# Sub-Indicator: Native Prey Fish Diversity

## Overall Assessment

**Status:** Fair

**Trends:**

**10-Year Trend (2014-2023):** Unchanging

**Long-term Trend (1973-2023):** Unchanging

**Rationale:** Prey fish status was assessed as Fair in Lakes Superior, Michigan, and Huron, and Poor in Lakes Erie and Ontario (Table 1), so basin-wide status was considered Fair, as it was in the 2022 report. However, in most lakes, one or both indices used to assess community status declined from 2021-2023. For example, the percent native index declined from Good to Fair in Lakes Michigan and Huron, and from Fair to Poor in Lake Erie (Table 1). Similarly, the prey diversity index declined from Good to Fair in Lakes Superior and Ontario (Table 1). However, deterioration in Great Lakes prey fish communities was not evident over longer periods, which suggests these changes are simply part of natural fluctuations in prey fish abundance and species composition. In support of this hypothesis, long-term trends were assessed as Unchanging in six of the possible ten metrics (two per lake), and three (percent native in Superior and Huron, and Diversity in Lake Michigan) were considered Improving (Table 2). Only Diversity in Lake Superior exhibited a Deteriorating long-term trend (Table 2). Likewise, nine of the possible ten 10-year trends were considered Unchanging, with the sole outlier being Lake Ontario, which had a diversity index assessment of Improving (Table 2). Overall, these trends support a basin-wide assessment of Unchanging. Prey fish biomass trends are not formally assessed in this sub-indicator; however, these trends have generally declined or remained low, as oligotrophication continues in all main-lake habitats other than western Lake Erie, and native and stocked predator populations naturally have reduced prey fishes. Prey fish communities are driven by changing ecosystem conditions including productivity, fluctuating predator populations, physical conditions, and non-native species. These factors are generally changing in similar directions across the region. However, because each lake is unique in its nutrient concentrations, morphometry, hydrology, and fish communities, the prey fish communities in each lake may respond differently to ecosystem drivers (Figure 1).

## Lake-by-Lake Assessment

### Lake Superior

**Status:** Fair

**10-Year Trend (2014-2023):** Unchanging

**Long-term Trend (1978-2024):** No Trend

**Rationale:** Lake Superior is the least anthropogenically-altered Great Lake and its prey fish community metrics reflect this with a dominance of native species. The percentage of the fish community biomass comprised of native species has averaged >80% over the long term and 83% over the past ten years (2014 – 2023). Rainbow Smelt is the only highly populous widespread non-native fish. In 2022, there was tremendous survival of Cisco, Bloater, and Kiyi to age-1m which boosted biomass estimates.

## Lake Michigan

**Status:** Fair

**10-Year Trend: (2014-2023)** Unchanging

**Long-term Trend (1973-2023):** Unchanging

**Rationale:** The Lake Michigan prey fish community is currently (2021-2023) assessed as Fair, which is the same status reported in 2019 and in 2022. While the Shannon Diversity Index ranking has remained constant (Fair) since 2022, the percent of native species ranking shifted from Good to Fair for this year's assessment. Overall, the 10-year and long-term status trends were Unchanging; the only metric to significantly ($P < 0.1$) change over the period assessed was the Shannon Diversity Index, which was assessed as Improving from 1973-2023.

## Lake Huron

**Status:** Fair

**10-Year Trend (2014-2023):** Unchanging

**Long-term Trend (1976-2023):** Unchanging

**Rationale:** The Lake Huron prey fish community is assessed as Fair, with both the percent native species and species diversity indices assessed as Fair (Table 1). These metrics were assessed as Unchanging over the most recent 10-year period. Trends in the diversity index over the entire time series improved from Deteriorating in the 2022 report to Unchanging in the current report, and the percent native index over the entire time series was again assessed as Improving as it was in the 2022 report (Table 2). Slight declines in the often-dominant bloater (*Coregonus hoyi*) and increases in other demersal species help improve diversity trends, whereas continued low abundance of non-native Alewife (*Alosa pseudoharengus*) and Rainbow Smelt (*Osmerus mordax*) has helped sustain long-term improvements in the percent native index. Long-term, consistent observations on prey fishes in the St Mary's River were not available for comparison.

## Lake Erie

**Status:** Poor

**10-Year Trend (2014-2023):** Unchanging

**Long-term Trend (1990 – 2023):** Unchanging

**Rationale:** The Lake Erie prey fish community status was assessed as Poor, since the percent native species metric was assessed as Poor while the diversity metrics were assessed as Fair (Table 1). This is a change from the previous reporting period when the percent native species value was assessed as Fair. Native species typically make up less than 50% of the Lake Erie prey fish community and while the proportion native has varied over time, it has not trended in a particular direction (Figure 1, Table 2). Lake Erie prey fish diversity values are among the highest in the Great Lakes, but they have fluctuated somewhat during the past 10 years (Figure 1, Table 2). Much of the changes in both metrics result from annual variability in Emerald Shiners (*Notropis atherinoides*), Yellow Perch (*Perca flavescens*), Spottail Shiner (*Notropis hudsonius*) and Trout-perch (*Percopsis omiscomaycus).* The classifications for Lake Erie are based on lake-wide assessment trends and may not accurately reflect regional prey fish population status or trends. Lake Erie prey fish surveys results are presented as density, as opposed to biomass, which can result in greater variability in the metrics used in this report. Long-term, consistent observations for prey fishes in the St Clair-Detroit River or upper Niagara River were not available for comparison.

