Lake Champlain Long-Term Water Quality and Biological Monitoring Program

Summary of Program Activities During 2019

June 10, 2020

Prepared by:

Vermont Department of Environmental Conservation
Watershed Management Division
1 National Life Drive, Davis 3
Montpelier, VT 05620-3522

New York State Department of Environmental Conservation
Region 5
P.O. Box 296
Ray Brook, NY 12977-0296

Lake Champlain Research Institute
SUNY Plattsburgh-Hudson 136D
101 Broad Street
Plattsburgh, NY 12901

Submitted to:

Lake Champlain Basin Program
P.O. Box 204
54 West Shore Rd.
Grand Isle, VT 05458

Purpose of Report

The workplan for the Lake Champlain Long-Term Water Quality and Biological Monitoring Program approved by the Lake Champlain Basin Program specifies the following annual reporting requirements:

An annual report will consist of a summary of the history and purpose of the (program), description of the sampling network, summary of field sampling and analytical methods, parameter listings, and data tables. The purposes of this annual report will be achieved by maintaining an up-to-date Program Description document, graphical presentations of the data, and an interactive database, including statistical summaries, on the project website…… In addition, the quarterly report produced in April each year will provide a summary of program accomplishments for the calendar year just ended, including the number of samples obtained and analyzed at each site by parameter.

The Program Description document, interactive access to the project data, and graphical and statistical summaries of the data are available on the program webpage. The purpose of this report is to provide a summary of sampling activities and other accomplishments during 2019.

Sampling Activities During 2019

The project QAPP outlines sampling frequency and methodology for all target parameters. In 2019, the QAPP was approved as a five-year document. Sampling and analytical methods are summarized annually; events impacting data quality are also noted. Table 1 lists the number of 2019 sampling visits to each lake and tributary station in relation to the target frequencies specified in the project work plan. Table 2 lists the number of samples collected and analyzed for each monitoring parameter. The New York lake and tributary field sampling was conducted by the Lake Champlain Research Institute at SUNY Plattsburgh under an MOU between NYSDEC and SUNY.

The frequency of lake sampling exceeded workplan targets at all stations during 2019. The frequency of tributary sampling was above the workplan targets for most of the stations. The number of tributary samples obtained each year depends to some extent on the number and timing of high flow events, since sampling is geared toward capturing the highest flow conditions when loading of phosphorus and other materials is greatest. Figure 1 shows that sampling at each tributary captured most peak flow events during 2019.

Table 1. Number of sampling visits during 2019 at each lake and tributary station in comparison with workplan targets.

Number of Lake Sampling Visits					Number of Tributary Sampling Visits				
Lake Station	**NY**	**VT**	**Total**	**Workplan Target[1]**	**Tributary Station**	**Crew**	**All Parameters** TP, DP, TSS, Cl, TN	**Total Phosphorus**	**Workplan Target[2]**
2	10	9	19	12	AUSA01	NY	13	13	14/17
4	10	9	19	12	BOUQ01	NY	14	15	14/17
7	10	8	18	12	GCHA01	NY	12	13	14/17
9	10	8	18	12	LAMO01	VT	15	17	14/17
16	10	9	19	12	LAPL01	VT	18	21	14/17
19	10	8	18	12	LAUS01	NY	14	15	14/17
21	10	10	20	12	LCHA01[3]	NY	13	14	14/17
25	10	10	20	12	LEWI01	VT	18	21	14/17
33	10	9	19	12	LOTT01	VT	4	6	14/17
34	10	9	19	12	LOTT03[7]	VT	18	20	14/17
36	10	9	19	12	METT01	VT	17	17	14/17
40	10	10	20	12	MISS01	VT	16	18	14/17
46	9	7	18	12	OTTE01	VT	18	20	14/17
50	10	8	19	12	PIKE01	VT	12	13	14/17
51[6]		6	6	12	POUL01	VT	17	17	14/17
53	10	2	12	12	PUTN01[4]	VT	1	1	14/17
					ROCK02	VT	17	19	14/17
					SALM01	NY	14	15	14/17
					SARA01	NY	14	16	14/17
					WINO01	VT	16	18	14/17
					JEWE02	VT	17	20	14/17
					STEV01[5]	VT	17	19	14/17
					MILL01	VT	17	19	14/17

[1] Workplan target for lake sampling (12) applies to most chemical parameters and to phytoplankton, zooplankton, and zebra mussel veligers. Sampling for zebra mussel juveniles in Lake Champlain and for veligers in tributaries and inland lakes is done once annually.

[2] The project workplan calls for 14 samples per year for most chemical parameters, including 10 samples at high flow and four samples at low flow. Additional sampling for total phosphorus only should occur on 3 other dates under high flow conditions, for a target of 17 samples per year for total phosphorus.

[3] Little Chazy flow gage was discontinued in 2014 but was re-established on 9-25-2015.

[4] Putnam Creek sampling was discontinued in 2015 due to lack of funding for the flow gage.

[5] The USGS gage at Stevens Brook was discontinued at the end of June 2017. A new gage was constructed by Stone Environmental and is available at http://vt-ms4-flow.stone-env.com/FlowDev/index.html .

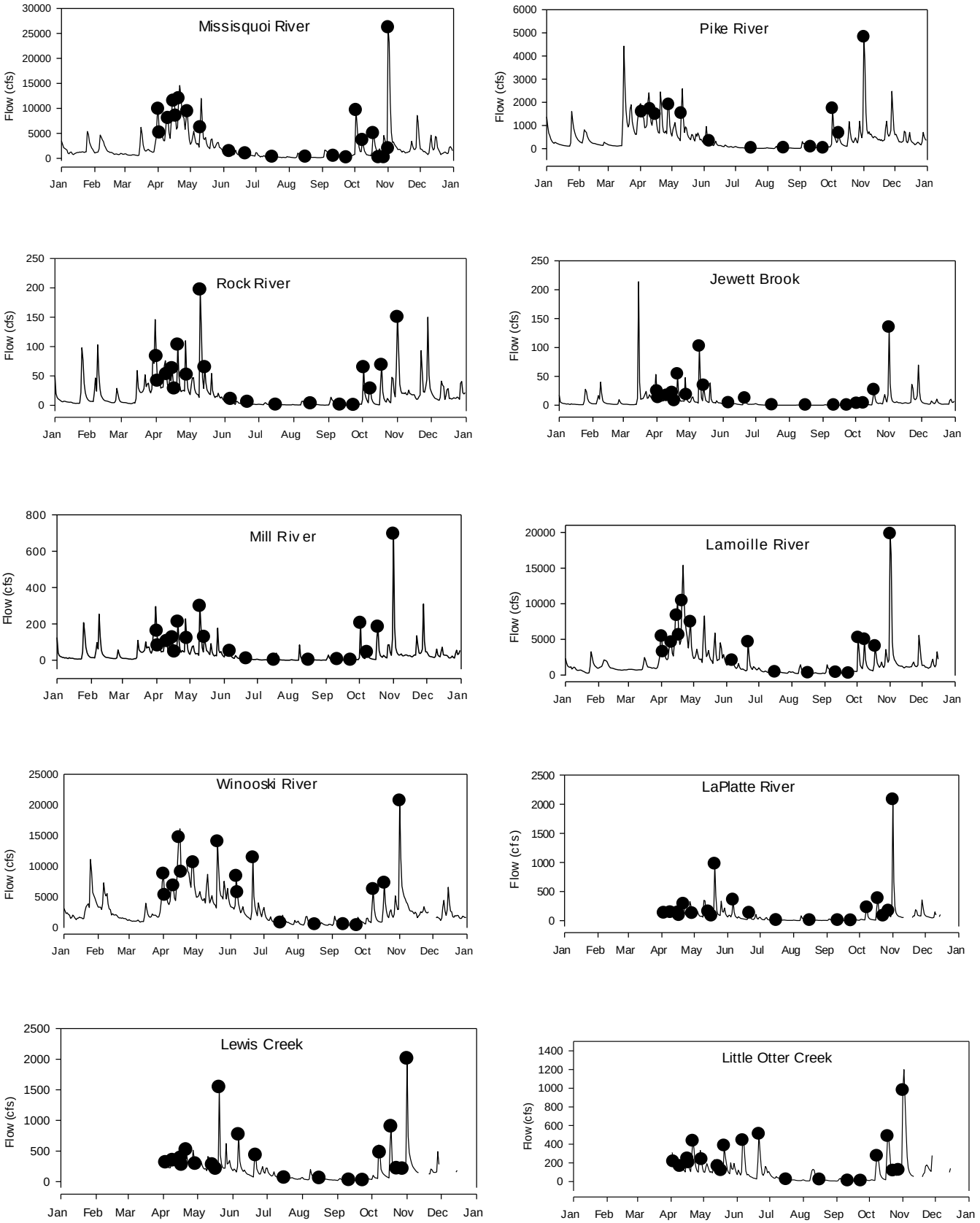
[6] In 2019, field crews were found to have different coordinates for LTM 51. All data have been re-assigned to the correct station and all both crews will sample at LTM 53 in the future.

