
Final Project Report May 1, 2017

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Scott Watershed Management Organization

# Estimating the abundance and biomass of common carp in Cedar Lake and developing a sustainable management strategy for carp using integrated pest management strategies

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## Introduction

Cedar Lake is a relatively shallow and productive lake in Scott County, Minnesota, and like many systems in the region could be susceptible to the impact of the common carp. The common carp (or 'carp') can have severe impacts on water quality in lakes due to their tendency to root in lake sediments while searching for food, which releases sediment-bound nutrients into the water column, increases sediment re-suspension and creates favorable conditions for algal blooms. The carp can also uproot aquatic vegetation, which destabilizes lake ecosystems even more. Research shows that the impacts of carp on lakes are biomass-dependent. Several whole-lake manipulations suggest that carp are not damaging to lake ecosystems as long as their biomass does not exceed 100 kg/ha (Bajer et al. 2009). This value is commonly used as a management goal in carp management efforts. Unfortunately, in many lakes in south-central Minnesota, carp biomass commonly reaches 300-500 kg/ha (Bajer and Sorensen 2012).

Reports on carp density in Cedar Lake are somewhat conflicting. Electrofishing surveys conducted by St Mary's University indicated low densities of carp. In addition, informal reconnaissance on the lake by Carps Solutions on two occasions in 2015 suggested that carp may not be at densities above the threshold of 100 kg/ha. Typically, high densities of carp (> 100 kg/ha) are associated with very low abundance of rooted aquatic vegetation in lakes, and the fact that much of Cedar Lake is at times covered by curlyleaf pondweed suggested that carp biomass might be lower than 100 kg/ha. However, the 2011 TMDL assessment suggested that carp biomass in Cedar Lake might be significantly higher (approximately 400 pounds/acre), based on the estimates of internal phosphorous loading. Further, carp bow-fishing tournaments conducted each spring result in capturing numerous large carp.

It was important for Scott WMO to determine the biomass of carp in Cedar Lake to facilitate further efforts to improve water quality in this lake in a cost-effective manner. It was also necessary to determine whether carp, or other processes, are responsible for the high internal loading of phosphorus suggested by the 2011 TMDL report. In this report, we summarized our results to address four objectives: 1) Develop a population/biomass estimate for carp in Cedar Lake 2) Assess spatial use of Cedar Lake by carp to identify areas where they aggregate and may be vulnerable to removal 3) Assess the age structure of carp in Cedar Lake to determine recruitment history 4) Recommend goals/strategies to reduce carp biomass in Cedar Lake to a level that will protect habitat and improve water quality.

## Objective 1: Develop a population and biomass estimate for carp in Cedar Lake

### Methods

To gain an initial assessment of carp population and decide if the project should continue past this initial phase, we conducted five boat electrofishing surveys in Cedar Lake following protocols developed by Bajer and Sorensen (2012). These surveys were conducted in the summer of 2016 (Table 1). For each survey, we counted the number of captured carp and calculated the mean catch per unit of effort (CPUE; carp/h). The CPUE values were used to generate preliminary estimates of carp density and biomass using an equation developed by Bajer and Sorensen (2012). In addition, because electrofishing allows for capturing carp in good physical condition, 20 of the captured carp were also implanted with radiotransmitters and released to facilitate Objective 2 (below). Young-of-year carp noted while conducting elctrofishing surveys were noted to inform Objective 3 (below).

Because the initial electrofishing CPUEs were relatively high (see below), the project progressed to its subsequent phase that involved estimating carp abundance and biomass using mark-recapture analyses, which are more accurate than boat electrofishing. We solicited the help of commercial fishermen to conduct mark-recapture estimates. First, we conducted open water netting in the fall of 2016 for two days. Captured carp were measured, given a right fin clip and released. Seining was conducted in two different areas to randomize the distribution of marked carp. We then returned to the lake in April 2017 after ice out, located the aggregation of carp using telemetry, and targeted this aggregation with a seine net. Captured carp were examined for marks and removed from the lake.

We used the Chapman mark-recapture estimator (Bernard and Hansen 1991) where N = carp population, C = number of carp caught in the 2017 spring open-water seine, M = number of carp given the fin clip in the fall 2016, and R = number of carp that were captured in the spring 2017 that had fin clips from the fall 2016 (recaptures).

$$N = \frac{(C+1)\cdot(M+1)}{(R+1)} - 1$$

We also calculated standard error and 90% confidence interval appropriate for this analysis.

