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Comprehensive Swimmer's Itch Assessment

Pickerel/Crooked Lake Association (PCLA)

Final Report

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Submitted by

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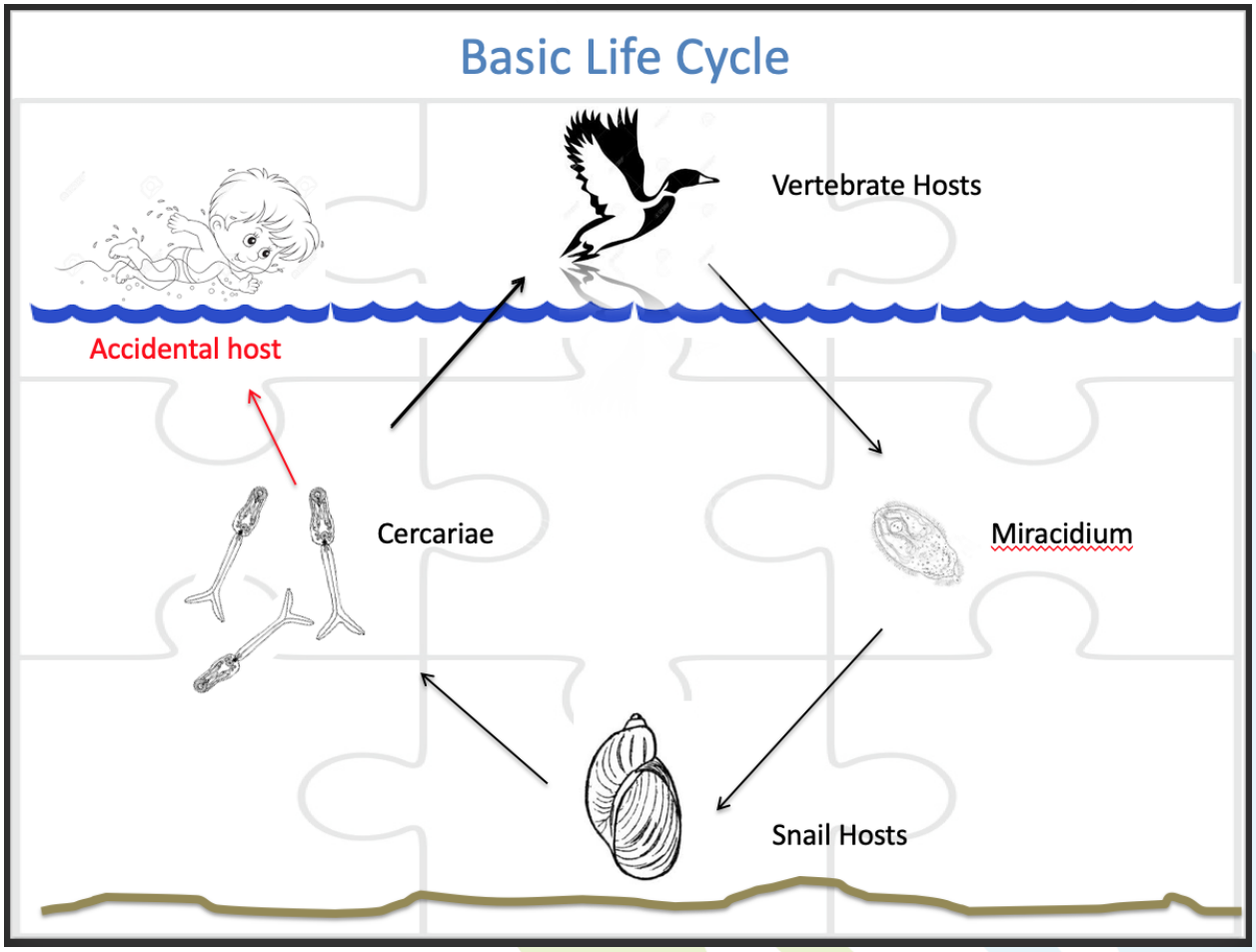
Introduction

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 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 in advancing the science of swimmer's itch assessment.

The 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 Pickerel/Crooked 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 Pickerel/Crooked Lake.

To further assist your association 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 much of the transmission to the snail intermediate host takes place.

