Swimmer's Itch Assessment, Research and Control on Higgins Lake in 2022-2023

Final Report

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by

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and

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* This report was written for the Higgins Lake Swimmer's Itch Organization (HLSIO), a non-profit 501 (c) (3) group tasked with managing and funding a comprehensive swimmer's itch control program on Higgins Lake.

Executive Summary

For the past two years (2022-2023) Swimmer's Itch Solutions, LLC (SIS) has continued to partner with the HLSIO for swimmer's itch control services on Higgins Lake.

In the summer of 2015, under the authority of federal and state permits, all common merganser broods were trapped and relocated off Higgins Lake. Not surprisingly, two metrics of the swimmer's itch (SI) problem — snail infection levels and cases of SI (measured by reports to our website) – showed dramatic decreases in all years (2016-2021) following a summer of brood relocation. However, in 2022 and 2023, the common merganser brood relocation program was suspended by MI-DNR because of highly pathogenic avian influenza (HPAI). Fortunately, no common merganser broods appeared on Higgins Lake in 2022. In 2023, common merganser broods returned, with two broods spotted on the lake.

With the suspension of the relocation program, it is expected that both SI metrics will see an increase next summer.

Introduction

Swimmer's itch, also known as schistosome cercarial dermatitis, is a common problem in many recreational lakes throughout the northern United States and the world. It can be caused by any of over 70 different avian schistosome parasite species that mistakenly penetrate human skin instead of the skin of their natural definitive host. When this happens, the parasite dies at the site of penetration causing an inflammation of the skin and the formation of a papule. Swimmer's itch papules can itch intensely for up to 10 days.

Brief Review of Avian Schistosome Life Cycles

All avian schistosome species have a similar two-host life cycle. As adults they live within a definitive host, most commonly a duck; when sexually mature the worms release their eggs, which make their way into the feces of their host. If these feces land in water, eggs of the parasite hatch into larval stages (miracidia), which are infective to an appropriate species of snail (the intermediate host). Upon finding a suitable snail, the miracidium will penetrate the soft tissue and develop within its digestive glands. Over the next 30 days it matures and then produces thousands of cercariae that are released into the water every day, especially during the warm-water summer months. If a cercaria locates the correct vertebrate host species, it penetrates and develops into an adult worm to complete its life cycle. If a cercaria accidentally penetrates human skin, it dies in the skin, and an immune reaction can result, usually causing a raised papule that can itch intensely.

In many northern Michigan lakes, severe outbreaks of swimmer's itch have predominantly and most commonly been attributed to the avian schistosome, *Trichobilharzia stagnicolae*. This parasite species typically utilizes the common merganser (*Mergus merganser*) as its definitive host and *Stagnicola emarginata* as its intermediate (snail) host.

Important Fact to Remember: *Given the life cycle of T. stagnicolae. and the biology of its hosts, infected common merganser broods affect the* ***following summer's*** *snail infection levels.*

Waterfowl Surveys

Summary of work completed: Waterfowl surveys of the entire shoreline of Higgins Lake were conducted once in 2022 (Figure 1) and twice in 2023 (Figures 2 and 3).

