THREE LAKES ASSOCIATION

Torch, Clam, & Bellaire Lakes

Comprehensive Swimmer's Itch Assessment:
North Torch Lake

Final Report
November 2019

Prepared for:
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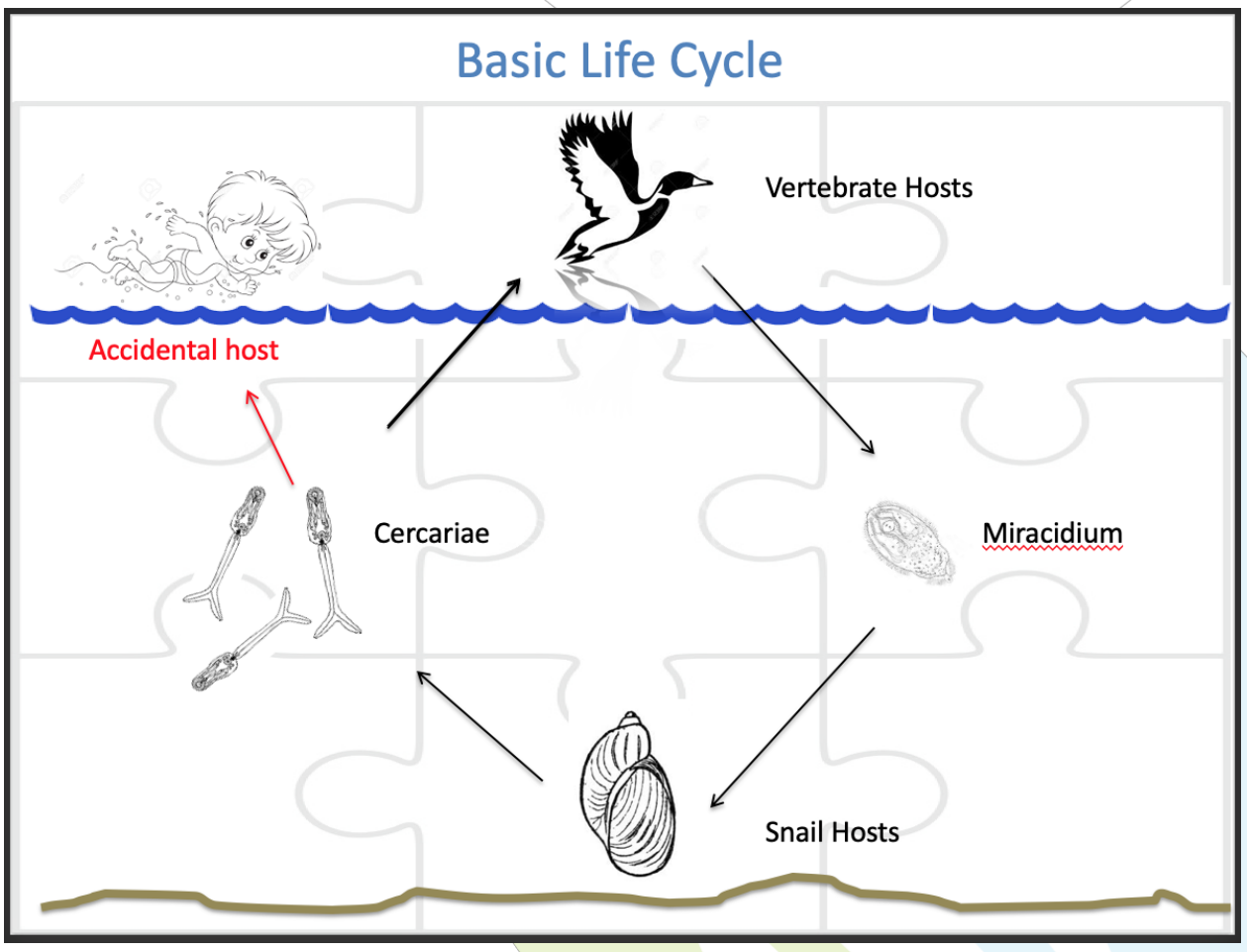
Introduction

