THREE LAKES ASSOCIATION

Torch, Clam, & Bellaire Lakes

Comprehensive Swimmer's Itch Assessment: *Lake Bellaire*

Final Report
November 2019

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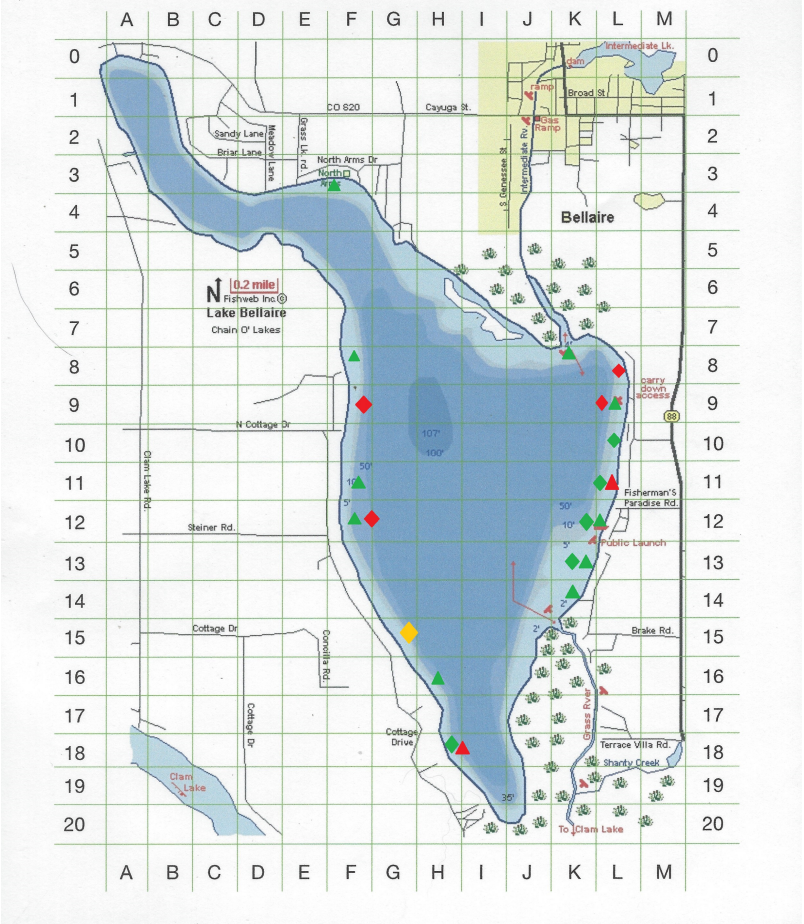
Additional Information:

Three Lakes Association's Summer Interns also collected water samples around the Lake Bellaire to determine if the swimmer's itch cecariae correlated with the other indicators at specific locations. The intern's samples were collected on July 30, 2019 at the locations shown as diamonds on the map; **red diamonds** indicating high numbers of cecariae, and **yellow** or **green diamonds** indicating low or non-detected numbers of cecariae measured by same qPCR method used by Freshwater Solution in their Comprehensive Assessment of Swimmer's Itch in Lake Bellaire. Freshwater Solution collected their samples on July 16, 2019. Their findings are shown as triangles on the same map, where the locations of high numbers of cecariae are indicated as **red triangles** and low or non-detected number indicated as **green triangles**.

Interestingly, the locations of high and low numbers of cecariae for both studies are in good agreement, which also correlates with website-survey findings from 2018 where swimmers report where they were swimming when they got swimmer's itch.

Although some lake associations have assessed swimmer's itch as a required prerequisite to obtain a DNR permit to capture and relocate merganser ducks…assuming that removing these ducks will reduce the incidence of swimmer's itch in their lakes. The data from these studies is not sufficiently convincing that merganser ducks are the primary source of the swimmer's itch parasite, nor that removing broods of mergansers will reduce the incidence of swimmer's itch. Three Lakes Association will continue offering helpful hints to accomplish that objective, and continue surveying the incidence around the lake.

Map of Lake Bellaire showing high and low numbers of swimmer's itch cecariae in water samples, as determined by TLA's Summer Interns and Freshwater Solutions, July 2019.



