Long Term Resource Monitoring Program

Technical Report 2002-T001

Evaluation and Proposed Refinement of the Sampling Design for the Long Term Resource Monitoring Program's Fish Component

October 2002

Long Term Resource Monitoring Program Technical Reports provide Long Term Resource Monitoring Program partners with scientific and technical support.

All reports in this series receive anonymous peer review.

Evaluation and Proposed Refinement of the Sampling Design for the Long Term Resource Monitoring Program's Fish Component

by

Brian S. Ickes and Randy W. Burkhardt

U.S. Geological Survey
Upper Midwest Environmental Sciences Center
2630 Fanta Reed Road
La Crosse, Wisconsin 54603

October 2002

Suggested citation:

Ickes, B. S., and R. W. Burkhardt. 2002. Evaluation and proposed refinement of the sampling design for the Long Term Resource Monitoring Program's fish component. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, October 2002. LTRMP 2002-T001. 17 pp. + Appendixes A–E. CD-ROM included.

Additional copies of this report may be obtained from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (1-800-553-6847 or 703-487-4650). Also available to registered users from the Defense Technical Information Center, Attn: Help Desk, 8725 Kingman Road, Suite 0944, Fort Belvoir, VA 22060-6218 (1-800-225-3842 or 703-767-9050).

Executive Summary

Environmental monitoring programs are frequently designed to track changes in key physical, chemical, and biological features of an ecosystem. As such, these programs provide critical information for detecting changes in system state, investigating causal mechanisms of the observed changes, and making resource management decisions. Because monitoring programs require significant investments of time, money, and human resources to implement and maintain, periodic evaluations of monitoring programs are necessary to determine if the sampling design adequately addresses program goals and objectives. Periodic evaluations also permit assessment of a program's ability to provide adequate and useful information for changing management and science needs.

We evaluated the Long Term Resource Monitoring Program's (LTRMP) fish sampling design by analyzing data from stratified random samples collected from 1993 to 1999 in six Trend Analysis Areas (TAAs). Specifically, we investigated whether the sampling design could provide similar information with fewer sampling gears. Our goals were to identify and quantify information provided by each gear used to monitor fish in the LTRMP, develop alternative sampling design scenarios based on our analyses and expert opinion, and engage program partners in a discussion on the relative value of each gear within the present sampling design.

Community characterization (presence or absence), community structure (relative abundance within the full community), and detection of annual changes in single-species catch-per-unit-effort (Lubinski et al. 2001) are the primary information provided by the fish component. Our analyses considered differences in these measures among TAAs, gear types, sampling strata, seasonal sampling period, and fish size. Results were made available to program partners through a Web site for review and comment. Based on these analyses, program partners developed a suite of potential options for component refinement. We then evaluated those options in more detail.

An option that proposed to develop a tailored set of gears for each TAA was considered the most viable option and was selected for further analysis to optimize its implementation. Detailed analyses of catch by gear within each TAA, however, resulted in identical conclusions regarding which gears produced the most useful information. Based on these results, we proposed eliminating four gears—seine, tandem fyke net, tandem mini fyke net, and night electrofishing—from the LTRMP sampling design for fish.

The proposed sampling design has the following characteristics relative to the present sampling protocol:

- Trend analyses within and among TAAs require an uninterrupted time series of data, but such analyses must typically be gear specific because of unknown differences in gear selectivity. Temporal data continuity required for analysis of trends will remain unchanged for the retained gears, within and among TAAs;
- Systemic analyses of differences in fish characteristics among TAAs require consistent spatial sampling. The gears we propose to eliminate are optional and inconsistently fished within and across TAAs. Also, strata unique to the tandem gears are not common among all TAAs. Therefore, systemic spatial data continuity remains unchanged;
- 91–100% of the species in each TAA that were observed under the present sampling protocol would still be detected. All of the species that would no longer be detected are rare (i.e., <10 individuals collected from 1993 to 1999);

- The probability of detecting a particular species in any 1 year will be minimally affected. Fewer than 12 species per TAA will be detected less frequently under the proposed design than under the present design;
- Of those species for which the present design provided >50% power to detect inter-annual changes in abundance, 85–100% of species will retain at least 50% power at the stratum scale, and 97–100% at the TAA scale;
- The above performance can be achieved with a 3–62% reduction in total catch by TAA. The vast majority of “lost catch” is fish less than 120 mm in total length from eight highly abundant and ubiquitous species. These taxa are collected in sufficient numbers to characterize their placement in the overall community and to detect changes in abundance when sufficient power is present, by gears retained under the proposed sampling design.
- All strata will continue to be sampled except impounded offshore and backwater contiguous offshore. However, these strata do not contribute to unique species or power to detect inter-annual change and are statistically similar in community composition and structure to their nearshore strata counterparts.

Contents

Page

Tables

Number *Page*

Figures

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 U.S. Army Corps of Engineers' Environmental Management Program. The LTRMP is being implemented by the Upper Midwest Environmental Sciences Center, a U.S. Geological Survey science center, in cooperation with the five Upper Mississippi River System (UMRS) States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The U.S. Army Corps of Engineers provides guidance and has overall Program responsibility. The mode of operation and respective roles of the agencies are outlined in a 1988 Memorandum of Agreement.

The UMRS encompasses the commercially navigable reaches of the Upper Mississippi River, as well as the Illinois River and navigable portions of the Kaskaskia, Black, St. Croix, and Minnesota Rivers. Congress has declared the UMRS to be both a nationally significant ecosystem and a nationally significant commercial navigation system. The mission of the LTRMP is to provide decision makers with information for maintaining the UMRS as a sustainable large river ecosystem given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and effects, develop management alternatives, manage information, and develop useful products.

Data and information are the primary products of the LTRMP. Data on water quality, vegetation, aquatic macroinvertebrates, and fish are collected using a network of six field stations on the Upper Mississippi and Illinois Rivers. Analysis, interpretation, and reporting of information are conducted at each of the six field stations and at the Upper Midwest Environmental Sciences Center. Informational products include professional presentations, reports, and professional publications.

This report was developed with funding provided by the U.S. Army Corps of Engineers in 2001, including a contract agreement between the Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, and the University of Wisconsin–La Crosse, River Studies Center.

Evaluation and Proposed Refinement of the Sampling Design for the Long Term Resource Monitoring Program's Fish Component

by

Brian S. Ickes and Randy W. Burkhardt

U.S. Geological Survey
Upper Midwest Environmental Sciences Center
2630 Fanta Reed Road
La Crosse, Wisconsin 54603

Abstract: Environmental monitoring programs are frequently designed to track changes in key physical, chemical, and biological features of an ecosystem. As such, these programs provide critical information for detecting changes in system state, investigating ecological relations, and making resource management decisions. However, monitoring programs require significant investments of time, money, and human resources to implement and maintain. Periodic evaluations are necessary to assess whether the sampling design adequately addresses program goals and objectives, and whether adequate and useful information can continue to be provided for changing management and science needs. We evaluated the Long Term Resource Monitoring Program (LTRMP) sampling design for fish by analyzing data from stratified random samples collected from 1993 to 1999 in six Trend Analysis Areas (TAAs). Specifically, we investigated whether the sampling design could provide similar information with fewer sampling gears. Our goals were to identify and quantify information provided by each gear used to monitor fish in the LTRMP, develop alternative sampling design scenarios based on our analyses and expert opinion, and engage program partners in a discussion on the relative value of each gear within the present sampling design. We forward a proposal to systemically eliminate four of the ten sampling gears presently used to monitor the status and trends in fish resources within the LTRMP.

Key words: community composition, community structure, ecological monitoring, ecosystem management, fishing gears, Illinois River, monitoring programs, river ecology, sampling efficiency sampling gears, status and trends, Upper Mississippi River.

Introduction

This report presents analytical results, conclusions, and recommendations from an investigation of sampling efficiencies within the Long Term Resource Monitoring Program's (LTRMP) fish component. The LTRMP is part of the federally funded Upper Mississippi River Environmental Management Program, established by Congress in 1986 and reauthorized in 1999 under the Water Resources Development Act. The LTRMP's fish component is one of several components within the LTRMP that collects and analyzes ecological data from selected areas within the Upper Mississippi River System (UMRS). Data are collected under standardized protocols from six Trend Analysis Areas (TAAs) within the UMRS (Figure 1; Gutreuter et al. 1995).

Environmental monitoring programs frequently are designed to track changes in key physical, chemical, and biological features of an ecosystem. As such, these programs provide critical information for detecting changes in system state, investigating causal mechanisms of the observed changes, and making resource management decisions. Ideally, a new monitoring program would effectively and efficiently meet the goals it was designed to address. However, this is an unrealistic expectation and it is more probable, as the program matures and observations accumulate, that certain ecosystem features may be under- or oversampled, that measured variables are redundant with one another (i.e., highly

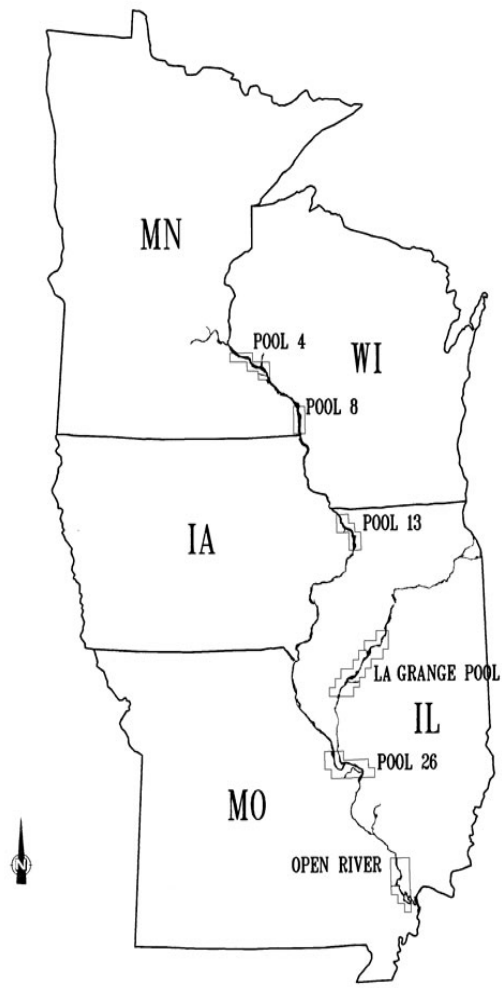

Figure 1: Location of the six Trend Analysis Areas for the Long Term Resource Monitoring Program on the Upper Mississippi River System.

correlated variables), or that some initial methods are not fully adequate. Because monitoring programs require significant investments of time, money, and human resources to implement and maintain, periodic evaluations of monitoring programs are necessary to determine if the sampling design adequately addresses program goals and objectives. Periodic evaluations also allow assessment of the program's ability to provide adequate and useful information for changing management and science needs.

