Minnesota
Study 2
Job 4

MINNESOTA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF FISH AND WILDLIFE
SECTION OF FISHERIES

COMPLETION REPORT FOR MINNESOTA WATERS OF LAKE SUPERIOR

2016

by

Josh Blankenheim

Reimbursed under Federal
Aid by the Sport Fish
Restoration Act

Executive Summary

Sea Lamprey (*Petromyzon marinus*) wounding rates were above the target level of 5.0 fresh wounds per 100 Lake Trout (*Salvelinus namaycush)* in MN-1 (6.8) and MN-3 (10.0), but below the target level in MN-2 (0.3). The wounding rate in MN-2 was the lowest ever observed. The shorewide wounding rate was slightly above the target at 5.3 wounds per 100 fish.

The overall catch rate of Lake Trout >17 inches in the May assessment was 11.6 fish per 1,000 feet of net, and 99% were wild fish. CPUE of wild Lake Trout continued to show an increasing trend. CPUE by management zone was 13.8 in MN-1, 7.3 in MN-2, and 26.0 in MN-3; all were increases over 2015 levels. There were some discrepancies between field-identified Lake Trout and subsequent age analysis that suggested some were likely Siscowet, primarily from commercially caught samples in MN-3. Measures should be taken to ensure correct identification of Lake Trout in the May assessment.

In the juvenile Lake Trout assessment (fish less than 17 inches), CPUE was 14.3 fish per 1,000 feet of net. CPUE in the juvenile Lake Trout assessment has remained relatively consistent during the past decade. Shorewide, 96% of juvenile Lake Trout captured were wild. Even in MN-1 where stocking has occurred in recent years, 92% of juveniles were wild fish. Stocking was discontinued in MN-1 in 2015 so the percent wild fish in all Lake Trout assessments will continue to increase.

Lake Trout harvest in MN-2 in the summer commercial assessment was 364 fish and the catch rate was 5.5 fish per 1,000 feet of net. Including Siscowet bycatch (which counts towards the quota), the harvest in MN-2 was only 20% of the 2,000 fish quota. In contrast, commercial harvest in MN-3 was 2,189 Lake Trout and the catch rate was 37.4 fish per 1,000 feet of net. Including the Siscowet bycatch, 74% of the 3,000 fish quota was harvested in MN-3.

Cisco (*Coregonus artedi*) abundance in the commercial catch has decreased in recent years, primarily due to a lack of a strong year-class since 2003. Cisco harvest in the traditional gill net fishery (all months excluding November) was only 119,822 pounds, which was the lowest harvest since 1987. The catch rate was 185 Cisco per 1,000 feet of net. Harvest during the November Cisco fishery was

105,514 pounds and the catch rate was 653 pounds per 1,000 feet of net. The 2003 and 2009 year-classes accounted for 76% of the commercial catch and further illustrates the dire need for a significant year-class of Cisco.

For the first time in at least 50 years, no commercial operators elected to fish for Rainbow Smelt (*Osmerus mordax*). Anecdotal reports suggested dip netters and beach seiners had some success collecting Rainbow Smelt, but numbers were minimal compared to catches in the 1970s. Rainbow Smelt remain an important diet item for Lake Trout and other predator species.

A Lake Sturgeon (*Acipenser fulvescens*) assessment was conducted as part of the lakewide Cooperative Science and Monitoring Initiative (CSMI) effort to better quantify juvenile/sub-adult Lake Sturgeon populations. Nine Lake Sturgeon were sampled and CPUE was 1.1 fish per 1,000 feet of net.

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Introduction

In 1995, the Minnesota Department of Natural Resources (MNDNR), working closely with stakeholders, developed the *Fisheries Management Plan for the Minnesota Waters of Lake Superior* (LSMP) describing specific goals for the Lake Superior fishery and outlining management strategies to accomplish these goals over the next 10 years (Schreiner 1995). With significant public input, the LSMP was revised in 2006 (Schreiner et al. 2006) and again in 2016 (Goldsworthy et al. 2016) to reflect both the progress in achieving previous goals as well as developing new objectives for emerging threats to the lake and its fishery resources. The LSMP serves as the guiding document for implementing a variety of management and assessment strategies for fishery management in the Minnesota waters of Lake Superior. This report summarizes annual assessment work conducted by the Lake Superior Area Office in Minnesota's portion of Lake Superior in 2016 including the May Lake Trout (*Salvelinus namaycush)*, juvenile Lake Trout, summer expanded commercial Lake Trout, forage fish (Cisco *Coregonus artedi* and Rainbow Smelt *Osmerus mordax*), and juvenile/sub-adult Lake Sturgeon (*Acipenser fulvescens*) assessments.

Rehabilitation of self-sustaining Lake Trout stocks has been the major goal for agencies around Lake Superior since the collapse of the Lake Trout fishery due to commercial over-exploitation and predation by Sea Lamprey (*Petromyzon marinus*) (Horns et al. 2003). Lake Trout is the primary species caught by anglers and at present supports a recreational fishery with an average annual harvest of 24,681 fish (2007-2016) in the Minnesota waters of Lake Superior (Reeves 2017). Lake Trout is the dominant predator species in Lake Superior and have a large influence on prey fish abundance, particularly the non-native Rainbow Smelt. Chinook Salmon (*Oncorhynchus tshawytscha)*, Coho Salmon (*O. kisutch)*, and Rainbow Trout (*O. mykiss*) are not vulnerable to MNDNR assessment gill nets. The status of these salmonid species is discussed in creel survey reports and reports on the operation of the French and Knife River traps (Peterson 2017a; Peterson 2017b; Peterson 2017c; Reeves 2017).

The deepwater morphotype of Lake Trout, known as the Siscowet, generally lives in depths greater than 240 feet, and is the most abundant predator in Lake Superior. For consistency throughout this report, lean Lake Trout will be referred to as “Lake Trout” and Siscowet Lake Trout will be referred to as “Siscowet”. Trends in Siscowet and other predator populations are monitored by a tri-annual lake-wide gill net assessment which samples a depth range from near zero to over 600 feet. The goal of assessing the Siscowet population is to gain insight into their ecological role, determine fish abundance in offshore waters, and better understand diet, age, and size structure of the population.

Cisco and Rainbow Smelt are important forage species in Lake Superior and both support commercial fisheries. Population dynamics are monitored by analyzing commercial fishing records, hydroacoustic surveys, and MNDNR assessment netting. Although Rainbow Smelt abundance has decreased since the 1960s, they are the primary prey item in the spring diets of Lake Superior predators (Ray et al. 2007).

Lake Sturgeon has become a species of significant management interest in recent years. As such, agencies around Lake Superior conduct a lakewide juvenile/sub-adult Lake Sturgeon assessment every five years which started in 2011 as part of the Cooperative Science Monitoring Initiative (CSMI). The goal of the survey is to facilitate Lake Sturgeon rehabilitation and objectives include: describe the current status of juvenile/sub-adult Lake Sturgeon, develop a relative abundance index, and describe the biological characteristics of juvenile/sub-adult Lake Sturgeon (Schloesser et al. 2014).

Methods

Assessment methods for the May Lake Trout, juvenile Lake Trout, and forage fish populations have been previously described in Halpern and Schreiner (2003). Locations for May and juvenile Lake Trout net sets and statistical zones are shown in Figures 1 and 2. Detailed net specifications can be found in Ebener (2001).

A limited summer expanded commercial Lake Trout assessment fishery was permitted beginning in 2007 for MN-3 and in 2010 for MN-2. The annual Lake Trout limits are 3,000 fish in MN-3 and 2,000 fish in MN-2 and the season is open from June 1st through September 30th. In 2016, four commercial operators fished in MN-3 and four commercial operators fished in MN-2. This limited commercial fishery serves as a surrogate for the September Lake Trout assessment that was discontinued in 2010 due to reduced budgets and staff. Detailed information on the limited commercial Lake Trout fishery can be found in Blankenheim (2017).

Beginning in 2006, catch per unit effort (CPUE) has been corrected for soak time (i.e., the numbers of nights the nets were fished). Correction factors for gill-net CPUE developed by G.L. Curtis (Great Lakes Science Center, unpublished; cited in Hansen et al. 1998) were used to standardize 2- and ≥3-night sets to a uniform base of one night. Thus, the net length was multiplied by 1.52 for 2-night sets and 1.8 for ≥3-night sets.

Previously in MN-1, Lake Trout CPUE was calculated using an average of individual net CPUE's:

$$\overline{CPUE_i} = \frac{\sum \frac{C_i}{f_i}}{n},$$

where C_i = individual net catch (number of Lake Trout), f_i = fishing effort (1,000 feet of gill net), and n = the number of net sets in a given year. The benefit of this equation is confidence limits can be calculated for the CPUE value, which we do not utilize in this report. For data clarity, consistency between statistical districts, and ease of understanding in reporting, the CPUE calculation was changed to:

$$CPUE = \frac{\sum C_i}{\sum f_i},$$

and all previous years CPUE were recalculated for MN-1. Therefore, historical CPUEs in this report may be slightly different than in previous reports.

