Biological Programs 2005
Intensive Survey Results
Series 2
Report 3

A Biological Study of the Markland Pool of the Ohio River

ORSANCO
Ohio River Valley Water Sanitation Commission
An Interstate Agency
Established June 30, 1948

Executive Summary

- In 2004, ORSANCO began using a probabilistic (random) design for monitoring fish communities in the Ohio River.

- The Ohio River was divided into 20 assessment units based primarily on the locations of navigational dams. Using the random design, each assessment unit was assigned 15 sampling locations.

- Once sampled, each site was graded as passing or failing. For an assessment unit to meet it aquatic life use designation, more than 75% of the sites assessed must be in passing condition.

- The Markland pool sites sampled in 2004 failed to meet these criteria, with only 59% of sites passing. Therefore, the Markland pool could have been reported to EPA as failing to meet its aquatic life use designation.

- The 2004 assessment was questioned based on unusually high flows that occurred during the sampling season. The 2004 Markland report recommended re-sampling the pool in 2005 with intense analysis of flow and its correlation to assessment results.

- In 2005, 100% of the sites assessed in Markland pool were in passing condition, which was contradictory to the 2004 assessment results.

- The flow analysis 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 efficiency and changes in fish behavior.

- After considering this relationship, the 2005 results were accepted over the 2004 results. Markland pool was reported as supporting its aquatic life use designation.

- Recommendations include moving to the next pool to be sampled while continuing to monitor flow and its influence on assessment results.

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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 that used electrofishing methods developed 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 incorporates 13 attributes, or metrics, of the fish community that when compiled together 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.

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 for its biological monitoring.

An objective of this program is to employ a probability-based monitoring design on the Ohio River in order to assess individual pool reaches based on the fish population. In 2005, the New Cumberland, Racine, Markland, and J.T. Myers pools were sampled as part of ORSANCO's normal monitoring. These four pools were selected because unusual river conditions (high rainfall and elevated water levels) occurred in 2004 when they were originally assessed. The higher than usual rainfall amounts and higher flows in the Ohio River in 2004 led biologists to question the accuracy of the data and the assessment results obtained in 2004. This report presents the data and assessment results obtained in 2005 and compares the 2005 results to the results from the 2004 assessment.

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 is 95.3 miles long, extending from Meldahl Locks and Dam (ORM 436.2) to Markland Locks and Dam (ORM 531.5) (Figure 2). 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 downstream of mile point 491. This pool receives water from three major sub-basins; the Little Miami River, Great Miami River and Licking River. The large metropolitan area of Cincinnati, OH is located mid-pool, subjecting the pool to large amounts of urban runoff.

A Bluegill collected by electrofishing

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 Markland pool of the Ohio River from mile marker 436.2 (Meldahl Locks and Dam) to 531.5 (Markland Locks 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 utilized to select all sampling locations. This survey design provided coordinates for 15 sampling sites in each of the selected pools. The data collected from these sites were used to make an initial assessment of the pool (see Section 3.6 and Appendix A).

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

3.2 Index Period and Sampling Restrictions

All sampling was conducted under the required conditions as described by Emery et al. (2003). This included sampling between July 1 and October 31 when water levels were within one meter of "normal flat pool" and Secchi depths were greater than 0.3m. 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). A sampling crew consisted of a three person team working from an 18-foot aluminum johnboat. Each boat was equipped with a 5000-watt generator and a Smith-Root Type VI-A electrofishing unit. Sampling was conducted over a 500m long section of near-shore habitat (shoreline out to a maximum distance of 30m or a depth of 20ft.) and was sampled for a minimum of 2000 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 weighed, measured,

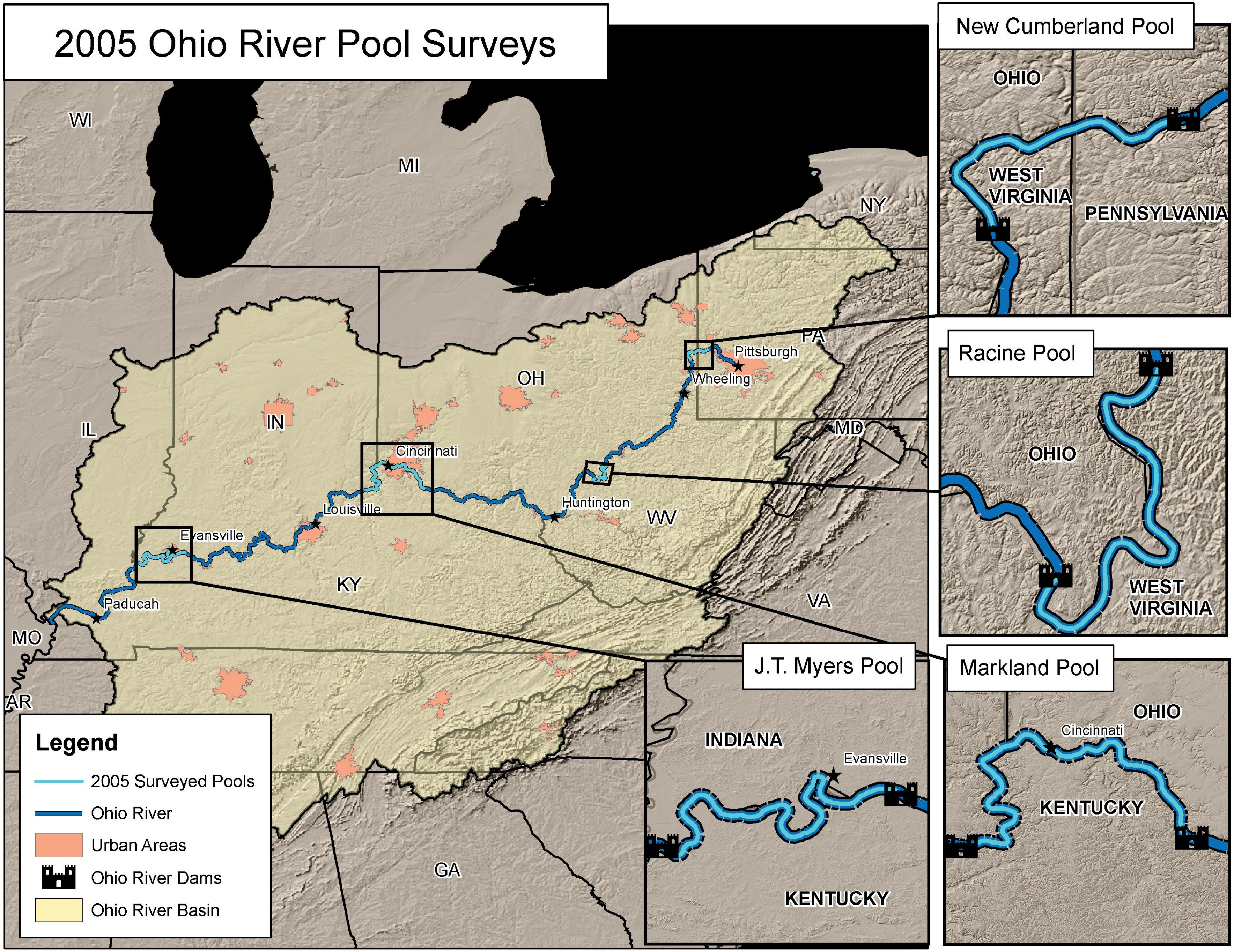

Figure 1. The Ohio River Basin and the four pools selected for 2005 sampling.