There have been two previous statistical assessments of LTRMP's sampling approaches. Callahan (1998) investigated spatial similarities in fish community, water quality, and macroinvertebrate data among the TAAs to determine if, spatially, all TAAs provided unique information. He concluded that some spatial structure was evident but that no two TAAs were identical in all of the information measured by the three components he investigated. Thus, he argued that each TAA provides sufficient unique information to the LTRMP to be maintained except under the most austere program-funding environment. Lubinski et al. (2001) conducted the second assessment, an analysis of change detection capabilities across LTRMP components. From their analyses, they concluded that sampling redundancies might exist among some gears used to sample fish in the UMRS. Thus, it might be appropriate to eliminate some gears while still maintaining critical information. However, this conclusion was based on just one of the types of information provided by the LTRMP's fish component, namely inter-annual changes in species-specific abundance.

Before concluding that some gears provide redundant information, it is important to quantify the effects of gear reductions on the program's ability to effectively monitor changes in community composition, community structure, and inter-annual changes in abundance of UMRS fish. Equally important is enlisting program partners in this process so that management and science needs are explicitly considered, and so that the relative value of each gear for addressing these needs is discussed. Thus, our goals were to identify and quantify information provided by each gear used to monitor fish in the LTRMP, develop alternative sampling design scenarios based on our analyses and those of Lubinski et al. (2001) and Callahan (1998), and engage program partners in a discussion on the relative value of each gear within the program.

Methods and Results

Background of the LTRMP'S Fish Component

The LTRMP's fish component is charged with monitoring and reporting trends in the status of fish populations and communities within the UMRS (U.S. Fish and Wildlife Service 1993). Data are collected within six study areas. Four are located in the impounded reach of the Upper Mississippi River (Pools 4, 8, 13, and 26), one in an impounded reach of the Illinois River (La Grange Pool), and one in an unimpounded stretch of the Upper Mississippi River (Open River Reach) near Jackson, Missouri (Figure 1). In this report, these study areas are referred to as TAAs.

From its inception in 1989 to 1993, the fish component sampling design was based on a fixed-site strategy. In 1993, the sampling strategy was modified to a spatially stratified random design, augmented with a few permanent fixed sites. Sampling strata were defined on the basis of surface areas of enduring geomorphic features (Wilcox 1993) within each TAA, measured from 1989 aerial photos (Table 1). The stratified random design allows unbiased estimation of poolwide relative abundance (Cochran 1977; Gutreuter et al. 1995) that constitutes the primary data for determining status and trends of UMRS fish. The change to stratified random sampling was the first major refinement of the LTRMP's fish component and greatly enhanced the scientific rigor of the information collected.

The fish component takes a community approach to monitoring. Both active and passive sampling gears (Gutreuter et al. 1995; Hayes et al. 1996; Hubert 1996) are used in each TAA (Table 2). The use of multiple gears was adopted because of the spatial complexity of the TAAs and an explicit intent to evaluate the fish community, as opposed to focusing on one or more individual species. Three to five gear types are fished within each stratum with a minimum of four independent collections per gear. Additional collections are optional. Annual sampling effort is divided into three periods: June 15–July 31; August 1–September 15; September 15–October 31. A complete deployment of all sampling gear and strata combinations is performed in each period at independent random sampling sites. Gutreuter et al. (1995) provide gear descriptions, their manner of deployment, and their physical specifications.

The LTRMP's fish component is designed to provide unbiased gear-specific estimates of mean annual catch-per-unit-effort within each TAA. Weighted averages are calculated for the pool across strata by gear, but no techniques exist for deriving multiple-gear estimates because the selectivity of each gear is unknown. In some instances, analyses can be conducted by period and stratum. However, at these scales, small sample sizes and high catch variance often result in low statistical power (Bartels 2000; Lubinski et al. 2001).

Defining Essential Information Derived from Sampling

To evaluate sampling redundancies, a baseline of essential information derived from sampling must be defined. The Operating Plan for the LTRMP (U.S. Fish and Wildlife Service 1993) defines the overall goal of the monitoring program as the monitoring and evaluation of long-term changes in the status and trends of selected physical, chemical, and biological components of the UMRS.

For the fish component, we considered community composition (presence or absence), community structure (ranked abundance of species measured as the mean catch-per-unit-effort or frequency of occurrence), and species-specific trend detection

Table 1. Strata codes, strata, and surface areas (ha) of aquatic area classifications within each Trend Analysis Area that comprise the strata weights in the Long Term Resource Monitoring Program's stratified random sampling design for fish. Surface areas are based on 1989 aerial photo interpretation of the six Trend Analysis Areas.

		Trend analysis area					
Strata code	Strata	Pool 4	Pool 8	Pool 13	Pool 26	Open River	La Grange Pool
BWCO	Backwater contiguous offshore	5,073	1,961	5,866	358	0	6,946
BWCS	Backwater contiguous shoreline	3,860	3,763	3,978	789	0	3,618
IMPO	Impounded offshore	0	13,936	10,070	512	0	0
IMPS	Impounded shoreline	0	548	420	182	0	0
MCBS	Main channel border shoreline	766	776	910	2,556	2,884	4,945
MCBU	Main channel border unstructured	1,486	1,756	3,527	10,644	1,0471	4,832
MCBW	Main channel border wing dam	27	27	70	7	148	0
SCB	Side channel border	2,887	4,185	3,028	5,671	1,816	639

Table 2. Names, codes, and deployment characteristics of sampling gears used in the Long Term Resource Monitoring Program's fish component.

Gear	Gear code	Mandatory gear?	Original program gear?	Deployment characteristics
Day electrofishing	D	Yes	Yes	Active gear used principally near shoreline areas in depths of 0.5 to 3.0 m—samples a wide range of size classes
Fyke net	F	Yes	Yes	Passive gear used principally near shoreline areas—selective for intermediate size fish
Large hoop net	HL	Yes	Yes	Baited passive gear deployed in parallel sets with small hoop nets—selective for larger fish
Small hoop net	HS	Yes	Yes	Baited passive gear deployed in parallel sets with large hoop nets—selective for intermediate size fish
Mini fyke net	M	Yes	Yes	Passive gear used principally near shoreline areas—selective for small fish
Night electrofishing	N	No	Yes	Active gear used principally near shoreline areas—samples a wide range of size classes
Seine	S	No	Yes	Active gear used in shallow water—selective for small fish
Bottom trawl	T	Yes	Yes	Active gear used principally at fixed tailwater sites—selective for smaller fish
Tandem fyke net	X	Yes	No—Implemented in 1991	Passive gear fished in impounded offshore stratum— selective for intermediate size fish
Tandem mini fyke net	Y	Yes	No—Implemented in 1991	Passive gear fished in the impounded offshore stratum—selective for small fish

(differences in mean catch-per-unit-effort among years or through time) as the core sets of information. This information can be combined with other LTRMP data in many ways to investigate and model community and species-specific responses to a multitude of factors. The metrics derived from LTRMP's fish component data that provide these core pieces of information are species presence or absence observations, species detection frequencies, and design-based estimates of mean catch-per-unit-effort and variance. These metrics were used in our analyses of data redundancies within the LTRMP's fish component.

Baseline Analyses and Assumptions

The goal of our initial analysis was to summarize LTRMP's fish component data on the basis of the metrics outlined above. We used data from stratified random sampling conducted from 1993 to 1999 and produced separate analyses for each TAA. The analyses considered differences among TAAs, gear types, sampling strata, sampling periods, and fish sizes. The results of these analyses were made available to interested parties through a Web site that served as a heuristic tool for developing various refinement scenarios. The types of analyses we performed and the volume of results we generated precluded detailed accounting in this report. Consequently, in an attempt to fully document our approaches and results, we developed a CD-ROM that contains the original Web material that served as a heuristic tool, details of specific analyses, and results from analyses that ultimately led to our recommendations (Appendix A).

Our analytical approach can be described as a retrospective analysis. We summarized and analyzed data collected from 1993 to 1999 under the present sampling protocol in a manner that permitted simulating different alternative sampling designs that used fewer gears or fewer samples. Differences in community composition (presence or absence), community structure (ranked abundance of species measured as the mean catch-per-unit-effort or frequency of occurrence), and species-specific trend detection (differences in mean catch-per-unit-effort between years or through time) provided the criteria for comparing alternative sampling designs with the present sampling design.

Development of the Options Matrix

Once the initial data summaries and analyses were complete, it was critical to engage the LTRMP program partners. First, program partner involvement was required to develop a list of alternative sampling designs. Secondly, while our analyses could estimate quantitatively what would be lost from the program, program partner input was required to weigh the qualitative value of any lost information. Consequently, we met with a group of the LTRMP partners in June 2001. The group developed 11 options for component refinement based on our initial analyses and those of Lubinski et al. (2001) and Callahan (1998; Table 3). This group considered a wide range of possibilities from no change to elimination of all fish sampling. Based on their expert opinion and available analytical results, the group outlined expected positive and negative consequences for each of the 11 options (Appendix B).

Narrowing the Options Matrix for Final Analyses

Some of the 11 options were more viable than others; thus, we used the perceived positive and negative consequences of each option (Appendix B) and the previous analyses to determine which options should receive further analysis. Below we briefly explain why we did not consider particular options further and why we adopted Option III (Appendix B) as the most viable alternative, addressing each option in numerical order.

Option I: Maintain Existing Fish Protocol. This option would have failed to capitalize on existing knowledge that efficiencies and improvements were possible (Lubinski et al. 2001; Appendix A). Thus, we did not pursue this option.

Option II: Maintain Existing Protocol and Add Main Channel Sampling to the Design. Option II was one of three different options that proposed additional monitoring efforts. While Option II recommended the addition of main channel sampling to the existing protocol, we considered this option as "additional monitoring under the existing protocol or a modified protocol." Because Option II recommended additional monitoring, we considered this option as a potential future enhancement and reserved analysis for future consideration.

Option III: Develop Best Pool-Specific Gear Combination. Option III proposed to develop a design composed of a reduced suite of gears, tailored to each TAA, that would provide community composition, community structure, and trend detection capabilities comparable to the present program. This option explicitly recognized that gear redundancies existed, but that they may differ by TAAs. It had the added advantage that standard sampling protocols would remain in place and that it could be implemented within the present sampling design. The group was concerned that implementation of Option III may result in losses in

Table 3. Suite of potential refinements of the sampling design for the Long Term Resource Monitoring Program's (LTRMP) fish component developed by a group of LTRMP partners.

Option	Title	Characteristics
I	Maintain existing fish protocol	No change
II	Maintain existing protocol and add main channel sampling to the design	Add an additional stratum that is presently not sampled
III	Develop best pool-specific gear combination	Tailors gears to each Trend Analysis Area with the goal of reducing effort and data while maintaining information
IV	Eliminate all passive gears from the present design	Active gears only
V	Adopt a guild approach sampling a few key species	Indicator species approach—assumes a few species represent the whole community
VI	Modify temporal sampling (periods)	Eliminate one or more sampling periods within a year
VII	Modify temporal sampling (years)	Biennial sampling is one example of many ways to implement this option
VIII	Eliminate "duplicative" pools	Prior analyses suggested some Trend Analysis Areas are similar in many characteristics
IX	Eliminate fish protocol from the LTRMP	Cease monitoring fish within the LTRMP
X	Recommend protocol and add enhanced spatial coverage	Expand LTRMP fish monitoring beyond the present six Trend Analysis Areas after refining the sampling protocol
XI	Recommend protocol and add Habitat Rehabilitation and Enhancement Project monitoring throughout the Upper Mississippi River System	Expand LTRMP fish monitoring to Habitat Rehabilitation and Enhancement Project projects after refining the sampling protocol

species detection, spatial and temporal data continuity, and statistical inference at the systemic scale.

