Lake Champlain Long-Term Water Quality and Biological Monitoring Program

Summary of Program Activities During 2015

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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 http://dec.vermont.gov/watershed/lakes-ponds/monitor/lake-champlain. The purpose of this report is to provide a summary of sampling activities and other accomplishments during 2015.

Sampling Activities During 2015

Table 1 lists the number of 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 2015. The frequency of tributary sampling was below the workplan targets for most 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. There is little value in obtaining more samples under low or moderate flow conditions simply to meet workplan targets since low flow data do not contribute significantly to improving the precision of annual loading estimates. Figure 1 shows that sampling at each tributary captured most peak flow events during 2015.

Table 1. Number of sampling visits during 2015 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	11	13	14/17
4	10	9	19	12	BOUQ01	NY	11	13	14/17
7	9	9	18	12	GCHA01	NY	11	13	14/17
9	10	8	18	12	LAMO01	VT	14	20	14/17
16	10	8	18	12	LAPL01	VT	13	22	14/17
19	10	7	17	12	LAUS01	NY	11	13	14/17
21	11	7	18	12	LCHA01[3]	NY	11	13	14/17
25	10	11	21	12	LEWI01	VT	13	22	14/17
33	10	9	19	12	LOTT01	VT	13	21	14/17
34	10	9	19	12	METT01	VT	11	12	14/17
36	10	9	19	12	MISS01	VT	14	21	14/17
40	10	10	18	12	OTTE01	VT	12	19	14/17
46	10	7	17	12	PIKE01	VT	9	11	14/17
50	10	10	20	12	POUL01	VT	11	12	14/17
51	10	10	20	12	PUTN01[4]	VT	0	0	14/17
					ROCK02	VT	12	18	14/17
					SALM01	NY	11	13	14/17
					SARA01	NY	12	14	14/17
					WINO01	VT	17	27	14/17
					JEWE02	VT	13	19	14/17
					STEV01	VT	13	19	14/17
					MILL01	VT	12	18	14/17

[1] Workplan target for lake sampling (12) applies to most chemical parameters and to phytoplankton, zooplankton, and zebra mussel veligers (at a subset of lake stations only). 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.

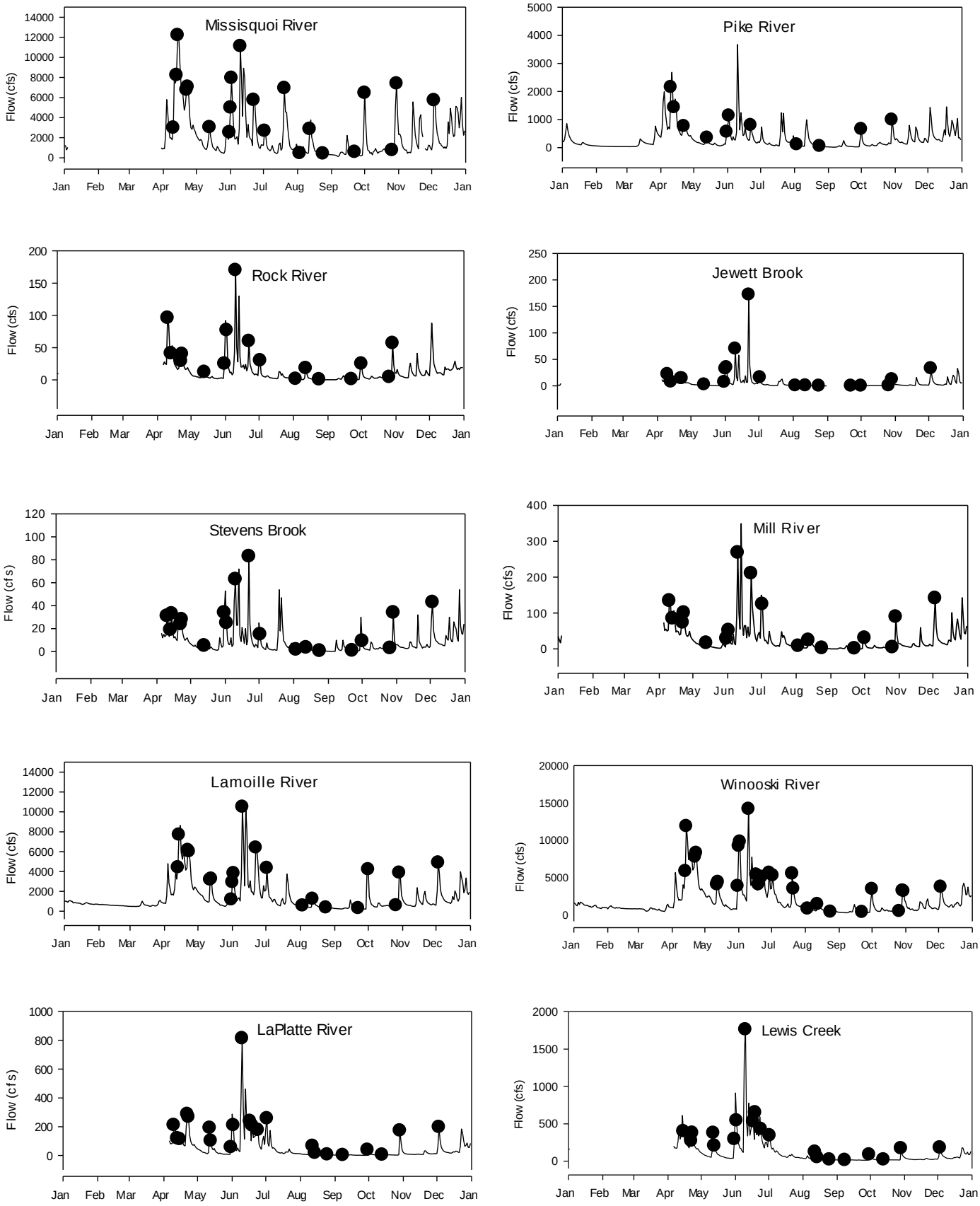
[3] Little Chazy flow gage was discontinued in 2014, but was re-established on 9-25-2015.

