Kingston Lake
Alger County, T48N, R15W, Sec 5, 6, 8
Lake Superior watershed, last surveyed 2018

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Environment

Kingston Lake is a 125-acre natural lake located approximately 30 miles northeast of the City of Munising, Michigan in Alger County. Kingston Lake rests just off H-58 at the northern edge of the Kingston Plains, site of a large wildland fire in the 1930's where much of the landscape has remained a barren stump field. In a straight line bearing northwest, Kingston Lake is roughly 2.5 miles from Lake Superior. Except for a small inlet from Kingston Pond (former trout lake), there is no other inlet or outlet for Kingston Lake and it remains disconnected from any specific watershed. The relatively small Kingston Lake watershed (catchment area- 1,401 acres) lies in the middle of the Lake Superior State Forest managed by Michigan DNR Forest Resources Division (FRD) out of the Shingleton Unit. Michigan DNR FRD recognizes this area as Compartment 136 of the Shingleton Unit, which consists primarily of a natural white pine community with some mixed deciduous species.

Resting directly adjacent to the Pictured Rocks National Lakeshore (PRNL) boundary, Kingston Lake is a dish-pan shaped basin only reaching a maximum depth of 32 ft (recorded 1955). The lake possesses an extensive littoral zone with an estimated 90% of the lake less than 15 ft (lake unmapped) in depth. As a medium size lake (100-1000 acres; Wehrly et al. 2015), there is one main basin in the center with many narrow and shallow bays extending in both north and south directions. Kingston Lake does have one island covering about 3 acres. The benthic substrate consists primarily of sand and pulpy peat while littoral zone substrate consists primarily of sand and sparse gravel with submergent aquatic vegetation. The shoreline is about 5.4 miles and development is limited to only four dwellings (about 25% private riparian ownership) with the remaining shoreline undeveloped. There is a State Forest Campground located on the main basin of the lake that is operated by Michigan DNR Parks and Recreation Division (PRD). The campground has 16 sites and is very popular for visitors of the PRNL and other area recreation opportunities. Other ownership around Kingston Lake is by the State of Michigan (about 50%) and Hancock Forest Management (about 25%). The property owned by Hancock Forest Management is listed under the Commercial Forest Act, which allows foot travel access for hunting, fishing, and trapping. Access to the lake is excellent with a semi-improved boat launch (hard surface; no assistance pier) and gravel parking lot adjacent to the campground. Parking is limited with room for about 4-5 vehicles with trailers.

Lake levels at Kingston Lake have sparked tremendous interest by fisheries managers and visitors of the lake and campground for many years. Understanding the fluctuations in water levels of the Great Lakes region and how it influences inland lake water levels is complicated; however, many believe that Kingston Lake has a correlation to the elevation of Lake Superior. The surficial geology around Kingston Lake is 95% ice contact/outwash/Alluvium fluvial consisting of coarse textured Rubicon and Kalkaska sands (USDA soil mapping tool). Since these surficial soil types are coarse textured, drainage is very rapid. According to Winter et al. (1998), glacial outwash soil types (coarse sand) is highly permeable allowing for rapid drainage of the Kingston Lake catchment area. In glacial terrain (land-surface depressions), groundwater is both gained and lost as water drains from the landscape.

Winter et al. (1998) also stated because of the lack of stream outlets, the water balance in "closed" types of systems is controlled largely by exchange of water with the atmosphere (precipitation and transpiration) and groundwater. Because of the many shallow bays and gradual sloping bathymetry of Kingston Lake, water level fluctuations are exaggerated. The earliest report of fluctuating water levels in Kingston Lake was in 1958 when the local fisheries biologist reported the lake to be "very low" with more exposed shoreline than had been previously observed. Then in the 1970's, fisheries staff reported the water level to be above normal and this held until the early 1990's when at that time the lake was reported to be 6 ft below normal. Following the lowest reported lake level in 2012, the water level in Kingston Lake has steadily rebounded and during the summer of 2018 was reported by area fisheries managers as the highest level the lake has experienced. History has shown Kingston Lake will fluctuate due to groundwater levels and in relation to Lake Superior levels (Table 1). As a result of these fluctuating water levels, the Kingston Lake fish community and associated ecosystem experience more environmental pressures than other stable systems (See Analysis section).

The trophic status of a lake refers to overall productivity (biomass). Lakes can be described as oligotrophic, mesotrophic, and eutrophic, which are defined as low, medium, or high productivity, respectively. Water samples collected in 2018 were examined for chlorophyll-a, total phosphorus, total nitrogen, and alkalinity, which are parameters used to measure a lake's productivity. While chlorophyll-a concentration was identified as low (0.22 ug/L), total phosphorus and total nitrogen were found to be high at 24.4 ug/L and 1.06 mg/L, respectively. Total alkalinity is a measure of buffering capacity and plays an important role in determining pH and consequently, overall lake productivity. In 2018, alkalinity in Kingston Lake was 54 mg/L, which is considered moderate for Michigan lakes (Wehrly et al. 2015). Comparably, pH was measured at 8.6 at the water surface.

Dissolved oxygen (DO) is a critical component to suitable habitat in aquatic ecosystems. Dissolved oxygen in lakes derives from the atmosphere as well as from aquatic plants during photosynthesis. Concentration of DO in lakes can limit the distribution and growth of fish in lakes as well as the size composition and biomass of zooplankton, which is a primary food resource for juvenile and prey fishes. Concentrations of DO begin to limit fish populations at approximately 4.0 mg/L and are often lethal below 0.5 mg/L. Summer profiles of the water column were conducted in August 2003 and 2018 (Figure 1). The profile conducted in 2003 found acceptable DO levels for fish through the thermocline (metalimnion) to a depth of 21 feet. In 2018, suitable DO was down to 15 feet. Critical depth is defined as the depth at which DO concentrations are below 0.5 mg/L, which may be lethal to fish populations. The recorded critical depth in Kingston Lake in 2003 was 23 ft, while no critical depth was indicated in the 2018 profile. In addition, Secchi disk readings are an excellent indicator for primary production occurring in the water column. Secchi disk readings were 13.7 ft and 11 ft in 2003 and 2018, respectively. Secchi disk transparency decreased from 2003 to 2018 by 20%. Using the above parameters, Kingston Lake can be characterized as a mesotrophic lake, which typically supports a relatively diverse fish community and moderate biomass (moderate production). The greatest proportion of lakes in Michigan are mesotrophic lakes (Wehrly et al. 2015).

Kingston Lake has a long history of interest by anglers and recreational boaters. Pleasure boating is rather limited on Kingston Lake due to its remote location; however, some does occur because of the semi-improved boat launch and popularity of the State Forest Campground. Ownership around Kingston Lake is primarily public land with the State of Michigan owning nearly 50%. Residential development activities such as manipulating vegetation in lakes and along lakeshores, removing large

woody debris, shoreline armoring, dock construction, increase in nutrients from lawn fertilizer and septic tanks, boating and fishing are some of the ways humans influence lake systems (Wehrly et al. 2015).In 2018 as part of the Status and Trends survey, a habitat assessment was also conducted investigating dwelling density, dock density, shoreline armoring, and large woody debris density nearshore. The number of dwellings per mile along the shoreline of Kingston Lake in 2018 was 0.73 per mile (low). The number of docks in Kingston Lake in 2018 was 0.18 per mile (low). Kingston Lake has had very little disturbances to its shoreline; however, where shorelines are modified from their natural state there can be compounding effects on the lake ecosystem. For Kingston Lake, the amount of shoreline estimated to be armored was <0.6% (low).