Supplemental Acknowledgement:

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Lake Bellaire

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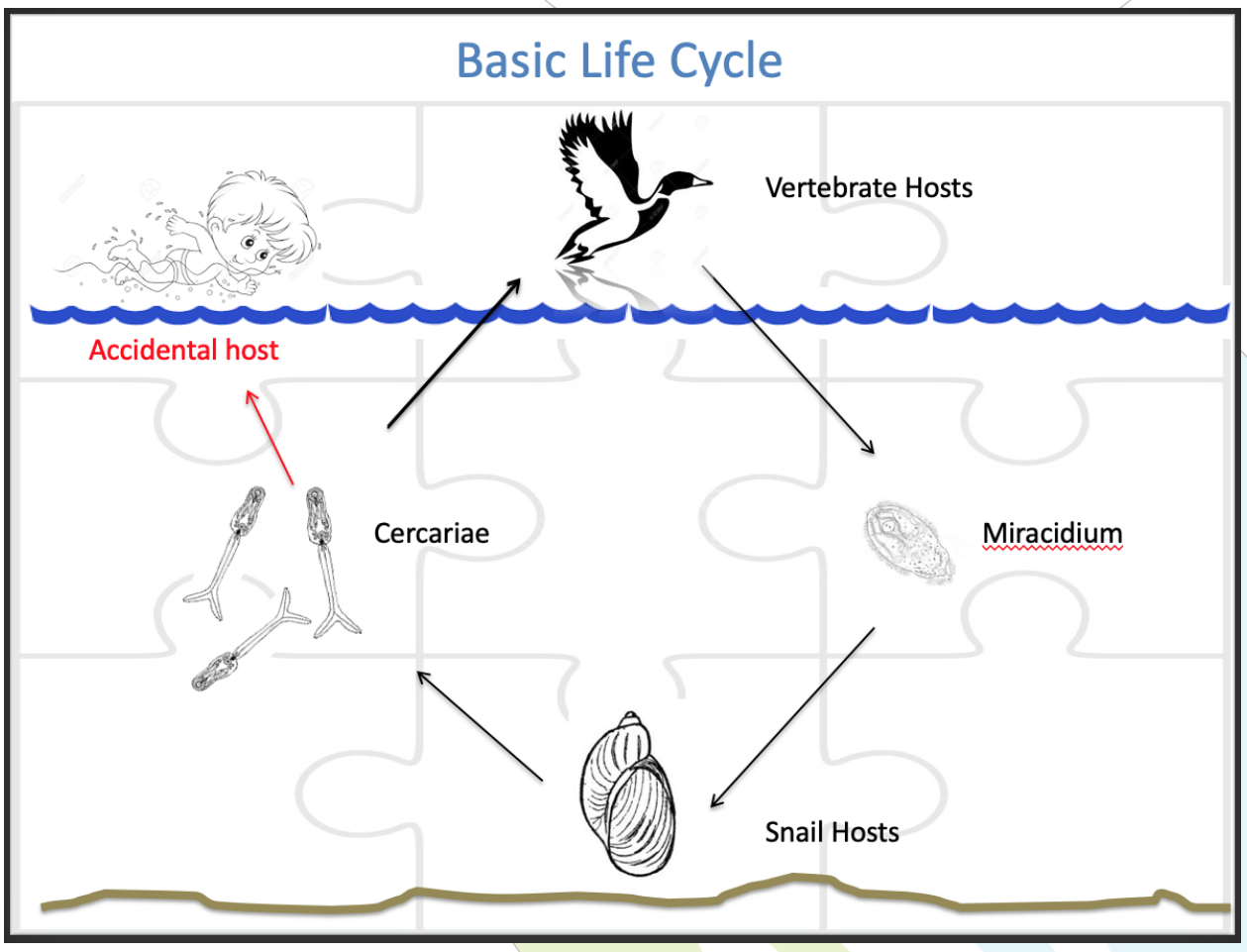
Introduction

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 Lake Bellaire 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 Lake Bellaire.

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 Lake Bellaire on 6 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 Lake Bellaire. 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.

