

What attracts people to Northern Michigan? In general, people come north to enjoy the natural beauty of the area's pristine ecosystems, but if asked for one specific landscape feature, most would undoubtedly say our "lakes". Lakes define the landscape of Northern Michigan and sustain local economies, providing stunning views, abundant fisheries, and tremendous recreational opportunities.

In the Tip of the Mitt Watershed Council service area there are nearly 60 lakes greater than 100 acres in size, and 14 of these are among the State's largest with over 1,000 acres of lake-surface area. The region also boasts some of the State's deepest lakes with five lakes having maximum depths of 100 feet or more. Mullett Lake, in northeastern Cheboygan County, stands among these lake "giants" with over 17,000 acres of surface area and 144 feet of depth.

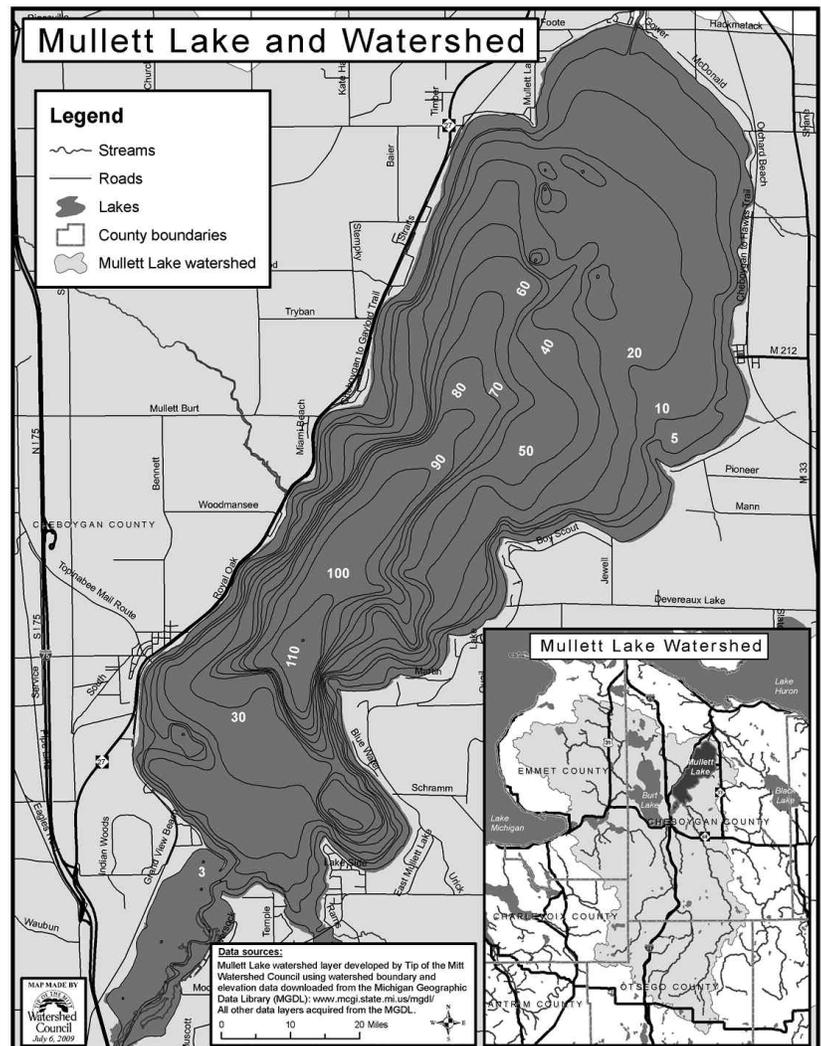
Many words come to mind to describe Mullett Lake: immense, fantastic, deep, enchanting, beautiful, vibrant, and diverse. Over the last few decades, the Watershed Council has put forth great effort to preserve Mullett Lake and ensure it remains a high quality resource for the enjoyment of future generations. Water quality of the region's lakes, both large and small, has been monitored by staff and volunteers alike, providing valuable data on the overall health of our waters. Our cornerstone water quality monitoring programs include Comprehensive Water Quality Monitoring and Volunteer Lake Monitoring.

The Comprehensive Water Quality Monitoring program is run by Watershed Council staff who have monitored water quality of Northern Michigan's lakes and streams for over 20 years. The Volunteer Lake Monitoring program was started in 1984 and has relied on hundreds of dedicated volunteers who monitor water clarity, algae abundance, phosphorus levels and more.

In addition to monitoring, the Watershed Council has worked with lake shoreline owners and lake organizations on a variety of projects to protect the lakes scattered throughout Northern Michigan. Projects carried out on these lakes have ranged

from comprehensive aquatic plant surveys to shoreline restoration projects. Details about recent monitoring activities and lake projects on Mullett Lake are included in this report.