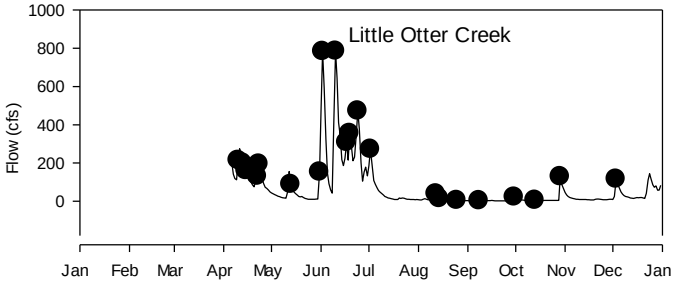
[4] Putnam Creek sampling was discontinued in 2015 due to lack of funding for the flow gage.

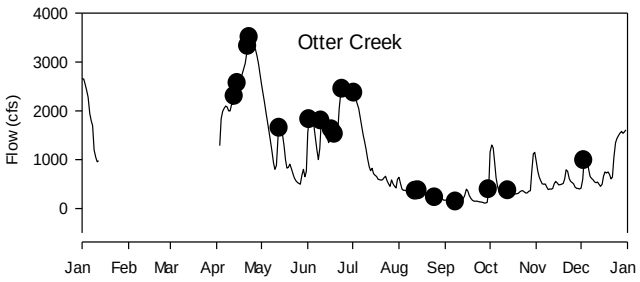
Table 2. Number of samples collected and analyzed for each monitoring parameter during 2015.

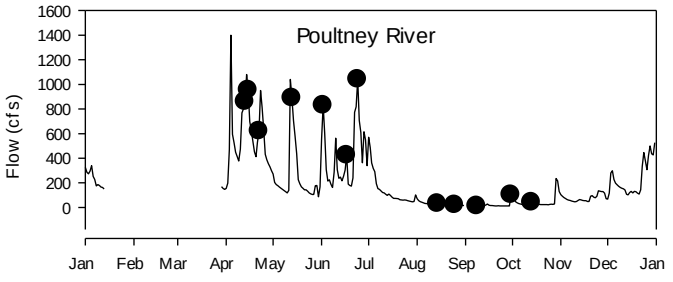
Parameter	Lake	Tributaries	Total
TP	404	397	801
DP	404	308	712
Cl	404	299	703
TN	404	379	783
Ca	61	76	137
SiO2	404	-	404
K	61	76	137
Na	61	76	137
Mg	61	76	137
Alkalinity	61	76	137
DO (Winkler)	405	-	405
Chl-a	314	-	314
TSS	-	293	293
Temperature	-	266	266
Conductivity	-	286	286
pH	-	285	285
Secchi depth	280	-	280
Multiprobe depth profiles	264	-	264
Zebra mussel veligers	124	-	124
Zebra mussel settled juveniles	5	-	5
Mysids	168	-	168
Zooplankton	150	-	150
Phytoplankton	145	-	145
Spiny waterflea	528	-	528

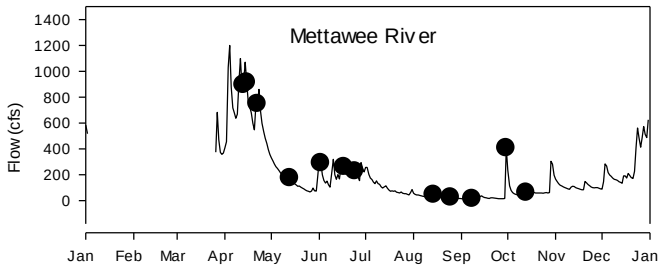
Figure 1. Sampling dates during 2015 in relation to daily flows at each tributary station. Daily flows are shown by lines, and sampling dates are shown by dots.