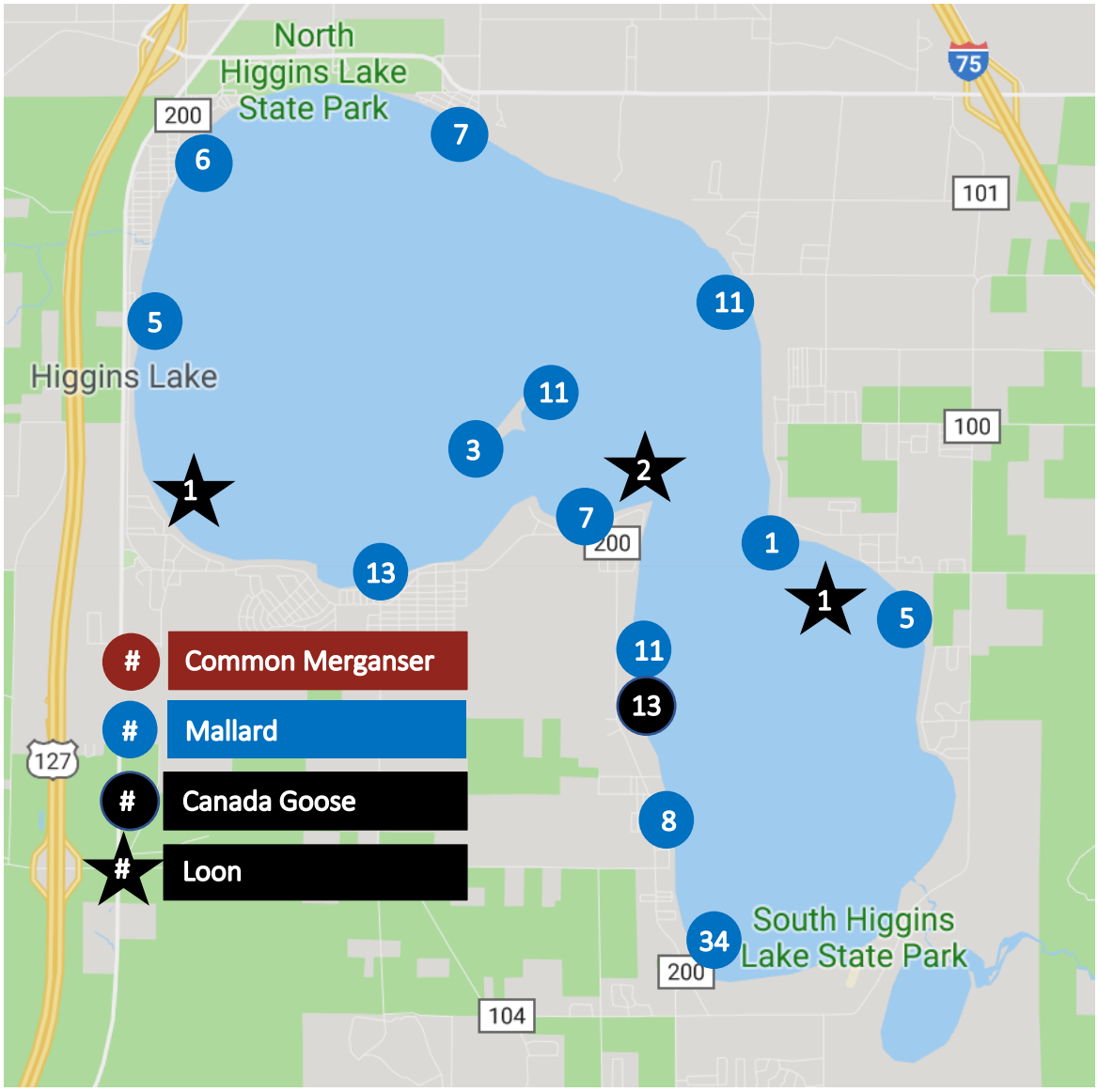

Figure 1. Number of common mergansers, mallards, Canada geese, and loons observed during a June 20, 2022 shoreline survey of Higgins Lake (Roscommon County, MI).

