# Lake Ontario August gillnet survey and Lake Trout assessment, 2022

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## Abstract

Lake Ontario Lake Trout (*Salvelinus namaycush*) rehabilitation has been annually assessed with fishery independent surveys since 1983, in an effort to evaluate program benchmarks and compare observations with management objectives. These surveys provide information on the abundance, strain composition, and condition of the adult Lake Trout stock, as well as information on levels of natural recruitment, Sea Lamprey (*Petromyzon marinus*) wounding rates, and abundance indices of other coldwater fish species (Burbot *Lota lota*, Cisco *Coregonus artedi*, and Lake Whitefish *C. clupeaformis*). In 2022, the catch per unit effort (CPUE) of total Lake Trout in gillnets remained high (18.9 fish/lift; highest since 1998) compared to lows observed during 2005–2009 (average = 7.5 fish/lift). The CPUE of immature Lake Trout in the 2022 survey was the highest since 1994. Wild-produced mature Lake Trout remain rare in the adult population (2.4% of adult catch). Strain composition of stocked fish indicated more than half (56%) of all coded-wire tagged Lake Trout captured in 2022 were from the Superior Klondike strain. Sea Lamprey wounding rates were above target levels in 2022 (3.15 A1 wounds per 100 Lake Trout) and were nearly double the 2021 rate. Lake Trout condition (predicted weight at length) was the highest since data collection began in 1983. Overall, the 2022 survey results indicate that adult Lake Trout are abundant and of high condition but composed mostly of hatchery-origin strains, suggesting recruitment of wild-produced offspring to the adult stock continues to be limited.

## Introduction

Restoration of a self-sustaining Lake Trout (*Salvelinus namaycush*) population in Lake Ontario is a binational management objective (Lantry et al. 2014, Stewart et al. 2017). In Lake Ontario, Lake Trout were historically abundant prior to European settlement, and served as a native top predator in the coldwater fish community along with Burbot (*Lota lota*) and Atlantic Salmon (*Salmo salar*) (Smith 1995, Owens et al. 2003). By the mid-1950s, Lake Trout were considered extirpated in Lake Ontario, largely due to anthropogenic influences, and Sea Lamprey (*Petromyzon marinus*) predation; initial attempts to rehabilitate the population by stocking Lake Trout fry failed (Elrod et al. 1995). The advent of Sea Lamprey suppression programs in the 1970s coincided with resumed attempts to stock Lake Trout with annual yearling and fingerling stocking events. Since the 1970s, annual stocking rates have varied from approximately 1 million spring yearling equivalents per year during the 1980s, to approximately 300,000 per year since 2019 (Great Lakes Stocking database: http://fsis.glfc.org/). Managers have also focused on stocking a diversity of genetically distinct strains, and more recently, diversifying functional diversity by stocking a deeper water ecotype (i.e., Lake Superior Klondike Reef (SKW) 'humper' strain). In their wild source populations, 'humper' strains, or more easily explained as an intermediate between 'lean' and 'deepwater' morphs, have higher fat content, deeper bodies, and tend to feed mainly on benthic prey

(Muir et al. 2012). In Lake Erie, stocked Lake Trout from Klondike Reef broodstock exhibited differences in diet, maturation, and survival, compared to lean ecotypes (Rogers et al. 2019).

In this report, we summarized findings from the 2022 Lake Ontario August gillnet survey in context with long term trends from 1983 to 2022. We report on the status of the adult Lake Trout stock with an emphasis on indicators useful to management for addressing binational fish community management objectives regarding Lake Trout rehabilitation (Stewart et al. 2017). We also summarized abundance indices for other native coldwater fish species, specifically Burbot, Cisco (*Coregonus artedi)* and Lake Whitefish (*Coregonus clupeaformis*).

## Methods

### *Gillnet Survey*

Since 1983, the Lake Ontario adult Lake Trout stock has been assessed on an annual basis during September with gillnets fished along transects at randomly selected locations distributed across 17 geographic areas within the US waters of Lake Ontario (Elrod et al. 1995). Not all 17 geographic areas are fished each year. During 1985–1995, eight to ten transects were also fished in Canadian waters at fixed locations. However, to standardize effort, all data and analyses presented in this report are based on US-only sites. Transects were fished perpendicular to shore, and the standard effort was typically three to four gillnets per transect. Survey design and gillnet construction (multi vs mono-filament netting) have changed through the years. For a description of survey history, including gear changes and corrections, see Elrod et al. (1995) and Owens et al. (2003). Since 1993, standard survey gillnets have consisted of monofilament netting with nine 15.2 x 2.4 m (50 x 8 ft) panels of 51 to 151 mm (2- to 6-in stretched measure) mesh in 12.5 mm (0.5 in) increments. Prior to 1993 standard survey gillnets were composed of multifilament netting with the same dimensions, except during 1990–1992 when one additional gillnet composed of monofilament netting was fished at each location for comparison.

During 2022, gillnets were fished from August-15 to August-22, instead of during September, when the survey has typically occurred (Figure 1), to accommodate room for experimental trawling also scheduled in September. Gillnets were fished at 14 locations from as far west as the Port of Youngstown and eastward to Charity Island Trench (Figure 2). At each location, three to four gillnets were set parallel to depth contours beginning at the 10°C isotherm and successively deeper at 10-m depth increments. Depths where gillnets were fished in the 2022 survey ranged from 15.7 to 70.7 m (average = 41 m). Catches for each gillnet panel were sorted by species; total lengths (TL) and weights of individual fish were measured.