### Lake Ontario

**Status:** Poor

**10-Year Trend (2014-2023):** Unchanging

**Long-term Trend (1978-2023):** Unchanging

**Rationale:** Lake Ontario prey fish percent native status in the most recent period was assessed as Poor while the diversity index was assessed as Fair, resulting in a conservative overall assessment of Poor (Table 1). The long-term trends in both metrics are Unchanging but at the 10-year scale, prey fish diversity is Improving (Table 2) as Deepwater Sculpin and Round Goby populations comprise greater portions of the community, while the 10-year trend for proportion native is Unchanging (O'Malley et al., 2024). Lake Ontario prey fish diversity and percent native is the lowest in the Great Lakes because Alewife continue to dominate the assemblage, and other non-native species such as Round Goby (*Neogobius melanostomus*) also remain abundant or have increased. Efforts to restore Bloater in Lake Ontario continue; however, recaptures of reintroduced fish have been limited (Weidel et al., 2022).

## Status Assessment Definitions

**Good:** The average percent by biomass (or density) of native prey fish in the total prey fish catch is at or above 75% and the diversity index value is greater than or equal to 75% of the maximum diversity index value observed in the time series.

**Fair:** The average percent by biomass (or density) of native prey fish in the total prey fish catch is at or above 25% and the diversity index value is greater than or equal to 25% of the maximum diversity index value observed in the time series.

**Poor:** The average percent by biomass (or density) of native prey fish in the total prey fish catch is below 25% and the diversity index value is below 25 % of the maximum diversity index value observed in the time series.

**Undetermined:** Data are insufficient to assess the metrics.

If the two metrics status categories differ, the lake status will either be the average or conservatively be the lower of the two categories. For example, a status of Good for percent native and Fair for diversity will result in a status assessment of Fair. A status of Good and Poor results in an overall status assessment of Fair.

## Trend Assessment Definitions

Trends at 10-year and long-term timescales are evaluated for each metric using linear models with yearly observations. If trends are significant with a *P*-value of 0.10 or lower, the trend is reported; otherwise the trend is considered Unchanging. If the trends of the two metrics differ the overall trend will conservatively be categorized as the 'lesser' of the two metrics (e.g. one metric Improving and the other Unchanging results in an assessment of Unchanging). If individual metric trends are opposite (e.g. Improving and Deteriorating) the overall trend is assed as No Trend.

**Improving:** The slopes for year in both metrics are positive ($P < 0.10$), indicating an increasing trend.

**Unchanging:** Both slopes are insignificant ($P < 0.10$) OR the slope for year is positive in one metric and insignificant in the other.

**No Trend:** The metric trends are opposite, with one being assessed as Improving and the other Deteriorating.

**Deteriorating:** The slopes for year in both metrics are negative, indicating a decreasing trend OR one slope is non-significant and one is negative ($P < 0.10$).

**Undetermined:** An insufficient amount of data are available to assess a trend.

## Endpoints and/or Targets

Lake-specific committees create Fish Community Objectives (FCOs) that identify how Great Lakes fisheries are managed according to the Joint Strategic Plan (Great Lakes Fishery Commission, 1981). Most of these objectives do not specify numerical targets or endpoints for prey fishes. Instead the objectives generally seek to 'maintain prey fish diversity' or 'maintain and restore native forage fish species' and often attempt to balance prey fishes (or forage fishes) with primary production or predator demand. The portions of these FCOs that relate to prey fishes are listed below.

**Lake Superior:** Fish Community Goal – "*To rehabilitate and maintain a diverse, healthy, and self-regulating fish community, dominated by indigenous species and supporting sustainable fisheries".* Additional principals note: "*Preservation of indigenous species is of the highest concern*" (Horns et al. 2003).

**Lake Michigan:** Planktivore Objective – "*Maintain a diversity of planktivore (prey) species at population levels matched to primary production and to predator demands. Expectations are for a lakewide planktivore biomass of 0.5 to 0.8 billion kg.*" (Eshenroder et al. 1995).

**Lake Huron:** Prey Objective – "*Maintain a diversity of prey species at population levels matched to primary production and to predator demands. Emphasis is placed on species diversity and self-regulation of the fish community*" (DesJardine et al. 1995).