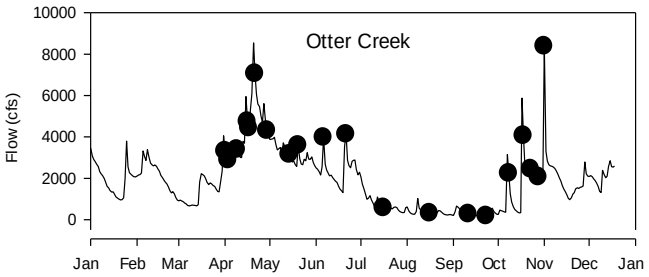
[7] Beginning in 2019, field crews now sample at LOTT03 on Satterly Road, Ferrisburg due to safety concerns after the original location (LOTT01) became overgrown. Concurrent sampling indicated water quality was very similar at the two locations.

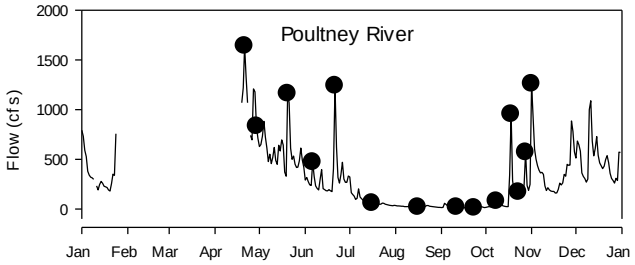
Table 2. Number of samples collected and analyzed for each monitoring parameter during 2019.

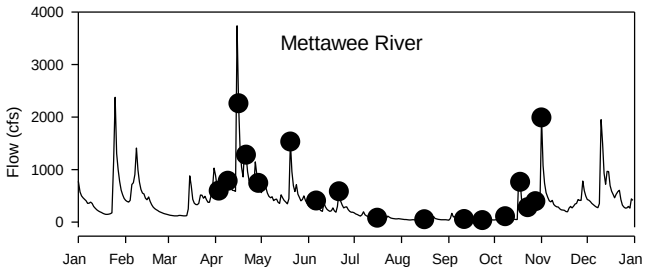
Parameter	**Lake**	**Tributaries**	**Total**
TP	423	429	852
DP	422	393	815
Cl	424	393	817
TN	424	430	854
Ca	66	77	143
Alkalinity	66	77	143
SiO2	424	-	424
K	66	77	143
Na	66	77	143
Mg	66	77	143
Al	66	77	143
Mn	66	77	143
Fe	66	77	143
DOC	63	243	306
DIC	63	243	306
NPOC	71	150	221
DO (Winkler)	41	-	41
Chl-a	314	-	314
TSS	-	391	391
Temperature	-	281	281
Conductivity	-	367	367
pH	-	360	360
Secchi depth	278	-	278
Multiprobe depth profiles	263	-	263
Zebra mussel veligers	99	-	99
Zebra mussel settled juveniles	6	-	6
Mysids	90	-	90
Zooplankton	150	-	150
Phytoplankton	150	-	150
Spiny/Fishhook waterflea	150	-	150

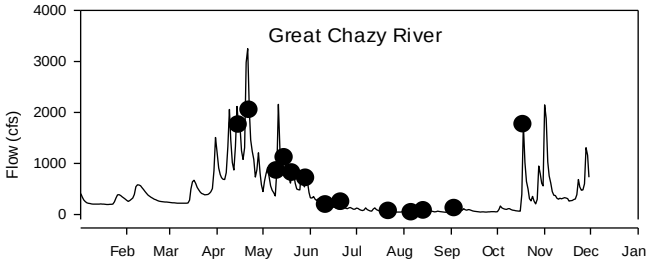
Figure 1. Sampling dates during 2019 in relation to daily flows at each tributary station. Daily flows are shown by lines, and sampling dates are shown by dots.

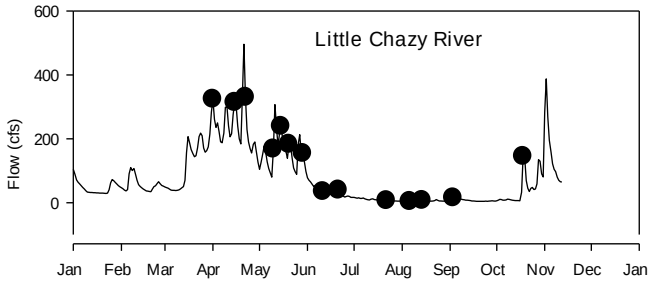


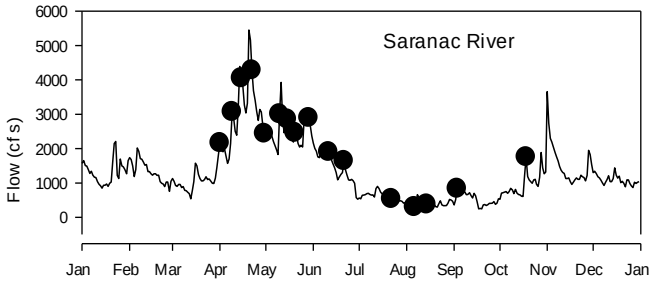

Otter Creek
Flow (cfs)
10000
8000
6000
4000
2000
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan

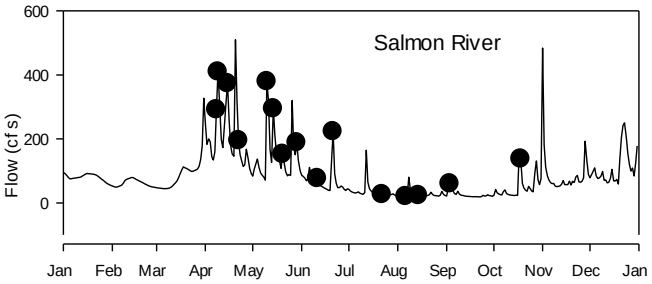

Poultney River
Flow (cfs)
2000
1500
1000
500
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan

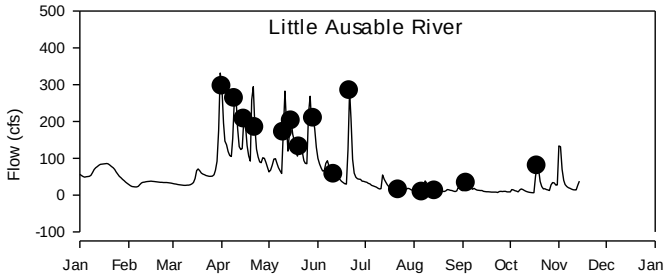

Mettawee River
Flow (cfs)
4000
3000
2000
1000
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan

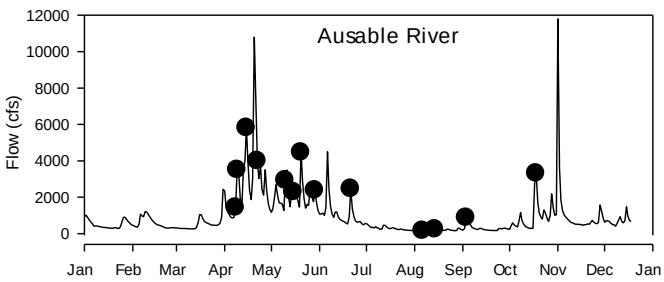

Great Chazy River
Flow (cfs)
4000
3000
2000
1000
0
Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan

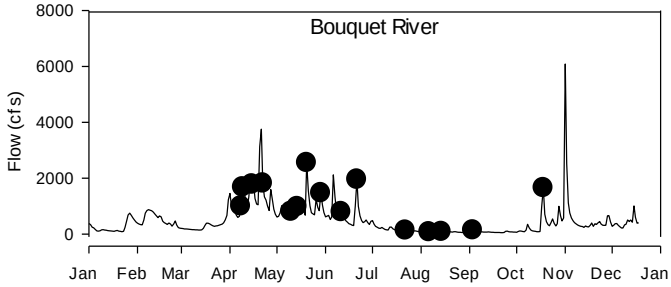

Little Chazy River
Flow (cfs)
600
400
200
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan


Saranac River
Flow (cfs)
6000
5000
4000
3000
2000
1000
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan


Salmon River
Flow (cfs)
600
400
200
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan


Little Ausable River
Flow (cfs)
500
400
300
200
100
0
-100
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan


Ausable River
Flow (cfs)
12000
10000
8000
6000
4000
2000
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan


Bouquet River
Flow (cfs)
8000
6000
4000
2000
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan

Data Quality Assurance Results

As described in the program's Quality Assurance Project Plan, field equipment blanks and field duplicate samples are obtained on each sampling run. The results for the blank samples are summarized in Table 3. Twelve of the 380 blank samples analyzed during 2019 (3.2%) had concentrations above the analytical detection limits. Results for field duplicate samples are summarized in Table 4 for the chemical analyses.

Table 3. Field equipment blank results during 2019 for lake and tributary samples.

Test	Detection Limit	Units	Number of Blanks Obtained	Number of Blanks Above Limit	High Blank Values
Alk	1.0	mg/l	9	0	
Cl	2.0	mg/l	46	1	16
TN	0.1	mg/l	48	1	
TP	5.0	µg/l	48	2	9, 14
DP	5.0	µg/l	46	1	8
Chl-a	0.5	µg/l	17	4	0.54, 0.51, 0.71,0.54
TSS	2.0	mg/l	29	1	11
SiO2	0.2	mg/l	17	0	
Al	20	µg/l	9	0	
Fe	50	µg/l	9	0	
Ca	0.5	mg/l	9	1	0.29
Na	0.5	mg/l	9	0	
K	0.5	mg/l	9	0	
Mg	0.02	mg/l	9	0	
Mn	5	µg/l	9	0	
DIC	1	mg/l	22	0	
DOC	1	mg/l	22	1	1.69
NPOC	1	mg/l	13	0	
Total			380	12	

Table 4. Field duplicate results for chemical tests during 2019 showing the number of duplicates obtained (N) and the mean relative percent difference (RPD) between duplicate pairs.

Test	N	Mean RPD
Chl-a	14	16.9
Cl	43	2.3
DIC	20	1.9
DOC	20	4.0
NPOC	15	11.2
DP	45	8.5
Alk	9	1.3
TN	46	7.0
TP	47	7.5
TSS	29	22.9
SiO2	16	3.5
Al	6	16.1
Ca	9	3.2
Fe	7	8.2
K	9	2.8
Na	9	2.6
Mg	9	2.7
Mn	9	7.0

Phytoplankton and Zooplankton Database

All phytoplankton data from 2006-2015 have been incorporated into the main Lake Champlain Monitoring Program database. Phytoplankton samples from 2016 were compromised by an initially undetected field error and were not analyzed. Zooplankton data are currently available for the project period of 1993-2013. The data available for download from the web interface include phytoplankton cell densities and biovolumes, and zooplankton densities grouped by major taxonomic category. Counts by individual taxa are available by request. Zooplankton data from 2014-2018 and phytoplankton data from 2017-2018 are available by request but have not been added to the project database.

Wastewater Phosphorus Discharge Data

The project workplan requires an annual compilation of wastewater phosphorus discharge data for all treatment facilities in the Vermont and New York portions of the Lake Champlain Basin. Data on annual mean flow, total phosphorus concentration, and phosphorus load at each facility have been compiled for 2019 along with data from previous years and are available electronically in spreadsheet form on request. The total loads and flows from Vermont and New York wastewater treatment facilities during 2007-2019 are summarized in Table 6.

Table 5. Annual wastewater facility phosphorus loading and flows for Vermont and New York.

State	Number of Facilities	Year	Phosphorus Load (mt/yr)*	Mean Flow Rate (mgd)**	Phosphorus Divided by Mean Flow Rate (mg/L)***
Vermont	60	2007	20.7	51.3	0.29
	60	2008	20.8	49.2	0.31
	60	2009	20.2	42.5	0.34
	60	2010	18.2	39.7	0.33
	59	2011	18.6	41.5	0.32
	59	2012	16.8	42.5	0.29
	59	2013	17	39.9	0.31
	59	2014	17.5	42.2	0.30
	59	2015	13.4	37.2	0.26
	59	2016	11.6	33.9	0.25
	59	2017	13.8	32.3	0.31
	59	2018	13.2	39.8	0.24
	59	2019	11.9	43.1	0.20
New York	29	2007	28.5	33.2	0.62
	29	2008	26.5	34.3	0.56
	29	2009	20.9	31.5	0.48
	29	2010	22	32.8	0.49
	29	2011	23	34.4	0.48
	29	2012	22.6	30.4	0.54
	29	2013	22.9	30.3	0.55
	29	2014	24.7	30.3	0.59
	29	2015	23.7	29.6	0.58
	29	2016	22.2	30.2	0.53
	29	2017	18.7	31.1	0.43
	29	2018	21.3	31.9	0.48
	29	2019	22.3	32	0.50

***** The annual phosphorus load represents the total of average monthly loads from all facilities in each state. Represented in metric tons (mt) per year.