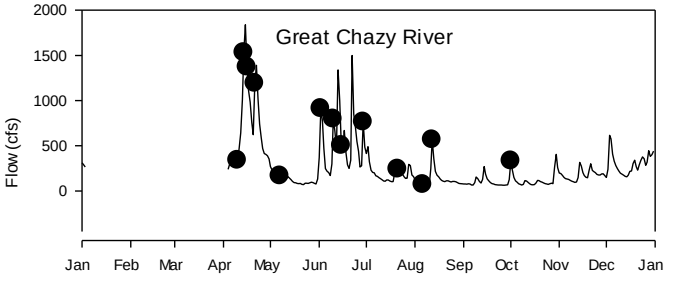


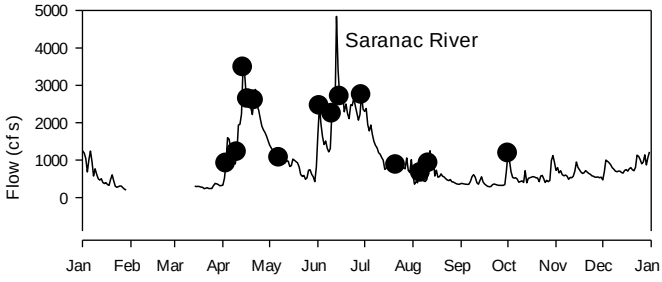

Little Otter Creek
Flow (cfs)
1000
800
600
400
200
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan

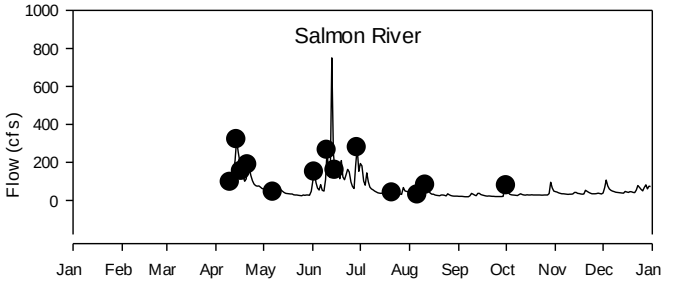

Otter Creek
Flow (cfs)
4000
3000
2000
1000
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan

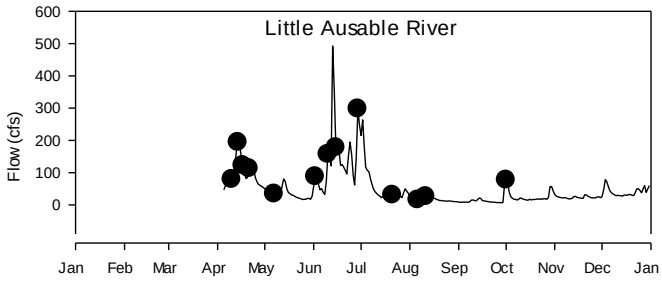

Poultney River
Flow (cfs)
1600
1400
1200
1000
800
600
400
200
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan

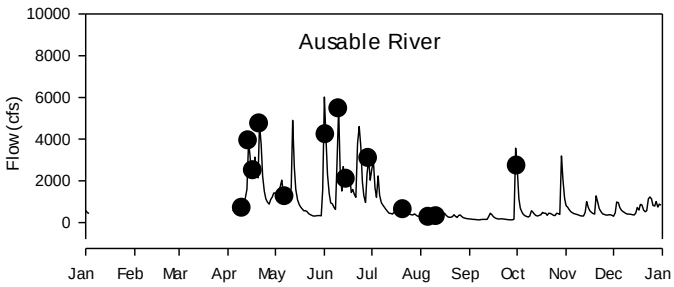

Mettawee River
Flow (cfs)
1400
1200
1000
800
600
400
200
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan

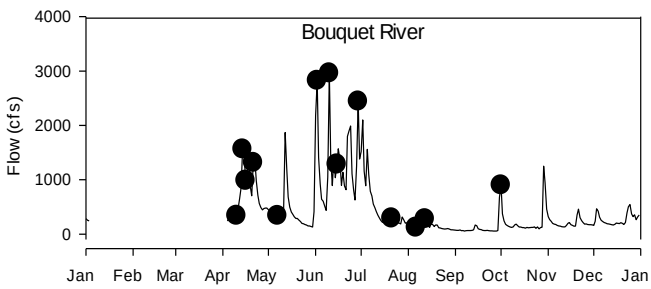

Great Chazy River
Flow (cfs)
2000
1500
1000
500
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan


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


Salmon River
Flow (cfs)
1000
800
600
400
200
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan


Little Ausable River
Flow (cfs)
600
500
400
300
200
100
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan


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


Bouquet River
Flow (cfs)
4000
3000
2000
1000
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. Six of the 224 blank samples analyzed during 2015 (2.6%) had concentrations above the analytical detection limits. Although this is better than the 8.5% of blanks that were above detection last year, we will continue to strive to be more diligent in 2016 and beyond to reduce blanks samples that are above the detection limit. Results for field duplicate samples are summarized in Table 4 for the chemical analyses.

The results from laboratory and field duplicate analyses run on phytoplankton samples obtained during 2006-2014 are shown in Table 5. Phytoplankton data are not yet finalized for 2015.