We hope you find this report both informative and helpful. If you have any questions, comments, or concerns, please contact Tip of the Mitt Watershed Council at (231) 347-1181 or visit our website at www.watershedcouncil.org.



MULLETT LAKE, located in northeastern Cheboygan County, has over 17,000 acres of surface area and a depth of 144 feet.

Comprehensive Water Quality Monitoring

Water Quality Trends: 20 years of data

In 2007, Tip of the Mitt Watershed Council completed its 20th year of comprehensive monitoring. Starting on just 10 lakes in 1987, the Watershed Council's Comprehensive Water Quality Monitoring Program has expanded to include over 50 lakes and rivers throughout Northern Michigan. An incredible amount of data has been generated from this program and utilized by the Watershed Council, lake and stream associations, local governments and regulatory agencies in an effort to protect and improve the water resources that are so important to the region.

Every three years, Watershed Council staff head into the field as soon as ice is out to monitor lakes and rivers spread across the tip of the mitt. Over 60% of the region's lakes greater than 100 acres in size, and all major rivers are included in the program. In each of these water bodies, the Watershed Council collects a variety of data, including parameters such as dissolved oxygen, pH, chloride, phosphorus and nitrogen.

Information gathered in the Comprehensive Water Quality Monitoring Program has proven to be very useful. The data are used by the Watershed Council and others to characterize water bodies, identify specific problems and examine trends over time. One obvious trend found by analyzing data from this program is that chloride (a component of salt) levels have increased significantly in many water bodies during the last 22 years. Why? We need not look any farther than ourselves to find the answer as we use salt in everything from de-icing to cooking.

The following pages contain descriptions of the types of data collected in the program as well as select data from Mullett Lake. We have also included charts to provide a graphic display of trends occurring in the lake. For additional information about the Comprehensive Water Quality Monitoring Program please visit our web site at www.watershedcouncil.org/protect

Parameters and Results

pH

pH values provide a measurement of the acidity or alkalinity of water. Measurements above 7 are alkaline, 7 is considered neutral, and levels below 7 are acidic. When pH is outside the range of 5.5 to 8.5, most aquatic organisms become stressed and populations of some species can become depressed or disappear entirely. State law requires that pH be maintained

within a range of 6.5 to 9.0 in all waters of the state. Data collected from Mullett Lake show that pH levels consistently fall within this range, with a minimum of 7.43 (1992) and maximum of 8.36 (2001).

Dissolved Oxygen

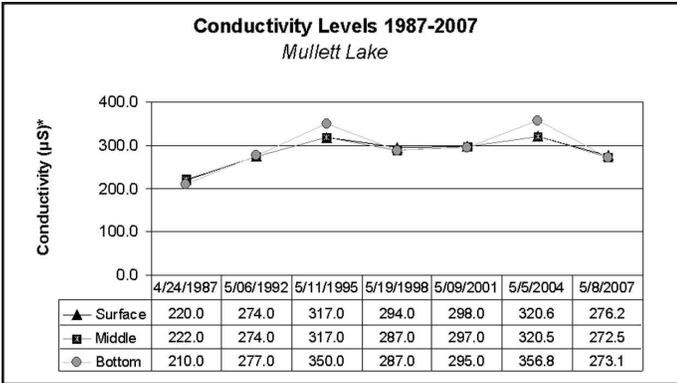
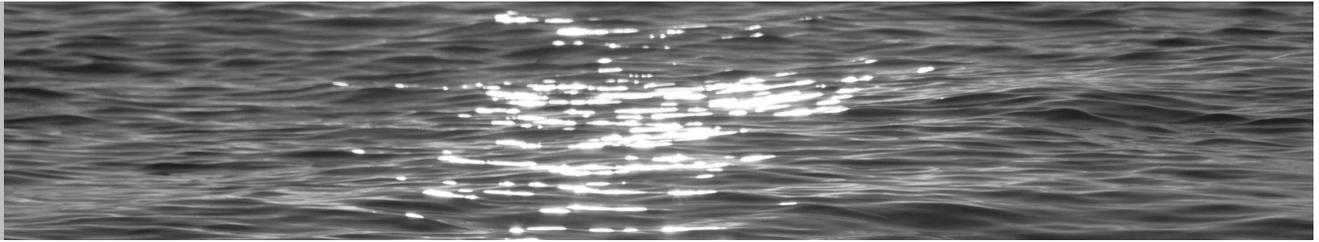
Oxygen is required by almost all organisms, including those that live in the water. Oxygen dissolves into the water from the atmosphere (especially when there is turbulence) and through photosynthesis of aquatic plants and algae. State law requires that a minimum of 5 to 7 parts per million (PPM) be maintained depending on the lake type. Dissolved oxygen levels recorded in Mullett Lake have consistently exceeded State minimums, ranging from 9.5 PPM (1998) to 12.5 PPM (2004).

