Biological Programs 2004
Intensive Survey Results
Series 1
Report 3

A Biological Study of the Markland Pool of the Ohio River

Executive Summary

- In 2004, ORSANCO introduced the utilization of random probabilistic design for sampling fish communities in the Ohio River.
- The Ohio River was divided into assessment units based on the locations of navigational dams.
- Based on the random design, each assessment unit was assigned 15 sampling locations, with the exception of Markland Pool that was assigned 29 sampling locations.
- Once sampled, each site is graded as passing or failing to meet it aquatic life use designation.
- For an assessment unit to be considered in passing condition, more than 75% of the sites assessed must be in passing condition.
- In 2004, the sites sampled in the Markland pool failed to meet these criteria, with nearly 45% of sites failing.
- Therefore, the Markland pool would be reported as failing to meet its aquatic life use designation.
- This assessment, however, is questionable based on unusually high flows that occurred during the 2004 sampling seasons.
- Recommendations include the re-sampling of the Markland pool in 2005 and more intense analysis of flow data and its relationship to sampling outcome, in order to validate the results from 2004.

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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 could 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 (fish and macroinvertebrate 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 suited 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 (ORFIn) (Emery et al. 2003). The ORFIn is a collection of 13 attributes, or metrics, of the fish community that when compiled provide an accurate representation of the overall condition of the Ohio River 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.

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). It is ORSANCO's goal to implement this approach on the Ohio River.

An objective of this program is to apply the probability-based monitoring design to the Ohio River to assess individual pool reaches based on the fish population. In 2004, four pools in the Ohio River were surveyed: New Cumberland, Racine, Markland, and J.T. Myers. This report will focus on the fish assemblage, the performance of the ORFIn and the effectiveness of the probabilistic design in the Markland pool.

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 acts 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 Markland Pool

The Markland pool extends from Meldahl Lock and Dam (ORM 436.2) to Markland Lock and Dam (ORM 531.5), for a total length of 95.3 miles. The pool has a gradient drop of 0.4 feet per mile, averages 1594 feet wide and 31 feet deep. The pool is bordered by the states of Ohio and Kentucky throughout its upper reaches, then by Kentucky and Indiana below mile point 491. This pool receives water from the three major sub-basins of the Licking River, the Little Miami River and the Great Miami River. The large metropolitan area of Cincinnati, Ohio is located mid-pool, subjecting the pool to large amounts of urban runoff.

3.0 Methods

3.1 Survey Design

A random, probability-based survey design was used to select sampling site locations within a pool of the Ohio River. 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 Markland pool of the Ohio River from mile marker 436.2 (Meldahl Lock and Dam) to 531.5 (Markland Lock and Dam). The total linear extent of the target population was approximately 190.6 miles. The sample frame was generated using RF3 river double lines for the Ohio River and river mile coverages 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.

3.2 Index Period and Sampling Frequency

All sampling was conducted between July 1 and October 31, 2004. This sampling period reduces 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. Seventy-four electrofishing events were conducted on the Ohio River from July through October, 29 of which were in the Markland pool. Most sites were sampled exactly in the location generated from the design, but in

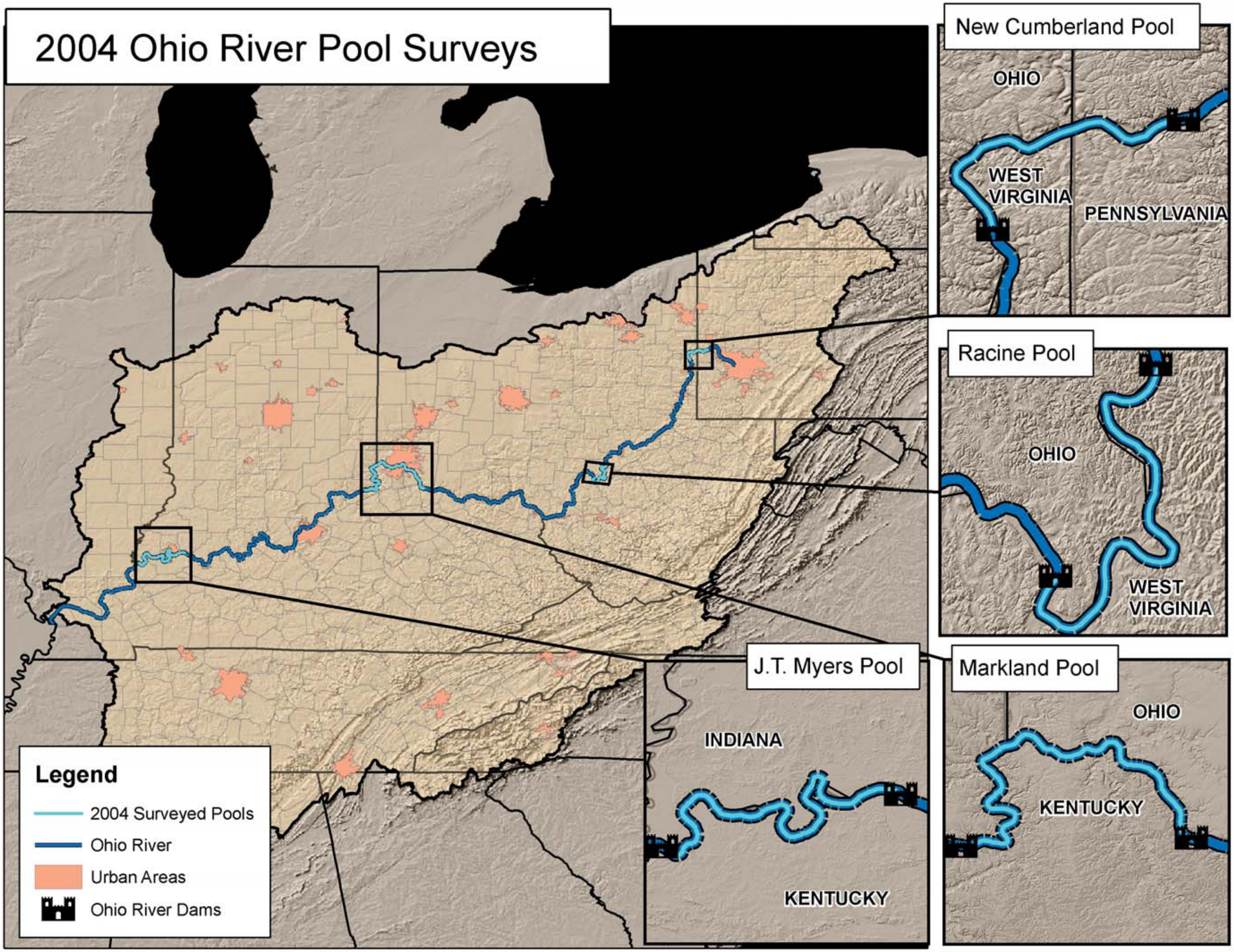

Figure 1. The Ohio River Basin and the four pools selected for 2004 sampling.

a few cases sampling zones were shifted (maximum of 500m up- or downstream) due to restricted access or unsafe sampling conditions.

