are theorized to have moved into the area by navigating the proglacial waters that existed in front of advancing ice age glaciers.[3] Since their arrival, approximately 3,500 years ago, these organisms have become the bottom layer of the food chain for a wide variety of aquatic organisms, especially young lake trout.[4] For fish that inhabit deep lake bottoms of 60 feet or more, glacial relicts are one of the rare food sources that thrive on the cold, dark bottom.[5] Such habitat selection makes glacial relict benthic invertebrates excellent indicators of oligotrophic conditions and, alongside other widespread food sources such as cladocerans and cyclopoids, signs of a lake's overall environmental health.

Unfortunately, recent years have seen a downward trend in the number and density of glacial relicts living in the Great Lakes basin. Studies by the Inland Seas Education Association of Traverse City, Michigan have shown a steady decline in the Lake Michigan population of one particular glacial relict, Diporeia affinis.[6] Commonly referred to as diporeia, this 0.5-1.0 cm organism is also common in the inland lakes located just east of the Lake Michigan coastline in northwest lower Michigan. In light of the organism's decline in Lake Michigan, concerns have been raised concerning the health and present population levels for Diporeia in neighboring lakes, as well as for the effects a Diporeia decline may have on a lake's overall physical condition.

To determine if a pronounced decline in Diporeia or other glacial relicts is indeed occurring in northwest lower Michigan's inland lakes, initial amounts of these organisms must be known. Unfortunately, few published scientific records concern glacial relicts living in Michigan inland lakes.[7,8,9,10,11,12] A University of Michigan research team published the last major study on this topic in 1978, which followed a similar study conducted in the 1950's. Neither one of these studies were meant to be especially quantitative, although they do provide relative densities for a variety of comparable benthic invertebrates. To analyze the current state of benthic invertebrate populations, however, more recent data is necessary. To provide these crucial statistics, the Three Lakes Association and Elk-Skegemog Lakes Association jointly conducted research to determine the current distribution and density of benthic invertebrates living in three of the eight lakes discussed in the 1978 report: Torch Lake, Elk Lake, and Lake Bellaire.

The main purpose of this report is to document and analyze the findings of this research. In addition to documenting benthic invertebrate distributions and densities, further information is provided concerning the overall physicochemical and biological conditions found in the three lakes. Results differing with the 1950's and 1970's studies will be analyzed, and possible explanations for the varying data will be presented. The information contained in this report will help contribute to any comprehensive analysis of the region's freshwater ecological systems.

Method

The information used in this report was obtained by multiple samples from Torch Lake, Elk Lake. and Lake Bellaire took place once a week during June and July of 2007. All samples were taken between 9 AM and noon. Three Lakes and Elk-Skegemog Lake Association's summer interns used a pontoon boat for weekly excursions. In the lakes we were able to use a Ponar dredge and plankton net to collect samples for examination. The sampling protocol was taken from the Inland Seas Educational Association where it has been used for many years. In fact, the dredge and plankton net were also borrowed from them.

The Ponar dredge is a metal device designed to collect sediment and clays that exist on the bottom of bodies of water. Each sample consisted of approximately 0.23 m^2 of sediment, based on the dimensions of the dredge mouth. This device was named for the five University of Michigan scientists who invented it: Charles E. Powers, Robert A. Ogle, Jr., Vincent E. Noble, John C. Ayers, and Andrew Robertson, Univ. of Michigan.

The dredge was used to find the benthic invertebrates that were examined. During the research outings the sampling position was recorded with a GPS

(Global Position Sensor) sensor and the depth was measured either with a tape or sonar depth gauge. All information was written on the sample bottles for identification and separately in a paper log. We lowered the dredge to the bottom of the lakes tied to rope. During the sampling the was lowered to the bottom on a rope. Once the dredge reached the bottom, slack was given on the rope for the self-releasing pin to fall out and the spring-loaded trap to close. When the dredge was pulled back onto the boat it was emptied into a mesh screen (0.6x0.6 mm square openings) to separate the larger organisms, pebbles, and shells from the sediment material. Notable specimens were taken from the screen with tweezers and placed into a sample bottle with 70% alcohol.

The plankton tow is a 0.15 mm mesh net that catches smaller microorganisms, including plankton. The net is towed vertically from the bottom of the lake. Water flows through the mesh and traps micro-organisms living in the water. On the bottom of the net is a catcher cylinder, called the cod end, that further concentrates the organisms for easier transfer into a sample bottle. To preserve the samples, bottles were filled with 70% denatured alcohol.

