WISCONSIN DEPARTMENT OF NATURAL RESOURCES

LAKE SUPERIOR SUMMER WI-1 ASSESSMENT REPORT 2021

DRAY CARL

DNR Lake Superior Fisheries Management Team

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INTRODUCTION

The fish community of Lake Superior has gone through a series of dramatic changes over the last 100 years. Agencies responsible for the management of Lake Superior's fishery resources have established a series of fish-community objectives, with the overarching goal to "rehabilitate and maintain a diverse, healthy and self-regulating fish community, dominated by native species while supporting sustainable fisheries" (Horns et al. 2003). Information from this survey is used to monitor population dynamics of recreational and commercially-important fisheries and to assess progress toward fish community objectives in Wisconsin waters of Lake Superior. The nets in this survey include a wide range of mesh sizes and are fished at a wide range of depths to incorporate as much of the Lake Superior fish community and life stages of individual species as possible.

There are three primary objectives for this assessment. First, the survey is used to track changes in the Lake Superior fish community (e.g., predators, prey, benthivores, etc.). Second, the survey is used to assess population dynamics (e.g., abundance, age, size) in Coregonid species (i.e., Lake Whitefish, Cisco and deepwater Chub species) in Wisconsin waters of Lake Superior. Third, the small meshes in the survey are used to monitor Lake Trout recruitment, or the number of Lake Trout entering the "fishable" population in a given year. This aspect of the survey is part of a larger, lake-wide, small-mesh juvenile Lake Trout monitoring effort.

METHODS

The Wisconsin Department of Natural Resources (DNR) Summer Community Assessment rotates between sampling the Western Arm (WI-1) during odd-numbered years and the Apostle Islands region (WI-2) during even-numbered years. In 2021, 16 stations were sampled in the Western Arm region (Figure 1) with 1,097-meter monofilament gill net gangs. Each gang is composed of a series of 91.4-meter nets constructed with 38 to 178 millimeter mesh (stretch measure), by 13-millimeter increments. Depth profiles of gill net sites were measured using sonar at the inside of the gill net gang, between each 91.4-meter panel and at the outside of the gill net gang. A temperature profile was measured at each site after deploying the net. Temperatures were recorded at the surface, bottom and 3, 6, 9, 12, 15, 18, 30, 45, 60, 75, 90 meter depths (Figure 2). All nets were set on the bottom for one night (24 hours) using the R/V Hack Noyes. Biological information (e.g., length, weight, sex, etc.) was collected from fish using standardized protocols.

The modern stations used in this survey have been consistently sampled since 1981 in odd years, so a time-series of geometric mean catch-per-unit-effort (CPE) was calculated using only catch data from 1981 to 2021. Geometric mean CPE+1 was calculated using stations as replicates (CPE calculated as number of fish per km of net per night). Juvenile Lean Lake Trout CPE was assessed using only trout captured in the 51 and 64 mm mesh sizes, excluding trout > 450 millimeters, and excluding trout with hatchery fin clips. Wild (non-hatchery origin) Lean Lake Trout CPE was assessed using trout captured in all mesh sizes but excluding trout with hatchery fin clips. Juvenile Cisco CPE was assessed using only fish captured in the 38-millimeter mesh panel. CPE for the Cisco Suite of species was assessed by combining all *C. artedi, C. hoyi, C. kiyi C. zenithicus*, and respective crosses. CPE for all other species (and all Lake Trout and Cisco) was assessed using all mesh sizes.

The "juvenile" and "adult" nomenclature does not necessarily refer to sexual maturity of individual fish in this case. It refers to the size-selective nature of graded-mesh gill net sampling, which allows separation of fish by size with known effort for each subset. Therefore, examination of CPE trends from small mesh sizes may allow insight into recruitment patterns, or a relative "year-class strength." Analyses were conducted using Program R, and this report was formatted with the package RMarkdown.

