Status and Trends in the Lake Superior Fish Community, 2019[1]

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Abstract

The Lake Superior fish community was sampled in 2019 with daytime bottom trawls at 76 nearshore and 35 offshore stations distributed throughout the lake. In the nearshore zone, 25,131 fish from 24 species or morphotypes were collected. The number of species collected at nearshore stations ranged from 0 to 15, with a mean of 5.6 and median of five. Nearshore mean biomass was 5.7 kg/ha which was similar to the past twenty-year average of 5.2 kg/ha and less than the 42-year period-of-record mean of 8.5 kg/ha. Lake Whitefish, Rainbow Smelt, Longnose Sucker, Bloater, lean Lake Trout, Cisco, Burbot, and siscowet Lake Trout had the highest total collected biomass. In the offshore zone, 13,145 fish from 11 species or morphotypes were collected. The number of species collected at offshore stations ranged from two to six, with a mean 3.6 and median of four. Deepwater Sculpin, Kiyi, and siscowet Lake Trout made up 99% of the total number of individuals and biomass collected in offshore waters. Mean and median offshore biomass for all species in 2019 was 7.0 kg/ha which was greater than the past eight-year average of 6.6 kg/ha. Recruitment, as measured by age-1 densities, was near the period-of-record lakewide average for Lake Whitefish (7 fish/ha) and Rainbow Smelt (137 fish/ha) and was lower than the period-of-record lakewide average for Bloater (4 fish/ha), Kiyi (1 fish/ha), and Cisco (<1 fish/ha). Lakewide average age-1 Cisco densities have been estimated at ≤1 fish/ha in twelve of the last twenty years. Survival of Coregonus species to age-1 continues to be a major concern of fishery managers.

[1] The data associated with this report have not received final approval by the U.S. Geological Survey (USGS) and are currently under review. The Great Lakes Science Center is committed to complying with the Office of Management and Budget data release requirements and providing the public with high quality scientific data. We plan to release all USGS research vessel data collected between 1958 and 2019 and make those publicly available. Please direct questions to our Information Technology Specialist, Scott Nelson, at snelson@usgs.gov.

Introduction

The U.S. Geological Survey Lake Superior Biological Station conducts annual daytime bottom trawl surveys in nearshore (~15-80 m depths) and offshore (~100-300 m depths) waters of Lake Superior. These surveys provide data for assessment of trends in species occurrence, relative abundance and biomass for principally demersal fish. These data have historically been considered population indices rather than absolute abundance and biomass estimates. The nearshore survey has been conducted annually since 1978 in U.S. waters, and since 1989 in Canadian waters. The offshore survey has been conducted annually since 2011. The primary goal of the surveys is to report on population biomass estimates for common species and age-1 density estimates (a.k.a., recruitment index) for selected commercial and recreational species (Rainbow Smelt, Cisco, Bloater, Kiyi, Lake Whitefish, and Lake Trout, scientific names are provided in Table 1). Age and diet analyses are conducted for selected species. Fish population data in this report are based solely on bottom trawl sampling. Fishing gear bias should be considered when interpreting the results, particularly for species with lower vulnerability to daytime bottom trawls, such as adult Cisco and adult Lake Trout (*Yule, et al. 2008. Factors affecting bottom trawl catches: implications for monitoring the fishes of Lake Superior. North American Journal of Fisheries Management*, *28:109-122*). At each fish sampling station, larval fish are sampled by surface trawling, zooplankton are sampled by a whole water column (up to 100 m) vertical zooplankton tow, and an electronic water profiler is deployed that collects data on depth, water temperature, specific conductance, pH, dissolved oxygen, chlorophyll a, photosynthetic active radiation (PAR), and beam transmission. Herein we report on bottom trawl fish and water temperatures collected during the survey.

Methods

Nearshore survey bottom trawling

Nearshore sites are located around the perimeter of the lake. In 2019, 76 of 78 planned long-term sampling locations were sampled between 29 May and 22 June (Figure 1). A site at Iroquois Island, Michigan was not sampled due to commercial fishing nets and a site at Alona Bay, Ontario was not sampled due to the bottom trawl snagging on a rock and being lost late in the day which precluded rigging a new net and re-trawling this site. At each location, a single bottom trawl tow was conducted with a 12-m Yankee bottom trawl with either a chain or 6-inch rubber roller foot rope. The roller foot rope was used at sites with steeper, rockier bottoms to reduce snagging. The median start and end depths for bottom trawl tows were 17 m (range 11-29 m) and 54 m (range 20-143 m), respectively. The median distance trawled was 1.6 km (range 0.5-4.0 km). The median trawl wingspread was 9.0 m (range 7.0-11.9 m). Fish collected in trawls were sorted by species, counted, and weighed in aggregate to the nearest gram. Total length was measured on a maximum of 50 individuals per species per trawl. Lengths for these individuals were extrapolated to the entire catch when more than 50 individuals were collected. Relative density (fish/ha) and biomass (kg/ha) were estimated by dividing sample counts and aggregate weights by the area of the bottom swept by each trawl tow (ha). Biomass estimates are reported for all species combined and individually for Bloater, Cisco, Lake Whitefish, Rainbow Smelt, Sculpin species (Slimy-, Spoonhead-, and Deepwater Sculpin), hatchery-, lean-, and siscowet Lake Trout, Burbot, and for a few less-common species. A composite estimate is also reported for all of the less-common species. Age-1 year-class strength was estimated as the mean lakewide density of age-1 fish as determined by total length; Cisco ≤140 mm, Bloater ≤130 mm, Lake Whitefish ≤160 mm, and Rainbow Smelt ≤100 mm. Young Lake Trout densities are presented for small, < 226 mm (ca. ≤ age-3) fish.

These age-size cutoffs were based on past unpublished age estimates and are approximate and are known to vary among years.

