Indicators of Ecosystem Health for the Upper Mississippi River System

Analysis Team Ad Hoc Indicators Group

Upper Mississippi River Restoration – Environmental Management Program

Long Term Resource Monitoring Program Element

May 2013

Table of Contents

List of Tables

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1. Background

Congress authorized the Upper Mississippi River Restoration - Environmental Management Program (UMRR-EMP) in the 1986 Water Resources Development Act to help address ecological needs on the Upper Mississippi River System[1] (UMRS). The two major elements of the UMRR-EMP, the Habitat Rehabilitation and Enhancement Projects (HREPs) and the Long Term Resource Monitoring Program (LTRMP), together, are designed to improve the environmental health of the UMRS and increase our understanding of its natural resources.

The LTRMP element combines environmental monitoring, research, and modeling with data management and dissemination to provide information and insight needed by river managers to more effectively manage and restore the UMRS. The LTRMP data set remains one of the most extensive and comprehensive data sets on any large river system in the world and is used to aid scientists, field managers, and biologists in habitat restoration planning, landscape modeling, and understanding the ecology of the UMRS and its habitats and communities.

Like other large rives, the UMRS serves a diversity of roles that present significant management and conservations challenges. There is a need for regular quantitative assessments of the condition of the UMRS ecosystem to improve conservation and management plans, to evaluate their effectiveness, and to measure progress towards meeting UMRS goals and objectives as they are developed, where appropriate. These assessments will provide general information on the status of the UMRS for the parameters presented and can be used as tools for use by river managers and agencies to inform their work. These assessments should also be used to communicate with managers outside the river valley and to target issues from the numerous watershed inputs into this river system. Together with assessments performed by others, a better understanding of the river condition, and trends in key components, can be attained.

2. Previous Reports

To date, the LTRMP has produced two Status and Trends (S&T) Reports. The first S&T Report produced by the LTRMP element (USGS 1999) provided a thorough introduction to the UMRS, including descriptions of historical context, watershed geology and land use, floodplain forests, bird populations, water quality, fishes, aquatic vegetation, and macroinvertebrates, with relatively little LTRMP collected trend data. This report compared river health criteria with measured observations and conveyed this comparison by a series of gages that reflect stable, declining or improving conditions. In addition to this assessment, the report provided a series of river forecasts, stating that the ecological potential of the UMRS remained high, despite the need for varying degrees of rehabilitation.

The second LTRMP S&T Report (Johnson and Hagerty 2008) provided a summary of the recent status of, and trends in, 24 selected indicators of the ecological condition of the Upper Mississippi and Illinois Rivers. This was the first attempt to define and present indicators of ecological health for the UMRS. This effort focused on the data collected by the LTRMP element of the UMRR-EMP, adding the hydrologic data, collected by the U.S. Army Corps of Engineers (USACE) and the U.S. Geological Survey (USGS) at long-term gaging stations within the UMRS. This report noted that the LTRMP data indicate a gradient of river health within the UMRS, ranging from a relatively healthy system in the northern reaches, to a system that is much less healthy in the south.

In anticipation of another S&T report, an After Action Report (AAR) (Ap E) was prepared by the USACE and delivered to EMP CC. The AAR noted that a vision and ecosystem goals for the UMRS, listed below, had been adopted in January of 2008 by the EMP-Coordinating Committee (EMP CC) and the Navigation Environmental Coordination Committee (NECC). The AAR also stated that the next S&T report should include other data sources, as appropriate, for content and interpretation, such as the Environmental Protection Agency's Environmental Monitoring and Assessment of Great River Ecosystems (EMAP-GRE), for additional spatial information on the Upper Mississippi River, and Illinois' Long Term Illinois River Fish Population Monitoring Program (LTEF), for long term data on the Illinois River.

Vision for UMRS:

"To seek long-term sustainability of the economic uses and ecological integrity of the Upper Mississippi River System"

Over-Arching System-wide Ecosystem Goal:

"To conserve, restore, and maintain the ecological structure and function of the Upper Mississippi River System to achieve the vision"

Ecosystem Goals:

1. Manage for a more natural hydrologic regime (hydrology and hydraulics)
2. Manage for processes that shape a physically diverse and dynamic river-floodplain system (geomorphology)
3. Manage for processes that input, transport, assimilate, and output material within the UMR basin river-floodplains: e.g. water quality, sediments, and nutrients (biogeochemistry)
4. Manage for a diverse and dynamic pattern of habitats to support native biota (habitat)
5. Manage for viable populations of native species within diverse plant and animal communities (biota).

In the future, objectives for UMRR-EMP could be developed under these goals above using data from the LTRMP datasets; fish, water quality, aquatic vegetation, land cover / land use, and LiDAR/bathymetry. The AAR also identified the need for an ad hoc committee to define indicators and targets once objectives for these ecosystem goals and objectives are established. The refinement of objectives for the goals above will continue to inform the development and refinement of indicators. When sufficient progress is made on system and/or floodplain reach goals and objectives, the issue of appropriate indicators of ecosystem health will be reexamined.

3. Purpose and Scope of This Indicator Report

In December 2008, the Analysis Team (A-Team) formed an ad hoc working group to evaluate the indicators used in the 2008 LTRMP S&T Report and other associated information, in order to provide recommendations to improve indicators used in future S&T Reports to better gauge the system's ecological health. A purpose statement was produced, modified and endorsed by the full A-Team on May 3, 2010, and forwarded to the EMP-CC for endorsement. The EMP-CC endorsed the purpose statement (Appendix A), as presented and in its entirety, on May 20, 2010.

This ad hoc group focused primarily on indicators of ecosystem health[1] or ecological integrity[2] as the basic criteria in evaluating, refining, and/or proposing new indicators. This report discusses the usefulness of the existing indicators with recommendations for improvement, modification or deletion, and proposes additional indicators, based on data collected by LTRMP, in anticipation of future S&T Reports. The text for each indicator in the 2008 S&T Report, as originally published (Johnson & Hagerty 2008), served as the template for individual indicator descriptions this report. The text was paraphrased or modified if needed by the ad hoc to more accurately capture the intent of each indicator. This ad hoc working group expects any indicators that are chosen and/or developed should be regularly reviewed and refined for adequacy and effectiveness, against a growing body of knowledge on large river ecosystems.

4. 2008 Status and Trends Indicators for Evaluation

This report focuses on the first four items of the purpose statement: focusing on indicators of ecosystem health; beginning with 2008 LTRMP S&T Report; including awareness of other efforts; and producing a report assessing the 2008 indicators and providing recommendations

[1] Defined as "A condition when a system's inherent potential is realized, its condition is stable, its capacity for self-repair, when perturbed, is preserved, and minimal external support for management is needed" (Johnson and Hagerty 2008)

[2] Defined as "A system's wholeness or "health," including presence of all appropriate elements, biotic and abiotic, and occurrence of all processes that generate and maintain those elements at the appropriate rates. The capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and a functional organization comparable to that of natural, unimpacted habitat of the region" (Johnson and Hagerty 2008)

for the next status and trends report. The recommendations presented in this report were developed through an interagency ad hoc group and were presented to the A-Team for discussion and evaluation on December 1, 2010. This report and the final recommendations therein will be provided to the A-Team for approval and to the Environmental Management Program Coordinating Committee (EMP CC) for endorsement, as appropriate. The ad hoc group investigated all the existing indicators and Table 1 presents a summary of the group's recommendations. Table 2 provides a summary of proposed new indicators. More detailed information is provided in Appendix D. The remainder of this report discusses the purpose, recommendations, and potential target benchmarks, if available, for each indicator. Once this report is completed, reviewed and endorsed by the A-Team, then endorsed by the EMP CC, if appropriate, the next step of developing benchmarks, or targets, for the selected indicators will begin. The final indicators also could be used in the development of a UMRS ecosystem health report card, a useful outreach and communication tool. In addition, some of the indicators, or their derivatives, may also be used to evaluate individual restoration projects.

Table 1. Summary of Existing Indicators, with recommendations for replacement, modification or deletion

Indicator Category	Indicator Name	Ad Hoc Recommendation	A-Team Recommendation	Additional Funding Required
River Hydrology	Mean Annual Discharge	Modify; Add mean seasonal discharge	Concur, medium priority	N
	Seasonal Cycle of Water Elevation	Delete; Replace with Indicators of Hydrologic Alteration (IHA)	Concur, medium priority	Y
Water Quality	Major Nutrients (Total Nitrogen and Total Phosphorus)	No Change	Concur	N
	Chlorophyll *a*	Modify for report card only to single seasonal average	Concur, medium high priority	N
	Total Suspended Solids	No Change	Concur	N
	Dissolved Oxygen	Modify; change to % frequency of hypoxia in BW, summer & fall	Concur, Medium priority	N
	Suitable winter habitat for sunfishes in backwaters	Needs additional research before use. Consider replacing with Backwater assemblage	Concur, Low priority	Y
Sedimenta-tion	Depth diversity in upper impounded areas	Table future analysis for approximately 25 years; these indicators only looked at the upper impounded reach and were part of a short-term special project	Concur	Y
	Net sedimentation rates in backwaters of the upper impounded reach		Concur	Y
Land Cover/ Land Use	Floodplain forest	Modify; change from acres to % of floodplain, Add patch connectivity, Add fragmentation	Concur, High priority	N
	Emergent vegetation	No change	Concur	N
	Areas of floodplain behind levees	keep; add reactive floodplain surface (requires research)	Concur, Medium priority	Y

Aquatic Vegetation	Submersed aquatic vegetation	No change	Concur	N
Macro invertebrates	Burrowing mayflies	Table	Concur	Y
	Fingernail clams	Table	Concur	Y
Fish	Bluegill	Under review; research change to backwater and main channel border bluegill CPUE; or replace with backwater assemblage	Concur	N
	Channel catfish	Delete	Concur	N
	Sauger	Delete	Concur	N
	Smallmouth Buffalo	Delete; replace with native to nonnative planktivore ratio indicator	Concur	Y
	Forage fish index	a. Modify; include all fishes <80mm; include all emerald shiners, gizzard & threadfin shad; b. Add annual index of biomass c. Trajectory analysis, 10-yr intervals	Concur a. High priority for mod b&c. Medium priority for adds	a. N b. ? c. Y
	Species Richness	keep; rename Community Structure indicator; add NMDS	Concur High priority for add	Y
	Nonnative fish biomass	Modify; change to stacked bar graph by species	Concur High priority for mod	N
	Recreationally harvested native fishes	Modify; change to stacked bar graph by species. Reclassify as social indicator	Concur High priority for mod	N
	Commercially harvested native fishes	Modify; change to include nonnative species; change to stacked bar graph by species. Reclassify as economic indicator	Concur High priority for mod	N

4.1 River Hydrology Indicators

A river's hydrology integrates the effects of climate, land forms, land use, and river management, and is a major driver of river processes. In the 2008 S&T Report, mean annual discharge and seasonal pattern of water elevations were presented as indicators of river hydrology. Refer to the 2008 S&T pages 24-29 for further information on data analysis, sampling design, patterns currently observed, and future pressures.

4.1.1 Mean Annual Discharge

Purpose: The purpose of mean annual discharge is to measure the average amount of water flowing through a river in any one year. Changes in flow affect a variety of physical processes which in turn affect ecological processes and distribution and abundance of biota. Mean annual discharge detects changes easily and can also point to extreme years as well as periods of above or below average discharge. This indicator is a long-term driver that affects many other resources.

Ad Hoc Group Recommendations: Retain mean annual discharge as an indicator of river hydrology. It is also recommended to add analyses such as seasonal means and deviations from seasonal means. Different periods of analysis could also be considered. Additionally, future discharge analyses should use a river gage closer to the LTRMP Open River study reach since, in the 2008 S&T, the St. Louis gage was used which is some 100 river miles upstream. There are no recommendations for developing target benchmarks; monitoring changes through time is the indicator.

A-Team Recommendation: Concur, medium priority for the modifications recommended.

4.1.2 Seasonal Cycle of Water Elevation

Purpose: Plants and animals in the UMRS have adapted to a relatively predictable seasonal cycle of water elevations, which is reflected in their life history strategies. Changes in the seasonal cycle can affect a variety of ecological functions. Annual variation in water elevation is always evident and biota must adapt continuously. This indicator considers the average conditions faced by biota over multiple years and multiple life cycles.

Ad Hoc Group Recommendations: This is not necessarily a good system-wide indicator of ecosystem health. It is highly correlated with discharge. The recommendation is to delete seasonal cycle of water elevation as an indicator and replace it with an indicator of hydrologic alteration (IHA). The IHA encompasses a number of relevant elements, such as, magnitude of monthly water conditions, magnitude and duration of annual extreme water conditions (mean daily flow), timing of annual extreme water conditions, frequency and duration of high and low flood pulses, or rate and frequency of water condition changes (Swanson 2002). Seasonal target benchmarks could be developed to correspond with pre-dam conditions within each study reach.

A-Team Recommendation: Concur, very important. Some analysis is already completed; wait for Gaugush's report (currently in prep). Medium priority.

4.2 Water Quality Indicators

Water quality in the Upper Mississippi River System is important in determining habitat quality and ecosystem function. The 2008 S&T included major nutrients, chlorophyll *a*, total suspended solids, dissolved oxygen, and suitable winter habitat for sunfishes in backwaters as indicators of water quality. Refer to the 2008 S&T pages 30 to 42 for further information on data analysis, sampling design, patterns currently observed, and future pressures.

4.2.1 Major Nutrients (Total Nitrogen and Total Phosphorus)

Purpose: Nitrogen and phosphorus are essential nutrients for the growth of algae and aquatic plants, however, excessive nutrients can cause a range of problems in aquatic systems (Smith et al. 1999). One effect of high nutrient concentrations is to cause high rates of algal production. These high rates of production produce a large amount of organic material that causes low oxygen concentrations as it decomposes. A second effect of high algal abundance is that light does not penetrate very deeply into the water and this can have a negative effect on the abundance of submersed aquatic vegetation. High nutrient concentrations can also promote the occurrence of abundant filamentous algae which can have detrimental effects on submersed vegetation. A third effect of high nutrient concentrations is rapid growth duckweed, a small aquatic plant that floats on the surface. When duckweed is abundant, very little light penetrates into the river. This may reduce submersed vegetation and promote conditions of low dissolved oxygen. In summary, excessive nutrients can lead to reduced submerged vegetation and dissolved oxygen through a variety of mechanisms. Because vegetation is important as fish habitat and as food for wildlife, excess nutrient concentrations may lead to less favorable habitats for fish and waterfowl. High nutrient concentrations can also cause additional problems, such as impacts to drinking water, Gulf of Mexico hypoxia, and recreation use impacts.

Ad Hoc Group Recommendations: Retain both major nutrients as indicators of water quality; however communication on what these indicators mean to the public must be improved. Target benchmarks could be the suggested ranges supplied by the U.S. Environmental Protection Agency for aquatic life. The suggested range for total nitrogen concentrations for the UMRS is 0.6 to 2.18 mg/L (USEPA 2000; Smith et al. 2003). For total phosphorus, the suggested guidelines are 0.01 to 0.08 mg/L (USEPA 2000; Smith et al. 2003). These ranges apply to aquatic life, rather than human health. Metaphyton concentration (low or lack of) can also be used as a target/endpoint for nitrogen in main channel and off channel areas.

A-Team Recommendation: Concur

4.2.2 Chlorophyll *a*

Purpose: Chlorophyll *a* concentration is a basic measure of the abundance of suspended algae and a measure of primary productivity. Algae are an important food source, but in excess, they have negative effects on the river ecosystem. Tracking Chlorophyll a can provide added understanding of ecosystem function; abundance of chlorophyll a may change if the system changes from a stable, macrophyte dominated stage to a planktonic algae dominated stage, and it may respond as Asian carps increase. Chlorophyll *a* concentrations in large rivers are generally determined by light availability, nutrient availability, and current velocity. In eutrophic systems such as the UMRS, algal blooms, occurring during the summer months, can consist of harmful blue-green algae and green algae mats that can harm aquatic life. High levels of chlorophyll *a* are considered to be an indicator of eutrophication.

Ad Hoc Group Recommendations: Retain chlorophyll *a* as an indicator of water quality as is for a S&T indicator. No target benchmarks for large rivers have been developed. The MN Pollution Control Agency (MPCA) has developed draft eutrophication criteria (maximum summer mean levels) for the Mississippi River as follows: Pools 1-Upper 4 (35 ug/L), in Lake Pepin (28 ug/L), and lower Pool 4-Pool 8 (35 ug/L) to maintain aquatic recreational and aquatic life uses. If used in a report card, modify how the data is presented. For potential report card use: instead of several seasonal averages over the span of a year, it is recommended to present a single seasonal average (*e.g.,* summer or spring). Future investigation on blue-green algae is also recommended, dependent on funding.

A-Team Recommendation: Concur. Change in how this could be displayed can be accomplished without additional funding. Medium-high priority. Blue green algae research is a low priority. Research by USGS-WRD/EPA may apply.

4.2.3 Total Suspended Solids

Purpose: Total suspended solids (TSS) are a measure of water clarity, specifically the concentration of particles in the water column and are frequently cited as a primary water quality concern in the river. The TSS reduces light penetration into the water, affecting aquatic vegetation growth (Barko et al. 1982, 1986; UMRCC 2003) and feeding efficiency of visual predators such as bluegill or bass (Simon 1999).

Ad Hoc Group Recommendations: Retain TSS as an indicator of water quality. Measuring TSS is more precise than Secchi disk readings; both are available.

The 2008 S&T supported the 25 mg/L target for TSS suggested by the UMRCC as an upper limit for vegetation (for the upper impounded reaches) or for sight feeding fishes (for the impounded Illinois River). However, this criterion may be unrealistic for the unimpounded Open River study reach, where TSS has always been high due to sediment inputs from the Missouri River.

The recommendation is to define TSS thresholds for the four main study reaches (upper impounded, lower impounded, Illinois River, and Open River) and should consider a biological endpoint, such as submersed aquatic vegetation or sight feeding native fishes. Greg Sass (LTRMP Havana field station) recommends TSS upper threshold of 30 mg/L for the Illinois River. Yao Yin (USGS-UMESC) recommends a TSS upper threshold of 40 mg/L for UMR vegetation. UMRCC recommends 25 mg/L, which is under discussion. A site specific standard of 32 mg/l (summer mean upper limit) has been established by the MPCA for Pool 2 through Upper Pool 4, based on SAV growth. However, none of these targets are appropriate for the Open River below the confluence of the Missouri River.

Currently, there is no target benchmark for TSS for the Open River reach. Historically, this reach of the river was more turbid than today, with biota is adapted to a turbid system. A potential biological target could be native fishes, such as flathead chub; some evidence suggests that site-feeding cyprinids out-compete this native fish. A target based on aquatic vegetation, which is absent in this reach, is not useful. In the Open River study reach, it would be mismanagement to try to increase water clarity.

A-Team Recommendation: Concur

Additional review comments: WI (Sullivan) - believes a direct measure of light penetration should be included as a key indicator in the UMR system. Underwater light energy is a key driver in influencing aquatic habitat in the UMRS. Although, light penetration can roughly be estimated from total suspended solids (TSS), the volatile suspended solids (VSS) content may play an important role influencing light attenuation (Giblin et al. 2010 -LTRMP 2010-T001). The VSS content may change longitudinally and seasonally and this will influence the light attenuation x TSS relationships. Light penetration can easily be measured using Secchi disks or with transparency tubes.

4.2.4 Dissolved Oxygen

Purpose: Sufficient dissolved oxygen (DO) concentration is an important characteristic of habitat suitability for aquatic organisms. The UMRS may have always experienced some degree of hypoxia and some native species are adapted to do well under such conditions. Increased inputs of nutrients and organic materials, and reduced water volume in backwaters as they become shallower due to sedimentation, will likely increase hypoxia.

Ad Hoc Group Recommendations: Retain dissolved oxygen as an indicator of water quality, but modify how the data is presented. Instead of percentage of backwater sites with DO < 5 mg/L, it is recommended to present the data as the percent frequency of hypoxia (DO < 5 mg/L) in backwaters in summer and fall. If the frequency of hypoxia is very low for some pools and/or seasons, consider examining the trends in DO concentration over time as a leading indicator of a potential problem or of improvement. We need to find out if trends we see in the amount of hypoxia or DO concentration are important. The concentration of DO requirements varies among organisms, but 5 mg/L is used as a water quality standard by all of the UMRS states (UMRBA 2004), however, it is probably too generous and may not always be biologically desirable. Some data suggest that 3 mg/L is acceptable but, in MN, data indicates 2 mg/L is approaching a winter kill situation (Stauffer, personal communication). It is recommended to continue using 5 mg/ml as the target benchmark until further data supports otherwise.

A-Team Recommendation: Concur. Change in how this could be displayed can be accomplished without additional funding. Medium priority.

4.2.5 Suitable winter habitat for sunfishes in backwaters

Purpose: Winter habitat conditions may cause stress, or even mortality, for fishes in rivers (Johnson and Charlton 1960; Bodensteiner and Lewis 1992; Sheehan et al. 2004). Research has identified suitable winter conditions for sunfishes in backwaters as dissolved oxygen > 5mg/L, temperature > 1.0°C, and depth >0.33 m of water (under ice). Velocity, an additional variable, was not included in this composite indicator, but is a critical variable for overwintering habitat.

Ad Hoc Group Recommendations: Drop this indicator and replace it with a more suitable indicator, such as backwater fish assemblage. Based on the 2008 S&T, it was concluded that the northern reaches had relatively little suitable winter habitat based on the above criteria, despite the most common sunfish, bluegills, being abundant and increasing. Thus, the usefulness of this metric, as currently defined, as an indicator is questionable. Further research is indicated on the effect of winter habitat suitability compared to other factors affecting centrarchid abundance.

A-Team Recommendation: Concur. Research on existing indicator is low priority. See new Ecological Function Indicators for full discussion of backwater assemblage.

4.3 Sedimentation Indicators

Sediments and sediment transport are integral parts of any large river. The processes of movement, storage, and resuspension of sediments produce the basic landscape mosaic within the river channel and floodplain. In the 2008 S&T, depth diversity and net sedimentation rates in backwaters in the upper impounded reaches were presented as indicators of sedimentation. Refer to the 2008 S&T pages 43 to 47 for further information on data analysis, sampling design, patterns currently observed, and future pressures.

Both of these indicators were limited in scope (only measured in Pools 4, 8, and 13) over a 5-year period, and were part of a special project which has since been discontinued.

Ad Hoc Group Recommendations: Table these indicators for approximately 25 years. Target benchmarks have not been developed, and there is a potential that the sediment transects used during the special project may not be recoverable in the future. Suitable sediment ranges could be developed in the future or using tributary delta growth could be used as a sedimentation indicator surrogate.

A-Team Recommendation: Concur.

4.4 Land Cover/Land Use Indicators

A healthy river floodplain consists of a diverse matrix of habitat types that are connected to the river by occasional flooding. This connection is critical to maintaining dynamic physical and chemical processes that support diverse plant and animal communities. The pattern of land cover and the degree of hydrological connectivity within a river's floodplain is the result of the underlying geomorphology, river dynamics, and human intervention and alterations. These data for these indicators is derived from land cover maps collected decadally for the entire UMRS floodplain. In the 2008 S&T, floodplain forest, emergent vegetation, and area of floodplain behind levees were presented as land cover/land use indicators. Refer to the 2008 S&T pages 48 to 54 for further information on data analysis, sampling design, patterns currently observed, and future pressures.

4.4.1. Floodplain Forest

Purpose: Floodplain forests are an important component of large river ecosystems and the primary natural habitat type along the UMRS. They provide habitat for a broad range of plants and animals, sequester carbon and nutrients, and play an essential role in maintaining biological diversity of the UMRS, which is a positive attribute of healthy ecosystems. In addition to clearing, changes in the spatial extent and changes in species composition of floodplain forests is also influenced by flooding regimes and in ground water levels.

Ad Hoc Group Recommendations: Retain floodplain forest as a land cover/land use indicator, but modify how the data is presented. Instead of presenting acres of floodplain forest per study reach, it is recommended to present the data as percent of study reach in floodplain forest. Patch connectivity and habitat fragmentation are other metrics that could be incorporated into a floodplain forest indicator. Target benchmarks have not been developed, but increasing percent of floodplain forest from current conditions could be target for the future desired trend. A recommendation was also made to develop a new indicator that reflects tree community composition.

A-Team Recommendation: Concur. These modifications can be made without additional funding; analysis completed under Landscape 2010 APE. High priority.

4.4.2 Emergent Vegetation

Purpose: Emergent vegetation describes a variety of annual and perennial plants that grow in moist or seasonally flooded soils, along shorelines or in marshes. Emergent vegetation provides food for migratory waterfowl and furbearers. Emergent plants are an important part of the transition zone between terrestrial and open water habitats and indicate a healthy hydrologic regime in floodplain rivers. Emergent vegetation is affected by variation in water levels, both annually and daily, as well as water depth, substrate type, and water velocity.

Ad Hoc Group Recommendations: Retain emergent vegetation as a land cover/land use indicator. However, more frequent information would be very helpful since emergent vegetation is highly variable year to year. LiDAR and bathymetric data could be used to define areas that could support emergent vegetation under various hydrological conditions. Use of remote sensing should be investigated to determine if it is appropriate for documenting changes in emergent vegetation at a broad scale. No target benchmarks have been developed. Upper and lower levels, optimal, and trends, as they relate to a "natural" range might be more important than % of study reach area with emergent vegetation. Over time, this indicator could be refined and adjusted as data at finer temporal resolutions is attained.

A-Team Recommendation: Concur.

4.4.3 Area of Floodplain behind Levees

Purpose: Levees constrict the floodplain and reduce storage of floodwater, which increases flood heights near and upstream of the levee. Levees limit or eliminate the connection of the river to its floodplain, which can reduce rates of vegetation turnover, nutrient and carbon sequestration, water quality and fish habitat. This indicator may generally characterize the biodiversity and productivity of the river corridor.