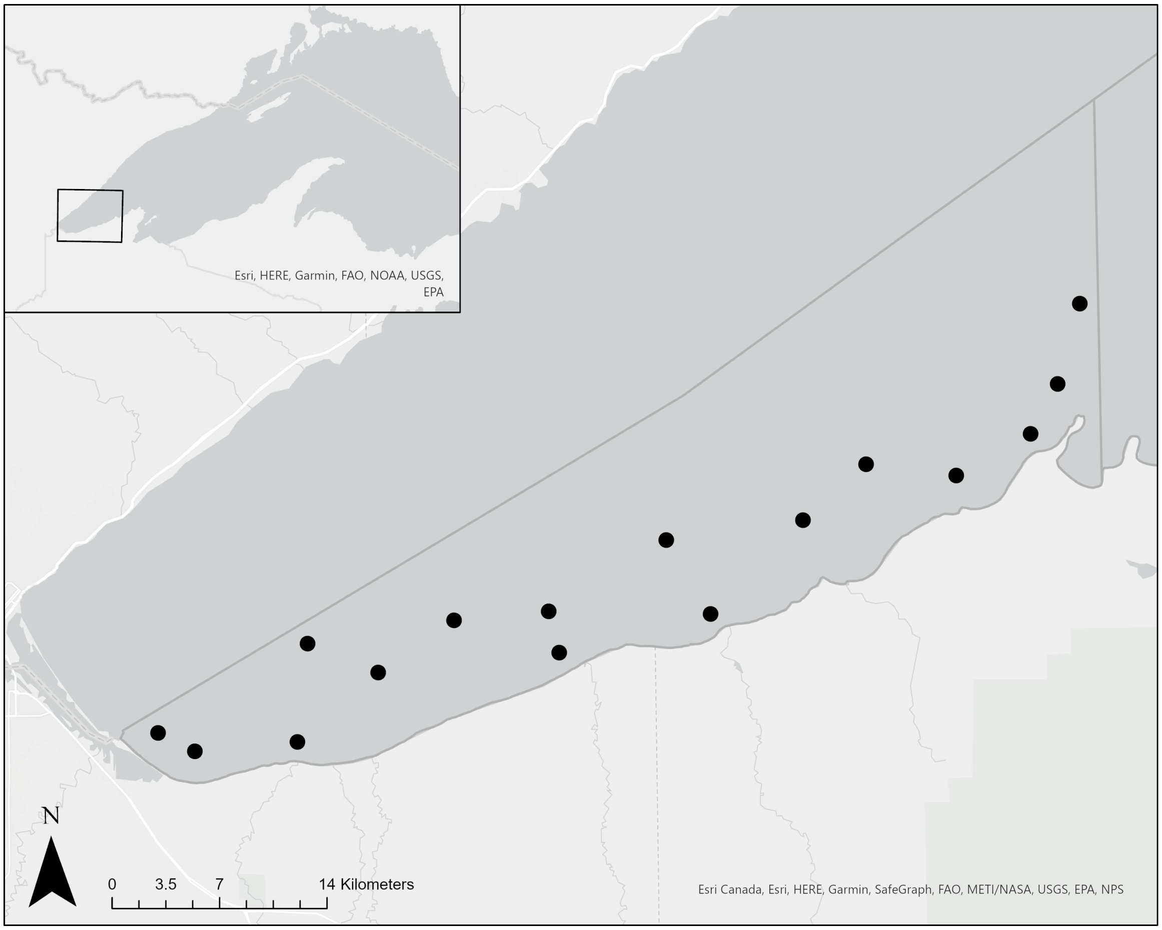

Figure 1. Map of the Western Arm (WI-1) region of Lake Superior and the sampling stations for the DNR Summer Community Assessment 2021.

RESULTS

LAKE TROUT

Relative abundance of all Lean Lake Trout was the lowest observed in the time series from 1981 to 2021 in WI-1, and relative abundance for wild Lean Lake Trout and juvenile Lean Lake Trout was also very low (Figure 3). Before this decline in the CPE index, wild Lean Lake Trout (non-hatchery origin) relative abundance in WI-1 had been relatively stable after a peak in 2005 and higher than the 1980s and 1990s. Length and age distributions (Figures 5 and 6, respectively) suggest strong recruitment classes from 2014-2016 have been working their way into the fishery, but 2021 relative abundance was at a lower magnitude than expected (i.e., lower CPE index). Similarly, the Spring Lake Trout survey in WI-1 detected an influx from the 2014-2016 year-classes as they recruited to this survey gear in spring 2021, but relative abundance was not low (see the Lake Superior Spring Lake Trout Assessment Report 2021). The mean water temperature profile measured during the 2021 summer community assessment was much warmer than any other year observed by a wide margin (up to 3 degrees Celsius higher at 10-meter depth; Figure 2). Lean Lake Trout size and age structure in both spring and summer surveys in 2021 and spring survey relative abundance were all within expected ranges; therefore, the abnormally low relative abundance estimates in the summer survey may have been an anomaly caused by extremely warm water temperatures during summer 2021 (i.e., effects on catchability by changing fish behavior or causing fish to leave the area).

Siscowet Lake Trout catches in the summer assessment are more variable and difficult to interpret. However, current relative abundance of Siscowet Lake Trout appears higher than in the 1980s, and the 2021 CPE was the highest on record. It is difficult to determine whether the increase in Siscowet Lake Trout relative abundance estimates is caused by an increase in true population size or simply catchability (i.e., Siscowet Lake Trout encroaching into steadily shallower water throughout the time series).

Median length of Lean Lake Trout in the 2021 summer community assessment was 509.5 millimeters and median length of Siscowet Lake Trout was 488 millimeters (Figure 4). Median length of fish in the juvenile Lean Lake Trout CPE index was 381 millimeters. Median length of Lean Lake Trout has increased from 2019 to 2021 (Figure 5).

COREGONIDS

Relative abundance of Cisco *C. artedi* in 2021 was very low in the WI-1 summer assessment (Figure 7). This is reflective of lake-wide trends of a Cisco population decline since the early 1990s. DNR hydroacoustic surveys have also indicated a decline in adult Cisco biomass in recent years in Wisconsin waters. Geometric mean CPE of juvenile Cisco was also very low in 2021, indicating little recruitment to the fishery in future years from the 2019 year-class (age-2 Cisco recruit to the juvenile Cisco index). The current Cisco population is primarily maintained by the 2015 and 2009 year-classes with diminishing numbers from large year-classes in 1998 and 2003. The meta-population in the Western region of Lake Superior is dependent on infrequent, large year-classes to maintain historical population sizes of the past couple decades. Median length of Cisco in the 2021 summer community assessment was 321.5 millimeters and median length of fish in the juvenile Cisco CPE index was 193 millimeters (Figure 8). Median length of Cisco in the WI-1 summer assessment has increased substantially from 2017 to 2021, indicating growth of the 2015 year-class and little recruitment in years prior (Figure 5).

Bloater *C. hoyi* relative abundance is more variable since it inhabits mainly deeper water that is not sampled as intensively in the WI-1 summer assessment (Figure 7). However, relative abundance of Bloater currently appears higher than levels in the early 2000s. Relative abundance of the combined Cisco suite of species (i.e., *C. artedi*, *C. hoyi*, *C. kiyi*, *C. zenithicus* and respective crosses) has decreased over the past four years, likely driven by Cisco trends. Relative abundance of the Cisco suite has fluctuated throughout the time series. Median length of Bloater in the 2020 summer community assessment was 239 millimeters (Figure 8).

Relative abundance of Lake Whitefish in 2021 was lower than 2019, but current CPE's in the past decade have been relatively stable and are much higher than observed in the 1980s and 1990s (Figure 7). Median length of Lake Whitefish in the 2021 summer commmunity assessment was 444 millimeters (Figure 8). Median length of Lake Whitefish has been stable since 2015 (Figure 5). This survey should be used to monitor Lake Whitefish population dynamics and could also serve as an input for future stock assessment models.

OTHER SPECIES

Other species encountered during the summer community assessment in WI-1 have much higher variability in relative abundance estimates due to either 1) they are captured in low numbers, or 2) they are captured in few of the 16 sampled sites. Burbot relative abundance appears lower than the 1980s (Figure 9). Longnose Sucker relative abundance was low in 2021. Rainbow Smelt relative abundance has been stable over the past couple decades but much lower than the 1980s. Round Whitefish relative abundance has decreased throughout the past decade. Eurasian Ruffe relative abundance has increased since the early 1990s but likely stabilized. Brown Trout and White Sucker relative abundance is too variable to determine trends using this survey.