For all Lake Trout, body cavities were opened and prey items were identified and enumerated from stomach contents. Body size was recorded for intact prey species that were not highly digested. Sex and maturity were determined by visual inspection of gonads. Presence and types of fin clips were recorded, and when present, coded wire tags (CWTs) were removed and decoded to retrieve information on age and strain for recaptured fish of hatchery-origin. Sea Lamprey wounds on Lake Trout were counted and graded according to King Jr. and Edsall (1979) and Ebener et al. (2006).

Because effort varied across locations, and catch per net generally decreases with depth from the thermocline, a stratified catch per unit effort (CPUE) was calculated using four depth-based strata, representing net position from shallowest to deepest. Gillnets were fished for one night and the unit of effort was one overnight set per net. We summarized demographic trends by sex and maturity, and for large (≥ 4,000 g) female Lake Trout. A condition index (predicted weight at a given length) was calculated using a linear regression based on length-weight data from all Lake Trout collected in the survey without deformed spines. Regression coefficients were used to predict the weight of a 700 mm TL Lake Trout each year. We calculated wounding rates from Sea Lamprey as the number of A1 wounds per 100 Lake Trout > 432 mm TL. For an index of natural reproduction, based on gillnet catches, we quantified the proportion of hatchery-origin Lake Trout (i.e, those with CWTs or fin clip marks) to putative-wild fish (i.e, unmarked fish) to provide an index of natural reproduction.

Stocking information was compiled from annual correspondence with the managers of the USFWS Alleghany National Fish Hatchery (ANFH, Pennsylvania), USFWS Eisenhower National Fish Hatchery (ENFH, Vermont), the White River National Fish Hatchery (WRNFH, Vermont), and the NYSDEC Bath Fish Hatchery, as well as from summaries presented in Elrod et al. (1995), Eckert (2001), and Connerton (2022). For detailed descriptions of stocking during 1973-2020 see Lantry et al. (2021).

## Results and Discussion

*Stocking*

In 2022, stocking occurred at four locations (Olcott, Oak Orchard, Sodus, and Stony Point, Figure 2). Lake Trout were stocked from shore at Stony Point, and offshore via barge at Olcott, Oak Orchard, and Sodus. Strain totals of stocked fish in 2022 (2021 year class) included 158,880 Huron Parry Sound (HPW), 79,398 Lake Champlain (LC), and 79,519 Seneca Lake (SEN, Figure 3 and Table 1).

*Abundance and Condition Indices*

A total of 1,034 Lake Trout were caught in 54 gillnet sets from 14 sites during the August 2022 survey. Total Lake Trout CPUE was 18.9 (fish/lift), which marks the highest total catch rate observed in the survey since 1998 (Figure 4a). Mature male Lake Trout CPUE (9.8) was similar to the last three years average (9.4 ± 0.3 sd), and mature female CPUE (4.1) remains above 4, consistent with observations in 8 out of the past 10 years (Figure 4b-c). Total immature Lake Trout CPUE was relatively high, marking the highest CPUE since 1994 (Figure 4d), which contributes to the observed increase in total Lake Trout CPUE in 2022. The proportion of immature and mature Lake Trout in gillnet catches varied by location, with generally a higher proportion of the catch being made up of immature fish in western sites compared to mostly mature fish from eastern sites (Figure 5). Abundance of mature female Lake Trout ≥ 4,000 g (Figure 6) remained above the 2.0 target level established in Lake Ontario Lake Trout management plans (Schneider et al. 1998; Lantry et al. 2014). In 2022, CPUE of mature females ≥ 4,000 g was 2.4 fish/lift. Since 2010, CPUE of mature females ≥ 4,000 g has remained near or above target after a period of below target during 2005–2009 (average CPUE = 1.4 ± 0.4). Condition, expressed as the predicted weight of a 700 TL mm Lake Trout, increased in 2022 (predicted weight = 4,062 g at 700-mm) and marked the highest predicted weight over the entire time series (Figure 7). Since 1983, condition has shown an overall increase, and has remained consistently high > 3,700 g during recent survey years 2015–2021.

*Sea Lamprey Predation*

Rates of A1 Sea Lamprey marks on Lake Trout (fresh wounds where the Sea Lamprey has recently detached) were low in most years since the mid-1980s compared to high rates during 1975–1980 (Lantry et al. 2021; Figure 8). Wounding in 2022 was above target at 3.15 A1 wounds per 100 Lake Trout > 432 mm TL, which is the highest rate observed in Lake Ontario Lake Trout since 2007. Host CPUE, expressed as the CPUE of Lake Trout > 432 mm TL, also increased in 2022 (18.24) and marked the highest host CPUE observation since 1996.

*Strain Composition of Recaptured Fish*

In total, 884 hatchery-origin Lake Trout with CWTs were recaptured in the 2022 gillnet survey (Figure 9). Strain composition based on CWT reads showed recaptured fish were mostly from the SKW strain (56 %), followed by HPW (17%), LC (14%), and SEN (13%).

*Percent Wild in Gillnet Catches*

One of the ultimate goals of the Lake Ontario Lake Trout restoration program is to achieve a self-sustaining population supported by natural reproduction. Young naturally reproduced Lake Trout have been detected in Lake Ontario bottom trawl surveys, however the percentage of wild fish (i.e., not clipped and not tagged) in gillnet surveys has remained low (Figure 10). In 2022, 18 mature adult Lake Trout that were not clipped and not tagged were captured during the survey. The overall percentage of mature adults in gillnet catches that were not clipped and not tagged remained low at 2.39% in 2022.