**Lake Erie:** Prey Fish Objective – *"Maintain a diverse, abundant prey-fish community that is capable of sustaining abundant warm-, cool-, and cold-water predators and that contributes to ecosystem function and sustainable human use. The LEC recognizes that it cannot directly manage prey-fish populations, even though they are essential to support the Lake Erie basin fisheries. The LEC especially values native prey species but recognizes that naturalized prey species can be an important part of the prey-fish community, predator diets, and targeted fisheries. Status indicator: Prey-fish populations support predator condition and growth rates near the long-term average"* (Francis et al., 2020).

**Lake Ontario:** Offshore Pelagic Zone Objective- "*Increase prey-fish diversity – maintain and restore a diverse prey-fish community that includes Alewife, Cisco (formerly Lake Herring), Rainbow Smelt, Emerald Shiner, and Threespine Stickleback (Gasterosteus aculeatus). Status and trend indicators are 1) maintaining or increasing populations and increasing species diversity of the pelagic prey fish community including introduced species (Alewife, Rainbow Smelt) and selected native prey fish species (Threespine Stickleback, Emerald Shiner and Cisco); and 2) increasing spawning populations of Cisco (formerly Lake Herring) in the Bay of Quinte, Hamilton Harbor, and Chaumont Bay*" (Stewart et al., 2017). The introductory material also notes: *"The LOC will continue with programs to protect and restore native species with an emphasis on... Cisco (Lake Herring), Round Whitefish (Prosopium cylindraceum), Deepwater Sculpin and deepwater coregonines"*, such as Bloater.

## Sub-Indicator Purpose

This sub-indicator attempts to quantify the status and trends of Great Lake's prey fish communities according to their diversity and the percent of the community comprised of native species, which are common elements

identified in the lake-specific FCOs. Prey fish abundance indices are also reported for context on the state of Great Lakes ecosystems.

## Ecosystem Objective

Ecosystem objectives for prey fishes vary across lakes, but at the lake level generally seek to maintain diverse prey fish communities, that support predator populations, are in balance with primary productivity, and in many cases favor native prey fishes (Desjardine et al., 1995; Eshenroder et al., 1995; Francis et al., 2020; Horns et al., 2003; Stewart et al., 2017). This sub-indicator results also inform '*forage fish*' elements of the " *Joint strategic plan for management of all great lakes fisheries, as revised, 10 June 1997*" (Great Lakes Fishery Commission, 2007).

In addition, this sub-indicator supports the Great Lakes Water Quality Agreement's Annex 4 as they consider setting the Substance Objective (phosphorus targets) by illustrating how phosphorus concentrations influence "*fisheries productivity requirements*" (United States of America and Canada, 2012). This sub-indicator supports General Objective #5 of the 2012 Great Lakes Water Quality Agreement which states that the Waters of the Great Lakes should "support healthy and productive wetlands and other habitats to sustain resilient populations of native species

## Methods

The status and trends of prey fishes are based on the diversity and the percent of native species within the community. Community diversity is represented by the Shannon diversity index and the status of a period is a quantified against the maximum diversity value observed in the time series. Unfortunately, theoretical, or even widely agreed upon metrics or thresholds for what constitutes a prey fish community as Good, Fair, or Poor do not exist. Categorizing the state of prey fish communities is subjective and is influenced by an individual's perspective on the different ecosystem services the prey communities provide. For instance, while Lakes Erie and Ontario prey fish communities often exhibit low prey fish diversity or percent natives, these prey fish communities support the largest sport and commercial fisheries in the basin, providing food and ecosystem services to the region and nation. We recognize the metrics chosen to characterize prey fish status are imperfect and incomplete, but they serve as a starting point from which to understand differences among the lakes and time trends within a lake.

Prey fish abundance indices are also reported for context but are not a graded metric in this report because management actions for phosphorus reduction and predator abundance increases naturally reduce prey fish abundance. Energy properties of lake food webs require that prey fish biomass is negatively dependent on lake nutrient concentration and piscivorous fish abundance (Carpenter et al., 2001; Downing and Plante, 1993). Within the Great Lakes, resource management has, in most regions, successfully reduced phosphorus concentration below targets (Dove and Chapra, 2015) and restored piscivorous fish populations, both of which confound the utility of prey fish abundance as a graded metric.

Data used to calculate metrics are from bottom trawl surveys. These surveys have been generally conducted annually and consistently across time, sample across a wide range of available habitats and catch the most abundant prey fishes. Diversity and percent native metrics are based on biomass (kilograms per hectare) indices from bottom trawl catches, except for Lake Erie where data are represented by density indices (number per hectare). Data come from the USGS Great Lakes Science Center (GLSC), Ontario Ministry of Natural Resources, New York State Department of Environmental Conservation, Ohio Department of Natural Resources Division of Wildlife, and Pennsylvania Fish and Boat Commission. For Lakes Superior, Huron, Michigan and Ontario data are managed by the USGS GLSC. In Lake Erie data are managed and provided by the separate state, federal and

provincial agencies. All data are provided at the whole-lake scale except for Lake Erie, which are provided at the basin scale and combined according to the proportional area of each of the three lake basins. Consistent annual or long-term data for prey fishes are not available for the connecting channel habitats.

