Assessment of the Ecological Health of Black Lake

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Background & Purpose:

The lakes of northern New York (NNY) support abundant and diverse wildlife communities as well as a variety of valuable human uses. Given the relatively remote and undisturbed condition of our region, these water bodies are attractive and appear to be healthy and thriving. However, certain of these regional ecosystems are showing signs of human impact and degradation and need to be carefully managed. For example, the US Environmental Protection Agency found that over 60% of nearly 350 lakes across 8 New England states (including NY) showed one to several types of ecosystem stress (Whittier et al. 2002). Two of the most familiar forms of disturbance are lake acidification and cultural eutrophication. Many lakes in our Adirondack region are acidified while eutrophication is common in lowland lakes situated in drainage basins with high levels of agriculture (Whittier et al. 2002, Carpenter et al. 2007). Shoreline development can also cause eutrophication (Whittier et al. 2002, Moore et al. 2003) and, along with clearance of natural riparian vegetation, lake fish communities have become degraded (Whittier et al. 2002, Carpenter et al. 2007).

More recent work also stresses the impacts of atmospheric mercury deposition and exotic species invasions. Mercury is biomagnifying in many lake food webs and causing certain sport fish to become so toxic that humans need to limit their consumption of these fish (Whittier et al. 2002, Evers et al. 2007). Also, as humans move between lakes we spread non-native species (e.g. zebra mussels, round gobies, Eurasian milfoil) that displace familiar lake biota and alter the function and even appearance of these water bodies (Whittier et al. 2002, Baldwin et al. 2012). Finally, some lakes are showing signs of warming, reduced mixing, and a resultant decrease in ecological production due to global climate change (Williamson et al. 2009).

One of the most important, yet impacted lakes of NNY is Black Lake, one of several major lakes within the Oswegatchie River watershed. Known for its productive recreational fishery and associated economic value to St. Lawrence County (approximately $7 million annually) it has been occasionally studied and managed in order to control the impacts of eutrophication and weedbed growth. Situated in the St. Lawrence River valley, with erodible, fertile soils, and receiving inputs from the large Indian River and Fish Creek watersheds (large portions of the Oswegatchie watershed), this lake has likely always been very productive, as suggested in early state reports (New York, 1931). But with the increase in human population in the watersheds and along the shorelines of the lake such high productivity has diminished certain recreational and aesthetic values, even as it also supports the central use of the lake, that of recreational fishing. The USEPA began examining lake productivity in the early 1970s and found Black Lake to be eutrophic, with nitrogen (N) limitation in summer and phosphorus (P) limitation in spring (USEPA 1974). This study also concluded that these nutrients entered the lake primarily from non-point sources entering the lake via the Fish Creek and Indian River inlets. Eutrophic conditions were confirmed several years later and users of the lake felt that managers should reduce weed growth in the lake, to restore historic recreational values (Van Slyke et al. 1977). Given the importance of non-point sources to lake nutrient supply (e.g. livestock waste, agricultural application of fertilizers) an initial watershed analysis was constructed and recommendations were made for government management of agricultural activities (Black River 1978). Young & DePinto (1983) initiated nutrient budget studies and found that lake sediment release of stored P exceeded that from fluvial sources such as the Indian River (Collins & Young 1988). Young et al. (1988) used lab studies to assess the effectiveness of reducing this sediment release using aluminum sulfate but apparently this was never applied in field trials. Unfortunately, it appears that sediment accumulation in the lake was higher during 1975-1990 than any previous time period (Young et al. 1994) suggesting that the lake has such a large pool of stored internal P that those releases may overwhelm any reductions gained from watershed management. Citizen-science monitoring programs with NYS indicate consistent eutrophic conditions in an open water site from 1989-2010 (CSLAP 2010). However, given the physical complexity of this lake, the variety of inlets from surrounding watersheds, and the patchy distribution of lakeshore camps, more extensive data on nutrients and trophic status is needed to support management goals that maintain lake health.

Although productive weedbed growth along lake shorelines is known to provide important nursery areas for juvenile fish (Carpenter et al. 2007) it too is influenced by nutrient supply and many lake users complain that such weed growth has become so high that it impairs other important recreational uses (boating, fishing, swimming). Thus lake managers need to target an appropriate abundance and distribution of weeds to balance all user goals. Costa et al. (1983) conducted a preliminary assessment of weeds in Black Lake and suggested the use of mechanical harvesters to reduce nuisance levels of weeds as well as to remove their stored nutrients from the lake ecosystem. Anecdotally I have heard from Black Lake Association members about periodic efforts to remove weeds using harvesters but, because such efforts are limited in scope and permanence, and since they also remove juvenile fish using these nursery plants, this management tool is likely not feasible as a long term solution. Weedbed growth continues to be problematic and many users feel it has gotten worse since exotic zebra mussels invaded the lake in 2002 (Baldwin, unpublished data) and increased water clarity. Moreover, the growth and spread of exotic weeds, such as Eurasian milfoil (CSLAP 2010), may also have increased the general coverage and density of weeds in the lake. Currently, however, there is no sound spatial data representing the coverage of weedbeds in the lake, and thus we lack the ability to objectively assess trends in their distribution and growth.

The key management target for the lake is maintaining a productive recreational fishery comprised of large piscivorous gamefish (walleye, bass, northern pike) and smaller panfish (yellow perch, crappie, various sunfish species). In the early 1980s populations of walleye were absent in gillnet surveys (Mills & Schiavone 1982), most likely because of predation and competition with the introduced black crappie (Schiavone 1983). Since then, stocking and other management efforts have apparently restored their populations and re-established a good balance of game- and panfish for recreational use and ecological function. However, while fish populations are occasionally assessed by DEC negligible data is collected on lower trophic levels (bacteria, plankton, aquatic weeds) or basic environmental conditions (temperature, pH, dissolved oxygen, etc.) that support this fishery, despite significant ecosystem changes expected with global climate change and the invasion of exotic species. Conducting this comprehensive ecological study in 2012 was meant to provide managers with solid data that would inform management decisions safeguarding the health and productivity of Black Lake.

Project Goals and Objectives: This study focused on: (1) the physical and chemical conditions of several Black lake habitats (open water basins, shorelines, outflow and inflow streams), (2) the biological conditions of lower trophic levels (bacteria, phytoplankton, zooplankton, aquatic vegetation), and (3) the distribution of exotic species (dreissenid mussels, round gobies, spiny water fleas, aquatic vegetation). These characteristics were measured from August to October, 2012, from as many as 26 sampling sites in the lake.

Results & Discussion:

Environmental Conditions

Temperature, pH, and dissolved oxygen. Factors such as temperature, pH, and dissolved oxygen fundamentally influence the environmental quality of the lake for fish and human recreational users. These conditions can vary over time as well as throughout the complex 3-dimensional space of the lake. As expected, we found surface waters (< 1 m) of the lake to be warm (14-26°C), slightly alkaline (pH 7.9 – 9.7), and generally well-oxygenated (76 – 132 % saturation) during midday sampling (Table 1). Primary inlets of the lake, such as Indian River and Fish Creek (Fig. 2), had lower ranges of pH (7.4 – 8.2) and dissolved oxygen (77 – 98%) than the pH (8.2 – 9.7) and dissolved oxygen (85 – 132 %) measured in open water sites and the lake outlet at Spile Bridge. This may be due to higher photosynthesis (i.e. primary production) in lake/outlet sites (more oxygen production, more carbon dioxide absorption) despite generally lower biomass of phytoplankton in lake/outlet sites (3.6 ug/L) than inlets (7.4 ug/L).

Environmental conditions in deep open lake sites are generally uniform from surface to bottom waters. Being shallow, with a large surface area and long fetch (length of lake aligned with prevailing SW winds) allows winds to vertically mix (turn over) the lake frequently during ice-free seasons. This polymictic condition helps homogenize temperature and dissolved oxygen (Fig. 3) so that fish and other organisms can inhabit most of the volume of the lake and not be restricted to surface waters, as can happen in other area lakes during summer. While physical conditions like temperature (and density) may be vertically uniform, biologically modified conditions such as dissolved oxygen (DO) often show supersaturation (>100% DO) near the surface, due to photosynthesis, and hypoxia (<30% DO) near the bottom lake sediments, where there are high rates of decomposition. In fact, being polymictic is the lake's "insurance policy" against large scale hypoxia, which would certainly occur if the deep, organic-rich sediments decomposed without aeration due to mixing.

Nutrient Supply. Another crucial chemical condition for Black Lake is the nutrient supply that supports the very high levels of biological productivity. The total concentration (dissolved and particulate) of phosphorus (TP) in surface water samples is typically used to compare productivity levels among lakes. TP levels at all 26 sampling sites (Fig. 4), in summer and fall sampling periods, exceeded the eutrophic threshold of 20 ug/L (Fig. 5). Levels declined with time, from a lakewide mean of 90.2 in mid August to a mean of 56.1 ug/L in early October. Mean soluble reactive phophorus (SRP) levels in August were 20-24 ug/L (22-29% of TP), declining to 8.5 ug/L (15% of TP) in early October. These data suggest that the majority of P was incorporated into particles (such as bacteria and plankton) and that there was capacity for even more production by bacteria and phytoplankton. In other words, bacteria and phytoplankton may not have been P-limited during late summer and fall and were capable of further population increase. However, nitrogen levels (mostly in the form of nitrate, NO_3) were mostly below detection limits of the analysis, suggesting that bacteria and phytoplankton had absorbed all available N and were N-limited in summer and fall. Our findings seem to agree with conclusions of the USEPA in the early 1970s (USEPA 1974). Moreover, the fact that Black Lake has excess P but limited N in summer and fall means that cyanobacteria (aka blue-green algae) such as *Microcystis*, which can fix N from the atmosphere, can continue to grow and reproduce when other phytoplankton cannot, leading to the noxious bloom conditions measured in August 2012 (Richard Henderson, President, Black Lake Association, personal communication). So while N inputs to the lake need to be managed, reducing P would limit all forms of bacteria and phytoplankton, even the cyanobacteria blooms that are independent of lake N supply.