In July, a Hydrolab Quanta profile was done on Lake Bellaire measuring temperature, pH, specific conductivity, and dissolved oxygen.[13] The device was calibrated *in situ*. Measurements were made from the surface to the bottom.

To identify the organisms collected, a dissection (x10 – x40) microscope with a laptop display was used for larger organisms. A computer screen image of what was seen underneath the microscope could be viewed. A dark-field research microscope was used to identify the plankton specimens found in the sample bottles. With this higher magnification (x100-x1000) smaller specimens collected from the plankton tow could also be identified.

Ponar Dredge

Plankton Net

Results

The research done on the inland lakes yielded the following data, organized by lake. This section includes the location, species, frequency, etc. Further descriptions and explanations can be found in the discussion section.

The most abundant and pertinent species were Mysis relicta, Diporeia, and midge and mayfly larvae. There were also miscellaneous shells and mussels found in the samples. These were noted, but are not central to the research.

Below is a table of the average sizes of the species found. The average was computed by measuring one representative specimen from each lake sample taken.

Table 1:

Average Lengths of Species Collected	
Species-	**Length (mm)-**
Mayfly larvae	18
Mysis relicta	12
Diporeia	6.9
Midge larvae	15.5
Plankton	0.5-1.0

Elk Lake-

Table 2: Dredge samples taken at north end of Elk Lake on July 9, 2007.

Organisms in Elk Lake Dredge Samples						
		Species				
Depth-ft	GPS	May	Mysis Relicta	Diporeia	Midge	Misc.
49	N 44º 52.451' W 085º 22.513'					2 snail shells
57	N 44º 52.388' W 085º 23.525'				1	8 zebra
80	N 44º 52.447' W 085º 22.575'				1	
81	N 44º 52.xxx' W 085º 22.xxxx'		1	1	3	1 flat spiral shell
140	N 44º 52.393' W 085º 22.944'			1	3	

Lake Bellaire-

Table 3: Dredge samples – Lake Bellaire, middle, east, and west taken July 24, 2007.

Organisms in Lake Bellaire Dredge Samples						
		Species				
Depth-ft	GPS	May	Mysis Relicta	Diporeia	Midge	Misc.
45	N 44º 56.978' W 085º 12.471'			2		
47	N 44º 56.720' W 085º 13.798'			9		1 no ID
68	N 44º 56.741' W 085º 13.749'			10		
90	N 44º 56.885' W 085º 12.985'				1	1 flat worm; 1 no ID

Torch Lake-

Multiple locations and dates were used while collecting data from Torch Lake July, 3, 9, and 29, 2007. These three tables summarize the information gathered.

Table 4: Dredge samples – Torch Lake, NE side, July 3, 2007.

Organisms in Torch Lake Dredge Samples - Number One							
		Species					
Depth-ft	GPS	May	Mysis Relicta	Diporeia	Midge	Misc.
50	N 45º 4.0xx' W 085º 20.901'					1 clam; 1 flat spiral
106	N 45º 4.940 W 085º 20.716'	1		4		
210	N 45º 4.122' W 085º 20.228'			3	1	
225	N 45º xx.xxx' W 085º xx.xxx'			3		

Table 5: Dredge samples – Torch Lake, north end near Eastport, July 9, 2007.

Organisms in Torch Lake Dredge Samples - Number Two						
		Species				
Depth-ft	GPS	May	Mysis Relicta	Diporeia	Midge	Misc.
40	N 45º 6.126' W 085º 20.791'	1				1 zebra mussel
90	N 45º 5.927' W 085º 20.658'			4	2	
155	N 45º 5.359' W 085º 20.383'			8		1 spiral shell

Table 6: Dredge samples – Torch Lake, east side, middle, July 29, 2007.

