Report on Carp Management Activities in the Cedar Chain of Lakes in 2023
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Summary

During the summer and fall of 2023, Carp Solutions conducted assessments of common carp (*Cyprinus carpio*) populations in the Cedar Chain of Lakes. Electrofishing surveys were conducted in Cedar Lake, Swartout, Albion and Henshaw. No carp were captured during these surveys in Albion and Henshaw. Two carp were seen but not captured in Cedar. Relatively high catches were observed in Swartout where 28 adult and 30 juvenile carp were captured. Using the catch per unit of effort data, the population in Swartout was estimated at 3,839 (90% CI: 3,670-4,008) with a biomass density of 122 kg/ha (90% CI: 103-141 kg/ha). Aging analysis was also conducted in Swartout, for which additional 43 carp were collected using boat electrofishing. This analysis showed that the population was dominated by relatively young, 2-5 year old carp, with the average age of 4.3 years old. A pilot of baited box netting was attempted in Swartout Lake, but the carp showed no interest in the bait (possibly due to extensive food resources as evidenced by very fast carp growth rates in this lake) and this effort was abandoned.

Methods and Results

Boat Electrofishing Surveys

During the summer of 2023, Carp Solutions conducted three boat electrofishing surveys on Albion, Cedar, Henshaw, and Swartout Lakes. The purpose of these surveys was to generate a population estimate of common carp in each lake using the methods of Bajer and Sorensen (2012). Each survey consisted of three to five transects, consisting of approximately twenty minutes of effective electrofishing time. When current was passed through the water, stunned fish would float to the surface where the carp were collected using dip nets. All collected carp were measured for length, had their left pelvic fin clipped, were tagged with a Passive Integrated Transponder (PIT) tag, and released back into the water.

No carp were captured or seen in the surveys of Albion and Henshaw Lakes. The dates and electrofishing time for these lakes are shown in Tables 1 and 2. During the first and third surveys of Cedar Lake, a single carp was seen each time, but was not close enough to be stunned, so no carp were captured in these surveys. The data for the surveys of Cedar Lake is shown in Table 3. However, in Swartout, a total of 28 adult and 30 juvenile carp were captured in the surveys. The data for adult carp captured in the surveys, along with the population and biomass density estimates is shown in Table 4. The carp population in Swartout was estimated to be 3,839 (90% CI: 3,670-4,008) with a biomass density of 122 kg/ha (90% CI: 103-141 kg/ha). The catch data for the juvenile carp is shown in Table 5. Due to low survival of juvenile carp, they were not implanted with PIT tags or clipped. Figure 1 shows the length distribution of these carp, both adult and juvenile. At least three size classes are clearly visible in this graph.

During all of these surveys, fish species other than carp were also noted, but not netted or measured. On Albion Lake, bluegill, central mudminnow, fathead minnow, golden shiner, white sucker, and yellow bullhead were observed. During the surveys of Cedar Lake, black and yellow bullheads, black and white crappies, bluegill, bowfin, largemouth bass, walleye, and yellow perch were seen. In Henshaw Lake, only very small numbers of black and yellow bullhead were seen, indicating that the lake most likely experienced a nearly complete winterkill in the winter of 2022-2023. For Swartout Lake, black and brown bullhead, black crappie, bluegill, bowfin, fathead minnow, green sunfish, largemouth bass, and pumpkinseed were observed, all in relatively low numbers. With the exception of Cedar Lake, all the lakes appeared to have limited numbers and relatively small sized native fishes. By contrast, Cedar Lake had a fairly diverse population of native fishes with varied sizes. However, all of these observations are anecdotal since no quantitative data was collected on species other than carp, which was the focus of those surveys.

Table 1: Albion Lake electrofishing survey data by date. No carp were captured in any of the surveys. CPUE stands for Catch Per Unit Effort, in units of carp per hour of shock time.

Date	Transects	Carp caught	Time shocking (min)	CPUE
8/28/2023	4	0	80	0.00
8/31/2023	4	0	80	0.00
9/13/2023	4	0	80	0.00
Average	4.00	0	80	0.00
Total	12	0	240	

Table 2: Henshaw Lake electrofishing survey data by date. No carp were captured in any of the surveys. CPUE stands for Catch Per Unit Effort, in units of carp per hour of shock time.

Date	Transects	Carp caught	Time shocking (min)	CPUE
6/29/2023	5	0	100	0.00
7/10/2023	3	0	56	0.00
7/20/2023	4	0	80	0.00
Average	4.00	0	79	0.00
Total	12	0	236	

Table 3: Cedar Lake electrofishing survey data by date. No carp were captured in any of the surveys. CPUE stands for Catch Per Unit Effort, in units of carp per hour of shock time.

