Klinger Lake

Saint Joseph County, White Pigeon Twp. Sec. 1
Surveyed May-December 2006

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Environment

Klinger Lake is an 822 acre lake located in White Pigeon Township, Saint Joseph County (Figure 1). Public access is available at a state-owned site off of Crooked Creek Road. Klinger Lake is located within the Fawn River Watershed. Sherman Mill Creek is the main outlet of the lake to the Fawn River. The water level of Klinger Lake is maintained at an elevation of 806.52 feet by a water control structure on Sherman Mill creek (Figure 1). Thompson and Tamarack Lakes flow into Klinger Lake from the northeast with one additional unnamed tributary stream flowing into the lake on the southeast side. Maximum depth of the lake is 71.5 feet and average depth is 20.8 feet. The estimated volume of water is 17,092 acre-feet (MDNR Digital Water Atlas, 2006). Approximately 52.3 % of the lake area is less than 10 feet deep (Figure 2). The bottom of the lake is marl with a large, shallow, sandy perimeter. Residential shoreline development of the lake is high. Dwelling density around the lake was estimated at 67 dwellings/ mi in 2006.

Important components of water quality include phosphorous, nitrogen (ammonia, nitrate, and nitrite), water temperature, oxygen, carbon dioxide, pH, and a number of metals and salts. Water temperature and dissolved oxygen are critical habitat components for aquatic organisms. Water temperature influences internal physical structure, chemistry, biological metabolism, and the types of aquatic organisms that live in lakes. Water temperatures in Michigan lakes vary from the southern portion of the state to the northern portion, a function of regional air temperatures. Internal lake water temperatures also vary. The warmest water temperatures are found near the surface of the lake (epilimnion) during summer months and near the bottom of the lake (hypolimnion) during winter months. This condition is called stratification. Stratification is most pronounced during summer months when temperature differences between the epilimnion and hypolimnion are the greatest. A zone of rapid temperature change occurs in the metalimnion (also called thermocline) and this often forms a physical barrier that prevents interchange of water, gases, organic material, and nutrients between the epilimnion and the hypolimnion. A single temperature profile was measured in Klinger Lake during mid-August 2006. This temperature profile illustrates that summer stratification occurred in the lake with the water forming a 33 foot deep metalimnion from 15 to 48 feet (Figure 3).

Dissolved oxygen is important for sustaining aquatic life. The solubility of oxygen and other gases depends on water temperature. Colder water can contain more dissolved gases. Oxygen enters the water from the atmosphere and it is produced by aquatic plants during photosynthesis. Oxygen is used by all animals and microorganisms in lakes and it is removed by plants during respiration when sunlight is not available. Oxygen depletion can occur in lakes with high plant and animal oxygen demand, especially in areas of lakes where waters do not mix freely or come in contact with the atmosphere. Water quality standards (related to point-source discharges) in Michigan require maintenance of 7 mg/l dissolved oxygen for all Great Lakes and connecting waters, designated trout streams, and coldwater inland lakes. The water quality standard for other water bodies is 5 mg/l. Minimum dissolved oxygen levels for suitable summer habitat are approximately 3.0 mg/l for coldwater and coolwater fish and 2.5 mg/l for warmwater fish (Schneider 2002). The influence of water temperature stratification, dissolved oxygen, and trophic status determine the types of aquatic organisms that live in a lake. The dissolved oxygen profile in Klinger Lake showed a heterograde curve where the oxygen content reached a maximum of 9.8 mg/L in the metalimnion and declined gradually by oxidative processes in a typical clinograde reduction by depth (Figure 3). This maximum is the result of oxygen produced by algal populations that develop more rapidly than they sink out of the lower water column and is a typical result in clear water environments with lower productivity. Dissolved oxygen concentrations were above the warmwater fish levels of 2.5 mg/l throughout the metalimnion with anaerobic conditions in the hypolimnion. Critical depth is defined as the point at which dissolved oxygen concentrations are less than 0.5 mg/l and refers to a maximum depth that will support microorganisms like zooplankton. The critical depth in Klinger Lake occurred between 54 and 57 feet. This means that approximately 86% of the lake would have dissolved oxygen during summer stratification and only 14% of the lake would not have suitable dissolved oxygen levels.

