WISCONSIN DEPARTMENT OF NATURAL RESOURCES

LAKE SUPERIOR DEEPWATER SURVEY REPORT 2024

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INTRODUCTION

Siscowet (i.e., "fat") lake trout *Salvelinus namaycush siscowet* evolved body morphology equipped to survive in the great depths of Lake Superior (e.g., stouter body, shorter snout, larger eyes, higher lipid content and longer paired fins). This lake trout morphotype primarily occupies depths greater than 70 m but can be encountered in shallower depths. Although siscowet are infrequently encountered by anglers, it is likely the most abundant predator in Lake Superior and is an important part of the fish community and energy flow in the Lake Superior ecosystem. Siscowet are also commercially harvested in the Wisconsin waters of Lake Superior.

Deepwater ciscoes (i.e., "chubs") are also prevalent in the offshore areas of Lake Superior and are critical to its energy flow and ecosystem. Kiyi *Coregonus kiyi* are the most abundant deepwater cisco in Lake Superior but primarily reside at depths greater than 100 m and are generally too small to be vulnerable to capture in this survey. Bloater *Coregonus hoyi* generally grow faster and bigger than kiyi and therefore have more commercial value. Bloater abundance is relatively high in Wisconsin waters of Lake Superior compared to other regions and supports one of the only viable commercial fisheries in Lake Superior (Goldsworthy et al. 2025).

Agencies responsible for the management of Lake Superior's fishery resources have established a series of fish community objectives, with the overarching goal to "rehabilitate and maintain a diverse, healthy and self-regulating fish community, dominated by native species and supporting sustainable fisheries" (Horns et al. 2003). The Lake Superior Technical Committee (LSTC) initiated a coordinated lake-wide Deepwater Survey with the primary objectives of sampling siscowet populations throughout the lake to gain a broader understanding of their ecological role, determine relative abundance and assess age and size composition. Information from this survey is used to monitor population dynamics and to assess progress toward fish community objectives in Lake Superior.

METHODS

The Wisconsin Department of Natural Resources (DNR) Lake Superior Deepwater Survey is conducted once every three years at sites chosen based on water depth and proximity to docking locations in management units WI-1 and WI-2. In 2024, eight stations were sampled, four in WI-1 and four in WI-2, with 823-m monofilament gill net gangs (Figure 1). Each gang covers one depth strata (0-19 fathoms, 20-39 fathoms, 40-59 fathoms and 60-79 fathoms) and is composed of a series of 91-m nets constructed with 51 to 152 mm mesh (stretch measure) by 13-mm increments. All nets were set on the lake bottom for one net-night (24 hours) using the R/V Hack Noyes. Biological information was collected from fish using standardized protocols.

Otoliths were dissected from most siscowet to estimate fish ages. Unaged fish were assigned an age using a standard age-length key approach using only age samples within a given year (Isermann and Knight 2005; Ogle et al. 2020). Sea Lamprey wounding rates were calculated as the total number of A-1, A-2 and A-3 wounds per 100 fish (King 1980; Eshenroder and Koonce 1984). All other species were measured as time permitted.

Analyses were conducted using the program R (version 4.4.2) with help from packages tidyverse (Wickham et al. 2019) and FSA (Ogle et al. 2020).

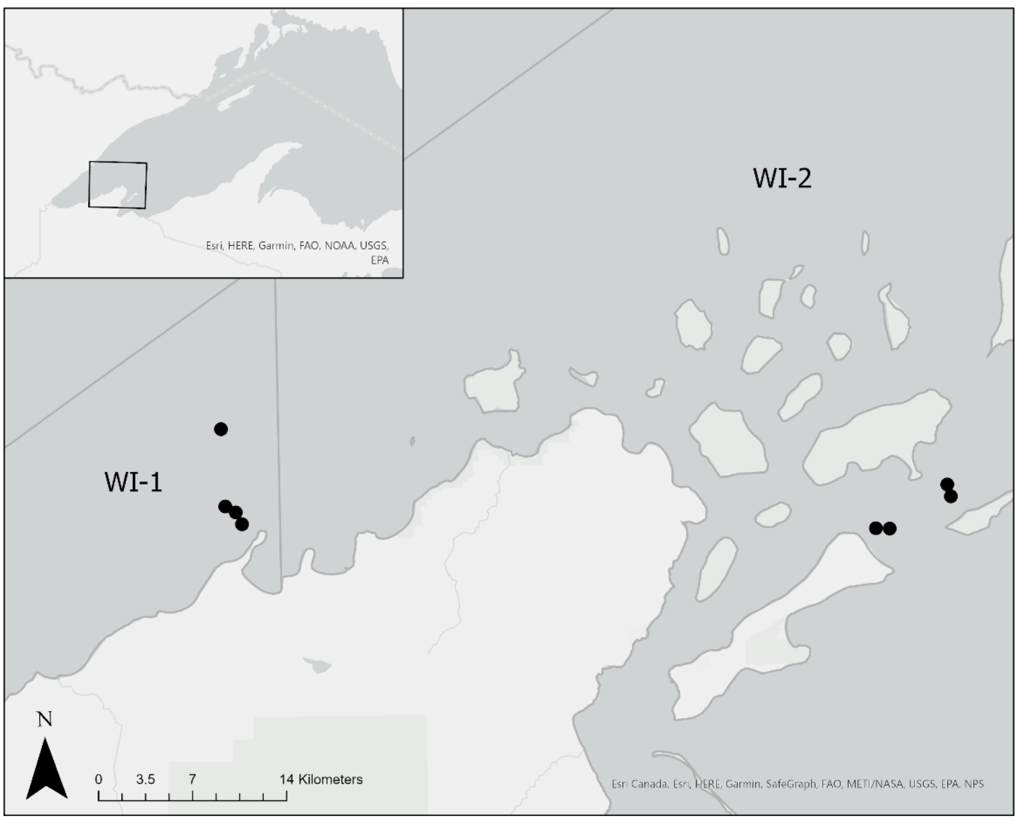

Figure 1. Map of the Wisconsin waters of Lake Superior and the inside-end buoy locations of all sampling stations in the DNR Deepwater Survey 2024. Wisconsin management units include WI-1 (Western Arm region) and WI-2 (Apostle Islands region).

RESULTS AND DISCUSSION

SISCOWET LAKE TROUT

Relative abundance of siscowet in all Wisconsin waters has declined slightly from 1997 to the present but has been relatively stable in the last decade from 2015 to 2024 (Figure 2). This trend was generally reflected in other jurisdictions around Lake Superior (Seider et al. 2021) and was common between both management units (Figure 2). Relative abundance was highest in the 40-59 fathoms (73-108 m) and 60-79 fathoms (109-144 m) depth stratifications in both management units (Figure 3).