Lake Bellaire Waterfowl Survey Summary 8/6/19

	Total Birds	AHY	HY	Broods	% of Population
Mallard	34	19	15	3	52.31%
Canada Goose	14	4	10	2	21.54%
Loon	4	3	1	1	6.15%
Wood Duck	11	4	7	2	16.92%
Hooded Merganser	2	2	0	0	3.08%
Totals	**65**	**32**	**33**	**8**	**100.00%**

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 Lake Bellaire. No broods of common mergansers were present.

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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**

Lake Bellaire has a much smaller waterfowl population than other NW Michigan lakes when comparing birds per mile of shoreline. Fewer birds does not necessarily mean less swimmer's itch, since a few heavily infected birds can infect many snails in a localized area in a short amount of time. Large groups of migratory waterfowl can also have significant impact.

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 13 fecal samples were collected and analyzed from Lake Bellaire, representing 10 Canada geese and 3 mallards. None of the samples were positive for avian schistosomes.

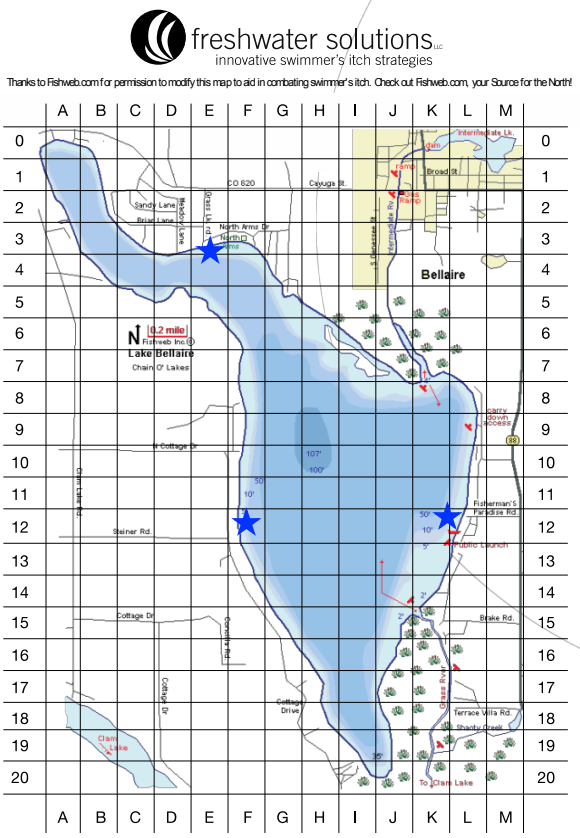
Invertebrate Snail Hosts

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 Lake Bellaire 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 841 snails were collected and analyzed from Lake Bellaire at locations indicated by blue dots 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.

Lake Bellaire Snail Totals				
	Snails Examined	**Snails in Hoops**	**Density (m_2)**	**% Snail Fauna**
Stagnicola sp.	369	229	3.63	44.47%
Physa sp.	94	58	0.92	11.26%
Lymnaea sp.	2	2	0.03	0.39%
Gyraulus sp.	20	20	0.32	3.88%
Pleurocera sp.	57	57	0.90	11.07%
Helisoma sp.	257	107	1.70	20.78%
Viviparus sp.	24	24	0.38	4.66%
Marstonia sp.	18	18	0.29	3.50%
Tot/Avg	**841**	**515**	**8.17**	**100.00%**

Stagnicola sp. snails were dominant, making up 44% of the total snail population. Four other species known to harbor avian schistosomes were also found: *Physa* sp. (11%), *Helisoma* sp. (21%), *Gyraulus* sp. (4%), and *Lymnaea* sp. (0.4%).

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 (m^2)**	**Pos. Schistosome**	**% infected Schistosome**	**Total Positive Infections**	**% that are infected with any parasite**
6/11/19	E3	207	10.1	0	0.00%	25	12.08%
6/11/19	F12	102	2.9	1	0.98%	22	21.57%
6/11/19	K12	60	0.7	0	0.00%	8	13.33%
Tot/Avg		**369**	**3.6**	**1**	**0.27%**	**55**	**14.91%**

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. Lake Bellaire had higher densities of *Helisoma* sp. than average and fairly robust snail diversity.

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	--	--	--	--	--	--

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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.