The trophic state of a lake refers to the rate of organic matter supply and is a measure of its productivity. Oligotrophic lakes are low in productivity and eutrophic lakes are high in productivity. Mesotrophic lakes have intermediate levels of productivity. Rates of productivity are regulated by natural and human-induced levels of carbon and inorganic nutrient inputs into the lake. Mesotrophic lakes have Secchi disc transparencies usually between 6 to 15 feet. Nutrient levels are moderately high, with phosphorous concentrations ranging from 0.01 to 0.03 mg/l. Aquatic macrophytes may be abundant in shallow waters. Chlorophyll-a concentrations are usually between 0.002 to 0.010 mg/l. Organic matter deposition in the hypolimnion can result in oxygen depletion for a portion of the year. Anaerobic conditions promote nutrient recycling from the hypolimnion and lower rates of organic matter deposition.

The Klinger Lake association has been collecting water quality data through the MDEQ Cooperative Lake Monitoring Program. An approximate evaluation of the transparency of water to light is accomplished by a measurement tool called a Secchi disk. In general, the Secchi disk transparency depth corresponds to the depth of approximately 10 % of surface light. Trends in water transparency in Klinger Lake indicate that light penetration has increased since 1981 (Figure 4). This increase is likely a result of the reduction in light reflection from its water surface because of decreased absorption characteristics of the water and reductions of dissolved or particulate matter. Light has a fundamental importance to the dynamics of aquatic ecosystems. Aquatic plants directly derive the energy needed for photosynthesis from light. Use of this energy within a lake influences the lake productivity and absorption of solar energy and its dissipation of heat effect the thermal structure and stratification of water layers (Wetzel 2001). Klinger Lake has become less productive over time probably as a result of changes in septic systems around the lake. Concentrations of total phosphorous (0.012 mg/l), Nitrogen-ammonia (0.022 mg/l), and Nitrogen-nitrate+nitrite (0.288 mg/l) in the lake suggest that the trophic status is somewhat mesotrophic. Alkalinity is a measurement of the buffering capacity of the carbonate system in water. The term hardness is used as a classification of the content of water supplies. Samples collected in Klinger Lake were 134 mg/l suggesting the water is classified as hard with a good buffering capacity. Chlorophyll a concentrations were measured at 0.0026 mg/l.

History

Klinger Lake was surveyed by netting (4 fyke, 2 trap, and 4 gill nets), electroshocking, and seining (3 hauls over a 50'x150' area near the public access) during a June 1969 effort for two net nights. During the survey a total of 288 fish were collected with largemouth bass and bluegill the most abundant fish species captured. The survey gear captured 20 different fish species that are still part of the present fish community.

The lake was first stocked with 6,500 rainbow trout in March 1973. An additional 6,000 splake were introduced to the lake in May of the same year. These were the initial introductions of trout to the lake. A survey conducted in April 1973 captured stocked rainbow trout and indicated early survival of these stocked fish. However, later hook and line surveys, a 1975 netting survey, and creel interviews indicated poor long-term survival of stocked trout. References in the file also noted some eutrophication problems as a result of deficient septic tank operation of riparian homes, but referred to the lake as still oligotrophic with limited abundance of aquatic vegetation.

After a decade of letters requesting the stocking of walleye, approximately 10,437 fingerling walleye were introduced in Klinger Lake in early 1985 (Table 1). Low densities (<15 fish/acre) of walleye were stocked in the lake every year from 1985 to 1988. Higher densities (>50 fish/acre) of walleye stocking occurred after 1990. A fall electroshocking survey (SERNS Index) captured 17 young-of-the-year walleye and revealed acceptable survival of stocked fish. Additional SERNS surveys were conducted in 1992, 1994, and 1996 with no captures of young walleye but a few adult walleye were captured. Subsequent management actions involved stocking of walleye on an alternate year schedule and at densities greater than 50 spring fingerlings per acre (Table 1).

A general survey conducted during spring 1996 was completed to obtain information on the fish community including species diversity, relative abundance, and growth of selected fish. There were three types of gear used during this survey that included four trap nets for an effort of 16 net nights, four gill nets (125 ft. experimental) for 16 net nights, and boat electroshocking for 1.6 hours. A total of 20 fish species were collected by these three gear types, including lake herring. Bluegill was the most abundant species collected. Common Carp was the only non-indigenous Michigan species captured. A total of 208 largemouth bass were captured by all gear types. Boat electroshocking resulted in a catch rate of 1.2 fish/min for largemouth bass. Temperature and dissolved oxygen profiles of the lake were also collected in August, 1996. These profiles showed similar conditions to the profiles collected in August 2006. Dissolved oxygen concentrations were above 2.5 mg/L to a depth between 35 and 40 feet. The critical depth was around 54 feet with summer stratification profiles similar to conditions observed a decade later.

