Minnesota
Statewide Fisheries Lake and Stream Management Planning
F19AF00978
R29G60F29RP35
Segment 35, Year 1
Study 2
03/24/2022

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

COMPLETION REPORT FOR THE MINNESOTA WATERS OF LAKE SUPERIOR

2021

Prepared by:

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Reimbursed under Federal
Aid by the Sport Fish
Restoration Act

Executive Summary

The Sea Lamprey (*Petromyzon marinus*) wounding rate in the May Assessment was above the target level of 5.0 fresh wounds per 100 Lake Trout (*Salvelinus namaycush)* in MN-3 (6.1) but below the target level in MN-1 (2.4) and MN-2 (0.0). The shorewide wounding rate was below the target at 3.2 wounds per 100 fish. The overall catch rate of Lake Trout in the May assessment was 6.5 fish per 1,000 feet of net and the lowest since 2005. CPUE by management zone was 7.1 in MN-1, 4.2 in MN-2, and 11.4 in MN-3. Shorewide, 99% of Lake Trout were wild fish. Rainbow Smelt often comprise upwards of 90% of Lake Trout diets in May, but only 30% of diet biomass were Rainbow Smelt in 2021.

In the juvenile Lake Trout assessment (fish less than 17 inches), the CPUE was 13.2 fish per 1,000 feet of net. CPUE has been relatively consistent since the mid-2000s especially when considering wild juveniles only. CPUE by management zone was 7.9 in MN-1, 13.5 in MN-2, and 24.8 in MN-3. Shorewide, 94% of juvenile Lake Trout captured were wild. Despite the discontinuation of stocking by the MNDNR in 2015, some clipped juveniles are still being caught and are likely originating from stocking efforts in Wisconsin waters.

In the deepwater predator assessment, the CPUE of Siscowet was 12.5 fish/1,000 feet of net and similar to all other years except 2009. Ninety-eight percent of Siscowet were caught at depths deeper than 240 feet. The CPUE of Lake Trout was 2.1 fish/1,000 feet of net and the CPUE of Burbot was 0.8 fish/1,000 feet of net. Siscowet outnumbered Lake Trout six to one.

In the summer expanded commercial assessment, commercial fishermen in MN-1 harvested 398 Lake Trout and the CPUE was 16.9 fish per 1,000 feet of net. Lake Trout harvest in MN-2 was 288 fish and the CPUE was 4.2 fish per 1,000 feet of net. In MN-3, 1,625 Lake Trout were harvested and the CPUE was 17.1 fish per 1,000 feet of net. Collectively, commercial fishermen harvested 59% of the available quota. Commercial fishermen accounted for 8.0% of the total shorewide Lake Trout harvest between sport (26,546) and commercial (2,311) fishermen combined.

In the Lake Trout spawning assessment, the CPUE was 34.0 fish/1,000 feet of net in MN-2, and 76.0 fish/1,000 feet of net in MN-3. MN-1 was not sampled due to a lack of staff. Wild fish accounted for 94% and 100% of the catches in MN-2 and MN-3.

The estimated biomass of spawning size Cisco from the fall hydroacoustic survey was 3,490 metric tons and represents a 20% decrease from 2019 (a hydroacoustics survey was not conducted in 2020 due to the pandemic). Cisco harvest in the traditional gill net fishery (all months excluding November) was 236,237 pounds which was an 88% increase over 2020. The catch rate was 392 pounds per 1,000 feet of net and ranked as the third highest CPUE since 1965. Harvest during the November fishery was 135,061 pounds and the catch rate was 468 pounds per 1,000 feet of net.

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Introduction

This report summarizes the assessment work conducted by the Lake Superior Area Office in Minnesota's portion of Lake Superior in 2021 including the May Lake Trout (*Salvelinus namaycush),* deepwater predator, juvenile Lake Trout, summer expanded commercial Lake Trout, spawning Lake Trout, and Cisco (*Coregonus artedi*) assessments.

Lake Trout are the top native predator in Lake Superior and historically supported important recreational and commercial fisheries. 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) in the mid-1950s. Over the past few decades, wild Lake Trout abundance has increased, limited commercial harvest of Lake Trout has resumed, and stocking was deemed no longer necessary and discontinued. Lake Trout is the primary species caught by anglers, presently supporting a recreational fishery with an average annual catch of 27,927 fish (2012-2021) in the Minnesota waters of Lake Superior (Reeves and Blankenheim 2021). 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".

Cisco are an important native forage species in Lake Superior and have also supported a commercial fishery since the late 1800s. Cisco stocks crashed in the 1950s, and although populations have rebounded, they remain well below historic levels. Cisco population dynamics are monitored by hydroacoustic surveys, MNDNR assessment netting, and analyzing commercial fishing records. Commercial harvest is summarized thoroughly in an annual commercial fishing report (Blankenheim 2022).

Chinook Salmon (*Oncorhynchus tshawytscha)*, Coho Salmon (*O. kisutch)*, and Rainbow Trout (*O. mykiss*) are generally not vulnerable to MNDNR assessment gill nets. The status of these salmonid species is discussed in creel survey reports (Peterson 2022a; Reeves and Blankenheim 2022) and Knife River trap reports (Peterson 2022b).

Methods

MNDNR conducts the May Lake Trout assessment in MN-1 while commercial operators provide data for MN-2 and MN-3. The May Lake Trout assessment utilizes 4.5 inch stretch-measure mesh. In MN-1 each gang consists of three 250-foot nets for a total of 750 feet per gang; commercial fishermen set gangs of variable length. Gangs were set in eight locations in MN-1, two in MN-2, and one in MN-3, with each gang set between 120 and 240 feet of water. Gang sets were for one night unless weather interfered with net retrieval.

MNDNR conducts a deepwater predator assessment every third year near Fisherman's Point northeast of Two Harbors. Gillnets for the deepwater predator assessment consist of nine 250 foot nets with stretch mesh sized from 2.0 to 6.0 inches in ½-inch increments. Randomly selected mesh sizes were combined into two gangs, one of five nets (1,250 feet) and one of four nets (1,000 feet). Six different depth strata of 120 feet apiece were sampled during the assessment, covering depth ranges from near zero to 600+ feet deep. Each gang fished one night in a depth strata, then was re-deployed in the complementing depth strata occupied by the other gang the previous night. For example, on the first day of the assessment in 2021 the five-net gang was set in the 480-600 foot depth strata and four-net gang was set in the 120-240 foot depth strata. The next day the five-net gang was set in the 120-240 foot depth strata and the four-net gang was set in the 480-600 foot depth strata. This way, two different depth strata were fished with the entire compliment of mesh sizes in two days.

The juvenile Lake Trout assessment is conducted solely by MNDNR. The assessment utilizes five nets each 200 feet in length tied together for a total gang length of 1,000 feet. Mesh sizes include 1.5, 1.75, 2.0, 2.25, and 2.5 inch stretch-measure mesh. Gangs were set in six locations in MN-1, four locations in MN-2, and three locations in MN-3 with each set starting in 120 feet of water and ending shallower than 240 feet. Gang sets were for two nights, except for Hovland which is always set for one night.

A limited summer expanded commercial Lake Trout assessment fishery was permitted beginning in 2007 for MN-3, 2010 for MN-2, and 2017 for MN-1. The annual Lake Trout limits are 3,000 fish in MN-3, 2,000 fish in MN-2, and 500 fish in MN-1. Commercial operators must select the statistical zone and grid they wish to fish in, with no more than two operators per grid. Lake Trout are allotted based on the number of applicants per zone, with a maximum of 1,000 Lake Trout per fisherman. The season is open from June 1st through September 30th. Detailed harvest information on the limited commercial Lake Trout fishery can be found in Blankenheim (2022).

The Lake Trout spawning assessment is conducted every other year. MNDNR conducts the Lake Trout spawning assessment in MN-1 while commercial operators assist in MN-2 and MN-3. Spawning assessment nets utilize 5.5 inch stretch-measure mesh. In MN-1 each net is a single 250 foot panel; commercial fishermen occasionally fish longer gangs. Nets were set in one location in MN-2 (Split Rock) and one location in MN-3 (Grand Marais). Typically four sets are conducted in MN-1 but due to a lack of staff this portion of the assessment was not completed in 2021. Spawning assessment sets begin in 20 feet of water and typically end by 50 feet of depth. Net sets were set for one night unless weather interfered with retrieval.

Diet analysis of all predator fish is usually conducted by MNDNR staff and tabulated for each survey within this report. In 2021 all stomachs were sent to Northern Michigan University (NMU) for analysis and inclusion in a lakewide diet project. The NMU lab identified insects more specifically (to Order when possible) than typically done by MNDNR staff, but results were tabulated into categories used in previous reports for continuity between years.

Statistical zones, grids, and locations for May Lake Trout, juvenile Lake Trout and spawning Lake Trout net sets are shown in Figure 1. Detailed specifications for survey nets can be found in Ebener (2001). In all surveys length, weight, sex, fin clips, and lamprey wounds were recorded for each fish caught. MNDNR collected otoliths and stomach contents on all Lake Trout while commercial operators did so on a subsample of the fish they harvested in the May assessment, summer expanded commercial assessment, and spawning assessment.

Beginning in 2006, catch per unit effort (CPUE) for Lake Trout 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' CPUEs were recalculated for MN-1. Therefore, historical CPUEs in this report may be slightly different than in some previous reports.

Cisco are assessed in two ways: netting assessments and hydroacoustic surveys. The MNDNR Cisco assessment consisting of 300 foot multi-mesh (2.0-, 2.5-, and 3.0-inch stretch mesh) nets, with 100 feet of each mesh size per net was not conducted in 2021 due to a lack of staff. However, Cisco samples were collected from commercial fishermen in both spring/summer and fall from each statistical zone. Due to the time constraints of otolith aging and reporting, age data of Cisco sampled in 2021 were not yet available but 2020 age data are presented in this report.

Hydroacoustic surveys with accompanying mid-water trawls have been conducted since 2003; methodology can be found in Hrabik et al. (2006). From 2003-2013 hydroacoustic surveys were conducted in the summer but have been conducted in the fall since 2014. Beginning in 2017, all hydroacoustic work has been conducted aboard the Large Lakes Observatory's R/V Blue Heron rather than split between the R/V Blue Heron and the MNDNR vessel. Sampling MN-3 nearshore was discontinued after 2015 because it contributes very little to the overall Cisco biomass estimate. Data analysis procedures are described in the MNDNR Lake Superior Hydroacoustics Standard Operating Procedure.