** The annual mean flow rate represents the total of average monthly flow rates from all facilities in each state. Represented in millions of gallons per day (mgd).

*** Calculated by dividing the annual phosphorus load (in mt/yr) by the annual mean flow rate (in mgd), and multiplying by a conversion factor of 0.723264 to produce a concentration in milligrams per liter (mg/L).

Rock River Monitoring Project

A Rock River Watershed Targeted Best Management Practice (BMP) Implementation Project was initiated in 2010 with funding provided by the Lake Champlain Basin Program (LCBP). It operates under oversight provided by a coordinating committee including the U.S. Natural Resource Conservation Service (NRCS), the Vermont Agency of Agriculture, Food, and Markets (AAFM) and the Vermont Department of Environmental Conservation (DEC). The initial purpose of the project is to demonstrate water quality improvements from focused agricultural BMP implementation in a small watershed where very high rates of phosphorus loading to Lake Champlain have

been documented. Ag BMP implementation got underway in 2010 and new installations continue to be added each year.

In order to document water quality improvements resulting from the targeted Ag BMP implementation in the Rock River watershed, the Vermont DEC established monitoring stations immediately upstream and downstream of the BMP implementation area in late 2010 and funded the construction and operation of a U.S. Geological Survey (USGS) stream flow gage at the downstream site. The DEC issues grants to the Friends of Northern Lake Champlain (FNLC) to support sample collection activities by trained local residents, and the DEC Laboratory conducts the sample analyses. The LCBP financially supports the laboratory analytical efforts and supported the stream gaging through September 2014. The State of Vermont now supports the Rock River stream gage through a cooperative agreement with the USGS.

In 2018, project oversight committee members recognized that the original paired watershed study design was no longer valid – NWQI projects as well as Vermont's Required Agriculture Practices (RAPs) and forestry Accepted Management Practices (AMPs) had been implemented in both watersheds for several years. Vermont's new Municipal Roads General Permit requirements will also affect the watershed in the near future. Members felt strongly, however, that monitoring should continue because information on water quality changes in response to BMP implementation at this watershed level are critical to understanding the success of management efforts. While improvements in water quality will not be attributable to a particular suite of BMPs, changes will be indicative of response to management changes at the sector level, primarily agriculture, forestry, and stormwater.

The new study design will be focused on the detection of change over time in load and concentration of TP, DP, TSS and particulate phosphorus (PP) following the approach used to evaluate change over time in the major tributaries monitored by the Long-Term Monitoring Project. Partners will track BMP implementation and provide periodic summaries to document cumulative improvement in the targeted watershed.

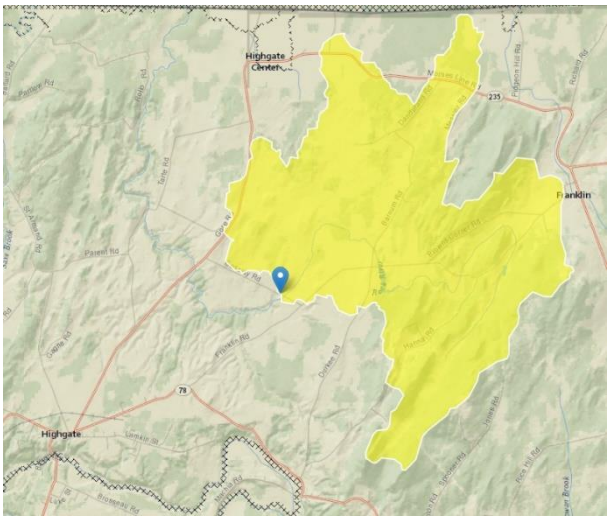
A map of the revised study area and sampling station is shown in Figure 2. The area is approximately 29.3 km^2 in size on the upper Rock River in the towns of Highgate and Franklin, VT. A USGS continuous stream flow gage is co-located with the sampling station (RR14). Sampling was discontinued at RR 20 in 2018.

There have been 364 upstream/downstream paired samples collected and analyzed for TP, DP, and TSS through 2018. This total includes some samples obtained during 2008-2009 by Vermont DEC as part of a previous study. The numbers of paired samples obtained each year are shown in Table 7. The project site map is show in Figure 2.

Table 7. Numbers of samples obtained.

Year	Number of sample pairs	Number of samples (RR14 only)
2008	10	
2009	2	
2010	18	
2011	66	
2012	55	
2013	55	
2014	51	
2015	27	
2016	33	
2017	42	
2018	5	23
2019		17
Total	364	40

Figure 2– Map of the project area showing targeted watershed draining to sampling station RR 14 (blue teardrop). Drainage areas were delineated using the USGS StreamStats tool. (https://streamstats.usgs.gov/ss/



Invasive Species Monitoring
Lake Champlain

Cercopagis pengoi (fish hook waterflea), an invasive predatory cladoceran in the same family as *Bythotrephes longimanus* (spiny waterflea), was first detected in Lake Champlain in August 2018. A total of 240 zooplankton samples were scanned for *Cercopagis* and *Bythotrephes* from monitoring stations on Lake Champlain in 2019 (Table 8, Figures 3 & 4). *Cercopagis* was first detected in late June, with densities greatly increasing into July and August before decreasing in the fall (Figures 4.1 - 4.4). *Bythotrephes* densities were higher throughout the season relative to 2017 and 2018, with peak densities recorded in Late September (Figures 3.1 – 3.4). Whole water vertical tows were taken at each monitoring station using a 250 μm mesh 50 cm plankton net. Samples were then taken to the laboratory where they were visually scanned under a dissecting microscope to determine population densities. All samples were also scanned for other potential invasive invertebrates, including *Hemimysis anomala*.

Table 8. Invasive plankton monitoring stations in the Lake Champlain. Basin.

			events	
62			4	24
51	45.0410	73.1290	10	10
50	45.0130	73.1740	10	10
46	44.9480	73.3400	10	10
40	44.7850	73.1620	10	10
36	44.7560	73.3350	10	10
34	44.7080	73.2270	10	10
33	44.7010	73.4180	10	10
25	44.5820	73.2810	10	10
21	44.4740	73.2320	10	10
19	44.4710	73.2990	12	52
16	44.4250	73.2220	10	10
10	44.3000	73.3214	4	24
9	44.2420	73.3340	10	10
7	44.1260	73.4120	10	10
4	43.9540	73.4050	10	10
2	43.7140	73.3830	10	10
			Total # of Samples	240