The MNDNR Cisco assessment consisted of two gangs of three multi-mesh (2.0-, 2.5-, and 3.0-inch stretch mesh) net which were each 100 feet long for a total of 300 feet of net per gang. One gang was set at 12 feet below the surface and the other at 25 feet below the surface. Sampling began in mid-October with a goal of 100 Cisco samples. Due to the time constraints of otolith aging and reporting, age data of Cisco sampled in 2016 were not yet available.

The lakewide juvenile/sub-adult Lake Sturgeon survey was conducted near river mouths around Lake Superior. In the Minnesota waters of Lake Superior, multi-mesh gill nets comprised of 4.5-inch, 8.0-inch, and 10.0-inch mesh (extension measure) were deployed in circular strata around the mouth of the St. Louis River. Net sets were 0 to 6.2 miles from the river mouth and in depths of 10 to 50 feet (Figure 12). Methods are described thoroughly in Schloesser (2014).

Results and Discussion

May Assessment

The number of fresh Sea Lamprey wounds per 100 Lake Trout, or wounding rate, observed in MN-1 during the May assessment rose from 2.1 fresh wounds in 2015 to 6.8 wounds in 2016 (Table 1, Figure 3). In MN-2, the zone that typically has the lowest wounding rate, the number of fresh wounds decreased from 0.7 wounds in 2015 to 0.3 in 2016 and represents the lowest wounding rate ever observed in MN-2. The wounding rate increased in MN-3, rising from 5.9 to 10.0 wounds per 100 fish. The overall wounding rate was 5.3 wounds (Figure 4). The target wounding rate for all zones is not more than 5 fresh wounds per 100 Lake Trout. Lake Trout in the 25.0 to 28.9 inch category had the highest incidence of wounding, in part due to their older age making them susceptible to attacks longer than smaller, younger fish (Table 1).

Sea Lamprey control is conducted by the U.S. Fish & Wildlife Service and Fisheries and Oceans Canada. Control efforts have kept the population at or below 10% of peak abundance. Nevertheless, Sea Lamprey are still a major cause of Lake Trout mortality in Minnesota waters and in most years kill more Lake Trout than the sport, commercial, assessment, and tribal fisheries combined. In 2005 and 2006, increased Sea Lamprey wounding was observed not only in Minnesota waters of Lake Superior, but in other jurisdictions of Lake Superior as well. Sea lamprey control efforts were intensified and wounding rates have generally been nearer the target rate of <5% in the Minnesota waters of Lake Superior, demonstrating the importance of continued control efforts by the U.S. Fish and Wildlife Service.

Overall CPUE of Lake Trout >17 inches was 11.6 fish per 1,000 feet of net in the 2016 May assessment (Table 2, Figure 5). It is likely that high Lake Trout abundance observed in the 1980s resulted from stocked fish filling niches made vacant by Sea Lamprey predation and increased availability of forage in the form of extremely high numbers of Rainbow Smelt. Subsequent decreases in overall Lake Trout abundance were predominantly the result of a decrease in the survival of stocked fish, probably due to direct predation and competition with wild fish (Hansen et al. 1996), and reflect a fishery approaching a more sustainable level (Corradin et al. 2008; Negus et al. 2008). Decreases in overall CPUE of Lake Trout, as well as increases in the proportions of wild and larger Lake Trout, have been observed by other agencies around Lake Superior as rehabilitation of Lake Trout has progressed.

Wild Lake Trout CPUE was 11.5 fish per 1,000 feet of net which continued the positive trend for wild Lake Trout abundance, and stocked Lake Trout CPUE was 0.1 fish per 1,000 feet of net (Figure 5). Lake Trout CPUE was highest for fish in the 17.0-20.9 inch range (Table 2). Lake Trout CPUEs for MN-1, MN-2, and MN-3 were 13.8, 7.3, and 26.0 fish per 1,000 feet of net (Table 3). Since the mid-2000s, a positive trend has been observed in Lake Trout CPUE MN-3, whereas CPUE in MN-2 has been lower and has not displayed a positive trend (Figure 6). CPUE in MN-1 had generally been increasing, but dropped substantially in 2015 before rebounding in 2016 to a level more representative of CPUEs observed in the past decade. Wild fish comprised 99% of Lake Trout sampled in the assessment (Table 3, Figure 5).

Lake Trout ages ranged from age-5 to age-27 (Table 4). By design, the May Assessment typically captures Lake Trout age-6 to age-10. Thirty-five percent (n=141) of Lake Trout sampled were age-7, with age-5 through age-11 fish well represented.

The age and growth patterns observed on otoliths help confirm correct species identification from the calls made in the field by biologists and commercial operators. Age analysis suggested that there may have been some Siscowet that were mistakenly identified as Lake Trout. There were no discrepancies with fish in MN-1, meaning that all fish that were called Lake Trout in the field appeared to be so based on the age and growth characteristics seen on the otoliths. In MN-2 only two fish were discrepancies where age analysis revealed the specimens were both likely Siscowet. One was a 22.1 inch female that was age-17 and the other was a 20.0 inch male that was age-23. Overall in MN-2 there was 99% agreement between the species identification in the field and verification through otolith analysis in a sample size of 169 fish. However, in MN-3 there was only 70% agreement between field identification and otolith analysis in a sample of 89 fish. This suggests incorrect identification in the field, incorrect age assignment, or possibly commercial operators in MN-3 caught fish displaying some level of hybridization. (Commercial operators conduct May Assessment netting in MN-2 and MN-3.) A review of five years of May Assessment aging data (2012-2016) showed 99-100% agreement between field identification and age analysis in MN-1, 98-99% in MN-2, and 70-99% in MN-3. Incorrect identification of Lake Trout could create a variety of problems such as biased CPUEs or poorly functioning Lake Trout models. Given this information, it is imperative to take measures to ensure proper identification of specimens occurs in MN-3.

By weight, diet composition of Lake Trout in the 2016 May assessment was Rainbow Smelt (68.2%), unidentifiable fish remains (26.0%), coregonids (2.0%), Burbot (*Lota lota*; 1.8%), and other diet items (2.0%) (Table 5). Rainbow Smelt commonly comprise the greatest weight of diet items in Lake Trout stomachs during the May Assessment. Thirty percent of Lake Trout (n=138) had no prey items in their stomachs, which was a greater percentage than in 2012 (12%), 2013 (3%), 2014 (17%), and 2015 (22%).

Juvenile Lake Trout Assessment

In 2016, CPUE of juvenile Lake Trout (less than 17 inches) was 14.3 fish per 1,000 feet of net and CPUE has been relatively consistent during the past decade (Table 6, Figure 7). CPUE of wild juveniles was 13.8 Lake Trout per 1,000 feet of net and CPUE of stocked fish was only 0.5 per 1,000 feet. Ninety-six percent of the juvenile Lake Trout catch was wild (Table 7, Figure 7). CPUEs in MN-1, MN-2, and MN-3 were 13.3, 9.7, and 23.8 Lake Trout per 1,000 feet of net, respectively. All juveniles captured in MN-2 and MN-3 were wild as expected due to the discontinuation of stocking in 2003 (MN-3) and 2007 (MN-2). Despite annual stocking in MN-1 through 2015, 92% of the juvenile Lake Trout catch in MN-1 was wild fish.

By weight, juvenile Lake Trout diets were comprised of Rainbow Smelt (32.8%), *Mysis* (30.6%), unidentifiable fish remains (28.5%), various sculpin species (5.5%), aquatic insects (1.1%), and other prey items (1.5%) (Table 5). Thirty-one percent (n = 85) of juvenile Lake Trout stomachs contained no prey items in 2016, similar to the 27% observed in 2015.

Lake Trout recruitment may be reaching a level representative of self-sustaining Lake Trout populations in Lake Superior indicated by high proportions of wild juveniles and plateauing CPUE. Additionally, there is little expectation for further large increases in the number of Lake Trout that were observed earlier in rehabilitation (Schreiner et al. 2006; Corradin et al. 2008; Negus et al. 2008). Based on what was observed with post-rehabilitated Lake Trout populations in eastern Lake Superior, it can be expected in Minnesota waters that wild Lake Trout abundance will continue to increase to its peak and subsequently decline to a point of equilibrium more aligned with forage availability, natural population dynamics, Sea Lamprey predation, and commercial and sport harvest. It is also expected that the increase in wild Lake Trout abundance will negate any potential negative effect of discontinuing stocking with little overall impact to the sport fishery. This scenario is similar to what occurred in other jurisdictions following the discontinuation of stocking. MNDNR will continue Lake Trout assessment activities to determine whether rehabilitated wild stocks can remain self-sustaining given current and anticipated future rates of harvest.

Summer Expanded Commercial Assessment

In 2016, the limited commercial fishery for Lake Trout in MN-2 entered its seventh year. The number of Lake Trout harvested in MN-2 was 364 and CPUE was 5.5 Lake Trout per 1,000 feet of net (Figure 8). An additional 36 Siscowet were harvested. Commercial netters only harvested 20% of the total-allowable-catch (TAC) of 2,000 trout (Lake Trout and Siscowet) from MN-2. The estimated number harvested in the sport fishery in MN-2 was 7,432 Lake Trout, demonstrating that commercial fishing accounted for only a small percentage (5%) of the total Lake Trout harvest in MN-2.