Results and Discussion

May Assessment

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. The number of fresh Sea Lamprey wounds per 100 Lake Trout (wounding rate) in the May assessment was 2.4 in MN-1, 0.0 in MN-2, and 6.1 in MN-3 (Table 1, Figure 2). The overall wounding rate was 3.2 (Figure 3). The target wounding rate for all zones is not more than 5 fresh wounds per 100 Lake Trout. Overall, wounding rates increased by size category (Table 1).

The overall CPUE of Lake Trout was 6.5 fish per 1,000 feet of net in the May assessment (Table 2), which was the lowest since 2005. The wild Lake Trout CPUE was 6.4 fish per 1,000 feet of net while stocked Lake Trout CPUE was 0.1 fish per 1,000 feet of net (Figure 4). Wild fish comprised 99% of all Lake Trout sampled in the assessment (Table 3, Figure 4). By zone, Lake Trout CPUEs for MN-1, MN-2, and MN-3 were 7.1, 4.2, and 11.4 fish per 1,000 feet of net (Table 3, Figure 5). Creel survey data and anecdotal reports have indicated that a higher proportion of the angler Lake Trout catch in MN-1 is stocked fish compared to what is observed in the May assessment, so Lester River/Brighton Beach was added as a station in 2015 after not being sampled since 2008. Even with the addition of this station that is closest to Duluth, wild fish have still accounted for over 90% of the catch in MN-1 each year since it was added back into the survey.

Lake Trout ages ranged from age-4 to age-20 (Table 4). By design, the May assessment typically captures Lake Trout age-6 to age-10. Sixty-one percent of Lake Trout captured were age-6 to age-10.

The age and growth patterns observed on otoliths help confirm correct species identification from the calls made in the field by MNDNR staff and commercial operators. In some years there are discrepancies between species identification in the field compared to otolith analysis, with some Siscowet mistakenly identified as Lake Trout, primarily in MN-3. In 2021, the commercial operators who assisted with the May Lake Trout Assessment did a good job identifying Lake Trout and Siscowet. In MN-2 nine fish were identified as Lake Trout in the field but were likely Siscowet based on the otoliths (94% agreement, n=139), and in MN-3 six fish were called a Lake Trout but were likely Siscowet based on the otoliths (91% agreement, n = 67). There was one discrepancy fish in MN-1 (98% agreement; n = 64). Misidentifying Lake Trout could create a variety of problems such as biased CPUEs or poorly functioning Lake Trout models.

Rainbow Smelt commonly comprise the greatest weight of diet items in Lake Trout stomachs during the May assessment, sometimes exceeding 90% of the diet biomass. In 2021, biomass of Rainbow Smelt in Lake Trout stomachs in the May assessment was well below the range observed the previous five years (61% to 92%) at only 30.2%. Other prominent diet items included unidentifiable fish remains (25.5%), coregonids (18.0%), *Mysis* (12.3%), and Burbot (9.5%) (Table 5). Only 17% of Lake Trout stomachs contained Rainbow Smelt, which was also lower than observed the previous five years (29% to

78%). Twenty-eight percent of Lake Trout (n=85) had no prey items in their stomachs, which was within the range observed the previous five years (9% to 30%).

Juvenile Lake Trout Assessment

The overall CPUE of juvenile Lake Trout (less than 17 inches) was 13.2 fish per 1,000 feet of net (Table 6). CPUE has been relatively consistent since the mid-2000s, especially when considering only the wild fish (Figure 6). CPUEs in MN-1, MN-2, and MN-3 were 7.9, 13.5, and 24.8 Lake Trout per 1,000 feet of net, respectively (Table 6, Figure 7). The MN-1 CPUE tied for the lowest on record. The CPUE of wild juveniles was 12.4 Lake Trout per 1,000 feet of net and the CPUE of stocked juveniles was 0.8 Lake Trout per 1,000 feet of net. Although the juvenile CPUE has been much lower than that observed in the 1980s, it is important to consider Lake Trout rehabilitation was still underway at that time and recent CPUEs likely represent recruitment levels of self-sustaining Lake Trout populations in Lake Superior.

Ninety-four percent of the juvenile Lake Trout catch was wild (Tables 6 and 7, Figure 6). Zones MN-2 and MN-3 were 100% wild fish, as would be expected since stocking was discontinued in those zones in 2007 (MN-2) and 2003 (MN-3). Stocking was discontinued in MN-1 after 2015, but despite this only 79% of juveniles caught in MN-1 were wild. The Wisconsin DNR continues to stock Lake Trout which may contribute to the lower percent wild fish in MN-1, especially at the Lester River/Brighton Beach and Pumping Station locations which are nearest to Wisconsin stocking locations.

By weight, juvenile Lake Trout diets were comprised primarily of *Mysis* (51.1%), unidentifiable fish remains (15.8%), Ninespine Stickleback (12.2%), Rainbow Smelt (7.6%), sculpin species (7.4%), and coregonids (4.1%) (Table 5). Ten percent (n = 27) of juvenile Lake Trout stomachs contained no prey items, which was below the range observed the previous five years (25% to 36%).

Deepwater Predator Assessment

Siscowet are the primary species captured in the deepwater predator assessment. In 2021, the Siscowet CPUE was 12.5 fish/1,000 feet of net (Table 8). With the exception of 2009, the CPUE of Siscowet has been very consistent, ranging only from 10.4 to 12.7 fish/1,000 feet (Figure 8). Siscowet abundance increased with depth strata, and 98% of all Siscowet were captured at depths greater than 240 feet. The overall wounding rate on Siscowet was 1.8 fresh wounds per 100 fish. The Lake Trout CPUE was 2.1 fish/1,000 feet (Table 8, Figure 8). Whereas 98% of Siscowet were captured at depths greater than 240 feet, 71% of Lake Trout were captured at depths shallower than 240 feet. Overall, Siscowet were six times more abundant than Lake Trout. Burbot CPUE was only 0.8 fish/1,000 feet (Table 8). Bloater and Kiyi, the “deepwater chubs”, were present in low abundance at depths greater than 480 feet (Table 8). Most mesh sizes used in the deepwater predator assessment are too large for adequately sampling these forage species. Siscowet ages ranged from age-5 to age-34 with ages 9-14 comprising 60% of the catch (Table 9). Average length-at-age is extremely variable due to the slow growing nature and longevity of Siscowet.

Siscowet diet composition by weight was predominantly sculpin species (36.2%), unidentifiable fish remains (23.2%), terrestrial insects (18.7%), coregonids (12.8%), and *Mysis* (4.5%) (Table 10). Ten percent of Siscowet stomachs were empty (n = 14). Burbot consumed sculpin species (88.7%) and unidentifiable fish remains (6.7%) (Table 10). Lake Trout captured during the deepwater predator assessment had consumed mainly *Mysis* (44.7%), terrestrial insects (21.8%), sculpin species (16.4%), and coregonids (11.6%) (Table 5).

Summer Expanded Commercial Assessment

In accordance with the 2016 Lake Superior Management Plan (LSMP; Goldsworthy et al. 2017), a limited commercial fishery for Lake Trout in MN-1 was established in 2017 and commercial fishermen in this zone got to target Lake Trout for the first time since the 1960s. The quota for MN-1 was set at 500 Lake Trout. A total of 398 Lake Trout and two Siscowet were harvested and the CPUE was 16.9 Lake Trout per 1,000 feet of net (Figure 9). Commercial fishermen harvested 80.0% of the total-allowable-catch (TAC; Lake Trout and Siscowet combined). Commercial harvest of Lake Trout represented 2.1%

of the estimated total Lake Trout harvest in MN-1 between sport (18,623) and commercial (398) fishers combined.

In MN-2, the number of Lake Trout harvested by commercial fishermen was 288 and the CPUE was 4.2 Lake Trout per 1,000 feet of net (Figure 9). Forty-four Siscowet were also harvested. Commercial fishermen harvested 16.6% of the 2,000 fish TAC from MN-2. Commercial harvest of Lake Trout represented 5.2% of the estimated total Lake Trout harvest in MN-2 between sport (5,251) and commercial (288) fishers combined.

In MN-3, commercial fishermen harvested 1,625 Lake Trout and the CPUE was 17.1 Lake Trout per 1,000 feet of net (Figure 9). An additional 155 Siscowet were harvested. Commercial fishermen harvested 59.3% of the 3,000 fish TAC. Commercial harvest of Lake Trout represented 37.8% of the estimated total Lake Trout harvest in MN-3 between sport (2,672) and commercial (1,625) fishers combined. In the three zones combined, commercial fishermen harvested 45.6% of the TAC. Overall, commercial harvest accounted for 8.0% of the total shorewide Lake Trout harvest between sport (26,546) and commercial (2,311) fishermen.

Lake Trout diet composition by weight in the summer commercial assessment was predominately terrestrial insects (22.7%), coregonids (18.4%), unidentifiable fish remains (16.9%), *Mysis* (16.0%), and Burbot (11.0%) (Table 5). Thirty-one percent of Lake Trout stomachs (n = 151) had no diet items, which was slightly below the previous five years (32% to 46%).

Spawning Lake Trout Assessment

A lack of staff precluded conducting the MN-1 portion of the Lake Trout spawning assessment in 2021. Commercial operators assisted as usual in MN-2 and MN-3. The CPUE in MN-2 was 34.0 Lake Trout per 1,000 feet of net while in MN-3 the CPUE was 76.0 Lake Trout/1,000 feet of net (Table 11, Figure 10). Males outnumbered females by a ratio of 7.5:1 in MN-2 and 3.6:1 in MN-3. Males are much more common in the spawning assessment, as they seem to congregate while awaiting the arrival of females. In MN-2 94.1% of Lake Trout were wild and in MN-3 100% were wild (Figure 11).

Lake Trout diet composition by weight was predominantly coregonids (38.4%), Burbot (25.7%), and unidentifiable fish remains (24.1%) (Table 5). Lake Trout captured in the spawning assessment often have empty stomachs, and 68% did not contain prey items.