A logical management option is the control of nutrients entering the lake from major streams draining the surrounding watershed. As with past studies (Collins & Young 1988) we found the highest nutrient *concentrations* in the Fish Creek inlet (site 9) and some of the lowest in the Indian River (site 1) (Fig. 5). However, it was beyond the scope of this study to measure volumetric inputs from these inlets which would allow estimates of annual incoming *masses* of P and N from these inlets. Still, if past studies by Young and colleagues hold today, we can assume that the greater annual input from the Indian River makes this the key control point for nutrients derived from the watershed. Interestingly, even though both the Indian River and Fish Creek supply the SW end of Black Lake (Fig. 1) the mean TP concentration of all 12 SW lake (non-inlet/outlet sites) sites (70.7 ug/L) was very similar to the mean TP concentration of all 11 NE lake sites (73.9 ug/L).

Both the Indian River and Fish Creek drain large portions of the watershed that are dominated by forests, agricultural activities, and, to a lesser extent, wetlands (Fig. 6). Regulating agricultural runoff of nutrients, while maintaining nutrient-retaining forests and wetlands is an obvious, if challenging, management objective. Surrounding the lake itself, landuse on the NW shore of the lake is dominated by agricultural activities whereas the SE shore appears dominated by natural forest and wetlands. Consistent with this landuse pattern, the mean TP of our 9 lake sites along the NW shore was slightly higher (76.1 ug/L) than that (67.8 ug/L) of the 10 SW sites. Certain sites along the NW shore (sites 21, 22, 24; Fig 4) showed particularly high summer TP levels but so too did certain SW sites (3-7) that were not near agricultural shorelines. Nutrients can also enter the lake from the septic fields of the approximately 900 shoreline camps of the lake (Fig. 7) and while there may be more and/or older camps and septic systems along the NW shore this type of nutrient source analysis was beyond the scope of this study.

Lower Trophic Levels

Phytoplankton. Nutrient supply ultimately supports the biological productivity and species diversity in Black Lake. Not surprisingly, phytoplankton abundance (indicated by concentrations of the pigment chlorophyll a) was normally high in lake sites (mean 3.6 ug/L) but it was even higher in inlet sites (7.4

ug/L), especially Fish Creek (12.1 ug/L)(Fig. 8). Lake sites had similar levels of phytoplankton, illustrating how uniform the base of the food web is lake wide. Our levels are similar to those measured recently by CSLAP but they are lower than many historic levels recorded for the lake (CSLAP 2010), suggesting an improvement in water quality over time. Because nutrients remain high today the decrease in phytoplankton is likely due to increased consumption by the population of exotic zebra mussels which have built up since 2002 (Baldwin, unpublished data). Despite this, our water clarity readings (secchi disc depth) for lake sites averaged a low 1.3 m, which may suggest that mussels selectively consume small, palatable phytoplankton (reducing Chl a levels) and avoid the large, noxious cyanobacteria blooms that still cloud the water in these seasons. Indeed the phytoplankton community was dominated by large cyanobacteria at each of 4 lake sites (sites 4, 6, 13, 16) during mid-August and early October (Table 2). And though attention has been paid to *Microcystis* and the toxins it produces, it is clear that other genera of cyanobacteria may be at least as troublesome to humans and lake animals that consume phytoplankton, such as zooplankton and insects (which feed fish) and zebra mussels. Lake managers should carefully monitor these noxious blooms to understand how dominant they are throughout the year and to better assess their impacts on beneficial lake biota. Whether these phytoplankton can be limited by nutrient controls for the lake remain an open question.

Trophic Status. Overall productivity of a lake, also called its trophic status, is typically assessed with measurements of the nutrients and phytoplankton at the base of the open water food web. Because phytoplankton abundance affects light penetration into the lake, a secchi disk measurement of water clarity is used as well. Based on mean values measured at lake sampling sites from August to October it is clear that Black Lake remains very eutrophic based on TP and Secchi depth criteria (Table 3). However, current phytoplankton levels, unlike those in the past (CSLAP 2010), now point to a mesotrophic status for the lake. Again, while a positive sign, phytoplankton has not declined thanks to nutrient controls but rather to increased consumption by the expanding zebra mussel population. Like many other invaded lakes in North America these mussels can decrease troublesome levels of phytoplankton but they may also reduce food availability for native lake biota (zooplankton, insects, young fish) as well as increase light penetration to aquatic weeds, thereby promoting their growth.

Bacteria. In addition to *Chl a* containing, photosynthetic cyanobacteria (part of the phytoplankton community) all aquatic ecosystems contain non-pigmented, heterotrophic bacteria, counted as Total Coliforms (TC) and *Escherichia coli* (*E. coli*). Total Coliforms are a broad group of bacteria that include natural bacteria that help decompose lake debris (detritus) as well as bacteria that may have originated in shoreline animal waste (human, cow, etc.). Governmental health thresholds are 1600 colony forming units (CFU) per milliliter (ml) of sample (http://www.health.ny.gov/environmental/water/drinking/coliform_bacteria.htm). *E. coli* are a subset of coliforms that normally originate in the lower intestine of warm-blooded organisms. Thus, their presence in natural lake samples may indicate sewage that originated from shoreline animal waste. Governmental health thresholds are 235 CFU per ml of sample.

In early August and early September samples, no sites exceeded the *E. coli* health threshold. In fact, most levels were <10 and the average for all sites and times was a mere 3.2 CFU/ml. Sites 6 (Drury Point), 8 & 9 (Fish Creek inlet area), and 24 (offshore of a farm) had the highest levels around the lake. In those same August samples 54% of sites exceeded the TC threshold of 1600 CFU/ml, 36% of those sites in the SW end of the lake. However, by early September, even after moderate rains from former hurricane Isaac, only 15% of sites exceeded the TC threshold and 75% of those were in the SW end of the lake. Interestingly, 10 of 11 sites (91%) along the NW side of the lake, which is dominated by agricultural landuse (see Nutrient results above), were at or above this TC health threshold in early August. However, by early September, only 18% of these sites were. Thus it appears that many sites in the lake have high levels of decomposition by bacteria (TC), especially NW shore sites, but very few of these bacteria originate from onshore sewage sites (EC). So on balance it appears that the lake, with its exceptionally high level of biological production, has an understandably high abundance of bacteria to decompose it. If lake managers can reduce lake production it is likely that these bacterial populations will decline as well. Thankfully, even with all these bacteria, there appears to be little sign of problems with shoreline septic/sewage management.

Zooplankton. These microscopic, shrimp-like animals feed on bacteria, phytoplankton, and protists (not evaluated in this study) and are themselves eaten by insects, young fish, and small adult fish (forage fish) that are eaten by top predator fish. Thus, these animals are a crucial link in the food web and transfer the high production of Black Lake into the bodies and populations of fish. We measured an average abundance of zooplankton (caught in a 300 um mesh net) of 727 individuals/meter^3 among 7 lake sites (2-6, 13, 16, as shown in Fig. 2) sampled in early August and early September. At present I do not have comparable, research-grade data for past years in Black Lake and thus cannot speak to any trends in zooplankton abundance in the same way we can for phytoplankton. This is also true for comparisons with other NNY lakes. However, after sampling zooplankton in NNY lakes for 17 years with SLU students (not research level) I can confidently say that we always find more and more diverse zooplankton here than in the other 10 or so lakes we sample. Zooplankton levels are likely fine for Black Lake but it would be useful to evaluate possible impacts of cyanobacteria blooms on the amount of zooplankton available for fish consumption.

Weedbeds. These prominent biological communities hug most of the lake shoreline and even grow, in scattered patches, across the entire width of the NE end of the lake. In fact, there were so many offshore patches there that we could not GPS-trace shoreline weedbeds in most of that basin (Fig. 4). Viewed from shore or a boat, most nearshore weedbeds develop an easily seen surface canopy/mat 10s of meters out from the shore. However, weedbeds normally grow additional 10s-100s of meters farther offshore from this visible canopy/mat. We GPS-traced the offshore extent of this growth, defining the ecological border between the littoral (nearshore) and pelagic (open water) zones (Fig. 11). We did so in 18 representative sections of the lake (some natural and some developed shorelines) and developed GIS-based borders (Fig. 4) that can be scientifically compared over time, to assess changes in weedbed growth (retreats, expansions). Distance between shoreline and outer weedbed borders were highly variable (33m – 917m), both among and within weedbeds, and thus no clear conclusions can be made about general distances or among site distances. Many homes have been built along shorelines with weedbeds and many residents struggle with maintaining clear access to open water for boating and fishing (Fig. 11). At present we lack objective data to gauge historic trends in weedbed coverage or the biological causes.

In these same weedbeds we sampled the plant community (147 total specimens) and found that, lakewide, most (39.5%) randomly sampled plants were from the genus *Potamogeton* (pondweeds), 4 species of which were native. Certain of these native species were found in each of the 18 weedbeds.

We only collected the exotic species, *P. crispus*, from a single weedbed, yet we observed it from the boat in several other locations. The next most commonly collected plants (22.5%)were from the genus *Myriophyllum* (milfoils) and they too were found in each of the 18 weedbeds. We believe that most of them were the exotic Eurasian milfoil (*Myriophyllum spicatum*) but, because even experts can't routinely discriminate between these and their native cousins without using molecular diagnostic tools, we cannot be certain. Other commonly sampled plants were *Ceratophyllum sp.* (coontail) (20.2%) and *Vallesineria sp.* (water celery) (13.2%), and a few weedbeds contained *Elodea sp.* (waterweed) (3.9%).

