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2016 Monitoring Report
For Spiny Water Flea
In Lake Winnipesaukee

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Background

The spiny water flea (*Bythotrephes longimanus*) is an invasive zooplankter first discovered in the Laurentian Great Lakes in the early 1980s and were likely introduced via ballast water. From there, the invasive zooplankter spread rapidly throughout the upper Midwest. In 2009, spiny water fleas were detected in an Adirondack lake in New York, and over the next four to five years, spread into nearby waterbodies, including Lake George and the Champlain Canal System. In 2014, spiny water fleas were detected and confirmed in Lake Champlain, Vermont. According to the Lake Champlain Basin Program, Lake Winnipesaukee is the fifth most common waterbody a boater has visited prior to visiting Lake Champlain within a two week period[1]. The popularity of both Lake Champlain and Lake Winnipesaukee suggest it is only a matter of time before spiny water fleas are introduced into New Hampshire's largest waterbody.

Spiny water flea can reach a length up to 15 mm, mostly due to a long, barbed tail spine. Research suggests the invasive zooplankter drastically alters its invaded zooplankton community by consuming small zooplankton[2]. Declines in the native zooplankton predator *Leptodora* have been recorded [2,3]. They are thought to negatively influence larval fishes by competing directly for zooplankton prey and being an undesirable food source due to the long, barbed tail. They are highly mobile throughout the water column and are known to foul fishing lines, nets and trawls.

Currently there is no known method of removal once spiny water flea become established in a waterbody. The best spiny water flea management is to prevent the invasive zooplankter from becoming established in the first place. A pilot study to monitor the zooplankton community in Lake Winnipesaukee was initiated in 2016, with the dual purposes of confirming spiny water fleas are not present in Lake Winnipesaukee and to establish a baseline understanding of the existing zooplankton community.

Methods

Field

Previously established lake deep spot locations based on coordinates recorded in the New Hampshire Department of Environmental Services (NHDES) Environmental Monitoring Database (EMD) were used to determine site selection (Table 1; Appendix A-1).

[1] "2015 State of the Lake and Ecosystem Indicators Report." http://sol.lcbp.org. Lake Champlain Basin Program, New England Interstate Water Pollution Control Commission. 2015. Web. 21 December 2016.

[2] Barbiero, Richard P. and Marc L. Tuchman. 2004. Changes in the crustacean communities of Lakes Michigan, Huron, and Erie following the invasion of the predatory cladoceran *Bythotrephes longimanus*. Canadian Journal of Fisheries and Aquatic Sciences 61(11):2111-2125.

[3] Branstrator, Donn. 1995. Ecological Interactions Between *Bythotrephes cederstroemi* and *Leptodora kindtii* and the Implication for Species Replacement in Lake Michigan. Journal of Great Lakes Research 21(4):670-679.

Four sample events were conducted to collect zooplankton at nine deep spot basins on Lake Winnipesaukee (Table 1). One 250-µm and one 80-µm plankton net sample were collected at every site expect WINTUFD, which had two 80-µm plankton samples collected at different depths (Table 1; for more detail on the plankton nets, see Appendix A-2). Therefore, a total of nine 250-µm plankton samples and ten 80-µm plankton samples were collected in 2016 (Table 1). Sample dates ranges from June to August (Table 1).

On each sample date per site, the following data collection procedures were followed:

1. A Secchi disk reading was collected on the shady side of the boat, and Secchi disk reading with a view scope was collected on the sunny side of the boat.
2. A 250-µm mesh net was attached to a chain, and lowered to 5 meters above the bottom sediment. If deep spot depth was unknown or too deep for the chain, the net was lowered to twice the depth of the Secchi disk reading.
3. The net was allowed to stabilize at the maximum depth for ten seconds before pulling it back up into the boat.
4. The contents of the net were rinsed into the collection cup of the net and sample was transferred into a plankton bottle and preserved with several drops of Lugol's solution.
5. The 250-µm mesh net was detached from the chain and an 80-µm mesh net was reattached. The 80-µm mesh net was lowered to twice the depth of the Secchi disk reading allowing the net to stabilize for ten seconds before pulling it back into the boat.
6. The contents of the net were rinsed into the collection cup of the net and the sample was transferred into a plankton bottle and preserved with several drops of Lugol's solution.
7. Sample bottles were stored in a cooler on ice for transport back to the lab.