Table 3. Field equipment blank results during 2015 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	7	0	
Cl	2.0	mg/l	34	0	
TN	0.1	mg/l	35	0	
TP	5.0	µg/l	37	0	
DP	5.0	µg/l	35	4	5.31 6.14 6.76 7.36
Chl-a	0.5	µg/l	14	2	.76 .97
TSS	1.0	mg/l	20	0	
SiO2	0.2	mg/l	14	0	
Ca	0. 5	mg/l	7	0	
Na	0.5	mg/l	7	0	
K	0.5	mg/l	7	0	
Mg	0.01	mg/l	7	0	
Total			224	6	

Table 4. Field duplicate results for chemical tests during 2015 showing the number of duplicates obtained (N) and the mean relative percent difference (RPD) between duplicate pairs.

	Lake		Tributaries	
Test	N	Mean RPD	N	Mean RPD
Chl-a	18	21.6	--	--
Cond	--	--	15	1.3
Cl	18	2.3	16	3.8
DP	18	15.7	18	7.1
pH	--	--	20	0.8
Alk	2	.4	6	3.4
TN	18	10.1	20	3.1
TP	18	6.1	21	4.6
TSS	--	--	18	17.2
SiO2	18	2.5	--	--
Ca	2	.8	4	3.7
Na	2	.8	4	3.4
K	2	2.1	4	3.6
Mg	2	.8	4	3.3

Phytoplankton and Zooplankton Database

All phytoplankton data from 2006-2014 have been incorporated into the main Lake Champlain Monitoring Program database. 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 will eventually be added to the web page, but are currently available only by request.

Table 6. Phytoplankton duplicate results for 2010–2014, the most recent sampling data, showing the number of pairs (N) and the mean relative percent difference (RPD) between pairs.

Test	Year	N	Sample Type	Mean RPD
Field Duplication	2010	14	Biovolume	41.7
			Cell Density	31.4
	2011	11	Biovolume	44.4
			Cell Density	44.8
	2012	12	Biovolume	42.3
			Cell Density	55.4
	2013	8	Biovolume	27.9
			Cell Density	33.4
	2014	8	Biovolume	37.8
			Density	35.3
Lab Duplication	2010	16	Biovolume	32.4
			Cell Density	41.3
	2011	15	Biovolume	32.1
			Cell Density	39.3
	2012	19	Biovolume	28.3
			Cell Density	27.5
	2013	12	Biovolume	26.9
			Cell Density	37.1
	2014	13	Biovolume	48.2
			Cell Density	51.7

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 2015 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 2007-2015 are summarized in Table 6. The phosphorus load for Vermont was 5.2 metric tons lower than in 2014. This result could be due to a combination of factors, plants optimizing, Waterbury's facility upgrade and the lower flows.

Table 6. Total phosphorus load to Lake Champlain from wastewater treatment facilities in Vermont and New York from 2007-2015.

State	Number of Facilities	Year	Total Phosphorus Load (mt/yr)	Total Flow (mgd)
Vermont	60	2007	20.9	43.5
	60	2008	21.1	45.1
	60	2009	20.3	40.5
	60	2010	18.4	39.7
	59	2011	19.3	45.5
	59	2012	16.9	37.6
	59	2013	17.1	40.6
	59	2014	18.8	40.7
	59	2015	13.6	38.5
New York	29	2007	28.5	33.2
	29	2008	26.5	34.3
	29	2009	20.9	31.5
	29	2010	22.0	32.8
	29	2011	23.0	34.4
	29	2012	22.6	30.4
	29	2013	22.9	30.3
	29	2014	24.7	30.3
	29	2015	23.7	29.6

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) and with 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 purpose of the project is to demonstrate water quality improvements from a focused agricultural BMP implementation effort in a small watershed where very high rates of phosphorus loading to Lake Champlain have been documented. Most of the identified BMP implementation projects were expected to begin in 2013 or 2014.

In order to document water quality improvements resulting from the targeted 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.

The area targeted for BMP implementation is approximately 13.5 km^2 in size on the upper Rock River in the towns of Highgate and Franklin, VT. Nearly all of the BMP implementation area is contained within the catchment area between the upstream monitoring station (RR20) and the downstream station (RR14). The implementation area occupies about 90% of the 15.1 km^2 drainage area between the upstream and the downstream stations. A USGS continuous stream flow gage is co-located with the downstream sampling station (RR14).

Samples are obtained manually as grab samples from the center of the river on each date for analysis of total phosphorus (TP), total dissolved phosphorus (DP), and total suspended solids (TSS). Sampling is conducted biweekly year-round except during the winter months when snow and ice in the river make sampling impossible. Additional sampling is conducted during high-flow events.

The study was designed as an upstream/downstream – before/after analysis, which is a type of a paired watershed design. It is anticipated that Analysis of Covariance (ANCOVA) will be used to test for statistically significant differences in TP, DP, and TSS concentrations at the downstream station before vs. after BMP implementation. If BMP implementation is more gradual without clear before/after periods, other regression methods with time as the independent variable may need to be employed.

There have been 284 upstream/downstream paired samples collected and analyzed for TP, DP, and TSS through 2015. 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.

Table 7. Numbers of paired samples obtained.