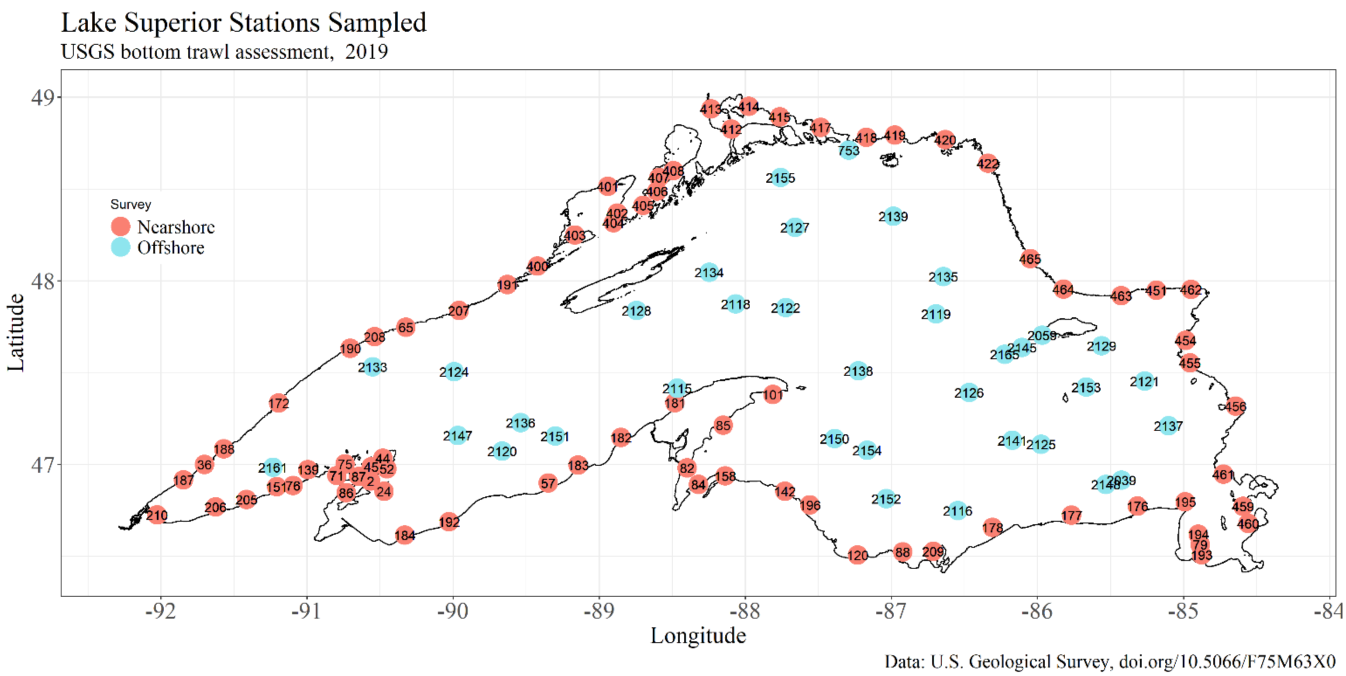

Figure 1. Location of 76 nearshore (orange) and 35 offshore (aqua) stations sampled May-July 2019. Samples collected at each location included bottom trawls for demersal fish, surface trawls for larval fish, whole water column (up to 100 m) zooplankton collections, and a water profile that electronically collected data on depth, temperature, specific conductance, pH, dissolved oxygen, chlorophyll a, photosynthetic active radiation, and beam transmission.

Offshore survey bottom trawling

Offshore sites were selected using a spatially-balanced, depth-weighted probabilistic sampling design that targets depths >90 m (Figure 1). Sample sites were selected in 2011 and these same sites have been sampled annually thereafter. In 2019, 35 locations were sampled during daylight hours from 11-25 July. A site on the west side of Isle Royale that had been sampled in previous years was not sampled to avoid collection of siscowet Lake Trout that had been implanted with acoustic tags near that location. A single bottom trawl tow was conducted at each site using a 12-m Yankee bottom trawl with a 6-inch rubber roller foot rope. All tows were made on-contour for 20 minutes. Station depths ranged from 92 to 318 m.

The median trawl distance was 1.4 km (range 1.3-1.6 km). The median trawl wing spread was 11.1 m (range 9.7-12.4 m). Catches were processed with the same methods described for nearshore trawls. Biomass estimates are presented for Kiyi, Deepwater Sculpin, and siscowet Lake Trout. Year-class recruitment strength was estimated for Kiyi as the mean lakewide density of Kiyi ≤130 mm collected at offshore stations.

Results

Nearshore survey

Nearshore water temperatures in 2019 were similar to the previous ten-year average (Figure 2). Nearshore water temperatures in June averaged 7.3 °C (range = 3-17°C) at the surface and 3.8 °C (range = 3-5 °C) at 50 m. The past ten-year average (2009-2019) water temperatures for these same locations and dates were 7.7 °C (range=1.9-19 °C) at the surface and 3.9 °C (range = 2-7 °C) at 50 m.

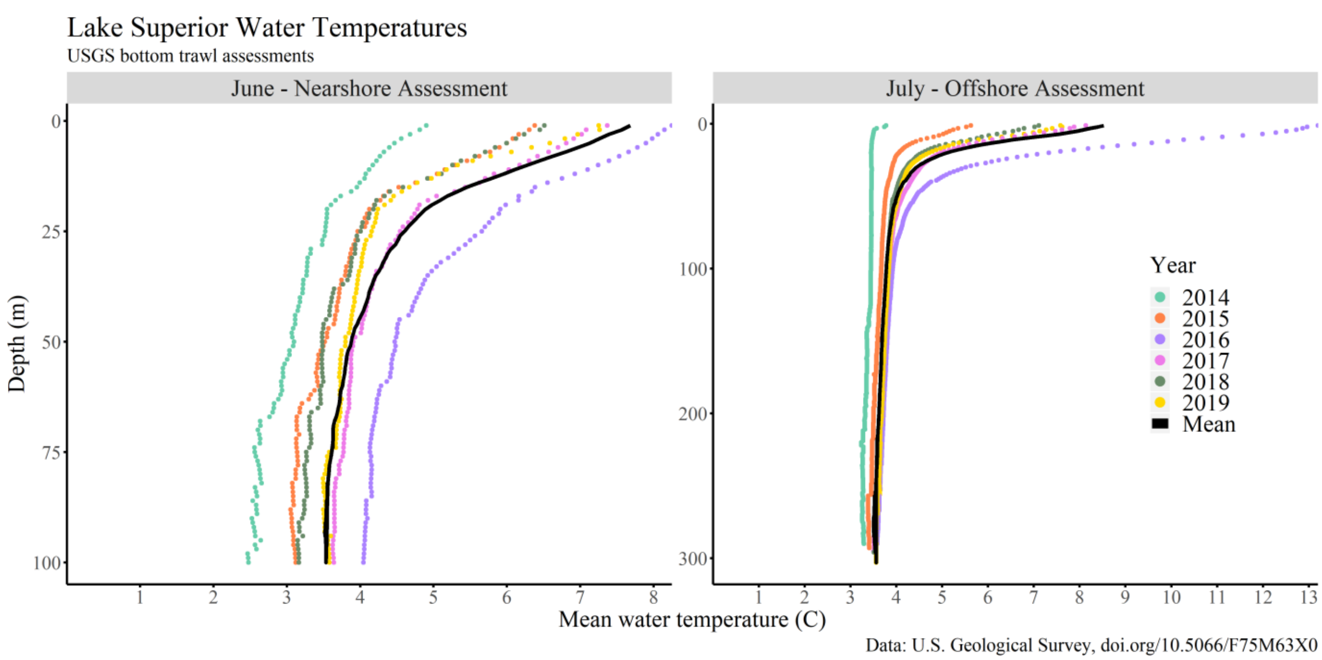

Figure 2. Left) Average water temperature profiles across sites sampled during the June-Nearshore and (right) July-Offshore fish community assessments over the previous six-years. The solid black line is the mean temperature over the previous ten years for the nearshore assessment and the previous eight years for the offshore assessment (2011-2019, excluding 2012 when no sampling was done in July).

A total of 25,131 individual fish from 24 species or morphotypes were collected at nearshore locations (Table 1). The number of species collected at each station ranged from zero to 15, with a mean of 5.6 and median of five. Estimated fish biomass at individual stations ranged from zero to 48.3 kg/ha (Figure 3). The distribution of biomass estimated for all sampling locations was non-normally distributed (Figure 3) as is always the case for this survey. The skewness of the distribution of individual station biomass estimates in 2019 was 2.2 which was less than the period-of-record average skewness of 3.6. Individual stations with the highest biomass were in the Apostle Islands (151-Bark Point, 71-Raspberry Island, 45-Cat Island, and 86-Basswood Island) and along the Canadian shoreline in Thunder (406) Black (408), and Nipigon Bays (413, Figure 3). Lakewide average nearshore fish biomass was 5.7 kg/ha, which was below the 42-year period-of-record average of 8.5 kg/ha (Table 2, Figure 4). In relation to more recent estimates of fish biomass, the 2019 average nearshore biomass estimate was similar to the 20-year average of 5.1 kg/ha and greater than the past 10 and 5-year averages of 3.7 and 3.5 kg/ha, respectively (Figure 4).