Label the sample bottles with the following information:

- Date
- Site ID
- Net mesh size
- Depth of tow

Table 1. Deep spot locations, depths, sample dates and sample depths on Lake Winnipesaukee.

Station ID	Station Description	Town	Max Depth (m)	Latitude	Longitude	Sample Date	Depth (m) of Sample	
							250-µm	80-µm
WINALTD	ALTON BAY	ALTON	39	43.51469	-71.25888	8/31/2016	12	13
WINBGILD	BROADS	GILFORD	54.6	43.59119	-71.341	8/31/2016	35	14
WINBWOLD	WOLFE. BAY	WOLFEBORO	33	43.56958	-71.21588	7/1/2016	25	25
WINCEND	CTR HARBOR	MEREDITH	35	43.6839	-71.4334	8/5/2016	20	16.5
WINGGILD	GOV ISLAND	GILFORD	37	43.614	-71.41038	8/5/2016	25	17
WINMERD	MEREDITH BAY	MEREDITH	32.6	43.6353	-71.47508	8/5/2016	20	16

WINMOUD	MOULT. BAY	MOULTONBORO	24	43.6885	-71.3415	6/17/2016	20	10/20
WINTUFD	COW ISLAND	TUFTONBORO	24	43.63988	-71.3065	6/17/2016	20	20
WINBMERD	BEAR ISLAND	MEREDITH	37	43.6353	-71.47508	8/5/2016	25	16

Sample processing

In the laboratory, the 250-µm mesh net samples were counted for macrozooplankton, excluding rotifers and Copepod Nauplius, in 1-mL subsamples. The total sample was diluted to a known volume, and subsamples drawn off using a 1-mL Henson-Stempel pipette and counted in 1-mL Sedgwick rafter cells under a compound microscope at magnification (10x). Additional 1-mL subsamples were counted until at least 100 individuals of one or multiple dominant species were enumerated. Identification was made to lowest possible taxon. The total sample was scanned for spiny water flea and rare species presence. Sample processing was performed at the Jody Connor Limnology Center at NHDES. This methodology was adapted from the 2015 Long-Term Water Quality and Biological Monitoring Project for Lake Champlain.

The 80-µm mesh net samples were counted for zooplankton, including rotifers and Nauplius, in 1-mL subsamples. The total sample was diluted to a known volume, and subsamples were drawn off using a 1-mL Henson-Stempel pipette and counted in 1-mL Sedgwick rafter cells under an inverted microscope at magnification (10-20x). Additional 1-mL subsamples were counted until at least 100 individuals of one or multiple dominant species are enumerated. Identification was made to lowest possible taxon.

Results

250-µm Samples

Spiny water fleas were not detected in any of the 250-µm samples. Total Cladoceran densities ranged from 313.2 – 10,925.9 $^{-1}m^3$ (Table 2). Total Copepod densities, excluding Nauplius, ranged from 112.1 – 1814.4 $^{-1}m^3$ (Table 2). The Cladoceran *Holopedidae* was the most abundant macrozooplankter at five of the nine sites, followed by Cladoceran *Daphnia* (n=2), Copepod *Calanoid* (n=1), and Cladoceran *Bosminidae* (n=1) (Table 3).

Table 2. Total Cladoceran and Copepod (excluding Nauplius) densities (#/m³) by Date and Site.

Date	Site	Cladoceran	Copepod
		#/m³	#/m³
6/17/2016	WINMOUD	5838.57	1252.87
6/17/2016	WINTUFD	10925.92	611.15
7/1/2016	WINBWOLD	4131.41	452.25
8/5/2016	WINBMERD	1414.01	325.95
8/5/2016	WINCEND	1494.06	392.16
8/5/2016	WINGGILD	1277.52	112.05

8/5/2016	WINMERD	1556.92	311.94
8/31/2016	WINALTD	1687.04	1814.37
8/31/2016	WINBGILD	313.22	198.63

Leptodora, a predatory Cladoceran that has been found to be adversely affected by spiny water flea, were observed in eight of the nine samples (absent at WINBWOLD). When present, *Leptodora* densities ranged from 0.2 – 5.86 $^{-1}m^3$ (Table 3). Phantom midge larvae (*Chaoborus*; Order: Diptera), another predator of macrozooplankton, were observed in seven of the nine samples (absent at WINBWOLD and WINALTD). When present, *Chaoborus* densites ranged from 0.61 – 10.19 $^{-1}m^3$ (Table 3).