Date	Transects	Carp caught	Time shocking (min)	CPUE
7/21/2023	4	0	81	0.00
7/26/2023	4	0	80	0.00
8/2/2023	4	0	84	0.00
Average	4.00	0	82	0.00
Total	14	0	285	

Table 4: Swartout Lake electrofishing survey data for adult carp by date. CPUE stands for Catch Per Unit Effort, in units of carp per hour of shock time. Only adult carp are shown in this table.

Date	Transects	Carp caught	Time shocking (min)	CPUE	Average Length (inches)	Population Estimate	Biomass Density Estimate (kg/ha)
7/26/2023	4	9	82	6.55	25.1	4,018	114
8/2/2023	4	8	81	5.91	26.3	3,662	118
8/8/2023	4	11	106	6.23	28.2	3,836	151
Average	4.00	9	90	6.23	26.1	3,839	122
Total	12	28	270				
SE				0.18	0.91	103	12
Lower 90%				6	25	3,670	103
Upper 90%				7	28	4,008	141

Table 5: Swartout Lake electrofishing survey data for juvenile carp by date. CPUE stands for Catch Per Unit Effort, in units of carp per hour of shock time.

Date	Transects	juvenile Carp caught	Time shocking (min)	CPUE	Average Length (inches)
7/26/2023	4	0	82	0.00	NA
8/2/2023	4	8	81	5.91	4.3
8/8/2023	4	22	106	12.45	4.6
Average	4.00	10	90	6.23	26.1
Total	12	30	270		

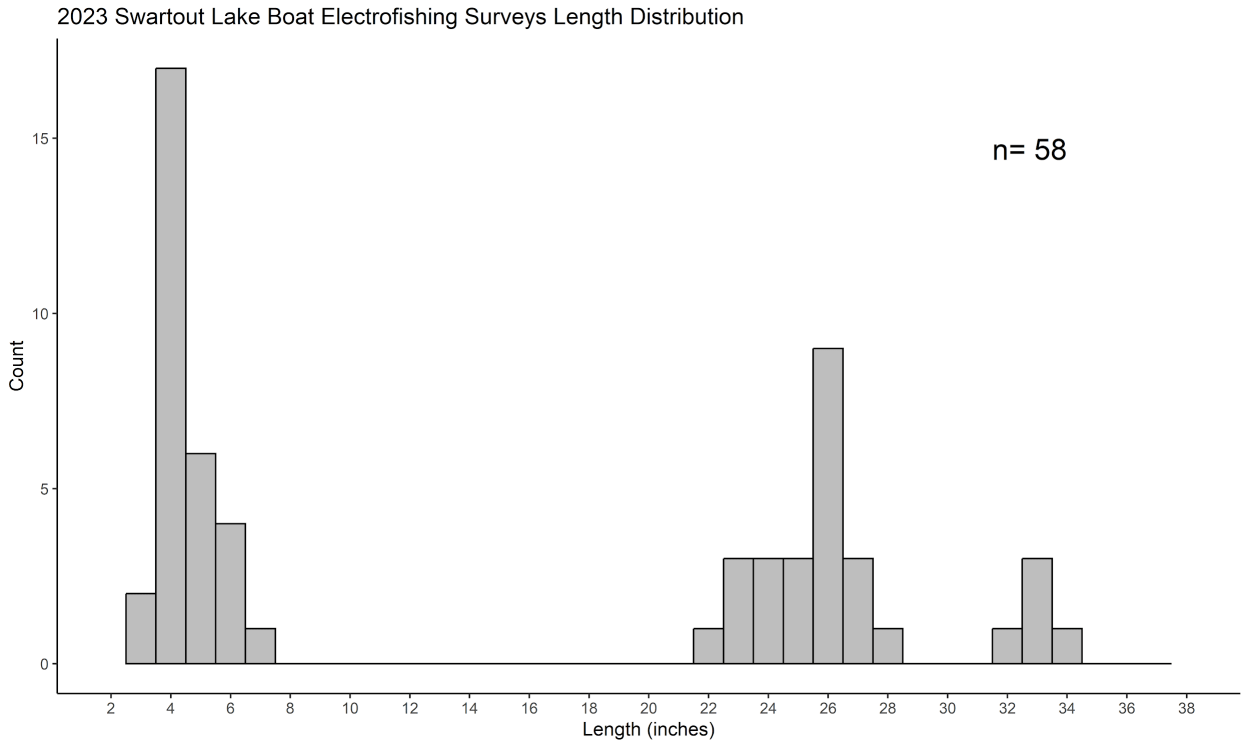

Figure 1: Length distribution of adult (n=28), and juvenile (n=30) carp captured in Swartout Lake boat electrofishing surveys. The red line represents the median length.