Distribution of exotic species

Assuming that most of the milfoil plants were the exotic *Myriophyllum spicatum*, then most of our 18 surveyed weedbeds (Fig. 4) were colonized and thus they are lakewide in distribution. Because it was beyond the scope of this project to apply molecular diagnostic tools to confirm their identity (we assumed morphological criteria would work) lake managers might want to fund DNA studies if this information would be useful to management goals. Whether or not they are exotic, regulating the growth and spread of weedbed plants will be challenging. Other lakes in the Oswegatchie River watershed, Bonaparte and Sylvia, have lake associations that are managing their more limited weedbed communities using biocontrol (insect herbivores) and smothering mats. However, neither lake is as large or eutrophic as Black Lake and thus their efforts may be more feasible.

The zebra mussel, a very troublesome exotic, was found on rocky substrates at most of the 26 sampling stations in Figure 4. Since finding 0-2 year old individuals at Tin and Raspberry Islands in 2004 (thus likely invaded as early as 2002) I have now found dense populations of adult and juvenile zebra mussels upstream as far as Grindstone Bay (site 2) and downstream as far as Snake Island (site 25). Mussels were sampled at 11 sites for population analysis and all were dominated (about 80% of all individuals) by reproductive adult animals (Fig. 12). Most sites also had intermediate age animals as well as 0+ year olds (young of the year), confirming continued reproductive success and dispersal around the lake. During our weedbed observations, we also noticed many plants, in most weedbeds, with attached young-of-the-year mussels, indicating good reproduction and recruitment around the lake, even into weedbeds rooted in muddy sediments (i.e. no rocky habitat for adults to flourish). It remains unclear as to how extensively these mussels have spread across the bottom of the lake, under the pelagic zone. Based on previous scuba observations, there are few rocks in such locations, but there are native mussels, which, in other colonized lakes, become heavily colonized by zebra mussels. In future research, it might be useful to survey the lake bottom with underwater cameras trolled behind a boat. Ecologically, the lakewide presence of these plankton-eating animals means that waters may remain clearer than in the past but also that some portion of the phytoplankton, rather than feeding zooplankton and young fish, is now feeding zebra mussels. However, given the highly eutrophic status of the lake, there may still be plenty of phytoplankton for zooplankton and fish.

Thankfully, we found no exotic round gobies in minnow trap sampling done at most of the zebra mussel assessment sites. Because this trapping method successfully collects round gobies in the St. Lawrence River, and because young native fishes were collected in (and released from) most of our

Black Lake traps, we feel our efforts strongly suggest the absence of gobies in Black Lake. This is good news, as gobies can be very disruptive to native fish and invertebrate communities. Finally, we saw no exotic zooplankton (such as spiny water fleas) in Black Lake samples.

Literature Cited

Baldwin, B.S., Carpenter, M., Rury, K., and Woodward, E. Low dissolved ions may limit secondary invasion of inland waters by exotic round gobies and dreissenid mussels in North America. Biological Invasions. 14 (6): 157-1175.

Black River 1978. 208 Study Report, Black Lake example area. Black River – St. Lawrence RC&D Council.

Carpenter, SR., Benson, BJ., Biggs, R., Chipman, JW., Foley, JA., Golding, SA., Hammer, RB., Hanson, PC. Johnson, PTJ., Kamarainen, AM., Kratz, TK., Lathrop, RC., McMahon, KD., Provencher, B., Rusak, JA. Solomon, CT., Stanley, EH., Turner, MG., Zanden, MJV., Wu, C., and Yuan, H. 2007. Understanding Regional Change: A Comparison of Two Lake Districts. BioScience 57: 323-335

Collins, A. and Young, T. 1988. Assessment of phosphorus sources to Black Lake, NY. J. Env. Engineering 114 (2):337-351.

Costa, R., Herwig, M., and Swisher, K. 1983. Evaluation of the vascular hydrophytes in cut and uncut areas of Black Lake, NY. Clarkson College of Technology.

CSLAP 2010. Citizen Science Lake Assessment Program, NYSDEC, Lake Water Quality Summary: Black Lake.

Evers D. C., Han Y. J., Driscoll C. T., Kamman N. C., Goodale M. W., Lambert K. F., Holsen T. M., Chen C. Y., Clair T. A., Butler T. 2007. Biological Mercury Hotspots in the Northeastern United States and Southeastern Canada. BioScience 57: 29–43.

Moore, JW., Schindler, DE., Scheuerell, MD., Smith D., and Frodge, J. 2003. Lake Eutrophication at the Urban Fringe, Seattle Region, USA. Ambio 32 (1): 13-18.

Mills, E. and Schiavone, A. 1982. Evaluation of fish communities through assessment of zooplankton populations and measures of lake productivity. N. Amer. J. Fish. Management. 2:14-27.

Moore, JW., Schindler, DE., Scheuerell, MD., Smith D., and Frodge, J. 2003. Lake Eutrophication at the Urban Fringe, Seattle Region, USA. *Ambio* 32 (1): 13-18.

New York, 1931. NYSDEC Biological Survey nno. VI. Supplement to 21st annual report. Albany NY.

Schiavone. A. 1983. The Black Lake fish community: 1931-1979. NY Fish & Game Journal 30(1): 76-90.

USEPA 1974. USEPA National Eutrophication survey, region 11. Report of Black Lake, Working paper 148.

Van Slyke, D., Cring, W., Raab, D., Schwartz, A. 1977. Black Lake Water quality study. The four county Resource Conservation and development council.

Whittier, TR., Paulsen, SG., Larsen, DP., Peterson, SA., Herlihy, AT., and Kaufmann, PR. 2002. Indicators of Ecological Stress and Their Extent in the Population of NE lakes: A regional scale assessment. *Bioscience* 52(3): 235-247

Williamson, CE, Saros, JE, Schindler DW. 2009. Sentinels of Change. *Science* 323: 887-888

Young, T. and DePinto, J. 1983. Preliminary diagnostic study of eutrophic conditions in Black Lake, NY.

Young, T., Collins, A., and Armstrong, R. 1988. A pilot-scale evaluation of alum tretments to reduce lake sediment phosphorus release. J. Env. Quality 17:673-676.

Young, T., Collins, A., and Sinsabaugh, R. 1994. Assessing sediment accumulation in a eutrophic in northern NY. Lake and Reserv. Management. 10(2): 85-93.

Table 1. Environmental conditions of inlets (Indian River, Fish Creek), outlet (Spile Bridge), and open water study sites in Black Lake during summer (first weeks of August and September) and fall (first week of October) of 2012.

Date	Site	Site #	Temp (˚C)	pH	DO (mg/L)	DO (%)
Aug	Indian R.	1	25	7.5	8.1	98
Sept			23	7.4	8.4	96
Oct			16	7.9	7.3	87
Aug	Fish Crk.	9	26	8.1	6.7	84
Sept			23	8.2	5.5	77
Oct			16	7.9	7.8	93
Aug	Grindstone Bay	2	25	8.2	5.9	86.6
Sept			23	9.1	7.4	103
Oct			15	8.1	8.2	78
Aug	Mile Arm Bay	3	26	8.2	6.9	85
Sept			24	9.0	8.9	107
Oct			16	7.9	8.5	81
Aug	Black Bay	4	26	8.9	7.2	105
Sept			23	8.4	6.6	92
Oct			14	7.9	9.1	85
Aug	Big Bay	5	26	9.0	7.5	109
Sept			24	9.7	9.4	132
Oct			16	8.7	9.3	90
Aug	Drury Pt.	6	25	9.5	7.7	111
Sept			23	9.2	6.9	97
Oct			15	8.4	8.7	83
Aug	CSLAP	13	24	9.4	8.6	103
Sept			23	9.6	8.3	113
Oct			16	9.3	8.6	102
Aug	Jennies Is.	16	26	9.2	8.3	102
Sept			24	8.9	8.4	99
Oct			14	9.0	7.4	86.4
Aug	Spile Bridge	26	26	9.4	8.6	108
Sept			23	9.6	8.5	116
Oct			14	8.6	8.2	76

Table 2. Phytoplankton community composition and abundance at CSLAP site (13) of Black Lake during summer and fall of 2012. Composition was similar at sites 4, 6, and 16.

Taxonomic Class	**Genus**	**August Cells/ml**	**October Cells/ml**
Chlorophyta	*Oocystis*	0.8	0
Chrysophyta	*Melosira*	18.3	0
	Fragilaria	2.5	0
	Staurastrum	1.7	0
	Navicula	0.8	0
Cyanophyta			
	Anacystis	27	170
	Microcystis	23	19
	Anabaena	47.3	1
	Aphanizomenon	58.1	72
	Oscillatoria	0	4
	Total	180	262

Table 3. Mean trophic status measurements for Black Lake in lake sampling sites from August to October, 2012.

	Oligotrophic	Mesotrophic	Eutrophic	Black Lake
TP (µg/L)	< 10	10-20	> 20	72.3
Chl a (µg/L)	< 2	2-8	> 8	3.6
Secchi depth (m)	> 5	2-5	< 2	1.3

Figure 1. Black Lake 2009 satellite image (FlashEarth.com), showing its size and position relative to the St. Lawrence River, the Oswegatchie River, and Mud and Hickory Lakes. The general flow of water is from the Indian River inlet to the Spile Bridge outlet. Our study examined sampling sites in the SW (upstream) and NE (downstream) "ends" of the lake (divided by the Rt. 58 causeway) and the NW and SE "sides" of the lake.

