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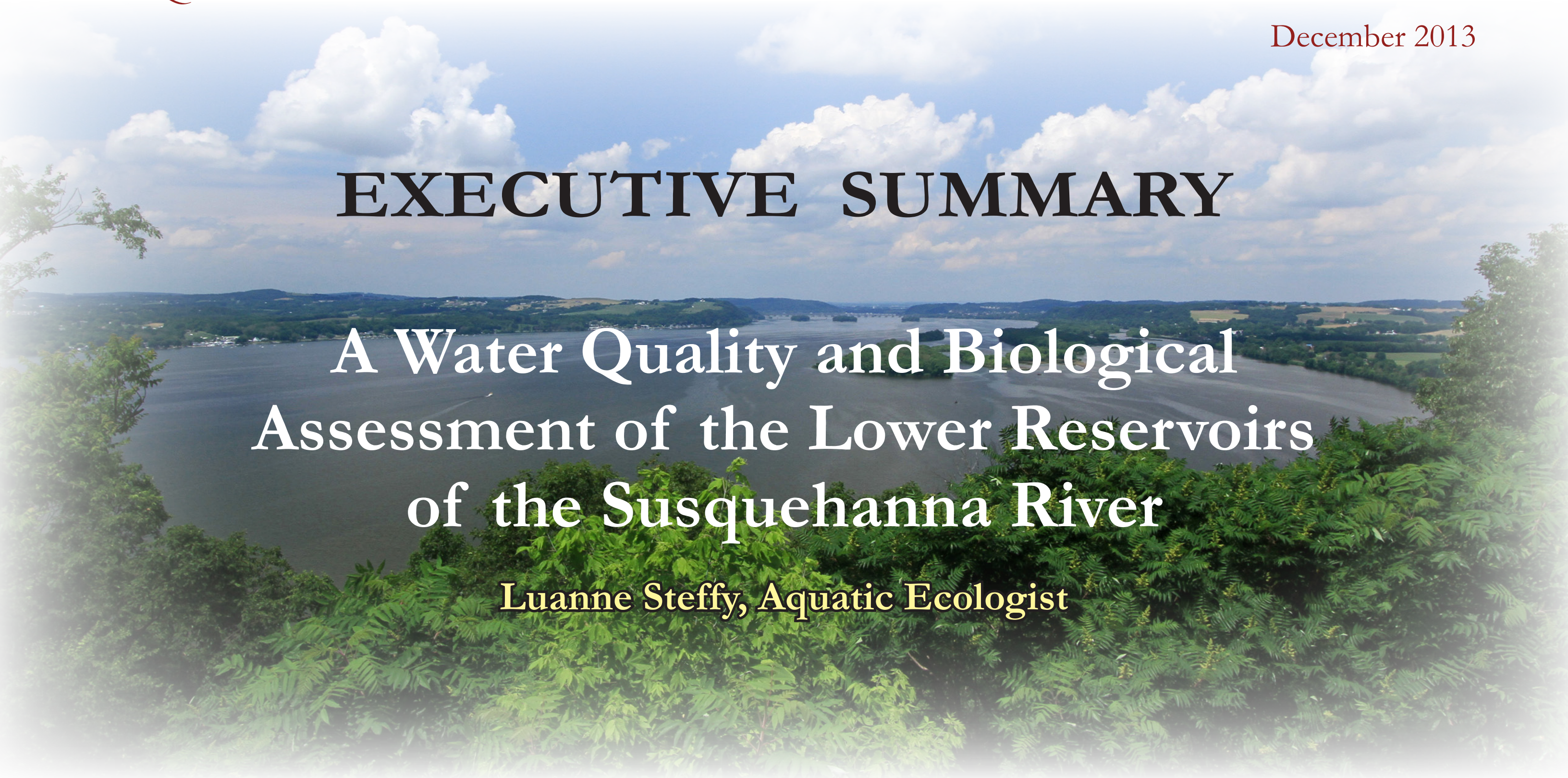

EXECUTIVE SUMMARY

A Water Quality and Biological Assessment of the Lower Reservoirs of the Susquehanna River

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Introduction

The Susquehanna River Basin Commission (SRBC) completed a water quality and biological assessment in the lower reservoirs of the Susquehanna River from April-October 2012 as part of the Year-2 Subbasin Survey Program (Figure 1). This project was an exploratory pilot study representing the first focused, extensive monitoring effort by SRBC on this portion of the river. The lower reservoirs are located in the final 45 miles of the Susquehanna River before its confluence with the Chesapeake Bay. Three large hydroelectric dam facilities within this reach of river create the three main reservoirs. The objectives of this project were to assess current chemical and biological conditions within the reservoirs while also exploring a variety of sampling methodologies with which to incorporate routine assessment of the reservoirs into SRBC's on-going monitoring program.