3.3 Fish Collections

Standard collection techniques were employed throughout the surveys as described by ORSANCO's Standard Operating Procedures (1999). Fish were collected using boat electrofishing techniques at night because nighttime electrofishing typically yields samples of increased diversity and richness (Sanders 1992). One three-person crew collected samples from an 18-foot aluminum johnboat. The boat was equipped with a 5000-watt generator and a Smith-Root Type VI-A electrofishing unit. Sampling was conducted over a section of 500 meter near-shore habitat for a minimum of 2000 seconds (Gammon 1988). Time could vary depending upon the density of the habitat within a given zone. Stunned fish were captured with nets and placed into large, aerated tubs for processing. Each fish was weighed, measured, inspected for anomalies, and identified to lowest taxonomic level (species) before being returned to the water. Fish that could not confidently be identified in the field (e.g. minnows) were preserved in a ten percent formalin solution and identified in the laboratory.

3.4 Habitat Characterizations

Large rivers have distinct habitat zones, including unique microhabitats (Reash 1999). Therefore, extensive habitat surveys were conducted for each electrofishing zone. The surveys included thorough substrate and depth measurements, as well as woody cover estimates and riparian zone descriptions. Depth and substrate composition were measured at 66 points throughout each 500m zone. Six points along the shoreline were selected at 0, 100, 200, 300, 400 and 500m. From each of these points, depth was recorded at 3m intervals beginning at the shore/water interface and moving out away from the shore for 30m. Woody cover, which included submerged brush, logs, and stumps, was estimated visually. Based on the data collected, habitat information will be delineated into three classes: 'A', 'B', and 'C'. 'A' habitats tend to be deeper, with more course substrate such as cobble and gravel. 'C' habitats tend to be shallow and dominated by finer substrates such as sand. 'B' habitats tend to be a mix of several depths and substrates.

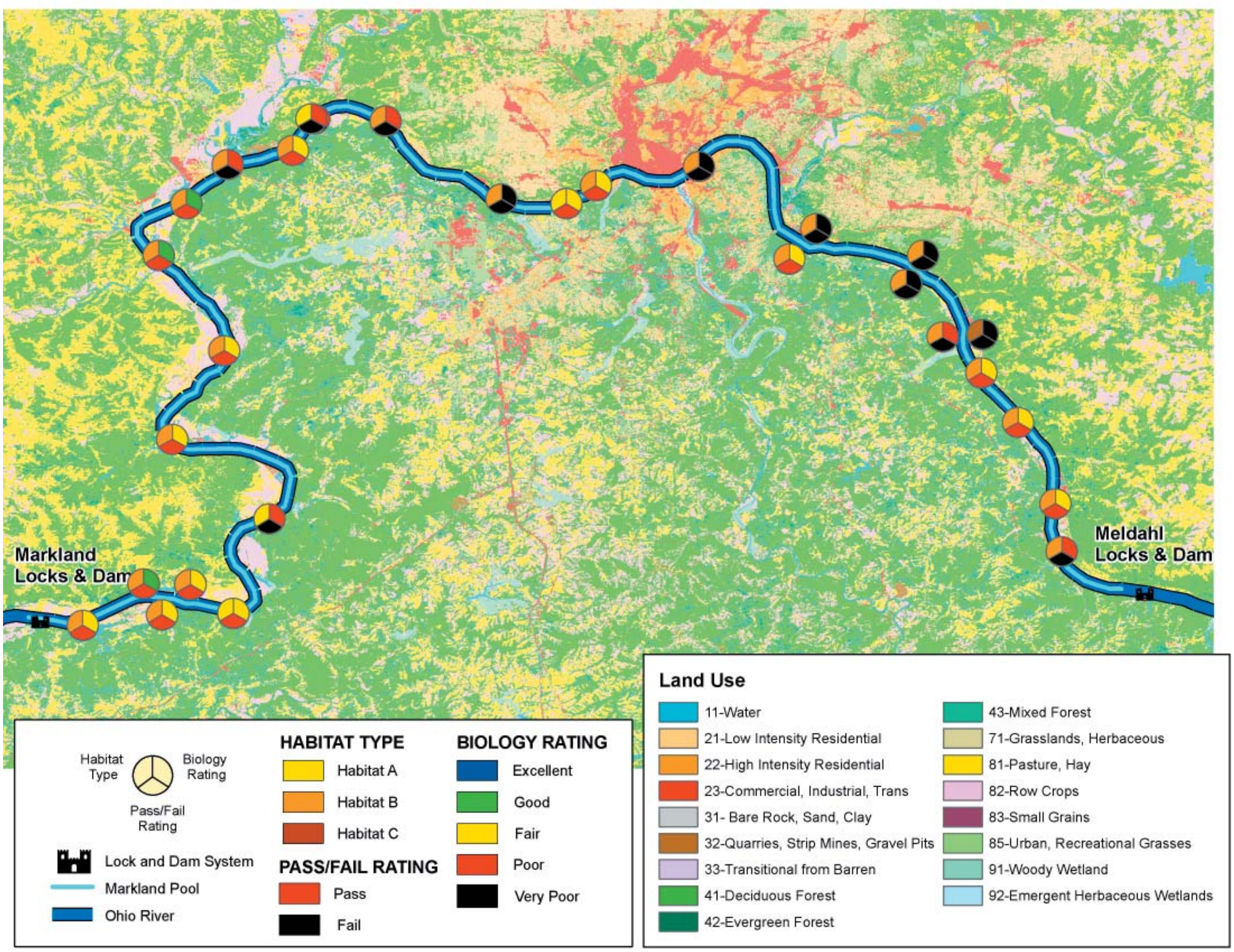

Figure 2. Results of sampling at 15 sites within the Markland pool.

This information is used by biologists to describe the influence of habitat on fish communities, and to determine if trends observed in populations are habitat induced or result from other factors.

3.5 Water Quality and Flow

Basic measures of water quality were collected at each sampling site prior to sampling. The following parameters were measured with a YSI meter: water temperature, pH, dissolved oxygen (DO), and conductivity. Secchi depth was measured using a standard Secchi disk. Flow data were obtained from the U.S. Army Corps of Engineers. These included daily average flows from the sampling station within or nearest to the sampled pool. Harmonic mean flow (HMF) values were determined by ORSANCO using 30-year means for the flow data obtained from the U.S. Army Corps of Engineers (ORSANCO 2003).