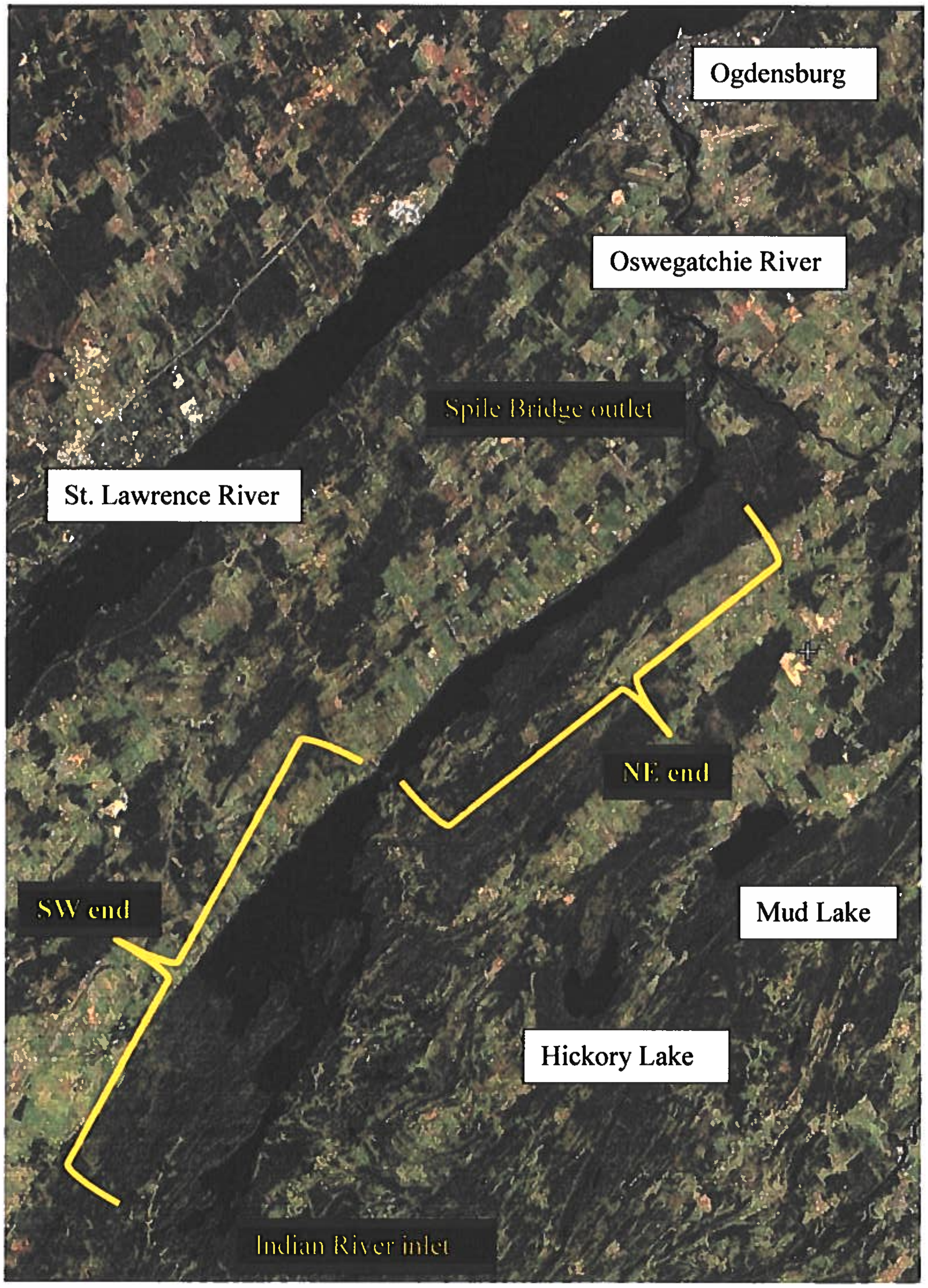


Figure 2a. Sampling sites for measurements of environmental conditions.

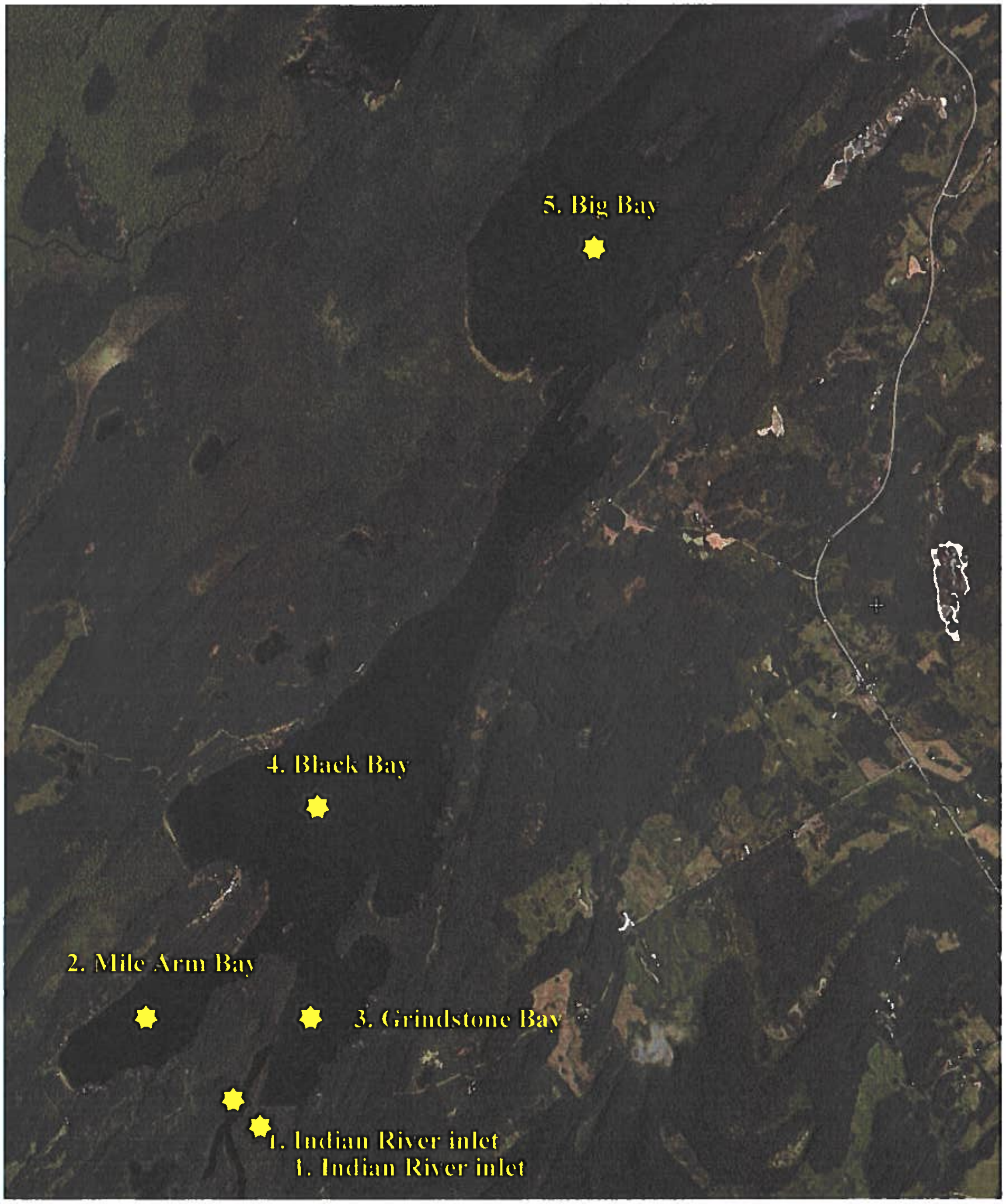


Figure 2b. Sampling sites for measurements of environmental conditions.