Conductivity

Conductivity is a measure of the ability of water to conduct an electric current, which is dependent upon the concentration of charged particles (ions) dissolved in the water. Readings on lakes monitored by the Watershed Council have ranged from 175 to 656 microSiemens (μS), and in Mullett Lake, ranging from a low of 210 μS (1987) to a high of 357 μS (2004). There was a trend of increasing conductivity levels from 1987 to 2004, followed by a decrease in 2007. A steady increase in conductivity levels generally occurs due to greater human activity in the watershed and may indicate that water pollution is occurring.

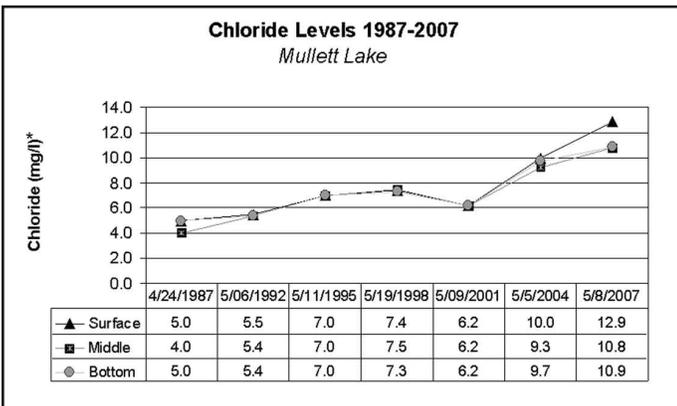


Kevin Cronk, our Monitoring and Research Coordinator, measures the water clarity on Mullett Lake with a secchi disc. This is just one of the many tests done to thoroughly check the health of the lake.



Chloride

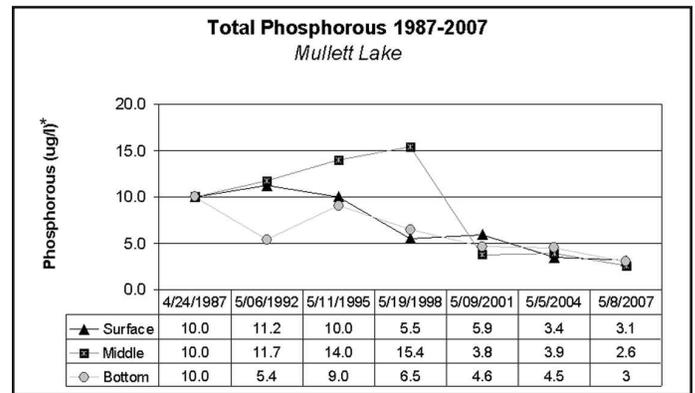
Chloride, a component of salt, is present naturally at low levels in Northern Michigan surface waters due to the marine origin of bedrock (typically < 5 PPM). Chloride is a “mobile ion,” meaning it is not removed by chemical or biological processes in soil or water. Many products associated with human activities contain chloride (e.g., de-icing salts, water softener salts, and bleach). Although most aquatic organisms are not affected until chloride concentrations exceed 1,000 PPM, increasing chloride concentrations are indicative of other pollutants associated with human activity (such as automotive fluids from roads or nutrients/bacteria from septic systems) reaching our waterways. Chloride concentrations have tripled in Mullett Lake, from a low of 4.0 PPM in 1987 to a high of 12.9 PPM in 2007.



Total Phosphorus

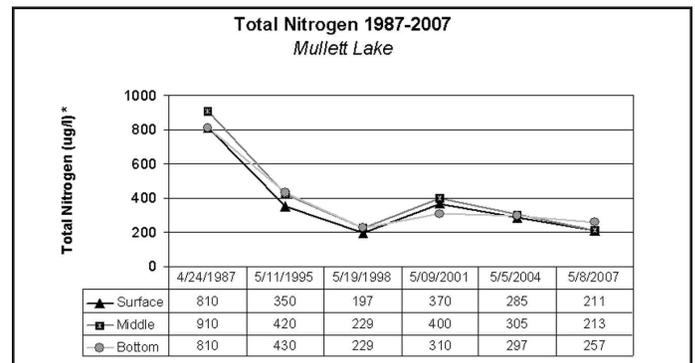
Phosphorus is the most important nutrient for plant productivity in surface waters because it is usually in shortest supply relative to nitrogen and carbon. A water body is considered phosphorus limited if the ratio of nitrogen to phosphorus is greater than 15:1.

