Proposed Index of Biological Integrity and Sampling Strategy for Fish for the Lower Kansas River

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Kansas Water Office

By

Kansas Biological Survey
University of Kansas
2101 Constant Avenue
Lawrence, KS 66047

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Paul Liechti, Principle Investigator
Phone: (785) 864-1527
Email: pliechti@ku.edu

KANSAS BIOLOGICAL SURVEY

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Background

In the report to the Kansas Water Authority (KWA), the Kansas River Channel Degradation Technical Advisory Committee included among its recommendations that the State should update studies to evaluate changes in biodiversity in the Kansas River. At the recommendation of the Kansas Water Office, the KWA endorsed providing funding for the completion of an index of biological integrity (IBI) for fish that would be limited to the lower portion of the Kansas River. Funding for this study and report was provided from the State Water Plan Fund (KWO 07-0116; KUCR KAN45500). For this study, the lower Kansas River is downstream of the dam at river mile 51.8 in Lawrence to the rivers confluence with the Missouri River.

Introduction

Biological integrity is the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region. The Index of Biotic Integrity (IBI) is a broad-based, quantitative, multi-parameter tool based on the composition of fish or other biological communities. An IBI uses several metrics that vary by ecoregion or locale. These metrics examine both structural and functional characteristics of biological communities. Each metric is qualitatively assigned a quantitative score that is indicative of observed conditions at a sample site, based on given criteria. Scores from each sample site metric are summed to provide an overall community score that reflects the health of the biological community.

The IBI is a versatile tool for identifying degradation resulting from different types of impacts such as the effects of sewage, urbanization, and sedimentation. For the Kansas River, the IBI may also be helpful in determining if accelerated river bed degradation or reservoir operations are having an impact the on biology of the river. The text "Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities" (T. P. Simon, 1999) describes the development and application of an IBI for fish and was extensively used in the preparation of the proposed IBI.

Fish IBIs are being used throughout the United States to assess the health of streams and rivers. Although similarly constructed, an IBI has to be tailored to reflect regional differences in fish species and fish community assemblages occurring in the respective ecoregion. One of perhaps the most strenuously evaluated fish IBIs is the multimetric index developed for the Ohio River (Emery, et al., 2003).

Examples of indexes that have been developed in closer proximity to Kansas are one developed for the Missouri River (Bergstedt, White and Zale, 2004), one developed to assess the integrity of a tributary to the Arkansas River in Colorado (Bramblett and Fausch, 1991), and an index developed to evaluate fish communities in several central Oklahoma streams (Spence, Smith and Nairn, 1999). The Kansas Department of Wildlife and Parks, although not referring to it as an IBI, uses similar principles and several of the metrics commonly used in an IBI for their stream evaluations.

While these regional indexes are useful as guides to selecting appropriate metrics for a lower Kansas River IBI, none were found that could be directly used without modifications because of the dissimilarity between the size and physical makeup of the Kansas River, and the different fish species and community composition the river supports. The KDWP evaluation procedure is mainly for smaller streams.

Fish IBIs are typically composed of from 9 to 12 metrics and many of the metrics are the same in all IBIs (e.g. Number of species, Number of native species, Percent tolerant species, etc.). IBIs differ, however, in the score or weight assigned to each metric. Individuals familiar with local fish species, their natural history, biology, habitat requirements and behavior, and the water body where the IBI will be used, subjectively derive the scores. The IBI is then calculated for fish sampled at predetermined sites, with each site receiving an IBI score. This process was used in the preparation of this proposed IBI.

Constructing a single IBI for the Kansas River may provide a unique challenge because of the obstruction created by the dam at Lawrence that does not allow for the free upstream and downstream movement of fish. Also, the fish community is likely different in the upper reaches near Junction City where the river is consistently shallower and the channel more braided in comparison to the community in the lower reach of the river where it is deeper and the channel more uniform. This proposed IBI was developed for use to assess the fish communities in the reach downstream of dam at Lawrence to the river's confluence with the Missouri River. However, after testing and adjustment, it may serve as a useful starting point for developing either a separate IBI for use in the upper Kansas River or a single IBI that can be used for the entire river.

A reference stream/river composed of a fish community unaffected by human activities and data from numerous samplings of fish populations is the ideal basis from which to construct an IBI. There is no known reference condition that can be used for the Kansas River and, while there is a reasonable amount of data about fish in Kansas River, the data is only of limited usefulness due to a lack of associated quantitative information, wide ranging dates of collection, and little or no information about collect methods used. One study of the impact of commercial dredging on the fishery of the lower Kansas River (Cross, et al., 1982) does contain very detailed information about the sample sites; sampling methodology and the fish collected. This study was extensively used to construct the proposed IBI. However, because the study primarily focused on the impact of dredging, absent were some aspects useful in constructing an IBI (e.g. impacts on the fish community from point source discharges or urban runoff).

Integral to the successful application of any IBI is reasonable consistency in the way the fish data is collected that is used to assess the integrity of the water body. Following a standard sampling methodology that identifies the procedures necessary to obtain the fish community data is integral to being able to compare data from different sampling sites and over time. The methodology should include a protocol for the selection of sampling sites, fish sampling techniques, recommendations on the number of samples that need to be taken and/or area that should be sampled, and optimal seasons for sample collection. A fish sampling strategy was developed for use with the proposed IBI (Appendix 1). The techniques used by Cross, et al. (1982) and sampling methods used or recommended by others (e.g. Simon and Sanders, 1999; USEPA, 2006; KDWP, 2002) were used to construct the sampling strategy. Information gathered by Eitzmann, J. L. and C. P. Paukert (2007 unpublished) aided in the selection of appropriate sampling gear.