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 10% formalin solution and identified in the laboratory.

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 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. Using these data, each site, or electrofishing zone, was assigned to one of three existing classes of habitat: 'A', 'B', or 'C'. By assigning each sampling site to one of three 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 the presence of large substrates such as cobble and boulders. Sites that fall in habitat class 'C' are dominated by sand and other small substrates and habitat class 'B' describes sites that fall between 'A' and 'C' with a mix of large and small substrate materials.

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. 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).

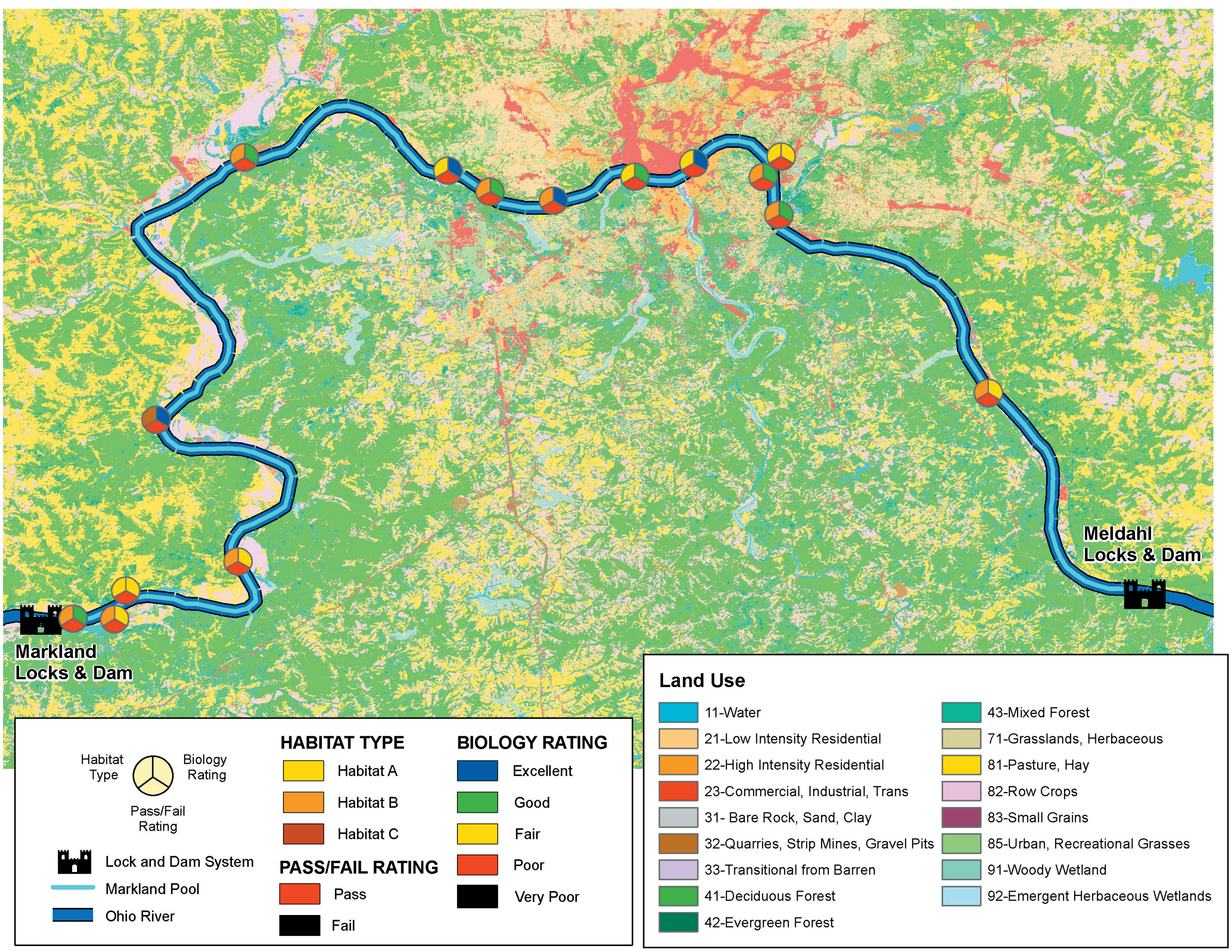

Figure 2. Results of sampling at 15 sites within the Markland pool.

3.6 Pool Assessment

In 2005, ORSANCO employed a probability-based sampling and assessment approach to provide a thorough assessment of biological condition. For the purpose of assessment, individual navigational pools served as the primary assessment units. Therefore, the Markland 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) and comparing observed ORFIn scores to habitat derived expectations for each site (Emery et al. 2003).

Typical 500 meter electrofishing reach.

The three distinct habitat classes ('A', 'B', and 'C') each exhibit different levels of ORFIn performance. Performance expectations for each habitat class were determined based on the statistical distribution of data (ORFIn scores) gathered from 'least impacted' (reference) sites within each habitat class. The 25th percentile value for each habitat class was established as the criterion for determining whether an individual site 'passes' (meets its aquatic life use designation) or 'fails' (does not meet its aquatic life use designation, Figure 3). Individual site scores were compared to expected values and the percentage of failing sites in the pool was then calculated. A precision estimate for the percentage of sites failing was also calculated (see Appendix A for a detailed explanation). The precision estimate was used to create a 90% confidence interval around the percentage of sites failing. The threshold for the pool assessment was set at 25% failure. If any part of the confidence interval contained 25%, the assessment required additional sampling. If the entire confidence interval was higher than 25%, the pool was assessed as failing. The pool passed the assessment if the whole confidence interval fell below 25%.