Box Netting

In order to test the removal of carp using box nets in Swartout Lake, two nets and a PIT antenna system were installed in the lake on August 22 (see map in Figure 2). These nets were baited with cracked corn, which was checked and occasionally changed through September 19. During this time, no bait was consumed and not a single tagged carp was detected by the PIT antennas. Due to the apparent lack of

interest by carp in the bait, the nets and PIT system were uninstalled on October 4 and no carp removal was conducted.

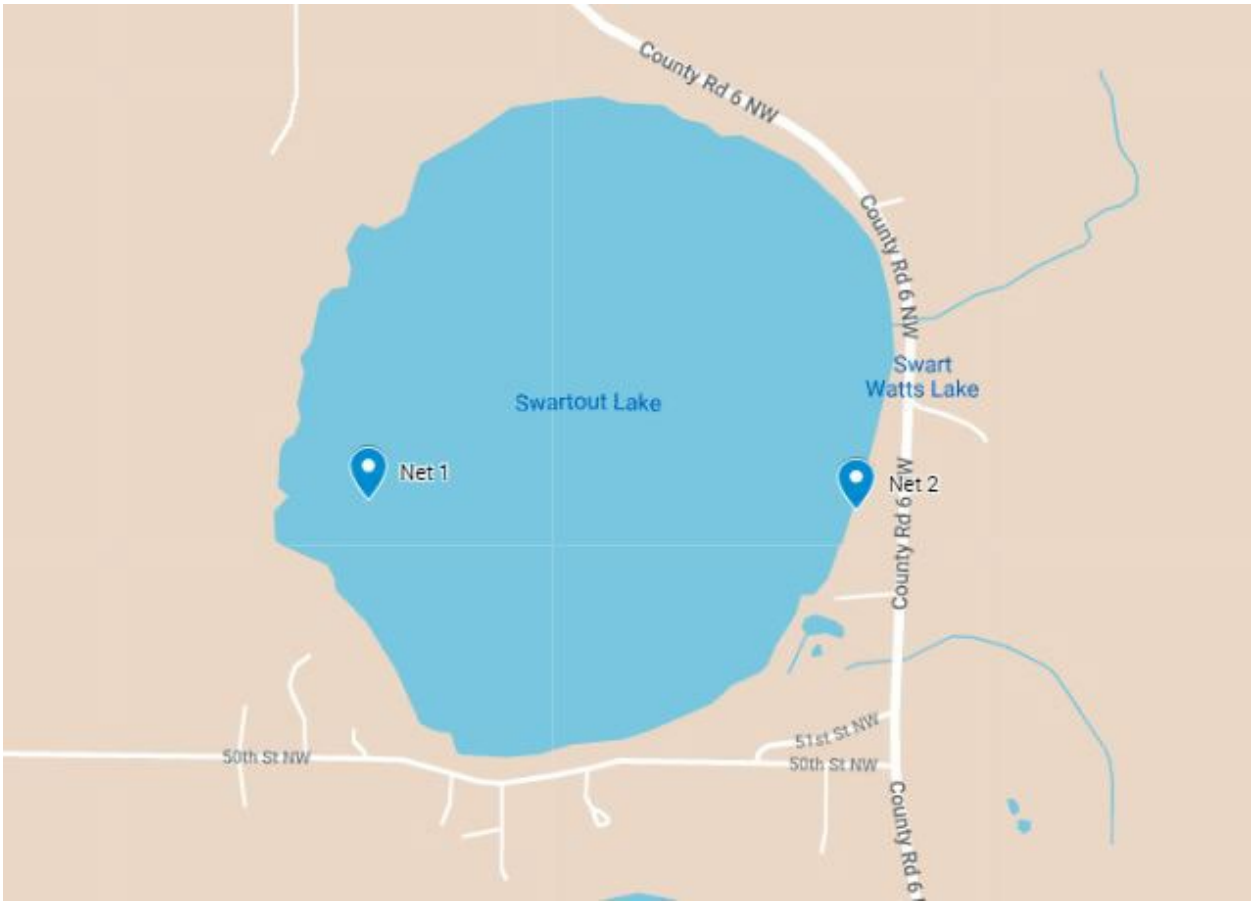

Figure 2: Map of the two box net sites in Swartout Lake.

Trap Netting

Originally, it was planned to conduct trap netting surveys in Illsley Wetland, WMA Wetland, and Albion Wetland. However, due to a combination of low water and thick cattail growth making the ponds unsuitable for carp recruitment and inaccessibility, the trap netting surveys in these wetlands were not carried out. PIT antennas in the streams leading to the wetlands in the spring of 2024 will provide information on carp migrations into the wetlands in lieu of trap netting surveys in the wetlands themselves.