Large woody debris is an important habitat component offering cover for fishes and other aquatic organisms as well as offering stability for the lake bottom and shorelines. Because Kingston Lake has experienced significant lake level fluctuations, large woody debris recruitment has been limited for extended periods of time and less than other mostly undeveloped inland lakes in Michigan. The amount of large woody debris in Kingston Lake in 2018 was recorded to be 95.6 trees per mile. However, due to the high water levels in 2018, all trees standing in water were counted and assumed to recruit to the lake when falling.

Overall, Kingston Lake is considered a low developed lake compared to other inland lakes in Michigan. Likely due to ownership, protections are high from shoreline manipulation, dwelling and dock construction, and removal of large woody debris. As a lake with medium depth, Kingston Lake performs very similar to other natural shallow inland lakes in the Upper Peninsula.

History

When fisheries management first began at Kingston Lake in the 1930s, it was estimated that the surface acreage was 250 acres. All stocking rates from the 1930s through 2000 were based on this acreage. Following many years of fluctuating water levels, fisheries managers worked to determine the actual surface acreage of Kingston Lake. In 2003, using a planimeter and updated aerial imagery in ArcView Software, it was determined the surface acreage of Kingston Lake was 124 acres and not the originally estimated 250 acres. This determination would have significant impact on management decisions moving forward. All stocking rates reported in this document will be calculated from 124 acres as estimated in 2003.

Kingston Lake has been stocked and surveyed by the State of Michigan on many occasions dating back to 1936. After 85 years of management, Kingston Lake has become well known for its Muskellunge fishery and remoteness for anglers seeking a destination fishery. Fisheries management began in 1936 with the Michigan Department of Conservation (MDNR today) stocking Smallmouth Bass (200 fall fingerlings). Through 1940 Bluegill, Brook Trout, Largemouth Bass, Pike-Perch (Walleye), and Smallmouth Bass were stocked in most years (Table 2). These efforts were with the intention to produce a diverse fishery. During this period angler reports indicated good fishing early for Brook Trout, Walleye, Yellow Perch, and Bluegill. Then around 1940, production had fallen off for these species. The next stocking occurred in 1943 with Brook Trout and no other stocking occurred until the 1970s. The local Fisheries Biologist (Leland Anderson, MDNR) kept personal angling creel records from 1949-1959. In these records, he indicated high catch rates for Bluegill, Smallmouth Bass, and Yellow Perch with the occasional Walleye. In the later years of his records, catch rates declined for these species, but size appeared to be increasing.

In the 1950s, managers investigated Walleye spawning and success, but found no evidence of natural reproduction. It was noted in 1955 the lake is lacking in gravel beds and might not be suitable for Walleye spawning. In 1955, a full investigation of the fish community took place which included seining, gill nets, hook and line, and a limnological profile. Collectively, these efforts captured Bluegill, Brook Trout, Brown Bullhead, Green Sunfish, Largemouth Bass, Pumpkinseed Sunfish, Smallmouth Bass, Walleye, Common White Sucker, Yellow Perch and an assortment of minnows, most notably Central Mudminnow, Bluntnose Minnow, Johnny Darter, and Mimic Shiner. The limnological profile found suitable DO down to 31 ft (8.2 mg/L) and a lake pH of 7.8. Through 1959, a productive mixed fishery existed, verified by local conservation officers. Reports included excellent Walleye fishing and with fish up to 5 lbs.

An abbreviated fish community survey was conducted in 1969 using gill nets. The survey captured Pumpkinseed Sunfish, Smallmouth Bass, Walleye, Common White Sucker, and Yellow Perch. One Walleye was captured and was aged at age 6, which was from the 1963 year class and indicated a naturally reproduced fish and first report of natural recruitment. This finding was encouraging for fisheries managers as they believed there may be an opportunity to create a sustainable Walleye fishery.

The fishery of Kingston Lake continued to grow in popularity for out-of-area anglers and many who frequented the campground. In 1972, another abbreviated survey was conducted using gill nets and a beach seine. This one-night netting and one seine haul survey captured Brook Trout, Largemouth Bass, Smallmouth Bass, Common White Sucker, and Yellow Perch. Yellow Perch were growing very slowly, which created concern for stunting. As indicated in the survey files, fishing at this time was only fair for Smallmouth Bass and anglers reported concerns about the fishery. As a result of the catch from this survey and recent angler reports, the fisheries biologist recommended to begin stocking Tiger Muskellunge (Northern Pike x Muskellunge hybrid). Fisheries biologists also stated this lake had potential for Bluegill. Duplicating effort from the 1972 survey, a return survey was conducted in 1973. This survey captured Largemouth Bass, Smallmouth Bass, and Yellow Perch. Yellow Perch were again found to be growing slowly. Fishing reports continued to be fair for Smallmouth Bass and Yellow Perch. Because it was stated that Kingston Lake would be a good fit for Tiger Muskellunge because of "good" Muskellunge habitat and no outlet, Tiger Muskellunge fall fingerlings were stocked in 1976 and 1978 at 24 and 8 per acre, respectively (Table 2). In 1979 an evaluation for the stocked Tiger Muskellunge was conducted using netting gear and electrofishing boat unit. A total of 10 Tiger Muskellunge were captured with 8 and 2 fish from the 1976 and 1978 cohorts, respectively. Tiger Muskellunge appeared to be growing well and fast enough to reach legal size by 1980 (30 inches). The survey also captured Bluegill, Largemouth Bass, Smallmouth Bass, Spottail Shiner, Common White Sucker, and Walleye. Negative effects from Tiger Muskellunge on the other species were not observed or considered to be an issue.

Fishery management in the 1980's for Kingston Lake included the continuation of stocking Tiger Muskellunge in alternate years with Largemouth Bass and Smallmouth Bass stocked in 1987 and 1989, respectively. Stocking rates for Tiger Muskellunge in the 1980s ranged from 2.8 to 20 per acre. A survey primarily targeting Tiger Muskellunge took place in June 1986 using fyke, trap and gill nets and electrofishing boat unit. A total of 3 Tiger Muskellunge were captured ranging in size from 29 to 40 inches. Also captured were Walleye (n=4) and Common White Sucker (n=24). All Walleye were

ages 5-10 and from natural reproduction. Catch per effort using the electrofishing boat for Common White sucker was 41.4 fish per hour. Comments from the survey included Smallmouth Bass and Tiger Muskellunge appear low in number while Common White Sucker appear numerous, with a small average size making them ideal prey for Tiger Muskellunge.