Cisco Assessment

USGS trawling data continues to indicate that Cisco recruitment is very sporadic. Since 2003, only relatively weak or nonexistent year-classes have been produced (Figure 12). Due to the backlog of otoliths, age data from the 2021 spring and fall commercial Cisco samples were not yet available at the time of this reporting. However, age analysis from the 2020 spring and fall Cisco samples collected from commercial fishermen (n = 662) showed the 2015, 2014, and 2009 year-classes accounted for 83% of their catch (Figure 12). In total there were 21 year-classes present, ranging from age-3 to age-29. The MNDNR fall Cisco assessment was not conducted in 2021 due to a lack of available staff.

The estimated biomass of spawning size Cisco in the fall of 2021 was 3,490 metric tons (Figure 13). This represents a 20% decrease in biomass from 2019 (the hydroacoustic assessment was not conducted in 2020) but was not statistically different. Offshore zones accounted for most of the Cisco biomass. Zone MN-3 Offshore accounted for 48.2% of the biomass, followed by MN-2 Offshore (41.1%), MN-1 Offshore (6.2%), MN-1 Nearshore (3.4%), and MN-2 Nearshore (1.1%). Both nearshore zones had a low proportion of biomass compared to the previous two years, which had been considered unusually high and possibly due to the nearshore transects being conducted from the RV Blue Heron rather than the MNDNR Blackfin. However, nearshore data were again collected from the RV Blue Heron in 2021. The survey was conducted earlier than usual though (October 11-14, 2021) which could further confound possible differences between sampling vessels.

No data were collected in the MN2 Nearshore zone, and the biomass estimate for this zone was modeled from MN1 Nearshore data because historically the two zones correlate well and have not contributed much to the overall estimate. In future years more nearshore zone data should be collected to ensure modeling data accurately reflects biomass distribution.

Commercial Cisco Harvest

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. Additionally, CPUEs can be very high during November and net saturation could occur.

Cisco harvest in the traditional fishery (all months except November) was 236,237 pounds in 2021 and was an 87% increase over the 2020 harvest (Figure 14). The increase in harvest was driven both by an increase in effort and a high CPUE. The CPUE was 392 pounds per 1,000 feet of net and ranked as the third highest observed since 1965 (Figure 14). The high catch rate was likely attributable to the distribution of effort rather than high Cisco abundance. There was considerable effort in grid 714 in 2021; forty-three percent of the traditional fishery effort occurred in this grid. By contrast, effort in grid 714 during the traditional fishery the three previous years was and 18% (2020), 0.4% (2019), 2% (2018). Additionally, grid 714 was by far the most productive grid in 2021 (outside of Grand Portage waters) with a CPUE of 458 lbs per 1000 feet of net, and it produced 50% of the catch. The next most productive grid had a CPUE of 189 lbs per 1000 feet of net.

Experimental netting for a potential November roe fishery started in 2001 and beginning in 2006 harvest was permitted during November using TAC quotas established for each statistical district (Schreiner et al. 2006). The yearly November TAC is calculated from hydroacoustic data and for 2021 was set at 329,913 pounds. Beginning in 2016, the Grand Portage Band of Chippewa set a November Cisco TAC for their waters. With permission, some Minnesota-licensed commercial fishermen are allowed to harvest from Grand Portage waters. Commercial fishermen operating in Minnesota waters harvested 109,021 pounds of Cisco and Minnesota-licensed commercial fishermen fishing in Grand Portage waters harvested 26,040 pounds for a combined harvest of 135,061 pounds of Cisco in the November season (Figure 14). The CPUE was 709 pounds per 1,000 feet of net. Further detail of commercial Cisco harvest is available in the annual Commercial Fishing Summary (Blankenheim 2022).

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2021

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Josh Blankenheim

Approved by: Cory Goldsworthy Digitally signed by Cory Goldsworthy Date: 2022.09.21 11:37:37 -05'00'
Area Fisheries Supervisor Date

Approved by: Leslie George Digitally signed by Leslie George Date: 2023.04.23 20:41:36 -05'00'
Regional Fisheries Approval Date

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Restoration Act

Table 1. Number of fresh lamprey wounds per 100 Lake Trout (>17") in 4.5 inch stretch mesh May assessment gill nets, by size class and statistical district, 2021. 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 (38)	2.9 (34)	12.5 (8)	0.0 (2)	2.4 (82)
MN-2	0.0 (78)	0.0 (93)	0.0 (33)	0.0 (3)	0.0 (207)
MN-3	2.8 (71)	6.7 (135)	5.9 (34)	40.0 (5)	6.1 (245)
TOTALS	1.1 (187)	3.8 (262)	4.0 (75)	20.0 (10)	3.2 (534)

Table 2. Number of Lake Trout by size class per 1,000 feet of 4.5 inch stretch mesh May assessment gill nets, 2021.

	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	0.1	2.2	3.1	0.9	0.1	6.5

Table 3. Corrected Lake Trout catch by station in the May assessment, 2021.

Location	Effort in Feet (corrected effort)	Number Caught	Total Pounds	Number per 1,000 feet	Pounds per 1,000 feet	Percent Wild
MN-1						
All stations (n = 8)	12,000 (12,000)	85	283	7.1	23.6	95.3
MN-2						
Split Rock	23,000 (31,420)	146	511	4.6	16.3	100
Silver Bay	12,500 (18,090)	61	203	3.4	11.2	100
Totals MN-2	35,500 (49,510)	207	714	4.2	14.4	100
MN-3						
Grand Marais	15,000 (21,760)	249	823	11.4	37.8	99.6
All locations						
Shorewide	**62,500 (83,270)**	**541**	**1,820**	**6.5**	**21.9**	**99.1**

Table 4. Age-length frequency distribution of otolith-aged Lake Trout in 4.5 inch stretch measure gill nets, May assessment, 2021. Bold numbers indicate fish that were identified as Lake Trout but age analysis suggested they were Siscowet.

Length (in)	III	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		1												
13.0 - 13.9														
14.0 - 14.9														
15.0 - 15.9														
16.0 - 16.9			1											
17.0 - 17.9				4	1	1		1	1					
18.0 - 18.9				6	1	1		2	1	1	2			**2**
19.0 - 19.9				4	11	1	1	4	4	3	1	1		**1**
20.0 - 20.9				3	10	6	1	4	5	3	1			**1**
21.0 - 21.9				3	10	8	4	4		5				**5**
22.0 - 22.9				1	2	6	5	4	3	5	1			**4**
23.0 - 23.9				1	2	9	8	1	1	3	3	1		**4**
24.0 - 24.9					2	1	7	7	2	3	6		1	**1**
25.0 - 25.9						3	2	3	5	1	2	1	2	2
26.0 - 26.9						2	1	2	1				1	**2**
27.0 - 27.9					1	1	2	1	1	3		1		**1**
28.0 - 28.9										1				
29.0 - 29.9							1							
30.0 - 30.9														1
31.0 - 31.9														1
32.0 - 32.9													1	
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	1	1	22	40	39	32	33	24	28	16	4	5	25
Average Length		12.6	16.5	19.5	20.9	22.3	23.6	22.4	22.4	22.6	22.9	23.9	26.9	24.8

Table 5. Diet composition by weight of prey items in Lake Trout stomachs in the May, juvenile, deepwater predator, summer, and spawning assessments, 2021. The number of stomachs sampled with prey items is shown in parentheses.

	Lake Trout									
Diet item	May		Juvenile		Deepwater		Summer		Spawning	
Aquatic insects	0.1%	(20)	0.0%	(1)			0.7%	(31)	0.9%	(2)
Artificial fishing bait			0.2%	(1)			0.0%	(1)		
Burbot	9.5%	(8)	0.9%	(1)			11.0%	(5)	25.7%	(2)
Cisco	1.3%	(1)					5.5%	(1)		
Clam spp			0.0%	(2)			0.0%	(1)		
Coregonid spp	16.7%	(13)	4.1%	(2)	11.6%	(1)	11.1%	(17)	38.4%	(2)
Deepwater Sculpin	0.6%	(3)	2.0%	(7)	12.9%	(1)	0.1%	(3)		
Detritus	0.0%	(5)	0.1%	(22)	0.0%	(1)	0.1%	(10)	0.8%	(2)
Empty		(85)		(27)		(10)		(151)		(51)
Fish eggs	0.0%	(3)			0.2%	(1)	0.0%	(2)	0.1%	(2)
Kiyi							1.8%	(2)		
Klinker	0.0%	(2)					0.0%	(1)		
Larval fish	0.0%	(1)								
Mysis	12.3%	(41)	51.1%	(171)	44.7%	(4)	16.0%	(121)	0.9%	(3)
Ninespine Stickleback			12.2%	(2)	0.6%	(1)	0.1%	(1)		
Pink Salmon							5.1%	(2)		
Rainbow Smelt	30.2%	(52)	7.6%	(16)			6.5%	(31)	7.0%	(2)
Rock	0.1%	(12)	0.1%	(13)			0.3%	(34)	1.0%	(3)
Sculpin spp	0.3%	(5)	2.4%	(15)			1.1%	(15)	0.3%	(1)
Slimy Sculpin	0.2%	(3)	3.0%	(11)	3.5%	(1)	0.1%	(2)		
Snail spp					0.0%	(1)	0.1%	(1)	0.0%	(1)
Snake							0.8%	(1)		
Terrestrial insects	2.8%	(45)	0.2%	(19)	21.8%	(4)	22.7%	(69)	0.8%	(2)
Threespine Stickleback							0.0%	(1)		
Unidentifiable fish remains	25.5%	(100)	15.8%	(68)	4.7%	(5)	16.9%	(125)	24.1%	(8)
Woody debris	0.3%	(14)	0.3%	(28)			0.1%	21)		

Table 6. Summary of fishing effort, catch, percentage of wild Lake Trout and CPUE (number of fish per 1,000 feet of 1.5-2.5 inch gill net) in the juvenile Lake Trout (less than 17 inches; 432 mm) assessment, 2021.

