

EFFECTIVENESS OF WALLEYE STOCKING IN WINTER KILL LAKES

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Abstract—Winter kill events, marked by extensive fish mortality due to hypoxic conditions under the ice, are a common phenomenon in shallow eutrophic lakes, especially in the northern lakes in the northern United States. These events can drastically alter fish communities and often result in the elimination of top predators. Though these lakes will typically slowly bounce back to what they were in a couple of years. This study evaluates the effectiveness of walleye, *Sander vitreus*, stocking in lakes after a winter kill. For this study, four known winter kill lakes that are consistently stocked with walleye were studied. Pre- and post-winter kill walleye data were analyzed. Results showed that stocking did not significantly change the typical walleye dynamics in these lakes, walleye populations were not significantly affected by stocking after a winter kill. Further understanding of how every different ecological factor affects walleye stocking and walleye population dynamics will have a heavy influence on stocking decisions and how lakes are further managed. This study was to test a possible idea that could further improve these management decisions.

INTRODUCTION

Furthering our understanding and knowledge of winter kill lakes is essential, as it is a common occurrence in many of the northern states. Fish kill offs in lakes are seen in lakes all around the world, and they can be caused by a variety of things (Eissa et al. 2013). Winter kill is a term to describe when mass numbers of fish are killed due to the event of winter hypoxia. Winter hypoxia is when the dissolved oxygen levels reach an amount too low for fish survival during the winter months. Winter hypoxia is caused by the lack of sunlight reaching the water columns stopping all production in lake production. Then the organisms that are using the dissolved oxygen to survive slowly drain it out of the lake until there is not enough to survive one. This happens typically in shallow eutrophic lakes (Ruuhijärvi et al. 2010). The lakes that experience winter kill will replenish the dissolved oxygen in the lakes rather quickly once the ice is off, if they are a highly productive lake. When a lake winter kills the population dynamics can become way different, and it can lead to some skewed fish populations that are not normal to what the lake is stable at. This is due to the hardier fish surviving and having less competition. On one lake in Finland this happened and in a few years the lake slowly returned to what it was naturally stable

at (Ruuhijärvi et al. 2010). But after a winter kill human intervention could control and change some of the natural stabilization of a lake by stocking it with certain species of fish.

Growth rates and overall population dynamics are affected by a multitude of things and understanding them further can help management of fish in the future. Figuring out the links between environmental conditions and instantaneous growth can give us insight into what limits the productivity of fish populations (Watson et al. 2022). There have been many factors that have been studied and found to affect fish growth and overall population health. Growth is a good tell of a fisheries health, it can show foraging success, size selective mortality, and spawning success (Watson et al. 2022). By looking at the growth of fish, biologists can predict what events will hinder fish growth and which ones will accelerate it. Lakes with high levels of dissolved organic carbon are a good predictor of a highly productive lake with accelerated fish growth (Benoît et al. 2022). The Lakes with high production are typically shallow, eutrophic lakes, which typically are also lakes that winter kill. In theory a lake after a winter kill could be a lake that is perfect for growing fish fast, because there would be less competition, less predators, and the ideal conditions for accelerated growth.

Walleye *Sander vitreus* is a very sought-after game fish, and they are commonly stocked fish, and a lot of time and money is put into their management understanding how these fish operate can save costs and time. Population dynamics in all aquatic systems are governed by reproduction rates (Pepin 2024). In most lakes in Minnesota, natural reproduction does not occur for walleye, or not enough happens to sustain a healthy population of walleye. This is not just a problem in Minnesota it is a problem in multiple states. A walleye stocking initiative was passed in the Wisconsin legislature due to the reduced natural recruitment of walleye (Elwer et al. 2023). Every year In Minnesota there are a variety of fish stocked in the lakes. According to the Minnesota DNR, each year the state spends around 7.5 million dollars on stocking fish, and 3.7 million of those dollars are spent on just stocking walleye. These walleye are spread out into

around 900 lakes. One of the biggest challenges with stocking fish is dealing with mortalities (Mohammed et al. 2018). Mortality rates of young of year fish can be affected by a variety of things, examples being predation, food availability, disease and water quality. In one winter kill lake, the average size of *Daphnia* increased, which increased the food source for the young of year roach (Ruuhijärvi et al. 2010). There are also some special variables that get added to the mortality rate when stocking is involved, including transport and dispersal (Pepin 2024). By choosing lakes that are more suitable for walleye stocking, it increases the stocking success and reduces the cost.