In 1990, as an effort to continue monitoring the fish community, a netting survey was conducted using fyke and gill nets (20 net nights). The survey captured Bluegill, Largemouth Bass, Pumpkinseed Sunfish, Smallmouth Bass, and Yellow Perch. Mostly notably in the catch were 76 Common White Sucker, 29 Brown Bullhead, one Walleye, and the first occurrences of Northern Pike and Rock Bass. Comments regarding the fish community were that black bass sizes decreased, Walleye and Tiger Muskellunge numbers decreased, and Common White Sucker and Yellow Perch numbers and size have increased. The last stocking effort for Tiger Muskellunge occurred in 1991 (3.6 per acre) as they were no longer available in the hatchery system due to difficulties in rearing and varied success. Northern Muskellunge would replace Tiger Muskellunge beginning in 1991 (stocking density of 2 per acre) with the intention of predation control on panfish. Walleye were also added to the management prescription (30 spring fingerlings per acre) to increase sport fishing opportunity. In 1992, following the first stocked cohort of Walleye under the new plan, a fall index survey was conducted to assess survival and condition ahead of winter. Catch per effort for young of year Walleye was 18 per mile. Seeing these results, fisheries managers were hopeful Kingston Lake would develop into a good Walleye lake. A fall index survey in 1996 captured 10 young of year Walleye and one young of year Northern Muskellunge. As a follow up to changes in management, a full fish community survey was conducted in the spring of 1997 using fyke and gill nets. The technician crew noted that due to the fyke nets being freshly treated with protectant, catch rates were much lower than expected during the survey (n=100) and can be recognized in the total catch compared with the 1990 netting survey (n=800). Growth rates for Yellow Perch and Walleye declined and it was decided a reduction in Walleye stocking was necessary. A total of 9 Common White Suckers were captured. The following year in 1998 a follow-up electrofishing boat survey (1.74 hours) was conducted capturing 8 Common White Suckers, 2 Walleye, and 1 Northern Muskellunge. Four other Muskellunge were observed but evaded the capture.

In 1999, because of the reduction in growth rates for Walleye, it was recommended to cease Walleye stocking for five years. Also, due to difficulties in rearing Northern Muskellunge in the hatchery system, zero were stocked from 1992 to 1998. Northern Muskellunge stocking was reinstated from 1999 to 2003 at a prescribed density of 6 per acre; however, actual stocking density was 3 to 4 per acre during this period due to limited supply.

In 2003, a survey using Status and Trends Protocol was conducted in Kingston Lake to provide managers with catch summaries, species growth, length-frequency information, and habitat characteristics. This was the first Status and Trends assessment conducted on Kingston Lake. The purpose of Status and Trends assessment is to provide a lake-wide inventory of various lake characteristics including fish community composition, water chemistry, and habitat status. Managers can then use results from this assessment and compare across similar waterbody types and species compositions to determine trends in the ecosystem. Summary of the total catch from the 2003 survey can be found in Table 3. Notable results from the survey were a decline in Common White Sucker and Yellow Perch biomass from the 1997 survey of 14% and 15%, respectively. Yellow Perch growth also declined. This survey also found some natural recruitment for Northern Muskellunge and Walleye.

Walleye natural reproduction appears to be carrying a small, residual population and fishery for anglers. Bluegill, Pumpkinseed Sunfish, and Yellow Perch populations are moderate and subject to predation by black bass and Walleye and angler harvest. Because the fish community appeared to be in better balance, Walleye stocking was recommended for reinstatement for 2004 (24 spring fingerlings per acre in alternate years).

In 2006, Walleye stocking was again ceased following results of a fall index survey that failed to capture any young of year Walleye. Managers believed that size at stocking of the spring fingerling walleye (1.4 in) was too small, thus limiting their success. Northern Muskellunge were continued for stocking at a recommended 3 per acre in every third year.

Because predators have been managed so intensively, a population estimate was attempted in 2008 for Northern Muskellunge, Largemouth and Smallmouth Bass, and Walleye. The mark and recapture electrofishing survey failed to capture enough of any species to calculate a population estimate. The survey did capture 68 Largemouth Bass, 20 Walleye, 15 Northern Muskellunge, and 6 Smallmouth Bass. Age analysis found 58% (11 of 19) Walleye and 80% (4 of 5) Northern Muskellunge from non-stocked years. Northern Muskellunge (n=11) were also jaw tagged during this survey to identify growth trends and angler exploitation (Table 4).

In March 2009, while on a pass-day, a local conservation officer was ice fishing on Kingston Lake for Northern Muskellunge using large sucker minnows. Each time a sucker was lowered down the hole, it quickly died. This triggered an investigation of the available DO in the water column. The technician crew measured DO in the water column just below the bottom of the ice and found unsuitable conditions for most game fish and suckers (2.6 mg/L @ 1 ft). At 2 ft below the bottom of the ice, DO readings were 0.7 mg/L. Managers suggested the lake was experiencing winter-kill conditions and the fish community should be monitored immediately after ice-out in the spring. In the spring, the technician crew conducted a site visit and found no floating fish or fish on the lake bottom.

Another fish community survey using netting gear was conducted in 2011 to investigate the effects of the winter-kill conditions in 2009 and a look at the predator/prey balance. Predators totaled 1.4% of the total catch (2003=9.4%). All Walleye and Northern Muskellunge captured were of legal sizes, while all black bass captured were sublegal. Of most concern from this survey was the Common White Sucker biomass. Common White Sucker biomass was 1% of the total biomass, down from 50% in 2003. The decline in Common White Sucker relative abundance was thought to be subject to the 2009 winter-kill conditions and continued high stocking rates of muskellunge (2.6 to 4 per acre) in the 2000s.

In spring 2012 another survey to evaluate predator and sucker relative abundance took place using an electrofishing boat unit. A total of 6 Northern Muskellunge (35 to 45 inches) were captured and jaw tagged (Table 4). A total of 25 Largemouth Bass (7 to 15 inches) and 3 Walleye (17 to 24 inches) were captured. These results triggered to skip the 2013 stocking of Northern Muskellunge to allow the Common White Sucker population to rebound. In the interim, the stocking density for Northern Muskellunge was reduced to 1.2 fish per acre every third year.

Tag returns for Northern Muskellunge from the 2008 and 2011 surveys were monitored and tracked through angler reports. Understanding growth and angler exploitation for a fish population is key to

proper management of a fishery. Of the 11 fish tagged in 2008, two fish were recaptured in the following years. Both fish showed zero growth over their time at large in Kingston Lake (Table 4). Poor growth is likely due to the consumption of only enough forage for maintenance and quite possible a result of poor temperature and DO conditions. In 2012 six fish were tagged, with five fish being recaptured by anglers and one of those fish being captured twice. Four of the six fish were captured within 2 years suggesting a low population density and vigorous fish. These four fish showed sporadic growth during their time at large in the lake. Three of the recaptured fish measured by anglers were smaller than when they were tagged. Nothing conclusive could be stated regarding growth of these fish.

Regulations for the Kingston Lake fishery have been relatively consistent since management began in the 1930s. All species have followed statewide regulations through 2021. In 1978 a spearing ban was first placed on Kingston Lake with the intent to protect stocked Tiger Muskellunge. The spearing ban remained through 1993 at which time, the statewide minimum size limit for Muskellunge was increased to 42 inches. Then in 1994 spearing was allowed due to the additional protections the larger minimum size limit provided. In 2011 and 2012 a statewide review of Northern Pike and Muskellunge spearing lakes was conducted and Kingston Lake was added to the spearing ban list. Because Muskellunge abundance in Kingston Lake was at such a low density, fisheries managers desired additional protections for the population to recover from the historically low lake levels and dismal Common White Sucker population. Since 2012, Kingston Lake continues to carry a spearing ban for muskellunge. The statewide possession limit for muskellunge was 1 fish per day through 2012 and then changed to 1 fish per angling year in 2013.

