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Long Term Resource Monitoring Program Outpool Fisheries Analysis

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Long Term Resource Monitoring Program
Outpool Fisheries Analysis

by

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Final Report submitted to

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Preface

The Long Term Resource Monitoring Program (LTRMP) was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the Environmental Management Program for the Upper Mississippi River System. The LTRMP is implemented by the Upper Midwest Environmental Sciences Center of the U.S. Geological Survey, in cooperation with the five Upper Mississippi River System states (Illinois, Iowa, Minnesota, Missouri, and Wisconsin), with guidance and Program responsibility provided by the U.S. Army Corps of Engineers.

The mission of the LTRMP is to provide decision makers with information to maintain the Upper Mississippi River System as a viable large river ecosystem given its multiple-use character. The longterm goals of the Program are to understand the system, determine resource trends and impacts, develop management alternatives, manage information, and develop useful products.

Long Term Resource Monitoring Program
Outpool Fisheries Analysis

Final report to

U.S. Geological Survey
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Abstract: This study was designed to assess whether fish community data collected for the Long Term Resource Monitoring Program (LTRMP) from six regional trend analysis (RTA) areas of the Upper Mississippi River System (UMRS) can be used to make inferences to the system as a whole. Spatial coverage of fish monitoring for three LTRMP field stations was extended to "outpools" immediately above and below RTA pools 4 and 13 and the Open River Reach from June 15 to October 31, 2000. Also, we sampled Navigation Pools 19 and 20 using LTRMP electrofishing methodology in September 2000. Multivariate statistical analyses were used to group pools on the basis of fish community composition and community structure. Cluster analysis of community composition and structure data revealed two major groups of pools: upper pools (i.e., northern) and lower pools (i.e., southern). Navigation Pools 19 and 20 grouped with lower pools in terms of community composition, and with upper pools in terms of community structure. Analysis of community composition data yielded four subgroups, with La Grange Pool forming its own subgroup. Analysis of community structure yielded five subgroups, with La Grange Pool and Pool 8 forming unique subgroups. In general, all outpools grouped with the nearest RTA pools for both community composition (no exception) and community structure (one exception). Strong correlations between the community composition and structure matrices with distance between pools suggest that fish communities in relatively close pools are more similar than in pools separated by larger distances. Habitat variables measured during electrofishing collections were significantly correlated with spatial variation of fish composition and community structure, but provided only marginal improvements to correlations with distance between pools alone.

Results of this study lend support to the premise that LTRMP fish community data could potentially be used to make inferences to the entire UMRS, because current RTA areas are evenly distributed within the major pool groupings identified in this study. Nevertheless, further research is needed to resolve how fish communities in Navigation Pools 19 and 20 and other lower UMRS pools compare to present RTA areas.

Key words: Analysis, fish community, LTRMP, Mississippi River, navigation pool, trend analysis, UMRS

Introduction

The Long Term Resource Monitoring Program (LTRMP) was authorized by the Water Resources Development Acts of 1986 and 1999 as an element of the U.S. Army Corps of Engineers' Environmental Management Program. The primary mission of the LTRMP is to provide resource managers with the information needed to maintain the Upper Mississippi River System (UMRS) as a viable multiple-use ecosystem. Four long-term goals established for the LTRMP are (1) increasing our understanding of how the river ecosystem operates, (2) monitoring UMRS natural resources status and trends, (3) assisting in the evaluation of management alternatives, and (4) managing and providing access to resulting data, information, and products (U.S. Army Corps of Engineers 1997). Standardized monitoring of water quality, aquatic vegetation, aquatic invertebrates, and fishes are key components of the LTRMP.

The vast geographic expanse of the UMRS, which includes 1,300 miles of navigable rivers and a basin encompassing 190,000 square miles including numerous tributaries, presents a major challenge to the LTRMP. The design of any monitoring program focused on a large ecosystem must find a balance between covering enough spatial area to allow for system wide inferences and the ability to obtain enough detailed information to describe and understand the interaction of ecosystem components. This challenge is even greater when populations and communities of organisms are a primary focus of a monitoring program, given that population dynamics of different species within an ecosystem usually operate at several different spatial and temporal scales (Wiens 1989; Levin 1992). Therefore, monitoring programs designed to track population variation of several species need to sample multiple spatial subunits appropriate for populations operating at small scales, with sufficient replication of subunits to track populations operating at larger scales and allow inferences to the entire system.

For a system as spatially extensive as the UMRS, it is clear that many species have multiple populations within this river-floodplain system. Because a major goal of LTRMP is to provide system wide inferences for the monitored components, it is also clear that the monitoring design must include substantial spatial coverage. The original plans for the LTRMP included sample collection from 22 river reaches (U.S. Army Corps of Engineers 1997). Logistical constraints, however, reduced the number of areas sampled from 22 river reaches to 6 regional trend analysis areas (RTA; Navigation Pools 4, 8, 13, and 26 and the Open River Reach on the Mississippi River and La Grange Pool on the Illinois River). Lubinski et al. (2001) conducted a power analysis demonstrating that the present LTRMP design provides adequate statistical power to detect inter-annual variation for most water quality parameters and many fishes within the six RTA areas. Nevertheless, how well these six RTA areas reflect the overall biotic and abiotic conditions of the entire UMRS remains unknown.

This study was initiated to expand the spatial coverage of LTRMP fisheries monitoring (specifically, electrofishing and seining) to outpools immediately above and below three RTA areas in an attempt to provide further insight into the ability of LTRMP to make ecological inferences to the UMRS as a whole. We present statistical analysis of this study, examining spatial variation of community composition (the presence or absence of species) and community structure (relative abundance of species) of UMRS fishes. Four major goals are addressed:

1. Determine how sampled pools group based on community composition of fishes.
2. Determine how sampled pools group based on community structure of fishes.
3. Determine where outpools group relative to adjacent RTA areas.
4. Determine whether groupings of pools based on community composition and structure correspond to spatial variation of important habitat factors.

Methods

Fish Sampling

This study extended the spatial coverage of fish monitoring for three LTRMP monitoring locations. Mississippi River navigation pools immediately above and below RTA pools 4 and 13 and Open River Reach (Figure 1) were sampled using standard LTRMP electrofishing methodology from June 15 to October 31, 2000. Throughout this report, these areas will be referred to collectively as outpools and individually as Pools 3, 5, 12, 14, 29, and 31 (note: 29 and 31 are nonpooled river reaches). Standard LTRMP monitoring also occurred in all six RTA pools (4, 8, 13, 26, La Grange, and Open River Reach) during 2000 and electrofishing samples were collected from Pools 19 and 20 by all LTRMP fisheries personnel on September 12 and 13, 2000 (Figure 1). We were interested in examining how fish communities in Pools 19 and 20 grouped with other UMRS pools because Lock and Dam 19 is believed to present a barrier to migrations of certain fishes (Kelner and Seitman 2000). Plans for this study called for seining in all outpools. Unfortunately, this proved to be logistically impractical and only was accomplished for two outpools (12 and 14).

Gutreuter et al. (1995) described standard LTRMP methodology for electrofishing and seining in detail. Sampling locations were selected using a stratified (by habitat type) random design (Lubinski et al. 2001). Electrofishing was conducted using pulsed-DC output with two ring anodes and the boat hull serving as the cathode and voltage and amperage were adjusted for water temperature and conductivity to achieve a power output of 3,000 W. Two dippers collected fish. Electrofishing was conducted along shorelines continuously for 15 min at each sample collection site. Data on water temperature, depth (average for each collection site), conductivity, and habitat were collected with each sample (Table 1). Seining was conducted using a 10.7-m-long 3-mm-mesh bag seine. Seines are fished along banks in water ≤1.2 m. One end of the seine was anchored to the bank and the other end was deployed perpendicular to the bank and swept downstream. All fish were

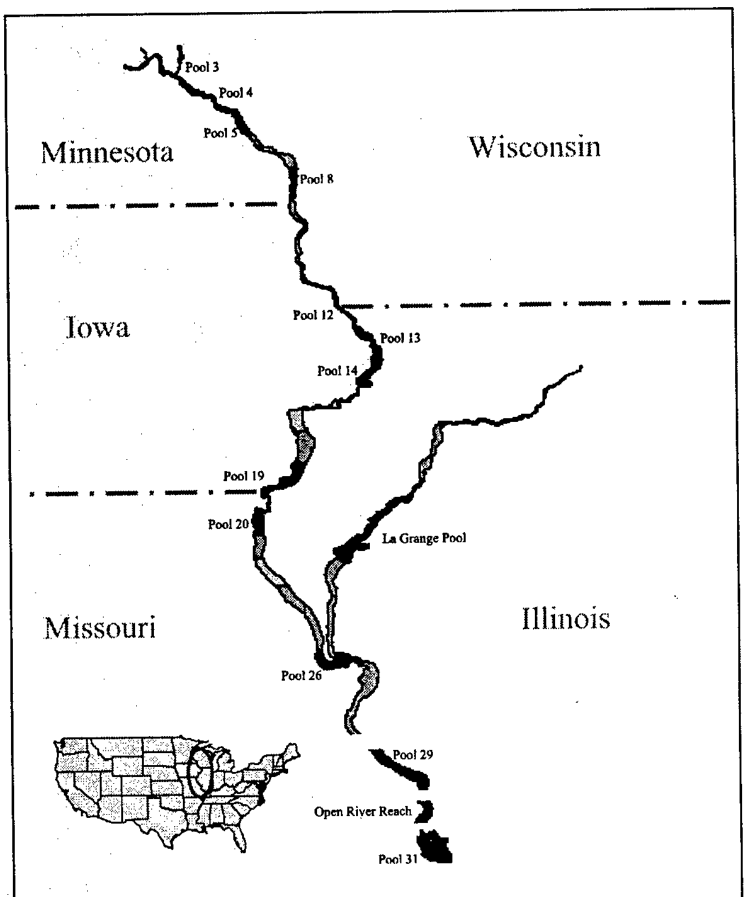

Figure 1. Map of the Upper Mississippi River System showing the six regional trend analysis pools monitored by the Long Term Resource Monitoring Program and the eight outpools sampled with electrofishing during 2000.