The median length of siscowet in 2024 was 408 and 472 millimeters in WI-1 and WI-2, respectively (Figure 4). Median lengths increased from 1997 to 2009 but have been relatively stable since (Figure 5). In 2024, size structure was similar to the previous survey in WI-2 but decreased in WI-1 as a few very small fish were detected (Figure 4 and 5). Siscowet lake trout grow substantially slower than lean lake trout, and individual growth rates are extremely variable (Figure 6). Therefore, assessing age structure of the population is essential to evaluate population trends. Most siscowet lake trout captured in the Deepwater Survey are between 5 and 25 years old (Figure 7). However, age structure became progressively older between 1997 and 2009 (Figure 7). Age structure shifted back to a slightly younger distribution and has been relatively stable from 2012 to 2024 (Figure 7). Similar patterns in siscowet age structure have been observed in other management units in Lake Superior throughout this period (Seider et al. 2021). Notably, we observed a good signal of age-4 siscowet in the 2024 survey, but very few 5- and 6-year-olds (Figure 7). A similar pattern was observed in lean lake trout stocks in Wisconsin waters (see DNR Lake Superior Spring Lake Trout Survey Report and DNR Lake Superior Summer Survey Report).

Trends in individual siscowet growth rates are difficult to parse out through time, but trends in fish condition can give insight into how growth rates have changed. The relative condition factor for an individual fish is the standardized residual from a linear model of length and weight of the population (Figure 8). Median relative condition factor increased from 2000 to 2012 and then decreased to 2021 (Figure 8). This decline in condition over the past decade may be explained by offshore prey biomass declines during this same period (Gorman et al. 2021). Prey biomass recently increased tremendously due to the 2022 cohort of ciscoes (lake herring, bloater and kiyi) and deepwater sculpin (Vinson et al. 2024), which may also explain the recent increase in relative condition of siscowet in the 2024 survey (Figure 8).

Sea lamprey wounding rate for siscowet greater than 533 mm was above the goal of 5 wounds per 100 fish in all Wisconsin waters in the 2024 survey (Figure 9). Wounding rates generally range between 5 and 15, but results should be evaluated with caution due to low sample sizes of fish greater than 533 mm (Figure 4). Siscowet lake trout are likely an important buffer of sea lamprey predation for lean lake trout populations (Goldsworthy et al. 2025).

BLOATER

Bloater relative abundance peaked in 2000, declined quickly until 2009, and increased quickly again until 2021 before decreasing in the 2024 survey (Figure 10). This pattern in relative abundance was also reflected in commercial catch rates. These large swings in population relative abundance are generally caused by intermittent large recruitment events (Goldsworthy et al. 2025). Therefore, as long as the “boom-or-bust” recruitment patterns continue, we expect to continue seeing large swings in adult abundance. Bloater relative abundance was low in the 0-19 fathoms (0-35 m) depth stratification, highest in the 20-39 fathoms (36-71 m) depth stratification in both management units and declined at greater depths (Figure 11). Median length of bloater was 254 and 251 mm in management units WI-1 and WI-2, respectively (Figure 12).

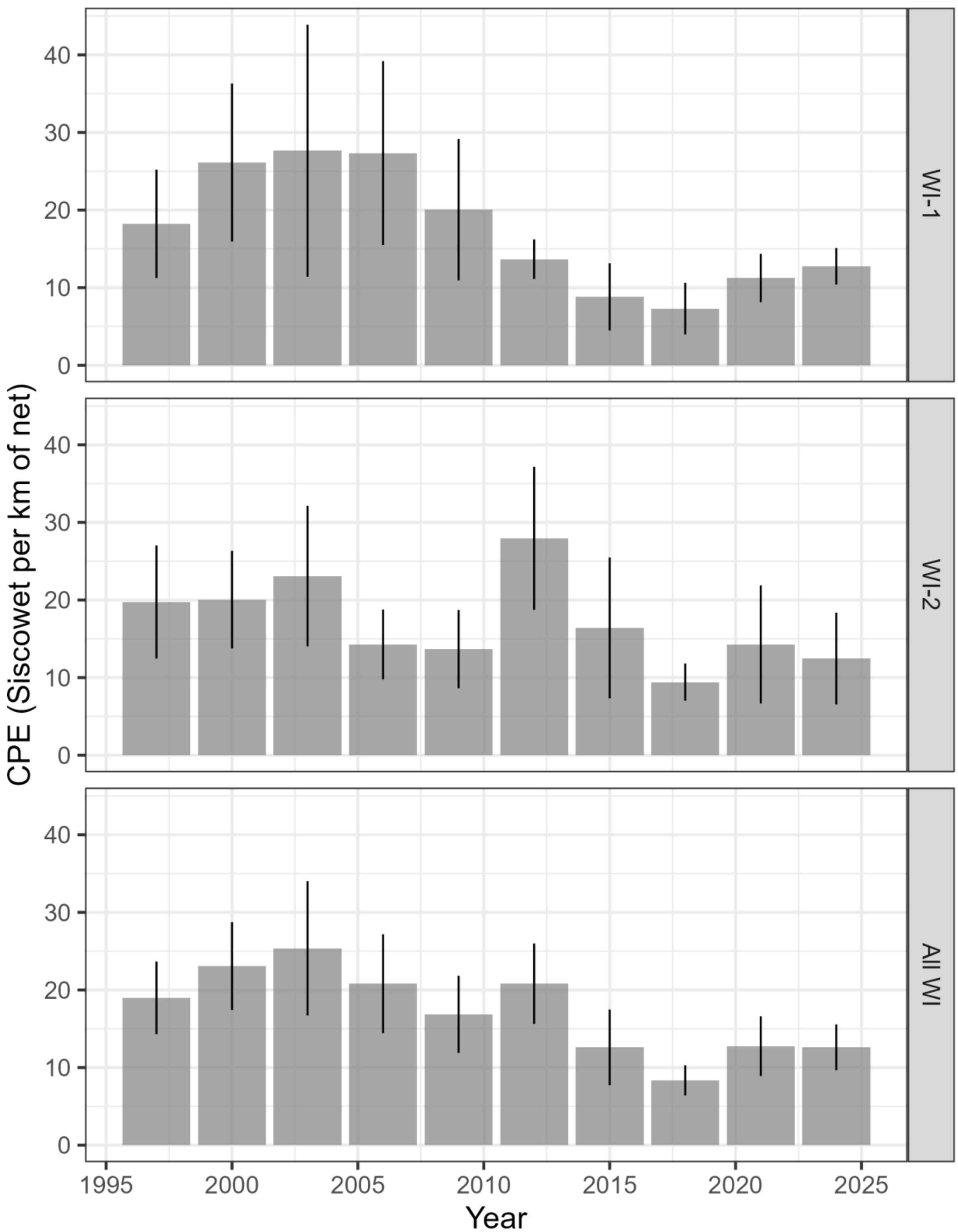

Figure 2. Mean CPE (catch-per-unit-effort) of siscowet lake trout in the Deepwater Survey conducted once every three years in WI-1 (top), WI-2 (middle) and all Wisconsin waters combined (bottom) from 1997 to 2024. Error bars are +/- one standard deviation.