The objective of this study was to determine the effectiveness of walleye stocking in lakes that experience winter kill by analyzing walleye size structure and population density before and after winter kills. By analyzing years of data provided by the DNR, lakes that experience winter kill can be looked into deeper, to give insight into what affects these lakes that commonly experience winter kill. Such information could be important for making decisions on walleye stocking numbers and which lakes to stock them in. There is a lot of time and money that goes into annual walleye stocking, and if it is possible to make it more effective in any way, it is greatly worth considering.

METHODS

The data for this study was all taken from standard survey data from the Detroit Lakes, Minnesota Department of Natural Resources (DNR) Fisheries Department (MNDNR 2026). The Detroit Lakes Fisheries Department utilizes gillnets with varying mesh sizes and trap nets to sample fish populations on the lakes in their designated region. The DNR surveys these lakes every few years, depending on the size of the lake. The four lakes chosen for this study were specifically selected to fit a criterion. The criteria for lake selection were that a lake had to have a history of being consistently stocked with walleye at least once every 3 years and had to have had a winter kill during a more recent year than the year 2010. The lakes ranged from as big as 3147 acres to as small as 237 acres, and the deepest was 19 feet.

The walleye catch per unit effort (CPUE) data and walleye average weight data were pulled from every standard survey ever done on those lakes since they have been stocked with walleye. The CPUE was the average amount of walleye caught in each gill net, and the average weight was the average weight of each fish pulled out of the gillnet. The oldest survey used was from 1980, and the newest was done in 2025. The survey closest to the year after the winter kill was compared to the averages of all the surveys done on that lake before the winter kill by running a t-test on Program R. This was done for all four lakes, and one of the lakes had two winter kill years after the year

2010, so the data for those two years was averaged and then run in the t-test. An alpha of 0.05 was chosen for this experiment. The average CPUE of walleye based on the data from the standard gillnet catches from each lake, and the average size of walleye caught in the standard gillnets, was then put in a bar graph with the winter kill numbers.

RESULTS

Across the four study lakes, pre-winter kill walleye CPUE differed among lakes and averages are shown, Cross $\bar{X} = (13.8) \pm SD = (17.3)$, Shell $\bar{X} = (3.4) \pm SD = (2.3)$, Waboose $\bar{X} = (4.8) \pm SD = (3.0)$, Whitefish $\bar{X} = (1.8) \pm SD = (1.7)$. The CPUE did not significantly differ between pre- and post-winter kill samples in Cross ($p = 0.15$), Shell ($p = 0.17$), and Waboose ($p = 0.54$). In contrast, Whitefish showed significant change in CPUE following the winter kill event ($p = 0.01$). Whitefish Lake had a very drastic increase in CPUE after the winter kill. Whitefish's average CPUE was 1.75 walleye per gill net, but in the survey following the winter kill, the CPUE was 11.33 walleye per gill net.

Average walleye weight showed different patterns, with pre-winter kill weight (lbs.) averaged as shown, Cross $\bar{X} = (2.4) \pm SD = (1.2)$, Shell $\bar{X} = (1.1) \pm SD = (0.6)$, Waboose $\bar{X} = (1.6) \pm SD = (0.5)$, Whitefish $\bar{X} = (2.7) \pm SD = (1.4)$. Average weight did not significantly differ before and after winter kill in Cross ($p = 0.40$) or Whitefish ($p = 0.21$). However, Shell and Waboose both exhibited significant differences in mean weight ($p < 0.01$ for each). Shell Lake's typical average walleye was 1.1 pounds, but in the survey following the winter kill, it was 2.5 pounds. Waboose Lake's typical average walleye was 1.6 pounds, but in the survey following the winter kill, it was 2.84 pounds.

These summary statistics provide the baseline for evaluating whether winter-kill events and subsequent stocking altered walleye abundance or size structure.

Across the four lakes that were studied, the walleye CPUE did not show consistent statistically significant changes following winter kills within the lakes to determine an effect (Figure 1). Similarly, across the four lakes that were studied, the average walleye weight surveyed in post-winter kill surveys did not show a consistent statistically significant difference compared to the average of a typical year (Figure 2).

Overall, the analysis showed that walleye stocking following winter kill events did not consistently alter walleye abundance or size structure from the historical averages in the 4 lakes studied. Despite the substantial ecological disturbance caused by winter hypoxia, on average, stocked walleye populations returned to levels comparable to historical

norms, suggesting that winter kill does not consistently help with walleye stocking.

DISCUSSION

Walleye stocking is a common practice in many Minnesota Lakes. Walleye stocking does occur in lakes that are prone to winter kill, and there is an idea that after a winter kill, there could be an increase in the success of the walleye stocking. Yet the results from this study show that post-winter kill stocking did not consistently alter walleye abundance or size structure across the four lakes examined. Despite the severe ecological disturbance caused by winter hypoxia, where dissolved oxygen declines under ice until fish can no longer survive, as described in the introduction. The walleye populations generally returned to levels similar to long-term historical averages.