### Results

*Preliminary boat electrofishing surveys*

In total, we completed 17 boat electrofishing transects that covered the entire shoreline of Cedar Lake. We captured a total of 52 adult carp and 5 young of year (Table 1). The mean

CPUE was 8.9 adult carp per hour, which was relatively high. The mean carp length was 671 mm and the mean weight was 3.88 kg. The mean CPUE suggested that Cedar Lake was inhabited by approximately 14,400 carp. This estimate was sufficiently high to proceed with the more accurate abundance and biomass estimate using mark-recapture analyses (see below). 20 of the adult carp were implanted with radiotransmitters (Objective 2 below; Appendix).

Table 1. Results of electrofishing boat surveys in Cedar Lake.

| Date | Transect# | Transect minute | Adults | YOY | Adults CPUE |
|---|---|---|---|---|---|
| 8/6/2016 | 1 | 20 | 3 | 0 | 9.00 |
| 8/6/2016 | 2 | 20 | 4 | 0 | 12.00 |
| 8/6/2016 | 3 | 20 | 1 | 0 | 3.00 |
| 8/22/2016 | 4 | 33 | 6 | 1 | 10.91 |
| 9/8/2016 | 5 | 35 | 0 | 0 | 0.00 |
| 9/8/2016 | 6 | 25 | 3 | 0 | 7.20 |
| 9/8/2016 | 7 | 7 | 3 | 0 | 25.71 |
| 9/9/2016 | 8 | 20 | 5 | 0 | 15.00 |
| 9/9/2016 | 9 | 20 | 5 | 0 | 15.00 |
| 9/9/2016 | 10 | 20 | 4 | 0 | 12.00 |
| 9/9/2016 | 11 | 21 | 3 | 0 | 8.57 |
| 9/9/2016 | 12 | 9 | 0 | 0 | 0.00 |
| 9/16/2016 | 13 | 20 | 0 | 3 | 0.00 |
| 9/16/2016 | 14 | 20 | 3 | 0 | 9.00 |
| 9/16/2016 | 15 | 21 | 0 | 0 | 0.00 |
| 9/16/2016 | 16 | 20 | 2 | 1 | 6.00 |
| 9/16/2016 | 17 | 43 | 10 | 0 | 13.95 |
| **Mean** | | | | | **8.90** |

*Mark-recapture analyses*

During the two open water seines in the fall of 2016, a total of 126 adult carp were captured, marked with fin clips and released. During the open water seine in April 2017, a total of 442 carp were captured, including 8 recaptures (carp that were marked and released in the fall of 2016). These numbers allowed us to estimate that Cedar Lake was inhabited by 6,250 ± 3.100 carp. **The biomass was 75.5 kg/ha (or 67.2 lbs/acre).**

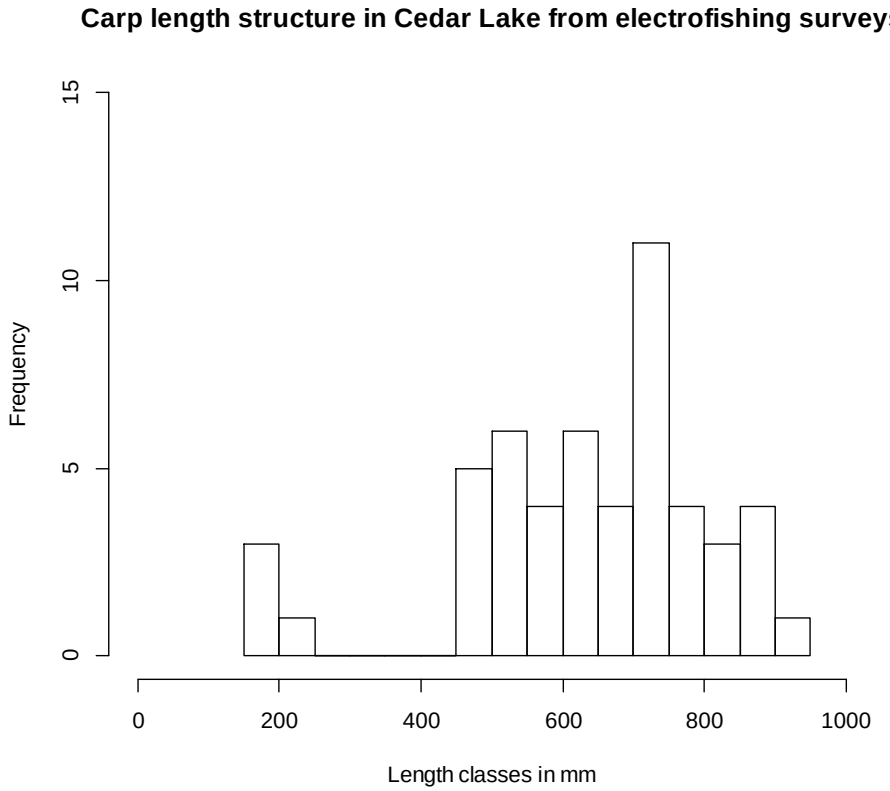



Figure 1. Top: One of 442 common carp captured in the open water seine in April 2017. Bottom: length structure of carp captured in boat electrofishing surveys.