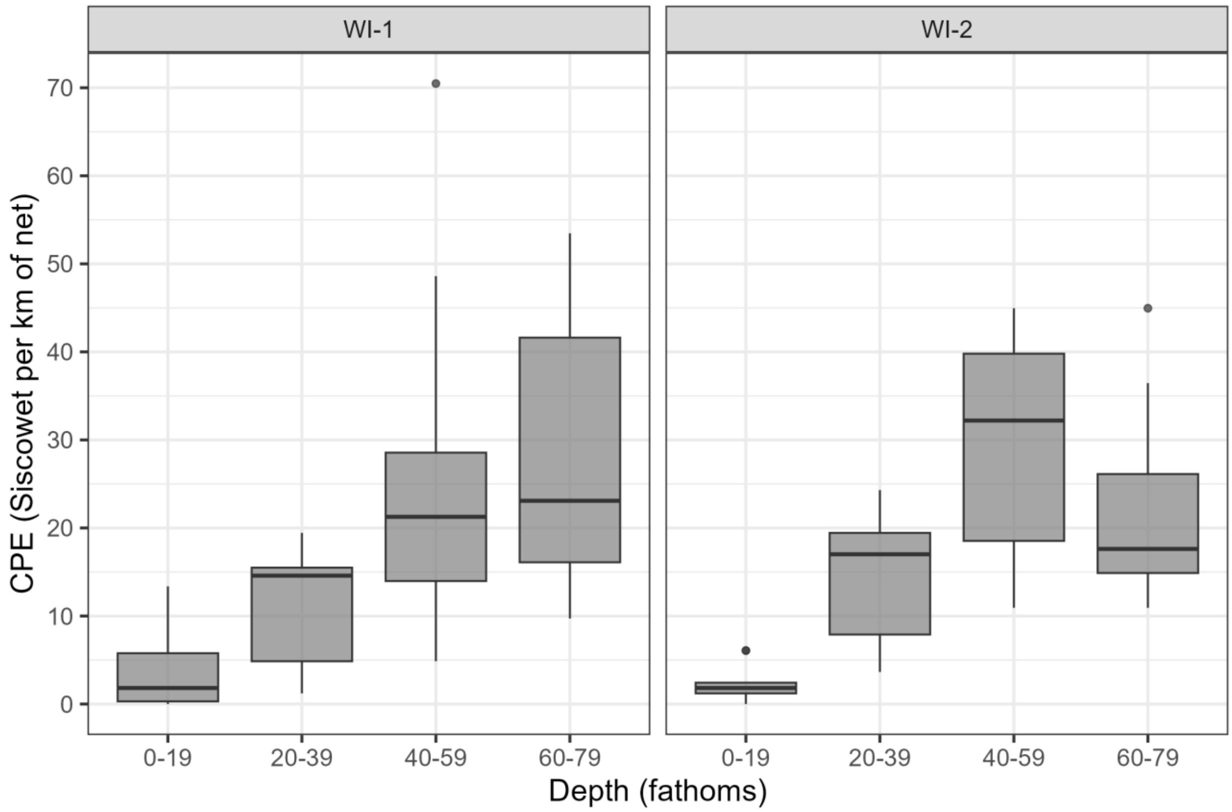

Figure 3. Siscowet lake trout CPE (catch-per-unit-effort) by depth category in the Deepwater Survey conducted once every three years in WI-1 (left) and WI-2 (right) from 1997 to 2024.

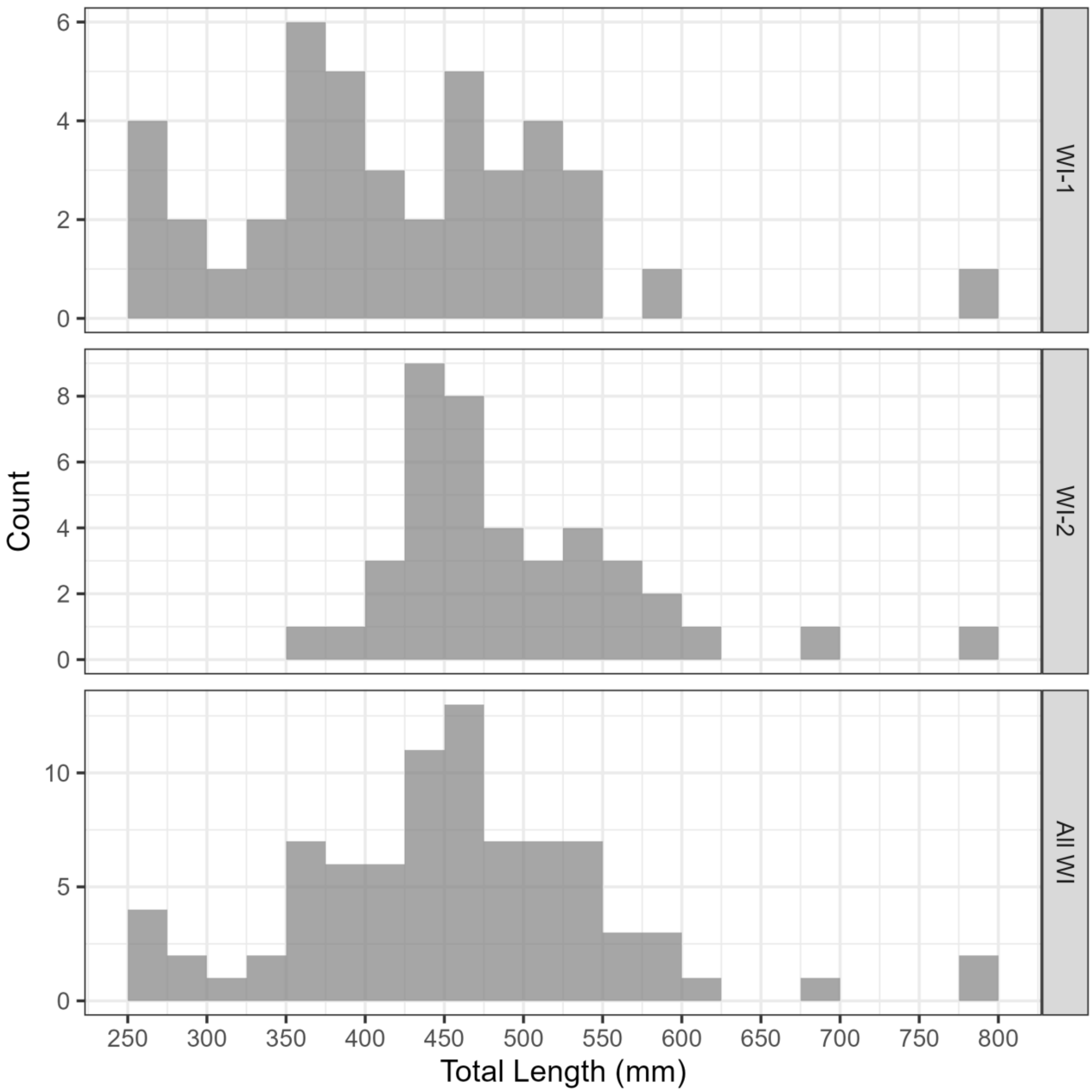

Figure 4. Length frequency histograms of siscowet lake trout captured in the 2024 Deepwater Survey in WI-1 (top), WI-2 (middle) and all Wisconsin waters combined (bottom).