In fact, most lakes monitored by the Watershed Council are found to be phosphorus limited. Although water quality standards have not been set for lakes, the U.S. EPA recommends that total phosphorus concentrations in streams discharging into lakes not exceed 50 parts per billion (PPB). Phosphorus is normally found at concentrations of less than 10 PPB in high quality surface waters. In Mullett Lake, total phosphorus concentrations have decreased during the last two decades, falling from 10 PPB in 1987 to approximately 3 PPB in 2007.



Total Nitrogen

Nitrogen is another essential nutrient for plant growth. It is a very abundant element throughout the earth’s surface and is a major component of all plant and animal matter. Although nutrients occur naturally, nutrient pollution is usually the result of human activities (e.g. fertilizers, faulty septic systems, and storm water runoff). In general, the lowest nutrient levels were found in Lake Michigan and large deep inland lakes, while the highest nutrient levels were found in small shallow lakes. Total nitrogen levels in Mullett Lake have ranged from 197 PPB in 1998 to 910 PPB in 1987. Nitrogen concentrations have gone up and down with a general trend of decreasing levels over time.



*Unit descriptions: mg/l = parts per million, µg/l = parts per billion, µS = microSiemens per centimeter

Comprehensive Water Quality Monitoring Program

2007 Data

Water Body	Date	Dissolved Oxygen (mg/l)	pH (units)	Specific Conductivity (µS)	Chloride (mg/l)	Nitrate-Nitrogen (µg/l)	Total Nitrogen (µg/l)	Total Phosphorus (µg/l)
Bass Lake	4/19/2007	12.33	8.41	309.6	38.1	17.0	504.0	7.9
Bear River	5/24/2007	8.78	8.26	338.0	12.3	103.5	305.0	8.6
Bellaire Lake	4/19/2007	12.43	8.36	294.9	8.5	428.1	469.0	4.6
Benway Lake	4/16/2007	11.37	8.08	311.7	8.5	419.4	556.0	1.6
Birch Lake	4/19/2007	12.48	8.30	257.0	15.6	42.5	279.0	3.7
Black Lake	5/4/2007	11.74	8.16	262.5	6.0	54.5	269.0	3.5
Black River	4/9/2007	13.14	8.17	260.7	2.9	62.4	250.0	3.1
Boyne River	4/2/2007	10.29	8.32	366.4	6.1	368.2	475.0	3.2
Burt Lake	5/8/2007	11.19	8.29	273.6	10.4	120.3	254.0	3.0
Charlevoix, Main Basin	5/2/2007	13.00	8.19	271.9	10.2	300.0	498.0	2.2
Charlevoix, South Arm	5/2/2007	12.28	8.30	285.3	9.1	570.6	508.0	2.4
Cheboygan River	4/9/2007	14.18	8.34	282.9	6.1	68.4	338.0	4.8
Clam Lake	4/17/2007	12.10	8.24	300.5	8.8	421.4	471.0	2.6
Crooked Lake	4/25/2007	11.62	8.31	275.1	7.8	267.9	404.0	2.8
Crooked River	3/28/2007	11.97	8.36	290.3	8.9	224.8	373.0	4.9
Deer Lake	4/24/2007	11.41	8.32	239.9	6.7	49.1	308.0	2.6
Douglas Lake	4/20/2007	12.24	8.22	194.9	6.8	46.9	455.0	9.4
Elk Lake	4/17/2007	13.24	8.31	249.4	9.3	262.3	338.0	2.9
Elk River	4/2/2007	11.64	8.47	267.1	8.0	245.0	305.0	1.0
Ellsworth Lake	4/16/2007	11.90	8.12	310.3	9.6	349.3	409.0	3.5
Hanley Lake	4/19/2007	11.79	8.26	316.5	9.4	443.7	547.0	3.3
Huffman Lake	4/30/2007	10.43	8.41	277.2	4.7	38.0	179.0	6.9
Huron, Duncan Bay	5/8/2007	12.11	8.27	215.5	8.2	170.5	311.0	3.9
Indian River	5/22/2007	10.13	8.25	284.7	10.4	105.2	316.5	3.9
Intermediate Lake	4/19/2007	12.11	8.33	315.9	11.3	442.6	608.0	3.4