Organisms in Torch Lake Dredge Samples - Number One						
		Species				
Depth-ft	GPS	May	Mysis Relicta	Diporeia	Midge	Misc.
38	N 44º 58.391' W 085º 17.386'	2			2	23 zebra; 1 flat; 1 spiral
70	N 44º 58.337' W 085º 17.537'			1		
95	N 44º 58.265' W 085º 17.512'			6	2	1 un-ID

Diporiea

Midge Larva

Mysis Relicta (Possum Shrimp)

Flatworm

Mayfly Larva

Zebra Mussels

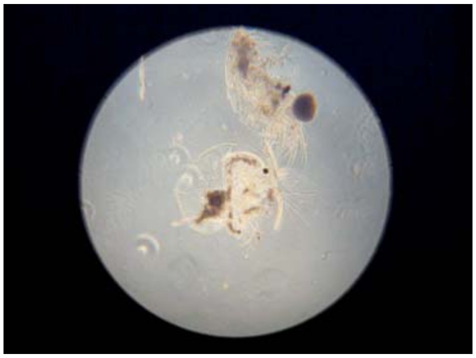
Pleurocerca

Plankton

Copepod

Amphipod

Copepod



Cladocerans

Discussion

Previous studies taken in Torch Lake, Elk Lake, and Bellaire have noted some changes since 1950 and 1975, the dates of the last samplings for glacial relicts. As detailed in the 1978 study, Diporeia was <u>not</u> found in Lake Bellaire. The present study found Diporeia in all three lakes with a smaller number of midges, mayfly larvae. Fewer diporeia were found in Elk Lake than either Torch or Bellaire, but the number of samples collected in each lake was relatively small (4 in Lake Bellaire, 5 in Elk Lake, and 10 in Torch Lake). Mysis relicta was only found in a dredge sample from Elk Lake. Zebra mussels were only found in Elk and Torch Lake above 60 ft. and at only three locations out of a total of 19 dredge samples. This density is lower than in that found in Grand Traverse Bay by the Inland Seas Educational AssocitION. No quagga mussels were seen in any samples.

The dissolved oxygen level at the bottom of the lake was low (~5 mg/l) only in Lake Bellaire and this might have been the reason that no diporeia were found at 90 ft. there (see Hydrolab Quanta profiles in Appendix I). Low oxygen has not been proven to be a cause of population decline, however, we can assume that it may cause stress on some glacial relict species. Typically, fish cannot tolerate dissolved oxygen below 5 mg/l. Figures 1 and 2 show examples of dissolved oxygen compared to summer temperatures. Appendix I shows typical depth profiles of temperature, dissolved oxygen, pH, and specific conductivity in each of the three lakes. Although, profiles were taken from Torch and Elk Lakes in the 2006 season, they are comparable from year to year.

Copepods include various, minute crustaceans of the subclass Copepoda. They have drawn out bodies and forked tails. They are plentiful in fresh water, and are a significant food source for young fish.

Mysis Relicta prefer to live in deep, cold, clean fresh water with heightened levels of dissolved oxygen. This study found only found one example of Mysis species that resided in Elk Lake. However, sampling was not done at night when Mysis may have been found due to their habit of living just above or in the top of the sediment during the day and swimming up to the thermocline at night. Our sampling technique was not well suited for the collection of Mysis. The 1978 report show that Torch Lake had a number of Mysis relicta. However, Mysis has not yet been seen in Lake Bellaire.

Diporeia were reported by Gannon (1978) to be found in Torch Lake, Elk Lake, and Lake Bellaire in the 1950's, but was not seen in Lake Bellaire by 1975. Diporeia spend their entire life cycle burrowed into the top centimeter of sediment at the lake bottom. Lake Bellaire is now known to become anoxic in the late fall and early winter, but the sensitivity of Diporeia to dissolved oxygen is unknown. The sediment itself is rich in phosphorus but insoluble. Low dissolved oxygen may have been the reason for their decline in 1950. This year diporeia were found in 12 of 19 dredge samples taken in all three lakes: 3 in Lake Bellaire, 2 in Elk Lake, and 5 in Torch Lake. The question as to whether the population density of Diporeia is increasing or decreasing is still unanswered. The 1978 report did not give densities and there were not enough samples in the current study to provide an unambiguous density at present. The densities we found range from 0 to about 500 m^{-2} in our sampling with an average of 140 m^{-2}. In comparison typical Diporeia densities in Grand Traverse Bay and Lake Michigan were 0-1800 m^{-2}. The density range in the inland lakes appears to be substantially lower than in Lake Michigan, but the reasons are not known.

Midge Larvae are able to live in lower levels of dissolved oxygen and can come up to the surface to breathe if necessary. Although we have no older data for comparison, we did find a number of them in each of the three lakes sampled.