Option IV: Eliminate All Passive Gears from the Present Design. Option IV proposed to eliminate all passive gears from the sampling design. Our initial analyses suggested that implementing this option might result in a significant loss of program information relative to the present sampling design. For example, the active gears tended to collect the most fish and species, as well as providing the greatest statistical power to detect inter-annual changes in abundance. However, some of the passive gears provided better information for particular important species than all of the active gears combined (e.g., channel catfish *Ictalurus punctatus*, black crappie *Pomoxis nigromaculatus*, white crappie *P. annularis*, smallmouth buffalo *Ictiobus bubalus*; Appendix A). The program partners highly valued the information provided by the passive gears as evidenced by the disproportionately large number of negative statements for Option IV (Appendix B). Thus, we did not analyze this option further.

Option V: Adopt a Guild Approach Sampling a Few Key Species. Option V proposed a guild approach that would focus on indicator species. This approach would constitute a radical departure from the present sampling design, resulting in data that were incongruous to past years. Moreover, the group was uncertain which species would best represent the overall community. Thus, we discounted Option V as a viable option.

Option VI: Modify Temporal Sampling (Periods). Option VI proposed a reduction in the number of intra-annual periods sampled for fish. The idea behind reduced temporal sampling (i.e., eliminating one of the three periods presently sampled) was as follows. If any of the three sampling periods consistently provided either low or highly variable catches for a majority of species, then it could be eliminated to reduce the overall annual variance and enhance the program's power to detect changes in abundance. We analyzed the potential for reduced period sampling on the basis of 14 species of special management interest (Appendix C). No one period consistently produced significantly smaller catches or more highly variable catches for even a majority of these 14 species (Appendix A). Consequently, elimination of any one period would have differential effects on critical program information. Thus, we abandoned reduced period sampling as a viable option.

Option VII: Modify Temporal Sampling (Years). Option VII proposed to modify the annual sampling cycle (i.e., biennial sampling rather than annual sampling). The negative consequences, as identified by the group, outweighed the positive consequences by a factor of three. This option would have resulted in a partial interruption of temporal continuity and delayed the time it would take to detect trends. The group seemed to view the rapid detection of trends as highly important and felt that this option could hamper those efforts. Thus, we did not consider Option VII as a viable option.

Option VIII: Eliminate "Duplicative" Pools (per Callahan 1998). Option VIII proposed to eliminate one or more of the TAAs from the sampling design. This option was predicated on the observation that some TAAs appear to be similar in some of their fish characteristics. However, Callahan (1998) concluded that while some TAAs were similar, each provided sufficient unique information to the program. Consequently, we did not pursue this option any further in our analyses.

Option IX: Eliminate Fish Protocol from the LTRMP. Option IX proposed to eliminate the fish protocol from the LTRMP. Implementation of this option would have eliminated the ability of the LTRMP to monitor fish resources in the UMRS. Effects of implementing this option, as identified by the group, included lost ability to detect exotic species, monitor status and trends of key species, integrate component data and model ecosystem responses to natural and anthropogenic stressors, and analyze the effects of habitat rehabilitation and enhancements within the basin. Thus, we did not consider Option IX as a viable option.

Option X: Recommend Protocol and Add Enhanced Spatial Coverage. Like Option II, Option X proposed additional monitoring to either the present or any recommended protocol. Consequently, we considered this option as a potential future enhancement and reserved analysis for future consideration.

Option XI: Recommend Protocol and Add Habitat Rehabilitation and Enhancement Project Monitoring throughout the Upper Mississippi River System. Like Options II and X, Option XI proposed additional monitoring to either the present or any recommended protocol. Consequently, we considered this option as a potential future enhancement and reserved analysis for future consideration.

Thus, Option III (best pool-specific gear combinations) was identified as the most viable option from the Options Matrix (Appendix B). We conducted a series of detailed analyses designed to determine the best gear combinations for each TAA and to address the concerns expressed by the group. These analyses included (1) simulated gear reduction scenarios designed to maximize species and trend detection information while minimizing catch and effort, (2) rank correlation analyses (Legendre and Legendre 1998) of community composition data measured by comparable gears in comparable strata, and (3) consequences of gear reductions on species-specific trend detection capabilities by strata and by TAA.

In the sections that follow, we compare results between the present program and the proposed refinement. We focus on identifying what core program information is retained and what is lost under the proposed refinement relative to the present sampling design for each TAA.

The Proposal

We recommend that four gears (night electrofishing, seine, tandem fyke net, and tandem mini fyke net) be eliminated from each TAA in the LTRMP's fish component sampling design. Before our analyses of Option III, we expected a different combination of gears to emerge as best for each or at least some TAAs. However, TAA-specific simulations resulted in identical conclusions among locations regarding redundant data. This occurred because each of the gears we proposed to eliminate had a comparable retained gear that provided similar information.

Comparison Between Present Program and Proposed Refinement

The proposed refinement removes gears from the present sampling design and, thus, reduces catch. Therefore, we considered how much catch would be lost within each TAA by species and size group. Additionally, we assessed the implications of these losses on species detection, community characterization, and change or trend detection at several spatial and temporal scales. In essence, we investigated whether catch lost under the proposed sampling design resulted in lost information. We also considered how the proposed gear reduction would affect the spatial and temporal continuity of data collected by the LTRMP.

Total Catch

We calculated total catch for each TAA using pooled data from 1993 to 1999 under both the present and proposed sampling designs (Table 4). Total catch under the present sampling design was nearly 2.1 million fish for the program as a whole. Gears retained under the proposed sampling design collected about 65% of the total catch observed under the present design. However, the percentage of total catch retained under the proposed sampling design in each TAA varied from 38% in Pool 13 to 97% in the Open River Reach (Figure 2 and Table 4).

Given the large differences in catch retention among the TAAs, we quantified which species and size classes accounted for the majority of the lost catch. Fish less than 120 mm in total length accounted for 74–99% of the reduction in total catch for each TAA (Table 5). Eight abundant and ubiquitous forage species—including cyprinids, clupeids, and young-of-the-year bluegill *Lepomis macrochirus*—accounted for a large majority of the catch that would be lost (Table 5). Thus, the proposed refinement primarily reduced the total catch of abundant forage species and some young-of-the-year fish.

Species Detection

Species detection (i.e., presence or absence) provides the primary data for deriving community composition information. Effects of the proposed refinement on species detection were quantified for each TAA by constructing cumulative distribution plots of percent species detection using successive simulations that added a new gear at each step. This analysis was designed to answer the question "If we had not fished with a particular gear or suite of gears, which species would we have failed to detect relative to the present sampling program?" The order in which the gears entered the simulation was determined from the results of Tukey–Kramer multiple means tests to determine which gears collected significantly more species than other gears (Zar 1984). Results of these tests can be found on the accompanying CD-ROM. Generally, gears that collected the most species entered the simulations first, while gears that collected fewest species entered last. This approach

Table 4. For each Trend Analysis Area in the Long Term Resource Monitoring Program, the total catch of fish from 1993 to 1999 under the present sampling design and in gears retained under the proposed sampling design. Numbers in parentheses indicate the percentage of the total catch under the present design that was collected by the gears retained under the proposed design.

	Total catch	
Trend Analysis Area	**Present design**	**Proposed design**
Pool 4	482,000	328,000 (66%)
Pool 8	378,000	183,000 (48%)
Pool 13	326,000	124,000 (38%)
Pool 26	178,000	128,000 (72%)
Open River	123,000	120,000 (98%)
La Grange Pool	583,000	469,000 (80%)
Total	2,070,000	1,352,000 (65%)

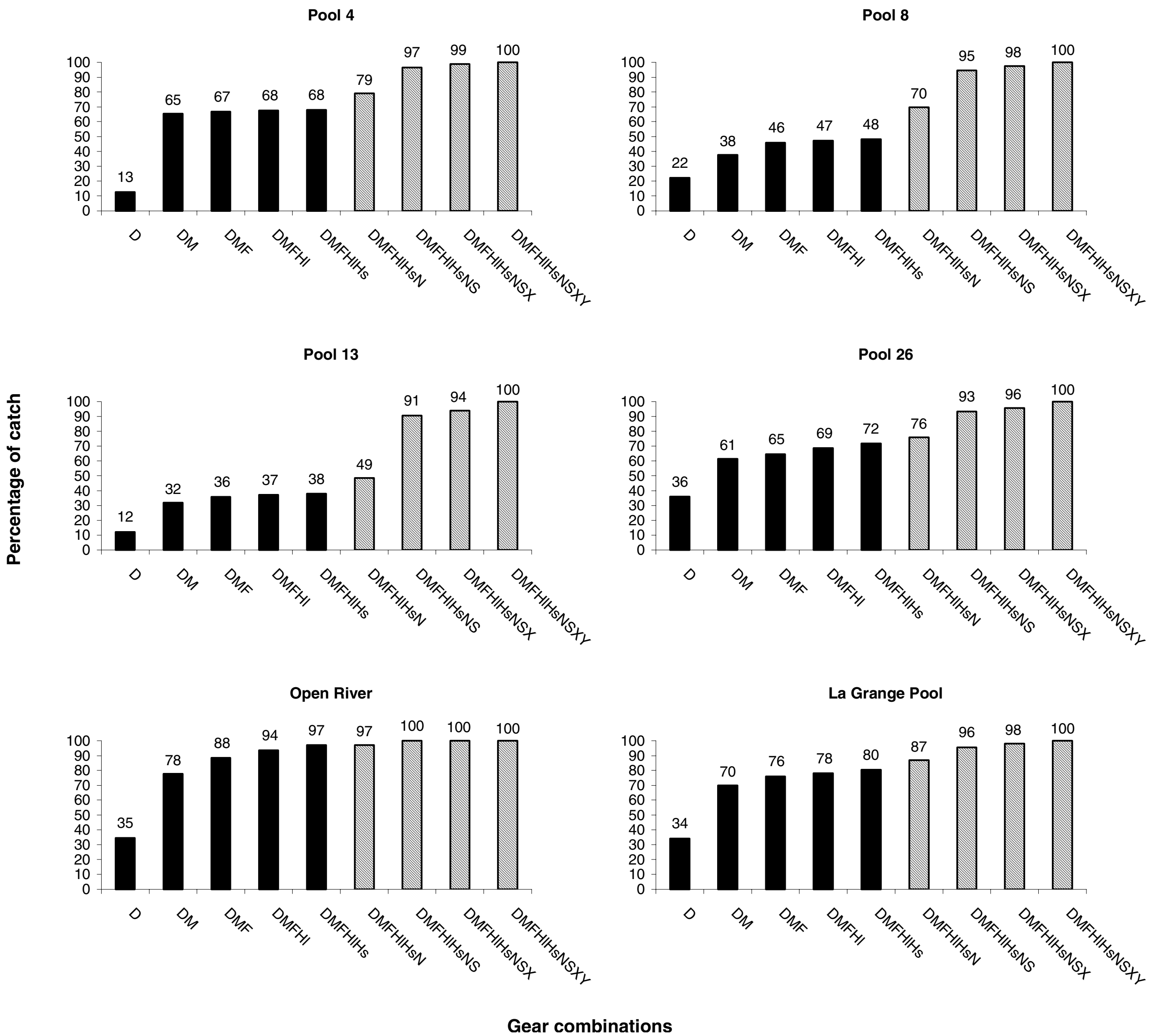

Figure 2. For each Trend Analysis Area, cumulative distribution of catch observed with different gear combinations expressed as a percentage of the total catch in all gears from 1993 to 1999. Each chart represents nine successive simulations for which gears were added starting on the left side of the chart. D = day electrofishing, M = mini fyke net, F = fyke net, Hl = large hoop net, Hs = small hoop net, N = Night electrofishing, S = seine, X = tandem fyke net, and Y = tandem mini fyke net. For example, in Pool 4, day electrofishing alone (D) collected 13% of the fish collected in all gears combined. The addition of mini fyke net to day electrofishing (DM) resulted in the collection of 65% of the fish collected in all gears combined. The four gears we propose to eliminate are represented in the last four bars on the right side of each chart (*gray*). Order of gear entry into the simulations was determined from results of Tukey–Kramer multiple means tests (see accompanying CD-ROM) and was the same for each Trend Analysis Area.

maximized species detection with the fewest number of gears.