To further characterize the condition of each pool, sites were given individual condition ratings. These ratings were based on the same distribution of data from 'least impacted' sites used to determine expectations (Figure 3) and consisted of Excellent, Good, Fair, Poor and Very Poor. The 90th, 75th, 25th, and 10th percentiles were used as cutoff points for the different ratings. Any sites that were classified as Poor or Very Poor were also sites that failed to meet expectations.

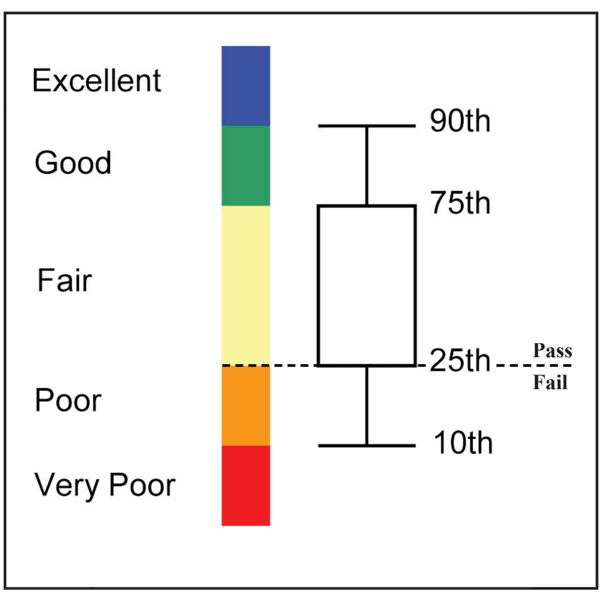

Figure 3: Illustration showing the approach used for assigning the various condition ratings.

4.0 Results

The results presented in Sections 4.1 to 4.5 are based on the 15 sites selected with the probability-based design for the 2005 assessment of the Markland pool. Three sites sampled in 2004 were resampled in 2005 and the results for these sites are included in 4.6 for a comparison of the two years.

4.1 Fish Population

In 2005, fish population data (Appendix B) were collected from 15 randomly selected locations throughout the length of the Markland pool (Table 1). These collections produced 48 taxa, representing 11 different families (Table 2). Three of these taxa are listed in one of the bordering states as either threatened or of special concern. In Ohio, these include the river darter (*Percina shumardi*), which is listed as threatened, and the river redhorse (*Moxostoma carinatum*) which is listed as a species of special concern. The river redhorse is also of special concern in Indiana and the black buffalo (*Ictiobus niger*) is of special concern in Kentucky. At the species level, the most abundant fish were freshwater drum (*Aplodinotus grunniens*) and gizzard shad (*Dorosoma cepedianum*), which comprised 26.9% and 26.4% of the catch respectively (Figure 4). The dominance of these

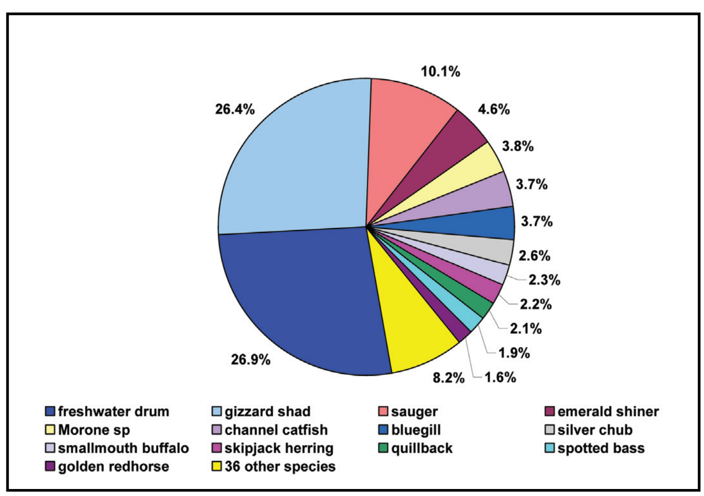

Figure 4. Species compositions of fish sampled in the Markland Pool.

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

River Mile	Bank	Date	Latitude	Longitude	Habitat Class	Exp. ORFIn	Obs. ORFIn	Result	Rating
449.1	LDB	10/18/05	38.939	84.281	B	33	45	Pass	Fair
462.6	RDB	10/17/05	39.067	84.432	B	33	47	Pass	Good
464.7	LDB	10/17/05	39.096	84.438	B	33	47	Pass	Good
465.5	RDB	08/15/05	39.104	84.436	A	39	47	Pass	Fair
469.3	RDB	08/15/05	39.104	84.494	A	39	55	Pass	Excellent
472.0	LDB	10/18/05	39.095	84.536	A	39	53	Pass	Good
475.9	RDB	08/31/05	39.078	84.595	B	33	51	Pass	Excellent
478.7	RDB	08/29/05	39.084	84.641	B	33	47	Pass	Good
480.6	RDB	08/29/05	39.099	84.671	A	39	59	Pass	Excellent
491.1	RDB	08/25/05	39.109	84.818	B	33	49	Pass	Good
508.5	LDB	08/24/05	38.918	84.873	C	26	49	Pass	Excellent
520.4	LDB	08/23/05	38.818	84.822	B	33	37	Pass	Fair
527.9	RDB	08/23/05	38.791	84.903	A	39	45	Pass	Fair
528.3	RDB	08/17/05	38.787	84.911	B	33	41	Pass	Fair
530.2	RDB	08/17/05	38.777	84.941	B	33	45	Pass	Good
473.8 Revisit	RDB	08/31/05	39.088	84.564	B	33	51	Pass	Excellent
487.5 Revisit	LDB	08/25/05	39.135	84.766	C	26	41	Pass	Fair
509.5 Revisit	LDB	08/24/05	38.906	84.870	B	33	41	Pass	Fair

Rmi – River mile
RDB – Right Descending Bank
LDB – Left Descending Bank
Exp ORFIn – Expected ORFIn Score
Obs ORFIn – Observed ORFIn Score

two species was very much reflected at the family level. The drum family (Sciaenidae) dominated in abundance, making up 26.9% of the total catch, followed by the shad and herring family (Clupeidae) which made up 28.6% of the catch (Figure 5).