In 2016, the limited commercial fishery for Lake Trout in MN-3 entered its tenth year. Commercial netters harvested 2,189 Lake Trout in MN-3 and CPUE was 37.4 Lake Trout per 1,000 feet of net (Figure 8). An additional 42 Siscowet were harvested. Commercial netters harvested 74% of the 3,000 fish TAC. Sport anglers harvested an estimated 3,872 Lake Trout in MN-3 in 2016; therefore commercial fishing accounted for 37% of the total Lake Trout harvest in MN-3.

Lake Trout diet composition by weight in the summer commercial assessment was unidentifiable fish remains (32.6%), *Mysis* (17.3%), coregonids (15.2%), terrestrial insects (11.5%), Rainbow Smelt (10.1%), various sculpin species (5.4%), Burbot (5.4%), Kiyi (1.0%), and other items (1.5%) (Table 5). Forty-one percent of Lake Trout stomachs (n = 177) had no diet items, which was similar to 37% in 2015 and 41% in 2014.

Lake Trout Modeling

In 2005, MN DNR developed a Statistical Catch-at-Age (SCAA) model for Lake Trout. This is an important tool for assessing the status of Lake Trout stocks in Minnesota waters of Lake Superior and will assist us in determining sport and commercial harvest levels. This type of model is presently used to help manage the tribal, sport and state commercial fisheries in Wisconsin and Michigan. A description of the model and discussion of the results from 2005 through 2009 can be found in Halpern (2010).

Lake Trout total annual mortality and spawning stock biomass (SSB) are parameters estimated in SCAA models. Healey (1978) suggested that a Lake Trout population would decline if it suffered more than 50% total annual mortality. Other models showed that Lake Trout spawner abundance decreased when total annual mortality exceeded 45% (Technical Fisheries Review Committee 1992; Ebener et al. 1989), so this figure was used as the maximum acceptable mortality in the *A Lake Trout Restoration Plan for Lake Superior (*LTRP*;* Hansen ed. 1996) and in the LSMP (Schreiner et al. 2006). However, Nieland et al. (2008) suggested Lake Trout populations in the eastern Wisconsin waters of Lake Superior are likely to be sustainable when total mortality is 40% or less. Moving forward MN DNR will manage the Lake Trout fishery using the 40% total mortality threshold, continue to monitor the fishery closely and adjust harvest levels, if appropriate. MN DNR is monitoring SSB and investigating its usefulness as another criterion for managing the Lake Trout population. Presently, we are updating and evaluating the Lake Trout SCAA model and investigating various means of assessing it, such as retrospective analysis, Monte Carlo simulations and others. We are continuing to refine our assessment of fish stocks, and our models for Lake Trout and Cisco, in order to better understand the population dynamics of these important fish in Minnesota waters of Lake Superior.

Cisco Assessment

Age data from the 2016 spring and fall Cisco assessments were not yet available at the time of this writing. Age analysis from the 2015 spring and fall Cisco samples collected from commercial netters (n = 377) showed that the 2003 and 2009 year-classes accounted for 76% of the total commercial catch and the 1998 and 2005 year-classes also contributed another 15% to the catch (Figure 9). These Cisco were age-6 (2009 year-class), age-12 (2003 year-class), and age-17 (1998 year-class), and age-10 (2005 year-class). Fish up to age-28 (1987 year-class) were captured. The MNDNR fall Cisco assessment uses multi-mesh nets, and despite having smaller meshes deployed did not detect any younger, smaller fish that may become available to commercial fishers in the next few years. Furthermore, U.S. Geological Survey trawling data indicates no significant year-classes have been produced since the 2003 year-class (Figure 9). There will not be a significant source of Cisco entering the fishery until a strong year-class is produced. Until then, the Cisco stocks will likely decline as the weak year-classes are fished heavily, so care must be taken to manage conservatively and avoid collapse of the fishery.

A management strategy to assess forage species as stated in the LSMP is to use hydroacoustic sampling and trawl surveys to monitor year-class strength and determine biomass of Cisco in Minnesota's portion of Lake Superior. In late summer of 2003 a pilot project was initiated to address this objective. The Lake Superior Area fisheries staff collaborated with Dr. Tom Hrabik from the University of Minnesota Duluth to develop a hydroacoustic program that would quantify prey fish abundance (Hrabik et al. 2006). From 2003- 2016, hydroacoustic surveys of Minnesota waters of Lake Superior have been conducted. These surveys have been used to produce estimates of Cisco biomass that are being used to the TAC for Cisco (Hrabik et al. 2006; Schreiner et al. 2006). In 2014 and 2015 both summer and fall assessments were conducted to assess differences in biomass estimates by season. Fall sampling was selected as the best option and only a fall survey was conducted in 2016, which will be the sampling season moving forward.

Commercial Cisco and Rainbow Smelt Harvest

From the mid-1980s through early 2000s, Cisco harvest by commercial netters gradually increased from a low of 55,000 pounds to a peak of 450,000 pounds annually, driven largely by strong year-classes produced in 1984 and 1988-1990, and moderately strong year-classes in 1985, 1998, and 2003 (Figures 10 and 11). In 2001, harvest in November began due to a developing roe fishery but the overall harvest did not increase; rather, the traditional gill net fishery (all months except November) declined. In 2016, harvest in the traditional fishery was only 119,822 pounds, which represents the lowest harvest in the traditional fishery since 1987. Cisco CPUE was 185 fish per 1,000 feet of net, which was up slightly from 2015 but only half the highest CPUEs seen in the late 1990s. Some caution should be used when assessing commercial Cisco CPUE data because it is not adjusted for soak time. It is possible that commercial fishermen could leave their nets in the water for longer periods of time to catch more fish when fishing is poor, thereby artificially inflating CPUE.

Experimental netting for a potential November roe fishery began in 2001 in Minnesota waters, and beginning in 2006 harvest was permitted during November using TAC quotas established for each statistical district (Schreiner et al. 2006). In 2016, the Cisco harvest and CPUE in the November fishery were 105,514 pounds and 653 fish per 1,000 feet of net (Figure 10). The November roe fishery has shown a declining trend in CPUE since its peak in 2004, which further indicates that Cisco stocks are being fished heavily and a strong year-class of Cisco is desperately needed to support the future of the fishery. Cisco do not fully recruit to commercial gear until age-4, so minimal additional Cisco biomass will be available at least through 2019, meaning November quotas may have to be reduced until a strong year-class of Cisco recruits to the fishery.

Anecdotal reports suggest the spring Rainbow Smelt run was minimal in 2016 with dip netters and beach seiners harvesting small quantities of fish compared to the pre-1980 period. From 1980-1990, commercial harvest had stabilized at approximately 15% of the average harvest during the 1970s. Since then, harvest has declined further to less than 5% of the average harvest of the 1970s (Figure 11). For the first time in at least 50 years, no commercial operators elected to fish for Rainbow Smelt. Details on both the Cisco and Rainbow Smelt fisheries can be found in Blankenheim (2017).

Lake Sturgeon Assessment

A total of 9 Lake Sturgeon were captured in the MNDNR's portion of the 2016 CSMI Lake Sturgeon assessment and CPUE was 1.1 fish per 1,000 feet of net. By comparison, 23 Lake Sturgeon were caught in the 2011 survey and CPUE was 2.9 fish per 1,000 feet of net. In 2016, Lake Sturgeon ranged from 31.6 inches to 47.4 inches in length. Lake Sturgeon were captured from the inner (0-1.2 miles), middle (1.2-3.1 miles), and outer (3.1-6.2 miles) strata, but all fish were captured on the south side of the Duluth Entry (Figure 12). Nets that captured Lake Sturgeon were set in areas characterized by gradual sloping contours and sandy substrate. None of the fish contained tags from previous Lake Sturgeon work. All fish were released alive, but aging structures were not collected due to warm water temperatures. Bycatch included Lake Trout, Northern Pike (*Esox Lucius*), Rainbow Smelt, Rockbass (*Ambloplites rupestris*), Silver Redhorse (*Moxostoma anisurum*), Walleye (*Sander vitreus*) and White Sucker (*Catostomus commersonii*).

Stocking

Stocking played an important role in rehabilitation of Lake Trout in Lake Superior, but has been discontinued in the Minnesota waters of the lake. Criteria regarding the use of Lake Trout stocking as a management tool in Lake Superior are discussed in the LTRP (Hansen ed. 1996) and the LSMP (Goldsworthy et al. 2016). Lake Trout stocking was discontinued in MN-3 in 2003, MN-2 in 2007, and finally in MN-1 in 2016 as criteria for discontinuation of stocking were met in each management zone. A contingency plan for re-establishing a Lake Trout broodstock was developed in the event that stocking needs to be utilized in the future.