The number of unique species under successive simulations was calculated for each TAA, and the percent species detection relative to the full suite of gears presently fished in the program was calculated as follows:

$$\text{Percent species detection}_i = (\text{number unique species}_i \,/\, \text{number unique species}_N) * 100,$$

Table 5. For each Trend Analysis Area, reduction in total catch under the proposed sampling design for the Long Term Resource Monitoring Program's fish component, percentage of the reduction in catch attributed to fish less than 120 mm, and the percentage of catch reduction composed of the eight most abundant taxa.

Trend Analysis Area	Reduction in total catch	Percent contribution of fish less than 120 mm total length to the lost catch	Percent contribution of the eight most abundant taxa[a] to the lost catch
Pool 4	154,000	89%	76%
Pool 8	195,000	76%	46%
Pool 13	202,000	87%	66%
Pool 26	50,000	81%	63%
Open River	3,000	99%	80%
La Grange Pool	114,000	74%	57%

[a]The eight taxa that compose >75% of the lost catch of fish less than 120 mm were gizzard, threadfin shad, emerald shiner, river shiner, mimic shiner, channel shiner, bullhead minnow, and bluegill. Scientific names for the species listed can be found in Appendix C.

where $i = 1, \ldots, n$ successive simulations adding gears and n = the full suite of gears presently fished in the program. Percent species detection for each simulation series was plotted for each TAA (Figure 3). Species that would not probably be detected under the proposed sampling design were identified for each gear (Table 6).

The percentage of species detected by the proposed sampling design ranged from 91% of the species presently sampled in Pool 13 to 100% of the species presently sampled in La Grange Pool (Table 6). The effect of eliminating individual gears on species detection varied. For example, elimination of tandem fyke nets had no effect on species detection because this gear did not detect any species that were not detected under the proposed sampling design. Conversely, most of the species that would have not been detected under the proposed sampling design were collected with seines (Table 6). In all TAAs, however, undetected species were rare in the catch (Appendix D); every species except bigmouth shiner *Notropis dorsalis* in Pool 4 (45 individuals collected by seining) had total catches of less than 10 individuals over 7 years in the present program.

Frequency of Species Detection

Measures of "species importance" in the overall community are required to effectively characterize community structure. One measure of importance is the frequency that a species is observed in a random sample. We calculated the frequency of occurrence for each species in each TAA and gear using pooled data from 1993 to 1999 as follows:

$$\text{Frequency of occurrence}_{shi} = (\text{number of occurrences}_{shi} / \text{total number of samples}_{si}) * 100,$$

where s = TAA, h = species and i = gear.

The gears we propose to eliminate provided little unique information for characterizing UMRS fish communities (see accompanying CD-ROM). The gears that are retained under the proposed sampling design detected nearly all species at similar or greater frequencies than the eliminated gears. The primary exceptions to this pattern were species that were infrequently detected by any gear.

To evaluate temporal variation in detection frequency, we quantified how frequently each gear detected each species in each TAA among years. For each TAA, we calculated the number of years from 1993 to 1999 that each gear detected each species (Appendix E). Gears retained under our proposed sampling design detected nearly every species in every TAA with equal or greater annual frequency as the gears we propose to eliminate (Appendix E). However, a few species were detected less regularly under the proposed sampling design. Exclusive of the species that were uniquely sampled by the dropped gears (listed in Table 6), the numbers of species with lower annual detection frequencies in the retained gears than in the dropped gears ranged from 0 in the Open River Reach to 11 in Pool 8 (Appendix E). However, detection frequencies generally differed by only 1 or 2 years between dropped and retained gears.

Population Trend and Change Detection

Estimates of mean abundance (catch-per-unit-effort) and its associated variance are the primary data used to determine population trends and annual

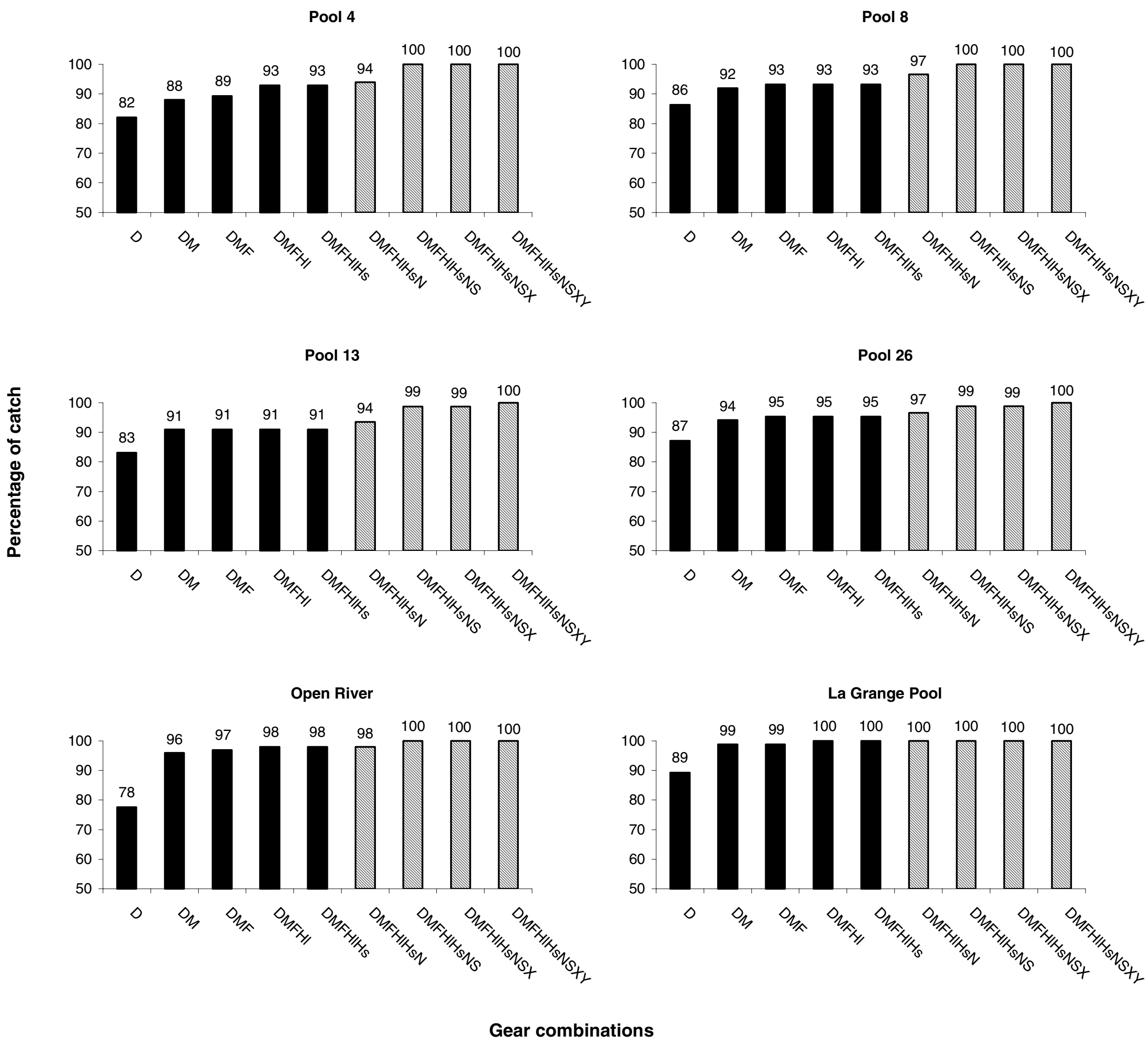

Figure 3. For each Trend Analysis Area, cumulative distribution of the number of species observed with different gear combinations, expressed as a percentage of the total number of species sampled in all gears from 1993 to 1999. Each chart represents nine successive simulations for which gears were added starting on the left side of the chart. D = day electrofishing, M = mini fyke net, F = fyke net, Hl = large hoop net, Hs = small hoop net, N = night electrofishing, S = seine, X = tandem fyke net, and Y = tandem mini fyke net. For example, in Pool 4, day electrofishing alone (D) detected 82% of the species observed in all of the gears combined. The addition of mini fyke net to day electrofishing (DM) resulted in detecting 88% of the species observed in all the gears combined. The four gears we propose to eliminate are represented in the last four bars on the right side of each chart (*gray*). Order of gear entry into the simulations was determined from results of Tukey–Kramer multiple means tests (see accompanying CD-ROM) and was the same for each Trend Analysis Area.

changes in species abundance. We used criteria from Lubinski et al. (2001) to determine the number of species with sufficient data to produce >50% power (Zar 1984) to detect a 20% annual change in catch-per-unit-effort ($\alpha = 0.05$) in each TAA, gear, and strata combination under the present and proposed sampling designs. Under the present sampling design, the number of species, gear, and strata combinations with >50% power (Lubinski et al. 2001) ranged from 29 in the Open River Reach to 100 in Pool 8 (Table 7).

Under the proposed sampling design, the number of species with sufficient power to determine trends within strata remained high in each TAA. In Pools 4 and 26, the Open River Reach, and La Grange Pool,

Table 6. For each Trend Analysis Area, the percentage of species that may still be detected (presence or absence) and species that may be lost under the proposed sampling design for the Long Term Resource Monitoring Program's fish component. Except for bigmouth shiners in Pool 4, species that may be lost have total catches of less than 10 individuals over 7 years of collections. Scientific names for the species listed in this table are found in Appendix C. Detailed information on the total catch, percent of total catch, number of occurrences, and frequency of detection for each species collected in each gear below can be found in Appendix D.