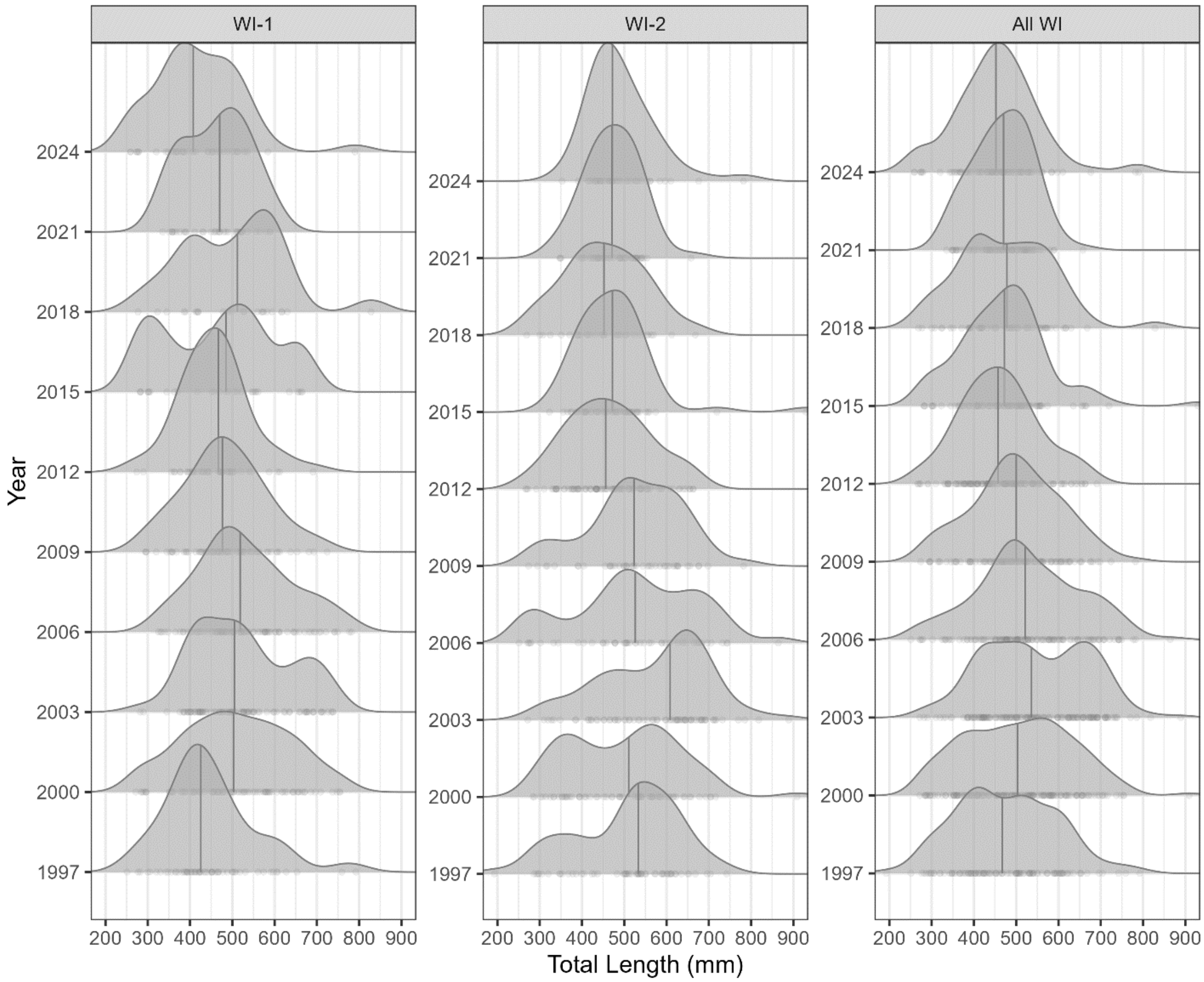

Figure 5. Time series of siscowet lake trout length frequency captured during the Deepwater Survey conducted once every three years from 1997 to 2024 in WI-1 (left), WI-2 (middle) and all Wisconsin waters (right). Vertical lines represent the median total length sampled each year.