During the summer of 2001 large numbers of largemouth bass were reported to be dead on the surface of the lake. Tournament anglers were asked to help collect fish to be tested for largemouth bass virus (LMBV). This virus was confirmed to be present in the population by pathologists at the LaCrosse, Wisconsin fish health laboratory. Klinger Lake was the second confirmed lake in Michigan to have LMBV. In the summer of 2003, a total of 30 largemouth bass ranging in size from 9.0 to 15.3 inches (mean = 11.6 in.) were collected using boat electroshocking. These fish ranged in age from two to eight years with 47% of the fish collected consisting of age two bass. This survey indicated that the presence of the virus has remained in Klinger Lake over a period of three years and although no mortalities were observed in 2003 the virus was present in several younger year classes. As these fish reach larger sizes, mortalities from the virus could be expected.

Current Status

Habitat

Habitat and lakeshore development metrics were visually assessed by boating during daylight hours. Data were recorded in 1,000-ft intervals. Submerged trees large enough to provide fish habitat (>3 inches diameter) were counted as the boat moved along the shoreline. Any submerged trees visible between the boat and the lakeshore were counted. Dwellings having obvious lake frontage were counted within each transect. Criteria for obvious lake frontage included: contiguous lawn from near edge of a dwelling to the near edge of the lake, and no road separation between a dwelling and the lake. Only dwellings located immediately along the shoreline were counted, visible dwellings occurring behind other shoreline dwellings were not counted. Docks extending from the shore were counted. Docks piled on the shore and not in obvious use were not counted. Size of docks and number of hoists or mooring positions were not evaluated. Percentage of shoreline, within a 1,000-ft transect, having armoring was visually estimated to the nearest 10% by each crew member and then averaged to the nearest 10% to obtain an estimate for the entire lake. Bank (shoreline) armoring included wood or steel sheet pilings, cement walls, or gabions positioned along the shoreline in a vertical or sloping position to prevent erosion. Twenty-four transects of 1,000 feet and one additional 450 ft. transect were sampled on Klinger Lake. Average number of dwellings for every 1,000 feet of shoreline was 12.8 homes with a density on the lake of 67 dwellings/ mi. Mean number of small and large docks was 8.1 and 5.4, respectively. Percentage of shoreline armored was estimated at 74%. Mean number of submerged logs was 0.125 for every 1,000 ft of shoreline.

Fishery

There were two survey efforts conducted on Klinger Lake in 2006. Sampling effort for fish was based on statewide status and trends protocol with standardized sampling gear by lake size (Hayes et al. 2003). The status and trends survey was conducted for three net nights in May and a single night of electrofishing in August. Nets were randomly set at different transects each day. We used three trap nets for three net nights, two large-mesh fyke nets for three net nights, two small-mesh fyke nets for one net night, three gill nets for three net nights, four seine hauls, and three 10-minute boat electrofishing transects. An additional three 10-minute transects were conducted for collecting bass to increase sample sizes. The second survey was conducted during the fall (November -December) with experimental and straight run gill nets to evaluate the presence of lake herring.

We recorded mean catch per unit effort (CPUE) by gear type as an indicator of relative abundance, utilizing the number of fish per net night (including recaptures) for all net lifts that were determined to have fished effectively. As one possible index of fish community composition, the percent by number of fish we collected in each of three feeding guilds was calculated for, 1) species that are primarily piscivores; 2) species that are primarily pelagic planktivores and/or insectivores; and 3) species that are primarily benthivores. Of the species collected, we classified northern pike, walleye, largemouth and smallmouth bass, bowfin, and longnose gar as fish predators; bluegill, rock bass, yellow perch (planktivore with highly variable percent contribution of benthic prey), black crappie, sand shiner, blacknose shiner, brook silverside, banded killifish, golden shiner, and warmouth as pelagic planktivores-insectivores; and brown and yellow bullheads, pumpkinseed (may be highly reliant on benthic resources), golden redhorse, redear sunfish, and bluntnose minnow as benthivores.