Materials and Methods

The first component in development of the lower Kansas River IBI was to identify the species of fish that have been found in lower Kansas River and the biology of the species. From occurrence records and available biological information, each species was then classified based upon native distribution (native or introduced), reproductive guild, feeding guild, macro habitat preference, and tolerance or intolerance to environmental perturbation (Table 1). Not all of this information is known for every species (e.g. historical range, detailed habitat use and preference information).

Candidate metrics were then selected from those used in other indices (e.g. Emery, et al., 2003; Bergstedt, 2004; Bramblett and Fausch, 1991) as well as other possible metrics prepared project personnel. The 50 candidate metrics (Table 2) were then evaluated in regard to relevance for the species known to occur in the lower Kansas River. Because there is no reference condition comparable to the Kansas River, special consideration and preference was given to metrics that were the most relevant to the species found in the study conducted by Cross, et al., 1982.

Table 1 – Lower Kansas River Fish and Biological Information

Common Name	Scientific Name	Found in Cross Study	Trophic Guild (1st Level)	Trophic Guild (2nd Level)	Tolerance	Large River Fauna (LRF)	Large River Tolerants (LRT)	Intolerant Species (INT)	Lithophilous Spawners (LS)	Benthic Invertivores (BI)	Insectivorous Cyprinids (IC)	Catostomid Species (CS)	Deep-bodied Catostomids (DBS)	Round-bodied Catostomids (RBC)	Detritivores & Filter Feeders (DFF)	Top Carnivores (piscivores) (TC)	Non-Native Species (NNS)	Native Pioneering Species (NPS)	Centrarchid Species (CRS)	Notes
Skipjack Herring	*Alosa chrysochloris*	Y	C; P	WB;FF	MOD[a]	LRF														waif
Black Bullhead	*Ameiurus melas*	Y	I; C	B; WB	TOL[c]		LRT			BI										
Freshwater Drum	*Aplodinotus grunniens*	Y	I; C	B; WB	MOD[a]	LRF				BI										
Central Stoneroller	*Campostoma anomalum*	Y	H	PF	MOD[a]															
White Sucker	*Catostomus commersoni*	Y	I; D	B; FF	TOL[a]		LRT		LS	BI		CS		RBC	DFF					
River Carpsucker	*Carpiodes carpio*	Y	P; D	B; FF	MOD[a]							CS	DBS		DFF					
Quillback	*Carpiodes cyprinus*	Y	I; D	B; FF	MOD[a]					BI		CS	DBS		DFF					
Highfin Carpsucker	*Carpiodes velifer*		I; D	B;FF	INT[a]			INT		BI		CS	DBS		DFF					rare/ext.
Common Carp	*Cyprinus carpio*	Y	I; D	B; FF	TOL[a]		LRT			BI	IC				DFF		NNS			
Blue Sucker	*Cycleptus elongatus*	Y	I; H	B	INT[a]	LRF		INT	LS	BI		CS		RBC						
Red Shiner	*Cyprinella lutrensis*	Y	I; H	B	TOL[a]		LRT			BI	IC							NPS		
Gizzard Shad	*Dorosoma cepedianum*	Y	H	FF	TOL[b]		LRT		LS						DFF			NPS		
Northern Pike	*Esox lucius*		C	WB	MOD[a]											TC				
Orangethroat Darter	*Etheostoma spectablie*	Y	I	B	MOD[a]					BI										
Speckled Chub	*Extrarius aestivalis*	Y	I	B	INT[a]	LRF		INT		BI	IC									
Plains Killifish	*Fundulus zebrinus*		I; H	D; PF	MOD				LS											accidental
Goldeye	*Hiodon alosoides*	Y	I	D	TOL[b]	LRF	LRT													
Western Silvery Minnow	*Hybognathus argyritius*	Y	D	PF	INT[b]	LRF		INT												
Plains Minnow	*Hybognathus placitus*	Y	H	PF	INT[b]	LRF		INT												
Bigmouth Shinner	*Hybopsis doralis*		I	B	MOD[a]					BI	IC							NPS		accidental
Bighead Carp	*Hypophthalmichthys nobilis*		I; D	FF	TOL[b]		LRT								DFF		NNS			
Chesnut Lamprey	*Ichthyomyzon castaneus*		C	P	MOD[a]															rare/ext.
Blue Catfish	*Ictalurus furcatus*		I; C	B; WB	INT[b]	LRF		INT		BI										??
Channel Catfish	*Ictalurus punctatus*	Y	I; C	B; WB	MOD[a]					BI										
Smallmouth Buffalo	*Ictiobus bubalus*	Y	I; H	B	MOD[a]	LRF	LRT			BI		CS	DBS							
Bigmouth Buffalo	*Ictiobus cyprinellus*	Y	I	D	MOD[a]	LRF	LRT					CS	DBS							
Black Buffalo	*Ictiobus niger*		I	B	MOD[a]					BI		CS	DBS							??
Longnose Gar	*Lepisosteus osseus*	Y	C	WB	TOL[b]		LRT									TC				
Shortnose Gar	*Lepisosteus platostomus*	Y	C	WB	TOL[b]	LRF	LRT									TC				
Green Sunfish	*Lepomis cyanellus*	Y	I; C	D; WB	TOL[a]		LRT												CRS	
Orangespotted Sunfish	*Lepomis humilis*	Y	I	D	MOD[a]		LRT												CRS	
Bluegill	*Lepomis macrochirus*	Y	I	D	MOD[a]		LRT												CRS	
Burbot	*Lota lota*		P		MOD															waif
Redfin Shiner	*Lythrurus umbratilis*	Y	I	D	MOD[a]						IC									
Sturgeon Chub	*Machrybopsis gelida*	Y																		rare/ext.
Sicklefin Chub	*Machrybopsis meeki*																			rare/ext.
Silver Chub	*Machrybopsis storeriana*	Y	I	B	MOD[a]	LRF			LS	BI	IC									
Largemouth Bass	*Micropterus salmoides*	Y	I; C	D; WB	MOD[a]											TC			CRS	
White Bass	*Morone chrysops*	Y	I; C	D; WB	TOL[b]		LRT											NPS		
Slender Madtom	*Noturus exilis*	Y	I	B	INT[a]			INT		BI										accidental
Stonecat	*Noturus flavus*	Y	I	B	INT[a]			INT		BI										
Shorthead Redhorse	*Moxostoma macrolepidotum*	Y	I	B	INT[c]			INT	LS	BI		CS		RBC						
Golden Shiner	*Notemigonus crysoleucas*	Y	I; H	PF	TOL[a]		LRT													
Emerald Shiner	*Notropis atherinoides*	Y	P	PF	MOD[a]	LRF			LS									NPS		
River Shiner	*Notropis blennius*	Y	I	B; D	MOD[a]	LRF			LS	BI	IC									
Sand Shiner	*Notropis ludibundus*	Y	I; D	B	INT[c]			INT	LS	BI	IC									
Rosyface Shiner	*Notropis rubellus*		I; H	D	INT[a]			INT	LS		IC									
Silverband Shiner	*Notropis shumardi*																			rare/ext.
Logperch	*Percina caprodes*	Y	I	B	INT[c]			INT	LS	BI										
Suckermouth Minnow	*Phenacobius mirabilis*	Y	I	B	MOD[a]				LS	BI	IC									
Bluntnose Minnow	*Pimaphales notatus*	Y	D	PF	TOL[a]		LRT								DFF					
Fathead Minnow	*Pimaphales promelas*	Y	D; I	PF	TOL[a]		LRT								DFF					
Bullhead Minnow	*Pimaphales vigilax*	Y	I; H	B	MOD[a]													NPS		
Flathead Chub	*Platygobio gracilis*		I	D	INT[b]	LRF		INT	LS		IC									rare/ext.
Paddlefish	*Polyodon spathula*			FF	INT															
White Crappie	*Pomoxis annularis*	Y	I; C	D; WB	MOD[a]														CRS	
Black Crappie	*Pomoxis niromaculatus*	Y	I; C	D; WB	MOD[a]														CRS	
Flathead Catfish	*Pylodictis olivarius*	Y	I; C	B; WB	MOD[a]											TC				
Pallid Sturgeon	*Scaphirhynchus albus*																			rare/ext.
Shovelnose Sturgeon	*Scaphirhynchus platorynchus*	Y	I	B	INT[b]	LRF		INT	LS	BI										
Creek Chub	*Semotiliux atromaculatus*	Y	I; C	D	TOL[b]		LRT				IC									
Sauger	*Stizostedion canadense*	Y	I; C	D; WB	MOD[a]	LRF			LS							TC				
Walleye	*Stizostedion vitreum*	Y	I; C	D; WB	MOD[a]	LRF			LS							TC				