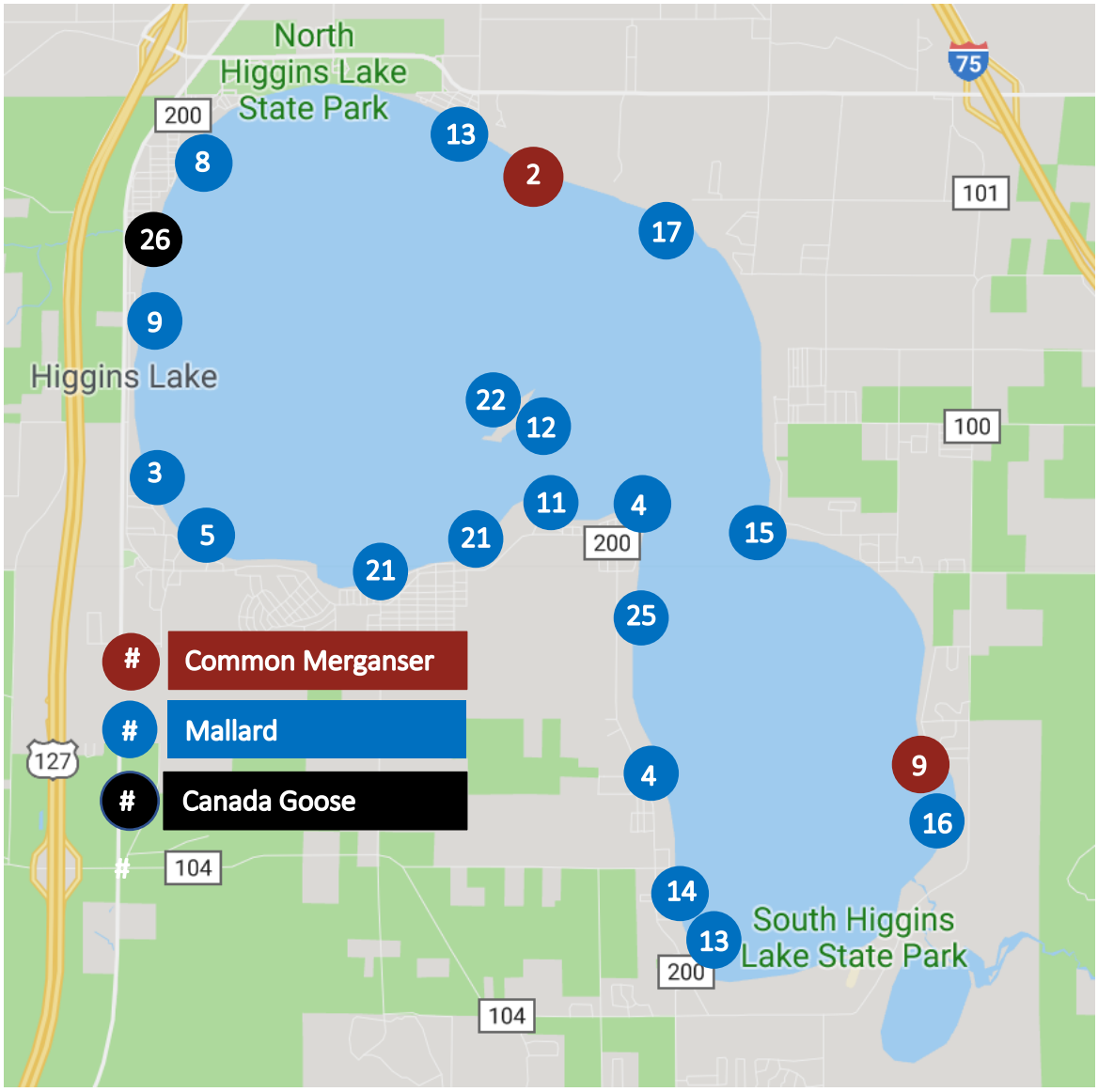

Figure 2. Number of common mergansers, mallards, and Canada geese observed during a July 25, 2023 shoreline survey of Higgins Lake (Roscommon County, MI).

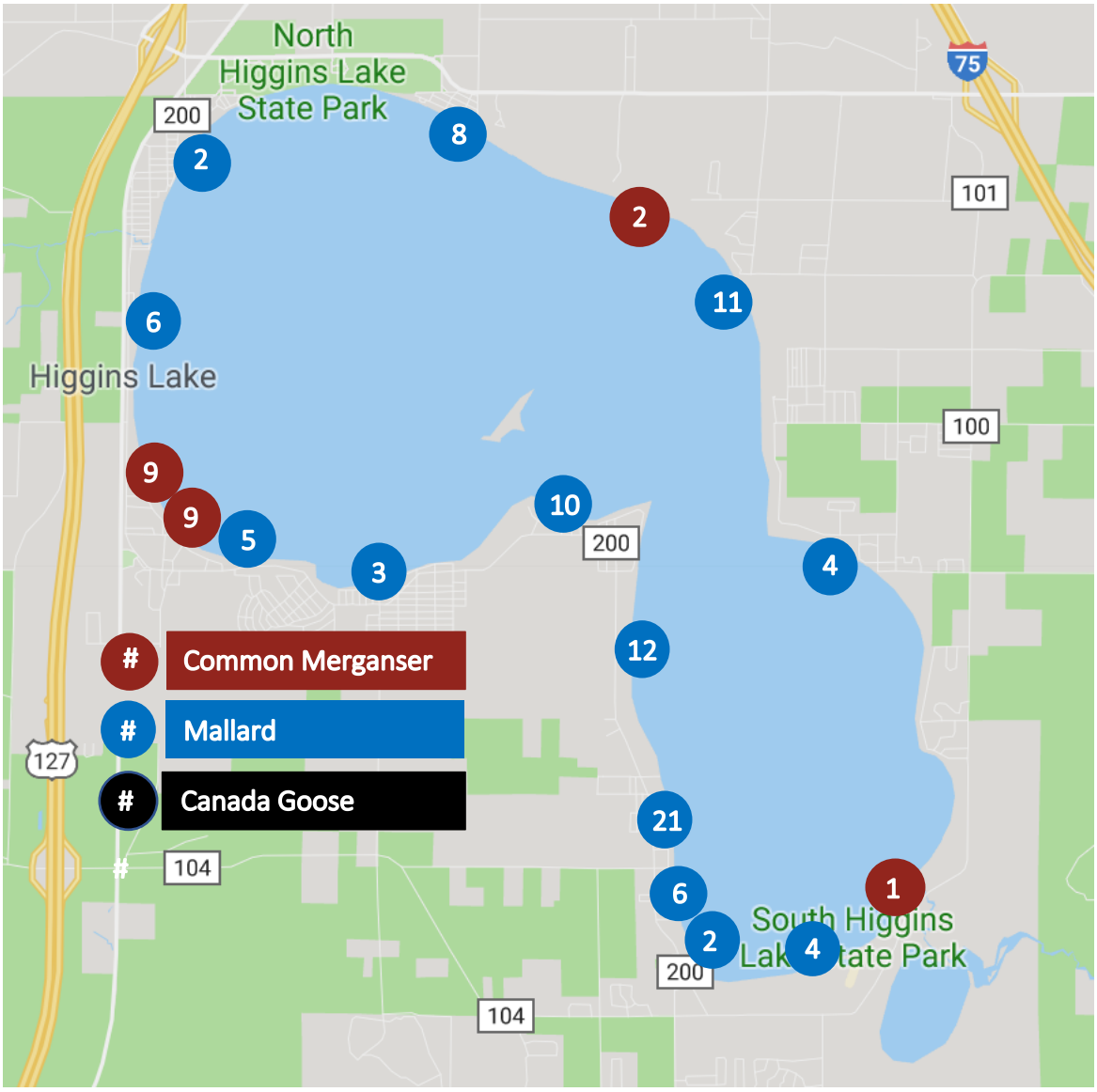

Figure 3. Number of common mergansers, mallards, and Canada geese observed during an August 18, 2023 shoreline survey of Higgins Lake (Roscommon County, MI).