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	3	33%	0.7	1.3	2.0
Pumping Station	1,000	1,520	8	25%	1.3	3.9	5.3
Stoney Point	1,000	1,520	36	83%	19.7	3.9	23.7
Larsmont	1,000	1,520	3	100%	2.0	0.0	2.0
Two Harbors	1,000	1,520	7	86%	3.9	0.7	4.6
Encampment Island	1,000	1,520	15	100%	9.9	0.0	9.9
MN-1 Total	**6,000**	**9,120**	**72**	**79%**	**6.3**	**1.6**	**7.9**
MN-2							
Split Rock	1,000	1,520	44	100%	28.9	0.0	28.9
Silver Bay	1,000	1,520	13	100%	8.6	0.0	8.6
Taconite Harbor	1,000	1,520	17	100%	11.2	0.0	11.2
Tofte	1,000	1,520	8	100%	5.3	0.0	5.3
MN-2 Total	**4,000**	**6,080**	**82**	**100%**	**13.5**	**0.0**	**13.5**
MN-3							
Grand Marais	1,000	1,520	36	100%	23.7	0.0	23.7
Hovland	1,000	1,000	18	100%	18.0	0.0	18.0
Grand Portage	1,000	1,520	46	100%	30.3	0.0	30.3
MN-3 Total	**3,000**	**4,040**	**100**	**100%**	**24.8**	**0.0**	**24.8**
Shorewide Total	**13,000**	**19,240**	**254**	**94%**	**12.4**	**0.8**	**13.2**

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 (432 mm) 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, 1980-2021.

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	625	1.3	31.6	32.9	4%
1981	914	2.2	51.7	54.0	4%
1982	551	1.9	37.7	39.6	5%
1983	453	4.5	22.2	26.7	17%
1984	585	6.7	33.7	40.4	17%
1985	336	4.1	19.9	24.0	17%
1986	404	5.6	22.6	28.2	20%
1987	346	6.0	16.5	22.5	27%
1988	285	4.7	15.1	19.8	24%
1989	168	2.7	8.6	11.3	24%
1990	236	3.7	10.7	14.4	25%
1991	363	4.9	14.5	19.4	25%
1992	274	5.1	11.4	16.6	31%
1993	387	6.0	18.4	24.4	25%
1994	458	6.7	19.4	26.1	26%
1995	352	7.3	12.6	20.0	37%
1996	468	10.3	16.0	26.3	39%
1997	440	12.0	14.9	26.9	45%
1998	557	13.5	16.9	30.4	44%
1999	640	19.0	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	14.0	6.3	20.3	69%
2006	306	11.0	4.9	15.9	69%
2007	222	8.4	3.1	11.5	73%
2008	282	13.0	1.6	14.7	89%
2009	295	14.0	1.3	15.3	92%
2010	235	11.5	0.7	12.2	94%
2011 [1]	-	-	-	-	-
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%
2017	273	13.4	0.4	13.8	97%
2018	315	15.6	0.6	16.2	97%
2019	208	10.4	0.4	10.8	96%
2020 [2]	-	-	-	-	-
2021	254	12.4	0.8	13.2	94%

[1] No data due to State of Minnesota government shutdown

[2] No data due to coronavirus pandemic

Table 8. Catch and CPUE (number per 1,000 feet) in the 2021 deepwater predator assessment.

Depth Stratum	Length of Net (ft)	Catch					CPUE (fish/1000 ft)				
		Lake Trout	Siscowet	Burbot	Bloater	Kiyi	Lake Trout	Siscowet	Burbot	Bloater	Kiyi
0-119	2,250	6	0	4	0	0	2.7	0.0	1.8	0.0	0.0
120-239	2,250	14	3	3	0	0	6.2	1.3	1.3	0.0	0.0
240-359	2,250	2	16	3	0	0	0.9	7.1	1.3	0.0	0.0
360-479	2,250	1	32	0	0	0	0.4	14.2	0.0	0.0	0.0
480-599	2,250	5	54	0	2	7	2.2	24.0	0.0	0.9	3.1
600+	2,250	0	64	1	1	5	0.0	28.4	0.4	0.4	2.2
Total	**13,500**	**28**	**169**	**11**	**3**	**12**	**2.1**	**12.5**	**0.8**	**0.2**	**0.9**

Table 9. Age-length frequency distribution of otolith-aged Siscowet in the deepwater predator assessment, 2021.

	Age																					
Length (in)	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI	XXII	XXIII	XXIV	XXV	XXVI+
9.0 - 9.9																						
10.0 - 10.9						1																
11.0 - 11.9					2																	
12.0 - 12.9					2	1		1														
13.0 - 13.9			1	1	2		1	1														
14.0 - 14.9			2		2	1	4	2	1													
15.0 - 15.9	1			1		1	3	3	2	1		2						1				
16.0 - 16.9						1	7	3	3	1			1									
17.0 - 17.9					1	1	4	2	2		2	1	1	1	1	1	1	1				
18.0 - 18.9					1	1		3	2	3	1	2	1	1		1	1	3			1	
19.0 - 19.9				1		1		1		3	1		2		2					1		1
20.0 - 20.9								1	1	2	1		2			1		2	1			1
21.0 - 21.9														1		1	1					
22.0 - 22.9											1											
23.0 - 23.9																						
24.0 - 24.9																						
25.0 - 25.9																						
26.0 - 26.9												1										
27.0 - 27.9																						
28.0 - 28.9																						
29.0 - 29.9																						
Total	1	0	3	3	10	8	19	17	11	10	6	6	7	3	3	4	3	7	1	1	1	2
Average Length	15.2		14.4	15.9	13.8	15.5	16.0	16.5	17.0	18.7	19.3	18.3	18.8	19.1	18.9	19.6	18.9	18.4	20.9	19.5	18.6	19.7

Table 10. Diet composition by weight of prey items in Burbot and Siscowet stomachs in the deepwater predator assessment, 2021. The number of stomachs sampled with prey items is shown in parentheses.

Diet item	Burbot		Siscowet	
Aquatic insects	0.1%	(1)	1.7%	(2)
Bird			0.0%	(2)
Clam spp			0.0%	(3)
Coregonid			7.1%	(2)
Deepwater Sculpin	40.0%	(1)	22.4%	(30)
Detritus	1.2%	(1)	0.0%	(3)
Empty		(2)		(14)
Fish Eggs			2.2%	(18)
Kiyi			5.7%	(1)
Klinker			0.2%	(1)
Mysis	1.7%	(4)	4.5%	(14)
Rainbow Smelt			0.3%	(2)
Rock	1.3%	(2)	0.1%	(8)
Sculpin spp	32.9%	(1)	12.0%	(20)
Slimy Sculpin	15.8%	(1)	1.8%	(3)
Snail spp	0.0%	(1)		
Terrestrial insects			18.7%	(55)
Unidentified fish remains	6.9%	(1)	23.2%	(61)
Woody debris			0.1%	(6)

Table 11. Effort, catch and CPUE (number per 1,000 feet) of Lake Trout in the 2021 spawning assessment.

	MN-1	MN-2	MN-3
Total effort (feet)	0	1,000	1,750
Total catch (number)	0	34	133
Number/1,000 feet	-	34.0	76.0
Percent wild	-	94%	100%
Number by Sex			
male	-	30	104
female	-	4	29
not examined	-	0	0

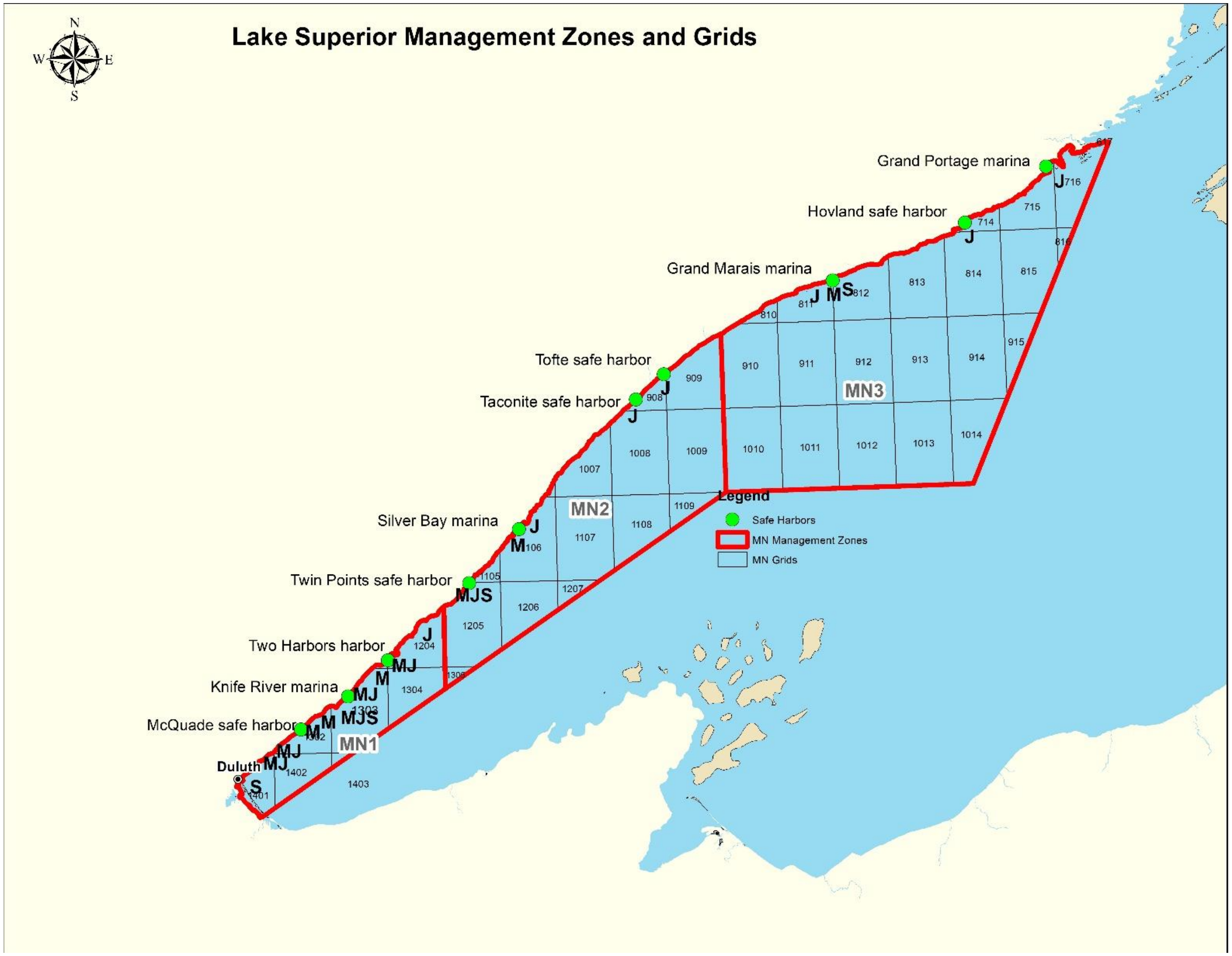

Figure 1. Statistical zones, grids, and sampling stations for May (M), juvenile (J), and spawning (S) assessments, Minnesota waters of Lake Superior.