**Objective 2: Assess spatial use of Cedar Lake by carp to identify areas where they aggregate and may be vulnerable to removal**

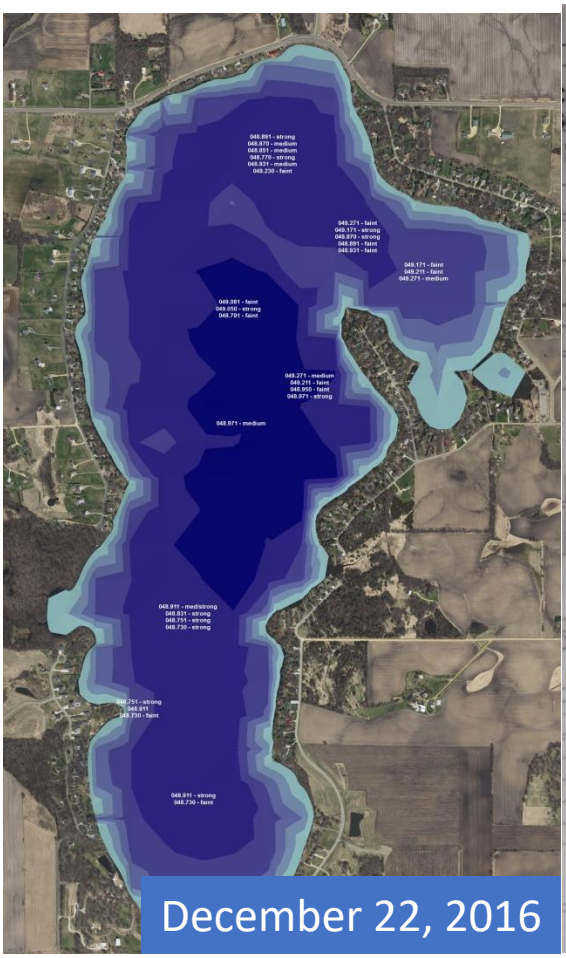
**Methods**

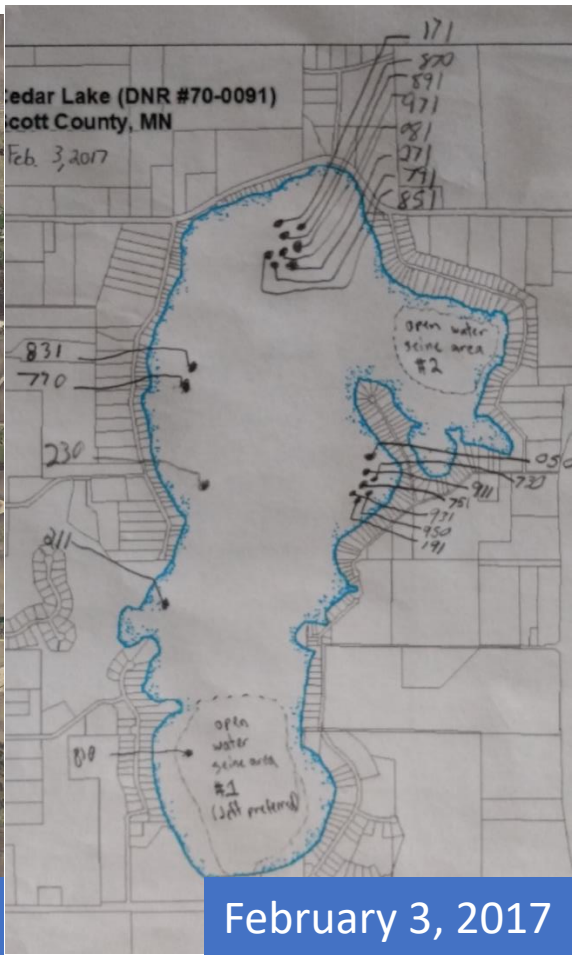
Common carp are known for forming seasonal aggregations that can be targeted with seine nets for removal. These fish are also known for seasonal migrations in/out of lakes for spawning or foraging. To locate seasonal aggregations and to determine if carp reside year-round in Cedar Lake, we implanted 20 adult carp with radiotransmitters in the summer of 2016 (as described above, Appendix A). All carp survived the surgery (Fig. 2), but one perished in the winter of 2016/17. We trained Scott WMO personnel (Melissa Bokman) to conduct radiotelemetry surveys as needed (one such survey was conducted in late fall 2016). Carp Solutions were contracted to conduct carp telemetry during winter (2016/17) to locate sites of winter aggregations. We conducted 4 of such surveys (Fig. 3). Whenever carp aggregations were found, we contacted commercial fishermen (Mr. Jeff Riedemann) to assess whether these carp could be removed with seine nets. We also conducted two surveys in March and April of 2017 to facilitate open water seining shortly after ice out.