Two strains of Rainbow Trout were stocked in Minnesota waters of Lake Superior in 2016: steelhead and Kamloops. Summaries of the 2016 stocking and proposed 2017 stocking are given in Table 8. More information on the return rates of these programs are available in the annual spring creel and trap reports (Peterson 2017a; Peterson 2017b; Peterson 2017c).

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Minnesota
Study 2
Job 4

MINNESOTA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF FISH AND WILDLIFE
SECTION OF FISHERIES

COMPLETION REPORT FOR MINNESOTA WATERS OF LAKE SUPERIOR

2016

by

Josh Blankenheim

Approved by: ______________________ 1/25/2017
Area Fisheries Supervisor Date

Approved by: ______________________ 5/1/2017
Regional Fisheries Approval Date

Reimbursed under Federal
Aid by the Sport Fish
Restoration Act

Table 1. Number of fresh lamprey wounds per 100 Lake Trout in 4.5 inch stretch mesh May assessment gill nets, by size class and statistical district, 2016. Number of Lake Trout sampled in each length range is listed in parenthesis.

	Size Class				
	432-532 mm (17-20.9 in.)	533-634 mm (21-24.9 in.)	635-736 mm (25-28.9 in.)	737 + mm (29 + in.)	Total
MN-1	0.0 (46)	2.5 (81)	27.6 (29)	14.3 (7)	6.8 (163)
MN-2	0.6 (171)	0.0 (128)	0.0 (14)	0.0 (3)	0.3 (316)
MN-3	6.6 (137)	13.4 (127)	15.0 (20)	0.0 (5)	10.0 (289)
TOTALS	2.8 (354)	5.7 (336)	17.5 (63)	6.7 (15)	5.3 (768)

Table 2. Number of Lake Trout by size class per 1,000 feet of 4.5 inch stretch mesh May assessment gill nets, 2016.

	Size Class					
Assessment	<432 mm (<17 inches)	432-532 mm (17-20.9 inches)	533-634 mm (21-24.9 inches)	635-736 mm (25-28.9 inches)	737+ mm (29 + inches)	Overall
May	0.21	5.37	5.10	0.96	0.23	11.87

Table 3. Corrected Lake Trout catch by station in the May assessment, 2016.

Location	Effort in Feet (corrected effort)	Total Catch (number)	Total Weight (pounds)	Number per 1,000 feet	Pounds per 1,000 feet	Percent Wild
MN-1						
All Stations (n = 7)	12,000 (12,000)	165	651	13.8	33.4	95.8
MN-2						
Split Rock	18,000 (26,040)	181	523	7.0	20.1	100
Silver Bay	11,750 (17,860)	141	458	7.9	25.6	98.6
Totals MN-2	29,750 (43,900)	322	981	7.3	22.3	99.4
MN-3						
Grand Marais	9,550 (11,342)	295	901	26.0	79.4	100
Totals MN-3	9,550 (11,342)	295	901	26.0	79.4	100
All locations						
Shorewide	**51,300 (67,242)**	**782**	**2,533**	**11.6**	**37.7**	**98.9**

Table 4. Age-length frequency distribution of otolith aged Lake Trout in 4.5 inch stretch measure gill nets, May assessment, 2016. Bold numbers indicate fish that were identified as Lake Trout but age analysis suggested they were Siscowet.

Length (in)	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI+
9.0 - 9.9													
10.0 - 10.9													
11.0 - 11.9													
12.0 - 12.9													
13.0 - 13.9													
14.0 - 14.9		2											
15.0 - 15.9													
16.0 - 16.9			4	1									**1**
17.0 - 17.9			9	3				**1**					**2**
18.0 - 18.9			15	9	1	2		**1**					**3**
19.0 - 19.9			8	28	6	2	1			**3**	**2**	**1**	**3**
20.0 - 20.9			2	54	6	5	1	1				**2**	**1**
21.0 - 21.9			1	31	19	1	3						**1**
22.0 - 22.9			1	11	25	4	2	2				1	**5**
23.0 - 23.9				3	13	9	1	3		1			**1**
24.0 - 24.9				1	6	9	8	4	2		1		**1**
25.0 - 25.9						1	2	3	2	2			1
26.0 - 26.9						1	1	2	6	1	2		2
27.0 - 27.9								3	1	1	1		
28.0 - 28.9							2			2	1	1	1
29.0 - 29.9									1			1	3
30.0 - 30.9								1					1
31.0 - 31.9											1		
32.0 - 32.9													3
33.0 - 33.9													
34.0 - 34.9													
35.0 - 35.9													
36.0 - 36.9													
37.0 - 37.9													
38.0 - 38.9													
39.0 - 39.9													
Total	0	2	40	141	76	34	21	21	12	10	8	6	29
Average Length		14.2	18.5	20.5	22.0	22.7	23.9	24.4	26.2	24.3	25.3	23.2	23.7

Table 5. Diet composition by weight of prey items in Lake Trout stomachs in the May, juvenile, and summer assessments, 2016. The number of stomachs sampled with prey items is shown in parentheses.

	Lake Trout					
Diet item	May		Juvenile		Summer	
Aquatic insects	0.1%	(16)	1.1%	(11)	0.3%	(10)
Burbot	1.8%	(4)			5.4%	(2)
Clam sp.	0.0%	(2)				
Coregonid sp.	1.9%	(10)	0.1%	(1)	15.2%	(20)
Deepwater Sculpin	0.5%	(8)	0.1%	(1)	0.6%	(8)
Detritus			0.4%	(1)		
Empty		(138)		(85)		(177)
Fish eggs	0.0%	(2)				
Kiyi					1.0%	(1)
Larval fish	0.0%	(5)				
Mysis	0.4%	(6)	30.6%	(63)	17.3%	(62)
Ninespine Stickleback	0.0%	(2)			0.2%	(2)
Rainbow Smelt	68.2%	(140)	32.8%	(22)	10.1%	(26)
Rocks	0.0%	(7)			0.7%	(25)
Round Whitefish	0.0%	(1)				
Salmonid sp.					0.0%	(1)
Sculpin sp.	0.3%	(14)	3.4%	(14)	5.4%	(26)
Slimy Sculpin	0.0%	(1)	1.7%	(5)	0.2%	(5)
Spoonhead Sculpin	0.0%	(3)	0.3%	(1)	0.1%	(3)
Stickleback sp.	0.0%	(2)				
Terrestrial insects	0.5%	(17)	0.9%	(17)	11.5%	(46)
Unidentifiable fish remains	26.0%	(203)	28.5%	(80)	32.6%	(130)
Woody debris	0.1%	(14)	0.1%	(5)	0.4%	(11)

Table 6. Summary of fishing effort, catch, percentage of wild Lake Trout and CPUE (number of fish per 1,000 feet) in the juvenile Lake Trout (less than 17 inches; 432 mm) assessment, 2016.

Location	Effort in Feet	Corrected Effort in Feet*	Number of lake trout	Percent Wild	CPUE Wild	CPUE Stocked	CPUE Total
MN-1							
Lester River	1,000	1,520	11	100%	7.2	0.0	7.2
Pumping Station	1,000	1,520	32	75%	15.8	5.3	21.1
Stoney Point	1,000	1,520	20	95%	12.5	0.7	13.2
Larsmont	1,000	1,520	23	96%	14.5	0.7	15.1
Two Harbors	1,000	1,520	7	100%	4.6	0.0	4.6
Encampment Island	1,000	1,520	28	100%	18.4	0.0	18.4
MN-1 Total	**6,000**	**9,120**	**121**	**92%**	**12.2**	**1.1**	**13.3**
MN-2							
Split Rock	1,000	1,520	27	100%	17.8	0.0	17.8
Silver Bay	1,000	1,520	7	100%	4.6	0.0	4.6
Taconite Harbor	1,000	1,520	19	100%	12.5	0.0	12.5
Tofte	1,000	1,520	6	100%	3.9	0.0	3.9
MN-2 Total	**4,000**	**6,080**	**59**	**100%**	**9.7**	**0.0**	**9.7**
MN-3							
Grand Marais	1,000	1,520	47	100%	30.9	0.0	30.9
Hovland	1,000	1,000	17	100%	17.0	0.0	17.0
Grand Portage	1,000	1,520	32	100%	21.1	0.0	21.1
MN-3 Total	**3,000**	**4,040**	**96**	**100%**	**23.8**	**0.0**	**23.8**
Shorewide Total	**13,000**	**19,240**	**276**	**96%**	**13.8**	**0.5**	**14.3**

*For CPUE calculations fishing effort was corrected for two night sets (1,000 ft. actual effort x 1.52 = 1,520 feet except for Hovland, which was a one night set).

Table 7. Historical catch summary of Lake Trout less than 17 inches caught in small mesh gill nets (1.5-2.5 inch stretch measure), CPUE (number of fish per 1,000 feet) and percent wild in the juvenile Lake Trout assessment, Minnesota waters of Lake Superior, 1980-2016.