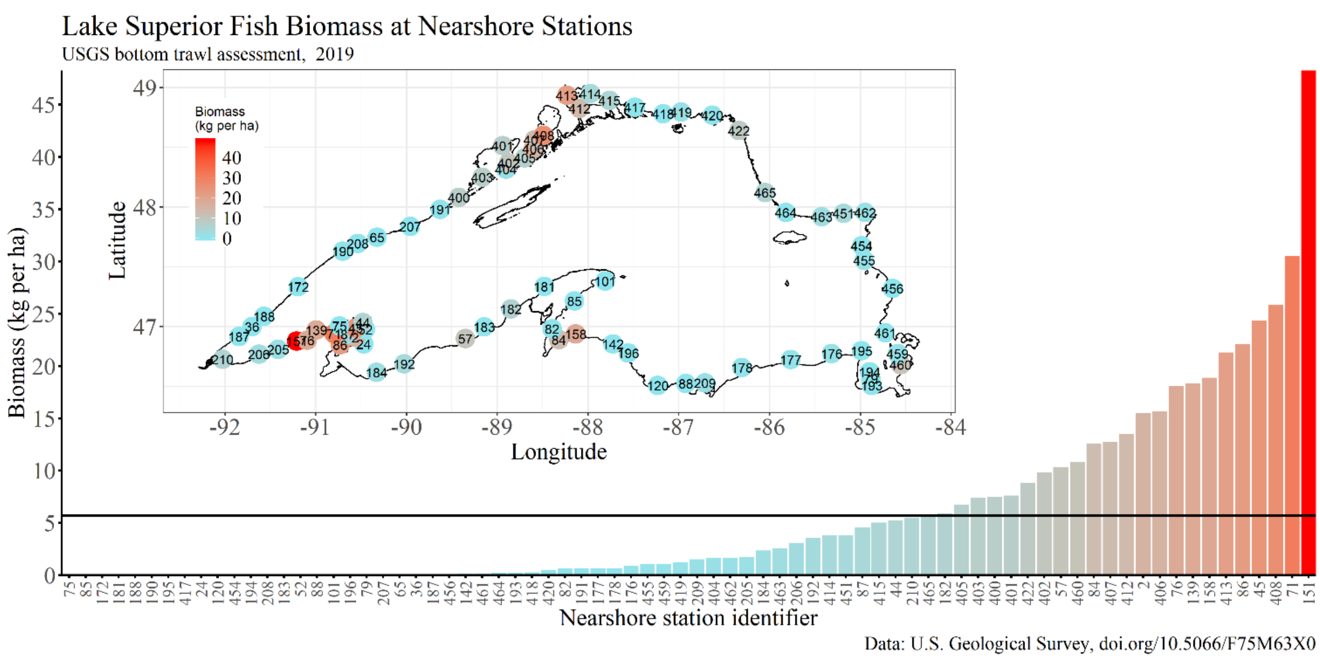

Figure 3. Estimated biomass (kg/ha) at individual nearshore sampling stations in 2019. The horizontal line is the 2019 lakewide nearshore average biomass (5.7 kg/ha). The inset figure shows station locations and biomass (kg/ha) in 2019.

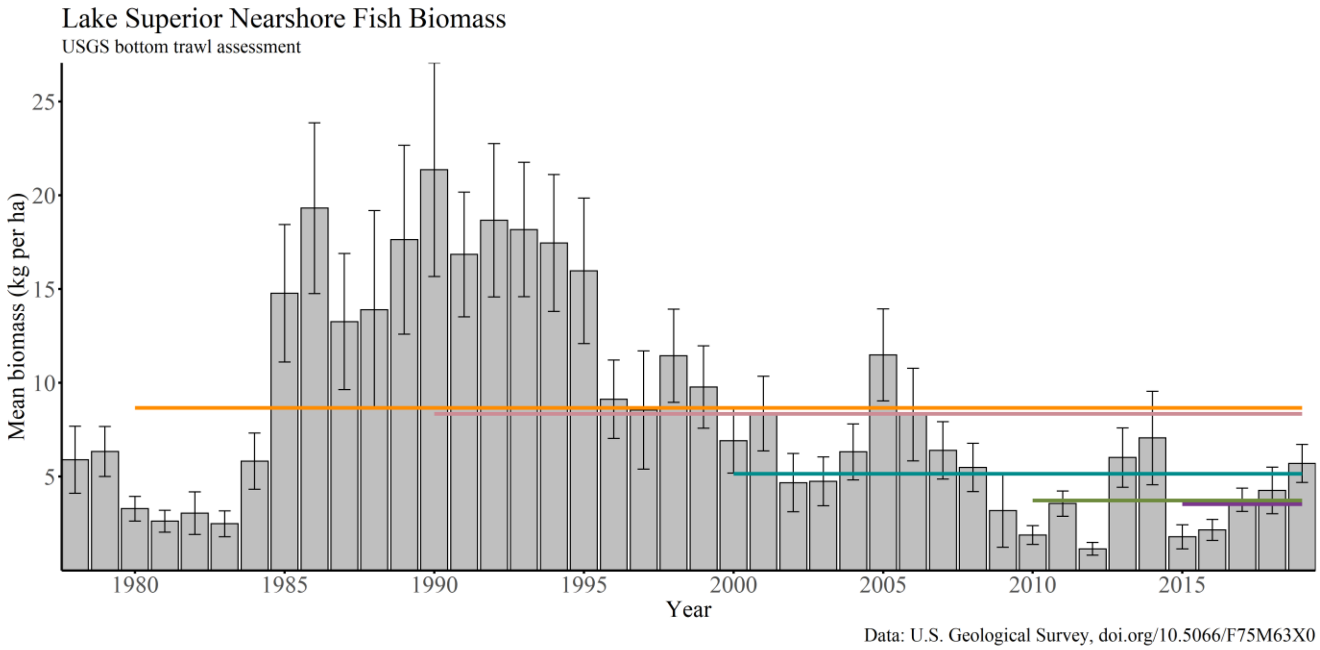

Figure 4. Annual nearshore biomass estimates (mean lakewide kg/ha ± standard error) for all fish species collected in bottom trawls from 1978-2019. Horizontal lines are averages for the previous 5, 10, 20, 30, and 40 years. The number of sites sampled in each year is presented in Table 2.

In 2019, Lake Whitefish, Rainbow Smelt, Longnose Sucker, Bloater, lean Lake Trout, Cisco, Burbot, and siscowet Lake Trout had the highest nearshore average biomass. Trends in lakewide nearshore average biomass of individual prey fish species varied among species. Cisco biomass averaged 0.1 kg/ha in 2019. This was generally similar to that observed during the prior ten-years and well below the period-of-record average of 2.2 kg/ha (Table 2). Trends in Bloater biomass were similar to that observed for Cisco. Mean nearshore biomass for Bloater was 0.7 kg/ha in 2019. This was below the period-of-record average of 1.6 kg/ha (Table 2). Conversely, Lake Whitefish biomass (2.5 kg/ha) was higher than the period-of-record average of 2.1 kg/ha and Rainbow Smelt biomass in 2019 (1.0 kg/ha) was similar to the period-of-record average.

Nearshore Sculpin (Slimy, Spoonhead, and Deepwater) biomass was 0.02 kg/ha in 2019. This was below the period-of-record average of 0.06 kg/ha. Other than the higher estimated biomass in 2001 and 2010-11 (~0.05 kg/ha), nearshore sculpin biomass has been between 0.01 and 0.03 kg/ha the past twenty years (Table 2). Proportionally, nearshore sculpin biomass has been distributed among three sculpin species as ~50% slimy, ~20% Spoonhead, and ~30% Deepwater Sculpin. Over the period-of-record, Slimy Sculpin biomass has declined, and Spoonhead and Deepwater Sculpin biomass have increased.