Study Area

The Lower Susquehanna River Subbasin is a very diverse watershed. It drains a mixture of both rural and urban land comprising nearly 6,000 square miles of central Pennsylvania and northern Maryland, from Sunbury, Pa., to the mouth of the Susquehanna River in Havre de Grace, Md. The Lower Susquehanna River Subbasin includes the urban areas of Harrisburg, York, and Lancaster, Pa., and more than a million acres of agricultural land spread throughout much of the subbasin.

Three individual reservoirs are formed by the three hydroelectric dams within the lower 45 miles of the Susquehanna River. All three reservoirs serve as drinking water supplies and are also used heavily for recreational activities. The most upstream reservoir, Lake Clarke, begins around the Route 30 bridge in Marietta, Pa., and is formed by the Safe Harbor Dam. Lake Clarke is approximately 10 miles long and is relatively shallow, with numerous rock outcroppings and small islands. The middle and smallest reservoir, Lake Aldred, is formed by Holtwood Dam and is about seven miles in length.

The third and largest reservoir is the interstate Conowingo Pond, a 15-mile-long pool created by the Conowingo Dam and situated in both Maryland and Pennsylvania. The Conowingo Dam is one of the largest non-federal dams in the country and is located in Maryland, five miles south of the Pennsylvania border, and also serves as the U.S. Route 1 bridge across the Susquehanna River. In addition, within the upper portion of Conowingo Pond is Muddy Run Pumped Storage Facility, which pumps water from Conowingo Pond up into Muddy Run reservoir during off-peak hours and releases the water through turbines during times of high demand to generate electricity. Despite many monitoring activities on the mainstem Susquehanna River, until this pilot study, SRBC had largely bypassed this lower 45-mile stretch of the river with regard to the agency's monitoring activities. This gap was due primarily to the immense complexities of the reservoir system resulting from the hydroelectric facilities and the inherent modifications to sampling protocol that monitoring this reach of river would entail.

Methods

Sampling was conducted in the reservoirs between April and October 2012. Figure 1 shows the locations of the various types of sampling. Seasonal water quality samples were taken in April, August, and October at nine transects throughout the reach. At each transect, a depth-integrated sample was taken along each bank and at mid-channel, and each was analyzed individually.

