Biological Programs 2009
Intensive Survey Results
Series 6
Report 4

A Biological Study of the Open Water Section 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 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 2009, fish population data from the Open Water section yielded 48 species and 1 hybrid taxa, representing 13 different families. Two of these taxa were listed in KY and as a species of concern [black buffalo (*Ictiobus niger*), Mississippi silvery minnow (*Hybognathus nuchalis*)]. No IL listed species were collected.

- At the species level, gizzard shad (*Dorosoma cepedianum*) was the most abundant, comprising 15.8% 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 2009 when sampling was conducted. Sampling was conducted at low flows as well as at moderately elevated flows. Flows did not appear to affect electrofishing surveys.

- In 2009, 47% of the sites assessed in Open Water had site quality scores $\geq$2.0 and the pool had an average quality score of 2.5 (out of 5.0). This score indicates the pool is in 'Fair' biological condition. Therefore, Open Water will be reported to EPA as meeting its aquatic life-use designation.

- As of 2009, all of the 19 pools (AUs) have been assessed which comprises 981 miles or 100% of the resource.

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A Biological Study of the Open Water of the Ohio River (2009)

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 fish populations of the Ohio River, ORSANCO developed the Ohio River Fish Index (ORFIn, Emery et al. 2003). The ORFIn 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 ORFIn 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 ORFIn (MORFIn).

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 2009, the Belleville pool, Markland pool, McAlpine pool, and the Open Water section of the Ohio River were sampled as part of ORSANCO's normal monitoring. This report presents the 2009 survey of the Open Water section 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

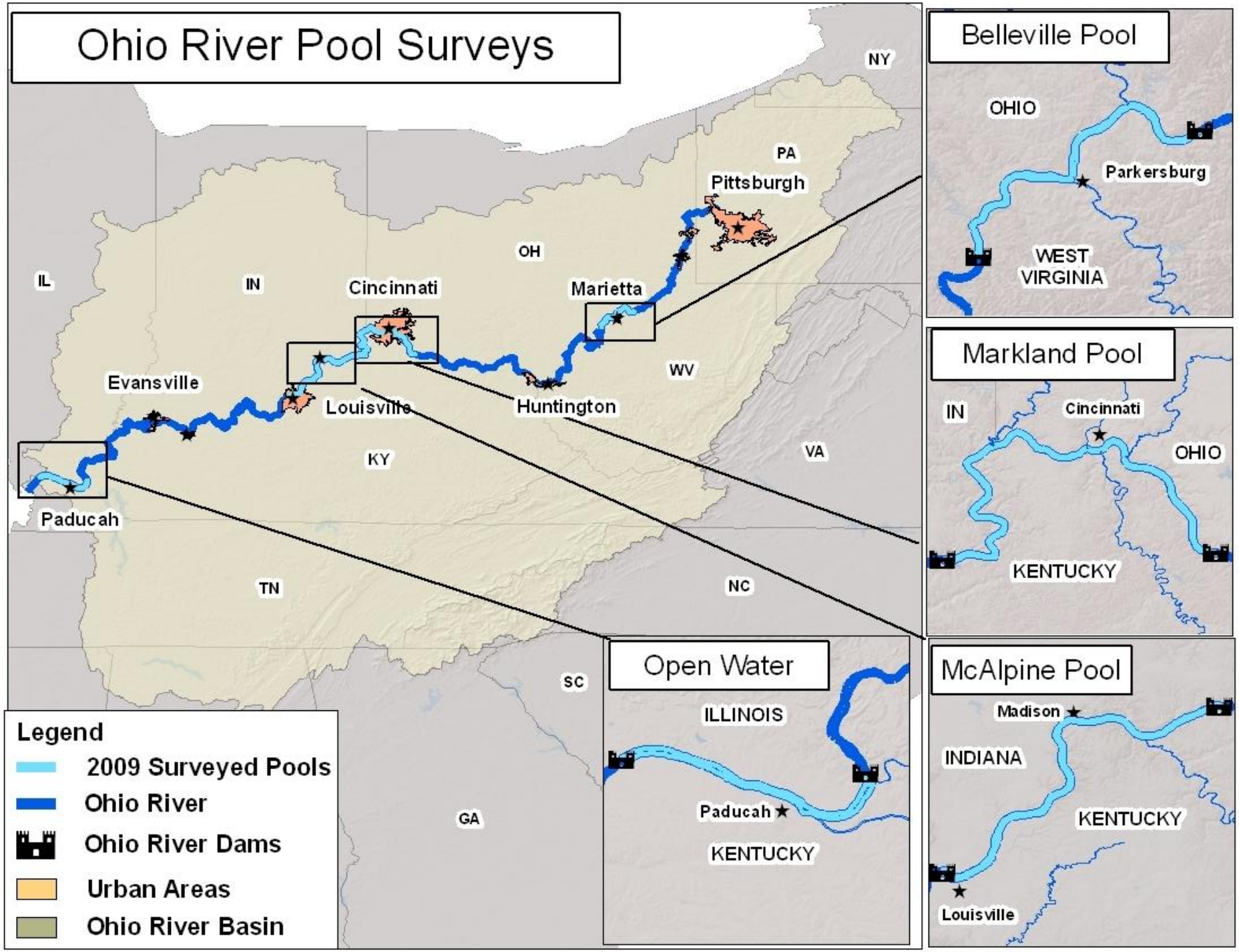


Figure 1. *The Ohio River basin and the four pools selected for 2009 sampling.*

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 Open Water Section

The Open Water section of the Ohio River (referred to as "Open Water" hereafter) is 62.5 miles long, extending from Smithland Locks and Dam (ORM 918.5) to the confluence with the Mississippi River (ORM 981.0). From Smithland Dam downstream to Lock and Dam 52 (ORM 938.9), the river has a gradient drop of 0.3 feet per mile and averages 3,662 feet wide and 26 feet deep (ORSANCO 1994). From Lock and Dam 52 downstream to Lock and Dam 53 (ORM 962.6), the river has a gradient drop of 0.2 feet per mile and averages 3,925 feet wide and 20 feet deep (ORSANCO 1994). From Lock and Dam 53 to the confluence with the Mississippi River, the river has a gradient drop of 0.2 feet per mile and averages 3,135 feet wide and 13 feet deep (ORSANCO 1994). Open Water is bordered by the states of Illinois and Kentucky. Upon completion of the Olmsted high-rise lock and dam at ORM 964.8, a portion of this section may be known as Olmsted pool.

2.3 Open Water Land Cover

Open Water lies in a portion of the Ohio River heavily influenced by industry with a large amount of barge activity. Open Water receives water from the following tributaries: Cumberland River in Kentucky with a drainage area of 17, 920 square miles, Tennessee River in Kentucky with a drainage area of 40,910 square miles, and Cache River in Illinois with a drainage area of 720 square miles. These watersheds are primarily forested (46.1%) but also have a considerable amount of row crops (19.5%) and pasture lands (15.3%; Figure 2).

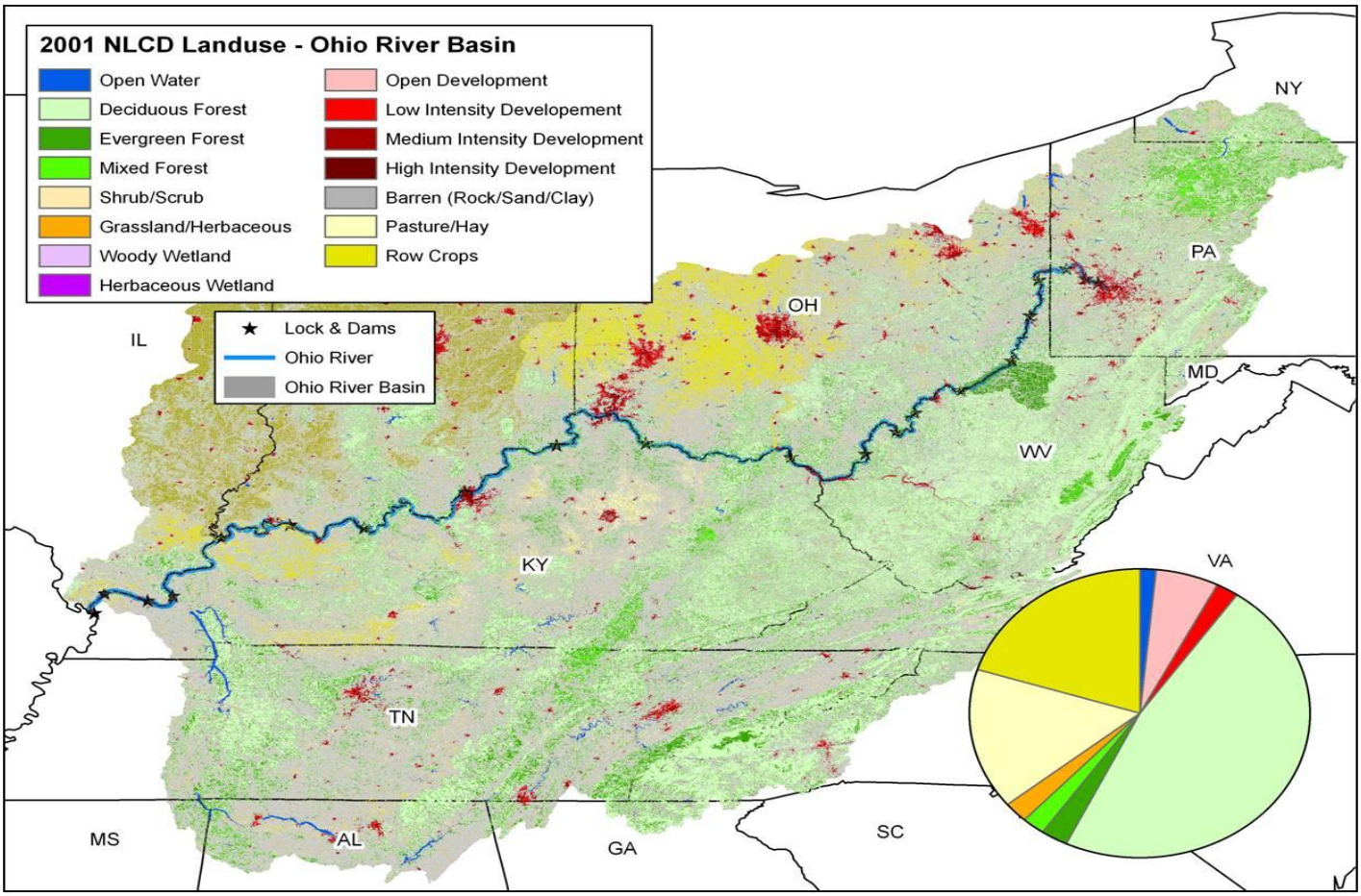


Figure 2. *Land cover within the Open Water pool catchment area.*

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 Open Water section of the Ohio River from mile marker 918.5 (Smithland Locks and Dam) to Locks and Dam 53 (confluence with Mississippi River). The total linear extent of the target population was approximately 44.1 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. In addition two targeted sites were sampled below L&D 53 to try to characterize the uncontrolled lower portion of the river. The data collected from all of 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

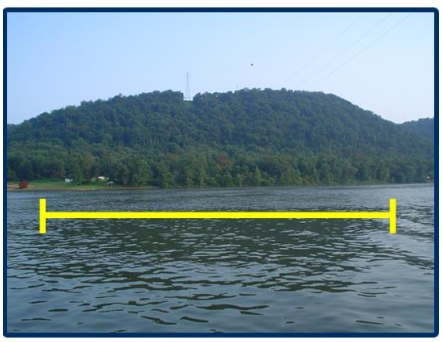
All sampling was conducted under the required conditions as described by Emery et al. (2003). This included sampling between June 29 and October 31 when water levels were within one meter of "normal flat pool" and Secchi depths were greater than 0.3m (12 in). These sampling restrictions were used to 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 5.0 GPP 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 4ºC until sent off for laboratory analyses. Water quality parameters analyzed included: ammonia (nitrogen), chloride, hardness, nitrate-nitrite, total Kjeldahl nitrogen (TKN), 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 2009, ORSANCO employed a probabilistic design to provide a thorough assessment of biological condition. Individual navigational pools served as the primary assessment units. Therefore, the Belleville 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 (i.e. different fish assemblages are found at each habitat). To account for these variations in our assessment, the condition of each site was determined by comparing its performance (i.e. MORFIn score) to those of previously sampled sites within its particular habitat class. The distribution of historical MORFIn scores was determined by compiling reference fish data (i.e.

habitat classes over a fifteen year period. A fish quality score between 0 and 5 was given to each individual site based upon how each site scored relative to the statistical distribution (5th, 25th, 50th, 75th, and 95th percentiles) of historical MORFIn scores (see Appendix A for a detailed explanation). For example, a fish quality score of 3 is applied to a site whose score falls between the 50th and 75th percentiles of the historical MORFIn scores specific to that habitat class (Figure 3). To further aid in interpretation, condition ratings were applied to each site quality score as follows: 0=Very Poor, 1=Poor, 2=Fair, 3=Good, 4=Very Good and 5=Excellent. Essentially, a site is considered in 'Good' biological condition when its MORFIn score is equal to or slightly better than the historical average (Figure 4).

To obtain a final bio-assessment of each pool, an average fish quality score was calculated. The 25th percentile (average fish quality score of at least 2.0) was established as the criterion for determining whether a pool 'passes' (meets its aquatic life-use designation) or 'fails' (does not meet its aquatic life-use designation). The pool was assessed as 'passing' if its average fish quality score was above the 25th percentile (≥2.0). Any pool with an average fish quality score less than 2.0 (i.e. a rating of 'Poor' or ''Very Poor') was assessed as failing to meet its aquatic life-use designation.