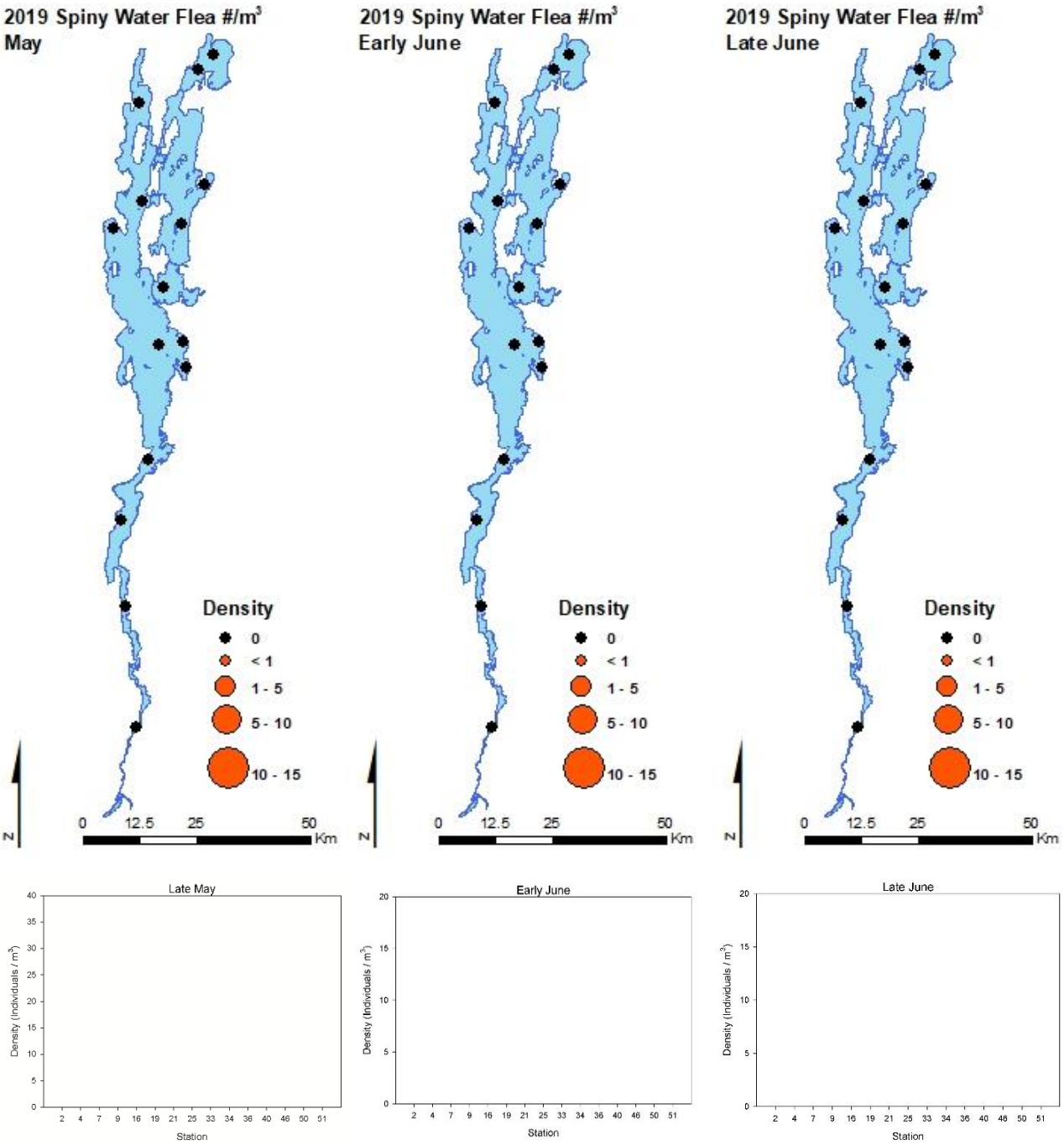


Figure 3.1 Spiny water flea density from vertical whole water tows from May-June 2019

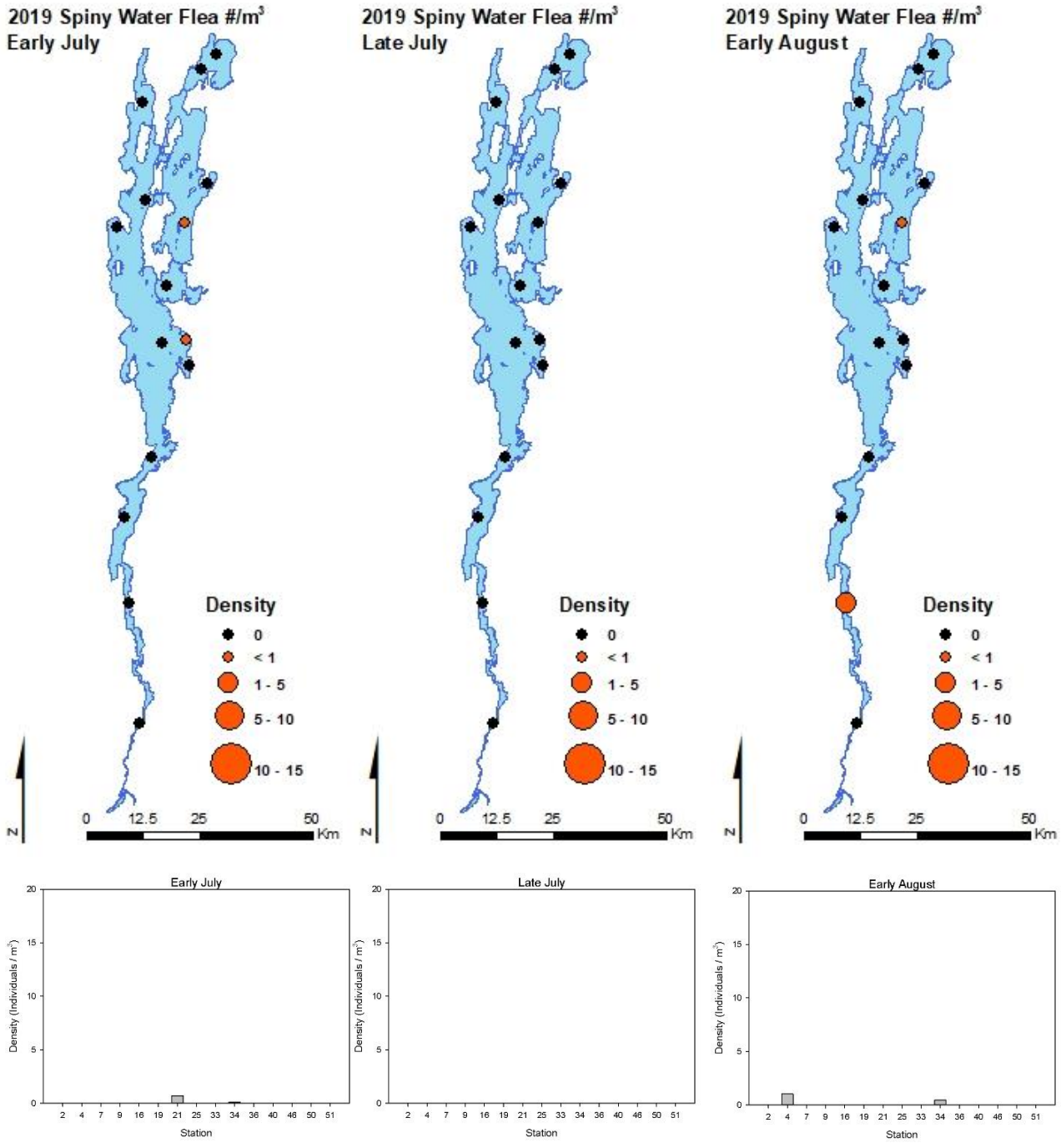


Figure 3.2 Spiny water flea density from vertical whole water tows from July-Early August 2019