We collected a total of 4,503 fish of 21species during the status and trends survey. Common map turtle and mudpuppy were also captured in our gear. The fish species collected represented a combination of warm water and cool water fish. Lake herring, a state threatened species, was collected during the fall gill net survey. Walleye and redear sunfish are not original members of the lakes species composition but have been intentionally introduced by stocking. The overall fish community composition in Klinger Lake was 5% fish predators, 86% pelagic planktivores-insectivores, and 9% benthivores.

Sand shiners were the most abundant forage fish captured in the survey (subsample of 2,280 individuals). Other forage fish captured included bluntnose minnow, blacknose shiner, golden redhorse, brook silverside, and banded killifish. Brook silversides are a unigue fish found mostly in marl lakes with low turbidity and a characteristic behavior of frequently jumping at the surface of the water to feed and avoid predators (Hubbs 1921). Banded killifish are another unique fish found in lakes where schools are usually found over sand-bottomed shallows with patches of submerged aquatic plants (Scott and Crossman 1973).

Bluegill, rock bass, redear sunfish, black crappie

Bluegill was the most abundant sunfish captured during the survey (49.22 fish/trap net). A total of 1,228 individuals were collected. Most bluegills sampled were age four (42.88%), age three (24.77%), and age five (16.44%); age two and three had not fully recruited to the gear, and only one age seven fish was captured. Size of bluegill at each age was good (Table 2). Growth was assessed using the time (in years) to reach a preferred length of 7 inches as derived from the von Bertalanffy growth model. Bluegill growth in Klinger Lake took 4.4 years to reach 7 inches. The maximum possible size as estimated by a von Bertalanffy growth model (K= 0.2516, Linf = 9.7, to = 0.24) was 9.7 inches. Bluegill size structure was quantified using the relative stock density of preferred length fish. A relative stock density value for bluegill was 25 for preferred length fish greater than 7 inches. Bluegill size at age was good relative to statewide averages. Rock bass was the second most abundant fish captured in trap nets (8.22 fish/net). Rock bass age structure consisted of ages from two to eight. A total of 177 fish were captured with 54.4 % of the catch consisting of age 4. Growth of rock bass was up to 11.3 inches with the average length near 8 inches. Most redear sunfish captured were age three (87%) and age four (13%), with age one and two absent. Most black crappies were age three (80%) and age four (20%), with all other age classes absent. We did observe numerous black crappie captured by anglers and the absence of fish in the sample may have been a result of these fish located in areas away from our gear.

Smallmouth bass and largemouth bass

The age structure for largemouth bass consisted of ages from two to nine. The age frequency distribution for largemouth bass was higher for the younger cohorts (age 2-5) but the status of the older successive age groups was proportionally lower. Most of the largemouth bass were age four (42.5%), age three (27.2%), and age two (12%); age's six to nine combined for 9.2% of the age structure. Catch per effort of legal largemouth bass from trap net catches was 0.15 fish/net. Catch rate of largemouth bass from electroshocking efforts was 0.02 fish/min and lower than regional values from other status and trends lakes. Only 13% of largemouth bass captured were of legal size (>14 in.) but size at all age groups was good (Table 2).

The age composition for smallmouth bass consisted of ages from one to eight. The sample of smallmouth bass indicated variable strengths of ages with ages two and four having similar strengths (23.8%). Ages three, five, and six had similarly low age class strengths (4.8%). Ages one and seven had similar age class strengths (14.29%). The catch rate (0.001 fish/min) of smallmouth bass was lower than other regional status and trends lakes and lower than the catch rate for largemouth bass.

Walleye, northern pike, and yellow perch
Walleye age groups matched well with stocking year classes. Among the groups captured were fish present from 2004, 2001, 1999, and 1996. The only year class not present in our survey was 1998 and this may have been a result of poor size at stocking (Table 1). Average length of young-of-the-year (Age 0) walleye captured during the fall survey was 11.4 inches. Walleye are reaching the 15" minimum size limit at age 2 with good size at age for all groups captured (Table 2). Absolute growth of age 2 walleye was 3.13 inches and a growth rate of 0.45 inches per month from May to December. Absolute growth of age 5 walleye was 0.35 inches and a growth rate of 0.05 inches per month from May to December.

Northern pike age composition consisted of ages from two to nine. Absolute growth of age 2 pike was 1.81 inches and a growth rate of 0.26 inches per month from May to December. Absolute growth of age 3 pike was 2.36 inches and a growth rate of 0.34 inches per month from May to December. Northern pike growth took 3.8 years to reach the 24" minimum size limit with the largest individual captured at 36 inches (Table 3).

