



A Biological Study of the Hannibal Pool of the Ohio River



Executive Summary

- Since 2004, ORSANCO has been using a probabilistic (random) design for monitoring fish communities in the Ohio River and conducting biological assessments.
- The Ohio River was divided into 19 assessment units based primarily on the locations of high-lift navigational dams. Using the random design, each assessment unit was assigned 15 sampling locations.
- Once fish assemblages are sampled, each site is assessed using a site quality score (0- 5) which is generated from an Ohio River fish index (MORFIn). The expectations for the MORFIn are derived from each site's substrate composition. For an assessment unit (i.e. pool) to meet its aquatic life-use designation, the average of the quality scores for the pool must be greater than 2.0.
- In 2008, fish population data from Hannibal pool yielded 41 species and 1 hybrid taxa, representing 10 different families. Two of these taxa were listed in OH as either threatened [channel darter (*Percina copelandi*)] or of special concern [river redhorse (*Moxostoma carinatum*)]. WV has no system for listings species.
- At the species level, gizzard shad (*Dorosoma cepedianum*) was the most abundant, comprising 73.6% of the catch.
- Previous analyses have identified a relationship between flow and ORFIn scores and the need for sampling thresholds and/or flow calibration. Increased flows appeared to cause lower ORFIn scores due to decreased sampling efficiency and changes in fish behavior.
- Flows were variable in 2008 when sampling was conducted. Sampling was conducted at very low flows as well as at moderately elevated flows. Flows did not appear to affect electrofishing surveys.
- In 2008, only 86.6% of the sites assessed in Hannibal pool had site quality scores >2.0 and the pool had an average quality score of 3.0 (out of 5.0). This score indicates the pool is in good biological condition. Therefore the Hannibal pool will be reported to EPA as meeting its aquatic life-use designation.
- Recommendations include characterizing Dashields pool as supporting its aquatic life-use designation and moving to the next pool to be sampled while continuing to monitor flow and its influence on assessment results.
- As of 2008, 16 of the 19 pools (AUs) have been assessed which comprises 801.0 miles or 81.7% of the resource.

Table of Contents

	Executive Summary.....	i
1.0	Introduction.....	1
2.0	Study Area	
2.1	Ohio River	1
2.1.1	Figure 1. Ohio River Basin.....	2
2.2	Hannibal Pool.....	3
2.3	Hannibal Land Cover	3
2.3.1	Figure 2. Land-cover within the Hannibal catchment area	3
3.0	Methods	
3.1	Survey Design and Site Location	4
3.2	Index Period and Sampling Restrictions.....	4
3.3	Fish Collections	4
3.4	Habitat Characterizations.....	5
3.5	Water Quality and Flow Condition Data.....	5
3.6	Pool Assessment	5
3.6.1	Figure 3. Biological Condition Ratings	6
3.6.2	Figure 4. Sites within Hannibal Pool	7
4.0	Results	
4.1	Fish Population	7
4.1.1	Figure 5. Species Composition	8
4.1.2	Figure 6. Family Composition.....	8
4.1.3	Table 1. Electrofishing Sites.....	8
4.1.4	Table 2. Species List.....	9
4.2	Metric Performance.....	10
4.3	Habitat Surveys.....	10
4.3.1	Figure 7. Substrate Composition by Pool.....	10
4.3.2	Figure 8. Substrate Composition by Site.....	10
4.3.3	Table 3. MORFIN Metrics and Scores	11
4.4	Water Quality and Flow Conditions	12
4.4.1	Figure 9. Flow Conditions	12
4.5	Assessment of Condition.....	12
4.5.1	Figure 10. Pool Condition Ratings.....	12
5.0	Discussion	
5.1	Fish Population	12
5.2	Metric Performance.....	12
5.3	Habitat Surveys.....	13
5.4	Water Quality and Flow Conditions	13
5.5	Conclusions and Assessment of Conditions	13
6.0	Interpool Comparisons	
6.1	Purpose	13
6.2	Land Cover.....	13
6.2.1	Figure 11. Cumulative land-cover within catchment area of each pool of the Ohio River ..	14
6.3	Substrate Composition	13
6.3.1	Figure 12. Substrate composition for each pool	14
6.4	Species Richness.....	15
6.4.1	Figure 13. Average number of native species	15
6.5	Number of Individuals.....	16
6.5.1	Figure 14. Average number of individual species.....	16
6.6	Noteworthy Fish Observations	16
6.7	MORFIN Deviation	17
6.7.1	Figure 15. Average MORFIN Deviation.....	17
6.8	Assessment of Condition.....	18
6.8.1	Figure 16. Average quality score per pool	18
6.8.2	Table 4. Compiled species list per pool	19
	Literature Cited	23
	Appendix A. Assessment Criteria Details	24
	Appendix B. Fish Survey Data.....	26
	Appendix C. Habitat Survey Data	32
	Appendix D. Water Quality Data	32
	Appendix E. Water Quality Parameters Analyzed	33

A Biological Study of the Hannibal Pool of the Ohio River (2008)

1.0 Introduction

The Ohio River Valley Water Sanitation Commission (ORSANCO) is an interstate water pollution control agency created in 1948 by an act of Congress to monitor and improve the water quality of the Ohio River. Until that time, water quality issues on the Ohio River had been charged to state water quality agencies. However, due to large-scale interstate implications and large pollution loads received by the Ohio River, these agencies were not sufficiently equipped to work with such a system. ORSANCO's role is to work in conjunction with state agencies to develop a set of pollution control standards exclusive to the Ohio River. The creation of these standards requires the establishment of monitoring programs that can efficiently be used on the Ohio River.

The routine ambient monitoring programs of ORSANCO are primarily directed at three monitoring and assessment priorities: spill detection (through an organics detection system), trend assessment (manual sampling system), and aquatic resource characterization (macroinvertebrate and fish studies). Another priority, water quality impacts assessment, is achieved through entire watershed intensive surveys.

In 1993, following direction from state and federal agencies, ORSANCO staff developed and implemented an intensive survey design that used electrofishing methods designed for the navigational pools of the Ohio River. This entailed extensive sampling of fish communities throughout the entire length of a particular pool. The surveys were intended to provide background information on fish populations and lay a foundation for establishing biological criteria (biocriteria) for the Ohio River. With appropriate biocriteria in place, information on the biological community provides insight into the health of the Ohio River.

After several years of collecting background data on the fish population of the Ohio River, ORSANCO

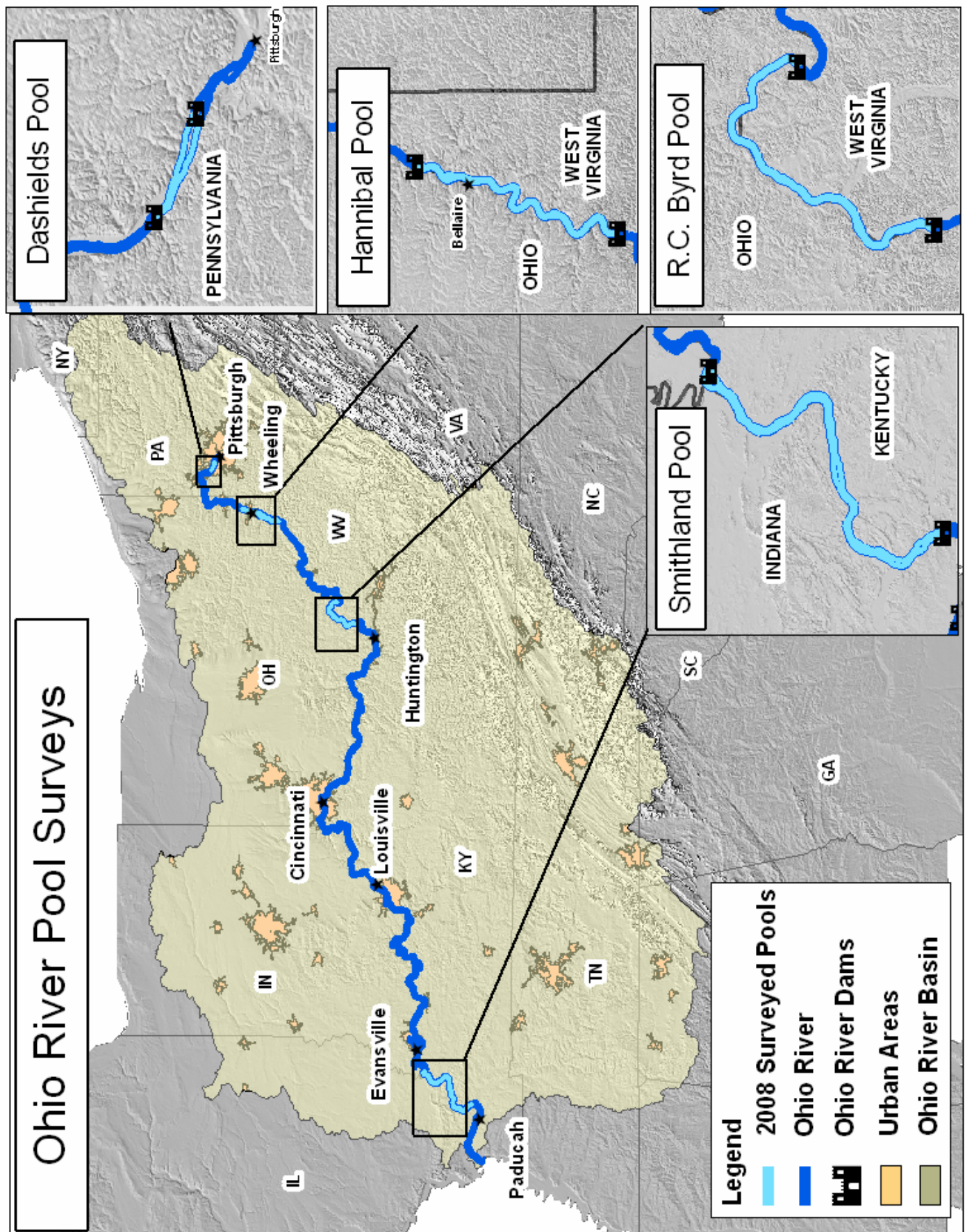
developed the Ohio River Fish Index (ORFI_n, Emery et al. 2003). The ORFI_n incorporates 13 attributes, or metrics, of the fish community that when compiled provide an accurate representation of the overall condition of the Ohio River fish community. These 13 metrics take into account several different aspects of the fish population, including diversity, abundance, feeding and reproductive guilds, pollution tolerance/intolerance, and fish health. In 2008, ORSANCO recalibrated the original ORFI_n and adjusted for more-detailed habitat classifications and a contemporary means of scoring the fish metrics (i.e. continuous in lieu of discrete scoring). A new assessment approach was also adopted for the modified ORFI_n (MORFI_n).

An important aspect of biological monitoring is the reduction of human induced bias in the samples. The use of probability-based sample site selection was designed to reduce this bias. Within this design, sample sites are randomly selected by computer generation, eliminating the tendency to sample only in the best or worst locations. Many states already have programs in place that use this design for sampling on smaller streams, and it is also used by the U.S. Environmental Protection Agency's (USEPA) Environmental Monitoring and Assessment Program (EMAP). ORSANCO has now begun using this approach on the Ohio River for its biological monitoring. In 2008, the Dashields, Hannibal, Robert C. Byrd, and Smithland pools were sampled as part of ORSANCO's normal monitoring. This report presents the 2008 survey of the Hannibal pool including the data collected and assessment results based on the fish population surveys.

2.0 Study Area

2.1 Ohio River

The Ohio River (Figure 1) begins at the confluence of the Monongahela and Allegheny rivers and flows 981 miles in a southwesterly direction to the confluence with the Mississippi River. Twenty navigational dams maintain a nine-foot minimum depth for commercial navigation throughout the entire length of the river. There are over 600 permitted discharges to the Ohio River, 49 of which



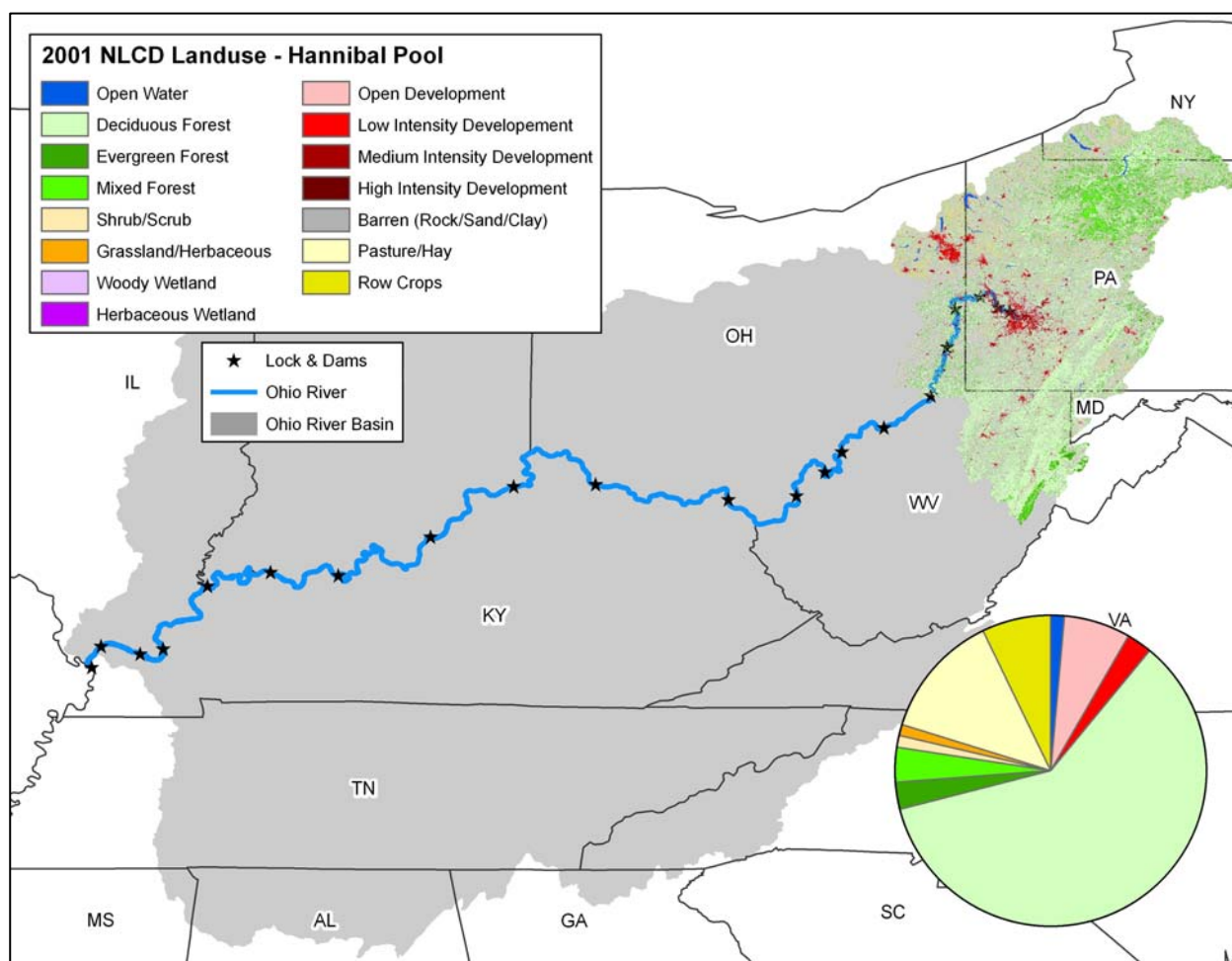
are power-generating facilities. The Ohio River Basin contains nearly ten percent of the nation's population, more than 25 million people, and serves as an avenue for transportation of approximately 250 million tons of cargo each year (ORSANCO 1994). The Ohio River dissects four ecoregions: the Western Allegheny Plateau, the Interior Plateau, the Interior River Lowland, and the Mississippi Alluvial Plain (Omernik 1987).

2.2 Hannibal Pool

The Hannibal pool is 42.2 miles long, extending from Pike Island Locks and Dam (ORM 84.2) to Hannibal Locks and Dam (ORM 126.4). The pool has a gradient drop of 0.5 feet per mile and averages 1,133 feet wide and 21 feet deep (ORSANCO 1994). The pool is bordered by the states of West Virginia and Ohio.

2.3 Hannibal Pool Land Cover

This pool lies in a portion of the Ohio River heavily influenced by industry with a large amount of barge activity. The Hannibal pool receives water from the following tributaries: Wheeling Creek in Ohio at mile point 91.0 with a drainage area of 108 square miles, Wheeling Creek in West Virginia at mile point 91.0 with a drainage area of 300 square miles, McMahon Creek at mile point 94.7 with a drainage area of 91 square miles, Grave Creek at mile point 102.5 with a drainage area of 75 square miles, Captina Creek at mile point 109.6 with a drainage area of 181 square miles, Fish Creek at mile point 113.8 with a drainage area of 250 square miles, and Sunfish Creek at mile point 118.0 with a drainage area of 114 square miles. These watersheds are primarily forested (64.6%) but also have a considerable amount of pasture lands (12.7%) and row crops (7.0%; Figure 2).