Lake Bellaire Snail Infections					
	Schistosome Infections	**% Schistosome**	**Trematode infections**	**% infections**	**% Total Infections**
Stagnicola sp.	1	0.27%	55	14.91%	68.75%
Physa sp.	0	0.00%	0	0.00%	0.00%
Lymnaea sp.	0	0.00%	0	0.00%	0.00%
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%	25	9.73%	31.25%
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	**1**	**0.27%**	**80**	**4.93%**	**100.00%**

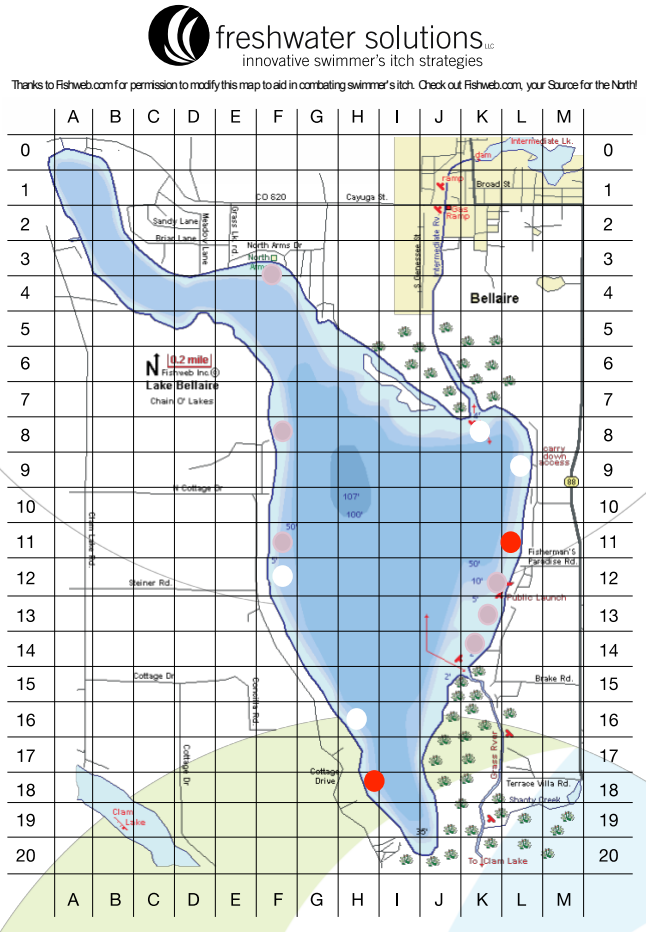
Schistosome barcoding from the schistosome cercariae and species identification showed *Trichobilharzia stagnicolae* from the *Stagnicola* sp. snail. *T. stagnicolae* is known to live in common mergansers. No summer resident common mergansers were present on Lake Bellaire in 2019. If that was true in 2018, we can conclude the snails harboring *T. stagnicolae* were infected by visits from spring and fall migratory birds.

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 a map showing collection sites. These sites were selected with input from lake association representatives.

Water Sample Data	
	16 July 2019
Site	Avg Cer/25L
L11	>100
L9	0.0
K8	0.0
F3	1.0
F8	3.5
F11	1.0
F12	0.0
H16	0.0
H18	>100
K14	1.0
K13	2.5
K12	1.0
Ratio >30/<30	**0.20**



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 Lake Bellaire were also run with our species-specific qPCR assays to determine what species of parasite were present. Of the 8 positive samples, 7 had *T. stagnicolae* present. No other species of schistosomes were found. This is notable since most other lakes showed at least two or more species.

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.

Four (4) cases were reported to "swimmersitch.ca" in 2019 from Lake Bellaire.

Objective Checklist

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

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 Lake Bellaire known to harbor the avian schistosomes responsible for causing swimmer's itch: *Stagnicola* sp., *Physa* sp., *Lymnaea* sp., *Gyraulus* sp., *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 *Trichobilharzia stagnicolae* cycling on Lake Bellaire:

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 6 August documented 5 species of waterfowl present on Lake Bellaire in the following proportions: Mallards (52%), Canada Geese (22%), Hooded Mergansers (3%), Wood Ducks (17%), and Common Loons (6%).