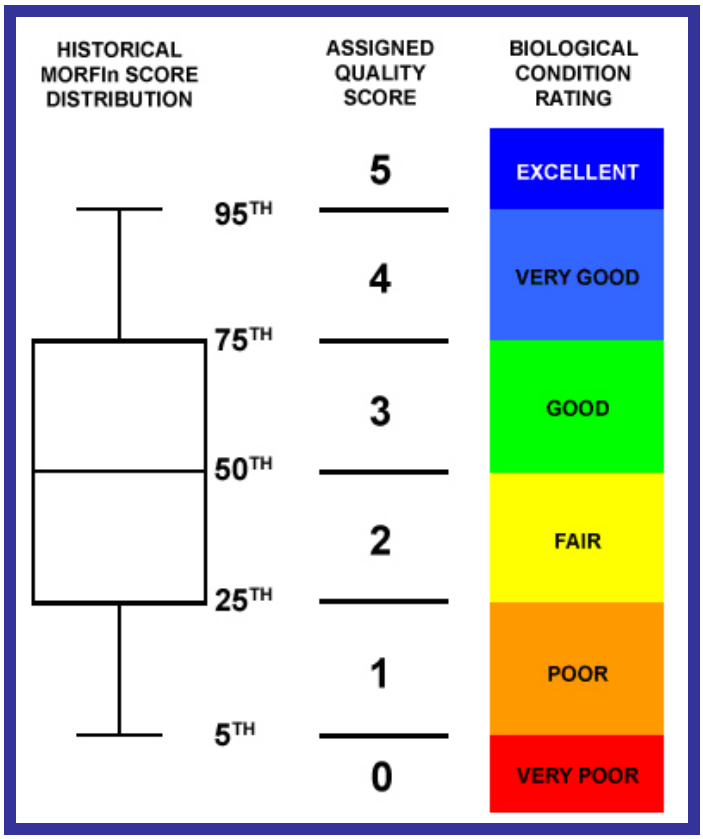


Figure 3. *Approach used to assign fish quality scores for each habitat class.*

Figure 4. *Locations and results of sampling at 17 sites within Open Water pool.*

4.0 Results

4.1 Fish Population

In 2009, fish population data (Appendix B) were collected from 17 randomly selected locations throughout the length of the Open Water (Figure 4). These collections produced 48 species and 1 hybrid taxa, representing 13 different families (Table 2). One of these taxa is listed in KY as special concern [black buffalo (*Ictiobus niger*)]. IL also has one taxa listed under special concern [Mississippi silvery minnow (*Hybognathus nuchalis*)]. No federally listed taxa were collected from the Open Water. At the species level, gizzard shad (*Dorosoma cepedianum*) was the most abundant, comprising 15.8% of the catch (Figure 5). As a result, the shad and herring family (Clupeidae), made up 16.3% of the total catch, followed by the sucker family (Catostomidae) which made up 15.7% of the catch (Figure 6).

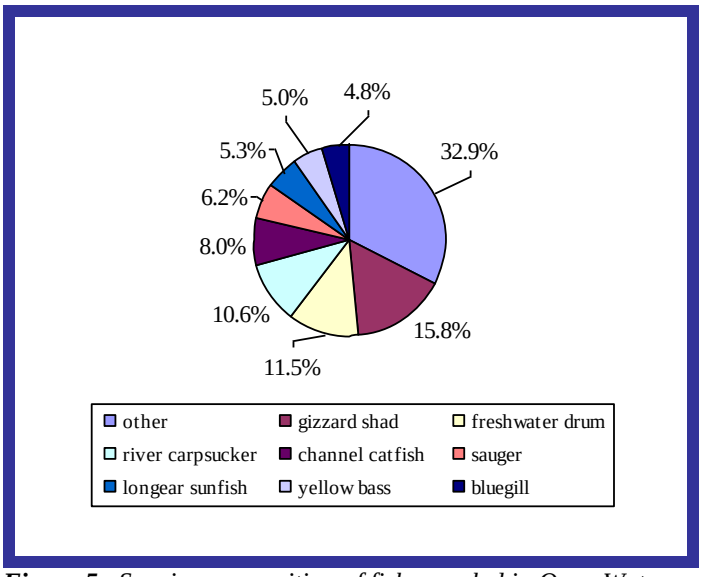


Figure 5. *Species composition of fish sampled in Open Water*

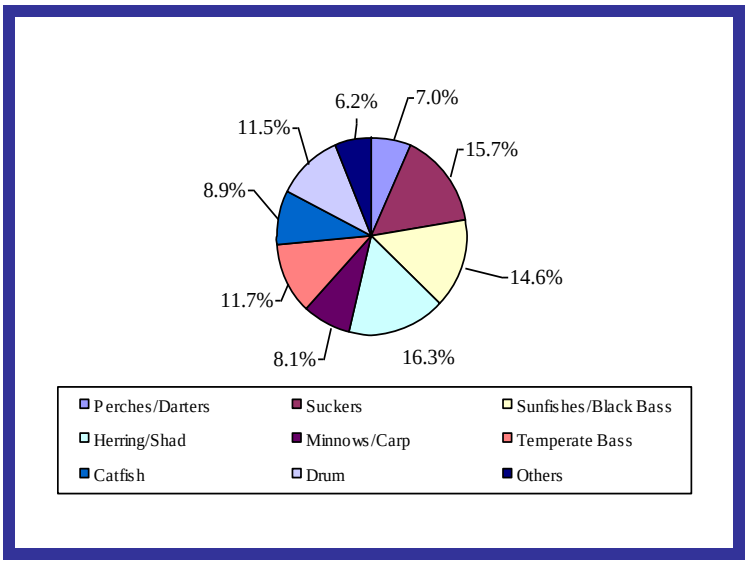


Figure 6. *Sampled fish composition by family in Open Water*

Table 1. *Electrofishing site list for the Open Water 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	919.2	LDB	06-Jul-09	37.158284	88.421797	D	41.80	48.84	2	Fair
2	923.4	RDB	06-Jul-09	37.110645	88.439109	D	41.80	70.06	5	Excellent
3	924.7	RDB	06-Jul-09	37.093928	88.446878	D	41.80	58.88	4	Very Good
4	926.2	RDB	09-Jul-09	37.075071	88.460838	D	41.80	69.00	5	Excellent
5	928.1	LDB	06-Jul-09	37.062661	88.487586	C	44.55	64.98	4	Very Good
6	935.6	RDB	06-Jul-09	37.103605	88.604443	D	41.80	63.35	4	Very Good
7	938.6	RDB	06-Jul-09	37.121073	88.650603	B	46.71	78.41	5	Excellent
8	939.9	LDB	08-Jul-09	37.128562	88.672239	D	41.80	36.37	1	Poor
9	940.7	LDB	08-Jul-09	37.133445	88.685126	D	41.80	30.21	0	Very Poor
10	950.1	LDB	07-Jul-09	37.191185	88.830529	D	41.80	31.19	0	Very Poor
11	950.4	RDB	07-Jul-09	37.192885	88.834617	C	44.55	47.57	2	Fair
12	952.2	RDB	07-Jul-09	37.203446	88.864156	D	41.80	41.71	1	Poor
13	953.3	RDB	07-Jul-09	37.20923	88.882706	C	44.55	52.95	3	Good
14	954.2	LDB	07-Jul-09	37.213267	88.897403	C	44.55	42.39	1	Poor
15	961	LDB	07-Jul-09	37.213908	89.014203	D	41.80	33.07	1	Poor
16	970.3	LDB	08-Jul-09	37.111835	89.115973	D	41.80	48.55	2	Fair
17	977.3	LDB	08-Jul-09	37.029328	89.177516	B	46.71	59.18	3	Good

Table 2. *Species collected in the Open Water pool during the 2009 survey. Species information are determined by and relative to the state of Kentucky (SC = 'Species of Concern'). No Illinois listed species were collected in 2009.*

Family	Species	Latin Name	KY
Polyodontidae	Paddlefish	*Polyodon spathula*	
Lepisosteidae	Longnose Gar	*Lepisosteus osseus*	
Lepisosteidae	Shortnose Gar	*Lepisosteus platostomus*	
Hiodontidae	Goldeye	*Hiodon alosoides*	
Hiodontidae	Mooneye	*Hiodon tergisus*	
Clupeidae	Skipjack Herring	*Alosa chrysochloris*	
Clupeidae	Gizzard Shad	*Dorosoma cepedianum*	
Clupeidae	Threadfin Shad	*Dorosoma petenense*	
Cyprinidae	Grass Carp	*Ctenopharyngodon idella*	
Cyprinidae	Spotfin Shiner	*Cyprinella spiloptera*	
Cyprinidae	Common Carp	*Cyprinus carpio*	
Cyprinidae	Miss. Silvery Minnow	*Hybognathus nuchalis*	
Cyprinidae	Silver Carp	*Hypophthalmichthys molitrix*	
Cyprinidae	Bighead Carp	*Hypophthalmichthys nobilis*	
Cyprinidae	Silver Chub	*Macrhybopsis storeriana*	
Cyprinidae	Emerald Shiner	*Notropis atherinoides*	
Cyprinidae	River Shiner	*Notropis blennius*	
Cyprinidae	Silverband Shiner	*Notropis shumardi*	
Cyprinidae	Mimic Shiner	*Notropis volucellus*	
Cyprinidae	Bullhead Minnow	*Pimephales vigilax*	
Catostomidae	Carpiodes Sp	*Carpiodes sp*	
Catostomidae	River Carpsucker	*Carpiodes carpio*	
Catostomidae	Quillback	*Carpiodes cyprinus*	
Catostomidae	Smallmouth Buffalo	*Ictiobus bubalus*	
Catostomidae	Bigmouth Buffalo	*Ictiobus cyprinellus*	
Catostomidae	Black Buffalo	*Ictiobus niger*	SC
Catostomidae	Golden Redhorse	*Moxostoma erythrurum*	
Ictaluridae	Blue Catfish	*Ictalurus furcatus*	
Ictaluridae	Channel Catfish	*Ictalurus punctatus*	
Ictaluridae	Flathead Catfish	*Pylodictis olivaris*	
Poeciliidae	Western Mosquitofish	*Gambusia affinis*	
Belonidae	Atlantic Needlefish	*Strongylura marina*	
Moronidae	Morone Sp	*Morone sp*	
Moronidae	White Perch	*Morone americana*	
Moronidae	White Bass	*Morone chrysops*	
Moronidae	Yellow Bass	*Morone mississippiensis*	
Moronidae	Hybrid Striper	*Morone saxatilis x M. chrysops*	
Centrarchidae	Green Sunfish	*Lepomis cyanellus*	
Centrarchidae	Pumpkinseed	*Lepomis gibbosus*	
Centrarchidae	Orangespotted Sunfish	*Lepomis humilis*	
Centrarchidae	Bluegill	*Lepomis macrochirus*	
Centrarchidae	Longear Sunfish	*Lepomis megalotis*	
Centrarchidae	Smallmouth Bass	*Micropterus dolomieu*	
Centrarchidae	Spotted Bass	*Micropterus punctulatus*	
Centrarchidae	Largemouth Bass	*Micropterus salmoides*	
Centrarchidae	White Crappie	*Pomoxis annularis*	
Centrarchidae	Black Crappie	*Pomoxis nigromaculatus*	
Percidae	Logperch	*Percina caprodes*	
Percidae	Sauger	*Sander canadensis*	
Percidae	Walleye	*Sander vitreus*	
Percidae	Saugeye	*Sander canandensis x S. vitreus*	
Sciaenidae	Freshwater Drum	*Aplodinotus grunniens*	
Sciaenidae	Freshwater Drum	*Aplodinotus grunniens*	

4.2 Metric Performance

Thirteen metrics were used to calculate MORFIn scores for each electrofishing site (See Emery et al. 2003). Each site's performance and scores for the MORFIn metrics are shown in Table 3. The number of native species collected at each site ranged from 10 to 25, with an average of 17.2 species per site. The number of sucker species found at each site ranged from 1 to 5 and the number of Centrarchid species varied from 1 to 7. The number of great river species ranged from 1 to 5. The number of intolerant species ranged from 0 to 3 at the sampled sites. The percentage of tolerant individuals at each site did not exceed 16.6% and the percentage of simple lithophils ranged between 0% and 28.8%. All sites had below 17.8% non-native individuals and the percent detritivores ranged from 1.3% to 64.5%. The percent invertivores ranged between 1.0% to 47.5%, and the percent piscivores ranged from 5.9% to 50.0%. Ten of the sites had DELT anomalies (deformities, eroded fins, lesions and tumors), but no site had more than two occurances. The CPUE (catch per unit effort) ranged from 53 to 275 individuals and averaged 113.1 individulas per site.

4.3 Habitat Surveys

Intensive habitat surveys at each of the 17 sampling locations revealed that the benthic substrate in Open Water was dominated by sand followed by fines and then gravel (Figure 7). There was some variation among the individual sites, with more fine sediments occurring in the lower half of Open Water (i.e. below L&D 52, Figure 8). The percentages of substrate variables were used to give each site a habitat classification of 'A', 'B', 'C', 'D', or 'E'. Two sites in the Open Water were classified as class 'B' habitat, 4 sites were class 'C' habitats, and 11 sites were class 'D' habitats. There were zero 'A' and 'E' habitat classes sampled in the section (Table 1).

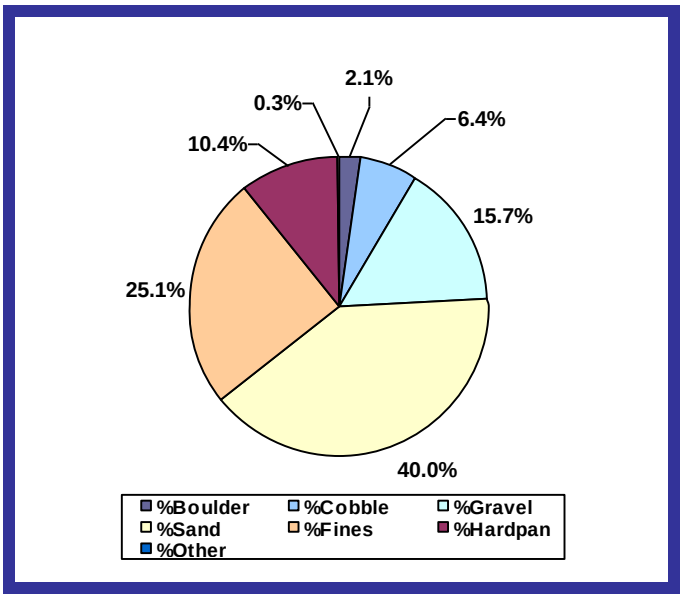


Figure 7. *Substrate composition of the Open Water pool.*

Woody cover was present at all 17 sites sampled. Riparian land cover was primarily natural forest with some agriculture and residential uses present. Barge activity was moderate throughout the pool and mooring structures were present at approximately half of the sites (see Appendix C).

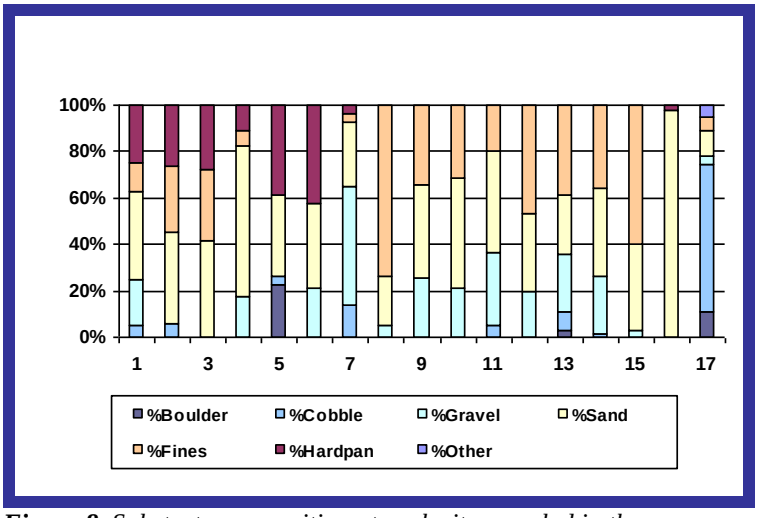


Figure 8. *Substrate composition at each site sampled in the Open Water section..*

Table 3. MORFIn metrics and scores from scores from the 2008 survey of Dashields.