Jordan River	4/2/2007	10.04	8.30	322.0	6.0	981.5	1021.0	5.6
Lancaster Lake	4/20/2007	10.08	8.25	201.1	7.9	53.8	444.0	13.5
Larks Lake	5/3/2007	10.88	8.50	189.6	4.2	66.0	453.0	7.6
Little Sturgeon River	5/21/2007	9.82	8.30	293.3	13.2	57.5	202.0	8.1
Long Lake	5/4/2007	11.40	8.21	191.3	8.9	45.3	346.0	4.4
Maple River	4/9/2007	14.41	8.17	222.3	3.3	270.3	472.0	3.0
Michigan, Bay Harbor	5/30/2007	10.87	8.13	262.2	13.4	279.0	391.0	2.5
Michigan, Grand Traverse Bay	4/17/2007	13.34	8.29	232.6	6.3	257.3	331.0	2.0
Michigan, Little Traverse Bay	5/17/2007	13.40	8.29	228.0	11.6	259.0	397.0	2.5
Mullett Lake	5/8/2007	11.54	8.28	276.2	12.9	73.0	211.0	3.1
Munro Lake	5/8/2007	11.88	8.35	187.8	4.0	79.6	948.0	9.5
Nowland Lake	5/10/2007	10.40	8.49	184.2	6.5	10.2	567.0	8.1
Paradise Lake	4/20/2007	12.58	8.29	180.7	10.9	35.5	569.0	8.3
Pickrel Lake	4/25/2007	11.07	8.31	267.5	6.3	209.1	361.0	2.7
Pigeon River	5/21/2007	9.75	8.37	316.0	6.8	28.0	247.0	7.8
Pine River	4/2/2007	13.54	8.47	277.7	7.7	322.2	418.0	4.6
Rainy River	4/9/2007	13.14	8.09	248.8	4.5	32.7	411.0	8.3
Round Lake (Emmet Cty)	5/1/2007	10.44	8.54	262.9	26.9	16.7	350.0	6.3
Silver Lake (Wolverine)	4/30/2007	11.15	8.30	190.0	4.2	35.2	1203.0	2.8
Six-mile Lake	4/24/2007	11.38	8.21	260.6	6.9	224.9	433.0	4.2
Skegemog Lake	4/17/2007	12.75	8.36	257.7	8.3	300.0	311.0	1.8
Spring Lake	5/1/2007	11.07	8.25	571.5	88.2	857.7	1292.0	7.3
St. Clair Lake	4/16/2007	11.97	8.13	293.6	6.1	283.8	385.0	3.2
Sturgeon River	4/9/2007	14.41	8.26	340.5	12.2	280.5	280.0	2.3
Susan Lake	4/24/2007	10.83	8.28	251.4	9.5	29.1	333.0	3.6
Tannery Creek	3/28/2007	12.22	8.22	428.1	37.1	705.2	902.0	5.7
Thumb Lake	4/30/2007	11.66	8.33	177.8	4.4	37.0	293.0	2.8
Torch Lake	4/17/2007	13.07	8.34	245.9	6.2	364.6	377.0	2.2
Twin Lakes	5/1/2007	11.27	8.40	239.5	2.3	10.3	275.0	7.7
Walloon, Foot	5/7/2007	11.77	8.18	243.6	12.4	91.2	279.0	1.9
Walloon, Mud Basin	5/9/2007	10.92	8.32	277.7	15.2	9.6	424.0	10.2
Walloon, North Arm	5/7/2007	10.91	8.24	267.1	14.2	268.5	458.0	4.1
Walloon, West Arm	5/9/2007	12.27	8.27	238.4	9.3	157.7	385.0	3.0
Walloon, Wildwood Basin	5/7/2007	11.79	8.24	238.8	12.5	82.9	255.0	2.7
Wildwood Lake	4/30/2007	10.13	8.42	247.0	13.2	>1	379.0	6.2
Wilson Lake	4/16/2007	11.75	8.11	317.6	9.7	405.2	595.0	1.9

Partnering to Protect Mullett Lake

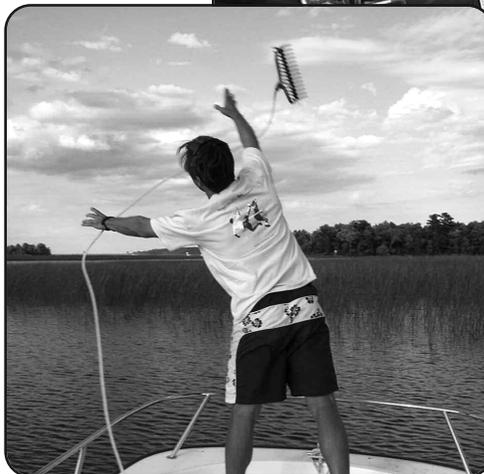
Tip of the Mitt Watershed Council and Mullett Lake Area Preservation Society (MAPS) Walk the Water Quality Protection Talk

During the summer of 2008, the Tip of the Mitt Watershed Council and the Mullett Lake Area Preservation Society (MAPS) collaborated to protect and improve the waters of Mullett Lake through simultaneous shoreline and aquatic plant surveys. The shoreline survey was carried out to document shoreline conditions and note stressors to water quality while the aquatic plant survey provided a baseline data set and an invasive aquatic plant inventory. MAPS sponsored the surveys with additional funding acquired by the Watershed Council through a grant from the National Fish and Wildlife Fund.