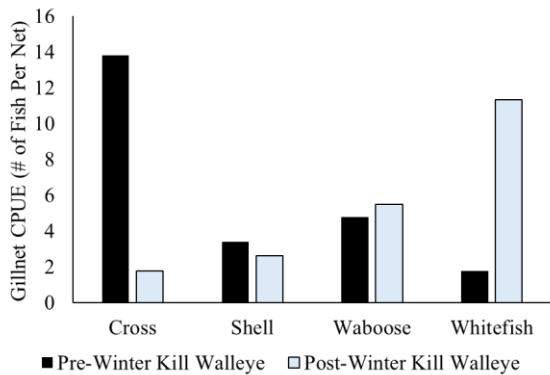


Figure 1. Catch per unit effort (CPUE) historical data, compared to CPUE data from the survey following the winter kill. Data was collected from the MN DNR Lake Survey Data (MNDNR 2026).

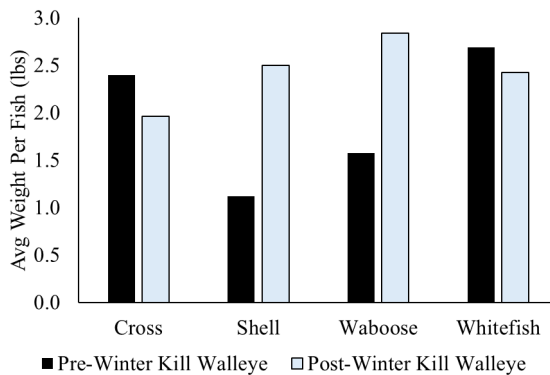


Figure 2. Average weight per walleye surveyed historical data, compared to average weight per walleye surveyed data from the survey following the winter kill. Data was collected from the MN DNR Lake Survey Data (MNDNR 2026).

Several ecological mechanisms may explain why stocking did not produce consistent changes. First, winter-kill lakes are typically shallow, highly productive systems, and productivity rebounds quickly once ice-off occurs. As noted earlier, the lakes that experience winter kill will replenish the dissolved oxygen in the lakes rather quickly once the ice is off,

if they are highly productive lakes. High productivity can accelerate growth and recruitment of surviving fish, reducing the relative influence of stocked individuals. This aligns with findings from Ruuhijärvi et al. (2010), who observed that fish communities in a Finnish winter-kill lake naturally returned to pre-kill conditions within a few years.

Second, the lack of strong stocking effects may reflect the complexity of walleye population dynamics. Growth and survival are influenced by density, temperature, prey availability, and size-selective mortality (Watson et al. 2022). Even in lakes where winter kill temporarily reduces competition, these factors may limit the success of stocked fish. Additionally, mortality associated with transport, dispersal, and early life-stage vulnerability can reduce stocking efficiency (Pepin 2024). One of the biggest challenges with stocking fish is dealing with mortalities, and these losses may offset any potential benefits of stocking after a winter kill.

The one notable exception in this study was Whitefish Lake, where CPUE increased dramatically following the winter kill. This suggests that in some systems, winter kill may create a temporary ecological window that could reduce predation, reduce competition, and increase abundant prey, which allows stocked walleye to thrive. However, because this pattern was not observed in the other lakes, it appears to be a lake specific rather than a generalizable outcome.

The mixed results for average walleye weight further support the idea that winter kill effects are context dependent. Shell Lake and Waboose Lake showed significant increases in average weight following winter kill, while Cross and Whitefish did not. Increased growth in some lakes may reflect reduced competition for prey, consistent with the idea that winter kill can temporarily enhance growth conditions. In one winter kill lake, the average size of *Daphnia* increased, which increased the food source for the young of year roach (Ruuhijärvi et al. 2010), illustrating how lower fish densities can shift lower trophic levels in ways that benefit growth.

Overall, the findings suggest that winter kill alone does not guarantee improved stocking outcomes for walleye. Instead, lake-specific ecological factors, such as productivity, prey availability, predator communities, and historical stocking intensity, likely play a larger role in determining stocking success. Given the substantial financial investment in walleye stocking, identifying which lakes are most likely to benefit from stocking remains an important management priority.

Future research should examine additional variables such as zooplankton abundance, predator densities, water clarity, and dissolved organic carbon

levels, which have been linked to fish growth and productivity (Benoit et al. 2022). Incorporating these ecological indicators into stocking decisions may help managers better predict when stocking after a winter kill will meaningfully influence walleye populations.

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