To address concerns for the lack of woody structure in Kingston Lake, in 2014 a habitat project partnered with Michigan United Conservation Clubs (MUCC), was completed. This habitat project intended to increase woody structure in the lake for refuge of juvenile fish. Due to extensive periods of low lake levels, woody debris recruitment was limited around the shoreline. The lack of woody structure affected the quality of the forage fish community and natural processes of the lake. Working with MUCC, 21 brush bundles were placed in the lake in water depths of 4-8 feet (Figure 2). A Forest Treatment Proposal and Completion Report was submitted and approved by Michigan DNR-FRD. In addition, as a wrap-up to this project in 2018, the MDNR Fisheries technician crew hinge cut trees around the shoreline offering additional woody habitat. A total of 11 groupings (2-3 hinge trees) were cut.

Current Status

The current status of Kingston Lake was determined by two surveys conducted to evaluate the fishery. Status and Trends surveys conducted in 2003 and 2018 by MDNR-Fisheries Division gathered information for the fish community, water chemistry, and habitat parameters. Each of these surveys used the following gear types: electrofishing, fyke nets, experimental gill nets, trap nets, and seine. In 2003 and 2018, total effort for these surveys totaled 37 and 31 efforts, respectively. A collection of other general surveys was used in the Analysis section for comparisons and trend information.

A total of 1,296 fish comprised of 12 species were captured during the 2018 Status and Trends survey (Table 5). Predators or gamefish species (Yellow Perch, Largemouth Bass, Smallmouth Bass, Great Lakes Muskellunge, and Northern Muskellunge) comprised 41% of the total catch by number and 61% of the total biomass. Pelagic species, such as shiners, minnows, and panfish comprised 58% of the

total catch by number and 29% of the total biomass. For benthic species, only Common White Sucker were captured and represented less than 1% of the total catch by number and 10% of the total biomass.

When considering the catch composition from the 2003 and 2018 surveys, except for Walleye, the fish species composition has mostly not changed. The presence of Walleye in Kingston Lake has been intermittent based on success of stocking and limited natural reproduction. Not capturing Walleye in the 2018 survey is not surprising since the last stocking occurred in 2006; however, Walleye should not be considered absent from the lake. The fish community found in the 2018 survey is much like that found during general netting surveys in the 1950s after Largemouth and Smallmouth Bass were introduced and those conducted in the early 1980s after Tiger Muskellunge were introduced. Through 2018, no invasive species have been captured in prior netting surveys or reported by anglers.

A total of 399 Yellow Perch were captured with an average length of 6.2 inches and a length range from 2 to 10 inches. Yellow Perch represented 31% of the total catch by number and 14% of the total biomass. Nearly 7% of Yellow Perch were greater than an acceptable size of 7 inches. Age distribution, as determined by scales and spines, indicated sufficient recruitment with 7 year classes (Age classes 2 to 8) represented. Age analysis indicated Yellow Perch were growing 2.1 inches below statewide average (Schneider et al. 2000). Yellow perch growth has decreased and remained below statewide average since 2003 (-0.6 inches reported in 2003). Catch per unit effort for Yellow Perch increased in 2018 (CPUE = 0.20) compared to that reported in 2003 (CPUE = 0.11).

A total of 344 Pumpkinseed Sunfish were captured with an average length of 5.0 inches and a length range from 2 to 8 inches. Pumpkinseed Sunfish represented 27% of the total catch by number and 20% of the total biomass. About 22% of Pumpkinseed Sunfish were greater than acceptable size of 6 inches. Age distribution as determined by scales indicated sufficient recruitment with four year classes represented. Age classes 3 to 6 were represented in the 2018 sample. Age analysis indicated that Pumpkinseed Sunfish were growing 0.3 inches above statewide average. Pumpkinseed Sunfish growth in 2018 was similar to that reported in 2003 (0.2 above statewide average). Catch per unit effort for Pumpkinseed Sunfish decreased in 2018 (CPUE = 0.09) compared to that reported in 2003 (CPUE = 0.12).

A total of 200 Bluegill were captured with an average length of 4.6 inches and a length range from 1 to 8 inches. Bluegill represented 15% of the total catch by number and 8% of the total biomass. About 16% of Bluegill were greater than acceptable size of 6 inches. Age distribution as determined by scales indicated sufficient recruitment with six year classes (Age classes 2 to 7) represented in the 2018 sample. Age analysis indicated that Bluegill were growing 0.7 inches above statewide average. Bluegill growth in 2018 was slightly higher than reported in 2003 (0.1 below statewide average). Catch per unit effort for Bluegill increased in 2018 (CPUE = 0.05) compared to that reported in 2003 (CPUE = 0.02).

A total of 113 Largemouth Bass were captured with an average length of 8.7 inches and a length range from 3 to 18 inches. Largemouth Bass represented 9% of the total catch by number and 19% of the total biomass. Only 5% of Largemouth Bass captured were of legal size (≥ 14 inches). Age distribution as determined by scales and spines indicated sufficient recruitment with six year classes represented. Age classes 1 to 5 and age 7 were represented in the 2018 sample. Age analysis indicated Largemouth Bass were growing 0.8 inches below statewide average, although growth in 2018 was

higher than that reported in 2003 (1.7 below statewide average). Catch per unit effort for Largemouth Bass in 2018 (CPUE = 0.03) was similar to that reported in 2003 (CPUE = 0.04).

A total of six Smallmouth Bass were captured with an average length of 10.4 inches and a length range from 6 to 16 inches. Smallmouth Bass represented less than 1% of the total catch by number and 2% of the total biomass. One-third (33%) of Smallmouth Bass were of legal size (≥ 14 inches). Age distribution as determined by scales and spines indicated inconsistent recruitment with only age classes 2 and 4represented in the 2018 sample. An estimation of growth for Smallmouth Bass could not be calculated due to a small sample size. Catch per unit effort for Smallmouth Bass in 2018 was similar to that reported in 2003 (CPUE= <0.01).

A total of nine Muskellunge (8 Great Lakes strain and 1 Northern strain) were captured with an average length of 29.1 inches and a length range from 25 to 31 inches. Muskellunge represented less than 1% of the total catch by number and 26% of the total biomass. None of the Muskellunge were legal size or greater (42 inches). Age distribution as determined by spines (dorsal rays) indicated only one year class, age 3, represented in the 2018 sample. Because only Great Lakes strain Muskellunge were stocked in 2015, the Northern Muskellunge is believed to be a natural recruit. Muskellunge growth in 2018 was 3.3 inches above statewide average. No growth estimate was calculated in 2003 due to small sample size. Muskellunge catch in 2003 and 2018 was 8 and 9, respectively. The average size of Muskellunge captured in 2003 was 32.8 inches with 12.5% at legal size or greater (42 inches).