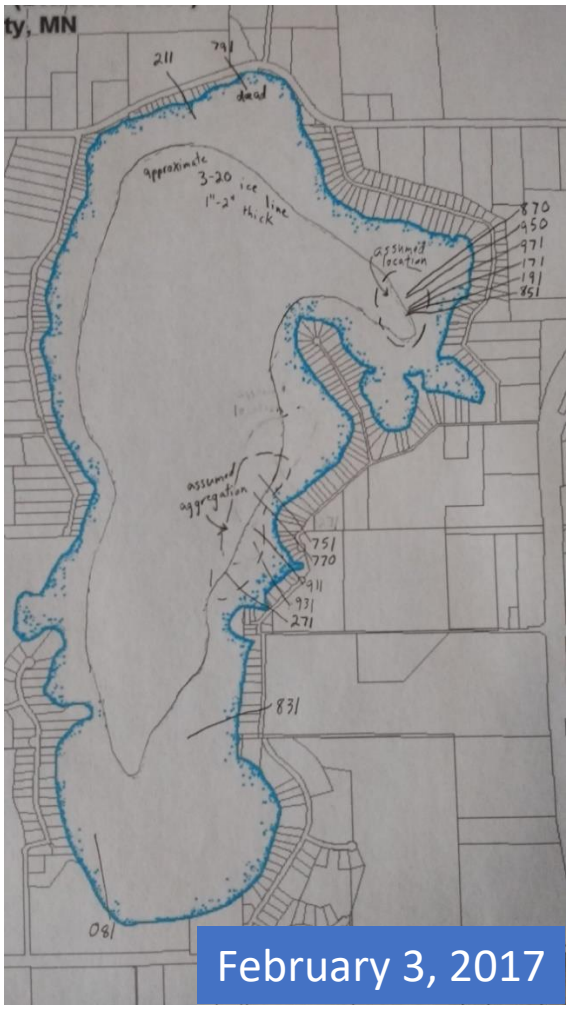
Figure 2. Common carp implanted with a radiotransmitter. Note that the surgery site is healed. The fish was captured eight months after the surgery was completed.

**Results**

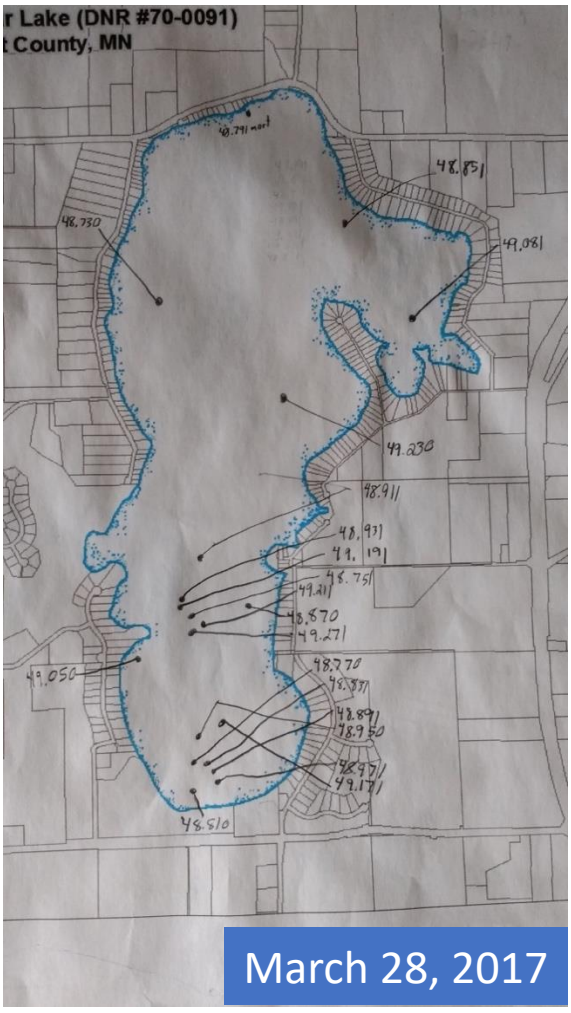
All carp remained in the lake throughout 2016. The carp formed two aggregations in February 2017 in the northern and eastern area of the lake (Fig.3). This information was shared with the commercial fisherman. However, the fisherman decided that these locations were not suitable for seining due to suspected snags on the bottom (boulders). Another aggregation was located in the southern part of the lake in early April 2017at which point the lake was ice-free (Fig. 3). This location was suitable for seining and the seine was conducted. Overall, 442 carp were captured including three radiotagged carp.