Walleye relative abundance is variable in this survey in the Western Arm because Walleye are often transients from the St. Louis River and often only encountered in a few locations in this assessment (i.e., shallower areas). However, Walleye relative abundance in 2021 was the highest observed throughout the time series, and Walleye were encountered in more sites than average. The timing and magnitude of Walleye movements within WI-1 from the St. Louis River can vary based on environmental factors, and I speculate the much warmer-than-average water temperatures during the 2021 summer survey led to more Walleye out-migrating into Lake Superior than normal. Interestingly, the majority of Walleye encountered were between 250 and 350 millimeters, suggesting lake conditions in the Western Arm were also suitable for smaller Walleye in addition to the larger, mobile individuals (Figure 10). Walleye continue to be an important species in the recreational fishery in WI-1, and other surveys conducted in the St. Louis River and estuary should be used in tandem with the summer community assessment to evaluate population dynamics and trends in population size.

Figure 10 shows the size structure of these other eight species captured during the 2021 summer community assessment.

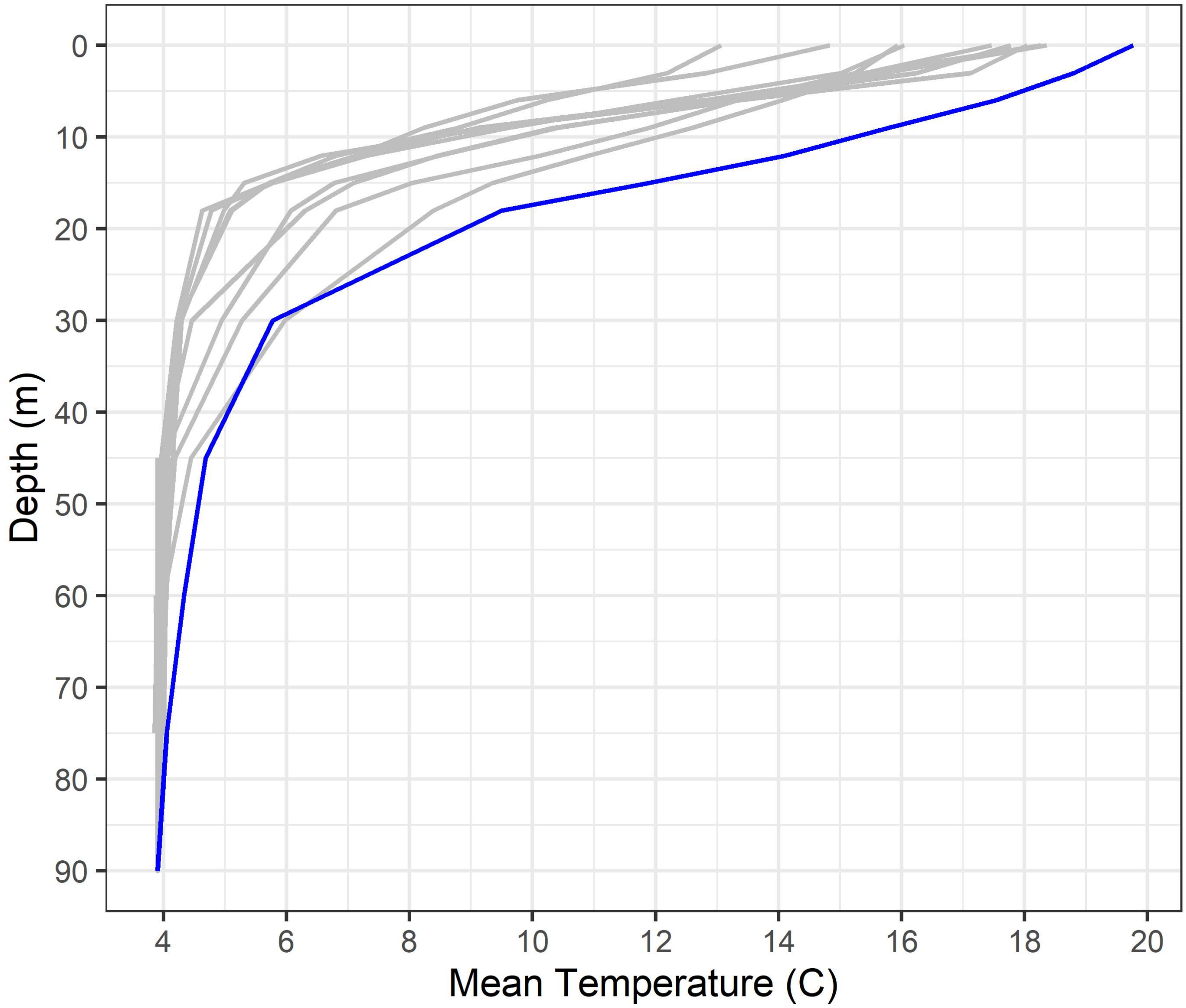

Figure 2. Mean temperature profiles measured from the 16 stations sampled during the summer community assessment in WI-1 waters of Lake Superior. The blue line represents the mean temperature profile measured in 2021, and the grey lines represent mean temperature profile measured in odd years from 1999 to 2019.