A total of 11 Common White Sucker averaging 16.9 inches were captured with a length range from 15 to 18 inches. Common White Sucker represented less than 1% of the total catch by number and 10% of the total biomass. In 2003 a total of 109 Common White Sucker were captured with an average length of 15.4 inches. Common White Sucker length range in 2003 was 6 to 20 inches. Catch per unit effort for white sucker decreased dramatically in 2018 (CPUE = <0.01), compared to that reported in 2003 (CPUE = 0.06).

Analysis and Discussion

Overall, the fish assemblage of Kingston Lake is similar to medium-deep lakes in Michigan. In 2018, species richness was moderate (12 species), where species richness can be classified as low (<10 species), moderate (10-17 species), and high (>17 species) (Wehrly 2015). For the Upper Peninsula, species richness for Kingston Lake would be considered above average for medium-deep lakes. Lastly, the number of species in Kingston Lake did not change from 2003 to 2018, however, a few different species were represented in each sample.

Although Kingston Lake is classified as a medium-deep lake, the lake has functioned much like a medium-shallow lake over the past 85 years. With widely fluctuating water levels, in some years the lake would not stratify during summer months losing the ability to offer cooler water as a refuge for many of the species found in Kingston Lake. Also, during these low water periods winter-kill conditions became more common due to lost stratification, resulting in anoxic and hypoxic conditions of dissolved oxygen <0.5 and <4.0, respectively. Lastly, during low water years nearshore spawning substrate (i.e. gravel or organic material) would become exposed and inaccessible for fish species, such as Muskellunge, Walleye, and Common White Sucker. With the loss of suitable spawning substrates because of low water, natural recruitment for Walleye and Muskellunge has been inconsistent and not enough to maintain a fishable population.

Fisheries management for Kingston Lake centered around predator/prey balances through the decades. Typically, the biomass of a balanced fish community should consist of 33% each of piscivores (i.e. predators), pelagic species (e.g. panfish and minnows), and benthic species (e.g. suckers). In 2018, total biomass was 61% piscivores, 29% pelagic species, and 10% benthic species. As a comparison, in 2003 total biomass was 41% piscivores, 9% pelagic species, and 50% benthic species. With the exception of benthic species, the fish community is nearing balance. Getting Kingston Lake to a more balanced fish community has been a goal for fisheries managers despite continued environmental challenges and unknowingly high stocking rates for muskellunge (prior to 2003). With the rebounded water level in Kingston Lake and adjusted stocking rates based on re-calculated surface area and frequency following Kovacs and Francis (2016), the fish community should continue to trend toward a balanced fish community offering plenty of opportunity for anglers.

Walleye management in Kingston Lake began with fry stocking in 1939 and 1940 in hopes to create a fishery. Management prescriptions written over the years have adjusted stocking rates, periodicity, and ultimately have been cancelled. Walleye at one point were stocked to help control the panfish population. Considering piscivore biomass has been high for many decades, panfish control was never a true concern. In general, Walleye stocking had some success, but was mostly limited due to competition with black bass (Largemouth and Smallmouth Bass) and suitable habitat availability during warm water periods. Walleye have been caught periodically by anglers and with MDNR-Fisheries sampling equipment, but never amounted to a targeted fishery. Since the 1960's natural reproduction for Walleye has been documented, but with no consistency and likely due to the limited spawning habitat and low spawning stock (adult densities). Assuming water levels remain high or near normal, some natural reproduction should continue to maintain a low-density population. The Walleye population should remain low, providing an incidental fishery for anglers with an occasional big fish.

Black bass in Kingston Lake have settled into the fish community and now comprise much of the proportion of the piscivore community. In the Upper Peninsula, black bass populations generally have slow growth rates despite the presence of moderate to high density of forage species. Black bass growth rates in Kingston Lake have remained near statewide average, which is considered good for populations in the Upper Peninsula. Using proportional stock density (PSD) as the number of quality length fish (12 inches) as a proportion to the number of stock length fish (8 inches) and relative stock density (RSD) for legal sized fish (≥14 inches) to examine Largemouth Bass in Kingston Lake, the PSD value in 2018 was 25 and the RSD-14 value was 15. Gabelhouse (1984) stated that an acceptable stock density index (PSD) for a balanced population of Largemouth Bass values fell between 40 and 70 and an acceptable relative stock density index of preferred length (RSD-14) fell between 10-40. Using these indices, the Largemouth Bass population appears to be near balance with the proportion of fish at early maturation improving. Low samples sizes in 2003 for black bass and 2018 for Smallmouth Bass prevented any calculation of these indices. Considering size structure for black bass, black bass are achieving legal sizes (≥14 inches) offering some harvest opportunity to those interested anglers. In general, the black bass population appears to be self-sustaining and providing consistent recruitment to the fishery.

Yellow Perch have been well represented in all surveys conducted on Kingston Lake. Yellow Perch populations are very density dependent and as density increases stunting becomes more common. From 2003 to 2018, the percentage of Yellow Perch achieving sizes greater than 7 inches increased

from 2% to 7%. Changes in Yellow Perch size structure can be correlated to recruitment success of other piscivores, such as Walleye, in any given year. Yellow Perch up to 8 years old have been captured in recent surveys suggesting they are relatively long-lived, however, also subject to increased mortality as they age in the population. In years when piscivore densities were high, Yellow Perch densities were likely to decrease due to competition and predation. In the 2018 sample, Yellow Perch growth was 2 inches below statewide average, which suggests an increase in population abundance. As the fish community approaches balance, Yellow Perch will provide forage for other piscivores as well as larger fish for anglers.

In 15 years, biomass of pelagic species such as Bluegill and Pumpkinseed Sunfish, has increased by 20% (9% in 2003 and 29% in 2018). Fluctuations in panfish populations are typically a response to densities of piscivores. Over the past 15 years, predators have declined (closer to balance) resulting in a higher number of pelagic species. Size structure for both Bluegill and Pumpkinseed Sunfish have remained similar during this period, but with a 51% decline in the number of preferred size Bluegill at 6 inches. This decline is most likely a response to increased Bluegill abundance, for in 2003 and 2018 CPUE was 0.02 and 0.05, respectively. Pumpkinseed Sunfish abundance has remained similar, although there was a slight increase in CPUE from 2003 to 2018. Panfish populations have shown resiliency despite fluctuations in water levels and periodic winter-kill conditions. Habitat improvements made in 2014 and 2018 in the form of brush shelters helped to increase cover for pelagic species. This in return should increase recruitment for panfish and minnow species commonly found in netting surveys.