Conducting a comprehensive swimmer's itch assessment on any recreational lake consists of collecting copious amounts of data to solve a complex biological puzzle. The complexity is due to the multiple-host life cycles and species diversity of the schistosomes responsible. In fact, we have identified at least eight (8) different itch-causing schistosome species in Northwest Michigan alone since 2017, and over 100 species have been described worldwide. Fortunately, new tools are continually being developed and refined to make assessment easier, less expensive, and more comprehensive. Freshwater Water Solutions (FWS), in collaboration with Dr. Patrick Hanington (University of Alberta), is the world leader on advancing the science of swimmer's itch assessment.

The simplified diagram below illustrates the complex life cycle of the flatworms responsible for swimmer's itch and the biological puzzle it represents.



Our comprehensive assessment of North Torch Lake included new molecular techniques to evaluate each piece of the complex life-cycle puzzle. By putting all the pieces together, we can provide an accurate picture of the parasites causing problems for North Torch Lake.

To further assist the Three Lakes Association (TLA) in the decision-making process leading to prevention and control, we share interesting comparison data from many other recreational lakes in NW Michigan where FWS has completed comprehensive assessments the last two years. Along with this, we also provide a brief summary of our current research efforts which may also prove beneficial for you to determine next steps for your lake.

Vertebrate Hosts

Since the adult worms (schistosomes) ultimately responsible for causing swimmer's itch typically live in the blood vessels surrounding the large intestine of ducks, geese, and swans, it is important to know the summer waterfowl community structure, since this is when it is believed much of the transmission to the snail intermediate host takes place.

A complete shoreline survey was conducted on North Torch Lake on 5 August. This survey consisted of two people traversing the near-shore perimeter by boat at slow speed, observing and recording the species and age of all waterfowl. Binoculars were used to aid in this vertebrate host assessment. The table below summarizes what we believe is a fairly stable summer resident waterfowl population on North Torch Lake. AHY refers to "after hatch-year" birds whose age is greater than 1 year and HY refers to "hatch-year" birds that are not flying yet and therefore are known to have been born on the lake where observed.

North Torch Lake Waterfowl Survey Summary 8/5/19					
	Total Birds	**AHY**	**HY**	**Broods**	**% of Population**
Mallard	172	85	87	14	65.65%
Common Merganser	77	10	67	7	29.39%
Common Loon	8	3	5	0	3.05%
Canada Goose	5	2	3	1	1.91%
Totals	**262**	**100**	**162**	**22**	**100.00%**

Mallards dominate the waterfowl community, a fairly common observation on recreational lakes in NW Michigan as seen in the table below. There is also a relatively large common merganser population present when compared to other lakes.

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The following table compares waterfowl community structures across all lakes where FWS conducted comprehensive assessments in 2018-19. Red numbers indicate exceptionally high values.