		Species lost by gear			
Trend Analysis Area	**Percentage of species still detected**	**Tandem mini fyke net**	**Tandem fyke net**	**Seine**	**Night electrofishing**
Pool 4	93%			Banded darter Bigmouth shiner Blacknose dace Central stoneroller Pallid shiner	Goldeye
Pool 8	93%			Crystal darter Pallid shiner Skipjack herring	American brook lamprey Black buffalo Fantail darter
Pool 13	91%	Brown trout		Bigmouth shiner Creek chub Fantail darter Rudd	Goldeye Western sand darter
Pool 26	95%			Bigmouth shiner Western sand darter	Shovelnose sturgeon
Open River	98%			Bigeye chub Western sand darter	
La Grange Pool	100%				

95% or more of species retained at least 50% power. Pools 8 and 13 were the most affected, but more than 85% of species retained at least 50% power.

Trend detection capabilities at the TAA scale were only slightly affected by the proposed sampling design. The percentage of power species retained was 97% or more in all TAAs (Table 7). Overall, only seven species were not detected with statistical power similar to the present sampling program (Table 7). Of these seven species, only walleye *Stizostedion vitreum* are of special interest to UMRS river managers. Walleye exhibited high power in Pool 8 night electrofishing samples (Lubinski et al. 2001) and would not be sampled with comparable power in any of the retained gears under the proposed sampling design. However, Pool 8 has historically targeted higher night electrofishing effort than the other TAAs. For a given mean and a given variance, power will increase with sample size (Zar 1984). Consequently, if Pool 8 night electrofishing effort had been more in line with the other TAAs, it is arguable whether sufficient power would have existed in the first place. Regardless, the ability to detect inter-annual change in abundance for walleye would be lost under the proposed sampling design.

Data Continuity

Data continuity is defined as the continuous collection of data under predefined sampling protocols designed to address key questions of interest to researchers and managers. Interruptions in data continuity may hamper attempts to elucidate patterns in monitoring data. We investigated the implications of the proposed sampling design on both spatial and temporal data continuity within the LTRMP's fish component.

Spatial Continuity

Spatial continuity concerns the collection of monitoring data across a predefined geographic area to define spatial patterns in species occurrence and relative abundance. We assessed whether the

Table 7. For each Trend Analysis Area (TAA), the number of species-gear-strata combinations with >50% power to detect a 20% inter-annual change in abundance ($\alpha = 0.05$) under the present sampling design and, under the proposed sampling design, the percentage of those species that retained 50% power at the stratum and TAA scales. Species that no longer retained 50% power under the proposed sampling design are listed for each TAA. Power summaries were derived from Lubinski et al. (2001).

	Present sampling design	Proposed fish sampling design		
		Percentage of species retaining at least 50% power		
TAA	Number of species with greater than 50% power	By stratum	By TAA	Species lost (by TAA)
Pool 4	44	95%	98%	Rock bass[a]
Pool 8	100	85%	98%	Channel shiner Walleye
Pool 13	58	91%	97%	River shiner Johnny darter
Pool 26	47	98%	100%	
Open River	29	100%	100%	
La Grange Pool	98	97%	98%	Spottail shiner Brook silverside

[a]Scientific names for the species listed can be found in Appendix C.

proposed sampling design would reduce capabilities to identify spatial patterns across TAAs (system scale) and within TAAs (reach scale).

The ability to identify systemic spatial patterns in population and community metrics would be nearly unaffected under the proposed sampling design. Investigation of such patterns require common gear and strata combinations across all six TAAs. Night electrofishing, tandem fyke nets, and tandem mini fyke nets are not fished in every TAA and, thus, could not be used to investigate systemic patterns in spatial population and community structure. Seines are fished in all TAAs and might be used to evaluate systemic patterns. However, adequate seining sites in Pool 26 and the Open River Reach are extremely sparse. As a consequence, systemwide analyses based on seine data would probably not be fully informative.

At the TAA scale, the proposed refinement would result in varying degrees of reduced effort in all strata within TAAs (Table 8). In most TAAs, all strata would continue to be monitored. However, backwater contiguous offshore and impounded offshore strata that are present in some TAAs would not be monitored. These strata are only sampled with tandem fyke nets and tandem mini fyke nets, which are gears eliminated under the proposed sampling design.

We investigated whether the cessation of monitoring effort in backwater contiguous offshore and impounded offshore strata would result in a loss of significant information. The similarity of fish communities in offshore and comparable nearshore strata (i.e., backwater contiguous nearshore versus backwater contiguous offshore, impounded offshore versus impounded nearshore) was assessed with a nonparametric rank correlation procedure (Spearman Rank Order Correlation, Legendre and Legendre 1998). We tested for significant correlations between fish communities in the nearshore and offshore samples based on rank abundances of species measured as pooled total catch from 1993 to 1999 (Table 9). Highly significant positive correlations existed between offshore and nearshore strata for every comparison made. Thus, nearshore and offshore strata were similar in the community information they provide, and nearshore data could be used to infer the status of offshore communities

Temporal Continuity

Temporal continuity concerns the collection of data through time for detecting trends. Stopping data collection, changing sampling frequency, or changing the procedures used to collect data can interrupt temporal continuity. For example, a fundamental change in fish data collection occurred in 1993 with the switch from fixed-site sampling to stratified random sampling (Gutreuter et al. 1995). This program refinement changed the spatial inference of the fish data from site-specific to poolwide, resulting in a discontinuity between pre-1993 and post-1993 samples.

Under the proposed sampling design, temporal continuity would obviously be interrupted for the four gears that would be eliminated. However, for the retained gears, temporal continuity would remain

Table 8. Changes in sample allocations by strata within each Trend Analysis Area (TAA) under the proposed refinement of the sampling design for the Long Term Resource Monitoring Program's (LTRMP) fish component. Information on the persistence of gear use between the present sampling design and proposed refinement is presented in column subheadings below headings for each respective TAA. Numbers in the columns labeled "P" designate how many gears are fished in a stratum (row) under the present (P) sampling design for each TAA. Numbers in the columns labeled "R" designate how many gears would continue to be fished in each stratum under the refined (R) sampling design for each TAA. The columns labeled "%" indicate the percent reduction in the number of independent samples collected under the proposed refinement. Comparisons are based on year 2000 sample allocations. Sampling strata that do not occur in a given pool are represented by a "–".

	Trend Analysis Area																	
Sampling strata	Pool 4			Pool 8			Pool 13			Pool 26			Open River[b]			La Grange Pool		
	P	R	% reduction	P	R	% reduction	P	R	% reduction	P	R	% reduction	P	R	% reduction	P	R	% reduction
Backwater contiguous offshore	2	0	100%	2	0	100%	2	0	100%	2	0	100%	–	–	–	2	0	100%
Backwater contiguous nearshore	3	3	0%	3	3	0%	5	3	33%	3	3	0%	–	–	–	4	3	20%
Impounded offshore	–	–	–	1	0	100%	2	0	100%	3[c]	1[c]	80%	–	–	–	–	–	–
Impounded nearshore	–	–	–	3	3	0%	4	3	40%	3	3	0%	–	–	–	–	–	–
Main channel border unstructured	5	4	37%	6	4	43%	6	4	47%	5	4	39%	8[d]	7[d]	32%	5	4	24%
Main channel border wing dam	1	1	0%	2	1	50%	4	4	0%	4	4	0%	5[d]	5[d]	0%	–	–	–
Side channel border	5	4	32%	6	4	40%	6	4	25%	6	5	33%	7[d]	6[d]	21%	6	4	27%
Tailwater zone[a]	6	5	26%	6	4	44%	5	4	13%	2	1	43%	–	–	–	7	6	13%

[a]The tailwater stratum is monitored under a fixed-site sample design (Gutreuter et al. 1995).
[b]The Open River Reach also recognizes a tributary stratum. In 2000, five gears were used in this stratum and all five would remain under the proposed refinement.
[c] Includes trammel nets that are an optional gear within the LTRMP's fish component.
[d]Includes gill nets that are an optional gear within the LTRMP's fish component.

unaffected. Annual collections would continue under the present stratified random sampling protocol (Gutreuter et al. 1995). Consequently, the data collected with the retained gears in future years would be "backwards compatible" with data collected since 1993. Thus, the proposed refinement compromises neither the temporal continuity of the LTRMP's fish component data set nor the sampling design that has existed since 1993.

Conclusions

The conclusion of Lubinski et al. (2001) that sampling efficiencies could probably be realized in the LTRMP's fish component seems appropriate. Among spatial, temporal, and gear reduction alternatives, gear reductions clearly provide the greatest potential for reducing effort while maintaining essential program information. Previous work to determine if spatial simplifications to the fish component design were advisable was largely inconclusive (Callahan 1998; Lubinski et al. 2001). The temporal analyses conducted as part of our study were also inconclusive owing mainly to the large number of species monitored and differences in mean catch and variance among species within TAAs (Appendix A). Consequently, we were unable to find a temporal refinement that did not eliminate substantial information and abandoned this option early in our analysis.

We demonstrated that four gears—night electrofishing, seine, tandem fyke net, and tandem mini fyke net—could be eliminated while retaining nearly all of the core information provided by the program. Under our proposed refinement, 91–100% of species detection capabilities are retained. All

Table 9. Results of Spearman Rank Order Correlation tests of the degree of similarity in community structure between backwater contiguous offshore (BWCO) and shoreline (BWCS) strata, and impounded offshore (IMPO) and shoreline (IMPS) strata, as measured with similar gears. "N/A" means that the stratum did not exist in that Trend Analysis Area.

Trend Analysis Area	Spearman's R statistic	P-value	N
Tandem fyke net (BWCO) versus fyke net (BWCS) comparison			
Pool 4	0.91	<0.001	44
Pool 8	0.93	<0.001	45
Pool 13	0.90	<0.001	40
Pool 26	0.81	<0.001	33
Open River	N/A	N/A	N/A
La Grange Pool	0.93	<0.001	47
Tandem mini fyke net (BWCO) versus mini fyke net (BWCS) comparison			
Pool 4	0.77	<0.001	60
Pool 8	0.78	<0.001	61
Pool 13	0.82	<0.001	53
Pool 26	0.60	<0.001	60
Open River	N/A	N/A	N/A
La Grange Pool	0.70	<0.001	61
Tandem fyke net (IMPO) versus fyke net (IMPS) comparison			
Pool 4	N/A	N/A	N/A
Pool 8	0.85	<0.001	39
Pool 13	0.77	<0.001	40
Pool 26	0.81	<0.001	36
Open River	N/A	N/A	N/A
La Grange Pool	N/A	N/A	N/A
Tandem mini fyke net (IMPO) versus mini fyke net (IMPS) comparison			
Pool 4	N/A	N/A	N/A
Pool 8	0.75	<0.001	58
Pool 13	0.64	<0.001	52
Pool 26	0.59	<0.001	50
Open River	N/A	N/A	N/A
La Grange Pool	N/A	N/A	N/A

species not retained are rare, and we are not able to sample them adequately even with the full suite of gears in the present sampling design. The proposed refinement does not interfere with the program's ability to characterize fish communities using frequency of detection or ranked abundance data. Annual detection rates used to gage species persistence also remain nearly unaffected. Additionally, the ability to detect significant annual changes in abundance are nearly unaffected at the pool scale and only modestly affected at the strata scale (85–100% of change detection capabilities are retained). Finally, temporal data continuity is maintained, and spatial data continuity is only minimally affected.