*Abundance Indices: Burbot, Cisco and Lake Whitefish*

Burbot abundance (CPUE) in the gillnet survey generally increased from 1983 to the mid-1990s when a peak CPUE of 0.3 (N=17 Burbot) was reached in 1998 (Figure 11). Since the mid-2000s, Burbot have been rare in gillnet catches. During 2006–2022, Burbot CPUE remained below 0.04, and Burbot were absent from catches in 9 out of the past 17 survey years. No Burbot were captured in the survey in 2022.

Cisco CPUE has been low throughout the time series (1983–2021 average CPUE = 0.3 ± 0.4, Figure 11) marked by several years with zero Cisco caught. In 2022, a total of 29 Cisco were captured in the gillnet survey for a CPUE of 0.5, which represents the highest Cisco CPUE during 1983–2022. Most of the Cisco catch in 2022 came from a single net (N = 25 Cisco) fished at Southwick 25-m (43.70°, -76.25°).

Lake Whitefish abundance has been low (CPUE < 0.2) but consistent across most survey years, with only three years in the time series where no Lake Whitefish were captured (Figure 11). In 2022, a total of four Lake Whitefish were captured representing a CPUE of 0.07.

**Acknowledgements**

We thank the diligent efforts of the vessel crews of the R/V Kaho and R/V Seth Green over the decades of survey years that made data collection possible. Recent vessel operations were performed with Captain Terry Lewchanin and Engineer Ted Strang on the R/V Kaho, and by Captain Alan Fairbanks on the R/V Seth Green. We also thank the numerous biologists and technicians from USGS, NYSDEC, and USFWS for their assistance in field collections, data management and analysis, and report editing. We thank Pippa Kohn, Kyle Morton, and Pascal Wilkins for providing reviews. We especially thank the retired biologists, Cliff Schneider and Thomas Eckert from NYSDEC, and Joseph Elrod, Robert O'Gorman and Randall Owens from USGS (formerly USFWS), who shaped the early surveys. USGS fish handling was carried out in accordance with guidelines from the American Fisheries Society.

**Data Release**

The data associated with this report are currently under review and will be publicly available in 2023. Previous versions of the data may be accessed at U.S. Geological Survey, Great Lakes Science Center, 2019, Great Lakes Research Vessel Operations 1958-2018. (ver. 3.0, April 2019): U.S. Geological Survey data release, https://doi.org/10.5066/F75M63X0. Please direct questions to our Data Management Librarian, Sofia Dabrowski, at sdabrowski@usgs.gov.

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**Tables**

Table 1. Lake Trout strains stocked in Lake Ontario with abbreviated name.

| Strain | Abbreviation |
|---|---|
| Clearwater Lake | CWL |
| Lake Huron-Parry Sound Wild | HPW |
| Jenny-Lewis Lakes | JEN-LEW |
| Lake Champlain | LC |
| Lake Ontario | LO |
| Lake Superior Lean | SUP |
| Seneca Lake | SEN |
| Lake Superior Klondikes | SKW |

**Figures**

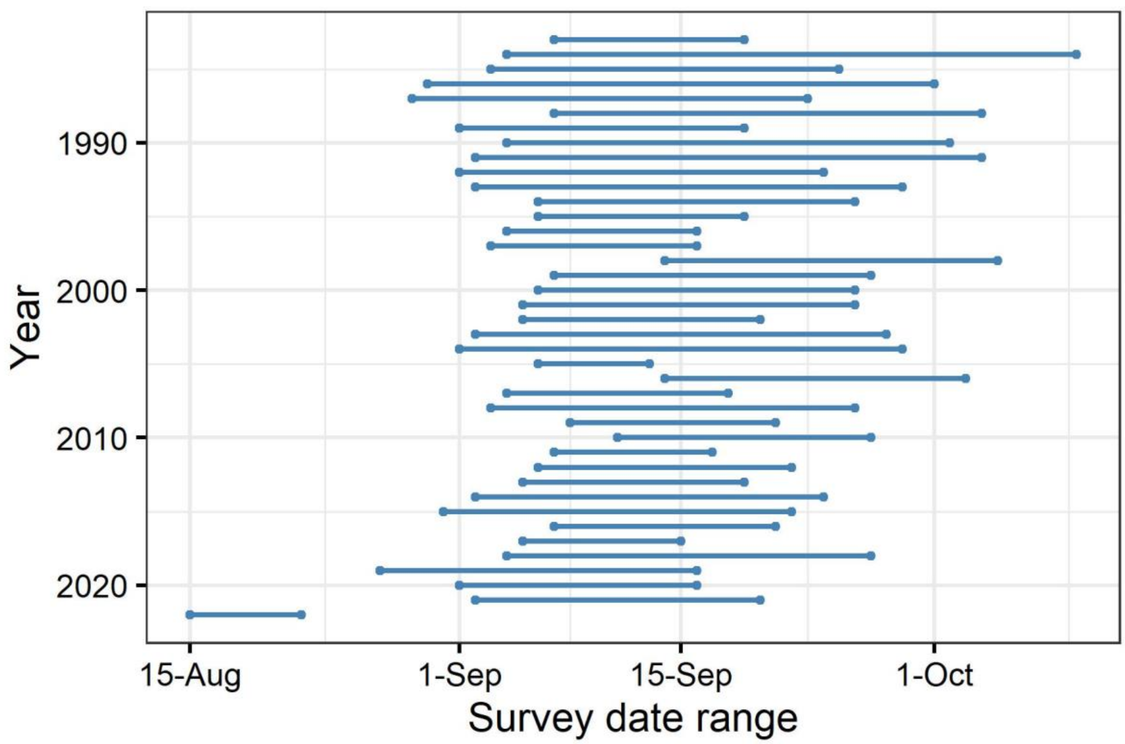


Figure 1. Calendar date range for the Lake Ontario Lake Trout gillnet survey by sampling year 1983–2022.