Lake Winnipesaukee experienced a low density cyanobacteria bloom of *Gloeotrichia* in August 2016. A large colony cyanobacteria that is often visible to the eye, *Gloeotrichia* colonies ranged from 10.2 – 1167.1 $^{-1}m^3$ (Table 3).

80-µm Samples

Samples collected using an 80-µm mesh were enumerated for Copepod Nauplius and rotifers. Macrozooplankton were enumerated if present in the sample; however, the entire sample was not scanned for spiny water flea or rare species. Due to the preservation techniques (Lugol's solution) rotifers were often difficult to identify. Rotifer densities ranged from 19,988.5 $^{-1}m^3$ to 740,588.4 $^{-1}m^3$ (Table 4). *Conochilus* was the most abundant rotifer, followed by *Gastropus*. *Asplanchna* was the largest rotifer, and was more effectively captured in the 250-µm net. Copepod Nauplius densities ranged from 1,826.4 $^{-1}m^3$ to 17,508.9 $^{-1}m^3$ (Table 4). The cyanobacteria *Gloeotrichia*, due to its large size as a colonial cyanobacteria, was more effectively captured at multiple sites by the 250-µm net; however, the 80-µm net captured very high densities at WINBGILD (38,423.2 $^{-1}m^3$; Table 4).

Table 3. Density estimates (#/m³) of individual species by Date and Site collected in a 250-µm plankton net.

	6/17/2016		7/1/2016	8/5/2016				8/31/2016	
	#/m³		#/m³	#/m³				#/m³	
Cladocerans	WINMOUD	WINTUFD	WINBWOLD	WINBMERD	WINCEND	WINGGILD	WINMERD	WINALTD	WINBGILD
Bosminidae	1039.0	3361.4	2041.3	30.6	18.7	30.6	160.4	0.0	2.5
Ceriodaphnia	0.0	15.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chydoridae	0.0	0.0	12.2	0.0	0.0	0.0	0.0	63.7	20.4
Daphnia	1986.3	3804.4	293.4	30.6	74.7	20.4	347.6	0.0	2.5
Holopedidae	2536.3	3743.3	1662.3	1314.0	1307.2	1212.1	1025.0	1103.5	257.2
Leptodora	1.0	0.3	0.0	0.2	2.5	4.1	5.9	**	**
Polyphemidae	1.0	1.3	**	8.1	37.3	0.2	0.3	0.0	2.5
Sididae	137.5	0.0	0.0	30.6	56.0	10.2	17.8	519.9	25.5
Unknown sp.	137.5	0.0	122.2	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	***5838.6***	***10925.9***	***4131.4***	***1414.0***	***1496.5***	***1277.5***	***1556.9***	***1687.0***	***310.7***
Copepods									
Calanoid	1069.5	412.5	232.2	234.3	289.4	112.0	303.0	1771.9	170.6
Cyclopoid	183.3	198.6	220.0	91.7	102.7	0.0	8.9	42.4	28.0
TOTAL	***1252.9***	***611.2***	***452.3***	***325.9***	***392.2***	***112.0***	***311.9***	***1814.4***	***198.6***
Other									
Chaoborus	3.6	0.8	0.0	0.6	1.8	10.2	1.0	0.0	**
Gloeotrichia colonies (cyano)	0.0	0.0	0.0	61.1	28.0	10.2	0.0	1167.1	685.0
Asplanchna (rotifer)	0.0	~~	0.0	~~	476.2	~~	6328.0	~~	~~
Water mite	5.6	2.8	**	30.6	140.1	20.4	53.5	0.0	2.5

**Observed but not enumerated.

~~Present in 80 µm sample and likely was present, but not enumerated.

Table 4. Density estimates (#/m³) of individual species by Date and Site collected in an 80-µm plankton net.