Typical 500 meter electrofishing reach.

3.6 Assessment

As described above, each electrofishing site is classified as containing 'A', 'B', or 'C' habitat characteristics. Based on this habitat designation, the longitudinal location of a given site, and the time of year (Julian day) the sample was collected, an expectation is developed for each electrofishing site in the form of a predicted ORFIn score. By comparing this expected ORFIn score to the observed ORFIn score, biologists are able to determine whether or not a given site is meeting its aquatic life use designation. Each site is then labeled as either passing or failing and given a condition rating of excellent, good, fair, poor, or very poor. Once each site has been designated as passing or failing, all sites sampled within the pool are aggregated. If upon aggregation more than 25% (within a particular confidence interval, see Appendix C) of the sites are deemed in failing condition, then the entire pool would be designated as being in failing condition, and therefore subject to further sampling.

4.0 Results

4.1 Fish Population

In 2004 crews collected fish population data (Appendix A) from 29 sites (Table 1) throughout the length of the Markland pool. These collections produced 47 taxa representing 11 families (Table 2). Among these taxa, there is one listed as threatened in KY, the American brook lamprey (*Lampetra appendix*) and one listed as threatened in OH, the river darter (*Percina shumardi*). One species is also listed as special concern in KY, the black buffalo (*Ictiobus niger*). The minnow family (Cyprinidae) was the most abundant within the collections made, comprising 31.1% of the total abundance captured (Figure 3). The drum family (Sciaenidae) and the herring and shad family (Clupidae) were the next most abundant groups making up 26.1% and 11.4% of the total abundance respectively (Figure 3). Specifically, abundance was dominated by the freshwater drum (*Aplodinotus grunniens*) and the emerald shiner (*Notropis atherinoides*), comprising 26.1% and 21.7% respectively (Figure 4). The gizzard shad (*Dorosoma cepedianum*) comprised 10.8% of samples collected, followed by temperate bass (*Morone sp*) comprising 10.4% (Figure 4). Raw fish population data for each site sampled are displayed in Appendix A.

ORSANCO crew conducting night-time electrofishing.

4.2 Metric Performance

Thirteen metrics were used to produce ORFIn scores at each electrofishing site (Emery et al. 2003). The performance of each metric and its score is listed in Table 3. The total number of native species ranged from eight to 20 per site, with an average of just over 13. The number of sucker species ranged from zero to six, averaging just fewer than three per site. The number of centrarchid species ranged from zero to six with an average of fewer than two. The number of great river species recorded for each site ranged from zero to four, averaging just over one per site. The number of intolerant species ranged from zero to four, averaging just over one per site. The percent tolerant individuals ranged from zero to 10.1%, averaging 1.9% per site. The percent simple lithophils ranged from zero to 48.5% with an average value of 20.9%. The percent non-native individuals ranged from zero to five

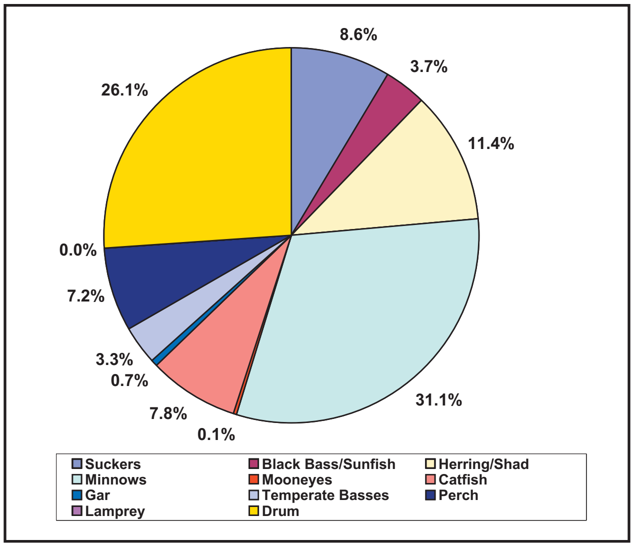

Figure 3. Fish composition by family in the Markland Pool

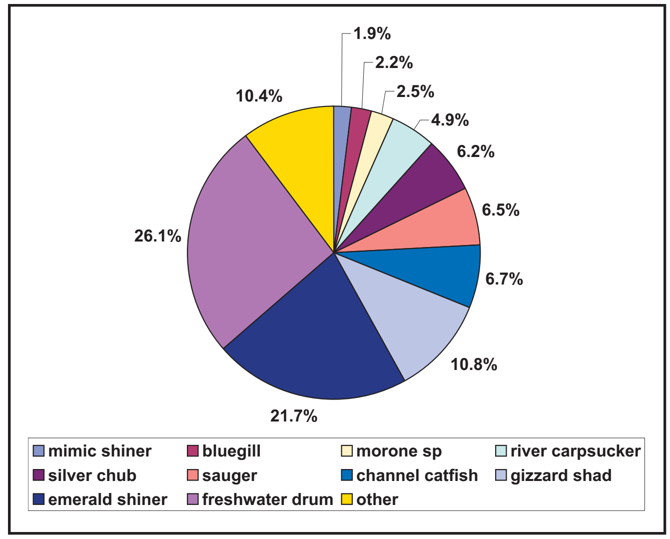

Figure 4. Species composition of fish sampled in the Markland Pool

Table 1. Electrofishing site list for the Markland pool, including habitat designation, ORFIn scores and status.