December 22, 2016


edar Lake (DNR #70-0091)
cott County, MN
Feb. 3, 2017
open water seine area #2
open water seine area #1
(All packed)
February 3, 2017




February 3, 2017




March 28, 2017

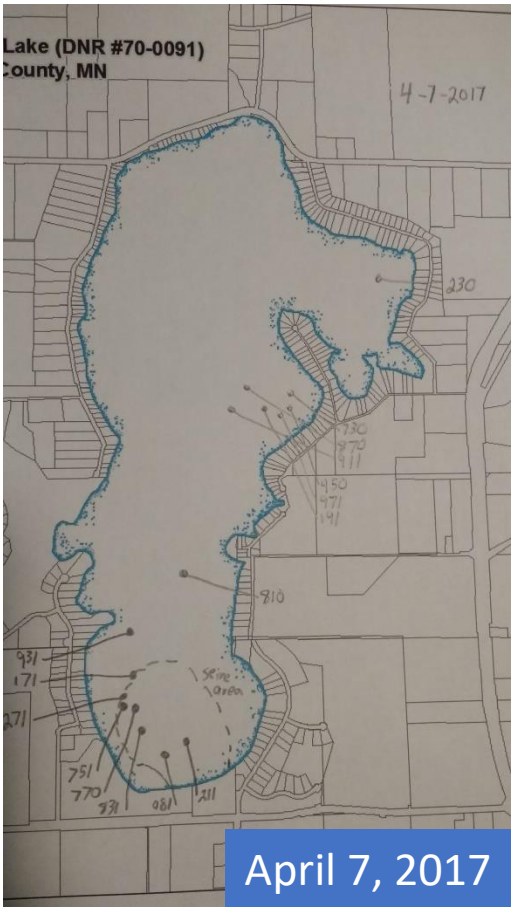



Figure 3. Maps of common carp locations in Cedar Lake.

**Objective 3: Assess the age structure of carp in Cedar Lake to determine recruitment history.**

**Methods**

Recruitment (production of young) is the most important aspect of carp management. Populations in which the recruitment occurs frequently are difficult to control using physical removal, while removal is recommended for populations where recruitment is low or infrequent. Two approaches are used to assess carp recruitment. First, a sample of the population is aged to determine age structure. Continuous age structure (all age classes present) suggests that recruitment occurs every year. Age structure with large gaps between year classes shows that recruitment fails during most years. In addition to age structure which informs about recruitment history, trapnet surveys are conducted to determine areas where recruitment occurs.

To develop age structure of carp population in Cedar Lake, we collected 66 carp (most collected during 2016 Carp Kabob and some collected during boat electrofishing surveys; Objective 1). We removed otoliths (inner ear bones that accrue annual growth rings) from each of those carp, embedded them in epoxy, sectioned using a high precision saw and aged under a microscope (Fig. 4).

