Status and Trends in the Lake Superior Fish Community, 2023

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Abstract

The U.S. Geological Survey annually conducts fishery surveys across Lake Superior that describe trends in fish species occurrence and relative abundance to inform fisheries management and large lake ecology. In 2023, the Lake Superior fish community was sampled with daytime bottom and surface trawls at 51 nearshore locations in June and 31 offshore locations in July. Nearshore bottom trawls collected 157,804 fish from 25 species or morphotypes. Nearshore mean biomass was 18.3 kg per ha which was the second highest biomass estimate over the survey's 46-year history. Offshore bottom trawls collected 15,458 fish from 10 species or morphotypes. Offshore mean biomass was 5.2 kg per ha, which was less than the annual average of 6.3 kg per ha. Recruitment, as measured by age-1 densities, was the highest recorded for Bloater, Cisco, and Rainbow Smelt in the nearshore and for Kiyi in the offshore survey's period-of-records. Lakewide average densities (fish per ha) of age-1 fish were 140 for Bloater, 1,019 for Cisco, 616 for Rainbow Smelt, and 54 for Kiyi, which were the highest estimates for the survey's period-of-record. Period-of-record averages for these species were 10, 67, and 9 age-1 fish per ha, respectively. Age-1 Lake Whitefish averaged 9 fish per ha which was similar to the long-term average of 8 age-1 Lake Whitefish per ha. If the future can be predicted by past large Bloater, Cisco, and Kiyi (collectively, ciscoe) year-class events, the unprecedented survival of the 2022 ciscoe year-class will influence the Lake Superior ecosystem for the next 10 to 20-years.

Introduction

The U.S. Geological Survey, Great Lakes Science Center, Lake Superior Biological Station, based in Ashland, Wisconsin conducts annual daytime lakewide fish community bottom trawl surveys in nearshore (~15-80 m depths) and offshore (~90-300 m depths) waters that describe trends in fish species occurrence and relative abundance to inform fisheries management and large lake ecology. Both surveys provide data for assessing trends in species occurrence, relative abundance, and biomass for principal fishes and estimates of survival to age-1 for Bloater, Cisco, Kiyi, Lake Whitefish, and Rainbow Smelt (scientific names are provided in Table 1). The number of age-1 fish per ha has been used historically as a measure of year-class strength to predict future populations sizes for these important species.

The nearshore bottom trawl survey has been conducted annually since 1978 in USA waters, and since 1989 in USA and Canadian waters. The offshore bottom trawl survey has been conducted annually since 2011 in USA and Canadian waters. Surface trawling has occurred annually during the nearshore and offshore surveys since 2014. In 2020 only nearshore locations in the Apostle Islands, north of Ashland, Wisconsin, (Management Unit WI-2) were sampled and in 2021 only nearshore locations in USA waters were sampled due to COVID-related travel restrictions. Surface trawling is conducted to collect larval *Coregonus* fishes as a measure of species occurrence and relative abundance in support of evaluating factors influencing survival to age-1. Larval *Coregonus* fishes have been identified using genomics since 2019. Genomic data for 2023 are not yet available. In addition to fish collections, a whole water column zooplankton tow and an electronic water column sampler that collects data on depth, temperature, beam transmission specific conductance, dissolved oxygen, pH, chlorophyll a, and photosynthetic active radiation is deployed at each location. Data for years prior to 2023 are publicly available (U.S. Geological Survey 2022, https://doi.org/10.5066/P9XVOLR1) and 2023 data will be available in 2024.

Methods

Nearshore bottom trawl fish collections

Nearshore locations are located around the perimeter of the lake (Figure 1). Locations were established in the USA in 1978 and in Canada in 1989. Locations are sampled with only slight annual variations due to commercial fishing operations, vessel crew manning, mechanical issues, and weather. In 2023, 59 locations were sampled from June 2-26. Thirteen traditionally sampled locations were not bottom trawled in 2023 due to not having roller trawls available (Figure 1). These 13 locations are known to have rock substrates that have proven to be detrimental to chain foot rope bottom trawls. Location 193-Salt Point in Whitefish Bay was not bottom trawled due to commercial fishing nets deployed across the transect. Two Canadian locations, 417-Schrieber Channel and 451-Dog River were not sampled due to a shortage of vessel crew. At each of the other 59 locations, a single bottom trawl tow was conducted with a 12-m Yankee bottom trawl with a chain foot rope. Bottom trawls were ripped at two locations, 177-Sucker River and 459-Maple Island, so these two locations were removed from the data set. The median start and end depths for bottom trawl tows were 17 (range 8-51 m) and 54 m (range 18-140 m), respectively. The median distance trawled was 1.6 km (range 0.7-4.0 km) at a speed of ~4.0 km per h. Specific location and trawling data for each sampling location are provided in Appendix A. Bottom trawl fishing area was calculated based on a fixed trawl wing spread of 7.8 m and the distance the trawl was on the lake bottom as determined using a trawl mensuration system (Marport.com) and the Research Vessel Kiyi's global positioning system.

Offshore bottom trawl fish collections

Offshore locations were randomly selected in 2011 and have been sampled annually thereafter, except for 2020 and 2021. In 2023, 31 locations were sampled during daylight hours from July 10-27. Five locations that are traditionally sampled were not sampled in 2023 due to a shortage of vessel crew (Figure 1). A single bottom trawl tow was conducted at each location using a 12-m Yankee bottom trawl with a chain foot rope. All tows were made on-contour for 20 minutes. Station depths ranged from 80 to 308 m. The median trawl distance was 1.4 km (range 1.3-1.4 km) at a speed of ~4.0 km per h. Specific location and trawling data for each sampling location are provided in Appendix A. Bottom trawl fishing area was calculated based on a fixed trawl wing spread of 7.8 m and the distance the trawl was on the bottom as determined using a trawl mensuration system (Marport.com) and the Research Vessel Kiyi's global positioning system.

Surface trawl fish collections

Surface trawling was conducted at all nearshore and offshore bottom trawl locations sampled in 2023 (Figure 1, Appendix A), except at locations 142-Big Bay, 187-French River, and 196-Baker's Point due to blustery winds. Fish were collected using a paired one-square-meter 500-micron mesh neuston net (model 9550, Sea-Gear Corporation, Melbourne, Florida). The bottom of the net frame was fished ~0.5 m below the lake surface for 10 minutes at ~4.0 km per h for ~0.7 km as determined from the Research Vessel Kiyi's global positioning system.

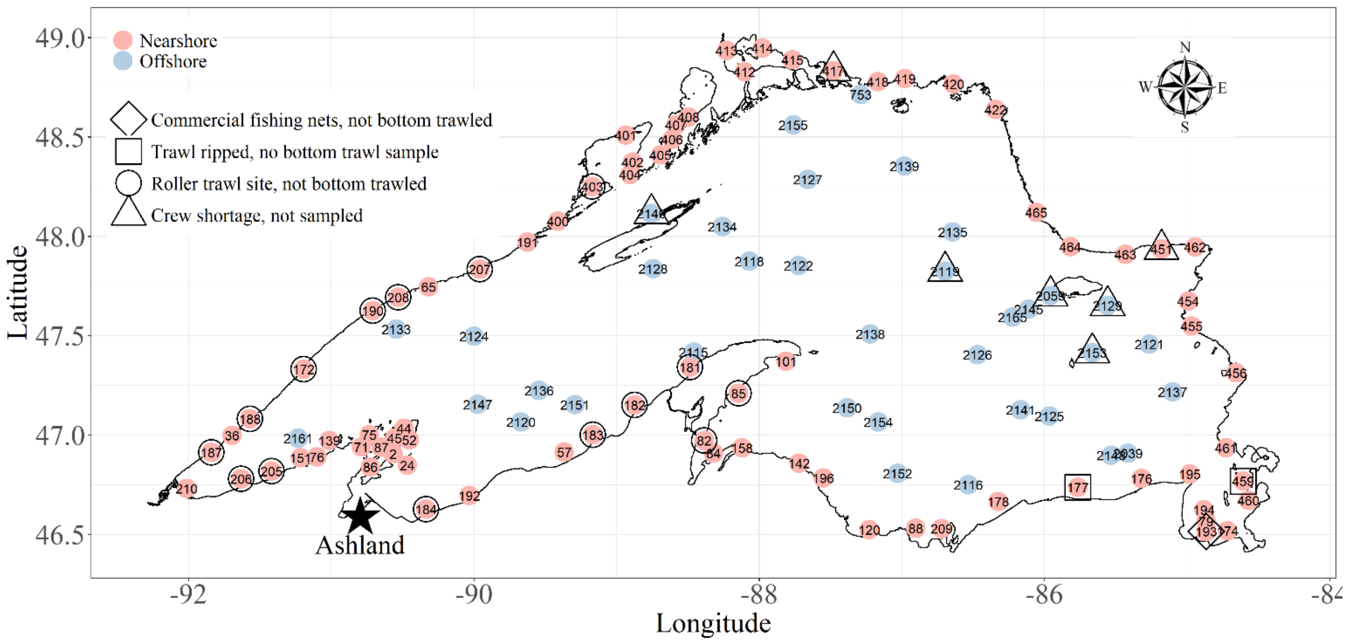

Figure 1. Location of 78 nearshore and 36 offshore sampling locations traditionally sampled with bottom and surface trawls, a whole water column zooplankton tow, and an electronic water column sampler that collects data on depth, temperature, beam transmission, specific conductance, dissolved oxygen, pH, chlorophyll a, and photosynthetic active radiation each year. Bottom trawls for benthic and demersal fish and surface trawls for larval fish occurred at 59 nearshore and 31 offshore sampling locations in 2023. Bottom trawls were not done at 13 nearshore locations due to the lack of roller trawls. Two nearshore locations were not bottom trawled due to a lack of vessel crew. Five offshore locations were not sampled for any attributes due to a lack of vessel crew. A single nearshore location was not sampled due to commercial fishing gear deployed across the transect. Bottom trawls were ripped at two locations and the partial catch was discarded. Surface trawling was not done at three locations due to high winds. Location numbers are unique identifiers that are sequentially added as new locations are sampled. Additional location and trawling data for each sampling location is provided in Appendix A.