The combined mean nearshore biomass for all other forage fish species was 1.0 kg/ha in 2019. This was greater than the period-of-record mean of 0.7 kg/ha (Table 2). Miscellaneous species included Ninespine Stickleback, Trout-perch, Kiyi, Shortjaw Cisco, Pygmy Whitefish, Round Whitefish, and Longnose Sucker. Individual species biomass was highest for Longnose Sucker (0.8 kg/ha), Pygmy Whitefish (0.06 kg/ha), Trout-Perch (0.03 kg/ha), and Ninespine Stickleback (0.01 kg/ha).

Two piscivorous fish vulnerable to our daytime nearshore bottom trawling are Burbot and juvenile Lake Trout. Burbot nearshore biomass averaged 0.1 kg/ha in 2019, which was equal to the period-of-record mean (Table 2). However, Burbot biomass was roughly twice as high in most years prior to 1996 as compared to the past twenty years. Ten hatchery Lake Trout were collected during the 2019 nearshore survey. Hatchery Lake Trout biomass has been near zero since 2000, except for 2005. Lean Lake Trout biomass was 0.3 kg/ha which was similar to the period-of-record average (Table 2). Siscowet Lake Trout nearshore biomass was 0.1 kg/ha, which was also equal to the period-of-record average (Table 2).

Densities of age-3 and younger lean and siscowet Lake Trout were 0.2 and 0.01 fish/ha in 2019, respectively (Table 3), which was less than period-of-record averages for both morphotypes (Table 3).

The density of age-1 prey fish was used as a measure of recruitment. Age-1 Cisco density was near zero (0.3 fish/ha) in 2019. Age-1 Cisco were collected at only 11 of the 76 nearshore stations sampled (Figure 5). Preliminary analysis of the effect of age-1 Cisco year-class strength (Table 3) on adult Cisco population size (D. Carl, Wisconsin Department of Natural Resources, unpublished data) suggests 10 age-1 fish/ha may be the threshold for meaningful contribution of that year class to future commercial fishery catch. Over the 42-year history of the nearshore survey, densities of age-1 Cisco have exceeded 10 age-1 Cisco/ha in about 30% of the years (14 of 42 years, Figure 6, Table 3). However, the last two Cisco year-classes to exceed 10 age-1 fish/ha were the 2009- and 2014-year classes.

Age-1 Bloater were collected at 18 of the 76 nearshore stations and the average lakewide density was 3.8 fish/ha in 2019 (Figure 5, Table 3). This was below the period-of-record average of 8.0 fish/ha (Figure 6) but greater than that observed in nine of the previous 13 years (Table 3). If the collection with the high number of age-1 Bloater (Station 2, Stockton Island, 236 fish/ha, Figure 5) is excluded the lakewide average density of age-1 Bloater was 0.7 fish/ha. The median lakewide age-1 Bloater density in 2019 was zero fish/ha with and without including the high-density site. In contrast to other *Coregonus* species (Cisco, Bloater, and Kiyi), Lake Whitefish has exhibited more consistent recruitment and lower overall population biomass fluctuations over the past 42 years. In 2019, age-1 Lake Whitefish density was 6.7 fish/ha which was similar to the period-of-record average of 6.9 fish/ha (Table 3). Age-1 Rainbow Smelt density was 137 fish/ha in 2019, which was similar to the long period-of-record average of 157 fish/ ha (Table 3).

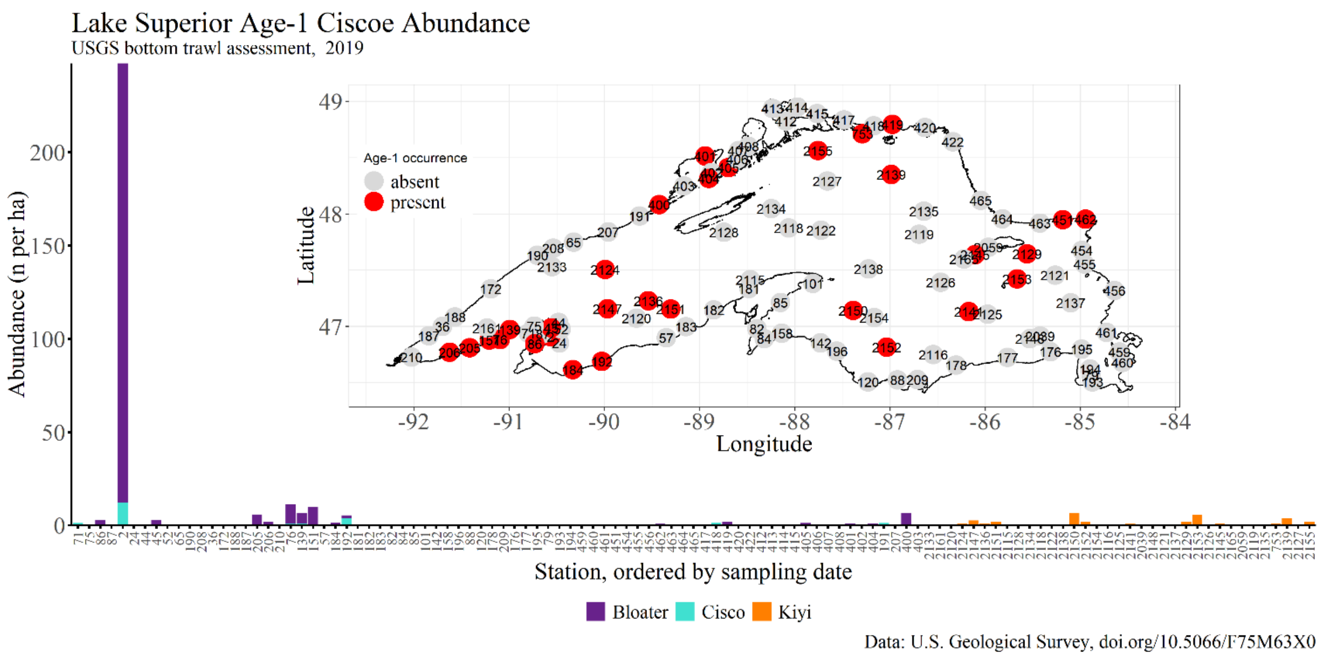

Figure 5. Estimated abundance (number/ha) of age-1 Bloater, Cisco, and Kiyi at individual nearshore and offshore sampling stations in 2019. The inset map shows locations where age-1 Bloater, Cisco, and Kiyi were present or absent in 2019. The one site with a large number ofage-1 Bloater collected was Station 2, Stockton Island, in the Apostle Islands.