A total of 47 yellow perch were captured during the survey with a majority of the fish (42) captured in gill nets. Average length of yellow perch from the gill net catch was 8.2 inches with sizes up to 11.3 inches. Yellow perch age composition consisted of ages from two to six with 38% of the catch consisting of age 4.

Analysis and Discussion

Alternate years of stocking spring fingerling walleyes at high densities from 1990 to 2006 have resulted in the creation of an acceptable walleye fishery in Klinger Lake. Redear sunfish were not stocked in Klinger Lake but have moved into the lake from Thompson Lake where they were first observed in the watershed. Redear sunfish are larger in size than their nearest family members, the bluegill and pumpkinseed, and should provide an additional angling opportunity. Bluegill growth was good with preferred lengths of fish greater than seven inches available to anglers. Black crappie was underrepresented in our sample, but is an abundant component of the fish community as demonstrated by the many crappies that were caught by anglers while we were conducting the survey.

Catch rates of largemouth bass decreased from the previous survey conducted in 1996. Relative abundance of bass in Klinger Lake appears to have decreased over the past decade. This may be a sign that LMBV has proportionally reduced the abundance of older fish in the population. It appears that smallmouth bass year class strength is variable and the lake environment might not be as suitable for smallmouth as it is for largemouth bass.

Relative abundance of northern pike, largemouth bass, and smallmouth bass may be low in the lake, but these species express fast growth and achieve lengths over time that are amenable to current management regulations, which also indicates a good balance in the fish community.

Management Direction

Users of Klinger Lake should take every precaution to prevent the transfer of fish from the lake to other lakes or streams to help prevent the spread of aquatic invasive species (e.g. zebra mussel) and pathogens of concern (e.g. LMBV). Anglers and boaters can help prevent the spread of largemouth bass virus and other viruses or bacteria that cause disease in fish by not transferring fish between water bodies, and by thoroughly cleaning boats, trailers, nets, and other equipment when traveling between different lakes and rivers. The use of a light disinfectant such as a solution of one part chlorine bleach to 10 parts water (i.e., one gallon of bleach to 10 gallons of water) to clean vessels and live wells is very effective against viruses and bacteria that cause disease in fish. Soaking exposed items such as live wells, nets, anchors, and bait buckets in a light disinfectant for 30 minutes is also an effective method to prevent the spread of a wide range of aquatic nuisance species.

Human activities can negatively affect inland lake ecosystems through alterations in water quality and physical habitat. For example, increased nutrient loadings from septic seepage and lawn fertilizers can increase primary production, increase algae and aquatic vegetation to nuisance levels, and decrease concentrations of dissolved oxygen when excess algae and vegetation decompose. In addition, the quantity and quality of physical habitat available to fishes in the littoral zone can be altered by removal of coarse woody structure, by an increase or decrease (via chemical or mechanical removal) of aquatic macrophytes, and by homogenization of the shoreline through erosion control efforts (e.g., rip-rap and sheet piling sea walls). Such changes in water quality and habitat features have been shown to negatively impact fish growth (Schindler et al. 2000), limit natural reproduction of certain fish species (Rust et al. 2002), and reduce fish species richness and shift assemblage structure towards more tolerant species (Jennings et al. 1999). Environmental regulations (e.g. Michigan water quality standards) to protect the water quality of Klinger Lake should be upheld to protect the habitat for lake herring, a state threatened fish. Landowners should also attempt to create diverse habitat structure along the shoreline by promoting the establishment of logs and reducing the effects of shoreline development by removing steel seawalls and replacing these structures with rock, logs, or natural vegetation.

Klinger Lake should be stocked with walleye spring fingerlings at densities greater than 50/acre on a biannual schedule. Growth of walleye and an abundant source of forage fish in the lake suggest that more walleye can be supported within this community.