4.2 Metric Performance

Thirteen metrics were used to calculate ORFIn scores for each electrofishing site (Emery et al. 2003). Each site's performance and scores for the ORFIn metrics are shown in Table 3. The number of native species collected at each site ranged from 14 to 27, with an average of 20.9 species per site. Most sites scored a five for the number of native species metric. The number of sucker species found at each site ranged from 2 to 8 and site scores covered the range of one, three, and five. The number of centrarchid species varied from 2 to 7 and metric scores also ranged from one to five. The number of great river species varied between one and four species per site, with scores mostly being either one or three. The one site with four great river species scored a five for that metric. There were between zero and eight intolerant species found at the sampled sites and scores covered the full range. All sites had less than 3.0 % tolerant individuals and scored a five for the tolerant individuals metric. The percentage of simple lithophils was between 13.7 and 43.2 % and sites scores covered the full range. All sites had below 5.7 % non-native individuals and all but one site scored a five. The percent detritivores ranged from 2.4 %, up to 18.4 % and scores were either three or five for all sites. The percent invertivores ranged from 3.1 % to 42.4 % with most sites scoring 1 for this metric. The percent piscivores ranged from 18.6 % to 55.0 % and metric scores ranged from 1 to 5. At most sites, no more than one DELT anomaly was found and these sites received a score of 5 for the DELT metric. However, at one site 12 DELTs were found and score of one was given. The CPUE (catch per unit effort) ranged from 122 to 837 individuals per site, with mostly scores of five.

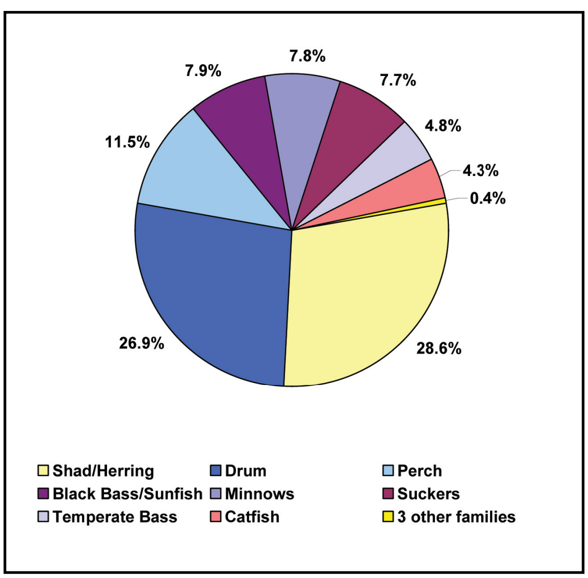

Figure 5. Fish composition by family in the Markland Pool.

4.3 Habitat Surveys

Intensive habitat surveys at each of the 15 sampling locations revealed that the most common bottom substrate in Markland pool was sand, which made up over 45% of the substrate encountered. Fines were the next most common substrate encountered at 23.6

Table 2. Species list for Markland pool in 2005.

Family	Scientific Name	Common Name	# Caught	OH	KY	IN
Lepisosteidae	*Lepisosteus osseus*	longnose gar	15			
Clupeidae	*Alosa chrysochloris*	skipjack herring	145			
Clupeidae	*Dorosoma cepedianum*	gizzard shad	1743			
Hiodontidae	*Hiodon tergisus*	mooneye	12			
Cyprinidae	*Cyprinus carpioa*	common carp	20			
Cyprinidae	*Cyprinella spiloptera*	spotfin shiner	2			
Cyprinidae	*Notropis atherinoides*	emerald shiner	303			
Cyprinidae	*Notropis volucellus*	mimic shiner	5			
Cyprinidae	*Notropis blennius*	river shiner	8			
Cyprinidae	*Macrhybopsis storeriana*	silver chub	171			
Cyprinidae	*Campostoma anomalum*	central stoneroller	1			
Cyprinidae	*Pimephales vigilax*	bullhead minnow	2			
Catostomidae	*Carpiodes cyprinus*	quillback	137			
Catostomidae	*Carpiodes carpio*	river carpsucker	47			
Catostomidae	*Carpiodes velifer*	highfin carpsucker	2			
Catostomidae	*Moxostoma breviceps*	smallmouth redhorse	31			
Catostomidae	*Moxostoma anisurum*	silver redhorse	19			
Catostomidae	*Moxostoma carinatum*	river redhorse	1	SC		SC
Catostomidae	*Moxostoma duquesnei*	black redhorse	1			
Catostomidae	*Moxostoma erythrurum*	golden redhorse	105			
Catostomidae	*Hypentelium nigricans*	northern hog sucker	14			
Catostomidae	*Ictiobus bubalus*	smallmouth buffalo	150			
Catostomidae	*Ictiobus niger*	black buffalo	2		SC	
Ictaluridae	*Ictalurus punctatus*	channel catfish	247			
Ictaluridae	*Pylodictis olivaris*	flathead catfish	38			
Atherinopsidae	*Labidesthes sicculus*	brook silverside	1			
Moronidae	*Morone sp*	morone sp	250			
Moronidae	*Morone saxatilis x M. chrysops*	hybrid striper	40			
Moronidae	*Morone americana*	white perch	5			
Moronidae	*Morone chrysops*	white bass	22			
Centrarchidae	*Lepomis cyanellus*	green sunfish	10			
Centrarchidae	*Lepomis gulosus*	warmouth	1			
Centrarchidae	*Lepomis macrochirus*	bluegill	245			
Centrarchidae	*Lepomis humilis*	orangespotted sunfish	1			
Centrarchidae	*Lepomis megalotis*	longear sunfish	53			
Centrarchidae	*Lepomis microlophus*	redear sunfish	2			
Centrarchidae	*Micropterus dolomieu*	smallmouth bass	28			
Centrarchidae	*Micropterus salmoides*	largemouth bass	56			
Centrarchidae	*Micropterus punctulatus*	spotted bass	123			
Centrarchidae	*Pomoxis annularis*	white crappie	1			
Centrarchidae	*Pomoxis nigromaculatus*	black crappie	2			
Percidae	*Etheostoma blennioides*	greenside darter	1			
Percidae	*Etheostoma caeruleum*	rainbow darter	8			
Percidae	*Etheostoma zonale*	banded darter	1			
Percidae	*Percina caprodes*	logperch	60			
Percidae	*Percina phoxocephala*	slenderhead darter	5			
Percidae	*Percina shumardi*	river darter	4	T		
Percidae	*Sander vitreus*	walleye	1			
Percidae	*Sander canadensis x S. vitreus*	saugeye	17			
Percidae	*Sander canadensis*	sauger	664			
Sciaenidae	*Aplodinotus grunniens*	freshwater drum	1778			

48 taxa were collected, representing 11 families

% (Figure 6). However, there was variation among the individual sites. The percentages of substrate variables were used to give each site a habitat classification of 'A', 'B', or 'C' (Table 1, Figure 7). The Markland pool was dominated by class 'B' habitats, which accounted for 60 % of the samples (Figures 7 and 8). There was one class 'C' habitat sampled in the pool, and the remaining third of the samples were classified as class 'A' habitats. Woody cover was present in 11 of the 15 sites sampled and riparian land use was mostly forested and residential (additional data in Appendix C).