All 30 miles of the Mullett Lake shoreline were surveyed in the early part of the summer by Watershed Council staff and interns. Traversing the shoreline in kayak, Watershed Council staff and interns noted conditions at each shoreline property, including nutrient pollution as indicated by algae growth, erosion, greenbelts, shoreline alterations (seawalls, riprap, etc.), and stream inlets. Heavy algae growth was observed along extensive shoreline areas, indicating either serious nutrient pollution problems or a lake-wide ecosystem problem. In addition, greenbelts along much of the shoreline were in poor condition. On a positive note, few problems with erosion were noted.

After two field seasons of work, the aquatic plant survey of Mullett Lake and the connected Indian River Spreads up to the 175 freeway bridge was completed in the fall of 2008. Watershed Council staff sampled over 700 sites to note aquatic plant species, densities, and communities. Using a GPS, sample site locations were recorded and aquatic plant communities delineated in order to develop a map of the extent and types of aquatic vegetation found in Mullett Lake. Two invasive species were found during the survey: Eurasian watermilfoil and curly-leafed pondweed. Although occurrences of these invasive species were limited, growth in some areas was heavy and is being addressed to prevent them from spreading and over-taking the native plant communities that, fortunately, still dominate Mullett Lake.

For further details regarding the aquatic plant survey, the final report can be downloaded at the Tip of the Mitt Watershed Council website (www.watershedcouncil.org/water-resources/inland-lakes/mullett-lake). Although the shoreline survey report is still in the works, additional information can be obtained by calling the Watershed Council office. Next steps for the shoreline survey include: sharing information with the community through summary reports, working with shoreline property owners to determine if there are problems on their shorelines that affect water quality, and correcting any problems that exist. Through these collaborative efforts, the Watershed Council and MAPS together walk the walk of the Mullett Lake water quality protection talk!



Kevin Cronk, Monitoring and Research Coordinator for Tip of the Mitt Watershed Council, collects a representative sample of the diverse aquatic flora found in the Indian River spreads.

Volunteer Lake Monitoring

Local Volunteers Monitor & Protect Our Lakes

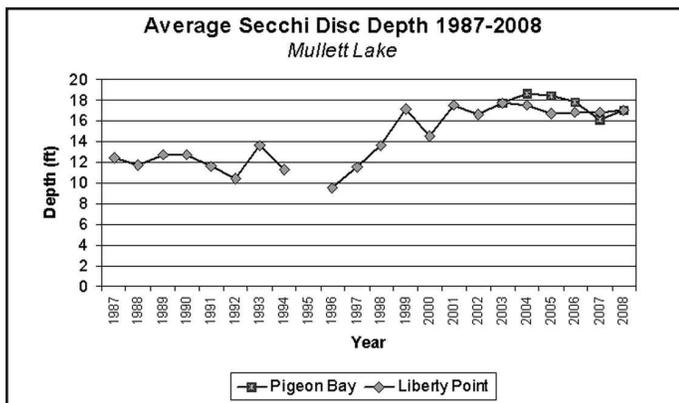
Since 1984, Tip of the Mitt Watershed Council has coordinated the Volunteer Lake Monitoring program (VLM), relying upon hundreds of volunteers to monitor the water quality of dozens of lakes in the northern Lower Peninsula of Michigan. During the summer of 2008, 40 volunteers monitored water quality at 33 stations on 25 lakes.

A tremendous amount of data has been generated by the VLM program and is available to the public via our web site (www.watershedcouncil.org/protect). This data is essential for discerning short-term changes and long-term trends in the lakes of Northern Michigan. Ultimately, the dedicated effort of volunteers and staff will help improve lake management and protect and enhance the quality of Northern Michigan's waters.

Volunteers measure water clarity on a weekly basis using a Secchi disc. Every other week volunteers collect water samples to be analyzed for chlorophyll-a. Staff at the Watershed Council process the data and determine Trophic Status Index (TSI) scores to classify the lakes and make comparisons. On Mullett Lake, volunteers have monitored water quality since 1987 and presently monitor in two locations: near the middle of the lake and in the south-east corner. The following section summarizes the results.