Water Exposure Study

Background: Higgins Lake has conducted a program of trap and relocation of common merganser broods since the summer of 2015. The primary assessment of the program has used snail infection data, which documents a dramatic decline in the percent of snails infected (from ~3% in 2015 to ~0.05% or less in 2019, 2020, and 2022). This means the population of the swimmer's itch parasite has drastically declined, but an important question is how much have swimmer's itch cases declined as a result?

During the 8-year period of the relocation program, our company website has also been open to receive reports of swimmer's itch (SI). The overall trend of this data is also a dramatic decrease (>150 reports in 2015 to only 10 in 2022), but the decrease was not as swift as the snail infection data and even went up slightly some years when snail infection rates were falling or very low. The data arising from a system of self-reporting of SI cases can be difficult to interpret because there is: 1) variability in people's knowledge of the importance of reporting and where to report it; 2) changing motivation for reporting, for example, there may have been more motivation when the problem was more severe (frustration, hope that something could be done) than when the problem had gotten better (cases less severe, fatigue from reporting); and 3) no motivation or mechanism to report when people entered the water and did NOT get swimmer's itch.

With the trap and relocation program suspended in 2022 by the DNR due to avian flu, it was recognized that another method to document SI cases was needed that would be less affected by the issues above. Hence, the 'Higgins Lake water exposure study' was initiated in summer 2022, with a handful of individuals/families that faithfully reported whenever they were in the water and whether any SI cases resulted. Thus, we obtained data on how many SI cases there were on a *per water use basis.* The purposes of gathering such data were to A) provide further documentation for the success of the relocation program, and B) have strong data to compare to future years if common merganser broods appeared and remained on the lake for the summer.

The water exposure study in 2022 was a success, and with the trap and relocate program again suspended in 2023 due to avian flu, the water exposure study was continued in summer 2023. The results of 2023 are summarized below and compared to 2022 results.

Recruitment and Training: Participants were again recruited through HLSIO communications. These individuals completed a Google form that asked for basic information like address and contact info (with ability to indicate preference for email or text) as well as choose a 4-digit PIN that would allow them to file reports without having to enter their name and address for each report. An online orientation zoom session was held to give instructions on reporting and to answer any questions. Although initial recruitment in 2023 showed promise to enlarge the study, the number of contributors only increased by one person (Table 1). In other words, the same 6 individuals/families contributed in both 2022 and 2023, plus one additional individual/family in 2023.

Table 1. Participant data in 2022 and 2023.

Year	Number of sign-ups	Number of contributors*
2022	9	6
2023	13	7

*The number of contributors who filed more than one report. In 2023, there were 4 individuals who only filed 1 report. Two of these were individuals who signed up later in the study, apparently to report that their families had contracted SI. Based on follow-up communication, they misunderstood the nature of the study. We therefore added these two SI records to the website reports and removed all instances of single reports from the water exposure study data set.

Reporting Forms: **The reporting form was identical in 2022 and 2023:** designed to take 1-2 minutes to complete, consisting of the following questions, most of which just required selecting one of a few choices (very little typing):

1. PIN
2. Date of water use
3. Location (Default was home address which could be obtained from the PIN; other choices were common places like the state parks, or the sunken island).
4. How many people were in the water
5. How long people were in the water
6. What time of day people were in the water
7. Whether wind was onshore/offshore (onshore winds can increase likelihood of SI)
8. Whether any precautions against SI were taken (e.g. wore Swimmer's Itch Guard, wet suite, etc.)
9. How many people got SI
10. Severity of the SI cases
11. Any other details they wished to provide (optional)

Participants also were also able to easily 'correct' any reports if SI appeared later.

Results: More reports were filed in 2023 than in 2022, mostly due to an earlier start to the study resulting in more reporting in the early part of the summer. **Overall, SI results were comparable to last year's low SI case rate.** Data from both years is summarized below in Table 2.

Table 2. Summary data from 2022 and 2023.

Year	Total No. of reports	Number of people in water	Avg. min. in water	Number of SI cases	Percent swimmers with SI cases	No. of swimming locations	Earliest water use	No. water reports in May & June
2022	182	440	35	4	0.9%	18	6/15	12
2023	233	739	56	11	1.5%	19	5/28	63

Moreover, all Higgins Lake cases tend to be relatively mild, as reported in Table 3 below.