Catch Processing

Fish collected in bottom trawls were sorted by species (also separated by morphotype for Lake Trout and hatchery vs wild for Lake Trout), counted, and weighed in aggregate to the nearest gram. In 2023, several nearshore bottom trawl catches were exceptionally large and diverse (>50 kg and >10 species) and were sub-sampled by first removing large fish (> ~175 mm) from the catch and processing them as described above. Smaller fish were then weighed in aggregate, then depending on the size of the catch, seven to 15 liters of fish were subsampled from the aggregate of small fish and a total weight was measured. This subsample was then sorted, weighed, and counted by species. From the subsample, the proportion by weight and average weight per fish for each species was calculated. These estimates were then projected to the aggregate sample of small fish to estimate the total weight and count for each species. These results were then combined with the aggregate of large fish total weights and counts. For large catches of Rainbow Smelt, the total number collected was estimated by weighing three subsamples of 50 randomly selected fish and dividing the average weight of an individual fish, as determined by the three subsamples, into the total weight. Total length was measured for a maximum of 50 individuals per species per trawl. Lengths of these individuals were extrapolated to the entire catch when more than 50 individuals were collected. Relative abundance (fish per ha) and biomass (kg per ha) were estimated by dividing sample counts and aggregate weights by the area swept by each trawl tow (ha). For annual nearshore bottom trawl collections, biomass estimates are reported for all species combined and individually for Bloater, Cisco, Lake Whitefish, and Rainbow Smelt, and combined for Sculpin species (Slimy, Spoonhead, and Deepwater Sculpin). A composite estimate is also reported for less-common species (Table 1). For offshore bottom trawl collections, biomass estimates are reported for all species combined and individually for Deepwater Sculpin, Kiyi, and siscowet Lake Trout. Age-1 year-class strength was estimated as the mean nearshore lakewide abundance (fish per ha) of age-1 fish as determined by total length; Cisco <140 mm, Bloater <130 mm, Lake Whitefish <160 mm, and Rainbow Smelt <100 mm, and for offshore collected Kiyi <130 mm. These age-size cutoffs were based on past published age estimates, are approximate, and are known to vary among years (Dryer and Beil, 1964, 1968. Lepak et al. 2017).

Larval fish collected in surface trawls were immediately removed from the nets and identified as *Coregonus*, Deepwater Sculpin, Rainbow Smelt, or Pacific Salmon based on morphological characters (Hinrichs 1979; Auer 1982). *Coregonus* larvae were counted and stored in 20 ml polyethylene scintillation vials filled with 90% ethanol. Other larval species were noted as being present and discarded. Larval fish densities were calculated based on the width of the sampling nets and the distance towed. Data are not reported for 2020 and 2021 as fewer locations were sampled due to COVID restrictions.

Data Analysis, Visualization, and Availability and USGS Disclaimer

All data manipulations, statistical analyses, and visualizations were performed in R version 4.0.5 (R Development Core Team 2023). Data visualizations were produced using ggplot2 (Wickham 2016). Data for years prior to 2023 are publicly available (U.S. Geological Survey 2022, https://doi.org/10.5066/P9XVOLR1) and 2023 data will be available in 2024. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Results

Nearshore Fish Collections

A total of 157,804 fish from 25 species or morphotypes were collected across 57 nearshore locations (Table 1). The number of species collected at each location ranged from 2 to 15, with a median of 9 species. Estimated fish biomass at individual locations ranged from <0.1 to 141.7 kg per ha (Figure 2). The five locations with the highest biomass in 2023 were 2-Stockton Island in the Apostle Islands (142 kg per ha), 151-Bark Point, Wisconsin west of the Apostle Islands (71 kg per ha), 101-Bete Grise on the east side of the tip of the Keweenaw Peninsula (62 kg per ha), 76-Mawikwe Point, Wisconsin, west of the Apostle Islands (51 kg per ha), and 418-Terrace Bay, Ontario, northeast of Thunder Bay, Ontario (49 kg per ha, Figure 2). Average lakewide fish biomass across all locations was 18.3 kg per ha, which was the second highest lakewide biomass estimate over the survey's 46-year history (Figure 3). Average lakewide biomass in 2023 was highest for Cisco (10.5 kg per ha), Lake Whitefish (2.4 kg per ha), Rainbow Smelt (2.4 kg per ha), and Bloater (1.1 kg per ha, Table 1), which were greater than the long-term averages for all of these species other than Bloater (long-term mean = 1.5 kg per ha, Table 2). Other species collected in nearshore bottom trawl tows in 2023 (number collected) included Ninespine Stickleback (3,564), Trout-perch (1,620), Slimy Sculpin (1,195), Pygmy Whitefish (580), Deepwater Sculpin (725), Spoonhead Sculpin (378), Kiyi (314), Longnose Sucker (96), Ruffe (55), lean Lake Trout (49), siscowet Lake Trout (46), hatchery Lake Trout (19), Round Whitefish (18), Johnny Darter (18), Burbot (16), Yellow Perch (6), unidentified *Coregonus* (6), Spottail Shiner (5), Threespine Stickleback (4), and one each of Lake Sturgeon and Logperch.

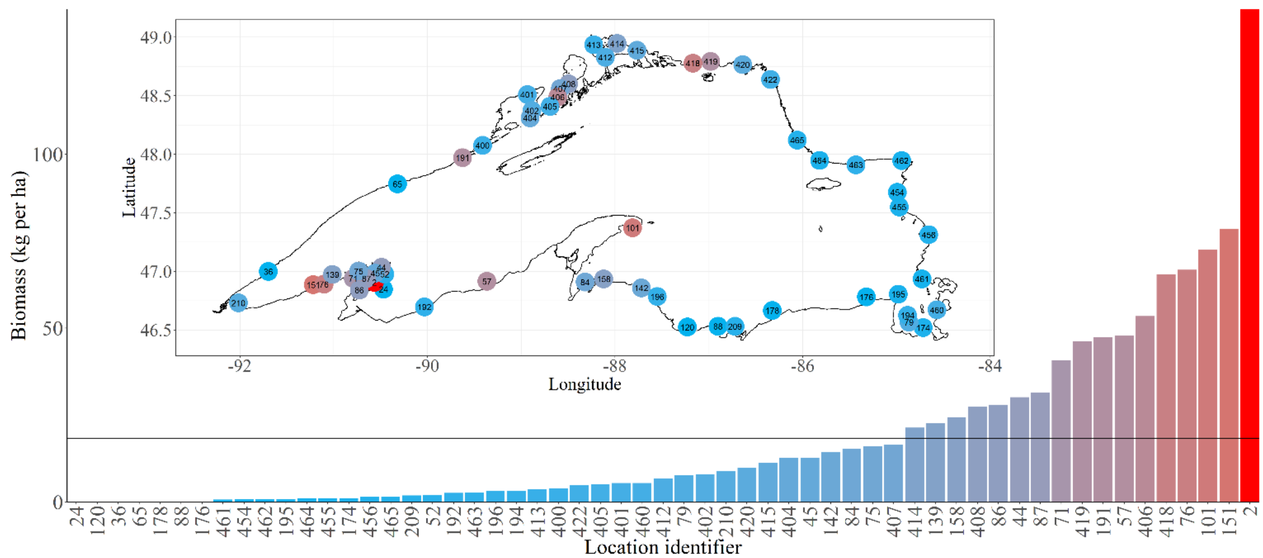

Figure 2. Estimated total fish biomass (kg per ha) at 57 nearshore bottom trawling locations in nearshore USA and Canada waters of Lake Superior in 2023. Nearshore sampling locations were 17-140 m deep. The horizontal line is the 2023 average biomass across all locations (18.3 kg per ha). The inset figure shows sampling locations colored by their estimated biomass (kg per ha) in 2023. Colors within inset map correspond to color in the histogram.

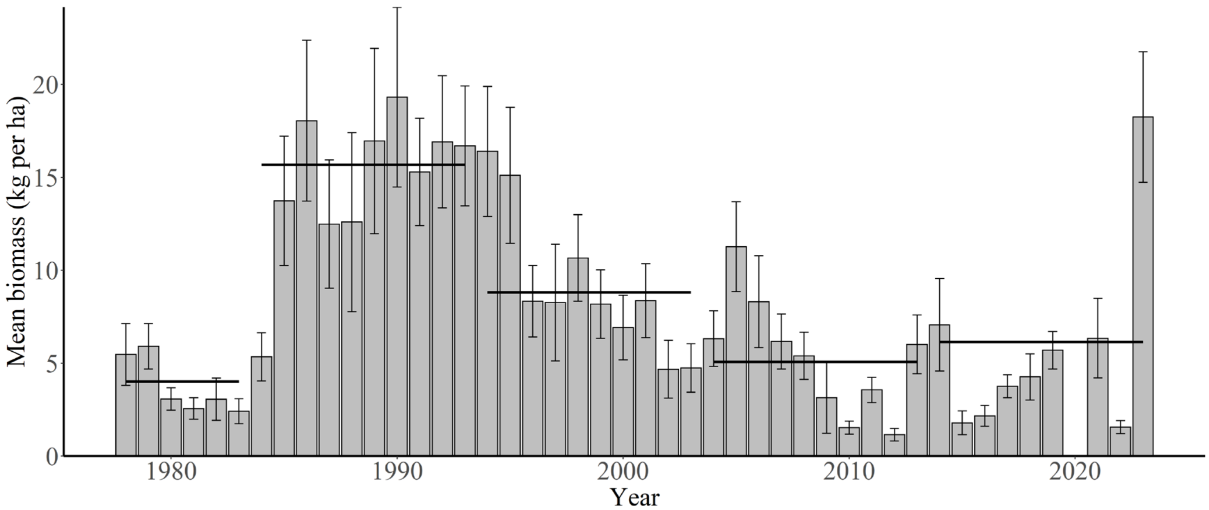

Figure 3. Annual (mean ± standard error) total fish biomass estimates for all fish species collected in bottom trawl tows from 1978-2023 in nearshore USA and Canada waters of Lake Superior. Nearshore sampling locations were 17-140 m deep. Horizontal lines are 10-year averages across different periods. In 2020 sampling occurred outside the standard sampling window and only 11 locations were sampled in the Apostle Islands, north of Ashland, Wisconsin (Figure 1), so these data were excluded. From 1978-1988 and in 2021 only USA waters were sampled. The number of locations sampled in each year is presented in Table 2.

Year-Class Strength

The number of age-1 fish per ha has been used historically as a measure of year-class strength. In 2023, age-1 Bloater were caught at 38 of 57 locations (Figure 4) and the average lakewide age-1 abundance was 140 per ha (Figure 5). Age-1 Cisco were caught at 43 of 57 locations (Figure 4) and the average lakewide age-1 abundance was 1,019 per ha (Figure 5). Age-1 Bloater and Cisco abundance estimates were the highest for the survey's 46-year period-of-record (Figure 5, Table 3). Period-of-record averages for these species were 10, 67, and 9 age-1 fish per ha, respectively. Age-1 Lake Whitefish were caught at 17 of 57 locations (Figure 4) and the average age-1 abundance was 9 per ha, which was similar to the long-term average of eight age-1 Lake Whitefish per ha (Figure 5, Table 3). Mean age-1 Rainbow Smelt abundance was the highest for the nearshore survey's period of record, 615 per ha (Table 3). Age-1 Rainbow Smelt abundance was particularly high (>600 per ha) in northern Ontario; stations 418-Terrace Bay, Ontario (9,371 per ha), 405, 406, 407, 408-Black Bay, Ontario (999-9,363 per ha), 404-Dublin Creek in Nipigon Bay, Ontario (953 per ha), and 420-Ashburton Bay, Ontario (779 per ha), as well as stations 101-Bete Grise (1,331 per ha), 192-Black River (1,276 per ha), and 158-Huron Bay (1,171 per ha) in the USA (Figure 6).