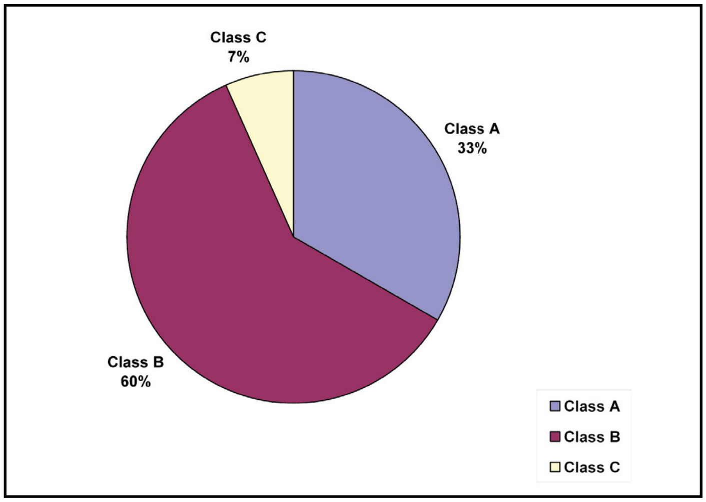

Figure 8. Habitat classification for Markland Pool.

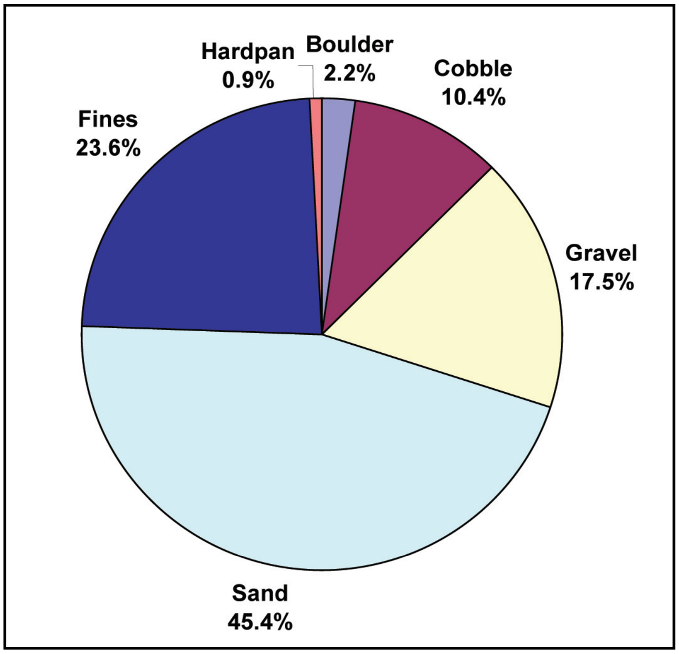

Figure 6. Average substrate composition of Markland Pool sites in 2005.

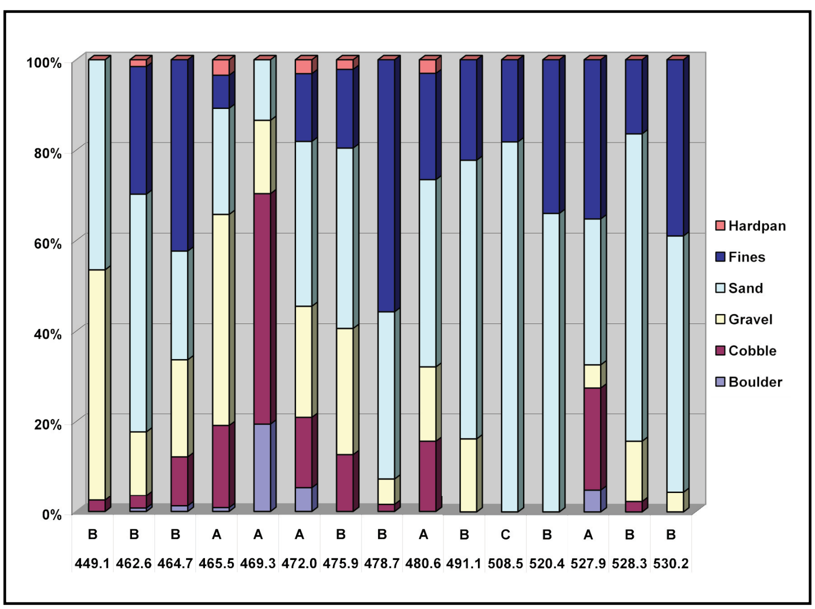

Figure 7. Substrate composition and habitat class at each of the 15 sites in Markland Pool.

4.4 Water Quality and Flow Conditions

Flow conditions were generally stable throughout the 2005 sampling period and river levels were at or below normal. There were very few rain events to cause increases in river flow and water levels throughout the Ohio River valley (Figures 9 and 10). The HMF for this part of the river is 45.3 kcfs and most sampling was conducted between 34% and 91% of the HMF (Figure 11). There was one sampling event conducted when the flow was elevated to 230% of the HMF. Measurements of water quality parameters did not reveal any unusual or poor water conditions present at the time of sampling (Appendix D). Secchi depths at the time of sampling ranged from 15 to 58 inches.

4.5 Assessment of Condition

ORFIn scores were calculated for each of the sites sampled. The maximum score achieved by any site in this pool was 59 and the minimum was 37. By comparing observed and expected ORFIn scores, ORSANCO assesses each site as either passing or failing (Table 3). All 15 sites sampled in 2005 scored higher than the minimum expected scores and received passing evaluations (Table 1, Figure 12). With 100% of the sites passing, the pool was also assessed as passing. Four sites received an excellent condition rating, six sites were found to be in good condition and five were in fair condition (Figure 13).

4.6 Revisits

The three sites that were sampled in both years scored between 6 and 16 points higher in 2005 than in 2004 (Table 4, Figure 14). In 2004, all of these sites met the expectation, but were only in fair condition. In 2005 the scores were higher and one site improved from a condition rating of fair to excellent. The 2005 scores for the revisit sites were similar to scores achieved by the other sites sampled in 2005 (Table 1).

Table 3. ORFIn metrics and scores from the Markland Pool 2005 study.