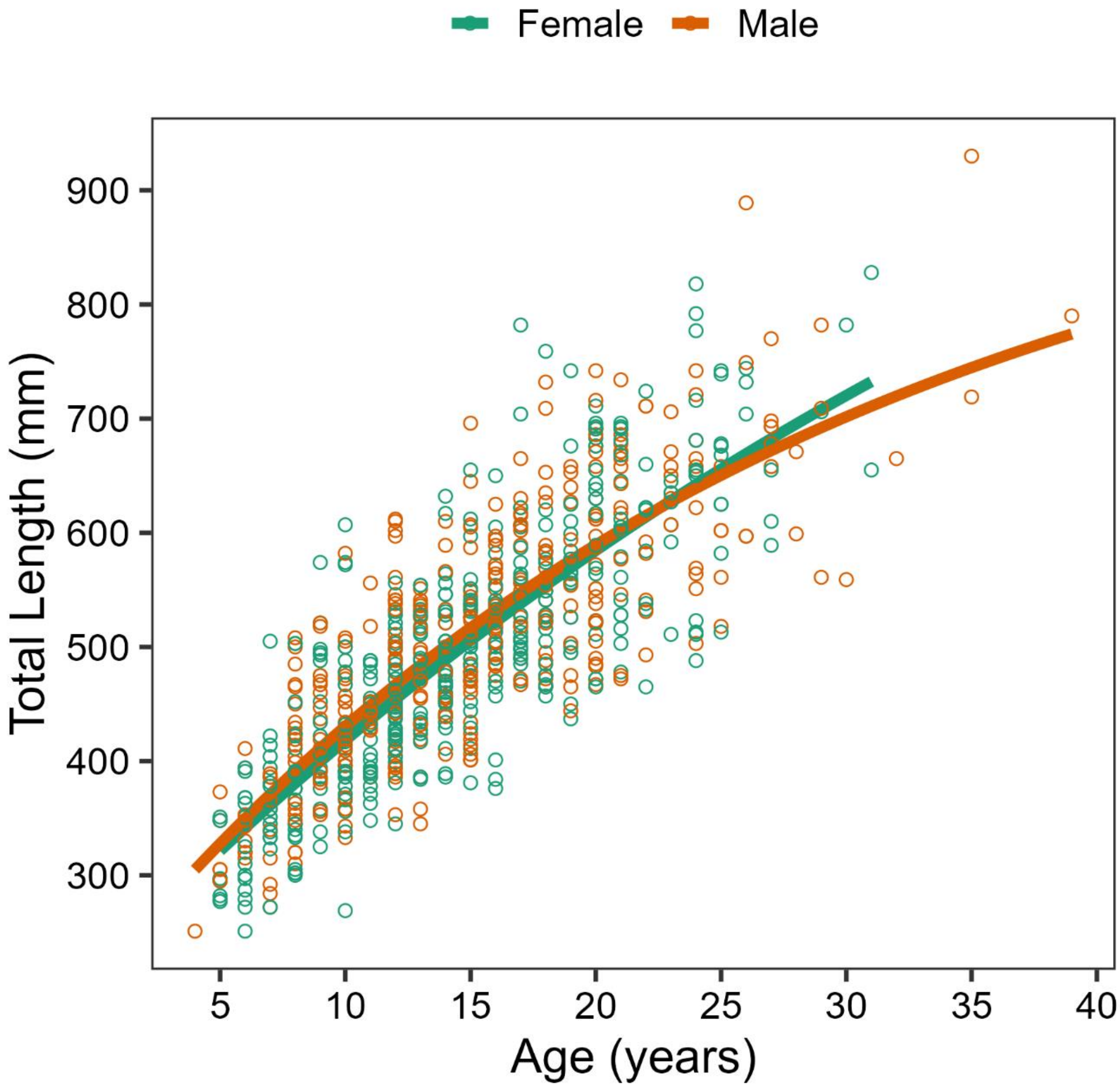

Figure 6. Length-at-age for all siscowet lake trout age samples from the Deepwater Survey from 1997 to 2024 and lines representing the von Bertalanffy growth model for female (green) and male (orange) individuals.

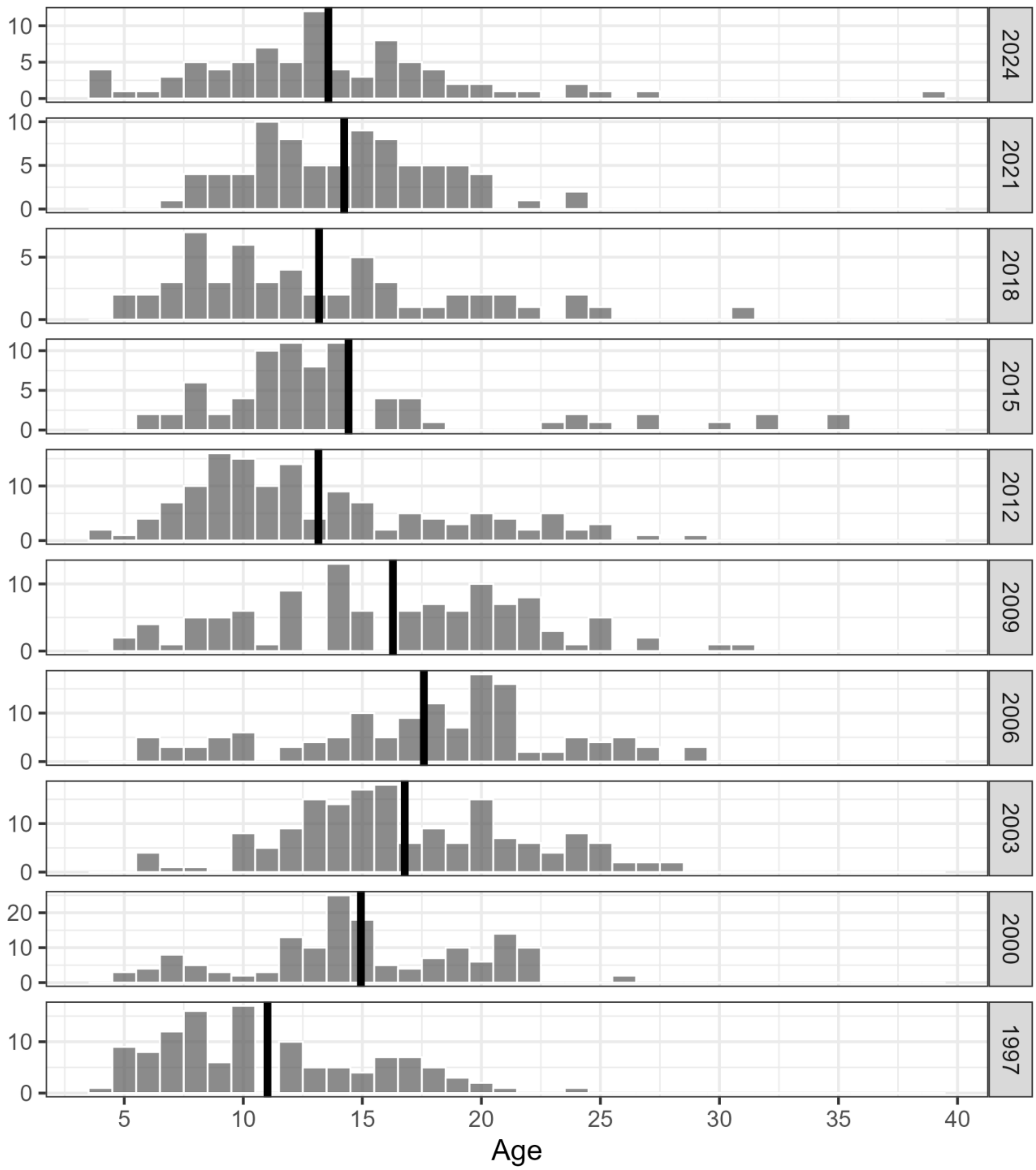

Figure 7. Age compositions of siscowet lake trout captured during the Deepwater Survey conducted once every three years from 1997 to 2024 in the Wisconsin waters of Lake Superior. Solid vertical lines represent the mean age within each sampled year.