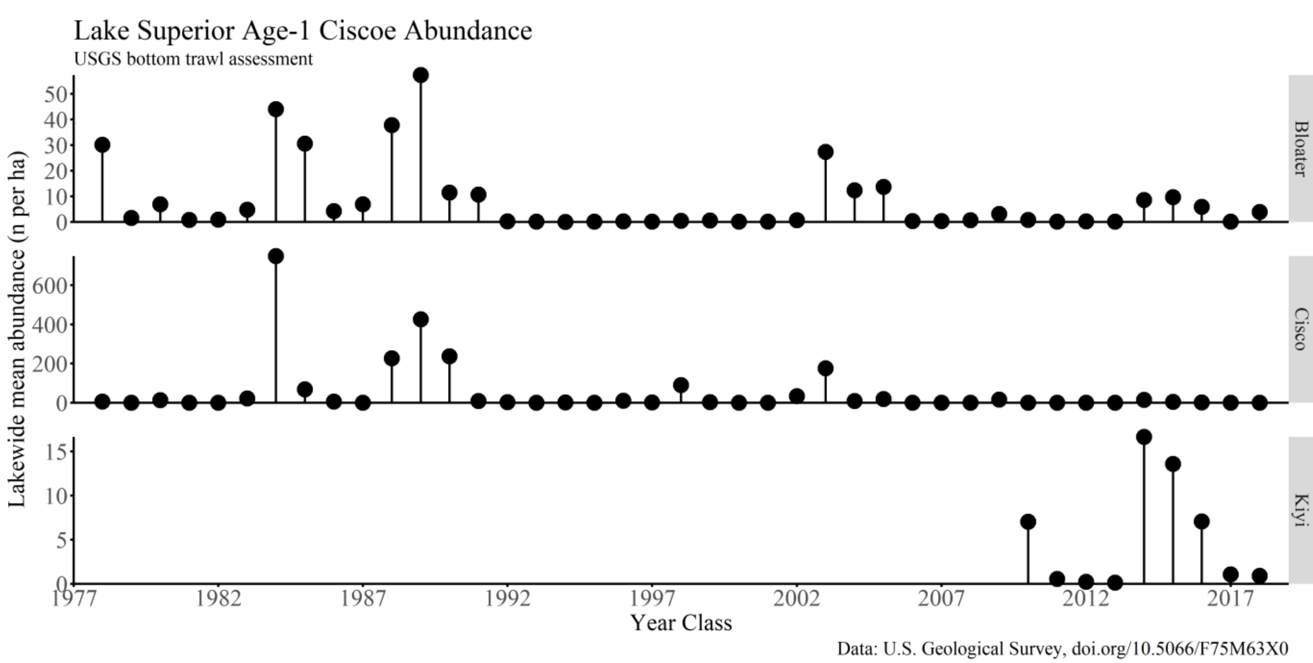

Figure 6. Estimated annual average lakewide abundance (number/ha) of age-1 Bloater, Cisco, and Kiyi from 1978-2019. Bloater and Cisco estimates are from nearshore sites and Kiyi estimates are from offshore sampling sites for which sampling began in 2011. Y-axis scales differ among species.

Offshore survey

Offshore water temperatures in July were similar to the past eight-year average (2011-2019, excluding 2012 when sampling was done in August rather than July, Figure 2). Offshore water temperatures in July 2019 averaged 7.6 °C (range = 4-14.2 °C) at the surface and 3.8 °C (range = 3.6-4.0 °C) at 100 m (Figure 2). The previous eight-year average water temperatures for these same locations in July were 7.7 °C (range=2-19 °C) at the surface and 3.8 °C (range = 3-5 °C) at 100 m.

Thirty-five offshore sites were sampled in 2019 from which 13,145 fish from 11 species or morphotypes were collected (Table 1). The average and median observed species richness across sites was 3.6 and four species, respectively, and ranged from two to six species. Individual offshore station biomass was non-normally distributed (Figure 7), but the variation in biomass estimates across offshore sites was less than that observed at nearshore locations (Figure 3). The skewness of the distribution of individual station biomass estimates in 2019 was 1.8 which was slightly greater than the period-of-record average skewness of 1.2.

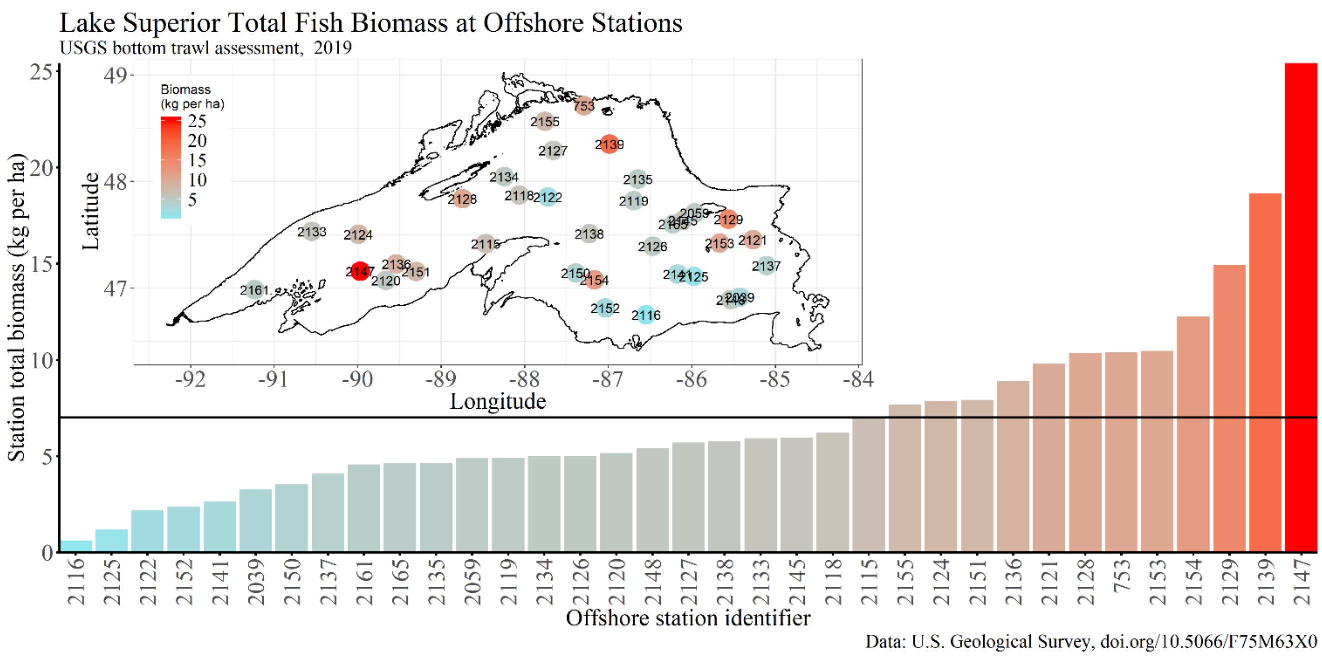

Figure 7. Estimated biomass (kg/ha) at individual offshore stations in 2019. The horizontal line is the 2019 lakewide offshore average biomass (7.0 kg/ha). The inset figure shows station locations and estimated biomass (kg/ha) in 2019.

Deepwater Sculpin, Kiyi, and siscowet Lake Trout made up 99% of the total number of individuals and biomass collected in offshore waters (Table 1, Figure 8). Pygmy Whitefish, Slimy Sculpin, and Bloater were the most common other species collected (Table 1), but these species were limited to depths ~<100 m. Total fish biomass at offshore sites is normally distributed across the sampled depths (90-320 m) and peaks at about 180 m deep (Figure 8). Kiyi biomass was highest from about 140-200 m. Deepwater sculpin biomass was greatest and relatively similar at depths >150 m. Siscowet Lake Trout biomass peaked at about 170-220 m but can be high at all depths sampled by this survey (90-320 m, Figure 8).

Deepwater Sculpin offshore biomass averaged 1.7 kg/ha in 2019, which was slightly less than the period-of-record mean of 1.9 kg/ha (Figure 9). Kiyi offshore biomass averaged 1.6 kg/ha in 2019 which was similar to the period-of-record mean of 1.5 kg/ha (Figure 9). Age-1 Kiyi density at offshore sites was 0.9 fish/ha in 2019 which was less than the 2011-2018 average of 5.8 fish/ha (Table 3, Figure 6).

Siscowet Lake Trout biomass averaged 3.7 kg/ha in 2019, which was greater than the period-of-record mean of 3.0 kg/ha (Figure 9).