Year	No. Fish Sampled	Number of Wild Fish Per 1,000 Feet	Number of Stocked Fish Per 1,000 Feet	Total Number Per 1,000 Feet	Percent Wild
1980	586	1.2	29.6	30.9	4%
1981	914	2.2	51.7	54	4%
1982	551	1.9	37.7	39.6	5%
1983	454	4.5	22.2	26.7	17%
1984	585	6.7	33.7	40.4	17%
1985	336	4.1	19.9	24	17%
1986	404	5.6	22.6	28.2	20%
1987	350	6	16.8	22.8	26%
1988	271	3.7	12.7	16.4	23%
1989	168	2.7	8.6	11.3	24%
1990	242	3.7	11.1	14.7	25%
1991	384	4.8	15.5	20.3	24%
1992	278	5.1	11.7	16.8	31%
1993	389	6	18.5	24.5	24%
1994	458	6.7	19.4	26.1	26%
1995	352	7.3	12.6	20	37%
1996	468	10.3	16	26.3	39%
1997	439	12	14.9	26.9	45%
1998	557	13.5	16.9	30.4	44%
1999	640	19	17.2	36.2	53%
2000	454	14.4	9.9	24.3	59%
2001	370	12.9	6.3	19.2	67%
2002	484	20.3	4.5	24.8	82%
2003	249	10.5	3.1	13.7	77%
2004	334	13.7	3.7	17.4	79%
2005	402	14	6.3	20.3	69%
2006	306	11	4.9	15.9	69%
2007	222	8.4	3.1	11.5	73%
2008	282	13	1.6	14.7	89%
2009	295	14	1.3	15.3	92%
2010	235	11.5	0.7	12.2	94%
2011*	-	-	-	-	-
2012	332	16.6	0.7	17.3	96%
2013	219	11.0	0.4	11.4	96%
2014	324	16.4	0.5	16.8	97%
2015	281	14.1	0.5	14.6	96%
2016	276	13.8	0.5	14.3	96%

*No data due to State of Minnesota government shutdown.

Table 8. Trout and salmon stocked in 2016 and proposed stocking for 2017, Minnesota waters of Lake Superior.

2016 Salmonid Stocking			
Species	**Number**	**Size**	**Fin Clip**
Rainbow Trout			
Kamloops	25,071	Yearling	Adipose Right Pectoral (ARP)
Kamloops	39,947	Yearling	Adipose Left Pectoral (ALP)
Kamloops	33,891	Yearling	Adipose (A)
Total Kamloops	98,909		
Steelhead	589,269	Fry	None
Steelhead	59	Adults	Right Maxillary (RM), T-bar anchor tag, PIT tag

Proposed 2017 Salmonid Stocking			
Species	**Number**	**Size**	**Fin Clip**
Rainbow Trout			
Kamloops	60,000	Yearling	Adipose Right Ventral (ARV)
Kamloops	32,500	Yearling	Adipose Left Ventral (ALV)
Total Kamloops	92,500		
Steelhead	450,000	Fry	None

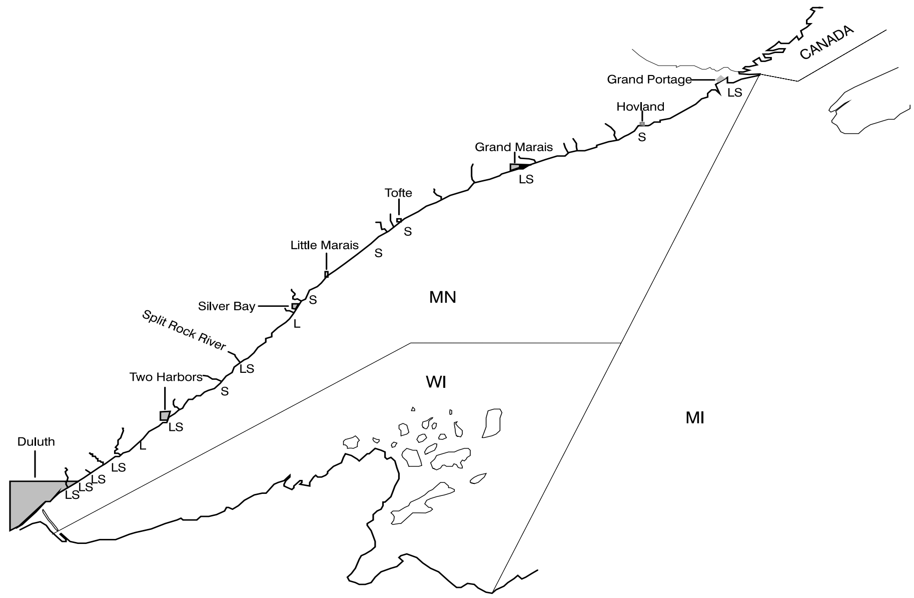

Figure 1. Sampling stations for adult (L) and juvenile (S) assessments, Minnesota waters of Lake Superior.

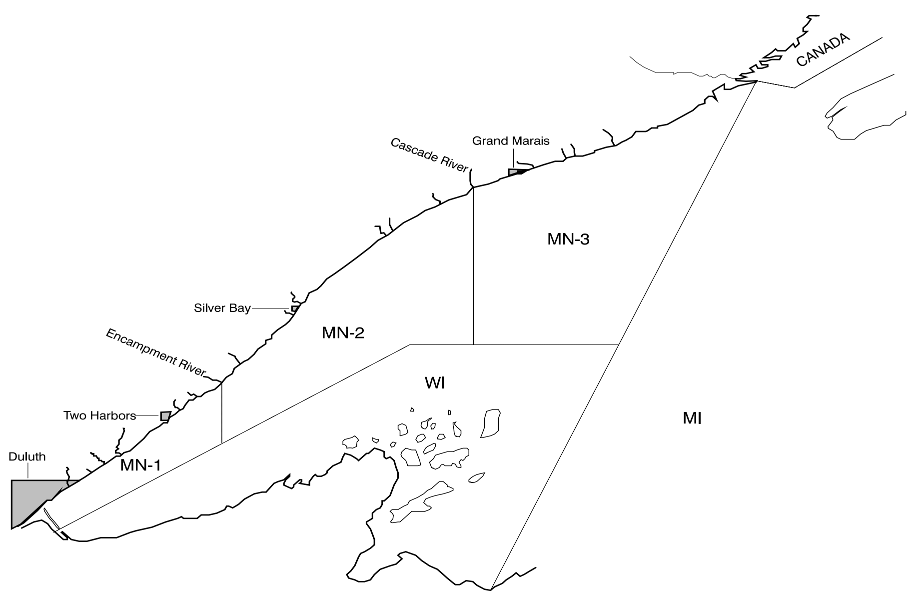

Figure 2. Statistical districts in Minnesota waters of Lake Superior.

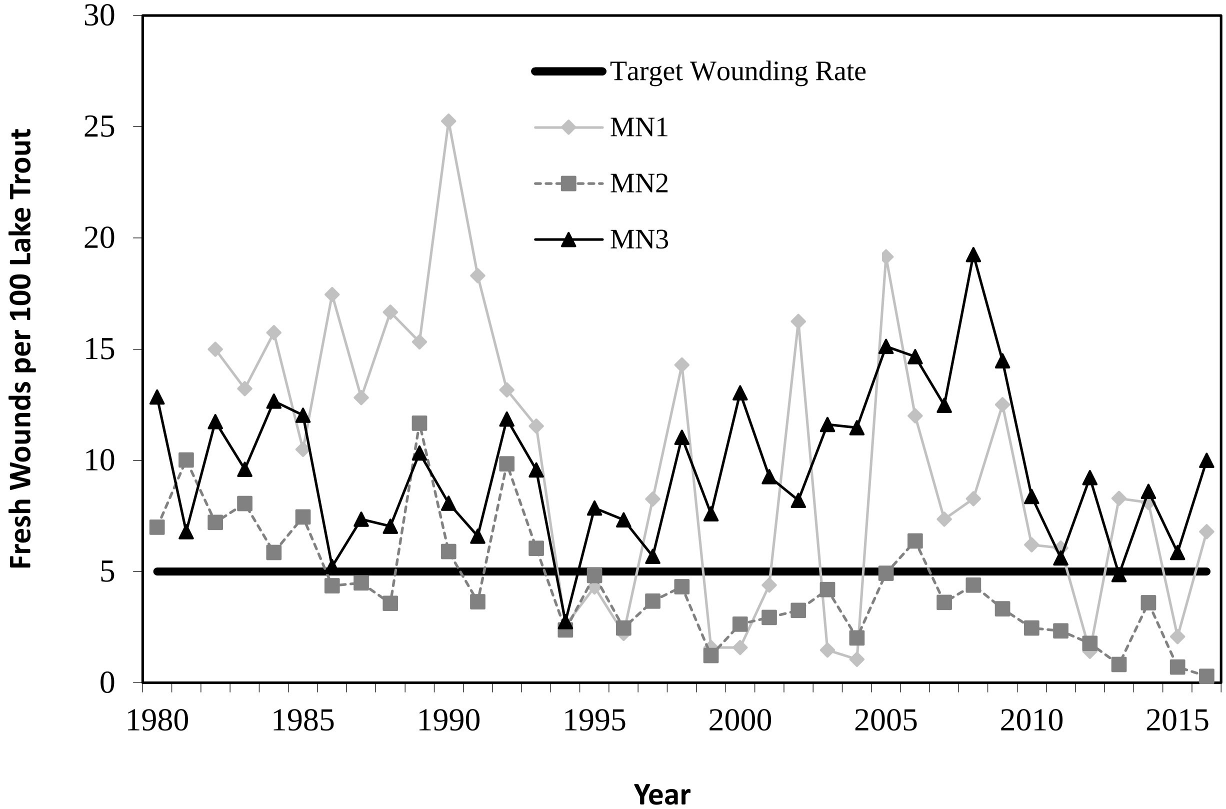

Figure 3. Number of fresh Sea Lamprey wounds per 100 Lake Trout in the May assessment, by statistical district, 1980-2016.