Table 1. Habitat variables routinely collected from each electrofishing site for the Long Term Resource Monitoring Program (Gutreuter et al. 1995).

Habitat factor	Units	Explanation
Secchi	cm	Measurement of water transparency in cm
Conductivity	S/cm	Conductivity measured to the nearest 1 S/cm
Flow	m/sec	Rate at which the water is flowing given in m/sec
Temperature	C	Temperature of the water in C
Depth	m	Water depth in fractions of meters
Emergent/Submersed vegetation	0, 1, 2, 3	0 = 0% coverage; 1 = 1–19% coverage; 2 = 20–49% coverage; 3 = 50% coverage
Vegetation density	0, 1, 2	0 = no veg; 1 = sparse; 2 = dense
Substrate	1, 2, 3, 4	1 = silt; 2 = silt/clay/little sand; 3 = sand/mostly sand; 4 = gravel/rock/hard clay
Woody structure	pres/abs	presence or absence of woody structure
Revetment	pres/abs	presence or absence of shoreline revetment
Inlet/Outlet	pres/abs	presence or absence on an inlet/outlet channel to a backwater lake
Flooded terrestrial vegetation	pres/abs	presence or absence of flooded terrestrial vegetation

identified, measured, and enumerated following standard LTRMP protocol (Gutreuter et al. 1995).

Statistical Analysis

We examined spatial variation in fish community composition and structure among the six RTA pools and eight outpools. Community composition refers to the presence or absence of species, whereas community structure refers to the abundance of species as measured by mean catch-per-unit-effort (CPUE equals number per 15 min, weighted by habitat strata). Separate analyses were conducted for electrofishing and seining data, and all analyses were conducted using SAS for Windows (SAS Institute, Inc. 1999) and Primer for Windows (Primer-E LTD 2001). Our analysis of seining data was limited to community composition because the power to detect variation in abundance of fishes from LTRMP seining data differs greatly among pools (Lubinski et al. 2001).

For both response variables (presence/absence, CPUE), we used cluster analysis and nonmetric multidimensional scaling (NMDS) to identify groupings of pools. These analyses were based on a Euclidian distance matrix for community composition data, and a Bray-Curtis similarity matrix for community structure data. Catch-per-unit-effort data were square-root transformed to better conform to multivariate normality assumptions. This transformation also dampens the influence of very abundant species for community structure analysis (Clarke and Warwick 1994). We limited the community structure analysis to 16 species for which electrofishing had power 0.80 to detect a 20% interannual abundance change in at least one habitat strata of an RTA pool based on the Lubinski et al. (2001) power analysis of LTRMP components (Table 2). This somewhat conservative criterion was adopted to help ensure that the patterns of relative abundance used in these analyses reflect true ecological patterns rather than sampling artifacts. Hybrids and fish not identified to species were omitted from all analyses.

Three criteria were used to determine the subgrouping level in our cluster analysis. First, we used rarefaction curves from the six RTA pools to visually determine the minimum number of individuals needed to reach the asymptote of the rarefaction curve (i.e., the sampling effort needed to adequately describe species composition). Acceptable subgrouping levels should not isolate undersampled pools because this isolation could have resulted from a sampling artifact.

Table 2. Mean abundance (square root # / 15 min) of the 16 species used in community structure analysis[a].

	Upper Mississippi River System Navigation Pool													
Species[b]	**3**	**4**	**5**	**8**	**12**	**13**	**14**	**19**	**20**	**LG**	**26**	**29**	**OR**	**31**
Gizzard shad	7.50	6.30	3.53	2.18	3.45	4.12	2.94	2.61	2.74	6.98	4.51	3.23	5.36	4.14
Emerald shiner	7.13	3.99	1.77	2.34	3.93	3.99	1.69	6.85	6.96	1.08	1.49	1.72	2.46	1.26
Common carp	2.07	2.23	2.19	1.18	2.23	2.30	2.30	2.11	1.79	2.76	2.46	1.99	1.20	1.71
Bluegill	0.52	2.97	3.09	6.28	3.19	3.00	3.76	1.48	0.17	1.75	0.84	0.05	0.09	0.08
Freshwater drum	1.44	0.67	0.56	0.34	0.82	0.97	0.91	1.86	1.46	1.50	0.95	1.26	1.22	0.97
Largemouth bass	0.05	1.43	1.21	2.66	1.88	2.27	2.24	1.22	0.12	1.23	0.26	0.00	0.04	0.02
Spotfin shiner	1.91	1.06	1.12	2.62	1.18	1.14	0.21	1.21	1.53	0.00	0.10	0.08	0.00	0.00
Bullhead minnow	1.16	0.75	0.89	3.08	2.03	1.46	0.89	0.81	0.36	0.11	0.13	0.00	0.01	0.02
White bass	1.45	0.63	0.39	0.45	0.76	0.76	0.41	0.89	0.72	1.63	0.49	0.69	0.72	0.46
Channel catfish	0.26	0.09	0.12	0.09	0.58	0.69	0.38	1.77	0.55	1.17	0.71	0.74	0.83	0.69
Black crappie	0.08	0.92	0.90	0.95	0.43	1.14	1.01	0.10	0.08	0.37	0.06	0.02	0.00	0.00
Smallmouth buffalo	0.22	0.20	0.15	0.23	0.84	0.24	0.12	0.22	0.63	1.68	0.59	0.08	0.42	0.40
Shorthead redhorse	0.82	1.16	1.18	0.91	0.55	0.28	0.12	0.13	0.07	0.12	0.06	0.08	0.04	0.00
Smallmouth bass	0.92	0.73	0.98	0.65	0.46	0.06	0.18	0.10	0.05	0.00	0.00	0.01	0.02	0.00
Silver redhorse	0.14	0.84	1.09	0.84	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bigmouth buffalo	0.02	0.10	0.19	0.00	0.42	0.41	0.15	0.13	0.00	1.05	0.16	0.01	0.17	0.10

[a]Samples were collected from June 15 through October 31, 2000. LG = La Grange Pool of the Illinois River. OR = Open River Reach. Note: Pools 29 and 31 are open river reaches.
[b]Common names for fishes follow Robins et al. (1991).

Second, we calculated the mean and range of Euclidian distance (community composition) and Bray-Curtis similarity (community structure) between consecutive years for each RTA pool using LTRMP data from 1994 to 2000. Many of the differences between consecutive years in community composition and structure data from LTRMP electrofishing can be attributed to sampling artifacts (i.e., electrofishing does not sample all the species present in a pool each year). Therefore, the critical Euclidean distance for deriving robust pool groupings should be greater than the range of these year-to-year differences. Finally, we accepted only subgrouping levels that produced groups that were easily illustrated using NMDS in either two or three dimensions with a stress value < 0.05. Stress value is a measure of "goodness-of-fit" for NMDS with small values indicating a better fit than large stress values (Clarke and Warwick 1994). Because seining data were available only for a small subset of pools, we determined subgrouping using NMDS criteria alone.

Because cluster analysis and NMDS are data exploration techniques, we used analysis of similarity (ANOSIM) to test for significant variation in fish community composition and structure among groups. Analysis of similarity is analogous to univariate ANOVA in that it tests for significant differences among groups. Unlike ANOVA, however, ANOSIM uses Monte Carlo simulation to determine significance rather than probability inferences from an assumed statistical distribution. Nonetheless, our use of ANOSIM here is clearly a post-hoc test and results should be interpreted with caution. Also, we used similarity breakdown analysis (Clarke and Warwick 1994; SIMPER procedure in Primer-E LTD 2001) to determine the contribution of species to Bray-Curtis dissimilarity between community structure groupings.