Secchi Disc

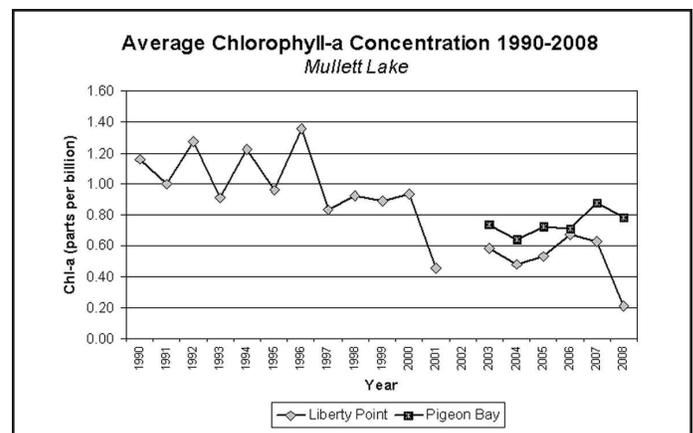
The Secchi disc is a weighted disc (eight inches in diameter, painted black and white in alternating quarters) that is used to measure water clarity. The disc is dropped down through the water column and the depth at which it disappears is noted. Using Secchi disc measurements, we are able to



determine the relative clarity of water, which is principally determined by the concentration of algae and/or sediment in the water. The clarity of water is a simple and valuable way to assess water quality. Lakes and rivers that are very clear usually contain lower levels of nutrients and sediments and, in most cases, boast high quality waters. Throughout the summer, different algae bloom at different times, causing clarity to vary greatly. Secchi disc depths have ranged from just a few feet in small inland lakes to 40-50+ feet in large inland lakes and Great Lakes' bays.

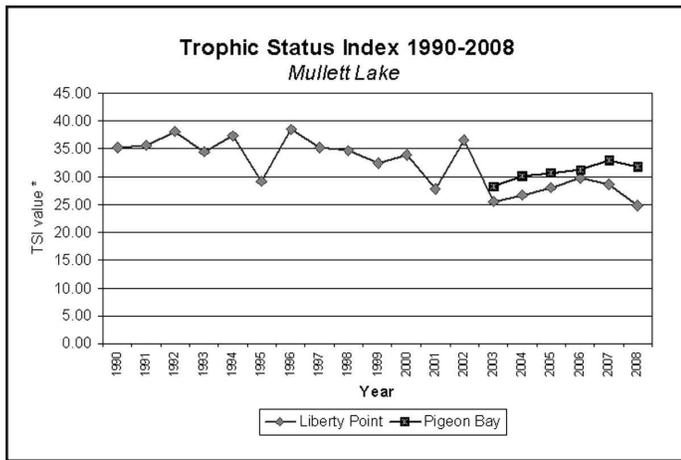
Chlorophyll-a

Chlorophyll-a is a pigment found in all green plants, including algae. Water samples collected by volunteers are analyzed for chlorophyll-a to determine the amount of phytoplankton (minute free-floating algae) in the water column. There is a strong relationship between chlorophyll-a concentrations and Secchi disc depth. Greater amounts of chlorophyll-a indicate greater phytoplankton densities, which reduce water clarity and, thus, the Secchi disc depth as well. So why collect chlorophyll-a data? The chlorophyll-a data provides support for Secchi disc depth data used to determine the productivity of the lake, but it can also help differentiate between turbidity caused by algal blooms versus turbidity caused by other factors such as sedimentation or calcite.



Trophic Status Index

Trophic Status Index (TSI) is a tool developed by Bob Carlson, Ph.D. from Kent State University, to determine the biological productivity of a lake. Formulas developed to calculate the TSI value utilize Secchi disc depth and chlorophyll-a



measurements collected by our volunteers. TSI values range from 0 to 100. Lower values (0-38) indicate an oligotrophic or low productive system, medium values (39-49) indicate a mesotrophic or moderately productive system, and higher values (50+) indicate a eutrophic or highly productive system. Lakes with greater water clarity and smaller phytoplankton populations would score on the low end of the scale, while lakes with greater turbidity and more phytoplankton would be on the high end.

TSI values do not measure water quality, but simply place the lake on a scale of biological productivity. Oligotrophic lakes are characteristically deep, clear, nutrient poor, and with abundant oxygen. On the other end of the spectrum, eutrophic lakes are shallow, nutrient rich and full of productivity, which when excessive can lead to oxygen depletion. Mesotrophic lakes lie somewhere in between and are moderately productive.