River Mile	Bank	# Individuals	# Individuals w/o gizzard shad and emerald shiners	# Individuals w/o gizzard shad, emerald shiners, and exotic, hybrid, and tolerant species	# Native Species	Native Species Score	# Sucker Species	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	# of DELTs	DELTs Score	CPUE	CPUE Score	Expected ORFIn Score	Observed ORFIn Score	Site Score Pass/Fail
449.1	LDB	354	60	59	14	3	4	3	2	1	1	1	3	3	0.0	5	41.7	5	1.7	5	13.3	3	3.3	1	55.0	5	0	5	353	5	33	45	Pass
462.6	RDB	310	229	228	19	5	4	3	2	1	3	3	3	3	0.4	5	37.1	5	0.4	5	4.8	5	17.0	1	29.7	3	1	5	309	5	33	47	Pass
464.7	LDB	440	192	190	19	5	3	3	3	3	2	3	2	1	1.0	5	43.2	5	1.0	5	4.2	5	18.2	1	36.5	3	0	5	438	5	33	47	Pass
465.5	RDB	287	209	205	20	5	4	3	4	3	3	3	4	3	1.0	5	38.8	5	1.0	5	2.4	5	14.8	1	37.3	3	3	3	283	3	39	47	Pass
469.3	RDB	126	101	97	25	5	6	5	6	5	2	3	5	5	3.0	5	28.7	3	3.0	5	6.9	5	24.8	3	39.6	5	0	5	122	1	39	55	Pass
472.0	LDB	411	287	283	27	5	6	5	4	3	4	5	8	5	0.3	5	28.2	3	1.4	5	3.5	5	19.9	1	18.8	1	0	5	407	5	39	53	Pass
475.9	RDB	844	443	436	23	5	7	5	3	3	3	3	3	3	0.0	5	20.5	3	1.6	5	4.1	5	6.1	1	22.3	3	1	5	837	5	33	51	Pass
478.7	RDB	414	219	210	18	3	6	5	2	1	2	3	3	3	0.0	5	35.2	3	4.1	5	3.2	5	16.0	1	30.1	3	1	5	405	5	33	47	Pass
480.6	RDB	638	374	365	29	5	8	5	6	5	2	3	6	5	0.5	5	36.9	5	2.1	5	6.4	5	27.8	3	27.3	3	0	5	629	5	39	59	Pass
491.1	RDB	520	403	380	26	5	6	5	5	3	3	3	5	5	0.7	5	21.8	3	5.7	3	18.4	3	7.4	1	33.7	3	1	5	497	5	33	49	Pass
508.5	LDB	455	386	381	20	5	5	5	3	3	2	3	1	1	0.0	5	20.5	3	1.3	5	8.0	5	3.1	1	28.5	3	1	5	450	5	26	49	Pass
520.4	LDB	778	688	683	18	3	4	3	4	3	1	1	1	1	0.6	5	15.7	1	0.3	5	11.3	3	6.3	1	18.6	1	0	5	773	5	33	37	Pass
527.9	RDB	285	278	273	19	5	2	1	7	5	2	3	2	3	1.4	5	13.7	1	1.1	5	2.9	5	42.4	3	27.0	3	3	3	280	3	39	45	Pass
528.3	RDB	416	385	378	17	3	4	3	6	5	1	1	1	1	1.3	5	19.0	3	1.8	5	11.4	3	23.1	3	26.8	3	12	1	409	5	33	41	Pass
530.2	RDB	322	300	297	19	5	4	3	7	5	1	1	0	1	1.0	5	15.0	1	0.7	5	8.3	5	29.3	3	31.0	3	2	3	319	5	33	45	Pass
473.8 Revisit	RDB	900	682	676	23	5	7	5	3	3	3	3	3	3	0.1	5	26.2	3	0.7	5	9.5	5	5.4	1	25.1	3	1	5	894	5	33	51	Pass
487.5 Revisit	LDB	258	224	217	17	3	3	3	3	3	3	3	1	1	0.0	5	16.1	1	3.1	5	6.7	5	8.5	1	27.7	3	0	5	251	3	26	41	Pass
509.5 Revisit	LDB	649	367	361	15	3	2	1	3	3	3	3	1	1	0.3	5	12.3	1	1.6	5	7.9	5	4.9	1	21.8	3	0	5	643	5	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

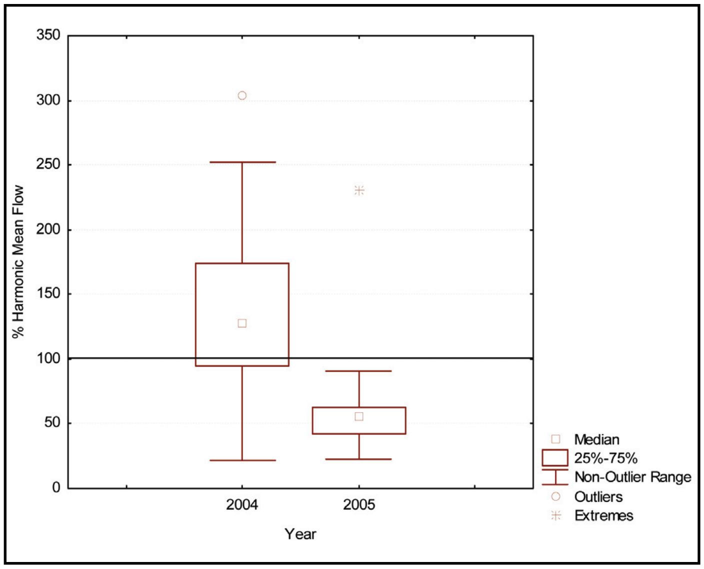

Figure 9. Daily harmonic mean flows (HMF) near sampling locations over the 2004 and 2005 sampling seasons.

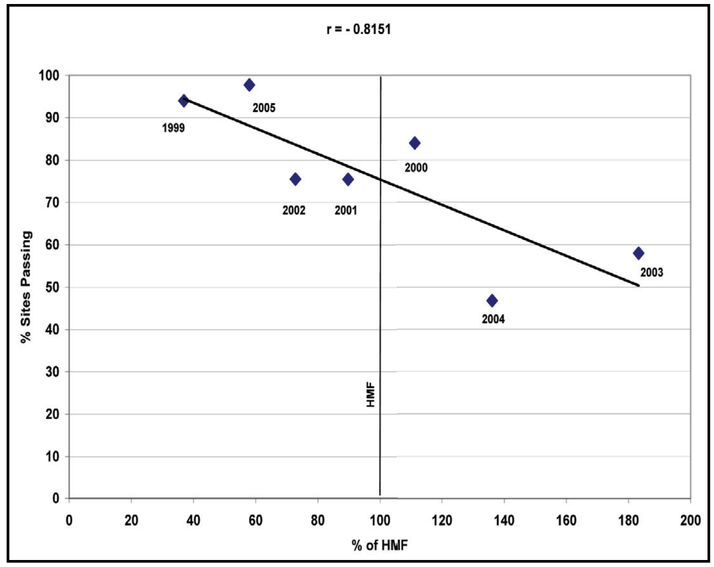

Figure 10. Correlation of harmonic mean flow (HMF) and percentage of sites passing for different years of sampling in multiple pools.