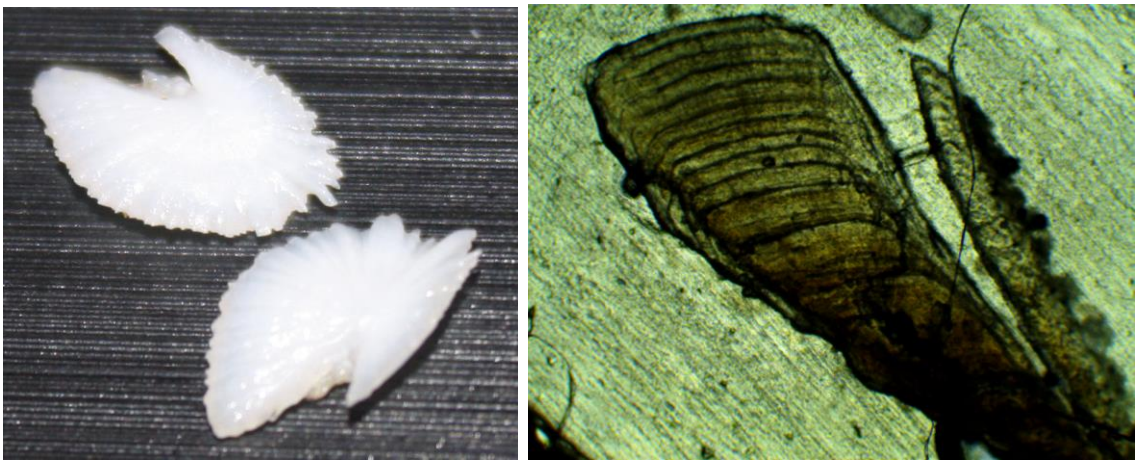


Figure 4. Left: Common carp otoliths (approximately 7 mm in length). Right: otolith cross-section used the microscope.

To conduct trapnet surveys, we set five trapnets (Fig 5.) in two areas (10 nets total) suspected to be functioning as carp nursery areas within Cedar Lake (Sanctuary Bay and South Inlet; Table 2).

Figure 5. Trapnets used to survey for young-of-year carp. Right: measuring an adult carp captured in a trapnet.

## Results

The age structure showed that the population was dominated by carp born during 2002 – 2016 (Fig. 6). Two age classes were particularly strong: 2002 and 2014. There was evidence of continuous recruitment during 2011-2016 because every year class from that period was present in the population (Fig. 6). Several carp older than 20 were also found among the aged sample, the oldest carp was 42 years old (Fig. 6). Presence of such old carp in the population suggests that natural mortality rates among adult carp are low (probably < 5%).

Although we saw evidence of annual recruitment since 2002, it is worth pointing out that the estimated number of young-of-year carp that recruit in Cedar Lake each year was relatively low (500 – 1,500 young-of-year carp per year). This suggests that although carp can successfully produce young in Cedar Lake, some processes (most likely game fish) suppress the survival of young carp to a relatively low level. By comparison, in lakes where predatory fish are lacking, such as in shallow lakes that winterkill, 100,000s of young-of year carp would be recruiting each year. Low recruitment rates were supported by trapnet surveys which did not capture a single young-of-year carp in the two areas of the lake where carp are seen spawning each spring (Table 2). In addition, among the 17 boat electrofishing transects conducted around the entire perimeter of the lake (Objective 1), only five young-of-year carp were captured.