Rmi	Bank	Date	Latitude	Longitude	Habitat Type	Exp ORFIn	Obs ORFIn	Site Pass/Fail	Rating
440.3	RDB	09-Aug-04	38.824	84.228	B	33	25	FAIL	Poor
442.8	RDB	09-Aug-04	38.859	84.232	B	33	39	PASS	Fair
447.2	LDB	10-Aug-04	38.917	84.259	B	33	33	PASS	Fair
450.1	RDB	10-Aug-04	38.953	84.286	B	33	37	PASS	Fair
451.8	RDB	13-Oct-04	38.975	84.295	C	32	17	FAIL	Very Poor
452.4	LDB	13-Oct-04	38.983	84.302	B	33	29	FAIL	Poor
456.1	LDB	27-Oct-04	39.026	84.337	B	33	17	FAIL	Very Poor
456.4	LDB	27-Oct-04	39.029	84.342	B	33	17	FAIL	Very Poor
460.4	LDB	18-Aug-04	39.042	84.408	B	33	21	FAIL	Very Poor
460.8	LDB	18-Aug-04	39.044	84.414	B	33	33	PASS	Fair
469.2	LDB	11-Oct-04	39.102	84.489	B	33	21	FAIL	Very Poor
473.8	RDB	11-Oct-04	39.088	84.564	B	33	35	PASS	Fair
475.3	LDB	14-Oct-04	39.075	84.585	A	39	39	PASS	Fair
478	RDB	14-Oct-04	39.078	84.632	B	33	19	FAIL	Very Poor
484.3	RDB	28-Oct-04	39.135	84.715	B	33	31	FAIL	Poor
487.5	LDB	26-Oct-04	39.136	84.767	C	34	27	FAIL	Poor
487.6	RDB	26-Oct-04	39.136	84.769	A	39	33	FAIL	Poor
488.9	RDB	31-Aug-04	39.121	84.782	B	33	41	PASS	Fair
491.8	RDB	31-Aug-04	39.103	84.829	B	33	31	FAIL	Poor
494.2	LDB	11-Aug-04	39.075	84.859	B	33	43	PASS	Good
498.3	LDB	11-Aug-04	39.038	84.879	B	33	43	PASS	Good
503.9	RDB	12-Aug-04	38.969	84.832	B	33	41	PASS	Fair
509.6	LDB	12-Aug-04	38.905	84.869	B	33	35	PASS	Fair
517.3	LDB	04-Aug-04	38.848	84.799	A	39	35	FAIL	Poor
523.6	LDB	04-Aug-04	38.780	84.825	A	39	39	PASS	Fair
525.8	RDB	03-Aug-04	38.792	84.863	B	33	39	PASS	Fair
526.5	RDB	03-Aug-04	38.793	84.876	B	33	39	PASS	Fair
527	LDB	02-Aug-04	38.792	84.887	B	33	45	PASS	Good
529.9	LDB	02-Aug-04	38.771	84.933	B	33	33	PASS	Fair
LDb - Left Descending Bank						Obs ORFIn - Observed ORFIn Score			
RDB - Right Descending Bank						Exp ORFIn - Expected ORFIn Score			
Rmi - River Mile									

Table 2. Species collected in the Markland pool in the 2004 survey.

Family	Common name	Latin name	IN status	KY status	OH Status
Lepisosteidae	longnose gar	*Lepisosteus osseus*			
Lepisosteidae	shortnose gar	*Lepisosteus platostomus*			
Clupeidae	skipjack herring	*Alosa chrysochloris*			
Clupeidae	gizzard shad	*Dorosoma cepedianum*			
Clupeidae	threadfin shad	*Dorosoma petenense*			
Hiodontidae	goldeye	*Hiodon alosoides*			
Hiodontidae	mooneye	*Hiodon tergisus*			
Cyprinidae	common carp	*Cyprinus carpio*			
Cyprinidae	miss. silvery minnow	*Hybognathus nuchalis*			
Cyprinidae	striped shiner	*Luxilus chrysocephalus*			
Cyprinidae	emerald shiner	*Notropis atherinoides*			
Cyprinidae	mimic shiner	*Notropis volucellus*			
Cyprinidae	river shiner	*Notropis blennius*			
Cyprinidae	silver chub	*Macrhybopsis storeriana*			
Cyprinidae	bullhead minnow	*Pimephales vigilax*			
Catostomidae	quillback carpsucker	*Carpiodes cyprinus*			
Catostomidae	river carpsucker	*Carpiodes carpio*			
Catostomidae	smallmouth redhorse	*Moxostoma breviceps*			
Catostomidae	northern hog sucker	*Hypentelium nigricans*			
Catostomidae	blue sucker	*Cycleptus elongatus*	SC		
Catostomidae	smallmouth buffalo	*Ictiobus bubalus*			
Catostomidae	bigmouth buffalo	*Ictiobus cyprinellus*			
Catostomidae	black buffalo	*Ictiobus niger*		SC	
Ictaluridae	blue catfish	*Ictalurus furcatus*			
Ictaluridae	channel catfish	*Ictalurus punctatus*			
Ictaluridae	stonecat	*Noturus flavus*			
Ictaluridae	flathead catfish	*Pylodictis olivaris*			
Moronidae	morone sp	*Morone sp*			
Moronidae	hybrid striper	*Morone saxatilis x chrysops*			
Moronidae	white bass	*Morone chrysops*			
Centrarchidae	green sunfish	*Lepomis cyanellus*			
Centrarchidae	bluegill	*Lepomis macrochirus*			
Centrarchidae	orangespotted sunfish	*Lepomis humilis*			
Centrarchidae	longear sunfish	*Lepomis megalotis*			
Centrarchidae	redear sunfish	*Lepomis microlophus*			
Centrarchidae	smallmouth bass	*Micropterus dolomieu*			
Centrarchidae	largemouth bass	*Micropterus salmoides*			
Centrarchidae	spotted bass	*Micropterus punctulatus*			
Centrarchidae	white crappie	*Pomoxis annularis*			
Centrarchidae	black crappie	*Pomoxis nigromaculatus*			
Percidae	logperch	*Percina caprodes*			
Percidae	blackside darter	*Percina maculata*			
Percidae	slenderhead darter	*Percina phoxocephala*			
Percidae	river darter	*Percina shumardi*			
Percidae	saugeye	*Sander canandensis x vitreus*			
Percidae	sauger	*Sander canadensis*			
Sciaenidae	freshwater drum	*Aplodinotus grunniens*			

SC= Special Concern

T=Threatened

E=Endangered

percent and averaged 1.6%. The three feeding guild metrics of percent detritivores, percent invertivores and percent piscivores averaged 15.1%, 42.5% and 22.9% respectively. The number of DELT anomalies (deformities, eroded fins, lesions and tumors) ranged at each site from zero to four, averaging less than one per site. The CPUE metric (catch per unit effort) ranged from 41 to 173 individuals per site, averaging just over 114 individuals per site. Additionally, two of the 29 sites sampled were subjected to the low-end scoring mechanism built into the ORFIn that applies when a given site produces less than 50 individuals (Emery et al. 2003).