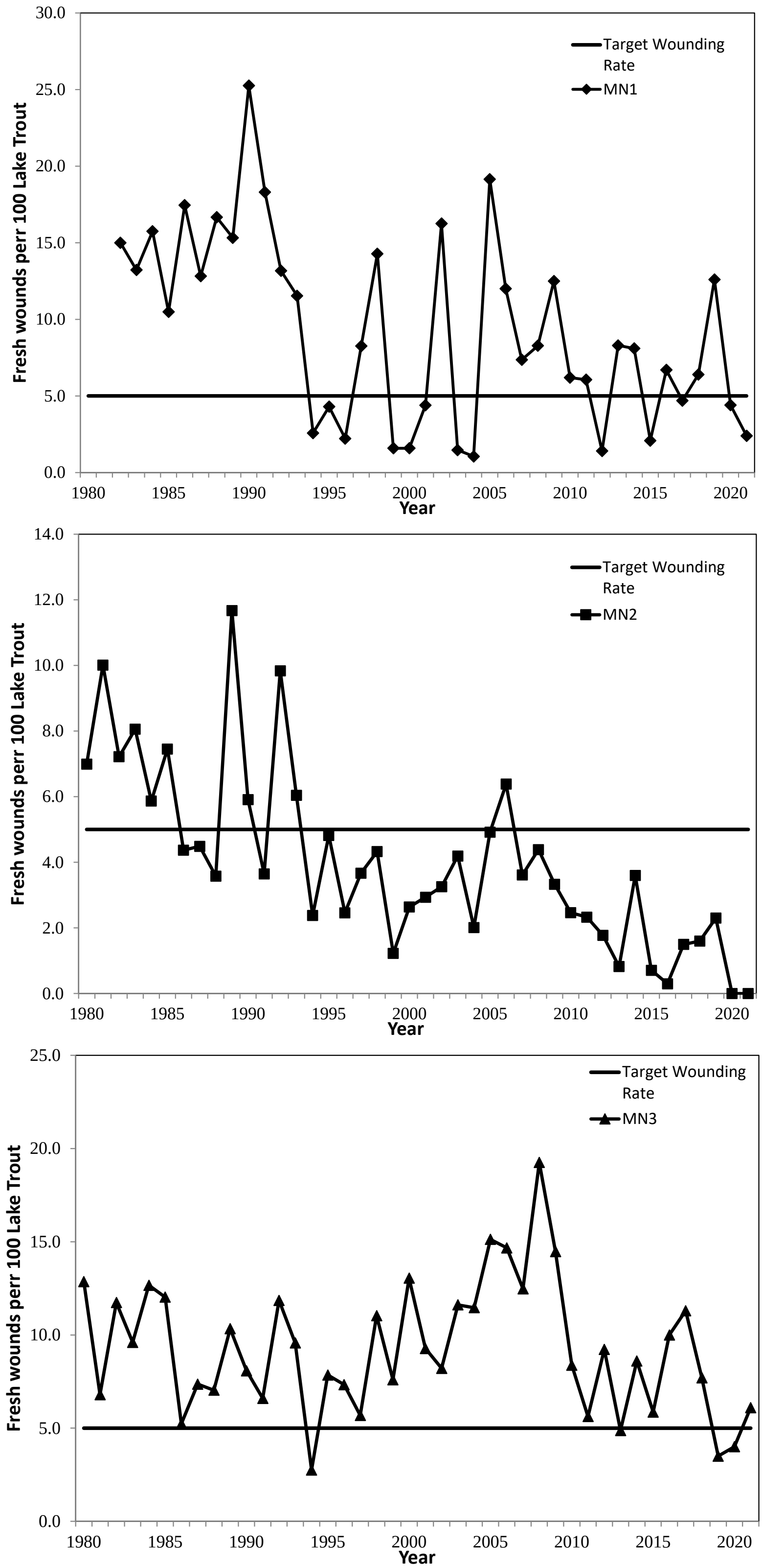

Figure 2. Number of fresh Sea Lamprey wounds per 100 Lake Trout in the May assessment, by statistical district, 1980-2021.

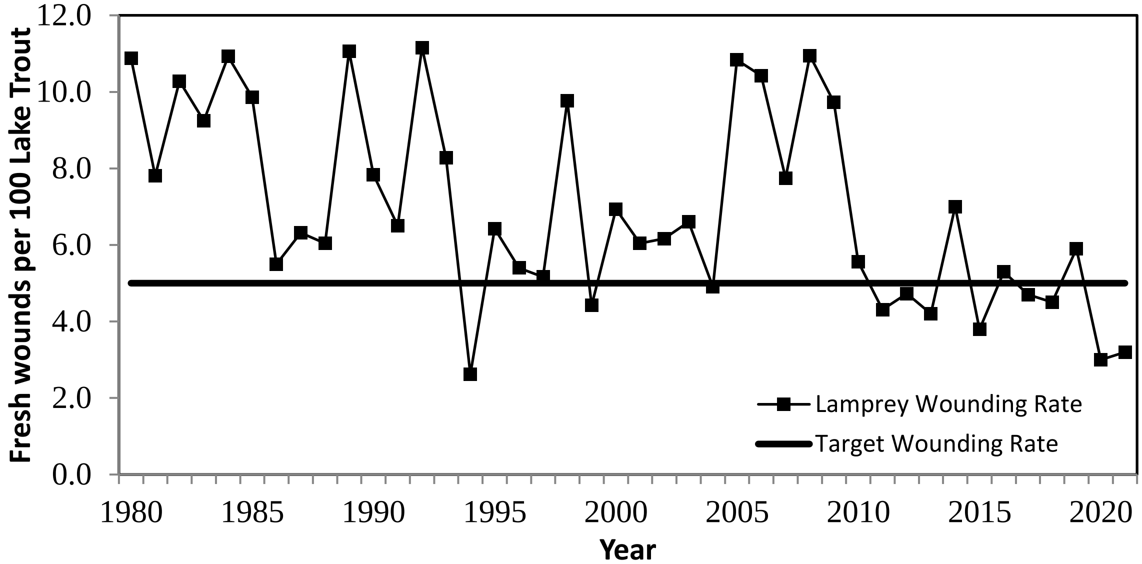

Figure 3. Shorewide number of fresh Sea Lamprey wounds per 100 Lake Trout in the May assessment, 1980-2021.

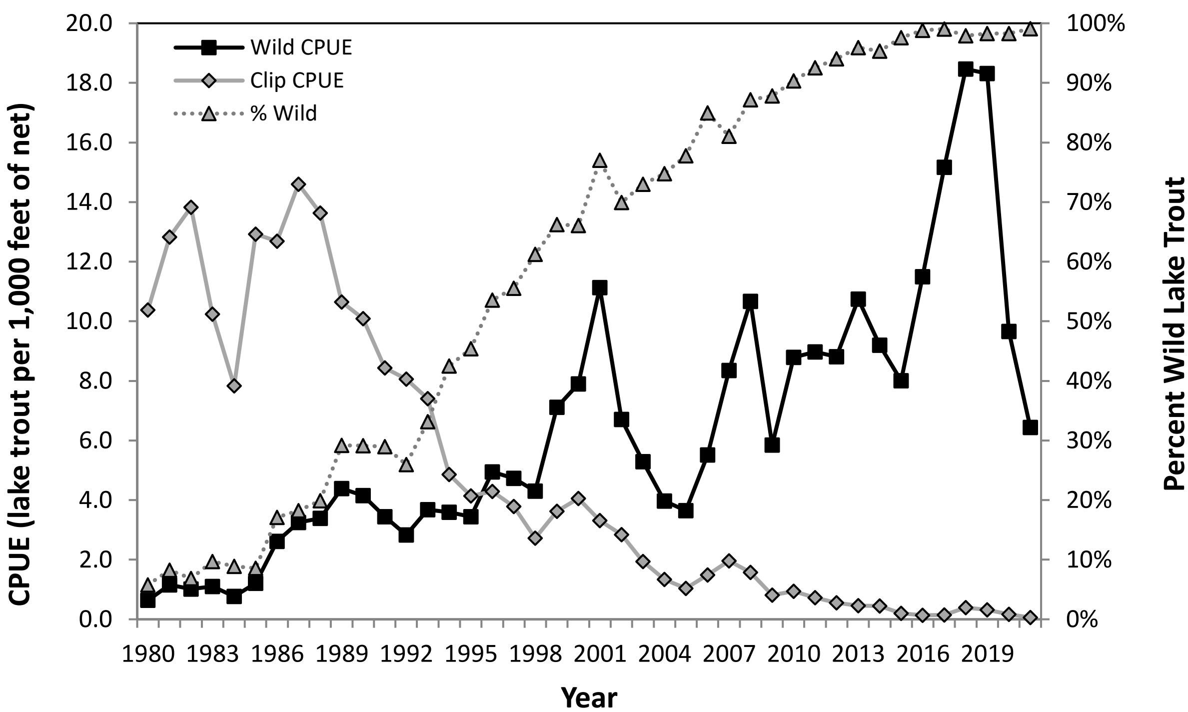

Figure 4. Catch rate (number of fish per 1,000 feet of net; CPUE) of wild and stocked Lake Trout, and percentage wild Lake Trout in the May assessment, 1980-2021.