Trophic Guilds (Level 1)	**Trophic Guilds (Level 2)**	**Tolerance:**	**Lithophilous spawners**	LRT- Large river tolerants (Simon, 1992)
C= Carnivore	P= Parasite	a= EPA RPB Wadeable Streams (1999)	References:	LRF- Large River Fauna (Simon, 1992)
I= Invertivore	FF = Filter Feeder	b=Bergstedt, et.al. (2004)	Emery, et.al (2003)	SLS- Simple Lithophilic Spawners (Simon, 1992)
H= Herbivore	B=Benthic	c=Ohio (Emery, et.al., 2003)	Lyons, et.al. (2001)	
D= Detritivore	WB= Whole Body	d=Karr, et.al. (1986)	Ohio EPA (1989)	
P= Planktivore	D= Drift	e= Pflieger (1997)	Simon (1999)	informtion lacking
	PF= Particulate Feeder	f=Wisconsin (Lyons, et.al., 2001)	Bergstedt, et.al. (2004)	
		g= based on reduced range; other		

Table 2 – Candidate Metrics

Metric 1- Total Number of Fish Species	Metric 26- % Catostomid Individuals
Metric 2- Metric 1 minus exotics	Metric 27- # Round-bodied Catostomid Species
Metric 3- # Large River Species	Metric 28- % Round-bodied Catostomid Species
Metric 4- % Large River Species	Metric 29- % Round-bodied Catostomid Individuals
Metric 5- % Large River Individuals	Metric 30- # Deep-bodied Catostomid Species
Metric 6- # Tolerant Species	Metric 31- % Deep-bodied Catostomid Species
Metric 7- % Tolerant Species	Metric 32- % Deep-bodied Catostomid Individuals
Metric 8- % Tolerant Individuals	Metric 33- # Centrarchid Species
Metric 9- # Sensitive Species	Metric 34- % Centrarchid Species
Metric 10- % Sensitive Species	Metric 35- % Centrarchid Individuals
Metric 11- % Sensitive Individuals	Metric 36- # Native Cyprinid Species
Metric 12- # Benthic Invertivore Species	Metric 37- % Native Cyprind Species
Metric 13- % Benthic Invertivore Species	Metric 38- % Native Cyprinid Individuals
Metric 14- % Benthic Invertivore Individuals	Metric 39- # Non-native Species
Metric 15- # Insectivorous Cyprinid Species	Metric 40- % Non-native Species
Metric 16 % Insectivorous Cyprinid Species	Metric 41- % Non-native Individuals
Metric 17- % Insectivorous Cyprinid Individuals	Metric 42- # Native Pioneering Species
Metric 18- # Top Carnivore Species	Metric 43- % Native Pioneering Species
Metric 19- % Top Carnivore Species	Metric 44- % Native Pioneering Individuals
Metric 20- % Top Carnivore Individuals	Metric 45- # Lithophilous Spawner Species
Metric 21- # Detritivore and Filter Feeding Species	Metric 46- % Lithophilous Spawner Species
Metric 22- % Detritivore and Filter Feeding Species	Metric 47- % Lithophilous Spawner Individuals
Metric 23- % Detritivore and Filter Feeding Individuals	Metric 48- CPUE Seining (#/100m2)
Metric 24- # Catostomid Species	Metric 49- CPUE Electrofishing (#/hour)
Metric 25- % Catostomid Species	Metric 50- Evenness