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 13 fecal samples were collected and analyzed from birds on Lake Bellaire: Mallards and Canada Geese. All fecal samples were negative for avian schistosomes.

Objective 2: Determine the level of parasite infestation on Lake Bellaire 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 Lake Bellaire and analyzed to determine the level of schistosome cercariae in the 25-liter sample. Although 8 of the 12 samples showed cercariae in the water, most levels were very light. Two sites, however, showed very high levels.

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 Lake Bellaire since not enough of the criteria necessary for obtaining the permit were met.

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.

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 Lake Bellaire 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 chances 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.

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Acknowledgements

It was our pleasure to work on Lake Bellaire 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.

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innovative swimmer's itch strategies

Additional Reporting

Matt Schuiling, a biology major who just graduated from Hope College, took personal interest in all of our work on Lake Bellaire in 2019. Matt plans to pursue graduate school with his interest in research and clinical psychology. He is currently taking a gap year, working as a research assistant at the University of Chicago. Matt created a poster presentation that summarizes our work on Lake Bellaire which he will formally present at Hope College in the spring. We present it as a tool you may want to use to educate your membership. We will supply the pdf file separately for more convenient printing.

Hope COLLEGE

Lake Bellaire Swimmer's Itch Assessment

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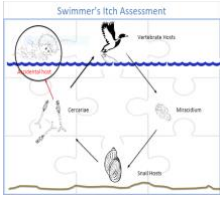
Lake Bellaire Assessment

Introduction

Cercarial dermatitis, commonly known as 'swimmer's itch,' is skin irritation caused by a family of parasitic flatworms called schistosomes. These schistosomes have a 2-host cycle including adult worms in a waterfowl host and a cercariae stage which exits an aquatic snail host. This free-living cercaria stage is the one that causes swimmer's itch.

Swimmer's itch occurs when the cercariae seeking a waterfowl host accidentally come into contact with humans wherein the cercariae die upon entering the body, resulting in itchy bumps.



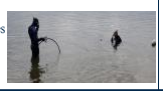
The goal of our study was to determine the species of schistosome cycling in Lake Bellaire, determine areas of high cercariae concentration, and investigate which waterfowl host may be responsible.

Methods

Snail Collection: 1 m² hoops were thrown at 3 locations around the lake. All snails in each hoop were collected to determine snail densities, and pulmonated snails previously shown to host schistosomes were further isolated in 12 well culture plates, allowed to sit overnight in the dark, and observed individually for the presence of schistosomes. Any positives were sent away to be genetically barcoded.

Water Sampling: Lake water samples from 12 locations underwent DNA extraction and were run through qPCR to determine the concentration and species of schistosome present at each site.

Bird Surveys: Number and species of waterfowl per shoreline mile were recorded along all 12 miles of Lake Bellaire. Any fresh fecal samples were examined, and all miracidia were DNA barcoded for species identification.



Results

Snail collection showed that one location on the western side of the lake near Steiner Rd. yielded a positive schistosome from a Stagnicola snail.

	Snails Examined	Snails in Heaps	Density [snails/m²]	% Snail Fauna	Schistosome Infections	% Schistosome	Trematode Infections	% Infections	% Total Infections
Stagnicola	369	229	3.83	43.08%	1	0.27%	55	14.91%	69.14%
Physa	94	58	0.92	11.18%	0	0.00%	0	0.00%	0.00%
Gyralus	20	20	0.32	2.38%	0	0.00%	0	0.00%	0.00%
Pisidiums	57	57	0.90	6.78%	N/A	N/A	N/A	N/A	N/A
Helisoma	257	197	1.70	30.56%	0	0.00%	25	9.73%	30.86%
Viviparus	24	24	0.38	2.85%	N/A	N/A	N/A	N/A	N/A
Marstonia	18	18	0.28	2.14%	N/A	N/A	N/A	N/A	N/A
Lymnaea	2	2	0.03	0.24%	0	0.00%	0	0.00%	0.00%
Total/Ave.	841	515	8.17	100.00%	1	0.05%	80	5%	100.00%

Water Sample Data	
	16 July 2019
Site	Avg Cer/25L
L11	>100
L9	0.0
K8	0.0
F3	1.0
F8	3.5
F11	1.0
F12	0.0
H16	0.0
H18	>100
K14	1.0
K13	2.5
K12	1.0
Ratio >30/<30	0.17

Water sampling showed very high levels of cercariae on the East side of the lake near Fisherman's Paradise Rd (L11) and in the lower arm of the lake south of Cottage Drive (H18). Other locations with moderate impacted were on the west side (F3, F8, F11) and the east side (K14, K13, K12).