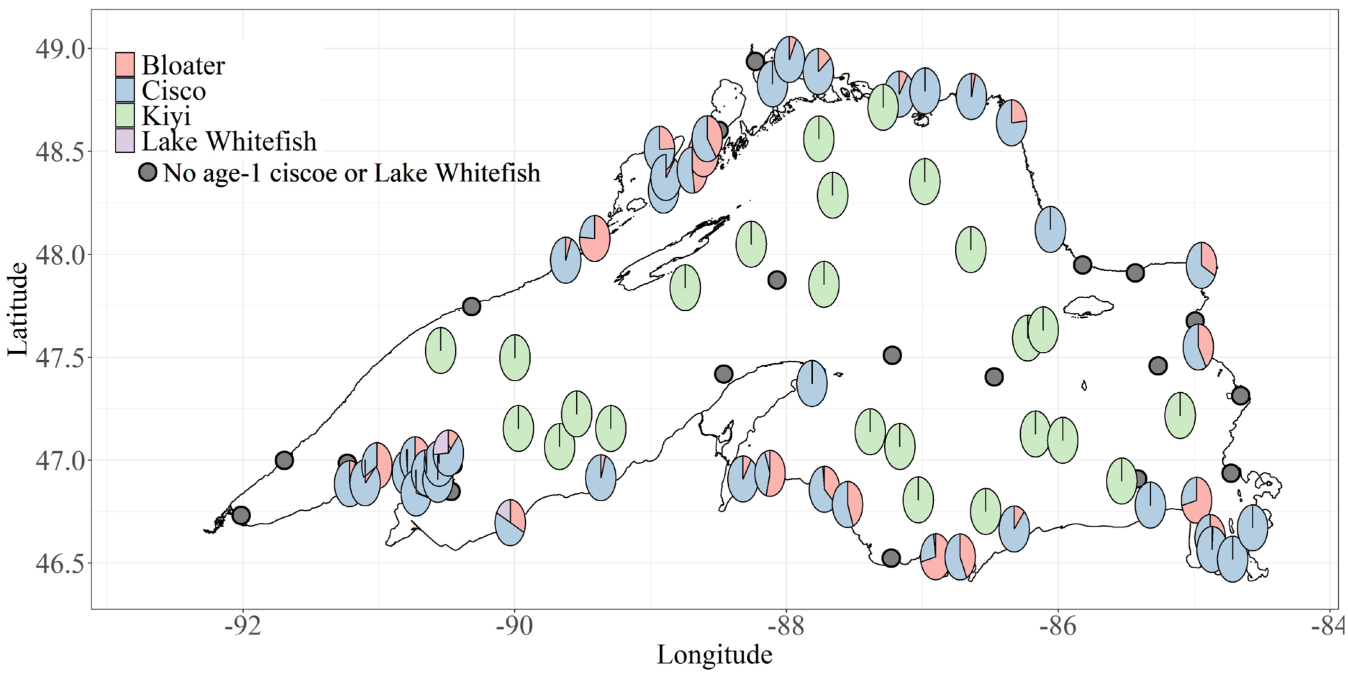

Figure 4. Proportional abundance occurrences of age-1 Bloater, Cisco, Kiyi, and Lake Whitefish collected in near- and off-shore surveys in USA and Canada waters of Lake Superior in 2023. Nearshore sampling locations were 17-140 m deep and offshore locations were 80-308 m deep. Gray solid points indicate no age-1 Bloater, Cisco, Kiyi, or Lake Whitefish were collected at that location. The location of individual stations by identification number is shown in Figure 1.

The effect of not sampling 13 traditional nearshore roller trawl locations

Thirteen traditionally sampled locations were not bottom trawled in 2023 due to not having any roller trawls available (Figure 1). The influence of not sampling these locations on lakewide total biomass and age-1 estimates for Bloater, Cisco, Lake Whitefish, and Rainbow Smelt was evaluated by excluding these locations for the nearshore survey period-of-record and comparing the annual indices with and without sampling roller trawl locations. The overall magnitude of the differences in lakewide total mean biomass and age-1 index values across all years among indices ranged from 8-13% higher estimates on average when roller trawl locations were removed from the data set (Appendix B, total biomass, 10.4%, age-1 Bloater 8.5%, age-1 Cisco 10.7%, age-1 Lake Whitefish 13%, and age-1 Rainbow Smelt 10.5%). Differences in median values across the period-of-record ranged from 7-15% (Appendix B). These results suggest that the index values estimated in 2023 were slightly higher than they would have been had the 13 roller trawl sites been sampled. These differences were not large enough however to change the general interpretation that fish population estimates in 2023 were some of the highest on record.

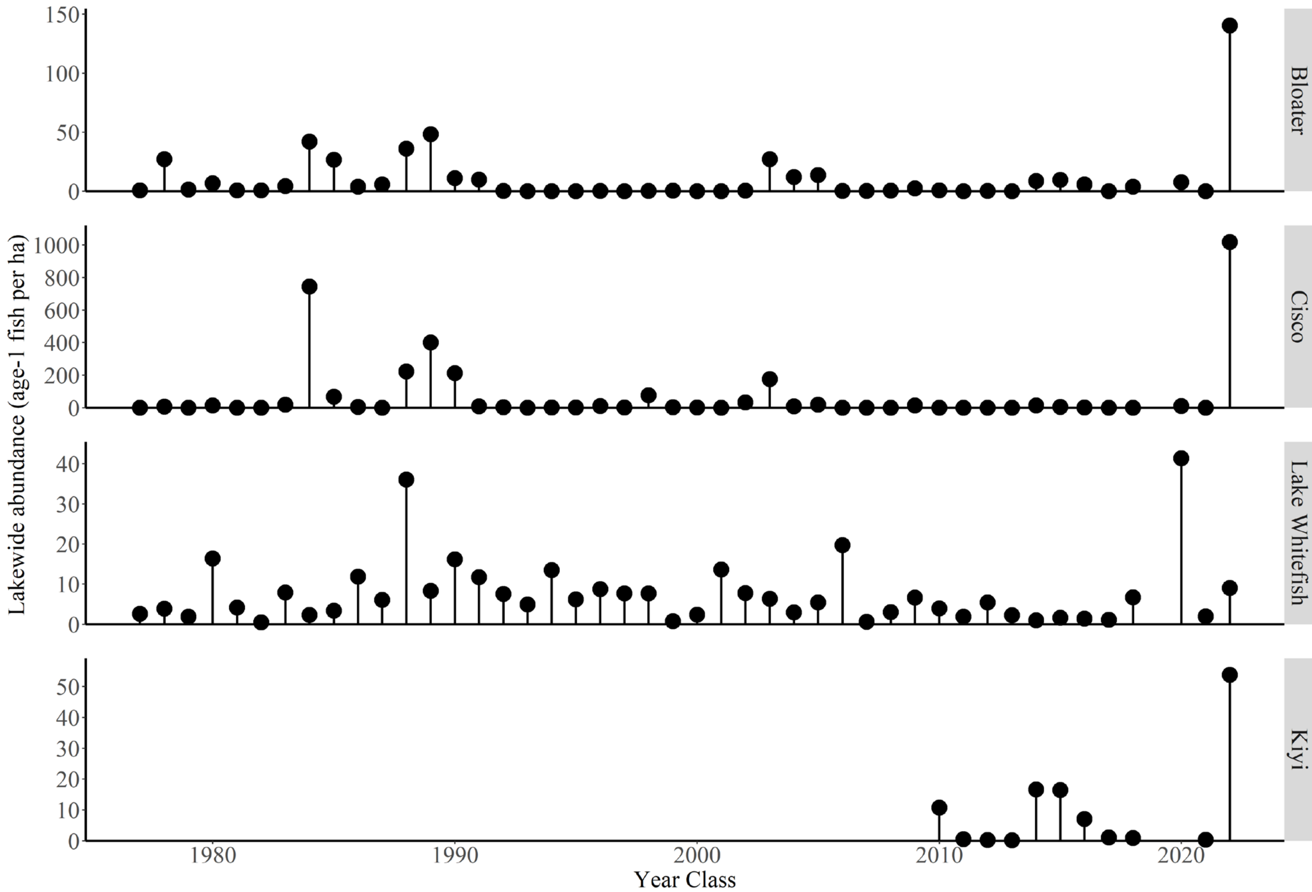

Figure 5. Annual mean age-1 nearshore Bloater, Cisco, and Lake Whitefish and offshore Kiyi abundance estimates (age-1 fish per ha) collected in bottom trawl tows from 1978-2023 in nearshore surveys and 2011-2023 in offshore surveys in USA and Canada waters of Lake Superior. Nearshore sampling locations were 17-140 m deep and offshore locations were 80-308 m deep. In 2020 sampling occurred outside the standard sampling window and only 11 locations were sampled in the Apostle Islands, north of Ashland, Wisconsin (Figure 1), so data for the 2019 year-class were excluded. From 1978-1988 and in 2021 only USA waters were sampled. The number of locations sampled in each year is presented in Table 3.