Year	Number of sample pairs
2008	10
2009	2
2010	18
2011	66
2012	55
2013	55
2014	51
2015	27
Total	**284**

Invasive Species Monitoring

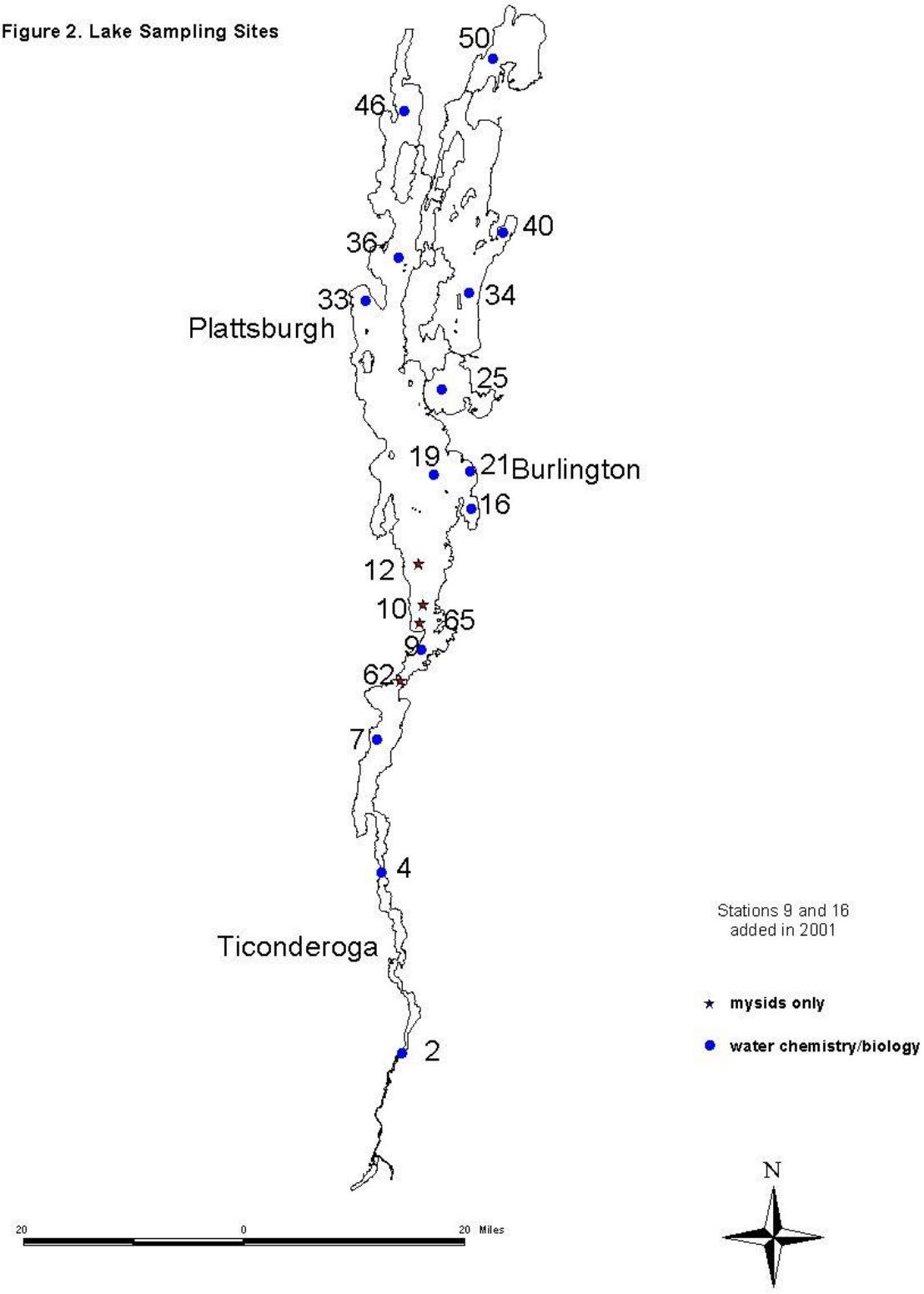
Lake Champlain

A total of 528 zooplankton samples were scanned for *Bythotrephes longimanus* (spiny waterflea) from monitoring stations on Lake Champlain in 2015 (Table 8, Figure 2). Whole water vertical tows were taken at each monitoring station using a 250 µm mesh 50 cm plankton net. In addition to the whole water tows, two duplicate epilimnion tows were conducted at each site. If the sites were isothermic, epilimnion tows were taken at 2x Secchi depth or 1m from the bottom. Samples were then visually scanned in the laboratory under a dissecting microscope to determine population densities (Figure 3, 4 and 5). All samples were also scanned for other potential invasive invertebrates including *Hemimysis anomala* and *Cercopagis pengoi.*

Table 8. Spiny waterflea (SWF) monitoring stations in the Lake Champlain.