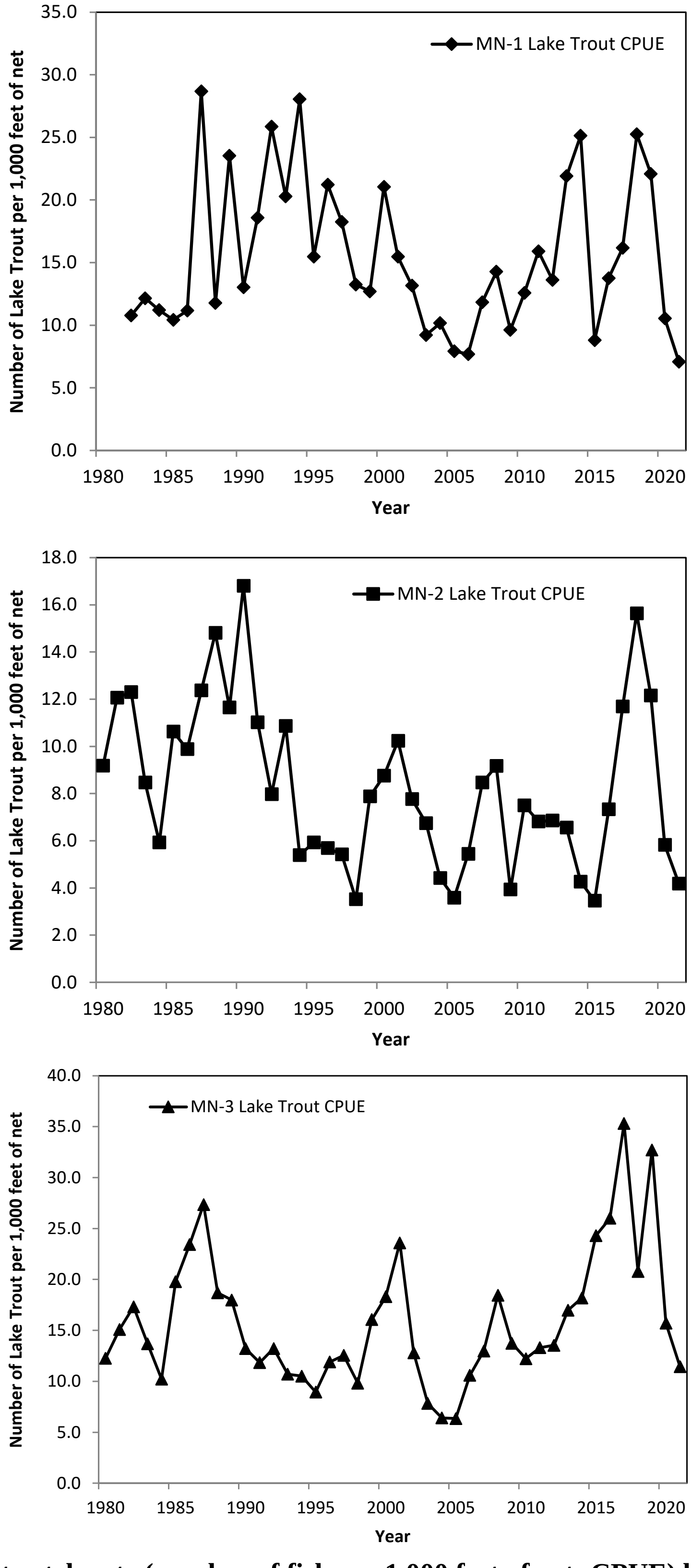

Figure 5. Lake Trout catch rate (number of fish per 1,000 feet of net; CPUE) by statistical district in the May assessment, 1980-2021.

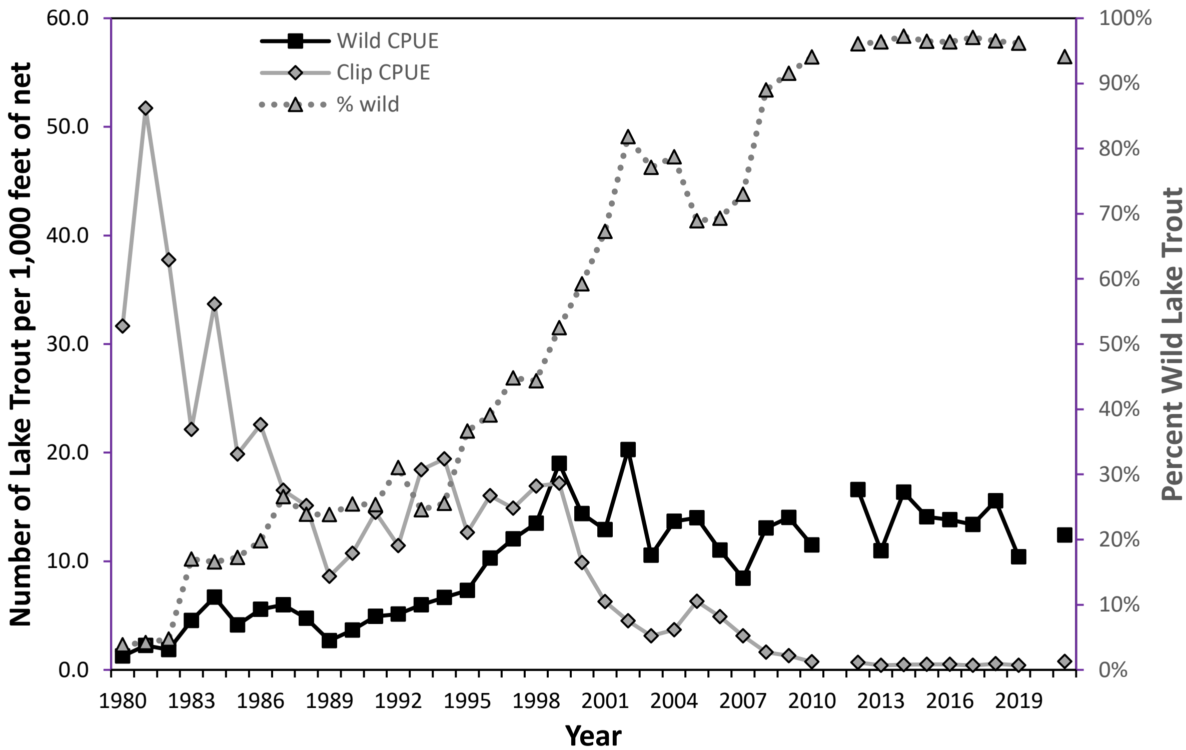

Figure 6. Catch rate (number of fish per 1,000 feet of net; CPUE) of wild and stocked Lake Trout, and percent wild Lake Trout in the juvenile (<17") Lake Trout assessment, 1980-2021.

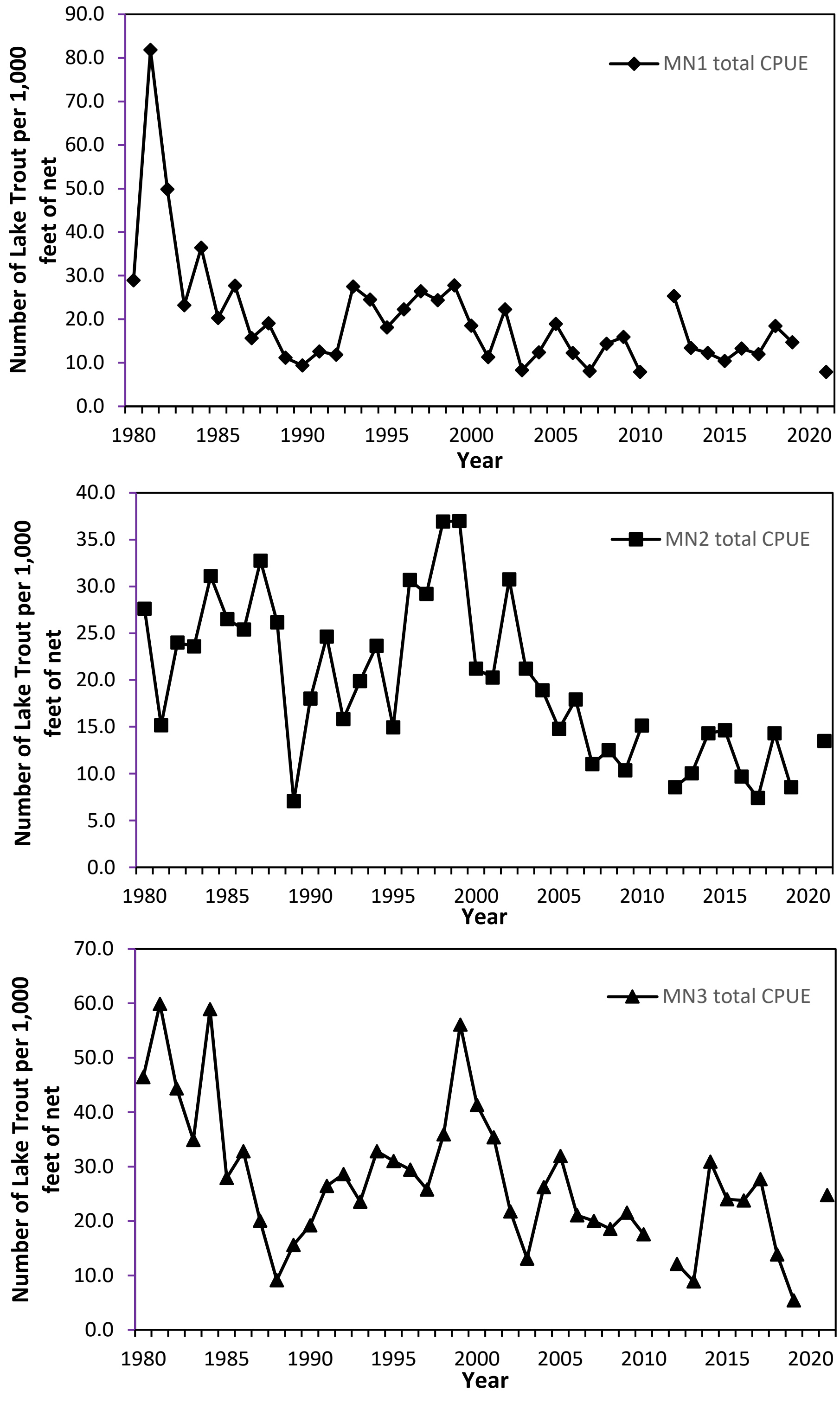

Figure 7. Lake Trout catch rate (number of fish per 1,000 feet of net; CPUE) by statistical district in the juvenile assessment, 1980-2021.