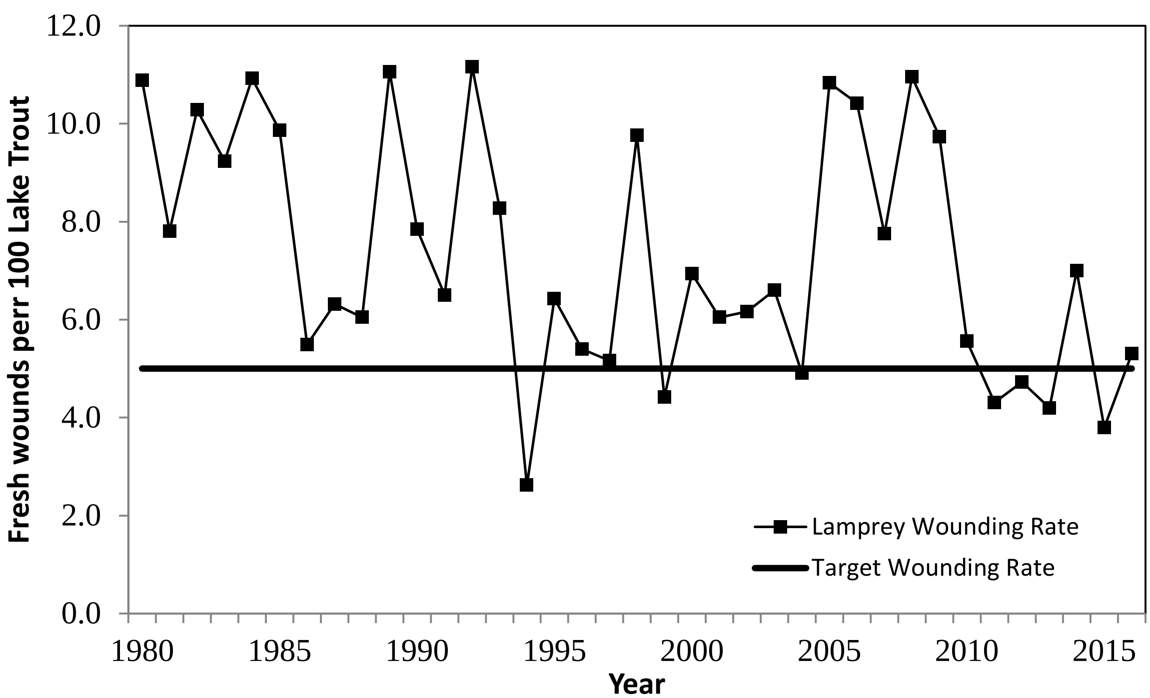

Figure 4. Shorewide number of fresh Sea Lamprey wounds per 100 Lake Trout in the May assessment, 1980-2016.

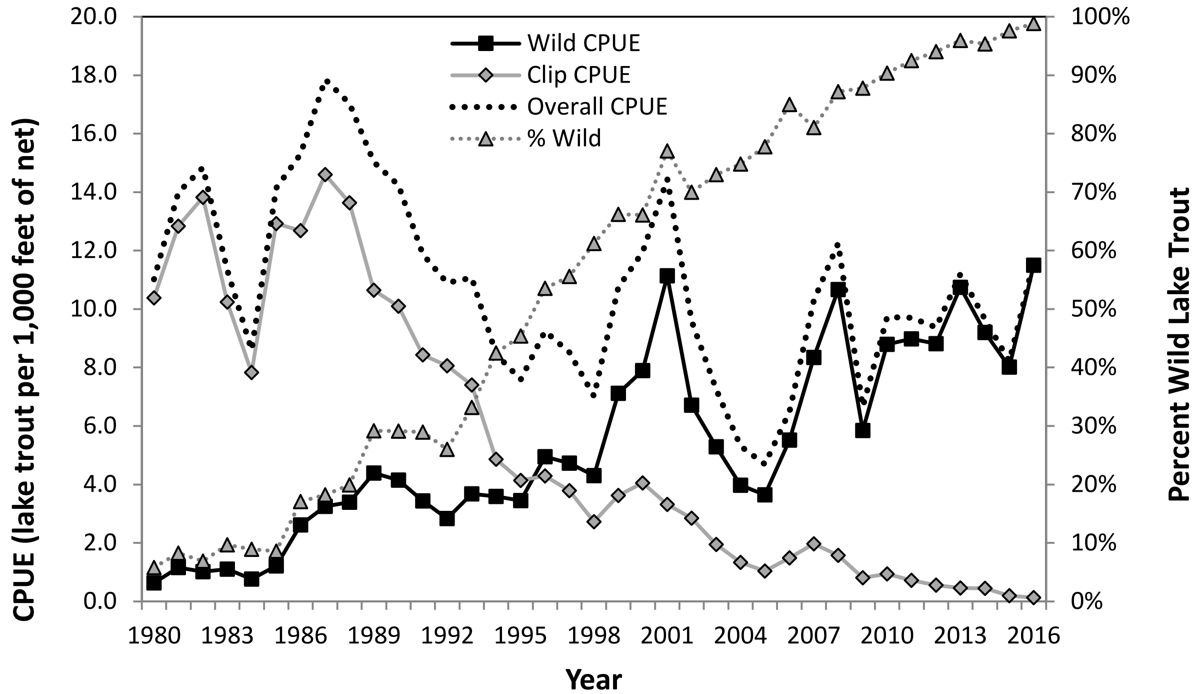

Figure 5. Catch rate (number of fish per 1,000 feet of net; CPUE) of wild, stocked, and overall Lake Trout, and percentage wild Lake Trout in the May assessment, 1980-2016.

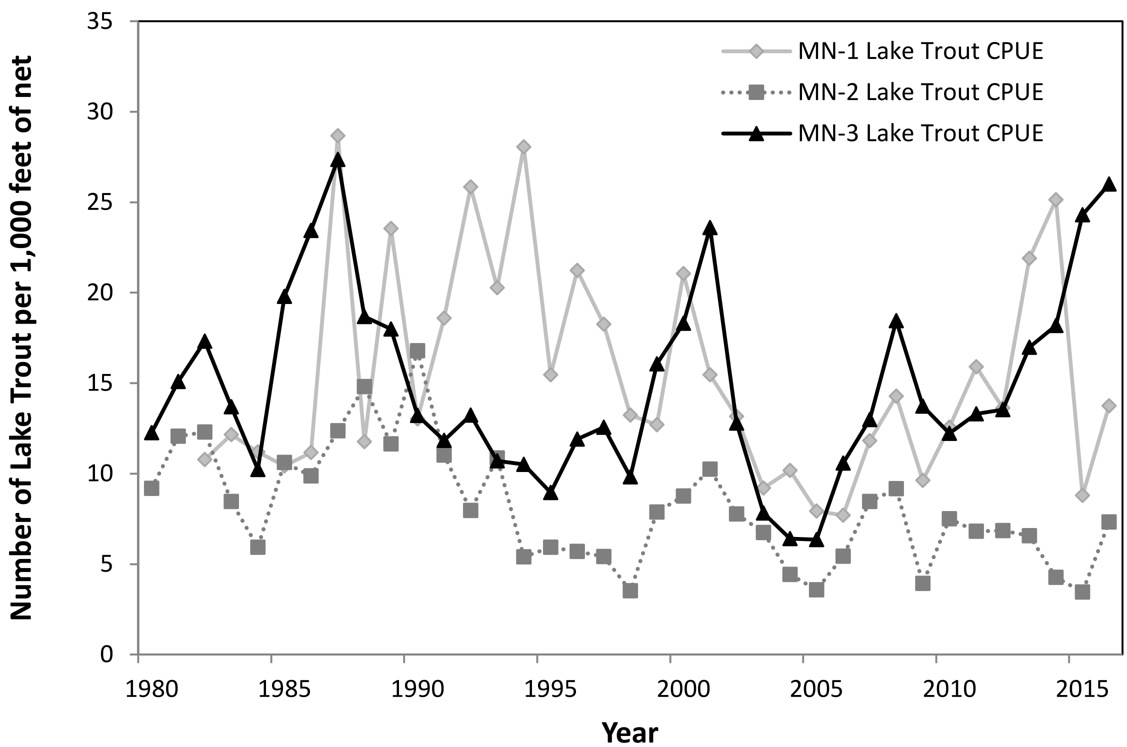

Figure 6. Lake Trout catch rate (number of fish per 1,000 feet of net; CPUE) by statistical district in the May assessment, 1980-2016.