Station	Lat	Long	# of sample events	# samples
62			9	54
51	45.0410	73.1290	10	20
50	45.0130	73.1740	10	20
46	44.9480	73.3400	10	20
40	44.7850	73.1620	10	20
36	44.7560	73.3350	10	30
34	44.7080	73.2270	10	30
33	44.7010	73.4180	10	21
25	44.5820	73.2810	10	26
21	44.4740	73.2320	10	21
19	44.4710	73.2990	11	96
16	44.4250	73.2220	10	21
10	44.3000	73.3214	8	48
9	44.2420	73.3340	10	30
7	44.1260	73.4120	11	30
4	43.9540	73.4050	10	21
2	43.7140	73.3830	10	20
			Total # of Samples	528

Figure 2. Lake Sampling Sites



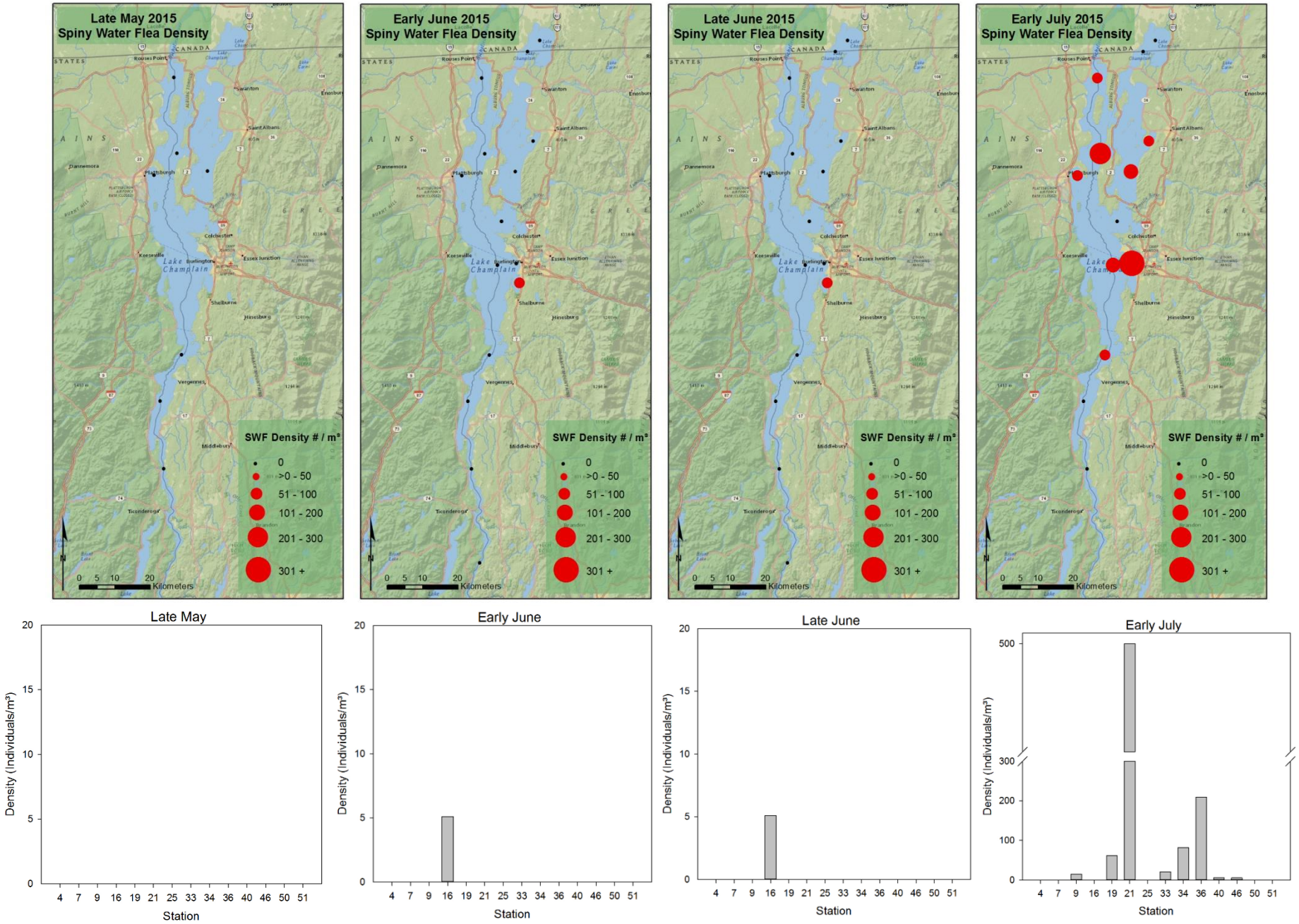


Figure 3. Population density estimates for *Bythrotrephes longimanus* (SWF) at LTM monitoring stations from late May to early July 2015.