Finally, we used the electrofishing data to determine whether variation in fish community composition and structure among pools corresponded with variation in habitat factors. Two sources of habitat data available for comparisons were those measured directly in the field with each electrofishing collection (Table 1) and a suite of aquatic or geomorphic variables quantified for the habitat needs assessment (HNA) query tool that were available for a subset of pools (Table 3; DeHaan et al. 2000; Koel 2001). For both sets of habitat variables, normalized (mean = 0, standard deviation = 1) Euclidean distance matrices were calculated and Mantel tests were used to determine correlations with both the Euclidian matrix from fish community composition data and the Bray-Curtis similarity matrix from community structure data. A canonical Mantel test (Clarke and Warwick 1994; BioEnv procedure in Primer-E LTD 2001) was used to determine the combination of habitat variables that would provide the greatest correlation with community data. Because many habitat variables can co-vary with latitude, we included distance in river miles (relative to Navigation Pool 3) in both habitat data sets to help determine whether correlations with habitat reflect covariation with the distance between pools. For La Grange Pool, distance was the sum of river miles between Pools 3 and 26, and river miles between Pool 26 and La Grange Pool. We also used a Mantel test to examine whether habitat similarity (normalized Euclidian distance matrix for all habitat features measured in the field) was correlated with distance between pools.

Results

Electrofishing

A total of 118,139 fishes were collected comprising 100 species (Table 4). The species with the greatest overall abundance were gizzard shad, emerald shiner, bluegill, and common carp, which together accounted for over 71% of the total catch. The mean number of species captured in a pool was 49, ranging from 38 to 60. Rarefaction curves suggest that sampling sufficient to collect at least 5,000 fishes is needed to do an adequate job of describing community composition within a given pool or reach (Figure 2). Because fewer than 5,000 fishes were collected from several of the outpools (Figure 3), we rejected any subgrouping level that isolated these undersampled pools in our cluster analysis of community composition and community structure data.

Table 3. Surface area (hectares) of aquatic/geomorphic habitat variables as defined by the habitat needs assessment query tool for Upper Mississippi River Navigation Pools 4-26 and open river reaches (29, OR, 31).[a]

	Area (ha) of aquatic/geomorphic habitat type											
Pool	**MNC**	**MCB**	**TWZ**	**SCH**	**TCH**	**TRC**	**CFL**	**CFS**	**CIM**	**TIS**	**CTF**	**TOC**
4	1,093	448	12	463	2	97	10,320	1,567	408	1,848	8,438	24,695
5	337	536	22	278	0	59	155	733	2,178	863	6,025	11,187
8	627	603	21	510	1	30	1,125	1,573	4,024	2,966	3,478	14,957
12	596	1,506	26	740	20	4	401	545	864	1,446	1,645	7,794
13	1,569	1,141	20	789	105	32	1,242	1,902	3,556	2,414	8,494	21,262
14	561	2,127	22	599	4	24	668	0	0	1,357	3,107	8,470
19	1,350	5,273	30	1,527	1	93	868	1,282	1,069	2,297	14,033	27,823
20	574	1,728	39	545	4	200	23	0	0	786	4,829	8,727
26	1,467	2,875	28	1,483	14	51	409	0	245	2,530	18,663	27,764

[a]Habitat variables were the main navigation channel (MNC), main channel border (MCB), tailwater (TWZ), secondary channel (SCH), tertiary channel (TCH), tributary channel (TRC), contiguous floodplain lake (CFL), contiguous floodplain shallow aquatic area (CFS), contiguous impounded area (CIM), terrestrial island (TIS), contiguous terrestrial floodplain (CTF), and total contiguous habitat area (TOC). Data were not available for Pool 3, La Grange Pool of the Illinois River, or open river reaches 29 and 31.

Table 4. Total number of individuals captured using boat electrofishing from regional trend analysis pools and outpools[a].

	Upper Mississippi River System Navigation Pools[b]														
Species	**3**	**4**	**5**	**8**	**12**	**13**	**14**	**19**	**20**	**LG**	**26**	**29**	**OR**	**31**	**Total**
Gizzard shad	7,802	7,539	2,954	868	895	1,385	711	149	375	7,806	2,947	478	2,736	1,429	38,074
Emerald shiner	7,479	7,487	3,158	942	2,136	2,121	526	2,896	1,772	788	1,121	167	731	125	31,449
Bluegill	57	746	1,268	2,375	691	630	966	254	8	1,164	564	17	24	5	8,769
Common carp	527	533	571	212	403	414	349	124	131	1,870	596	245	183	172	6,330
Spotfin shiner	625	298	413	1,437	178	143	16	60	108	0	107	1	0	0	3,386
Mimic shiner	47	173	15	1,076	616	568	48	85	60	0	0	0	0	0	2,688
Largemouth bass	3	240	232	572	242	376	270	81	8	573	47	0	8	1	2,653
Bullhead minnow	194	171	161	927	444	256	123	48	15	16	50	0	4	1	2,410
White bass	250	231	33	43	84	89	35	24	57	1,254	54	22	48	21	2,245
Freshwater drum	253	79	54	43	90	93	81	86	151	552	260	65	170	63	2,040
Orangespotted sunfish	8	1	0	5	379	363	261	55	3	37	407	2	32	1	1,554
Shorthead redhorse	128	323	259	482	115	76	40	3	2	22	6	1	6	0	1,463
River shiner	1	7	43	402	223	194	18	230	68	0	4	2	2	2	1,196
Smallmouth buffalo	22	23	16	16	76	16	7	8	71	766	79	2	30	19	1,151
Bigmouth buffalo	1	9	32	0	40	29	9	2	1	684	30	4	22	3	866
Threadfin shad	0	0	0	0	0	0	0	0	0	173	14	3	192	481	863
Channel catfish	28	10	10	6	48	68	29	58	18	317	90	47	74	35	838
Smallmouth bass	155	176	211	158	58	13	17	4	4	1	0	4	2	0	803
Black crappie	7	130	158	100	30	104	96	21	2	154	8	5	0	0	815
Channel shiner	0	0	0	0	0	2	0	64	140	0	179	121	106	35	647
Silver redhorse	12	175	221	198	1	4	16	0	0	1	0	0	0	0	628
River carpsucker	15	6	7	1	16	36	100	5	29	109	31	13	90	30	488
Golden redhorse	4	50	247	98	10	1	6	0	0	8	0	0	0	0	424

Table 4. Continued

Species	Upper Mississippi River System Navigation Pools[a]														
	3	4	5	8	12	13	14	19	20	LG	26	29	OR	31	Total
Rock bass	11	93	137	155	20	3	2	0	0	0	0	0	0	0	421
Sauger	45	53	36	61	84	56	16	3	2	41	2	1	11	4	415
White crappie	11	12	6	6	112	35	101	7	1	80	16	1	2	2	392
Spotted sucker	0	60	119	85	27	19	21	3	0	0	0	0	0	0	334
Flathead catfish	25	14	14	14	21	10	14	23	30	76	32	26	19	13	331
Shortnose gar	7	1	0	6	8	9	5	7	20	43	67	36	54	58	321
Red shiner	0	0	0	0	0	0	0	1	17	10	3	50	103	45	229
Yellow perch	3	132	52	22	2	10	1	0	0	0	0	0	0	0	222
Walleye	35	35	44	24	16	18	34	0	2	2	2	0	0	0	212
Logperch	26	71	33	46	5	9	2	3	1	10	2	0	0	1	209
Skipjack herring	0	0	0	0	0	0	0	0	4	156	13	3	24	6	206
Brook silverside	0	7	13	20	40	52	5	0	0	6	8	8	38	2	199
Pugnose minnow	1	46	36	95	11	8	0	0	0	0	0	0	0	0	197
Golden shiner	0	0	4	67	40	71	7	1	0	4	0	0	0	0	194
Goldeye	0	0	0	0	1	0	0	0	1	0	3	106	26	43	180
Silver chub	38	12	1	0	21	18	14	8	2	16	33	0	1	0	164
Spottail shiner	1	9	30	32	26	24	24	1	0	0	0	0	0	0	147
Green sunfish	17	8	5	25	3	0	0	0	1	16	51	1	10	0	137
Silverband shiner	0	0	0	0	0	0	0	0	12	6	3	87	13	19	140
Grass carp	0	0	0	0	0	0	0	0	7	104	8	1	0	3	123
Johnny darter	5	7	7	77	13	1	5	0	0	0	0	0	0	0	115
Black buffalo	0	0	0	0	1	4	0	1	2	62	18	3	16	4	111
Pumpkinseed	0	5	5	23	1	44	29	2	0	0	0	0	0	0	109

Table 4. Continued

Species	Upper Mississippi River System Navigation Pools[b]														
	3	4	5	8	12	13	14	19	20	LG	26	29	OR	31	Total
Spotted bass	0	0	0	0	0	0	0	0	0	0	0	22	45	13	80
Quillback	22	21	17	6	5	2	1	0	0	3	1	0	0	0	78
Longnose gar	5	6	3	9	11	7	4	4	17	6	3	0	1	3	79
Bowfin	3	3	6	11	7	12	17	6	0	7	2	1	5	0	80
River redhorse	1	41	6	26	0	0	0	0	0	0	0	0	0	0	74
Northern pike	0	19	18	11	4	7	9	0	0	0	0	0	0	0	68
Blue sucker	2	6	6	1	3	0	0	0	46	0	1	0	2	0	67
Bighead carp	0	0	0	0	0	0	0	0	3	57	0	0	1	1	62
Western mosquitofish	0	0	0	0	0	0	0	0	4	3	50	0	1	0	58
Yellow bass	0	0	0	2	0	5	1	0	0	41	0	0	0	1	50
Warmouth	0	0	0	1	3	4	6	2	0	19	14	0	2	0	51
Silver carp	0	0	0	0	0	0	0	0	2	37	0	1	4	0	44
Mooneye	0	12	1	3	1	1	2	1	2	0	0	10	0	0	33
Sand shiner	1	3	0	3	0	0	0	18	24	0	11	0	0	0	60
Silver lamprey	5	3	14	5	4	1	0	0	0	0	0	0	0	0	32
Blue catfish	0	0	0	0	0	0	0	0	0	0	0	6	10	15	31
Weed shiner	0	0	0	26	0	0	0	0	0	0	0	0	0	0	26
Highfin carpsucker	0	0	0	1	18	0	2	0	1	2	0	0	0	0	24
Goldfish	0	0	0	0	0	0	0	0	0	23	0	0	0	0	23
Slenderhead darter	4	4	3	3	0	0	0	1	1	1	0	0	0	0	17
Bluntnose minnow	11	0	0	0	0	0	1	0	0	1	0	0	3	0	16
Inland silverside	0	0	0	0	0	0	0	0	0	0	0	2	14	0	16
Spotted gar	0	0	0	0	0	0	0	0	0	6	5	0	3	2	16