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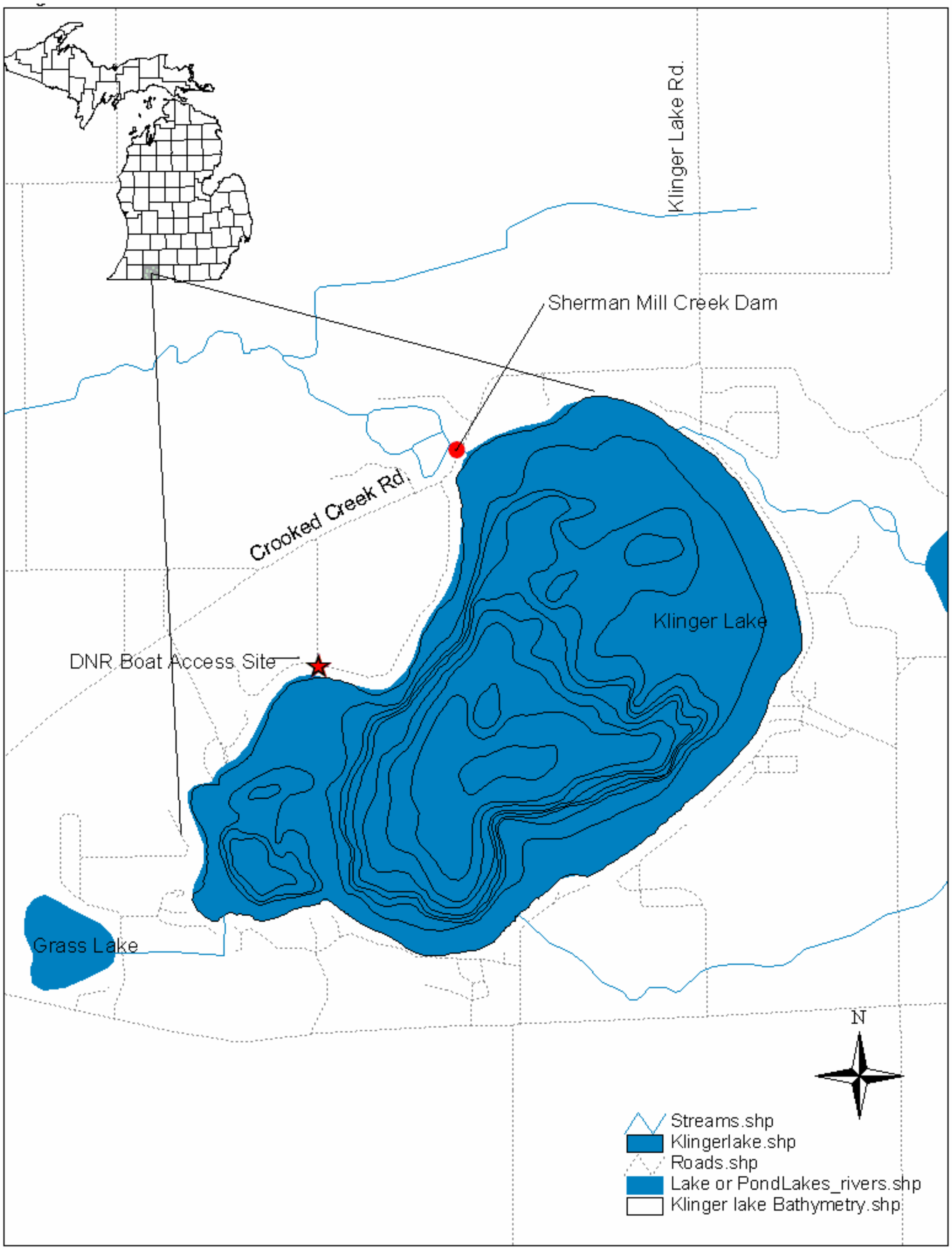

Figure 1. Klinger Lake, Saint Joseph County, illustrating the water depth bathymetry lines at 5 ft. intervals and location of public access. Insert in the top left corner is the state of Michigan with Saint Joseph County highlighted in gray.

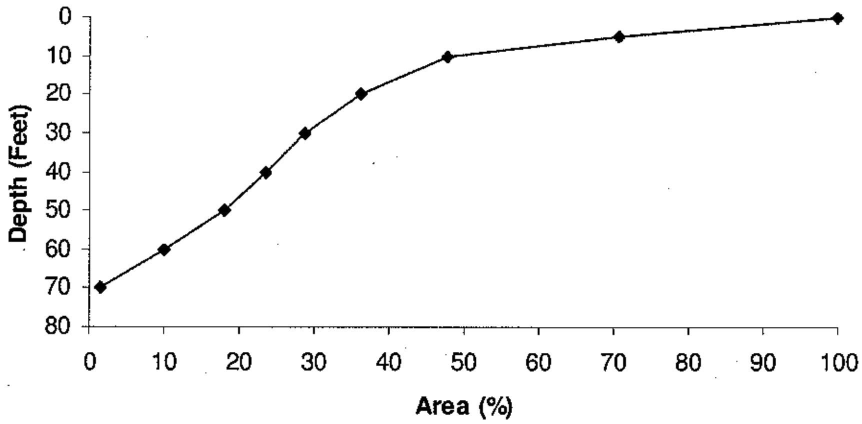

Figure 2. Hypsographic curve (depth-area) of Klinger Lake, Saint Joseph County. Data obtained from MDNR Digital Water Atlas.