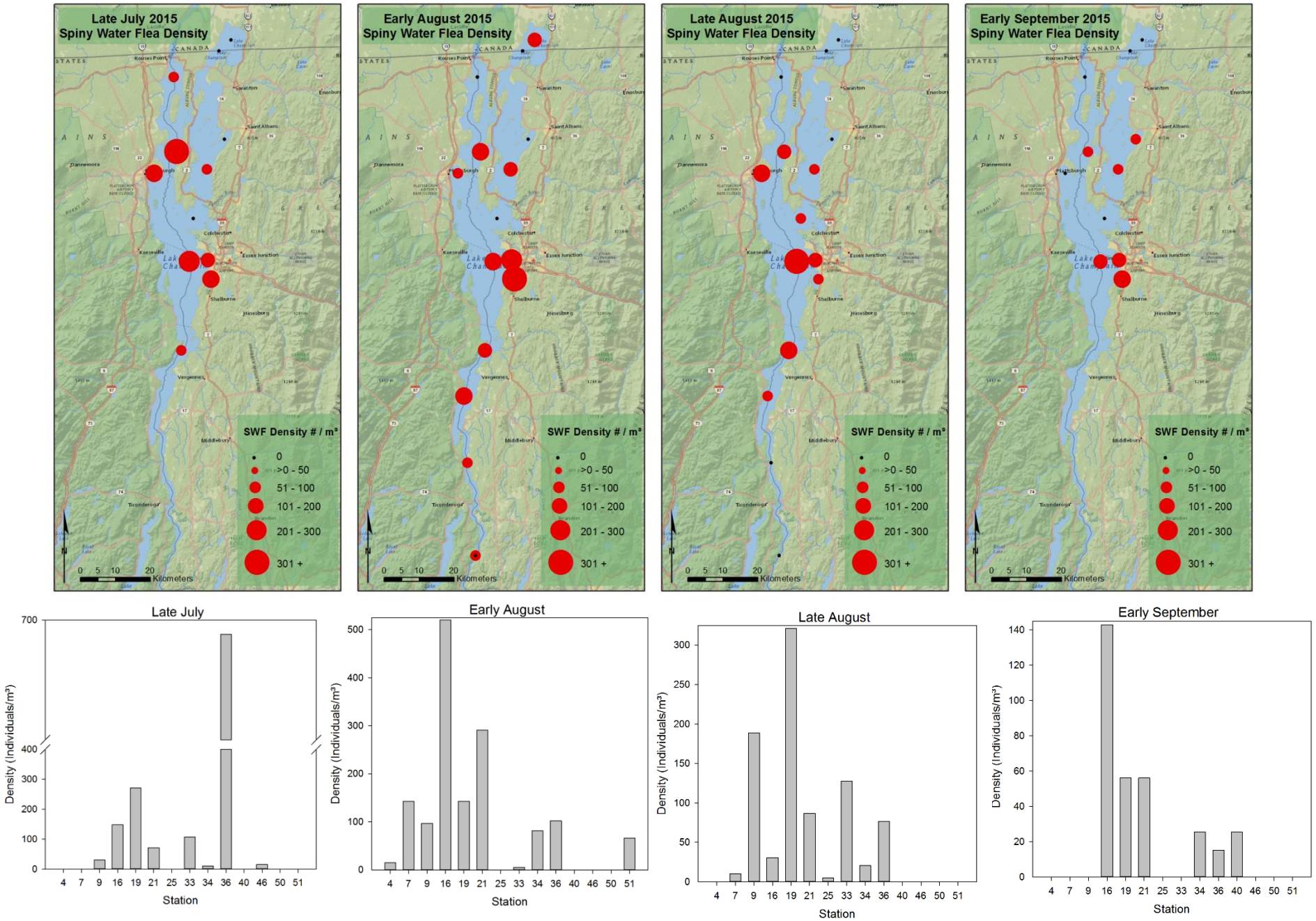
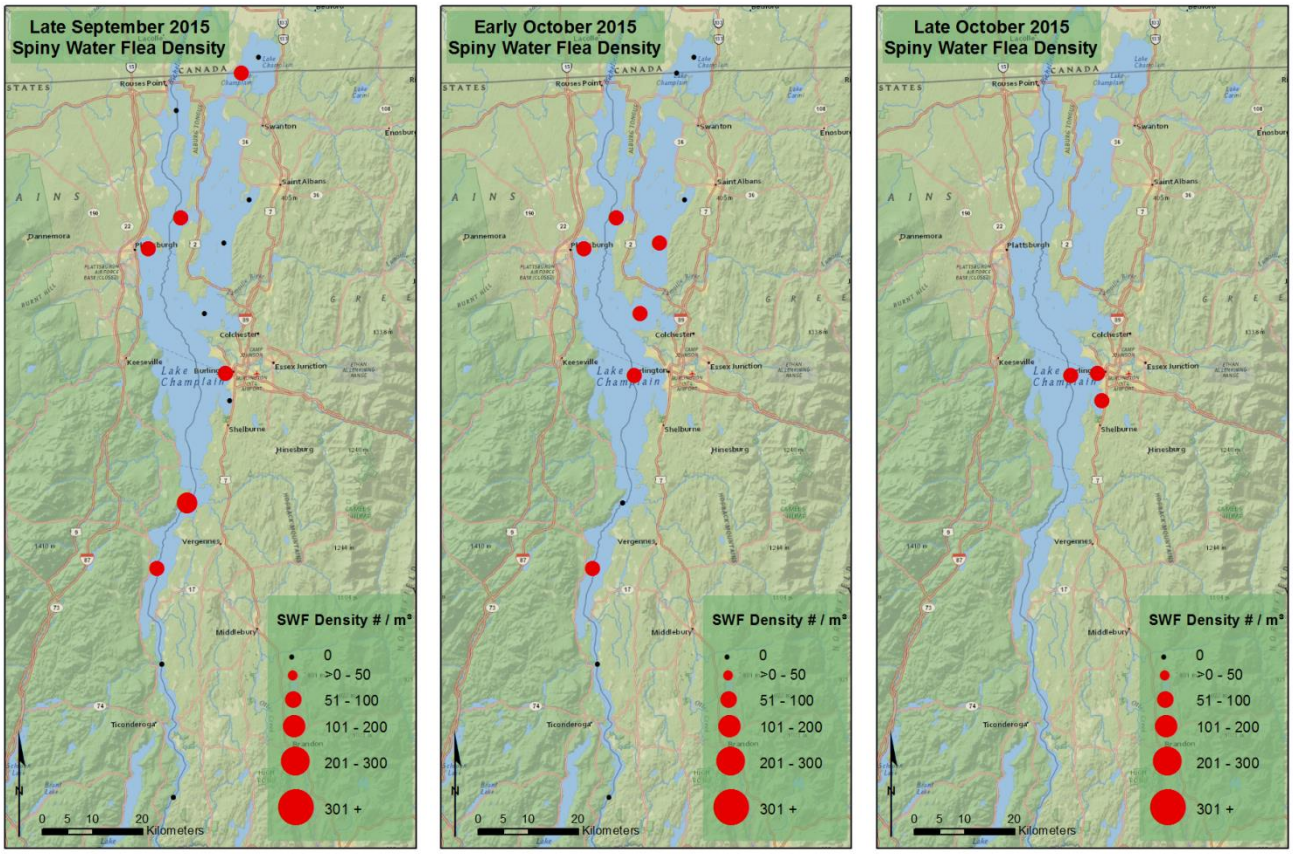