Waterfowl Densities (birds/shoreline mile) - All Lakes									
Lake	Shoreline (mi)	Mallard	C. Goose	M. Swan	C. Merganser	H. Merganser	RB. Merganser	Trumpeter Swan	Total Birds
Charlevoix	60.0	7.08	2.78	0.10	1.12	0.30	0.00	0.00	11.38
Elk	28.0	5.25	1.54	0.14	0.54	0.00	0.21	0.00	7.68
Big Glen	10.8	8.70	0.65	0.37	0.28*	0.00	0.00	0.00	10.00
Little Glen	6.4	9.22	1.25	0.00	4.22*	0.00	0.00	0.00	14.69
NL Leelanau	15.0	6.27	0.87	0.40	0.07*	0.00	0.00	0.00	7.60
SL Leelanau	26.2	14.12	1.72	0.00	0.00	0.08	0.00	0.00	15.84
Lime Lake	4.2	8.33	0.95	0.00	0.48*	0.00	0.00	0.00	9.77
Long	16.7	6.47	0.66	0.00	0.00	0.06	0.00	0.00	7.13
Skegemog	15.0	2.73	1.20	0.93	0.00	0.00	0.00	0.00	4.87
Walloon	30.5	1.61	1.34	0.00	1.80	0.00	0.00	0.00	4.75
White Sand	11.2	0.45	0.00	0.00	0.00	2.23	0.00	0.00	0.45
Pickerel	7.1	14.37	6.62	0.00	0.00	0.42	0.00	0.00	20.99
Crooked	16.3	13.62	2.33	0.86	0.00	6.56	0.00	0.00	16.81
North Torch	21.0	8.19	0.24	0.00	3.67	0.00	0.00	0.00	12.10
South Torch	20.0	3.35	2.40	0.00	0.55	0.00	0.00	0.00	6.30
Bellaire	12.0	2.83	1.17	0.00	0.00	0.17	0.00	0.00	4.00
Intermediate	14.6	12.12	0.89	1.30	1.16	0.75	0.00	0.00	15.48
Big Platte	9.3	12.69	2.26	0.00	4.73	0.00	0.00	1.18	19.68
Averages	**18.0**	**7.63**	**1.60**	**0.23**	**1.03**	**0.59**	**0.01**	**0.07**	**10.53**

When compared to other recreational lakes in NW Michigan, North Torch Lake has fewer Canada geese than most, leaving a waterfowl community consisting of mostly mallards and common mergansers.

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Miracidia

Adult female schistosomes living in the blood vessels surrounding the large intestine of infected waterfowl pass their eggs into the lumen where they mix with feces and are expelled each time the bird defecates. If the feces lands in lake water, the fully embryonated eggs soon hatch and the free-living miracidia (larvae) are released to swim and infect an appropriate intermediate snail host. By collecting and analyzing fresh fecal samples from HY birds, we can definitively determine the species of parasites cycling on the lake.

A total of 24 fecal samples were collected and analyzed from North Torch Lake, representing 10 mallards, 3 Canada geese, and 11 common mergansers. Interestingly, none of the mallards or geese were positive for avian schistosomes, yet all of the common mergansers carried the parasites. Miracidia DNA was extracted and barcoded for species identification as show in the table below.

North Torch Lake Waterfowl Fecal Sample Analysis 8/6/19

Date	Species	Location	Age/Certainty	Ave Miracidia/g/min	Species (if determined)
8/6/19	C. Merganser	G6	8/9 HY	1.01	Insufficient DNA
8/6/19	C. Merganser	G6	8/9 HY	10.26	*T. stagnicolae*
8/6/19	C. Merganser	G6	8/9 HY	3.77	Insufficient DNA
8/6/19	C. Merganser	G6	8/9 HY	40.74	*T. stagnicolae*
8/6/19	C. Merganser	F0	AHY	38.75	*T. stagnicolae*
8/6/19	C. Merganser	I7	5/6 HY	1.59	Insufficient DNA
8/6/19	C. Merganser	I7	5/6 HY	5.15	*T. stagnicolae*
8/6/19	C. Merganser	I7	5/6 HY	1.09	Insufficient DNA
8/6/19	C. Merganser	I7	5/6 HY	22.73	*T. stagnicolae*
8/6/19	C. Merganser	I7	5/6 HY	2.03	Insufficient DNA
8/6/19	C. Merganser	I7	5/6 HY	3.17	Insufficient DNA