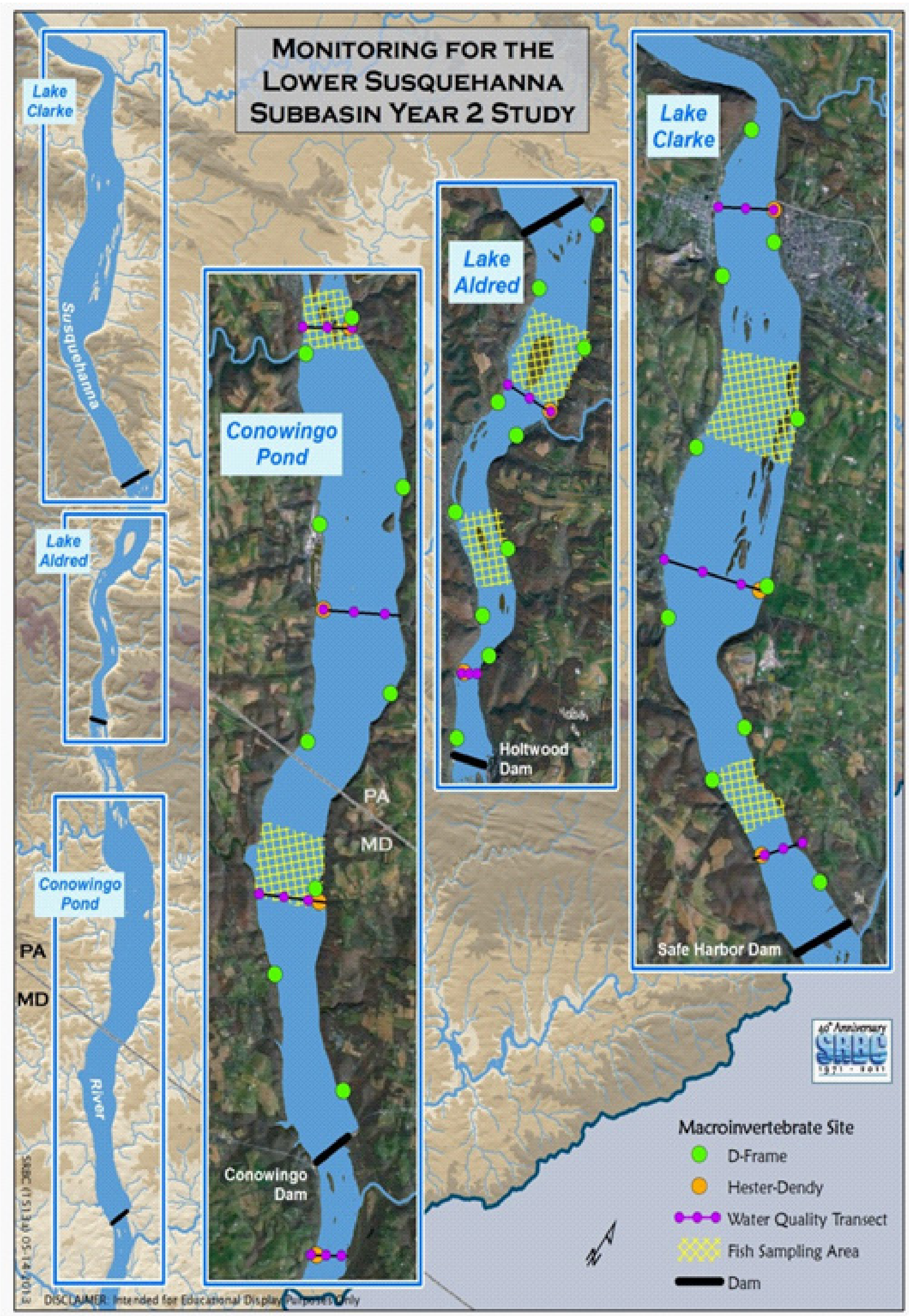

Figure 1. Sampling Locations within the Lower Reservoirs

In addition, a multi-meter probe was used to collect field parameters in-situ at each location. At the mid-channel sampling location (or whichever sampling location along the transect was deepest) a vertical profile of field chemistry parameters was recorded to document the extent of vertical mixing within the water column.

In early August, 11 Hester-Dendy (H-D) samplers were deployed and left out for eight weeks to allow for macroinvertebrate colonization. When the H-D samplers were retrieved in early October, an additional macroinvertebrate sample was taken for each reservoir by compositing ten D-frame net kicks spaced evenly around the shoreline. A general assessment of physical habitat and substrate was completed along the shoreline at every transect in each reservoir. The multi-habitat composite macroinvertebrate protocol and the physical habitat assessment along the shoreline were patterned after USEPA's National Lake Survey protocol (USEPA, 2012).

Fish sampling was completed in early September using a combination of benthic trawling and boat electroshocking. Boat electroshocking was completed in the late afternoon and evening along representative, fishable shoreline habitat in each reservoir as well as below Conowingo Dam. All shocked fish were captured with dip nets and put into a live well in the boat until the whole reach was completed. Fish were identified in the field when possible and returned immediately to the river. In addition, lengths and weights for all game fish were recorded, and any deformities, erosions, lesions, or tumors (DELTs) were noted.

Cover Photo: Lake Clarke and the Conejohela Flats on the Susquehanna River.

Photo Credit: Casey Kreider

Results/Discussion

The evaluation of water quality in reservoirs is partially dependent on whether they are considered to be functioning more as rivers or lakes. The reservoirs in the lower Susquehanna River seem to be functioning as a hybrid. In river systems, nitrogen is more frequently the nutrient of concern, but in lakes, phosphorus tends to be more of a problem.