Lakes may be placed in the eutrophic category as a result of algal blooms, which are often a public concern and can be indicative of water pollution problems. On the other hand, low productivity of oligotrophic lakes may result in a lackluster fishery when compared to highly productive eutrophic lakes.

(2007 TSI Values for all lakes on back page.)

Results from Mullett Lake

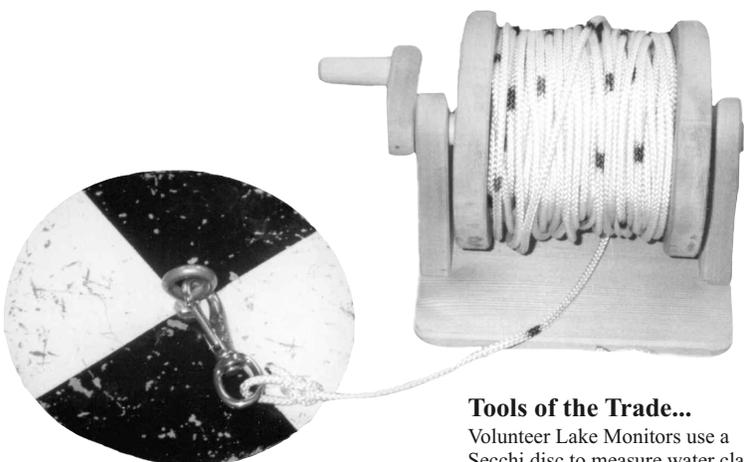
Volunteer monitors have collected water quality on Mullett Lake for over 20 years! Since 1987, the lake has been monitored in its deepest waters near Liberty Point, just out from the mouth of Mullett Creek. Due to the immense size of Mullett Lake and the potential for water quality to vary in different areas of the lake, a second monitoring location near Pigeon Bay was added in 2003. The long-term Secchi disc and chlorophyll-a data from these two sites allow Watershed Council staff to assess water quality and examine changes over time.

During the last 20 years, average Secchi disc depths in Mullett Lake have increased while average chlorophyll-a concentrations have decreased. These changes occurred in a time period that coincides with the introduction of the invasive zebra mussel. Zebra mussels are voracious filter-feeders that feed upon algae and essentially clear the water column. Unfortunately, zebra mussels are not cleaning the water, but rather removing the algae that are the base of the food chain and ultimately, causing ecosystem disruptions. Their feeding habits make them a very likely culprit for the changes we are seeing in Mullett Lake. If quagga mussels (another invasive in the Great Lakes) have made it into Mullett Lake, then the lake ecosystem will be more heavily impacted as quaggas cluster more densely and live at greater depths than zebra mussels.

Trophic status index numbers show that Mullett Lake is in the oligotrophic category (low productivity). Recently, since 2000, TSI scores have dropped considerably and now fall consistently in the 25 to 30 range. Mullett Lake appears to have become more oligotrophic: clearer, fewer nutrients, but maintaining high dissolved oxygen levels.

Overall, data show that Mullett Lake has exceptionally high quality waters. Without dedicated volunteers, we would have less data, so we would like to send out a big "thank you" to all those that have helped with the program. We would also like to encourage others to become involved with our volunteer program to help us monitor and protect the aquatic treasures of Northern Michigan.

If you would like to get involved, please contact the program coordinator, Kevin Cronk, at (231) 347-1181 ext. 109 or by e-mailing kevin@watershedcouncil.org.



Tools of the Trade...

Volunteer Lake Monitors use a Secchi disc to measure water clarity.

Trophic Status Index (TSI) Values for Lakes Monitored in 2008

Lake	TSI	Lake	TSI	Lake	TSI
Bass Lake	44	Lake Charlevoix, South Arm	32	Pickerel Lake	38
Black Lake	28	Huffman Lake	31	Six Mile Lake	44
Burt Lake, Central Basin	34	Lake Marion	23	Thayer Lake	43
Burt Lake, North	34	Lake Michigan, Bay Harbor	14	Thumb Lake	32
Burt Lake, South	36	Lake Michigan, Little Traverse Bay	27	Twin Lake	38
Crooked Lake	38	Long Lake, Cheboygan County	31	Walloon Lake, Foot Basin	34
Douglas Lake - Cheboygan	39	Mullett Lake, Center	25	Walloon Lake, North	37
Douglas Lake - Otsego	42	Mullett Lake, Pigeon Bay	32	Walloon Lake, West Arm	33
Elk Lake	38	Munro Lake	39	Walloon Lake, Wildwood	33
Lake Charlevoix, Main	24	Paradise Lake	45		

*Special Thanks to Our Mullett Lake Volunteers
We couldn't do it without you.*



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