4.3 Habitat Surveys

Intensive habitat surveys at each of the 29 sampling locations (Figure 5), revealed fines and sand, comprising 40% and 28% respectively, dominated bottom substrate (Figure 6). Cobble and gravel substrates were also fairly common, comprising 13% and

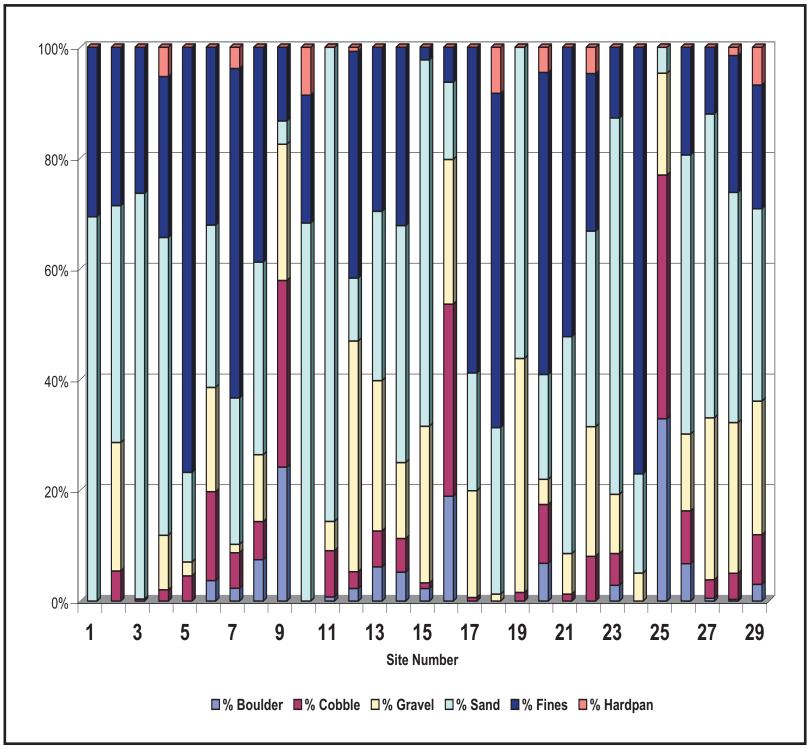

Figure 5. Sediment composition at each site.

12%, respectively (Figure 6). Boulder and hardpan substrates were the least common found, combining to comprise only seven percent of the sites sampled (Figure 6). The variables mentioned were compiled within a habitat index to give each site a habitat classification of A, B, or C (Table 1). The Markland pool was dominated by B habitats, which accounted for 77% of the samples (Figure 7). Habitat types A and C made up 13% and ten percent of the samples respectively (Figure 7). Woody cover was present in 21 of the 29 sites sampled; riparian land use was primarily agricultural and industrial, with the major city of Cincinnati, Ohio centrally located within the pool contributing substantial urban and storm-water run-off (Appendix B).

4.4 Water Quality and Flow

The basic water quality parameters of temperature, dissolved oxygen (DO), conductivity and pH were recorded at the electrofishing sites (Table 4). Additionally, secchi depth readings

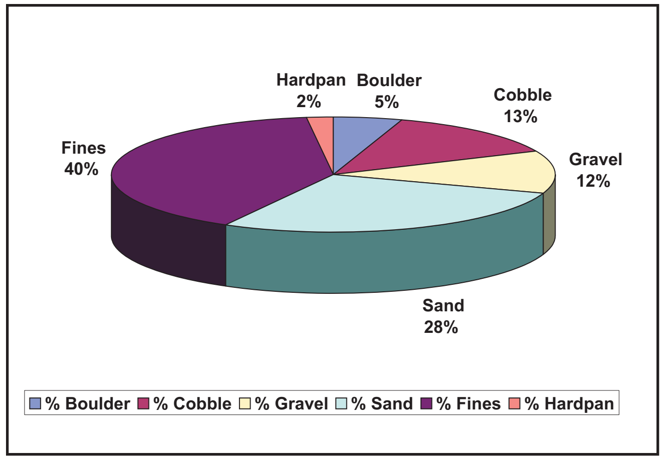

Figure 6. Substrate composition in the Markland pool.

were collected as a measure of turbidity before each electrofishing event. Temperature ranged from 15.8° C to 26.5° C and averaged 21.7°C. DO ranged from 7.03 mg/l to 12.31 mg/l with an average of 9.5 mg/l. Conductivity readings ranged from 240 µS/cm to 460 µS/cm and averaged 365.9 µS/cm. Readings for pH ranged from 7.16 to 7.59 and averaged 7.35. Secchi depth readings ranged from 25.4 cm to 106.6 cm and averaged 62 cm. The harmonic mean flow of the Ohio River used for this area is 45.3 kcfs based on stream-flow data analyzed by US Geological Survey (USGS). Flows for the Markland pool during our sampling season ranged from 22.07 % to 249.44 % HMF, averaging 125.3 % HMF (Figure 8).

4.5 Assessment of Condition

The data collected from each zone was subjected to the ORFIn (Emery et al. 2003). The performance of each metric can be seen in Table 3. The maximum score achieved by any site in this pool was 45 and the minimum was 17. An expected ORFIn was generated from least impacted site data (Emery et al. 2003) for each zone based on habitat type (Table 1). Observed ORFIn scores in the Markland pool averaged slightly over 32, nearly two points lower than expected. By comparing observed and expected ORFIn scores, ORSANCO assigns sites a classification of passing or failing, as well as condition ratings (Fig. 9). Of the 29 sites sampled in 2004, only 16

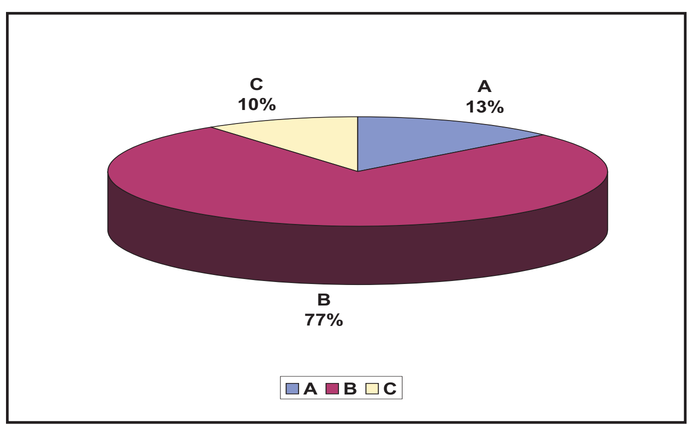

Figure 7. Habitat classes sampled in the Markland pool.