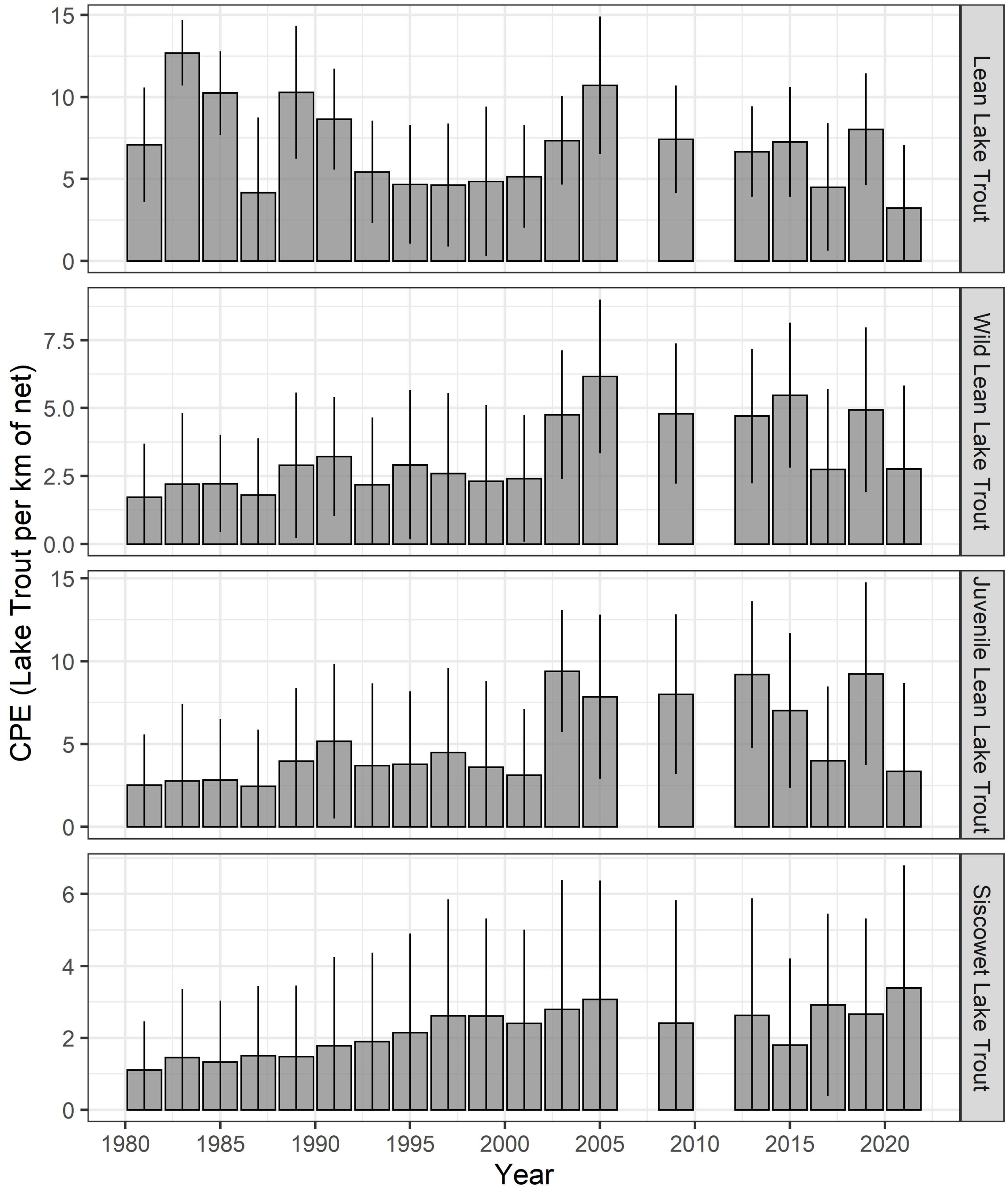

Figure 3. Time series of geometric mean CPE for all Lean Lake Trout (all meshes), wild Lean Lake Trout (non-hatchery origin, all meshes), Juvenile Lean Lake Trout (non-hatchery origin, 51 and 64 millimeter meshes, < 450 millimeters total length) and Siscowet Lake Trout (all meshes) in the Western Arm region of Lake Superior, 1981-2021. Summer community assessment sampling did not occur in 2007 or 2011. Error bars represent one standard deviation.

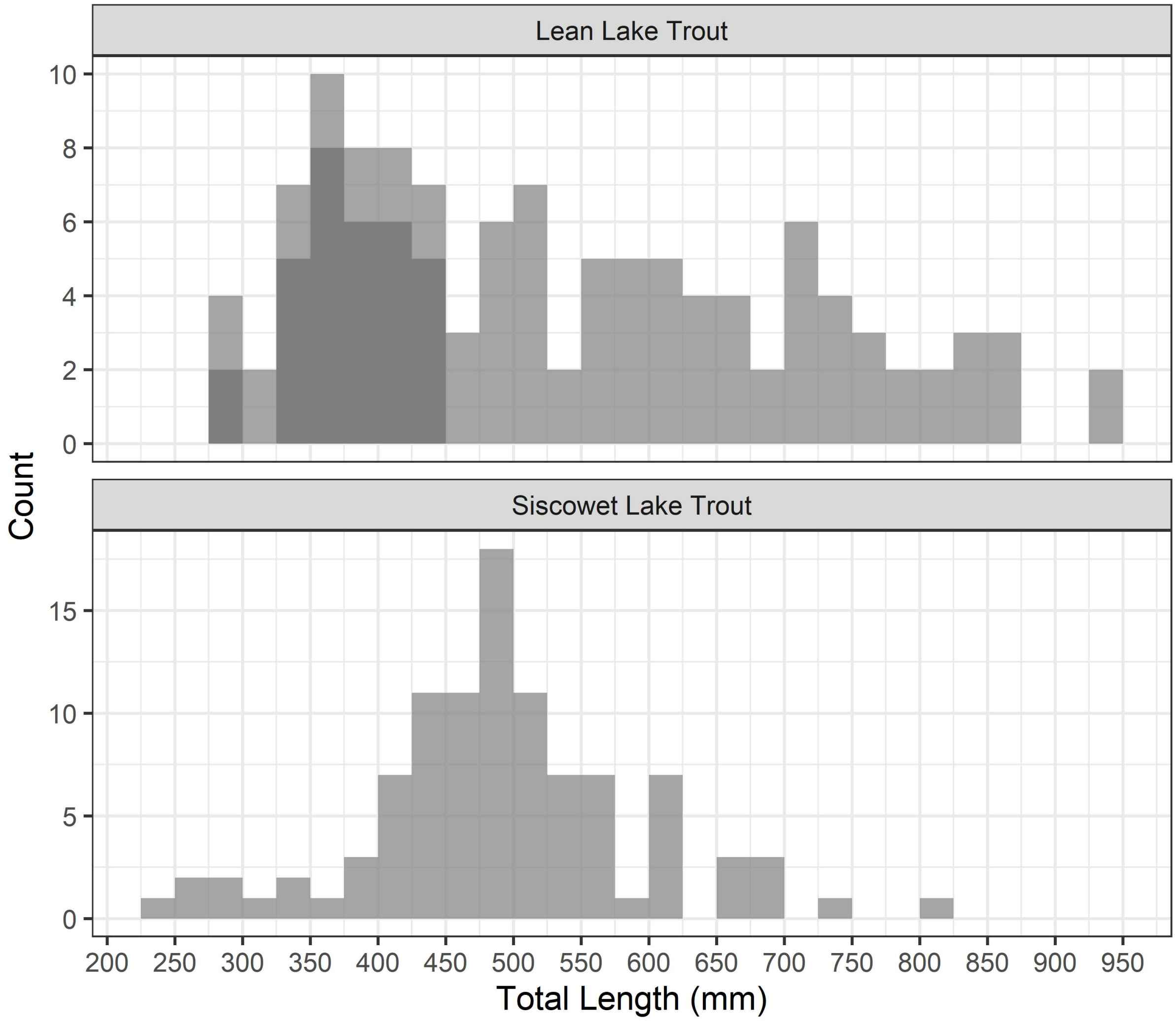

Figure 4. Length frequency histograms of Lean Lake Trout (top) and Siscowet Lake Trout (bottom) caught in the Western Arm region of Lake Superior during the 2021 summer community assessment. Darker grey bars represent fish that were counted in the Juvenile Lean Lake Trout CPE index (i.e., non-hatchery origin, caught in 51 or 64 millimeter mesh, < 450 millimeters total length).