A complete shoreline survey was conducted on both Pickerel and Crooked Lakes on 31 July. Each 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 tables below summarize what we believe is a fairly stable summer resident waterfowl population on Pickerel and Crooked Lakes. 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.

Pickerel Lake Waterfowl Survey Summary

	Total Birds	AHY	HY	Broods	% of Population
Mallard	102	44	58	12	67.11
Canada Goose	47	47	0	0	30.92
Hooded Merganser	3	3	0	0	1.97
Totals	**152**	**94**	**58**	**12**	**100.00**

Crooked Lake Waterfowl Survey Summary 7/31/19

	Total Birds	AHY	HY	Broods	% of Population
Mallard	222	113	109	19	57.07%
Canada Goose	38	23	15	3	9.77%
Hooded Merganser	107	70	37	5	27.51%
Wood Duck	8	5	3	1	2.06%
Mute Swan	14	10	4	2	3.60%
Totals	**389**	**221**	**168**	**30**	**100.00%**

Mallards dominate the waterfowl community on both lakes, a fairly common observation on recreational lakes in NW Michigan as seen in the table below. There is also a sizeable Canada goose population present and, surprisingly, hooded mergansers made up 27% of the waterfowl community on Crooked Lake. No common mergansers, a species often implicated in schistosome parasite transmission, were observed on either lake, another surprising observation.

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, both Pickerel and Crooked Lakes had well-above average number of summer resident waterfowl, due in part to greater numbers of both mallards and Canada geese. Most surprising was the large number of hooded mergansers found on Crooked Lake, where they comprised over a quarter of the total waterfowl species.

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 39 fecal samples were collected and analyzed from Pickerel and Crooked Lake, representing 23 mallards, 10 Canada geese, and 6 hooded mergansers. Miracidia were found in 7 samples but only one was infected heavily enough to extract DNA for barcoding and species identification. DNA analysis yielded an unknown species. Further analysis may reveal species identification and will be reported as a memo addendum.

Crooked/ Pickerel Lake Waterfowl Fecal Sample Analysis

Date	Species	Location	Age/Certainty	Ave Miracidia/g/min	Species (if determined)
8/1/19	H. Merganser	H7(C)	13/14 HY	0.31	*Insufficient Miracidia*
8/1/19	Mallard	A7 (C)	AHY	2.64	Unknown
8/1/19	Mallard	L4 (C)	HY	0.28	*Insufficient Miracidia*
8/1/19	Mallard	M16 (P)	6/7 HY	0.27	*Insufficient Miracidia*
8/1/19	Mallard	L12 (P)	5/6 HY	0.62	*Insufficient Miracidia*
8/1/19	Canada Goose	G1 (P)	35/47 HY	1.26	*Insufficient Miracidia*
8/1/19	Canada Goose	G1 (P)	35/47 HY	0.61	*Insufficient Miracidia*

Most importantly, we found all three dominant summer resident waterfowl species infected with schistosome parasites capable of carrying the parasites responsible for causing swimmer's itch.

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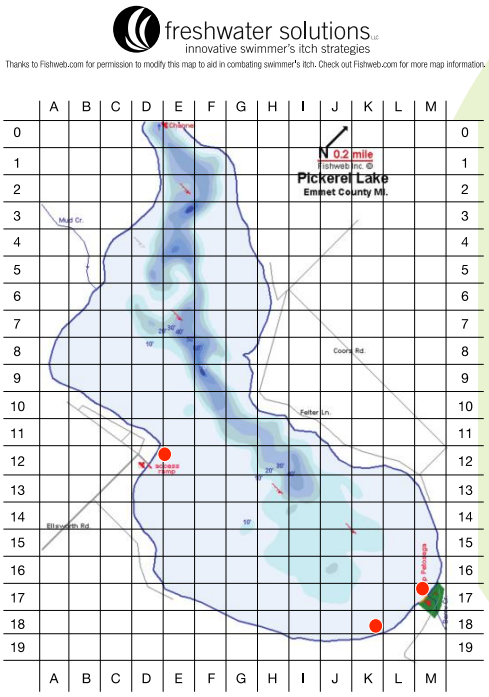
Invertebrate Snail Hosts