Final metric selection is typically based on a rigorous statistical analysis of a large number of samples taken from a stream or river from multiple locations. With only the Cross, et al., (1982) data available, reliance on this level of analysis for selection of metrics was considered problematic. The Cross-study data was collected from fixed sites that focused on the evaluation of the impact of dredging on the fish; therefore, care had to be take to avoid the selection of metrics so that the IBI is not biased to a reflection of only the effects of dredging. However, the data did provide a substantial amount of information that was useful for the determination of weighting factors to apply to the metrics. For example, substrate affinities for various species collected during the study aided in determining habitat relationships for different species. The number of species collected per site, per sampling event, for each sampling technique used to collect the fish helped to set reasonable values for the number of species that are likely to be collected at any one time. Using the list of lower Kansas River species, their biological information, and data from the Cross-study, 12 candidate metrics and metric scores were chosen to include in the proposed IBI (Table 3). A description and discussion of the metrics follows.

Table 3 – IBI Metrics and Scoring for Lower Kansas River

IBI Metrics	Best = 5		Medium = 3		Worst = 1
Total Number of Fish Species	>16		>8 and <16		<8
Evenness	>0.8		>0.6 and <0.8		<0.6
% Large River Tolerant Species	50>		<50 and >20		<20
% Native Cyprinid Species	5 to 6		2 to 4		<2
Number Round Bodied Catostomid Species	3		1 or 2		0
% Sensitive Species	11 to 18		5 to 10		<5
% Tolerant Species	>25%		25% to 50%		>50%
% Onmivores	20% to 30%		10% to 20%		<10% or >30%
% Insectivores	>45%		44% to 30%		<30%
% Top Carnivores	20% to 30%		>10% and <20%		<10 and >30%
% Simple Lithophils	20% to 30%		10% to 20%		<10% or >30%
Catch per unit effort (Not Scored: see discussion)					

Total Number of Species

The total number of species has been used in nearly all IBIs that have been developed. The premise for its use is that the number of taxa will decrease as anthropogenic impacts increase (Karr et al. 1986). However, Karr et al. (1986) also contend the total number of native species may be more valid because introduced species are likely replacing native species and represent another form of anthropogenic stress on the fish community. Of the 63 fish species that have been found in the lower Kansas River, three are considered introduced and information about the abundance of these few species is lacking. Therefore, for this proposed IBI, the total number of species was considered the more appropriate metric. If the collection of additional fish data shows that the populations of these species are increasing or additional introduced species are found, it may be prudent to either replace this metric with a “native species only” metric or add another metric that considers the proportion of native to non-native species to increase the sensitivity of the IBI.

Evenness

Niemela, et al. (1999) adopted this metric for a proposed IBI for use in the Lake Agassiz Plain Ecoregion in North Dakota and Minnesota, which they described as “species-depauperate” with a total of 75 species in the basin but many fewer in various tributaries. Although the species composition is different from those found in the lower Kansas River, the low number of species encounter in their sampling efforts and disparity in the number of individuals per species collected at any given site is similar to that reported in the study by Cross et al. (1982). Utilization of an evenness metric to account for the variable abundance in number of individuals of a species seems appropriate. Compared to a theoretical maximum diversity, evenness refers to the distribution and abundance of individuals among species. Following Pielou (1975), a maximum of 1.0 implies that all species are equally abundant. As the difference in abundance becomes greater between species, evenness becomes smaller and closer to zero. In some degraded conditions, the number of species may not be reduced but dominance, in terms of numbers of individuals, by a few tolerant species, may emerge. Other diversity indexes (e.g. Shannon Index) would serve the same purpose and could be use in place of the Pielou Index.

Percent Large River Tolerant Species

The number or percent of large river species is the most often used metric in IBIs for large rivers like the Ohio and Missouri. For streams, the preferred metric is one that enumerates species of higher importance in these types of water bodies (e.g. darters). The lower Kansas River has the physical characteristics of both a large river in some reaches, and areas of small braided channels characteristic of wadeable streams in others. Because fish fauna reflects these varied conditions, exclusive use of one or the other of these metrics was deemed inappropriate since a portion of the fish fauna would not be adequately considered in the IBI, depending on which metric was chosen. As a compromise, the metric that considers species tolerance of large river conditions was adopted.

Percent Native Cyprinid Species

Bergstedt, et al., (2004) used this metric in the Missouri River IBI. As in the Missouri River, minnows are an important faunal component of the lower Kansas River. The unfortunate circumstance is that a few species have not been found for a number of years and may already be extirpated from the Kansas River (Haslouer, et al., 2005).