Table 4. Continued

Species	Upper Mississippi River System Navigation Pools[b]														
	3	4	5	8	12	13	14	19	20	LG	26	29	OR	31	Total
Mud darter	0	0	1	8	1	0	2	0	0	0	0	0	0	0	12
Yellow bullhead	0	0	0	0	0	0	2	0	0	10	0	0	0	0	12
Chestnut lamprey	0	1	1	2	0	0	1	0	0	0	0	1	2	3	11
Fathead minnow	2	0	0	5	3	0	0	0	0	0	0	0	0	0	10
Miss. silvery minnow	0	0	0	0	0	6	2	0	0	0	0	0	2	0	10
American eel	0	0	0	0	0	0	0	0	0	0	0	1	3	5	9
Tadpole madtom	0	0	0	3	3	1	1	1	0	0	1	0	0	0	10
White sucker	0	3	3	2	1	0	0	0	0	0	0	0	0	0	9
Black bullhead	0	1	0	0	1	0	0	0	0	6	0	0	0	0	8
Blacktail shiner	0	0	0	0	0	0	0	0	0	0	0	0	6	0	6
Blackstripe topminnow	0	0	0	0	0	0	0	0	0	2	0	0	4	0	6
River darter	0	0	0	1	1	0	1	1	1	0	0	1	0	0	6
Western sand darter	0	0	2	3	0	0	0	0	1	0	0	0	0	0	6
Burbot	4	1	0	0	0	0	0	0	0	0	0	0	0	0	5
Grass pickerel	0	0	0	0	3	0	1	0	0	1	0	0	0	0	5
Paddlefish	0	0	0	0	0	0	0	0	3	0	0	0	1	0	4
Redear sunfish	0	0	0	0	0	0	0	0	0	4	0	0	0	0	4
Freckled madtom	0	0	0	0	0	0	0	2	0	0	0	0	3	0	5
Longear sunfish	0	0	0	0	0	0	0	0	0	0	0	0	2	1	3
Stonecat	0	0	0	0	0	0	1	0	0	0	0	0	0	2	3
Brown bullhead	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
Blackspotted topminnow	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
Central munminnow	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2

Table 4. Continued

Species	Upper Mississippi River System Navigation Pools[b]														
	3	4	5	8	12	13	14	19	20	LG	26	29	OR	31	Total
Speckled chub	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2
Trout perch	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Banded darter	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Brook stickleback	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Blackside darter	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Striped bass	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Striped mullet	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Species richness	**46**	**52**	**49**	**60**	**56**	**49**	**53**	**43**	**46**	**55**	**44**	**40**	**52**	**38**	**100**
Total catch	**17,905**	**19,097**	**10,686**	**10,855**	**7,296**	**7,418**	**4,058**	**4,357**	**3,228**	**17,165**	**6,943**	**1,568**	**4,894**	**2,669**	**118,139**
Total samples	**72**	**83**	**84**	**72**	**63**	**63**	**51**	**21**	**31**	**126**	**77**	**25**	**52**	**34**	**854**

[a]Samples were collected from June 15 through October 31, 2000.

[b]LG = La Grange Pool of the Illinois River. OR = Open River Reach. Note: Pools 29 and 31 are open river reaches. Common names for fishes follow Robins et al. (1991).

*The shaded bars are intended only as an aid to reading the table.

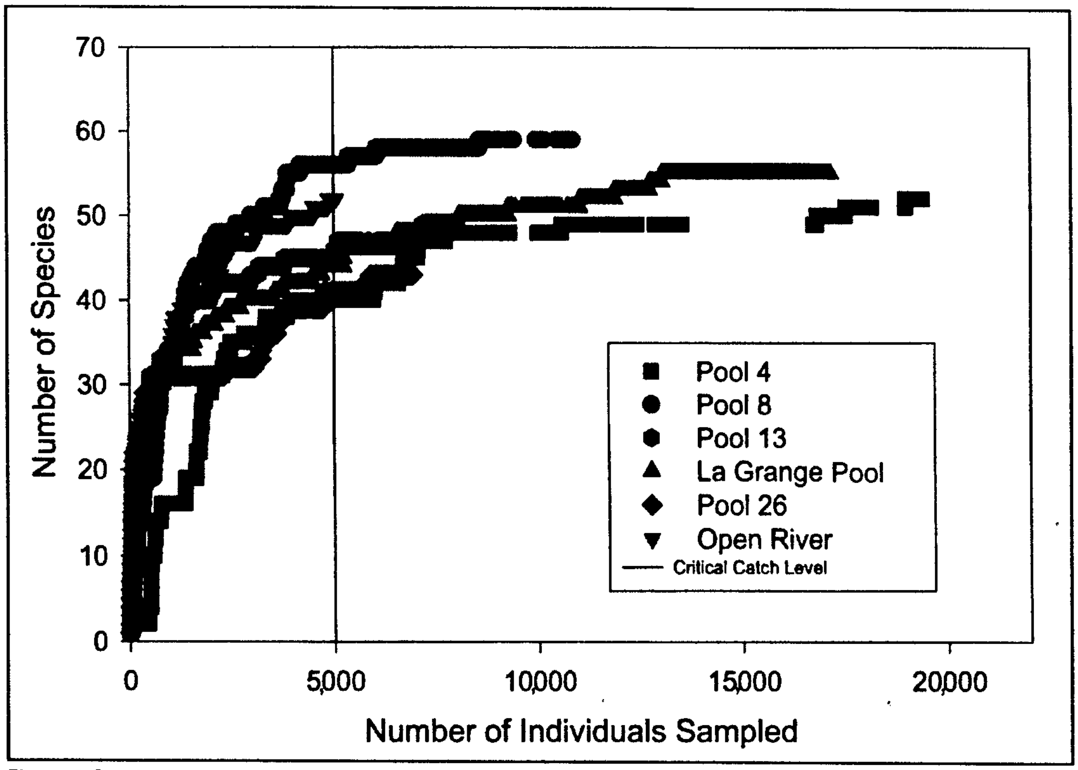

Figure 2. Rarefaction curves from electrofishing data for the six regional trend analysis pools in 2000. At least 5,000 individuals, it seems, should be sampled to adequately describe fish community composition (i.e., to reach the rarefaction curve asymptote).

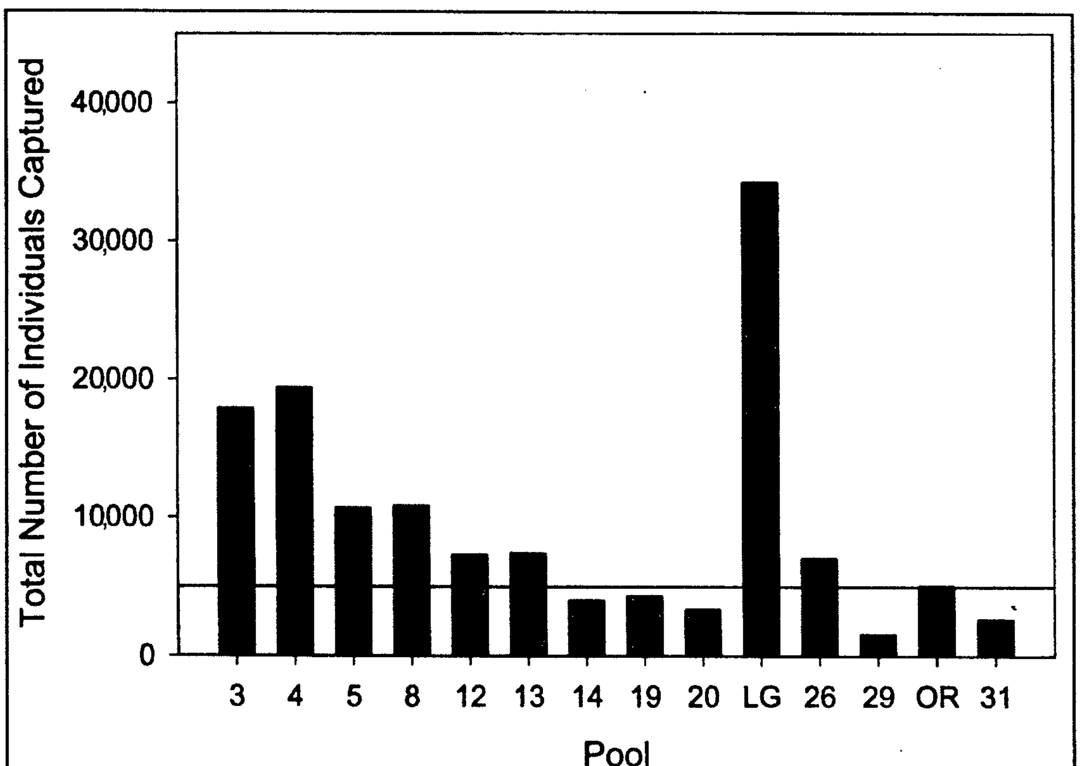

Figure 3. The total number of fish captured by electrofishing from the six regional trend analysis pools and eight outpools during 2000. The horizontal line depicts the minimum number of individuals (5,000) needed to be sampled to adequately describe community composition (see Figure 2).