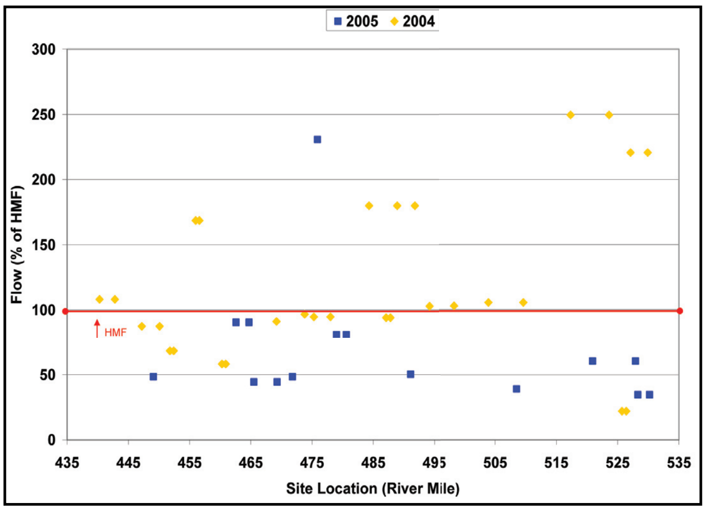

Figure 11. Flows relative to harmonic mean flow (HMF) on day of sampling for 2004 and 2005 in Markland pool.

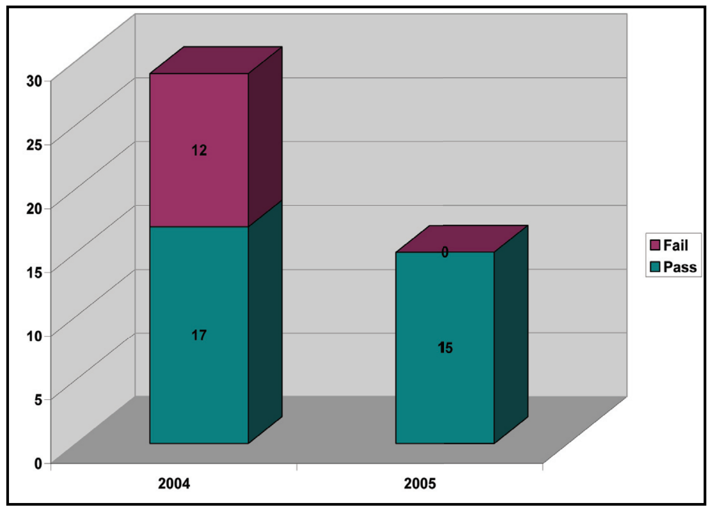

Figure 12. Comparison of site assessment results for 2004 and 2005.

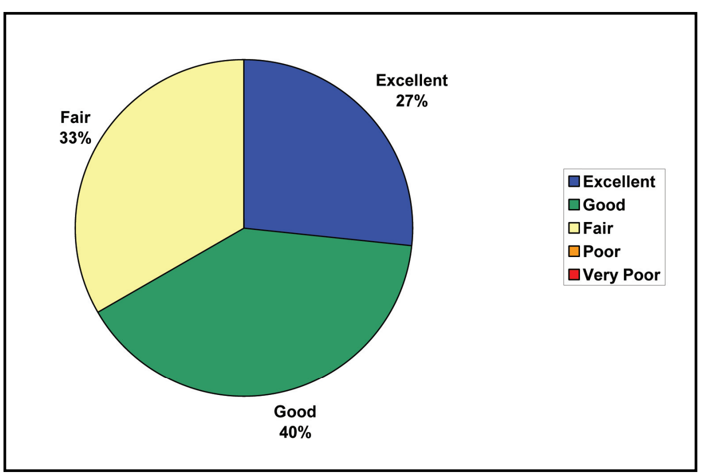

Figure 13. Condition ratings for sites in Markland Pool, based on ORFIn scores at 15 sites in 2005.

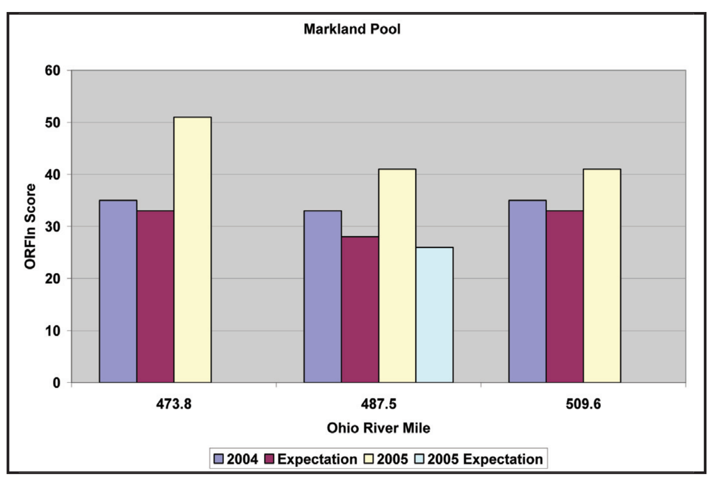

Figure 14. ORFIn scores and expectations for sites sampled in 2004 and 2005. The site at river mile 487.5 is a class 'C' habitat, therefore the expectation changes depending on the date sampled.

Table 4. Comparison of sites sampled in Markland Pool in both 2004 and 2005

Year	River Mile	Bank	Date	Latitude	Longitude	Secchi (in)	Habitat Class	Exp. ORFIn	Obs. ORFIn	Site Pass/ Fail	Condition Rating
2004	473.8	RDB	10/11/04	39.088	84.564	27	B	33	35	Pass	Fair
2005	473.8	RDB	08/31/05	39.088	84.564	12	B	33	51	Pass	Excellent
2004	487.5	LDB	09/07/04	39.135	84.766	38	C	27.7	33	Pass	Fair
2005	487.5	LDB	08/25/05	39.135	84.766	51	C	26	41	Pass	Fair
2004	509.6	LDB	08/12/04	38.906	84.870	24	B	33	35	Pass	Fair
2005	509.5	LDB	08/24/05	38.906	84.870	43	B	33	41	Pass	Fair

5.0 Summary and Discussion of 2004 Markland Pool Results

This section provides a concise summary of the results from 2004 for the sake of comparison to 2005. These results are fully explained in the report "A Biological Study of the Markland Pool of the Ohio River (2004)" (ORSANCO 2006).