Table 3. *MORFIn metrics and scores from the 2008 survey of Open Water section.*

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 MORFIn	Observed MORFIn
1	919.2	L	56.0	49	46	15	57.5	2	48.2	1	16.7	3	100.0	1	49.5	2.0	78.4	16.3	34.6	6.1	43.3	12.2	58.6	16.3	44.1	30.6	37.3	2	50.0	53	16.8	41.80	48.8
2	923.4	R	127.0	66	65	21	100.0	2	48.5	3	50.0	5	100.0	1	49.8	0.0	100.0	28.8	57.1	1.5	86.0	7.6	75.0	16.7	44.8	50.0	70.8	0	100.0	126	28.8	41.80	70.1
3	924.7	R	142.0	68	56	21	100.0	1	29.2	6	100.0	4	100.0	0	31.3	0.0	100.0	25.0	50.3	17.6	0.0	7.4	75.8	17.6	46.3	39.7	53.0	2	50.0	130	29.5	41.80	58.9
4	926.2	R	127.0	115	113	20	94.1	3	68.0	3	50.0	3	100.0	0	31.4	0.0	100.0	27.8	55.4	1.7	83.9	7.8	74.2	31.3	67.0	34.8	44.5	0	100.0	125	28.7	41.80	69
5	928.1	L	87.0	84	81	20	94.1	2	48.7	6	100.0	3	100.0	2	68.7	3.6	62.1	9.5	22.5	2.4	77.9	4.8	85.0	19.0	48.6	32.1	39.9	1	75.0	84	22.1	44.55	65
6	935.6	R	87.0	76	74	17	72.6	1	29.8	5	83.3	2	66.7	1	50.6	0.0	100.0	14.5	31.5	2.6	75.6	1.3	97.1	18.4	48.0	35.5	45.7	0	100.0	85	22.4	41.80	63.3
7	938.6	R	285.0	223	213	25	100.0	5	100.0	7	100.0	4	100.0	2	69.4	1.3	85.7	16.1	34.6	2.2	79.2	7.2	76.5	47.5	92.0	25.6	28.4	0	100.0	275	53.4	46.71	78.4
8	939.9	L	90.0	77	68	14	50.9	2	49.4	1	16.7	2	66.7	1	50.9	6.5	31.2	3.9	12.6	11.7	0.0	19.5	33.0	5.2	28.3	15.6	11.2	0	100.0	81	21.9	41.80	36.4
9	940.7	L	170.0	169	139	16	65.5	4	88.1	2	33.3	1	33.3	0	32.4	16.6	0.0	1.2	7.7	17.8	0.0	64.5	0.0	3.6	25.9	5.9	0.0	1	75.0	140	31.5	41.80	30.2
10	950.1	L	68.0	66	56	12	36.7	3	69.3	4	66.7	1	33.3	1	51.6	9.1	3.6	0.0	5.8	15.2	0.0	50.0	0.0	3.0	25.6	34.8	44.4	2	50.0	58	18.4	41.80	31.2
11	950.4	R	76.0	72	70	17	73.1	2	50.0	4	66.7	2	66.7	0	33.1	1.4	85.3	5.6	15.8	2.8	74.3	29.2	0.0	12.5	39.8	19.4	17.8	1	75.0	74	21.0	44.55	47.6
12	952.2	R	139.0	100	89	16	65.9	4	88.8	2	33.3	1	33.3	0	33.2	0.0	100.0	6.0	16.6	11.0	0.0	23.0	20.6	1.0	22.6	37.0	48.1	2	50.0	128	29.8	41.80	41.7
13	953.3	R	100.0	73	70	18	80.5	1	30.9	3	50.0	2	66.7	1	51.9	2.7	71.0	9.6	23.1	4.1	61.9	16.4	43.8	8.2	33.5	38.4	50.5	0	100.0	97	24.8	44.55	53
14	954.2	L	119.0	115	105	17	73.2	3	69.6	4	66.7	2	66.7	0	33.3	7.0	26.3	2.6	10.5	8.7	19.5	40.9	0.0	3.5	26.4	27.8	32.2	0	100.0	109	26.8	44.55	42.4
15	961	L	93.0	90	87	10	22.5	2	50.6	1	16.7	1	33.3	0	33.8	2.2	76.4	0.0	5.9	3.3	69.1	27.8	3.8	1.1	23.2	21.1	20.6	2	50.0	90	23.8	41.80	33.1
16	970.3	L	84.0	72	67	14	52.0	2	51.2	4	66.7	1	33.3	0	34.4	1.4	85.3	13.9	31.1	6.9	35.7	9.7	67.5	5.6	30.3	36.1	46.4	1	75.0	79	22.3	41.80	48.5
17	977.3	R	210.0	195	174	20	95.9	4	90.3	5	83.3	3	100.0	3	90.7	2.1	78.3	10.3	24.7	10.3	5.0	17.9	38.4	9.2	36.2	30.3	36.3	2	50.0	189	40.3	46.71	59.2

R = Right Descending Bank
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
Tolerant Individuals = individuals with high 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

As rain events were relatively common throughout the sampling period in 2009, river levels and flows were variable. Sampling was conducted in Open Water primarily when flows were below the harmonic mean flow (HMF), with one site sampled during slightly higher flows. Flow conditions during sampling varied from 61% and 102% 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 12 to 32 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).

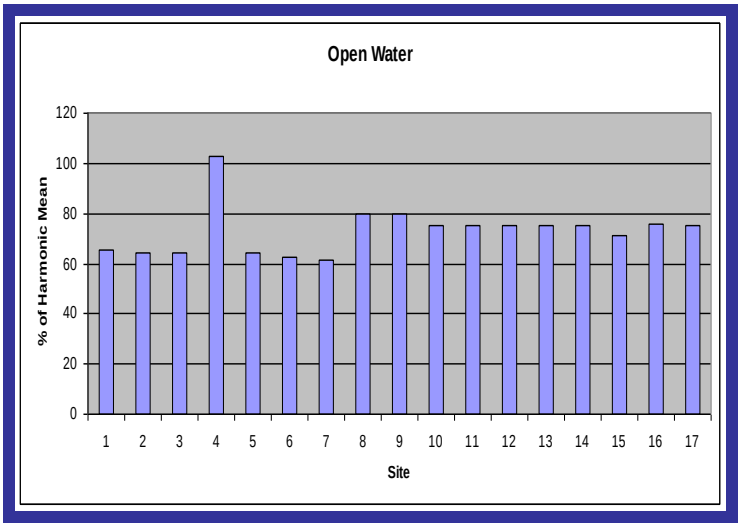


Figure 9*. Relative flows (%HMF) at the time of sampling.*

4.5 Assessment of Condition

MORFIn scores were calculated for each of the sites sampled. The maximum score achieved by any site in this section, 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). Six of the 17 sites (35.3%) assessed in 2009 scored less than the minimum expected and were assessed as either poor or very poor (Table 1; Figure 4). The remaining 11 sites received a fair (17.6%), good (11.8%), very good (17.6%), or excellent quality rating (17.6%; Figure 4).

5.0 Discussion

5.1 Fish Population

In 2009, the fish population of Open Water was in 'Fair' condition. This was supported by the diversity and types of species collected. Multiple pollution intolerant species such as smallmouth bass (*Micropterus dolomieu*), logperch (*Percina caprodes*), paddlefish (*Polyodon spathula*), goldeye (*Hiodon alosoides*), and mooneye (*Hiodon tergisus*) were collected from Open Water, suggesting that pollution may not be a problem in the area. Common carp (*Cyprinus carpio*) and silver carp (*Hypophthalmichthys molitrix*) were the only non-native species collected during the survey.

The three most abundant species in the survey were gizzard shad (*Dorosoma cepedianum*; 325 individuals), freshwater drum (*Aplodinotus grunniens*; 234 ind.), and river carpsucker (*Carpiodes carpio*; 218 ind.).

5.2 Metric Performance

Most of the metric scores in Open Water were relatively high with the exception of three metrics: % simple lithophils, CPUE, and % piscivores. The low percentage of % simple lithophilic spawners is largely due to the low number of sucker family individuals collected as well as the lack of available coarse substrate. There is no explanation for the low % piscivores. 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.

Four metrics stood out as the highest performing in Open Water; DELTs, # species, # of great river species, and % tolerant individuals. DELT anomalies were found at 10 sites, though no site had more than 2 occurences, suggesting the majority of fishes in Open Water are not experiencing environmental stressors severe enough to decrease their health. Low proportions

of pollution-tolerant individuals were collected, while a relatively high number of species were recorded. Sites also scored well for the number of great river species, which was expected given the proximity of this section to the Mississippi River. Other metrics that performed relatively well include: # sucker species and # centrarchid species. Overall, these metric scores indicated that Open Water is in 'Fair' condition.

5.3 Habitat Surveys

The habitat assessments show that in Open Water there was a relatively high number of sites classified as class 'D' habitat, with fairly equal proportions of 'B' and 'C' also present. This indicated that the majority of the benthic substrate was comprised of sand, with lesser amounts of gravel 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 Open Water. Rain events were relatively frequent throughout the field season causing some sampling to be conducted during higher flow events. This did not cause issue as the only site sampled above HMF had the third-highest MORFIn score. High flows can alter fish behavior and increase turbidity. Secchi depths however, indicated sufficient visibility for sampling. No water quality measurements exceeded their respective criteria or provided any major insight into the assessment results for Open Water.

5.5 Conclusions and Assessments of Condition

Prior to this survey, the dataset for the Open Water section of the Ohio River pertaining to the natural variation of fish communities with respect to habitat was limited. The data gathered in 2009 will aid in our understanding of the unique instream habitats within this section of the Ohio River and the fishes that inhabit them. Though our reference dataset for Open Water used to calibrate the MORFIn was not as robust as other pools, the MORFIn is still the best tool available to assess its condition. Therefore ORSANCO's Biological Water Quality Subcommittee (BWQSC) believed it was still applicable and was therefore used to assess the Open Water section.

The overall average quality score in Open Water was 2.5, indicating the section was in 'Fair' biological condition. Though six of the sites assessed as being in 'Poor' or 'Very poor' condition, there were also six sites in 'Very good' and 'Excellent' condition, and as a whole the assessment of Open Water met the criteria established by ORSANCO's BWQSC (Appendix A). The data collected in 2009 indicated that Open Water met its aquatic life-use designation.

6.0 Interpool Comparison

6.1 Purpose

As of 2009, all of the 19 pools have been surveyed and assessed. This section was developed to compare Open Water to other previously surveyed pools in the Ohio River.

6.2 Land Cover

The Open Water section lies in the lower portion of the Ohio River and therefore has a relatively large catchment area. Despite many industrial facilities immediately surrounding the section, the primary land cover within the watershed is deciduous forest. Agricultural practices are secondary land uses but in higher proportions than pools in the upper third of the Ohio River (Figure 10).

6.3 Substrate Composition

This section had a relatively high percentage of sand, followed by fines and gravel. The heterogeneous substrate composition is somewhat unique in its makeup, though higher percentages of sand are representative of pools assessed in the lower third of the river (Figure 11).

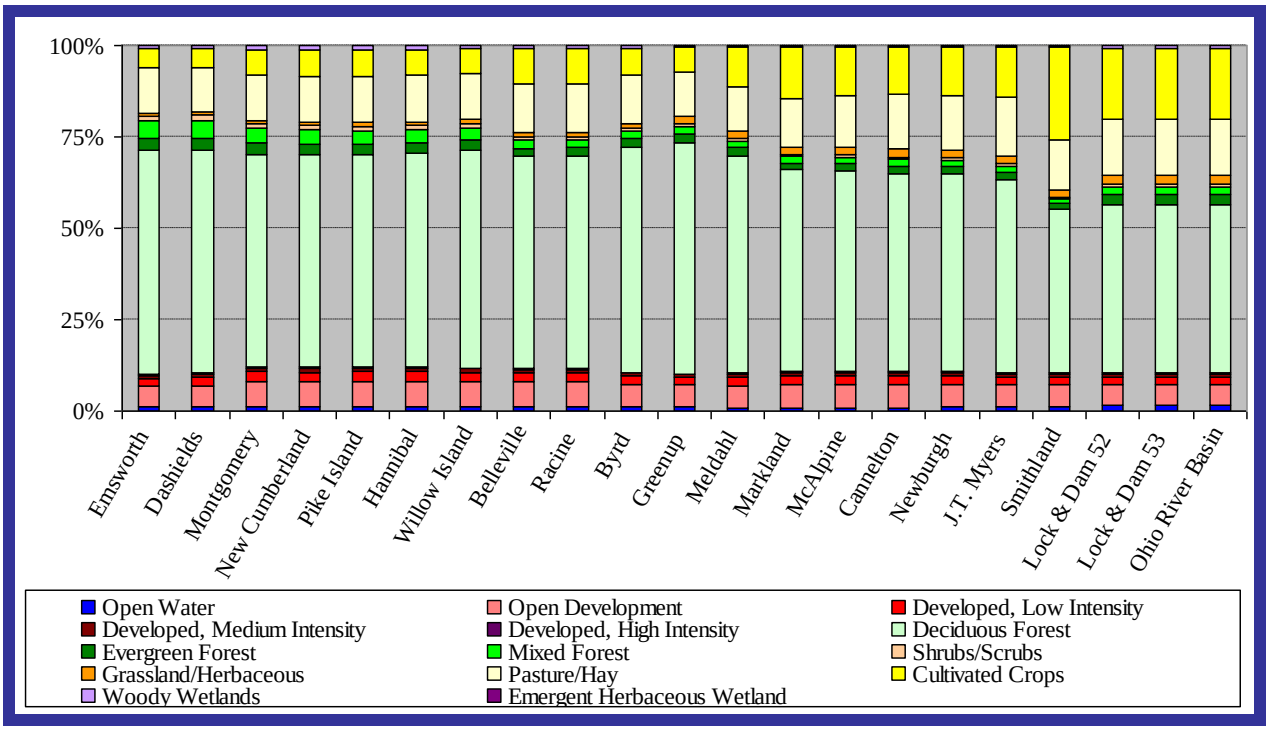


Figure 10. *Cumulative land-cover within the catchment area of each pool of the Ohio River.*