Table 3. Swimmer's itch cases at Higgins Lake reported in the water exposure study in 2022 and 2023.

Date	Location	No. people in water	Time in water	No. of SI cases	Case severity	Wind	Precautions
7/9/22	South side of island	6	31-60 min	2	11-30 papules	Calm	None
7/31/22	N shore, east of B&B marina	1	31-60 min	1	2 papules	Calm	Short wet suit
8/21/22	N shore, east of B&B marina	1	1-2 hr	1	1 papule	Calm	Short wet suit
7/16/23	N shore, east of B&B marina	1	31-60 min	1	1-10 papules	Calm	Short wet suit
7/18/23	N shore, east of B&B marina	1	16-30 min	1	1-10 papules	Light onshore winds	Short wet suit
7/21/23	North State Park	6	31-60 min	2	1-10 papules	Light onshore winds	None
7/25/23	South side of upper basin	7-9	31-60 min	2	11-30 papules	Light onshore winds	Sunscreen
8/3/23	N shore, east of B&B marina	1	31-60 min	1	1-10 papules	Light onshore winds	Short wet suit
8/4/23	North of Flag Point	7-9	31-60 min	1	1-10 papules	Calm	Sunscreen
8/11/23	N shore, east of B&B marina	1	31-60 min	1	1-10 papules	Calm	Short wet suit, sunscreen
9/4/23	South side of upper basin	1	1-15 min	1	1-10 papules	Calm	None
9/5/23	South side of upper basin	1	1-15 min	1	1-10 papules	Calm	None

Discussion: The data from this study represent the first time that SI cases have been recorded on a lake-wide basis as a rate per water exposure, providing a better measure of the SI situation. Moreover, the low SI case rate determined from the data in both years is good news for Higgins Lake. It affirms the value of the trap and relocation program and suggests that the low number of SI cases reported on our SIS website over the last few years is reflective of a much-reduced SI issue, and not due to reporting fatigue or lack of knowledge about where to report. The only other study we know like this one has been conducted by the Congregational Summer Assembly (CSA) at Crystal Lake, which is specific to their

beach at the southwest end of the lake where many swimmers participate in lessons. The results are comparable: the CSA has seen case rates of 3-6% before common merganser relocation be reduced to less than 0.5% in 2019 and 2022.

All cases have occurred in calm conditions or with light onshore winds. With modest onshore winds, the parasites can be brought in from a vast offshore area, increasing the SI risk for people wading or swimming near the shore (though strong onshore winds seem to damage the parasites or bring them up on the beach). In calm conditions, the parasites tend to disperse slowly away from the snail that they came from, so people who do not happen to swim or wade through the immediate area near an infected snail will not get SI. However, many of the participants were actively swimming a substantial distance or playing all through the area they visited, and thus were more likely to pass through an area near an infected snail sometime during their time in the water.

Conclusion and Recommendation. *This data provides excellent evidence that can be provided to the Michigan DNR to substantiate the effectiveness of the trap and relocation program and to show that HLSIO continues to be motivated to scientifically assess the program in the best ways possible. It also provides excellent baseline data now that merganser broods have returned to the lake in 2023. A jump in the SI case rate is expected in 2024. An increase in case severity (number of papules) might also be seen.*

Based on the success of this study and the value of the data generated, ***we recommend extending this study into summer 2024 to document that the return of two merganser broods in 2023 leads to an increase in SI cases.*** *By all accounts, this was seen in the 2023 CSA beach data at Crystal Lake due to the 9 broods left on the lake in 2022. Though we have not seen the final 2023 data yet, in mid-July there were news reports that the SI case rate had jumped from <1% in 2022 to over 10% in 2023 at the CSA. While we do not expect and surely hope that Higgins Lake does not see this kind of an increase (due to having only 2 broods), it will be important to document what happens. It seems likely that we can get the same people to participate in 1 more year of data collection, and they deserve our thanks.*

Website SI Case Reports

Background: From the beginning of the relocation program, SIS has hosted a website where Higgins Lake residents and visitors can report SI cases. These data are only a rough measure of the SI issue on Higgins Lake because it does not include any reporting of times that individuals used the water *without getting SI.* In addition, the rate of reporting probably varies depending on the prior expectations of the person getting in the water, the severity of the case, and the motivation for reporting. Thus, while a substantial decline in SI reports was seen starting the year following relocation (2016), it did not quite mirror the data from snails or the good reports people were telling us in person. A probable factor is that once people heard that SI risk was being reduced, they expected not to get it, and hence motivation to report was high when they did get it.

In Figure 4 below, the numbers of SI case reports from 2019-2023 are plotted, broken down by case severity (Low = 1-10 papules, Medium-high = 11-99 papules, Severe = 100+ papules). While 2021 and 2022 had the fewest reports, 2023 appears to be very similar to 2019 and 2020, both in terms of total

number of reports (41 cases in 2023, 42 in 2020, and 35 in 2019) and case severity. While we unfortunately do not have case severity data before the relocation program started the total number of cases was much greater in 2015 (152, and in addition we know of an approximately similar number of reports filed with Roscommon County).