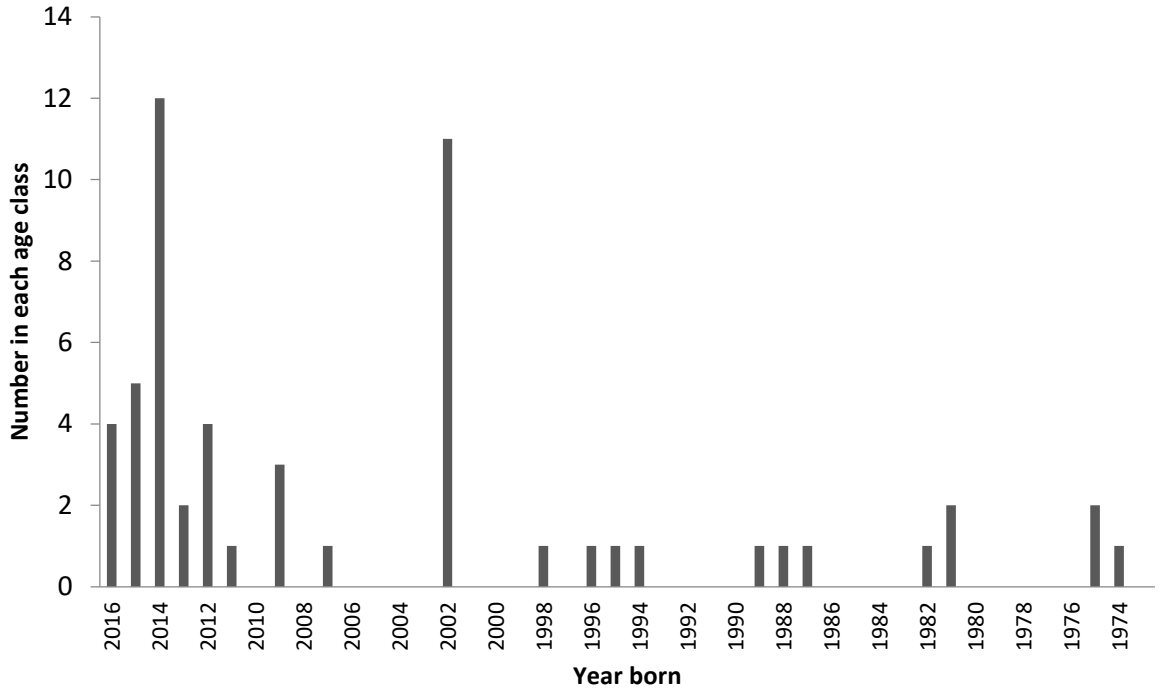



Figure 6. Age structure of common carp in Cedar Lake. In total, 66 carp were aged.

Table 2. Results of trapnet surveys in Cedar Lake. Shown are mean catches per net. Five nets were set overnight at each location.

| | Sanctuary Bay | Southern inlet |
|---|---|---|
| Common carp (young-of-year) | 0.0 | 0.0 |
| Common carp adults | 0.0 | 0.3 |
| Black bullhead | 0.0 | 0.3 |
| Black crappie | 0.6 | 11.7 |
| Bluegill sunfish | 42.8 | 19.0 |
| Largemouth bass | 1.2 | 0.3 |
| Pumpkinseed | 4.2 | 11.7 |
| Yellow bullhead | 5.6 | 0.0 |

**Objective 4: Recommend goals and strategies to reduce carp density in Cedar Lake to a level that will protect critical habitat and improve water quality.**

**Methods**

Although common carp biomass is currently relatively low in Cedar Lake (75 kg/ha; Objective 1), it is close to the 100 kg/ha management goal and it is worth considering how to suppress the biomass even more. To do so we incorporated the data gathered while addressing objectives 1 through 3 (abundance, recruitment) into an existing carp population dynamics model (Bajer et al. 2015). We then used the model to simulate carp abundance and biomass under the scenario where 10% of carp were removed annually (this removal efficiency was assumed to be achievable because Objective 1 showed that nearly 10% of population was captured in a single seine pull). This management scenario was run for 30 years and repeated 5 times to assess the consistency of model simulations. This management scenario was contrasted against the "do nothing" scenario. It is worth emphasizing that our model is based on only one year of data, and its predictions need to be approached with caution. For example, any future changes in Cedar Lake that might increase carp recruitment beyond rates documented in this study would require model revisions and a new modeling analysis. While using the model we assumed that Cedar Lake is essentially a closed lake to carp immigration/emigration.

**Results**

The model predicted that under the "do nothing" scenario, the biomass of carp in Cedar Lake would remain relatively stable ~ 80 kg/ha (Fig. 7). If 10% of the population was removed annually, carp biomass would decline to 50 kg/ha in 5 years and 30 kg/ha in 10 years (Fig. 7), which are very low carp biomass levels. This suggests that systematic removal of even low percentage of the population each year should lead to a substantial decline in common carp biomass over time (Fig. 7).