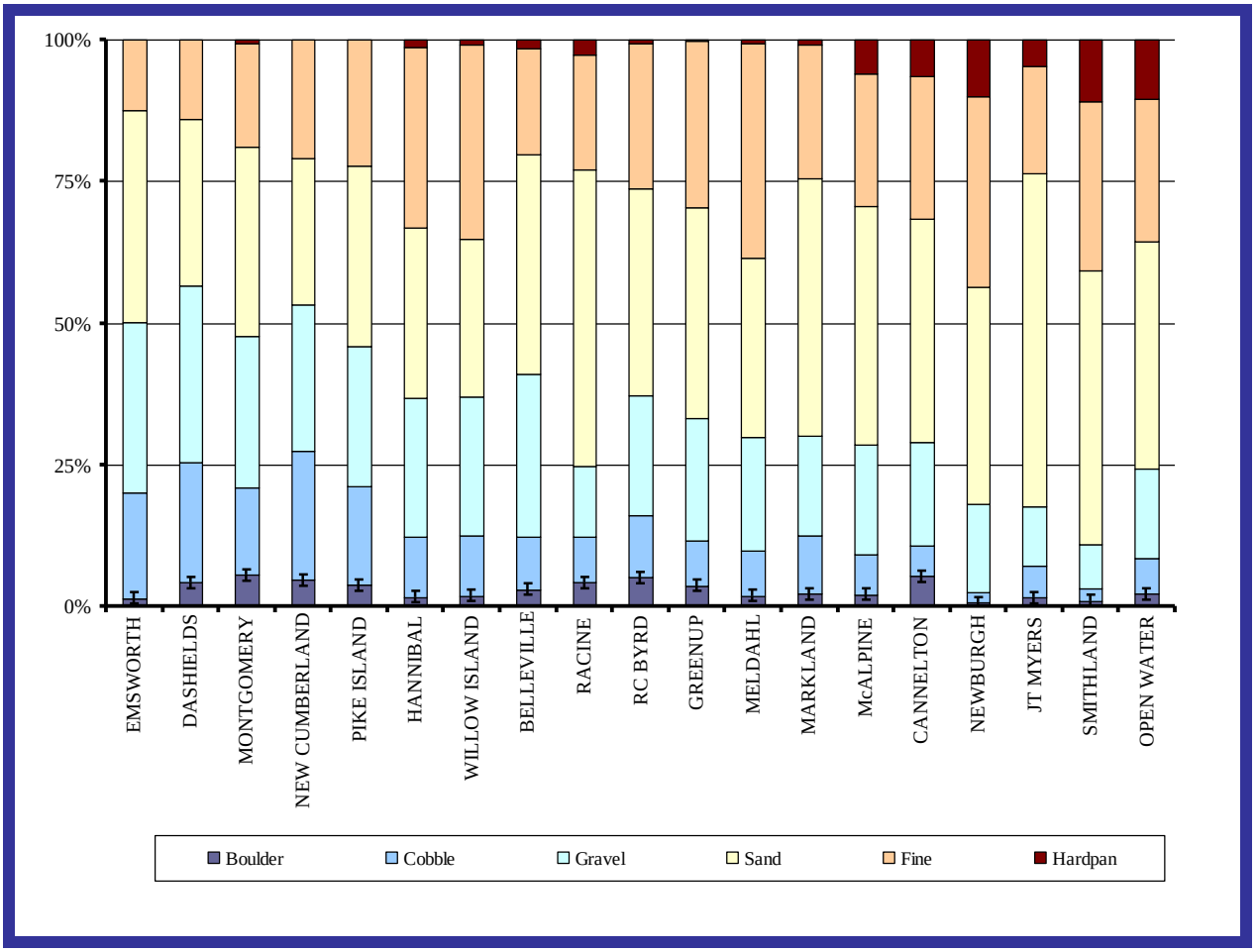


Figure11. *Substrate composition for each pool surveyed as of 2009.*

6.4 Species Richness

Open Water was similar to other surveyed pools in the average number of native species per site (17.2) and ranked 9th in comparison (Figure 12).

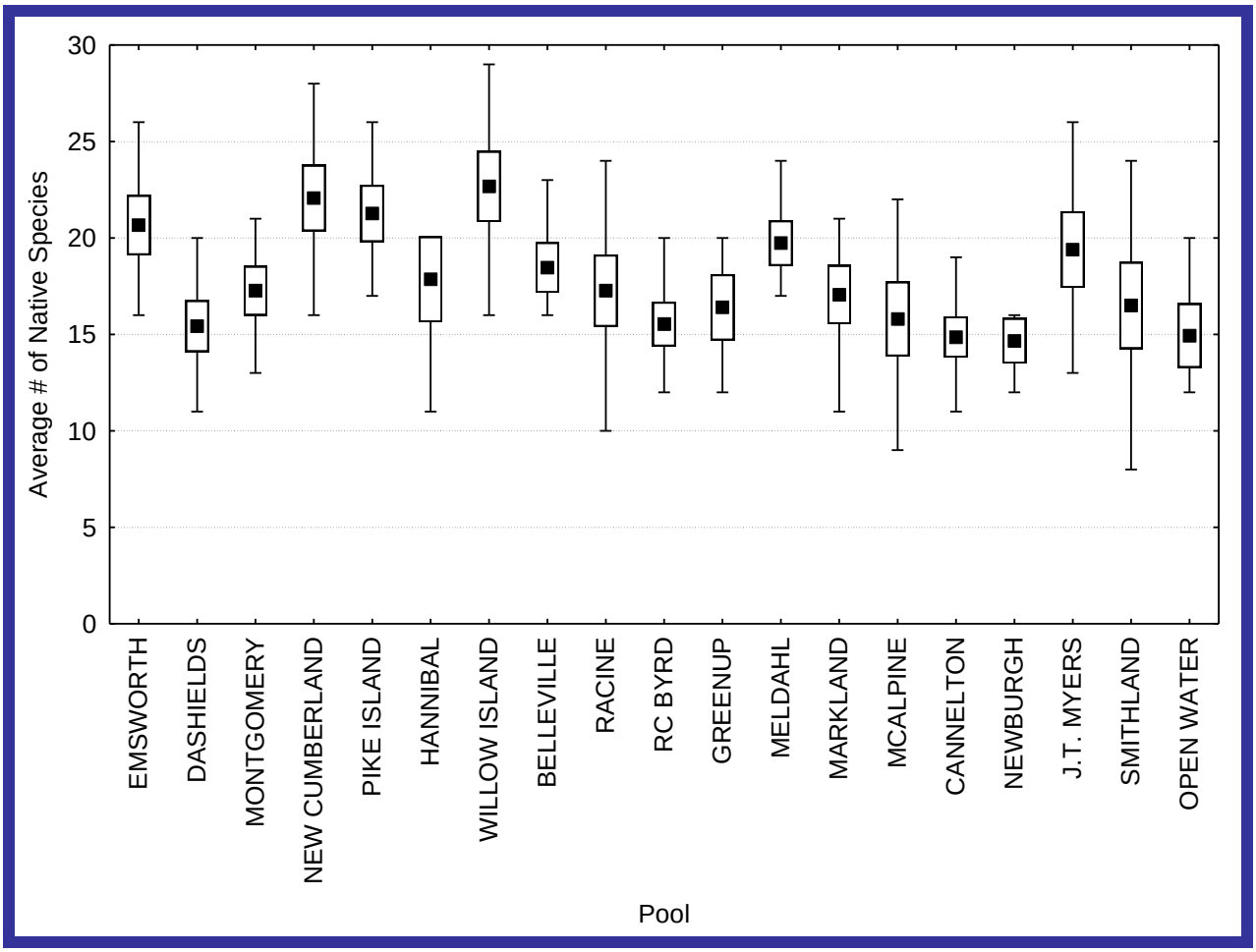


Figure 12. *The average number of native species collected at each site within each pool surveyed as of 2009 (■=Average, □= 90% Confidence Interval, I=Non-Outlier Range).*

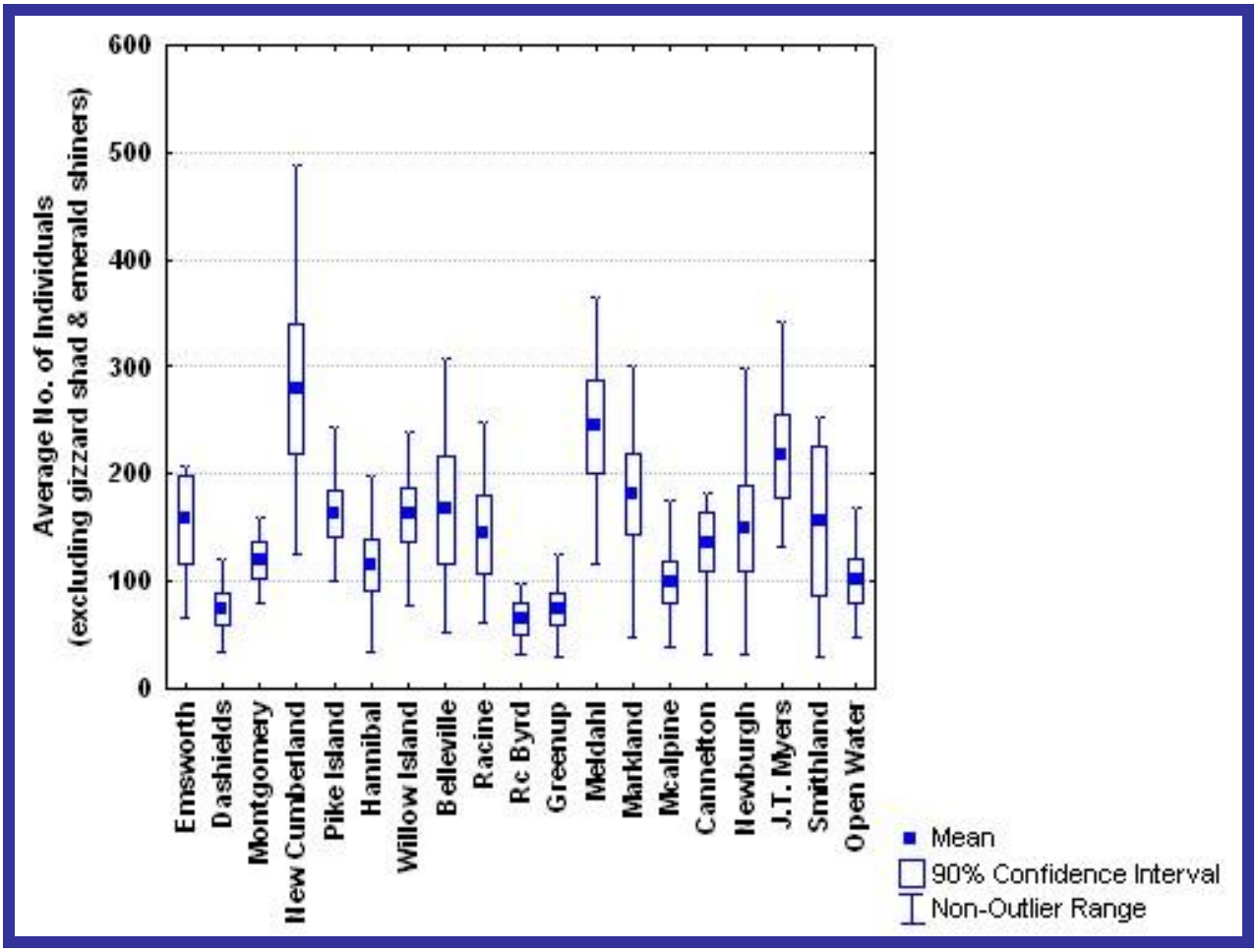


Figure 13. *The average number of individuals (excluding gizzard shad & emerald shiner) collected at each site within each pool surveyed as of 2009.*

6.5 Number of Individuals

An average of 92.5 individuals (excluding gizzard shad and emerald shiner) was collected at each site in Open Water which ranked 16th in comparison (Figure 13).

6.6 Noteworthy Fish Observations

Some of the species collected in Open Water were unique to the section ([paddlefish (*Polyodon spathula)*, silver carp (*Hypophthalmichthys molitrix*), and Atlantic needlefish (*Strongylura marina*)]) during our random survey design. Several species were collected from this section that are only typically found in the lower portions of the Ohio River such as: yellow bass, shortnose gar, and blue catfish (Table 4).

6.7 Assessment of Condition

The average quality score in Open Water was 2.5 and it was assessed as being in 'Fair' condition. The nearest surveyed pool upstream (Smithland) was considered to be in 'Good' condition (Figure 14).

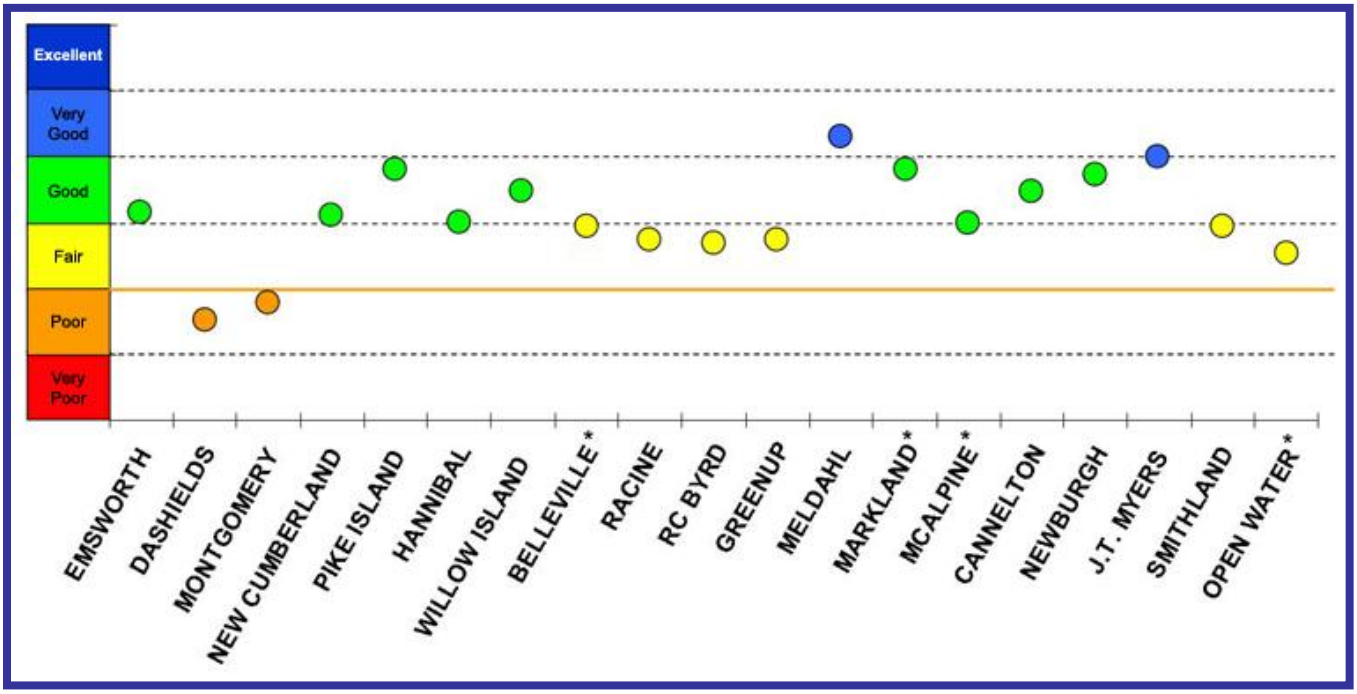


Figure 14. *The average quality score for each pool surveyed as of 2009 (* = pools surveyed in 2009). Data points are color-coded to indicate the biological condition of a pool*.