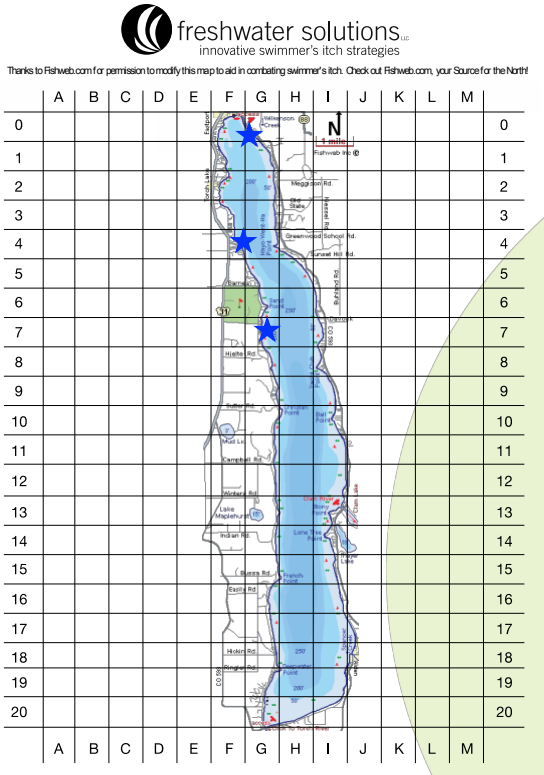
Invertebrate Snail Hosts

Different species of snails are known to carry different species of schistosomes responsible for causing swimmer's itch. Over 100 schistosome species have been discovered worldwide and we have found at least 8 species in NW Michigan since 2017. A comprehensive assessment of the community structure of the snail species present in North Torch Lake is important for understanding what parasites can potentially cycle and cause swimmer's itch.

To assess both species diversity and relative abundance, $1m^2$ weighted hoops were randomly tossed throughout 3 different collection sites. The sites were selected with input from lake association representatives and identified as locations where swimmer's itch is likely to occur. All snails of all species within the hoops were collected using snorkeling equipment and FWS specially designed snail scoops with attached mesh bag nets.

The collected snails were placed in labeled buckets filled with fresh lake water and transported to the lab. Snails were sorted morphologically and each snail known to host any species of schistosome was placed in its own compartment of a 12-well culture plate partially filled with conditioned water. The isolated snails were exposed to natural lighting until dark, kept in the dark until dawn, and then exposed to natural and artificial light for several hours before each snail was examined for shedding cercariae using a dissection microscope.

A total of 1,189 snails were collected and analyzed from North Torch Lake from locations indicated by blue stars on the map below. These locations were selected with input from association representatives as locations where swimmer's itch might likely be reported.



Snail diversity and relative abundance results are summarized in the table below.

North Torch Lake Snail Totals				
	Snails Examined	Snails in Hoops	Density (m_2)	% Snail Fauna
Stagnicola sp.	688	63	0.90	17.75%
Physa sp.	151	38	0.54	10.70%
Gyraulus sp.	18	7	0.10	1.97%
Pleurocera sp.	224	224	3.20	63.10%
Helisoma sp.	87	2	0.03	0.56%
Campeloma sp.	21	21	0.30	5.92%
Tot/Avg	**1189**	**355**	**5.07**	**100.00%**

Pleurocera sp. snails were dominant, making up 63% of the total snail population. However, they are not known to harbor avian schistosomes. Of the four species known to carry larval schistosomes, *Stagnicola* sp. were more prevalent (18%), followed by *Physa* sp. (11%), *Gyraulus* sp. (2.0%), and *Helisoma* sp. (0.6%).

Only *Stagnicola* sp. snails were found harboring patent schistosome infections. Collection and infection rate details are contained in the table below.

Stagnicola sp.							
Date	**Site**	**No. Examined**	**Density (m^2)**	**Pos. Schistosome**	**% infected Schistosome**	**Total Positive Infections**	**% that are infected with any parasite**
7/2/19	G7	309	0.8	12	3.88%	104	33.66%
7/2/19	G4	201	1.4	7	3.48%	67	33.33%
7/2/19	G0	178	0.6	3	1.69%	113	63.48%
Tot/Avg		**688**	**0.9**	**22**	**3.20%**	**284**	**41.28%**

The following table compares the snail community structure from all lakes FWS worked on in 2018-19 (*denotes 2018 data). Red numbers indicate exceptionally high values.