Nutrients were the biggest water quality concern throughout the study area, with no other parameter consistently exceeding water quality standards or levels of concern. Using the normal criteria for rivers, total nitrate exceeded background (0.6 mg/l) concentration in 99 percent of the samples collected. Much of the total nitrogen in the Susquehanna River is in the form of nitrate and, as a result, total nitrogen exceeded background (1.0 mg/l) concentration in approximately half of the samples collected. Total phosphorus exceeded the natural background (0.1 mg/l) concentration of rivers and streams in less than 10 percent of the samples collected.

Table 1. Comparison of Select Macroinvertebrate Metrics by Reservoir

Summary of Macroinvertebrate Data for each Reservoir

MULTI-HABITAT (500-count subsample)

	Lake Clarke	Lake Aldred	Conowingo Pond
Taxa Richness	36	32	26
EPT Taxa	4	7	4
Hilsenhoff Biotic Index	5.63	4.54	3.51
Chironomidae taxa	12	6	9
% Chironomidae	17.1	5.6	10.4
% Dominant Taxa	42.1	40.8	40.6

HESTER-DENDY SAMPLERS (200-count subsample)

	Lake Clarke		Lake Aldred		Conowingo Pond		
	top	bottom	top	bottom	top	mid	bottom
Taxa Richness	22	11	11	5	18	5	15
EPT Taxa	4	0	2	0	4	0	6
Hilsenhoff Biotic Index	5.94	7.54	7.69	7.99	6.42	7.79	6.34
Chironomidae taxa	11	9	5	3	10	3	5
% Chironomidae	59.1	99.1	87.8	99.0	58.4	97.3	62.2
% Dominant Taxa	17.5	80.1	83.8	98.1	37.8	96.4	57.6

Typically, lakes, even those only a few meters deep, exhibit some vertical stratification throughout the water column. Temperature and dissolved oxygen decrease rapidly at a certain depth, called the thermocline, and the difference in temperature keeps the colder water below separated from the warmer water on top. No vertical stratification was seen in any of the three reservoirs, even in depths of up to 30 meters. All the water in these reservoirs seems to be extremely well-mixed.

The multi-habitat composite macroinvertebrate samples yielded more taxa, more Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa, better Hilsenhoff scores, and a lower percentage of Chironomidae than the H-D samples (Table 1). While more than 75 taxa were found throughout the study area, multi-habitat samples were comprised of 26-36 taxa, and H-D samples had far fewer, ranging from 3-22 taxa. The multi-habitat samples were dominated by the mayfly genera *Brachycercus* (Caenidae), which is well suited to slow-moving rivers where fine sediment is the dominant substrate. The average Hilsenhoff score for the multi-habitat samples was 4.5 compared to 7.1 in the H-D samples. All samples, regardless of sample collection methods, were comprised of at least 60 percent collector/gatherer genera. Taxa classified in this functional feeding group primarily collect fine particulate organic matter from the river bottom. In all the H-D artificial substrate samples, Chironomidae genera made up from 59-99 percent of the sample, comprised of 25 total genera.

An interesting pattern that emerged from the H-D data was the greater similarity of assemblages from the lower transects in each reservoir than among all samples within the same reservoir. Additionally, at the sampling transect where an H-D was placed on each bank along the transect, macroinvertebrate communities were quite similar. This suggests that perhaps macroinvertebrate assemblages in these reservoirs may be more dependent on local habitat and flow patterns than on potential water quality issues associated with the shoreline where they live.

Table 2. Comparison of Select Fisheries Statistics for Each Survey Area

Survey Area	Smallmouth Bass CPUE (fish/hr)	Smallmouth Bass DELT prevalence	Flathead: Channel Catfish Ratio	Total Richness
Lake Clarke	11.20	23%	1:5	21
Lake Aldred	10.96	9%	1:16	19
Conowingo Pond	9.31	8%	10:1	16
Below Conowingo Dam	2.98	0%	1:16	25
Total	**9.2**	**13%**	**1:13**	**29**

One interesting pattern that emerged from the H-D data was the greater similarity of macroinvertebrate assemblages from the lower transects in each reservoir than among all samples within the same reservoir. This similarity suggests that macroinvertebrate communities may be more dependent on local habitat and flow patterns than on potential water quality issues associated with the shoreline where they live.