Number Round Bodied Catostomid Species

Use of this metric to tally either the number of species or percentage of the fauna is often used in IBIs because Catosomid species are long lived and several are sensitive to chemical pollutants and loss of habitat. Nine species of Catostomids have been recorded in the lower Kansas River but only three in round-bodied group. Cross, et al. (1982) found seven Catostomid species, but only 2 were round bodied (Shorthead Redhorse and Blue Sucker). The number of species has been retained for this metric because round-bodied Catostomids are the most intolerant of the group; the balance of the species being more indicative of degraded habitats (Bergstedt, 2004). Additional data needed to determine if this metric should be retained or changed it to include all Catostomid species.

Percent Sensitive Species
Percent Tolerant Species

These two metrics are intended to reflect whether the fish community is dominated by tolerant species, indicative of a degraded condition; or the community has a reasonably high percentage of sensitive species, indicative of an un-impacted condition. Records of fish found in the lower Kansas River indicate an approximately even mix of tolerant and sensitive species (16 vs. 18 species, respectively). Also, four of the sensitive species are either extremely rare or extirpated, and two of the tolerant species are not native. In the absence of a reference condition, it is difficult to determine an appropriate proportional balance between number of sensitive and tolerant species, but the assumption would be that the least impacted condition would not be dominated by tolerant species. The metric scoring reflects this assumption.

Percent Omnivores
Percent Insectivores
Percent Top Carnivores

The percentage of species in different feeding guilds is indicative of the quality of the food base. Approximately one half of the species found in the lower Kansas River are insectivores. Feeding habits are not know for some species and insectivores and omnivores been approached differently in some IBIs. For example, in the Missouri River IBI, for increased metric sensitivity only insectivorous Cyprinids are considered, but the percent detritivores and filter feeders is used in place of omnivores (Bergstedt, et al., 2004). With additional sampling data and feeding habit information, either one or both of the more sensitive metrics could be used in place of the broader omnivore and insectivore feeding categories proposed in these two IBI metrics. Top carnivores are not represented by a large number of species in the lower Kansas River, but their presence is generally indicative of a balanced fish community (Karr et al. 1986). Scores derived for these three metrics are generally based on data contained in the Cross-study, but should be considered subjective.

Percent Simple Lithophilous Spawners

Lithophils spawn in rocks and gravel and larvae hide beneath rocks and stones (Simon, 1999). This metric is used in the Ohio IBI (Emery, et al., 2003). Bergstedt, et al. (2004) evaluated the use of reproductive guild metrics but did not consider Lithophils and did not include any metrics related to reproductive strategies. Sixteen species known from lower Kansas River are considered in this reproductive guild and 66% to 78% of the control sites in the Cross et al. (1982) study were found to be composed of sand and gravel, which may afford lithophils species appropriate reproduction habitat and is the reason for inclusion of this metric. However, many of the species in this guild may utilize tributary streams for spawning; therefore, inclusion of this metric may be inappropriate or better suited for inclusion in an IBI for tributary streams of the lower Kansas River. Data on the actual breeding habitat locations of species in this guild is needed for acceptance or rejection of this metric.

Catch Per Unit Effort (CPUE)

The number of individuals collected per unit area sampled is a common metric used in the majority of indexes of fish biological integrity. While the basis for the metric is an expected decrease in CPUE as anthropogenic stress increases, the reverse effect can be observed due to a large number individuals being found, but only of a few tolerant species. This metric is most sensitive to moderate to severe levels of stream degradation (Karr et al., 1986). No score is offer for this metric (see discussion).

Metric Scoring and Discussion

A best to worst scoring method (Table 3) of 5, 3 or 1 for each metric was adopted for use in the proposed lower Kansas IBI. This is a common scoring method used in a number of IBIs. After the score for each metric is determined, the scores are summed or an average score calculated that represents the overall condition of a site or series sites where the data was collected. Most often, an IBI is used to assess the condition of a river as part of a long-term monitor program.

The greatest challenge was to determine how each metric should be scored. With data from only one study and no reference condition with which to compare the data, the values provided in Table 3 to score each metric should be considered as highly subjective. Eight of the metric scores are determine by a percentage of the number of species, two by a direct count of the number of species, Evenness by a value calculated on the basis of numbers of individuals of each species, and Catch per unit effort is the number of individuals per unit of area sampled and does not receive a metric score.

The number of species and community composition changes from the headwaters to the mouth of rivers. Consequently, many IBIs use adjustment calculations to compensate for expected natural shifts in fish community composition and number of species. The scaling factors are typically applied on the basis of the river mile where the data is collected (e.g. Emery, et al., 2003; Bergstedt, et al., 2004) and sometimes on drainage area above the data collection site (e.g. Niemela, et al., 1999). A considerable amount of information from many different sites along the length of a river is needed to be able to derive scaling factors that are not arbitrary. Because of a lack of sufficient data, it was decided to use percentages for the majority of the metrics instead of number of species. Use of proportional representation (percentages) is based on the premise that, in a healthy river, while the number of species may vary, the proportional number of species in each of the different trophic classes remains similar. As the river becomes degraded, the percentage of species in the trophic classes changes (e.g. more generalist species and fewer specialists; more tolerant species and fewer sensitive). Use of percentages in this IBI is not to imply that the trophic structure of the fish community is the same throughout the Kansas River, but that it is relatively consistent through the majority of the lower Kansas River. The exception to this assumption is the lower few miles of the river above the confluence with the Missouri River where the channel is wider, deeper, within channel habitat is reduce, and the flow velocity is slower. The fish community could be different in this lower reach compared to upstream, but information is lacking to make this judgment.