Ad Hoc Group Recommendations: Retain area of floodplain behind levees as a land cover/land use indicator. In the 2008 S&T, the data for this indicator were derived by applying a Geographic Information System (GIS) coverage of levee locations developed by the Scientific Assessment and Strategy Team (SAST) following the flood of 1993 to land cover maps generated by LTRMP for 2000. This levee coverage is not all inclusive. Change over time was not calculated since only one levee coverage map was available, thus, this indicator only showed status. For future analysis, area of floodplain behind levees could be refined using LiDAR. Another recommendation would be to not only look at acres behind levees, but also look at acres in the active (frequently flooded) floodplain. No target benchmarks have been developed, but decreasing area behind levees from current conditions could be a target for the future desired trend.

A-Team Recommendation: Concur. Research on reactive floodplain surface is a medium priority.

4.5 Aquatic Vegetation

Aquatic vegetation is a vital component of this nationally significant navigation and ecosystem. It provides food, spawning areas, and shelter to fish, wildlife and invertebrates. In the 2008 S&T, percent frequency of submersed aquatic vegetation was presented as an indicator of aquatic vegetation. Refer to the 2008 S&T pages 55 to 57 for further information on data analysis, sampling design, patterns currently observed, and future pressures.

4.5.1 Submersed Aquatic Vegetation

Purpose: Submersed aquatic vegetation (SAV) provides an important food source for migratory waterfowl and habitat for fish, as well as invertebrates and other wildlife. The percent frequency of occurrence of submersed aquatic vegetation (all species combined) is used as the primary indicator of the status of submersed aquatic vegetation in the system (Rogers et al. 1998; Yin et al. 2000). The Open River study reach and the La Grange Pool on the Illinois River currently do not support persistent or abundant SAV due to lack of appropriate habitat conditions. The distribution and abundance of submersed vegetation depends mainly on water depth (which changes with water levels) and water clarity (which depends mainly on levels of suspended solids) (Yin and Langrehr 2005).

Ad Hoc Group Recommendations: Retain submersed aquatic vegetation as an aquatic vegetation indicator for the upper 3 study reaches (Pools 4, 8 and 13). No target benchmarks have been developed. Open water areas and edge are also important. Upper and lower levels optimal amounts and trends, as they relate to a “natural” range, might be more important than hard and fast numbers. For example, the percent of area with SAV might be a place to start. The MN South Metro Mississippi River TSS TMDL has set a standard of 21% frequency of occurrence for SAV, using LTRMP data, in main and side channel borders of the impaired reach from Pool 2 through upper Pool 4.

A-Team Recommendation: Concur.

4.6 Macroinvertebrate Indicators

Mayflies, fingernail clams, and midges, part of the soft-sediment substrate fauna, were chosen as target organisms because of their important ecological role in the UMRS. Mayflies, fingernail clams, and midges have been historically used as indicators of river water quality (Fremling 1964, 1973, 1989; Steingraber and Wiener 1995). Macroinvertebrates also perform an important ecological function by digesting organic material and recycling nutrients (Reice and Wohlenberg 1992). Prior to 2004, two macroinvertebrate indicators were sampled as a component within LTRMP. These included burrowing mayflies (*Hexagenia* spp.) nymphs and fingernail clams (*Musculium transversum*). Refer to the 2008 S&T pages 58 to 62 for further information on data analysis, sampling design, patterns currently observed, and future pressures. In 2004, sampling was discontinued due to budget constraints and poor detection of mayfly nymphs and fingernail clams in Pool 26, Open River, and La Grange Pool.

An effort to re-evaluate a macroinvertebrate component within LTRMP began in 2009 with a designated sub-committee of the ad hoc group (Appendix B - Dukerschein et al. 2010). This effort investigated the usefulness of the macroinvertebrate indicator for ecosystem health, the organisms being present systemically, and sampling protocols were capable of detecting the organisms throughout the entire UMRS, including the unimpounded Open River study reach.

Purpose: The main objective of the LTRMP macroinvertebrate component is to provide a better understanding of the conditions needed to support viable populations of benthic macroinvertebrates that are important indicators of food availability for native fishes and migrating waterfowl (Hoopes 1960; Jude 1968; Ranthum 1969; Thompson 1973). Mayflies have a broad potential to function not only as ecological (*e.g.,* food availability, pollution indicator) and water quality indicators (Fremling 1964, 1973, 1989; Steingraber and Weiner 1995), but also as a climate change indicator due to their synchronized mass emergences which are triggered by a developmental regimen that depends on water temperature (Fremling 1973; Wright et al. 1982).

Sub-Committee Recommendations: From these investigations, if funding becomes available, it was recommended to pursue a LTRMP sampling component for mayflies, but not for fingernail clams. Live fingernail clams have not been recorded system-wide (Sauer 2004), therefore would not be an appropriate indicator of ecosystem health for the entire UMRS. Monitoring mayflies have the potential of being a system-wide indicator of ecosystem health if the LTRMP macroinvertebrate sampling is reinstated. The following recommendation describes how the existing burrowing mayfly indicator could be improved and modified. A new tool that could be used to monitor burrowing mayflies throughout the system is described in the New Indicators section.

Recommendation: Mayfly Nymphs

Based on the investigation by Dukerschein et al. (2010), the reason for low mayfly numbers in the lower reaches may not be solely due to environmental stress or poor environmental conditions, but rather due to the standard LTRMP gear and sampling design not being appropriate to detect mayflies in the lower reaches, especially in the Open River study reach. Other gear, like the benthic sled developed by the Missouri Department of Conservation, may be more appropriate to sample the benthic environment in a free, fast-flowing river like the Open River study reach. If implemented, it is recommended to stratify the sampling design based on habitats key to mayflies (see Battle et al. 2007) and sample consistently the same time each year to gain additional information about climate change.

A-Team Recommendation: Table both existing macroinvertebrate indicators. See Appendix D for more comments. Wisconsin dissented on this issue since macroinvertebrates are important and the existing protocols are appropriate in the Upper Impounded Reach.

4.7 Fish Indicators

A diverse and healthy fish community generally indicates a diversity of habitats and important river functions. Work by UMRR-EMP LTRMP researchers has shown that those UMRS river reaches with the greatest variety of habitat types have the greatest variety of fish species (Koel 2004). Refer to the 2008 S&T pages 63 to 79 for further information on data analysis, sampling design, patterns currently observed, and future pressures of the existing fish indicators.

In December 2009, discussion within the ad hoc group led to the recommendation that an interagency Fish Indicator sub-committee be formed to further consider fishery indicators for use in future Status and Trends assessments. The committee was charged to 1) define what constitutes a healthy UMRS ecosystem from a fisheries perspective; 2) make recommendations for indicating fish community health attributes and for making data-informed judgments on their status and trends in the future; and 3) make recommendations for additional indicators to consider and /or additional analytic work that may be needed in either selecting additional indicators or optimizing their implementation. Table 2 summarizes the proposed changes to the fish indicators. The following is a summary of the sub-committee's recommendations on the existing 2008 S&T fish indicators. For full details on this effort, see Appendix C (Ickes et al. 2010).

Table 2. Fish Indicator Realignment (Ickes et al 2010).

Indicator*	Indicator Class	Former intent	Realigned intent
Recreationally harvested native fishes	Social	Multi-species social indicator	Multi-species social indicator
Forage fish	Ecological - functional	2-species functional ecologic indicator	Multi-species functional ecologic indicator
Bluegill	Ecological - functional	Single species "everything" indicator	Single species indicator of "off-channel" areas (ecological function)
Species Richness	Ecological - structural	Univariate ecologic structure	Multivariate ecologic structure
Non-native fishes	Ecological - structural	Proportion of community in non-natives	Proportion of community in non-natives
Commercially harvested native fishes	Economic	Native commercial species index	All commercial species index

* Note: Three indicators presented in Johnson and Hagerty (2008) are recommended from removal from the fish indicator portfolio (Channel catfish, Sauger, and Smallmouth Buffalo)

4.7.1 Bluegill

New Purpose Statement: Bluegill are a major characteristic species of backwater environments because all major life cycles typically occur within these habitats. Correspondingly, the public perceives the ecological health of the UMRS, in part, by the abundance of bluegill. Tracking bluegill catch-per-unit-effort (CPUE) provides direct information on this resource and may provide insight into habitat quality. The indicator is pool-wide CPUE (number per 15 minutes) of adult bluegill >150 mm (the minimum size generally acceptable to anglers) captured by day electrofishing.

Sub-Committee Recommendations: Retain bluegill as a fish indicator. Off-channel aquatic habitat is an important habitat class in the UMRS and has been the focus of many HREP projects and research. This indicator could be used to measure changes in off-channel habitat quality, either through continued degradation and loss or through increases brought about by management actions; however, the indicator can be improved. In addition to looking at pool-wide CPUE, the ratio of main channel border to backwater shoreline catch rates should be examined. There are concerns among mangers that over-vegetation of backwaters results in low dissolved oxygen during summer months that make certain off-channel areas unusable for fish. The ratio coupled with water quality and vegetation data would provide insight into this issue. Further investigation would be needed to recommend a target benchmark for the ratio of main channel border to backwater shoreline CPUE.

The recommendation for a target benchmark for bluegill will vary throughout the system. As such, targets should be set on a study reach by study reach basis. Setting targets at smaller spatial scales may also be appropriate for assessing off-channel habitat quality within pools.

Overall, the desired future trend should be increasing or stable. The committee realigned bluegill as a functional indicator of off-channel environments.

In addition, rather than a single species as an indicator of off-channel habitat, a backwater assemblage could be developed. This species make up of this assemblage would be adjusted for each study reach.

A-Team Recommendation: Concur

Additional review comments: (WI) While it is true bluegills represent off-channel areas, it is not necessarily applicable to the system's off-channel areas. For example, MO has said they would choose crappie as the representative BW species. So, while BLG may be important in 4, 8 and 13, another species may be a better representative species further downstream.

4.7.2 Channel Catfish

New Purpose Statement: Channel catfish is a significant component of the commercial and recreational fisheries in the UMRS. It is a characteristic species of river channels, so monitoring CPUE of channel catfish may provide insight into habitat quality of channel environments. This indicator is the pool-wide CPUE of adult (>280 mm) channel catfish collected in large hoop nets. Adults were selected because they are the size harvested commercially and recreationally.

Sub-Committee Recommendations: Drop channel catfish as a fish indicator. Channel catfish are fairly tolerant to water quality issues and habitat loss, are omnivorous, and able to adapt to lentic or lotic environments making them poor indicators of changes to channel conditions within the UMRS. Other species are better at providing information on quality of channel habitat, such as sucker species. Some suckers could also be used to evaluate water quality (*e.g.*, *Moxostoma* species, blue suckers, or hogsuckers) and the quality of the macroinvertebrate food sources. Most species of suckers are also simple lithophils which aid in analyzing available habitat.

To characterize overall habitat, water quality and food web interactions, investigating intolerant species of suckers and invertivore/insectivore suckers should be used. If the sucker indicator is pursued in the future, CPUE, overall abundance, and diversity of suckers could be measures used to characterize channel habitat.

A-Team Recommendation: Concur

4.7.3 Sauger

New Purpose Statement: Sauger is a characteristic species of river channels and is recreationally exploited throughout the UMRS. Monitoring CPUE of sauger provides direct information on the state of this resource and may provide insight into habitat quality of channel environments. This indicator includes the pool-wide CPUE of adult (>200 mm) sauger which is the size available for exploitation, as well as the CPUE of juvenile and sub-adult (<200 mm) sauger.

Sub-Committee Recommendations: Drop sauger as a fish indicator. Sauger does have some merit as a stand-alone indicator species. It is one of the few species that occurs in all reaches and with socioeconomic implications within the UMRS. Historic data is fairly prevalent in most reaches, and there life history is well known in the UMRS. As a relatively high profile fish, academic and agency studies are periodically conducted on sauger in the UMRS, which would further support LTRMP data. However, this species is already included in the Recreationally Harvested Fish Indicator, and is likely not one of the primary sport fishes sought in the Open River study reach. Trends in the sauger population by itself are likely not sufficient to reflect socioeconomic values throughout the UMRS.

The same would hold true for sauger as an ecological indicator of channel habitat, in that impacts to UMRS would be better indicated by a group of species that have life history requirements that overall, as opposed to an individual species.

A-Team Recommendation: Concur

4.7.4 Smallmouth Buffalo

New Purpose Statement: Smallmouth buffalo is a characteristic larger river species and is commercially exploited throughout the UMRS. Being ubiquitous in the UMRS, monitoring CPUE of smallmouth buffalo provides direct information on the commercial fishing value of this resource and may provide insight into ecosystem services of larger river environments. This indicator is the pool-wide CPUE of adult (>280 mm) smallmouth buffalo, which is the size available for commercial harvest.

Sub-Committee Recommendations: Drop smallmouth buffalo as a fish indicator. This indicator is redundant with the indicator of Commercially Harvested Native Fishes. It is recommended to replace this indicator with a native to nonnative planktivore ratio in the context of Asian Carp impacts.

A-Team Recommendation: Concur

4.7.5 Forage Fish Index

New Purpose Statement: The abundance of forage (or prey) fishes represents production at lower trophic levels, which provides food for large predatory fish that are important to anglers. Major changes in forage resources could indicate major shifts in ecosystem health and function. Currently, this indicator is the pool-wide CPUE of emerald shiner (*Notropis atherinoides*) and gizzard shad (*Dorosoma cepedianum*) combined, the two most prominent forage fishes in the

UMRS. A composite forage indicator will be the pool-wide day electrofishing CPUE of all fishes <80 mm, and includes all sizes of gizzard and threadfin shad, and all sizes of emerald shiner (emerald shiners occasionally reach lengths > 80 mm).

Sub-Committee Recommendations: Retain and modify forage fish as a fish indicator. Historically gizzard shad and emerald shiners have been systemically abundant in the UMRS, and they will continue to serve as important indicator species for assessing the status and trends of forage fishes at a species level. The new purpose statement was modified from the 2008 S&T to include all fishes <80 mm, not just gizzard shad and emerald shiners. Further recommendations include:

1) Develop and use collective forage fish index to follow trends in forage fishes for all sizes in LTRMP study reaches. This index would be derived from the cumulative pool-wide day electrofishing CPUE of all fish species <80 mm, plus all sizes of gizzard shard, threadfin shad, and emerald shiners. Mean CPUE ± 1 standard error should be reported for all six LTRMP study reaches.
2) Develop a biomass component/metric to supplement quantifying local shifts in forage fish health due to potential impacts of exotic species. This index could be annually computed from the summations of standard length/weight equations from existing LTRMP data, and followed in 10-year increments.
3) Consider using analysis of similarity and/or non-metric multidimensional scaling ordinations (such as trajectory analysis) as a supplemental means of quantifying local community shifts in forage fish composition over time (10 year intervals).

Target benchmarks for forage fish would be considered "stable" or "good" if individual species mean CPUE remains within the 10^{th} and 90^{th} percentiles of the historic median catches in their respective river reach. The desired future trend for individual and composite CPUE of forage fish should remain stable or increase, and should not decrease below the 10^{th} percentile of the baseline LTRMP median catches.

A-Team Recommendation: Concur. Recommendation #1 incurs no additional cost; high priority. Recommendation #2 and #3 - medium priority.

4.7.6 Species Richness (Community Structure)

New Purpose Statement: The UMRS represents the center of freshwater fish diversity in North America. Collectively, UMRS fish community contains representative species of socioeconomic value, exotic origins, and special conservation status. Thus, the public perceives the ecological health of the UMRS, in part, by the diversity of fishes present. This indicator describes the diversity and structure of the fish community observed annually in LTRMP collections and whether or not each reach is heading in a well defined, desirable direction.

Sub-Committee Recommendations: Retain species richness as a fish indicator, but be renamed Community Structure and modified to include species diversity and species evenness or dominance. An acceptable level of diversity and a desired fish community structure should be defined for each study reach and non-metric multidimensional scaling (NMDS) should be used to show whether or not each pool is heading in a well-defined direction. These goals should involve the specific management interest of each reach.

Ideally, the future desired target would be zero capture of exotics, stable to increased capture of recreationally and commercially harvested fishes and non-game fishes, and increased capture of species of conservation concern. Target benchmarks should be developed for each study reach.

A-Team Recommendation: Concur. Additional NMDS analysis – High priority

4.7.7 Nonnative Fishes

Purpose Statement: Nonnative fishes (species originating from outside the basin) occur in all monitored study reaches. The fraction of nonnative biomass to total fish biomass is frequently regarded as an indicator of ecological impairment. Nonnative species can compete with more desirable native species, thereby reducing abundance and distribution of natives. Tracking nonnative fish biomass provides direct information on the prominence of nonnative species and may indicate stresses on native fish assemblages. This indicator is the proportion of total fish biomass composed of seven nonnative species: goldfish (*Carassius auratus*), grass carp (*Ctenopharyngodon idella*), common carp, silver carp, bighead carp, white perch (*Morone americana)*, and striped bass (*Morone saxatilis)*.

Sub-Committee Recommendations: Retain the nonnative fish indicator. This indicator is relatively simple and visually shows impairment or improvement in the system. To improve presentation of the data, modify graphs to a stacked bar graph by nonnative species. Stacking by species could visually show shifts in dominance within the nonnative species monitored.

Target benchmarks should be established for each LTRMP study reach. Based on 1993-2002 graphs in presented in the 2008 S&T, a potential target of percent biomass of nonnatives within each reach could be less than 40%, which would an improvement for most reaches and stable for Pool 4. Another potential target would be a declining trend over time.

A-Team Recommendation: Concur. Proposed modification does not incur additional costs, high priority.

4.7.8 Recreationally Harvested Native Fishes

New Purpose Statement: Sport or recreational fishing is valued by the communities along the UMRS and many who travel considerable distances to utilize this resource. Participants range from casual to dedicated and novice to professional. Fish are harvested recreationally in all reaches of the UMRS. Thus, the recreationally-harvested fishes of the UMRS warrant indicator status from a social standpoint, as they provide valuable services to individual people and communities throughout the UMRS. Recreationally-harvested fishes are reported as the combined catch per hour of daytime electrofishing of adults collected from a group of 19 native fish species (Table 2.3 in 2008 S&T, page 75).

Sub-Committee Recommendations: Retain recreationally harvested fishes as an indicator because they are valuable to people as food and recreational resources. These species are widely recognized, and for many people is the most direct biological measure of a healthy river. This indicator could be improved by identifying which of the 19 species contributes to the overall CPUE score. It is not recommended to subdivide these 19 species into separate groups, but present the data as stacked bar graphs (one for each reach), showing the annual percentage composition of the CPUE for each of the 19 species. This would provide greater utility in depicting how many species are available for recreational harvest, and how their relative abundances might have changed through time. Additionally, verification that only adult fish are used in calculating this indicator is needed.

Target benchmarks should be developed for each study reach. Presumably, all reaches could have better recreational fishing. The recommended target is a stable CPUE of recreationally-harvested fishes in all reaches at some level higher that currently reported.

It is also recommended to change this indicator from an ecological indicator to a social indicator.

A-Team Recommendation: Concur. Proposed modification does not incur additional costs, high priority.

4.7.9 Commercially Harvested Native Fishes

New Purpose Statement: Commercial fisheries exist throughout the UMRS, and the production of commercially harvestable fishes is one of the important services provided by this ecosystem. Additionally, and increasingly, commercial fisheries are also being used to manage nonnative fishes invading the UMRS. Monitoring CPUE of commercially harvested fishes provides direct information on this socially and economically important resource, and provides insight into the health of the fishery and the fishes that support it. This indicator is the combined CPUE from seven native fish species (bigmouth buffalo, smallmouth buffalo, black buffalo, channel catfish, blue catfish, flathead catfish, and freshwater drum) and the combined CPUE of four species of nonnative carp (grass carp, common carp, silver carp, and bighead carp), coupled with information on the number of commercial fishing licenses.

Sub-Committee Recommendations: Retain this as an indicator but to modify it to include nonnative carp, and present the data as stacked bar graphs of species for each reach. Commercial fisheries clearly represent a social and economic benefit extracted from the river system, but as an ecological indicator it holds little value since exploitation confounds interpretations relative to habitat and fundamental ideas of ecological health. Using this as an economic indicator could be more useful. This indicator could be improved by incorporating UMRCC commercial fishery statistics if through further analysis these data can be correlated with LTRMP data. Additionally, when presenting the data in future Status and Trends report, separate native and nonnative species since different status and trends goals may apply for each of these groups. Furthermore, supplementing LTRMP fish catch data with economic data (*e.g.,* number of active license, total landings value, etc.) should be considered.

Target benchmarks should be developed for each reach. The general future desired trend should show native species increasing or being stable, and nonnative species decreasing or being stable.

It is also recommended to change this indicator from an ecological indicator to an economic indicator.

A-Team Recommendation: Concur. Proposed modification does not incur additional costs, high priority.

5. Potential New Indicators

The A-Team ad hoc group discussed the potential for developing new indicators. Some of these new indicators could replace or supplement existing indicators in the 2008 S&T. Table 3 provides a summary of these future potential indicators, but, at this time, each of these need further research to refine and apply their use. It was also noted that there is generally a movement away from single-species indicators and towards assemblage or community-based indicators. The make-up of these assemblages would be data-driven and, given the differences across the UMRS, some regionalization in defining and evaluating indicator goals and benchmarks will be necessary.

Table 3. Recommended New Indicators and Research

Indicator Category	Indicator Name	Ad Hoc Recommendation	A-Team Recommendation
River Hydrology	Indicators of Hydrologic Alteration (IHA)	Adopt, see draft Gaugush report, currently in draft	Important, need final IHA report, Medium priority
Water Quality	Blue-green algae (Indicator of eutrophication)	research	Research required, Low priority
	Metaphyton	Future consideration	Concur

	(Indicator of eutrophication)	(Giblin et al research)	
Land Cover/ Land Use	Patterns of land cover change (pool scale)	Add	Concur High priority
	Patterns of aquatic area diversity	Add	Concur High priority
Ecological Indicator	Emergent Vegetation	Investigate using remote sensing	Low priority
		Investigate analyzing Veg Component data for EAV	Research required, Medium priority
	Floodplain Forest	Investigate using USACE forest quality data, permanent plots	Research required, Medium priority
	Mayfly mass emergence	Ground based detection of mass emergence in LTRMP field notes, River alert Network, L/D personnel	Requires new data sheets & database. Low priority
Ecological Structure Indicator	Fish Community Structure (expansion of species richness)	Define desired fish community structure by reach; calculate diversity and evenness; explore use of non-metric multidimensional scaling	Research required, high priority
Ecological Function Indicator	Backwater Fishes Assemblage	Define desired fish community structure by reach; include NMDS for all assemblages. Research required for all	Highest priority
	Migratory Fishes Assemblage		High priority
	Channel Habitat Fishes Assemblage		High priority
	Ratio of Asian Carp biomass to total zooplanktivore biomass		Medium high priority
Social Indicator	Threatened and Endangered Species	Literature review of fishery social indicators; Consider both LTRMP data and other data sources	Low priority
Economic Indicator	Standing Fish Economic Value	Literature review of fishery economics	Low priority

5.1 Ecosystem Function Indicators

Ecosystem attributes that support ecosystem functions required to maintain healthy UMRS fisheries are numerous and varied. Examples include (1) diverse and stable metabolic pathways (food webs) that assure sustainable fisheries; (2) recruitment and growth processes that maintain healthy populations, and (3) hydro-fluvial dynamics that assure necessary habitats remain available. Any number of indicators could be readily conceived to address these and other functional ecosystem attributes. Those items requiring additional research and with low priority (see Table 3 Above) or for future consideration are not described below.

5.1.1 Indicators of Hydrologic Alteration (IHA)

The flow regime of rivers is a major driver of the ecological integrity of river systems. The spatial and temporal differences in river discharge magnitude, time, frequency, and duration, including extreme events, are the primary components (Poff et al. 1997). Indicators of Hydrologic Alteration (IHA) refers to a method of analyzing the extent of hydrologic alteration or the differences between time periods that are assumed to be the result of man-induced change (Richter et al. 1996). The IHA approach includes analysis of temporal variability in hydrologic regimes using biologically relevant attributes of the annual hydrograph, quantifies the alterations associated with changes, and quantifies the natural range of variation to determine to what extent the changes have exceeded the natural bounds and whether they can be managed to more closely approximate the natural condition (Gaugush in draft).

A-Team Recommendation: Concur; medium priority

5.1.2 Land cover/Land use Patterns

The purpose of the Landscape Patterns Research Framework is for developing a suite of quantitative measures that can be used to 1) track status and trends of landscape patterns that affect various ecological processes (e.g. community succession and nutrient cycling), 2) identify areas for restoration on a systemic basis, and 3) develop a better understanding of the ecological consequences of modifications to landscape patterns in the contexts of ecosystem restoration and climate change in the Upper Mississippi and Illinois River floodplains. The first objective of the research is to develop measures of landscape structure that may only capture very general aspects of ecosystem function. The purpose of these measures is to identify areas for ecosystem restoration and to track status and trends at broad scales; regardless of the particular role such patterns may play in population and ecosystem dynamics.

(a) Patterns of Land cover change (pool scale). The major changes in land cover that occurred from c.1890 to 1975 consisted of changes from clusters characterized by relatively high proportions of forest to clusters characterized by high proportions of water (blue, B and C) in the north and to clusters characterized by high proportions of agriculture in the south (brown, F) (Fig. 3). These simple measures of historic changes to land cover composition can help managers identify locations and quantify magnitudes of land cover change as well as set goals for restoration actions that seek to alter land cover.

(b) Patterns of aquatic area diversity The hallmark of large floodplain rivers is their incredible diversity of aquatic areas (e.g. main and side channels, shallow aquatic areas, and floodplain lakes). However, like most large floodplain rivers, the spatial patterns of diversity that characterize the Upper Mississippi and Illinois Rivers have been fundamentally altered in many locations. As river managers set out to restore large-scale aquatic habitat diversity through island and secondary channel restoration, there is a strong need for quantitative measures that identify areas for restoration on a systemic basis.

A-Team Recommendation: Concur, analysis complete under 2010 Landscape APE; no additional funds required; high priority.