Zebra Mussel densities are low in these lakes in comparison with Grand Traverse Bay despite their presence in these lakes for about ten years. The reason for their low population density is still unknown. However, most zebra mussels in the Bay have been replaced by quagga mussels by now whereas all of the shells found in the three lakes in the current study were zebras. Zebra mussels do not readily live on sandy or marl bottoms which appear to predominate these lakes. In the future quagga mussels that do live on sandy substrates and over a larger range of depths than zebras, may well colonize the inland lakes. Quagga larvae can hitch-hike on the boat bottoms just like zebra mussels.

Mayfly samples were only found in Torch Lake (3 examples).

Flatworm samples were found only in Lake Bellaire (1 example).

Shell fragments were found in most dredge samples at intermediate depths (40 – 60). Pleurocerca (unicorn shaped shell) were found in Torch and Elk Lakes. Heliodiscus (small flat spiral shell) were found in many samples. Native freshwater clams were found occasionally.

Plankton were found in visible quantities from all samples. Detailed identifications of the species were not attempted. However, most examples were copepods and cladocerans. A single density estimate was made as 3.8 ft^{-3} averaged from the top to the bottom in Torch Lake.

Summary

This study provides a snapshot of life on the bottoms of Torch Lake, and Elk Lake, and Lake Bellaire, in 2007. Similar information has not been available since 1978 and little density information is available from any timeframe. Only ongoing studies in Grand Traverse Bay and Lake Michigan give us some information from this time period for comparison.

One of the most important sediment dwelling species is Diporeia. Diporeia was present in all of the lakes studied and at densities that are somewhat lower than in Grand Traverse Bay. Densities are not available from the 1950s and 1975s studies of our lakes for comparison. The largest Diporeia sample was taken from Lake Bellaire where no specimens at all were found in 1975. In general, Diporeia is the dominant species living near the surface of the bottom sediments. Although samples were taken at depths of about 40-60, 80-110 in all lakes and at about 200 ft. in Torch Lake, the number of samples taken in this study and the variation from sample to sample could not determine the distribution of Diporeia with lake depth.

Another significant difference in these lakes since the 1978 report is the presence of zebra mussels. Examples were found at intermediate depths (40-60 ft.) but there was a wide variation in the distribution from the none to significant numbers (~1,000 m^{-2}). Zebra mussels were found in only three of eight dredge samples taken between 40 and 60 ft.

This study was not designed to look for Mysis relicta and only one example was found. In the future sampling can be designed to more effectively search for this species, especially night sampling or tow sampling near the bottom.

Plankton samples were taken at each location but the task of identifying counting even a small sample appeared too daunting for the scope of this study. We only noted that most of the species were copepods and cladocerans and one example of the density was 3.8 ft^{-3}.

Recommendations for future research would include (1) collecting more samples including night sampling and tows near the bottom for Mysis relicta, (2) sampling a larger number of sites, and (3) using a higher power microscope and using a systematic protocol for counting plankton number densities. In fact, dredging and net towing could be separate studies.