No score was suggested for the metric Catch Per Unit Effort (CPUE). While an important metric that is used in nearly all IBIs, difficulties were encountered interpreting the available data (Cross, et al., 1982). Measurements of CPUE were consistently recorded for all samples taken during the study, but the amount variability between samples precluded selection of a score that could be meaningfully applied in most circumstances. However, the metric was retained and scoring is left to the best professional judgment of those who may wish to use the IBI.

The problems encountered in the selection of a score for the CPUE metric was also encountered in the selection of scores for other metrics, including selection of the metrics themselves. The “traditional” metrics being used in the majority of IBIs may not be appropriate for the streams and rivers in the western Great Plains. Bramblett and Fausch (1991) alluded to this in their discussion of the development of an IBI for use in streams in southeastern Colorado. The climatic conditions and geology of the region resulted in the formation of streams and rivers with highly variable flow regimes. For those like the Kansas River that are predominantly composed of sand, the diversity of habitat is also low. Accordingly, the fish community is not diverse and made up of many species tolerant to large changes in physical and chemical conditions. An additional complication in developing an IBI for the lower Kansas River are impacts that have taken place over several decades that placed stress on the aboriginal fish community. For example, reservoir altered flow, aggregate removal, construction of weirs, appearance of non-native species, escape of fish stocked in reservoirs, non point source pollutants from urban and agricultural areas, plus other impacts have likely altered the fish community. Sanders, et al. (1993) mention some of these as well as other stresses in their paper on “The Kansas River System and Its Biota.”

Indexes of biological integrity use metrics that generally rank streams and rivers with high species richness and a low ratio of tolerant to sensitive species as being of better overall quality or condition. Rivers in the Great Plains that have an inherently low species richness and composed of species tolerant of naturally highly variability in conditions do not rank very high in these indexes even though the number of species and species composition may be within the range expected for a given site. For example, in the Cross-study, while no sites scored as being un-impacted, the Control sites generally scored as slightly more impacted than the dredged sites. Dredging created an artificial increase in habitat diversity allowing for higher species richness and better IBI scores. Comparing IBI scores for individual samples at both the Control and Dredge sites over the duration of the 1 ½ year study showed a more impacted condition at sites at the lower end of areas where dredging was occurring. This is consistent with effects of dredging on the fish community discussed in the study (Cross et al., 1982). However, this situation points to problems using traditional IBI metrics that place a high level of importance on species richness as a measure of the level of impact on a river that has a naturally low species and habitat diversity.

The proposed IBI may provide some level of usefulness in evaluating impacts on the fish community of the lower Kansas River, but only after it has been thoroughly tested. Collection of fish data using a standardized sampling methodology is a logical next step, but other important influences on the fish community should also be considered beyond enumerating the number of species and number of individuals at various sites along the lower Kansas River. A concurrent assessment of the quantity and quality of available habitat would be highly advantageous. A Habitat Suitability Index (HSI) for the lower Kansas River could prove to be as useful as a Fish IBI and HSIs have been in use for nearly as long as Fish IBIs. Unfortunately, most existing HSIs are models that have been developed for single species or guidance on how to develop an HSI for a river system. Nevertheless, some form of habitat evaluation at the community level may be helpful or equally as useful.

The overriding purpose for development of an IBI for fish for the lower Kansas River was to provide a possible a tool that might help gain a better understanding of how degradation in the Kansas River, natural or from man’s activities, is affecting the river’s biology. Regardless of whether the fish community or some other ecological component of the river is chosen, an as yet to be established baseline of information, and long-term monitoring strategy must be put into place that can be used to measure change. Without this, the biological health of the Kansas River will continue to be illustrated through what has mostly been conjecture and anecdotal evidence from desultory sampling. Because of the in-dept study by Cross et al. (1982) and recently initiated investigations of fish in the Kansas River by the USGS Fish and Wildlife Cooperative at Kansas State University, fish appear to be a logical biological component upon which to concentrate initial efforts. Due to the size and complexities of sampling the Kansas River, a group (e.g. multi agency) effort may be needed for an endeavor of this magnitude. Beginning with validation, refinement or rejection of the proposed fish IBI could be beneficial first step before embarking on a larger scale monitoring program.

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APPENDIX 1

Sampling Strategy for Fish in the Lower Kansas River

The Kansas River has changed much over the past several decades through both natural processes and in response to human activities. The biological community adjusts to these changes. Monitoring to detect changes in the biology has not been done in a consistent manner to determine either natural variations or perturbations resulting from human activities. A reasonably thorough study of the impact of dredging on fish in the lower Kansas River was conducted nearly three decades ago, but no investigations of this magnitude has been done since then except for occasional small scale sampling excursions. To begin to gather meaningful information about the fish community, a structured sampling procedure that can be replicated to allow comparison of data over time is needed.

The primary impetus for developing a sampling strategy for fish is collection of data that can be used to assess the health of the fish community using an Index of Biological Integrity (IBI). However, the methodology described below should allow for analysis of the data collected using metrics or other analytical procedures in addition to metrics included in the IBI.

The methodology is principally designed for use in the lower Kansas River. The lower Kansas River is generally recognized as being from the dam in Lawrence (at approximately river mile 51) downstream to the river's confluence with the Missouri River. Downstream of the weir at river mile 15, the river is generally deeper with slower flow velocities and is often influenced by the level of the Missouri River. Upstream of the weir, the river becomes shallower and more braided with a higher density of sandbars resulting in greater diversity of flow velocity conditions. The methodology is designed for sampling fish in both of these two distinct types of habitat. Potentially the methodology could be used throughout the Kansas River, but the proportional use of deep water sampling techniques to techniques better suited for collecting fish in shallow water and wadeable habitats would likely change. This will be a critical aspect for evaluating the fish community in both the lower Kansas River, with two relative distinct types of habitat, as well as the fish communities inhabiting the river further upstream.