These results can be achieved while decreasing total catch by one–third for the program as a whole. Most of this decrease is attributable to losses in catch of a few widely distributed and abundant forage fish and young-of-the-year nonforage fish. These taxa generally exhibit large variability in their catch and consequently low statistical power to detect annual changes in abundance (e.g., Appendixes C, D, and E in Lubinski et al. 2001). Variability tends to be so high that even a doubling of effort would not appreciably improve power for these species (Lubinski et al. 2001). However, sufficient numbers of these taxa are collected in the retained gears to adequately detect and characterize them within the community and to determine size distributions and growth rates.

Gear reductions provide an effective means for addressing data redundancies within the LTRMP's fish component. This occurs because some gears provide information similar to other gears. For example, seines use small mesh and tend to collect small-sized species as well as young of larger species. Mini fyke nets, which will be retained, also use small mesh and catch similar species and size classes. As a consequence, the two gears collect similar, though not identical data. Thus, because the four gears we propose to eliminate have retained analogues that collect similar information, they can be eliminated with little loss of information. Impacts on spatial and temporal continuity are also minimized because the retained analogues tend to be fished more consistently among TAAs and in a wider variety of strata and habitats.

Implementing the Proposed Sampling Design

Estimating Saved Effort

We determined the amount of effort that would be saved under the proposed sampling design at each field station and at the Upper Midwest Environmental Sciences Center (UMESC). This process was a cooperative effort among the fish component specialist at the UMESC and field station leaders. For each field station, we estimated savings of effort in selecting sampling sites, field sampling, preparation time, sample processing, gear maintenance, data entry, database management, analysis, and reporting. In fiscal year 2002, only partial savings were realized because samples and data from summer 2001, which were collected under the present sampling design, would still need to be processed and analyzed. Most of the effort saved in 2002 would come in summer when field sampling is reduced. In fiscal year 2003 and thereafter, a full year of savings would be realized.

Among field stations, the estimated number of person days saved annually varied from 20 to 88 person days (Table 10) depending on the level of effort and catch historically associated with each of the eliminated gears. For all field stations, most effort savings came from field sampling. Effort saved at the UMESC was estimated at 14 person days per year and the mean reduction in contracted data entry was 37% (Table 10).

Table 10. Estimates of effort saved annually by eliminating four gears (night electrofishing, seine, tandem fyke net, and tandem mini fyke net) from the fish sampling design of the Long Term Resource Monitoring Program. Categories of effort considered included selecting sampling sites, field sampling, preparation time, sample processing, gear maintenance, data entry, database management, analysis, and reporting. In fiscal year 2002, only partial effort savings (mean of about 80%) would be realized because samples and data from summer 2001 would need to be processed and analyzed.

Location or type of effort saved	Estimated annual effort savings
Pool 4	62 person days
Pool 8	88 person days
Pool 13	61 person days
Pool 26	67 person days
Open River	20 person days
La Grange Pool	82 person days
Program administration	14 person days
Contracted data entry	37% mean reduction

Plans for Redirecting Saved Effort

Effort saved by improving sampling efficiency of the fish component may be redirected to other program needs. Development of a redirection plan required input from field stations and from the LTRMP Analysis Team and approval by the Environmental Management Program Coordination Committee. Initially, efforts focused on fiscal year 2002, when partial effort savings would be realized. Each field station leader submitted suggestions on how to redirect effort to Dr. L. Holland-Bartels, the U.S. Geological Survey (USGS) LTRMP administrator. These suggestions were evaluated based on a variety of factors including their application to program goals, their potential for adding value to existing projects or analyses, their ability to achieve timely products, and the unique capabilities and situations available at each field station. In addition, because saved effort was not available in a single block of time or from a single individual, the distribution of saved time over the year and among staff was considered. The LTRMP administrator forwarded preferred suggestions to the LTRMP Analysis Team for comment, then developed a final plan that was submitted to the Environmental Management Program Coordination Committee for approval. Final work guidance for summer 2002 was provided in spring 2002. A similar process began in summer 2002 to develop a redirection plan for fiscal year 2003 and beyond.

Acknowledgments

This project was conducted by the USGS UMESC, La Crosse, Wisconsin, as part of the LTRMP partly under contract with the University of Wisconsin–La Crosse, River Studies Center. The U.S. Army Corps of Engineers provided funding, with overall program guidance and support by the USGS UMESC. The LTRMP field station staff in Iowa, Illinois, Minnesota, Missouri, and Wisconsin collected data used in this report. Members of the LTRMP Analysis Team, a program advisory body, provided critical input, reviewed analyses, and generated a suite of program refinements to consider. The LTRMP field station leaders—John Chick (Brighton, Illinois); Terry Dukerschein (Onalaska, Wisconsin); Robert Hrabik (Jackson, Missouri); Mark Pegg (Havana, Illinois); Walt Popp (Lake City, Minnesota); and Mike Steuck (Bellevue, Iowa)—along with their fisheries staff and LTRMP component specialists—Yao Yin (aquatic vegetation); Dave Soballe (water quality); and Jenny Sauer (invertebrates)—provided critical review of the analyses. Jim Rogala (USGS, UMESC, La Crosse, Wisconsin) assisted with geographic information system-based analyses. Mike Caucutt and Dave Bergstedt (USGS, UMESC, La Crosse, Wisconsin) assisted in serving analytical results on the UMESC Web server. This report has been improved thanks to the critical reviews of three anonymous reviewers.

References

Bartels, A. 2000. Fish sampling data from Navigation Pool 8 of the Upper Mississippi River, 1991–1997. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, April 2000. LTRMP 2000-S001. 105 pp.

Callahan, E. 1998. Similarities between Upper Mississippi River pools included in the Long Term Resource Monitoring Program (LTRMP). Unpublished. Environmental Statistics, P.O. Box 563, Fountain City, Wisconsin 54629.

Cochran, W. G. 1977. Sampling techniques, 3rd edition. John Wiley and Sons, New York.

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

Hayes, D. B., C. P. Ferrari, and W. W. Taylor. 1996. Active fish capture methods. Pages 193–220 *in* B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Hubert, W. A. 1996. Passive capture techniques. Pages 157–192 *in* B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Legendre, P., and L. Legendre. 1998. Numerical ecology, 2nd English edition. Elsevier, New York.

Lubinski, K. R., 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.

Robins, C. R., 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.

U.S. Fish and Wildlife Service. 1993. Operating Plan for the Upper Mississippi River System Long Term Resource Monitoring Program. Environmental Management Technical Center, Onalaska, Wisconsin, Revised September 1993. EMTC 91-P002R. 179 pp. (NTIS #PB94-160199)

Wilcox, D. B. 1993. An aquatic habitat classification system for the Upper Mississippi River System. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin. EMTC 93-T003.

Zar, J. H. 1984. Biostatistical analysis, 2nd edition. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Appendix A

A CD-ROM containing analytical results used as a heuristic tool by the Long Term Resource Monitoring Program (LTRMP) partners to investigate potential sampling design refinement scenarios (accessible using Netscape or Microsoft Explorer browser software). Details on analytical methods and results too voluminous to document within this report are documented within the Web-browser accessible portion of this CD-ROM. In addition, we provided the database we analyzed (Microsoft Access format), analytical program files we wrote (SAS program file format), and an electronic version of this report (Microsoft Word format) on this CD-ROM. Terminology between this printed report may differ slightly from that found on the CD-ROM.

Appendix B

Matrix generated by a group of the Long Term Resource Monitoring Program (LTRMP) partners, in 2001 to identify options for addressing sampling efficiencies in the LTRMP's fish component.

	Consequences	
Options	**Positive**	**Negative**
Option I: Maintain existing fish protocol	1. Existing protocol has good power for many species of management interest within lentic habitats (see report) 2. Maintains data continuity 3. Presence or absence of threatened or endangered species 4. Detection of invasives 5. Information on young-of-the-year, recruitment, growth, reproduction for many species (mostly lentic) 6. Vested program w/ protocols and training and gears in place 7. Starting to identify dynamics and trends for many species 8. Ability to characterize communities (especially lentic)	1. Present protocol does not sample the main channel, an area of significant management conflict related to navigation and dam operation 2. Present protocol does not effectively sample species of concern (threatened, endangered). 3. FY 2001 costs = $1.4 million. Increases about $100 K annually to continue FY 2001 protocol (too expensive?) 4. Does not free up resources to address the other objectives of LTRMP 5. Unrealized efficiencies and improvements based on existing knowledge 6. Unknown spatially limited inference
Option II: Maintain existing protocol and add main channel sampling to the design	1. See Option I positive consequences 2. Detection of channel species and communities 3. More effective sampling of channel strata 4. Ability to integrate presently under-sampled strata w/ data from the other components 5. Information exists for initial development of new protocols 6. Improved sampling for threatened and endangered species 7. Improved ability to make cross strata comparisons and inference 8. Additional information on species in navigation channel	1. Costs will increase above the $100 K annual inflation estimate 2. See responses #4 and #5 from Option I 3. Unknown spatially limited inference
Option III: Develop best pool-specific gear combination	1. Eliminate gears that are not effective in certain pools, strata, and periods 2. Precedent exists (see Open River) 3. Potential time and cost savings per unit of sample 4. Redirected effort to optimize trend detection within each pool 5. Added flexibility to address topics of special interests of program partners	1. Unknown potential losses in statistical inference at the systemic level 2. Potential losses in species detection associated with dropping gears or strata 3. Potential loss of program continuity in favor of meeting changing management needs
Option IV: Eliminate all passive gears from the present design	1. Frees up time and effort (resources) 2. More efficient database for common species	1. Loss of species detection, size structure data, and power for certain species (varies by pool; (e.g., channel catfish *Ictalurus punctatus*—Pools 4, 8, and 13) 2. Loss of hoop nets will eliminate the collection of most age I+ channel catfish and smallmouth buffalo *Ictiobus bubalus* 3. Loss of fyke nets will eliminate population trend information for bluegill *Lepomis macrochirus*, crappie *Pomoxis* spp., and bullhead *Ameiurus* spp.