Carp Aging

In order to examine the patterns of recruitment in the carp population of Swartout Lake, it was originally planned to remove, embed, and section the otoliths from 50 carp captured in the box nets in the lake. Due to the lack of success of the box nets, we attempted to capture the 50 carp using boat electrofishing. Two days of boat electrofishing were carried out on October 5 and 17 where 43 carp were captured. After being euthanized, these carp were measured for length and weight before their otoliths

were removed. From the 43 carp collected for aging, 42 pairs of otoliths were removed. Later on, these otoliths were embedded in epoxy and sectioned using a jewelers saw. These sections were then read under a microscope to count the annuli of the otolith and determine their age.

The length and weight measurements taken from the carp that were aged show some important characteristics of the carp population of Swartout Lake. The linear relationship between the length and weight of the collected carp is shown in Figure 3. Weights of carp ranged from 0.17 lb for juvenile carp to a maximum of 27.3 lb for adult carp. The mean weight was 10.6 lbs and most carp weighed between 7 and 11 lbs.

The aging analysis revealed a very young population of carp in Swartout Lake. Ages ranged from 0-14 with an average age of 4.3 years and a median age of 3.0 (Figure 6). Over 90% of the carp aged were under 10 years old. The multiple and relatively young age classes of carp indicate frequent and recent recruitment in Swartout Lake, while the presence of juvenile carp indicates that at least some of this recruitment may be occurring in Swartout Lake itself. Based on the aging data, it appears that carp recruitment has been occurring nearly annually over the last decade.

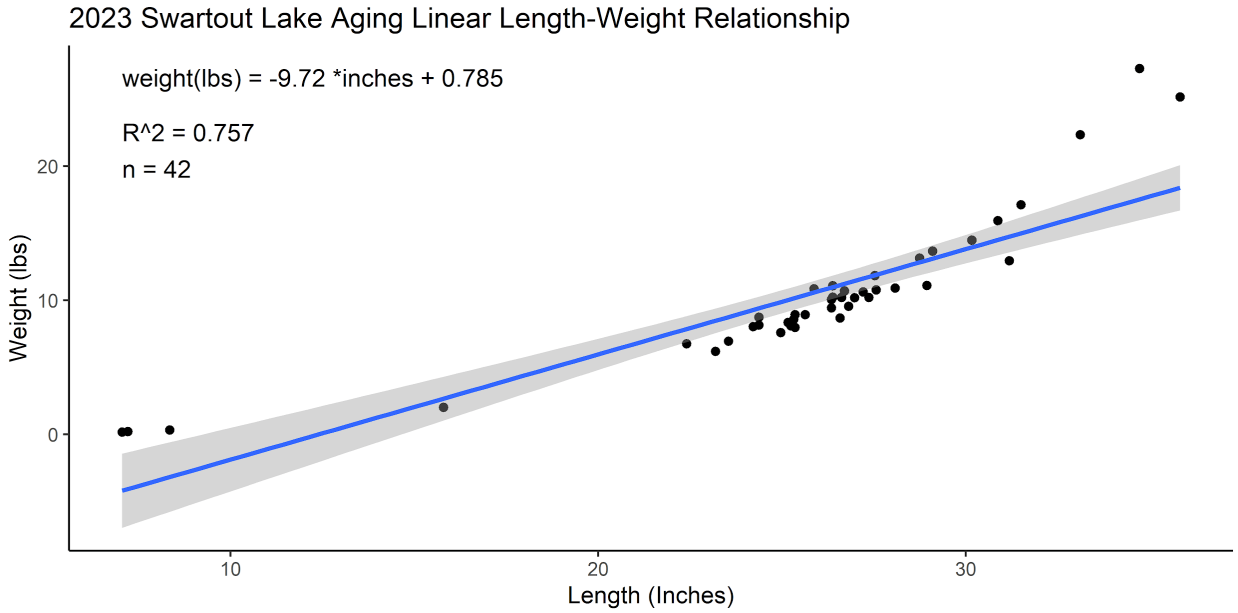

Figure 3: Relationship between the lengths and weights of carp captured for aging.