Stocking of Muskellunge should not occur in lakes that are less than 100 acres (Kovacs and Francis 2016). At 124 acres, Kingston Lake is one of the smaller inland lakes managed for Muskellunge in Michigan. Muskellunge in Kingston Lake has been the primary focus of management since 1976. Michigan DNR Fisheries Division Fish Stocking Guidelines for Muskellunge recommend stocking 1.5 fall fingerlings per acre every third year. Stocking rates through 2010 were determined to be too high and were putting strain on a preferred forage species, Common White Sucker. Because the Common White Sucker population needs to recover, the stocking rate for muskellunge since 2010 has been one fall fingerling per acre or less in every third year (2013 cancelled). This stocking rate should continue to slowly rebuild the Muskellunge population while concurrently allowing the Common White Sucker population to recover. Historically, Muskellunge growth rates were high in Kingston Lake despite high densities due to overstocking. With reduced stocking rates to keep the population at a low to moderate density, growth rates should be high enough to allow Muskellunge to achieve trophy sizes. The occasional natural reproduction of Muskellunge documented in Kingston Lake will likely continue, but at a very low level and not enough to contribute significantly to the population. Because Muskellunge were introduced to Kingston Lake to create a fishery, stocking on top of the nominal natural reproduction is not a genetic concern as the primary objective of stocking is to maintain a fishery. Overall, like Knapp et al. (2021) found in 36 study lakes in Minnesota, Muskellunge have not negatively impacted the gamefish populations of Kingston Lake. Knapp et al. actually observed an increase in Yellow Perch and Bluegill relative abundance (CPUE) and increased catch rates for Walleye in the presence of Muskellunge.

Soft-rayed species such as suckers are the primary diet for muskellunge (Bozek et al. 1999). Knapp et al. (2021) found a decrease in Common White Sucker populations where Muskellunge had been introduced in lakes without Cisco. Because Muskellunge management has been the primary

management for Kingston Lake, the Common White Sucker population has been an important focus for fisheries managers. From 2002 to 2007, Common White Sucker were the most frequently captured species throughout Michigan, being caught in 70% of all Michigan lakes sampled (Wehrly et al. 2015). Over this period, mean CPUE for Common White Sucker in fyke nets and trap nets for medium-deep lakes were 3.4 and 3.8 fish per lift, respectively. For this same period for Upper Peninsula sampled waters, mean CPUE for Common White Sucker in fyke and trap nets was 4.6 and 3.7 fish per lift, respectively. Common White Sucker CPUE for Kingston Lake in 2003 for fyke and trap nets was 2.2 and 5.3 fish per lift. In 2011, zero Common White Sucker were captured in fyke and trap nets (1 caught in gill nets). In the 2018 Kingston Lake survey, CPUE for Common White Sucker captured in fyke and trap nets was 0.67 and 0.5 fish per lift, respectively. Although CPUE is a rough indicator of relative abundance of a species, the Common White Sucker population has clearly shown decline from the 2003 survey. An increased catch of Common White Sucker in the 2018 survey is encouraging and likely a result of increased water levels offering more lake stratification during winter months and a lower density of muskellunge (reduced stocking rate). The Common White Sucker population has been slowly rebounding and should continue to be monitored as they represent the preferred forage for Muskellunge. Harrison and Hadley (1979) and Hanson (1986) found when an abundance of minnows and suckers was present, Muskellunge growth rates were positively related. As the Common White Sucker population recovers in Kingston Lake, Muskellunge growth rates should increase, allowing them to achieve trophy sizes once again.

Management Direction

Although Kingston Lake is classified as a mesotrophic lake, it has historically performed as an oligotrophic lake experiencing highly variable fluctuations in lake level. When making changes to management strategies, managers should consider the physical attributes of this lake along with the history of efforts to keep the fish community in balance. Kingston Lake receives increased interest by anglers for its Muskellunge fishery and because of the popular State Forest Campground. Management goals for this lake are 1) maintain a healthy balance of predators and prey, 2) maintain Muskellunge fishery through stocking while keeping densities low, and 3) continue prevention of invasive species introductions to the lake.

The Walleye population in Kingston Lake should remain an incidental fishery through nominal natural reproduction. Walleye stocking in Kingston Lake should not take place as their presence at low and moderate densities has shown to dramatically change the balance of the fishery. The pelagic species community should continue to be controlled by black bass, allowing for an acceptable size structure of Bluegill and Pumpkinseed Sunfish for anglers.

Muskellunge management in Kingston Lake should continue under the following circumstances: stocking rates remain below the recommend stocking guideline at 1.5 per acre and the Common White Sucker population continues to rebound. In the event the Muskellunge population becomes too large and the Common White Sucker population declines, Muskellunge stocking should cease. Continued monitoring of both populations will be critical in maintaining the Muskellunge fishery in Kingston Lake. With the absence of an adequate forage resource, Muskellunge management will result in a poor use of angler funds and resources.

To continue the prevention of invasive species in Kingston Lake, it will be important to work with the local Cooperative Invasive Species Management Area (CISMA) groups and Conservation Districts

(CD). Various opportunities for education and outreach regarding prevention, identifying, reporting, and managing invasive species are available to the public and management agencies. Because of the popularity of the State Forest Campground and the fishery at Kingston Lake, communication will be paramount regarding invasive species to continue their absence in the lake.

The following recommendations can be made to accomplish these goals:

1. Monitor and track muskellunge and white sucker relative abundance through spring netting surveys using fyke and trap nets. Surveys should be conducted when staff and funding resources are available. Recommend conducting a monitoring survey every 6 to 8 years.

2. Conduct a Status and Trends survey on Kingston Lake every 8 to 10 years to identify trends in relative abundance and continue monitoring physical attributes of the lake. Particular attention should be given to the predator and prey balance.

3. To continue prevention of invasive species, work with the local CISMA and CD groups to secure funding for a boat wash station and interpretive signage at the Kingston Lake State Forest Campground. Continued monitoring and reporting of invasive species should be made using the Midwest Invasive Species Network (MISIN) and through the Michigan Department of Environment, Great Lakes, and Energy (EGLE).

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Table 1.-Water level descriptions for Lake Superior and Kingston Lake, Alger County from 1918 to 2018. Water level data obtained from United States Army Corps of Engineers Great Lakes Water Level Data. Water level description for Kingston Lake as noted from Michigan Department of Natural Resoures staff for each period.

	Water Level Description	
Period	Lake Superior	Kingston Lake
1918-1927	mean level mostly below LTA	not reported in file
1927-1954	mean level mostly above LTA	not reported in file
1954-1968	mean level mostly below LTA	1958-very low
1968-1987	mean level mostly above LTA	1979-18 inches above normal
1987-1996	mean level mostly below LTA	1992-6 ft low, beginning to rebound
1996-1998	mean level mostly above LTA	1998-somewhat refilled
1998-2014	mean level mostly below LTA	2012-lowest observed lake level
2014-present	mean level mostly above LTA	2018-water in trees above OHWM

LTA= Long Term Average

OHWM=Ordinary High Water Mark

Table 2.-Species, life stage, number, and length by year stocked into Kingston Lake, Alger County from 1936 to 2018.