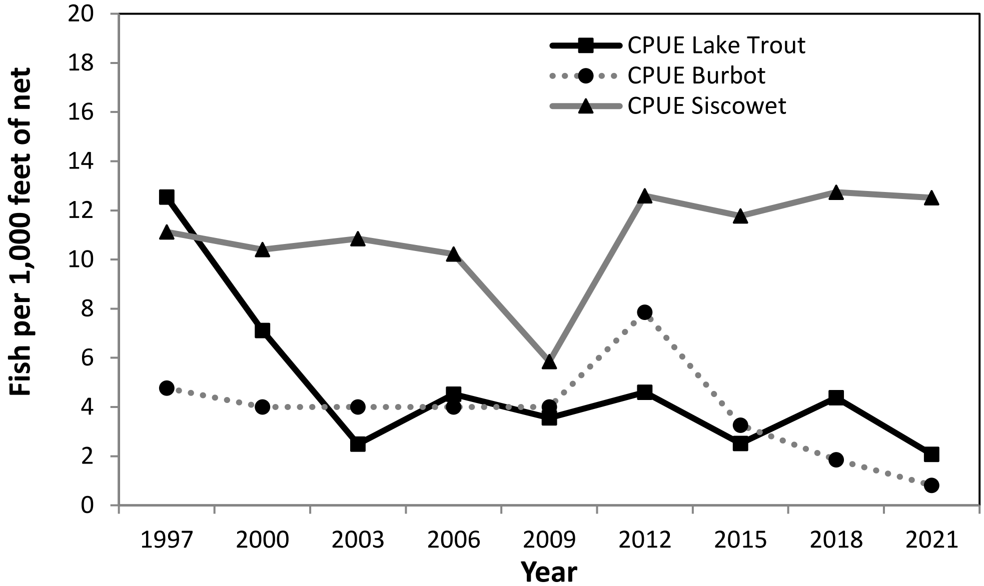

Figure 8. CPUE of Lake Trout, Burbot, and Siscowet in the deepwater predator assessment, 1997-2021.

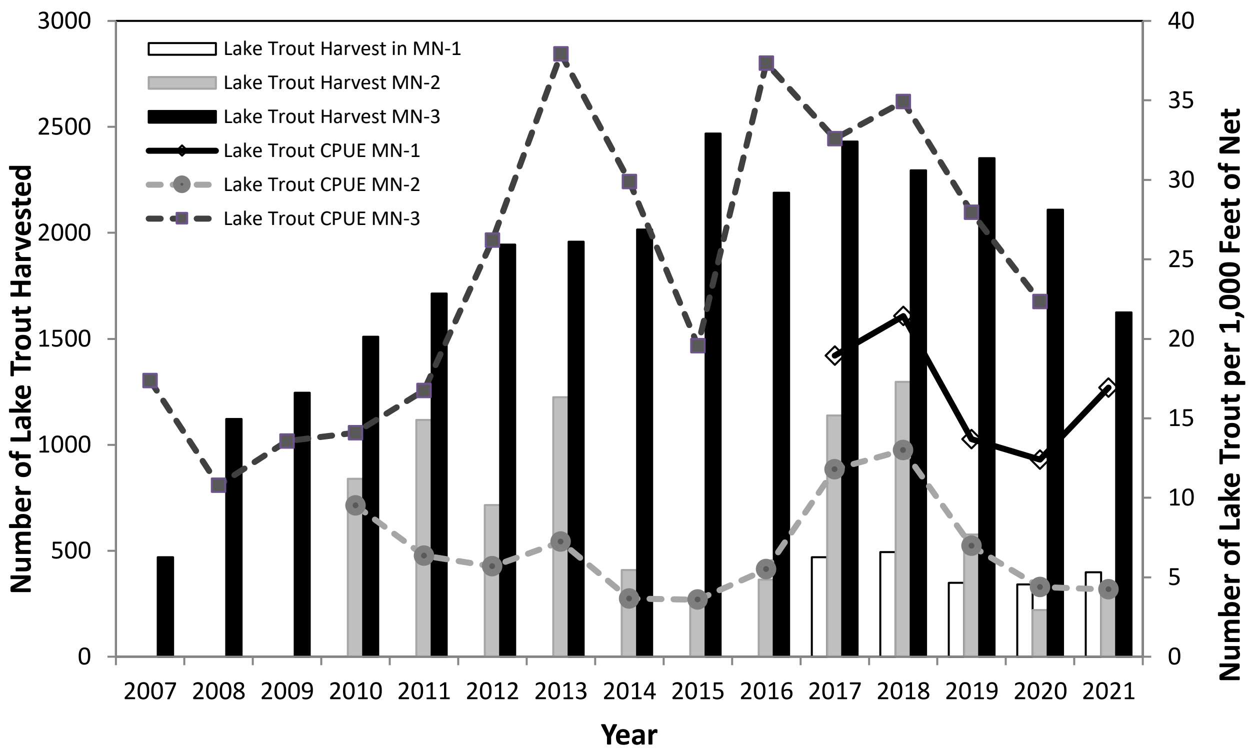

Figure 9. Lake Trout harvest and catch rate (number of fish per 1,000 feet of net; CPUE) in the summer commercial assessment, 2007-2021.

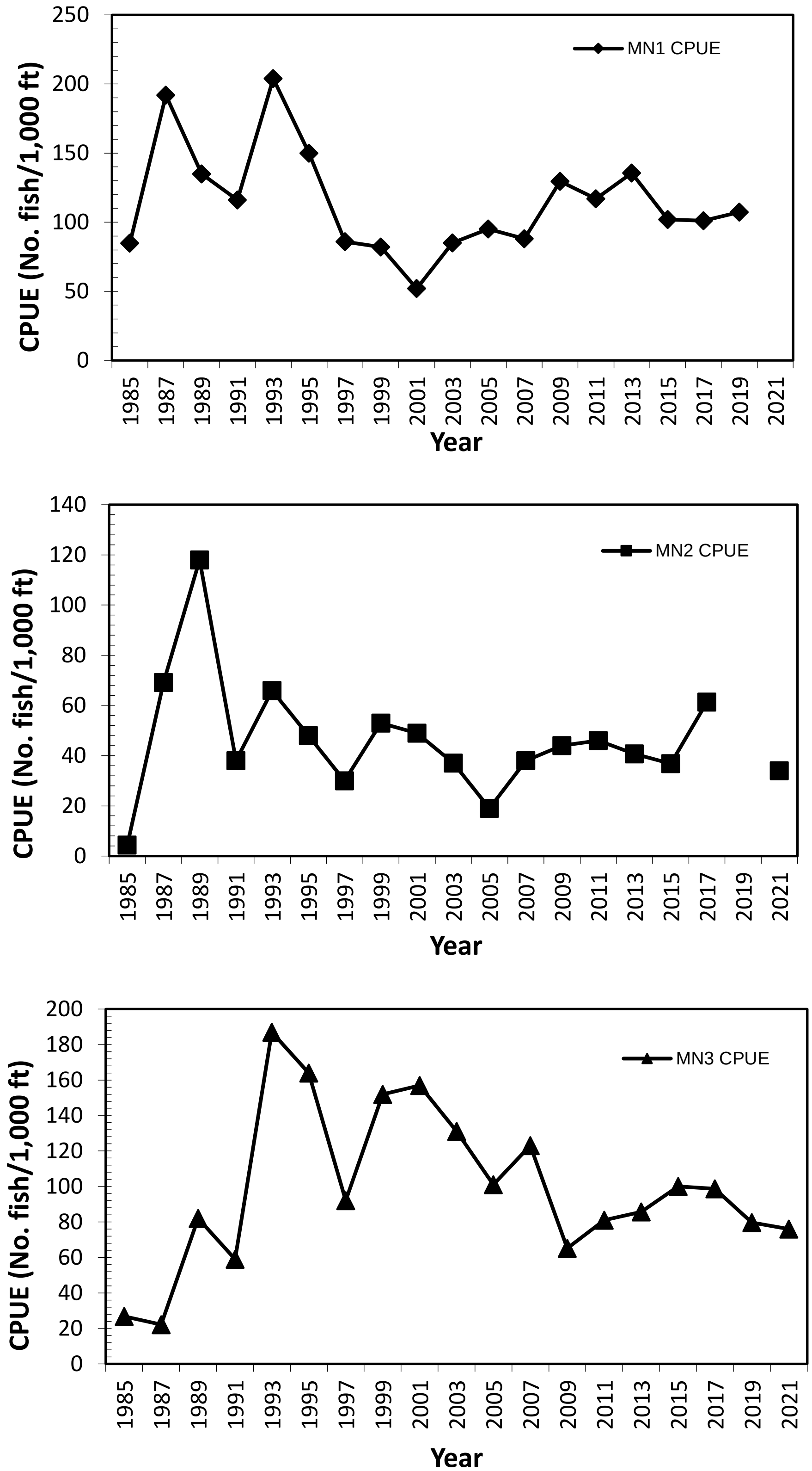

Figure 10. Catch per unit effort (CPUE) of Lake Trout in the spawning assessment, 1997-2021.