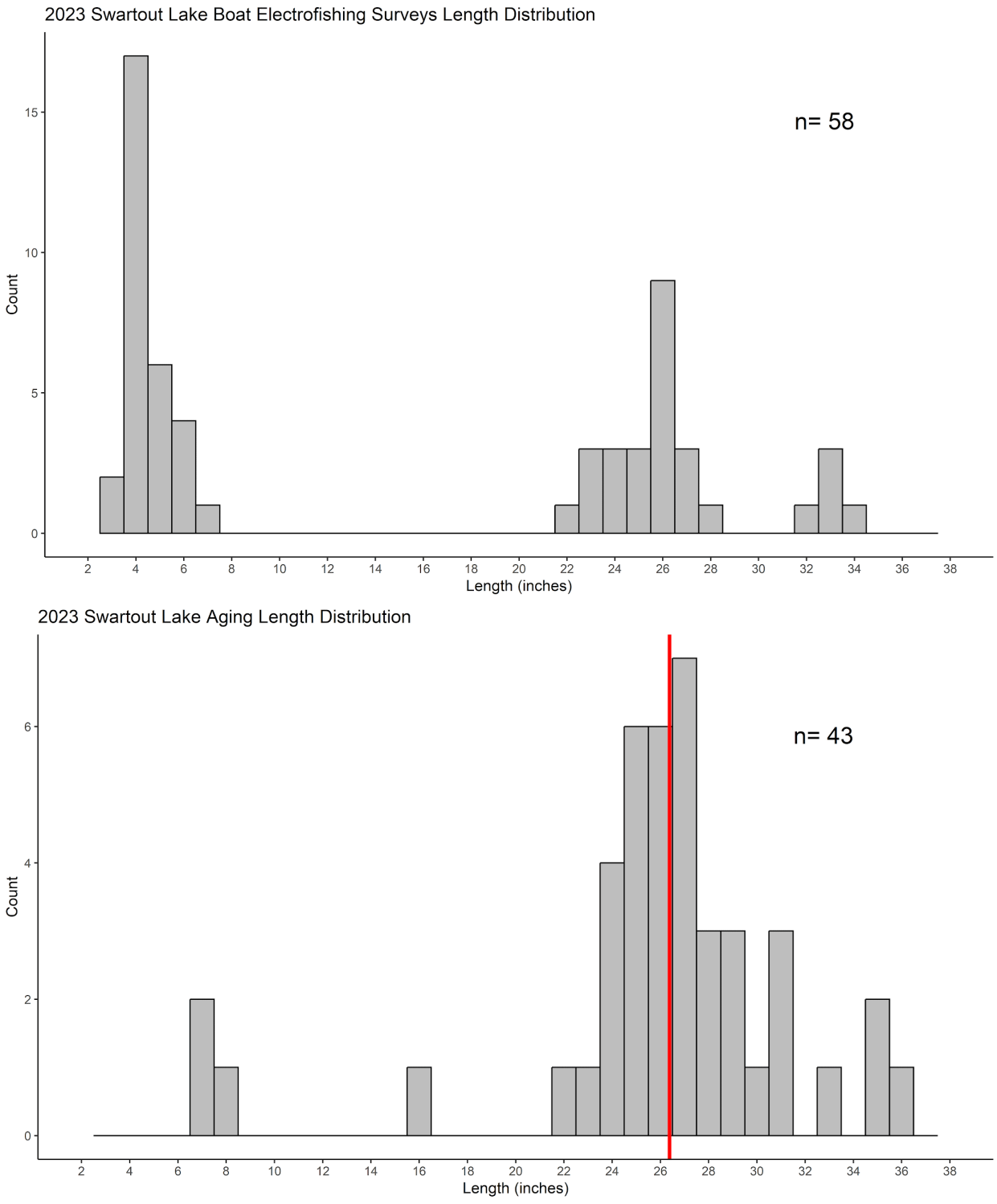

Figure 4: Comparison of length distributions of carp captured during the boat electrofishing surveys (top) and collected for aging (bottom).