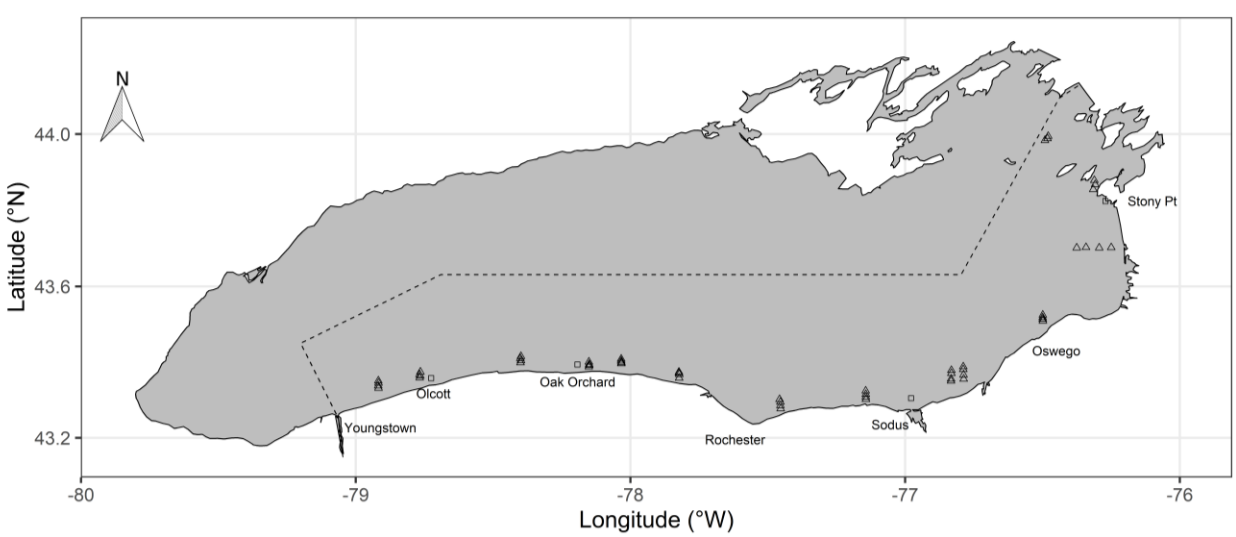


Figure 2. Map of Lake Ontario gillnet sets from the 2022 adult Lake Trout survey (triangles; N = 54), and 2022 Lake Trout stocking locations (squares; N = 4). Dashed line indicates US-Canada international boundary.

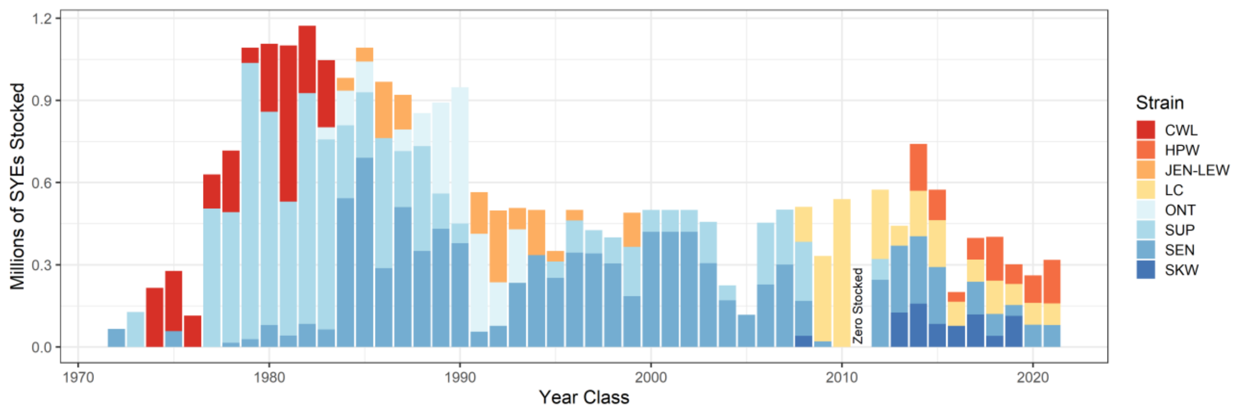


Figure 3. Total spring yearling equivalents (SYE) for lake trout strains (strain descriptions for ONT, JEN-LEW, CWL, SEN, LC, SUP, SKW, HPW appear in Table 1) stocked in U.S. waters of Lake Ontario for the 1972 – 2021 year-classes. For year-classes beginning in 2006, SUP refers to Lake Superior lean strains (SAW and STW) other than the Superior Marquette Domestics stocked prior to that time. SYE = 1 spring yearling or 2.4 fall fingerlings. No Lake Trout from the 2011 year-class were stocked in 2012.