5.1.3 Mass Emergence of Adult Mayflies

Dukerschein et al. (2010) investigated ways to monitor mass emergences of adult mayflies which could provide a basic, relatively low-cost way to retain mayflies as a system-wide indicator of ecosystem health. Water temperature thresholds, often related to rising temperatures, are important for timing of mayfly emergence (Schowalter 2009). In addition, monitoring the timing of mayfly emergence in conjunction with temperature has a potential to be an indicator of climate change.

Two techniques for monitoring mayfly emergence were examined for their suitability as a system-wide indicator. These techniques included using emergence traps or documenting emergence with ground reporting and/or weather radar.

1. Emergence traps Dukerschein et al. (2010) did not recommend the use of emergence traps as a system-wide macroinvertebrate indicator. See Appendix B for a full discussion.
2. Ground data reporting system would provide a tool to document mass mayfly emergence dates system-wide. A simple low-cost solution would be to have the LTRMP field station staff make note of the mass emergence date in the "Comments" section of their data sheets while sampling the other components. These approximate emergence dates and emergence size data would then be stored in a long-term database (yet to be developed) or shared with an existing communication network such as the National Phenology Network or the River Alert Network. Additionally, these data can be verified with weather radar data (*i.e.,* NEXRAD). NEXRAD radar would provide emergence dates and information related to spatial extent and wind dispersal of each mass emergence, within an 80km radius for each radar location. The information gathered would be useful as a presence/absence indicator of pollution, as a phenological indicator of climate change, and for constructing a predictive model for mayfly emergence dates.

A-Team Recommendation: Concur with recommendation #2; low priority. Radar tracking still requires more development before it will be useful in this context. Requires development of new database.

5.1.4 Backwater Fishes Assemblage

The backwater assemblage is a functional indicator of off-channel environments and should be considered as a possible replacement for the Bluegill indicator. This indicator should be sensitive to changes in backwater fish assemblages. The efforts needed to construct this indicator would be to: (a) elucidate the present status of backwater fishes in the UMRS, and (b) devise a way to detect responses of backwater species to changes in habitat quantity and quality; a frequent objective of HREP projects.

A-Team Recommendation: Concur, highest priority.

Additional review comments: (WI) What about some historic work since the only snapshot in time for the fish appears to focus only on the life of LTRM while some of the other indicators (IHA, land patterns) use historic data as a benchmark? Similar to the channel species, this indicator should also just focus on using adult fish.

5.1.5 Migratory Fishes Assemblage

Migration is a key functional attribute required to maintain diverse and sustainable fish stocks in large rivers. Migration as an important functional attribute for the following reasons: (a) impediments to fish migration result from a direct, apparent and quantifiable economic use of the river, presenting an opportunity to consider ecosystem service valuation and tradeoff assessments in future reports, (b) providing fish passage is a major management thrust, offering an opportunity to elicit a measurable response or change in the status of migratory species, (c) additional faunal groups are health-impaired by restricted fish passage (e.g., freshwater mussels), and (d) this attribute shows promise as a potential management indicator which will assist in linking ecosystem health evaluations with management actions in the future.

This indicator should be sensitive to changes in migratory fish assemblages. The efforts needed to construct this indicator would be to: (a) elucidate the present status of migratory fishes in the UMR, and (b) devise a way to detect responses of migratory species to fish passage, presently under consideration in parts of the UMRS. Some previous staff work has already begun to address this issue (Chick et al. 2006; Ickes et al 2005; Ickes in prep). Achieving the development of a migratory fish indicator will require additional research and development work.

A-Team Recommendation: Concur, high priority. Some work on American eel has been done (Ridings).

5.1.6 Channel Habitat Fishes Assemblage

With bluegill or the backwater assemblage a functional indicator of off-channel environments, the functional health of channel environments is needed to achieve balance. It is recommended efforts be directed at developing a channel habitat fish indicator. Attributes this indicator should possess include the following: it should be comprised of adult fishes to minimize inter-annual variability attributable to stochastic recruitment events; it should take an assemblage approach, focusing on species that are fluvial specialists and/or dependents. Sucker species has also been suggested as an appropriate indicator.

A-Team Recommendation: Concur; high priority. May be able to use Steve Gutreuter's work (Gutreuter et al, 2006) on main and side channel trawling.

5.1.7 Ratio of Asian Carps biomass to total zooplanktivore biomass

This indicator would indicate shifts in foodwebs, largely in response to zooplanktivorous invasive Asian carp species resulting from the active invasion of the UMRS by Asian carp. The proposal is to track the proportional biomass of Asian carp to all zooplanktivore species, surmising that any Asian carp impacts on UMRS foodwebs should manifest first and foremost in the native zooplanktivore assemblage.

This indicator would require the development of a ratio index of Asian carp biomass to total zooplanktivore biomass in the UMRS. An alternative or complementary approach would be to tally fish biomass within each of seven identified feeding guilds (O'Hara et al. 2007) and look for proportional shifts among these guild classes over time. Upon completion of the indicator, report results should be presented to the A-Team for further consideration and indicator benchmark determination.

A-Team Recommendation: Concur; medium high priority.

5.2 Potential Social and Economic Indicators

Although outside the original consideration of indicators of ecosystem health, the fish sub-committee felt strongly that social and economic indicators are important and useful. No program or agency they are presently aware of tracks social indicators of UMRS fisheries resources, per se. It was difficult to consider ways in which meaningful social indicators could be crafted from existing observational data streams. The main objective was to reflect social values that may be other than exploitative, yet not directly measured in the basin. In addition to the two potential indicators below, it was recognized that neither the ad hoc group nor the fish sub-committee had much knowledge regarding construction and use of social or economic indicators. The first task needed prior to proceeding with either indicator below would be to conduct a literature review, focusing on means by which fisheries social and economic indicators have been developed and used in other systems.

5.2.1 Threatened and Endangered Species

Threatened and Endangered species, in a very real way, reflect past, present, and future societal values in that past values perhaps led to the status of such species (exploitative), and such designations speak to present social norms (conservation/restoration), and intended future social benefits (aesthetics/ethics). It is doubtful that the existing systemic data sources (e.g., LTRMP, EMAP) can fully inform such an indicator and other resources are required for additional fact-finding work, including a canvass of agency-specific data resources and an assessment of their utility for advancing such an indicator. Some baseline work has previously been achieved (see Chapter 5 in Ickes et al 2005), and additional information is likely available from the USFWS as a trust species agency.

A-Team Recommendation: Concur; low priority. Concern expressed about LTRMP's ability to capture uncommon species. USACE dissented on this issue since UMRR-EMP/LTRMP lacks expertise in this area; better for another entity.

5.2.2 Standing Economic Value

The fish sub-committee recommendation is the dedication of staff time towards the development and refinement of a "standing economic value indicator", which tallies the replacement values for each and every fish observed in the LTRMP fisheries database (OHara et al. 2007). Additionally, they recommend some exploratory analysis work that attempts to correlate patterns in economic valuation with both rehabilitation expenditures, as well as any of a number of environmental and social covariates.

A-Team Recommendation: Concur; low priority. USACE dissented on this issue since UMRR-EMP/LTRMP lacks expertise in this area; better for another entity.

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8. Appendices

Appendix A. LTRMP Analysis Team Ad Hoc Indicator Group Purpose Statement

INDICATORS OF ECOSYSTEM HEALTH
FOR THE UPPER MISSISSIPPI RIVER SYSTEM[1]

Purpose Statement
LTRMP Analysis Team Ad hoc Indicators Group

May 20, 2010

1. This effort will focus primarily on scientifically based indicators of ecosystem health[2] or ecological integrity[3], as defined in the 2008 EMP Long Term Resource Monitoring Program Status and Trends Report (Johnson and Hagerty). Some of the indicators discussed may also be used, or have derivatives that can be used, at the project level. This work complements work underway at the pool or geomorphic reach scale, designed to measure progress towards achieving management objectives.

2. This effort will begin by evaluating indicators used in the 2008 EMP-LTRMP Status and Trends Report for use in next Status and Trends Report, but this may not be the sole use of these indicators. In addition, the final indicators could be used in the development of a UMRS ecosystem health report card.

3. This effort will strive to be aware of the results of other efforts addressing objectives and indicators (e.g., UMRS objective setting, UMRBA bio-indicators work), but not be driven by them or wait for them. The outcomes of this effort will be linked to these other efforts when possible/appropriate. Coordination with NESP and 519 efforts will continue.

4. The initial product will be a written report assessing all indicators in the 2008 Status and Trends Report and will contain recommendations for the next S&T Report. The indicator criteria, as defined in Dale and Beyeler (2001) and as identified in Section 4.1, will be the primary basis of this assessment. Other criteria may be added if needed, based upon the unique nature of individual indicators.

    4.1. Strengths and weaknesses of each indicator:
        4.1.1. Purpose - how used to evaluate changes in ecosystem health,
        4.1.2. Spatial and temporal scales of the sampling design,
        4.1.3. Detection,
        4.1.4. Variability,
        4.1.5. Patterns currently observed,
        4.1.6. Differences among focal areas,
        4.1.7. Responsiveness to change in drivers or management actions.

    4.2. Usefulness of indicator with recommendations for improvement, alteration or deletion. Also address applicability at trend pool and floodplain reach.
    4.3. Timeline for completion of draft report: one year (August 2010), for endorsement by the A-Team and transmittal to EMP-CC.

5. Another proposed product will be development of an approach to determine and propose benchmarks (or targets). This may be based on observed range over time or trend direction for the indicator. In addition, consideration will be provided on how benchmarks might change for different locations within the system.

6. Other indicators could be explored, either with current data or requiring new data collection. Ultimately, this will not be limited to the focus areas identified in the LTRMP Strategic and Operational Plan (SOP) though the SOP should serve as a guide during this first step.

DEFINITIONS (from 2008 EMP-LTRMP S&T Report)

[1]**Upper Mississippi River System**: as defined by Congress in the Water Resources Development Act of 1986, includes the Upper Mississippi River (UMR) from Minneapolis, MN to Cairo, IL (854 river miles); the Illinois Waterway (IWW) from Chicago to Grafton Illinois (327 miles); and navigable portions of the Minnesota (15 river miles), St. Croix (24 river miles), Black (1 river mile) and Kaskaskia Rivers (36 river miles). The UMRS encompasses a total area of approximately 2.6 million acres of land and water in public and private ownership.

[2]**Ecosystem health:** a condition when a system's inherent potential is realized, its condition is stable, its capacity for self-repair, when perturbed, is preserved, and minimal external support for management is needed

[3]**Ecological (or biological) integrity:** a system's wholeness or "health," including presence of all appropriate elements, biotic and abiotic, and occurrence of all processes that generate and maintain those elements at the appropriate rates. The capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and a functional organization comparable to that of natural, unimpacted habitat of the region

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Appendix B. Macroinvertebrate Indicator Sub Committee Report

Report from the Macroinvertebrate Indicators Subcommittee

To the LTRMP Analysis Team's Ad Hoc Indicators Committee

By

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July 21, 2010

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08.08.2007

Introduction and Framing of the Problem

The macroinvertebrate subcommittee was appointed as a group of experts by the Long Term Resource Monitoring Program's (LTRMP) *ad hoc* Indicators Committee and tasked with recommending which, if any, macroinvertebrate indicators (i.e., burrowing mayfly nymphs of the *Hexagenia* spp. and fingernail clams, *Musculium transversum*) listed in the 2008 LTRMP Status and Trends report (Johnson and Hagerty 2008) should be continued as indicators in subsequent LTRMP Status and Trends Reports. Burrowing mayflies and fingernail clams are well-known as ecological indicators of food availability for fish and waterfowl (Thompson 1973, Hoopes 1960; Jude 1968; Ranthum 1969). Additionally, both, especially mayflies, are also well-represented in scientific literature as sensitive water quality indicators (Fremling 1964, 1973, 1989; Steingraber and Wiener 1995). Furthermore, although not used as indicators in the 2008 Status and Trends Report in this way, burrowing mayflies have the potential to be excellent indicators of phenology and climate change due to their synchronized mass emergences. These mass emergences are easily observable and are triggered by a developmental regimen that depends directly on water temperature (Fremling 1973; Wright et al. 1982).

According to the March 30-31, 2010 meeting minutes, the tasks for this subgroup as determined by the A-Team Indicators Ad Hoc Committee were to:

- Investigate NEXRAD (weather radar) as a possible tool for detecting mayfly emergence (could it be used as a screening tool? Limitations for its use?)
- Review 10-yr report and component evaluation report and provide recommendations to larger group for use of macroinvertebrates as indicators of ecosystem health.

The subcommittee's task is complicated by the fact that LTRMP macroinvertebrate sampling of mayfly nymphs and fingernail clams was discontinued in 2004, mainly for budgetary reasons. However, a number of non-budgetary factors based on information available at the time also influenced the decision, the primary factor being poor detection of mayfly nymphs and fingernail clams in Pool 26, Open River, and La Grange Pool. In addition, the Open River Reach experienced sampling complications using the standard LTRMP method of ponar dredges since these dredges were not designed to be used in fast, free-flowing river conditions as observed in the Open River. In fact, few mayflies and no fingernail clams were detected by LTRMP crews 1993-2002 in the Open River Reach (Sauer 2004). A study in the Open River Reach that compared various sampling methods for macroinvertebrates in an attempt to find a more suitable method for use in the Open River; however, due to loss of samples and the graduate student departing mid-project the conclusions from this report written with only 1 year worth of data should be taken lightly (Pers. Comm. Kathryn McCain May 17, 2010; McCain et al. 2008). New information not included in the 10-year report or in the component evaluation report also came to light as our subcommittee sifted through historical data and new scientific literature that has become available since the reports mentioned were written. Both mayfly nymphs and mass emergences of adults have been observed or detected in the Open River Reach at various times by various methods (Fremling 1973; Battle et al. 2007).

We were charged with supporting any recommendation we make to continue a macroinvertebrate indicator in the LTRMP Status and Trends Report not only by the evidence of the usefulness of the indicator, but also by compelling evidence that the organism is present systemically and that sampling protocols used should be capable of detecting it throughout the entire Upper Mississippi River System

(UMRS), including the (unimpounded) Open River Reach. Historical data (Fremling1970), field observations by biologists at the Open River Field station (Pers. Comm. Kathryn McCain May 17, 2010) and ponar sampling behind wingdams in the Open River Reach (Battle et al. 2007) all provide records that *Hexagenia* mayfly adults and nymphs are present and detectable in the Open River Reach (and other LTRMP study reaches), but we have no documentation for live fingernail clams in the Open River Reach. While they have not documented live fingernail clams from the Open River reach, they have observed dead shell. "We simply do not know if the dead shell originated in the MMR or entered the reach from the pooled potion of the UMR. We suspect that fingernail clams exist in the MMR in very limited locations (e.g., some side channel habitats). Fingernail clams are very common in our Bootheel region of Missouri, which consists of thousands of miles of ditches, which should act as a source for dispersal of this species to the Mississippi River" (Robert Hrabik, pers. comm., July 2, 2010).

We read and discussed multiple research papers, including the Great River Macroinvertebrate Index (GRMIN) recently published by Ted Angradi et al. (2009). The GRMIN is a multimetric index of biological condition that was developed from a comprehensive, system-wide dataset collected by Environmental Monitoring and Assessment Program for Great Rivers (EMAP-GRE) cooperators, including the state LTRMP field stations. The GRMIN has many advantages including that it is an index of overall condition rather than a single-species indicator, it includes continuous coverage of the upper Mississippi's impounded and unimpounded reaches, it allows comparisons with other large mid-continental rivers (i.e., Ohio and Missouri Rivers), and an objectively determined, empirical stressor gradient along each river is used in development. Index metrics are based in abundances of various species of macroinvertebrates that colonize the littoral zones of the main channel borders, as sampled per standard EMAP-GRE protocols with D-frame kick-nets. Ten metrics of condition passed all standard response tests for the impounded section of the upper Mississippi River, and the GRMIN shows statistically significant inverse relationships to a human stressor gradient in the impounded reach of the UMR. While the GRMIN index works well for the impounded reach of the UMR (from the Twin Cities in Minnesota downstream to St. Louis, MO) , the ten different metrics chosen for the Open River do not yet work well for the unimpounded reach of the UMR. Also, the GRMIN does not include a developmental dataset or metrics for the Illinois River. These particular geographical constraints especially limit GRMIN's potential as a system-wide indicator for the LTRMP Status and Trends Report. The GRMIN methods also are time-consuming and expensive due to the laboratory idenfitication required.

Thus, we focused most of our attention on mayflies as a potential single-species macroinvertebrate indicator to continue in the Status and Trends Report. Mayflies of the family Ephemeropetera, genus *Hexagenia*, are well-documented and detectable along the entire UMRS. They have broad potential to function not only as ecological and water quality indicators, but also as a climate change indicator. Climate change is a relatively new scientific concern that was not factored into the decision made in 2002 to end macroinvertebrate component of the LTRMP. Likewise NEXRAD weather radar has since emerged as a tool that, in conjunction with ground observations, can document adult mayfly emergences within an 80 km radius of a Doppler radar. Finally, we now have statistically more explicit descriptions of our past macroinvertebrate dataset that we did not have when the program discontinued the component in 2003/2004.

Overall, existing data documents that mayflies have been detected as either nymphs or adults throughout large extents of the UMRS and in every LTRMP study reach (Fremling 1970). We will present each case with its advantages and constraints separately followed by our recommendation(s).

Option 1: Mayfly Nymphs

Although we were not specifically tasked with taking a closer look at our present Status and Trends Indicators, mayfly nymphs, new information came to light in this subcommittee. To assure a more complete evaluation, we have listed advantages and constraints in the light of this new information. Currently LTRMP does not have the budget to reinstate the macroninvertebrate component to the monitoring program nor is reinstatement of monitoring nymphs a priority in the LTRMP 2010-1014 Strategic Plan. Therefore, this committee realized we needed to keep any additional costs of monitoring macroinvertebrates to a minimum. Since all alternatives, besides the current plan of no action, will have some additional costs we need to carefully weigh costs and benefits of retaining mayflies as an indicator. We need to look at the added information (not otherwise captured) we would gain for the additional cost.

Advantages:

1. Presumably we could detect mayfly nymphs throughout UMRS with ponar sampling, but we would need to modify methods per Battle et al. 2007, at least in the Open River Reach, if we want a chance at detecting *Hexagenia* mayfly nymphs in the Open River (see constraints for more details).

2. Mayfly nymphs as sampled with ponar dredges are quantitative, location specific ecological indicator of food availability for fish and waterfowl (references as cited in Sauer 2004).

3. We now have more information about our ability to detect trends in mayfly abundance and our power of detection than we did when we discontinued the macroinvertebrate sampling in 2003. A power analysis done by USGS statistician Brian Gray (LTRMP website http://www.umesc.usgs.gov/ltrmp/power_plots.html accessed 6/29/2010) indicates statistical power of LTRMP ponar sampling for mayfly nymphs in some reaches was good enough by 2004 using LTRMP methods to use statistics to detect trends after 12 years (Pool 8). And power to detect a 5% per year change in mayfly (Ephemeridae) counts ("relative abundance") in Pool 13 was expected to reach 80% after approximately 14 years of sampling.

4. Mayfly nymphs can be indicators of pollution or other habitat problems (or habitat characteristics) in areas of known occurrence or where not detected.

5. By resuming the LTRMP macroinvertebrate sampling, we would also capture other important soft-substrate macroinvertebrates such as fingernail clams ..

Constraints:

While mayflies are present in the Open River Reach, they are likely not a major component of its invertebrate community in that reach and might be coming from non-riverine “altered” areas such as ponds in back of levees or. Caddis flies are very abundant and would probably be a better indicator of riverine productivity. Caddis flies appear to be a large component of the invertebrate community in other reaches as well and might be a more universal indicator. Bob Hrabik has also suggested, for example, using *Pseuderon* mayflies (sand dwellers) quantitatively sampled by a Missouri mini trawl with a fine mesh as a possible mayfly indicator for the Open River Reach or using caddis flies (Bob Hrabik, MODOC June 25, 2010 pers. comm.). The Open River Reach macroinvertebrate community is still largely unknown. In this reach a larger percentage of productivity is likely to come from allochthonous sources as compared to upstream (which is primarily autothonous), meaning macroinvertebrates play a vital role in overall total productivity in this riverine ecosystem. We will need comprehensive evaluation of macroinvertebrate ecology and appropriate indicators in that reach (as well as other reaches) when the LTRMP arrives at and prioritizes science questions for the macroinvertebrate component per the 2010-2014 strategic plan. Even if we were to retain mayfly nymphs as a single-species indicator in all study reaches, based on known pollution sensitivity, a pilot study would be necessary to determine if Battle et al. (2007) protocols or other protocols work in both impounded and unimpounded reaches and target areas more likely to provide mayfly habitat. According to Bob Hrabik, the problem with using the original LTRMP macroinvertebrate design in the Open River Reach was that “we did not properly stratify mesohabitats to key in on m*ayflies*. Because we were bound to a systematic design, we spent a lot of time sampling in areas that we would not expect to capture mayflies (like lots and lots of sand). Mayflies may also be present on the unprotected side of the levees (what we southerners call the "batture lands"), where numerous wetlands and borrow areas exist. These areas are periodically flooded by the Mississippi River and we should investigate the invertebrate (and vertebrate for that matter) community.” If we were to adopt the methods in Battle et al. (2007) by sampling dike fields or other areas more likely to yield mayflies however, it would not relate back to previous LTRMP macroinvertebrate sampling unless these methods were done only in the Open River Reach mainly to detect presence/absence of *Hexagenia* mayflies. Battle et al. (2007) sampled for several consecutive years in October or November with a petite ponar and a much finer-meshed wash screen relative to past LTRMP methods, and they targeted potentially suitable habitat by sampling only in dike fields. For more detail on Battle et al. (2007) methods refer to Appendix 2.2. Another method possible for the Open River Reach or other reaches is the benthic sled built by Dave Ostendorf, MODOC. This sled was used as noted in McCain et al. (2009). In other applications of this sled, it worked well and perhaps better than indicated in McCain (2009) (Robert Hrabik, pers. Comm. 7/2/2010). Bob Hrabik also suggested referencing a Canadian paper in which a macroinverte index was developed as a flow indicator for riverine systems (Armanini et al. 2010).Sampling nymphs only, would not neces*sarily pr*ovide additional information about phenology and climate change unless sampling occurred consistently at the same time of year and applied some type of developmental index yet to be determined to the nymphs collected. However, many other organisms besides mayflies could provide phenological information.

3. Cost per sample using Battle et al. (2007) protocol appears somewhat similar to, at least in number of personnel and type of equipment to previous LTRMP macro*invertebrat*e monitoring, except that the LTRMP SRS samples are less concentrated spatially so the

LTRMP completes only half to a third as many sites per day as Battle et al. (2007) completed, but LTRMP also covers a much larger area and more types of aquatic areas.

4. More information on the entire macroinvertebrate community present in the *Open River* Reach is needed as resources become available. "Understanding system processes" is an important objective of LTRMP monitoring and the Missouri field station (Robert Hrabik, pers. Comm. 7/2/2010).

Option 2 Adult Mayflies: Monitor mass emergences of adult mayflies.

A. *Set up a dependable ground data reporting system* to document mass mayfly emergence dates and attributes and *use NEXRAD radars on the UMR and Illinois River in conjunction to document emergences and wind dispersal*. Possible networks include:

- *the Nati*onal Phenology Network (NPN)
- LTRMP field stations typing observations in comments section of data sheets
- using the River Alert Network
- using TV weather stations
- using the National Weather Service
- using our own ground radars
- using emergence or light traps to get quantitative information
- or some combination of the above

In previous years, observations in LTRMP datasets from past LTRMP field station sampling have been spotty at best—for example, the La Crosse field station has not customarily been noting mass mayfly emergences in "comments" section of their data sheets while sampling the other 3 components. We recommend that if the partnership retains mayflies as an indicator, that LTRMP field stations be required in protocols to note mass mayfly emergences in com*ments sect*ion of any component they happen to be sampling at the time. This should be implemented through USGS component scientists or through the USGS invertebrate specialist.

It is unknown what network or combination of networks would be most effective in reporting mayfly emergences. There would be additional program costs for processing and managing data and time/expertise of remote-sensing scientist at UMESC required for any of the above options. From ground observations we would get approximate emergence dates, and an approximation of emergence size. From NEXRAD radar currently we would get emergence dates and information related to spatial extent and wind dispersal of each mass emergence, within an 80 km radius of detection for each radar. Light traps would provide specimens for chemical analysis and emergence traps would provide quantitative and location-specific information, but both would cost significantly more.

In 2-3 years with advances in radar technology (dual polarization) a signature specific for insects could possibly be developed, but the Weather Service has yet to make decisions on whether it will be able to archive all the data in all the dimensions necessary to do these theoretically possible things (Manuel Suarez, USGS and Randy Breeser, La Crosse Weather Service, NOAA pers. Comm.).

For 2010, the subcommittee e-mailed 2 requests on the River Alert Network for Resource Managers and biologists to report emergences and through the first of those requests, there was also a similar request posted in Illinois Riverwatch Newsletter, a Citizen's Monitoring Network for the Illinois River. We have had success with this method and a summary of reports provided so far in 2010 can be viewed in Appendix 1. We also e-mailed a request to all the National Weather Service Stations that have radar to ask if they would be willing to work with us to generate radar coverages if we provided them with dates of reported emergences. All were willing but requested a protocol to follow for generating the radar coverages. Manuel Suarez plans to write up a protocol and e-mail it to them later this year.

Advantages

1. Radar data, especially in a time series of images, is helpful to verify emergence dates observed, examine wind dispersal, extent of emergence etc.
2. Radar data provides compelling images for use with the public and in reports.
3. Radar data can be consulted retrospectively within the limits of data storage and when the technology was in use.
4. Ground observations and radar data, along with water temperatures and developmental temperature threshold data from Wright et al ( ) provide the basic information to run a model that predicts mass emergences dates of mayflies (Mark Steingraeber, USFWS, pers. comm.).
5. We get requests to predict emergences every year and this model will thus fill a need.
6. Documenting mass emergence dates by either radar or ground observations documents
    a. Availability of suitable mayfly habitat
    b. River is clean enough to support mayflies, which are sensitive to low D.O.'s and organic pollution.
7. Mayflies are well-documented in scientific literature as both pollution and ecological indicators.
8. The Metropolitan XXXXX District has already written an easy to use guide so that observers can rate the size of mass emergences of mayflies (Appendix 3).