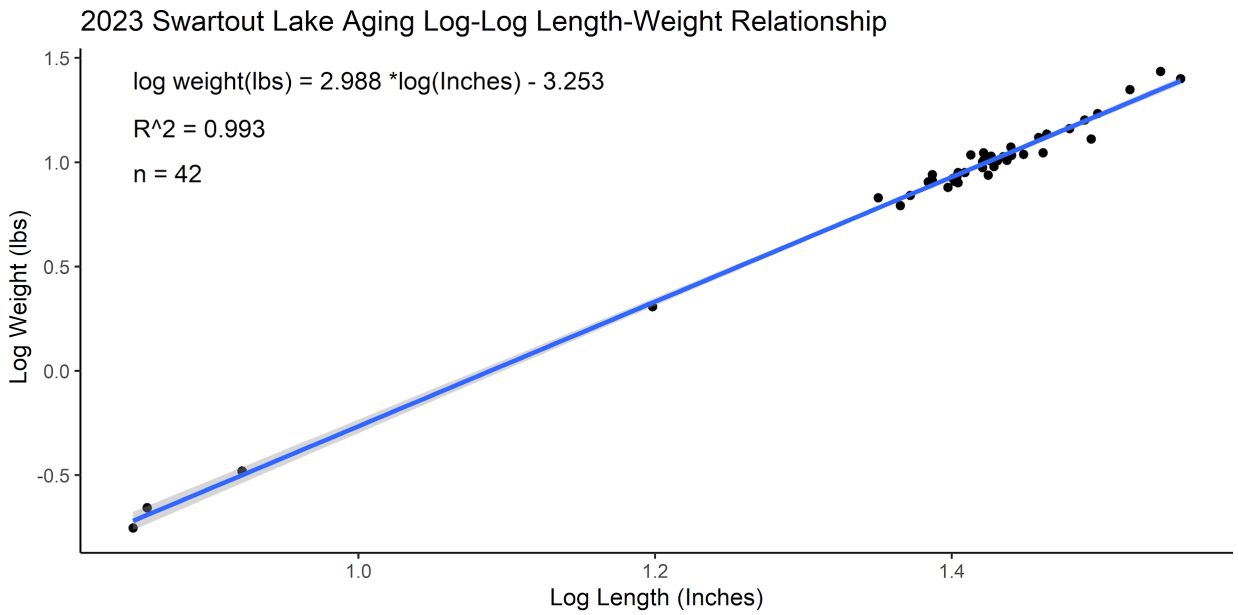

Figure 5: Log-transformed length-weight scatterplot for the carp collected for aging in Swartout Lake. The equation can be used to estimate carp weights from this lake using the equation: weight (lbs)=$10^{-3.253}$ x inches$^{2.988}$

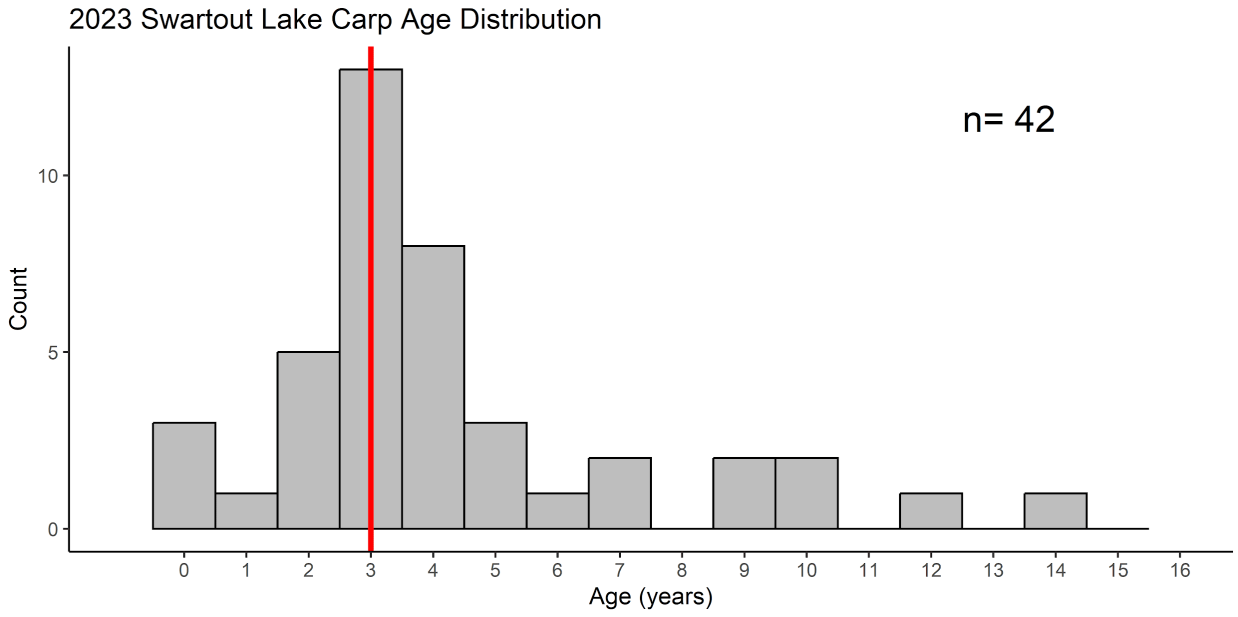

Figure 6: Histogram of the determined ages of carp collected in Swartout Lake.

Discussion

Carp Population Size and Structure

The four lakes studied this year reveal very different carp populations. Since no carp were captured in Albion, and Henshaw Lakes, these lakes currently do not appear to have significant, if any, carp populations. This may be a result of recent winterkills that eliminated resident carp populations. We anticipate that both Henshaw and Albion may function as nurseries for carp from Swartout and Cedar lakes, if adult carp can access them during the spawning season. As such, carp populations can increase quickly in those systems following a successful spawning event. This is especially likely given that native fish populations that could control the survival of carp eggs and larvae, such as bluegills, are sparse and most likely unstable in these lakes due to periodic winterkills.

Cedar Lake appears to have a very sparse carp population. It is likely that the abundant native fish populations, especially bluegill sunfish, successfully limit the recruitment of carp in the lake so that the carp population remains at a very low level. Bluegill in particular have been found to nearly completely limit carp recruitment by consuming the unguarded eggs and larvae of carp so that even when they spawn, only an insignificant number reach reproductive age (Poole & Bajer, 2019). Thus, for the moment at least, carp are not a significant concern in Cedar Lake.