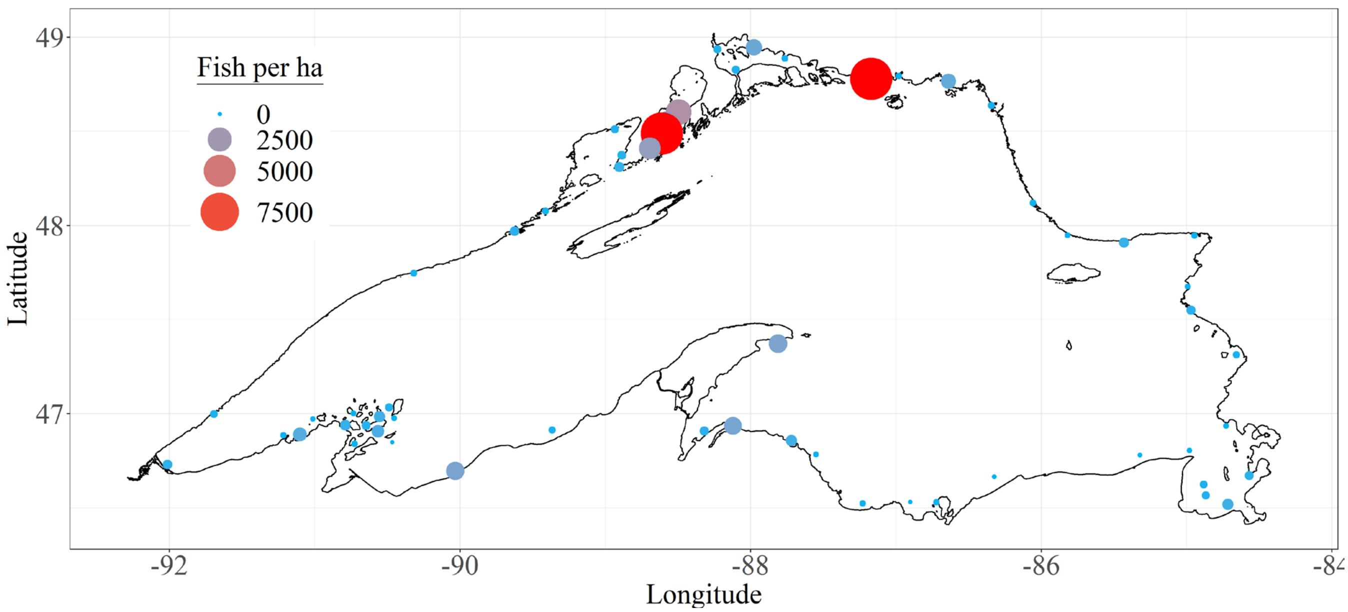

Figure 6. Rainbow Smelt abundance (fish per ha) in nearshore surveys in USA and Canada waters of Lake Superior in 2023. Nearshore sampling locations were 17-140 m deep. The location of individual stations by identification number is shown in Figure 1.

Annual Offshore Fish Collections

Thirty-one offshore locations were sampled in 2023 from which 15,458 fish from 10 species or morphotypes were collected (Table 1). Estimated fish biomass at individual locations ranged from 1.0 to 15.4 kg per ha (Figure 7). Individual locations with the highest biomass in 2023 were locations 2135, a 140 m deep location near Superior Shoal, Ontario, 2125, a 175 m deep location north of Grand Marais, Michigan, and 2116, a 165 m deep location north of Munising, Michigan (Figure 7). Offshore mean biomass was 5.2 kg per ha, which was less than the long-term (2011-2023) annual average of 6.3 kg per ha.

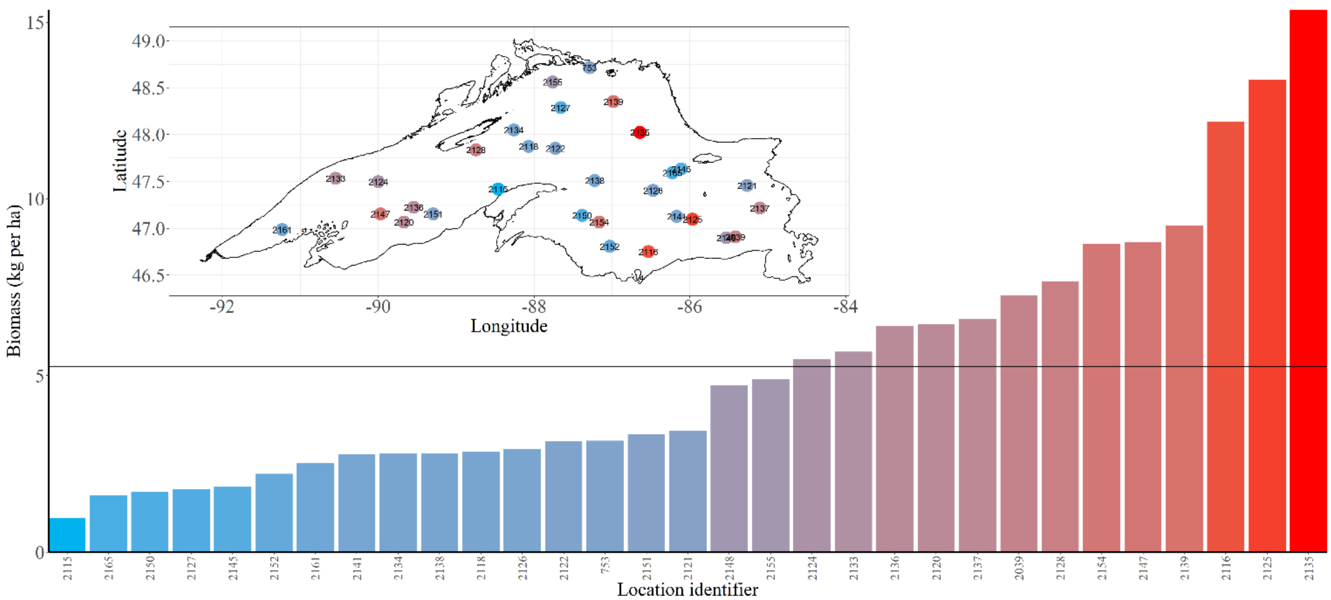

Figure 7. Estimated biomass (kg per ha) at individual offshore locations in USA and Canada waters of Lake Superior in 2023. The horizontal line is the 2023 lakewide offshore average biomass (5.2 kg per ha). The inset figure shows sampling locations colored by their estimated biomass (kg per ha) in 2023. Colors within inset map correspond to color in the histogram.

Deepwater Sculpin, Kiyi, and siscowet Lake Trout made up 99% of the total number of individuals and biomass collected in offshore waters (Table 1). Other fish collected in much lower abundances were Bloater (18 fish), Slimy Sculpin (15 fish), Spoonhead Sculpin (6 fish), Cisco (3 fish) and two fish each of Rainbow Smelt, Pygmy Whitefish, and Burbot (Table 1). Deepwater Sculpin offshore biomass averaged 1.8 kg per ha in 2023, which was similar to the long-term average of 1.9 kg per ha (Figure 8). Kiyi offshore biomass averaged 0.9 kg per ha in 2023 which was less than the long-term average of 1.3 kg per ha (Figure 8). Age-1 Kiyi abundance at offshore locations was 54 fish per ha in 2023 which was the highest estimate for the period-of-record of the survey (2011-2023, Figure 5, Table 3). The previous high abundance for age-1 Kiyi was 17 and 16 fish per ha for the 2014 and 2015 year-classes.

Siscowet Lake Trout biomass averaged 2.6 kg per ha in 2023, which was slightly less than the long-term average of 2.8 kg per ha (Figure 8).

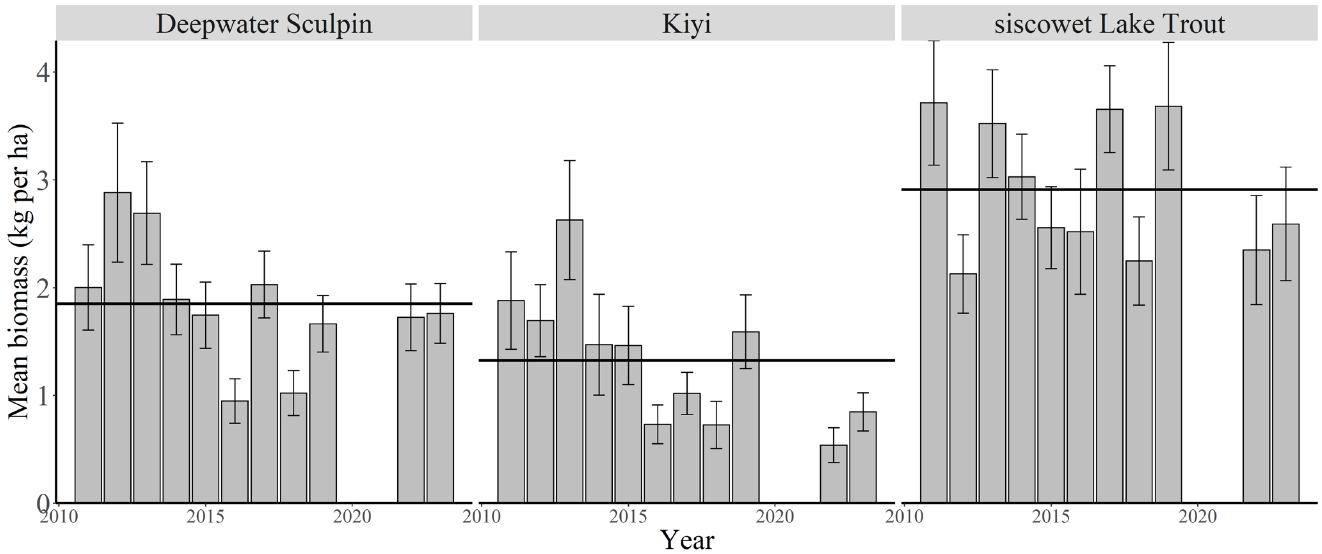

Figure 8. Annual offshore biomass estimates (mean lakewide kg per ha ± standard error) for Deepwater Sculpin, Kiyi and siscowet Lake Trout in USA and Canada waters of Lake Superior from 2011-2023. Offshore locations were 80-308 m deep. Annual offshore sampling locations were not sampled in 2020 and 2021 due to COVID-related travel restrictions. Scientific names are presented in Table 1.

Surface trawl fish collections

A total of 4,369 larval *Coregonus* individuals were collected in June-July 2023. This was the fewest *Coregonus* larvae collected in a whole lake survey since the survey began in 2014 (range 4,369-21,197 fish). In 2023, nearshore mean larval *Coregonus* densities were 416 per ha in June and offshore densities were 26 per ha in July (Figure 9). Average 2023 larval *Coregonus* densities were the second lowest estimate in June (range 336-1,027 per ha) and the lowest estimate in July (range 26-501 per ha) as compared to all previous years (2014-2023). Low larval *Coregonus* populations in 2023 were a stark contrast to that observed in

2022 when survival through July was the highest for the period-of-record for this survey which in turn led to high survival of *Coregonus* species to age-1.