5.1 Fish Population

In 2004, 29 sites were sampled in the Markland Pool. The catch was lead by the minnow (Cyprinidae) family with emerald shiner (*N. atherinoides*) being the most common minnow and the second most common species overall. The freshwater drum (*Aplodinotus grunniens*) was the most common species and the drum (Sciaenidae) family was the second most dominant. At many of the sites sampled, the number of fish caught was below normal. At five of the 29 sites the numbers were low enough to cause the sites to be low-end scored (see Emery et al. 2003), which penalizes sites for not supporting a large enough fish population.

5.2 Metric Performance

Generally, the sites scored lowest on the number of centrarchid species, intolerant species and great river species metrics. The number of DELT anomalies was the highest scoring metric throughout the pool, followed number of tolerant individuals and non-native species.

5.3 Habitat Surveys

The habitat surveys showed that fines (40%) were the most common bottom substrate, followed by sand at 28%. Most (77%) of the sites were class 'B' habitats. However, both 'A' and 'C' habitats were present in the pool.

5.4 Water Quality and Flow Conditions

In 2004 multiple heavy rainfall events in the spring and summer caused both the water levels and flow volume to become elevated. These were sustained at moderately high levels throughout the sampling season and resulted in much higher flow volumes in 2004 than are normally encountered (Figure 10). Despite the higher flows and water levels, sampling was only conducted under the conditions required by Emery et al. (2003). No unusual measurements for temperature, pH, DO, and conductivity were recorded in 2004. Secchi depths ranged from 10 to 42 inches.

5.5 Assessment of Condition

In 2004, only 17 sites of the 29 sites met expectations (passed) and only a few sites received a rating higher than fair. With 59% of the sites passing, the Markland pool was assessed as failing to meet its aquatic life use designation. However, concerns were raised that the data may have been influenced by the higher than normal flows seen in 2004, and more monitoring in Markland pool was recommended for 2005.

6.0 Discussion

6.1 Fish Population

The collections from Markland pool showed several important differences between 2004 and 2005. The 2005 survey results show higher diversity and abundance than was seen in the 2004 surveys. One more species was recorded in 2005 even though only half the number of sites was sampled. The average number of individuals caught in 2005 was about three times higher than that from 2004. Each year's catch showed differences regarding fish species and families. For example, in 2004 the minnow family was the most common, but it was only the fifth most common family in 2005. The fish population would not normally be expected to change so much within one year's time and it is unlikely that these differences reflect an actual change in the overall fish population. It seems more likely that something affected the sampling efficiency and accuracy in 2004. It is hypothesized that the lower flow conditions in 2005 were more conducive to efficient sampling and allowed for a better representation of the fish population than the conditions of 2004. It is also suspected that fish move to different locations during periods of higher flow, similar to seeking refugia in the winter (Garvey et al. 2003). These movements resulted in a biased catch in 2004.

6.2 Metric Performance

The higher diversity and abundance of the 2005 catch resulted in metric scores that were generally higher than the 2004 metric scores. The most significant improvement was seen in the CPUE metric, which went from being one of the lowest scoring metrics to one of the highest. This was a direct result of the increased numbers seen in 2005. The percent tolerant individuals, percent non-native species and number of DELTs remained as high scoring metrics. The major exception to increased scores was for the percent invertivores metric, which produced scores comparable to 2004. Although the number of fish per site nearly tripled, the percentage of invertivores remained about the same through out the pool. The low scoring metrics were the percent invertivores and number of great river species. No specific factors contributing to the lower scores in these metrics have been identified.

6.3 Habitat Surveys

The habitat assessments of both years show that most areas in Markland pool are classified as class 'B' habitats and that there are some 'A' and 'C' habitats. The 2004 habitat surveys showed a higher percentage of fines than were seen in the 2005 assessments. The difference in the percentage of fines is probably an artifact of the probabilistic design. There is variation throughout the pool and the sites selected in 2005 happened to have fewer fines present. Still, the habitat assessments in both years showed similar results for the percentage of each habitat class present. The available habitat is of suitable quality for supporting a fish population of Markland pool.

6.4 Water Quality and Flow Conditions

There were no water quality measurements that were out of the ordinary or that provide any major insight into the assessment results for either year. The differing amounts of rainfall in each year affected the flow conditions under which the biological data were collected. Higher stage and flow conditions are generally associated with higher turbidity levels, which can hinder effective fish collection. All Secchi depths indicated sufficient visibility for sampling; however measurements were slightly lower in 2004. Sites in 2004 may have experienced lower visibility, slightly reducing the catch at some sites, but not enough to explain the differences alone. Swift flows can also adversely affect capture efficiency by making boat maneuvering and fish netting more difficult. Finally, these periods of high flow may alter the habits and locations of the fish (see Section 6.5)

6.5 Assessments of Condition and Conclusions

The assessments conducted in the Markland pool over 2004 and 2005 have provided a lot of information about the fish population and the overall biological condition of the pool. However, the information provided does not agree between the two years. In 2004, nearly 40% of the Markland pool sites were deemed as failing, therefore this AU would be reported as impaired (and not supporting its designated aquatic life use). The 2005 assessment found all of the sample sites to be in passing condition and so the pool would be considered as passing (or fully supporting its aquatic life use). The sites that were revisited also showed that scores were better in 2005, highlighting the difference between the years.

It is important to understand why the 2004 and 2005 assessments are so different because each result has different implications. An AU that is considered passing or unimpaired receives no sanctions, but impaired AU's are viewed negatively and are subjected to further sampling, 303(d) listing and possible TMDL (Total Maximum Daily Load) development.

At this time an explanation for the differences in the assessments is not certain, but flow volume has been identified as one very important factor. It appears that increases in flow are associated with lower assessment scores. A better understanding of the relationship between flow and assessment scores is needed. This includes determining what flow conditions are appropriate for sampling and then calibrating the assessments for certain flow levels. As this relationship is better understood, ORSANCO will be able to provide more accurate assessments of biological condition.

It is hypothesized that the higher than normal flows seen in 2004 reduced the overall catch and biased the species that were caught. The higher flows decreased the visibility in the water, reduced boat maneuverability, and altered the movement of the fish, all of which reduced the number of fish that were seen and netted. At normal summer flow levels, fish orient to the near shore habitat, where the electrofishing is conducted. However, when flows are increased and the water is turbid, some species behave differently. It is probable that during the high flows of 2004, the fish sought refugia in different parts of the pool (e.g. deeper water, embayments, etc.) and therefore lower catch rates were encountered.

The assessment 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/eliminate human bias and provide statistically valid results. Although further sampling is needed to confirm our results, this design appears to have accomplished these goals.

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