Acknowledgement

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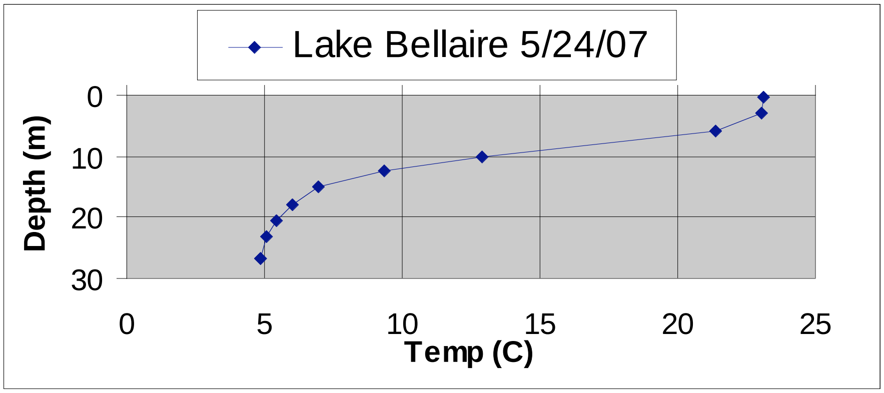
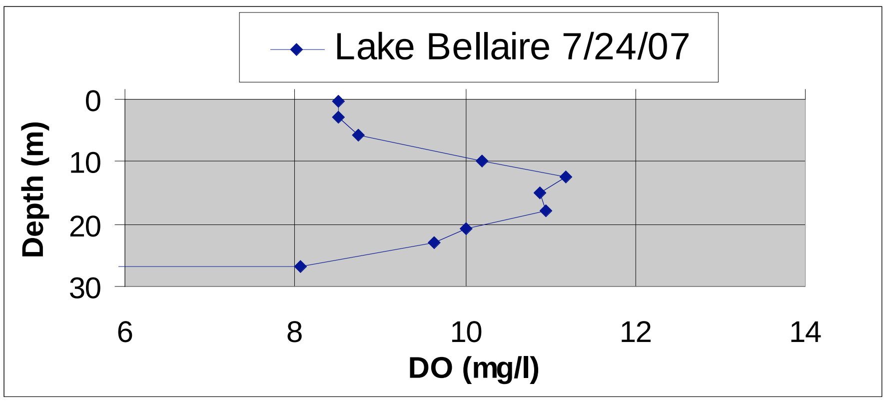
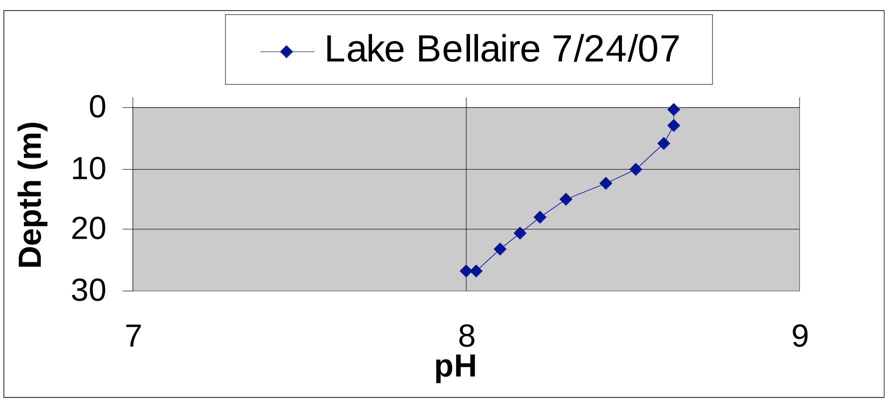
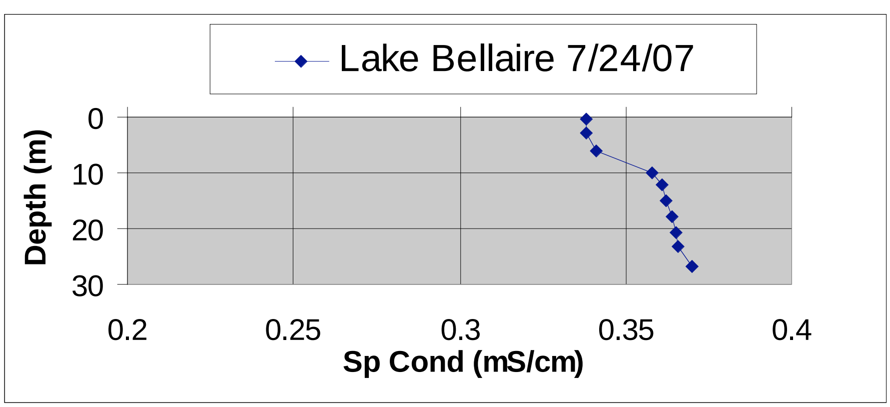
Appendix I - Lake Bellaire