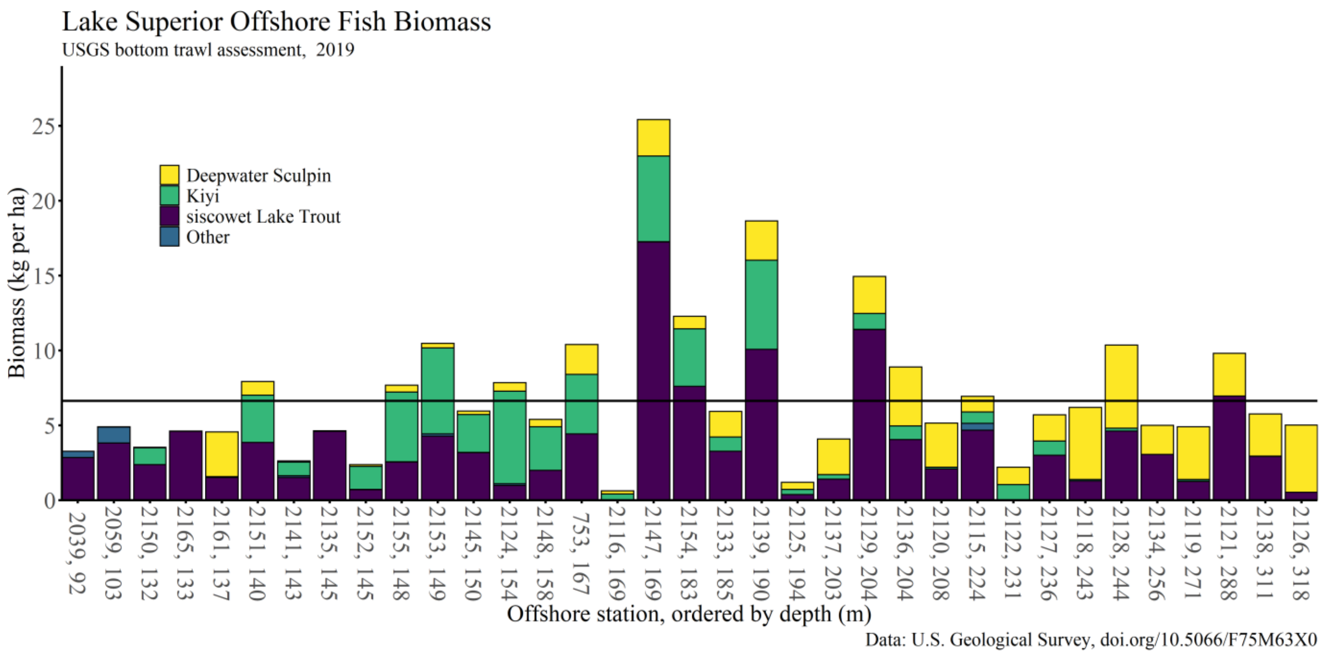

Figure 8. Estimated biomass (kg/ha) at individual offshore stations in 2019 for Deepwater Sculpin, Kiyi, siscowet Lake Trout, and other fish. The horizontal line is the average lakewide offshore total biomass in 2019 (7.0 kg/ha). Bars are ordered by depth from shallowest to deepest.

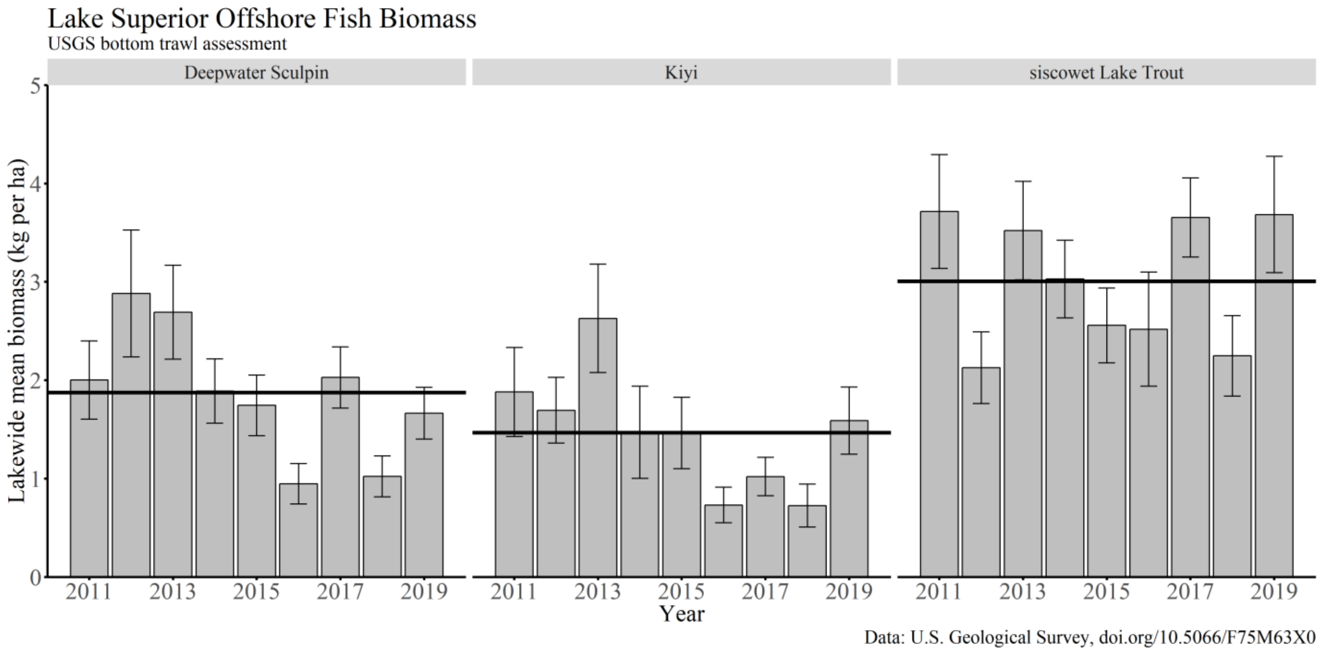

Figure 9. Annual offshore biomass estimates (mean lakewide kg/ha ± standard error) for Deepwater Sculpin, Kiyi and siscowet Lake Trout. The horizontal lines are period-of-record (2011-2019) means for each species.

Summary

Over the 42-year history of the U.S. Geological Survey's Lake Superior nearshore fish community survey, total estimated biomass of demersal fish has been a reflection of the survival of Bloater, Cisco, and Lake Whitefish populations to age-1+ as well as survival of Rainbow Smelt to age-3 or older. The lack of significant survival of Bloater and Cisco to age-1 over the past twenty years has resulted in lower adult prey fish biomass estimates than were observed during 1985-2000. This is disconcerting to fishery managers as these have historically been important commercial species and native prey for a rehabilitated Lake Trout population. Factors underlying low survival to age-1 are not known but are being studied. Biomass trends in other nearshore demersal species have been generally steady over the past five years with some species, such as Lake Whitefish, Ninespine Stickleback, and Longnose Sucker exhibiting increases in biomass over the past 10 -20 years (Figure 10). In a turnaround from 2018 estimates, 2019 offshore demersal fish biomass estimates were similar to or greater than the period-of-record average for Deepwater Sculpin, Kiyi, and Siscowet Lake Trout (Figure 9).

The combination of our near- and offshore bottom trawl surveys provide a lakewide picture of the status and trends of the Lake Superior fish community susceptible to bottom trawls, particularly with respect to describing survival of *Coregonus* species to age-1 and offshore Deepwater Sculpin, Kiyi, and siscowet Lake Trout populations. Our plan is to continue these surveys into the future and adapt them as needed to address emerging issues.