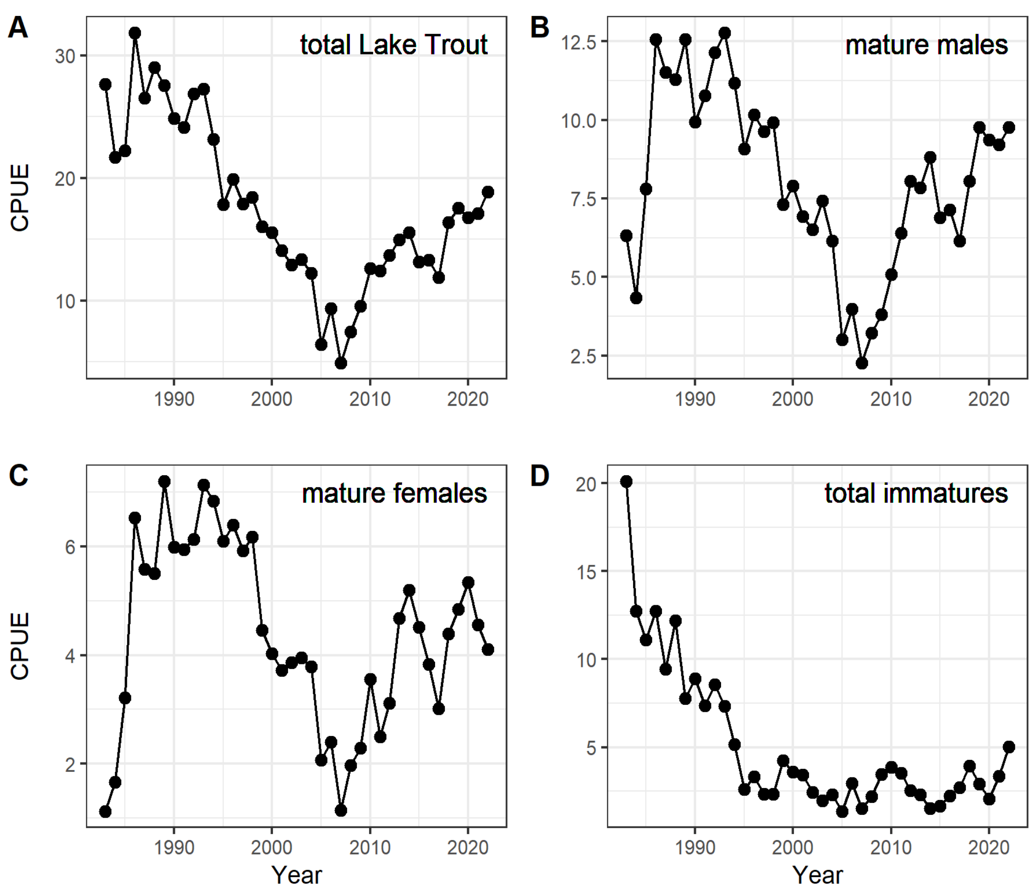


Figure 4. Abundance (stratified catch per unit effort, CPUE) of (A) total Lake Trout, (B) mature male Lake Trout, (C) mature female Lake Trout, and (d) total immature Lake Trout captured in the Lake Ontario Lake Trout gillnet survey 1983–2022.

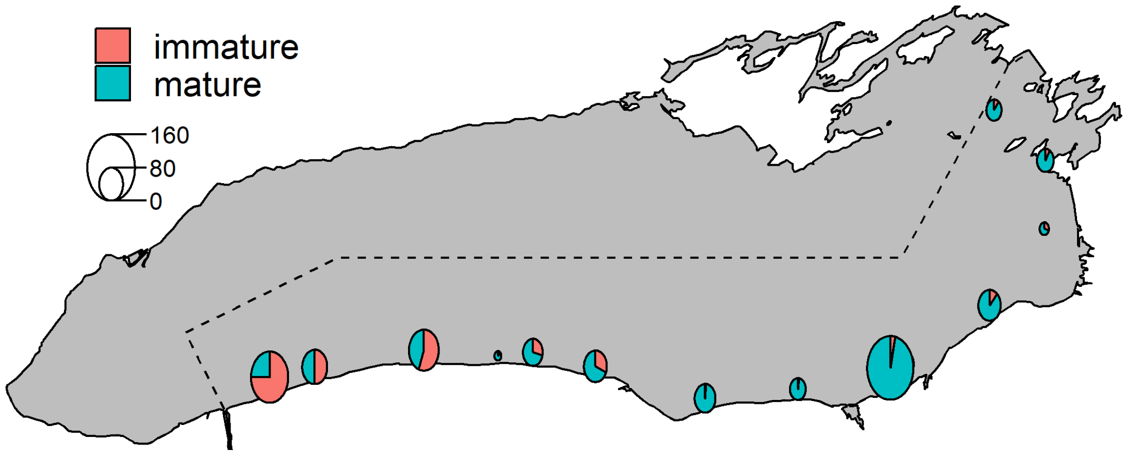


Figure 5. Spatial distribution of Lake Ontario Lake Trout catches summarized by port and maturity from the 2022 gillnet survey. Bubble size is scaled according to the total Lake Trout catch, not adjusted for effort. Note that the number of gillnets fished varies among sites (see methods). Dashed line indicates US-Canada international boundary.