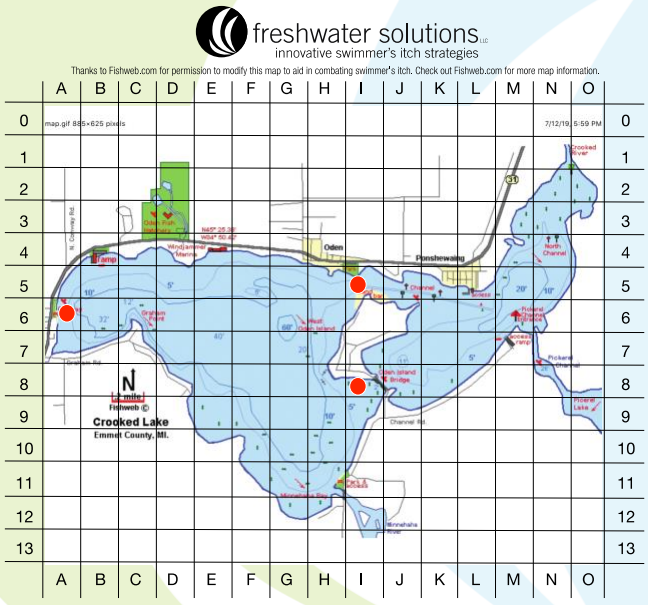
Different species of snails are known to carry different species of schistosomes responsible for causing swimmer's itch. Over 100 schistosome species have been discovered worldwide and we have found at least 8 species in NW Michigan since 2017. A comprehensive assessment of the community structure of the snail species present in Pickerel and Crooked Lakes 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 6 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 1,114 snails were collected and analyzed from Pickerel/Crooked Lake from locations indicated by red dots on the maps below. These locations were selected with input from association representatives as locations where swimmer's itch is commonly reported.





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

Crooked-Pickerel Lakes Snail Totals				
Snail Species	**Snails Examined**	**Snails in Hoops**	**Density (snail/m)**	**% Snail Fauna**
Stagnicola sp.	642	457	4.76	51.12%
Physa sp.	13	10	0.10	1.12%
Lymnaea sp.	1	1	0.01	0.11%
Gyraulus sp.	61	60	0.63	6.71%
Pleurocera sp.	144	144	1.50	16.11%
Helisoma sp.	102	71	0.74	7.94%
Viviparus sp.	145	145	1.51	16.22%
Marstonia sp.	6	6	0.06	0.67%
Tot/Avg	**1114**	**894**	**9.31**	**100.00%**

Stagnicola sp. snails were dominant, making up 51% of the total snail population. However, 67% (427) of these 642 snails were collected from just two locations on Pickerel Lake: K18 and M17.

Three different snail species were found to harbor patent schistosome infections: *Stagnicola* sp., *Physa* sp., and *Helisoma* sp. Collection and infection rate details are contained in the tables below.

Stagnicola sp.							
Date	**Site**	**No. Examined**	**Density (snail/m)**	**Pos. Schistosome**	**% infected Schistosome**	**Total Positive Infections**	**% that are infected with any parasite**
7/17/19	P K18	209	8.0	2	0.96%	45	21.53%
7/17/19	P M17	218	9.7	1	0.46%	30	13.76%
7/17/19	P D12	16	1.0	0	0.00%	1	6.25%
7/17/19	C I8	128	3.4	2	1.56%	50	39.06%
7/17/19	C I5	71	0.0	0	0.00%	49	69.01%
7/17/19	C A6	0	0.0	0	0.00%	0	0.00%
Tot/Avg		642	**4.1**	**5**	**0.78%**	175	**27.26%**

Physa sp.							
Date	Site	No. Examined	Density (snail/m)	Pos. Schistosome	% infected Schistosome	Total Positive Infections	% that are infected with any parasite
7/17/19	P K18	1	0.1	0	0.00%	0	0.00%
7/17/19	P M17	0	0.0	0	0.00%	0	0.00%
7/17/19	P D12	7	0.4	1	14.29%	1	14.29%
7/17/19	C I8	0	0.0	0	0.00%	0	0.00%
7/17/19	C I5	3	0.2	0	0.00%	1	33.33%
7/17/19	C A6	2	0.0	0	0.00%	0	0.00%
		13	**0.1**	**1**	**7.69%**	2	**15.38%**