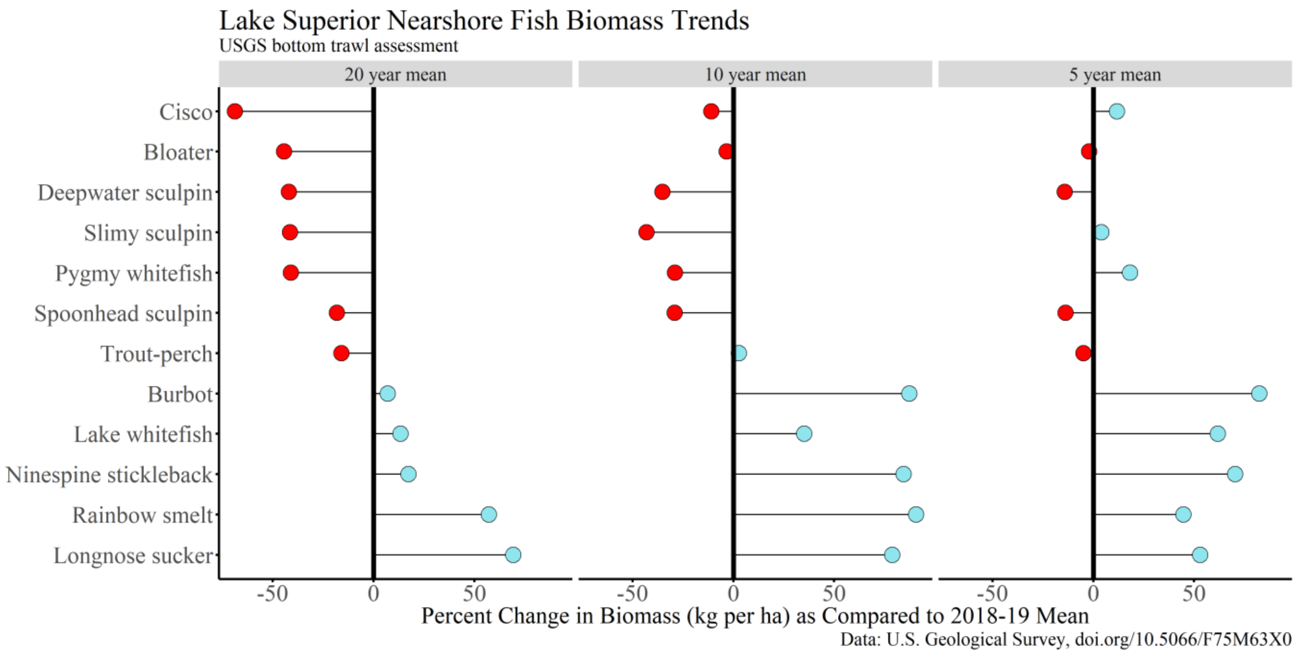

Figure 10. Comparison of the average biomass of common nearshore species in 2018-2019 to average biomass estimates for the previous five, ten, and 20-year time periods.

Note: All GLSC sampling and handling of fish during research are carried out in accordance with guidelines for the care and use of fishes by the American Fisheries Society (http://fisheries.org/docs/wp/Guidelines-for-Use-of-Fishes.pdf).

Table 1. *Fish species and the number of individuals collected in nearshore and offshore bottom trawl surveys in Lake Superior in 2019. Sampling locations shown in Figure 1.*

Common name	Scientific name	Nearshore	Offshore
Alewife	*Alosa pseudoharengus*	10	0
Blackfin Cisco	*Coregonus nigripinnis*	4	0
Bloater	*Coregonus hoyi*	1622	8
Burbot	*Lota lota*	18	1
Cisco	*Coregonus artedii*	139	0
Deepwater Sculpin	*Myoxocephalus thompsonii*	32	11073
hatchery Lake Trout	*Salvelinus namaycush*	10	0
Kiyi	*Coregonus kiyi*	24	1706
Lake Whitefish	*Coregonus clupeaformis*	1512	0
lean Lake Trout	*Salvelinus namaycush*	104	2
Longnose Sucker	*Catostomus catostomus*	122	0
Ninespine Stickleback	*Pungitius pungitius*	914	1
Pygmy Whitefish	*Prosopium coulteri*	878	62
Rainbow Smelt	*Osmerus mordax*	18542	5
Round Whitefish	*Prosopium cylindraceum*	3	0
Ruffe	*Gymnocephalus cernuus*	17	0
Shortjaw Cisco	*Coregonus zenithicus*	19	0
siscowet Lake Trout	*Salvelinus namaycush siscowet*	12	254
Slimy Sculpin	*Cottus cognatus*	345	27
Spoonhead Sculpin	*Cottus ricei*	104	6
Spottail Shiner	*Notropis hudsonius*	3	0
Threespine Stickleback	*Gasterosteus aculeatus*	2	0
Trout-perch	*Percopsis omiscomaycus*	693	0
Yellow Perch	*Perca flavescens*	2	0
Total: 24 species or morphotypes		25,131	13,145

Table 2. *Mean annual Lake Superior nearshore bottom trawl biomass (kg/ha) estimates for common fishes. Sculpin includes Slimy, Spoonhead, and Deepwater Sculpin. Mean and median total biomass includes all species. Other species includes Ninespine Stickleback, Trout-Perch, Kiyi, Shortjaw Cisco, Pygmy Whitefish, Round Whitefish, and Longnose Sucker. No fish sites are the number of locations where no fish were collected.*