3.0 Methods

3.1 Survey Design and Site Location

A random, probability-based survey design was used to select sampling site locations within each Ohio River survey pool. The USEPA National Health and Environmental Effects Laboratory, Western Ecology Division provided assistance by generating the survey design for this project. The target population was the linear shorelines of the Hannibal pool of the Ohio River from mile marker 84.2 (Pike Island Locks and Dam) to 126.4 (Hannibal Locks and Dam). The total linear extent of the target population was approximately 84.4 miles. The sample frame was generated using RF3 river double lines for the Ohio River and river mile coverage provided by ORSANCO. A generalized random tessellation stratified (GRTS) survey design for a linear network with reverse hierarchical randomization (RHR) was used to select all sampling locations. This survey design provided coordinates for 15 sampling sites in each of the selected pools. The data collected from these sites were used to make an assessment of the pool (see Section 3.6 and Appendix A).

Sites were sampled as closely as possible to the location generated from the design, but in cases of restricted access or unsafe sampling conditions (e.g. barge loading/mooring area), sampling zones were shifted if possible (up to a maximum of 500m up- or downstream). The survey design supplied additional sampling sites to be used if a site could not be placed within 500m of the original location.

3.2 Index Period and Sampling Restrictions

All sampling was conducted under the required conditions as described by Emery et al. (2003). This included sampling between July 1 and October 31 when water levels were within one meter of “normal flat pool” and Secchi depths were greater than 0.3m (12 in). These sampling restrictions were used to reduce community variability by increasing the likelihood that samples were collected during the stable, low-flow conditions usually present on the Ohio River during the summer and early fall months.

3.3 Fish Collections

Standard collection techniques were employed throughout the surveys as described by Emery et al. (2003). Fish were collected using boat

electrofishing techniques at night because nighttime electrofishing typically yields samples of increased diversity and richness (Sanders 1992).



ORSANCO crew conducting night-time electrofishing

A sampling crew consisted of a three-person team working from an 18-foot aluminum johnboat. Each boat was equipped with a 5000-watt generator and a Smith-Root Type VI-A electrofishing unit. Sampling was conducted over a 500m long section of near-shore habitat (shoreline out to a maximum distance of 100 ft or a depth of 20 ft.) and was sampled for a minimum of 1800 seconds (Gammon 1998). Time could vary depending upon the complexity of the habitat within a given zone. Stunned fish were captured with nets and placed into large, aerated tubs for processing. Each fish was measured, inspected for anomalies, and identified to lowest possible taxonomic level (species) before being returned to the water. Fish that could not be confidently identified in the field (e.g. minnows) were preserved in a ten percent formalin solution and identified in the laboratory.



Typical 500 meter electrofishing reach

3.4 Habitat Characterizations

Large rivers have distinct habitat types, including unique microhabitats (Reash 1999). Therefore, extensive habitat surveys were conducted for each electrofishing zone, including thorough substrate

and depth measurements. Descriptions of the riparian corridor adjacent to the sampling zone and the presence of woody material available as fish cover were also recorded. Depth and substrate composition were measured at 66 points throughout each 500m zone. Six points along the shoreline were selected throughout the length of the zone at 0, 100, 200, 300, 400 and 500m. From each of these points, depth was recorded at 10ft intervals beginning at the shore/water interface and moving away from the shore for 100ft. Woody cover, which included submerged brush, logs, and stumps, was estimated visually. Using these data, each site, or electrofishing zone, was assigned to one of five existing classes of habitat: 'A', 'B', 'C', 'D' or 'E' (Emery et al, in prep). By assigning each sampling site to one of five habitat categories, biologists can reduce the amount of assessment variability, or 'noise', because each habitat class has a slightly different expectation. Sites assigned to habitat class 'A' are characterized by a >81% presence of boulder, cobble, and gravel at depths <10 feet. Sites assigned to habitat class 'B' are characterized by a ≤81% and >50% presence of boulder, cobble, and gravel at depths <10 feet. Classes 'C', 'D', and 'E' each exhibit substrate compositions of boulder, cobble, and gravel that are ≤50%. Sites that fall in habitat class 'C' exhibit a lower percentage of smaller substrates (≤77%; sand, fine, and hardpan) at depths <10 feet. Class 'D' and 'E' sites similarly exhibit large amounts of sand and fine substrates (>77%), however these two classes differ with respect to depth. Habitat class 'D' sites are relatively shallow while class 'E' sites exhibit a larger percentage of >20' depths.

3.5 Water Quality and Flow Condition Data

Basic measures of water quality were collected at each site prior to sampling. The following parameters were measured with a YSI meter: water temperature, pH, dissolved oxygen (DO), and conductivity. Water samples were also collected using a Kemmerer and consisted of a single-point, mid-depth grab sample at the downstream end of each 500m zone. Samples were collected approximately 100ft from shore at each site on three separate occasions throughout the field season. Samples were kept at or below 4°C until sent off for laboratory analyses. Water quality parameters analyzed included: ammonia nitrogen, chloride,

hardness, nitrate-nitrite, total Kjeldahl nitrogen (TKN), phenolics, sulfate, total suspended solids (TSS), total phosphorus, and total organic carbon (TOC).

Secchi depth was measured using a standard Secchi disc just prior to electrofishing. The potential effects of flow on fish assemblages are unclear therefore flow was also monitored. Flow data were obtained from the U.S. Army Corps of Engineers. These included daily average flow volumes and velocities from the nearest-upstream sampling station to any particular site. There are 234 flow stations on the mainstem of the Ohio River from which data is recorded or modeled. Harmonic mean flow (HMF), the 22-year average flow, was calculated for every Julian day and flow station by ORSANCO using raw flow data obtained from the U.S. Army Corps of Engineers (ORSANCO 2003)

3.6 Pool Assessment

In 2008, ORSANCO employed a probability-based sampling and assessment approach to provide a thorough assessment of biological condition. For the purpose of assessment, individual navigational pools served as the primary assessment units. Therefore, the Hannibal pool served as one distinct assessment unit (AU) and will be reported on as such in the 305(b) report issued to EPA. The approach to assessing each AU involved sampling a statistically determined number of sites (15). Observed MORFIN scores were compared to habitat derived expectations for each site (Emery et al. 2003).

The five distinct habitat classes ('A', 'B', 'C', 'D', and 'E') each exhibit different levels of historical MORFIN performance. Performance expectations for each habitat class were determined based on the statistical distribution of data (MORFIN scores) gathered from 'least impacted' (reference) sites within each habitat class. The 25th percentile value for each habitat class was established as the criterion for determining whether an individual site 'passes' (meets its aquatic life-use designation) or 'fails' (does not meet its aquatic life-use designation, Figure 3).

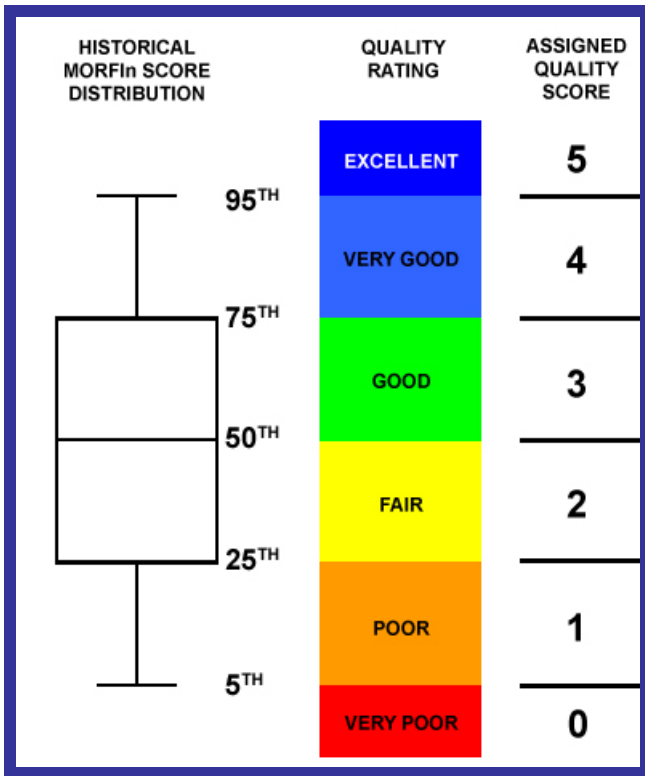


Figure 3. Approach used to assign fish quality scores for each habitat class.

Individual site scores were compared to historical MORFIn score values for a particular habitat class. Historical MORFIn values were determined by compiling fish data from the five distinct habitat classes over a fifteen year period to determine the range of scores that exists within each habitat class. A fish quality score (between 0 and 5) was assigned based on how each site scored relative to the statistical distribution of historical MORFIn scores (see Appendix A for a detailed explanation). For example, a fish quality score of 0 corresponds to the 5th percentile of the range of historical MORFIn scores specific to that habitat class (Figure 3).

Quality scores were determined to obtain a final bio-assessment and the threshold for the pool assessment was set at 25% failure. The pool passed the assessment if the average fish quality score for the pool was above the 25th percentile (≥ 2.0). If the average fish quality score for a pool was below the 25th percentile, the pool was assessed as failing. To further characterize the condition of each pool, sites were given individual condition ratings. The 95th, 75th, 50th, 25th, and 5th percentiles were used as cutoff points for the different ratings. These ratings were based on the same distribution of data from 'least impacted' sites used to determine expectations and consisted of Excellent, Very Good, Good, Fair, Poor, and Very Poor. Any sites that were classified as Poor or Very Poor were sites that failed to meet expectations (Figures 3 and 4).

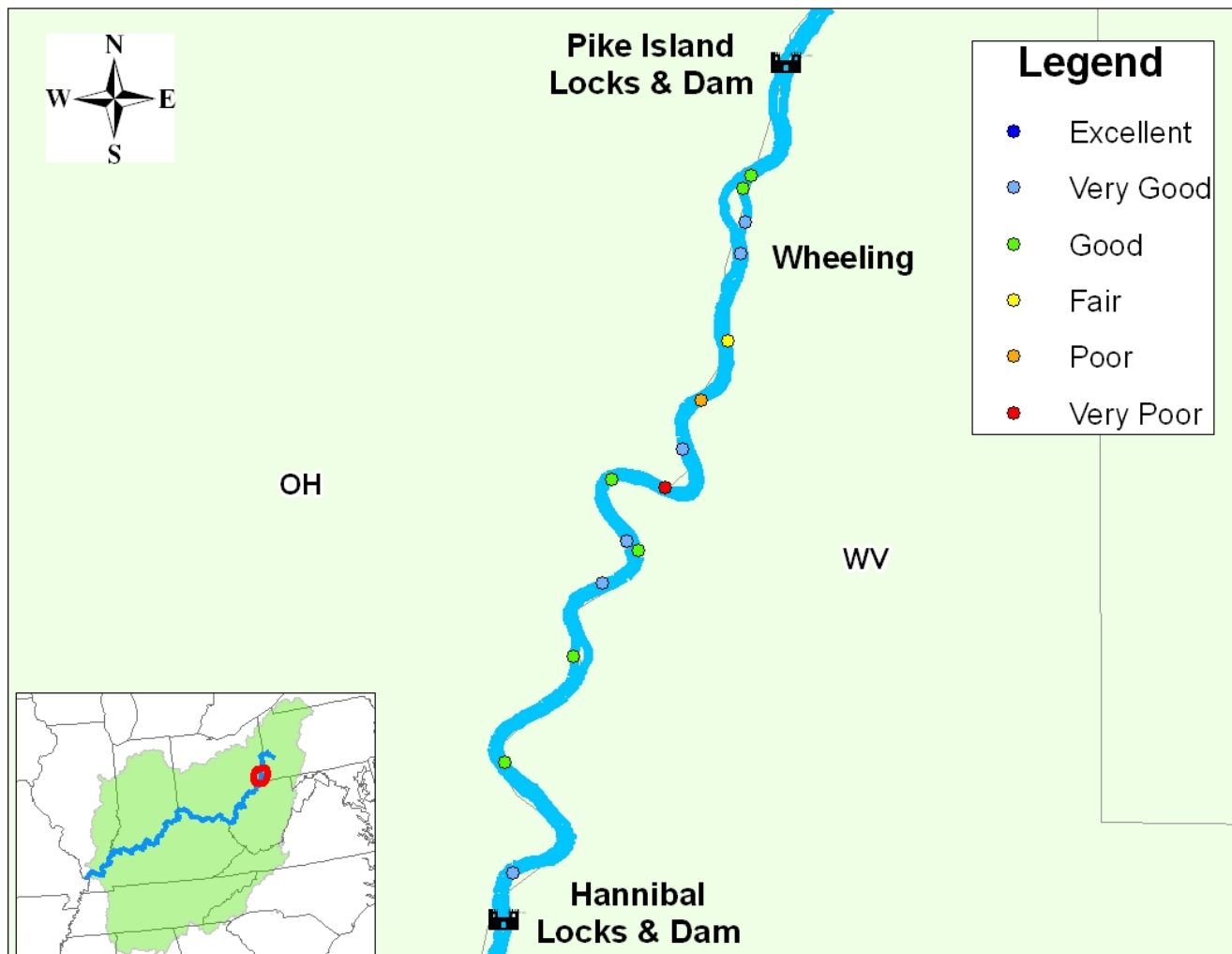


Figure 4. Locations and results of sampling at 15 sites within Hannibal pool.

4.0 Results

4.1 Fish Population

In 2008, fish population data (Appendix B) were collected from 15 randomly selected locations throughout the length of the Hannibal pool (Table 1). These collections produced 41 species and 1 hybrid taxa, representing 10 different families (Table 2). Two of these taxa were listed in OH as either threatened [channel darter (*Percina*

copelandi)] or of special concern [river redhorse (*Moxostoma carinatum*)]. WV has no system for listings species. No federally listed taxa were collected from the Hannibal pool. At the species level, gizzard shad (*Dorosoma cepedianum*) was the most abundant, comprising 73.6% of the catch (Figure 5). As a result, the shad and herring family (Clupeidae), made up 73.6% of the total catch, followed by the drum family (Sciaenidae) which made up 5.0% of the catch (Figure 6).

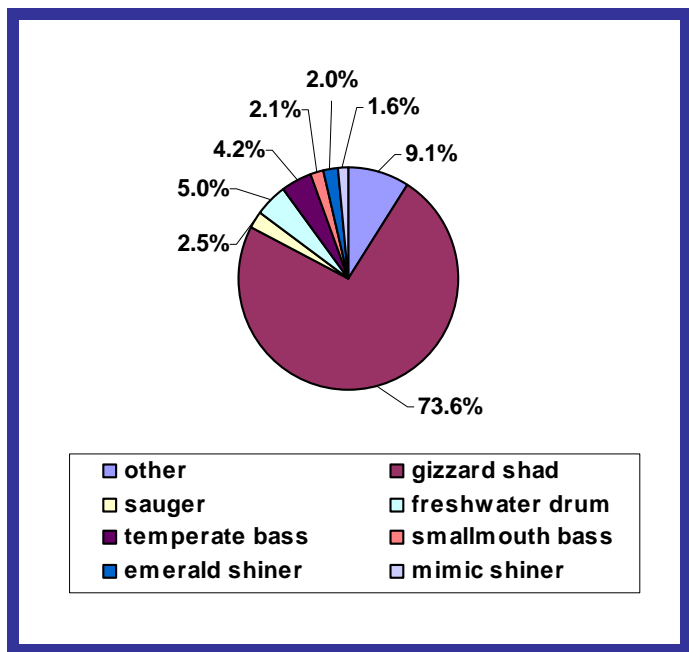


Figure 5. Species composition of fish sampled in Hannibal pool.

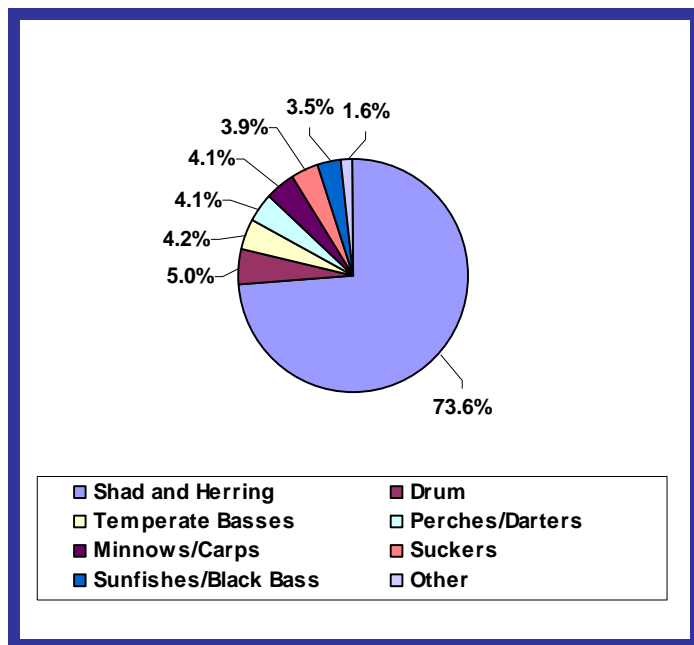


Figure 6. Sampled fish composition by family in Hannibal pool.