Figure 4. Population density estimates for *Bythrotrephes longimanus* (SWF) at LTM monitoring stations from late July to early September 2015.



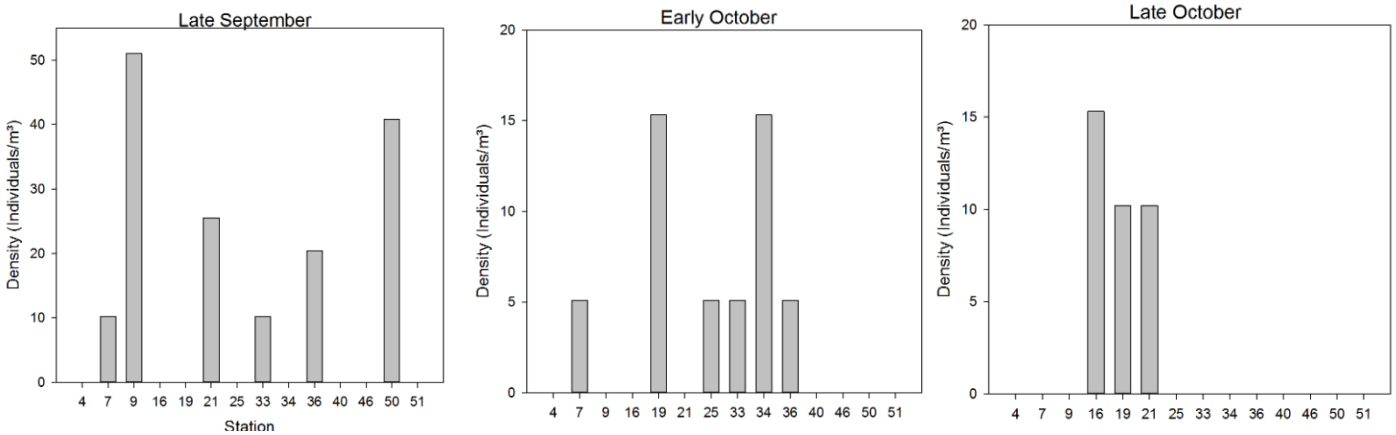


Figure 5. Population density estimates for *Bythrotrephes longimanus* (SWF) at LTM monitoring stations from late July to early September 2015.

Zooplankton and Mysid Sampling:

During the 2015 field season 150 zooplankton samples were collected from the 16 monitoring stations (Table 9). Zooplankton samples were analyzed using a compound microscope, identifying and counting zooplankton in the process. Bio-volumes were calculated for zooplankton samples from 5 lake stations (Stations 4, 19, 34, 36 and 50) throughout the field season. Ten percent of all samples were examined by a second identifier to ensure accuracy of counts and identification. Quality assurance was conducted on the same slide examined by the original identifier to control for natural variability in subsampling. In addition to zooplankton sampling, 168 samples of Mysids were collected and analyzed from 3 monitoring stations (Table 10). Mysid processing includes measuring body length, sexing, and dissecting brood pouch to count the number and developmental stage of the young.

Table 9. 2015 Lake Champlain LTM Zooplankton sample inventory.

Site	Sample Events
2	10
4	10
7	10
9	10
16	10
19	10
21	10
25	10
33	10
34	10
36	10
40	10
46	10
50	10
51	10
Total # of Samples	150

Table 10. 2015 Lake Champlain LTM Mysid Sampling.

Site	Sample Events	# of Samples
10	8	48
19	11	66
62	9	54
	Total # of Samples	168