Appendix B. Continued

Options	Consequences: Positive	Consequences: Negative
		4. Most of turtle data will be lost 5. Decreased sample sizes—loss of ability to make population estimates 6. Incomplete length-frequency distributions 7. Loss of young-of-the-year information (reproduction, recruitment, growth) 8. Loss of deep lentic and strata information (all of backwater and impounded offshore data) 9. Loss of data continuity 10. Loss of ability to validate population trends using data from multiple gears 11. Some passive gears more powerful for some pools, species, strata, and times than any or all of the active gears (e.g., seine—Pools 4 and 26) 12. The LTRMP would provide less unique data to the state partners 13. Reduced ability to detect invasive species (e.g., Asian carps *Hypopthalmichthys molitrix*)
Option V: Adopt a guild approach sampling a few key species	1. Better quality data for chosen species or guilds (e.g., threatened and endangered, species of concern) 2. Detailed population dynamics data (egg to hook) 3. Increased sampling efficiency 4. Potential saved time 5. Links to habitat needs assessment (HNA) 6. Simplified data set	1. Not clear which species are keystone or sentinel in the system; even so, they may vary across space (e.g., assessment pools) 2. Guild membership is incomplete for some species 3. Sacrifice of species richness and community composition information (can step down from community sampling but not back up from guilds) 4. Loss of ability to detect invasive species 5. Potential loss of species-specific information 6. Requires a lot more detailed study 7. Potential to lose some integration with other components.
Option VI: Modify temporal sampling (periods)	1. Time savings for other projects 2. Potential to reduce variance in relative abundance estimates for some species 3. Potential to improve integration with other components	1. No clear way to drop any one sampling period systemically 2. Catch and sample size would decline 3. Potential loss of growth and year class strength information 4. May miss migration / movements / seasonal strata use 5. Missed species detection 6. Loss of flexibility to deal with floods or droughts, etc. (e.g., if only two periods and river floods, we may lose one of the two periods) 7. Potential to lose some integration with other components.
Option VII: Modify temporal sampling (years)	1. Expanded scope of work and activities (spatially expanded sampling, focused research, publication of findings, data analysis) 2. Professional interaction, communication, presentation, coordination 3. Addition of more trend pools	1. Increased administrative duties (e.g., contract preparation) 2. Loss of temporal continuity 3. Decreased ability to detect annual trends 4. Increased probability of spurious relations in short time frames 5. Loss of potential integration with other components

Appendix B. Continued

Options	Consequences: Positive	Consequences: Negative
		6. Loss of ability to investigate causative factors driving population dynamics 7. Unknown effect on our ability to detect inter-annual trends 8. Reduced ability to address socio-political issues associated with extreme events in the system 9. Reduced probability to detect rare events and consequences 10. Litigation issues
Option VIII: Eliminate "duplicative" pools	1. Free up time and money for directed research 2. Elimination of redundant information 3. Potential to "replace or relocate" station(s) to areas of geobiochemologic interest	1. Political upheaval 2. Loss of corroboration among pools 3. Unclear that field stations are duplicative
Option IX: Eliminate fish protocol from the LTRMP	1. Possible shift from a fish-driven design to something more holistic (broadened sampling frame) 2. Increased program flexibility 3. Ability to increase focused research (basic and applied)	1. Political upheaval 2. Termination of fish trend information 3. Assumes: "If we build it, they will come"—in reference to habitat improvement 4. Loss of partner support 5. Loss of ability to detect invasive species 6. Loss of integration across components 7. Loss of validation data for modeling efforts 8. Logistics associated with retraining and hiring existing and new personnel 9. Loss of an ecosystem perspective for the Upper Mississippi River System 10. Fish component proven statistically adequate or appropriate
Option X: Recommend protocol and add enhanced spatial coverage (e.g., field station and/or roving crew)	1. Able to address assumptions associated with spatial inference from the present protocol 2. Improve sampling for threatened and endangered species and improved detection of exotics or invasives 3. Document effects of barrier dams on distribution and abundance 4. Improved ability to make cross strata comparisons and inference 5. Increased partner or local support	1. Increased costs, logistical challenges to overcome 2. Needs additional statistical support to implement 3. Reduced probability to detect rare events and consequences 4. Litigation issues
Option XI: Recommend protocol and add Habitat Rehabilitation and Enhancement Project monitoring throughout the Upper Mississippi River System	1. Consistency in data collection protocols 2. Leads to evaluation or optimization of the effectiveness of various Habitat Rehabilitation and Enhancement Project designs 3. Expanded data 4. Baseline data for directed research 5. Validation of subjective HNA transition matrix 6. Expand HNA baseline data	1. Monitoring Habitat Rehabilitation and Enhancement Projects may not provide managers the answers they want (attractors or producers?) 2. Reduced program flexibility to do other things 3. Increased costs and logistical challenges to overcome 4. Increased database complexity 5. May require additional data on other components (physical, chemical, and biological)

Appendix C

List of fish collected by the Long Term Resource Monitoring Program, arranged phylogenetically by family, then alphabetically by genus and species. Hybrids are listed after their respective genera. Nomenclature follows Robins et al. (1991). The 14 species of special management interest are indicated by an asterisk (*).

Common name	Family name	Scientific name
	Petromyzontidae	
Chestnut lamprey		*Ichthyomyzon castaneus*
Silver lamprey		*I. unicuspis*
American brook lamprey		*Lampetra appendix*
	Acipenseridae	
Lake sturgeon		*Acipenser fulvescens*
Pallid sturgeon		*Scaphirhynchus albus*
Shovelnose sturgeon		*S. platorynchus*
Pallid sturgeon × Shovelnose sturgeon		*S. albus* × *S. platorynchus*
	Polyodontidae	
Paddlefish		*Polyodon spathula*
	Lepisosteidae	
Spotted gar		*Lepisosteus oculatus*
Longnose gar		*L. osseus*
Shortnose gar		*L. platostomus*
	Amiidae	
Bowfin		*Amia calva*
	Hiodontidae	
Goldeye		*Hiodon alosoides*
Mooneye		*H. tergisus*
	Anguillidae	
American eel		*Anguilla rostrata*
	Clupeidae	
Skipjack herring		*Alosa chrysochloris*
Gizzard shad*		*Dorosoma cepedianum*
Threadfin shad		*D. petenense*
	Cyprinidae	
Central stoneroller		*Campostoma anomalum*
Goldfish		*Carassius auratus*
Grass carp		*Ctenopharyngodon idella*
Red shiner		*Cyprinella lutrensis*
Spotfin shiner		*C. spiloptera*
Blacktail shiner		*C. venusta*
Common carp*		*Cyprinus carpio*
Goldfish × common carp		*Carassius auratus* × *C. carpio*
Western silvery minnow		*Hybognathus argyritis*
Brassy minnow		*H. hankinsoni*
Mississippi silvery minnow		*H. nuchalis*
Plains minnow		*H. placitus*
Silver carp		*Hypopthalmichthys molitrix*

Common name	Family name	Scientific name
Bighead carp		*H. nobilis*
Striped shiner		*Luxilus chrysocephalus*
Bleeding shiner		*Luxilus zonatus*
Speckled chub		*Macrhybopsis aestivalis*
Sturgeon chub		*M. gelida*
Sicklefin chub		*M. meek*i
Silver chub		*M. storeriana*
Hornyhead chub		*Nocomis biguttatus*
Golden shiner		*Notemigonus crysoleucas*
Bigeye chub		*Notropis amblops*
Pallid shiner		*N. amnis*
Emerald shiner*		*N. atherinoides*
River shiner		*N. blennius*
Bigeye shiner		*N. boops*
Ghost shiner		*N. buchanani*
Spottail shiner		*N. hudsonius*
Ozark minnow		*N. nubilus*
Silverband shiner		*N. shumardi*
Sand shiner		*N. stramineus*
Weed shiner		*N. texanus*
Mimic shiner		*N. volucellus*
Channel shiner		*N. wickliffi*
Pugnose minnow		*Opsopoeodus emiliae*
Suckermouth minnow		*Phenacobius mirabilis*
Southern redbelly dace		*P. erythrogaster*
Bluntnose minnow		*Pimephales notatus*
Fathead minnow		*P. promelas*
Bullhead minnow		*P. vigilax*
Blacknose dace		*Rhinichthys atratulus*
Creek chub		*Semotilus atromaculatus*
	Catostomidae	
River carpsucker		*Carpiodes carpio*
Quillback		*C. cyprinus*
Highfin carpsucker		*C. velifer*
White sucker		*C. commersoni*
Blue sucker		*Cycleptus elongatus*
Creek chubsucker		*Erimyzon oblongus*
Northern hog sucker		*Hypentelium nigricans*
Smallmouth buffalo		*Ictiobus bubalus*
Bigmouth buffalo		*I. cyprinellus*
Black buffalo		*I. niger*
Spotted sucker		*Minytrema melanops*
Silver redhorse		*Moxostoma anisurum*
River redhorse		*M. carinatum*
Golden redhorse		*M. erythrurum*
Shorthead redhorse		*M. macrolepidotum*
	Ictaluridae	
Black bullhead		*Ameiurus melas*
Yellow bullhead		*A. natalis*
Brown bullhead		*A. nebulosus*
Blue catfish		*Ictalurus furcatus*
Channel catfish*		*I. punctatus*
Slender madtom		*Noturus exilis*

Appendix C. Continued

Common name	Family name	Scientific name
Stonecat		*N. flavus*
Tadpole madtom		*N. gyrinus*
Freckled madtom		*N. nocturnus*
Flathead catfish		*Pylodictis olivaris*
	Esocidae	
Gass pickerel		*Esox americanus vermiculatus*
Northern pike*		*E. lucius*
Muskellunge		*E. masquinongy*
Tiger muskellunge		*E. masquinongy* × *E. lucius*
Chain pickerel		*E. niger*
	Umbridae	
Central mudminnow		*Umbra limi*
	Osmeridae	
Rainbow smelt		*Osmerus mordax*
	Salmonidae	
Brown trout		*Salmo trutta*
	Percopsidae	
Trout-perch		*Percopsis omiscomaycus*
	Aphredoderidae	
Pirate perch		*Aphredoderus sayanus*
	Gadidae	
Burbot		*Lota lota*
	Cyprinodontidae	
Northern studfish		*Fundulus catenatus*
Starhead topminnow		*F. dispar*
Blackstripe topminnow		*F. notatus*
Blackspotted topminnow		*F. olivaceus*
	Poeciliidae	
Western mosquitofish		*Gambusia affinis*
	Atherinidae	
Brook silverside		*Labidesthes sicculus*
Inland silverside		*Menidia beryllina*
	Gasterosteidae	
Brook stickleback		*Culaea inconstans*
	Percichthyidae	
White perch		*Morone americana*
White bass*		*M. chrysops*
Yellow bass		*M. mississippiensis*
Striped bass		*M. saxatilis*
White bass × striped bass		*M. chrysops* × *M. saxatilis*
	Centrarchidae	
Shadow bass		*Ambloplites ariommus*