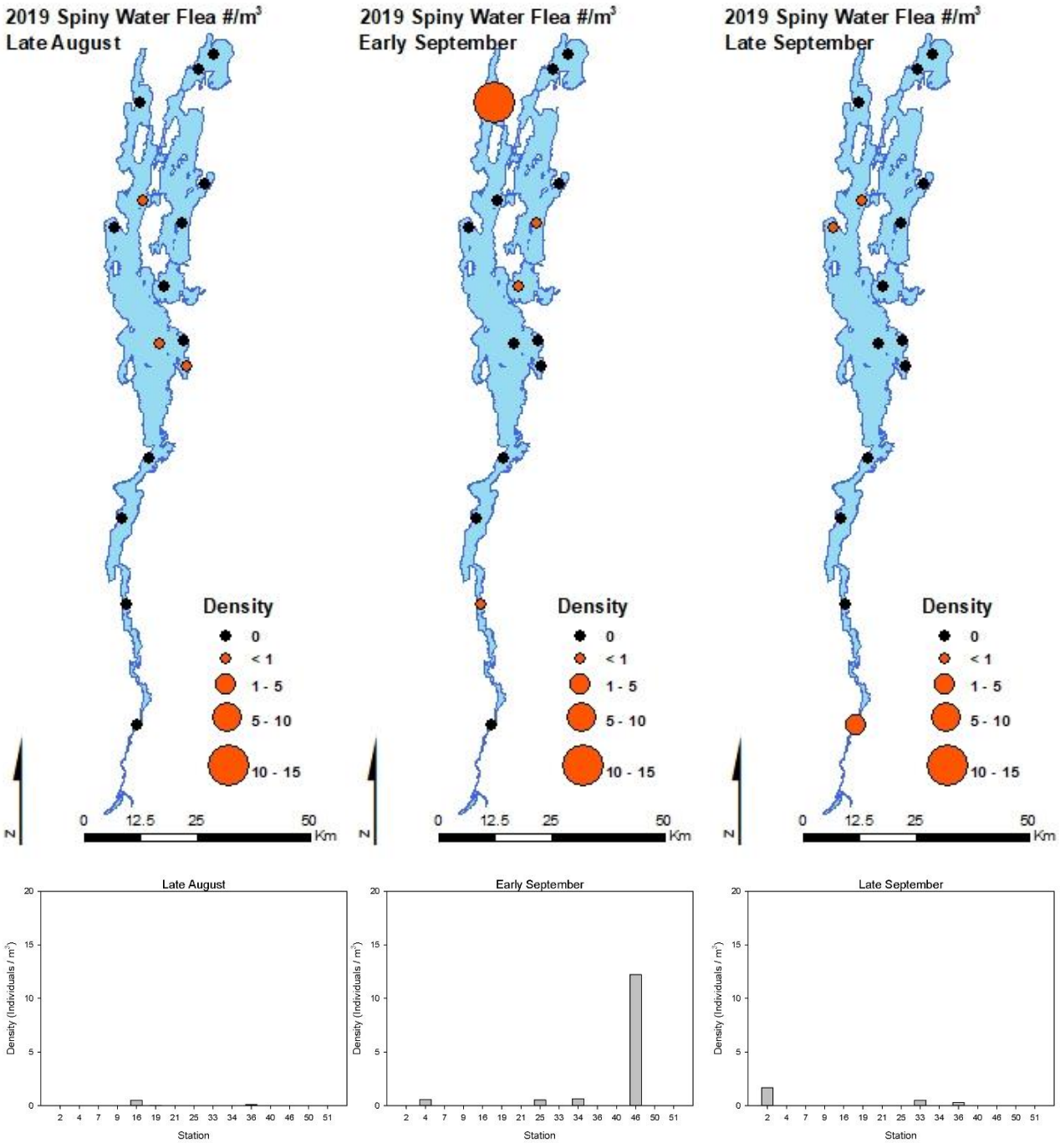


Figure 3.3 Spiny water flea density from vertical whole water tows from Late August– Late September 2019

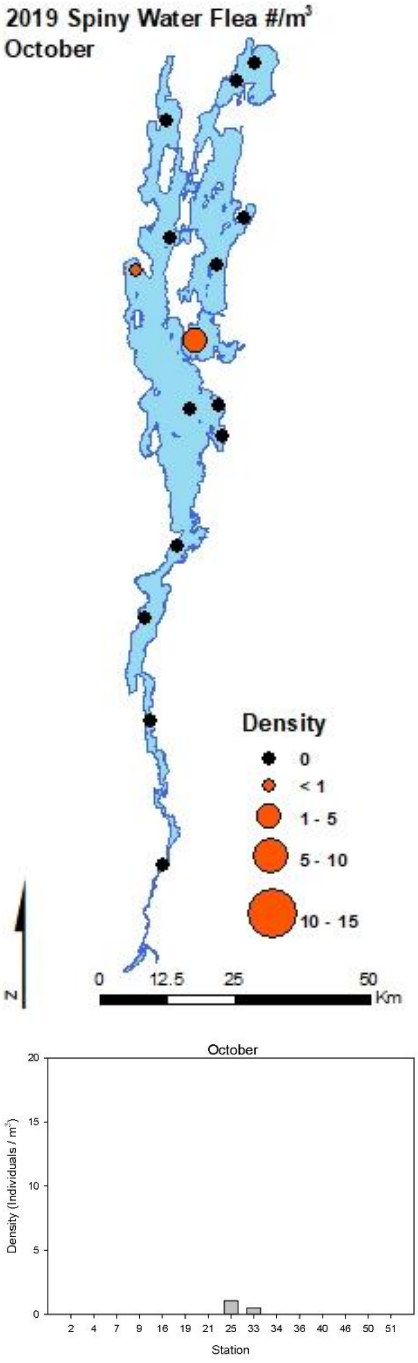


Figure 3.4 Spiny water flea density from vertical whole water tows from October 2019