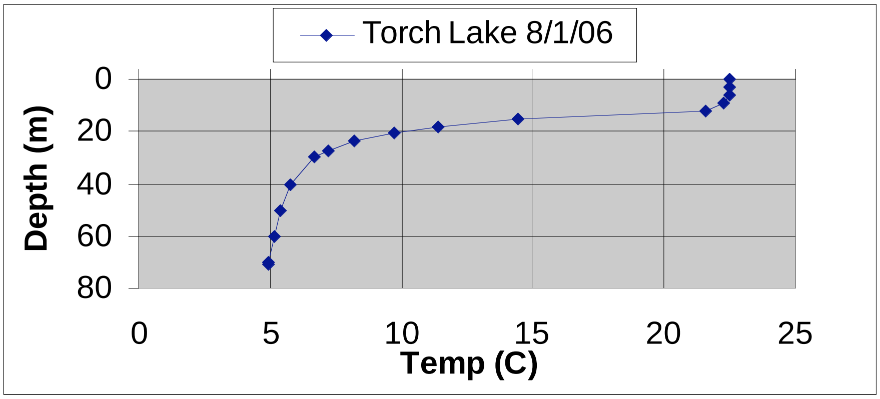


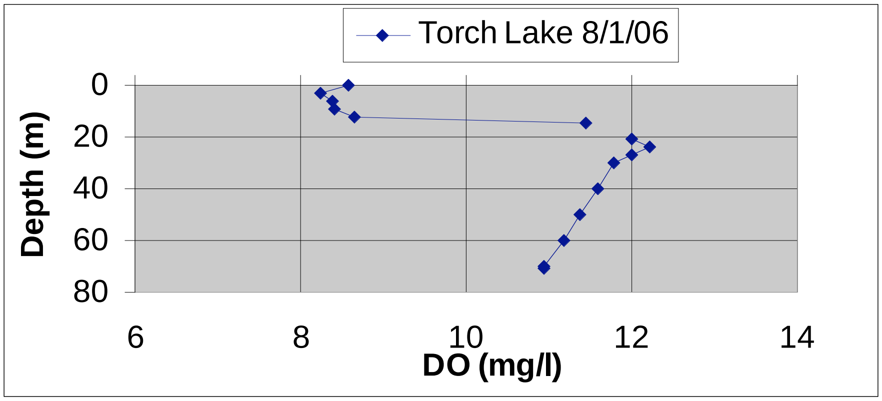


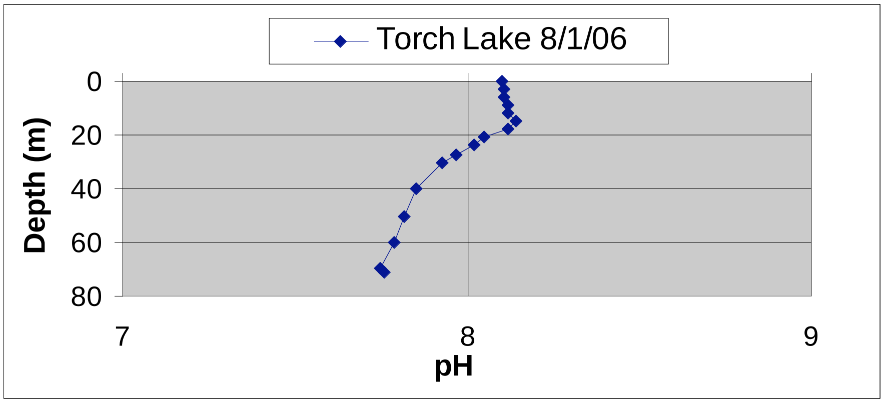


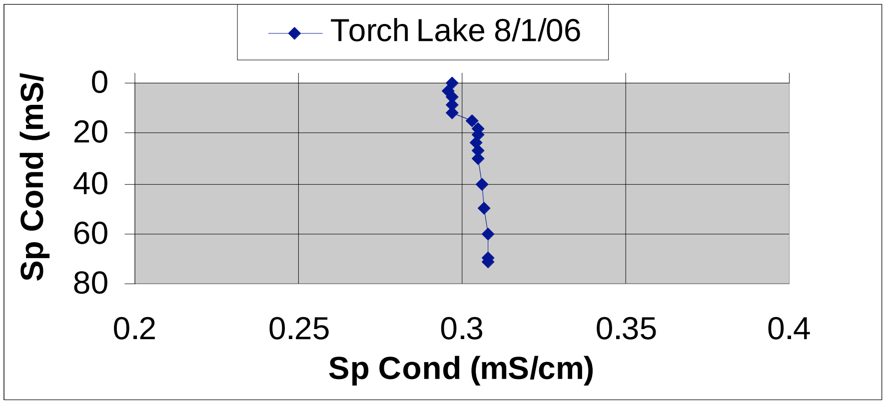


Appendix I - Torch Lake

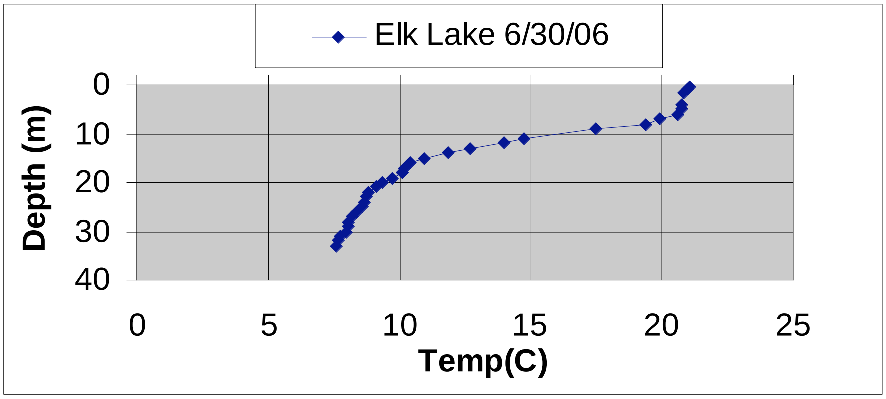