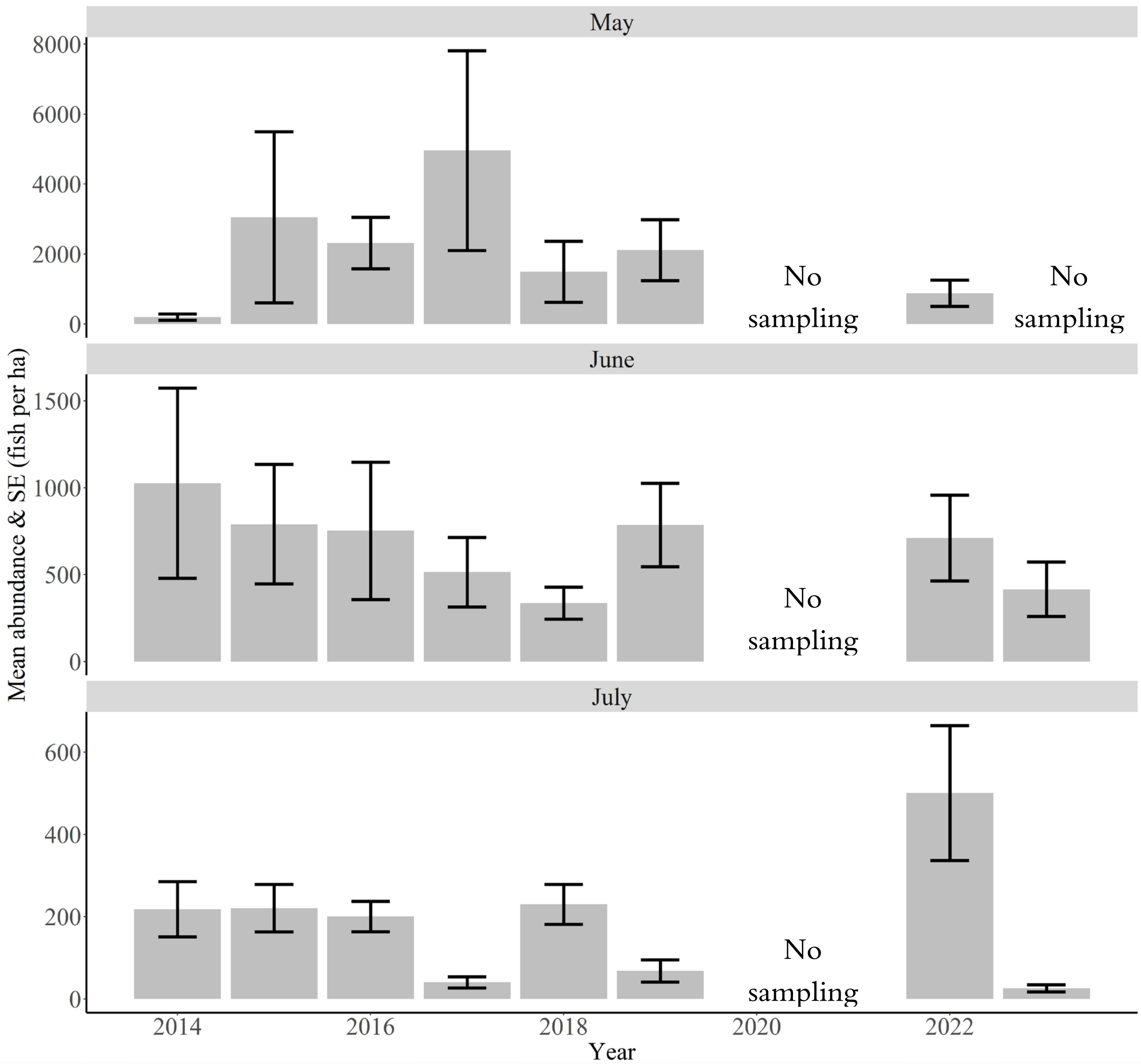

Figure 9. Monthly mean larval Coregonus abundance estimates (fish per ha ± standard error) for May, June, and July from USA and Canada waters of Lake Superior from 2014-2023, sans 2020 and 2021, due to COVID-related travel restrictions. Nearshore sampling locations were sampled in June and were 17-140 m deep. Offshore locations sampled in July and were 80-308 m deep. In 2023, sampling did not occur in May due to a vessel crew shortage. Sampling locations were from the nearshore survey in May and June and from the offshore survey in July. Sampling locations are shown in Figure 1. Note different y-axis scales.

Summary

Over the 46-year history of the U.S. Geological Survey's Lake Superior nearshore fish community surveys, total estimated biomass of benthic and demersal fish has reflected the survival of Bloater, Cisco, and Lake Whitefish populations to age-1+. In 2023, record survival of the Bloater and Cisco 2022 year-class to age-1 led to the second highest nearshore prey fish biomass estimate for the nearshore survey's period-of-record (1978-2023). If the future can be predicted by past large ciscoe year-class events, the unprecedented survival of the 2022 ciscoe (Bloater, Cisco, and Kiyi, *sensu* Eshenroder et al. 2016) year-class will influence the Lake Superior ecosystem for the next 10 to 20-years.

The combination of our near- and offshore bottom and surface trawl surveys provide a lakewide picture of the status and trends of the Lake Superior fish community susceptible to these trawls, particularly with respect to describing larval and age-1 *Coregonus* species population metrics 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.

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Table 1. *Summary of 2023 nearshore and offshore fish collections from USA and Canada waters of Lake Superior. Nearshore sampling locations were 17-140 m deep and offshore locations were 80-308 m deep. Shown are the 25 species or morphotypes collected, the number of locations collected at, the number of individuals collected, and the average estimated abundance (fish per ha) and biomass (kg per ha) from 57 nearshore and 31 offshore locations in Lake Superior in 2023. Sampling locations are shown in Figure 1.*

		Nearshore survey				Offshore survey			
Common name	Scientific name	Locations caught	Number caught	Abundance, number per ha	Biomass, kg per ha	Locations caught	Number caught	Abundance, number per ha	Biomass kg per ha
Lake Sturgeon	*Acipenser fulvescens*	1	1	0.01	0.00	0	0	0.00	0.00
Rainbow Smelt	*Osmerus mordax*	56	47428	819.49	2.35	2	2	0.06	0.00
Burbot	*Lota lota*	12	16	0.21	0.12	2	2	0.06	0.02
Threespine Stickleback	*Gasterosteus aculeatus*	3	4	0.07	0.00	0	0	0.00	0.00
Ninespine Stickleback	*Pungitius pungitius*	52	3564	50.82	0.06	0	0	0.00	0.00
Trout-Perch	*Percopsis omiscomaycus*	37	1620	22.07	0.06	0	0	0.00	0.00
Cisco	*Coregonus artedii*	43	87042	1,113.57	10.53	2	3	0.09	0.01
Lake Whitefish	*Coregonus clupeaformis*	32	1413	21.54	2.41	0	0	0.00	0.00
Bloater	*Coregonus hoyi*	39	10485	144.83	1.14	7	18	0.54	0.01
Kiyi	*Coregonus kiyi*	25	314	3.39	0.03	27	2228	66.93	0.85
Pygmy Whitefish	*Prosopium coulteri*	24	580	7.30	0.03	2	2	0.06	0.00
Round Whitefish	*Prosopium cylindraceum*	5	18	0.27	0.01	0	0	0.00	0.00
Unidentified Coregonid	*Coregonus*	6	2726	17.67	0.15	0	0	0.00	0.00
hatchery Lake Trout	*Salvelinus namaycush*	2	19	0.21	0.02	0	0	0.00	0.00
siscowet Lake Trout	*Salvelinus namaycush siscowet*	12	46	0.42	0.12	27	142	4.30	2.59
lean Lake Trout	*Salvelinus namaycush*	18	49	0.65	0.21	0	0	0.00	0.00
Longnose Sucker	*Catostomus catostomus*	16	96	1.36	0.88	0	0	0.00	0.00
Spottail Shiner	*Notropis hudsonius*	1	5	0.12	0.00	0	0	0.00	0.00
Johnny Darter	*Etheostoma nigrum*	6	18	0.36	0.00	0	0	0.00	0.00
Logperch	*Percina caprodes*	1	1	0.01	0.00	0	0	0.00	0.00
Yellow Perch	*Perca flavescens*	1	6	0.17	0.03	0	0	0.00	0.00
Ruffe	*Gymnocephalus cernuus*	8	55	1.04	0.01	0	0	0.00	0.00
Slimy Sculpin	*Cottus cognatus*	43	1195	15.29	0.04	5	15	0.44	0.00
Spoonhead Sculpin	*Cottus ricei*	31	378	4.46	0.01	5	6	0.18	0.00
Deepwater Sculpin	*Myoxocephalus thompsoni*	23	725	6.53	0.05	31	13040	391.59	1.76

Table 2. *Annual lakewide bottom trawl biomass (kg per ha) estimates for all species and for a few common prey fishes collected in the nearshore bottom trawl survey in USA and Canada waters of Lake Superior, 1978-2023. Nearshore sampling locations were 17-140 m deep. 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, Longnose Sucker, and lean, siscowet, and hatchery Lake Trout. Scientific names are presented in Table 1. Zero fish locations are the number of locations where no fish were collected.*

Year	Sampling locations	Zero fish locations	Total species	Total mean biomass	Total median biomass	Bloater	Cisco	Lake Whitefish	Rainbow Smelt	Sculpins	Other fishes
1978	43	0	17	5.47	0.74	0.12	0.01	0.70	3.72	0.12	0.80
1979	49	0	17	5.91	2.25	0.40	0.06	1.27	2.00	0.18	2.00
1980	48	0	16	3.08	1.11	0.27	0.26	0.57	0.81	0.16	1.00
1981	48	2	19	2.56	0.39	0.41	0.36	0.67	0.20	0.16	0.77
1982	32	0	18	3.06	0.29	0.43	0.35	0.85	0.25	0.03	1.16
1983	50	0	19	2.41	0.54	0.42	0.16	0.20	0.90	0.05	0.68
1984	53	0	21	5.34	1.43	1.50	0.59	1.23	0.72	0.05	1.24
1985	53	0	19	13.74	3.52	2.28	6.45	1.94	1.20	0.07	1.80
1986	53	2	19	18.05	3.53	3.22	8.25	2.61	2.68	0.06	1.21
1987	53	0	16	12.49	1.21	2.31	5.34	1.93	1.74	0.06	1.10
1988	53	0	19	12.59	0.82	5.15	2.93	2.26	1.13	0.04	1.08
1989	76	0	21	16.96	3.23	1.57	5.95	5.43	2.03	0.07	1.90
1990	81	0	22	19.32	5.04	4.09	9.08	2.29	1.88	0.08	1.90
1991	84	1	22	15.30	3.32	0.74	9.02	2.63	1.12	0.09	1.69
1992	85	0	24	16.91	3.21	7.26	3.06	3.59	0.94	0.07	1.99
1993	87	1	23	16.70	5.12	3.62	4.51	3.56	2.06	0.08	2.86
1994	87	0	23	16.40	3.59	0.42	6.52	5.33	1.84	0.08	2.22
1995	87	0	27	15.11	2.54	0.54	3.42	5.80	2.10	0.09	3.16
1996	87	0	26	8.33	2.35	2.79	0.93	1.50	1.23	0.10	1.78
1997	85	1	30	8.27	2.06	0.81	1.34	2.73	1.30	0.05	2.04
1998	87	0	22	10.66	1.66	3.86	1.06	2.20	1.43	0.06	2.05
1999	83	5	23	8.18	1.39	2.62	2.28	1.07	0.93	0.03	1.25
2000	85	4	25	6.92	1.12	0.94	2.42	1.60	0.83	0.04	1.09
2001	83	1	32	8.37	1.70	1.19	1.15	2.78	1.52	0.04	1.68
2002	84	2	26	4.68	0.53	0.57	1.48	1.69	0.18	0.02	0.74
2003	86	8	26	4.75	0.98	0.88	0.64	1.84	0.31	0.02	1.06
2004	75	1	25	6.32	1.87	1.15	1.80	1.88	0.32	0.03	1.14
2005	52	0	27	11.27	4.39	1.65	2.23	4.37	1.00	0.01	2.02
2006	55	2	24	8.31	1.57	1.79	2.25	1.70	0.95	0.02	1.59