Table 3. ORFIn metrics and scores from the Markland pool 2004 survey

River Mile	Bank	# Indindividuals	# Individuals w/o gizzard shad and emerald shiners	# Individuals w/o gizzard shad, emerald shiners, exotics, hybrid, and tolerant species	# Species	# Species Score	# Suckers Score	# Sucker Species 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 ORFIn Score	Observed ORFIn Score	Site Score Pass/Fail
440.3	RDB	72	62	62	9	1	2	1	1	1	0	1	1	1	0.00	5	0.00	1	0.00	5	16.13	3	3.23	1	4.84	1	3	3	72	1	33	25	FAIL
442.8	RDB	139	100	98	18	3	4	3	2	1	1	1	4	3	0.00	5	19.00	3	2.00	5	1.00	5	39.00	3	28.00	3	2	3	137	1	33	39	PASS
447.2	LDB	88	67	62	12	3	3	3	1	1	1	1	2	1	0.00	5	13.43	1	7.46	3	4.48	5	31.34	3	11.94	1	0	5	83	1	33	33	PASS
450.1	RDB	80	57	55	16	3	2	1	2	1	2	3	3	3	0.00	5	10.53	1	3.51	5	7.02	5	19.30	1	21.05	3	0	5	78	1	33	37	PASS
451.8	RDB	27	24	18	9	1	3	3	1	1	0	0	0	0	8.33	1	20.83	1	25.00	1	29.17	1	4.17	1	33.33	1	0	5	21	1	32	17	FAIL
452.4	LDB	131	74	70	9	1	1	1	0	1	1	1	1	1	4.05	3	21.62	3	5.41	3	5.41	5	32.43	3	12.16	1	0	5	127	1	33	29	FAIL
456.1	LDB	40	34	33	8	1	0	0	0	0	2	3	1	1	2.94	1	35.29	1	2.94	1	2.94	1	11.76	1	26.47	1	0	5	39	1	33	17	FAIL
456.4	LDB	83	52	48	11	3	2	1	1	1	1	1	2	1	5.77	1	32.69	1	7.69	1	7.69	1	13.46	1	32.69	1	2	3	79	1	33	17	FAIL
460.4	LDB	276	42	41	11	3	1	1	0	0	3	3	0	0	2.38	1	38.10	1	2.38	1	4.76	1	9.52	1	47.62	1	0	5	275	3	33	21	FAIL
460.8	LDB	93	75	75	13	3	3	3	1	1	1	1	1	1	0.00	5	5.33	1	0.00	5	6.67	5	1.33	1	21.33	3	2	3	93	1	33	33	PASS
469.2	LDB	81	69	60	13	3	5	5	0	1	1	1	1	1	10.15	1	13.04	1	13.04	1	46.38	1	4.35	1	20.29	3	4	1	72	1	33	21	FAIL
473.8	RDB	90	58	53	12	3	4	3	0	1	3	3	2	1	0.00	5	24.14	3	8.62	1	8.62	5	6.90	1	32.76	3	1	5	85	1	33	35	PASS
475.3	LDB	90	55	54	10	3	1	1	0	1	4	5	1	1	0.00	5	32.73	3	1.82	5	3.64	5	16.36	1	25.45	3	0	5	89	1	39	39	PASS
478	RDB	75	50	47	10	3	1	1	1	1	2	3	2	1	0.00	0	32.00	1	6.00	1	0.00	0	2.00	1	46.00	1	0	5	72	1	33	19	FAIL
484.3	RDB	166	149	140	12	3	5	5	0	1	1	1	0	1	5.37	3	20.13	3	6.04	3	39.60	1	8.72	1	14.09	1	0	5	157	3	33	31	FAIL
487.5	LDB	279	65	63	9	1	1	1	0	1	1	1	1	1	1.54	5	6.15	1	1.54	5	1.54	5	26.15	3	12.31	1	0	5	277	3	28	33	PASS
487.5	LDB	95	88	83	11	3	3	3	0	1	1	1	0	1	1.14	5	1.14	1	5.68	3	42.05	1	0.00	1	12.50	1	0	5	90	1	34	27	FAIL
487.6	RDB	100	71	71	12	3	2	1	1	1	1	1	1	1	0.00	5	14.08	1	0.00	5	2.82	5	11.27	1	12.68	1	1	5	100	1	39	31	FAIL
487.6	RDB	135	91	86	15	3	5	5	2	1	0	1	2	3	4.40	3	24.18	3	5.49	3	23.08	1	5.49	1	26.37	3	1	5	130	1	39	33	FAIL
488.9	RDB	227	149	148	16	3	3	3	3	3	2	3	1	1	0.67	5	24.83	3	0.67	5	2.01	5	18.79	1	18.79	1	1	5	226	3	33	41	PASS

RDB – Right Descending Bank
LDB – Left Descending Bank
Centrarchid Species – black bass, sunfishes, crappie
Great River Species – fish expected to predominate in great rivers
Intolerant Species – species of fish with low pollution/disturbance tolerance
Tolerant Individuals – individuals with high pollution/disturbance tolerance

Simple Lithophils – reproductive grouping of fish species that are sensitive to substrate disturbance
Detritivore – feeding guild of fish species that feed primarily on detritus
Invertivore – feeding guild of fish species that feed primarily on invertebrates
Piscivore – feeding guild of fish species that feed primarily on fish
DELT – Deformities, Eroded fins, Lesions, and Tumors
CPUE – Catch Per Unit Effort

Table 3. ORFIn metrics and scores from the Markland pool 2004 survey

River Mile	Bank	# Indindividuals	# Individuals w/o gizzard shad and emerald shin-ers	# Individuals w/o gizzard shad, emerald shiners, exotics, hybrid, and tolerant species	# Species	# Species Score	# Suckers Score	# Sucker Species 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 ORFIn Score	Observed ORFIn Score	Site Score Pass/Fail
491.8	RDB	168	114	114	14	3	4	3	1	1	1	1	0	1	0.00	5	9.65	1	0.00	5	9.65	3	7.02	1	6.14	1	3	3	168	3	33	31	FAIL
494.2	LDB	152	100	100	16	3	4	3	0	1	2	3	2	3	0.00	5	47.00	5	0.00	5	11.00	3	42.00	3	16.00	1	0	5	152	3	33	43	PASS
498.3	LDB	92	74	74	20	5	5	5	4	3	2	3	3	3	0.00	5	24.32	3	0.00	5	21.62	1	16.22	1	25.68	3	0	5	92	1	33	43	PASS
503.9	RDB	230	200	198	11	3	1	1	2	1	1	1	0	1	0.50	5	48.50	5	1.00	5	0.50	5	19.00	1	41.00	5	0	5	228	3	33	41	PASS
509.6	LDB	265	233	232	16	3	3	3	4	3	1	1	0	1	0.00	5	16.31	1	0.43	5	6.01	5	11.16	1	17.60	1	2	3	264	3	33	35	PASS
517.3	LDB	227	112	110	17	3	3	3	5	3	1	1	2	3	0.89	5	8.04	1	1.79	5	20.54	1	35.71	3	14.29	1	3	3	225	3	39	35	FAIL
523.6	LDB	118	75	72	18	3	3	3	5	3	1	1	3	3	2.67	5	6.67	1	2.67	5	10.67	3	26.67	3	22.67	3	0	5	115	1	39	39	PASS
525.8	RDB	223	206	196	18	3	5	5	3	3	2	3	2	3	3.40	3	28.16	3	4.85	3	10.68	3	27.67	3	10.68	1	2	3	213	3	33	39	PASS
526.5	RDB	190	122	118	16	3	2	1	3	3	1	1	2	3	1.64	5	26.23	3	2.46	5	6.56	5	31.15	3	18.03	1	2	3	186	3	33	39	PASS
527	LDB	182	164	158	19	5	5	5	6	5	1	1	3	3	2.44	5	34.76	3	3.66	5	7.32	5	27.44	3	18.90	1	4	1	176	3	33	45	PASS

RDB – Right Descending Bank
LDB – Left Descending Bank
Centrarchid Species – black bass, sunfishes, crappie
Great River Species – fish expected to predominate in great rivers
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Table 4: Water quality data from the Markland pool 2004 survey.