Constraints

1. Radar coverage is not continuous up and down the river—reads an 80 km radius of each weather station.
2. The St. Louis radar has more noise and interference, leaving radar coverage in the Open River Reach weak—the radar at Paduca, KY covers a portion of the Open River Reach.
3. Radar is like a camera—has setting options and some are more optimal (Clear weather) for mayflies than others (Storm).
4. It costs to pay a specialist's time to download and interpret the radar data. At this time the weather service is assisting us but cannot do detailed analysis.
5. Radar data requires lots of storage space, especially after dual polarization occurs in a couple years. Weather Service hasn't yet determined if they will have enough storage (Randy Breeser, NOAA, La Crosse.)
6. Radar data is so far not quantitative.

7. The spatial information radar provides is general to an area, not location-specific and also depends on wind speed and altitude of the insect swarms.
8. While mayflies occur throughout the UMRS, organisms like caddis flies are even more ubiquitous and also consistently productive throughout the entire system (Hoopes 1960). In the Open River Reach, Hexagenia mayflies are present, but not as common as caddis flies (Robert Hrabik, pers. comm. June 29, 2010). Caddis flies seem to be common throughout, but data from Hoopes (1960) in Pool 19 near Keokuk, Iowa seems to indicate that at least in that area, mayflies were consumed by somewhat more species of fish than caddis flies.

B. *Use Emergence Traps*

Location-specific and quantitative data on adult mayflies might also be possible using emergence traps, but there would be the cost of setting them and maintaining/monitoring them plus some methods development costs. Bill Richardson (USGS) and Roger Haro (UW-La Crosse) had a research project with graduate students that recently finished in Pool 8 using emergence traps in backwaters (pers. comm. Roger Haro, June 16, 2010 and Bill Richardson, June 18, 2010). When they completed their study they loaned the emergence traps to Mark Steingraeber (USFWS), Terry Dukerschein (WIDNR), and Patrick Kelly (UW-La Crosse). Seven of these traps were deployed likely mayfly habitat in Stoddard Bay, Pool 8, on June 28, 2010 as a small pilot study to gain more information about how they work. These traps will be deployed until the big emergence of *H. bilineata* occurs in Pool 8. Mark Steingraeber, USFWS, has modeled mayfly emergence on developmental temperature thresholds reported by Wright et al. (1982) and daily surface water temperatures as measured and reported by USACE staff at Locks and Dams. Mark's model predicts a major emergence of *H. bilineata* in Pool 8 between July 3 and July 6, 2010. A major emergence in the La Crosse area reported by numerous observers yielded no mayflies caught by the emergence traps, although some evidence of their presence was detected near the traps (Mark Steingraeber, pers. Comm. July 6, 2010).

Advantages

1. Emergence traps are quantitative and location-specific and if checked consistently could provide exact phenological information about emergence dates, as well as yielding analysis grade specimens.
2. Mark Steingraeber's new model predicts time of first emergence of *H. bilineata, if ultimately proven to be dependable throughout the system,* makes emergence traps somewhat more practical to consider for use in conjunction with radar.
3. Ground observations and radar data, along with water temperatures and developmental temperature threshold data from Wright et al. (1982) provide the basic information to run a model that predicts mass emergences dates of mayflies (Mark Steingraeber, USFWS, pers. comm.).
4. We get requests to predict emergences every year and this model will thus fill a need.
5. Documenting mass emergence dates by either radar or ground observations documents
    a. Availability of suitable mayfly habitat
    b. River is clean enough to support mayflies, which are sensitive to low D.O.'s and organic pollution.
6. Mayflies are well-documented in scientific literature as both pollution and ecological indicators.

Constraints

1. Even a simple database tracking only ground observations of mayfly emergence dates will cost money and time and be necessary to report mayflies if this indicator is retained as an indicator in the Status and Trends Report.
2. Continual funding needed. Emergence traps require a minimum of 2 site visits-- one to set them and one to go back, empty them, pull them out, and identify the collected specimens. Since two site visits are required per sample they would likely be more costly than ponar sampling of mayfly nymphs. The catch also would need to be sorted and quantified.
3. Even if we get a good predictive model for the date of first mass emergence of *H. bilineata* throughout the system, it is doubtful emergence traps could be effectively deployed under spring high water conditions in the Open River Reach and other downstream field stations, but land-based mercury light traps (not quantitative or location-specific) possibly could be used if specimens were needed for any reason.
4. While mayflies occur throughout the UMRS, organisms like caddis flies are even more ubiquitous and also consistently productive throughout the entire system (Hoopes 1960). Hexagenia mayflies are present, but not as common as caddis flies (Robert Hrabik, pers. comm. June 29, 2010) in the lower reaches as in the upper reaches, but caddis flies seem to be common throughout.
5. When sets of 5-7 emergence traps were deployed in Pool 8 in two separate areas of Pool 8, the traps did not catch any mayflies, even when adult mayflies were observed at the same time in the general area where the traps were set (Patrick Kelly, Pers. Comm. June 25, 2010 and Mark Steingraeber, Pers. Comm. July 6, 2010).

The emergence traps were awkward, and bulky to transport and work with while deploying them or retrieving them.

Recommendations of the Macroinvertebrate indicators subcommittee:

1. Long-term costs and applicability system-wide were heavily considered for the present recommendations of using observations of adult mayfly mass emergences as an indicator. Procedures would need to be developed to document and report dates and locations of mass mayfly emergences consistently. To implement this recommendation, a dedicated, long-term database will need to be developed along with staff time for data maintenance and report writing will be needed. The information generated will be useful as a presence/absence indicator of pollution, as a phenological indicator of climate change, and for constructing a predictive model for mayfly emergence dates. The latter being of special interest for invertebrate specialists and resource managers to answer special concerns from the public.
2. This minimum step is also essential to support radar documentation of spatial extent and density of mass emergences once technology has advanced sufficiently. Sub-objectives supporting this recommendation would include:
   - Continue to work with the National Phenology Network to develop consistent protocols for reporting mayfly mass emergences as a potential citizen-based science approach. We have contacted them and several members of the macroinvertebrate ad hoc committee will review their mayfly and stonefly protocols later this summer.
   - Continue to use the River Alert Network (through UMRCC) as a mechanism for diverse professional resource managers to report mass mayfly emergences in the UMRS.
   - Require LTRMP sampling crews to note in comments section on datasheets when mass mayfly emergences are observed while sampling other components.

- Continue to work with weather stations on providing radar images of emergences in Clear Air mode. (Emergences might or might not be obscured in Precipitation Mode.)
- As new technology, data storage, and funding permit develop algorithms in the future to more easily and precisely obtain radar images of mass mayfly emergences. Any work with radar will require time and cost of a specialist to interpret the signal and produce the images.

3. Sampling nymphs with ponars by the protocols of Battle et al. (2007) or with some combination of our former protocols is another method potentially possible if more funding resources become available. So far, this is the only method with potential to provide quantitative, location-specific information at a fine-scale throughout all LTRMP study reaches.

4. Our evaluation currently is that neither the GRMIN (Angradi et al. 2009) nor emergence traps would work well in the Open River Reach as presently developed. We also estimate cost and effort level would be considerably higher than for the first two recommendations and consistent outside funding would be required.

5. More macroinvertebrate monitoring methods still need to be tested in the Open River reach, such as fine-meshed mini-Missouri trawls, and at a minimum, the study reported by McCain et al. (2009) needs to be resumed and properly completed.

6. Allochthonous energy sources such as macroinvertebrates likely play a vital role in riverine productivity and we recommend that the strategic planning process addresses macroinvertebrate monitoring from a holistic perspective and across the system.

7. With present resources, retaining mayflies as system-wide indicator by tracking and recording ground observations and confirming with existing weather radar data is a minimum, basic, relatively low-cost step we can take at this time.

Acknowledgments: Although unable to participate in our conference calls due to scheduling issues, we wish to thank the following people and agencies for contributing substantial expertise and technical assistance: Jan Battle, Stroud Water Resources Consultants; Dr. Roger Haro and Patrick Kelly, UW-La Crosse; Robert Hrabik, Missouri Department of Conservation; Dr. William Richardson, and Brent Knights USGS/UMESC; Mark Steingraeber, USFWS, La Crosse Fisheries Resource Office; Dan Baumgardt and Randy Breeser, NOAA, La Crosse Weather Service and all who reported mayfly emergences.

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Appendix 1: Observations of Mayflies Reported in 2010 (as of July 7, 2010) and Some Prior Years

- 5/28-30/2010 Multiple observances of *H.limbata* reported to M. Suarez by multiple observers as enabled by River Alert Network in Pools 7 and 8, MN and WI side
  - Confirmed on La Crosse Weather Service radar, also WXOW and MPR weather reports and websites published the radar image
  - 6/1-2/2010 More *H. limbata* reported by multiple observers, Pools 7 and 8, might be same emergence
- 6/15/2010- at Lock and Dam 9. Minor emergence containing both species reported by John Sullivan, WIDNR. Confirmed on weather radar and appeared as dense as 5/28-30 emergence on radar from DeSoto, WI to Ferryville, WI.
- 6/14-15/2010- significant emergence at the north end of LeClaire, Iowa, Pool 14,about river mile 499 - 500, 6/14 - 6/15 reported by Jody Millar, USFWS. Confirmed as *H.bilineata* and since then smaller emergences have taken place almost continuously there as reported by Jody Millar on June 29, 2010.
- 6/17/2010-significant mayfly emergence in Bellevue and Sabula, IA reported by Mel Bowler, IADNR.
- 6/24/2010-smaller mayfly emergence in La Crosse, WI reported by Dan Baumgardt, NOAA while playing baseball.
- 6/26/2010-evidence of significant mayfly emergence in Dubuque, IA reported by Ken Lubinski, probably occurred evening of June 25, 2010.
- 6/28/2010- 11:50 am-- mayfly emergence in lower Pool 8, Horseshoe Island area, called in from the field by Andy Bartels, WI DNR, likely *H. bilineata* imagoes and also called in by Heidi Langrehr and Ruth Nissen in the Goose Island complex of Pool 8. Radar report from Dan Baumgardt of La Crosse weather service for previous night of June 29 is as follows: "some localized target that shows up, mainly south of Brownsville. It is fairly subtle, and appears on the west side of the river south to about Reno. This could be mayfly action, but certainly not a large hatch spatially when compared to others (like late-May). It appears after 9 pm and remains through about 3-4am." In a subsequent e-mail about the June 29 radar image, Dan Baumgardt speculated "The wind field was quite light last night - less than 10 mph through 5000ft. This provides two thoughts: 1) a smaller hatch can appear with higher reflectivity (dBZ) because the flies would not be dispersed as fast via the wind. The radar measures density of the targets, and 2) It is harder for us to definitively say a hatch occurred via radar because a lighter hatch is more obvious on radar with a stronger wind field. The radar echo looks plume-like, like a smoke plume, as the bugs are carried off the river - with the echo beginning point anchored to the river. In weaker wind flow, the flies remain on the river and stationary. The cause of stationary targets can be hard to identify. There was a large target region that showed up over northern Vernon county last night....not likely Mayflies but all insects, bats, birds. " <u>Note: These observations illustrate the complexity of interpreting radar images.</u>
- The morning of June 30 Mark Steingraeber, USFWS, observed a few exuvae and a few subimagoes near the seven experimental emergence traps we set in Stoddard Bay on June 28, 2010. Nothing was in the traps, however.

- 7/1/2010-Mandi Stark reported filming mayflies swarming south of Stoddard, WI during the evening hours. Dan Dieterman, MNDNR, observed what was likely part of the same emergence in the Reno Bottoms area of upper Pool 9, commenting they were dark and appeared to be *H. bilineata.*
- 7/4/2010-Swarms of mayflies reported in the evening at Riverside Park, La Crosse, by Andrew Bartels, Bill Richardson, and Patrick Kelly.
- 7/6/2010- evidence of a previous large mayfly emergence extending to downtown La Crosse area and over bridges into Minnesota (observed by Dukerschein, Steingraeber, Sullivan and others). Morning trap check report by Mark Steingraeber, USFWS was "no mayflies in the traps, 2 emergent mayflies within the buoys (1 *bilineata*, 1 *limbata*) ... no exuviae on the water surface", however he observed many mayflies on light poles at the Stoddard Landing and John Sullivan, WI DNR, reported evidence of swarms the previous night at both Lock and Dams 8 and 9. Surface water temperature was 24.4 C at both Locks and Dams in late morning and DO was 4.6 to 4.8 mg/L as reported by John Sullivan, WI DNR.
- 7/7/2010- Kent Johnson (Twin Cities Metro Wastewater Commission) observed a mayfly emergence in Pool 2
- 7/12-13/2010-Dan Baumgardt (NOAA) reported radar pattern of mayfly emergence night of July 12 and observed *H. limbata* at Kwik Trip on South side of La Crosse, WI. Mark Steingraeber also observed *H. limbata* on South side of La Crosse previous day an in area while pulling out emergence traps on July 12, 2010.
- July 17/18- Terry Dukerschein and Mark Steingraeber observed live adult mayflies in south La Crosse and observed piles of dead adult mayflies on Cass Street Bridge over Mississippi River July 19-20, 2010. Dukerschein captured subimago of *H. limbata* July 17 and Steingraeber captured an imago of *H. limbata* the same day. This emergence was confirmed by weather radar.
- July 19-John Sullivan observed a substantial number of dead imagoes of probable *H. bilineata* at Lock and Dam 9. Extent of emergence confirmed by La Crosse weather radar.
- July 20, 2010. Mark Steingraeber made more ground observations of mayflies. URL of Link to radar loop the night of July 19 provided by Dan Baumgardt, NOAA: http://www.crh.noaa.gov/news/display_cmsstory.php?wfo=arx&storyid=55478&source=0

- **7/21/10: Lock and Dam No. 2 (UM 815.3):** Dave Hed of the Metro Council reported a very heavy (**5**) emergence of H. bilineata on LD2 property, and collected 12 female imagoes. Several of these specimens were still alive. Lock and Dam personnel indicated that a very large emergence occurred last evening (7/20/10). Confirmed by weather radar.

- 7/21/2010. Medium sized emergence of *H. bilineata* reported night of July 20, 2010 in Pool 13 by Mel Bowler, IADNR.

Partial list of La Crosse area mass Mayfly emergences from recent past years as known. Documented by Manuel Suarez (USGS) / National Weather Service radar or in the case of 2009 based on previous ground reports (WKBT-TV La Crosse. All times came from radar images documented by Suarez and are in GMT. All times are roughly at peak signal.

- 2010-05-30 @ 0213
- 2009-07-10 (WKBT TV La Crosse website)
- 2008-07-10 @ 0236
- 2008-07-06 @ 0246
- 2007-08-08 @ 1047
- 2007-07-22 @ 1017
- 2006-07-01 @ 0241
- 2003-07-25 @ 1009

Appendix 2: Details for Battle et al. (2007) Dredging Methods used in Open River

Battle et al. (2007) targeted potentially suitable habitat for mayfly nymphs by sampling only in dike fields. They used a crew of 3 in an 18-foot boat and easily sampled 2 stations of 18 samples each in a day (36 samples/day) in the Open River Reach near Cape Girardeau—commented they could have easily done more. Behind the dikes they never had trouble obtaining samples because of depth unless the water was very high—the most challenging water depth during sampling was 6.4 m based on USGS gage 07020850 in Oct 2008 (water level was at the top of the dikes, some dikes were submerged). The petite ponar is easily deployed over the boat side as long as the boat can be kept stationary. Back in the lab, they process the samples in their entirety. It typically takes them a day or less to sort a sample and identify them, but it might take longer in upper impounded reaches that have more vegetation and detritus. They've found Rose Bengal speeds up picking, especially for finding the small (immature) *Hexagenia*. Most of the time picking is removing oligochaetes, if they were to just remove all but oligochaetes, their processing time could be speeded up considerably. They have done a paper examining the effect of mesh size on the metrics and one on how the removal of oligochaetes affects the metrics (Jan Battle, 6/24/2010 pers. comm.)

Appendix 3: Rating the Size of Mass Emergences of Mayflies

Hexagenia limbata

Hexagenia bilineata

Quantitative Ratings of Mayfly (Hexagenia) Emergence Strength

Emergence Strength:

1 = Slight
(Total individuals in immediate observation area ranging from 1-50)

2 = Light
(Total individuals in immediate observation area ranging from 100-500)

3 = Moderate
(Consistent coverage of surfaces (pavement areas, building walls and windows); small aggregations of individuals under lights)

4 = Heavy
(Very noticeable aggregations of individuals under lights, including small-medium-sized "piles"; thick coverage of surfaces)

5 = Very Heavy
(Large aggregations (large "piles") of individuals under lights; very thick coverage of surfaces, with minimal surface area exposed)

Long-Term Observation Sites:

St. Paul, MN
(Observation location for St. Paul is the Metro WWTP (UM 836.3))

Hastings, MN
(Observation location for Hastings is the general vicinity of Lock and Dam No. 2 (UM 815.3))

Red Wing, MN
(Observation location for Red Wing is the general vicinity of Lock and Dam No. 3 (UM 796.9))

Appendix C. Fish Indicator Sub Committee Report

Environmental Management Program Coordinating Committee
Analysis Team
Indicators Ad Hoc Committee

Special Committee on Fish Indicators for Status and Trends Assessments

Final Report
30 July 2010

Report on the advancement of indicators for Status and Trends assessments in the Upper Mississippi River System

Committee Members:
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Andy Bartels, Wisconsin Department of Natural Resources, La Crosse, WI
Mel Bowler, Iowa Department of Natural Resources, Bellevue, IA
Kenneth Cook, U.S. Army Corps of Engineers, St. Louis, MO
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Table of Contents

Executive summary

Partnering federal and state agencies within the Upper Mississippi River System (UMRS), that are parties to the Environmental Management Program (EMP), must periodically assess and report on the Status and Trends of the ecological health of the UMRS. Developing a framework within which to conduct Status and Trends assessments remains an ongoing process. Previous reports have 1) laid the conceptual foundation for conducting assessments; and 2) brought unprecedented empirical resources to bear on the assessments. Still remaining are the tasks of establishing reference conditions, selecting responsive indicators, and stating long-term management objectives against which progress towards a healthier UMRS can be measured and charted.

In March 2010, the A-Team of the Environmental Management Program Coordinating Committee (EMPCC) established a special committee on fish indicators to address the following three objectives: (1) define what constitutes a healthy UMRS ecosystem (from a fisheries point of view); (2) make recommendations for indicating fish community health attributes and for making data-informed judgments on their status and trends in the future; and (3) make recommendations for additional indicators to consider and/or additional analytic work that may be needed in either selecting additional indictors or optimizing their implementation. Our report is presented in three chapters that align with each committee objective.

Meeting the first objective required the committee deliberating and making value-informed judgments. As such, we present Chapter 1 as a consensus document so as to be fully transparent in our deliberations and thoughts as possible. **The only recommendation and action item deriving from Chapter 1 is for the A-Team, and ultimately the EMPCC, to either wholly or conditionally affirm our definitions and framework, or to reject them outright.**

Chapter 2 presents the results of the committee's evaluation of indicators used in the most recent Status and Trends report (Johnson and Hagerty 2008). Three former indicators are recommended for elimination and specific recommendations are made for improving most of the remaining indicators. These recommendations are presented within Chapter 2 and are associated with each individual indicator evaluation. **Some recommendations will require additional analysis or fact finding work to address and an important role of the A-Team will be to prioritize our recommendations and direct resources (principally staff time) towards addressing them.**

Finally, Chapter 3 presents the committee's thoughts and ideas for additional or alternative indicators. **Similarly, our recommendations will require additional analysis or fact finding work to address and an important role of the A-Team will be to prioritize our recommendations and direct resources (principally staff time) towards addressing them.**

Acknowledgments

The committee would like to acknowledge and thank all of the professional managers, scientists, and administrators who have dedicated themselves to understanding, improving, and assuring the future of the Upper Mississippi River to future generations.

Background and charge of the committee

Every 10 years, the Environmental Management Program (EMP) is charged with conducting an assessment and drafting a report on the status and trends of environmental resources in the Upper Mississippi River System. To date, two reports have been generated in the history of the EMP. The first laid the conceptual framework for conducting Status and Trends assessments (USGS 1999), while the second sought to bring unprecedented empirical observations available through the Long Term Resource Monitoring Program (LTRMP) to the task (Johnson and Hagerty 2008). Consequently, each previous report has represented a major advancement in Status and Trends assessments in one of the world's largest river basins. The larger and wider intent of the material presented in this report, and other similar reports, is to lay the foundation for further advancing such assessments in the future.

Picking up at the most recent report, the second Status and Trends (S&T) report (Johnson and Hagerty 2009; http://pubs.usgs.gov/mis/LTRMP2008-T002/) was the partnership's first meaningful attempt to bring unprecedented data sources to bear on the task of assessing overall ecosystem health for the UMRS. Long Term Resource Monitoring Program (LTRMP) data were used to (1) identify potential health indicators, collectively presented in Chapter 2 of the above cited report; and (2) portray differences in the status of the indicator (magnitudes, perhaps relative to other areas or to accepted standards) as well as trends over time.

Following publication of the report, and anticipating future reports, the partnership took a step back and reviewed some lessons that were learned during the development of the second S&T report, in sincere hopes of advancing such ecosystem health assessments in the future. A couple of points were readily apparent:

(1) While LTRMP data were very useful in demonstrating how different ecosystem attributes varied in their status, and whether any discernible trends were evident, it remained unclear what levels of each attribute represented "good", "fair", or "poor" status, and what might constitute either a hopeful or disconcerting trend. It was also unclear whether the partnership had selected the best indicators possible to make health assessments. In other words, the last Status and Trends report largely lacked a reference system against which to make system health judgments and further refine indicators.

(2) It remained unclear exactly what each indicator was intended to indicate. This occurred largely because potential indicators were chosen in the abstract. In other words, the indicators were selected without considering their ability to indicate changes in system health attributes people care about. Principally, this is because people have yet to define what constitutes a healthy UMRS ecosystem.

Realizing these limitations and the need to advance ecosystem health assessments in the basin, the partnership, through the auspices of the A-Team, decided to go back and re-evaluate both the process by which ecosystem health evaluations are made, as well as the individual indicators used in making these assessments.

In December 2009, following a mini-symposium on ecosystem health assessment frameworks, the A-Team convened an Ad Hoc Indicators team. Discussions within this group led to the recommendation that a Fish Indicator sub-committee be formed to further consider fishery indicators for use in Status and Trends assessments. The committee was provided three primary charges. They are: (1) define what constitutes a healthy UMRS ecosystem (from a fisheries point of view); (2) make recommendations for indicating fish community health attributes and for making data-informed judgments on their status and trends in the future; and (3) make recommendations for additional indicators to consider and/or additional analytic work that may be needed in either selecting additional indictors or optimizing their implementation. As such, this report presents the findings and recommendations of the Fish indicators sub-committee, predicated upon these charges, and drafted on behalf of the A-Team Indicators Ad Hoc Committee.

Format of the Report

The report is presented in three sections, each of which aligns with the three charges of the Fish Indicator sub-committee, presented above. Each topic was addressed and discussed in each of three separate conference calls for which a quorum could be assembled. Materials presented in the report either derive directly from discussions that occurred during the conference calls, or “homework” the committee assigned itself to supplement content addressed during scheduled calls.

Chapter 1 presents a consensus finding on what comprises a healthy UMRS fishery and the essential attributes that should be used to assess its health. A consensus finding is provided because defining what a healthy fishery is, and what it is comprised of, represents a value-based judgment. Following our discussions on this topic, a consensus opinion paper was drafted and circulated among all participants. Committee members had the option to concur with each major section of the opinion, or to dissent (and provide dissenting views). Our goal was to capture those attributes of a healthy UMRS fishery that the committee agreed upon, those the committee nearly agreed upon and those that require further resolution.

Chapter 2 presents findings and opinions on each of the indicators presented in the last Status and Trends report (Johnson and Hagerty 2008). Each indictor was evaluated relative to several criteria the committee defined for assessing indicator adequacy (defined in Chapter 1). Thus, Chapter 2 contains the result of each evaluation.

Chapter 3 presents additional ideas the committee identified to replace, complement, or clarify indicators presented in the previous Status and Trends Report. When analytical support and results were available to support recommendations, they are referenced. When such results were not available, the committee outlined additional analytic work that should precede A-Team adoption of Fish Indicator sub-committee recommendations.

Chapter 1: Defining a healthy UMRS fishery and its essential attributes

Introduction: The Fish Indicators sub-committee held their first conference call on April 26, 2010 from 8:00 AM – 9:30 AM. The agenda for the call is provided in Appendix A (Appendix A.1). The principal agenda item for the call was to discuss and seek consensus on the following question: "What constitutes a healthy UMRS fish community?". A few key points need to be made here.

First, the committee clearly recognized the inherent value-based judgments that would need to be made to answer this question. Clearly, different people with different backgrounds and experiences may answer this question differently. Our response was to draft our opinions as a consensus document, drafting statements deriving from majority thoughts and opinions, while simultaneously permitting individual committee members the opportunity to either concur with the drafted statement(s) or to dissent (and present a dissenting opinion). Our goals using this approach were to (1) acknowledge the normative nature of our deliberations; (2) share the committee's majority views which derive from nearly a century and a half of collective experience in studying and managing the Upper Mississippi River System; (3) permit a transparent account of our opinions, including those aspects of the issue the committee fully agrees upon, those for which we nearly agree, and those that require future reconciliation.

Second, the committee realized the foundational importance of attempting to answer this question to advance Status and Trends assessments in the future. Only by defining what a healthy system looks like can value-based, yet data-informed judgments, be made on the health status of the UMRS, and the investments the partnership has made in ecosystem restoration and monitoring be fully realized. In effect, such a definition is a major component of developing a reference framework against which data can be applied to make a health judgment and support management actions in the basin.