SAMPLING PROCEDURES

Site Selection

Sampling locations may vary depending on a particular studies objective, but consistent use of the basic methodology will allow comparison of data collected over time. For example, the study of the effects of dredging (Cross, et. al, 1982) concentrated sampling efforts at active dredging sites with two control sites in non-dredging locations. While these locations were appropriate for the study, influences on the fish community from urbanized areas, tributaries streams, and areas of altered in-stream habitat (except for dredging sites) would be less apparent in the data collected. Therefore, sampling sites should be predetermined and situated in locations that reflect the array of different habitat types occurring in the lower Kansas River. Reconnaissance should be made prior to sampling. Reconnaissance should include recording GPS coordinates of the sample site locations and notes regarding the apparent habitat types within the site and the best location(s) for launching watercraft for sampling the site. More accurate GPS coordinates of each site should be recorded during sampling that reflects the precise location and extent of the site (upstream/downstream extent) sampled, and the locations and habitat types where samples were collected including the location where seining is conducted.

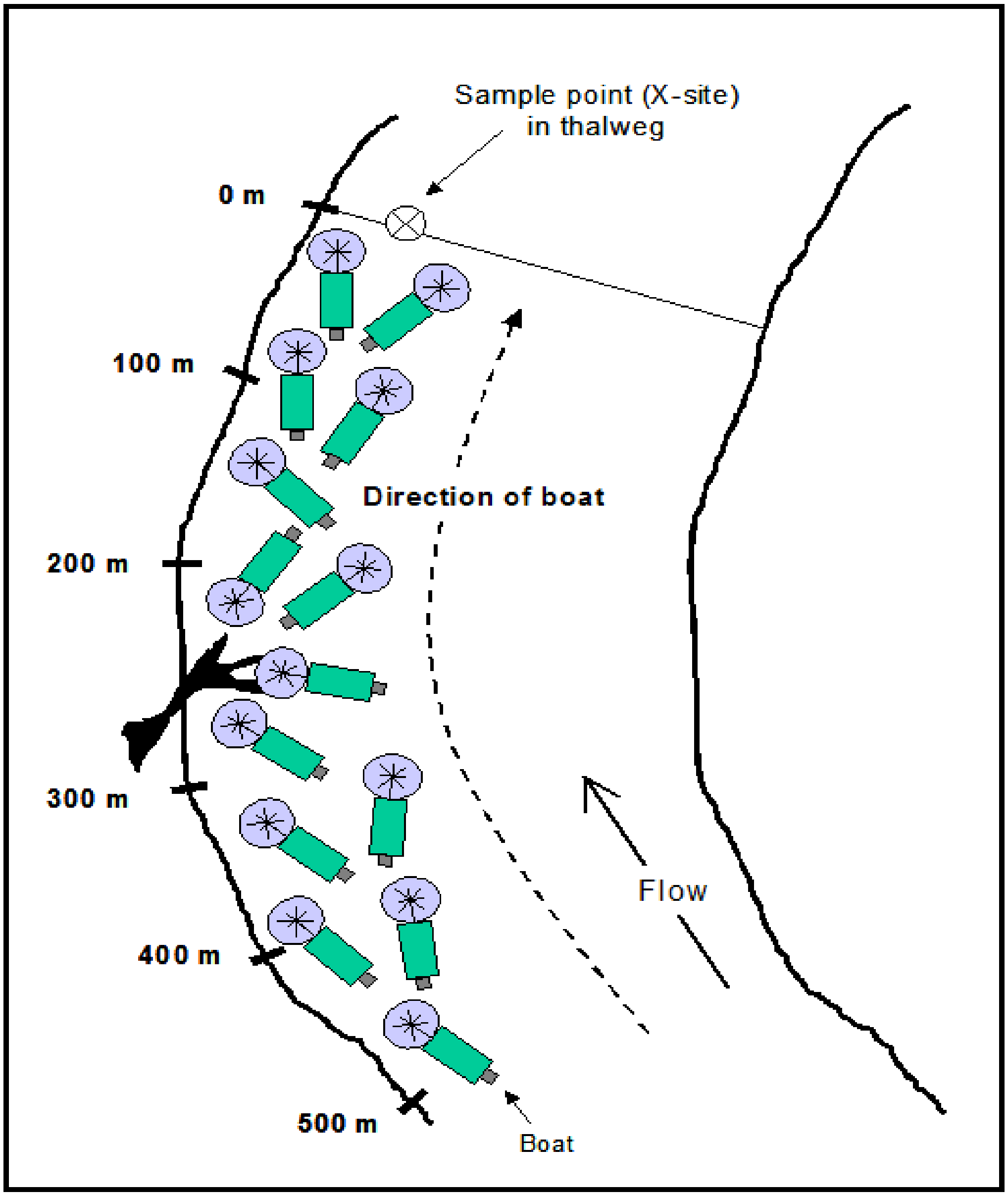
Sampling should occur between mid-May and October with 3 visits, one each during: May 15- June 30, July 1–September 15, and September 16-October 30. This time frame will allow for the fish to be relatively active, feasible weather conditions, and stable water flow. In general, sampling should occur between 8 am and 5 pm with sampling each site completed within eight hours or less. Electro-fishing and seining will be the primary collection methods, however, seining may not be possible in all locations (e.g. lowest reach of the river). Surveys should be halted during inclement weather (extreme wind, lightning, or rain). To characterize the fish community of the lower Kansas River, a minimum of 10 sites from downstream of the dam at Lawrence to the confluence with the Missouri (roughly, one every 5 miles) should be sampled initially.