2007	56	0	31	6.17	0.97	0.90	0.27	1.86	1.77	0.02	1.34
2008	59	3	23	5.40	1.57	0.17	0.38	2.37	0.94	0.02	1.52
2009	64	6	20	3.14	0.14	1.18	0.30	0.15	0.38	0.02	1.12
2010	76	11	24	1.54	0.13	0.23	0.31	0.27	0.22	0.05	0.46
2011	82	6	21	3.56	1.28	0.56	0.41	0.94	0.62	0.05	0.98
2012	72	16	25	1.15	0.31	0.35	0.02	0.15	0.16	0.03	0.44
2013	79	3	27	6.01	1.17	0.49	0.52	2.98	0.53	0.02	1.47
2014	73	3	28	7.06	1.86	0.50	0.35	4.31	0.43	0.02	1.46
2015	76	4	21	1.79	0.19	0.40	0.23	0.54	0.22	0.02	0.38
2016	76	5	23	2.16	0.23	0.38	0.22	0.53	0.44	0.02	0.59
2017	76	4	27	3.77	1.81	0.49	0.16	1.11	0.94	0.01	1.05
2018	77	10	24	4.26	0.28	0.13	0.36	1.52	1.24	0.02	1.00
2019	76	8	25	5.70	1.38	0.68	0.14	2.48	0.96	0.02	1.42
2020	11	1	17	10.55	3.35	6.23	0.95	2.27	0.34	0.01	0.75
2021	45	6	23	6.35	0.79	1.45	0.32	3.22	0.50	0.02	0.84
2022	71	1	25	1.56	0.52	0.21	0.05	0.39	0.29	0.01	0.62
2023	57	0	25	18.25	6.77	1.14	10.53	2.41	2.35	0.10	1.73
Mean	67.6	2.54	22.98	8.17	1.83	1.49	2.16	2.04	1.08	0.05	1.35
Median	75.5	1.00	23.00	6.64	1.50	0.89	0.94	1.90	0.94	0.04	1.24

Table 3. Age-1 Bloater, Cisco, Lake Whitefish, and Rainbow Smelt densities (fish per ha) in an annually conducted nearshore bottom trawl survey and age-1 Kiyi densities from an annual offshore survey in USA and Canada waters of Lake Superior. Nearshore sampling locations were 17-140 m deep and offshore locations were 80-308 m deep. Age-1 fish were defined by species-specific lengths: Cisco <140 mm, Bloater <130 mm, Kiyi <130 mm, Lake Whitefish <160 mm, and Rainbow Smelt <100 mm. Scientific names are presented in Table 1.

Sampling year	Year class	Sampling locations nearshore / offshore	Cisco	Bloater	Kiyi	Lake Whitefish	Rainbow Smelt
1978	1977	43 /	0.72	0.02		2.60	83.85
1979	1978	49 /	27.18	6.30		3.86	216.06
1980	1979	48 /	1.44	0.09		1.91	89.18
1981	1980	48 /	6.85	13.47		16.43	105.90
1982	1981	32 /	0.75	0.16		4.16	63.81
1983	1982	50 /	0.81	0.05		0.45	96.77
1984	1983	53 /	4.35	18.48		7.93	211.03
1985	1984	53 /	42.02	743.43		2.32	145.10
1986	1985	53 /	26.57	68.32		3.41	137.11
1987	1986	53 /	3.82	5.10		11.88	252.95
1988	1987	53 /	5.76	0.44		6.09	149.00
1989	1988	76 /	36.07	222.37		36.08	260.68
1990	1989	81 /	48.23	400.22		8.30	250.74
1991	1990	84 /	11.13	213.27		16.15	150.12
1992	1991	85 /	9.81	8.33		11.73	158.81
1993	1992	87 /	0.18	3.32		7.56	152.38
1994	1993	87 /	0.06	0.75		4.92	192.62
1995	1994	87 /	0.00	1.43		13.50	386.15
1996	1995	87 /	0.05	0.91		6.22	159.81
1997	1996	85 /	0.15	11.08		8.75	242.70
1998	1997	87 /	0.12	1.18		7.70	141.15
1999	1998	83 /	0.34	75.83		7.68	180.88
2000	1999	85 /	0.48	3.85		0.77	58.39
2001	2000	83 /	0.12	0.84		2.37	257.37
2002	2001	84 /	0.12	0.53		13.66	56.79

2003	2002	86 /	0.59	33.23		7.75	77.88
2004	2003	75 /	27.26	175.35		6.36	70.28
2005	2004	51 /	12.07	8.19		2.97	110.39
2006	2005	55 /	13.61	18.58		5.43	249.53
2007	2006	54 /	0.32	0.41		19.74	366.45
2008	2007	58 /	0.28	0.20		0.63	279.75
2009	2008	63 /	0.59	0.27		3.00	71.55
2010	2009	62 /	2.46	14.03		6.64	45.37
2011	2010	82 / 35	0.76	0.30	10.71	3.98	73.98
2012	2011	72 / 34	0.06	0.03	0.55	1.90	10.90
2013	2012	79 / 35	0.22	0.17	0.21	5.46	142.90
2014	2013	73 / 30	0.06	0.01	0.12	2.27	68.46
2015	2014	76 / 33	8.57	14.31	16.65	1.00	30.66
2016	2015	76 / 35	9.68	4.99	16.41	1.62	83.04
2017	2016	76 / 36	5.81	1.37	7.07	1.39	146.95
2018	2017	77 / 35	0.07	0.01	1.07	1.10	161.39
2019	2018	76 / 35	3.82	0.31	0.89	6.70	137.07
2020	2019	11 /	0.89	0.14		12.45	5.14
2021	2020	45 /	7.59	10.58		41.33	140.45
2022	2021	71 / 35	0.04	0.06	0.33	1.98	77.83
2023	2022	57 / 31	140.39	1,018.73	53.78	9.06	615.46
Mean			10.05	67.41	9.02	7.59	155.76
Median			0.85	2.38	0.98	5.78	142.03

Status and Trends in the Lake Superior Fish Community, 2023

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Appendix A. Lake Superior fish community survey locations from the United States (USA) and Canada and trawling data for locations sampled in 2023. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Survey	Date	Time	Location identifier	Management Unit	Country	Mid-latitude	Mid-longitude	Begin depth, m	End depth, m	Surface temperature, C	Bottom temperature, C	Bottom trawl distance, km	Surface trawl collected
nearshore	06/02/2023	1304	24	WI2	USA	46.84855	-90.4671	15.1	61.4	4.9	4.0	0.34	Yes
nearshore	06/02/2023	1436	2	WI2	USA	46.90671	-90.566	21.1	94.5	9.6	4.4	0.91	Yes
nearshore	06/03/2023	918	52	WI2	USA	46.97668	-90.4536	16.4	98.9	9.7	4.1	0.65	Yes
nearshore	06/03/2023	1110	44	WI2	USA	47.03447	-90.4888	14.7	53.5	7.5	4.3	0.50	Yes
nearshore	06/03/2023	1241	45	WI2	USA	46.98465	-90.5562	11.3	63.8	9.4	4.3	0.40	Yes
nearshore	06/03/2023	1422	87	WI2	USA	46.93883	-90.6484	16.6	58.5	10.5	5.8	0.45	Yes
nearshore	06/04/2023	933	71	WI2	USA	46.94022	-90.7905	8.4	35.6	11.7	4.9	0.44	Yes
nearshore	06/04/2023	1206	75	WI2	USA	47.00231	-90.7336	30.3	46.2	11.2	4.2	0.32	Yes
nearshore	06/04/2023	1413	86	WI2	USA	46.84076	-90.7255	19.7	52.2	14.4	5.1	0.55	Yes
nearshore	06/05/2023	1509	65	MN3	USA	47.74676	-90.3181	12.6	71.1	3.9	3.5	0.33	Yes
nearshore	06/06/2023	1530	36	MN1	USA	46.99888	-91.6957	26.3	38.2	3.7	3.3	0.27	Yes
nearshore	06/07/2023	749	210	WI1	USA	46.73115	-92.0142	13.6	21	12.5	6.6	0.85	Yes
nearshore	06/08/2023	1052	151	WI1	USA	46.88568	-91.2159	11.5	72.3	5.9	4.3	0.68	Yes
nearshore	06/08/2023	1243	76	WI2	USA	46.89006	-91.1013	18.5	35.8	8.4	4.3	0.54	Yes
nearshore	06/10/2023	1328	192	MI2	USA	46.69643	-90.0333	15.1	39.1	8.3	4.4	0.83	Yes
nearshore	06/10/2023	1802	57	MI2	USA	46.91463	-89.3669	19.9	46.8	6.8	4.0	1.54	Yes
nearshore	06/12/2023	1103	84	MI4	USA	46.9088	-88.3202	18	140	10.4	6.2	1.31	Yes
nearshore	06/12/2023	1642	101	MI4	USA	47.3725	-87.8128	18	53.2	5.4	4.4	0.74	Yes
nearshore	06/13/2023	910	158	MI4	USA	46.93586	-88.1214	14.2	47.9	11.4	5.0	1.02	Yes
nearshore	06/13/2023	1214	142	MI5	USA	46.8587	-87.7209	18.1	63.8	10.8	8.9	0.68	No, wind
nearshore	06/13/2023	1405	196	MI5	USA	46.78478	-87.5509	28.1	74.2	5.8	5.0	0.79	No, wind
nearshore	06/14/2023	804	120	MI5	USA	46.52395	-87.2286	18.9	57.7	8.5	5.8	1.49	Yes