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Snail Genera	Charlevoix*	Elk*	Glen	SLLeelanau	NLLeelanau	Lime*	Long*	Skegemog*	Walloon	White Sand*	NTorch	STorch	Bellaire	Platte	Intermediate	Crook/Pick
Stag	2.71	5.61	2.77	0.04	10.04	0.08	0.15	9.17	1.79	6.95	0.9	0.85	3.63	0.24	2.52	4.76
Phys	1.37	0.24	2.79	1.02	0.12	0.01	0.27	0.61	0.32	0.4	0.54	4.52	0.92	0.16	2.04	0.1
Lymn	--	--	--	0	--	0.03	--	--	--	0.1	--	--	0.03	--	--	0.01
Gyra	0.24	0.01	0.62	6.18	0.50	0.08	1.17	--	0.15	0.1	0.1	--	0.32	0.09	1.87	0.63
Pleu	0.85	5.22	6.16	4.42	2.10	1.56	0.01	5.59	2.18	--	3.2	14.8	0.9	14.4	0.29	1.5
Heli	0.30	0.23	1.55	1.6	0.32	0.03	0.68	0.52	1.79	7.25	0.03	--	1.7	0.12	0.22	0.74
Camp	--	--	0.01	0.02	--	--	--	1.15	0.10	--	0.3	--	--	0.03	--	--
Mars	0.04	--	0.02	0.92	0.10	0.01	0.09	0.55	0.04	0.05	--	--	0.29	0.25	--	0.06
Vivi	--	--	--	--	--	--	0.84	--	--	11.75	--	--	0.38	--	0.49	1.51
Cipa	--	--	--	--	--	--	--	--	--	11.75	--	--	--	--	--	--

Cercariae – Snail Analysis

The cercariae (larvae) that are released from snails each morning are the parasitic stages that burrow into human skin causing swimmer's itch. Several thousand cercariae are released from each infected snail most mornings during the warmer summer months. The free-swimming cercariae cannot feed and so live for only a day.

This piece of the biological puzzle can help determine what species of parasites are actually in the water and accurately assess the severity of the problem. Using a microscope, snails were examined and cercariae, both itch-causing schistosomes and non-schistosomes, were collected for DNA analysis. All schistosome cercariae were preserved and their DNA extracted and barcoded for species identification. Results from snail shedding are reported in the table below.

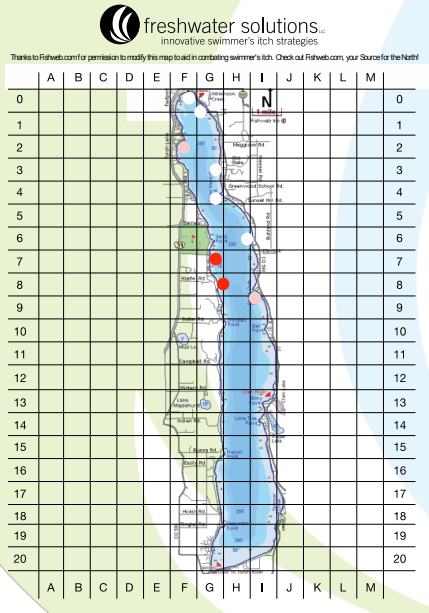
North Torch Lake Snail Infections					
	Schistosome Infections	% Schistosome	Trematode Infections	% Infections	% Total Infections
Stagnicola sp.	22	3.20%	284	41.28%	98.61%
Physa sp.	0	0.00%	4	2.65%	1.39%
Gyraulus sp.	0	0.00%	0	0.00%	0.00%
Pleurocera sp.	n/a	n/a	n/a	n/a	n/a
Helisoma sp.	0	0.00%	0	0.00%	0.00%
Campeloma sp.	n/a	n/a	n/a	n/a	n/a
Tot/Avg	**22**	**3.20%**	**288**	**10.98%**	**100.00%**

Barcoding from the schistosome cercariae and species identification showed *Trichobilharzia stagnicolae* from all *Stagnicola* sp. snails, as expected.