Third, the committee also recognized that their discussions, deliberations, decisions, and recommendations were unlikely to result in an entirely comprehensive definition, due to limited time and resources. It is the hope of the committee, however, that we addressed all major aspects of such a definition and that most would agree with most of what we present. Without question, the committee approached this task with the utmost humility and respect. At a minimum, the committee hopes our efforts provide a solid foundation upon which to build and progress.

Finally, it is crucially important for the A-Team Ad Hoc committee, the A-team, and the wider EMP partnership to understand that much of the information, recommendations, and thoughts presented in the balance of this report depend sensitively upon our definition of what comprises a healthy fishery for the UMRS. As such, it is necessary for the parent committee, and ultimately the wider partnership, to either fully endorse or conditionally endorse our definition and supporting recommendations. Absent such affirmation, there remains a fundamental vacuum for establishing a reference system, against which to make health judgments, and by which to support continued management efforts in the future.

The balance of Chapter 1 presents our consensus-based deliberations and recommendations. Each committee member has individually endorsed each section within our recommendation document, as denoted by name and signature, except in those instances when consensus could not be gained. In those situations, each dissenting committee member was provided the opportunity to draft a minority opinion statement, which was appended to each recommendation.

Consensus view and statement assumptions

Our consensus view makes the following essential assumptions:

(1) **We assume that a definition for what constitutes a healthy UMRS fishery, and how it may be measured, assessed, and indicated, exists independent of agency and programmatic considerations.** Therefore, this committee shall provide no consideration towards management and assessment tools the EMP partnership presently possesses or aspires towards as the committee seeks to develop, define, and recommend a statement of what comprises a healthy UMRS fishery and how it may best be assessed. We further assume this approach permits an articulated vision that is reasonably free from agency and program bias and will provide a reasonably coherent and shared view of what constitutes a healthy fishery in the UMRS and guidance on how it may be reasonably assessed.

(2) **We assume transparency in deliberations is beneficial.** We further assume that reasoned judgments we are required to make will promote efforts to develop a reference framework against which health judgments can be made in the future, rather than harm these efforts. Towards this end, we provide consensus opinions, in concert with individual dissenting views, at each stage in our statement. Our purpose is to be transparent in our collective and individual assumptions, as well as in our apparent unanimity. We accept accountability for our judgments and assume that such accountability will assist in advancing status and trends assessments in the future.

(3) **We assume that recommendations provided in the balance of this report (e.g., responsive and reasonable indicators of health) are sensitively dependent upon our consensus view of a healthy fishery.** It only makes reasonable sense that how one indicates and measures health depends sensitively upon how one defines health in the first place. As such, we view the full or conditional affirmation of our consensus opinion by the wider partnership, through appropriate administrative channels, to be an absolute and necessary requirement if advancing status and trends assessment remains a larger program goal.

(4) **We assume our efforts will be neither perfect nor fully comprehensive.** However, we expect that most of our recommendations will prove reasonable to most people.

Concur:
Kirk Hansen, Mel Bowler, Andy Bartels, Donovan Henry, Len Kring, Ken Cook, Joe Ridings, Brian S. Ickes, and Kevin Stauffer concur with statements 1-4 above.

Notes: None

Dissent: None

Dissenting Opinion: None

I. Essential Health Attributes

Attempts to define what constitutes a healthy fishery in the UMRS must first begin with a discussion of what a healthy fishery may look like. This is defined in the broadest sense and provides a vision of what is a desirable status of the fishery. Its definition is free of programmatic and agency considerations, present health condition, and arguably any reference condition (e.g., historic past, desired future, acceptable present). Simply it is a statement of the essential characteristics one is likely to use to assess whether the fishery is healthy.

Committee deliberations on this topic resulted in a few basic attributes that must be considered essential as health assessments are made, and indicators to measure health are developed. We present each in the order in which they were raised and discussed in our deliberations (though no priority is to be inferred by this ordering). At this point, we make no recommendations on how one may indicate each of these essential attributes, but reserve this task to be reported in a later chapter of this report.

A. **Diversity / Richness:** The Upper Mississippi River System provides habitat to a diverse and species rich ichthyofauna. Nearly one in every four North American freshwater fish species is native to the UMRS basin, with over 140 species represented (Ickes et al 2005). This comprises the richest freshwater fish fauna at temperate latitudes on the planet. As such, the ichthyofauna of the UMRS is a globally unique and important resource and maintenance of this diversity and richness must be at the forefront of any assessment of its ecological health.

B. **Sustainable:** Any reasonable assessment of biological or ecological system must consider the degree to which it can sustain itself. The committee termed this propensity “sustainable” and considered it one of the essential attributes of a healthy fishery in the UMRS. With regards to this report and future fishery health assessments on the UMRS, the committee defines “sustainable” as “the ability of the ichthyofauna of the UMRS basin to maintain individual populations, community assemblages, and food webs without human intervention or management”.

C. **Resilient:** Resilience is a term that attempts to represent the ability of a system to withstand perturbations, both natural and man-made. Resilience has great conceptual appeal, but has proven difficult to make operational in the ecological sciences. While the committee recognizes resiliency as a desirable health attribute for UMRS fisheries, the committee also realizes that much consideration and care will be required to meaningfully measure and indicate it. The committee also seemed to recognize at least two different “flavors” of resilience as it discussed this attribute. The first represents the fauna’s ability to withstand and recover from short-term but high magnitude stresses, what one may term “acute resilience”, such as may be associated with a flood, chemical spill, or species invasion. The second type represents the fauna’s ability to withstand and recover from long-term but low magnitude stresses, also known as press stresses. The committee termed this type “chronic resilience”.

Thus, the committee has established, through consensus view, that any health assessment on the UMRS ichthyofauna must at a minimum consider (1) the innate diversity of the UMRS fish fauna, (2) its ability to sustain itself, and (3) its resiliency to both short-term and long-term stresses.

Concur:

Kirk Hansen, Mel Bowler, Andy Bartels, Donovan Henry, Len Kring, Ken Cook, Joe Ridings, Brian S. Ickes, and Kevin Stauffer concur with the committee statements above.

Notes: (Cook) If you take the goals and objectives of NESP and tweak the wording, you come up with what the SP considers constitutes a healthy UMRS ecosystem – base on the Essential Ecosystem Components

Dissent: None

Dissenting Opinion: None

II. Essential Indicator Classes

The committee discussed a variety of classes of indictors that would prove essential in any reasonable assessment of UMRS fishery health. A balanced health assessment should possess representative indicators and metrics for each indicator class. The basic intent of conceiving indicator classes is to begin to logically break down different aspects of the health of the fishery and organize them in a meaningful way. The committee identified three primary classes of indicators, some of which contain minor sub-groupings. Below, we identify and describe each.

A. **Ecological Indicators:** Ecological Indicators are those indicators that attempt to speak to the ecological organization, structure, function, and/or associations of UMRS fishes relative to each other or their environment. The committee discussed ecological indicators at some depth and arrived at a simple bifurcation in their definition:

   1. Structural Ecological Indicators: Structural Ecological Indicators are intended to say something about the structural attributes of UMRS fish populations, assemblages and/or communities. Such structural attributes may apply to the fauna as a whole (e.g., species richness, community composition), particular assemblages (e.g., distribution of limnophils, proportional abundance or biomass of one assemblage relative to another assemblage), or particular species (e.g., largemouth bass size structure, blue sucker associations with specific habitat features or environmental conditions). Essentially, this class of indicators aims to say something about how the UMRS ichthyofauna, or some part of it, is organized and distributed and how such organization helps to maintain or improve essential health attributes.

   2. Functional Ecological Indicators: Functional Ecological Indicators are intended to say something about the functional attributes of UMRS fishes. Such functional attributes may apply to the fauna as a whole (e.g., biomass per functional feeding guild class), particular assemblages (e.g., distribution of migratory species), or particular species (e.g., recruitment and growth rates of bluegill). Essentially, this class of indicators aims to say something about processes that maintain essential health attributes.

B. **Social Indicators:** US citizens exact many ecosystem services from the fisheries of the UMRS. Examples range from aesthetic enjoyment and study to direct protein extraction through recreational and commercial fisheries. In some cases, UMRS fishes support other ecosystem attributes that people value as well (e.g., eagles, herons, otters, etc…). Consequently, US citizens judge the health of the UMRS, in part, by the health of its fisheries, particularly relative to their direct and indirect uses of the fisheries resources. Therefore, the committee recommends that social indictors be developed which reflect the value US citizens' place on UMRS fisheries as part of an integrated health assessment.

C. **Economic Indicators:** The committee also feels that it is likely necessary and beneficial to include economic indicators that reflect the uses and values of UMRS fisheries as part of a comprehensive health assessment. Our rationale is that economic indicators provide a means by which the ecosystem services that UMRS fishes provide society can be defined, evaluated, and assessed relative to the fishery's capacity to withstand economic uses.

Thus, health assessments on UMRS fisheries should include, at a minimum, (1) indicators that are meant to reflect both structural and functional aspects of basic UMRS fisheries ecology and that are conceived independent of human uses of the resource; (2) sociological indictors that seek to link social values and attitudes with the resource; and (3) economic indicators that seek to convey and valuate the services provided to society by UMRS fishes.

The committee also recognizes that other categories of Essential Indicator Classes may be conceived depending on the ultimate audience and purpose of the health assessment, once this is clearly articulated by the wider partnership through the auspices of the A-Team and EMPCC. For example, if the health assessment is targeted to diagnose the system's response to management actions enacted to improve health, another class of indicators may be conceived and developed to measure system responses to such management actions, termed perhaps "Management Indicators" or "Learning Indicators". However, since no such assessment purpose has yet been stated, we do not presently recognize management or learning indicators as Essential Indicator Classes. Presently, our committee views the primary Essential Indicator Classes to be Ecological, Social, and Economic. However, we also view these designations as conditional upon a defined purpose and audience for the future Status and Trends assessments, to be provided at a later time by the A-Team of the EMP.

Concur:
Kirk Hansen, Mel Bowler, Andy Bartels, Donovan Henry, Ken Cook, Joe Ridings, Brian S. Ickes, and Kevin Stauffer concur with the committee statements above.

Notes: (Hansen and Bowler) We wondered if it may be beneficial to use one species to represent more than one indicator class, or if we could possibly combine indicators classes (ecological and social, for instance) in certain situations.

Dissent: Len Kring

Dissenting Opinion:
(Kring) As I was not available for the call, I may have missed some of the points. I agree with the ecological and social indicators, but have some thoughts on the economic indicators. I think we need to focus on the actual catch of commercial fishers rather than on overall economics. The system may continue to provide a viable fishery, but if for some reason the market diminishes because of commercial aquaculture or other reasons, the general public may think it is because the fishery has crashed. Even if one or two economically viable populations of viable species goes down, it doesn't mean the overall health and sustainability of the fishery has diminished.

III. Essential Indicator Attributes

In anticipation of identifying new indicators, and evaluating indicators used in Johnson and Hagerty (2008), the committee decided it would be useful to list and define some key attributes that we would like to see any prospective indictor possess. In essence, we sought to answer the question: "what makes a good indicator"? The committee identified and discussed several attributes that Status and Trends indicators should possess. In many ways, the committee's discussions paralleled ideas widely known as "SMART/SMARTER criteria", a mnemonic used in a variety of objective-setting situations, though we did not use this mnemonic during our deliberations. We present and define these below, as discussed by the committee:

(1) Potential indicators should be developed for, and targeted at, a single indicator class. For example, do not attempt to craft an indicator that addresses both ecological and social dimensions of system health. Basically, be as specific and targeted in defining an indicator as possible;
(2) All indicator classes should be indicated by at least one indicator;
(3) Potential indicators should be clearly defined relative to what they are expected to indicate. In other words, they should be explicit and clear;
(4) Potential indicators should be measureable. Moreover, methods for measuring them should be fully standardized over time and space so that meaningful comparisons can be made with regards to status over space and trends over time;
(5) Potential indicators should be relevant and meaningful. In other words, selected indicators must say something unambiguous about the health of the system under consideration;
(6) Potential indictors should seek to minimize or eliminate confounding factors that may obscure interpretation. For example, if a fish species is selected for an indicator, and trends in its abundance will be used to infer habitat quality, then this species should not also be subject to exploitation effects. If it is, this creates a confounded situation since its abundance response will be a function of both habitat quality/quantity and exploitation and it will be impossible to fully attribute the response to either;
(7) Potential indicators should be sensitive to changes in the system under consideration. These changes may arise from changes in key system drivers and/or stressors (USGS 2009), or from management actions enacted to improve or maintain system health.

While it may not always be possible to incorporate every single attribute listed above into a prospective indicator, the committee feels that all prospective indicators should accommodate these attributes to the fullest extent possible.

Concur:
Kirk Hansen, Mel Bowler, Andy Bartels, Donovan Henry, Len Kring, Ken Cook, Joe Ridings, Brian S. Ickes, and Kevin Stauffer concur with defined attributes and statements 1-7 above.

Notes: None

Dissent: None

Dissenting Opinion: None

IV. Reference System(s)

The committee clearly recognized that a major limitation to advancing Status and Trends assessments in the future hinges on expressing a reasonable reference system against which to compare data and make judgments. All agreed that lack of an accepted reference framework limited the utility of the most recent Status and Trends assessment (Johnson and Hagerty 2008). Almost immediately in our deliberations, the committee recognized that there is no purely objective answer to the question “what reference system should be used in making Status and Trends assessments”? As such, some judgments will need to be made. The following expresses the consensus judgment of the committee with regards to a suitable reference framework against which to make Status and trends judgments. The committee views this issue as central for advancing future Status and Trends assessments. As such, parent committees and the wider partnership need to either affirm (fully or conditionally) or reject our consensus opinion on the road towards establishing an acceptable reference system.

The committee discussed many different ways in which a reference system may be crafted. Most of these followed from discussion on this topic presented in Chapter 1 of the second Status and Trends report (Johnson and Hagerty 2009). For example, the committee discussed the pros, cons, and tradeoffs associated with basing a reference framework on each of the following:

1. Historical system
2. Virtual system
3. Comparable control system
4. Well-articulated desired future state
5. Internal

A historical (e.g., > 100 years before present) reference system was at face value conceptually appealing, however, the committee felt that it was fraught with too many cons to be widely useful as a reference framework. Conceptually, a historical perspective is an implicit statement that conditions during a period of less-intensive human impacts are to be favored, and arguably, managed towards. This seemed a reasonable goal to the committee, but several technical issues make clearly defining this historic condition, which will serve as a point of reference, problematic. First, the committee agreed that good historical data, while available for some UMRS attributes, are not particularly strong for fishes. Thus, establishing a meaningful quantitative historical reference will prove problematic, if not impossible. Second, it remains fundamentally unclear to the committee how accurate qualitative characterizations of past historical conditions may be. Such characterizations are presented through the lens of individuals reporting such conditions, each account of which is affected by individual biases and preferences. Thus, it is not clear to the committee how a reasonably accurate historical qualitative reference could be established.

An alternative to a historical reference can be characterized as a virtual reference system. Essentially, such a virtual reference system is a model, or mathematical framework, comprised of various reference systems. It is represented by a mix of reference conditions types (e.g., best achievable, relative condition, desired future, etc…). While such a framework is again conceptually appealing, there are a multitude of choices and judgments that need to be made to implement such a reference strategy, perhaps far more than can be accommodated in a complex, multi-jurisdictional system such as the Mississippi River.

A third option considered by the committee was defining or identifying a comparable control river system. Conceptually, this is only appealing if a comparable system exists and its health status can be deemed to be both superior and desirable relative to the referenced system. Clearly, no comparable river system exists on Earth by which the Upper Mississippi could be indexed and referenced. Therefore, the committee rejected this alternative outright as a viable framework.

A fourth alternative the committee explored was a reference system defined purely by human value judgments on what a desirable future condition may look like (e.g., well-articulated future condition). This is desirable because at its foundation it forces people to consider and explicitly state their ecosystem health objectives. The committee clearly felt that articulating such future objectives is crucially important for advancing Status and Trends assessments, but that doing so based only on human judgment was not the wisest approach. Basing such objectives only on human perceptions runs the risk of introducing potentially large biases into the objectives. It also ignores significant investments partnership agencies have made to gather baseline and trend data across the UMRS (e.g., LTRMP, EPA EMAP, state DNR and DoC survey data, etc…).

A final alternative the committee considered in its deliberations was to reference the system relative to itself over time. This requires establishing a quantitative baseline condition against which future data will be compared for progress in health status. It also requires making data-informed judgments concerning the relative health status expressed by the baseline condition (e.g., are present conditions reasonably healthy or not?). While the committee did not see a need to limit defining such a baseline to a single data source (e.g., LTRMP), the committee also expressed it was reasonable to accept the past 15 years as a reasonable baseline of contemporary conditions. Establishing such a baseline provides a context for assigning whether or not contemporary conditions are acceptable, in need of improvement, or severely impaired. Having completed such a determination, long term objectives can then be stated, comprised of human judgments yet informed by unprecedented data sources, which will then express the desired future state.

In summary, the committee recognizes the need to insert values into the objective setting process, required to develop a reference framework against which to make future health assessment judgments. Moreover, the committee recommends that such a framework should be forged using readily available data the partnership has invested in over the past 20+ years. The committee further recommends that an empirical baseline be established by considering the average and range of conditions observed over the past 17 years (1993 – present). Our thought is that the scope and scale of LTRMP data sources is sufficient to reasonably define the average or expected condition for each monitored reach, as well as how much that condition may be expected to vary through time and over space. The committee also recommends expressing qualitative opinions on the observed empirical baseline condition (e.g., poor, fair, good, excellent) so that future observations can be compared to these rankings. Finally, the committee recommends the articulation of a desired endpoint against which future progress will be evaluated (e.g., increase, decrease, rate of change, etc…). We recommend that the partnership adopt a process by which such value statements can be made and decided upon. For the fisheries indicators we will evaluate in the balance of this report, we will provide our judgments relative to each of our recommendations. The partnership should simply affirm (fully or conditionally) or reject them.

Concur:

Kirk Hansen, Mel Bowler, Andy Bartels, Donovan Henry, Len Kring, Ken Cook, Joe Ridings, Brian S. Ickes, and Kevin Stauffer concur with the committee statements and recommendations above.

Notes: (Cook) Use what makes sense, are there species/communities that are still "sorting things out" since major disturbances..e.g., impoundment or heavy pollution/contamination in the 1950's thru 1970's? I guess this is the same as next section Special Considerations (1)

Dissent: None

Dissenting Opinion: None

V. Special Considerations

In the committee's deliberations, several special considerations were made relative to defining and establishing our recommended reference framework. We present these here to fully disclose our thoughts and acknowledge the self-apparent limitations of our proposed framework, as well as to spark continued discussion on these topics.

(1) Using the past 17 years of empirical observations as a baseline may not work (or be reasonable) for all prospective health indicators. During its deliberations, the committee easily conceived several potential health attributes for which such a baseline may prove inadequate. As one example, assume a diverse, self-sustaining fishery is viewed as healthy. Now consider that available monitoring data have very little to contribute towards establishing a baseline condition on threatened and endangered fauna, which by their nature are rare and poorly indexed by large scale random sampling efforts, yet are an important component of a healthy system. Also, historical issues (targeted, intensive exploitation; habitat loss) may have more to do with their present abundance and distribution than data from the past 15-20 years may imply. The committee recognizes this limitation in our proposed framework and recommends that when such limitations are readily apparent, alternative or supporting information be brought to bear on the assessment (e.g., data from other targeted studies or monitoring efforts).

(2) Even when using an empirical baseline to establish a frame of reference, the committee quickly and clearly recognized additional considerations need to be made. Perhaps the most crucial, which we present here by way of example, is a consideration of scale. For example, should future observations from a given place (e.g., pool) be compared only to a baseline developed for that same single place, to a regional mean or expected value (e.g., geomorphic or floodplain reach), or to an expected mean and range for the entire UMRS? Clearly there is no objective answer to this question. Generally, given their experiences in studying and managing UMRS fishes, the committee felt that "regionalization" will be both necessary and prudent for most indicators. Moreover, the committee deemed it largely acceptable to consider that different places should likely have different expectations in regards to what is achievable in terms of overall health (e.g., benchmarks).

Concur:

Kirk Hansen, Mel Bowler, Andy Bartels, Donovan Henry, Len Kring, Ken Cook, Joe Ridings, Brian S. Ickes, and Kevin Stauffer concur with statements 1 and 2 above.

Notes: None

Dissent: None

Dissenting Opinion: None

Overall Consensus Statement

The committee broadly defines a healthy UMRS fishery as one in which its innate diversity is both present and maintained, its fishery stocks are self-sustaining, and its members are resilient to both acute and chronic stresses imposed upon it, as defined and outlined in Section I. Essential indicator classes that the committee recognizes as foundational and essential to developing meaningful indicators of such health include (1) ecological, represented by both structural and functional attributes of the fishery, (2) social indicators, and (3) economic indicators, as detailed in Section II. The committee acknowledges additional or alternative indicator classes may be conceived once a clearly defined audience for ecosystem health assessments is forwarded by the EMP partnership. However, we presently limit our recommendations to the essential indicator classes just noted. As indicators are developed, they should seek to incorporate as many essential indicator attributes as possible. These include: specific, targeted, explicit, measureable, relevant, responsive, and clear (non-ambiguous); as detailed in Section III. The committee acknowledges the need to make data-informed value judgments with regards to health status of selected indicators, as well as benchmarks that reflect a desired future state. The committee recommends basing such an evaluation framework on substantial standardized data resources the EMP partnership has invested in over the past 20 years. The committee also recognizes additional judgments are required concerning the scale(s) at which health assessments are conducted, and additional data sources are likely required for particular indicators. As reflected in Sections IV and V, the committee recommends these considerations be made on an indictor-by-indicator basis.

The ultimate definition and statement of health made by the committee will be evident in later chapters as specific indicators are developed to address the essential health attributes the committee has identified in this chapter. Moreover, the committee will express its expert judgment in (1) recommending scales at which assessments should be made of each indicator, (2) making qualitative statements concerning the relative health status of each indicator, and (3) making qualitative or quantitative statement concerning desired future health status for each indicator (e.g., benchmarks).

This chapter, as a consensus document, seeks to provide transparency in our deliberations; express unanimity and/or dissention in our recommendations; and provide an accountable process within which we make our recommendations. Our expectations as a committee are that our recommendations be either affirmed (wholly or conditionally) by the parent committee, or simply rejected outright.

Concur:
Kirk Hansen, Mel Bowler, Andy Bartels, Donovan Henry, Len Kring, Ken Cook, Joe Ridings, Brian S. Ickes, and Kevin Stauffer concur with Overall Consensus statements above.

Notes: None

Dissent: None

Dissenting Opinion: None

References

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Johnson, B. L., and K. H. Hagerty, editors. 2008. Status and trends of selected resources of the Upper Mississippi River System. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, December 2008. Technical Report LTRMP 2008-T002. 102 pp + Appendixes A–B.

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.

Chapter 2: Evaluation of existing Status and Trends indicators

Introduction:

The Fish Indicators sub-committee held their second conference call on May 20, 2010 from 8:00 AM – 9:30 AM. The agenda for the call is provided in Appendix A (Appendix A.2). The principal agenda item for the call was to evaluate the existing Status and Trends indicators for fishes, presented in Johnson and Hagerty (2008). Our approach to this task was as follows:

1. Assign an indicator to each member of the committee to conduct a detailed individual assessment as per indicator evaluation criteria presented in Chapter 1 (see Table 2.1 for assignments);

2. Discuss each indicator during the call, permitting wider committee opinions to enter the evaluation;

3. Draft an evaluation for each indicator, including both the detailed individual evaluation and committee opinions.

For the balance of Chapter 2, we present these assessments in something of a standardized and formulaic manner. For each indicator, we attempted to provide the following: align each indicator with our defined essential indicator classes; clarify the purpose statement for each indicator; make judgments as to whether the indicator should be considered for retention or not; make judgments concerning ways in which the indicator may be improved; and make judgments concerning the scales at which each indicator should be assessed, what may constitute a reasonable status, and what might constitute a reasonable trend response.

Table 2.1. Indicator assignments (selected randomly).

Name	Indicator
Andy Bartels (WDNR)	Recreationally harvested native fishes
Mel Bowler (Iowa DNR)	Forage fish
Ken Cook (USACE)	Smallmouth buffalo
Kirk Hansen (Iowa DNR)	Bluegill
Donovan Henry (USACE)	Sauger
Len Kring (USACE)	Channel catfish
Joe Ridings (MDoC)	Species richness
Kevin Stauffer (MDNR)	Non-native fishes
Brian S. Ickes (USGS)	Commercially harvested native fishes

Status and Trends Indicator Assessments – Fish Indicators

Indicator Title: Recreationally harvested native fishes

Reviewer: Andy Bartels (WDNR)

Original Purpose Statement:
(cut and pasted from S&T report - http://pubs.usgs.gov/mis/LTRMP2008-T002/)
The production of recreationally harvestable fishes is one of the important services that the UMRS ecosystem provides to humans. Tracking CPUE of recreationally harvested fishes provides direct information on this resource and may provide insight into habitat quality. This indicator is the combined CPUE from 19 native fish species (Table 2.3) and includes fishes common in backwaters and channel habitats.

New Purpose Statement:
Sport or recreational fishing is valued by the communities along the UMR and many who travel considerable distances to utilize this resource. Participants range from casual to dedicated, and novice to professional. Fish are harvested recreationally in all reaches of the UMR. Thus, the recreationally-harvested fishes of the UMR warrant indicator status from a social standpoint, as they provide valuable services to individual people and communities throughout the UMR basin. Recreationally-harvested fishes are reported as the combined catch per hour of daytime electrofishing of adults collected from a group of 19 native fish species (Table 2.3).

Essential Health Attribute(s) addressed by this indicator:
(check one or more)
_______ Diversity / Richness
X Sustainable
X Resilient

Notes: None

Essential Indicator Class(es) to be indicated by this indicator:
(check one or more)
_______ Ecological
____ Structural
____ Functional
X Social
_______ Economic

Notes: None

Should this indicator be retained?:
X YES _________ NO

Why?: Recreationally-harvested fishes are valuable to people as a resource in several ways – as food, a source of recreation and leisure. These species are also widely recognized and, for many people, are the most direct biological measure of how healthy the river is.