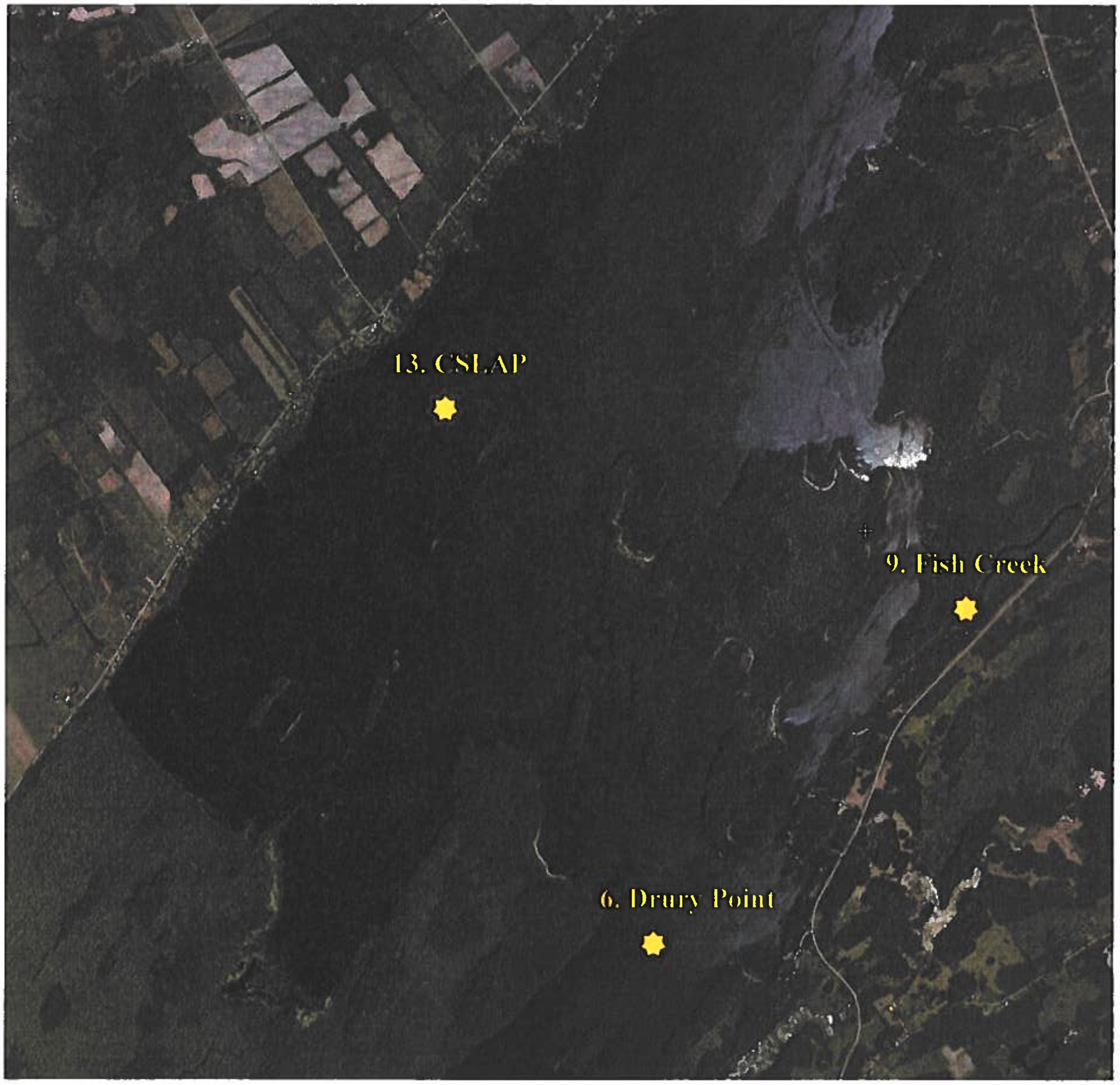


Figure 2c. Sampling sites for measurements of environmental conditions.

Figure 3. Vertical profile of temperature (panel A) and dissolved oxygen (panel B) for the CSLAP long term monitoring site (our site 13) in early September 2012.

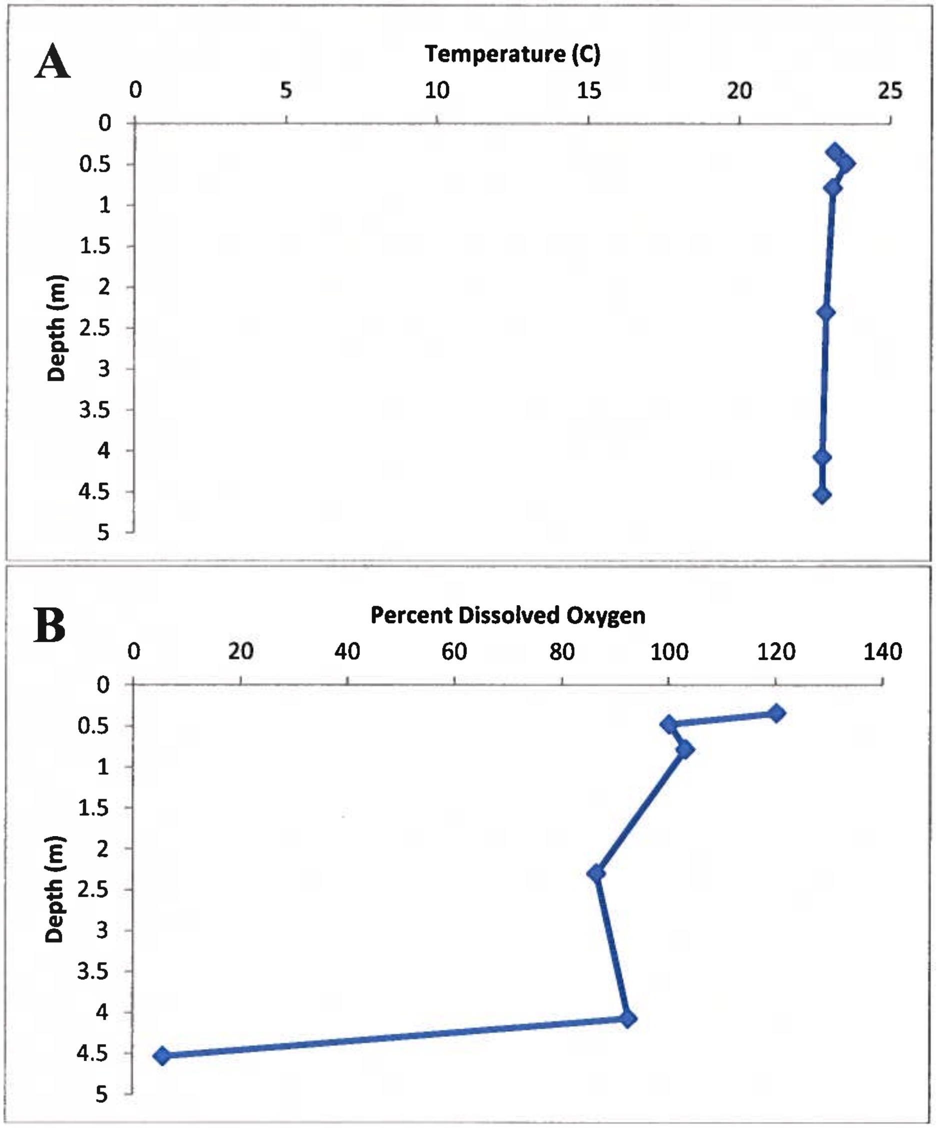


Figure 4. Sampling sites (yellow) for measurements of nutrients and bacteria. The outer edge of shoreline weedbeds were also GPS-traced (red lines) in 18 representative areas of the lake.

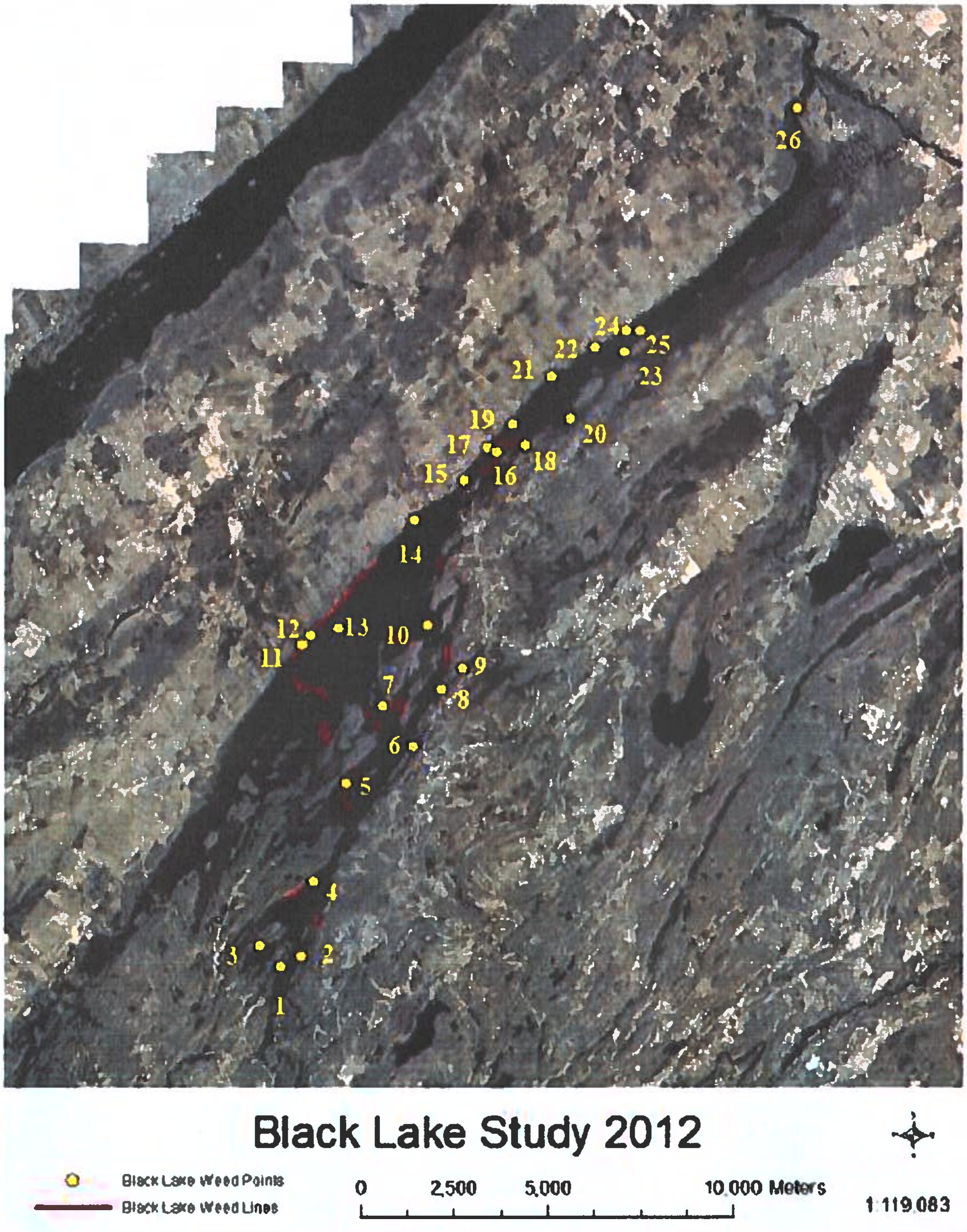


Figure 5. Concentrations of total phosphorus (TP) at nutrient sampling sites in summer and fall 2012. Dashed line represents threshold level for eutrophic concentrations. Site 9 concentration for 14 August (actual level of 252.3) was truncated to enhance comparison among other site levels.