# Discussion

## Lake Superior, Status: Fair, 10-year trend: Unchanging

Native species dominate the relatively diverse Lake Superior prey fish community (Figure 1). Rainbow Smelt are the only non-native species that substantially contributes to the Lake Superior bottom trawl catch (Vinson et al., 2020). Changes in Lake Superior prey fish metrics are primarily driven by fluctuations in Bloater, Cisco, and Kiyi, the three dominant whitefish species, as well as Rainbow Smelt and Lake Trout populations. Lake Trout are voracious predators of these prey species. These whitefish species are long-lived, up to 25 years, and have exhibited high interannual variability in survival to age-1, aka, year class strength (Vinson et al., 2020). This year class strength variability leads to fluctuations in overall prey fish biomass, which can be readily observed across the time series (Figure 2). While 10-year trends in prey fish metrics are assessed as Unchanging (Goldsworthy et al., 2024), there are concerns among fish managers over population declines of whitefish species which support significant commercial fisheries and are prey for Lake Trout (*Salvelinus namaycush*). The large 2022 year-classes of Cisco, Bloater, and Kiyi doubled to tripled nearshore biomass estimates over that reported over the past 30 years. This year class will likely increase total biomass and stabilize the lake ecosystem for several years.

## Lake Michigan, Status: Fair, 10-year trend: Unchanging

Consistent with previous reports, the status of Lake Michigan prey fish is assessed as Fair (Table 1). However, the native species metric score changed from Good to Fair between the 2022 and 2025 reports. Variation in bloater, alewife and goby biomass densities have largely driven recent interannual differences in the percent native species. For example, high densities of bloater (6.5 kg/ha) in 2022 resulted in 82% native species. This followed a year where bloater densities were much lower and similar to alewife (0.6 and 0.7 kg/ha, respectively) while goby density was the second highest in the 10-year time series (1.3 kg/ha) and native species comprised only 45% of biomass. The Shannon Diversity Index was 1.15 in 2023, nearly identical to the average value since 2021 (1.14; Table 1). Overall, trends in Shannon Diversity Index and the percent native species over the past 10 years were assessed as Unchanging. While the annual estimates are highly variable for both metrics and are dependent on year-class strength for key species (i.e., bloater, alewife), we considered both trends to be Unchanging over the past decade as they never fell below the threshold for Poor conditions. Prey fish biomass, based on the fall bottom trawl survey, remains low compared to historic values despite increases in biomass of bloater since 2022. Bloater have accounted for at least 40% of total biomass in all but one year since 2015 (2021; 24%). While the status of Lake Michigan remains assessed as Fair, the overall low prey fish biomass remains a key concern in light of Lake Michigan fish community objectives (Eshenroder et al. 1995). In addition to top-down controls of predators on Alewife populations and potential reductions in catchability of some species (e.g., Alewife and Bloater; Tingley et al. 2021), reductions in nutrient loading and concentration and the proliferation of dreissenid mussels may be contributing to the long-term downward trend in Lake Michigan prey fish biomass estimates (Dove and Chapra, 2015; Rowe et al., 2017; Warner and Lesht, 2015).

## Lake Huron Status: Fair, 10-year trend: Unchanging

The Lake Huron prey fish community has undergone a dramatic transformation since the late 1970s. In the 1970s, non-native Alewife and Rainbow Smelt dominated the prey fish community (Riley and Adams 2010). Declines in those non-native species and lake-wide recovery of Bloater (a native coregonid) during the 1980s resulted in a

steady increase in the proportion of the community comprised of native species (Figure 1). Prey fish biomass in Lake Huron began a steady decline in the mid-1990s and reached a historic low in 2008 (Figure 2). As prey fish biomass decreased, the proportion of native species in the community initially dropped, but then quickly increased with decline of Alewife populations in the early 2000s. Loss of Alewife from the prey fish community has been attributed to physical factors including cold winters, reduced nutrients, proliferation of dreissenid mussels, and predation from naturally-reproduced Lake Trout and Pacific Salmon (Collingsworth et al., 2014; Dunlop and Riley, 2013; Kao et al., 2016). Prey fish biomass over the last decade had remained near historic lows, and the community is dominated by native Bloater, which during 2021-2023 accounted for 50-75% of prey fish biomass sampled in bottom trawls, which was down from 2018-2020 when bloater represented on average over 80% of prey fish biomass in bottom trawls. Given the recent success of bloater and current low abundance of non-native planktivores, management agencies in Lake Huron are attempting to reintroduce Cisco (*Coregonus artedi*), a close relative of bloater, into Saginaw Bay (Lake Huron Technical Committee, 2023). Historically, Cisco was a pelagic planktivore (Koelz, 1929), so fishery managers hope Cisco will diversify the Lake Huron prey fish community and reconnect bentho-pelagic and nearshore-offshore food webs.