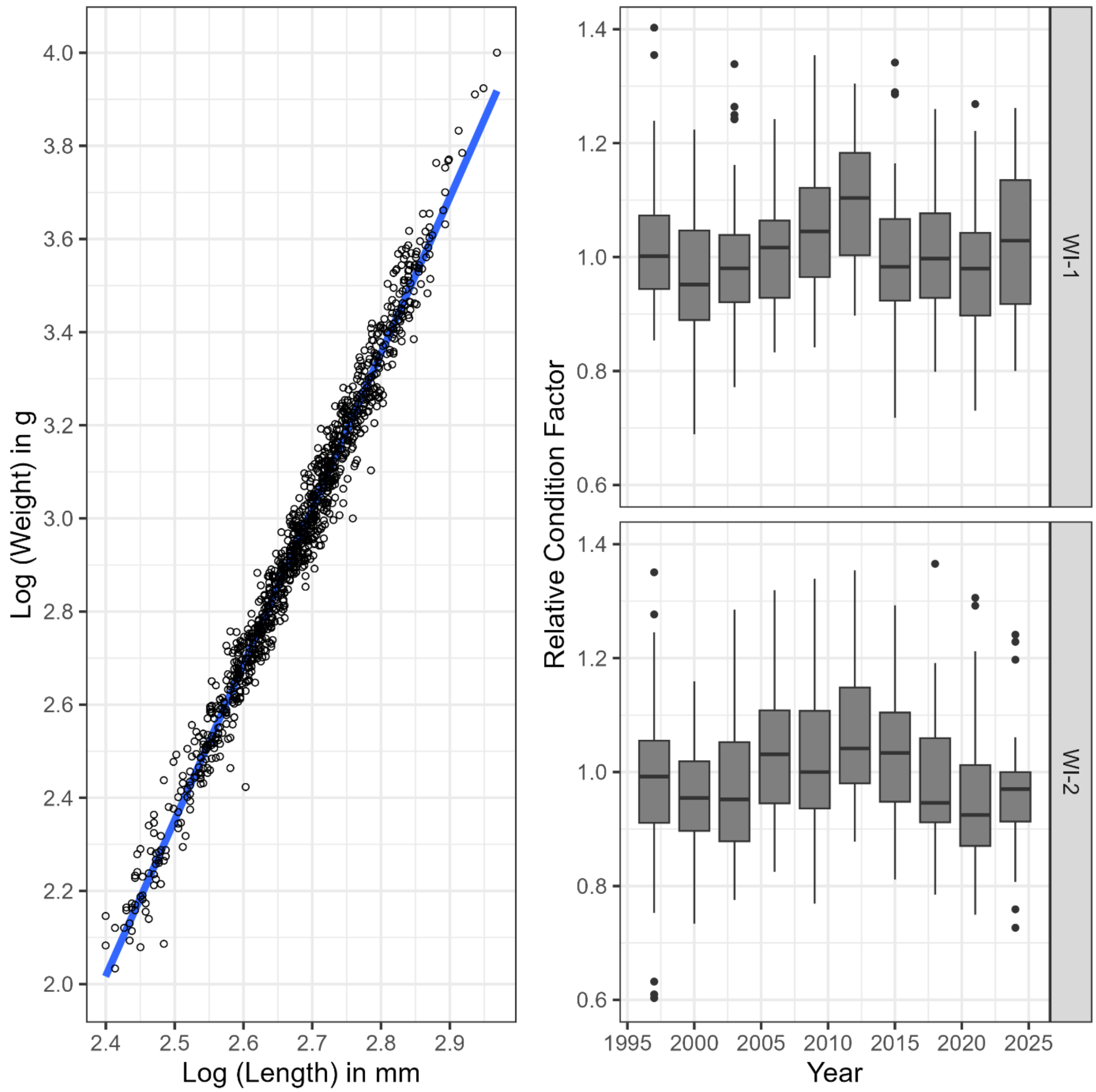

Figure 8. Length-weight regression model using all siscowet lake trout sampled during the Deepwater Survey from 1997 to 2024 (left) and relative condition factor by year (right).

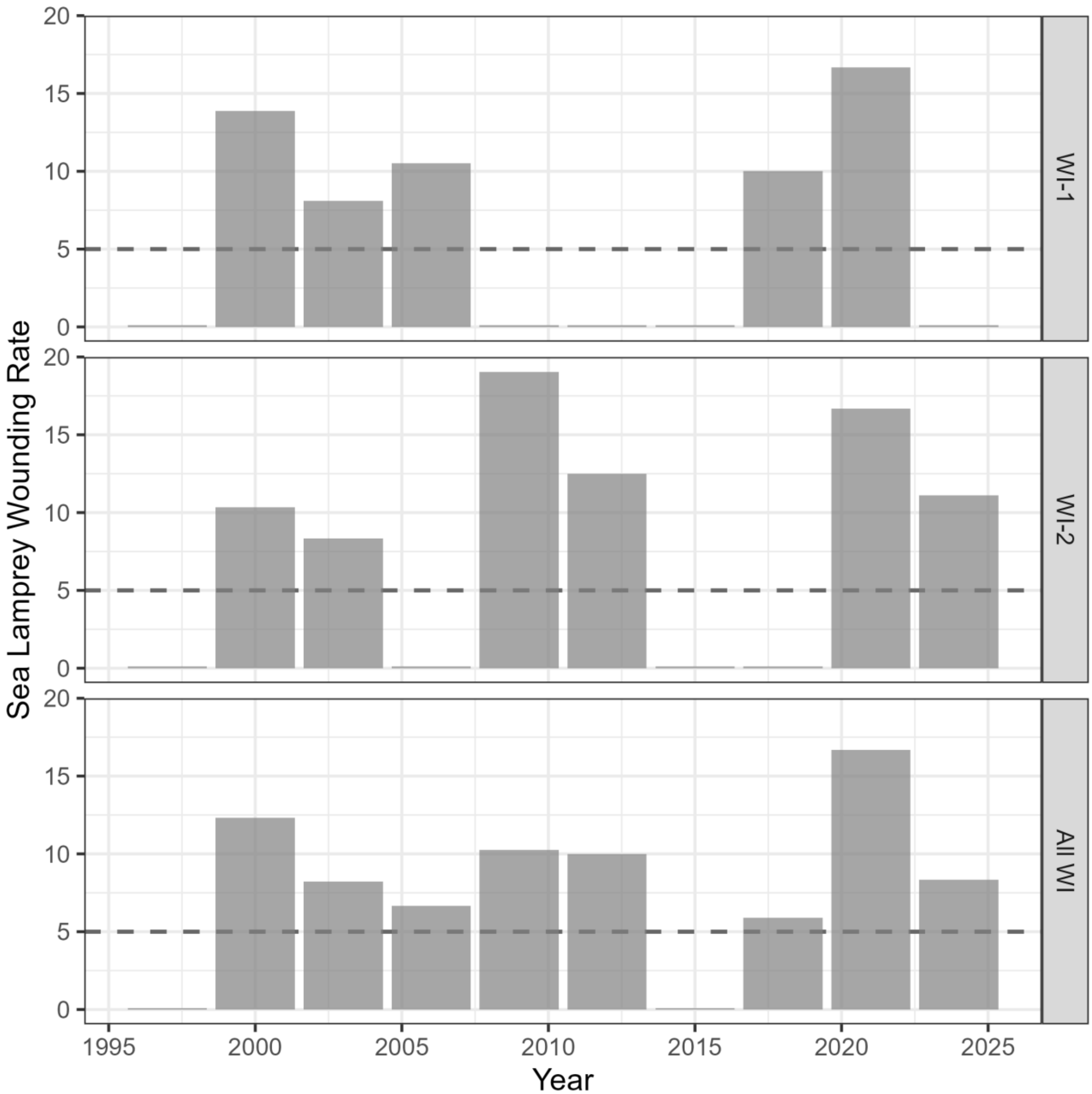

Figure 9. Sea lamprey wounding rate of siscowet lake trout greater than 533 mm in the Deepwater Survey conducted once every three years in WI-1 (top), WI-2 (middle) and all Wisconsin waters combined (bottom) from 1997 to 2024. Horizontal dashed lines are the target wounding rate of 5 wounds per 100 fish set by the Lake Superior Technical Committee.