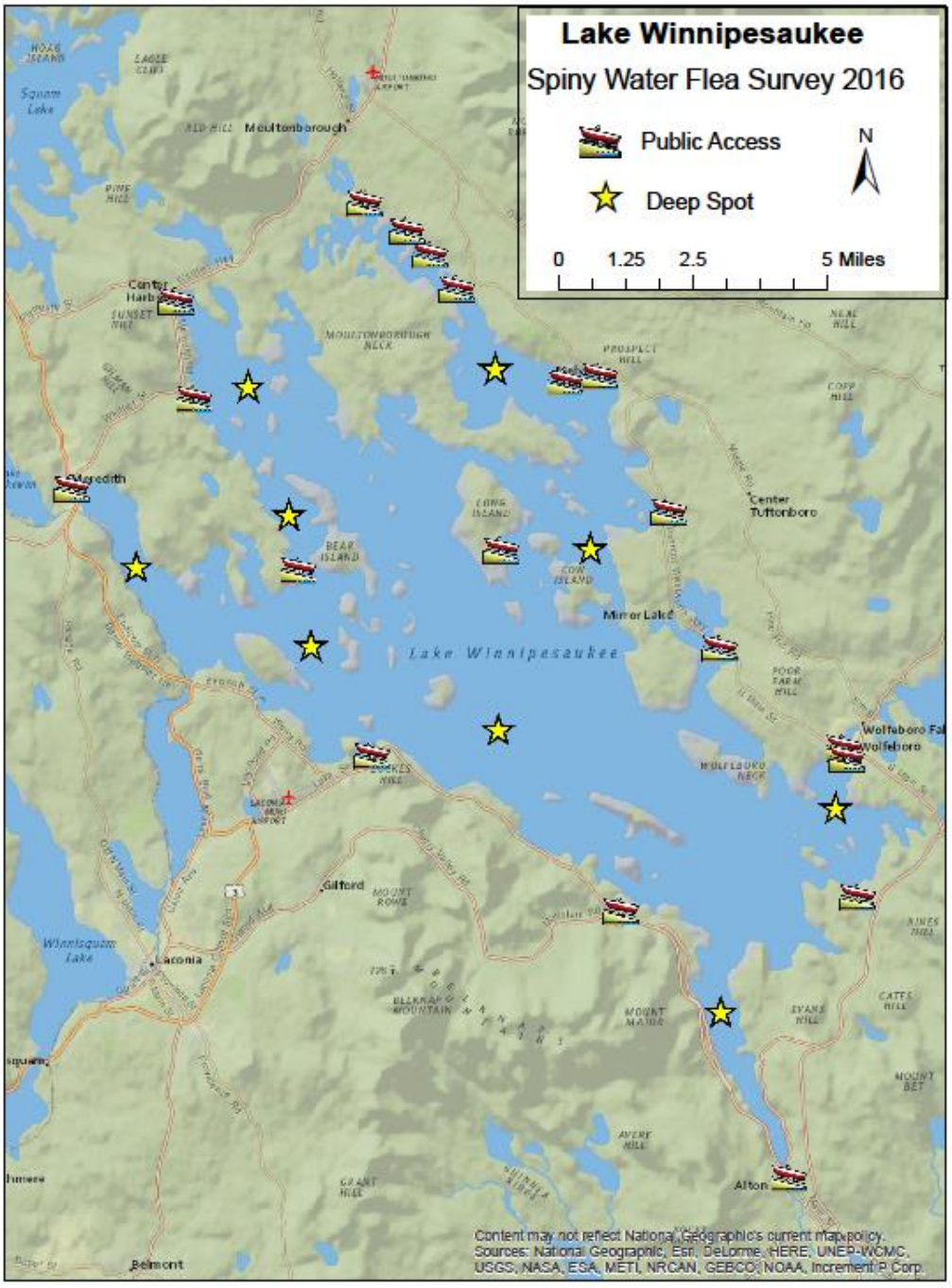
	6/17/2016			7/1/2016	8/5/2016				8/31/2016	
	#/m³			#/m³	#/m³				#/m³	
Rotifer	WINMOUD	WINTUFD (10m)	WINTUFD (20m)	WINBWOUD	WINBMERD	WINCEND	WINGGILD	WINMERD	WINALTD	WINBGILD
Asplanchna	0.0	1318.4	0.0	0.0	502.3	0.0	110.8	1553.9	695.4	10547.5
Conochilus	15633.0	6215.5	10848.9	18352.7	4394.8	19725.3	3988.6	8051.9	22949.6	698398.3
Gastropus	2071.8	16763.1	1657.5	27212.7	3013.6	913.2	4210.2	3814.1	695.4	5273.8
Kellicottia	1130.1	2260.2	1958.8	2320.5	502.3	365.3	997.1	565.0	3303.4	4520.4
Keratella	1318.4	6968.9	5123.1	4640.9	5148.2	5114.0	6315.2	3178.4	14604.3	8287.4
Polyarthra	1318.4	4708.7	2712.2	1371.2	5399.3	4018.1	3545.4	2542.7	6780.6	6027.2
Trichocera	188.3	0.0	301.4	105.5	753.4	182.6	997.1	282.5	521.6	0.0
Unknown sp.	1130.1	0.0	0.0	3164.3	2888.0	0.0	664.8	0.0	2434.0	7534.0
TOTAL	***22790.2***	***38234.9***	***22601.9***	***57167.7***	***22601.9***	***30318.5***	***20829.2***	***19988.5***	***51984.3***	***740588.4***
Macrozooplankton	6/17/2016			7/1/2016	8/5/2016				8/31/2016	
Cladocerans	#/m³			#/m³	#/m³				#/m³	
Bosminidae	376.7	1883.5	1808.2	1054.8	502.3	182.6	332.4	70.6	347.7	0.0
Daphnia	376.7	376.7	753.4	211.0	0.0	0.0	0.0	141.3	0.0	0.0
Holopedidae	188.3	1506.8	904.1	316.4	1757.9	1643.8	332.4	282.5	1217.0	1506.8
Leptodora	0.0	0.0	0.0	0.0	0.0	182.6	0.0	0.0	0.0	0.0
Sididae	0.0	0.0	0.0	105.5	125.6	0.0	0.0	0.0	0.0	0.0
TOTAL	***941.7***	***3767.0***	***3465.6***	***1687.6***	***2385.8***	***2009.1***	***664.8***	***494.4***	***1564.7***	***1506.8***
Copepods										
Cyclopoid	188.3	753.4	150.7	1265.7	502.3	1278.5	332.4	423.8	347.7	3767.0
Calanoid	0.0	188.3	301.4	843.8	1004.5	0.0	554.0	706.3	2781.8	5273.8
Nauplii	4143.7	6027.2	16122.7	17508.9	2385.8	1826.4	2437.5	4379.1	9214.6	3767.0
TOTAL	***4332.0***	***6968.9***	***16574.7***	***19618.4***	***3892.5***	***3104.9***	***3323.8***	***5509.2***	***12344.1***	***12807.7***
Other										
Chaoborus	0.0	0.0	0.0	0.0	0.0	0.0	221.6	0.0	0.0	0.0
Gloeotrichia colonies (cyano)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	173.9	38423.2