### Lake Erie Status: Poor, 10-year trend: Unchanging

The Lake Erie prey fish community has varied over the past 10 years (Figure 1). While the percent native and the diversity metrics are assessed as Unchanging, there are peaks and valleys due to variation in the abundance of Emerald Shiners, Yellow Perch, Walleye, Spottail Shiner and Trout-perch (Forage Task Group, 2022). Diversity is generally high, and is often the highest among all of the lakes (Figure 1), however this value has been oscillating over the past 10 years. Above-average reproductive success of Walleye has been observed multiple times over the past decade so that Lake Erie predator abundance is currently high and could partially explain some of the variation in Lake Erie prey fishes (Forage Task Group, 2021).

### Lake Ontario, Status: Poor, 10-year trend: Unchanging

The Lake Ontario prey fish community and biomass continue to change over time (Figures 1, 2). Nonnative Alewife dominate the Lake Ontario prey fish community (>90% by biomass), which over the entire time series generally results in Poor and Unchanging values of diversity and the proportion of native prey fish metrics (Table 1). At the 10-year scale, Lake Ontario prey fish diversity is assessed as Improving (Table 2), as Deepwater Sculpin and Round Goby populations comprise greater portions of the community while the 10-year trend for proportion native is Unchanging (O'Malley et al., 2024). Since the late 1970's when long term surveys began, Lake Ontario Alewife biomass has declined and mirrored declines in spring phosphorus concentration (Figure 2; Dove and Chapra, 2015). More recent changes in annual Alewife biomass are attributed to recruitment variability that appears to be driven by warmer springs and early summers, which result in greater Alewife reproduction success (Warren et al., 2024; Weidel et al., 2024). Lake Ontario management agencies continue to stock Bloater in an effort to restore this native pelagic, prey fish species and diversify the prey fish community (Weidel et al., 2022). Wild-collected Lake Michigan Bloater gametes, and broodstock developed from those wild fish are the source for the Lake Ontario restoration (Presello et al., 2021). From 2015 – 2023, 14 genetically-confirmed Bloater have been captured in Lake Ontario surveys. Long-term surveys are not conducted for prey fishes in the Niagara River or the St. Lawrence River.

## Linkages

Prey fish communities are influenced by primary production and invertebrates as well as by higher trophic levels including stocked and naturally-reproduced piscivores and avian predators. Physical factors such as water

temperature, water clarity, geomorphology and spawning habitat quality also influence prey fish community composition and abundance by modifying their behavior, growth dynamics, and spawning success.

- Nutrient inputs and internally recycled nutrients are the primary driver of Great Lakes primary productivity and therefore are also a strong driver of prey fish biomass. Nutrient concentration is often the primary determinant of how many prey fish a lake supports while physical conditions, habitat, species introductions and predators determine which species comprise the community. Physical conditions also influence productivity at given nutrient levels by changing the volume or depth of the warm surface layers within lakes (Rowe et al., 2017; Warner and Lesht, 2015).
- Zooplankton are the primary food of pelagic prey fishes while benthic invertebrates are primary food of benthic or demersal prey fishes.
- *Diporeia* spp. are a genus of native, deepwater amphipods that were historically an important food source for Great Lakes prey fishes. As a detritivore, the species feeds on freshly settled organic material such as diatoms, linking those energy sources to prey fishes (Nalepa et al., 2006).
- Dreissenid mussels provide food for some prey fishes such as Round Goby and also act to increase water clarity which can shift prey fish behavior and intensify predator – prey interaction strength (O'Gorman et al., 2000).
- Lake Trout, Walleye (*Stizostedion vitreum*), and the other Great Lakes piscivores are a dominate driver of prey fish biomass and community composition.
- Changes in physical conditions influence Great Lakes water temperature, ice coverage, and other aspects of hydrodynamics, all of which have strong influences on prey fishes.
- Water temperature drives prey fish energetics, behavior and habitat and food availability which in turn influence prey fish abundance and community dynamics.
- Ice cover influences the quality of egg incubation for fishes with overwintering egg stages and larval fish habitat.
- Water levels influence the availability of nearshore habitats which can affect prey fishes spawning and nursery habitat availability.