***Table 4**. A compiled species list containing the number of individuals collected per pool as of 2009*

#	Species	Emsworth 07	Dashields 08	Montgomery 06	New Cumberland 05	Pike Island 07	Hannibal 08	Willow Island 06	**Belleville 09**	Racine 05	R.C. Byrd 08	Greenup 06	Meldahl 07	**Markland 09**	**McAlpine 09**	Cannelton (30) 06-07	Newburgh 07	Myers 05	Smithland 08	**Open Water 09**
1	Ohio Lamprey								**1**											
2	Silver Lamprey											1							1	
3	Paddlefish																1			**1**
4	Spotted Gar																1		1	
5	Longnose Gar	13	11	10	11	43	49	46	**49**	24	27	23	22	**15**	**40**	48	20		16	**40**
6	Shortnose Gar													**1**	**1**		9	2	13	**75**
7	Goldeye																12		2	**4**
8	Mooneye	20	11	6	22	37	10		**4**	1	7		48	**9**	**10**	8	10	4		**1**
9	Skipjack Herring	8			3	6			**2**	1	2		64	**2**	**6**	174	70	249	1	**8**
10	Gizzard Shad	167	123	266	1202	7326	1461	216	**439**	8048	301	267	2408	**185**	**490**	3527	600	444	409	**325**
11	Threadfin Shad														**1**	1	9	112	25	**3**
12	Central Stoneroller				4		3	1												
13	Goldfish				1															
14	Grass Carp				1												1			**3**
15	Spotfin Shiner			1	21	14		24	**159**	63	1	2	32	**1**	**6**	63	8	12	4	**12**
16	Common Carp	63	36	44	25	15	15	22	**36**	9	12	9	8	**28**	**12**	5	4	10	17	**51**
17	Gravel Chub												1							
18	Miss. Silvery Minnow																	1		**1**
19	Silver Carp																2		4	**6**
20	Bighead Carp																2			**2**
21	Striped Shiner						2			2										
22	Silver Chub	26	26	12	20	11	19	57	**32**	44	11	33	90	**372**	**39**	130	126	206	47	**25**
23	River Chub				1	1														
24	Golden Shiner	1			1															
25	Emerald Shiner	82	5	8	342	197	21	728	**637**	795	16	50	637	**204**	**67**	1331	166	801	28	**25**
26	River Shiner	1											54	**12**	**10**	276	3	91	2	**9**

Table 4. *A compiled species list containing the number of individuals collected per pool as of 2009*

#	Species	Emsworth 07	Dashields 08	Montgomery 06	New Cumberland 05	Pike Island 07	Hannibal 08	Willow Island 06	**Belleville 09**	Racine 05	R.C. Byrd 08	Greenup 06	Meldahl 07	**Markland 09**	**McAlpine 09**	Cannelton (30) 06-07	Newburgh 07	Myers 05	Smithland 08	**Open Water 09**
27	Silverjaw Minnow						1													
28	Spottail Shiner				6	2	1													
29	Silverband Shiner																			**6**
30	Sand Shiner								**1**											
31	Mimic Shiner	35	1	13	76	162	16	306	**795**	402	1	61	7	**45**	**30**	195	6	43		**8**
32	Suckermouth Minnow													**1**						
33	Bluntnose Minnow				2	2	4	120	**11**	3		1	1		**1**	2			1	
34	Fathead Minnow									6										
35	Bullhead Minnow							4	**1**	5			23	**9**	**1**			8	2	**19**
36	Creek Chub				1								3							
37	Ictiobinae Sp				20															
38	Carpiodes Sp		1			14			**3**	2			1			2				**1**
39	River Carpsucker	18	18	13	46	36	64	18	**12**	50	25	49	87	**85**	**88**	122	179	86	114	**218**
40	Quillback	17	12	30	80	27	28	66	**6**	16	8	17	31	**21**	**12**	21	34	57	28	**15**
41	Highfin Carpsucker			37	3	10	13	1	**1**	7		4			**18**	1	12	3	24	
42	Northern Hog Sucker	3	1	3	132	4	2	15	**3**		1			**1**	**2**	1	1			
43	Ictiobus Sp.						19													
44	Smallmouth Buffalo	97	99	217	283	94	45	60	**75**	96	40	49	123	**110**	**102**	147	72	314	77	**76**
45	Bigmouth Buffalo									1							3	7	5	**5**
46	Black Buffalo	1	13			5	1	2	**1**			1		**1**	**1**	1	7	3	4	**7**
47	Spotted Sucker							1		1		5	1			1			7	
48	Moxostoma Sp				58															
49	Silver Redhorse	221	93	157	63	78	105	51	**55**	11	11	12	25	**3**	**41**	3			1	

Table 4. *A compiled species list containing the number of individuals collected per pool as of 2009*

#	Species	Emsworth 07	Dashields 08	Montgomery 06	New Cumberland 05	Pike Island 07	Hannibal 08	Willow Island 06	**Belleville 09**	Racine 05	R.C. Byrd 08	Greenup 06	Meldahl 07	**Markland 09**	**McAlpine 09**	Cannelton (30) 06-07	Newburgh 07	Myers 05	Smithland 08	**Open Water 09**
50	Smallmouth Redhorse	61	16	110	110	28	41	168	**97**	5	27	30	62	**38**	**66**	12	3	11		
51	Shorthead Redhorse																		10	
52	River Redhorse	39	13	3	5	27	35	2	**1**		2	6	1		**2**		1			
53	Black Redhorse	18			11			4	**2**							1				
54	Golden Redhorse	7	33	227	90	66	204	277	**115**	11	33	39	120	**219**	**194**	4	14		3	**1**
55	Brown Bullhead											1								
56	Blue Catfish																	1	7	**4**
57	Channel Catfish	32	17	34	123	40	62	61	**89**	70	53	58	89	**113**	**84**	48	11	330	291	**165**
58	Flathead Catfish	14	11	11	15	35	38	21	**27**	32	42	32	49	**24**	**11**	63	11	43	16	**15**
59	Muskellunge	1																		
60	Trout-Perch								**7**	3										
61	Banded Killifish							1												
62	Western Mosquitofish																			**1**
63	Brook Silverside									1						1	1	1	1	
64	Inland Silverside																		26	
65	Atlantic Needlefish																			**5**
66	Morone Sp	27		6	568	419	91	17	**35**	561	73	2	152	**44**	**63**	625	403	253	190	**31**
67	White Perch	5			4		1	3						**1**	**1**					**7**
68	White Bass	9	16	36	6	2	3	58	**41**	3	29	64	18	**19**	**26**	66	4	17	76	**54**
69	Yellow Bass																		2	**104**
70	Striped Bass						14	1								6		12	2	
71	Hybrid Striper			4	17			1	**3**	46	1			**15**	**6**	6		11	2	**45**
72	Rock Bass	16	9	8	5	1	2	3	**9**					**2**				1		
73	Lepomis Hybrid			1				9												
74	Lepomis Sp					1		16		1						2		2	1	

Table 4. *A compiled species list containing the number of individuals collected per pool as of 2009*

#	Species	Emsworth 07	Dashields 08	Montgomery 06	New Cumberland 05	Pike Island 07	Hannibal 08	Willow Island 06	**Belleville 09**	Racine 05	R.C. Byrd 08	Greenup 06	Meldahl 07	**Markland 09**	**McAlpine 09**	Cannelton (30) 06-07	Newburgh 07	Myers 05	Smithland 08	**Open Water 09**
75	Green Sunfish	12	3	2	4	2	2	4	**8**	6	6	4	3	**9**	**3**	2	4	10	1	**2**
76	Pumpkinseed			2			2	18	**1**					**1**						**1**
77	Warmouth							1					1	**2**	**1**			1		
78	Orangespotted Sunfish				1			2	**1**	1	1		1					2		**5**
79	Bluegill	379	32	216	53	46	36	232	**413**	58	52	112	207	**206**	**105**	103	11	31	64	**98**
80	Longear Sunfish						9	23	**18**	3	9	14	35	**149**	**91**	39	3	11	92	**110**
81	Redear Sunfish			4		1		1	**4**	1		1		**1**	**1**	16		1	20	
82	Micropterus Sp																		1	
83	Smallmouth Bass	339	163	185	262	208	92	61	**45**	6	32	7	4	**32**	**7**	7	1	4		**10**
84	Spotted Bass	125	34	15	79	74	38	62	**43**	22	30	43	90	**102**	**23**	53	49	104	31	**36**
85	Largemouth Bass	4	2	8	8	16		16	**72**	22	25	65	16	**25**	**11**	37	2	70	21	**23**
86	White Crappie	5	1						**3**		1	4		**2**		1	1			**13**
87	Black Crappie	3	1	6	2	2			**2**	3	1				**4**	3				**3**
88	Greenside Darter	5		2	11	5														
89	Rainbow Darter			4	1			2	**1**									12		
90	Fantail Darter	3		1									1							
91	Johnny Darter	1						2												
92	Banded Darter			1	4													1		
93	Yellow Perch			4	2		3		**2**											
94	Logperch	141	166	67	244	85	105	108	**48**	6	72	12	20	**24**	**7**	39	4	3	1	**1**
95	Channel Darter	16		1	9		1	3				20		**3**				1		
96	Slenderhead Darter													**1**				5		
97	Dusky Darter																	3	1	
98	River Darter					2		1	**2**	2		1	6	**7**	**1**	11		4		
99	Sauger	283	192	243	180	244	317	341	**133**	173	259	220	1174	**378**	**184**	1314	747	484	105	**127**
100	Walleye	44	7	11	31	70	11	1	**4**	4	1	1	3		**5**		7			**1**

***Table 4**. A compiled species list containing the number of individuals collected per pool as of 2009*

#	Species	Emsworth 07	Dashields 08	Montgomery 06	New Cumberland 05	Pike Island 07	Hannibal 08	Willow Island 06	**Belleville 09**	Racine 05	R.C. Byrd 08	Greenup 06	Meldahl 07	**Markland 09**	**McAlpine 09**	Cannelton (30) 06-07	Newburgh 07	Myers 05	Smithland 08	**Open Water 09**
101	Saugeye	2	8		5	4	1		**1**	4	1			**13**				7	2	**16**
102	Freshwater Drum	254	58	47	1468	496	211	120	**33**	375	83	121	1000	**572**	**177**	435	378	612	837	**236**
	Total # of Individuals	2618	1232	2076	5742	9958	3198	3378	**3582**	11006	1296	1441	6718	**3107**	**2051**	8953	3013	4501	**2636**	**2060**
	Total # of Taxa	43	33	42	53	43	43	51	**50**	46	36	38	41	**45**	**44**	45	44	49	**49**	**52**

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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.

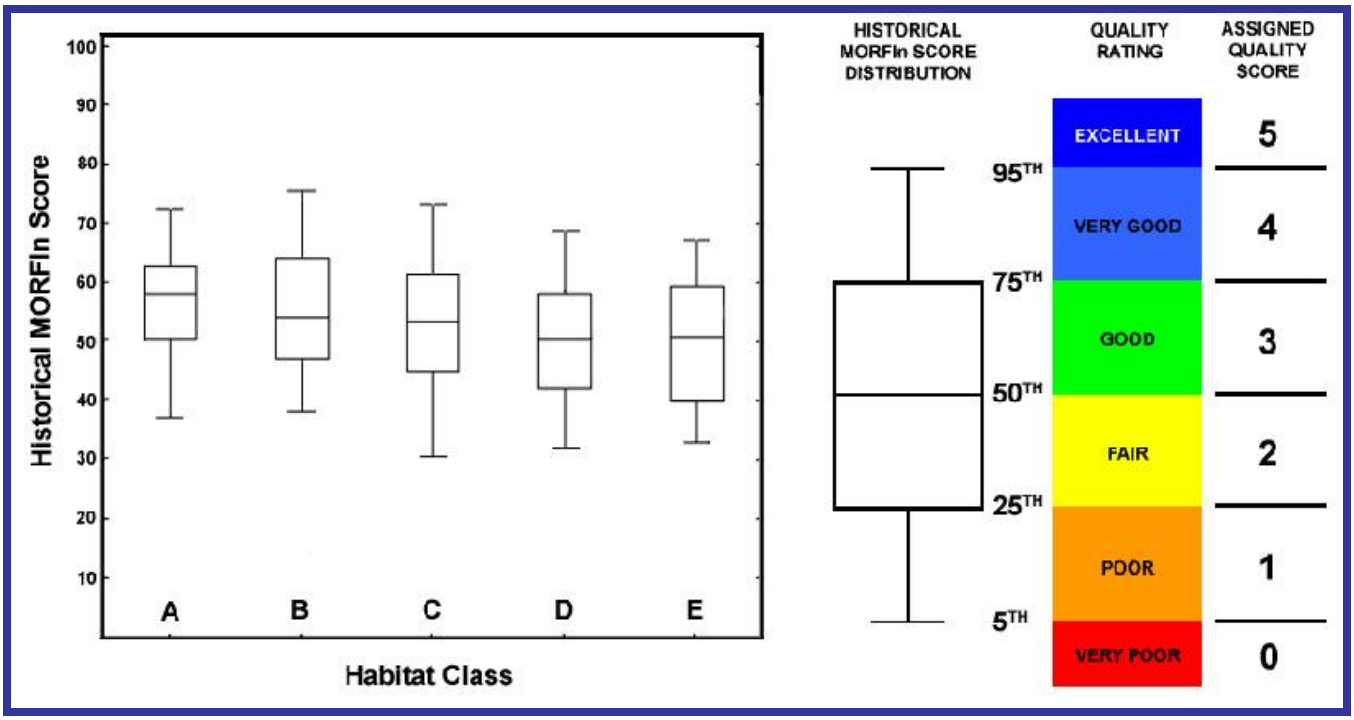
	Emsworth	Dashields	Montgomery	New Cumberland	Pike Island	Hannibal	Willow Island	Belleville	Racine	R. C. Byrd	Greenup	Meldahl	Markland	McAlpine	Cannelton	Newburgh	Uniontown	Smithland	Olmsted	Sites
2005				15					15				15				15			60
2006			15				15				15				11					56
2007	15				15							15			19	15				79
2008		15				15				15								15		60
2009								15					15	15					15	60
SUM	15	15	15	15	15	15	15	15	15	15	15	15	30	15	30	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 (see table below). These MORFIn expectations for each habitat are the 25th percentiles of historical MORFIn scores for each habitat.