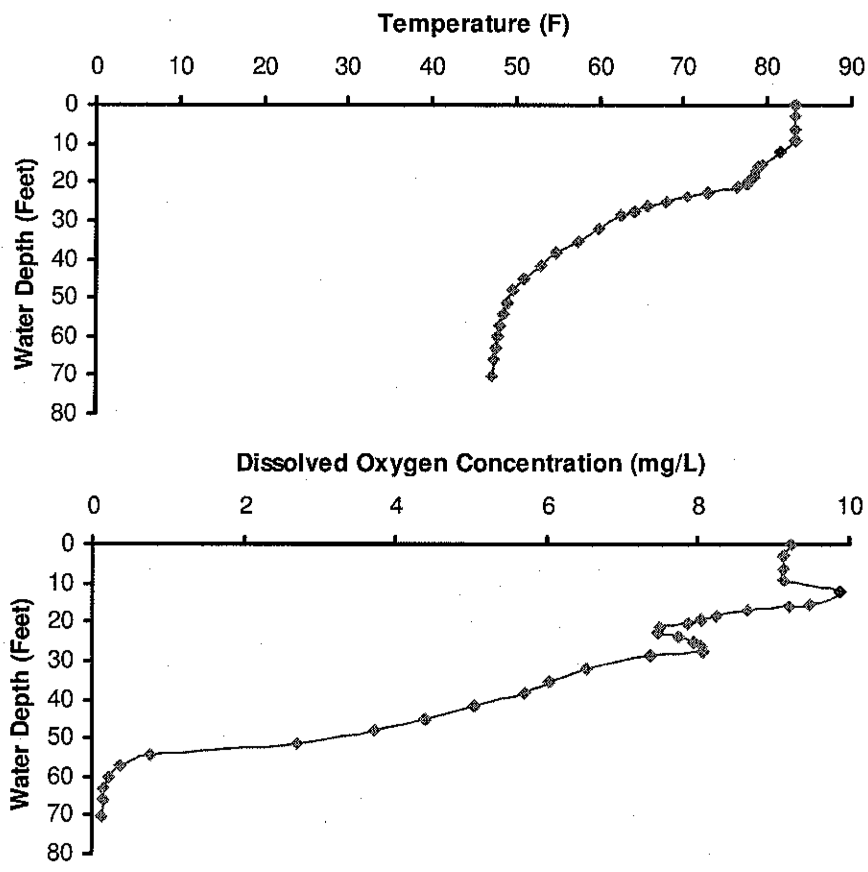

Figure 3. Temperature (upper panel) and dissolved oxygen (lower panel) profiles during summer stratification of Klinger Lake, Saint Joseph County.