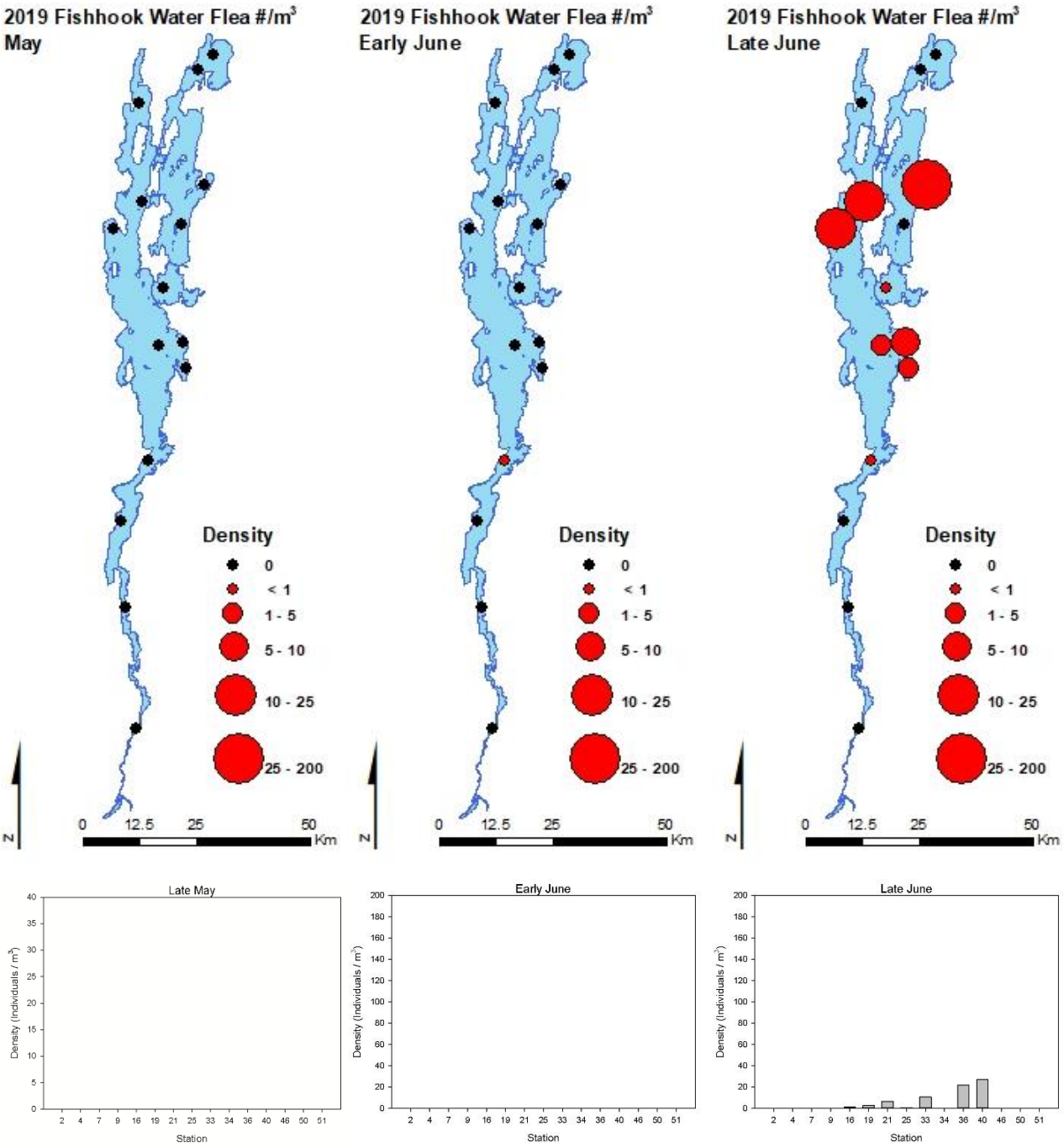


Figure 4.1 Fish hook water flea density from vertical whole water tows from May-June 2019

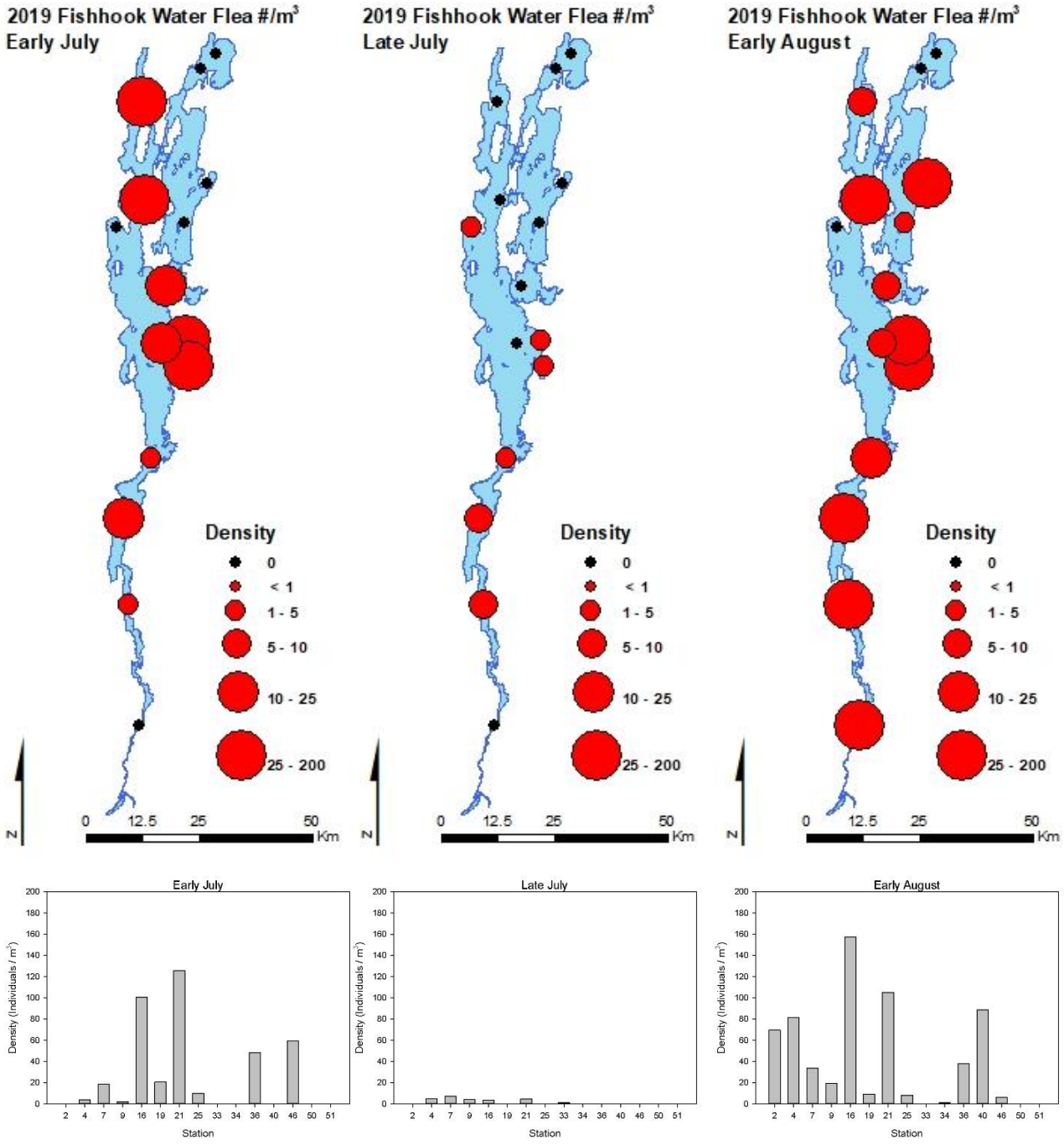


Figure 4.2 Fish hook water flea density from vertical whole water tows from July-Early August 2019