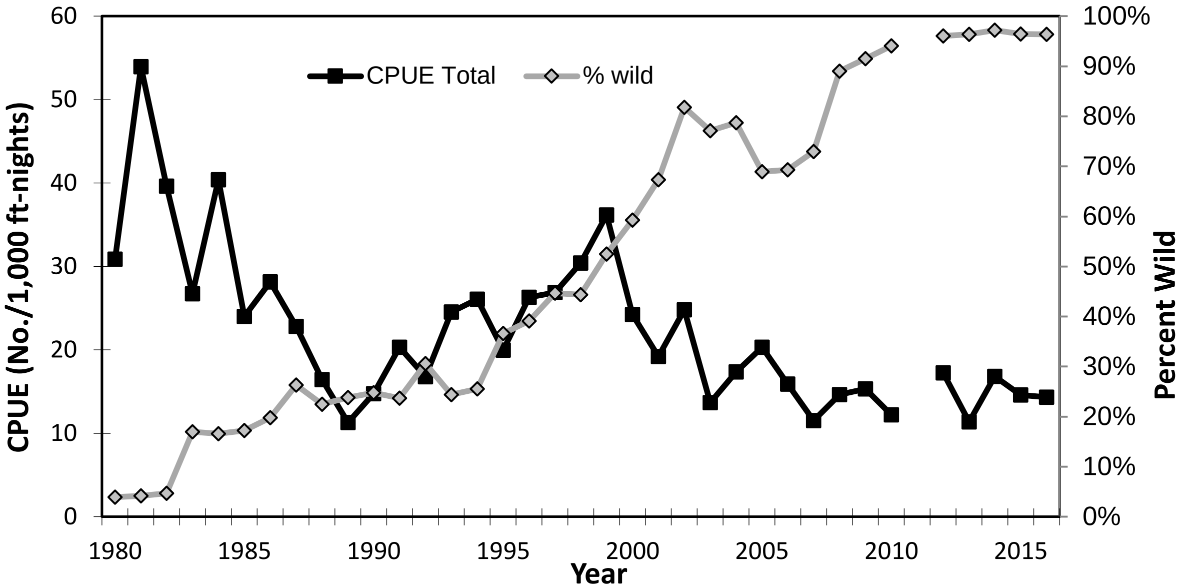

Figure 7. Catch rate (number of fish per 1,000 feet of net; CPUE) and percent wild Lake Trout in the juvenile (<17") Lake Trout assessment, 1980-2016.

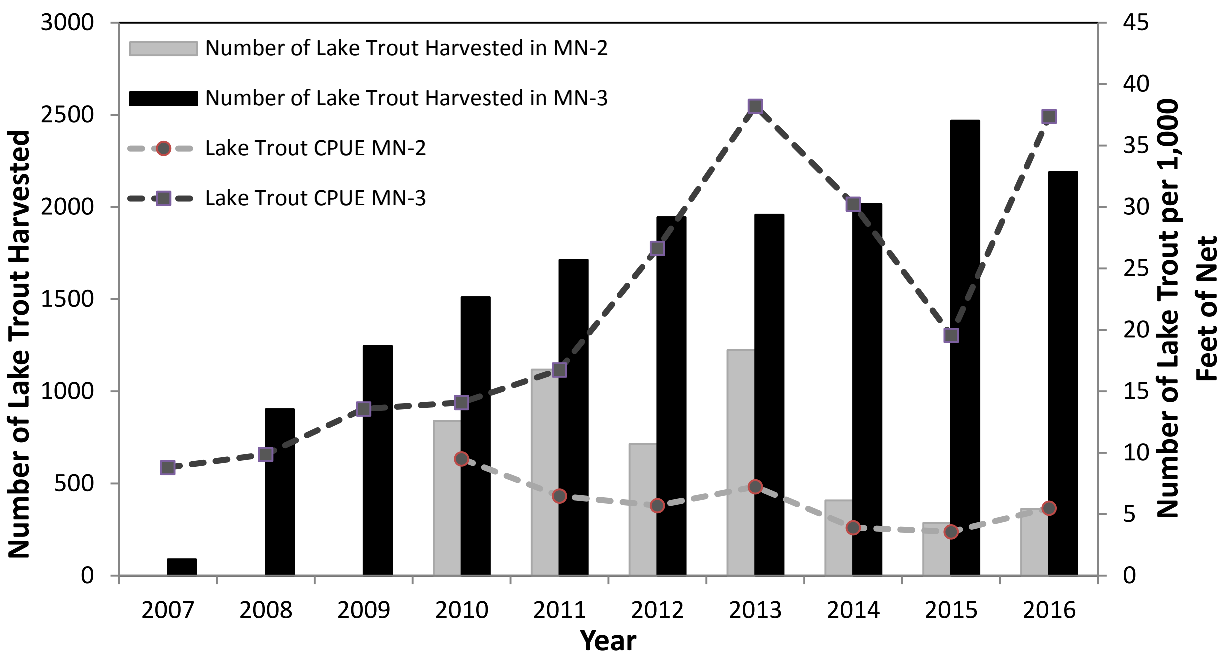

Figure 8. Lake Trout harvest and catch rate (number of fish per 1,000 feet of net; CPUE) in the summer commercial assessment, 2007-2016.

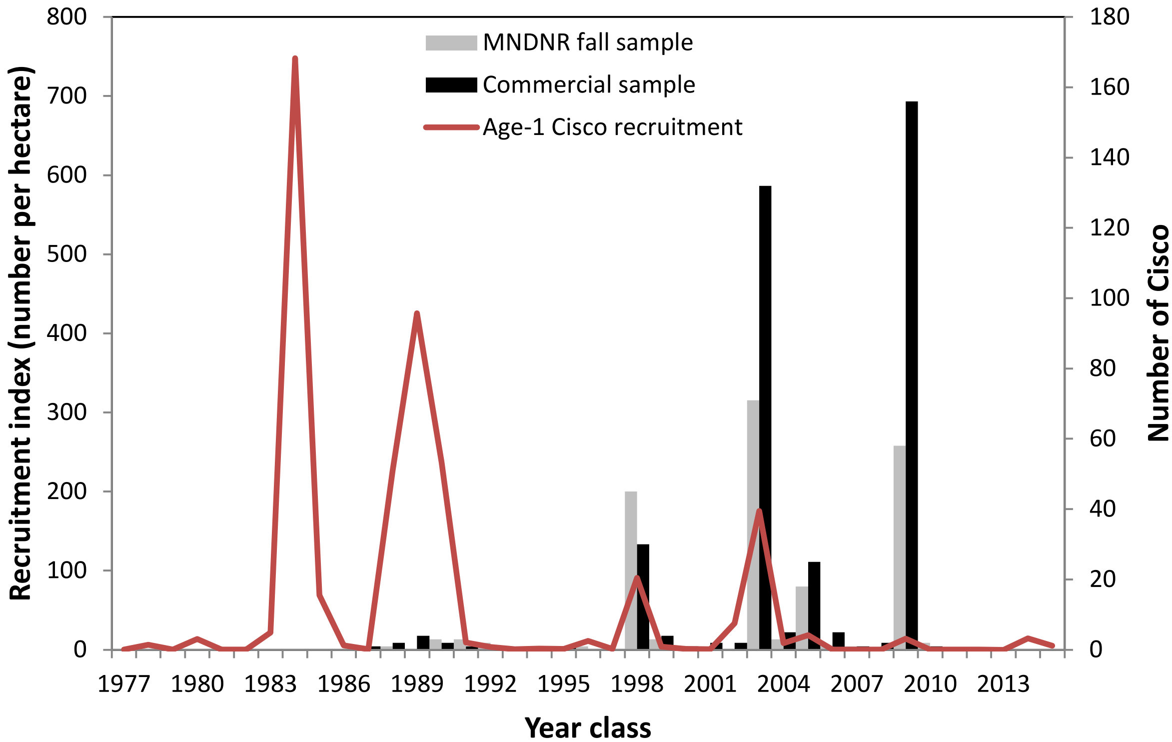

Figure 9. Cisco year-class strength, 1977-2015, as measured by the relative density of age-1 Cisco that were caught during USGS bottom trawl surveys, and the number of Cisco caught by age-class sampled in commercial and MNDNR surveys, 2015.