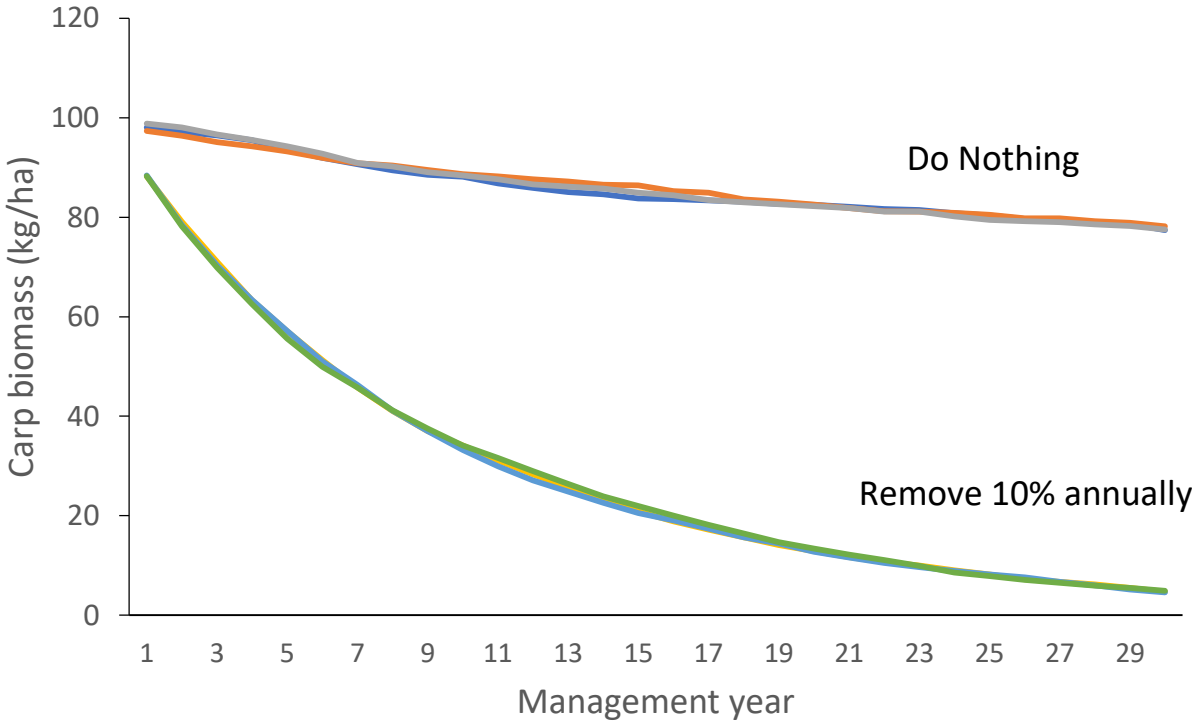



Figure 7. Model simulations of carp biomass in Cedar lake under two management scenarios.

Removal of 10% carp annually can be achieved in a number of ways. We recommend that open water seining is considered as the main strategy. It should be conducted in early spring or late fall when most carp are found in large aggregations and when the lake is free of ice. The timing is important because carp aggregations typically form in mid-November and disperse by mid-April. The chief advantage of open water seining over winter seining (under the ice) is that the net can be more easily freed of obstacles during open water seines than during seines pulled under the ice. Seining in the summer is not recommended because the carp are dispersed and large areas of the lake can be covered by aquatic vegetation. The main disadvantage of seining is that it cannot be performed in areas with snags and requires extensive coordination with commercial fishermen. The carp can also relatively easily escape from seine nets, especially in areas with uneven bottom, and can quickly learn to avoid seines if unsuccessfully targeted multiple times.

As an alternative to seining, baited box nets could also be used to trap and remove carp. This technique is used in the summer when carp are foraging. Large traps (30 x 60 feet) are set in the lake and baited with corn for several days. Once the carp are “trained” to come to bait, the traps are pulled at night when carp are at the bait. This process can be repeated multiple times

each summer and multiple nets can be set in different areas of the lake to increase efficiency. The advantage of this technique is that only 2 people are needed to operate the traps. This technique can be used among snags (as the trap does not move). This approach is very selective as only carp are attracted to the bait; native fish are not harmed. Finally, it is very difficult for the carp to escape from the baited traps (which have mesh bottom and mesh walls) and they cannot easily learn how to avoid those devices over time (unlike seine nets). The disadvantage of this technique is that, typically, fewer carp are captured in baited traps than in in a successful seining operation.

A final option is to continue the Carp Kabob tournament. Seeing that the population in Cedar is relatively low, even removing 50-100 each year could add up to that 10% of the population goal for removal each year. It is a relatively low investment event and it seems to engage the community in a positive way.

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## Appendix

Radiotransmitters implanted in common carp in Cedar Lake in the summer of 2016.

| Date | Length (mm) | RADIO FREQUENCY |
|---|---|---|
| 8/6/2016 | 464 | 49.211 |
| 8/6/2016 | 488 | 48.870 |
| 8/6/2016 | 520 | 49.081 |
| 8/6/2016 | 542 | 48.911 |
| 8/6/2016 | 675 | 49.230 |
| 8/6/2016 | 750 | 48.791 |
| 8/6/2016 | 750 | 49.050 |
| 8/6/2016 | 770 | 49.171 |
| 8/22/2016 | 666 | 48.770 |
| 8/22/2016 | 707 | 48.950 |
| 8/22/2016 | 714 | 48.851 |
| 8/22/2016 | 781 | 48.971 |
| 8/22/2016 | 882 | 49.191 |
| 9/8/2016 | 600 | 49.271 |
| 9/8/2016 | 622 | 48.751 |
| 9/8/2016 | 800 | 48.891 |
| 9/8/2016 | 894 | 48.931 |
| 9/8/2016 | 897 | 48.831 |
| 9/8/2016 | 925 | 48.810 |