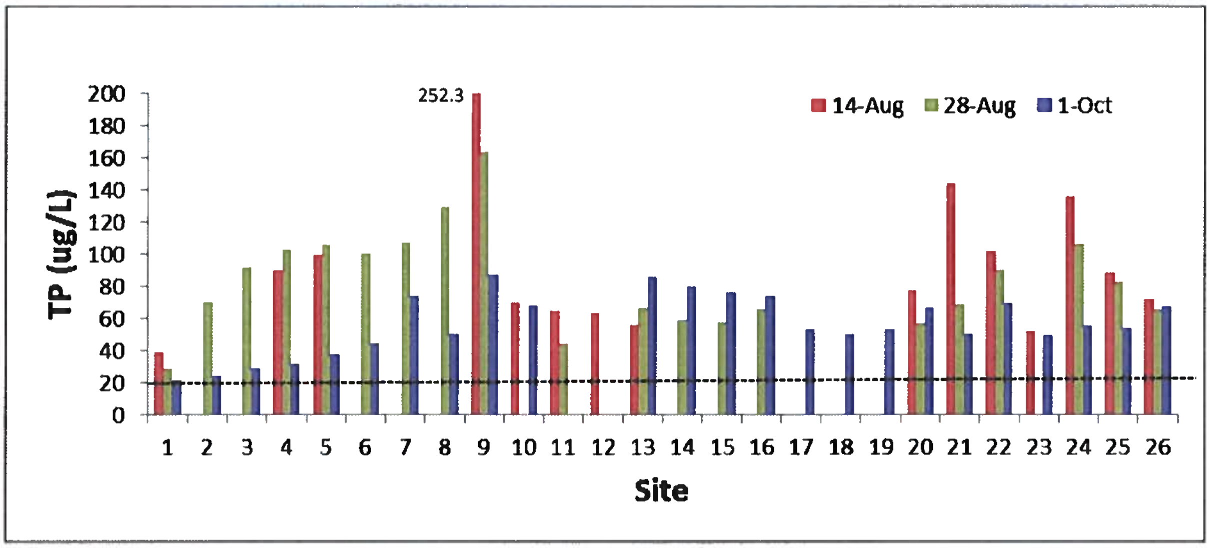


Figure 6. Watershed landuse of Black Lake. Top panel illustrates spatial coverage and distribution of major landuse types. Bottom panel shows the percent of total coverage of those landuse types.

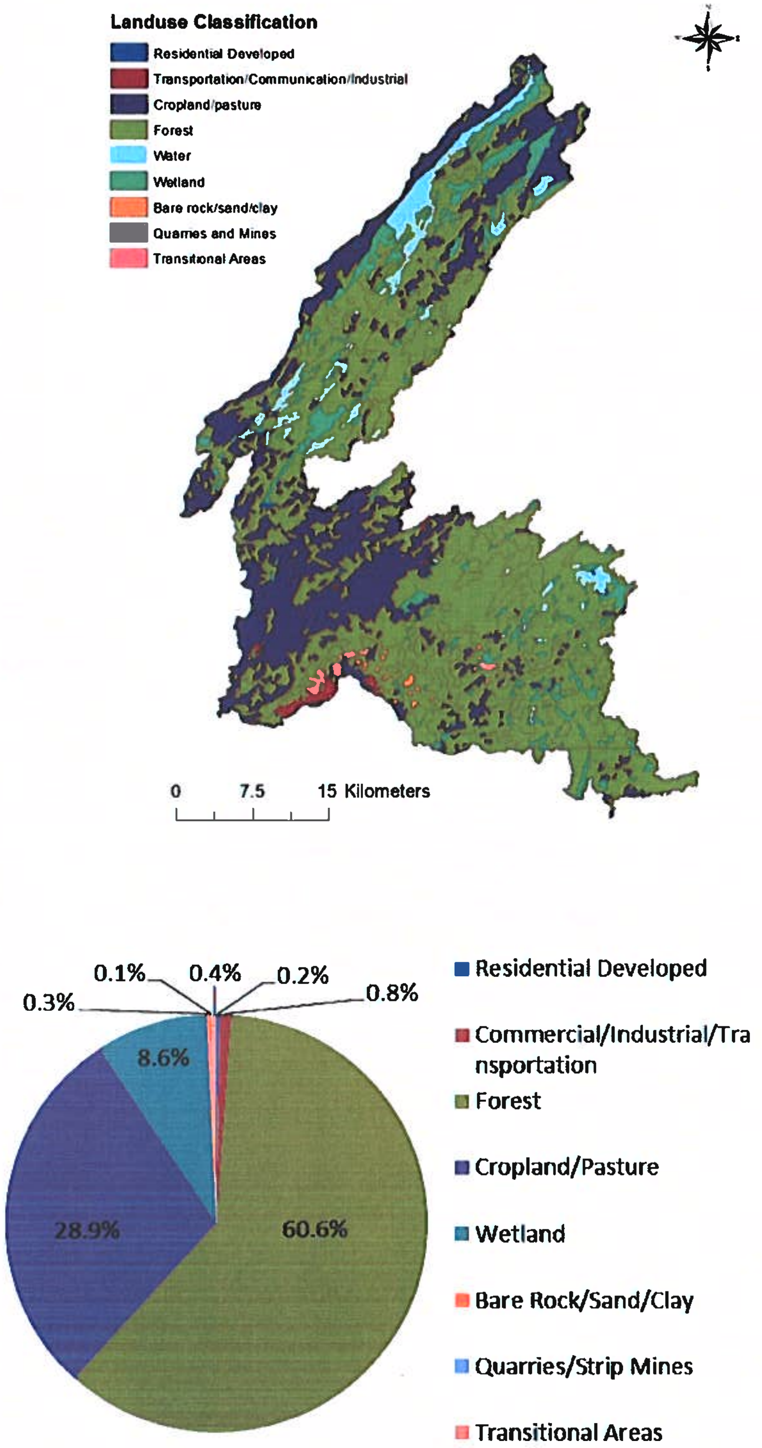


Figure 7. Shoreline residences of Black Lake within 100m of the waterline.

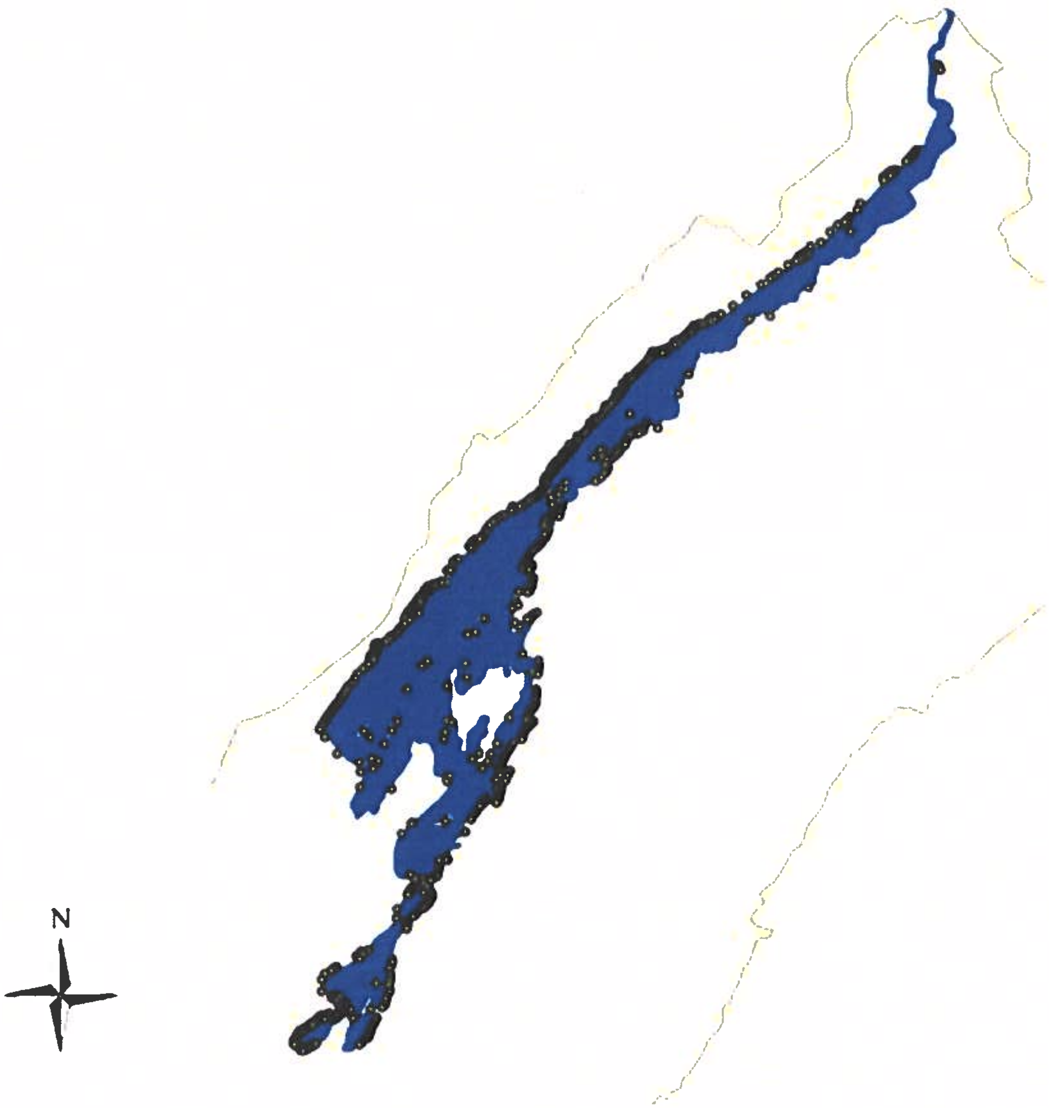


Figure 8. Mean (± SD) concentrations of Chl a at inlet (Indian River, site 1; Fish Creek, site 9), outlet (26) and lake sites in summer and fall 2012. Site numbers correspond to those in Fig. 2.