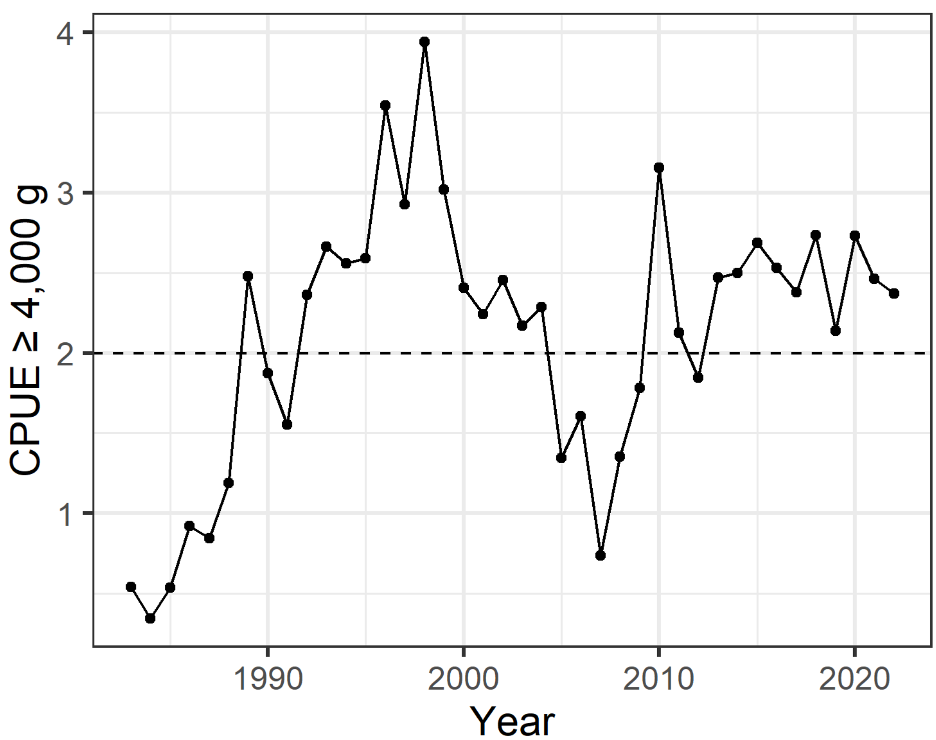


Figure 6. Abundance (CPUE unstratified) of mature female Lake Trout ≥ 4,000 g calculated from gillnet catches in the Lake Ontario Lake Trout gillnet survey 1983-2022. The dashed line represents the target CPUE from Schneider et al. (1998) and Lantry et al. (2014).

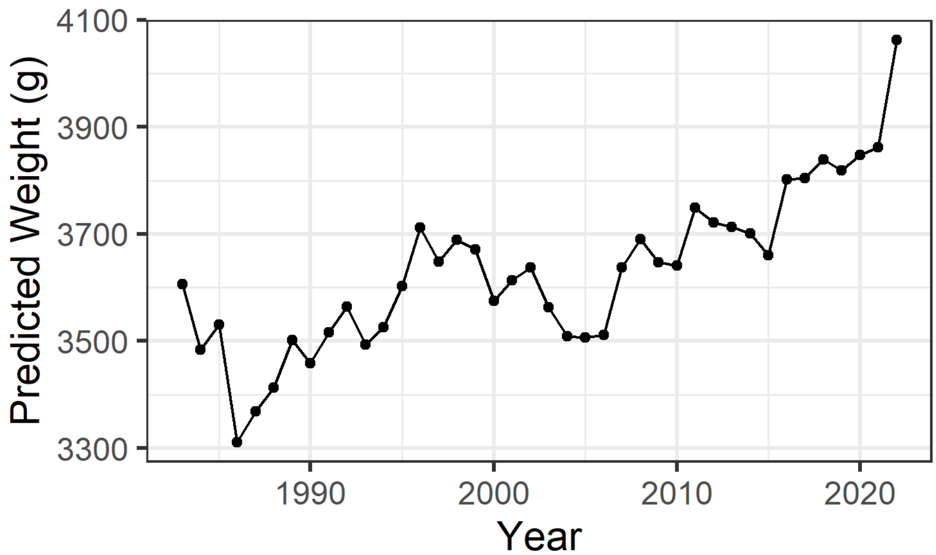


Figure 7. Lake Ontario Lake Trout condition expressed as the predicted weight (g) at 700 mm TL from length-weight regressions calculated from all fish collected during the annual gillnet survey by year.