Quality Score Constants	Class A	Class B	Class C	Class D	Class E
95th Percentile	72.53610	75.70669	73.19395	68.57603	67.26375
75th Percentile	62.59448	63.77092	61.13696	57.90023	59.17819
50th Percentile	55.97259	55.05460	52.23313	49.71604	50.53237
25th Percentile	50.03279	46.71055	44.54931	41.80374	39.59005
5th Percentile	36.62273	37.89377	30.12705	31.55379	32.57287

- 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 the 5th, 25th, 50th, 75th, or 95th percentiles of historical MORFIn scores. For example, the range less than the 25th percentile receives a quality score <2.0 (see figure below).

- 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 Open Water section.

Site #	Rmi	Bank	Date	Common Name	Latin Name	Count
1	919.2	LDB	06-Jul-09	Bluegill	*Lepomis macrochirus*	1
1	919.2	LDB	06-Jul-09	Channel Catfish	*Ictalurus punctatus*	6
1	919.2	LDB	06-Jul-09	Emerald Shiner	*Notropis atherinoides*	3
1	919.2	LDB	06-Jul-09	Freshwater Drum	*Aplodinotus grunniens*	8
1	919.2	LDB	06-Jul-09	Gizzard Shad	*Dorosoma cepedianum*	4
1	919.2	LDB	06-Jul-09	Hybrid Striper	*Morone saxatilis x M. chrysops*	1
1	919.2	LDB	06-Jul-09	Longnose Gar	*Lepisosteus osseus*	2
1	919.2	LDB	06-Jul-09	Mimic Shiner	*Notropis volucellus*	5
1	919.2	LDB	06-Jul-09	Quillback	*Carpiodes cyprinus*	3
1	919.2	LDB	06-Jul-09	River Carpsucker	*Carpiodes carpio*	3
1	919.2	LDB	06-Jul-09	Sauger	*Sander canadensis*	5
1	919.2	LDB	06-Jul-09	Saugeye	*Sander canandensis x S. vitreus*	1
1	919.2	LDB	06-Jul-09	Shortnose Gar	*Lepisosteus platostomus*	2
1	919.2	LDB	06-Jul-09	Silver Carp	*Hypophthalmichthys molitrix*	1
1	919.2	LDB	06-Jul-09	Silver Chub	*Macrhybopsis storeriana*	2
1	919.2	LDB	06-Jul-09	Skipjack Herring	*Alosa chrysochloris*	4
1	919.2	LDB	06-Jul-09	White Bass	*Morone chrysops*	4
1	919.2	LDB	06-Jul-09	Yellow Bass	*Morone mississippiensis*	1
2	923.4	RDB	06-Jul-09	Blue Catfish	*Ictalurus furcatus*	1
2	923.4	RDB	06-Jul-09	Bluegill	*Lepomis macrochirus*	1
2	923.4	RDB	06-Jul-09	Bullhead Minnow	*Pimephales vigilax*	4
2	923.4	RDB	06-Jul-09	Channel Catfish	*Ictalurus punctatus*	2
2	923.4	RDB	06-Jul-09	Emerald Shiner	*Notropis atherinoides*	5
2	923.4	RDB	06-Jul-09	Gizzard Shad	*Dorosoma cepedianum*	56
2	923.4	RDB	06-Jul-09	Longear Sunfish	*Lepomis megalotis*	4
2	923.4	RDB	06-Jul-09	Longnose Gar	*Lepisosteus osseus*	4
2	923.4	RDB	06-Jul-09	Mimic Shiner	*Notropis volucellus*	1
2	923.4	RDB	06-Jul-09	Miss. Silvery Minnow	*Hybognathus nuchalis*	1
2	923.4	RDB	06-Jul-09	Morone Sp	*Morone sp*	4
2	923.4	RDB	06-Jul-09	River Carpsucker	*Carpiodes carpio*	1
2	923.4	RDB	06-Jul-09	River Shiner	*Notropis blennius*	2
2	923.4	RDB	06-Jul-09	Sauger	*Sander canadensis*	13
2	923.4	RDB	06-Jul-09	Saugeye	*Sander canandensis x S. vitreus*	1
2	923.4	RDB	06-Jul-09	Shortnose Gar	*Lepisosteus platostomus*	1
2	923.4	RDB	06-Jul-09	Silver Chub	*Macrhybopsis storeriana*	3
2	923.4	RDB	06-Jul-09	Silverband Shiner	*Notropis shumardi*	1
2	923.4	RDB	06-Jul-09	Smallmouth Buffalo	*Ictiobus bubalus*	4
2	923.4	RDB	06-Jul-09	Spotfin Shiner	*Cyprinella spiloptera*	3
2	923.4	RDB	06-Jul-09	Spotted Bass	*Micropterus punctulatus*	10
2	923.4	RDB	06-Jul-09	Threadfin Shad	*Dorosoma petenense*	2
2	923.4	RDB	06-Jul-09	Yellow Bass	*Morone mississippiensis*	3
3	924.7	RDB	06-Jul-09	Black Crappie	*Pomoxis nigromaculatus*	2
3	924.7	RDB	06-Jul-09	Blue Catfish	*Ictalurus furcatus*	1
3	924.7	RDB	06-Jul-09	Bluegill	*Lepomis macrochirus*	6
3	924.7	RDB	06-Jul-09	Bullhead Minnow	*Pimephales vigilax*	4
3	924.7	RDB	06-Jul-09	Channel Catfish	*Ictalurus punctatus*	7
3	924.7	RDB	06-Jul-09	Emerald Shiner	*Notropis atherinoides*	5
3	924.7	RDB	06-Jul-09	Freshwater Drum	*Aplodinotus grunniens*	4
3	924.7	RDB	06-Jul-09	Gizzard Shad	*Dorosoma cepedianum*	69
3	924.7	RDB	06-Jul-09	Largemouth Bass	*Micropterus salmoides*	2
3	924.7	RDB	06-Jul-09	Longear Sunfish	*Lepomis megalotis*	5
3	924.7	RDB	06-Jul-09	Longnose Gar	*Lepisosteus osseus*	2
3	924.7	RDB	06-Jul-09	River Carpsucker	*Carpiodes carpio*	5

3	924.7	RDB	06-Jul-09	River Shiner	*Notropis blennius*	1
3	924.7	RDB	06-Jul-09	Sauger	*Sander canadensis*	4
3	924.7	RDB	06-Jul-09	Saugeye	*Sander canandensis x S. vitreus*	12
3	924.7	RDB	06-Jul-09	Shortnose Gar	*Lepisosteus platostomus*	2
3	924.7	RDB	06-Jul-09	Skipjack Herring	*Alosa chrysochloris*	1
3	924.7	RDB	06-Jul-09	Spotfin Shiner	*Cyprinella spiloptera*	4
3	924.7	RDB	06-Jul-09	Spotted Bass	*Micropterus punctulatus*	2
3	924.7	RDB	06-Jul-09	White Bass	*Morone chrysops*	2
3	924.7	RDB	06-Jul-09	White Crappie	*Pomoxis annularis*	1
3	924.7	RDB	06-Jul-09	Yellow Bass	*Morone mississippiensis*	1
4	926.2	RDB	09-Jul-09	Bigmouth Buffalo	*Ictiobus cyprinellus*	2
4	926.2	RDB	09-Jul-09	Bluegill	*Lepomis macrochirus*	7
4	926.2	RDB	09-Jul-09	Bullhead Minnow	*Pimephales vigilax*	3
4	926.2	RDB	09-Jul-09	Channel Catfish	*Ictalurus punctatus*	4
4	926.2	RDB	09-Jul-09	Emerald Shiner	*Notropis atherinoides*	6
4	926.2	RDB	09-Jul-09	Freshwater Drum	*Aplodinotus grunniens*	16
4	926.2	RDB	09-Jul-09	Gizzard Shad	*Dorosoma cepedianum*	6
4	926.2	RDB	09-Jul-09	Hybrid Striper	*Morone saxatilis x M. chrysops*	1
4	926.2	RDB	09-Jul-09	Longear Sunfish	*Lepomis megalotis*	23
4	926.2	RDB	09-Jul-09	Longnose Gar	*Lepisosteus osseus*	1
4	926.2	RDB	09-Jul-09	Morone Sp	*Morone sp*	2
4	926.2	RDB	09-Jul-09	Quillback	*Carpiodes cyprinus*	2
4	926.2	RDB	09-Jul-09	River Carpsucker	*Carpiodes carpio*	5
4	926.2	RDB	09-Jul-09	River Shiner	*Notropis blennius*	1
4	926.2	RDB	09-Jul-09	Sauger	*Sander canadensis*	25
4	926.2	RDB	09-Jul-09	Saugeye	*Sander canandensis x S. vitreus*	1
4	926.2	RDB	09-Jul-09	Shortnose Gar	*Lepisosteus platostomus*	1
4	926.2	RDB	09-Jul-09	Silver Chub	*Macrhybopsis storeriana*	5
4	926.2	RDB	09-Jul-09	Silverband Shiner	*Notropis shumardi*	1
4	926.2	RDB	09-Jul-09	Spotfin Shiner	*Cyprinella spiloptera*	4
4	926.2	RDB	09-Jul-09	Spotted Bass	*Micropterus punctulatus*	5
4	926.2	RDB	09-Jul-09	White Bass	*Morone chrysops*	4
4	926.2	RDB	09-Jul-09	Yellow Bass	*Morone mississippiensis*	2
5	928.1	LDB	06-Jul-09	Bighead Carp	*Hypophthalmichthys nobilis*	1
5	928.1	LDB	06-Jul-09	Blue Catfish	*Ictalurus furcatus*	1
5	928.1	LDB	06-Jul-09	Bluegill	*Lepomis macrochirus*	4
5	928.1	LDB	06-Jul-09	Bullhead Minnow	*Pimephales vigilax*	5
5	928.1	LDB	06-Jul-09	Channel Catfish	*Ictalurus punctatus*	2
5	928.1	LDB	06-Jul-09	Flathead Catfish	*Pylodictis olivaris*	2
5	928.1	LDB	06-Jul-09	Freshwater Drum	*Aplodinotus grunniens*	14
5	928.1	LDB	06-Jul-09	Gizzard Shad	*Dorosoma cepedianum*	3
5	928.1	LDB	06-Jul-09	Goldeye	*Hiodon alosoides*	1
5	928.1	LDB	06-Jul-09	Green Sunfish	*Lepomis cyanellus*	1
5	928.1	LDB	06-Jul-09	Longear Sunfish	*Lepomis megalotis*	6
5	928.1	LDB	06-Jul-09	Longnose Gar	*Lepisosteus osseus*	1
5	928.1	LDB	06-Jul-09	Morone Sp	*Morone sp*	6
5	928.1	LDB	06-Jul-09	Orangespotted Sunfish	*Lepomis humilis*	5
5	928.1	LDB	06-Jul-09	River Carpsucker	*Carpiodes carpio*	3
5	928.1	LDB	06-Jul-09	River Shiner	*Notropis blennius*	1
5	928.1	LDB	06-Jul-09	Sauger	*Sander canadensis*	6
5	928.1	LDB	06-Jul-09	Silver Carp	*Hypophthalmichthys molitrix*	1
5	928.1	LDB	06-Jul-09	Smallmouth Bass	*Micropterus dolomieu*	1
5	928.1	LDB	06-Jul-09	Smallmouth Buffalo	*Ictiobus bubalus*	1
5	928.1	LDB	06-Jul-09	Spotted Bass	*Micropterus punctulatus*	5
5	928.1	LDB	06-Jul-09	White Bass	*Morone chrysops*	6

5	928.1	LDB	06-Jul-09	Yellow Bass	*Morone mississippiensis*	11
6	935.6	RDB	06-Jul-09	Bluegill	*Lepomis macrochirus*	7
6	935.6	RDB	06-Jul-09	Channel Catfish	*Ictalurus punctatus*	12
6	935.6	RDB	06-Jul-09	Emerald Shiner	*Notropis atherinoides*	3
6	935.6	RDB	06-Jul-09	Freshwater Drum	*Aplodinotus grunniens*	17
6	935.6	RDB	06-Jul-09	Gizzard Shad	*Dorosoma cepedianum*	8
6	935.6	RDB	06-Jul-09	Hybrid Striper	*Morone saxatilis x M. chrysops*	2
6	935.6	RDB	06-Jul-09	Largemouth Bass	*Micropterus salmoides*	1
6	935.6	RDB	06-Jul-09	Logperch	*Percina caprodes*	1
6	935.6	RDB	06-Jul-09	Longear Sunfish	*Lepomis megalotis*	6
6	935.6	RDB	06-Jul-09	Longnose Gar	*Lepisosteus osseus*	1
6	935.6	RDB	06-Jul-09	Morone Sp	*Morone sp*	6
6	935.6	RDB	06-Jul-09	River Carpsucker	*Carpiodes carpio*	1
6	935.6	RDB	06-Jul-09	Sauger	*Sander canadensis*	10
6	935.6	RDB	06-Jul-09	Shortnose Gar	*Lepisosteus platostomus*	1
6	935.6	RDB	06-Jul-09	Skipjack Herring	*Alosa chrysochloris*	1
6	935.6	RDB	06-Jul-09	Spotted Bass	*Micropterus punctulatus*	3
6	935.6	RDB	06-Jul-09	White Bass	*Morone chrysops*	2
6	935.6	RDB	06-Jul-09	White Crappie	*Pomoxis annularis*	1
6	935.6	RDB	06-Jul-09	Yellow Bass	*Morone mississippiensis*	4
7	938.6	RDB	06-Jul-09	Atlantic Needlefish	*Strongylura marina*	4
7	938.6	RDB	06-Jul-09	Black Buffalo	*Ictiobus niger*	1
7	938.6	RDB	06-Jul-09	Bluegill	*Lepomis macrochirus*	34
7	938.6	RDB	06-Jul-09	Channel Catfish	*Ictalurus punctatus*	22
7	938.6	RDB	06-Jul-09	Common Carp	*Cyprinus carpio*	2
7	938.6	RDB	06-Jul-09	Emerald Shiner	*Notropis atherinoides*	1
7	938.6	RDB	06-Jul-09	Flathead Catfish	*Pylodictis olivaris*	1
7	938.6	RDB	06-Jul-09	Freshwater Drum	*Aplodinotus grunniens*	5
7	938.6	RDB	06-Jul-09	Gizzard Shad	*Dorosoma cepedianum*	61
7	938.6	RDB	06-Jul-09	Golden Redhorse	*Moxostoma erythrurum*	1
7	938.6	RDB	06-Jul-09	Green Sunfish	*Lepomis cyanellus*	1
7	938.6	RDB	06-Jul-09	Hybrid Striper	*Morone saxatilis x M. chrysops*	1
7	938.6	RDB	06-Jul-09	Largemouth Bass	*Micropterus salmoides*	10
7	938.6	RDB	06-Jul-09	Longear Sunfish	*Lepomis megalotis*	56
7	938.6	RDB	06-Jul-09	Longnose Gar	*Lepisosteus osseus*	1
7	938.6	RDB	06-Jul-09	Mimic Shiner	*Notropis volucellus*	1
7	938.6	RDB	06-Jul-09	Morone Sp	*Morone sp*	6
7	938.6	RDB	06-Jul-09	Quillback	*Carpiodes cyprinus*	8
7	938.6	RDB	06-Jul-09	River Carpsucker	*Carpiodes carpio*	4
7	938.6	RDB	06-Jul-09	River Shiner	*Notropis blennius*	1
7	938.6	RDB	06-Jul-09	Sauger	*Sander canadensis*	21
7	938.6	RDB	06-Jul-09	Shortnose Gar	*Lepisosteus platostomus*	2
7	938.6	RDB	06-Jul-09	Silver Chub	*Macrhybopsis storeriana*	13
7	938.6	RDB	06-Jul-09	Skipjack Herring	*Alosa chrysochloris*	2
7	938.6	RDB	06-Jul-09	Smallmouth Bass	*Micropterus dolomieu*	4
7	938.6	RDB	06-Jul-09	Smallmouth Buffalo	*Ictiobus bubalus*	1
7	938.6	RDB	06-Jul-09	Spotted Bass	*Micropterus punctulatus*	8
7	938.6	RDB	06-Jul-09	White Crappie	*Pomoxis annularis*	3
7	938.6	RDB	06-Jul-09	White Perch	*Morone americana*	2
7	938.6	RDB	06-Jul-09	Yellow Bass	*Morone mississippiensis*	8
8	939.9	LDB	08-Jul-09	Bluegill	*Lepomis macrochirus*	4
8	939.9	LDB	08-Jul-09	Channel Catfish	*Ictalurus punctatus*	1
8	939.9	LDB	08-Jul-09	Common Carp	*Cyprinus carpio*	5
8	939.9	LDB	08-Jul-09	Emerald Shiner	*Notropis atherinoides*	1
8	939.9	LDB	08-Jul-09	Flathead Catfish	*Pylodictis olivaris*	1