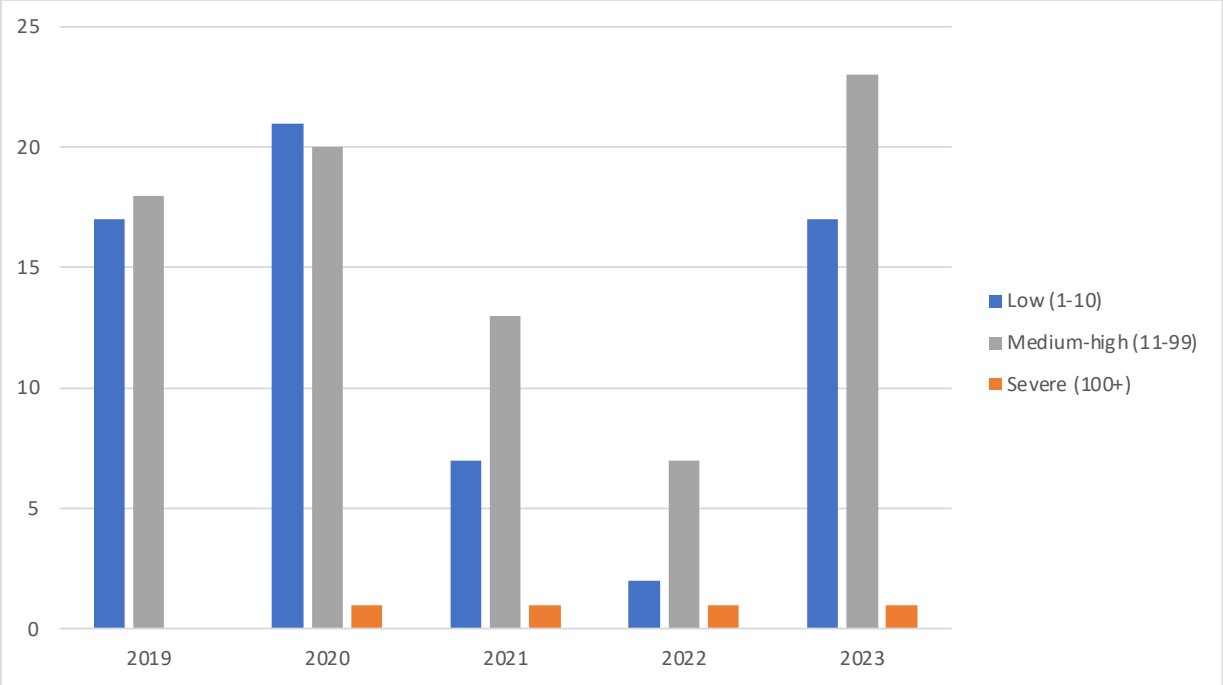

Figure 4. Higgins Lake 2010-2023 SI case reports categorized by severity.

Conclusion: *Website reporting data are consistent with the data we have obtained from snails and the two years of data obtained from the water exposure study. Despite tens of thousands of visitors to the state parks and elsewhere on the lake, these data indicate a low number of cases.*

As stated earlier, with common merganser broods on the lake all summer in 2023, we predict that SI cases will go up. It will be interesting to see if the expected uptick is detected by both the water exposure study and the website reporting or just one of the methods.

Worm Development Study

Background: Trap and relocation of common merganser broods has been a very successful strategy for controlling swimmer's itch at Higgins Lake and Crystal Lake. This strategy is dependent upon trap and relocation occurring before parasites in the ducklings reach maturity and begin to produce eggs. However, how quickly ducklings first get infected and how quickly the parasites become patent (i.e., shedding eggs through their host's feces) is a research question that is not fully answered.

Based on Harvey Blankespoor and Ronald Reimink's research and statements, we and others have been operating under the assumption that ducklings start shedding large numbers of eggs at the age of 4

weeks. However, we have suspected that ducklings begin shedding parasite eggs earlier, and that it may even be possible that 4 weeks may be the peak or even just past the peak of parasite egg production. The literature has laboratory studies with mallards in which parasite eggs are produced as early as 13-14 days and peak production is 15-22 days. In our control work, Swimmer's Itch Solutions has taken the approach of removing ducklings as early as is possible, at 3 weeks or younger, usually at 10-15 days old. We believe that this may be a factor in why our work has been so much more successful at Higgins and Crystal than the work of others at Glen Lake (don't tell them!).

Together with HLSIO, it was identified as being of scientific and practical value to know more precisely how quickly the worms mature. The findings would likely influence the relocation programs, either leading us to relocate broods even earlier, or give us assurance that the timing of our current approach works well.