Rmi	pH	Temp (C)	Dissolved Oxygen (mg/L)	Conductivity	Secchi (cm)
440.3	N/A	N/A	N/A	N/A	76.2
442.8	N/A	N/A	N/A	N/A	76.2
447.2	N/A	N/A	N/A	N/A	76.2
450.1	N/A	N/A	N/A	N/A	76.2
451.8	7.3	17.98	12	260	68.58
452.4	7.3	17.98	12	260	68.58
456.1	7.32	15.84	N/A	320	45.72
456.4	7.32	15.84	N/A	320	45.72
460.4	7.49	25.15	9.5	432	83.82
460.8	7.49	25.15	9.5	432	76.2
469.2	7.21	18.59	12.31	240	25.4
473.8	7.3	18.66	12	270	68.58
475.3	7.35	18.19	12	270	55.88
478	7.35	18.19	12	270	55.88
484.3	7.27	16.25	N/A	330	45.72
487.5	7.4	25.9	8.38	430	96.52
487.5	7.16	15.96	N/A	349	60.96
487.6	7.42	25.93	8.42	435	96.52
487.6	7.43	16.06	N/A	368	60.96
488.9	7.38	26.1	8.4	394	106.68
491.8	7.59	25.95	8.4	455	76.2
494.2	N/A	N/A	N/A	N/A	60.96
498.3	N/A	N/A	N/A	N/A	45.72
503.9	N/A	N/A	N/A	N/A	60.96
509.6	N/A	N/A	N/A	N/A	60.96
517.3	7.27	26.22	7.35	403	53.34
523.6	7.3	26.1	7.4	411	45.72
525.8	7.38	26.54	7.03	425	60.96
526.5	7.41	26.44	7.21	422	35.56
527	7.33	25.45	8.78	460	27.94
529.9	7.33	25.45	8.78	460	27.94

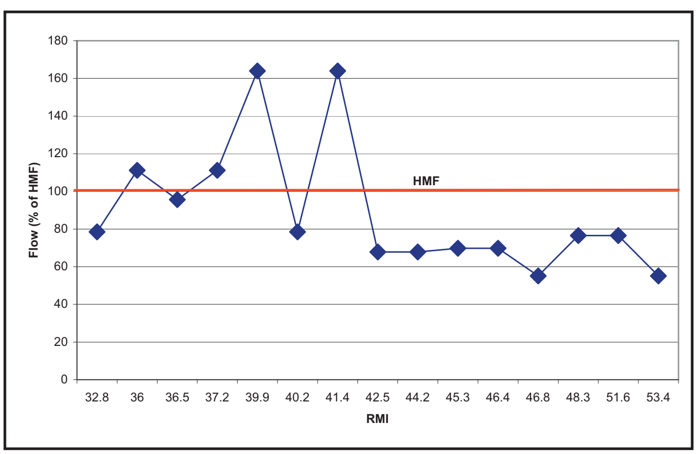

Figure 8. Daily flow for sampling events in the Markland pool.

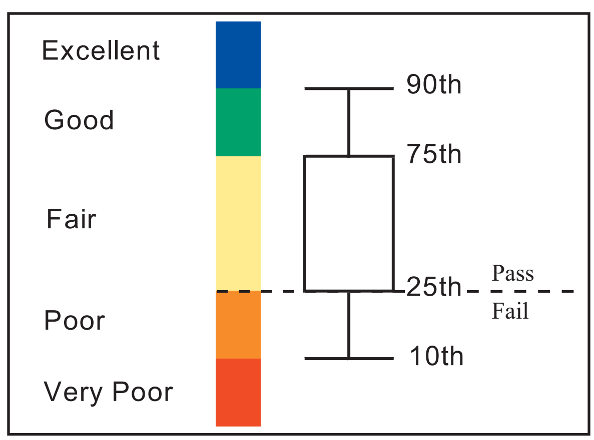

Figure 9. The approach used for assigning various condition ratings, using data from least impacted sites for each of the three habitat classes.

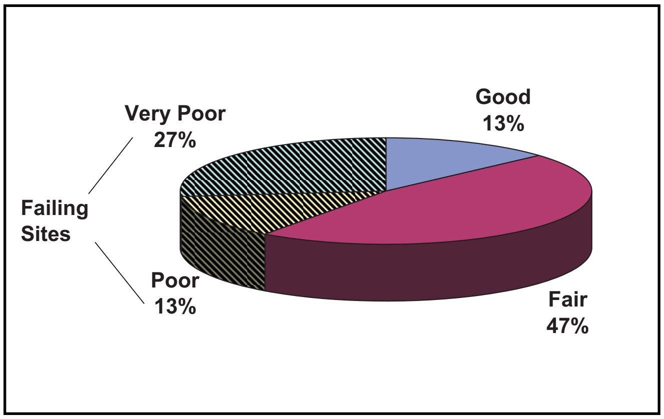

Figure 10. Condition of the Markland pool based on ORFIn scores at 29 sites.

received passing evaluations (Table 1). All sites sampled are assigned to one of the three habitat classes based on substrate composition. Sites determined to be 'least impacted' are used in lieu of true reference sites to develop expectations for each habitat class. For each of the three habitat classes, condition ratings are assigned based on statistical distribution of the data as shown in Figure 9. The 13 failing sites received condition ratings of either poor (seven) or very poor (six), while the 16 passing sites were classified as either fair (13) or good (three) (Figure 10).

5.0 Discussion

5.1 Fish Population

In general, the fish population appeared healthy, as evidenced by the lack of external anomalies present. Of the 38 species collected, two are currently listed as species of concern on state threatened and endangered lists. These species, the blue sucker (*Cycleptus elongatus*), listed as special concern in Indiana and the black buffalo (*Ictiobus niger*), listed as special concern in Kentucky, were collected in low numbers. Both of these species are dependant on large rivers, and we believe that they are more prevalent than our sampling indicates. The status of the species may be a function of the limitations imposed by our particular sampling methods. It is also important to note the low percentage of non-native species collected. Recent invasions of exotic species, such as the silver and big-head carp (*Hypophthalmichthys molitrix* and *H. nobilis*), which are becoming more dominant in the lower stretches of the Ohio River, have not become an issue in this pool.