Year	Species	Life Stage	Number	Average Length (inches)
1936	Smallmouth Bass	Fingerling	200	-
1937	Brook trout	Fingerling	500	-
1937	Pike-perch (walleye)	Fry	180,000	-
1937	Smallmouth Bass	Fingerling	600	-
1938	Bluegill	Fingerling	7,560	-
1938	Brook trout	Fingerling	1,000	-
1939	Bluegill	Fingerling	13,000	-
1939	Largemouth Bass	Fingerling	600	-
1939	Pike-perch (walleye)	Fry	300,000	-
1940	Bluegill	Fingerling	2,400	-
1940	Brook trout	Fingerling	2,000	-
1940	Pike-perch (walleye)	Fry	150,000	-
1940	Smallmouth Bass	Fingerling	225	-
1943	Brook trout	Adult	500	-
1976	Tiger Muskellunge	Fall Fingerling	3,000	-
1978	Tiger Muskellunge	Fall Fingerling	1,000	-
1981	Tiger Muskellunge	Fall Fingerling	2,500	6.9
1983	Tiger Muskellunge	Fall Fingerling	500	7.6
1985	Tiger Muskellunge	Fall Fingerling	350	10.2
1987	Largemouth Bass	Fall Fingerling	4,000	8.3
1989	Smallmouth Bass	Fall Fingerling	11,440	2.0
1989	Tiger Muskellunge	Fall Fingerling	750	8.6
1991	Muskellunge-Northern	Fall Fingerling	250	9.7
1991	Tiger Muskellunge	Fall Fingerling	450	9.2
1992	Walleye	Spring Fingerling	5,000	1.7
1994	Walleye	Spring Fingerling	5,000	1.7
1996	Walleye	Spring Fingerling	6,100	1.6
1998	Walleye	Spring Fingerling	3,000	1.6
1999	Muskellunge-Northern	Fall Fingerling	456	10.8
2001	Muskellunge-Northern	Fall Fingerling	400	12.0
2003	Muskellunge-Northern	Fall Fingerling	500	11.5
2004	Walleye	Spring Fingerling	3,893	1.4
2006	Muskellunge-Northern	Fall Fingerling	325	9.6
2006	Walleye	Spring Fingerling	2,509	1.4
2010	Muskellunge-Northern	Fall Fingerling	300	9.8
2015	Muskellunge-Great Lakes	Fall Fingerling	150	9.2
2018	Muskellunge-Northern	Fall Fingerling	150	11.6

Table 3.-Numbers, weights, lengths, and mean growth indices for fish species collected during the S&T surveys on Kingston Lake, Alger County in 2003 and 2018. Fish were captured using fyke nets, gill nets, trap nets, seines, and nighttime electrofishing gear.

2003 Catch Summary

Species	Number	Percent by number	Weight (lb)	Percent by weight	Length range (inches)	Average Length (inches)	Percent legal or harvestable[1]	Growth Index[2]
Yellow Perch	363	36.0	13.7	3.7	1-8	4.3	2	-0.6
Pumpkinseed sunfish	215	21.3	18.4	5.0	1-6	4.5	12	0.2
Blacknose shiner	117	11.6	0.6	< 1	2-2	2.5	-	-
White sucker	109	10.8	185.9	50.4	6-20	15.4	-	-
Largemouth bass	71	7.0	18.9	5.1	1-18	4.7	8	-1.7
Bluegill	42	4.2	15	2.0	3-7	6.2	67	-0.1
Common shiner	30	3.0	< 0.1	0	-	-	-	-
Smallmouth bass	26	2.6	10.3	2.8	4-18	6.8	12	-0.4
Bluntnose minnow	19	1.9	< 0.1	< 1	0-2	1.4	-	-
Muskellunge-Northern	8	0.8	90.6	24.6	13-42	32.8	13	N/A
Walleye	8	0.8	23.1	6.3	17-25	20.4	100	N/A
Logperch	1	0.1	< 0.1	0	-	-	-	-
Total	1,009	100	368.8	100				

2018 Catch Summary

Species	Number	Percent by number	Weight (lb)	Percent by weight	Length range (inches)	Average Length (inches)	Percent legal or harvestable[1]	Growth Index[2]
Yellow Perch	399	30.8	29.7	13.9	2-10	6.2	7	-2.1
Pumpkinseed sunfish	344	26.5	43.5	20.3	2-8	5	22	0.3
Bluegill	200	15.4	17.4	8.1	1-8	4.6	16	0.7
Sand shiner	185	14.3	0.9	0.4	2-3	2.5	-	-
Largemouth bass	113	8.7	41.1	19.2	3-18	8.7	5	-0.8
Bluntnose minnow	16	1.2	0.2	0.1	2-3	2.8	-	-
White sucker	11	0.8	21.1	9.9	15-18	16.9	-	-
Spottail shiner	10	0.8	< 0.1	0	1-3	2.4	-	-
Muskellunge -Gr. Lks.	8	0.6	48.3	22.6	25-31	29.3	0	3.3
Smallmouth bass	6	0.5	4.6	2.1	6-16	10.4	33	N/A
Common shiner	3	0.2	< 0.1	0	2-3	3	-	-
Muskellunge-Northern	1	0.1	7.2	3.3	30-30	30.5	0	N/A
Total	1,296	100	214	100				

[1] Harvestable size is 6 inches for Bluegill and Pumpkinseed Sunfish and 7 inches for Yellow Perch. All other game species based on statewide regulations.

[2] Average deviation from the statewide average length at age. Mean growth indices <-1 indicate below average growth, indices between -1 and +1 indicate average growth, and indices >+1 indicate growth is faster than statewide average.

Table 4.-Tag return summary for Muskellunge tagged in Kingston Lake, Alger County in 2008 and 2012. Growth per year calculated using difference of total length at tagging and length at recapture divided by time at large (years and months).

Year	Tag Number	Total Length (inches)	Age	Sex (M/F)	Recapture [Year 1]*	Recapture [Year 2]*	Length at Recapture (inches)	Time at Large (years:months)	Growth Per Year (inches)
2008	0001	32	-	-	-	-	-	-	-
2008	0023	34.1	-	-	-	-	-	-	-
2008	0028	31.9	-	-	-	-	-	-	-
2008	0052	33.3	-	-	2009	-	33.9	1:0	0.6
2008	0054	32.3	-	-	-	-	-	-	-
2008	0098	33.4	-	-	-	-	-	-	-
2008	0170	42.3	7	-	-	-	-	-	-
2008	0178	31.4	3	-	-	-	-	-	-
2008	0192	31.7	3	-	-	-	-	-	-
2008	0195	36.1	4	-	2011	-	36	3:1	0
2008	0196	34.8	4	-	-	-	-	-	-
2012	0058	37.5	10	M	2012	-	40	0:2	2.14
2012	0059	35.0	5	F	2012	-	38.5	0:2	2.99
2012	0180	35.9	7	F	2013	2013	37	1:1 and 1:5	0.78
2012	0188	35.0	8	M	-	-	-	-	-
2012	0189	37.6	7	F	2014	-	36	2:2	0
2012	230268	45.7	9	F	-	-	-	-	-

*Tag returns reported through February 2021.