Helisoma sp.							
Date	Site	No. Examined	Density (snail/m)	Pos. Schistosome	% infected Schistosome	Total Positive Infections	% that are infected with any parasite
7/17/19	P K18	6	0.3	0	0.00%	0	0.00%
7/17/19	P M17	2	0.1	0	0.00%	1	50.00%
7/17/19	P D12	4	0.3	0	0.00%	0	0.00%
7/17/19	C I8	48	1.4	1	2.08%	8	16.67%
7/17/19	C I5	38	1.4	0	0.00%	5	13.16%
7/17/19	C A6	4	0.2	0	0.00%	0	0.00%
		102	**0.6**	**1**	**0.98%**	14	**13.73%**

Although the highest snail infection rate for schistosomes was found in *Physa* sp. (7.69%), parasites from *Stagnicola* sp. snails may be having a greater impact on swimmer's itch (at least in some locations) since their density is much greater (4.1 vs. 0.1 m^2). The new schistosome species we discovered in *Helisoma* sp. snails in 2018 is also contributing cercariae into the waters of Crooked and Pickerel Lakes.

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.

Crooked-Pickerel Lakes Snail Infections					
	Schistosome Infections	% Schistosome	Trematode infections	% Infections	% of Total Infections
Stagnicola sp.	5	0.78%	175	27.26%	90.21%
Physa sp.	1	7.69%	2	15.38%	1.03%
Lymnaea sp.	0	0.00%	0	0.00%	0.00%
Gyraulus sp.	0	0.00%	3	4.92%	1.55%
Pleurocera sp.	n/a	n/a	n/a	n/a	n/a
Helisoma sp.	1	0.98%	14	13.73%	7.22%
Viviparus sp.	n/a	n/a	n/a	n/a	n/a
Marstonia sp.	n/a	n/a	n/a	n/a	n/a
Tot/Avg	**7**	**3.15%**	**194**	**12.26%**	**100.00%**

Barcoding from the schistosome cercariae and species identification showed *Trichobilharzia stagnicolae* from the *Stagnicola* sp. snails, *Trichobilharzia physellae* from the *Physa* sp. snail, and the newly discovered (yet unnamed) schistosome from the *Helisoma* snail.

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.

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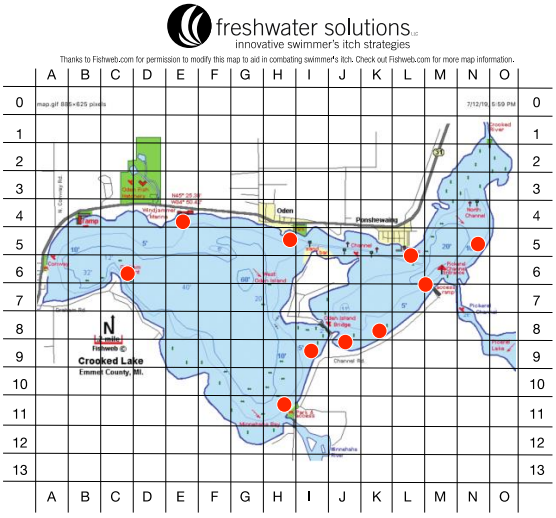
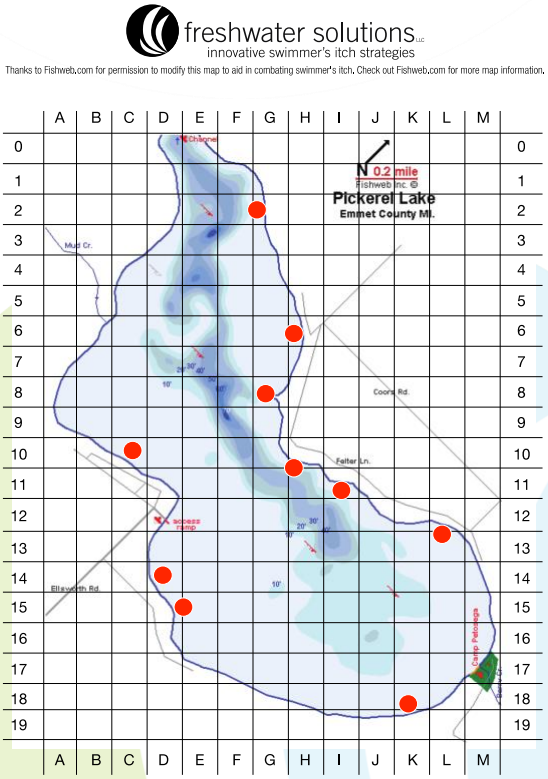
Crooked/Pickerel Water Samples Data		
Site	**Date**	**Ave/25L**
C E4	7/24/19	21
C H5	7/24/19	0
C L5	7/24/19	0
C N5	7/24/19	0
P G2	7/24/19	0
P H6	7/24/19	0
P G8	7/24/19	0
P H10	7/24/19	0
P I11	7/24/19	0
P L12	7/24/19	1.75
P K19	7/24/19	17
P D15	7/24/19	0
P D14	7/24/19	0
P C10	7/24/19	10
C M7	7/24/19	0
C K8	7/24/19	>100
C J8	7/24/19	0
C I9	7/24/19	1.5
C H11	7/24/19	10.75
C C6	7/24/19	79.25
	Ratio>30/<30	**0.11**