## Assessing Data Quality

The data quality assessments below are based on the consensus expert opinions of the primary and contributing authors.

| Data Characteristics | Agree | Neutral or Unknown | Disagree | Not Applicable |
|---|---|---|---|---|
| Data are documented, validated, or quality-assured by a recognized agency or organization | X | | | |
| Data are from a known, reliable and respected generator of data and are traceable to original sources | X | | | |

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|---|---|---|---|---|
| Geographic coverage and scale of data are appropriate to the Great Lakes Basin | | X | | |
| Data obtained from sources within the U.S. are comparable to those from Canada | | | X | |
| Uncertainty and variability in the data are documented and within acceptable limits for this sub-indicator report | | X | | |
| Data used in assessment are openly available and accessible* | Yes | https://www.sciencebase.gov/catalog/item/5ca76163e4b0c3b0064dca6b<br>https://www.sciencebase.gov/catalog/item/58e2940fe4b09da67996a821 | | |

## Notes on Accessing Data

USGS prey fish data from all lakes are available via links, however they may not always include the most recent year's data. Some Lake Erie prey fish data, from state and provincial agencies, is available upon request while open data access processes are under development.

## Data Limitations

Evaluating this sub-indicator using bottom trawl data from across the basin helps to maintain consistency in our comparisons, but differences in trawl surveys may influence our results. Prey fish survey designs differ because the five lakes vary in size, bathymetry, habitat suitable for trawling, fish communities, survey history, and management information needs. For instance, across all five lakes bottom trawl surveys vary in: seasonal timing (April – October), annual effort (0.8 – 18 trawls per 1000 $km^2$ lake area), bottom trawl types, and reported statistics (biomass vs density, whole-lake vs basin-specific). Differences among surveys do not necessarily invalidate the results presented here but they are important to consider when interpreting results.

Time series of bottom trawl data have historically been used to infer relative changes of a prey fish over time in a lake, but they may not catch all species in equal proportion to their abundance in the environment. Pelagic species may be underestimated by bottom trawling relative to more demersal, or bottom oriented species (Yule et al., 2008). For example in Lake Superior, acoustic surveys estimated substantially greater biomass of pelagic Kiyi and Cisco, than bottom trawls estimates from the same year (Yule et al., 2013). Similarly, in Lake Ontario, acoustic and midwater trawl observations suggest Cisco can be a greater portion of the fish community than bottom trawls have indicated (Holden et al., 2017; Weidel et al., 2017). Alewife abundance relative to other fishes may also be biased by trawl survey type or seasonal timing. In Lake Michigan, fall-collected bottom trawl Alewife biomasses are usually lower than September acoustic estimates from the same year (Bunnell et al., 2017; Warner et al., 2017), and in Lake Ontario Alewife biomass is much higher in spring than fall-based surveys (Weidel et al., 2017). Efforts to understand potential biases in surveys will be critical for Improving cross-basin prey fish comparisons such as those presented in this report.

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## List of Tables

**Table 1.** Status of Great Lakes prey fish communities in the current period (2021-2023) and previous reporting period (2018-2020) based on the percent native and the Shannon diversity index. For the percent native status, an assessment of Good is for communities with 75% or more native species, while Fair is above 25% and Poor is below 25%. To attain as status of Good for the diversity index, the current period average indicator must be 75% or more of the maximum value observed in the time series. Similarly, the Poor status represents average values within the current period that are less than 25% of the maximum observed index value. If the metrics differ, they are averaged (Good and Poor yield Fair) or if they are only more closely related the overall status is conservatively chosen as the lower metric (Fair and Poor yield Poor). Metrics from 2020 were not available for Lake Ontario because precautions associated with COVID-19 pandemic prevented sampling therefore the previous period represents 2018-2019.

**Table 2.** Trend assessment for prey fish communities of the Great Lakes as determined by the community diversity index and proportion native species. A lake's metric was determined to be changing (Improving or Deteriorating) based on the slope (time) of a linear model with a $p$-value < 0.1. Asterisk denotes that the COVID-19 pandemic prevented sampling, so data from 2020 is missing from the time series.

# List of Figures

**Figure 1.** Shannon Diversity index values and proportion of native species of Great Lakes prey fish communities. Horizontal lines in the percent native plot denote the 75% (solid) and 25% (dashed) thresholds, which are used to determine if native species status is Good (percent native > 75%), Fair (25% < percent native ≤ 75%), or Poor (percent native ≤ 25%).

Source: Data primarily derive from bottom trawl surveys conducted by U.S. federal and state and Canadian provincial agencies. Metrics from 2020 were not available for Lake Ontario because precautions associated with COVID-19 pandemic prevented sampling nor for Lake Huron in 2000 because the survey was not conducted. Data from the 1998 Lake Michigan survey and from the 2008 Lake Huron survey were excluded because survey methods deviated from standard practices, and the resulting data were not considered comparable to other years.