Can this indicator be improved?:

X YES ________ NO

How?: The original group of 19 species is large and diverse. The indicator could be more useful and interpretable if there was a way to identify what and how many species contribute to the score in each reach. In the interest of conserving space in a printed report, and since this is a social indicator for which all species have similar societal values (i.e., food, recreation), this indicator should remain as the sum of all recreationally-harvested fishes, and not be subdivided into groups. However, stacked bar charts (one for each reach), showing the annual percentage composition of the CPUE for each species within the indicator group would have greater utility in depicting how many species are available for recreational harvest, and how their relative abundances might have changed over time.

What additional considerations should be made?: Daytime electrofishing is a robust and effective gear for sampling many fish species, but it is not the most efficient gear for deep water habitats, where some of the recreationally-harvested fishes usually reside. Creel surveys or other angler surveys may provide more precise information on the overall value, including economic, of the recreational fishery of the UMR. These surveys are not currently performed on a routine basis throughout the UMR, but could be done as a research project on a periodic basis. A standardized approach with a predetermined frequency of data collection would be required.

Recommendations for measuring, quantifying, and reporting:

Verify that only adult fish are used in calculating this indicator. We define adult fish as presented in the LTRMP Fish Life History Database (O'Hara et al 2007).

Recommended status goal(s):

Four of the six reaches had similar mean CPUE's, and two were lower. Presumably, all reaches could have better recreational fishing. The recommended goal is a stable cpue of recreationally-harvested fishes in all reaches at some level higher than presently reported. Because previous LTRMP fisheries studies have indicated a north-south dichotomy of fish communities, it might be best to have separate goals for this indicator based upon that north-south dichotomy.

Recommended trend goal(s):

There is room for improvement in all reaches, especially in the Pool 26 and Open River reaches. Increasing health for this indicator would be indicated by increasing trends in CPUE of adult fishes over time.

Appended supporting information:

Status and Trends Indicator Assessments – Fish Indicators

Indicator Title: Forage Fish

Reviewer: Bowler

Original Purpose Statement: The abundance of forage fishes represents production at lower trophic levels, which provides food for large predatory fish that are important to anglers. Major changes in forage resources could indicate major shifts in ecosystem health and function. This indicator is the pool-wide CPUE of emerald shiner (*Notropis atherinoides*) and gizzard shad (*Dorosoma cepedianum*) combined, the two most prominent forage fishes in the UMRS.

New Purpose Statement: The abundance of forage fishes represents production at lower trophic levels, which provides food for large predatory fish that are important to anglers. Major changes in forage resources could indicate major shifts in ecosystem health and function. This indicator is the pool-wide CPUE of emerald shiner (*Notropis atherinoides*) and gizzard shad (*Dorosoma cepedianum*) combined, the two most prominent forage fishes in the UMRS. A composite forage indicator will be the pool-wide day electrofishing CPUE of all fishes <80 mm, and includes all sizes of gizzard and threadfin shad and all sizes of emerald shiner (emerald shiners occasionally reach lengths > 80 mm).

Essential Health Attribute(s) addressed by this indicator:
(check one or more)
___X____ Diversity / Richness
___X____ Sustainable
___X____ Resilient

Notes:

Essential Indicator Class to be indicated by this indicator:
(check one or more)
___X____ Ecological
_____ Structural
__X__ Functional
_______Social
_______Economic

Notes: Group consensus was that forage fishes (grouped collectively) will be classified as functional indicators of ecologic river health rather than as structural indicators as defined (i.e., forage fishes as important structural indicators will be more aptly captured in the diversity segment of the status and trends report).

Should this indicator be retained?:
___X____ YES ________ NO

Why?: Historically gizzard shad and emerald shiners have been systemically abundant in the UMR, and they will continue to serve as important indicator species for assessing the status and trends of forage fishes at a species level.

Can this indicator be improved?:

____X___ YES ________ NO

How?: To better understand changes at this trophic level, we recommend that this indicator be supplemented to incorporate all fishes <80 mm, and this will include the all sizes of gizzard shad and emerald shiners as originally set forth. A composite forage index (CPUE) will be calculated to include multiple fish species at this specific minimum length. Also, we recommend that an index of biomass be developed on an annual basis to follow long-term trends of forage fishes. See recommendations below.

What additional considerations should be made?:

Recommendations for measuring, quantifying, and reporting:

1.) We recommend that a collective abundance metric will be developed and used (collective forage fish index) to follow trends in forage fishes for all six LTRMP trend areas. This index will be derived from the cumulative pool-wide day electrofishing CPUE of all fish species < 80 mm, plus all sizes of gizzard shad and threadfin shad. Mean CPUE $\pm$ 1 standard error will be reported by for all six LTRMP trend areas.

2.) In light of the potential for exotic species to impact the abundance and condition of native fishes, we recommend that a biomass component/metric should be added as a supplemental means of quantifying local shifts in the fisheries' health of forage fishes. This index can be annually computed from the summations of standard length/weight equations from existing LTRMP data, and followed in ten-year increments.

3.) Additionally, we should consider using analysis of similarity and/or non-metric multidimensional scaling ordinations (such as trajectory analysis) as a supplemental means of quantifying local community shifts in the fisheries' compositions (forage species in this particular instance) over time. In essence, the same criteria (datasets) will be used as the collective forage index above, to examine shifts in the forage fish communities in the six LTRMP trend areas in ten-year intervals.

Recommended status goal(s): To be considered stable or good, individual species mean CPUE should remain within the 10th and 90th percentiles of the historic median catches in their respective regions.

Recommended trend goal(s): The individual species and composite CPUE trends of forage fish derived from LTRMP data should remain static or be increasing, and should not decrease below the 10th percentile of the baseline LTRMP median catches.

Appended supporting information:

Status and Trends Indicator Assessments – Fish Indicators

Indicator Title: Smallmouth buffalo

Reviewer: Ken Cook (USACE)

Original Purpose Statement:
(cut and pasted from S&T report - http://pubs.usgs.gov/mis/LTRMP2008-T002/)
Smallmouth buffalo is a characteristic large river species and is commercially exploited throughout the UMRS. Tracking CPUE of smallmouth buffalo provides direct information on the state of this resource and may provide insight into habitat quality of large river environments. This indicator is the pool-wide CPUE of adult (>280 mm) smallmouth buffalo, which is the size available for commercial harvest.

New Purpose Statement:
Smallmouth buffalo is a characteristic large river species and is commercially exploited throughout the UMRS. Being ubiquitous in the UMRS, tracking CPUE of smallmouth buffalo provides direct information on the commercial fishing value of this resource and may provide insight into ecosystem services of large river environments. This indicator is the pool-wide CPUE of adult (>280 mm) smallmouth buffalo, which is the size available for commercial harvest.

Essential Health Attribute(s) addressed by this indicator:
(check one or more)
X Diversity / Richness
X Sustainable
X Resilient

Notes:

Essential Indicator Class(es) to be indicated by this indicator:
(check one or more)
X Ecological
  Structural
  X Functional
Social
Economic

Notes:

Should this indicator be retained?:
X ~~YES~~ ____X____ NO

Why?: 1) Group felt that this indicator was redundant with commercially harvested native fishes if considered as an economic indicator, 2) group felt that another species would be better to use to look at

Asian Carp competition for resources, 3) group felt that we could/should replace this indicator with a Native/Non-Native Planktivore Ratio in the context of Asian Carp impacts

Can this indicator be improved?:

X YES ________ NO

• **How?:** More analysis/exploration into commercial harvest. Mel Bowler's observations of commercial harvest data include: 1) can't factor out SMB from commercial harvest – Buffalo's are lumped together in Illinois, Iowa, and Wisconsin, 2) that said, using commercial harvest data may be problematic if we wanted to examine species specific Ictiobuds as ecological indicators, 3) commercial harvest and LTRMP trends not correlated, and 4) also problematic because of various economic considerations? (e.g., decreasing trend in commercial license sales).

• Brian comment: commercial fishery effort may vary widely over time, whereas LTRMP effort does not.

• If we were to keep the species as an indicator it would be desirable to focus on which essential indicator class it is associated with – Group felt it may have potential more as a functional ecological indicator.

What additional considerations should be made?:

- Again, positive aspect is that it is ubiquitous in system, sampling methods appear to have the capability to show meaningful trends (or stability) over time – especially see day electrofishing, all strata, La Grange Pool

Recommendations for measuring, quantifying, and reporting:

Stick with LTRMP protocols. Document what Mel and Joe have found from the commercial data.

- May optimize functional component by looking at changes in SMB recruitment, age class, biomass, etc…relative to process-based restoration activities. However, collections currently only involve individuals >280 cm. May also associate with flooding or vegetation management scenarios, or other altered major drivers in the UMRS.

Recommended status goal(s):

Without examining any data, an initial suggestion would be to set the goal at one standard deviation above the overall mean CPUE.

To be considered stable or good, individual species mean CPUE should remain within the 10^{th} and 90^{th} percentiles of the historic median catches in their respective regions.

Recommended trend goal(s):

Increasing or stable, resilient

Use Population size/abundance models? Occupancy dynamics?

Stable, resilient

Increasing health would be indicated by increasing trends in CPUE over time.

Appended supporting information:

Status and Trends Indicator Assessments – Fish Indicators

Indicator Title: Bluegill

Reviewer: Kirk Hansen (Iowa DNR)

Original Purpose Statement:
(cut and pasted from S&T report - http://pubs.usgs.gov/mis/LTRMP2008-T002/)
Bluegills are a major component of the recreational fishery within the UMRS and are a characteristic species of backwater environments because all major life cycles typically occur within these habitats. Correspondingly, the public perceives the ecological health of the UMRS, in part, by the abundance of bluegill. Tracking bluegill catch-per-unit-effort (CPUE) provides direct information on this resource and may provide insight into habitat quality. The indicator is the pool-wide CPUE (number/15 minutes) of adult bluegills >150 mm (the minimum size generally acceptable to anglers) captured by day electrofishing.

New Purpose Statement:
Bluegill are a major characteristic species of backwater environments because all major life cycles typically occur within these habitats. Correspondingly, the public perceives the ecological health of the UMRS, in part, by the abundance of bluegill. Tracking bluegill catch-per-unit-effort (CPUE) provides direct information on this resource and may provide insight into habitat quality. The indicator is pool-wide CPUE (number/15 minutes) of adult bluegill > 150 mm (the minimum size generally acceptable to anglers) captured by day electrofishing.

Essential Health Attribute(s) addressed by this indicator:
(check one or more)
_______ Diversity / Richness
X Sustainable
X Resilient

Notes: None

Essential Indicator Class(es) to be indicated by this indicator:
(check one or more)
X Ecological
____ Structural
X Functional
______ Social
______ Economic

Notes: Bluegill are a functional ecological indicator of the condition and/or quantity of off-channel aquatic habitat.

Should this indicator be retained?:
X YES _________ NO

Why?: Off-channel aquatic habitat is an important habitat class in the UMR and has been the focus of many HREP projects and research. Additionally, this habitat is seen as important by managers and the public as vital to many popular sport fish populations. This indicator could be used to measure changes in off-channel habitat quality either through continued degradation and loss or through increases brought about by management actions.

Can this indicator be improved?:

X YES ________ NO

How?: In addition to looking at pool-wide CPUE, the ratio of main channel border to backwater shoreline catch rates should be examined. There are concerns among managers that over-vegetation of backwaters results in dissolved oxygen sags during summer months that make certain off-channel areas unusable for fish. This ratio coupled with water quality and vegetation data would provide insight into this issue.

What additional considerations should be made?:

As an important recreation fish, bluegill are subject to human exploitation. While this could be a confounding factor for its use as an indicator, a trend is still observed throughout the UMRS (areas with greater amount of quality off channel habitat have greater CPUE). While exploitation could potentially mask the magnitude of the relationship, it has not erased the trend. Without extensive research, teasing out the effects of exploitation would be very difficult, at best.

Recommendations for measuring, quantifying, and reporting:

Continue to measure, quantify, and report bluegill indicator as is has been.

The ratio of main channel border to backwater shoreline CPUE will need to be investigated and quantified before any recommendations on reporting and recommendations toward status goals may be made.

Additionally, with updated system-wide bathymetry currently being collected, we should soon be able to quantify the current amount of suitable overwintering off-channel habitat, overall bathymetric diversity, and changes between the current and previous bathymetry efforts.

Recommended status goal(s):

The UMRS should contain healthy and bathymetrically diverse off-channel aquatic habitat which in turn support diverse and healthy fish populations. We recognize there are drastic geologic and anthropogenic floodplain differences throughout the system, and desired or reasonably attainable bluegill CPUE will vary. As such, goals should be set on a study reach by study reach basis. Setting goals at smaller spatial scales may also be appropriate for assessing off-channel habitat quality within pools.

Recommended trend goal(s):

Increasing or stable

Appended supporting information:

Status and Trends Indicator Assessments – Fish Indicators

Indicator Title: Sauger

Reviewer: Donovan Henry (USACE)

Original Purpose Statement:
(cut and pasted from S&T report - http://pubs.usgs.gov/mis/LTRMP2008-T002/)
Sauger is a characteristic species of river channels and is recreationally exploited throughout the UMRS. Tracking CPUE of sauger provides direct information on the state of this resource and may provide insight into habitat quality of channel environments. This indicator is the pool-wide CPUE of adult (>200 mm) sauger, which is the size available for exploitation.

New Purpose Statement:
Sauger is a characteristic species of river channels and is recreationally exploited throughout the UMRS. Tracking CPUE of sauger provides direct information on the state of this resource and may provide insight into habitat quality of channel environments. This indicator includes the pool-wide CPUE of adult (>200 mm) sauger, which is the size available for exploitation, as well as the CPUE of juvenile and sub-adult (<200 mm) sauger.

Essential Health Attribute(s) addressed by this indicator:
(check one or more)
_______ Diversity / Richness
X Sustainable
X Resilient

Notes: Has sustainability and resiliency. Sensitive but resilient to environmental shifts – floods, water quality (can withstand turbidity but would likely improve with increased clarity), prey remains abundant (emerald shiners, shad), but could be impacted by Asian carp increase.

Essential Indicator Class(es) to be indicated by this indicator:
(check one or more)
Ecological
Structural
X Functional
Social
Economic

Notes: As one of the primary species sought by anglers in the UMRS, the strength and size of the sauger population may influence the perception the citizens have on the health of the UMRS and value they place on the fishery, thus making this species valuable as a social indicator. Sauger is present in all reaches, and is important to public and resource managers for recreation. As an economic indicator, this species may be able to be monitored to assess the capability of the fishery to withstand economic uses. Sauger also has some potential as a structural ecological indicator in that they are specific to flowing channel habitats, more so than other indicators in the last status and trends report.

Overall, sauger does not necessarily reflect diversity and health of the UMRS fish community by itself, but may still best fit as a functional ecological indicator. Being a migratory species, population trends would be expected to increase with increased opportunity for upstream passage through UMRS dams. Also, recent literature indicates that sauger respond positively to more natural river processes. Graeb et al (2008) found that sauger spawning shifted to restored "delta" areas of the river. The delta areas likely functions more similarly to the historic remnant reach of this system (warmer temperature, turbidity, active meandering, complex habitats, etc.), indicating that sauger prefer to spawn in areas with historic riverine function. Thus, future management activities intended to enhance sauger populations should focus on the restoration of riverine function, such as that provided by emerging reservoir deltas, which may mimic pre-impoundment conditions.

Should this indicator be retained?:

YES ____X____ NO

Why?: Sauger does have some merit as a stand-alone indicator species. It is one of the few species that occurs in all reaches and with socioeconomic implications the in UMRS. Historic data is fairly prevalent for sauger in most reaches, and their life history is well known in the UMRS. As a relatively high profile fish, academic and agency studies are periodically conducted on sauger in the UMRS, which would further support LTRM data. However, this species is already included in the "Recreationally Harvested Fishes" as a social indicator, and is likely not one of the primary sport fish species sought in the open river reach. Trends in the sauger population by itself are likely not sufficient to reflect socioeconomic values throughout the UMRS. The same would hold true for sauger as an ecological indicator, in that impacts to the UMRS would be better indicated by a group of species that have life history requirements that overlap, as opposed to an individual species.

Can this indicator be improved?:

X YES _________ NO

How?: To be considered as a functional ecological indicator, sauger would be better included in a functional group of fishes instead of by itself. For example, as a migratory species, sauger population trends could be monitored with all or a subset of migratory fish species in the UMRS. As an indicator of riverine function or channel habitat condition, sauger would again be more valuable as an indicator if included with other species that would be impacted by the same changes in river processes or channel habitat. In addition, as an ecological indicator all size classes should be included.

What additional considerations should be made?:

There are other sources of data and past, current, and future studies being conducted on sauger that could be correlated with LTRM data (e.g. USACE fish passage studies, agency monitoring, academic research, etc.)

Recommendations for measuring, quantifying, and reporting:

1) Compile and assess other sources of data for relatedness to LTRM data and ability to indicate population trends, socioeconomic value, and ecological impacts. 2) In addition to including in "Recreationally Harvested Fishes", sauger could be included in "Migratory Fishes" and "Channel Habitat Fishes" indicator groups.

Recommended status goal(s):
The UMRS should continue to support sustainable recreational exploitation of its native fish stocks. As such, local native stocks should be sufficiently large and possess an age-structure that demonstrates it can support the fishery utilizing it. Sauger should at a minimum maintain their current status and a harvestable population size or increase toward a carrying capacity and sustain increased harvest.

Recommended trend goal(s):
Increasing or stable in all reaches.

Appended supporting information:

Status and Trends Indicator Assessments – Fish Indicators

Indicator Title: Channel catfish

Reviewer: Len Kring (USACE)

Original Purpose Statement:
(cut and pasted from S&T report - http://pubs.usgs.gov/mis/LTRMP2008-T002/)
Channel catfish is a significant component of the commercial and recreational fisheries in the UMRS. It is a characteristic species of river channels so tracking CPUE of channel catfish may provide insight into habitat quality of channel environments. This indicator is the pool- wide CPUE of adult (>280 mm) channel catfish collected in large hoop nets. Adults were selected because they are the size harvested commercially and recreationally.

New Purpose Statement:
Channel catfish is a significant component of the commercial and recreational fisheries in the UMRS. It is a characteristic species of river channels so tracking CPUE of channel catfish may provide insight into habitat quality of channel environments. This indicator is the pool-wide CPUE of adult (>280 mm) channel catfish collected in large hoop nets. Adults were selected because they are the size harvested commercially and recreationally.

Essential Health Attribute(s) addressed by this indicator:
(check one or more)
_______ Diversity / Richness
X Sustainable
X Resilient

Notes: Channel catfish are resilient and sustainable. I don't think a single species that is omnivorous and fairly tolerant lends much to diversity/richness.

Essential Indicator Class(es) to be indicated by this indicator:
(check one or more)
_______ Ecological
______ Structural
______ Functional
X Social
X Economic

Notes: Channel catfish are omnivorous and fairly tolerant to water quality issues and habitat loss. They seem to be able to adapt to either lentic or lotic environments.

Should this indicator be retained?:
_______ YES X NO

Why?: I believe it will be used for both recreational and commercially harvested fishes, however we decide to flesh those indicators out. One purpose of this indicator was to show quality of channel habitat. Channel catfish have adapted to many differing habitats and are not a good indicator of one kind of habitat. Other species are better at providing information on quality habitat. Also, channel catfish are very tolerant to poor water quality conditions. This species will not be helpful in determining ecological function or structure.

Can this indicator be improved?:
X YES ________ NO

How?: If the purpose is to evaluate channel habitat, we should be looking at sucker species. Also suckers will help us evaluate water quality and the quality of the macroinvertebrate food source. Most species are also simple lithophils which aids in analyzing available habitat.

What additional considerations should be made?:
Some sucker species are tolerant such as white suckers, carp suckers, and buffalo. These species would help with habitat but maybe not water quality considerations. The Moxostoma species, blue suckers and hogsuckers would do both. May be difficult to do.

YOY suckers should also be included in forage fish dialect. These fish are very important from a prey standpoint. Everything from walleye and pike in the north to catfish in the south utilize these species. It is a direct link from macroinvertebrates to top predators.

Recommendations for measuring, quantifying, and reporting:
CPUE, overall abundance, diversity and biomass could be considered measures. CPUE, overall abundance and diversity is available through current LTRMP data. This data may also be available through state agencies. Biomass data would need to be collected in the future if this is something we want to use. I think along with CPUE, overall abundance, and diversity of suckers to characterize channel habitat, we should look at intolerant species of suckers and invertivore/insectivore suckers to characterize overall habitat, water quality and food web interactions. This would take some calculations as far as percentages of each of these categories in each pool. This may help management decisions and also point out areas that could be candidates for EMP HREP projects.

Recommended status goal(s):
Good for pools with substantial current, fair for pools with large lentic habitats

Recommended trend goal(s):
Stable.

Appended supporting information:
IBIs that I have used in the past have not only had a metric for number of sucker species, but they were also key players in the intolerant metric, the invertivore/insectivore metric and simple lithophil metric. That is 25% of the metrics that were affected by sucker species. I think the group should look hard at incorporating this group of species into the S&T report in some way.

Status and Trends Indicator Assessments – Fish Indicators

Indicator Title: Species Richness

Reviewer: Joe Ridings

Original Purpose Statement:
The UMRS represents the center of freshwater fish diversity in North America. Collectively, UMRS fish community contains representative species of socioeconomic value, exotic origins and special conservation status. Thus the public perceives the ecological health of the UMRS, in part, by the diversity of fishes present. This indicator is the number of fish species observed annually in LTRMP collections.
New Purpose Statement:
The UMRS represents the center of freshwater fish diversity in North America. Collectively, UMRS fish community contains representative species of socioeconomic value, exotic origins and special conservation status. Thus the public perceives the ecological health of the UMRS, in part, by the diversity of fishes present. This indicator describes the diversity and structure of the fish community observed annually in LTRMP collections and whether or not each reach is heading in a well defined, desirable direction.

Essential Health Attribute(s) addressed by this indicator:
(check one or more)
____x__Diversity / Richness
_______ Sustainable
_______ Resilient

Notes:

Essential Indicator Class(es) to be indicated by this indicator:
(check one or more)
___x___Ecological
___x___Structural
_______Functional
_______ Social
_______ Economic

Notes:

Should this indicator be retained?:
___x____ YES ____ ___ NO

Why?:

Can this indicator be improved?:
____x___ YES ________ NO

How?: This indicator should incorporate some aspect of species diversity and the degree of representation of each species observed. An acceptable level of diversity and a desired fish community structure should be defined. It should be renamed Community Structure

What additional considerations should be made?:

Recommendations for measuring, quantifying, and reporting:
A desired fish community structure should be defined and non-metric multi-dimensional scaling (NMDS) used to show whether or not each pool is heading in a well defined direction. These goals should involve the specific management interests of each reach. I recommend eventual zero capture of exotics, stable to increased capture of recreationally and commercially harvested fishes and non-game fishes and increased capture of species of conservation concern (SOCC). Specific goals including SOCCs and exotics for each reach should be determined in a workshop setting. Capture of each species should be evaluated individually using NMDS software to determine if it is heading in the prescribed desirable direction and then the entire fish community of each reach should be evaluated as a whole to see if it is generally heading in the prescribed desirable direction. The latter will require weighting net increase or decrease in capture of a SOCC against net increase or decrease in capture of an exotic. For reason of simplicity I recommend a 2:2:1 ratio; exotics and SOCCs being weighted twice as heavily as other species. For example, <u>all other species remaining constant</u>, an increase in capture of a SOCC by 15% combined with an increase in capture of one exotic species by 12% and another exotic species by 10% (22% total exotic increase) would indicate that the system is not quite heading in the desired direction. Or, <u>all other species again remaining constant</u>, if a SOCC increased by 15%, an exotic decreased by 1% but channel catfish capture decreased by 30% the system would not quite be heading in the desired direction. Because the vast majority of species will be neither SOCC nor exotic, the natural variation that is evident in spikes or valleys in capture of these species will likely be evened out among this large group. Some species that seem to have perpetually high variation may need to be weighted accordingly (<1) to dull the variation. LTRMP data should be researched by each reach to determine which if any species need to be weighted as such.

Recommended status goal(s):
The goal of each reach should be for the fish community structure to be heading more closely to the prescribed direction than the previous year.

Recommended trend goal(s):
The fish community structure of each reach should be heading in the prescribed direction.

Appended supporting information:
http://www.umesc.usgs.gov/reports_publications/ltrmp/fish/2000/fish-srs.html

http://www.umesc.usgs.gov/reports_publications/ltrmp/fish/2001/fish-srs.html

http://www.umesc.usgs.gov/reports_publications/ltrmp/fish/2002/fish-srs.html

http://www.umesc.usgs.gov/reports_publications/ltrmp/fish/2003/fish-srs.html

Status and Trends Indicator Assessments – Fish Indicators

Indicator Title: Non-native fishes

Reviewer: Kevin Stauffer (MNDNR)

Original Purpose Statement:
(cut and pasted from S&T report - http://pubs.usgs.gov/mis/LTRMP2008-T002/)
Nonnative fishes (species originating from outside the basin) occur in all monitored study reaches. The fraction of nonnative biomass to total fish biomass is frequently regarded as an indicator of ecological impairment. Nonnative species can compete with more desirable native species, thereby reducing abundance and distribution of natives. Tracking nonnative fish biomass provides direct information on the prominence of nonnative species and may indicate stresses on native fish assemblages. This indicator is the proportion of total fish biomass composed of seven nonnative species: goldfish (*Carassius auratus*), grass carp (*Ctenopharyngodon idella*), common carp, silver carp, bighead carp, white perch (*Morone americana)*, and striped bass (*Morone saxatilis)*.

New Purpose Statement:
If we choose to use the same indicator, I think the statement above is sufficient.