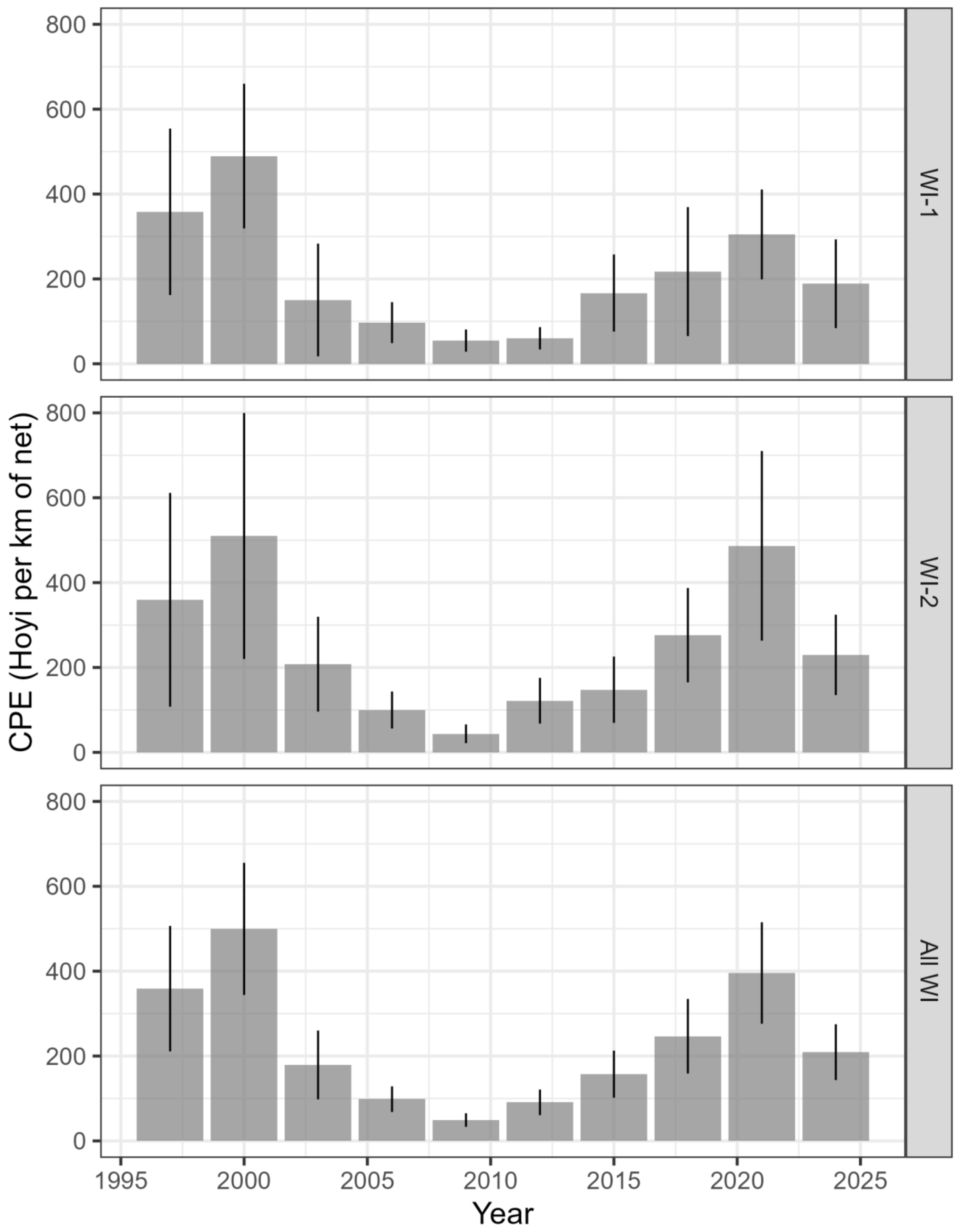

Figure 10. Mean CPE (catch-per-unit-effort) of bloater *Coregonus hoyi* in the Deepwater Survey conducted once every three years in WI-1 (top), WI-2 (middle) and all Wisconsin waters combined (bottom) from 1997 to 2024. Error bars are +/- one standard deviation.

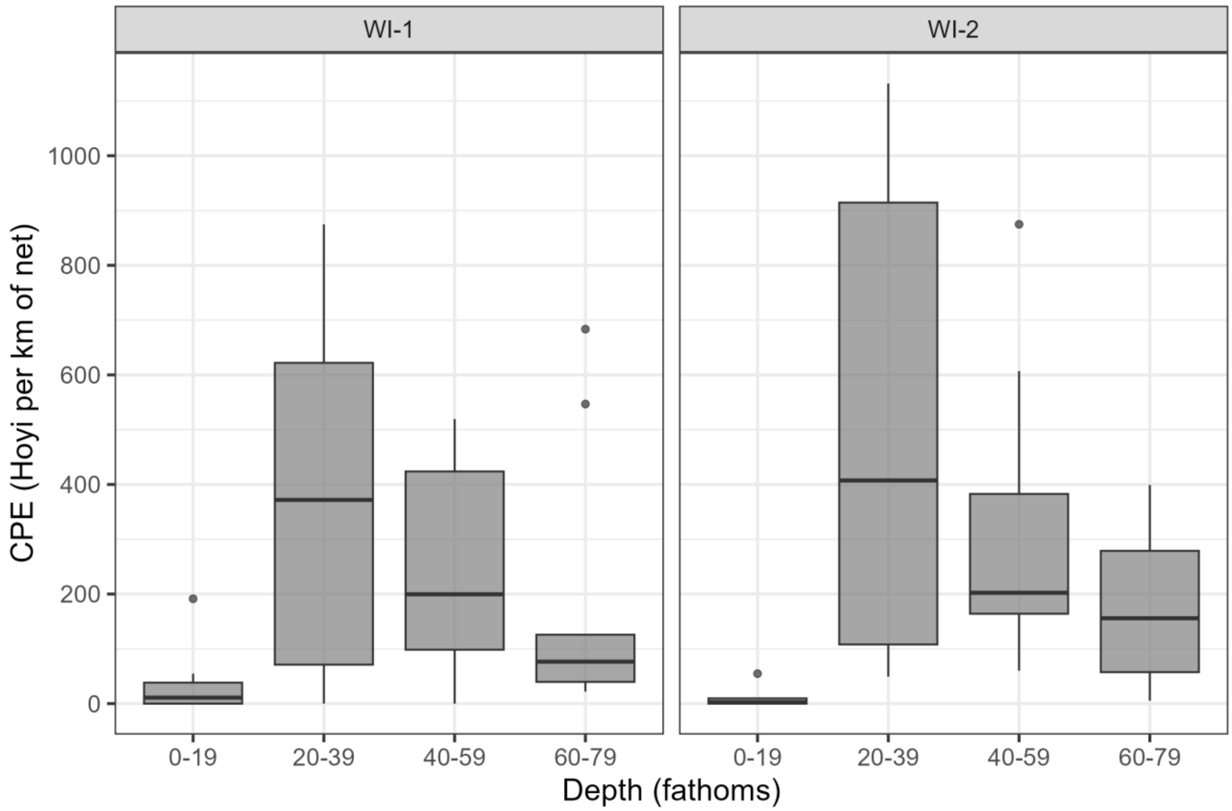

Figure 11. Bloater *Coregonus hoyi* CPE (catch-per-unit-effort) by depth category in the Deepwater Survey conducted once every three years in WI-1 (left) and WI-2 (right) from 1997 to 2024.