Cercariae – Water Analysis

New technology allows us to not only identify the parasites by using a microscope and DNA barcoding, but also by using a molecular technique called qPCR (quantitative polymerase chain reaction). qPCR allows us to take a known volume of water (25 liters) and count the number of "worms in the water", using a pan-avian assay. We recently developed and published a species-specific assay that also allows us to report the relative numbers of each species found in each water sample. Results from the pan-avian (all schistosomes) work are found in the table below, along with maps showing collection sites. These sites were selected with input from lake association representatives.

Water Sample Data	
	19 July 2019
Site	**Avg Cer/25L**
F0	0.0
G0	0.0
G3	0.0
G4	0.0
H6	0.0
I8	4.0
G8	>100
G7	>100
F2	6.3
Ratio >30/<30	**0.29**



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Comparing the number of cercariae in the water across many recreational lakes in NW Michigan provides a perspective lake boards may find useful for making decisions regarding next steps towards control of swimmer's itch. The table below provides information across two years and over a dozen lakes. Greater than 30 cercariae/25 liters of water represents a heavy or severe level as shown in this table:

# Cercariae/25L	Severity Index
0-10	Light
11-30	Medium
31-100	Heavy
100+	Severe

qPCR Values - All Lakes Comparison 2018			
Lake	**% Sites >30 Cer./25L**	**% Sites ≤30 Cer./25L**	**Ratio >30/≤30**
Charlevoix	19.23	80.77	0.24
Elk	48.39	51.61	0.94
Big Glen	37.50	62.50	0.60
Little Glen	25.00	75.00	0.33
SL Leelanau	22.72	77.28	0.29
NL Leelanau	45.45	54.55	0.83
Lime	25.00	75.00	0.33
Long	13.33	86.67	0.15
Skegemog	14.29	85.71	0.17
Walloon	19.44	80.56	0.24
White Sand	12.50	87.50	0.14
qPCR Values - All Lakes Comparison 2019			
N. Torch	22.22	77.78	0.29
S. Torch	0.00	100.00	0.00
Bellaire	16.67	83.33	0.20
Intermediate	25.00	75.00	0.33
Pickerel/Crooked	10.00	90.00	0.11
Platte	44.44	55.56	0.80

All positive water samples from North Torch Lake were also run with our species-specific qPCR assays to determine what species of parasite were present. Of the 4 positive samples, all had *T. stagnicolae* present and all had the newly discovered schistosome from *Helisoma* snails present, in even greater numbers than *T. stagnicolae*.

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Swimmer's Itch Cases

We are working on establishing one swimmer's itch-reporting site for all of North America ("swimmersitch.ca"), the definitive "911" site where everyone can go to report cases of swimmer's itch. The data collected will be invaluable for not only examining cross-continent trends but also for documenting the thousands of cases necessary to apply for federal funding and international collaboration. In 2019 alone, this site recorded 946 cases from 155 lakes.

We are continually improving the reporting aspects of this site to make it valuable to the scientific world and also to each individual lake association. We recommend you encourage your riparians to report all cases of swimmer's itch, throughout the swim season, to this website: "swimmersitch.ca". Open the tab "Report Your Itch!" and fill in the survey.

Forty-one (41) cases were reported to "swimmersitch.ca" in 2019 from Torch Lake (both North and South Torch).

Objective Checklist

Objective 1: Determine the natural history of the parasite(s) causing swimmer's itch on North Torch Lake.

A. Determine the schistosome intermediate host(s).

•Survey locations where swimmer's itch is a perennial problem to identify the presence of *Stagnicola* sp., *Physa* sp., *Gyraulus* sp., or *Helisoma* sp. snails (or any other genera that harbor avian schistosomes).

•Collect several hundred carrier snails of each species known to harbor avian schistosomes (if present) and shed them for patent infections.

Accomplished: We identified 4 species of snails in North Torch Lake known to harbor the avian schistosomes responsible for causing swimmer's itch: *Stagnicola* sp., *Physa* sp., *Gyraulus* sp., and *Helisoma* sp.