nearshore	06/14/2023	1109	88	MI6	USA	46.53095	-86.9022	34	85.1	9.2	5.6	1.18	Yes
nearshore	06/14/2023	1316	209	MI6	USA	46.53008	-86.7219	51.1	90.7	11.7	6.2	0.46	Yes
nearshore	06/14/2023	1602	178	MI6	USA	46.66589	-86.324	28.3	101	8.7	4.5	1.18	Yes
nearshore	06/15/2023	1138	176	MI7	USA	46.78162	-85.3218	18.1	51.1	9.9	6.2	0.73	Yes
nearshore	06/15/2023	1357	195	MI8	USA	46.80526	-84.9821	14	62.6	7.6	5.6	0.79	Yes
nearshore	06/16/2023	1009	174	MI8	USA	46.51947	-84.7166	21.8	51.1	12.4	7.2	0.57	Yes
nearshore	06/16/2023	1252	79	MI8	USA	46.5665	-84.8679	19.5	79.3	9.9	5.4	1.16	Yes
nearshore	06/16/2023	1453	194	MI8	USA	46.62446	-84.8823	26.5	96.9	9.7	4.9	1.12	Yes
nearshore	06/18/2023	1055	460	ONT12	Canada	46.67149	-84.5696	14	54.1	13.1	5.9	0.87	Yes
nearshore	06/18/2023	1600	461	ONT11	Canada	46.93594	-84.7278	12.8	70.2	9.1	4.3	0.91	Yes
nearshore	06/19/2023	648	456	ONT11	Canada	47.31338	-84.6573	23.3	83.1	12.1	4.0	0.78	Yes
nearshore	06/19/2023	955	455	ONT11	Canada	47.54967	-84.9694	20.8	108	9.2	4.9	0.75	Yes
nearshore	06/19/2023	1215	454	ONT9	Canada	47.67556	-84.992	15	93.2	8.0	4.1	0.43	Yes
nearshore	06/19/2023	1511	462	ONT9	Canada	47.94638	-84.9456	19.3	113	10.4	4.2	0.63	Yes
nearshore	06/20/2023	938	463	ONT9	Canada	47.90995	-85.4324	25.8	75.4	11.1	4.5	0.62	Yes
nearshore	06/20/2023	1219	464	ONT9	Canada	47.94838	-85.8195	14.1	105	7.6	5.3	0.61	Yes
nearshore	06/20/2023	1516	465	ONT7	Canada	48.12103	-86.0578	12.1	102	9.3	4.6	0.57	Yes
nearshore	06/21/2023	731	422	ONT7	Canada	48.6387	-86.3433	24.3	54.4	10.6	4.1	0.29	Yes
nearshore	06/21/2023	956	420	ONT7	Canada	48.76635	-86.6393	13	44.7	12.1	4.7	0.61	Yes
nearshore	06/21/2023	1301	419	ONT7	Canada	48.79369	-86.9807	27.8	44.6	11.9	4.9	0.25	Yes
nearshore	06/21/2023	1542	418	ONT4	Canada	48.77832	-87.1699	17.9	40.6	11.0	4.4	0.35	Yes
nearshore	06/22/2023	736	415	ONT4	Canada	48.8879	-87.7662	12.7	39.4	11.9	5.1	0.43	Yes
nearshore	06/22/2023	937	414	ONT4	Canada	48.94637	-87.9784	13.3	23.2	13.9	8.3	0.50	Yes
nearshore	06/22/2023	1135	413	ONT4	Canada	48.93587	-88.2287	16.5	26.8	16.1	10.7	0.38	Yes
nearshore	06/22/2023	1335	412	ONT4	Canada	48.8279	-88.1029	13	48.2	15.4	8.0	0.53	Yes
nearshore	06/23/2023	911	408	ONT3	Canada	48.6012	-88.4961	16	18.4	18.4	7.8	0.30	Yes
nearshore	06/23/2023	1024	407	ONT3	Canada	48.56132	-88.5837	14.5	27.7	16.5	7.3	0.43	Yes
nearshore	06/23/2023	1136	406	ONT3	Canada	48.48891	-88.6122	16	44.6	15.8	7.7	0.50	Yes
nearshore	06/23/2023	1312	405	ONT3	Canada	48.40905	-88.6932	11.6	54.1	16.3	6.4	0.42	Yes
nearshore	06/24/2023	849	401	ONT1	Canada	48.51035	-88.935	15.2	42.4	15.5	4.9	0.48	Yes
nearshore	06/24/2023	1030	402	ONT1	Canada	48.37326	-88.8873	14.1	47.9	17.7	4.3	0.81	Yes
nearshore	06/24/2023	1236	404	ONT2	Canada	48.31138	-88.9052	18.2	60.4	10.4	5.2	0.42	Yes
nearshore	06/25/2023	1019	400	ONT2	Canada	48.07692	-89.4113	13.3	64.8	12.9	7.7	0.84	Yes
nearshore	06/25/2023	1252	191	MN3	USA	47.97117	-89.6251	16.8	51.9	9.1	5.5	0.83	Yes
nearshore	06/26/2023	1121	139	WI2	USA	46.97283	-91.0144	25.5	48.9	8.7		0.73	Yes

offshore	07/10/2023	1450	2120	MI2	USA	47.06625	-89.67	197	200	10.1	3.7	0.53	Yes
offshore	07/10/2023	1220	2147	MI2	USA	47.15431	-89.9732	161	163	4.3	3.7	0.53	Yes
offshore	07/11/2023	935	2136	MI2	USA	47.22465	-89.5441	194	194	4.4	3.7	0.50	Yes
offshore	07/11/2023	1141	2151	MI2	USA	47.15381	-89.2931	134	132	10.8	3.8	0.55	Yes
offshore	07/12/2023	1301	2124	MN3	USA	47.49748	-89.9984	144	144	9.9	3.7	0.55	Yes
offshore	07/12/2023	1625	2133	MN3	USA	47.53293	-90.5458	170	176	8.6	3.7	0.55	Yes
offshore	07/13/2023	1244	2161	WI1	USA	46.98501	-91.2324	125	130	16.0	3.8	0.55	Yes
offshore	07/18/2023	902	2115	MI3	USA	47.41774	-88.461	184	193	11.7	3.8	0.55	Yes
offshore	07/18/2023	1237	2128	MI1	USA	47.83774	-88.7456	225	233	7.8	3.6	0.54	Yes
offshore	07/18/2023	1603	2134	MI1	USA	48.04906	-88.2596	235	237	10.4	3.6	0.53	Yes
offshore	07/19/2023	1013	2118	MI1	USA	47.87455	-88.0702	236	236	5.2	3.6	0.55	Yes
offshore	07/19/2023	1245	2122	MI3	USA	47.85417	-87.7243	214	211	5.8	3.6	0.56	Yes
offshore	07/19/2023	1650	2138	MI4	USA	47.50989	-87.2211	278	284	7.3	3.5	0.55	Yes
offshore	07/20/2023	845	2150	MI5	USA	47.13828	-87.3837	127	126	14.3	3.8	0.55	Yes
offshore	07/20/2023	1044	2154	MI5	USA	47.06668	-87.1656	168	169	13.5	3.8	0.55	Yes
offshore	07/20/2023	1315	2152	MI5	USA	46.80737	-87.0301	138	137	14.9	3.7	0.52	Yes
offshore	07/21/2023	922	2116	MI6	USA	46.75093	-86.5336	164	167	14.8	3.8	0.54	Yes
offshore	07/21/2023	1300	2141	MI6	USA	47.12733	-86.1678	144	136	11.5	3.7	0.52	Yes
offshore	07/21/2023	1451	2125	MI7	USA	47.09662	-85.9668	173	178	12.0	3.8	0.52	Yes
offshore	07/22/2023	925	2148	MI7	USA	46.89869	-85.532	149	150	14.3	3.7	0.54	Yes
offshore	07/22/2023	1110	2039	MI7	USA	46.90933	-85.4156	80	87	15.2	3.9	0.55	Yes
offshore	07/24/2023	1406	2137	ONT10	Canada	47.21718	-85.1026	203	195	14.3	3.7	0.53	Yes
offshore	07/24/2023	1644	2121	ONT10	Canada	47.45764	-85.2651	259	260	16.9	3.5	0.53	Yes
offshore	07/25/2023	808	2145	ONT10	Canada	47.63303	-86.1112	135	134	13.5	3.8	0.54	Yes
offshore	07/25/2023	934	2165	ONT10	Canada	47.59317	-86.2248	121	124	12.9	3.8	0.53	Yes
offshore	07/25/2023	1208	2126	MI6	USA	47.40485	-86.4712	292	308	12.6	3.7	0.53	Yes
offshore	07/26/2023	812	2135	ONT8	Canada	48.02297	-86.6434	143	135	10.8	3.7	0.49	Yes
offshore	07/26/2023	1152	2139	ONT8	Canada	48.35361	-86.9816	174	176	12.7	3.7	0.53	Yes
offshore	07/26/2023	1512	753	ONT4	Canada	48.71422	-87.2891	157	157	15.2	3.8	0.53	Yes
offshore	07/27/2023	815	2155	MI3	USA	48.56068	-87.762	143	139	15.0	3.7	0.54	Yes
offshore	07/27/2023	1050	2127	ONT6	Canada	48.28718	-87.6601	212	222	10.5	3.6	0.55	Yes

Status and Trends in the Lake Superior Fish Community, 2023

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Appendix B. Comparison of annual Lake Superior total fish community biomass (kg per ha) and age-1 abundance estimates for Bloater (*Coregonus hoyi*), Cisco (*C. artedi*), Lake Whitefish (*C. clupeaformis*), and Rainbow Smelt (*Osmerus mordax*) from the United States (USA) and Canada with and without roller-trawl locations. Nearshore sampling locations were 17-140 m deep. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