Bird survey data shows high numbers of mallard, Canada geese and wood duck. Some hooded mergansers were also found.

Lake Bellaire Waterfowl Survey Summary 8/6/19					
	Total Birds	AHY	HY	Broods	% of Population
Mallard	34	19	15	3	32.31%
Canada Goose	14	4	10	2	21.54%
Loon	4	3	1	1	6.15%
Wood Duck	15	4	7	2	19.87%
Hooded Merganser	2	2	0	0	3.08%
Totals	69	32	33	8	100.03%

No positive fecal samples were found upon sampling of goose and mallard.

Conclusion

Infected snails were concentrated on the western part of the lake, while areas of high infection were on the Eastern and Southern shores. It is known that cercariae are easily blown across the lake, so the wind may be responsible for this dichotomy.

There is evidence that the species of schistosome cycling on Lake Bellaire is the species found in the Stagnicola host.

Implications

1. Limited range of the intermediate host on the lake could cause hyper concentrated areas of swimmer's itch, and some areas of no swimmer's itch

2. Migratory birds may have more impact that previously thought

Limitations: It is possible that the sites from which water and snails were collected did not contain the largest portion of the schistosomes/hosts on the lake. Migratory birds could also be causing a significant portion of the swimmer's itch, diminishing the theorized impact of summer residents.

Cercariae Water Column Experiment

Introduction

It is known that schistosome cercariae are released from snails and swim to the surface within the top foot of water. Developing a more precise understanding of their location could lead to more accurate water sampling techniques.

Methods

While still unexposed to light for the day, a previously screened positive snail was placed inside a 300mL syringe (pictured below) and subsequently filled with 200mL of water. The syringe was left to sit for a half hour exposing the snail to light, thus initiating cercariae output and allowing them to swim to their preferred location in the water column.

Water from the syringe was fractionally distilled in increments of about 10mL into separate dishes for examination. Each water sample was massed to determine water column depth and treated with crystal violet solution (3µL per 1mL) to stain potential cercariae. Cercariae were then counted in each fraction.

Results

The total volume of 200mL was equivalent to a total depth of about 10cm (~4 inch). 65% of all cercariae were present within the top 2.69cm (~1 inch) of the water column.

The bottom fraction, from 8.78cm to 10.10cm, contains a high concentration of cercariae, likely because that is the location of the snail that is producing and releasing the cercariae into the water column or those cercariae were dead.

Stagnicola Cercariae Depth Analysis		
Water Column Depth (cm)	# of Cercariae	Percent of Cercariae
0 - 0.16	294	15.8%
0.16 - 0.62	362	19.4%
0.62 - 1.15	159	8.5%
1.15 - 1.67	156	8.4%
1.67 - 2.17	104	5.6%
2.17 - 2.69	137	7.4%
2.69 - 3.15	72	3.9%
3.15 - 3.69	89	4.8%
3.69 - 4.18	59	3.2%
4.18 - 4.73	35	1.9%
4.73 - 5.21	31	1.7%
5.21 - 5.74	32	1.7%
5.74 - 6.23	27	1.5%
6.23 - 6.76	31	1.7%
6.76 - 7.29	24	1.3%
7.29 - 7.84	45	2.4%
7.84 - 8.33	26	1.4%
8.33 - 8.78	27	1.5%
8.78 - 10.10	152	8.2%
Total	1862	100.0%

Conclusion

1. Cercariae prefer being even closer to the surface than was originally confirmed.
2. A more efficient water sampling technique may be to collect water samples from only the first few centimeters of the water.

Limitations: These results are based upon only a single trial, so more trials are necessary to definitively form and expand conclusions. Additionally, the snails may have been stressed which could influence the number of cercariae which emerged.