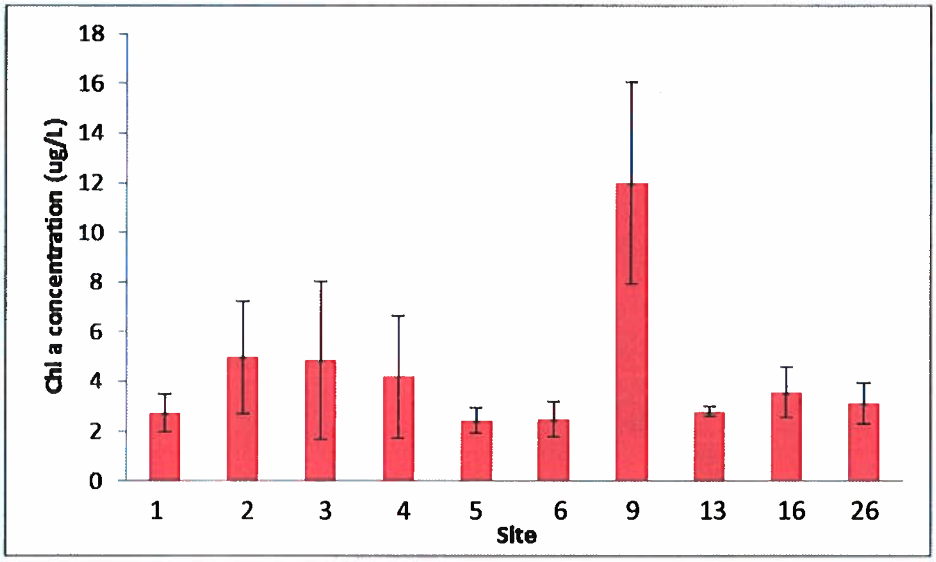


Figure 9. Abundance of total coliform (TC) bacteria (colony forming units per ml sample) at sampling sites in early August and early September 2012. Sites correspond to those shown in Fig. 4. Dashed line represents government health threshold level of 1600. Site abundances near 2500 actually represent >2420, which is the highest detection level in this analysis. Thus, these levels may be slightly or exceptionally >2420.

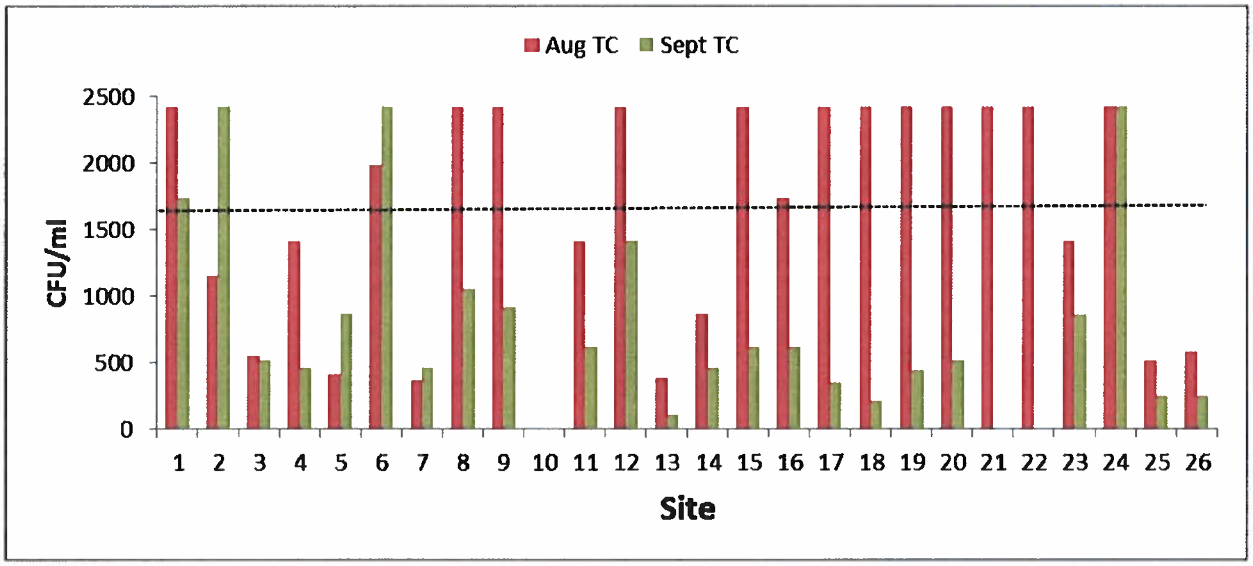


Figure 10. Abundance of *Escherichia coli* (EC) bacteria (colony forming units per ml sample) at sampling sites in early August and early September 2012. Sites correspond to those shown in Fig. 4. All values are well below the government health threshold level of 235.

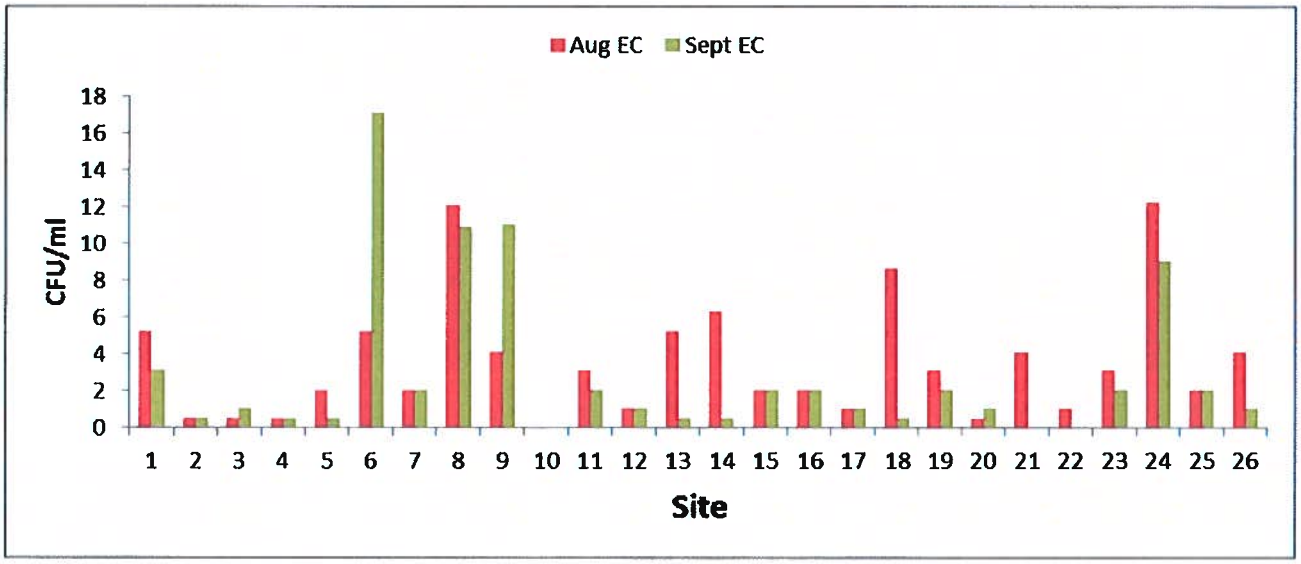


Figure 11a. Aerial photograph showing weedbed and littoral zone composition. Border was traced using a GPS unit on a small boat. Photo taken August 2012.

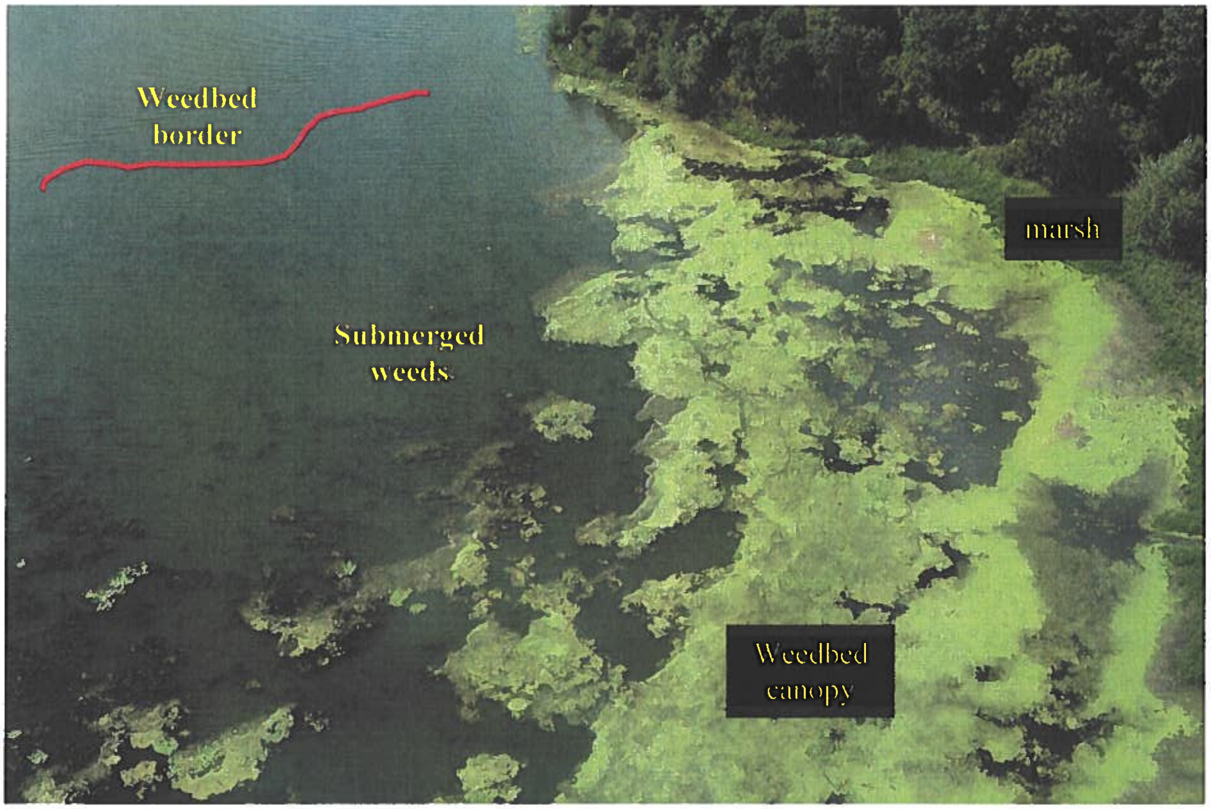


Figure 11b. Aerial photograph showing docks and boats situated in a weedbed. Most boats have reasonably clear access to open water while other dock areas appear to have been cleared of some weeds.