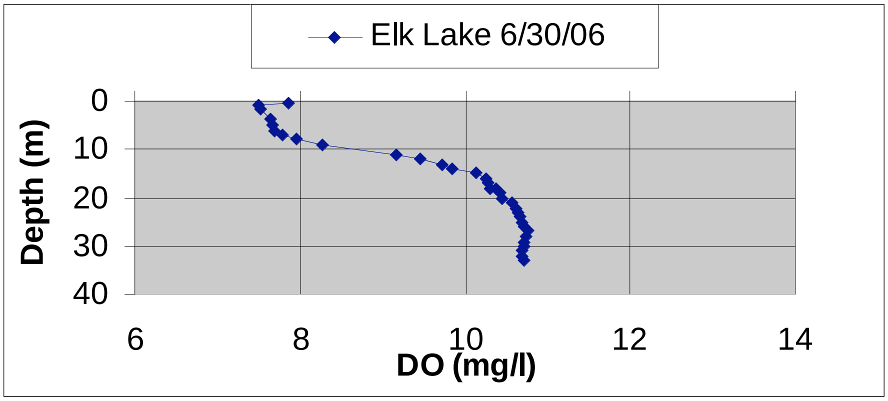


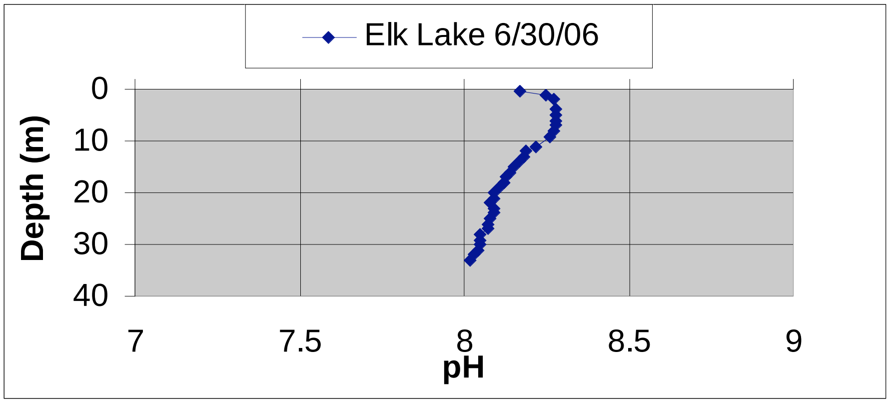


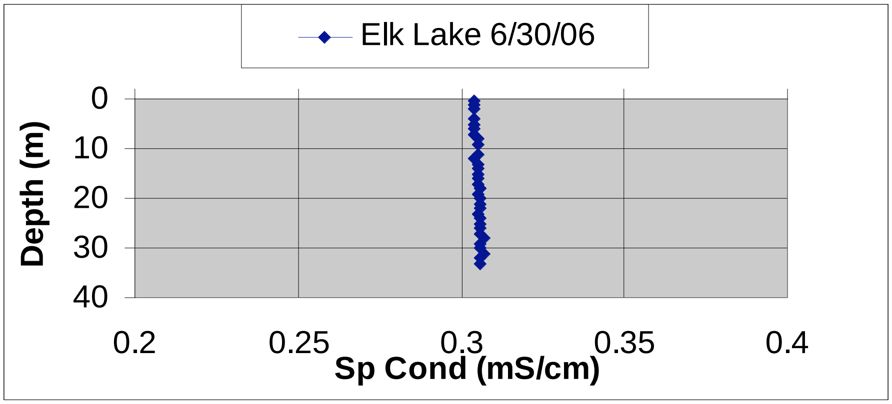


Appendix I - Elk Lake









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