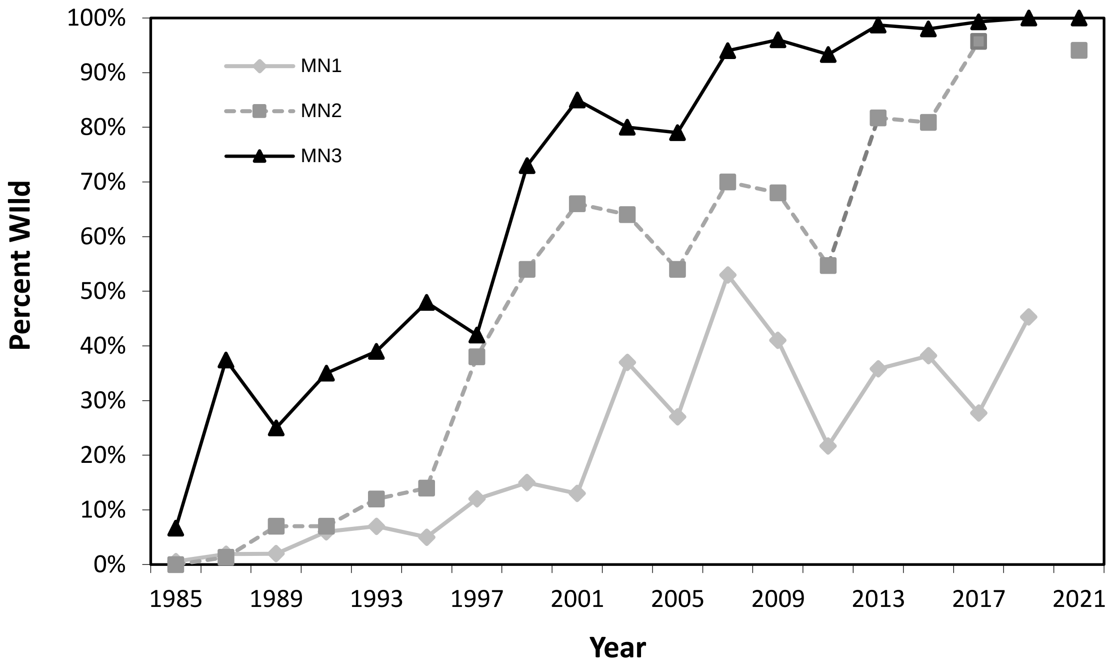

Figure 11. The percent wild Lake Trout by zone in the spawning assessment, 1985-2021.

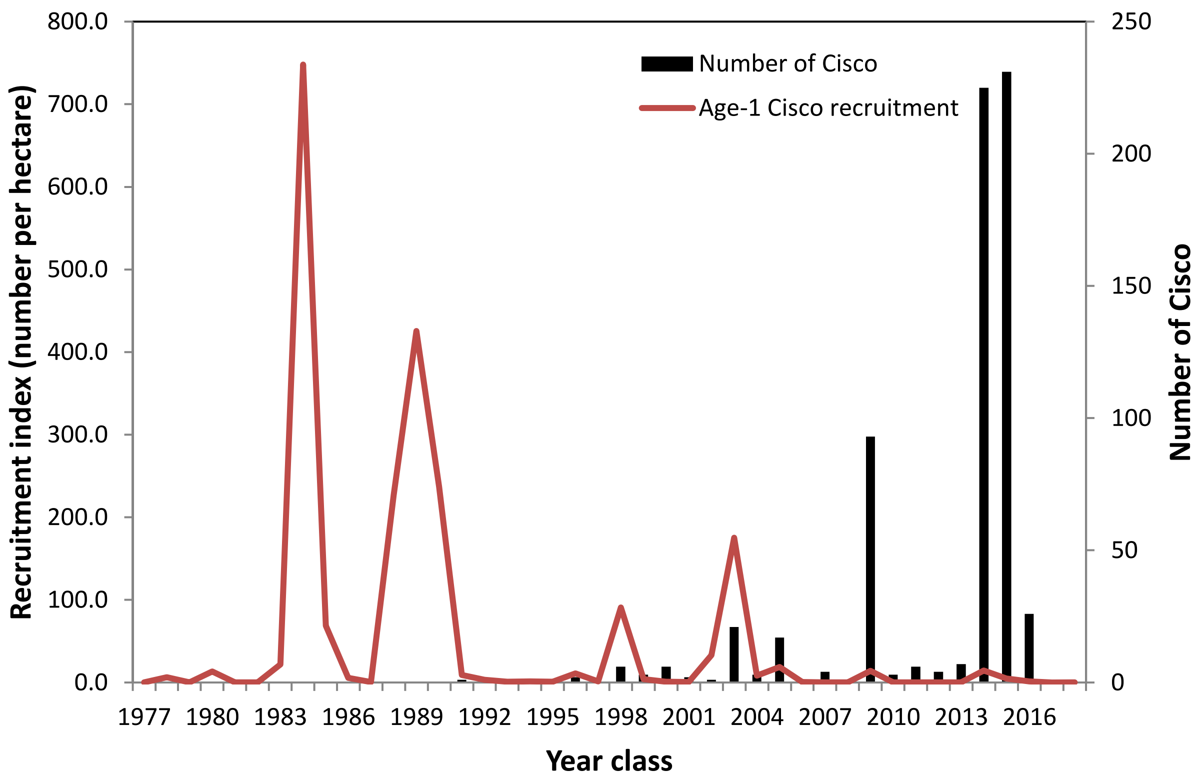

Figure 12. Cisco year-class strength, 1977-2028, as measured by the relative density of age-1 Cisco that were caught during USGS bottom trawl surveys, and the number of Cisco by year-class from commercial fishermen samples (spring and fall combined), 2020.

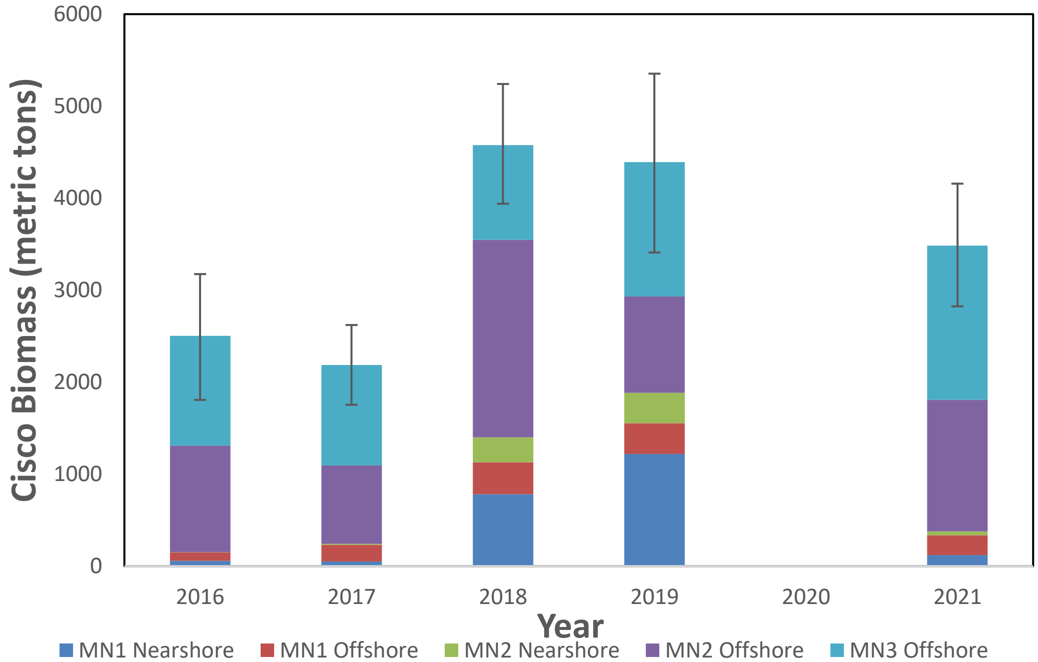

Figure 13. The estimated biomass of spawning-size Cisco from fall hydroacoustic surveys, 2016-2021. The survey was not conducted in 2020 due to the pandemic.

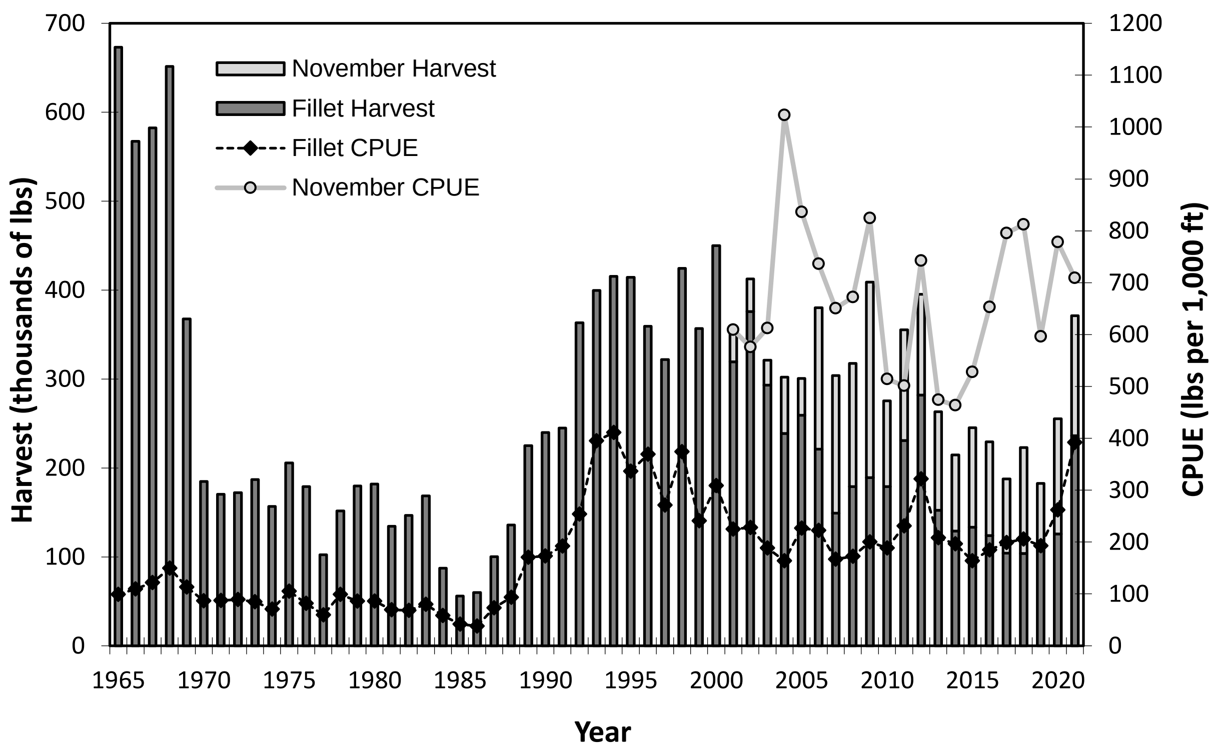

Figure 14. Cisco harvest (thousands of pounds) and catch rate (pounds per 1,000 feet of net; CPUE) in the commercial gill net fishery in Minnesota waters of Lake Superior, 1965-2021.