Figure 11c. Aerial photograph showing docks and boats in a weedbed. Open water is to the left of this embayment. The left dock appears to have been cleared of weeds while that on the right is more blocked by weed growth.

Figure 11d. Aerial photograph showing dock and boat in a weedbed. A long cleared path gives boat access to open water.

Figure 11e. Aerial photograph showing dock and boats in a weedbed. Weeds have likely been cleared to maintain access to open water. Three other boats are in the weedbed fishing.

Figure 11f. Aerial photograph showing large weedbed NE of Rt. 58 causeway.

Figure 11g. Aerial photograph showing boat channel, W of Biggie Island, passing between weedbeds.

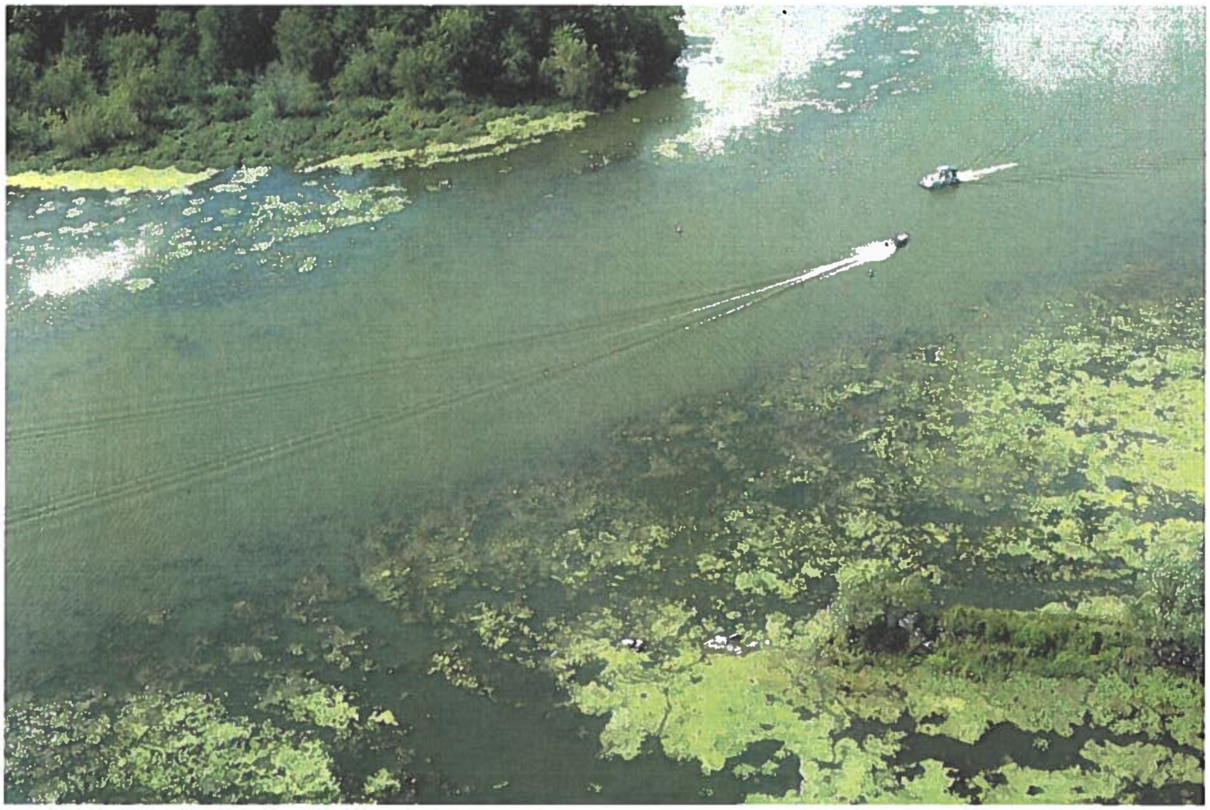
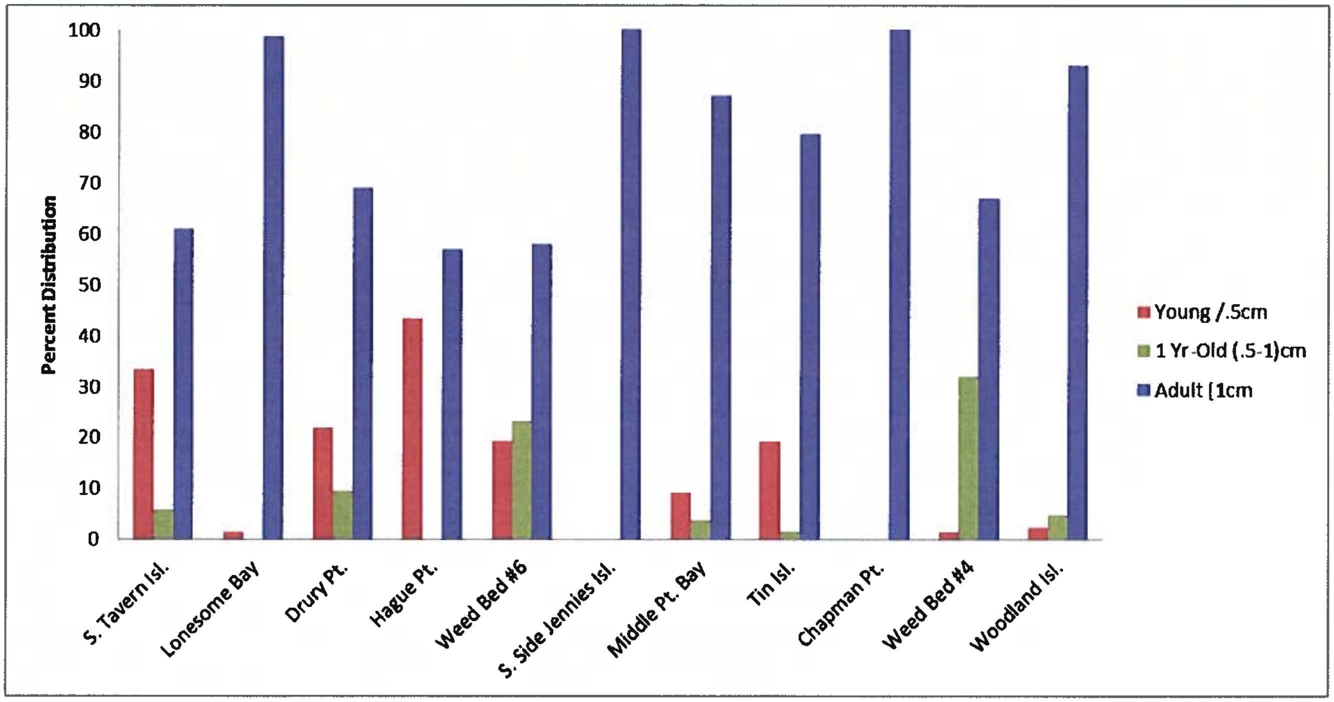


Figure 11h. Aerial photograph showing scattered weedbeds across the majority of the narrow NE end of Black Lake.

Figure 12. Population structure of zebra mussel populations from around Black Lake.



Spending Summary: Below I list the spending per budget category by the end of December 2012. With permission from Sophie Baj I transferred savings from certain categories into others but total spending is within the original bounds of the award. Dr. Baj has also indicated her willingness for project work to continue into October.

DR. BRAD BALDWIN
U.S. Army Corps PROJECT BUDGET REPORT: December 2012

Budget Component	**Detail/Calculation**	**Original Budge**	**Actual Expenses**
Salaries:			
PI Summer Salary		$ 15,000	$ 15,000
FICA on PI Salary	Calculated at 7.65%	$ 1,148	$ 1,148
Subtotal		**$ 16,148**	**$ 16,148**
Labor/Contractors:			
Upstate Freshwater Institute (UFI)		$ 7,700	$ 2,550
Converse Labs (CL)		$ 2,500	$ 1,408
Analytical Services		$ -	$ 650
Private plane (aerial photos; 2 days)		$ 4,000	$ 550
Photographer (aerial photos; 2 days)		$ 800	$ 323
Student wages (2 students for 2 weeks)		$ 2,500	$ 2,349
Student housing at SLU (2 weeks)		$ 600	$ 409
Research Assistant			$ 3,633
Subtotal		**$ 18,100**	**$ 11,872**
Equipment/Material:			
Hydrolab service and repair		$ 1,500	
Miscellaneous Lab Supplies		$ 500	
Subtotal		**$ 2,000**	**$ -**
Other			
Shipping samples to UFI and CL		$ 1,200	$ 214
Boat rental		$ 400	$ 175
Research-related Travel	Car travel to research site	$ 500	$ 1,222
Subtotal		**$ 2,100**	**$ 1,611**
Grant Total		**$ 38,348**	**$ 29,631**