8	939.9	LDB	08-Jul-09	Freshwater Drum	*Aplodinotus grunniens*	24
8	939.9	LDB	08-Jul-09	Gizzard Shad	*Dorosoma cepedianum*	12
8	939.9	LDB	08-Jul-09	Hybrid Striper	*Morone saxatilis x M. chrysops*	4
8	939.9	LDB	08-Jul-09	Longnose Gar	*Lepisosteus osseus*	2
8	939.9	LDB	08-Jul-09	Paddlefish	*Polyodon spathula*	1
8	939.9	LDB	08-Jul-09	River Carpsucker	*Carpiodes carpio*	8
8	939.9	LDB	08-Jul-09	Sauger	*Sander canadensis*	2
8	939.9	LDB	08-Jul-09	Shortnose Gar	*Lepisosteus platostomus*	1
8	939.9	LDB	08-Jul-09	Smallmouth Buffalo	*Ictiobus bubalus*	2
8	939.9	LDB	08-Jul-09	White Bass	*Morone chrysops*	2
8	939.9	LDB	08-Jul-09	Yellow Bass	*Morone mississippiensis*	20
9	940.7	LDB	08-Jul-09	Black Buffalo	*Ictiobus niger*	2
9	940.7	LDB	08-Jul-09	Bluegill	*Lepomis macrochirus*	6
9	940.7	LDB	08-Jul-09	Channel Catfish	*Ictalurus punctatus*	10
9	940.7	LDB	08-Jul-09	Common Carp	*Cyprinus carpio*	28
9	940.7	LDB	08-Jul-09	Flathead Catfish	*Pylodictis olivaris*	1
9	940.7	LDB	08-Jul-09	Freshwater Drum	*Aplodinotus grunniens*	28
9	940.7	LDB	08-Jul-09	Gizzard Shad	*Dorosoma cepedianum*	1
9	940.7	LDB	08-Jul-09	Hybrid Striper	*Morone saxatilis x M. chrysops*	2
9	940.7	LDB	08-Jul-09	Longnose Gar	*Lepisosteus osseus*	1
9	940.7	LDB	08-Jul-09	Quillback	*Carpiodes cyprinus*	1
9	940.7	LDB	08-Jul-09	River Carpsucker	*Carpiodes carpio*	75
9	940.7	LDB	08-Jul-09	Sauger	*Sander canadensis*	1
9	940.7	LDB	08-Jul-09	Shortnose Gar	*Lepisosteus platostomus*	2
9	940.7	LDB	08-Jul-09	Smallmouth Buffalo	*Ictiobus bubalus*	3
9	940.7	LDB	08-Jul-09	Walleye	*Sander vitreus*	1
9	940.7	LDB	08-Jul-09	White Bass	*Morone chrysops*	1
9	940.7	LDB	08-Jul-09	White Crappie	*Pomoxis annularis*	1
9	940.7	LDB	08-Jul-09	Yellow Bass	*Morone mississippiensis*	6
10	950.1	LDB	07-Jul-09	Bighead Carp	*Hypophthalmichthys nobilis*	1
10	950.1	LDB	07-Jul-09	Bluegill	*Lepomis macrochirus*	1
10	950.1	LDB	07-Jul-09	Common Carp	*Cyprinus carpio*	5
10	950.1	LDB	07-Jul-09	Freshwater Drum	*Aplodinotus grunniens*	5
10	950.1	LDB	07-Jul-09	Gizzard Shad	*Dorosoma cepedianum*	2
10	950.1	LDB	07-Jul-09	Hybrid Striper	*Morone saxatilis x M. chrysops*	2
10	950.1	LDB	07-Jul-09	Longear Sunfish	*Lepomis megalotis*	1
10	950.1	LDB	07-Jul-09	Longnose Gar	*Lepisosteus osseus*	4
10	950.1	LDB	07-Jul-09	Quillback	*Carpiodes cyprinus*	1
10	950.1	LDB	07-Jul-09	River Carpsucker	*Carpiodes carpio*	24
10	950.1	LDB	07-Jul-09	Shortnose Gar	*Lepisosteus platostomus*	13
10	950.1	LDB	07-Jul-09	Smallmouth Bass	*Micropterus dolomieu*	1
10	950.1	LDB	07-Jul-09	Smallmouth Buffalo	*Ictiobus bubalus*	3
10	950.1	LDB	07-Jul-09	White Bass	*Morone chrysops*	2
10	950.1	LDB	07-Jul-09	White Crappie	*Pomoxis annularis*	1
10	950.1	LDB	07-Jul-09	White Perch	*Morone americana*	2
11	950.4	RDB	07-Jul-09	Bluegill	*Lepomis macrochirus*	6
11	950.4	RDB	07-Jul-09	Bullhead Minnow	*Pimephales vigilax*	1
11	950.4	RDB	07-Jul-09	Channel Catfish	*Ictalurus punctatus*	10
11	950.4	RDB	07-Jul-09	Flathead Catfish	*Pylodictis olivaris*	3
11	950.4	RDB	07-Jul-09	Freshwater Drum	*Aplodinotus grunniens*	6
11	950.4	RDB	07-Jul-09	Gizzard Shad	*Dorosoma cepedianum*	4
11	950.4	RDB	07-Jul-09	Grass Carp	*Ctenopharyngodon idella*	1
11	950.4	RDB	07-Jul-09	Hybrid Striper	*Morone saxatilis x M. chrysops*	1
11	950.4	RDB	07-Jul-09	Largemouth Bass	*Micropterus salmoides*	1
11	950.4	RDB	07-Jul-09	Longear Sunfish	*Lepomis megalotis*	1

11	950.4	RDB	07-Jul-09	River Carpsucker	*Carpiodes carpio*	8
11	950.4	RDB	07-Jul-09	Sauger	*Sander canadensis*	2
11	950.4	RDB	07-Jul-09	Shortnose Gar	*Lepisosteus platostomus*	5
11	950.4	RDB	07-Jul-09	Silver Chub	*Macrhybopsis storeriana*	2
11	950.4	RDB	07-Jul-09	Smallmouth Buffalo	*Ictiobus bubalus*	13
11	950.4	RDB	07-Jul-09	Spotted Bass	*Micropterus punctulatus*	1
11	950.4	RDB	07-Jul-09	Western Mosquitofish	*Gambusia affinis*	1
11	950.4	RDB	07-Jul-09	White Bass	*Morone chrysops*	1
11	950.4	RDB	07-Jul-09	Yellow Bass	*Morone mississippiensis*	9
12	952.2	RDB	07-Jul-09	Bigmouth Buffalo	*Ictiobus cyprinellus*	2
12	952.2	RDB	07-Jul-09	Black Buffalo	*Ictiobus niger*	1
12	952.2	RDB	07-Jul-09	Black Crappie	*Pomoxis nigromaculatus*	1
12	952.2	RDB	07-Jul-09	Bluegill	*Lepomis macrochirus*	1
12	952.2	RDB	07-Jul-09	Channel Catfish	*Ictalurus punctatus*	7
12	952.2	RDB	07-Jul-09	Freshwater Drum	*Aplodinotus grunniens*	8
12	952.2	RDB	07-Jul-09	Gizzard Shad	*Dorosoma cepedianum*	39
12	952.2	RDB	07-Jul-09	Hybrid Striper	*Morone saxatilis x M. chrysops*	10
12	952.2	RDB	07-Jul-09	Longnose Gar	*Lepisosteus osseus*	5
12	952.2	RDB	07-Jul-09	Morone Sp	*Morone sp*	1
12	952.2	RDB	07-Jul-09	River Carpsucker	*Carpiodes carpio*	2
12	952.2	RDB	07-Jul-09	Sauger	*Sander canadensis*	5
12	952.2	RDB	07-Jul-09	Saugeye	*Sander canandensis x S. vitreus*	1
12	952.2	RDB	07-Jul-09	Shortnose Gar	*Lepisosteus platostomus*	2
12	952.2	RDB	07-Jul-09	Silverband Shiner	*Notropis shumardi*	1
12	952.2	RDB	07-Jul-09	Smallmouth Buffalo	*Ictiobus bubalus*	18
12	952.2	RDB	07-Jul-09	Threadfin Shad	*Dorosoma petenense*	1
12	952.2	RDB	07-Jul-09	White Bass	*Morone chrysops*	13
12	952.2	RDB	07-Jul-09	Yellow Bass	*Morone mississippiensis*	21
13	953.3	RDB	07-Jul-09	Bluegill	*Lepomis macrochirus*	2
13	953.3	RDB	07-Jul-09	Bullhead Minnow	*Pimephales vigilax*	2
13	953.3	RDB	07-Jul-09	Channel Catfish	*Ictalurus punctatus*	9
13	953.3	RDB	07-Jul-09	Emerald Shiner	*Notropis atherinoides*	1
13	953.3	RDB	07-Jul-09	Flathead Catfish	*Pylodictis olivaris*	1
13	953.3	RDB	07-Jul-09	Freshwater Drum	*Aplodinotus grunniens*	4
13	953.3	RDB	07-Jul-09	Gizzard Shad	*Dorosoma cepedianum*	26
13	953.3	RDB	07-Jul-09	Grass Carp	*Ctenopharyngodon idella*	1
13	953.3	RDB	07-Jul-09	Hybrid Striper	*Morone saxatilis x M. chrysops*	1
13	953.3	RDB	07-Jul-09	Longnose Gar	*Lepisosteus osseus*	5
13	953.3	RDB	07-Jul-09	Mimic Shiner	*Notropis volucellus*	1
13	953.3	RDB	07-Jul-09	Morone Sp	*Morone sp*	4
13	953.3	RDB	07-Jul-09	River Shiner	*Notropis blennius*	3
13	953.3	RDB	07-Jul-09	Sauger	*Sander canadensis*	4
13	953.3	RDB	07-Jul-09	Shortnose Gar	*Lepisosteus platostomus*	10
13	953.3	RDB	07-Jul-09	Silver Carp	*Hypophthalmichthys molitrix*	1
13	953.3	RDB	07-Jul-09	Silverband Shiner	*Notropis shumardi*	3
13	953.3	RDB	07-Jul-09	Smallmouth Buffalo	*Ictiobus bubalus*	12
13	953.3	RDB	07-Jul-09	Spotfin Shiner	*Cyprinella spiloptera*	1
13	953.3	RDB	07-Jul-09	Spotted Bass	*Micropterus punctulatus*	2
13	953.3	RDB	07-Jul-09	White Crappie	*Pomoxis annularis*	1
13	953.3	RDB	07-Jul-09	Yellow Bass	*Morone mississippiensis*	6
14	954.2	LDB	07-Jul-09	Black Buffalo	*Ictiobus niger*	2
14	954.2	LDB	07-Jul-09	Blue Catfish	*Ictalurus furcatus*	1
14	954.2	LDB	07-Jul-09	Bluegill	*Lepomis macrochirus*	2
14	954.2	LDB	07-Jul-09	Carpiodes Sp	*Carpiodes sp*	1
14	954.2	LDB	07-Jul-09	Channel Catfish	*Ictalurus punctatus*	5