Fish Community Sampling

Fish sampling gear selected and method of use were developed from a combination of gear and methods detailed elsewhere (e.g. Gutreuter, et al. 1995; Angradi, et al. 2006; Eitzmann and Paukert, 2007 unpublished) and are designed to collect all but the rarest fish inhabiting a site. The selection of appropriate sampling gear is a critical component in monitoring changes in fish populations. Eitzmann and Paukert (2007, unpublished) evaluated six different types of sampling gear in the Kansas River to compare which was most efficient in representing the fish community in this sandy bottom Great Plains River. Their' results indicated that, while different gear were more likely to capture certain species, electorfishing and seining, in combination, yielded approximately 90% of species collected during their study. Three of the sites where the gear comparisons were conducted were in the lower Kansas River. Therefore, electrofishing and seining were selected for this sampling procedure and it is assumed this gear and methodology will accurately represent the proportional abundance of the fish assemblage at a site.

Electrofishing

Electrofishing is conducted with a minimum of a three-person crew during the day along a 500 meter shoreline transect. The shoreline electrofishing zone extends out from shore to a depth of 6 m (20 ft) or a distance of 30 m (100 ft), whichever is closer to the shore. Electrofishing is conducted for a minimum of 1800 seconds (0.5 h) of total shock time to collect fish from the designated zone. Increased shock time will be necessary to fish shorelines with abundant cover. The fish sampling will take at least over 90 minutes of time simply for the electroshocking and ignoring the fish identification and data recording. Electrofishing may begin as early as 1 hour after sunrise (Gutreuter et al. 1995). Record GPS locations for at least each start and end point of each run or record the path using GPS. Fish should be processed after each run and the data should be labeled accordingly by run number. Be sure to thoroughly traverse areas of snags, piers, and other cover. (See figure below for the approximate path of the boat during electroshocking.)



(*Typical path of boat during electrofishing; from Angradi et. al. 2006*)

All stunned fish are captured in 1/8” or 3/16” mesh landing nets and transferred into buckets or tanks filled with water until processed. The holding tank should be at least 300 L in volume. An aerator should be used to maintain oxygen in the tank. Fish should be processed immediately following each run. If fish are processed during the run, e.g. due to excessive stress, then these individuals should be released behind the boat into deeper water to ensure they are not recaptured.

Additional data collected include the type of equipment used to stun the fish; the beginning and ending times for the use of the electro-shocker, and stream reach length and average width.

A standard electrofishing boat is sufficient for the sampling (see example below). The watercraft should be a 16 foot or large aluminum welded modified V- jon boat with a 25 hp or large motor. The boat should be outfitted with duel booms, an electric generator capable of producing a minimum of 3000 watts of DC pulsed current (7-11 A; 400-500 V; 40-60 pulses) and have bow kill switches for netters and the boat operator. Deviations from a 3000 watt generator should be noted in the collection data.

Fish and Wildlife Research Unit at Kansas State University 17-foot electrofishing boat

Seining

Seining is an efficient method to sample for small fish species. The primary seine used should be 15 feet by 5 feet with an 1/8" mesh size, and have floats attached at the top and weights attached at the bottom. Seining will be done along the shoreline, islands, riffles, or backwater areas where take-out is practicable. A minimum of four seine hauls, two on each side of the river, should be made. Other size seines may be used and additional seining may be done if several habitats occur at a site, provided data pertaining to the habitat type, size of seine used, number of hauls made, and size of the area seined is recorded. Haul lengths should be measured in meters between fixed points parallel to the shoreline. The fish should be removed from the net and can be processed on-site, data recorded, and fish returned to the river, or all can be preserved in 10% formalin and returned to lab for processing. As close as possible to a 200 meter length of shoreline should be covered with this method.

Supplementary Sampling

Electrofishing and seining will be the primary means of collecting fish. However, downstream of the weir at Interstate 435 especially near the confluence with the Missouri River has stretches of deeper water and slower water velocity. Also, there are deep depressions where there are active aggregate dredging operations. In these areas, supplementary sampling gear may be advantageous. Record all pertinent data for any supplementary sampling that is conducted.

Fish Handling

Collect information on all captured fish, regardless of size (i.e. those less than 1 inch in size should also be identified if possible, and counted) or method of capture. Make sure fish in holding tanks have fresh water to limit mortality. These data should be collected (and identified as such on each data sheet) for each of the methods used. At pre-determined stopping points, identify and count the fish. Measure and mark the fish if applicable. Then release the fish at areas where they are unlikely to be resampled.

A minimum of 50 fish should be measured for each species captured. Lengths should be measured to the nearest 1 mm. The rest of the captured fish should be counted to obtain valid catch per unit effort information. Some samples will be preserved for vouchers or later identification. Fish chosen for preservation should be placed into 10% formalin solution.

Data should be collected in the following sequence:
1). Conduct fish sampling.
2). Collect water samples for physicochemical water quality parameters.
3). Measure water temperature, velocity, water depth, Secchi transparency, conductivity.
4). Collect semi-quantitative benthic macroinvertebrate samples.
5). Collect qualitative, multi-habitat benthic macroinvertebrate sample.
6). Complete habitat measurements.

Fish sample data to be recorded include species composition and the size of individual fish. Other measures of assemblage structure and function can be calculated from the data and combined into indices of biotic condition potentially useful for assessing the condition of lower Kansas River.

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