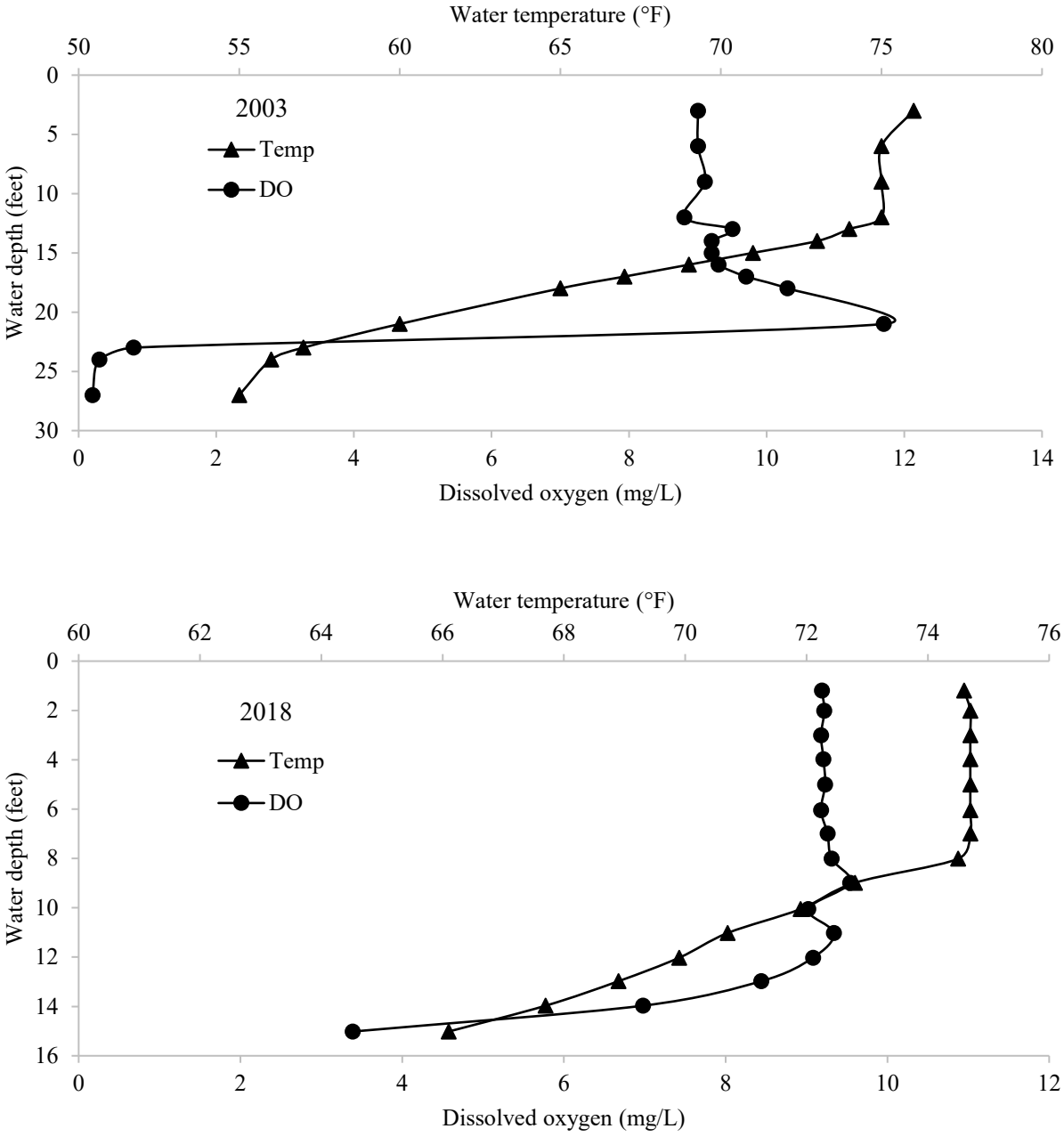

Figure 1.-Limnological profiles for Kingston Lake, Alger County conducted in August 2003 and 2018.

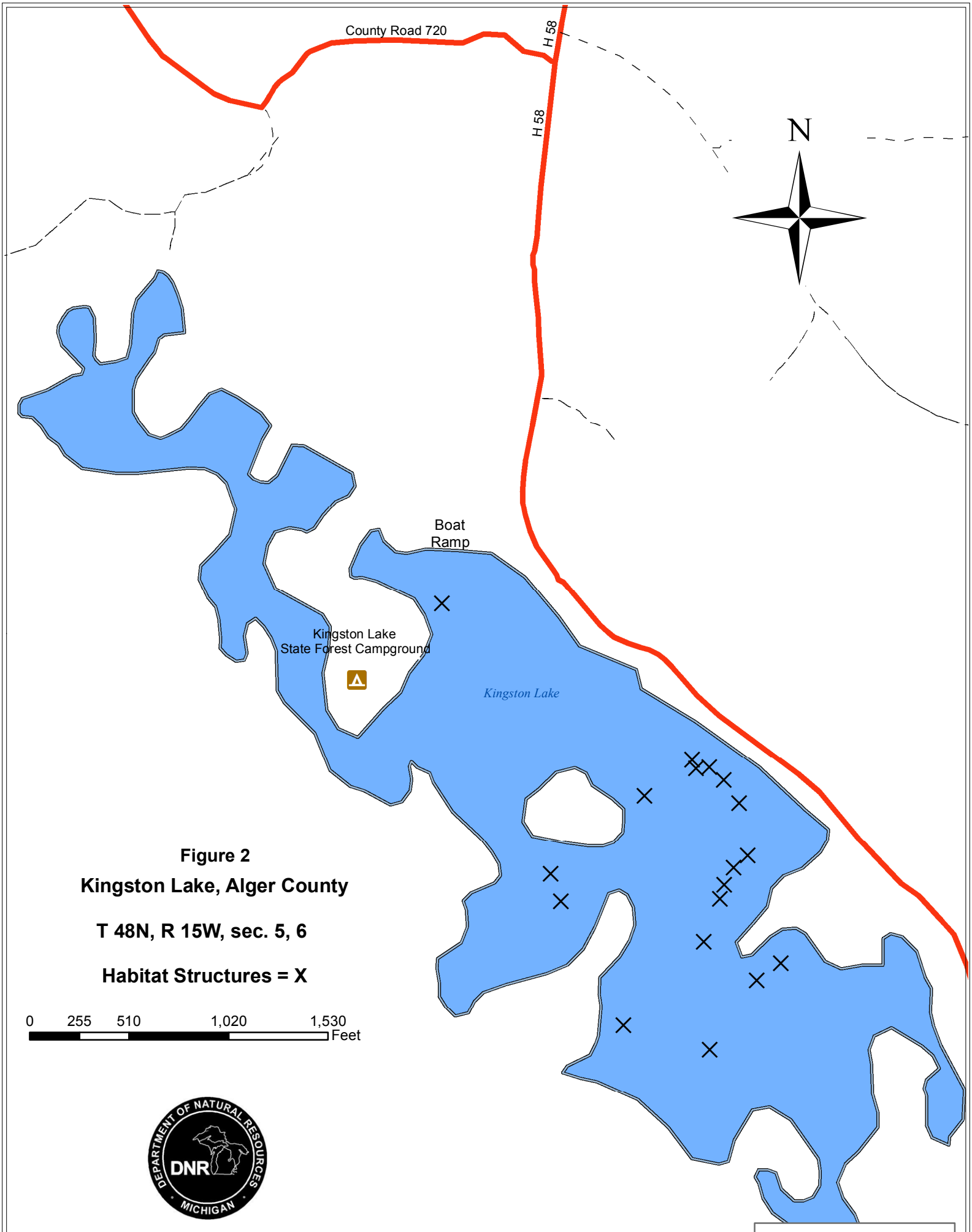

Figure 2

Kingston Lake, Alger County

T 48N, R 15W, sec. 5, 6

Habitat Structures = X

Michigan Department of Natural Resources-Fisheries Division

Map Produced 9/01/2015