14	954.2	LDB	07-Jul-09	Common Carp	*Cyprinus carpio*	7
14	954.2	LDB	07-Jul-09	Flathead Catfish	*Pylodictis olivaris*	2
14	954.2	LDB	07-Jul-09	Freshwater Drum	*Aplodinotus grunniens*	24
14	954.2	LDB	07-Jul-09	Gizzard Shad	*Dorosoma cepedianum*	4
14	954.2	LDB	07-Jul-09	Grass Carp	*Ctenopharyngodon idella*	1
14	954.2	LDB	07-Jul-09	Hybrid Striper	*Morone saxatilis x M. chrysops*	2
14	954.2	LDB	07-Jul-09	Longear Sunfish	*Lepomis megalotis*	1
14	954.2	LDB	07-Jul-09	Longnose Gar	*Lepisosteus osseus*	5
14	954.2	LDB	07-Jul-09	Pumpkinseed	*Lepomis gibbosus*	1
14	954.2	LDB	07-Jul-09	River Carpsucker	*Carpiodes carpio*	28
14	954.2	LDB	07-Jul-09	Sauger	*Sander canadensis*	3
14	954.2	LDB	07-Jul-09	Shortnose Gar	*Lepisosteus platostomus*	16
14	954.2	LDB	07-Jul-09	Smallmouth Buffalo	*Ictiobus bubalus*	9
14	954.2	LDB	07-Jul-09	White Bass	*Morone chrysops*	2
14	954.2	LDB	07-Jul-09	White Crappie	*Pomoxis annularis*	2
14	954.2	LDB	07-Jul-09	Yellow Bass	*Morone mississippiensis*	1
15	961	LDB	07-Jul-09	Bluegill	*Lepomis macrochirus*	1
15	961	LDB	07-Jul-09	Channel Catfish	*Ictalurus punctatus*	2
15	961	LDB	07-Jul-09	Common Carp	*Cyprinus carpio*	2
15	961	LDB	07-Jul-09	Flathead Catfish	*Pylodictis olivaris*	1
15	961	LDB	07-Jul-09	Freshwater Drum	*Aplodinotus grunniens*	43
15	961	LDB	07-Jul-09	Gizzard Shad	*Dorosoma cepedianum*	3
15	961	LDB	07-Jul-09	Hybrid Striper	*Morone saxatilis x M. chrysops*	1
15	961	LDB	07-Jul-09	Longnose Gar	*Lepisosteus osseus*	4
15	961	LDB	07-Jul-09	Morone Sp	*Morone sp*	1
15	961	LDB	07-Jul-09	River Carpsucker	*Carpiodes carpio*	21
15	961	LDB	07-Jul-09	Shortnose Gar	*Lepisosteus platostomus*	10
15	961	LDB	07-Jul-09	Smallmouth Buffalo	*Ictiobus bubalus*	2
15	961	LDB	07-Jul-09	White Bass	*Morone chrysops*	2
16	970.3	LDB	08-Jul-09	Bluegill	*Lepomis macrochirus*	3
16	970.3	LDB	08-Jul-09	Channel Catfish	*Ictalurus punctatus*	6
16	970.3	LDB	08-Jul-09	Common Carp	*Cyprinus carpio*	1
16	970.3	LDB	08-Jul-09	Freshwater Drum	*Aplodinotus grunniens*	25
16	970.3	LDB	08-Jul-09	Gizzard Shad	*Dorosoma cepedianum*	12
16	970.3	LDB	08-Jul-09	Hybrid Striper	*Morone saxatilis x M. chrysops*	4
16	970.3	LDB	08-Jul-09	Largemouth Bass	*Micropterus salmoides*	2
16	970.3	LDB	08-Jul-09	Longear Sunfish	*Lepomis megalotis*	1
16	970.3	LDB	08-Jul-09	Longnose Gar	*Lepisosteus osseus*	1
16	970.3	LDB	08-Jul-09	Morone Sp	*Morone sp*	1
16	970.3	LDB	08-Jul-09	River Carpsucker	*Carpiodes carpio*	3
16	970.3	LDB	08-Jul-09	Sauger	*Sander canadensis*	10
16	970.3	LDB	08-Jul-09	Shortnose Gar	*Lepisosteus platostomus*	3
16	970.3	LDB	08-Jul-09	Smallmouth Buffalo	*Ictiobus bubalus*	3
16	970.3	LDB	08-Jul-09	White Bass	*Morone chrysops*	4
16	970.3	LDB	08-Jul-09	White Crappie	*Pomoxis annularis*	1
16	970.3	LDB	08-Jul-09	Yellow Bass	*Morone mississippiensis*	4
17	977.3	RDB	08-Jul-09	Atlantic Needlefish	*Strongylura marina*	1
17	977.3	RDB	08-Jul-09	Bigmouth Buffalo	*Ictiobus cyprinellus*	1
17	977.3	RDB	08-Jul-09	Black Buffalo	*Ictiobus niger*	1
17	977.3	RDB	08-Jul-09	Bluegill	*Lepomis macrochirus*	12
17	977.3	RDB	08-Jul-09	Channel Catfish	*Ictalurus punctatus*	60
17	977.3	RDB	08-Jul-09	Common Carp	*Cyprinus carpio*	1
17	977.3	RDB	08-Jul-09	Flathead Catfish	*Pylodictis olivaris*	3
17	977.3	RDB	08-Jul-09	Freshwater Drum	*Aplodinotus grunniens*	5
17	977.3	RDB	08-Jul-09	Gizzard Shad	*Dorosoma cepedianum*	15

17	977.3	RDB	08-Jul-09	Goldeye	*Hiodon alosoides*	3
17	977.3	RDB	08-Jul-09	Hybrid Striper	*Morone saxatilis x M. chrysops*	13
17	977.3	RDB	08-Jul-09	Largemouth Bass	*Micropterus salmoides*	7
17	977.3	RDB	08-Jul-09	Longear Sunfish	*Lepomis megalotis*	6
17	977.3	RDB	08-Jul-09	Longnose Gar	*Lepisosteus osseus*	1
17	977.3	RDB	08-Jul-09	Mooneye	*Hiodon tergisus*	1
17	977.3	RDB	08-Jul-09	River Carpsucker	*Carpiodes carpio*	27
17	977.3	RDB	08-Jul-09	Sauger	*Sander canadensis*	16
17	977.3	RDB	08-Jul-09	Shortnose Gar	*Lepisosteus platostomus*	4
17	977.3	RDB	08-Jul-09	Silver Carp	*Hypophthalmichthys molitrix*	3
17	977.3	RDB	08-Jul-09	Smallmouth Bass	*Micropterus dolomieu*	4
17	977.3	RDB	08-Jul-09	Smallmouth Buffalo	*Ictiobus bubalus*	5
17	977.3	RDB	08-Jul-09	White Bass	*Morone chrysops*	9
17	977.3	RDB	08-Jul-09	White Crappie	*Pomoxis annularis*	2
17	977.3	RDB	08-Jul-09	White Perch	*Morone americana*	3
17	977.3	RDB	08-Jul-09	Yellow Bass	*Morone mississippiensis*	7

Appendix C. Habitat survey data from the Open water pool.

Site #	River Mile	Bank	% Boulder	% Cobble	% Gravel	% Sand	% Fine	% Hardpan	% Other	Depth	% Submerged Vegetation	% Woody Cover	% Overhanging Vegetation	Landuse	Human Influence	Bank Profile
1	919.2	LDB	0.0	5.5	19.1	38.2	12.7	24.5	0.0	8.4	0.0	1.4	8.3	NF, I	ramps	Gradua
2	923.4	RDB	0.0	5.7	0.0	39.6	28.3	26.4	0.0	13.3	0.0	7.0	10.0	NF, A, R	mooring cells, ramps	Steep
3	924.7	RDB	0.0	0.0	0.0	41.5	30.5	28.0	0.0	8.9	0.0	3.8	1.0	NF, A	barges	Cliff
4	926.2	RDB	0.0	0.0	17.7	64.5	6.5	11.3	0.0	14.1	0.0	0.2	0.0	NF, A, R	none	Cliff
5	928.1	LDB	22.4	4.1	0.0	34.7	0.0	38.8	0.0	17.5	0.0	2.0	8.0	NF, A, R	mooring cells, ramps	Slope
6	935.6	RDB	0.0	0.0	21.3	36.3	0.0	42.5	0.0	10.4	0.0	2.4	0.0	NF, U, A	barges, mooring cells, boats/docks, ramps	Steep
7	938.6	RDB	0.0	14.2	50.8	27.5	4.2	3.3	0.0	7.1	0.0	3.2	0.0	NF, A, P	barges, mooring cells	Slope
8	939.9	LDB	0.0	0.0	4.8	21.7	73.5	0.0	0.0	6.4	0.0	1.2	0.0	NF, A, P	none	Slope
9	940.7	LDB	0.0	0.0	25.7	40.4	33.9	0.0	0.0	9.7	0.0	1.4	5.0	NF, A, P	none	Slope
10	950.1	LDB	0.0	0.0	21.2	47.5	31.4	0.0	0.0	8.8	0.0	0.4	5.0	NF, R, A	ramps	Steep
11	950.4	RDB	0.0	5.4	31.0	44.2	19.4	0.0	0.0	5.3	0.0	1.6	0.0	NF, R, A	ramps	Steep
12	952.2	RDB	0.0	0.0	19.6	33.6	46.7	0.0	0.0	8.5	0.0	1.8	5.0	NF, I, A	barges, mooring cells, ramps	Slope
13	953.3	RDB	2.7	8.0	25.0	25.9	38.4	0.0	0.0	6.1	0.0	2.6	5.0	NF, A, I	barges, mooring cells	Slope
14	954.2	LDB	0.0	1.7	24.3	38.3	35.7	0.0	0.0	6.4	0.0	0.4	2.0	NF, A, I	barges, mooring	Slope
15	961	LDB	0.0	0.0	2.9	37.5	59.6	0.0	0.0	6.4	0.0	1.0	0.0	NF, A, R	none	Slope
16	970.3	LDB	0.0	0.0	0.0	98.1	0.0	1.9	0.0	12.3	n/a	n/a	n/a	n/a	n/a	n/a
17	977.3	RDB	10.9	63.6	3.6	10.9	5.5	0.0	5.5	16.6	n/a	n/a	n/a	n/a	n/a	n/a

A = Agriculture, I = Industry, NF = Natural Forest, P = Pasture, R = Residential, U = Urban (Listed in order of prevalence.)

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

Site #	Rmi	Bank	pH	Temp(C)	Dissolved Oxygen(mg/L)	Conductivity	Secchi(in)
1	919.2	LDB	7.8	26.19	7.61	415	30
2	923.4	RDB	7.8	26.99	7.22	323	30
3	924.7	RDB	7.7	26.27	7.56	416	24
4	926.2	RDB	–	27.12	8.58	425	26
5	928.1	LDB	7.37	26.26	7.27	644	24
6	935.6	RDB	7.37	26.06	7.39	774	24
7	938.6	RDB	7.3	26.51	7.02	629	24
8	939.9	LDB	7.1	27.27	7.78	331	18
9	940.7	LDB	7.2	27.23	7.87	333	18
10	950.1	LDB	–	27.11	6.95	645	18
11	950.4	RDB	8.36	27.01	6.62	643	18
12	952.2	RDB	8.55	33.87	7.84	650	12
13	953.3	RDB	6.8	27.53	6.91	344	32
14	954.2	LDB	6.8	27.75	6.61	342	14
15	961	LDB	6.7	27.88	7.26	334	26
16	970.3	LDB	7.26	27.3	7.05	645	20
17	977.3	RDB	7.59	27.26	6.83	646	27

Appendix E. Water quality parameters analyzed from Open Water in 2009.

Site #	River Mile	Round	Ammonia	Chloride	Hardness	Nitrate-Nitrite	Phenolics	Sulfate	TKN	TOC	Phosphorus	TSS
1	919.2	1	0.05	18.0	180	1.17	68	0.654	3.77	0.070	18.6	1
		2	0.10	22.0	196	0.541	70	0.789	4.22	0.088	19.0	
		3	0.03	24	144	1.03	49	1.29	8.08	0.355	237	
2	923.4	1	0.04	12.0	124	0.599	44	0.661	3.81	0.085	18.0	2
		2	0.08	6.00	120	0.254	40	0.758	3.78	0.100	18.1	
		3	0.03	22	152	1.05	43	2.21	9.71	0.568	444	
3	924.7	1	0.05	16.0	172	1.20	82	0.655	3.96	0.101	28.6	3
		2	0.05	20.0	188	0.558	70	0.572	4.47	0.104	15.4	
		3	0.05	22	140	0.989	51	1.22	7.74	0.320	172	
4	926.2	1	0.05	16.0	180	1.21	40	0.605	3.89	0.093	26.4	4
		2	0.08	20.0	168	0.568	74	0.584	4.09	0.109	16.0	
		3	0.03	24	144	1.00	51	1.26	8.46	0.368	232	
5	928.1	1	0.04	16.0	172	0.924	68	0.890	3.50	0.094	32.8	5
		2	0.06	14.0	160	0.429	54	0.699	3.90	0.100	21.3	
		3	0.03	16	124	0.777	38	0.983	5.80	0.882	122	
6	935.6	1	0.05	16.0	180	1.22	70	0.827	3.65	0.084	26.0	6
		2	0.07	26.0	164	0.464	62	0.809	4.22	0.092	19.6	
		3	0.03	22	132	0.962	44	1.51	7.85	0.373	276	
7	938.6	1	0.05	12.0	136	0.704	54	0.536	3.34	0.077	19.4	7
		2	0.05	18.0	172	0.516	66	0.626	4.16	0.087	16.2	
		3	0.03	22	136	0.976	50	1.42	7.30	0.384	219	
8	939.9	1	0.04	16.0	168	0.964	52	0.625	3.39	0.126	64.2	8
		2	0.07	14.0	176	0.346	36	0.822	3.71	0.151	53.3	
		3	0.03	16	104	0.670	29	0.915	5.16	0.261	120	
9	940.7	1	0.04	14.0	160	0.950	56	0.725	3.70	0.127	59.6	9
		2	0.07	18.0	164	0.352	68	0.739	4.16	0.140	42.1	
		3	0.03	14	104	0.679	36	0.943	4.73	0.232	89.7	
10	950.1	1	0.04	16.0	160	0.842	48	0.714	3.94	0.175	83.4	10
		2	0.08	14.0	132	0.284	42	0.708	4.17	0.141	48.2	
		3	0.04	16	120	0.767	29	1.46	6.59	0.552	408	
11	950.4	1	0.05	12.0	156	0.849	48	0.608	3.94	0.083	25.2	11
		2	0.09	16.0	160	0.436	52	0.901	4.09	0.126	32.8	
		3	0.04	22	132	1.03	54	1.07	7.19	0.286	146	
12	952.2	1	0.05	12.0	144	0.831	42	0.666	4.02	0.106	35.6	12
		2	0.09	18.0	164	0.427	50	0.785	4.06	0.101	22.7	
		3	0.04	22	136	0.995	51	1.03	7.67	0.350	157	
13	953.3	1	0.06	16.0	152	0.821	50	0.644	3.92	0.148	40.8	13
		2	0.09	16.0	160	0.422	50	0.686	4.22	0.101	32.2	
		3	0.03	22	136	0.948	50	1.06	7.53	0.311	196	
14	954.2	1	0.06	12.0	148	0.829	48	0.760	4.96	0.284	112	14
		2	0.10	14.0	152	0.301	30	0.900	4.45	0.152	54.7	
		3	0.03	18	104	0.768	33	1.17	6.17	0.385	362	
15	961	1	0.05	14.0	144	0.828	64	0.889	4.69	0.292	224	15
		2	0.09	18.0	124	0.324	28	0.833	4.70	0.171	90.0	
		3	0.04	16	120	0.782	31	1.27	6.52	0.421	339	