	Locations sampled		Total biomass, kg per ha		age-1 Bloater per ha		age-1 Cisco per ha		age-1 Lake Whitefish per ha		age-1 Rainbow Smelt per ha	
Year	All trawls	No roller trawls	All trawls	No roller trawls	All trawls	No roller trawls	All trawls	No roller trawls	All trawls	No roller trawls	All trawls	No roller trawls
1978	43	43	5.47	5.47	0.72	0.72	0.02	0.02	2.60	2.60	83.85	83.85
1979	49	41	5.91	6.82	27.18	32.21	6.30	0.21	3.86	4.61	216.06	245.51
1980	48	46	3.08	2.91	1.44	1.15	0.09	0.09	1.91	2.00	89.18	92.92
1981	46	39	2.68	2.80	7.14	6.80	14.05	14.92	17.14	20.22	110.51	114.12
1982	32	24	3.06	3.70	0.75	0.89	0.16	0.21	4.16	5.52	63.81	80.81
1983	50	41	2.41	2.78	0.81	0.84	0.05	0.06	0.45	0.54	96.77	112.98
1984	53	44	5.34	6.27	4.35	5.19	18.48	22.20	7.93	9.56	211.03	252.57
1985	53	44	13.74	16.35	42.02	48.50	743.43	889.72	2.32	2.79	145.10	167.11
1986	51	44	18.76	21.60	27.62	31.90	71.00	80.83	3.55	4.11	142.49	157.97
1987	53	44	12.49	14.85	3.82	4.56	5.10	5.90	11.88	14.30	252.95	288.66
1988	53	44	12.59	15.10	5.76	6.93	0.44	0.53	6.09	7.34	149.00	175.29
1989	76	65	16.96	19.53	36.07	41.99	222.37	253.79	36.08	42.17	260.68	296.72
1990	81	73	19.32	21.22	48.23	53.09	400.22	433.18	8.30	9.18	250.74	266.45
1991	83	73	15.48	16.71	11.26	12.19	215.83	234.43	16.34	18.57	151.93	168.57
1992	85	74	16.91	18.54	9.81	11.09	8.33	9.18	11.73	13.25	158.81	172.85
1993	86	75	16.89	18.96	0.18	0.21	3.36	3.63	7.65	8.67	154.15	168.87
1994	87	76	16.40	18.38	0.06	0.04	0.75	0.86	4.92	5.61	192.62	211.79
1995	87	76	15.11	17.06	0.00	0.00	1.43	1.59	13.50	15.45	386.15	430.03

1996	87	76	8.33	9.24	0.05	0.04	0.91	1.03	6.22	7.01	159.81	167.96
1997	84	75	8.37	9.31	0.16	0.18	11.22	12.53	8.85	9.91	245.59	267.17
1998	87	76	10.66	11.61	0.12	0.08	1.18	1.24	7.70	8.55	141.15	149.10
1999	78	70	8.71	9.60	0.36	0.40	80.69	89.13	8.17	9.10	192.48	204.95
2000	81	76	7.26	7.69	0.50	0.51	4.04	4.24	0.80	0.86	61.27	64.87
2001	82	71	8.47	9.37	0.12	0.13	0.85	0.97	2.40	2.69	260.50	295.27
2002	82	71	4.80	5.08	0.12	0.13	0.54	0.50	13.99	16.15	58.17	63.96
2003	78	68	5.23	5.78	0.65	0.74	36.64	39.05	8.55	9.81	85.87	97.54
2004	74	70	6.41	6.57	27.62	27.92	177.72	169.15	6.45	6.82	71.23	71.40
2005	52	48	11.27	12.01	12.07	9.98	8.19	8.58	2.97	3.19	110.39	108.51
2006	53	49	8.62	9.21	14.13	15.24	19.28	20.84	5.64	6.09	258.94	277.39
2007	56	51	6.17	6.72	0.32	0.17	0.41	0.33	19.74	21.66	366.45	396.18
2008	56	51	5.69	5.72	0.30	0.27	0.22	0.16	0.66	0.72	294.73	321.25
2009	64	59	3.14	3.40	0.59	0.64	0.27	0.29	3.00	3.25	71.55	74.89
2010	75	67	1.56	1.73	2.50	2.79	14.22	15.91	6.73	7.53	45.97	46.65
2011	82	67	3.56	3.87	0.76	0.80	0.30	0.34	3.98	4.78	73.98	88.83
2012	72	56	1.15	1.45	0.06	0.08	0.03	0.04	1.90	2.44	10.90	13.48
2013	79	61	6.01	6.85	0.22	0.24	0.17	0.21	5.46	4.91	142.90	176.48
2014	73	57	7.06	8.44	0.06	0.04	0.01	0.01	2.27	2.77	68.46	84.28
2015	76	61	1.79	2.19	8.57	6.21	14.31	15.18	1.00	0.96	30.66	35.75
2016	76	60	2.16	2.68	9.68	11.86	4.99	6.21	1.62	1.99	83.04	101.11
2017	76	61	3.77	3.64	5.81	2.82	1.37	1.25	1.39	1.70	146.95	173.06
2018	77	63	4.26	5.15	0.07	0.07	0.01	0.01	1.10	1.34	161.39	196.35
2019	76	62	5.70	6.64	3.82	4.55	0.31	0.36	6.70	8.21	137.07	164.57
2020	11	11	10.55	10.55	0.89	0.89	0.14	0.14	12.45	12.45	5.14	5.14
2021	45	36	6.35	7.89	7.59	9.49	10.58	13.19	41.33	51.66	140.45	174.71
2022	71	60	1.56	1.67	0.04	0.04	0.06	0.06	1.98	2.34	77.83	88.54
Mean	67.09	57.76	8.03	8.96	7.21	7.88	46.67	52.27	7.63	8.79	147.08	164.37
Median	75	61	6.35	6.85	0.81	0.89	1.43	1.25	5.64	6.09	142.49	167.11

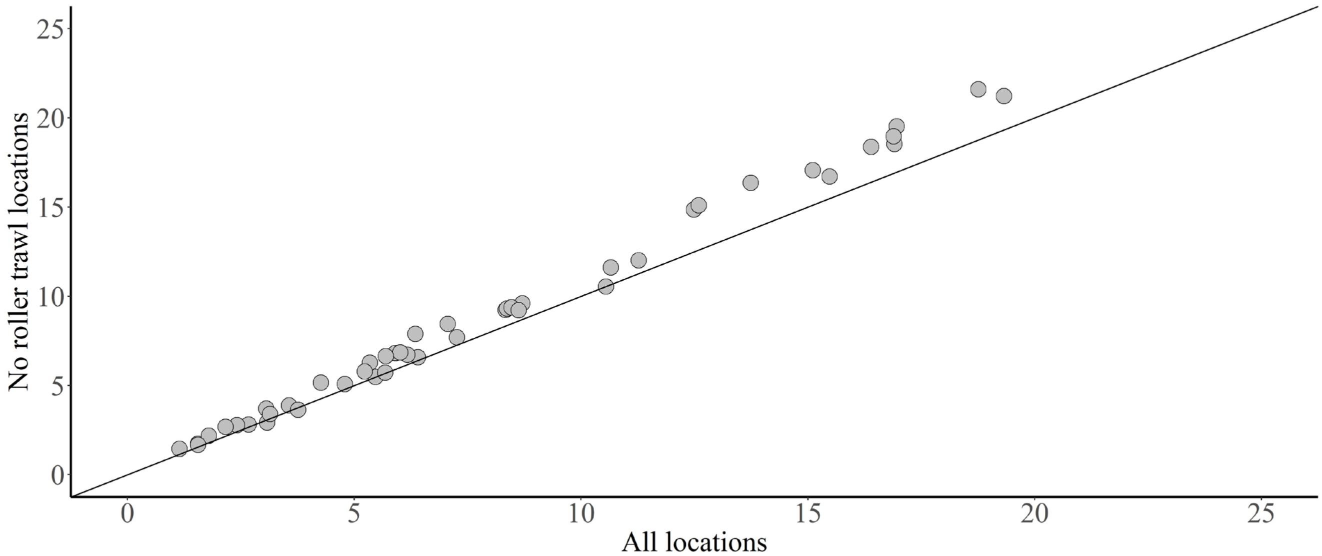

Figure B1. Annual mean total fish biomass estimates from bottom trawls for all sampling locations and for non-roller trawl locations from 1978-2023 in nearshore USA waters of Lake Superior. From 1978-1988 and in 2021 only USA waters were sampled. The number of locations sampled in each year are presented in Appendix B. The diagonal line indicates equality between the two data sets.

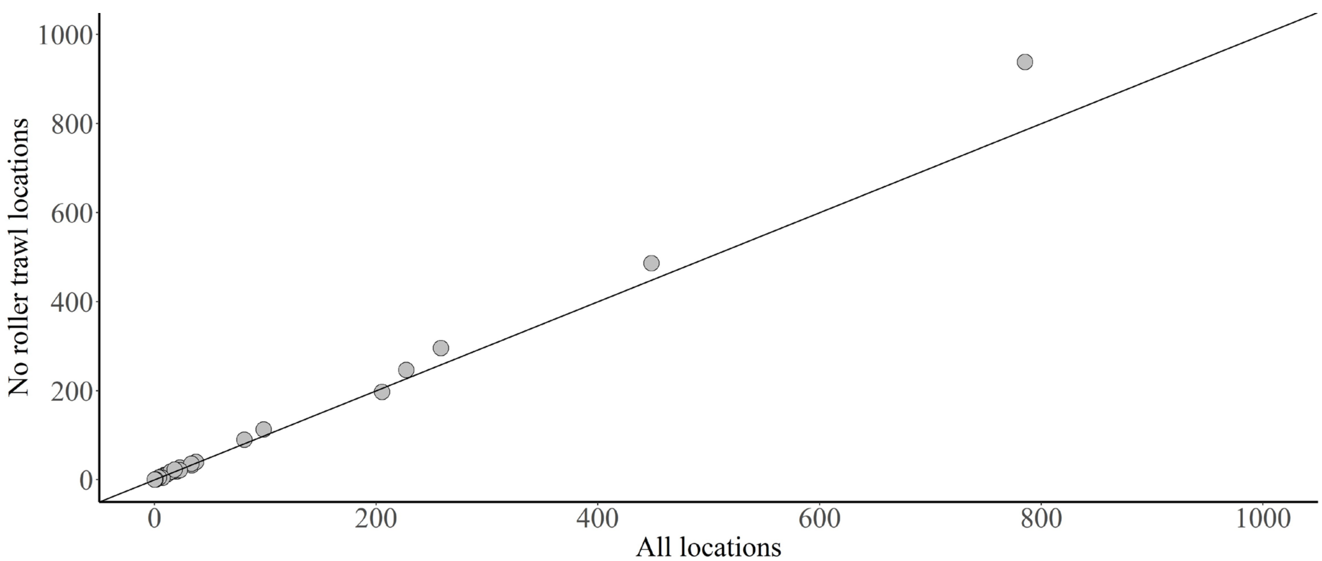

Figure B2. Annual mean age-1 Cisco (Coregonus artedi) abundance estimates (age1- Cisco per ha) from bottom trawls for all sampling locations and for non-roller trawl locations from 1978-2023 in nearshore USA waters of Lake Superior. From 1978-1988 and in 2021 only USA waters were sampled. The number of locations sampled in each year are presented in Appendix B. The diagonal line indicates equality between the two data sets.