Conclusion

Spiny water fleas were not detected in Lake Winnipesaukee during NHDES' 2016 pilot program. In the 250-µm samples, total Cladoceran densities ranged from 313.2 – 10,925.9 $^{-1}m^3$ (Table 3). Total Copepod densities, excluding Nauplius, ranged from 112.1 – 1814.4 $^{-1}m^3$ (Table 3). The Cladoceran *Holopedidae* was the most abundant macrozooplankter at a majority of sites, followed by Cladoceran *Daphnia*. In the 80-µm samples, rotifer densities ranged from 19,988.5 $^{-1}m^3$ to 740,588.4 $^{-1}m^3$ (Table 4). *Conochilus* was the most abundant rotifer, followed by *Gastropus*. Routine monitoring is recommended to continue to determine the invasion status of spiny water flea, as well as to better document natural variability in the native zooplankton community.

Appendix A

A-1. Lake Winnipesaukee Site Map



A-2. Plankton Net Specifications

Wisconsin Plankton Sampler 80-µm

Mouth Diameter: 130 mm

Ring Diameter: 180 mm

Wildco Part Number: 3-40-A55

Watermark Simple Plankton Net 250-µm

Mouth Diameter: 50 cm

Length: 150 cm

Forestry Suppliers Stock Number: 77989