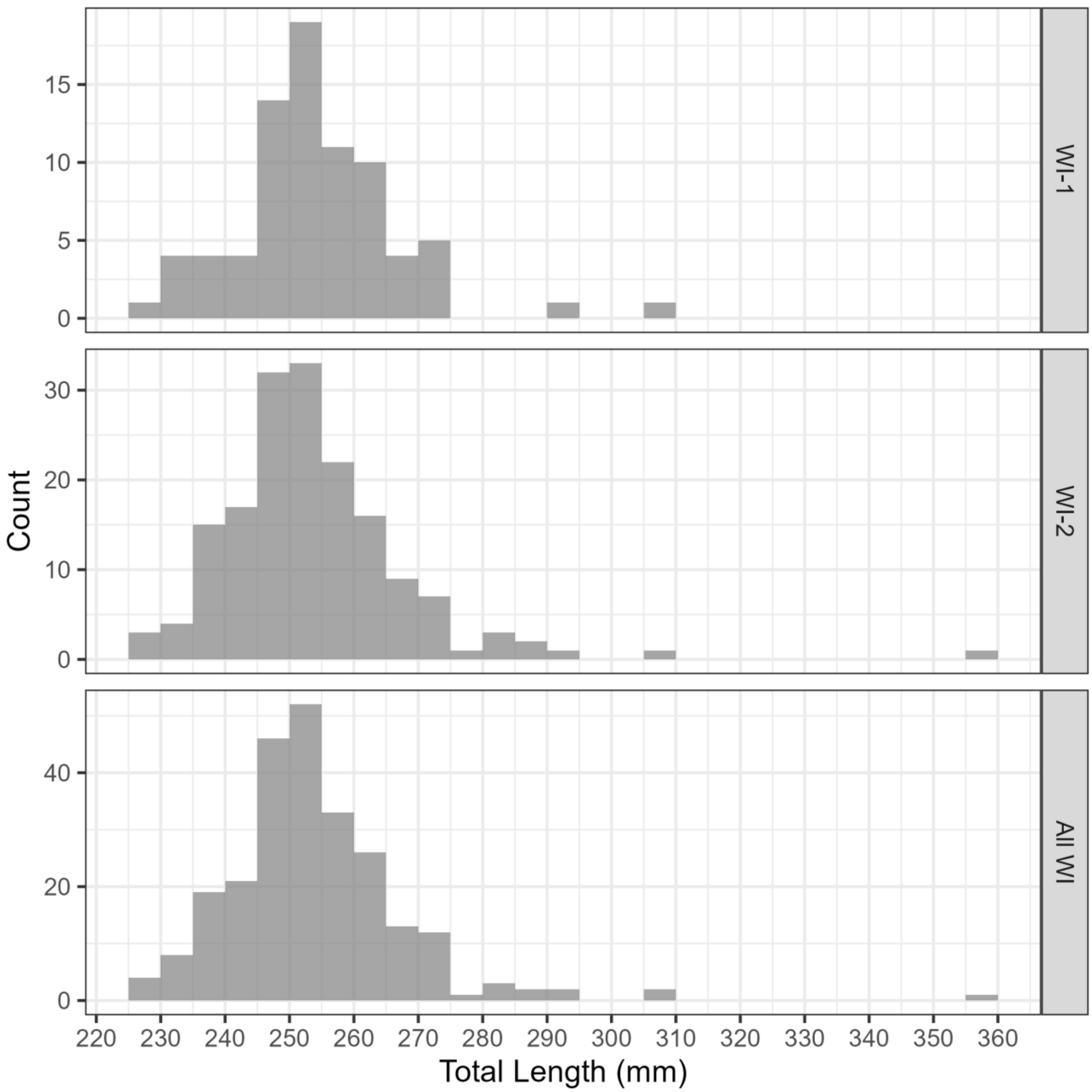

Figure 12. Length frequency histograms of bloater *Coregonus hoyi* captured in the 2024 Deepwater Survey in WI-1 (top), WI-2 (middle) and all Wisconsin waters combined (bottom).

REFERENCES

Eshenroder, R.L., and Koonce, J.F. 1984. Recommendations for standardizing the reporting of sea lamprey marking data: a report from the Ad Hoc Committee. Great Lakes Fishery Commission, Spec. Pub. 84-1.

Goldsworthy, C. A., Carl, D. D., Sitar, S. P., Seider, M. J., Vinson, M. R., Harding, I., Pratt, T. C., Piszczek, P. P., Berglund, E. K., Michaels, S. B., & Barber, J. M. 2025. Lake Superior fish community and fisheries, 2001–2022: An era of stability. Journal of Great Lakes Research, 51(1), 102414.

Gorman, O.T., Vinson, M.R., and Yule, D.L. 2021. Status of Prey Fish in Lake Superior in 2017. in The State of Lake Superior in 2017. Edited by M.P. Ebener and T.C. Pratt [online]. Available from http://www.glfc.org/pubs/SpecialPubs/Sp21_02.pdf

Isermann, D. A., and C. T. Knight. 2005. A computer program for age–length keys incorporating age assignment to individual fish. North American Journal of Fisheries Management 25(3): 1153-1160.

King, E.L. Jr. 1980. Classification of sea lamprey (Petromyzon marinus) attack marks on Great Lakes lake trout (Salvelinus namaycush). Canadian Journal of Fisheries and Aquatic Science 37: 1989-2006.

Ogle, D.H., P. Wheeler, and A. Dinno. 2020. FSA: Fisheries Stock Analysis. R package version 0.8.30, https://github.com/droglenc/FSA.

Seider, M.J., S.P. Sitar, and M.R. Vinson. 2021. Status of Siscowet Lake Trout in Lake Superior in 2017. in The State of Lake Superior in 2017. Edited by M.P. Ebener and T.C. Pratt [online]. Available from http://www.glfc.org/pubs/SpecialPubs/Sp21_02.pdf

Vinson, M.R., Evrard, L., Gorman, O.T., Phillips, S.B., Yule, D.L. 2024. Status and Trends of the Lake Superior Fish Community, 2023. Great Lakes Fishery Commission, Ann Arbor, Michigan.

Wickham et al. 2019. Welcome to the tidyverse. Journal of Open Source Software, 4(43), 1686, https://doi.org/10.21105/joss.01686