On the other hand, the data from the boat electrofishing surveys show the carp population in Swartout Lake could cause water quality problems and has the potential to increase rapidly, given the relatively strong production of young and rapid individual growth rates. Research has shown that carp biomass densities above 100 kg/ha significantly affect water quality (Bajer et al. 2016). In particular, once the biomass density gets above 100 kg/ha, aquatic vegetation cover and species richness decreases sharply (Figure 8). From the boat electrofishing surveys, the carp population in Swartout Lake was estimated to be 122 kg/ha (90% CI: 103-141 kg/ha), so slightly over this ecologically damaging threshold. It is important to note that this estimate does not include juvenile carp, since their populations fluctuate too much to accurately include in this estimate. Further management, including removal of carp, is recommended for Swartout Lake.

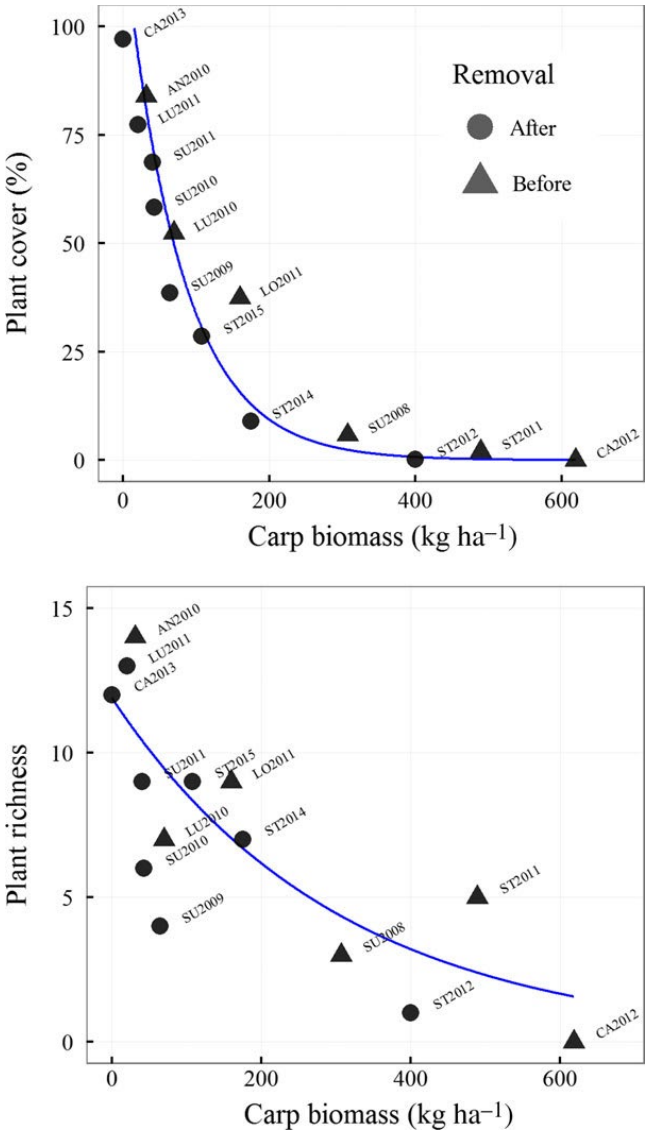

Figure 8: Relationship between common carp biomass and aquatic macrophyte cover in the littoral (top) and plant richness (bottom) in small Minnesota lakes. From Bajer et al. 2016.

Carp Removal Methods

Current common carp removal methods include baited box nets, commercial seining, and removal in streams during spawning runs. A pilot test of box netting did not turn out to be successful due to the lack of interest in bait. Limited test baiting could be tried at other times of year, especially in the early summer after the carp spawn, roughly from mid-June to mid-July, and if bait consumption occurs, removal with baited traps could be attempted. But other removal options might be more successful in Swartout. Swartout has a history of carp removal with commercial seine nets. Also, PIT antennas that will be used in the spring of 2024 will reveal whether there are significant spawning migrations out of Swartout. If such migrations occur, removal could be conducted using temporary barriers and electrofishing systems.