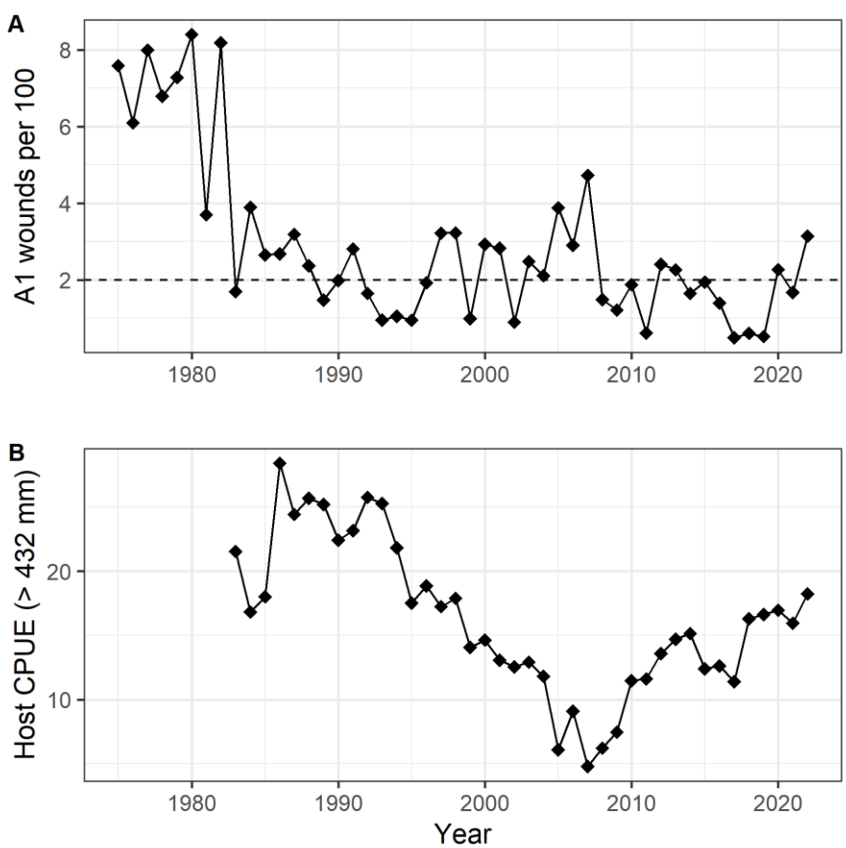


Figure 8. (A) Wounding rates (A1 wounds per 100 Lake Trout) inflicted by Sea Lamprey on fish > 432 mm TL and (B) the gillnet CPUE of Lake Trout hosts > 432 mm TL collected in the fall 1983–2022. Data from 1975–1982 are from Lantry et al. (2021).

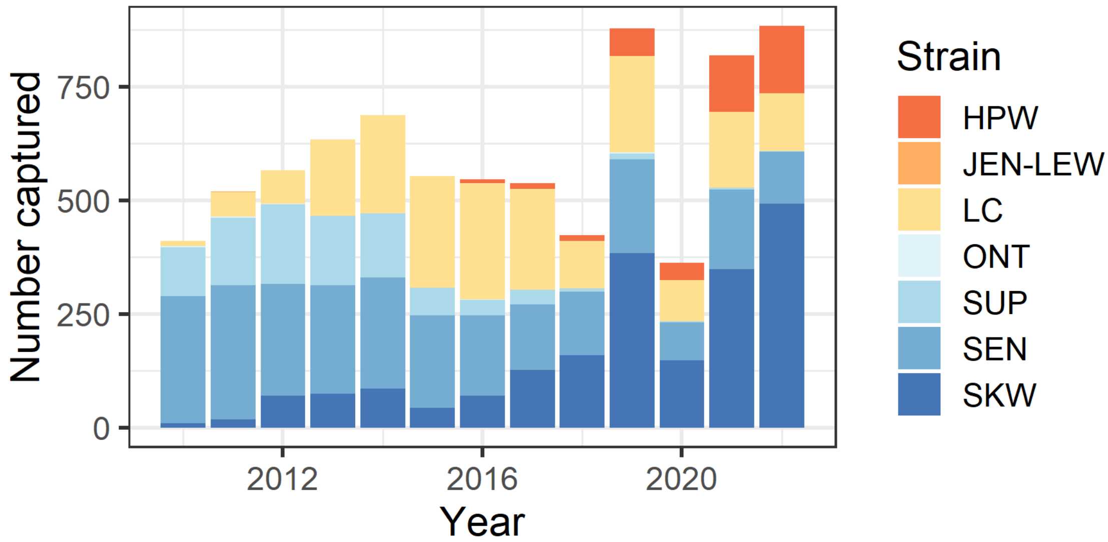


Figure 9. Strain composition of coded-wire tagged Lake Trout captured during the Lake Ontario gillnet survey by survey year. For strain descriptions, see Lantry et al. (2021).