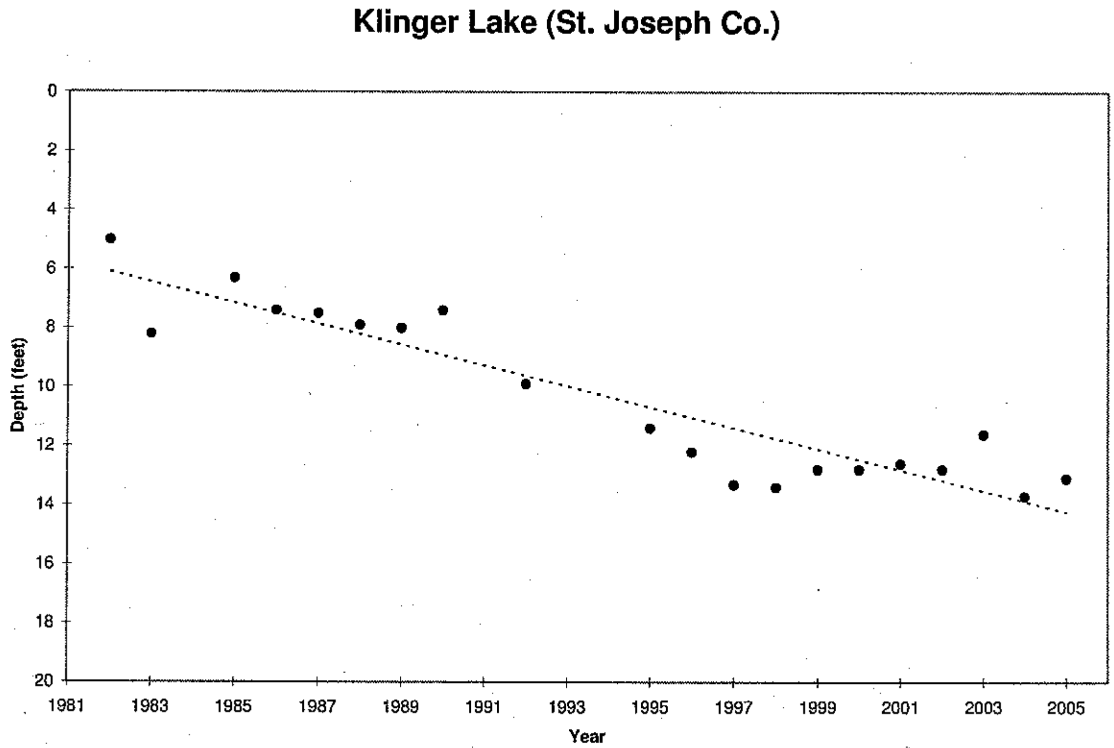

Figure 4. Secchi Disk measurements of water transparency from 1982-2005 in Klinger Lake, Saint Joseph County.

Table 1. Walleye spring fingerlings stocked in Klinger Lake 1985-2006

Date Stocked	Number	Weight (kg)	No/kg	Avg. Length	Number/Acre
06/01/2006	42,333	20.3	2,085	1.63	51.5
06/02/2004	41,569	11.7	3,559	1.24	50.6
06/13/2001	42,084	23.45	1,794.60	1.77	51.2
06/03/1999	111,438	56.03	1,988.90	1.54	135.6
06/05/1998	17,984	5.7	3,155.10	0.5	21.9
05/20/1998	37,677	10.16	3,708.40	1.14	45.8
06/14/1996	14,825	26.7	555.24	1.6	18.0
06/10/1996	40,271	86.8	463.95	1.26	49.0
06/09/1994	41,545	28.17	1,474.8	1.7	50.5
06/15/1992	46,564	17.6	2,645.7	1.4	56.6
06/14/1990	41,500	41.0	1,012.2	2.1	50.5
06/24/1988	12,512	10.7	1,169.4	1.9	15.2
06/15/1987	9,912	10.7	926.4	2.1	12.1
06/18/1986	12,580	10.1	1,245.5	1.9	15.3
06/17/1985	10,437	6.2	1,683.4	0.7	12.7

Table 2. Weighted mean length by age for selected fish species with sample sizes (number aged >3) collected from Klinger Lake, May 2006.

Age	Bluegill	Rockbass	Largemouth	Smallmouth	Walleye	Northern Pike	Yellow Perch
1	1.8			5.17			
2	3.3		7.6	7.32	16.36	19.75	6.45
3	5.3	5.8	9.5			22.37	7.68
4	6.4	7.96	11.25	12.32		26.7	8.07
5	7.1	9.5	13.5		20.68	27.2	8.67
6	7.7	10.3	15.6				11.25
7			15.85	16.6	22.85		
8			16.8				
9			17.1				
10					26.8		

Table 3. Number of fish measured for each inch group in Klinger Lake, May 2006.

Inch Group	bluegill	largemouth	northern pike	rockbass	smallmouth	walleye	yellow perch
1	86						
2	17						
3	44						
4	103			1	1		
5	393			10	3		
6	289	2		19	2		12
7	207	9		36			7
8	62	11		54	2		15
9	8	22		29			11
10		24		25			
11		19		2	2		2
12		11			3		
13		6			1		
14		3					
15		5			2	1	
16		3	2		2	8	
17		5	1		1	1	
18			2		2		
19						2	
20			2			9	
21			2			5	
22			2			1	
23						3	
24			2			2	
25			4				
26			1			1	
27			1				
28			1				
29						1	
31			1				
35			1				
36			1				
Total	1209	120	23	176	21	34	47