Cluster analysis of community composition data revealed two major groupings of pools: upper and lower pools (Figure 4*A*). Twenty-eight species were captured only within lower pools and 18 only within upper pools. The average Euclidian distance between consecutive years at an RTA pool was 3.60, and ranged from 3.16 to 4.47. Therefore, we chose 5.0 as our subgrouping distance, resulting in four subgroups: all upper pools, La Grange Pool, the Open River Reach and Pools 29 and 31, and Pools 19, 20, and 26 (Figure 4*A*). These four groups were illustrated by NMDS in three dimensions with a stress value = 0.02 (Figure 4*B*). Analysis of similarity revealed significant differences between the two major groupings (Global $R = 0.83$; $P = 0.001$), and among the four subgroups (Global $R = 0.95$; $P = 0.001$).

As with community composition, cluster analysis based on community structure of fishes revealed two major subgroups of pools, upper and lower. In this analysis, however, Pools 19 and 20 grouped with the upper pools rather than the lower pools (Figure 5*A*). Six species accounted for more than 70% of the dissimilarity between upper and lower pool groupings. Upper pools were characterized by greater abundance of emerald shiner, bluegill, largemouth bass, bullhead minnow, and spotfin shiner relative to lower pools. Lower pools had greater abundance of gizzard shad compared with upper pools.

The mean Bray-Curtis similarity value for consecutive years in RTA pools was 85.7 (range from 74.4 to 92.6; Figure 5*A*). We chose a

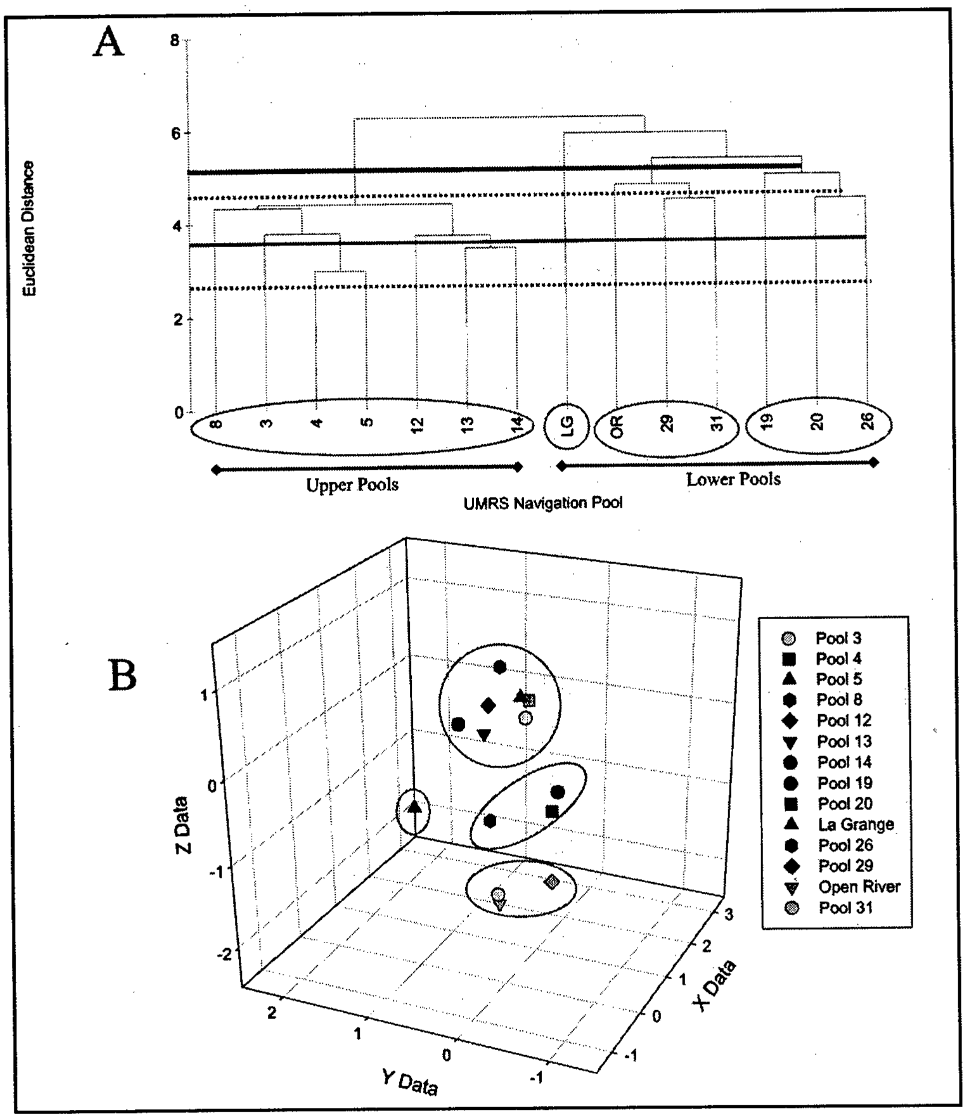

Figure 4. *(A)* Cluster analysis of fish community composition data collected through electrofishing. The lower solid line and two dashed lines indicate the mean and range of Euclidean distance for consecutive years in regional trend analysis pools. The upper solid line indicates the subgrouping level (Euclidean distance of 5) resulting in four subgroups (circled). *(B)* Nonmetric multidimensional scaling plot of Upper Mississippi River System in three dimensions. The four subgroups from the cluster analysis are circled.

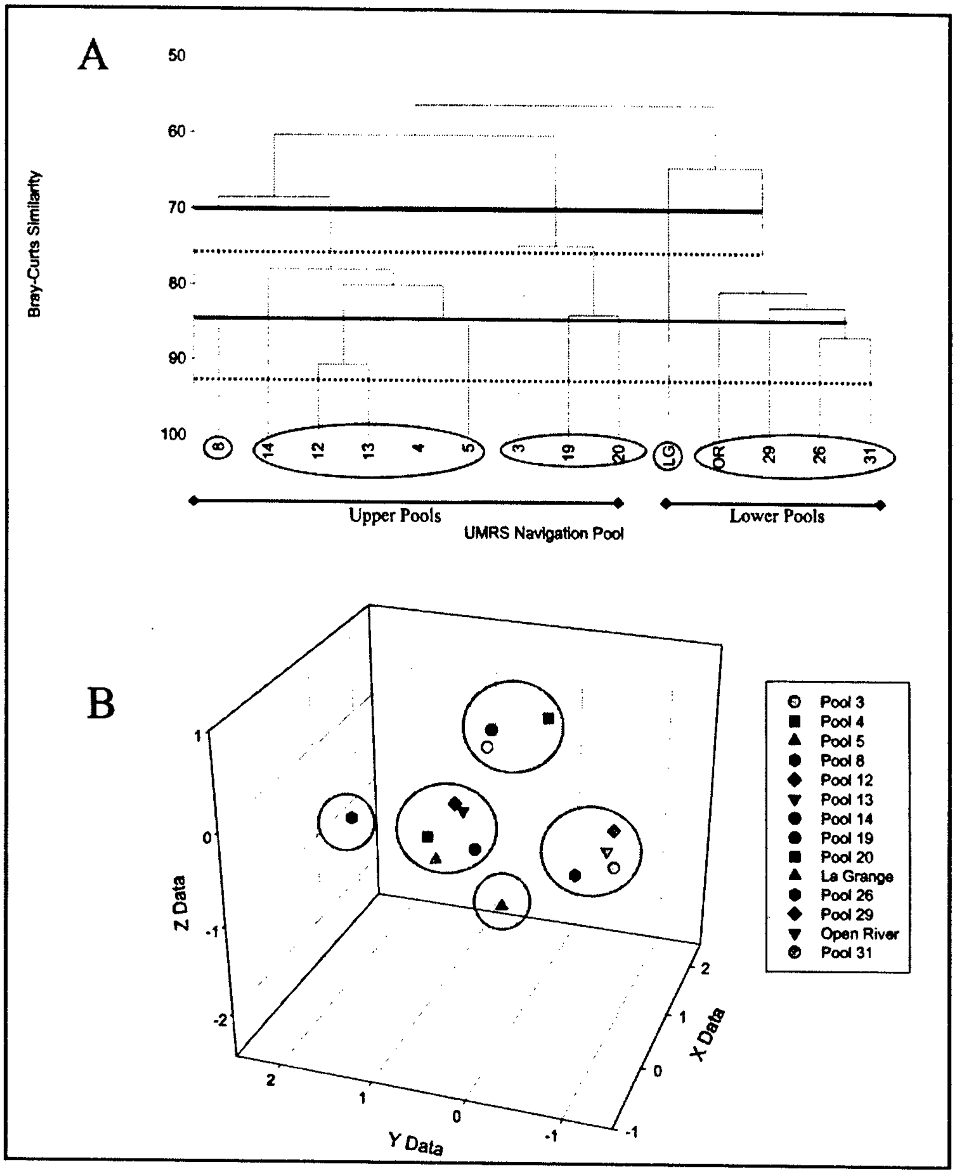

Figure 5. *(A)* Cluster analysis of fish community structure data collected through electrofishing. The lower solid line and two dashed lines indicate the mean and range of Bray-Curtis similarity for consecutive years in regional trend analysis pools. The upper solid line indicates the subgrouping level (Bray-Curtis similarity = 70) resulting in five subgroups (circled). *(B)* Nonmetric multidimensional scaling plot of Upper Mississippi River System in three dimensions. The five subgroups from the cluster analysis are circled.