Appendix C. Continued

Common name	Family name	Scientific name
Rock bass		*A. rupestris*
Flier		*Centrarchus macropterus*
Green sunfish		*Lepomis cyanellus*
Pumpkinseed		*L. gibbosus*
Warmouth		*L. gulosus*
Orangespotted sunfish		*L. humilis*
Bluegill*		*L. macrochirus*
Longear sunfish		*L. megalotis*
Redear sunfish		*L. microlophus*
Green sunfish × pumpkinseed		*L. cyanellus* × *L. gibbosus*
Green sunfish × warmouth		*L. cyanellus* × *L. gulosus*
Green sunfish × orangespotted sunfish		*L. cyanellus* × *L. humilis*
Green sunfish × bluegill		*L. cyanellus* × *L. macrochirus*
Pumpkinseed × warmouth		*L. gibbosus* × *L. gulosus*
Pumpkinseed × orangespotted sunfish		*L. gibbosus* × *L. humilis*
Pumpkinseed × bluegill		*L. gibbosus* × *L. macrochirus*
Orangespotted sunfish × longear sunfish		*L. humilis* × *L. megalotis*
Bluegill × warmouth		*L. macrochirus* × *L. gulosus*
Bluegill × orangespotted sunfish		*L. macrochirus* × *L. humilis*
Bluegill × longear sunfish		*L. macrochirus* × *L. megalotis*
Bluegill × redear sunfish		*L. macrochirus* × *L. microlophus*
Smallmouth bass*		*Micropterus dolomieu*
Spotted bass		*M. punctulatus*
Largemouth bass*		*M. salmoides*
White crappie*		*Pomoxis annularis*
Black crappie*		*P. nigromaculatus*
White crappie × black crappie		*P. annularis* × *P. nigromaculatus*
	Percidae	
Crystal darter		*Crystallaria asprella*
Western sand darter		*Ammocrypta clara*
Mud darter		*Etheostoma asprigene*
Greenside darter		*E. blennioides*
Bluntnose darter		*E. chlorosomum*
Iowa darter		*E. exile*
Fantail darter		*E. flabellare*
Slough darter		*E. gracile*
Johnny darter		*E. nigrum*
Banded darter		*E. zonale*
Yellow perch		*Perca flavescens*
Logperch		*Percina caprodes*
Blackside darter		*P. maculata*
Slenderhead darter		*P. phoxocephala*
Dusky darter		*P. sciera*
River darter		*P. shumardi*
Sauger*		*Stizostedion canadense*
Walleye*		*S. vitreum*
Sauger × walleye		*S. canadense* × *S. vitreum*
	Sciaenidae	
Freshwater drum		*Aplodinotus grunniens*

Appendix D

For each Trend Analysis Area and each gear eliminated under the proposed refinement to the Long Term Resource Monitoring Program's fish sampling design, the species that were collected only by that gear and, thus, would no longer be detected, total catch and the number of occurrences of each species, and the frequency of occurrence of the species in the dropped gear. All data were pooled from 1993 to 1999.

Trend Analysis Area	Gear eliminated and number (in parentheses) of samples	Species unique to that gear[a]	Total catch	Number of occurrences	Frequency occurrence (%)
Pool 4	Night electrofishing (82)	Goldeye	1	1	1.22%
	Seines (213)	Banded darter	2	2	0.94%
		Bigmouth shiner	45	6	2.82%
		Blacknose dace	1	1	0.47%
		Central stoneroller	1	1	0.47%
		Pallid shiner	1	1	0.47%
	Tandem fyke nets	*No species lost*			
	Tandem mini fyke nets	*No species lost*			
Pool 8	Night electrofishing (378)	American brook lamprey	5	5	1.32%
		Black buffalo	1	1	0.27%
		Fantail darter	2	2	0.53%
	Seines (368)	Crystal darter	3	3	0.82%
		Pallid shiner	5	2	0.54%
		Skipjack herring	1	1	0.27%
	Tandem fyke nets	*No species lost*			
	Tandem mini fyke nets	*No species lost*			
Pool 13	Night electrofishing (151)	Goldeye	1	1	0.66%
		Western sand darter	2	2	1.33%
	Seines (364)	Bigmouth shiner	1	1	0.28%
		Creek chub	1	1	0.28%
		Fantail darter	1	1	0.28%
		Rudd	2	1	0.28%
	Tandem fyke nets	*No species lost*			
	Tandem mini fyke nets (145)	Brown trout	1	1	0.69%
Pool 26	Night electrofishing (36)	Shovelnose sturgeon	2	1	2.78%
	Seines (246)	Bigmouth shiner	8	4	1.63%
		Western sand darter	5	4	1.63%
	Tandem fyke nets	*No species lost*			
	Tandem mini fyke nets	*No species lost*			
Open River	Night electrofishing[b]				
	Seines (41)	Bigeye chub	1	1	2.44%
		Western sand darter	2	2	4.88%
	Tandem fyke nets[b]				
	Tandem mini fyke nets[b]				
La Grange Pool	Night electrofishing	*No species lost*			
	Seines	*No species lost*			
	Tandem fyke nets	*No species lost*			
	Tandem mini fyke nets	*No species lost*			

[a]Scientific names are presented in Appendix C.
[b]Night electrofishing, tandem fyke net, and tandem mini fyke net are not conducted in the Open River Reach.

Appendix E

For each Trend Analysis Area (TAA) of the Long Term Resource Monitoring Program, the number of years that a species was collected by each fish sampling gear in 1993–1999. For each TAA, we list only these species that were collected more often in at least one of the gears proposed for elimination compared to the retained gears.

		Fish sampling gear									
		Retained gears						Eliminated gears			
TAA	Species[a]	Day electrofishing	Fyke net	Mini fyle net	Large hoop net	Small hoop net	Bottom trawl	Night electrofishing	Seine	Tandem fyke net	Tandem mini fyke net
Pool 4	American eel	2	4	2	0	1	0	5	0	3	0
	Bluntnose minnow	1	0	2	0	0	0	0	5	0	0
	Brook stickleback	0	0	1	0	0	0	0	2	0	1
	Fathead minnow	1	0	0	0	0	0	0	2	0	1
	Mud darter	2	0	4	0	0	0	0	6	0	4
	Sand shiner	3	0	3	0	0	0	0	6	0	1
	Speckled chub	0	0	5	0	0	5	0	7	0	1
	Trout perch	3	0	6	0	0	0	0	7	0	4
	Western sand darter	2	0	1	0	0	0	0	0	6	0
Pool 8	Chestnut lamprey	6	3	2	0	1	0	7	1	1	0
	Crystal darter	0	0	0	0	0	1	0	2	0	0
	Goldeye	1	0	0	0	0	0	2	1	0	0
	Mississippi silvery minnow	2	0	2	0	0	0	5	2	0	0
	Northern hog sucker	3	0	0	0	0	0	5	1	0	0
	Sand shiner	3	0	5	0	0	0	5	7	0	1
	Silver chub	4	0	0	0	4	4	7	1	0	0
	Slenderhead darter	6	0	6	0	0	0	7	7	0	3
	Trout perch	3	0	2	0	0	0	5	4	0	3
	Western sand darter	5	0	1	0	0	1	7	7	0	0
	Yellow bass	2	0	0	0	0	0	4	0	1	0
Pool 13	Bluntnose minnow	0	0	2	0	0	0	0	3	0	0
	Brook silverside	6	0	6	0	0	1	7	7	0	0
	Golden redhorse	6	1	1	2	1	0	7	3	2	0
	Quillback	6	4	3	5	1	0	7	3	3	0
	Rock bass	6	3	5	0	0	0	7	1	0	0
	Suckermouth minnow	0	0	1	0	0	0	0	4	0	0
	Yellow bass	6	6	2	0	0	0	7	1	5	1
Pool 26	Brook silverside	5	0	5	0	0	0	1	7	0	2
	Sand shiner	5	0	5	0	0	0	0	6	0	0
	Speckled chub	1	0	2	0	0	4	0	5	0	5
	Walleye	4	3	2	0	0	0	5	1	2	0
	Yellow bullhead	3	4	3	1	1	0	0	0	5	0
Open River[b]	None										
La Grange Pool	Blacknose dace	0	0	1	0	0	0	0	3	0	0
	Brook silverside	6	0	5	0	0	0	6	7	0	1
	Sand shiner	0	0	2	0	0	0	0	4	0	0
	Slenderhead darter	1	0	2	0	0	0	0	4	0	0
	Suckermouth minnow	1	0	1	0	0	0	0	2	0	0

[a]Scientific names can be found in Appendix C.
[b]Night electrofishing, tandem fyke net, and tandem mini fyke net are not conducted in the Open River Reach.

REPORT DOCUMENTATION PAGE			Form approved OMB No. 0704-0188

1. **AGENCY USE ONLY** (Leave Blank)	2. **REPORT DATE** October 2002	3. **REPORT TYPE AND DATES COVERED**

4. TITLE AND SUBTITLE
Evaluation and Proposed Refinement of the Sampling Design for the Long Term Resource Monitoring Program's Fish Component

5. FUNDING NUMBERS

6. AUTHOR(S)
Brian S. Ickes and Randy W. Burkhardt

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESSES
U.S. Geological Survey
Upper Midwest Environmental Sciences Center
2630 Fanta Reed Road
La Crosse, Wisconsin 54603

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESSES
U.S. Geological Survey
Upper Midwest Environmental Sciences Center
2630 Fanta Reed Road
La Crosse, Wisconsin 54603

10. SPONSORING, MONITORING AGENCY REPORT NUMBER
2002-T001

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Release unlimited. Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (1-800-553-6847 or 703-487-4650. Available to registered users from the Defense Technical Information Center, Attn: Help Desk, 8725 Kingman Road, Suite 0944, Fort Belvoir, VA 22060-6218 (1-800-225-3842 or 703-767-9050).

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

Environmental monitoring programs are frequently designed to track changes in key physical, chemical, and biological features of an ecosystem. As such, these programs provide critical information for detecting changes in system state, investigating ecological relations, and making resource management decisions. However, monitoring programs require significant investments of time, money, and human resources to implement and maintain. Periodic evaluations are necessary to assess whether the sampling design adequately addresses program goals and objectives, and whether adequate and useful information can continue to be provided for changing management and science needs. We evaluated the Long Term Resource Monitoring Program (LTRMP) sampling design for fish by analyzing data from stratified random samples collected from 1993 to 1999 in six Trend Analysis Areas (TAAs). Specifically, we investigated whether the sampling design could provide similar information with fewer sampling gears. Our goals were to identify and quantify information provided by each gear used to monitor fish in the LTRMP, develop alternative sampling design scenarios based on our analyses and expert opinion, and engage program partners in a discussion on the relative value of each gear within the present sampling design. We forward a proposal to systemically eliminate four of the ten sampling gears presently used to monitor the status and trends in fish resources within the LTRMP.

14. SUBJECT TERMS (Keywords)

community composition, community structure, ecological monitoring, ecosystem management, fishing gears, Illinois River, monitoring programs, river ecology, sampling efficiency sampling gears, status and trends, Upper Mississippi River.

15. NUMBER OF PAGES
17 pp. + Appendixes A–E
CD-ROM included

16. PRICE CODE

17. **SECURITY CLASSIFICATION OF REPORT**	18. **SECURITY CLASSIFICATION OF THIS PAGE**	19. **SECURITY CLASSIFICATION OF ABSTRACT**	20. **LIMITATION OF ABSTRACT**
Unclassified	Unclassified	Unclassified	

The Long Term Resource Monitoring Program (LTRMP) for the Upper Mississippi River System was authorized under the Water Resources Development Act of 1986 as an element of the Environmental Management Program. The mission of the LTRMP is to provide river managers with information for maintaining the Upper Mississippi River System as a sustainable large river ecosystem given its multiple-use character. The LTRMP is a cooperative effort by the U.S. Geological Survey, the U.S. Army Corps of Engineers, and the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin.