

WATER QUALITY CHARACTERIZATION OF THE GRAND CALUMET RIVER BASIN USING THE INDEX OF BIOTIC INTEGRITY

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ABSTRACT: Water quality in the Grand Calumet River has shown steady improvement from 1985 to 1988 as determined by the index of biotic integrity (IBI), a measure of fish community health. Forty-three fish collections were made in the basin from 1985 to 1988, which resulted in a cumulative total of 21 fish species documented. The East Branch of the Grand Calumet River and Indiana Harbor Canal showed the most dramatic improvements from IBI ratings of very poor during 1985 to poor during 1987 in the Harbor. The West Branch showed a significant reduction in water quality with the decrease in Lake levels. Index of biotic integrity ratings of very poor were observed, during 1985, while no fish were collected in some areas during 1987 and 1988. The low water levels during drought conditions in 1988 influenced the entire river basin by reducing IBI values to baseline 1985 conditions and below.

INTRODUCTION

Instream quantification of impacts from point and non-point pollution sources on fish communities has been difficult to estimate. Separation of habitat degradation from organic enrichment and toxins has been especially difficult. Differences in professional interpretation of results and methodology have caused environmental regulatory agencies to reject biological evaluations for establishing permit limits for dischargers and has limited their utility. The recently developed index of biotic integrity (IBI; Karr, 1981; Karr, *et al.*, 1986) allows a more consistent application of biological sampling results and uses professional interpretation for categorizing water resource integrity.

Environmental problems within the Grand Calumet River basin have been documented (Federal Water Pollution Control Administration, 1966, 1967) and have concerned residents of northwestern Indiana for several decades. These chemical and sediment studies have documented where toxicants settled out in the basin, but little effort has been made to document the direct additive and syn-

TABLE 1. List of collection localities in the Grand Calumet River and Indiana Harbor Canal from October 1985 to July 1988. All stations are in Lake County, Indiana.

Station Number	Station Description
1	Marquette Park Lagoon, Miller, Calumet Township.
2	East Branch Grand Calumet River, E and W of Broadway from USX oil skimmer downstream, Gary, Calumet Township.
3	East Branch Grand Calumet River, W Bridge Street bridge, Gary, Calumet Township.
4	East Branch Grand Calumet River W Grant Street, Gary, Calumet Township.
5	East Branch Grand Calumet River, W Cline Ave. (SR 912), Gary, North Township.
6	East Branch Grand Calumet River, E Kennedy Ave, Gary, Calumet Township.
7	East Branch Grand Calumet River, adjacent Dupont de Nemours discharge canal including upstream segment, East Chicago, North Township.
8	Junction between the East and West Branch Grand Calumet River, Hammond-East Chicago, North Township.
9	West Branch Grand Calumet River, E Indianapolis Blvd. (US 20-SR 152), East Chicago, North Township.
10	West Branch Grand Calumet River, East I-90 bridge to eastern edge of Roxanna Marsh, East Chicago, North Township.
11	West Branch Grand Calumet River, East of Columbia Avenue to I-90 bridge, Hammond, North Township.
12	Indiana Harbor Canal, at Dickey Road bridge, East Chicago-Whiting, North Township.

ergistic effects on the resident aquatic community. The current study investigates the impact of water quality degradation and fluctuating Lake Michigan levels on the fish community of the Grand Calumet River basin.

METHODS AND MATERIALS

Karr, *et al.* (1986) established twelve metrics for categorizing biological integrity in streams. The cumulative total of these metrics comprise the IBI, with higher IBI values indicating ecologically healthier streams. The index is based on the premises that: 1) species diversity increases in a balanced community; 2) community dominance of tolerant forms indicates a stressed environment; 3) fewer top level carnivores and a higher proportion of omnivores are present in stressed environments; and 4) stressed conditions cause an increase in hybrids and disease within the community.

The prior use of the index has been limited to small streams and rivers and not to lake tributaries or harbors (Karr, *et al.*, 1986). The Grand Calumet River joins Lake Michigan via the channelized Indiana Harbor Canal, which is distinctly different from the east and west branches of the River. The harbor is dredged, and a 6 m channel is maintained for navigation purposes. The east and west branches are bordered by cattail marsh along the shores with depths usually less than 2 m. Neither of the branches are maintained for navigation, although they have been dredged in the past. Studies determined that species typical of the area could be categorized and the IBI metrics applied to the basin. Species considered

TABLE 2. Scoring criteria for second and third order reference stations comprising the northeastern Illinois watershed for calibrating the index of biotic integrity metrics (Gerking, 1946).

Metric	IBI Scoring Criteria		
	1	3	5
Species Diversity and Composition			
Number of Species - 2nd order	<6	6-10	>10
3rd order	<7	7-12	>12
Number of Sucker Species - 2nd order	<2	2	>2
3rd order	<2	2- 3	>3
Number of Sunfish Species - 2nd order	0	1	>1
3rd order	1	2	>2
Intolerant Species - 2nd order	<2	2- 3	>d3
3rd order	<2	2- 3	>3
Proportion of Green Sunfish	>20%	5-20%	<5%
Tropic Composition			
Proportion of Omnivores	>45%	20-45%	<20%
Proportion of Insectivores	<20%	20-45%	>5%
Proportion of Piscivores	<1	1-5%	>5%
Fish Abundance and Condition			
Number of Fish in a Sample ^a	<300	300-600	>600
Proportion of Hybrids	>1%	0-1%	0
Proportion of Individuals with disease, tumors, fin damage, and anomalies	>5%	>2-5%	0-2%

^a Ratings based on electrofishing gear methods, as number of fish per hour.

transients and not reproducing in the river were excluded from metric scoring. The Grand Calumet River basin provides a unique opportunity to study a harbor tributary using the IBI.

The east and west branches of the Grand Calumet River, Marquette Park Lagoon, and the Indiana Harbor Canal were sampled at twelve stations (Table 1). Sampling was conducted by two collection teams during the spring, summer, and fall of each year from October 1985 to July 1988, using a DC electroshocker mounted either in a sport canoe or a Jon boat. Replicate sampling at three stations was conducted during the spring of 1987 to verify that representative samples were being collected by the two teams. Species were dip-netted as they were sighted, identified to species (Gerking, 1946; Nelson and Gerking, 1981; Trautman, 1981), weighed, measured for total length, and released.

The computer calculation of the index of biotic integrity was generated using the Illinois Environmental Protection Agency's BIBI water quality program (Kelly, 1986). The data used for calibrating reference stations was based on fish collections from the Illinois Department of Conservation (Table 2), using a watershed approach similar to the ecoregion concept of Omernik (1987). The Grand Calumet River and Indiana Harbor Canal are second and third order streams, respectively. The Grand Calumet River basin was scored against other typical drainages of similar size for the upper Illinois River system. The numerical score calculated from the index was compared to the attributes composed by Karr, *et*

TABLE 3. Total index of biotic integrity scores, integrity classes, and the attributes of those classes (modified from Karr, 1981; Karr, *et al.*, 1986).

Total IBI Score	Integrity Class	Attributes
58-69	Excellent	Comparable to the best situations without human disturbance; all regionally expected species for the habitat and stream size, including the most intolerant forms, are present with full array of age (size) classes; balanced tropic structure.
48-52	Good	Species richness somewhat below expectations, especially due to the loss of the most intolerant forms; some species are present with less than optimal abundances or size distributions; tropic structure shows some signs of stress.
40-44	Fair	Signs of additional deterioration include loss of intolerant forms, fewer species, highly skewed trophic structure (e.g., increasing frequency of omnivores and green sunfish or other tolerant species); older age classes of top predators may be rare.
28-34	Poor	Dominated by omnivores, tolerant forms, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; hybrids and diseased fish often present.
12-22	Very Poor	Few fish present, mostly introduced or tolerant forms; hybrids common; disease, parasites, fin damage, and other anomalies regular.
0	No Fish	Repeated sampling finds no fish.

al. (1986) to determine the river reaches biological integrity based on the stability of the fish community (Table 3).

RESULTS AND DISCUSSION

Species composition. Meek and Hildebrand (1910) documented the species historically present in the Calumet area. They concluded that 29 species were present in the Little and Grand Calumet Rivers, Deep River, Wolf Lake, Calumet Lake, and Lake George. With the introduction of the alewife, grass carp, and coho and chinook salmon into the Great Lakes system, the total number of species within the basin became 33. A total of 22 species are attributed to the Grand Calumet River (Gerking, 1945; Table 4).

The current study documented the presence of 21 fish species within the Grand Calumet basin (Table 5). Although Marquette Park Lagoon is no longer connected to the River proper, we continued to include it as the headwater for the historic Grand Calumet River. The most dominant taxa included golden shiner (46.5%), goldfish (20.2%), and carp (15.0%). After the rise in Lake Michigan levels during 1986 and the subsequent steady decline, the River has been invaded by lake-dwelling species such as alewife, gizzard shad, emerald shiner, and rainbow smelt.

TABLE 4. Fishes collected by Meek and Hildebrand (1910) from the Grand Calumet basin and deposited in the Field Museum of Natural History.

Common Name	Species Name
Amiidae	
Bowfin	<i>Amia calva</i>
Cyprinidae	
Carp	<i>Cyprinus carpio</i>
Golden shiner	<i>Notemigonus crysoleucas</i>
Emerald shiner	<i>Notropis anthernoides</i>
Spottail shiner	<i>N. hudsonius</i>
Bluntnose shiner	<i>Pimephales notatus</i>
Catostomidae	
White sucker	<i>Catostomus commersoni</i>
Ictaluridae	
Channel catfish	<i>Ictalurus punctatus</i>
Black bullhead	<i>Ameiurus melas</i>
Brown bullhead	<i>A. nebulosus</i>
Yellow bullhead	<i>A. natalis</i>
Tadpole madtom	<i>Noturus gyrinus</i>
Esocidae	
Northern pike	<i>Esox lucius</i>
Grass pickerel	<i>E. americanus</i>
Umbridae	
Central mudminnow	<i>Umbra limi</i>
Centrarchidae	
Green sunfish	<i>Lepomis cyanellus</i>
Pumpkinseed	<i>L. gibbosus</i>
Bluegill	<i>L. macrochirus</i>
Black crappie	<i>Pomoxis nigromaculatus</i>
Percidae	
Yellow perch	<i>Perca flavescens</i>
Logperch	<i>Percina caprodes</i>
Scianidae	
Freshwater drum	<i>Aplodinotus grunniens</i>

Resident pumpkinseed and central mudminnow have exhibited steady decline in abundance since 1986.

The number of species collected annually increased in the basin between 1985 and 1987. Seven species were collected during 1985 (Simon, 1985), 13 species in 1986, 17 species in 1987, and 9 species during drought conditions in 1988. These species represented indigenous fauna and not transient species. The recent community represents a return to conditions similar to 1985.

TABLE 5. Collection of fishes from twelve locations in the Grand Calumet River and Indiana Harbor Canal from 1985 to 1988.

Species	1985											1986											1987											1988											Percent Dominance					
	EB ¹					WB ²						EB					WB IHC						J ³					EB					IHC						WB					IHC						
	2	5	7	10	11	1	3	5	6	9	12	2	3	4	5	6	7	8	9	10	12	3	5	6	9	12	3	5	6	9	12	Total																		
<i>Oncorhynchus kisutch</i>																					1												1	0.04																
<i>O. tshawytscha</i>															1																		1	0.04																
<i>Salmo gairdneri</i>											10										1											11	0.40																	
<i>Dorosoma cepedianum</i>												1	101		11	44					65											225	8.16																	
<i>Alosa pseudoharengus</i>												2									4		6	2								14	0.51																	
<i>Cyprinus carpio</i>	18	3	10	2		18	4	34	21	20	28	5	9	10	64	55	22	21	17		16	8	15	13							413	14.97																		
<i>Carassius auratus</i>	22	2	10	12		15	87	55	22	3		47	2	47	43	1			1		22	24	53	84	4						556	20.16																		
<i>Carp x Goldfish hybrid</i>																					1										1	0.04																		
<i>Notemigonus crysoleucas</i>	12	12	100			53	78	91				1	14	315	17	258	75	2	1	1	12	115	59	65							1281	46.45																		
<i>Notropis atherinoides</i>										5											2	14										21	0.76																	
<i>N. spilopterus</i>																					1	12									13	0.47																		
<i>Pimephales notatus</i>												1				4					10	3									19	0.69																		
<i>P. promelas</i>	1																			1											2	0.07																		
<i>Osmerus mordax</i>															1							1									20	0.73																		
<i>Umbra limi</i>												4	4	1	1	5	1					1									20	0.73																		
<i>Ameiurus melas</i>			1																													2	0.07																	
<i>Lepomis cyanellus</i>																																9	0.33																	
<i>L. gibbosus</i>	3										1		5		25	28	1				8	10	2	29	3						149	5.40																		
<i>L. macrochirus</i>													2								2										10	0.36																		
<i>Pomoxis nigromaculatus</i>																																2	0.04																	
<i>Micropterus salmoides</i>																																2	0.04																	
<i>Perca flavescens</i>											1	2	1								2										6	0.22																		
Number of Species	4	5	4	2	0	7	5	5	4	2	7	7	8	5	7	7	5	2	3	1	14	6	7	5	2	0					21																			
Number of Collections	1	1	1	1	1	1	2	2	2	2	2	1	3	1	3	2	1	1	3	1	2	2	2	2	2	1					43																			

¹ EB = East Branch ² WB = West Branch ³ J = Junction

TABLE 6. Index of biotic integrity values for forty-three fish collections conducted in the east and west branches of the Grand Calumet River and Indiana Harbor Canal (IHC) from 1985 to 1988.

	Index of Biotic Integrity Value by Station											IHC
	East Branch						Junc.	West Branch				
	1	2	3	4	5	6		7	8	9	10	
1985												
October		24			24		24			24	0	
1986												
June	32		26		24	24			22			24
October			28		30	28			20			26
1987												
April ^a		30	32	24	22		22	22	24	24		
April			24		24	26			22			28
November			32		30	30			0			34
1988												
May			26		22	24			0			
July			28		32	26			0			24

^a Two collection teams sampled in April one day apart.

Carp comprised 88% of all collections, followed by golden shiner and goldfish, each comprising 76% of the collection. Coho and chinook salmon, rainbow smelt, black crappie, and a carp x goldfish hybrid were all represented by a single specimen (Table 5).

Index of biotic integrity. Annual changes in fish community composition are reflected in fluctuating IBI values each year. During 1985, the east and west branches of the Grand Calumet River had a water quality rating of very poor. IBI values increased by several points in the summer of 1986, coinciding with rising Lake Michigan levels. By autumn 1986, IBI values increased an additional two to four points (Table 6). This raised the water quality classification from very poor to poor. Another factor in the improved water quality in the east branch may be the strike at USX corporation. The shutdown of the facility had dramatic impacts on the east branch, since the facilities discharge provides as much as 95% of the flow (U.S. Environmental Protection Agency, 1985). With the lowering of lake levels during 1987, the dilution of toxicants in the East Branch channel enabled additional fish species to use the river.

The reverse relationship was observed in the west branch. When Lake Michigan levels dropped, the average depth of the river decreased, while the surface to volume exposure ratio of the sediment to the water column increased. IBI values dropped drastically at Indianapolis Boulevard and within Roxana Marsh. During the 1988 drought, the low depth in the west branch prohibited any species use of the river from Indianapolis Boulevard to the Interstate I-90 bridge. Discharge was less then the reported 7Q10 estimated for the west branch, and flow was eastward to the Indiana Harbor Canal from Columbia Street bridge. Much of the Roxanna Marsh dried up, and only a small channel remained through much of the summer. No fish were collected in the west branch in 1987 and 1988 from

Indianapolis Boulevard to the Interstate bridge. The east branch has improved and now supports the best portion of the Grand Calumet resident community.

Seasonal trends. The Grand Calumet River typically has highest utilization by age group 0 fish, some transient pioneer species from Lake Michigan. Summer IBI values either remained constant or improved slightly over the duration of this study. Fall values for all east branch stations increased from 1985 to 1987, while spring values declined from 1987 to 1988 (Table 6).

IBI values based on duplicate collections on successive days in the spring of 1987 were relatively consistent for two of three stations. The Bridge Street location was the only station, which deviated significantly between collection teams (Students t-test; $p \leq 0.05$). Species composition was similar, but the numbers of each species differed. In a stable environment, this would not be a problem, because of the presence of more species. However, due to low diversity and dominance by tolerant taxa, a profound impact was produced, when a shift toward tolerant taxa occurred. Another problem may have been an inadequate period for mixing between the first and second collections.

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