Study Location and Methods: Since Higgins Lake has not had common merganser broods for the last 3 years, we anticipated that most of our activity would occur on Crystal Lake, where broods have numbered 9 or more each year. This year, Crystal again had 9 broods which gave us a good source of samples, but Higgins Lake had 2 broods, and we were able to obtain some samples from Higgins also.

Fecal samples were taken from common mergansers, with a focus on ducklings, by either getting fresh samples off of docks where they were seen roosting moments before, or by trapping common merganser broods, placing them in cages, and obtaining individual samples from underneath the mats in our cages which prevent samples from getting mixed together. Ducklings were aged by comparing them to the progression of plumage development described in the literature. Plumage was easy to examine for ducklings that were trapped, and for birds on docks it was observable through binoculars by approaching slowly and getting in close range.

Samples are kept in a cooler or refrigerated until they can be examined. Examination occurs by weighing the sample (or a portion of larger samples) and placing it in a glass petri dish, then diluting and mixing the sample in artificial pond water until the water in the dish is relatively clear (versus cloudy). The samples are then exposed to light for at approximately one hour to make sure all eggs are hatched before being viewed.

The number of parasites is each sample is quantified by examining the sample under a microscope for one minute and all parasites seen are captured and removed by pipette. The one-minute counts are repeated two more times so that there is a total of three counts. These counts are then averaged and divided by the mass of the sample to obtain the number of parasites per minute per gram of feces (parasites/min/g).

Results: We were very successful in obtaining fecal samples from common mergansers, reaching a total of 61 samples. Of these, 54 were from ducklings, 4 from hens with broods, and 3 were second-year birds (at least 1 year old, but not yet breeding). The average size sample was 0.32 grams.

Among the adult birds we sampled, there was a large contrast. The four hens with broods were positive, but with low counts (0.8, 6.7, 7.1, and 8.3 parasites/g/min), and this is what we normally see. The

second-year birds, however, were positive with very high counts (54.7, 66.7, and 286.7 parasites/g/min; the last one is probably overestimated due to the very small sample (0.05 g) that was obtained).

All the duckling data are plotted by duckling age in Figure 5 below. Note that while some younger ducklings are found negative, all samples from older ducklings (7+ weeks) are positive. Also, a minor note is that the samples for just over 7 weeks and 8 weeks were taken 9 days apart from almost certainly the same brood (same number of individuals in brood; seen resting on the same dock both times just before sampling).