5.2 Metric Performance

The "low-end" scoring technique (Emery et al. 2003) caused lower overall ORFIn scores at two sites. This was most notable in the number of centrarchid species metric and number of great river species metric, scoring a '0' on more than one occasion. Other metrics associated with low ORFIn scores include the number of intolerant species and catch per unit effort (CPUE), scoring a '1' at several sites. Based on the combined experience of the biologists conducting this survey and findings of Emery et al. (2003), higher species diversity was expected. It was anticipated that 15 sites concentrated within a relatively small spatial area and encompassing diverse habitat types would have produced higher abundance and diversity. Again, since this was the first application of a probability design and since unusual flow and weather conditions were encountered, it is not known which factor(s) singularly or in concert contributed to the observed conditions.

5.3 Habitat

Three distinct habitat classes, 'A', 'B', and 'C', have been identified on the Ohio River. 'A' habitats are generally deeper and dominated by more course substrates. Additionally, 'A' habitats generally score higher than 'B' or 'C'. Generally speaking, 'A' and 'B' habitats tend to support a more diverse and abundant fish population (unpublished data). In the Markland pool, 'B' habitats were dominant, with 'A' only slightly more abundant than 'C' habitat types. It would be expected that a pool dominated by more coarse substrates would produce more diverse fish populations and higher ORFIn scores. This leads researchers to believe that poor metric performance, and subsequently, poor ORFIn performance is not a function of poor habitat.

5.4 Water Quality and Flow

Parameters measured at each electrofishing site provided no explanation for the low ORFIn scores generated from the data at these sites. Values for temperature, DO, conductivity, and pH all fell into a range that would be considered normal or background for this section of the river. In addition, other monitoring activities conducted by ORSANCO provided no data that could account for low ORFIn scores being attributed to water quality. Flow values, in contrast, were elevated during the majority of the time period when sampling occurred. In some cases, flows reached values over twice that of the harmonic mean flow. Higher flows can cause several problems during sampling, including reducing capture efficiency, which could potentially reduce metric and index performance.

5.5 Assessment and Conclusions

The probabilistic design was implemented on the Ohio River to biologically assess a navigation pool. Hence, each navigational pool will serve as a distinct assessment unit (AU) and will be reported on individually in the 305(b) report to EPA.

The criteria for reporting on the condition of an AU are based on the performance of the ORFIn in relation to the habitat at the 15 (in the case of Markland pool, 29 sites) sites sampled in each unit. Each site, based upon its habitat classification, will have an "expected" ORFIn score generated. This score reflects how a particular site should perform. The observed score for each site within the AU is then compared to the expected score, with each site assigned as passing or failing. The sites are then aggregated and the AU is viewed as a percentage of sites passing and failing. If an AU is assessed and exhibits greater than 25%, + or – the estimated precision (see Appendix C), of the sites as failing, then the assessment is accepted as valid, and the AU would be reported as failing to meet the established aquatic life use designation. If the estimated precision was not achieved, then the AU would be considered unassessed and further sampling would be needed. Less than 25% failing sites would indicate that the AU meets the aquatic life use designation.

In the Markland pool, 40% of the sites sampled were deemed as failing, and therefore the pool would be reported as impaired and not supporting its designated aquatic life use criteria. However, in the case of Markland pool the estimated precision was not achieved, which would require further sampling. In the Markland pool 29 sites were sampled, allowing us to assess the use of additional sites and determine whether more sites sampled yields more accurate assessments. Although increasing the number of sample sites did increase the precision around the assessment, accuracy did not improve, with nearly equal percentage of failing sites regardless of the number of sites included in the assessment (Table 3). Even after 29 sites are sampled, Markland pool would remain classified as failing to attain its designated use criteria. Designating the AU as impaired leads to implications that would cause it to be included in the 305(b) report on stream condition required by the Clean Water Act (CWA). By reporting this stream segment as impaired, it would be placed on the list of impaired streams as directed by Section 303(d) of the CWA. This list has several categories for classifying streams based on the type of stressor involved and whether a specific stressor or pollutant can be identified as the source of the impairment. It is likely that the Markland pool AU would be placed on the 303(d) list in category 5a, which states that an impaired biological condition has been detected, but due to an unknown stressor or cause. Listing the AU in category 5a would require additional sampling efforts (e.g. intense chemical and/or physical habitat measurements) to identify the cause. If this follow-up work identifies the source of impairment as a pollutant then the AU would be reclassified as category 5c, which would require the development of a Total Maximum Daily Load (TMDL) for that stressor. If it is determined that impairment is caused by something other than a pollutant (e.g. habitat, natural, hydrologic, etc.), then the AU would be reclassified as category 4c, again requiring additional sampling to allow for a more precise determination of cause, without TMDL development.

An explanation for the high proportion of failing sites remains unclear. By design, the probability-based method eliminates human bias in the selection of sample sites. Sampling locations avoided in the past due to elevated human activity were sampled in this design. The Markland pool was designated as "fully supporting" the aquatic life use based on water quality. This assessment was determined using water quality data from bimonthly and dissolved metals sampling sites. Parameters such as DO, ammonia, and various dissolved metals have criteria that must be met to provide protection of warm water aquatic life. No violations of the aquatic life criteria for dissolved metals or bimonthly parameters were observed. This indicates that multiple factors other than water quality may be influencing fish populations and therefore affecting ORFIn scores.

As described above, water quality results did not indicate impairment during 2004, nor were any significant differences in parameters observed during this time period that could have led to a drastic change in the fish community. This suggests that based on ORSANCO's monitoring, water quality conditions did not affect the fish community in 2004. Explanations for low ORFIn scores other than water quality may include elevated flows and river stage that occurred during the 2004 sampling season. Higher stage and flow conditions are generally associated with higher turbidity levels, which can hinder effective fish collection. Swift flows can also adversely affect capture efficiency by making both boat operation and netting more difficult. Additionally, many species normally common in the mainstem seek refuge during these periods of high flow. Future sampling and more intense analysis of flow data may offer better explanations to the lower observed scores.

The probabilistic assessment design was successfully conducted in the Markland pool. The primary goals of this method were to adequately assess a given AU while minimizing resource expenditure, reduce or eliminate human bias and provide statistically valid results. Although further sampling is needed to confirm these results, this design appears to have accomplished these goals.

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