Table 1. Electrofishing site list for the Hannibal pool including habitat designation, MORFIn scores, and quality scores.

Site #	River Mile	Bank	Date	Latitude	Longitude	Habitat Class	MORFIn Expectation	MORFIn	Quality Values	Quality Score
1	89.0	LDB	02-Jul-08	40.0879	80.72326	B	46.76	63.36	3	Good
2	89.9	LDB	02-Jul-08	40.08100	80.72779	C	43.13	56.33	3	Good
3	91.0	LDB	09-Jul-08	40.06144	80.7264	A	50.22	63.63	4	Very Good
4	92.2	LDB	07-Jul-08	40.04388	80.72901	B	46.76	63.87	4	Very Good
5	95.8	LDB	21-Jul-08	39.9942	80.73634	C	43.13	49.17	2	Fair
6	98.4	LDB	21-Jul-08	39.96028	80.7516	C	43.13	38.90	1	Poor
7	100.6	RDB	01-Jul-08	39.93264	80.76174	B	46.76	63.91	4	Very Good
8	103.1	RDB	01-Jul-08	39.91093	80.77167	D	41.00	19.97	0	Very Poor
9	105.0	LDB	23-Jul-08	39.91576	80.80212	C	43.13	55.12	3	Good
10	107.9	RDB	23-Jul-08	39.88067	80.79341	D	41.00	63.15	4	Very Good
11	108.4	LDB	23-Jul-08	39.87509	80.78706	D	41.00	52.59	3	Good
12	109.9	RDB	23-Jul-08	39.85683	80.80758	C	43.13	68.49	4	Very Good
13	113.4	RDB	23-Jul-08	39.81516	80.82378	D	41.00	52.01	3	Good
14	118.6	LDB	24-Jul-08	39.75531	80.86326	C	43.13	54.25	3	Good
15	124.6	LDB	24-Jul-08	39.69201	80.8587	C	43.13	67.77	4	Very Good

LDB = Left Descending Bank

RDB = Right Descending Bank

Table 2. Species collected in the Hannibal pool during the 2008 survey. Species information are determined by and relative to the state of Ohio (T = 'Threatened' and SC = 'Species of Concern').

Family	Species	Latin Name	OH
Catostomidae	River Carpsucker	<i>Carpiodes carpio</i>	
Catostomidae	Quillback	<i>Carpiodes cyprinus</i>	
Catostomidae	Highfin Carpsucker	<i>Carpiodes velifer</i>	
Catostomidae	Northern Hog Sucker	<i>Hypentelium nigricans</i>	
Catostomidae	Smallmouth Buffalo	<i>Ictiobus bubalus</i>	
Catostomidae	Black Buffalo	<i>Ictiobus niger</i>	
Catostomidae	Ictiobus sp.	<i>Ictiobus sp.</i>	
Catostomidae	Silver Redhorse	<i>Moxostoma anisurum</i>	
Catostomidae	Smallmouth Redhorse	<i>Moxostoma breviceps</i>	
Catostomidae	River Redhorse	<i>Moxostoma carinatum</i>	SC
Catostomidae	Golden Redhorse	<i>Moxostoma erythrurum</i>	
Centrarchidae	Rock Bass	<i>Ambloplites rupestris</i>	
Centrarchidae	Green Sunfish	<i>Lepomis cyanellus</i>	
Centrarchidae	Pumpkinseed	<i>Lepomis gibbosus</i>	
Centrarchidae	Bluegill	<i>Lepomis macrochirus</i>	
Centrarchidae	Longear Sunfish	<i>Lepomis megalotis</i>	
Centrarchidae	Smallmouth Bass	<i>Micropterus dolomieu</i>	
Centrarchidae	Spotted Bass	<i>Micropterus punctulatus</i>	
Clupeidae	Gizzard Shad	<i>Dorosoma cepedianum</i>	
Cyprinidae	Central Stoneroller	<i>Camptostoma anomalum</i>	
Cyprinidae	Common Carp	<i>Cyprinus carpio</i>	
Cyprinidae	Striped Shiner	<i>Luxilus chrysocephalus</i>	
Cyprinidae	Silver Chub	<i>Macrhybopsis storeriana</i>	
Cyprinidae	Emerald Shiner	<i>Notropis atherinoides</i>	
Cyprinidae	Silverjaw Minnow	<i>Notropis buccatus</i>	
Cyprinidae	Spottail Shiner	<i>Notropis hudsonius</i>	
Cyprinidae	Mimic Shiner	<i>Notropis volucellus</i>	
Cyprinidae	Bluntnose Minnow	<i>Pimephales notatus</i>	
Hiodontidae	Mooneye	<i>Hiodon tergisus</i>	
Ictaluridae	Channel Catfish	<i>Ictalurus punctatus</i>	
Ictaluridae	Flathead Catfish	<i>Pylodictis olivaris</i>	
Lepisosteidae	Longnose Gar	<i>Lepisosteus osseus</i>	
Moronidae	White Perch	<i>Morone americana</i>	
Moronidae	White Bass	<i>Morone chrysops</i>	
Moronidae	Striped Bass	<i>Morone saxatilis</i>	
Moronidae	Morone sp.	<i>Morone sp.</i>	
Percidae	Yellow Perch	<i>Perca flavescens</i>	
Percidae	Logperch	<i>Percina caprodes</i>	
Percidae	Channel Darter	<i>Percina copelandi</i>	T
Percidae	Sauger	<i>Sander canadensis</i>	
Percidae	Saugeye	<i>Sander canadensis</i> x <i>S. vitreus</i>	
Percidae	Walleye	<i>Sander vitreus</i>	
Sciaenidae	Freshwater Drum	<i>Aplodinotus grunniens</i>	

4.2 Metric Performance

Thirteen metrics were used to calculate MORFI scores for each electrofishing site (See Emery et al. 2003). Each site's performance and scores for the MORFI metrics are shown in Table 3. The number of native species collected at each site ranged from 11 to 31, with an average of 17.5 species per site. The number of sucker species found at each site ranged from 3 to 8 and the number of centrarchid species varied from 1 to 7. The number of great river species ranged from 0 to 2. The number of intolerant species ranged from 0 to 6 at the sampled sites. The percentage of tolerant individuals at each site did not exceed 6.8% and the percentage of simple lithophils ranged between 6.8% and 78.8%. All sites had below 11.9% non-native individuals and the percent detritivores ranged from 0.7% to 47.5%. The percent invertivores ranged between 1.7% to 57.6%, and the percent piscivores ranged from 27.4% to 77.1%. One of the sites had two DELT (deformities, eroded fins, lesions and tumors) anomalies. The CPUE (catch per unit effort) ranged from 41 to 721 individuals and averaged 210.8 individuals per site.

4.3 Habitat Surveys

Intensive habitat surveys at each of the 15 sampling locations revealed that the benthic substrate in Hannibal pool was in nearly equal proportions of fines, sand, and gravel (Figure 7). There was some variation among the individual sites and the percentage of fines increased as river miles increased (Figure 8) within the pool. The percentages of substrate variables were used to give each site a habitat classification of 'A', 'B', 'C', 'D', or 'E'. One site in the Hannibal pool was classified as class 'A' habitat, 3 sites were class 'B' habitats, 7 sites were class 'C' habitats, and 4 sites were class 'D' habitats. There were zero 'E' habitat classes sampled in the pool (Table 1).

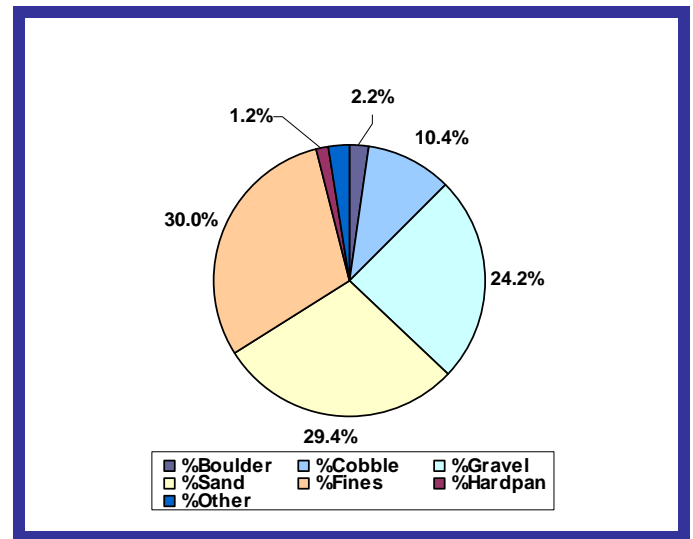


Figure 7. Substrate composition of the Hannibal pool.

Woody cover was present at all 15 sites sampled and overhanging vegetation was also present at all sites. Riparian land cover was primarily natural forest with some residential and industrial uses present. Barge activity was moderate throughout the pool, however mooring structures were present at only one of the sites (see Appendix C).

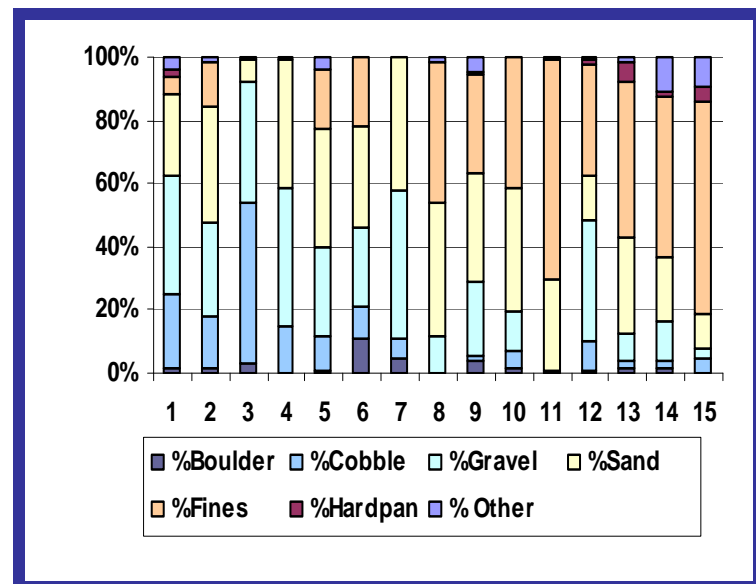


Figure 8. Substrate composition at each site sampled in the Hannibal pool.

Table 3. MORFI metrics and scores from the 2008 survey of Hannibal pool.

Site #	Rmi	Bank	# Individuals	# Individuals w/o G & E	# Individuals w/o GETHEX	# Species	# Species Score	# Suckers	Suckers Score	# Centrarchid Species	Centrarchid Species Score	# Great River Species	Great River Species Score	# Intolerant Species	Intolerant Species Score	% Tolerant Individuals	Tolerant Individuals Score	% Simple Lithophils	Simple Lithophils Score	% Non-native Individuals	Non-native Individuals Score	% Detritivores	% Detritivores Score	% Invertivores	Invertivores Score	% Piscivores	% Piscivores Score	# DELTs	DELT score	CPUE	CPUE score	Expected MORFI	Observed MORFI
1	89.0	L	148	139	137	18	50.3	7	96.7	1	16.7	1	33.3	6	85.4	0.7	92.4	56.8	93.3	1.4	86.7	2.9	91.6	36.0	33.5	52.5	81.5	2	50	146	12.3	46.8	63.4
2	89.9	L	159	156	149	14	21.2	7	96.8	2	33.3	0	0.0	3	29.6	0.0	100.0	68.6	100.0	4.5	58.4	6.4	79.1	46.8	49.9	34.6	50.6	0	100	152	13.3	43.1	56.3
3	91.0	L	74	65	65	14	21.3	6	77.5	2	33.3	1	33.3	5	66.9	0.0	100.0	64.6	100.0	0.0	100.0	6.2	80.1	46.2	49.0	43.1	65.2	0	100	74	0.7	50.2	63.6
4	92.2	L	149	139	138	18	50.4	4	38.9	4	66.7	0	0.0	4	48.4	0.0	100.0	77.7	100.0	0.7	93.3	0.7	99.2	56.1	64.0	38.1	56.6	0	100	148	12.7	46.8	63.9
5	95.8	L	78	69	69	17	43.3	6	77.8	2	33.3	0	0.0	2	11.5	0.0	100.0	23.2	32.9	0.0	100.0	14.5	50.6	10.1	0.0	56.5	88.4	0	100	78	1.4	43.1	49.2
6	98.4	L	42	35	34	13	14.2	3	19.9	2	33.3	0	0.0	2	11.6	2.9	69.7	11.4	11.8	2.9	73.5	8.6	71.5	8.6	0.0	77.1	100.0	0	100	41	0.0	n/a	38.9
7	100.6	R	200	198	194	18	50.7	8	100.0	4	66.7	0	0.0	4	49.0	0.5	94.6	78.8	100.0	2.0	81.3	11.6	60.8	57.6	66.6	28.8	40.4	0	100	196	20.7	46.8	63.9
8	103.1	R	64	59	52	11	0.0	4	39.6	2	33.3	0	0.0	0	0.0	6.8	28.1	6.8	3.5	11.9	0.0	47.5	0.0	1.7	0.0	37.3	55.1	0	100	57	0.0	41.0	20.0
9	105.0	L	715	49	49	13	14.5	4	39.7	1	16.7	0	0.0	2	12.1	0.0	100.0	38.8	61.1	0.0	100.0	10.2	65.8	22.4	14.0	59.2	92.9	0	100	715	100.0	43.1	55.1
10	107.9	R	114	84	83	19	58.2	5	59.2	3	50.0	2	66.7	4	49.5	1.2	87.4	50.0	81.3	1.2	89.0	8.3	72.4	10.7	0.0	69.0	100.0	0	100	113	7.4	41.0	63.1
11	108.4	L	147	128	127	20	65.5	7	97.9	1	16.7	2	66.7	1	0.0	0.8	91.7	42.2	67.3	0.8	92.8	22.7	21.8	18.0	7.4	30.5	43.2	0	100	146	12.8	41.0	52.6
12	109.9	R	138	116	115	19	58.3	6	78.6	3	50.0	2	66.7	4	49.6	0.9	90.9	73.3	100.0	0.9	92.0	4.3	86.6	47.4	51.8	37.1	54.6	0	100	137	11.3	43.1	68.5
13	113.4	R	316	168	167	18	51.1	4	40.1	5	83.3	0	0.0	2	12.7	0.6	93.7	28.6	42.8	0.0	100.0	12.5	57.7	23.8	16.4	27.4	37.9	0	100	315	40.3	41.0	52.0
14	118.6	L	123	114	114	20	65.9	6	79.1	3	50.0	1	33.3	2	13.0	0.0	100.0	28.1	42.0	0.0	100.0	10.5	64.6	16.7	5.9	29.8	42.1	0	100	123	9.3	43.1	54.2
15	124.6	R	246	187	187	31	100.0	6	79.5	7	100.0	2	66.7	4	50.6	0.0	100.0	142.0	100.0	0.0	100.0	10.0	100.0	10.0	10.0	10.0	10.0	0	100	246	100.0	43.1	67.8

L = Left Descending Bank

w/o G & E = Individuals minus gizzard shad and emerald shiners

w/o GETHEX = Individuals minus gizzard shad, emerald shiners, tolerants, hybrids, and exotics

Centrarchid Species = black bass, sunfishes, crappie

Great River Species = fish expected to be predominant in great rivers

Intolerant Species = species with low pollution/disturbance tolerance

Simple Lithophils = fish that are sensitive to substrate disturbance based on reproductive needs

Detritivore = fish that feed primarily on detritus

Invertivore = fish that feed primarily on invertebrates

Piscivore = fish that feed primarily on other fish

DELT = individuals with Deformities, Eroded fins, Lesions, and/or Tumors

CPUE = Catch Per Unit Effort

4.4 Water Quality and Flow Conditions

Rain events were relatively common throughout the sampling period in 2008; therefore river levels and flows were variable. Sampling was conducted in Hannibal pool when flows were above and below the harmonic mean flow (HMF). Flow conditions during sampling varied from 30% and 173% of the HMF (Figure 9).

Measurements of water quality parameters did not reveal any unusual or poor water conditions present at the time of fish sampling (Appendix D). Secchi depths at the time of sampling ranged from 15 to 48 inches.

The water quality parameters measured from water samples, collected three times with Kemmerers, did not reveal any parameters exceeding water quality criteria (Appendix E).

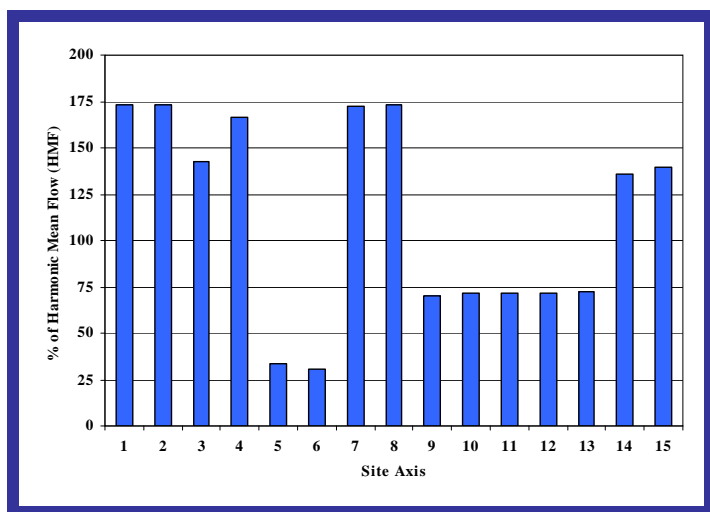


Figure 9. Relative flows (%HMF) at the time of sampling.

4.5 Assessment of Condition

MORFIN scores were calculated for each of the sites sampled. The maximum score achieved by any site in this pool, out of a possible 100, was 68.5 and the minimum was 20.0. By comparing observed and expected MORFIN scores, ORSANCO determined if a site met its expectations (based on habitat class) or not (Table 3). Two of the 15 sites (13.3%) assessed in 2008 scored less than the minimum expected scores and were assessed as either poor or very poor (Table 1; Figure 10). The remaining 13 sites received a fair (6.7%), good (40%), or very good quality rating (40%; Figure 10).

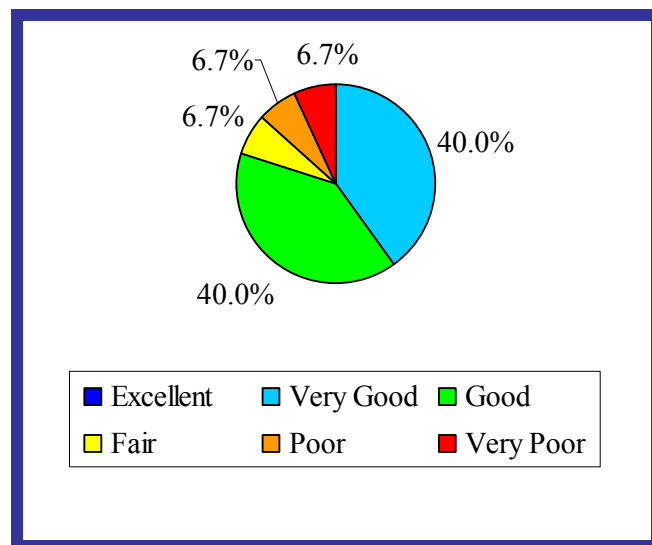


Figure 10. Condition of the Hannibal pool based on MORFIN scores at 15 sites (Pass=Excellent-Fair, Fail=Poor-Very Poor).

5.0 Discussion

5.1 Fish Population

In 2008, the fish population of Hannibal pool was in good condition. This was supported by the diversity and types of species collected. Multiple pollution intolerant species such as smallmouth redhorse (*Moxostoma breviceps*), river redhorse (*M. carinatum*), northern hogsucker (*Hypentelium nigricans*), mimic shiner (*Notropis volucellus*), smallmouth bass (*Micropterus dolomieu*), channel darter (*Percina copelandi*), logperch (*Percina caprodes*), and mooneye (*Hiodon tergisus*) were collected from Hannibal pool, suggesting that pollution may not be a problem in the area. Common carp (*Cyprinus carpio*) was only non-native species collected during the survey.

The 3-most abundant species in the survey were gizzard shad (*Dorosoma cepedianum*; 1,461 individuals), sauger (*Sander canadensis*; 317 ind.), freshwater drum (*Aplodinotus grunniens*; 211 ind.), and golden redhorse (*Moxostoma erythrurum*; 204 ind.).

5.2 Metric Performance

Most of the metric scores in Hannibal pool were relatively high with the exception of four metrics: CPUE, # of great river species, % invertivores, and % intolerant individuals. The longitudinal

position of Hannibal pool on the river (i.e. nearer the Ohio River headwaters) may be responsible for the lower great river species metric scores. There was no known reason or explanation for the low percentage of % invertivorous or % intolerant individuals. Gizzard shad was the dominant species collected (by abundance) and the CPUE metric does not include gizzard shad or emerald shiners in calculating its score. That is potentially the reason for the lower CPUE metric scores.

Three metrics stood out as the highest performing in Hannibal pool; DELTs, the % tolerant individuals, and the # of non-native individuals metrics. DELT anomalies were only found at one site suggesting the majority of fishes in Hannibal pool are not experiencing environmental stressors severe enough to decrease their health. Low proportions of pollution-tolerant individuals and non-native species were collected. These metrics indicate that Hannibal pool is in good condition. Other metrics that performed relatively well include: # sucker species, % simple lithophilic spawners, % detritivores, and % piscivores.

5.3 Habitat Surveys

The habitat assessments show that in Hannibal pool there was a relatively balanced number of sites classified as class 'B', 'C', and 'D' habitats. This indicates that the majority of the benthic substrate is comprised of gravel, sand, and fines. The heterogeneous substrate compositions, supplemented with the presence of woody cover, provided adequate habitat to support the diverse populations of fishes in the pool.

5.4 Water Quality and Flow Conditions

The fluctuations in river level could potentially have affected the survey of Hannibal pool. Rain events were relatively frequent throughout the field season causing some sampling to be conducted during higher flow events. High flows can alter fish behavior and increase turbidity, however Secchi depths however, indicated sufficient visibility for sampling. One of the sites

was that was assessed as very poor (River Mile 103.1; Site #8) and was sampled during a period of increased % HMF (Figure 9). No water quality measurements exceeded their respective criteria or provided any major insight into the assessment results for Hannibal pool.

5.5 Conclusions and Assessments of Condition

The overall average quality score in Hannibal pool was 3.0, indicating the pool is in good biological condition. Despite two of the sites assessed as being in poor and very poor condition, the assessment of Hannibal pool met the criteria established by ORSANCO's Biological Water Quality Subcommittee (Appendix A). The data collected in 2008 indicated that Hannibal pool met its aquatic life-use designation.

6.0 Interpool Comparison

6.1 Purpose

As of 2008, 16 of 19 pools have been surveyed and assessed. This section was developed to compare Hannibal pool to other previously surveyed pools in the Ohio River.

6.2 Land Cover

Hannibal lies in the upper portion of the Ohio River and therefore has a relatively small catchment area. Despite many industrial facilities immediately surrounding the pool, the primary land cover within the watershed is deciduous forest. Agricultural practices are secondary land uses but in lower proportions than pools in the lower third of the Ohio River (Figure 11).

6.3 Substrate Composition

This pool had a relatively equal percentage of cobble, gravel, sand, and fine substrates. The heterogeneous substrate composition is most similar to its closest downstream pool (Willow Island). However, these percentages are quite different from the other pools assessed in the lower third of the river (Figure 12).

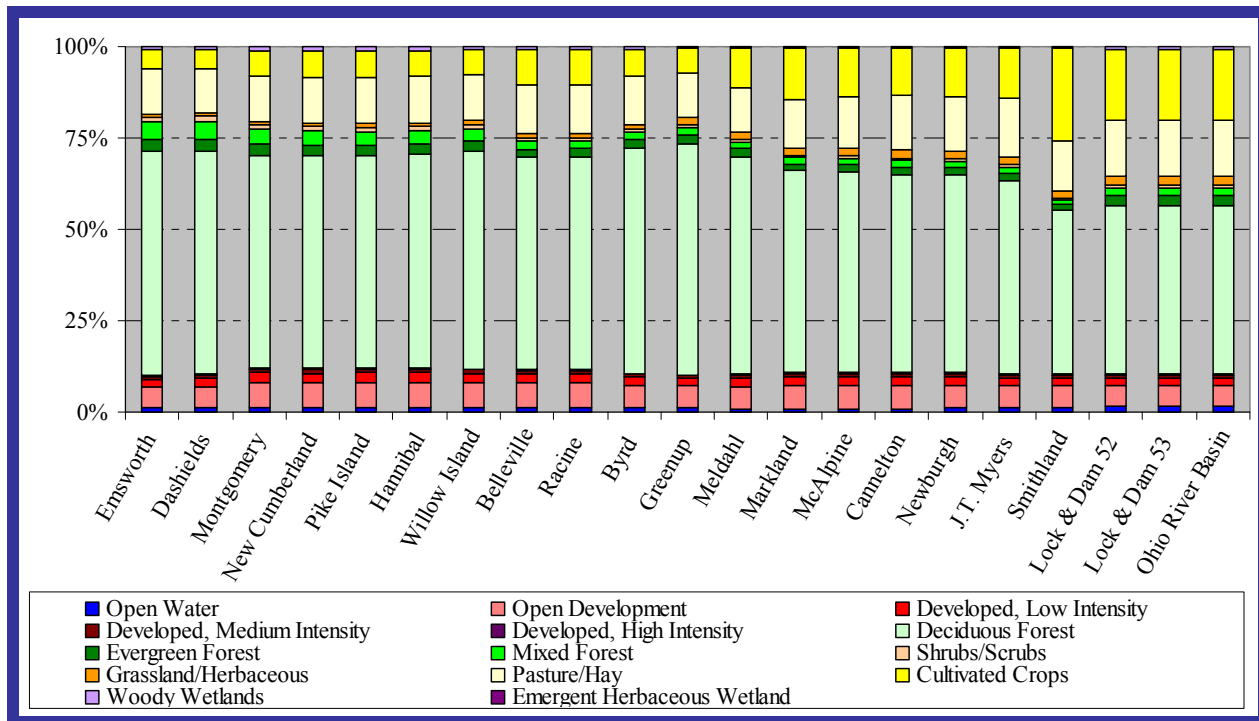


Figure 11. Cumulative land-cover within the catchment area of each pool of the Ohio River.

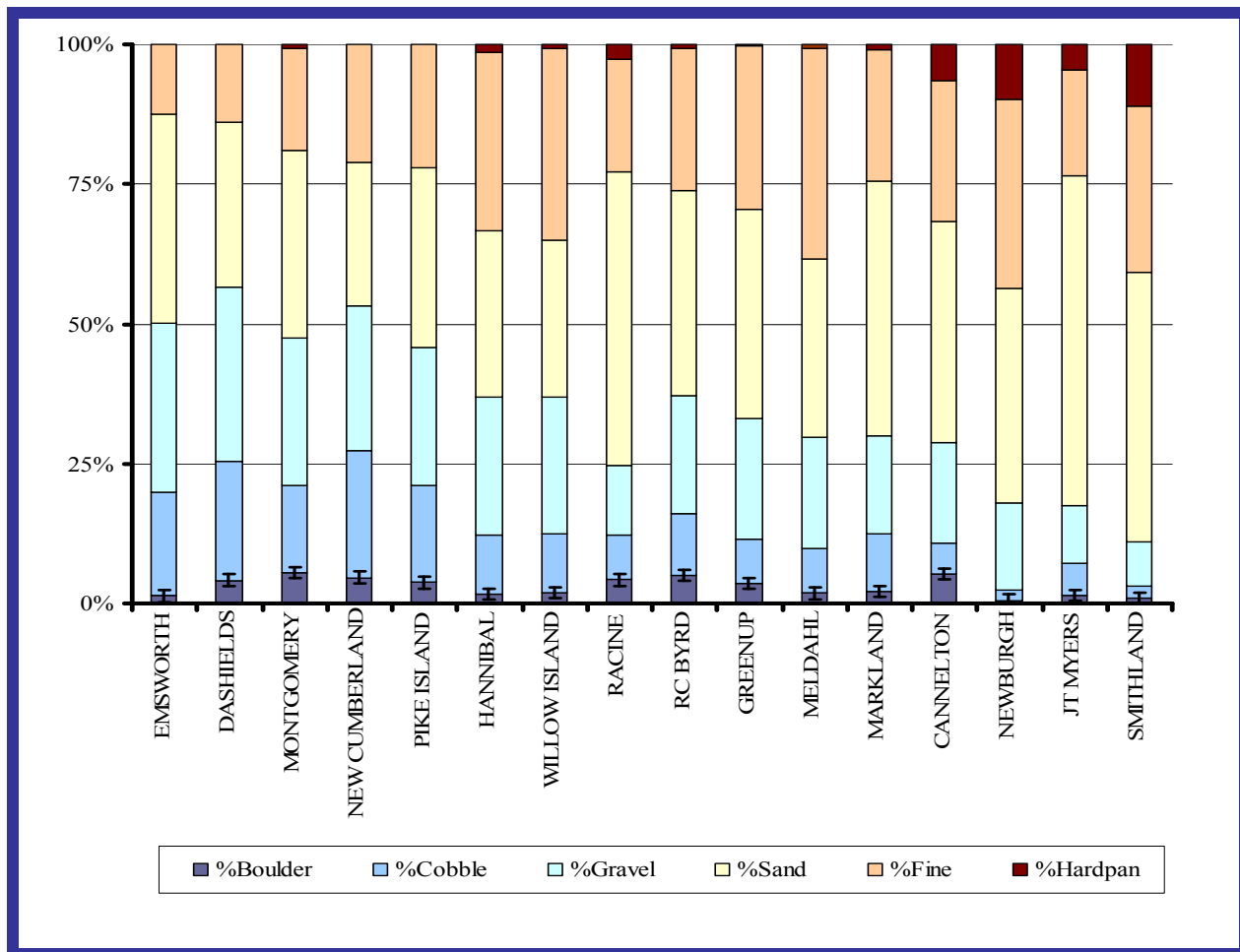


Figure 12. Substrate composition for each pool surveyed as of 2008.

6.4 Species Richness

Hannibal pool was similar to other surveyed pools in the average number of native species per site (17.5) and ranked 8th in comparison (Figure 13).

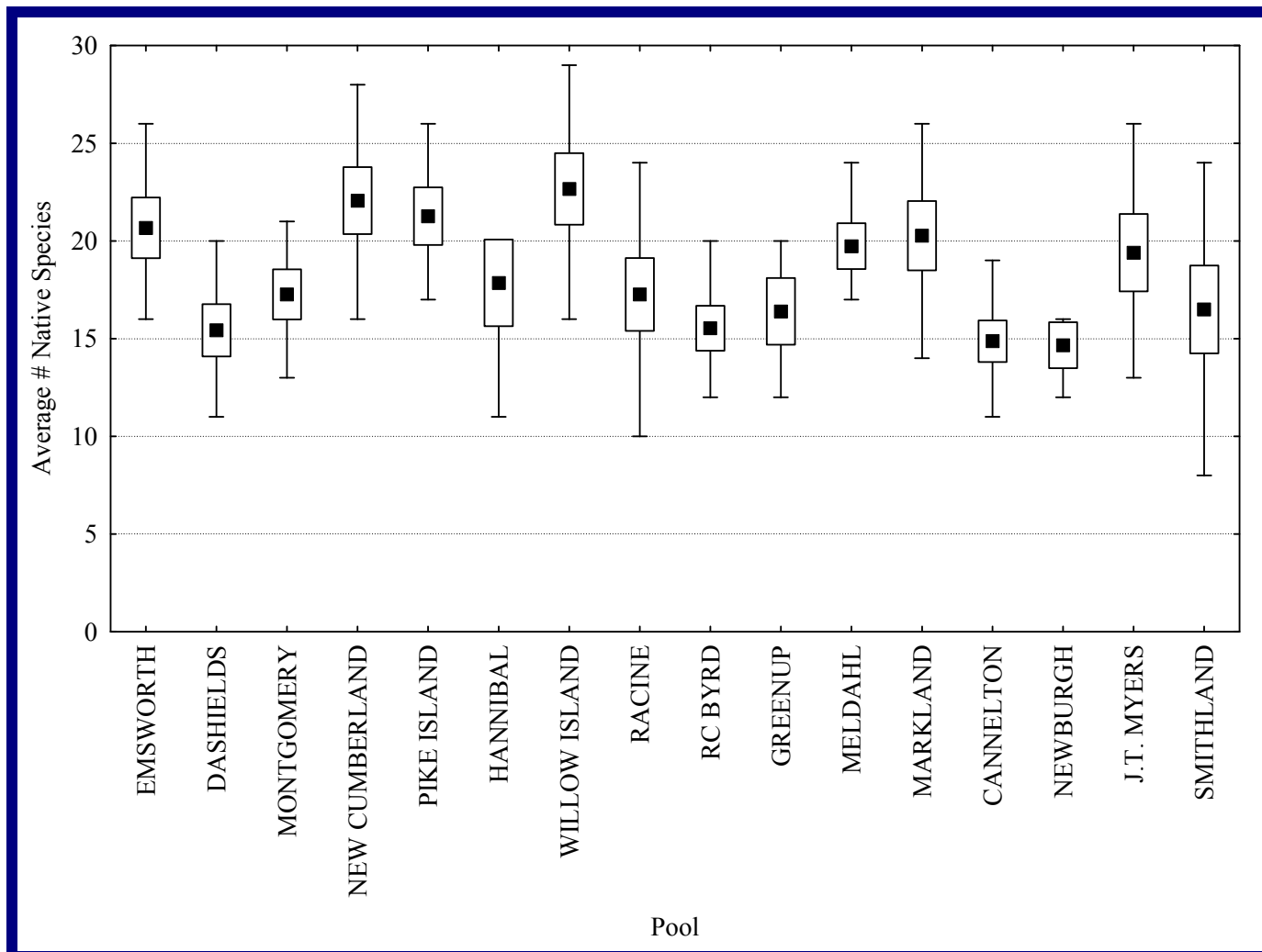


Figure 13. The average number of native species collected at each site within each pool surveyed as of 2008 (■=Average, □=90% Confidence Interval, I=Non-Outlier Range).

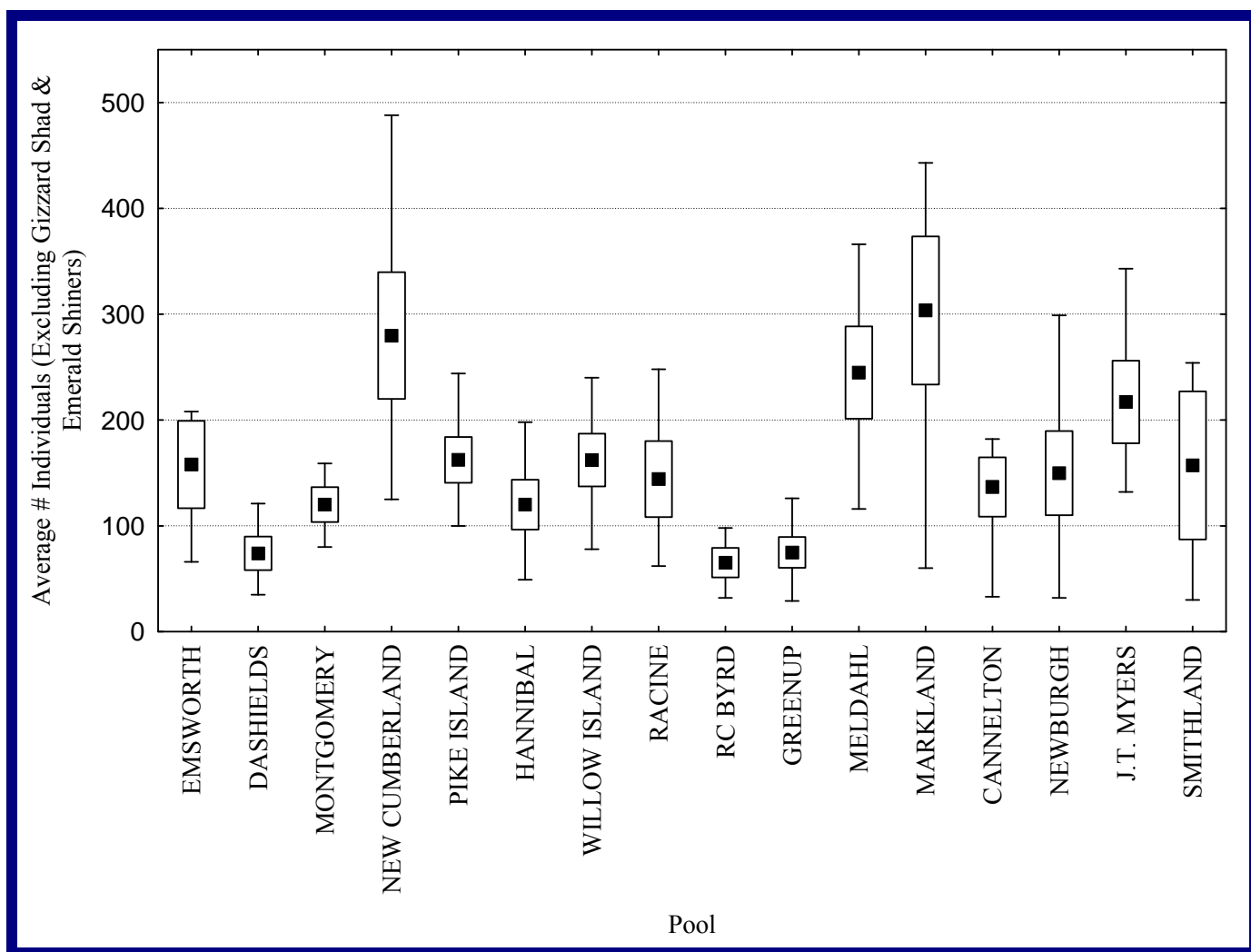


Figure14. The average number of individuals (excluding gizzard shad & emerald shiner) collected at each site within each pool surveyed as of 2008 (■=Average, □= 90% Confidence Interval, I=Non-Outlier Range).

6.5 Number of Individuals

An average of 120.0 individuals (excluding gizzard shad and emerald shiner) was collected at each site in Hannibal pool which ranked 13th in comparison (Figure 14).

6.6 Noteworthy Fish Observations

One of the species collected in Hannibal pool was unique to the pool (silverjaw minnow; *Ericymba buccata*) during our random survey design. However this species is commonly found in tributaries of the Ohio River. Several species were collected from this pool that are only found in the upper portions of the Ohio

River such as: rock bass, yellow perch, and spottail shiner (Table 4).

In addition to our random sampling protocol, targeted sites were sampled within the pool during the field season. Several other species were found from these collections including river darters (*Percina shumardi*), bluebreast darters (*Etheostoma camurum*) and a paddlefish (*Polyodon spathula*: approx. 34" long); all of which are listed in Ohio as threatened. One other notable catch was a northern pike (*Esox lucius*) collected from the mainstem of the Ohio that was 36" long.

Collections were also made in May during a special project and several large hybrid striped bass (as much as 10 lbs) and smallmouth bass (as much as 5 lbs) were collected near the tailwaters of Pike Island dam.

Benthic trawling occurred within Hannibal pool from which tippecanoe darters (*Etheostoma tippecanoe*) were collected. Trawls also yielded these darters in Dashields pool. These are the first records of tippecanoe darters to be collected from

the mainstem of the Ohio River. This species is listed in the state of Ohio as threatened.

6.7 MORFIn Deviation

The MORFIn deviation is a measure of how well the pool performed with regard to expected MORFIn values. Positive values indicate that scores were greater than expected. Hannibal pool had an average deviation of 11.7 and was ranked 10th out of other pools surveyed as of 2008 (Figure 15).

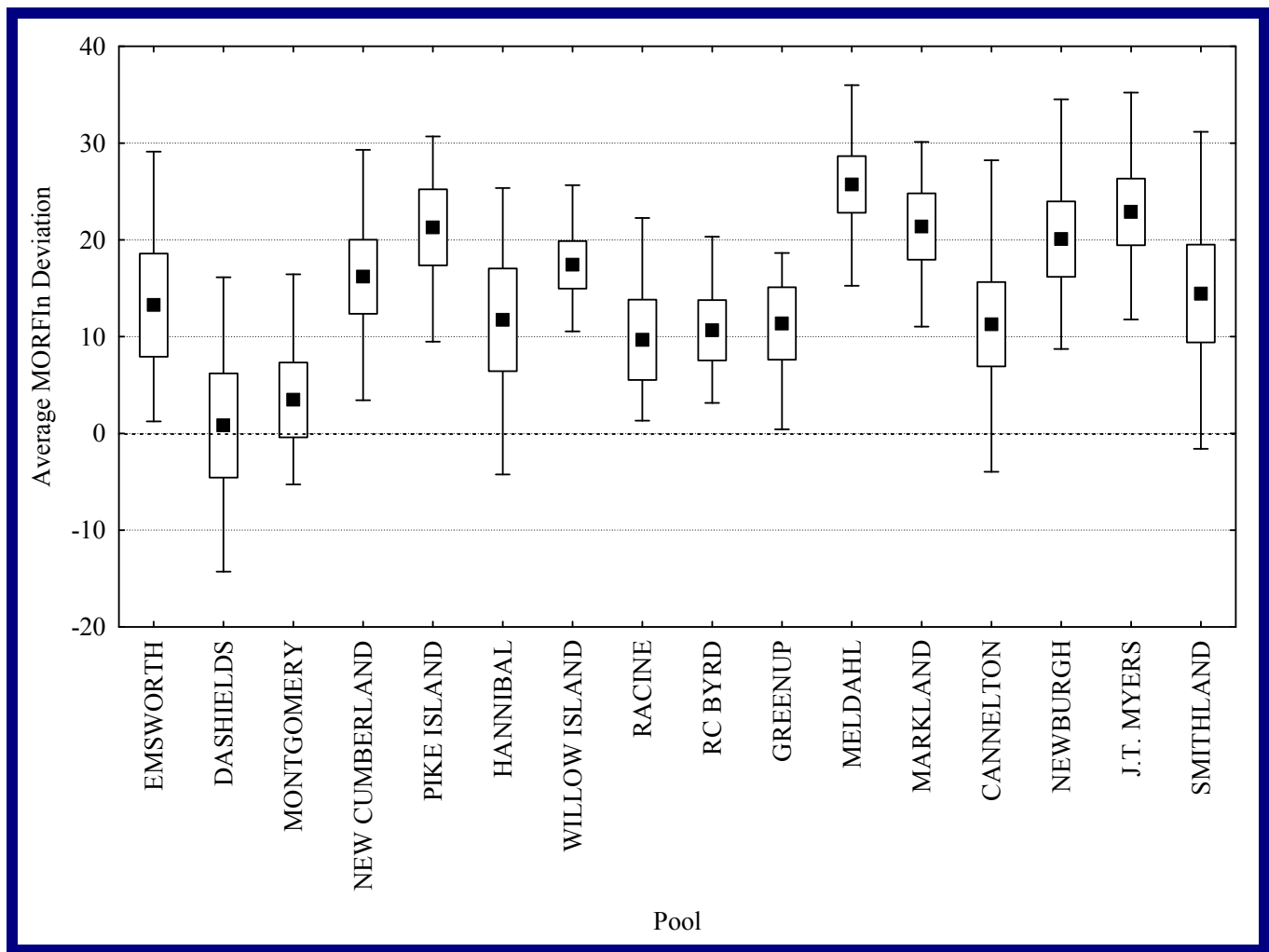


Figure 15. The average MORFIn deviation of each site within pools surveyed as of 2008 (■=Average, □= 90% Confidence Interval, I=Non-Outlier Range).

6.8 Assessment of Condition

The average quality score in Hannibal pool was 3.0 and it was assessed as being in good condition. The nearest surveyed pool upstream

(Pike Island) and downstream (Willow Island) of Hannibal pool were also considered to be in good condition (Figure 16).

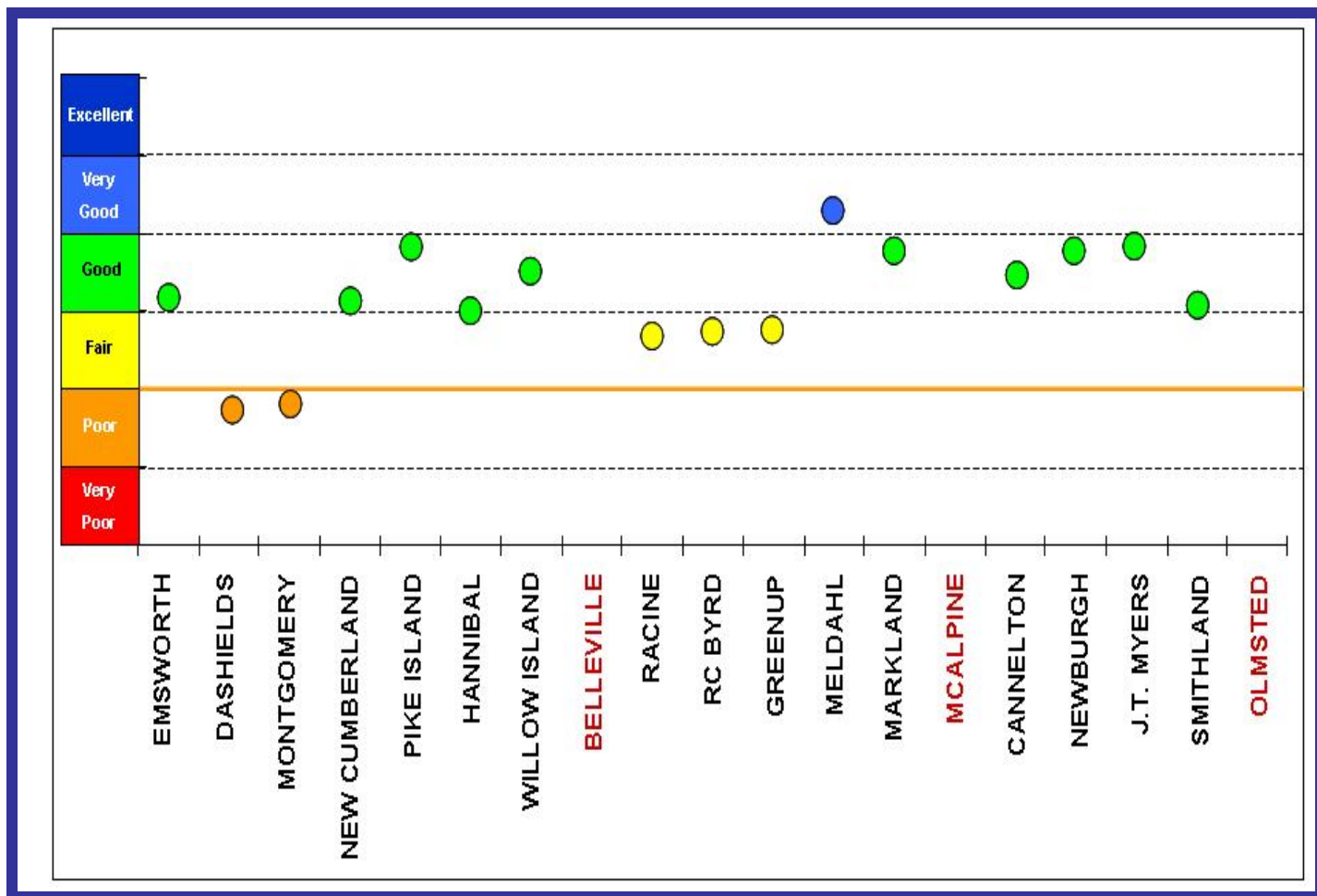


Figure 16. The average quality score for each pool surveyed as of 2008 (black text, red text = pools to be surveyed in 2009). Data points are color-coded to indicate the biological condition of a pool.

Table 4. A compiled species list containing the number of individuals collected per pool as of 2008.

#	Species	Emsworth 07	Dashields 08	Montgomery 06	New Cumberland 05	Pike Island 07	Hannibal 08	Willow Island 06	Racine 05	RC Byrd 08	Greenup 06	Meldahl 07	Markland 05	Cannelton (30) 06-07	Newburgh 07	Myers 05	Smithland 08
1	Silver Lamprey										1						1
2	Paddlefish														1		
3	Longnose Gar	13	11	10	11	43	49	46	24	27	23	22	15	48	20		16
4	Spotted Gar														1		1
5	Shortnose Gar														9	2	13
6	Skipjack Herring	8			3	6			1	2		64	145	174	70	249	1
7	Gizzard Shad	167	123	266	1202	7326	1461	216	8048	301	267	2408	1743	3527	600	444	409
8	Threadfin Shad													1	9	112	25
9	Goldeye														12		2
10	Mooneye	20	11	6	22	37	10		1	7		48	12	8	10	4	
11	Muskellunge	1															
12	Common Carp	63	36	44	25	15	15	22	9	12	9	8	20	5	4	10	17
13	Grass Carp				1										1		
14	Silver Carp														2		4
15	Bighead Carp														2		
16	Goldfish				1												
17	Golden Shiner	1			1												
18	Miss. Silvery Minnow															1	
19	Notropis Sp																1
20	Striped Shiner						2		2								
21	Spottail Shiner				6	2	1										
22	Spotfin Shiner			1	21	14		24	63	1	2	32	2	63	8	12	4
23	Emerald Shiner	82	5	8	342	197	21	728	795	16	50	637	303	1331	166	801	28
24	Mimic Shiner	35	1	13	76	162	16	306	402	1	61	7	5	195	6	43	
25	River Shiner	1										54	8	276	3	91	2
26	Silver Chub	26	26	12	20	11	19	57	44	11	33	90	171	130	126	206	46
27	River Chub				1	1											

Table 4. A compiled species list containing the number of individuals collected per pool as of 2008.

#	Species	Emsworth 07	Dashields 08	Montgomery 06	New Cumberland 05	Pike Island 07	Hannibal 08	Willow Island 06	Racine 05	RC Byrd 08	Greenup 06	Meldahl 07	Markland 05	Cannelton (30) 06-07	Newburgh 07	Myers 05	Smithland 08
28	Central Stoneroller				4		3	1					1				
29	Bluntnose Minnow				2	2	4	120	3		1	1		2			1
30	Fathead Minnow								6								
31	Bullhead Minnow							4	5			23	2			8	2
32	Silverjaw Minnow						1										
33	Gravel Chub											1					
34	Creek Chub				1							3					
35	Carpiondes Sp		1			14			2			1		2			
36	Ictiobinae Sp				20												
37	Quillback	17	12	30	80	27	28	66	16	8	17	31	137	21	34	57	28
38	River Carpsucker	18	18	13	46	36	64	18	50	25	49	87	47	122	179	86	114
39	Highfin Carpsucker			37	3	10	13	1	7		4		2	1	12	3	24
40	Shorthead Redhorse																10
41	Smallmouth Redhorse	61	16	110	110	28	41	168	5	27	30	62	31	12	3	11	
42	Moxostoma Sp				58												
43	Silver Redhorse	221	93	157	63	78	105	51	11	11	12	25	19	3			1
44	River Redhorse	39	13	3	5	27	35	2		2	6	1	1		1		
45	Black Redhorse	18			11			4					1	1			
46	Golden Redhorse	7	33	227	90	66	204	277	11	33	39	120	105	4	14		3
47	Northern Hog Sucker	3	1	3	132	4	2	15		1			14	1	1		
48	Ictiobus Sp						19										
49	Smallmouth Buffalo	97	99	217	283	94	45	60	96	40	49	123	150	147	72	314	77
50	Bigmouth Buffalo								1						3	7	5
51	Black Buffalo	1	13			5	1	2			1		2	1	7	3	4
52	Spotted Sucker							1	1		5	1		1			7
53	Blue Catfish															1	7
54	Brown Bullhead										1						

Table 4. A compiled species list containing the number of individuals collected per pool as of 2008.

#	Species	Emsworth 07	Dashields 08	Montgomery 06	New Cumberland 05	Pike Island 07	Hannibal 08	Willow Island 06	Racine 05	RC Byrd 08	Greenup 06	Meldahl 07	Markland 05	Cannelton (30) 06-07	Newburgh 07	Myers 05	Smithland 08
55	Channel Catfish	32	17	34	123	40	62	61	70	53	58	89	247	48	11	330	291
56	Flathead Catfish	14	11	11	15	35	38	21	32	42	32	49	38	63	11	43	16
57	Trout-Perch								3								
58	Banded Killifish							1									
59	Inland Silverside																26
60	Brook Silverside								1				1	1	1	1	1
61	Morone Sp	27		6	568	419	91	17	561	73	2	152	250	625	403	253	190
62	Striped Bass						14	1						6		12	2
63	Hybrid Striper			4	17			1	46	1			40	6		11	2
64	White Perch	5			4		1	3					5				
65	White Bass	9	16	36	6	2	3	58	3	29	64	18	22	66	4	17	76
66	Yellow Bass																2
67	Rock Bass	16	9	8	5	1	2	3								1	
68	Lepomis Hybrid			1				9									
69	Lepomis Sp							16	1					1		1	
70	Green Sunfish	12	3	2	4	2	2	4	6	6	4	3	10	2	4	10	1
71	Warmouth							1				1	1			1	
72	Bluegill	379	32	216	53	46	36	232	58	52	112	207	245	103	11	31	64
73	Bluegill X Longear Sunfish																1
74	Bluegill X Green Sunfish					1								1			
75	Pumpkinseed			2			2	18									
76	Orangespotted Sunfish				1			2	1	1		1	1			2	
77	Longear Sunfish						9	23	3	9	14	35	53	39	3	11	92
78	Longear X Green Sunfish															1	
79	Redear Sunfish			4		1		1	1		1		2	16		1	20
80	Micropterus Sp																1
81	Smallmouth Bass	339	163	185	262	208	92	61	6	32	7	4	28	7	1	4	

Table 4. A compiled species list containing the number of individuals collected per pool as of 2008.

#	Species	Emsworth 07	Dashields 08	Montgomery 06	New Cumberland 05	Pike Island 07	Hannibal 08	Willow Island 06	Racine 05	RC Byrd 08	Greenup 06	Meldahl 07	Markland 05	Cannelton (30) 06-07	Newburgh 07	Myers 05	Smithland 08
82	Largemouth Bass	4	2	8	8	16		16	22	25	65	16	56	37	2	70	21
83	Spotted Bass	125	34	15	79	74	38	62	22	30	43	90	123	53	49	104	31
84	White Crappie	5	1							1	4		1	1	1		
85	Black Crappie	3	1	6	2	2			3	1			2	3			
86	Johnny Darter	1						2									
87	Greenside Darter	5		2	11	5							1				
88	Rainbow Darter			4	1			2					8			12	
89	Fantail Darter	3		1								1					
90	Banded Darter			1	4								1			1	
91	Yellow Perch			4	2		3										
92	Logperch	141	166	67	244	85	105	108	6	72	12	20	60	39	4	3	1
93	Dusky Darter															3	1
94	Channel Darter	16		1	9		1	3			20					1	
95	Slenderhead Darter												5			5	
96	River Darter					2		1	2		1	6	4	11		4	
97	Walleye	44	7	11	31	70	11	1	4	1	1	3	1		7		
98	Saugeye	2	8		5	4	1		4	1			17			7	2
99	Sauger	283	192	243	180	244	317	341	173	259	220	1174	664	1314	747	484	105
100	Freshwater Drum	254	58	47	1468	496	211	120	375	83	121	1000	1778	435	378	612	837
	Total # of Taxa	43	33	42	53	43	43	51	46	36	38	41	51	46	44	50	50
	Total # of Individuals	2618	1232	2076	5742	9958	3198	3378	11006	1296	1441	6718	6600	8953	3013	4501	2636

Literature Cited

- Emery, E.B., T.P. Simon, F.H. McCormick, P.L. Angermeier, J.E. Deshon, C.O. Yoder, R.E. Sanders, W.D. Pearson, G.D. Hickman, R.J. Reash, and J.A. Thomas. 2003. Development of a multimetric index for assessing the biological condition of the Ohio River. *Transactions of the American Fisheries Society*. 132:791-808.
- Gammon, J.R. 1998. *The Wabash River Ecosystem*. Indiana University Press, Bloomington, IN.
- Omernik, J.M. 1987. Ecoregions of the conterminous United States. *Annals of the Association of American Geographers*. 77:179-190.
- ORSANCO (Ohio River Valley Water Sanitation Commission). 1994. *Ohio River Fact Book*. ORSANCO, Cincinnati, OH.
- ORSANCO. 2003. *Pollution Control Standards for Discharges to the Ohio River*. ORSANCO, Cincinnati, OH.
- Reash, R.J. 1999. Considerations for characterizing Midwestern large river habitats. Pages 463-473, *In* T.P. Simon. 1999. *Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities*. CRC Press, Boca Raton, FL.
- Sanders, R.E. 1992. Day versus night electrofishing catches from near-shore waters of the Ohio and Muskingum rivers. *Ohio Journal of Science* 92:51-59.

Appendix A

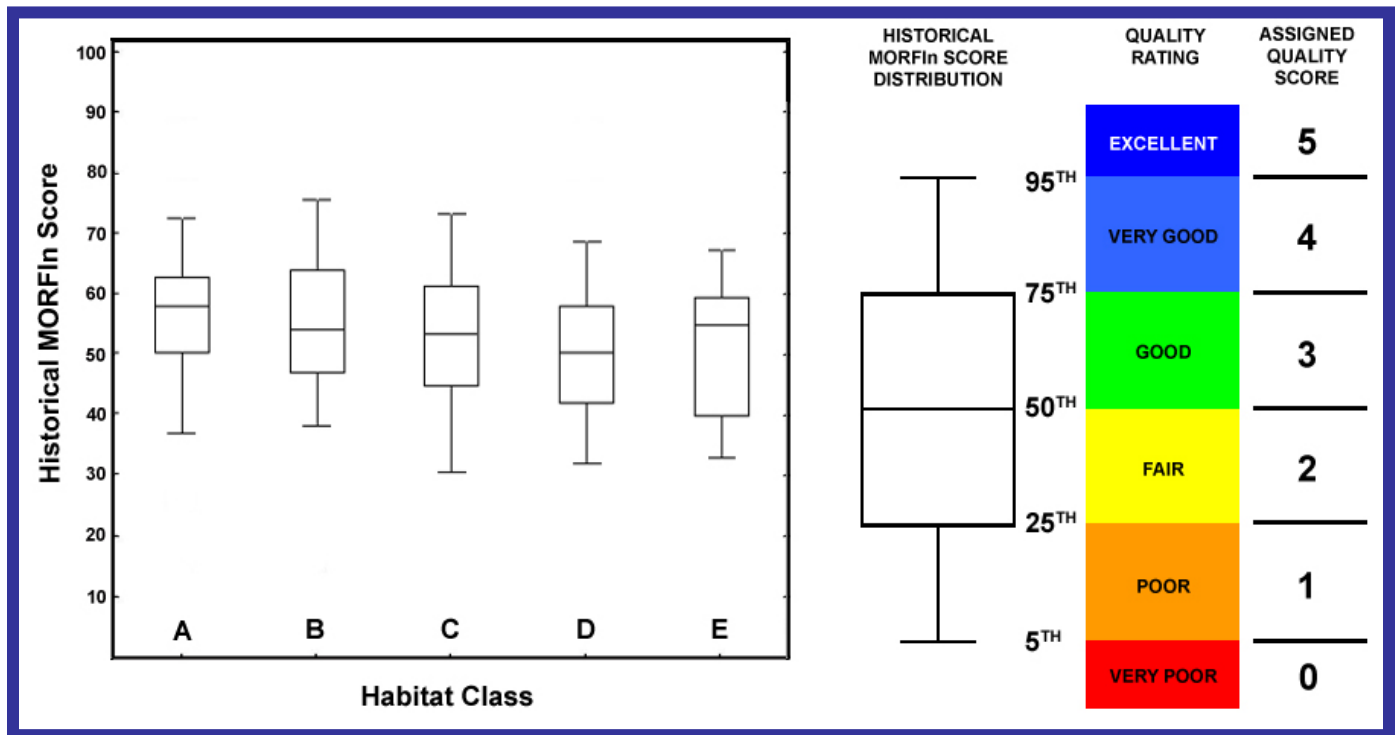
Assessment Unit Criteria Details

- Each individual navigational pool will serve as a separate and distinct Assessment Unit (AU), with the exception of the area below Smithland dam will also be considered one distinct AU.
 - This is based on the observation that biologically, each pool more closely resembles a lake, and not a free-flowing river. Therefore, biological condition becomes more homogeneous throughout, exhibiting little longitudinal change.
 - The dams are seen as the only real barriers that isolate individual populations. This observation is supported by research at the University of Louisville indicating little or no synchrony between pools. Each pool behaves independent of even its nearest neighbor, indicating isolated and independent populations among pools.
 - Isolated pockets, or areas, with poorly performing biotic communities have not been observed over the last ten years of sampling.
 - The BWQSC believes that a subset of randomly selected sites within each pool can accurately describe the condition of the target population (the fish population of that pool).
- All AUs will be sampled and assessed on a 5-year rotating basis. This is consistent with state schedules, and it will allow ORSANCO (after one full rotation) in each 305(b) report, to incorporate 5 years worth of data and report on 100% of the resource.
 - It is acceptable to EPA to include the most recent 5 years of data in each 305(b) report.

	Ernsworth	Deshields	Montgomery	New Cumberland	Pike Island	Hannibal	Willow Island	Belleville	Racine	R. C. Byrd	Greenup	Meldahl	Markland	McAlpine	Cannelton	Newburgh	Uniontown	Smithland	Olmsted	Sites
2005				15				15				15			11	15				60
2006			15						15						19					56
2007	15				15					15										79
2008		15				15			15								15			60
2009							15					15	15						15	60
SUM	15	15	15	15	15	15	15	15	15	15	15	30	15	30	15	15	15	15	15	315

- Assessment Units that yield an average quality score that is less than 2.0 will be listed as failing to meet (support) its aquatic life-use designation. The process of conducting a bioassessment and determining an AU's biological condition is outlined below:
 - Individual sites were assigned to a habitat class ('A', 'B', 'C', 'D' and 'E') based on its substrate composition. Each of these 5 habitat classes exhibits a different range of historical MORFIN scores and expectations. Therefore, the expected MORFIN score changes for each of the habitat classes. For example, if a site is characterized as habitat class 'A', then the MORFIN expectation is 50.03 whereas a habitat class 'E' site is 39.59. These MORFIN expectations for each habitat are the 25th percentiles of historical MORFIN scores for each habitat.
 - A quality score (between 0 and 5) was assigned to a site based on its score relative to the statistical distribution of historical MORFIN scores. Each quality score corresponds to the ranges between

- Those sites with MORFIn scores less than the 25th percentile are considered to be in poor or very poor condition and fail to meet its expected MORFIn score. The quality scores for individual sites are averaged within an AU (pool) to determine the AU's biological condition.



Appendix B. Fish survey data from the Hannibal pool.

Site #	River Mile	Bank	Date	Common Name	Latin Name	Count
1	89.0	LDB	02-Jul-08	Longnose Gar	<i>Lepisosteus osseus</i>	3
1	89.0	LDB	02-Jul-08	Gizzard Shad	<i>Dorosoma cepedianum</i>	9
1	89.0	LDB	02-Jul-08	Common Carp	<i>Cyprinus carpio</i>	1
1	89.0	LDB	02-Jul-08	Mimic Shiner	<i>Notropis volucellus</i>	10
1	89.0	LDB	02-Jul-08	Silver Chub	<i>Macrhybopsis storeriana</i>	1
1	89.0	LDB	02-Jul-08	Quillback	<i>Carpiodes cyprinus</i>	1
1	89.0	LDB	02-Jul-08	Smallmouth Redhorse	<i>Moxostoma breviceps</i>	5
1	89.0	LDB	02-Jul-08	Silver Redhorse	<i>Moxostoma anisurum</i>	2
1	89.0	LDB	02-Jul-08	River Redhorse	<i>Moxostoma carinatum</i>	8
1	89.0	LDB	02-Jul-08	Golden Redhorse	<i>Moxostoma erythrurum</i>	14
1	89.0	LDB	02-Jul-08	Northern Hog Sucker	<i>Hypentelium nigricans</i>	1
1	89.0	LDB	02-Jul-08	Smallmouth Buffalo	<i>Ictiobus bubalus</i>	2
1	89.0	LDB	02-Jul-08	Channel Catfish	<i>Ictalurus punctatus</i>	10
1	89.0	LDB	02-Jul-08	Flathead Catfish	<i>Pylodictis olivaris</i>	2
1	89.0	LDB	02-Jul-08	Striped Bass	<i>Morone saxatilis</i>	1
1	89.0	LDB	02-Jul-08	Smallmouth Bass	<i>Micropterus dolomieu</i>	28
1	89.0	LDB	02-Jul-08	Logperch	<i>Percina caprodes</i>	9
1	89.0	LDB	02-Jul-08	Walleye	<i>Sander vitreus</i>	3
1	89.0	LDB	02-Jul-08	Sauger	<i>Sander canadensis</i>	36
1	89.0	LDB	02-Jul-08	Freshwater Drum	<i>Aplodinotus grunniens</i>	2
2	89.9	LDB	02-Jul-08	Longnose Gar	<i>Lepisosteus osseus</i>	3
2	89.9	LDB	02-Jul-08	Gizzard Shad	<i>Dorosoma cepedianum</i>	3
2	89.9	LDB	02-Jul-08	Quillback	<i>Carpiodes cyprinus</i>	5
2	89.9	LDB	02-Jul-08	River Carpsucker	<i>Carpiodes carpio</i>	2
2	89.9	LDB	02-Jul-08	Smallmouth Redhorse	<i>Moxostoma breviceps</i>	5
2	89.9	LDB	02-Jul-08	Silver Redhorse	<i>Moxostoma anisurum</i>	29
2	89.9	LDB	02-Jul-08	River Redhorse	<i>Moxostoma carinatum</i>	8
2	89.9	LDB	02-Jul-08	Golden Redhorse	<i>Moxostoma erythrurum</i>	31
2	89.9	LDB	02-Jul-08	Smallmouth Buffalo	<i>Ictiobus bubalus</i>	3
2	89.9	LDB	02-Jul-08	Channel Catfish	<i>Ictalurus punctatus</i>	13
2	89.9	LDB	02-Jul-08	Striped Bass	<i>Morone saxatilis</i>	7
2	89.9	LDB	02-Jul-08	Smallmouth Bass	<i>Micropterus dolomieu</i>	8
2	89.9	LDB	02-Jul-08	Spotted Bass	<i>Micropterus punctulatus</i>	2
2	89.9	LDB	02-Jul-08	Sauger	<i>Sander canadensis</i>	34
2	89.9	LDB	02-Jul-08	Freshwater Drum	<i>Aplodinotus grunniens</i>	6
3	91.0	LDB	09-Jul-08	Gizzard Shad	<i>Dorosoma cepedianum</i>	9
3	91.0	LDB	09-Jul-08	Smallmouth Redhorse	<i>Moxostoma breviceps</i>	14
3	91.0	LDB	09-Jul-08	Silver Redhorse	<i>Moxostoma anisurum</i>	3
3	91.0	LDB	09-Jul-08	River Redhorse	<i>Moxostoma carinatum</i>	4
3	91.0	LDB	09-Jul-08	Golden Redhorse	<i>Moxostoma erythrurum</i>	5
3	91.0	LDB	09-Jul-08	Smallmouth Buffalo	<i>Ictiobus bubalus</i>	3
3	91.0	LDB	09-Jul-08	Black Buffalo	<i>Ictiobus niger</i>	1
3	91.0	LDB	09-Jul-08	Channel Catfish	<i>Ictalurus punctatus</i>	3
3	91.0	LDB	09-Jul-08	White Bass	<i>Morone chrysops</i>	1
3	91.0	LDB	09-Jul-08	Smallmouth Bass	<i>Micropterus dolomieu</i>	13

Site #	River Mile	Bank	Date	Common Name	Latin Name	Count
3	91.0	LDB	09-Jul-08	Spotted Bass	<i>Micropterus punctulatus</i>	2
3	91.0	LDB	09-Jul-08	Logperch	<i>Percina caprodes</i>	3
3	91.0	LDB	09-Jul-08	Channel Darter	<i>Percina copelandi</i>	1
3	91.0	LDB	09-Jul-08	Sauger	<i>Sander canadensis</i>	12
4	92.2	LDB	07-Jul-08	Longnose Gar	<i>Lepisosteus osseus</i>	1
4	92.2	LDB	07-Jul-08	Gizzard Shad	<i>Dorosoma cepedianum</i>	9
4	92.2	LDB	07-Jul-08	Emerald Shiner	<i>Notropis atherinoides</i>	1
4	92.2	LDB	07-Jul-08	Mimic Shiner	<i>Notropis volucellus</i>	5
4	92.2	LDB	07-Jul-08	Silver Redhorse	<i>Moxostoma anisurum</i>	7
4	92.2	LDB	07-Jul-08	River Redhorse	<i>Moxostoma carinatum</i>	1
4	92.2	LDB	07-Jul-08	Golden Redhorse	<i>Moxostoma erythrurum</i>	22
4	92.2	LDB	07-Jul-08	Smallmouth Buffalo	<i>Ictiobus bubalus</i>	1
4	92.2	LDB	07-Jul-08	Channel Catfish	<i>Ictalurus punctatus</i>	7
4	92.2	LDB	07-Jul-08	Flathead Catfish	<i>Pylodictis olivaris</i>	2
4	92.2	LDB	07-Jul-08	Morone Sp	<i>Morone sp</i>	1
4	92.2	LDB	07-Jul-08	Bluegill	<i>Lepomis macrochirus</i>	1
4	92.2	LDB	07-Jul-08	Longear Sunfish	<i>Lepomis megalotis</i>	1
4	92.2	LDB	07-Jul-08	Smallmouth Bass	<i>Micropterus dolomieu</i>	7
4	92.2	LDB	07-Jul-08	Spotted Bass	<i>Micropterus punctulatus</i>	5
4	92.2	LDB	07-Jul-08	Logperch	<i>Percina caprodes</i>	41
4	92.2	LDB	07-Jul-08	Walleye	<i>Sander vitreus</i>	3
4	92.2	LDB	07-Jul-08	Sauger	<i>Sander canadensis</i> x <i>S. vitreus</i>	1
4	92.2	LDB	07-Jul-08	Sauger	<i>Sander canadensis</i>	33
5	95.8	LDB	21-Jul-08	Longnose Gar	<i>Lepisosteus osseus</i>	1
5	95.8	LDB	21-Jul-08	Gizzard Shad	<i>Dorosoma cepedianum</i>	8
5	95.8	LDB	21-Jul-08	Emerald Shiner	<i>Notropis atherinoides</i>	1
5	95.8	LDB	21-Jul-08	Quillback	<i>Carpoides cyprinus</i>	1
5	95.8	LDB	21-Jul-08	River Carpsucker	<i>Carpoides carpio</i>	5
5	95.8	LDB	21-Jul-08	Highfin Carpsucker	<i>Carpoides velifer</i>	3
5	95.8	LDB	21-Jul-08	Silver Redhorse	<i>Moxostoma anisurum</i>	2
5	95.8	LDB	21-Jul-08	Golden Redhorse	<i>Moxostoma erythrurum</i>	1
5	95.8	LDB	21-Jul-08	Smallmouth Buffalo	<i>Ictiobus bubalus</i>	1
5	95.8	LDB	21-Jul-08	Channel Catfish	<i>Ictalurus punctatus</i>	2
5	95.8	LDB	21-Jul-08	Flathead Catfish	<i>Pylodictis olivaris</i>	3
5	95.8	LDB	21-Jul-08	Morone Sp	<i>Morone sp</i>	21
5	95.8	LDB	21-Jul-08	Bluegill	<i>Lepomis macrochirus</i>	3
5	95.8	LDB	21-Jul-08	Smallmouth Bass	<i>Micropterus dolomieu</i>	2
5	95.8	LDB	21-Jul-08	Logperch	<i>Percina caprodes</i>	1
5	95.8	LDB	21-Jul-08	Sauger	<i>Sander canadensis</i>	12
5	95.8	LDB	21-Jul-08	Freshwater Drum	<i>Aplodinotus grunniens</i>	11
6	98.4	LDB	21-Jul-08	Longnose Gar	<i>Lepisosteus osseus</i>	5
6	98.4	LDB	21-Jul-08	Gizzard Shad	<i>Dorosoma cepedianum</i>	7
6	98.4	LDB	21-Jul-08	Common Carp	<i>Cyprinus carpio</i>	1
6	98.4	LDB	21-Jul-08	Quillback	<i>Carpoides cyprinus</i>	1
6	98.4	LDB	21-Jul-08	Silver Redhorse	<i>Moxostoma anisurum</i>	1
6	98.4	LDB	21-Jul-08	Smallmouth Buffalo	<i>Ictiobus bubalus</i>	1

Site #	River Mile	Bank	Date	Common Name	Latin Name	Count
6	98.4	LDB	21-Jul-08	Channel Catfish	<i>Ictalurus punctatus</i>	1
6	98.4	LDB	21-Jul-08	Flathead Catfish	<i>Pylodictis olivaris</i>	2
6	98.4	LDB	21-Jul-08	Morone Sp	<i>Morone sp</i>	17
6	98.4	LDB	21-Jul-08	Smallmouth Bass	<i>Micropterus dolomieu</i>	1
6	98.4	LDB	21-Jul-08	Spotted Bass	<i>Micropterus punctulatus</i>	1
6	98.4	LDB	21-Jul-08	Logperch	<i>Percina caprodes</i>	2
6	98.4	LDB	21-Jul-08	Sauger	<i>Sander canadensis</i>	1
6	98.4	LDB	21-Jul-08	Freshwater Drum	<i>Aplodinotus grunniens</i>	1
7	100.6	RDB	01-Jul-08	Longnose Gar	<i>Lepisosteus osseus</i>	1
7	100.6	RDB	01-Jul-08	Gizzard Shad	<i>Dorosoma cepedianum</i>	2
7	100.6	RDB	01-Jul-08	Common Carp	<i>Cyprinus carpio</i>	1
7	100.6	RDB	01-Jul-08	Quillback	<i>Carpodes cyprinus</i>	2
7	100.6	RDB	01-Jul-08	River Carpsucker	<i>Carpodes carpio</i>	12
7	100.6	RDB	01-Jul-08	Highfin Carpsucker	<i>Carpodes velifer</i>	3
7	100.6	RDB	01-Jul-08	Smallmouth Redhorse	<i>Moxostoma breviceps</i>	15
7	100.6	RDB	01-Jul-08	Silver Redhorse	<i>Moxostoma anisurum</i>	34
7	100.6	RDB	01-Jul-08	River Redhorse	<i>Moxostoma carinatum</i>	14
7	100.6	RDB	01-Jul-08	Golden Redhorse	<i>Moxostoma erythrurum</i>	37
7	100.6	RDB	01-Jul-08	Smallmouth Buffalo	<i>Ictiobus bubalus</i>	5
7	100.6	RDB	01-Jul-08	Channel Catfish	<i>Ictalurus punctatus</i>	4
7	100.6	RDB	01-Jul-08	Flathead Catfish	<i>Pylodictis olivaris</i>	2
7	100.6	RDB	01-Jul-08	Striped Bass	<i>Morone saxatilis</i>	3
7	100.6	RDB	01-Jul-08	Bluegill	<i>Lepomis macrochirus</i>	3
7	100.6	RDB	01-Jul-08	Longear Sunfish	<i>Lepomis megalotis</i>	1
7	100.6	RDB	01-Jul-08	Smallmouth Bass	<i>Micropterus dolomieu</i>	4
7	100.6	RDB	01-Jul-08	Spotted Bass	<i>Micropterus punctulatus</i>	1
7	100.6	RDB	01-Jul-08	Logperch	<i>Percina caprodes</i>	10
7	100.6	RDB	01-Jul-08	Sauger	<i>Sander canadensis</i>	46
8	103.1	RDB	01-Jul-08	Longnose Gar	<i>Lepisosteus osseus</i>	14
8	103.1	RDB	01-Jul-08	Gizzard Shad	<i>Dorosoma cepedianum</i>	5
8	103.1	RDB	01-Jul-08	Common Carp	<i>Cyprinus carpio</i>	4
8	103.1	RDB	01-Jul-08	Quillback	<i>Carpodes cyprinus</i>	11
8	103.1	RDB	01-Jul-08	River Carpsucker	<i>Carpodes carpio</i>	5
8	103.1	RDB	01-Jul-08	Highfin Carpsucker	<i>Carpodes velifer</i>	3
8	103.1	RDB	01-Jul-08	Smallmouth Buffalo	<i>Ictiobus bubalus</i>	5
8	103.1	RDB	01-Jul-08	Channel Catfish	<i>Ictalurus punctatus</i>	1
8	103.1	RDB	01-Jul-08	Striped Bass	<i>Morone saxatilis</i>	3
8	103.1	RDB	01-Jul-08	Pumpkinseed	<i>Lepomis gibbosus</i>	1
8	103.1	RDB	01-Jul-08	Spotted Bass	<i>Micropterus punctulatus</i>	1
8	103.1	RDB	01-Jul-08	Sauger	<i>Sander canadensis</i>	4
8	103.1	RDB	01-Jul-08	Freshwater Drum	<i>Aplodinotus grunniens</i>	7
9	105.0	LDB	23-Jul-08	Longnose Gar	<i>Lepisosteus osseus</i>	2
9	105.0	LDB	23-Jul-08	Gizzard Shad	<i>Dorosoma cepedianum</i>	666
9	105.0	LDB	23-Jul-08	Quillback	<i>Carpodes cyprinus</i>	1
9	105.0	LDB	23-Jul-08	River Carpsucker	<i>Carpodes carpio</i>	3
9	105.0	LDB	23-Jul-08	Golden Redhorse	<i>Moxostoma erythrurum</i>	2

Site #	River Mile	Bank	Date	Common Name	Latin Name	Count
9	105.0	LDB	23-Jul-08	Smallmouth Buffalo	<i>Ictiobus bubalus</i>	1
9	105.0	LDB	23-Jul-08	Channel Catfish	<i>Ictalurus punctatus</i>	2
9	105.0	LDB	23-Jul-08	Flathead Catfish	<i>Pylodictis olivaris</i>	8
9	105.0	LDB	23-Jul-08	Morone Sp	<i>Morone sp</i>	1
9	105.0	LDB	23-Jul-08	Smallmouth Bass	<i>Micropterus dolomieu</i>	10
9	105.0	LDB	23-Jul-08	Logperch	<i>Percina caprodes</i>	9
9	105.0	LDB	23-Jul-08	Sauger	<i>Sander canadensis</i>	8
9	105.0	LDB	23-Jul-08	Freshwater Drum	<i>Aplodinotus grunniens</i>	2
10	107.9	RDB	23-Jul-08	Longnose Gar	<i>Lepisosteus osseus</i>	2
10	107.9	RDB	23-Jul-08	Gizzard Shad	<i>Dorosoma cepedianum</i>	30
10	107.9	RDB	23-Jul-08	Mooneye	<i>Hiodon tergisus</i>	1
10	107.9	RDB	23-Jul-08	Common Carp	<i>Cyprinus carpio</i>	1
10	107.9	RDB	23-Jul-08	Silver Chub	<i>Macrhybopsis storeriana</i>	2
10	107.9	RDB	23-Jul-08	River Carpsucker	<i>Carpionodes carpio</i>	2
10	107.9	RDB	23-Jul-08	Highfin Carpsucker	<i>Carpionodes velifer</i>	1
10	107.9	RDB	23-Jul-08	Golden Redhorse	<i>Moxostoma erythrurum</i>	4
10	107.9	RDB	23-Jul-08	Northern Hog Sucker	<i>Hypentelium nigricans</i>	1
10	107.9	RDB	23-Jul-08	Smallmouth Buffalo	<i>Ictiobus bubalus</i>	3
10	107.9	RDB	23-Jul-08	Channel Catfish	<i>Ictalurus punctatus</i>	5
10	107.9	RDB	23-Jul-08	Morone Sp	<i>Morone sp</i>	20
10	107.9	RDB	23-Jul-08	White Bass	<i>Morone chrysops</i>	1
10	107.9	RDB	23-Jul-08	Bluegill	<i>Lepomis macrochirus</i>	1
10	107.9	RDB	23-Jul-08	Smallmouth Bass	<i>Micropterus dolomieu</i>	1
10	107.9	RDB	23-Jul-08	Spotted Bass	<i>Micropterus punctulatus</i>	1
10	107.9	RDB	23-Jul-08	Logperch	<i>Percina caprodes</i>	1
10	107.9	RDB	23-Jul-08	Walleye	<i>Sander vitreus</i>	1
10	107.9	RDB	23-Jul-08	Sauger	<i>Sander canadensis</i>	32
10	107.9	RDB	23-Jul-08	Freshwater Drum	<i>Aplodinotus grunniens</i>	4
11	108.4	LDB	23-Jul-08	Longnose Gar	<i>Lepisosteus osseus</i>	4
11	108.4	LDB	23-Jul-08	Gizzard Shad	<i>Dorosoma cepedianum</i>	12
11	108.4	LDB	23-Jul-08	Mooneye	<i>Hiodon tergisus</i>	7
11	108.4	LDB	23-Jul-08	Common Carp	<i>Cyprinus carpio</i>	1
11	108.4	LDB	23-Jul-08	Emerald Shiner	<i>Notropis atherinoides</i>	7
11	108.4	LDB	23-Jul-08	Silver Chub	<i>Macrhybopsis storeriana</i>	8
11	108.4	LDB	23-Jul-08	Silverjaw Minnow	<i>Notropis buccatus</i>	1
11	108.4	LDB	23-Jul-08	Quillback	<i>Carpionodes cyprinus</i>	1
11	108.4	LDB	23-Jul-08	River Carpsucker	<i>Carpionodes carpio</i>	6
11	108.4	LDB	23-Jul-08	Highfin Carpsucker	<i>Carpionodes velifer</i>	1
11	108.4	LDB	23-Jul-08	Silver Redhorse	<i>Moxostoma anisurum</i>	5
11	108.4	LDB	23-Jul-08	Golden Redhorse	<i>Moxostoma erythrurum</i>	10
11	108.4	LDB	23-Jul-08	Ictiobus Sp	<i>Ictiobus sp</i>	19
11	108.4	LDB	23-Jul-08	Smallmouth Buffalo	<i>Ictiobus bubalus</i>	1
11	108.4	LDB	23-Jul-08	Flathead Catfish	<i>Pylodictis olivaris</i>	1
11	108.4	LDB	23-Jul-08	Morone Sp	<i>Morone sp</i>	6
11	108.4	LDB	23-Jul-08	White Bass	<i>Morone chrysops</i>	1
11	108.4	LDB	23-Jul-08	Spotted Bass	<i>Micropterus punctulatus</i>	3