The mean Bray-Curtis similarity value for consecutive years in RTA pools was 85.7 (range from 74.4 to 92.6; Figure 5*A*). We chose a Bray-Curtis value of 70 for our subgrouping distance, producing five subgroups: Pools 26, 29, and 31 and the Open River Reach (subgroup A); La Grange Pool (subgroup B); Pools 3, 19, and 20 (subgroup C); Pools 4, 5, 12, 13, and 14 (subgroup D); and Pool 8 (subgroup E). Nonmetric multidimensional scaling illustrates these five subgroups in three dimensions with a stress value = 0.03 (Figure 5*B*). Eleven species contributed more than 70% to the dissimilarity among subgroups (Table 5). Pool 8 (subgroup E) had the greatest abundance of black crappie, bullhead minnow, bluegill, largemouth bass, and spotfin shiner. La Grange Pool (subgroup B) had the greatest abundance of bigmouth buffalo, common carp, smallmouth buffalo, and white bass. Subgroup C had the greatest abundance of emerald shiner and freshwater drum. Analysis of similarity revealed significant differences between upper and lower pool groupings (Global $R = 0.67$; $P = 0.001$) and among the five subgroups (Global $R = 99$; $P = 0.001$).

Habitat Correlations

Strong correlations between community composition ($r = 0.80$) and structure ($r = 0.63$)

Table 5. Mean abundance (square root # / 15 min) of the 11 species that contributed more than 70% to the dissimilarity among pool subgroups identified through cluster and non-metric multidimensional scaling analysis of electrofishing community structure data.

	Subgroups and UMRS Pools				
	A	B	C	D	E
Species[b]	26–31	La Grange	3, 19, 20	4, 5, 12, 13, 14	8
Black crappie	0.02	0.37	0.09	0.88	**0.95**[a]
Bluegill	0.26	1.75	0.72	3.20	**6.28**
Bigmouth buffalo	0.11	**1.05**	0.05	0.25	0.00
Bullhead minnow	0.04	0.11	0.78	1.20	**3.08**
Common carp	1.84	**2.76**	1.99	2.25	1.18
Emerald shiner	1.73	1.08	**6.98**	3.07	2.34
Freshwater drum	1.10	1.50	**1.59**	0.79	0.34
Gizzard shad	4.31	**6.98**	4.28	4.07	2.18
Smallmouth buffalo	0.37	**1.68**	0.35	0.31	0.23
Spotfin shiner	0.04	0.00	0.94	0.94	**2.62**
White bass	0.59	**1.63**	1.02	0.59	0.45

[a]The maximum abundance for each species are in bold.
[b]Common names for fishes follow Robins et al. (1991).

matrices with distance between pools suggest that fish communities in relatively close pools are more similar than pools separated by larger distances (Figures 6*A*–6*B*). Also, habitat similarity was correlated (r = 0.74) with distance between pools (Figure 6*C*) and most of the habitat variables measured during electrofishing sampling showed longitudinal variation (Figure 7). These habitat variables were significantly correlated with both community composition ($r = 0.75$; $P = 0.0001$) and community structure ($r = 0.64$; $P = 0.0010$). The canonical Mantel procedure revealed that the strongest correlations ($r = 0.90$) with community composition were with a habitat matrix composed of distance between pools, water depth, conductivity, vegetation density, and the frequency of woody structure presence. The strongest correlations ($r = 0.73$) for community structure were with a habitat matrix composed of distance between pools, flow, vegetation density, frequency of woody structure presence, and the frequency of flooded terrestrial vegetation presence. Note that these correlations are only marginal improvements over correlation with distance between pools alone.

Mantel tests revealed significant correlations between HNA variables with both community composition ($r = 0.46$; $P = 0.0083$) and community structure ($r = 0.37$; $P = 0.0225$). Nevertheless, correlations with distance between pools alone were stronger ($r = 0.79$; $r = 0.69$) and the canonical Mantel procedure was unable to add any HNA habitat variables that could more than trivially improve these correlations.

Seining

A total 115,820 fishes from 81 species were captured. The species with the greatest overall abundance were emerald shiner, mimic shiner, river shiner, bluegill, bullhead minnow, and gizzard shad. Together, these six species accounted for over 80% of the total catch. Cluster analysis of seining data revealed two major groupings of pools: upper (4, 8, 12, 13, and 14) and lower pools (26, La Grange, and Open River Reach; Figure 8*A*). These two groupings were illustrated in two dimensions by NMDS with a stress value = 0.01 (Figure 8*B*). Of the 81 species captured, 13 species were captured only in the lower pools and 30 only in the upper pools. Nevertheless, several of the species captured only in the upper pools, including bigmouth buffalo, bowfin, quillback, and walleye, are known to be established in the lower pools. Thus, at least some of the difference in community composition between upper and lower pools reflects sampling artifacts.

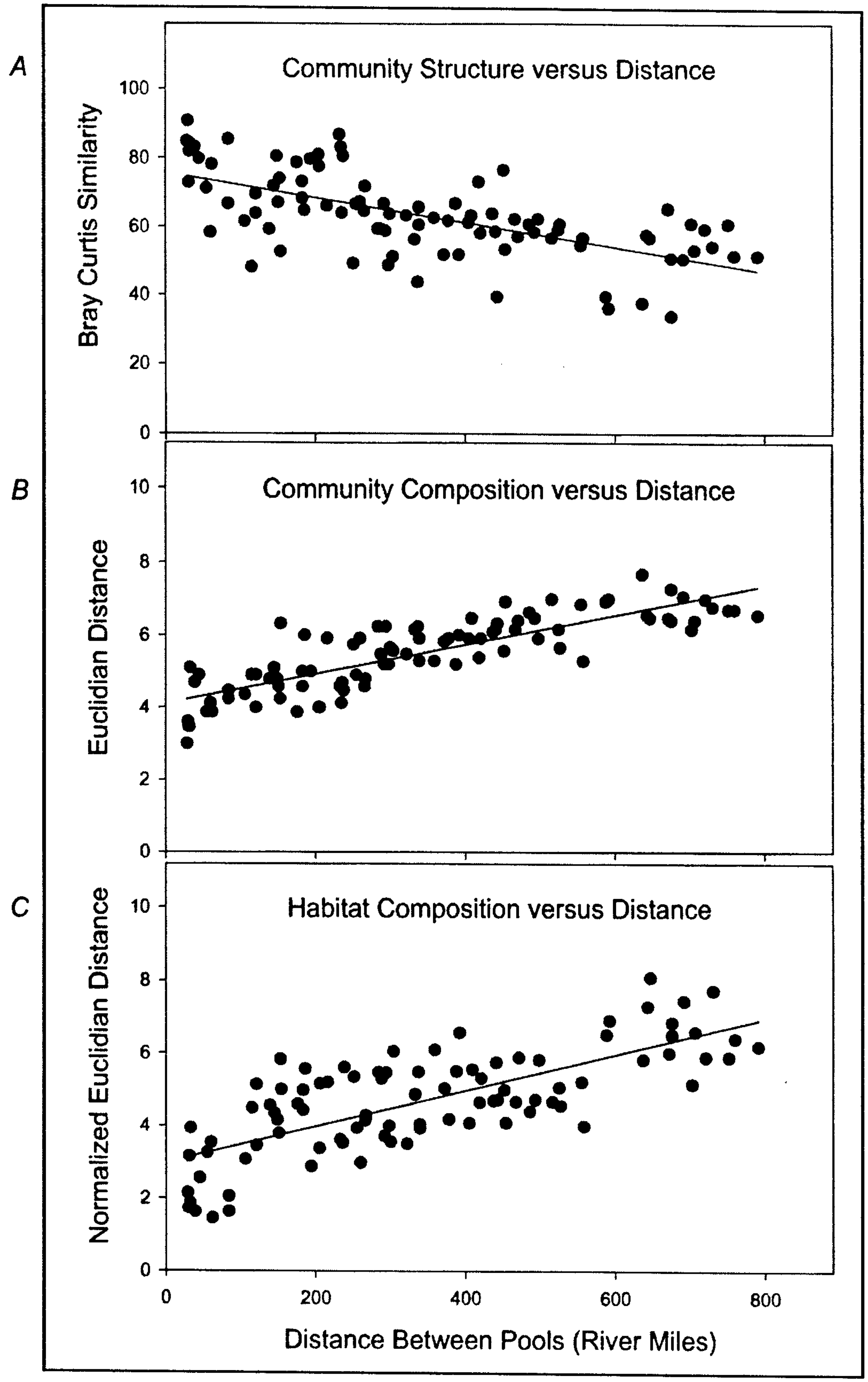

Figure 6. Relations between the distance between pools (river miles) with (A) community structure of fish (Bray-Curtis similiarity), (B) community composition of fishes (Euclidian distance), and (C) habitat composition (normalized Euclidian distance). Plotted are all possible pairwise comparisons among the six regional trend areas and outpools.