**Figure 2.** Prey fish biomass or density trends based on annual bottom trawl surveys. Note different scales.

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**Last Updated**

*State of the Great Lakes 2025 Report*

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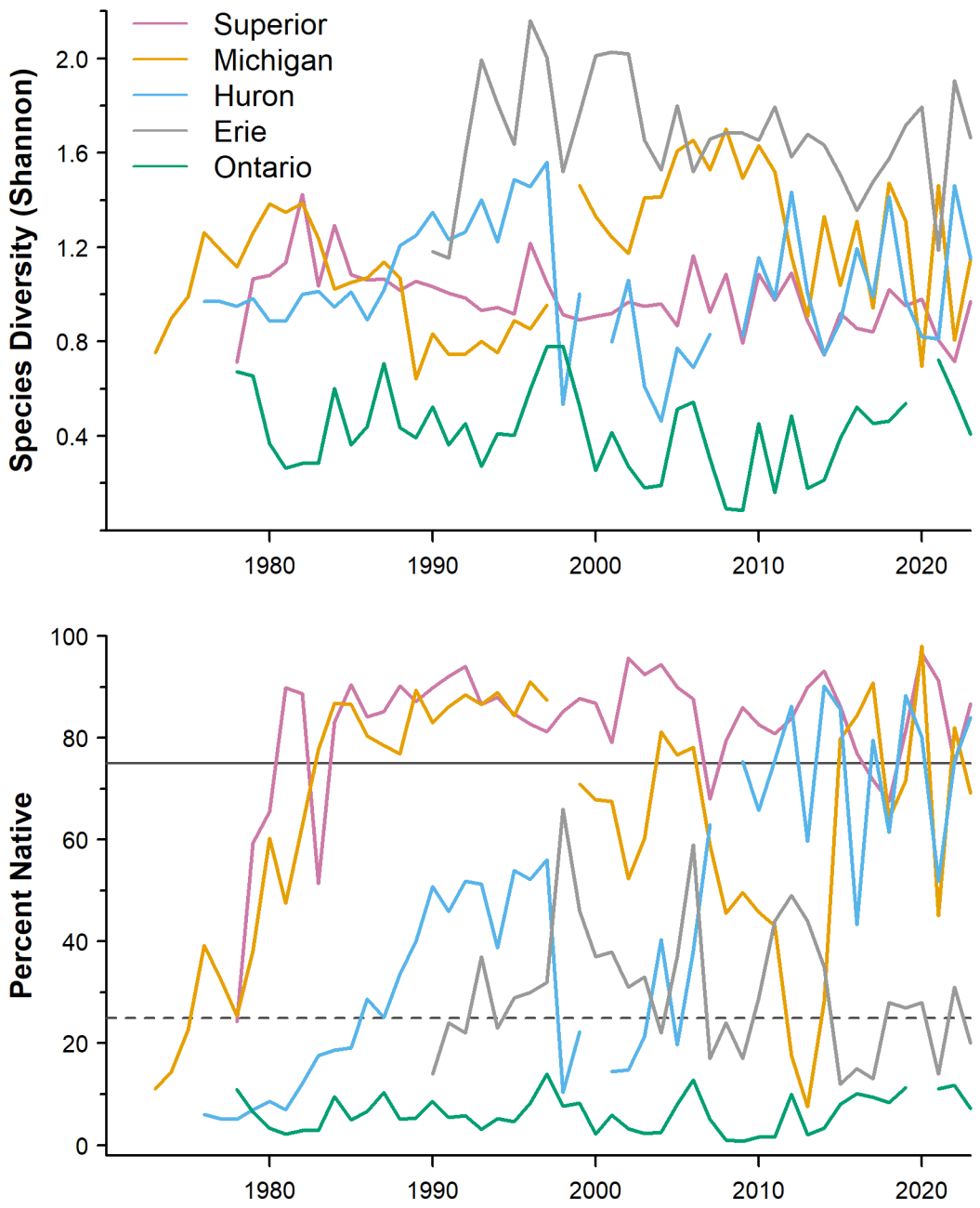
| Lake | Percent Native | | | | Diversity Index | | | | Overall |
|---|---|---|---|---|---|---|---|---|---|
| | Current | Previous | Max. | Status | Current | Previous | Max. | Status | Status |
| Superior | 84 | 82 | 97 | Good | 0.8 | 1.0 | 1.4 | Fair | Fair |
| Michigan | 65 | 78 | 98 | Fair | 1.1 | 1.2 | 1.7 | Fair | Fair |
| Huron | 70 | 77 | 90 | Fair | 1.1 | 1.1 | 1.6 | Fair | Fair |
| Erie | 22 | 28 | 66 | Poor | 1.6 | 1.7 | 2.2 | Fair | Poor |
| Ontario | 10 | 10 | 14 | Poor | 0.6 | 0.5 | 0.8 | Fair | Poor |

**Table 2.** Trend assessment for prey fish communities of the Great Lakes as determined by the community diversity index and proportion native species. A lake's metric was determined to be changing (Improving or Deteriorating) based on the slope (time) of a linear model with a *p*-value < 0.1. Asterisk denotes that the COVID-19 pandemic prevented sampling, so data from 2020 is missing from the time series.