Essential Health Attribute(s) addressed by this indicator:
(check one or more)
X Diversity / Richness
X Sustainable
X Resilient

Notes:

Essential Indicator Class(es) to be indicated by this indicator:
(check one or more)
____ Ecological
X Structural
____ Functional
? Social
X Economic

Notes: This indicator could be interpreted as having Social implications, but I'm not sure it really fits the definition we use in Chapter 1 draft. Certainly there is a negative social factor as the relative biomass of Asian carp increases, but I don't know that would necessarily be true of common carp and other nonnatives.

Should this indicator be retained?:
X YES ________ NO

Why?: I think this is a relatively simple, and visual, indicator that will show impairment/improvement in the system.

Can this indicator be improved?:
X YES _________ NO

How?: Should we consider separating out species like common carp that are ubiquitous in the system as an indicator for nonnative species that have become "naturalized" in the system vs. Asian carp that are still expanding and have varying levels of impact among river reaches? I would assume that the decreasing (improving) trends the last S&T report for Pools 4, 8 & 13 is primarily driven by common carp. Since we don't have Asian carp up here in detectable numbers, and I don't have good feel for their vulnerability to LTRMP methods – would we be able to measure the Asian carp portion of the nonnative biomass as it increases? Maybe we should do a quick analysis just with common carp to see if they could be used as the indicator for biomass changes. Other nonnatives, perhaps, could be used in a different metric (presence/absence, diversity index, etc.) Just some random thoughts……….

What additional considerations should be made?:
This indicator is not sensitive to "new" species that might be detected at low levels. The Species Richness indicator (if retained) may be sufficient to identify trends and set goals in this regard?

Recommendations for measuring, quantifying, and reporting:
See above

Recommended status goal(s):
Suggest using observed trends over LTRMP sampling to establish goals. From the 1993-2002 graphs it looks like somewhere around 40% or lower would be a goal that would be an improvement for most reaches and at least stable for Pool 4.

Recommended trend goal(s):
Stable at worst, decreasing at best.

Appended supporting information:

Status and Trends Indicator Assessments – Fish Indicators

Indicator Title: Commercially harvested native fishes

Reviewer: Brian Ickes (USGS)

Original Purpose Statement:
(cut and pasted from S&T report - http://pubs.usgs.gov/mis/LTRMP2008-T002/)
Commercial fisheries exist throughout the UMRS, and the production of commercially harvestable fishes is one of the important services provided by this ecosystem. Tracking CPUE of commercially harvested fishes provides direct information on this resource, and may provide insight into habitat quality and the likelihood of overharvest. This indicator is the combined CPUE from seven native fish species (Table 2.4). Common carp and Asian carps are also commercially harvested, but are nonnative species and are not included in this indicator.

New Purpose Statement:
Commercial fisheries exist throughout the UMRS, and the production of commercially harvestable fishes is one of the important services provided by this ecosystem. Additionally, and increasingly, commercial fisheries are also being used to manage non-native fishes invading the UMRS. Tracking CPUE of commercially harvested fishes provides direct information on this socially and economically important resource, and provides insight into the health of the fishery and the fishes that support it. This indicator is the combined CPUE from seven native fish species (Table 2.4) and the combined CPUE of four species of non-native carp (Table 2.5), coupled with information on the number of commercial fishing licenses.

Essential Health Attribute(s) addressed by this indicator:
(check one or more)
_______ Diversity / Richness
X Sustainable
X Resilient

Notes:

Essential Indicator Class(es) to be indicated by this indicator:
(check one or more)
_______ Ecological
____ Structural
____ Functional
X Social
X Economic

Notes: Little value as an ecological indicator since exploitation confounds interpretations relative to habitat and fundamental ideas of ecological health. Best benefit is as a social or economic indicator, since market prices can be tracked and the fishery readily valued. In many ways, it is perhaps our cleanest cut economic indicator. If we need to peg each indicator to a single Indicator Class, I would argue this indicator should represent the Economic Indicator Class.

Should this indicator be retained?:

? YES ________ NO

Why?: Perhaps it should be retained, but perhaps not as well. Commercial fisheries clearly represent a social and economic benefit extracted from the river system, but in most cases, commercial fisheries are small, arguably artisanal. As such, commercial fisheries do not necessarily possess a meaningful social welfare focus, or carry noteworthy commercial / industrial / economic interest and impact.

Can this indicator be improved?:

X YES ________ NO

How?: Presently, LTRMP data are used to infer the status of the fishery and trends in its health. A more direct way would be to compile and report UMRCC commercial fishery statistics. However, we are not fully certain of the completeness, accuracy, and adequacy of the UMRCC data to support such a use. We recommend an evaluation of UMRCC commercial fishery records be conducted, to include correlation analyses with LTRMP data.

What additional considerations should be made?:

Presently, this indicator excludes non-native fish species. However, in the future, it is conceivable that new fisheries may manifest, focusing on expanding and abundant non-native species. It is also possible that commercial fisheries may be used to manage non-native species. Thus, we recommend including non-native species (subject to commercial exploitation) in this indicator.

Recommendations for measuring, quantifying, and reporting:

We recommend the following: (1) survey UMRCC commercial catch records and assess them for completeness, accuracy, and relationships to LTRMP index statistics; (2) expand the species composing this indicator to include commercially-exploitable non-native fishes; (3) when reporting, present separate trend lines for native and non-native species since different status and trends goals may apply to native vs. non-native stocks; (4) consider supplementing fish catch data with data reflecting the health of the economic enterprise itself (e.g., number of active licenses, total landings value, etc…).

Recommended status goal(s): The UMRS should continue to support sustainable commercial exploitation of its native fish stocks. As such, local native stocks should be sufficiently large and possess an age-structure that demonstrates it can support the fishery utilizing it. We recommend assessments be made on a study reach by study reach basis. Additionally, non-native fish stocks should possess a long term status goal that is at worst comparable to their present status, and at best targets their elimination from the UMRS.

Recommended trend goal(s): Native species – increasing or stable. Non-native species – decreasing or stable.

Appended supporting information:

Chapter 2 Concluding remarks and recommendations

Based on the content of Chapter 2, as well as our deliberations as we evaluated indicators presented in the last Status and Trends report (Johnson and Hagerty 2008), we would also like to convey to the parent committee some general observations and recommendations.

1. As is evident in the "Recommended Status Goals" section of each indicator evaluated for Chapter 2 above, as a committee, we remained largely reticent to advance hard numeric goals. If one could paraphrase what we presented, it would likely be something like "do no harm and try to generally improve things". This reticence likely derives from the fact that no recognized program entity has made a judgment on a formal evaluation framework yet. Such a judgment is very much needed. We found considering indicators, absent a formal framework within which to evaluate them, to be a rather abstract and difficult undertaking. Absent such a framework, which provides a solid grounding against which to evaluate indicators, it is exceedingly difficult to arrive at quantitative status and trends goals and benchmarks. We generally agreed that a framework based on describing the past 20 years as a baseline, and comparing future observations relative to this baseline, is likely our best course of action. However, we did not discuss this topic explicitly – our remarks here represent an emergent and implied opinion deriving from our deliberations on indicators themselves. Still, a meaningful and recognized partnership body needs to either affirm our implied framework or advance an actionable alternative.

2. Where we did make quantitative goals or benchmark recommendations, they tended to be based on statistical properties of the data (e.g., future observations should not exceed the 10th and 90th percentiles – in other words, the observed average and range of variability). This approach stands in stark contrast to goals based on management objectives, which may be conceived to push certain indicators beyond historical (last 20 years) system behavior. Yet, until the partnership clearly and unambiguously states such goals, we feel our approach is the best that can presently be achieved.

3. In nearly every case, the committee found alternative, and arguably improved, ways to consider, quantify, and evaluate indicators presented in the last Status and Trends report. We proposed specific actionable recommendations for additional fact finding or analysis that will advance existing indicators.

4. Another emergent finding from our deliberations was that there is generally a movement away from single-species indicators and towards assemblage or community-based indicators. Some time, consideration, and resources should be dedicated to investigating / developing ways to track changes in full assemblages.

5. We recognized that the indicators selected for the last Status and Trends report were heavy on ecological structure and function aspects of system health, but rather light on the social and economic dimensions of system health. We attempted to better balance this by recasting some former indicators and by conceiving new indicators.

6. Our committee also wrestled quite a bit with issues of scale (e.g., at what spatial scale should goals and benchmarks be defined for any given indicator?). Generally our deliberations resulted in the following points: (a) given stark differences in river characteristics across the > 1200km UMRS, some "regionalization" in defining and evaluating indicator goals and benchmarks will be necessary; (b) it is unlikely that selecting a single scale at which to define goals and set benchmarks, applied across all selected indicators uniformly, will be workable. We believe much

of our uncertainty on this topic could be resolved by simply adopting a formal reference framework. However, this was outside the charge of our committee (but see #1 above for our thoughts on such a framework).

Chapter 3: Alternative Status and Trends indicators for UMRS fishes

Introduction

The final objective of the committee was to brainstorm alternative indicators that could be considered for use in later Status and Trends assessments. The committee approached this task from the point of view of creating an overall indicator portfolio that was reasonably balanced among the three primary Indicator Classes the committee outlined and defined in Chapter 1; namely, ecological, sociological, and economic indicator classes. Following our evaluation of existing indicators in Chapter 2, Table 3.1 presents the indicators that remained in our recommended indicator portfolio, including indicators that were realigned among Indicator Classes. Specific recommendations to achieve realignment for each indicator in Table 3.1 are presented in Chapter 2 and will not be presented again here. In Chapter 3, we focus upon rounding out the overall indicator portfolio by considering new alternative indicators.

Table 3.1 Indicators remaining following the committee's review of indicators presented in Johnson and Hagerty (2008), including notes on Indicator Class membership / realignment and newly stated indicator intents.

Indicator*	Indicator Class	Former intent	Realigned intent
Recreationally harvested native fishes	Social	Multi-species social indicator	Multi-species social indicator
Forage fish	Ecological - functional	2-species functional ecologic indicator	Multi-species functional ecologic indicator
Bluegill	Ecological - functional	Single species "everything" indicator	Single species indicator of "off-channel" areas (ecological function)
Species Richness	Ecological - structural	Univariate ecologic structure	Multivariate ecologic structure
Non-native fishes	Ecological - structural	Proportion of community in non-natives	Proportion of community in non-natives
Commercially harvested native fishes	Economic	Native commercial species index	All commercial species index

* Note: Three indicators presented in Johnson and Hagerty (2008) are recommended from removal from the fish indicator portfolio (Channel catfish, Sauger, and Smallmouth Buffalo)

For the balance of Chapter 3, our committee presents additional ideas for indicators, presented by Indicator Class. We close our report with some alternative ideas for presenting and tracking indicator progress over time.

Additional Ecologic Structural Indicators

The committee's thoughts on additional ecological structure indicators can be distilled into two categories. The first category is represented by a group of classical ecological community indicators, such as Simpson's or Shannon-Wiener diversity indices, community richness, community evenness, and dominance metrics. Such metrics are potentially beneficial because they are widely used, generally possess a sound theoretical basis, and can be readily calculated from existing data sources (e.g., LTRMP, EMAP, etc…). In fact, several earlier LTRMP reports have already provided insights into some of these community metrics (Koel 2004; Barko et al 2004; Sass et al. in press). These are certainly some options for consideration, easy to conceive and implement. But there are some limitations with these metrics/indicators as well. For example, thus calculated, each of these metrics is inherently univariate and much species-level information is entirely lost. Second, because we can calculate such metrics does not mean we understand what may be reasonable or acceptable for the UMRS. By way of example, the UMRS fish community is presently highly uneven (see Figure 1.4 in Ickes et al. 2005), and it is likely that it has always been so. Indeed, speciose communities generally tend to be rather uneven by the very nature of being speciose. In most cases, for this class of indicators, the committee wondered whether a reasonable basis of expected values could be defined. Thus, the committee was not entirely convinced of their utility in ecosystem health assessments in the UMRS.

An alternative to the classical community metrics, representing our second category, is an approach that is inherently multivariate yet retains species-level information. Chick et al (2005) provides an excellent example of how to characterize differences in community composition and structure among different river reaches, as well as changes over time within study reaches. The approach of Chick et al. (2005) was to use an indirect ordination technique known as Non-Metric Multidimensional Scaling (NMDS) to infer and assess similarity among comparative fish communities (e.g., either among LTRMP study reaches, or over time within a single LTRMP study reach). Moreover, single species contributions to observed differences can be elucidated with this technique, retaining information otherwise lost in classical univariate community metrics. Recently, Dr. Peter Minchin (Southern Illinois University – Edwardsville) has developed a new technique known as trajectory analysis (http://www.siue.edu/~pminchi/) that permits a scientific assessment of directional shifts in entire assemblages or communities. Ideally such shifts would occur in response to management actions enacted to elicit directional change in the community under consideration. It uses well-founded NMDS principles to achieve such assessments.

Committee recommendations:

- *Given the ease of calculation and the fact that some information already exists in previous LTRMP reports, the committee recommends a minor, yet reasoned, effort should be made to calculate and assemble a variety of classical community metrics for consideration by the A-Team Ad hoc Committee on Indicators. This should require a modest allocation of staff time, and no new data collection.*

- *More substantive, and preferred, our committee recommends resources be directed at developing both the methods and the means to assess directional shifts in entire assemblages or communities. In time, it is the committee's hope that such directional shifts could be tied to stated management objectives, permitting an adaptive assessment of ecosystem response to continued management interventions and actions. Enacting this recommendation would likely require a greater commitment of staff time and perhaps some minor fiscal resources to engage Dr. Minchin's expertise in this area.*

Additional Ecologic Functional Indicators

Ecosystem attributes that support ecosystem functions required to maintain healthy UMRS fisheries are numerous and varied. Examples include (1) diverse and stable metabolic pathways (food webs) that assure sustainable fisheries; (2) recruitment and growth processes that maintain healthy populations, and (3) hydro-fluvial dynamics that assure necessary habitats remain available. Any number of indicators could be readily conceived to address these and other functional ecosystem attributes.

Our committee wrestled a bit with selecting one or two good examples for the parent committee to consider and perhaps carry forward into new indicator development. All of the example attributes presented above are “systemic” and “universal”, and thus worthy of consideration as a prospective Status and Trends indicator of system health. However, our committee settled on three additional examples the parent committee may choose to entertain.

The first of these relates to the migratory requirements of many fishes in the UMRS. Migration is a key functional attribute required to maintain diverse and sustainable fish stocks in large rivers. Our committee settled on migration as an important functional attribute for the following reasons: (a) impediments to fish migration result from a direct, apparent and quantifiable economic use of the river, presenting an opportunity to consider ecosystem service valuation and tradeoff assessments in future reports, (b) provisioning fish passage is a major management thrust, offering an opportunity to elicit a measurable response or change in the status of migratory species, (c) additional faunal groups are health-impaired by restricted fish passage (e.g., freshwater mussels), and (d) this attribute, in the committee’s opinion, shows promise as a potential management indicator which will assist us in linking ecosystem health evaluations with management actions in the future.

The second attribute the committee decided to focus on and advance was a way to indicate shifts in foodwebs, largely in response to zooplanktivorous invasive Asian carp species. Members considered the active invasion of the UMRS by Asian carp to be a threat worth indicating and tracking. Our proposed means is to track the proportional biomass of Asian carp to all zooplanktivore species, surmising that any Asian carp impacts on UMRS foodwebs should manifest first and foremost in the native zooplanktivore assemblage.

The third attribute sought to balance a re-alignment the committee made for the bluegill indicator, presented in Chapter 2. In Chapter 2, the committee realigned bluegill as a functional indicator of off-channel environments. To achieve balance, the committee discussed ways to indicate the functional health of channel environments as well.

Committee recommendations:

- *Our committee recommends resources are dedicated to devising a means to sensitively indicate changes in migratory fish assemblages. One part should seek to elucidate the present status of migratory fishes in the UMRS. The second part should seek to devise a way to detect responses of migratory species to fish passage provisioning, presently underway in parts of the UMRS. Some previous staff work has already begun to address this issue (Chick et al. 2006; Ickes et al 2002; Ickes in prep). Achieving the development of a migratory fish indicator will require additional research and development work and some measure of staff time. However, no additional expenses beyond staff time would likely be required.*

- *Our committee recommends the dedication of staff time to develop a ratio index of Asian carp biomass to total zooplanktivore biomass in the UMRS. An alternative or complementary approach would be to tally fish biomass within each of seven identified feeding guilds (O'Hara et al. 2007) and look for proportional shifts among these guild classes over time. Said staff, upon completion of the indicator, shall report results to the A-Team Indicators ad hoc Committee for further consideration and indicator benchmark determination. It should require only a modest commitment of program resources to further develop and advance this indicator, if deemed useful by the parent committee.*

- *Our committee also recommends that staff time be directed at developing a channel habitat fish indicator. Attributes the committee feels this indicator should possess include the following: it should be comprised of adult fishes to minimize inter-annual variability attributable to stochastic recruitment events; it should take an assemblage approach, focusing on species that are fluvial specialists and/or dependents.*

Additional Social Indicators

No program or agency we are presently aware of tracks social indicators of UMRS fisheries resources, *per se*. For example, direct assessments, such as creel surveys, are intermittent and variously targeted and conducted. Our committee struggled with ways in which meaningful social indicators could be crafted from existing observational data streams. Our primary thought was to attempt to reflect social values that may be other than exploitative, yet not directly measured in the basin. Our only example in this regard was to develop an indicator centered on Threatened and Endangered species in the basin. Threatened and Endangered species, in a very real way, reflect past, present, and future societal values in that past values perhaps led to the status of such species (exploitative), and such designations speak to present social norms (conservation/restoration), and intended future social benefits (aesthetics/ethics). Our committee makes two recommendations with regards to additional social indicators:

- *Our first recommendation is the dedication of staff time to conduct a literature review, focusing on means by which fisheries social indicators have been developed and used in other systems. Our committee admits an inherent weakness in this class of indicators, and recommends additional fact-finding work.*

- *Our second recommendation is the dedication of staff time towards the development and refinement of a Threatened and Endangered species indicator, crafted for social values indication. Our committee seriously doubts the ability of existing systemic data sources (e.g., LTRMP, EMAP) to fully inform such an indicator and we recommend resources be provisioned for additional fact-finding work, including a canvass of agency-specific data resources and an assessment of their utility for advancing such an indicator. Some baseline work has previously been achieved (see Chapter 5 in Ickes et al 2005), and additional information is likely available from the USFWS as a trust species agency.*

Additional Economic Indicators

Similar to Social Indicators above, our committee admits an innate weakness in Economic valuation and indication. One thought the committee had was to recast the entire LTRMP fisheries database into economic replacement value units, achievable using data presented in the LTRMP Fish Life History Database (O'Hara et al. 2007). The idea would be to explore patterns in "standing economic value index", perhaps correlating such patterns with habitat rehabilitation expenditures or any of a number of environmental or social covariates. Our recommendations are similar to those above for Social Indicators:

- *Our first recommendation is the dedication of staff time to conduct a literature review, focusing on means by which fisheries economic indicators have been developed and used in other systems. Our committee admits an inherent weakness in this class of indicators, and recommends additional fact-finding work.*

- *Our second recommendation is the dedication of staff time towards the development and refinement of a "standing economic value indicator", which tallies the replacement values for each and every fish observed in the LTRMP fisheries database. Additionally, we recommend some exploratory analysis work that attempts to correlate patterns in economic valuation with both rehabilitation expenditures, as well as any of a number of environmental and social covariates.*

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Appendix A. Call to arms and meeting agendas for the Fish Indicator Sub-Committee of the A-Team Indicators Ad Hoc Committee.

Appendix A.1

United States Department of the Interior

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

5 April 2010

To: Members / volunteers for the fish indicator sub-group of the A-Team ad hoc working group on ecosystem health indicators

From: Brian. S. Ickes

Subject: Call to arms and charge of the group

All:

Each of you has expressed interest (or been volunteered) to assist the A-Team in its deliberations on ecosystem health indicators. I'll begin with a brief background on this effort, describe where the effort stands right now, and explain what our sub-group is charged with completing. Before I do so, however, I first wish to thank and acknowledge each of you for your involvement and willingness to contribute.

Background

The second Status and Trends (S&T) report, published last year (http://pubs.usgs.gov/mis/LTRMP2008-T002/), was the partnership's first meaningful attempt to bring unprecedented data sources to bear on the task of assessing overall ecosystem health for the UMRS. LTRMP data were used to (1) identify potential health indicators, collectively presented in Chapter 2 of the above cited report; and (2) portray differences in the status of the indicator (magnitudes, perhaps relative to other areas or to accepted standards) as well as trends over time.

Following publication of the report, and anticipating future reports, the partnership took a step back and reviewed some lessons that were learned during the development of the second S&T report, in sincere hopes of advancing such ecosystem health assessments in the future. A couple of points were readily apparent:

(1) While LTRMP data were very useful in demonstrating how different ecosystem attributes varied in their status, and whether any discernible trends were evident, it remained unclear what levels of each attribute represented "good", "fair", or "poor" status, and what might constitute either a

hopeful or disconcerting trend. It was also unclear whether the partnership had selected the best indicators possible to make health assessments. In other words, the last Status and Trends report largely lacked a reference system against which to make Status and Trends judgments and further refine indicators.

(2) It remained unclear exactly what each indicator was intended to indicate. For example, was bluegill CPUE intended to indicate recreationally-available fishes, habitat quality, a forage base for large predators, an ecological response to management actions in the basin, or their own internal population dynamics (e.g., are populations sustainable?)? This occurred largely because potential indicators were chosen in the abstract. In other words, the indicators were selected without considering their ability to indicate changes in system health attributes people care about. Principally, this is because people have yet to define what constitutes a healthy UMRS ecosystem.

Realizing these limitations and the need to advance ecosystem health assessments in the basin using unprecedented data resources, the partnership, through the auspices of the A-Team, decided to go back and re-evaluate both the process by which ecosystem health evaluations are made, as well as the individual indicators used in making these assessments.

Where we are now

In December 2009, The A-Team convened an Ad Hoc Indicators team with full agency representation. Discussions within this group led to the recommendation that a Fish Indicator sub-committee be formed to (1) evaluate existing indicators; (2) conceive alternative indicators; and (3) express some judgments concerning what constitutes a healthy UMRS fish community. This is us folks….

Our charge

It's pretty clear to me that the Ad Hoc group needs someone to make some decisions concerning what a healthy UMRS fish community and fishery should look like. We will be that group. Moreover, I think we also need to clarify and reaffirm the indicators presented in the second S&T report, and/or conceive additional or alternative indicators that we believe reflect our definition of a healthy UMRS fish community.

As a starting point, I ask only 2 things: (1) everyone should read Chapter 1 of the second S&T report (http://pubs.usgs.gov/mis/LTRMP2008-T002/) as well as each of the fish indicator sections in Chapter 2. I want you to particularly focus on pages 18-22; (2) I also ask that everyone spend at least 30-60 minutes familiarizing yourself with the LTRMP Graphical Fish Database Browser, available at this link (http://www.umesc.usgs.gov/data_library/fisheries/graphical/fish_front.html).

Ultimately our efforts will result in a brief report with recommendations to the A-Team Indicator Ad Hoc Team. I will head up the development of this report, with substantial help and input provided by all of you. We have a June 30th, 2010 deadline…

Immediate task(s)

1. Complete this Doodle Poll (http://www.doodle.com/59xmafm4wp9n9dyd) by April 9th (this Friday). Check boxes for dates you are available. I will use results to schedule a conference call.

2. I'll pull together an agenda to focus our discussions by April 9th as well.

3. Think independently how you would characterize what a healthy UMRS fish community and fishery looks like (what are the essential attributes), and ways you might indicate these attributes. While we will focus mostly on LTRMP data sources, do NOT constrain your thinking to LTRMP data sources only. **Be prepared to discuss your independent ideas during the first conference call.** I also ask that you think beyond "local" issues. Our goal here is to come up with definitions of healthy fish communities for the entire UMRS, coupled with responsive indicators that can be tracked over long periods of time to assess health. I'd also like to see us make some statements about long term fish community health goals. **I will expect folks to have some thoughts to share.**

4. I insist that if you will be participating that you read Chapter 1 of the S&T report, as well as each fish indicator section in Chapter 2 before our first call. It's this report (and specifically, these sections) we will be seeking to improve with our efforts. I have provided a link to the report above.

Future tasks

I'm viewing this group as largely advisory at this point. Part of this advisory responsibility is likely to include identifying additional analyses of existing data sources (e.g., to develop and assess additional indicators for consideration). We will NOT be doing these analyses as part of this work, in large part to minimize your time and efforts on this volunteer project (though we may assemble some information from past reports folks don't seem to be too aware of that would broaden the pool of prospective indicators for consideration). However, some or all of us are likely to be involved with conducting these analyses in the near future, if needed, which will be funded by the Program.

I expect only 2 or perhaps 3 calls will be needed to draft our initial advisory report. If you have in interest in being part of a small writing team, let me know and we'll figure out a way to divide things up.

Most important is our June 30th deadline for a report, so please be mindful of our deadline as you make commitments.

In closing, thank you for your participation and interest. Developing an ecosystem health evaluation framework with purposeful indicators is a lofty, but desperately needed goal for the partnership. I sincerely appreciate your commitment towards this end.

At any point in this process, if you should have questions or concerns, please do not hesitate to contact me.

Sincerely,

Brian S. Ickes (electronic signature)

Brian S. Ickes

cc:

Dr. Barry Johnson, UMESC, La Crosse

Karen Hagerty, USACE, Rock Island

Andy Bartels, Wisconsin DNR, La Crosse

Kevin Stauffer, Minnesota DNR, Lake City

Mel Bowler, Iowa DNR, Bellevue

Kirk Hanson, Iowa DNR, Bellevue

Len Kring, USACE, Rock Island

Donovan Henry, USACE, St Paul

Joe Riddings, Missouri DoC, Jackson

Ken Cook, USACE, St Louis

Appendix A.2

Conference Call Agenda #1

A-Team Indicators Ad Hoc, special committee on Fish Indicators

26 April 2010
8:00 – 9:30 AM

Call details:

The participant passcode is: **7904595#** (you must enter # after the number)

The phone number is: **1-866-507-5538**

Our first call (I anticipate 3 in all) will have a singular purpose. Namely, our task is to discuss and seek unanimity on the following question:

"What constitutes a healthy UMRS fish community"

Please note, there is absolutely NO objective answer to this question – we will each need to make judgments, and discuss those judgments, in order to answer this question. Our goal will be to have made some progress towards defining an answer to this question.