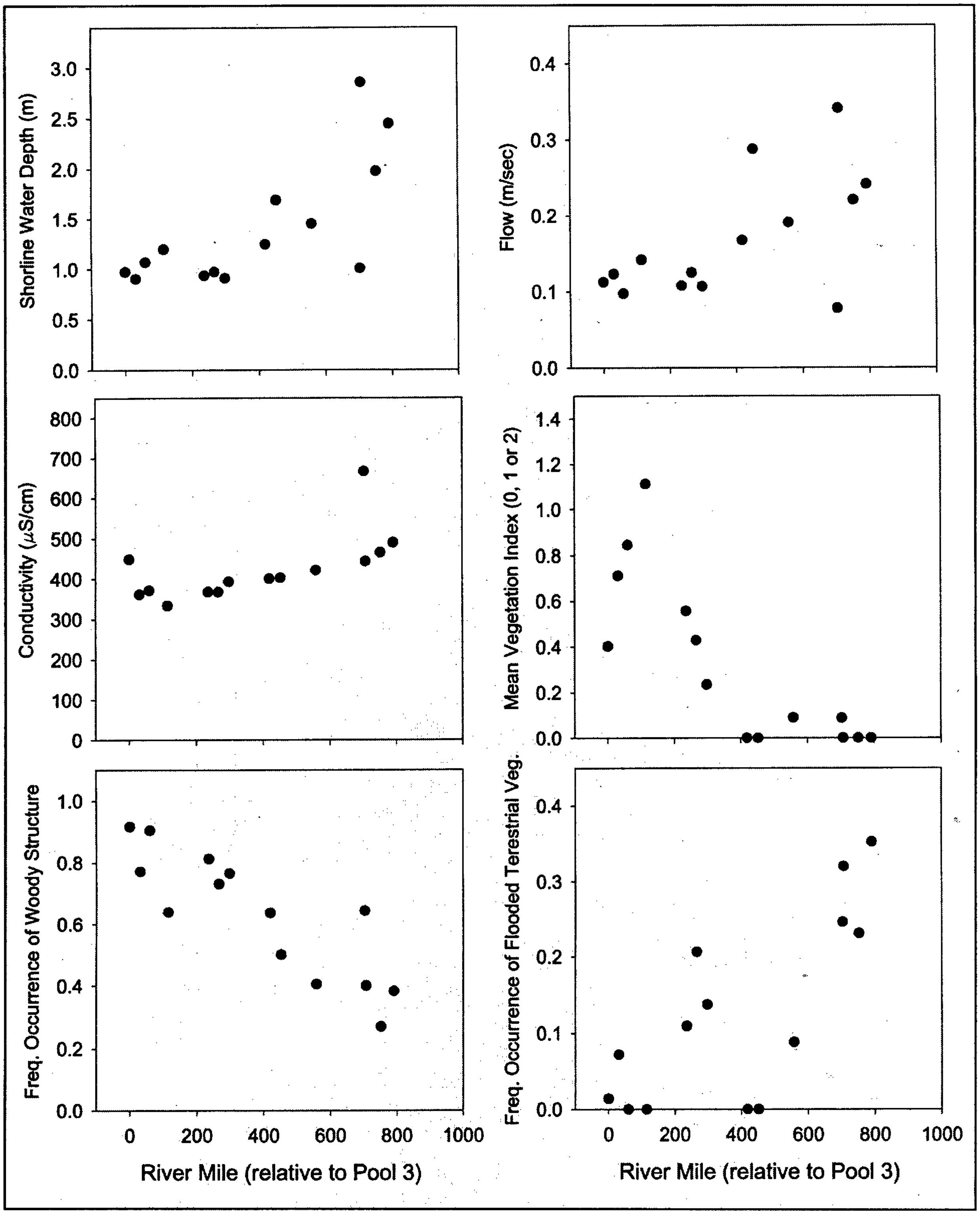

Figure 7. Relation between water depth, flow, conductivity, vegetation density, presence of woody structure, and presence of flooded terrestrial vegetation with river mile (relative to Pool 3). All habitat measures were collected at the electrofishing sites sampled in 2000.

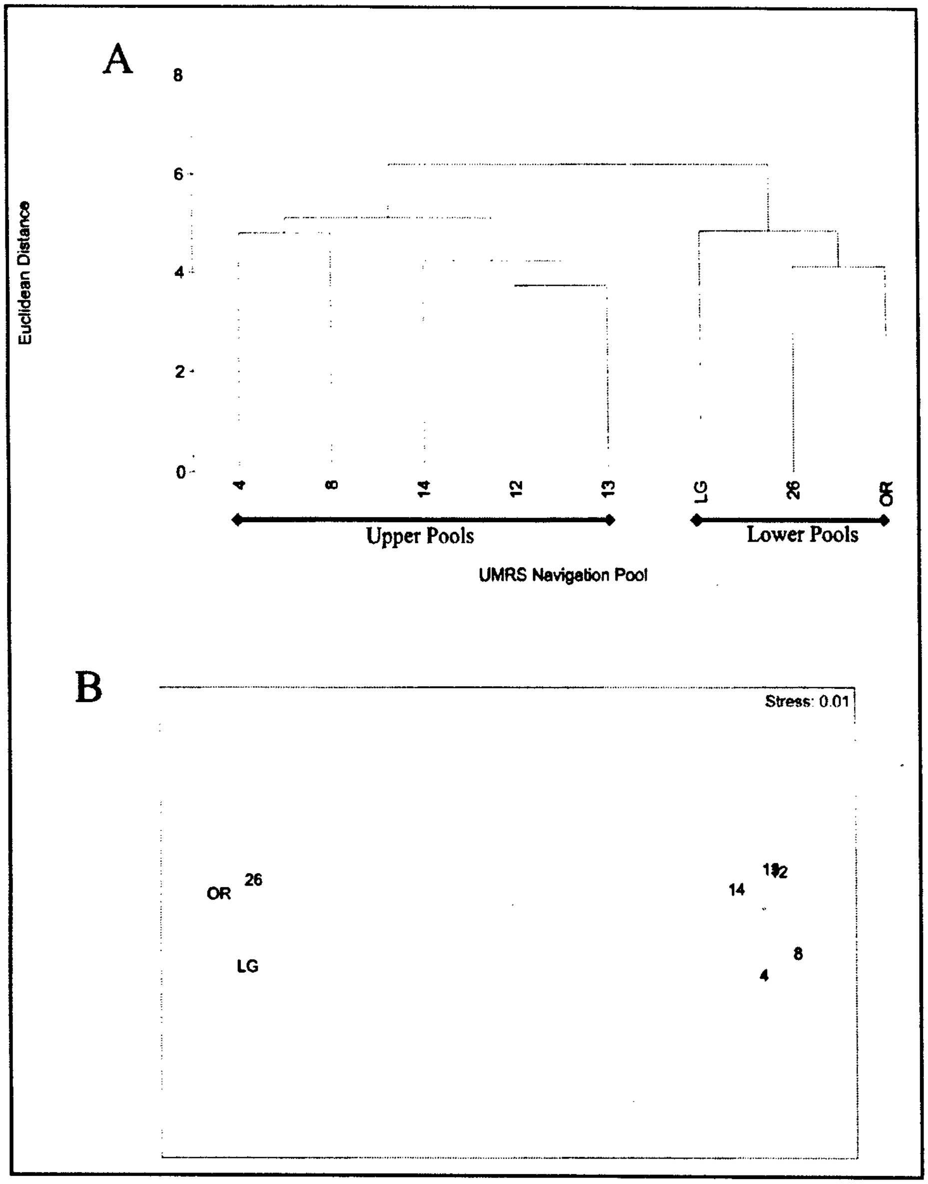

Figure 8. *(A)* Cluster analysis of fish community composition data collected through seining. Major pool groupings (upper and lower) are noted. *(B)* Nonmetric multidimensional scaling plot and stress value for Upper Mississippi River System pools in two dimensions. The two major groups from the cluster analysis are easily identifiable.