Year	Sites	No fish sites	Total species collected	Total biomass	Median biomass	Rainbow Smelt	Cisco	Lake Whitefish	Bloater	lean Lake Trout	siscowet Lake Trout	Burbot	Sculpins	Other species
1978	43	0	17	5.9	0.8	4.1	0.0	0.7	0.1	0.0	0.0	0.2	0.14	0.3
1979	49	0	17	6.3	2.3	2.2	0.1	1.3	0.5	0.1	0.0	0.3	0.20	1.2
1980	48	0	16	3.3	1.1	0.9	0.3	0.6	0.3	0.1	0.0	0.2	0.19	0.4
1981	48	2	18	2.6	0.4	0.2	0.4	0.7	0.4	0.0	0.0	0.2	0.18	0.2
1982	32	0	17	3.1	0.3	0.3	0.4	0.9	0.4	0.1	0.0	0.1	0.03	0.3
1983	50	0	18	2.5	0.5	0.9	0.2	0.2	0.4	0.0	0.0	0.1	0.06	0.2
1984	53	0	21	5.8	1.7	0.8	0.7	1.3	1.8	0.3	0.0	0.2	0.06	0.3
1985	53	0	19	14.8	3.5	1.3	6.5	2.1	2.7	0.8	0.0	0.1	0.08	0.8
1986	53	2	19	19.3	4.0	2.8	8.7	2.7	3.8	0.6	0.1	0.2	0.07	0.2
1987	53	0	16	13.3	1.4	1.8	5.7	2.0	2.6	0.3	0.0	0.1	0.07	0.4
1988	53	0	19	13.9	0.9	1.2	3.1	2.4	6.0	0.8	0.0	0.1	0.04	0.2
1989	76	0	21	17.6	3.4	2.1	6.2	5.5	1.7	0.5	0.2	0.2	0.08	0.9
1990	81	0	22	21.4	5.4	2.0	10.1	2.4	4.9	0.3	0.2	0.1	0.08	1.2
1991	84	1	22	16.8	3.6	1.2	10.2	2.7	0.8	0.7	0.0	0.2	0.10	0.8
1992	85	0	24	18.7	3.3	1.0	3.4	3.7	8.4	0.6	0.1	0.2	0.07	1.1
1993	87	1	23	18.2	6.0	2.1	5.0	3.7	4.3	0.6	0.1	0.3	0.09	1.7
1994	87	0	23	17.5	3.6	1.9	7.2	5.4	0.4	0.6	0.1	0.1	0.08	1.3
1995	87	0	27	16.0	3.0	2.2	4.0	5.8	0.6	0.9	0.1	0.1	0.09	1.9
1996	87	0	26	9.1	2.5	1.3	1.0	1.6	3.1	0.5	0.4	0.2	0.11	0.7
1997	85	1	30	8.6	2.2	1.4	1.4	2.8	0.9	0.7	0.3	0.1	0.06	0.8
1998	87	0	22	11.4	2.0	1.5	1.1	2.3	4.4	0.6	0.2	0.1	0.07	1.1
1999	83	5	23	9.8	1.7	1.1	2.7	1.3	3.1	0.4	0.2	0.1	0.04	0.8
2000	85	4	25	6.9	1.1	0.8	2.4	1.6	0.9	0.3	0.2	0.0	0.04	0.6
2001	83	1	32	8.4	1.7	1.5	1.2	2.8	1.2	0.7	0.1	0.1	0.04	0.6
2002	84	2	26	4.7	0.5	0.2	1.5	1.7	0.6	0.2	0.0	0.1	0.02	0.4
2003	86	8	26	4.8	1.0	0.3	0.6	1.8	0.9	0.3	0.2	0.0	0.02	0.5
2004	75	1	25	6.3	1.9	0.3	1.8	1.9	1.2	0.1	0.2	0.2	0.03	0.7
2005	51	0	27	11.5	4.5	0.9	2.3	4.5	1.7	0.6	0.0	0.3	0.01	0.5
2006	55	2	24	8.3	1.6	1.0	2.3	1.7	1.8	0.3	0.1	0.1	0.02	1.0
2007	54	0	31	6.4	1.1	1.8	0.3	1.9	0.9	0.2	0.1	0.1	0.02	0.9
2008	58	3	23	5.5	1.6	1.0	0.4	2.4	0.2	0.2	0.1	0.3	0.02	0.8
2009	63	6	20	3.2	0.2	0.4	0.3	0.2	1.2	0.3	0.1	0.0	0.02	0.7
2010	62	7	24	1.9	0.2	0.2	0.4	0.2	0.2	0.0	0.1	0.0	0.05	0.3
2011	82	6	21	3.6	1.3	0.6	0.4	0.9	0.6	0.1	0.1	0.0	0.05	0.7
2012	72	16	25	1.2	0.3	0.2	0.0	0.2	0.4	0.1	0.1	0.0	0.03	0.3
2013	79	3	27	6.0	1.2	0.5	0.5	3.0	0.5	0.3	0.3	0.1	0.02	0.8
2014	73	3	28	7.1	1.9	0.4	0.4	4.3	0.5	0.4	0.3	0.1	0.02	0.7
2015	76	4	21	1.8	0.2	0.2	0.2	0.5	0.4	0.1	0.1	0.0	0.02	0.2
2016	76	5	23	2.2	0.2	0.4	0.2	0.5	0.4	0.1	0.1	0.1	0.02	0.3
2017	76	4	27	3.8	1.8	0.9	0.2	1.1	0.5	0.2	0.1	0.0	0.01	0.7
2018	77	10	24	4.3	0.3	1.2	0.4	1.5	0.1	0.2	0.1	0.1	0.02	0.6
2019	76	8	25	5.7	1.4	1.0	0.1	2.5	0.7	0.3	0.1	0.1	0.02	0.9
Mean	69.2	2.5	23.0	8.5	1.8	1.1	2.2	2.1	1.6	0.3	0.1	0.1	0.06	0.7
Median	76.0	1.0	23.0	6.4	1.6	1.0	0.8	1.9	0.8	0.3	0.1	0.1	0.05	0.7

Table 3. *Mean annual Lake Superior bottom trawl age-1 density (number/ha) estimates for nearshore collected Cisco, Bloater, Lake Whitefish, and Rainbow Smelt, nearshore collected small lean and siscowet Lake Trout (<age-3) and offshore collected age-1 Kiyi. Age-1 fish were defined by species-specific lengths: Cisco <140 mm, Bloater <130 mm, Lake Whitefish <160 mm, Rainbow Smelt <100 mm, and Kiyi <130 mm. Lean and siscowet Lake Trout data are for fish <226 mm (~< age 3).*

Year	Year Class	Rainbow Smelt	Cisco	Bloater	Lake Whitefish	Kiyi	lean Lake Trout	siscowet lake Trout
1979	1978	234.1	6.3	30.1	3.9	N/A	0.4	0.0
1980	1979	96.8	0.1	1.6	2.0	N/A	0.3	0.0
1981	1980	106.3	13.5	6.9	16.4	N/A	0.6	0.1
1982	1981	63.8	0.2	0.8	4.2	N/A	0.4	0.0
1983	1982	103.6	0.1	0.8	0.5	N/A	0.4	0.0
1984	1983	223.7	21.8	4.7	8.0	N/A	1.2	0.0
1985	1984	149.5	748.0	44.0	2.5	N/A	1.3	0.0
1986	1985	150.4	68.9	30.6	3.5	N/A	0.9	0.1
1987	1986	273.8	5.4	4.2	11.9	N/A	0.7	0.0
1988	1987	155.3	0.5	6.9	6.1	N/A	0.5	0.0
1989	1988	274.8	226.8	37.7	36.1	N/A	0.3	0.1
1990	1989	269.5	425.6	57.3	8.8	N/A	0.4	0.1
1991	1990	162.0	236.9	11.4	17.5	N/A	0.7	0.0
1992	1991	176.8	9.1	10.7	11.8	N/A	0.8	0.1
1993	1992	155.2	3.3	0.2	7.7	N/A	0.8	0.2
1994	1993	198.6	0.8	0.1	5.0	N/A	1.1	0.0
1995	1994	401.8	1.5	0.0	13.5	N/A	1.7	0.1
1996	1995	168.3	1.0	0.1	6.3	N/A	2.3	0.2
1997	1996	253.0	11.1	0.2	8.8	N/A	0.8	0.1
1998	1997	145.0	1.2	0.1	7.7	N/A	1.2	0.0
1999	1998	216.2	90.6	0.4	9.2	N/A	0.3	0.1
2000	1999	58.4	3.9	0.5	0.8	N/A	0.4	0.0
2001	2000	257.4	0.8	0.1	2.4	N/A	0.5	0.0
2002	2001	56.8	0.5	0.1	13.7	N/A	0.2	0.1
2003	2002	77.9	33.2	0.6	7.8	N/A	0.2	0.0
2004	2003	70.3	175.4	27.3	6.4	N/A	0.3	0.0
2005	2004	111.0	8.4	12.3	3.0	N/A	0.6	0.1
2006	2005	249.5	18.6	13.6	5.4	N/A	0.4	0.2
2007	2006	377.6	0.4	0.3	20.5	N/A	0.1	0.1
2008	2007	284.5	0.2	0.3	0.6	N/A	0.2	0.1
2009	2008	72.2	0.3	0.6	3.0	N/A	0.1	0.1
2010	2009	47.2	16.5	3.0	8.1	N/A	0.0	0.1
2011	2010	74.0	0.3	0.8	4.0	7.0	0.4	0.0
2012	2011	10.9	0.0	0.1	1.9	0.6	0.4	0.1
2013	2012	142.9	0.2	0.2	5.5	0.2	0.4	0.1
2014	2013	68.5	0.0	0.1	2.3	0.1	0.3	0.1
2015	2014	30.7	14.3	8.6	1.0	16.7	0.1	0.1
2016	2015	83.0	5.0	9.7	1.6	13.6	0.4	0.1
2017	2016	147.0	1.4	5.8	1.4	7.1	0.8	0.0
2018	2017	161.4	0.0	0.1	1.1	1.1	0.1	0.1
2019	2018	137.1	0.3	3.8	6.7	0.9	0.2	0.0
Mean		157.0	51.2	8.0	6.9	5.2	0.6	0.1
Median		148.2	2.4	0.8	5.4	1.1	0.4	0.1