| Lake | Indicator | Whole Time Series (Long-Term Trend) | | Last 10 Years | |
|---|---|---|---|---|---|
| | | Years | Trend | Years | Trend |
| Superior | Diversity Index | 1978-2023 | Deteriorating | 2014-2023 | Unchanging |
| | Percent Native | 1978-2023 | Improving | 2014-2023 | Unchanging |
| Michigan | Diversity Index | 1973-2023 | Improving | 2014-2023 | Unchanging |
| | Percent Native | 1973-2023 | Unchanging | 2014-2023 | Unchanging |
| Huron | Diversity Index | 1976-2023 | Unchanging | 2014-2023 | Unchanging |
| | Percent Native | 1976-2023 | Improving | 2014-2023 | Unchanging |
| Erie | Diversity Index | 1990-2023 | Unchanging | 2014-2023 | Unchanging |
| | Percent Native | 1990-2023 | Unchanging | 2014-2023 | Unchanging |
| Ontario | Diversity Index | 1978-2023* | Unchanging | 2014-2023* | Improving |
| | Percent Native | 1978-2023* | Unchanging | 2014-2023* | Unchanging |

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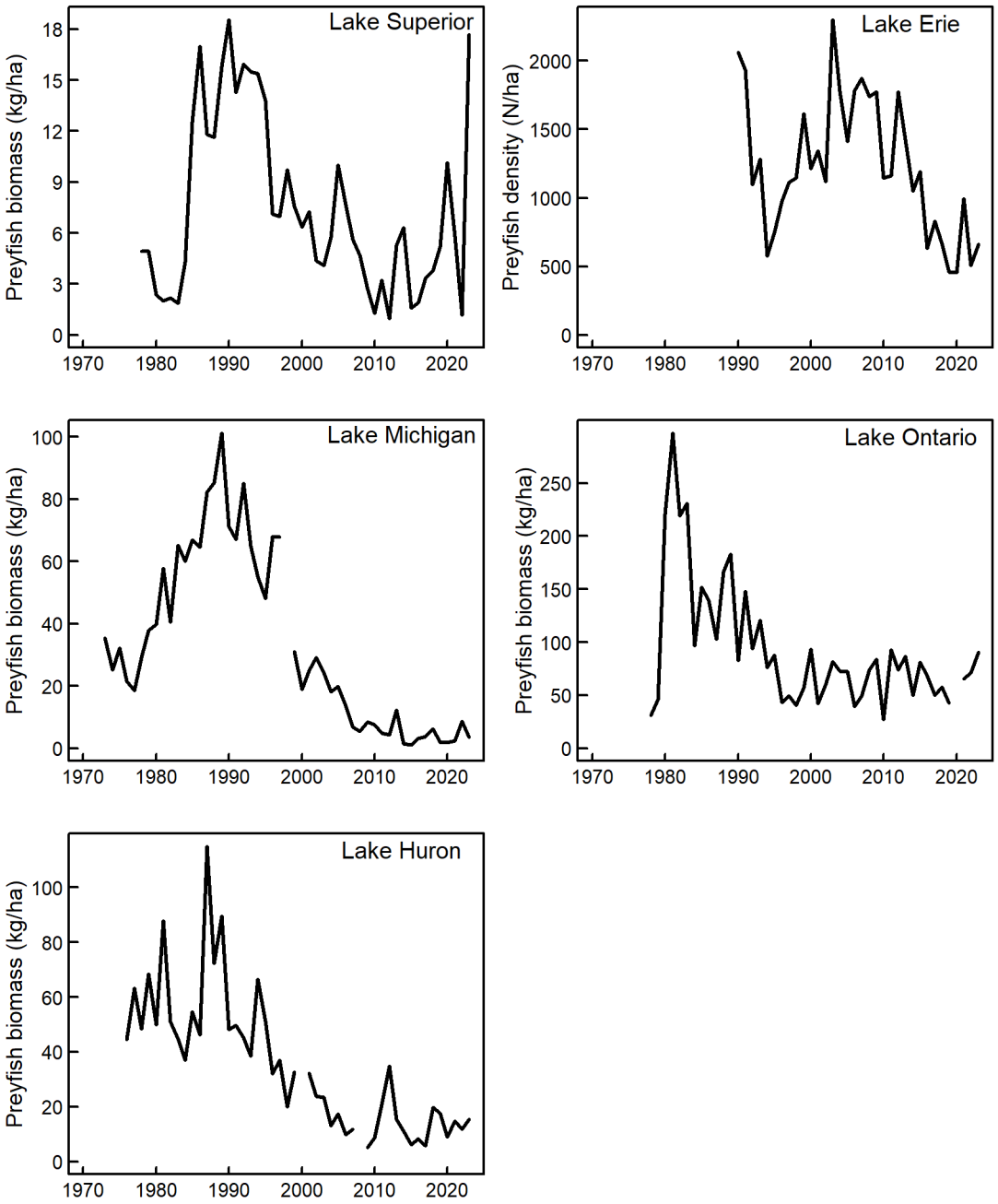


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