Discussion

Our analysis of both the community composition and community structure of fishes in the UMRS each yielded two major pool groups, upper and lower. Two previous studies also classified UMRS pools into upper and lower reaches based on habitat variables (U.S. Geological Survey 1999; Koel 2001). It is likely that geographic range limitations of fishes, habitat factors, and possibly historical barriers have all influenced the fish composition and community structure differences between upper and lower pools. Our analysis also revealed four or five subgroups of pools. Based on the strength of our analysis of similarity tests (i.e., Global *R* values) and NMDS plots, these subgroupings may present a more accurate description of the similarity of community composition and structure among the UMRS pools sampled. Although there were clear differences between the upper and lower pool groups based on community structure and community composition, it is clear that more spatial structure exists in this system than a simple dichotomy of upper and lower pools.

Results from this study should be interpreted with caution because the data available for analysis were limited to 1 year (covariation of communities cannot be addressed) and essentially one sampling gear, an electrofishing boat. Lubinski et al. (2001) reported that among all gears used in the LTRMP, electrofishing generally had the greatest statistical power to detect trends across all species and habitat types. Nevertheless, boat electrofishing does not sample all species within the UMRS equally well. For example, electrofishing is conducted near the shoreline and will not be effective for species that primarily occupy offshore habitats. Because of the limitations of boat electrofishing, seining was included in the plans for this study to provide additional information on the small fish community. Unfortunately, we found seining to be logistically untenable to conduct in all outpools, but the limited seining data collected showed major pool groupings (upper and lower pools) consistent with our analysis of electrofishing data. Given the vast spatial extent of the UMRS and the great diversity of habitat types and fish species it contains, it is unlikely that any single study could fully address both the patterns and causes of spatial variation of fish communities within this system. We feel the present study provides a useful first step in addressing this issue.

In general, outpools tended to group with adjacent RTA pools. Outpools 5, 12, 14, 29, and 31 were within the same subgroups as their adjacent RTA pools (4, 13, and the Open River Reach). These results, and our habitat correlation analysis, suggest a strong negative relation between the distance among pools and similarity of fish community composition and structure. In other words, our results suggest fish communities in adjacent UMRS pools and reaches tend to be similar. The exception to this trend, the subgrouping of outpools 3, 19, and 20 in our community structure analysis, may have arisen as a result of similarity in habitat features or low sample sizes in Pools 19 and 20. La Grange Pool was a unique subgroup for both community composition and structure analyses, which was an expected result for this tributary RTA pool. Pool 8 was a unique subgroup in terms of community structure. This RTA pool had the greatest abundance of centrarchid species, which may be related to the relatively greater abundance of aquatic vegetation found in this pool (Figure 7).

Our attempts to correlate spatial variation of fish communities with habitat data were hindered by the confounding of habitat similarity and distance between pools. Both the composition and community structure of fishes should vary as a function of distance between pools because of zoogeography, immigration and emigration, source-sink dynamics and similar histories of large scale disturbances such as major floods and droughts (Drake 1990, 1991; Hamrick and Nason 1996; Pullium 1996). Because habitat similarity was also correlated with distance between pools, it is difficult to determine the influence of habitat on fish communities independent of the spatial demographic processes listed above. To gain a better understanding of the influence of habitat on fish communities, future studies could attempt to account for both spatial proximity and habitat variation by selecting pairs of study pools that are relatively close together, but differ substantially in specific habitat measures. Also, future analyses could devise an index of historic habitat alterations for each RTA and outpool to assess if fish community variation correlates with this index.

This study was not able to resolve where Navigation Pools 19 and 20 fit within the UMRS as a whole. Pools 19 and 20 were similar to lower pools in terms of community composition, but similar to upper pools with regard to community structure. Electrofishing collections from Pools 19 and 20 differed from all other pools in that all data were collected over a period of 2 days, rather than over a period of 5 months. It is interesting, however, that Pools 19 and 20 grouped together in both the community composition and structure analyses because Lock and Dam 19 is known to be a barrier to migratory fishes such as skipjack herring (Kelner and Seitman 2000). Despite this barrier, this study suggests the overall fish communities with Pools 19 and 20 are relatively similar. An important caveat to this study is that only three UMRS pools below Pool 14 were sampled (19, 20, and 26), whereas seven upper UMRS pools were sampled (3, 4, 5, 8, 12, 13, and 14). Studies including a greater number of lower UMRS pools might improve our understanding of spatial variation of fish communities.

Implications for Long Term Resource Monitoring Program and Future Studies

Current RTA areas are evenly distributed within the major pool groupings identified in this study (i.e., three RTA areas in upper pool group, three RTA areas in the lower group), which supports the premise that LTRMP fisheries data can be used to make inferences to the entire UMRS. Subgroupings of outpools with nearby RTA pools and the importance of distance between pools in habitat correlations suggest that fish community data from RTA pools should at least be relevant to other nearby UMRS pools. Furthermore, these results suggest that expanding LTRMP fish monitoring to pools adjacent to current RTA areas would yield minimal additional information. Further research is needed to resolve how fish communities within Navigation Pools 19 and 20 and other lower UMRS pools compare to current RTA areas. Future studies in this area should (1) address covariation of community measures through time, (2) examine additional pools and reaches in the lower portion of the system, and (3) further examine relations between fish communities and habitat features using experimental designs that specifically account for the confounding of habitat similarity and distance between pools.

References

Clarke, K. R. and R. M. Warwick. 1994. Change in marine communities: an approach to statistical analysis and interpretation. Plymouth Marine Laboratories, Plymouth, United Kingdom.

DeHaan, H. C., T. J. Fox, C. E. Korschgen, C. H. Theiling, and J. J. Rohweder. 2000. Habitat needs assessment GIS query tool for the Upper Mississippi River users manual. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin. 96 pp.

Drake, J. A. 1990. Communities as assembled structures: do rules govern patterns? Trends in Ecology and Evolution 5:159–164.

Drake, J. A. 1991. Community assembly mechanics and the structure of an experimental species ensemble. American Naturalist 137:1–26.

Gutreuter, S., R. Burkhardt, and K. Lubinski. 1995. Long Term Resource Monitoring Program procedure: fish monitoring. National Biological Service, Environmental Management Technical Center, Onalaska, Wisconsin. LTRMP 95-P002-1. 42 pp + Appendixes A–J.

Hamrick, J. L., and J. D. Nason. 1996. Consequences of dispersal in plants. Pages 203–236 *in* O. E. Rhodes, R. K. Chesser, and M. H. Smith, editors. Population dynamics in ecological space and time. The University of Chicago Press, Chicago.

Kelner, D E., and B. E. Seitman. 2000. Relic populations of the ebony shell, *Fusconaia ebena* (Bivalvia : Unionidae), in the upper Mississippi River drainage. Journal of Freshwater Ecology 15:371–377.

Koel, T. M. 2001. Classification of Upper Mississippi River pools based on contiguous aquatic/geomorphic habitats. Journal of Freshwater Ecology 16:159–170.

Levin, S. A. 1992. The problem of pattern and scale in ecology. Ecology 73:1943–1967.

Lubinski, K, R. Burkhardt, J. Sauer, D. Soballe, and Y. Yin. 2001. Initial analyses of change detection capabilities and data redundancies in the Long Term Resource Monitoring Program. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, September 2001. LTRMP 2001-T001. 23 pp + Appendixes A–E.

Primer-E LTD. 2001. Primer for Windows Version 5.2.4. Plymouth Marine Laboratory, Plymouth, United Kingdom.

Pullium, H. R. 1996. Sources and sinks: empirical evidence and population consequences. Pages 45–69 *in* O. E. Rhodes, R. K. Chesser, and

M. H. Smith, editors. Population dynamics in ecological space and time. The University of Chicago Press, Chicago.

Robins, C. R., R. M. Bailey, C. E. Bond, J. R. Brooker, E. A. Lachner, R. N. Lea and W. B. Scott. 1991. Common and scientific names of fishes from the United States and Canada. 5th edition. Special Publication (20). American Fisheries Society, Bethesda, Maryland. 183 pp.

SAS Institute, Inc. 1999. The SAS System for Windows. Release 8.01. Cary, North Carolina.

U.S. Army Corps of Engineers. 1997. Upper Mississippi River System - Environmental Management Program Report to Congress. Public Review Draft.

U.S. Geological Survey. 1999. Ecological status and trends of the Upper Mississippi River System 1998: A report of the Long Term Resource Monitoring Program. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin. April 1999. LTRMP 99-T001. 236 pp.

Wiens, J. A. 1989. Spatial scaling in ecology. Functional Ecology 3:385-397.

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13. ABSTRACT (Maximum 200 words)

Abstract: This study was designed to assess whether fish community data collected for the Long Term Resource Monitoring Program (LTRMP) from six regional trend analysis (RTA) areas of the Upper Mississippi River System (UMRS) can be used to make inferences to the system as a whole. Spatial coverage of fish monitoring for three LTRMP field stations was extended to "outpools" immediately above and below RTA pools 4 and 13 and the Open River Reach from June 15 to October 31, 2000. Also, we sampled Navigation Pools 19 and 20 using LTRMP electrofishing methodology in September 2000. Multivariate statistical analyses were used to group pools on the basis of fish community composition and community structure. Cluster analysis of community composition and structure data revealed two major groups of pools: upper pools (i.e., northern) and lower pools (i.e., southern).

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