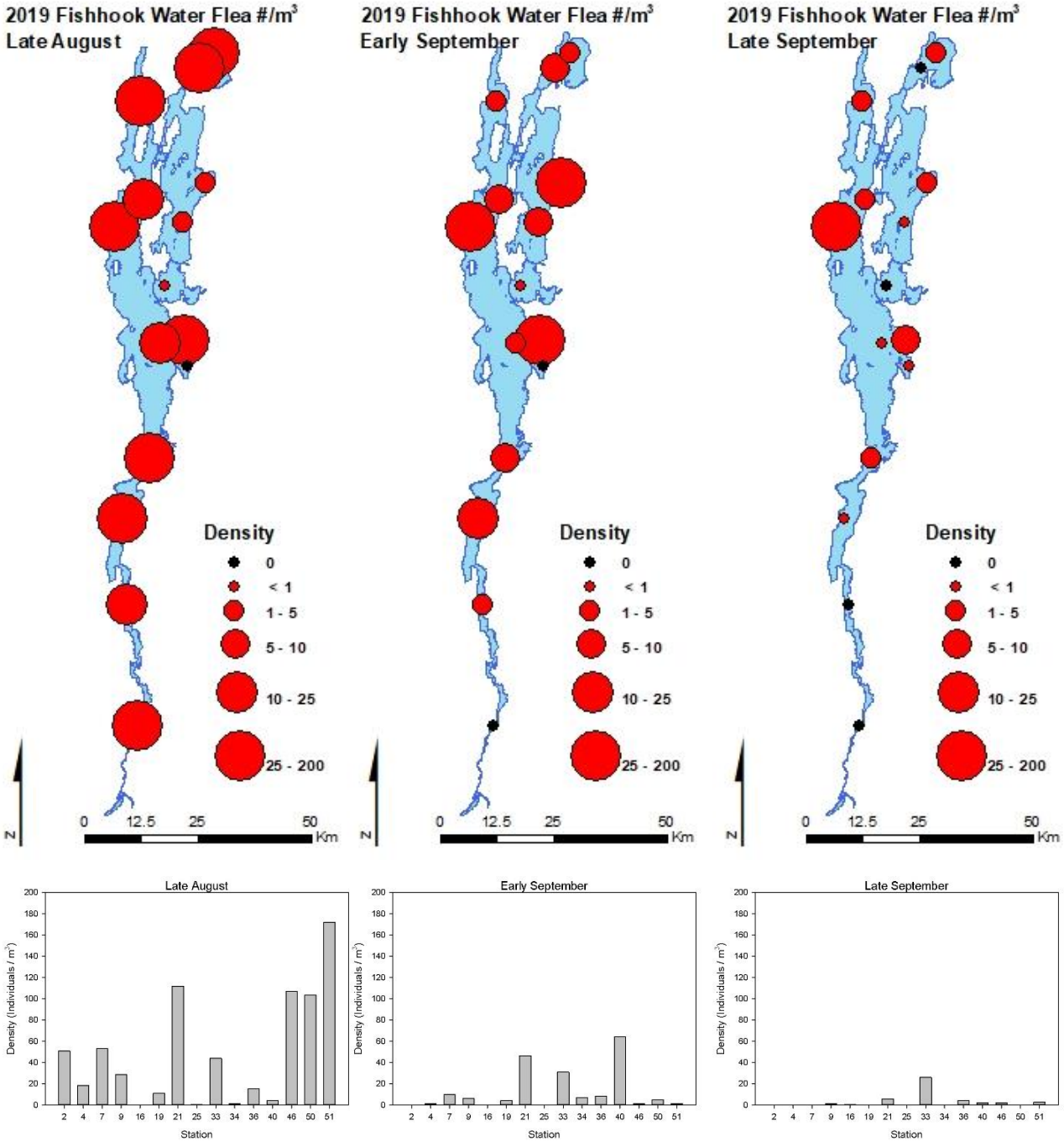


Figure 4.3 Fish hook water flea density from vertical whole water tows from Late August– Late September 2019

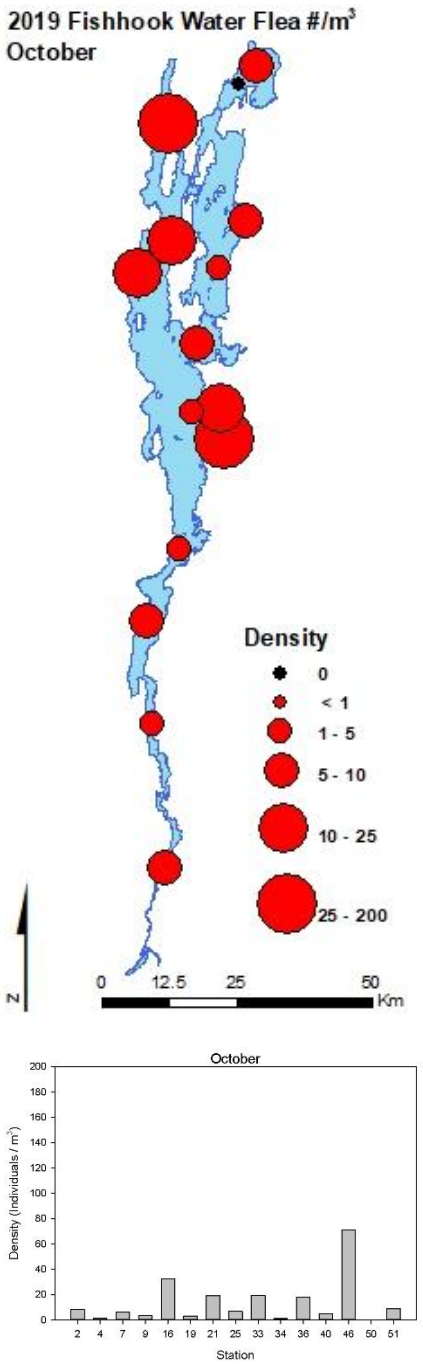


Figure 4.4 Fish hook water flea density from vertical whole water tows from October 2019

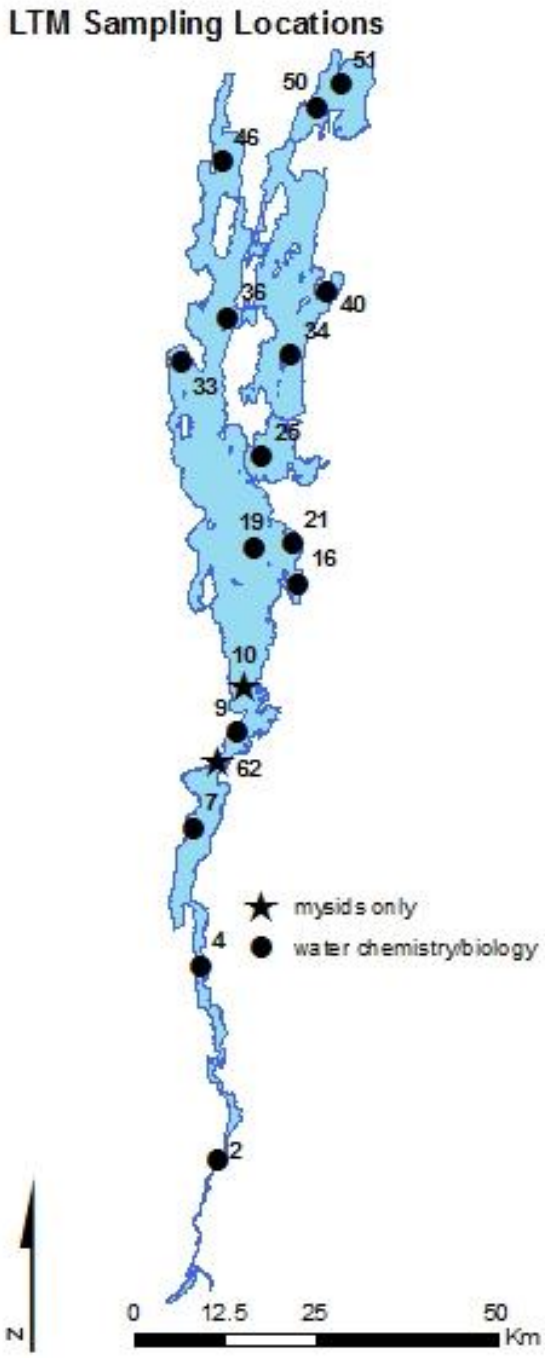


Figure-5 Lake Champlain LTM Sampling Locations