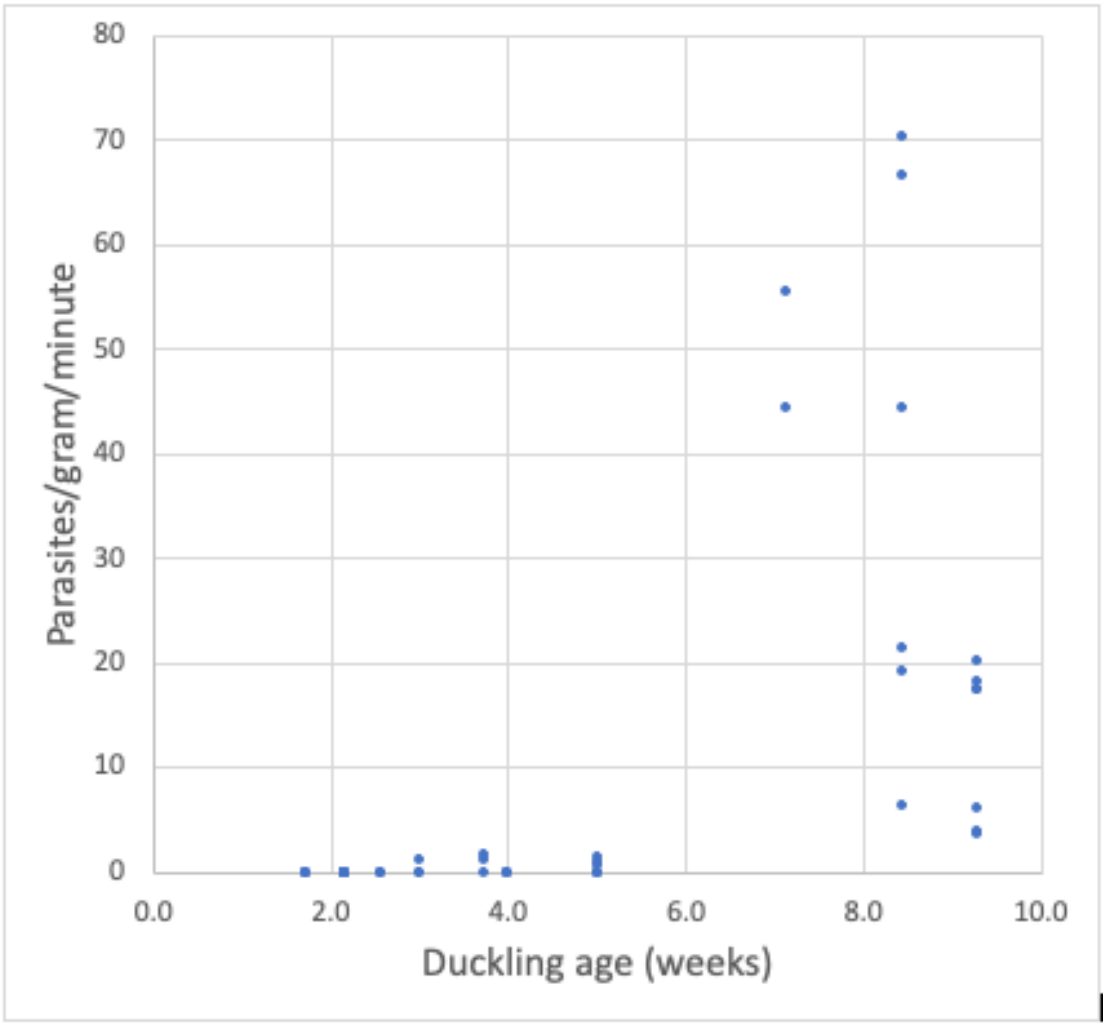

Figure 5. Parasite numbers observed in fecal samples from 54 common merganser ducklings from Crystal Lake and Higgins Lake. Some dots with a value of 0 represent more than one individual sampled because there were many young ducklings that were negative for parasites. For instance, a total of 21 ducklings were sampled at ages 12, 15, or 18 days and all were negative.

Important Takeaways from the data:

1. ***Ducklings were negative at 12, 15, and 18 days old.*** *This is consistent with the literature and our experience.*
2. ***Ducklings were first found infected at only 3 weeks old, not 4 weeks****. This tells us that it is helpful to relocate them early, and it is consistent with the literature. The number of parasites is low at this point.*
3. ***Ducklings also had a low number of parasites at 4 and 5 weeks old****. This was a little bit surprising, as we expected these values to show some increase after infections first appeared.*
4. ***At 7 weeks old or older, the number of parasites in the feces is much higher.*** *Some individuals were also high when sampled at 8 and 9 weeks. There may also some hint of the number of parasites diminishing at 9 weeks, but the sample size is too small at that age to say for sure.*

Discussion: The results provide some insight into the pace at which wild common merganser ducklings accrue worms and the rate at which the worms mature and begin to produce eggs. Since positive samples were found in some 3-week-old common merganser ducklings, this indicates that these ducklings became infected sometime in the first week after hatching and that the worms were available to develop almost as quickly as described for *T. szidati* in mallards in the laboratory [1,2].

The number of parasites produced appears to remain low through 4- and 5-weeks-old, which was a little surprising. However, the type of results in the laboratory studies should not necessarily be expected in nature because in the laboratory, individual ducklings are exposed to hundreds of cercariae at a time and are confined in such a way that nearly all of them successfully are observed to penetrate. In the wild, ducklings likely only encounter a few cercariae per day, and the success of contact and penetration is unknown.

By 7 weeks, however, the high number of parasites found in the feces implies the presence of adult worms in the duckling that are reproducing with high success. It was interesting that similar numbers of parasites were seen at weeks 8 and 9 (though there was quite a range among individual birds).

Conclusions: *While our data suggest that the number of parasites produced by 3- to 5-week-old ducklings is relatively low, we would not say that this means that we can leave them on the lake longer than we have been. We still think it is quite possible that removing them prior to 3 weeks has been a factor in our success, as it just ensures that no ducklings end up contributing to the problem. In addition, we know that there are numerous adult birds on the lake during the migration seasons as well as in the summer, and their presence does not seem to prevent the substantial SI reductions we've seen with brood relocation. One possible explanation is that the parasites produced within young birds may be more vigorous and/or less affected by the host immune system – one laboratory study found that parasites obtained from ducklings early in their infection were more infective to snails [2].*

We were able to obtain even more data than we anticipated, so this study is quite robust for only one season of data. If the relocation program would again be suspended in 2024 (shudder), we would request another year of funding to produce a data set that would be easily published. A special effort could be made to obtain samples from ducklings between 5 and 7 weeks to see where the increase really happens. However, with hopes high that the relocation program will be revived in 2024 (fingers crossed!), we anticipate that we will be limited to taking samples from younger ducklings that we trap. Even so, adding them to the data set will probably make it quite publishable.

References

1. Meuleman, E.A.; Huyer, A.R.; Mooij, J.H. Maintenance of the life cycle of *Trichobilharzia ocellata* via the duck *Anas platyrhynchos* and the pond snail *Lymnaea stagnalis*. *Neth. J. Zool.* **1983**, *34*, 414–417, doi:10.1163/002829684X00236.

2. Rau, M.E.; Bourns, T.K.R.; Ellis, J.C. Egg Production by *Trichobilharzia Ocellata* (Trematoda: Schistosomatidae) after Initial and Challenge Infection in Ducks. *Can. J. Zool.* **1975**, *53*, 642–650, doi:10.1139/z75-078.