Twenty-nine unique fish species were detected across all sites, and the fish community was dominated by tolerant species (Table 2). The most abundant fish species was gizzard shad. Smallmouth bass are the most prominent game fish in the Susquehanna River. Historic catch per unit effort (CPUE) for smallmouth for the lower river is about 75 fish per hour, although CPUE catch rates in the lower reaches of the Susquehanna River have been dropping over the last number of years (PFBC, 2010). During this study, CPUE for smallmouth bass (age >1) in the lower reservoirs was under 10 fish per hour. The overall percentage of fish with DELTs was 13 percent, and melanosis was not observed in any fish. The highest percentage of DELTs were found in smallmouth bass in Lake Clarke, which was also had the highest CPUE for smallmouth bass. Invasive flathead catfish were outnumbered by native channel catfish everywhere except Conowingo Pond, where the ratio of flathead to channel catfish was 10:1. Table 2 is a comparative summary of key data results for the overall fish survey as well as each individual fish survey area.

Fluctuating river levels are a significant issue for fish populations in the lower reservoirs of the Susquehanna River. The constant, but inconsistent, rise and fall of river levels greatly compromises the persistent shallow, near-shore habitat necessary for juvenile life stages of many fish species.

Conclusions

One of the biggest challenges encountered throughout this pilot study, which also significantly complicated and hindered monitoring efforts, was the rapidly fluctuating river levels in each of the reservoirs. While it is well-known that these river level fluctuations occur and are an unavoidable by-product of hydroelectric power generation, they appear to be having an observable, negative impact on the ecology of the three lower reservoirs in the Susquehanna River. Because of the lack of any USGS gaging stations between Marietta and Conowingo Dam, the magnitude and frequency of flow fluctuations were not able to be characterized for this study. It is not uncommon for there to be a two- to three-foot increase or decrease in river level in just a few hours. Not only do these rapid, unpredictable changes make sampling very difficult, but they also result in the degradation of critical ecosystem habitat areas along the shorelines. Where the river is not steeply sloped, these shoreline areas are likely submerged and exposed multiple times during the day, which limits their capacity to continually support aquatic life and compromises critical habitat. This lack of persistent shallow, near-shore habitat can be ecologically detrimental.

The lower reservoirs in the last 45-mile reach of the Susquehanna River comprise a complex system of waterways in an already unusual river system. By successfully completing this pilot study, SRBC better understands how these reservoirs function and what their biological communities include. This pilot study also provides excellent baseline data from which to plan future monitoring efforts. The use of new methods and protocols, some more successful than others, has expanded SRBC's monitoring capabilities and allowed for a more diverse monitoring and assessment program. SRBC will begin to incorporate the data gathered and the effective approaches used in this pilot study into a more routine monitoring effort on the lower reservoirs. Plans are underway for the existing Large River Monitoring Program to be expanded to include a monitoring component in the lower reservoirs, in addition to the free-flowing portions of the river throughout the basin.

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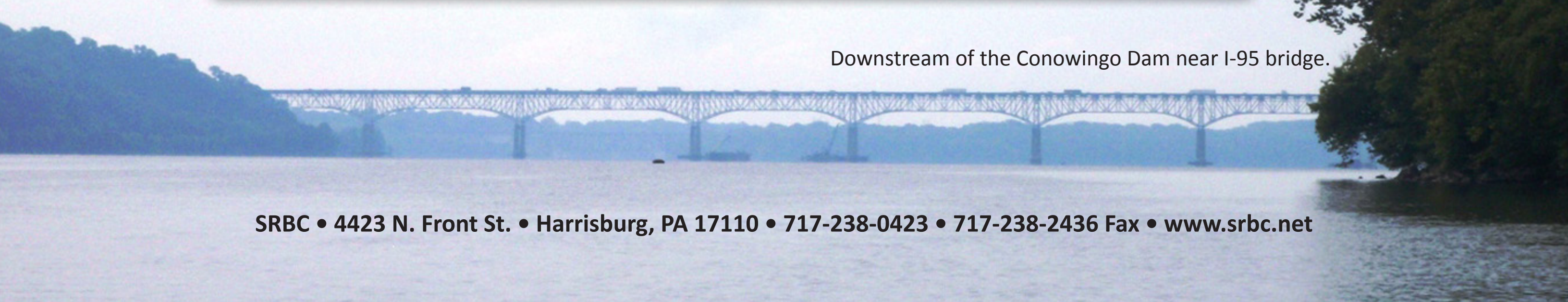

Downstream of the Conowingo Dam near I-95 bridge.

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