Site #	River Mile	Bank	Date	Common Name	Latin Name	Count
11	108.4	LDB	23-Jul-08	Walleye	<i>Sander vitreus</i>	1
11	108.4	LDB	23-Jul-08	Sauger	<i>Sander canadensis</i>	23
11	108.4	LDB	23-Jul-08	Freshwater Drum	<i>Aplodinotus grunniens</i>	29
12	109.9	RDB	23-Jul-08	Longnose Gar	<i>Lepisosteus osseus</i>	3
12	109.9	RDB	23-Jul-08	Gizzard Shad	<i>Dorosoma cepedianum</i>	19
12	109.9	RDB	23-Jul-08	Mooneye	<i>Hiodon tergisus</i>	1
12	109.9	RDB	23-Jul-08	Common Carp	<i>Cyprinus carpio</i>	1
12	109.9	RDB	23-Jul-08	Emerald Shiner	<i>Notropis atherinoides</i>	3
12	109.9	RDB	23-Jul-08	Mimic Shiner	<i>Notropis volucellus</i>	1
12	109.9	RDB	23-Jul-08	Silver Chub	<i>Macrhybopsis storeriana</i>	1
12	109.9	RDB	23-Jul-08	River Carpsucker	<i>Carpionodes carpio</i>	2
12	109.9	RDB	23-Jul-08	Highfin Carpsucker	<i>Carpionodes velifer</i>	1
12	109.9	RDB	23-Jul-08	Smallmouth Redhorse	<i>Moxostoma breviceps</i>	1
12	109.9	RDB	23-Jul-08	Silver Redhorse	<i>Moxostoma anisurum</i>	17
12	109.9	RDB	23-Jul-08	Golden Redhorse	<i>Moxostoma erythrurum</i>	34
12	109.9	RDB	23-Jul-08	Smallmouth Buffalo	<i>Ictiobus bubalus</i>	1
12	109.9	RDB	23-Jul-08	Flathead Catfish	<i>Pylodictis olivaris</i>	2
12	109.9	RDB	23-Jul-08	Morone Sp	<i>Morone sp</i>	5
12	109.9	RDB	23-Jul-08	Bluegill	<i>Lepomis macrochirus</i>	1
12	109.9	RDB	23-Jul-08	Smallmouth Bass	<i>Micropterus dolomieu</i>	1
12	109.9	RDB	23-Jul-08	Spotted Bass	<i>Micropterus punctulatus</i>	1
12	109.9	RDB	23-Jul-08	Sauger	<i>Sander canadensis</i>	31
12	109.9	RDB	23-Jul-08	Freshwater Drum	<i>Aplodinotus grunniens</i>	12
13	113.4	RDB	23-Jul-08	Longnose Gar	<i>Lepisosteus osseus</i>	5
13	113.4	RDB	23-Jul-08	Gizzard Shad	<i>Dorosoma cepedianum</i>	148
13	113.4	RDB	23-Jul-08	Quillback	<i>Carpionodes cyprinus</i>	1
13	113.4	RDB	23-Jul-08	River Carpsucker	<i>Carpionodes carpio</i>	12
13	113.4	RDB	23-Jul-08	Golden Redhorse	<i>Moxostoma erythrurum</i>	11
13	113.4	RDB	23-Jul-08	Smallmouth Buffalo	<i>Ictiobus bubalus</i>	8
13	113.4	RDB	23-Jul-08	Channel Catfish	<i>Ictalurus punctatus</i>	5
13	113.4	RDB	23-Jul-08	Flathead Catfish	<i>Pylodictis olivaris</i>	7
13	113.4	RDB	23-Jul-08	Morone Sp	<i>Morone sp</i>	8
13	113.4	RDB	23-Jul-08	Green Sunfish	<i>Lepomis cyanellus</i>	1
13	113.4	RDB	23-Jul-08	Bluegill	<i>Lepomis macrochirus</i>	8
13	113.4	RDB	23-Jul-08	Longear Sunfish	<i>Lepomis megalotis</i>	1
13	113.4	RDB	23-Jul-08	Smallmouth Bass	<i>Micropterus dolomieu</i>	6
13	113.4	RDB	23-Jul-08	Spotted Bass	<i>Micropterus punctulatus</i>	3
13	113.4	RDB	23-Jul-08	Logperch	<i>Percina caprodes</i>	20
13	113.4	RDB	23-Jul-08	Walleye	<i>Sander vitreus</i>	1
13	113.4	RDB	23-Jul-08	Sauger	<i>Sander canadensis</i>	16
13	113.4	RDB	23-Jul-08	Freshwater Drum	<i>Aplodinotus grunniens</i>	55
14	118.6	LDB	24-Jul-08	Longnose Gar	<i>Lepisosteus osseus</i>	3
14	118.6	LDB	24-Jul-08	Gizzard Shad	<i>Dorosoma cepedianum</i>	9
14	118.6	LDB	24-Jul-08	Striped Shiner	<i>Luxilus chrysocephalus</i>	1
14	118.6	LDB	24-Jul-08	Silver Chub	<i>Macrhybopsis storeriana</i>	4
14	118.6	LDB	24-Jul-08	Quillback	<i>Carpionodes cyprinus</i>	3

Site #	River Mile	Bank	Date	Common Name	Latin Name	Count
14	118.6	LDB	24-Jul-08	River Carpsucker	<i>Carpiodes carpio</i>	7
14	118.6	LDB	24-Jul-08	Highfin Carpsucker	<i>Carpiodes velifer</i>	1
14	118.6	LDB	24-Jul-08	Silver Redhorse	<i>Moxostoma anisurum</i>	1
14	118.6	LDB	24-Jul-08	Golden Redhorse	<i>Moxostoma erythrurum</i>	11
14	118.6	LDB	24-Jul-08	Smallmouth Buffalo	<i>Ictiobus bubalus</i>	1
14	118.6	LDB	24-Jul-08	Channel Catfish	<i>Ictalurus punctatus</i>	2
14	118.6	LDB	24-Jul-08	Flathead Catfish	<i>Pylodictis olivaris</i>	4
14	118.6	LDB	24-Jul-08	Morone Sp	<i>Morone sp</i>	8
14	118.6	LDB	24-Jul-08	Bluegill	<i>Lepomis macrochirus</i>	2
14	118.6	LDB	24-Jul-08	Smallmouth Bass	<i>Micropterus dolomieu</i>	1
14	118.6	LDB	24-Jul-08	Spotted Bass	<i>Micropterus punctulatus</i>	3
14	118.6	LDB	24-Jul-08	Logperch	<i>Percina caprodes</i>	1
14	118.6	LDB	24-Jul-08	Walleye	<i>Sander vitreus</i>	1
14	118.6	LDB	24-Jul-08	Sauger	<i>Sander canadensis</i>	14
14	118.6	LDB	24-Jul-08	Freshwater Drum	<i>Aplodinotus grunniens</i>	46
15	124.6	LDB	24-Jul-08	Longnose Gar	<i>Lepisosteus osseus</i>	2
15	124.6	LDB	24-Jul-08	Gizzard Shad	<i>Dorosoma cepedianum</i>	525
15	124.6	LDB	24-Jul-08	Mooneye	<i>Hiodon tergisus</i>	1
15	124.6	LDB	24-Jul-08	Common Carp	<i>Cyprinus carpio</i>	5
15	124.6	LDB	24-Jul-08	Striped Shiner	<i>Luxilus chrysocephalus</i>	1
15	124.6	LDB	24-Jul-08	Spottail Shiner	<i>Notropis hudsonius</i>	1
15	124.6	LDB	24-Jul-08	Emerald Shiner	<i>Notropis atherinoides</i>	9
15	124.6	LDB	24-Jul-08	Silver Chub	<i>Macrhybopsis storeriana</i>	3
15	124.6	LDB	24-Jul-08	Central Stoneroller	<i>Campostoma anomalum</i>	3
15	124.6	LDB	24-Jul-08	Bluntnose Minnow	<i>Pimephales notatus</i>	4
15	124.6	LDB	24-Jul-08	Quillback	<i>Carpiodes cyprinus</i>	1
15	124.6	LDB	24-Jul-08	River Carpsucker	<i>Carpiodes carpio</i>	8
15	124.6	LDB	24-Jul-08	Smallmouth Redhorse	<i>Moxostoma breviceps</i>	1
15	124.6	LDB	24-Jul-08	Silver Redhorse	<i>Moxostoma anisurum</i>	4
15	124.6	LDB	24-Jul-08	Golden Redhorse	<i>Moxostoma erythrurum</i>	22
15	124.6	LDB	24-Jul-08	Smallmouth Buffalo	<i>Ictiobus bubalus</i>	9
15	124.6	LDB	24-Jul-08	Channel Catfish	<i>Ictalurus punctatus</i>	7
15	124.6	LDB	24-Jul-08	Flathead Catfish	<i>Pylodictis olivaris</i>	5
15	124.6	LDB	24-Jul-08	Morone Sp	<i>Morone sp</i>	4
15	124.6	LDB	24-Jul-08	White Perch	<i>Morone americana</i>	1
15	124.6	LDB	24-Jul-08	Rock Bass	<i>Ambloplites rupestris</i>	2
15	124.6	LDB	24-Jul-08	Green Sunfish	<i>Lepomis cyanellus</i>	1
15	124.6	LDB	24-Jul-08	Bluegill	<i>Lepomis macrochirus</i>	17
15	124.6	LDB	24-Jul-08	Pumpkinseed	<i>Lepomis gibbosus</i>	1
15	124.6	LDB	24-Jul-08	Longear Sunfish	<i>Lepomis megalotis</i>	6
15	124.6	LDB	24-Jul-08	Smallmouth Bass	<i>Micropterus dolomieu</i>	10
15	124.6	LDB	24-Jul-08	Spotted Bass	<i>Micropterus punctulatus</i>	15
15	124.6	LDB	24-Jul-08	Yellow Perch	<i>Perca flavescens</i>	3
15	124.6	LDB	24-Jul-08	Logperch	<i>Percina caprodes</i>	8
15	124.6	LDB	24-Jul-08	Walleye	<i>Sander vitreus</i>	1
15	124.6	LDB	24-Jul-08	Sauger	<i>Sander canadensis</i>	15

Site #	River Mile	Bank	Date	Common Name	Latin Name	Count
15	124.6	LDB	24-Jul-08	Freshwater Drum	<i>Aplodinotus grunniens</i>	36

Appendix C. Habitat survey data from the Hannibal pool.

Site #	River Mile	Bank	% Boulder	% Cobble	% Gravel	% Sand	% Fine	% Hardpan	% Other	Depth	% Submerged Vegetation	% Woody Cover	% Overhanging Vegetation	Land Use	Human Influence	Bank Profile
1	89.0	LDB	1.5	23.5	37.1	26.5	5.3	2.3	3.8	11.9	9.8	1.3	5.0	R	none	steep
2	89.9	LDB	1.2	17.2	29.0	37.3	14.2	0.0	1.2	8.3	9.8	1.4	0.0	R	none	steep
3	91.0	LDB	3.2	50.5	38.7	6.5	1.1	0.0	0.0	11.9	4.4	0.6	0.0	R	none	steep
4	92.2	LDB	0.0	14.7	44.0	40.5	0.9	0.0	0.0	8.1	2.5	1.8	5.0	I,R	none	steep
5	95.8	LDB	1.0	10.3	28.9	37.1	18.6	0.0	4.1	11.3	18.6	1.8	5.0	R	none	steep
6	98.4	LDB	10.9	10.0	25.5	31.8	21.8	0.0	0.0	15.9	5.3	1.4	5.0	NF	none	steep
7	100.6	RDB	4.8	6.0	47.0	42.2	0.0	0.0	0.0	13.3	2.3	1.8	6.3	NF,I	none	steep
8	103.1	RDB	0.0	0.0	12.0	42.2	44.6	0.0	1.2	13.4	2.5	1.6	10.0	NF,I	mooring cells, barges	sloped
9	105.0	LDB	3.8	1.5	23.8	33.8	31.5	0.8	4.6	11.7	2.0	1.4	6.3	I	none	steep
10	107.9	RDB	1.9	5.1	12.8	38.5	41.7	0.0	0.0	6.3	23.4	2.4	0.0	NF	none	gradual
11	108.4	LDB	0.0	0.0	1.1	28.7	69.1	0.0	1.1	5.7	3.3	3.8	0.0	NF,R	boat docks	sloped
12	109.9	RDB	0.7	9.5	38.1	14.3	34.7	2.0	0.7	10.8	2.0	1.0	0.0	NF,R	none	cliff
13	113.4	RDB	1.8	1.8	9.0	30.6	48.6	6.3	1.8	8.4	13.0	7.6	12.5	NF	none	steep
14	118.6	LDB	1.8	1.8	12.7	20.0	50.9	1.8	10.9	16.5	2.0	4.2	5.0	I	none	steep
15	124.6	LDB	0.0	4.8	3.2	11.1	66.7	4.8	9.5	11.8	2.0	1.8	5.0	I	ramp	steep

I = Industry, NF = Natural Forest, R = Residential lawns, A = Agriculture (Listed in order of prevalence)

Appendix D. Water quality parameters measured prior to fish sampling in Hannibal pool.

Site #	River Mile	Bank	pH	Temp (C)	Dissolved Oxygen (mg/L)	Conductivity	Secchi (in)
1	89.0	LDB	6.00	24.05	8.36	441	18
2	89.9	LDB	6.63	24.22	8.41	441	18
3	91.0	LDB	6.57	24.60	8.86	451	15
4	92.2	LDB	6.83	24.28	9.04	450	24
5	95.8	LDB	6.70	28.02	9.50	457	42
6	98.4	LDB	6.70	28.02	9.50	457	42
7	100.6	RDB	6.40	24.52	7.95	454	20
8	103.1	RDB	6.40	24.52	7.95	454	20
9	105.0	LDB	6.97	27.70	8.52	448	42
10	107.9	RDB	8.04	27.34	8.20	454	48
11	108.4	LDB	8.34	28.12	9.99	446	42
12	109.9	RDB	8.30	28.08	10.26	447	41
13	113.4	RDB	6.54	28.50	8.98	450	40
14	118.6	LDB	7.47	28.34	8.91	448	30
15	124.6	LDB	7.93	27.84	8.46	463	41

Appendix E. Water quality parameters analyzed from Hannibal in 2008. Values in bold exceed water quality criteria for respective analyte.

Site #	River Mile	Round	Ammonia	Chloride	Hardness	Nitrate-Nitrite	Phenolics	Sulfate	TKN	TOC	Phosphorus	TSS
1	89.0	1	0.12	38	148	0.742	<5.0	100	0.533	3.50	0.057	19.40
		2	<0.03	30	120	0.447	<5.0	80	0.386	3.88	0.084	2.80
		3	0.10	48	148	1.070	<5.0	110	0.336	3.94	0.014	3.83
2	89.9	1	0.14	36	140	0.725	<5.0	96	0.426	3.75	0.089	26.60
		2	<0.03	26	104	0.481	<5.0	76	0.384	4.08	0.134	4.00
		3	0.08	48	168	0.985	<5.0	128	0.307	4.12	0.018	3.83
3	91.0	1	0.14	32	148	0.693	<5.0	96	0.373	3.24	0.062	28.20
		2	<0.03	30	108	0.472	<5.0	70	0.438	3.86	0.075	4.60
		3	0.08	45	148	1.050	<5.0	112	0.330	4.25	0.027	4.17
4	92.2	1	0.15	36	152	0.750	<5.0	94	0.531	3.65	0.076	30.20
		2	<0.03	46	104	0.499	<5.0	74	0.611	3.99	0.095	3.40
		3	0.11	50	152	1.080	<5.0	118	0.234	3.68	0.050	4.50
5	95.8	1	0.13	32	148	0.686	<5.0	88	0.649	4.16	0.133	55.20
		2	0.05	36	112	0.547	<5.0	84	0.524	4.09	0.023	5.40
		3	0.10	50	148	1.080	<5.0	112	0.316	3.85	0.028	4.00
6	98.4	1	0.12	30	152	0.663	<5.0	96	0.538	3.10	0.069	36.00
		2	0.04	34	116	0.563	<5.0	84	0.514	4.19	0.020	3.00
		3	0.10	52	136	1.120	<5.0	122	0.234	3.72	0.026	4.17
7	100.6	1	0.11	32	144	0.660	<5.0	102	0.548	2.90	0.092	28.00
		2	0.04	34	120	0.578	<5.0	86	0.482	4.06	0.025	2.80
		3	0.11	54	168	1.120	<5.0	124	0.289	4.27	0.024	3.50
8	103.1	1	0.10	30	176	0.684	<5.0	102	0.573	3.37	0.139	53.70
		2	0.03	32	116	0.586	<5.0	90	0.415	4.00	0.010	4.60
		3	0.10	54	180	1.190	<5.0	116	0.582	3.88	0.024	6.00
9	105.0	1	0.10	34	160	0.685	<5.0	90	0.984	3.54	0.191	164.00
		2	0.03	30	116	0.594	<5.0	86	0.503	4.36	0.145	6.60
		3	0.12	40	160	1.230	<5.0	124	0.400	3.58	0.037	7.00
10	107.9	1	0.11	32	144	0.781	<5.0	98	0.429	3.29	0.109	27.80
		2	<0.03	30	120	0.610	<5.0	88	0.462	3.88	0.024	2.40
		3	0.13	54	164	1.250	<5.0	124	0.315	3.83	0.142	5.33
11	108.4	1	0.11	30	148	0.784	<5.0	90	0.420	3.38	0.093	40.60
		2	<0.03	22	120	0.630	<5.0	94	0.521	3.88	0.036	6.00
		3	0.13	52	156	1.280	<5.0	122	0.315	7.12	0.034	5.67
12	109.9	1	0.10	30	156	0.748	<5.0	96	0.503	3.30	0.108	43.20
		2	<0.03	30	120	0.611	<5.0	90	0.459	3.79	0.119	5.20
		3	0.10	48	152	1.280	<5.0	122	0.476	4.13	0.030	8.00
13	113.4	1	0.08	30	148	0.718	<5.0	92	0.419	3.08	0.242	35.80
		2	0.03	28	116	0.636	<5.0	106	0.675	3.78	0.054	6.75
		3	0.11	52	124	1.180	<5.0	124	0.457	5.65	0.018	7.50
14	188.6	1	0.08	50	192	0.670	<5.0	86	0.789	4.17	0.162	77.60
		2	0.03	28	124	0.664	<5.0	120	0.480	3.51	0.081	6.20
		3	0.10	50	136	1.070	<5.0	116	0.499	3.74	0.024	7.83
15	124.6	1	0.09	30	148	0.731	<5.0	94	0.349	3.28	0.070	29.00
		2	0.03	32	124	0.706	<5.0	104	0.496	3.04	0.026	4.60
		3	0.13	56	144	1.010	<5.0	94	0.404	3.84	0.018	7.17