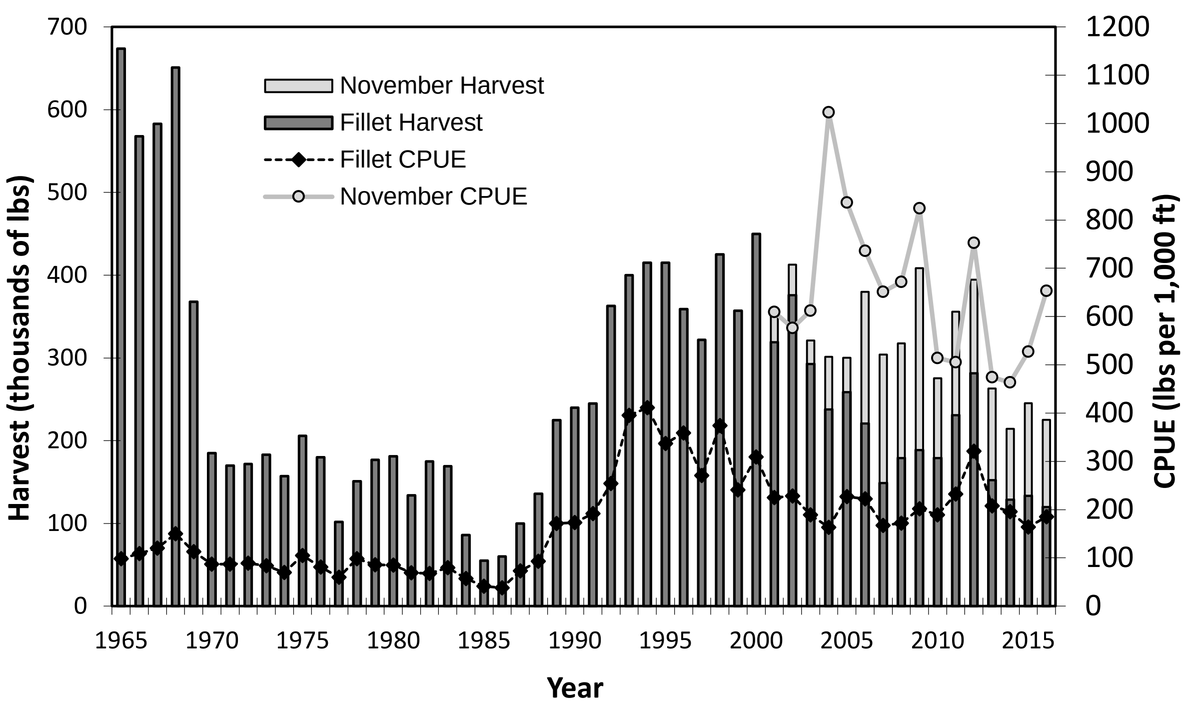

Figure 10. Cisco harvest (thousands of pounds) and catch rate (pounds per 1,000 feet of net; CPUE) in the commercial gill net fishery in Minnesota waters of Lake Superior, 1965-2016.

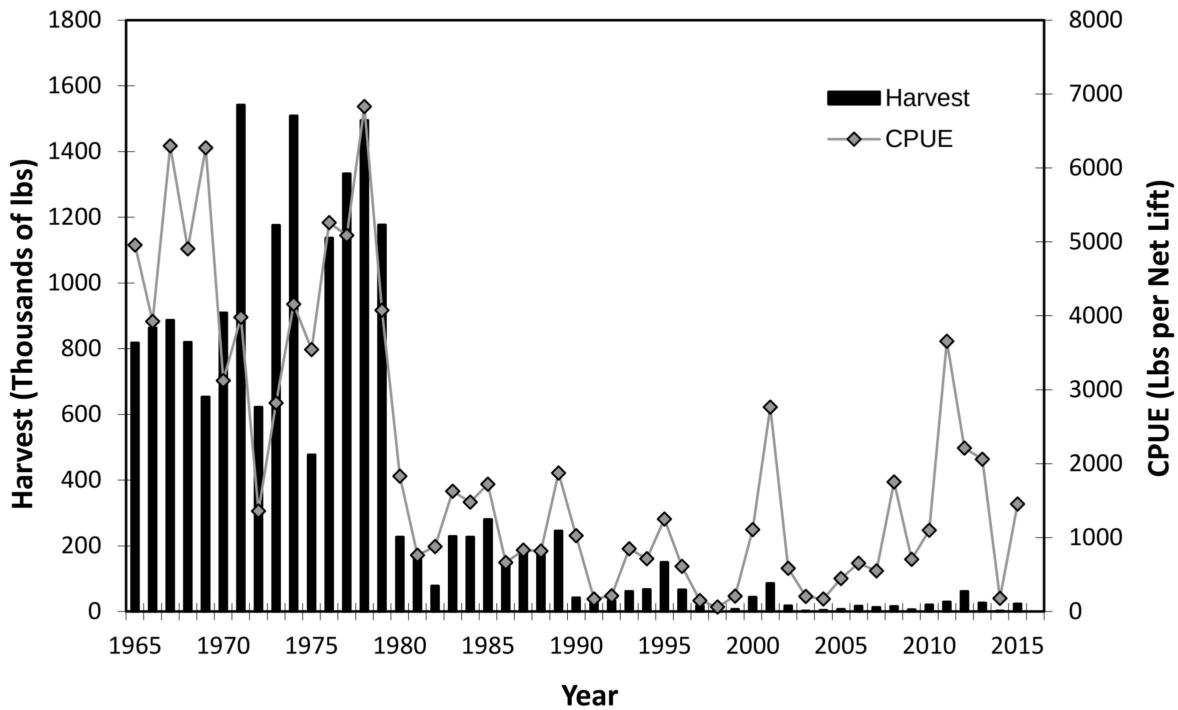

Figure 11. Rainbow Smelt harvest (thousands of pounds) and catch per unit effort (pounds per lift; CPUE) in the commercial pound net fishery, Minnesota waters of Lake Superior, 1965-2016.

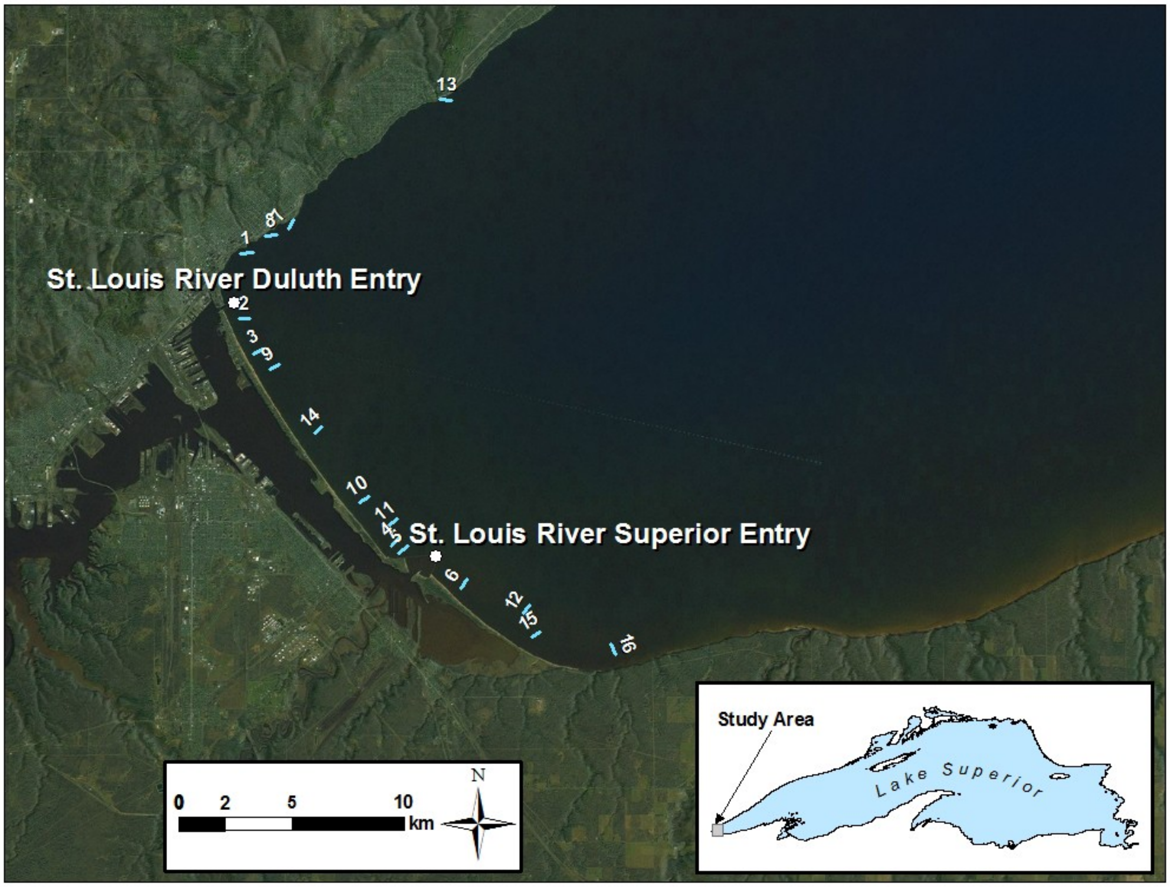

Figure 12. The location of Lake Sturgeon net sets near the mouth of the St. Louis River. The MNDNR was responsible for net sets 1-3 (inner stratum), 7-9 (middle stratum), and 13-14 (outer stratum). The Wisconsin DNR was responsible for nets near the Superior Entry.