B. Determine what parasite species are present and their relative abundance.

•Preserve pure samples of all schistosome cercariae shed from all species of snails present, extract their DNA, and sequence the DNA to compare against species housed in GenBank for species identification.

Accomplished: *Stagnicola* sp. was the only snail found shedding the itch-causing cercariae. DNA barcoding showed *T. stagnicolae* cycling on North Torch Lake:

C. Assess population dynamics (size, age structure, etc.) of all summer resident anatids (ducks, geese, swans).
•Conduct a boat survey of the entire lake shoreline to record summer resident anatid species, number of birds, and age categories.

Accomplished: A waterfowl survey conducted on 5 August documented 4 species of waterfowl present on North Torch Lake in the following proportions: Mallards (66%), Common Mergansers (29%), Common Loons (3%) and Canada Geese (2%).

D. Assess relative infection levels and species identification in definitive hosts.
•Collect avian fecal samples, where possible, and examine for avian schistosomes.
•Preserve pure samples of all miracidia obtained from examined waterfowl, extract their DNA, and sequence the DNA to compare against species housed in GenBank for species identification.

Accomplished: A total of 24 fecal samples were collected and analyzed from birds on North Torch Lake: Mallards, Canada Geese, and Common Mergansers. Only fecal samples from Common Mergansers were found to harbor avian schistosomes responsible for causing swimmer's itch. DNA barcoding identified this species as *T. stagnicolae*.

Objective 2: Determine the level of parasite infestation on North Torch Lake for data necessary to obtain a MDNR merganser trap & relocate permit in 2020 if mergansers are implicated.

A. Use qPCR analysis to accurately gauge schistosome cercariae levels in the water.
•Collect water samples using the FWS established collection protocol at strategic locations around the lake perimeter, extract the DNA, and run qPCR to determine the level of cercariae.
B. Use snail infection rates to assess schistosome parasite load.

Accomplished: Water was collected at 9 sites around North Torch Lake and analyzed to determine the level of schistosome cercariae in the 25-liter sample. Only 4 of the 9 sites had some parasites in the water, ranging from just a few to >100.

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Objective 3: Prepare a Letter of Authority documenting all assessment data for submission to the MDNR to obtain a common merganser trap and relocation permit for 2020-22.

A. FWS will prepare and supply the TLA with an official Letter of Authority, a document required by the MDNR to apply for a common merganser control permit.
B. FWS will assist the TLA in preparation of a MDNR application, if desired.

Letter of Authority North Torch Lake, MI

This document provides all necessary information for the Three Lakes Association (TLA) to apply for a Common Merganser Control Program Permit issued by the MDNR. Ron Reimink, owner of Freshwater Solutions, LLC, has worked on swimmer's itch education, research, and control since 1977 and has published numerous papers on various aspects of research and control.

1. Presence of the swimmer's itch parasite and evidence that Common Mergansers are the host associated with the parasite's lifecycle on the lake.

Common Mergansers were identified as definitive hosts in 2019. Fecal samples from hatch-year birds were collected and examined for schistosome miracidia. All miracidia from positive samples were preserved and the DNA extracted and barcoded. Results, identified through GenBank, identified the schistosomes as *Trichobilharzia stagnicolae*.

2. Documentation of Common Merganser broods on the lake.

Several Common Mergansers broods were observed on a bird survey in early August.

3. Evidence of increasing swimmer's itch cases or severity.

Swimmer's itch cases were anecdotally recorded each summer through the TLA. Cases became more numerous and severe in recent years, prompting TLA to seek assessment in 2019 with hopes of control beginning in 2020.

4. In addition, one of the following criteria must be met to be eligible:
• Snail infection rate for the lake is greater than 0.5% with a minimum sample of 1,000 snails taken from a minimum of 5 sampling locations on the lake.
• A qPCR assessment of the lake that is greater than 50 cercariae/25 L of water with a minimum of 5 sampling locations.