Following the call, I will draft a statement that captures all the major points and attributes we discussed. I will then circulate this among the group wherein each individual will have an opportunity to concur with the statements provided, or offer a dissenting view. In this way, we will capture those attributes of a healthy UMRS fish community that we agree upon, those we nearly agree upon and those that require further resolution.

I expect a reasonable and ranging discussion to ensue during the call, and I know and trust all views will be heard and respected.

The task for the second call will be to begin getting into the technical details of how we may indicate those fish community attributes we define as central to a healthy UMRS ecosystem. I will provide more details and thoughts on how we might proceed to tackle this second phase at a later time. I simply wanted to give you an idea at this point where we are headed.

Our final task (third call) will be to state, review, and ultimately draft recommendations to provide the A-Team Indicators Ad Hoc. These recommendations will focus on 3 things:

(1) Our definition of a healthy UMRS ecosystem (from a fisheries point of view);
(2) Our recommendations for indicating fish community health attributes and for making data-informed judgments on their status and trends in the future; and
(3) Our recommendations for additional indicators to consider and/or additional analytic work that may be needed in either selecting additional indictors or optimizing their implementation.

Appendix A.3

Conference Call Agenda #2

A-Team Indicators Ad Hoc, special committee on Fish Indicators

20 May 2010
8:00 – 9:30 AM

Call details:

The participant passcode is: **7904595#**

The phone number is: **1-866-507-5538**

Our second call (I anticipate 3 in all) will have two purposes. Our first task is to review and briefly discuss issues related to summarizing our first call and its associated consensus finding, presented as Chapter 1 of our draft report. I'd like to limit this discussion to 15 minutes, so if there are questions or comments that need to be made, please be prepared to present them within this time limit. Otherwise, please feel free to simply call me and discuss.

Our second, and primary, task is to evaluate the fish indicators presented in the second Status and Trends Report (http://pubs.usgs.gov/mis/LTRMP2008-T002/).

To make this efficient given limited time, I'd like to assign one indictor to each call participant (see Table 1). Thus, each one of us is responsible for conducting a detailed evaluation on one of the indicators. We will base our evaluation on the indicator evaluation criteria, presented in our draft report from our first call (Essential Indicator Attributes; page 8). Each of us will lead a discussion on our assigned indicator, but all are expected to help and support the discussion by offering our insights and opinions.

Following the call, I will ask each person to draft an evaluation on their assigned indicator that reflects both (a) your detailed individual evaluation; and (b) additional group thoughts and opinions, so keep notes on group comments concerning your assigned indicator. I will send out a basic outline of the format I'd like all of these evaluations to use. We will compile these evaluations into Chapter 2 of our report.

Our final task (third call) will be to state, discuss, and make recommendations for additional indicators to consider and/or additional analytic work that may be needed in either selecting additional indictors or optimizing their implementation. So jot down ideas as you have them and be ready to discuss this topic during our final call.

Table 1. Indicator assignments (selected randomly).

Name	**Indicator**
Andy Bartels (WDNR)	Recreationally harvested native fishes
Mel Bowler (Iowa DNR)	Forage fish
Ken Cook (USACE)	Smallmouth buffalo

Kirk Hansen (Iowa DNR)	Bluegill
Donovan Henry (USACE)	Sauger
Len Kring (USACE)	Channel catfish
Joe Ridings (MDoC)	Species richness
Kevin Stauffer (MDNR)	Non-native fishes
Brian Ickes (USGS)	Commercially harvested native fishes

Thanks folks and talk with you on May 20th, if not sooner!

Appendix A.4

Conference Call Agenda #3

A-Team Indicators Ad Hoc, special committee on Fish Indicators

3 June 2010
8:00 – 10:00 AM

Call details:

The participant passcode is: **7904595#**

The phone number is: **1-866-507-5538**

Our final call will service our final objective – namely…

1) Finalize our earlier assessment of existing Status and Trends indicators, and
2) Conceiving additional and/or alternative indicators to consider for the next Status and Trends report.

During the last call, we evaluated all existing Status and Trends indicators relative to the criteria we collectively defined to assess them. I would like us to consider whether:

1) We feel this list is fully complete;
2) We feel these indicators sufficiently meet our criteria;
3) We feel these indicators can be improved (and if so, how).

This discussion will follow from our indicator evaluations, which I will compile and forward ahead of the call. We will use those assessments to make final judgments on existing indicators. As part of those judgments, I would also like us to make some recommendations on:

1) The scale at which each indicator should be assessed (e.g., system, reach, pool, etc…);
2) A judgment on current status and trend (poor, fair, good, excellent, increasing, decreasing, stable, etc…);
3) Future status and trend goals;

Our final task will be to discuss whether the next Status and Trends assessments would benefit from additional or alternative indicators and to brainstorm what those may be.
I'd also like us to consider and identify any analytic work that may be needed in either selecting or evaluating such additional indictors. So have some ideas handy and come to the call ready to discuss this topic.

Appendix D. Detailed Indicator Evaluation Table

A-TEAM RECOMMENDATIONS

INDICATOR	Ad Hoc recommendation	Concur	Dissent	FINAL	USACE	UMESC	State Average	WI DNR	MN DNR	IOWA DNR	MDC	Notes [UMESC additions in RED][GREEN BOX OR ALL CAPS FROM DISCUSSION]	MO Comments: including notes on interested participants to help develop indicator	WI DNR Comments	IA DNR Comments
RIVER HYDROLOGY												Important indicator and primary system driver			
Mean annual discharge	Keep &	IA, MN, WI, MO			X										
MODIFY: add seasonal analysis	Modify	IA, MN, WI, MO		M	H	M	MH	H	H	M	H	Can we tie this to a biotic component? CAPTURED IN IHA			
Seasonal water elevation	Replace w/	IA, MN, WI, MO													
NEW: Indicators of Hydrologic Alteration (IHA)	IHA	IA, MN, WI, MO		M	M*	H	MH	M	H	M	H	Some analysis already completed, wait for report (Gaugush) <-- Yes, so let's make it H to be sure we get it done. BUT IMPORTANT			
WATER QUALITY															
Major Nutrients	Keep	IA, MN, WI, MO			X										
Chlorophyll a	Keep &	IA, MN, WI, MO			X										
MODIFY: use seasonal average, not annual	Modify	IA, MN, WI, MO		MH-no $	MH	M	MH	M	H	M	H				
INVESTIGATE: blue green algae (new research)	Research	IA, MN, WI, MO		L	L	L	ML	L	L	M	M	Research by USGS-WRD/EPA may apply			
Total suspended solids	Keep	IA, MN, WI, MO			X										
Dissolved oxygen	Keep &	IA, MN, WI, MO			X										
MODIFY: use seasonal averages	Modify	IA, MN, WI, MO		M-no $	MH	M	M	M	M	M	H				
Suitable winter habitat in backwaters	Research	IA, MN, WI, MO		L	ML	L	M	L	L	H	H		Definitions needed for Open River		
NEW: Metaphyton (eutrophication indicator)	Future consideration	IA, MN, WI, MO			X							current APE underway (Giblin et al), wait for report, then reconsider			
SEDIMENTATION												limited duration studies, Upper Impounded Reach only			
Depth diversity in impounded areas	Table ~ 25 years	IA, MN, WI, MO			X										
Sedimentation rates in backwaters	Table ~ 25 years	IA, MN, WI, MO			X										
LAND COVER/LAND USE															
Floodplain forest	Keep &	IA, MN, WI, MO			X	H						We assume this is for work identified in Line 26??			
MODIFY/ADD: change from acres to %, add patch connectivity, add fragmentation	Modify	IA, MN, WI, MO		H-no $	X		NA	M	M	M	H	Analyses completed under Landscape 2010 APE			
Emergent vegetation	Keep	IA, MN, WI, MO			X	H	NA		H	M	See comment	This seems to be covered in line 62 re: analyzing veg component data for emergent veg info. Is any other new analysis needed?	Since the rec. is to keep, this was not ranked. Agree with keeping. No new work needed.		
Area of floodplain behind levees	Keep &	IA, MN, WI, MO			X										
MODIFY: reactive floodplain surface	Research	IA, MN, WI, MO		M	H	M	M	L	L	M	H	Need to define specific analyses to do here. THEILING, DE JAGER, NELSON ON TEAM? BUT IMPORTANT	Note: Frank Nelson at ORWFS could be a big help in this effort		
NEW: Patterns of land cover change (pool scale)	Add	IA, MN, WI, MO		H-no $	X	H	NA	H	H	H	See Comment	Analyses completed under Landscape 2010 APE. <-- Yes, but need to finalize as graphic for S&T report	Not ranked, because analyses already completed. And no funds needed.		
NEW: Patterns of aquatic area diversity	Add	IA, MN, WI, MO		H-no $	X	H		H	M	H	See Comment	Analyses completed under Landscape 2010 APE <-- Yes, but need to finalize as graphic for S&T report.	Not ranked, because analyses already completed. And no funds needed.		
AQUATIC VEGETATION															
Submersed aquatic vegetation	Keep	IA, MN, WI, MO			X	M?	NA		H	M	See Comment	What needs to be done?	Since the rec. is to keep, this was not ranked. Agree with keeping. No new work needed.		
MACROINVERTEBRATES												Component terminated in 2004, original design not appropriate for Open River			

Burrowing mayflies	Table	IA, MN, MO	WI		X	L	M	M	M	M	H	Regular monitoring is addressed by & through LTRMP 2010-2014 Strategic & Operational Plan		Re-establishing gives most info for $-already set up-could be like veg for upper UMR only	
Fingernail clams	Table	IA, MN, MO	WI		X	L	M	M	M	M	H		Invertebrate research is sorely needed in the UMR, especially in the Open River	Re-establishing gives most info for $-already set up-could be like veg for upper UMR only	
NEW: ground based detection of mayfly mass emergences by LTRMP field notations, River Alert Network, L/D personnel - requires new data sheets and database repository	Add	IA, MN, WI, MO		L	M	L	M	H	L	M	H and see comment	Still focuses on mayflies; may not be right species for Open River Requires a major effort, probably with low return at this point. Wait until radar can quantify emergences.	High if additional work is minimial for staff. If expectation this will take much time, it is M, based on other additions reported.	Open River is so different it should be addressed differently but that doesn't mean we should skip macroinverts in the other reaches.	
FISH															
Bluegill	Under review or Replace	IA, MN, WI, MO			X							Compare with proposed backwater assemblage			
Channel catfish	Drop	IA, MN, WI, MO			X							tolerant species			
Sauger	Drop	IA, MN, WI, MO			X										
Smallmouth buffalo	Drop	IA, MN, WI, MO			X										
Forage fish index	Keep &	IA, MN, WI, MO			X								General comment on semantics: cattle forage, fish are prey. Minor but maybe label should be revised.		
MODIFY: incorporate all fishes < 80mm, include all emerald shiners,	Modify	IA, MN, WI, MO		H-no $	H	H	MH	H	L	M	H	Size analyses should be easy. Biomass is more difficult and time consuming. STACKED BAR GRAPH? OR OTHER METHOD?	Agree with IA comment. We need to think more about this topic.		It would be nice to see an analysis of this with available data to see what additional insight, if any, this would provide before we dicide to add this.
ADD: index of biomass annually				M								BIOMASS SPLIT OUT AS SEPARATE ITEM IN DISCUSSION. CONSIDER DOING THE SAME FOR PREDATOR SPECIES OR USE RELATIVE WEIGHT INDEX.			
Species richness	Keep &	IA, MN, WI, MO			X										
NEW: Community Structure	Add	IA, MN, WI, MO		H	H	H	H	H	H	M	H		ORFWS staff wish to participate: Hrabik, Phelps, Ridings		
Non-native fish biomass	Keep &	IA, MN, WI, MO			X										
MODIFY: include stacked bar of species	Modify	IA, MN, WI, MO		H-no $	H	M	MH	M	H	M	H	SCHLIFER TREE MAP TOOL			This is just displaying data in different format, why additional funds needed?
Recreational native fishes	Keep &	IA, MN, WI, MO			X										
MODIFY: include stacked bar of species	Modify	IA, MN, WI, MO		H-no $	M	M	MH	M	H	M	H				This is just displaying data in different format, why additional funds needed?
RECLASSIFY as social indicator	Reclassify	IA, MN, WI, MO		YES	X										
Commercial native fishes	Keep &	IA, MN, WI, MO			X								Herzog has MO's commercial fish responsbility; would be good for him to participate.		
MODIFY: include non-native species	Modify	IA, MN, WI, MO		H-no $	M	M	MH	M	H	M	H	JUST LTRMP DATA			
MODIFY: include stacked bar of species	Modify	IA, MN, WI, MO		H-no $	M	M	MH	M	H	M	H				This is just displaying data in different format, why additional funds needed?
RECLASSIFY as economic indicator	Reclassify	IA, MN, WI, MO		YES	X										
NEW ECOLOGICAL INDICATORS															
EMERGENT VEGETATION												Important habitat/community, highly variable, annual changes/coverage more relevant than decadal			
Investigate: (1)analyzing veg component data for emergent veg information	Research	IA, MO		M	L	H	M	H	M	M	M	IS THIS VIABLE GIVEN THE AREAS SAMPLED			
Investigate: (2) using remote sensing	Research	IA, MO		L	L	L	ML	L	L	M	M				

FLOODPLAIN FOREST COMMUNITY															
INVESTIGATE: adding Corps forest quality data, data only partially available	Research Research	IA, MN, WI, MO		**M**	H	H	M	M	M	M	M	Pilot study, pools 3-10, incorporating forest quality info from COE underway. Data not yet available for remaining pools. <-- True, but when data are available (hopefully end of 2011?), this will be one of the few systemic databases outside of LTRMP. Let's do the	Note: availablility of Dawn Henderson		
NEW FISH INDICATORS												Assemblage make-up would be data driven			
BACKWATER FISHES ASSEMBLAGE	Research	IA, MN, WI, MO		**H**	H	H	H	H	H	M	H		Definitions needed for Open River reach		
MIGRATORY FISHES ASSEMBLAGE	Research	IA, MN, WI, MO		**H**	H	H	M	H	M	M	M		Note: Joe Ridings, and Open River eel work		
CHANNEL HABITAT FISHES ASSEMBLAGE	Research	IA, MN, WI, MO		**H**	H	H	H	H	H	M	H	May be able to use data/info from Steve Gutreuter's work on MC & SC trawling to help.	Note: Hrabik, Phelps, Ridings anc Crites should be involved for MO		
RATIO OF ASIAN CARP BIOMASS TO TOTAL ZOOPLANKTIVORE BIOMASS	Research	IA, MN, WI, MO		**MH**	H	M	MH	H	M	M	H	Are others outside LTRMP doing this already?			
NEW SOCIAL & ECONOMIC INDICATORS															
THREATENED & ENDANGERED FISH SPECIES (social)	Research	IA, MN, WI, MO	USACE	**L**	L	L	M	M	L	M	H	Easy to come up with abundance of species in this category, but agree with IA comment. Data likely to be highly variable since we're not designed to address this.	Hrabik and ORFWS is interested in participating in this effort		Do we do a good enough job of sampling these species?
STANDING ECOMONIC FISH VALUE (economic)	Research	IA, MN, WI, MO	USACE	**L**	L	L	ML	L	L	L	H				I'm sure we could come up with a number, but I'm not sure what that number would mean.

LEGEND	
Green	Keep
Blue	New analysis, have data, requires funding
Purple	New analysis or research,need data, requires funding
Orange	Replace
Red	Delete or table
Black	No funds needed
Priority ranking	high (H), medium (M) or low (L)

USFWS Comments	
Clevenstine	Summary Table and Recommendations for Additional Analysis - many of the indicators on the draft summary table can be cross-walked to the essential ecosystem characteristics (EEC) endpoints provided in Environmental Report 52, referenced above. Program-neutral restoration objectives have been developed which are organized around EECs. As a "cross-walk" example, the Landscape Indicators noted such as floodplain forest, wet meadow, emergent vegetation and aquatic vegetatiion would be subsumed under the Habitat EEC, with measures similar to those described in Appendix F of that report. Land managers on the river could benefit from standardized monitoring of these habitat components in relation to annual hydrographs. Better understanding of the trajectory of these habitats on managed and unmanaged portions of the floodplain would assist development of management strategies at multiple scales. One or more indicators of habitat condition in a report card format could communicate management effectiveness to decision makers and the public, and thus help develop support where appropriate to advance management objectives. It is likely that decision makers and the public would also desire one or more terrestrial vertebrate indicators that relate to or link selected habitat conditions, landscape patterns, climate, and/or the hydrograph.
Yager	I've only done a cursory review of the information you've provided, so please accept my comments as fairly uninformed. I can't speak to the technical merits/details of the indicators the A-team has selected, but I am pleased to see the A-team is considering floodplain forest health as a key ecosystem indicator. I'd like to see some expansion of the key indicators to include some of the "non-aquatic" parts of the ecosystem. Floodplain vegetation is a very good starting point. Perhaps we should also be looking at resident wildlife populations, furbearers for example, as indicators of ecosystem health. It also seems to me that amphibians are particularly good indicators of potential contamination issues, perhaps they would make good indicators too. We (Upper Miss Refuge) have developed a pretty good database of bald eagle nesting over the last several decades ... could this data be a useful indicator. If not, is there a better way to collect eagle nesting data to make it useful? Is there other data being collected outside of LTRMP that would be useful? Thanks again Tex for taking on the A-team role.

Summary of A-Team Recommendations			
2008 STATUS & TRENDS INDICATORS	**Ad Hoc recommendation**	**ACTION**	**PRIORITY**
RIVER HYDROLOGY			
Mean annual discharge	Keep &	MODIFY: add seasonal analysis	M
Seasonal water elevation	Replace w/	NEW: Indicators of Hydrologic Alteration (IHA)	M
WATER QUALITY			
Major Nutrients	Keep		
Chlorophyll a	Keep &	MODIFY: use seasonal average, not annual	MH-no $
INVESTIGATE: blue green algae (new research)	Research		L
Total suspended solids	Keep		
Dissolved oxygen	Keep &	MODIFY: use seasonal averages	M-no $
Suitable winter habitat in backwaters	Research		L
NEW: Metaphyton (eutrophication indicator)	Future consideration		
SEDIMENTATION			
Depth diversity in impounded areas	Table ~ 25 years		
Sedimentation rates in backwaters	Table ~ 25 years		
LAND COVER/LAND USE			
Floodplain forest	Keep &	**MODIFY/ADD**: change from acres to %, add patch connectivity, add fragmentation	H-no $
Emergent vegetation	Keep		
Area of floodplain behind levees	Keep &	MODIFY/RESEARCH: reactive floodplain surface	M
NEW: Patterns of land cover change (pool scale)	Add		H-no $
NEW: Patterns of aquatic area diversity	Add		H-no $
AQUATIC VEGETATION			
Submersed aquatic vegetation	Keep		
MACROINVERTEBRATES			
Burrowing mayflies	Table		
Fingernail clams	Table		
NEW: ground based detection of mayfly mass emergences by LTRMP field notations, River Alert Network, L/D personnel - requires new data sheets and database repository	Add		L
FISH			
Bluegill	Under review or Replace		
Channel catfish	Drop		
Sauger	Drop		
Smallmouth buffalo	Drop		
Forage fish index	Keep &	MODIFY: incorporate all fishes < 80mm, include all emerald shiners,	H-no $
ADD: index of biomass annually			M
Species richness	Keep &	ADD NEW: Community Structure	H
Non-native fish biomass	Keep &	MODIFY: include stacked bar of species	H-no $
Recreational native fishes	Keep &	MODIFY: include stacked bar of species	H-no $
RECLASSIFY as social indicator	Reclassify		YES
Commercial native fishes	Keep &	MODIFY: include non-native species	H-no $
		MODIFY: include stacked bar of species	H-no $
RECLASSIFY as economic indicator	Reclassify		YES
NEW ECOLOGICAL INDICATORS			
EMERGENT VEGETATION			
Investigate: (1)analyzing veg component data for emergent veg information	Research		M
Investigate: (2) using remote sensing	Research		L
FLOODPLAIN FOREST COMMUNITY			
INVESTIGATE: adding Corps forest quality data, data only partially available	Research Research		M
NEW FISH INDICATORS			
BACKWATER FISHES ASSEMBLAGE	Research		H
MIGRATORY FISHES ASSEMBLAGE	Research		H
CHANNEL HABITAT FISHES ASSEMBLAGE	Research		H
RATIO OF ASIAN CARP BIOMASS TO TOTAL ZOOPLANKTIVORE BIOMASS	Research		MH
NEW SOCIAL & ECONOMIC INDICATORS			
THREATENED & ENDANGERED FISH SPECIES (social)	Research		L
STANDING ECOMONIC FISH VALUE (economic)	Research		L

LEGEND	
Green	Keep
Blue	New analysis, **have data**, requires funding
Purple	New analysis or research,need data, requires funding
Orange	Replace
Red	Delete or table
Black	No funds needed
Priority ranking	high (H), medium (M) or low (L)
NO $	no funding needed

A-Team Top Priorities				
2008 STATUS & TRENDS INDICATORS	**Ad Hoc recommendation**	**ACTION**	**PRIORITY**	**completed**
WATER QUALITY: Chlorophyll a	**Keep &**	**MODIFY: use seasonal average, not annual**	**MH-no $**	**Y**
LAND COVER/LAND USE				
Floodplain forest	**Keep &**	**MODIFY/ADD**: change from acres to %, add patch connectivity, add fragmentation	**H-no $**	**Y**
NEW: Patterns of land cover change (pool scale)	**Add**		**H-no $**	**Y**
NEW: Patterns of aquatic area diversity	**Add**		**H-no $**	**Y**
FISH				
Forage fish index	**Keep &**	**MODIFY: incorporate all fishes < 80mm, include all emerald shiners,**	**H-no $**	**Y**
Species richness	**Keep &**	**ADD NEW: Community Structure**	**H**	
Non-native fish biomass	**Keep &**	**MODIFY: include stacked bar of species**	**H-no $**	**Y**
Recreational native fishes	**Keep &**	**MODIFY: include stacked bar of species**	**H-no $**	**Y**
		MODIFY: add non-native species	**H-no $**	**Y**
NEW FISH INDICATORS				
BACKWATER FISHES ASSEMBLAGE	**Research**		**H**	
MIGRATORY FISHES ASSEMBLAGE	**Research**		**H**	
CHANNEL HABITAT FISHES ASSEMBLAGE	**Research**		**H**	
RATIO OF ASIAN CARP BIOMASS TO TOTAL ZOOPLANKTIVORE BIOMASS	**Research**		**MH**	

LEGEND	
Green	Keep
Blue	New analysis, **have data**, requires funding
Priority ranking	high (H), medium (M) or low (L)
NO $	no funding needed

Appendix E. Status & Trends Report After Action Review (AAR)

MEMORANDUM FOR RECORD **Jan 29, 2009**

FOR: EMP-CC

SUBJECT: Status & Trends Report After Action Review (AAR)
Date: October 8, 2008
Location: UMESC, La Crosse, WI

Attendees:

USACE:	Marvin Hubbell, Karen Hagerty
UMESC:	Mike Jawson, Barry Johnson, Jennie Sauer, Bob Gaugush, Brian Ickes, Jeff Houser

Meeting Purpose:

- To review the process used for scoping, developing, and producing the Status & Trends (S&T) Report
- To improve this process in preparation for the next S&T Report
- To provide formal feedback to the EMP-CC

1. Report Process: Cultural differences between the Corps and UMESC resulted in miscommunication and misunderstanding of the objectives in the Scope of Work (SOW). More coordination and communication between the Corps, UMESC, and EMP-CC are needed. Among the issues that need more clarification of and agreement upon are as follows:

- Is the report a scientific or public relations document?
- The report must differentiate between S&T and ecosystem understanding.
- What data will be used in the development of the report?
- How are the selected indicators linked to formal goals and objectives?
- What is the relationship between selected indicators and the potential development of a report card?

2. Target audiences: Although the defined target audience was the mid-level manager, the question was raised if that was clear and appropriate. Several documents may be more appropriate in the future; one for scientists (scientific synthesis), one for managers (S&T), and a summary document (i.e. Taking the Pulse) for public relations; reflecting differing levels of detail.

3. Scope of Work (SOW): The SOW must clearly define all products & audiences. The next report should use entire data string and will be prepared **after** goals, objectives, indicators, & targets are defined. The report should include other data sources, as appropriate, for content and interpretation (EMAP, LTEF, etc). While the self-imposed limitation to use only LTRMP data was insightful, a more comprehensive report is preferred for future reports. The review process and level of detail should be established prior to development of the report and included in SOW. A well written SOW is critical to a successful outcome.

4. Report Content: Was this supposed to be a scientific or public relations document? This was not well defined initially. Some miscommunication resulted from UMESC-Corps culture clash.

Chapter 1 set the stage well for Chapter 2. 10-Year reports were basis of S&T, however, from the Corps' perspective, they were expected to contain more detail and analysis than they did. Therefore, the S&T report drew heavy criticism by Corps reviewers. UMESC stated that the 10-yr reports contained hypothesis but did not answer questions.

Key pools versus floodplain reaches – Can data from key pools be interpolated to floodplain reach or between key pools? This works best for WQ, but possible with other components.

5. Report Writing and Management: Collaborative writing between the Corps and UMESC was challenging. How this is structured next time depends on report purpose.

Bottom Line: What are the key items needed to ensure success of future S&T reports?

- The report must have clear purpose,
- All aspects of the report and its preparation must be clearly defined before beginning;
- No new report should be written before goals, objectives, indicators, and targets are established.

Prepared by: Karen Hagerty

"Complicated we do well. It's simplicity we have difficulty with." Jeff Houser