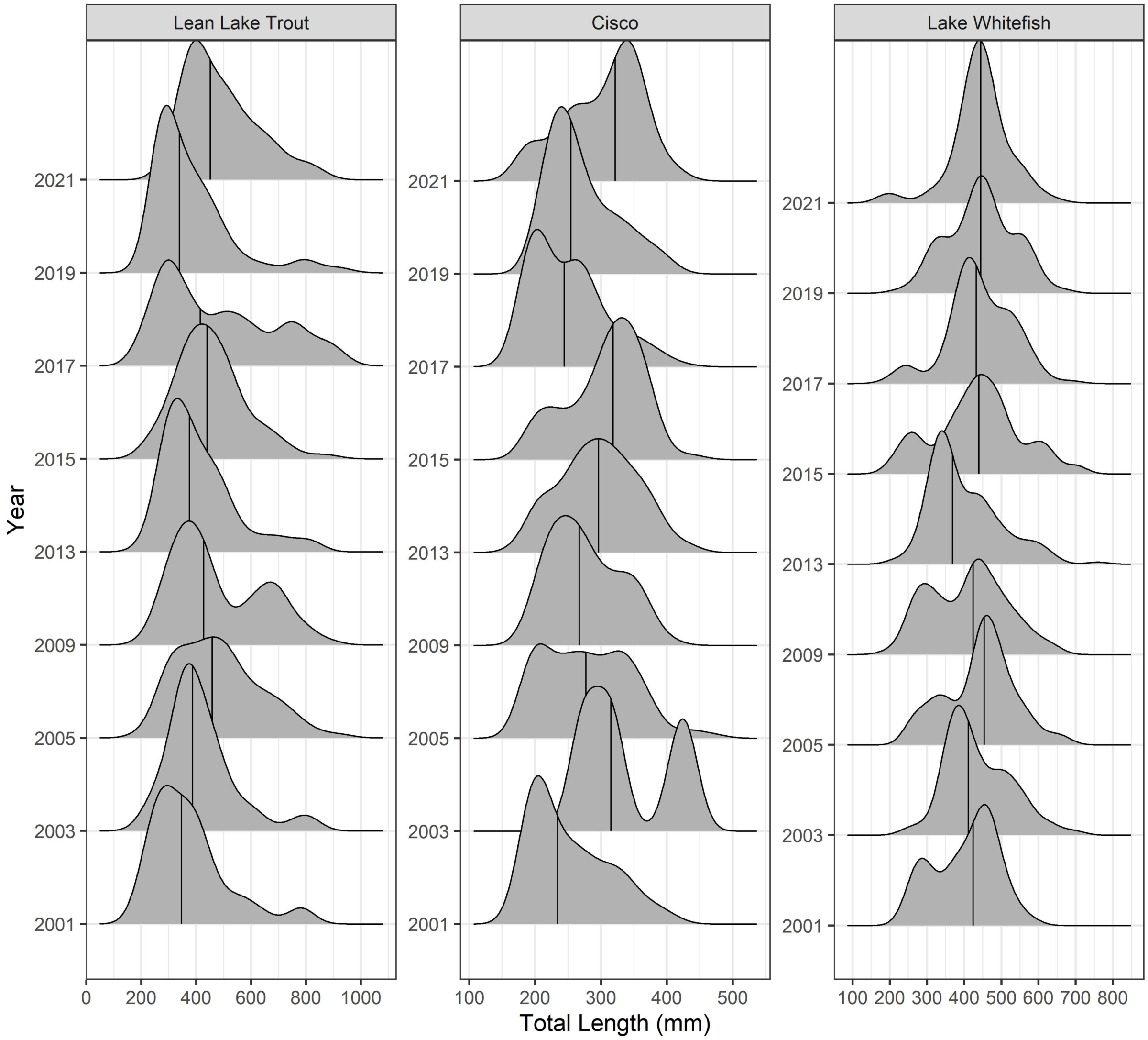

Figure 5. Time series of Lean Lake Trout, Cisco and Lake Whitefish length distributions from 2001 to 2021 captured during the summer community assessment in the Western Arm region of Lake Superior. Vertical lines represent the median total length sampled in a given year.

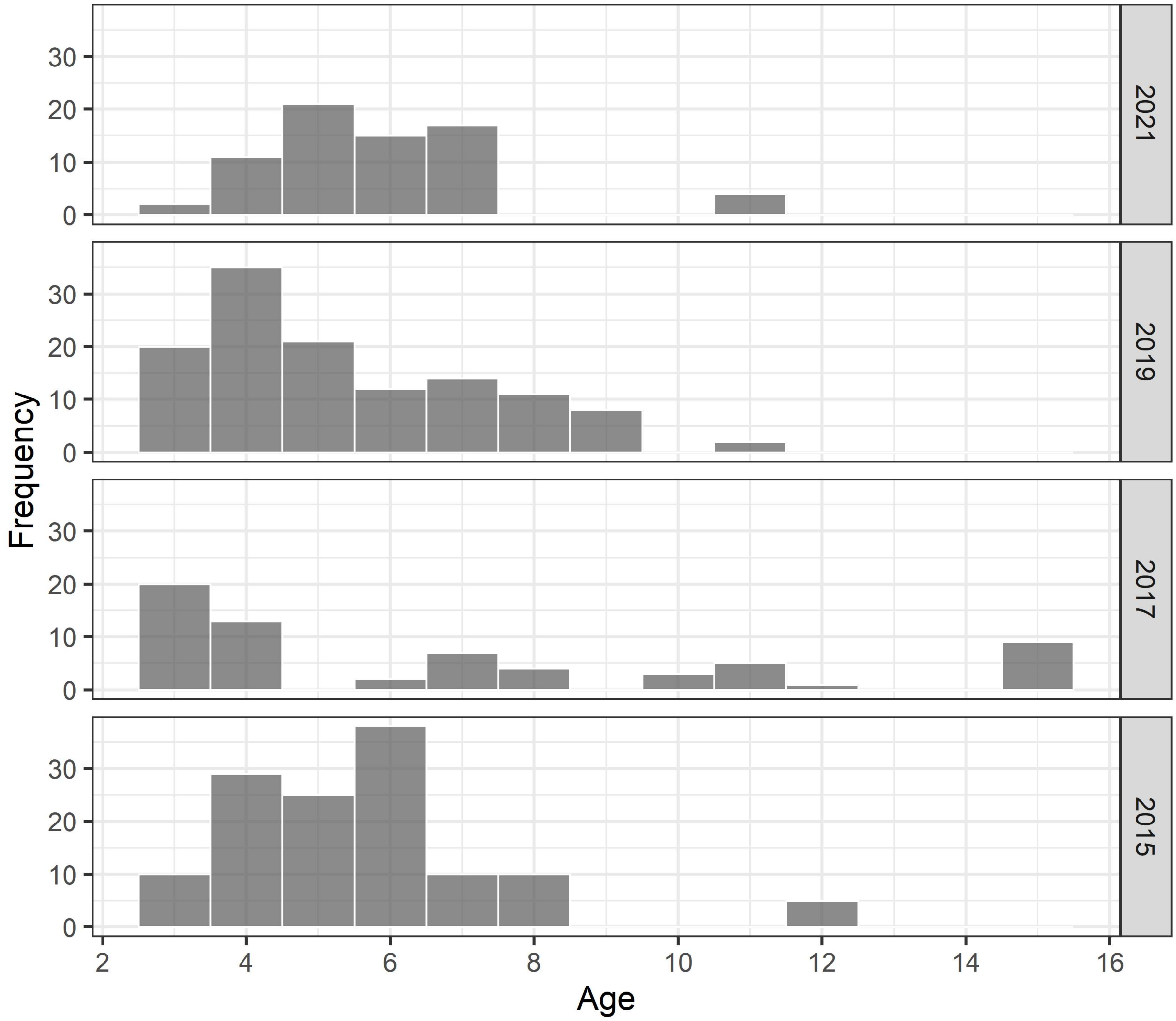

Figure 6. Age frequencies of wild Lean Lake Trout captured during the summer community assessment in the Western Arm region of Lake Superior from 2015 to 2021.

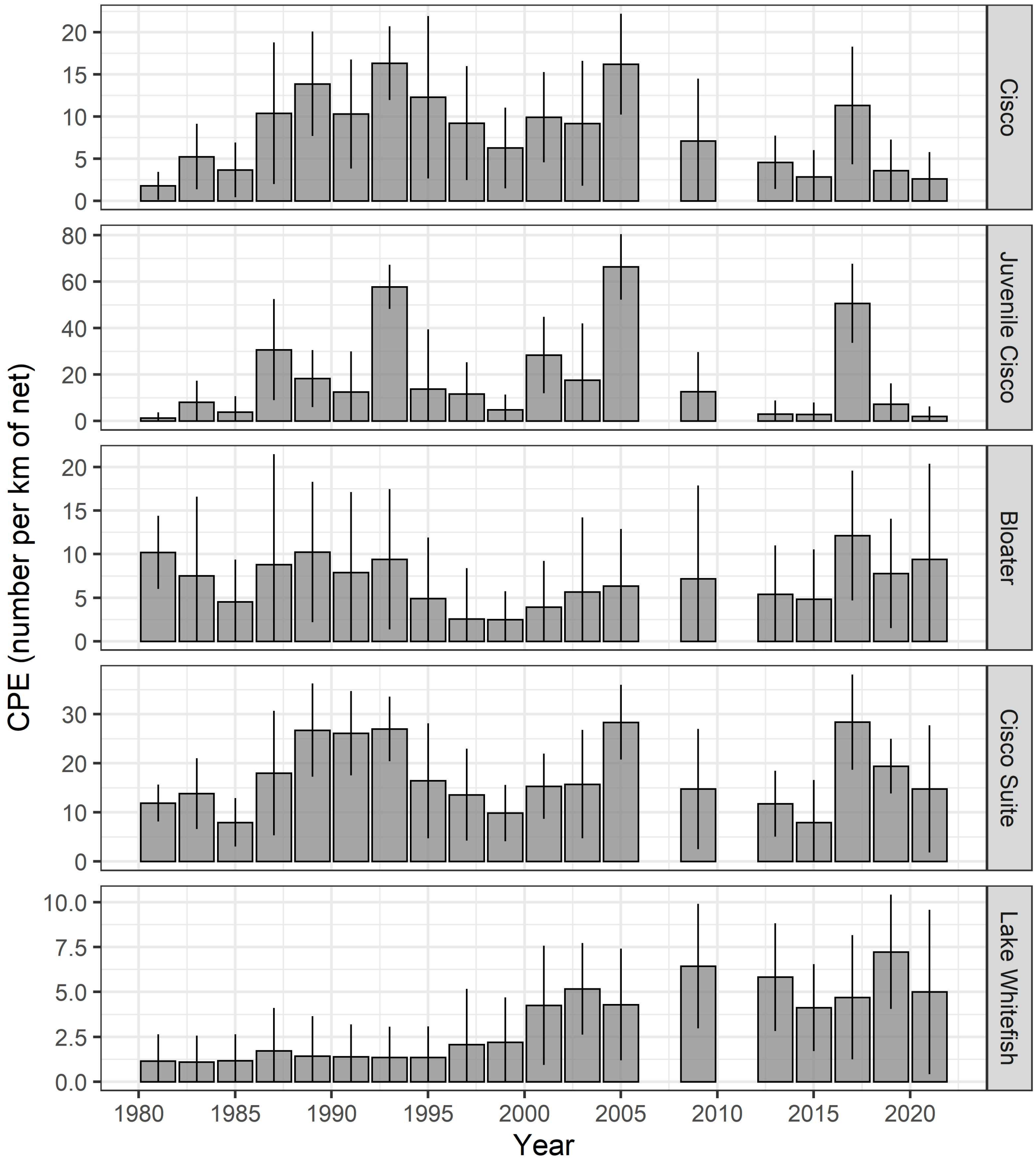

Figure 7. Time series of geometric mean CPE for all Cisco C. artedi *(all meshes), Juvenile Cisco (fish captured in the 38 millimeter mesh panel), Bloater* C. hoyi *(all meshes), the Cisco Suite of species, including* C. artedi, C. hoyi, C. kiyi *and* C. zenithicus *(all meshes) and Lake Whitefish* C. clupeaformis *(all meshes) in the Western Arm region of Lake Superior, 1981-2021. Summer community assessment sampling did not occur in 2007 or 2011. Error bars represent one standard deviation.*

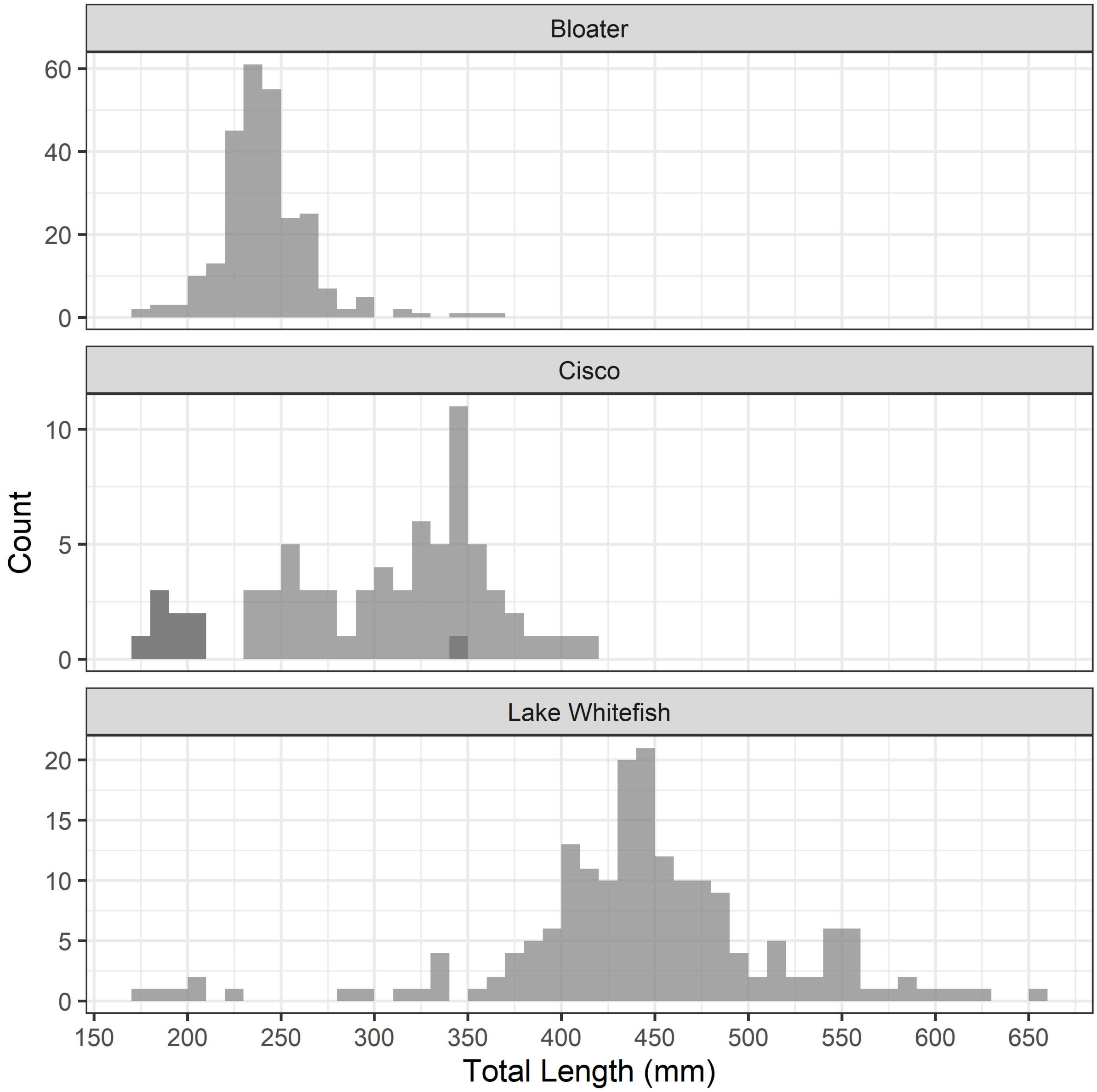

Figure 8. Length frequency histograms of Bloater C. hoyi *(top), Cisco* C. artedi *(middle) and Lake Whitefish* C. clupeaformis *(bottom) caught in the Western Arm region of Lake Superior during the 2021 summer community assessment. Darker grey bars represent fish that were counted in the Juvenile Cisco CPE index (i.e., caught in the 38 millimeter mesh panel).*

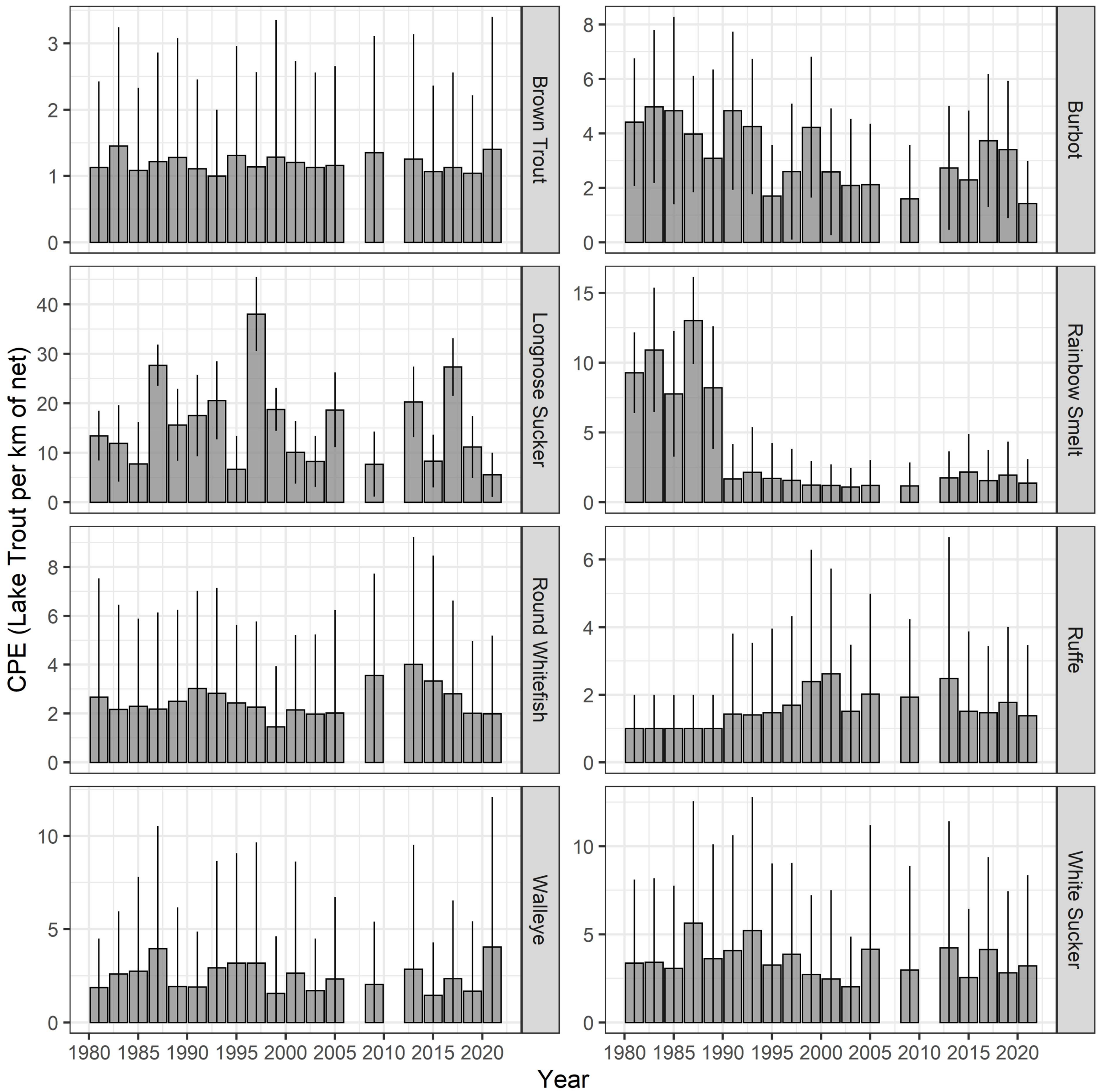

Figure 9. Time series (1981-2021) of geometric mean CPE for eight common species in the Western Arm region of Lake Superior including: Brown Trout, Burbot, Longnose Sucker, Rainbow Smelt, Round Whitefish, Eurasian Ruffe, Walleye and White Sucker. Summer community assessment sampling did not occur in 2007 or 2011. Error bars represent one standard deviation.

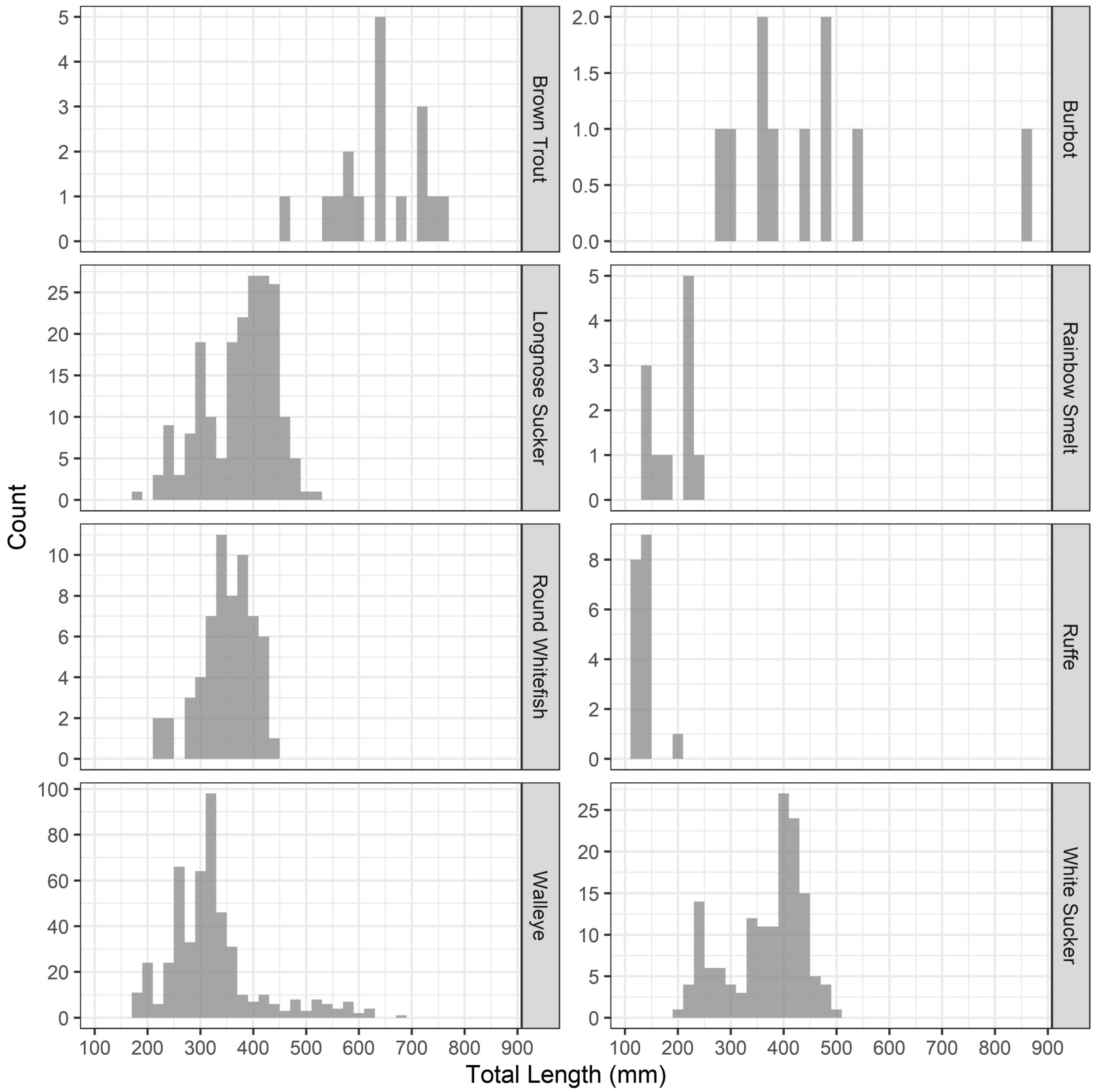

Figure 10. Length frequency histograms of eight common species captured in the Western Arm region of Lake Superior in the 2021 summer community assessment including: Brown Trout, Burbot, Longnose Sucker, Rainbow Smelt, Round Whitefish, Eurasian Ruffe, Walleye and White Sucker.