***Stagnicola emarginata* snails were collected from multiple locations. A total of 688 were collected and examined, showing an overall infection rate of 3.2%.**

Additionally, 9 water samples were collected and checked via qPCR to count the cercariae. Of those 9 samples, 4 sites had cercariae in the water, with 2 sites severe (counts >100).

5. The Letter of Authority must describe the lake's plans for Common Merganser control and management activities for the three-year period of the site permit and specify which control activities are proposed.

The TLA is requesting a 3-year permit to trap and relocate Common Mergansers. TLA will hire trained and certified contractors to do the trapping and relocating after the permit is secured.

For more information on the 2019 assessment work, please contact me for a copy of the North Torch Lake 2019 Final Report.

Ronald Reimink Freshwater Solutions

November, 2019

Recommendations

1. **Stay tuned.**

   Ongoing research being conducted by FWS in 2019 will be of interest and possibly influence decisions about next steps for the TLA. We will provide you with complete results and conclusions regarding this research once completed (likely in early 2020). This research will hopefully shed light on the impact migratory vs. resident waterfowl have on lakes across NW Michigan, provide better resolution as to the community structure of the different parasite species responsible, and reveal new information about MDNR-approved common merganser relocation sites. This may provide better direction about whether to pursue merganser removal in 2020.

2. **Discontinue further assessment unless it answers an important and specific question.**

   While another year of bird surveys and water sample analyses would provide more data on which to draw increasingly definitive conclusions, the costs of more assessments in 2020 should be weighed against other lake-wide concerns that TLA continues to battle. FWS does not recommend further assessment unless it seeks to answer important and specific questions.

3. **Report swimmer's itch cases to "swimmersitch.ca".**

   We encourage you to promote to your membership the reporting of all swimmer's itch cases from North Torch Lake to the University of Alberta website at "swimmersitch.ca". This

website is becoming the "911" site for all swimmer's itch cases across North America and will provide important data for obtaining federal and international grants to battle swimmer's itch. We are modifying this reporting mechanism so it can not only detect trends across the continent, but also provide detailed information about cases for each specific lake association. Changes to the website will be ready for the 2020 swimming season. This service is provided free of charge to lake associations like the TLA, with whom FWS has worked.

4. **Educate TLA riparians on ways they can personally reduce their chance of contracting swimmer's itch.**

   Project '17 and '18, FWS research, funded largely by lake associations in Leelanau County (Glen, Lime, Leelanau), provided discoveries into innovative site-specific control options as well as cercariae behavior. This knowledge can help riparians reduce their risk of contracting swimmer's itch. FWS recently produced a document entitled *"Preventing Swimmer's Itch with 2020 Vision"* that describes the many options riparians have to greatly reduce their chance of getting swimmer's itch. This document can be used by lake associations to educate and empower their members to prevent swimmer's itch in 2020 and beyond.

5. **Encourage TLA members to join TLA and FWS in assessing the efficacy of various prevention measures in 2020.**

   FWS will be presenting the TLA with an opportunity to join a multiple-lake project in 2020 that will assess the various prevention strategies presented in *"Preventing Swimmer's Itch with 2020 Vision".* The details of this initiative will be shared in the coming months.

Acknowledgements

It was our pleasure to work on North Torch Lake this past summer. We try not to take for granted the natural beauty of the water and landscapes in NW Michigan, even though that is where we go to "work" every day in the summer. Thanks to the countless hours of work by volunteer members of the TLA on water and land preservation issues, we have good reason to believe we will leave our beautiful slice of earth in great shape for our children and grandchildren.

One of the best things about engaging a new lake association in our battle against swimmer's itch is the relationships that develop. Behind every good lake association are a myriad of individuals giving of their time and money to promote the noble causes of the association. Although we only had the opportunity to work closely with a few, we especially want to

recognize Dean Branson and Becky Norris. They have been accommodating, helping make 2019 a very successful field season. Thank you!

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