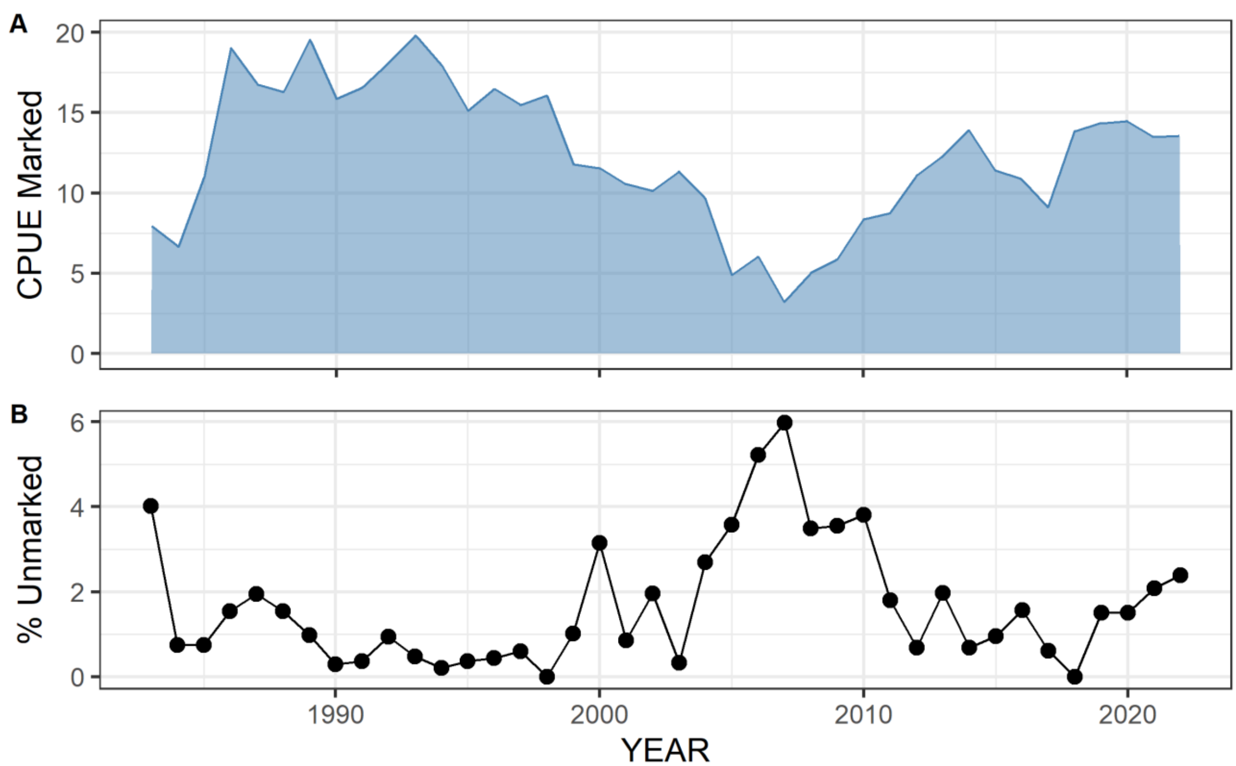


Figure 10. (A) CPUE of all mature Lake Trout and (B) the percentage of unmarked (no clips or tags) sexually mature Lake Trout, by year in Lake Ontario 1983–2022.

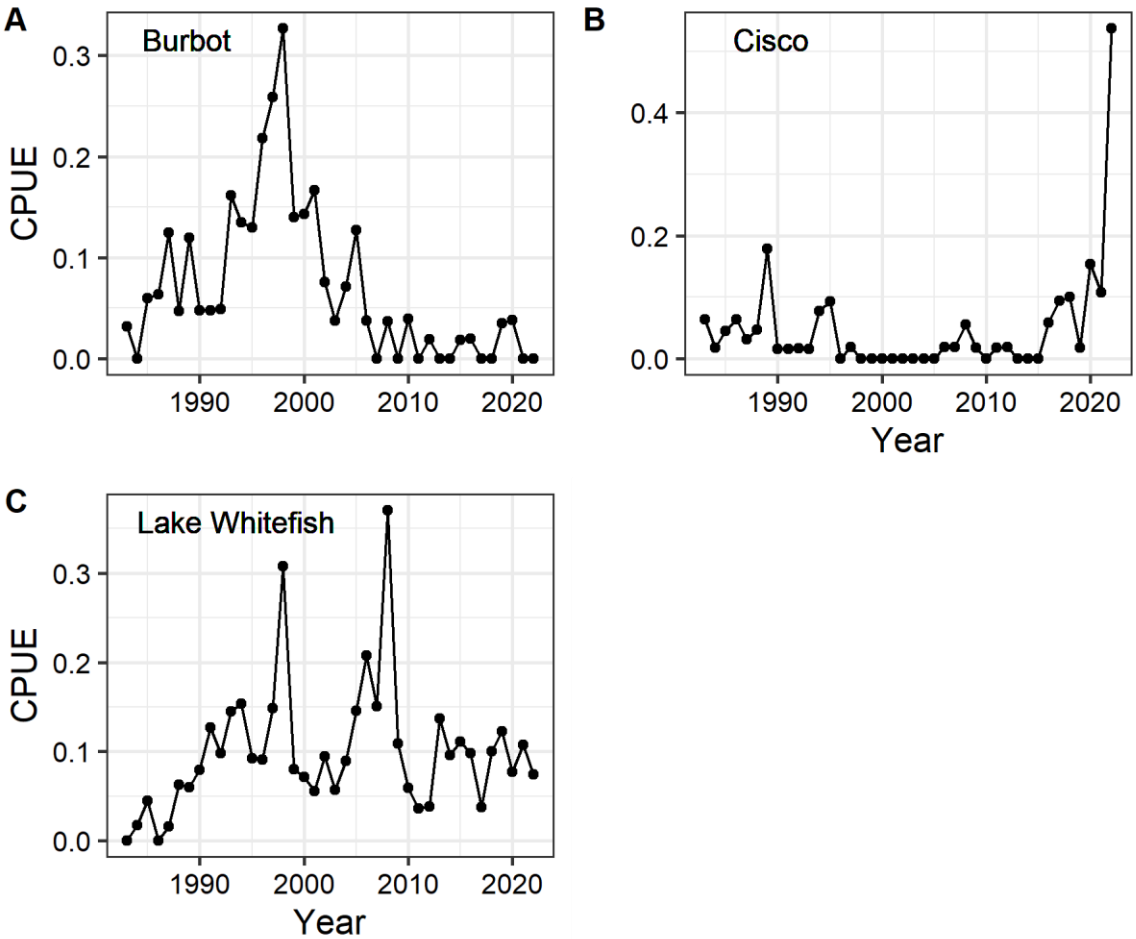


Figure 11. CPUE of (A) Burbot, (B) Cisco, and (C) Lake Whitefish, from the Lake Ontario August gillnet survey 1983–2022.