

Comprehensive Swimmer's Itch Assessment: South Torch Lake

Final Report November 2019

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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 South 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 South 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.

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 South 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 South 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.

South Torch Lake Waterfowl Survey Summary 8/5/19								
	Total Birds	AHY	HY	Broods	% of Population			
Mallard	67	20	47	9	50.38 <mark>%</mark>			
Common Merganser	11	2	9	2	8.27%			
Common Loon	7	2	5	2	<mark>5.2</mark> 6%			
Canada Goose	48	10	38	5	<mark>36.0</mark> 9%			
Totals	133	34	99	18	<mark>100.</mark> 00%			

Mallards dominate the waterfowl community, a fairly common observation on recreational lakes in NW Michigan as seen in the table below. Canada geese also made up a substantial percent of the waterfowl community on South Torch Lake with higher than average numbers compared to other lakes. Two broods of common mergansers were also present.



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



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 19 fecal samples were collected and analyzed from South Torch Lake, representing 10 Canada geese, 7 mallards, and 2 common mergansers. Four Canada geese were positive for avian schistosomes as well as 1 mallard. Interestingly, neither of the common mergansers were positive. Miracidia DNA was extracted and barcoded for species identification as show in the table below.

	South Torch Lake Waterfowl Fecal Sample Analysis								
Date	Species	Location	Age/Certainty	Ave Miracidia/g/min	Species (if determined)				
8/6/19	Canada Goose	G20	8/10 HY	0.72	Anserobilharzia brantae				
8/6/19	Canada Goose	G20	8/10 HY	1.96	Anserobilharzia brantae				
8/6/19	Mallard	111	6/7 HY	1.85	Unknown				
8/6/19	Canada Goose	117	15/19 HY	0.71	Anserobilharzia brantae				
8/6/19	Canada Goose	117	15/19 HY	0.33	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 South 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 682 snails were collected and analyzed from South 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.



South Torch Lake Snail Totals								
	Snails Examined Snails in Hoops Density (m2) % Snail Faun							
Stagnicola sp.	147	23	0.85	4.23%				
Physa sp.	133	122	4.52	22.43%				
Pleurocera sp.	402	399	14.78	73.35%				
Tot/Avg	682	544	20.15	100.00%				

Pleurocera sp. snails were dominant, making up 73% of the total snail population. However, they are not known to harbor avian schistosomes. Of the four species known to carry larval schistosomes, *Physa* sp. were most prevalent (22%), followed by *Stagnicola* sp. (4%).

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 (m²)	Pos. Schistosome	% infected Schistosome	Total Positive Infections	% that are infected with any parasite			
6/12/19	112	6	n/a	0	0.00%	0	0.00%			
6/12/19	H18	0	0.0	0	0.00%	0	0.00%			
6/12/19	G20	141	1.2	2	1.42%	17	12.06%			
Tot/Avg		147	0.9	2	1.36%	17	11.56%			

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. South Torch had exceptionally high densities of both *Physa* sp. and *Pleurocera* sp. and very little snail diversity.



Snail Genera	Charlevoix*	Elk*	Glen	SLLeelanau	NtLeelanau	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.

Sou <mark>th Torch Lake Snail Infe</mark> ctions								
	Schistosome Infections	% Schistosome	Trematode infections	% infections	% Total Infections			
Stagnicola sp.	2	1.36%	17	11.56%	94.44%			
Physa sp.	0	0.00%	1	0.75%	5.56%			
Pleurocera sp.	n/a	n/a	n/a	n/a	n/a			
Tot/Avg	2	1.36%	18	6.16%	100.00%			



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

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					
	23 July 2019				
Site	Avg Cer/25L				
G20	0.0				
119	0.0				
l18	0.0				
l16	0.0				
l15	0.0				
114	0.0				
l13	1.8				
112	0.0				
G12	0.0				
H13	0.0				
G16	0.0				
G18	0.0				
Ratio >30/<30	0.0				



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	Неаvy
100+	Severe

qPCR Values - All Lakes Comparison 2018							
Lake	% Sites >30 Cer./25L	% Sites <30 Cer./25L	Ratio >30/ <u><</u> 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				
qP	CR Values - All Lake	es Comparison 2019	Ð				
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				

The one positive water sample from South Torch Lake was also run with our species-specific qPCR assays to determine what species of parasite were present. *T. stagnicolae* was the only species present.

It was very unusual and quite surprising to find schistosomes at only one site on South Torch Lake and in very low numbers. There may have been an inhibitor in the water that prevented the qPCR process, but that is highly unlikely, since we have rarely seen inhibition in the hundreds of samples we have examined from NW Michigan lakes over the last 3 years. It is more likely the snails were not shedding cercariae on the day samples were collected. Our work on another research initiative this year involved collecting 30 samples on the same morning



every week from 3 different lakes from mid-May to late October. We discovered some weeks showed very little cercariae output and we will continue our efforts to figure out why.

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 South 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 2 species of snails in South Torch Lake known to harbor the avian schistosomes responsible for causing swimmer's itch: *Stagnicola* sp. and *Physa* 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 through *Stagnicola* sp. snails. It is very possible *Physa* sp. snails are hosting *T. physellae* on South Torch Lake as well, since this species was found in HY mallards, the definitive host. With the large population of *Physa* sp. snails, *T. physellae* is likely contributing to swimmer's itch on South 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 South Torch Lake in the following proportions: Mallards (50%), Canada Geese (36%), Common Mergansers (8%), and Common Loons (5%).

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 19 fecal samples were collected and analyzed from birds on South Torch Lake: Mallards, Canada Geese, and Common Mergansers. Fecal samples from both Mallards and Canada Geese were found to harbor avian schistosomes responsible for causing swimmer's itch. DNA barcoding revealed these species present: *Anserobilharzia brantae* and an unknown species in mallards.

Objective 2: Determine the level of parasite infestation on South 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 12 sites around South Torch Lake and analyzed to determine the level of schistosome cercariae in the 25-liter sample. Surprisingly, only 1 of the 12 sites had parasites in the water, and the severity was very light. This is most likely due to sampling on a morning when snails shed very few cercariae.



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.

N.A. The TLA will not be allowed to apply for a MDNR permit to trap and relocate Common Mergansers on South Torch Lake since not enough of the criteria necessary for obtaining the permit were met. However, North Torch Lake does qualify so one permit could be obtained for Torch Lake allowing common mergansers to be trapped anywhere in Torch Lake.

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 South 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 South 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!

Finally, we could not function without the dedicated and talented work of our other team members: Chris Froelich, Kelsey Froelich, Sydney Rudko, Brooke McPhail, Dan Clyde, Matt



Schuiling, and Annette Dobrzynski. Their pursuit of excellence and tireless commitment to quality is what has made FWS so successful. Without their behind-the-scenes diligence, we could not have produced the results we presented to you in this report.