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.

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# 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 Pickerel/Crooked Lake were also run with our species-specific qPCR assays to determine what species of parasite were present. Of the 8 positive samples, 5 had *T. stagnicolae* present, and all 8 had the newly discovered schistosome from *Helisoma* snails present. None showed any *T. physellae* present.

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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.

Three (3) cases were reported to "swimmersitch.ca" in 2019 from Pickerel/Crooked Lake.

Objective Checklist

Objective 1: Determine the natural history of the parasite(s) causing swimmer's itch on Pickerel and Crooked Lakes.

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 5 species of snails in Pickerel/Crooked Lake known to harbor the avian schistosomes responsible for causing swimmer's itch: *Stagnicola* sp., *Physa* sp., *Gyraulus* sp., *Lymnaea* 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: Three of the snails known to harbor avian schistosomes were found shedding the itch-causing cercariae: *Stagnicola* sp., *Physa* sp., *Helisoma* sp. DNA barcoding showed the following species cycling on Pickerel/Crooked Lake: *T. stagnicolae*, *T. physellae*, new species from *Helisoma* snails.

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 31 July documented 5 species of waterfowl present on Crooked Lake in the following proportions: Mallards (57%), Canada Geese (10%), Hooded Mergansers (27%), Wood Ducks (2%), and Mute Swans (4%). A waterfowl survey on Pickerel Lake documented 3 species of waterfowl in the following proportions: Mallards (67%), Canada Geese (31%), Hooded Mergansers (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 39 fecal samples were collected and analyzed from Pickerel/Crooked Lake. Fecal samples from Mallards, Canada Geese, and Hooded Mergansers, the three dominant waterfowl species, were found to harbor avian schistosomes responsible for causing swimmer's itch. DNA barcoding revealed these species present: *Anserobilharzia brantae*, others unknown at this time.

Objective 2: Determine the level of parasite infestation on Pickerel and Crooked Lakes 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 20 sites around Pickerel/Crooked Lake and analyzed to determine the level of schistosome cercariae in the 25-liter sample. Nearly half (8/10) sites had some parasites in the water, ranging from just a few to over 100.

Note: Summer resident Common Mergansers, implicated as hosts on some other Michigan lakes, were absent from Pickerel/Crooked Lake. Although the parasites known to cycle through Common Mergansers were found in the snails, those infections likely came from spring/fall migratory birds.

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 PCLA 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 PCLA in preparation of a MDNR application, if desired.

N.A. The PLCA will not be allowed to apply for a MDNR permit to trap and relocate Common Mergansers since summer residents of this species are not present and it appears other waterfowl are contributing to swimmer's itch problem on Pickerel/Crooked 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 PCLA. 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.

   Progress towards swimmer's itch prevention the last three years has been greater than any time in history. State and local funding, combined with technological advances, has allowed us to innovate and test new prevention measures and discover a much more complex system of itch-causing parasites than originally expected. This is driving a paradigm shift away from whole-lake control and towards empowering individual riparians to prevent swimmer's itch themselves. This is especially important for Pickerel/Crooked Lake since whole-lake control by common merganser removal is not an option.

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 PCLA 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 Pickerel/Crooked 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 PCLA, with whom FWS has worked.

4. **Educate PCLA 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 PCLA members to join PCLA and FWS in assessing the efficacy of various prevention measures in 2020.**

   FWS will be presenting the PCLA 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 Pickerel/Crooked 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 PCLA 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. We didn't have opportunity to connect personally with PCLA members due to the late start on assessment, but we found board members to be very accommodating (via email), 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.