Carp Aging

The majority of carp in Swartout Lake were under 7 years old with an average age of only 4.3 years old and a median of 3 years old. This is a remarkably young population of carp. For comparison, carp aged in the Clearwater River Chain of Lakes (Betsy, Caroline, Louisa, Marie, Scott, and Union Lakes) were dominated by individuals that were 10-40 years old, which is typical for many metro carp populations that inhabit deeper, ecologically stable lakes. Despite the young age, the size of the carp in Swartout Lake was large; a 3 to 4 year old carp was ~ 26-28” in length. This indicates a very rapid growth rate. The young age structure of carp in Swartout suggests that a) carp successfully produced year classes in recent years, and b) natural mortality rates of carp are relatively high (very few carp were older than 10 years old). The rapid individual growth rate and high mortality rates of carp might be partially attributed to avian predation and periodic partial winterkills often seen in shallow hypereutrophic lakes. Pelicans were observed during the surveys and cormorants also have a large colony on the lake. Both avian predation and winterkills could eliminate large portions of the carp population and drive down competition for food resources leading to rapid growth of the remaining individuals.The winterkill events would also disrupt native fish species such as hypoxia-sensitive bluegills, increasing the survival of juvenile carp and opening possible ecological space for carp within the lake. Lowered populations of bluegills limit the potential for natural biological control of carp populations via predation on carp eggs and larvae (Poole & Bajer, 2019). The low competition for natural food resources in the lake might explain the lack of bait consumption in the attempted box netting pilot project.

PIT antenna sites

In the spring of 2024, it is planned to place five PIT antennas throughout the system to monitor for carp spawning migrations. PIT antennas will be placed in the stream between Cedar Lake and Ilsley Wetland, the stream between Illsley Wetland and Swartout Lake, the stream between the WMA pond and Swartout Lake, the stream between the WMA Pond and Henshaw Lake, and the stream between Swartout and Albion Lakes. To evaluate the effectiveness of the barriers between Swartout Lake and the WMA Pond and Illsley Wetland and Cedar Lake and Illsley Wetland, PIT antennas will be installed on both sides of the barriers to detect whether carp are able to cross the barriers. Because no carp were caught in Cedar Lake, a remote access camera will be placed below the barrier. When carp aggregations are observed at the barrier, backpack electrofishing will be used to capture carp so that they can be implanted with PIT tags and released back into the stream. The 28 PIT tagged carp already present in Swartout Lake will provide a sufficient sample size to determine if the carp from that lake can cross the barriers into Illsley Wetland and WMA Pond. Although no carp were seen or

tagged in Albion and Henshaw Lakes, PIT antennas between these lakes and Swartout Lake will show the extent to which carp migrate from Swartout into these other lakes, potentially spawning in them and at least temporarily establishing a population there.

Management Recommendations

Carp management and removal is recommended in Swartout Lake, where the biomass density exceeds 100 kg/ha and carp reproduction occurs frequently. General principles of Integrated Pest Management should be followed and focus should be placed on:

- Determining processes that drive successful carp reproduction. This can be addressed by conducting boat electrofishing or small-mesh trapnet surveys in Swartout and connected probable nursery lakes (Albion and Henshaw Lakes) annually, at least initially.
- Monitoring carp movement patterns between Swartout and potential nursery lakes (Albion, Henshaw, WMA Wetland, Illsley Pond) during the spawning season using PIT systems - already planned for spring 2024.
- If significant spring migrations are observed, they could be targeted for removal in the future.
- Seasonal physical barriers need to be maintained to prevent carp access to nursery sites and their performance assessed with PIT systems - already planned for 2024.
- If presence of juvenile carp is detected in nursery lakes, their dispersal patterns can also be assessed using the PIT systems, and dispersal barriers can be implemented for juvenile carp if needed (e.g. low-voltage electric barriers). No need for dispersal barriers for juvenile carp exists for 2024, and this need should be re-examined at the end of the 2024 field season.
- Opportunistic removal of carp with commercial seines should occur in Swartout Lake as feasible. If possible, removed carp should be scanned for PIT tags and their sample measured for length.
- Continued surveys of carp biomass and abundance are recommended in Swartout Lake using boat electrofishing, initially annually, then every second or third year. In particular, these surveys would be valuable to aid in removal efforts through the continued implantation of PIT tags and monitoring of recruitment success.
- Since the population was young, periodic aging of carp (every two to four years) would provide valuable information on the progress of carp removal, carp recruitment and mortality.

Citations

Bajer, P. G., & Sorensen, P. W. (2012). Using boat electrofishing to estimate the abundance of invasive common carp in small Midwestern lakes. North American Journal of Fisheries Management, 13 817-822.

Bajer, P.G., Beck, M.W., Cross, T.K., Koch, J.D., Bartodziej, W.M. and Sorensen, P.W., 2016. Biological invasion by a benthivorous fish reduced the cover and species richness of aquatic plants in most lakes of a large North American ecoregion. Global Change Biology, 22(12), pp.3937-3947.

Poole, J. R., & Bajer, P. G. (2019). A small native predator reduces reproductive success of a large invasive fish as revealed by whole-lake experiments. PloS one, 14(4), e0214009.